



# UNIVERSITY OF NAIROBI

UNIVERSITY EXAMINATIONS 2015/2016

FIRST YEAR EXAMINATIONS FOR THE DEGREES OF BACHELOR OF SCIENCE  
IN ENGINEERING

FEE 112 : ELECTRICAL & ELECTRONIC ENGINEERING  
FME 174 : MECHANICAL ENGINEERING

APPLIED MATHS IB

DATE: MAY 31, 2016

TIME: 9.00 A.M. – 11.00 A.M.

## INSTRUCTIONS

Answer Question ONE and any other TWO Questions.  
(Gravity =  $9.8 \text{ ms}^{-1}$ , water density =  $1000 \text{ kg/m}^3$ )

### Question One - (30 Marks)

- a) A ball of mass 3 kg is struck by a bat in the opposite direction to the motion of the ball. Before the impulse, the ball is travelling at 32 m/s and the impulse of the bat on the ball is 100 Ns. Find the velocity of the ball immediately after the impact. (3 marks)
- b) A railway truck of mass 2500 kg is travelling in a straight line at  $5 \text{ ms}^{-1}$ . A second truck of mass 2000 kg is travelling in the opposite direction at  $8 \text{ ms}^{-1}$ . They collide, (without breaking up), and couple together. With what speed and in what direction are they moving? (4 marks)
- c) A ball is dropped from a height of 10 m onto a horizontal plane. If the coefficient of restitution between the ball and the plane is 0.5, find the total time it takes for the ball finally to rest. (4 marks)
- d) A particle of mass 300 g is attached to the end of a light string of length 1 m. The string hangs vertically with its upper end A fixed. The particle is given a horizontal velocity of  $1.5 \text{ ms}^{-1}$ . Find the height to which it rises and the angle between the string and the vertical when it reaches this height. (6 marks)
- e) A 900 kg vehicle fitted with a 6 kw engine is travelling up a slope where for every 12 m travelled, the vertical inclination is 2 m, at a maximum speed. Given that the frictional resistance is 120 N, find this speed. (3 marks)
- f) At a certain moment, a particle describing SHM is at a point y and moving away from its central position with a speed of  $4 \text{ ms}^{-1}$ . After 5 seconds, it returns to y for the first time, and 6 seconds after this, it comes to an instantaneous rest. Find the period and the amplitude of the motion. (4 marks)

$X = A \cos t$   
 $V = -A \omega \sin t$   
 $V =$

- g) A light rod has particles of unit mass fixed at distances of 4, 8, 9, 13 and 16 cm from one end of the rod. Find the radius of gyration about an axis through the centre of gravity perpendicular to the rod. (3 marks)

- f) Every week, Sports Pesa betting company offers 13 different football matches and to win the jackpot, a punter must, (in a single bet), predict the right outcome of each of the 13 matches. Fortunately, in every list of 13 matches, one is allowed to bet as many times as possible. By recalling that, in every football match, there are 3 expected outcomes, find the probability of:

- Winning the jackpot after betting once.
- Winning the jackpot after betting 10 times
- Predicting the right outcome of exactly 10 matches, (from the list of 13 matches), after betting 10 times.

(3 marks)

### Question Two - 20 Marks

- a) A shell of mass 180 kg is fired from a piece of mass 4200 kg with a velocity of  $1500 \text{ ms}^{-1}$ . Find the impulse of the explosion and the velocity of recoil at the instant when the shell leaves the muzzle. If the recoil is taken up by a constant force in a distance of 2 m, find this force. (5 marks)
- b) A pile driver of mass 10 tonnes falls from a height of 3 m onto a pile of mass 6 tonnes. If the average frictional resistance of the ground is  $2 \times 10^6 \text{ N}$ , find the distance the pile penetrates. (6 marks)
- c) Water flows at  $1.5 \text{ ms}^{-1}$  round a bend of  $35^\circ$  in a pipe of diameter 60 cm. Assuming the water fills the pipe, find the average force exerted by the water on the pipe due to the bend. (Density of water =  $1000 \text{ kg/m}^3$ ). (4 marks)
- d) By using an assumed mean, ( $a = 45.5$ ) and a constant, ( $c = 10$ ), evaluate the Sheppard's standard deviation of the following grouped data:

Class	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
Frequency	1	2	5	11	8	2	1

(5 marks)

### Question Three - 20 Marks

- a) Two balls A and B with masses in the ratio 3 to 2 lie on a smooth, horizontal surface. A is set in motion and collides directly with B, which goes on to impinge directly on a vertical wall. B rebounds and strikes A, thus bringing A to rest. If the coefficient of restitution of the two balls is  $3/4$ , find that of B and the wall. (6 marks)
- b) A bullet of mass 20 g is fired with a horizontal velocity of  $500 \text{ ms}^{-1}$  into a block of wood of mass 580 g, which hangs on the end of a string. Find the loss of energy during the impact and the maximum height to which the block rises. (8 marks)

$$\frac{1}{2} \times M \frac{m^2 v^2}{M^2 v^2}$$

$$2$$

$$Mv = mv$$

$$v = \frac{mv}{M}$$

$$\frac{1}{2} \times M \cdot$$

$$Mv = mv$$

$$v = \frac{mv}{M}$$

- c) If the probability that an individual suffers a bad reaction from injection of a certain serum is 0.002, determine the probability that out of 2000 individuals:

- Exactly 3 suffer a bad reaction
- More than 2 individuals will suffer a bad reaction

(6 marks)

✓ Question Four - (20 Marks)

α .

- A car working with a constant power  $P$  against a constant resistance has a maximum speed of  $v$  when travelling up a slope of 1 in 12, and a maximum speed of  $3v$  on the level. Obtain expressions in terms of  $P$ ,  $v$  and  $g$  for the resistance and the mass of the car and show that the acceleration when the car is travelling down the slope at a speed of  $v$  is  $g/6 \text{ ms}^{-2}$ . (6 marks)
- A car of mass 750 kg is climbing a hill of slope 1 in 50. The engine is working at 20 kw and the resistance to motion, (assumed constant), is 400 m. Compute;
  - The acceleration when the speed is  $30 \text{ ms}^{-1}$ .
  - The maximum speed.
 (8 marks)
- The masses of boxes of orange are normally distributed such that 30% of them are greater than 4 kg and 20% are greater than 4.53 kg. Estimate the mean and the standard deviation of the masses. (6 marks)

Question Five - 20 Marks

- a) Starting with the equation

$$\frac{d^2x}{dt^2} = -\omega^2 x,$$

derive the six standard equations of simple harmonic motion.

(5 marks)

- A particle moving with SHM performs 20 complete oscillations of amplitude 5 m every 90 seconds. Evaluate:
  - The maximum speed
  - The maximum acceleration
  - The average speed
  - The speed when the particle is 3 m from the central position.
  - The particle's position 0.5 seconds after leaving the central position
 (5 marks)

Handwritten calculations:

$$\frac{P}{3v} \cdot \frac{P}{3v} = \frac{P}{3v} \cdot \frac{P}{3v} = \frac{P^2}{9v^2}$$

$$\frac{2}{3} P \times \frac{P}{9v} = \frac{P^2}{13.5v}$$

$$\frac{P}{3v} \cdot \frac{P}{3v} = \frac{P^2}{9v^2}$$

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