NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH, NATURAL RESOURCES AND APPLIED SCIENCES

DEPARTMENT OF MATHEMATICS AND STATISTICS

QUALIFICATION: Bachelor of science in Applied Mathematics and Statistics	
QUALIFICATION CODE: 07BSAM	**LEVEL: 7**
COURSE CODE: MCS702S	**COURSE NAME:** MECHANICS
SESSION: JANUARY 2023	**PAPER: THEORY**
DURATION: 3 HOURS	**MARKS:76**

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

INSTRUCTIONS
1. Answer ALL questions in the booklet provided. 2. Show clearly all the steps used in the calculations. 3. All written work must be done in blue or black ink and sketches must be done in pencil.

PERMISSIBLE MATERIALS

1. Non-programmable calculator without a cover.

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

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

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

   i. At what value of t does the velocity vector of the fly make an angle of 32° clockwise from the +x-axis? (5)

   ii. 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

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

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

   i. Calculate the position and accelerationvectors of the bird as functions of time. (5)

   ii. What is the bird's altitude (y- coordinate) as it flies over $x = 0$ for the first time after $t = 0$? (3)

2. (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

$$x(t) = 9000t^3m/s^2 - 8000t^3m/s^3.$$

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

   i. How long must the gun barrel be? (4)

   ii. Find the general solution of What will be the speed of the objects as they leave the end ofthe barrel? (4)

   iii. What net force must be exerted on a 1.50 kg object at

      $\alpha)$ $t = 0$ (3)

      $\beta)$ $t = 0.025s$ (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

$$\vec{F}_x = k_1 + k_2 y \quad \vec{F}(t) = k_3 t$$

   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)

3. (a) An uncooperative cow is leaving the barn as you try harder and harder to push her back in. In coordinates with the originat 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)

4. An object has several forces acting on it. One of theseforces is

$$\vec{F} = 2.5xyi,$$

a force in the x-direction whose magnitude dependson the position of the object. Calculate the workdone on the object by this force for the following displacements of the object:

(a) The object starts at the point $x = 0, y = 3$ and moves parallel to the x-axis to the point $x = 2, y = 3$. (4)

(b) The objectstarts at the point $x = 2, y = 0$ and moves in the y-directionto the point $x = 2, y = 3$. (2)

(c) The object starts at the originand moves on the line $y = 1.5x$ to the point $x = 2, y = 3$. (4)

5. (a) A force parallel to the x-axis acts on a particle moving along the x-axis. This force produces potential energy $P(x)$ given $P(x) = 1.43x^4 J/m^2$. What is the force (magnitude anddirection) when the particle is at $x = -0.780m$? (5)

(b) A small block with mass 0.04 kg is moving in the xy-plane. The net force on the block is described by the potential energy function

$$P(x, y) = (3.85J/m^2)x^2 - (3.65J/m^3)y^3..$$

What are the magnitude and direction of the acceleration of the block when it is atthe point $x = 0.28m, y = 0.57m$? (10)

End of Exam!