



**MASINDE MULIRO UNIVERSITY OF
SCIENCE AND TECHNOLOGY
(MMUST)
(MAIN CAMPUS)**

**UNIVERSITY MAIN EXAMINATIONS
2021/2022 ACADEMIC YEAR**

SECOND YEAR SECOND SEMESTER EXAMINATIONS

**FOR THE DEGREE
OF
BACHELOR OF SCIENCE IN MATHEMATICS**

COURSE CODE: MAT 226

COURSE TITLE: CLASSICAL MECHANICS

DATE: 29TH APRIL 2022

TIME: 8.00 -10.00 AM

INSTRUCTION

- Answer question **ONE** and **ANY OTHER TWO** questions.

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QUESTION ONE -COMPULSORY (30 Marks)

- a. Derive the relationship Force= mass x acceleration **(5 Marks)**
- b. A body of mass $10kg$ at rest is subjected to a force of $16N$. Find the kinetic energy at the end of 10seconds
- c. Show that $\mathbf{F} = x^2yz\mathbf{i} - xyz^2\mathbf{k}$ is non-conservative **(2 Marks)**
- d. If $x(t) = 4t^2\mathbf{i} - (t^2 + 3t)\mathbf{j} + (t^3 - 2t^2)\mathbf{k}$, find the velocity and acceleration all at $t = 1$ **(4 Marks)**
- e. Find the potential (V) associated with the force field $\mathbf{F} = (2xy + z^3)\mathbf{i} + x^2\mathbf{j} + 3xz^2\mathbf{k}$ **(5 Marks)**
- f. Find the curvature and the unit normal vector of the circle radius a centered at the origin whose equation is $\mathbf{r} = a \cos t\mathbf{i} + a \sin t\mathbf{j}$ **(5 Marks)**
- g. What is a rigid body? **(1 Mark)**
- h. A particle is thrown with a velocity of $5m/s$ at an elevation of 60° to the horizontal. Find the velocity of another particle thrown at an elevation of 45° which will have equal range as that of the first particle **(4 Marks)**

QUESTION TWO (20 Marks)

- a. show that $\mathbf{F} = (2x \cos y - 2z^3)\mathbf{i} - (3 + 2ye^z - x^2 \sin y)\mathbf{j} + (y^2e^z - 6xz^2)\mathbf{k}$ is a conservative force field **(3 Marks)**
- b. find the potential associated with the force field in a) above **(5 Marks)**
- c. State and prove the work energy Theorem **(5 Marks)**
- d. Prove that impulse is equal to the change in linear momentum **(4 Marks)**
- e. Find the magnitude of tangential acceleration of a particle whose position is given by $\mathbf{r} = t\mathbf{i} + \frac{1}{2}t^2\mathbf{j} + t\mathbf{k}$ **(3 Marks)**

QUESTION THREE (20 Marks)

A projectile is launched with initial speed v_0 at an angle α with respect to the horizontal (i.e y axis). Find

- i. The position vector at any time t **(7 Marks)**
- ii. Time taken to reach the highest point (i.e maximum height) **(5 Marks)**
- iii. The maximum height reached **(3 Marks)**
- iv. The time of flight **(2 Marks)**
- v. The range **(3 Marks)**

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QUESTION FOUR (20 Marks)

- a. A particle of mass 3 units moves in a force field given in terms of t by $\mathbf{F} = 3\mathbf{i} + 6\mathbf{j} + 18t\mathbf{k}$. Its initial position and velocity are given respectively by $\mathbf{r}_0 = \mathbf{i} - 2\mathbf{j} + 3\mathbf{k}$ and $\mathbf{v}_0 = \mathbf{j} - \mathbf{k}$. Find the position and velocity of the particle at any time t **(6 Marks)**
- b. A particle moves so that its position vector is given by $\mathbf{r} = \cos \omega t \mathbf{i} + \sin \omega t \mathbf{j}$ where ω is a constant. Show that **(7 Marks)**
- The particle is moving in an elliptical path
 - The force is directed towards the origin
- c. Find the constants a, b and c so that the force field defined by $\mathbf{F} = (x + 2y + az)\mathbf{i} + (bx - 3y - z)\mathbf{j} + (4x + cy + 2z)\mathbf{k}$ is conservative **(2 Marks)**
- d. What is the potential (V) associated with the force field in c) above **(5 Marks)**

QUESTION FIVE (20 Marks)

- a. Calculate the amplitude, frequency and period for the simple harmonic oscillation given by $y = 0.3 \cos(40\pi t + 1.1)$ **(4 Marks)**
- b. A particle of mass 3kg moving in a straight line decelerates uniformly from a speed of 40m/s to 20m/s in a distance of 300m . How much further does it travel before it comes to rest and how longer will this take? **(5 Marks)**
- c. A particle P of mass 2 units moves along the x axis attracted towards the origin O by a force whose magnitude is numerically equal to $8x$. If it is initially at rest at $x = 20$, find
- the differential equation and initial conditions describing the motion
 - The position of the particle at any time
 - The speed and velocity of the particle at any time **(8 Marks)**
- d. A particle moves along the x axis from $x = 0$ to $x = 8$ under the influence of a force given by $\mathbf{F} = 3x^2 - 4x + 5$. Find the work done **(3 Marks)**