



**NAMIBIA UNIVERSITY**  
OF SCIENCE AND TECHNOLOGY

**FACULTY OF HEALTH, NATURAL RESOURCES AND APPLIED SCIENCES**

**DEPARTMENT OF MATHEMATICS AND STATISTICS**

<b>QUALIFICATION:</b> Bachelor of science in Applied Mathematics and Statistics	
<b>QUALIFICATION CODE:</b> 07BSAM	<b>LEVEL:</b> 7
<b>COURSE CODE:</b> MCS702S	<b>COURSE NAME:</b> MECHANICS
<b>SESSION:</b> NOVEMBER 2022	<b>PAPER:</b> THEORY
<b>DURATION:</b> 3 HOURS	<b>MARKS:</b> 82

<b>FIRST OPPORTUNITY EXAMINATION QUESTION PAPER</b>	
<b>EXAMINER</b>	Prof A.S EEGUNJOBI; Ms K. DAVID
<b>MODERATOR:</b>	Prof O.D MAKINDE

<b>INSTRUCTIONS</b>
<ol style="list-style-type: none"><li>1. Answer ALL questions in the booklet provided.</li><li>2. Show clearly all the steps used in the calculations.</li><li>3. All written work must be done in blue or black ink and sketches must be done in pencil.</li></ol>

**PERMISSIBLE MATERIALS**

1. Non-programmable calculator without a cover.

**THIS QUESTION PAPER CONSISTS OF 3 PAGES** (Including this front page)

1. (a) A diver springs upward from a board that is  $5.50m$  above the water. At the instant he contacts the water his speed is  $18.4\text{ m/s}$  and his body makes an angle of  $64^\circ$  with respect to the horizontal surface of the water. Determine his
- initial velocity (4)
  - magnitude (3)
  - and direction. (3)
- (b) A small object moves along the x-axis with acceleration  $a_x(t) = -(0.032m/s^3)(15s - t)$ . At  $t = 0$  the object is at  $x = -14m$  and has velocity  $v_{0x} = 8m/s$ . What is the x- coordinate of the object when  $t = 10s$ ? (7)

2. (a) The position of a fly that is flying parallel to the ground is given as a function of time by

$$\vec{r} = (2.9m + (0.09m/s^2)t^2)\vec{i} - (0.015m/s^3)t^3\vec{j}$$

- At what value of  $t$  does the velocity vector of the fly make an angle of  $32^\circ$  clockwise from the  $+x$ -axis? (5)
  - At the time calculated in part (a), what are the magnitude and direction of the fly's acceleration vector? (5)
- (b) A bird flies in the  $xy$ -plane with a velocity vector given by

$$\vec{v} = (2.4m/s - 1.6m/s^3t^2)\vec{i} + 4tm/s^2\vec{j}.$$

The positive  $y$ -direction is vertically upward. At  $t = 0$  the bird is at the origin.

- Calculate the position and acceleration vectors of the bird as functions of time. (5)
  - What is the bird's altitude ( $y$ - coordinate) as it flies over  $x = 0$  for the first time after  $t = 0$ ? (3)
3. (a) You design a test gun that will accelerate chicken-sized objects, to study damage to aircraft that collide with largebirds, so that their displacement along the gun barrel is given by

$$x(t) = 9000t^2m/s^2 - 80000t^3m/s^3.$$

The object leaves the end of the barrel at  $t = 0.025s$ .

- How long must the gun barrel be? (4)
  - Find the general solution of What will be the speed of the objects as they leave the end ofthe barrel? (4)
  - What net force must be exerted on a  $1.50\text{ kg}$  object at
    - $t = 0$  (3)
    - $t = 0.025s$  (3)
- (b) An object of mass  $m$  is at rest in equilibrium at the origin. At  $t = 0$  a new force  $\vec{F}(t)$  is applied that has components

$$\vec{F}_x = k_1 + k_2y \quad \vec{F}(t) = k_3t$$

where  $k_1, k_2,$  and  $k_3$  are constants. Calculate the position  $\vec{r}(t)$  and velocity  $\vec{v}(t)$  vectors as functions of time. (6)

4. (a) An uncooperative cow is leaving the barn as you try harder and harder to push her back in. In coordinates with the origin at the barn door, the cow walks from  $x = 0$  to  $x = 6.9m$  as you apply a force with x-component

$$F_x = -(20N + (3N/m)x).$$

How much work does the force you apply do on the cow during this displacement? (6)

- (b) A net force along the x-axis that has x-component  $F_x = -12N + (0.3N/m^4)x^2$  is applied to a 5 kg object that is initially at the origin and moving in the -x-direction with a speed of  $6m/s$ . What is the speed of the object when it reaches the point  $x = 5m$ ? (7)

5. A batter hits a baseball straight upward at home plate and the ball is caught 5.0 s after it is struck in figure below.

- (a) What is the initial velocity of the ball? (3)
- (b) What is the maximum height the ball reaches? (3)
- (c) How long does it take to reach the maximum height? (3)
- (d) What is the acceleration at the top of its path? (2)
- (e) What is the velocity of the ball when it is caught? Assume the ball is hit and caught at the same location. (3)

**End of Exam!**