UNIVERSITY OF SWAZILAND

15

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2011/12

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 INFORMATION THAT MAY BE USEFUL IN SOME QUESTIONS

IF IN DOUBT, RAISE YOUR HAND AND ASK

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

QUESTION 1

a) An industrial machine produces isotropic sound at an average power P. At a distance r = 10.0 m, the sound level is = 80.0 dB. Find the power of the sound source? **(7 marks)**

b) With the aid of a diagram briefly explain how a rainbow is formed. **(5 marks)**

c) An opaque cylindrical tank with an open top has a diameter of 3.00 m and is completely filled with water. A light ray incident just inside the top edge of the tank on the left enters the water at an angle $\theta_i = 62.0°$ with the vertical as shown in Figure 1. The refracted light ray just touches the edge of the bottom of the tank on the other side. Find the height of the tank h. **(5 marks)**

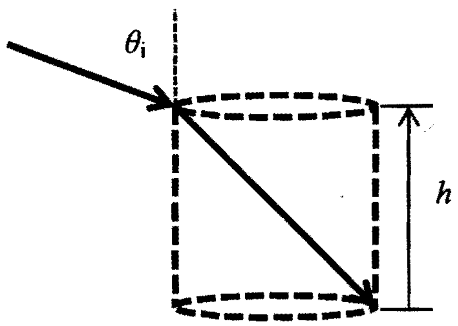

Figure 1.

d) An object is placed 8.00 cm in front of a lens of focal length f = 12.0 cm.

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

ii. Determine the magnification. **(2 marks)**

iii. Describe with justification the nature of the image. **(3 marks)**

QUESTION 2

Three point charges $q_1 = 2.00$ μC and $q_2 = -4.00$ μC and $q_3 = 7.00$ μC are located at the corners of an equilateral triangle as shown in Figure 2.

i. Use a diagram to determine the unit vectors $\hat{r}_{1,3}$ and $\hat{r}_{2,3}$ for the directions from q_1 to q_3, and q_2 to q_3, respectively. **(4 marks)**

ii. Find the force on q_3 due to q_1 in vector form. **(3 marks)**

iii. Find the force on q_3 due to q_2 in vector form. **(3 marks)**

iv. Find the total force vector on q_3 due to the other two charges. **(2 marks)**

v. Find the electric field vector at the location of q_3 due to q_1. **(2 marks)**

vi. Find the electric field vector at the location of q_3 due to q_2. **(2 marks)**

vii. Find the total electric field vector at the position of q_3 due to the other two charges. **(2 marks)**

viii. Use the total electric field vector to obtain the force on q_3 due to the other two charges. **(2 marks)**

ix. With what charge must q_3 be replaced by to make the potential at point P to be 1000 V? **(5 marks)**

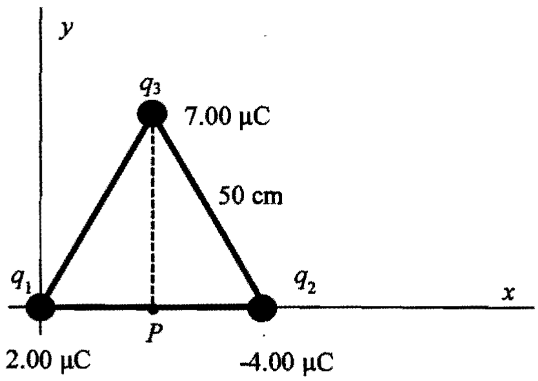

Figure 2.

QUESTION 3

a) A platinum wire with thermal coefficient of expansion $\alpha = 3.92 \times 10^{-3}\ ^{o}C^{-1}$ has a resistance of 1.00 Ω at 20.0 °C. It is immersed into liquid nitrogen at 77.0 K. Determine its resistance in liquid nitrogen. **(4 marks)**

b) A student connects a 100 W microwave oven, a 1500 W electric iron, and a 1200 W electric kettle in parallel to a 220 V household socket? Find the current drawn from the socket. **(5 marks)**

c) First Year student looking for a 25 V full-scale deflection voltmeter finds a galvanometer with an internal resistance of 50 Ω. The galvanometer requires a current of 2.00 mA for full-scale deflection.

   i. Make a sketch that illustrates how the student can covert the galvanometer into a voltmeter. **(2 marks)**

   ii. Find the value of the resistor required to turn the galvanometer into a 25 V voltmeter. **(5 marks)**

d) A 6.00 μF capacitor is charged with a 12 V battery through a 4.70 kΩ resistor for a very long time.

   i. What is the total energy stored in the capacitor. **(2 marks)**

   ii. Determine the power delivered in one time constant when the fully charged capacitor is discharged through the charging resistor, and when it is discharged through a 0.470 Ω resistor? **(4 marks)**

   iii. Using the results from the two parts above, explain how a capacitor can deliver more power than the charging source. **(3 marks)**

QUESTION 4

a) A rod carries current I along its length l and is balanced horizontally in air by the gravitational force acting downward and the magnetic force acting upward. The mass per unit length of the rod is $\lambda = 0.040\,0$ kg/m (so that the mass of the rod is $m = \lambda l$) and the magnetic field which is into the page is of magnitude $B = 3.60$ T. The direction vectors (unit vectors) are as shown in Figure 3 on the right.

   i. Find the direction of the current in the rod. **(4 marks)**

   ii. What is the current through the rod? **(4 marks)**

b) A mixture of protons, deuterons and alpha particles are accelerated from rest by an electric potential difference $\Delta V = 10$ kV. They enter a region with a magnetic field of magnitude $B = 0.2.00$ T perpendicular to their direction of motion.

   i. Find an expression for the radius of curvature of the particles in the magnetic field in terms of B, m, q and ΔV. **(5 marks)**

   ii. Show by the calculation of the radii of curvature whether it would be possible to separate these using the magnetic field. **(7 marks)**

c) Figure 3 shows a bar sliding without friction on conducting rails separated by a distance l = 1.20 m in a region with a magnetic field of magnitude $B = 2.50$ T into the page. The resistor R is 6.00 Ω, and the bar slides with a velocity of 2.00 m/s. What is the current through the resistor? **(5 marks)**

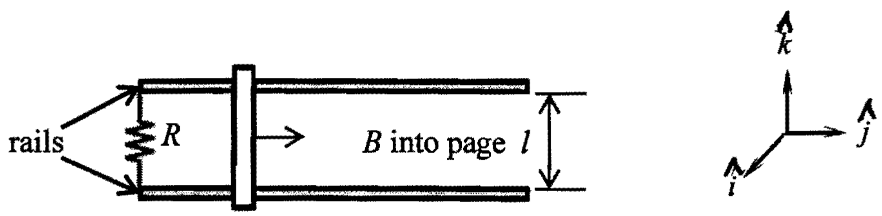

Figure 3.

QUESTION 5

a) An independent power producer generates electricity at 4.50 kV rms and transmits the power at 500 kV rms, to a town 80 km away. The resistance per unit length of the transmission wires is $2.65 \times 10^{-4}\ \Omega/\mathrm{m}$. The electricity is generated at a cost of 70 cents per kilowatt-hour.

i. What is the turns ratio of the transformer windings? **(3 marks)**

ii. Find the cost of the electricity lost in transmission per day. **(5 marks)**

iii. What would be the financial loss per day if the electricity was transmitted at the generation voltage of 4.50 kV? **(5 marks)**

b) An inductor ($l = 400$ mH), a capacitor ($C = 4.43\ \mu$F) and a resistor ($R = 500\ \Omega$) are connected in to a 50.0 Hz power source with a peak current of 250 mA.

i. Find the peak voltage V_{max}. **(6 marks)**

ii. Find the phase angle and state with justification whether the current lags or leads the voltage. **(4 marks)**

iii. What is the power consumed by the network? **(2 marks)**

DATA SHEET

General data

Air refractive index = 1.00
Avogadro's number $N_A = 6.022 \times 10^{23}$ mol^{-1}
Boltzmann's constant $k_B = 1.38 \times 10^{-23}$ J/K
Density of mercury = 1.36×10^4 kg/m^3
Gas constant $R = 8.314$ J/(mol.K)
Gravitational acceleration $g = 9.80$ m/s^2
Standard atmospheric pressure = 1.013×10^5 Pa
Speed of light in vacuum $c = 2.997\ 8 \times 10^8$ m/s
Speed of sound in air $\upsilon_s = 343$ m/s
Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}$ W/(m^2.K^4)
Threshold of hearing $I_0 = 10^{-12}$ W/m^2
Universal gravitational constant $G = 6.67 \times 10^{-11}$ N. m^2/kg^2
1 calorie = 1 c = 4.186 J
1 food calorie = 1 Calorie = 1C = 10^3 calories = 4.186×10^3 J

Water data

$c(water)$ = 4186 J/(kg.K)	$c(ice)$ = 2090 J/(kg.K)	$c(steam)$ = 2079 J/(kg.K)
$L_f(ice) = 3.33 \times 10^5$ J/kg	$L_v(water) = 2.260 \times 10^6$ J/kg	
ρ (water) = 1000 kg/m^3	refractive index $n_w = 1.333$	

Electricity and nuclear data

Alpha particle mass = $6.644\ 657 \times 10^{-27}$ kg
Charge of an electron = -1.6×10^{-19} C
Charge of a proton = $+1.6 \times 10^{-19}$ C
Coulomb's constant $k_e = 8.987\ 5 \times 10^9$ Nm^2/C^2
Deuteron mass = $3.343\ 583 \times 10^{-27}$ kg
Electron mass, $m_e = 9.109 \times 10^{-31}$ kg
Neutron mass $m_n = 1.675 \times 10^{-27}$ kg
Proton mass, $m_p = 1.673 \times 10^{-27}$ kg
1 atomic mass unit = 1 amu = 1 u = 1.66×10^{-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