UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2008/09

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

(a) An isotropic sound source produces 100 W of acoustic power.

(i) What is the sound intensity at a distance of 10 m? **(2 marks)**

(ii) What is the sound level at a distance of 10 m? **(2 marks)**

(iii) At what distance is the sound level at the threshold of pain? **(3 marks)**

(b) What is the velocity of sound in sea water? **(2 marks)**

(c) A light ray enters a slab of extra dense flit glass of refractive index $n_g = 1.720$ that is floating on water of refractive index $n_w = 1.333$ at an angle $\theta = 60°$ with the normal. See Figure 1. Determine the path of the light ray. **(8 marks)**

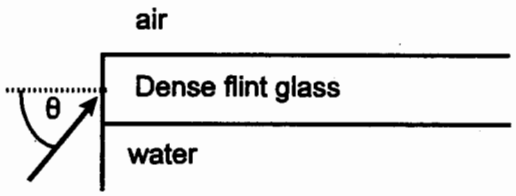

Figure 1.

(d) A lens has a focal length of $f = 14$ cm and an object of height $y = 5$ cm is placed a distance $s = 7$ cm in front of the lens.

(i) Find the image distance. **(3 marks)**

(ii) What is the nature of the image? **(2 marks)**

(iv) What is the image size? **(3 marks)**

QUESTION 2

Three charges are arranged at the vertices of an equilateral triangle as shown in Figure 2.

(i) Use a diagram to find the unit vectors $\hat{r}_{1,3}$ and $\hat{r}_{2,3}$. **(4 marks)**

(ii) Find the force between q_1 and q_3 and the force between q_2 and q_3. **(4 marks)**

(iii) What are the x- and y-components of the force on q_3 due to the other two charges? **(6 marks)**

(iv) What are the x- and y-components of the electric field at point P due to all the charges? **(4 marks)**

(iii) What is the electric potential at point P? **(2 marks)**

(iv) How much energy is required to move a charge $q' = 5\ \mu C$ from infinity to point P? **(2 marks)**

(iv) By what charge must q_3 be replaced by to make the electric potential at point P to be 1000 V? **(3 marks)**

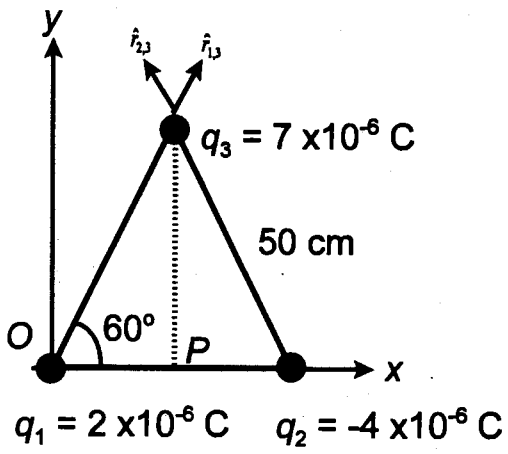

Figure 2.

QUESTION 3

(a) Briefly discuss the cause of electrical resistance in materials. **(4 marks)**

(b) 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)**

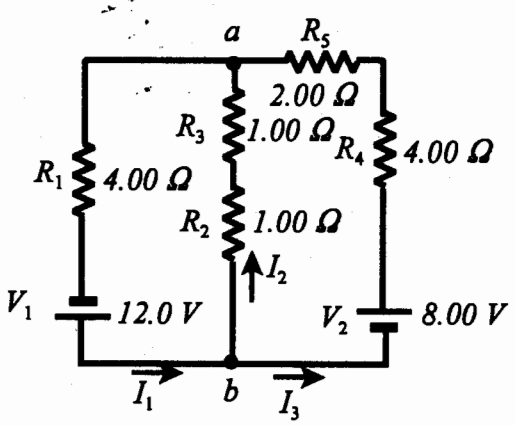

Figure 3.

(c) 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 shunt resistor R_s to make an ammeter with a full-scale deflection of 0.500 A? **(5 marks)**

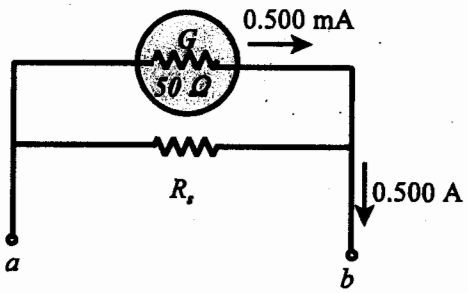

Figure 4.

QUESTION 4

(a) To select a single velocity of charged particles, the particles are directed to a velocity selector with the electric and magnetic fields perpendicular. Discuss how the velocity selector works. **(8 marks)**

(b) Derive with explanation an expression for the radius of curvature of a charged particle of mass m, charge q and velocity v if it enters a region with only a perpendicular magnetic field of magnitude B. **(4 marks)**

(c) Singly ionized (1 electron removed) krypton ions (atomic mass 83.912 u) are accelerated through a potential difference of 2000 v. Find the velocity of the ions when they reach the lower potential point ad determine their radius of curvature when they are directed to a perpendicular magnetic field of magnitude 0.700 T. **(5 marks)**

(d) A wire segment is placed in a region with magnetic field B that is out of the page as shown in Figure 5. The current I is moving clockwise.

(i) Determine how the wire will move if it will move at all. **(4 marks)**

(ii) If the magnetic field is oriented in the minus y $(-\hat{j})$ direction, determine how the wire will move. **(4 marks)**

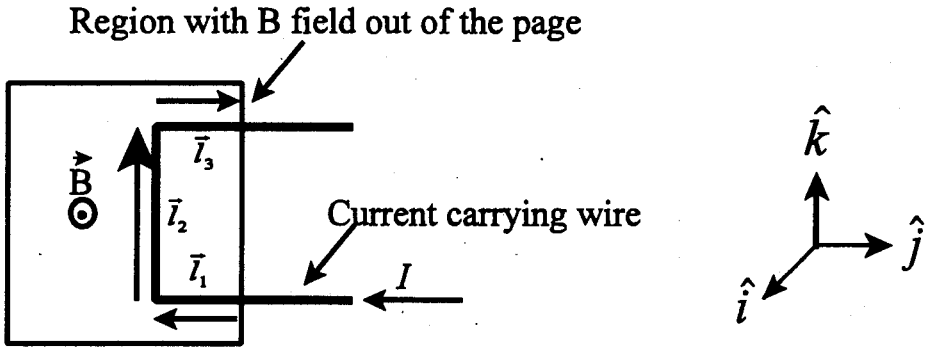

Figure 5.

QUESTION 5

(a) In AC currents the root-mean-square (rms) value of current and voltage are used in the calculations of power. Explain why the rms values are used instead of the average values of voltage and current, and also show how the rms values are determined? Use equations and diagrams to illustrate your answer. **(6 marks)**

(b) A step-down transformer is used for recharging the batteries of a portable device. The turns ratio (primary to secondary) inside the transformer is 26:1 and it is used with 240 V rms household power socket. The transformer draws 0.175 A from the house outlet.

(i) What is the secondary voltage? **(2 marks)**

(ii) What is the current supplied to the battery charger? **(2 marks)**

(iii) How much power is delivered to the battery charger? **(2 marks)**

(iv) If it takes 2 hours to charge the batteries, how much energy is needed to charge the batteries, and how much does it cost if electricity costs 0.600 cents per kWh. **(3 marks)**

(c) Nuclear Physics

(i) Fully explain what the notation ${}^{A}_{Z}X$ mean in nuclear physics. **(5 marks)**

(ii) A sample with an activity R_0 10.0 mCi and a decay constant $\lambda = 0.0558\ h^{-1}$. How many nuclei are present in the sample? **(3 marks)**

(iii) What is the half life of the isotope in hours. **(2 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