

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.*

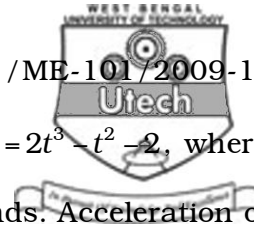
GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives of the following : $10 \times 1 = 10$

- 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) $0.22 R^4$
 - b) $0.055 R^4$
 - c) $0.11 R^4$
 - d) none of these.
- iv) The maximum strain energy can be stored in a body is known as
- a) impact energy
 - b) resilience
 - c) proof resilience
 - d) modulus of resilience
 - 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

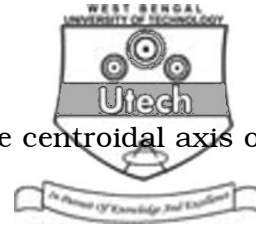
- a) 8 m/sec^2 b) 9 m/sec^2
- c) 10 m/sec^2 d) 5 m/sec^2 .

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) The 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 shown 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
- The forces of interaction of the bars in the process of motion
 - 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 $E = 2.1 \times 10^5 \text{ N/mm}^2$.

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

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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 $E = 2 \times 10^5 \text{ N/mm}^2$.

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 $E_{CU} = 2 \cdot 10 \times 10^5 \text{ N/mm}^2$, $E_S = 1 \cdot 10 \times 10^5 \text{ N/mm}^2$ and $\alpha_{CU} = 17.5 \times 10^{-6}/^\circ\text{C}$, $\alpha_S = 12 \times 10^{-6}/^\circ\text{C}$. 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

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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 l 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

