EX/ChE/AM/ME/T/1A/2018(S)

B.E. CHEMICAL ENGINEERING

FIRST YEAR FIRST SEMESTER SUPPLEMENTARY EXAM-2018

Subject: ENGINEERING MECHANICS

Full Marks: 100 **Time: Three Hours**

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 and marks will be deducted if not complied properly. Answers must be in SI units. Assume g=9.81 m/s² unless mentioned otherwise.

GROUP A

1(a) Replace the two forces acting on the bent pipe as show in **Fig. Q1a** by an equivalent force-couple system at the point ***A***. Find the distance from the point ***A*** to the point on *y*-axis through which the single resultant force (with zero moment) will pass. **[10]**

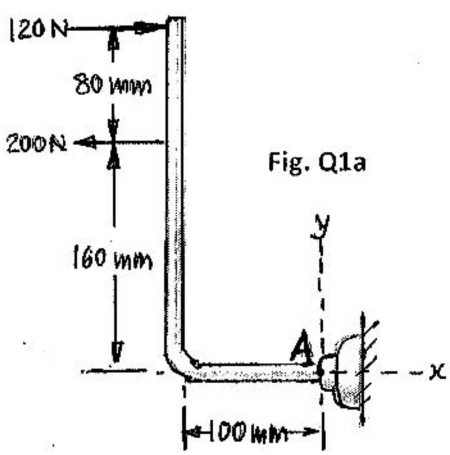


Fig. Q1a

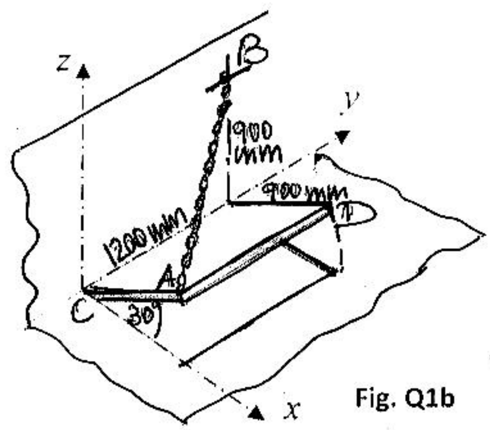


Fig. Q1b

(b) The access door in **Fig. Q1b** is held in the **30°** open position by the chain ***AB***. The tension in the chain is known to be **100 N**. Express this tension as a vector with the suitably defined axes system. Find the component of this force along the direction parallel to the line ***CD***. **[10]**

2(a) A **6.5-m** ladder ***AB*** of mass **10 kg** leans against a wall as shown in **Fig. Q2a**. Assuming that the coefficient of static friction μ_s is same at both surfaces of contact, determine the smallest value of μ_s for which equilibrium can be maintained. **[10]**

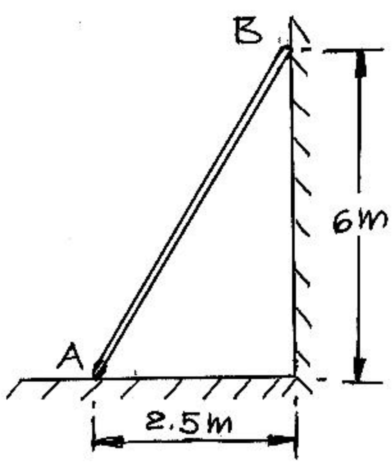


Fig. Q2a

[Turn over

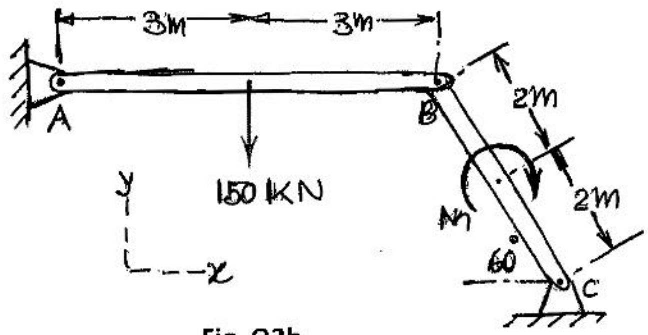


Fig. Q2b

(**b**) For which value of the clockwise couple acting on the member ***BC*** of the frame shown in **Fig. Q2b** will the horizontal component of the pin reaction at ***A*** be zero? If the couple of same magnitude were applied in counter clockwise sense, what will the corresponding value of horizontal component of the pin reaction at ***A***? **Draw the necessary free body diagram(s).** **[10]**

3. Each of the three uniform **1200-mm** bars, as shown in **Fig. Q3**, has a mass of **20 kg**. The bars are welded together into the configuration shown and suspended by three vertical wires. Bars ***AB*** and ***BC*** lie in the horizontal $x - y$ plane, and the third bar lies in a plane parallel to the $x - z$ plane. Compute the tension in each wire. **Draw the necessary free body diagram(s).** [20]

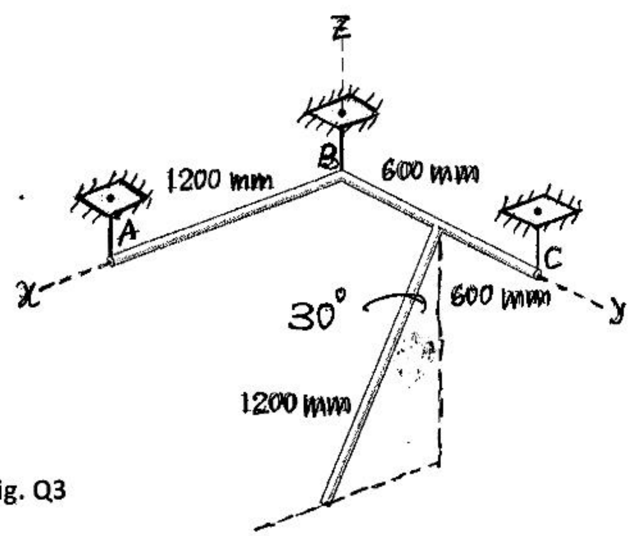


Fig. Q3

4. Find the *x*- and *y*-coordinates of the centroid of the shaded area shown in **Fig. Q4**. Also find the second moments of the shaded area about *y*-axis. Eqn. of Curve is $x = ky^2$ **[20]**

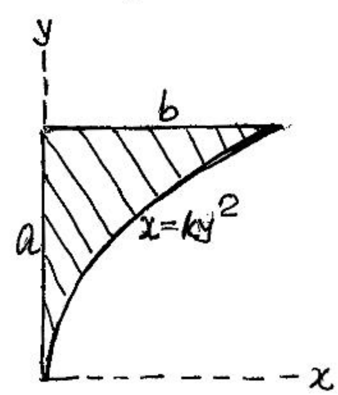
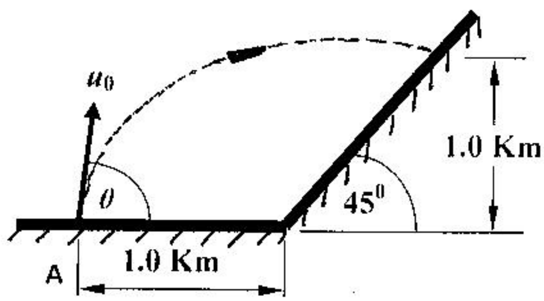


Fig. Q4

GROUP B

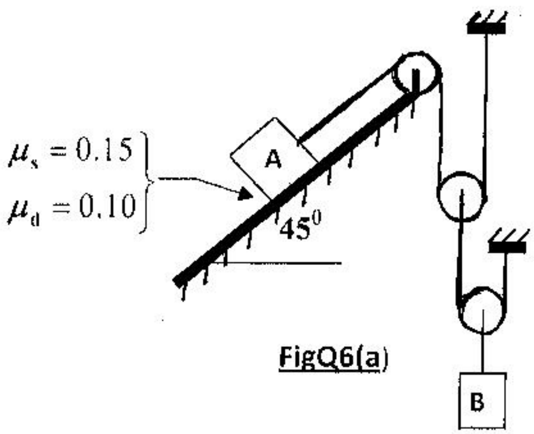
Q5(a) A projectile is fired from point **A** with an initial velocity u_0 to hit a target at point **B** as shown in **FigQ5(a)**. Find the minimum velocity to achieve this. Also, find the angle θ corresponding to this minimum velocity. **[12]**



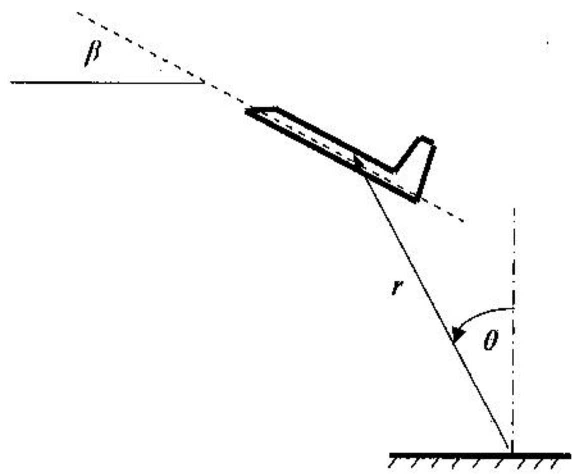
FigQ5(a)

(b) Derive with suitable neatly drawn sketches, the expressions of **velocity** and **acceleration** of a moving particle in **tangent –normal** co-ordinate system. **[8]**

Q6 (a) The system is released from the condition of rest. Calculate the **magnitude** and **senses** of **accelerations** of blocks **A** and **B** immediately after release. Also, calculate the **tensions** developed in the strings. Assume, the strings are light, inextensible and pulleys are small and ideal. Refer to **FigQ6(a)**. Assume weights of each block as **200 N**. **[10]**



FigQ6(a)



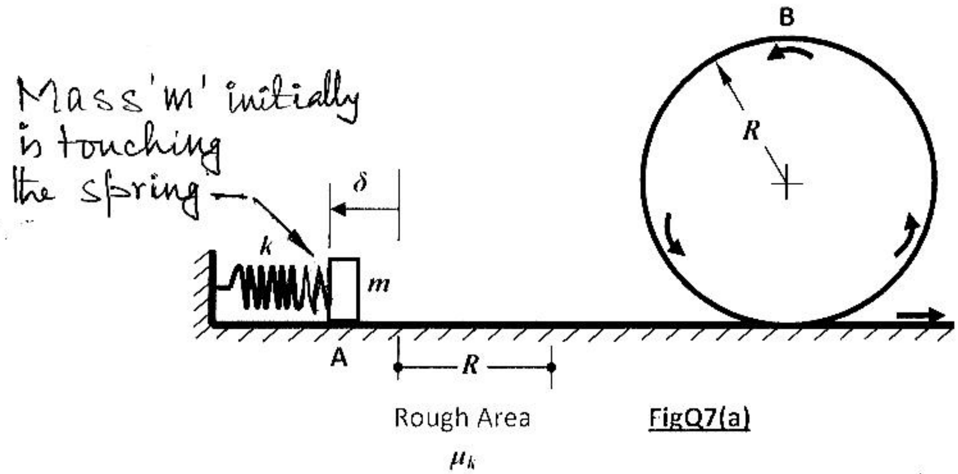
FigQ6(b)

(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:

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

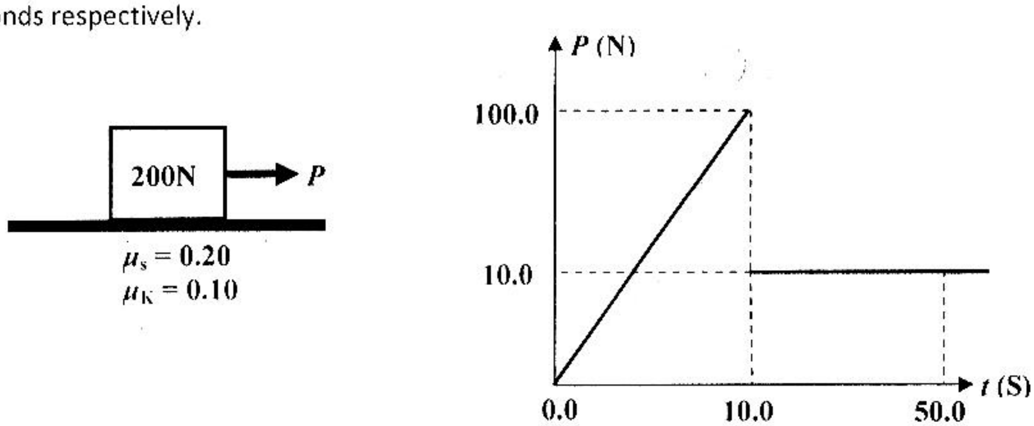
For this instant, determine the **aircraft altitude**, its **velocity**, **angle of climb** β and **acceleration**. Treat the aeroplane as a particle. **[10]**

Q7(a) The spring of stiffness k is compressed and suddenly released, sending the particle of mass m sliding along the track. Determine the minimum spring compression δ for which the particle will not lose contact with the loop-the-loop track. The sliding surface is smooth except for the rough portion equal to the length R, where the coefficient of kinetic friction is μ_k. Refer to **FigQ7(a)**. **[10]**



FigQ7(a)

(b) **FigQ7(b)** shows a **200N** weighing block resting on a rough surface, when a force P begins to act on it. The variation of the magnitude of the force with time is shown in the adjoining graph. Using the principle of impulse-momentum, calculate the **velocities** of the block at the end of t = **10.0** seconds and **50.0** seconds respectively. **[10]**



FigQ7(b)

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