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QUALIFICATION: **Bachelor of Science in Applied Mathematics**	
QUALIFICATION CODE: **07BAMS**	LEVEL: **7**
COURSE: **MECHANICS**	COURSE CODE: **MCS702S**
DATE: **NOVEMBER 2024**	SESSION: **1**
DURATION: **3 HOURS**	MARKS: **85**

1ST 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 [15 marks]

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

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 car is moving in a south-easterly direction at a speed of $50\ m/s$. Find the components of the car's velocity in the southerly and easterly directions. [4]

Question 2 [8 marks]

A car traveling west along a highway accelerates at a constant rate of $3m/s^2$ after passing a rest area. At time $t = 0$, the car is $10.0\ m$ west of the rest area and is moving at $20\ m/s$ to the west.

a) Find the car's position and velocity at $t = 3$ [4]
b) How far has the car travelled when its speed reaches $35\ m/s$? [4]

Question 3 [8 marks]

A balloon starts from rest and moves upward from the surface of the earth. For the first $12.0\ s$ of its motion, the vertical acceleration of the balloon is given by $a_y = (3.50\ m/s^3)t$ where the +y-direction is upward.

a) What is the height of the balloon above the surface of the earth at $t = 12.0s$? [4]
b) What is the speed of the balloon when it is $400m$ above the surface of the earth?[4]

Question 4 [14 marks]

A robotic vehicle is exploring the surface of Mars. The stationary Mars lander is the origin of coordinates, and the surrounding Martian surface lies in the xy-plane. The rover, which we represent as a point, has x- and y-coordinates that vary with time :

$$x = 2.0m + (0.25\ m/s^2)t^2$$
$$y = (1.0\ m/s)t + (0.025\ m/s^3)t^3$$

a) Find the rover's coordinates and distance from the lander at $t = 2.0\ s$. [4]
b) Find the rover's displacement and average velocity vectors for the interval $t = 0.0\ s$ to $t = 2.0\ s$. [4]
c) Find a general expression for the rover's instantaneous velocity vector. Express $\vec{v}$ at $t = 2.0\ s$ in component form and in terms of magnitude and direction. [6]

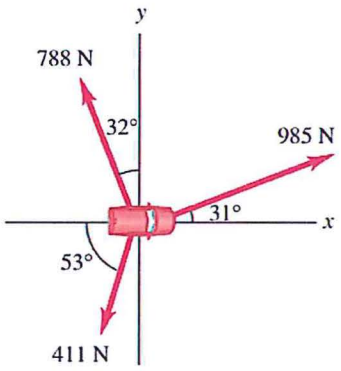
Question 5 [10 marks]

A projectile is launched from a point on the ground with an initial velocity of $50\,m/s$, at an angle of 30^o above the horizontal.

a) Determine the maximum height reached by the projectile. [4]
b) Calculate the total time of flight until the projectile hits the ground. [3]
c) Find the horizontal range of the projectile. [3]

Question 6 [10 marks]

Workmen are trying to free an SUV stuck in the mud. To extricate the vehicle, they use three horizontal ropes, producing the force vectors shown in the figure below.



(a) Find the x- and y-components of each of the three pulls. [6]
(b) Use the components to find the magnitude and direction of the resultant of the three pulls. [4]

Question 7 [14 marks]

A student suspends a chain consisting of 3 links, each of mass $m = 0.250\,kg$, from a light rope. The rope is attached to the top link of the chain, which does not swing. She pulls upward on the rope, so that the rope applies an upward force of $9.00\,N$ to the chain.

3.1.1. Draw a free-body diagram for the entire chain, considered as a body, and one for each of the three links, clearly indicating all forces involved in each case. [4]
7.2. Use your diagrams of 3.1 and Newton's laws to find:

a) the acceleration of the chain. [5]

b) the force exerted by the top link on the middle link. [5]

Question 8 **[6 marks]**

A 1500-kg car starts from rest and moves along a horizontal road. The car travels 50 meters, during which a total work of 40 000 J is done on it by an external force (ignoring friction). Using the work-energy theorem, determine the car's final velocity. [6]

END OF QUESTION PAPER