MACHAKOS UNIVERSITY

University Examinations 2017/2018

SCHOOL OF PURE AND APPLIED SCIENCES
DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

ECU 101: PHYSICS FOR ENGINEERS I

DATE: 15/12/2017 **TIME: 8.30-10.30 AM**

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 10^3 kg/m^3
- Acceleration due to gravity g = 9.8 m/s^2
- Universal gravitational constant G = 6.67 x 10^{-11} Nm^2kg^{-2}
- Mean radius of the earth Re= 6378 km
- Mass of the Earth, Me, = 5.98 x 10^{21} kg
- Permittivity of free-space, $\varepsilon_o = 8.85 \times 10^{-12}$ F/m

QUESTION ONE (COMPULSORY)

a) Distinguish between vector and scalar quantities giving an example of each

If A = 2i + 3j + 4k and B = 5i+6j+7k then what is $\vec{A} \times \vec{B}$ and $\vec{A}.\vec{B}$ (3 marks)

b) An electron in a cathode ray tube (CRT) accelerates from 2.00 x 10^4 m/s to 6.00 x 10^6 m/s over length 1.50 cm.

i) How long does the electron take to travel this 1.50 cm? (2 marks)

ii) What is its acceleration? (3 marks)

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

d) Derive the three equations of motion for a space rocket projected from a NASA station. (4 marks)

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

f) State Bernoulli's theorem and the law of continuity (2 marks)

g) Distinguish between longitudinal and transverse waves. (2 marks)

h) 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)

i) State Zeroth law of thermodynamics (1 mark)

j) 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)

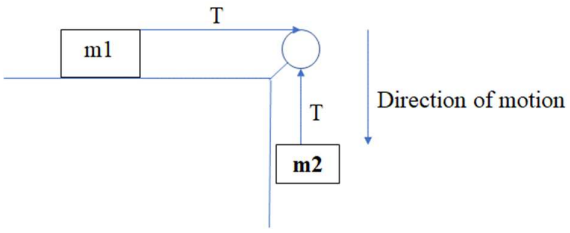
a) What physical designs dictate the difference in speeds between a fighter-jet and a helicopter? (2 marks)

b) 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)

c) A simple pendulum moves in a horizontal circle of radius r and a constant velocity of v. If the string is of length L makes an angle of θ with the vertical, show that the period of oscillation is given by;

$$T = 2\pi\sqrt{\frac{LCos\theta}{g}}$$ (5 marks)

d) 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)



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

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

ii) The range, R is maximum when $\theta = 45^{\circ}$ (3 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) Define escape velocity and show that;

$$\boldsymbol{v} = \sqrt{\frac{2Gm_e}{r_e}}$$

Determine 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,

$y = 6.0Sin(4.0\pi t + 0.02\pi x)$ where y is in cm and t in sec. Find the amplitude, frequency, Period, velocity of the wave. (4 marks)

QUESTION FOUR (20 MARKS)

a) Define surface tension and state 3 factors that affect it. (5 marks)

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

c) Show that the acceleration due to gravity g at height h above the earth's surface is given by

$$g_h = \frac{g}{\left(1+\frac{h}{R_e}\right)^2}$$ (5 marks)

where go is the acceleration due to gravity on the earth and Re is the radius of the earth.

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

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

e) 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 μ = 0.6 then calculate the angle with which he must lean to negotiate the turn safely. Will the rider skid? (3 marks)

QUESTION FIVE (20 MARKS)

a) State Hooke's law (2 marks)

b) A 0.12 kg mass attached to a spring oscillates with amplitude A = 0.075 m and a maximum speed of 0.524 m/s. Find;

i) The spring constant

ii) The period

iii) The maximum acceleration (6 marks)

c) 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 and strain

ii) Young's modulus (4 marks)

d) A drop of water of radius 0.0015 m is falling in air. If the coefficient of viscosity of air is 1.8×10^{-5} Kg/msec, what will be the terminal velocity of the drop? (Density of water is $1000 Kgm^{-3}$, neglect density of air). (3 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.

i) What is the volume flow rate? (1 mark)

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

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