

**Instructions to candidates**

Duration: Two (02) hours

Number of questions: Four (04) Esseys

Number of questions to be answered: Four (04)

Mark allocation: 100

All symbols carry their usual meaning.

1. a. By considering an object moving along an  $x$  axis, define the following terms.

- i. Position of the object
- ii. Displacement of the object
- iii. Average velocity of the object
- iv. Average acceleration of the object

(10 marks)

b. The position of an object moving along an  $x$  axis is given by

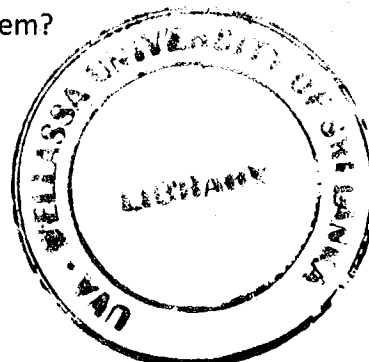
$$x = 3t - 4t^2 + t^3, \text{ where } x \text{ is in meters and } t \text{ is in seconds.}$$

- i. What is the particle's velocity function  $v(t)$
- ii. What is its acceleration function  $a(t)$
- iii. Find the magnitude of the velocity  $v$  and the acceleration  $a$  of the particle when  $t = 1 \text{ s}, 2 \text{ s}, 3 \text{ s}$  and  $4 \text{ s}$ .
- iv. Graph  $v$  versus  $t$  for  $0 \leq t \leq 4$ .
- v. In the same graph, display  $a$  versus  $t$  also. What you can say about the two graphs.

(10 marks)

c. The position of an electron moving in a constant electric field is given by  $\vec{r} = 3.00ti - 4.00t^2j + 2.00k$ , with  $t$  in seconds and  $\vec{r}$  in meters. In unit vector notation, find the electron's velocity vector  $\vec{v}(t)$  and acceleration vector  $\vec{a}(t)$ . At  $t = 2.00 \text{ s}$ , what are the magnitudes of them?

(05 marks)



2. a. Define the linear momentum  $p$  of a particle with mass  $m$  and moving at a constant speed  $v$ . (05 marks)
- b. Express Newton's second law in terms of momentum  $p$  for a system of particles. (05 marks)
- c. Write the law of conservation of linear momentum for a system of particles. (05 marks)
- d. A box of mass  $M$  slides with speed  $v$  m/s across a frictionless floor in the positive direction of  $x$  axis. The box suddenly explodes in to two pieces. One piece with mass  $m$  moves into positive direction of the  $x$  axis at  $v_1$  velocity. Obtain an expression for the velocity  $v_2$  of the second piece. If the corresponding values for  $M = 6.0$  kg,  $v = 4.0$  m/s,  $m = 2.0$  kg, and  $v_1 = 8.0$  m/s, what is the value of  $v_2$ . (10 marks)
- e. An object with a disk shape is spun with angular acceleration

$$\alpha = 5t^3 - 4t, \text{ with } t \text{ in seconds and } \alpha \text{ in radians/sec}^2.$$

At  $t = 0$ , the disk has angular velocity 5 rad/s, and a reference line on it at angular position  $\theta = 2$  rad. Obtain expressions for angular velocity  $\omega(t)$  and angular position  $\theta(t)$  of the disk.

(10 marks)

3. a. Write Newton's law of gravitation. (05 marks)
- b. According to Newton, every single object has a tendency to gravitate (attract) towards any other object. Nevertheless, objects in the real physical world exist separately without being attracted by one another. How do you explain this? (05marks)
- c. i. Obtain an expression for "gravitation acceleration  $a_g$ " near earth surface by considering a particle of mass  $m$  located outside Earth a distance  $r$  from Earth's center.

- ii. An astronaut whose height  $h$  is 1.70 m floats "feet down" in an orbiting space shuttle at distance  $r = 6.77 \times 10^6$  m away from the center of Earth. What is the difference between the gravitational acceleration at her feet and at her head? Mass of Earth =  $5.98 \times 10^{24}$  kg. Is the difference in acceleration tends to effect her body?
- iii. What do you mean by Principle of equivalence, Curvature of space and Gravitational lensing.

(10 marks)

4. a. What do you mean by "damped simple harmonic motion"

(05 marks)

- b. Assuming that the resistive damping force  $F$  is linearly proportional with the speed of the motion ( i.e.,  $F \propto V$ ), obtain a differential equation for the motion for a damped spring-mass oscillator system ( spring constant =  $k$ , damping constant  $b$  and mass  $m$ ).

(05 marks)

- c. Without solving the differential equation obtained above, write the solution for displacement  $x$ , when the oscillator displays oscillatory damped simple harmonic motion ( i.e., when  $b^2/4m^2 < k/m$

(05 marks)

- d. For a typical damped spring-mass oscillator system having mass = 250g and spring constant = 85 N/m and damping constant = 70 g/s, calculate

- i. Period of motion
- ii. Time taken for the amplitude of the oscillations to drop to half its initial value

(05 marks)

