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OFFICE OF THE DEPUTY PRINCIPAL

ACADEMICS, STUDENT AFFAIRS AND RESEARCH

UNIVERSITY EXAMINATIONS

2020 /2021 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER REGULAR EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE & BACHELOR OF EDUCATION ARTS

COURSE CODE: **MAT 320**

COURSE TITLE: **DYNAMICS**

DATE: 13/7/2021 **TIME: 1300-1600HRS**

INSTRUCTION TO CANDIDATES

- **SEE INSIDE**

THIS PAPER CONSISTS OF 4 PRINTED PAGES **PLEASE TURN OVER**

REGULAR - MAIN EXAM

MAT 320: DYNAMICS

STREAM: EDA & EDS **DURATION: 3 Hours**

INSTRUCTIONS TO CANDIDATES

i. Answer **All** questions from **Section A** and any **Three** from **Section B**

ii. Take $g = 9.8m/s^2$.

SECTION A (31 MARKS). Answer ALL Questions

Question One (16 Marks)

(a) A body moving with simple harmonic motion has a velocity of $3m/s$ when $375mm$ from the mid position and acceleration of $1m/s^2$ when $250mm$ from the mid position. Calculate the;

(i) period time, (2 Marks)

(ii) amplitude. (4 Marks)

(b) A body whose true weight is $13kg$ appeared to weigh $12kg$, when weighed by a spring in a moving lift. What was the acceleration of the moving lift? (2 Marks)

(c) A mass of $500kg$ moves on a straight line from a speed of $540km/h$ to $720km/h$ in 2 minutes. What impulse developed in this time? (3 Marks)

(d) A small stone of mass m is thrown vertically upwards with initial speed u. If the air resistance at speed v is mkv^2, where k is a positive constant, show that the stone attains maximum height H given by $H = \left(\frac{1}{2k}\right) \log\left(1 + \frac{ku^2}{g}\right)$. (5 Marks)

Question Two (15 Marks)

(a) State the Hamilton's principle. (2 Marks)

(b) The kinetic energy of a pendulum is given by $T = \frac{1}{2}ml^2\theta^2$ and potential energy is given by $U = mgl(1 - \cos\theta)$. Obtain its Lagrangian. (2 Marks)

(c) Show that the total work done by the external force F in carrying a particle from point A to point B on a curve C is equal to kinetic energy gained in the process. (4 Marks)

(d) The particle P with mass 2 moves along x-axis is attracted towards the origin O by a force whose magnitude is numerically equal to $8x$. If it is initially at rest at $x = 20$ and has also a dumping force whose magnitude is numerically equal to 8 times equal to instantaneous speed. Evaluate the;

(i) position of the particle at any time t, (4 Marks)

(ii) velocity of the particle at any time t. (3 Marks)

SECTION B (39 MARKS)

Question Three (13 Marks)

Given that a particle moves along a space curve described by $r = 3\cos t\hat{i} + 3\sin t\hat{j} + 4t\hat{k}$. Determine the;

(a) unit tangent to the curve, (4 Marks)

(b) unit normal to the curve, (3 Marks)

(c) unit binormal to the curve, (3 Marks)

(d) torsion and radius of torsion. (3 Marks)

Question Four (13 Marks)

(a) An object of mass $20kg$ moves with simple harmonic motion in x-axis. Initially it is located at a distance of $4m$ from the origin and has a velocity of $15m/s$ and acceleration of $100m/s^2$ directed towards the origin. Find the;

(i) position at any time, (4 Marks)

(ii) amplitude, frequency and periodic time, (4 Marks)

(iii) force on the object when $t = \frac{\pi}{10}$ seconds (2 Marks)

(b) The position vector of a moving a particle P relative to the fixed point O at any time t is given by $r = (10 - t^2)\hat{i} + 3t\hat{j} - 4t\hat{k}$. Find the value of t when the acceleration of P is perpendicular to the vector $\vec{OP}$. (3 Marks)

Question Five (13 Marks)

(a) State Lagrange equation of motion. (2 Marks)

(b) A particle is projected with the velocity of $49m/s$ at an elevation of 30^0. Determine the;

(i) time of flight, (2 Marks)

(ii) horizontal range, (2 Marks)

(iii) greatest height attained. (2 Marks)

(c) A particle of mass $5g$ moves along x-axis under the influence a force of attraction to origin O which is numerically equal to 40 times the instantaneous distance from origin O and, damping force proportional to instantaneous speed; when the speed is $10m/s$ the damping is 200. Assuming that the particle from rest at a distance of $20cm$ from O, find the position of the particle at any time t. (5 Marks)

Question Six (13 Marks)

(a) A projectile is launched with the initial speed v_0 at an angle α with the horizontal. Calculate the;

(i) position vector at any time t, (2 Marks)

(ii) time it takes to reach the highest point, (2 Marks)

(iii) maximum speed reached, (2 Marks)

(iv) time of flight back to the earth. (2 Marks)

(b) A particle moves along a straight line $\overrightarrow{OX}$ such that its displacement X from O at time t is given by $x'' + 2\sqrt{\frac{g}{l}}x' + \frac{3g}{l}x = 0$. Find the position of the particle at any time t. Write down the period of the oscillation. (5 Marks)

Question Seven (13 Marks)

(a) State the Newton's laws of motion. (3 Marks)

(b) A particle of mass m is constrained to execute Simple harmonic motion under a force towards O of magnitude mw^2x, x being the particle's displacement from O. When passing through O, its velocity is v, and when its velocity has become $\frac{v}{2}$ in the same direction and impulse I is applied to the particle in the direction of its motion. Assuming the law of force, find time and total distance travelled from O to the first position of instantaneous rest. (10 Marks)

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