ME 1029 Mechanical Design 2

Fall 2021

Student Name (Last, First): _____

Student ID: _____

Section Exam 03

(Total Points: 111)

Instructor: Prof. Ping C. Sui

Test Date: December 8, 2021

Total Points:

Question 01. (5 points)

A machine screw is found with no information given as to its size. The following data are found by using a standard micrometer caliper: The major diameter is 0.196 in; the axial length for 20 full threads is 0.630 in.

Identify this thread based on provided information in Table 8-1 and 8-2.

Scored Points:

Question 02 (6 points)

Define the term proof strength and preload.

Proof Strength	
Preload	

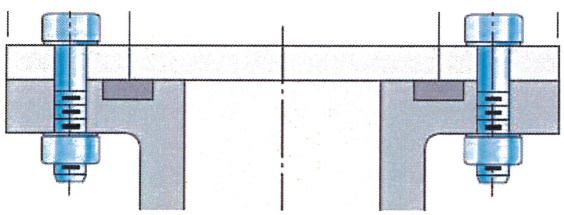
Question 03 (4 points)

A preloaded ordinary bolted joint carries axial loads. The preload is Qp, the external load is F. The total load the bolt carries is _____.

(a) = Qp +F (b) < Qp +F (c) > Qp +F (d) = Qp +F/2

Question 04 (6 points)

For a cylinder illustrated below with constant force inside, by increasing the bolt grip length of the joint while keeping everything else the same, in principle, does this design change make it easier or more difficult to leak? State your reason.



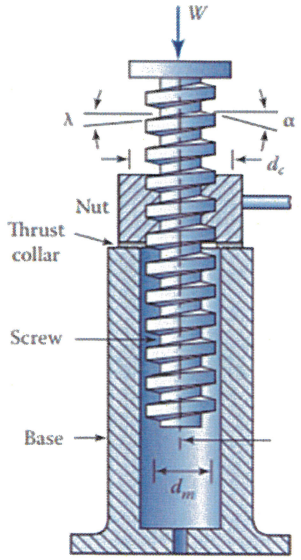
Question #5. (38 points)

Scored Points:

A power-lifting device as shown below is driven by a hydraulic motor of 5 hp. The lifting force is supported by a double-threaded, ACME power screw which has a major diameter of 2 inches. The power screw pair is made of steel screw and bronze nut.

a) Specify the thread profile details (5 points)

Items	Unit	Values
Pitch	in	
Thread Depth	in	
Minor Diameter	in	
Lead per turn	in	
Tensile Stress Area	in^2	



b) Hydraulic motor is capable of turning the power screw at 1.5 revolutions per second. Friction coefficients on threads is 0.1 and on collar is 0.15. The friction collar diameter (d_c) is 2.5 in. What is the max lifting force W can be generated by the motor? (10 points)

c) Check whether the screw jack is self-locking or not. (3 points)

d) What is the efficiency of the screw? (3 points)

Assume 40 percent of the screw axial load is carried by the first engaged thread.

e) Calculate the average bearing pressure on the thread flank face and its safety factor. Use the maximum value of the material pair as the limiting strength. (4 points)

f) Calculate the max transverse shear on the first engaged thread. (3 points)

g) Calculate safety factor against static failure at the root of the thread body per Distortion Energy Theory. (7 points)

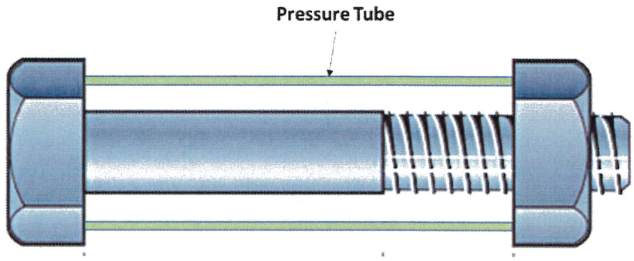
h) Will the thread survive the operation per calculated safety factor? If not, identify the riskiest failure mode. (3 points)

Question #6. (22 points)

Scored Points:

A 300mm long steel pressure tube is clamped between a M20 X 1.5 UNF 316mm long, Grade 5.8 bolt and a regular hexagonal nut. The tube outer diameter is 28mm and inner diameter is 20 mm. Modulus of the steel tube is 207 GPa.

a. Determine the bolt stiffness, the tube stiffness, and the joint constant C. (15 points)
b. Apply a one-fourth turn on the nut, calculate the tension force in the bolt. (7 points)



Question #7. (30 points)

Scored Points:

A non-permanent connection uses the 1/2 in-20 UNF SAE grade 5 bolt to tighten a steel cylinder head to a steel flange of a pressure vessel. Thickness of both the cylinder head and the flange are 0.675 in.

Washer is used on both sides of clamping surface. Mating washer is a type-N and the nut is a regular hexagonal type. Total bolt length includes two threads beyond nut height and then is rounded to the next nearest fraction or decimal length per Table A-17.

Preload the joint to 75 percent of the bolt proof strength with torque factor of 0.2. Gas pressure inside the pressure vessel fluctuates between 20 kips and 120 kips. Assume the load is equally distributed to all bolts. Apply a safety factor of 1.5 for risk assessment.

a. Report calculated total bolt length and grip length. (4 points)
b. Calculate the bolt stiffness, member stiffness, and stiffness coefficient. Calculate member stiffness with D=1.5 times bolt diameter and $\alpha=30°$. (10 points)
c. Calculate preload on the bolt. (4 points)
d. Determine the minimum number of bolts to avoid overloading the bolts by gas pressure. (3 points)
e. Determine the minimum number of bolts to avoid joint separation. (3 points)
f. Determine the minimum number of bolts to avoid bolt fatigue. (4 points)
g. Consider the failure scenarios in d, e, and f, what is the recommended minimum number of bolts? (2 points)

Summary	Results	Unit
Bolt length		in
Bolt grip length		in
bolt stiffness		Mlbf/in
member stiffness		Mlbf/in
stiffness coefficient		
preload		lbf
number of bolts to avoid overloading		
number of bolts to avoid joint separation		
number of bolts to avoid bolt fatigue		
recommended minimum number of bolts