

I B.Tech Supplementary Examinations, Aug/Sep 2007
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

1. (a) A system of forces consists of
 - i. Force $P_1 = 3i + 5j - 6k$ acting through point (2,1,-3)
 - ii. Force $P_2 = 5i - 4j + 3k$ acting through point (1,4,2) and a moment $M = 20i - 35j + 60k$. The forces are in Newton (N) units, distances in 'm' units and the moment in 'N-m' units. Calculate
 - i. The component of the resultant forces and its magnitude
 - ii. The total moment of the system about the origin 'O'.
 - iii. The moment of the system about the line through 'O' drawn in the 1st octant which makes angles of 65° and 75° with X and Y axes respectively.
- (b) Write the Equilibrium equations for concurrent force system in space. [12+4]
2. (a) Referring to figure2a the coefficient of the friction is as follows: 0.25 at the floor, 0.30 at the wall, and 0.20 between blocks. Find the minimum value of a horizontal force P applied to the lower block that will hold the system in equilibrium.

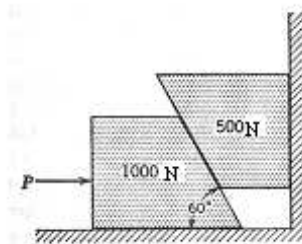


Figure 2a

- (b) Two identical blocks A and B are connected by a rod and rest against vertical and horizontal planes respectively, as shown in figure2b. If sliding impends when $\theta = 45^\circ$, determine the coefficient of friction μ , assuming it to be the same at both floor and wall. [8+8]

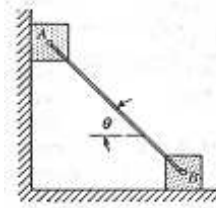


Figure 2b

3. (a) Distinguish between open and crossed belt drives.
 (b) A belt weighing $1000\text{kg}/\text{m}^3$ has a maximum permissible stress of $2.5\text{N}/\text{mm}^2$. Determine the maximum power that can be transmitted by a belt of $200\text{mm} \times 12\text{mm}$ if the ratio of the tight side to slack side tension is 2. [6+10]
4. (a) State and prove parallel axis theorem.
 (b) Find the centroid of the shaded lamina shown in Figure 4b. [6+10]

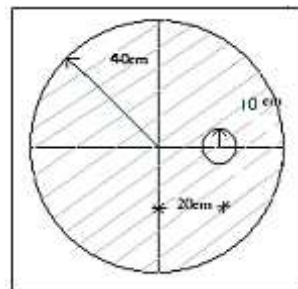


Figure 4b

5. Derive the expression for the moment of inertia of a cylinder length 'l', radius 'r' and density 'w' about longitudinal centroidal axis and about the centroidal transverse axis. [16]
6. A roller of radius 0.1m rides between two horizontal bars moving in opposite directions as shown in figure 6. Assuming no slip at the points of contact A and B, locate the instantaneous center 'I' of the roller. Also locate the instantaneous center when both the bars are moving in the same directions. [16]

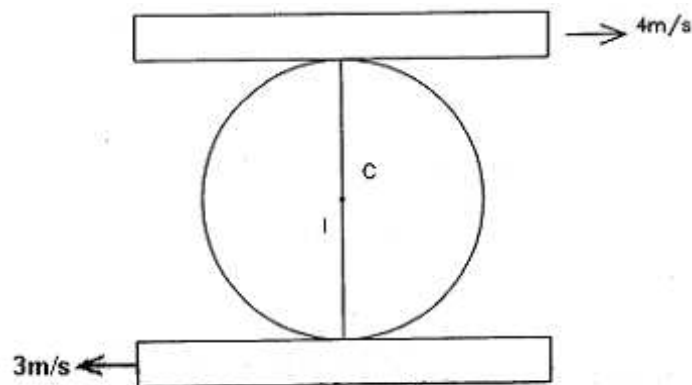


Figure 6

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]

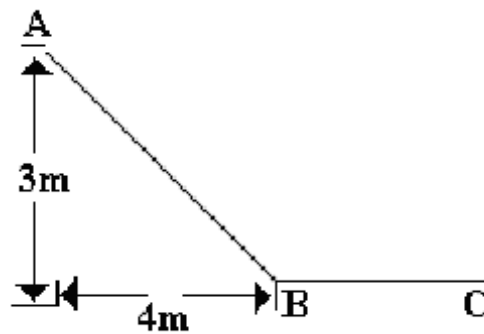


Figure 7b

8. A pendulum having a time period of 1 sec. is installed in a lift. Determine its time period when
- (a) the lift is moving upwards with an acceleration of $\frac{g}{10}$.
- (b) the lift is moving downwards with an acceleration of $\frac{g}{20}$. [16]

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1. The uniform 30kg bar with end rollers is supported by the horizontal and vertical surfaces and by the wire AC. Calculate the tension (T) in the wire and the reactions against the rollers at A and at B, as shown in Figure 1. [16]

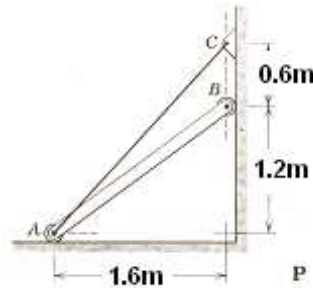


Figure 1

2. (a) A screw jack has a pitch of 6 mm. The mean radius of the threads is 60 mm. The mean diameter of the bearing surface under the cap is 80 mm. The coefficient of friction for all surfaces is 0.06. What turning moment is necessary to raise a load of 7 kN.
- (b) Determine the magnitude and direction of the friction force acting on the 1000N block shown in figure 2b. If, first $P = 500$ N and second $P = 100$ N. The coefficient of static friction is 0.2, and the coefficient of kinetic friction is 0.17. The forces are applied with the block initially at rest. [6+10]

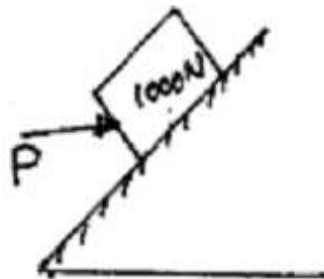


Figure 2b

3. An open belt drive connects two pulleys 1200mm and 500mm diameter on parallel shafts 4000mm apart. The belt weigh 9N/m length and maximum tension in it is not to exceed 2000N. The coefficient of friction is 0.3. The 1200mm pulley, which is the driver runs at 200r.p.m Due to belt slip on one of the pulleys, the velocity of the

driven shafts is only 450 r.p.m Calculate the torque on each of the two shafts, the power transmitted and power lost in friction. What is the efficiency of the drive.

[16]

4. (a) State and prove parallel axis theorem.

(b) Find the centroid of the shaded lamina shown in Figure4b.

[6+10]

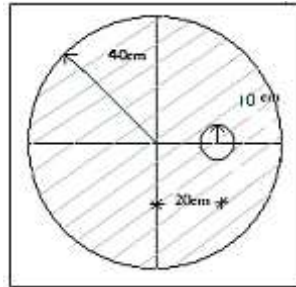


Figure 4b

5. (a) Prove that the mass moment of inertia of a right circular cone of base radius 'R' and height 'h', with respect to a diameter of the base is $M(3R^2 + 2h^2)/20$ where M is the mass of the cone.

(b) Calculate the mass moment of inertia of a circular cone of base radius 300mm and height 600mm about a line which passes through the mass centre of the cone and which is parallel to the base of the cone. The mass density of the cone is 2500 kg/m^3 . [8+8]

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 per 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 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 Figure7b.

[8+8]

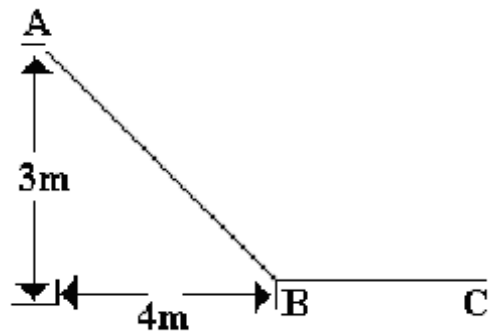


Figure 7b

8. The circular disc shown in the figure 8 has a radius $r=150$ mm and weight of 225 N. The observed frequency of torsional vibration is 1 oscillation/sec. When another body is attached to the same shaft the observed frequency of torsional vibration is 1.2 oscillations/sec. Find the moment of inertia of the second body with respect to the axis of the shaft. [16]

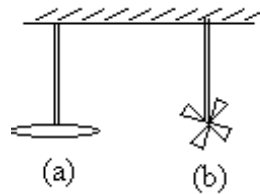


Figure 8

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1. Determine the resultant of the four forces and one couple that act on the plate shown in Figure 1. [16]

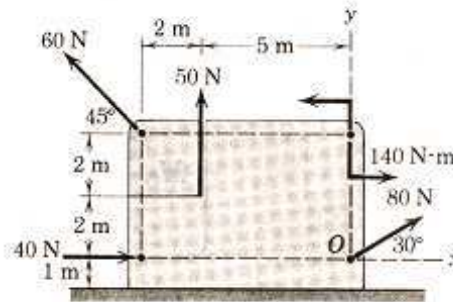


Figure 1

2. The two 5° wedges shown in Figure 2 are used to adjust the position of the column under a vertical load of 5 kN. Determine the magnitude of the forces P required to raise the column if the coefficient of friction for all surfaces is 0.40. [16]

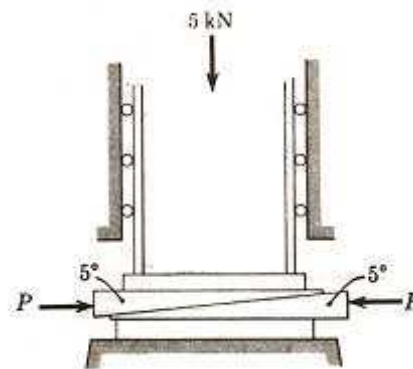


Figure 2

3. An open flat belt drive connects two parallel shafts 1200mm apart. The driving and driven shafts rotate at 350 r.p.m and 140 r.p.m respectively and the driven pulley is 400 mm in diameter. The belt is 5mm thick and 80mm wide. Coefficient of friction between belt and pulley is 0.3 and maximum permissible tension in the belting is $1.4N/mm^2$. Determine.

(a) Diameter of driving pulley.

- (b) Maximum power that may be transmitted by the belting and
 (c) Required initial tension in the belt. Neglect 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. (a) Prove that the mass moment of inertia of a right circular cone of base radius 'R' and height 'h', with respect to a diameter of the base is $M(3R^2 + 2h^2)/20$ where M is the mass of the cone.
 (b) Calculate the mass moment of inertia of a circular cone of base radius 300mm and height 600mm about a line which passes through the mass centre of the cone and which is parallel to the base of the cone. The mass density of the cone is 2500 kg/m^3 . [8+8]
6. (a) An airplane is flying horizontally with a velocity of 450 km/hr at an altitude of 1960 m towards a target on the ground which is to be bombed. Estimate where the bomb must be released in order to hit the target and the time of travel of the bomb. What is the velocity with which the bomb will hit the target? Also find the angle made by the line of sight of the pilot when the bomb is released.
 (b) The acceleration of a particle is defined by the relation $a = kt - 4$. Knowing that $v = 4 \text{ m/s}$ when $t = 2 \text{ sec}$ and $v = 1 \text{ m/s}$ when $t = 1 \text{ sec}$, determine the constant 'k'. Write the equations of motion when $x = 0$ at $t = 3 \text{ secs}$. [8+8]
7. (a) A homogeneous solid cylinder of weight 100 N whose axis is horizontal rotates about its axis, in frictionless bearings under the action of the weight of a 10N block which is carried by a rope wrapped around the cylinder. What will be angular velocity of cylinder two seconds after the motion starts? Assume the diameter of cylinder as 100cm.
 (b) A block of mass 5Kg resting on a 30° inclined plane is released. The block after travelling a distance of 0.5m along the inclined plane hits a spring of stiffness 15N/cm. Find the maximum compression of spring. Assume coefficient of friction between the block and the inclined plane is 0.2. As shown in the Figure 7b. [8+8]

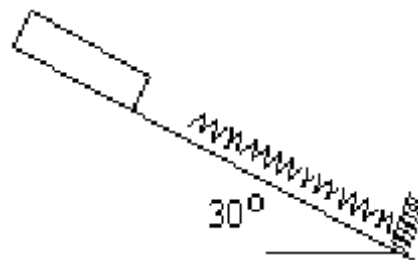


Figure 7b

8. A pendulum having a time period of 1 sec. is installed in a lift. Determine its time period when

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- (a) the lift is moving upwards with an acceleration of $\frac{g}{10}$.
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1. (a) Two forces equal to $2P$ and P respectively act on a particle. If first be doubled and the second increased by 12N the direction of the resultant is unaltered, find the value of 'P'?
- (b) A 675 N man stands on the middle rung of a 225 N ladder, as shown in Figure 1b. Assuming a smooth wall at B and a stop at A to prevent slipping, find the reactions at A and B. [8+8]

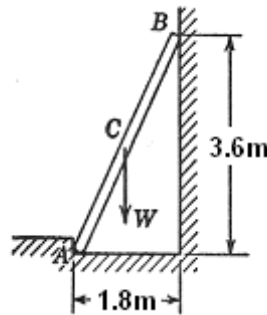


Figure 1b

2. The vertical position of the 100kg block is adjusted by the screw activated wedge {As shown in the Figure2}. Calculate the moment 'M' which must be applied to the handle of the screw to raise the block. The single threaded screw has square threads with a mean diameter of 30 mm and advances 10 mm for each complete turn. The coefficient of friction for the screw threads is 0.25 , and the coefficient of friction for all mating surfaces of the block and wedge is 0.40 . Neglect friction at the ball joint A. [16]

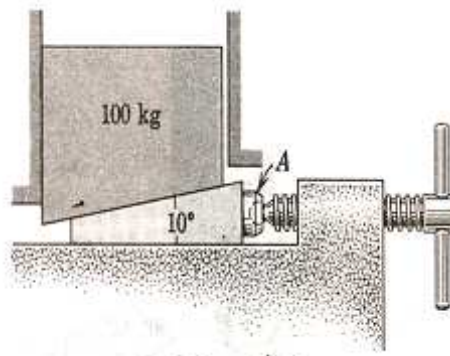


Figure 2

3. A leather belt is required to transmit 9kW from a pulley 1200 mm in diameter running at 200 r.p.m The angle embraced is 165° and the coefficient of friction between leather belt and pulley is 0.3. If the safe working stress for the leather belt is $1.4N/mm^2$ the weight of leather is $1000Kg/m^3$ and the thickness of the belt is 10mm, determine the width of the belt taking the centrifugal tension in to account. [16]

4. Determine the moment of inertia of a triangle about x – x axis as shown in figure 4. [16]

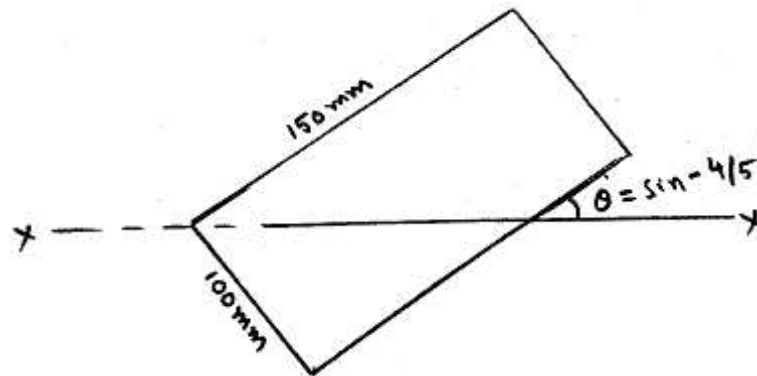


Figure 4

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

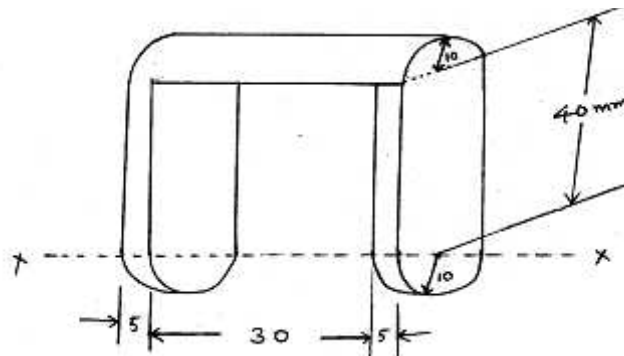


Figure 5

6. A roller of radius 0.1m rides between two horizontal bars moving in opposite directions as shown in figure6 Assuming no slip at the points of contact A and B, locate the instantaneous center 'I' of the roller. Also locate the instantaneous center when both the bars are moving in the same directions. [16]

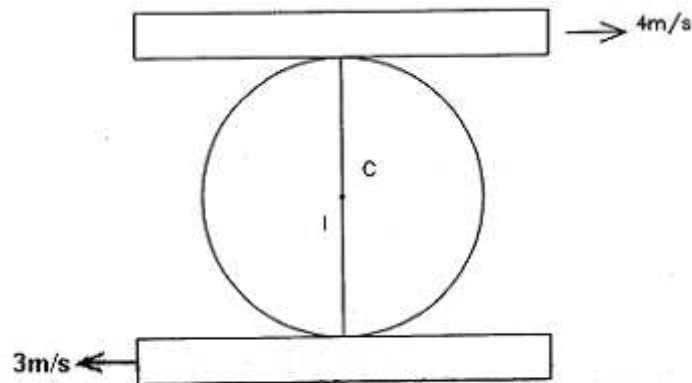


Figure 6

7. (a) A homogeneous solid cylinder of weight 100 N whose axis is horizontal rotates about its axis, in frictionless bearings under the action of the weight of a 10N block which is carried by a rope wrapped around the cylinder. What will be angular velocity of cylinder two seconds after the motion starts? Assume the diameter of cylinder as 100cm.
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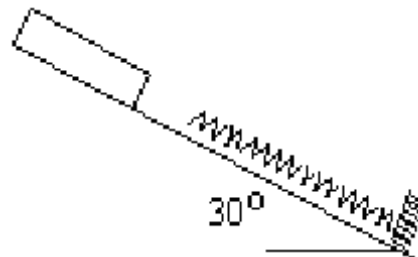


Figure 7b

8. (a) Explain how a simple pendulum differ from a compound pendulum briefly with the help of differential mathematical equations.
- (b) Determine the stiffness in N/cm of a vertical spring to which a weight of 50 N is attached and is set vibrating vertically. The weight makes 4 oscillations per second. [8+8]
