



Bristol Public Schools
Office of Teaching & Learning

Department	Engineering & Technology Education
Department Philosophy	<p>Courses in the Engineering & Technology department are designed to:</p> <ul style="list-style-type: none">• Encourage students to pursue advanced technical study• Provide experiences for students to develop and demonstrate technological skills and knowledge• Employ instructional methods and interdisciplinary activities that stimulate student interest in technology• Emphasize the ethical and safe use of tools and technology• Engage students with real-world problem solving experiences• Prepare students to be responsible, technologically literate citizens and consumers• Prepare students to work cooperatively as a team member toward a common goal• Prepare students to explore, understand and evaluate different aspects of technology• Prepare students to competently use a variety of technologies, tools, materials and technical processes
Course	Manufacturing Design

Manufacturing Design (updated December 2018)

Course Description for Program of Studies	<p>Students will follow curriculum through Mastercam University to earn certification recognized in the manufacturing industry. Students will utilize skills to transform CAD Solid Modeling drawings into tool paths to create tool paths in Mastercam to operate CNC machines</p> <p>This course is the third level in a 3 part sequence designed to prepare students for an industry Certification as well as prepare them for post-secondary training, education, and careers. Careers in industries such manufacturing, medical, aeronautical & space, and maritime.</p>
Grade level	10-12
Pre-requisites	Successful completion with a minimum of a C in Automation & Robotics AND CAD & Solid Modeling or Introduction to Engineering or Tools & Materials or Principles of Engineering
Credit (if applicable)	.5

P indicates standard will be a priority for the unit; S indicates a supporting standard

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CTE Performance Standards & Competencies	Unit 1: Creating CAD Geometry	Unit 2: Introduction to CAM	Unit 3: Toolpaths, CNC & Machining Strategies	Unit 4: Machining Setup & Safety
MAN.01 Employ engineering design process to achieve desired outcomes				
MAN.01.02 Demonstrate the process for interpreting technical drawings to extrapolate information from a set of plans using appropriate mathematical functions	S			
MAN.02 Identify and use appropriate engineering materials				
MAN.02.03 Select materials based on properties required by the project		S		
MAN.02.04 Describe the relationship between materials and manufacturing		S		
MAN.03 Demonstrate the methods involved in turning raw materials into usable products				
MAN.03.01 Identify and describe the primary processes for obtaining raw materials.	S	P		
MAN.03.02- Demonstrate the safe and accurate secondary process to create a finished product; forming; separating; combining; assembly; finishing.				P
MAN.03.03- Apply a variety of manufacturing techniques and processes to create a usable product			P	S
ENG.02 Use the design process to solve problems by creating and refining prototypes.				
ENG.02.09- Build a prototype from working drawings using appropriate materials.*(H30)				P
ENG.03 Ensure quality control using the major components of manufacturing processes including measurement systems, tools and instruments to produce a product.				
ENG.03.01- Explain the major manufacturing processes			S	
ENG.06 Use engineering equipment, laboratory materials and tools appropriately and safely.				
ENG.06.02- Demonstrate safe personal behavior in the classroom				P
ENG.07 Identify and demonstrate the use of various software programs used in				

the engineering field.				
EGR.07.04 Describe and demonstrate the process for using CAD in a design	P			
CADD.02 Analyze the use of current CADD design technology.				
CADD.02.08 Export and import images/files in a variety of file formats*(A6)			P	
CADD.03 Utilize measurement and annotation systems as they apply to CADD technology design.				
CADD.03.03 Determine the proper dimensioning styles for a variety of applications	P			
CADD.03.04 Apply dimensioning to various objects and features.	P			
CADD.04 Identify, describe, and utilize the basic hardware and operating systems used in CADD.				
CADD.04.04 View file names of a storage device. *(C14)				
CADD.04.05 Store, copy, move, and retrieve information to/from various drives. *(C15)	P			
CADD.04.06 Rename and backup files	P			
CADD.05 Utilize Proper projection techniques to develop orthographic and pictorial drawings.				
CADD.05.01 Understand the commands and concepts necessary for producing drawings through traditional or computer-aided means	S			
CADD.05.04 Use the concepts of geometric construction in the development of design drawings.	P			
CADD.05.08 Create and edit line types, colors and layers/ levels. *(E22)	P			
CADD.06 Demonstrate use and application of alternate view applications and functions.				
CADD.06.03 Create and edit construction planes through reference geometry. *(G35)	P			
CADD.06.04 Generate/modify geometric components on construction planes. *(G33)	P		P	
CADD.06.06 Create a 3-D model from a 2-D drawing. *(G35)	P			

UNWRAPPED STANDARDS

UNIT 1 Creating CAD Geometry

CT State Dept. of Ed Tech ED Standards Performance Standard asterisked	CTE	Type of Standard	Concepts and Disciplinary-Specific Vocabulary	Academic Vocabulary
MAN.01 Employ engineering design process to achieve desired outcomes MAN.01.02 Demonstrate the process for interpreting technical drawings to extrapolate information from a set of plans using appropriate mathematical functions	x	Content Knowledge	Design Process	Full scale
	x	Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)		
		Physical Skill		
	x	Product development		
		Learning Behavior		
MAN.02 Identify and use appropriate engineering materials MAN.02.03 Select materials based on properties required by the project MAN.02.04 Describe the relationship between materials and manufacturing	x	Content Knowledge	Ferrous Non-ferrous	
	x	Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)		
		Physical Skill		
	x	Product development		
		Learning Behavior		
MAN.03 Demonstrate the methods involved in turning raw materials into usable products MAN.03.01 Apply a variety of manufacturing techniques and processes to create a usable product	x	Content Knowledge	Milling	Machining
	x	Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)		
		Physical Skill		
		Product development		
		Learning Behavior		
ENGR Identify and demonstrate the use of various software programs used in the	x	Content Knowledge	CAD	
	x	Skill (Problem-Solving, Writing, Speaking,	CAM	

engineering field. EGR.07.04 Describe and demonstrate the process for using CAD in a design		Listening, Reasoning)	Mastercam	
		Physical Skill		
	x	Product development		
		Learning Behavior		
CADD.03 Utilize measurement and annotation systems as they apply to CADD technology design. CADD.03.03 Determine the proper dimensioning styles for a variety of applications. CADD.03.04 Apply dimensioning to various objects and features.	x	Content Knowledge	Annotation Tolerance	Parallel Perpendicular Tangent
	x	Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)		
		Physical Skill		
	x	Product development		
		Learning Behavior		
CADD.04 Identify, describe, and utilize the basic hardware and operating systems used in CADD. CADD.04.04 View file names of a storage device. *(C14) CADD.04.05 Store, copy, move, and retrieve information to/from various drives. *(C15) CADD.04.06 Rename and backup files	x	Content Knowledge	Input Output Hard Drive Flash Drive Server	
	x	Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)		
		Physical Skill		
	x	Product development		
		Learning Behavior		
CADD.05 Utilize Proper projection techniques to develop orthographic and pictorial drawings. CADD.05.01 Understand the commands and concepts necessary for producing drawings through traditional or computer-aided means. CADD.05.04 Use the concepts of geometric	X	Content Knowledge	Offset Extrude Trim Mirror	Parallel Perpendicular Tangent Hole Diameter
	X	Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)		
		Physical Skill		
	X	Product development		
		Learning Behavior		

<p>construction in the development of design drawings. CADD.05.08 Create and edit line types, colors and layers/ levels. *(E22)</p>				
<p>CADD.06 Demonstrate use and application of alternate view applications and functions.</p> <p>CADD.06.03 Create and edit construction planes through reference geometry. *(G35) CADD.06.04 Generate/modify geometric components on construction planes. *(G33) CADD.06.06 Create a 3-D model from a 2-D drawing. *(G35)</p>	X	Content Knowledge	<p>Construction Plane Solid Model</p>	
		Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)		
	X	Physical Skill		
	X	Product development		
	X	Learning Behavior		

UNIT ESSENTIAL QUESTIONS

UNIT 1 Introduction to CAD Geometry

1. What are the steps and processes involved with the production of a *product*?
2. Why does accuracy matter in the design process?
3. How are tool-paths affected by changes in CAD geometry when CNC machining parts?

CTE Standard	Objective(s) The students will be able to:	Summative Assessment Strategy	Additional Student Outcomes							Common Learning Experiences	
MAN.0 1.02 MAN.0 3.01 EGR.0 7.04	Identify and explain the advantages of using a CAD/CAM.	x	Selected Response	Read	X	Writing	Math	Tech.	Students will create a part utilizing the CAD component of Mastercam.		
			Constructed Response	Writing: Write informative /explanatory tests to examine and convey complex ideas, concepts, and information clearly and accurately through effective selection, organization and analysis of content. (Presentations)							
		x	Performance								
			Observation								
CADD. 04.04 CADD. 04.05 CADD. 04.06	Utilize the Mastercam interface to navigate the menu structure to open and save files, choose display functions as well as use CAD and CAM functionality		Selected Response	Read		Writing	Math	Tech.			
			Constructed Response								
		x	Performance								
		x	Observation								
CADD.0 5.01 CADD.0 5.04 CADD.0 6.03 CADD.0 6.04 CADD.0 6.06	Utilize CAD functions to create 2D geometry of a part including lines, circles, arcs chamfers and fillets.		Selected Response	Read		Writing	X	Math	Tech.	Mathematics: Apply mathematics learned to solve problems arising in everyday life, society, and the workplace.	
			Constructed Response								
		x	Performance								
		x	Observation								
CADD.0 5.08	Apply understanding of CAD to edit line color and type.		Selected Response	Read		Writing	Math	Tech.			
			Constructed								

			Response	
		x	Performance	
		x	Observation	

CTE Standard	Objective(s) The students will be able to:	Summative Assessment Strategy		Additional Student Outcomes				Common Learning Experiences
			Selected Response	Read	Writing	Math	Tech.	
MAN.0 3.01	Analyze and change attributes of entities and utilize transform function.		Constructed Response					Students will add appropriate dimension, notes, and labels needed to create a part in CAD.
		x	Performance					
		x	Observation					
			Selected Response					
CADD. 03.03 CADD. 03.04	Annotate 2D and 3D parts		Constructed Response					
		x	Performance					
		x	Observation					
			Performance					
			Observation					

ADDITIONAL CONSIDERATIONS			
COMMON MISCONCEPTIONS	PRIOR KNOWLEDGE NEEDED TO MASTER STANDARDS FOR THIS UNIT	ADVANCED STANDARDS FOR STUDENTS WHO HAVE DEMONSTRATED PRIOR MASTERY	OPPORTUNITIES FOR STUDENT-DIRECTED LEARNING WITHIN THE UNIT
Machines make parts, not people. While this is true, the part must be first designed in CAD and then specific code created which will instruct the machine how to precisely create the part.	Students will have been exposed to what automation is and robotics is and how it is implemented in manufacturing. Additionally, they should have the ability to read and interpret information on a technical drawing		Students have the opportunity to export CAD files they created as input for the creation of a product utilizing technologies such as 3D printing or laser engraving.

UNWRAPPED STANDARDS

UNIT 2 Introduction to CAM Toolpaths

SDE Engineering & Tech Ed Standards	Type of Standard	Concepts and Disciplinary-Specific Vocabulary	Academic Vocabulary
<p>MAN.02 Identify and use appropriate engineering materials</p> <p>MAN.02.03 Select materials based on properties required by the project</p> <p>MAN.02.04-Describe the relationship between materials and manufacturing</p>	x Content Knowledge	Ferrous	Metal Polymer Wood
	Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)	Non Ferrous	
	Physical Skill		
	x Product development		
	Learning Behavior		
<p>MAN.03 Demonstrate the methods involved in turning raw materials into usable products</p> <p>MAN.03.03- Apply a variety of manufacturing techniques and processes to create a usable product</p>	x Content Knowledge	Convention Cut	
	Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)	Climb Cut	
	Physical Skill	Linking Parameters	
	x Product development	Cut Parameters	
	Learning Behavior	Clearance Height Rapid Height Feed Height Top of Stock Step over Percentage Feed rate Depth of Cut Tool-Path Dynamic Toolpath High Speed Classic Toolpath Step Down Depth Stock Allowance Contour Peck Drill Facing Slot	

Pocket
Chaining
Feed Direction
Tip Compensation

UNIT ESSENTIAL QUESTIONS

UNIT 2 Introduction to CAM Toolpaths

1. How are materials transformed into usable goods and products?
2. How does a tool path affect the outcome and production of a product?
3. How will material processing effect the world we live in?

CTE Standard	Objective(s) The students will be able to:	Summative Assessment Strategy	Additional Student Outcomes							Common Learning Experiences	
MAN.03.03	Compare, select, create and assign a toolpath type. Apply appropriate geometry to produce a tool path	Selected Response	Read		Writing	X	Math		Tech.	Students will create toolpaths and corresponding code utilizing CAM software. Students will identify and select product materials that support the function of the product.	
		Constructed Response	Mathematics: Examine mathematical problems to discern a pattern or structure.								
		X Performance									
		X Observation									
MAN.02.03 MAN.02.04 MAN.03.03	Select and assign a material that suits the needs of the final product. Design a toolpath for the design that considers considering the material.	Selected Response	Read		Writing		Math		Tech.		
		Constructed Response									
		X Performance									
		X Observation									
MAN.03.03	Define and assign a toolpath that identifies: cut parameters, linking parameters, depth cuts, and multiple passes.	Selected Response	Read		Writing		Math		Tech.		
		Constructed Response									
		X Performance									
		X Observation									
MAN.03.03	Compare, select, and explain the difference between classic, high speed, and dynamic toolpaths.	Selected Response	X	Read	X	Writing		Math		Tech.	Reading: Determine the meaning, symbols, key terms, and other domain specific words and phrases as they are used in specific scientific or technical context relevant to grades 9-12 texts and topics.
		Constructed Response									
		X Performance									
		X Observation									

ADDITIONAL CONSIDERATIONS			
COMMON MISCONCEPTIONS	PRIOR KNOWLEDGE NEEDED TO MASTER STANDARDS FOR THIS UNIT	ADVANCED STANDARDS FOR STUDENTS WHO HAVE DEMONSTRATED PRIOR MASTERY	OPPORTUNITIES FOR STUDENT-DIRECTED LEARNING WITHIN THE UNIT
	Students will demonstrate proficiency in the use of CAD and have a basic understanding of the characteristics of metals.		Students have the opportunity to export CAM files they created as input for the creation of a product utilizing technologies a CNC router or mill.

UNWRAPPED STANDARDS

UNIT 3 Tool Paths, CNC, and Machining Strategies

SDE Engineering & Tech Ed Standards; CTE Standards in asterisk	Type of Standard	Concepts and Disciplinary-Specific Vocabulary	Academic Vocabulary
MAN.03 Demonstrate the methods involved in turning raw materials into usable products MAN.03.03- Apply a variety of manufacturing techniques and processes to create a usable product	x Content Knowledge	Back Plot Verify Dirty Operation Regenerate Translate Transform	
	x Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)		
	Physical Skill		
	x Product development		
	Learning Behavior		
ENG.03 Ensure quality control using the major components of manufacturing processes including measurement systems, tools and instruments to produce a product. ENG.03.01- Explain the major manufacturing processes	x Content Knowledge	Machining Strategy Keep Tool Down Break Through	Efficiency Simulate
	x Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)		
	Physical Skill		
	x Product development		
	Learning Behavior		
CADD.02 Analyze the use of current CADD design technology. CADD.02.08 Export and import images/files in a variety of file formats*(A6)	x Content Knowledge		
	x Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)		
	Physical Skill		
	x Product development		
	Learning Behavior		
CADD.06 Demonstrate use and application of alternate view applications and functions. CADD.06.04- Generate/modify geometric components on construction planes.*(G33)	x Content Knowledge	Absolute Incremental Associative	
	x Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)		
	Physical Skill		
	x Product development		
	Learning Behavior		

UNIT ESSENTIAL QUESTIONS

UNIT 3 Tool Paths, CNC, and Machining Strategies

1. How do changes in geometry change toolpaths?
2. How does a focus on efficiency improve the process of manufacturing?
3. How does continual improvement benefit production?

Standard	Objective(s) The students will be able to:	Summative Assessment Strategy	Additional Student Outcomes				Common Learning Experiences
ENG.03 .01	Back plot and verify toolpaths	Selected Response	Read	Writing	Math	Tech.	Students will verify & augment toolpaths and then export the code for a specific post processor.
		Constructed Response					
		x Performance					
		x Observation					
ENG.03 .01	Modify and regenerate dirty operations	Selected Response	Read	Writing	Math	Tech.	
		Constructed Response					
		x Performance					
		x Observation					
MAN.0 3.03	Generate a CNC code written for a specific post processor	Selected Response	Read	Writing	Math	Tech.	
		Constructed Response					
		x Performance					
		x Observation					
MAN.0 3.03	Produce a report for a CNC processing operation	Selected Response	Read	Writing	Math	Tech.	
		Constructed Response					
		x Performance					
		x Observation					
ENG.03 .01	Reorder toolpath operations	Selected Response	Read	Writing	Math	Tech.	Students will save changes to the program in an CNC and MC file format
		Constructed Response					
		x Performance					
		x Observation					
CADD. 02.08	Export and save a CNC file and a MC file	Selected Response	Read	Writing	Math	Tech.	
		Constructed Response					

		<input checked="" type="checkbox"/>	Performance					
		<input checked="" type="checkbox"/>	Observation					
CADD. 06.04	Edit geometry and associated toolpaths		Selected Response	Read	Writing	Math	Tech.	
			Constructed Response					
		<input checked="" type="checkbox"/>	Performance					
		<input checked="" type="checkbox"/>	Observation					
CADD. 06.04	Translate, transform, copy, and move entities and geometry to increase productivity, safety, and efficiency		Selected Response	Read	Writing	Math	Tech.	
			Constructed Response					
		<input checked="" type="checkbox"/>	Performance					
		<input checked="" type="checkbox"/>	Observation					

ADDITIONAL CONSIDERATIONS			
COMMON MISCONCEPTIONS	PRIOR KNOWLEDGE NEEDED TO MASTER STANDARDS FOR THIS UNIT	ADVANCED STANDARDS FOR STUDENTS WHO HAVE DEMONSTRATED PRIOR MASTERY	OPPORTUNITIES FOR STUDENT-DIRECTED LEARNING WITHIN THE UNIT
Student often believe that machining operations are completely automated and the computers are able to figure out the best case scenarios of CNC operations. Students need to understand the systems to achieve the most efficient and effective way of manufacturing a product given a multitude of variables.	Students need to have attained knowledge and understanding of Unit 1 in order to master the standards of this unit.		Students have the opportunity to excel at their own pace in this curriculum by delving deeper into each concept with further project/exercises and real world work.

UNWRAPPED STANDARDS

UNIT 4 CNC Machining Setup & Safety

CT State Standards	Type of Standard	Concepts and Disciplinary-Specific Vocabulary	Academic Vocabulary
ENG.02.09- Build a prototype from working drawings using appropriate materials. *(H30)		Content Knowledge	Computer Aided Machining (CAM) Material Clamp Collet Collet Lock Spanner Wrench Revolutions Per Minute Post
	X	Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)	
	X	Physical Skill	
	X	Product development	
ENG.06.02- Demonstrate safe personal behavior in the classroom ENG.06.04- Describe and demonstrate the proper use of engineering laboratory equipment. *(B6)		Content Knowledge	Zero Reference Home Computer Integrated Manufacturing (CIM)
	X	Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)	
	X	Physical Skill	
		Product development	
MAN.03.02- Demonstrate the safe and accurate secondary process to create a finished product; forming; separating; combining; assembly; finishing		Content Knowledge	Safety OSHA PPE
	X	Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)	
	X	Physical Skill	
	X	Product development	
MAN.03.03- Apply a variety of manufacturing techniques and processes to create a usable product		Content Knowledge	Ramping Entry & Exit Helical Entry Program Zero Feed Hold
	X	Skill (Problem-Solving, Writing, Speaking, Listening, Reasoning)	
		Physical Skill	
	X	Product development	
	X	Learning Behavior	

UNIT ESSENTIAL QUESTIONS

UNIT 4 CNC Machining Setup & Safety

1. How is the world we live in affected by Technology?
2. How can I safely produce a product using Technology?

CTE Standard	Objective(s) The students will be able to:	Summative Assessment Strategy	Additional Student Outcomes	Common Learning Experiences
MAN.0 3.02 MAN.0 3.03	Demonstrate the directions of control along the X,Y,Z axis on a CNC end mill or router	Selected Response Constructed Response X Performance Observation	Read <input type="checkbox"/> Writing <input checked="" type="checkbox"/> Math <input type="checkbox"/> Tech. <input type="checkbox"/> <u>Mathematics:</u> Make sense of quantities and their relationships in problem situations (geometry).	Students will safely set up CNC machinery to manufacture a part or product.
MAN.0 3.02 MAN.0 3.03	Demonstrate how positions used in a program are specified from a program reference zero position	Selected Response Constructed Response X Performance Observation	Read <input type="checkbox"/> Writing <input type="checkbox"/> Math <input type="checkbox"/> Tech. <input type="checkbox"/>	
MAN.0 3.02 MAN.0 3.03	Demonstrate how an origin position, 0,0,0 is assigned and aligned with the WCS CAD system	Selected Response Constructed Response X Performance Observation	Read <input type="checkbox"/> Writing <input type="checkbox"/> Math <input type="checkbox"/> Tech. <input type="checkbox"/>	
MAN.0 3.03 ENG.06 .02	Perform an emergency shut down	Selected Response Constructed Response X Performance Observation	Read <input type="checkbox"/> Writing <input type="checkbox"/> Math <input type="checkbox"/> Tech. <input type="checkbox"/>	
ENG.06 .04	Describe CIM	X Selected Response X Constructed Response Performance Observation	Read <input type="checkbox"/> X Writing <input type="checkbox"/> Math <input type="checkbox"/> Tech. <input type="checkbox"/> <u>Writing:</u> Write informative/explanatory text to convey complex ideas, concepts, and information clearly and accurately through effective selection, organization and analysis of content.	
ENG.02 .09	Modify tool entry methods with w/ramping and helical	Selected Response Constructed	Read <input type="checkbox"/> Writing <input type="checkbox"/> Math <input type="checkbox"/> Tech. <input type="checkbox"/>	

			Response					
		X	Performance					
			Observation					
ENG.06 .04 MAN.0 3.03	Demonstrate the safe set up and operation of a CNC machine		Selected Response	Read	Writing	Math	Tech.	
			Constructed Response					
		X	Performance					
			Observation					

ADDITIONAL CONSIDERATIONS			
COMMON MISCONCEPTIONS	PRIOR KNOWLEDGE NEEDED TO MASTER STANDARDS FOR THIS UNIT	ADVANCED STANDARDS FOR STUDENTS WHO HAVE DEMONSTRATED PRIOR MASTERY	OPPORTUNITIES FOR STUDENT-DIRECTED LEARNING WITHIN THE UNIT
Students often think that what is designable in a CAD system is attainable in reality. This often leads students to design and create in a way that is not practical in the real world.	Students need to have gained the knowledge and understanding of the content and concepts in Unit 3 Toolpaths, CNC, and Machining Strategies		Utilizing the concepts and skills in this unit student have the opportunity to design and run programs on CNC routers and end mill that will satisfy real world problems.