SkillsUSA
2010 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.

2010 SKILLS USA CHAMPIONSHIP

AUTOMATED MANUFACTURING TECHNOLOGY COMPETITION

TEAM GUIDE

Contents

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.
AutoDesk, Inc.
CNC Software, Inc.
Depco, LLC.
River Valley Technical Center
MSC
Rolla Technical Institute
SolidWorks
Learning Labs
Holmquist Educational Resources
LS Starrett

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

Terry Graham
Depco, Inc.

Brenda Quinn
intelitek

Rod Murphy
Depco, Inc.

Richard Walker
National Tooling & Machining Assoc.

Mike Ogilvy
VP Sales and Marketing
intelitek

Dan Larochelle
intelitek

Dustin Spieth
CNC Software

Dan Newbey
CNC Software

Robert Clarke
intelitek

Judges

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

Terry Graham
Depco, LLC.

Rod Murphy
Depco, LLC.

Rick Knisely
Aztech Educational Resources

Dan Newby
CNC Software

Stephanie Holmquist
Holmquist Educational Consultants, Inc

Dan Hanson
Honeywell

Terry Johnson
R.T. Johnson Co., Inc.

Matt Selter
Honeywell

Jess Mooney
Honeywell

Dustin Spieth
CNC Software

Sheldon Richardson
Sales Manager
Learning Labs

Ben Richarson
Sales Manager
Learning Labs

National Educational Technical Committee

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

Don Block, Chairperson
Rolla Technical Institute
Rolla, MO 65401

Samuel Dolson
Manteca High School
Manteca, CA 95336

Rick Huddleston
Tulsa Technology Center
Tulsa, OK 74147-7200

Jeffrey Fisher
South Central Technical College
New Ulm, MN 56073

George Skena
Old Dominion University
NASA Langley Research Center
NorthStar Research Institute

Awards

The following companies have supplied awards:

Intelitek, Inc

AutoDesk, Inc.

CNC Software Inc.

Newell Rubbermaid

Solid Works

1: Contest Overview

1.1: 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.

1.2: 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. 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)

1.3: 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 Rotary Stamp assembly 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 Rotary Stamp assembly, incorporate any changes that the client might make, then manufacture the final assembly.

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 for a Rotary Stamp assembly. This assembly is made up of five pieces, and 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

The prototype parts are considered perfect if their measurements are within the following 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 transport it to your CAM computer via floppy disk or 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. The 2005 Kansas City competition was the largest Skills Automated Manufacturing Technology Competition.

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). At this time you will be presented with a new drawing(s); either a change order or an additional part(s) request.

3. Each team will be issued a notebook. This three-ring view binder 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 binders, 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's Super proLIGHT 1000 series CNC milling machines and tooling will be provided.
2. Teams must provide two computers, one of which must accept a full size PCI card.
3. Each team will have licensed versions of CAD/CAM software.
4. 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" or ½" holding shank), a calculator, a set of 1" parallels, 6" or 12" steel rule and a soft face hammer.
5. Teams must consist of 3 members.
6. The Prototype and the finished part will be machined in a prototype material.
7. Each team can provide 3/8 or ½ edge finder.
8. Each team can provide a set of parallels.
9. Each team can provide appropriate sized end mills.
10. Each team must provide a machinist handbook.

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 3-ring view binder 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 Super proLIGHT 1000 CNC Machining Center with:

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

Part(s) design.
Competition notebook.
Pencils.
Blank diskettes.
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 full-sized PCI slot and Windows 2000 or higher operating system.

Licensed versions of the above CAD and CAM software must be available at start of the orientation/practice session on Tuesday 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" or ½" holding shank to fit into tool holder supplied by Technical Committee.
One calculator.
One pair of ¾" or 1" parallels.
One soft-face hammer
One 6" or 12" steel rule.
Each team can provide 3/8 or ½ edge finder.
Each team must provide a machinist handbook.
Each team can provide appropriate size end mills.

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

Process Documentation Notebook	*Possible Division of Duties*
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

2.11.1: 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 Sequence Plan, defining machining order, tool paths, tool definitions and sequencing.

C. CNC operator squares up the vise and the CNC operator confers with the CAM operator on tool definition and sequencing. The CNC operator 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 diskette 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 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, sets the touch off point, and then runs the program.

2.11.4: PROTOTYPE COMPLETE, QUALITY CONTROL

A. Each team member inspects the part and fills out inspection sheet. If errors are found, they are documented and the part is submitted.

2.11.5: RECEIVE CHANGE ORDER

A. CAD operator revises CAD drawing and produces new-dimensioned drawings for plotting assurance.

B. CAM operator and the CNC operator review the change order and develop a new Job Process Plan, as deemed necessary.

C. CNC operator loads the program, runs a simulation, sets the touch-off point, and then runs the program.

2.11.6: MANUFACTURE FINISHED PART

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
- Concurrent Engineering Process Plan

4.2: Judge Prepared Documentation

Judges will prepare the following documentation for each team:

- CAD Evaluation
- Surface Finish/ Dimensional Accuracy
- 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 2010

	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. Engineering Change Order Drawing	25		
2. Process Plan Form	30		
3. CAD Drawing (top, front, side & pictorial), Hard Copy	70		
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

Base Block

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

Base Block

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

Base Block

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	Met Tolerance		Amount Off	Finish Errors	
			Yes	No		Yes	No

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

2010

Competition for contracts with companies like D&J Industries is very strong. Your R&D department at Pro Design, Incorporated, has asked your team to provide a prototype production run of a Rotary Stamp assembly as designed by D&J Industries, the client. A rapid response is essential to capture new business for your employer, Pro Design. The client requires that you provide a total of 16 prototypes of the rotary stamp assembly. These will be distributed evenly to 4 different testing labs for final inspection and testing. The client needs to verify the quality and production capability of rotary stamp manufacturers, before going into a mass production contract.

The rotary stamp assembly has 5 pieces that require assembly. The assembly consists of a base block that is 5-1/4" x 2" x 3/4", a rotating crank approximately 1.9" x 1.9" x 1.0", a stamp made of two parts, each 1-1/4" x 1-1/4" x 3/4" (approx) and a lever (connecting the crank and the stamp) 3-1/2" x 3/4" x 1/4". The complete prototype will be made of Ren Board-440. The Ren Board is supplied in standard sheets measuring 48" x 48" x 2" each costing $230 per sheet. It takes 60 minutes to make one set of the 5 pieces. Each set has a material cost of $5.35. The machine overhead rate is assumed to cost $100.00 per hour. It therefore costs $5.35 plus $100 to make each set. It takes $42.00 to assemble, package, and ship each set of the 5 pieces. 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 total pieces are required to complete the order for the client?
2. How many total prototype sets is Pro Design, required to manufacture?
3. How many square inches of Ren Board are in a 2" thick standard sheet?
4. How many square inches of Ren Board are required to manufacture 1 set of parts for a complete rotary stamp assembly?
5. What is the machine operation cost for 2-1/2 hours of machining time?
6. What is the total cost of one complete rotary stamp assembly, manufactured, assembled and delivered?
7. How many square inches of Ren Board are required to make one base block and rotating crank?
8. How many prototypes will be sent to each testing lab?
9. From the supplied prototype drawings, calculate both the length of travel of the stamp and the total distance travelled through one complete rotation of the crank?
10. How many machine hours will be required to manufacture all 16 prototypes?