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University Examinations 2013/2014

SECOND YEAR, SECOND SEMESTER EXAMINATIONS FOR DEGREE OF BACHELOR OF SCIENCE IN COMPUTER SCIENCE AND BACHELOR OF SCIENCE IN MATHEMATICS AND COMPUTER SCIENCE

SMA 2221: CLASSICAL MECHANICS

DATE: DECEMBER 2013 **TIME: 2 HOURS**

INSTRUCTIONS: *Answer question **one** and any other **two** questions*

QUESTION ONE – (30 MARKS)

(a) A particle is moving along a curve defined by parametric equation

$x = 2\cos 3t$

$y = 2\sin 3t$

$z = 4t^2$

(i) Find velocity and acceleration at any given time t. (3 Marks)

(ii) Find the magnitude of velocity and acceleration at $t = 0$. (2 Marks)

(b) A particle moves in a circle of radius $20cm$. If its tangential speed is $40cms^{-1}$. Find

(i) Angular speed. (2 Marks)

(ii) Angular and normal acceleration. (4 Marks)

(c) (i) State the Newton second law of motion. (1 Mark)

(ii) A car of mass 1000kg moves uphill along a street inclined at 30^0 to the horizontal. Determine the force which the car must produce to move with uniform motion and with an acceleration of 0.2m/s^2. (Neglect the effect of friction). (6 Marks)

(d) A force $\vec{F} = 6N$ acts on a particle whose mass = 2kg. if the particle starts at rest. Find the work done by force in the first and second second. (6 Marks)

(e) Particle moves with force field $\vec{F} = 2xyzi + x^2zj + x^2yk$. Show that the force $\vec{F}$ is conservative. Find the potential associated with the force field. (5 Marks)

(f) Show that the equation $x = 4\cos 2t + 3\sin 2t + 3$ execute simple harmonic motion. (4 Marks)

QUESTION TWO – (20 MARKS)

(a) The position vectors of two particles are given as
$\overrightarrow{r_1} = t\,\boldsymbol{i} - t^2\boldsymbol{j} + (2t + 3)\boldsymbol{k}$
$\overrightarrow{r_2} = (2t - 3t)\boldsymbol{i} + 4t\boldsymbol{j} - t^3\boldsymbol{k}$**.** Find the relative velocity and acceleration of the second particle with respect to the first at $t = 1$ (7 Marks)

(b) The power applied to a particle by a force field is given as a function of time t by $p(t) = 3t^2 - 4t + 2$. Find the work done in moving a particle from $p_1\ at\ t = 2$ to $p_2\ at\ t = 4$ respectively. (6 Marks)

(c) A particle of mass 40 kg requires a constant force to accelerate it from velocity $\overrightarrow{v_1} = (4i - 5j + 3k)$ m/s to a velocity $\overrightarrow{v_2} = (8i + 3j + 5k)$m/s in 20 seconds. Find:

(i) The constant force needed to accelerate the particle and its magnitude. (4 Marks)

(ii) The work done by the particle in (i) above. (3 Marks)

QUESTION THREE – (20 MARKS)

(a) A particle of unit mass moves along curve in a force field
$\vec{F} = (6i - 8) - 60t^3j + (20t^3 + 36t^2)k$ where t is the time. If initial position and velocity are respectively given by:
$\vec{r}_0 = 2i - 3k$
$\overrightarrow{v_0} = 5i + 4j$

Find:

(i) The position, velocity, acceleration and momentum of particles at $t = 2$. (2 Marks)

(ii) The Kinetic energy (K.E) at $t = 2$. (2 Marks)

(iii) The work done from $t = 0$ to $t = 2$ (2 Marks)

(iv) The power applied to the particle at any time t. (3 Marks)

(b) A particle of unit mass moves along the curve $\vec{r} = a\cos wt\ i + b\sin wt\ j$. Find the torque. (3 Marks)

QUESTION FOUR – (20 MARKS)

(a) A bullet is fired straight upward with a velocity of $98m/s$ from the top of a building 490m high. Find:

(i) The maximum height above the ground the bullet reaches. (3 Marks)

(ii) Time required to reach maximum height. (3 Marks)

(iii) The velocity of the bullet when it reaches ground. (3 Marks)

(b) (i) Two cars A and B are traveling in the same direction with constant velocities $V_A and\ V_B$ respectively. When car A is at distance d from B, brakes are applied decelerating at a rate r. Demonstrate that in order to collide.

$V_A - V_B \geq \sqrt{2ad}$ (6 Marks)

(ii) Two particles A and B are moving in the same direction, when $t = 0$, their respective velocities are 1cm/s and 3cm/s and their respective accelerations are 2cm/sec^2 and 1cm/s^2. If the particle A is 1.5cm ahead of B at $t = 0$, after how long will they be side by side. (6 Marks)

QUESTION FIVE – (20 MARKS)

(a) In a damped harmonic oscillation, a restoring force is given by $m(k^2 + n^2)x$ and the damping force is $2mku$ where m is the mass, k is a positive constant and u is the velocity. The body starts from rest at $t = 0$ from position $x = a$. Show that its position at time t is given by:

$x = {}^{q}/_{n}\,(n\cos nt + k\sin nt\,)e^{-kt}$ (10 Marks)

(b) A particle travels with uniform angular speed to around a circle of radius a prove that its projection on the diameter oscillates with simple harmonic motion of period $\frac{2\pi}{w}$ about the center of the circle. (5 Marks)

(c) A particle on a circle of radius R has constant angular acceleration $\propto$. If a particle starts from rest. Show that after time t its angular velocity $w = \propto t$. (5 Marks)