MACHAKOS UNIVERSITY

University Examinations 2019/2020Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SPH 400: CLASSICAL MECHANICS

DATE: 2/12/2019 **TIME: 2.00-4.00 PM**

INSTRUCTIONS TO CANDIDATES

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

Required data and constants:

Earth's gravitational pull = 9.8 N/Kg

The Universal Gravitational Constant $G = 6.67 \times 10^{-11}\ N.m^2/Kg^2$

SECTION A (COMPULSORY)

QUESTION ONE (30 MARKS)

a) State Kepler's Laws (3 marks)

b) Shown that if there is no external force acting on two bodies colliding elastically then the total momentum of the system is conserved (5 marks)

c) State three application of Lagrange's equation for motion of various mechanical system (3 marks)

d) Distinguish the following terms:

i. Discrete and continuous systems (2 marks)

ii. Constraints and Degrees of freedom (2 marks)

iii. Rigid and elastic bodies (2 marks)

e) Show that rate of change of angular momentum is equal to the applied torque (6 marks)

f) Consider a circular disc of mass M and radius R rolling down an inclined plane without slipping. Find the speed of its center of mass when it reaches the bottom of the incline. (6 marks)

QUESTION TWO (20 MARKS)

A radioactive nucleus, initially at rest, decays by emitting an electron and a neutrino at right angles to one another.The momentum of the electron is 1.2 x 10^{-22} kg.m.s^{-1}and that of the neutrino is 6.4 x 10^{-23} kg.m.s^{-1}.

a) Find the direction and magnitude of the momentum of the recoiling nucleus. (12 marks)

b) If the mass of the residual nucleus is 5.8 x 10^{-26} kg, what is its kinetic energy of recoil? (8 marks)

QUESTION THREE (20 MARKS)

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

b) Find the velocity of a rocket moving vertically upward at any time t in a constant gravitational field. Assume that the gas is ejected at a constant rate and at a constant velocity with respect to the rocket. (10 marks)

QUESTION FOUR (20 MARKS)

a) State Hamilton's principle (2 marks)

b) Use Hamilton's Principle to find the equation of motion of a one-dimensional harmonic oscillator. (18 marks)

QUESTION FIVE (20 MARKS)

a) 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.

i. What is the final velocity of the couple? (5 marks)

ii. What fraction of the initial kinetic energy is lost because of the collision? (5 marks)

b) From linear momentum of system of particles show that $\vec{P} = \vec{p}_1 + \vec{p}_2 + \vec{p}_3 + ... + \vec{p}_n$ = constant. Where the symbols carry their usual meaning (10 marks)