UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2006

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) At a distance of 50 m from a noisy industrial machine the sound level is 80 dB.

(i) What is the sound intensity at this distance? **(3 marks)**

(ii) What is the power of the sound source? **(2 marks)**

(iii) At what distance is the sound level at the threshold of pain? **(4 marks)**

(b) A light ray starts in air and enters a glass (n_g = 1.52) fish tank at an angle of incidence θ_i of 80° as shown in Figure 1. The water in the tank has a refractive index of 1.333. Use the aid of diagrams to correctly determine the angles of incidence in the glass-water interface and water-air interface.

(i) What is the angle of refraction θ_g at the air-glass interface? **(2 marks)**

(ii) What is the angle of refraction θ_w at the glass-water interface? **(4 marks)**

(iii) Use calculations to explain what happens to the light ray at the water-air interface **(4 marks)**

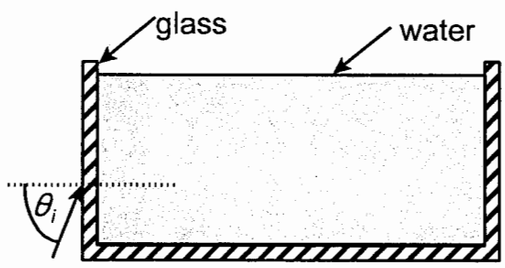

Figure 1.

(c) Use fully labelled diagrams to show how real and virtual images can be formed by the a converging lens. **(6 marks)**

QUESTION 2

(a) Three charges are arranged at the vertices of a triangle as shown in Figure 2. The inclined sides of the triangle make an angle of $\theta = 45^{\circ}$ with the horizontal and are 20 cm long.

(i) What are the *x*- and *y*-components of the force on q_3 due to the other two charges? **(10 marks)**

(ii) What are the x- and y-components of the electric field at the origin due to all the charges? **(6 marks)**

(iii) What is the electric potential at the origin? **(3 marks)**

(iv) How much energy is required to move a charge q′ = 10 μC from infinity to the origin? **(2 marks)**

(v) What must q_3 be replaced by to make the electric potential at the origin to be zero? **(4 marks)**

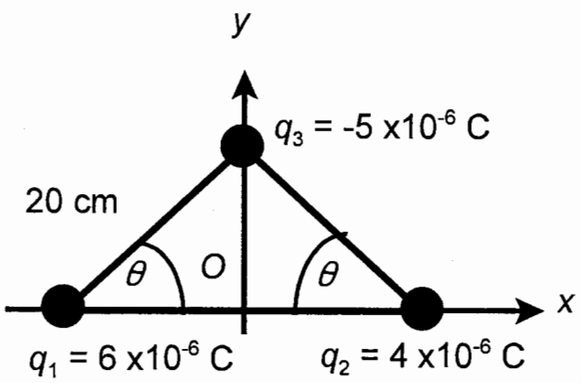

Figure 2.

QUESTION 3

(a) In the circuit shown in Figure 3, use Kirchoff's laws and a diagram to set-up the equations for determining the currents I_1, I_2, I_3 and I_4. Do not solve the equations. **(8 marks)**

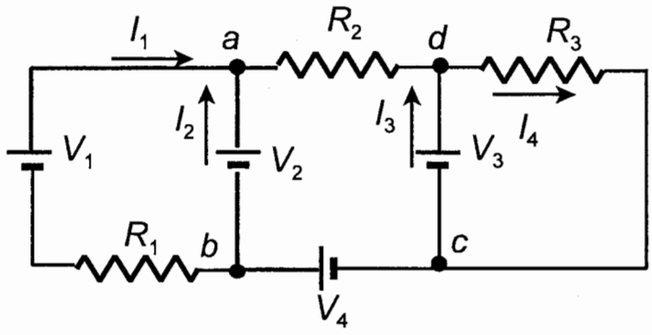

Figure 3.

(b) A capacitor of capacitance C is charged and discharged though a resistor R.

(i) Write down the general equations for charging and discharging a capacitor and include sketches of the associated graphs. **(4 marks)**

(ii) Use the equations for charging and discharging a capacitor to determine the general values of the charge after one time-constant in each case. **(4 marks)**

(iii) If C = 30 μF and V = 24 V what is the energy stored in the capacitor when fully charged? **(2 marks)**

(c) How can a capacitor deliver more power than the power source used to charge it? Give an example of a device where this is principle is applicable. **(4 marks)**

(d) What do you understand by electrical resistance at the atomic and electron scales. **(3 marks)**

QUESTION 4

(a) The rectangular wire loop shown in Figure 4 carries a current *I* in the anticlockwise direction. It is placed in a magnetic field ***B*** in the *x*-direction (out of the page). Use the cross product to determine how the wire will move if it will move at all. **(7 marks)**

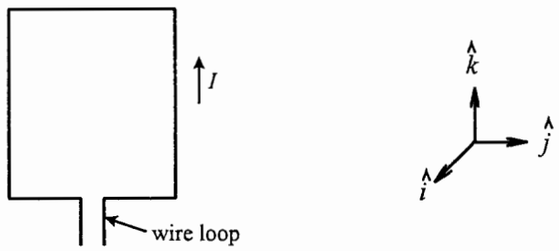

Figure 4.

(b) A vertical conductor slides (in contact) over two horizontal conductors with a constant velocity *v* to the right (see Figure 5). The conductors are in the presence of a magnetic field B int the x-direction. A resistor *R* is connected between the left ends of the horizontal conductors. The mobile charges in the conductor are negative. Discuss in detail with the aid of equations what happens in this arrangement. What does this system behave like? **(7 marks)**

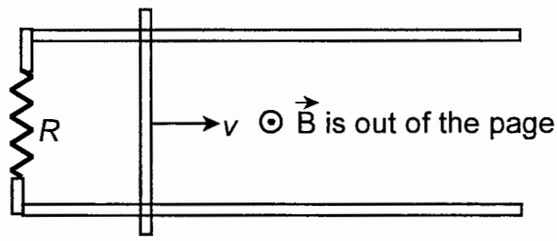

Figure 5.

(c) Consider positively charged particles of charge *q* moving in the negative $z(-\hat{k})$ direction with velocity v.

(i) How will they be deflected when subjected to an electric field **E** in the *y*- $(\hat{j})$ direction? **(2 marks)**

(ii) How will they be deflected when subjected to a magnetic field **B** out of the page, *x*- $(\hat{i})$ direction? **(2 marks)**

(iii) What condition must be met for the particles to go through without deflection. i.e. how must *E* and *B* relate to the velocity *v*? **(3 marks)**

(d) With the aid of equations explain what happens when a charged particle with some velocity v enters a region with only a magnetic field B perpendicular to the velocity. **(4 marks)**

QUESTION 5

(a) An industrial machine rated is at 5000 W at 440 V(rms).

(i) How much current is drawn by the machine? **(2 marks)**

(ii) What is the effective resistance of the machine? **(2 marks)**

(iii) If the machine is kept on for 8 hours, what is the cost of the electricity consumed assuming that electrical energy cost 55 cents per kilowatt-hour. **(3 marks)**

(b) An isolated small town is powered by a hydro-electric power plant that delivers 8 MW of power. The power plant is located 5 km away from the town. The resistance of the wires is 4 Ω. The voltage is generated at 25 kV and transmitted at 240 kV.

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

(ii) If the company generates the electricity at 55 cents per kilo-watt-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 it loose per day assuming the rate of 55 cents per kilo-watt-hour? Compare with the result from (ii) and comment. **(6 marks)**

(c) A step-down transformer is used for recharging a cell phone battery. The turns ratio in the transformer are 26:1 and is used with a 240 V (rms) household service. The transformer draws a current of 0.350 A from the house outlet.

(i) What is the voltage supplied to the battery? **(2 marks)**

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

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

GENERAL DATA SHEET

Speed of light in vacuum $c = 2.9978 \times 10^8$ m/s
Speed of sound in air = 334 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
Gas constant $R = 8.314$ J/(K mol)
Avogadro's number $N_A = 6.022 \times 10^{23}$ mol^{-1}
$I_0 = 10^{-12}$ 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

$$k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 \text{ Nm}^2/\text{C}^2$$

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