

## I B.Tech Supplementary Examinations, Aug/Sep 2008

## ENGINEERING MECHANICS

( Common to Mechanical Engineering, Mechatronics, Metallurgy & Material Technology, Production Engineering, Aeronautical Engineering and Automobile Engineering)

Time: 3 hours

Max Marks: 80

Answer any FIVE Questions  
All Questions carry equal marks

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1. (a) A ball of weight 'W' rests upon a smooth horizontal plane and has attached to its center two strings AB and AC which pass over frictionless pulleys at B and C and carry loads P and Q, respectively, as shown in Figure 1a. If the string AB is horizontal, find the angle  $\alpha$  that the string AC makes with the horizontal when the ball is in a position of equilibrium. Also find the pressure R between the ball and the plane.

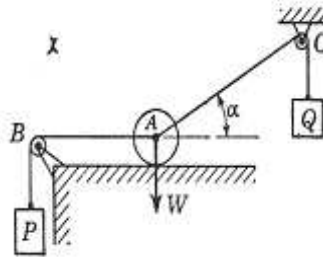


Figure 1a

- (b) Determine the forces  $S_1$  and  $S_2$  induced in the bars AC and BC in Figure 1b. due to the action of the horizontal applied load at C. The bars are hinged together at C and to the foundation at A and B. [8+8]

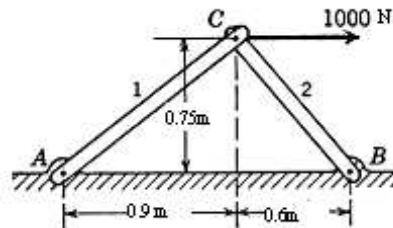


Figure 1b

2. (a) Explain the types of friction with examples.  
(b) Two equal bodies A and B of weight 'W' each are placed on a rough inclined plane. The bodies are connected by a light string. If  $\mu_A = 1/2$  and  $\mu_B = 1/3$ , show that the bodies will be both on the point of motion when the plane is inclined at  $\tan^{-1} (5/12)$ . [6+10]
3. A laminated belt 9 mm thick and 125 mm broad drives a pulley of 1.2 m diameter at 180 r.p.m the angle of lap being  $190^\circ$ . The weight of the belt material is  $1.16 \text{ kg/m}^3$ , the friction coefficient between the belt and the pulley is 0.3. If the stress in the

belt is not to exceed  $1.75 \text{ N/mm}^2$

Determine:

- (a) The power transmitted, neglecting the centrifugal tension effect,
  - (b) The power transmitted considering the centrifugal tension. [16]
4. (a) From the first principles determine product of inertia for right angle triangle of base 'b' and altitude 'h'.
- (b) State and prove transfer formula for product of inertia. [8+8]
5. Compute the mass moment of inertia about the x – axis of the steel link shown in figure5. [16]

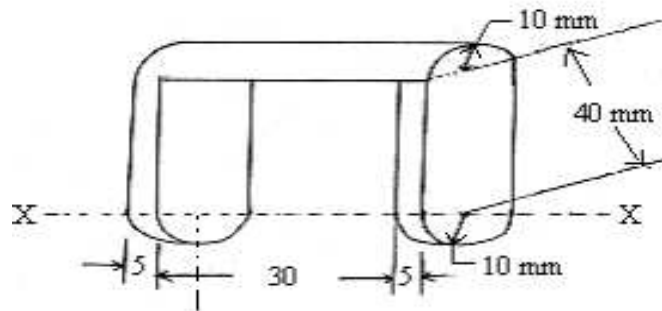


Figure 5

6. (a) A train is traveling at a speed of 60 km/hr. It has to slow down due to certain repair work on the track. Hence, it moves with a constant retardation of 1 km/hr/second until its speed is reduced to 15 km/hr. It then travels at a constant speed of for 0.25 km/hr and accelerates at 0.5 km/hr per second until its speed once more reaches 60 km/hr. Find the delay caused.
- (b) The motion of a particle in rectilinear motion is defined by the relation  $s = 2t^3 - 9t^2 + 12t - 10$  where s is expressed in metres and t in seconds. Find
- i. the acceleration of the particle when the velocity is zero
  - ii. the position and the total distance traveled when the acceleration is zero. [8+8]
7. (a) A body weighing 20 N is projected up a  $20^\circ$  inclined plane with a velocity of 12 m/s, coefficient of friction is 0.15. Find
- i. The maximum distance S, that the body will move up the inclined plane
  - ii. Velocity of the body when it returns to its original position.
- (b) Find the acceleration of the moving loads as shown in figure 7b. Take mass of P=120 kg and that of Q=80 Kg and coefficient of friction between surfaces of contact is 0.3. Also find the tension in the connecting string. [8+8]

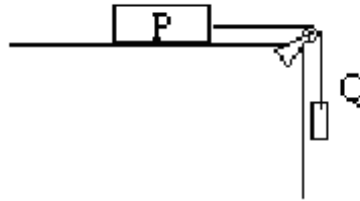


Figure 7b

8. Determine the frequency of torsional vibrations of the disc shown in figure 8 if both the ends of the shaft are fixed and diameter of the shaft is 40mm. The disc has a mass of 600Kg, and a radius of gyration of 0.4m. Taking modulus of rigidity for the shaft material as  $85\text{GN/m}^2$ .  $l_1=1\text{m}$ , and  $l_2= 0.8\text{m}$ . [16]



Figure 8

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1. A bar AB hinged to the foundation at A and supported by a strut CD is subjected to a horizontal 50 kN load at B, as shown in Figure 1. Determine the nature and magnitude of the force in the strut and also the reaction at A. [16]

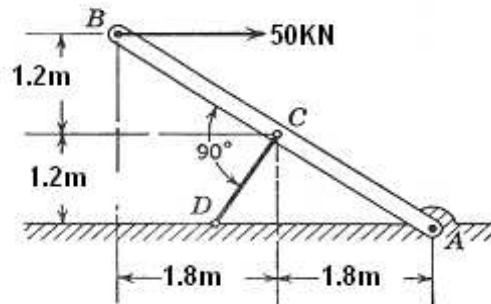


Figure 1

2. (a) Explain the types of friction with examples.  
(b) Two equal bodies A and B of weight 'W' each are placed on a rough inclined plane. The bodies are connected by a light string. If  $\mu_A = 1/2$  and  $\mu_B = 1/3$ , show that the bodies will be both on the point of motion when the plane is inclined at  $\tan^{-1} (5/12)$ . [6+10]
3. An open belt running over two pulleys 1500 mm and 1000 mm diameters connects two parallel shafts 4800 mm apart. The initial tension in the belt when stationary is 3000N. If the smaller pulley is rotating at 600 r.p.m and coefficient of friction between the belt and pulley is 0.3. Determine the power transmitted taking centrifugal tension into account. The mass of belt is given as 0.6703 kg/m length. [16]
4. (a) Derive an expression to determine the moment of inertia of a semi circle about its diametric base.  
(b) Find the moment of inertia of the shaded area, as shown in figure 4b about its centroidal axes parallel to x-axis. [8+8]

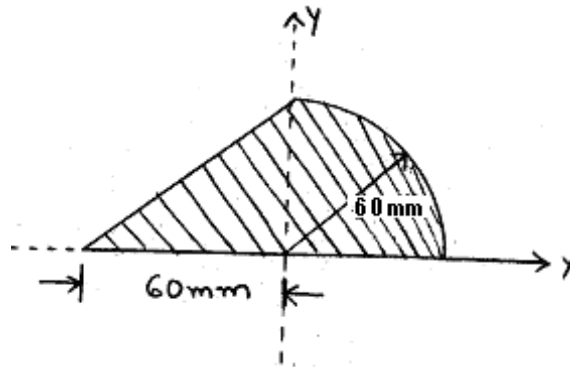


Figure 4b

5. Compute the mass moment of inertia about the x – axis of the steel link shown in figure5. [16]

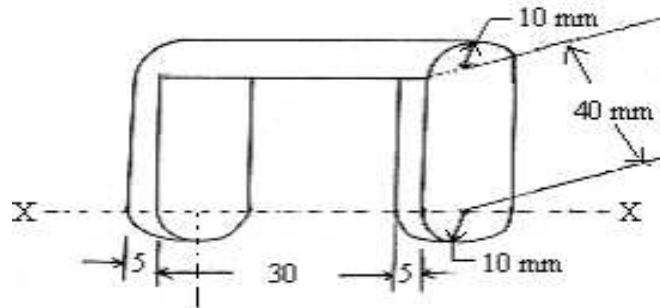


Figure 5

6. An enemy ship was located at a distance of 25km in north-west direction by a warship. If the enemy ship is moving with a velocity of 18kmph N30°E, in which direction the warship must move with a velocity of 36 kmph, to strike at its earliest. Assume the fire range of warship is 5km. When is the shell to be fired? [16]
7. (a) A homogeneous sphere of radius of  $a=100$  mm and weight  $W=100$  N can rotate freely about a diameter. If it starts from rest and gains, with constant angular acceleration, an angular speed  $n=180$ rpm, in 12 revolutions, find the acting moment. .
- (b) A block starts from rest from 'A'. If the coefficient of friction between all surfaces of contact is 0.3, find the distance at which the block stop on the horizontal plane. Assume the magnitude of velocity at the end of slope is same as that at the beginning of the horizontal plane. As shown in the Figure7b [8+8]

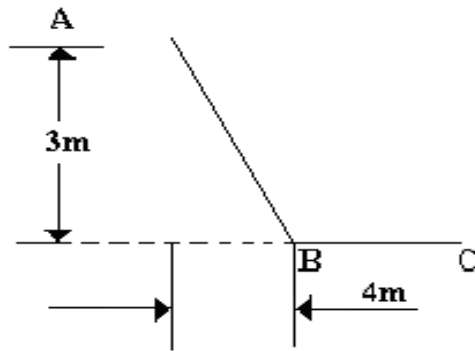


Figure 7b

8. The weight of an empty railway wagon is 240 kN on loading it with goods weighing 320 kN, its springs get compressed by 80 mm.
- (a) calculate its natural period of vibration when
- empty and
  - loaded as above.
- (b) It is set into natural vibrations with amplitude of 100 mm, when empty. Calculate the velocity when its displacement is 40 mm from statical equilibrium position. [16]

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1. A mast AB supported by a spherical socket at A and horizontal guy wires BC and BD carries a vertical load P at B as shown in Figure 1. Find the axial force induced in each of the three members of this system. [16]

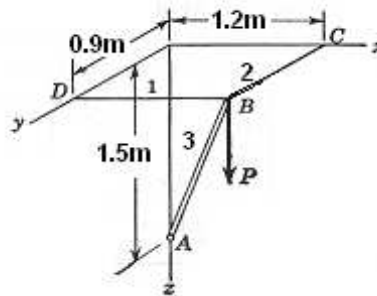


Figure 1

2. (a) Find the least horizontal force 'P' to start motion of any part of the system of three blocks resting upon one another as shown in figure2a. The weights of the blocks are  $A = 3000\text{N}$ ,  $B = 1000\text{N}$ ,  $C = 2000\text{N}$ . Between A and B  $\mu = 0.3$ , between B and C,  $\mu = 0.2$  and between C and the ground  $\mu = 0.1$ .

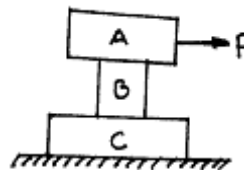


Figure 2a

- (b) A block overlying a  $10^\circ$  wedge on a horizontal floor and leaning against a vertical wall and weighing  $1500\text{N}$  is to be raised by applying a horizontal force to the wedge. Assuming the coefficient of friction to be  $0.3$ , determine the minimum horizontal force to be applied to raise the block. As shown in the Figure2b.

[8+8]

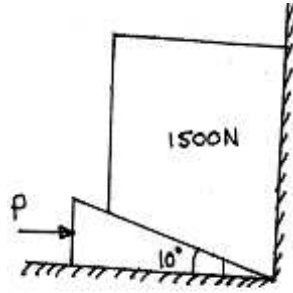


Figure 2b

3. An open belt running over two pulleys 240 mm and 600mm diameters connects two parallel shafts 3000mm apart and transmits 4KW from the smaller pulley that rotates at 300 r.p.m. Coefficient of friction between the belt and the pulley is 0.3 and the safe working tension is 10 N/mm width.

Determine :

- (a) Minimum width of the belt.
  - (b) Initial belt tension and
  - (c) Length of the belt required. [16]
4. (a) Calculate the moment of inertia of the shaded area about the x – axis  
{As shown in the Figure 4a}

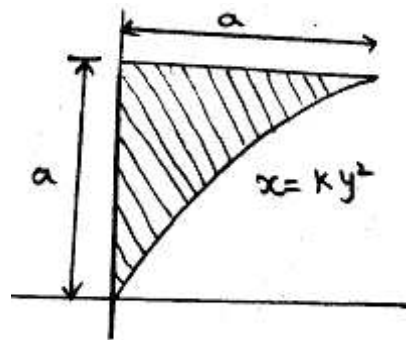


Figure 4a

- (b) Determine the moment of inertia of a hollow circular section about its centroidal axes as shown in figure 4b. [8+8]

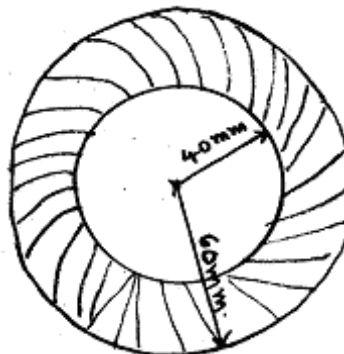


Figure 4b

5. A brass cone with base diameter of 400 mm and height of 225 mm is placed on a vertical aluminum cylinder of height 300 mm and diameter 400 mm. Density of brass =  $85 \text{ kN/m}^3$  and density of aluminium =  $25.6 \text{ kN/m}^3$ . Determine the mass moment of inertia of the composite body about the vertical geometrical axis. [16]
6. (a) A body moves along a straight line and its acceleration 'a' which varies with time 't' is given by  $a = 2 - 3t$ . Five seconds after the start of observation, the velocity is 20 m/s. The distance moved by the body 10 sec after the start of observation of motion from origin is 85 m  
Determine
- the acceleration, velocity and distance from the origin at the start of observation.
  - the time after the start of observation at which the velocity becomes zero and the distance travelled from the origin.
- (b) A car is uniformly accelerated and passes successive kilometre-stones with velocities of 20 km/hour and 30 km/hour respectively. Calculate its velocity when it passes the next kilometre stone and the time taken for each of these two intervals of one kilometre. [8+8]
7. (a) A homogeneous sphere of radius of  $a = 100 \text{ mm}$  and weight  $W = 100 \text{ N}$  can rotate freely about a diameter. If it starts from rest and gains, with constant angular acceleration, an angular speed  $n = 180 \text{ rpm}$ , in 12 revolutions, find the acting moment. .
- (b) A block starts from rest from 'A'. If the coefficient of friction between all surfaces of contact is 0.3, find the distance at which the block stop on the horizontal plane. Assume the magnitude of velocity at the end of slope is same as that at the beginning of the horizontal plane.  
As shown in the Figure 7b [8+8]

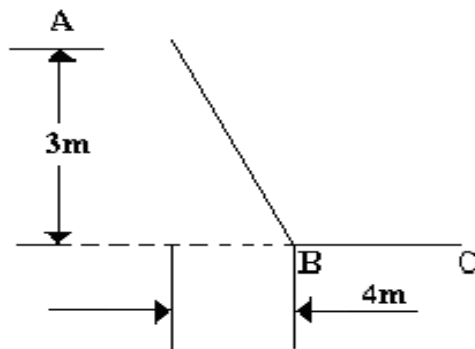


Figure 7b

8. A vertical shaft 100 mm in diameter and 1m in length has its end fixed to the ceiling. At the other end, it carries a disc of mass 500 kg having a radius of gyration of 450 mm. The modulus of rigidity for the material of shaft is 80 GPa. Determine the frequency of torsional vibrations. [16]

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1. (a) Three identical cylinders, each weighing 'W', are stacked as shown in figure 1a, on smooth inclined surfaces, each inclined at an angle ' $\theta$ ' with the horizontal. Determine the smallest angle ' $\theta$ ' to prevent stack from collapsing.

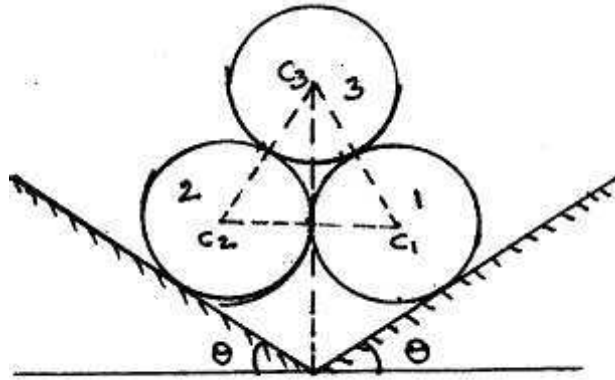


Figure 1a

- (b) The boom of a crane is shown in figure 1b, if the weight of the boom is negligible compared with the load ( $W$ ) = 60 kN, find the compression in the boom and also the limiting value of the tension ('T') when the boom approaches the vertical position. [8+8]

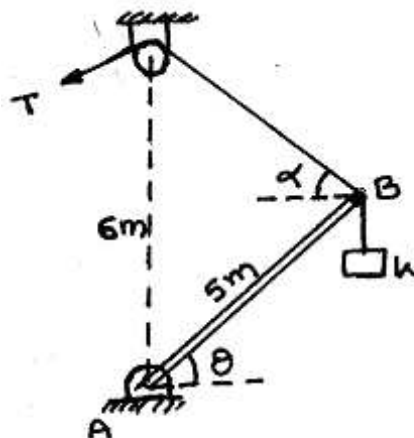


Figure 1b

2. (a) Define the following:

- i. Friction
  - ii. Angle of friction
  - iii. Limiting friction
  - iv. Cone of friction
- (b) A ladder 5 m long and of 250 N weight is placed against a vertical wall in a position where its inclination to the vertical is  $30^\circ$ . A man weighing 800 N climbs the ladder. At what position will he induce slipping? The co-efficient of friction for both the contact surfaces of the ladder viz. with the wall and the floor is 0.2. [8+8]
3. A shaft which rotates at a constant speed of 160 r.p.m is connected by belting to a parallel shaft 1800mm apart, which has to run at 60, 80 and 100 r.p.m. the smallest pulley on the driver shafts is 150mm in radius. Determine the remaining radii of the two stepped pulleys for
- (a) A crossed belt
  - (b) An open belt.
- Neglect belt thickness and slip form. [16]
4. (a) Derive an expression to determine the moment of inertia of a semi circle about its diametric base.
- (b) Find the moment of inertia of the shaded area, as shown in figure 4b about its centroidal axes parallel to x-axis. [8+8]

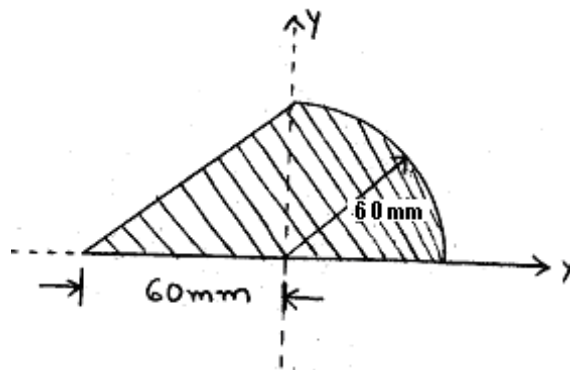


Figure 4b

5. A rectangular parallelopiped has the following dimensions.
- Length along x-axis = 'l'
  - Height along y-axis = 'a'
  - Breadth along z-axis = 'b'
  - Density of the material is 'w'
- Determine the mass moment of inertia of the parallelopiped about the centroidal axes. [16]
6. (a) The motion of a disk rotating about a fixed point is given by the relation  $\theta = 2(1 + e^{-3t})$  where  $\theta$  is in radians and 't' is in seconds. Determine the angular coordinates, velocity and acceleration of the disk when

- i.  $t=0$  and  
ii.  $t=2\text{secs}$ .
- (b) A projectile is aimed at a mark on the horizontal plane through the point of projection and falls 12m short when the angle of projection is  $15^\circ$  while it overshoots the mark by 24m when the angle of projection is  $45^\circ$ . Find the angle of projection to hit the mark neglecting the resistance of air.  
Take  $g = 9.81 \text{ m/s}^2$ . [8+8]
7. (a) A homogeneous sphere of radius of  $a=100 \text{ mm}$  and weight  $W=100 \text{ N}$  can rotate freely about a diameter. If it starts from rest and gains, with constant angular acceleration, an angular speed  $n=180\text{rpm}$ , in 12 revolutions, find the acting moment. .
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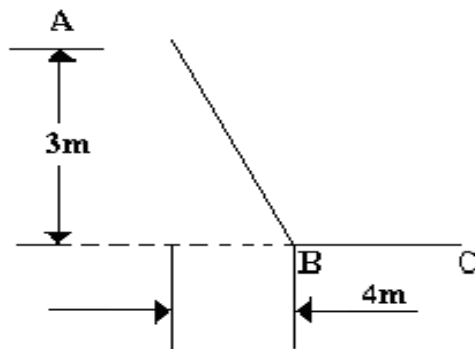


Figure 7b

8. Calculate the period  $\tau$  of the torsion pendulum shown in the figure 8. The following data are given. Weight of pendulum = 60 N, length of the rod = 0.5 m, diameter of the rod = 3 mm, radius of disc = 0.1 m, thickness of disc  $h= 25 \text{ mm}$ ,  $G = 8.16 \times 10^5 \text{ N/m}^2$ . Neglect the thickness of the disc in computing its moment of inertia. Also calculate the percentage error in the period  $\tau$  of the torsion pendulum in the figure8, due to neglecting the thickness 'h' of disk in computing its moment of inertia. [16]

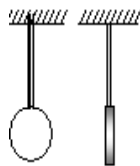


Figure 8

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