CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE PHYSICS AND GENERAL, BACHELOR OF EDUCATION (SCIENCE) AND BACHELOR OF SCIENCE COMPUTER SCIENCE AND APPLIED COMPUTER SCIENCE

PHYS 131: MECHANICS 1

STREAMS: **TIME: 2 HOURS**

DAY/DATE: THURSDAY 19/12/2024 **8.30 A.M – 10.30 A.M**

INSTRUCTIONS:

- Attempt question ONE (30 marks) and any other TWO questions (20 marks each).
- Start each question on a fresh page

USEFUL CONSTANTS

- g = 10 m/s^2
- G = 6.672 $\times 10^{-11} Nm^2/kg^2$

QUESTION ONE (30MARKS)

a) If vector **A** = **i** + 2**j** - 2**k**, **B** = 2**i** + **j** + **k** and **C** = **i** - 3**j** - 2**k**. find the magnitude and direction cosines of vector **R** = **A** + **B** + **C**. [4 marks]

b) State the Kepler's laws. [3marks]

c) A wheel rotates with a constant angular acceleration of 7.0 rad/s ^{2}. If the angular speed of the wheel is 2.00 rad/s at t =0, through what angle does the wheel rotate between t =0 and t = 2.00 s? [2marks]

d) A race car accelerates uniformly from a speed of 40.0 m/s to a speed of 60.0 m/s in 5.00 s while traveling counterclockwise around a circular track of radius 4.00 × 10^2 m. When the car reaches a speed of 50.0 m/s, find;

(i) the magnitude of the car's centripetal acceleration. [2marks]

(ii) the angular speed. [1mark]

(iii) the tangential acceleration. [2marks]

(iv) the magnitude of the total acceleration. [1 mark]

e) A van of mass 500 kg skids to a halt from an initial speed of 24 m/s covering a distance of 36 m. Find the;

i) acceleration of the van [3marks]
ii) the retarding force [2marks]

f) A force field **F**=20**i**+5**j**-30**k** acts on a body located at **r** = 3**i**-2**j**+5**k**, calculate the moment of this force [3marks]

h) The rotor on a helicopter turns at an angular speed of 3.20×10^{2} revolutions per minute.

a) Express this angular speed in radians per second. [3 marks]

(b) If the rotor has a radius of 2.00 m, what arc length does the tip of the blade trace out in 3.00×10^{2} s? [2 marks]

i) *Figure* **1** shows a bicycle turned upside down so that a repair technician can work on the rear wheel. The bicycle pedals are turned so that at time t_i the wheel has angular speed ω_i fig 1a and at a later time t_f it has angular speed ω_f. Derive an expression for the angular acceleration of the wheel. [2 marks]

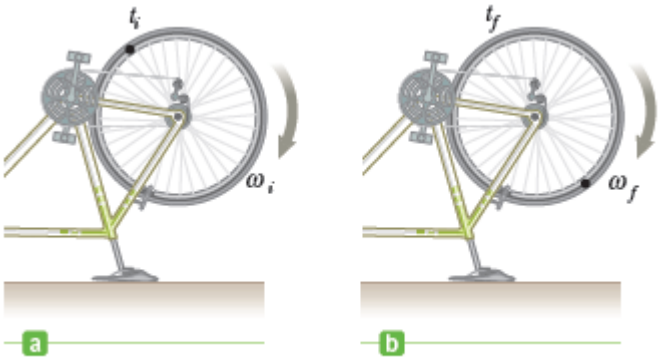


Figure 1

QUESTION TWO (20MARKS)

a) A man is dragging a log along a horizontal surface by means of a rope. The rope makes an angle of 30° to the horizontal, and the tension in the rope is 400N. Calculate the components of the tension along the horizontal and the vertical directions. [4marks]

b) A particle is acted upon by the forces $\mathbf{F}_1 = 5\,\mathbf{i} - 10\,\mathbf{j} + 15\,\mathbf{k}$, $\mathbf{F}_2 = 10\mathbf{i} + 25\mathbf{j} - 20\mathbf{k}$ and $\mathbf{F}_3 = 15\mathbf{i} - 20\mathbf{j} + 10\mathbf{k}$. Find the force needed to keep it in equilibrium. [3marks]

c) Find the angle between the vectors **A** = 2**i** +3**j**-**k** and **B** = **-i**+**j**+2**k.** [4 marks]

d) A man applies a force of **F** = 6.00 × 10 ^{2} N at an angle of 60.0^0 to the door, 1.80 m from the hinges. Find the torque on the door, choosing the position of the hinges as the axis of rotation. [4 marks]

e) Consider a block of mass m_1 resting on a flat rough surface of coefficient of friction μ Mass m_2, is connected to mass m_1 by means of a massless and inextensible cord over a frictionless pulley. Show that the acceleration of the masses is given by:

$$a = \left(\frac{m_2 - \mu m_1}{m_1 + m_2} \right) g$$

[5marks]

QUESTION THREE (20MARKS)

a) A bar of length 2 m and mass 2 kg is acted upon by a number of forces as shown in ***figure 2***.

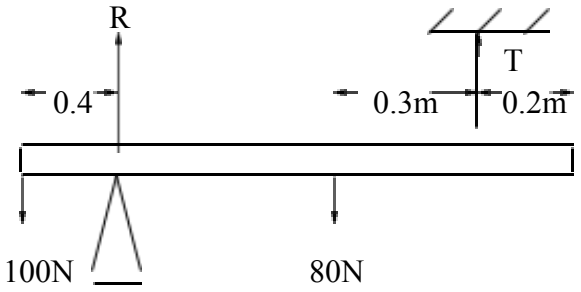


Figure 2

Calculate i) Tension T on the rope [4mks]

ii) Reaction R at the pivot [4mks]

b) An object is thrown horizontally from a cliff 30 m high with an initial velocity of 8 m/s. Calculate the distance from the foot of the cliff to the point where it hits the water surface. [4mks]

c) A man on top of a building 25.8 m high throws an object straight upwards with an initial velocity of 12 m/s. Take g to be 10 m/s^2 and find:

(i) the maximum height above the ground reached by the body, and [4mks]

(ii) the velocity with which the body hits the ground [4mks]

QUESTION FOUR (20MARKS)

(a) State Newtons law of universal gravitation. [2 marks]

(b) A compact disc rotates from rest up to an angular speed of 31.4 rad/s in a time of 0.892 s. What is the angular acceleration of the disc, assuming the angular acceleration is uniform? [4 marks]

(c) A car travels at a constant speed of 13.4 m/s on a level circular turn of radius 50.0 m. What minimum coefficient of static friction, μ_s , between the tires and roadway will allow the car to make the circular turn without sliding? [3 marks]

(d) A giant cannon dug into the Earth in Florida fired a spacecraft all the way to the Moon.

(i) If the spacecraft leaves the cannon at escape speed, at what speed is it moving when 1.50×10^5 km from the center of Earth? Neglect any friction effects. [2marks]

(ii) Approximately what constant acceleration is needed to propel the spacecraft to this speed through a cannon bore a kilometer long? [3marks]

(e) An astronaut standing on the surface of Ceres, the largest asteroid, drops a rock from a height of 10.0 m. It takes 8.06 s to hit the ground.

(i) Calculate the acceleration of gravity on Ceres. [2 marks]

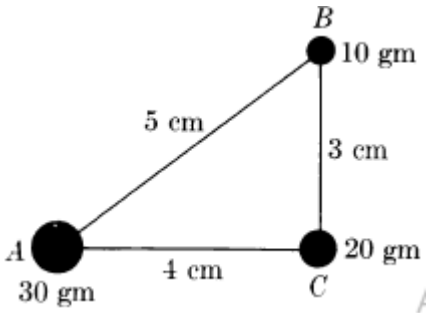
(ii) Find the mass of Ceres, given that the radius of Ceres is $R_C = 5.10 \times 10^2$ km. [2marks]

(iii) Calculate the gravitational acceleration 50.0 km from the surface of Ceres. [2marks]

QUESTION FIVE (20MARKS)

a) For angular rotation show that $\theta = \omega_o t + \frac{1}{2}\alpha t^2 + C$ [5 marks]

b) Three small bodies are connected as shown in *figure3.*



Determine the moment of inertia of the system:

(i) about an axis through point *A,* perpendicular to the plane of the diagram. [5 marks]

(ii) about an axis coinciding with the rod *BC?* [4 marks]

iii) If the body rotates about an axis through *A* and perpendicular to the plane of the diagram, with an angular velocity ω = 4 rad/sec, Calculate its rotational kinetic energy. [6 marks]
