1. (a) For the mechanism shown in FIGURE 1 determine for the angle $\theta = 45°$:

(i) the velocity of the piston relative to the fixed point O (V_{BO})

(ii) the angular velocity of AB about point A (i.e. ω_{AB})

(iii) the acceleration of point B relative to A (a_{BA}).

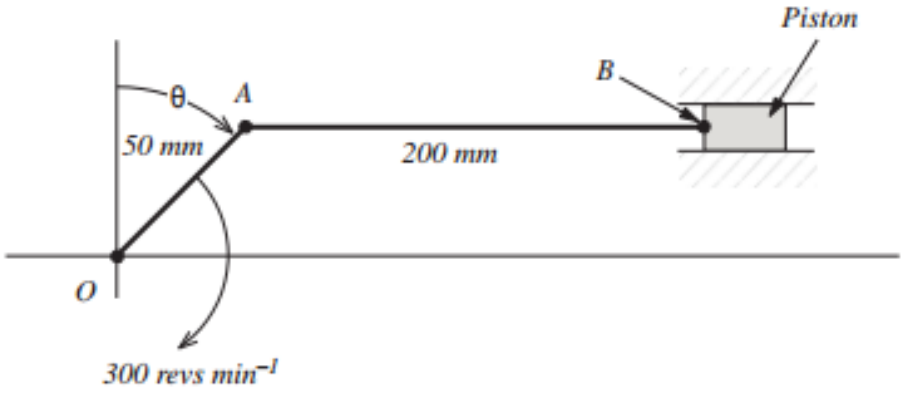

FIG. 1

Note: Link AB is horizontal when $\theta = 45°$

(b) Determine the value of the angle θ (measured from vertical) when:

(i) the velocity of point B = 0

(ii) the angular velocity of link AB a maximum.

(c) What is the maximum angular velocity of link AB?

2. (a) A shaft 2 m long rotates at 1500 revs min^{-1} between bearings as shown in FIGURE 2. The bearings experience forces of 5 kN and 3 kN acting in the same plane as shown. A single mass is to be used to balance the shaft, so that the reactions are zero. The mass is to be placed at a radius of 200 mm from the shaft centre, 180° from the direction of the bearing reactions. Determine the size and position (*a* and *b*) of the mass to be used.

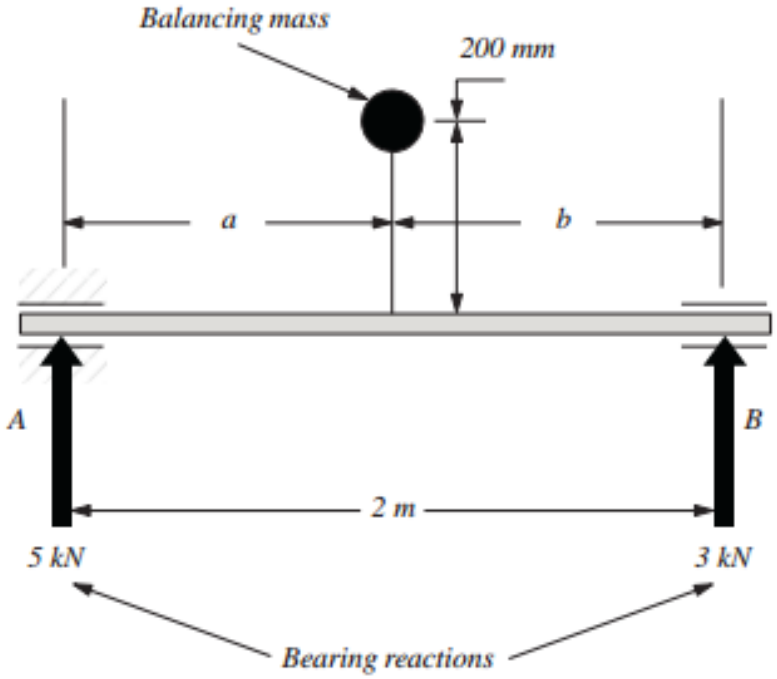

FIG. 2

(b) The shaft in part (a) is to be balanced using two masses (m_1 and m_2) placed 0.5 m and 1.5 m from end A and 180° from the direction of the bearing reactions, each on radius arms 100 mm long. Calculate the sizes of m_1 and m_2.

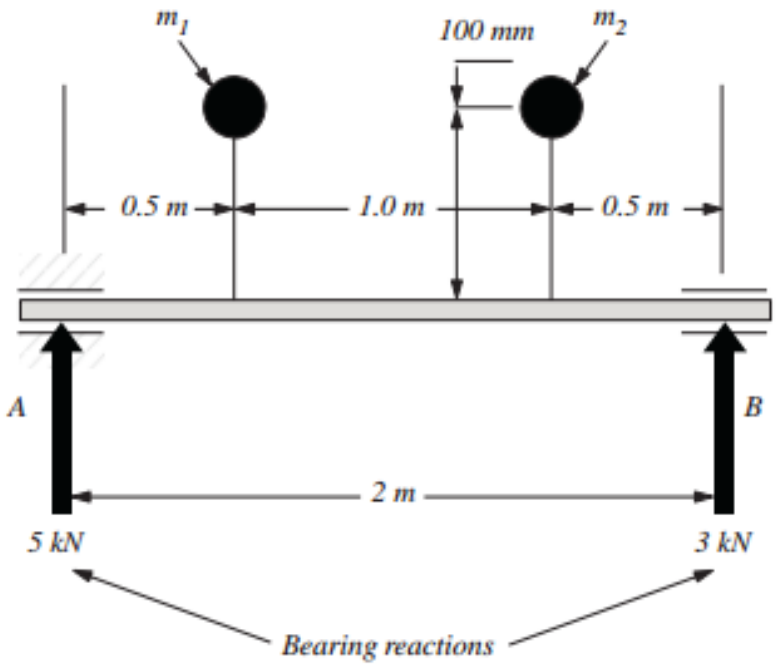

FIG. 3

3. A gearbox and flywheel are as shown in FIGURE 4. The output shaft rotates in the opposite direction to the input shaft at 5 times its speed. The gearbox has an efficiency of 92%.

   If the flywheel is solid, has a mass of 50 kg, a diameter of 1.5 m and is to accelerate from rest to 300 revs min^{-1} in 1 minute:

   (a) Calculate the torque required at input T_1.

   (b) Calculate the magnitude and direction of the torque required to hold the gearbox stationary (holding torque T_h). Show the direction of the holding torque applied to the shaft with the aid of a sketch.

   (c) Plot a graph of the input power against time when taking the flywheel from rest to 300 revs min^{-1}.

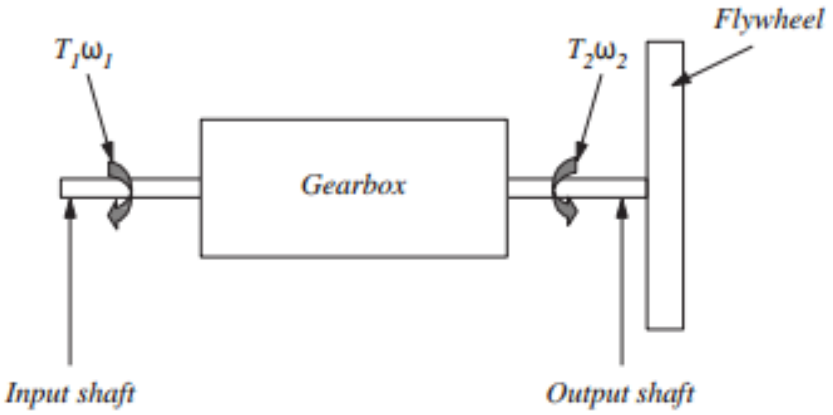

FIG. 4