

SkillsUSA 2015 Contest Projects

Automated Manufacturing Technology

Click the “Print this Section” button above to automatically print the specifications for this contest. Make sure your printer is turned on before pressing the button.

Skills ECO 2015

Using the geometry from the insert, make a cover. Allow .005 clearance for bosses and pockets per line (.010 for overall dimension). The cover will consist of 6 locator pins, and will sit on the out flange area of the insert.

2015 SKILLS USA CHAMPIONSHIP

AUTOMATED MANUFACTURING TECHNOLOGY COMPETITION

TEAM GUIDE

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Acknowledgments

The success of the competition is the result of the motivated contestants and their instructors, the determined efforts of the National and State Technical Committees, and the generosity of companies donating equipment. The following companies have contributed resources and support.

- | | |
|-------------------------------|---------------------------|
| Intelitek, Inc. | Rolla Technical Institute |
| AutoDesk, Inc. | SolidWorks |
| Calculated Industries | Learning Labs |
| CNC Software, Inc. | LS Starrett |
| River Valley Technical Center | CG Tech |
| MSC | Verisurf |
| 3Dconnexion Inc. | |

AMT Competition Technical Committee

The following individuals contributed their time and energy to the Technical Committee.

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Judges

The following individuals contributed their time and energy as Judges for the competition.

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National Educational Technical Committee

The following individuals contributed their time and energy to the National Educational Technical Committee.

Don Block, Chairperson

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Jon Morgan

South Central College
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Awards

The following companies have supplied awards:

Intelitek, Inc

3Dconnexion Inc.

CNC Software Inc.

MSC

SolidWorks

1: Contest Overview

1.1: Time Schedule for Contest

On the first day of competition teams will have a half day (approximately 5 hours) to complete a Virtual Part as defined by “Organizational Flow” Steps 2.11.1 to 2.11.4. The top 5 teams for secondary, and the top 5 teams for post-secondary, as selected by the judges will return for the second day to complete Steps 2.11.5 to 2.11.7 working on the Benchmill 6000 CNC Machine to manufacture the final part.

1.2: Cutting-edge Technology

Current advances in manufacturing technologies such as CAD, CAM, and CNC, have allowed the United States to remain competitive within the global market. To compete in this evolving field, companies worldwide must remain at the forefront of both current and emerging technologies in design and manufacturing. With today's complex design and manufacturing challenges, no individual is equipped with all the answers, so it is imperative for manufacturers to combine the resources and abilities of a team to resolve problems.

1.3: Your Team

Success in Automated Manufacturing is often found using a team approach. In the interest of emulating industry, this competition will be structured in this manner. Proving of part design in a “Virtual CNC Machine” is an industry cost savings process. For optimum team efficiency, we suggest your team be comprised of a specialist in each of the following fields:

- Computer Aided Design (CAD)
- Computer Aided Manufacturing (CAM)
- Computer Numeric Control (CNC)

1.4: Cost Reduction

Rapid Prototyping and Concurrent Engineering are two of the most efficient methods used by industry to reduce the time and cost of bringing a new product from concept to market. Rapid Prototyping is simply the development of a prototype as quickly as possible. Concurrent Engineering is the pairing of the designer with the manufacturer to simultaneously work on the design of the product throughout the development of the product in its entirety.

1.1: Statement of the Problem

1.1.1: The Client's Needs

D&J Industries, Incorporated (hereafter referred to as The Client) is dissatisfied with its old supplier. They used manual machines causing the part signatures to have an unacceptable variance, their quotations were inaccurate, and their lead-time was unacceptable.

It is critically important that The Client locate a firm able to rapid prototype and meet engineering changes at any point of the prototyping process. The Client wishes to find the best shop to have the part(s) prototyped and manufactured.

As an Automated Manufacturing Technology team, known as Pro Design, Incorporated, your company will be competing for this lucrative contract against several other firms.

1.1.2: Your Assignment

Pro Design has been presented with a sample part drawing that the Client wishes to have mass produced. Your team will need to prototype the part(s), incorporate any changes that the client might make, then manufacture the final product.

Pro Design's Team Leader is responsible for communication between your company and D&J Industries, Incorporated.

1.2: Instructions

1.2.1: Rapid Prototype

The Client is a manufacturing plant that needs a new product designed and created. Currently, the only information they can supply is a rough concept and drawing. The prototype material (Ren board-440) will be provided by the client. Your team's job is to machine this prototype.

The Client requires that each stage of the CAD/CAM/CNC process be well documented, including a properly dimensioned CAD print for each of the components. All drawings should meet proper guidelines for engineering drawings.

After your prototype has been "virtually" cut and has passed your internal quality control, you will submit it to The Client's Quality Assurance Group. The Client has specified accuracy, finish, and the turn-around-time it takes to complete the process.

1.2.2: Concurrent Engineering

The Client will review the prototype and may require one or more changes. The Client requires quick updates to product design throughout the development process. Significant issues in this stage are The Client's specified dimensional accuracy, finish, and efficiency in part programming.

1.3: Guidelines

1.3.1: Requirements

The Client's Engineering Project Manager has provided an outline of materials to begin your planning and manufacturing process. Your success on this project is based upon the following criteria:

1. Provide complete documentation of your design.
2. Provide complete documentation of process plan, tooling and setup.
3. Provide Quality Assurance on all parts.
4. Use the technology in preparation of documentation, setups, design, and machining properly.
5. Package completed project with accompanying documentation in an orderly, professional presentation.
6. Use team work in project management effectively.
7. Take safety precautions in the manufacturing process.
8. Use time, materials, and resources effectively.

1.4: QA and Design Restrictions

1.4.1: Tolerances

:

1. Hole Locations = + OR - .005"
2. Hole Diameter = + OR - .003" on finished holes
3. Slot Dimension = + OR - .005"
4. Hole Depths = + OR - .010"
5. Slot and Shoulder Locations = + OR - .010"

1.5: Team Guidelines

1.5.1: Production Guidelines

Your team should follow these guidelines:

1. Primary responsibilities and duties are organized.
2. A team leader is identified to interact with Technical Committee representatives.
3. Your team decides upon appropriate break times with the exception of the mandatory lunch break.
4. Breaks are to be taken within assigned individual work areas.
5. Team members must notify a Technical Committee representative before taking a bathroom break. Only one team member is allowed to leave the contest area at a time.
6. You must create a separate file of your CAD drawing on your CAD computer and transfer it to your CAM computer via USB memory stick.

1.5.2: Equipment Malfunctions

IN THE CASE OF A MACHINE FAILURE: The team leader will communicate the problem to a representative of the Technical Committee. The representative will then notify the Project Manager.

If it is determined that it is in fact a machine problem, the running time clock may be stopped for that team. In the case of a stopped time clock, all work will stop for the entire team until the problem is resolved.

IN THE CASE OF SOFTWARE PROBLEMS: The choice of CAD and CAM software is the responsibility of the team. All software must be original copies. If your team develops a problem with your software, the Technical Committee will work in whatever way it can to resolve the problem but the clock will not be stopped.

2: Official Competition

2.1: History

This competition is officially sanctioned by SkillsUSA and has run continuously since 1994. This competition is unique due to its three-member team concept and the intensive use of hardware and software.

2.1: Purpose

2.1.1: Goals of the Competition

To evaluate each contestant's preparation for employment in automated manufacturing and the team approach to problem solving in the work environment. To recognize outstanding students for excellence and professionalism in the field of automated manufacturing technology.

2.2: Clothing Requirement

2.2.1: Correct Attire

- official khaki work shirt
- official khaki work pants
- black or brown leather work shoes
- safety glasses with side shields or goggles (prescription glasses must be covered with goggles unless they are equipped with side shields)

To purchase official work clothing, contact Midwest Trophy Manufacturing Co., Inc. by calling 1-800-324-5996 or order online at: <http://www.mwtrophy.com/>.

2.3: Eligibility

2.3.1: Qualifications

This competition is open to active SkillsUSA members enrolled in programs with precision machining, automated manufacturing, or CAD/CAM or CNC as their occupational objective.

2.4: Scope of Contest

2.4.1: Teams and Documentation

1. Teams MUST be composed of three members. Teams will demonstrate their ability to perform, utilize skills and knowledge necessary to complete the project as presented to them by the Technical Committee.
2. Your team is presented with a dimensioned drawing(s) of a part(s) to prototype. When you finish "Virtual" machining the prototype part(s) you will present it to The Client (judges). The top five (5 from secondary and 5 from post-secondary) teams will move on to the second day. At this time you will be presented with a new drawing(s); either a change order or an additional part(s) request. Proceed to machine final product.
3. Each team will be issued a notebook. This will include all of the necessary information and forms to complete the project. These forms will not be highly specific but will coach the teams. All forms and drawings must be turned in to the judges at the end of the competition.

2.4.2: Required Competencies

Successful competitors possess the following skills:

- A. Mathematics and Measurement
 1. Measure to the nearest .001 inch
 2. Calculate CNC speed and feeds
 3. Calculate stock utilization and setup
 4. Calculate tolerances
 5. Estimate costs and material usage and write an evaluation
- B. Designing, Sketching, Planning
 1. Translate information from drawing to CAD
 2. Create CAD file for manufacturing
 3. Manufacturing documentation
 4. Process plan
 5. Plot CAD file
 6. Export CAD file
 7. Process Engineering Change Orders (ECOs)
- C. Create Toolpath (CAM file), CNC Code
 1. Create Process/Job Plan
 2. Read-in CAD export file
 3. Create toolpath
 4. Verify toolpath
 5. Create CNC code
 6. Send CNC code to machine tool
 7. Process ECO
- D. Perform CNC Machining Functions
 1. Verify CNC file
 2. Verify toolpath
 3. Setup part blank on mill
 4. Set all offsets and tooling
 5. Adjust speeds and feeds as needed
 6. In-process Quality Assurance
 7. Perform tool changes
 8. Perform multiple machining operations in one setup
 9. Verify (TQM) process and part
 10. Process
- E. Inspect Part TQM Process
 1. Verify part to standards
 2. Verify part to ECO standards
 3. Document process
- F. Safety

1. Follow proper safety procedures in a general industrial workplace environment.
 2. Follow proper safety procedures in running and programming a CNC Machine tool.
- G. Quotation
1. Take a written evaluation that measures ability to solve various solutions to the process that is involved to quoting a job in a rapid prototyping environment.

2.5: Group Organizational Goal

2.5.1: Team Dynamics

The competition should run much like you would expect from industry; with group members interacting at will. The CAD operator will construct the part geometry, the CAM operator will generate the toolpaths, and the CNC operator will do the setup and machine the part.

The contest is designed to promote creativity in organization of production responsibility. Teams should divide duties among all team members. No one individual should dominate by taking responsibility for more than one project specialty. When a team member has spare time, they will help their teammates. All Team members are responsible for double-checking each other's work and quality control.

2.6: General Information

2.6.1: Necessities

The following items are required to compete in this contest:

1. Intelitek CNCMotion **Virtual Software** will be provided. (Virtual CNC Machine)
2. Intelitek's Benchmill 6000 series CNC milling machines and tooling will be provided.
3. Teams must provide two computers, one of which must accept an Ethernet connection.
4. Each team will have licensed versions of CAD/CAM software.
5. Each team will provide a 6" dial or digital Vernier caliper. Dial indicator (i.e. Starrett Last Word Dial Test Indicator, must have 3/8" holding shank), a calculator, a set of 3/4" and/or 1" parallels (or a complete set), 6" or 12" steel rule and a soft face hammer.
6. Teams must consist of 3 members.
7. The Prototype and the finished part will be machined in a prototype material.
8. Each team can provide 3/8 edge finder.
9. Each team can provide a set of parallels.
10. Each team can provide appropriate sized end mills.
11. Each team must provide a machinist handbook.
12. Each team must provide USB Memory Device (thumb drive) for file transfer.

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2.7: Goals

2.7.1: Team Objectives

1. To have every team complete the competition.
2. To have each team member demonstrate reading and writing skills.
3. To have each team member use their critical thinking and problem solving abilities in the contest.
4. To have each team member illustrate responsibility, teamwork, self-management skills, and professionalism.

2.8: Notebook

2.8.1: Supplied Documentation

Each team is issued this notebook and information packet. This will allow the team to display a plot or print of their operation. Required documentation is also included.

2.9: Required Materials

2.9.1: Workstation Components

Teams require the following materials to complete the competition. The Technical Committee provides many of these materials, but the teams must also bring certain items.

AMT Technical Committee provides:

Intelitek's Benchmill 6000 CNC Machining Center with:

- Machinist vise
- Hold-downs and clamps
- Tool holders

Part(s) design.

Competition notebook.

Pencils.

Prototype Material for machining.

Information and furnishings for judges and technical committee.

2.9.2: Team Provided Components

Teams provide:

Two computers:

- One computer loaded with CAD software for CAD program.
- One computer loaded with software for CAM program. This computer MUST have an open LAN Port (Ethernet connection) and Windows XP SP3 / Vista / 7 - 32 or 64bit.

Licensed versions of the above CAD and CAM software must be available at start of the orientation for loading onto the technical committee's computer(s).

One six inch dial or digital vernier caliper.

One dial indicator (example: L.S. Starrett Last Word dial test indicator) Dial indicator MUST have 3/8" holding shank to fit into tool holder supplied by Technical Committee.

One calculator.

One pair of 3/4" and/or 1" parallels (or a complete set).

One soft-face hammer

One 6" or 12" steel rule.

Each team can provide 3/8 edge finder.

Each team must provide a machinist handbook.

Each team can provide appropriate size end mills.

Each team must provide a USB memory device.

Note: ONLY the above listed items will be allowed in the contest area during the competition.

2.10: Division of Duties

2.10.1: Department Contributions

CAD Department

Stage 1, Rapid Prototype
Original print
CAD dimensioned views necessary to detail part completely

Stage 2, Finish Part Production
Change order
CAD dimensioned print (views necessary to detail part completely) and pictorial view

CAD Engineer

All CAD system import and export
Creating part geometry
Exporting necessary geometry to CAM system
Dimensioning parts
Plots
Receive change order
Communication of changes to team
Update all CAD files
All drawings should meet guidelines for engineering drawings

CAM Department

Stage 1, Rapid Prototype
Process documentation to include selection of tools, machining order, etc.
Generate NC code

Stage 2, Finish Part Production
Develop new process plan
Program new toolpath
Generate NC code

CAM Engineer

All CAM system input and output
Importing CAD geometry
Creating tool paths
Process sequencing
Tool selection
Creating NC code

CNC Department

Stage 1, Rapid Prototype
Fixturing description
Tool description
Tool setup

Fixture and set-up
Stage 2, Finish Part Production
Finish ECO part production

CNC Engineer

All CNC setup and operation
CNC control software input
Fixturing stock, tool offsets

Quality Control Department

Stage 1, Rapid Prototype
Part inspection sheet, all team members sign-off
All members check positions, tolerances, etc.

Stage 2, Finish Part Production
Part inspection sheet, all members sign
All members double-check work, clean-up

Quality Control

All Members

2.11: Suggested Organizational Flow

2.11: Suggested Organizational Flow (Half Day Sessions)

(Steps 2.11.1 to 2.11.4 to be performed in a half day (approx. 5 hrs.)

2.11.1: RECEIVE THE PART DRAWING

- A. CAD operator confers with the CAM operator and draws only what is necessary for the CAM operator to program a toolpath. Once that drawing is ready, the drawing is transferred to the CAM operator.
- B. CAM operator, after consulting with the CAD operator, consults with the CNC operator and fills out the Job Process Plan, defining machining order, tool paths, tool definitions and sequencing.
- C. CNC operator sets up the Virtual CNC Machine and the CNC operator confers with the CAM operator on tool definition and sequencing. The CNC operator virtually sets and mounts selected tools in holders and sets tool length offsets in the CNC control software. The CNC operator then sketches the fixture.

2.11.2: CAD OPERATOR TRANSFERS FILE TO CAM

- A. CAD operator copies the CAM transfer file to USB Memory device to be transferred to the CAM operator, then begins work on documenting the part with all necessary views.
- B. CAM operator transfers in the CAD file and double checks against the supplied drawing. The CAM operator begins programming tool paths and, if necessary, documents any changes to the Job Process Plan.
- C. CNC operator helps either the CAD or CAM operator, staying aware of CAM toolpath sequencing and tool changes. CNC operator could also study part for most efficient tool paths.

2.11.3: TRANSFER OF NC-CODE TO "VIRTUAL" CNC MACHINE

- A. CAD operator continues to document part and prints the dimensioned CAD drawing.
- B. CAM operator transfers NC-Code to the CNC operator.
- C. CNC operator loads the program, runs a simulation, Virtual CNC. (sets the touch off point, and then runs the program in Virtual CNC.)

2.11.4: "VIRTUAL" PROTOTYPE COMPLETE, QUALITY CONTROL

- A. Each team member inspects the virtual part and fills out inspection sheet. If errors are found, they are documented and the "virtual" part "observed/judged" and is submitted for participation in 2.11.6.

(Steps 2.11.5 and 2.11.7 to be performed from on the second day)

TOP FIVE (5 secondary and 5 post-secondary) TEAMS Qualify to move on to Steps 2.11.5, 2.11.6 and 2.11.7

2.11.5: same as above 2.11.1-2.11.3

2.11.6: MANUFACTURE FINISHED PART ON CNC MACHINE

- A. CAD operator completes all part documentation and hard copies.
- B. CAM operator assembles part documentation booklet and assists CAD and CNC operators.
- C. CNC operator manufactures and inspects part.

2.11.7: QUALITY CONTROL AND FINAL HAND-IN

- A. CAD, CAM, and CNC operators complete part inspection, documentation, and work area cleanup.

3: Safety

3.1: Importance of Safety

To maintain an effective and competitive company, it is in the best interest of both employer and employee to maintain a safe work environment. When a company's history of incidents resulting in injury is minimal, the company increases its likelihood of reduced insurance rates and workman compensation fees.

Safety considerations are taken into account during judging to further replicate a professional industrial environment.

3.2: Safety Violations

If a team or a team member violates a safety rule, or operates their work cell in an unsafe manner, the following penalties will be enforced:

1st Violation:

Team will be issued a written warning.

2nd Violation

Team will have 50 points deducted from their total score.

3rd Violation

Team will be disqualified.

3.3: Avoiding Safety Hazards

Some safety issues:

1. Team members must keep their work area reasonably clean. Clean work places promote efficient and safe working conditions.
2. Team members must keep their teammates and other teams aware of possible dangerous situations, such as flying chips, noise, possible tool breakage, etc.
3. Safety guards must be in place and properly interlocked during machining and when the spindle is turning.
4. Team members must wear safety glasses when they are in the proximity of the machine during setup as well as during machining.
5. Spindle must NOT be in motion during a tool change.
6. Tampering with or dismantling of any part of the supporting equipment (ie: computers, printers, ect.) is a direct safety violation, and can be grounds for immediate disqualification.

4: Additional Forms

4.1: Document Submission

The following documentation must be prepared by teams for judging. These sheets are included on the following pages of this team information packet:

- Notebook Judging Form
- Process Plan
- Fixturing Description
- Quality Assurance
- Mathematics Problem

4.2: Judge Prepared Documentation

Judges will prepare the following documentation for each team:

- CAD Evaluation
- Interview/Test
- Hand-In Time Run
- Concurrent Engineering CAD Evaluation
- Area Clean-Up
- Safety Violations (if applicable)

SKILLS USA
AUTOMATED MANUFACTURING TECHNOLOGY
NOTEBOOK JUDGING FORM 2015

	MAXIMUM POINTS	CHECK	POINTS AWARDED
CAD Rapid Prototype			
1. Dimensioned Print of Prototype, Hardcopy (top and front views)	170		
2. Prototype Contest Drawing	25		
CAD Subtotal	195		
CAM Rapid Prototype			
1. Process Plan Form	100		
CAM Subtotal	100		
CNC Rapid Prototype			
1. Fixturing Description Form	80		
2. Quality Assurance Form	50		
3. Interview/Test	150		
4. Hand-In-Time	100		
CNC Subtotal	380		
Concurrent Engineering			
1. CAD Drawing (top, front, side & pictorial), Hard Copy	100		
2. Engineering Change Order Drawing	25		
3. Process Plan Form	75		
4. Area Clean-up	75		
Concurrent Engineering Subtotal	275		
Math Problem	50		
Safety (deductions)			
GRAND Total	1000 pts		

AUTOMATED MANUFACTURING TECHNOLOGY

PROCESS PLAN

TEAM NUMBER _____ CUSTOMER _____

COMPLETED BY _____

DATE _____ PART DUE DATE _____

PART NAME _____

PART NUMBER _____ CNC MACHINE _____

BLANK SIZE _____ MATERIAL _____

Operation #	Operation Description	Tool #	Tool Description	Spindle Speed	Feed Rate	Plunge Rate

NOTES _____

Possible Pts. 100

Total _____

Team # _____

AUTOMATED MANUFACTURING TECHNOLOGY

FIXTURING DESCRIPTION

TEAM NUMBER _____ CUSTOMER _____

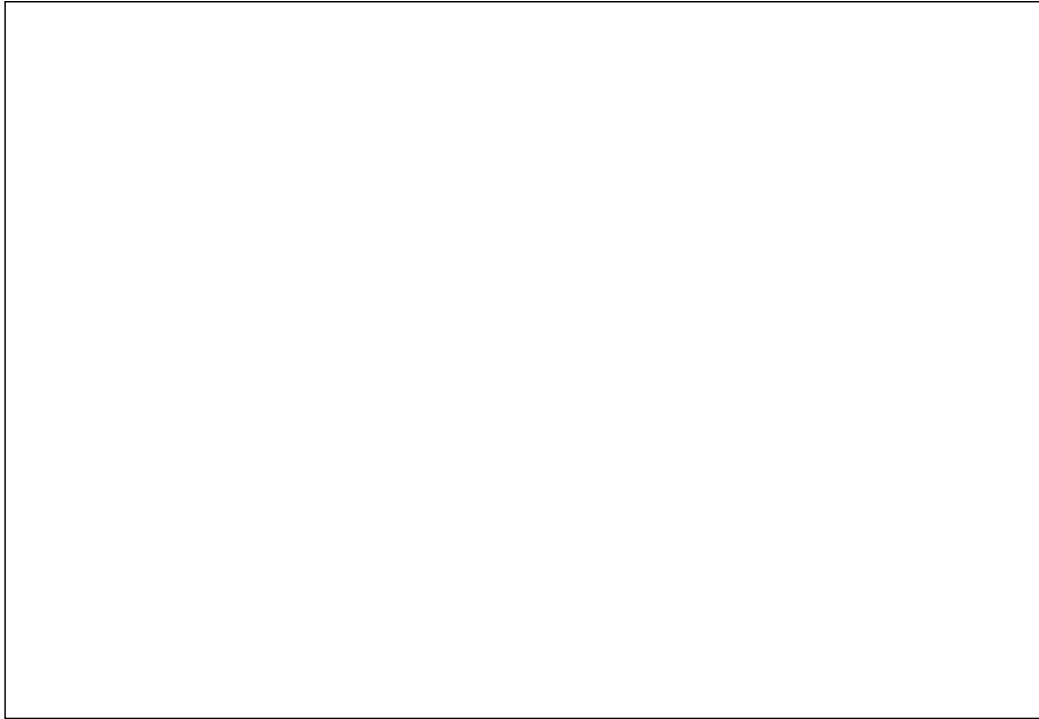
DRAWN BY _____

DATE _____ PART DUE DATE _____

PART NAME _____

PART NUMBER _____

SKETCH FIXTURE WITH TOOL TOUCH-OFF INDICATED



Possible Pts. 80

Total _____

Team # _____

AUTOMATED MANUFACTURING TECHNOLOGY

QUALITY ASSURANCE FORM

TEAM NUMBER _____ CUSTOMER _____

COMPLETED BY _____

DATE _____ PART DUE DATE _____

PART NAME _____

PART NUMBER _____ CNC MACHINE _____

BLANK SIZE _____ MATERIAL _____

Object #	Object Description	Defined Tolerance	Dimension Margin	
			High	Low

Identify errors on picture

NOTES _____

Signature

Signature

Signature

Possible Pts. 50

Total _____
Team# _____

**AUTOMATED MANUFACTURING TECHNOLOGY
CONCURRENT ENGINEERING
PROCESS PLAN**

TEAM NUMBER _____ CUSTOMER _____

COMPLETED BY _____

DATE _____ PART DUE DATE _____

PART NAME _____

PART NUMBER _____ CNC MACHINE _____

BLANK SIZE _____ MATERIAL _____

Operation #	Operation Description	Tool #	Tool Description	Spindle Speed	Feed Rate	Plunge Rate

Possible Pts. 75

Total _____

Team # _____

Automated Manufacturing Technology

Math Problem Day 1

2015

Your R&D department at Golden Design Group, has been asked to provide a prototype production run of a component as designed by the client, Chicago Acoustic. A rapid response is essential to capture new business. The client requires that you provide a total of 6 prototypes of the Component. These will be shipped in equal quantities to 3 testing labs for final inspection and testing.

The prototype component has 3 pieces. The component consists of a Top and a Bottom with an Insert.

The raw stock measurements are:

Material block 1 Piece: 2.2" x 2.5" x 1"

Material block 2 Pieces: 6.5" x 5.5" x 1.25".

The complete prototype will be made of Ren Board-440. The Ren Board is supplied in standard sheets measuring 18" x 18" x 1.5". The machine overhead rate is assumed to cost \$90.00 per hour. It is estimated to take 20 minutes to make one prototype. Each prototype has a material cost of \$7.50. The "Additional" cost to assemble, package, and ship each set is \$9.00.

Please answer the following questions. When answering DO NOT allow for waste material from the saw blade used to cut the parts to size. Each question is worth 5 points. TOTAL 50 Points.

NOTE: This math problem is similar too but does not resemble the exact dimensions of your prototype parts, made in the AMT competition.

1. What is the total cost of one complete prototype, manufactured, assembled and shipped? _____
2. How many prototypes will ship to each testing lab? _____
3. Calculate the machine operation time to make all prototypes? _____
4. Calculate the material cost to manufacture all prototypes? _____
5. Calculate the machine overhead cost for one Prototype. _____
6. Calculate the area (square inches) of Ren Board in a standard sheet? _____
7. How many prototypes are required to complete the order for the client? _____
8. Calculate how much more each prototype will cost if machine overhead was \$120 per hour? _____
9. Calculate the total cost savings if the "Additional" cost of \$9.00 was cut to \$7.00? _____
10. Calculate the volume (cubic inches) of Ren Board in a standard sheet? _____

NOTE: Round your answer up to a two place decimal.

Automated Manufacturing Technology

Math Problem Day 1

2015

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Please answer the following questions. When answering DO NOT allow for waste material from the saw blade used to cut the parts to size. Each question is worth 5 points. TOTAL 50 Points.

NOTE: This math problem is similar too but does not resemble the exact dimensions of your prototype parts, made in the AMT competition.

1. What is the total cost of one complete prototype, manufactured, assembled and shipped? _____
2. How many prototypes will ship to each testing lab? _____
3. Calculate the machine operation time to make all prototypes? _____
4. Calculate the material cost to manufacture all prototypes? _____
5. Calculate the machine overhead cost for one Prototype. _____
6. Calculate the area (square inches) of Ren Board in a standard sheet? _____
7. How many prototypes are required to complete the order for the client? _____
8. Calculate how much more each prototype will cost if machine overhead was \$120 per hour? _____
9. Calculate the total cost savings if the "Additional" cost of \$9.00 was cut to \$7.00? _____
10. Calculate the volume (cubic inches) of Ren Board in a standard sheet? _____

NOTE: Round your answer up to a two place decimal.

Automated Manufacturing Technology

Math Problem Day 1

ANSWER KEY

2015

Q1. \$46.50 ($\$30 + \$7.50 + \9.00)

Q2. 2 prototypes for each testing lab (6 Prototypes going equally to 3 labs).

Q3. 2 Hours ($6 \times 20 \text{ mins.} = 120 \text{ Mins OR } 2 \text{ Hrs.}$)

Q4. \$45.00 ($6 \times \7.50)

Q5. \$30.00 ($\$90/\text{hr}$ divided by 3) (20 Mins. per prototype = $1/3$ Hour)

Q6. 324 square inches ($18'' \times 18''$)

Q7. 6 Prototypes.

Q8. \$10.00 (at \$120 per hour each prototype is \$40. Original cost \$30. Therefore \$10 additional cost per prototype).

Q9. \$12 (If "Additional Cost" is cut to \$7 from \$9. Total savings for 6 prototypes is $6 \times \$2 = \12).

Q10. 486 Cubic Inches ($18'' \times 18'' \times 1.5'' = 486 \text{ cubic inches}$).

NOTE: Round up all dimensions to a two place decimal

2015 SKILLS USA CHAMPIONSHIP

AUTOMATED MANUFACTURING TECHNOLOGY COMPETITION

TEAM GUIDE

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Acknowledgments

The success of the competition is the result of the motivated contestants and their instructors, the determined efforts of the National and State Technical Committees, and the generosity of companies donating equipment. The following companies have contributed resources and support.

- | | |
|-------------------------------|---------------------------|
| Intelitek, Inc. | Rolla Technical Institute |
| AutoDesk, Inc. | SolidWorks |
| CNC Software, Inc. | Learning Labs |
| Calculated Industries | LS Starrett |
| River Valley Technical Center | Verisurf |
| MSC | CG Tech |
| 3Dconnexion Inc. | |

AMT Competition Technical Committee

The following individuals contributed their time and energy to the Technical Committee.

Richard McManus Aztech Educational Resources	Rick Knisely Aztech Educational Resources
Jeff Stone Intelitek	Alex Taliadouros Intelitek
Dan Newby CNC Software	Robert Clarke Intelitek
Richard Walker National Tooling & Machining Assoc.	Dustin Spieth CNC Software

Judges

The following individuals contributed their time and energy as Judges for the competition.

Rick Knisely
Aztech Educational Resources

Dan Newby
CNC Software

Ray Ellege
Verisurf

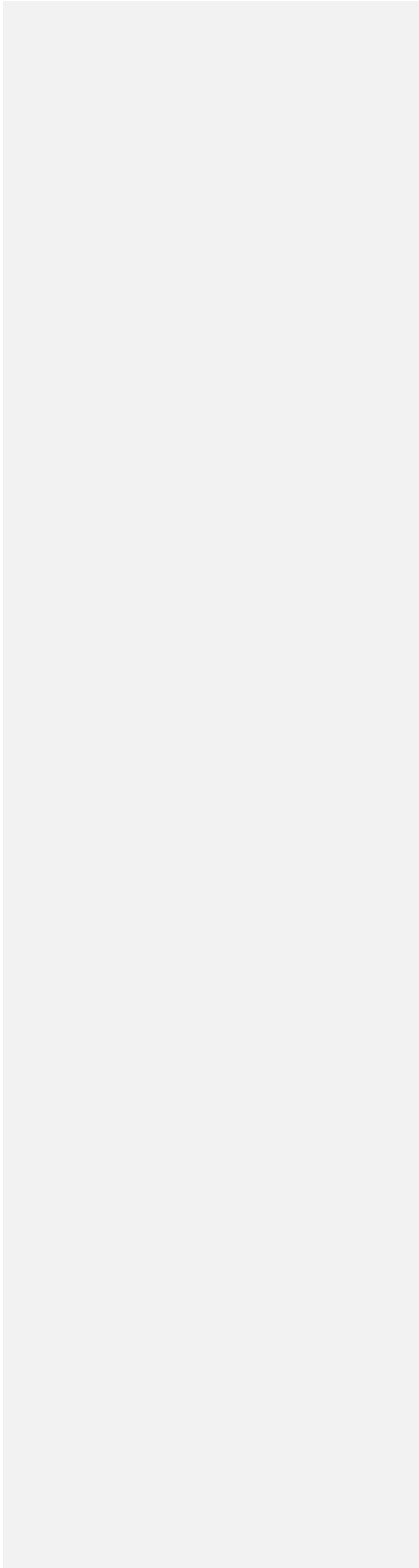
Mike McDonald
CG Tech

Sheldon Richardson
Learning Labs

Steve Bardonner
Ivy Technical Community College

Ben Richardson
Learning Labs

Dustin Spieth
CNC Software



National Educational Technical Committee

The following individuals contributed their time and energy to the National Educational Technical Committee.

Don Block, Chairperson Rolla Technical Institute	Jeffrey Fisher South Central Technical College
Samuel Dolson Manteca High School	George Skena Old Dominion University
Rick Huddleston Tulsa Technology Center	Jon Morgan South Central College

Awards

The following companies have supplied awards:

- Intelitek, Inc
- Solidworks
- CNC Software Inc.
- 3Dconnexion Inc.
- MSC

1: Contest Overview

1.1: Time Schedule for Contest

On the first day of competition teams will have a half day (approximately 5 hours) to complete a Virtual Part as defined by “Organizational Flow” Steps 2.11.1 to 2.11.4. The top 5 teams for secondary, and the top 5 teams for post-secondary as selected by the judges will return for the second day to complete Steps 2.11.5 to 2.11.7 working on the Benchmill 6000 CNC Machine to manufacture the final part.

1.2: Cutting-edge Technology

Current advances in manufacturing technologies such as CAD, CAM, and CNC, have allowed the United States to remain competitive within the global market. To compete in this evolving field, companies worldwide must remain at the forefront of both current and emerging technologies in design and manufacturing. With today's complex design and manufacturing challenges, no individual is equipped with all the answers, so it is imperative for manufacturers to combine the resources and abilities of a team to resolve problems.

1.3: Your Team

Success in Automated Manufacturing is often found using a team approach. In the interest of emulating industry, this competition will be structured in this manner. Proving of part design in a “Virtual CNC Machine” is an industry cost savings process. For optimum team efficiency, we suggest your team be comprised of a specialist in each of the following fields:

- Computer Aided Design (CAD)
- Computer Aided Manufacturing (CAM)
- Computer Numeric Control (CNC)

1.4: Cost Reduction

Rapid Prototyping and Concurrent Engineering are two of the most efficient methods used by industry to reduce the time and cost of bringing a new product from concept to market. Rapid Prototyping is simply the development of a prototype as quickly as possible. Concurrent Engineering is the pairing of the designer with the manufacturer to simultaneously work on the design of the product throughout the development of the product in its entirety.

1.1: Statement of the Problem

1.1.1: The Client's Needs

D&J Industries, Incorporated (hereafter referred to as The Client) is dissatisfied with its old supplier. They used manual machines causing the part signatures to have an unacceptable variance, their quotations were inaccurate, and their lead-time was unacceptable.

It is critically important that The Client locate a firm able to rapid prototype and meet engineering changes at any point of the prototyping process. The Client wishes to find the best shop to have the part(s) prototyped and manufactured.

As an Automated Manufacturing Technology team, known as Pro Design, Incorporated, your company will be competing for this lucrative contract against several other firms.

1.1.2: Your Assignment

Pro Design has been presented with a sample part drawing that the Client wishes to have mass produced. Your team will need to prototype the part(s), incorporate any changes that the client might make, then manufacture the final product.

Pro Design's Team Leader is responsible for communication between your company and D&J Industries, Incorporated.

1.2: Instructions

1.2.1: Rapid Prototype

The Client is a manufacturing plant that needs a new product designed and created. Currently, the only information they can supply is a rough concept and drawing. The prototype material (Ren board-440) will be provided by the client. Your team's job is to machine this assembly prototype.

The Client requires that each stage of the CAD/CAM/CNC process be well documented, including a properly dimensioned CAD print for each of the components. All drawings should meet proper guidelines for engineering drawings.

After your prototype has been cut and has passed your internal quality control, you will submit it to The Client's Quality Assurance Group. The Client has specified accuracy, finish, and the turn-around-time it takes to complete the process.

1.2.2: Concurrent Engineering

The Client will review the prototype and may require one or more changes. The Client requires quick updates to product design throughout the development process. Significant issues in this stage are The Client's specified dimensional accuracy, finish, and efficiency in part programming.

1.3: Guidelines

1.3.1: Requirements

The Client's Engineering Project Manager has provided an outline of materials to begin your planning and manufacturing process. Your success on this project is based upon the following criteria:

1. Provide complete documentation of your design.
2. Provide complete documentation of process plan, tooling and setup.
3. Provide Quality Assurance on all parts.
4. Use the technology in preparation of documentation, setups, design, and machining properly.
5. Package completed project with accompanying documentation in an orderly, professional presentation.
6. Use team work in project management effectively.
7. Take safety precautions in the manufacturing process.
8. Use time, materials, and resources effectively.

1.4: QA and Design Restrictions

1.4.1: Tolerances

1. Hole Locations = + OR - .005"
2. Hole Diameter = + OR - .003" on finished holes
3. Slot Dimension = + OR - .005"
4. Hole Depths = + OR - .010"
5. Slot and Shoulder Locations = + OR - .010"

1.5: Team Guidelines

1.5.1: Production Guidelines

Your team should follow these guidelines:

1. Primary responsibilities and duties are organized.
2. A team leader is identified to interact with Technical Committee representatives.
3. Your team decides upon appropriate break times with the exception of the mandatory lunch break.
4. Breaks are to be taken within assigned individual work areas.
5. Team members must notify a Technical Committee representative before taking a bathroom break. Only one team member is allowed to leave the contest area at a time.
6. You must create a separate file of your CAD drawing on your CAD computer and transfer it to your CAM computer via USB memory stick.

1.5.2: Equipment Malfunctions

IN THE CASE OF A MACHINE FAILURE: The team leader will communicate the problem to a representative of the Technical Committee. The representative will then notify the Project Manager.

If it is determined that it is in fact a machine problem, the running time clock may be stopped for that team. In the case of a stopped time clock, all work will stop for the entire team until the problem is resolved.

IN THE CASE OF SOFTWARE PROBLEMS: The choice of CAD and CAM software is the responsibility of the team. All software must be original copies. If your team develops a problem with your software, the Technical Committee will work in whatever way it can to resolve the problem but the clock will not be stopped.

2: Official Competition

2.1: History

This competition is officially sanctioned by SkillsUSA and has run continuously since 1994. This competition is unique due to its three-member team concept and the intensive use of hardware and software.

2.1: Purpose

2.1.1: Goals of the Competition

To evaluate each contestant's preparation for employment in automated manufacturing and the team approach to problem solving in the work environment. To recognize outstanding students for excellence and professionalism in the field of automated manufacturing technology.

2.2: Clothing Requirement

2.2.1: Correct Attire

- official khaki work shirt
- official khaki work pants
- black or brown leather work shoes
- safety glasses with side shields or goggles (prescription glasses must be covered with goggles unless they are equipped with side shields)

To purchase official work clothing, contact Midwest Trophy Manufacturing Co., Inc. by calling 1-800-324-5996 or order online at: <http://www.mwtrophy.com/>.

2.3: Eligibility

2.3.1: Qualifications

This competition is open to active SkillsUSA members enrolled in programs with precision machining, automated manufacturing, or CAD/CAM or CNC as their occupational objective.

2.4: Scope of Contest

2.4.1: Teams and Documentation

1. Teams MUST be composed of three members. Teams will demonstrate their ability to perform, utilize skills and knowledge necessary to complete the project as presented to them by the Technical Committee.
2. Your team is presented with a dimensioned drawing(s) of a part(s) to prototype. When you finish machining the prototype part(s) you will present it to The Client (judges). Proceed to machine final product.
3. Each team will be issued a notebook. This will include all of the necessary information and forms to complete the project. These forms will not be highly specific but will coach the teams. All forms and drawings must be turned in to the judges at the end of the competition.

2.4.2: Required Competencies

Successful competitors possess the following skills:

- A. Mathematics and Measurement
 1. Measure to the nearest .001 inch
 2. Calculate CNC speed and feeds
 3. Calculate stock utilization and setup
 4. Calculate tolerances
 5. Estimate costs and material usage and write an evaluation
- B. Designing, Sketching, Planning
 1. Translate information from drawing to CAD
 2. Create CAD file for manufacturing
 3. Manufacturing documentation
 4. Process plan
 5. Plot CAD file
 6. Export CAD file
 7. Process Engineering Change Orders (ECOs)
- C. Create Toolpath (CAM file), CNC Code
 1. Create Process/Job Plan
 2. Read-in CAD export file
 3. Create toolpath
 4. Verify toolpath
 5. Create CNC code
 6. Send CNC code to machine tool
 7. Process ECO
- D. Perform CNC Machining Functions
 1. Verify CNC file
 2. Verify toolpath
 3. Setup part blank on mill
 4. Set all offsets and tooling
 5. Adjust speeds and feeds as needed
 6. In-process Quality Assurance
 7. Perform tool changes
 8. Perform multiple machining operations in one setup
 9. Verify (TQM) process and part
- 10. Process
- E. Inspect Part TQM Process
 1. Verify part to standards
 2. Verify part to ECO standards
 3. Document process
- F. Safety

1. Follow proper safety procedures in a general industrial workplace environment.
 2. Follow proper safety procedures in running and programming a CNC Machine tool.
- G. Quotation
1. Take a written evaluation that measures ability to solve various solutions to the process that is involved to quoting a job in a rapid prototyping environment.

2.5: Group Organizational Goal

2.5.1: Team Dynamics

The competition should run much like you would expect from industry; with group members interacting at will. The CAD operator will construct the part geometry, the CAM operator will generate the toolpaths, and the CNC operator will do the setup and machine the part.

The contest is designed to promote creativity in organization of production responsibility. Teams should divide duties among all team members. No one individual should dominate by taking responsibility for more than one project specialty. When a team member has spare time, they will help their teammates. All Team members are responsible for double-checking each other's work and quality control.

2.6: General Information

2.6.1: Necessities

The following items are required to compete in this contest:

1. Intelitek CNCMotion **Virtual Software** will be provided. (Virtual CNC Machine)
2. Intelitek's Benchmill 6000 series CNC milling machines and tooling will be provided.
3. Teams must provide two computers, one of which must accept an Ethernet connection.
4. Each team will have licensed versions of CAD/CAM software.
5. Each team will provide a 6" dial or digital Vernier caliper. Dial indicator (i.e. Starrett Last Word Dial Test Indicator, must have 3/8" holding shank), a calculator, a set of 3/4" and/or 1" parallels (or a complete set), 6" or 12" steel rule and a soft face hammer.
6. Teams must consist of 3 members.
7. The Prototype and the finished part will be machined in a prototype material.
8. Each team can provide 3/8 edge finder.
9. Each team can provide a set of parallels.
10. Each team can provide appropriate sized end mills.
11. Each team must provide a machinist handbook.
12. Each team must provide USB Memory Device (thumb drive) for file transfer.

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2.7: Goals

2.7.1: Team Objectives

1. To have every team complete the competition.
2. To have each team member demonstrate reading and writing skills.
3. To have each team member use their critical thinking and problem solving abilities in the contest.
4. To have each team member illustrate responsibility, teamwork, self-management skills, and professionalism.

2.8: Notebook

2.8.1: Supplied Documentation

Each team is issued this notebook and information packet. This will allow the team to display a plot or print of their operation. Required documentation is also included.

2.9: Required Materials

2.9.1: Workstation Components

Teams require the following materials to complete the competition. The Technical Committee provides many of these materials, but the teams must also bring certain items.

AMT Technical Committee provides:

Intelitek's Benchmill 6000 CNC Machining Center with:

- Machinist vise
- Hold-downs and clamps
- Tool holders

Part(s) design.

Competition notebook.

Pencils.

Prototype Material for machining.

Information and furnishings for judges and technical committee.

2.9.2: Team Provided Components

Teams provide:

Two computers:

- One computer loaded with CAD software for CAD program.
- One computer loaded with software for CAM program. This computer MUST have an open LAN Port (Ethernet connection) and Windows XP SP3 / Vista / 7 - 32 or 64bit.

Licensed versions of the above CAD and CAM software must be available at start of the orientation for loading onto the technical committee's computer(s).

One six inch dial or digital vernier caliper.

One dial indicator (example: L.S. Starrett Last Word dial test indicator) Dial indicator MUST have 3/8" holding shank to fit into tool holder supplied by Technical Committee.

One calculator.

One pair of 3/4" and/or 1" parallels (or a complete set).

One soft-face hammer

One 6" or 12" steel rule.

Each team can provide 3/8 edge finder.

Each team must provide a machinist handbook.

Each team can provide appropriate size end mills.

Each team must provide a USB memory device.

Note: ONLY the above listed items will be allowed in the contest area during the competition.

2.10: Division of Duties

2.10.1: Department Contributions

CAD Department

Stage 1, Rapid Prototype
Original print
CAD dimensioned views necessary to detail part completely

Stage 2, Finish Part Production
Change order
CAD dimensioned print (views necessary to detail part completely) and pictorial view

CAD Engineer

All CAD system import and export
Creating part geometry
Exporting necessary geometry to CAM system
Dimensioning parts
Plots
Receive change order
Communication of changes to team
Update all CAD files
All drawings should meet guidelines for engineering drawings

CAM Department

Stage 1, Rapid Prototype
Process documentation to include selection of tools, machining order, etc.
Generate NC code

Stage 2, Finish Part Production
Develop new process plan
Program new toolpath
Generate NC code

CAM Engineer

All CAM system input and output
Importing CAD geometry
Creating tool paths
Process sequencing
Tool selection
Creating NC code

CNC Department

Stage 1, Rapid Prototype
Fixturing description
Tool description
Tool setup

Fixture and set-up
Stage 2, Finish Part Production
Finish ECO part production

CNC Engineer

All CNC setup and operation
CNC control software input
Fixturing stock, tool offsets

Quality Control Department

Stage 1, Rapid Prototype
Part inspection sheet, all team members sign-off
All members check positions, tolerances, etc.

Stage 2, Finish Part Production
Part inspection sheet, all members sign
All members double-check work, clean-up

Quality Control

All Members

2.11: Suggested Organizational Flow

2.11: Suggested Organizational Flow (Half Day Sessions)

(Steps 2.11.1 to 2.11.4 to be performed in a half day (approx. 5 hrs.))

2.11.1: RECEIVE THE PART DRAWING

- A. CAD operator confers with the CAM operator and draws only what is necessary for the CAM operator to program a toolpath. Once that drawing is ready, the drawing is transferred to the CAM operator.
- B. CAM operator, after consulting with the CAD operator, consults with the CNC operator and fills out the Job Process Plan, defining machining order, tool paths, tool definitions and sequencing.
- C. CNC operator sets up the Virtual CNC Machine and the CNC operator confers with the CAM operator on tool definition and sequencing. The CNC operator virtually sets and mounts selected tools in holders and sets tool length offsets in the CNC control software. The CNC operator then sketches the fixture.

2.11.2: CAD OPERATOR TRANSFERS FILE TO CAM

- A. CAD operator copies the CAM transfer file to USB Memory device to be transferred to the CAM operator, then begins work on documenting the part with all necessary views.
- B. CAM operator transfers in the CAD file and double checks against the supplied drawing. The CAM operator begins programming tool paths and, if necessary, documents any changes to the Job Process Plan.
- C. CNC operator helps either the CAD or CAM operator, staying aware of CAM toolpath sequencing and tool changes. CNC operator could also study part for most efficient tool paths.

2.11.3: TRANSFER OF NC-CODE TO "VIRTUAL" CNC MACHINE

- A. CAD operator continues to document part and prints the dimensioned CAD drawing.
- B. CAM operator transfers NC-Code to the CNC operator.
- C. CNC operator loads the program, runs a simulation, Virtual CNC. (sets the touch off point, and then runs the program in Virtual CNC.)

2.11.4: "VIRTUAL" PROTOTYPE COMPLETE, QUALITY CONTROL

- A. Each team member inspects the virtual part and fills out inspection sheet. If errors are found, they are documented and the "virtual" part "observed/judged" and is submitted for participation in 2.11.6.

(Steps 2.11.5 and 2.11.7 to be performed from on the second day)

TOP FIVE (5 secondary and 5 post-secondary) TEAMS Qualify to move on to Steps 2.11.5, 2.11.6 and 2.11.7

2.11.5: same as above 2.11.1-2.11.3

2.11.6: MANUFACTURE FINISHED PART ON CNC MACHINE

- A. CAD operator completes all part documentation and hard copies.
- B. CAM operator assembles part documentation booklet and assists CAD and CNC operators.
- C. CNC operator manufactures and inspects part.

2.11.7: QUALITY CONTROL AND FINAL HAND-IN

- A. CAD, CAM, and CNC operators complete part inspection, documentation, and work area cleanup.

3: Safety

3.1: Importance of Safety

To maintain an effective and competitive company, it is in the best interest of both employer and employee to maintain a safe work environment. When a company's history of incidents resulting in injury is minimal, the company increases its likelihood of reduced insurance rates and workman compensation fees.

Safety considerations are taken into account during judging to further replicate a professional industrial environment.

3.2: Safety Violations

If a team or a team member violates a safety rule, or operates their work cell in an unsafe manner, the following penalties will be enforced:

1st Violation:

Team will be issued a written warning.

2nd Violation

Team will have 50 points deducted from their total score.

3rd Violation

Team will be disqualified.

3.3: Avoiding Safety Hazards

Some safety issues:

1. Team members must keep their work area reasonably clean. Clean work places promote efficient and safe working conditions.
2. Team members must keep their teammates and other teams aware of possible dangerous situations, such as flying chips, noise, possible tool breakage, etc.
3. Safety guards must be in place and properly interlocked during machining and when the spindle is turning.
4. Team members must wear safety glasses when they are in the proximity of the machine during setup as well as during machining.
5. Spindle must NOT be in motion during a tool change.
6. Tampering with or dismantling of any part of the supporting equipment (ie: computers, printers, ect.) is a direct safety violation, and can be grounds for immediate disqualification.

4: Additional Forms

4.1: Document Submission

The following documentation must be prepared by teams for judging. These sheets are included on the following pages of this team information packet:

- Notebook Judging Form
- Process Plan
- Fixturing Description
- Quality Assurance
- Mathematics Problem

4.2: Judge Prepared Documentation

Judges will prepare the following documentation for each team:

- CAD Evaluation
- Hand-In Time Run
- Concurrent Engineering CAD Evaluation
- Concurrent Engineering Surface Finish/ Dimensional Accuracy
- Area Clean-Up
- Safety Violations (if applicable)

SKILLS USA
AUTOMATED MANUFACTURING TECHNOLOGY
NOTEBOOK JUDGING FORM 2015

	MAXIMUM POINTS	CHECK	POINTS AWARDED
CAD Rapid Prototype			
1. Dimensioned Print of Prototype, Hardcopy (top and front views)	170		
2. Prototype Contest Drawing	25		
CAD Subtotal	195		
CAM Rapid Prototype			
1. Process Plan Form	100		
CAM Subtotal	100		
CNC Rapid Prototype			
1. Fixturing Description Form	80		
2. Quality Assurance Form	50		
3. Surface Finish/Dimensional Accuracy	150		
4. Hand-In-Time	100		
CNC Subtotal	380		
Concurrent Engineering			
1. CAD Drawing (top, front, side & pictorial), Hard Copy	70		
2. Engineering Change Order Drawing	25		
3. Process Plan Form	30		
4. Surface Finish/Dimensional Accuracy	100		
5. Area Clean-up	50		
Concurrent Engineering Subtotal	275		
Math Problem	50		
Safety (deductions)			
GRAND TOTAL	1000 pts		

AUTOMATED MANUFACTURING TECHNOLOGY

PROCESS PLAN

TEAM NUMBER _____ CUSTOMER _____

COMPLETED BY _____

DATE _____ PART DUE DATE _____

PART NAME _____

PART NUMBER _____ CNC MACHINE _____

BLANK SIZE _____ MATERIAL _____

Operation #	Operation Description	Tool #	Tool Description	Spindle Speed	Feed Rate	Plunge Rate

NOTES _____

Possible Pts. 100

Total _____

Team # _____

AUTOMATED MANUFACTURING TECHNOLOGY

FIXTURING DESCRIPTION

TEAM NUMBER _____ CUSTOMER _____


DRAWN BY _____

DATE _____ PART DUE DATE _____

PART NAME _____

PART NUMBER _____

SKETCH FIXTURE WITH TOOL TOUCH-OFF INDICATED



Possible Pts. 80

Total _____

Team # _____

AUTOMATED MANUFACTURING TECHNOLOGY

QUALITY ASSURANCE FORM

TEAM NUMBER _____ CUSTOMER _____

COMPLETED BY _____

DATE _____ PART DUE DATE _____

PART NAME _____

PART NUMBER _____ CNC MACHINE _____

BLANK SIZE _____ MATERIAL _____

Object #	Object Description	Defined Tolerance	Dimension Margin	
			High	Low

Identify errors on picture

NOTES _____

Signature

Signature

Signature

Possible Pts. 50

Total _____
Team# _____

**AUTOMATED MANUFACTURING TECHNOLOGY
CONCURRENT ENGINEERING
PROCESS PLAN**

TEAM NUMBER _____ CUSTOMER _____

COMPLETED BY _____

DATE _____ PART DUE DATE _____

PART NAME _____

PART NUMBER _____ CNC MACHINE _____

BLANK SIZE _____ MATERIAL _____

Operation #	Operation Description	Tool #	Tool Description	Spindle Speed	Feed Rate	Plunge Rate

Possible Pts. 30

Total _____

Team # _____

Automated Manufacturing Technology

Math Problem

2015

Competition for contracts with companies like Xfly Systems is very strong. Your R&D department at ABC Design, Incorporated, has asked your team to provide a prototype production run of an Assembly as designed by the client, Xfly Systems. A rapid response is essential to capture new business. The client requires that you provide a total of 4 prototypes of the Assembly. These will be distributed evenly to 2 different testing labs for final inspection and testing.

The prototype has 2 pieces. The assembly consists of a Top and a bottom with orientation guide pins.

The raw stock measurements are:

Material block 1 Piece: 3.8" x 5.2" x 1.5"

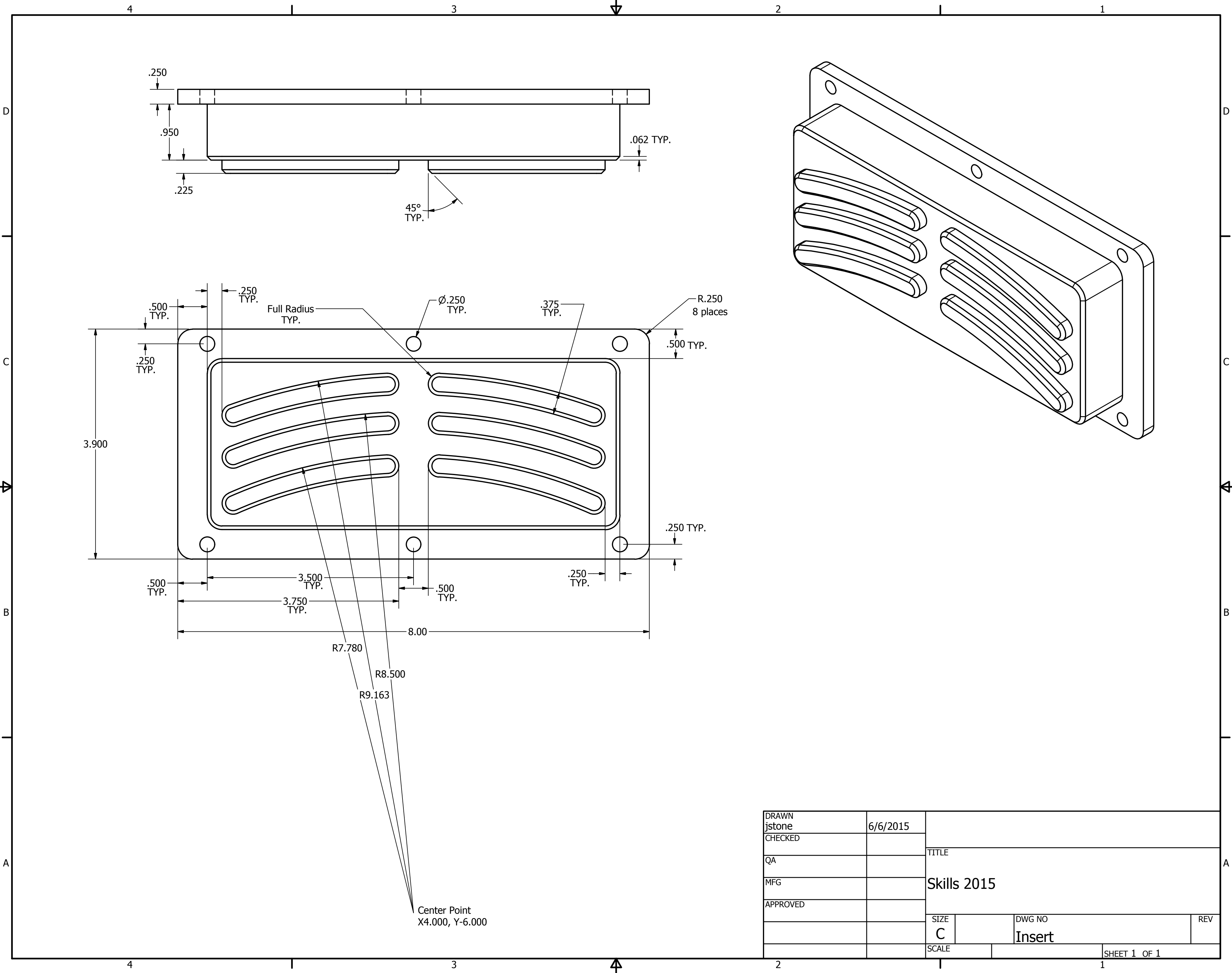
Material block 2 Pieces: 2.0" x 2.3" x .8".

The complete prototype will be made of Ren Board-440. The Ren Board is supplied in standard sheets measuring 24" x 24" x 1.5". It is estimated to take 15 minutes to make one prototype. The machine overhead rate is assumed to cost \$124.00 per hour. Each prototype has a material cost of \$4.35. The additional cost to assemble, package, and ship each set is \$16.00. Please answer the following questions. When answering DO NOT allow for waste material from the saw blade used to cut the parts to size. Each question is worth 5 points. TOTAL 50 Points.

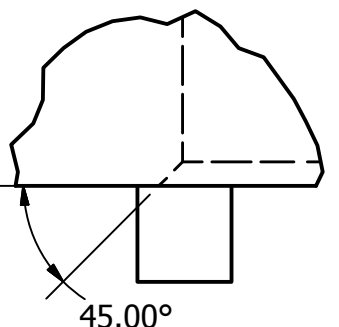
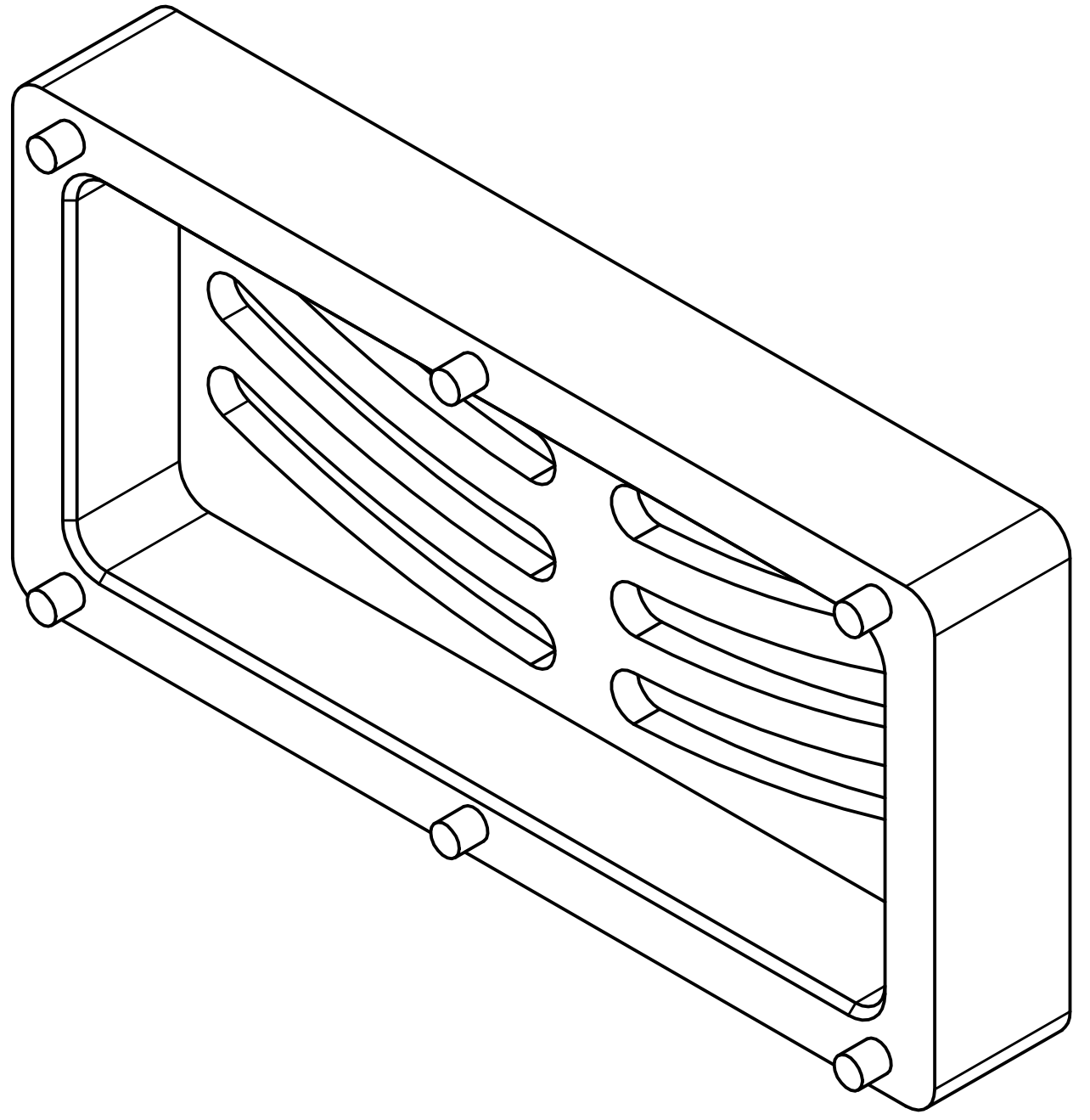
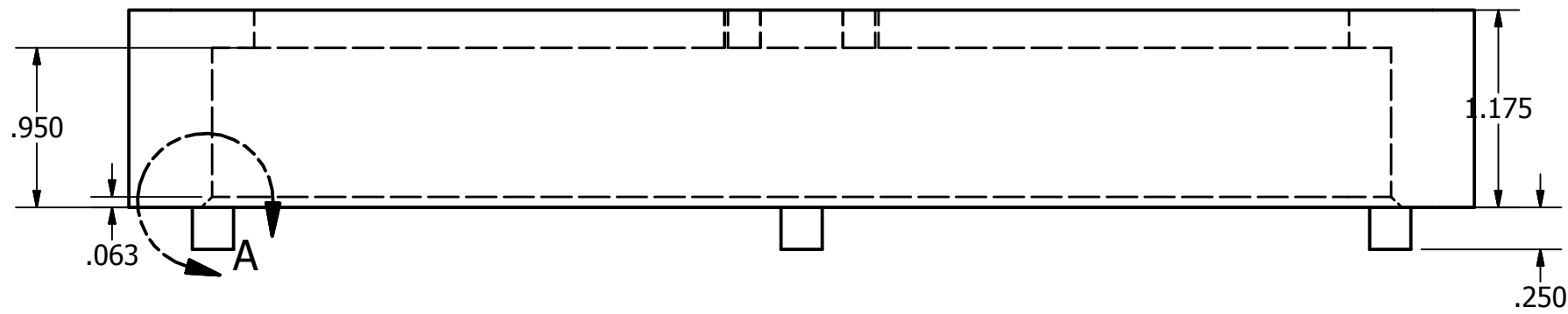
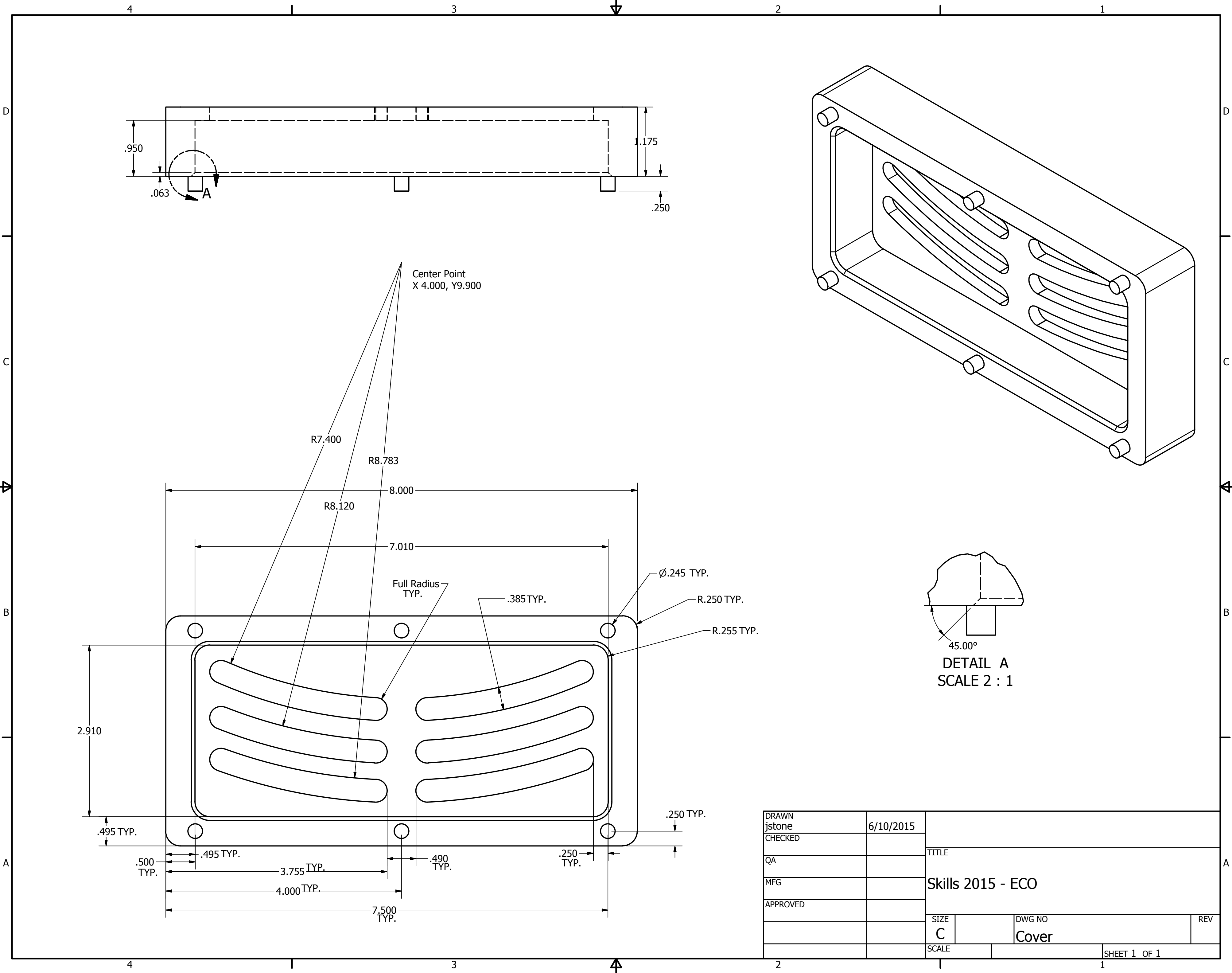
NOTE: This math problem is similar too but does not resemble the exact dimensions of your prototype parts, made in the AMT competition.

1. How many prototypes are required to complete the order for the client? _____
2. How many prototypes will each testing lab receive? _____
3. Calculate the area (square inches) of Ren Board are in a standard sheet? _____
4. Calculate the material cost to manufacture all 4 prototypes? _____
5. Calculate the machine overhead cost for one Prototype. _____
6. Calculate the machine operation time to make all 4 prototypes? _____
7. What is the total cost of one complete prototype, manufactured, assembled and shipped? _____
8. Calculate the cost savings per prototype if machine overhead was \$100 per hour? _____
9. Calculate the total cost savings if the additional cost of \$16 was cut in half? _____
10. Calculate the volume (cubic inches) of Ren Board in a standard sheet? _____

NOTE: Round your answer up to a two place decimal.

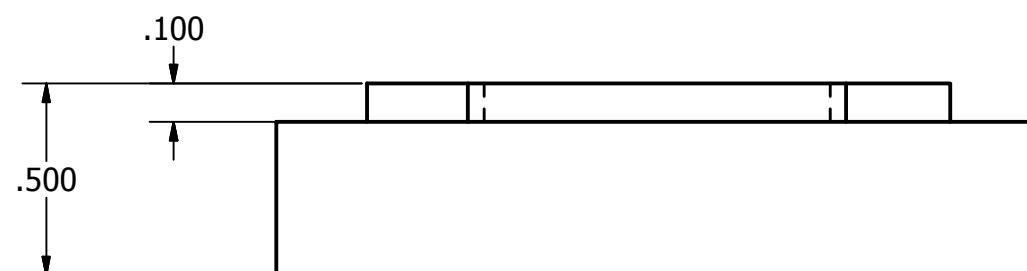
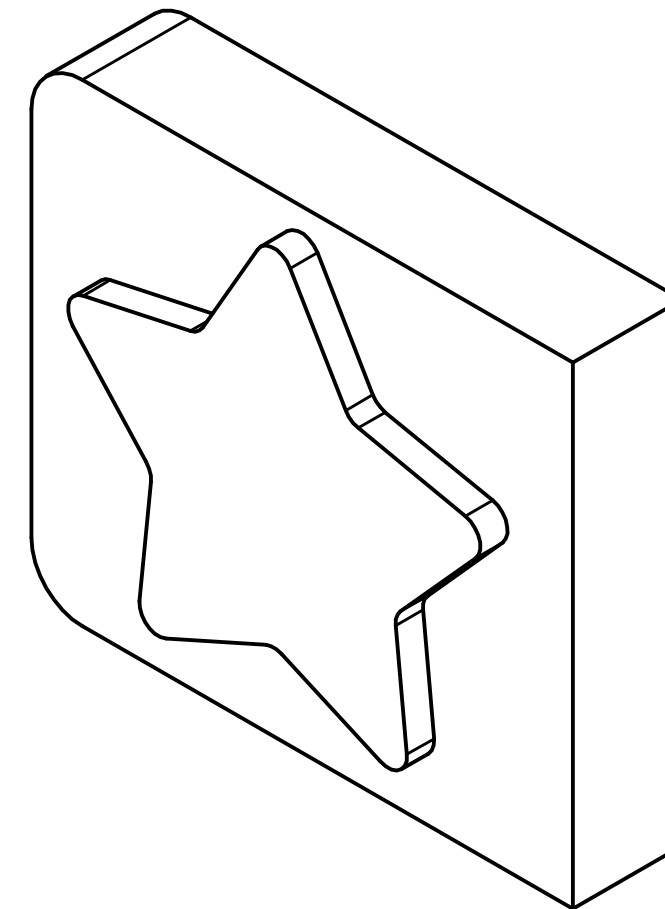
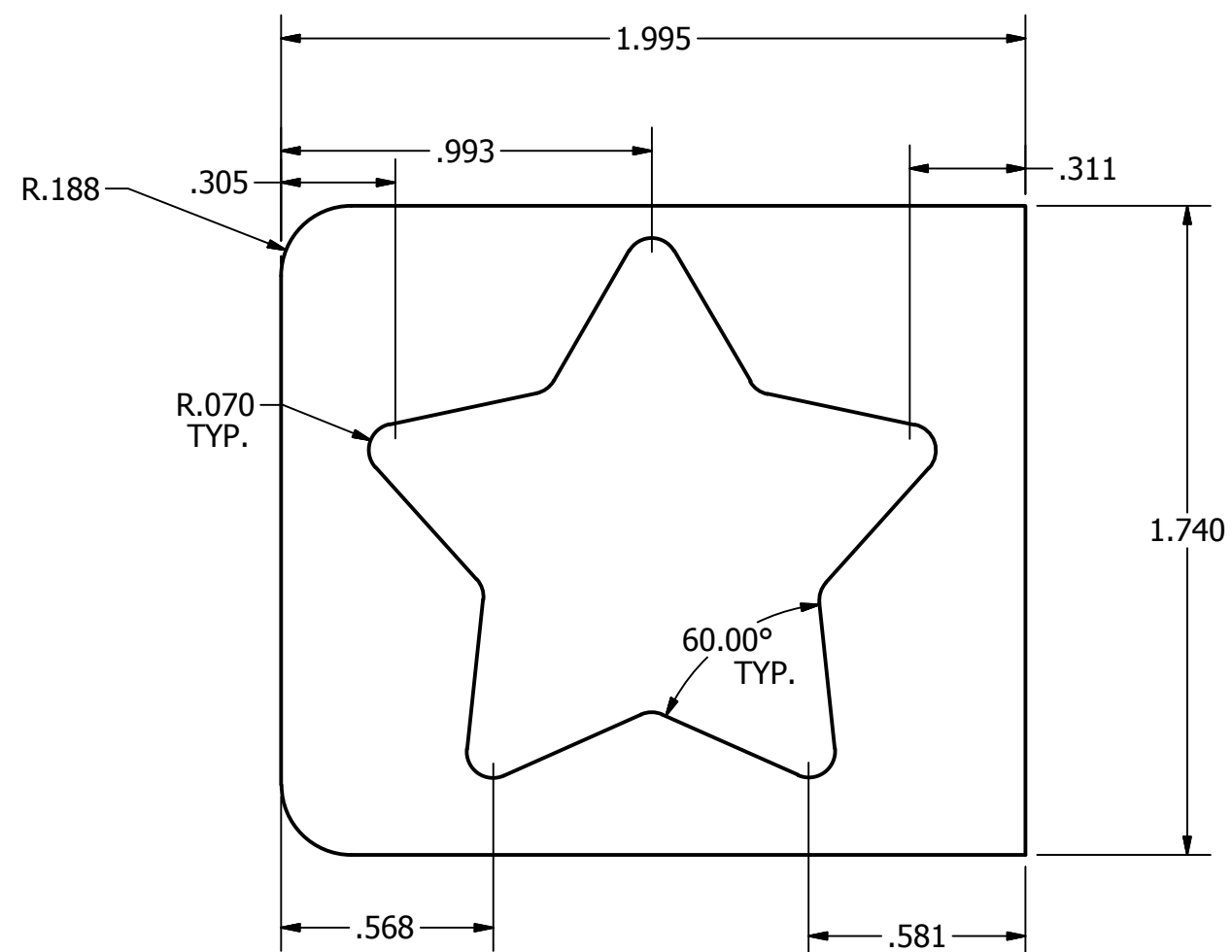


DRAWN jstone	6/6/2015	TITLE Skills 2015		
CHECKED				
QA		SIZE C		
MFG				
APPROVED		DWG NO Insert		REV
		SCALE	SHEET 1 OF 1	

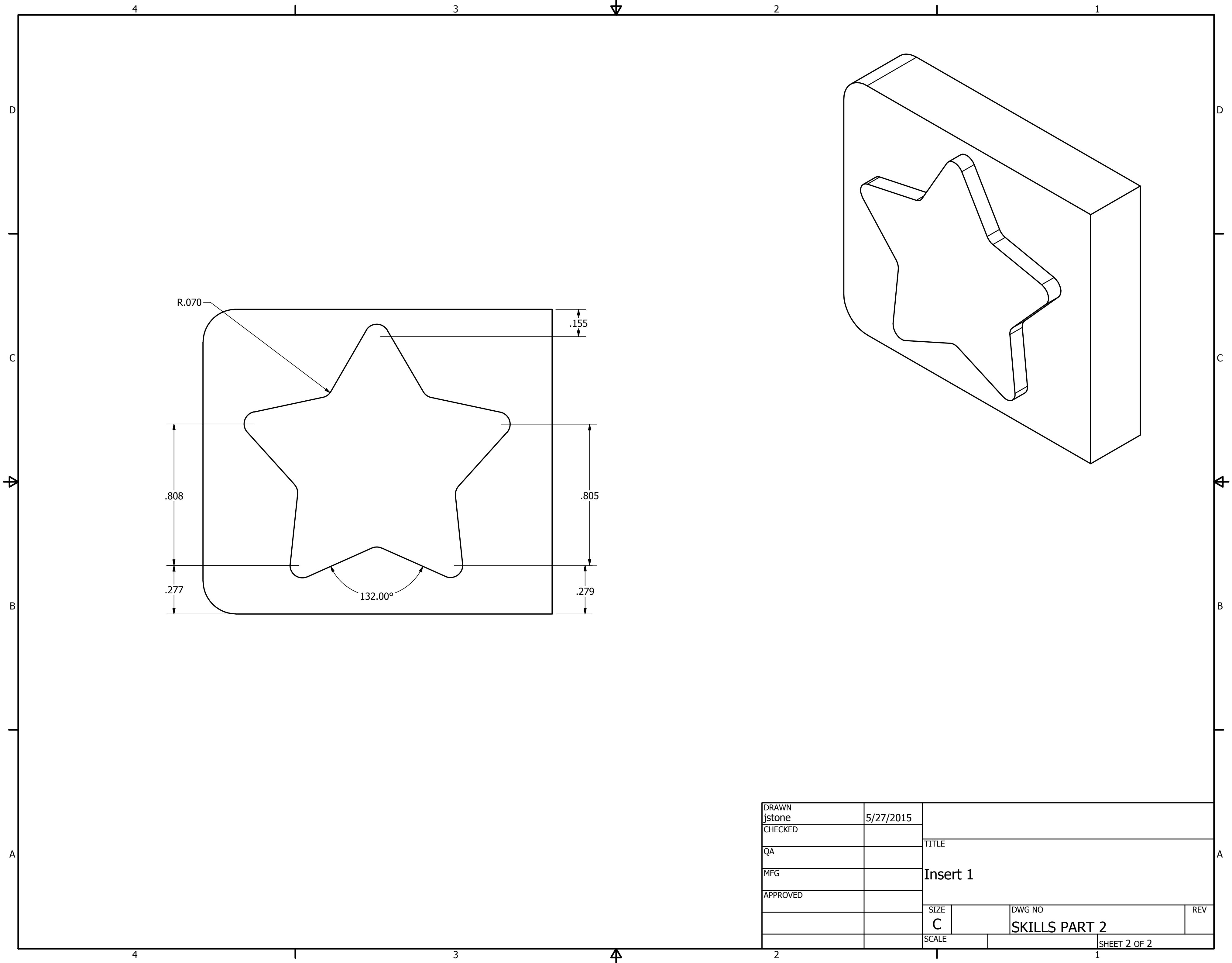


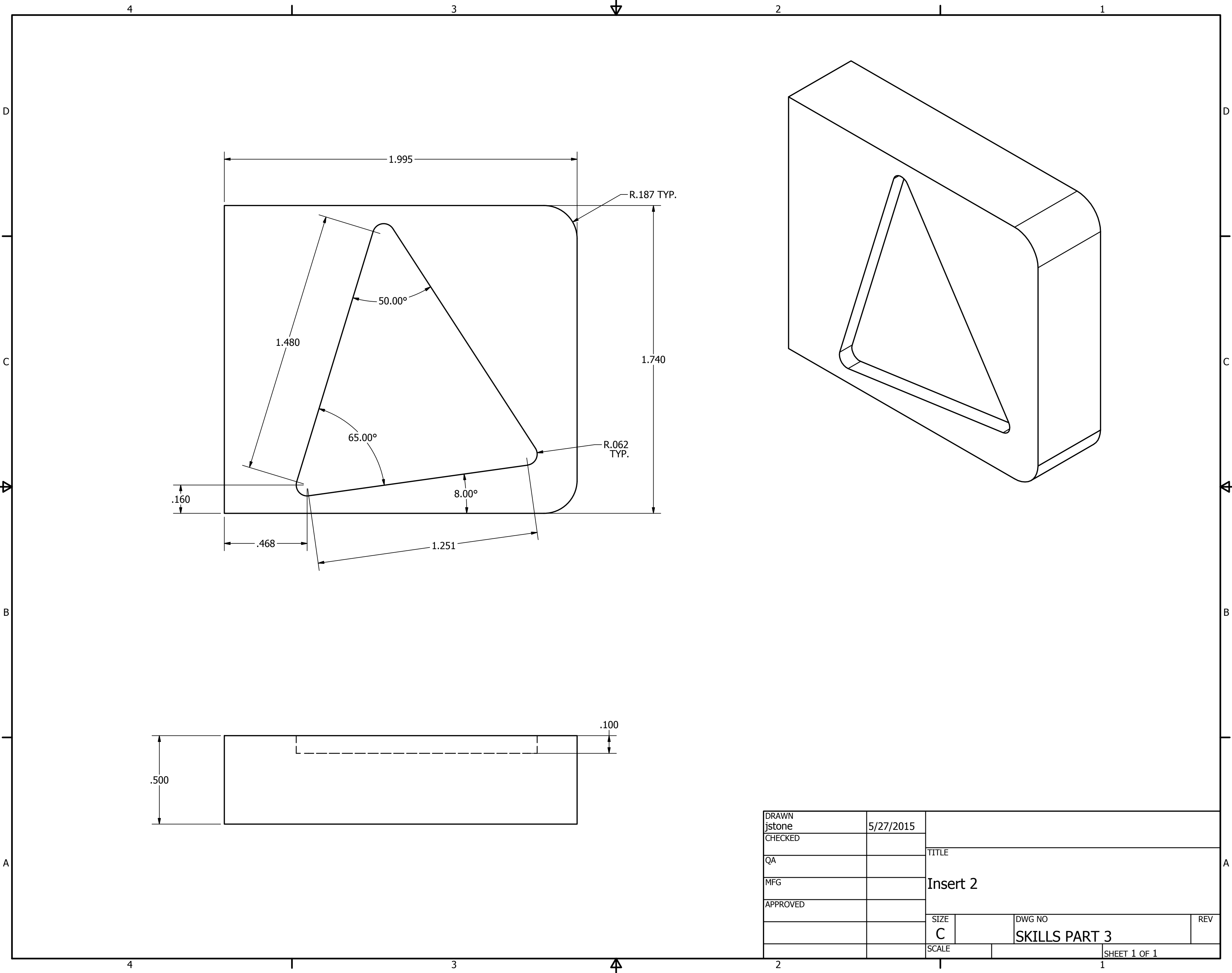
DETAIL A
SCALE 2 : 1

DRAWN jstone	6/10/2015	TITLE		
CHECKED				
QA		Skills 2015 - ECO		
MFG				
APPROVED		SIZE C	DWG NO Cover	REV
		SCALE	SHEET 1 OF 1	



DRAWN jstone	5/27/2015	<div style="text-align: center;"> <h1>Insert 1</h1> </div>			A
CHECKED					
QA					
MFG					
APPROVED					
		SIZE C		DWG NO SKILLS PART 2	REV
		SCALE		SHEET 1 OF 2	





DRAWN	jstone	5/27/2015	TITLE		
CHECKED					
QA			Insert 2		
MFG					
APPROVED			SIZE	DWG NO	REV
			C	SKILLS PART 3	
			SCALE	SHEET 1 OF 1	

Skills 2015
Station Questions
For
Students

Team # _____

Skills 2015
Station Question
Answers

Station 1

From the NC file below, plot the 4 corner points and identify the cutting direction.

N0; Benchmill 6000

N1; Single Tool

N2; Post Processor: Benchmill 6000 Single Tool

N3; Material Type: Machinable Wax

N4; Material Size: X3.0000 Y2.0000 Z1.5000

N5; Material Origin: X0.0000 Y0.0000 Z0.0000 (Lower Left Corner)

N6; Units: Inch

N7; Tool #1: 0.1250 1/8" End Mill

N78G90

N9G05

N10M05

N11G05

N12M03

N13;Engrave, Engrave 1

N14S5000

N15M03

N16G0Z0.1

N17G0X1.0Y0.5

N18Z0.07

N19G1Z-0.1F5

N20G1X2F15

N21Y1.5

N22X1

N23Y0.5

N24G0Z0.1

N25M02

Possible Points: 15

Total:
Team#

Answers to Station 1



P1 = N16G0X1.0Y0.5 (X1.0, Y.5)

P2 = N19G1X2F15 (X2.0, Y.5)

P3 = N20Y1.5 (X2.0, Y1.5)

P4 = N21X1 (X1.0, Y1.5)

Total question is worth 15 point. Each wrong piece of the answer subtract 3 points.

This question has 5 parts.

P1, P2, P3, P4, and the direction

Scoring Example:

15 (all right)

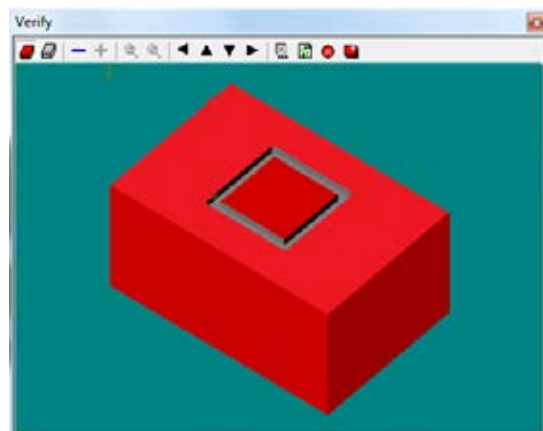
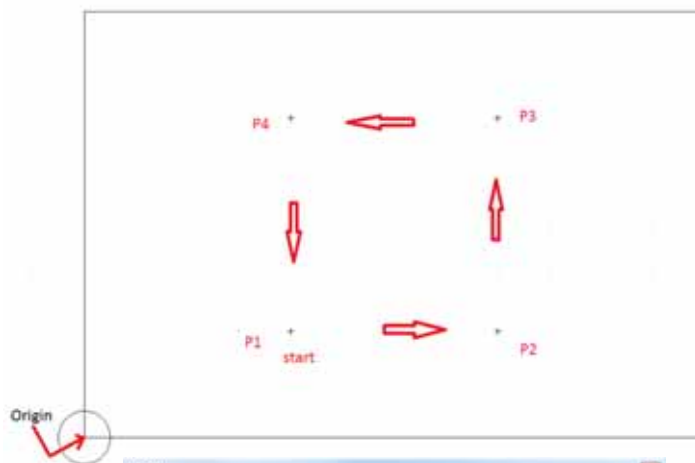
12 (1 wrong)

9 (2wrong)

6 (3 wrong)

3 (4 wrong)

0 (5 wrong)



Station 2

From the NC file below, plot the center points of the circle, Plot the start point of the circle, plot the end point of the circle and identify the cutting direction.

N0; Benchmill 6000

N1; Single Tool

N2; Post Processor: Benchmill 6000 Single Tool

N3; Material Type: Machinable Wax

N4; Material Size: X3.0000 Y2.0000 Z1.5000

N5; Material Origin: X0.0000 Y0.0000 Z0.0000 (Lower left corner)

N6; Units: Inch

N7; Tool #2: 0.1250 1/8" End Mill

G90

N8G05

N9M05

N10G05

N11M03

N12;Engrave, Engrave 1

N13S5000

N14M03

N15G0Z0.1

N16X2.25Y1

N17Z0.07

N25G1Z-0.1F5

N28G03X1.5Y0.25I1.5J1F15

N29X1.5Y1.75I1.5J1

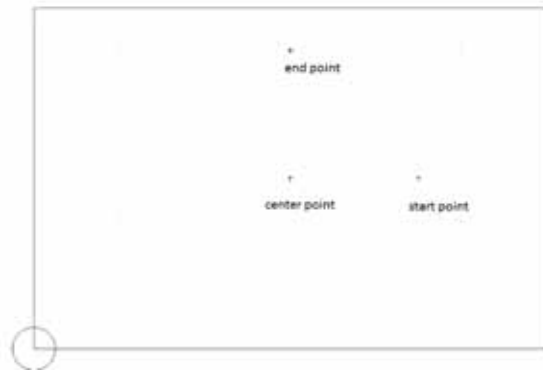
N30G0Z0.1

N31M02

Possible Points: 15

Total:
Team#

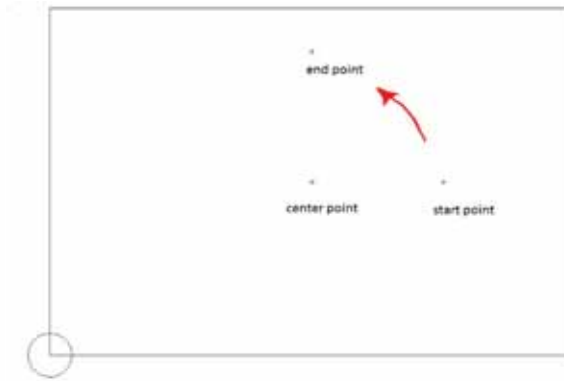
Answer to station 2



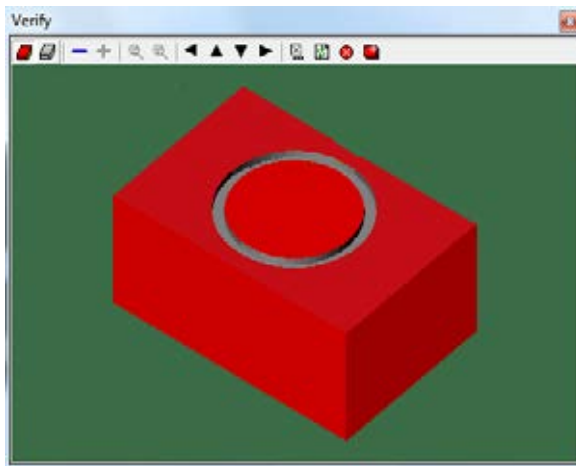
Center = X1.5, Y1.0

SP = X2.25, Y1.0

EP = X1.5, 1.75



Direction



Total question is worth 15 point. Each wrong piece of the answer subtract 3.75 points.

This question has 4 parts.

Center, ST, EP, and the direction

Scoring Example:

15 (all right)

11.25 (1 wrong)

7.5 (2wrong)

3.75 (3 wrong)

0 (4 wrong)

Station 3

Using the program below describe what the characters below mean.

N0; Benchmill 6000

N1; Single Tool

N2; Post Processor: Benchmill 6000 Single Tool

N3; Material Type: Machinable Wax

N4; Material Size: X3.0000 Y2.0000 Z1.5000

N5; Material Origin: X0.0000 Y0.0000 Z0.0000

N6; Units: Inch

N7; Tool #1: 0.1250 1/8" End Mill

N78G90

N9G05

N10M05

N11G05

N12M03

N13;Engrave, Engrave 1

N14S5000

N15M03

N16G0Z0.1

N17G0X1.0Y0.5

N18Z0.07

N19G1Z-0.1F5

N20G1X2F15

N21Y1.5

N22X1

N23Y0.5

N24G0Z0.1

N25M02

Describe Each

S

G0

G1

G90

M03

Possible Points: 15

Total:
Team#

Answer to station 3

S = Spindle speed, S needs to be followed by an RPM value; sets spindle speed to 5000 RPM

G0 = Rapid Traverse; machine moves at fast feed rate

G1 = Linear Interpolation; straight line

G90 = Absolute Positioning

M03 = Spindle rotation clockwise

Total question is worth 15 point. Each wrong piece of the answer subtract 3 points.

This question has 5 parts.

Scoring Example:

15 (all right)

12 (1 wrong)

9 (2wrong)

6 (3 wrong)

3 (4 wrong)

0 (5 wrong)

Station 4

Using the program below describe what the characters below mean.

N0; Benchmill 6000

N1; Single Tool

N2; Post Processor: Benchmill 6000 Single Tool

N3; Material Type: Machinable Wax

N4; Material Size: X3.0000 Y2.0000 Z1.5000

N5; Material Origin: X0.0000 Y0.0000 Z0.0000

N6; Units: Inch

N7; Tool #2: 0.1250 1/8" End Mill

G90

N8G05

N9M05

N10G05

N11M03

N12;Engrave, Engrave 1

N13S5000

N14M03

N15G0Z0.1

N16X2.25Y1

N17Z0.07

N25G1Z-0.1F5

N28G03X1.5Y0.25I1.5J1F15

N29X1.5Y1.75I1.5J1

N30G0Z0.1

N31M02

Describe each

F

G03

I

J

M02

Possible Points: 15

Total:
Team#

Answer to station 4

F = Feedrate, F needs to be followed by an numeric value; sets feedrate to 5IPM (inches per minute)

G03 = Circular interpolation Counterclockwise direction

I = X axis coordinate defining circle center

J = Y axis coordinate defining circle center

M02 = End of program

Total question is worth 15 point. Each wrong piece of the answer subtract 3 points.

This question has 5 parts.

Scoring Example:

15 (all right)

12 (1 wrong)

9 (2wrong)

6 (3 wrong)

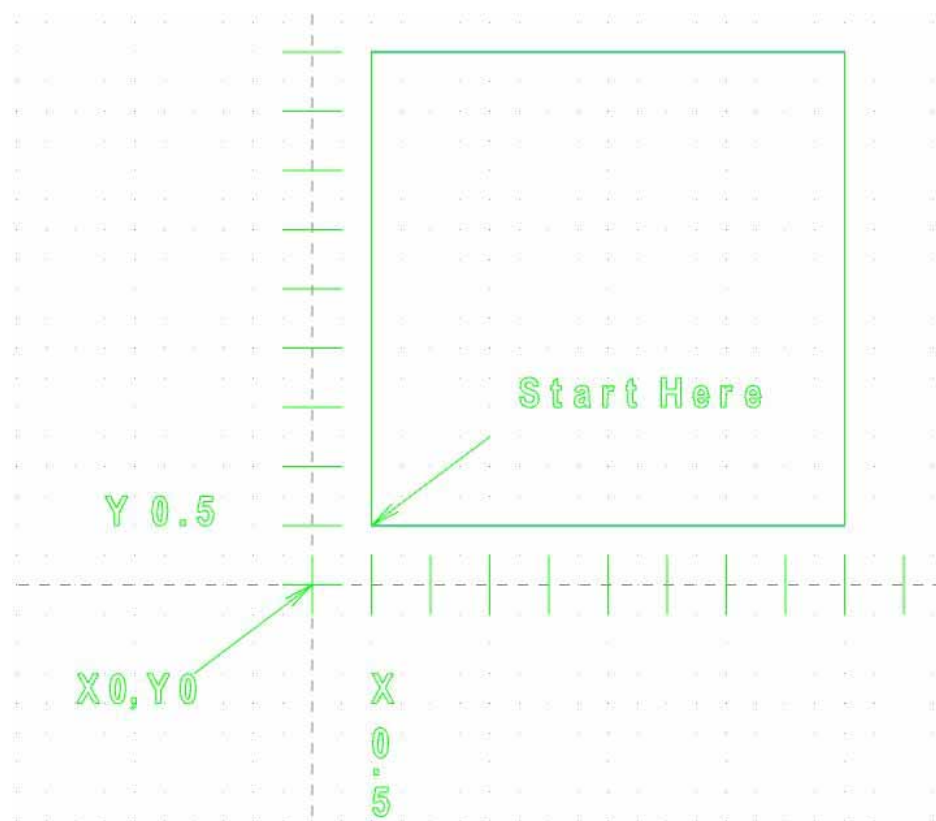
3 (4 wrong)

0 (5 wrong)

Station 5

Using the image below fill in the four missing lines of code

```
%
O0000 (SKILLS TEST)
(MATERIAL - ALUMINUM INCH - 2024)
(T285 | 1/4 FLAT ENDMILL | H285)
N100 G20
N110 G0 G17 G40 G49 G80 G90
N120 T2 M6
N130 G0 G90 G54 X.5 Y.5 A0. S2139 M3
N140 G43 H285 Z.25
N150 Z.2
N160 G1 Z-.125 F6.42
N170
N180
N190
N200
N210 Z.2
N220 G0 Z.25
N230 M5
N240 G91 G28 Z0.
N250 G28 X0. Y0. A0.
N260 M30
%
```



Possible Points: 15

Total:
Team#

Answers to station 5

N170 X4.5

N180 Y4.5

N190 X.5

N200 Y.5

Or (depending on direction)

N170 Y4.5

N180 X4.5

N190 Y.5

N200 X.5

Total question is worth 15 point. Each wrong piece of the answer subtract 3.75 points.

This question has 4 parts.

Scoring Example:

15 (all right)

11.25 (1 wrong)

7.5 (2wrong)

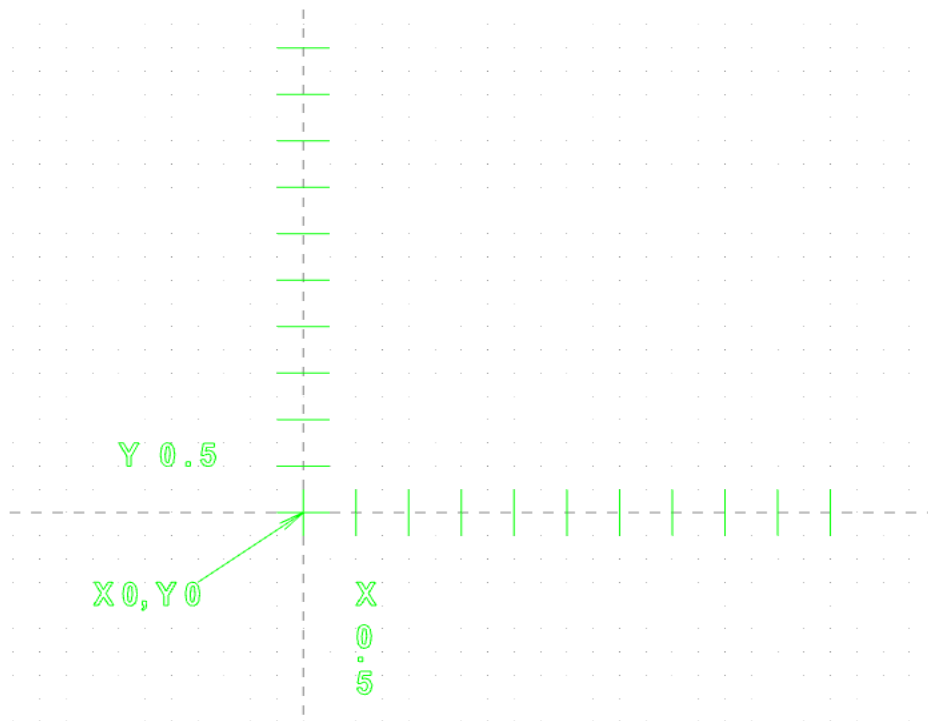
3.75 (3 wrong)

0 (4 wrong)

Station 6

Use the following NC code to plot the toolpath

```
%  
O0000 (PLOT THE CODE)  
(MATERIAL - ALUMINUM INCH - 2024)  
(T285 | 1/4 FLAT ENDMILL | H285 )  
N100 G20  
N110 G0 G17 G40 G49 G80 G90  
N120 T285 M6  
N130 G0 G90 G54 X.5 Y.5 A0. S2139 M3  
N140 G43 H285 Z.25  
N150 Z.2  
N160 G1 Z-.125 F6.42  
N170 X4.5  
N180 Y2.75  
N190 X2.5 Y4.5  
N200 X1.5  
N210 Y4.  
N220 X1. Y3.5  
N230 X.5  
N240 Y.5  
N250 Z.2  
N260 G0 Z.25  
N270 M5  
N280 G91 G28 Z0.  
N290 G28 X0. Y0. A0.  
N300 M30  
%
```



Possible Points: 15

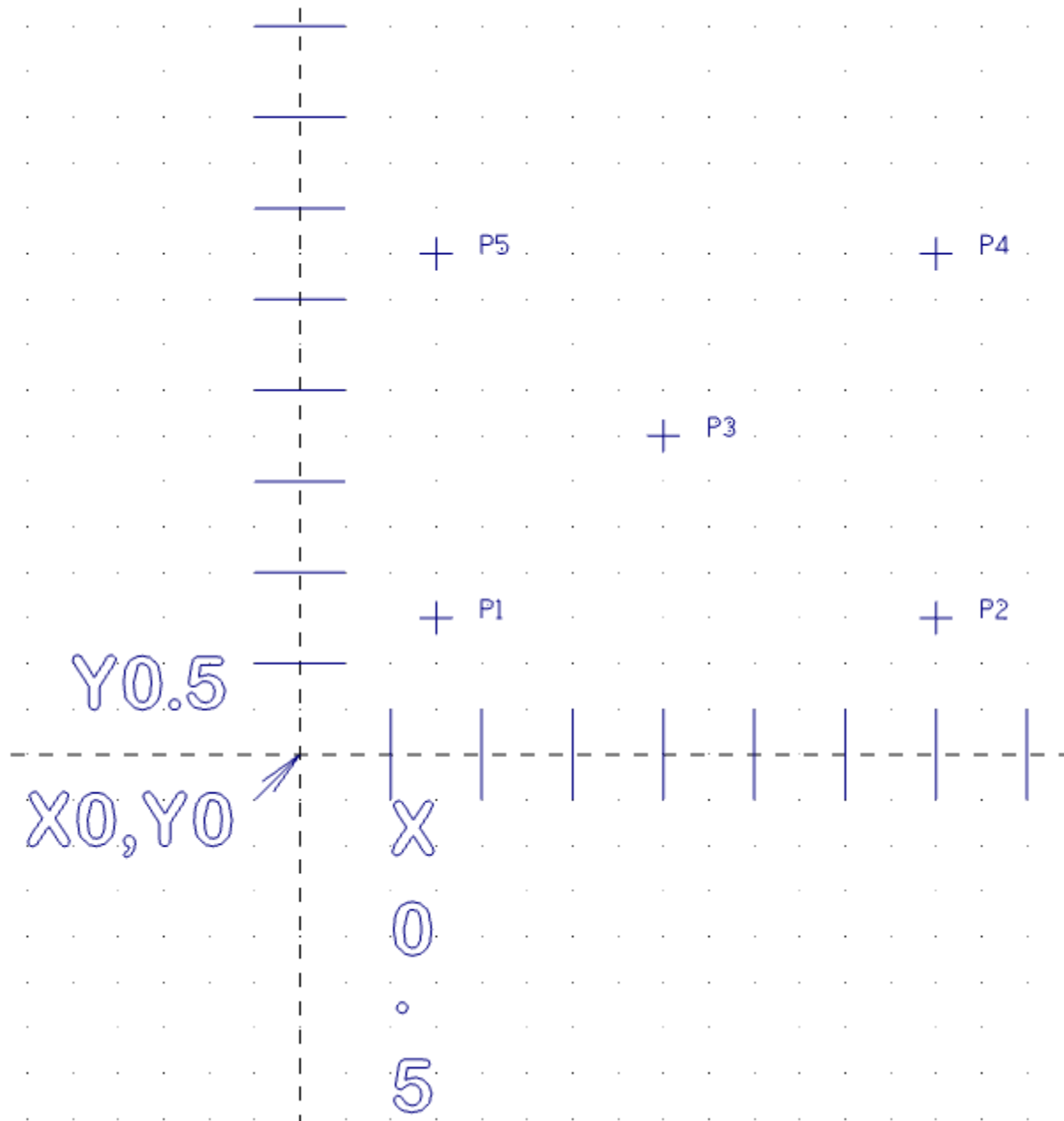
Total:
Team#

This question has 9 parts

15 (all right)
13.328 (1 wrong)
11.662 (2wrong)
9.996 (3 wrong)
8.33 (4 wrong)
6.664 (5 wrong)
4.998 (6 wrong)
3.332 (7 wrong)
1.666 (8 wrong)
0 (9 wrong)

Station 7

Write the appropriate X and Y locations for the points below in both Absolute and Incremental values.
Starting at X0, Y0, and moving point to point in numeric order.



Possible Points: 15

Total:
Team#

Answer to station 7

Absolute positioning

P1 X .75, Y.75

P2 X3.50,

P3 X2.00, Y1.75

P4 X3.50, Y2.75

P5 X.75

Incremental positioning

P1 X .75, Y.75

P2 X2.75

P3 X-1.50, Y1.00

P4 X1.50, Y1.00

P5 X-2.75

Total question is worth 15 point. Each wrong piece of the answer subtract 1.5 points.

This question has 10 parts

Scoring Example:

15 (all right)

13.5 (1 wrong)

12 (2wrong)

10.5 (3 wrong)

9 (4 wrong)

7.5 (5 wrong)

6 (6 wrong)

4.5 (7 wrong)

3 (8 wrong)

1.5 (9 wrong)

0 (10 wrong)

Station 8

Define the following commands:

- G -
- X -
- Y -
- Z -
- R -
- F -
- S -
- H -
- D -
- T -

Possible Points: 15

Total:
Team#

Answers to station 8

- G - Preparatory function
- X - X axis designation (left and right movement)
- Y - Y axis designation (in and out movement)
- Z - Z axis designation (up or down movement)
- R - Radius designation
- F - Feedrate designation
- S - Spindle speed designation
- H - Tool length offset designation
- D - Tool radius offset designation
- T - Tool Designation

Total question is worth 15 point. Each wrong piece of the answer subtract 1.5 points.

This question has 10 parts

Scoring Example:

15 (all right)

13.5 (1 wrong)

12 (2wrong)

10.5 (3 wrong)

9 (4 wrong)

7.5 (5 wrong)

6 (6 wrong)

4.5 (7 wrong)

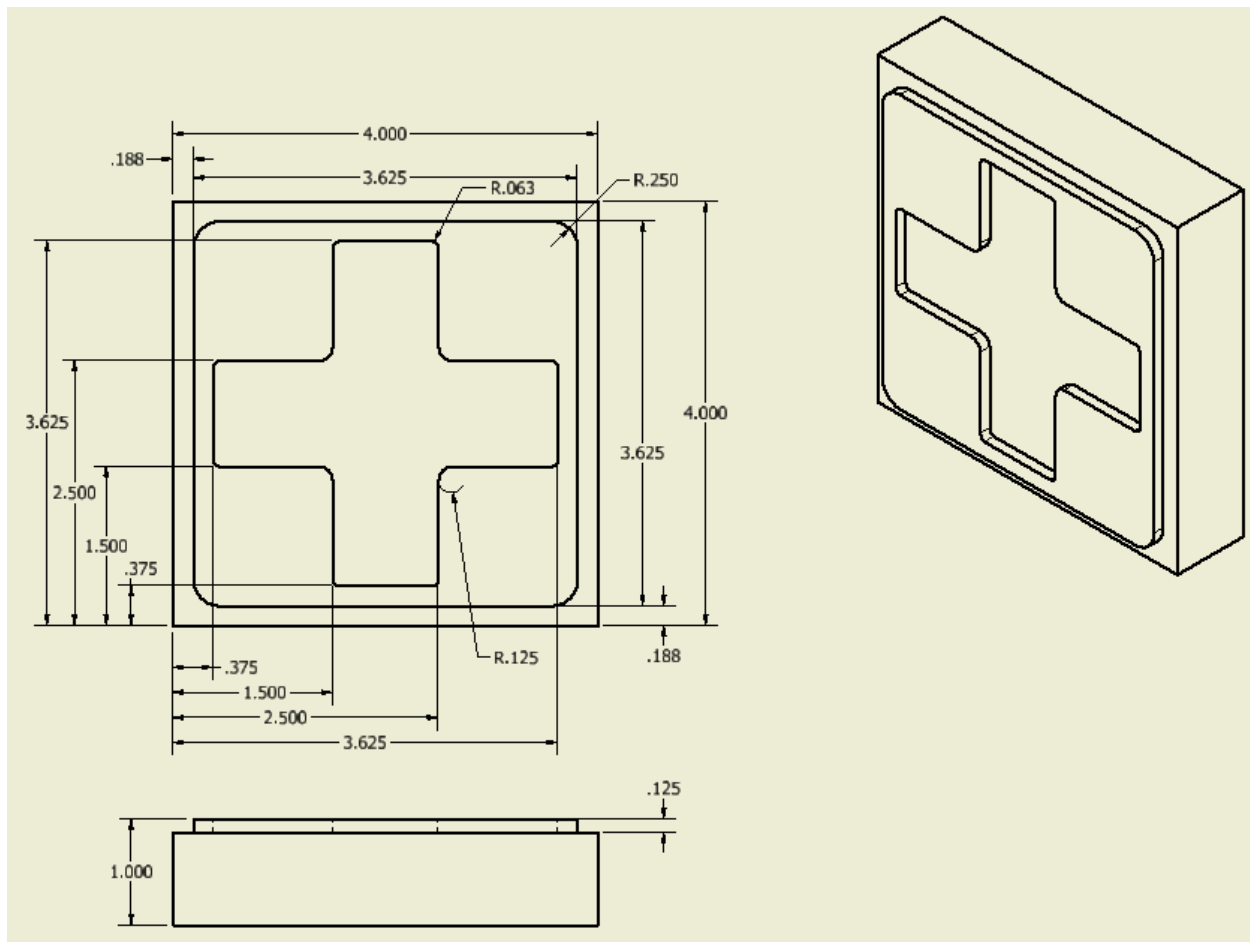
3 (8 wrong)

1.5 (9 wrong)

0 (10 wrong)

Station 9

Using the print below, what is the diameter of the largest cutter that can be used to finish the geometry.



Possible Points: 15

Total:
Team#

Answer to station 9

.125 diameter end mill, or .126 diameter end mill (either or)

Total question is worth 15 point.

This question has 1 parts

Scoring Example:

15 (right)

0 (wrong)

Station 10






Define the geometric dimensioning symbols below



Possible Points: 15

Total:
Team#

Answer to station 10

	Straightness
	Flatness
	Circularity
	Angularity
	Parallelism

Total question is worth 15 point. Each wrong piece of the answer subtract 3 points.

This question has 5 parts.

Scoring Example:

15 (all right)

12 (1 wrong)

9 (2wrong)

6 (3 wrong)

3 (4 wrong)

0 (5 wrong)

Skills ECO 2015

Using the geometry from the base, insert 1, and insert 2, make the mirror image off all three items. Allow .005 clearance for bosses and pockets per line (.010 for overall dimension).