Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B. Tech/SEM-1/ME-101/2009-10

2009
MECHANICAL SCIENCE – I

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 of the following : 10 × 1 = 10

   i) Lami's theorem is applicable to

      a) Equilibrium of two co-planar, concurrent forces

      b) Equilibrium of three co-planar, concurrent forces

      c) Equilibrium of three co-planar, non-concurrent forces

      d) none of these.

   ii) Stain energy is the

      a) maximum energy which can be stored in a body

      b) energy stored in a body when stressed to the elastic limit

      c) energy stored in a body when stressed to the breaking point

      d) none of these.

iii) Poisson's ratio is defined as

a) Longitudinal stress by lateral stress

b) Lateral stress by longitudinal stress

c) Longitudinal strain by lateral strain

d) Lateral strain by longitudinal strain.

iv) Free body diagram of a body is drawn

a) by isolating the body its surrounding

b) by indicating the forces acting on it

c) both of these

d) none of these.

v) If a momentum of a body is doubled, its kinetic energy will

a) increase by two times

b) increase by four times

c) remain same

d) get halved

e) reduced to four times.

vi) A body falling freely from a height of 10 m rebounds from the floor. If it losses 20% of its energy in the impact how high will it rebounds ?

a) 10 m b) 8 m

c) 12 m d) none of these.

vii) The dot product of two orthogonal vector is

a) one b) zero

b) no definite value d) none of these.

viii) The centre of gravity of a uniform lamina lies at

a) the centre of heavy portion

b) the bottom surface

c) the mid-point of its axis

d) none of these.

ix) If the velocity of projectile is u and the angle of projection is α, the maximum height attained by a projectile above the horizontal plane is

a) $u^2 \cos^2 \alpha/2g$

b) $u^2 \sin^2 \alpha/2g$

c) $u^2 \tan^2 \alpha/2g$

d) $u^2 \sin^2 \alpha/g$.

x) Three forces $\sqrt{3}p$, p and $2p$ acting on a particle are in equilibrium. If the angle between first and second be 90°, the angle between second and third will be

a) 30° b) 60°

c) 120° d) 150°.

GROUP – B
(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. a) State D' Alembert's principles.

   b) A smooth circular cylinder of radius 1·5 is lying in a rectangular groove is shown in Figure 1. Find the reactions at the surfaces of contact, if there is no friction and the cylinder weighs 1000 N. 1 + 4

Figure 1

3. Refer to the Figure 2, determine the range of values of mass m_0 so that the 100 kg block will neither move up nor slip down the inclined plane. The coefficient of static friction for the surfaces in contact is 0·3.

Figure 2

4. a) State Varigon's principle.

   b) A circular roller of weight 100 N and radius 10 cm hangs by a ties rod AB = 20 cm and rests against a smooth vertical wall at C as shown in Figure 3. Determine the force F in the rod.

Figure 3

5. Referring to Figure 4, r = 12 cm, Q = 500 N and h = 6 cm. Find magnitude of P required to start the roller over curb.

Figure 4

6. Two smooth circular cylinders of Figure 5, each of weight W = 100 N and radius r = 6 cm are connected by a string AB of length l = 16 cm and rest upon a horizontal plane, supporting a third cylinder of weight Q = 200 N and radius r = 6 cm above them. Find the tension S in the string AB and the pressure produced by the floor at points of contact D and E.

Figure 5

GROUP – C
(Long Answer Type Questions)

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

7. a) A 150 kg man stands on the mid-point of a 50 kg ladder as shown in Figure 6. Assuming that floor and the wall are perfectly smooth, find the reactions at points A and B.

Figure 6

b) Determine the moment of inertia for the T section (as shown in Figure 7) with respect to a centroidal axis parallel to *x*-axis. All dimensions are in mm. 8 + 7

Figure 7

8. a) Prove that the volumetric strain of a rectangular bar is the algebraic sum of strains of length, width and height.

b) Show that elongation of a conical bar under its own weight is independent of its base diameter but on length only.

c) Determine the strain energy stored within a bar of length l, cross-sectional area A, density ρ and modulus of elasticity E, hanging vertically due to its own height.

6 + 4 + 5

9. a) Two spheres P and Q rests in the channel as shown in Figure 8. The sphere P has a diameter 400 mm and weight of 200 N, whereas the sphere Q has diameter 500 mm and weight 500 N. If bottom width of the channel is 500 mm and with one side vertical and other side inclined at 60°, determine the reaction induced in the contacts.

Figure 8

b) In the Figure 9 shown, find the minimum value of horizontal force P applied to the lower block that will keep the system in equilibrium. Given, coefficients of friction between lower block and floor = 0·25, between the upper block and the vertical wall = 0·30, between the two blocks = 0·20. 8 + 7

Figure 9

10. a) State the principle of virtual work. 3

b) Two blocks weighing W_1 and W_2 resting on smooth inclined planes are connected by an inextensible string passing over a smooth pulley as shown in Figure 10. Find the value of W_2 when W_1 = 500 N and $\alpha = 30^\circ$, $\beta = 60^\circ$. 7

Figure 10

c) Determine velocity V of the falling weight W of the system as shown in Figure 11 as a function of its displacement from the initial position of rest. Assume weight of the cylinder as 2W. 5

Figure 11

11. a) From top of a tower, 60 m high a bullet is fired at an angle of 20° up the horizontal with velocity 120 m/s. Determine

i) time of flight

ii) horizontal range of ground

iii) maximum height of the bullet from ground

iv) velocity of the bullet after 8 seconds.

Assume horizontal ground at the foot of the tower.

b) Determine the tension in the strings and accelerations of two blocks of masses 150 kg and 50 kg connected by a string and a frictionless, weightless pulley as shown in Figure 12. 10 + 5

Figure 12