



# TECHNICAL UNIVERSITY OF MOMBASA

## Faculty of Applied & Health Sciences

DEPARTMENT OF MATHEMATICS & PHYSICS

UNIVERSITY EXAMINATION FOR:

**DEGREE FOR THE BACHELOR OF TECHNOLOGY IN RENEWABLE ENERGY &  
ENVIRONMENTAL PHYSICS  
BACHELOR OF TECHNOLOGY IN APPLIED PHYSICS  
(BTRE & BTAP)**

APS 4104: MECHANICS I

**END OF SEMESTER EXAMINATION**

SERIES: DECEMBER 2014

**TIME ALLOWED: 2 HOURS**

**Instructions to Candidates:**

You should have the following for this examination

- *Mathematical tables*
- *Scientific Calculator*

This paper consist of **FOUR** 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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**The following information may be useful:**

Acceleration due to gravity  $g = 9.8\text{ms}^{-2}$

Mass of earth  $M_e = 5.98 \times 10^{24}\text{kg}$

Radius of earth  $R_e = 6.37 \times 10^6\text{m}$

Speed of electromagnetic waves  $C = 3 \times 10^8 \text{ms}^{-1}$

Universal gravitational constant  $G = 6.673 \times 10^{-4} \text{Nm}^2 \text{kg}^{-2}$

**Question One (Compulsory)**

- a) (i) Explain what is meant by dimensional analysis and state two significant uses of dimensional analysis in physical problem **(3 marks)**

(ii) A standing wave is set up in a stretched string by plucking it. The velocity (V) of the wave in the

plucked string depends on the tension (F) in the string, its length (L) and its mass (M). By using the method of dimensional analysis, express the velocity V in terms of the tension F, the length L and mass M of the string. **(4 marks)**

b) A particle moves along a curve whose parametric equations are:

$$x = 3e^{-2t}, \quad y = 4 \sin 3t, \quad z = 5 \cos 3t$$

where t is the time. Find:

(i) The velocity and acceleration of the particle at any time t. **(2 marks)**

(ii) The magnitude of velocity and acceleration at t = 0 **(4 marks)**

c) (i) With what velocity must a ball be thrown upwards to reach a height of 15m? **(3 marks)**

(ii) A ball rolls off the edge of a horizontal table 4m high. If it strikes the floor at a point 5m horizontally away from the edge of the table, what is its speed at the instant it left the table? **(3 marks)**

d) (i) State the THREE Newton's Laws of motion? **(3 marks)**

(ii) Explain what inertia means based on Newton's first law of motion. **(1 mark)**

e) Explain the difference between mass and weight. **(2 marks)**

f) (i) What is linear momentum? **(1 mark)**

(ii) State the principle of conservation of linear momentum. **(1 mark)**

(iii) Differentiate between elastic and inelastic collisions **(2 marks)**

### Question Two

a) State the significance of vector product and dot product. **(2 marks)**

b) State the THREE laws of vector addition. **(3 marks)**

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

c) If vectors  $\vec{A}, \vec{B}, \vec{C}$  are coplanar, find the magnitude and direction of the

$$\vec{R} = \vec{A} + \vec{B} + \vec{C}$$

vector **(5 marks)**

$$\eta = \frac{\text{Frictional Force}}{\text{Area} \times \text{Velocity Gradient}}$$

d) The coefficient of viscosity of a liquid is  $\eta$

Using the method of dimensional analysis determine the basic units of  $\eta$  **(5 marks)**

e) A jet engine on a test bed takes in 20.0kg of air per second at a velocity of 100ms<sup>-1</sup> and burns 0.80kg of fuel per second. After compression and heating the exhaust gases are ejected at 500ms<sup>-1</sup> relative to the aircraft. Calculate the thrust of the engine. **(5 marks)**

### Question Three

- a) (i) State Newton's Law of universal gravitation. **(2 marks)**
- (ii) Consider a satellite orbiting the earth in a circular path at a distance of 500km above the earth's surface. Show that the square of the period of the satellite is proportional to the cube of the radius of the orbit with a constant of proportionality depending on the mass of the central body (earth) **(4 marks)**
- (iii) Given that the mean orbital radius of the earth is  $1.496 \times 10^{11}$ m, find the mass of the sun (the earth has a period of one year) **(4 marks)**
- b) Consider the motion of a body of mass  $m$ , about a massive body of mass  $M$  in circular orbit. Show that the total energy of a circular orbit is negative and is exactly one half the potential energy. **(5 marks)**
- c) A Meteorite is initially at rest in interplanetary space at a large distance from the sun. Under the influence of gravity, the Meteorite begins to fall towards the sun in a straight radial line. With what speed does it strike the sun? **(5 marks)**

#### Question Four

- a) Starting from rest a car travels for 2 minutes with a uniform acceleration of  $0.3 \text{ ms}^{-2}$ , after which it kept a constant speed for 4000m. The car is then brought to rest with a retardation of  $0.6 \text{ ms}^{-2}$ . What is the time taken for the journey? **(5 marks)**
- b) A pendulum bob of mass 1.0kg is attached to a string 1.0m long and made to revolve in a horizontal cycle of radius 0.6m. Find the period of the motion and tension of the string. **(5 marks)**
- c) A 60kg woman stands on a scale on the floor of an elevator. What is the reading when:
- (i) The elevator is at rest? **(1 mark)**
  - (ii) The elevator is accelerating upwards at  $1.8 \text{ ms}^{-2}$  **(2 marks)**
  - (iii) The elevator is moving upwards with a constant velocity. **(1 mark)**
  - (iv) The elevator cable is cut **(1 mark)**
- d) Water in a bucket is whirled round a vertical circle. Under what condition will water stay in the bucket? **(5 marks)**