



# TECHNICAL UNIVERSITY OF MOMBASA

## Faculty of Applied & Health Sciences

DEPARTMENT OF MATHEMATICS & PHYSICS

UNIVERSITY EXAMINATION FOR:

**BACHELOR OF SCIENCE IN MATHEMATICS & COMPUTER SCIENCE**

AMA 4214: CLASSICAL MECHANICS

**END OF SEMESTER EXAMINATION**

SERIES: APRIL 2014

**TIME ALLOWED: 2 HOURS**

**Instructions to Candidates:**

You should have the following for this examination

- *Mathematical tables*
- *Scientific Calculator*

This paper consist of **FIVE** questions

Answer question **ONE (COMPULSORY)** and any other **TWO** questions

Maximum marks for each part of a question are as shown

This paper consists of **THREE** printed pages

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**Question One (Compulsory)**

- a) Show that the path taken by a projectile is parabolic and give values for constants b and c. **(6 marks)**
- b) State the **THREE** Newtons' Laws of motion. **(5 marks)**

$$r = r(t) = xi + yi + zk$$

- c) If the position vector of an automobile is given by  $r = r(t) = xi + yi + zk$  . What would be the values of its instantaneous velocity, instantaneous acceleration and speed? **(3 marks)**
- d) Derive the **THREE** equations of linear motion. **(5 marks)**

- e) Find the kinetic energy of a particle of mass 40 units moving with a velocity  $V = 6i - 10j + 8k$ . (3 marks)
- f) An object of mass 0.25kg on the end of a string is whirled in a vertical circle of radius 2m with a constant speed of 20m/s. What are the maximum and minimum tensions in the string. (4 marks)
- g) Calculate the speed at which a plane must be flying when looping the loop of radius 0.80km so that the pilot feels no force from either his harness or his seat. (4 marks)

### Question Two

A projectile is launched with an initial speed of  $u$  m/s and at an angle  $\theta$  to the horizontal. Determine:

- (i) Time it takes to reach highest point. (5 marks)
- (ii) The highest point reached. (5 marks)
- (iii) Time of flight back to Earth. Comment. (5 marks)
- (iv) Range (5 marks)

### Question Three

- a) Two particles have position vectors given by:  $r_1 = 2ti - t^2j + (3t^2 - 4t)k$  and  $r_2 = (5t^2 - 12t + 4)i + t^3j - 3tk$

Find:

- (i) Relative velocity of the 2<sup>nd</sup> particle with respect to the first one at the instant where  $t = 2$  units. (5 marks)
- (ii) Relative acceleration of the first particle with respect to the second one at the instant where  $t = 2$  units. (5 marks)

$$\vec{A} = i + 2j - 2k \quad \vec{B} = 2i + j + k \quad \vec{C} = i - 3j - 2k$$

- b) If  $\vec{R} = \vec{A} + \vec{B} + \vec{C}$  find the magnitude and direction cosine of the vector  $\vec{R}$ . (5 marks)

- c) A 5.0kg mass moves on a smooth horizontal surface under the action of a horizontal force given by  $F = 80 + 10t^2$ . Determine the velocity of the mass at  $t = 3.0$ s if it was at the origin at  $t = 0$ s. (5 marks)

### Question Four

$$\vec{r} = a \cos wt i + b \sin wt j$$

- a) A particle of mass  $m$  moves on a path by the equation  $\vec{r} = a \cos wt i + b \sin wt j$ . Calculate the torque and angular momentum about the origin. (6 marks)
- b) A grind stone weighing 40kg has a radius of 1.2m starting from rest it acquires a speed of 150 revolutions. In 12 seconds calculate the torque acting on it. (6 marks)

c) A circular disc of a mass  $m$  and radius  $r$  is set rolling on a table. If  $w$  is the angular velocity, show that

$$\frac{3}{4}Mr^2w^2$$

its total energy is given by

**(6 marks)**

d) When is a force field said to be conservative.

**(2 marks)**

### Question Five

A ball is fired at a speed of 25.0m/s from ground level at an angle of 30.0° above the horizontal. Ignoring air resistance use kinematics in two dimensions to solve.

a) The minimum speed of the ball while it is in the air.

**(4 marks)**

b) How far does the ball travel

**(6 marks)**

c) When does the speed of the ball equal 22.5m/s

**(4 marks)**

d) What is the balls height when it has travelled 41m

**(6 marks)**