UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

MEC 3351 – STRENGTH OF MATERIALS I

Torsion Assignment Preparation Sheet **Due Date: 10th May 2024**

Prepare to ALL questions but you will be required to answer THREE questions upon advice on the due date.

1. The two solid steel shafts shown in Figure Q1 are coupled together using the meshed gears. Determine the angle of twist of end *A* of shaft *AB* when the torque *T* = 45 Nm is applied. Take *G* = 80 GPa. Shaft *AB* is free to rotate within bearing *E* and *F*, whereas shaft *DC* is fixed at *D*. Each shaft has a diameter of 20 mm.

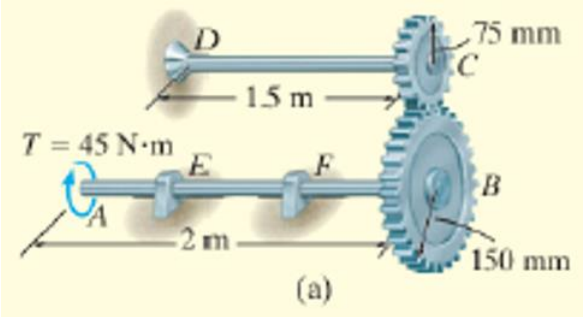

Figure Q1

2. A shaft tapers uniformly from a radius *(r + a)* at one end to *(r - a)* at the other. If it is under the action of an axial torque *T* and *a = 0.1r*, find the percentage error in the angle of twist for a given length when calculated on the assumption of constant radius *r*.

3. A gun metal sleeve is fixed securely to a steel shaft as shown in Figure Q3. The compound shaft then subjected to a torque. If the torque on the sleeve is twice the torque on the shaft, find the ratio of external diameter of the sleeve to the diameter of the shaft. Given that the modulus of rigidity for steel is 2.5 time that of the gun metal.

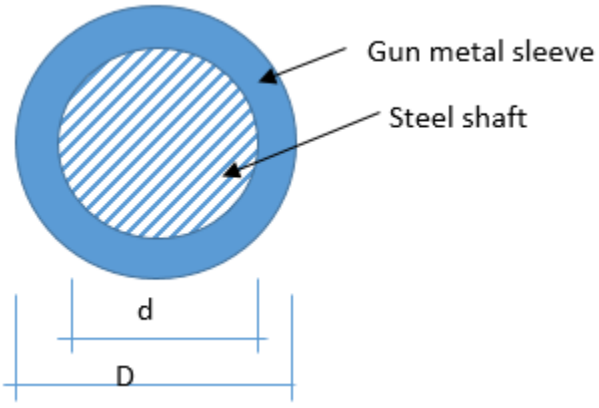

Figure Q3

4. The solid steel shaft *DF* in Figure Q4 has a diameter of 25mm and is supported by bearings at *D* and *E*. It is coupled to a motor at *F*, which delivers 12kW of power to the shaft while it is turning at 50 rev/sec. If gears *A*, *B*, and *C* remove 3kW, 4kW, and 5kW respectively,

   a) Determine the maximum shear stress in the shaft within regions *CF* and *BC*. The shaft is free to turn in its support bearings *D* and *E*.
   b) Determine the absolute maximum shear stress developed in the shaft.

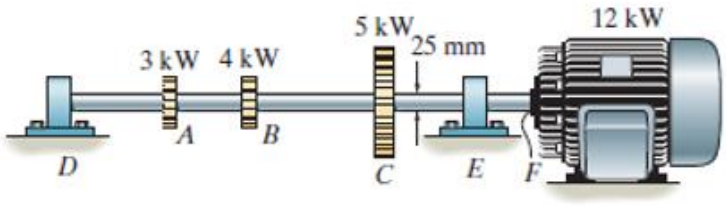

Figure Q4

5. A shaft is required to transmit 50 H.P at 240 rpm. The maximum torque maybe twice the mean torque. The shear stress in the shaft should not exceed 400kg/cm^2 and twist angle 1^o per metre. Determine the external diameter, if

   a. The shaft is solid.
   b. The shaft is hollow and external diameter is 1.5 times the internal diameter.

   Take the modulus of rigidity of the shaft material in both cases to be 8 x 10^{5}kg/cm^2.