UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2009/10

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 sound at a power $P = 50$ W.

(i) What is the sound intensity at a distance $r = 30$ m? **(3 marks)**

(ii) What is the sound level at the distance r and explain whether it is safe for listening by the human ear? **(3 marks)**

(iii) By what factor must the power be reduced so that the sound level is halved at the distance r? **(3 marks)**

(b) A slab of cubic zirconia (a diamond imitation) floats on water of refractive index 1.33. Above the slab is air. The arrangement is shown in Figure 1. A light ray enters the slab of refractive index 2.20 from air at an angle $\theta = 70°$ with the normal. The light ray is refracted at an angle θ_s in the slab. Determine by calculation the path of the light ray in the cubic zirconia (i.e determine whether it is transmitted to the water, transmitted back to air or trapped in the cubic zirconia and transmitted to the other end). **(8 marks)**

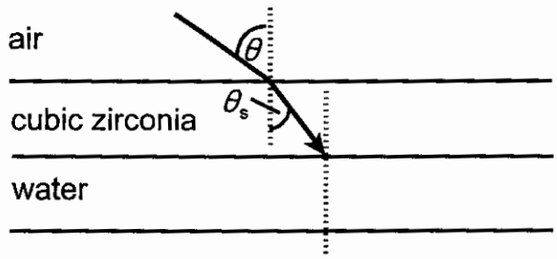

Figure 1.

(c) With the aid of fully labeled diagrams, show how both virtual and real images can be formed by a converging lens? **(8 marks)**

QUESTION 2

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 $q' = 8 \times 10^{-5}$ 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)**

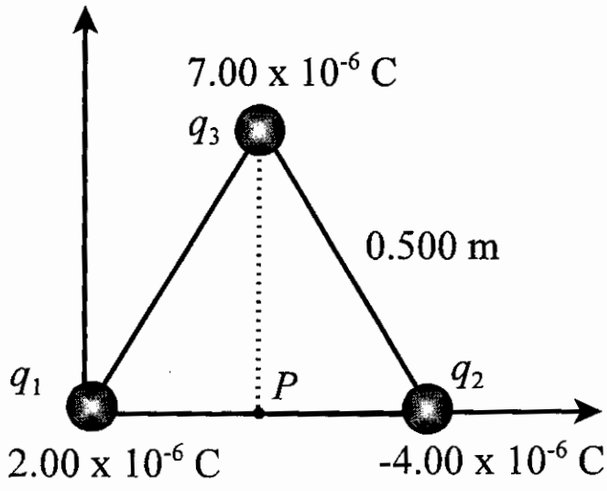

Figure 2.

QUESTION 3

(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)**

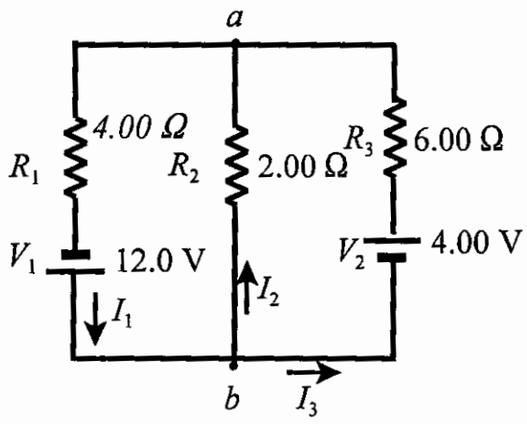

Figure 3.

(b) An *RC* circuit consists of a charging/discharging resistor R, a capacitor of capacitance C and the capacitor is fully charged.

(i) After how many time constants is the charge on the capacitor one-fourth of its initial value?. **(4 marks)**

(ii) After how many time constants is the energy stored reduced to one-fourth of its initial value? Comment on the two times obtained in (i) and (ii). **(5 marks)**

QUESTION 4

(a) A wire segment is placed in a region with magnetic field B that is out of the page as shown in Figure 4. 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-direction, determine how the wire will move, if it will move at all. **(3 marks)**

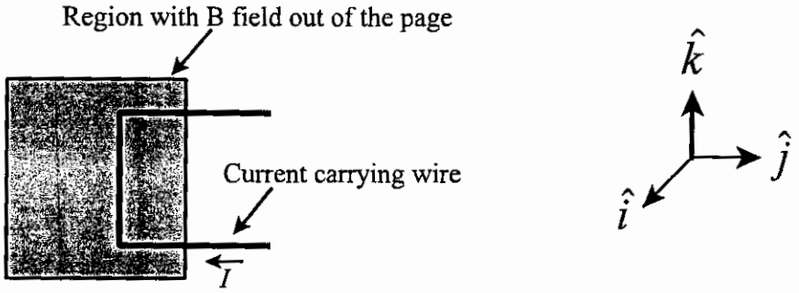

Figure 4.

(b) A proton is accelerated through a voltage of 1000 V. It enters a region with a magnetic field of magnitude 0.45 T, perpendicular to its direction of motion.

(i) Find the velocity of the proton before entering th magnetic field? **(3 marks)**

(ii) Determine the expression for the radius of curvature of the proton when it is in the magnetic field and calculate its radius of curvature. **(8 marks)**

(c) A flat wire coil of $N = 60$ turns enclose an area $A = 0.200$ m^2 and has a total resistance of $R = 100.0\ \Omega$, rotates with angular velocity $\omega = 30.0$ rad/s about the x axis in a region where a magnetic field $B = 1.00$ T is directed along the $-y$ axis. The wire starts to rotate with the area perpendicular to the magnetic field. See Figure 5. Hint: $\theta = \omega t$.

(i) What is the flux that goes through the area A at any time t? **(3 marks)**

(ii) Find the expression for the *emf* and evaluate the *emf* and the current for time t = 0.0500 s. **(4 marks)**

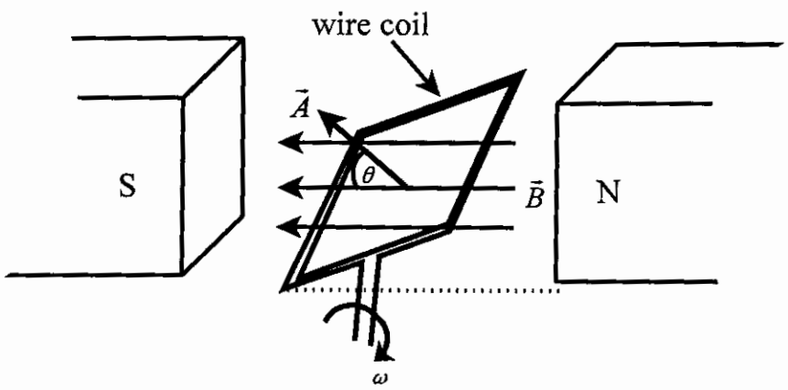

Figure 5.

QUESTION 5

(a) An isolated town is powered by a small hydro-power plant located a short distance from the town. The company generates 20 MW of power at 22 kV. A step-up transformer is used to boost the voltage to 230 kV before transmission. The transmission wires have a resistance of 2 Ω. The production cost of electricity is 40 cents per kilowatt-hour.

(i) Find the current through the wires, the energy lost in transmission, and the cost of the lost electricity to the company? **(6 marks)**

(ii) If the power were to be transmitted at the generation voltage of 22 kV, what would be the cost to the company in lost electricity? Comment on your result as compared to the one obtained in (i). **(6 marks)**

(b) A step-down transformer is used for recharging batteries for a portable device. The turns ratio of the transformer is 26:1 and it is used with a 230 V rms laboratory service. The transformer draws a current of 0.100 A from the service outlet.

(i) Find the secondary rms voltage. **(2 marks)**

(ii) What is the secondary rms current? **(2 marks)**

(c) A series RLC circuit has the following circuit parameter: $R = 500\ \Omega$, $L = 400$ mH, and $C = 4.43\ \mu$F. The applied AC voltage at 50 Hz produces a peak current of 250 mA.

(i) Find the impedance Z for the circuit. **(3 marks)**

(ii) Determine the peak voltage V_{max}. **(2 marks)**

(iii) Find the phase angle and state what it means? **(2 marks)**

(iv) What is the power dissipated by the circuit? **(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