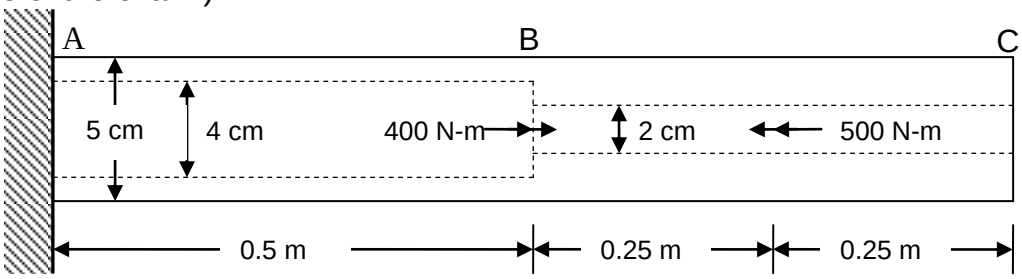
EM 203 Exam 1 Fall 2007 Problem # 1 40 pts

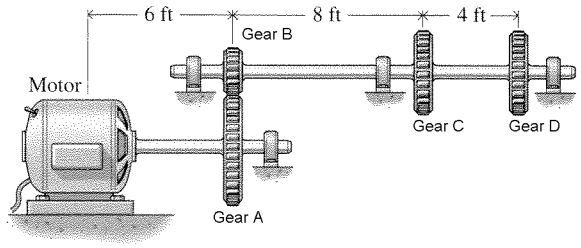
Consider the pipe shown below. It is a 17-7 PH (17 Cr 7 Ni, precipitation hardened) stainless steel pipe with an outside diameter of 5 cm and an inside diameter of 2 cm. Section AB has been hollowed out to create an inside diameter of 4 cm. (Material properties for 17-7 PH pipe are given on the last page of the exam.)



a) What is the maximum shear stress in section AB?
b) Consider an angle β that is 15° counter-clockwise from the horizontal. On that plane, what is the normal stress in section AB?
c) What is the shear stress on an oblique plane at β=45° in section AB?
d) What is the angle of twist at A, with respect to its unloaded position?
e) What is the angle of twist at B, with respect to its unloaded position?

EM 203 Exam 1 Fall 2007 Problem # 2 30 pts

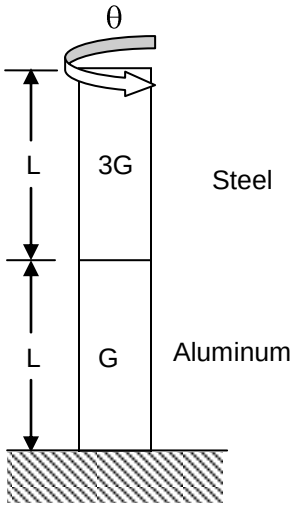
Consider the motor and gears shown below. The motor develops 100 hp at a speed of 360 rpm. Gear D delivers 60 hp to operating units in a factory. Gear B is 1/6 the radius of Gear A. The shaft BCD is 1" in diameter.



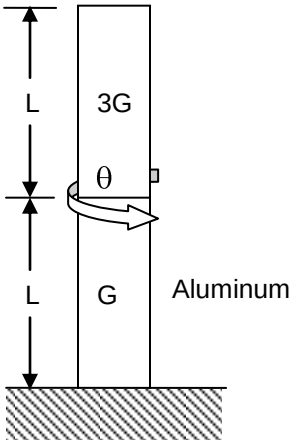
a) What is the power delivered by Gear C? (Neglect frictional losses.)
b) What is the rpm of the shaft BC?
c) What is the rpm of the shaft CD?
d) What is the torque in shaft BC?

EM 203 Exam 1 Fall 2007 Problem # 3 30 pts

Consider the vertically mounted bi-metal shaft shown below. The top half of the shaft is steel, and the bottom half is aluminum, and both shafts have radius c.



a) The top end of the steel is twisted through an angle θ with respect to its unloaded position. What is the torque in the steel? What is the torque in the aluminum? (Express your answer in terms of G, L, θ, and c.) Be sure to draw the free body diagram.



b) Now suppose that, instead, we apply the twist θ at the joint between the steel and the aluminum. What is the torque in the steel now? What is the torque in the aluminum? (Express your answer in terms of G, L, θ, and c.) Be sure to draw the free body diagram.

Material properties for 17-7 PH stainless steel

Yield stress, σ_y	1310 MPa
Ultimate tensile stress, σ_{uts}	1450 MPa
Modulus of elasticity, E	204 GPa
Shear modulus, G	100 GPa
Density, ρ	7650 kg m^{-3}
Melting temperature, T_m	1600 K
Coefficient of thermal expansion, α_{CTE}	11 ppm $°C^{-1}$

Did you draw the FBD?