MACHAKOS UNIVERSITY

University Examinations 2019/2020Academic year

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 ENGENEERING

ECU 101: PHYSICS FOR ENGINEERS I

DATE: 11/12/2019 **TIME: 11.00-1.00 PM**

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 R_e=6400 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)

a) If vectors **A**=2**i**-**j**-3**k** and **B**=3**i**-6**j**-**k**. Find $\boldsymbol{A} \times \boldsymbol{B}$ and angle between **A** and **B** (4 marks)

b) Define the center of mass of a body (2 marks)

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

d) State Kepler's Laws of planetary motion. (3 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 2 factors that affect surface tension. (2 marks)

g) Describe two similarities of gravitational and Coulombic forces. (4 marks)

h) A curve of radius 30m is to be banked so that a car may make a turn at a speed of 13m/s without depending on friction. What must be the slope of the curve? (3 marks)

i) State Zeroth law of thermodynamics (1 mark)

j) A stretched string has linear density of 525g/m and is under a tension of 45 N. A sinusoidal wave with frequency 120 Hz and amplitude 8.5 mm is sent along the string from one end. Calculate the power of the wave. (3 marks)

k) 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. (1 mark)

QUESTION TWO (20 MARKS)

a) What is the rate of heat transfer in a circular slab of a material of radius 7cm and thickness 3mm if the temperature of the inner and outer sides is 58^0C and 36^0C respectively (coefficient of thermal conductivity of the material is 4.0×10^{-4}J/mKs) (4 marks)

b) A car runs at a constant speed of 15m/s for 300 seconds and then accelerates uniformly to a speed of 25m/s over a period of 20 seconds. This speed is maintained for 300 seconds and then accelerates uniformly for 30 sec. Draw a velocity time graph to represent the journey described above. From the graph

   i. find the acceleration while the body changes from 15m/s to 25m/s.

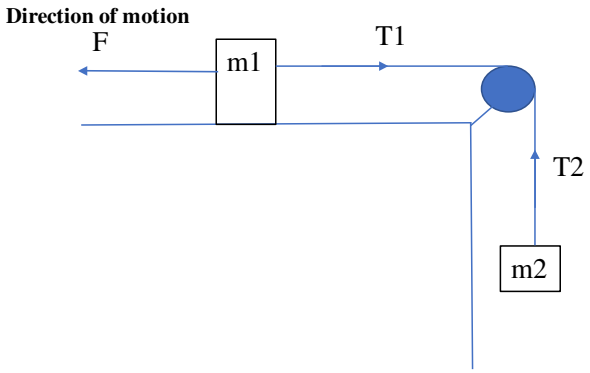
   ii. the total distance travelled in the time described.

   iii. The average speed over the time described. (6 marks)

c) 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

   ii. the tension in the string. (5 marks)



d) 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)

QUESTION THREE (20 MARKS)

a) Derive the equation for escape velocity and determine the escape velocity for a body on the earth's surface. (7 marks)

b) A trailer of mass 6000 kg rams into a stationery car of mass 1600 Kg. The velocity of the trailer before impact is 80 km/hr. Find the final velocity of the system of the junk. Is KE conserved in this system? (4 marks)

c) 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)

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

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

where go is the acceleration due to gravity on the earth and Re is the radius of the earth (5 marks)

QUESTION FOUR (20 MARKS)

a) A small steel sphere of radius, r and density, ρ is dropped on a viscous fluid of density, σ and coefficient of viscosity, η. After some time, it attains terminal velocity, v. Show that this terminal velocity of the steel sphere falling under gravity through the fluid is given by,

$$v = \frac{2r^2 g(\rho - \sigma)}{9\eta}$$ (6 marks)

b) Prove the consistency of Kepler's third law with the Universal law of gravitation. (4 marks)

c) An aluminium rod 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)

d) Show that for an ideal fluid flowing in a horizontal pipe of equal height, the total energy per unit volume $\boldsymbol{P + \frac{1}{2}\rho v^2 = Constant}$ (Where all the terms have their usual meanings)(7 marks)

QUESTION FIVE (20 MARKS)

a) 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. Find;

i. The spring constant 2 marks)

ii. The period 2 marks)

iii. The maximum acceleration 2 marks)

b) A rod 1.2 m long and 0.050 cm^2 in cross-sectional area is stretched 0.6cm under a tension of 2.0 N. Calculate;

i. Stress and strain (3 marks)

ii. Young's modulus (2 marks)

c) A drop of water of radius 0.0008 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)

d) 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? (2 marks)

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

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