National Examinations – May 2013

07-Mec-A4, Design and Manufacture of Machine Elements

3 Hours Duration

Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an open book examination. Candidates may use any non-communicating calculator.
3. There are 8 questions on the following 6 pages, divided into Part A and Part B. Answer three (3) questions from Part A and two (2) questions from Part B. 5 (five) questions constitute a complete paper. Only the first five questions, as they appear in your answer book, will be marked. Clearly cross off any question you do not want marked.
4. All questions are of equal mark value (20%).

PART A: Choose any three (3) problems from part A.

Q1

In a surface grinding operation, the grade of the only available grinding wheel is "T" (hard). During grinding, the workpiece surface shows discoloration indicating the burning of the surface. The shop foreman suggest using a softer wheel.

(a) Is this a sound advice? Why?

It turns out no other grinding wheels are available. The same foreman states that the wheel can be made to behave softer if cutting conditions are changed.

(b) Is the foreman right? If yes which cutting condition and how?

Q2

An automotive part formed by pressing pressing fails in production. The part is formed by almost pure stretching, using drawbeads in the dies. (a) What would you do to analyze the problem? (b) What is the likely strain state at the point of fracture (use forming limit diagram). (c) Indicate in the FLD two possible remedies, keeping the shape of the pressing unchanged. (d) If none of this works, what else could be attempted?

Q3

A lever-shaped component is made by bending a blanked form. In the middle of a large production run, it is noted that a number of parts fracture, partially or fully, during bending. (a) Suggest the most likely cause, assuming that all blanks are sheared from the same batch of material, and suggest remedies in the (b) blanking and (c) bending operation.

Q4

A cast iron, T-type fitting is being produced for the oil drilling industry, using an air-set or no-bake sand for both the mold and the core. Figure S3 shows a cross section of the mold with the core in place (Figure S3.a), and a cross section of the finished casting (Figure S3.b). Note that there are several significant defects. Gas bubbles are observed at one location in the base of the tee. A penetration defect is observed near the bottom of the inside diameter, and there is an enlargement of the casting at location "C".

(a) Why are these gas bubbles present only at the location noted?

(b) What factors may have caused the penetration defect?

(c)What factors led to the enlargement of the casting at point "C"?

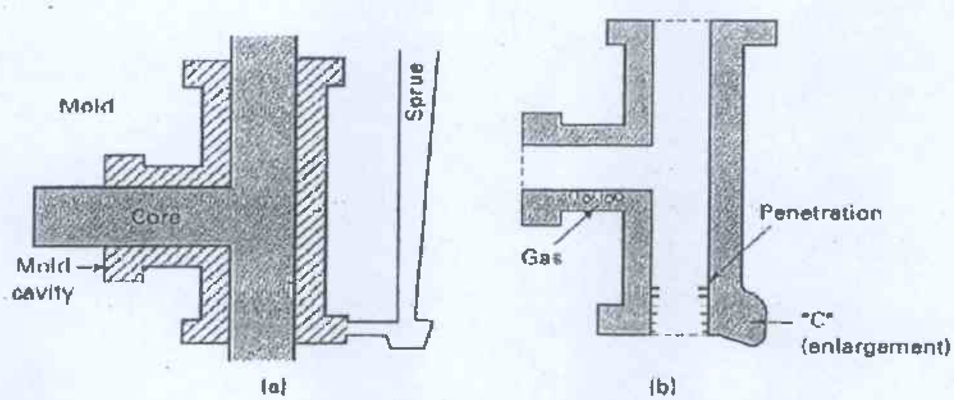

Fig. S3

Q5

The Figure S4 shows a crank loaded by a force F=190 lbf which causes twisting and bending of the ¾-in-diameter shaft fixed to a support at the origin of the reference system. The material of the shaft AB is hot-rolled AISI 1 steel (yield strength S_y = *32 kpsi* and tensile strength S_{ut} = 58 kpsi). Using the maximum-shear-stress theory, find the factor of safety based on the stress at point A.

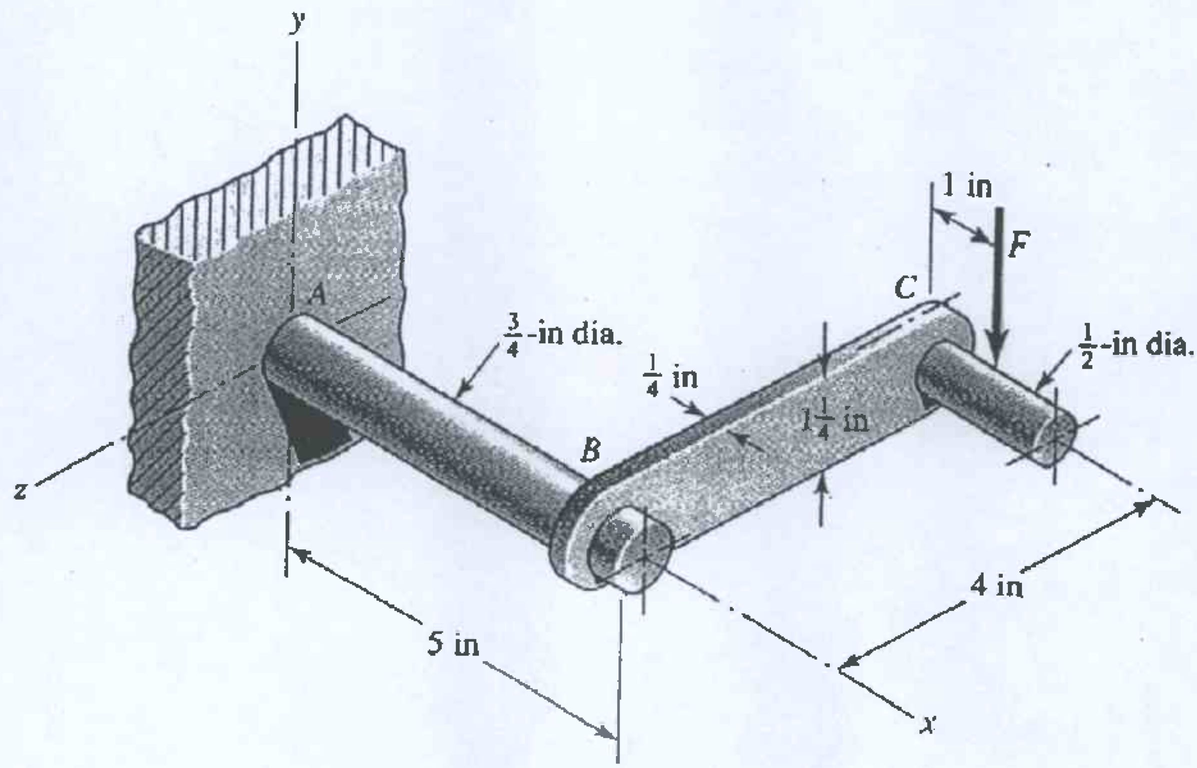

Fig. S4

Q6

The rotating solid steel shaft in Figure S5 is simply supported by bearings at points B and C and is driven by a gear (not shown) which meshes with the spur gear at D, which has a 6-in pitch diameter. The force F from the drive gear acts at a pressure angle of 20 degrees. The shaft transmits a torque to point A of $T_A = 3000\ lbf.in.$ The shaft is machined from steel with $S_y = 60\ kpsi$ and $s_{ut} = 80\ kpsi$. Using a factor of safety of 2.5, determine the minimum allowable diameter of the 10 in section of the shaft based on (a) a static yield analysis using the distortion energy theory and (b) a fatigue-failure analysis. Assume sharp fillet radii at the bearing shoulders for estimating stress concentration factors.

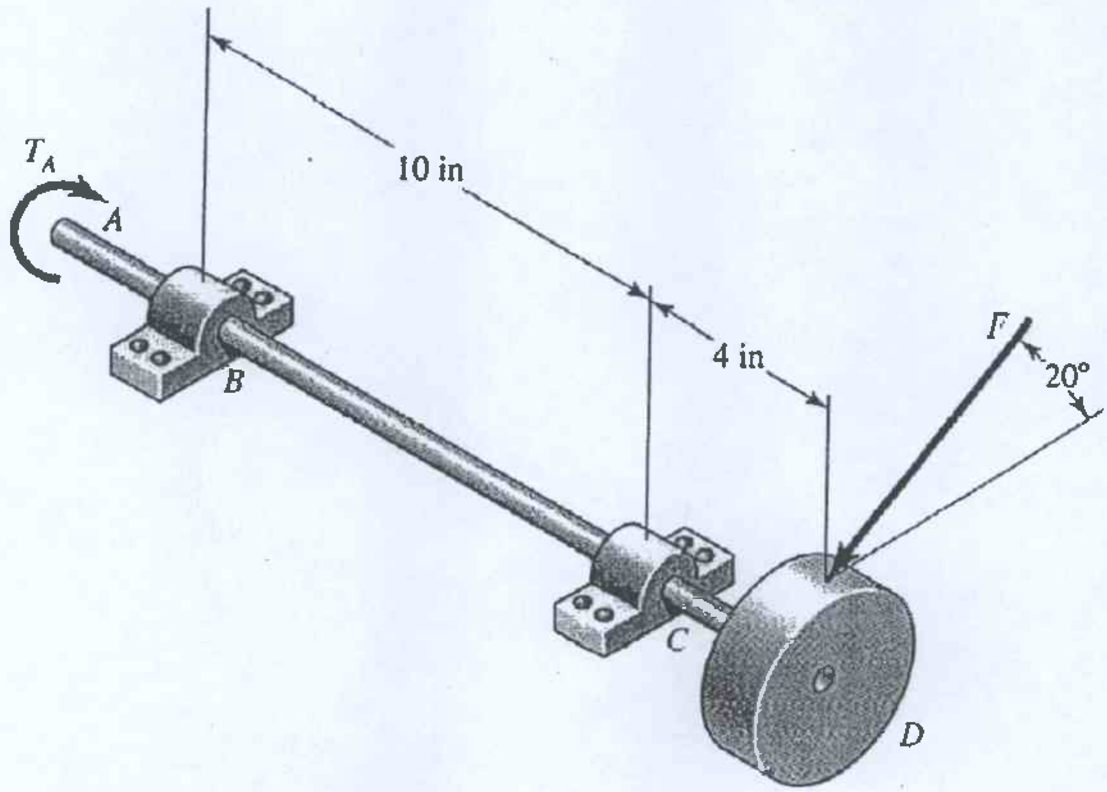

Fig. S5

Q7

A vertical channel 152 x 76 has a cantilever beam bolted to it as shown in Figure S6. The channel is hot-rolled AISI 1006 steel. The bar is of hot-rolled AISI 1015 steel. The shoulder bolts are M12 x 1.75 ISO 5.8. For a design factor of 2.8, find the safe force F that can be applied to the cantilever.

Use the following information:

Bolts; Sp= 380 Mpa, Sy=420 Mpa

Channel: t = 6.4 mm, Sy=170 Mpa

Cantilever: Sy= 190 MPa

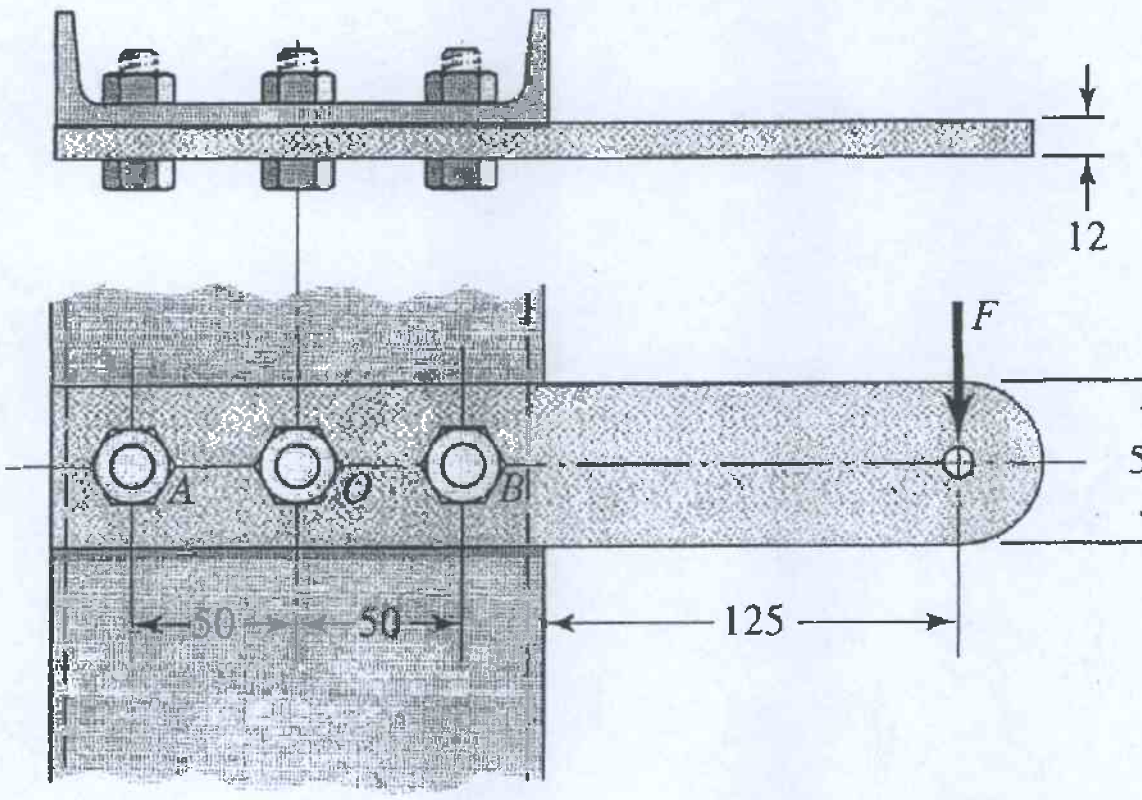

Fig. S6

- Q8
- Without bracing, a machinist can exert only about 100 lbf on a wrench or tool handle. The lever shown in the Figure S7 has t= 0.5 in and w = 2 in. We wish to specify the fillet-weld size to secure the lever to the tubular part at A. Both parts are of steel, and the shear stress in the weld throat should not exceed 3000 psi. Find a safe weld size.

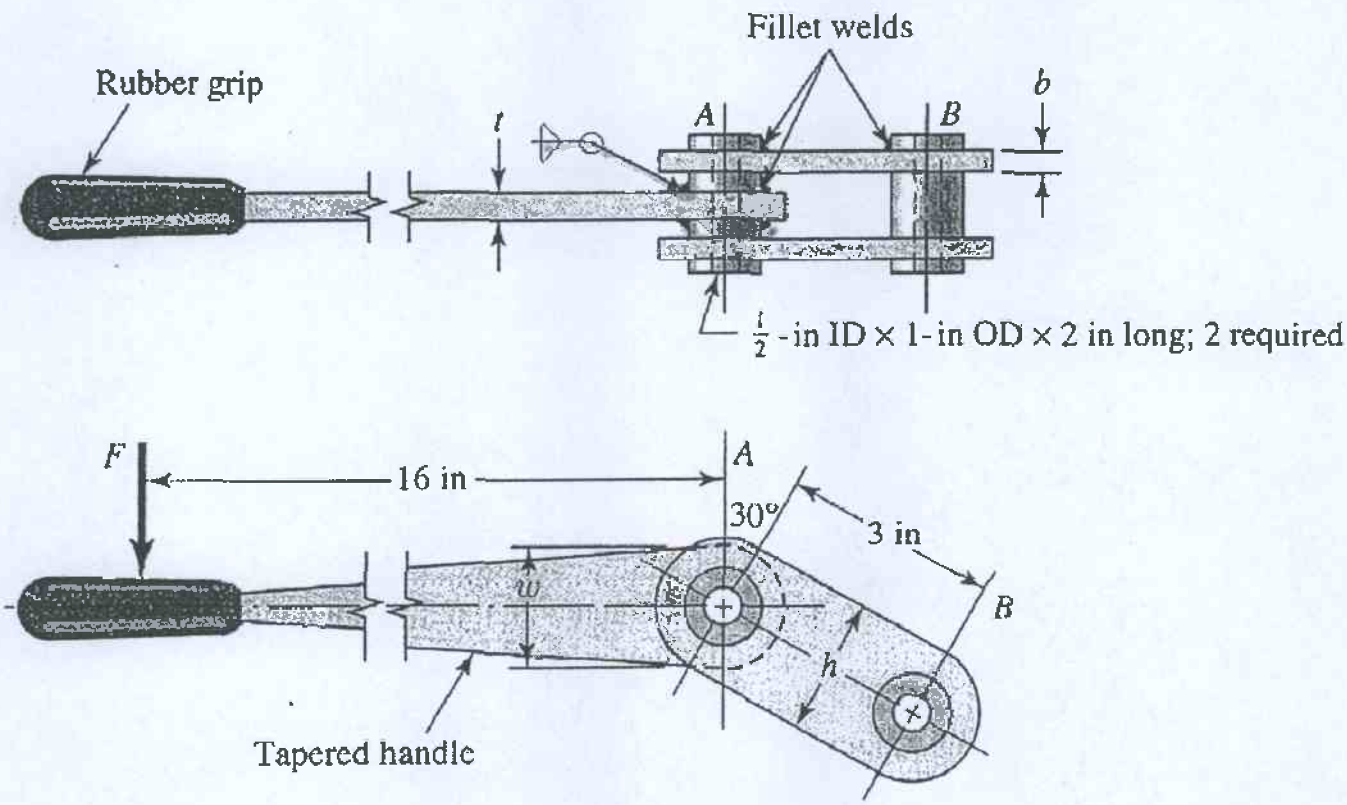

Fig. S7