2014

ENGINEERING MECHANICS

(MECH 1101)

Time Alloted : 3 Hours *Full Marks : 70*

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable

GROUP - A

(Multiple Choice Type Questions)

1. Choose the correct alternative for the following : **[10×1=10]**

   i) The simplest resultant of a couple on a plane and a force acting on the same plane is :

   (a) another couple (b) a null vector

   (c) a force (d) none of these

   ii) The angle made by the vector $(\hat{i}+\hat{j}+\hat{k})$ with Z-axis is

   (a) 45° (b) 54.7°

   (c) 59° (d) 60°

iii) A free body diagram is considered for analyzing a problem of a body in

(a) equilibrium only
(b) non-equilibrium only
(c) both equilibrium and non-equilibrium
(d) neither equilibrium nor non-equilibrium

iv) Polar moment of inertia of an area is defined about

(a) an axis in the plane of the area
(b) a point in the plane
(c) an axis perpendicular to the plane of the area
(d) any one of these

v) For mild steel, linear relationship of stress and strain is valid till

(a) elastic limit (b) proportional limit
(c) lower yield point (d) upper yield point

vi) 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

vii) The angle between the vectors $2\hat{i}+\hat{j}-\hat{k}$ and $\hat{i}-\hat{j}+\hat{k}$ is :

(a) 90° (b) 0°
(c) 45° (d) 60°

viii) The materials having same elastic properties in all directions are called

(a) isotropic materials (b) elastic materials
(c) ideal materials (d) homogeneous materials

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ix) If the velocity of projection is u m/sec and the angle of projection is α, the maximum height of the projectile on a horizontal plane is

(a) $\frac{u^2 \cos^2 \alpha}{(2g)}$ (b) $\frac{u^2 \sin^2 \alpha}{(2g)}$

(c) $\frac{u^2 \sin^2 \alpha}{g}$ (d) $\frac{u \sin \alpha}{g}$

x) Which of the following are not dimensionally identical?

(a) kinetic energy and work done against friction

(b) torque and power

(c) movement of a force and work

(d) momentum and impulse

GROUP - B

2. (a) Given a rectangular parallelopiped in **Fig. 1**. Take D as the origin, **X-**, **Y-** and **Z-**axes along DC, DE and DA respectively. Find out the angle between the solid diagonals DG and EB.

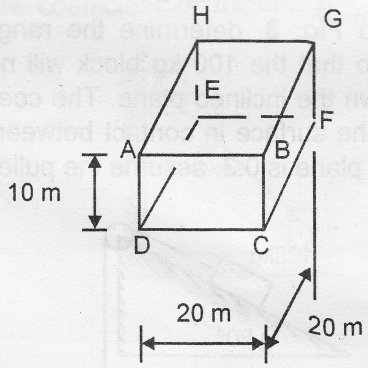


Fig. 1

(b) A force of 300 kN acts through a point A (1, 6, –5) towards B (0, 4, –3). Find out the moment of the force about point C (1, 0, –1). Distances are in cm.

6+6 = 12

3. (a) Define : (i) Equivalent Vector (ii) Bound Vector

(b) A force ***F*** acts along AB (sense from A to B) where A (4m, 1m, 4m) and B (3m, –4m, 1m). Moment of ***F*** about **Z**-axis is (–1900 N-m). Determine the moments of the force ***F*** about **X**-axis and **Y**-axis. **(2+2)+8 = 12**

GROUP - C

4. (a) A smooth right circular cylinder of radius ***r*** rests on a horizontal plane and is kept from rolling by an inclined string AC of length ***2r*** as shown in **Fig. 2**. A prismatic bar AB of length ***3r*** and weight ***Q*** is hinged at point A and leans against the roller. Find the tension ***T*** that will be induced in the string AC.

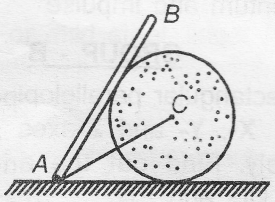


Fig. 2

(b) Referring to **Fig. 3**, 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 surface in contact between the block and the inclined plane is 0.3, assume the pulley is frictionless.

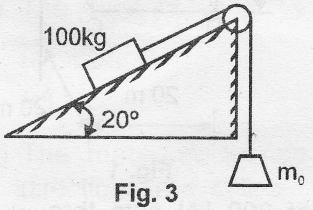


Fig. 3

6+6 = 12

5. (a) A prismatic bar AB, of weight Q and length l, is supported at one end B by a string CB of length a, and rests at A, vertically below C, against a perfectly smooth vertical wall as shown in **Fig. 4**. Find the position of the bar, as defined by the length x, for which equilibrium will be possible.

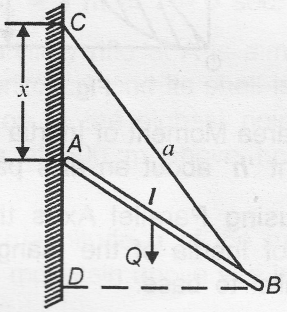


Fig. 4

(b) Two identical blocks A and B each having weight W are connected by rigid rod and supported by a vertical wall and a horizontal plane having same co-efficient of friction (μ) as shown in **Fig. 5**. If sliding impends for $\theta = 45°$, calculate coefficient of friction, μ.

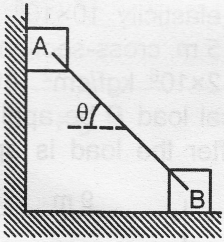


Fig. 5

6+6 = 12

Group - D

6. (a) Determine the co-ordinate x_c and y_c of the centroid C of the shaded area between the parabola $y = x^2/a$ and the straight line $y = x$, as shown in **Fig. 6**.

GROUP - E

8. (a) The velocity of a particle which moves along the ***s***-axis is given by $v = 2 - 4t + 5t^{3/2}$, where ***t*** is in seconds and ***v*** is in m/s. Evaluate the position ***s***, velocity ***v*** and acceleration ***a*** of the particle, at $t = 3$ sec. The particle is at position $s_0 = 3$ m at $t = 0$ sec.

(b) A long range artillery rifle at A is aimed at an angle of 45° with the horizontal, and its shell is just able to clear the mountain top at the highest point of its trajectory. The point A is at 600 m above horizontal sea level (**Fig. 8**).

Determine the magnitude **u** of the muzzle velocity, the height **H** of the mountain above sea level and the range **R** of the rifle.

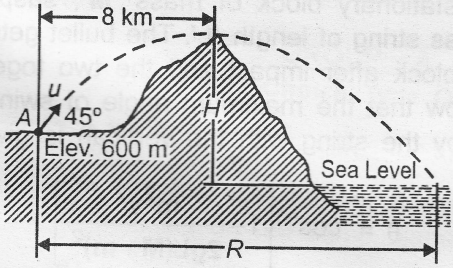


Fig. 8

5+7 = 12

9. (a) The mechanical system is released from rest with cable taut (**Fig. 9**). For the friction co-efficients $\mu_s = 0.25$ and $\mu_k = 0.20$, calculate the acceleration of 60 kg and 20 kg mass and the tension T in the cable. Neglect the mass and friction in the pulley.

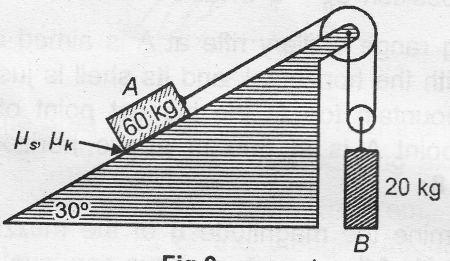


Fig.9

(b) 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 given by

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

6+6 = 12

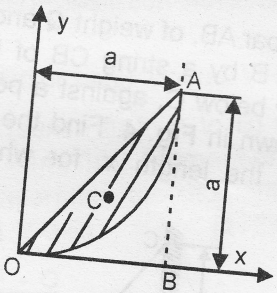


Fig. 6

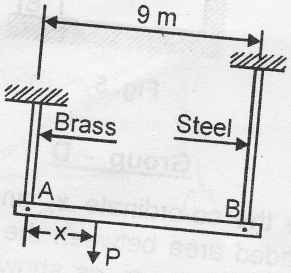
(b) Find the area Moment of Inertia of a triangle of base ***'b'*** and height ***'h'*** about an axis passing along its base.

Hence, using Parallel Axes theorem, find the area Moment of Inertia of the triangle, about its centroidal axis parallel to base.

5+7 = 12

7. (a) Draw the stress-strain diagram for a ductile material indicating the different points on it.

(b) A rigid bar AB, 9 m long, is suspended by two vertical rods at its ends and hangs in a horizontal position under its own weight as shown in **Fig. 7**. The rod at A is made of brass; length 3 m, cross-sectional area 10 cm^2, modulus of elasticity 10×10^5 kgf/cm^2. The rod at B is steel; length 5 m, cross-sectional area 4.45 cm^2, modulus of elasticity 2×10^6 kgf/cm^2. At what distance ***x*** from A may a vertical load ***P*** be applied if the bar is to remain horizontal after the load is applied? (Refer **Fig. 7**)



4+8 = 12

Fig. 7