UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2010/11

TITLE O F PAPER: INTRODUCTORY PHYSICS II

COURSE NUMBER: P102

TIME ALLOWED: THREE HOURS

INSTRUCTIONS: ANSWER ANY FOUR OUT OF FIVE QUESTIONS

EACH QUESTION CARRIES 25 MARKS

MARKS FOR EACH SECTION ARE IN THE RIGHT HAND MARGIN

GIVE CLEAR EXPLANATIONS AND USE CLEAR DIAGRAMS IN YOUR SOLUTIONS. MARKS WILL BE LOST WHERE IT IS NOT CLEAR HOW THE EQUATIONS USED WERE OBTAINED

THIS PAPER HAS SEVEN PAGES INCLUDING THE COVER PAGE

THE LAST PAGE CONTAINS DATA THAT MAY BE USEFUL IN SOME QUESTIONS

DO NOT OPEN THE PAPER UNTIL PERMISSION HAS BEEN GIVEN BY THE CHIEF INVIGILATOR

QUESTION 1

23

(a) An isotropic source produces sound level at a power of 1.25 W.

(i) What is the sound intensity of the sound at the distance of 15 m? **(2 marks)**

(ii) What is the sound level at the distance of 15 m? **(2 marks)**

(iii) If the power is increased by a factor of 10, by how much will the sound level be increased at the distance of 15 m? **(4 marks)**

(b) A light ray enters oil of refractive index 1.5 from air at an angle θ. The light ray is refracted at an angle of 30° in the oil. The oil floats on water of refractive index 1.33. Upon reaching the oil-water interface, the light ray is refracted by an angle θ'. Refer to Figure 1.

(i) Find the angle θ. **(4 marks)**

(ii) Find the angle θ'. **(4 marks)**

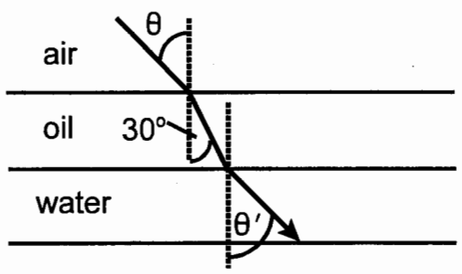

Figure 1.

(c) A lens has a focal length of 14 cm and an object 5 cm high is placed in front of the lens. Find

(i) the image distance when the object is placed 10 cm from the lens, and **(3 marks)**

(ii) the image distance when the object is placed 20 cm from the lens? **(2 marks)**

(iii) What is the nature of the image in each of the two cases in (i) and (ii)? Give justifications for your answers. **(4 marks)**

QUESTION 2 24

Three point charges are located at the corners of an equilateral triangle as shown in Figure 2.

(a) Make a diagram that can be used to determine the unit vectors $\hat{r}_{1,3}$ (the unit vector for the direction from the position of q_1 to q_3) and $\hat{r}_{2,3}$ (the unit vector for the direction from the position of q_2 to q_3), and write down the two unit vectors. **(4 marks)**

(b) Find the force on q_3 due to q_1, $F_{1,3}$, and the force on q_3 due to q_2, $F_{2,3}$. **(4 marks)**

(c) Determine the x- and y-components of the force on q_3 due to the other two charges. **(4 marks)**

(d) What is the electric field due to all the charges at point P? **(4 marks)**

(e) What is the electric potential at point P? **(3 marks)**

(f) How much work would be required to move a charge $q' = 6 \times 10^{-5}$ Coulomb from infinity to point P? **(2 marks)**

(g) By what charge must q_3 be replaced by to make the electric potential at point P to be zero? **(4 marks)**

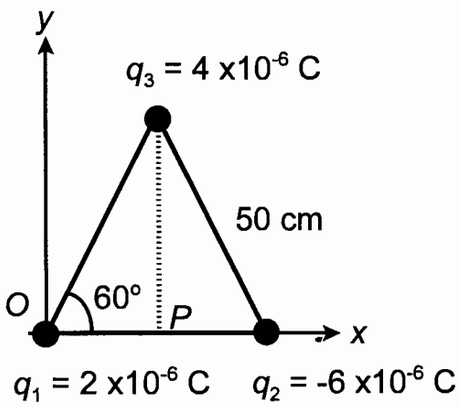

Figure 2.

QUESTION 3

25

(a) In the circuit shown in Figure 3,

(i) use Kirchoff's laws and a diagram to obtain three equations to determine the currents I_1, I_2, and I_3, and **(6 marks)**

(ii) determine the currents I_1, I_2, and I_3. **(10 marks)**

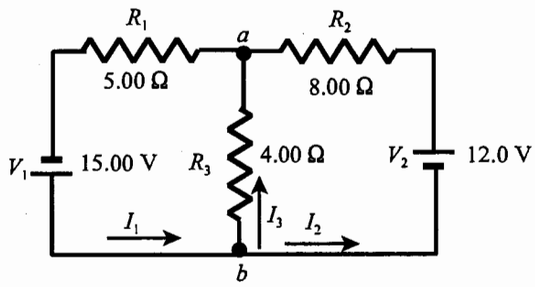

Figure 3.

(b) An *RC* circuit consists of a charging/discharging resistor $R = 5.8$ kΩ, a capacitor of capacitance $C = 60$ μF and the capacitor is fully charged by an *emf* of 12 V.

(i) What is the total charge in the capacitor? **(2 marks)**

(ii) What is the total energy stored in the capacitor? **(2 marks)**

(iii) What is the charge left in the capacitor after one time constant? **(2 marks)**

(iii) What is the power delivered by the capacitor in one time constant? **(3 marks)**

QUESTION 4

26

(a) In Figure 4 the galvanometer of internal resistance 50 Ω is to be used as ammeter and requires a current of 0.500 mA for full scale deflection. What should be the series resistor R_s to make a voltmeter with a full-scale deflection of 30.000 V from the galvanometer? **(5 marks)**

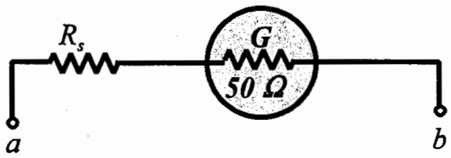

Figure 4.

(b) In a mass spectrometer charged particles enter the velocity selector with some velocity, after which they enter the electric field free region which only has a magnetic field. Discuss with the aid of diagrams and equations what happens to the charged particles in the velocity selector and in the electric field free region. (See Figure 5.) **(12 marks)**

(c) The rectangular wire loop shown in Figure 6 carries a current I in the anticlockwise direction. It is placed in a region with a magnetic field $\boldsymbol{B}$ in the negative x-direction. Use the cross product to determine how the wire will move if it will move at all. **(8 marks)**

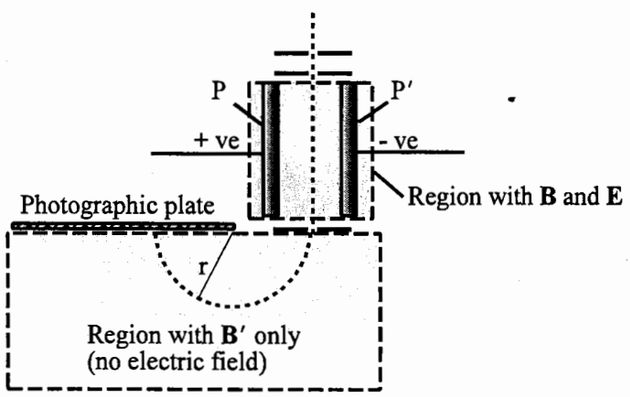

Figure 5.

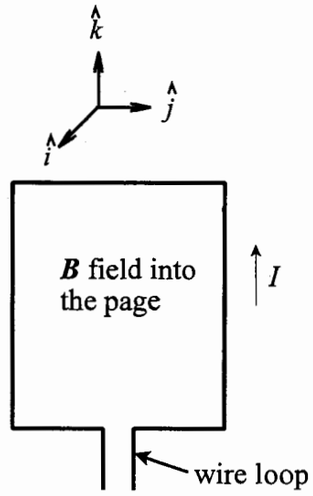

Figure 6.

QUESTION 5

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(a) An inductor (L = 600 mH), a capacitor (C = 4.8 μF) and a resistor (R = 500 Ω) are connected in series. A 50.0 Hz AC source produces a peak current of 212.13 A in the circuit.

(i) What is the reactance of the inductor? **(2 marks)**

(ii) What is the reactance of the capacitor? **(2 marks)**

(iii) What is the impedance of the network? **(2 marks)**

(iv) What is the required voltage? **(2 marks)**

(v) What is the power factor for this network? **(2 marks)**

(vi) Find the apparent power and real power consumed by the network. **(4 marks)**

(b) A company at a isolated location produces its own electricity to supply its plant and the company village 2 km away. The company village is supplied with 40 MW of power. The resistance of the wires is 4 Ω. The voltage is generated at 25 kV and transmitted at 440 kV.

(i) How much electrical energy is lost by the company per day during transmission? **(4 marks)**

(ii) If the company generates the electricity at 55 cents per kilowatt-hour how much money does the company lose per day. **(2 marks)**

(iii) If the company delivers the power at the production voltage of 25 kV, how much money would the company loose per day assuming the production rate of 55 cents per kilowatt-hour? **(5 marks)**

GENERAL DATA SHEET

Speed of light in vacuum $c = 2.9978 \times 10^8$ m/s
Speed of sound in air $\upsilon_s = 343$ m/s
Gravitational acceleration = 9.80 m/s^2
Universal gravitational constant $G = 6.67 \times 10^{-11}$ N. m^2/kg^2
Density of mercury = 1.36×10^4 kg/m^3
Density of water = 1000 kg/m^3
Standard atmospheric pressure = 1.013×10^5 Pa
Boltzmann's constant $k_B = 1.38 \times 10^{-23}$ J/K
Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}$ W/(m^2.K^4)
Gas constant $R = 8.314$ J/(mol.K)
Avogadro's number $N_A = 6.022 \times 10^{23}$ mol^{-1}
Threshold of hearing $I_0 = 10^{-12}$ W/m^2
1 calorie = 1 c = 4.186 J
1 food calorie = 1 Calorie = 1C = 10^3 calories = 4.186×10^3 J

c(*water*) = 4186 J/(kg.K) c(*ice*) = 2090 J/(kg.K) c(*steam*) = 2079 J/(kg.K)
L_f(*ice*) = 3.33×10^5 J/kg L_v(*water*) = 2.260×10^6 J/kg

$$k_e = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 \text{ N.m}^2/\text{C}^2$$

Charge of an electron = -1.6×10^{-19} C
Charge of a proton = $+1.6 \times 10^{-19}$ C
1 atomic mass unit = 1 amu = 1 u = 1.66×10^{-27} kg
Electron mass, $m_e = 9.109 \times 10^{-31}$ kg
Proton mass, $m_p = 1.673 \times 10^{-27}$ kg
Neutron mass $m_n = 1.675 \times 10^{-27}$ kg
$\epsilon_0 = 8.85 \times 10^{-12}$ C^2(N.m^2)
1 Ci = 3.7×10^{10} decays/s
1Bq = 1 decay/s