B.E. CHEMICAL ENGINEERING

FIRST YEAR FIRST SEMESTER EXAMINATION-2018

Time: Three Hours | Subject: ENGINEERING MECHANICS | Full Marks: 100

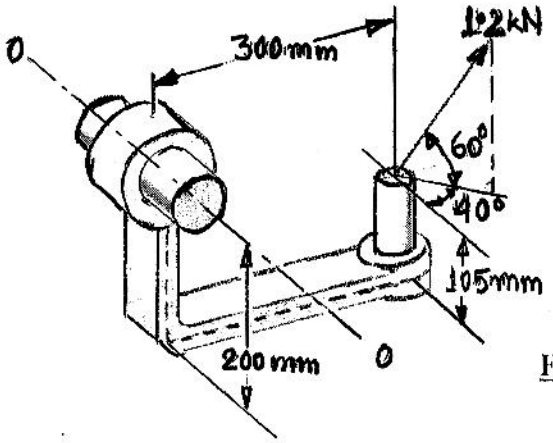
Read the following Instructions carefully before answering

Answer any FIVE(5) Question taking at least TWO(2) from EACH GROUP

Any missing data may be suitably assumed. Draw Free Body Diagrams wherever necessary. Answers to different parts of the same question are to be written in the same place. Marks will be deducted if not complied properly. Answers must be in SI units. Assume g=9.81 m/s^2 unless mentioned otherwise.

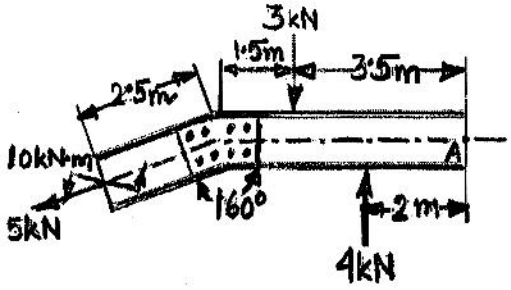
GROUP A

Q1 (a) Find the moment of **1.2 kN** force about the axis ***O-O*** as shown in **FigQ1(a)**. **[10]**



FigQ1(a)

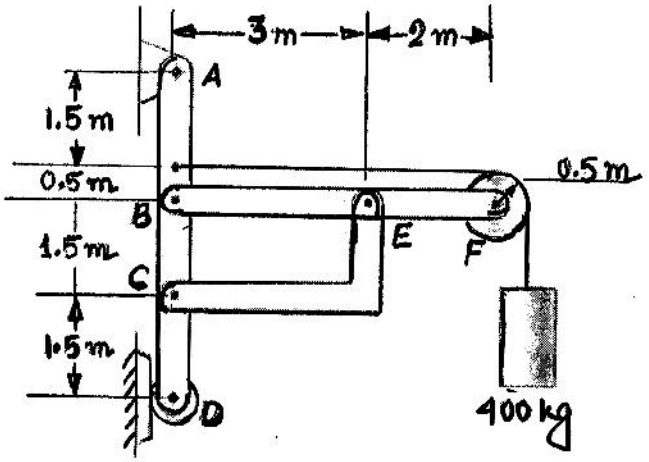
(**b**) Represent the resultant of the three forces and a couple as shown in **FigQ1b** by an equivalent system of a single force and single couple moment at A. What will be the vector expressions for these single equivalent force and single couple moment at A? Find the point on the horizontal line through A, through which line of action of the simplest equivalent resultant force of this force system will pass. **[6 + 4 = 10]**



FigQ1(b)

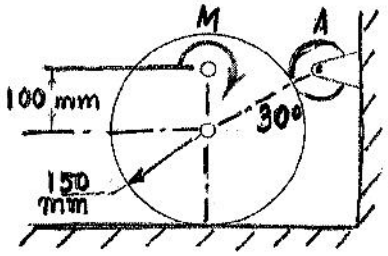
Q2 (a) The frame supports a load of mass **400 kg** as shown in **FigQ2a**. Assume the weight of the frame members are negligible as compared to the weight of the load.
(i) Find the components of reaction forces at supports A and D.

(ii) Find the force carried by the member ***CE***.
(iii) Find the force at joint ***B*** of the member ***AD***.
Draw the necessary **free body diagrams**. **[12]**



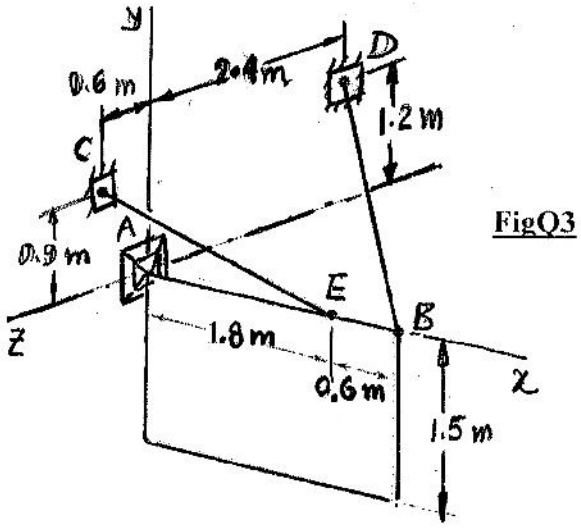
FigQ2(a)

(b) Under the action of the applied couple $M = 20$ **N·m** the **25-kg** cylinder bears against a roller A, which is free to turn. If the co-efficient of static and kinetic friction between the cylinder and the horizontal surface are **0.5** and **0.4** respectively, determine the friction force F acting on the cylinder. Find also the reaction force acting at roller A. **Draw the necessary free body diagram(s).** **[8]**



FigQ2(b)

Q3. A sign board of uniform density weighs **540 N** and is supported by a ball-and-socket joint at A and by two cables EC and BD. Determine the tension in each cable and the reaction at A. Draw the necessary free-body diagram(s). **[20]**

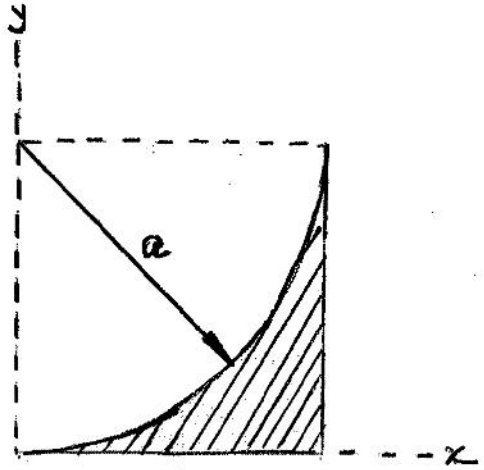


FigQ3

Q4. For the figure shown in **FigQ4**:
(i) find the x- and y-coordinates of the centroid of the shaded part of the area, **[6]**

(ii) find the moment of inertia of the shaded part of the area about x- and y-axes, **[10]**

(iii) find the total outer surface area of the solid generated by revolving the shaded part of the area **360°** about **x-axis.** **[4]**

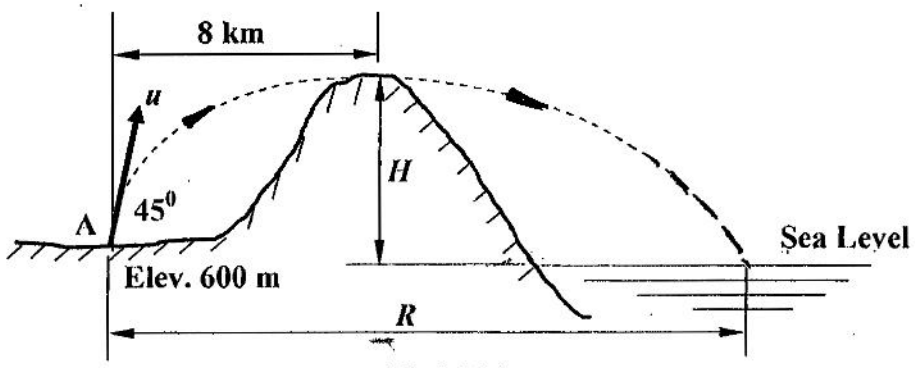


FigQ4

GROUP B

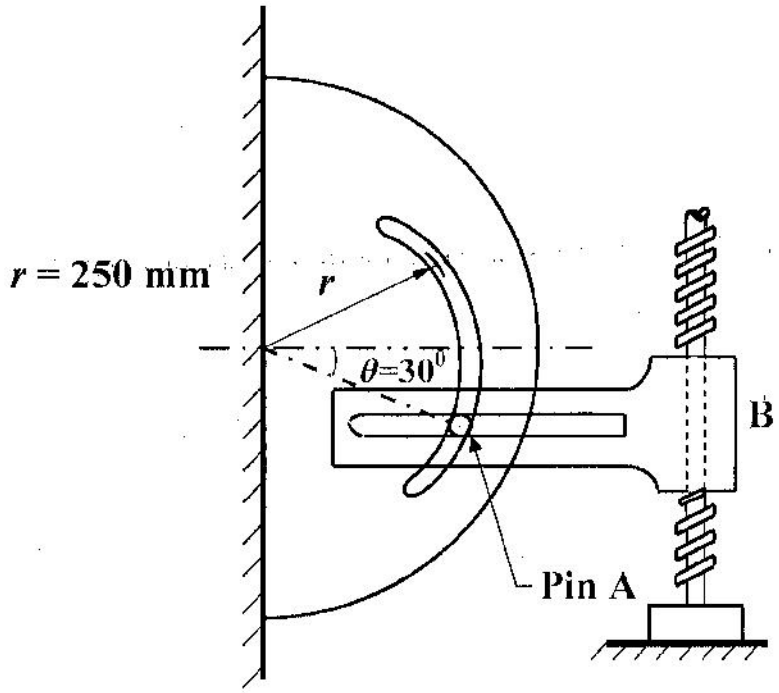
Q5(a) A particle moves along the s-direction with constant acceleration. The displacement, measured from a convenient position, is **2.0 meters** at time t=**0** and is zero when t =**10 seconds**. If the velocity of the particle is momentarily zero when t=**6 seconds**, calculate the acceleration and velocity of the particle when t = **10 seconds**. **[8]**

(b) A long range artillery rifle at **A** is aimed at an angle of 45^0 with the horizontal, and its shell is just able to clear the mountain peak at the top of its trajectory. Calculate the magnitude of the muzzle velocity, u, the height H of the mountain above the sea level, and the range R to the sea. **[12]**



FigQ5(b)

Q6(a) In the design of a timing mechanism the motion of the pin **A** in the fixed circular slot is controlled by the guide **B**, which is being elevated by its lead screw with a constant upward velocity v_0 = **2 m/s** for an interval of its motion. Calculate both the normal and tangential components of acceleration of pin **A** as it passes the position for which $\theta = 30°$. **[10]**

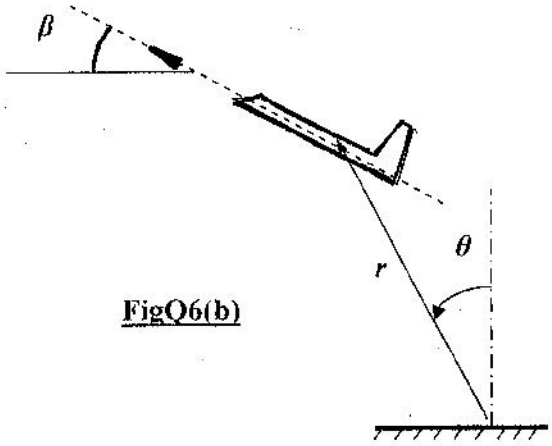


FigQ6(a)

(b) An aircraft flying in a straight line at a climb angle β to the horizontal is tracked by a radar (assumed to be small and not shown in the figure) located directed below the line of flight. At a certain instant, the following data are recorded:

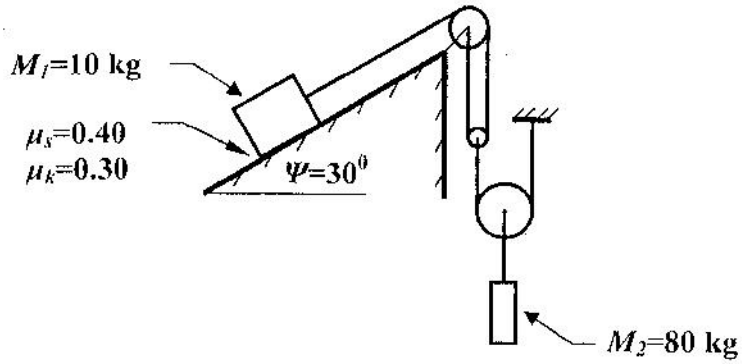
$$r = 3600 \text{ m}, \dot{r} = 110 \text{ m/s}, \ddot{r} = 6 \text{ m/s}^2, \theta = 30^0, \text{ and } \dot{\theta} = 2.20 \text{ deg/s}.$$

For this instant, determine the aircraft altitude, its velocity, angle of climb β and acceleration. Treat the aeroplane as a particle. **[10]**



FigQ6(b)

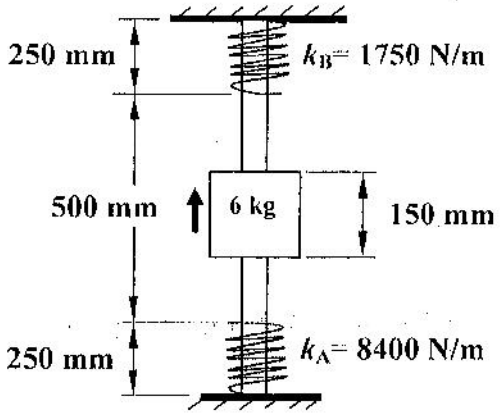
Q7(a) The system shown in the figure has been released from the condition of rest. Ascertain first that there will be motion of the system. Calculate the acceleration of each mass block. Assume the pulleys are massless and ideal. The strings are light and inextensible. **[10]**



FigQ7(a)

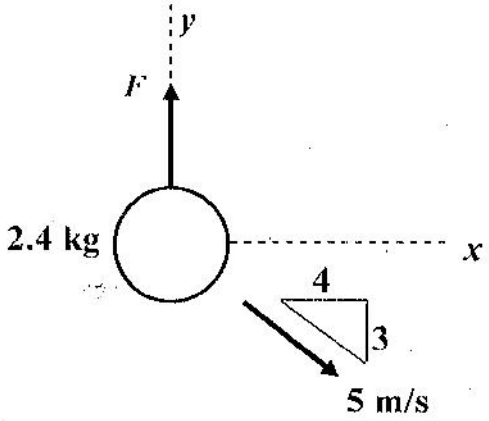
(b) Derive the expressions of velocity and acceleration of a particle undergoing curvilinear motion in terms of *r-θ* co-ordinate system with necessary neat sketches. **[10]**

Q8 (a) The springs are undeformed in the position shown. If the **6.0 kg** collar is released from rest in the position where the lower spring is compressed **125 mm**, determine the maximum compression of the upper spring. Assume the system to be in *vertical plane*. Assume there is no friction between the collar and the rod. **10]**



FigQ8(a)

(b) The **2.4 kg** particle mass moves in the *horizontal x-y* plane and has the velocity shown at time t=**0**. If the force $F = 2 + \frac{3t^2}{4}$ Newton, where t is in seconds, is applied to the particle in the y-direction beginning at time t=**0**, determine the velocity v of the particle **4 seconds** after F is applied and specify the corresponding angle θ measured counterclockwise from the x-axis to the direction of the velocity. **[10]**



FigQ8(b)

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