EMBU UNIVERSITY COLLEGE

(A CONSTITUENT COLLEGE OF THE UNIVERSITY OF NAIROBI)

FIRST SEMESTER EXAMINATIONS 2014/2015

THIRD YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

SPH 305: CLASSICAL MECHANICS

DATE: DECEMBER 11, 2014 **TIME: 10:30AM– 12:30PM**

INSTRUCTIONS:

Answer Question ONE and ANY Other TWO Questions.

QUESTION ONE

a) State the three Newtons'laws of motion. (3 marks)

b) State and describe the three Euler angles. (3 marks)

c) Name and write the four Maxwell differential equations. (4 marks)

d) Describe what is meant by resonance for a body undergoing oscillatory motion and give two salient features of it. .(4 marks)

e) State the laws of conservation of linear and angular momentum giving the equations for each. (4 marks)

f) Compare and contrast between generalized coordinates and degrees of freedom? (4 marks)

g) State the D'Alemberts principle and virtual work. (4 marks)

h) Write the two Hailtons' equations of motion. (4 marks)

QUESTION TWO

Two astronauts each having a mass M, are connected by a rope of length d having negligible mass. They are isolated in space, moving in circles around the point halfway between them at a speed v.

a) Calculate the magnitude of the angular momentum of the system by treating the astronauts as particles.

b) Calculate the rotational energy of the system. By pulling on the rope, the astronauts shorten the distance between them to $d/2$.

c) What is the new angular momentum of the system?

d) What are their new speeds?

e) What is the new rotational energy of the system?

f) How much work is done by the astronauts in shortening the rope? (20 marks)

QUESTION THREE

a) In a circus performance, a large 5.0 kg hoop of radius 3.0 m rolls without slipping. If the hoop is given an angular speed of 3.0 rad/s while rolling on the horizontal ground and is then allowed to roll up a ramp inclined at 20 with the horizontal, how far along the incline does the hoop roll? (10 marks)

b) A 5.00 kg cylindrical reel with a radius of 0.600 m and a frictionless axle starts from rest and speeds up uniformly as a 3.00-kg bucket falls into a well, making a light rope unwind from the reel. The bucket starts from rest and falls for 4.00 s. (i) Find the linear acceleration of the falling bucket? (ii) How far does it drop? (iii) What is the angular acceleration of the reel? (10 marks)

QUESTION FOUR

a) A merry-go-round rotates at the rate of 0.20 rev/s with an 80-kg man standing at a point 2.0 m from the axis of rotation. (i) What is the new angular speed when the man walks to a point 1.0 m from the center? Assume that the merry-go-round is a solid 25-kg cylinder of radius 2.0 m. (ii) Calculate the change in kinetic energy due to the man's movement. How do you account for this change in kinetic energy? (12 marks)

b) A solid, horizontal cylinder of mass 10.0 kg and radius 1.00 m rotates with an angular speed of 7.00 rad/s about a fixed vertical axis through its center. A 0.250-kg piece of putty is dropped vertically onto the cylinder at a point 0.900 m from the center of rotation and sticks to the cylinder. Determine the final angular speed of the system. (8 marks)

QUESTION FIVE

The standard Lagrangian has a unique specification for a system

$$L = T - V$$

But a non – standard Lagrangian L_n can be created by adding suitable functions to L that cancel out of the Lagrangian equations. These non-standard forms might be more convenient to use sometimes; they may for instance fewer terms than the standard Lagrangian. If L is the standard Lagrangian for a system, show that the Lagrangian equations are also satisfied by

$$L_n = L + dF(q, t)/dt$$

where the unsubscribed q stands for a set of generalized coordinates. Give some obvious simple examples of possible F and dF/dt functions. What can you do as a simplification if say you have a dF/dt function in a Lagrangian and all you want immediately is the equations of motion?

(20 marks)

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