Sheet (1) Problems on Design of Shafts

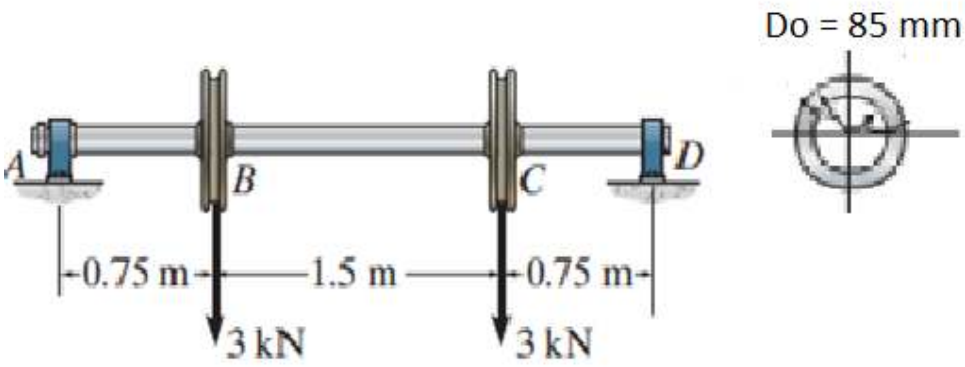
Problem (1)

A centrifugal pump is driven by **10 kW** power **1440 rpm** electric motor. The design toque is 150% of the rated torque. The motor and pump shafts are made of plain carbon steel 40C8 (**Sy= 380 MPa**) and the factor of safety is **4**. Determine the diameter of the motor and pump shafts.

Problem (2)

The shaft shown below transmits power of **10 kW** at speed of **300 rpm** through from pulley **B** to pulley **C.** The shaft is supported on a smooth thrust bearing at ***A*** and smooth journal bearing at **D.** If the shaft has a hollow cross section as shown in figure above, where **outer diameter = 85 mm,** submit the following

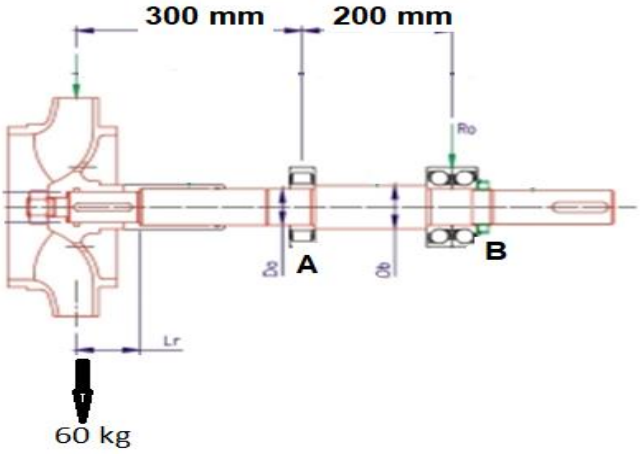
a- Determine the inner diameter for shaft. Use material **St. 52** with safety factor= 4.
b- Check the rigidity of shaft



Problem (3)

The given figure shows a pump shaft rotating the pump impeller with **1450 RPM** and **12 kW** power. The shaft is supported on two bearings A and B, as shown in figure. By assuming the impeller weight = **60 kg**, determine the following:

a- The radial reactions at both bearings.
b- Shaft diameter at bearings A and B (assume allowable shear strength of shaft material = 45 MPa) .



Problem (4)

The following figure shows a coupling connecting two shafts of a pump and motor. The power transmitted is **10 HP** at **1500 RPM**. Determine the following:-

a- Shafts' diameter of pump and motor (Take shafts' material yielding strength= **380 MPa** and **safety factor = 3**).

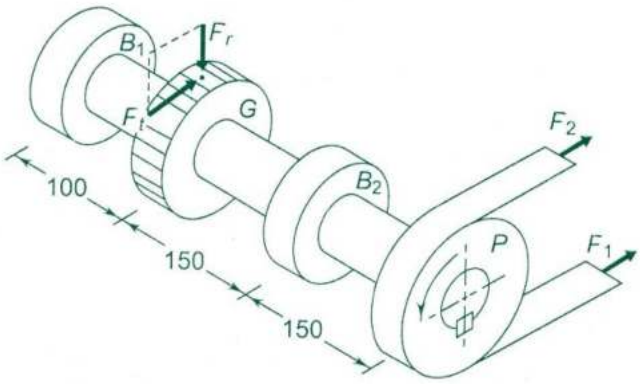
Problem (5)

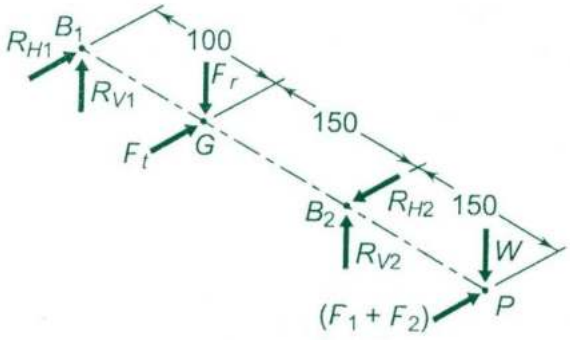
A transmission shaft rotating at **720** rpm and transmitting a power of **10 HP** from the pulley **P** to the spur gear **G** is shown in figure below. The belt tensions and the gear tooth forces are as follows:

F_1 = 498 N,
F_2 = 166 N,
F_t = 497 N,
F_r = 181 N,

The weight of the pulley **W** is **100 N**. Find the following:

a- Bearing reactions.
b- Minimum shaft diameter, if its material has **40 MPa** allowable shear strength.
c- Check shaft rigidity, assume **G= 80 GPa**.



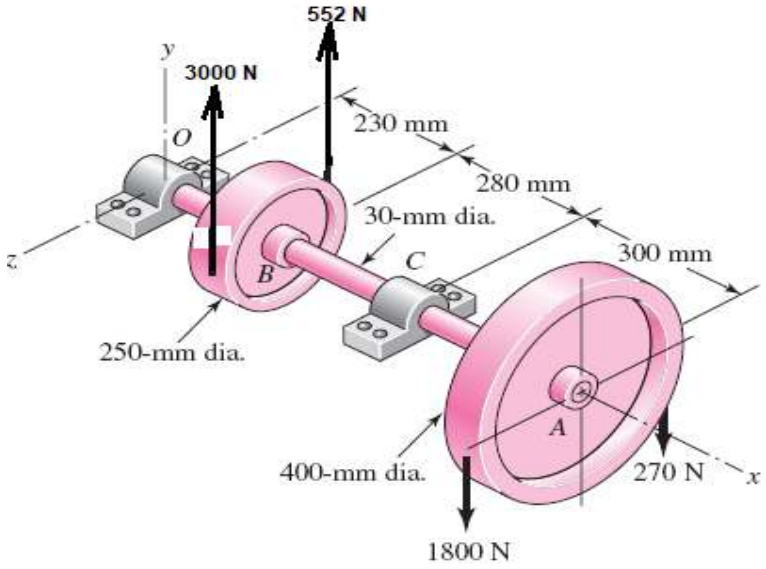


Problem (6)

A countershaft carrying two **V-**belt pulleys is shown in the following figure. Pulley ***A*** receives a torque of **306 Nm** from a motor through a belt with the belt tensions shown. The power is transmitted through the shaft and delivered to the belt on pulley ***B***. Assume the belt tensioning forces on pulley ***A*** are **1800** and **270 N** and the belt tensioning forces on pulley **B** are **3000** and **552 N**.

(*a*) Find the magnitudes of the reactions at bearings **O** and **C**, assuming the bearings act as simple supports.

(b) Find the safety factor of the shaft if its material has a yielding strength (S_y= **560 MPa**)



ASME Eq. for shaft design

$$d_o = \left[\frac{16}{\pi S_{s\,allow.}(1-\lambda^4)} \sqrt{\left(k_b M_b + \frac{\alpha F d_o (1+\lambda^2)}{8} \right)^2 + (K_t M_t)^2} \right]^{1/3}$$

$$\theta = \left[\frac{TL}{GJ} \right] \quad \text{radians}$$