



MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

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University Examinations 2023/2024

SECOND YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF
BACHELOR OF SCIENCE IN MATHEMATICS AND COMPUTER, BACHELOR OF
SCIENCE IN MATHEMATICS AND BACHELOR OF SCIENCE IN EDUCATION

SMA 3252: CLASSICAL MECHANICS

DATE: APRIL 2024

TIME: 2 HOURS

INSTRUCTIONS: Answer question *one* and any other *two* questions

QUESTION ONE (30 MARKS)

- a) A ball is kicked with initial velocity of 16m/s in the horizontal direction and 12m/s in the vertical direction (take $g=9.8 \text{ m/s}^2$)
- At what time does the ball reach the ground (3 marks)
 - What is the maximum height reached by the ball (3 marks)
 - Find the range (2 marks)
- b) The position vector \vec{r} of a moving particle of unit mass at time t is given by
- $$\vec{r} = (4 + 10t)\mathbf{i} + (15 - 20t - 5t^2)\mathbf{j} + (10t^3 - 20t)\mathbf{k}$$
- Find the work done by resultant force \vec{F} acting on the particle in time interval from $t = 0$ to $t = 2$ (10 marks)
- c) A force $F = 4t\mathbf{i} + (6t^2 - 2)\mathbf{j} + 12\mathbf{k}$ is acting on a particle. Find
- Find impulse developed by the force from $t_0 = 0$ to $t = 2$ (2 marks)
 - Find the magnitude of the impulse (2 marks)

d) If particle moves along a curve given by the parametric equation

$x = t^2, y = 2t^3 - 1$ and $z = \sin 3t$. Determine the magnitude of velocity and acceleration of the particle at $t = 2$ (8 marks)

QUESTION TWO (20 MARKS)

a) A particle P is describing SHM of amplitude 2.5cm. when P is 2m from the centre of the path, the speed is 3m/s find

i. The periodic time of the oscillation (4 marks)

ii. The greatest speed (3 marks)

iii. The magnitude of the greatest acceleration (2 marks)

b) The power applied to a particle by a force field given as a function of time t by $p(t) = 3t^2 - 4t + 2$. Find the workdone in moving the particle from P_1 at $t = 2$ to P_2 at $t = 4$ (5 marks)

c) A particle moves in a circle of radius 20cm. if the tangential speed of the particle is 40cm/s find

i. Angular speed (2 marks)

ii. Angular acceleration (2 marks)

iii. Normal acceleration (2 marks)

QUESTION THREE (20 MARKS)

a) A particle of unit mass moves along a space curve defined by the position vector

$\vec{r} = a \cos wt\mathbf{i} + b \sin wt\mathbf{j}$ where a and b are constants. Find

i. Torque (5 marks)

ii. Angular momentum about the origin (5 marks)

iii. Impulse developed by a force field between $t = 0$ and $t = \frac{\pi}{2w}$ (5 marks)

b) The position vectors of two particles are given as

$$\vec{r}_1 = t\vec{i} + t^2\vec{j} + (2t + 3)\vec{k}$$

$$\vec{r}_2 = (2t - 3t^2)\vec{j} + 4t\vec{j} - t^3\vec{k}$$

Find the relative velocity and acceleration of the second particle from the first

(5 marks)

QUESTION FOUR (20 MARKS)

a) A particle of mass 40kg require a constant force to accelerate it from velocity

$$V_1 = (4\vec{i} - 5\vec{j} + 3\vec{k})\text{m/s to } V_2 = (8\vec{i} + 3\vec{j} - 5\vec{k})\text{m/s in 20 seconds. Find}$$

i. The constant force needed to accelerate the particle and its magnitude (5 marks)

ii. The work done on the particle (5 marks)

b) A particle of mass m moves along a space curve C of a force field

$$F = 6t - 8)\vec{i} - 60t^3\vec{j} + (20t^3 + 36t^2)\vec{k}. \text{ Its initial position and velocity are}$$

$$\vec{r}_0 = 2\vec{i} - 3\vec{k}, \vec{v}_0 = 5\vec{i} + 4\vec{j}. \text{ Find}$$

i. Acceleration velocity and position of the particle at time t (2 marks)

ii. The momentum of particle at a time when $t = 2$ (5 marks)

iii. Power applied to the particle at any time t (3 marks)

QUESTION FIVE (20 MARKS)

a) A piston is performing simple harmonic motion at the rate of 4 oscillations per minute.

The maximum speed is 0.3m/s. by modelling the position as a particle find the

i. Amplitude of the motion (3 marks)

ii. The speed of the position when it is at 0.5m from the centre of the path (3 marks)

b) A particle P is projected from a point 5m above the ground. The horizontal velocity and vertical velocity of projection are each 24m/5

i. Find the angle of projection (3 marks)

ii. Taking $g = 10\text{m/s}^2$. Find horizontal distance of P from the point of projection when it hits the ground (5 marks)

c) A body is moving in a straight line with constant acceleration of a m/s. if the initial velocity is u at the start of motion, show that after t seconds

i. The final velocity V is given $v = u + at$ (3 marks)

ii. The distance travelled is given by $x = \frac{1}{2}at^2 + ut$ (3 marks)