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UNIVERSITY EXAMINATIONS 2023/2024

SECOND YEAR, FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN MATHEMATICS AND PHYSICS AND BACHELOR OF EDUCATION SCIENCE

SPH 3200: MECHANICS II

DATE: DECEMBER 2023 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

a) Show that the rate of change of angular momentum of a body is equal to torque (4 Marks)

b) i. Explain what is mean by a conservative system (2 Marks)

ii. State a necessary and sufficient condition for a system to be conservative (2 Marks)

iii. A girl walks 4 kilometers west, then 3 kilometers in a direction 30 degrees east of north, before coming to a halt. Determine the girl's distance from her starting position. (10 Marks)

c) i. Define the centre of mass of a system (2 Marks)

ii. Locate the centre of mass of a system of 3 particles such that M_1=3kg is located at point A(0,2), particle m_2=4kg is located at point B(0,0) and particle M_3=5kg is located at point C(3,0). (5 Marks)

d) A typical small rescue helicopter has four blades forming a cross: Each blade is 4.00 m long and has a mass of 50.0 kg. The blades can be approximated as thin rods that rotate anticlockwise about one end of an axis perpendicular to their length. The helicopter has a total loaded mass of 1000 kg. (a) Calculate the rotational kinetic energy in the blades when they rotate at 300 rpm. (b) Calculate the translational kinetic energy of the helicopter when it flies at 20.0 m/s, and compare it with the rotational energy in the blades (5 Marks)

QUESTION TWO (20 MARKS)

A student stands at the centre of a rotating platform that has frictionless bearings. He has a 2 kg object in each hand, held 1m from the axis of rotation of the system. The system is initially rotating at 10 rpm. Determine: -

a) The angular velocity of the system in radians per second after the objects are brought to a distance of 0.2m from the axis of rotation (7 Marks)
b) The change in rotational kinetic energy of the system as the objects are pulled closer to the centre of rotation (7 Marks)
c) The critical angular velocity in radians per second (3 Marks)
d) What causes the increase in rotational kinetic energy? (Assume that moments of inertia of the system plus that of the student remains constant at 1 kg) (3 Marks)

QUESTION THREE (20 MARKS)

Consider a painter on a ladder as indicated in the picture below. The mass of the ladder is m=7 kg and the mass of the painter is M=62 kg. Suppose the coefficient of friction is 0.6 between the floor and ladder. Assume there is no friction force between the ladder and the wall. Using the principle of equilibrium, obtain

a) The net force along the x-axis (4 Marks)
b) The net force along the y-axis (3 Marks)
c) The force of reaction of the wall on the ladder (3 Marks)
d) The net torque (3 Marks)

e) How high up the ladder can the painter climb in the y-direction? (5 Marks)

f) Can the painter climb up the maximum possible y=4.0 m? (2 Marks)

QUESTION FOUR (20 MARKS)

a) i. State the work-energy theorem (2 Marks)

ii. Prove the work-energy theorem for a variable force (5 Marks)

iii. You are playing a game of pinball and want to know how fast the 0.1 kg ball is going when you launch it off the first spring. You worked for a spring manufacturer in the past and you recognize that the spring in use has a spring constant of 150 N/m. You compress the spring 6.0 cm downward from equilibrium. With what velocity does the ball leave the spring? (3 Marks)

b) A roller coaster car be filled with people has a mass of 700 kg. On this particular coaster, the car is brought up to its first hill, which is 75 m75 m tall. Assuming the vehicle is at rest at the top of the hill and no work is done on the car as it falls, what will be its velocity at the bottom of the hill? (10 Marks)