

GX 2160

1BA1;1BS1;1EL1;1ER1;1MR1;1CS1;1PT1.

## First Year and First Arts

MP102

Mathematical Physics

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Special Paper

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Attempt all questions. You may assume throughout that the Earth's gravitational acceleration is  $g = 10\text{ms}^{-2}$ .

2 hrs

Yes - Log Tables

3

Mathematical Physics

1. A car accelerates with constant acceleration of  $0.4 \text{ ms}^{-2}$  from an initial velocity of  $2 \text{ m/s}$  over 5 seconds. Find its final position and velocity.
2. A particle moves with acceleration  $3\hat{i} - 2\hat{j} + 3\hat{k}$  at time  $t$ . If the initial velocity is  $2\hat{i} + \hat{j}$  and initial position vector is  $2\hat{j} + \hat{k}$ , find the position vector for any time  $t$ .
3. Use the scalar product to find values of  $\lambda$  for which the vectors  $3\lambda\hat{i} - \lambda\hat{j} - 3\hat{k}$  and  $2\lambda\hat{i} + 7\hat{j} + \hat{k}$  are perpendicular.
4. A block is projected with velocity  $4 \text{ m/s}$  along a rough horizontal plane with coefficient of friction  $\mu = 1/3$ . How long does it take for the velocity to decrease to  $2 \text{ m/s}$ ?
5. A ball is projected at  $4 \text{ m/s}$  at angle  $30^\circ$  to the horizontal. Find the range on a horizontal plane.
6. A particle is projected vertically upwards with velocity  $30 \text{ m/s}$ . Ignoring frictional effects, find the greatest height reached and how long it takes to reach that height.
7. A force of magnitude  $21 \text{ N}$  acts in a direction parallel to  $\hat{i} - 2\hat{j} + 2\hat{k}$ . Find the work done when the point of application undergoes a displacement of  $\hat{i} - \hat{j} + \hat{k} \text{ m}$ .
8. A particle is moving with simple harmonic motion of period  $\pi \text{ s}$  and maximum speed  $10 \text{ m/s}$ . Find the amplitude of the motion.
9. Masses of  $2 \text{ kg}$ ,  $3 \text{ kg}$ , and  $5 \text{ kg}$  are placed at A  $(3, 1)$ , B  $(1, 3)$ , C  $(3, 5)$  respectively. Find the location of the centre of mass of the system.
10. Find the moment about the origin of a force  $(4\hat{i} + 2\hat{j} - 5\hat{k}) \text{ N}$  acting at the point with coordinates  $(1, -3, 4) \text{ m}$ .
11. A  $4 \text{ kg}$  ball with initial velocity  $3 \text{ m/s}$  collides elastically with a second ball of mass  $2 \text{ kg}$  and initial velocity  $1 \text{ m/s}$ , in same direction. If the coefficient of restitution is  $1/2$ , find the velocity of the  $4 \text{ kg}$  ball after the collision.
12. Solve the differential equation

$$\frac{dx}{dt} + 3x = e^t$$

subject to the initial condition  $x(0) = 1$ .

13. A cyclist A moves due East at 5 m/s and sees a car moving North at 12 m/s, find the speed of the car relative to the cyclist.
14. Find the moment of inertia of a uniform rod of length 3m and mass 4 kg about an axis perpendicular to one end.
15. Find in vector terms the acceleration of a body of mass 3 kg acted on simultaneously by forces  $\hat{i} + \hat{j} + 5\hat{k}$ ,  $3\hat{i} + \hat{j} + \hat{k}$  and  $\hat{i} + 7\hat{j} + 2\hat{k}$ .
16. An object of mass 50 kg is on the floor of a lift. Find the reaction between the object and the floor of the lift when the lift is accelerating upwards with acceleration  $2 \text{ ms}^{-2}$ .