MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

APRIL SESSION EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SPH 400: CLASSICAL MECHANICS

DATE: SCHOOL BASED **TIME: 2 Hours**

INSTRUCTIONS

Answer **QUESTION ONE** which COMPULSORY and ANY OTHER TWO questions.

Question 1 carries **30** marks and the rest **20** marks each.

YOU MAY USE:

You may need to use the following constants

- Earth's gravitational acceleration = 9.8 N/Kg
- The Universal Gravitational Constant G = 6.67×10^{-11} $N.m^2/Kg^2$
- Permeability of free space, $\mu o = 4\pi \times 10\text{-}7Tm/A$

QUESTION ONE (COMPULSORY) (30 MARKS)

a) State the three laws of classical motion (3 marks)

b) Identify the two assumptions made under Galilean transformations. (2 marks)

c) Find the number of degrees of freedom for a rigid body which has one point fixed but can move in space about this point. (3 marks)

d) A system of particles consists of particles of mass 3g located at point P (1, 0, -1), 5g at point Q (-2, 1, 3) and 2g at point R (3, -1, 1). Find the coordinates of the center of mass of the system. (4 marks)

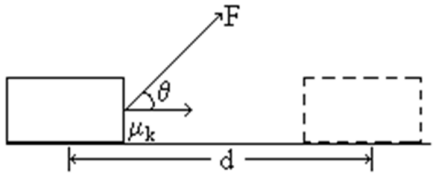
e) Describe the three constraints on a system that are involved in constrained motion. (6 marks)

f) A 600kg rocket is set for vertical firing. If the exhaust speed is 1000ms^{-1}, how much gas must be ejected each second to supply the thrust needed

i) to overcome the weight of the rocket (4 marks)

ii) to give the rocket an initial upward acceleration of 20ms^{-2}? (3 marks)

g) Consider a body of mass m be subjected to a force making an angle θ with the direction of motion, show that $F\cos\theta - \mu_k(mg - F\sin\theta) = 0$ when there's a d displacement. (5 marks)



QUESTION TWO (20 MARKS)

a) Due to a force field, a particle of mass 5 units moves along a space curve whose position vector is given as a function of time t by $\vec{r} = (2t^3 + t)\hat{i} + (3t^4 - t^2 + 8)\hat{j} - 12t^2\hat{k}$. Find

(i) the velocity (2 marks)

(ii) the momentum (2 marks)

(iii) the acceleration (2 marks)

(iv) the force at any time t. (2 marks)

b) An alpha particle, which is the nucleus of the He-atom, is emitted from a Uranium-238 nucleus, originally at rest, with a speed of 1.4 x 10^{7}ms^{-1} and a kinetic energy of 4.1MeV. Find the recoil speed of the residual nucleus which is Thorium-234. (6 marks)

c) A rocket is moving away from the solar system at a speed of 6.0 x 10^{3}ms^{-1}. It fires its engine which ejects exhaust with a relative velocity of 3.0 x 10^{3}ms^{-1}. The mass of the rocket at this time is 4.0 x 10^{4}kg and it experiences an acceleration of 2.0ms^{-2}. Find;

i) the velocity of the exhaust relative to the solar system (3 marks)

ii) the rate at which the exhaust was ejected during the firing. (3 marks)

QUESTION THREE (20 MARKS)

a) Show that the theory of Parallel axis is $I = I_{CM} + Mh^2$. Where all the terms have their usual meaning (10 marks)

b) Use Hamilton's Principle to find the equation of motion of a one-dimensional harmonic oscillator. (10 marks)

QUESTION FOUR (20 MARKS)

Two skaters collide and embrace each other. One has mass m_1 = 70kg and is initially moving east at a speed u_1 = 6km/h while the other has mass m_2 = 50kg and is initially moving north at a speed u_2 = 8km/h.

(a) What is the final velocity of the couple? (10 marks)

(b) What fraction of the initial kinetic energy is lost because of the collision? (10 marks)

QUESTION FIVE (20 MARKS)

a) Consider a system of many particles. Show that under rotational motion, $\vec{L} = \vec{R} \times M v_{CM} + \sum_i \vec{r}_i' \times \vec{p}_i'$

where all the terms have their usual meaning. (10 marks)

b) Consider a mass *m* be attached to a spring of force constant *k*. Obtain its equation of motion and the frequency of oscillation using Lagrange equations. (10 marks)