Name : .....

Roll No. : .....

Invigilator's Signature : .....

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

2009
MECHANICAL SCIENCE

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) The area under the acceleration-displacement curve represents the

      a) velocity of a particle

      b) acceleration of the particle

      c) change in kinetic energy of the particle considering unit mass.

      d) displacement of the particle.

ii) If two bodies, one light and other heavy, have equal kinetic energy, which one has a greater linear momentum ?

a) heavy body

b) light body

c) both have equal momentum

d) unpredictable.

iii) Moment of inertia of a semicircle of radius R about its centroidal axis x-x is

a) $0{\cdot}22\,R^4$ b) $0{\cdot}055\,R^4$

c) $0{\cdot}11\,R^4$ d) none of these.

iv) The maximum strain energy can be stored in a body is known as

a) impact energy

b) resilence

c) proof resilence

d) modulus of resilence

e) toughness.

v) Equation of motion of a particle is $S = 2t^3 - t^2 - 2$, where S is displacement & t is time in seconds. Acceleration of the particle after 1 sec will be

a) $8\ m/sec^2$ b) $9\ m/sec^2$

c) $10\ m/sec^2$ d) $5\ m/sec^2$.

vi) Which one of the following does not have identical dimension ?

a) momentum & impulse

b) torque & energy

c) torque & work

d) momentum of force & angular momentum.

vii) D'Alembert's principle is used for

a) reducing the problem of kinetics to equivalent statics problem

b) determining stress in the truss

c) stability of floating bodies

d) solving kinematic problems.

viii) The first moment of an area about the centroidal axis of that area is

a) maximum

b) minimum

c) zero

d) cannot be defined.

ix) Te centre of gravity of a solid hemisphere of radius R is

a) $3R/4$ b) $3R/8$

c) $R/2$ d) none of these.

x) Thermal stress is induced within a material due to

a) free expansion

b) free contraction

c) free expansion or contraction

d) restricted expansion or contraction

e) none of these.

GROUP – B
(Short Answer Type Questions)

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

2. Three pieces of wood having 5 cm × 5 cm square section are glued together and to the foundations as shown in Figure 1. If a horizontal force P = 30000 N is applied to the central piece of wood which is glued to the adjacent pieces up to a length of 10 cm, determine the average shear stress in each of the glued joint.

Figure 1

3. Locate the centroid of the quadrant of a circle of radius r as show in Figure 2.

Figure 2

4. Two touching bars 1 and 2 are placed on an inclined plane forming an angle α with the horizontal as show in the Figure 3. The masses of the bars are M_1 and M_2 respectively and the coefficient of friction between the plane and these bars are equal to k_1 and k_2 respectively with $k_1 > k_2$. Find

   a) The forces of interaction of the bars in the process of motion

   b) Min. value of α at which the bars will start sliding down.

Figure 3

5. State and prove Varignon's theorem.

6. Cross-section of the prismatic steel bar in Figure 4 is 3 cm^2. Neglecting localized stress distribution, find net increase δ of the bar while $E = 2{\cdot}1 \times 10^5$ N/mm^2.

Figure 4

GROUP – C
(Long Answer Type Questions)
Answer any *three* of the following. 3 × 15 = 45

7. a) Differentiate between angle of friction and cone of friction.

b) Write down the Coulumb's laws of friction. Mention at least three uses of friction for desired effects.

c) Two blocks, *A* and *B* connected by a horizontal link *AB*, are supported on two rough planes as shown in Figure 5. The coefficient of friction for block *A* on the horizontal plane is 0·4 and for block *B* on the inclined plane is 0·364. What is the smallest weight *W* of block *A* for which equilibrium of the system can exist ? 2 + 5 + 8

Figure 5

8. Find the tension induced in the string *CDE* attached at the point *C* and *E* of the right angle bar *AC* of weight *P* supported as shown in Figure 6. Assume a perfectly inextensible string, frictionless pulley and an ideal hinge at *A*.

Figure 6

9. a) Find the total elongation of a steel bar as shown in Figure 7. Take $E = 2 \times 10^5$ N/mm^2.

Figure 7

b) A composite bar consists of copper of length 600 mm and area 1000 mm^2 and steel of length 300 mm and area of 500 mm^2 is held between two supports. The bars are stressfree at a temperature of 38° C. What will be the stresses in the two bars, when the temperature is 20° C, if (i) the supports are unyielding, (ii) the supports come nearer to each other by 0·1 mm ? It can be assumed that the change of temperature is uniform all along the length of the bar. Take $E_{CU} = 2{\cdot}10 \times 10^5$ N/mm^2, $E_S = 1{\cdot}10 \times 10^5$ N/mm^2 and $\alpha_{CU} = 17{\cdot}5 \times 10^{-6}$/°C, $\alpha_S = 12 \times 10^{-6}$/°C. 5 + 10

10. a) A right-circular roller of weight W rests on a smooth horizontal plane and is subjected to a pull force P as shown in Figure 8. It is held in position by string AC. Find the tension T in the string AC and reaction R_B at B.

Figure 8

b) State Coulomb's laws of friction.

c) A force given by $F = 3i + 2j - 4k$ is applied at point P (1, – 1, 2). Find the moment of the force F about point O (2, – 1, 3). 5 + 5 + 5

11. a) Determine the moment of inertia of the shaded area as shown in Figure 9 about the centroidal axis and reference axis. Also determine the radius of gyration about reference axis.

Figure 9

b) A slender prismatic bar *AB* of length 1 and weight *Q* stands in a vertical plane and is supported by smooth surfaces at *A* and *B* as shown in Figure 10. Using the principle of virtual work, find the magnitude of the horizontal force *P* applied at *A* if the bar is in equilibrium. 10 + 5

Figure 10