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Polymer Science

Polymer Science

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Research and Curriculum Unit for Workforce Development
Vocational and Technical Education
Attention: Reference Room and Media Center Coordinator
P.O. Drawer DX
Mississippi State, MS 39762
www.rcu.msstate.edu/curriculum/download/
662.325.2510

Direct inquiries to

Myra Pannell
Instructional Design Specialist
P.O. Drawer DX
Mississippi State, MS 39762
662.325.2510
E-mail: myra.pannell@rcu.msstate.edu

Kendra Taylor
Program Coordinator
Office of Vocational Education and Workforce Development
Mississippi Department of Education
P.O. Box 771
Jackson, MS 39205
601.359.3479
E-mail: bmcgrew@mde.k12.ms.us

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Robin Parker, EdD, Curriculum Coordinator
Jolanda Harris, Educational Technologist
Johnny Jones, Digital Print Specialist
Louis Randle, Binding Specialist
Kelly Agee, Editor
Kim Harris, Graphic Artist

The Research and Curriculum Unit (RCU), located in Starkville, MS, as part of Mississippi State University, was established to foster educational enhancements and innovations. In keeping with the land grant mission of Mississippi State University, the RCU is dedicated to improving the quality of life for Mississippians. The RCU enhances intellectual and professional development of Mississippi students and educators while applying knowledge and educational research to the lives of the people of the state. The RCU works within the contexts of curriculum development and revision, research, assessment, professional development, and industrial training.

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Finally, standards in the *Polymer Science Curriculum Framework and Supporting Materials* are based on the following:

Society of the Plastics Industry Standards
Founded in 1937, SPI is the plastics industry trade association representing the third largest manufacturing industry in the United States. SPI's member companies represent the entire plastics industry supply chain, including processors, machinery and equipment manufacturers, and raw materials suppliers.
http://www.plasticsindustry.org

Polymer Standards for the State of Mississippi
From the study, *Analysis of the Micro Economic Environment and Labor Needs for Development of the Plastics and Polymers Industry Cluster in Mississippi* prepared for the Mississippi Development Authority Mississippi Technology Alliance with the University of Southern Mississippi, Center for Community and Economic Development, Workforce Training and Development, March 2002

Applied Academic Credit Benchmarks
Mississippi Department of Education 2010 Mississippi Science Framework Revised

21st Century Skills and Information and Communication Technologies Literacy Standards
In defining 21st century learning, the Partnership for 21st Century Skills has embraced five content and skill areas that represent the essential knowledge for the 21st century: global awareness; civic engagement; financial, economic, and business literacy; learning skills that encompass problem-solving, critical-thinking, and self-directional skills; and Information and Communication Technology (ICT) literacy.

National Educational Technology Standards for Students
Reprinted with permission from *National Educational Technology Standards for Students: Connecting Curriculum and Technology*, Copyright © 2007, ISTE (International Society for Technology in Education), 800.336.5191 (U.S. and Canada) or 541.302.3777 (International), iste@iste.org, www.iste.org. All rights reserved. Permission does not constitute an endorsement by ISTE.

ACT College Readiness Standards

The College Readiness Standards are sets of statements intended to help students understand what is expected of them in preparation for the ACT. These standards are integrated into teaching and assessment strategies throughout the curriculum framework.

Preface

Secondary vocational–technical education programs in Mississippi are faced with many challenges resulting from sweeping educational reforms at the national and state levels. Schools and teachers are increasingly being held accountable for providing true learning activities to every student in the classroom. This accountability is measured through increased requirements for mastery and attainment of competency as documented through both formative and summative assessments.

The courses in this document reflect the statutory requirements as found in Section 37-3-49, Mississippi Code of 1972, as amended (Section 37-3-46). In addition, this curriculum reflects guidelines imposed by federal and state mandates (Laws, 1988, ch. 487, §14; Laws, 1991, ch. 423, §1; Laws, 1992, ch. 519, §4 eff. from and after July 1, 1992; Carl D. Perkins Vocational Education Act IV, 2007; and No Child Left Behind Act of 2001).

Polymer Science Executive Summary

Pathway Description

Polymer Science is an instructional pathway that introduces an individual to the field of plastics and polymer materials manufacturing. The pathway allows an individual to prepare for employment or continued education in the occupations of plastics and polymer materials manufacturing. The pathway is designed to provide students with hands-on experiences related to the application of polymer science concepts in the workplace. Students will develop academic and technical skills, 21st century skills, and human relations competencies that accompany technical skills for job success and lifelong learning. Students who complete the pathway will be better prepared to enter and succeed in related programs offered by Mississippi community and junior colleges and institutions of higher education.

Industry Certification

Two national certifications are associated with the polymer science industry. They are the **Certified Composites Technician (CCT)** and **the National Certification in Plastics (NCP).**

Assessment

Students will be assessed using the Polymer Science MS-CPAS2 test. The MS-CPAS2 blueprint can be found at http://info.rcu.msstate.edu/services/curriculum.asp. If there are questions regarding assessment of this program, please contact the STEM instructional design specialist at the Research and Curriculum Unit at 662.325.2510.

Student Prerequisites

In order for students to experience success in the Polymer Science program, the following prerequisites are recommended:

1. C or Higher in a Physical Science or Biology
   or
2. Instructor Approval

Applied Academic Credit

The Polymer Science curriculum is aligned and correlated with the competencies in the Organic Chemistry course found in the 2010 Mississippi Science Framework. The student must complete the 2-course sequence (4 Carnegie units) of Polymer Science.

Licensure Requirements

The 989 licensure endorsement is needed to teach the Polymer Science pathway. The requirements for the 989 licensure endorsement are listed below:

1. Applicant must have earned a 4-year degree (bachelor's degree) or higher from an accredited institution of higher education. The degree must be in polymer science, chemistry, or an appropriate field of science and must be approved by the MDE program coordinator.
2. Applicant must enroll immediately in the Vocational Instructor Preparation (VIP) or the *Redesign* Education Program (REP).
3. Applicant must complete the individualized Professional Development Plan (PDP) requirements of the VIP or REP prior to the expiration date of the 3-year vocational license.
4. Applicant must successfully complete an MDE-approved computer literacy certification exam.

5. Applicant must successfully complete certification for an online learning workshop, module, or course that is approved by the MDE.
6. Applicant must successfully complete a Polymer Science certification workshop, module, or course that is approved by the MDE.

Note: If an applicant meets all requirements listed above, that applicant will be issued a 989 endorsement—a 5-year license. If the applicant does not meet all requirements, the applicant may be issued a 3-year endorsement (license), and all requirements must be satisfied prior to the ending date of that license.

Exception: LEAs converting to this pathway from existing programs in Plastics and Polymer Science Applications (with teachers currently licensed and endorsed #379 Plastics and Polymer Science Applications) may continue to employ those teachers and seek 989 endorsement for them although they do not meet the above stated requirement for a 4-year degree in certain major fields of study. These teachers must satisfy all other requirements stated above. All other teachers must meet the requirements for this endorsement.

Professional Learning

The professional learning itinerary for the middle school or individual pathways can be found at http://redesign.rcu.msstate.edu. If you have specific questions about the content of each training session provided, please contact the Research and Curriculum Unit at 662.325.2510, and ask for the Professional Learning Specialist.

Course Outlines

This curriculum framework is divided into four one-Carnegie-unit courses as outlined below. The first two courses are comprised of units from Polymer Science Year 1. The last two courses are comprised of units from Polymer Science Year 2.

Option 1 – Four One-Carnegie-Unit Courses

Course Description: Introduction to Polymer Science I orients the students to the course and lab. During this course, students learn computer applications relevant to polymer science. They are also introduced to chemistry concepts and the structures and properties of polymers.

Course Description: Introduction to Polymer Science II teaches students the processing techniques associated with polymers as well as the methods and benefits of plastics recycling.

Course Description: Advanced Topics in Polymer Science is a comprehensive course that focuses on polymer synthesis, surface coatings, and composite materials.

Course Description: Careers in Polymer Science explores the job opportunities that are available for individuals in this area. The course also teaches job application and workplace skills as well as offers a potential for job shadowing.

Introduction to Polymer Science I (One Carnegie Unit) - Course Code: 994502

Unit		Title	Hours
1		Orientation and Safety	40
2		Information, Media, and Computer Applications	40
3		Introduction to Chemistry	30
4		Structure and Properties of Polymers	30
			140

Introduction to Polymer Science II (One Carnegie Unit) - Course Code: 994503

Unit		Title	Hours
5		Polymer Processing	60
6		Recycling	60
			120

Advanced Topics in Polymer Science (One Carnegie Unit) - Course Code: 994504

Unit		Title	Hours
7		Orientation and Safety Review	10
8		Polymer Synthesis	60
9		Surface Coatings	20
10		Composite Materials, Processing, and Applications	30
			120

Careers in Polymer Science (One Carnegie Unit) - Course Code: 994505

Unit		Title	Hours
11		School to Work	110
			110

Option 2 – Two Two-Carnegie-Unit Courses

Course Description: Polymer Science I orients the students to the course and lab. During this course, students learn computer applications relevant to polymer science. They are also introduced to chemistry concepts and the structures and properties of polymers. This course also teaches students the processing techniques associated with polymers as well as the methods and benefits of plastics recycling.

Course Description: Polymer Science II is a comprehensive course that focuses on polymer synthesis, surface coatings, and composite materials. This course explores the job opportunities that are available for individuals in this area. It also teaches job application and workplace skills as well as offers a potential for job shadowing.

Polymer Science I (Two Carnegie Units) - Course Code: 994500

Unit		Title	Hours
1		Orientation and Safety	40
2		Information, Media, and Computer Applications	40
3		Introduction to Chemistry	30
4		Structure and Properties of Polymers	30
5		Polymer Processing	60
6		Recycling	60
			260

Polymer Science II (Two Carnegie Units) - Course Code: 994501

Unit		Title	Hours
7		Orientation and Safety Review	10
8		Polymer Synthesis	60
9		Surface Coatings	20
10		Composite Materials, Processing, and Applications	30
11		School to Work	110
			230

Secondary Polymer Science Research Synopsis

Research Design

A mixed-methods approach was used when conducting the research for secondary Polymer Science. The quantitative data were analyzed to find similarities and/or differences among the responses to the surveys as well as to see if the different stakeholders had similar or differing views on the topics covered. The qualitative data were derived from existing public documents and examined for the needs of the workforce, employability expectations, and possible curriculum content.

Sampling

Data used were collected from survey responses from secondary and Institutes of Higher Learning (IHL) instructors as well as from members of the polymer science industry. Instructors from the postsecondary or community college were not consulted as there is not a postsecondary curriculum that articulates with secondary Polymer Science.

Data Analysis

The population sampled was from similar backgrounds. Of those surveyed, 100% were Caucasian adults, of which almost 90% held college degrees. Additionally, 80% of the industry contacts held a college degree, while 75% of the polymer science instructors had advanced degrees. Though the college majors vary, industry and instructors alike majored in polymer science, engineering, mathematics, or occupational training. Furthermore, 80% of the industry contacts who responded were female, while 75% of the instructors who responded were male. Seventy-five percent of the instructors surveyed also have experience working in the polymer science industry.

When dealing specifically with industry, the trend to hire entry-level employees is higher among companies that employ many individuals. Of those surveyed, the smaller, less populated companies were more

likely to hire a worker with a few years of experience over someone who, for example, just graduated high school. Based on this information, a high school graduate would be more likely to obtain a job at a larger company rather than a small one. However, 80% of those surveyed stated that the lowest level of education they would consider employing is a high school graduate/GED recipient. Most of the industry respondents also expect high school graduates to have at least 1 year of industry experience, with 100% of them responding that completion of a polymer science career and technical program is acceptable work experience.

Of the employees surveyed, 80% of the companies they work for provide in-house job training. Additionally, 100% of these companies who provide training prefer to offer face-to-face, hands-on instruction in areas such as injection molding, coatings, and even basic math.

Of the instructors surveyed, 100% of them actively recruit students to their programs. All of them give tours of the career and technical center as well as rely on the career and technical counselors to recruit students who would be interested in the program. Seventy-five percent also use brochures, newsletters, and career fairs to recruit students. All of the instructors declare to follow the Polymer Science state curriculum framework when developing lesson plans as well as implement teaching and assessment strategies found in the curriculum. All instructors also state that they communicate with their colleagues via the Polymer Science B.R.I.D.G.E Web site, provided by the Research and Curriculum Unit (RCU). The majority of the instructors also claim to use the rubrics provided in the curriculum as well as make use of the student competency profile. Some of the most widely used teaching strategies among the polymer science instructors are lecture and note taking, brainstorming, cooperative learning, problem-based learning, nonlinguistic representations, technology, demonstration, and visuals.

Technology is very important in this industry. Industry and instructors combined chose the same technology skills as being of some, if not extreme, importance. Both chose word processing as a vital skill among workers and students. In fact, 100% of those surveyed place a high level of importance on word processing as

well as Internet skills and electronic communication. The respondents place less importance on spreadsheet and presentation skills and software and hardware installation.

Needs of the Future Workforce

Employment

Currently, there are approximately 93,000 chemists and materials scientists in the United States. According to the Bureau of Labor and Statistics, employment needs in these areas are expected to rise by 9% before 2016. Chemists will be needed to conduct additional pharmaceutical, biomedical, and genetic research for treatment of diseases, while materials scientists will continue to improve the quality of manufacturers' products. However, non-pharmaceutical chemist positions are expected to decline.

			Number	Percent	
Chemists and materials scientists	93,000	102,000	8,500	9	67,240
Chemists	84,000	91,000	7,600	9	59,870
Materials scientists	9,700	11,000	800	9	74,610

Perkins IV Requirements

The redesigned Polymer Science curriculum will meet Perkins IV requirements of high-skill, high-wage, and/or high-demand occupations by offering articulation to a Polymer Science program at an Institute of Higher Learning (IHL). It will also offer students a program of study, including secondary, postsecondary, and IHL courses that will prepare them for occupations in this field. Additionally, the Polymer Science curriculum is integrated with academic standards and articulated to the organic chemistry course in the 2010 Mississippi Science Framework. The Polymer Science curriculum focuses on ongoing and meaningful professional development for teachers as well as relationships with industry. The curriculum is written in accordance with the May 2006 Society of the Plastics Industry Standards. Lastly, students will be assessed using the Mississippi Career Planning Assessment System 2 (MS-CPAS2).

Program of study	**X**
Aligned to careers	**X**
Standards and content	**X**
Continuous improvement	**X**
Alignment and articulation	**X**
Accountability and assessment	**X**

Pathway Map

Upon completion of the 2-year Polymer Science program, students can enter the workforce as an apprentice (at some locations) or enter a postsecondary or IHL program. Currently, no postsecondary curriculum supports Polymer Science, with the exception of science-related majors, that will prepare students to further their education at an IHL. The Polymer Science curriculum will prepare students seeking a bachelor's degree in chemistry, pharmacy, fiber and polymer science, materials science, plastics engineering, biomedical engineering, and other related fields.

Curriculum Content

Standards

The standards to be included in the Polymer Science curriculum are the Society of the Plastics Industry Standards, 21st Century Skills, ACT Academic Readiness Standards, the National Educational Technology Standards (NETS) for Students, and the academic Chemistry Standards. Combining these standards to create this document will result in highly skilled, well-rounded students who are prepared to enter postsecondary education or the workforce.

Industry Certification

Two national certifications are associated with the polymer science industry. They are the Certified Composites Technician (CCT) and the National Certification in Plastics (NCP). Following is a list of many of the objectives from each certification:

Certified Composites Technician

Program Overview - Open Molding

- General Composite Knowledge
- Composites Manufacturing Process
- Composites Materials
- Gel Coat Application
- Open Molding Laminating Techniques
- Controlled Spraying
- Fluid Handling Equipment
- Composites Plant Safety
- Open Molding Quality Assurance

Program Overview - Marine Molding

- History of Fiberglass
- General Composites Knowledge
- Composites Manufacturing Process
- Composites Materials for Boat Building
- Marine Gel Coat Application
- Marine Laminating Techniques
- Controlled Spraying
- Fluid Handling Equipment

Program Overview - Cast Polymer

- Composites Manufacturing Process
- Gel Coat Application
- Matrix Casting Techniques for Gel-Coated Products
- Controlled Spraying for Cast Polymer Production
- Fluid Handling Equipment Principles
- Cast Polymer Plant Safety
- Cast Polymer Quality Assurance

Program Overview - Solid Surface

- Composites Manufacturing Process
- Solid Surface Materials
- Matrix Casting Techniques for Solid Surface Products

- Postcuring Solid Surface
- Surface Finishing
- Fabrication
- Cast Polymer Plant Safety
- Solid Surface Quality Assurance

Program Overview - Compression Molding

- General Composites Knowledge
- Composites Manufacturing Processes
- Compression Molding Materials
- Overview of the Matched Metal-Die Process
- Hydraulic Press Systems
- Compression Molding Process Quality Control and Troubleshooting
- Compression Molding Plant Safety

Program Overview - Corrosion

- General Composites Knowledge
- Composites Manufacturing Process
- Composites Materials
- Gel Coat Application
- Molding Laminating Techniques
- Controlled Spraying
- Fluid Handling Equipment Principles
- Composites Plant Safety
- Corrosion Quality Assurance

National Certification in Plastics

- Basic Process Control
- Preventive and Corrective Action in Primary and Secondary Equipment
- Handling, Storage, Packaging, and Delivery of Plastic Materials
- Quality Assurance
- Safety
- Tools and Equipment
- General Knowledge

Applied Academic Credit

The Polymer Science curriculum is written to correlate with the competencies in the organic chemistry course found in the 2008 Mississippi Science Framework. The heavy academic science content prompted a request for 1/2 credit of applied science. This correlation is evident in the following table.

Apply inquiry-based and problem-solving processes and skills to scientific investigations.	• Demonstrate the ability to interpret the different views of a blueprint. • Design a part with appropriate draft angle. • Define and demonstrate homogeneous and heterogeneous mixtures. • Define and demonstrate various solution saturations. • Demonstrate structure of monomers. • Demonstrate structure and synthesis of homopolymers. • Demonstrate structure and synthesis of copolymers. • Describe and demonstrate different types of polymer synthesis to include condensation and addition polymerization.
Demonstrate an understanding of the properties, structure, and function of organic compounds.	• Describe atomic structures to include protons, neutrons, and electrons. • Demonstrate ionic and covalent bonding, including multiple bonds (double and triple). • Apply IUPAC nomenclature, and illustrate structures for aliphatic, aromatic, and cyclic hydrocarbons. • Write, complete, and classify common reactions for aliphatic, aromatic, and cyclic hydrocarbons. • Describe functional groups to include structures, nomenclature, and properties. • Demonstrate structure of monomers. • Demonstrate structure and synthesis of homopolymers. • Demonstrate structure and synthesis of copolymers. • Illustrate the synthesis of surface coatings. • Demonstrate the various properties of surface coatings in relation to physical testing (i.e., blocking, scrub resistance, etc.). • Describe and demonstrate extrusion processes. • Describe and demonstrate injection molding. • Describe and demonstrate blow molding. • Describe and demonstrate different types of polymer synthesis to include condensation and addition polymerization.
Discuss the versatility of polymers and the diverse application of organic chemicals.	• Evaluate resources available for safe handling and disposal of chemicals. • Demonstrate structure of monomers. • Demonstrate structure and synthesis of homopolymers. • Demonstrate structure and synthesis of copolymers. • Describe natural polymers (cellulose, DNA/RNA,

	natural rubber, starches, and proteins). • Describe synthetic polymers (plastics, thermoplastics, thermosets, fibers, films, elastomers, and adhesives). • Demonstrate properties of natural and synthetic polymers. • Research the history of rheology/viscosity. • Explain the importance of rheology/viscosity. • Demonstrate polymer melt rheology. • Explain how compounding and formulation changes the properties of polymers by using additives or modifiers. • Describe the types of coatings, to include architectural (DIY), OEM, and specialty purpose coatings and their uses in industry. • Illustrate the synthesis of surface coatings.

Academic Infusion

The Polymer Science curriculum is tied not only to academic science standards but also to academic mathematics and language arts. There are obvious ties to chemistry in the curriculum, but geometry also plays a role. Students use mathematical formulas to solve problems and create compounds. There is also a considerable amount of writing in this curriculum. Students will be required to communicate effectively in the classroom and in the workplace. The Polymer Science curriculum provides multiple opportunities to enhance these academic skills. In addition, the curriculum prepares students for the 21st century workforce by incorporating the 21st Century Literacy Skills. The students will be exposed to all elements of 21st century learning: information, culture, visual, and media.

Transition to Postsecondary Education

Vertical Alignment/Articulation Agreement

At the current time, there is no postsecondary polymer science program at the community college level. Therefore, the secondary polymer science curriculum holds no articulation agreement with community colleges. However, the secondary polymer science curriculum is vertically aligned to many of the IHL requirements in the undergraduate polymer science program. The secondary curriculum is closely tied to chemistry, organic

chemistry, composition, writing, problem solving, and responsibility, all of which are elements in the undergraduate curriculum for Polymer Science.

Dual Enrollment

At the present time, there are no options for dual enrollment with Polymer Science.

Program of Study

A program of study has been developed to guide students' course selections in order to be successful in the field of polymer science. Several teachers and professionals met and studied the list of approved electives in the state of Mississippi. From this list, they chose courses that are relevant to polymer science and that would prepare students for a career in the field.

Professional Preparation

Teacher Competence

Teachers of the Polymer Science curriculum must prove themselves competent by holding a bachelor's degree or higher in a science-related field and by completing the licensure requirements. At the current time, there is no industry certification available to show competency in this field. Therefore, evaluators will rely heavily on the applicant's background, work history, and training performance to assess competency.

Teacher Licensure

Teachers of the Polymer Science curriculum will need to meet the following licensure requirements to obtain a 989 Polymer Science Endorsement:

1. Applicant must have earned a 4-year degree (bachelor's degree) or higher from an accredited institution of higher education. The degree must be in polymer science or an appropriate field of science and must be approved by the MDE program coordinator.
2. Applicant must enroll immediately in the Vocational Instructor Preparation (VIP) or the *Redesign* Education Program (REP).

3. Applicant must complete the individualized Professional Development Plan (PDP) requirements of the VIP or REP prior to the expiration date of the 3-year vocational license.
4. Applicant must successfully complete an MDE-approved computer literacy certification exam.
5. Applicant must successfully complete certification for an online learning workshop, module, or course that is approved by the MDE.
6. Applicant must successfully complete a Polymer Science certification workshop, module, or course that is approved by the MDE.

A bachelor's degree is required to teach Polymer Science because the science content in the curriculum requires a deep understanding of chemistry and other related sciences. Additionally, if an applicant does not hold a teaching license, he or she must complete the Vocational Instructor Preparation (VIP) program in order to receive instruction valuable to a quality educator. The VIP program teaches pedagogy, best practices, and multiple teaching strategies to produce effective teachers. Due to the heavy technology integration, applicants must prove themselves technology literate by passing an approved computer literacy exam. Because the course is taught in a hybrid environment (online and face to face), applicants must also obtain a certification of online learning to show that they are able to teach effectively online as well as prepare students to take online classes. Finally, all applicants will be required to complete endorsement training that will prepare them to teach the content of the Polymer Science curriculum.

Assessment

Students will be assessed using the Polymer Science MS-CPAS2 test. The MS-CPAS2 blueprint can be found at http://redesign.rcu.msstate.edu/curriculum/. If there are questions regarding assessment of this program, please contact the STEM instructional design specialist at the Research and Curriculum Unit at 662.325.2510.

Best Practices

Innovative Instructional Technologies

Recognizing that today's students are digital learners, the classroom should be equipped with tools that will teach them in the way they need to learn. The redesigned Polymer Science curriculum includes teaching

strategies that incorporate current, state-of -the-art technology. Each classroom houses 20 desktop student computers and one teacher laptop. Additionally, each classroom is equipped with an interactive white board and projector, intensifying the interaction between students and teachers during class. A voting system, or "clickers," is also included in each classroom to engage students in what would be routine instruction. To make use of the latest online communication tools such as wikis, blogs, and podcasts, the classroom is also equipped with a digital camera, a digital video camera, headsets with microphones, and webcams. Teachers are also encouraged to teach using the content delivery system Blackboard, which introduces students to education in an online environment and places the responsibility of learning on the student.

Differentiated Instruction

Students learn in a variety of ways. Some are visual learners, needing only to read information and study it to succeed. Others are auditory learners, thriving best when information is read aloud to them. Still others are tactile learners, needing to participate actively in their learning experiences. Add the student's background, emotional health, and circumstances, and a very unique learner emerges. To combat this, the Polymer Science curriculum is written to include several instructional methods by using the Understanding by Design (UbD) approach. This method of instruction design leads students to a deeper understanding of course material and provides multiple opportunities for students to succeed in different ways. Students will be assessed with reading response; podcast creation; wiki, blog, and discussion board posts; and portfolio compilation. Many activities are graded by rubrics that allow students to choose the type of product they will produce. By providing various teaching and assessment strategies, students with various learning styles can succeed.

Career and Technical Education Student Organizations

At the current time, there are no state or national career and technical education student organizations that support the Polymer Science curriculum.

Conclusions

Based on the previous information, the Mississippi Polymer Science curriculum will be filled with opportunities to teach and learn using technology. It will also reflect the need for extensive word processing knowledge in the polymer science industry by including multiple opportunities to develop those skills. Other widely used teaching strategies such as cooperative learning, problem-based learning, and demonstration will also be included. These will help to prepare students for the hands-on instruction they will likely received upon entering the workforce. Because many of the instructors make use of the rubrics and teaching and assessment strategies, they will continue to be included in the curriculum document. Additionally, because many of the instructors rely on collaboration among their colleagues, a P.A.C.E site, similar to the B.R.I.D.G.E site, will be created for the Polymer Science instructors to share ideas and lesson plans. The curriculum document will be updated regularly to reflect the needs of the polymer science workforce.

Using This Document

Unit Number and Title

Suggested Time on Task
An estimated number of clock hours of instruction that should be required to teach the competencies and objectives of the unit. A minimum of 140 hours of instruction is required for each Carnegie unit credit. The curriculum framework should account for approximately 75–80% of the time in the course.

Competencies and Suggested Objectives
A competency represents a general concept or performance that students are expected to master as a requirement for satisfactorily completing a unit. Students will be expected to receive instruction on all competencies. The suggested objectives represent the enabling and supporting knowledge and performances that will indicate mastery of the competency at the course level.

Suggested Teaching Strategies
This section of each unit indicates research-based strategies that can be used to enable students to master each competency. Emphasis has been placed on strategies that reflect active learning methodologies. Teachers should feel free to modify or enhance these suggestions based on needs of their students and resources available in order to provide optimum learning experiences for their students.

Suggested Assessment Strategies
This section indicates research-based strategies that can be used to measure student mastery. Examples of suggested strategies could include rubrics, class participation, reflection, and journaling. Again, teachers should feel free to modify or enhance these suggested assessment strategies based on local needs and resources.

Integrated Academic Topics, 21st Century Skills and Information and Communication Technology Literacy Standards, ACT College Readiness Standards, and Technology Standards for Students
This section identifies related academic topics as required in the Subject Area Testing Program (SATP) in Algebra I, Biology I, English II, and U.S. History from 1877, which are integrated into the content of the unit. Research-based teaching strategies also incorporate ACT College Readiness standards. This section also identifies the 21st Century Skills and Information and Communication Technology Literacy skills. In addition, national technology standards for students associated with the competencies and suggested objectives for the unit are also identified.

References
A list of suggested references is provided for each unit. The list includes some of the primary instructional resources that may be used to teach the competencies and suggested objectives. Again, these resources are suggested, and the list may be modified or enhanced based on needs and abilities of students and on available resources.

Introduction to Polymer Science I

Unit 1: Orientation and Safety

Competency 1: Evaluate the local program, and explore how personality traits and learning styles can impact success in the classroom and workplace. SPI-I, SPI-VI, MPC1, MPC4, MPC6, MPC14, MPC16, MPC18, MPC25-MPC28, MPC33-MPC35 **(DOK 1)**

Suggested Enduring Understandings

1. The Polymer Science program curriculum and workplace are highly technical, demanding, and constantly changing.
2. Personality and learning styles can greatly impact educational and professional success.

Suggested Essential Questions

1. What are the expectations and responsibilities for a student in the Polymer Science program? How does the program prepare students to be successful in the workplace?
2. How can each student's personality and learning styles be an asset in the program and the workplace?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Examine the local student handbook and program, establishing rules and guidelines. (DOK 1)	a. Introduce Enduring Understandings and Essential Questions. **Hook:** Divide students into two groups. Assign one of the following scenarios to each group. Have groups present a role-play for their assigned scenario: W5, CLS1-CLS5 o Imagine a school without rules. What would a normal day be like? What would a normal class be like? How productive would your day be? o Imagine a school that has created a rule and a procedure for everything. What would a normal day be like? What would a normal class be like? How productive would your day be?	a. Teacher observation **Role-Play or Skit Assessment Rubric**
	Students assemble a sectioned notebook to use throughout the course. Notebooks should include a journal section for self-evaluation. Notebooks should be evaluated each grading period using a **Notebook Rubric** with the following criteria: completion of required sections, format, accuracy, organization, and neatness. E1-E6, W1-W5, CLS2, CLS4	**Notebook Rubric**
	Pair students and assign each pair a section(s) of the local student handbook to read, interpret, and then teach to the rest of the class. Students take notes in their notebooks. R1-R5, W4, W5, CLS1-CLS5	Teacher observation of peer teaching
	In small groups, students prepare a contract stating the rules and regulations they agree to follow throughout the year. Each group presents its version to the class, culminating in	

		development of an acceptable classroom contract. Each student gets a classroom contract signed by the student, parent/guardian, and teacher. E1-E6, R1-R5, W1-W5, CLS1-CLS5, T1-T6 Review the local program syllabus and requirements. Journal five to seven sentences on "what it will take to be successful in the Polymer Science program." E1-E6, R1-R5, W1-W5, CLS2, CLS4, CLS5 Review the following Web sites: • http://abeflorida.org/pdf/Resource_Guides/work_checklist04.pdf • http://www.pawerc.org/foundationskills/lib/foundationskills/competency_lists_04.pdf In small groups, students analyze likenesses and differences among local program and workplace requirements. Based on student analyses, create a class Venn diagram to add to students' notebooks. R1-R5, W1-W5, CLS1-CLS5, T1-T3 Review for a quiz providing immediate feedback using response pads and so forth.	**Journal Rubric** Blackboard Learning System quiz
b. Examine how understanding personality and learning styles can impact learning and workplace performance. (DOK 1)	b.	Take the TABE assessment. Determine student deficiencies, and work with the Related Studies teachers for remediation. Assign remediation and enhancement during times when students are caught up with regular classroom assignments. M1-M7, R1-R5, W1-W5 Complete learning styles, interests, and personality inventories. Reflect on results with a journal entry on "3 findings that met my expectations, 2 findings that surprised me, 1 question that I have, GO apply what I learned." R1-R5, CLS1, CLS2 Have students revisit requirements to be successful in the Polymer Science field, followed by a brainstorm session. After classroom discussion, revisit and revise the journal entry on "what it will take to be successful in the Polymer Science program," developing into a two- to three-paragraph report on "Attributes for Success in the Field of Polymer Science." Close with a paragraph on how you believe this program will help develop those attributes. Evaluate with the **Writing Rubric**. E1-E6, R1-R5, W1-W5, CLS2, T3, T4 **Performance Task:** You have been selected by the governor to serve on a task force to develop a plan for interstate beautification. To help team members get acquainted, your first responsibility is to submit through the Blackboard Learning System a multimedia presentation entitled "What	b. TABE Assessment Results **Journal Rubric** **Writing Rubric**

		Makes Me Tick." Essential elements include your personality traits, learning styles, and personal motivators. Close with thoughts on how to best empower various personalities and learning styles in a team setting. Assess with the **Multimedia Presentation Rubric**. W1-W5, CLS1-CLS5, T1-T5	**Multimedia Presentation Rubric**
c. Describe SkillsUSA activities and participate in a polymer skills competition. (DOK 1)	c.	Introduce students to SkillsUSA by showing a PowerPoint presentation of previous SkillsUSA competitions and the Mississippi/National SkillsUSA Web sites. Describe the role of SkillsUSA in developing leadership. Have students join, elect officers, learn parliamentary procedures, participate in competitions, and so forth: http://www.skillsusa.org/compete/updates.shtml.	c. Student participation
		Journal topic: Have students relate their performances in student organizations to the importance of joining professional organizations.	**Journal Rubric**
		Use SkillsUSA's online *Champions* magazine for students to stay current on SkillsUSA and on peer-related articles and events. Have students complete the corresponding assignment for each magazine. An example can be found at the Web site http://www.skillsusa.org/champions/2009_Winter/lessonplan_winter09.html.	Online assignment associated with current *Champions* magazine
		Performance task: Apply the information learned about leadership and teamwork as well as polymer skills and knowledge to a competitive level by participating in Polymer Skills Competition at The Polymer Science Institute at the University of Southern Mississippi and/or among students within the state or nation at SkillsUSA competition.	

Competency 2: Examine the history and development of the polymer industry/profession, to include career opportunities, earnings, and educational requirements. SPI-I, MPC1, MPC4, MPC14, MPC16, MPC21, MPC26,-MPC28, MPC31 **(DOK 1)**

Suggested Enduring Understandings	Suggested Essential Questions
1. The introduction of polymer technology revolutionized both industrial and consumer worlds. 2. Although entrance requirements are demanding, career opportunities in the polymer field are varied and rewarding.	1. In what ways do polymers impact our daily lives? How did the introduction of polymer technology affect global industries? 2. How can I benefit from preparing for a career in a polymer-related field?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Trace the development of polymer technologies/ industries from beginning through present day. (DOK 1) [OC3]	a. Introduce Enduring Understandings and Essential Questions. **Journal entry:** "What comes to mind when I hear the word polymer? How do polymers impact my life?" [E1-E6, W1-W5] Students use classroom resources and the Internet (http://matse1.mse.uiuc.edu/polymers/time.html) to research the history and development of polymer technologies/industries. [R1-R5, T1-T6] Students create a visual/oral presentation, such as a poster, multimedia presentation, timeline, and so forth, using technology productivity tools, to summarize the history and development of polymer technologies/ industries. Presentations will be evaluated via rubric. [E,1-E6, W1-W5, CLS2, CLS4, T1-T6] Compile all student research into a master timeline for the notebook as a means of test preparation.	a. Teacher observation **Journal Rubric** **Oral Presentation Rubric** Blackboard Learning System test
b. Describe career opportunities, including educational requirements, earning potential, and so forth for polymer-related fields. (DOK 1)	b. **Hook:** Distribute "baseball cards" featuring various polymer-related career stats with "player name and picture" area blank. (Include educational requirements, earning potential, job responsibilities, perks, challenges, etc.) Allow students to look through the deck and select a card for which they would like to become the "player." Take photos and add students to their selected cards. [T1, T6] Show the video *Careers in the Plastics Industry* (approximately 23 minutes long from Career and Education Network). As students view the tape, encourage students to note 10 jobs that interest them in their journals. [W1] Students evaluate Careers in Advanced Manufacturing's *In Demand* magazine (http://www.careervoyages.gov/advmanufacturing-videos.cfm) and record reactions in their journals. [E1-E6, W1-W5, S1, CLS2] In pairs, students develop a survey/questionnaire to interview an industry representative. (Find industry	b. Teacher observation **Journal Rubric**

	representatives who are willing to serve as mentors.) E1-E6, W1-W5, CLS1-CLS5	
	Performance Task: You are a freelance journalist on assignment for *technicalcareers.com*. (Vary journalist assignments by geographical region, industry type, etc.) Fully research your assignment concerning career opportunities in polymer-related fields, and design a computer-based product describing various careers including educational, skills, and certification requirements; earning potential; job responsibilities; perks; challenges; and so forth. Your posting will be evaluated by the site editor according to the **Research Project Rubric** for accuracy, completeness, and appeal. Present your findings to the class. E1-E6, W1-W5, CLS1, CLS2, CLS4, T1, T6	**Research Project Rubric**

Competency 3: Describe and demonstrate safe laboratory practices and environmental responsibility working with laboratory equipment, chemicals, and processing equipment commonly encountered in polymer-related industries. SPI-I , SPI-IV, SPI-VI, MPC1, MPC4, MPC14, MPC8, MPC16, MPC18, MPC21, MPC26,-MPC28, MPC31, MPC33-MPC35 **(DOK 2)**

Suggested Enduring Understandings

1. Safety is the number-one priority in the laboratory and industrial workplace. Safe practices, attention to detail, and cautious behavior result in a safe work environment.
2. There is a wealth of information concerning the safe workplace and environmental responsibilities, including guidelines and regulations provided by governmental, industrial, and watchdog organizations.
3. Laboratory and processing equipment have specific uses, procedures to be followed, and safe use guidelines that must be considered.

Suggested Essential Questions

1. What part do I play personally in providing a safe lab/workplace? To what extent do I have personal responsibility for care of my classmates and the environment?
2. What organization acronyms have you heard that you think may be related to a safe workplace and environment? How do these organizations impact laboratory and industrial operations?
3. How will I decide which pieces of laboratory equipment will best suit the task at hand?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Determine how to apply safety rules/guidelines for the lab and workplace and to use safety equipment properly. (DOK 2)	a. Introduce Enduring Understandings and Essential Questions. **Hook:** Display a cartoon, slide, or video clip illustrating unsafe laboratory practices (http://www.biologycorner.com/worksheets/safety.html). Respond with a journal entry answering the questions or identifying unsafe acts or conditions represented. E1-E6, W1-W5 View a safe laboratory practices video or video clips, and research safe laboratory practices using available classroom resources and the Internet (http://www.cdc.gov/niosh/ docs/2004-101/chap4.html). Include details of Mississippi	a. Teacher observation **Journal Rubric**

			state law for safety eyewear. R1-R5, T1,T6 Develop a consensus list of rules and guidelines to follow in the lab, accompanied by a safety contract to be signed by student, teacher, and parent/guardian. Include in the Safety section of the notebook. E1-E6, W1-W5, CLS1-CLS5 Give a laboratory tour, focusing on locations and proper usage of available safety equipment. (Be sure to discuss and demonstrate the safe use of fire extinguishers for different classes of fires.) Students make notes on fire safety and sketch lab layout indicating locations of safety equipment. Include in the Safety section of the notebook. S1 Students role-play various safety scenarios. Evaluate responses with the **Role-Play or Skit Assessment Rubric**. S1, S2, CLS1-CLS5 Have students complete a safety quiz.		**Role-Play or Skit Assessment Rubric** Safety quiz
b.	Investigate how industrial, governmental, and environment organizations impact safe operations in polymer-related industries. (DOK 1)	b.	Students research the origin and purpose of the Occupational Safety and Health Administration (OSHA) and which of its guidelines impact polymer-related laboratories and manufacturing facilities (http://www.osha.gov). Take notes and share with the class in an open discussion. Develop a set of notes for the notebook. E1-E6, R1-R5, S1, S2, W1-W5, T1, T6 **Lecture and note taking:** Discuss the Environmental Protection Agency (EPA) and EPA regulations that directly apply to polymer-related industries. S1, W1-W5 Student pairs research other industrial, governmental, and environment watchdog organizations that influence workplace safety and environmental responsibility. Select one organization to feature in a poster project to present to the class. E1-E6, R1-R5, S1, W1-W5, T1, T6	b.	**Notebook Rubric** **Poster Assessment Rubric**
c.	Identify basic laboratory equipment and functions while correctly and safely using selected pieces of equipment. (DOK 2)	c.	Viewing an assortment of basic lab equipment, students K-W-L via journal entry. W1-W5, CLS2 **Lecture and note taking:** Preview **Equipment Note Cards Checklist** with students. Displaying each piece of equipment, discuss intended uses and safety considerations, demonstrating proper operation (providing written procedures where needed). Students create a pictorial note card for	c.	**K-W-L Chart** **Equipment Note Cards Checklist**

			each piece of equipment. Evaluate note cards with checklist. S1, S2, E1-E6, W1-W5 As review, have students role-play proper usage of laboratory equipment—for example, "I am a graduated cylinder, and my function is…." Evaluate via **Role-Play or Skit Assessment Rubric**. CLS1 Revisit **K-W-L**. W1-W5, CLS2		**Role-Play or Skit Assessment Rubric**
d.	Detail safe practices particular to operation of equipment in polymer-related laboratories and manufacturing facilities. (DOK 1)	d.	Discuss/demonstrate safe practices when working with fluids under pressure, machines, and equipment in polymer-related industries. (Students either take notes or insert teacher-provided procedures in Lab section of notebook.) E1-E6, R1-R5, W1-W5, CLS3, CLS5 Visit http://www.cdc.gov/niosh/docs/2004-101/chap4.html, and discuss workplace environmental safety rules specific to plastics and polymer materials manufacturing. Develop a set of notes for the Safety section of the notebook. E1-E6, R1-R5, W1-W5, CLS3, CLS5, T1, T3, T6 Give students a Blackboard Learning System test on safety and equipment. Include a section for a lab practical—identifying, selecting, and using equipment safely and properly given a certain laboratory situation.	**d.**	**Notebook Rubric** **Notebook Rubric** Blackboard Learning System test with lab practical
e.	Evaluate resources available for safe handling and disposal of chemicals. (DOK 1) OC3	e.	**Lecture and note taking**: Discuss and give examples of standard industry safety color codes. Add to the Safety section of the notebook. E1-E6, W1-W5, S1 Examine NFPA Hazard Diamond format either online (http://www.ilpi.com/msds/ref/nfpa.html) or using a real-life sample. Practice properly interpreting several samples. Add samples and notes to the Safety section of the notebook. R1-R5, T1, T6 Students research the origin of the material safety data sheet (MSDS) and report findings in a brief five- to seven-sentence journal entry. E1-E6, R1-R5, W1-W5, T1, T6 Provide students with a computer-based or actual guided tour of MSDS format (http://www.flinnsci.com/ search_MSDS.asp). Students practice pulling useful information from two hardcopy sample MSDSs using prompt questions from the **MSDS Reading Guide** developed by the teacher. E1-E6, R1-R5, W1-W5, T1, T6	e.	Teacher observation **Journal Rubric** **MSDS Reading Guide**

Discuss factors that must be considered when preparing to dispose of chemicals in the laboratory or at a manufacturing facility. Brainstorm how these considerations affect personal responsibilities at home also. Respond with a journal entry of a personal viewpoint of these responsibilities. E1-E6, W1-W5, CLS1-CLS5	Teacher observation of brainstorm session
Skill check: Interpret industry color code, hazard diamonds, and MSDS.	
Performance task: You and a partner are laboratory TAs for Chemistry 101 at PolySci University. Your professor has assigned you the responsibility of designing an experiment. [Teacher may assign the same or different labs to each team. They may be labs that can actually be conducted or simulated, or they may be hypothetical labs. Sample: to investigate oxidation/reduction reactions, where students will submerge iron-based steel wool in copper(II)sulfate solution and then repeat the experiment using aluminum wire in a sodium nitrate solution. Part two of the experiment involves heating steel wool in a Bunsen burner flame, recording mass change.] You are provided with MSDSs and chemicals for the lab. You must prepare a detailed lab handout for your students, including background, materials/equipment list, safety considerations, pre-lab questions, experimental procedure, cleanup/disposal, data/observations, and post-lab questions/analysis. Once your handout is ready, meet with another team and critique each other's handouts, discussing possible modifications. Make revisions and then set up a lab station for the experimental procedure. [If possible, have another team use the lab handout to conduct the lab, marking trouble spots as needed in red.] Results will be assessed according to criteria set forth in the **Experimental Design Rubric**. E1-E6, R1-R5, W1-W5, CLS1-CLS5, T1-T6	Skill check **Experimental Design Rubric**

Standards

Industry Standards: Society of Plastics Industry Standards

I. Essential Knowledge
VI. Safety Components

Industry Standards: Polymer Standards for the State of Mississippi

MPC1 Business Understanding: Understanding the inner workings of business functions and how business decisions affect financial or non-financial work results
MPC4 Communication: Applying effective verbal, nonverbal, and written communication methods to achieve desired results
MPC6 Customer Focus: Dedication to meeting or exceeding the expectations and requirements of both internal and external customers
MPC14 Group Process Understanding: Understanding how groups function; influencing people so that group, work, and individual needs are addressed
MPC16 Industry Understanding: Understanding the vision, strategy, goals, and culture of other companies within the polymer processing industry
MPC18 Leadership: The ability to influence and guide members of the organization to achieve organizational objectives
MPC25 Project Management: Planning, implementing, and evaluating assignments to ensure that the desired outcomes of the assignment are produced on time and within budget
MPC26 Questioning: Gathering information from stimulating insight in individuals and groups through use of interview, questionnaires, and other probing methods
MPC27 Relationship Building Skills: Establishing relationships and networks across a broad range of people and groups
MPC28 Research Skills: Selecting, developing, and using methodologies such as statistical and data collection techniques for formal inquiry
MPC33 Teamwork: Successfully and efficiently working and communicating with group or project members such that the team's final output meets or exceeds predefined expectations
MPC34 Technical Communications: The ability to translate and communicate required technical information to non-technical operational people
MPC35 Time Management: Valuing time and ensuring that it is used efficiently for all tasks

Mississippi Academic Course Competencies and Benchmarks

OC3 Discuss the versatility of polymers and the diverse application of organic chemicals.

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
M1 Basic Operations and Applications
M2 Probability, Statistics, and Data Analysis
M3 Numbers: Concepts and Properties
M4 Expressions, Equations, and Inequalities
M5 Graphical Representations
M6 Properties of Plane Figures

M7	Measurement
R1	Main Ideas and Author's Approach
R2	Supporting Details
R3	Sequential, Comparative, and Cause—Effect Relationships
R4	Meaning of Words
R5	Generalizations and Conclusions
S1	Interpretation of Data
S2	Scientific Investigation
W1	Expressing Judgments
W2	Focusing on the Topic
W3	Developing a Position
W4	Organizing Ideas
W5	Using Language

21st Century Skills Standards

CLS1	Flexibility and Adaptability
CLS2	Initiative and Self-Direction
CLS3	Social and Cross-Cultural Skills
CLS4	Productivity and Accountability
CLS5	Leadership and Responsibility

National Educational Technology Standards for Students

T1	Creativity and Innovation
T2	Communication and Collaboration
T3	Research and Information Fluency
T4	Critical Thinking, Problem Solving, and Decision Making
T5	Digital Citizenship
T6	Technology Operations and Concepts

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Suggested Rubrics and Checklists

Name: _____

Date: _____

Period: _____

Role-Play or Skit Assessment Rubric

	EXCELLENT (4)	GOOD (3)	AVERAGE (2)	POOR (1)	TOTAL
Accuracy	All information was accurate.	Almost all information was accurate.	Most information was accurate.	Very little information was accurate.	
Role	Excellent character development; student contributed in a significant manner.	Good character development; student contributed in a cooperative manner.	Fair character development; student may have contributed.	Little or no character development; student did not contribute much at all.	
Knowledge Gained	Can clearly explain several ways in which his or her character "saw" things differently than other characters and can explain why	Can clearly explain several ways in which his or her character "saw" things differently than other characters	Can clearly explain one way in which his or her character "saw" things differently than other characters	Cannot explain any way in which his or her character "saw" things differently than other characters	
Props	Used several props and showed considerable creativity	Used 1 or 2 appropriate props that made the presentation better	Used 1 or 2 props that made the presentation better	Used no props to make the presentation better	
Required Elements	Included more information than required	Included all required information	Included most required information	Included less information than required	
				Total	

Name: _____

Date: _____

Period: _____

Notebook Rubric

	EXCELLENT (3)	SATISFACTORY (2)	UNSATISFACTORY (1)	SCORE
Completion of Required Sections	All required sections are complete. Supporting research and references have been included.	All required sections are complete.	Required sections are incomplete.	
Format	Appropriate format that is consistently used; extra desktop publishing enhancements	Appropriate format is consistently used.	Inappropriate format is used, or there is no consistency.	
Accuracy	Information is accurate and error free.	Information is accurate with minimal typographical errors.	Information is inaccurate and/or has numerous typographical errors.	
Organization	All assignments and/or notes are kept in a logical sequence.	Most assignments and/or notes are kept in a logical sequence.	Several assignments and/or notes are not in logical sequence.	
Neatness	Overall notebook is kept very neat.	Overall notebook is kept in satisfactory condition.	Overall notebook is unkempt and disorganized.	
			Total	

Name: _____

Date: _____

Period: _____

Journal Rubric

Use this rubric to assess students' abilities to complete the journal activities assigned for this lesson. Share this assessment with students prior to completing the journal-writing lessons so they will understand how they will be assessed. You can also use the rubric as a basis for discussion and feedback with each student.

1. The student writes journal responses in complete sentences. _____
2. The student writes five or more sentences to answer questions. _____
3. The student responds to questions by self-questioning, retelling, predicting, or assuming the role of a character. _____
4. The student's experiences and opinions are clear. _____
5. The student works with a peer to share journal responses and to develop a combined response when requested. _____

TOTAL: _____

EXCELLENT (4)	VERY GOOD (3)	FAIR (2)	POOR (1)
The student completes the task with mo major errors. The student demonstrates a full understanding of the concepts.	The student completes the task with only a few major errors and some minor errors. The student demonstrates a strong understanding of the concepts.	The student completes the task with some major errors and many minor errors. The student has difficulty understanding the concepts.	The student fails to complete the task. The student does not understand the concepts.

Teacher Comments:

Name: _____

Date: _____

Period: _____

Writing Rubric

	EXCELLENT (3)	SATISFACTORY (2)	UNSATISFACTORY (1)	SCORE
Content	Paper is well developed with more than enough information. Information is clearly presented with elaborations.	Paper is fairly well developed with enough information to inform the reader about the topic. Information is clearly presented with some elaborations.	Paper has little development and a minimum amount of information. Some information is confusing.	
Details	Plenty of specific details that more than adequately explain the topic	Some specific details that adequately explain the topic. Some do not help explanation.	May not have details, and/or details may be wrong.	
Organization	Clear organization and no straying	Has somewhat of an organization and tries to stick to it	If there is an organization, it is not clear and writer strays from it.	
Audience	Written for intended audience	Written for intended audience in most cases	Does not address the intended audience	
Language Choices	Uses language choices to maintain a style or a tone	Uses some language choices to maintain style or tone	Does not use language choices to help with style or tone.	
			Total	

Teacher Comments:

Name: _____

Date: _____

Period: _____

Multimedia Presentation Rubric

	Exemplary 4 points	Accomplished 3 points	Developing 2 points	Beginning 1 point	Score Obtained
Content	Addressed all assignment components	Addressed all but one assignment component	Omitted two assignment components	Omitted more than two assignment components	
Detail	Fully addressed all assignment components	Fully addressed most assignment components	Partially addressed most assignment components	Partially addressed few assignment components	
Accuracy	No grammatical, typographical, spelling, or punctuation errors	1–2 grammatical, typographical, spelling, or punctuation errors	3–5 grammatical, typographical, spelling, or punctuation errors	More than 5 grammatical, typographical, spelling, or punctuation errors	
Clarity	Logical, orderly sequence	Somewhat logical sequence	Confusing sequence	No evidence of order/sequence	
Design	Excellent design selection and usage	Adequate design selection or 1–2 design errors	Inadequate design selection or 3–5 design errors	Poor design selection or more than 5 design errors	
Appeal	Very appealing; excellent use of animation, transitions, sound, etc.	Somewhat appealing; adequate use of animation, transitions, sound, etc.	Not very appealing; limited use of animation, transitions, sound, etc.	Not appealing; very limited or no use of animation, transitions, sound, etc.	
				Score	

Teacher Comments:

Name: _____

Date: _____

Period: _____

Oral Presentation Rubric

	EXCEPTIONAL (4)	ADMIRABLE (3)	ACCEPTABLE (2)	AMATEUR (1)	TOTAL
Content	An abundance of material clearly related to topic; points are clearly made and all evidence supports topic; varied use of materials.	Sufficient information that relates to topic; many good points made but there is an uneven balance and little variation.	There is a great deal of information that is not clearly connected to the topic.	Topic not clear; information included that does not support topic in any way	
Coherence and Organization	Topic is clearly stated and developed; specific examples are appropriate and clearly develop topic; conclusion is clear; shows control; flows together well; good transitions; succinct but not choppy; well organized.	Most information presented in logical sequence; generally very well organized but better transitions from idea to idea and medium to medium needed	Concept and ideas are loosely connected; lacks clear transitions; flow and organization are choppy.	Presentation is choppy and disjointed; does not flow; development of topic is vague; no apparent logical order of presentation.	
Creativity	Very original presentation of material; uses the unexpected to full advantage; captures audience's attention	Some originality apparent; good variety and blending of materials/media	Little or no variation; material presented with little originality or interpretation	Repetitive with little or no variety; insufficient use of multimedia	
Material	Balanced use of multimedia materials; properly used to develop topic; use of media is varied and appropriate.	Use of multimedia not as varied and not as well connected to topic	Choppy use of multimedia materials; lacks smooth transition from one medium to another; multimedia not clearly connected to topic	Little or no multimedia used or ineffective use of multimedia; imbalance in use of materials—too much of one, not enough of another	
Speaking Skills	Poised, clear articulation; proper volume; steady rate; good posture and eye contact; enthusiasm; confidence	Clear articulation but not as polished	Some mumbling; little eye contact; uneven rate; little or no expression	Inaudible or too loud; no eye contact; rate too slow/fast; speaker seemed uninterested and used monotone.	
Audience Response	Involved the audience in the presentation; points made in creative way; held the audience's attention throughout	Presented facts with some interesting "twists"; held the audience's attention most of the time	Some related facts but went off topic and lost the audience; mostly presented facts with little or no imagination	Incoherent; audience lost interest and could not determine the point of the presentation.	
Length of Presentation	Within 2 minutes of allotted time +/–	Within 3–4 minutes of allotted time +/–	Within 5–6 minutes of allotted time +/–	Too long or too short; 10 or more minutes above or below the allotted time	
Total					

Research Project Rubric

	Excellent (4)	Very Good (3)	Fair (2)	Poor (1)	Score
Thesis/Problem/Question	Student posed a thoughtful, creative question that engaged him or her in challenging or provocative research.	Student posed a focused question involving him or her in challenging research.	Student constructed a question that lends itself to readily available answers.	Student relied on teacher-generated questions or developed a question requiring little creative thought.	
Information Seeking/Selecting and Evaluating	Student gathered information from a variety of quality electronic and print sources.	Student gathered information from a variety of relevant sources—print and electronic.	Student gathered information from a limited range of sources and displayed minimal effort in selecting quality resources.	Student gathered information that lacked relevance, quality, depth, and balance.	
Analysis	Student carefully analyzed the information collected and drew appropriate and inventive conclusions supported by evidence. Voice of the student writer is evident.	Student product shows good effort was made in analyzing the evidence collected.	Student conclusions could be supported by stronger evidence. Level of analysis could have been deeper.	Student conclusions simply involved restating information. Conclusions were not supported by evidence.	
Synthesis	Student developed appropriate structure for communicating product, incorporating variety of quality sources. Information is logically and creatively organized with smooth transitions.	Student logically organized the product and made good connections among ideas.	Student could have put greater effort into organizing the product.	Student work is not logically or effectively structured.	

Documentation	Student documented all sources, including visuals, sounds, and animations. Sources are properly cited. Documentation is error free.	Student documented sources with some care. Sources are cited. Few errors are cited.	Student needs to use greater care in documenting sources. Documentation was poorly constructed or absent.	Student clearly plagiarized materials.	
Product/Process	Student effectively and creatively used appropriate communication tools to convey her or his conclusions and demonstrated thorough, effective research techniques. Product displays creativity and originality.	Student effectively communicated the results of research to the audience.	Student needs to work on communicating more effectively.	Student showed little evidence of thoughtful research. Product does not effectively communicate research findings.	
Layout and Design	Pages are eye appealing, appropriate use of graphics, and layout is clean. Font is readable, with a creative title.	There are mostly complete pages and correct use of graphics. Layout and font are somewhat appropriate, with a somewhat creative title.	One page is eye appealing, but others are incomplete. Graphics are inserted haphazardly, but it has a good title.	Layout is incomplete on all pages, with no graphics and poor, non-creative title.	
Total					

Teacher Comments:

Name: _____

Date: _____

Period: _____

Poster Assessment Rubric

	EXEMPLARY (4)	ACCOMPLISHED (3)	DEVELOPING (2)	BEGINNING (1)	SCORE
Required Content	The poster includes all required content elements as well as additional information.	All required content elements are included on the poster.	All but one of the required content elements is included on the poster.	Several required content elements were missing.	
Labels	All items of importance on the poster are clearly labeled with labels that are easy to read.	Almost all items of importance on the poster are clearly labeled with labels that are easy to read.	Many items of importance on the poster are clearly labeled with labels that are easy to read.	Labels are too small to read, or no important items were labeled.	
Attractiveness	The poster is exceptionally attractive in terms of design, layout, and neatness.	The poster is attractive in terms of design, layout, and neatness.	The poster is acceptably attractive though it may be a bit messy.	The poster is distractingly messy and very poorly designed.	
Grammar	There are no grammatical or mechanical mistakes on the poster.	There are 1–2 grammatical or mechanical mistakes on the poster.	There are 3–4 grammatical or mechanical mistakes on the poster	There are more than 4 grammatical or mechanical mistakes on the poster.	
				Total	

Teacher Comments:

Name: _____

Date: _____

Period: _____

K-W-L Chart

Topic _____

What I Know	What I Want to Know	What I Learned

_____

_____

_____

Equipment Note Cards Checklist

1. Each piece of equipment included _____
2. Equipment adequately pictured _____
3. Equipment name spelled correctly _____
4. Intended uses detailed _____
5. Safety considerations described _____
6. Special instructions referenced _____

Percentage Achieved _____

Name: _____

Date: _____

Period: _____

Experimental Design Rubric

	Exemplary (4)	Accomplished (3)	Developing (2)	Beginning (1)	Score
Background	Well developed, clearly explained, ample detail	Fairly well developed, somewhat clear, short on detail	Somewhat developed, confusing, lacking detail	Poorly developed, unclear, bare bones	
Materials/Equipment List	All necessary supplies listed, correctly referenced	Missing 1–2 necessary supplies, and/or incorrect references	Missing 3–4 necessary supplies, and/or incorrect references	Missing 5+ necessary supplies, and/or incorrect references	
Safety Considerations	Complete, well described, avoidance actions suggested	Somewhat complete, described, few avoidance suggestions	Less complete, poorly described, few avoidance suggestions	Incomplete, not described, no avoidance suggestions	
Pre-Lab Questions	7 or more, truly preparatory, thought provoking	5–6, pertinent, somewhat thought provoking	3–4, somewhat pertinent, not thought provoking	1–2, not pertinent, yes/no type	
Experimental Procedure—Format	Well-structured numbered steps, correctly ordered, succinctly written	Numbered steps too long/short, sequence could be improved, too much/too little detail	Poor numbering of steps, confusing sequence, inadequate detail	Steps not numbered, numerous sequence errors, lacks detail	
Experimental Procedure—Usability	No procedural errors, clearly written, easy to follow	1–2 procedural errors, fairly clear, mostly easy to follow	3–4 procedural errors, lacks clarity, fairly easy to follow	5+ procedural errors, confusing, difficult to follow	
Cleanup and Disposal	Completely safe and environmentally sound, easy to follow	Mostly safe and environmentally sound, fairly easy to follow	Somewhat safe and environmentally sound, not easy to follow	Unsafe and not environmentally sound, confusing	
Data and Observations	Excellent prompts	Adequate prompts	Fair prompts	Poor prompts	
Analysis/Post-Lab Questions	7 or more, pertinent and reflective, thought provoking	5–6, pertinent, somewhat thought provoking	3–4, somewhat pertinent, not thought provoking	1–2, not pertinent, yes/no type	
Overall Quality	Excellent, well-structured, easy to read, no obvious errors	Average, fair structure, easily read, few obvious errors	Fair, poorly defined structure, difficult to follow, several obvious errors	Poor, lacks structure, confusing, multiple errors	
				Total Score	

Unit 2: Information, Media, and Computer Applications

Competency 1: Demonstrate the ability to manage a computer operating system in relation to plastics and polymer applications. [SPI-I, MPC1, MPC34] **(DOK 3)**

Suggested Enduring Understandings

1. Workers in the 21st century workforce must be technologically adept.
2. We live in a society that craves multimedia stimulation.
3. Technology changes rapidly.

Suggested Essential Questions

1. How are workplace skills for today's workforce different from those of workers working a few decades ago?
2. How is multimedia input more effective than single media input?
3. Which media input is most effective in influencing a target audience today?
4. In what ways is computing technology changing?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Create files and transfer them between directories and subdirectories. (DOK 2) (ongoing)	a. **Hook:** "Just push the button, George Jetson." Have students discuss the rapid changes occurring in the computer industry. Have them view a video on the surface computers recently developed and read an article on quantum computing. Have students discuss the possible computer designs of the future. Video clips from *Quantum of Solace*, *Minority Report*, and *The Dark Knight* could serve to help students in this task. Ask the students whether they believe the computer will ever do everything when we push the button to turn it on like George Jetson does. Give students a pretest on managing operating systems, **<u>or</u>** have students complete a **K-W-L Chart** for operating system management. Use the information from the pretest or K-W-L Chart to group students to work through computer applications to teach one another how to format discs, label discs, examine contents of discs, produce files and records, and transfer files between directories and sub-directories.	a. Pretest or **K-W-L Chart**
	Have students create a graphical representation summarizing the vast variety of uses of computers in the plastics and polymer science industry. Note: This task could be expanded to become the performance task as explained in the teaching strategies for performance indicator (c). Students could peer assess this document. [T1, T2, T3]	**Presentation Assessment Rubric**
	Have students record notes and journal entries into their notebooks. Have them include any handouts, diagrams, or other important documents necessary for studying for the unit	**Notebook Rubric**

		exam. Use the **Notebook Rubric** to evaluate student progress. W1, W5 Throughout the year, monitor individual students as they work on the computers to ensure that they are adept at file and system management.	
b.	Produce and utilize graphics in relation to research for plastics design and production. (DOK 2) (ongoing)	b. **Hook:** "A picture is worth a thousand words." Have students discuss the value of having visuals among the text in reports, brochures, presentations, and so forth. Have students discuss their learning style preferences and poll the class to see how many are visual or tactile–kinesthetic learners. Have students discuss the importance of presenting information in a way that is comfortable to assimilate for audience members. Discuss necessary vocabulary with students.	b. Class poll
		Have students complete a **K-W-L Chart** for producing and manipulating graphics within programs such as Microsoft Word (pages) and PowerPoint (Keynote).	**K-W-L Chart**
		Introduce the performance task.	
		Use a multimedia presentation and a classroom lecture to model this performance indicator and to introduce students to the use of computers in all areas of the plastics industry. Be sure to inform students of computer and technology use from the concept of a product design to raw material to process, to marketing and sales, and to recycling. This will foreshadow many objectives found in other units. Explain to students that computers have their place as a tool in the plastics industry. However, emphasize that it is the person involved in using hardware and software in order to operate them efficiently that is critical to the process. Emphasize for students that the computer is another tool for designers, fabricators, and others to use in fulfilling their roles. When students take tours of industry sites like Nissan, point out the use of computers and automation for students. T1, T3, T6, W1, W5,	
		Performance task: Have students create a multimedia presentation framework on the history of the computer and how it has transformed in shape and performance over the years since its creation. Emphasize that this presentation is to highlight student ability in using and manipulating graphics within the PowerPoint (Keynote) program. This means that only the visual media (pictures, diagrams, animations, movies) are being evaluated at this time. Inform students that their quality written work will be evaluated when the next performance indicator is covered. Alternatively, the teacher might choose	**Multimedia Presentation Rubric**

		to introduce performance indicators (b) and (c) together in the interest of time. In either case, have students try to project future designs for computers using pictures. [T1, T3, T6] Have students record notes and journal entries into their notebooks. Have them include any handouts, diagrams, or other important documents necessary for studying for the unit exam. Use the **Notebook Rubric** to evaluate student progress. [W1, W5] Note: The adept use of technology tools to create and utilize graphics is critical to the success of the 21st century worker, so have students demonstrate appropriate use of these skills in an ongoing manner in each unit of study.	**Notebook Rubric**
c.	Produce quality word processing documents related to polymer science topics. (DOK 2) (ongoing)	c. **Hook:** "The pen is mightier than the sword." Have students discuss this idiom that has been expressed by so many great writers throughout history. Give students examples of the authors having used this statement in one form or another since the 16th century. Have students analyze the validity of the statement. Is the written word more powerful than the weapons of war? [W1, W5] Have students complete a **K-W-L Chart** for producing and manipulating appropriate text within programs such as Microsoft Word (pages) and PowerPoint (Keynote). **Performance task (cont'd.):** Have students create the written material for their multimedia presentation on the history of the computer and how it has transformed in shape and performance over the years since its creation. Emphasize that this part of the presentation is about producing quality written work. This includes the ability to use text appropriately from its original sources. Grammar and punctuation are important to this task as well. Students should strive always to produce quality work. The **Writing Rubric** can be used to evaluate student performance on this part of the task, or the Multimedia Presentation Rubric can be used to assess both the visuals and written work in the report. An oral presentation can be added to this performance task to allow students to get comfortable in presenting their work to peers. If this is the case, the **Oral Presentation Rubric** can be used to evaluate student performance. [W1, W5] Have students record notes and journal entries into their notebooks. Have them include any	c. **K-W-L Chart** **Multimedia Presentation Rubric** **Writing Rubric** **Oral Presentation Rubric** **Notebook Rubric**

		handouts, diagrams, or other important documents necessary for studying for the unit exam. Use the Notebook Rubric to evaluate student progress. W1, W5 Note: The adept use of technology tools to create and present research in various report formats is critical to the success of the 21st century worker, so have students demonstrate appropriate use of these skills in an ongoing manner in each unit of study. T1, T3, T6 Note: An alternative performance task could be used in lieu of the one listed above. The multimedia presentation could center on the industrial use of computers. Students would concentrate efforts to explain how the computer hardware and software are similar and different from that found in the average home computer. The use of computers to monitor and control processes and to facilitate quality control, distribution, and statistical analysis of processing parameters should be highlighted using visual and written descriptions. Specialty software such as Point Of Sale, Process Control (National Instruments "LabView"), and Statistical Analysis software should be covered in detail. Other than the change in theme, the GRASP would be scored in the same manner as the GRASP listed above.	**Multimedia Presentation Rubric**
d.	Create an e-portfolio to include all relevant materials. (DOK 4) (ongoing)	d. **Hook:** "Show me what you're made of." Have students discuss the importance of a resumé and portfolio in providing documentation of their accomplishments. Have students analyze how the e-portfolio is superior to the basic resumé. Discuss with students the power inherent in having the ability to self-assess what has been learned and how it was accomplished. Discuss with students what metacognition is and how powerful it can be when used as a strategy for deep learning and problem solving. Have students complete a **K-W-L Chart** for e-portfolios. Use the results of the K-W-L as a guide to discussing with students the creation of their own e-portfolios using Blackboard resources. Have students create the initial documents on Blackboard to keep an e-portfolio of their best work from class. Remind them that this documentation process will be used in an ongoing fashion throughout the course. From time to time, allow students to review their e-	d. **K-W-L Chart**

	portfolios to add, modify, delete, and rearrange their work to best effect. Have students use a rubric to self-assess their submissions. Peer and teacher assessment can also be used to further refine the collection of documents. W1, W5 T1, T3, T5, T6	
	Have students record notes and journal entries into their notebooks concerning the proper format for their e-portfolios. Have them include any handouts, diagrams, or other important documents necessary for studying for the unit exam. Use the **Notebook Rubric** to evaluate student progress. W1, W5	**Notebook Rubric**

Competency 2: Demonstrate the ability to read and interpret a basic blueprint. SPI-I, MPC1, MPC7, MPC34 (DOK 3)

Suggested Enduring Understandings

1. Blueprints are standardized communication tools used by parties involved in manufacturing.
2. The ability to read blueprints can be compared to having the ability to speak the language of a business associate.

Suggested Essential Questions

1. How important is blueprint reading?
2. How are blueprints used as communication between business partners?
3. How can we communicate needs or requirements to others using blueprints if we are blueprint illiterate?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Demonstrate the ability to read the various parts of a blueprint. (DOK 2)	a. **Hook:** "Blueprints give me the blues." Have a variety of blueprints laid out on tables as students enter the classroom. Give students time to look at the blueprints in detail. Introduce the enduring understandings and essential questions. Have students complete a **K-W-L Chart** on blueprints. Have students also include statements about any particular difficulties they have in examining these documents. Use the results of this K-W-L to address student needs. Discuss important vocabulary with students, which may include the following: architect, architect's scale, architectural plans, beam, blueprints, civil plans, computer-aided drafting, contour lines, detail drawings, dimensional line, dimensions, electrical plans, elevation, elevation drawing, engineer, engineer's scale, floor plan, foundation plan, heating, ventilating, air-conditioning, hidden line, isometric drawing, leader legend, mechanical plans, metric scale, not to scale, piping and instrumentation drawings, plumbing, plumbing plans, request for information, roof plan, scale, schematic, section drawing, specifications,	a. **K-W-L Chart**

		structural plans, symbol, and title block. Have the blueprints laid out on tables again. Lead a classroom discussion, and allow students to compare and contrast the various blueprints present. Discuss with students the important role blueprints play in standardizing communication between parties in manufacturing and other fields. Discuss the various fields that blueprints are used in, and ask students to evaluate the importance of being able to read blueprints and "talk the language" of blueprints in the workplace. Using the teaching materials created by Northrop Grumman, explain or show how the Mississippi shipbuilding industry uses blueprints. Have students record notes and journal entries into their notebooks concerning the reading of blueprints. Have them include any handouts, diagrams, or other important documents necessary for studying for the unit exam. Use the **Notebook Rubric** to evaluate student progress. W1, W5 Introduce the performance task: Before students begin to look at multiple views and different types of views and scale, assist them as they create a simple blueprint drawing using the **A Safe Playground GRASP** activity in the appendix of this unit. Help students to plan their work in an organized and presentable manner and to identify all the drawing information that must be included in any blueprint for playground equipment. Use the suggested rubrics to evaluate student work. Note: This performance task will tie this indicator to performance indicator (b) below. One performance task can be used for both performance indicators if both isometric and orthogonal drawings are used in the blueprint portion of the task. CLS2, CLS4	**Notebook Rubric** **Blueprint Rubric** **Playground Model Rubric** **Oral Presentation Rubric** **Notebook Rubric**
b. Demonstrate the ability to interpret the different views of a blueprint. (DOK 2) OC1	b.	**Hook:** "Is that your face?" Show students examples of isometric drawings of an object or objects and the orthogonal drawings of each face of the same object(s). If possible, have manufactured pieces for the drawings as well. Aluminum parts are available, or you could use rapid prototyped plastic parts from the 3D printer from a previous year's work (or ask Ty Posey at USM to make a sample using his laser scintering prototyper) for this purpose. Have students examine the drawings and the part(s) and lead a discussion of how the drawings relate to one another. Ask students to explain how the orthogonal "face" drawings tie to the isometric	b. **K-W-L Chart**

	drawing. Ask them to explain how many individual "face" views can be determined from each isometric drawing. Discuss with students how the isometric and orthogonal drawings relate to the manufactured part(s). Have students complete a **K-W-L Chart** on blueprint drawing views. Use the results to plan instruction for this performance indicator. Discuss important vocabulary with students, which may include the following: architect, architect's scale, architectural plans, beam, blueprints, civil plans, computer-aided drafting, contour lines, detail drawings, dimensional line, dimensions, electrical plans, elevation, elevation drawing, engineer, engineer's scale, floor plan, foundation plan, heating, ventilating, air-conditioning, hidden line, isometric drawing, leader legend, mechanical plans, metric scale, not to scale, piping and instrumentation drawings, plumbing, plumbing plans, request for information, roof plan, scale, schematic, section drawing, specifications, structural plans, symbol, and title block. Discuss what the term *scale* is as related to a map. Use this prior knowledge to help students to understand drawing to scale. M5, M7 Lecture/discuss with students orthogonal drawings, isometric drawings, first angle projection, and third angle projection. Use the Web site http://www.ul.ie/~rynnet/keanea/introduc.htm to explain how isometric drawings and orthogonal projection drawings are related. M5, M7, S3 Gather samples of isometric and orthogonal drawings with missing lines for students to analyze and complete. Work some of these together during class using guided practice, and assign additional ones for homework using unguided practice. There are several good books available for both of these assignments. Use the **Drawing Rubric** to assess student performance. M5 Guide students through activities ensuring they understand dimension lines and hidden and center lines and why they are used in drawings. Create wax carvings of each of the shapes for students to better understand the relationship among an actual object, the object's isometric view drawing, and the object's first angle and/or third angle projection view drawing. Have	**Drawing Rubric**

	students peer and self assess performance on this task. T1, T3, T6	
	Review with students the main points to study concerning blueprint reading in order for them to perform adequately on the unit exam. If possible, use a classroom game/review activity to show students sample assessment items that are equivalent to unit exam assessment items.	Jeopardy or other game review document using classroom response pads
	As an authentic assessment, give students samples of blueprints and ask them to interpret them.	Authentic assessment
	Have students read a blueprint and build a model. Have students peer evaluate models.	
	Have students record information concerning blueprint reading in their notebooks. Ask students to discuss the consequences of not following the blueprint in the journal section of their notebooks. Use the **Notebook Rubric** to evaluate student responses. W1, W5	
	Note: The performance task for this performance indicator is integrated with that of performance indicator (a) above.	**Notebook Rubric**

Competency 3:	Apply the principles of computer assisted design and drafting (CADD) as applied to the plastics and polymer manufacturing industry. SPI-I, MPC1, MPC8, MPC34 (DOK 4)

Suggested Enduring Understandings

1. CADD is an important industrial art extensively used in many applications, including automotive, shipbuilding, aerospace, industrial and architectural design, prosthetics, movie animation and special effects, and advertising.
2. The power and widespread use of computers means that even perfume and shampoo bottles are designed using technologies unheard of by shipbuilders of the 1960s.
3. The importance of CADD is a major driving force in advancements in computational geometry, computer graphics hardware and software, and discrete differential geometry.

Suggested Essential Questions

1. How is CADD used in industry?
2. How does the capability of running CADD programs affect the system requirements (hardware, software, RAM, graphics card choice, platform, etc.) of computers used in the workplace?
3. How can using CADD affect the price of a shampoo bottle?
4. How is CADD used in manufacturing plastics?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Interpret and use basic CADD symbols and terms. (DOK 1)	a. **Hook:** "Hey, I'm a Mac…and I'm a PC." Have students look at a Mac versus PC ad to discuss the strengths and weakness of each platform. These are available on the Apple.com Web site or on YouTube. Have students examine the various CADD programs available (AutoCAD, ProEngineer, SolidWorks, etc.) and discuss the pervasiveness of the PC platform in the CADD industry market. Have students examine the minimum system requirements for AutoCAD and SolidWorks. Have students compare these minimum requirements with the configuration for average home computers. Introduce the enduring understandings and essential questions. Have students complete a **K-W-L Chart** for CADD. Introduce important vocabulary terms for students. Introduce GRASP performance task. Lecture to instruct students to apply the following principles of computer assisted design and drafting (CADD) as applied to the plastics and polymer manufacturing industry: • If using a 3D software, create 3D files and 2D drawings. • If using 2D software, create drawings/prints. Have students write notes concerning CADD skills in their notebooks. W1, W5	a. **K-W-L Chart** **Notebook Rubric**

b.	Apply basic CADD skills to create, edit, and print/plot 2D and 3D. (DOK 2)	b.	**Hook:** "I'm a Jack of all trades." Have students look at the list of proficiencies they will be asked to demonstrate, and have them discuss what it means to be a "Jack of all trades." Have students complete a K-W-L on applying CADD skills to create, edit, and print 2D and 3D files. Use the results of this chart to plan instruction. Introduce/review important vocabulary for students. Have students demonstrate proficiency in using shape commands, printing drawings, using editing commands and coordinates, understanding orthographic projection and projection symbols, representing 3D objects in 2D, and using a polar coordinate system. Have them also demonstrate ability using polygons and ellipses to draw architectural symbols, creating fillets and chamfers, using the trim and extend commands, mirroring objects, making use of red hot grips, using viewports, printing preparation, using blocks and snaps, operating with linear and radial dimensions, and using layers to organize a drawing. Provide hands-on activities for students to demonstrate these proficiencies. Have students self-evaluate their work. T1, T3, T6 **Performance task:** You are an advertising specialist team that has been asked to submit a proposal designed to get information to consumers on behalf of a company that sells shampoo. The company uses one third less plastic than the industry average and runs an aggressive recycling program for its plastic shampoo bottles. Your job is to create a multimedia campaign that communicates effectively the company's "green" efforts to consumers. This campaign can take any of several forms (brochures/newspaper ads, posters/billboards, television/radio ads, etc.), but any format chosen should include a 3D CADD model of the company's shampoo bottle as a central feature of the advertisement. The final campaign should be prepared and ready to present to a steering committee for the company. All visuals (including the 3D CADD model), written documentation, and so forth must be used in an oral presentation of the multimedia campaign before this committee. Other advertising teams will present their work before the committee as well. The committee will decide on the campaign to use in the company's marketing efforts, but all	b.	**K-W-L Chart** **Presentation Assessment Rubric**

	advertising firms seeking the campaign contract will be given feedback from the committee concerning the strengths and weaknesses of their presentations and campaign proposals. Note: The 3D CADD model can be time intensive and might extend the time requirement for this task beyond what we might want to use for task completion. One way of reducing the amount of time required for this GRASP activity is to use a 3D laser scanner and a common plastic shampoo bottle to facilitate creating the original 3D CADD file for modification. There are several relatively inexpensive 3D laser scanners available for this purpose. Monitor team progress on this task closely as the campaign is designed and prepared for presentation. Build in several peer/self assessment checkpoints as teams work to completion. T1, T3, T6, W1, W5, CLS2, CLS4 Have students write notes concerning CADD skills in their notebooks. W1, W5	**Notebook Rubric**

Competency 4:	**Apply geometry and incorporate CADD and CAM (computer-aided machining) processes into the prototype production phase of plastics and polymer manufacturing.** SPI-I, MPC1, MPC8, MPC34 **(DOK 4)**
Suggested Enduring Understandings	**Suggested Essential Questions**
1. CAM can be used to create a faster production process (with streamlined components and more precise dimensions and material consistency) in order to minimize waste (in time and materials and to reduce energy consumption). 2. CAM does not eliminate the need for skilled professionals such as manufacturing engineers and NC (numerical control) operators; it leverages the value of manufacturing professionals through advanced productivity tools. 3. Draft angle, ribs, fillets, and rounds are used for safety, strength, and efficiency (and for reducing the number of pieces into which a mold must be separated in order to remove parts).	1. How can CAM be used to reduce manufacturing time and costs? 2. How does the use of CAM affect the workers in the plastics industry? 3. Why is draft angle important? 4. How are ribs, fillets, and rounds used in making molds for plastics production? 5. How can CAM be used in the mold design and prototyping processes?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Design a part with appropriate draft angle. (DOK 2) OC1	a. **Hook:** "Uncle Sam wants you" **<u>or</u>** "I've Been Drafted?" Show students an Uncle Sam poster or draft notice, and discuss the many different uses of the word *draft*. Lead the discussion toward the correct use of this word as it applies to plastics production mold design. Introduce the enduring understandings and essential	a. Teacher observation

questions.

Introduce important vocabulary for students, which could include the following:

- Shape command
- Printing drawing
- Editing command
- Coordinates
- Orthographic projection
- Projection symbols
- Representing 3D objects in 2D
- Polar coordinate system
- Polygons and ellipses
- Architectural symbols
- Fillets
- Chamfers
- Trim command
- Extend command
- Mirroring objects
- Red hot grips
- Viewports
- Printing preparation
- Blocks
- Snaps
- Linear dimensions
- Radial dimensions
- Layers
- Draft angle
- Rounds
- Ribs
- Wall thickness
- Vernier caliper
- Structural strength

Bring in a variety of plastic products that give evidence that draft angles, ribs, fillets, and rounds were used in the mold design process. Encourage students to speculate why the objects are tapered, have rounded edges, and/or have ribs (corrugated tin and corrugated cardboard would be examples of adding strength with ribs). Inform students that we will examine each of these design aspects for molded objects because they are important. Discuss with students that their ability to demonstrate proficiency on performance indicators (a) through (d) of this competency will greatly influence their eventual success on the performance task they will complete for this competency. You might introduce the performance task at this point so that students will see where they are being asked to go with CADD and CAM skills.

Lecture/lead a class discussion for students to differentiate the terms *CADD* and *CAM*. Discuss ways CADD and CAM are

		used in the production of plastics and polymer manufacturing. Have students research and discuss ways that CAM and rapid prototyping are used to cut costs in terms of material usage and waste and in terms of energy and time minimization. Have them record their findings and notes on CADD and CAM use in plastics production in their notebooks.	
		Have students research and discuss the changing role of workers in the plastics production industry. Are manufacturing jobs being lost as computer aided drafting and machining are used to greater effect? How is the job of the plastics process technician changing? After small-group discussion on these issues, have students, in groups, prepare a short written summary of their findings. Use the **Writing Rubric** to evaluate student work. T1, T2, T3, W1, W5	**Writing Rubric**
		Have students record their findings and notes in their notebooks. W1, W5	**Notebook Rubric**
		Discuss how draft angle is used in mold design for plastics processing. Explain that a draft angle is the angle of a taper on a mold that facilitates removal of the finished part. Have students examine draft angles used in various drawings, and have them demonstrate use of draft angle in designing for a plastic part. Have students design a part with an appropriate draft angle, and have them peer- and self-assess the part they design. Emphasis should be on safety in design rather than on choice of material, color, and finish (although these are important considerations to take into account). Use the **Model Rubric** to evaluate student work.	
b.	Calculate and measure wall thickness. (DOK 2)	b. Have students complete a **K-W-L Chart** on measuring using Vernier calipers. Use this information to plan instruction.	b. **K-W-L Chart**
		Demonstrate how to measure a plastic part wall thickness using a Vernier caliper. Have students demonstrate their ability to use Vernier calipers to measure the thickness of the walls of given plastic objects (Lego blocks and a variety of other molded objects can be used at little cost for this activity). Have students peer- and self-assess their ability with the Vernier calipers. M5, M7	
		A lab practical on the use of the Vernier calipers could be quite effective here.	**Lab Activity Rubric**
		Have students record their information in their notes. Use the Notebook Rubric to assess student work. W1, W5	**Notebook Rubric**
c.	Demonstrate the importance of ribs in relation to wall	c. Have students complete a **K-W-L Chart** on the use of ribs in plastics mold design. Use this information to plan instruction.	c. **K-W-L Chart**

	thickness. (DOK 2)	Show students examples of plastic objects that do and do not have ribs reinforcing the "wall structure." Have students analyze the parts to correlate the need for ribs to wall thickness of the part. Show students how to place ribs in their part designs in SolidWorks, and have them demonstrate the skill of placing ribs in a part design. Have students peer- and self-assess their use of ribs in SolidWorks files. M5, M7, T4 Have students record their information in their notes. Use the **Notebook Rubric** to assess student work. W1, W5	**Notebook Rubric**
d.	Demonstrate the importance of fillets and rounds. (DOK 2)	d. Have students complete a K-W-L Chart on using fillets and rounds in plastics mold design. Use this information to plan instruction. Using SolidWorks software and materials, guide students to understand what a fillet and a round are and allow students to use the fillet and round commands to edit a drawing they have already made. **or** Using SolidWorks software and materials, guide students through the process of measuring and drawing a robot jaw. This drawing will require the use of fillets and rounds. Have students peer- and self-assess their progress on this indicator. T1, T3, T6 Have students record their information in their notes. Use the **Notebook Rubric** to assess student work. Using SolidWorks software, guide students through the process of creating a playground block. Instructions may be found at http://www.ptc.com/WCMS/files/73441/en/playground.pdf. After students finish the assigned playground block activity, have students create their own new and improved block using similar principles of using draft angles, ribs, fillets, and rounds. T1, T3, T6, M5, M7	d. **K-W-L Chart** **Notebook Rubric**
e.	Produce a rapid prototyped part according to specifications. (DOK 3)	e. **Hook:** "I'm just doin' my part." Discuss with students the GRASP performance task for this competency. **Performance task:** You are a CADD team member for Lego. The company wants to create a new Lego shape for a new product line, and you have been asked to design and rapid prototype a sample brick for the new line. The brick can be cylindrical, spherical, triangular, and so forth, but it must be designed to connect to standard Lego bricks. When you and your team have successfully created the design and prototyped it, you will present your design and model to a review board that will analyze both the design and the brick for marketability and for the brick's ability to "mesh" with current Lego bricks on the market. If your brick is accepted, you and your team will get to fully develop the new product line and oversee the brick production process. Have students self-evaluate and peer review the projects after completing the design and after completing the prototype	e. Teacher observation **Writing Rubric** **Notebook Rubric**

	brick. T1, T3, T6	
	Have students record important notes and journal entries in their notebooks. W1, W5	
	Review important material from the unit, and help students prepare for their summative exam. A Jeopardy game or similar activity with model questions would help students to prepare for the test.	Unit exam (using ExamView and Blackboard)
	Have students take a summative exam using ExamView test bank items and Blackboard to demonstrate mastery of unit competencies.	
	Have students reflect on their unit performance and update their e-portfolios with appropriate items from the unit that offer evidence of their mastery of unit content. W1, W5	

Standards

Industry Standards: Society of Plastics Industry Standards

I. Essential Knowledge

Industry Standards: Polymer Standards for the State of Mississippi

MPC1 Business Understanding: Understanding the inner workings of business functions and how business decisions affect financial or non-financial work results
MPC7 Decision-Making Ability: Selecting, in a timely manner, appropriate course(s) of action that is(are) consistent with the organization's mission, vision, and strategies.
MPC8 Design of Experiments: Familiarity with this discipline and method of experimentation that is used to gather and analyze data and to efficiently determine process and product interactions.
MPC34 Technical Communications: The ability to translate and communicate required technical information to non-technical operational people.

Mississippi Academic Course Competencies and Benchmarks

OC1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.

ACT College Readiness Standards

M5 Graphical Representations
M7 Measurement
S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
W5 Using Language

21st Century Skills Standards

CLS2 Initiative and Self-Direction
CLS4 Productivity and Accountability

National Educational Technology Standards for Students

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

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Suggested Rubrics and Checklists

Name: _____

Date: _____

Period: _____

K-W-L Chart

Topic _____

What I Know	What I Want to Know	What I Learned

Name: _____

Date: _____

Period: _____

Multimedia Presentation Rubric

	Exemplary 4 points	**Accomplished 3 points**	**Developing 2 points**	**Beginning 1 point**	**Score Obtained**
Content	Addressed all assignment components	Addressed all but one assignment component	Omitted two assignment components	Omitted more than two assignment components	
Detail	Fully addressed all assignment components	Fully addressed most assignment components	Partially addressed most assignment components	Partially addressed few assignment components	
Accuracy	No grammatical, typographical, spelling, or punctuation errors	1–2 grammatical, typographical, spelling, or punctuation errors	3–5 grammatical, typographical, spelling, or punctuation errors	More than 5 grammatical, typographical, spelling, or punctuation errors	
Clarity	Logical, orderly sequence	Somewhat logical sequence	Confusing sequence	No evidence of order/sequence	
Design	Excellent design selection and usage	Adequate design selection or 1–2 design errors	Inadequate design selection or 3–5 design errors	Poor design selection or more than 5 design errors	
Appeal	Very appealing; excellent use of animation, transitions, sound, etc.	Somewhat appealing; adequate use of animation, transitions, sound, etc.	Not very appealing; limited use of animation, transitions, sound, etc.	Not appealing; very limited or no use of animation, transitions, sound, etc.	
				Score	

Name: _____

Date: _____

Period: _____

Presentation Assessment Rubric

	EXEMPLARY	ACCOMPLISHED	DEVELOPING	BEGINNING	SCORE
	(4)	(3)	(2)	(1)	
Content	Clear, appropriate, and correct	Mostly clear, appropriate, and correct	Somewhat confusing, incorrect, or flawed	Confusing, incorrect, or flawed	
Clarity	Logical, interesting sequence	Logical sequence	Unclear sequence	No sequence	
Presentation	Clear voice and precise pronunciation	Clear voice and mostly correct pronunciation	Low voice and incorrect pronunciation	Mumbling and incorrect pronunciation	
Visual Aids	Attractive, accurate, and grammatically correct	Adequate, mostly accurate, and few grammatical errors	Poorly planned, somewhat accurate, or some grammatical errors	Weak, inaccurate, or many grammatical errors	
Length	Appropriate length	Slightly too long or short	Moderately too long or short	Extremely too long or short	
Eye Contact	Maintains eye contact, seldom looking at notes	Maintains eye contact most of time but frequently returns to notes	Occasionally uses eye contact but reads most of information	No eye contact because reading information	
				Total	

Teacher Comments:

Name: _____

Date: _____

Period: _____

Notebook Rubric

	EXCELLENT (3)	SATISFACTORY (2)	UNSATISFACTORY (1)	SCORE
Completion of Required Sections	All required sections are complete. Supporting research and references have been included.	All required sections are complete.	Required sections are incomplete.	
Format	Appropriate format that is consistently used; extra desktop publishing enhancements	Appropriate format is consistently used.	Inappropriate format is used, or there is no consistency.	
Accuracy	Information is accurate and error free.	Information is accurate with minimal typographical errors.	Information is inaccurate and/or has numerous typographical errors.	
Organization	All assignments and/or notes are kept in a logical sequence.	Most assignments and/or notes are kept in a logical sequence.	Several assignments and/or notes are not in logical sequence.	
Neatness	Overall notebook is kept very neat.	Overall notebook is kept in satisfactory condition.	Overall notebook is unkempt and disorganized.	
			Total	

Teacher Comments:

Name: _____

Date: _____

Period: _____

Writing Rubric

	EXCELLENT (3)	SATISFACTORY (2)	UNSATISFACTORY (1)	SCORE
Content	Paper is well developed with more than enough information. Information is clearly presented with elaborations.	Paper is fairly well developed with enough information to inform the reader about the topic. Information is clearly presented with some elaborations.	Paper has little development and a minimum amount of information. Some information is confusing.	
Details	Plenty of specific details that more than adequately explain the topic	Some specific details that adequately explain the topic. Some do not help explanation.	May not have details, and/or details may be wrong.	
Organization	Clear organization and no straying	Has somewhat of an organization and tries to stick to it	If there is an organization, it is not clear and writer strays from it.	
Audience	Written for intended audience	Written for intended audience in most cases	Does not address the intended audience	
Language Choices	Uses language choices to maintain a style or a tone	Uses some language choices to maintain style or tone	Does not use language choices to help with style or tone.	
			Total	

Teacher Comments:

Name: _____

Date: _____

Period: _____

Oral Presentation Rubric

	EXCEPTIONAL (4)	ADMIRABLE (3)	ACCEPTABLE (2)	AMATEUR (1)	TOTAL
Content	An abundance of material clearly related to topic; points are clearly made and all evidence supports topic; varied use of materials.	Sufficient information that relates to topic; many good points made but there is an uneven balance and little variation.	There is a great deal of information that is not clearly connected to the topic.	Topic not clear; information included that does not support topic in any way	
Coherence and Organization	Topic is clearly stated and developed; specific examples are appropriate and clearly develop topic; conclusion is clear; shows control; flows together well; good transitions; succinct but not choppy; well organized.	Most information presented in logical sequence; generally very well organized but better transitions from idea to idea and medium to medium needed	Concept and ideas are loosely connected; lacks clear transitions; flow and organization are choppy.	Presentation is choppy and disjointed; does not flow; development of topic is vague; no apparent logical order of presentation.	
Creativity	Very original presentation of material; uses the unexpected to full advantage; captures audience's attention	Some originality apparent; good variety and blending of materials/media	Little or no variation; material presented with little originality or interpretation	Repetitive with little or no variety; insufficient use of multimedia	
Material	Balanced use of multimedia materials; properly used to develop topic; use of media is varied and appropriate.	Use of multimedia not as varied and not as well connected to topic	Choppy use of multimedia materials; lacks smooth transition from one medium to another; multimedia not clearly connected to topic	Little or no multimedia used or ineffective use of multimedia; imbalance in use of materials—too much of one, not enough of another	
Speaking Skills	Poised, clear articulation; proper volume; steady rate; good posture and eye contact; enthusiasm; confidence	Clear articulation but not as polished	Some mumbling; little eye contact; uneven rate; little or no expression	Inaudible or too loud; no eye contact; rate too slow/fast; speaker seemed uninterested and used monotone.	
Audience Response	Involved the audience in the presentation; points made in creative way; held the audience's attention throughout	Presented facts with some interesting "twists"; held the audience's attention most of the time	Some related facts but went off topic and lost the audience; mostly presented facts with little or no imagination	Incoherent; audience lost interest and could not determine the point of the presentation.	
Length of Presentation	Within 2 minutes of allotted time +/–	Within 3–4 minutes of allotted time +/–	Within 5–6 minutes of allotted time +/–	Too long or too short; 10 or more minutes above or below the allotted time	
Total					

Lab Activity Rubric

SKILL OR BEHAVIOR	ALWAYS (3)	MOST OF THE TIME (2)	RARELY (1)	NEVER (0)	TOTAL
Cooperated well with lab partners Listened to others Expressed opinions in professional manner Responded appropriately to others Respected others' opinions					
Followed verbal and written instructions Followed directions the first time Listened to teacher Accepted responsibility for actions Remained on task Allowed others to remain on task					
Followed safety rules Wore lab coat if applicable Wore goggles if applicable Wore gloves if applicable Followed specific safety rules for this particular lab Followed all other safety rules					
Cleaned and returned tools, supplies, lab coats, and goggles to proper location Cleaned all supplies Returned all supplies to proper place Disposed of all trash properly Cleaned lab tables Left chairs/stools in proper location					
Rate finished product. 1 to 5 (5 being the best)					
				Total	

Teacher Comments:

Name: _____

Date: _____

Period: _____

Drawing Rubric

Criteria	Excellent 3	Satisfactory 2	Insufficient Concept Attainment 1	Score
Completed Drawings	Drawing contains clean and sharp lines.	Drawing has mostly clean lines.	Drawing has many lines that are not cleanly drawn.	
Erasures	All lines are accurately drawn with little or no erasures evident.	Drawing has some erasures evident, but most are removed completely.	Drawing shows many erasures that are not cleanly removed.	
Discussion	Student shows accuracy and understanding of drawing method.	Student shows satisfactory command of drawing method.	Student shows signs of misunderstanding of drawing method.	
CADD Concepts	Student shows command of hidden lines and 3D connections in drawing.	Student shows adequate command of hidden lines and 3D connections in drawing.	Student shows poor understanding of hidden lines and 3D connections in drawing.	
Total				

Name: _____

Date: _____

Period: _____

Blueprint Rubric

	Architect 4	Journeyman 3	Apprentice 2	Novice 1	Score
SCALE	All playground equipment is drawn to scale. The spacing between equipment is also correctly scaled.	All playground equipment is drawn to scale. Spacing is a little off. Somewhat clear and easy to read	One piece of equipment is not drawn to scale. Spacing is off. Somewhat unclear and difficult to read	Two or more pieces of equipment are not drawn to scale. Spacing is non-existent. Unclear and difficult to read	
FALL/SAFETY ZONE	The diameter of the fall/safety zone has been correctly calculated and is clearly marked by a shaded circle for each piece of equipment.	The diameter of the fall or safety zone has been correctly calculated for three of the four pieces of equipment and is clearly marked by a shaded circle for each piece of equipment.	The diameter of the fall or safety zone has been correctly calculated for two of the four pieces of equipment and is clearly marked by a shaded circle for each piece of equipment.	The diameter of the fall or safety zone has been correctly calculated for one of the four pieces of equipment and is clearly marked by a shaded circle for each piece of equipment.	
KEY	The key clearly tells the meaning of each symbol on the blueprint and shows the maximum and minimum height for each piece of equipment. The key is neat and easy to read.	The key clearly tells the meaning of each symbol on the blueprint and shows the maximum and minimum height for each piece of equipment. The key is somewhat neat and easy to read.	The key clearly tells the meaning of each symbol on the blueprint and shows the maximum and minimum height for three of the four pieces of equipment. The key is somewhat unclear and difficult to read.	The key clearly tells the meaning of each symbol on the blueprint and shows the maximum and minimum height for two of the four pieces of equipment. The key is unclear and difficult to read.	
ORAL PRESENTATION	All group members participated. Blueprint and playground were well presented. Presentation was clear, composed, and easy to understand.	All group members participated. Blueprint and playground were presented. Presentation was easy to understand.	Most group members participated. One of the major components was missing. Presentation was difficult to understand.	Few members participated. Two or more components were missing. Presentation was unclear and difficult to understand.	
Total					

Name: _____

Date: _____

Period: _____

Playground Model Rubric

	Architect 4	Journeyman 3	Apprentice 2	Novice 1	Score
3D MODEL	The 3D model is created to scale and clearly demonstrates knowledge of geometric concepts.	The 3D model is missing one of the main components or is not drawn to scale.	The 3D model is missing several main components or is not drawn to scale.	The 3D model is not drawn to scale and bears little relationship to the 2D figure on the blueprint.	
RESEARCH	Creates a model using information gained from research. Accurately solves the problems and researches other aspects of geometry or physics	Can create a model to accurately represent the material presented. Can successfully solve the mathematical problems presented	Can create a basic mode, but leaves out some major aspects. Tries the problems but cannot accurately solve them	Has difficulty constructing the model Cannot solve the problems	
PLAYGROUND	Creative use of materials. A good visual representation of the blueprint. Includes fall or safety zones and a 3D model of the equipment. Colorful	Good use of materials. Somewhat representative of blueprint. Missing one component. Colorful	Fair use of materials. Fair representation of blueprint. Missing two components. Not very colorful	Poor use of material. Not representative of blueprint. Missing more than two components. Not colorful	
ORAL PRESENTATION	All group members participated. Blueprint, survey, playground and budget were well presented. Presentation was clear, composed, and easy to understand.	All group members participated. Blueprint, survey, playground, and budget were presented. Presentation was easy to understand.	Most group members participated. One of the major components was missing. Presentation was difficult to understand.	Few members participated. Two or more components were missing. Presentation was unclear and difficult to understand.	
Total					

Name: _____

Date: _____

Period: _____

A Safe Playground GRASP

Scenario

Have you ever thought about how many children are injured each year in playground accidents? You know from personal experience just how many bumps, cuts, and bruises you and your friends have gotten on your school's playground equipment, but did you know how many children are hurt each year? According to U.S. Consumer Product Safety Commission (CPSC) data, 190,000 children in the U.S. were injured seriously enough on playgrounds to require emergency room treatment in 2001 alone. Many of these injuries could be prevented if playgrounds were designed with safety in mind. To keep our students safe, the PTA has decided to sponsor a Safe Playground Contest.

To enter the contest, you must first research safe playground design. Then, you must use your knowledge of mathematics and science to create a working model of a safe playground. Models that pass the safety test (see Assessments below) will be awarded a certificate and be displayed at the next PTA meeting.

How can your knowledge of mathematics and science help you create a safer playground?

First, you will form into groups of four. Each of you is responsible for researching a specific piece of playground equipment: swings, slides, seesaws, and climbing equipment.

After you gather information about ways to make playgrounds safer, you will share your information with your group. Then, you will use your knowledge of mathematics and science to design the blueprint for the playground. Each person in the group is responsible for determining the safe fall zone and the height of and distance from other equipment. For example, the person who researched swings would calculate the fall zone; the maximum and minimum heights of the swing; and the distance the swing must be from the slides, seesaws, and other climbing equipment. Finally, your group must build the sturdiest and safest model of playground equipment you can construct.

Product

After you complete your research, you will use your knowledge to create the following:

a. A blueprint drawn to scale showing the placement of each piece of equipment. Your blueprint should:
   - be drawn to scale (1 in. = 1 ft).
   - have a key that tells the meaning of each symbol and maximum/minimum height of each piece of equipment.
   - indicate the fall zone by drawing a shaded circle the correct distance around the piece of equipment (see student resources to help you).
   - be a representation. Remember that a blueprint is NOT a drawing; instead, a blueprint is a 2D representation of a 3D object.

b. A model created to scale of the playground equipment. Your teacher may choose to have you construct your models using Connects, straws and marshmallows, or recycled materials.

Assessments

The following scoring tools will be used to assess both the process of gathering information and your finished products:

- Blueprint Assessment Rubric
- Playground Model Assessment Rubric
- Safety Assessment

- Certificate of Safe Playground Design
- Group Work Scoring Rubric

Essential Questions

What makes playgrounds dangerous?
How can I make climbing equipment safer?
What is a fall or safety zone?
What is the maximum height your equipment can safely be? The minimum?
What geometric shape(s) create the strongest structures?
How do you calculate how far away each piece of equipment must be from any other piece of equipment?
What is a pendulum?
Is a swing a pendulum?
How does a seesaw work? How can I make it safer?
How does a slide work? How is a slide like a roller coaster?
What is kinetic energy?
What does kinetic energy have to do with playground equipment?

Gather and Sort

Your group should complete the following note taking and planning activities for your playground:

- Complete the Safe Playground Organizer.
- Gather information about the essential questions from a variety of sources.

Note: Be sure to avoid plagiarism and keep track of your resources for a bibliography. Need help documenting your resources? Use the interactive tools at Noodle Tools Quick Site.

Organize

Using the research you did on the essential questions, explain how to determine the diameter of the fall or safety zone for each piece of equipment on your playground. You can use words and calculations in your explanation. Explain how you would calculate the perimeter of your playground.

After all work is completed, use the planning checklist again to make sure that you have completed all requirements. If you are missing any information, go back and use resources to find the missing information.

Prepare an oral presentation of your research to go along with the blueprints and model you construct.

Conclusion

Reflection and/or Extension Activities:

How safe is your playground? Use resources like America's Playground Safety Report Card to assess the safety of your playground and record and report your assessment.

Unit 3: Introduction to Chemistry

Competency 1: Illustrate atomic contributions to chemical structures. SPI-I, MPC4, MPC14, MPC26, MPC27, MPC31, MPC33, MPC34 (DOK 2)

Suggested Enduring Understandings

1. The atom is composed of subatomic particles that contribute to its chemical behaviors.
2. The associations of subatomic particles between atoms are responsible for various bonds and molecular interactions.

Suggested Essential Questions

1. How do subatomic particles contribute to chemical behaviors of elements?
2. Why do elements exhibit a preference for the types of bonds they will form?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe atomic structures to include protons, neutrons, and electrons. (DOK 1) OC2	a. **Hook:** "It's a give and take relationship." Show the students the +/- attraction cartoon at http://www.webelements.com/_media/elements/cartoons/li.jpg . Ask students to interpret the cartoon through a **K-W-L Chart**. E1-E6, W1-W5 Introduce enduring understandings and essential questions. **Lecture and note taking:** Introduce vocabulary (when appropriate) to include subatomic particles, protons, neutrons, electrons, nucleus, covalent bond, ionic bond, electronegativity, hydrogen bonding and other intermolecular forces, and so forth. S1 Discuss and model the use of the periodic table to compute the types and numbers of subatomic particles in various elements. Demonstrate constructing Bohr atoms from subatomic particle information. M1, S1, S3 Offer students guided practice and cooperative group calculation of numbers of subatomic particles and construction of Bohr atoms for various elements. M1, S1, S3, CLS3 **Skill check:** Calculating numbers of subatomic particles and constructing Bohr atoms M1, S1, S3	a. **K-W-L Chart** Peer tutoring and assessment Skill check
b. Demonstrate ionic and covalent bonding, including multiple bonds (double and triple). (DOK 2) OC2	b. **Lecture and modeling:** Using Lewis structures, discuss the transfer of electrons versus sharing of electrons and why elements tend to have certain bonding tendencies. M1, S1, S3 In pairs, students create a Venn diagram for the two major bond types. Review and create a master Venn for the class. W4 Revisit K-W-L and review for a quiz on the atom and bonding. E1-E6, W1-W5	b. Teacher observation Quiz

	Introduce multiple bonds using Lewis structures and a polystyrene ball and toothpick model of ethane, proceeding to ethene and ethyne. [S1, S3] **Performance task:** You are a middle school science teacher who just received two new chemicals for a lab experiment. As an introductory activity, you would like to visually represent the formation of these compounds from their elements. Use the MSDS enclosed in the packages as a resource to identify chemical formulas and devise a way to visually represent electron movements and interactions within the compounds. Your ability to correctly and effectively illustrate the formations of these compounds to your students will be evaluated through a rubric. [E5, S1, S3, CLS2, CLS4, T1-T4]	Self-assessment

Competency 2: Identify common organic molecules, and relate their structures to chemical and physical properties. [SPI-I, MPC19, MPC26-28, MPC31, MPC33] (DOK 3)

Suggested Enduring Understandings

1. There are finite rules that apply to organic compound nomenclature and structures.
2. Organic compounds with different backbone structures behave differently with respect to chemical activity.
3. Varying functionalities provide for differences in chemical and physical properties.

Suggested Essential Questions

1. What is the significance of a name?
2. To what extent does the way a compound is put together impact its behaviors?
3. How does the introduction of other elements into a hydrocarbon affect its properties?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Apply IUPAC nomenclature and illustrate structures for aliphatic, aromatic, and cyclic hydrocarbons. (DOK 2)[OC2]	a. **Hook:** "What's in a name?" Brainstorm in small groups how names vary in different cultures (use available resources such as international students and the Internet) and how a name shapes a person. [W4, CLS3, T2, T3]	a. Teacher observation
	Introduce enduring understandings and essential questions.	
	Discuss and model IUPAC rules for naming organic compounds, demonstrating structures with models. Include aliphatic, aromatic, and cyclic hydrocarbons. [S1, S3]	Teacher observation
	Practice naming and drawing organic hydrocarbons in a Think-Pair-Share activity. [S1, S3]	**Model Building Checklist**
	Create models of various compounds using edible atoms and connectors (i.e., grapes, marshmallows, and toothpicks). Transcribe models to written structures. [S1, S3]	Quiz

			Review for and then administer a quiz.		
b.	Write, complete, and classify common reactions for aliphatic, aromatic, and cyclic hydrocarbons. (DOK 3)[OC2]	b.	Lecture and visually illustrate common chemical reactions for aliphatic, aromatic, and cyclic hydrocarbons, to include substitution, addition, dehydrogenation, and so forth. [S1, S3] Research saturated and unsaturated fats, relating them to bond types, properties, nutrition, and the chemistry of conversion from one to the other. Prepare a two- to three-page paper to be evaluated by the **Report Rubric**. Provide an opportunity for peer assessment/editing during the writing process. [S1, S3, E1-E6, W1-W5, CLS2, CLS4, T1, T3, T5] Offer lecture and guided practice on reaction writing and classifying followed by independent practice. [S1, S3]	b.	Teacher observation Peer- and self-assessment **Report Rubric**
c.	Describe functional groups to include structures, nomenclature, and properties. (DOK 1) [OC2]	c.	Discuss and demonstrate use of IUPAC system for naming and drawing hydrocarbon derivatives to include alcohols, ethers, aldehydes, ketones, carboxylic acids, esters, amines, amides, and isocyanates. [S1, S3] Practice naming and drawing hydrocarbon derivative compounds through team competition. [S1, S3, CLS3, CLS5, T4] Relate functional groups to chemical and physical properties of derivatives, using various demonstrations or data tables/graphs of data for solubilities, densities, boiling points, reactivities, and so forth. [M2, M5, S1, S3] Offer lecture and demonstration of reaction equation writing representing the transformation of one functional group into another (i.e., acid + alcohol = ester +water). [S1, S3] Facilitate student equation writing and predicting of products through quick response Q&A (response pads, game/learning software, etc.). [S1, S3] **Performance Task:** Pretend you are an organic molecule. (Assign each student a molecule name to represent.) Research your assigned molecule, and make a wearable sign depicting your name, structure, and classification (i.e., alcohol, acid, alkene, cycloalkane, etc.). Role-play a high school setting with your classmates, selecting your friends, acquaintances, and enemies based on chemical structures. Respond as your teacher introduces various “new students” and proposed pairings. You will be judged on the accuracy of your responses and randomly prompted explanations. [R3, R5, S1, S3, W5, CLS1- CLS3, T1, T3, T4]	c.	Teacher observation Instant feedback from games Teacher evaluation of performance task via **Role-Play or Skit Assessment Rubric**

	Lead review for test and then assess.	Test

Competency 3: Investigate compositions and properties of various mixtures and conditions that impact mixture formation and stability. SPI-I, MPC4, MPC7, MPC14, MPC18, MPC21, MPC26, MPC27 (DOK 2)

Suggested Enduring Understandings

1. Various combinations of substances form different types of mixtures based on components' chemical and physical attributes.
2. Numerous conditions can result in an effective mixture or change mixture stability, even when components appear incompatible.

Suggested Essential Questions

1. Why do combinations of some substances mix completely, where others will not? How can seemingly incompatible substances become an effective mixture?
2. How do environmental factors affect how well substances mix or remain mixed?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Define and demonstrate homogeneous and heterogeneous mixtures. (DOK 1) OC1	a. Provide two mixture samples, one homogeneous and one heterogeneous, to each small group of students. Teams create Venn diagrams analyzing likenesses and differences. Present diagrams to the class, culminating in a master Venn diagram for the class. Introduce vocabulary terms when appropriate (homogeneous mixture, heterogeneous mixture, solution, solute, solvent, solubility, unsaturated, saturated, supersaturated, emulsion, emulsifier, etc.). S1-S3, W1-W5, CLS1-CLS5 Introduce enduring understandings and essential questions. Identify a variety of materials as homogeneous or heterogeneous mixtures, designating solute, solvent, and so forth where possible. S1, S3	a. Teacher assessment of Venn diagrams Skill check on identifying mixtures and components
b. Define and demonstrate various solution saturations. (DOK 1) OC1	b. **Hook:** Ask students, "Don't you hate it when you have to sweeten iced tea at the table in a restaurant? Why is it difficult? What is the best way to prepare sweet tea?" Respond with three to seven sentences. E1-E6, W1-W5 Use a multimedia presentation to lecture while students use the Cornell note-taking system to take notes. Describe the progression from unsaturated to saturated to supersaturated solutions, incorporating factors that affect solubility and equilibrium concepts. S1, S3 Show a video on crystal caves or crystal growth: http://channel.nationalgeographic.com/series/hd/3569/Overview#tab-Videos/05857_00 or https://lasers.llnl.gov/multimedia/video_gallery/kdp_crystal_growth.php. **Performance task**: You are a team of crystallographers at the Smithsonian. Your goal is to grow the most perfect crystal for an upcoming science exposition. You must grow crystals from supersaturated solutions (potassium alum or copper sulfate in water), making observations and	b. **Journal Rubric** **Cornell Note-Taking Template** **Lab Activity Rubric** Formal Lab Report (ECI Solids Module)

	measurements throughout the process. You will be judged on the detail and accuracy of observations and data, graphing of growth rate, and the perfection of your crystal. M2, M5, M7, S1-S3, CLS1-CLS5	
	Review for quiz.	Quiz

Standards

Industry Standards: Society of Plastics Industry Standards

I. Essential Knowledge

Industry Standards: Polymer Standards for the State of Mississippi

MPC4 Communication: Applying effective verbal, nonverbal, and written communication methods to achieve desired results
MPC7 Decision-Making Ability: Selecting, in a timely manner, appropriate course(s) of action that is(are) consistent with the organization's mission, vision, and strategies
MPC14 Group Process Understanding: Understanding how groups function; influencing people so that group, work, and individual needs are addressed
MPC18 Leadership: The ability to influence and guide members of the organization achieve organizational objectives
MPC19 Model Building: The ability to develop frameworks from complex and theoretical ideas
MPC21 Organization: The use of coordination and communication as tools used to accomplish tasks in a systematic manner
MPC26 Questioning: Gathering information from stimulating insight in individuals and groups through use of interview, questionnaires, and other probing methods
MPC27 Relationship Building Skills: Establishing relationships and networks across a broad range of people and groups
MPC28 Research Skills: Selecting, developing, and using methodologies such as statistical and data collection techniques for formal inquiry
MPC31 Self-Knowledge/Self-Management: Knowing one's personal values, needs, interests, style, and competencies and being able to manage their effects on others
MPC33 Teamwork: Successfully and efficiently working and communicating with group or project members such that the team's final output meets or exceeds predefined expectations
MPC34 Technical Communications: The ability to translate and communicate required technical information to non-technical operational people

Mississippi Academic Course Competencies and Benchmarks

OC1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
OC2 Demonstrate an understanding of the properties, structure, and function of organic compounds.

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
M1 Basic Operations and Applications
M2 Probability, Statistics, and Data Analysis
M5 Graphical Representations
M7 Measurement
R3 Sequential, Comparative, and Cause—Effect Relationships
R5 Generalizations and Conclusions
S1 Interpretation of Data

S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language

21st Century Skills Standards

CLS1 Flexibility and Adaptability
CLS2 Initiative and Self-Direction
CLS3 Social and Cross-Cultural Skills
CLS4 Productivity and Accountability
CLS5 Leadership and Responsibility

National Educational Technology Standards for Students

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship

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Suggested Rubrics and Checklists

Name: _____

Date: _____

Period: _____

Presentation Assessment Rubric

	EXEMPLARY	ACCOMPLISHED	DEVELOPING	BEGINNING	SCORE
	(4)	(3)	(2)	(1)	
Content	Clear, appropriate, and correct	Mostly clear, appropriate, and correct	Somewhat confusing, incorrect, or flawed	Confusing, incorrect, or flawed	
Clarity	Logical, interesting sequence	Logical sequence	Unclear sequence	No sequence	
Presentation	Clear voice and precise pronunciation	Clear voice and mostly correct pronunciation	Low voice and incorrect pronunciation	Mumbling and incorrect pronunciation	
Visual Aids	Attractive, accurate, and grammatically correct	Adequate, mostly accurate, and few grammatical errors	Poorly planned, somewhat accurate, or some grammatical errors	Weak, inaccurate, or many grammatical errors	
Length	Appropriate length	Slightly too long or short	Moderately too long or short	Extremely too long or short	
Eye Contact	Maintains eye contact, seldom looking at notes	Maintains eye contact most of time but frequently returns to notes	Occasionally uses eye contact but reads most of information	No eye contact because reading information	
				Total	

Name: _____

Date: _____

Period: _____

K-W-L Chart

Topic _____

What I Know	What I Want to Know	What I Learned

Name: _____

Date: _____

Period: _____

Journal Rubric

Use this rubric to assess students' abilities to complete the journal activities assigned for this lesson. Share this assessment with students prior to completing the journal-writing lessons so they will understand how they will be assessed. You can also use the rubric as a basis for discussion and feedback with each student.

1. The student writes journal responses in complete sentences. _____
2. The student writes five or more sentences to answer questions. _____
3. The student responds to questions by self-questioning, retelling, predicting, or assuming the role of a character. _____
4. The student's experiences and opinions are clear. _____
5. The student works with a peer to share journal responses and to develop a combined response when requested. _____

TOTAL: _____

EXCELLENT (4)	VERY GOOD (3)	FAIR (2)	POOR (1)
The student completes the task with mo major errors. The student demonstrates a full understanding of the concepts.	The student completes the task with only a few major errors and some minor errors. The student demonstrates a strong understanding of the concepts.	The student completes the task with some major errors and many minor errors. The student has difficulty understanding the concepts.	The student fails to complete the task. The student does not understand the concepts.

Teacher Comments:

Name: _____

Date: _____

Period: _____

Model Building Checklist

1. Legend available for atom identification

   _____

2. Correct types of atoms in model

   _____

3. Correct numbers of each atom in model

   _____

4. Correct arrangements of atoms in model

   _____

5. Correct bond types represented

   _____

6. Correct geometries represented

   _____

7. Overall model appearance

   _____

Percentage Achieved _____

Name: _____

Date: _____

Period: _____

Report Rubric

	EXEMPLARY (4)	ACCOMPLISHED (3)	DEVELOPING (2)	BEGINNING (1)	SCORE
Topic	Directly relevant	Somewhat relevant	Remotely related	Totally unrelated	
Organization	Good organization; events are logically ordered; sharp sense of beginning and end.	Organized; events are somewhat jumpy.	Some organization; events jump around; start and end are unclear.	Not organized; events make no sense.	
Quality of Information	Supporting details specific to subject	Some details are non-supporting to the subject.	Details are somewhat sketchy.	Unable to find specific details	
Grammar and Spelling	All grammar and spelling are correct.	Only one or two errors	More than two errors	Very frequent grammar and/or spelling errors	
Interest Level	Vocabulary is varied; supporting details are vivid.	Vocabulary is varied; supporting details need work.	Vocabulary is constant; details lack “color.”	Needs descriptive words	
Neatness	Word processed or typed; clean and neatly bound in a report cover; illustrations provided	Legible writing; well-formed characters; clean and neatly bound in a report cover; illustrations provided	Legible writing; some ill-formed letters; print too small or too large; papers stapled together	Illegible writing; loose pages	
Timeliness	Report handed in on time	Up to 2 days late	Up to 1 week late	Report handed in more than 1 week late	
				Total	

Teacher Comments:

Name: _____

Date: _____

Period: _____

Role-Play or Skit Assessment Rubric

	EXCELLENT (4)	GOOD (3)	AVERAGE (2)	NEEDS IMPROVEMENT (1)	TOTAL
Accuracy	All information was accurate.	Almost all information was accurate.	Most information was accurate.	Very little information was accurate.	
Role	Excellent character development; student contributed in a significant manner.	Good character development; student contributed in a cooperative manner.	Fair character development; student may have contributed.	Little or no character development; student did not contribute much at all.	
Knowledge Gained	Can clearly explain several ways in which his or her character "saw" things differently than other characters and can explain why	Can clearly explain several ways in which his or her character "saw" things differently than other characters	Can clearly explain one way in which his or her character "saw" things differently than other characters	Cannot explain any way in which his or her character "saw" things differently than other characters	
Props	Used several props and showed considerable creativity	Used 1 or 2 appropriate props that made the presentation better	Used 1 or 2 props that made the presentation better	Used no props to make the presentation better	
Required Elements	Included more information than required	Included all required information	Included most required information	Included less information than required	
				Total	

Teacher Comments:

Name: _____

Date: _____

Period: _____

Lab Activity Rubric

SKILL OR BEHAVIOR	ALWAYS (3)	MOST OF THE TIME (2)	RARELY (1)	NEVER (0)	TOTAL
Cooperated well with lab partners Listened to others Expressed opinions in professional manner Responded appropriately to others Respected others' opinions					
Followed verbal and written instructions Followed directions the first time Listened to teacher Accepted responsibility for actions Remained on task Allowed others to remain on task					
Followed safety rules Wore lab coat if applicable Wore goggles if applicable Wore gloves if applicable Followed specific safety rules for this particular lab Followed all other safety rules					
Cleaned and returned tools, supplies, lab coats, and goggles to proper location Cleaned all supplies Returned all supplies to proper place Disposed of all trash properly Cleaned lab tables Left chairs/stools in proper location					
Rate finished product. 1 to 5 (5 being the best)					
				Total	

Teacher Comments:

Name: _____

Date: _____

Unit/Chapter: _____

Cornell Note-Taking Template

Cue Column:	Notes:

Unit 4: Structure and Properties of Polymers

Competency 1: Relate small molecule chemistry to the production of polymers. [SPI-I, SPI-IV, MPC3-4, MPC14, MPC18-19] (DOK 3)

Suggested Enduring Understandings

1. Organic chemistry forms the basis of polymer synthesis.
2. Different polymers can be combined in one structure to create new products.

Suggested Essential Questions

1. How can something that you cannot see turn in to something that you can see and touch?
2. How do the types of monomers in a copolymer and their arrangement within the structure affect the behavior of the material?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Using models, demonstrate the structure of monomers. (DOK 2)[OC1, OC2, OC3]	a. **Hook:** "It's magic!" Pose the following questions to the students: How can you seemingly make something out of nothing? How can you turn something that you cannot see into something that you can see and touch? Lead the discussion into the formation of tangible polymers from monomers that may be gases.	a. Teacher observation
	Provide students with enduring understandings and essential questions.	Teacher observation
	Review vocabulary as needed, to include monomer, polymer, homopolymer, copolymer, terpolymer, and vinyl monomer.[S1]	Self-assessment and teacher observation
	Guide students in the "Mickey Mouse" activity to illustrate the formation of polymer chains. Have the students act as monomers and link together to form a chain until all of the "monomers have reacted." Relate this activity to polymer synthesis.[CLS3, T1]	Student self-assessment
	Introduce students to the two main types of monomers: those containing functional groups for condensation polymerization and those containing double bonds for addition polymerization.	Teacher observation
	Discuss the structures of six common monomers: ethylene, propylene, isobutylene, styrene, vinyl chloride, and methyl methacrylate. Have students create note cards with the name of the monomer on one side and its structure on the other.[T1]	Teacher observation
	Have students create molecular models of the monomers in two groups. One group creates the models, and the second group then tries to name them. Have the students then reverse roles and try again.[CLS3-5, T1]	Peer assessment, teacher assessment
b. Using models,	b. Illustrate the	b. Teacher observation

	demonstrate the structure and synthesis of homopolymers. (DOK 2) OC1, OC2, OC3	conversion of monomers to polymers through diagrams.[T1] Use guided practice to identify the repeat units in given polymer structures. Introduce the concepts of condensation and addition polymerization. Have the students create a Venn diagram to compare and contrast the two techniques. Review for quiz. Carry out the experiment to create Nylon 6,10 (or Nylon 6,6) (ECI Polymers manual) to illustrate the formation of a homopolymer. Have the students keep accurate notes and write a lab report on their experiment.[CLS2, E1-E6, S1-3, W1-W5]	Teacher observation and self-assessment Teacher observation and Venn diagram Quiz **Lab Report Checklist**
c.	Using models, demonstrate the structure and synthesis of copolymers. (DOK 2) OC1, OC2, OC3	c. Introduce vocabulary, to include alternating copolymer, block copolymer, random copolymer, graft copolymer, and star polymer. Diagram the structures.[S1] Have the students link arms to create the various copolymer structures by using personality or physical differences in the students to represent the two monomer units (i.e., shy students vs. outspoken students). Have the students brainstorm about how their "polymer" would interact in different social situations based on the way the monomers are arranged.[CLS1-3, CLS5, T1-T2] Review for test with quick response pads. **Performance Task:** Pretend you are a monomer unit near the center of a copolymer structure (you choose which structure would best fit your life). Your family members are the other monomers of your type. Your teachers are the other monomer type in the polymer molecule. Write a one-page summary of a day in your life, keeping in mind that you are permanently attached in this molecule. You must figure out how to operate and go about your business while being restricted by the actions and needs of others. Write a summary of your day. You will then present your work to a small group of classmates, who will decide whether your daily activities were feasible. If you can operate throughout the day, you are a successful copolymer. If you have trouble, you may need to rethink your design.[CLS1-2, CLS4, E1-E6, W1-W5, T1-T2]	c. Teacher observation Peer and self-assessment Test **Performance Task Checklist: Copolymer Structures**

Competency 2: Recognize and define natural and synthetic polymers.	
Suggested Enduring Understandings	**Suggested Essential Questions**
1. Though many polymers are considered plastics, there are a large number of naturally occurring polymers. 2. Scientists are still learning about polymer synthesis from nature.	1. Why do we still use natural polymers if we can make synthetic polymers? Why do we need synthetic polymers if we have natural ones? 2. Why do scientists have such a difficult time mimicking the properties of natural polymers?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe natural polymers (cellulose, DNA/RNA, natural rubber, starches, and proteins). (DOK 1) [OC3]	a. Have the students create a list of natural polymers and a list of synthetic ones. Discuss why they put each item in its proposed list. Pose the question "Which is better, natural polymers or synthetic?" Have the students volunteer their answers and explanations.[CLS2] Use the Internet to research some natural polymers and how they are created. The Macrogalleria is a good resource. Have the students discuss their research in small groups.[R1-R5, T3, T5]	a. Peer assessment and teacher observation Self-assessment Peer assessment
b. Describe synthetic polymers (plastics, thermoplastics, thermosets, fibers, films, elastomers, and adhesives). (DOK 1) [OC3]	b. Introduce vocabulary to include plastics, thermoplastics, thermosets, fibers, films, elastomers, adhesives, coatings, etc.[S1] Review polymer history. Stress that most synthetic polymers are derived from petroleum products, and review the refining process. Discuss that many synthetic polymers are a result of trying to mimic nature (i.e., nylon imitates silk).[R3] Pair the students and have them create a list of the advantages and disadvantages of synthetic polymers and natural polymers, including why it is difficult to completely reproduce natural polymers in a lab. Discuss the answers as a class, and prepare a group list.[CLS3, T2] Have the students revisit which is better, natural or synthetic. Ask the students to reflect on their choices and decide if they have changed their opinions. Have volunteers explain their choices.[CLS1-2]	b. Teacher observation Teacher observation Peer assessment Self-assessment and teacher observation
c. Differentiate between properties of natural and synthetic polymers. (DOK 2) [OC3]	c. Have the students use the Internet, books, or other resources to research the following products or topics and write a brief summary of each one's source and properties. Require them to create three test questions about each topic,	c. Test/quiz from student-created questions Teacher observation

	including the answer. Facilitate a class discussion using the questions and answers as a review. (Cellulose plastics, cellulose nitrate, cellulose acetate, cellophane, natural rubber, vulcanized rubber, carbon black, gutta percha, synthetic rubber, neoprene, ameripol, silly putty, nylon, pvc, Velcro, Kevlar, bakelite, Perspex, Teflon, raincoat, textile, and genetic engineering)[CLS2, E1-E6, R1-R5, W1-W5, T3-T5]	
	Performance Task: You are a sorter at a recycling plant—the first of several groups. You need to sort your latest load: a group of random objects and household/classroom items. You must sort each item into its proper category of thermoplastic, thermoset, elastomer, or natural polymer (only certain ones can be recycled at your plant). Your boss has also asked for a report on the percentages of each group that come into the facility. If you do not report the proper numbers, your job may be at stake. And trust that your boss will be checking your figures.[CLS2, CLS4, M1]	**Performance Task Checklist: Sorting Polymers**
	Review for quiz on natural and synthetic polymers.	Quiz (may be combined with the student-created questions)

Competency 3: Relate rheology and viscosity to polymer properties.[SPI-I, SPI-II, SPI-IV, MPC4, MPC28, MPC30-31, MPC35] (DOK 2)

Suggested Enduring Understandings

1. Rheology describes how a material flows.
2. Rheological properties directly affect how a polymer can be synthesized and processed.

Suggested Essential Questions

1. How is polymer flow related to Isaac Newton?
2. Why should flow properties be considered when pouring Oobleck (a cornstarch and water mixture) down the sink?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Research the history of rheology/viscosity. (DOK 1)[OC3]	a. **Hook:** Pose the question "How is polymer flow related to Isaac Newton?" Have the students use concept mapping software (i.e., Inspiration) to brainstorm.	a. Teacher observation and self-assessment
	Have the students do an Internet search on Newton's laws of motion and create a visual representation of them (posters, booklets, etc.).[CLS2, CLS4, E1-E3, R1-R5, T1-T5]	**Visual Representation Rubric**
	Introduce vocabulary as needed, to include Newtonian, non-Newtonian, viscosity, rheology, melt index, shear thinning, shear thickening, dilatant, and thixotropic.[S1]	Teacher observation
	Lecture on Newtonian and non-Newtonian	

			properties. Demonstrate the flow properties with household items, such as water and ketchup.[T1]		Teacher observation
			Divide the class into two groups. Have one group list examples of materials that exhibit Newtonian properties and the other group list examples that show non-Newtonian properties. Share the results with the class.[T2]		Peer assessment
			Carry out an experiment to create "Oobleck" (cornstarch and water), which is a non-Newtonian fluid. When pressure is applied, the material acts like a solid.[S1-S3, T1]		Teacher observation
			Brainstorm why Oobleck acts the way it does. Have small groups of students research different opinions on the Internet and compare them.[CLS3,R1-R5]		Self-assessment and peer assessment
b.	Explain the importance of rheology/viscosity. (DOK 1) [OC3]	b.	Revisit the concepts of rheology and viscosity.[S1]	b.	Teacher observation
			Describe shear thinning and shear thickening. Ask the students to give examples of materials that exhibit each behavior.[S1]		Teacher observation
			Describe flow through a pipe. Illustrate that material in the center of the pipe flows faster than material on the edges or walls.[T1]		Teacher observation
			Have students carry out an experiment to demonstrate the viscosities of different materials (**Viscosity Lab Activity**) and write a lab report on their findings.[CLS3, E1-E6, M1 ,S1-S3, W1-W5]		**Lab Report Checklist** **Viscosity Lab Activity**
c.	Demonstrate polymer melt rheology. (DOK 2) [OC3]	c.	Describe melt index, and relate it to the viscosity experiment in part B.[S1]	c.	Teacher observation
			Have students research the melt index for various polymers.[T3]		Self-assessment and teacher observation
			Relate melt rheology to the injection molding and extrusion experiments performed with the thermoforming center.[S1]		Teacher observation
			Performance Task: Students should each be assigned a material. As a polymer science student who is curious about the rheology of household fluids, research your assigned material's properties and decide whether it is Newtonian or non-Newtonian. Carry out a simulated melt index experiment, and observe the results. Push the material through a tube at three different temperatures, and record your observations. Make a visual presentation of your choice (PowerPoint, poster, chart, etc.) to illustrate your		**Performance Task Rubric: Newtonian and Non-Newtonian Materials**

findings to the class. You must include a graphical representation of your data. You will be graded on knowledge, research, accuracy, and presentation with a **Performance Task Rubric**.[CLS2, CLS4, M5, R1-R5, S1-S3, W2-W4, T1-T4]

Review for quiz/test.

Quiz/test

Competency 4:	**Explain how additives affect the properties of a polymeric material.**[SPI-I, SPI-II, SPI-IV, MPC4-5, MPC7,MPC14, MPC27-29, MPC34] (DOK 2)

Suggested Enduring Understandings	**Suggested Essential Questions**
1. In most applications, the polymer is only one ingredient in what can be a complex recipe of ingredients, referred to in industry as a formulation. 2. Compounding is the actual mixing of ingredients into one product.	1. How does adding an extra or different ingredient to a cake mixture change the outcome of the dessert? How does this analogy apply to polymeric materials?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Explain how compounding and formulation changes the properties of polymers by using additives or modifiers. (DOK 2)[OC3]	a. **Hook:** Discuss favorite cakes. Ask students to describe the taste and texture of their favorite cake. Then ask them what their cake would be like if they put too much salt in it, added pepper instead of cinnamon, or left out the baking powder/soda to make it rise, and so forth. Bring examples of a good cake and a cake that did not rise to class to show the students.	a. Teacher observation
	Introduce vocabulary, to include compounding, formulation, additive, modifier, stabilizer, colorant, plasticizer, pigment, carbon black, and so forth.[S1]	Teacher observation
	Carry out a dip coating experiment (ECI Polymers manual) with Plastisol, which is plasticized PVC. Compare the properties of the rubbery product with PVC pipe to illustrate how the plasticizer changes the properties. Have the students write a lab report on the experiment.[E1-E6, S1-S3, W1-W5]	**Lab Report Checklist**
	Carry out an experiment to produce a hand lay-up composite of fiberglass (ECI Composites manual). Have the students work in small groups, with each group using a different number of glass fiber mats and amount of resin. Compare the properties of the cured material in regard to appearance and toughness. Discuss the results as a class.[CLS1-3,	Peer assessment

	CLS4, S1-S3, T4	
	Performance task: You are a science teacher trying to promote participation in the school science fair. You want to give a presentation and demonstration to parents to encourage them to participate with their children. Your task is to design a simple experiment that illustrates a change in properties by the addition of an additive. Design the experiment, research the topic, and then present your demonstration to parents and students. Be prepared to answer questions about your topic. You will be judged on how well you present your topic/demo to people who do not understand science, knowledge of the topic, and accuracy. CLS2, CLS4, S1-S3, T2, T4, T5	Self-assessment and **Performance Task Rubric: Science Demonstration**
	Review for unit test.	Test

Standards

Industry Standards: Society of Plastics Industry Standards

I. Essential Knowledge

II. Extrusion Process

IV. Material and Product Handling/Storage

Industry Standards: Polymer Standards for the State of Mississippi

MPC2 Change Management: Helping people adapt to the changes brought on by new technologies and helping them to see the value and benefits of new technologies
MPC3 Coaching: problems, alternatives, and goals
MPC4 Communication: Applying effective verbal, nonverbal, and written communication methods to achieve desired results
MPC5 Compounding: Understanding the process of blending polymers with additives to produce a product for the forming industry
MPC7 Decision-Making Ability: Selecting, in a timely manner, appropriate course(s) of action that is(are) consistent with the organization's mission, vision, and strategies
MPC14 Group Process Understanding: Understanding how groups function; influencing people so that group, work, and individual needs are addressed
MPC18 Leadership: The ability to influence and guide members of the organization to achieve organizational objectives
MPC19 Model Building: The ability to develop frameworks from complex and theoretical ideas
MPC27 Relationship Building Skills: Establishing relationships and networks across a broad range of people and groups
MPC28 Research Skills: Selecting, developing, and using methodologies such as statistical and data collection techniques for formal inquiry
MPC29 Resin and Additive Formulation: Knowledge of polymer materials to achieve appropriate formulation for intended purpose
MPC31 Self-Knowledge/Self-Management: Knowing one's personal values, needs, interests, style, and competencies and being able to manage their effects on others
MPC33 Teamwork: Successfully and efficiently working and communicating with group or project members such that the team's final output meets or exceeds predefined expectations
MPC34 Technical Communications: The ability to translate and communicate required technical information to non-technical operational people

Mississippi Academic Course Competencies and Benchmarks

OC1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
OC2 Demonstrate an understanding of the properties, structure, and function of organic compounds.
OC3 Discuss the versatility of polymers and the diverse application of organic chemicals.

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation

M1	Basic Operations and Applications
M5	Graphical Representations
R1	Main Ideas and Author's Approach
R2	Supporting Details
R3	Sequential, Comparative, and Cause—Effect Relationships
R4	Meaning of Words
R5	Generalizations and Conclusions
S1	Interpretation of Data
S2	Scientific Investigation
S3	Evaluation of Models, Inferences, and Experimental Results
W1	Expressing Judgments
W2	Focusing on the Topic
W3	Developing a Position
W4	Organizing Ideas
W5	Using Language

21st Century Skills Standards

CLS1	Flexibility and Adaptability
CLS2	Initiative and Self-Direction
CLS3	Social and Cross-Cultural Skills
CLS4	Productivity and Accountability
CLS5	Leadership and Responsibility

National Educational Technology Standards for Students

T1	Creativity and Innovation
T2	Communication and Collaboration
T3	Research and Information Fluency
T4	Critical Thinking, Problem Solving, and Decision Making
T5	Digital Citizenship

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Teegarden, D. M. (2004). *Polymer chemistry introduction to an indispensable science.* New York: National Science Teachers Association.

Suggested Rubrics and Checklists

Name: _____

Date: _____

Period: _____

Lab Report Checklist

Did the student include the following information?

_____ Report title

_____ Appropriate section titles (i.e., Abstract, Introduction, Materials, Procedures, Results, and Conclusion)

_____ Use of complete sentences when appropriate

_____ Relevant background information on the experiment in the introduction

_____ A list of all materials used in the experiment

_____ Detailed procedures for the experiment

_____ Any observations and reported results

_____ An explanation as to why the observed results occurred

_____ At least two sources of error

_____ A summary of any knowledge or insight gained from the lab experiment

_____ Correct and quality information throughout the report

_____ Was the report turned in on time?

_____ Did the student use proper grammar?

_____ Was the information organized appropriately?

_____ Was the report legible?

Teacher comments:

Name: _____

Date: _____

Period: _____

Performance Task Checklist: Copolymer Structures

Did the student…

_____ Identify his or her copolymer structure?

_____ Carry out a normal day?

*Was the day simplified to account for the activity?

_____ Adjust to activities appropriately?

_____ Remain attached to her or his group throughout the day?

_____ Act appropriately with other “monomers” in the group?

_____ Come up with any especially creative solutions to the problem?

*Explain.

Name: _____

Date: _____

Period: _____

Performance Task Checklist: Sorting Polymers

NOTE: Teacher should create an appropriate key for the items presented to the students to identify correct and incorrect answers.

Did the student…

_____ Identify each item?

_____ Identify each item CORRECTLY?

*Points may be deducted for missing or incorrect answers.

_____ Calculate the percentages of each group in the factory?

_____ CORRECTLY calculate percentages?

*Points may be deducted for missing or incorrect answers.

Teacher comments:

Name: _____

Date: _____

Period: _____

Visual Representation Rubric

Criteria	1	2	3	4	Score
Organization	A large amount of missing information; no topic	No title, but contains a vague topic; obvious improvement needed; hard to follow; missing parts	Generally follows science rules; some editing or refinement needed	Clear and well organized; easy to understand; flows smoothly	
Creativity	Bland presentation; no color or graphics; obvious lack of interest in presentation	Some use of color; does not hold attention for long periods of time	Good use of graphics and color; interesting, but not stimulating	Very good incorporation of color and images; aesthetically appealing; stimulating to the viewer	
Content	No analysis of the topic; no resources; no or poor explanation	Poor explanation; inaccurate connection of science	Adequate analysis of the topic; explanation of the science could be further developed.	Good analysis of the topic; well-understood science that is explained properly	
Level of Difficulty	Irrelevant; not suitable for grade level (too easy)	Minimal level of difficulty; needs major revisions	Adequate level of difficulty; some slight revisions may be necessary	Appropriate for grade level; good understanding of the topic	
Total					

Teacher comments:

Name: _____

Date: _____

Period: _____

Viscosity Lab Activity

Have the students test the flow rates of different materials.

- Ask them to first hypothesize the order of the materials in regard to how fast they flow.
- Pour the same amount of various chemicals and household fluids through a funnel (water, ethanol, acetone, mayonnaise, honey, oil, etc).
- Time how long it takes each fluid to empty the funnel. This will help demonstrate the viscosities of the materials.

Convert the data to flow rates (g/s or mL/s).

- Materials that have a faster flow time have a lower viscosity, and vice versa.
- Rank the products according to how fast they flow, and compare them to the hypothesized results.
- Have the students create a chart or graph of the data for a class discussion and for their lab reports.

Name: _____

Date: _____

Period: _____

Performance Task Rubric: Newtonian and Non-Newtonian Materials

Criteria	1	2	3	4	Score
Presentation	Unorganized; does not flow; hard to follow; does not account for the knowledge of the audience; bland; no use of color or graphics	Ideas are organized, but presentation requires further explanation to follow; some use of color and graphics; obvious improvement needed.	Appropriately organized; some improvement needed to clearly understand the topic; appropriate use of graphics	Presentation flows easily and can be understood easily by the audience; good use of color and graphics; all required information is present.	
Knowledge of the Topic	Little to no understanding of the project; shows lack of interest and research; unable to answer questions on the topic	Basic understanding of the task; very little interest (too easy); unable to sufficiently answer questions	Adequate understanding of the task; appropriate information for the audience; could be further studied	Questions answered easily; information appropriate for the audience; shows interest and good investment of time	
Research	No understanding of the science involved; no references; uses “guess work”; no data	Poor understanding of the science; 1 reference; needs more information to be understood; poor data	Decent explanation of the science; 2 references; further research could provide more in-depth answers; decent data but should be explained further.	Effective explanation of science; 3 or more references; adequate answers to further inquiries; good data representation	
Accuracy	Incorrect facts throughout the presentation; no data inclusion	One or two correct facts, but primarily poor information; poor representation of data	A few incorrect facts, but effective overall presentation; should improve representation of data	Complete factual information; good overall presentation and representation of data	
Total					

Teacher comments:

Name: _____

Date: _____

Period: _____

Performance Task Rubric: Science Demonstration

Criteria	1	2	3	4	Score
Presentation	Unorganized; does not flow; hard to follow; does not account for the knowledge of the audience; bland; no use of color or graphics	Ideas are organized, but presentation requires further explanation to follow; some use of color and graphics; obvious improvement needed.	Appropriately organized; some improvement needed to clearly understand the topic; appropriate use of graphics	Presentation flows easily and can be understood easily by the audience; good use of color and graphics; all required information is present.	
Knowledge of the Topic	Little to no understanding of the project; shows lack of interest and research; unable to answer questions on the topic	Basic understanding of the task; very little interest (too easy); unable to sufficiently answer questions	Adequate understanding of the task; appropriate information for the audience; could be further studied	Questions answered easily; information appropriate for the audience; shows interest and good investment of time	
Accuracy	Incorrect facts throughout the presentation	One or two correct facts, but primarily poor information	A few incorrect facts, but effective overall presentation	Complete factual information; good overall presentation	
Total					

Teacher comments:

Introduction to Polymer Science II

Unit 5: Polymer Processing and Applications

Competency 1: Explain how each manufacturing processing technique is used to convert polymer feedstock into plastic end products, participate in manufacturing plastic parts using each processing technique, and identify parts made from each thermoplastic and thermoset processes. SPI-I, SPI-II, MPC5, MPC11, MPC25 (DOK 4)

Suggested Enduring Understandings

1. Students will understand the relationship between the end product and the choice of polymer processing technique used to create that product.

Suggested Essential Questions

1. What is polymer processing?
2. Is one processing technique better than another in producing plastic parts?
3. What factors drive the choice to use a particular processing technique to produce a product?
4. How can we determine which processing technique was used to create a particular plastic part?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe and demonstrate extrusion processes. (DOK 2) OC2	a. **Hook**: "Piece of cake." Discuss with students how making PVC pipe is like decorating a cake. Both PVC pipe production and cake decorating make use of extrusion devices. Discuss with students similarities and differences for the processes. **<u>or</u>** **Hook**: "How is a PVC pipe like toothpaste?" Ask students to consider the hook question. Discuss with students that both PVC pipes and toothpaste are extruded materials, and highlight for them that extrusion is one of several important processing techniques used to create plastic parts in industry. Introduce the enduring understanding and essential questions. Discuss important vocabulary to include extrusion, plastic extrusion, metal extrusion, pipe, and so forth. Introduce the performance task. Have students complete a K-W-L chart for the extrusion process. Give students a diagram of the polymer extrusion machine. Have students know the parts of the extrusion machine. Use classroom resources such as a multimedia presentation to preview information on the extrusion processing technique. Have students watch and summarize a video about the process. Videos have been found at http://www.unitedstreaming.com, http://www.me.gatech.edu/jonathan.colton/me4210/polymer.html, and http://www.traininteractive.com/free/. Have students identify and explain the purpose for each of the major parts and steps of the plastic extrusion machine on a diagram. The use of this device in other processing	a. **K-W-L Chart**

			techniques can be foreshadowed at this time. [T1, T3, T6] Gather materials made from the extrusion processing technique, and challenge students to bring examples from home as well. Have students discuss the similarities and differences for plastic and metal extrusion processing and end products in their notebooks. [W1, W5] Have students develop a multimedia presentation (who, what, when, where, why, and how) on extrusion molding. Have students discuss when this process should be used and for which types of plastic it is most appropriate. Note: In the interest of time, it is probably a good idea to assign a group of students within the class this processing technique to share with their classmates. Other groups would develop similar multimedia presentations on one of the other processing techniques. Have students develop handouts to share with classmates for their notebooks. [T1, T3, T6, CLS2, CLS4] Guide students through lab activities that demonstrate extrusion molding. Hot glue guns and cake decorating sets are both simple examples of this. So is the Play-Doh Fun Factory. There are dies sold that can be used with the hot glue guns to demonstrate extrusion and injection molding. The hand-operated injection molding machines might be used to demonstrate this process as well. If you use these simplified machines, have students compare and contrast the parts of the simplified machine to those found on the diagram of the machine used in industry in their notebooks. Have students discuss specific safety concerns and quality control issues for the polymer extrusion process in their notes. [S3, T1, T3, T6, W1, W5] If you are near a plastic pipe manufacturing business, you could have students see the process being applied as a field trip experience. Quality control issues could be examined in detail during the visit.	**Multimedia Presentation Rubric** Lab or Performance skill/safety rubric Lab or performance skill/safety rubric
b.	Describe and demonstrate injection molding. (DOK 2) [OC2]	b.	**Hook:** "Give it a shot." Discuss with students the similarities and differences of the injection molding process to getting a shot at the doctor's office. The differences will foreshadow mold design considerations. Have students complete a K-W-L chart for the injection molding process. Discuss important vocabulary with students to include model, mold, injection molding, extruder, blow molding, pipe, and so forth. Show students a piece from a plastic model that has been injection molded so many parts are attached by runners. Have students discuss the considerations a mold designer would have to take into account in using the injection molding process to make such parts. Use classroom resources such as a multimedia presentation to preview information on the injection molding processing	b. **K-W-L Chart**

		technique. Have students watch and summarize a video about the process. Videos have been found at http://www.unitedstreaming.com, http://www.me.gatech.edu/jonathan.colton/me4210/polymer.html, and http://www.traininteractive.com/free/. Have students identify and explain the purpose for each of the major parts and steps of the plastic injection molding machine on a diagram. The use of the extruder in this process can be reviewed at this time. Have students know the parts of the injection molding machine. Gather materials made from the injection molding processing technique, and challenge students to bring examples from home as well. Have students discuss the similarities and differences for extruding plastic through dies or into molds. Have students record information on the process in their notebooks. W1, W5	
		Have students develop a multimedia presentation (who, what, when, where, why, and how) on injection molding. Have students discuss when this process should be used and for which types of plastic it is most appropriate. Note: In the interest of time, it is probably a good idea to assign a group of students within the class this processing technique to share with their classmates. Other groups would develop similar multimedia presentations on one of the other processing techniques. Have students develop handouts to share with classmates for their notebooks. T1, T3, T6, CLS2, CLS4	**Multimedia Presentation Rubric**
		Guide students through lab activities that demonstrate injection molding. Hot glue guns with appropriate dies can be used for this purpose. The hand-operated injection molding machines might be used to demonstrate this process as well. A bottle and cap die mold set is available to demonstrate this process and the blow molding process. You might have students make the bottle cap to practice this processing technique. If you use these simplified machines, have students compare and contrast the parts of the simplified machine to those found on the diagram of the machine used in industry in their notebooks. Have students discuss specific safety concerns and quality control issues for the injection molding process in their notes. S3, W1, W5	Lab or Performance skill/safety rubric
		If you are near a university that has an injection-molding machine or have an industrial-sized machine for your program, you can have students see injection molding at true scale. Have students view the process of making a part, and have them discuss safety concerns and quality control issues for the process. Have them record their understandings of the process in their notebooks.	Lab or performance skill/safety rubric
c.	Describe and demonstrate blow molding. (DOK 2) OC2	c. **Hook**: "Thar' she blows." Discuss with students the need for a whale to "blow" as it surfaces (before intaking air). Discuss with students the ways that humans have used blasts of air in applications that include forging (blacksmiths), producing glass vessels (blown glass), music (wind instruments, brass	c. **K-W-L Chart**

	instruments, pipe organs, pan pipes, bagpipes, accordion), and preparing surfaces for surface coatings (sand blasting). Have students complete a K-W-L chart for the blow molding process. Introduce necessary vocabulary to include model, mold, injection molding, extruder, blow molding, pipe, and so forth. Give the students some SuperBubble bubblegum, and have them watch a video of the glass blowing process. After the video, ask students to try blowing the biggest sustained bubble. Have them consider the changes taking place in the gum as the bubble is formed. Have them consider similarities and differences between the glass or bubble blowing process and the blow molding technique used with plastics. What difference does the term *molding* imply? [S3] Use classroom resources such as a multimedia presentation to preview information on the blow molding processing technique. Have students watch and summarize a video about the process. Videos have been found at http://www.unitedstreaming.com, http://www.me.gatech.edu/jonathan.colton/me4210/polymer.html, and http://www.traininteractive.com/free/. Have students identify and explain the purpose for each of the major parts and steps of the plastic blow molding machine on a diagram. The use of the extruder in this process can be reviewed at this time. Gather materials made from the blow molding processing technique, and challenge students to bring examples from home as well. You might show students the dies for the bottle and top project. Have students discuss why the top of the bottle is injection molded and the bottom of the bottle is blow molded. Have students know the parts of a blow molding machine. Have students record information on the blow molding process in their notebooks. [W1, W5, CLS2]	
	Have students develop a multimedia presentation (who, what, when, where, why, and how) on blow molding. Have students discuss when this process should be used and for which types of plastic it is most appropriate. Note: In the interest of time, it is probably a good idea to assign a group of students within the class this processing technique to share with their classmates. Other groups would develop similar multimedia presentations on one of the other processing techniques. Have students develop handouts to share with classmates for their notebooks. [T1, T3, T6, CLS2, CLS4]	**Multimedia Presentation Rubric**
	Guide students through lab activities that demonstrate blow molding. The hand-operated blow molding machine might be used to demonstrate this process. If you use this simplified machine to make the bottle, have students compare and	Lab or Performance skill/safety rubric

		contrast the parts of the simplified machine to those found on the diagram of the machine used in industry in their notebooks. Have students discuss specific safety concerns and quality control issues for the blow molding process in their notes. If the lab for making the bottle and cap is being used to demonstrate this process and the injection molding process, have students analyze how well the two parts they have made fit together, and have them discuss quality control issues for multi-part assemblies. [S3, T1, T3, T6] If you are near an industry source that uses blow molding, you can have students see the process at true scale. Have students view the process of making a part, and have them discuss safety concerns and quality control issues for the process. Have them record their understandings of the process in their notebooks.	Lab or performance skill/safety rubric
d.	Describe and demonstrate thermoforming/ vacuum forming. (DOK 2) [OC2]	d. **Hook**: "I can't take the pressure!" Discuss with students the use of negative air pressure to accomplish tasks. Show the glass of water and card trick to illustrate the importance of air pressure. Several pressure demonstrations are available to further illustrate this concept including egg in a bottle, balloon in a flask, the stubborn trash bag, Magdeburg hemispheres, pressure mats, and so forth. Use some of these demonstrations and activities to make sure students understand the concept of air pressure thoroughly. Have students complete a K-W-L chart for the vacuum forming process. Introduce vocabulary terms to include thermoforming, vacuum forming, pressure, plaster, opaque, and so forth. Use classroom resources such as a multimedia presentation to preview information on the vacuum forming processing technique. Have students watch and summarize a video about the process. Videos have been found at http://www.unitedstreaming.com, http://www.me.gatech.edu/jonathan.colton/me4210/polymer.html, and http://www.traininteractive.com/free/. Have students identify and explain the purpose for each of the major parts and steps of the vacuum forming machine on a diagram. Gather materials made from the vacuum forming processing technique, and challenge students to bring examples from home as well. There are several suppliers of vacuum-formed molds for use in candy making and for plaster projects. Have students discuss reasons that most candy molds are clear when most plaster molds are opaque. [S3] Have students develop a multimedia presentation (who, what, when, where, why, and how) on vacuum forming. Have students discuss when this process should be used and for which types of plastic it is most appropriate. Note: In the interest of time, it is probably a good idea to assign a group of students within the class this processing technique to share with their classmates. Other groups	d. **K-W-L Chart** **Multimedia Presentation Rubric**

		would develop similar multimedia presentations on one of the other processing techniques. Have students develop handouts to share with classmates for their notebooks. [T1, T3, T6, CLS2, CLS4]	
		Guide students through lab activities that demonstrate the vacuum forming process. The Clarke machine has a vacuum forming capacity that can be used for this purpose. Small vacuum forming devices are also available to make small 8-in. by 10-in. and 9-in. by 14-in. projects. There is an Einstein vacuum-formed shadow mask available that could be used with these machines. The students can use plaster to create an Einstein face from the vacuum-formed mold and then use the plaster cast to recreate the vacuum-formed original. If you use these simplified machines, have students compare and contrast the parts of the simplified machine to those found on the diagram of the machine used in industry in their notebooks. Have students discuss specific safety concerns and quality control issues for the vacuum forming process in their notes. [S3, T1, T3, T6]	Lab or performance skill/safety rubric – self-assessment
		If you are near an industry source that uses vacuum forming techniques, you can have students see the process at true scale. Have students view the process of making a part, and have them discuss safety concerns and quality control issues for the process. Have them record their understandings of the process in their notebooks.	**Journal Rubric**
e.	Describe and demonstrate rotational molding. (DOK 2) [OC2]	e. **Hook**: "Round and round it goes." Discuss with students the use of centrifuges in various applications by NASA (space training), the Red Cross (blood centrifuge), and chemists (separation of solids), and have students consider the purpose rotational molding might serve in polymer processing. How might it work? Have students complete a K-W-L chart for the rotational molding process. Discuss important vocabulary with students to include rotational molding, mold, blow molding, injection molding, and so forth. Use classroom resources such as a multimedia presentation to preview information on the rotational molding processing technique. Have students watch and summarize a video about the process. Videos have been found at http://www.unitedstreaming.com, http://www.me.gatech.edu/jonathan.colton/me4210/polymer.html, and http://www.traininteractive.com/free/. Have students identify and explain the purpose for each of the major parts and steps of the rotational molding machine on a diagram. Gather materials made from the rotational molding processing technique, and challenge students to bring examples from home as well. Have students discuss why large objects are more likely to be created through the rotational molding or vacuum forming processes rather	e. **K-W-L Chart**

than injection molding or blow molding techniques. [S3]	
Have students develop a multimedia presentation (who, what, when, where, why, and how) on rotational molding. Have students discuss when this process should be used and for which types of plastic it is most appropriate. Note: In the interest of time, it is probably a good idea to assign a group of students within the class this processing technique to share with their classmates. Other groups would develop similar multimedia presentations on one of the other processing techniques. Have students develop handouts to share with classmates for their notebooks. [T1, T3, T6, CLS2, CLS4]	**Multimedia Presentation Rubric**
Guide students through lab activities that demonstrate the rotational molding process. There is an oven and rotational molding attachment available to illustrate this processing technique. There are also several dies to create rotational molded objects (hollow ball, etc.) with the oven and attachment. If you use this simplified machine, have students compare and contrast the parts of the simplified machine to those found on the diagram of the machine used in industry in their notebooks. Have students discuss specific safety concerns and quality control issues for the rotational molding process in their notes. [S3, T1, T3, T6]	Lab or Performance skill/safety rubric
Have students compare the casting process to rotational molding by making chocolate Easter eggs. Discuss with students the two common ways to make hollow eggs or rabbits. Then have students complete each method to create chocolate items. First, if you are using a mold that is open at one end, fill a mold full of melted chocolate, let it sit for a moment, and then pour the liquid chocolate out. Some of the chocolate will have solidified on the inside of the mold. It works well if there can be a hole in the figure (usually on the bottom). If you are using a complete mold, open the mold, fill it with melted chocolate, close the mold, and turn it so that the liquid chocolate coats the entire inside of the mold. After a few moments, open the mold and pour out the excess liquid chocolate and reseal the mold to completely cool. Next have students try the second approach. Have some chocolate and a plastic Easter egg that opens at the middle. Melt the chocolate and pour some into the plastic egg. Close the egg and rotate it in all directions to coat the interior evenly. Open the plastic egg and remove the chocolate. Cooling in the refrigerator may make things easier. If you find it sticks, coat the inside of the plastic eggs with a bit of oil or butter first. If you use this activity, remember to have students compare similarities and differences between the processes used in class and in industry to minimize the possibility of student misconception. For example, ask students to explain why an oven is often used for the industrial rotational molding process, and ask how the use of an oven would affect the chocolate Easter egg or bunny project. [S3]	Lab or performance skill/safety rubric
	Lab or

			If you are near an industry source that uses rotational molding techniques, you can have students see the process at true scale. Have students view the process of making a part, and have them discuss safety concerns and quality control issues for the process. Have them record their understandings of the process in their notebooks. W1, W5		performance skill/safety rubric
f.	Describe and demonstrate casting. (DOK 2) OC2	f.	**Hook:** "*Cast Away*." Discuss with students this play on words and the movie with Tom Hanks and his trusty volleyball, Wilson. Give students one of the quotes from this movie like "First thing it's two minutes, then four, then six, then the next thing you know, we're the U.S. mail" or "We live and we die by time. And we must not commit the sin of losing our track on time." Discuss with students the importance of time to most casting techniques. Have students complete a K-W-L chart for the casting process. Remind students of important vocabulary terms to include casting, molding, plastic, rotational molding, and so forth. Use classroom resources such as a multimedia presentation to preview information on the casting processing technique. Have students watch and summarize a video about the process. Videos have been found at http://www.unitedstreaming.com, http://www.me.gatech.edu/jonathan.colton/me4210/polymer.html, and http://www.traininteractive.com/free/. Have students identify and explain the purpose for each of the major parts and steps of the casting process on a diagram. Gather materials made from the casting processing technique, and challenge students to bring examples from home as well. Have students discuss the casting processes used in the metal and ceramics industries. You might remind students of the casting methods used for comparison to rotational molding techniques in the Easter egg lab at this time. Have students record information of plastic casting in their notebooks. S3	f.	**K-W-L Chart**
			Have students develop a multimedia presentation (who, what, when, where, why, and how) on plastics casting. Have students discuss when this process should be used and for which types of plastic it is most appropriate. Note: In the interest of time, it is probably a good idea to assign a group of students within the class this processing technique to share with their classmates. Other groups would develop similar multimedia presentations on one of the other processing techniques. Have students develop handouts to share with classmates for their notebooks. T1, T3, T6, CLS2, CLS4		**Multimedia Presentation Rubric**
			Guide students through lab activities that demonstrate the casting process. If time allows, have students make pewter or ceramic slip castings in order for them to adequately compare and contrast the use of casting procedures for these materials to those made with plastics. Then have		Lab or Performance skill/safety

		students make plastic castings to practice the process. The ECI manuals have lab activities for this process. Have students make the silicone mold and cast plaster parts from it. Next, have students make the large clothes pin using the casting process. If time allows, have students complete a life cast of their hands (or, if you are very careful, a life mask of their face) using alginate or similar product. This may be a good time to make use of vacuum-formed parts students may have made earlier in this unit of study. Students can use vacuum-formed molds created earlier to now make cast parts from. Have students compare and contrast the parts of the simplified molds used in class activities to those found on the diagram of the molds used in industry in their notebooks. Have students discuss specific safety concerns and quality control issues for the plastics casting process in their notes. S3, T1, T3, T6 If you are near an industry source that uses plastics casting techniques, you can have students see the process at true scale. Have students view the process of making a part, and have them discuss safety concerns and quality control issues for the process. Have them record their understandings of the process in their notebooks.	Lab or performance skill/safety rubric
g. Describe and demonstrate expanded bead molding. (DOK 2) OC2	g.	**Hook**: "Honey, I blew up the beads." Have students compare and contrast the expansion of the baby in the Disney movie implied in this hook with the expansion of styrene beads using heat. Describe the purpose of the blowing agent, and have students discuss the need to use "fresh" beads. Have students complete a K-W-L chart for the expanded bead molding process. Discuss important vocabulary terms with students to include bead molding, casting, molding, plastic, rotational molding, and so forth. Use classroom resources such as a multimedia presentation to preview information on the expanded bead molding technique. Have students watch and summarize a video about the process. Videos have been found at http://www.unitedstreaming.com, http://www.me.gatech.edu/jonathan.colton/me4210/polymer.html, and http://www.traininteractive.com/free/. Have students identify and explain the purpose for each of the major parts and steps of the expanded bead molding process on a diagram. Gather materials made from the expanded bead molding technique, and challenge students to bring examples from home as well. Have students discuss the casting processes used thus far to this new technique. Ask students to explain the special steps added to the casting process to facilitate the expanding of the styrene beads. Ask students how this affects the type of mold material used. Have students record information on expanded bead molding in their notes. S3 Have students develop a multimedia presentation (who, what, when, where, why, and how) on expanded bead	g. **K-W-L Chart**

		molding. Have students discuss when this process should be used and for which types of plastic it is most appropriate. Note: In the interest of time, it is probably a good idea to assign a group of students within the class this processing technique to share with their classmates. Other groups would develop similar multimedia presentations on one of the other processing techniques. Have students develop handouts to share with classmates for their notebooks. T1, T3, T6, CLS2, CLS4	**Multimedia Presentation Rubric**
		Guide students through lab activities that demonstrate the expanded bead molding process. There are several molds available for this set of activities. The ECI manual uses a football mold for this process. Have students make expanded foam footballs using the ECI materials and football molds (or substitute other molds for this purpose). If time allows, have students make several different objects of the expanded styrene beads in order to complete quality control observations and analysis. Have students compare and contrast the parts of the simplified molds used in class activities to those found on the diagram of the molds used in industry in their notebooks. Have students discuss specific safety concerns and quality control issues for the expanded bead molding process in their notes. S3, T1, T3, T6	Lab or Performance skill/safety
		If you are near an industry source that uses expanded bead molding techniques, you can have students see the process at true scale. Have students view the process of making a part, and have them discuss safety concerns and quality control issues for the process. Have them record their understandings of the process in their notebooks.	Lab or performance skill/safety
h.	Describe and demonstrate foam processing. (DOK 2) OC2	h. **Hook:** "Jumpin' Jack Flash, it's a gas, gas, gas." Discuss the title of this Rolling Stones song with students. Have them discuss the lyrics and how they might apply to the foaming process. Have students complete a K-W-L chart for the foam molding process. Discuss important vocabulary terms with students to include foam processing, casting, molding, plastic, rotational molding, and so forth. Use classroom resources such as a multimedia presentation to preview information on the foam molding technique. Have students watch and summarize a video about the process. Videos have been found at http://www.unitedstreaming.com, http://www.me.gatech.edu/jonathan.colton/me4210/polymer.html, and http://www.traininteractive.com/free/. Have students identify and explain the purpose for each of the major parts and steps of the foam molding process on a diagram. Gather materials made from rigid and flexible foam molding techniques, and challenge students to bring examples from	h. **K-W-L Chart**

			home as well. Have students discuss the casting processes used thus far to this new technique. Ask students to explain the special steps added to the casting process to facilitate the expanding of the two-part rigid or flexible foam in the mold cavity. Ask students how this affects the type of mold material used. Have students record information on foam processing in their notebooks. [S3]		
			Have students develop a multimedia presentation (who, what, when, where, why, and how) on rigid and flexible foam molding. Have students discuss when this process should be used and for which types of plastic it is most appropriate. Note: In the interest of time, it is probably a good idea to assign a group of students within the class this processing technique to share with their classmates. Other groups would develop similar multimedia presentations on one of the other processing techniques. Have students develop handouts to share with classmates for their notebooks. [T1, T3, T6, CLS2, CLS4]		**Multimedia Presentation Rubric**
			Guide students through lab activities that demonstrate the foam molding process. There are several molds available for this set of activities. The ECI manual has students mix two-part rigid foams but does not have students cast parts using the system. Have students make foam items using the ECI materials and available molds. If time allows, have students make several different objects of the rigid and flexible systems in order to complete quality control observations and analysis. Have students compare and contrast the parts of the simplified molds used in class activities to those found on the diagram of the molds used in industry in their notebooks. Have students discuss specific safety concerns and quality control issues for the foam molding process in their notes. [S3, T1, T3, T6]		Lab or Performance skill/safety
			If you are near an industry source that uses foam-molding techniques, you can have students see the process at true scale. Have students view the process of making a part, and have them discuss safety concerns and quality control issues for the process. Have them record their understandings of the process in their notebooks. The Ford company advertises the use of soy-based foams in their seating applications. You might contact Ford to see if videos of the process or examples of the material are available to teachers for educational purposes.		Lab or performance skill/safety rubric
i.	Describe and demonstrate coatings and adhesives principles. (DOK 2) [OC2]	i.	**Hook:** "I got it covered." Discuss with students this common term and how it applies to the dip molding process. Have students examine PVC dip coated objects, and discuss how the material on these objects is similar and different from other items made from PVC. Have students complete a K-W-L chart for using coatings and adhesives in the manufacturing of plastics. Discuss important vocabulary terms with students to include coatings, adhesives, casting, molding, plastic, rotational	i.	**K-W-L Chart**

			molding, and so forth. Use classroom resources such as a multimedia presentation to preview information on using surface coatings and adhesives. Have students watch and summarize a video about the use of these materials. Videos have been found at http://www.unitedstreaming.com, http://www.me.gatech.edu/jonathan.colton/me4210/polymer.html, and http://www.traininteractive.com/free/. Have students discuss the dip molding and powder coating processes as examples of surface coating treatments. Have students compare and contrast the dip coating and powder coating processes, and have students produce a word processing document outlining the steps involved in producing coated articles using each process, complete with visuals to highlight each step. Have students record information on dip molding in their notebooks. S3		
			Have students develop a multimedia presentation (who, what, when, where, why, and how) on dip molding and/or powder coating. Have students discuss when this process should be used and for which types of plastic it is most appropriate. Note: In the interest of time, it is probably a good idea to assign a group of students within the class this processing technique to share with their classmates. Other groups would develop similar multimedia presentations on one of the other processing techniques. Have students develop handouts to share with classmates for their notebooks. T1, T3, T6, CLS2, CLS4		**Multimedia Presentation Rubric**
			Guide students through lab activities that demonstrate the dip coating process. There are several molds available for this set of activities. The ECI manual has students make a dip molded coin purse using plastisol, but there are several optional molds available. If time allows, have students make several different objects of the dip molding process in order to complete quality control observations and analysis. Have students compare and contrast the simplified molds used in class activities to those molds used in industry in their notebooks. Have students discuss specific safety concerns and quality control issues for the dip molding process in their notes. S3, T1, T3, T6		Lab or Performance skill/safety
			If you are near an industry source that uses dip molding or powder coating techniques, you can have students see the process at true scale. Have students view the process of making a part or coating a part, and have them discuss safety concerns and quality control issues for the process. Have them record their understandings of the process in their notebooks.		Lab or performance skill/safety rubric
j.	Describe and demonstrate fiber formation. OC2	j.	**Hook:** "Hangin' by a thread." Introduce for students this common saying, and have them discuss how it might be applied to the production processes used to make fibers and fabrics.	j.	**K-W-L Chart**

	Have students complete a K-W-L chart for the production of polymer fibers. Discuss important vocabulary with students to include fiber formation, coatings, casting, molding, plastic, rotational molding, and so forth. Use classroom resources such as a multimedia presentation to preview information on the production of polymer fibers and fabrics. Have students watch and summarize a video about the process. Videos have been found at http://www.unitedstreaming.com, http://www.me.gatech.edu/jonathan.colton/me4210/polymer.html, and http://www.traininteractive.com/free/. Have students identify and explain the purpose for each of the major parts and steps of the fiber production and/or fabric production process on a diagram. Gather materials made from polymer fibers and/or fabrics, and challenge students to bring examples from home as well. Ask students to explain the steps involved in the production of polymer fibers and/or fabrics. Have them record their observations about the products observed in their notebooks.	
	Have students develop a multimedia presentation (who, what, when, where, why, and how) on polymer fiber and/or fabric production methods. Have students discuss when this process should be used and for which types of plastic it is most appropriate. Note: In the interest of time, it is probably a good idea to assign a group of students within the class this processing technique to share with their classmates. Other groups would develop similar multimedia presentations on one of the other processing techniques. Have students develop handouts to share with classmates for their notebooks. T1, T3, T6, CLS2, CLS4	**Multimedia Presentation Rubric**
	Guide students through lab activities that demonstrate the production of polymer fibers and/or fabrics. The ECI modules do not offer labs for this performance indicator, but there are sources that describe the production of strands of viscose rayon fibers. Using a syringe and a description of the procedure for making regenerated cellulose, have students create rayon fibers for observation. If time allows, have students make several different samples of these fibers in order to complete quality control observations and analysis. Have students compare and contrast the steps of the simplified process used in class activities to those used in industry in their notebooks. Have students discuss specific safety concerns and quality control issues for the fiber creation procedure in their notes. S3, T1, T3, T6	Lab or Performance skill/safety rubric
	If you are near an industry source that creates polymer fibers and/or fabric, you can have students see the process at true scale. Have students view the process of making a	Lab or performance skill/safety rubric

			fiber and/or fabric, and have them discuss safety concerns and quality control issues for the process. Have students record their understandings of the process in their notebooks. Have students discuss the special properties of Gore-Tex, Kevlar, carbon fiber, and other fabrics that make them suitable for given applications. Students might also discuss the special fabric used in air bags at this time.		
k.	Describe and demonstrate compression molding. OC2	k.	**Hook:** "If you can't stand the heat, get out of the kitchen." Discuss this statement with students, and have them discuss how this is usually used to talk about pressure in the workplace. Have students think about how heat and pressure are used in the compression molding process. What role does heat play in the production of a product? Have students complete a K-W-L chart for the compression molding process. Discuss important vocabulary with students to include compression molding, coatings, casting, molding, plastic, rotational molding, and so forth. Use classroom resources such as a multimedia presentation to preview information on the compression molding technique. Have students watch and summarize a video about the process. Videos have been found at http://www.unitedstreaming.com, http://www.me.gatech.edu/jonathan.colton/me4210/polymer.html, and http://www.traininteractive.com/free/. There is a particularly good video using this process to produce hockey pucks. Have students identify and explain the purpose for each of the major parts and steps of the compression molding process on a diagram. Gather materials made from compression molding techniques, and challenge students to bring examples from home as well. Have students discuss the molding processes used thus far to this new technique. Ask students to explain the special steps added to the molding process to facilitate the application of heat and pressure in the mold cavity. Ask students how this affects the type of mold material used. Have students record information on compression molding in their notebooks. S3 Have students develop a multimedia presentation (who, what, when, where, why, and how) on compression molding. Have students discuss when this process should be used and for which types of plastic it is most appropriate. Note: In the interest of time, it is probably a good idea to assign a group of students within the class this processing technique to share with their classmates. Other groups would develop similar multimedia presentations on one of the other processing techniques. Have students develop handouts to share with classmates for their notebooks. T1, T3, T6, CLS2, CLS4 Guide students through lab activities that demonstrate the production of a compression molded product. The ECI	k.	**K-W-L Chart** **Multimedia Presentation Rubric**

	modules do not offer labs for this performance indicator, but there are sources that provide machines to teach compression molding. The *How Its Made* video series shows compression molding being used to create hockey pucks, and there is a company that has a compression molding machine capable of making this type of object. Compression molding can be simulated with embossing of metals, so making copper ceiling tile patterns could be a workable solution to a compression molding lab here. S3, T1, T3, T6 If you are near an industry source that uses compression molding techniques, you can have students see the process at true scale. Have students view the process of making a part, and have them discuss safety concerns and quality control issues for the process. Have them record their understandings of the process in their notebooks.	Lab or Performance skill/safety rubric
	Note: The following performance task could be used as, or in lieu of, the multimedia presentations listed for each of the performance indicators given for this unit. Groups of students in the class would choose a particular processing technique to handle. Once the choice was made, each group would complete the assigned performance task, which is detailed below.	
	Performance Task: You are a (your choice) process engineer for Polymers, Inc. Your role at the plant is to instruct and oversee technicians at the plant as they safely operate machinery in completing the (your choice) process. You need to train a new team of technicians on each step of the (your choice) process used in the plant. You need to construct an animation or several animations of the (your choice) process to share with your new team. You also need to create a PowerPoint (Keynote) presentation to be used with the animation(s) to train your team on safely completing the process with plant machinery. The animation(s) should include each step of the process and should emphasize safety concerns and quality control issues that should be at the forefront of each technician's mind as the process is completed. The animation(s) and PowerPoint (Keynote) presentation along with any needed handouts and so forth need to be ready for immediate delivery to your supervisor (teacher) and for later delivery to your team (classmates). The animation(s) and PowerPoint (Keynote) presentations will be graded using the multimedia presentation rubric. T1, T3, T6, CLS2, CLS4	**Multimedia Presentation Rubric**

Competency 2: Explain the major types of resins or materials. SPI-I, SPI-II, MPC29 (DOK 1)

Suggested Enduring Understandings	Suggested Essential Questions
1. The type of resin used for a part often determines the production process that can be used to create that part. 2. The use of recycled plastics (regrind) affects the properties of plastic parts created in a process.	1. What is a polymer resin? 2. How does the inclusion of recycled thermoplastic affect the properties of plastic parts? 3. Why are thermoplastic resins and

thermoset resins processed differently?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Identify the major types of resins: thermoplastics, thermosets, and recycled plastics. (DOK 1) [OC3]	a. **Hook:** "It's not such a sticky situation after all." Have students look at the resin entry in Wikipedia at http://en.wikipedia.org/wiki/Resin. Have students compare the meaning of the word *resin* used in this article to the use of the word in the field of polymers. Have students complete a K-W-L chart for the types of polymer resins. Introduce enduring understandings and essential questions. Discuss important vocabulary with students to include thermoplastics, thermosets, resin, recycle, and so forth. Using classroom resources and a multimedia presentation, introduce students to thermoplastic, thermoset, and recycled resins. Discuss with the students when each resin type is used. Help students to compare the strengths and limitations of each resin type. Have students record important information in their notebooks. [W1, W5] **Performance task:** You are a student council member for the class of 20_ _. You have been assigned to a team charged to design a class key chain to be prototyped out of plastic resin. Some of the design concerns you and your team will have to worry about include the following: What processing techniques should be used and why? What type of mold would you use and why? What kind of resin would you use and why? What is an estimate of the cost of each key chain using this method, and is this cost reasonable? What safety concerns should the student council members charged with mass producing the actual key chains be aware of? When you have finished the key chain design (and have answered the design questions adequately), you will present your design to a panel of council members for their consideration. The members will decide whether your efforts merit continuing through the prototyping stage of production. The council will be using a rubric to evaluate each design team's efforts. You and your team will peer- and self-assess your design before presenting the final proposal before the council panel. [T1, T3, T6, S3, W1, W5]	a. **K-W-L Chart** **Multimedia Presentation Rubric**

	After all groups have presented their multimedia presentations, review with students the important points of each production process in preparation for their test. As a review activity, a game such as "Processing Jeopardy" might be used with the classroom response pads and test bank questions to prepare students for their summative exam.	Jeopardy game (immediate feedback to teacher and students during this process)
	Have students take a unit exam to illustrate mastery of unit objectives and competencies. This can be done using ExamView and Blackboard resources.	Unit exam instrument on Blackboard (ExamView)

Standards

Industry Standards: Society of Plastics Industry Standards

I. Essential Knowledge
II. Extrusion Process

Industry Standards: Polymer Standards for the State of Mississippi

MPC5 Compounding: Understanding the process of blending polymers with additives to produce a product for the forming industry
MPC11 Extruding: Understanding the process of forming a continuous piece of matter by forcing it through a shaping orifice
MPC25 Project Management: Planning, implementing, and evaluating assignments to ensure that the desired outcomes of the assignment are produced on time and within budget
MPC29 Resin and Additive Formulation: Knowledge of polymer materials to achieve appropriate formulation for intended purpose

Mississippi Academic Course Competencies and Benchmarks

OC2 Demonstrate an understanding of the properties, structure, and function of organic compounds.
OC3 Discuss the versatility of polymers and the diverse application of organic chemicals.

ACT College Readiness Standards

S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
W5 Using Language

21st Century Skills Standards

CLS2 Initiative and Self-Direction
CLS4 Productivity and Accountability

National Educational Technology Standards for Students

T1 Creativity and Innovation
T3 Research and Information Fluency
T6 Technology Operations and Concepts

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Suggested Rubrics and Checklists

Name: _____

Date: _____

Period: _____

K-W-L Chart

Topic _____

What I Know	What I Want to Know	What I Learned

Name: _____

Date: _____

Period: _____

Multimedia Presentation Rubric

	Exemplary 4 points	Accomplished 3 points	Developing 2 points	Beginning 1 point	Score Obtained
Content	Addressed all assignment components	Addressed all but one assignment component	Omitted two assignment components	Omitted more than two assignment components	
Detail	Fully addressed all assignment components	Fully addressed most assignment components	Partially addressed most assignment components	Partially addressed few assignment components	
Accuracy	No grammatical, typographical, spelling, or punctuation errors	1–2 grammatical, typographical, spelling, or punctuation errors	3–5 grammatical, typographical, spelling, or punctuation errors	More than 5 grammatical, typographical, spelling, or punctuation errors	
Clarity	Logical, orderly sequence	Somewhat logical sequence	Confusing sequence	No evidence of order/sequence	
Design	Excellent design selection and usage	Adequate design selection or 1–2 design errors	Inadequate design selection or 3–5 design errors	Poor design selection or more than 5 design errors	
Appeal	Very appealing; excellent use of animation, transitions, sound, etc.	Somewhat appealing; adequate use of animation, transitions, sound, etc.	Not very appealing; limited use of animation, transitions, sound, etc.	Not appealing; very limited or no use of animation, transitions, sound, etc.	
				Score	

Teacher Comments:

Name: _____

Date: _____

Period: _____

Journal Rubric

Use this rubric to assess students' abilities to complete the journal activities assigned for this lesson. Share this assessment with students prior to completing the journal-writing lessons so they will understand how they will be assessed. You can also use the rubric as a basis for discussion and feedback with each student.

1. The student writes journal responses in complete sentences. _____
2. The student writes five or more sentences to answer questions. _____
3. The student responds to questions by self-questioning, retelling, predicting, or assuming the role of a character. _____
4. The student's experiences and opinions are clear. _____
5. The student works with a peer to share journal responses and to develop a combined response when requested. _____

TOTAL: _____

EXCELLENT (4)	VERY GOOD (3)	FAIR (2)	POOR (1)
The student completes the task with mo major errors. The student demonstrates a full understanding of the concepts.	The student completes the task with only a few major errors and some minor errors. The student demonstrates a strong understanding of the concepts.	The student completes the task with some major errors and many minor errors. The student has difficulty understanding the concepts.	The student fails to complete the task. The student does not understand the concepts.

Teacher Comments:

Name: _____

Date: _____

Period: _____

Lab Activity Rubric

SKILL OR BEHAVIOR	ALWAYS (3)	MOST OF THE TIME (2)	RARELY (1)	NEVER (0)	TOTAL
Cooperated well with lab partners Listened to others Expressed opinions in professional manner Responded appropriately to others Respected others' opinions					
Followed verbal and written instructions Followed directions the first time Listened to teacher Accepted responsibility for actions Remained on task Allowed others to remain on task					
Followed safety rules Wore lab coat if applicable Wore goggles if applicable Wore gloves if applicable Followed specific safety rules for this particular lab Followed all other safety rules					
Cleaned and returned tools, supplies, lab coats, and goggles to proper location Cleaned all supplies Returned all supplies to proper place Disposed of all trash properly Cleaned lab tables Left chairs/stools in proper location					
Rate finished product. 1 to 5 (5 being the best)					
				Total	

Teacher Comments:

Unit 6: Recycling

Competency 1: Relate plastics recycling/conservation principles and their effects on the environment. SPI-I, SPI-IV, SPI-V, MPC1, MPC24 (DOK 2)

Suggested Enduring Understandings

1. It is people's civic duty to conserve, reuse, and recycle plastics resources in order to sustain the environment.
2. Short term costs of recycling are outweighed by the long term effects of not recycling.

Suggested Essential Questions

1. What is recycling?
2. How does plastics waste affect the environment?
3. What can you do differently to conserve, reuse, and/or recycle plastics?
4. Why do most plastics not readily degrade?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Classify the different types of plastics and their recycle codes including PETE, HDPE, V, LDPE, PP, PS, and others. (DOK 1)	**a. Hook:** "Just throw it away!" Lead discussion while dissecting previously collected trash, and have students propose what will happen to each item over time. Brainstorm options of disposing of plastics waste and the problems generated from previous and current methods of disposal. Model locating recycling codes on a variety of commonly used plastic products. Create a K-W-L chart with students concerning plastics recycling and conservation. Provide students with enduring understandings and introduce essential questions.	a. **K-W-L Chart**
	Introduce vocabulary including reduce, reuse, recycle, repurpose, conservation, renewable, nonrenewable, commodity resin, recycling codes 1–7, polyethylene terephthalate (PETE), high-density polyethylene (HDPE), low-density polyethylene (LDPE), polypropylene (PP), polystyrene (PS), polymer cycle, degradation, thermal degradation, mechanical degradation, oxidative degradation, chemical degradation, photo degradation, bio degradation, primary recycling (regrind), secondary recycling (mechanical), tertiary recycling (feedstock or chemical), including quaternary recycling (energy recovery).	Vocabulary test
	Use technology and classroom resources to introduce recycling. Lecture and give a demonstration on plastics recycling/conservation using quick response questions with clickers throughout. T1, T3, T6 **Journal entry:** Imagine that you are a PETE bottle. Write an autobiography of your life.	Lab report

		Where were you born? Where did you come from? What are your strengths/weaknesses? What tasks did you perform during your life? What happened to you after you were no longer useful for your original purpose? If you could change anything, what would you change? Illustrate your life using the visual "life of a PETE bottle" journal prompt. [W1, W5] Review for test. **Performance task:** You have been elected as President of the Plastics Recycling Association of Mississippi. You have been asked to persuade the city council to start a community service recycling program for (your choice of plastics recycling topic). Your persuasive presentation should make use of your cost analysis (developed in performance task part 1) and your visual representation (developed in performance task part 2) to better inform the council. If you are successful in persuading the council to start your recycling program, you will be promoted to President of the Plastics Recycling Association of America. [T1, T3, T6]	Recycling code test
b.	Debate the cost of using recycled polymers versus virgin polymers in manufacturing. (DOK 3) [OC2]	b. **Performance task continued:** Model the cost analysis process using a commodity resin. Have students perform a similar cost analysis on another commodity resin. Have students use technology tools and the writing process to prepare a summary of their cost analysis. The summary should include a graphical representation (charts and graphs) comparing the costs of using recycled polymers versus virgin polymers in manufacturing. Based on research, students will debate the "true cost" of using recycled polymers instead of virgin polymers in manufacturing. [E4, CLS2, CLS4, CLS5]	b. **Rubric**
c.	Examine issues and post-recycling uses for the different types of plastics. (DOK 1) [OC2]	c. **Hook:** "Have you been fleeced?" Discuss the terms *fleeced* and *fleece*. Display a fleece jacket, and discuss how other polymer students from Alcorn collected milk jugs that were used to make the fleece jacket. Show students a video about recycling. Have students journal in response to the video. [W1, W5] **Hook:** "How degrading!" Lecture on the effects recycling has on polymer properties and the use of recycled plastics in manufacturing. Use the "Hands on Plastics" teaching kit to allow students to analyze samples of recycled plastic	c. **Journal Rubric**

	materials and products made from recycled plastics. Have students complete the polymer identification lab. Students will conduct a series of tests to identify unknown plastics and their respective recycling codes. Extend the tensile strength test lab [incorporating ASTM (American Society of Testing Materials) standards] and the injection molding/cast parts labs to test tensile strength of 100% recycled polymer to 100% virgin polymer and the student's choice of a combination of recycled/virgin polymer.	
	Performance task continued: Have students prepare a project explaining the different types of recycled plastics and their post-recycling uses. Allow students to choose their project based on their learning styles—poster, multimedia presentation, booklet, and so forth to be presented in part 3 of the performance task. Remind students of the introduction to the performance task, and have them reflect on and revise their products from parts 1 and 2 to support their oral presentation in part 3. CLS2-5, S3, T1, T3, T6	**Rubric**
	Performance task continued: Have students prepare and present an oral presentation to "city council members" (composed of other students, teachers, counselors, and elected officials) in order to persuade them to adopt their recycling programs. In order to best prepare for the presentation to the council, students will self-assess a videotape of a practice presentation. During the oral presentation, students must be prepared to field questions and defend their proposals. City council will score and critique (using a given rubric) each proposal and decide which proposal to adopt.	
	Extension projects: Have students analyze (weigh/measure) the amount of waste found in trash (home/school/cafeteria) that could be composted, reused, and recycled. M5, M7 Have students analyze degradation of polymer/plastic products and organic waste over time in a longitudinal study. Students will keep a visual journal (choice of pictures and/or video) with commentary representing their findings.	[Extension Assessments] **Lab Report Checklist**

Standards

Industry Standards: Society of Plastics Industry Standards

I. Essential Knowledge
IV. Material and Product Handling/Storage
V. Measurement, Analysis, and Response

Industry Standards: Polymer Standards for the State of Mississippi

MPC1 Business Understanding: Understanding the inner workings of business functions and how business decisions affect financial or non-financial work results
MPC24 Processing: Understanding the methods used to control processes to achieve product, safety, quality, and environmental specifications

Mississippi Academic Course Competencies and Benchmarks

OC2 Demonstrate an understanding of the properties, structure, and function of organic compounds.

ACT College Readiness Standards

E4 Sentence Structure and Formation
M5 Graphical Representations
M7 Measurement
S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
W5 Using Language

21st Century Skills Standards

CLS2 Initiative and Self-Direction
CLS3 Social and Cross-Cultural Skills
CLS4 Productivity and Accountability
CLS5 Leadership and Responsibility

National Educational Technology Standards for Students

T1 Creativity and Innovation
T3 Research and Information Fluency
T6 Technology Operations and Concepts

References

Allcock, H. R. (2003). *Contemporary polymer chemistry.* Upper Saddle River, NJ: Pearson/Prentice Hall.

Ambrose, A., Bergerud, M., Busche, D., & Morrison, C. (2005). *Computer literacy BASICS: A comprehensive guide to IC^3*. Boston: Course Technology.

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Smoot, R. C. (1987). *Merrill chemistry: A modern course*. Upper Saddle River, NJ: Merrill.

Teegarden, D. M. (2004). *Polymer chemistry introduction to an indispensable science.* New York: National Science Teachers Association.

Suggested Rubrics and Checklists

Name: _____

Date: _____

Period: _____

Lab Report Checklist

Did the student include the following information?

_____ Report title

_____ Appropriate section titles (i.e., Abstract, Introduction, Materials, Procedures, Results, Conclusion)

_____ Complete sentences when appropriate

_____ Relevant background information on the experiment in the introduction

_____ A list of all materials used in the experiment

_____ Detailed procedures for the experiment

_____ Any observations and reported results

_____ An explanation as to why the observed results occurred

_____ At least two sources of error

_____ A summary of any knowledge or insight gained from the lab experiment

_____ Correct and quality information throughout the report

_____ Was the report turned in on time?

_____ Did the student use proper grammar?

_____ Was the information organized appropriately?

_____ Was the report legible?

Teacher comments:

Name: _____

Date: _____

Period: _____

Performance Task Rubric: Product Research

Criteria	1	2	3	4	Score
Presentation	Unorganized; does not flow; hard to follow; does not account for the knowledge of the audience; bland; no use of color or graphics	Ideas are organized, but presentation requires further explanation to follow; some use of color and graphics; obvious improvement needed.	Appropriately organized; some improvement needed to clearly understand the topic; appropriate use of graphics	Presentation flows easily and can be understood easily by the audience; good use of color and graphics; all required information is present.	
Thoroughness	No understanding of the science involved; did not include all topics	Poor understanding of the science; one reference; only a couple of topics researched	Decent explanation of the science; two references; most topics present	Effective explanation of science; all topics present	
Accuracy	Incorrect facts throughout the presentation; no data inclusion	One or two correct facts, but primarily poor information; poor representation of data	A few incorrect facts, but effective overall presentation; should improve representation of data	Complete factual information; good overall presentation and representation of data	
Total					

Teacher comments:

Name: _____

Date: _____

Period: _____

Performance Task Rubric: Product Analysis

Criteria	1	2	3	4	Score
Cleanliness	Unorganized experimentation; poor lab skills; messy and unorganized report; lacks direction	Ideas are organized, but presentation requires further explanation to follow; poor lab skills; obvious improvement needed.	Appropriately organized; some improvement needed to clearly understand the topic; only a few errors in lab skills	Report flows easily and is easily understood; good lab skills; all required information is present.	
Thoroughness	No understanding of the science involved; did not test all samples	Poor understanding of the science; too many “guesses”	Decent explanation of the science; did not test one to two samples	Effective explanation of science; all samples tested	
Accuracy	Incorrect facts throughout the presentation; no data inclusion	One or two correct facts, but primarily poor information; poor representation of data	A few incorrect facts, but effective overall presentation; should improve representation of data	Complete factual information; good overall presentation and representation of data	
Total					

Teacher comments:

Name: _____

Date: _____

Period: _____

Journal Rubric

Use this rubric to assess students' abilities to complete the journal activities assigned for this lesson. Share this assessment with students prior to completing the journal-writing lessons so they will understand how they will be assessed. You can also use the rubric as a basis for discussion and feedback with each student.

1. The student writes journal responses in complete sentences. _____
2. The student writes five or more sentences to answer questions. _____
3. The student responds to questions by self-questioning, retelling, predicting, or assuming the role of a character. _____
4. The student's experiences and opinions are clear. _____
5. The student works with a peer to share journal responses and to develop a combined response when requested. _____

TOTAL: _____

EXCELLENT (4)	VERY GOOD (3)	FAIR (2)	POOR (1)
The student completes the task with mo major errors. The student demonstrates a full understanding of the concepts.	The student completes the task with only a few major errors and some minor errors. The student demonstrates a strong understanding of the concepts.	The student completes the task with some major errors and many minor errors. The student has difficulty understanding the concepts.	The student fails to complete the task. The student does not understand the concepts.

Teacher Comments:

Name: _____

Date: _____

Period: _____

K-W-L Chart

Topic _____

What I Know	What I Want to Know	What I Learned

Advanced Topics in Polymer Science

Unit 7: Orientation and Safety (Review)

Competency 1: Evaluate the local program and explore how personality traits and learning styles can impact success in the classroom and workplace. SPI-I, SPI-VI, MPC1, MPC4, MPC6, MPC14, MPC16, MPC18, MPC25-MPC28, MPC33-MPC35 (DOK 1)

Suggested Enduring Understandings

1. The Polymer Science program curriculum and workplace are highly technical, demanding, and constantly changing.
2. Personality and learning styles can greatly impact educational and professional success.

Suggested Essential Questions

1. What are the expectations and responsibilities for a student in the Polymer Science program? How does the program prepare students to be successful in the workplace?
2. How can each student's personality and learning styles be an asset in the program and the workplace?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Examine the local student handbook and program, establishing rules and guidelines. (DOK 1)	a. Pretest students' knowledge from the previous year. Use the results to group students, plan focused instruction, and provide remediation. Review program requirements, student handbook, classroom, and lab rules. For students who need further explanation, have them complete Unit 1 in the first course. W1-W5, CLS1-CLS5, E1-E6, R1-R5, T1-T6	a. Pretest Teacher observation Teacher observation
b. Examine how understanding personality and learning styles can impact learning and workplace performance. (DOK 3)	b. Students revisit http://www.polymer.ms/docs/polymer_study%202002.pdf and read about requirements to be successful in the polymer science field, followed by a brainstorming session. After classroom discussion, revisit and revise journal entry on "What it will take to be successful in the polymer science program," developing into a two- to three-paragraph report on "Attributes for Success in the Field of Polymer Science." Close with a paragraph on how you believe this program will help develop those attributes. Evaluate with **Writing Rubric**. E1-E6, R1-R5, W1-W5, CLS2, T3, T4 **Performance Task:** You have been selected by the governor to serve on a task force to develop a plan for interstate beautification. To help team members get acquainted, your first responsibility is to submit through Blackboard Learning System a multimedia presentation entitled "What Makes Me Tick." Essential elements include your personality traits, learning styles, and personal motivators. Close with thoughts on how to best empower various personalities and learning styles	**b. Journal Rubric** **Writing Rubric** **Multimedia Presentation Rubric**

in a team setting. Assess with **Multimedia Presentation Rubric**. W1-W5, CLS1-CLS5, T1-T5

Competency 2: Describe and demonstrate safe laboratory practices and environmental responsibility working with laboratory equipment, chemicals, and processing equipment commonly encountered in polymer-related industries. SPI-I , SPI-IV, SPI-VI, MPC1, MPC4, MPC8, MPC14, MPC16, MPC18, MPC21, MPC26,MPC28, MPC31, MPC33-MPC35 (DOK 1)

Suggested Enduring Understandings

1. Safety is the number-one priority in the laboratory and industrial workplace. Safe practices, attention to detail, and cautious behavior result in a safe work environment.
2. There is a wealth of information concerning the safe workplace and environmental responsibilities, including guidelines and regulations provided by governmental, industrial, and watchdog organizations.
3. Laboratory and processing equipment have specific uses, procedures to be followed, and safe use guidelines that must be considered.

Suggested Essential Questions

1. What part do I play personally in providing a safe lab/workplace? To what extent do I have personal responsibility for care of my classmates and the environment?
2. What organization acronyms have you heard that you think may be related to a safe workplace and environment? How do these organizations impact laboratory and industrial operations?
3. How will I decide which pieces of laboratory equipment will best suit the task at hand?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Determine how to apply safety rules/guidelines for the lab and workplace and to use safety equipment properly. (DOK 1)	a. Review safety rules in the laboratory. For students who need further explanation, have them complete Unit 1 in the first course. E1- E6, W1-W5, R1-R5, T1,T6, CLS1-CLS5, S1, S2	a. Teacher observation Safety quiz
b. Investigate how industrial, governmental, and environment watchdog organizations impact safe operations in polymer-related industries. (DOK 2)	b. Review safe operations through various organizations in the polymer industry. For students who need further explanation, have them complete Unit 1 in the first course. E1-E6, R1-R5, S1, S2, W1-W5, T1, T6	b. Teacher observation
c. Identify basic laboratory equipment and functions while correctly and safely using selected pieces of equipment. (DOK 1)	c. Review proper use of equipment in the laboratory. For students who need further explanation, have them complete Unit 1 in the first course. W1-W5, CLS1, CLS2, S1, S2, E1-E6	c. Teacher observation

d.	Detail safe practices particular to operation of equipment in polymer-related laboratories and manufacturing facilities. (DOK 1)	d.	Review safe practices in relation to polymer-related laboratories and equipment. For students who need further explanation, have them complete Unit 1 in the first course. E1-E6, R1-R5, W1-W5, CLS3, CLS5, T1, T3, T6	d.	Teacher observation
e.	Evaluate resources available for safe handling and disposal of chemicals. (DOK 3) OC3	e.	Review proper use of equipment in the laboratory. For students who need further explanation, have them complete Unit 1 in the first course. E1-E6, W1-W5, S1, R1-R5, T1, T6, CLS1-CLS5 **Performance Task:** You and a partner are laboratory TAs for Chemistry 101 at PolySci University. Your professor has assigned you the responsibility of designing an experiment. [Teacher may assign the same or different labs to each team. They may be labs that can actually be conducted or simulated or hypothetical labs. Sample: to investigate oxidation/reduction reactions, where students will submerge iron-based steel wool in copper(II)sulfate solution and then repeat the experiment using aluminum wire in a sodium nitrate solution. Part 2 of the experiment involves heating steel wool in a Bunsen burner flame, recording mass change.] You are provided with MSDS and chemicals for the lab. You must prepare a detailed lab handout for your students, including background, materials/equipment list, safety considerations, pre-lab questions, experimental procedure, cleanup/disposal, data/observations, and post-lab questions/analysis. Once your handout is ready, meet with another team and critique each other's handouts, discussing possible modifications. Make revisions and then set up a lab station for the experimental procedure. [If possible, have another team use the lab handout to conduct the lab, marking trouble spots as needed in red. E1-E6, R1-R5, W1-W5, CLS1-CLS5, T1-T6	e.	Teacher observation

Standards

Industry Standards: Society of Plastics Industry Standards

I. Essential Knowledge
VI. Safety Components

Industry Standards: Polymer Standards for the State of Mississippi

MPC1 Business Understanding: Understanding the inner workings of business functions and how business decisions affect financial or non-financial work results
MPC4 Communication: Applying effective verbal, nonverbal, and written communication methods to achieve desired results
MPC6 Customer Focus: Dedication to meeting or exceeding the expectations and requirements of both internal and external customers
MPC8 Design of Experiments: Familiarity with this discipline and method of experimentation that is used to gather and analyze data and to efficiently determine process and product interactions.
MPC14 Group Process Understanding: Understanding how groups function; influencing people so that group, work, and individual needs are addressed
MPC16 Industry Understanding: Understanding the vision, strategy, goals, and culture of other companies within the polymer processing industry
MPC18 Leadership: The ability to influence and guide members of the organization to achieve organizational objectives
MPC21 Organization: The use of coordination and communication as tools used to accomplish tasks in a systematic manner
MPC25 Project Management: Planning, implementing, and evaluating assignments to ensure that the desired outcomes of the assignment are produced on time and within budget
MPC26 Questioning: Gathering information from stimulating insight in individuals and groups through use of interview, questionnaires, and other probing methods
MPC27 Relationship Building Skills: Establishing relationships and networks across a broad range of people and groups
MPC28 Research Skills: Selecting, developing, and using methodologies such as statistical and data collection techniques for formal inquiry
MPC31 Self-Knowledge/Self-Management: Knowing one's personal values, needs, interests, style, and competencies and being able to manage their effects on others
MPC33 Teamwork: Successfully and efficiently working and communicating with group or project members such that the team's final output meets or exceeds predefined expectations
MPC34 Technical Communications: The ability to translate and communicate required technical information to non-technical operational people
MPC35 Time Management: Valuing time and ensuring that it is used efficiently for all tasks

Mississippi Academic Course Competencies and Benchmarks

OC3 Discuss the versatility of polymers and the diverse application of organic chemicals.

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation

M1	Basic Operations and Applications
M2	Probability, Statistics, and Data Analysis
M3	Numbers: Concepts and Properties
M4	Expressions, Equations, and Inequalities
M5	Graphical Representations
M6	Properties of Plane Figures
M7	Measurement
R1	Main Ideas and Author's Approach
R2	Supporting Details
R3	Sequential, Comparative, and Cause—Effect Relationships
R4	Meaning of Words
R5	Generalizations and Conclusions
S1	Interpretation of Data
S2	Scientific Investigation
W1	Expressing Judgments
W2	Focusing on the Topic
W3	Developing a Position
W4	Organizing Ideas
W5	Using Language

21st Century Skills Standards

CLS1	Flexibility and Adaptability
CLS2	Initiative and Self-Direction
CLS3	Social and Cross-Cultural Skills
CLS4	Productivity and Accountability
CLS5	Leadership and Responsibility

National Educational Technology Standards for Students

T1	Creativity and Innovation
T2	Communication and Collaboration
T3	Research and Information Fluency
T4	Critical Thinking, Problem Solving, and Decision Making
T5	Digital Citizenship
T6	Technology Operations and Concepts

References

Allcock, H. R. (2003). *Contemporary polymer chemistry.* Upper Saddle River, NJ: Pearson/Prentice Hall.

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Teegarden, D. M. (2004). *Polymer chemistry introduction to an indispensable science.* New York: National Science Teachers Association.

Suggested Rubrics and Checklists

Name: _____

Date: _____

Period: _____

Journal Rubric

Use this rubric to assess students' abilities to complete the journal activities assigned for this lesson. Share this assessment with students prior to completing the journal writing lessons so they will understand how they will be assessed. You can also use the rubric as a basis for discussion and feedback with each student.

6. The student writes journal responses in complete sentences. _____
7. The student writes five or more sentences to answer questions. _____
8. The student responds to questions by self-questioning, retelling, predicting, or assuming the role of a character. _____
9. The student's experiences and opinions are clear. _____
10. The student works with a peer to share journal responses and to develop a combined response when requested. _____

TOTAL: _____

EXCELLENT (4)	VERY GOOD (3)	FAIR (2)	POOR (1)
The student completes the task with mo major errors. The student demonstrates a full understanding of the concepts.	The student completes the task with only a few major errors and some minor errors. The student demonstrates a strong understanding of the concepts.	The student completes the task with some major errors and many minor errors. The student has difficulty understanding the concepts.	The student fails to complete the task. The student does not understand the concepts.

Teacher comments:

Name: _____

Date: _____

Period: _____

Writing Rubric

	EXCELLENT (3)	SATISFACTORY (2)	UNSATISFACTORY (1)	SCORE
Content	Paper is well developed with more than enough information. Information is clearly presented with elaborations.	Paper is fairly well developed with enough information to inform the reader about the topic. Information is clearly presented with some elaborations.	Paper has little development and a minimum amount of information. Some information is confusing.	
Details	Plenty of specific details that more than adequately explain the topic	Some specific details that adequately explain the topic. Some do not help explanation.	May not have details, and/or details may be wrong.	
Organization	Clear organization and no straying	Has somewhat of an organization and tries to stick to it	If there is an organization, it is not clear and writer strays from it.	
Audience	Written for intended audience	Written for intended audience in most cases	Does not address the intended audience	
Language Choices	Uses language choices to maintain a style or a tone	Uses some language choices to maintain style or tone	Does not use language choices to help with style or tone.	
			Total	

Teacher comments:

Name: _____

Date: _____

Period: _____

Multimedia Presentation Rubric

	Exemplary 4 points	Accomplished 3 points	Developing 2 points	Beginning 1 point	Score Obtained
Content	Addressed all assignment components	Addressed all but one assignment component	Omitted two assignment components	Omitted more than two assignment components	
Detail	Fully addressed all assignment components	Fully addressed most assignment components	Partially addressed most assignment components	Partially addressed few assignment components	
Accuracy	No grammatical, typographical, spelling, or punctuation errors	1–2 grammatical, typographical, spelling, or punctuation errors	3–5 grammatical, typographical, spelling, or punctuation errors	More than 5 grammatical, typographical, spelling, or punctuation errors	
Clarity	Logical, orderly sequence	Somewhat logical sequence	Confusing sequence	No evidence of order/sequence	
Design	Excellent design selection and usage	Adequate design selection or 1–2 design errors	Inadequate design selection or 3–5 design errors	Poor design selection or more than 5 design errors	
Appeal	Very appealing; excellent use of animation, transitions, sound, etc.	Somewhat appealing; adequate use of animation, transitions, sound, etc.	Not very appealing; limited use of animation, transitions, sound, etc.	Not appealing; very limited or no use of animation, transitions, sound, etc.	
				Score	

Teacher comments:

Unit 8: Polymer Synthesis

Competency 1: Explore how the chemistry of polymer preparation affects performance properties. SPI-I, SPI-IV, SPI-VI , MPC3, MPC7, MPC17, MPC21, MPC25, MPC28-29, MPC34-36 **(DOK 1)**

Suggested Enduring Understandings

1. Polymer synthesis represents the mechanics of chemical connections that form giant molecules such as Styrofoam and nylon.
2. Molecular weight is a primary factor that affects the properties of polymers.
3. By understanding how condensation and addition polymerization work, we can tailor the polymer materials to meet specific applications.
4. In contrast to polymer synthesis, cross-linking establishes links between existing polymer chains and affects the properties of the polymers.

Suggested Essential Questions

1. How does polymer synthesis produce giant molecules?
2. How could the same gas that ripens fruit later become a garbage bag?
3. How does molecular weight affect the properties of polymers?
4. How can we use the two polymerization mechanisms, condensation and addition, to produce products to meet our needs?
5. How can cross-linking affect the properties of polymers?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe and demonstrate different types of polymer synthesis to include condensation and addition polymerization. (DOK 2) OC1, OC2, OC3	a. **Hook:** "From food gas to trash bag?" Lead discussion on how ripening fruit creates the gas that is the monomer for creating the polymer used in trash bags **<u>and/or</u>** introduce the concept of 1 + 1 = 1 and demonstrate what it means with models. CLS3	a. Teacher observation
	Create a K-W-L chart with students concerning polymer synthesis.	**K-W-L Chart**
	Provide students with enduring understandings and introduce essential questions.	Teacher observation
	Introduce vocabulary including functional groups, vinyl, polymerization, addition, condensation, monomer, polymer, copolymer, terpolymer, anionic, cationic, radical, free radical, initiation, propagation, saturation, molecular weight, molecular weight distribution, ring opening, living polymerization, interfacial polymerization, cross-linking, and so forth.	Vocabulary quiz
	Use models to demonstrate various monomers, oligomers, and polymers.	**Molecular Models Skills Checklist**
	Lecture and provide a demonstration of condensation mechanism using quick response questions with clickers throughout.	Teacher observation

	Complete nylon lab in teams, emphasizing the importance of safety. Complete individual lab reports.[CLS4, M7, R4, S1-S3, W1-W5]	**Lab Report Checklist**
	Review for test on condensation mechanism.	Mechanisms test
	Lecture and provide a demonstration of addition mechanism using quick response questions.	Teacher observation
	Introduce/revisit vinyl monomers and examples.	Teacher observation
	Use molecular models and/or complete simulation lab with addition polymerization in teams, emphasizing the importance of safety.[CLS3]	**Molecular Models Skills Checklist** and teacher observation
	Complete a lab using sodium polyacrylate, which is the absorbent material found in diapers, to determine how much water it can hold and why. See if students can find other uses of sodium polyacrylate. Write a lab report on the experiment. [CLS4, M7, R4, S1-S3, W1-W5, T1-T6]	**Lab Report Checklist**
	To accommodate various learning styles, assign a poster/paper/multimedia presentation/3D model project to demonstrate different mechanisms (cationic, anionic, free radical, emulsion, etc.) to be completed in groups or individually, according to students' various learning styles. NOTE: Encourage students to create and revise their own research questions according to the mechanism that they choose.[CLS2, CLS4, W1-W5, T1, T3-T6]	**Poster Assessment Rubric** Peer assessment
	Review for test on addition mechanism.	Mechanisms test
	Performance task: You are a scientist experimenting with the synthesis of a polymer product used for holding and carrying recyclable materials. You are responsible for synthesizing the polymer to create the container. You must choose all necessary materials from the available chemicals and illustrate the detailed mechanism of polymerization for the product. You must also include any additional information, such as cross-linking to complete the polymer structure. You will then present your product to the board of the recycling company. Your product should be a written	**Performance Task Rubric**

	or oral presentation that includes an illustration, CAD diagram, cost analysis, and an explanation of your container. You may choose a formal proposal or a PowerPoint presentation for presenting. You will be judged using a rubric that evaluates your presentation, research, knowledge of the topic, and the accuracy of the chemistry involved in the process.[CLS2, CLS4, W1-W5, T1, T3-T6]	
b. Explore the effects of molecular weight and cross-linking on polymer properties. (DOK 2) [OC3]	b. Lecture on calculating molecular weight and degree of polymerization using quick response questions with clickers throughout.	b. Teacher observation
	Show students examples of materials with different molecular weights to allow them to compare and contrast the properties.	Teacher observation
	Skill check on calculating molecular weight and degree of polymerization from given information.[M1]	Skill check on molecular weight
	Lecture on cross-linking, using quick response questions with clickers throughout.	Teacher observation
	Complete latex ball lab experiment and lab report to demonstrate the effect of cross-linking.[CLS4, R4, S1-S3, W1-W5]	**Lab Report Checklist**
	Use the silly putty and slime experiments to compare cross-linking in similar materials (silly putty uses white glue and Borax, while slime is a product of sodium borate and polyvinyl alcohol). Discuss as a class what is similar and different between the two products.[CLS4, R4, S1-S3]	Peer and teacher assessment
	Review molecular weight and cross-linking for test.	
	Complete performance task, providing opportunity for revisiting, revising, rethinking, and refining throughout.[CLS2, CLS4, W1-W5, T1, T3-T6]	Test
		Self-assessment and peer-assessment of performance task **Performance Task Rubric**

Standards

Industry Standards: Society of Plastics Industry Standards

I. Essential Knowledge
IV. Material and Product Handling/Storage
VI. Safety Components

Industry Standards: Polymer Standards for the State of Mississippi

MPC3 Coaching: problems, alternatives, and goals
MPC7 Decision-Making Ability: Selecting, in a timely manner, appropriate course(s) of action that is(are) consistent with the organization's mission, vision, and strategies
MPC17 Innovativeness: The ability to generate unique ideas and concepts that, if applied, could provide the organizations with a competitive advantage
MPC21 Organization: The use of coordination and communication as tools used to accomplish tasks in a systematic manner
MPC25 Project Management: Planning, implementing, and evaluating assignments to ensure that the desired outcomes of the assignment are produced on time and within budget
MPC28 Research Skills: Selecting, developing, and using methodologies such as statistical and data collection techniques for formal inquiry
MPC29 Resin and Additive Formulation: Knowledge of polymer materials to achieve appropriate formulation for intended purpose
MPC34 Technical Communications: The ability to translate and communicate required technical information to non-technical operational people
MPC35 Time Management: Valuing time and ensuring that it is used efficiently for all tasks
MPC36 Troubleshooting: The ability to formulate and evaluate alternative solutions to current or forecasted problems and implement the appropriate course(s) of action using rigorous logic and other probing methods

Mississippi Academic Course Competencies and Benchmarks

OC1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.
OC2 Demonstrate an understanding of the properties, structure, and function of organic compounds.
OC3 Discuss the versatility of polymers and the diverse application of organic chemicals.

ACT College Readiness Standards

M1 Basic Operations and Applications
M7 Measurement
R4 Meaning of Words
S1 Interpretation of Data
S2 Scientific Investigation
S3 Evaluation of Models, Inferences, and Experimental Results
W1 Expressing Judgments
W2 Focusing on the Topic
W3 Developing a Position
W4 Organizing Ideas
W5 Using Language

21st Century Skills Standards

CLS2	Initiative and Self-Direction
CLS3	Social and Cross-Cultural Skills
CLS4	Productivity and Accountability

National Educational Technology Standards for Students

T1	Creativity and Innovation
T2	Communication and Collaboration
T3	Research and Information Fluency
T4	Critical Thinking, Problem Solving, and Decision Making
T5	Digital Citizenship
T6	Technology Operations and Concepts

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Suggested Rubrics and Checklists

Name: _____

Date: _____

Period: _____

Molecular Models Skills Checklist

Did the student…

_____ differentiate between different elements?

_____ show the appropriate number of bonds to each atom?

_____ illustrate appropriate bond angles or avoid bond strain?

_____ illustrate the correct chemical structure of each molecule?

_____ recognize his or her own mistakes in the models?

_____ recognize similarities and differences in the various molecules?

Teacher comments:

Name: _____

Date: _____

Period: _____

Lab Report Checklist

Did the student include the following information?

_____ Report title

_____ Appropriate section titles (i.e., Abstract, Introduction, Materials, Procedures, Results, Conclusion)

_____ Complete sentences when appropriate

_____ Relevant background information on the experiment in the introduction

_____ A list of all materials used in the experiment

_____ Detailed procedures for the experiment

_____ Any observations and reported results

_____ An explanation as to why the observed results occurred

_____ At least two sources of error

_____ A summary of any knowledge or insight gained from the lab experiment

_____ Correct and quality information throughout the report

_____ Was the report turned in on time?

_____ Did the student use proper grammar?

_____ Was the information organized appropriately?

_____ Was the report legible?

Teacher comments:

Name: _____

Date: _____

Period: _____

Poster Assessment Rubric

Criteria	1	2	3	4	Score
Organization	A large amount of missing information; no definitive sections	No title, but sectioned; obvious improvement needed; hard to follow; missing parts	All sections present, but unclear; some editing or refinement needed	Clear and well organized; defined sections; flows smoothly	
Creativity	Bland presentation; no color or graphics; obvious lack of interest in presentation	Some use of color; does not hold attention for long periods of time	Good use of graphics and color; interesting, but not stimulating	Very good incorporation of color and images; aesthetically appealing; stimulating to the viewer	
Content	No analysis of the topic; no resources; no or poor explanation	Poor explanation; inaccurate connection of science; one resource	Adequate analysis of the topic; explanation of the science could be further developed	Good analysis of the topic; well-understood science that is explained properly; several resources	
Level of Difficulty	Irrelevant; not suitable for grade level (too easy)	Minimal level of difficulty; needs major revisions	Adequate level of difficulty; some slight revisions may be necessary	Appropriate for grade level; good understanding of the topic	
Total					

Teacher comments:

Name: _____

Date: _____

Period: _____

Molecular Weight Calculations Checklist

Was the student able to:

_____ calculate molecular weight of a molecule based on its structural formula and information given in the periodic table of elements?

_____ calculate molecular weight of the polymer given a structure and degree of polymerization?

_____ calculate degree of polymerization given a structure and total molecular weight?

_____ identify the location for the numerical representation of degree of polymerization? (i.e., show where *n* goes and translate *n* to a number)

Name: _____

Date: _____

Period: _____

Performance Task Rubric

Criteria	1	2	3	4	Score
Presentation	Unorganized; does not flow; hard to follow; does not account for the knowledge of the audience; bland; no use of color or graphics	Ideas are organized, but presentation requires further explanation to follow; some use of color and graphics; obvious improvement needed.	Appropriately organized; some improvement needed to clearly understand the topic; appropriate use of graphics	Presentation flows easily and can be understood easily by the audience; good use of color and graphics; all required information is present.	
Knowledge of the Topic	Little to no understanding of the project; shows lack of interest and research; unable to answer questions on the topic	Basic understanding of the task; very little interest (too easy); unable to sufficiently answer questions	Adequate understanding of the task; appropriate information for the audience; could be further studied	Questions answered easily; information is appropriate for the audience; shows interest and good investment of time.	
Research	No understanding of the science involved; no references; uses “guess work”	Poor understanding of the science; one reference; needs more information to be understood	Decent explanation of the science; two references; further research could provide more in-depth answers.	Effective explanation of science; three or more references; adequate answers to further inquiries	
Accuracy	Incorrect facts throughout the presentation	One or two correct facts, but primarily poor information	A few incorrect facts, but effective overall presentation	Complete factual information; good overall presentation	
Total					

Teacher comments:

Name: _____

Date: _____

Period: _____

K-W-L Chart

Topic _____

What I Know	What I Want to Know	What I Learned

Unit 9: Surface Coatings

Competency 1: Describe the production of various types of surface coatings. SPI-I, SPI-IV, SPI-V, MPC4-6, MPC12-13, MPC17, MPC24, MPC28-30, MPC33-36 (DOK 1)

Suggested Enduring Understandings

1. The types of coatings that most people are familiar with are called architectural coatings.
2. There has been a big push to reduce and eventually eliminate volatile organic compounds (VOCs) in coatings.
3. Latex, which is the product of an emulsion polymerization, is a primary foundation for surface coatings.

Suggested Essential Questions

1. How is it possible to categorize coatings when there are so many uses for them?
2. Other than federal legislation, what factors could influence the drive for no VOC coatings?
3. If a latex glove is not paint, why is it called latex?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe the types of coatings, to include architectural (DIY), OEM, and specialty purpose coatings and their uses in industry. (DOK 1) OC3	a. **Hook:** "It's just paint." Ask students what their definition of a coating is, and then ask them to define paint. Facilitate a discussion about how coatings are more than just paint. Show students examples of various types of coatings, and discuss their uses. CLS1	a. Teacher observation
	Define a coating. Lecture on the three main categories of coatings and their uses in industry.	Teacher observation
	Discuss industry drivers that influence the production of coatings.	Teacher observation
	Define *adhesive*. Have the students discuss why adhesives may be considered specialty coatings.	Teacher observation
	Divide the class into three groups. Have each group identify local businesses that work in each of the areas of coatings (OEM, architectural, and specialty). Have them share their results with their classmates and discuss their findings. CLS3	Teacher observation, self-assessment, and peer assessment
	Show the students clips of the TLC show *Paint Misbehavin* to illustrate some new advances in coatings and their specialty uses. T3,T6	Teacher observation
	Performance task: You are a product research specialist for a coatings company whose job is to check out the work of the competition. You must choose a commercial product, research its synthesis, use, and any modifications (new versions or improvements) that have been made to the product in the last 10 years. Write a summary of your findings, and present an oral and written report to your superiors. Use any visual supplements (graphs, charts,	**Performance Task Rubric: Product Research**

			pictures, etc.) needed to help illustrate your findings. You will be graded on accuracy, thoroughness, and your presentation.[CLS1-2, CLS4-5, E1-E6, R1-R5, W1-W5, T3, T6]		
b.	Illustrate the synthesis of surface coatings. (DOK 1) [OC2, OC3]	b.	Introduce vocabulary, to include polymer/binder, pigment, additive, solvent, lacquer, stain, varnish, oil varnish, spirit varnish, adhesion, substrate, emulsion, and so forth.	b.	Teacher observation
			Lecture on the four ingredients that compose coatings (polymer/binder, pigment, additive, solvent).		Teacher observation
			Lecture on the three criteria for coating performance (formation of a continuous film, adhesion to the substrate, binder T_g). Discuss how the four components of a coating affect these criteria.		Teacher observation
			Discuss the concept of film formation as a class. Ask the students to brainstorm how continuous films are formed. Have some class artists draw their representations on the board.		Peer assessment and teacher observation
			Illustrate emulsion polymerization through an animated PowerPoint presentation. Revisit free radical addition polymerization, and relate the concept to emulsions.[T6]		Self-assessment and teacher observation
			Show the students examples of emulsions, such as milk and mayonnaise. Discuss the components of the examples, and see if the students can visually identify the individual components.		Peer assessment and self-assessment
			Lecture on UV curable and powder coatings as alternative types of coatings. Revisit the dip coating process. Describe why plastisol is considered a surface coating.		Teacher observation and self-assessment
			Carry out the experiment "Painting with Latex." Have the students write a lab report on the results they obtain.[CLS2, CLS4, E1-E6, R1-R5, S1- 3, W1-W5]		**Lab Report Checklist** Teacher observation
c.	Identify legislation that influences the push for no VOC coatings. (DOK 1) [OC3]	c.	Define VOC, latex, environmentally friendly, waterborne, and high-solids coatings. Explain that there are four main types of environmentally friendly coatings (waterborne, high solids, UV curable, and powder coatings).	c.	Teacher observation
			Discuss the 1990 Clean Air Act Amendments, to include Title I, Title III, Title V, and Title VI, and how they affect the coatings industry.		**Essay Rubric**

	Have the students use the Internet or other resources to write a short essay on one of the amendments to explain its impact on coatings and consumers.[CLS5, E1-E6, R1-R5, W1-W5, T3, T6]	
	Review for quiz or test.	Quiz/test
	Complete performance task.	**Performance Task Rubric**

Competency 2: Demonstrate the properties of coatings.[SPI-I, SPI-IV, SPI-V, MPC4, MPC12-13, MPC24, MPC34-36] (DOK 3)

Suggested Enduring Understandings

1. Coatings must be able to withstand the environmental factors they may encounter during their lifetime; thus, there are a variety of tests that help simulate these conditions.
2. Not all coatings need to be resistant to every factor that may cause degradation.

Suggested Essential Questions

1. Why should the properties of coatings be individually tailored to their uses?
2. How do laboratory tests compare to actual conditions that coatings may encounter during their lifetimes?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Demonstrate the various properties of surface coatings in relation to physical testing (i.e., blocking, scrub resistance, etc.). (DOK 3) [OC2, OC3]	a. **Hook:** "But I just wanted to color…." Give each student some markers or crayons and a piece of aluminum foil that has been painted with an indoor paint. Have them color or draw on the painted portion. When they are done, hang them up and ask the students to imagine this were their wall at home. Describe how their parents would react and what features would be nice for the paint to possess. How do they think these properties could be achieved?[CLS2]	a. Teacher observation
	Describe the various properties that would be desirable for coatings to possess. Have the students brainstorm why these properties are important, and give some examples of products where they would find them. Include properties such as impact resistance, adhesion, scrub resistance, weatherability (e.g., UV, water, salt, and fog), and so forth. Have the students switch examples with others and add to their partner's list.[CLS3, W1-W5]	Self-assessment and peer assessment
	Lecture on various physical tests of polymer coatings using the comic from the USM Macrogalleria: http://www.pslc.ws/ret2003/.	Teacher observation
	Complete lab experiments to examine adhesion, density, hardness, impact, bend, shrinkage, and exposure of various commercial coatings, such as Kilz spray, Kilz in a can, tempera, car wax, a gloss enamel, acrylic paint, Krylon spray, and epoxy: http://www.pslc.ws/ret2003/. Have the students	**Lab Report Checklist** Teacher observation

	write lab reports on the experiments.[E1-E6, R1-R5, S1-S3, W1-W5]	
	Performance task: You are an analysis technician for a local paint company. Your supervisor would like to know which of the company's products has specific properties, but your data has been mixed up by an intern. You do not know which sample matches the properties that your boss has given you. You must test each of a variety of unknown samples to find the product that most closely matches the properties and then write a lab report for your supervisor describing your findings. You will be graded on your accuracy, cleanliness, and thoroughness with experimentation.[E1-E6, R1-R5, S1-S3, W1-W5]	**Performance Task Rubric: Product Analysis**
	Review for test.	Test

Standards

Industry Standards: Society of Plastics Industry Standards

I. Essential Knowledge
IV. Material and Product Handling/Storage
V. Measurement, Analysis, and Response

Industry Standards: Polymer Standards for the State of Mississippi

MPC4 Communication: Applying effective verbal, nonverbal, and written communication methods to achieve desired results
MPC5 Compounding: Understanding the process of blending polymers with additives to produce a product for the forming industry.
MPC6 Customer Focus: Dedication to meeting or exceeding the expectations and requirements of both internal and external customers.
MPC12 Film Formation: Understanding the process of forming film by casting, extrusion, or other film-producing processes
MPC13 Finishing and Decorating: Understanding the methods used to decorate a part, or otherwise provide required surface appearance or properties
MPC17 Innovativeness: The ability to generate unique ideas and concepts that, if applied, could provide the organizations with a competitive advantage
MPC24 Processing: Understanding the methods used to control processes to achieve product, safety, quality, and environmental specifications
MPC28 Research Skills: Selecting, developing, and using methodologies such as statistical and data collection techniques for formal inquiry
MPC29 Resin and Additive Formulation: Knowledge of polymer materials to achieve appropriate formulation for intended purpose
MPC30 Rheology: Understanding formulation and flow of matter, including linkage and cross-linking of molecules to achieve specific properties
MPC33 Teamwork: Successfully and efficiently working and communicating with group or project members such that the team's final output meets or exceeds predefined expectations
MPC34 Technical Communications: The ability to translate and communicate required technical information to non-technical operational people
MPC35 Time Management: Valuing time and ensuring that it is used efficiently for all tasks
MPC36 Troubleshooting: The ability to formulate and evaluate alternative solutions to current or forecasted problems and implement the appropriate course(s) of action using rigorous logic and other probing methods

Mississippi Academic Course Competencies and Benchmarks

OC2 Demonstrate an understanding of the properties, structure, and function of organic compounds.
OC3 Discuss the versatility of polymers and the diverse application of organic chemicals.

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
R1 Main Ideas and Author's Approach

R2	Supporting Details
R3	Sequential, Comparative, and Cause–Effect Relationships
R4	Meaning of Words
R5	Generalizations and Conclusions
S1	Interpretation of Data
S2	Scientific Investigation
S3	Evaluation of Models, Inferences, and Experimental Results
W1	Expressing Judgments
W2	Focusing on the Topic
W3	Developing a Position
W4	Organizing Ideas
W5	Using Language

21st Century Skills Standards

CLS1	Flexibility and Adaptability
CLS2	Initiative and Self-Direction
CLS3	Social and Cross-Cultural Skills
CLS4	Productivity and Accountability
CLS5	Leadership and Responsibility

National Educational Technology Standards for Students

T3	Research and Information Fluency
T6	Technology Operations and Concepts

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Bettelheim, F. A., Brown, W. H., Campbell, M. K., & Farrell, S. O. (2006). *Introduction to general, organic, and biochemistry*. Thompson Brooks/Cole.

Davis, R. E. (2004). *Modern chemistry*. New York: Holt, Rinehart, and Winston.

Hill, J. W. (1992). *Chemistry for changing times*. New York: Macmillan, Maxwell Macmillan Canada.

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Polymer Science Learning Center. (n.d.). *Protector Man*. Retrieved November 12, 2009, from University of Southern Mississippi Web site: http://www.pslc.ws/ret2003/

Smoot, R. C. (1987). *Merrill chemistry: A modern course*. Upper Saddle River, NJ: Merrill.

Strong, A. B. (2008). *Fundamentals of composites manufacturing materials, methods, and applications*. Dearborn, MI: Society of Manufacturing Engineers.

Teegarden, D. M. (2004). *Polymer chemistry introduction to an indispensable science*. New York: National Science Teachers Association.

Suggested Rubrics and Checklists

Name: _____

Date: _____

Period: _____

Performance Task Rubric: Product Research

Criteria	1	2	3	4	Score
Presentation	Unorganized; does not flow; hard to follow; does not account for the knowledge of the audience; bland; no use of color or graphics	Ideas are organized, but presentation requires further explanation to follow; some use of color and graphics; obvious improvement needed.	Appropriately organized; some improvement needed to clearly understand the topic; appropriate use of graphics	Presentation flows easily and can be understood easily by the audience; good use of color and graphics; all required information is present.	
Thoroughness	No understanding of the science involved; did not include all topics	Poor understanding of the science; one reference; only a couple of topics researched	Decent explanation of the science; two references; most topics present	Effective explanation of science; all topics present	
Accuracy	Incorrect facts throughout the presentation; no data inclusion	One or two correct facts, but primarily poor information; poor representation of data	A few incorrect facts, but effective overall presentation; should improve representation of data	Complete factual information; good overall presentation and representation of data	
Total					

Teacher comments:

Name: _____

Date: _____

Period: _____

Lab Report Checklist

Did the student include the following information?

_____ Report title

_____ Appropriate section titles (i.e., Abstract, Introduction, Materials, Procedures, Results, Conclusion)

_____ Complete sentences when appropriate

_____ Relevant background information on the experiment in the introduction

_____ A list of all materials used in the experiment

_____ Detailed procedures for the experiment

_____ Any observations and reported results

_____ An explanation as to why the observed results occurred

_____ At least two sources of error

_____ A summary of any knowledge or insight gained from the lab experiment

_____ Correct and quality information throughout the report

_____ Was the report turned in on time?

_____ Did the student use proper grammar?

_____ Was the information organized appropriately?

_____ Was the report legible?

Teacher comments:

Name: _____

Date: _____

Period: _____

Essay Rubric

Criteria	1	2	3	4	Score
Writing Skills	Poor grammar and punctuation; only one paragraph; incomplete thoughts; no conclusion or defined topic	Poor grammar, but understandable; one or two paragraphs; no conclusion	Appropriately organized; some improvement needed to clearly understand the topic; poor conclusion	Correct grammar and punctuation; defined topic and conclusion; easy to read and understand	
Knowledge of the Topic	Little to no understanding of the project; shows lack of interest and research; unable to answer questions on the topic	Basic understanding of the task; very little interest (too easy); unable to sufficiently answer questions	Adequate understanding of the task; appropriate information for the audience; could be further studied	Questions answered easily; information is appropriate for the audience; shows interest and good investment of time	
Accuracy	Incorrect facts throughout the presentation	One or two correct facts, but primarily poor information	A few incorrect facts, but effective overall presentation	Complete factual information; good overall research	
Total					

Teacher comments:

Name: _____

Date: _____

Period: _____

Performance Task Rubric: Product Analysis

Criteria	1	2	3	4	Score
Cleanliness	Unorganized experimentation; poor lab skills; messy and unorganized report; lacks direction	Ideas are organized, but presentation requires further explanation to follow; poor lab skills; obvious improvement needed.	Appropriately organized; some improvement needed to clearly understand the topic; only a few errors in lab skills	Report flows easily and is easily understood; good lab skills; all required information is present.	
Thoroughness	No understanding of the science involved; did not test all samples	Poor understanding of the science; too many “guesses”	Decent explanation of the science; did not test one to two samples	Effective explanation of science; all samples tested	
Accuracy	Incorrect facts throughout the presentation; no data inclusion	One or two correct facts, but primarily poor information; poor representation of data	A few incorrect facts, but effective overall presentation; should improve representation of data	Complete factual information; good overall presentation and representation of data	
Total					

Teacher comments:

Name: _____

Date: _____

Period: _____

Polymer Activity from the POLYMER AMBASSADORS

*Teachers may reproduce this activity for their use.

Painting with Latex

Grades: 3–5, 6–8, and 9–12

Science Standards: Content Standard B: Physical Science; Content Standard G: History and Nature of Science; and Integration with Fine Arts

Concept: If you have purchased a T-shirt or a sweatshirt recently with a rubberized material on the front, you may have wondered how that material was originally applied. Many sports-related pieces of clothing such as numerals or team names and mascots are applied using colored and flexible elastomeric materials. This activity is designed to simulate how that process of applying colored elastomers can be duplicated in the classroom.

Materials
Liquid latex, stiff paint brushes, popsicle sticks (for stirring)
Tempera paint colors, 9-oz clear polystyrene cups, vinegar in spray bottles
Safety goggles, paper towels, plastic sheeting
Fine-point magic marker, optional latex gloves, cloth or fabric to paint

Safety
1. As liquid latex contains ammonia as a stabilizing agent, safety goggles should be worn in this activity to minimize any eye contact with the ammonia. Contact lenses should also not be worn for the same reason. Use copious amounts of water to flush any ammonia that may come into contact with the eyes.
2. A small portion of people are allergic to latex. Do not do this activity if you have allergies to latex or proteins.
3. Avoid contact of liquid latex with eyes, hair, body, and clothing. When the latex solution sets, it forms rubber. This material is extremely durable and is difficult to remove from unwanted materials. Old clothes or protective garments should be worn. Place long hair in ponytails and remove and store jewelry, watches, and so forth.
4. Although vinegar is considered relatively safe, avoid contact with the eyes and flush with water if contact with the eyes occurs.
5. Tightly cap latex containers when not in use to minimize ammonia vapors.
6. Paint brushes can be cleaned in soapy water.

Procedure
1. Prior to the activity, place protective plastic sheeting on work tables. Students are usually directed to wear old clothing on this day because it may get messy.
2. If the colors have not already been added to the liquid latex, this should be done.
   a. Fill a small plastic cup (i.e., 9-oz polystyrene cup) about half full of liquid latex.
   b. To the cup, add liquid tempera coloring and mix with a popsicle stick until the shade you desire is achieved. Discard the popsicle sticks.

3. We will be applying colored liquid latex to a size 3X Tyvek☐ab coat. You may wish to sketch your name or a design with a fine-point black magic marker prior to actually applying the colored liquid latex.
4. Paint your lab coat lightly with the colored liquid latex. If you were using cloth fabric, you should gently scrub the paint into the cloth. The liquid latex because of its thickness is sometimes difficult to apply with a normal paint brush. For this reason, I prefer the stiffer brushes. Return the brush to the same cup.
5. Pick another colored liquid latex if desired, and repeat the painting procedure.
6. After your masterpiece is finalized, the latex should be set. There are two methods:
   a. Air-dry the material or garment overnight.
   b. Spray the painted areas with vinegar. Dip in water and allow to dry.

Explanation

So what exactly is happening here? Latex is an elastomeric material that occurs naturally in the rubber tree. Its chemical composition includes many tiny particles or globules of this latex suspended in water in the natural state. When this sap is collected from the rubber tree, ammonia is added as a sort of preservative and a stabilizing agent. This keeps the latex from clumping and coagulating before it is used in an activity like "Painting with Elastomers."

After painting the latex on the fabric, it must be set so it will adhere to the fabric. We do this by adding a weak acid (like the vinegar we used) to the latex material. Vinegar is sometimes called acetic acid. When it is added to the latex, it reacts with the ammonia. The acidic vinegar neutralizes or destroys the activity of the ammonia and in so doing allows the latex to coagulate as rubber. After all of the ammonia has been neutralized, you may notice the characteristic ammonia smell is gone. Of course other acids (e.g., citric acid) could be used to achieve the same neutralizing effect. In a pinch, even a carbonated soft drink such as Coca-Cola or Pepsi-Cola, which contain phosphoric acid, could be used as the setting agent.

In eliminating the characteristic ammonia smell, you might possibly notice another entirely different smell. That smell would be sulfur as sulfur compounds are normally added to your latex. It should be remembered that the colors used in our latex will intensify (get darker) as the latex ages.

Extensions and History Link

1. Waterproof Coaster

A waterproof coaster can be made by taking a piece of cotton cloth fabric and cutting it into a circle. Apply the liquid latex to both sides of the fabric, and set the latex to the fabric as discussed in the procedure section above. After the latex has dried, test the coaster by placing water on the coaster to see if it sheds water.

(Painting with Latex, cont.)

2. Rubber-Soled Shoes

Polymer clothing had its infancy in 1868 when the Candee Manufacturing Company of New Haven, CT, created a type of canvas shoe with rubber soles it dubbed as "croquet sandals." Because they made no noise when people wore them, they became forever known as "sneakers." Even prior to this, approximately 400 years ago, Spanish explorers in Central and South America noticed that the native Indians had protective shoes and clothing. Indians coated their feet with rubber in what must have been the original "sneakers." They also had rubber-coated fabric they wore when it rained to keep dry.

References

Goates, W. (1995). *Chain gang: The chemistry of polymers*. Miami University, Middletown: Terrific Science Press.

Name: _____

Date: _____

Period: _____

Preparation of the Substrate Coatings

TEACHER NOTES

Objective: Students will prepare the substrates (surfaces) with various coatings for physical testing.

*** The teacher may choose to prepare the substrates the day before the classroom activities will be performed.

Supplies

- Reynolds Heavy Duty aluminum (cut into 50-mm by 150-mm strips)
- Microscope glass slides
- Various coatings (including paints, epoxies, and waxes)
- Paint brushes
- Tongue depressors
- Newspapers and boxes for splatter control

Safety

- Follow manufacturer's instructions on coating containers.
- Wear eye protection, lab coats or aprons, and gloves.
- Eye protection and gloves are extremely important in this activity, as paint tends to get everywhere.
- Preparations and paintings should be done in an adequately well-ventilated area.

Preparation

- Obtain the necessary number of microscope slides and strips of aluminum as you will need.
- Thoroughly clean the slides with lab detergent and acetone prior to preparation.
- Label each slide and/or aluminum foils with identifying numbers and letters on the underside of the substrate you plan to coat.
- Apply a very thin and even coat on the selected number of substrates for each coating that you will be testing.
- Let dry thoroughly in an undisturbed area.
- Examine the substrates and coatings after the coating is completely dry.

Name: _____

Date: _____

Period: _____

Adhesion Determinations of Various Polymer Coatings

TEACHER NOTES

Objectives: Students will

- test coating adhesion by the tape test.
- determine which coatings have the best and worst adhesion property.
- compare adhesion properties of coatings to other properties.

Applicable Science Concepts

- Following testing procedures
- Classification of results
- Comparisons between properties

Supplies

- Coating samples in their original containers
- Glass slides
- Straightedge metric ruler that can read 1 mm, preferably steel
- A cutting tool (sharp razor blade, scalpel, knife, or other cutting device)
- Pressure-sensitive tape, 1-in. wide (use the same brand type throughout)
- Rubber eraser (on the end of a pencil)

Safety

Manufacturers provide instructions for the use of their products, and these instructions should be followed completely. Protective gloves and lab coats should be used when preparing and handling the glass slides with coatings, and safety glasses should be used at ALL times. **EXTREME CAUTION** should be used at all times when handling sharp objects.

Activity

Taken from the ASTM Standard Test Method for Film Adhesion by Tape Test: ASTM D 3359 - 90 http://www.astm.org/cgi-bin/SoftCart.exe/BOOKSTORE/COMPS/CONTENTS/71.html?L+mystore+mhth9641

Preparation

Each group will need one glass slide of each coating obtained from the teacher.

Investigation Procedures

TEST METHOD A – X-Cut Tape Test

- An X-cut is made in the film, pressure-sensitive tape is applied over the cut and then removed, and adhesion is assessed qualitatively on the 0 to 5 scale.
- Select an area free of imperfections. Make sure that the surface is clean and dry. (Extremes in temperature or relative humidity may affect the adhesion of the tape or the coating.)
- Make two cuts (1.5 in., 40 mm) in the film that intersect near the middle (looks like an X). When making the cuts, use the straightedge and cut through the coating in one steady motion.
- Place the end of the tape on the edge of the counter, and pull the tape off the roll smoothly at a steady rate, not jerked, until about 3 in. (75 mm) is removed, and cut it with the razor blade. DO NOT TOUCH the adhesive side of the tape.
- Line up the cut edge of the glass slide with the tape, and slowly bring the glass slide up, adhering the tape to the cut film. Smooth the tape into place by running your finger over the glass slide, and then use the eraser end of a pencil to rub the tape down firmly.
- Slowly remove the tape from the counter edge by pulling up with the glass slide.
- Within 90 ±30 seconds of application, remove the tape by laying the glass slide down on a flat counter and slowly pulling the free end of the tape back at a constant rate, not jerked, at as close to an angle of 180° as possible.
- Inspect the X-cut area for removal of coating from the glass slide, and rate the adhesion in accordance with the following scale:
    - 5A No peeling or removal.
    - 4A Trace peeling or removal along incisions or at their intersection.
    - 3A Jagged removal along incisions up to 1/16 in. (1.6 mm) on either side.
    - 2A Jagged removal along most of incisions up to 1/8 in. (3.2 mm) on either side.
    - 1A Removal from most of the area of the X under the tape.
    - 0A Removal beyond the area of the X.

TEST METHOD B – Cross-Cut Tape Test

- A lattice pattern with six cuts in each direction is made in the film, pressure-sensitive tape is applied over the lattice and then removed, and adhesion is evaluated by comparison with descriptions and illustrations.
- Select an area free of imperfections. Make sure that the surface is clean and dry. (Extremes in temperature or relative humidity may affect the adhesion of the tape or the coating.)
- Cut through the film in one steady motion, making a lattice. Make six cuts across the slide, and make six cuts perpendicular to the first six (making a 6 by 6 chart). When using the guide (ruler) to make your cuts, place the guide on the uncut area. Space the lattice cuts about 2 mm apart.
- Place the end of the tape on the edge of the counter, and pull the tape off the roll smoothly at a steady rate, not jerked, until about 3 in. (75 mm) is removed, and cut it with the razor blade. DO NOT TOUCH the adhesive side of the tape.
- Line up the cut edge of the glass slide with the tape and slowly bring the glass slide up, adhering the tape to the cut film. Smooth the tape into place by running your finger over the glass slide, and then use the eraser end of a pencil to rub the tape down firmly.
- Slowly remove the tape from the counter edge by pulling up with the glass slide.
- Within 90 ±30 seconds of application, remove the tape by laying the glass slide down on a flat counter and slowly pulling the free end of the tape back at a constant rate, not jerked, at as close to an angle of 180° as possible.
- Inspect the lattice area for removal of coating from the glass slide and rate the adhesion in accordance with the following scale:
    - 5B The edges of the cuts are completely smooth; none of the squares of the lattice is detached.
    - 4B Small flakes of the coating are detached at intersections; less than 5% of the area is affected.
    - 3B Small flakes of the coating are detached along edges and at intersections of cuts. The area affected is 5 to 15% of the lattice.
    - 2B The coating has flaked along the edges and on parts of the squares. The area affected is 15 to 35% of the lattice.

- 1B The coating has flaked along the edges of cuts in large ribbons and whole squares have detached. The area affected is 35 to 65% of the lattice.
- 0B Flaking and detachment worse than grade 1B.

Report

- Which test was done
- The adhesion ratings
- Any deviation from standard conditions, including roughness in the finish

Conclusions

Have groups of students share their data with other groups by putting their data either on the board or on an overhead. Students should discuss why adhesion is important. Where would you use stronger or weaker adhesive coatings? Why? They can then compare the results of the adhesion test to other physical characteristics they have already observed.

OUR TEST RESULTS (TEST METHOD B – Cross-Cut Tape Test):

A: Armorall Car Wax – 2B	E: Epoxy – 5B
B: 100% Acrylic Latex – 1B	F: Krylon Spray Enamel – 1B
C: Oil-Based High-Gloss Enamel – 0B	G: Kilz Spray – 4B
D: Krylon Fusion – 2B	H: Kilz in a Can – 3B

Name: _____

Date: _____

Period: _____

Density Determination of Various Polymer Coatings

Teacher Notes

Objective

The purpose of this activity is to:

- determine the density of selected coatings such as house paints, epoxies, and waxes.
- compare density to impact resistance or hardness, for example.
- understand that density is defined as the mass per unit volume and in this activity is expressed in grams per milliliter.

Applicable Science Concepts

Density, volume, mass, volume measuring, and mass measuring

Supplies

- 20 mL and 1.0 mL syringes
- Coating samples in their original containers
- Electronic balances
- Paper towels

Safety

Manufacturers provide instructions for the use of their products and these instructions should be followed completely. Protective gloves, eye wear, and lab coat should be used when handling the coatings.

Preparation

Begin the activity with a discussion on coatings. Ask the students to identify the coatings, covering layers that they see around them every day. They should mention paint and waxes among others. Then ask what characteristics they would want in a paint for their car, house, boat, and so forth. Narrow the list to measurable characteristics, and discuss how each would be measured. Next, focus on density and direct a discussion on how they would go about finding the density of a liquid such as paint.

Investigation Procedures

The instructions are inquiry based and directed by you. To find the volume of the syringe mass of an empty syringe, fill it with distilled water to the 20.0 mL mark, and mass the filled syringe. Suggest that the students perform the same procedure three times. Then students should dry the syringe completely and fill it with the coating to the 20.0 mL mark. Mass the filled syringe being careful to cap the syringe and wipe any excess paint (coating) off the syringe and record all findings. Students

can then calculate the density of the coating. If time permits, each group could find the density of more than one coating. Paints can easily be handled in 20.0 mL syringes, but waxes would better be handled in a 1.0 mL syringe.

Tests results we obtained: Kilz liquid in a can - 1.23 g/mL; Krylon oil enamel - 0.94 g/mL; 100% acrylic latex- 1.07 g/mL; and Armor all car wax - 0.78 g/mL

Conclusions

Have teams of students put data on the board or overhead or put into a composite PowerPoint program. Students should then discuss the importance of this lab and how they might compare each coating with other physical characteristics they observed.

Reference

American Society for Testing and Materials (ASTM) D 1475-90 Standard Test Method for Density of Paint, Varnish, Lacquer, and Related Products

Name: _____

Date: _____

Period: _____

Hardness Determinations of Various Polymer Coatings

TEACHER NOTES

Objectives: Students will

- test coating hardness by the pencil test.
- determine which coatings have the best and worst hardness property.
- compare hardness properties of coatings to other properties.

Applicable Science Concepts

- Following testing procedures
- Variable control
- Angles
- Pressure control

Supplies

- Coating samples in their original containers
- Glass slides
- Set of calibrated drawing leads (preferred) or equivalent calibrated wood pencils meeting the following scale of hardness:

  6B- 5B- 4B- 3B- 2B- B- HB- F- H- 2H- 3H- 4H- 5H- 6H

  Softer Harder

- Abrasive paper (grit No. 400)

Safety

Manufacturers provide instructions for the use of their products, and these instructions should be followed completely. Protective gloves and lab coats should be used when preparing and handling the glass slides with coatings, and safety glasses should be used at ALL times.

Activity

Taken from the ASTM Standard Test Method for Film Hardness by Pencil Test: ASTM D 3363 - 74 (1989)
http://www.astm.org/cgi-bin/SoftCart.exe/BOOKSTORE/COMPS/CONTENTS/71.html?L+mystore+mhth9641

Preparation

- Each group will need one glass slide of each coating obtained from the teacher.
- A set of pencils with a hardness scale should be ready to use. Each group could obtain one of the pencils out of the set and test all of the different coatings with their pencil hardness. This will increase communication and sharing after the lab.

Investigation Procedures

- Each of the lead pencils should have approximately 3/16 to 1/4 in. (5 to 6 mm) of wood removed from the point of each pencil. A draftsman-type mechanical sharpener should be used, if possible, to leave a smooth cylinder of lead.
- Holding the pencil at an angle of 90° (straight up and down) to the abrasive paper, rub the lead against the paper in only ONE direction until a flat, smooth and circular cross-section is obtained, free of chips or nicks in the edge of the cross-section.
- Place the coated panel on a level, firm, horizontal surface, such as the top of a lab table.
- Starting with the softest lead, hold the pencil against the film at a 45° angle (point away from the operator) and push away from the operator. Exert sufficient uniform pressure downward and forward so that one of two results occur: one, the pencil will cut or scratch the film, or two, the edge of the lead will crumble.
- Repeat the process up the hardness scale until a pencil is found that will scratch the coating or will cut through the film to the glass slide below. You can feel for scratches with your fingernail.
- You can do the scratch test, gouge test, or both tests. Scratch hardness: at which hardness the coating is scratched. Gouge hardness: at which hardness the coating is cut or gouged.

Report

The one/two endpoints as follows:

- Gouge hardness – The hardest pencil that will leave the film uncut for a stroke length of at least 1/8 in. (3 mm)
- Scratch hardness – The hardest pencil that will not rupture or scratch the film
- The make and grade of lead or pencil used
- Any deviation from standard conditions, including roughness in the finish

Conclusions

Have groups of students share their data with other groups by putting their data either on the board or on an overhead. Students should discuss why hardness is important. Where would you use softer or harder coatings? Why? They can then compare the results of the hardness test to other physical characteristics they have already observed.

OUR TEST RESULTS (Scratch Hardness):

A: Armorall Car Wax – none	E: Epoxy – F
B: 100% Acrylic Latex – HB	F: Krylon Spray Enamel – F
C: Oil-Based High-Gloss Enamel – none	G: Kilz Spray – none
D: Krylon Fusion – none	H: Kilz in a Can – none

Name: _____

Date: _____

Period: _____

Impact Testing of Selected Coatings

Teacher Notes

Objective

Impact testing is used to evaluate the point at which the coating fails to protect the substrate by being degraded. Evidence of the point of failure includes but is not limited to the coating cracking, chipping, or completely separating from the substrate. You should lead a class discussion on the usefulness of impact testing and how to go about such testing. Students might come up with some interesting ways to perform the tests. A hammer struck on a surface might suffice. But try to lead the discussion to an organized approach with measurable results—science works that way. Where would such testing be important and what applications are evident?

Materials

- Prepared substrates on aluminum foil from the coatings preparation activity and the impact tester, which consists of a tube, a set of three marbles (use the big marbles in a marble pack available at WalMart), and a glass jar (50 mm in diameter by 50 mm high)
- The impact tester is made from a 4-ft piece of 1-in. PVC pipe available at any local hardware store. Drill a small hole perpendicular to the tube that is centered 15 cm from one end. The hole should be just large enough to loosely accommodate a nail. Continue to drill holes at 15-cm intervals down the tube. You should have approximately 10 cm remaining on one end so that a number of marbles can be held at the 105-cm mark.
- Use a ring stand and clamp to support the tube over the jar.
- Position the tube so that the first hole is 15 cm from the end closest to the jar.

Safety

Eye protection should be observed throughout this activity.

Procedures

1. Obtain coatings on prepared substrates and impact tester.
2. Place the aluminum strip with coating side up over jar opening so that the strip completely covers the jar opening.
3. Place the nail provided with the tube into the 15-cm hole so that the nail goes through the tube and provides a barrier for the marble.
4. Mass the marble you will use in the test, and drop it into the tube so that it rests above the nail at the 15-cm mark.
5. Center the tube over the jar containing the strip at least 1.0 cm above the jar. Measure the distance from the top of the strip/jar to the bottom of the tube and record that distance.
6. While holding the sides of the strip firmly to the sides of the jar, pull the nail out of the tube.
7. Carefully removed the marble from the strip and observe the results of the impact of the marble on the coating.
8. Repeat steps 2 through 7 using an untested portion of the strip and increasing the distance the marble falls by 15 cm by moving the nail further up the tube.
9. Continue to increase the distance the marble moves until the coating deforms to the point determined by your team and teacher. You might set a scale on distance of crack or break in the coating and other deformations. Possibly students could perform one test and then meet as a group to discuss how to interpret the results.

10. If after 105 cm the coating shows no sign of deformation, use a second marble and repeat the process starting at the 15-cm mark. If after 105 cm the two marbles show no deformation, use a third marble. Continue the process until the coating deforms.

We approximated the acceleration due to gravity as $10m/s^2$ ($9.8\ m/s^2$). The force of a 20.0-g marble would be :

$F = mxa = (0.020kg)(10m/s^2) = 0.2N$

To find the Nm of energy of the impact of the marble on the coating, multiply the force, in the example 0.2N, by the distance the marble travels in meters. Use the distance at which deformation first takes place. Using the above information, the following coatings failed at the specified Nm:

- Armor all car wax 0.03 Nm
- Krylon fusion 0.09 Nm
- Krylon spray enamel and Kilz spray 0.12 Nm
- 100% acrylic latex and oil based enamel over 0.6 Nm

Analysis

Develop a suitable means to visually present your findings to include a comparison of impact resistance to type of coating tested. The report also should include the thickness of coating and the thickness of the substrate. The Reynolds Heavy Duty aluminum used in our tests was 0.07 mm in thickness, and coatings were categorized as thin or thick.

Conclusion

Write a summary of your analysis and include which type of coatings would be suitable for high-impact use such as coatings on toys and low-impact use such as coatings on furniture.

Name: _____

Date: _____

Period: _____

Bend Test Determinations of Various Polymer Coatings

TEACHER NOTES

Objectives:

Students will:

- test coating bendability by the bend test.
- determine which coatings have the best and worst bendability property.
- compare bendability properties of coatings to other properties.

Applicable Science Concepts

- Following testing procedures
- Comparing and contrasting results
- Bending can rate how well a substrate will endure manufacturing bending and abuse during service and the ability to resist cracking when elongated.

Supplies

- Coating samples in their original containers
- Heavy duty aluminum foil
- Cylinders of various diameters
- We used the following:

Diameter *in.(mm)*	**Object**
1(25)	30-mL syringe
3/4(19)	White board marker
1/2(12.7)	Sharpie marker with added tape
3/8(9.5)	Pen

1/4(6.4)	Pencil
1/8(3.2)	No. 3 Allen wrench

Safety

Manufacturers provide instructions for the use of their products, and these instructions should be followed completely. Protective gloves and lab coats should be used when preparing and handling the glass slides with coatings, and safety glasses should be used at ALL times.

Activity

Taken from the ASTM Standard Test Method for Mandrel Bend Test of Attached Organic Coatings: ASTM D 522 - 88
http://www.astm.org/cgi-bin/SoftCart.exe/BOOKSTORE/COMPS/CONTENTS/71.html?L+mystore+mhth9641

Preparation

- Each group will need one aluminum foil panel of each coating obtained from the teacher.
- A set of objects with various diameters should be ready to use.

Investigation Procedures

- Place the test panel over the largest diameter.
- Using a steady pressure with your fingers, bend the panel approximately 180° around the diameter.
- Remove and examine the panel immediately for cracking visible to the unaided eye.
- If cracking has not occurred, repeat the procedure using successively smaller diameter objects on another area of the foil until either cracking occurs or the smallest diameter has been used.
- This procedure can be applied as a pass/fail test by determining whether cracking is produced by a specified diameter size.
- The resistance to cracking value for a coating is taken as the diameter greater than that at which cracking occurs—so, the last diameter where cracking does NOT occur.

Report

- The objects and their diameters used in the test (If need be, you can calculate diameter by wrapping a sheet of paper around the object, marking where the paper overlaps, laying the paper flat and measuring it with a ruler, and then finding the diameter from the equation "Circumference (perimeter) = $2\pi r = \pi d$" by dividing the length of the paper by π.)
- The value at which cracking occurs and the value before it cracks

Conclusions

Have groups of students share their data with other groups by putting their data either on the board or on an overhead. Students should discuss why bendability is important. Where would you use stiff or flexible coatings? Why? They can then compare the results of the bendability test to other physical characteristics they have already observed.

OUR TEST RESULTS (Diameter *in.(mm)*):

A: Armorall Car Wax – 1 (25)	E: Epoxy – 1 (25)
B: 100% Acrylic Latex – none	F: Krylon Spray Enamel – none
C: Oil-Based High-Gloss Enamel – none	G: Kilz Spray – 3/4(19)
D: Krylon Fusion – 1/4(6.4)	H: Kilz in a Can – none

Name: _____

Date: _____

Period: _____

Test for Coating Shrinkage

Teacher Notes

Objectives

Shrinkage is a concern to paint and dental adhesive manufacturers among others. Coatings should adhere to the applied substrate uniformly. This test determines the shrinkage among various coatings and serves as a comparison of different substrates on which the coatings are applied.

Applicable Science Concepts

- Scientific measurement
- Scientific method

Materials

- Saran wrap
- Wax paper or other suitable substrates that will allow the coating to shrink when applied
- Possibly students could select their own substrate to test and then compare results with other class members.
- Coatings in liquid or spray form
- Templates cut from folders with a 6-cm by 6-cm square cut in the middle of each sheet

Safety

Manufacturer's instructions should be followed, and eye, hand, and body protection is required.

Procedures

- The substrate should be placed in a space that has minimum traffic.
- Possibly this could be achieved by putting the substrate on top of newspaper, applying the coatings, and then placing the sheet of substrate in a safe place.
- Coating is normally dry in less than an hour but could take longer depending on the coating.
- Students should take care to paint or spray only on the template and quickly remove the template once the entire square is covered.

Analysis

Results of individual class groups can be arranged and statistical analysis performed. Our test results showed none to over 2 mm shrinkage among the various paints, epoxies, and waxes tested.

Conclusions

The results of this test should be correlated with other tests to determine the optimum coating for a given application. Also, the physical and chemical parameters should be explored and correlated with each other for a given application.

Name: _____

Date: _____

Period: _____

Environmental/Exposure of Various Polymer Coatings

TEACHER NOTES

Objectives: Students will

- gain an understanding of the effects of exposure on the physical characteristics of various polymeric coatings.
- gather data from extended observation to make conclusions/comparisons.
- use data to determine applicability of coatings in business/industry/environment.

Applicable Science Concepts

- Scientific inquiry
- Variable control
- Connection between science and technology
- Ultraviolet radiation/light frequency
- Data collection/comparison
- Temperature measurement

Supplies

- 2% NaCl solution (ocean water)
- Acetic acid solution, pH 6.5 (saliva)
- Acetic acid solution, pH 5.0 (acid rain)
- Ammonia solution, pH 10 (household cleaners)
- Disposable plastic pipettes
- Tray to secure slides to
- Clean glass slides
- Suggested coatings:
    1. Car wax (Turtle wax, Armorall)
    2. 100% acrylic latex paint (semi-gloss)
    3. Oil-based enamel (high-gloss)
    4. Krylon fusion (plastic restorative spray paint)
    5. Epoxy glue
    6. Krylon spray enamel
    7. Kilz spray paint

Safety

Manufacturers provide instructions for the use of their products, and these instructions should be followed completely. Protective gloves and lab coats should be used when preparing and handling the glass slides with coatings, and safety glasses should be used at ALL times. **EXTREME CAUTION** should be used at all times when handling sharp objects.

Preparation

- Before applying the coatings, each slide should be labeled on the side not to be coated according to which coating will be applied to that slide (e.g., Car wax slides will each be labeled (A).). The coatings should then be applied in thin even layers at least 48 hours in advance to ensure complete dryness. Proper safety attire (gloves, goggles, and apron) and ventilation are important in the application process. Therefore, coating application may serve as a fun outdoors activity.
- Prior to actual testing, divide the class into four groups, and assign a different environmental test to each group (HW1a).
- Each group will research each of the seven above listed coatings and study the performance of the coatings under various exposure related conditions such as ultraviolet radiation, acid rain, basic conditions, salt water, and even the slightly acidic conditions as those seen in the mouth (HW 1b).
- Each group should receive one of each of the seven coated sample slides. Upon receipt of their slides, each group should secure their samples to their group's tray. [IDEA: Tape white copy paper to the trays before securing slides in advance to reduce differences in reflected light.]
- The teacher should also prepare a tray of coated sample slides to be used as a control. [IDEA: Prepare control tray in advance to serve as an example for students.]
- Upon coated sample tray assembly, each group should receive its pre-prepared solutions of specific pH. The Ocean Water group should receive a salt water solution, the Acid Rain group should receive an acetic acid solution with a pH of ~5 (check the pH of acid rain in your area), the Saliva group should receive an acetic acid solution with a pH of ~6.5, and the Basic Solution group should receive an ammonia solution with a pH of ~10.
- Each group should also receive one dropper/disposable pipette per group. [IDEA: Have students determine how many drops of solution from an un-calibrated plastic pipette equals 0.1 mL of solution.]

Investigation Procedures:\

- Each group should make an initial observations data table of the physical characteristics of each coating before applying any of the solutions.
- After making initial observations, each group should add 0.1mL of its solution to each coating sample slide. Note whether the solution is absorbed or repelled, and compare the drop size among the different coatings/solutions.
- Place each group's slide tray in a sunny windowsill (trays should be clearly labeled to avoid future confusion/complications).
- Every 24 hours after the initial test, students observe the effect the solutions had on the coatings (see example data table).
- Following observations, students should reapply the 0.1 mL of test solution to each sample on their tray, taking care to keep the newly introduced amount of solution in the same proximity/area as in the prior test. [IDEA: Have students search the Web for the daily UV index for their area and record the UV index and temperature for each day of testing; check the weather channel Web site.]
- Repeat this procedure for approximately 2 weeks. The longer the experiment is maintained, the more pronounced the effects of the environmental test.
- Probable results after 2 weeks of "exposure": see typical results with sample coatings.

Conclusions/Class Discussion

- Have each group rank its coatings from best to worst performance under the specific exposure circumstances. Which coating performed the best? The worst?
- Have each group compare data and calculate which coating exhibited the best performance overall? The worst overall?
- What coating would be ideal for use in high-pressure/exposure circumstances? Is this practical in terms of economics/cost effectiveness?
- What coating would be ideal for coating the inside of a bottle used to store extremely basic cleaning solutions? Which would be the worst?

- What coating would be the most useful as a protectant of statues or even automobiles from acid rain? Which coating would be the least useful in this application? Name several current protective coatings used on automobiles.

Follow-Up

The following are links to end-of-lab quizzes. They can be administered with or without the student lab book, depending on competency level of the students.

NOTE: Open lab-book quizzes often encourage better note taking in the lab.

ACID RAIN ASSESSMENT
OCEAN WATER ASSESSMENT
BASIC SOLUTION ASSESSMENT
SALIVA SOLUTION ASSESSMENT

- Other possibilities of follow-up work include exploring the coatings further with other physical tests as seen throughout the Web site. Have students compare the results in exposure tests with results of adhesion or hardness tests in an “ultimate coating” project.
- Another possibility is a project-end research paper in which the students tabulate their data and make a mock presentation before the class with charts and visuals demonstrating why they think a certain coating has superior or inferior exposure qualities and give supporting evidence for their statements.

Unit 10: Composite Materials, Processing, and Applications

Competency 1: Examine composite materials to determine how such materials affect the finish properties of a composite structure. SPI-I, MPC16, MPC17, MPC24, MPC26, MPC28, MPC29, MPC33 (DOK 2)

Suggested Enduring Understandings

1. Composites are two or more materials combined to enhance and/or reinforce the finished material or product.
2. By understanding thermoplastic and thermoset resins, we can tailor the composite material to meet specific application requirements.
3. Cross-linking is used in thermoset composites to establish links between existing polymer chains.
4. Reinforcements for a composite can be fibers, particles, and/or strands that strengthen or improve the composite's performance.

Suggested Essential Questions

1. What types of materials or products are considered composite materials?
2. What advantages do composite structures have over traditional materials such as metals?
3. What is the chemical difference between thermoplastic and thermoset resins, and how does this difference affect their application?
4. How are typical thermoset resins (i.e., polyester and epoxy) utilized in common composite applications?
5. What effect does cross-linking have on the physical properties of composites?
6. How do fibers reinforce a composite matrix?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Demonstrate composite materials and how they are utilized in composite structures. (DOK 2) OC3	a. **Hook:** "1+1=3" Lead a discussion on the types of composite materials and how combining two types of materials (i.e., resins and fibers) will result in improved properties as a whole, versus their individual components. T4, R1-R3, CLS1	a. Teacher observation
	Create a K-W-L chart with students concerning composite materials. CLS1, CLS2	**K-W-L Chart**
	Provide students with enduring understanding and introduce essential questions.	Teacher observation
	Introduce vocabulary including composite, thermoplastic, thermoset, cross-linking, resin, epoxy, polyester, vinyl ester, polyurethane, fiber, particulate, chopped strand, aspect ratio, fiberglass, carbon fiber, graphite fiber, E-glass, laminate, Young's modulus, compression, tension, strength, strength to weight ratio, fillers, and additives. S1-S3	Self-assessment and teacher observation
	Lecture on composite's definition and composite materials such as resins, fibers, fillers, and additives. Also, tie in polymer synthesis mechanism to cross-linking mechanisms and how cross-linking is different from polymerization. S1	Teacher observation
	Have students prepare a journal entry on where/how composites influence and are present in their everyday lives. Have them	**Journal Rubric** Student self-assessment

	include at least 10 of the vocabulary terms in their journal entry. T1, T2, T4	
	Perform demonstrations: "String to Composite," "Varying the Stiffness of Paper," and "Examples of Fibers Used for Reinforcement." E2	Peer-assessment and demonstrations
	Complete the experiment "Stressed-Skin Composites." Have students compare Young's modulus, specific stiffness, and specific strength of beams of varying lengths, widths, heights, and cores. M1, M2, M4, M7,S1-S3, T6	**Lab Activity Rubric** Peer-assessment and demonstrations
	Perform the demonstration "Compression and Tension in a Bending Beam."	**Lab Activity Rubric**
	Complete at least one of the following experiments: "Plaster of Paris Matrix Composite," "Laminated Wood Beams," and/or "Using Portland Cement to Make and Test Concrete." All experiments calculate the breaking strengths of various beams by performing destructive tests in a three-point testing device. M1, M2, M4, M7,S1-S3, T6	Teacher observation and Self-assessment
	Review labs for quiz.	Quiz
	Performance task: *Note:* The performance task located in competency 2 involves both competencies 1 and 2.	**Performance Task Rubric**

Competency 2: Demonstrate different composite processing methods and composite applications. SPI-I, MPC16, MPC17, MPC24, MPC26, MPC28, MPC29, MPC33 **(DOK4)**

Suggested Enduring Understandings

1. Common composite processing methods are open molding, compression molding, resin infusion technologies, filament winding, and pultrusion.
2. Vacuum-assisted resin transfer (VARTM) and Seeman's composite resin infusion molding process (SCRIMP) are two composite processes that are utilized by Mississippi companies.
3. Automotive, marine, aerospace, and construction industries are all adopting composites technology to utilize improved strength to weight properties of composites.

Suggested Essential Questions

1. What are the most common composites techniques and which ones are important to Mississippi?
2. Why is the fiber loading (fiber/resin ratio) important in composites?
3. What physical properties are important to measure in composites, and how do you calculate them?
4. What applications/industries are adopting composites technology and why?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Demonstrate composite processes and applications and how they are utilized in composite structures. (DOK 2) [OC3]	**a. Hook:** "It's a boat, it's a plane, it's a super-composite!" Lead discussion on composites processing and what methods are used for different applications. [T4, R1-R3, CLS1]	a. Teacher observation
	Create a K-W-L chart with students concerning composite processes and applications. [CLS1, CLS2]	**K-W-L Chart**
	Provide students with enduring understanding and introduce essential questions.	
	Introduce vocabulary including hand lay-up, vacuum bagging, SCRIMP, VARTM, wet out, pultrusion, drop test, hardener, resin, peel ply, sealant, mold, balsa wood, breather, pre-preg, gel coat, mold release, curing, autoclave, viscosity, tacky tape, and spring. [S1-S3]	Self-assessment
	Lecture on composite's definition and composite materials such as resins, fibers, fillers, and additives. Also, tie in polymer synthesis mechanism to cross-linking mechanisms and how cross-linking is different from polymerization. [S1-S3]	
	Combine and complete the following experiments: "Hand Lay-Up of a Glass Fiber Reinforced Polymer" and "Pressure Laminated Glass Fiber Reinforced Polymer." Calculate and compare the weight percentage and Young's modulus for both types of beams. [M1, M2, M4, M7, S1-S3, T6]	**Lab Activity Rubric** **Journal Rubric**
	Lecture on the VARTM and SCRIMP processes. [S1-S3]	
	Invite local industry representatives to discuss details of process with the class and aid in designing a lab specific to their process (i.e., Northrup Grumman and Seeman's Composites).	**Lab Activity Rubric** Self-assessment
	Complete the experiment "Using Vacuum Bag Process to Form a Honeycomb Composite." Students will create an epoxy composite with a honeycomb core by utilizing the vacuum bagging process. Compare Young's modulus of this beam with those from beams made by other manufacturing processes (e.g., hand lay-up and pressure reinforced). [M1, M2, M4, M7, S1-S3, T6]	Peer-assessment **Performance Task Rubric**
	Break students into five groups. Assign each group one of the five composite manufacturing techniques: 1) open molding, 2) compression molding, 3) filament winding, 4) pultrusion, and 5)	

	vacuum bagging. Have students prepare a PowerPoint presentation describing the process, its common applications, and products. Have students present findings to the class. Web sites for students to consult: • http://www.acmanet.orgbsa/overview-processes.cfm • www.wikipedia.com CLS1-4, S1-S3, T1, T2, T3, T4, T6, W4	
		Test
	Review for test on the various manufacturing processes for composites.	
	Have students review the "Composite Beam Contest" lab. This will give the students a head start with their Performance Task. M1, M2, M4, M7, S1-S3, T6	Self-assessment
	Performance task: You are a research and development engineer for a leading boat manufacturer in the U.S. Your company is trying to find the most cost-effective way to produce a new line of recreational ski boats. Your job is to produce a boat with the greatest strength-to-cost ratio. You are responsible for carrying out destructive tests on laminate beams that you will produce using various resins, materials, and manufacturing processes. You will be required to give an oral presentation with a poster to accompany your results to the president of the company. You must prepare the following: 1) a formal lab report showing how you reached your conclusion, 2) a poster presentation outlining your results from your experiments, and 3) an oral persuasive presentation to the president of the company showing the money saved by using the qualifying beam. CLS1-4, M1-M5, M7, S1-S3, T1-T4, T6	**Performance Task Rubric** **Lab Report Rubric**

Standards

Industry Standards: Society of Plastics Industry Standards

I. Essential Knowledge

Industry Standards: Polymer Standards for the State of Mississippi

MPC16 Industry Understanding: Understanding the vision, strategy, goals, and culture of other companies within the polymer processing industry
MPC17 Innovativeness: The ability to generate unique ideas and concepts that, if applied, could provide the organizations with a competitive advantage.
MPC24 Processing: Understanding the methods used to control processes to achieve product, safety, quality, and environmental specifications
MPC26 Questioning: Gathering information from stimulating insight in individuals and groups through use of interview, questionnaires, and other probing methods
MPC28 Research Skills: Selecting, developing, and using methodologies such as statistical and data collection techniques for formal inquiry
MPC29 Resin and Additive Formulation: Knowledge of polymer materials to achieve appropriate formulation for intended purpose
MPC33 Teamwork: Successfully and efficiently working and communicating with group or project members such that the team's final output meets or exceeds predefined expectations

Mississippi Academic Course Competencies and Benchmarks

OC3 Discuss the versatility of polymers and the diverse application of organic chemicals.

ACT College Readiness Standards

E2 Organization, Unity, and Coherence
M1 Basic Operations and Applications
M2 Probability, Statistics, and Data Analysis
M3 Numbers: Concepts and Properties
M4 Expressions, Equations, and Inequalities
M5 Graphical Representations
M7 Measurement
R1 Main Ideas and Author's Approach
R2 Supporting Details
R3 Sequential, Comparative, and Cause—Effect Relationships
S1 Interpretation of Data
S2 Scientific Investigation
S3 Evaluation of Models, Inferences, and Experimental Results
W4 Organizing Ideas

21st Century Skills Standards

CLS1 Flexibility and Adaptability
CLS2 Initiative and Self-Direction
CLS3 Social and Cross-Cultural Skills
CLS4 Productivity and Accountability

National Educational Technology Standards for Students

T1	Creativity and Innovation
T2	Communication and Collaboration
T3	Research and Information Fluency
T4	Critical Thinking, Problem Solving, and Decision Making
T6	Technology Operations and Concepts

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Suggested Rubrics and Checklists

Name: _____

Date: _____

Period: _____

K-W-L Chart

Topic _____		
What I Know	**What I Want to Know**	**What I Learned**

Name: _____

Date: _____

Period: _____

Lab Activity Rubric

SKILL OR BEHAVIOR	ALWAYS (3)	MOST OF THE TIME (2)	RARELY (1)	NEVER (0)	TOTAL
Cooperated well with lab partners Listened to others Expressed opinions in professional manner Responded appropriately to others Respected others' opinions					
Followed verbal and written instructions Followed directions the first time Listened to teacher Accepted responsibility for actions Remained on task Allowed others to remain on task					
Followed safety rules Wore lab coat if applicable Wore goggles if applicable Wore gloves if applicable Followed specific safety rules for this particular lab Followed all other safety rules					
Cleaned and returned tools, supplies, lab coats, and goggles to proper location Cleaned all supplies Returned all supplies to proper place Disposed of all trash properly Cleaned lab tables Left chairs/stools in proper location					
Rate finished product. 1 to 5 (5 being the best)					
				Total	

Teacher comments:

Name: _____

Date: _____

Period: _____

Journal Rubric

Use this rubric to assess students' abilities to complete the journal activities assigned for this lesson. Share this assessment with students prior to completing the journal-writing lessons so they will understand how they will be assessed. You can also use the rubric as a basis for discussion and feedback with each student.

1. The student writes journal responses in complete sentences. _____
2. The student writes five or more sentences to answer questions. _____
3. The student responds to questions by self-questioning, retelling, predicting, or assuming the role of a character. _____
4. The student's experiences and opinions are clear. _____
5. The student works with a peer to share journal responses and to develop a combined response when requested. _____

TOTAL: _____

EXCELLENT (4)	VERY GOOD (3)	FAIR (2)	POOR (1)
The student completes the task with mo major errors. The student demonstrates a full understanding of the concepts.	The student completes the task with only a few major errors and some minor errors. The student demonstrates a strong understanding of the concepts.	The student completes the task with some major errors and many minor errors. The student has difficulty understanding the concepts.	The student fails to complete the task. The student does not understand the concepts.

Teacher Comments:

Name: _____

Date: _____

Period: _____

Performance Task Rubric

Criteria	1	2	3	4	Score
Presentation	Unorganized; does not flow; hard to follow; does not account for the knowledge of the audience; bland; no use of color or graphics	Ideas are organized, but presentation requires further explanation to follow; some use of color and graphics; obvious improvement needed.	Appropriately organized; some improvement needed to clearly understand the topic; appropriate use of graphics	Presentation flows easily and can be understood easily by the audience; good use of color and graphics; all required information is present.	
Thoroughness	No understanding of the science involved; did not include all topics	Poor understanding of the science; one reference; only a couple of topics researched	Decent explanation of the science; two references; most topics present	Effective explanation of science; all topics present	
Accuracy	Incorrect facts throughout the presentation; no data inclusion	One or two correct facts, but primarily poor information; poor representation of data	A few incorrect facts, but effective overall presentation; should improve representation of data	Complete factual information; good overall presentation and representation of data	
Total					

Teacher comments:

Careers in Polymer Science

Unit 11: School to Work

Competency 1: Explain and demonstrate the role human relations, teamwork, and leadership play in plastics and polymer manufacturing. SPI-I, MPC1, MPC4, MPC18, MPC33 (DOK 3)

Suggested Enduring Understandings

1. Human relations and interpersonal communication skills are essential to working effectively in plastics and polymer manufacturing.
2. A successful team is composed of members who do their jobs and work together toward a common goal.
3. Leaders start things, trigger and shape change, and guide others toward a common goal.

Suggested Essential Questions

1. What causes problems in human relations and communication?
2. Why do teams fail?
3. What is a leader?
4. How can you be taught to be a leader?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe and practice the qualities of an effective leader including positive attitude, image, decisiveness, communication skills, and being knowledgeable. (DOK 3)	a. **Hook:** "Following the leader" Use the "When somebody claps twice" instructions (at end of this unit) to require each student to model being a leader and a follower and the importance of working together to accomplish a goal. Keep in mind: "The human race has only one really effective weapon, and that is laughter. The moment it arises, all our harnesses yield, all our irritations and resentments slip away and a sunny spirit takes their place." -- Mark Twain Use response pads for quizzes and ExamView/Blackboard for tests throughout the unit. Have students consider the qualities of leadership. Compile a list of leaders chosen by the students on the whiteboard. Ask the people who nominated each leader what qualities the leader exemplifies. Write a list of unsuitable leadership qualities on the board after consultation with the group. Sum up that a boss may require people to obey because of the position she or he occupies but that this is not in itself enough for good leadership. A leader will inspire and motivate so that the group is empowered to achieve. List and rank the qualities of leadership, creating a hierarchy from most important to least important. Consider using the qualities below to provoke further analysis. Some qualities to consider in your hierarchy: strong-willed, receptive, visionary, committed, thoughtful, conscientious, innovative, charismatic, ambitious, empowering, communicative, progressive, intellectual, expert, passionate, tenacious, pioneering, inspiring, courageous, daring, positive attitude, image, decision maker, communication skills, and knowledgeable (include additional qualities).	a. Teacher observation

	List terminology related to human relations, teamwork, and leadership. Terms may include but are not limited to leadership, position authority, earned authority, vision, delegate, dynamics, and group dynamics. Have students work in small groups to define each word. Next, have students work in groups to determine a keyword or word clue for each vocabulary word. As an individual assignment, have students use technology productivity tools to define and illustrate terms and document in an e-notebook. Review for quiz.	Terminology quiz
	Discuss the importance of good human relations. CLS1, CLS3 Ask students, "Who would you be willing to follow anywhere with no questions asked?" Allow students to discuss their responses to this question. Make a list of leadership qualities on the board.	
	Read the following scenario to your students: Passengers are free to do a lot of things the driver cannot do. As a driver, your focus needs to be on the road and not on the distractions. As a driver, you no longer have the right to "mess around"—like listening to music—even though it seems okay to do that as a passenger. The same principle applies when you become a leader. You are no longer a passenger; you become the driver. Even though your responsibilities increase when you become a leader, you lose some of the rights or freedom you may have enjoyed in the past. For instance, if you want to be successful as a leader, you do not have the right to join employee pity parties and talk about your upper school/district administration. You lose the right to blame others for a problem in your center when you are a leader. You are the person responsible for everything that happens in your center, and that can be pretty hard to swallow. What type of driver are you? Have students use technology productivity tools, the writing process, and graphics to describe the type of "driver" they see themselves as. CLS4	**Journal Rubric**
	Jigsaw cooperative learning: Find two or three journal or Internet articles that have information related to different leadership styles, the importance of positive attitudes, decision-making skills, communication skills, and so forth. Divide students into home-base groups of three to five members depending on the number of texts to be read. Assign each student to a base group and a section of the article(s) to read (10 to 15 minutes of independent reading). Have students who have read the same section form small expert groups to discuss key aspects from their portion of the article (15–20 minutes). Have student experts return to their base groups, and invite each person to share the key points from his or her reading and discussion with others of the group (20–30 minutes). Then	**Cooperative Learning Activity Rubric**

		facilitate a large-group discussion identifying key concepts from the information that was read. Have students brainstorm to identify local community activities that provide leadership opportunities. Have students select someone they know who is a good leader and write a paper about what makes this person a leader. Students should be given a choice in projects based on their learning styles—PowerPoint, poster, video, audio recording, Web page, booklet, and so forth. Have students present their projects. E5 Have students evaluate themselves on leadership traits. Have students determine where they are now, decide what they need to do to become a successful leader, and develop an action plan to improve leadership and put in their notebooks. E3, E6, CLS3 Use the following Web site: http://www.fastennetwork.org/qryArticleDetail.asp?ArticleId=DBE41372-41AC-41AD-8A9C-F247DE4DD652. For every lab experience, have students evaluate their communication/teamwork/leadership skills and those of their peers with whom they worked.	**Oral Presentation Rubric** **Writing Rubric**
b. Prepare a project management methodology, and use it consistently. (DOK 4)	b.	**Hook:** "Don't be puzzled!" Bring a jigsaw puzzle in a Ziploc bag with no picture of the finished puzzle. Dump the puzzle on the table and ask students to attempt to put the puzzle together. Students may be able to piece together some edges; however, they quickly realize it will take longer, they must work harder, and they are very frustrated without a clear plan and without knowing what the outcome should be. Relate this to starting a project without using project management methodology. According to Wikipedia, *project management* is "the discipline[1] of planning, organizing and managing resources to bring about the successful completion of specific project goals and objectives." Have students research using the Internet to determine what project management methodology is. Have students use electronic sources, textbooks, and research articles to develop a strong understanding of project management. E3, E6, CLS2, CLS4 Lead a class discussion about the project manager's role, the importance of planning projects, good and bad organizational structures, and how project management will impact their success in class and the world of work. Have students work individually to develop and document a project management philosophy and methodology. Throughout the year, assign "project managers" on group projects. Allow that student to implement his or her project management methodology and reflect upon the process. CLS2, CLS5	b. Teacher observation **Writing Rubric**

c. Research and/or participate in personal development seminars, leadership conferences, and national/international exchange programs. (DOK 4)	c. Have students determine what the professional organizations are for polymer science. Have students use the following Web sites during their research: • http://www.certifyme.org • http://www.polymerprocessing.com/resources/soc.html • http://www.chemistry.org • http://www.4spe.org/index/php **Journal entry:** Have students list the advantages of belonging to professional organizations. Have students subscribe to publications provided by their professional organizations. Explain opportunities for leadership development through SkillsUSA and other professional organizations, such as the Society of Plastics Engineers (SPE). CLS2, CLS3, CLS5 Describe contests and awards programs. Encourage participation in personal development seminars. CLS5 Encourage students to attend leadership conferences and conventions. CLS3, CLS5 Explain national and international exchange programs. CLS1 Encourage students to participate in personal and community development programs. CLS3 Have students look at SPI industry standards and correlate these with their curriculum. Have students develop and document a plan in electronic notebooks for gaining the National Certification in Plastics (http://www.certifyme.org/studyguide/studyguide.htm). CLS5	c. Teacher observation **Journal Rubric** **Writing Rubric**

Competency 2: Explain and demonstrate employability skills over the course of the program. SPI-I, MC1, MPC4, MPC18, MPC33 (DOK 4)

Suggested Enduring Understandings

1. Employability skills are the basic skills for getting, doing, and keeping a job.
2. There are basic skills and employability traits that are transferable between job markets.
3. There are basic steps one must take to successfully gain employment.
4. There are laws to ensure fairness/equity in the workplace.

Suggested Essential Questions

1. What are the traits of a quality employee?
2. How can the traits of a quality employee transfer from job to job?
3. How does one find and get the job of her or his dreams?
4. What has happened in the past/present to justify the need for laws to ensure fairness/equity in the workplace?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Describe traits of a quality employee, including integrity, loyalty, responsibility, and so forth. (DOK 1)	a. **Hook:** "You're fired!" Use the **Employability Skills and Me** activity to guide students to partner and explore the process of looking at personal attributes and employability skills. Use response pads for quizzes and Examview/Blackboard for tests throughout the unit.	a. Teacher observation

		NOTE: From the first day students walk into your classroom, expect and accept nothing less than high-quality employee behaviors. Throughout each learning experience, continue to demonstrate employee expectations and expect high-quality employee behaviors. Have students describe traits of a quality employee. Write their responses for everyone to see. Discuss each trait. Use Internet sites to compare the student list of traits of quality employees: (http://www.rockingham.k12.va.us/WSPMS/Careers/goodemployee.htm and http://ezinearticles.com/?Becoming-A-Great-Employee---The-10-Top-Traits&id=950883). E2, E6, CLS3, CLS5 Ask students to evaluate themselves based on those traits. Have students discuss their answers within small groups. Have students work individually to develop a written plan to improve their traits. E2, E6, CLS3, CLS5 Use a communications activity to emphasize communication skills: http://www.skillsusa.org/educators/preppro.shtml. Use a web site for students to check employability skills: http://www.jobsetc.ca/toolbox/checklists/employability.jsp?lang=e. Invite a guest speaker to describe ethics in the workplace. CLS3 Give students an activity sheet (http://www.jobsetc.ca/toolbox/checklists/employability.jsp?lang=e) to use to gather data that can be transferred to a resume. CLS2, CLS5, E1-E5, E9 Have students use a role-play activity or use scenarios to demonstrate their understanding of good work ethics. E2, E5, E6, CLS3, CLS5 Teach students about employability skills using cartooned characters from the module demo found at http://www.workgo.net/?gclid=CNPchdWBlJsCFURM5QodHVEqqg. Click on module demo and have free access to the introduction: be there, be flexible, and stay calm. Introduce students to job-seeking skills to become employed in the plastics and polymer materials manufacturing industry. Have students save/print materials for their portfolios for future reference (http://www.udel.edu/CSC/jobskills.html). Review for quiz. Have students record their information in their notebooks. **Performance task part 1:** Choose any job in your town that you would really like to pursue right now. Write a list of traits that a person with this job should possess.	**Journal Rubric** Completed online activity sheet **Role-Play or Skit Assessment Rubric** Quiz **Notebook Rubric**
b. Prepare a resume containing essential information. (DOK 2)	b.	Discuss the importance of resumes and how to effectively develop a high school resume. Without any discussion, require students to list their current education, skills, work experience, awards, and activities. Students' lists will not be very long and	b. Employability skills lists

		will be incomplete. Revisit each list and brainstorm with students to help them recognize their valuable skills, work experiences, and important leadership/community activities. Emphasize that each student has valuable skills that have been learned during this class: CAD, MS Word, PowerPoint, e-mail, communication skills, presentation skills, safety precautions, operate Thermoforming Center 911, proper use of chemistry lab equipment, make molds, cast parts, hand-lay-up composites, vacuum-assisted resin transfer composites, and so forth. Emphasize the importance of working—mowing yards, baby sitting, and cleaning the house as well as traditional jobs available to high school students. Promote student involvement in extracurricular activities: sports, band, choir, organizations, clubs, volunteer work, community service, church work, and so forth. **Employability skills checklist:** Have students use the Web site http://www.kent.ac.uk/careers/sk/skillsinventory.html to develop a list of employability skills they have and a list of employability skills they need to work on. As students click on the skills, the Web site creates two separate lists available to copy and paste into MS Word.	
		The Web site http://www.theworkbuzz.com/category/resume may be used for students to get help writing resumes. Have students review and analyze sample resumes—good and bad. Review for quiz.	Analysis of good/bad resumes Quiz
		Have students use their lists and MS Word resume templates to prepare resumes containing essential information. Discuss the importance of format, education, and experience. (Extension: Student lists offer excellent aids in writing essays telling who students are and why someone should hire them or why they should be awarded scholarships. Students are more likely to apply for scholarships and jobs if they have such an essay already prepared.) Have students write/type a resume specific to a job they would like to have. CLS2, CLS5, E1-E5, E6	**Resume Rubric**
		Have students look at samples of letters of application/cover letters (http://jobsearch.about.com/od/coverlettersamples/a/targeted2.htm) and write a letter of application to mail with the resume. CLS2, CLS5, E1-E5, E6	Application letter/cover letter
		Have students record their information in their electronic notebooks. **Performance task part 2:** Remember the job you chose in your town that you would really like to pursue. Write a resume for that job. Try to incorporate some traits from the list you made of traits a person with this job should possess.	**Notebook Rubric**
c. Complete a job	c.	Discuss the purpose of job applications and tips on how to	c. Teacher

	application. (DOK 1)		complete applications that will help students impress employers. Discuss the importance of the format, completeness, zero mistakes, grammar, and spelling. Have students review and analyze sample completed job applications—good and bad. Use the Web site http://www.kent.ac.uk/careers/applicn.htm to explore do's and don'ts of job applications. Review for quiz. Have students complete job applications (paper/pen and online) of their choice. **Performance task part 3:** Remember the job you chose in your town that you would really like to pursue. Complete a job application for that job. Have students record their information in their electronic notebooks.		observation Analysis of good/bad job applications Quiz **Job Application Rubric** **Notebook Rubric**
d.	Describe and demonstrate the procedures for a job interview. (DOK 2)	d.	Discuss the importance of job interviews as well as tips to prepare for successful interviews. Use the Web site http://www.kent.ac.uk/careers/applicn.htm to explore do's and don'ts of interviews. Use the Web site http://www.kent.ac.uk/careers/interviews/ivquest.htm to allow students to discover sample interview questions and accompanying appropriate answers. Use http://www.theworkbuzz.com/category/interviews to help students prepare for interviews. Review for quiz. Have students role-play interviews and evaluate themselves and each other. Set up real or mock interviews conducted by adult(s) to simulate student interviews with industry. Stress to students the importance of writing a thank-you letter after an interview. E3, E6, CLS2, CLS4, CLS5 **Performance task part 4:** Remember the job you chose in your town that you would really like to pursue. You have a real (or mock) interview for this job. Have students record their information in their notebooks.	d.	Teacher observation Quiz **Role-Play or Skit Assessment Rubric**

			Interview Rubric **Writing Rubric** **Notebook Rubric**
e. Explain personnel law, requirements of Title IX Law, and employment procedures as related to plastics and polymer materials manufacturing industry. (DOK 1)	e. Use a multimedia presentation to explain personnel law as applied to employees in the plastics and polymer materials manufacturing industry. Describe requirements of the Title IX Law as it applies to equity and protection from harassment and discrimination in the plastics and polymer materials manufacturing workplace (http://www.dol.gov/oasam/regs/statutes/titleix.htm). Invite the EEOC (Equal Employment Opportunity Commission) to speak to students. Review employment procedures as outlined by the Civil Rights Act. Describe Medical Family Leave Act provisions. Conduct role-playing activity to ensure understanding of these laws. CLS1-CLS3, CLS5, E2, E6 Review for quiz. Have students record their information in their notebooks. E1	e. Teacher observation **Role-Play or Skit Assessment Rubric** Quiz **Notebook Rubric**

Competency 3: Apply skills needed to be a viable member of the workforce. SPI-I, MPC1, MPC4, MPC18, MPC33 (DOK 4)

Suggested Enduring Understandings	Suggested Essential Questions
1. A variety of skills are needed to be a viable member of the workforce. 2. Hiring and developing the right people with appropriate expertise is critical to maintaining an effective and sustainable workforce.	1. What skills do you need to be able to do the job that you would like? 2. How can you prove/show a potential employer that you have the skills/expertise required to do a certain job? 3. What difference will you make in the world if you get the job you want?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Prepare a description of and demonstrate	a. **Hook:** "Got skills?" Have students read the article at http://careerplanning.about.com/	a. **Journal Rubric**

	technical skills to be developed in the supervised work experience program. (DOK 4) [OC3]	b/2008/09/26/got-skills-2.htm. Lead a discussion about the need to have and apply skills for the 21st century workplace. Use response pads for quizzes and ExamView/Blackboard for tests throughout the unit. Use http://online.onetcenter.org/ for students to find the skills required to do particular jobs of their choice. The home page allows the user to find occupations and conduct a skills search and a tools and technology search. Have students use the tools and technology search to match skills they already have to particular jobs—document results. Have students research three jobs for which they would like to participate in a supervised work experience program and document the required skills for each job. [T1, T2, T3, T4, T5, T6] Promote the value of work experience by encouraging mastery of new and diverse skills for work and real life. Relate student's choice of jobs to polymer science class. Update notebooks. [W1, W5]	**Notebook Rubric**
b.	Demonstrate human relationship skills in the supervised work experience program. (DOK 4)	b. Have students review human relations skills and work ethic skills to include knowing the following: what your employer expects, problem solving and teamwork, how to communicate on the job, mathematics in the workplace, computer and Internet skills, the importance of appearance, safety on the job, leadership and group dynamics, how to participate in meetings, about careers, how to job hunt, job satisfaction and the law, how to succeed in the economic system, entrepreneurship, how to manage a budget, insurance, and citizenship. [CLS3, CLS5] Students will role-play and evaluate acceptable/unacceptable scenarios. [CLS3, CLS5, E1-E5, E6] **Performance activity:** Write and perform a skit that demonstrates application of information to solve potential problems (technical skills and/or human relationships) faced in the work place.	b. Use ExamView and/or the Blackboard Learning System to administer a test. **Role-Play or Skit Assessment Rubric** **Role-Play or Skit Assessment Rubric**

Competency 4:	**Work with instructor and/or employer to develop, assess, and document performance of written occupational objectives to be accomplished during a polymer-related internship and/or simulated polymer industry.** SPI-I, MPC1, MPC4, MPC18, MPC33 (DOK 4)

Suggested Enduring Understandings	**Suggested Essential Questions**
1. A weekly job plan is essential to keep employees on task and to keep projects on schedule. 2. Job expectations and performance results should be documented in order to ensure clarity and to avoid confusion.	1. Why is it necessary to document a plan of action/results per week, month, year, and so forth? 2. What skills are needed to design and manufacture a polymer product?

Suggested Performance Indicators	Suggested Teaching Strategies	Suggested Assessment Strategies
a. Develop and follow a set of written guidelines for the supervised work experience program. (DOK 4)	a. **Hook:** "The clock is ticking!" Have a time clock and time cards ready for students to punch when they walk into the classroom. Emphasize that while students are "on the clock" they will be earning points instead of dollars. **Performance task 1: Are you bringing home the bacon?** Have students fill out W-2 forms. Reality check: employee payment is strictly by the hour; therefore, if students are absent for any reason (no paid sick leave), either the time must be made up or they will be "docked." Teach students to compute their time from punched time cards. After students calculate time cards, have them search for and use free Internet time card calculator sites to verify their calculations. At the end of the week, have students calculate their total hours and turn in time cards. Convert hours from time cards into a simulated 40-hour work week (for example, 1.5 hours per day [or 7.5 hours/week] in class would be the same as working an 8-hour day [or 40 hours/week]). The following week, give students a fake paycheck ($8/hour * # hours worked) showing gross pay and net pay showing deducted taxes. Ask students to use MS Office to make a budget for the week showing how their paycheck will be spent. Continue the process for a month. After the first week, give students unexpected expenses, such as car repair, medical bill, house repair, and so forth. T1, T2, T3, T4, T5, T6 Have students complete one or more of the following school-to-work activities and develop and follow written guidelines for each. Students may use the Weekly Work Plan to plan each week and revisit the previous week to rethink and revise work experience. **Work-based learning:** Work with industry to	a. NOTE: The following assessment strategies should be used as needed according to the teaching strategies you choose. **Journal Rubric** **Employability Skills and Me** **Workplace Readiness Rubric** Weekly self-evaluation of project **Weekly Work Plan** **Research and Project Rubric** **Role-Play or Skit Assessment Rubric** **Presentation Assessment Rubric** Use response pads for quizzes and ExamView/Blackboard for tests throughout the unit.

determine skills needed for the job and to place students appropriately. Prepare materials to help students be prepared for personal and technical success in the position. Job assignment cards prepared with input from the employer enhance productivity and direction (http://pblchecklist.4teachers.org/testing.php3?idunique=3&max=6&checklist=9). Partner with the supervisor to provide the optimal learning experience. Examples of work-based learning forms and documentation may be found at http://www.eed.state.ak.us/tls/cte/wblguide.html CLS1-6

Design and manufacture a polymer product:

Note to instructor: Emphasis should be placed on **student** design and manufacture of a polymer product—NOT teacher-given instructions. Require students to think through and plan the entire project from initial idea to finished product; include plans for unanticipated problems/delays. Transform the classroom into a true polymer/plastics manufacturing industry for an authentic supervised school-to-work experience. The instructor should act as a facilitator/supervisor to monitor and intervene with probing questions to redirect student thinking to avoid mistakes and potential problems when necessary. This instruction method will allow students to retain full ownership of their projects.

Have students read information regarding the business component of the polymer product design process. This is an excellent site that summarizes polymer/plastics processes/products (http://www.cpia.ca/files/files/files_BusinessSC.pdf). Use a text-based seminar (http://www.turningpts.org/pdf/TextBasedSeminar.pdf) to facilitate discussion about the article.

Use a multimedia presentation and resources from the Internet to explain polymer product design.

Have students work in groups to **design a polymer and manufacture a polymer product**. Have students develop a marketing presentation for why the product is needed. Have students develop a budget including materials needed and costs associated with materials and building the product. Have students develop a procedure that documents quality control based on Six Sigma standards. CLS2, CLS5, E1-E5

Have students manufacture their products following their procedures. Have students evaluate the processes and products and make necessary changes. Have students simulate an internal audit (done by them) and then an external audit (done by the teacher). CLS2, CLS5, E1-5, E6 Have students make presentations to the class. Have class members peer evaluate the processes and products and vote on the best product. CLS2, CLS5, E1-5, E6

Teach elementary/middle school students: Teach a unit to elementary/middle school students. Have a discussion with the students about the need for more polymer science workers and the need for more students to take the course. Show the students an example of a good lesson plan and the components (http://www.teachnology.com/teachers/lesson_plans/science/chemistry/).Have them select a unit with activities that are appropriate for their audience and prepare their lesson plans, materials, and assessments.

PRACTICE: Videotape each student practice teaching. Require students to self-assess and peer assess videos. Upon approval by the teacher, the student will practice teach to his or her peers for another evaluation. Have the student visit with the teacher and set up a time to teach the lesson. After teaching the lesson, the teacher should evaluate the student. Feedback from students being taught is valuable for growth and improvement.

Teach elementary/middle school students by conducting a "Polymer and Plastics Technology Fair." Allow students to choose a polymer-/plastics-related topic to showcase/demonstrate/lead experiment with elementary students. Require students to write the script they are going to say when students visit the booth emphasizing polymer terms/science/processes. Have polymer students set up booths and materials for each polymer student to manage during the fair. Rotate groups of four to five elementary/middle school students through the booths at 5- to 7-minute intervals. Promote hands-on booths that allow elementary/middle school students to participate and take home polymer-related products.

PRACTICE: Videotape each student practicing her or his booth presentation. Require students to self-assess and peer assess videos. Student will practice booth operation to his or her peers for another evaluation. Following the fair, ask the visiting instructors and students to evaluate each booth/student. Feedback from students being

taught is valuable for growth and improvement.

Performance task 2: Allow students to work in teams of two to four and follow the guidelines for the ExploraVision Awards found on the Web site www.exploravision.org. The ExploraVision project must start at the beginning of the school year because the deadline for entry submission is in January of each school year.

Performance task 3:

Have the student do the following:

- Select a real-world problem related to his or her polymer career interest.
- Conduct research related to the problem.
- Identify teachers, business, and postsecondary education partners with relevant expertise of the problem and possible solution. (The student will work closely with adults of content expertise.)
- Analyze and synthesize information to solve the problem. (Challenge the student to apply knowledge related to both academic and technical subjects.)
- Maintain reflective journals of the project's progress. Students should use photos/video and writing to document progress, self-assessment, and necessary revisions.
- Establish with teacher checkpoints for assessment to ensure the project timeline is on track and student is meeting standards for the project. (Assessment is formative, with multiple checkpoints along the way, providing feedback to the student. Adults outside the classroom help the student develop a sense of real-world standards.)
- Develop a multimedia presentation to adult partners detailing problem identification, research, and the student's solution or recommendation. The presentation should demonstrate what the student has learned.

					Assess progress and final entry using the ExploraVision rubric found at www.exploravision.org. **Polymer Project Task Proposal**
b.	Perform written occupational objectives in the supervised work experience program. (DOK 3)	b.	Have students keep an electronic journal in table format in Blackboard of all work activities including samples of their work. Using digital cameras, document daily progress, skills, and safety precautions used during the experience. With each photograph, an explanation of polymer processes and relevance should be included.	b.	**Journal Rubric**
c.	Prepare daily written assessment of	c.	Have students keep an electronic reflective journal in table format in Blackboard where they evaluate	c.	**Journal Rubric**

	accomplishment of objectives. (DOK 3)		their work each day. Comments should include evaluation of what should have been done differently and what are the next day's steps for achieving work objectives. If working with other students, their electronic reflective journal should include a daily peer evaluation as well. CLS3-6, E1, E6		
d.	Present weekly written reports to instructor of activities performed and objectives accomplished. (DOK 3)	d.	Have students turn in the week's worth of work in table format from performance indicators (b) and (c) above. Instructors should give appropriate feedback to promote student achievement of objectives. Students should make any adjustments and corrections as needed. W1, W5	d.	**Journal Rubric**
e.	Prepare and finalize electronic portfolio to include all relevant materials. (DOK 4)	e.	Have students tweak their electronic journals in Blackboard and submit artifacts as a separate electronic portfolio of the supervised work experience program. W1, W5	e.	**Notebook Rubric**

Standards

Industry Standards: Society of Plastics Industry Standards

I. Essential Knowledge

Industry Standards: Polymer Standards for the State of Mississippi

MPC1 Business Understanding: Understanding the inner workings of business functions and how business decisions affect financial or non-financial work results
MPC4 Communication: Applying effective verbal, nonverbal, and written communication methods to achieve desired results
MPC18 Leadership: The ability to influence and guide members of the organization to achieve organizational objectives
MPC33 Teamwork: Successfully and efficiently working and communicating with group or project members such that the team's final output meets or exceeds predefined expectations

ACT College Readiness Standards

E1 Topic Development in Terms of Purpose and Focus
E2 Organization, Unity, and Coherence
E3 Word Choice in Terms of Style, Tone, Clarity, and Economy
E4 Sentence Structure and Formation
E5 Conventions of Usage
E6 Conventions of Punctuation
W1 Expressing Judgments
W5 Using Language

21st Century Skills Standards

CLS1 Flexibility and Adaptability
CLS2 Initiative and Self-Direction
CLS3 Social and Cross-Cultural Skills
CLS4 Productivity and Accountability
CLS5 Leadership and Responsibility

National Educational Technology Standards for Students

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

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Suggested Rubrics and Checklists

Name: _____

Date: _____

Period: _____

When Somebody Claps Twice Directions for Instructor

Cut out the "When someone…." statements into separate slips of paper.

Hand out slips of paper to participants (one to each; if you have more papers than group members, it is okay to duplicate)

Explain to the group that you are working toward a goal (of receiving a piece of candy). Each person must do his or her part to accomplish the goal. This equals PROBLEM SOLVING. The group may not get this exercise right away.

Make sure that each member in the group does not share the content of her or his slip of paper with anyone else.

After giving them a moment to read their papers, the facilitator claps twice.

If the exercise stalls or someone messes up, you must start the game over.

Evaluation
Talk about what happened. What did they have to do to complete the task? Were there any problems, and if so, how did they go about fixing them? Why is it important to pay attention when someone else is talking? How important is it to multitask? Is it easy to be distracted?

- When somebody claps twice, stand up and say, "**Good morning**."
- When somebody says, "Good morning," get up and say, "**The lights are out**."
- When somebody says, "The lights are out," yell "**It's dark in here**!"
- When somebody says, "It's dark in here," stand up and say, "**But the lights are on**."
- When somebody says, "But the lights are on," **stand up and spin around twice**.
- When somebody spins around twice, **make a cow noise**.
- When somebody makes a cow noise, stand up and say, **"I'm glad to be here."**
- When somebody says, "I'm glad to be here," **stand up and flap your arms like a bird.**
- When somebody flaps his or her arms like a bird, **make a loud sneezing sound**.

- When somebody makes a loud sneezing sound, **feel the forehead of the person next to you and shout, "Somebody get a doctor**!"
- When somebody shouts, "Somebody get a doctor," sing, "**I'm a Little Teapot**."
- When somebody sings, "I'm a Little Teapot," **walk around the leader/counselor three times**.
- When somebody walks around the advisor three times, **laugh really loudly.**
- When somebody laughs really loudly, **stomp your feet.**
- When somebody stomps her or his feet, **do a cheerleading move and say,** "**Rah! Rah! Rah!**"
- When somebody does a cheerleading move and says, "Rah! Rah! Rah," **tell us what time it is.**
- When somebody tells us what time it is, **shake hands with the person next to you and loudly say,** "**Nice to meet you**."
- When somebody says, "Nice to meet you," say, "**I have a question.**"
- When somebody says, "I have a question," yell, "**The answer is seven**."
- When somebody says, "The answer is seven," **go to the front of the room, and make the letter Y with your body.**
- When somebody makes the letter Y with his or her body, **grab two other people, go to the front of the room, and make the letters M, C, and A; then sing** "**YMCA**."
- When somebody sings "YMCA," **hop on one foot for 5 seconds, and say,** "**I'm a rabbit**."
- When somebody says, "I'm a rabbit," say, "**Here comes Peter Cottontail**."
- When somebody says, "Here comes Peter Cottontail," **give everybody a piece of candy**.

Name: _____

Date: _____

Period: _____

Journal Rubric

Use this rubric to assess students' abilities to complete the journal activities assigned for this lesson. Share this assessment with students prior to completing the journal writing lessons so they will understand how they will be assessed. You can also use the rubric as a basis for discussion and feedback with each student.

1. The student writes journal responses in complete sentences. _____
2. The student writes five or more sentences to answer questions. _____
3. The student responds to questions by self-questioning, retelling, predicting, or assuming the role of a character. _____
4. The student's experiences and opinions are clear. _____
5. The student works with a peer to share journal responses and to develop a combined response when requested. _____

Total _____

EXCELLENT (4)	VERY GOOD (3)	FAIR (2)	POOR (1)
The student completes the task with mo major errors. The student demonstrates a full understanding of the concepts.	The student completes the task with only a few major errors and some minor errors. The student demonstrates a strong understanding of the concepts.	The student completes the task with some major errors and many minor errors. The student has difficulty understanding the concepts.	The student fails to complete the task. The student does not understand the concepts.

Teacher comments:

Name: _____

Date: _____

Period: _____

Cooperative Learning Activity Rubric

Skill or Behavior	Always (3)	Most of the Time (2)	Rarely (1)	Never (0)	Score
Cooperated well with lab partners Listened to others Expressed opinions in professional manner Responded appropriately to others Respected others' opinions					
Followed verbal and written instructions Followed directions the first time Listened to teacher Accepted responsibility for actions Remained on task Allowed others to remain on task					
Rate finished product. 1 to 5 (5 being the best)					
				Total	

Teacher comments:

Name: _____

Date: _____

Period: _____

Oral Presentation Rubric

	EXCEPTIONAL (4)	ADMIRABLE (3)	ACCEPTABLE (2)	AMATEUR (1)	SCORE
Content	An abundance of material clearly related to topic; points are clearly made and all evidence supports topic; varied use of materials.	Sufficient information that relates to topic; many good points made but there is an uneven balance and little variation.	There is a great deal of information that is not clearly connected to the topic.	Topic not clear; information included that does not support topic in any way	
Coherence and Organization	Topic is clearly stated and developed; specific examples are appropriate and clearly develop topic; conclusion is clear; shows control; flows together well; good transitions; succinct but not choppy; well organized.	Most information presented in logical sequence; generally very well organized but better transitions from idea to idea and medium to medium needed	Concept and ideas are loosely connected; lacks clear transitions; flow and organization are choppy.	Presentation is choppy and disjointed; does not flow; development of topic is vague; no apparent logical order of presentation.	
Creativity	Very original presentation of material; uses the unexpected to full advantage; captures audience's attention	Some originality apparent; good variety and blending of materials/media	Little or no variation; material presented with little originality or interpretation	Repetitive with little or no variety; insufficient use of multimedia	
Material	Balanced use of multimedia materials; properly used to develop topic; use of media is varied and appropriate	Use of multimedia not as varied and not as well connected to topic	Choppy use of multimedia materials; lacks smooth transition from one medium to another; multimedia not clearly connected to topic	Little or no multimedia used or ineffective use of multimedia; imbalance in use of materials—too much of one, not enough of another	
Speaking Skills	Poised, clear articulation; proper volume; steady rate; good posture and eye contact; enthusiasm; confidence	Clear articulation but not as polished	Some mumbling; little eye contact; uneven rate; little or no expression	Inaudible or too loud; no eye contact; rate too slow/fast; speaker seemed uninterested and used monotone.	
Total					

Writing Rubric

	EXCELLENT (3)	SATISFACTORY (2)	UNSATISFACTORY (1)	SCORE
Content	Paper is well developed with more than enough information. Information is clearly presented with elaborations.	Paper is fairly well developed with enough information to inform the reader about the topic. Information is clearly presented with some elaborations.	Paper has little development and a minimum amount of information. Some information is confusing.	
Details	Plenty of specific details that more than adequately explain the topic	Some specific details that adequately explain the topic. Some do not help explanation.	May not have details, and/or details may be wrong.	
Organization	Clear organization and no straying	Has somewhat of an organization and tries to stick to it	If there is an organization, it is not clear and writer strays from it.	
Audience	Written for intended audience	Written for intended audience in most cases	Does not address the intended audience	
Language Choices	Uses language choices to maintain a style or a tone	Uses some language choices to maintain style or tone	Does not use language choices to help with style or tone.	
			Total	

Teacher comments:

Name: _____

Date: _____

Period: _____

Role-Play or Skit Assessment Rubric

	EXCELLENT (4)	GOOD (3)	AVERAGE (2)	POOR (1)	TOTAL
Accuracy	All information was accurate.	Almost all information was accurate.	Most information was accurate.	Very little information was accurate.	
Role	Excellent character development; student contributed in a significant manner.	Good character development; student contributed in a cooperative manner.	Fair character development; student may have contributed.	Little or no character development; student did not contribute much at all.	
Knowledge Gained	Can clearly explain several ways in which his or her character "saw" things differently than other characters and can explain why	Can clearly explain several ways in which his or her character "saw" things differently than other characters	Can clearly explain one way in which his or her character "saw" things differently than other characters	Cannot explain any way in which his or her character "saw" things differently than other characters	
Props	Used several props and showed considerable creativity	Used 1 or 2 appropriate props that made the presentation better	Used 1 or 2 props that made the presentation better	Used no props to make the presentation better	
Required Elements	Included more information than required	Included all required information	Included most required information	Included less information than required	
				Total	

Name: _____

Date: _____

Period: _____

Notebook Rubric

	EXCELLENT (3)	SATISFACTORY (2)	UNSATISFACTORY (1)	SCORE
Completion of Required Sections	All required sections are complete. Supporting research and references have been included.	All required sections are complete.	Required sections are incomplete.	
Format	Appropriate format that is consistently used; extra desktop publishing enhancements	Appropriate format is consistently used.	Inappropriate format is used, or there is no consistency.	
Accuracy	Information is accurate and error free.	Information is accurate with minimal typographical errors.	Information is inaccurate and/or has numerous typographical errors.	
Organization	All assignments and/or notes are kept in a logical sequence.	Most assignments and/or notes are kept in a logical sequence.	Several assignments and/or notes are not in logical sequence.	
Neatness	Overall notebook is kept very neat.	Overall notebook is kept in satisfactory condition.	Overall notebook is unkempt and disorganized.	
			Total	

Teacher comments:

Name: _____

Date: _____

Period: _____

Employability Skills and Me

This activity guides you and a partner through a process of looking at personal attributes and employability skills. Very often careers reflect people's unique qualities and strengths. Many of these personal characteristics are related to skills that employers want. Build self-confidence and understanding of the world of work by looking at how personal qualities relate to what employers want.

1. Read the following list of personal characteristics.

2. Choose five qualities that best describe your partner, and write them on a piece of paper.

3. Without telling your partner the qualities you have chosen, ask your partner to read through the list and choose five qualities that he or she feels are the most self-descriptive.

4. After both of you have made your choices, use the questions below as talking points.

- Why did each of you select these five characteristics? Did you have examples in mind of how and when your partner has demonstrated that quality?
- Was it easy or difficult to choose just five qualities?
- How do these qualities relate to your partner's career preferences or educational paths? Get specific about those goals and plans he or she has already made or has expressed in the past.

Personal Characteristics

social	fun	laid back	dependable	organized	precise
active	serious	hard-working	shy	independent	mature
friendly	mathematical	bold	team player	punctual	sharing
responsible	cooperative	persistent	helpful	outgoing	patient
motivated	curious	studious	good listener	creative	supportive
kind	open-minded	talkative	understanding	flexible	honest
conscientious	trustworthy	deliberate	enthusiastic	energetic	competent

Most people are not fired because they lack specific job skills but because they do not possess strength in general employability skills, such as getting along well with coworkers. The Secretary's Commission on Achieving Necessary Skills (SCANS) produced a national report that identified the skills employers need in today's workplace. The five

COMPETENCIES and three FOUNDATION areas are listed below; these are skills that employers and colleges **expect** from applicants. The qualities your partner has identified are directly related to these employability skills. For example, being patient, outgoing, and curious all relate to having strengths in interpersonal skills.

1. Review the skill areas in the table below. Write your personal characteristics that relate to each defined skill area.

2. How do those strengths relate to success in school now, and how might they impact future success in the workplace?

3. How do you use SCAN skills in class? Help your partner identify ways she or he uses these skills.

4. How is your classroom a system? Which SCANS skills might be critical for the career goal your partner is thinking about now?

SCANS Skills COMPETENCIES. Effective workers can productively use:	**My Personal Characteristics**
□ **Resources** - allocating time, money, materials, space, staff	
□ **Interpersonal Skills** - working on teams, teaching others, serving customers, leading, negotiating, and working well with people from culturally diverse backgrounds	
□ **Information** - acquiring and evaluating data, organizing and maintaining files, interpreting and communicating, and using computers to process information	
□ **Systems** - understanding social, organizational, and technological systems; monitoring and correcting performance; and designing or improving systems	
□ **Technology** - selecting equipment and tools, applying technology to specific tasks, and maintaining and troubleshooting technologies	
THE FOUNDATION. Competence requires:	
□ **Basic Skills** - reading, writing, arithmetic and mathematics, speaking, and listening	
□ **Thinking Skills** - thinking creatively, making decisions, solving problems, seeing things in the mind's eye, knowing how to learn, and reasoning	
□ **Personal Qualities** - individual responsibility, self-esteem, sociability, self-management, and integrity	

Name: _____

Date: _____

Period: _____

Resume Rubric

	EXCELLENT 25	WELL DONE 20	MEETS STANDARDS 15	BEGINNING 10	NO EVIDENCE 0	SCORE
Format	Resume contains appropriate contact information such as name, address, phone number, email. Resume contains other information such as objectives, education, experience, and references. There are no spelling or formatting errors.	Resume contains appropriate contact information such as name, address, phone number, email. Resume contains other information such as objectives and education. There are 2–4 spelling or formatting errors.	Resume contains appropriate contact information such as name, address, phone number, email. Resume contains other information such as objectives. There are 5–7 spelling or formatting errors.	Resume contains appropriate contact information such as name, address, phone number, and e-mail. There are 8–10 spelling or formatting errors.	Assignment was not turned in.	
Education	Resume contains details regarding education. All schools that were attended, graduation dates, diploma/degree received, and major field of study are included.	Resume contains details regarding education. All schools that were attended, graduation dates, and major field of study are included.	Resume contains details regarding education. All schools that were attended and major field of study are included.	Resume contains details regarding education. All schools that were attended are included.	Assignment was not turned in.	
Experience	Resume contains details regarding work experiences. Experience includes internships in the field, service learning, entry-level jobs relevant to current position, and current position.	Resume contains details regarding work experiences. Experience includes service learning, entry-level jobs relevant to current position, and current position.	Resume contains details regarding work experiences. Experience includes entry-level jobs relevant to current position and current position.	Resume contains details regarding work experiences. Experience includes current position.	Assignment was not turned in.	
Realism	Resume contains realistic names and dates. Resume is believable.	Resume is fairly believable with realistic names or dates.	Resume has unrealistic dates or names.	Resume is obviously unrealistic and contains conflicting information.	Assignment was not turned in.	

Name: _____

Date: _____

Period: _____

Job Application Rubric

	Excellent	Good	Satisfactory	Minimum	Score/ Comments
Presentation/Format	Overall appearance is clean, neat, and professional looking. Printing is consistent in size and legible.	Overall appearance is clean and neat. Printing is consistent in size and legible.	Overall appearance is clean and neat. Printing could be improved, and there are some inconsistencies in size.	Overall appearance is messy. Printing and size are inconsistent.	
Ranking Points	10	9	7	6	
Completeness	All sections are answered thoroughly and appropriately.	One or two sections are not answered thoroughly and/or appropriately.	Three to four sections are not answered thoroughly and/or appropriately.	Five to six sections are not answered thoroughly and/or appropriately.	
Ranking Points	**20**	**17**	**15**	**12**	
Grammar	Correct verb tense, capitalization, and punctuation used throughout the application	There are one or two errors in verb tense, capitalization, and/or punctuation.	There are three or four errors in verb tense, capitalization, and/or punctuation.	There are five or six errors in verb tense, capitalization, and/or punctuation.	
Ranking Points	**10**	**8**	**7**	**6**	
Spelling	There are no spelling errors.	There are one or two spelling errors.	There are three or four spelling errors.	There are five or six spelling errors.	
Ranking Points	**10**	**8**	**7**	**6**	
				Total	

Teacher comments:

Name: _____

Date: _____

Period: _____

Interview Rubric

THE STUDENT…	EXCELLENT (4)	GOOD (3)	NEEDS IMPROVEMENT (2)	UNACCEPTABLE (1)	SCORE
Arrives prior to the interview					
Displays confidence with body language					
Maintains eye contact					
Maintains proper facial expression					
Provides a self-introduction					
Extends hand and shakes hands firmly with the interviewer					
Dresses appropriately for the interview					
Responds in a concise, grammatically correct, and appropriate manner					
Asks appropriate questions and demonstrates awareness of background of company and requirements of the job					
Cues on interviewer's closure and responds appropriately					
				Total	

Teacher comments:

Name: _____

Date: _____

Period: _____

Workplace Readiness Rubric

STANDARD	93% AND ABOVE (A)	86–92% (B)	79–85% (C)	70–78% (D)	Score
1. The student identifies ways to plan for employment. • Identifies reasons people work • Describes the relationship among jobs, careers, family life, and leisure activities • Conducts a self-inventory of skills, experience, education, work preferences, abilities, and values using technological and/or traditional resources as they relate to the job market • Develops a career plan for future career options to include job preferences, training requirements, and task/responsibilities • Understands the knowledge and skills required for a variety of careers of interest to the student • Compares occupations based on entry-level requirements and benefits associated with employment					
2. The student identifies ways to search for a job. • Locates, selects, and processes classified ads • Identifies and locates government and private employment agencies and/or computer-assisted job search programs • Identifies and locates personal resource materials (birth certificates, diplomas, etc.) • Understands the importance of personal/professional networking to obtain job search information • Develops a portfolio • Develops a job card file to record specific job leads, requirements, employer names, interview information, and personal notes • Practices telephone etiquette when					

calling an employer for job information					
3. The student understands how to apply for a job and/or applies for a job. • Describes and gives examples of effective interviewing situations, including prepared questions to ask the interviewer • Identifies appropriate behavior and attitudes in interview situations • Demonstrates competence in job interview techniques to include grooming, dress, and verbal/nonverbal communication • Develops a personal fact sheet to include, but not be limited to, personal references, work history, educational information, and other pertinent data • Interprets and completes job applications • Composes a resume with a cover letter • Writes a follow-up letter after the interview					
4. The student demonstrates understanding of wages, benefits, taxes, and concepts of employee organizations or identifies resources to assist in this interpretation. • Interprets wages, deductions, benefits, and taxes • Interprets timekeeping forms, such as timecards/timesheets • Interprets pay schedules • Identifies fringe benefits (medical insurance, etc.) • Understands importance of contract and union agreements • Demonstrates knowledge of employee handbooks, personnel policies, and worker's compensation					
5. The student understands the importance of safety standards and procedures in the workplace. • Identifies safety signs found in places of employment training and in public buildings • Identifies safe work procedures • Wears safe work attire • Understands the importance of reporting training and job-related hazards, accidents, injuries, and/or damages to the appropriate person(s) • Demonstrates acceptable employee health habits.					

6. The student demonstrates understanding of concepts and materials related to job training, performance, retention, promotion, and changes. • Discusses realistic career goals • Identifies positive and negative feelings that affect success at work and elsewhere • Identifies factors the employer considers when promoting/retaining employees • Interprets general work-related vocabulary • Demonstrates the ability to apply or transfer skills learned in one job situation to another • Interprets job-related signs, charts, diagrams, forms, and procedures • Identifies appropriate computer skills that affect job retention and advancement • Recognizes job responsibilities • Interprets and writes work-related correspondence including notes, memos, and letters • Reacts appropriately to constructive criticism • Demonstrates a knowledge of how and when to make job changes or to resign from a job • Analyzes and solves workplace problems • Identifies and maintains appropriate attire and hygiene standards for employment situations • Lists probable stress factors of various jobs					
7. The student is made aware of and/or utilizes common workplace technology. • Identifies common tools, equipment, machines, and materials required for one's job • Demonstrates simple keyboarding skills • Demonstrates ability to use a filing system • Identifies common business machines • Demonstrates basic computer skills and use of common software programs, including reading or interpreting computer-generated printouts • Leaves messages on answering machines • Demonstrates appropriate use of the telephone in a workplace setting • Demonstrates awareness of the importance of word processing and					

computer skills in the workplace					
8. The student demonstrates the ability to effectively utilize common interaction techniques in employment situations. • Demonstrates ability to work cooperatively with others as a member of a team, to contribute to team efforts, to maximize the strengths of team members, to promote effective group interaction, and to take personal responsibility for accomplishing goals. • Demonstrates effective communication skills in working with customers and clients • Demonstrates initiative and resourcefulness in meeting the needs and solving the problems of customers • Demonstrates effective body language and its influence on the observer • Identifies sexual harassment issues in the workplace • Identifies and uses effective approaches to working within a multicultural workforce, including respecting cultural diversity, avoiding stereotypes, and recognizing concerns of members of other ethnic and gender groups • Identifies techniques for handling stress and time management problems on the job					
9. The student utilizes the computer to enhance personal, academic, vocational, and social communication. • Identifies basic terminology associated with computers • Identifies the parts of a computer • Identifies hardware • Identifies software • Demonstrates appropriate use and care of computer hardware and software • Demonstrates the steps necessary to “boot up” a computer system • Utilizes computer directories to locate files • Identifies the basic components of a computer system • Understands advantages and disadvantages of computers					

Name: _____

Date: _____

Period: _____

Self-Evaluation

Out of **100 points** for each of the following areas, score your work for your project this week.

☐ 1. Have you worked the entire time you have been in class?

☐ 2. How productive have you been?

☐ 3. What is the quality of your project so far?

☐ 4. Have you been to work every day?

☐ 5. How do you think your classmates would rate your work so far?

☐ TOTAL

Comments:

_____

_____

_____

_____

_____

_____

_____

_____

Name: _____

Date: _____

Period: _____

Weekly Work Plan

Name of Work Project: _____ Employee: _____

Work Plan for Dates: _____

Goal/Expected Outcome	Tasks/Activities (Include task, who is responsible, and by when.)	Completed	In Progress	Results/Accomplishments Toward This Goal
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	

Comments:

Name: _____

Date: _____

Period: _____

Research and Project Rubric

	Excellent (4)	Very Good (3)	Fair (2)	Poor (1)	Score
Thesis/Problem/Question	Student posed a thoughtful, creative question that engaged him or her in challenging or provocative research.	Student posed a focused question involving him or her in challenging research.	Student constructed a question that lends itself to readily available answers.	Student relied on teacher-generated questions or developed a question requiring little creative thought.	
Information Seeking/Selecting and Evaluating	Student gathered information from a variety of quality electronic and print sources.	Student gathered information from a variety of relevant sources—print and electronic.	Student gathered information from a limited range of sources and displayed minimal effort in selecting quality resources.	Student gathered information that lacked relevance, quality, depth, and balance.	
Analysis	Student carefully analyzed the information collected and drew appropriate and inventive conclusions supported by evidence. Voice of the student writer is evident.	Student product shows good effort was made in analyzing the evidence collected.	Student conclusions could be supported by stronger evidence. Level of analysis could have been deeper.	Student conclusions simply involved restating information. Conclusions were not supported by evidence.	
Synthesis	Student developed appropriate structure for communicating product, incorporating variety of quality sources. Information is logically and creatively organized with smooth transitions.	Student logically organized the product and made good connections among ideas.	Student could have put greater effort into organizing the product.	Student work is not logically or effectively structured.	

Documentation	Student documented all sources, including visuals, sounds, and animations. Sources are properly cited. Documentation is error free.	Student documented sources with some care. Sources are cited. Few errors are cited.	Student needs to use greater care in documenting sources. Documentation was poorly constructed or absent.	Student clearly plagiarized materials.	
Product/Process	Student effectively and creatively used appropriate communication tools to convey her or his conclusions and demonstrated thorough, effective research techniques. Product displays creativity and originality.	Student effectively communicated the results of research to the audience.	Student needs to work on communicating more effectively.	Student showed little evidence of thoughtful research. Product does not effectively communicate research findings.	
Layout and Design	Pages are eye appealing, appropriate use of graphics, and layout is clean. Font is readable, with a creative title.	There are mostly complete pages and correct use of graphics. Layout and font are somewhat appropriate, with a somewhat creative title.	One page is eye appealing, but others are incomplete. Graphics are inserted haphazardly, but it has a good title.	Layout is incomplete on all pages, with no graphics and poor, non-creative title.	

Teacher comments:

Name: _____

Date: _____

Period: _____

Presentation Assessment Rubric

	EXEMPLARY	ACCOMPLISHED	DEVELOPING	BEGINNING	SCORE
	(4)	(3)	(2)	(1)	
Content	Clear, appropriate, and correct	Mostly clear, appropriate, and correct	Somewhat confusing, incorrect, or flawed	Confusing, incorrect, or flawed	
Clarity	Logical, interesting sequence	Logical sequence	Unclear sequence	No sequence	
Presentation	Clear voice and precise pronunciation	Clear voice and mostly correct pronunciation	Low voice and incorrect pronunciation	Mumbling and incorrect pronunciation	
Visual Aids	Attractive, accurate, and grammatically correct	Adequate, mostly accurate, and few grammatical errors	Poorly planned, somewhat accurate, or some grammatical errors	Weak, inaccurate, or many grammatical errors	
Length	Appropriate length	Slightly too long or short	Moderately too long or short	Extremely too long or short	
Eye Contact	Maintains eye contact, seldom looking at notes	Maintains eye contact most of time but frequently returns to notes	Occasionally uses eye contact but reads most of information	No eye contact because reading information	
				Total	

Teacher comments:

Name: _____

Date: _____

Period: _____

Polymer Project Task Proposal

Name: _____

Date: _____Polymer Project Class Period: _____

Proposal and Timeline Development
Extended Task

Your School Career and Technology Center

Polymer Project

Proposal Worksheet

Use this worksheet to develop your Polymer Project proposal. Make sure you address each of the components. Meet with your Polymer teacher or Polymer Project mentor to discuss the proposal when needed. The final proposal must be signed by the teacher/mentor, parent or guardian, and student.

I. A Polymer Project question is . . .

- based on your interests.
- clearly stated as a question.
- open-ended and exploratory.
- directed toward a path to new knowledge.
- related to real-world issues.

My Polymer Project question is:

_____?

II. Overview of your project plans

Write a brief description of your project plan. In your description, identify the research that you plan to pursue, and describe the problem that your Polymer Project will solve. If more space is needed, attach a separate sheet to this worksheet.

_____

III. Identify and describe the learning stretch or new knowledge that applies to this Polymer Project.

List five items/skills/new learning that you want to either improve upon or acquire. Briefly summarize each.

1. _____
   Summary:
   _____

2. _____
   Summary:
   _____

3. _____
   Summary:
   _____

4. _____
   Summary:
   _____

5. _____
   Summary:
   _____

IV. Select the Applied Learning Standards for the project.

1 – Problem Solving - Choose <u>one</u> of the problem-solving standards, and describe how you will achieve the chosen standard.

- **Design a product.**

- **Improve a system (job shadow).**
- **Plan and organize an event or an activity.**

I choose _____.

I will achieve this standard by _____.

2 – Communication Tools and Techniques - Choose one of the communication tools and techniques standards, and describe how you will achieve the chosen standard.

- **Make an oral presentation of project plans or findings to an audience with expertise in the relevant subject matter.**
- **Prepare a formal written proposal or report to an organization beyond the school.**
- **Prepare a multimedia presentation combining text, images, and/or sound.**

I choose _____.

I will achieve this standard by _____.

3 – Information Tools and Techniques - Choose one of the information tools and techniques standards, and describe how you will achieve the chosen standard.

- **Gather information to assist in completing project work.**
- **Use online sources to exchange information for specific purposes.**
- **Use word-processing software to produce a multi-page document.**
- **Write, add content to, and analyze a database program that uses a relational database.**
- **Create, edit, and analyze a spreadsheet of information that displays data in tabular, numeric format and includes multiple graphs.**

I choose _____.

I will achieve this standard by _____.

4 – Learning and Self-Management Tools and Techniques - Choose two of the learning and self-management tools and techniques standards, and describe how you will achieve the chosen standard.

- **Learn from models.**
- **Review own progress in completing work activities, and adjust priorities as needed to meet deadlines.**
- **Evaluate own performance.**

I choose _____ and _____.

I will achieve these standards by _____.

V. Select the English and Content Standards for the project.

1 – Reading - Choose one of the reading standards, and describe how you will achieve the chosen standard.

- **Obtain information from text features [e.g., table of contents, glossary, index, transition words/phrases, transitional devices (including use of white space), bold or italicized text, headings, subheadings, graphic organizers, charts, graphs, or illustrations].**
- **Use information from the text to answer questions; to state the main/central ideas; to provide supporting details; to explain visual components supporting the text; or to interpret maps, charts, timelines, tables, or diagrams.**
- **Organize information to show understanding or relationships among facts, ideas, and events.**
- **Evaluate the clarity and accuracy of information (e.g., consistency, effectiveness of organizational pattern, or logic or arguments).**

I choose _____.

I will achieve this standard by _____.

2 – Writing - Choose one of the writing standards, and describe how you will achieve the chosen standard.

- **Select and summarize key ideas to set context, appropriate to audience.**
- **Include facts and details relevant to focus/controlling idea or thesis and excluding extraneous information.**
- **Write with frequency, including in school, out of school, and during the summer.**
- **Share thoughts, observations, or impressions.**
- **Analyze a condition or situation of significance (e.g., reflecting on a personal learning or personal growth) or develop a commonplace, concrete occasion as the basis for the reflection.**
- **Use an organizational structure that allows for a progression of ideas to develop.**

I choose _____.

I will achieve this standard by _____.

3 – Oral Communication - Choose one of the communication tools and techniques standards, and describe how you will achieve the chosen standard.

- **Exhibit logical organization and language use, appropriate to audience, context, and purpose.**
- **Maintain a consistent focus.**
- **Include smooth transitions, supporting thesis with well-chosen details and providing a coherent conclusion.**
- **Effectively respond to audience questions and feedback.**
- **Use a variety of strategies of address (e.g., eye contact, speaking rate, volume, articulation, enunciation, pronunciation, inflection, voice modulation, intonation, rhythm, and gesture) to communicate ideas effectively.**
- **Use tools of technology to enhance message.**

I choose _____.

I will achieve this standard by _____.

Explanation of Why You Selected This Project

Write a brief explanation as to why you chose this particular field of inquiry, industry, or discipline to investigate.

_____

Polymer Project

Preliminary Timeline Worksheet

I. A timeline is extremely important for the management of a project. When creating a timeline, you need to consider the timeframe available in order to complete your project. You will have many tasks to complete that are specific to your project. Ask your teacher for a listing of task suggestions. You will have the following major components to complete; use these as a framework, and develop all the minor steps within the major steps to guide you to complete the project.

a. Task Proposal
b. Journals – Minimum 10
c. Mid-Semester Reflection
d. Research – Minimum10 Items
e. Product – Presentation, Event, Job Shadow, and So Forth
f. Slide Show
g. Final Reflection
h. Portfolio

Note: It is helpful to consult a calendar to establish the total number of days available to complete your project.

You are beginning this project on: _____.

The last day for presentations for this semester is: _____.

Preliminary Timeline

II. In chronological order, complete the preliminary timeline template. Expand your timeline to include major as well as minor tasks that must be completed for the successful completion of your Polymer Project. Assign tentative dates to each entry, and identify when each task is completed.

III. Reminders

- Consider the time constraints of both teacher and student schedules. How do these constraints affect the completion of your work? Plan ahead. Regularly update and refer to your timeline.
- If you are dependent upon input from another person, be sure to give that person sufficient time to provide you with your request.
- It is recommended that you use word processing to complete this timeline. If you do, attach your typed timeline to this proposal. (Using word processing allows for updates to be made easily.)

Polymer Project Task List / Timeline Worksheet

1. Polymer Project Question: _____

_____

2. Identify as many tasks as you can that are associated with the completion of your Polymer Project. List the major and also the minor activities. Write each task beginning with an action word, and apply an anticipated due date to each line item. Match each task to its major group.

Major Components/Groups	
A. Task Proposal	D. Product
B. Written Components	E. Judging Presentation
C. Research	F. Binder

Minor Components

Tasks	Date Due	Major Group	Finished Date
1.			
2.			
3.			
4.			
5.			
6.			
7.			
Tasks	Date Due	Major Group	Finished Date

8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			
21.			
22.			

Polymer Project Task Rubric

This rubric explains the elements of the prompt and standards that should be included in the work. To achieve a successful score on this task, a student must MEET standard for all expectations. A student cannot meet the standard on this task if he or she receives "**Below Standard**" on any of the expectations.

Expectations	Exceeds Standard	Meets Standard	Below Standard
Proposal	Uses exemplary description of project with exceptional detail Identifies all components necessary Thoroughly identifies a learning stretch or a path to new knowledge Identifies all appropriate standards with a comprehensive link to the particular project Fully explains why this field of inquiry, industry, or discipline was chosen	Accurately describes the project plan with sufficient detail Identifies many of the components necessary to complete the project Identifies a learning stretch or a path to new knowledge Identifies most of the standards and includes a link to applied learning and content standards Nearly explains why this field of inquiry, industry, or discipline was chosen	Does not accurately describe project Lacks necessary detail Lacks many of the appropriate components to complete the project Does not address a learning stretch Lacks one or more standards appropriate to project Choice of field of inquiry not explained
Timeline	Identifies all tasks necessary to successfully complete the project Develops a detailed timeline that accounts for the time required to complete the project Includes all individual due dates as well as projected completion dates in the timeline	Identifies most of the tasks necessary to complete the project Develops an incomplete schedule that fails to account for the time required to complete the project Includes many of the required due dates as well as projected completion dates in the timeline.	Develops an unrealistic and/or incomplete timeline to complete components of the project Timeline is missing most of the required due dates as well as projected completion dates.
Solutions and Strategies for Achievement	Addresses innovative solutions and strategies necessary to complete each component in relationship to the final product.	Identifies most of the effective solutions and strategies necessary to complete each component in relationship to final project	Does not identify effective solutions and strategies necessary to complete each component in relationship to final project

Score _____ Scorer's Initials _____

Score _____ Scorer's Initials _____

Student Competency Profile (Course 1)

Student's Name: _____

This record is intended to serve as a method of noting student achievement of the competencies in each unit. It can be duplicated for each student, and it can serve as a cumulative record of competencies achieved in the course.

In the blank before each competency, place the date on which the student mastered the competency.

Unit 1: Orientation and Safety

_____ 1. Evaluate the local program, and explore how personality traits and learning styles can impact success in the classroom and workplace.

_____ 2. Examine the history and development of the polymer industry/profession, to include career opportunities, earnings, and educational requirements.

_____ 3. Describe and demonstrate safe laboratory practices and environmental responsibility working with laboratory equipment, chemicals, and processing equipment commonly encountered in polymer-related industries.

Unit 2: Information, Media, and Computer Applications

_____ 1. Demonstrate the ability to manage a computer operating system in relation to plastics and polymer applications.

_____ 2. Demonstrate the ability to read and interpret a basic blueprint.

_____ 3. Apply the principles of computer assisted design and drafting (CADD) as applied to the plastics and polymer manufacturing industry.

_____ 4. Apply geometry and incorporate CADD and CAM (computer-aided machining) processes into the prototype production phase of plastics and polymer manufacturing.

Unit 3: Introduction to Chemistry

_____ 1. Illustrate atomic contributions to chemical structures.

_____ 2. Identify common organic molecules, and relate their structures to chemical and physical properties.

_____ 3. Investigate compositions and properties of various mixtures and conditions that impact mixture formation and stability.

Unit 4: Structure and Properties of Polymers

_____ 1. Relate small molecule chemistry to the production of polymers.

_____ 2. Recognize and define natural and synthetic polymers.

_____ 3. Relate rheology and viscosity to polymer properties.

_____ 4. Explain how additives affect the properties of a polymeric material.

Student Competency Profile (Course 2)

Student's Name: _____

This record is intended to serve as a method of noting student achievement of the competencies in each unit. It can be duplicated for each student, and it can serve as a cumulative record of competencies achieved in the course.

In the blank before each competency, place the date on which the student mastered the competency.

Unit 5: Polymer Processing and Applications

_____ 1. Explain how each manufacturing processing technique is used to convert polymer feedstock into plastic end products, participate in manufacturing plastic parts using each processing technique, and identify parts made from each thermoplastic and thermoset processes.

_____ 2. Explain the major types of resins or materials.

Unit 6: Plastics Recycling and Conservation

_____ 1. Relate plastics recycling/conservation principles and their effects on the environment.

Unit 7: Orientation and Safety (Review)

_____ 1. Evaluate local program and explore how personality traits and learning styles can impact success in the classroom and workplace.

2. Describe and demonstrate safe laboratory practices and environmental responsibility working with laboratory equipment, chemicals, and processing equipment commonly encountered in polymer-related industries.

Unit 8: Polymer Synthesis

1. Explore how the chemistry of polymer preparation affects performance properties.

Unit 9: Surface Coatings

_____ 1. Describe the production of various types of surface coatings.

_____ 2. Demonstrate the properties of coatings.

Unit 10: Composite Materials, Processing, and Applications

_____ 1. Examine composite materials to determine how such materials affect the finish properties of a composite structure.

_____ 2. Demonstrate different composite processing methods and composite applications.

Student Competency Profile (Course 3)

Student's Name: _____

This record is intended to serve as a method of noting student achievement of the competencies in each unit. It can be duplicated for each student, and it can serve as a cumulative record of competencies achieved in the course.

In the blank before each competency, place the date on which the student mastered the competency.

Unit 11: School to Work

_____ 1. Explain and demonstrate the role human relations, teamwork, and leadership play in plastics and polymer manufacturing.

_____ 2. Explain and demonstrate employability skills over the course of the program.

_____ 3. Apply skills needed to be a viable member of the workforce.

_____ 4. Work with instructor and/or employer to develop, assess, and document performance of written occupational objectives to be accomplished during a polymer-related internship and/or simulated polymer industry.

Appendix A: 21st Century Skills Standards

CLS1 Flexibility and Adaptability
CLS2 Initiative and Self-Direction
CLS3 Social and Cross-Cultural Skills
CLS4 Productivity and Accountability
CLS5 Leadership and Responsibility

Today's life and work environments require far more than thinking skills and content knowledge. The ability to navigate the complex life and work environments in the globally competitive information age requires students to pay rigorous attention to developing adequate life and career skills.

CS 1 Flexibility and Adaptability

- Adapting to varied roles and responsibilities
- Working effectively in a climate of ambiguity and changing priorities

CS 2 Initiative and Self-Direction

- Monitoring one's own understanding and learning needs
- Going beyond basic mastery of skills and/or curriculum to explore and expand one's own learning and opportunities to gain expertise
- Demonstrating initiative to advance skill levels toward a professional level
- Defining, prioritizing, and completing tasks without direct oversight
- Utilizing time efficiently and managing workload
- Demonstrating commitment to learning as a lifelong process

CS 3 Social and Cross-Cultural Skills

- Working appropriately and productively with others
- Leveraging the collective intelligence of groups when appropriate
- Bridging cultural differences and using differing perspectives to increase innovation and the quality of work

CS 4 Productivity and Accountability

- Setting and meeting high standards and goals for delivering quality work on time
- Demonstrating diligence and a positive work ethic (e.g., being punctual and reliable)

CS 5 Leadership and Responsibility

- Using interpersonal and problem-solving skills to influence and guide others toward a goal
- Leveraging strengths of others to accomplish a common goal
- Demonstrating integrity and ethical behavior
- Acting responsibly with the interests of the larger community in mind

Appendix B: Mississippi Academic Standards

Organic Chemistry

OC1 Apply inquiry-based and problem-solving processes and skills to scientific investigations.

OC2 Demonstrate an understanding of the properties, structure, and function of organic compounds.

OC3 Discuss the versatility of polymers and the diverse application of organic chemicals.

Appendix C: ACT College Readiness Standards

English

E1 Topic Development in Terms of Purpose and Focus

- Identify the basic purpose or role of a specified phrase or sentence.
- Delete a clause or sentence because it is obviously irrelevant to the essay.
- Identify the central idea or main topic of a straightforward piece of writing.
- Determine relevancy when presented with a variety of sentence-level details.
- Identify the focus of a simple essay, applying that knowledge to add a sentence that sharpens that focus or to determine if an essay has met a specified goal.
- Delete material primarily because it disturbs the flow and development of the paragraph.
- Add a sentence to accomplish a fairly straightforward purpose such as illustrating a given statement.
- Apply an awareness of the focus and purpose of a fairly involved essay to determine the rhetorical effect and suitability of an existing phrase or sentence or to determine the need to delete plausible but irrelevant material.
- Add a sentence to accomplish a subtle rhetorical purpose such as to emphasize, to add supporting detail, or to express meaning through connotation.
- Determine whether a complex essay has accomplished a specific purpose.
- Add a phrase or sentence to accomplish a complex purpose, often expressed in terms of the main focus of the essay.

E2 Organization, Unity, and Coherence

- Use conjunctive adverbs or phrases to show time relationship in simple narrative essays (e.g., *then, this time*, etc).
- Select the most logical place to add a sentence in a paragraph.
- Use conjunctive adverbs or phrases to express straightforward logical relationships (e.g., *first, afterward, in response*).
- Decide the most logical place to add a sentence in an essay.
- Add a sentence that introduces a simple paragraph.
- Determine the need for conjunctive adverbs or phrases to create subtle logical connections between sentences (e.g., *therefore, however, in addition*).
- Rearrange the sentences in a fairly uncomplicated paragraph for the sake of logic.
- Add a sentence to introduce or conclude the essay or to provide a transition between paragraphs when the essay is fairly straightforward.
- Make sophisticated distinctions concerning the logical use of conjunctive adverbs or phrases, particularly when signaling a shift between paragraphs.
- Rearrange sentences to improve the logic and coherence of a complex paragraph.
- Add a sentence to introduce or conclude a fairly complex paragraph.
- Consider the need for introductory sentences or transitions, basing decisions on a thorough understanding of both the logic and rhetorical effect of the paragraph and essay.

E3 Word Choice in Terms of Style, Tone, Clarity, and Economy

- Revise sentences to correct awkward and confusing arrangements of sentence elements.
- Revise vague nouns and pronouns that create obvious logic problems.
- Delete obviously synonymous and wordy material in a sentence.
- Revise expressions that deviate from the style of an essay.
- Delete redundant material when information is repeated in different parts of speech (e.g., *alarmingly startled*).
- Use the word or phrase most consistent with the style and tone of a fairly straightforward essay.
- Determine the clearest and most logical conjunction to link clauses.
- Revise a phrase that is redundant in terms of the meaning and logic of the entire sentence.
- Identify and correct ambiguous pronoun references.

- Use the word or phrase most appropriate in terms of the content of the sentence and tone of the essay.
- Correct redundant material that involves sophisticated vocabulary and sounds acceptable as conversational English (e.g., *an aesthetic viewpoint* versus *the outlook of an aesthetic viewpoint*).
- Correct vague and wordy or clumsy and confusing writing containing sophisticated language.
- Delete redundant material that involves subtle concepts or that is redundant in terms of the paragraph as a whole.

E4 Sentence Structure and Formation

- Use conjunctions or punctuation to join simple clauses.
- Revise shifts in verb tense between simple clauses in a sentence or between simple adjoining sentences.
- Determine the need for punctuation and conjunctions to avoid awkward-sounding sentence fragments and fused sentences.
- Decide the appropriate verb tense and voice by considering the meaning of the entire sentence.
- Recognize and correct marked disturbances of sentence flow and structure (e.g., participial phrase fragments, missing or incorrect relative pronouns, dangling or misplaced modifiers).
- Revise to avoid faulty placement of phrases and faulty coordination and subordination of clauses in sentences with subtle structural problems.
- Maintain consistent verb tense and pronoun person on the basis of the preceding clause or sentence.
- Use sentence-combining techniques, effectively avoiding problematic comma splices, run-on sentences, and sentence fragments, especially in sentences containing compound subjects or verbs.
- Maintain a consistent and logical use of verb tense and pronoun person on the basis of information in the paragraph or essay as a whole.
- Work comfortably with long sentences and complex clausal relationships within sentences, avoiding weak conjunctions between independent clauses and maintaining parallel structure between clauses.

E5 Conventions of Usage

- Solve such basic grammatical problems as how to form the past and past participle of irregular but commonly used verbs and how to form comparative and superlative adjectives.
- Solve such grammatical problems as whether to use an adverb or adjective form, how to ensure straightforward subject—verb and pronoun—antecedent agreement, and which preposition to use in simple contexts.
- Recognize and use the appropriate word in frequently confused pairs such as *there* and *their*, *past* and *passed*, and *led* and *lead*.
- Use idiomatically appropriate prepositions, especially in combination with verbs (e.g., *long for, appeal to*).
- Ensure that a verb agrees with its subject when there is some text between the two.
- Ensure that a pronoun agrees with its antecedent when the two occur in separate clauses or sentences.
- Identify the correct past and past participle forms of irregular and infrequently used verbs and form present—perfect verbs by using *have* rather than *of*.
- Correctly use reflexive pronouns, the possessive pronouns *its* and *your*, and the relative pronouns *who* and *whom*.
- Ensure that a verb agrees with its subject in unusual situations (e.g., when the subject—verb order is inverted or when the subject is an indefinite pronoun).
- Provide idiomatically and contextually appropriate prepositions following verbs in situations involving sophisticated language or ideas.
- Ensure that a verb agrees with its subject when a phrase or clause between the two suggests a different number for the verb.

E6 Conventions of Punctuation

- Delete commas that create basic sense problems (e.g., between verb and direct object).
- Provide appropriate punctuation in straightforward situations (e.g., items in a series).
- Delete commas that disturb the sentence flow (e.g., between modifier and modified element).
- Use commas to set off simple parenthetical phrases.
- Delete unnecessary commas when an incorrect reading of the sentence suggests a pause that should be punctuated (e.g., between verb and direct object clause).
- Use punctuation to set off complex parenthetical phrases.

- Recognize and delete unnecessary commas based on a careful reading of a complicated sentence (e.g., between the elements of a compound subject or compound verb joined by *and*).
- Use apostrophes to indicate simple possessive nouns.
- Recognize inappropriate uses of colons and semicolons.
- Use commas to set off a nonessential/nonrestrictive appositive or clause.
- Deal with multiple punctuation problems (e.g., compound sentences containing unnecessary commas and phrases that may or may not be parenthetical).
- Use an apostrophe to show possession, especially with irregular plural nouns.
- Use a semicolon to indicate a relationship between closely related independent clauses.
- Use a colon to introduce an example or an elaboration.

Math

M1 Basic Operations and Applications

- Perform one-operation computation with whole numbers and decimals.
- Solve problems in one or two steps using whole numbers.
- Perform common conversions (e.g., inches to feet or hours to minutes).
- Solve routine one-step arithmetic problems (using whole numbers, fractions, and decimals) such as single-step percent.
- Solve some routine two-step arithmetic problems.
- Solve routine two-step or three-step arithmetic problems involving concepts such as rate and proportion, tax added, percentage off, and computing with a given average.
- Solve multistep arithmetic problems that involve planning or converting units of measure (e.g., feet per second to miles per hour).
- Solve word problems containing several rates, proportions, or percentages.
- Solve complex arithmetic problems involving percent of increase or decrease and problems requiring integration of several concepts from pre-algebra and/or pre-geometry (e.g., comparing percentages or averages, using several ratios, and finding ratios in geometry settings).

M2 Probability, Statistics, and Data Analysis

- Calculate the average of a list of positive whole numbers.
- Perform a single computation using information from a table or chart.
- Calculate the average of a list of numbers.
- Calculate the average, given the number of data values and the sum of the data values.
- Read tables and graphs.
- Perform computations on data from tables and graphs.
- Use the relationship between the probability of an event and the probability of its complement.
- Calculate the missing data value, given the average and all data values but one.
- Translate from one representation of data to another (e.g., a bar graph to a circle graph).
- Determine the probability of a simple event.
- Exhibit knowledge of simple counting techniques.*
- Calculate the average, given the frequency counts of all the data values.
- Manipulate data from tables and graphs.
- Compute straightforward probabilities for common situations.
- Use Venn diagrams in counting.*
- Calculate or use a weighted average.
- Interpret and use information from figures, tables, and graphs.
- Apply counting techniques.
- Compute a probability when the event and/or sample space is not given or obvious.
- Distinguish between mean, median, and mode for a list of numbers.
- Analyze and draw conclusions based on information from figures, tables, and graphs.
- Exhibit knowledge of conditional and joint probability.

M3 Numbers: Concepts and Properties

- Recognize equivalent fractions and fractions in lowest terms.
- Recognize one-digit factors of a number.
- Identify a digit's place value.
- Exhibit knowledge of elementary number concepts including rounding, the ordering of decimals, pattern identification, absolute value, primes, and greatest common factor.
- Find and use the least common multiple.
- Order fractions.
- Work with numerical factors.
- Work with scientific notation.
- Work with squares and square roots of numbers.
- Work problems involving positive integer exponents.*
- Work with cubes and cube roots of numbers.*
- Determine when an expression is undefined.*
- Exhibit some knowledge of the complex numbers.†
- Apply number properties involving prime factorization.
- Apply number properties involving even and odd numbers and factors and multiples.
- Apply number properties involving positive and negative numbers.
- Apply rules of exponents.
- Multiply two complex numbers.†
- Draw conclusions based on number concepts, algebraic properties, and/or relationships between expressions and numbers .
- Exhibit knowledge of logarithms and geometric sequences.
- Apply properties of complex numbers.

M4 Expressions, Equations, and Inequalities

- Exhibit knowledge of basic expressions (e.g., identify an expression for a total as b + g).
- Solve equations in the form x + a = b, where a and b are whole numbers or decimals.
- Substitute whole numbers for unknown quantities to evaluate expressions.
- Solve one-step equations having integer or decimal answers.
- Combine like terms (e.g., 2x + 5x).
- Evaluate algebraic expressions by substituting integers for unknown quantities.
- Add and subtract simple algebraic expressions.
- Solve routine first-degree equations.
- Perform straightforward word-to-symbol translations.
- Multiply two binomials.*
- Solve real-world problems using first-degree equations.
- Write expressions, equations, or inequalities with a single variable for common pre-algebra settings (e.g., rate and distance problems and problems that can be solved by using proportions).
- Identify solutions to simple quadratic equations.
- Add, subtract, and multiply polynomials.*
- Factor simple quadratics (e.g., the difference of squares and perfect square trinomials).*
- Solve first-degree inequalities that do not require reversing the inequality sign.*
- Manipulate expressions and equations.
- Write expressions, equations, and inequalities for common algebra settings.
- Solve linear inequalities that require reversing the inequality sign.
- Solve absolute value equations.
- Solve quadratic equations.
- Find solutions to systems of linear equations.
- Write expressions that require planning and/or manipulating to accurately model a situation.
- Write equations and inequalities that require planning, manipulating, and/or solving.
- Solve simple absolute value inequalities.

M5 Graphical Representations

- Identify the location of a point with a positive coordinate on the number line.
- Locate points on the number line and in the first quadrant.
- Locate points in the coordinate plane.
- Comprehend the concept of length on the number line.*
- Exhibit knowledge of slope.*
- Identify the graph of a linear inequality on the number line.*
- Determine the slope of a line from points or equations.*
- Match linear graphs with their equations.*
- Find the midpoint of a line segment.*
- Interpret and use information from graphs in the coordinate plane.
- Match number line graphs with solution sets of linear inequalities.
- Use the distance formula.
- Use properties of parallel and perpendicular lines to determine an equation of a line or coordinates of a point.
- Recognize special characteristics of parabolas and circles (e.g., the vertex of a parabola and the center or radius of a circle).†
- Match number line graphs with solution sets of simple quadratic inequalities.
- Identify characteristics of graphs based on a set of conditions or on a general equation such as y = ax2 + c.
- Solve problems integrating multiple algebraic and/or geometric concepts.
- Analyze and draw conclusions based on information from graphs in the coordinate plane.

M6 Properties of Plane Figures

- Exhibit some knowledge of the angles associated with parallel lines.
- Find the measure of an angle using properties of parallel lines.
- Exhibit knowledge of basic angle properties and special sums of angle measures (e.g., 90°, 180°, and 360°).
- Use several angle properties to find an unknown angle measure.
- Recognize Pythagorean triples.*
- Use properties of isosceles triangles.*
- Apply properties of 30°-60°-90°, 45°-45°-90°, similar, and congruent triangles.
- Use the Pythagorean theorem.
- Draw conclusions based on a set of conditions.
- Solve multistep geometry problems that involve integrating concepts, planning, visualization, and/or making connections with other content areas.
- Use relationships among angles, arcs, and distances in a circle.

M7 Measurement

- Estimate or calculate the length of a line segment based on other lengths given on a geometric figure.
- Compute the perimeter of polygons when all side lengths are given.
- Compute the area of rectangles when whole number dimensions are given.
- Compute the area and perimeter of triangles and rectangles in simple problems.
- Use geometric formulas when all necessary information is given.
- Compute the area of triangles and rectangles when one or more additional simple steps are required.
- Compute the area and circumference of circles after identifying necessary information.
- Compute the perimeter of simple composite geometric figures with unknown side lengths.*
- Use relationships involving area, perimeter, and volume of geometric figures to compute another measure.
- Use scale factors to determine the magnitude of a size change.
- Compute the area of composite geometric figures when planning or visualization is required.

M8 Functions

- Evaluate quadratic functions, expressed in function notation, at integer values.
- Evaluate polynomial functions, expressed in function notation, at integer values.†
- Express the sine, cosine, and tangent of an angle in a right triangle as a ratio of given side lengths.†
- Evaluate composite functions at integer values.†

- Apply basic trigonometric ratios to solve right-triangle problems.†
- Write an expression for the composite of two simple functions.†
- Use trigonometric concepts and basic identities to solve problems.†
- Exhibit knowledge of unit circle trigonometry.†
- Match graphs of basic trigonometric functions with their equations.

Notes

- Students who score in the 1–12 range are most likely beginning to develop the knowledge and skills assessed in the other ranges.
- Standards followed by an asterisk (*) apply to the PLAN and ACT Mathematics Tests only.
- Standards followed by a dagger (†) apply to the ACT Mathematics Test only.

Reading

R1 Main Ideas and Author's Approach

- Recognize a clear intent of an author or narrator in uncomplicated literary narratives.
- Identify a clear main idea or purpose of straightforward paragraphs in uncomplicated literary narratives.
- Infer the main idea or purpose of straightforward paragraphs in uncomplicated literary narratives.
- Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in uncomplicated passages.
- Identify a clear main idea or purpose of any paragraph or paragraphs in uncomplicated passages.
- Infer the main idea or purpose of straightforward paragraphs in more challenging passages.
- Summarize basic events and ideas in more challenging passages.
- Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in more challenging passages.
- Infer the main idea or purpose of more challenging passages or their paragraphs.
- Summarize events and ideas in virtually any passage.
- Understand the overall approach taken by an author or narrator (e.g., point of view, kinds of evidence used) in virtually any passage.
- Identify clear main ideas or purposes of complex passages or their paragraphs.

R2 Supporting Details

- Locate basic facts (e.g., names, dates, events) clearly stated in a passage.
- Locate simple details at the sentence and paragraph level in uncomplicated passages.
- Recognize a clear function of a part of an uncomplicated passage.
- Locate important details in uncomplicated passages.
- Make simple inferences about how details are used in passages.
- Locate important details in more challenging passages.
- Locate and interpret minor or subtly stated details in uncomplicated passages.
- Discern which details, though they may appear in different sections throughout a passage, support important points in more challenging passages.
- Locate and interpret minor or subtly stated details in more challenging passages.
- Use details from different sections of some complex informational passages to support a specific point or argument.
- Locate and interpret details in complex passages.
- Understand the function of a part of a passage when the function is subtle or complex.

R3 Sequential, Comparative, and Cause—Effect Relationships

- Determine when (e.g., first, last, before, after) or if an event occurred in uncomplicated passages.
- Recognize clear cause—effect relationships described within a single sentence in a passage.
- Identify relationships between main characters in uncomplicated literary narratives.
- Recognize clear cause—effect relationships within a single paragraph in uncomplicated literary narratives.
- Order simple sequences of events in uncomplicated literary narratives.

- Identify clear relationships between people, ideas, and so forth in uncomplicated passages.
- Identify clear cause–effect relationships in uncomplicated passages.
- Order sequences of events in uncomplicated passages.
- Understand relationships between people, ideas, and so forth in uncomplicated passages.
- Identify clear relationships between characters, ideas, and so forth in more challenging literary narratives.
- Understand implied or subtly stated cause–effect relationships in uncomplicated passages.
- Identify clear cause–effect relationships in more challenging passages.
- Order sequences of events in more challenging passages.
- Understand the dynamics between people, ideas, and so forth in more challenging passages.
- Understand implied or subtly stated cause–effect relationships in more challenging passages.
- Order sequences of events in complex passages.
- Understand the subtleties in relationships between people, ideas, and so forth in virtually any passage.
- Understand implied, subtle, or complex cause–effect relationships in virtually any passage.

R4 Meaning of Words

- Understand the implication of a familiar word or phrase and of simple descriptive language.
- Use context to understand basic figurative language.
- Use context to determine the appropriate meaning of some figurative and nonfigurative words, phrases, and statements in uncomplicated passages.
- Use context to determine the appropriate meaning of virtually any word, phrase, or statement in uncomplicated passages.
- Use context to determine the appropriate meaning of some figurative and nonfigurative words, phrases, and statements in more challenging passages.
- Determine the appropriate meaning of words, phrases, or statements from figurative or somewhat technical contexts.
- Determine, even when the language is richly figurative and the vocabulary is difficult, the appropriate meaning of context-dependent words, phrases, or statements in virtually any passage.

R5 Generalizations and Conclusions

- Draw simple generalizations and conclusions about the main characters in uncomplicated literary narratives.
- Draw simple generalizations and conclusions about people, ideas, and so forth in uncomplicated passages.
- Draw generalizations and conclusions about people, ideas, and so forth in uncomplicated passages.
- Draw simple generalizations and conclusions using details that support the main points of more challenging passages.
- Draw subtle generalizations and conclusions about characters, ideas, and so forth in uncomplicated literary narratives.
- Draw generalizations and conclusions about people, ideas, and so forth in more challenging passages.
- Use information from one or more sections of a more challenging passage to draw generalizations and conclusions about people, ideas, and so forth.
- Draw complex or subtle generalizations and conclusions about people, ideas, and so forth, often by synthesizing information from different portions of the passage.
- Understand and generalize about portions of a complex literary narrative.

Science

S1 Interpretation of Data

- Select a single piece of data (numerical or nonnumerical) from a simple data presentation (e.g., a table or graph with two or three variables, a food web diagram).
- Identify basic features of a table, graph, or diagram (e.g., headings, units of measurement, axis labels).
- Select two or more pieces of data from a simple data presentation.
- Understand basic scientific terminology.
- Find basic information in a brief body of text.

- Determine how the value of one variable changes as the value of another variable changes in a simple data presentation.
- Select data from a complex data presentation (e.g., a table or graph with more than three variables, a phase diagram).
- Compare or combine data from a simple data presentation (e.g., order or sum data from a table).
- Translate information into a table, graph, or diagram.
- Compare or combine data from two or more simple data presentations (e.g., categorize data from a table using a scale from another table).
- Compare or combine data from a complex data presentation.
- Interpolate between data points in a table or graph.
- Determine how the value of one variable changes as the value of another variable changes in a complex data presentation.
- Identify and/or use a simple (e.g., linear) mathematical relationship between data.
- Analyze given information when presented with new, simple information.
- Compare or combine data from a simple data presentation with data from a complex data presentation.
- Identify and/or use a complex (e.g., nonlinear) mathematical relationship between data.
- Extrapolate from data points in a table or graph.
- Compare or combine data from two or more complex data presentations.
- Analyze given information when presented with new, complex information.

S2 Scientific Investigation

- Understand the methods and tools used in a simple experiment.
- Understand the methods and tools used in a moderately complex experiment
- Understand a simple experimental design.
- Identify a control in an experiment.
- Identify similarities and differences between experiments.
- Understand the methods and tools used in a complex experiment.
- Understand a complex experimental design.
- Predict the results of an additional trial or measurement in an experiment.
- Determine the experimental conditions that would produce specified results.
- Determine the hypothesis for an experiment.
- Identify an alternate method for testing a hypothesis.
- Understand precision and accuracy issues.
- Predict how modifying the design or methods of an experiment will affect results.
- Identify an additional trial or experiment that could be performed to enhance or evaluate experimental results.

S3 Evaluation of Models, Inferences, and Experimental Results

- Select a simple hypothesis, prediction, or conclusion that is supported by a data presentation or a model.
- Identify key issues or assumptions in a model.
- Select a simple hypothesis, prediction, or conclusion that is supported by two or more data presentations or models.
- Determine whether given information supports or contradicts a simple hypothesis or conclusion and why.
- Identify strengths and weaknesses in one or more models.
- Identify similarities and differences between models.
- Determine which model(s) is/are supported or weakened by new information.
- Select a data presentation or a model that supports or contradicts a hypothesis, prediction, or conclusion.
- Select a complex hypothesis, prediction, or conclusion that is supported by a data presentation or model.
- Determine whether new information supports or weakens a model and why.
- Use new information to make a prediction based on a model.
- Select a complex hypothesis, prediction, or conclusion that is supported by two or more data presentations or models.
- Determine whether given information supports or contradicts a complex hypothesis or conclusion and why.

Writing

W1 Expressing Judgments

- Show a little understanding of the persuasive purpose of the task but neglect to take or to maintain a position on the issue in the prompt.
- Show limited recognition of the complexity of the issue in the prompt.
- Show a basic understanding of the persuasive purpose of the task by taking a position on the issue in the prompt but may not maintain that position.
- Show a little recognition of the complexity of the issue in the prompt by acknowledging, but only briefly describing, a counterargument to the writer's position.
- Show understanding of the persuasive purpose of the task by taking a position on the issue in the prompt.
- Show some recognition of the complexity of the issue in the prompt by doing the following:
    - Acknowledging counterarguments to the writer's position
    - Providing some response to counterarguments to the writer's position
- Show clear understanding of the persuasive purpose of the task by taking a position on the specific issue in the prompt and offering a broad context for discussion.
- Show recognition of the complexity of the issue in the prompt by doing the following:
    - Partially evaluating implications and/or complications of the issue, and/or
    - Posing and partially responding to counterarguments to the writer's position
- Show clear understanding of the persuasive purpose of the task by taking a position on the specific issue in the prompt and offering a critical context for discussion.
- Show understanding of the complexity of the issue in the prompt by doing the following:
    - Examining different perspectives, and/or
    - Evaluating implications or complications of the issue, and/or
    - Posing and fully discussing counterarguments to the writer's position

W2 Focusing on the Topic

- Maintain a focus on the general topic in the prompt through most of the essay.
- Maintain a focus on the general topic in the prompt throughout the essay.
- Maintain a focus on the general topic in the prompt throughout the essay, and attempt a focus on the specific issue in the prompt.
- Present a thesis that establishes focus on the topic.
- Maintain a focus on discussion of the specific topic and issue in the prompt throughout the essay.
- Present a thesis that establishes a focus on the writer's position on the issue.
- Maintain a clear focus on discussion of the specific topic and issue in the prompt throughout the essay.
- Present a critical thesis that clearly establishes the focus on the writer's position on the issue.

W3 Developing a Position

- Offer a little development, with one or two ideas; if examples are given, they are general and may not be clearly relevant; resort often to merely repeating ideas.
- Show little or no movement between general and specific ideas and examples.
- Offer limited development of ideas using a few general examples; resort sometimes to merely repeating ideas.
- Show little movement between general and specific ideas and examples.
- Develop ideas by using some specific reasons, details, and examples.
- Show some movement between general and specific ideas and examples.
- Develop most ideas fully, using some specific and relevant reasons, details, and examples.
- Show clear movement between general and specific ideas and examples.
- Develop several ideas fully, using specific and relevant reasons, details, and examples.
- Show effective movement between general and specific ideas and examples.

W4 Organizing Ideas

- Provide a discernible organization with some logical grouping of ideas in parts of the essay.
- Use a few simple and obvious transitions.
- Present a discernible, though minimally developed, introduction and conclusion.

- Provide a simple organization with logical grouping of ideas in parts of the essay.
- Use some simple and obvious transitional words, though they may at times be inappropriate or misleading.
- Present a discernible, though underdeveloped, introduction and conclusion.
- Provide an adequate but simple organization with logical grouping of ideas in parts of the essay but with little evidence of logical progression of ideas.
- Use some simple and obvious, but appropriate, transitional words and phrases.
- Present a discernible introduction and conclusion with a little development.
- Provide unity and coherence throughout the essay, sometimes with a logical progression of ideas.
- Use relevant, though at times simple and obvious, transitional words and phrases to convey logical relationships between ideas.
- Present a somewhat developed introduction and conclusion.
- Provide unity and coherence throughout the essay, often with a logical progression of ideas.
- Use relevant transitional words, phrases, and sentences to convey logical relationships between ideas.
- Present a well-developed introduction and conclusion.

W5 Using Language

- Show limited control of language by doing the following:
    - Correctly employing some of the conventions of standard English grammar, usage, and mechanics, but with distracting errors that sometimes significantly impede understanding
    - Using simple vocabulary
    - Using simple sentence structure
    - Correctly employing some of the conventions of standard English grammar, usage, and mechanics, but with distracting errors that sometimes impede understanding
    - Using simple but appropriate vocabulary
    - Using a little sentence variety, though most sentences are simple in structure
    - Correctly employing many of the conventions of standard English grammar, usage, and mechanics, but with some distracting errors that may occasionally impede understanding
    - Using appropriate vocabulary
    - Using some varied kinds of sentence structures to vary pace
    - Correctly employing most conventions of standard English grammar, usage, and mechanics with a few distracting errors but none that impede understanding
    - Using some precise and varied vocabulary
    - Using several kinds of sentence structures to vary pace and to support meaning
    - Correctly employing most conventions of standard English grammar, usage, and mechanics with just a few, if any, errors
    - Using precise and varied vocabulary
    - Using a variety of kinds of sentence structures to vary pace and to support meaning

Appendix D: National Industry Standards

Society of the Plastics Industry Standards

C=Content

K=Knowledge

I. Essential Knowledge

- C1 Communicate with co-workers and supervisors using standard industry terminology.
- C2 Identify underlying technical principles to account for observations.
- K1 K of relevant industry terminology
- K2 K of relevant technical principles (mechanical, hydraulic, thermodynamic, electrical, chemical, rheological)

II. Extrusion Process

- GC1 Follow rules and regulations.
- GC2 Follow specifications in order to produce a quality product while continuously suggesting improvements to the process.
- GC3 Communicate essential information at shift change.
- GC4 Respond to process alarms.
- A. Materials
  - C5 Identify proper material from label.
  - C6 Blend materials.
  - C7 Maintain control, traceability, and separation of materials.
  - C8 Evaluate materials for color and other visible defects.
  - C9 Repackage and label materials.
  - C10 Modify environment to prevent degradation of material.
  - C11 Prevent contamination of materials.
  - C12 Understand calibration methods for blending equipment and other process controls.
  - C13 Identify the impact of material rheology on the process and product.
  - K1 K of rheology (flow behavior; effects of shear, pressure, time, temperature, moisture, and speed)
  - K2 K of plasticization process (screw design, length to diameter ratio, rpm, back pressure, pressure drop)

K3 K of characteristics of hydrophobic and hydrophilic materials

K4 K of characteristics of recycled materials

K5 K of degradation and its causes

K6 K of amorphous or crystalline material behavior

K7 K of thermoplastic or thermoset material behavior

K8 K of types of plastic

K9 K of additives and colorants

K10 K of impact of variability of materials (off-spec/wide-spec resin)

K11 K of impact of changes in materials on process (in regard to product changeovers)

K12 K of environmental conditions (humidity, temperature, dust, pressure) and impact on materials

K13 K of materials incompatibilities

K14 K of blends, blending methods (tumbling materials, proportional, gravimetric, volumetric), and effects of blending

K15 K of material handling (covers, containment liners, air or vacuum systems)

K16 K of contamination-prevention methods

K17 K of material identification (labels)

K18 K of methods to obtain proper moisture content in materials

K19 K of wear characteristics in dies (impact of plastic type on wear characteristics)

B. Single and Twin Screw Processing

C14 Carry out requirements of work instructions.

C15 Perform process setup for reliable and safe operations.

C16 Identify hardware components by name and function.

C17 Start up the process.

C18 Operate the process.

C19 Shut down the process.

C20 Safe operation of auxiliary equipment/processes

C21 Identify alarms, safety hazards, and non-standard operating conditions and notify the proper personnel.

K20 K of plasticization process (single and twin screw design, length to diameter ratio, rpm, back pressure)

K21 K of different sections of plasticization process: feeding, compression, and metering

K22 K of different types of mixing (dispersive and distributive)

K23 K of devolatilization sections and equipment

K24 K of feed options for single and twin screw extruders

K25 K of heating and cooling options for extruders: band and cast heaters, heat only elements, heat and cooling elements, cooling media: air, water, oil, and so forth

K26 K of auxiliary equipment (blenders, chillers, dryers, temperature control systems, crystallizers)

K27 K of machine startup and shut-down procedures

K28 K of product changeover and purge procedures

K29 K of residence time and its effect on materials

K30 K of processing profiles (temperature, pressure, amperage)

K31 K of process monitoring/control systems (closed loop, open loop)

K32 K of standard operating procedures for equipment

K33 K of hand tools used in conjunction with machine

K34 K of troubleshooting for process problems

K35 K of required personal protective equipment (PPE)

K36 K of rupture disks

C. Tooling/Die and Forming

C22 Proper use of melt-filtration device, if applicable

C23 Operate gear pump, if applicable.

C24 Configure and attach die and related equipment (heaters, cooling, thermocouples, mandrel, automatic profile control die, and NDC).

K37 K of impact of polymer flow on product quality

K38 K of types and operation of screen changes

K39 K of adapter plates

K40 K of operation of gear pumps

K41 K of selection, installation, and maintenance procedures for tooling/die

K42 K of hand tools for use with tooling/die

K43 K of the use of heaters and temperature monitoring devices for use with tooling/die

K44 K of co-extrusion systems

K45 K of mechanical die-adjustment options (centered, off-centered, flex-lip)

K46 K of die configuration

K47 K of heat treatment of dies

D. Cooling and Sizing

C25 Operate the cooling/sizing system to achieve desired product qualities.

K48 K of impact of cooling time and rate on product properties at the time of production and in the future (internal stresses that appear after a given time to change physical properties)

K49 K of impact of cooling medium (air and liquid or contact surface) on product properties

K50 K of types of product cooling/sizing systems (towers, chillers, heat exchangers)

K52 K of the use of microbiological filtration systems, if necessary

K53 K of the effect of the environment on cooling process

K54 K of pull systems and the effect of line speed on properties and cross-sectional ratio dimensions

K55 K of changes to make if process is out-of-limits (OOL)

E. Downstream Processing, Including Cutting/Winding/Finishing/Printing

C26 Safe operation of finishing equipment

C27 Monitor product quality to identify defects.

K56 K of functions of downstream equipment

K57 K of standard operating procedures for downstream equipment

K58 K of open- and closed-loop dimensional monitoring equipment

K59 K of product specifications

K60 K of hand tools used in conjunction with downstream processing

K61 K of parameters for identifying visible and physical property defects

III. Major Components of the Injection Molding Process

GC1 Follow rules and regulations.

GC2 Follow specifications in order to produce a quality product.

GC3 Communicate essential information at shift change.

GC4 Safe operation of injection molding machines and auxiliary equipment

A. Materials

C5 Identify types of materials by amorphous or crystalline properties.

C6 Identify proper material from label.

C7 Blend materials.

C8 Maintain control and separation of materials.

C9 Evaluate materials for color, texture, and any visible defects.

C10 Repackage and identify materials.

C11 Analyze properties of rheology and the impact on the process.

C12 Modify environment to reduce impact on materials.

C13 Prevent contamination of materials.

C14 Perform stock rotation (lot traceability).

K1 K of rheology (flow behavior; pressure, time, temperature, and speed)

K2 K of plasticization process (screw design, barrel size, rpm, non-return valve, back pressure)

K3 K of types of plastic

K4 K of additives and colorants

K5 K of impact of variability of materials (off-spec/wide-spec resin)

K6 K of impact of changes in materials on process (in regard to product changeovers)

K7 K of impact of changes to process on the material

K8 K of environmental conditions (humidity, temperature, dust, pressure) and impact on materials

K9 K of material properties and incompatibility

K10 K of blends and blending methods (tumbling materials, proportional blending, gravimetric blending, volumetric blending)

K11 K of materials handling (covers, containment liners, air or vacuum systems)

K12 K of material identification (labels)

K13 K of how drying materials affect processing and final material properties (brittle if processed while not properly dried)

K14 K of unique drying techniques for engineering resins

B. Machine

C15 Fixture, degate, assemble, and remove flash from parts as instructed with minimum of scrap, and package parts in the prescribed manner to avoid causing defects and with cycle limits.

C16 Carry out requirements of work instructions.

C17 Identify alarms or non-standard operating conditions, and notify the proper personnel.

C18 Understand operation of auxiliary equipment.

C19 Use work tools for product assembly, function, and aesthetic requirements.

C20 Report and clear jammed part.

C21 Ensure that proper part containment is maintained (install temporary guards, catch bins).

K15 K of plasticization process (screw design, barrel size, rpm, non-return valve, back pressure)

K16 K of injection molding machine (IMM) setup

K17 K of auxiliary equipment (for example, granulators, conveyors, robots)

K18 K of secondary equipment

K19 K of machine startup and shut-down procedures

K20 K of special processes (gas-assist, endothermic, and exothermic molding, in mold labeling rotational molding)

K21 K of processing profiles (temperature, pressure, velocity)

K22 K of cooling capacity (manifolding, length and diameter of hose, temperatures, BTU, coolant type, gallons per minute)

K23 K of hydraulic, toggle, combination molding machine

K24 K of process monitoring systems (closed loop or open loop)

K25 K of standard operating procedures for equipment

K26 K of hand tools used in conjunction with machine

K27 K of process parameters (temperature, time, range, position)

K28 K of dryer setup and importance of dew point

K29 K of the different types of nozzle tips (std, tapered, reverse taper nylon)

K30 K of sizing the nozzle tip to the sprue bushing (1/32 smaller than sprue bushing opening)

K31 K of required personal protective equipment (PPE)

C. The Mold

C22 Report and clear stuck parts.

C23 Report blocked gates.

C24 Clean and grease mold.

C25 Respond to alarms and other feedback from mold protection systems.

C26 Clean vents and perform minor maintenance and servicing.

K32 K of mold types (high production, proto types, unit tools, stack mold)

K33 K of mold components (core, cavities, slides, unscrewing)

K34 K of mold setup

K35 K of methods for applying grease (grease the bushing, not the pin)

K36 K of cooling capacity (manifolding, length and diameter of hose, temperatures, BTU, coolant types, gallons per minute)

K37 K of cooling problems and possible solutions

K38 K of mold cooling and heating systems (mold temperature controller, heat exchangers, oil)

K39 K of runner systems (insulated runners, cold or hot runner, gate systems, valve gates, cold to hot, three plate, ejector system—pin or stripper)

K40 K of ejection systems (runner balance, water location, part removal, draft, undercuts)

K43 K of mold-making material properties (thermal conductivity, strength, wear, care, hardness)

K44 K of mold preventive maintenance during processing

K45 K of mold post-processing—cleaning, greasing, and repair

K46 K of mold handling and storage

K47 K of authorizations and procedures to remove stuck plastic parts (work instructions)

K48 K of process monitoring systems (pressure transducer, thermocouple)

K49 K of hand tools used in conjunction with mold

K50 K of how to determine correct nozzle size and type

K51 K of mold protection systems

IV. Material and Product Handling/Storage

C1 Package and label cartons in accordance with work instructions.

C2 Evaluate finished product for defects.

C3 Follow verbal/written instructions in order to ensure proper handling, storage, and delivery of finished materials.

C4 Look, listen, feel, and/or smell for changes (use sensory input).

C5 Use visual job aids.

C6 Notify proper production and quality personnel when non-conforming product/process conditions warrant adjustment or disposition.

C7 Assemble packaging.

C8 Prevent contamination of materials.

K1 K of lot traceability

K2 K of blending methods (tumbling materials, proportional, gravimetric, volumetric)

K3 K of materials handling (covers, containment liners, venture systems)

K4 K of material-handling equipment and systems (lifts, robotics, silos, conveyor systems, pneumatic conveying; dense and dilute phase, skids, fork-truck lifts)

K5 K of equipment conditions (dryers, filters, conveying systems) and impact on materials

K6 K of storage requirements (tagging, segregation, inventory control, labeling/identification)

K7 K of lifting and moving techniques

K8 K of required personal protective equipment (PPE)

K9 K of training requirements

K10 K of hand tools used for finished product

K11 K of secondary equipment

K12 K of non-standard conditions (temporary deviations)

K13 K of packing and shipping requirements

K14 K of production reporting

K15 K of procedures to prevent the buildup of static electricity when handling or conveying material

K16 K of the impact of handling and storage methods on final product quality

V. Measurement, Analysis, and Response

GC1 Perform inspections to identify product defects—gels, burns, streaks, blemishes, color, dimensions, shorts, flash, sinks, and warping, and other visual defects as defined by customer or industry standards.

GC2 Identify root cause of product defects.

GC3 Identify abnormal events and notify the proper personnel.

GC4 Follow verbal/written job instructions.

GC5 Proactive problem solving as authorized

GC6 Accurate production reporting

GC7 Implement various corrective actions.

GC8 Apply statistical techniques such as process capability index, process performance index, and root cause analysis in the analysis and investigation of process performance.

A. Quality Tools

C9 Read blueprints and or specifications, as appropriate, to establish acceptance criteria.

C10 Use basic metrology equipment and tools.

C11 Perform conversions (units of measure, fractions to decimals, and decimals to fractions).

C12 Use statistical process control to gather and analyze data.

C13 Document and/or validate process checks.

K1 K of defect classification systems (visual, dimensional, functional)

K2 K of process repeatability/reliability, including capability studies (CPk and PPk)

K3 K of calculations required to identify trends

K4 K of statistical process control (average of averages, x-bar charts)

K5 K of measuring devices (gauges, gram scale, micrometers, vision measuring systems)

K6 K of tests performed to verify quality

K7 K of inspection techniques (pull tests, statistical sampling plans)

K8 K of company quality procedures

K9 K of continuous improvement process

K10 K of formal problem solving techniques (design of experiment, bar charting)

K11 K of causes of potential problems (molds, material, machine, man, methods)

K12 K of customer master specifications, including product specifications

K13 K of customer feedback (customer surveys and complaints)

K14 K of rejection criteria, including procedures to handle non-conforming products

K15 K of cost of poor quality

K16 K of tolerance as assigned to products

K17 K of quality systems (Six Sigma, 5S, lean manufacturing system)

K18 K of process validation (installation quality, operation quality, and performance quality)

K19 K of process monitoring (impact of changes in temperature, time, speed, and pressure, how to mitigate)

K20 K of conversions, units, percentages/fractions

K21 K of document control

K22 K of handling, storage and preservation of gauges and measurement devices

B. Preventive Actions

C14 Identify and report potential problems.

C15 Perform root cause analysis.

K23 K of preventive actions

K24 K of machine safety checklist

K25 K of non-standard conditions (temporary deviations)

K26 K of document control

K27 K of impact of changes in equipment on process and profit

K28 K of general housekeeping requirements

K29 K of preventive maintenance audit techniques

K30 K of maintenance schedules

K31 K of benchmarking

K32 For Injection Molding only: K of hand tools used in plastics operations

K33 For Injection Molding only: K of secondary/downstream equipment

C. Corrective Action

C16 Rework products as appropriate.

C17 Notify proper production and quality personnel when non-conforming product/process conditions warrant adjustment or disposition.

C18 Perform root cause analysis.

C19 Implement and evaluate effectiveness of corrective actions.

K34 K of corrective actions

K35 K of document control

K36 K of procedures to identify and document equipment problems and corrective actions

K37 K of troubleshooting

K38 K of communication procedures for problem reporting and resolution regarding manufacturing

VI. Safety Components

C1 Maintain cleanliness of the work station area.

C2 Perform and/or follow all safety guidelines and regulations.

C3 Report hazardous conditions.

C4 Locate and use HAZCOM information.

C5 Report any near misses, accidents, and/or injuries.

C6 Conform to all plant good manufacturing practices.

K1 K of OSHA standards (bloodborne pathogens, record keeping)

K2 K of HAZCOM (MSDS, labeling, training requirements)

K3 K of personal protection equipment

K4 K of lockout/tagout and machine guarding

K5 K of “right-to-know”

K6 K of plant-specific safety guidelines

K7 K of safety information resources

K8 K of accident and near-miss reporting

K9 K of impact of safety-related requirements on production

K10 K of safety training and documentation requirements

K11 K of first aid procedures (eye wash stations, medicine cabinets, showers)

K12 K of procedures for injuries beyond first aid (CPR, burns, use of first responders)

K13 K of emergency procedures (drills, evacuation, hazardous material spills, natural disasters, fires)

K14 K of accident investigation (job safety analysis, hazard elimination, reporting)

K15 K of job hazard analysis techniques

K16 K of general housekeeping requirements

K17 K of procedures to create and reinforce safety awareness

K18 K of safe use of hand tools

K19 K of safety considerations for equipment

K12 K of safety checklist

K21 K of the potential for dangerous interactions among materials

Appendix E:
National Educational Technology Standards for Students

T1 Creativity and Innovation
T2 Communication and Collaboration
T3 Research and Information Fluency
T4 Critical Thinking, Problem Solving, and Decision Making
T5 Digital Citizenship
T6 Technology Operations and Concepts

T1 Creativity and Innovation
Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students:
a. apply existing knowledge to generate new ideas, products, or processes.
b. create original works as a means of personal or group expression.
c. use models and simulations to explore complex systems and issues.
d. identify trends and forecast possibilities.

T2 Communication and Collaboration
Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others. Students:
a. interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media.
b. communicate information and ideas effectively to multiple audiences using a variety of media and formats.
c. develop cultural understanding and global awareness by engaging with learners of other cultures.
d. contribute to project teams to produce original works or solve problems.

T3 Research and Information Fluency
Students apply digital tools to gather, evaluate, and use information. Students:
a. plan strategies to guide inquiry.
b. locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
c. evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
d. process data and report results.

T4 Critical Thinking, Problem Solving, and Decision Making
Students use critical-thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources. Students:
a. identify and define authentic problems and significant questions for investigation.
b. plan and manage activities to develop a solution or complete a project.
c. collect and analyze data to identify solutions and/or make informed decisions.
d. use multiple processes and diverse perspectives to explore alternative solutions.

T5 Digital Citizenship
Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. Students:
a. advocate and practice safe, legal, and responsible use of information and technology.
b. exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.
c. demonstrate personal responsibility for lifelong learning.
d. exhibit leadership for digital citizenship.

T6 Technology Operations and Concepts

Students demonstrate a sound understanding of technology concepts, systems, and operations. Students:

a. understand and use technology systems.
b. select and use applications effectively and productively.
c. troubleshoot systems and applications.
d. transfer current knowledge to learning of new technologies.

Appendix F: Polymer Standards for the State of Mississippi*

MPC1 **Business Understanding:** Understanding the inner workings of business functions and how business decisions affect financial or non-financial work results

MPC2 **Change Management:** Helping people adapt to the changes brought on by new technologies and helping them to see the value and benefits of new technologies

MPC3 **Coaching:** Problems, alternatives, and goals

MPC4 **Communication:** Applying effective verbal, nonverbal, and written communication methods to achieve desired results

MPC5 **Compounding:** Understanding the process of blending polymers with additives to produce a product for the forming industry

MPC6 **Customer Focus:** Dedication to meeting or exceeding the expectations and requirements of both internal and external customers

MPC7 **Decision-Making Ability:** Selecting, in a timely manner, appropriate course(s) of action that is(are) consistent with the organization's mission, vision, and strategies

MPC8 **Design of Experiments:** Familiarity with this discipline and method of experimentation that is used to gather and analyze data and to efficiently determine process and product interactions

MPC9 **Electromechanical Technology:** The ability to install, maintain, and use electromechanical measuring and control instruments

MPC10 **Equipment-Based Computer Skills:** The ability to understand and use vocabulary and grammatical rules for instructing equipment-based computers to perform specific tasks

MPC11 **Extruding:** Understanding the process of forming a continuous piece of matter by forcing it through a shaping orifice

MPC12 **Film Formation:** Understanding the process of forming film by casting, extrusion, or other film-producing processes

MPC13 **Finishing and Decorating:** Understanding the methods used to decorate a part or otherwise provide required surface appearance or properties

MPC14 **Group Process Understanding:** Understanding how groups function; influencing people so that group, work, and individual needs are addressed

MPC15 **Hydraulics and Pneumatics:** The ability to install, maintain, and use hydraulic and pneumatic systems

MPC16 **Industry Understanding:** Understanding the vision, strategy, goals, and culture of other companies within the polymer processing industry

MPC17 **Innovativeness:** The ability to generate unique ideas and concepts that, if applied, could provide the organizations with a competitive advantage

MPC18 **Leadership:** The ability to influence and guide members of the organization to achieve organizational objectives

MPC19 **Model Building:** The ability to develop frameworks from complex and theoretical ideas

MPC20 **Molding:** Understanding the methods used to form various types of product shapes

MPC21 **Organization:** The use of coordination and communication as tools used to accomplish tasks in a systematic manner

MPC22 **Print Reading:** The ability to interpret drawings, schematics, and other structural prints

MPC23 **Process Management:** Providing support and coordination for one or many operational processes, with the objectives being increased efficiency and waste reduction

MPC24 **Processing:** Understanding the methods used to control processes to achieve product, safety, quality, and environmental specifications

MPC25 **Project Management:** Planning, implementing, and evaluating assignments to ensure that the desired outcomes of the assignment are produced on time and within budget

MPC26 **Questioning:** Gathering information from stimulating insight in individuals and groups through use of interview, questionnaires, and other probing methods

MPC27 **Relationship Building Skills:** Establishing relationships and networks across a broad range of people and groups

MPC28 **Research Skills:** Selecting, developing, and using methodologies such as statistical and data collection techniques for formal inquiry

MPC29 **Resin and Additive Formulation:** Knowledge of polymer materials to achieve appropriate formulation for intended purpose

MPC30 **Rheology:** Understanding formulation and flow of matter, including linkage and cross-linking of molecules to achieve specific properties

MPC31 **Self-Knowledge/Self-Management:** Knowing one's personal values, needs, interests, style, and competencies and being able to manage their effects on others

MPC32 **Systems Thinking:** Identifying inputs, throughputs, and outputs of a subsystem, system, or suprasystem and applying that information to improve the application of polymer science; realizing the implications of these technologies on many parts of an organization, process, or individual; taking steps to address the impact of applying these technologies

MPC33 **Teamwork:** Successfully and efficiently working and communicating with group or project members such that the team's final output meets or exceeds predefined expectations

MPC34 **Technical Communications:** The ability to translate and communicate required technical information to non-technical operational people

MPC35 **Time Management:** Valuing time and ensuring that it is used efficiently for all tasks

MPC36 **Troubleshooting:** The ability to formulate and evaluate alternative solutions to current or forecasted problems and implement the appropriate course(s) of action using rigorous logic and other probing methods

*Adapted from standards developed by the Mississippi Polymer Cluster Group, in association with the Workforce Development and Training Group at the University of Southern Mississippi