22/11/19

Indian Institute of Engineering Science and Technology, Shibpur

B.Tech 1st Semester (AE, CE, ME, MT, MN) Final Examination, November, 2019

Mechanics (AM 1101)

Full marks: 50 Time: 3 Hrs

All notations have their usual meanings

Marks for each question are shown in the right

Two marks are reserved for neatness

(i) Take $g = 9.81\ m/s^2$.

(ii) Assume any other data not given in the question.

Answer Total **Six (6)** Questions Taking **Two (2)** from **Part A and Four (4)** From **Part B**

Answer both Part A and Part B in a **SINGLE ANSWER SCRIPT**

Part A

(Answer any two questions from this Part)

1. (a) The light bar is used to support the 50 kg block in its vertical guides as shown in **Fig. Q. 1 (a).** If the coefficient of static friction is 0.3 at the upper end of the bar and 0.4 at the lower end of the bar, find the friction force acting at each end for x = 80 mm. Also find the maximum value of x for which the bar will not slip. [4]

   (b) The special box wrench with head B swiveled at C to the handle A, will accommodate a range of sizes of hexagonal bolt heads. For the nominal size shown in **Fig. Q. 1 (b),** where the center O of the bolt and the pin C are in line with the handle, compute the magnitude of the force supported by the pin at C if P = 180 N. Assume the surface of the bolt head to be smooth. [4]

2. Determine the force in the member AB, CG and DE of the loaded truss shown in **Fig. Q. 2** [8]

3. Determine the distance $\overline{H}$ from the bottom of the base plate to the centroid of the built-up structural section as shown in **Fig. Q. 3.** [8]

4. Determine the maximum and minimum moments of inertia with respect to the centroidal axes through C for the composite of the two rectangular areas shown in **Fig. Q. 4.** Find the angle α measured from the x-axis to the axis of maximum moment of inertia. [8]

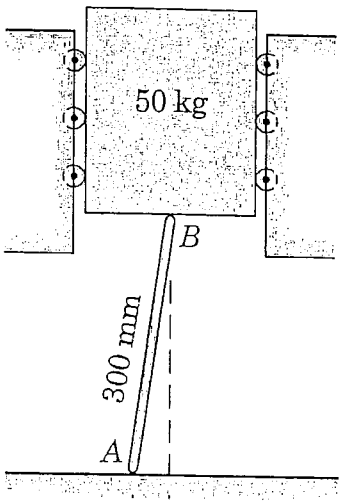


Fig. Q. 1(a)

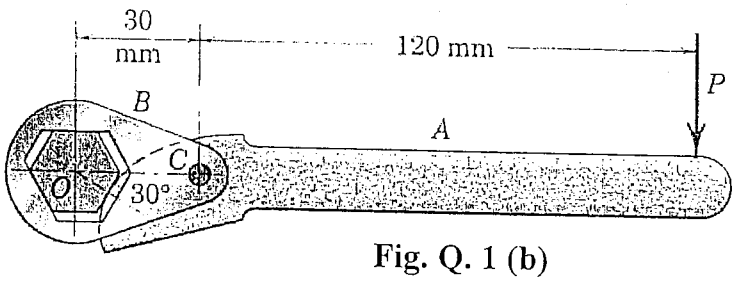


Fig. Q. 1 (b)

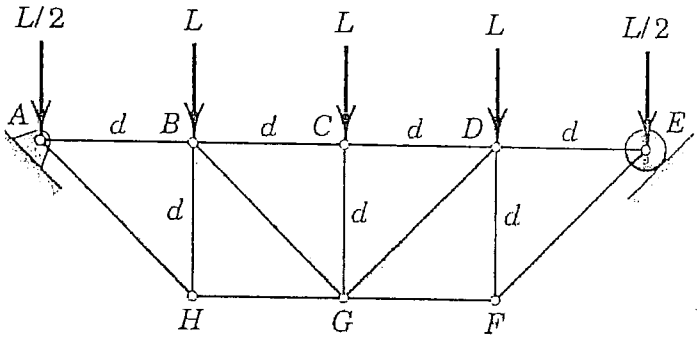
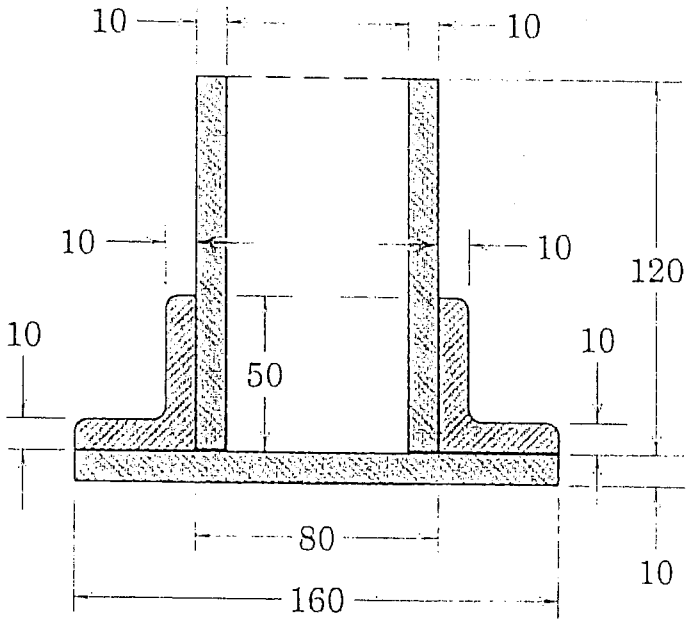


Fig. Q. 2



Dimensions in millimeters

Fig. Q. 3

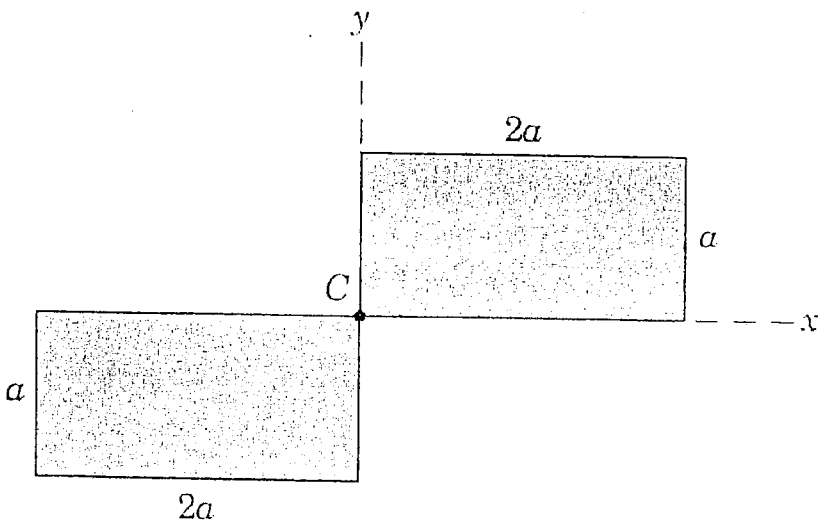


Fig. Q. 4

Part B

(Answer any four questions from this Part)

5. (a) The horizontal motion of the plunger and shaft is arrested by the resistance of the attached disc which moves through the oil bath as shown in the **Fig. Q. 5 (a).** If velocity of the plunger is v_0 at the position A where $x = 0$ at $t = 0$, and if the deceleration is proportional to v so that $a = -kv$, derive the expression for velocity v and position coordinate x in terms of the time t. Also express v in terms of x. [4]

(b) A projectile is launched with speed v_0 from point A shown in **Fig. Q. 5 (b).** Determine the launch angle θ that results in the maximum range R up the incline of angle α (where, $0 \le \alpha \le 90^0$). Evaluate your results for $\alpha = 0^0, 30^0$ and 45^0. [4]

6. (a) 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 $v_0 = 4$ m/sec for an interval of its motion shown in **Fig. Q. 6 (a)** . Calculate both the normal and tangential components of acceleration of pin A as it passes the position for which $\theta = 30^0$. [4]

(b) A race driver traveling at a speed of 250 km/h on the straightaway applies his brakes at point A and reduces his speed at a uniform rate to 200 km/h at C in a distance of total 300 m from A to C (A to B is 150 m and B to C is 150 m) as shown in **Fig. Q. 6 (b).** Calculate the magnitude of the total acceleration of the race car at an instant after it passes point B. [4]

7. Neglect the diameter of the small pulley attached to body A and determine the magnitude of the total velocity of B in terms of the velocity v_A that body A has to the right as shown in **Fig. Q. 7**. Assume that the cable between B and the pulley remains vertical and solve for a given value of x. [8]

8. (a) The 2 kg collar is released from rest at A and slides down the inclined fixed rod in the vertical plane as shown in **Fig. Q. 8 (a).** The coefficient of kinetic friction is 0.40. Calculate (i) the velocity v of the collar as it strikes the spring and (ii) the maximum deflection x of the spring. [4]

(b) The small object of mass m is placed on the rotating conical surface at the radius shown in **Fig. Q. 8 (b)**. If the coefficient of static friction between the object and the rotating surface is 0.7, calculate the maximum angular velocity ω of the cone about the vertical axis for which the object will not slip. Assume very gradual changes of the angular velocity. [4]

9. The force P, which is applied to the 10-kg block, initially at rest as shown in **Fig. Q. 9**, varies linearly with time as indicated. If the coefficients of static and kinetic friction between the block and the horizontal surface are 0.60 and 0.40, respectively, determine the velocity of the block when $t = 3.5\,\text{sec}$. [8]

10. Cylinder B is connected with the block A as shown in **Fig. Q. 10.** Neglecting all friction and mass of the pulleys, determine the accelerations of bodies A and B when release from rest. [8]

11. During a pregame warm up period, two basketballs of identical mass and dimensions collide above the hoop when in the positions shown in **Fig. Q. 11**. Just before impact, ball 1 has a velocity v_1 which makes a 30^0 angle with the horizontal. If the velocity v_2 of ball 2 just before impact has the same magnitude as v_1, determine the two possible values of the angle, measured from the horizontal, which will cause ball 1 to go directly through the center of the basket. The coefficient of restitution (e) is 0.7. [8]

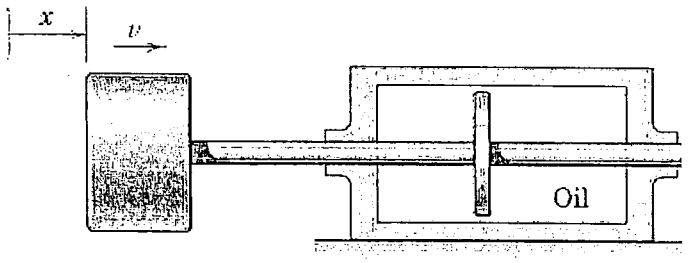


Fig. Q. 5 (a)

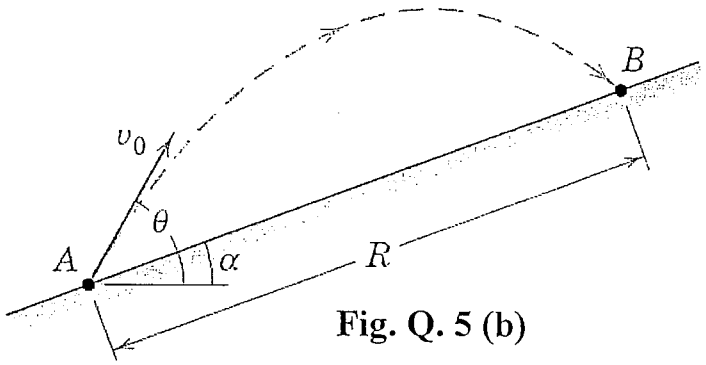


Fig. Q. 5 (b)

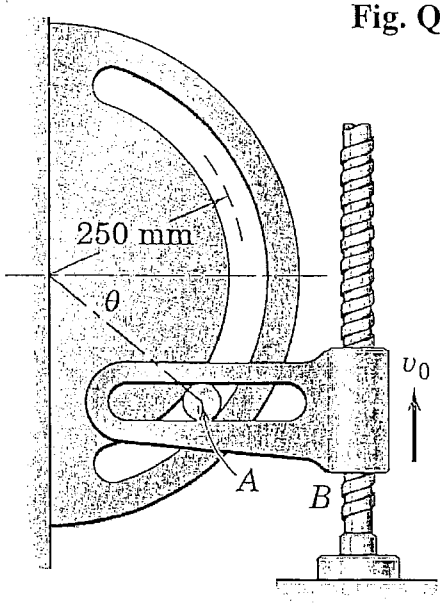


Fig. Q. 6 (a)

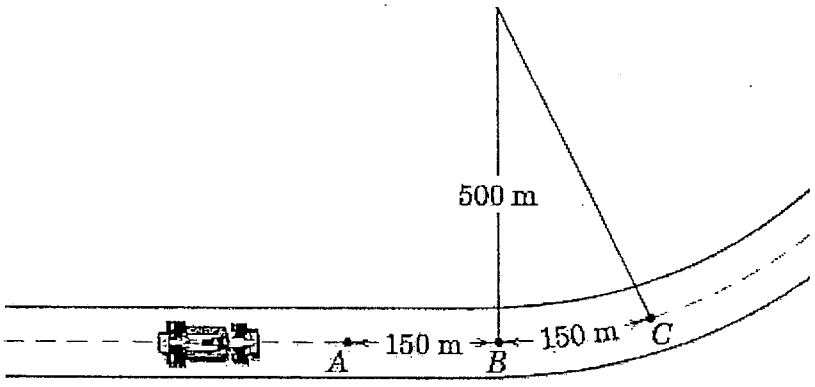


Fig. Q. 6 (b)

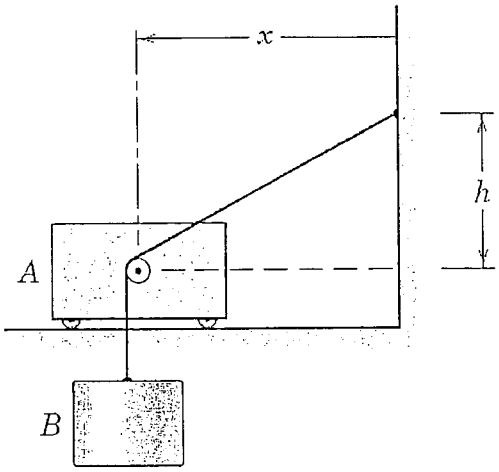


Fig. Q. 7

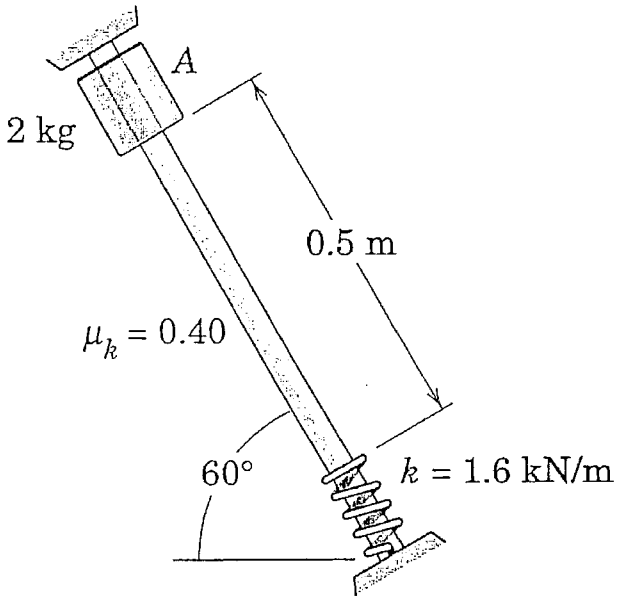


Fig. Q. 8 (a)

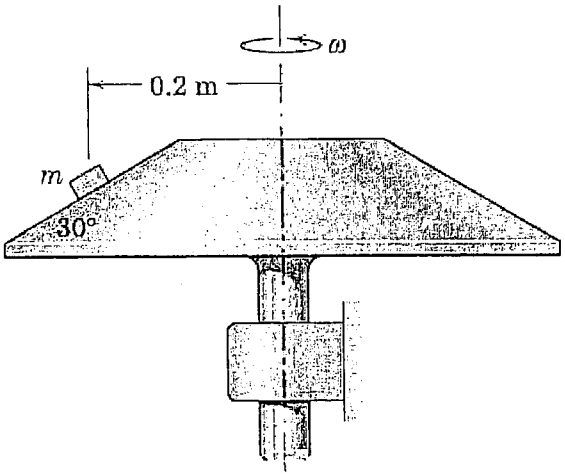
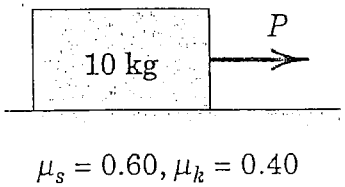


Fig. Q. 8 (b)



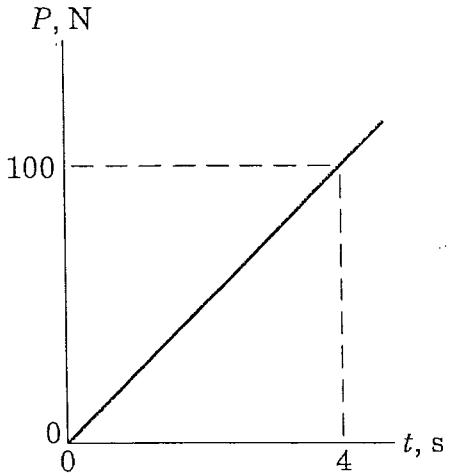


Fig. Q. 9

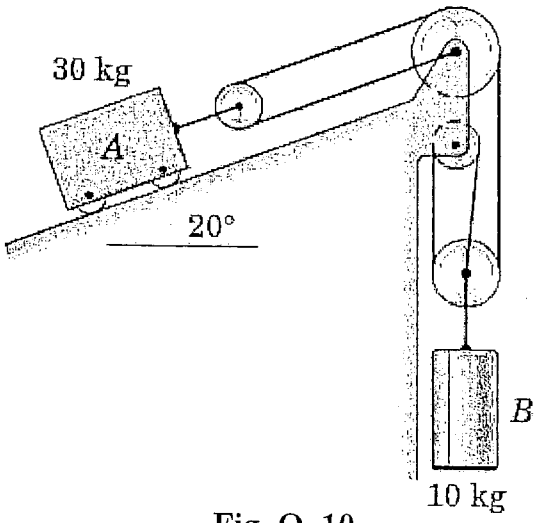


Fig. Q. 10

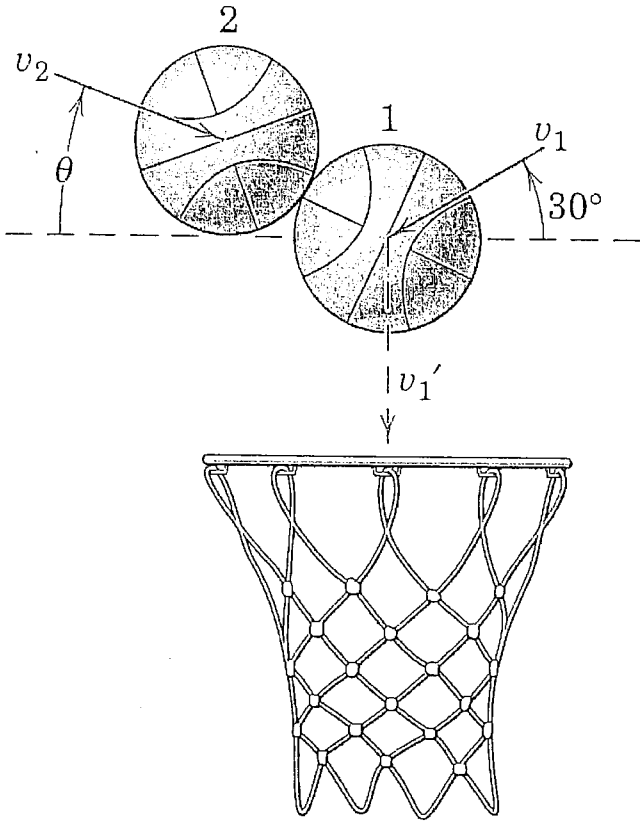


Fig. Q. 11