

E91: DYNAMICS
Lab 3: Machine Shop Fundamentals

Introduction

The goal of this is for you to familiarize yourself with the elements in the Machine Shop and in the process fabricate a scale model piston. This lab will compose of two tasks: 1) fabrication of the piston, and 2) detailing of the fabrication procedure for certain parts of the piston.

General instructions on how to work the various pieces of equipment in the Machine Shop can be found on the course website, on the Supplemental Information page. Please read over these notes.

Task 1

Please refer to the Appendix of this document for the CAD drawings of the various components of the piston and fabrication procedures.

Task 2

As you may have noticed, the instructions in the Appendix are not complete. Please provide any missing instructions. Include figures that may help you explain the procedures more clearly.

Write-up

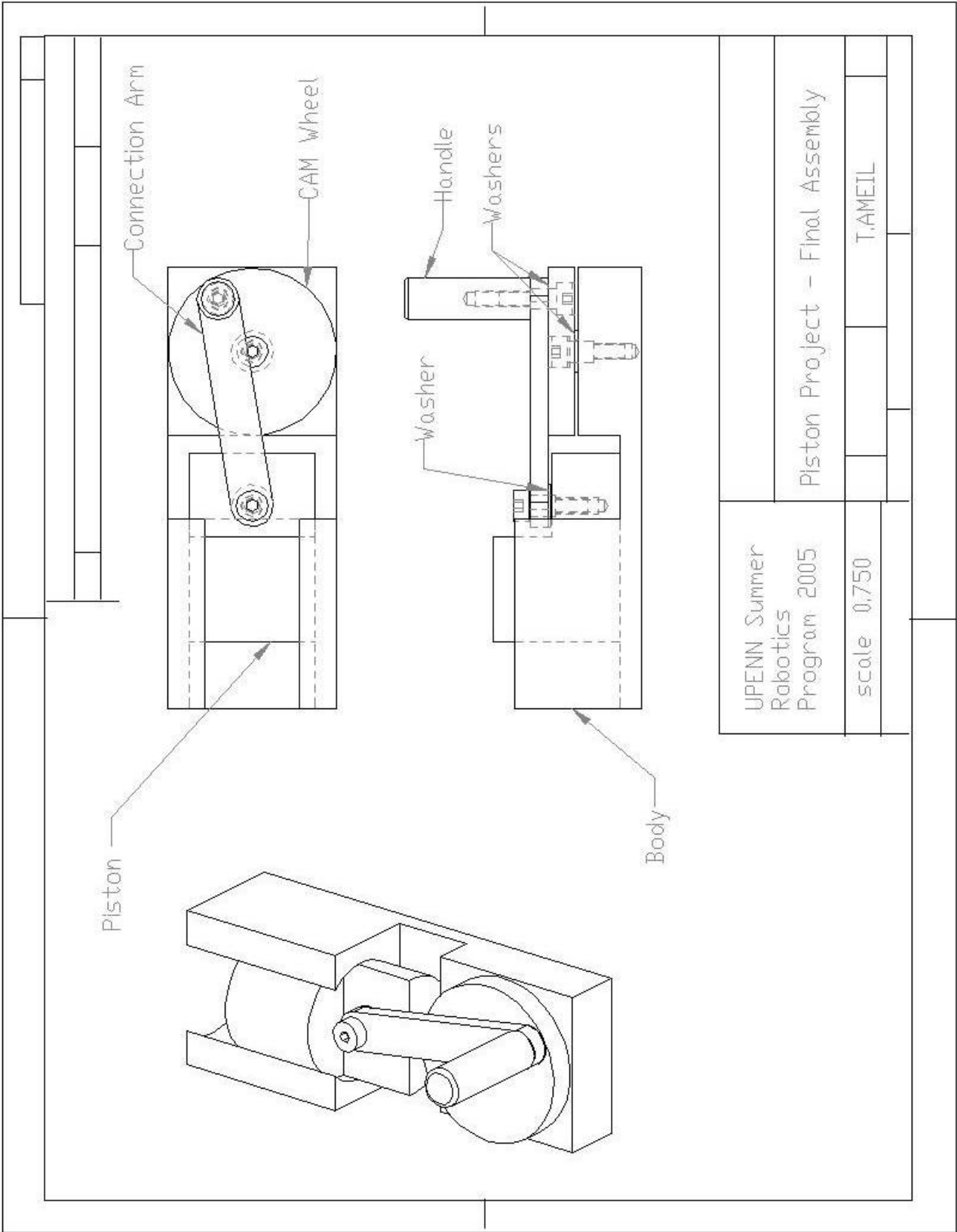
For your write-up, please provide the following:

1. Your completed scaled modeled piston.
2. The missing instructions in the Appendix along with any figures you deem necessary.
3. Short answers to the following questions: (Maximum 2 page.)
 - a. What was easy to do, what was hard to do?
 - b. After reading the general instructions to the various pieces of equipment in the Machine Shop (available on the course website), did you find any differences between what those instruction said and what you did different?
 - c. Did you follow all the instructions in the Fabrication Procedure section of the Appendix? If not, which ones did you not follow and why?

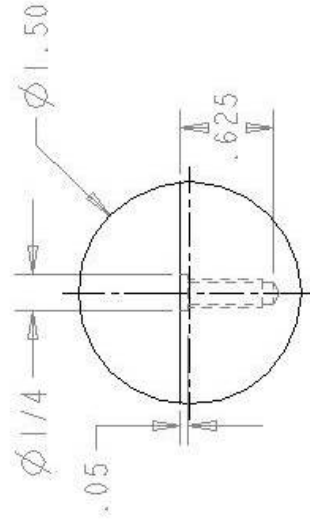
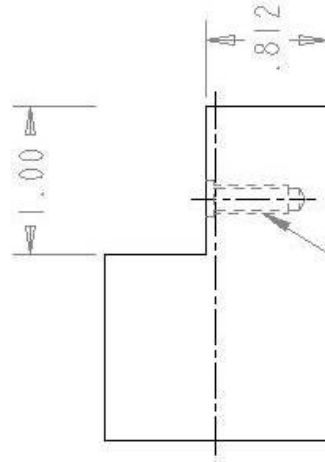
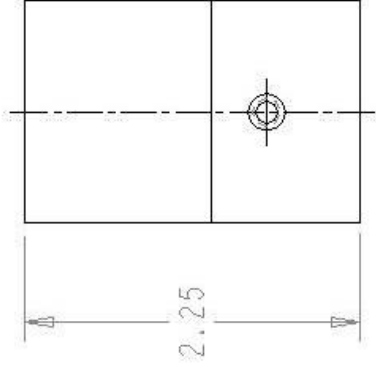
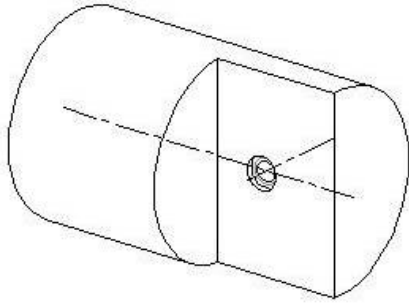
Appendix

CAD drawings.

Mechanical Drawings



UPENN Summer Robotics Program 2005	Piston Project - Final Assembly		
scale 0.750	T.AMEIL		



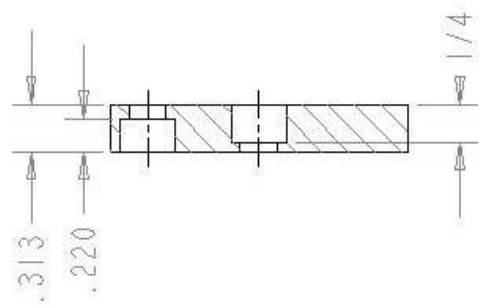
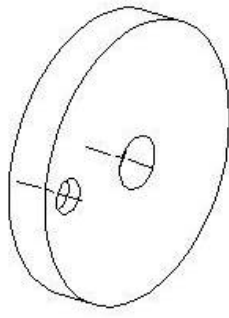
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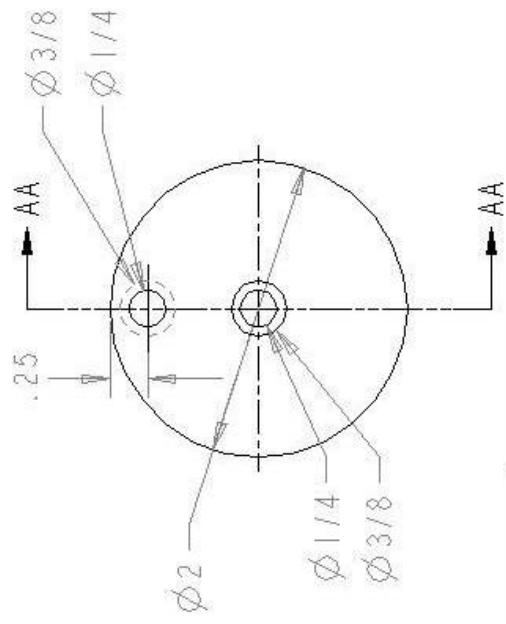
Piston Project - Piston

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SECTION AA-AA

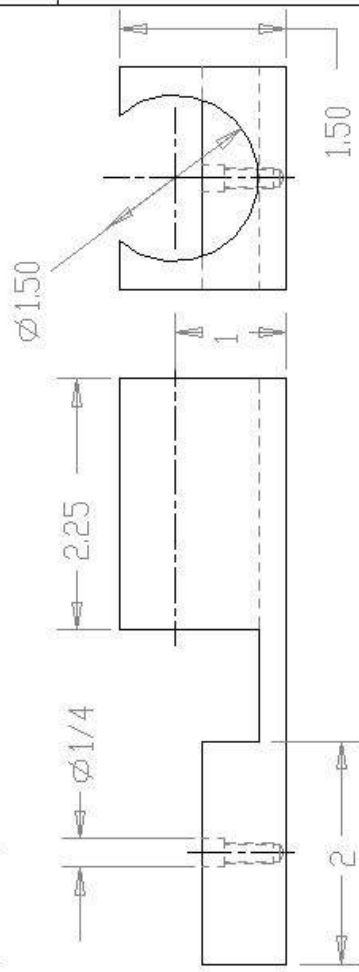
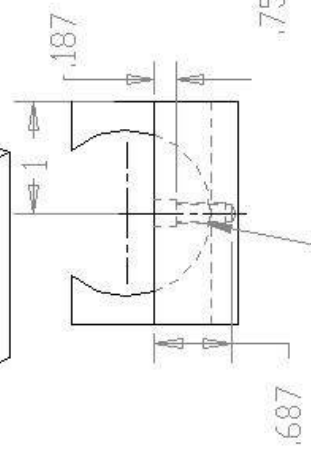
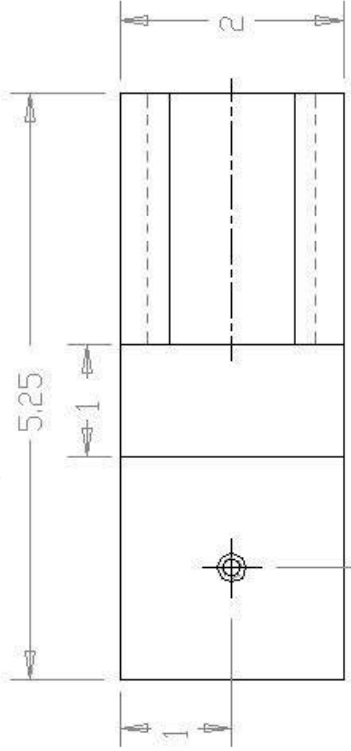
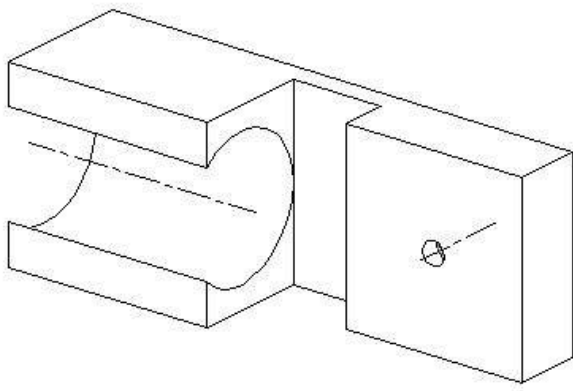


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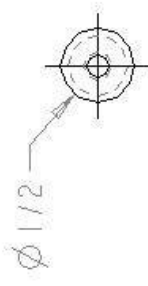
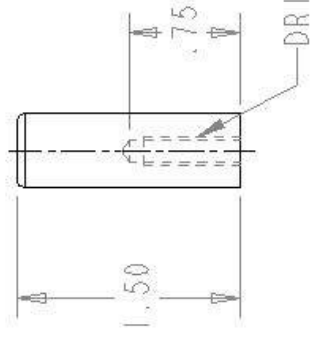
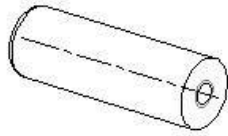
Piston Project - CAM Wheel

Scale 1:000

T.AMEIL



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Scale: 0.750		T.AMEIL	

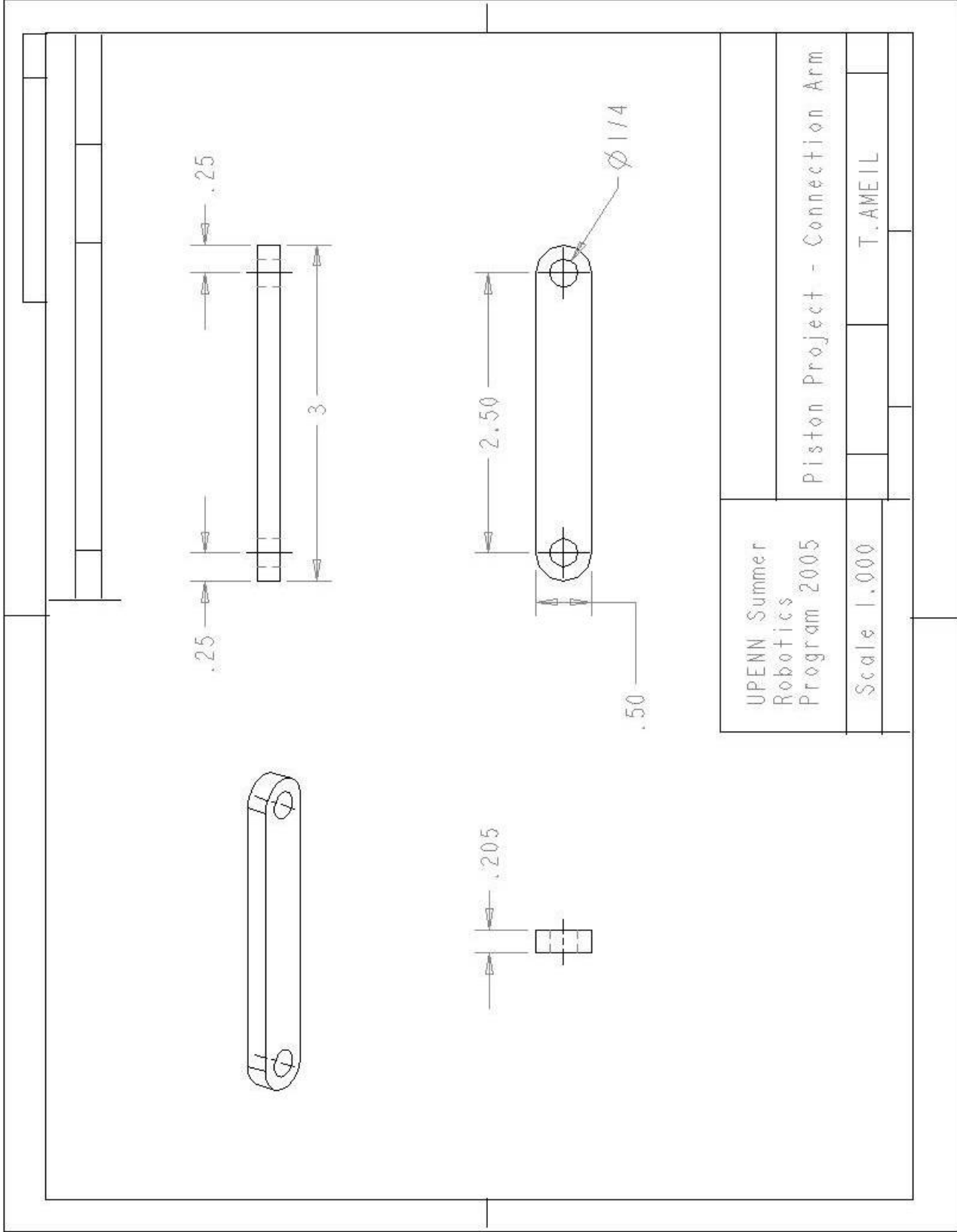


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Piston Project - Handle

Scale 1.000

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UPENN Summer Robotics Program 2005	Piston Project - Connection Arm		
Scale 1,000		T.AMEIL	

FABRICATION PROCEDURE

The following steps are used to fabricate most parts of the piston.

1 Handle

Material: Aluminum

1. Cut stock to length on vertical bandsaw
 - a. Scribe line 1.625" from end of stock.
 - b. Cut at scribed line.

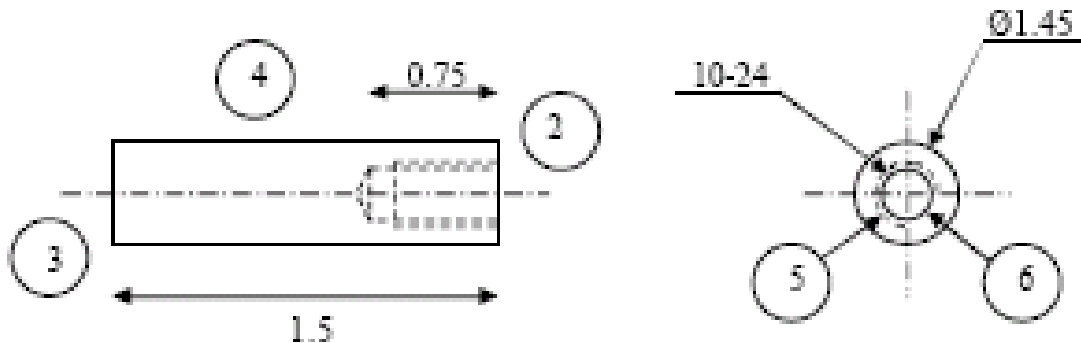
2. Face the right surface. (lathe)
 - a. Clamp the part securely in the 0.5" collet.
 - b. Turn the chuck by hand to ensure that no parts interfere with the rotation of the spindle.
 - c. Verify that the cutting tool tip is aligned with the center of the part, adjust if necessary.
 - d. Take material off (no more than 0.02" at a time) the parts end surface until it is completely flat (faced).
 - e. Round edge of part with a file.

3. Face the left surface/Make part desired length (lathe)
 - a. Re-orientate the part in the collet.
 - b. Face the part as done in step 2.
 - c. Remove the part from the collet and measure its length.
 - d. Reinstall part in collet and remove materials until you reach the desired length for the part.
 - e. Round edge of part with a file.

4. Turn the outer surface (lathe)
 - a. Clamp the part in the collet so that a little more than half of the part extends from the collet.
 - b. Remove material from the outer surface of the part until it is 1.49" diameter.
 - c. Rotate the part in the collet so that the unfinished side extends from the collet.
 - d. Remove material from the outer surface of the part until it is 1.49" diameter.

5. Drill the hole (lathe)
 - a. Clamp the part in the collet so that approximately 0.75" extends.
 - b. Install a #2 counter sink in the tailstock.
 - c. Move the tailstock into position and lock it in place.
 - d. Spot drill the shaft approximately 0.25" deep. Use cutting fluid with the sink.
 - e. Replace the counter sink with a #25 drill.
 - f. Drill the hole 0.75" deep using scale on the tailstock.
 - g. Insert counter sink in tailstock and debur the hole

6. Tap the hole. (hand)
 - a. Lock the lathe spindle so it doesn't rotate.
 - b. Put the 10-24 tap into the holder and install the tap center in the tailstock drill chuck.
 - c. Tap the hole. After approximately 6 turns, take the tap out of the hole and remove the chips. Do these operations until you reach the bottom of the hole.



2 Piston

Material: Aluminum

1. Face the right/left surface (lathe)
 - a. Clamp the part securely in the lathe chuck.
 - b. Turn the chuck by hand to ensure that no parts interfere with the rotation of the spindle.
 - c. Take material off (no more than 0.02" at a time) the parts end surface until the it is completely flat (faced).
 - d. Round edge of the part with a file.
 - e. Remove the part, re -orientate, and place back in chuck.
 - f. Repeat the procedure to face the other side of the part.
2. Turn the outer surface (lathe)
 - a. Clamp the part in the lathe chuck so that a little more than half of the part extends from the chuck.
 - b. Remove material from the outer surface of the part until it is ~1.496" in diameter, you will only be able to remove ~ 0.001" to 0.002" of material.
 - c. Round the edge of part with a file.
 - d. Rotate the part in the chuck so that the unfinished side extends.
 - e. Remove material from the outer surface of the part until it is ~1.496" in diameter.
 - f. Round edge of part with a file.
3. Cut the part in half (horizontal bandsaw)
 - a. Scribe a line 2.375" from one side of the part.
 - b. Use the horizontal bandsaw to cut the part along the scribed line.

4. Face part/Make part desired length (lathe)
 - a. Clamp part in lathe chuck so unfinished side can be faced.
 - b. Remove material until you reach the desired length for the part.

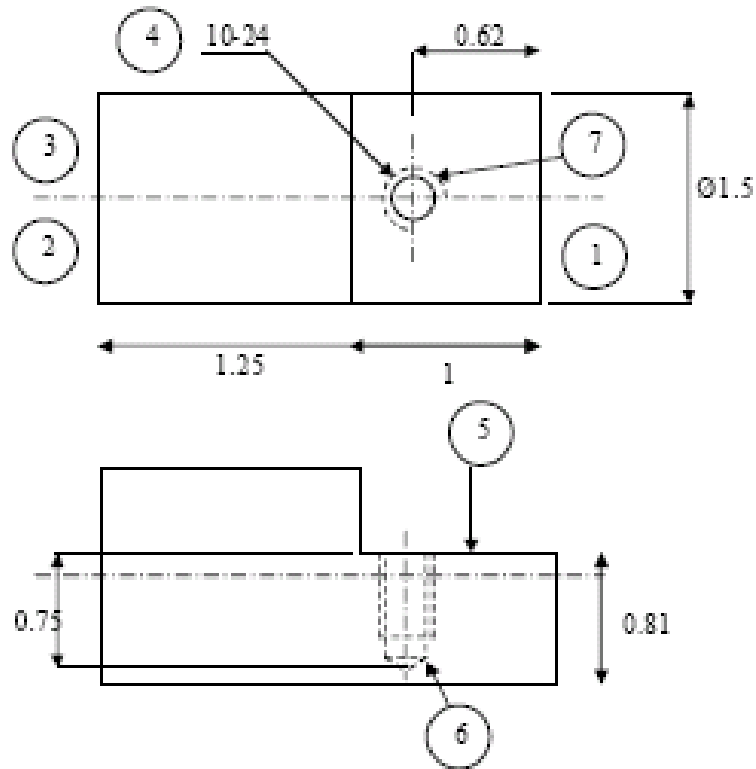
5. Mill the flat surface (milling machine)
 - a. Clamp the part in the milling vise using two V-blocks. Extend the part more than 1" off the right side of the vise.
 - b. Put an edge finder into 0.5" collet.
 - c. Set the right surface as the X-reference zero and the front surface as the Y-reference zero.
 - d. Replace the edge finder with a 1" end mill. Move the end mill Z-axis so the bottom of the end mill is ~0.2" above the part.
 - e. Move the X-axis so the end mill is 0.95" from the end of the part.
 - f. Turn on the spindle and adjust the Z-axis until the mill just touches the outer surface (top) of the part, set this as the Z-reference zero.
 - g. Move the tool out of the part by moving the Y-axis.
 - h. Adjust the Z -axis so the end mill is 0.02" into the part.
 - i. Cut the piece by moving the tool forward and backward along the Y-axis.
 - j. Repeat until the Z-axis has been decreased to 0.60" (don't take more than 0.020" for each pass).
 - k. Move the X-axis so the end mill is 1" into the part and the Z -axis is 0.69" into the part. Move the Y-axis forward and backward to make the finishing pass.

6. Drill the hole. (milling machine)
 - a. Remove the end mill and the collet. Install a drill chuck in the spindle. Put an edge finder inside the drill chuck.
 - b. Set the back surface as the Y-reference surface.
 - c. Move the tool 0.25" inside the part for both directions so that its center of rotation stands exactly on top of the back right corner of the part. Set the X and Y position to zero.
 - d. Take the edge fin der out of the chuck and replace it by a #1 sink.
 - e. Set the sink at the right position to drill the hole.
 - f. Spot drill the part approximately 0.25" deep. Use cutting fluid with the sink.

7. Replace the sink by a #25 drill
 - a. Drill the hole to a depth of 0.75".

8. Machine the counter bore (milling machine)
 - a. Take off the drill and the drill chuck.
 - b. Put a 0.375" collet in the spindle. Put a 0.375" end mill in the collet.
 - c. Counter bore to a depth of 0.05".

 - d. Tap the hole. (hand)
 - e. Follow the same steps as when tapping the handle.

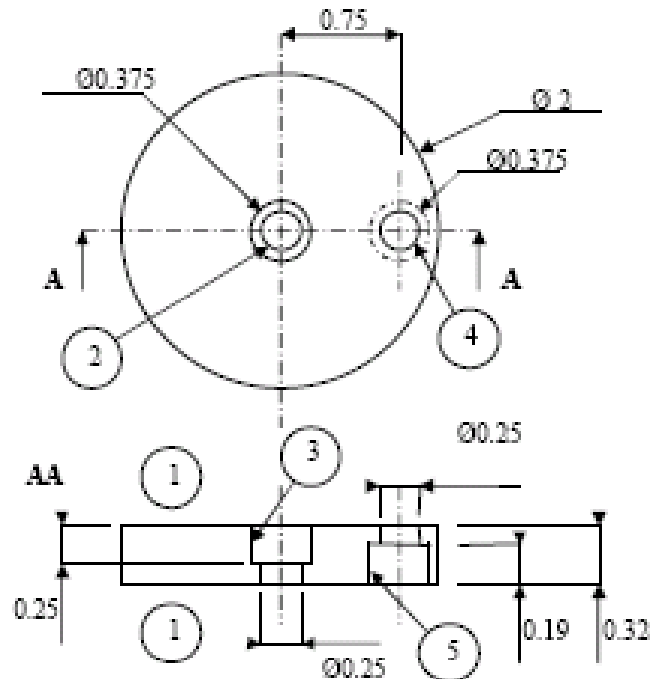


3 Cam Wheel

Material: Aluminum

1. Facing the upper/lower surface. (lathe)
 - a. Follow the same steps as described in the first operation of the piston.
 - b. If needed, use small parallels to help position the part in chuck.
 - c. Round edge of part with a file.
2. Drilling the hole in the center. (lathe)
 - a. Follow the same steps as described in the fourth operation of the shaft but replace the #1 sink by a #3 sink and the #25 drill by a 0.25" drill.
3. Cutting the counter bore (lathe)
 - a. Take the drill off and replace it by a 0.375" end mill.
 - b. Cut materials for a depth of 0.25".
4. Drilling the second hole. (milling machine)
 - a. Take the part out of the lathe and put it in the vise of a milling machine. Place some parallels under the part so that it will be exactly horizontal.
 - b. Put an edge finder into the drill chuck.
 - c. Set the back surface to the reference surface for the Y axis (Don't forget to move the edge finder by half its diameter to put the center of rotation on top of the reference surface).
 - d. Move the edge finder by 1" toward your direction so that its center of rotation is in the middle of the part.

- e. Set the right edge of the part to the reference surface for the X axis (Don't forget to move the edge finder by half its diameter to put the center of rotation on top of the reference surface).
 - f. Replace the edge finder by a number 2 sink. And place it at the right position to drill the hole.
 - g. Spot drill the shaft approximately 0.25" deep. Use cutting fluid with the sink
 - h. Replace the sink by a 0.25" drill.
 - i. Make sure the parallels are not under the hole you're about to drill.
 - j. Drill the hole all the way through the part.
5. Cutting the second counter bore. (milling machine)
 - a. Replace the drill by a 0.375" end mill (you need to take off the drill chuck and put a 0.375" collets instead).
 - b. Counter bore to a depth of 0.19".



4 Body

Material: Aluminum

1. Facing the right surface. (milling machine)
 - a. Put the part vertically in the vise of a milling machine so that the surface you want to cut is horizontal. Ensure part is square to vise bottom surface.
 - b. Install a fly cutter in the spindle.
 - c. Remove material until the surface you get is flat.
2. Facing the left surface. (milling machine)
 - a. Flip the part in the vise. Ensure part is square to vise bottom surface.
 - b. Remove material until part is desired length

3. Provide the remaining instructions along with appropriate figures.

5 Connection Arm

Please provide your instructions for the fabrication of the connection arm along with appropriate figures.