ENGINEERING & TECHNOLOGY EXAMINATIONS, DECEMBER – 2005

MECHANICAL SCIENCES

SEMESTER – 1

Time : 3 Hours] [Full Marks : 70

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

Note : Answer Question No. *1* which is compulsory and any *six* from the remaining.

1. Choose the correct answers with proper justification : $5 \times 2 = 10$

a) First area moments (of a plane surface area) about centroidal axes is equal to
   i) zero
   ii) non-zero.

b) For a two-dimensional equilibrium (static) problem, the maximum number of unknowns that can be evaluated using equilibrium equations are
   i) one
   ii) three
   iii) six.

c) Thermal stress is induced within a material due to
   i) free expansion
   ii) free contraction
   iii) free expansion or contraction
   iv) restricted expansion or contraction
   v) none of these.

d) When a body slides down an inclined surface (of inclination θ) the acceleration 'f' of the body is
   i) $f = g$
   ii) $f = g \sin \theta$
   iii) $f = g \cos \theta$
   iv) $f = g \tan \theta$.

e) The kinetic energy of a body rotating with an angular speed ω depends on
   i) ω only
   ii) ω^2 only
   iii) mass only
   iv) the distribution of mass and angular speed
   v) all of these.

[Turn over

2. a) State and prove perpendicular axis theorem of area moment of inertia. 4

b) Locate the centroid of the quadrant of a circle of radius r (*fig. 1*) 6

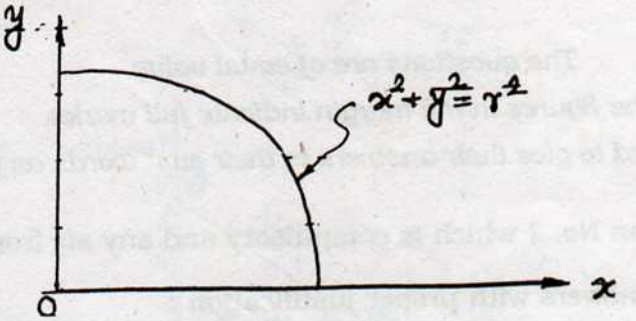

Fig. 1

3. a) State the laws of static friction. 3

b) A block of weight W_1 = 1290N rests on a horizontal surface and supports another block of weight W_2 = 570 N on top of it as shown in *fig. 2*. Block of weight W_2 is attached to a vertical wall by an inclined string *AB*. Find the force *P* applied to the lower block, that will be necessary to cause the slipping to impend. Given :

Coefficient of friction between blocks (1) and (2) = 0·25

Coefficient of friction between (1) and horizontal surface = 0·40. 7

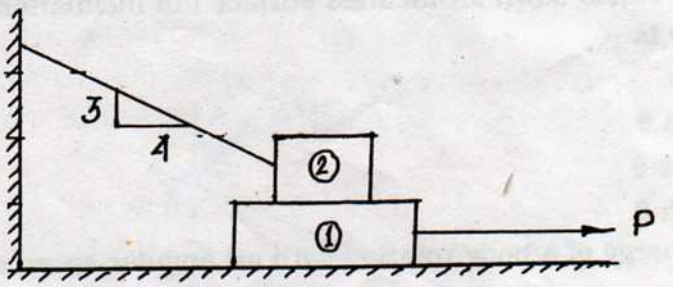

Fig. 2

4. a) State and prove Lami's theorem. 3

b) Define free body diagram. 2

c) Two cylinders of diameters 60 mm and 30 mm weighing 160 N and 40 N respectively are placed as shown. Assuming all the contact surfaces to be smooth, find the reactions at *A*, *B* and *C*. 5

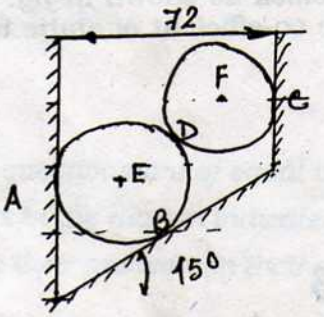

Fig. 3

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

b) Using the principle of virtual work, find the value of the angle θ defining the configuration of equilibrium of the system as shown in *fig.* 4. The balls *D* and *E* can slide freely along the bars *AC* and *BC* but the string *DE* connecting them is inextensible. 7

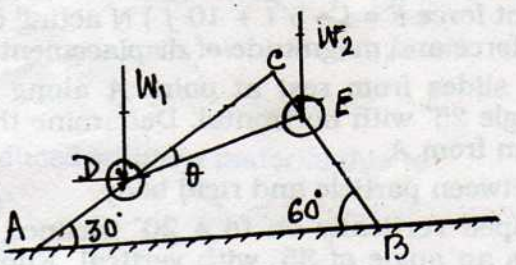

Fig. 4

6. a) Define Hooke's law. 3

b) A bronze bar 3 m long with a cross-sectional area of 320 mm^2 is placed between two rigid walls as shown in *fig.* 5. At a temperature of – 20°C, the gap $\Delta = 2{\cdot}5$ mm. Find the temperature at which the compressive stress in the bar will be $\sigma = 35$ MPa. Use $\alpha = 18 \times 10^{-6}$ m/m°C and $E = 80$ GPa. 7

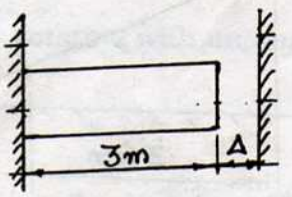

Fig. 5

[Turn over

7. a) State Coulomb's Law of friction.

b) A block of weight $W_1 = 500$ N rests on a horizontal surface and supports on top of it another block of weight $W_2 = 100$ N. The block W_2 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 co-efficient of static friction for all contiguous surfaces is $\mu = 0{\cdot}3$. 2 + 8 = 10

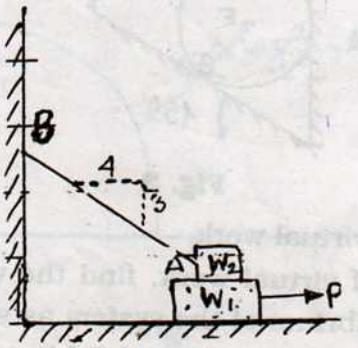

Fig. 6

8. a) A particle moving in the $x-y$ plane undergoes a displacement $\bar{S} = (4\,\bar{i} + 6\,\bar{j})$ m with a constant force $\bar{F} = (-5\,\bar{i} + 10\,\bar{j})$ N acting on it. Calculate the work done, magnitude of force and magnitude of displacement. 5

b) A 5 kg block slides from rest at point A along a frictionless inclined plane making an angle 25° with horizontal. Determine the speed of the block at B at a distance of 3 m from A. 5

9. a) Distinguish between particle and rigid body. 2

b) A ball is dropped vertically on to a 20° inclined plane at A. The direction of rebound forms an angle of 35° with vertical. Knowing that the ball strikes the inclined plane at B, determine

i) the velocity of rebound at A.

ii) the time required for the ball to travel from A to B. 8

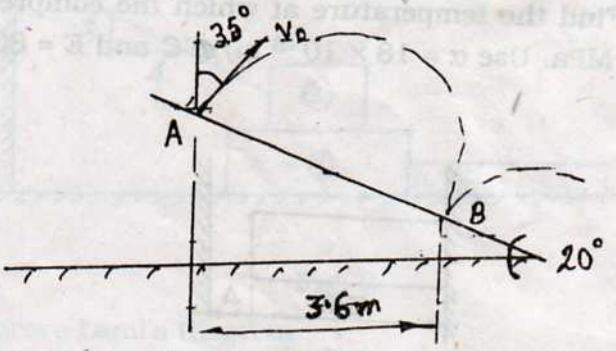

Fig. 7