UNIVERSITY OF CALCUTTA · Previous Year Question Paper

# 2025

## MATHEMATICS — MDC

**Paper: CC-4**

**(Mechanics)**

**Full Marks: 75**

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*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

**1. Answer *any six* questions :** $2 \times 6$

(a) What is moment of force?

(b) State the Lami's theorem.

(c) The velocity of a particle distant $x$ from a fixed point O is given by $v^2 = a - bx^2$, where $a$ and $b$ are constants. Find the time period of S.H.M.

(d) If a particle falls under gravity (assuming gravity is uniform) in a medium where resistance is square of the velocity of the particle. Find the terminal velocity.

(e) A particle describes the curve $p^2 = ar$ under a force $F$ to the pole. Find the law of force.

(f) What is impulsive force?

(g) Find the Horsepower of an engine which draws a train at a uniform rate of $V$ ft/sec against a resistance of $P$ lb-wt.

(h) State the Newton's Law of Collision.

(i) What is escape velocity? What is it approximate value?

(j) Show that the rate of change of kinetic energy of particle is equal to its power.

### Group - B

**2. Answer *any seven* questions :** $6 \times 7$

(a) State and prove the necessary and sufficient conditions for a concurrent force system.

(b) State Varignon's Theorem of Moments. Three forces $P, Q, R$ act along the sides of $BC$, $CA$ and $AB$ of a triangle $ABC$ taken in order. Then show that, if the resultant passes through the incentre, then $P + Q + R = 0$.

(c) A particle moving in a straight line subject to a resistance which produces the retardation $kv^3$, where $v$ is the velocity and $k$ is a constant. Show that $v = \dfrac{u}{(1 + ksu)}$, where $u$ is the initial velocity.

(d) If a particle of mass $m$ moves in a straight line under an attractive force $mn^2x$ towards a fixed point on the line, when at a distance $x$ from it. It is projected with a velocity $V$ towards the centre of force from the initial distance $a$ from it. Prove that it reaches the centre of force in time $\dfrac{1}{n}\tan^{-1}\left(\dfrac{na}{V}\right)$.

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(e) A particle moves towards a centre of force, the acceleration at a distance $x$ being given $\mu\left(x+\frac{a^4}{x^2}\right)$; if it starts at a distance $a$, show that it will arrive at the centre in time $\frac{\pi}{4}\sqrt{\mu}$.

(f) If a particle is projected vertically upwards with a velocity $u$ in a medium whose resistance varies as the square of the velocity. If $v$ is the velocity at any time $t$, then show that $\tan^{-1}\left(\frac{v}{c}\right)=\tan^{-1}\left(\frac{u}{c}\right)-\frac{gt}{c}$, where $c$ is the terminal velocity.

(g) Find the horse power required for a car weighing 10 tons if it has to attain a speed of 30 mph in 30 second from rest up an incline 1 in 200, the frictional resistance being 20 lb wt/ton.

(h) Prove that for a particle of mass $m$ falling from rest under gravity from a height $h$ above the ground, the sum of the K.E. and the P.E. of the particle is constant at every point of its path.

(i) If a particle moving in a straight line is acted upon by force which works at a constant rate and changes its velocity from $u$ to $v$ in passing over a distance $x$. Prove that the time taken is

$$t=\frac{3x(u+v)}{2(u^2+uv+v^2)}.$$

(j) A body of mass $(m_1+m_2)$ is split into two parts of masses $m_1$ and $m_2$ by an internal explosion which generates kinetic energy $E$. Show that if after explosion the parts move in the same line as before, their relative speed is $\sqrt{2E\left(\frac{m_1+m_2}{m_1m_2}\right)}$.

(k) A smooth sphere of mass $m$ and coefficient of restitution $e$ impinges directly on a fixed horizontal plane. Find the motion of the sphere after impact.

## Group - C

**3. Answer *any three* questions :** $7\times 3$

(a) If a particle describes a parabola $x^2=8y$ under a force always perpendicular to the $y$ axis. Find the law of force and the velocity at any point of its orbit.

(b) Derive tangential and normal components of velocity and acceleration.

(c) If $F$ is the force at apse and $v$ is the velocity there, then find the law of force to the pole when the path is cardioid $r=a(1-\cos\theta)$ and also show that $3v^2=4aF$.

(d) A particle moves from rest in a straight line at a distance '$a$' from a fixed point O in the line under the repulsive force $\{\mu\div(\text{distance})^2\}$ per unit mass. Determine the velocity of the particle at any time $t$.

(e) An artificial satellite goes round the earth in 90 minutes in a circular orbit. Calculate the height of the satellite above the earth, taking the earth to be a sphere of radius 6370 km and $g$ at the orbit of the satellite to be 980 cm/sec$^2$.

(f) Derive the equation of path of a particle which describes a plane curve and the particle always directed towards a fixed point on the plane.

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