TECHNICAL UNIVERSITY OF MOMBASA
FACULTY OF APPLIED AND HEALTHY SCIENCES
DEPARTMENT OF MATHEMATICS AND PHYSICS
UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF TECHNOLOGY IN APPLIED PHYSICS AND BACHELOR OF TECHNOLOGY IN RENEWABLE ENERGY AND ENVIROMENTAL PHYSICS

APS 4201: MECHANICS II
SPECIAL/ SUPPLIMENTARY EXAMINATIONS

SERIES: SEPTEMBER 2018

TIME: 2 HOURS **DATE: SEPTEMBER 2018**

INSTRUCTION TO CANDIDATES

You should have the following for this examination. *Answer Booklet, examination pass and student ID.* This paper consists of FIVE questions. Answer question ONE (COMPULSORY) and ANY other TWO questions. The maximum marks for each question is shown. Do not write on the question paper. Mathematical tables and scientific calculators may be used.

The following constants may be useful: Mass of earth, $M_e = 5.97 \times 10^{24}$ kg, mass of moon $M = 7.35 \times 10^{22}$ kg, radius of earth = 6.371×10^{6} m, radius of moon = 3.80×10^{8}m, Gravitation acceleration, g = 9.89 m/s^2; G = 6.67×10^{-11}Nm^2 kg^{-2}

QUESTION ONE (30 mks)

(a) A typical adult human has a mass of about 70.0kg.

(i) What force does a full moon exert on such a human when it is directly overhead with its centre 380,000 km away? (4mks)

(ii) Compare this force with that exerted on the human by the earth. (4mks)

(b) In 2004 astronomers reported the discovery of a large Jupiter-sized planet orbiting very close to the star HD 179949. The orbit was just 1/9 the distance of Mercury from our sun, and it takes the planet only 3.09 days to make one orbit (assumed to be circular). Given that one *solar day* has 86,400 s, the mass of the sun is 1.99 x 10^{30} kg and mass of mercury is 5.79 x 10^{10} kg;

(i) What is the mass of star? (2mks)

(ii) How fast is this planet moving? (2mks)

(c) A satellite is launched horizontally from a distance *r* from the centre of the earth. Determine the launch speed, *v*, necessary for the satellite to enter into a circular orbit about the earth. (3mks)

(d) (i) List the three laws of Kepler that explains planetary motion. (3mks)

(ii) Does any planet have a geostationary orbit? Explain. (4mks)

(iii) Mention four Natural satellites of the earth. (4mks)

(e) List four types of fundamental forces. (4mks)

QUESTION TWO (20 mks)

(a) What are Galilean transformations? (2mks)

(b) State three implications of Lorentz transformations. (3mks)

(c) (i) Show that the moment of inertia, I, of a thin hallow sphere of mass, M and radius, R, can be expressed as;

$$I = MR^2$$ (6mks)

(ii) If this hallow sphere in c(i) has a mass of 0.12kg and a radius of 0.36m, determine its moment of inertia. (2mks)

(d) (i) List three factors that determine moment of inertia of solid objects. (3mks)

(ii) State the law of gravitation and express its mathematical form. (4mks)

QUESTION THREE (20 mks)

(a) Define the term "radius of gyration" and express its mathematical form. (4mks)

(b) A disc of radius of 10 cm and mass of 20g is set to rotate about an axis through a point of 3cm from the centre of the disc as shown in figure 1. Determine its moment of inertia about the new axis. (6mks)

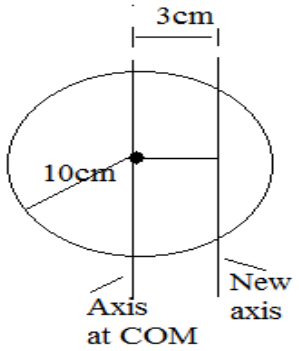

Figure 1: Parallel axis on a regular disc

(c) What is a conservative force? (2mks)

(d) A flywheel of radius of 3.2 cm has a moment of inertia of 8.4kgM^2 is attached upon by a constant force of 50.4N for 4 seconds.

(i) What is the final angular velocity reached by the wheel? (4mks)

(ii) How many revolutions will the flywheel make if an opposing torque of 10Nm^2 acts on it after the removal of the first force? (4mks)

QUESTION FOUR (20 mks)

(a) Consider an annular shaped radius 'a' and 'b' as inner and outer radius respectively and having a mass of M. Show that its moment of inertia can be given by

$$I = \frac{1}{2}[M(a^2 + b^2)] \qquad \text{(8mks)}$$

(b) A small mass of 0.75kg is attached to one end of 1.25m rod whose other end is fixed to a point from where it can swing when the resulting pendulum is 30^o from the vertical. Determine the magnitude of its torque about the pivot. (4mks)

(c) A motorized wheel of radius of 1.5m is used to raise concrete block using a rope. If tension on the rope is not to exceed 100N, determine the torque resulting from the tension. (4mks)

(d) A block of concrete of mass 150kg is raised by a motorized wheel of radius, 1.5m. if a constant torque of $50Nm^2$ is applied to the wheel whose moment of inertia is $20kgm^2$; determine

(i) the tension in the cable. (2mks)

(ii) the linear acceleration of the block. (2mks)

QUESTION FIVE (20 mks)

(a) Consider a wheel of mass, m, and radius, r, connected to a block by a tight rope as shown in figure 3.

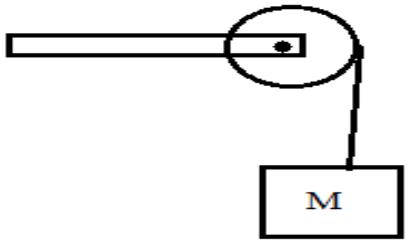

Figure 3: Falling Mass

Derive an expression for tension, T, and linear acceleration, a, if the block is falling. (5mks)

(b) Referring to figure 3, if mass, M, falls through a height, h, show that its angular acceleration of the block can be given by

$$\omega = \sqrt{\frac{2Mgh}{I + MR^2}} \qquad \text{(5mks)}$$

(c) Study the inclined plane carrying a sliding mass, M, as shown in figure 4.

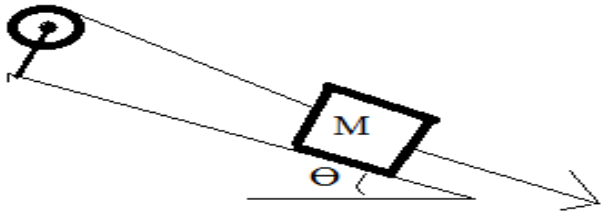

Figure 4: Inclined system

Given that the radius of the wheel is R, mass of the pulley is m, while the mass of the block is M and the angle of inclination is Θ, show that the block will accelerate with an acceleration given by;

$$a = \left(\frac{3Mg \sin\theta}{2m + M} \right)$$ (5mks)

(d) If the surface is changed and a new surface with a coefficient of friction of μ_k, show that its acceleration in (c) above will change to;

$$a = \left(\frac{2Mg(\sin\theta - \mu_k \cos\theta}{2m + M} \right)$$ (5mks)