ENGINEERING MECHANICS

Time Allowed: 2.5 Hours   *Full Marks: 60*

Answer to Question No. 1 of Group A must be written in the main answer script. In Question No. 1, out of 2 marks for each MCQ, 1 mark is allotted for right answer and 1 mark is allotted for correct explanation of the answer.
Answer any Five (05) Questions from Group-B.

GROUP-A

1. Choose the correct answer from the given alternatives and explain your answer (any ten):   2x10=20
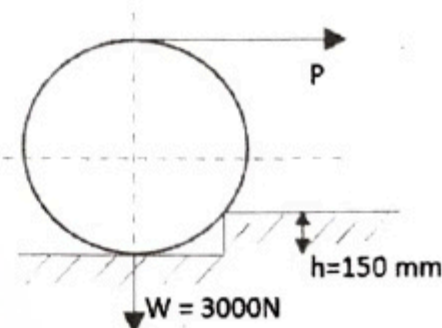
(i)   According to the Principle of Transmissibility of Force, the effect of a force on a rigid body remains unchanged if (a) the force is removed from the body (b) the force is applied to a different body (c) the force is shifted along its line of action (d) the force is doubled.

(ii)   Which of the following is **NOT** a condition for the equilibrium of a co-planar system of non-concurrent parallel forces? (a) Sum of all horizontal forces must be zero (b) Sum of all vertical forces must be zero (c) Sum of all moments about any point must be zero (d) The forces must always be equal in magnitude.

(iii)   A force of 100 N is acting at an angle of 60° with the horizontal. What is the vertical component of the force? (a) 50 N (b) 86.6 N (c) 100 N (d) 43.3 N

(iv)   The unit of a couple is: (a) N/m^2 (b) N/m (c) N-m (d) N.

(v)   The resultant in parallelogram law of forces has maximum value when the angle between two forces is equal to: (a) 30° (b) 90° (c) 0° (d) 180°.

(vi)   A block resting on a rough plane having angle of friction 12° will impend motion, if the inclination of the surface with the horizontal is: (a) 11° (b) 12° (c) 13° (d) 15°.

(vii)   The stability of an object increases when: (a) Its centre of gravity is raised (b) Its base is made smaller (c) Its centre of gravity is lowered (d) It is tilted.

(viii) Limiting force of friction is the (a) ratio of limiting friction and normal reaction (b) the friction force acting when the body is in motion (c) the friction force acting when the body is just about to move (d) all of the above.

(ix)   In the law of simple machine, P = mW + C, the constant C denotes (a) effort lost in friction under load W (b) effort lost in friction under no load (c) effort lost in friction when M.A. is maximum (d) none of the above.

(x)   If a wheel rotates at 10 rad/s, what is the linear velocity of a point on its rim if the radius is 0.5 m? (a) 2 m/s (b) 5 m/s (c) 10 m/s (d) 20 m/s.

(xi)   A machine has a power rating of 500 W. How much work does it do in 30 seconds? (a) 1500 J (b) 1000 J (c) 15kJ (d) 150 kJ.

(xii)   If efficiency of a lifting machine is kept constant, then it's V.R. is directly proportional to it's (a) effort applied (b) M.A. (c) machine friction (d) all of the above.

(xiii) If a semi- circular lamina has diameter 12cm then the distance of its C.G. from the base is (a) $\frac{8}{\pi}$ cm (b) $\frac{12}{\pi}$ cm (c) $\frac{4}{3\pi}$ cm (d) $\frac{8}{3\pi}$ cm.

(xiv) The co-efficient of friction depends on (a) area of contact (b) shape of surfaces (c) strength of surfaces (d) nature of surfaces.

(xv) A projectile is fired at an angle θ with the horizontal. The maximum height will be reached when θ is (a) 0° (b) 45° (c) 90° (d) 60°.

GROUP-B

2. (a) State and prove Varignon's theorem.
   (b) Four forces equal to 10N, 20N, 30N and 40N are respectively acting along the four sides (1 m each) of a square ABCD, taken in order. Find the magnitude, direction and position of the resultant force.   [3+5]
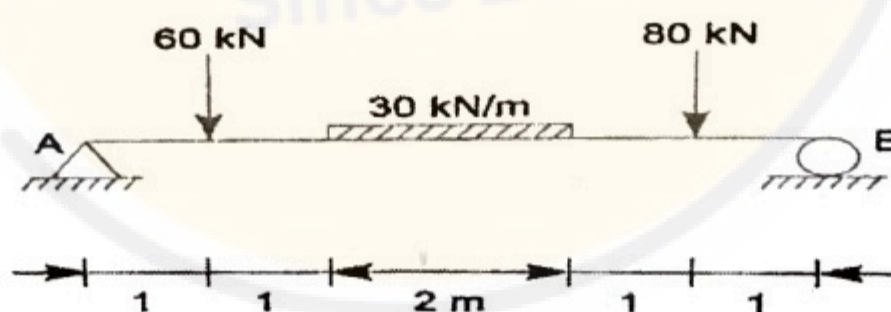
3. (a) A uniform wheel of diameter 600 mm and weight 3 kN is to be pulled over a rigid rectangular block of height (h) 150 mm by a horizontal force P applied to the end of a string wound around the circumference of the wheel shown in the Fig. Find the least pull required just to turn the wheel over the corner of the block.
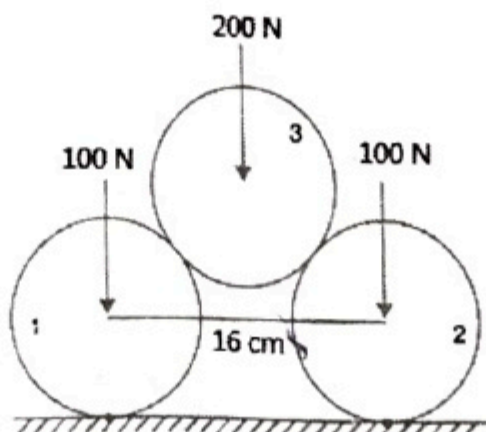

   (b) ABCDEF is a regular hexagon. Forces of magnitude 2 N, $4\sqrt{3}$ N, 8 N, $2\sqrt{3}$ N and 4 N act at in the direction of AB, AC, AD, AE and AF respectively. Determine the resultant and its direction.   [4+4]

4. (a) State and explain the parallelogram law of forces.
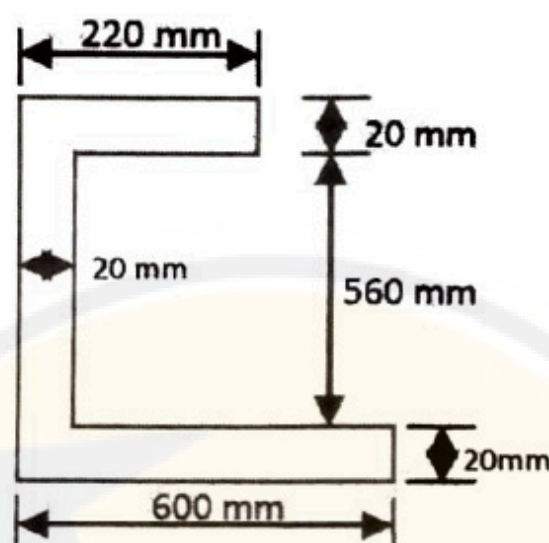   (b) Find out the reactions at supports for the beam shown in the fig.   [3+5]

5. Two smooth circular cylinders, each of weight 100N and diameter 12cm are connected at their centres by a string of length 16cm, rest upon a horizontal plane, supporting above a third cylinder of weight 200N and diameter 12cm, find the tension in the string and reaction produced by the horizontal plane at the point of contacts.   [8]

6. (a) State the Coulomb's law of friction.
   (b) An effort of 200 N is required just to move a certain body up an inclined plane of 15°, the force acting parallel to the plane. If the angle of inclination of the plane is made 20°, the effort required, again applied parallel to the plane, is found to be 230 N. Find the weight of the body.

7. (a) What is the relationship between effort and the load lifted of a simple lifting machine? Plot the graph of effort vs load lifted for actual machine.

   (b) In a lifting machine, the effort of 15 N lifted a load of 700 N. Find the velocity ratio (V.R.) if the efficiency at this load is 60%. If a load of 1300 N is lifted by an effort of 25 N by the same machine, find the law of the machine. What will be effort required to lift the load of 1000 N? Determine maximum Mechanical Advantage (M.A.) and maximum efficiency. [3+5]

8. (a) Derive a relationship for the distance travelled by a body in the 'n'th second.

   (b) A motorist rushing at 15 m/sec, finds a block on the road 40 m ahead. He instantly applies brakes to stop the car within 5 m of the block, calculate: (i) retardation and (ii) time required to stop the car. [4+4]

9. (a) Define centre of gravity, centroid and centre of mass.

   (b) Locate the centroid of the lamina given in the fig below. [3+5]

10. (a) Deduce the condition for self-locking of a machine.

    (b) A load of 2 kN is to be lifted by a screw-jack, having threads of 10 mm pitch. The efficiency of the jack at load is 50%. Determine the effort applied at the end of the handle of 50 cm length. [3+5]

11. (a) Write mathematical expression of potential energy and kinetic energy with SI units. Give one example of each of potential energy and kinetic energy.

    (b) Water from a tank of capacity 18000 litres is to be lifted in 20 minutes by a pump through a height of 12m. If the efficiency of the pump is 65%, find the power of the pump. (Take 1 litre = 1 kg). [4+4]

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