SPH 2174 Physics FOR Engineers 2 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 SECOND 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 2174: PHYSICS FOR ENGINEERS II

DATE: APRIL 2024 **TIME: 2 HOURS**

INSTRUCTIONS

Attempt QUESTION ONE and any other TWO questions.

QUESTION ONE carries 30 marks and the rest carry 20 marks each.

The following information may be used where applicable

Planck's constant, h	=	6.63×10^{-34} Js
Electronic charge, e	=	1.602×10^{-19} C
Velocity of light, c	=	3.0×10^{8} m/s
1 eV	=	1.602×10^{-19} J
Mass of electron, m_e	=	9.11×10^{-31} Kg
Mass of proton, m	=	1.67×10^{-27} Kg
Permittivity, ε_0	=	8.85×10^{-12} C^2/Nm^2

QUESTION ONE

a) Distinguish between regular and diffuse reflections of light **(2 marks)**

b) Derive the relation between the angle of rotation of a plane mirror and the angle of deflection of a reflected ray, when the direction of the incident ray is constant. **(3 marks)**

c) A ray of light is incident on a water- glass boundary at an angle of 41° as shown in Figure 1 below.

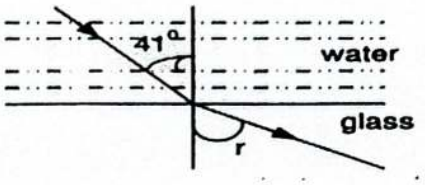

Figure 1

Calculate the angle of refraction, if the refractive indices of water and glass are 1.33 and 1.50 respectively **(2 marks)**

d) A monochromatic ray of light is incident from a liquid on to the upper surface of a transparent glass block Figure 2.

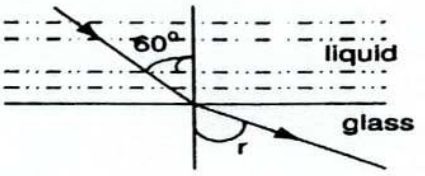

Figure 2

Given that the speed of light in the liquid and glass is $2.4 \times 10^8\ ms^{-1}$ and $1.92 \times 10^8\ ms^{-1}$ respectively, calculate the angle of refraction, r. **(3 marks)**

e) By use of a ray diagram, derive the relation between the refractive index η of a medium and critical angle, C for a ray of light traveling from the medium to air. **(3 marks)**

f) Define the terms principal focus and focal length of a converging lens. **(2 marks)**

g) i) State Coulomb's law. **(1 mark)**

ii) Two point charges q_1=5μC and q_2= 3μC are fixed 4cm apart. Calculate the distance between them at which the resultant field is zero. **(3 marks)**

h) Two capacitors when connected in parallel give an equivalent capacitance of 9pF and when connected in series give an equivalent capacitance of 2pF. What is the capacitance of each capacitor? **(5 marks)**

i) Calculate the total resistance between points A and B in Figure 3 below **(4 marks)**

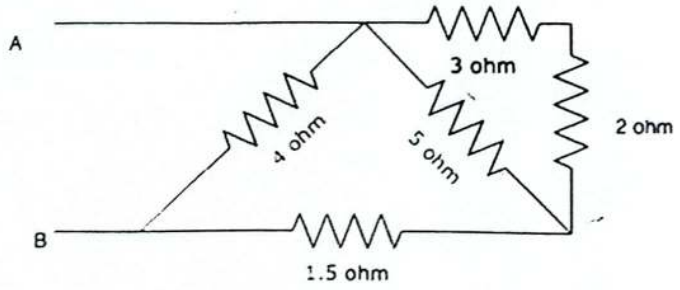

Figure 3

j) State the four factors that determine the force on a conductor carrying current in a magnetic field. **(2 marks)**

QUESTION TWO

a) Calculate the angle of incidence at minimum deviation for light passing through a Prism of refracting angle 70° and refractive index of 1.65. **(3 marks)**

b) An object is placed 20cm from a converging lens of focal length 15cm. Find the nature, position and the magnification of the image formed **(3 marks)**

c) A prism of refracting angle 67° and refractive index of 1.6 is immersed in a liquid of refractive index 1.2 Figure 4. If a ray of light traveling through the liquid makes an angle of incidence of 53° at the left face of the prism, determine the total deviation of the ray **(4 marks)**

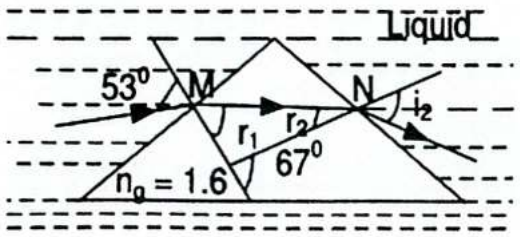

Figure 4

d) Two capacitors of 50μF each are connected in parallel. The combination is further connected in series with two capacitors of 40μF and 80μF. Calculate the total capacitance of the circuit. **(3 marks)**

e) A certain parallel- plate capacitor consists of two plates, each with area 200cm^2 separated by a 0.4 cm air gap. The capacitor is connected across a 500 volt source. Find:

i) The capacitance for the capacitor **(2 marks)**

ii) The charge on the capacitor **(1 mark)**

iii) The stored energy **(1 mark)**

iv) If a liquid with $\varepsilon = 2.6\varepsilon_0$ is poured between the plates so as to fill the air gap, how much additional charge will flow onto the capacitor from the 500 volt source? **(3 marks)**

QUESTION THREE

a) Explain with diagrams where necessary the following terms:

i) Coherent sources

ii) Constructive interference

iii) Destructive interference **(3 marks)**

b) Two pinholes, equidistant from a monochromatic source of light are at a distance d from one another in a vertical plane. A screen is placed in front of them at a distances D parallel to them. If λ is the wavelength of the monochromatic light, state the equation relating d, D, λ and β, where β is the distance between any two consecutive bright or dark fringes on the screen; also sketch the arrangement.

If the distance between two slits is 0.050 mm and the distance to a screen is 2.50 m, find the spacing between the first- and second – order bright fringes for yellow light of 600 nm wavelength. **(7 marks)**

c) A train producing sound of pitch ***n*** approaches a stationary observer ***O*** at a speed of a m/s. If the speed of sound in air is v m/s and the wavelength of the sound wave produced by the train is λ; deduce the expression for apparent wavelength and apparent frequency of the sound wave as heard by the observer ***O***. **(4 marks)**

d) A train moving at 25.00 m/s emits a whistle of frequency 200.0 Hz. If the speed of sound in air is 343.0 m/s, find the frequency observed by a stationary observer (i) in advance of the moving source and (ii) behind the moving source **(6 marks)**

QUESTION FOUR

a) Determine the currents through resistors R_1 in the circuit of Figure 5 below given that

$R_1 = 40\ \Omega,\ R_2 = 20\ \Omega,\qquad R_3 = R_4 = 10\Omega$ **(3 marks)**

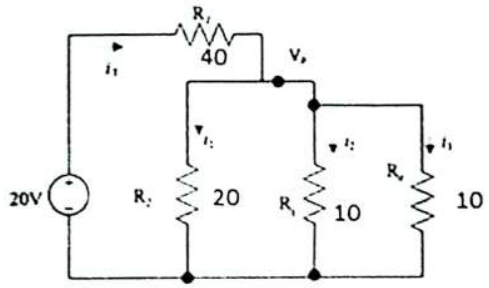

Figure 5

b) i) State the Kirchhoff's laws. **(2 marks)**

ii) Use Kirchhoff's laws to determine the value and direction of the currents i_1 and i_2 in the circuit of Figure 6 below. **(5 marks)**

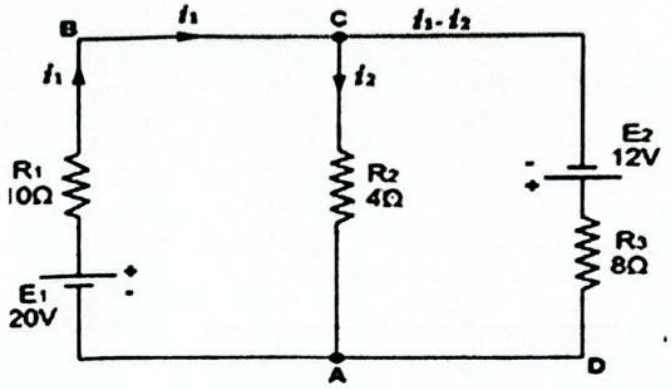

Figure 6

c) Use loop current analysis technique to find the current flowing through each of the resistor R_2 in the circuit of Figure 7 below. **[4 marks]**

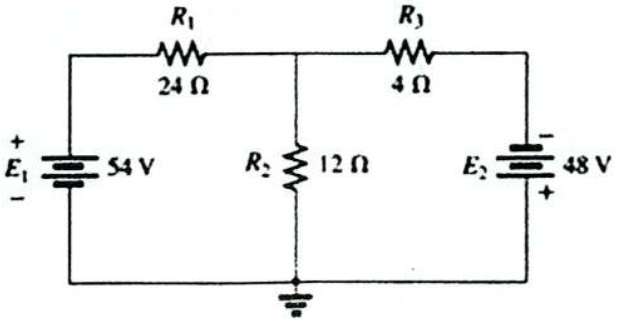

Figure 7

d) i) State the superposition theorem. **[1 mark]**

ii) Use the superposition theorem to determine the currents through resistors R_1, R_2 and R_3 in the circuit of Figure 8 below. **(5 marks)**

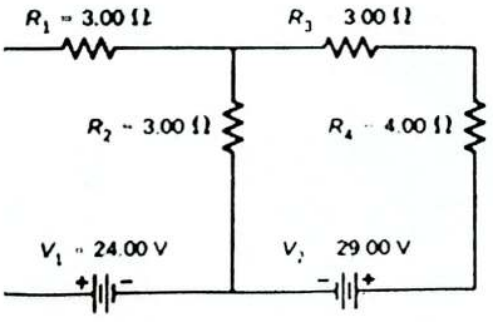

Figure 8