ME 328 – Machine Design
Exam 1– Closed book, closed notes, NO calculator
February 13, 2019
Possible points 60pts (plus 2 pts extra credit)

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. If it is not possible to answer the question based upon the information given, briefly explain what information would be needed, make an assumption about that information, and proceed.

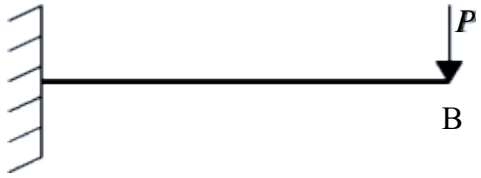
Use the following material properties for applicable problems:

	Steel	Ceramic
Young's modulus	200 GPa	20 GPa
Density	8000 kg/m^3	2500 kg/m^3
Poison's ratio	0.30	0.25
Yield strength	100 MPa	N/A
Tensile strength	150 MPa	10 MPa

Some equations:
$E=mc^2$, $F=ma$, $KE = \frac{1}{2} mv^2$, $PE = mgh$, $C=\pi D$, $A=\pi D^2/4$, $I=1/12\ bh^3$, $J=\pi D^4/32$, $\tau=Tr/J$, $\sigma=My/I$

Beam deflection charts, L is the total length of the beam:

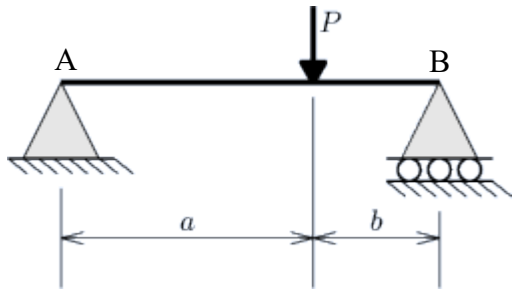
Chart 1



$$\delta_B = \frac{PL^3}{3EI}$$

$$\theta_B = \frac{PL^2}{2EI}$$

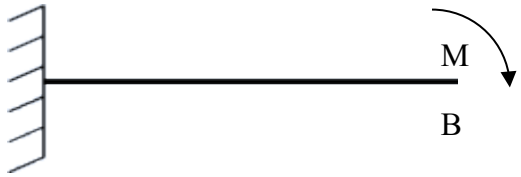
Chart 2



$$\theta_A = \frac{Pab(L+b)}{6LEI}$$

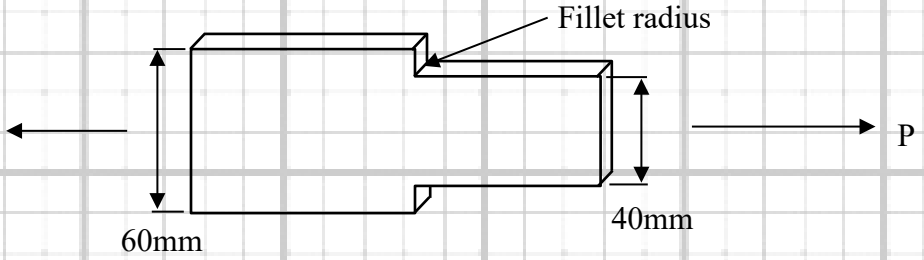
$$\theta_B = \frac{Pab(L+a)}{6LEI}$$

Chart 3

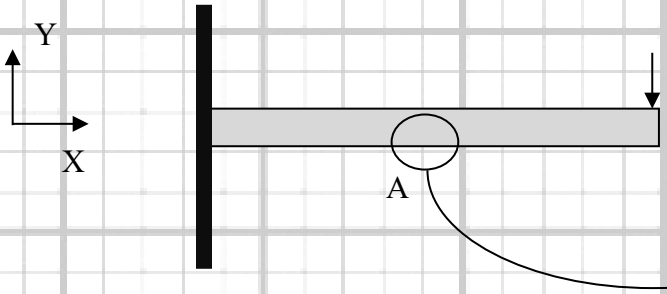


$$\theta_B = \frac{ML}{EI} \qquad \delta_B = \frac{ML^2}{2EI}$$

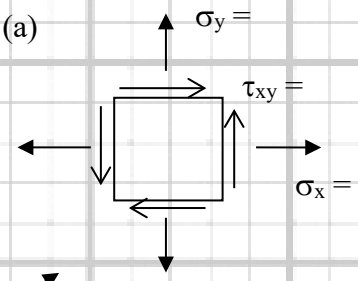
1. (15 pts) A plate shown below is 10mm thick. The stress concentration factor at the fillet radius is 5. An axial force, P, is applied.
   a) If the plate was **steel**, what is the maximum force, P, before the plate would "fail?" Briefly, explain what you define as "failure" and describe where it would occur.
   b) If the plate was **ceramic**, what is the maximum force, P, before the plate would "fail?" Briefly, explain what you define as "failure" and describe where it would occur.



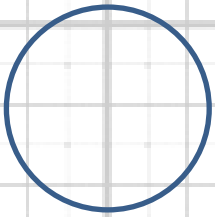
2. (20 pts) A 100 inch-long cantilever steel beam is loaded at the end as shown below. The maximum bending stress (σ=My/I) in the beam is calculated to be 10ksi.
   a) What are σ_x, σ_y, and τ_{xy} for a point at the bottom surface of the beam at the mid-length (Point A, 50 inches from the attachment)?
   b) Draw Mohr's circle for Point A. Use the circle below. Add the appropriate axes, labels, scales, etc.).
   c) What are the three principal stresses and maximum shear stress at Point A?
   d) What is the angular deflection at the mid-length (point A)? You do NOT need to do complete calculations but do set up the appropriate equations in variable form and then include all numbers possible. Include relevant FBD's.



(a)



b)



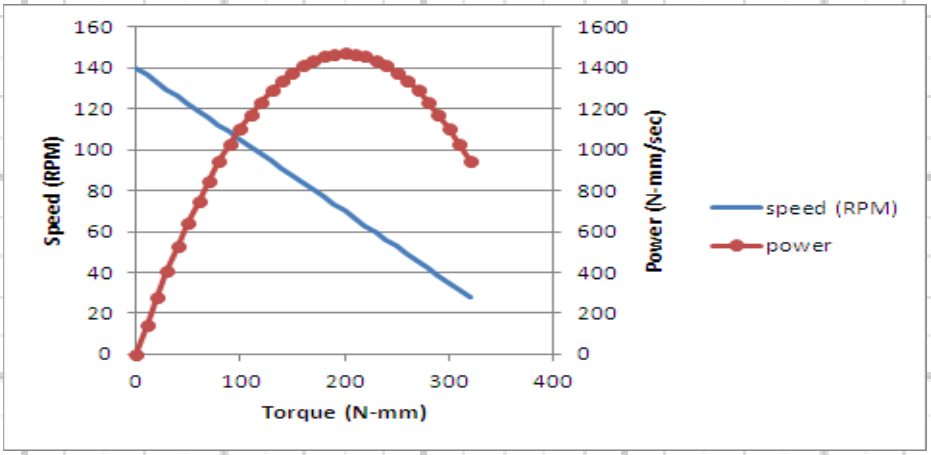
c)

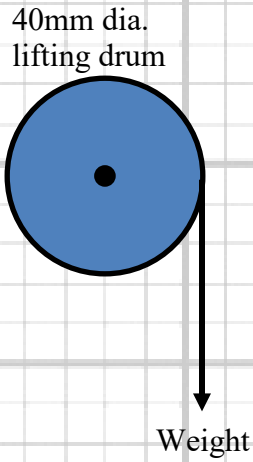
d)

3. (20 pts) Gear ratios are expressed as fractions or ratios: $\omega_{driving} / \omega_{driven}$ or typically $\omega_{driving}:\omega_{driven}$ or $\omega_{in}:\omega_{out}$ (input speed to output speed). Consider a DC electric motor with the performance curve shown below.

Similar to the "lego test stand" available for the project, a string is wrapped around a 40mm diameter lifting drum and is used to lift small weights vertically. Unlike the lego test stand, there are gears between the motor and the lifting drum.

a) If the gear ratio is 2:1, what is the output speed (the speed of the lifting drum) if no load (0kg) is applied? Express your answer in revolutions per minute.
b) If a gear ratio was designed for lifting a 2kg load as fast as possible, how long will it take to raise load 300mm assuming constant velocity? Assume $a_g=10m/s^2$.





4) (5 pts) Briefly define and/or describe the following:

a) dislocation

b) brittle fracture

5) (2 pts extra credit): what is a Zerk fitting?

EXTRA SPACE FOR WORKING PROBLEMS: