Code: D-02 **Subject: APPLIED MECH**
Time: 3 Hours **Max. Marks:**

NOTE: There are 11 Questions in all.

- **Question 1 is compulsory and carries 16 marks. Answer to Q. 1. must be written in the space provided for it in the answer book supplied and nowhere else.**
- **Answer any THREE Questions each from Part I and Part II. Each of these questions carries 14 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or best alternative in the following: **(2x8)**

a. In case of frictionless support

(A) the reactions acts normal to the surface at the point of contact.
(B) there is no reaction.
(C) the reaction acts tangential to the surface at the point contact.
(D) the reaction acts neither normal to the surface at the point of contact nor tangential to the surface at the point of contact.

b. For the equilibrium of a body subjected to two forces, both the forces must be

(A) equal in magnitude. **(B)** opposite in direction.
(C) both **(A)** & **(B)**. **(D)** None of these.

c. Polar moment of inertia is

(A) equal to the product of I_{xx} & I_{yy}.
(B) equal to the sum of I_{xx} & I_{yy}.
(C) equal to the difference of I_{xx} & I_{yy}.
(D) None of the above.

d. A stone is dropped into a well & the sound of the splash is heard after 4 seconds. Assuming velocity of sound to be 350 m/s, the depth of the well will be equal to

(A) 7.077 m. **(B)** 70.77 m.
(C) 707.7 m. **(D)** None of the above.

e. A motorist is travelling on a curved road of radius 200 m at a uniform speed of 72 Km/hour. The normal component of acceleration will be

(A) $2\ m/s^2$. **(B)** $2.2\ m/s^2$.
(C) $0.2\ m/s^2$. **(D)** None of the above.

f. To calculate shear stress while punching a hole of 'D' diameter in a plate of thickness 't' by a force 'F', the expression used is

(A) $\frac{F}{\left(\frac{\pi}{4}D^2\right)}$. **(B)** $\frac{F}{\pi Dt}$.

(C) $\frac{F}{\pi D^2}$. **(D)** None of the above.

g. The ratio of direct stress & direct strain within elastic limit is called

(A) modulus of rigidity. **(B)** modulus of elasticity.
(C) bulk modulus. **(D)** None of the above.

h. In case of a cantilever loaded with a concentrated load at its free end, the maximum B.M. occurs at

(A) free end. **(B)** fixed end.
(C) mid span. **(D)** None of the above.

PART I
Answer any THREE Questions. Each question carries 14 marks.

Q.2 Determine the centroid of the cross sectional area of an unequal I–section as shown in Fig. 1. **(14)**

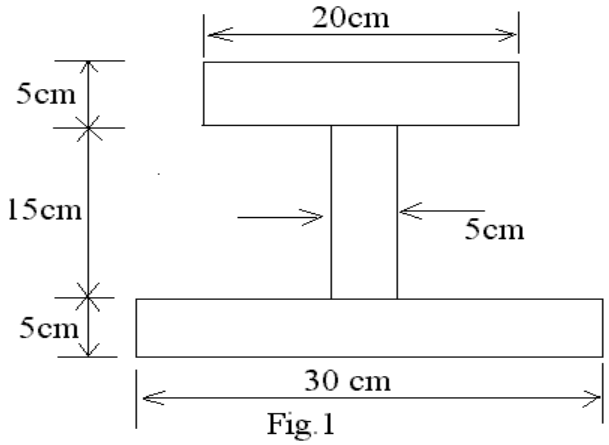

Fig. 1

Q.3 Determine the axial forces in the bars of a plane truss loaded as shown in Fig. 2. **(14)**

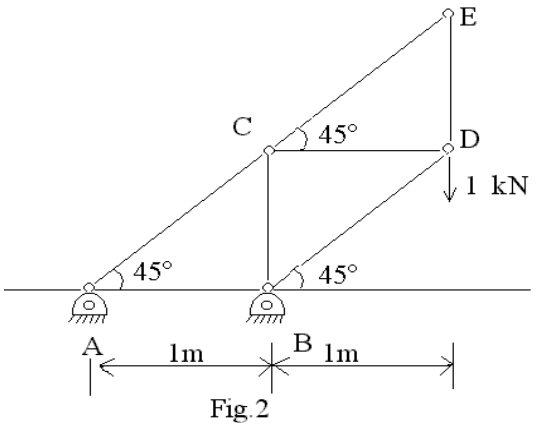

Fig. 2

Q.4 A screw jack has square threads of mean diameter of 10.0 cm & a pitch of 1.25 cm. Determine the force that must be applied to the end of 50 cm lever
(i) to raise a weight of 50 kN (ii) to lower a weight of 50 kN
Find the efficiency of the jack. Is it a self-locking jack ? Assume $\mu = 0.20$. **(14)**

Q.5 Two blocks of masses M_1 & M_2 are connected by a flexible but inextensible string as shown in Fig.3. Assuming coefficient of friction between M_1 & horizontal surface to be $\mu = 0.25$. Find the acceleration of the masses & tension in the string. Assume $M_1 = 10\,\text{kg}$ & $M_2 = 5\,\text{kg}$. **(14)**

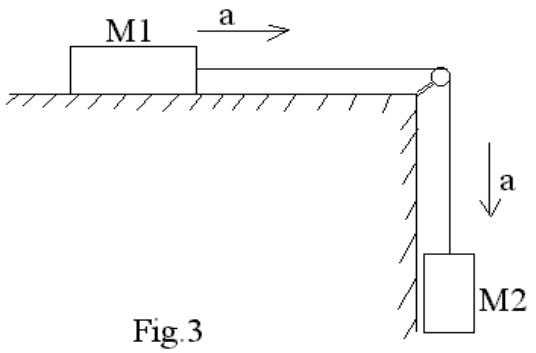

Fig.3

Q.6 A car starts from rest on curved portion of road of radius 250 m & attains a speed of 18 km/hour at the end of 60 seconds while traveling with a uniform acceleration. Find the tangential & normal accelerations of the car 30 seconds after it started. **(14)**

PART II
Answer any THREE Questions. Each question carries 14 marks.

Q.7 A cylinder of radius 1 m rolls without slipping along a horizontal plane AB. Its center has a uniform velocity of 20 m/s. Find the velocity of points E & F on the circumference of the cylinder as shown in Fig.4. **(14)**

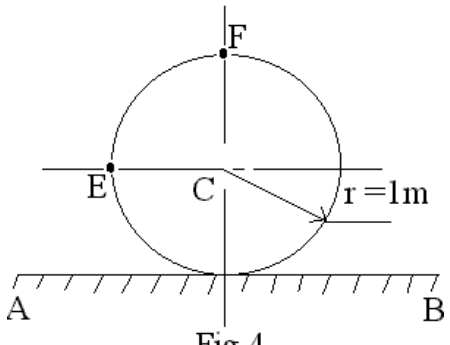

Fig.4

Q.8 Draw the shear force and bending moment diagrams for the beam shown in Fig.5. Indicate the numerical value at all important sections in the diagrams. **(14)**

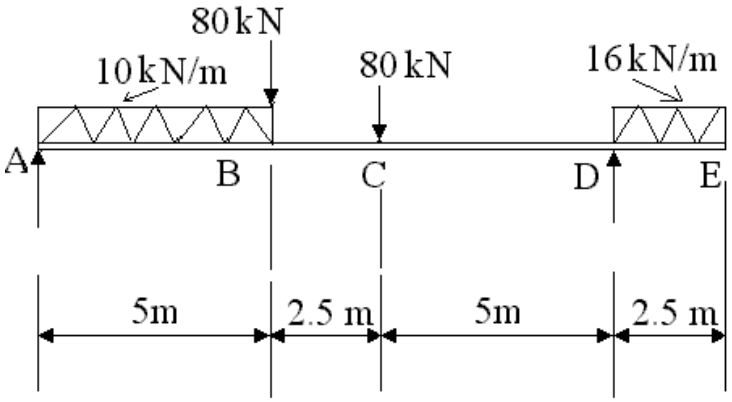

Fig.5

Q.9 A steel bar 25 mm diameter is loaded as shown in Fig.6. Determine the stresses in each part and the total elongation. E = 210 G Pa. **(14)**

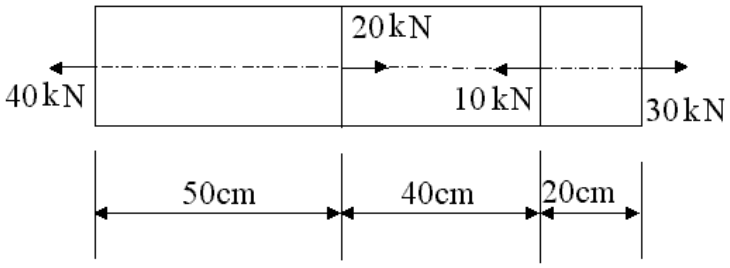

Fig.6

Q.10 Derive the following expression for a circular shaft of radius r and length ℓ.

$$\frac{T}{J} = \frac{G\theta}{\ell} = \frac{\tau}{r}$$

Where T = Torque applied
J = Polar moment of inertia
G = Modulus of rigidity
θ = Angle of twist
ℓ = Length of shaft
τ = Shear stress
r = radius of shaft **(14)**

Q.11 Explain the following :
(i) Complementary shear stress.
(ii) Tensile stress strain curve for a ductile material.
(iii) Law of polygon of forces.
(iv) "General plane motion of a rigid body can be considered as the sum of a plane translation & a rotation about an axis perpendicular to the plane motion." **(14)**

Code: D-02 **Subject: APPLIED MECH**
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- **Answer any THREE Questions each from Part I and Part II. Each of these questions carries 14 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or best alternative in the following: **(2x8)**

a. If the sum of all the forces acting on a body is zero, then the body may be in equilibrium provided

(A) concurrent. **(B)** parallel.
(C) like parallel. **(D)** unlike parallel.

b. The maximum frictional force which comes into play when a body just begins to slide over the surface of another body is

(A) Dynamic friction. **(B)** Rolling friction.
(C) Kinetic friction. **(D)** Limiting friction.

c. A weight of 1000 N can be lifted by an effort of 90 N. If the velocity ratio of the machine is 15, then the machine is

(A) Reversible. **(B)** Non-Reversible.
(C) Ideal. **(D)** Imperfect.

d. The C.G of an equilateral triangle with each side 'a' measured from any of the three sides is

(A) $\frac{a\sqrt{3}}{2}$. **(B)** $\frac{a\sqrt{2}}{3}$.

(C) $\frac{a}{2\sqrt{3}}$. **(D)** $\frac{a}{3\sqrt{2}}$.

e. In a compound lever, the Leverage of all the simple levers is

(A) Added. **(B)** Subtracted.
(C) Multiplied. **(D)** Divided.

f. The horizontal range of a projectile is maximum when the angle of projection is

(A) 22 ½ °. **(B)** 30°.
(C) 45°. **(D)** 60°.

g. A torque of 50 Nm is applied on the wheel operating a valve. If the wheel is rotated through 2 rotations, the work done in Nm is

(A) 25. **(B)** 100.
(C) 314 . **(D)** 628.

h. The point of contra flexure occurs in

(A) simple supported beam only. **(B)** cantilever beam only.
(C) continuous beams only. **(D)** overhanging beams only.

PART I

Answer any THREE Questions. Each question carries 14 marks.

Q.2 A gun is mounted on a gun carriage which can move on a smooth horizontal plane. The gun is directed at an angle α with the horizontal. A shot is fired which leaves the gun at an angle θ to the horizontal. If the total mass of the gun and the carriage is m times that of the shot. Show that $\tan\alpha = \left(\frac{m}{m+1}\right)\tan\theta$. **(14)**

Q.3 A block of weight, W rests on the smooth surface inclined at 20° with the horizontal. The block is supported by an effort, P hung from a pulley as shown in Fig.1. Using the principle of virtual work obtain an expression for P in terms of W, when the system is at rest.

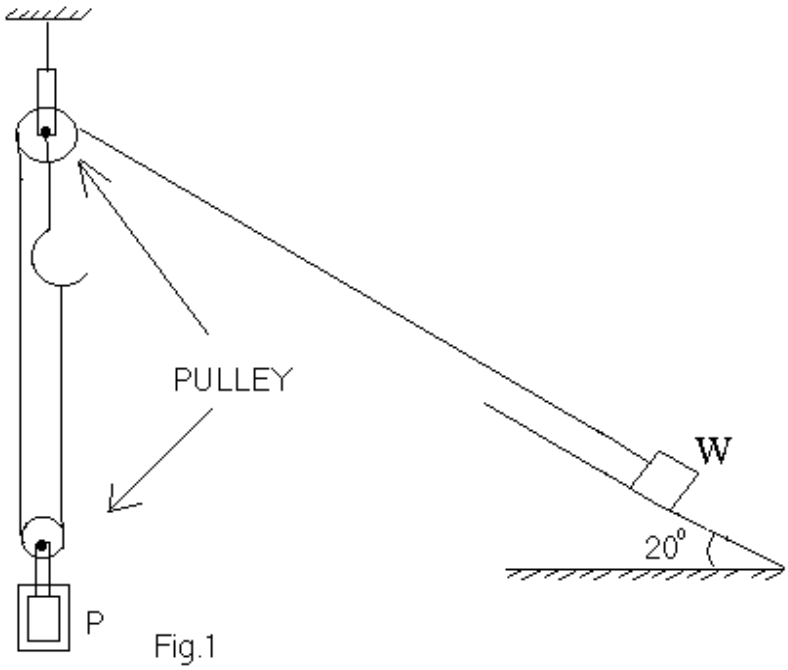

Fig.1

(14)

Q.4 A bird is sitting on the top of a tree 10 m high. With what velocity should a person, standing at a distance of 25 m from the tree throw a stone at an angle of 30° with the horizontal so as to hit the bird. **(14)**

Q.5 An inclined plane is used to unload slowly a heavy safe weighing 4000 N from a truck 1.2 m high into the ground as shown in Fig.2. The coefficient of friction between the underside of the safe and the plank is 0.3. Will the safe slide down the plane on its own? Justify your answer by calculation.

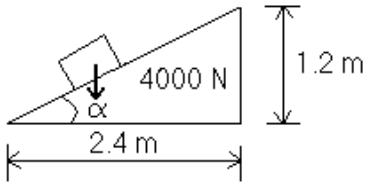

Fig. 2

(14)

Q.6 A cantilever truss as shown in Fig. 3 is carrying a point load of 15 kN at J. Find the forces in all the members of the truss. All the inclined members are at 45° with the horizontal.

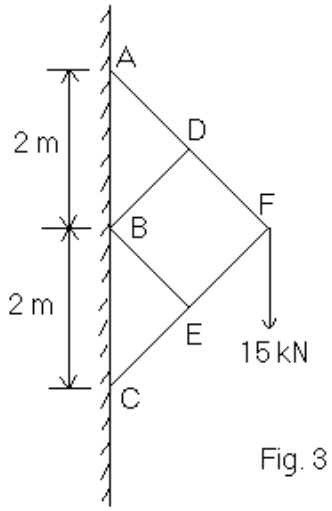

Fig. 3

(14)

PART II

Answer any THREE Questions. Each question carries 14 marks.

Q.7 Derive an expression for the maximum velocity of a vehicle to avoid overturning while negotiating a curve on a level circular path. **(14)**

Q.8 Draw the S.F. and B.M. diagram for the structure as shown in Fig.4.

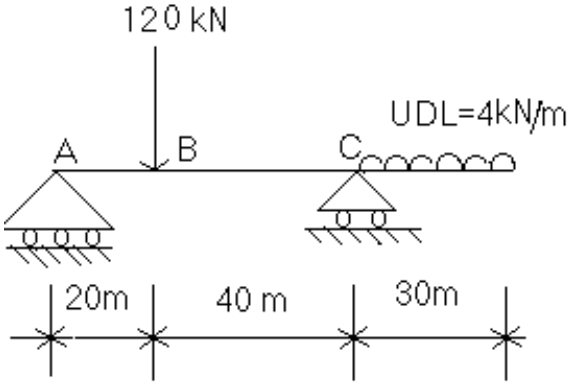

Fig. 4

(14)

Q.9 Prove that a hollow shaft is always stronger than a solid shaft of same material, weight and length, when subjected to same pure torque. **(14)**

Q.10 Define stress, strain and Young's modulus of Elasticity. Two rods A and B of equal length hang vertically 60 cm apart and support a rigid bar horizontally. The bar remains horizontal when carrying a load of 50,000 N at 20 cm from A. If the stress in B is 50 N/mm^2, find the stress in A and areas of rods A and B, E_A = 200,000 N/mm^2, E_B = 90,000 N/mm^2. **(14)**

Q.11 A beam simply supported at A and B, is loaded with a force P at D as shown in the Fig. 5. Determine the deflection at D.

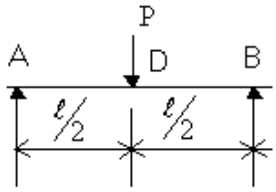

Fig.5

(14)

DEC./2003

Code: D-02 **Subject: APPLIED MECH**
Time: 3 Hours **Max. Marks:**

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Q.1 Choose the correct or best alternative in the following: **(2x8)**

a. A two force body will be in equilibrium when two forces acting on it, are

(A) colinear. **(B)** equal in magnitude.
(C) opposite. **(D)** all the above.

b. The centroid of a semicircular area of radius R lies at a distance of $\bar{y}$ from diameter. The value of $\bar{y}$ is

(A) $\frac{R}{\pi}$. **(B)** $\frac{2R}{\pi}$.
(C) $\frac{4R}{3\pi}$. **(D)** $\frac{3R}{4\pi}$.

c. IF R = Normal reaction, μ = Coefficient of friction and F = Limiting force of friction, which one of the following statement is correct

(A) $F = \mu R$. **(B)** $\mu = R/F$.
(C) $R = \mu F$. **(D)** All of them.

d. In a screw jack α = helix angle of square threads and ϕ = angle of friction between threads, the screw jack is self locking if

(A) $\alpha = \phi$. **(B)** $\alpha > \phi$.
(C) $\alpha < \phi$. **(D)** $\alpha = \frac{\pi}{4}$.

e. A semi circular section is of radius 4 cm. What is its moment of inertia about its diameter

(A) $64\,\pi\,cm^4$. **(B)** $32\,\pi\,cm^4$.
(C) $16\,\pi\,cm^4$. **(D)** $8\,\pi\,cm^4$.

f. A particle is moving along a straight line such that its displacement is $S = 7t^2 + 10t + 3$. What is the initial velocity of the body

(A) 14 m/s. **(B)** 10 m/s.
(C) 6 m/s. **(D)** 3 m/s.

g. A beam carries transverse loads and is simply supported with overhung on both the sides. The point of contra flexure is a point where

(A) shear force is max. **(B)** shear force is zero.
(C) bending moment changes sign. **(D)** bending moment is maximum.

h. Torsional rigidity of a shaft is given by

(A) $\frac{T}{G}$. **(B)** T/J.
(C) GJ. **(D)** TJ.

PART I
Answer any THREE Questions. Each question carries 14 marks.

Q.2 A uniform wheel of 60.00 cm diameter and weighing 1000 N rests against a rectangular block 15 cm high lying on a horizontal plane as shown in the Figure 1. It is to be pulled over this block by a horizontal force P applied to the end of a string would round the circumference of the wheel. Find the force P when the wheel is just about to roll over the block. **(14)**

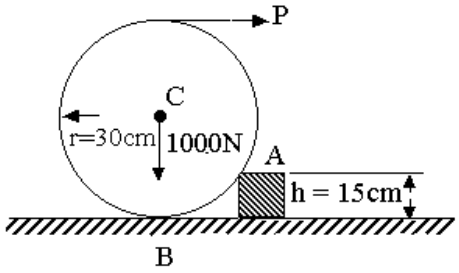

Fig. 1

Q.3 Determine the moment of inertia of the T-section as shown in Figure 2, with respect to the centroidal x-axis. **(14)**

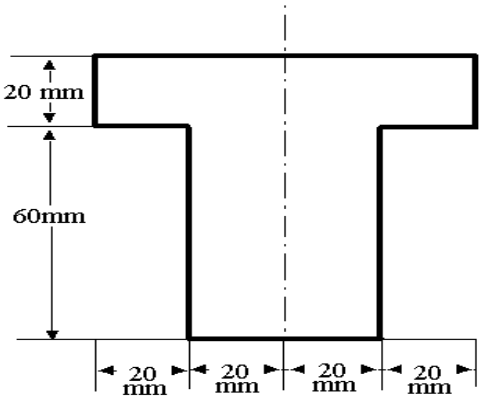

Fig. 2

Q.4 Determine the axial forces and their nature in the bars of a plane truss subjected to a force of 2 kN as shown in Figure 3. **(14)**

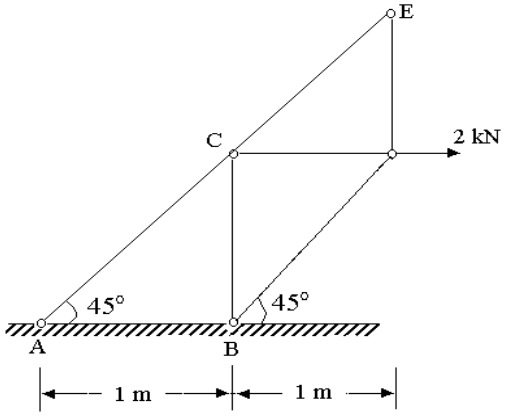

Fig. 3

Q.5 A 7.0 m long ladder rests against a vertical wall, with which it makes an angle of 45°. If a man, whose weight is one half of that of the ladder, climbs it, at what distance along the ladder will he be, when the ladder is about to slip? The coefficient of friction between the ladder and the wall is $\frac{1}{3}$ and that between the ladder and the floor is $\frac{1}{2}$. **(14)**

Q.6 A weight W of 1000 N is to be raised by a system of pulleys as shown in Figure 4. Using the principle of virtual work find the value of the force P which can hold the system in equilibrium. **(14)**

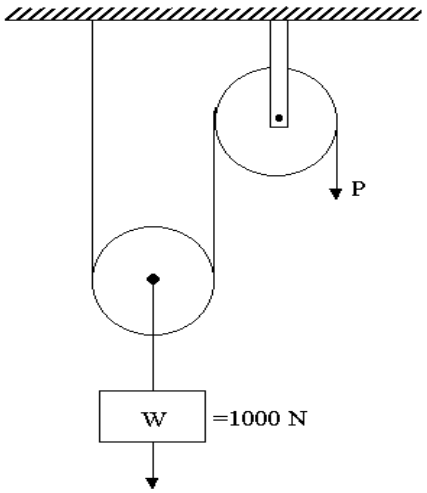

Fig. 4

PART II

Answer any THREE Questions. Each question carries 14 marks.

Q.7 A car starts from rest on a curved road of radius 250 m and attains a speed of 18 km / hour at the end of 60 seconds while traveling with a uniform acceleration. Find the tangential and normal accelerations of the car 30 seconds after it started. **(14)**

Q.8 A round bar as shown in Figure 5, is subjected to an axial tensile load of 100 kN. What must be the diameter 'd' if the stress there is to be 100 MN / m^2. Find also the total elongation. E = 290 Gpa. **(14)**

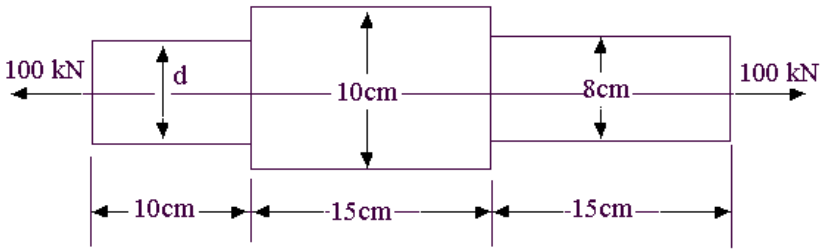

Fig.5

Q.9 A horizontal girder which is freely supported at its ends and has a span of 9 m as shown in Figure 6. It supports a uniformly distributed load of 20 kN /m run over the whole span and also two concentrated loads of 30 kN and 40 kN at points 6 m and 7.5 m respectively from the left support. Draw the bending moment and shearing force diagrams and state the values of the maximum bending moment and maximum shear force. **(14)**

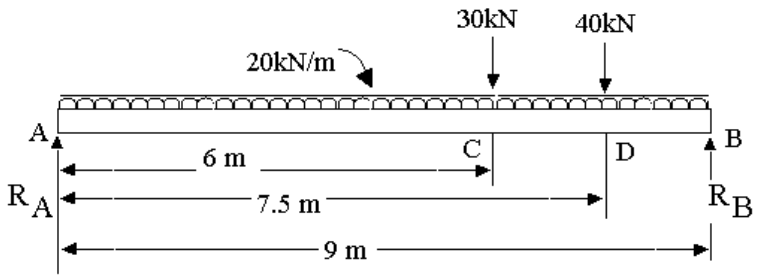

Fig. 6

Q.10 A horizontal girder of steel having uniform section is 14m long and is simply supported at its ends. It carries a concentrated load of 120 kN at a distance of 4.5 m from the left end. I for the section of girder is 16×10^4 cm^4 and E for steel is 210 Gpa. Calculate the deflection of the girder at points under the two loads. Derive the expression used. **(14)**

Q.11 A circular steel shaft of 30 mm diameter is subjected to a torque of 0.56 kNm. Determine:

(i) The maximum shear stress developed in the shaft.
(ii) Angular twist over 1 meter length of the shaft.
(iii) The shear stress at a point which is at a distance of 1 cm from the center of shaft. G for steel = 82×10^3 N/mm^2. **(14)**

JUNE/2004

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- **Answer any THREE Questions each from Part I and Part II. Each of these questions carries 14 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or best alternative in the following: **(2x8)**

a. A motor boat moves due East with a speed of 12 km/h for ½ hour and then moves due North with a speed of 8 km/h for 1 hour. The magnitude of the displacement would be
(A) 6 km. **(B)** 8 km.
(C) 10 km. **(D)** None of these.

b. A force of 5 N moves a body of weight 20 N by 5 m on a rough horizontal table. The work done by the weight would be
(A) 0. **(B)** 25 J.
(C) 50 J **(D)** 100 J.

c. The distance between the corner and centroid of an L of equal side *b* is
(A) 0. **(B)** $\frac{b}{\sqrt{4}}$.
(C) $\frac{b}{\sqrt{2}}$. **(D)** $\frac{b}{\sqrt{8}}$.

d. In a simple machine an effort of 20 N, moving a distance of 80 cm, lifts a load of 120 N by 10 cm. The mechanical efficiency would be
(A) 60%. **(B)** 75%.
(C) 80%. **(D)** 90%.

e. A particle is executing simple harmonic motion. Its path would be
(A) a circle **(B)** a parabola
(C) a sine curve **(D)** none of these

f. A uniform rod of mass m and length L is pinned at one end and rotating at an angular velocity ω. The kinetic energy of the rod would be
(A) $mL^2\omega^2/24$. **(B)** $mL^2\omega^2/12$
(C) $mL^2\omega^2/6$ **(D)** none of these.

g. A solid shaft of radius r, length L, modulus of rigidity G has an angle of twist θ. The maximum shear strain γ_{max} in the shaft would be
(A) $\theta r/L$ **(B)** θ/L
(C) $G\theta r/L$ **(D)** none of these.

h. A beam is subjected to pure bending. Its curvature would be
(A) zero. **(B)** constant.
(C) varying linearly. **(D)** none of these.

PART I

Answer any THREE Questions. Each question carries 14 marks.

Q.2 a. A mass of 2 kg is acted upon by a force of 8 N in the x direction and another force of 16 N at an angle of 120° to the x axis in the xy plane. Determine the acceleration of the mass in the x and y directions. **(6)**

b. Determine the magnitude, direction and location on the plate of the simplest resultant of the forces shown in Fig.1. **(8)**

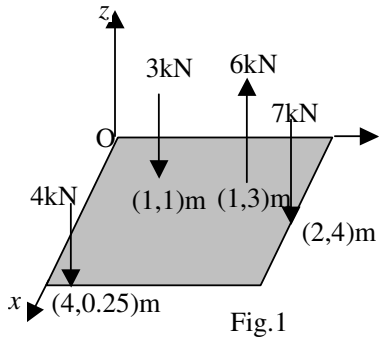


Fig.1

Q.3 a. Two smooth balls A and B, each having a weight of 20 N, rest between the inclined planes shown in Fig.2. Draw the free body diagrams for ball A and for ball B. **(7)**

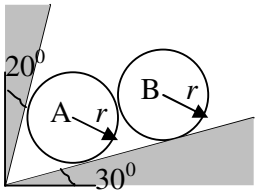


Fig.2

b. Determine the forces in each member of the truss shown in Fig.3. **(7)**

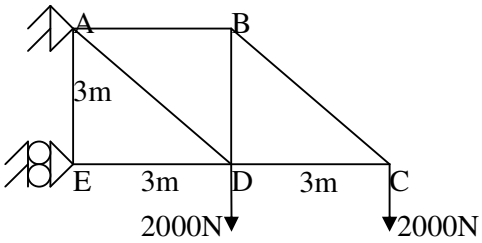
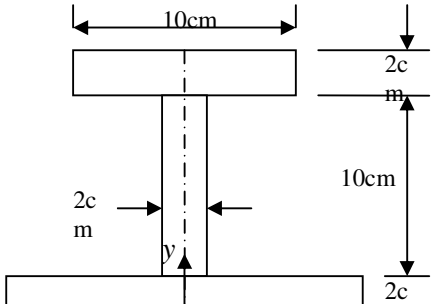


Fig.3

Q.4 For the unequal flange I section shown in Fig.4, determine the location of the centroid and the polar moment of inertia about its centroidal axis. **(14)**



NOT TO SCALE

14

Q.5 A symmetrical wedge of angle θ is driven into a wooden block. If the weight of the wedge is negligible and the coefficient of friction between the wedge and the block is μ, determine an expression for the minimum force P required to drive the wedge in. Also find the minimum value of the coefficient of friction μ so that the wedge is self locking. **(14)**

Q.6 a. An enemy plane is flying in a straight path at 200 km/hr at a height of 1000 m above the ground. An anti-aircraft gun located on the ground fires a shell with an initial velocity of 300 m/s at an instant when the plane is vertically above it. Determine the required inclination to the vertical of the gun to hit the plane. Obtain the time after firing when the shell hits the plane and the horizontal distance of the plane from the gun. **(8)**

b. A flywheel of diameter 1m is rotating with angular speed of 2 rad/s and angular acceleration of 3 rad/s^2. Determine the acceleration of a point on the rim of the wheel. **(6)**

PART II

Answer any THREE Questions. Each question carries 14 marks.

Q.7 a. A 10 kg mass is suspended by a light string wound round a drum of mass 50 kg and radius 40 cm. If the radius of gyration of the drum is 30 cm and the drum is free to rotate about its axis, determine the angular acceleration of the drum and the tension in the string. **(8)**

b. A hammer of mass 50 kg drops freely from a height of 2.5 m on to a pile of mass 20 kg and drives it 10 cm into the ground. If the impact is perfectly plastic, determine the average resistance of the ground. **(6)**

Q.8 a. In a uniaxial tension test, the load-elongation diagram is an shown in Fig 5. The specimen cross-sectional area was 100 mm^2 and gauge length was 200 mm. Obtain the Young's modulus, 0.2% proof stress, the ultimate stress and percentage elongation. Take the elastic limit as 30 kN. **(10)**

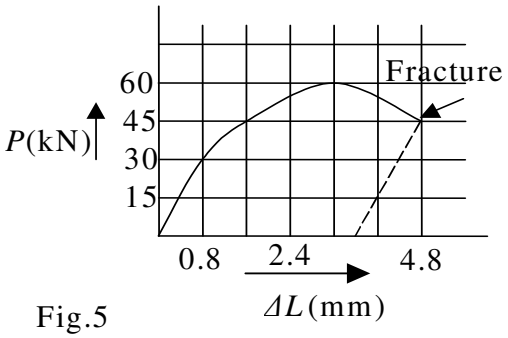


Fig.5

b. A hole of diameter *d* has to be punched in a plate of thickness *t*. If the ultimate shear strength of the plate material is τ, determine the punch force required. **(4)**

Q.9 A hollow steel shaft is to transmit 628 kW at 200 rpm without exceeding a shearing stress of 80 Mpa and an angle of twist of $3.0°$ over a length of 4 m. Determine the shaft diameter. Take the modulus of rigidity for steel as 80 Gpa. **(14)**

Q.10 A beam is supported and loaded as shown in Fig.6. Draw the S.F. and B.M. diagrams. Find the maximum bending moment and its location. **(14)**

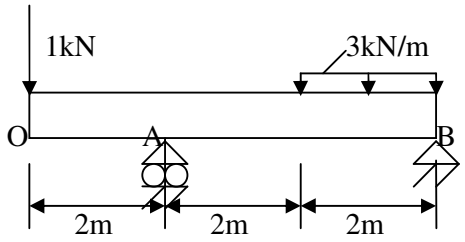


Fig.6

Q.11 a. State the moment area theorems. **(4)**

b. A cantilever BCD is subjected to a load *P* at the free end B as shown in Fig.7. The flexural rigidity of the beam for the portion BC is *EI* and for the portion CD is 2*EI*. Find the slope and deflection at the free end. Neglect the weight of the beam. **(10)**

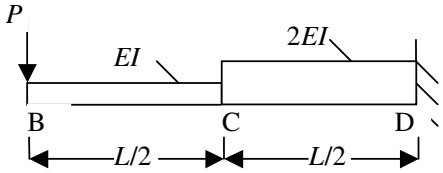


Fig.7

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