ALUPE UNIVERSITY

OFFICE OF THE DEPUTY VICE CHANCELLOR

ACADEMICS, RESEARCH AND STUDENTS' AFFAIRS

UNIVERSITY EXAMINATIONS

2024/2025 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER REGULAR MAIN EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE & COMPUTER SCIENCE

COURSE CODE: MAT 320

COURSE TITLE: DYNAMICS

EQUATIONS II

09^{TH} APRIL 2025 TIME: 8:00-11:00AM

INSTRUCTION TO CANDIDATES

SEE INSIDE

THIS PAPER CONSISTS OF 3 PRINTED PAGESPLEASE TURN OVER

STREAM: CS 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 COMPULSARY, (31 MARKS)

QUESTION ONE (16 MARKS)

a) A uniform bar AB of length $l = 100cm$ rotates anticlockwise about a point A with constant angular speed ω. At the instant midpoint C of AB the linear speed and V_C of the center of mass C is $100cm/s$.

i. Find the angular speed and angular velocity of the bar. **(4 marks)**

ii. What is the linear velocity of point B after a rotation of 30^0? **(2 marks)**

iii. By what angles do the angular positions of point C and B change in 2 seconds? **(2 marks)**

b) A ship moves with velocity $V_x = 10m/s$ and a drone takes off from the ship with velocity (3, 4) m/s relative to the ship. If the ship also rotates at $\omega = 1\ rad/s$, find the velocity of the drone in the stationary frame. **(4 marks)**

c) A planet has twice the mass of Earth and half its radius. If a person weighs $700N$ on earth, what would be their weight on this planet? (gravity of earth; $g = 9.8\ m/s^2$) **(4 marks)**

QUESTION TWO (15 MARKS)

a) A mass spring system has a mass $M = 2kg, k = 100N/m, b = 5Ns/m$. An external periodic force $F(t) = 10\cos 2t$ N is applied to the system. The initial displacement is $x(0) = 0$ and initial velocity is $\dot{x}(0) = 0$. Find the steady-state solution for the displacement x(t). **(6 marks)**

b) A wheel with a mom of inertia of 2 kgm^2 slows from 20rad/s to rest in 5 sec. Find the torque acting on the wheel. **(4 marks)**

c) A car moves along the x-axis with velocity $V_x = 5m/s$. A person inside the car throws a ball with velocity $V_x = 2m/s$ in the x direction and velocity $V_y = 3m/s$ in the y-direction What is the velocity of the ball as seen by a stationary observer? **(5 marks)**

SECTION B ANSWER ANY THREE QUESTIONS, (39 MARKS)

QUESTION THREE (13 MARKS)

a) A particle executes circular motion in the xy-plane with constant speed $v = 5m/s$. At $t = 0$, the particle is at $\theta = 0$. Given that the radius of the circular orbit is $2.5m$, find the velocity of the particle at $t = 3s$. **(10 marks)**

b) A spaceship moves at 0.8c relative to Earth. A light signal is sent inside the spaceship at speed c. What is the observed speed of light from Earth? **(3 marks)**

QUESTION FOUR (13 MARKS)

a) The position of a particle moving in xy-plane is given as a function of time in seconds as $r = \cos(2\pi t)i + \sin(2\pi t)j$ meters

i. Find velocity v and acceleration a of the particle as function of time **(5 marks)**

ii. Show that velocity is always perpendicular to acceleration **(4 marks)**

iii. Determine the magnitude of the velocity when $t = 5sec$ **(4 marks)**

QUESTION FIVE (13 MARKS)

a) State Newton's second law of motion **(2 marks)**

b) An ice skater with a moment of inertia of 3kgm/s is spinning at 5 rad/s. If she pulls her arms and reduces her moment of inertia to 2kgm/s^2, what is her angular velocity. **(2 marks)**

c) A 10N force is applied at a 30° angle to move a 2kg box 5m along a flat surface. Find the work done **(3 marks)**

d) Find the moments and center of mass of the system of objects that have masses 3, 4 and 8 at the points (-1, 1), (2, -1) and (3, 2) respectively. **(6 marks)**

QUESTION SIX (13 MARKS)

a) A mass spring system with mass M=0.5kg, spring constant k=100N/m, damping coefficient b=2Ns/m is subject to damping. The displacement x(t) of the mass at time t is given by the differential equation; $m\ddot{x} + b\dot{x} + kx = 0$ Find the solution for displacement x(t) given that the initial displacement $x_0 = 0.1m$ and the initial velocity is $\dot{x}\,(0) = 0m/s$. **(7 marks)**

b) If the acute angle between two vectors A and B is θ, show that $A \cdot B = \| A \| \| B \| \cos\theta$.

(6 marks)

QUESTION SEVEN (13 MARKS)

a) A stone is dropped from a height of 20m. Find the time it takes to reach the ground and its velocity just before impact. Assume $g = 9.8m/s^2$ **(3 marks)**

b) A ball is thrown with an initial velocity of 20m/s at an angle of 30° to the horizontal. Find;

i. Time of flight **(2 marks)**

ii. The maximum height **(2 marks)**

iii. Horizontal displacement **(2 marks)**

c) A 2kg mass spring system with $k = 5N/m$ and $b = 4Ns/m$ is subjected to a force F(t)=10 cos $5t$. Find the steady-state amplitude **(4 marks)**