Bengal Engineering and Science University, Shibpur
BE 2nd Semester(CST,CE, ETc,EE, IT, Met & Min) Final Examination, 2013

Subject: Engineering Mechanics **Subject code AM-201**

Full Marks- 70 **Time – 3 Hours**

(i) Use Separate answer scripts for each halves.
(ii) All questions carry equal marks.
(iii) TWO marks are reserved in each halves for neatness.
(iv) Take g = 9.807 m/s²

First Half

(Answer any three questions)

1.(a)The exercise machine consists of a lightweight cart which is mounted on small rollers [Fig.1(a)] so that it is free to move along the inclined ramp. Two cables are attached to the cart, one for each hand. If the hands are together so that the cables are parallel and if each cable lies essentially in a vertical plane, determine the force P which each hand must exert on its cable in order to maintain an equilibrium position. The mass of the person is 70 kg, the ramp angle is $\theta = 15^0$ and angle β is 18^0. In addition, calculate the force R which the ramp exerts on the cart.

(b) Two light pulleys are fastened together and form an integral unit [Fig.1(b)]. They are prevented from turning about their bearing at O by a cable wound securely around the smaller pulley and fastened to point A. Calculate the magnitude R of the force supported by the bearing O for the applied 2 kN load.

2(a) Calculate the forces in members CF, CG, EF of the loaded truss shown in Fig.2(a).

(b) A lifting device for transporting 135 kg steel drums is shown in Fig.2(b). Calculate the magnitude of the force exerted on the drum at E and F.

3 (a)The thickness of the triangular plate [Fig.3(a)] varies linearly with y from a value t_0 along its base y = 0 to $2t_0$ at y = h. Determine the y-coordinate of the center of the mass of the plate.

(b) Determine the polar radius of gyration of the area of the equilateral triangle [Fig.3(b)] about the midpoint M of its base.

4. The industrial truck is used to move the solid 1200 kg roll of paper up the 30^0 incline [Fig.4]. If the coefficients of static and kinetic friction between the roll and the vertical barrier of the truck and between the roll and the incline are both 0.40, compute the required tractive force P between the tires of the truck and the horizontal surface.

5.(a) The uniform slender rod of mass m and length L is initially at rest in a centered horizontal position on the fixed circular surface [Fig.5(a)] of radius R = 0.6L. If a force normal to the bar is gradually applied to its end until the bar begins to slip at the angle $\theta = 20^0$, determine the coefficient of static friction μ_s between the rod and the circular surface.

(b)A former student of mechanics wishes to weigh himself but has access only to a scale A with capacity limited to 400 N and a small 80-N spring dynamometer B. With the rig shown [Fig.5(b)], he discovers that when he exerts a pull on the rope so that B registers 76 N, the scale A reads 268 N. What are his correct weight and mass m?

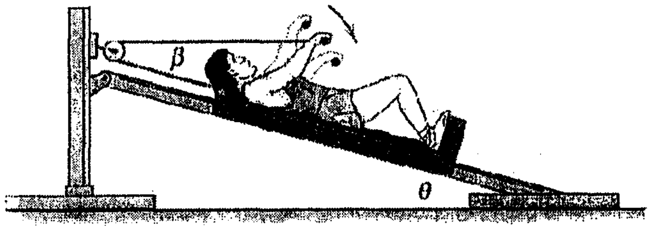

Fig. 1(a)

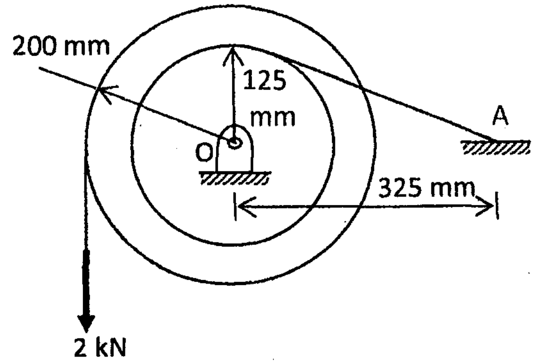

Fig. 1(b)

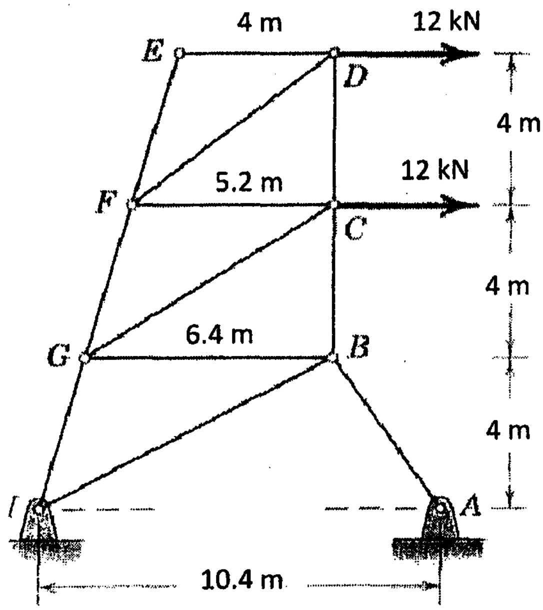

Fig. 2(a)

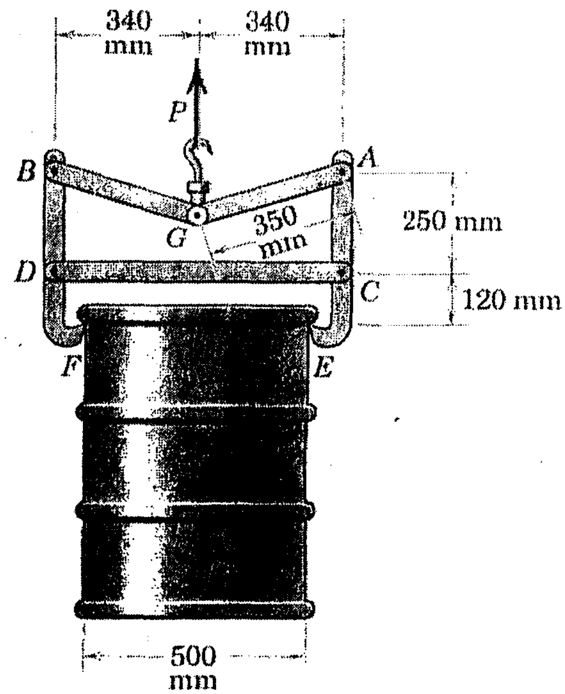

Fig. 2(b)

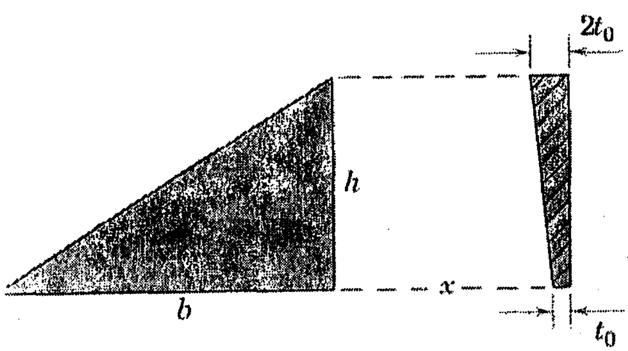

Fig. 3(a)

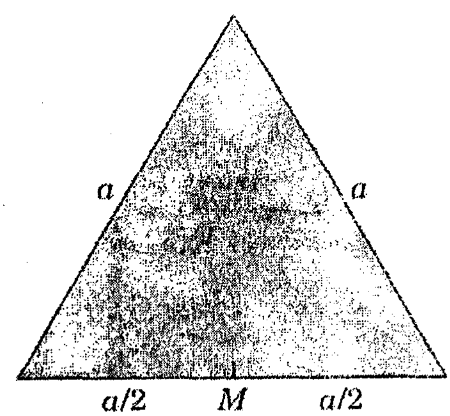

Fig. 3(b)

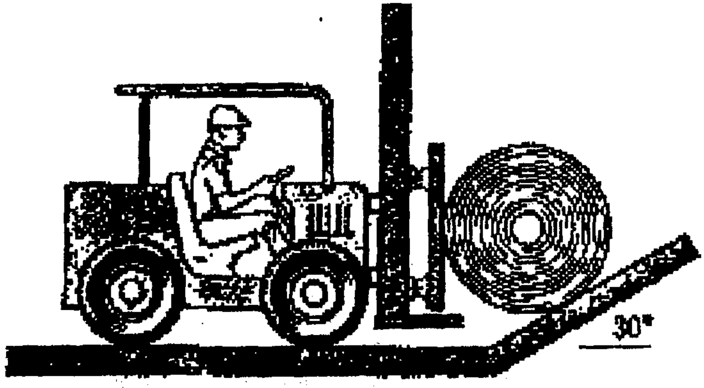

Fig. 4

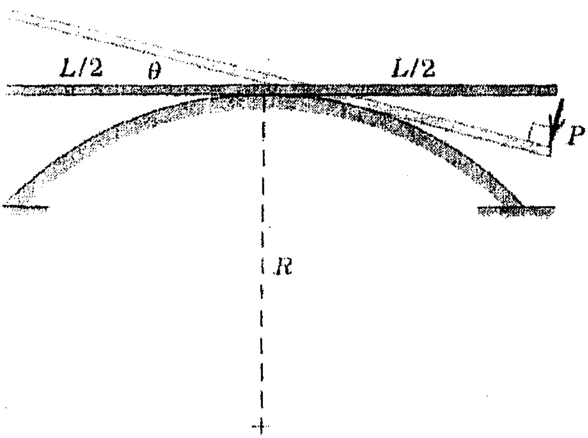

Fig. 5(a)

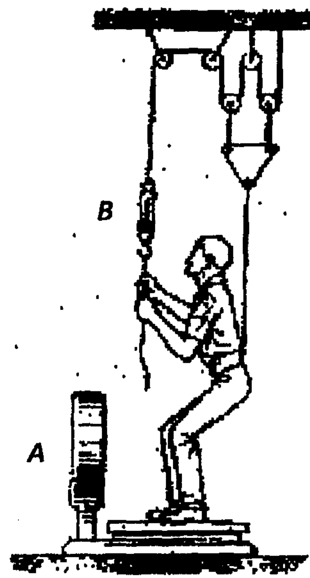

Fig. 5(b)

SECOND HALF

Answer any three questions from this half

6. (a) A projectile is launched from point A with the initial conditions shown in the Fig.6 (a). Determine the slant distance s which locates the point B of impact. Calculate the time of flight t.

   (b) 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 as shown in Fig. 6 (b). Calculate both the normal and tangential components of acceleration of pin A as it passes the position for which $\theta = 30^0$.

7. (a) The rocket is fired vertically and tracked by the radar as shown in Fig. 7 (a). When θ reaches 60^0, other corresponding measurements give the values, $r = 9\,\text{km}$, $\frac{d^2r}{dt^2} = 21\,\text{m/s}^2$ and $\frac{d\theta}{dt} = 0.02\,\text{rad/s}$. Calculate the magnitudes of the velocity and acceleration of the rocket at this position.

   (b) The slotted arm is pivoted at O and carries the slider C in Fig. 7 (b). The position of C in the slot is governed by the chord which is fastened at D and remains taut. The arm turns counterclockwise with a constant angular rate $\frac{d\theta}{dt} = 4\,\text{rad/s}$ during an interval of its motion. The length DBC of the cord equals to R, which makes $r = 0$ when $\theta = 0$. Determine the magnitude of the acceleration, α of the slider at the position for which $\theta = 30^0$. The distance R is 375 mm.

8. (a) Determine the relationship that governs the velocities of the four cylinders shown in Fig. 8 (a). Express all velocities as positive down. How many degrees of freedom exist in the system?

   (b) The 2-Kg collar is released from rest at A and slides down the inclined fixed rod in the vertical plane shown in Fig. 8 (b). The coefficient of kinetic friction is 0.4. Calculate (i) the velocity v of the collar as it strikes the spring and (ii) the maximum deflection x of the spring.

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9. (a) A small collar of mass m is given an initial velocity of magnitude v_0 on the horizontal circular track fabricated from a slender rod shown in Fig. 9 (a). If the coefficient of kinetic friction is μ_k, find the expression for distance traveled by the collar before it comes to rest in terms of r, μ_k v_0 and g.

(b) The vertical plunger shown in Fig. 9 (b) has a mass of 2.5 kg and is supported by the two springs that are always in compression. Calculate the natural frequency f_n of the vibration of the plunger, if it is deflected from the equilibrium position and released. Friction in the guide is negligible.

10. (a) Sphere A has a mass of 23 kg and a radius of 75 mm, while sphere B has a mass of 4 kg and a radius of 50 mm. If the spheres are traveling initially along the parallel path with the speeds shown in Fig.10 (a), determine the velocities of the spheres immediately after the impact. Specify the angles θ_A and θ_B with respect to the *x*-axis made by the rebound velocity vectors. The coefficient of restitution is 0.4 and friction is neglected.

(b) The force P, which is applied to the 10-kg block initially at rest, varies linearly with the time as indicated in Fig. 10 (b). If the coefficients of static and kinetic friction between the block and the horizontal surface are 0.6 and 0.4 respectively, determine the velocity of the block when t = 4 s.

11. (a) Neglect all friction and the mass of the pulleys shown in Fig. 11 (a) and determine the accelerations of bodies A and B upon release from rest.

(b) What load will be lifted by an effort of 12 N if the velocity ratio is 18 and efficiency of the machine at this load is 60% ? If the machine has a constant frictional resistance, determine the law of the machine and find the effort required to run the machine at a load of 90 N.

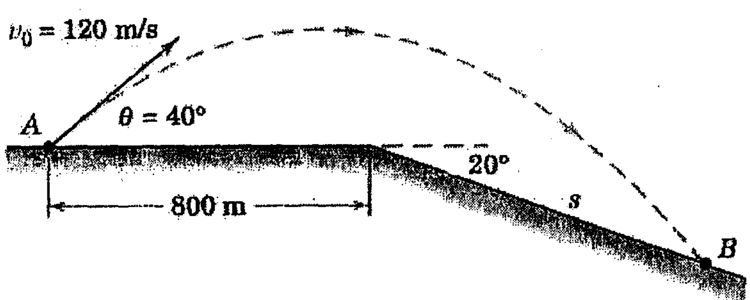

Fig. 6 (a)

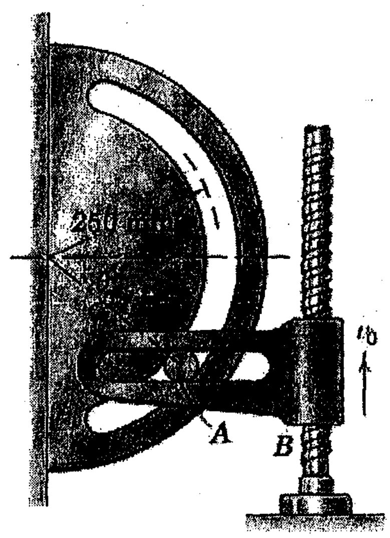

Fig. 6 (b)

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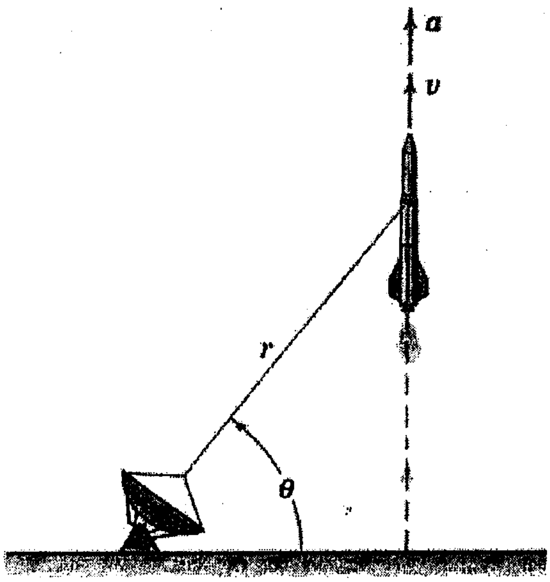

Fig. 7 (a)

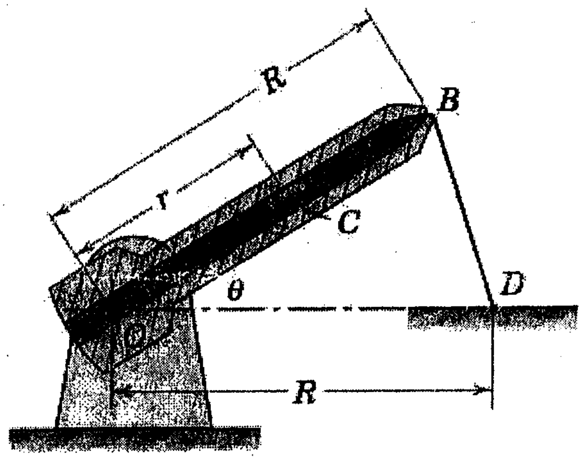

Fig. 7 (b)

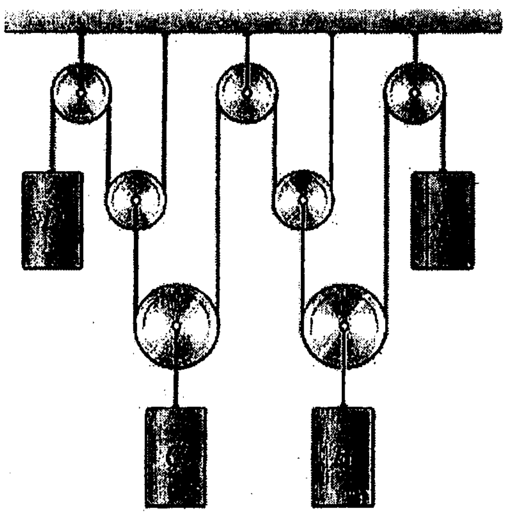

Fig. 8 (a)

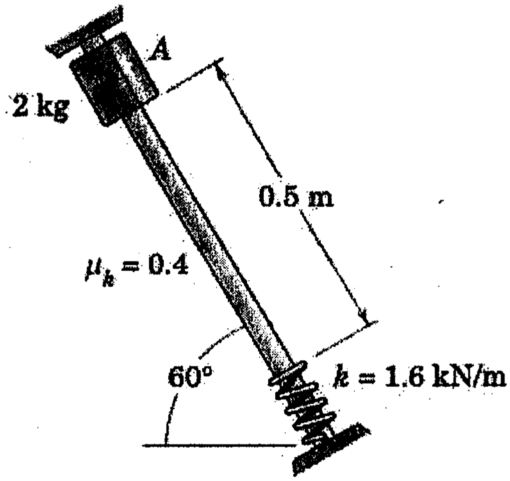

Fig. 8 (b)

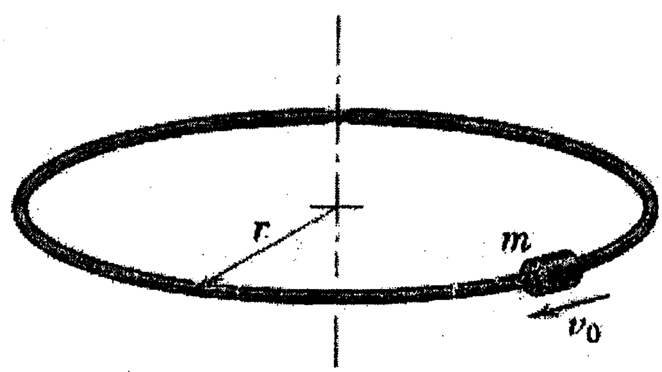

Fig. 9 (a)

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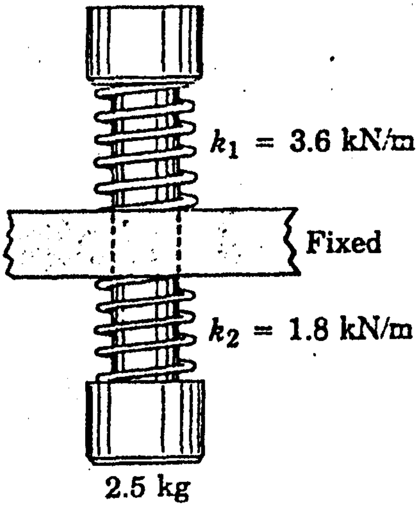

Fig. 9 (b)

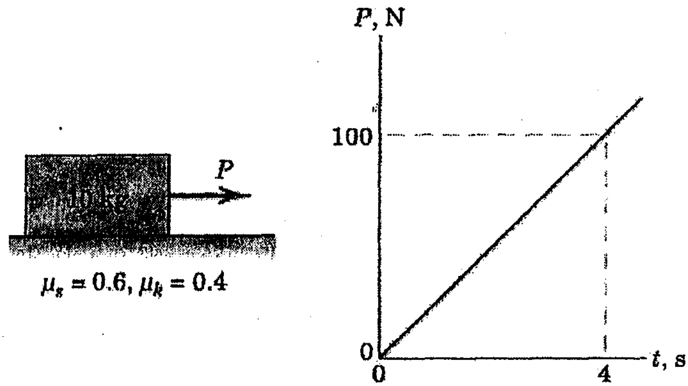

Fig. 10 (b)

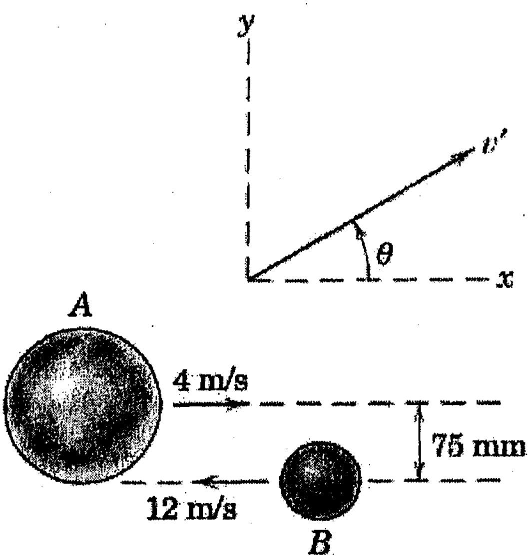

Fig. 10 (a)

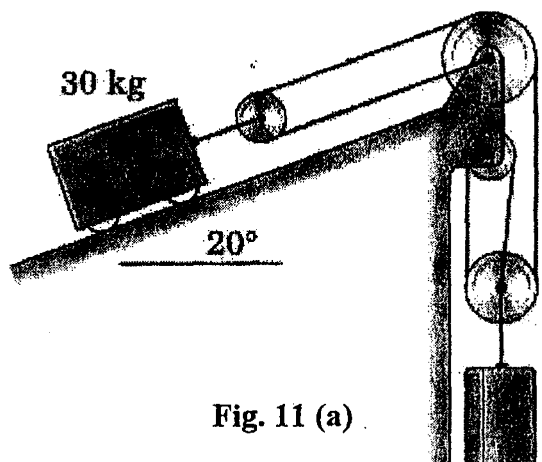

Fig. 11 (a)