Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/B.TECH (NEW)/SEM-1/ME 101/2010-11

2010-11
ENGINEERING MECHANICS

Time Allotted : 3 Hours   *Full Marks* : 70

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words
as far as practicable.

GROUP – A
(Multiple Choice Type Questions)

1.   Choose the correct alternatives for the following :   10 × 1 = 10

   i)   Mass moment of inertia of body is

      a)   moments of its inertia

      b)   rotational analogue of mass

      c)   Inertial moment about the centroidal axis

      d)   none of these.

   ii)   the centre of percussion of a rigid body is a point

      a)   through which resultant of all forces acts

      b)   where minimum external force acts

      c)   where impact is made

      d)   all of these.

   iii)   Two coplanar couples having equal and opposite moments

      a)   balance each other

      b)   produce a couple and an unbalance force

      c)   an equivalent

      d)   all of these.

1215   [Turn over

iv) The moment of inertia of a rectangle having base *b* and height *h* with respect to its base is

a) $\frac{1}{3}h^2h^2$

b) $\frac{1}{3}b^3h$

c) $\frac{1}{3}bh^3$

d) $\frac{1}{3}b^2h^2$.

v) The D' Alembert's principle

a) is based upon the presence of inertia force

b) provides advantage over Newton's law

c) is purely a hypothetical principle

d) allows a dynamic problems to be treated as a static one

vi) Centroid of a line segment

a) must lie on the line

b) may not lie on the line

c) must be same as the cetre of gravity.

d) none of these.

vii) Volumetric strain of a rectangular body subjected to an axial force, in terms on terms of linear strain ε and Poisson's ratio √ is given by

a) $\varepsilon(1 + 2\sqrt{})$

b) $\varepsilon(1 - 2\sqrt{})$

c) $\varepsilon(1 + \sqrt{})$

d) $\varepsilon(1 - \sqrt{})$.

viii) Poisson's ratio is defined as

a) lateral stress and lateral strain

b) longitudinal stress and longitudinal strain

c) lateral stress and longitudinal stress

d) none of these.
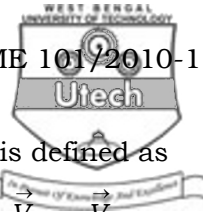
ix) Relative velocity of $\vec{A}$ with respect to $\vec{B}$ is defined as

a) $\vec{V}_{A/B} = \vec{V}_B - \vec{V}_A$

b) $\vec{V}_{A/B} = \vec{V}_A - \vec{V}_B$

c) $\vec{V}_{A/B} = \vec{V}_B + \vec{V}_A$

d) None of these.

x) When a change in length takes place, the strain is known as

a) Linear strain

b) lateral strain

c) shear strain

d) volumetric strain.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following.

$3 \times 5 = 15$

2. The position vector of a particle moving in the x-y plane at time t = 3·60s is 2·76 j m. At t = 3·62s its position vector has become 2·79i-3·33 j m. Determine the magnitude v of its average velocity during this interval and the angle θ made by v with x-axis.

3. What do you mean by a free body diagram ? Draw the FBD from the given Fig. 1.   1 + 4
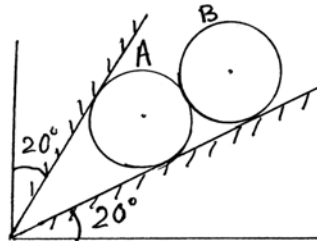

Fig. 1

1215   3   [Turn over

4. If two equal tensions T in the pulley cable are 400-N, cable as shown in Fig. 2 express in vector notation the force R exerted on the pulley by the two tensions. Determine the magnitude of R.
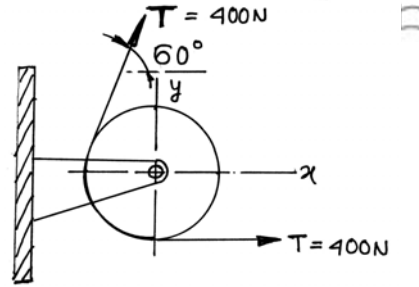
Fig. 2

5. i) State and prove Lami's theorem.

ii) Define free-body diagram. 3 + 2

6. A bullet of mass m, moving with a horizontal velocity v, hits a stationary block of mass M, suspended by a massless string of length L. The bullet gets embedded in the block after impact and the two together swings up. Show that the maximum angle of swing (i.e. angle made by the string with the vertical) is

$$\theta = \cos^{-1}\left(1 - \frac{m^2 v^2}{2gL(M + m)^2}\right).$$

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) A 50 N block is released from rest on an inclined plane which is making an angle of 35° to the horizontal (Fig. 3). The block starts from 'A' slides down a distance

of 1·2 m and strikes a spring with a stiffness of 8 kN/m. The co-efficient of friction between the inclined plane and the block is 0·25. Determine (i) the amount the spring gets compressed and (ii) distance of the block will rebound up the plane from the compressed position.
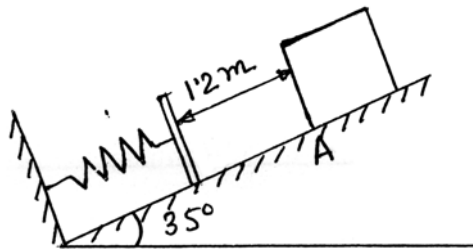

Fig. 3   8

b)   A reinforced concrete column having cross-section 300 mm × 300 mm is provided with 9 bars of 20 mm diameter (Fig. 4). The column carried a load of 300 KM. Find the stress developed in the steel bars and concrete. Take Es = 2·1 × 10^5 N/mm^2 and Ec = 0·14 × 10^5 N/mm^2.
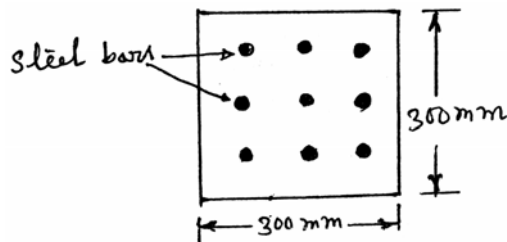
Fig. 4   7

8.   A rigid bar AB is hinged to a vertical wall and supported horizontally by a tie rod CD as shown in Fig. 5. The cross-

sectional area of CD is A = 0·5 sq.cm and its allowable stress in tension is σ_w = 1,500 kg/sq. cm. Find the safe value of P and the corresponding vertical displacement Δ_B of B. Modulus of elasticity of tie rod E = 2 × 10⁶ kg/sq. cm.
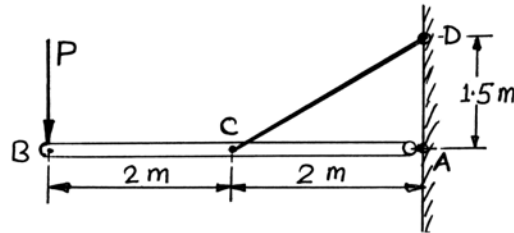

Fig. 5

9.   a)   A block of weight W1 = 200 N rests on a horizontal surface and supports on top of it, another block of weight W2 = 50 N. The block W2 is attached to a vertical wall by the inclined string AB. Find the magnitude of the horizontal force P applied to the lower block as shown in Fig. 6, that will be necessary to cause slipping to impend. The coefficient of static friction for all contiguous surfaces is μ = 0·3.   7
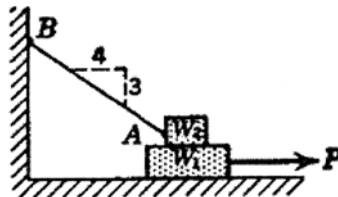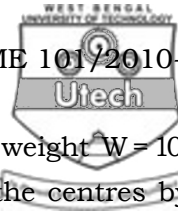

Fig. 6

b) Two smooth circular cylinders, each of weight W = 100 N and radius r = 6 cm are connected at the centres by a string AB of length 1 = 16 cm and rest upon a horizontal plane, supporting above them a third cylinder of weight Q = 200 N and radius 1 = 6 cm as show in Fig. 7. Find the force S in the string AB and pressure produced on the floor at D and E. 8

Fig. 7

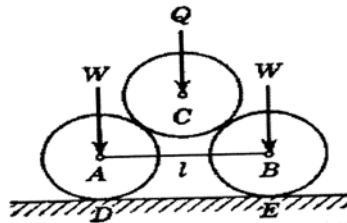10. a) Two rollers of diameters 60 mm and 30 mm weighing 200 N and 150 N respectively. They are supported by an inclined plane and vertical walls as shown in Fig. 8. Assuming smooth surfaces, determine the reactions at the contact surfaces.

b) Find out the moment of inertia about centroidal axes of an area as shown in Fig. 9.
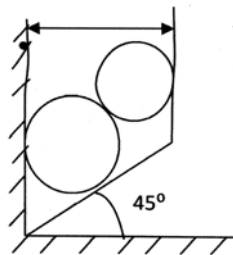

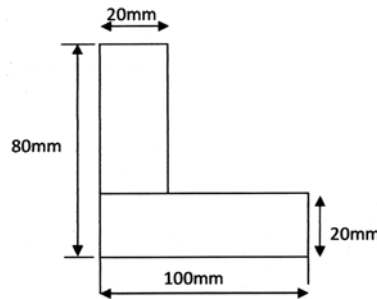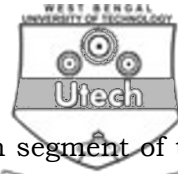Fig. 8   Fig. 9

11. a) Calculate the increase in stress for each segment of the compound bar shown in Fig.10. If the temperature increases by 100°F, assume that the supports are unyielding and that the bar is suitably braced against buckling,　　　　8
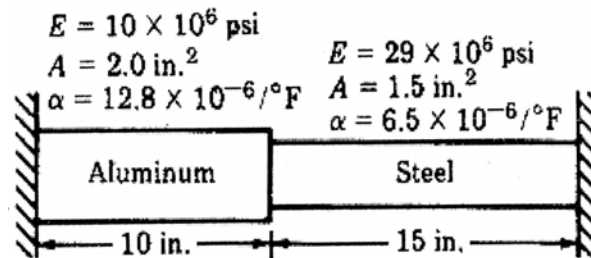
$E = 10 \times 10^6$ psi
$A = 2.0$ in.^{2}
$\alpha = 12.8 \times 10^{-6}/°F$

$E = 29 \times 10^6$ psi
$A = 1.5$ in.^{2}
$\alpha = 6.5 \times 10^{-6}/°F$

Aluminum   Steel

— 10 in. —   — 15 in. —

Fig.10

b) In Fig. 11 a lever is attached to a spindle 2·5 cm in diameter by means of a square key 6 mm × 6 mm if the average shear stress in the key not to exceed 700 N/cm². What is the safe value of the load P applied to the end of the lever.　　　　7
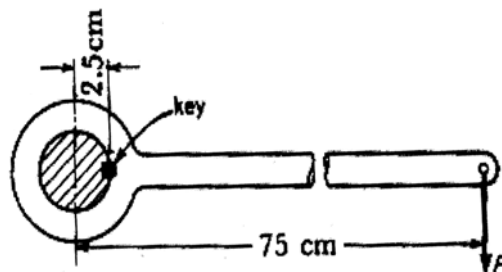
2.5 cm

key

— 75 cm —   P

Fig. 11