UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS (APK)

MODULE: PHYE0B1

INTRODUCTORY PHYSICS 1B

Examination Paper C

	Student's Mark	Question's Mark
Q 1		10
Q 2		20
Q 3		20
Q 4		10
Q 5		20
Q 6		20
Total		100

EXAMINER/SECOND EXAMINER/MODERATOR **Prof. B. Sondezi**
Dr S. Jacobs
Dr R. Warmbier

TIME 150 MINUTES

MARKS **100 MARKS**

INSTRUCTIONS: ANSWER ALL THE QUESTIONS IN THE SPACES PROVIDED

NUMBER OF PAGES: 19 INCLUDING COVER PAGE
REQUIREMENTS: SCIENTIFIC CALCULATOR, NO PROGRAMMABLE CALCULATORS ARE ALLOWED

Student Number									

ID Number													

Surname and Initials: ____

Contact Number: ____

Venue: ______________

1.1	
1.2	
1.3	
1.4	
1.5	

CONSTANTS

$k = 9 \times 10^{9}$ N. m^{2}. C^{-2}

$c = 3 \times 10^{8}$ m. s^{-1}

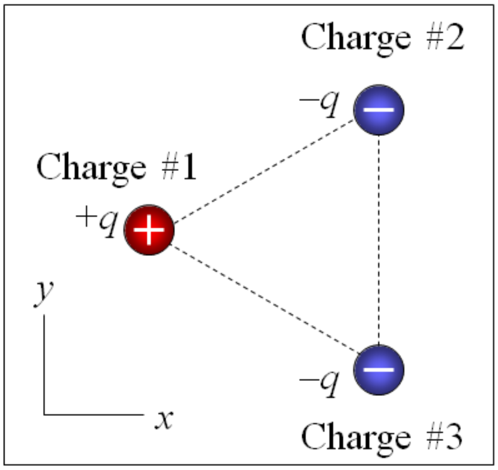
$\mu_0 = 4\pi \times 10^{-7}$ T $\cdot$ m. A^{-1}

$\varepsilon_0 = 8.85 \times 10^{-12}$ C^{2}. N. m^{-2}

QUESTION 1 [10]

WRITE THE SYMBOL CORRESPONDING TO YOUR ANSWER IN THE TABLE ABOVE

1.1 Three point charges lie on the vertices of an equilateral triangle as shown. All three charges have the same magnitude, but charge #1 is positive (+q) and charges #2 and #3 are negative (–q). The net electric force that charges #2 and #3 exert on charge #1 is in



A) the +x-direction.
B) the –x-direction
C) the +y-direction
D) the –y-direction.

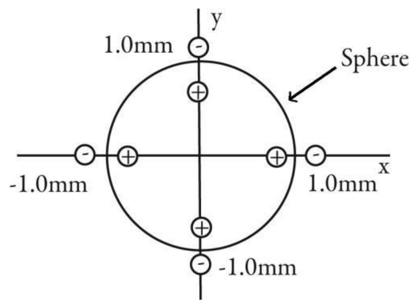
1.2 A piece of plastic has a net charge of +2.00 μC. How many more protons than electrons does this piece of plastic have? ($e = 1.60 \times 10^{-19}$ C)

A) 1.25×10^{13}
B) 1.25×10^{19}
C) 2.50×10^{13}
D) 2.50×10^{19}

1.3 Two identical small conducting spheres are separated by 0.60 m. The spheres carry different amounts of charge and each sphere experiences an attractive electric force of 10.8N. The total charge on the two spheres is -24 μC. The two spheres are now connected by a slender conducting wire, which is then removed. The electric force on each sphere is closest to

A) zero.
B) 3.6 N, attractive.
C) 5.4 N, attractive.
D) 3.6 N, repulsive.
E) 5.4 N, repulsive.

1.4 Four dipoles, each consisting of a +10-μC charge and a 10-μC charge, are located in the *xy*-plane with their centers 1.0 mm from the origin, as shown. A sphere passes through the dipoles, as shown in the figure. What is the electric flux through the sphere due to these dipoles? Given ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N • m^2/C^2)



A) 4.5 × 106 N m^2/C
B) 0.09 N m^2/C
C) 9.0 × 106 N m^2/C
D) 11 × 105 N m^2/C

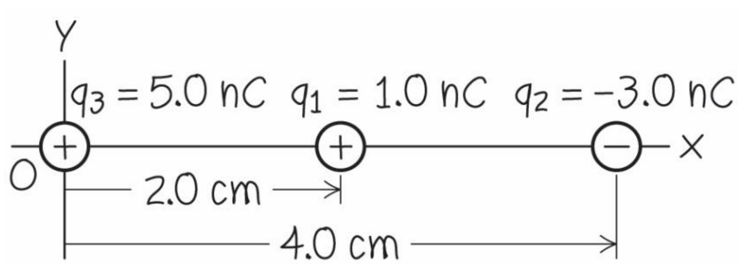
1.5 Two point charges of +1.0 μC and -2.0 μC are located 0.50 m apart. What is the minimum amount of work needed to move the charges apart to double the distance between them?
A) -36 mJ
B) +18 mJ
C) 0 mJ
D) +36 mJ
E) -18 mJ

QUESTION 2 [20]

2.1 Explain why an insulator can be attracted to a charged comb. [2]

2.2 With the use of an equation and proper scientific explanation, state Coulomb's Law [3]

2.3 Two point charges are located on the x-axis of a coordinate system: q_1 = 1.0 nC is at x = +2.0 cm, q_2 = -3.0 nC is at x = +4.0 cm. Calculate the total electric force exerted by q_1 and q_2 on a charge q_3 = 5.0 nC at x = 0. NB. **Start by drawing a Free Body Diagram**. [6]



2.4 Charge Q is uniformly distributed around a conducting ring of radius a. Calculate the electric field at a point P on the ring axis at a distance x from its centre. Draw a suitable figure and show and explain all steps. [9]

QUESTION 3 [20]

3.1. With the aid of an equation define a **vector** current density that includes the direction of the drift velocity. [2]

3.2 A 46 Ω resistor and a 20 Ω resistor are connected in parallel, and the combination is connected across a 230 V DC supply.

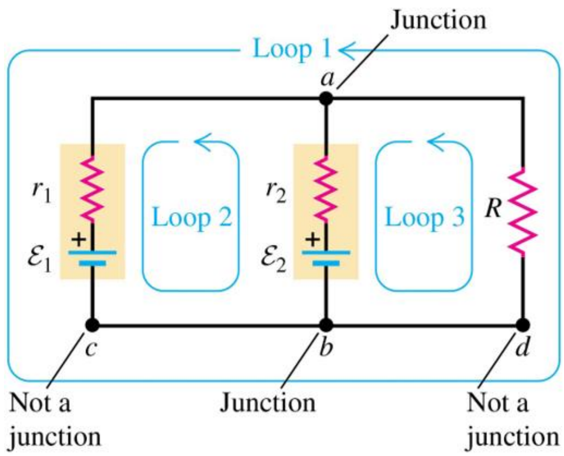
(a) Calculate the resistance of the parallel combination. [2]

(b) Calculate the total current through the parallel combination. [2]

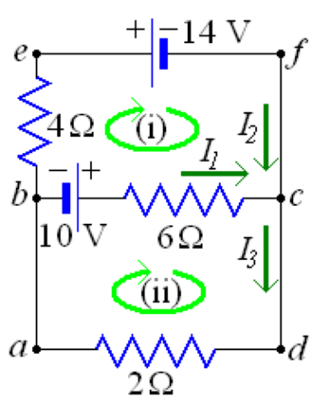
(c) Determine through calculations, the current through each resistor. [2]

3.3. Define a potentiometer. [2]

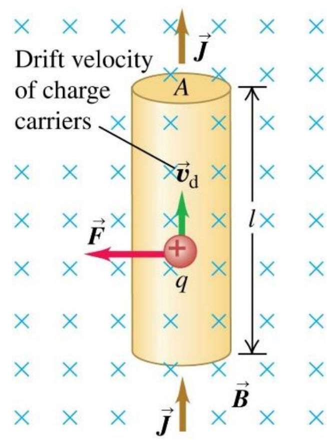
3.4 Many practical resistor networks cannot be reduced to simple series-parallel combinations; hence Kirchhoff developed a technique to make this possible. Consider the figure below and only write relevant equations that could be used to calculate the current passing through each resistor. [2]



3.5 Consider a circuit below and calculate currents, I_1, I_2 and I_3. [6]



3.5 Consider the figure below and give the equation of the total force experienced by the charges if the number of charges per unit volume is *n*, in a given segment. [2]



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QUESTION 4 [10]

WRITE THE SYMBOL CORRESPONDING TO YOUR ANSWER IN THE TABLE ABOVE

4.1 A horizontal wire carries a current straight toward you. From your point of view, the magnetic field at a point directly below the wire points

A) directly away from you.
B) to the left.
C) to the right.
D) directly toward you.
E) vertically upward.

4.2 A capacitor is charging in a simple *RC* circuit with a dc battery. Which one of the following statements about this capacitor is accurate?

A) There is a magnetic field between the capacitor plates because charge travels between the plates by jumping from one plate to the other.
B) There is no magnetic field between the capacitor plates because no charge travels between the plates.
C) There is a magnetic field between the capacitor plates, even though no charge travels between them, because the magnetic flux between the plates is changing.
D) There is a magnetic field between the capacitor plates, even though no charge travels between them, because the electric flux between the plates is changing.
E) The magnetic field between the capacitor plates is increasing with time because the charge on the plates is increasing.

4.3 If the electric field and magnetic field of an electromagnetic wave are given by $E = E_0 \sin(kx - \omega t)$ and $B = B_0 \sin(kx - \omega t)$, and if the value of E_0 is 51 μV/m, what is the value of B_0?

A) 1.7×10^{14} T
B) 1.7×10^{3} T
C) 1.7×10^{-14} T
D) 1.7×10^{4} T
E) 1.7×10^{-13} T

4.4 Which one of the following is an accurate statement about light?

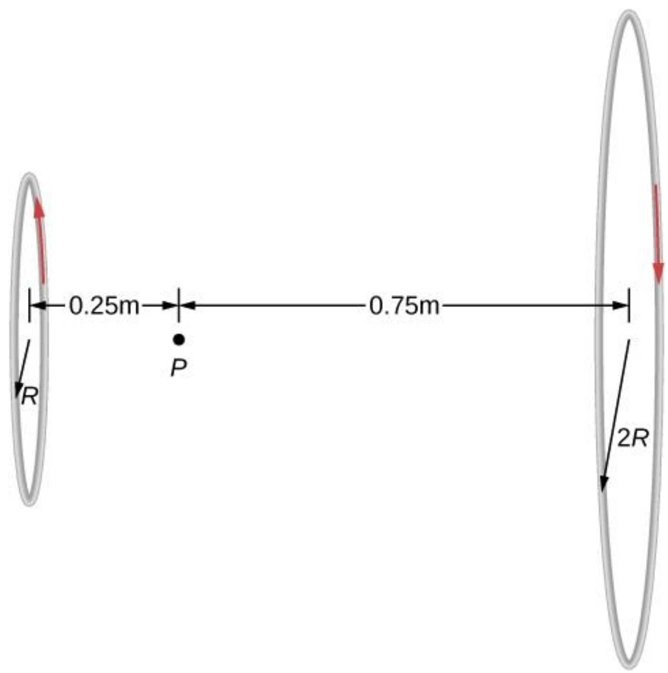
A) When light strikes a surface at Brewster's angle, the reflected and transmitted light are both 100% polarized.
B) When light strikes a surface at Brewster's angle, it is completely reflected at the surface.
C) When light strikes a surface at Brewster's angle, only the reflected light is 100% polarized.
D) When light strikes a surface at the critical angle, only the reflected light is 100% polarized.
E) When light strikes a surface at the critical angle, all the light passes through the surface

4.5 A convex spherical mirror with a focal length of magnitude 25 cm has a 4.0-cm tall flower placed 100 cm in front of it. What is the height of the image of the flower?

A) 0.80 cm
B) 20 cm
C) 4.0 cm
D) 1.6 cm
E) 8.0 cm

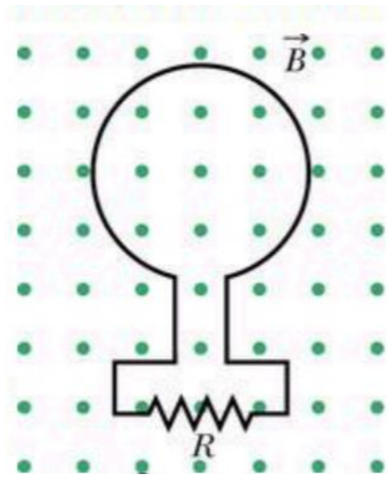
QUESTION 5 [20]

5.1 Consider two loops of wire carrying the same current of 10mA but flowing in opposite directions as shown in figure. If R = 50 cm and point P is at distances from the loops as shown, calculate the net magnetic field at P. [6]



5.2 The magnetic flux through the loop shown in the figure increases according to the relation $\phi_B = 6t^2 + 7t$ where ϕ_B is in milliwebers and t is in seconds.

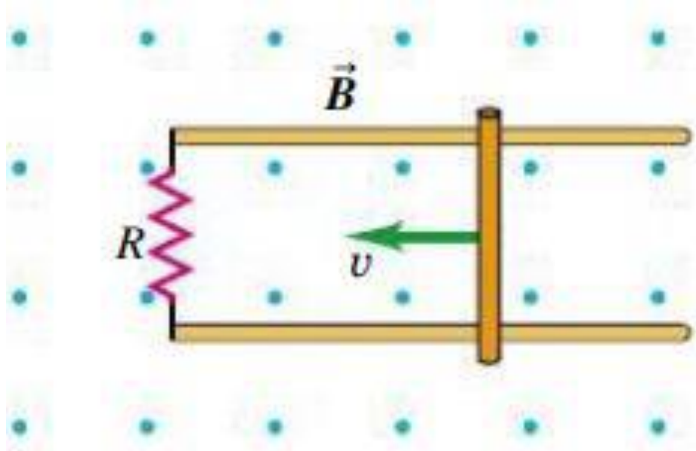
(a) Calculate the magnitude of the emf induced in the loop when t = 2s. [4]
(b) What is the direction of the current through R? Explain your answer. [3]



5.3 A 0.360-m-long metal bar is pulled to the left by an applied force F. The bar rides on parallel metal rails connected through a 45.0 Ω resistor, as shown below so the apparatus makes a complete circuit. You can ignore the resistance of the bar and rails. The circuit is in a uniform 0.650 T magnetic field that is directed out of the plane of the figure. At the instant when the bar is moving to the left at 5.90 m/s:

(a) is the induced current in the circuit clockwise or counter clockwise? Justify your answer. [3]

(b) what is the rate at which the applied force is doing work on the bar? [4]

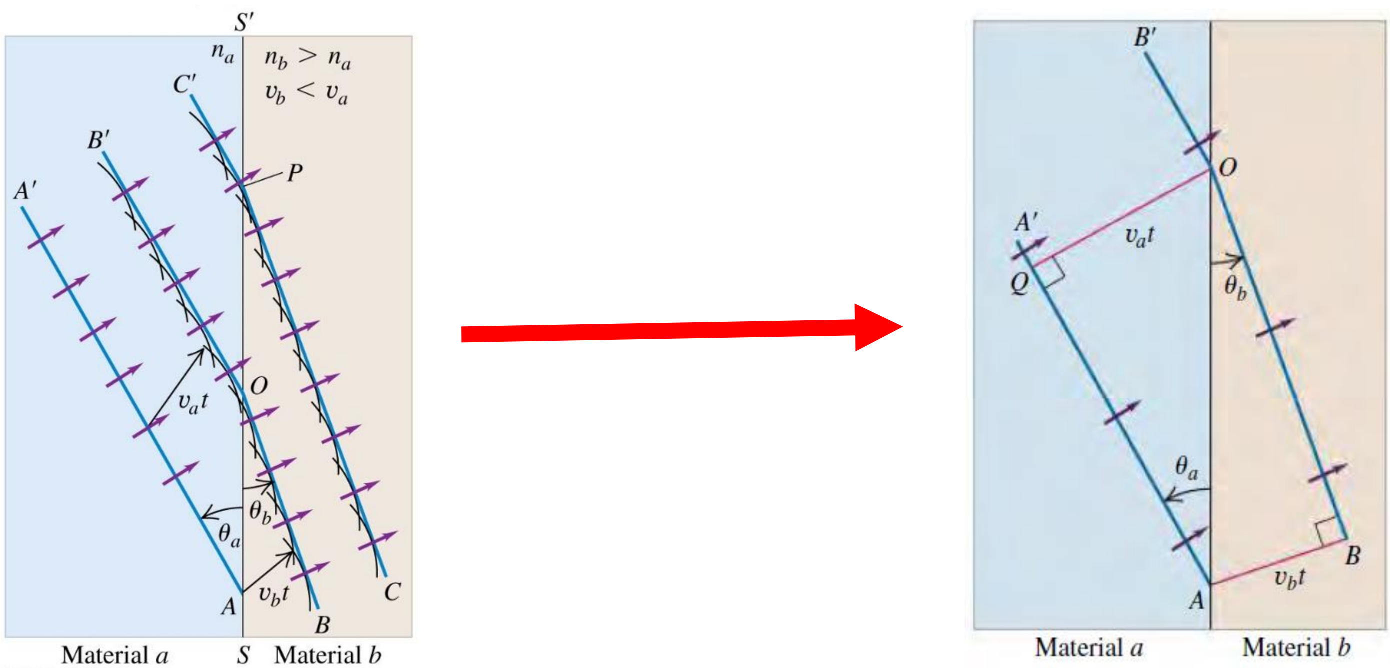


QUESTION 6 [20]

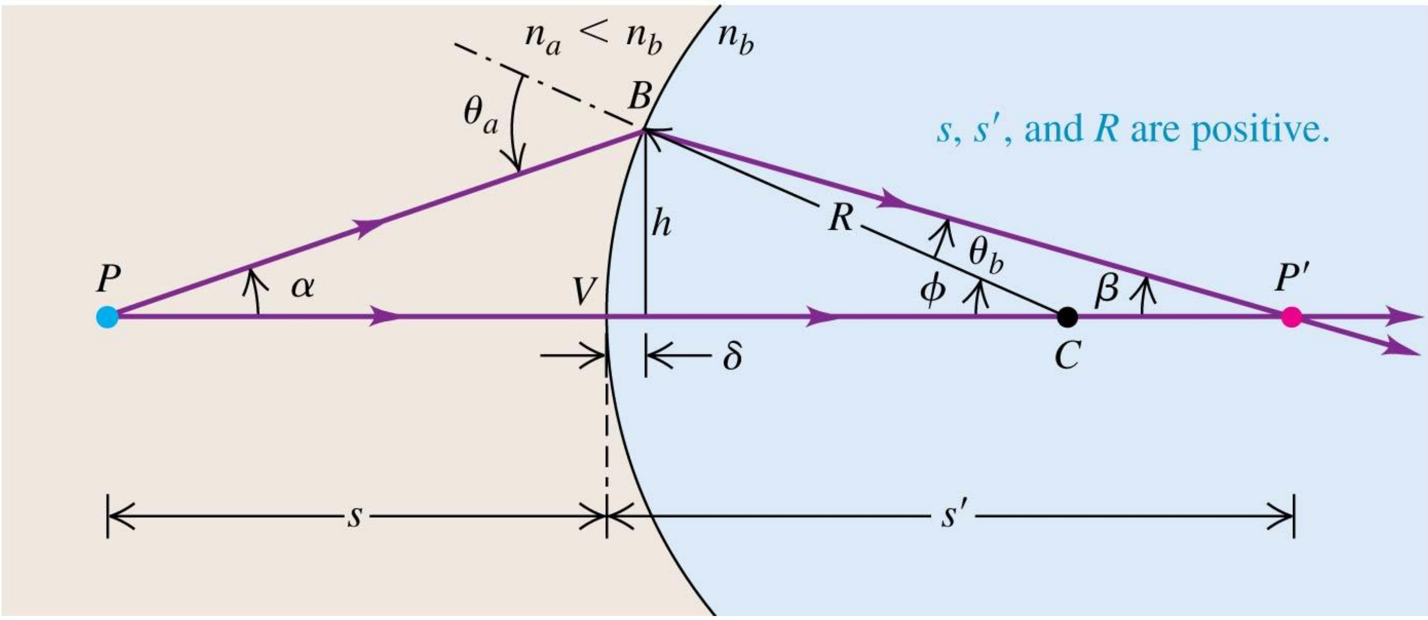
6.1 A nonsinusoidal electromagnetic wave has uniform electric and magnetic fields. The magnitude of the Poynting vector for this wave is 11.0 W/m². Calculate

(a) the magnitudes of the electric and magnetic fields and [4]
(b) the energy density in the wave. [2]

6.2 Using Huygen's principle and the figures below, derive the law of refraction. Explain all steps. [6]



6.3 Using the figure below, derive the object-image relationship for a spherical refracting surface. [8]



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