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ABSTRACT

This document, which is intended to assist individuals responsible for developing tech prep programs, lists the occupational, academic, and employability competencies that representatives from education, business/industry, and labor throughout Ohio have identified as being necessary for employment in technician-level positions involving the manufacture and/or use of plastics. Included in the introductory section are the following: overview of the technical competency profile (TCP) process used to identify the technical competencies; lists of TCP team members; plastics job definitions; and plastics technical competency profile matrix. The plastics technical competencies identified by the TCP team are listed by the following categories: communications literacy; mathematics literacy; science literacy; technological literacy; employability skills; professionalism; teamwork; technical recording and reporting; problem analysis; project management; computer literacy; basic economics; workplace safety; industrial electricity; electric test and measurement equipment; drafting technology; print reading; computer-aided design fundamentals; equipment maintenance; electromechanical technology; basic machining; hydraulics and pneumatics; industrial manufacturing technology; programmable logic controllers; welding basics; supervision; quality assurance; plastics press technology; sheet metal fabrication; mold making; polymer technology; plastics troubleshooting; plastics product design; color matching; instrumental methods; rheology; and plastics manufacturing. Concluding the document are a sample glossary and plastics TCP index. (MN)

Plastics Technical Competency Profile

A Collaborative Project of the:

Ohio Department of Development

Ohio Tech Prep Initiative
(co-sponsored by the Ohio Department of Education and Ohio Board of Regents)

Polymer Processors Association (PPA)

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"The plastics industry has played a major role in Ohio's resurgence as an economic leader. Ohio accounts for approximately 10% of the national plastics industry workforce, employing more than 100,000 people, and is responsible for the manufacture and shipment of products valued at more than $15 billion."

—Ohio Governor George V. Voinovich

A Collaborative Plastics Curriculum

More than a year ago, members of the Polymer Processors Association (PPA), Society of Plastics Engineers (SPE), and the plastics industry at-large sought the assistance of the Ohio Department of Development and the Ohio Tech Prep Initiative to develop a statewide core curriculum. This curriculum would provide career paths for students at the end of a high school vocational program, adult education program, 8,000 hour apprenticeship program, Tech Prep (2 + 2) program, applied associate degree program, and/or baccalaureate program.

As the plastics project curriculum facilitator, Cathy Scruggs, Ohio Tech-Prep Curriculum Specialist, would like to thank the following individuals for their help and support with this collaborative effort.

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◆◆◆ The TCP Process ◆◆◆

The "Technical Competency Profile (TCP) Process" produces a list of occupational, academic, and employability competencies that need to be obtained in preparation for technician level positions in business, industry, and labor. The "TCP Process" allows individuals from both secondary and postsecondary education and business, industry, and labor to deal with change in a positive manner by being active decision makers in the development of curriculum. Prior to the first official TCP meeting, labor market need has been determined and occupations identified for the targeted curriculum cluster. Then the following three "panel sessions" occur.

Part I of the TCP Process:

Business, industry, and labor representatives from a labor market area are convened to identify the occupational, academic, and employability competencies needed by one or more technician-level positions.

- First, a brainstorming session is conducted to identify the critical skills needed by the technician(s) positions being targeted (e.g., Process Technician, or a cluster of occupations within the plastics industry).
- Second, a draft competency list that has been compiled in accordance with definitions of the individual or group of technician-level position(s) identified as the labor market need is offered for consideration. Then, business, industry, and labor representatives eagerly (1) add to, (2) delete from, and (3) alter the wording of the draft competency list until it reflects the needs in the consortium's labor market area. It is critical that business, industry, and labor representatives alter the draft to fit the needs of their area, because it will be the catalyst for systemic curriculum reform in their schools and colleges—ultimately altering the type of employee pool available.
- Then the business, industry, and labor representatives are provided with state required competencies in academic courses such as mathematics, language arts (communications), and science. They are asked to circle the code beside each competency that could be taught in the context of the technologies being addressed by the TCP. This is done by silent, written votes so that the educational levels of committee members will not sway the results. After tabulating the responses, the corresponding competencies are identified with an asterisk (*) and used during Parts II and III of the TCP Process.

Part II of the TCP Process:

Both the academic and vocational-technical faculty members who will be delivering the competencies in the consortium's participating secondary schools and postsecondary colleges meet to assign grade levels and mastery levels to each competency on the list.

• "Leveling" codes are used to indicate two-year increments (by the end of grade 10, grade 12, AD-an associate degree, BD-a baccalaureate degree) during which competencies will be introduced (I) and/or reinforced (R); when students will expected to be competent (C), or proficient (P), or as having mastered (M) the competency; provided at a worksite (WS); or are lifelong learning (LL) skills due to technological change. Competencies may carry one code (e.g., M12) **or** multiple codes such as I-10, P-12, R-AD, M-BD, WS, LL. Faculty members are also asked to list obstacles to delivering the competencies as stated (e.g., wording, equipment, training needs). These issues are recorded and addressed during TCP Part III.
• Faculty members are also given the list of academic competencies that business, industry, and labor representatives identified during Part I as appropriate to be taught in the context of those technologies (indicated by an asterisk*) and asked to verify the validity of those choices. They are also asked to identify (using #) any additional competencies that need to be taught in the context of those technologies (Note—this is necessary due to educational terms not being understood by industry representatives.) In this way faculty begins to discuss ways to apply academic content to the various technologies and ways to collaborate across disciplines to accomplish that task.

Part III of the TCP Process:

Both groups, from TCP Parts I and II, meet together to address perceived obstacles to accomplishing the competencies and how they, as a team, can best work together to facilitate delivery of the curriculum by removing or addressing each of the obstacles identified in Parts II and III. This is the "magic" of the TCP Process. With all the individual "players" at the same table, planning for true systemic change can take place—especially if the focus is improving the education and training of students who will be their future employees and community members.

Post-TCP Steps:

• Following the three "panel sessions" of the TCP Process, committees are formed to complete the leveling of the competency builders and to create "pathways" that aid parents, teachers, and counselors in guiding students toward career choices.

Sample Section of TCP Accountability Chart

Unit: Computer Literacy	10	12	AD	BD	WS	LL
Competency: Operate computer hardware	I	R	M	R	√	√
Competency Builders: Practice proper media handling techniques (e.g., magnetic fields, dust, liquids)		M	R		√	√
Identify hardware and its use	I	M	R	R	√	√
Use hardware (e.g., mouse, drives, modems, cables, printers, digitizers, scanners, protection devices)	I	R	M	R	√	√
Keyboard efficiently		M	R	R	√	√
Demonstrate basic care of hardware	I	M	R		√	√

• The TCP chart is then used to extrapolate competencies into Competency Documentation Sheets that outline the content of each course/worksite experience on the curriculum pathway and verify that all the competencies in the TCP are covered.

Sample Competency Documentation Sheet

Futures County High School, Plastics Technologies Program

Integrated Math I covers the following competencies:

NR2 Estimate answers, compute, and solve problems involving real numbers
M1 Estimate and use measurements
M8 Establish ratios with and without common units
M13 Compute total sales from a variety of items
M18 Identify area and volume
D1 Organize data into tables, charts, and graphs
D7 Use tables, charts, and graphs to identify trends, draw conclusions, and make predictions
A13 Set up and solve linear equations
A21 Graph linear equations
A36 Translate verbal statements into symbolic language
G1 Create and interpret drawings of three-dimensional objects
G2 Represent problem situations with geometric models and apply properties of figures
G4 Demonstrate knowledge of angles, parallel, and perpendicular lines
(the list would continue...)

• To complete the TCP Process, committees often use both the "pathways" and the TCP chart to assist in the development of actual projects, lessons, modules, courses of study, and eventually curriculum resource guides for the various components of the program at each grade level.

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Plastics Job Definitions

Production Associate—An operator of plastics processing equipment. Technical skills should include, but not be limited to:

- safety issues in plastic processing
- trimming/finishing operation
- visual inspection for appearance/defects
- performs basic quality procedures (e.g., use of go/no go gauges, calipers, scales)
- document process information (e.g., production reports, traceability, SPC charts)

Preferred Minimum Education Level: High School Graduation or GED equivalent

Set-Up Person—An individual who set-ups plastics processing equipment utilizing set-up specifications and prints. Technical skills should include, but not be limited to:

- has above plus
- enhanced safety training
- can read and understand set-up sheets, follow written instruction, keep records
- set-up tooling and auxiliary equipment
- can startup and run initial samples
- basic tooling and equipment maintenance
- material handling capabilities

Preferred Minimum Education Level: High School Graduation or GED equivalent

Maintenance Person—An individual who maintains, troubleshoots, and repairs equipment. Technical skills should include, but not be limited to:

- work experience of set-up/production associate
- advanced safety requirements
- understanding of electrical, hydraulic, pneumatic and mechanical systems on processing and related equipment
- reading schematic diagrams
- basic machining capabilities
- basic welding
- document changes

Preferred Minimum Education Level: High School Graduation or GED equivalent

Plastics Job Definitions

Quality Assurance Person—An individual who monitors and documents products conformance to specifications. Technical skills should include, but not be limited to:

- work experience of set-up/production associate
- reads prints
- maintain calibration program
- generate first piece inspection
- can apply SPC technologies
- handling the responsibility of being in an unpopular position
- capability of team problem solving

Preferred Minimum Education Level: High School Graduation or GED equivalent

Process Technician—An individual who troubleshoots and corrects processing problems. Would also be used to improves processes. Technical skills should include, but not be limited to:

- has above plus
- abilities of quality assurance
- knowledge of material properties
- capability of team problem solving

Preferred Minimum Education Level: Two-year Applied Associate Degree and/or Postsecondary Apprenticeship Certificate

Journeyman—An individual who possesses the technical skills of the molder, set-up, maintenance, quality assurance, and processing technician.

Preferred Minimum Education Level: Completion of an 8,000 hour Apprenticeship Program or a Two-year Applied Associate Degree and several years of experience

Baccalaureate Degree—An individual who has obtained a four-year degree in either (1) Plastics Manufacturing/Processing or Materials Science; (2) Industrial Technology with an emphasis in plastics; or (3) an area of Engineering Technologies with a capstone in plastics.

Plastics Technical Competency Profile Matrix
(March 1996)

A = Production Associate
B = Set-Up Person
C = Maintenance Person
D = Quality Assurance Person
E = Process Technician
F = Journeyman
G = Baccalaureate Degree

PG	UNITS	A	B	C	D	E	F	G
3	*Communications Literacy	X	X	X	X	X	X	X
19	*Mathematics Literacy	X	X	X	X	X	X	X
29	*Science Literacy	X	X	X	X	X	X	X
48	*Technology Literacy	X	X	X	X	X	X	X
50	Employability Skills	X	X	X	X	X	X	X
56	Professionalism	X	X	X	X	X	X	X
61	Teamwork	X	X	X	X	X	X	X
64	Technical Recording & Reporting	X	X	X	X	X	X	X
65	Problem Analysis	X	X	X	X	X	X	X
67	Project Management				X	X	X	X
69	Computer Literacy	X	X	X	X	X	X	X
71	Basic Economics	X	X	X	X	X	X	X
73	Workplace Safety (Level 1)	X	X	X	X	X	X	X
77	Workplace Safety (Level 2)			X		X	X	X
78	Industrial Electricity		X	X		X	X	X
85	Electrical Test & Measurement Equipment		X	X		X	X	X
86	Drafting Technology			X	X	X	X	X
92	Print Reading		X	X	X	X	X	X
94	CAD Fundamentals			X	X	X	X	X
97	Equipment Maintenance		X	X		X	X	X
101	Electromechanical Technology			X		X	X	X
103	Basic Machining			X			X	X
111	Hydraulics & Pneumatics		X	X		X	X	X
118	Industrial Manufacturing Technology (Level 1)			X		X	X	X
122	Industrial Manufacturing Technology (Level 2)							X

Plastics Technical Competency Profile Matrix
(continued)

A = Production Associate
B = Set-Up Person
C = Maintenance Person
D = Quality Assurance Person
E = Process Technician
F = Journeyman
G = Baccalaureate Degree

PG	UNITS	A	B	C	D	E	F	G
123	Programmable Logic Controllers (PLCs)			X			X	X
126	Welding Basics			X			X	X
129	Supervision			X	X	X	X	X
131	Quality Assurance (Level 1)	X	X	X	X	X	X	X
134	Quality Assurance (Level 2)						X	X
140	Quality Assurance (Level 3)							X
142	Plastics Press Technology (Level 1)	X	X	X	X	X	X	X
143	Plastics Press Technology (Level 2)		X	X		X	X	X
146	Sheet Metal Fabrication			X		X	X	X
149	Moldmaking (Level 1)			X		X	X	X
151	Moldmaking (Level 2)					X	X	X
152	Polymer Technology (Level 1)	X	X	X	X	X	X	X
161	Polymer Technology (Level 2)				X	X	X	X
163	Plastics Troubleshooting (Level 1)		X	X	X	X	X	X
164	Plastics Troubleshooting (Level 2)		X			X	X	X
165	Plastics Product Design				X	X	X	X
169	Color Matching (Level 1)				X	X	X	X
171	Color Matching (Level 2)							X
172	Instrumental Methods (Level 1)				X	X	X	X
174	Instrumental Methods (Level 2)							X
175	Rheology				X	X	X	X
180	Plastics Manufacturing (Level 1)	X	X	X	X	X	X	X
185	Plastics Manufacturing (Level 2)		X	X	X	X	X	X

TCP LEVELING CODES

10 = by end of grade 10

12 = by end of grade 12

AD= by end of the Associate Degree

BD= by end of the Baccalaureate Degree

LL = lifelong learning necessary due to technological change

WS = on-job-training that occurs at an actual worksite

I = introduce (applies to at least 3 competency builders)

R = reinforce or add depth (after introducing or mastery)

M or C or P = master, competent, or proficient (achievement of the competency and all its competency builders)

Example: M12, RAD	Example: I-10, R12, PAD, LL
Example: R10, C12, WS	Example: I-12, RAD, MBD

Special Academic Codes used **only** for Communications Literacy, Mathematics Literacy, Science Literacy, and Technology Literacy.

* = Industry identified this competency to be taught using applied methods in context of technology

\# = Teachers identified this competency to be taught using applied methods in context of technology

Note: All academic competencies not identified by * or # are to be taught using regular or applied teaching methods.

	Unit: Communications Literacy	* = Industry identified these to be taught using applied methods # = Teachers identified these to also be taught using applied methods Note: The remaining competencies are to be taught using regular or applied methods.					
	Subunit: Reading—Structure	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	RS1 Exhibit knowledge of language structure	C	P	R	R		√
*	**RS2** Recognize that there may be more than one interpretation of reading selections	R	C	P	R		√
*	**RS3** Recognize various literary devices	R	C	P	R		√
	RS4 Recognize and discuss literary elements	R	C	P	R		√
*	**RS5** Develop and use an increasingly sophisticated vocabulary gained through context	R	C	R	R	√	√
*	**RS6** Apply knowledge of language structure to reading	C	P	R	R		√
*	**RS7** Explain why there may be more than one interpretation of reading selections	I	R	C	P		√
*	**RS8** Recognize effect of literacy devices on meaning	I	R	R	C		√
	RS9 Analyze author's use of literary elements				C		√
*	**RS10** Recognize relationship of structure to meaning	I	C	P	R		√
	RS11 Describe various interpretations of reading selections	I	R	C	P		√
	RS12 Characterize author's use of literary devices				C		√
	RS13 Characterize use of literary techniques				C		√
	RS14 Critique a variety of literature with regard to plot, dialogue, theme, setting, and characterization	R	C	R	R		√
*	**RS15** Apply an expanding vocabulary gained through reading	R	C	R	R	√	√
	RS16 Explain various interpretations selections and meaning levels in reading	I	R	C	P		√

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	Subunit: Reading—Structure (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	RS17 Analyze use of literary techniques (e.g., extended metaphor, simile, personification, hyperbole, pun, alliteration)				C		√
	RS18 Understand use of literary devices (e.g., irony, satire, allegory, onomatopoeia)				C		√
	RS19 Analyze and synthesize pieces of literature with regard to plot, dialogue, theme, setting, and characterization				C		√
	Subunit: Reading—Meaning Construction	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	RM1 Demonstrate ability to recognize appropriate pre-reading strategies	R	C	P	R		√
*	**RM2** Describe effectiveness of a reading selection	R	C	P	R		√
*	**RM3** Read to clarify personal thinking and knowledge	R	C	P	R	√	√
*	**RM4** Support interpretation of text by locating and citing specific information	R	C	P	R	√	√
	RM5 Develop and support personal response to a variety of literary works	I	R	R	R		
	RM6 Recognize diverse literary interpretations	I	R	C	P		√
*	**RM7** Engage in self-selected reading activities	P	R				√
*	**RM8** Confirm and extend meaning in reading by researching new concepts and facts	I	C	P	R	√	√
*	**RM9** Self-monitor and apply corrective strategies when communication has been interrupted or lost	R	C	P	R		√
	RM10 Use features of literary genres to extend meaning				C		√

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	Subunit: Reading—Meaning Construction (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	RM11 Assess effectiveness of a selection read	R	C	P	R		√
*	**RM12** Use reading as a possible problem-solving strategy to clarify personal thinking and knowledge	R	C	P	R	√	√
	RM13 Use knowledge of semantic elements (e.g., figurative language, denotation, connotation, dialect) to clarify meaning when reading	R	C	P	R		√
	RM14 Predict, recognize, interpret, and analyze themes based on familiarity with author's work				C		√
	RM15 Compare and contrast literary genres	R	C	P	R		√
	RM16 Assess validity and quality of selection read	R	C	P	R		√
*	**RM17** Clarify meaning when reading	R	C	P	R		√
	RM18 Compare personal reaction to critical assessment of a literary selection				C		√
	RM19 Assess validity of diverse literary interpretations				C		√
*	**RM20** Use reference books to find, evaluate, and synthesize information	R	C	P	R	√	√
	RM21 Identify tone of a literary work	C	P	R	R		√
	RM22 Critique validity of diverse literary interpretations				C		√
	RM23 Integrate personal reaction to and critical assessment of a literary selection				C		√
	Subunit: Reading—Application	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**RA1** Select and read material for personal enjoyment and information	P	R				√
	RA2 Read a variety of complete, unabridged works	R	R	R	R		√

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	Subunit: Reading—Application (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**RA3** Employ various reading strategies according to purpose	R	C	P	R		√
	RA4 Participate in selection of books, materials, and topics for literature study groups				C		√
	RA5 Develop and apply knowledge of the interrelationship of concepts				C		√
	RA6 Read selections from a variety of styles and formats, recognizing that style and format influence meaning	R	C	P	R		√
*	**RA7** Extend value of reading, writing, speaking, viewing, and listening by pursuing, through reading, new concepts and interests developed as a result of these activities	R	R	R	R		√
	RA8 Read extensively from a particular author's work and explain elements of author's style				C		
	Subunit: Reading—Multidisciplinary	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**RM1** Connect themes and ideas across disciplines through literature	I	C	P	P		√
*	**RM2** Read to facilitate learning across curriculum	R	R	R	R	√	√
*	**RM3** Read to develop awareness of human rights and freedom	R	R	R	R	√	√
	RM4 Participate actively in a community of learners				C		√
	RM5 Recognize and explain interaction between literature and various cultural domains (e.g., social technological, political, economic)	R	R	R	R		√

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	Subunit: Reading—Multidisciplinary (cont.)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	RM6 Explore and analyze a variety of cultural elements, attitudes, beliefs, and value structures by men and women of many racial, ethnic, and cultural groups	R	R	R	R		√
	RM7 Value thinking and language of others	R	R	R	R		√
	RM8 Relate literature to historical period about which or in which it was written	R	C	P	R		√
*	**RM9** Read to facilitate content learning	C	P	R	R	√	√
	Subunit: Writing—Structure	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**WS1** Develop and expand a repertoire of organizational strategies (e.g., narration, comparison/contrast, and description) through a practice and discussion	R	C	P	R		√
*	**WS2** Clarify word choice according to audience, topic, and purpose	C	P	R	R		√
*	**WS3** Locate and correct errors in usage, spelling, and mechanics using a variety of resources	R	C	P	R		√
*	**WS4** Recognize information gained from primary and secondary sources	P	R	R	R		√
*	**WS5** Develop writing which contains ordered, related, well-developed paragraphs with sentences of varied lengths and patterns	C	P	R	R		√
*	**WS6** Use information from a variety of sources to develop an integrated piece of writing	C	P	R	R		√
*	**WS7** Evaluate and revise writing to focus on such things as audience, tone, and purpose	C	P	R	R		√

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	Subunit: Writing—Structure (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**WS8** Recognize differences between documentation and reference list styles			I	C		√
	WS9 Develop extended pieces of writing which contain ordered, related, well-developed paragraphs with sentences of varied lengths and patterns	I	C	P	R		√
	WS10 Select from a repertoire of organization strategies a pattern appropriate to a topic	C	P	R	R		√
*	**WS11** Synthesize information from a variety of sources	I	C	P	R		√
*	**WS12** Refine word choice and tone according to audience, situation, and purpose	C	P	R	R		√
*	**WS13** Appropriately cite information gained from primary and secondary sources	I	C	P	R		√
*	**WS14** Use style manuals or software to prepare documentation and reference lists	I	C	P	R		√
*	**WS15** Develop effectively organized pieces of expository writing containing strong voice, clear thesis, and well-developed ideas	R	C	P	R		√
*	**WS16** Identify organization patterns appropriate to writing topic	C	P	R	R		√
*	**WS17** Respond to others' suggested revisions to a writing piece	R	R	C	P		

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	Subunit: Writing—Meaning Construction	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	WM1 Demonstrate knowledge of the recursive nature of the writing process by applying it appropriately to various topics, situations, and audiences	R	R	C	P		√
	WM2 Develop criteria for writing evaluation using scoring guides and peer/teacher				I		√
	WM3 Respond to others' suggested revisions to a piece of writing	R	R	C	P		√
*	**WM4** Use word processing, graphics, and publishing aids to construct meaning in writing	C	P	R	R	√	√
	WM5 Engage in self-initiated writing activities	P					√
*	**WM6** Incorporate personal criteria with generally accepted standards for writing evaluation	R	C	P	R		√
*	**WM7** Evaluate, analyze, and synthesize information for writing	I	C	P	R		√
	WM8 Evaluate own writing using personal and established scoring criteria	R	C	P	R		√
	WM9 Assess personal/peer revisions to a writing piece	R	C	P	R		√
	WM10 Recognize and refine personal writing styles	R	C	P	R		√
	Subunit: Writing—Application	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**WA1** Apply appropriate writing techniques suitable for varied writing tasks	C	P	R	R		√
*	**WA2** Use sentence-combining techniques to improve syntactic fluency and maturity	C	P	R	R		√

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	Subunit: Writing—Application (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**WA3** Write in response to prompted and self-selected topics in practical, persuasive, descriptive, narrative, and expository domains	C	P	R	R		√
	WA4 Develop personal voice in writing	R	C	P	R		√
*	**WA5** Consider audience and purpose for writing	C	P	R	R		√
	WA6 Develop criteria for selection and potential development of topic				I		√
	WA7 Write in a journal or learning log to clarify personal thinking and knowledge	R	R	R	R		√
*	**WA8** Apply an expanding vocabulary gained through writing	R	R	R	R		√
*	**WA9** Make judicious use of reference sources (e.g., dictionary, thesaurus, on-line data base, encyclopedia)	R	R	R	R		√
	WA10 Demonstrate an appreciation for aesthetically pleasing language through word choice and style	R	R	R	R		√
*	**WA11** Apply revising and editing strategies needed for writing task	R	R	R	R		√
	WA12 Vary sentence lengths and patterns	C	P	R	R		√
	WA13 Refine personal voice in writing	R	R	R	R		√
	WA14 Vary styles and formats for intended purpose and audience	C	P	R	R		√
	WA15 Apply criteria for selection and development of topic	C	P	R	R		√
	WA16 Participate in peer review of writing in progress	C	P	R	R		√
	WA17 Use transitions between sentences, ideas, and paragraphs in writing	C	P	R	R		√

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	Subunit: Writing—Application (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	WA18 Revise and edit papers extensively in preparation for presentation/publication	R	C	P	R		√
	WA19 Develop a variety of genres				I		√
	WA20 Focus writing and tone on such elements as audience, situation, and purpose	C	P	R	R		√
*	**WA21** Develop topic fully and appropriately	C	P	R	R		√
*	**WA22** Use writing process to clarify personal thinking and knowledge	C	P	R	R		√
	WA23 Apply appropriate recursive writing process as suggested by writing task and writer's process		I	C	P		
	WA24 Develop an extended piece of writing		I	C	P		
	WA25 Revise writing and tone to assure focus on such elements as audience, situation, and purpose	C	P	R	R		√
	WA26 Use writing process to write reflectively			I	R		√
	Subunit: Writing—Multidisciplinary	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	WM1 Use writing process for learning across curriculum	R	R	R	R		√
*	**WM2** Use writing process to demonstrate knowledge of need for human rights and freedom	R	R	R	R		√
	WM3 Value and apply collaborative skills in writing process	R	R	R	R		√
*	**WM4** Write in response to reading, speaking, viewing, and listening	R	R	R	R		√
*	**WM5** Use multidisciplinary resources in writing projects	R	R	R	R		√
	WM6 Use writing process to facilitate learning across curriculum				I		√

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	Subunit: Writing—Multidisciplinary (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	WM7 Recognize value of and engage in collaboration in writing process	R	R	R	R		√
	WM8 Use communication processes to develop a published writing piece in collaboration with others	I	C	P	R		√
	WM9 Record experiences and observations related to content learning	C	P	R	R		√
	WM10 Apply collaborative skills in writing process	R	R	R	R		√
	WM11 Write collaboratively with peers	R	R	R	R		
	WM12 Use cross-disciplinary resources in writing projects	R	R	R	R		√
	Subunit: Listening/Visual Literacy—Structure	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	LS1 Listen to and view a wide variety of genres	C	P	R	R		√
	LS2 Become aware of an author's style through listening and viewing a variety of works	C	P	R	R		√
	LS3 Recognize correct and appropriate grammar, diction, and syntax	C	P	R	R		√
*	**LS4** Expand vocabulary through listening to and viewing varied media	R	R	R	R		√
	LS5 Recognize beauty of language		I	R	R		
	LS6 Enhance recognition of an author's style through listening and viewing a variety of works	R	R	R	R		√
	LS7 Recognize use and misuse of language in media	C	P	R	R		√
	LS8 Refine knowledge of style through listening and viewing multiple works by the same author	R	R	R	R		√

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	Subunit: Listening/Visual Literacy—Structure (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**LS9** Expand and refine grammar, diction, and syntax through listening	R	R	R	R		√
	LS10 Compare authors' styles through viewing and listening to their works	R	R	R	R		√
	LS11 Expand knowledge of complex grammar, diction, and syntax issues	R	R	R	R		√
	Subunit: Listening/Visual Literacy—Meaning Construction	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**LM1** Develop critical thinking skills necessary to evaluate media and assess oral presentations	I	C	P	R		√
	LM2 Compare new oral texts to past experiences and knowledge in order to enhance comprehension	I	C	R	P		√
	LM3 Recognize how rhythmic patterns, silence, and cadences enhance quality of speech and literature	P	R	R	R		√
	LM4 Focus listening and viewing on themes and/or plots	P	R	R	R		√
*	**LM5** Gather information from listening and viewing experiences to enhance research	C	P	R	R		√
*	**LM6** Use critical thinking skills to evaluate media and oral presentations	C	P	R	R	√	√
	LM7 Use prior knowledge and experiences to facilitate comprehension of new oral texts	I	R	R	R		√
	LM8 Identify rhythmic and time patterns in speech and literature	P	R	R	R		
	LM9 Identify and analyze themes and/or plots when listening and viewing	P	R	R	R		√
	LM10 Use information gathered from listening and viewing experiences to expand research	C	P	R	R		√

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	Subunit: Listening/Visual Literacy—Meaning Construction (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	LM11 Enhance use of critical thinking skills to evaluate media and oral presentations	R	R	R	R		√
	LM12 Consider prior knowledge and experiences when attempting to understand the meaning of new texts	R	R	R	R		√
	LM13 Appreciate rhythmic and time patterns of speech and literature	R	R	R	R		√
	LM14 Select viewing and listening materials to support written text	C	P	R	R		√
*	**LM15** Evaluate media and oral presentations analytically and critically	C	P	R	R	√	√
	LM16 Organize prior knowledge and experiences to comprehend new texts	R	R	R	R		√
	LM17 Organize and use viewing and listening materials to support written text	C	P	R	R		√
	Subunit: Listening/Visual Literacy—Application	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**LA1** Listen attentively during oral reading	R	R	R	R		√
*	**LA2** Use media as stimuli for learning and thinking	R	R	R	R		√
	LA3 Develop knowledge of structure through art, music, and literature			I	R		√
	LA4 Use electronic media to enhance and highlight language learning	R	R	R	R		√
	LA5 Listen and view for entertainment and enjoyment	R	R	R	R		√
*	**LA6** Use technology and other media as means of expressing ideas	R	R	R	R		√

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	Subunit: Listening/Visual Literacy—Multidisciplinary	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	LM1 Facilitate learning across curriculum through critical listening and viewing				I		√
*	**LM2** Engage in individual, small-group, and whole-group listening and viewing activities	R	R	R	R	√	√
	LM3 Develop language arts (e.g., viewing, listening) projects collaboratively	R	R	R	R		√
	LM4 Investigate language and cultural differences through listening and viewing activities	R	R	R	R		√
	LM5 Participate in a community of learners through productive listening	R	R	R	R		√
	Subunit: Oral Communication—Structure	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**OS1** Refine oral communication skills	R	R	R	R	√	√
*	**OS2** Demonstrate knowledge of grammar, usage, and syntax when presenting	C	P	R	R		√
*	**OS3** Select topics and vocabulary suitable to audience	C	P	R	R		√
*	**OS4** Organize notes and ideas for speaking	C	P	R	R		√
	OS5 Use language imaginatively	R	R	R	R		√
	OS6 Modulate voice to meaning when interpreting literature orally	R	R	R	R		√
*	**OS7** Organize notes and ideas for formal, semiformal and informal presentations of information	I	C	P	R		
*	**OS8** Refine speaking techniques for formal, semiformal, and informal settings	R	R	R	R		√

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	Subunit: Oral Communication—Structure (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	OS9 Develop repertoire of organizational strategies for presenting information orally		I	C	R		√
*	**OS10** Expand vocabulary to fit topic	R	R	R	R		√
*	**OS11** Select topics suitable to audience, situation, and purpose	C	P	R	R		√
*	**OS12** Select appropriate strategies when organizing notes and ideas for speaking	C	P	R	R		√
	Subunit: Oral Communication—Meaning Construction	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**OM1** Make connections between prior knowledge and new information for oral presentations	R	R	R	R		√
*	**OM2** Participate in informal speaking activities	R	R	R	R	√	√
*	**OM3** Use interviewing techniques to gather information	R	R	R	R	√	√
*	**OM4** Communicate orally to entertain and to inform	R	R	R	R		√
*	**OM5** Participate in group communication activities	R	R	R	R		√
*	**OM6** Take and organize notes when preparing speech/presentation	C	P	R	R		√
	OM7 Interpret texts orally to illustrate meaning	R	C	P	R		√
*	**OM8** Respond to needs of various audiences	C	P	R	R		√
*	**OM9** Gather and assess information for speaking	C	P	R	R		√
*	**OM10** Communicate orally to inform and persuade	I	C	P	R		√
*	**OM11** Prepare and deliver formal speech/presentation		I	C	R		√
	OM12 Participate in a variety of oral interpretations		I	R	R		√

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	Subunit: Oral Communication—Meaning Construction (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**OM13** Assess needs of audience and adjust language and presentation according to their knowledge	C	P	R	R		√
	OM14 Analyze and synthesize information for speaking	I	C	P	R		√
	OM15 Describe effectiveness of literary selection	C	R	R	P		√
*	**OM16** Describe topic or idea in order to clarify personal/audience thinking	R	C	P	R	√	√
*	**OM17** Analyze and synthesize information gathered from a variety of sources for speaking	I	C	P	R		√
	OM18 Describe validity and/or quality of a literary selection and justify selection				I		
	OM19 Interpret orally a variety of literature	I	R	R	C		√
*	**OM20** Describe topic or idea to clarify meaning for others	R	C	P	R		
	Subunit: Oral Communication—Application	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**OA1** Become proficient at using interviewing techniques		I	C	R		√
	OA2 Give an oral interpretation for a specific audience	I	C	P	R		√
*	**OA3** Develop and apply oral communication skills for cooperative/collaborative learning	R	C	R	P		√
*	**OA4** Use oral communication for a variety of purposes and audiences (e.g., negotiations, book reviews, rationales)	R	R	R	R		√
*	**OA5** Develop and apply decision-making strategies	I	C	P	R		√
	OA6 Practice interviewing techniques	R	R	R	R		√

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	Subunit: Oral Communication—Application (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**OA7** Apply interviewing techniques to purposeful interviews	I	C	R	P		√
	OA8 Focus oral interpretation on a specific audience		I	R	R		√
	Subunit: Oral Communications—Multidisciplinary	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**OM1** Value thinking and language of others	R	R	R	R		√
	OM2 Develop oral projects collaboratively	R	C	P	R		√
	OM3 Be involved in individual, small-group, and whole-group language activities	R	R	R	R		√
	OM4 Participate actively in a community of learners	R	R	R	R		√
	OM5 Investigate language and cultural differences through oral language activities	R	R	R	R		√

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	Subunit: Numbers and Number Relations	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**NR1** Compare, order, and determine equivalence of real numbers	C	P				
*	**NR2** Estimate answers, compute, and solve problems involving real numbers	C	P				
*	**NR3** Compare and contrast real number system, rational number system, and whole number system	R	C	R	P		
*	**NR4** Extend knowledge to complex number system and develop facility with its operation		I	R	C		
	Subunit: Measurement	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**M1** Estimate and use measurements	C	P	R	M	√	√
*	**M2** Understand need for measurement and probability that any measurement is accurate to some designated specification	I	R	C	P	√	√
*	**M3** Understand and apply measurements related to power and work	I	R	C	P	√	√
*	**M4** Understand and apply measurement concepts of distance-rate-time problems and acceleration problems	I	R	C	P	√	√
*	**M5** Use real experiments to investigate elasticity, heat, sound, electricity, magnetism, light, acceleration, velocity, energy, and gravity	I	R	C	P	√	√
*	**M6** Use real-world problem situations involving mass and weight	R	C	P		√	
*	**M7** Use real-world problem situations involving simple harmonic motion		I	R	C	√	
*	**M8** Establish ratios with and without common units	C	P	R	R		
*	**M9** Construct and interpret maps, tables, charts, and graphs as they relate to real-world mathematics	I	C	P		√	√

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	Subunit: Measurement (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**M10** Understand and solve rate-change problems	I	C	P		√	
*	**M11** Understand and solve right triangle relationships as they relate to measurement, specifically to Pythagorean theorem	I	C	P			
*	**M12** Graph and interpret ordered pairs	C	P	R			
*	**M13** Compute total sales from a variety of items	C	P				
*	**M14** Comprehend and compute rates of growth or decay	I	C	P		√	
	M15 Comprehend, compute, and interpret real problems involving annuities		I	C			
*	**M16** Develop techniques to identify real problems and provide possible solutions	I	C	R	R	√	√
*	**M17** Identify and apply different types of measurement scales	R	C	R	P	√	√
*	**M18** Identify area and volume	C	P	R			
	Subunit: Estimation and Mental Computation	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**E1** Use estimation to eliminate choices in multiple-choice tests	R	C	P			
*	**E2** Use estimation to determine reasonableness of problem situations in a wide variety of applications	C	P	R		√	√
*	**E3** Estimate shape of graphs of various functions and algebraic expressions	I	R	C	P		
*	**E4** Use mental computation when computer/calculator are inappropriate	P	R	R			

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	Subunit: Data Analysis and Probability	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**D1** Organize data into tables, charts, and graphs	I	C	P		√	√
*	**D2** Understand and apply measures of central tendency, variability, and correlation		I	C	P	√	√
*	**D3** Use curve fitting to predict from data	I	R	C	P	√	√
*	**D4** Use experimental or theoretical probability, as appropriate, to represent and solve problems involving uncertainty	I	R	R	C	√	√
*	**D5** Use computer simulations and random number generators to estimate probabilities	I	C	R	P	√	√
*	**D6** Test hypotheses using appropriate statistics	I	R	C	P	√	√
*	**D7** Read, interpret, and use tables, charts, and graphs to identify patterns, note trends, draw conclusions, and make predictions	C	P	R	R	√	√
*	**D8** Identify probabilities of events involving unbiased objects	I	C	R	P		
*	**D9** Use sampling and recognize its role in statistical claims	I	R	C	P	√	
*	**D10** Design a statistical experiment to study problem, conduct experiment, and interpret and communicate outcomes	I	R	C	P	√	√
*	**D11** Describe normal curve in general terms and use its properties		I	C	P		
*	**D12** Create and interpret discrete probability distributions		I	C	P		
*	**D13** Understand concept of random variable		I	C	P		

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	Subunit: Data Analysis and Probability (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**D14** Apply concept of random variable to generate and interpret probability distributions, including binomial, uniform, and chi square		I	C	P	√	√
	Subunit: Algebra	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**A1** Describe problem situations by using and relating numerical, symbolic, and graphical representations	C	R	P	R		
*	**A2** Use language and notation of functions in symbolic and graphing settings	I	C	P	R		
*	**A3** Recognize and use equivalent zeros of a function, roots and the solution of an equation in terms of graphical and symbolic representations	I	C	P			
*	**A4** Describe and use logic of equivalence (<,>,=) in working with equations, inequalities, and functions	I	C	P			
*	**A5** Develop graphical techniques of solution for problem situations involving functions	I	C	R	P		
*	**A6** Explore and describe characterizing features of functions	I	C	R	P		
*	**A7** Make arguments in algebraic settings (solve literal equations)		I	R	C		
*	**A8** Factor difference of two squares	I	P	R	R		
*	**A9** Identify slope, midpoint, and distance	I	C	P	R		
	A10 Explore and combine rational functions	I	C	R	P		
*	**A11** Explore factoring techniques	I	C	P	R		
*	**A12** Solve quadratic equations by factoring and formula	I	C	P	R		
*	**A13** Set up and solve linear equations	C	R	P	R		
*	**A14** Solve systems of linear equations with two variables	I	C	P	R		

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	Subunit: Algebra (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**A15** Describe geometric situations and phenomena using variables, equations, and functions	R	R	C	P		
*	**A16** Describe measures of central tendency, mean, median, mode, and variance algebraically and graphically	I	R	C	P		
*	**A17** Represent inequalities on number line and in coordinate plane	I	C	P			
*	**A18** Use coordinate arguments in making geometric proofs	I	R				
*	**A19** Symbolize transformations of figures and graphs		I	R			
	A20 Explore geometric basis for functions of trigonometry		I				
*	**A21** Graph linear functions	I	C	P			
*	**A22** Develop and use vectors to represent direction and magnitude including operations		I	C	P		
*	**A23** Use polar and parametric equations to describe, graph, and solve problem situations		I	R	C		
*	**A24** Represent sequences and series as functions both algebraically and graphically		I	C	P		
*	**A25** Explore recursive functions and procedures using spreadsheets, other computer utilities, and appropriate notions			I	R		
	A26 Describe and solve algebraic situations with matrices		I	R			
	A27 Describe and use inverse relationship between functions including exponential and logarithmic		I	R			
*	**A28** Analyze and describe errors and error sources that can be made when using computers and calculators to solve problems	I	R	R	C		

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	Subunit: Algebra (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**A29** Decide whether problem situation is best solved using computer, calculator, paper and pencil, or mental arithmetic/estimation techniques	C	P	R	R		
	A30 Explore relationships between complex numbers and vectors			I			
	A31 Make arguments concerning limits, convergence and divergence in context involving sequences, series, and other types of functions		I				
	A32 Represent transformations in plane with matrices				I		
	A33 Contrast and compare the algebras of rational, real, and complex numbers with characteristics of a matrix algebra system				I		
	A34 Construct polynomial approximations of a function over specified intervals of convergence				I		
	A35 Examine complex numbers as zeros of functions		I				
#	**A36** Translate verbal statements into symbolic language	I	R	C	P		
*	**A37** Simplify algebraic expressions	I	C	P	R		
*	**A38** Use laws of exponents (including scientific notation)	I	C	P			
	A39 Expand and extend idea of vectors and linear algebra to higher dimensional situations				I		
	A40 Use the idea of independent basis elements for a vector space and associated fundamental concepts of finite dimensional linear algebra				I		
	A41 Develop and communicate arguments about limit situations			I			
	A42 Use matrices to describe and apply transformations				I		

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	Subunit: Algebra (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	A43 Develop and use polar and parametric equations to represent problem situations			I			
	A44 Explore proofs by mathematical induction				I		
	Subunit: Geometry	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	G1 Create and interpret drawings of three-dimensional objects	I	R	C			
*	G2 Represent problem situations with geometric models and apply properties of figures	I	C	R	P		
*	G3 Apply Pythagorean theorem	I	C	P			
*	G4 Demonstrate knowledge of angles and parallel and perpendicular lines	C	P	R			
*	G5 Explore inductive and deductive reasoning through applications to various subject areas	I	R				
	G6 Translate between synthetic and coordinate representations				I		
*	G7 Identify congruent and similar figures using transformation with computer programs	I					
	G8 Deduce properties of figures using transformations and coordinates				I		
*	G9 Use deductive reasoning	I	R	C	P		
*	G10 Explore compass and straightedge constructions in context of geometric theorems	I	R				
	G11 Demonstrate knowledge of and ability to use proof	I	R				
	G12 Use variety of proof techniques (e.g., synthetic, transformational, and coordinate)				I		
	G13 Use variety of proof formats, including T-proof (i.e., two-column) and paragraph proof	I	R				

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	Subunit: Geometry (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	G14 Explore different proof strategies	I	R				
	G15 Investigate different proofs of theorems		I	R			
	G16 Develop knowledge of an axiomatic system		I				
	G17 Apply transformations and coordinates in problem solving		I				
*	**G18** Represent problem situations with geometric models and apply properties of figures	I	C	R	P		
	G19 Deduce properties of figures using vectors				I		
	G20 Analyze properties of Euclidean transformations and relate translations to vectors				I		
	G21 Apply vectors in problem solving		I	R	C		
	G22 Develop further knowledge of axiomatic systems by investigating and comparing various geometry's				I		
	Subunit: Patterns, Relations, and Functions	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	P1 Model real-world phenomena with polynomial and exponential functions		I	R			
	P2 Explore relationship between zeros and intercepts of functions	I	C	P			
*	**P3** Translate among tables, algebraic expressions, and graphs of functions	I	R	C			
*	**P4** Use graphing calculator or computer to generate graph of a function	I	C	P		√	√
	P5 Explore relationship between a linear function and its inverse		I				
#	**P6** Describe and use characteristics of polynomial functions in problem-solving situations		I				

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	Subunit: Patterns, Relations, and Functions (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	P7 Explore conic sections and graph using graphing calculator or computer		I	R			
*	**P8** Apply trigonometric functions to problem situations involving triangles		I	C	P		
	P9 Discover relationships between algebraic description, kind, and properties of conic		I				
	P10 Explore periodic real-world phenomena using sine and cosine functions		I				
	P11 Analyze effects of parameter changes on graphs		I	R			
	P12 Use graphing calculator or computer to graph functions	I	C	P		√	√
	P13 Develop a knowledge of rational and transcendental functions		I				
	P14 Understand connections between trigonometric and circular functions		I	R	C		
	P15 Use circular functions to model periodic real-world functions		I	R	C		
	P16 Solve trigonometric equations and verify trigonometric identities		I	R	C		
	P17 Understand connections between trigonometric, exponential, and logarithmic functions and polar coordinates, complex numbers, and series			I	R		
#	**P18** Model real-world phenomena with a variety of functions	I	R	R	C		
	P19 Graph using polar coordinates		I	R			
*	**P20** Explore graphs in three dimensions			I	R		

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	Subunit: Patterns, Relations, and Functions (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	P21 Explore functions of several variables		I	R			
	P22 Explore recursive functions using spreadsheets and/or programming languages			I			

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	Subunit: Scientific Inquiry	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**Q1** Check the appropriateness and accuracy of measures and computations using various strategies (e.g., estimations, unit analysis, determination of significant figures)	I	C	P	R	√	√
*	**Q2** Use ratios, proportions, and percentages in appropriate problem situations	R	P	M	R	√	√
*	**Q3** Translate information from and represent information in various forms with equal ease (e.g., tables, charts, graphs, diagrams, geometric figures)	R	P	M	R	√	√
*	**Q4** Derive algebraic formulas and create new ones in appropriate problem-solving situations	I	P	M	R		
*	**Q5** Estimate and justify probabilities of outcomes of familiar situations based on experimentation and other strategies	R	C	R	P	√	√
*	**Q6** Invent apparatus and mechanical tools needed to perform unique tasks in various situations	I	R	R	C	√	√
*	**Q7** Identify, compare, and contrast different modes of inquiry	R	C	P	R	√	√
*	**Q8** Design investigations that are safe and ethical (i.e., obtain consent and inform others of potential outcomes, risks and benefits, and show evidence of concern for human health and safety, concern for non- human species)	R	C	P	R	√	√
*	**Q9** Make and read scale drawings, maps, models, and other representations to aid planning and understanding	R	C	P	M	√	√
*	**Q10** Seek elaboration and justification of data and ideas, and reflect on alternative interpretations of the information	R	R	C	P	√	√

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	Subunit: Scientific Inquiry (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**Q11** Use appropriate units for counts and measures	C	P	M	R	√	√
*	**Q12** Create and use databases (electronic and other) to collect, organize, and verify data and observations	R	C	P	R	√	√
*	**Q13** Design and conduct investigations with multiple variables	R	R	C	P	√	√
*	**Q14** Communicate the results of investigations clearly in a variety of situations	R	C	P	R	√	√
*	**Q15** Examine relationships in nature, offer alternative explanations for the observations, and collect evidence that can be used to help judge among explanations	R	R	R	C	√	√
*	**Q16** Trace the development (e.g., history, controversy, and ramifications) of various theories, focusing on supporting evidence and modification with new evidence	R	C	R	P	√	√
*	**Q17** Select, invent, and use tools, (including analog and digital instruments) to make and record direct measurements	C	P	M	R	√	√
*	**Q18** Observe and document events and characteristics of complex systems	R	C	P	M	√	√
	Q19 Explain the influence of perspective (e.g., spatial, temporal, and social) on observation and subsequent interpretations	R	R	R	R	√	√
#	**Q20** Create multiple representations of the same data using a variety of symbols, descriptive languages, mathematical concepts, and graphic techniques	R	C	P	R	√	√

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	Subunit: Scientific Inquiry (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
#	**Q21** Generate testable hypotheses for observations of complex systems and interactions	R	C	P	M	√	√
*	**Q22** Document potentially hazardous conditions and associated risks in selected homes and public areas	R	C	M	R	√	√
#	**Q23** Participate in public debates, relying on documented and verified data to construct and represent a position on scientific issues	R	R	C	P	√	√
#	**Q24** Construct and test models of physical, biological, social, and geological systems	R	R	C	R	√	√
*	**Q25** Read, verify, debate, and, where necessary, refute research published in popular or technical journals of science (e.g., *Discover, Omni, Popular Mechanics*)	I	R	C	P	√	√
#	**Q26** Explore discrepant events and develop and test explanations of what was observed	I	R	C	P	√	√
*	**Q27** Conduct theory-based research using surveys, observational instruments, and other methods	R	R	C	P	√	√
*	**Q28** Modify personal opinions, interpretations, explanations, and conclusions based on new information	R	C	P	R	√	√
*	**Q29** Analyze error and develop explanations in various domains	R	R	C	P	√	√
	Q30 Formulate taxonomic schemes based upon multivariate models that help to explain similarities and differences in form, distribution, behavior, survival, and origin of objects and organisms	R	R	R	C	√	√

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	Subunit: Scientific Inquiry (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
#	**Q31** Demonstrate various logical connections between related concepts (e.g., entropy, conservation of energy)	R	C	P	R	√	√
*	**Q32** Account for discrepancies between theories and observations	R	C	P	R	√	√
*	**Q33** Analyze the changes within a system when inputs, outputs, and interactions are altered	R	C	P	M	√	√
*	**Q34** Create, standardize, and document procedures	R	C	P	M	√	√
*	**Q35** Determine the sources of significant disparities between the predicted and recorded results and change research procedures to minimize disparities	R	R	C	P	√	√
	Q36 Research, locate, and propose applications for abstract patterns (e.g., fractals, Fibonacci sequences, string theory, o[illegible])				I	√	√
#	**Q37** Recognize and utilize classification systems for particles, elements, compounds, phenomena, organisms, and others for exploring and predicting properties and behaviors	R	C	P	M	√	√
*	**Q38** Suggest and defend alternative experimental designs and data explanations (e.g., sampling, controls, safeguards)	R	R	P	R	√	√
*	**Q39** Recognize and communicate differences between questions that can be investigated in a scientific way and those that rely on other ways of knowing (resource materials; intuitive)				I	√	√

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	Subunit: Scientific Inquiry (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**Q40** Draw conclusions based on the relationships among data analysis, experimental design, and possible models and theories	R	C	P	R	√	√
#	**Q41** Suggest new questions as a result of reflection on and discussions about their own scientific investigations	R	C	P	R	√	√
	Q42 Investigate, assess, and comment on strengths and weakness of the descriptive and predictive powers of science	R	C	P	R	√	√
#	**Q43** Create new information from representations of data in a variety of forms (e.g., symbols, descriptive languages, graphic formats) utilizing a variety of techniques (e.g., interpolations, extrapolations, linear regressions, central tendencies, correlation's)	I	R	C	P	√	√
	Subunit: Scientific Knowledge	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**K1** Investigate various types of dynamic equilibrium (e.g., biological, geological, mechanical, chemical)	R	C	P	M	√	√
*	**K2** Investigate the relationship between the rates of energy exchange and the relative energy level of components with systems (e.g., tropic levels of ecosystems, osmosis, rate of heating and cooling, storms)	R	C	P	M	√	√
#	**K3** Investigate patterns in the natural world (e.g., heredity, crystalline structures, population and resource distributions, diffraction, dispersion, polarization)	R	C	P	M	√	√

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	Subunit: Scientific Knowledge (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
#	**K4** Investigate models and theories that help to explain the interactions of components in systems (e.g., conservation of mass, energy, and momentum; food webs; natural selection; entropy; plate tectonics; chaos; relativity; social-psychology)	**R**	**C**	**P**	**M**	√	√
	K5 Investigate degrees of kinship among organisms and groups of organisms	**R**	**C**	**P**	**R**	√	√
	K6 Investigate the limits of the definition of life, and investigate organisms and physical systems that exist at or near these limits (e.g. viruses, quarks, black holes)				**I**		
	K7 Investigate estimates and measurements of a wide range of distances and rates of change				**I**		
	K8 Investigate the historical development of theories of change over time (e.g., natural selection, continental drift, the big bang, geologic change)				**I**		
	K9 Investigate physical and chemical changes in living and non-living systems (e.g., photosynthesis, weathering processes, glaciation, thermal effects of materials, energy cells)	**R**	**R**	**C**	**P**	√	√
	K10 Investigate simulations of nuclear change (e.g., radioactivity, half life, carbon dating)		**I**	**R**	**C**	√	√
	K11 Investigate conservation principles associated with physical, chemical, and nuclear changes	**R**	**R**	**C**	**P**	√	√

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Subunit: Scientific Knowledge (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
K12 Formulate descriptions of the impacts of various forms of mechanical and electromagnetic waves on various organisms on each other over time				I		
K13 Formulate models and hypotheses for patterns in the natural world (e.g., earth structures, transportation systems, migrations, communications, constellations)				I		
K14 Formulate explanations for the influences of objects and organisms on each other over time				I		
K15 Formulate and interpret explanations for change phenomena (e.g., mass extinction's, stellar evolution, punctuated equilibrium, molecular synthesis)			I	C	√	√
K16 Formulate and interpret explanations for the magnitudes of diversity at different periods of geologic time (e.g., mutation, global cataclysms, continental drift, competition, mass extinction's)				I		
K17 Formulate interpretations of the structure, function, and diversity in a variety of organisms and physical systems (e.g., DNA and RNA variants, nucleons, interaction particles)				I		
K18 Formulate understandings of geologic time (e.g., millennia, periods, epochs)				I		
K19 Formulate an understanding of the historical development of the model of the universe				I		

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Subunit: Scientific Knowledge (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
K20 Formulate explanations and representations of the production, transmission, and conservation of energy in biological and physical systems (e.g., weather, volcanism, earthquakes, electricity, magnetism, cellular respiration)	I	R	C	R	√	√
K21 Formulate models and hypotheses about patterns in the natural world (e.g., social behavior, molecular structure, energy transformation, entropy, randomness, aging, chaos, hormonal cycles)	I	R	C	P	√	√
K22 Formulate interpretations of the relationship between energy exchange and the interfaces between components within systems	I	R	C	P	√	√
K23a Formulate estimations for the range of energies within and between various phenomena (e.g., thermal, electromagnetic, thermonuclear, chemical, electrical)	I	R	C	P	√	√
K23b Formulate explanations for the historical development of descriptions of motions interactions and transformations of matter and energy (e.g., classical Newtonian mechanics, special and general relativity, chaos)				I		
K24 Formulate models that can be used to describe fundamental molecular interactions in living and non-living systems (e.g., cell membranes, semiconductors).			I	C	√	√

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	Subunit: Scientific Knowledge (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	K25 Formulate an understanding of the degree of relationship among organisms and objects based on molecular structure (e.g., proteins, nucleic acids)				I		
	K26 Formulate hypotheses and models that may account for observable events (e.g., electricity and magnetism, gravitation, atoms, bonding, chemical reactions, quantum effects, energy flow on biological systems, predator-prey relationships)				I		
	K27 Formulate models and hypotheses about change over time (e.g., natural selection, speciation, punctuated equilibrium, phyleytic gradualism, stellar evolution, plate tectonics, radioactive decay, quantum mechanical theory)				I		
	K28 Formulate lists of limitations and propose refinements of standard classification systems (e.g., periodic table, IUPAC, Linnean, standard model)				I		
	K29 Formulate specific cases of limitations and possible exceptions of theories and principles regarding the interactions of moving objects and organisms (e.g., fluid flow in vessels, motion near the speed of light, Heisenberg uncertainty principle, meteorological prediction, local variation and diversity, predicting earthquakes, energy transport in cellular respiration)				I		

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	Subunit: Scientific Knowledge (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	K30 Formulate plans and contingencies that can be used to accommodate for changes to and stresses on systems (e.g., wildlife and habitat management, corrosion prevention, noise abatement, structure design)				I		
	K31 Formulate models of molecular, atomic, ionic, and subatomic structures and the physical and biological implications of these structures (e.g., genes, nucleons, quarks)				I		
	K32 Formulate estimates for a wide range of measurements and scales (e.g., angstroms to light years)				I		
	K33 Formulate and interpret representations of time from origin to present accounting for phenomena of scale (e.g., smoothness, punctuation's, chaos)				I		
	K34 Formulate interpretations of the historical development of various theories of possible causes of diversity among physical and biological phenomena (e.g., the works of Aristotle, Mendel, Darwin, McClintock)				I		
	K35 Formulate models and hypotheses that can be used to explain the interactions of components within technological and ecological systems				I		
	Subunit: Conditions for Learning Science	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	C1 Participate actively in dialogue about and resolution of community issues				I		

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	Subunit: Conditions for Learning Science (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	C2 Assess information from various countries in the original language or translated form to ascertain the perspectives of many cultures				I		
	C3 Analyze the scientific ideas presented in science fiction stories and films				I		
*	**C4** Perform and repeat investigations to verify data, determine regularity, and reduce the impact of experimental error	R	C	P	R	√	√
*	**C5** Present the results of investigations in a variety of forums	R	C	P	R	√	√
*	**C6** Contribute to the decisions regarding topics for investigation	C	R	R	R	√	√
*	**C7** Use various creative means to communicate interpretations of scientific ideas, concepts, phenomena, and events	R	C	P	R	√	√
*	**C8** Consider the scientific thinking and language of others	C	R	R	R	√	√
*	**C9** Individually and collaboratively produce clearly written representations of investigative results	R	C	P	R	√	√
*	**C10** Fulfill responsibilities as part of a research group	C	R	P	R	√	√
*	**C11** Select and utilize resources by various criteria (e.g., efficiency, effectiveness, health, safety) that are appropriate to the investigations being conducted by groups	C	R	P		√	√
	C12 Present persuasive argument based on the scientific aspects of controversial issues				I		

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	Subunit: Conditions for Learning Science (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**C13** Collect, store, retrieve, and manipulate information with available technologies alleges that may range from hand processes up through computer applications	R	C	P	R	√	√
	C14 Investigate social issues with a scientific perspective (e.g., human rights, wellness, economics, futurism, environmental ethics)				I		
	C15 Keep journals of observations and inferences made over an extended period of time and reflecting upon the impact of these recorded ideas on their thinking and actions	R	C	P	R	√	√
	C16 Examine the intellect, perspectives, and ethics of notable scientists				I		
	C17 Collect and analyze observations made over extended periods of time and compare these to scientific theories	R	C	P	R	√	√
	C18 Create presentations of scientific understandings using diverse modes of expressions	R	C	P	R	√	√
	C19 Conduct formal scientific debates in the classroom				I		
	C20 Wonder about the likelihood of events that may occur by chance or coincidence				I		
*	**C21** Plan and conduct field trips and experiences for small and large groups	R					
	C22 Analyze the historical context which leads to and has lead to scientific theories				I		
	C23 Seek information on topics of personal scientific interest from a variety of sources				I		

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	Subunit: Conditions for Learning Science (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	C24 Conduct learner-developed investigations independently and collaboratively over periods of week and months				I		
	C25 Listen attentively and critically to presentations of scientific information made by others				R		
	C26 Conduct analyses of propaganda related to scientific issues				R		
	C27 Perform investigations that require observations over varying periods of time				R		
	C28 Experience scientific concepts as interpreted by other cultures through multimedia and local and global specialists				I		
*	**C29** Access appropriate technology to perform complicated, time-consuming tasks	R	C	P	R	√	√
	C30 Relate historical accounts of science to the cultural context in which they were written				I		
*	**C31** Work as a contributing member of a collaborative research group	R	R	R	R	√	√
	C32 Examine the influences of social and political structures and realities that contribute to inquiry about scientific issues				I		
*	**C33** Use technology (e.g., desktop publishing, teleconferencing, networking) to communicate scientific ideas	R	C	P	R	√	√
	C34 Explore and analyze a variety of perspectives on science (e.g., works by men and women of many racial, ethnic, and cultural groups)				I		

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	Subunit: Conditions for Learning Science (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	C35 Lead groups of learners of various ages in designing, planning, and conducting science activities				I		
*	**C36** Respect the scientific thinking of others and self	R	R	R	R	√	√
	C37 Recognize and contrast different epistemologies				I		
	C38 Develop possible courses of action in response to scientific issues of local and global concern				R		
#	**C39** Determine the validity of research conclusions in relation to the design, performance, and results	R	C	P	R	√	√
	C40 Develop multimedia presentations of group and individual research projects and investigations appropriate for a variety of audiences and forums				I		
	C41 Produce interesting and scientifically correct stories and present them using various modes of expression				I		
	C42 Reflect on the ideas and content found in their own journal records				R		
	C43 Examine ambiguous results and formulate explanations				R		
	C44 Recognize and synthesize the contributions to scientific thought of individuals from many cultures				I		
	C45 Construct models and simulations of the component structures and functions of living and non-living entities				I		
	C46 Lead multi-age groups in the examination of and planned resolution for scientific issues				I		

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	Subunit: Conditions for Learning Science (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	C47 Recognize and choose members of research teams based upon the merit of their ideas and skills				I		
*	**C48** Construct a portfolio of products, documentation, and self-evaluations of his/her own abilities, skills, and experiences	R	C	P	R	√	√
	C49 Synthesize scientific information from a variety of sources	R	R	R	R	√	√
	C50 Evaluate and prioritize scientific issues based upon risk-benefit analyses				I		
	C51 Refining scientific skills from a variety of experiences	R	R	R	R	√	√
	Subunit: Applications for Science Learning	**10**	**12**	**AD**	**BD**	**WS**	**LL**
	A1 Answer student-determined questions by designing databases and drawing inferences from the analyses of the information in these databases				I		
	A2 Make personal behavior decisions by interpreting information that has a scientific basis				I		
*	**A3** Propose courses of action that will validate and demonstrate personal understandings of scientific principles	I	R	R	R	√	√
	A4 Guide other learners in their understanding of the interactions of technologies and society at various periods in time				I		
	A5 Promote and carry out practices that contribute to a sustainable environment				I		
	A6 Study and propose improvements in public services and systems in their community				I		

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	Subunit: Applications for Science Learning (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**A7** Choose consumer materials utilizing personal and environmental risk and benefit information	R	R	R	R	√	√
*	**A8** Make inferences and draw conclusions using databases, spreadsheets, and other technologies		I	P	R	√	√
*	**A9** Do simple troubleshooting on common electrical and mechanical systems, identifying and eliminating possible causes of malfunctions	I	C	P	R	√	√
*	**A10** Construct devices that perform simple, repetitive actions	I	C	P	M	√	√
*	**A11** Investigate the functionality of various geometric shapes in the natural world and the designed world (e.g., translations from spherical to plane representations cause distortions, triangular shapes contribute to rigidity and stability in structures, round shapes minimize boundary for a given capacity)		I	R	C	√	√
	A12 Make decisions regarding personal and public health				R		
	A13 Evaluate the social and ecological risks and benefits resulting from the use of various consumer products				R		
	A14 Analyze the contributions of advances in technology through history to his/her everyday life				I		
	A15 Identify and reduce risks and threats to a sustainable environment				R		
	A16 Extend the limits of human capabilities using technological enhancements				I		
	A17 Use and recognize various propaganda techniques				I		

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	Subunit: Applications for Science Learning (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
#	**A18** Solve unique problems using the results of systematic analyses		I	C	P	√	√
	A19 Choose everyday consumer products that utilize recent innovation and pass appropriate performance criteria				R		
*	**A20** Refine personal career interests through investigations of the diversity of manufacturing, research, service, and invention processes	R	R	R	R	√	√
*	**A21** Predict and investigate the working of toys and tools while controlling and manipulating variables (e.g., friction, gravity, forces)	R	C	P	M	√	√
*	**A22** Write, follow, modify, and extend instructions (e.g., equations, algorithms, formulas, flow diagrams, illustrations)	R	C	P	M	√	√
*	**A23** Create products, make inferences, and draw conclusions using databases, spreadsheets, and other technologies	R	C	P	R	√	√
	A24 Predict various scenarios and propose solutions to community issues using scientific information (e.g., actuarial tables, census data, topographic maps, incidence data, climatic data)				I		
	A25 Use scientific evidence to consider options and formulate positions about the health and safety of others and him/herself				I		
*	**A26** Search for, use, create, and store objects and information using various strategies and methods of organization and access	R	R	R	R	√	√

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	Subunit: Applications for Science Learning (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**A27** Research and write environmental impact statements of his/her own design		I	C	P	√	√
*	**A28** Compare school-based science perspectives with those gained through cutting-edge technological applications		I	C	R	√	√
	A29 Design management plans for natural and human-altered environments (e.g., woodlots, patios, lots, lawns, farmlands, forests)				I		
*	**A30** Refine personal career interests	R	R	R	R	√	√
	A31 Promote public awareness of the interaction of technology with social issues				I		
	A32 Advocate and propose courses of action for local and global scientific issues using global networks				R		√
*	**A33** Use appropriate technologies to prepare and present the findings of investigations incorporating tables, graphs, diagrams, and text		I	C	P		√
	A34 Make informed consumer choices by evaluating and prioritizing information, evidence, and strategies				R		
	A35 Develop an informed point-of-view that allows for validation or refutation of the scientific statements and claims of advocated before pursuing courses of action (e.g., contributing support, signing petitions, casting votes)				I		
	A36 Differentiate between observations and inferences in the exploration of evidence related to personal, scientific, and community issues				R		

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Subunit: Applications for Science Learning (continued)	**10**	**12**	**AD**	**BD**	**WS**	**LL**
A37 Develop and write environmental impact and safety and hygiene management plans				I		
A38 Use technology to collect, analyze, and communicate information (e.g., electronic networks, desktop publishing, remote sensing, graphing calculators, satellite telemetry, and others)		I	R	R		√
A39 Design, construct, and market inventions				I		

	Unit: Technology Literacy **Note:** Over 600 Ohio business, industry, and labor representatives examined, altered, and then verified the content extracted from the Report of the Task Force on Technology Competence—Learner Goals for All Minnesotans. This unit stresses the impact of technology on both teaching and learning.	* = Industry identified these to be taught using applied methods # = Teachers identified these to also be taught using applied methods **Note:** The remaining competencies are to be taught using regular or applied methods.					
	Competencies:	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**T1** Demonstrate a systems view of technology based on the interdependence of social, political, economic, and ecological systems	I	R	R	C	√	√
*	**T2** Assess the career, family, and personal development implications of technological change	I	R	R	R	√	√
*	**T3** Demonstrate continuous learning via technology	R	R	R	R	√	√
*	**T4** Demonstrate global appreciation for technology's potential effects on cultures, geographic areas, and the environment	R	C	R	P	√	√
*	**T5** Apply historical perspective on technology to the development and use of new technologies	R	C	R	P	√	√
*	**T6** Apply diverse technologies to store, access, process, create, and communicate information needed to solve problems	R	C	P	R	√	√
*	**T7** Apply legal principles and ethical conduct to the use of technology	I	P	R	R	√	√
*	**T8** Demonstrate competency in mathematics, science, social sciences, communication, and computer skills through the analysis, design, and evaluation of technological systems	R	R	C	P	√	√
*	**T9** Analyze the potential of alternative technological systems to solve problems and/or to extend human capabilities	R	C	R	R	√	√

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	Competencies:	**10**	**12**	**AD**	**BD**	**WS**	**LL**
*	**T10** Use a variety of tools, materials, and equipment in solving problems and extending human capabilities	**R**	**C**	**P**	**M**	√	√
*	**T11** Assess risks and benefits of technological developments from an ecological, economic, social, and political perspective	**R**	**C**	**R**	**P**	√	√
*	**T12** Value human diversity as part of a team in suggesting, designing, and testing solutions to technological problems	**I**	**R**	**R**	**R**	√	√

Unit: Employability Skills

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	C	P	R	√	√

Competency: Develop a career plan

Competency Builders:
Identify current interests and aptitudes
Identify common barriers to employment
Describe strategies to overcome employment barriers
Locate resources for finding employment
Research job trends
Identify career options
Identify advantages and disadvantages of career options (in addition to monetary)
Identify job requirements
Investigate education/training opportunities
Evaluate personal strengths and weaknesses

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	R	C	R	√	√

Competency: Prepare for employment

Competency Builders:

Identify traditional and non-traditional employment sources
Identify present and future employment opportunities (by geographic location)
Research job opportunities, including non-traditional careers
Compare salary ranges and benefit packages
Compile occupational profile
Identify rights and responsibilities of equal employment opportunity laws
Design resume and cover letter
Target resume
Secure references
Investigate generic and specific employment tests (e.g., civil service exam, drug screening)
Use follow-up techniques to enhance employment potential
Demonstrate legible written communication skills using correct grammar, spelling, punctuation, and concise wording
Describe methods for handling illegal questions on job application forms and during interviews
Write letter of application
Research prospective employer and services performed
Explain critical importance of personal appearance, hygiene, and demeanor
Interpret job description
Demonstrate appropriate interview question and answer techniques
Demonstrate methods for handling difficult interview questions
Evaluate job offers
Write letter of acceptance
Write letter of declination
Demonstrate good listening skills
Ask for the job tactfully
Participate in extracurricular activities (e.g., student government, community projects)

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	R	R	R	√	√

Competency: Evaluate the importance of self-esteem as an employability skill

Competency Builders:
Identify factors that affect self-esteem
Compare effects of low self-esteem and high self-esteem
Identify strategies to promote positive self-esteem

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	C	P	R	√	√

Competency: Demonstrate job retention skills

Competency Builders:
Identify employer expectations regarding job performance, work habits, attitudes, personal appearance, and hygiene
Exhibit appropriate work habits and attitude
Demonstrate ability to set priorities
Identify behaviors to establish successful working relationships
Identify alternatives for dealing with harassment, bias, and discrimination based on race, color, national origin, sex, religion, handicap, or age
Identify opportunities for advancement
List reasons for termination
List consequences of being absent frequently from job
List consequences of frequently arriving late for work
Demonstrate interpersonal relations skills (i.e., verbal and written)
Demonstrate negotiation skills
Demonstrate teamwork
Follow chain-of-command
Exhibit appropriate job dedication

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	C	P	R	√	

Competency: Demonstrate knowledge of work ethic

Competency Builders:
Define work ethic
Identify factors that influence work ethic
Differentiate law and ethics
Describe how personal values are reflected in work ethic
Describe how interactions in the workplace affect personal work ethic
Describe how life changes affect personal work ethic

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	R	R	R	√	

Competency: Exhibit appropriate work ethic

Competency Builders:
Use time-management techniques
Avoid personal activity during work hours
Attend work as scheduled
Adhere to company and/or governmental policies, procedures, rules, and regulations
Exercise confidentiality
Demonstrate appropriate human relations skills
Adhere to rules of conduct
Accept constructive criticism
Offer constructive criticism
Take pride in work
Resolve conflict
Manage stress
Avoid sexual connotations and harassment
Adjust to changes in the workplace
Demonstrate punctuality
Assume responsibility for personal decisions and actions
Take responsibility for assignments
Follow chain-of-command

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	C	R	R	√	√

Competency: Apply decision-making techniques

Competency Builders:
Identify decision to be made
Identify ownership of decision to be made
Identify possible alternatives and their consequences
Make decisions based on facts, legality, ethics, goals, and/or culture
Apply time factor(s)
Present decision to be implemented
Evaluate decision made
Take responsibility for decision

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	R	C	R	√	√

Competency: Apply problem-solving techniques

Competency Builders:
Identify problem
Select appropriate problem solving tools/techniques
Identify root problem cause(s)
Track root problem cause(s)
Identify possible solutions and their consequences (e.g., long term, short term, crisis)
Use resources to explore possible solutions to problem
Contrast advantages and disadvantages of each solution
Identify appropriate action
Evaluate results
Identify post-preventive action

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	R	C	√	√

Competency: Exhibit characteristics for job advancement

Competency Builders:

Display positive attitude
Demonstrate knowledge of position
Perform quality work
Adapt to changing situations and technology
Demonstrate capability/responsibility for different positions
Identify characteristics of effective leaders
Identify opportunities for leadership in workplace/community
Demonstrate initiative to affect change in workplace
Participate in continuing education/training program
Responds appropriately to criticism from employer, supervisor, or other employees
Exhibit awareness of corporate culture
Prepare for job setbacks
Exhibit continual growth based on performance evaluation
Set realistic goals

Unit: Professionalism

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	R	√	√

Competency: Project professional image

Competency Builders:
Define professionalism
Exhibit professional appearance
Exhibit professional manners
Project professional attitude
Identify individuals' vital role in organization
Exhibit proper etiquette in professionally-related situations

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	R	C	R	√	√

Competency: Achieve individual and professional goals

Competency Builders:
Set flexible, realistic, and measurable goals
Identify potential barriers to achieving goals
Identify strategies for addressing barriers to goal achievement
Breakdown long-term goals into short-term goals
Prioritize goals
Commit to goals
Adjust goals
Obtain support for goals
Reward goal achievement

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	R	R	√	√

Competency: Manage personal finances

Competency Builders:
Explain need for personal management records
Balance checkbook
Identify tax obligations
Analyze how credit affects financial security
Compare types and methods of investments
Compare types and methods of borrowing
Compare types and methods of insurance
Compare types of retirement options/plans
Identify discriminatory vs. non-discriminatory expenditures

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	R	R	R	√	√

Competency: Support community well-being

Competency Builders:
Identify environmental, educational, and social issues
Participate in social and/or community activities

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	R	C	R	√	√

Competency: Achieve organizational goals

Competency Builders:
Evaluate personal goals in relation to organizational goals
Monitor progress by evaluating feedback
List responsibilities in relation to organization goals
Accomplish assigned tasks
Exercise responsibility in relation to organizational goals
Set appropriate personal performance standards
Communicate goals with supervisor and peers
Demonstrate knowledge of products and services
Promote organizational image and mission

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	C	R	√	√

Competency: Demonstrate positive relations in the workplace

Competency Builders:
Identify personality types of self and other
Identify various management styles
Support employer expectations
Support employer decisions
Accept constructive criticism
Give constructive feedback
Adapt to changes in workplace
List factors to consider before resigning
Write letter of resignation

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	R	R	R	√	√

Competency: Manage stressful situations

Competency Builders:
Learn how to accept stress as part of daily life
Identify personal and professional factors contributing to stress
Describe physical and emotional responses to stress
Evaluate positive and negative effects of stress on productivity
Identify strategies for reducing stress
Implement strategies to manage stress
Create strategies for developing and maintaining support systems

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	R	R	R	√	√

Competency: Analyze effects of family on work and work on family

Competency Builders:
Identify how family values, goals, and priorities are reflected in workplace
Identify responsibilities and rewards associated with paid and non-paid work
Identify responsibilities and rewards associated with families
Explain how family responsibilities can conflict with work
Explain how work can conflict with family responsibilities
Explain how work-related stress can affect families
Explain how family-related stress can affect work
Identify family support systems and resources
Identify work-related support systems and resources
Communicate with family regarding work

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	R	R	R	√	√

Competency: Apply lifelong learning skills

Competency Builders:
Define lifelong learning
Identify factors that cause need for lifelong learning
Analyze effects of change
Identify reasons why goals change
Describe importance of flexibility and adaptability
Evaluate need for continuing education/training

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	R	C	P	√	√

Competency: Manage professional development

Competency Builders:
Identify career opportunities
Modify career plan
Participate in continuing education/training opportunities
Document continuing education/training
Read profession-related manuals, technical journals, and periodicals
Attend meetings, workshops, seminars, conferences, and demonstrations
Participate in professional organizations
Build personal/professional mentor relationship
Build personal/professional support system
Build professional network
Strengthen communication skills
Strengthen leadership skills
Strengthen management skills

Unit: Teamwork

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	R	√	√

Competency: Demonstrate knowledge of teamwork

Competency Builders:

Define empowerment
Differentiate work groups and teams
Identify conditions essential to teamwork (e.g., brainstorming)
Explain influence of culture (e.g., corporate, community) on teamwork
Identify appropriate situations for using teams
Define team structures (e.g., cross functional, quality improvement, task force, quality circles)
Identify team building concepts
Describe characteristics and dynamics of teams
Identify characteristics of effective team leaders and members
Identify responsibilities of a valuable team member
Identify methods of involving each member of a team
Explain how individuals from various backgrounds contribute to work-related situations (e.g., technical training, cultural heritage)
Explain the purpose of facilitators
Define consensus
Define reward/recognition system

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	R	√	√

Competency: Demonstrate teamwork

Competency Builders:
Identify purpose of team and intended goal (include time frames)
Structure team around purpose
Define responsibilities of team members
Contribute to efficiency and success of team
Work toward individual and team milestones
Analyze results of team project
Facilitate a team meeting
Assist team member(s) with problem
Monitor time frame
Stress continuous improvement
Accept failure as part of learning

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	R	√	√

Competency: Use teamwork to solve problems

Competency Builders:
Identify appropriate situations for using teams
Use problem-solving process in a team setting
Identify quality management processes/techniques
Identify quality assurance processes/techniques
Prepare presentation

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	R	R	√	√

Competency: Conduct team meetings

Competency Builders:
Plan agenda
Schedule meeting and location
Invite appropriate personnel
Solicit outside speakers as needed
Assign someone to take minutes
Facilitate introductions
Invite questions and comments and group participation
Focus team on agenda items
Assign appropriate action, time frame and accountability to tasks
Monitor time
Close meeting on time
Publish minutes in timely manner
Set ground rules
Avoid placing individual agendas above the group's agenda

Unit: Technical Recording and Reporting

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	R	√	√

Competency: Demonstrate technical recording skills

Competency Builders:
Describe various documentation procedures
Interpret specifications or drawings
Observe process
Ask open-ended questions
Record process (e.g., flowchart, step-by-step)
Identify parameters
Record accurate, truthful data
Maintain test logs
Compile cumulative reference notebook/record
Measure identified parameters

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	R	√	√

Competency: Demonstrate technical reporting skills

Competency Builders:
Use data books and cross reference/technical manuals
Compose technical memoranda
Identify type of report or format needed
Use appropriate format
Compile relevant data
Design charts and graphs
Analyze data
Draw conclusions
Explain analytical methods used
Outline reports
Write reports
Present reports
Draft preventive maintenance and calibration procedures

Unit: Problem Analysis

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	R	√	√

Competency: Appraise situations

Competency Builders:
Identify concerns
Classify concerns
Set priorities
Identify resolution process
Plan resolution

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	R	√	√

Competency: Analyze potential problems

Competency Builders:
Identify potential problems
Identify likely causes
Identify preventive actions
Identify contingent actions

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	R	√	√

Competency: Analyze actual problems

Competency Builders:
Identify deviation
Identify problem and possible causes
Test for probable causes
Verify cause

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	R	√	√

Competency: Analyze decision(s)

Competency Builders:
Identify objective(s)
Classify objective(s)
Identify alternatives
Evaluate alternatives
Assess risks
Make final choice
Verify effectiveness of decision(s)

Unit: Project Management

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C		√	√

Competency: Explain project management

Competency Builders:
Identify project purpose/goal
Identify project objectives
Identify work breakdown structure (WBS)
Identify resource requirements

	10	12	AD	BD	WS	LL
Leveling of this competency...			I	C	√	√

Competency: Plan projects

Competency Builders:
Apply responsibility assignment matrix (RAM)
Apply Gantt or bar charts
Apply network diagrams
Apply critical path method (CPM)
Apply project education and review techniques
Apply software programs

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	R	C	√	√

Competency: Implement projects

Competency Builders:
Monitor project
Control project
Modify project

	10	12	AD	BD	WS	LL
Leveling of this competency...			I	C	√	√

Competency: Evaluate projects

Competency Builders:
Analyze performance
Close-out project evaluation
Draw project management conclusions

Unit: Computer Literacy

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	C	P	R		√

Competency: Describe personal computer operations

Competency Builders:
Explain how data is stored in main computer memory
Explain how computer system executes program instruction
Explain computer storage capacity
Explain how data is represented
Describe data storage techniques
Identify types of memory

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	R		√

Competency: Explain information processing cycle

Competency Builders:
Define operating systems (e.g., DOS, OS/2, UNIX, MAC)
Describe computer languages and their use
Describe difference between data files and program files
Explain PC layout
Explain network layout
Differentiate between hardware and software
Differentiate open from proprietary architecture

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	C	P	R	√	√

Competency: Operate computer hardware

Competency Builders:
Practice proper media handling techniques (e.g., magnetic fields, dust, liquids)
Identify hardware and its use
Use hardware (e.g., mouse, diskettes, drive, modems, touch screen, printers, digitizers, scanners, cables, protection devices)
Keyboard efficiently
Demonstrate basic care of hardware
Explain need for and application of security levels/procedures
Perform basic hardware troubleshooting
Explain hardware addressing techniques

	10	12	AD	BD	WS	LL
Leveling of this competency...	R	R	C	P	√	√

Competency: Use software

Competency Builders:
Define software types and functions
Describe basic disk operations and care
Perform functions necessary to operate software
List advantages and disadvantages of integrated and dedicated software
Operate system software
Operate diagnostic software
Demonstrate basic proficiency in spreadsheet use
Demonstrate basic proficiency in word processing
Demonstrate basic proficiency in database use
Demonstrate basic proficiency in network use
Demonstrate basic proficiency of utility (e.g., WINDOWS, GUI)
Demonstrate basic proficiency in report writing
Demonstrate system commands
Differentiate ethical use/misuse of software
Describe bulletin boards/electronic mail
Apply security levels/procedures while handling sensitive data
Explain data compression
Explain use and deletion of passwords

Unit: Basic Economics

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	R	C		√

Competency: Explain basic economic concepts

Competency Builders:
Differentiate between needs and wants
Explain concept of supply and demand
Explain concept of price
Explain how supply, demand, and price are related
Explain concept of private enterprise and business ownership
Explain concept of cost, profit, and cash flow
Explain concept of risk
Explain concept of competition
Explain relationship among risk, competition, and profit
Compare types of economic systems
Describe the free enterprise system

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	

Competency: Identify cost and profit influences

Competency Builders:
Identify importance of maximizing quality
Identify importance of maximizing productivity
Differentiate between specialized training and cross training
Differentiate between labor and management
Differentiate between government and business

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	C	P		

Competency: Explain basic business concepts

Competency Builders:

Identify functions of business
Explain role of management
Explain role of labor
Explain role of R&D (i.e., research and development)
Explain role of administration
Explain role of sales and marketing
Explain role of operations
Explain role of advertising
Identify role of company objectives
Identify role of mission statement
Identify importance of ethical business practices
Explain role of teams in business
Explain concept of service as a product
Identify types of ownership
Identify components of a business plan
Explain laws relating to working conditions, wages and hours, civil rights, social security, disability, and unemployment insurance

Unit: Workplace Safety (Level 1)

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	R	√	√

Competency: Describe general workplace safety and hazards and understand both personal and company responsibility

Competency Builders:

Identify types and potential level of workplace hazards (e.g., physical hazards, fire, chemicals, noise, ionizing radiation, ultraviolet, temperature extremes, ergonomics, biological hazards, toxicity)

Identify safety materials/equipment (e.g., absorbent socks, oil dry, air-moving equipment, sonic-absorption panels, fire extinguishers)

Explain purpose(s) of OSHA, NIOSH, and NFPA

Identify purpose of emergency evacuation/relocation routes, master switch, lockout/tagout locations, safety color coding systems, and basic machine guarding

Identify roles of industrial hygienists, safety professionals, occupational physicians, and occupational nurses

Describe methods of evaluating potential hazards (e.g., visual analysis)

Describe methods of correcting potential hazards

Describe corrective procedures for unsafe conditions

Explain precautions required when using toxic (e.g., ingested, contact, inhaled) or flammable materials

Describe various types of toxicity (e.g., chronic, immediate)

Define confined space and related requirements

Explain how international directives relate to safety

Recognize personal responsibility for acts (e.g., running, shouting, horseplay, practical jokes, drug use/abuse, arguing, not paying attention, personal distractions)

Locate Material Safety Data Sheets (MSDS)

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	R	√	√

Competency: Apply general workplace safety precautions/procedures

Competency Builders:

Identify local, state, and federal rules and regulations (e.g., worker's compensation)
Identify personal protective wear and equipment (e.g., safety glasses, helmet, respirator)
Identify visual controls (e.g., monitors, read outs)
Identify visual and audible alarms
Define and explain hazardous materials notices on containers (e.g., flammable, combustible, ignitable, inflammable, non-flammable)
Use personal protective wear and equipment
Apply workplace safety rules and procedures
Apply personal safety rules and procedures (e.g., do not wear dangling clothing/jewelry, inappropriate footwear, restrain hair)
Apply workplace organization (e.g., housekeeping)
Apply applicable electrical, mechanical, steam, hydraulic, and pneumatic safety rules and procedures
Apply fire safety rules and procedures
Apply hazardous waste rules and procedures, including disposal
Define and explain Material Safety Data Sheets (MSDS)
Perform lockout and tagout
Recycle materials
Use preventive maintenance checklists

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	R	R	√	√

Competency: Perform first aid

Competency Builders:

Acquire state approved first aid certification
Acquire blood-borne pathogen training (e.g., hepatitis, AIDS)
Assist with first aid for wounds or fractures
Administer first aid to control bleeding
Administer first aid for shock
Administer first aid for electrical shock (e.g., chemical, electrical, heat-related)
Identify chemical, electrical, and heat-related burns
Administer first aid for burn patient
Assist with first aid for poisoned patient
Assist with choking patient
Assist with patient having seizure
Assist with unconscious patient
Perform head to toe assessment
Describe signs and symptoms of emergency situations
Identify and locate basic emergency procedures and equipment
Contact local emergency assistance
Demonstrate first responder procedures

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	C	R	√	√

Competency: Explain purpose of industrial pollution control systems

Competency Builders:

Describe types of air, water, ground, groundwater, solid waste, and noise pollution
Explain purpose of air pollution control systems
Explain purpose of water pollution control systems
Explain purpose of solid waste pollution control systems
Explain purpose of noise pollution control systems
Explain basic philosophy of "right to know" legislation
Explain purpose(s) of EPA
Identify "costs" of industrial pollution control (i.e., dollars vs. impact to environment)
Describe ethics of environmental issues

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	R	R	√	√

Competency: Maintain environmental health and safety regulations

Competency Builders:
Comply with current environmental health and safety laws
Demonstrate the ability to perform safety inspections
Participate in safety audits
Participate in safety, health, and environmental training (at home and work)
Use safety monitoring equipment
Organize and store chemicals and equipment properly (e.g., label chemicals, materials, tools, and equipment with appropriate safety, health, and environmental details)
Keep workspace clean and orderly
Report unsafe or potentially unsafe conditions and acts
Demonstrate safe handling of materials

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	R	R	√	√

Competency: Explain basic ergonomics in the workplace

Competency Builders:
Define ergonomics
Define risk factor
Define maximum permissible limit (MPL) and action limit (AL) for lifting
Explain need for mats and footrest for standing jobs
Explain need for appropriate working heights of chairs, stools, workbenches, equipment
Explain need for adequate lighting

Unit: Workplace Safety (Level 2)

	10	12	AD	BD	WS	LL
Leveling of this competency...	I				P	√

Competency: Maintain cardiopulmonary resuscitation (CPR) certification

Competency Builders:
Acquire CPR certification
Update CPR certification
Administer CPR to infants and children
Administer CPR to adults
Administer care for obstructed airways for infants, children, and adults

Unit: Industrial Electricity

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	P	R	R	√	√

Competency: Explain basic industrial electricity theory

Competency Builders:
Describe atomic structure and its relationship to electricity
Describe the relationship between electrical and magnetic properties
Describe the photoelectric effect
Describe the thermocouple effect
Describe the electrical effect of friction
Identify sources of electricity
Identify sources of potential electricity (e.g., static)
Describe differences between AC/DC
Describe differences between single and 3-phase
Describe effects varying degrees of electricity have on the human body

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	R		√	√

Competency: Use the National Electrical Code (NEC)

Competency Builders:
Use NEC to identify correct materials
Use NEC to identify correct applications

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	R		√	√

Competency: Explain operation of electrical distribution systems

Competency Builders:
Follow NFPA, local, state, and national codes
Describe functions of permits and licensing requirements
Explain generation of electricity
Explain transmission of electricity
Explain end user distribution
Describe interfacing control circuits to a microprocessor

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	R	√	√

Competency: Maintain basic electrical systems

Competency Builders:
Replace electrical cords
Replace batteries
Replace fuse(s)
Replace switches and other sensors
Replace plugs and sockets
Replace control panel components (e.g., relays, motor starters)
Replace AC motors (e.g., 3-phase, single-phase)
Replace DC motors
Repair/replace electrical control devices

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	R	√	√

Competency: Read and apply electrical/electronic drawings

Competency Builders:
Interpret basic electric/electronic standards and symbols (e.g., NEC, IEC)
Interpret schematic drawings
Interpret cable drawings
Interpret component drawings
Interpret logic diagrams
Interpret control panel drawings
Interpret connection drawings
Interpret interconnection drawings
Interpret printed circuit board drawings
Interpret harness drawings
Interpret package drawings
Interpret mechanical/electronic production prints, schematics, and assembly drawings

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	R	√	√

Competency: Demonstrate proficiency in direct current (DC) circuits

Competency Builders:

Describe voltage, current, resistance, power, and energy
Measure properties of a circuit using volt-ohm meter (VOM) and digital volt-ohm meter (DVM) meters and oscilloscopes
Apply Ohm's Law
Construct parallel circuits
Construct series circuits
Construct series parallel and bridge circuits
Define voltage divider circuits (loaded and unloaded)
Construct DC circuits that demonstrate the maximum power transfer theory
Solve problems in electrical units utilizing metric units
Describe the principles and operation of electrochemical supplies
Apply Kirchoff's law
Interpret color codes and symbols to identify electrical components and values
Measure conductance and resistance of conductors and insulators
Describe magnetic properties of circuits and devices
Describe the physical and electrical characteristics of capacitors and inductors
Describe RC and RL time constants
Set up and operate power supplies for DC circuits
Analyze frequency spectrums
Apply Thevenin's and Norton's theorems

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	P	R	√	√

Competency: Demonstrate proficiency in alternating current (AC) circuits

Competency Builders:

Analyze AC signals utilizing VOM, DVM, oscilloscope, frequency counter and function generator
Analyze power in AC circuits
Measure power in AC circuits
Operate capacitor and inductor analyzers for AC circuits
Analyze properties of an AC signal
Describe the principles and operation of the characteristics of sinusoidal and non-sinusoidal wave forms
Identify AC sources
Describe the principles and operation of the characteristics of capacitive circuits
Demonstrate the operation of capacitive circuits
Describe the principles and operation of the characteristics of inductive circuits
Demonstrate the operation of inductive circuits
Describe the principles and operation of the principles of transformers
Demonstrate the operation of AC circuits utilizing transformers
Operate differentiators and integrators to determine RC and RL time constants
Describe the principles and operation of the characteristics of RLC circuits
Demonstrate the operation of RLC circuits (i.e., series, parallel, and complex)
Describe the principles and operation of the characteristics of series and parallel resonant circuits
Operate series and parallel resonant circuits
Describe the principles and operation of the characteristics of frequency selective filter circuits
Demonstrate the operation of frequency selective filter circuits
Operate polyphase circuits
Describe basic motor theory and operation
Describe basic generator theory and operation
Operate power supplies for AC circuits
Describe the principles and operation of various power conditioning (e.g., isolation transformers, surge suppressors, uninterruptable power systems)
Describe the principles and operation of various safety grounding systems (e.g., lightning arresters, ground fault interrupters)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Demonstrate proficiency in power distribution systems

Competency Builders:
Describe power distribution systems
Describe 3-phase distribution systems
Describe single-phase distribution systems
Describe AC distribution systems
Describe delta distribution systems
Describe wye distribution systems
Describe medium-voltage distribution systems (less than 600v)
Troubleshoot 3-phase distribution systems
Troubleshoot single-phase distribution systems
Troubleshoot AC distribution systems
Troubleshoot delta distribution systems
Troubleshoot wye distribution systems
Troubleshoot medium-voltage distribution systems (less than 600v)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Demonstrate proficiency in power distribution equipment

Competency Builders:
Describe power transformers
Describe power capacitors
Describe power oil switches and cutouts
Describe application of NEMA or IEC controls
Describe different types of enclosures for controls
Describe current transformers
Describe potential transformers
Describe medium-voltage circuits breakers and fuses
Use medium-voltage safety equipment
Troubleshoot power transformers
Troubleshoot power capacitors
Troubleshoot power oil switches and cutouts
Troubleshoot current transformers
Troubleshoot potential transformers
Troubleshoot medium-voltage circuit breakers and fuses

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Demonstrate proficiency in motors and motor control

Competency Builders:
Describe integrated circuits
Test solid state components with ohmmeter
Test solid state DC motor control circuits
Test solid state AC motor control circuits
Calibrate or recalibrate equipment
Identify SCR and TRIAC AC control circuits
Explain how load is connected to 3-phase wye configured AC generator
Identify wye connected and delta connected 3-phase motors
Explain revolving fields in AC motors
Describe operation of common AC motors
Describe operation of variable frequency AC drives
Define advantages and disadvantages of common DC motors
Explain how motor load affects speed regulation
Describe operation of stepper motors
Describe speed control of various types of motor drives using sensors
Identify defective motors
Describe regenerative dynamic breaking
Describe operation of various feedback loops

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	R		√	√

Competency: Apply electromechanical maintenance management practices

Competency Builders:

Keep maintenance records
Complete work order
Complete internal requisition
Complete external requisition
Explain planned maintenance
Explain breakdown maintenance
Explain preventive maintenance
Explain predictive maintenance
Perform preventive and predictive maintenance
Establish maintenance schedules
Explain reasons for keeping maintenance records
Explain reasons for keeping cost records
Analyze system failure
Make minor adjustments/repairs
Coordinate maintenance service
Make new/replacement equipment recommendations
Interpret bill of materials for allocation, stocking, and raw material information
Analyze use of bill of materials for workplace decision making

Unit: Electrical Test and Measurement Equipment

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Demonstrate proficient use of electrical test equipment

Competency Builders:
Describe function and operation of logic probe and logic analyzer
Describe function and operation of power monitor
Describe function and operation of signal generator
Describe function and operation of spectrum analyzer
Describe function and operation of AC/DC hi-pot
Describe function and operation of time-domain reflectometer (TDR)
Describe function and operation of megger (1 million value)
Describe function and operation of curve tracer/analogger
Apply test equipment to DC circuits
Apply test equipment to AC circuits
Apply test equipment to solid-state devices
Apply test equipment to digital circuits
Apply test equipment to analog circuits
Apply test equipment to microprocessors

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Demonstrate proficient use of electrical measurement equipment

Competency Builders:
Describe function and operation of analog volt-ohm-meter (AVOM)
Describe function and operation of digital volt-ohm-meter (DVOM)
Describe function and operation of amp probe
Describe function and operation of oscilloscopes
Describe function and operation of operation of infrared heat sensor
Apply measurement equipment to DC circuits
Apply measurement equipment to AC circuits
Apply measurement equipment to solid-state devices
Apply measurement equipment to digital circuits
Apply measurement equipment to analog circuits
Apply measurement equipment to microprocessors

Unit: Drafting Technology

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	P			

Competency: Apply basic drafting skills

Competency Builders:

Use drafting equipment, measuring scales, drawing media, drafting instruments and consumable materials
Identify line styles and weights (alphabet of lines)
Select proper drawing scale, introduction to different types
Prepare title blocks and other drafting formats
Apply freehand and other lettering techniques
Prepare multi-view drawings
Prepare multi-view sketches
Prepare orthographic views
Prepare change control block
Describe change control block/revision block
Measure angles
Draw horizontal, vertical, angular, parallel, and perpendicular lines
Transfer an angle
Construct tangent lines (to arcs) and tangent arcs (to arcs)
Bisect angles and arcs
Bisect lines
Divide lines
Construct three-point circle
Construct regular hexagon, pentagon, and octagon
Reproduce a drawing
Prepare single-view drawings
Prepare dimension drawings
Interpret notes and dimensions to determine part
Draw arcs, circles, and conics
Transfer measurements

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	P		√	

Competency: Apply advanced drafting skills

Competency Builders:

Describe types of blueprints and their applications
Apply isometric, oblique and perspective sketching techniques
Prepare isometric, oblique and perspective sketches
Prepare sectional views
Prepare auxiliary views
Identify ANSI symbols
Prepare views of drilled and tapped holes, counterbores, countersinks
Apply systems drafting techniques
Create a bill of materials
Dimension drawings using ANSI standards
Describe purpose of auxiliary and sectional views
Interpret reports and specifications
Prepare pictorial drawings
Prepare schematics
Draw conics
Interpret basic pneumatic/hydraulic standard and symbols
Interpret various drawings (e.g., welding, casting, stamping, pattern shop, trim dies)
Interpret mold prints

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P		√	√

Competency: Prepare mechanical drawings

Competency Builders:
Interpret basic mechanical standards and symbols
Prepare assembly drawings
Prepare welding drawings
Prepare bearing drawings
Prepare casting drawings
Prepare tool drawings
Prepare molding diagrams
Prepare stamping drawings
Prepare numerical control drawings/instructions
Prepare assembly and installation drawings
Prepare purchase part drawings
Prepare plant layout drawings
Prepare approval drawings
Resolve problems by descriptive geometry and revolutions
Use precision dimensioning to include geometric characters
Use precision measuring instruments

	10	12	AD	BD	WS	LL
Leveling of this competency..		I	P	R	√	√

Competency: Explain geometric dimensioning and tolerancing

Competency Builders:

Identify geometric characteristics and symbols (i.e., flatness, straightness, roundness, cylindricity, profile of line, profile of surface, perpendicularly, angularity, parallelism, circular, runout, total indicated runout, position, concentricity, and symmetry)
Define maximum material condition
Define least material condition
Define regardless of feature size condition
Describe feature control blocks
Describe datum surfaces and targets
Define flatness (pitch)
Define straightness (yaw)
Define roundness
Define cylindricity
Define profile of line
Define profile of surface
Define perpendicularity
Define angularity
Define parallelism
Define circular runout
Define total runout
Define true position concept to determine tolerance for location of holes in mating parts

	10	12	AD	BD	WS	LL
Leveling of this competency...	C	P	R			

Competency: Convert dimensions and tolerances

Competency Builders:

Convert dimensions and tolerances from English units to metric units
Convert dimensions and tolerances from metric units to English units

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P		√	√

Competency: Demonstrate dimensioning techniques

Competency Builders:
Construct arrowheads using various styles/disciplines
Apply symbols for surface and texture control
Add labels/notes to drawing
Interpret decimal tolerance dimensions
Dimension arcs
Dimension angles
Dimension curves
Dimension rounded-end shapes
Dimension spherical objects
Dimension cylindrical objects
Dimension cones, pyramids, and prisms
Dimension features on circular center line
Dimension theoretical point of intersection
Dimension object using rectangular coordinate system
Dimension object using polar coordinate system
Dimension object using tabular coordinate system
Dimension object using ordinate dimensioning system

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Apply geometric dimensioning and tolerancing

Competency Builders:

Interpret decimal tolerance dimensions
Calculate clearance fit tolerances of mating parts
Dimension clearance fit tolerances of mating parts
Calculate interference fit tolerances of mating parts
Dimension interference fit tolerances of mating parts
Calculate tolerances to mating parts using standard fit tables
Assign tolerances to mating parts using standard fit tables
Apply positional and form tolerancing symbols
Apply symbols for true position
Apply symbols for maximum material control and regardless of feature size
Calculate effects of dimensional stack-up
Calculate transitional fit tolerances
Dimension transitional fit tolerances

Unit: Print Reading

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	R	P	√	√

Competency: Interpret drawings/prints/schematics

Competency Builders:

Interpret machine drawings/prints/schematics
Interpret basic hydraulic and pneumatic drawings/prints/schematics
Interpret instrument drawings/prints/schematics
Interpret electrical drawings/prints schematics
Interpret process flow drawings
Interpret P & ID (piping and instrument) diagrams that are commonly used in process facilities
Identify the types of information found on floor plans, elevation plans, flow diagrams, piping and instrumentation diagrams, and electrical diagrams
Identify commonly used symbols and abbreviations
Explain how to trace diagrams
Explain how to use diagrams to locate actual components
Visualize object from drawing
Interpret orthographic projections
Interpret isometric views
Interpret sectional views
Interpret detail and assembly drawings
Interpret dimensions
Interpret tolerances
Interpret GD&T characteristic symbols
Interpret GD&T supplementary symbols
Interpret mold prints

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	R	√	√

Competency: Interpret structural drawings

Competency Builders:

Define terms related to structural drafting
Define structural drawing
List types of structures
Identify types of materials used for structures
Describe types of steel members
Identify structural steel shapes
Explain drawing practices for steel members
Describe the placement of gage lines for steel members
Describe fastener sizes and spacings
Explain dimensioning procedures for steel structures
Label a structural steel callout
Explain structural steel marking
Describe anchor bolts
Differentiate among types of concrete
Identify types of concrete reinforcement
Identify standard prestressed concrete units
Describe foundation parts
Describe types of structural drawings for concrete
Create chart of symbols and abbreviations for concrete placing drawings
Identify standard practices for documentation of rebar
Identify typical details of concrete structures
Describe wood construction
Identify types of wood connectors
Identify types of framing connectors
Describe components of wood construction
Explain heavy timber construction

Unit: CAD Fundamentals

	10	12	AD	BD	WS	LL
Leveling of this competency...	C	P	R	R	√	√

Competency: Demonstrate basic use of computer operating system

Competency Builders:
Create ASCII text files with a text editor
Explain rules for naming files and directories
Manage files
Create directories
Remove directories
Change directories
Copy files
Rename files
Erase files
Format diskettes
Label diskettes
Explain the syntax of operating system commands
Use wildcards in operating system commands

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	P	R	√	√

Competency: Operate a CAD system

Competency Builders:
Execute CAD system
Use keyboard input
Use screen and tablet menus
Use other input devices (e.g., scanner, digitizer)
Create scaled plots
Operate a pen plotter
Operate a printer-plotter (i.e., laser plotter)
Access on-line help for commands
Use file conversion
Use data transfer
Add or remove entities separately
Add or remove entities using a window
Add or remove entities with a crossing-box
Select entities by other methods (e.g., last, previous, type, all)
Create primitive drawing entities
Draw utilizing absolute Cartesian coordinates
Draw utilizing relative Cartesian coordinates
Draw utilizing polar coordinates
Draw using construction aides (e.g., snaps, grid, snap, etc.)
Change drawing attributes
Edit drawing entity properties (e.g., color, layer, thickness, linetype)
Construct drawing entities (e.g., offset, timer, extend, break, mirror)
Edit drawing entities (e.g., offset, trim, extend, break, mirror)
Set system variables (e.g., units, scale)
Use system variables
Create layers
Name layers
Manipulate layers
Save files
Create back-ups
Create hatches, patterns, symbols
Recall drawing templates/blocks
Create text styles
Edit text styles
Select text styles
Apply notes
Create dimensions

Competency Builders: **(continued from previous page)**

Edit text
Control dimension variables/models
Apply view control while drawing (e.g., zoom and pan)
Control view resolution (e.g., viewers)
Save views
Display views
Measure distances
Measure areas
Identify locations
List entity characteristics (e.g., length, size, location, properties)

Unit: Equipment Maintenance

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	P	R		√	√

Competency: Perform housekeeping

Competency Builders:
Dispose of trash and recyclable waste
Clean work area
Store hand tools, cutters, fixtures, jigs, and attachments
Follow tool crib procedures
Inspect machine guards
Replace or adjust machine guards
Report problems to supervisor

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	R	√	√

Competency: Perform recordkeeping

Competency Builders:
Explain reasons for keeping maintenance records
Explain reasons for keeping cost records
Complete work order
Complete internal requisition
Complete external requisition
Complete time cards
Complete job status reports
Complete equipment failure reports
Record preventive maintenance activities
Record repair activities
Read job orders and process sheets
Locate tooling and set up information
Maintain historical files
Explain reasons for maintenance scheduling
Prepare new/replacement equipment recommendations
Track processing anomalies with unassigned causes
Chart maintenance expenses
Define and explain "machine capability study"

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	R	√	√

Competency: Inspect machine systems

Competency Builders:
Coordinate preventative maintenance services with production in advance
Inspect safety systems
Analyze system failure
Explain planned maintenance
Explain predictive maintenance measures
Explain preventive maintenance measures (e.g., lubrication)
Log machine histories
Log machine events (in hours)
Explain machine system(s) calibration
Inspect linkages and lever mechanisms
Inspect drive couplings
Inspect clutches
Inspect roller ball bearings/bushings/shoes

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	C		√	√

Competency: Perform machine maintenance

Competency Builders:
Coordinate preventative maintenance services with production in advance
Apply lockout/tagout procedure
Use operator's and manufacturer's manuals
Operate individual machines
Diagnose malfunctions
Disassemble defective section
Clean equipment
Lubricate equipment
Check equipment for wear and alignment
Repair or replace defective parts
Test machine for proper operation and follow-up for performance
Make minor adjustments to equipment
Prepare and coordinate planned maintenance schedules
Explain breakdown maintenance

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	R	R	√	√

Competency: Maintain hand tools

Competency Builders:

Demonstrate use and care of common hand tools
Demonstrate use and care of measuring devices (e.g., rules, tapes, calipers, micrometers, multimeter, thermometer, and coordinate measuring system)
Demonstrate use and care of equipment used to bend and assemble rigid conduit and tubing
Demonstrate use and care of wood working tools (e.g., saws, planes, drills, hammers)
Demonstrate use and care of sheet metal tools (e.g., sheet metal gauges, hand seamers, soldering irons)
Demonstrate use and care of ropes, slings, pullers, and block and tackle
Demonstrate proper metal working bench skills (including use of vices, hacksaws, files, taps, dies, and reamers)
Demonstrate use and care of pipe cleaning equipment

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	R		√	√

Competency: Maintain portable power tools

Competency Builders:

Demonstrate use and care of light-duty and heavy-duty drills
Demonstrate use and care of power screwdrivers and impact wrenches
Demonstrate use and care of linear motion saws
Demonstrate use and care of belt, pad and disc sanders
Demonstrate use and care of grinders and shears

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	R	R	√	√

Competency: Maintain stationary equipment

Competency Builders:
Demonstrate care of mechanical presses
Demonstrate care of hydraulic presses
Demonstrate care of drill presses
Demonstrate care of bench grinders
Demonstrate care of power saws (e.g., hack, cut-off, chop, band, jig, and table)
Demonstrate care of band saws
Demonstrate care of pipe threaders

Unit: Electromechanical Technology

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	C	R	√	√

Competency: Interpret electromechanical drawings

Competency Builders:
Identify types of drawings and their applications
Transfer measurements
Explain the use of auxiliary views, revolutions, and sectional views
Describe dimensioning practices and techniques on drawings
Interpret mechanical/electronic production and assembly drawings

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	R	√	√

Competency: Describe and demonstrate proficiency in transducers (sensors) and instrumentation

Competency Builders:
Describe characteristics associated with transducers and instrumentation
Describe the principles and operations of various types of transducers (e.g., thermal, shock/vibration, acceleration, positional, pressure, flow, optical, gas and humidity)
Describe the use of various transducers (e.g., thermal, shock/vibration, acceleration, positional, pressure, flow, optical, gas and humidity)
Troubleshoot transducers
Differentiate among thermocouple types
Interpret specifications of temperature sensors (e.g., thermocouples, thermistors, resistance temperature devices)
Interpret specification of pressure sensors (e.g., strain gage, piezzo electric/piezzo resistive) to electrical circuits
Interpret specifications of flow sensors (e.g., orifice flow meter, turbine meter, mass flow meters, ultrasonic)
Interpret specifications of speed or position sensor (e.g., tachometer, resolver encoder, linear voltage differential transformer [LVDT])
Interpret specifications of controllers, indicators, and recorders (e.g., process controllers, programmable logic controllers with interfaces, R-chart recorders, dataloggers/indicators)

Competency Builders: **(continued from previous page)**

Interpret specifications of final control elements (i.e., silicon controlled rectifiers [SCR], power controllers, motor drives, actuators/robots)
Describe application circuits
Explain use of proximity sensors
Explain use of photo electric sensors
Explain use of mechanically activated switches
Troubleshoot switch failure
Describe transducer control and measurement circuits
Demonstrate the use of control and measurement circuits
Troubleshoot control and measurement circuits

Unit: Basic Machining

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	C		√	

Competency: Perform prerequisite machining skills

Competency Builders:
Demonstrate maintenance of immediate work area, machinery, tools and gages
Demonstrate proficiency in interpreting prints/drawings
Demonstrate proficiency in planning work sequence/set up
Follow safety rules and regulations for each machine

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C		√	√

Competency: Analyze machine shop jobs

Competency Builders:
Identify sequence of work on specified project(s)
Identify tolerances and finishes on specified project(s)
Identify variables that effect job efficiency (e.g., speeds, feeds)
Use Machinery Handbook
Identify causes of workpiece defects

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C		√	

Competency: Explain basic machining operations

Competency Builders:
Identify the parts of basic toolroom lathe
Identify the parts of basic milling machines
Identify the parts of basic drilling machines
Identify the parts of horizontal and vertical saws
Identify the parts of basic surface grinders
Describe the types of grinding operations: lapping, honing, drum, and blasting
Describe operations which the following machines can perform: sand blasting, lathes, shapers, mills, drills, saws, grinders, hones, EDM, and welders

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P		√	

Competency: Perform bench operations

Competency Builders:
Use measuring instruments and hand tools
Deburr workpiece, where appropriate
Lay out workpiece
Drill hole
Hand tap hole
Cut threads with die
Apply basic metallurgy knowledge

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P			

Competency: Operate metal cutting saw

Competency Builders:
Identify types and uses
Identify proper cutting fluids
Transfer dimensions from blueprint
Clean metal cutting saw
Lubricate metal cutting saw
Install guides
Adjust guides
Select proper blades
Weld saw blade
Install saw blade
Select speeds and feeds
Cut metal
Deburr workpiece
Apply basic metallurgy knowledge

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P			

Competency: Operate drill press

Competency Builders:
Clean drill press
Lubricate drill press
Identify proper cutting fluid
Mount part
Select proper bit, speed, and feed
Demonstrate proper bit sharpening techniques
Drill part
Countersink
Tap hole
Apply basic metallurgy knowledge

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P			

Competency: Operate tool and cutter grinding machine

Competency Builders:
Identify parts of machine
Identify proper cutting fluids
Identify causes of workpiece defects
Select proper wheels and work holding devices (e.g., superabrasives)
Perform truing operations
Perform dressing operations
Perform forming operations
Select proper speeds and feeds
Sharpen end mill
Sharpen horizontal milling cutter
Sharpen drills and countersinks
Apply basic metallurgy knowledge

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P			

Competency: Operate pedestal grinder

Competency Builders:
Clean pedestal grinder
Lubricate pedestal grinder
Identify proper wheel
Identify proper coolant
Check wheel for defects
Mount wheel and check balance
Position guard and rest
Dress wheel
Sharpen drill bit
Apply basic metallurgy knowledge

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P			

Competency: Operate lathe

Competency Builders:
Clean and lubricate lathe
Identify proper cutting fluid
Identify proper tools and holders
Sharpen tools properly
Mount workpiece
Use dial indicator
Position guards
Select feed(s) and speed(s)
Face workpiece
Turn shaft
Turn taper
Cut off workpiece
Deburr
Demonstrate use of a 4-jaw chuck
Center drill hole
Cut threads (inside and outside)
Turn inside bore
Demonstrate use of steady rest

Competency Builders: (continued from previous page)
Demonstrate use of centers
Apply basic metallurgy knowledge

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P			

Competency: Operate milling machine

Competency Builders:
Clean milling machine
Lubricate milling machine
Identify proper cutting fluid
Select proper tool
Select proper feeds and speeds
Type of cut (e.g., climb, std.)
Mount workpiece
Mount tool
Mill surface
Mill keyway
Drill workpiece
Bore with milling machine
Mill angle
Apply basic metallurgy knowledge

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P		√	√

Competency: Operate surface grinder

Competency Builders:
Clean surface grinder
Lubricate surface grinder
Identify proper cutting fluid
Select proper wheel
Select proper speeds and feeds
Check wheel for defects
Mount wheel and balance
Position guard
Dress wheel
Grind chuck
Identify proper mounting techniques
Mount workpiece
Apply surface grinder techniques
Apply basic metallurgy knowledge

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P			

Competency: Select materials for job

Competency Builders:
Interpret color codes, numbering systems, and classification systems of materials (i.e., ANSI, SAE)
Identify materials (e.g., hazardous materials)
Apply basic metallurgy knowledge

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	R	√	

Competency: Explain nontraditional machining processes

Competency Builders:

Describe principles of chemical etching
List applications of chemical etching
List advantages/disadvantages of chemical etching
Describe principles of photochemical etching
List applications of photochemical etching
List advantages/disadvantages of photochemical etching
Describe electrical-discharge machining (EDM)
List applications of EDM
Differentiate between EDM and wire EDM
List applications for wire EDM
Describe principles of electrochemical machining
List applications of electrochemical machining
List advantages/disadvantages of electrochemical machining
Describe principles of water jet cutting
List applications of water jet cutting
Describe principles of torch cutting
List applications of torch cutting
Describe principles of laser cutting
List applications of laser cutting
List advantages/disadvantages of laser cutting
Describe shot peen
Describe media finish
Describe glass bead
Describe principles of laser welding

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P		√	√

Competency: Demonstrate use of precision layout devices

Competency Builders:
Identify appropriate tools for measuring
Describe precision, accuracy, tolerance, reliability, and discrimination
Distinguish between precision and semiprecision measuring
Define standard stock dimensions and tolerances
Demonstrate knowledge of different units of measure (e.g., metric, English)
Describe common measurement errors and correction procedures
Calibrate measuring machines and devices
Demonstrate care of measuring instruments
Demonstrate use of rule
Demonstrate use of shrink rule
Demonstrate use of tape
Demonstrate use of pi tape
Demonstrate use of combination square
Demonstrate use of calipers
Demonstrate use of micrometers (inside and out)
Demonstrate use of dial indicators
Demonstrate use of sine bar
Demonstrate use of gauges (e.g., dial bore, dial snaps)
Demonstrate use of surface plate
Demonstrate use of protractor
Explain use of profilometer
Demonstrate use of thermometer and pyrometer
Demonstrate use of dividers
Demonstrate basic use of gage blocks and gage pins
Demonstrate use of threading specs
Explain use of optical comparitor
Explain use of digital ı ,truments
Explain use of electronic gauging equipment
Explain use of data acquisition equipment
Explain operation of manual coordinate measuring machine (CMM)
Explain use and application of laser alignment/measurement

Unit: Hydraulics and Pneumatics

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P			

Competency: Describe fluid flow concepts

Competency Builders:
Explain Pascal's Law
Explain Boyle's Law
Explain Bernoulli's Principle
Describe flow velocity
Explain how heat and pressure relate to power and transmission
Describe physical and chemical properties of a fluid
Describe fluids in motion in closed conductors
Describe continuity of mass flow
Identify types of fluids
Identify properties of fluids
Identify English and metric units of measurement for pressure, density, and viscosity

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P			

Competency: Describe energy considerations

Competency Builders:
Differentiate work and power
Differentiate potential and kinetic energy
Explain energy conservation concept
Explain hydraulic horsepower
Explain work of compression in compressible fluids

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R		

Competency: Describe system losses

Competency Builders:
Differentiate turbulent and laminar flow
Explain friction factor
Explain pressure losses and why they occur
Identify potential system losses (e.g., leaks, wear, component sizing, heat, dirt)

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P		√	√

Competency: Describe hydrostatics

Competency Builders:
Explain pressure, density, and viscosity
Explain buoyancy
Explain equilibrium

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P		

Competency: Design basic hydraulic/pneumatic system

Competency Builders:
Use common symbols
Create circuit diagrams (i.e., schematics)
Diagram closed-loop hydraulic system
Diagram an air supply system

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P		

Competency: Describe component operation

Competency Builders:
Identify functions and operation of hydraulic components
Identify functions and operation of pneumatic components
Explain application(s) of different materials (e.g., plastic, copper)

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P			

Competency: Interpret hydraulic and pneumatic schematics

Competency Builders:
Identify common symbols
Sketch circuit diagrams (i.e., schematics)
Interpret circuit diagrams (i.e., schematics)
Sketch circuit analysis
Diagram an air supply system

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C			

Competency: Perform hydraulic system maintenance and repair

Competency Builders:
Identify standard fittings for hose, pipe, and tube
Identify types and operating features of pumps
Identify pump capacity and system requirements
Explain packing and seal requirements
Explain operating principles of pumps (e.g., centrifugal, propeller and turbine rotary, metering)
Perform pump maintenance
Disassemble a pump
Reassemble a pump
Test pump

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P		√	

Competency: Maintain piping and accessories for high and low pressure fluid power systems

Competency Builders:
Identify components of a piping system
Explain maintenance features of both metallic and non-metallic piping systems
Explain types of valves and their operation and maintenance
Explain pipe schedule and their application
Explain use and maintenance of strainers, filters, and traps in piping systems
Join common fittings
Join metallic pipe
Join plastic pipe for water cooling systems
Join copper and steel tubing
Bend copper and steel tubing
Cut copper and steel tubing
Flare tubing

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R		

Competency: Maintain hydraulic system components

Competency Builders:
Install an oil filtration system
Maintain an oil filtration system
Explain maintenance of fouled heat exchangers
Explain operation and use of heat exchanges
Explain fouling and its effect
Identify reservoir requirements
Identify leaking heat exchangers
Compute hose requirements
Install hydraulic lines
Select control valves and servo-type valves
Install control valves and servo-type valves

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Troubleshoot hydraulic systems

Competency Builders:
Interpret hydraulic schematic
Identify causes of failure modes
Connect electrically controlled valves
Explain hydraulic system troubleshooting techniques
Repair or replace hydraulic valves
Repair or replace hydraulic cylinders
Repair or replace hydraulic pumps and motors
Install hydraulic components
Analyze hydraulic circuits
Troubleshoot hydraulic circuits

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Describe reciprocating and rotary air compressors

Competency Builders:
Explain relationship of force, weight, mass, and density in pneumatic system
Explain operation of reciprocating compressors
Explain operation of rotary compressors
Explain primary and secondary air treatment (e.g., air dryers, lubricating systems)
Explain operation of compressor valves, cylinders, and motors

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Maintain pneumatic systems

Competency Builders:
Install pneumatic system components
Explain pneumatic system maintenance techniques
Explain pneumatic system troubleshooting procedures
Isolate faults in air compressors
Repair or replace air compressors
Isolate faults in control valves
Repair or replace control valves
Isolate faults in air motors
Repair or replace air motors
Isolate faults in air dryers
Repair or replace air dryers
Maintain proportioning and servo valves
Analyze pneumatic circuits
Troubleshoot pneumatic circuits
Interpret pneumatic schematic
Diagram an air supply system
Install pneumatic system components
Explain pneumatic system troubleshooting procedures
Troubleshoot air compressors
Troubleshoot pneumatic control valves
Troubleshoot air motors
Troubleshoot air dryers

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Maintain vacuum systems

Competency Builders:

Describe characteristics associated with vacuum systems and sub atmospheric pressure
Describe different units of vacuum
Describe the principles and operation of vacuum gauges
Demonstrate use of vacuum gauges
Repair or replace vacuum gauges
Describe the principles and operation of vacuum pumps
Demonstrate use of vacuum pumps
Repair or replace vacuum pumps
Describe the principles and operation of vacuum controls
Demonstrate use of vacuum controls
Repair or replace vacuum controls

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	R		

Competency: Calculate energy

Competency Builders:

Apply Pascal's Law
Apply Bernoulli's Principle
Apply Boyle's Law
Calculate work and power
Calculate potential and kinetic energy
Calculate hydraulic horsepower
Calculate flow velocity and pressure
Calculate pressure losses
Calculate laminar flow
Calculate pump capacity
Calculate system requirements

Unit: Industrial Manufacturing Technology (Level 1)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P		

Competency: Describe industrial manufacturing process

Competency Builders:
Explain techniques of measuring motion, forces, distance, time, and temperature
Explain mechanical and chemical properties of various plastics, metals, ceramics, fillers, and additives
Explain industrial manufacturing process
Explain industrial use of non-metallic liquids, gases, and solids (e.g., ceramics, polymers)
Develop flow chart and process sheets

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P		

Competency: Describe materials requirements planning

Competency Builders:
Define materials requirements planning
Explain importance of maintaining and controlling inventory (e.g., quantity, price, quality, minimal lot sizes, and timeliness)
Define master production schedule and bill of materials
Explain inventory carrying cost and economic order quantity
Describe the use of the computer in MRP
Calculate net requirements

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	

Competency: Describe role of supply materials

Competency Builders:
Describe role of purchase requisitions
Describe role of material specifications
Describe role of quality parameters
Define supplier certification rating methods
Describe role of source inspector
Describe role of receiving

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe plant layouts

Competency Builders:
Describe the importance of flexibility
Differentiate among product layout, process layout, fixed position layout, and cellular layout
Describe the type of production suited to each layout
Describe advantages and disadvantages of each layout

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe material flow

Competency Builders:
Describe importance of flexibility
Differentiate straight-line, U-shaped, S-shaped, convoluted and comb patterns
Describe advantages and disadvantages of each pattern

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Maintain quality control of materials handling

Competency Builders:

Maintain system for physical handling and movement of material in-process and in-storage
Monitor system of physical handling and movement of material in-process and in-storage
Maintain system for physical handling and movement of finished products
Monitor system of physical handling and movement of finished products
Write requests for deviation from specifications
Implement quality control and inspection standards and procedures
Write engineering change notices and rejection reports
Monitor reports of discrepancy or rejects during production process
Conduct quality tests under different environmental conditions

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe post-production control

Competency Builders:

Explain importance of product protection, packaging, identification, and storage
Describe methods of identifying products (e.g., labels, bar codes, radio frequency systems and magnetic strip systems)
Describe manual methods of storage and retrieval
Describe automated storage and retrieval systems (ASRS)
Describe automated guided vehicle moving systems (AGVS)

	10	12	AD	BD	WS	LL
Leveling of this competency...			C	P	√	√

Competency: Analyze a manufacturing project

Competency Builders:
Explain the "how" of project selection
Explain the "how" of project implementation
Explain the "how" of project evaluation
Explain the "how" of planning continuing improvement
Explain the "how" of planning predictive maintenance

Unit: Industrial Manufacturing Technology (Level 2)

	10	12	AD	BD	WS	LL
Leveling of this competency...				C		

Competency: Demonstrate knowledge of JIT

Competency Builders:
Define just-in-time concept (JIT)
Describe various production methodologies (e.g., standard cycle times, routings, standard quantities, multiple-machine tending)
Describe types of inventory control (e.g., Kanban)
Describe importance of flexibility
Differentiate product layout, process layout, fixed position layout, and cellular layout
Differentiate straight-line, U-shaped, S-shaped, convoluted and comb patterns
Describe advantages/disadvantages of layout and patterns
Explain importance of product protection, identification and storage
List methods of identifying products (e.g., labels, bar codes, radio frequency systems and magnetic strip systems)

	10	12	AD	BD	WS	LL
Leveling of this competency...				C		

Competency: Apply JIT

Competency Builders:
Maintain system for physical handling and movement of material in-process and in-storage
Monitor system of physical handling and movement of material in-process and in-storage
Maintain system for physical handling and movement of finished products
Monitor system of physical handling and movement of finished products
Write requests for deviation from specifications
Implement quality control and inspection standards and procedures
Write engineering change notices and rejection reports
Monitor reports of discrepancy or rejects during production process
Conduct quality tests under different environmental conditions

Unit: Programmable Logic Controllers (PLCs)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	

Competency: Differentiate among process controls

Competency Builders:
Describe characteristics associated with automatic controls
Define proportional control
Define integral control
Define derivative control
Describe advantages of using proportional, integral or derivative control
Describe disadvantages of using proportional, integral or derivative control

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P		

Competency: Explain basic operation of PLCs

Competency Builders:
Describe basic applications of PLCs
Identify program symbols and language functions
Describe function of block transfers
Describe operation of timers, counters, and sequences
Describe operation of analog I/O modules
Describe operation of servo motion control
Describe the principles and operation of PLCs

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	R	C		

Competency: Demonstrate use of PLCs

Competency Builders:
Draw block diagram of a PLC
Define individual blocks of a PLC
Use operator's and/or manufacturer's manual(s)
Translate relay logic to logic for a PLC
Use function of block transfers
Operate timers, counters and sequencers
Operate analog I/O modules
Operate servo motion control
Install a PLC
Connect controller to sensors
Describe test procedures for new installation of a PLC
Troubleshoot hardware faults on a PLCs
Use safety interlock
Describe use of GPP (i.e., Graphic Programmable Panel)
Write a statement and ladder logic program
Document a statement and ladder logic program
Use a PLC program
Troubleshoot a program for a PLC
Repair a program for a PLC
Use specific manufacturer of PLCs (e.g., Allen Bradley, Siemens, Texas Instruments)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C			

Competency: Apply robot fundamentals

Competency Builders:
Describe the operation of robotic work cells
Operate robotic work cells
Troubleshoot robotic work cells
Repair robotic work cells
Classify robots according to industry criteria
Identify robot power drive types
Describe positioning in terms of axis, actuators and coordinate system
Identify types of control systems and sensors
Apply different methods of programming (e.g., teach, off-line)
Write simple programs to exercise robot functions
Join programs to perform full function
Identify principles of robot safety
Describe operation of various sensors used in robot control
Interface sensors to robot
Interface robots
Define open loop and closed loop control
Design a simple automated system to perform manufacturing operation
Identify operation of end-effectors

Unit: Welding Basics

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	R		√	

Competency: Explain welding/cutting processes

Competency Builders:
Explain process of resistance welding
Explain process of projection welding
Explain process of flash-butt welding
Explain process of laser welding
Explain process of friction welding
Explain process of spot welding
Explain process of shielded metal-arc welding (SMAW)
Explain process of gas metal-arc welding (GMAW)
Explain process of gas tungsten-arc welding (GTAW)
Explain process of carbon arc gouging and cutting
Explain process of welding plastics
Explain welding rod alloys
Explain mild steel welding rod
Explain low hydrogen welding electrode
Explain rationale for preheating and post-heating metal
Explain (GMAW) welding in flat, horizontal, vertical positions
Explain (GTAW) welding on mild steel, stainless steel, and aluminum
Explain process of build up and hard facing
Explain process of submerged arc welding
Explain process of plasma arc welding
Explain process of oxy-hydrogen welding
Explain process of stud welding
Explain process of oxy-acetylene welding
Explain process of percussion welding
Explain process of upset welding
Explain process of resistance spot welding
Explain process of pressure gas welding
Explain process of furnace brazing
Explain process of torch brazing
Explain process of resistance brazing
Explain process of induction brazing
Explain process of infra-red brazing
Explain process of cold welding
Explain process of diffusion welding
Explain process of explosion welding

Competency Builders: **(continued from previous page)**
Explain process of forge welding
Explain process of ultrasonic welding
Explain process of electron beam welding
Explain process of electro-slag welding

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	R		√	

Competency: Perform basic gas welding, brazing, and cutting

Competency Builders:
Follow safety guidelines
Differentiate welding and brazing
Identify gas welding and cutting equipment and accessories
Use personal protective equipment required for welding and cutting
Explain capillary attraction as it applies to metal
Demonstrate proper lighting, adjusting, and shutting down of gas torch
Layout mild steel
Cut mild steel
Braze mild steel
Solder non-ferrous metals
Apply basic metallurgy technology

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	R			

Competency: Perform basic arc welding/cutting (i.e., stick)

Competency Builders:
Identify arc welding equipment and accessories
Read welding rods
Apply basic metallurgy technology
Weld stainless steel using (SMAW) process
Weld steel requiring preheat
Weld cast iron
Weld aluminum

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C			

Competency: Evaluate welds

Competency Builders:

Evaluate the quality of welds by using the fracture test, tensile test, bend test, metallographic test, visual inspection, magnetic particle inspection, liquid penetrant tests, ultrasonic tests, and/or radiographic test

Identify the following types of weld defects: cracks, porosity, cold shut, inclusions, lack of fusion, and undercut

Unit: Supervision

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R		

Competency: Perform supervisory functions

Competency Builders:
Define supervision
Conduct task analysis
Create organizational and/or departmental charts
Apply company policies and procedures
Maintain workplace procedures manuals
Prepare budgets
Monitor budgets
Prepare managerial reports
Analyze daily production reports
Maintain appropriate work environment
Conduct tours
Facilitate assignments
Assign work
Delegate job tasks
Monitor progress
Prepare productivity reports
Provide training for new policies
Troubleshoot workplace problems
Coordinate workplace activities
Appraise performance and coach for improvement
Document personnel issues
Coordinate administrative duties

	10	12	AD	BD	WS	LL
Leveling of this competency...			I	C		√

Competency: Coordinate training

Competency Builders:
Assess training needs
Secure training resources, materials and equipment
Train employees
Evaluate progress of trainee
Provide feedback
Solicit feedback
Receive feedback
Assess feedback

Unit: Quality Assurance (Level 1)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Demonstrate knowledge of inspection

Competency Builders:

Explain purpose of inspection
Describe scope of inspection
Explain purpose of incoming, ongoing, and final inspections
Explain early detection inspection
Explain how statistical process control (SPC) aids inspection
Define rework, salvage, and scrap
Define safety terms of product
Identify safety responsibility within the organization
Explain customer approval process
Define types of nonconformance
Define degrees of nonconformance
Define corrective action
Describe when to 100% inspect
Describe when to sample inspect
Describe methods of testing for material properties (e.g, harness, strength, chemical makeup, flaws, errors in tooling or setup)
Describe ethical decisions an inspector may make
Identify purposes of computer-automated inspection
Explain advantages and limitations of automated inspection
Explain disposition of non-conforming material

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Demonstrate knowledge of quality assurance

Competency Builders:

Explain the ISO 9000 and QS 9000 process
Explain continuing improvement
Define quality terms
Define quality functions
Explain the historical evolution of quality assurance (e.g., Deming, ISO 9000)
Explain changes brought about by quality leaders in the world
Describe control devices used in functional areas (e.g., SPC, equipment)
Use checksheets to organize and record inspection results
Conduct in-process inspection
Conduct incoming materials inspection using sampling plan criteria
Identify safe and unsafe equipment
Explain importance of internal and external customers
Identify internal and external customers
Describe successful efforts by industry to improve quality and/or reduce costs
Explain basic foolproofing concept to build inspection into process (i.e., poka-yoke)
Differentiate prevention and detection
Differentiate variable and attribute data
Identify types of control charts
Explain how statistical techniques are tools used to control quality (e.g., SPC, DOE, CR)
Identify features of quality planning
Explain the relationship among organizational structures, policies, procedures, and quality assurance

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	P	√	√

Competency: Explain importance of interdepartmental relationships to quality assurance

Competency Builders:
Explain need for everyone's commitment in assuring quality
Explain phrase "Everyone is a customer/supplier"
Define quality improvement team models
Explain the importance of top management's support of quality
Associate customer satisfaction with product characteristics (e.g., usefulness, price, operation, life, reliability, safety, cost of operation)

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P		√	√

Competency: Demonstrate knowledge of basic statistics

Competency Builders:
Describe data collection methods
Collect data
Check chart for out-of-control conditions
Define mean, median, and mode
Explain significance of standard deviation
Explain normal distribution

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P		√	√

Competency: Demonstrate knowledge of precontrol

Competency Builders:
Explain uses of precontrol
Explain significance of the limits
Plot values on a precontrol chart
Explain "out-of-control" situation
Make decisions on green, yellow and red conditions

Unit: Quality Assurance (Level 2)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Demonstrate knowledge of engineering a quality product

Competency Builders:
Define manufacturability
Define reliability factors (e.g., cost, human, producibility)
Define failure
Describe predictive maintenance

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Inspect machinery, materials, and products

Competency Builders:
Identify critical material characteristics from specification(s) or drawing(s)
Perform capability studies for machinery and materials acceptance
Identify appropriate acceptance sampling plan
Identify critical in-process characteristics from specification(s) or drawing(s)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Use testing equipment

Competency Builders:
Identify safe and unsafe testing equipment
Demonstrate tensile-compression testing
Demonstrate bending testing
Demonstrate impact testing
Demonstrate fatigue testing
Demonstrate shear testing
Demonstrate hardness testing
Demonstrate liquid-penetrant testing
Demonstrate radiographic testing
Demonstrate ultrasonic testing
Demonstrate electrical-analysis testing
Demonstrate ability to clean, adjust, calibrate, and set up testing equipment and measuring devices
Select proper tools and equipment for testing materials and products

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Demonstrate knowledge of nondestructive testing

Competency Builders:
Describe purpose of nondestructive testing
Identify anomalies
Define defects and discontinuities
Identify factors contributing to defects and discontinuities
Describe ultrasonic testing
Describe advantages and limitations of ultrasonic testing
Describe industrial radiography
Explain advantages and limitations of penetrant inspection
Explain choice of most suitable nondestructive test method

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P		√	√

Competency: Demonstrate knowledge of basic statistics

Competency Builders:
Organize data by flow chart
Interpret data by cause and effect diagrams
Define nominal, ordinal, interval, and ratio data

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P		√	√

Competency: Demonstrate knowledge of precontrol

Competency Builders:
Identify appropriate inspection reports and follow-up
Gauge R and R (reproducibility and repeatability) and traceability
Calibrate to national standards
Apply geometric tolerancing
Explain C = 0 (zero) acceptance plan
Interpret instructions in a control plan

	10	12	AD	BD	WS	LL
Leveling of this competency...			I	C	√	√

Competency: Construct $\bar{X}$ and R charts

Competency Builders:
Arrange data into statistical sub-groups
Explain importance of random sampling
Compute $\bar{X}$ (i.e., average of values) and R (i.e., range of values in subgroup) within sample
Plot in X and R on chart
Construct control chart with $\bar{\bar{X}}$ (grand average) and R (average range) calculated
Calculate upper and lower control limits for $\bar{X}$-chart
Calculate upper and lower control limits for R-chart

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Interpret $\bar{X}$ and R charts

Competency Builders:
Plot percentages for normal distribution
Test distribution for normality
Explain difference between common cause and special cause
Define an "in-control" process
Explain significance of an out-of-control point on $\bar{X}$ or R chart
Identify patterns and trends on control chart
Identify run up and run down
Test for middle third on control chart
Explain significance of middle third on control chart
Explain Rule of Sevens

	10	12	AD	BD	WS	LL
Leveling of this competency...			I	C	√	√

Competency: Demonstrate knowledge of scattergrams

Competency Builders:
Construct scattergram
Interpret for positive, negative, or no correlation between X and Y variables
Test for significance between one and five percent
Explain regression analysis

	10	12	AD	BD	WS	LL
Leveling of this competency...			C	P	√	√

Competency: Use quality control charts

Competency Builders:
Identify operational definitions for attribute criteria
Interpret histogram
Interpret scattergrams
Interpret NP chart
Interpret P chart
Interpret flowchart
Interpret cause-and-effect diagram
Construct P (percentage defective) chart for attributes
Plot control limits of P chart and data points
Construct an NP (number defective) chart with control limits and data

	10	12	AD	BD	WS	LL
Leveling of this competency...			C	P	√	√

Competency: Demonstrate knowledge of process capability

Competency Builders:
Use X, R, USL, and LSL to determine process capability (upper and lower specification limits)
Calculate precontrol limits
Calculate estimated process standard deviation
Plot right hand and left hand tail of process variation
Compute Z value for percent of probable defect for process
Calculate C_{PK} values that describe process capability
Describe skewed distributions
List probable causes of skewed distribution
Construct C (count of defects) and U (number of defects per unit) charts
Check data on C and U charts
Construct flowchart
Construct cause-and-effect chart

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Demonstrate knowledge of quality/cost implications

Competency Builders:
Identify cost/quality objectives
Classify costs (i.e., direct and indirect, fixed and variable, methods and standards)
Classify quality costs (i.e., prevention, evaluation, pre-delivery failure, post-delivery failure)
Define product liability

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P		√	√

Competency: Manipulate quality cost data

Competency Builders:
Develop quality cost data
Translate cost reports
Graph quality cost data (e.g., pareto)
Interpret quality cost reports

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Manipulate cost control data

Competency Builders:
Develop cost control data
Analyze cost control reports
Provide cost control data
Provide advice on "Make or Buy" decisions (including economical lot size decisions)

Unit: Quality Assurance (Level 3)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	R	P	√	√

Competency: Demonstrate knowledge of engineering a quality product

Competency Builders:

Identify steps in product design (e.g., brainstorming, thumbnail sketches, rendering)
Identify ways reliability is achieved (e.g., maintainability, good design, design simplification, design redundancy)
Explain the relationship of maintainability to reliability
Explain the role of testing and reliability
Define value engineering
Define quality objectives
Identify cost components as they relate to quality objectives
Classify quality costs (i.e. preventive, evaluation, pre-delivery failures, post delivery failures)
Describe FMEA (Failure Mode Effects Analysis)

	10	12	AD	BD	WS	LL
Leveling of this competency...			I	C	√	√

Competency: Demonstrate knowledge of probability theory

Competency Builders:

Define classical probability
Define empirical probability
Calculate probability for outcomes

	10	12	AD	BD	WS	LL
Leveling of this competency...			C	P	√	√

Competency: Conduct process improvement studies

Competency Builders:

Analyze production methods and processes applying statistical process improvement techniques (e.g., SPC, C_{PK})

Identify appropriate statistical techniques for study (e.g., T-tests, F-test, capability, DOEX)

Identify major steps in conducting a study

Define "report" for a study (e.g., goal, objective, study conduct, results, conclusions, discussions)

Integrate results into the total system

	10	12	AD	BD	WS	LL
Leveling of this competency...			I	C	√	√

Competency: Explain importance of interdepartmental relationships to quality assurance

Competency Builders:

Explain project selection

Explain project implementation

Explain project evaluation

Describe future trend of experiment design

Describe future trend of predictive maintenance

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Demonstrate knowledge of quality/cost implications

Competency Builders:

Explain consumerism and liability prevention

Define contracts and torts

Differentiate express and implied warranty

Differentiate warranty and product liability

Explain how warranties are part of contract law

List questions that would need answering in liability claim(s)

Unit: Plastics Press Technology (Level 1)

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	M	√	√

Competency: Explain press operation

Competency Builders:
Identify types of presses (e.g., injection, compression, blow, extrusion, etc.)
Describe functions of each type of press
Identify capacity of presses (e.g., tonnage, materials, shot size, etc.)
Describe shutheight
Identify and explain function of press operator safety devices
Explain how mold dimension can affect the size of press
Define terms used in plastics press operations
Explain the sequence of operation of each type of machine
Describe function of monitors, proximity switches, and die protection

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	M	√	√

Competency: Demonstrate knowledge of auxiliary press accessories

Competency Builders:
Describe function of barrel heaters
Describe function of loaders and vacuum loaders
Describe function of chillers, mold heaters, and hot runners
Describe function of blenders and dryers
Describe function of feeders and conveyors
Describe function of part grinders
Describe use of quick die change
Describe function of bridge crane and fork lift
Describe function of part weight scale

Unit: Plastics Press Technology (Level 2)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P		

Competency: Explain various controls

Competency Builders:
Define relay controls
Define solid state controls
Define numerical control (NC) and computerized numerical control (CNC)
Differentiate between types of NC and CNC
Describe open loop and closed loop controls
Identify data input mediums
Identify computer memory types
Identify information stored relative to computer memory types

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Perform preventive maintenance of control systems

Competency Builders:
Follow proper safety procedures
Describe care of various control systems
Calibrate NC and CNC control systems

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	M	R	√	√

Competency: Prepare setup sheet

Competency Builders:
Prepare basic setup sheet for press with relay controls
Prepare basic setup sheet for press with solid state controls
Prepare basic setup sheet for press with NC controls
Prepare basic setup sheet for press with CNC controls
Adapt to various control system setup sheets

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	M	√	√

Competency: Describe basic press operations

Competency Builders:
Define manual mode
Define semiautomatic mode
Define full automatic mode
Define dry cycle mode
Explain core pull operation according to SPI and EUROMAP standards
Describe different types of ejection (e.g., air, hydraulic, mechanical)
Describe purpose of purging and its sequence

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	R	√	√

Competency: Describe relay control operations

Competency Builders:
Identify parts of the press
Identify various molding parameters
Apply basic setup skills to setup press
Set press molding parameters using setup sheet or create a new setup sheet if needed

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	R	√	√

Competency: Describe solid state control operations

Competency Builders:
Identify various types of solid state controls
Identify parts of the press
Identify various molding parameters
Apply basic setup skills to setup press
Set press molding parameters to setup sheet or create new setup sheet if needed

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	R	√	√

Competency: Describe NC and CNC control operations

Competency Builders:

Differentiate between NC and CNC (e.g., open loop control, closed loop control)
Define total closed loop control and partial closed loop control
Identify parts of the press
Identify various molding parameters
Apply basic setup skills to setup press
Load mold parameters from storage media
Load molding parameters from setup sheet or printout
Write setup sheet for new molds or make printout of molding parameters or load to storage media

Unit: Sheet Metal Fabrication

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	M	√	√

Competency: Describe sheet metal fabrication

Competency Builders:
Demonstrate safety handling of sheet metal and tools
Describe sheet metal fabricated products
Describe press working process
Describe process(es) of straightening metal
Describe metal finishing and coating
Explain bend allowances
Identify materials used for sheet metal fabrication (e.g., hot roll, cold roll, aluminum, stainless)
Explain process of determining metal thicknesses
Explain process of layout
Explain process of fastening
Demonstrate the capability to finish (e.g., cleaning, painting, plating)

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	M	√	√

Competency: Describe types of metal fabrication manufacturing

Competency Builders:
Describe shear
Describe press brake
Describe cut-to-length lines
Describe roll forming

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	R	√	√

Competency: Explain machining fabrication processes

Competency Builders:

Explain the processes necessary to accomplish the following fabrication requirements: cutting, shaping, forming, turning, drilling, finishing, pressing, drawing, bending, shearing, slitting, rolling, forging, swaging, hobbing, coining, surfacing, extruding, braking, notching, nibbling, piercing, blanking, trimming, perforating, trueing, shaving

Identify the measuring tools, hand tools, machines, and materials necessary to perform each of the fabrication processes listed above

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	P	√	√

Competency: Layout sheet metal

Competency Builders:

Lay out 90° ells
Lay out 45° and 30° ells
Use radial line development to lay out
Use development by triangulation to lay out

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P		√	√

Competency: Fabricate components

Competency Builders:

Layout design
Measure materials
Create pattern and/or prototype
Use hand tools
Cut materials
Form materials
Use fasteners
Spot weld

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	R	√	√

Competency: Perform sheet metal fabrication

Competency Builders:
Identify sheet metal fabrication jobs
Identify tools (e.g., manual and hand powered) needed
Fabricate round ells
Fabricate tees
Fabricate pyramids
Fabricate cones
Fabricate square to round transitions

Unit: Moldmaking (Level 1)

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	R	√	√

Competency: Explain basics of building molds

Competency Builders:

Describe types of molds and their components
Describe process of making a mold
Describe machinery used in moldmaking
Describe types of metal castings used for molds
Identify types of components used in the building process (e.g., gibs, core, cavity, slides, heaters)
Identify surface finishes for molds
Identify specialty mold materials (e.g., beryllium copper, lead-zinc alloys, epoxy resins)
Describe the fitting and assembly process
Describe hardness testing (e.g., Brinell, Rockwell)
Explain how draft and shrinkage must be allowed for in a mold
Describe how core and cavity blocks are mounted
Describe ejectors and their applications
Describe slide/side actions and their use
Identify hardware used in components of molds/tooling used in plastics (e.g., screws, taps and drills, dowel pins, leader pins, bushing)
Describe types and purposes of venting

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	M	√	√

Competency: Explain heating and cooling of molds

Competency Builders:
Identify types of heating/cooling used with molds
Describe flow patterns
Describe baffles
Describe using O-rings
Describe bubbler
Describe cooling zone
Describe diverting plugs
Describe high volume cooling
Describe "heat pipes" and their applications
Describe steam channels
Describe application of oil heaters, water heaters, and electric heaters

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P		√	√

Competency: Explain injection mold runners and gates

Competency Builders:
Describe purpose of runners
Describe size and shape of runners
Describe purpose of gates
Describe types, dimensions, and functions of gates
Describe hot/cold/insulated runner molds
Describe acceptable and unacceptable shapes of runners
Explain purpose of cold slug wells
Describe hot bushings
Describe sprue pullers
Describe sizing and types of sprues

Unit: Moldmaking (Level 2)

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P		√	√

Competency: Explain heating and cooling of molds

Competency Builders:
Describe the pattern and placement of heating/cooling lines

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	M	√	√

Competency: Describe the machining and/or manufacturing of plastics tooling

Competency Builders:
Describe applications for manufacturing of dies for extruders, forms for thermoforming, and related tooling to blow molding and roto molding, etc. by using mills (i.e., vertical, horizontal [boring]), lathes, grinders (surface, I.D. [jig], O.D.), EDM, wire EDM, saws, drills and hones
Explain how NC and CNC apply to applicable machines above
Explain heat treat

Unit: Polymer Technology (Level 1)

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	M	√	√

Competency: Demonstrate knowledge of plastics

Competency Builders:

Explain the history, organization, importance, and potential of the plastics industry

Explain the various plastics standards (e.g., ASTM) that are essential for consistent manufacturing and testing

Describe the inter-relationship between materials and processing

Identify the primary plastics trade and professional organizations

List the advantages and disadvantages of plastics

Define terminology used in the plastics industry

Identify sources of raw materials

Identify and define the families and applications of thermoplastics, thermosets, elastomers, rubbers, and Liquid Crystal Polymers (LCP)

Define polymers

Classify polymers by physical and chemical properties

Classify polymers by reactions

Identify processing methods (typical materials processed)

Identify various uses of plastics in relation to the environment

Identify types and uses of additives and modifiers in plastics production

Explain composition of color

Define thermo-analysis testing (e.g., melt flow, moisture control)

Define plastics and polymers

Describe plastics and polymers manufacturing processes

Describe structure of plastics and polymers

List chemical properties of plastics and polymers

List physical properties of plastics and polymers

Differentiate thermoset and thermoplastic

Describe plastics and polymer property variables

Describe measure of plastic and polymer strength

Identify examples of raw materials processed by machining, extrusion, stamping, injection, blow, stretch-blow, molding, compression molding, and injection compression molding, etc.

Identify molding defect (e.g., flash, sink marks, warp, contamination, wet material, stuck parts, short shot, burn marks, surface blemishes)

Identify secondary operations performed on plastic parts (e.g., plating, milling, painted)

Perform tensile test

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P		√	√

Competency: Demonstrate basic knowledge of rubber manufacturing

Competency Builders:

Explain history of rubber industry
Compare properties of natural rubber with those of synthetic rubber
Explain how natural rubber is manufactured
Explain vulcanization, mastication, and cure systems
Explain use of compounding ingredients (e.g., carbon blacks, accelerators, fillers, antioxidants)
Explain press and autoclave curing
Explain how synthetic rubber is manufactured (e.g., neoprene, butyl, styrene-butadiene)
Explain rubber testing (e.g., tensile, durometer)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Define plastics materials

Competency Builders:

Define olefins (polyolefins)
Define styrenics
Define PPO/PPE
Define thermoplastic polyesters (PBT & PET)
Define nylon (polyamides)
Define acetals
Define acrylics, polyarylate, polymethypentene
Define polycarbonate
Define polysulfone (and sulfone based polymers)
Define fluoropolymers
Define ketone polymers
Define high heat specialty plastics
Define vinyl and additives
Define cellulose
Define silicone
Define commercial blends
Define thermoplastic elastomers
Define natural rubber, EPDM
Define SBR & latex, polybutadiene

Competency Builders: **(continued from previous page)**

Define isoprene, butyl rubbers
Define fluorocarbon elastomers
Define nitrite, polyacrylic rubbers
Define polyurethanes
Define ureas
Define polyesters
Define epoxies
Define polyimides and polyamides
Define high heat thermoset plastics

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	R	√	√

Competency: Describe additives

Competency Builders:
Define additives and their benefits/effects
Define impact modifiers
Define colorants (e.g., dyes and pigments)
Define flame retardants
Define antimicrobials, antioxidants, and antistats
Define lubricants
Define release agents (internal & external)
Define glass fibers, carbon fibers, and metal fibers
Define glass microspheres
Define mineral fillers, glass fillers
Define plasticizers and processing aids (rubber)
Define vulcanizing agents
Define antidegradents
Define UV stabilizers and their effects
Define thermal stabilizers and their effects
Define compatabilizers and their effects
Define filler and reinforcements (rubber)
Define accelerators and activators

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	C	P	√	√

Competency: Demonstrate knowledge of polymer chemistry

Competency Builders:

Explain the structure of polymers (e.g., amorphous, crystalizing, and LCP)
Describe how to make polymers from corresponding monomers
Explain the polymerization of polyethylene, addition and condensation polymers, and blends and alloys
Explain degradation (e.g., heat, light, oxygen)
Describe the characteristics of polymeric materials
Describe feedstock materials
Differentiate between organic and inorganic compounds
List four (4) major classes of hydrocarbons and explain how they are structurally different
Describe trends in physical and chemical properties of alkanes and cycloalkanes, alkenes, alkynes, aromatics, alcohols, phenols, ethers
Describe the structures of carbon double and triple bonds
Describe the structure and importance of addition polymers
List reasons for the toxicity of most simple alcohols
Explain the mechanism by which soap cleans dirt and nonpolar substances
Predict the hydrolysis products of esters
Describe the basicity of amines

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe basic polymer processing

Competency Builders:

Explain melt flow and rheology
Explain physical and chemical properties of blends
Explain compatibilizers
Explain reinforcement with filler and fiber additives
Explain reactive polymer processing
Explain recycling for post consumption
Explain morphology

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Prepare polymer blends and alloys

Competency Builders:
Define blends
Define alloys
Prepare resin-blends
Prepare recipes and reaction batches
Prepare samples for ASTM testing procedures

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	C	P	M		

Competency: Demonstrate knowledge of polymeric testing

Competency Builders:
List reasons to test polymers
Explain purpose of standards
Identify factors affecting test results
Identify principles of sample conditioning
Prepare samples for ASTM, DIN, and ISO testing procedures

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Perform analytical testing of polymeric materials

Competency Builders:

Analyze products by functional requirements
Describe plastics by appearance (e.g., color, gloss)
Identify plastics by reaction to solvents
Dissect products
Flame test plastics
Identify the burning rates of plastics
Identify the softening point of plastics
Test deformation plastics
Identify specific gravity determinations
Identify specific gravity using density gradient
Use Melt Index
Identify ash content of filled plastics
Identify principles of hardness testing
Use shore A & D Durometers
Test with Clark hardness tester
Define the Law of Conservation of Energy
Use Chapy/Izod Impact tester
Perform permeation testing
Identify principles of falling dart impacting
Use Film Dart Impact tester
Perform creep and creep-rupture testing
Explain use of abrasion and friction testing

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe effects of weathering and aging on polymeric materials

Competency Builders:
Explain the purpose of weathering/aging tests
Explain the theory of accelerated testing
Perform water absorption tests
Explain water absorption properties of plastics
Explain thermal expansion of plastics
Compare test results performed under different laboratory conditions (e.g., UV, salt-water, and accelerated weathering testing)

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	M	√	√

Competency: Tensile test polymeric materials

Competency Builders:
Explain polymer stress and strain
Use tensiometer
Identify modulus of elasticity
Use tear tester
Test for stiffness and resilience of polymeric materials
Describe tensile tests
Describe flexural properties
Describe compressive properties
Describe creep properties
Describe stress relaxation
Describe impact properties
Describe shear strength
Describe abrasion
Describe fatigue resistance
Describe hardness tests
Describe tests for elevated temperature performance
Describe thermal conductivity
Describe expansion
Describe brittleness temperature

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Identify electrical and weathering properties

Competency Builders:
Describe dielectric strength
Describe dielectric constant and dissipation factor
Describe electrical resistance tests
Describe arc resistance
Describe accelerated weathering tests
Describe outdoor weathering of plastics
Describe miscellaneous resistance to organic attacks tests

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Identify optical properties and material characterization tests

Competency Builders:
Describe refractive index
Describe luminous transmittance and haze
Describe color
Describe specular gloss
Describe melt index test
Describe capillary rheometer test
Describe dynamic mechanical testing
Describe viscosity tests
Describe gel permeation chromatography
Describe thermal analysis techniques
Describe material characterization tests for thermosets

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Identify flammability, chemical properties, and analytical tests

Competency Builders:
Describe UL testing (e.g., flame/temperature)
Describe chemical resistance tests
Describe specific gravity
Describe density by density gradient technique
Describe bulk (apparent) density test
Describe water absorption
Describe moisture analysis
Describe sieve analysis (particle size) test

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Identify tests and identification analysis of polymers

Competency Builders:
Describe torque rheometer test
Describe burst strength test
Describe crush test
Describe chemical and thermal analysis for identification of polymers
Describe flame test

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Identify testing of foam plastics and nondestructives

Competency Builders:
Describe rigid foam test methods
Describe flexible foam test methods
Describe types of failure
Describe FMEA (Failure Mode Effects Analysis)
Describe nondestructive tests

Unit: Polymer Technology (Level 2)

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	R	P		

Competency: Demonstrate knowledge of polymer chemistry

Competency Builders:

Plot and explain the development of atomic theory
Explain the Bohr atomic model
Construct models of atoms, molecules, and macromolecules
Explain carbon-carbon bonding
Explain theory of electron probability
Describe the behavior of electrons in various atoms
Identify atoms and characteristics of the families from the periodic chart
Demonstrate knowledge of molecular weight definitions
Describe intermolecular bonds
Describe various types of primary bonds
Use Lewis Dot structures to represent primary bonding
Describe various types of secondary bonds
Draw structural formulas for alkanes and alkyl halides
Define structural isomers and geometric isomers
Draw the structures of simple alcohols, phenols, and ethers
Identify primary, secondary, and tertiary alcohols and differences in their properties
Contrast the physical properties of aldehydes and ketones and compare them to other organic compounds
Identify carbonyl compounds that are natural fragrances
Write equations that show the acidic properties of organic acids
Describe the trends in the physical properties of carboxylic acids, esters, amines and amides

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P		

Competency: Apply instrumental methods of analysis

Competency Builders:
Explain linear regression and its uses
Explain purposes of instrumental analysis
Explain precision and error analysis
Explain atomic absorption
Use spectroscopic methods
Use thermal analysis methods
Use chromatographic methods
Use microscopy
Use non-destructive testing methods (e.g., acoustic, strain gauges)

Unit: Plastics Troubleshooting (Level 1)

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	R	√	√

Competency: Identify abnormal conditions

Competency Builders:
Describe color streaking
Describe short shots
Describe sink marks
Describe flash
Describe weak weld
Describe brittleness
Describe poor surface finish
Describe blush at gate
Describe jetting
Describe weld burns
Describe lamination
Describe warpage
Describe wave marks
Describe poor dimensional stability
Describe sticking in cavity
Describe sprue sticking
Describe voids (bubbles)
Describe knit-lines (weld lines)

Unit: Plastics Troubleshooting (Level 2)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Correct abnormal conditions

Competency Builders:
Increase injection pressure
Decrease injection pressure
Increase cycle time
Increase injection hold-time
Decrease injection hold-time
Use larger opening in nozzle
Adjust feed
Increase clamp pressure
Increase stock temperature
Decrease stock temperature
Increase mold temperature
Decrease mold temperature
Change flow path of cooling media
Pre-dry material
Polish surface of mold
Increase injection speed
Decrease injection speed
Re-seat nozzle (machine)
Check nozzle heating band
Check material for contamination
Polish sprue bushing
Decrease screw RPM
Increase back pressure
Decrease back pressure
Adjust mold protection
Clamp sequence and adjusting clamp velocities
Set ejector strokes
Increase sprue runner or gate size
Decrease gate land length
Re-match mold parting line
Add more gas vents
Change location of gate

Unit: Plastics Product Design

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Define product requirements

Competency Builders:
Define customer requirement(s) for mechanical and thermal loads
Define customer requirement(s) for features required
Define customer requirement(s) for product life expectancy
Explain customer requirement(s) for product/material recycling and coding (e.g., 1, 2-7)
Identify customer requirement(s) for agency/regulatory issues
Identify customer requirement(s) for environmental resistance

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Select a plastic material based on evaluating constraints

Competency Builders:
Identify target price (e.g., cost and percentage of raw materials)
Identify specific gravity parameters
Identify electrical property parameters
Identify mechanical property parameters
Identify glass transition temperature parameters
Identify chemical property parameters (e.g., chemical resistance)
Identify friction, wear, and abrasion parameters
Identify machinability parameters
Identify appearance parameters (e.g., transparency)
Identify flammability parameters
Identify processing concerns
Explain effect of material change on product performance

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe plastic product design concepts

Competency Builders:

Describe nominal wall/uniform wall/draft
Describe projections
Describe depressions (e.g., sink marks)
Describe plating concerns
Describe part quality
Describe print format
Describe tolerance guidelines
Describe gating/ejection/texturing parting lines, radii, and location of each
Describe the value of concurrent engineering program
Describe post mold handling (e.g., robot arm, sprue picker)
Describe packaging requirements
Describe possible quality concerns, sink, bow, out-of roundness, cosmetic issues, and shrinkage
Describe FMEA (Failure Mode Effects Analysis)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Select process based on criteria

Competency Builders:

Define injection molding criteria
Define thermoset and thermoplastic molding criteria
Define extrusion criteria
Define blow molding criteria
Define thermoforming criteria
Define composites criteria
Define compression/transfer criteria
Define pultrusion criteria
Define injection compression criteria
Define gas-assist criteria
Define co-injection criteria
Define RIM/RRIM criteria
Define co-extrusion criteria
Define coining criteria
Define injection blow molding criteria
Define tubular film blowing criteria
Define sheet extrusion criteria
Define gas counter pressure molding criteria
Define foam extrusion criteria
Define microwave cure criteria
Define rotational molding criteria

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe advanced part/tool design concepts

Competency Builders:
Identify prototyping systems (e.g., machining, molding, stereolithography)
Explain analysis of part designs
Explain effect of part design changes on tooling/mold flow
Identify need for 3-plate, sprue gate, hot runner
Contrast plastic part design-to-cost analysis
Perform product analysis (including Computer Modeling)
Perform process analysis (including Computer Modeling)
Explain in-mold degating
Explain integrated tool/part handling devices
Explain gating options
Explain in-mold decorating
Explain insert molding

Unit: Color Matching (Level 1)

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	C	P	√	√

Competency: Explain how color is perceived

Competency Builders:
Describe physical factors influencing the perception of color
Describe models for seeing color

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Explain color measurement principles

Competency Builders:
Describe sample collection and visual assessment
Describe spectrophotometer use
Perform color difference calculations (e.g., tristimulus values, chromiticity, coordinates CIE lab color space, lab diagrams, LCH diagrams, tolerencing, CMC)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Analyze colorants

Competency Builders:
Describe color pigment or dye characteristics and users
Identify and describe organic and inorganic pigments
Identify families of dyes
Describe properties of specific classes of colorants
Explain evaluating performance
Identify sources of colorant information
Define colorant selection criteria
Describe dispersion
Define metamerism

	10	12	AD	BD	WS	LL
Leveling of this competency...			C	P	√	√

Competency: Formulate colored plastic compounds

Competency Builders:
Prepare mass-tone and letdown samples of a colorant
Perform spectrophotometer
Use colorant file for computer color math evaluation
Perform batch correction capabilities of the spectrophotometer
Explain dispersion aids

Unit: Color Matching (Level 2)

	10	12	AD	BD	WS	LL
Leveling of this competency...				I		

Competency: Interpret spectral curves

Competency Builders:
Describe how spectral curves are developed
Describe characteristics of spectral curves
Identify components of a color mixture

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Explain industry coloring materials

Competency Builders:
Identify additives for plastics
Explain color mixing laws
Explain color matching types
Explain colorant replacement
Explain colorant strength
Explain pigment selection for typical plastics

Unit: Instrumental Methods (Level 1)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Explain principles of instrumental analysis

Competency Builders:
Explain linear regression
Explain Precision of Measurements Theory
Explain purpose of instrumental analysis

	10	12	AD	BD	WS	LL
Leveling of this competency...			C	R	√	√

Competency: Explain microscopy methods

Competency Builders:
Explain optical
Explain SEM
Explain TEM

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Explain non-destructive testing methods

Competency Builders:
Explain acoustic emission
Explain strain gauges
Explain x-rays
Explain birefringence
Explain index of refraction
Explain specific gravity

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Perform instrumental analysis

Competency Builders:

Determine the specific gravity of a plastic material
Run melt index determinations to characterize flow properties
Run stress-strain analysis (e.g., tensile, compression)
Run dynamic mechanical properties (e.g., ASTM, QS, ISO)
Run tear tests
Use heat shrinkage tests to determine internal stress levels due to processing
Run heat aging tests to study long term environmental effects on material properties
Run hardness tests
Run heat and light stability tests
Run falling ball (ASTM)
Run low temperature brittleness and stiffness tests
Run falling dart test
Run Izod impact test
Run charpy impact test
Explain the reason for differences in test results on machine direction and transverse direction samples
Identify unknown plastic materials through the use of observations of physical appearance, burning characteristics, specific gravity, and stress-strain properties
Identify the various safety hazards associated with the testing of plastic material, and take appropriate precautions to avoid injury to both personnel and equipment

Unit: Instrumental Methods (Level 2)

	10	12	AD	BD	WS	LL
Leveling of this competency...			I	C		

Competency: Explain spectroscopic methods

Competency Builders:
Explain infrared, near infrared, ultrasound, and microwave
Explain mass spectroscopy
Explain atomic absorption
Explain NMR and other advanced techniques
Explain light scattering

	10	12	AD	BD	WS	LL
Leveling of this competency...			C	P		

Competency: Explain thermal analysis methods

Competency Builders:
Explain DSC
Explain TGA
Explain TMA
Explain DMA

	10	12	AD	BD	WS	LL
Leveling of this competency...			C	R	√	√

Competency: Explain chromatographic methods

Competency Builders:
Explain GPC
Explain liquid chromatography

Unit: Rheology

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	R	P	√	√

Competency: Describe the effects of heat on polymers

Competency Builders:
Describe the effects of heat softening
Describe the effects of volume increase
Describe the effects of melting crystals
Describe the effects of no melting temperature for amorphous polymers

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe types of polymer flow

Competency Builders:
Describe laminar flow
Describe velocity profile
Describe turbulent flow
Describe plug flow

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe the effects of polymer flow on molded parts

Competency Builders:
Describe areas of flow profile with greater orientation
Describe finished part properties exhibit anisotropy

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	R	P		

Competency: Describe the influence of orientation in thermosets

Competency Builders:
Explain how lower flow rates are used to minimize orientation
Explain how 3D network reduces anisotropy
Explain why there is lower orientation in thermosets than thermoplastics

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P		

Competency: Describe the concepts of shear rheology

Competency Builders:
Describe the origin of shear viscosity
Describe concept and measurement of shear rate
Convert from Pa-s to mPa-s to Poise to cp to lb-sec/in2
Describe and cite examples of Newtonian/non-Newtonian flow
Describe shear thinning behavior
Cite advantages of non-Newtonian flow
Explain how non-Newtonian flow fills thin wall cavities easier
Explain how non-Newtonian flow has less pressure loss at higher flow rates
Cite disadvantages of non-Newtonian flow
Explain why non-Newtonian is more difficult to control
Describe orientation variations in non-Newtonian flow
Cite examples of viscosity changes
Explain how acrylics can reduce viscosity by a factor of 100
Explain how polyethylenes can reduce viscosity by a factor of 30
Explain why polycarbonates exhibit minimal non-Newtonian behavior
Explain why polycarbonates, polysulfones, polyphenylene oxides, and polyphenylene sulfides show few orientation effects

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe the effects of orientation in injection molded parts

Competency Builders:
Explain the layer of oriented polymer near surfaces
Explain the unoriented layer near center
Explain how layering determines structural properties of a part

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe the effects of orientation in compression molded parts

Competency Builders:
Explain how flow affects orientation
Explain how 3D network in thermosets determines structural properties

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe the effects of orientation in transfer molded parts

Competency Builders:
Explain why some orientation is seen in the direction of flow
Explain how 3D network in thermosets determines structural properties

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe the effects of orientation in extruded parts

Competency Builders:
Explain why orientation is dependent upon shear rate in the die
Explain why orientation is dependent upon post processing (draw rates)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe processes which induce little orientation

Competency Builders:
Explain why foamed parts (any process) induces little orientation
Explain why rotational molding induces little orientation
Explain why casting induces little orientation
Explain why RIM induces little orientation

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe the effects of orientation in reinforced molded parts

Competency Builders:
Explain why the fibers will orient in the direction of flow
Explain why fibers account for most of the strength

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe viscoelasticity using dynamic mechanical rheology and methods

Competency Builders:

Describe viscoelasticity and cite examples
Describe time dependent behavior
Describe viscous liquid response (long time)
Describe elastic solid response (short time)
Explain linear and non linear regions
Describe processes that require a predominantly viscous response (e.g., extrusion, injection molding, and compression molding)
Describe processes that require a predominantly elastic response (e.g., fiber spinning, injection blow molding, and tubular film blowing)
Relate the viscous response to imaginary numbers
Explain the tangent delta ratio
Cite modes and examples used for dynamic mechanical testing
Describe tensile (Autovibron)
Describe shear (Rheometrics, DMA)
Describe the relationships between E', E", and E*
Describe the relationships between G', G", and G*

Unit: Plastics Manufacturing (Level 1)

	10	12	AD	BD	WS	LL
Leveling of this competency...		P	R	R	√	√

Competency: Identify plastic forms

Competency Builders:
Describe molding compounds (e.g., powders, pellets, flakes)
Describe adhesives (e.g., co-extrusion)
Describe profiles
Describe films
Describe fibers
Describe liquids
Describe cellular
Describe reinforced

	10	12	AD	BD	WS	LL
Leveling of this competency...		P	R	R	√	√

Competency: Identify property enhancers

Competency Builders:
Describe filler (e.g., calcium, wood, mineral)
Describe reinforcements (e.g., fiberglass, carbonfibers)
Describe solvents
Describe lubricants
Describe plasticizers
Describe stabilizers
Describe antioxidants
Describe antiozonants
Describe antistatics
Describe flame-retardants
Describe catalysts
Describe colorants
Describe coatings
Describe UV protectors
Describe EMI/RFI shielding
Describe conductivity enhancers
Describe blowing agents

	10	12	AD	BD	WS	LL
Leveling of this competency...		P	R			

Competency: Identify plastics processing methods

Competency Builders:
Describe injection molding
Describe extrusion
Describe blow molding
Describe stretch-blow molding
Describe thermoforming
Describe rotational molding
Describe (RIM reaction injection molding)
Describe calendering
Describe compression molding
Describe cast
Describe pulltrusion
Describe liquid injection molding (e.g., silicone)
Describe hybrid technology (e.g., metal injection molding [MIM], ceramics)
Describe spray lay-up
Describe rotational blow molding
Describe multi-layered processing
Describe co-processing (e.g., injection, extrusion, blow)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Describe fiberglass reinforced plastics (FRP) method

Competency Builders:
Describe match die
Describe hand lay-up
Describe spray-up
Describe rigidizing
Describe bag
Describe filament wind
Describe centrifugal
Describe pultrusion
Describe stamping/cold forming
Explain reinforced plastic molding methods
Identify machines and molds used in reinforced plastic moldings

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Describe thermoforming processes

Competency Builders:
Describe vacuum forming
Describe drape forming
Describe match molding
Describe plug assist
Describe snap back
Describe pressure bubble
Describe trapped sheet
Describe free forming
Describe mechanical forming

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Describe expansion and coating processes

Competency Builders:
Describe in-place expansion (e.g., foam)
Describe spraying
Describe extrusion coating
Describe calendering
Describe powder coating
Describe transfer coating
Describe knife coating
Describe dip
Describe spray
Describe metal coating
Describe in-mold painting
Describe granular in-mold painting technology

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Assemble plastics

Competency Builders:
Explain how different adhesives are used in product assembly
Describe solvent bonding processes
Describe spin welding
Describe fusion bonding
Describe vibration welding
Describe ultrasonic welding
Describe dielectric sealing
Describe induction bonding
Describe cold pressing
Describe hot boss staking
Describe hot gas welding
Describe riveting
Describe mechanical assembly (screws/clips/hardware)
Describe snap-fit and press fit assembly
Describe heat staking

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Print/coat plastics

Competency Builders:
Explain hot stamping
Explain pad printing
Explain subliminal printing
Explain electrostatic coating
Explain ink jet
Explain laser printing and etching
Explain solvent and water based painting
Explain electroplating
Explain electroless plating
Explain screen printing
Explain vacuum metallizing/sputtering
Explain corona discharge

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Explain surface preparation

Competency Builders:
Explain corona discharge
Explain flame
Explain plasma
Explain chemical etching

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	P	R	√	√

Competency: Describe annealing

Competency Builders:
Explain conduction
Explain convection
Explain what effect internal stresses have on plastics
Explain post-part curing (annealing)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Explain deflashing

Competency Builders:
Differentiate between various degrees of product cleanliness
Explain cryogenics
Explain vibration
Explain media
Explain tumbling
Explain degreasing
Explain ultrasonic bath
Explain knife trimming
Explain trim fixture
Explain laser deflashing
Explain water jet deflashing
Explain glass beading

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Unit: Plastics Manufacturing (Level 2)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	R	√	√

Competency: Transport plastic parts from mold

Competency Builders:
Use vibratory bowls
Use pick and place
Use robotics
Use separators
Use pickers
Use conveyors
Use chutes

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Perform physical testing on final parts

Competency Builders:
Use insert pull test
Use bond strength test
Use drop impact test
Use vibration and cyclic loading test
Use porosity weight test

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Apply extrusion method

Competency Builders:
Explain extrusion method
Identify machines and dies used in extrusion
Identify applications for extrusion
Conduct extrusion method experiment
Describe products which can be produced by extrusion
Describe dies to produce various extrusion shapes

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Apply compression molding method

Competency Builders:
Explain compression molding method
Define well, draft, bulk factor, shrinkage, and molding cycle
Identify machines and molds used in compression molding
Identify applications for compression molding (e.g., flash molds, semi-positive)
Conduct compression molding experiment
Describe products which are compression molded
Describe molds which are used to produce products utilizing the compression molding process

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Apply injection molding method

Competency Builders:
Explain injection molding methods (e.g., horizontal, vertical)
Identify components of 2-plate injection mold and their functions
Identify components of 3-plate injection mold and their functions
Determine shrinkage allowance
Calculate clamp pressure
Identify machines and molds used in injection molding
Identify application for injection molding
Conduct injection molding experiment
Describe products which can be injection molded
Describe molds for injection molding

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Apply blow molding method

Competency Builders:
Explain blow molding method
Identify machines and molds used in blow molding
Identify applications for blow molding
Describe the high volume input and output characteristics of blow molding
Conduct blow molding experiment
Describe product that can be blow-molded
Describe molds for products produced using the blow-mold process

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Apply thermoforming method(s)

Competency Builders:
Explain thermoforming method
Identify machines and molds used in thermoforming
Identify applications for thermoforming
Describe downstream equipment for thermoformed parts
Conduct thermoforming experiment

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Apply rotational molding method

Competency Builders:
Explain rotational molding method
Identify machines and molds used in rotational molding
Identify applications for rotational molding
Conduct rotational molding experiment

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Apply calendering method

Competency Builders:
Explain calendering method
Identify machines and molds used in calendering
Identify applications for calendering
Conduct calendering experiment

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Apply foam processes method

Competency Builders:
Explain foam processes method
Identify machines and materials used in foam processing
Identify applications for foam processes
Conduct foam processes experiment
Describe structural foam
Explain gas assist
Describe expandable beads
Describe foaming agents

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Apply powder coating method(s)

Competency Builders:
Explain powder coating method
Identify machines and materials used in powder coating
Identify applications for powder coating
Conduct powder coating experiment

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Describe thermoset sheet molding (i.e., mechanical forming)

Competency Builders:
Explain sheet molding method
Identify machines and molds used in sheet molding
Identify applications for sheet molding
Describe products which utilize contact, vacuum bag, pressure bag, autoclave, matched die, filament wound and spray processes
Describe molds to produce products using contact, vacuum bag, pressure bag, autoclave, matched die, filament wound and spray molding processes

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Describe slush, rotational, and dip casting

Competency Builders:
Explain slush, rotational, and dip casting
Identify machines and molds used in slush, rotational, and dip casting
Identify applications for slush, rotational, and dip casting
Describe products which are formed by slush, rotational or dip casting
Describe molds to produce products utilizing slush, rotational and dip casting processes

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	P	R	√	√

Competency: Describe transfer molding

Competency Builders:
Explain transfer molding method
Identify machines and molds used in transfer molding
Identify applications for transfer molding
Identify compositions associated with transfer molds

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	R	√	√

Competency: Describe pressure forming

Competency Builders:
Explain pressure forming methods
Identify machines and molds used in pressure forming
Identify applications for pressure forming
Describe products which are pressure formed
Describe pressure forming molds

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	R	√	√

Competency: Describe vacuum forming

Competency Builders:
Explain vacuum forming methods
Identify machines and molds used in vacuum forming
Identify applications for vacuum forming
Describe products which are vacuum formed
Describe patterns and molds to produce products using the vacuum forming process

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	P	M	√	√

Competency: Describe polymer nomenclature

Competency Builders:
Locate the major polymer names
Locate the major material trade names
Define terms (See Sample Glossary on pp. 197-201.)

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	R	C	√	√

Competency: Finish/assemble plastic products

Competency Builders:

Describe the processes, tools, materials, and machines necessary to finish/assemble plastic products
Flash remove plastic product
Slot cut plastic product
Polish plastic product
Anneal plastic product
Saw plastic product
File plastic product
Drill plastic product
Tap plastic product
Turn plastic product
Plane plastic product
Mill plastic product
Shape plastic product
Route plastic product
Sand plastic product
Shear plastic product
Punch plastic product
Laser cut plastic product
Tumble plastic product
Grind plastic product
Determine ash content of plastic product
Buff plastic product
Transparent coat plastic product
Polish by solvent plastic product
Post-cure plastic product
Describe types of assembly methods which can be performed on various types and classes of plastic products
Identify types of products which can be used to perform successful repairs
Identify appropriate tools, machines, and processes which can be used to perform successful repair of plastic products
Describe cohesive cementing of plastic products
Describe solvent cementing of plastic products
Describe mechanical fastening of plastic products
Describe stapling of plastic products
Describe snap fit of plastic products
Describe press fit of plastic products

Competency Builders: **(continued from previous page)**

Describe heat staking of plastic products
Describe ultrasonic staking of plastic products
Describe thermal sealing of plastic products
Describe impulse sealing of plastic products
Describe ultrasonic sealing of plastic products
Describe dielectric sealing of plastic products
Describe hot gas welding of plastic products
Describe spin welding of plastic products
Describe hot plate welding of plastic products
Describe ultrasonic welding of plastic products
Describe hot blade welding of plastic products
Describe high pressure lamination of plastic products

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Demonstrate basic knowledge of material handling

Competency Builders:

Describe identification of received material (e.g., type, nomenclature, etc.)
Describe major polymer names and their abbreviations (e.g., Acrylonitrile-Butadiene-Styrene [ABS], Polycarbonate [PC])
Describe major material trade names (e.g., ABS [Cycolac, Lustran])
Define a letter of material certification
List procedures of testing incoming materials (e.g., thermo-analysis)
Describe good housekeeping procedures to prevent dust and water contamination
Define proper lift truck techniques in moving materials (e.g., stacking, accessibility)
Explain material quarantine
Describe "First in—First out" concept
Define safety concerns in lift truck operations
Define proper storing of materials (e.g., location, room temperature, ventilation)
Describe necessity of strict stock control system

	10	12	AD	BD	WS	LL
Leveling of this competency...		C	P	R	√	√

Competency: Demonstrate basic knowledge of material types for proper handling procedures

Competency Builders:
Describe amorphous resins
List examples of amorphous materials
Describe crystalline resins
List examples of crystalline materials
Describe hygroscopic materials
Describe non-hygroscopic materials

	10	12	AD	BD	WS	LL
Leveling of this competency...	I	R	C	P	√	√

Competency: Demonstrate basic knowledge of material drying techniques

Competency Builders:
Describe vented machine method
Describe oven drying
Describe vacuum method of drying
Describe desiccant drying
Describe auto hopper loader
Explain insulation of inlet air lines to dryers
Describe hopper insulation
Describe use of temperature monitors at hopper inlets
Describe dewpoint
Describe continuous dewpoint analyzer
Describe air flow meter
Define effect of air temperature
Define effect of moisture content in resin
Define effect of residence time
Define effect of air flow rate
Define effect of moisture content of air
Explain formula to calculate hopper size
Explain formula to calculate airflow requirements
Explain formula to calculate resin throughput

Competency Builders: **(continued from previous page)**
Describe drying range for soft flow materials
Describe drying range for hard flow materials
Describe drying temperatures and time for commonly used materials (e.g., acetal, ABS, nylon, polycarbonate, and polyurethanes)

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe basic knowledge of regrind materials

Competency Builders:
Describe effect of regrind percentage on physical properties (e.g., 25%-50%-75%)
Define importance of proper size, design, and maintenance of granulator
Define cascade regrind system
Describe "fines" and their adverse affect on melt quality
Describe relationship of blades to screens
Explain importance of screen hole sizes and monitoring wear
Describe best materials for granulator blades (e.g., tungsten carbide, etc.)
Describe blade gaps and how they should be set (e.g., PE-Polypro—.003 to .005)
Describe soundproofing safety (e.g., OSHA limit)
Explain safety concerns in granulator operations

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Describe basic knowledge of blending/mixing material

Competency Builders:
Describe gravimetric blender
Describe proportional or volumetric blender
Describe methods of weighing
Define how to determine let down ratios and percentages
Describe basic tumbling equipment
Describe tumbling methods
Describe effects of static electricity

	10	12	AD	BD	WS	LL
Leveling of this competency...		I	C	P	√	√

Competency: Demonstrate knowledge of material conveying and loading systems

Competency Builders:

Describe equipment used for hand filling machine hoppers
Describe hopper loaders and their function
Describe tube system operations
Describe use and operation of tipsters
Describe the functions of cyclones
Describe advantage of machine side granulators
Describe maintenance of loading and conveying systems
Define importance of constant monitoring of systems
Describe source and type of material contamination in the work area
Describe source and type of material contamination in molding operations
Describe preventative methods and procedures to eliminate material contamination

Sample Glossary of Terms

Automatic Mold: A mold for injection, compression or transfer molding that repeatedly goes through the entire molding cycle, including ejection, without human assistance.

Back Pressure: Pressure applied to the rear end of a screw to slow its rate of return to a starting position.

Cavity: Female or recessed portion of a mold which shapes the surface opposite that formed by a core.

Center Gated Mold: An injection or transfer mold wherein the cavity is filled with molding material through a sprue or gate directly into the center of the part.

Clamping Force: In injection molding and in transfer molding, the pressure which is applied to the mold to keep it closed.

Clamping Plate: A plate fitted to a mold and used to fasten mold to a molding machine.

Cooling Channels: Channels or passageways located within the body of a mold through which a cooling medium can be circulated to control temperature on the mold surface. May also be used for heating a mold by circulating steam, hot oil or other heated fluid through channels as in molding of the thermosetting and some thermoplastic materials.

Core (n.): Male portion of a mold which shapes the inside of a hollow part. Also called force, plug or male section.

Cycle: A series of operations which performs all or part of a mold sequence. In injection molding a single cycle involves closing a mold, injection material, cooling the piece, opening the mold, and ejection. The cycle time is the elapsed time between a certain point in one cycle and the same point in the next cycle.

Ejector Pin: Or ejector sleeve. A rod, pin or sleeve which pushes a molding off of a force out of a cavity of a mold. It is attached to an ejector bar or plate which can be actuated by the ejector rod(s) of the press or by auxiliary hydraulic or air cylinders.

Family Mold: A multi-cavity mold wherein each of the cavities forms one of the component parts of the assembled finished object. The term often applied to molds wherein parts from different customers are grouped together in one mold for economy of production. Sometimes called Combination Mold.

Sample Glossary of Terms (continued)

Flash: Extra plastic attached to a molding along the parting line; under most conditions it would be objectionable and must be removed before the parts are acceptable.

Flights: The spaces between the "turns" of a screw.

Flow: A qualitative description of the fluidity of a plastic material during the process of molding.

Force: That portion of the mold which forms the inside of the molded part. Sometimes called a Core or a Plunger.

Gate (mold): Restricted opening leading from a runner to a cavity.

Hopper: Container (located at the feed end of an injection machine) from which pellets drop by gravity into the heating cylinder, or into a feed mechanism.

Injection Molding: A molding procedure whereby a heat-softened plastic material is forced from a cylinder into a cavity which gives the article the desired shape.

Mold (n.): The tool which imparts final shape to the molten plastic. Injection molds are machined from tool steel, special types of aluminum, and may have cores and cavities of beryllium copper. Molds are also referred to as tooling.

Molding Material: Plastic material in varying stages of granulation often comprising resin, filler, pigments, plasticizers and other ingredients, ready for use in the molding operation. Also called Molding Compound or Powder.

Mold Release Agent: A lubricant used to coat a mold cavity to prevent the molded piece from sticking to it, and thus to facilitate its removal from the mold. Also called Release Agent.

Moveable Platen: The moving platen of a injection molding machine to which half of the mold is secured during operation. This platen is moved either by hydraulic ram or toggle mechanism.

Nozzle: An adapter containing an orifice through which hot plastic flows from the heating cylinder into the sprue bushing.

Sample Glossary of Terms (continued)

Packing: The term applied when a slight excess of plastic is pushed into a cavity while the molded part is cooling and shrinking. Packing can cause sticking; can cause hidden stresses in a molded part. Packing increases shot weight, which runs the cost of the job higher.

Pellet: Small, uniform particles of thermoplastic material usually cylindrical or cubical in shape, with a cross section of 1/8 to 1/16 inch.

Plastic: Natural and synthetic material and chemicals that can be transformed into a solid, as either or both heat and pressure is applied.

Plasticate: To render a plastic workable by means of heat or mechanical shearing.

Plasticity: A property of plastics which allows the material to be deformed continuously and permanently without rupture upon the application of a force that exceeds the yield value of the material.

Platen: Rugged steel plate which provides the means for clamping the mold and exerting clamping pressure.

Purging: Cleaning one color or type of material from the cylinder of an injection molding machine by forcing it out with new color or material to be used in subsequent production. Purging materials are also available.

Pyrometer: A device for measuring temperature. Electronic controllers regulate the current furnished to heating bands, based on pyrometer signals.

Reject (n.): A molded product that does not meet manufacturing specifications.

Residence Time: The total time required for pellets to be conveyed from the feed end of a heating cylinder to the sprue bushing.

Rhythm: The ability of the machine operator to regulate his movements in time with the established molding cycle.

Runner: Feed channels cut into the mold on the parting line to direct the plastic to cavities. The term, runner, also applied to the cooled plastic formed in the channel.

Runner System: (Refers to plastic) The term usually applied to all the material in the form of sprues, runners and gates which lead material from the nozzle of an injection machine to the mold cavity.

Sample Glossary of Terms (continued)

Screw: A device that accepts the pellets and conveys them forward into the heated barrel, where the pellets are melted. The melted plastics coming off of the end of the screw cause the screw to pump itself backward thereby preparing the next shot of plastics for molding.

Semi-Automatic Molding Machine: A molding machine in which only part of the operation is controlled by the direct action of a human. The automatic part of the operation is controlled by the machine according to a predetermined program.

Shearing: An action which results in one portion of a substance or body to slide away from, or be torn from, another portion.

Short and Short Shot: A molded part produced when the mold has not been filled completely.

Shot: The amount of plastic that can be injected by one forward stroke of the injection ram.

Shot Capacity: The maximum weight of material which a machine can produce from one forward motion of the plunger or screw.

Sink Mark: A depression or dimple on the surface of an injection molded part due to collapsing of the surface following local internal shrinkage after the gate seals.

Sprue Bushing: A steel insert, usually cylindrical, containing a tapered hole in its center, and a spherical seat which mates with the nozzle of the injection cylinder. Heat-softened plastic flows through the sprue bushing, either directly into a mold cavity, or to runners which lead to cavities. The term, sprue, applied to the cooled plastic formed in the sprue bushing.

Stationary Platen: The plate of an injection or compression molding machine to which the front plate of the mold is secured during operation. This platen does not move during normal operation.

Thermoplastic: (a) Capable of being repeatedly softened by heat and hardened by cooling. (b) A material that will repeatedly soften when heated and harden when cooled. Typical of the thermoplastic family are the styrene polymers and copolymers, acrylics, cellulosics, polyethylenes, polypropylene, vinyls, nylons, and the various fluorocarbon materials.

Sample Glossary of Terms (continued)

Toggle Action: A mechanism which exerts pressure developed by the application of force on a knee joint. It is used as a method of closing presses and also to apply pressure at the same time.

Torque: Power applied to turn the screw.

Vent: In a mold, a shallow channel or minute hole cut in the cavity to allow air to escape as the material enters. Also called Breathers.

Warpage: Dimensional distortion on a plastic object after molding.

Weld Line: A mark on a molded piece made by the meeting of two flow fronts during molding.

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