MIDTERM EXAM I

Name: SOLN KEY

Instructions: *This exam may be completed with the use of an engineering notebook (9.75" x 7.5") containing the course slides, the provided handouts, any handwritten notes, and a calculator.*

NO ring binders, textbooks or old exams may be used during this exam.

Do not start this exam until instructed to begin.

This exam has NO time limit.

Score: 100 of 100 pts = 100 %

A turning operation is to be performed on a 4.25 inch diameter brass bar using a feed of .025, and a cutting speed of 165 feet per minute. The final diameter will be 4.15 inches with a final length of 7.5 inches. The unit horsepower for 125 HB brass is 0.8 hp-min/in^3. Answer the following questions:

1. (2 pts) There are 2.54 cm in 1 inch. What is the appropriate METRIC feed rate?

$$f = \left(.025 \frac{IN}{REV}\right)\left(\frac{2.54 cm}{IN}\right)\left(\frac{10 MM}{CM}\right) = 0.635 \text{ mm/REV}$$

$$f_r = Nf = (148 \text{ REV/MIN})(.635 \text{ mm/REV}) = 94 \text{ mm/MIN}$$

Use (AND SHOW) U.S. Customary Units for the rest of this page.

2. (5 pts) What is the spindle speed for the cut?

$$N = \frac{V}{\pi D_o} = \frac{(165 \text{ FT/MIN})(12 \text{ IN/FT})}{\left[\pi (4.25 IN)\right]} = \frac{1980 \text{ IN/MIN}}{13.35 \text{ IN/REV}} = 148 \frac{REV}{MIN}$$

3. (3 pts) What is the feed rate for the cut?

$$f_r = Nf = (148 \text{ REV/MIN})(.025 \text{ IN/REV}) = 3.71 \text{ IN/MIN}$$

4. (4 pts) What is the depth of cut for the operation?

$$d = \frac{D_o - D_f}{2} = \frac{(4.25 IN - 4.15 IN)}{2} = 0.05 IN$$

5. (5 pts) What is the material removal rate for the part?

$$MRR = \frac{\pi (D_o^2 - D_f^2) f N}{4} = \frac{\pi\left[(4.25 IN)^2 - (4.15 IN)^2\right]\left(.025 \frac{IN}{REV}\right)\left(148 \frac{REV}{MIN}\right)}{4}$$

$$= 2.44 \text{ IN}^3/\text{MIN}$$

6. (3 pts) How long does the cutting operation take?

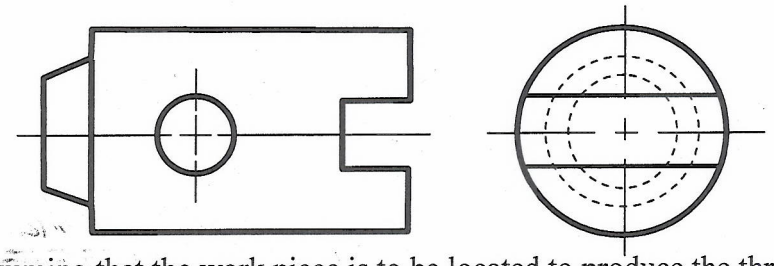
$$T_m = \frac{L}{f_r} = \frac{7.5 IN}{3.71 \text{ IN/MIN}} = 2.02 \text{ MIN}$$

7. (6 pts) If it is 80% efficient, how much rated horsepower should the lathe have?

$$HP_u = \frac{HP_c}{MRR} \quad \text{SINCE} \quad HP_g = \frac{HP_c}{E} \quad \text{THEN} \quad HP_g = \frac{(HP_u)(MRR)}{E}$$

$$HP_G = \frac{\left(0.8 \frac{HP - MIN}{IN^3}\right)\left(2.44 \frac{IN^3}{MIN}\right)}{0.8} = 2.44 \text{ HP}$$

The top and right side views of a part are given below. Answer the following questions:

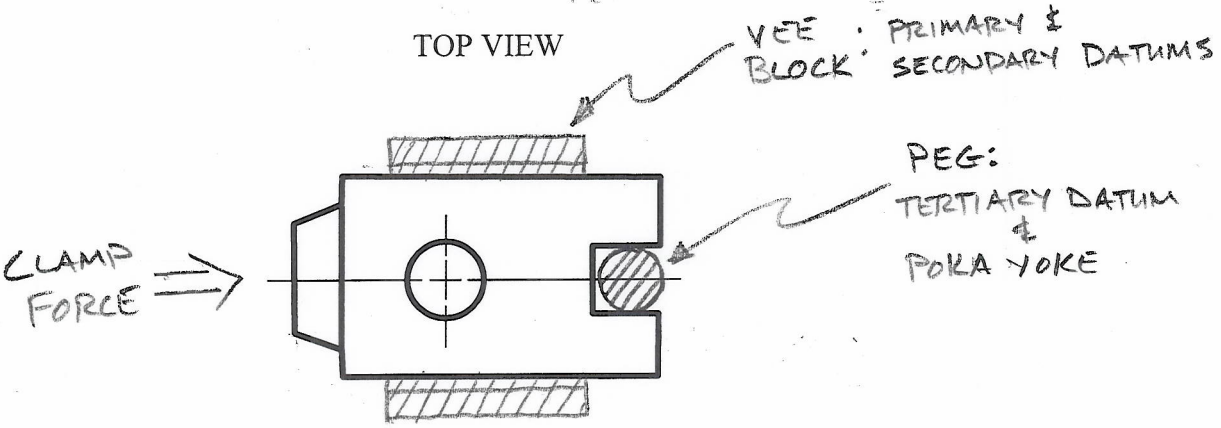


8. (2 pts) Assuming that the work piece is to be located to produce the through hole, what kind of tooling component (term) would be used to keep the part from being incorrectly oriented for the hole production operation?

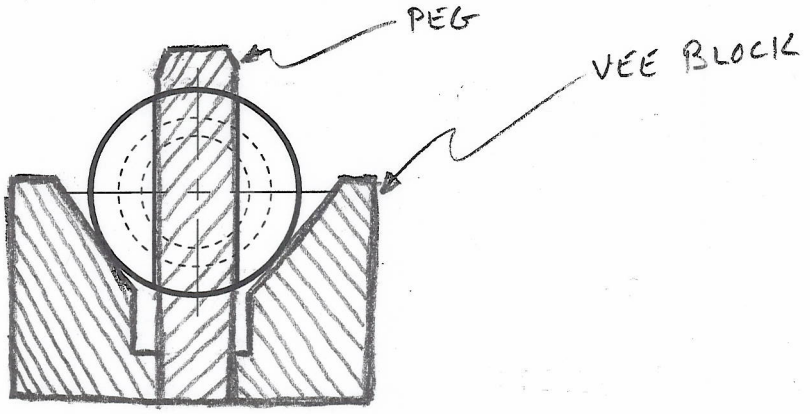
POKA YOKE

9. (10 pts) Sketch your design for a device to constrain the part while drilling the hole (draw TOP and RIGHT views, only):
   a. Use leaders and notes to describe the various features of your design
   b. Indicate appropriate clamping force direction(s) with labeled arrows
   c. Identify (in your TOP view) a feature to correctly orient the part every time

TOP VIEW

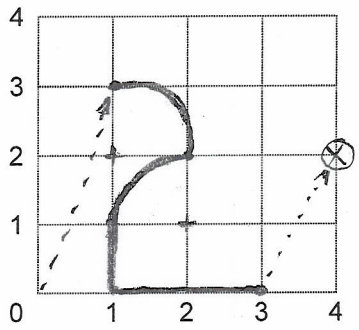


RIGHT SECTION VIEW (rotated 90°, so through hole and slot open upward for drilling)



10. (10 pts, total) A milling operation is performed using the following CNC code. Assuming that the tool begins at a home position above the part top, and that the part home position is at the lower, left corner of the top face (same as in our lab):
Note: Uses FULL CIRCLE INTERPOLATION

```
N10   G90   G94   G70   F5.0   S1800   M03
N20   T04   M06
N30   G00   X1    Y3    Z1
N40   G01   X1    Y3    Z-1
N50   G02   X2    Y2    Z-1    I0      J-1    K0
N60   G03   X1    Y1    Z-1    I0      J-1    K0
N70   G01   X1    Y0    Z-1
N80   G01   X3    Y0    Z-1
N90   G01   X3    Y0    Z1
N100  G91   M05
N110  G00   X1    Y2    Z-1    M02
```



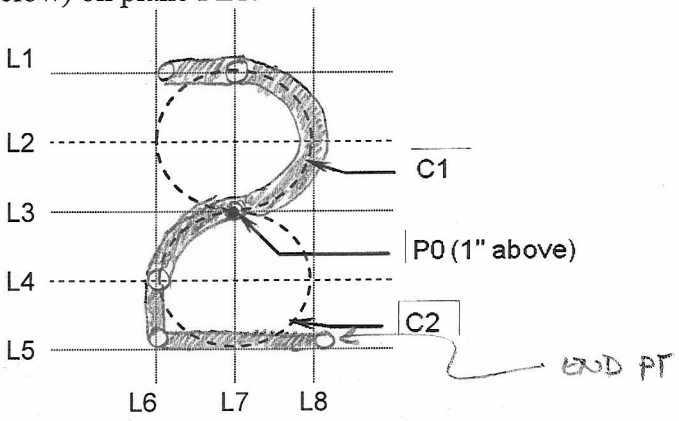
(a) (5 pts) Draw the letter/number **cut** into the part in the 4 x 4 grid (above).

(b) (5 pts) What is the final position of the tool center after the last block?

X = 4 Y = 2 Z = 0

11. (10 pts, total) The following APT code segment cuts a letter or a number on a plane (PL1) that is 0.5 inches below the top surface of the part, and point P0 is 1.0 inches above the center of the part (as shown). Assume the APT geometry statements defined the lines and circles (shown below) on plane PL1:

```
MACHIN/MILL,1
CUTTER/0.75
FROM/P0
GO/ON,L3,TO,PL1,ON,L5
GORGT/C1,TO,L7
GOFWD/L1,TO,L6
GOBACK/L1,TO,L7
GOFWD/C1,ON,L7
GOFWD/C2,ON,L4
GOFWD/L6,TO,L5
GOLFT/L5,PAST,L8
FINI
```



(a) (5 pts) Draw the letter/number **cut** into the part on the diagram (above).

(b) (5 pts) If the intersection of L5 and L8 is at (3.0, 0.0, -0.5), what is the final position of the tip of the tool center after completion of the code?

$3+\left(\frac{.75}{2}\right)=$ $0+\left(\frac{.75}{2}\right)$

X = 3.375 Y = .375 Z = -0.5

12. (3 pts) According to the 1991 figures from J T. Black, what percentage of the selling price is the material that goes into making the typical product?

$(.50)(40\%) = 20\%$

13. (2 pts) For our mill or lathe, what NC code should show up at the end of a program:

a. to make sure the program is backward-compatible with older NC machines?

M30 (REWIND)

b. to be sure the machine starts at a known, physical location before each part?

G28 (HARD) HOME

14. (15 pts) Estimate the break-even quantity (N) for a new set of tooling, if:

a. The cost of the tooling is $ 8 500.
b. The same machines will perform the operation, regardless of whether the tool is used or not, and they cost $12.50/hr (including all labor overhead);
c. The operator cost is $15/hr with the new tooling;
d. The operator cost without the tooling is $20/hr;
e. It takes 1 hour to produce 25 pcs without the tooling;
f. The production rate with the tooling is 35 pcs/hr;
g. The tool life is 4 years (interest rate is 2% per year, compounded annually)

$$(R+R_m)t - (R_t+R_m)t_t \geq \frac{C_t}{N}\left[\frac{i(1+i)^n}{(1+i)^n-1}\right]$$

$$\Rightarrow N\left[(R+R_m)t - (R_t+R_m)t_t\right] \geq C_t\left[\frac{i(1+i)^n}{(1+i)^n-1}\right]$$

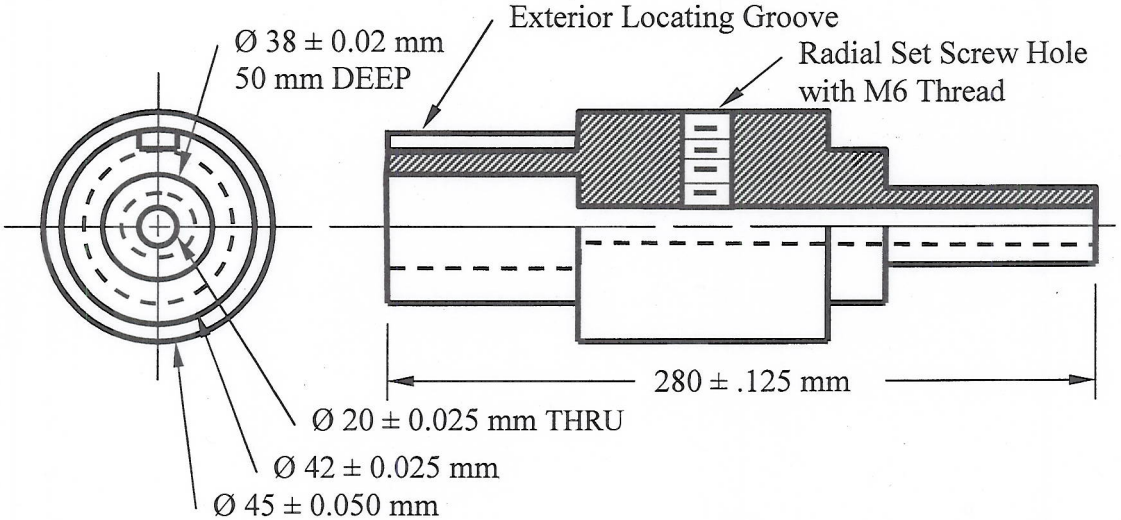
$$\Rightarrow N \geq \frac{C_t\left[\frac{i(1+i)^n}{(1+i)^n-1}\right]}{(R+R_m)t - (R_t+R_m)t_t}$$

$$N = \frac{(\$8500)\left[\frac{.02(1+.02)^4}{(1+.02)^4-1}\right]}{\left(\frac{\$20+\$12.50}{HR}\right)\left(\frac{1\,HR}{25\,PCS}\right) - \left(\frac{\$15+\$12.50}{HR}\right)\left(\frac{1\,HR}{35\,PCS}\right)} = \frac{(\$8500)(.26262)}{(\$1.30)-(\$0.786)}$$

$$= 4343\ PCS$$

Construct the specified GT code for the following part, initially made from thick-walled, magnesium tube stock. Support your answer on each digit for credit.

Note: Above the axis is an interior section view; below is the un-sectioned exterior view.



15. (20 pts) Opitz:

2	6	1	3	3	-	1	7	3	5
(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)	(9)

(1): $L/D = \frac{280}{45} = 6.22 > 3 \Rightarrow (2)$

(2): EXTERNAL: STEPPED TO BOTH ENDS, W/ FUNCTIONAL GROOVE ⇒ (6)

(3): INTERNAL: STEPPED TO ONE END, NO SHAPE ELEMENTS ⇒ (1)

(4): GROOVE IS A PLANAR, MILLED FEATURE ⇒ (3)

(5): NO GEAR TEETH, RADIAL HOLE NOT ON PITCH CIRCLE DIA. ⇒ (3)

(6): D = 45 (>20, ≤ 50) ⇒ (1)

(7): MAGNESIUM IS NON-FERROUS ⇒ (7)

(8): ORIGINAL MATERIAL WAS TUBE ⇒ (3)

(9): 2 DIGITS & 3 DIGITS ACCURACY ON DIAMETERS ⇒ (5)

This is the end of the exam. Put your name on the front, gather your materials quietly, and turn this in as you leave.