



# MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 225: ENGINEERING MECHANICS II

DATE: 12/4/2023

TIME: 11:00 – 1:00 PM

## INSTRUCTIONS:

1. This examination contains **FIVE** questions. Question ONE(1) is compulsory and carries 30 marks. All the other questions carry 20 marks each.
2. Answer question **ONE** and any other **TWO** questions

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

- a) Define clearly the following terms as used in Engineering mechanics:
  - i) Momentum
  - ii) Impulse
  - iii) Elastic collision
  - iv) Oblique impact (4 marks)
- b) A locomotive provides an impulse of  $40\text{ kN s}$  to set in motion a stationary 8 tonne wagon which then moves off freely at a velocity ' $u$ ' against a track resistance of  $60\text{ N/tonne}$  and finally attains a velocity ' $v$ ' after 20 seconds. Find the values of  $u$  and  $v$  (5 marks)
- c)
  - i) State Newton's law of collision of elastic bodies (2 marks)
  - ii) A ball of mass 1 kg moving with a velocity of  $2\text{ m/s}$  impinges directly on a ball of mass 2 kg at rest. The first ball, after impinging, comes to rest. Find the velocity of the second ball after the impact and the coefficient of restitution. (6 marks)
- d) A body falling freely, under the action of gravity passes two points 10m apart vertically in 0.2 second. How far above the higher point did it start to fall ? (4 marks)

- e) i) Distinguish between work and energy. (2 marks)
- ii) A wagon of mass 50 tonnes starts from rest at the top of a slope inclined at 1 in 100 and travels 30 m down the slope before being stopped by a bumper spring. If in its motion, the wagon experiences a rolling resistance of 50 N/tonne and the bumper spring has a compression of 1mm per 20 kN force. Determine:
- i) the velocity with which the wagon strikes the bumper spring. (4 marks)
- iii) the amount by which the spring will be compressed (3 marks)

### QUESTION TWO (20 MARKS)

- a) In a car racing competition, car **A** starts from rest and accelerates at  $0.5 \text{ ms}^{-2}$ . 10 seconds later, car **B** starting at the same point from rest, accelerates at  $0.8 \text{ ms}^{-2}$  and follows the same path as car **A**. Determine:
- i) the time taken for car **B** to overtake **A** (3 marks)
- ii) the distance travelled when car **B** overtakes **A** (3 marks)
- b) An engine shaft is uniformly accelerated from rest to 20 rpm in 15 sec. The shaft continues to accelerate at this rate for the next 30 sec. Thereafter, the shaft rotates with uniform speed. Find the total time taken to complete 1000 revolutions. (6 marks)
- c) The acceleration of a particle varies with time **t** and is given by  $a = 2 - 3t$ . It is observed that the velocity of the particle is 20 m/s when time is 5 sec and also that the particle is 85m from the origin when time is 10 sec. Determine:
- i) the acceleration, velocity and distance when  $t = 0$  (5 marks)
- ii) the time when velocity is zero (3 marks)

### QUESTION THREE (20 MARKS)

- a) Distinguish between the following terms as used in circular motion
- i) Centripetal and centrifugal force
- ii) Banking and super-elevation (6 marks)
- iii) Show that the centripetal acceleration for a body moving along a circular path is given by
- $$a = \frac{v^2}{r}$$
- where the symbols have the usual meaning (6 marks)

- b) A body of mass 0.5 kg is tied to a string and whirled in a vertical circle making 120 rpm. If the radius of the circle is 0.84 m, determine the tensions in the string when the body is at :
- the top of the circle
  - the bottom of the circle. (5 marks)
- c) i) It is commonly observed that a cyclist has to lean inwards while negotiating a curved section of a road. Explain. (2 marks)
- ii) What is the significance of critical speeds in the design of banked roads?(2 marks)

#### QUESTION FOUR (20 MARKS)

- a) i) State D'Alemberts principle (2 marks)
- ii) Two blocks of mass 80 kg and 400 kg respectively are connected by a cable and move along a rough horizontal plane under the action of a force of 400 N applied to the first body as shown in figure Q4a. If  $\mu=0.3$  between the contacting surfaces, determine the acceleration of the two blocks and the tension in the connecting cable (8 marks)



Fig Q4a

- b) A body of mass 200kg is stationary on a  $15^\circ$  inclined plane. What distance along the incline must the body slide before it attains a speed of 12m/s Take  $\mu = 0.1$  (6 marks)
- c) An elevator of mass 500kg is descending with an acceleration of  $3\text{m/s}^2$ . During the descent a passenger whose mass is 80kg stands on a weighing scale placed on the cage floor. Determine:
- the scale reading
  - the tension in the cable carrying the elevator (4 marks)

**QUESTION FIVE (20 MARKS)**

- a) i) Distinguish between linear and projectile motion (2 marks)
- ii) Show that path traced by a projectile is parabolic (5 marks)
- b) An aircraft, moving horizontally at 108 km/hr at an altitude of 1000 m towards a target on the ground, releases a bomb which hits it. Determine:
- i) the horizontal distance of the aircraft from the target, when it released the bomb (4 marks)
- ii) the direction and velocity with which the bomb hits the target.. (3 marks)
- c) A projectile is aimed at a mark on the horizontal plane through the point of projection. It falls 12 metres short when the angle of projection is  $15^\circ$ ; while it overshoots the mark by 24 metres when the angle is  $45^\circ$ . Determine:
- i) The horizontal distance from the point of projection to the target mark (4 marks)
- ii) the angle of projection required to hit the mark. (2 marks)