NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH AND APPLIED SCIENCES

DEPARTMENT OF MATHEMATICS AND STATISTICS

QUALIFICATION: BACHELOR OF SCIENCE : APPLIED MATHEMATICS AND STATISTICS	
QUALIFICATION CODE: 07BAMS	**LEVEL: 7**
COURSE: MECHANICS	**COURSE CODE:** MCS702S.
SESSION: NOVEMBER 2019	**PAPER:** THEORY
DURATION: 180 Minutes	**MARKS:** 100

FIRST OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINER:	**Dr IKO AJIBOLA**
MODERATOR:	**Prof D. MAKINDE**

INSTRUCTIONS

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

PERMISSIBLE MATERIALS

1. Non-programmable calculator without a cover

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

ATTACHMENTS

None

QUESTION 1 (22 marks)

1.1 If $\vec{r} = \left(t^3 + 2t\right)i - 3e^{-2t}j + 2\sin 5tk$.

1.1 .1 Find the vector $\frac{d\vec{r}}{dt}$ at $t = 0$ [3]

1.1.2 Determine the magnitude of $\frac{d\vec{r}}{dt}$ at $t = 0$ [3]

1.1.3 Find the unit vector along vector $\frac{d^2\vec{r}}{dt^2}$ $at\ t = 0$ in terms of the unit vectors **i** , **j** and **k** [3]

1.1.4 What is the magnitude of the unit vector of $\frac{d^2\vec{r}}{dt^2}$ $at\ t = 0$ [3]

1.2 If **A** and **B** are 3-dimensional vectors. Define:

1.2.1 the scalar product of the vectors [2]
1.2.2 the vector or cross product of the vectors. [3]

1.3 Find the magnitude and direction cosines of the product vector of the following vectors $\overline{P} = 5i + 3j - k$ and $\overline{Q} = 2i - j + 4k$, in that order. [5]

QUESTION 2(20 marks)

2.1 If $\overline{P} = 6t^3\underline{i} + 10t^{\frac{1}{2}}\underline{j} - 9t\underline{k}$ and $\overline{Q} = 16\underline{i} + t^5\underline{j} + t^{\frac{3}{2}}\underline{k}$ are two position vectors.

Determine $\frac{d}{dt}\left(\overline{Q} \bullet \overline{P}\right)$ at $t = 2.50$ [6]

2.2 Find $\frac{1}{7}\frac{d}{dt}\left(\overline{P} \times \overline{Q}\right)$ $at\ t = 3.0$ [6]

2.3 Find the definite integral $\int_0^2 \left(\overline{P} \times \overline{Q}\right)dt$ [8]

QUESTION 3 (19 marks)

3.1

3.1.1 Define the average velocity $v_{av,x}$ of a particle in a straight line motion between two points **A** and B. [3]

3.1.2 Using your result in (3.1.1) obtain the **instantaneous** velocity v_x of the straight line motion. [3]

3.2 A Sailboat has coordinates $(x_1, y_1) = (130m, 205m)$ at $t_1 = 60.0s$
Two minutes later at time t_2 it has coordinates $(x_2, y_2) = (110m, 218m)$

3.2.1 Find the average velocity $\overline{V}_{av}$ of the Sailboat for this time interval. [5]

3.2.2 Find the magnitude and direction of $\overline{V}_{av}$. [3]

3.2.3 For $t \geq 20.0s$ the position of a second sailboat as a function of time is
$x(t) = b_1 + b_2$ t and $y(t) = c_1 + \frac{c_2}{t}$ for
$b_1 = 100m,\ b_2 = 0.500m/s,\ c_1 = 200m,\ and\ c_2 = 360m/s$.
Find the instantaneous velocity as a function of time t for $t \geq 20.0s$ [5]

QUESTION 4 (17 marks)

4.1 Derive an expression for the work done by a constant force $\vec{Q}$ of magnitude *Q* on an object that undergoes a displacement $\vec{S}$ along a straight line, when *Q* makes an angle ϕ with $\vec{S}$ when acting on the object. [4]

4.2 The acceleration of a point in rectilinear motion is given by $a = -9.8$
It is observed that the velocity *v* is zero, and displacement *x* is +25 when $t = 0$
Determine the equation of the displacement. [6]

4.3.1 Using $\sum \overline{F} = m\vec{a}$ state Newton's second law of motion in its component forms. [3]

4.3.2 A Railway station attendant with spikes on his shoes pulls with a constant horizontal force of magnitude 35N on a box with mass 50kg resting on a flat, frictionless surface.
Determine the acceleration of the box. [4]

QUESTION 5 (22 marks)

5.1 A projectile of mass m is given an initial velocity v_0 at an angle θ with the horizontal. Determine

5.1.1 the Range [4]

5.1.2 the maximum height [3]

5.1.3 the time of flight, assuming the projectile hits on the same plane from which it was fired (neglecting, air resistance). [5]

5.2 A small compact car with mass 1500kg traveling due North, with a speed of 25m/s, collides at an intersection with an Intercampus bus of mass 7500kg traveling due West at 13.5m/s. treating each vehicle as a particle, find the total momentum just before collision. [10]

END OF EXAMINATION