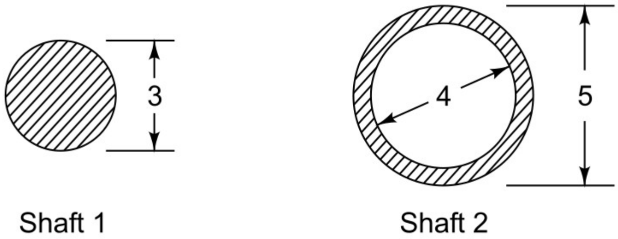
ME231: Tutorial – V

November 10, 2020

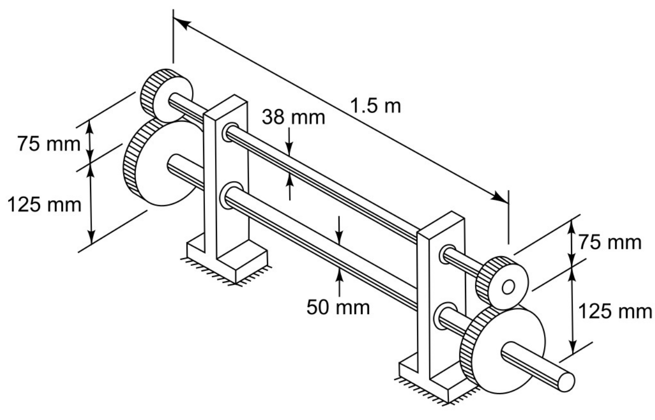
Q.1: Consider the a solid shaft (Shaft 1) and a hollow shaft (Shaft 2) having same cross-sectional area, as shown in the figure. Determine the ratio of maximum stress and torsional stiffness for same amount of twisting moment applied to both the shafts.



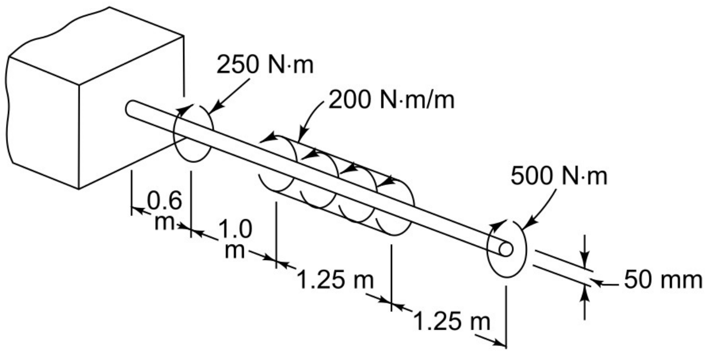
Q.2: Compare the stresses in a uniform thin-walled circular shaft as predicted by the approximate theory of thin section and as predicted by the exact theory (stresses in hollow shaft).

Q.3: A composite shaft is made up of an inner circular cylinder of elastic material with shear modulus G_1 and an outer circular annulus of elastic material with shear modulus G_2. The materials are bonded securely at the interface r_i. Derive formulas for the twist angle ϕ and for the shear stress $\tau_{\theta z}$ which result from the application of the twisting moment M_t.

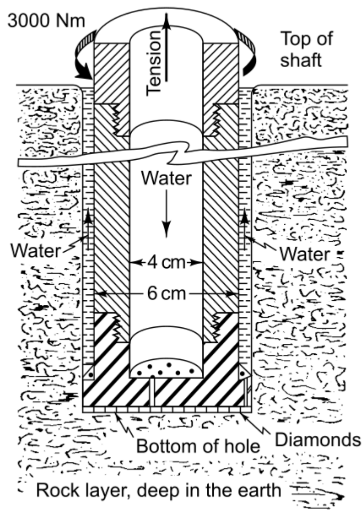
Q:4: In testing the fatigue behavior of gears, the illustrated system of gears and shafts is frequently employed. The parts are made so that in assembly it is necessary to hold one of the 75 mm gears stationary and rotate the corresponding 125 mm gear through a 3° angle in order to get the gears to mesh. There is a "locked-in" torque in the system, and when the system is driven by application of an external torque to one of the gears, the system of gears and shafts constitutes a power loop in which the average power is much larger than the externally supplied power. Calculate the maximum shear stresses in the two shafts after they are assembled but before external torque is applied. The shafts are made of 1020 CR steel.



Q.5: Find the distribution of twisting moment and angle of twist distribution along the steel shaft shown.



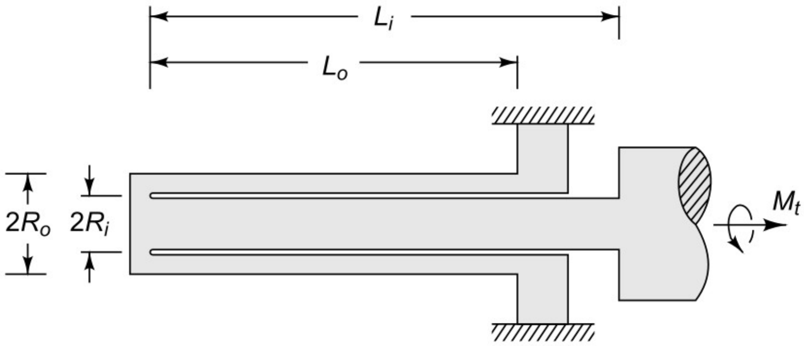
Q.6: A diamond-drill boring machine consists of a steel bit set with diamonds which is rotated by means of hollow steel rods coupled by screw joints. Water is forced through the hollow rods by a pump, and returns to the surface through the annular space between the rods and the walls of the hole, carrying the cuttings with it. Enough tension is maintained at the top of the shaft so that the compressive force between the bit and the bottom of the hole is small. If a torque of 3000 Nm is applied to the top of the shaft, how deep would the hole be when yielding begins in the shaft? The yield stress in simple tension is $Y = 350$ MPa. Use either the Mises or maximum shear yield criterion.



Q.7: The compact torsion-bar spring sketched below consists of an inner shaft of radius R_i and a sleeve whose outer radius is R_o . There is a very small clearance between the shaft and the inner surface of the sleeve. The material has an elastic shear modulus G and a yield stress in shear of τ_Y .

(a) Determine the torsional spring constant of the spring under the action of the twisting moment M_t .

(b) In a well-designed spring the outer sleeve will yield under the same twisting moment as the inner shaft. Develop an equation for determining the ratio R_o/R_i in order that this will occur.



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