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QUALIFICATION: **Bachelor of Science in Applied Mathematics**	
QUALIFICATION CODE: **07BAMS**	LEVEL: **7**
COURSE: **MECHANICS**	COURSE CODE: **MCS702S**
DATE: **JANUARY 2025**	SESSION: **1**
DURATION: **3 HOURS**	MARKS: **81**

2nd OPPORTUNITY EXAMINATION: QUESTION PAPER

EXAMINER: Ms K. DAVID

MODERATOR: Prof D. MAKINDE

INSTRUCTIONS:

1. Answer **ALL** questions on the separate answer sheet.
2. Please write neatly and legibly.
3. Do not use the left side margin of the exam paper. This must be allowed for the examiner.
4. No books, notes and other additional aids are allowed.
5. Mark all answers clearly with their respective question numbers.

PERMISSIBLE MATERIALS:

1. Non-Programmable Calculator

This paper consists of 4 pages including this front page.

Question 1 [20 marks]

1.1. Let $A = 2i - 3j + 4k$ and $B = -i + 2j + 5k$ be two vectors in 3D space.

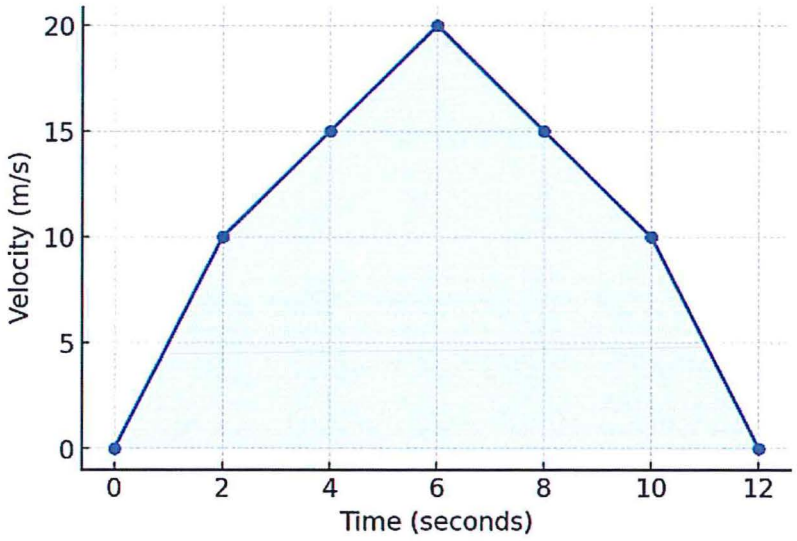
a) Find the angle between Vector A and B. [4]
b) Find the cross product between vector A and B [4]
c) Find the unit vector in the direction of vector B [3]

1.2. A boat is moving in a north-westerly direction at a speed of $60\ m/s$. Find the x-component and the y-component of the boat. (Assume north is along the positive y-axis and west is along the negative x-axis). [4]

1.3. If $r(t) = a\cos\omega t + b\sin\omega t$, where $\boldsymbol{a}$ and $\boldsymbol{b}$ are any constant non-collinear vectors and ω is a constant scalar, prove that $r(t) \times \frac{dr}{dt} = w(a \times b)$. **Hint: " × " implies the cross product.** **[5]**

Question 2 [6 marks]

The graph below shows the velocity (in m/s) of a car plotted as a function of time t.



Based on the graph, calculate:

(a) The distance travelled by the car in the first 4 seconds. [2]

(b) The distance travelled by the car in the first 8 seconds. [2]

(c) The distance travelled by the car in the first 12 seconds. [2]

Question 3 **[8 marks]**

A particle starts from rest and moves along the x-axis. For the first $8.0\ s$ of its motion, the horizontal acceleration of the particle is given by $a_x = (4.0\ m/s^3)t$ where the +x-direction is to the right.

a) What is the position of the particle along the x-axis at $t = 8.0$? [4]
b) What is the speed of the particle when it is $250\ m$ away from the origin? [4]

Question 4: **[10 marks]**

A web designer creates an animation in which a dot on a computer screen has a position of $\vec{r} = [4.0cm + (2.5cm/s^2)t^2]i + (5.0cm/s^2)tj$.

a) Find the magnitude and the direction of the dot's average velocity between $t = 0s$ and $t = 2.0s$. [4]
b) Find the magnitude and direction of the instantaneous velocity $t = 0s$, $t = 1.0s$ and $t = 2.0s$. [6]

Question 5 **[11 marks]**

A projectile is launched from the ground with an initial velocity v_0 at an angle θ with the horizontal. Assuming that the only force acting on the projectile after launch is gravity (with acceleration g), derive the equations for:

a) the horizontal displacement (range) $x(t)$ as a function of time t. [3]

b) the vertical displacement $y(t)$ as a function of time t. [3]

c) the total time of flight T. [5]

Question 6 **[10 marks]**

Three workers are attempting to move a large crate across a rough floor by pulling on it using ropes. The forces applied by the workers are represented by the following vectors:

Force 1: 150N at an angle of 30^o above the positive x-axis.

Force 2: 200N along the negative x-axis.

Force 3: 250N at an angle of 45^o above the negative x-axis.

a) Draw a sketch of these force vectors on the same x-y plane. [3]
b) Calculate the x- and y-components of each of the three forces. [6]
c) Use the components to find the magnitude and direction of the resultant force acting on the crate. [4]

Question 7 **[10 marks]**

7.1. A 3000 N Tesla Model S is moving along the +y-direction and suddenly applies its brakes for an emergency stop. The y-component of the net force acting on it is −2000 N. What is the car's acceleration? [4]

7.2. A student pushes a soda can with mass 0.60 kg to the left along a smooth, flat table. The can leaves her hand moving at 3.5 m/s, then gradually slows down due to a constant horizontal friction force exerted on it by the table. The can slides for 1.5 m before coming to a stop. What are the magnitude and direction of the friction force acting on the can? [6]

Question 7 **[6 marks]**

A 1500-kg car travels 50 meters along a horizontal road, during which a total work of 40 000 J is done on it by an external force (ignoring friction). The car initially had a velocity of 2 m/s before the work was applied. Using the work-energy theorem, determine the car's final velocity. [6]

END OF QUESTION PAPER