



# MACHAKOS UNIVERSITY

University Examinations 2022/2023

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF BACHELOR OF SCIENCE (MATHEMATICS)

SPH 100: MECHANICS I

DATE: 20/4/2023

TIME: 11:00 – 1:00 PM

## INSTRUCTIONS:

- (a) The paper consists of FIVE questions. Attempt Question ONE and any other TWO  
(b) All working must be clearly shown

## SECTION A

### QUESTION ONE (COMPULSORY) (30 MARKS)

- a) A student in an experiment takes the light intensity readings of LEDs (light emitting diodes) as follows

| LED           | A     | B     | C     | D     | E     | F     | G     | H     | I     |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Intensity (I) | 11.13 | 12.46 | 12.68 | 12.79 | 12.88 | 12.57 | 12.55 | 12.44 | 12.25 |

Calculate

- i) Average deviation
- ii) Standard deviation
- iii) Variance

(6 marks)

- b) A Ferry transporting passengers and cars to the main land at a speed of 10 m/s, accidentally its back is tilted downwards making car A with its occupants a woman and a child, slide into water with a velocity of 3 m/s as shown by the arrow. The water has a flow rate of 5 m/s eastwards. Study the figure and answer the questions that follow

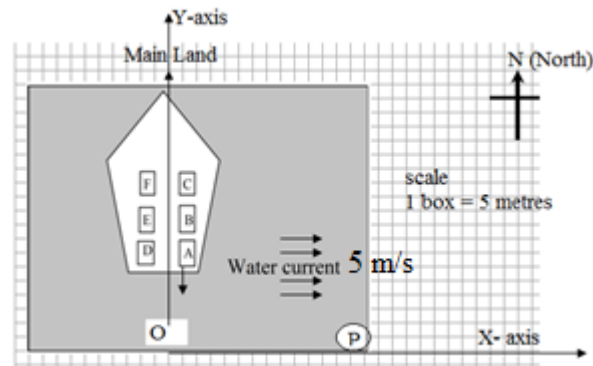


Figure 1

Calculate

- velocity of the car as it slides into the water relative to an observer in the Ferry (3 marks)
  - velocity of the car relative to the observer labeled O standing on the shore, i.e velocity relative to shore, in absence of water currents (3 marks)
- c) A standard gauge rail line engine pulls four cabins (Figure 2) of mass  $m_1 = 4.0 \times 10^4 \text{ kg}$ ,  $m_2 = 3.0 \times 10^4 \text{ kg}$ ,  $m_3 = 3.5 \times 10^4 \text{ kg}$  and  $m_4 = 2.8 \times 10^4 \text{ kg}$ . The system accelerates at  $20 \text{ m/s}^2$ . Calculate
- Pulling force applied by the engine (4 marks)
  - Tension on the hinge between the cabins (4 marks)

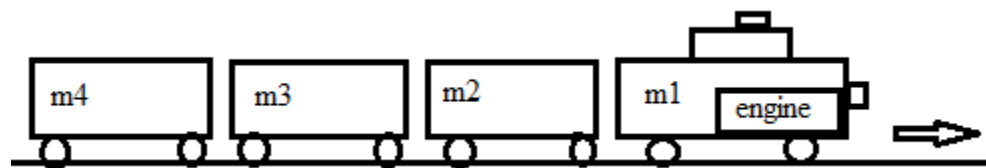


Figure 2

- d) Derive the dimensions of
- Force (3 marks)
  - Pressure (3 marks)
- e) Show that centripetal force of a particle executing a circle of radius  $r$  with angular speed  $(\omega)$  is given by  $a = r\omega^2$  (4 marks)

## SECTION B

### QUESTION TWO (20 MARKS)

- a) A shopper is in a hurry to catch a bargain in a department store. She walks up the escalator, rather than letting it to carry her, at a speed of 2.5 m/s relative to the escalator. If the escalator is 30 m long and it takes her 12.5 sec for the shopper to get to the next floor, calculate the speed of the escalator. (5 marks)
- b) Show that  $\mu = \tan \theta$  for a body resting on an inclined plane making an angle  $\theta$  with horizontal. Illustrate with a well labeled diagram. (5 marks)
- c) In an experiment to determine acceleration due to gravity, length of the pendulum is measured as 40.2 cm and periodic time T as 2.2 sec. Find
- i) gravitational acceleration (3 marks)
  - ii) error in gravitational acceleration (3 marks)
- d) An automobile drives around a traffic circle with a maximum permissible speed of 30 m/s. If the wheels of the automobile can withstand a maximum transverse acceleration of  $8 \text{ m/s}^2$  without skidding, Calculate radius of the circle? (4 marks)

### QUESTION THREE (20 MARKS)

- a) A war spy measures the length of a distant war tanker as an angular measure of  $1.8^\circ$  with a divided circle. He knows that the length of the tanker is 100 m. Approximate how far the warship is. (6 marks)
- b) A skier slides down a steep slope of angle  $\theta$  with horizontal, on an ideal frictionless snow. If her mass is “m” and g is the gravitational acceleration,
- i) show that his acceleration will be given by  $a = g \sin \theta$  (6 marks)
  - ii) Suppose the magnitude of his acceleration is  $8 \text{ m/s}^2$  find  $\theta$  (3 marks)
- c) Using dimensional analysis, derive the equation for a simple pendulum (5 marks)

#### QUESTION FOUR (20 MARKS)

- a) A block of mass 0.5 kg travels with a speed of 2 m/s in +x-direction on a flat frictionless surface. On passing through origin the block experiences a constant force of 4 N at an angle  $60^\circ$  relative to y –axis for 1.5s. Find
- i. Magnitude of the forces in component form (3 marks)
  - ii. Components of acceleration (3 marks)
  - iii. Velocity in components form. (3 marks)
  - iv. Velocity of the block (3 marks)
- b) A  $10.0 \times 10^3$  kg Malaysian air ship cruising at 100 m/s horizontally in the troposphere is struck by a terrorist missile from above at an angle of  $30^\circ$  with horizontal. The missile gets embedded on the airship and the system falls in the Mediterranean Sea. If the mass of the missile is 200 kg and its velocity is 800 m/s, calculate the final common velocity of the system. (8 marks)

#### QUESTION FIVE (20 MARKS)

- a) A  $3.0 \times 10^4$  kg steel file cabinet is in the back of a truck. The truck's bed, also made of steel, is slowly tilted.
- i. What is the magnitude of the static friction force on the cabinet when the bed is tilted  $30^\circ$ ? (5 marks)
  - ii. At what angle will the file cabinet begin to slide? (3 marks)
- b) Show that the relationship between angular velocity and linear velocity is  $v = r\omega$  (6 marks)
- c) A missile is shot 200 m from the ground in front of an observer with an initial velocity of 400 m/s and passes 40 meters above her.
- i) Represent the information in a 2- dimensional plane (2 marks)
  - ii) Find where it falls 36 sec later (4 marks)