MACHAKOS UNIVERSITY

University Examinations 2022/2023

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

BACHELOR OF SCIENCE (CIVIL ENGINEERING)

ECU 101/112: PHYSICS FOR ENGINEERS I

DATE: **TIME:**

INSTRUCTIONS TO CANDIDATES

Answer QUESTION ONE which is ***COMPULSORY*** and **ANY OTHER TWO** questions. Question 1 carries **30** marks and the others carry **20** marks each.

YOU MAY USE:

You may need to use the following constants

- Density of water= 1.0 x 10^3kg/m^3
- Acceleration due to gravity g=9.8 m/s^2
- Universal gravitational constant G=6.67 x10^{-11}N$m^2$$kg^{-2}$
- Mean radius of the earth Re=6378 km
- Mass of the Earth, Me, = 5.98 x 10^{24} kg
- Mass of the Sun, Ms, = 1.98 x 10^{30} kg
- Permittivity of free-space, $\varepsilon_o = 8.85 \times 10^{-12}$ F/m

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Find the angle between $\boldsymbol{a}$ and $\boldsymbol{b}$ in the case $\boldsymbol{a} = 2i - 3j + k$ and $\boldsymbol{b} = i - 4j + 3k$ (3 marks)

b) A projectile is launched at an initial velocity u_o and at angle θ relative to the horizontal surface. Show that;

i) The range, $R = \frac{{u_o}^2 \sin 2\theta}{g}$ (3 marks)

ii) The range, R is maximum when $\theta = 45^{\circ}$ (2 marks)

c) An electron in a cathode ray tube (CRT) accelerates from 2 x 10^4 m/s to 6 x 10^6 m/s over length 1.5 cm.

i) How long does the electron take to travel this 1.50 cm? (1 mark)

ii) Calculate its acceleration? (2 marks)

d) State Kepler's Laws of planetary motion. (3 marks)

e) Derive the three equations of linear motion. (5 marks)

f) What is simple harmonic motion? Prove that the total energy of a body executing simple harmonic motion remains constant. (3 marks)

g) State Stoke's law (2 marks)

h) The mass of a bicycle and its rider is 100kg and he wants to take a turn of radius 80m with speed of 20m/s. If the coefficient of friction between the tyres and the road is $\mu = 0.6$ then calculate the angle with which he must lean to negotiate the turn safely. Will the rider skid? (3 marks)

i) A stone of mass 0.4 kg is tied to a string of length 0.5m and whirled in a circle. If the stone revolves uniformly and makes one complete revolution per second, calculate;

i) its acceleration (2 marks)

ii) force exerted on the stone by the string. (2 marks)

QUESTION TWO (20 MARKS)

a) State Zeroth law of thermodynamics (1 mark)

b) What physical designs dictate the difference in speeds between a fighter-jet and a helicopter? (2 marks)

c) Describe how a driver can steer a car traveling at constant speed so that (i) the acceleration is zero or (ii) the magnitude of the acceleration remains constant. (3 marks)

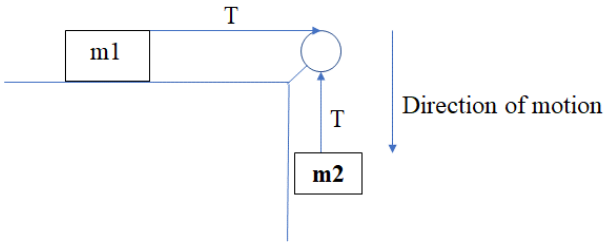
d) In cartesian co-ordinate system, show that

(i) $\mathbf{i}\cdot\mathbf{i} = \mathbf{j}\cdot\mathbf{j} = \mathbf{k}\cdot\mathbf{k} = 1$ (3 marks)

(ii) $\mathbf{i}\times\mathbf{i} = \mathbf{j}\times\mathbf{j} = \mathbf{k}\times\mathbf{k} = 0$ (3 marks)

e) Describe two similarities of gravitational and the electrostatic forces. (3 marks)

f) Two blocks of mass m_1 and m_2 are connected by a massless string that passes over a frictionless pulley. The inclines are frictionless. Find (i) the acceleration of each block and (ii) the tension in the string. (5 marks)



QUESTION THREE (20 MARKS)

a) A person weighs a fish of mass m on a spring scale attached to the ceiling of an elevator. Show that if the elevator accelerates either upward or downward, the spring scale gives a reading that is different from the weight of the fish. Suppose the elevator cable breaks, so that the elevator and its contents are in free-fall. What happens to the reading on the scale? (4 marks)

b) Derive the equation for escape velocity and use it to estimate the escape velocity for a body on the earth's surface. (7 marks)

c) A trailer of mass 6000 kg rams into an oncoming car of mass 1600 Kg. The velocity of the trailer before impact is 80 km/hr and the initial velocity of the car is 140 km/hr. Find the final velocity of the system of the junk. Is KE conserved in this system? (5 marks)

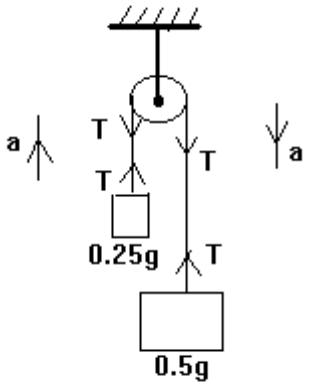
d) The equation of motion of a transverse wave in a string is given by, $y = 3.0Sin(4.0\pi t + 0.02\pi x)$ where y is in cm and t in sec. Calculate the amplitude, frequency, Period, velocity of the wave. (4 marks)

QUESTION FOUR (20 MARKS)

a) Define surface tension and state three factors that affect it. (5 marks)

b) State and write the mathematical expression for Newton's law of universal gravitation. (3 marks)

c) Two masses of 0.5 and 0.25 Kg are connected by a light inextensible string, which passes over a smooth pulley. If the system is released from rest with the string taut, find the acceleration of each mass and the distance travelled in 1 s. from rest. (5 marks)



d) Show that for an orbiting satellite around the earths,

$T^2 \propto r^3$ (4 marks)

e) An aluminium stick of length 1.5 m is cooled from 20^0 C to -180^0 C. Find the final length if its coefficient of linear expansion is 23×10^{-6}/K (3 marks)

QUESTION FIVE (20 MARKS)

a) State the law continuity of fluid flow (2 marks)

b) A 0.12 kg mass attached to a spring oscillates with amplitude A = 0.05 m and a maximum speed of 0.17 m/s. Calculate;

i) The spring constant (2 marks)

ii) The maximum acceleration (2 marks)

c) A drop of water of radius 0.002m is falling in air. If the coefficient of viscosity of air is 1.8 x 10^{-5} Kg/m.sec, calculate the terminal velocity of the drop. (Consider the density of water is 1000Kgm^{-3}, neglecting the density of air) (3 marks)

d) A rod 4.2 m long and 0.50 cm^2 in cross-sectional area is stretched 0.20 cm under a tension of 12.0 N. Calculate;

i) Stress (2 marks)

ii) Strain (2 marks)

iii) Young's modulus (2 marks)

e) In a water supply system, a horizontal pipe of radius 10 mm is joined to a horizontal pipe with radius 15 mm with both pipes at the same height. A fluid flows through both pipes from the narrow pipe to the wider pipe with an average velocity of 3 mm/s in the narrow pipe. Assume that the fluid has zero viscosity and the density of the fluid is equal to the density of water. Determine

i) the volume flow rate? (1 mark)

ii) the average speed for the wider pipe? (2 marks)

iii) the pressure difference between the two pipes? (2 marks)