ALUPE UNIVERSITY

OFFICE OF THE DEPUTY VICE CHANCELLOR

ACADEMICS, RESEARCH AND STUDENTS AFFAIRS

UNIVERSITY EXAMINATIONS

2023/2024 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER REGULAR MAIN EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE/ARTS

COURSE CODE: MAT 215

COURSE TITLE: CLASSICAL MECHANICS

DATE: 25TH APRIL, 2024   TIME: 9– 12PM

INSTRUCTION TO CANDIDATES

- **SEE INSIDE**

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MAT 215: CLASSICAL MECHANICS

STREAM: BED   DURATION: 3 Hours

INSTRUCTION TO CANDIDATES

i.   *Answer **ALL** questions from **section A** and any **THREE** from **section B***

ii. *Do not write on the question paper.*

SECTION A [31 MARKS] ANSWER ALL QUESTIONS

QUESTION ONE [16 MARKS]

a) Find the volume of the parallelopipe determined by
   $$\vec{A} = i + 2j - k, \vec{B} = -2i + 3k, \vec{C} = 7j - 4k$$ [3mks]

b) Find an equation for the cylinder $x^2 + (y - 3)^2 = 9$ is cylindrical coordinates   [3mks]

c) The vector $r(t) = 3\cos ti + 3\sin tj + t^2 k$ gives the position of a moving body at any time t. Find the body speed and direction when $t = 2$ and at what time if any, are the body's velocity and acceleration orthogonal?   [4mks]

d) A long jumper leaves the ground at an angle of 20° above the horizontal and at a speed of $11 m/s$.
   i.   How far does he jump in the horizontal direction?   [3mks]
   ii. What is the maximum height reached?   [2mks]

QUESTION TWO [15 MARKS]

a) What is the centripetal acceleration of the earth as it moves in its orbit around the sun give that the period of the earth's orbit is one year and the radius of the earth's orbit around the sun is $1.496 \times 10^{11} m$ [3mks]

b) Two vectors $\vec{A}, \vec{B}$ are given by $\vec{A} = 2i + 3j, \vec{B} = -i + 2j$
   i.   Determine the scalar product   [3mks]
   ii. Find the angle θ between vectors A and B   [2mks]

c) A spring has natural length of 1m. A force of 24K stretches spring to a length of 1.8m
   i.   Find the force constant K.   [2mks]
   ii. How much work will it take to stretch the spring 2m beyond its natural length.[3mks]
   iii. How far will 45N force stretch the spring   [2mks]

SECTION B: ANSWER ANY THREE QUESTIONS [39 MARKS]

QUESTION THREE [13 MARKS]

a) Find work done by a conservative force field   along a smooth curve C joining the point [3mks]

b) Riding your 14kg bicycle at a steady speed of 18km/h, you experience a 30N force from air resistance. If your mass is 68kg, at what power must you supply on a level ground and going up a 5° incline?   [3mks]

c) A ball of mass m is suspended from a string of length L. The ball revolves with a constant speed V in a horizontal circle of radius r. Find the expression for V in terms of geometry.   [6mks]

QUESTION FOUR [13 MARKS]

a) In a particular crash test, a car of mass 1500kg collides with a wall. The initial and final velocity of car is $v_i = -15i, v_f = 2.6i$ respectively. If the collision last for 0.15s, find the impulse caused by the collision and the average force exerted on the car.   [7mks]

b) Using the known radius of the earth and that g=9.8m/s^2 at the earth surface. Find the average density of the earth.   [6mks]

QUESTION FIVE [13 MARKS]

a) The international space station is a circular orbit at an altitude of 380km. What are its orbital speed and period?   [5mks]

b) Find the centre of mass of barbell consisting of 50kg and 80kg weights at the opposite ends of 1.5m long bar of negligible mass.   [8mks]

QUESTION SIX [13 MARKS]

a) A wind turbines blade 28m long and rotates at 21rpm. When the wind dies, the turbine spins down with a constant angular acceleration of magnitude 0.12rad/s^2. How many revolutions does the turbine make before coming to a stop?   [8mks]

b) A student holds one end of flexible ruler against a desk and strikes the other end setting it into oscillation. The student notes that 28 complete cycles occur in 10s and that the end of the ruler moves a distance of 8cm. What are the amplitude, period and frequency?   [5mks]

QUESTION SEVEN [13 MARKS]

a) Describe torsional oscillator   [3mks]

b) A tuned mass damper consists of 373mg concrete block that completes one oscillation in 6.80s. The oscillation amplitude in high wind is 110cm. Determine the spring constant and the maximum speed and acceleration of the block.   [10mks]