ME 328 – Machine Design
Quiz 2– Closed book, closed notes, NO calculator
February 12, 2020

This exam is MY work, and my work ONLY:

Signature:

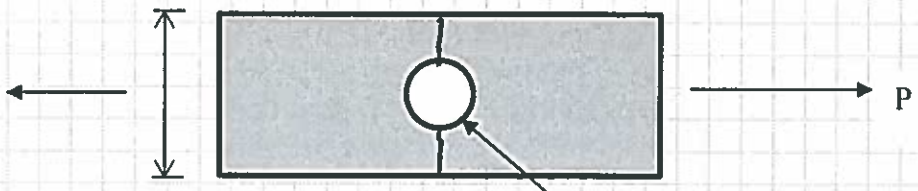
Print name:

For full credit, you must show units at every step and show variable form of equations before inserting values. Values must include units at every step. Since you do not have a calculator, you do not need to calculate the answer, but solve it symbolically (with variables only) and then include appropriate numbers so that if you had a calculator it would be a matter of simple number crunching. If you don't have values for all parameters, leave them as variables in your final equation. If you cannot calculate answers with the information provided in this exam, explain why and/or what information would be required.

Use the following material properties for applicable problems:

	Steel	Ceramic
Young's modulus	30 Mpsi	10 Mpsi
Density	0.3 lb/in^3	0.1 lb/in^3
Poisson's ratio	0.33	0.3
Yield strength	100 kpsi	N/A
Tensile strength	150 kpsi	10 kpsi

1. The 15-inch-wide ceramic plate shown below is 2 inches thick. The stress concentration factor, K_t, at the 5" diameter hole is 3. A uniformly distributed axial force, P, is applied.
   a. Describe the failure and failure location – include a sketch to show failure location.
   b. What force, P, is required to cause the plate to "fail"?



a) Ceramic is brittle (no S_{ys} given) ∴ brittle fracture will begin @ stress concentration and immediately the part will break!

b) Failure (brittle fracture): $\sigma_1 \geq S_{ut}$ $\quad \sigma_1 = \sigma_{max} = K_t \sigma_{nom}$

$$\sigma_1 = K_t \sigma_{nom} = \frac{K_t P}{A} = \frac{K_t P}{t(w-d)} = S_{ut} \Rightarrow P = \frac{S_{ut}\, t(w-d)}{K_t}$$

$$= \frac{\left(10 \frac{kip}{in^2}\right)(2in)(15in-5in)}{3} = \frac{200}{3} kip = \underline{67{,}000\ lb}$$

2. a) Explain why bearings and gears may experience "spalling" failures as a result of Hertzian contact stress. Spalling example of a bearing is shown here (spalling is also referred to as "pitting" failure – but it is ***not*** pitting corrosion):

With use, fatigue cracks originate at locations of highest shear stress. Highest shear stress is just under the surface. The cracks grow from there to the surface cause material to 'spall' ('flake off')

b) i) Where is the maximum magnitude normal stress due to Hertzian contact stress located in the spherical element? Let a=radius of the contact area.

a) at the surface (where the sphere contacts the inner race, z/a=0)

b) at a very small distance from the surface (about z/a=0.5)

c) at a moderate distance from the surface (about z/a=5)

d) at a relatively large from the surface (about z/a=50)

ii) Where is the maximum shear stress due to Hertzian contact stress located in the spherical element? Let a=radius of the contact area.

a) at the surface (where the sphere contacts the inner race)

b) at a very small distance from the surface (about z/a=0.5)

c) at a moderate distance from the surface (about z/a=5)

d) at a relatively large distance from the surface (about z/a=50)

iii) Circle the best answer:

a) all three principal stresses due to Hertzian contact are compressive.

b) all three principal stresses due to Hertzian contact are tensile.

c) Two of principal stresses due to Hertzian contact are compressive, one is tensile

d) One of principal stresses due to Hertzian contact is compressive, two are tensile