



MACHAKOS UNIVERSITY

University Examinations 2023/2024 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR, FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION
TECHNOLOGY)

BACHELOR OF SCIENCE IN APPLIED PHYSICS AND TECHNOLOGY

BACHELOR OF EDUCATION (SPECIAL NEEDS)

BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR OF EDUCATION (SCIENCE)

SPH 100: MECHANICS I

DATE:

TIME:

INSTRUCTIONS:

- The paper consists of **TWO** sections.
- Section A is **COMPULSORY (30 MARKS)**.
- Answer any **TWO** questions from section B (each **20 MARKS**).

YOU MAY FIND THIS USEFUL:

You may need to use the following constants

- Density of water = $1.0 \times 10^3 \text{ kg/m}^3$
- Acceleration due to gravity $g = 9.8 \text{ m/s}^2$
- Universal gravitational constant $G = 6.67 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$
- Mean radius of the earth $R_e = 6400 \text{ km}$
- Mass of the Earth, $M_e = 5.98 \times 10^{24} \text{ kg}$
- Mass of the Sun, $M_s = 1.98 \times 10^{30} \text{ kg}$
- Permittivity of free-space, $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$

QUESTION ONE (30 MARKS)

- a) Differentiate between units and dimensions. [2 marks]
- b) Determine the dimensional formula of the following quantities.
- i. Momentum [1 mark]
 - ii. Energy [1 mark]
 - iii. Density [1 mark]
- c) When a small sphere moves at low speed through a fluid, the viscous force F opposing the motion is found experimentally to depend on the radius ' r ', the velocity v of the sphere and the viscosity η of the fluid according to the equation $F = 6\pi\eta vr$. Use dimension analysis to determine the dimensions of η . [3 marks]
- d) Define the term error [1 mark]
- e) Distinguish between the terms 'precision' and 'accuracy' as used in error analysis [2 marks]
- f) The dimensions of a plot of land are determined as $27.0 \pm 0.03 \text{ m}$ by $31.0 \pm 0.12 \text{ m}$. determine the uncertainty around the plot. [3 marks]
- g) A long jumper leaves ground at an angle of 20° to the horizontal and at a speed of 11.0 m/s . Calculate
- i. How far he jumps [3 marks]
 - ii. The maximum height reached [2 marks]
- h) A motorist is driving north on a straight two-lane road at a constant speed of 48 kmh^{-1} . A truck travelling at a constant speed of 64 kmh^{-1} is approaching him in the other lane. Calculate the truck's velocity relative to the motorist. [2 marks]
- i) State any three reasons why the value of gravitational acceleration differs at different locations on earth. [3 marks]
- j) Define the term 'escape speed' as used in gravitation. [1 mark]
- k) State any two Kepler's laws of planetary motion. [2 marks]
- l) Determine the gravitational field on the surface of the moon given that Mass and radius of the moon are: $M_m = 7.38 \times 10^{22} \text{ kg}$, $R_m = 1.595 \times 10^6 \text{ m}$ [3 marks]

QUESTION TWO (20 MARKS)

- a) Two identical balls released simultaneously from the top of a tower, one thrown horizontally and the other dropped vertically, reach the ground at the same time. Explain. [2 marks]
- b) A "moving sidewalk" in an airport terminal building moves at 1.0 m/s and is 80.0 m long. If a woman steps on at one end and walks at 2.0 m/s relative to the moving sidewalk, how much time does she require to reach the opposite end if she walks in the same direction the sidewalk is moving? [3 marks]
- c) A projectile is shot at an angle of 60° above the horizontal and strikes a building

30 m away at a point 15 m above the point of projection. Calculate,

- i. Initial velocity of the projectile [3 marks]
 - ii. Time taken to strike the building [4 marks]
- d) A body is dropped from a height of 90 m from the ground and at the same time another body is projected vertically upwards from the ground with a velocity of 30 ms^{-1} . Calculate
- i. How much time it will take for the two balls to pass each other [5 marks]
 - ii. The height above the ground where the two balls pass each other [3 marks]

QUESTION THREE (20 MARKS)

- a) Distinguish between static and dynamic friction force. Explain how their magnitude compare. [2 marks]
- b) Five copies of identical textbooks each weighing 4 N are placed on top of each other as shown in Figure 1.

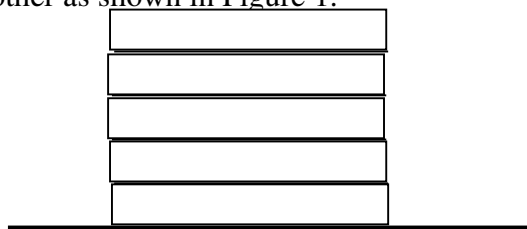


Figure 1

Given that the coefficient of friction between any two surfaces of the books in contact is 0.3, Calculate the minimum horizontal force necessary to remove:

- i. The second book from the bottom [3 marks]
 - ii. The fourth book from the bottom [3 marks]
- c) A woman in a car on a level ground sees an airplane travelling in the same direction but climbing at an angle of 30° above the horizontal. By driving at 110 kmh^{-1} she can stay directly below the airplane. Calculate the airplanes velocity. [2 marks]
- d) The Figure 2 below shows a 4 kg block M_2 attached to a 1.2 kg mass by a light inextensible string passing over a frictionless pulley. The coefficient of friction between the table and the block M_2 is 0.2025. When the block is released from rest, both masses move through a distance of 0.3m. Calculate the

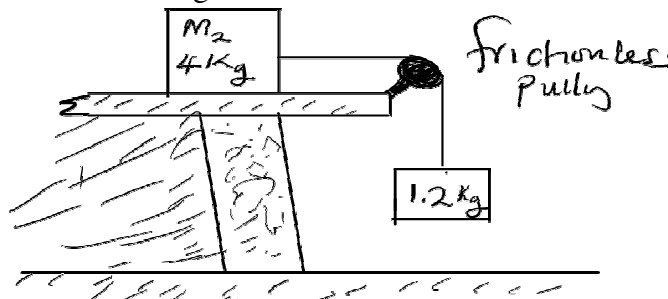


Figure 2

- i. Net acceleration of the system [5 marks]
- ii. Tension on the string [2 marks]
- iii. Velocity of the string when the distance covered in 0.3 m. [3 marks]

QUESTION FOUR (20 MARKS)

- a) Show that for a body moving in circular path of radius, r , the linear velocity v and angular velocity ω are related by the equation. [3 marks]
$$v = \omega r$$
- b) Compare the maximum speeds at which a car can safely negotiate an unbalanced turn whose radius is 50.0 m in dry weather (coefficient of static friction = 0.9) and icy weather (coefficient of static friction = 0.1). [5 marks]
- c) A shaft is uniformly accelerated from 10 rev/s to 18 rev/s in 4 seconds. The shaft continues to accelerate at this rate for the next 8 seconds. Thereafter, the shaft rotates with a uniform angular speed. Calculate the total time to complete 400 revolutions. [5 marks]
- d) A model car moves round a circular track of radius 0.3 m at 2 revolutions per second. Calculate
- i. The angular speed, ω [3 marks]
 - ii. The period, T [2 marks]
 - iii. The speed v , of the car. [2 marks]

QUESTION FIVE (20 MARKS)

- a) State Newton's law of gravitation. [2 marks]
- b) Sirius B and Neutron stars have an equal mass of $2 \times 10^{30} \text{ kg}$ and radii of 10^7 m and 10^4 m respectively. Which of the two has a higher escape speed? Justify your answer. [2 marks]
- c) A robotic lander with an earth weight of 3430 N is sent to Mars, which has radius $R_m = 3.40 \times 10^6 \text{ m}$ and mass $M_m = 6.42 \times 10^{23} \text{ kg}$. Calculate the
- i. Mass of the lander on the Martian surface of Mars [2 marks]
 - ii. The acceleration there due to gravity, g_m on Mars [3 marks]
 - iii. Escape velocity of Mars [3 marks]
- d) Comet Halley orbits the Sun with a period of 76 years and, in 1986, had a distance of closest approach to the Sun, (*perihelion distance*) R_p , of $8.9 \times 10^{10} \text{ m}$. Calculate.
- i. The comet's farthest distance from the Sun, (*aphelion distance*) R_a [5 marks]
 - ii. The eccentricity e of the orbit of comet Halley. [3 marks]