SPH 2173 Physics FOR Engineers ONE END-OF- Semester EXAM

Mechatronics engineering (Jomo Kenyatta University of Agriculture and Technology)

W1-2-60-1-6

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
UNIVERSITY EXAMINATIONS 2023/2024

FIRST YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING, BACHELOR OF SCIENCE IN AEROSPACE ENGINEERING, BACHELOR OF SCIENCE IN MECHATRONIC ENGINEERING, BACHELOR OF SCIENCE IN MARINE ENGINEERING AND BACHELOR OF SCIENCE IN AGRICULTURAL ENGINEERING.

SPH 2173: PHYSICS FOR ENGINEERS 1

DATE: DECEMBER 2023 **TIME: 2 HOURS**

INSTRUCTIONS: Answer question one (compulsory) and any other two questions

Take acceleration due to gravity $g = 9.81\ ms^{-2}$
Thermal conductivity of brick = $0.13 Wm^{-1} K^{-1}$

QUESTION ONE (30 MARKS)

a) i) Define "physical quantities" (1 mark)
ii) Distinguish between fundamental and derived quantities and give one example of each. (2 marks)

b) i) State two important reasons of expressing physical quantities in dimensions (2 marks)
ii) Determine the correctness of the equation $F = \frac{mv}{r}$ where symbols have their usual meaning, by use of dimensional analysis. (2 marks)

c) A 5.0 kg mass undergoes an acceleration given by $\vec{a} = (2.0\hat{i} + 5.0\hat{j})\ m/s^2$. Find the resultant force $\sum F$ and its magnitude. (3 marks)

d) Define the terms impulse and linear momentum (2 marks)

e) A 10 g metal bob attached to an inelastic string is whirled in a circular path of radius 15 cm at an angular velocity of 5 rad/sec. Calculate the centripetal force experienced by the bob. (3 marks)

f) Define the following terms.
i) Tensile Stress (1mark)

ii) Tensile Strain (1mark)

iii) Young's Modulus (1mark)

iv) Torsion (1mark)

g) Suspension cables are used to carry gondolas at ski resorts. (See Figure 1 below). Consider a suspension cable that includes an unsupported span of 3 km. Calculate the amount of stretch in the steel cable. Assume that the cable has a diameter of 5.6 cm and the maximum tension it can withstand is 3.0×10^6 N. (4marks)

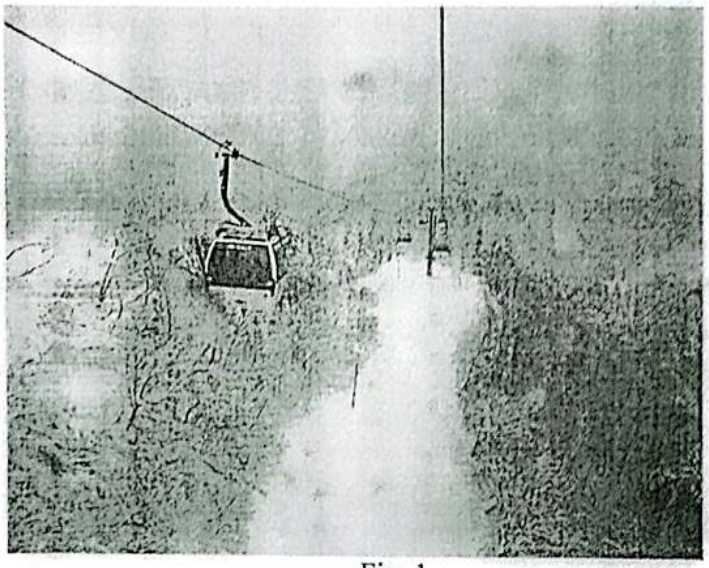

Fig. 1

h) Calculate the quantity of heat conducted through 2 m^2 of a brick wall 12 cm thick in 1 hour if the temperature on one side is 8 ^{0}C and on the other side is 28 ^{0}C. (4marks)

i) A 200 g piece of iron at 120 ^{0}C and a 150 g piece of copper at -50 ^{0}C are dropped into an insulated beaker containing 300 g of ethyl alcohol at 20 ^{0}C. What is the final temperature? (3marks)

QUESTION TWO (20 MARKS)

a) i) State the three factors that affect Centripetal force ($1\frac{1}{2}$ marks)

ii) Derive the expression for the Centripetal force of a body in a circular path ($1\frac{1}{2}$ marks)

b) A particle moves in the $x - y$ plane so that its x and y coordinates vary with time according to $x(t) = t^3 - 32t$ and $y(t) = 5t^2 + 12$, where distance is measured in meters and time in seconds. Find the position, velocity and acceleration of the particle expressed in Cartesian unit vectors when $t = 5\ s$ (7 marks)

c) The pressure recorded by a constant volume gas thermometer at a *Kelvin* Temperature *T* is 4.0×10^4 *N/m.* Calculate *T* if the pressure at triple point 273.16K is 4.2×10^4 *N/m.* (3marks)

d) Convert the following values into Kelvin scale.

i) 80 ^{0}C (1mark)

ii) -40 ^{0}C (1mark)

e) 5 kg of ice is heated from $-20\ ^0C$ *until* it vaporizes at $100\ ^0C$. How much heat is absorbed by the 5 kg ice? Take specific heat capacities of ice and water as $2100\ Jkg^{-1}\ K^{-1}$ and $4200\ Jkg^{-1}\ K^{-1}$ respectively, specific latent heat of fusion of ice as $3.34 \times 10^5\ Jkg^{-1}$ and specific latent heat of vaporization as $2.26 \times 10^6\ Jkg^{-1}$ (5 marks)

QUESTION THREE (20 MARKS)

a) A gas bubble from an explosion under water oscillates with a period T proportional to $p^a \rho^b E^c$ where p is the static pressure, ρ is the density of water and E is the total energy of explosion. Find the values of a, b, and c using dimensional analysis method . (6 marks)

b) A bag of cement of weight 325 N hangs from three wires as shown in Figure 2 below. Two of the wires make angles $\theta_1 = 60.0^\circ$ and $\theta_2 = 25.0^\circ$ with the horizontal. If the system is in equilibrium, find the tensions T_1, T_2, and T_3 in the wires. (7 marks)

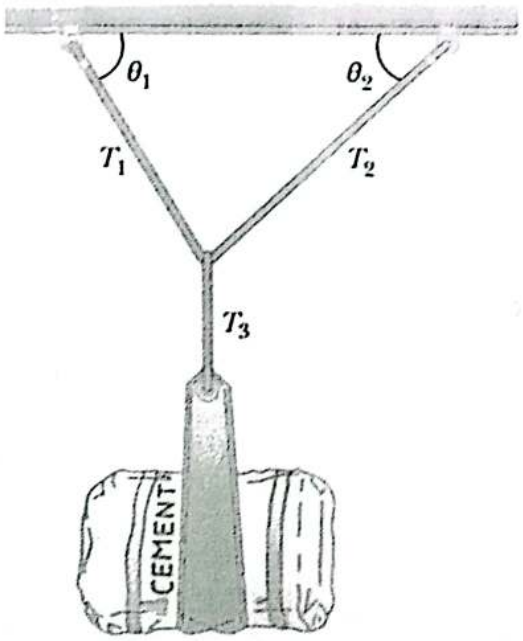

Fig. 2

c) Show that acceleration is proportional to negative of displacement in a simple harmonic motion. (4 marks)

d) In a particular crash test, an automobile of mass 1200 kg collides with a wall. The initial and final velocities of the automobile are $\mathbf{v}_i = -10.0\mathbf{i}\ \text{m/s}$ and $\mathbf{v}_f = 2.20\mathbf{i}\ \text{m/s}$, respectively. If the collision lasts for 0.120 s, calculate the impulse caused by the collision and the average force exerted on the automobile. (3 marks)

QUESTION FOUR (20 MARKS)

a) A 4 m long copper wire of cross-sectional area 1.2 cm^2 stretched by a force of 4.8×10^3 N. If the young's modulus $Y = 1.2 \times 10^{11}$ N/M^2, calculate:

i. Tensile stress (2marks)

ii. Tensile strain (2marks)

iii. Increase in length of wire (2marks)

b) Calculate the change in length of the upper leg bone (the femur) when a 70.0 kg man supports 62.0 kg of his mass on it, assuming the bone to be equivalent to a uniform rod that is 40.0 cm long and 2.00 cm in radius. (3marks)

c) As an oil well is drilled, each new section of drill pipe supports its own weight and that of the pipe and drill bit beneath it. Calculate the stretch in a new 6.00 m length of steel pipe that supports 3.00 km of pipe having a mass of 20.0 kg/m and a 100-kg drill bit. The pipe is equivalent in stiffness to a solid cylinder 5.00 cm in diameter. (4marks)

d) A constant-volume gas thermometer is placed in contact with a reference cell containing water at the triple point. After reaching equilibrium, the gas pressure is recorded as 55.78 kPa. The thermometer is then placed in contact with a sample of unknown temperature. After the thermometer reaches a new equilibrium, the gas pressure is 65.12 kPa. What is the temperature of this sample? (4marks)

e) Define the following terms:

i. Surface tension (1mark)

ii. Convection (1mark)

iii. Conduction (1mark)