SURNAME:____________________________ INITIALS: ____

STUDENT NUMBER:_________________________________

UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MODULE: **PHYS0B1/PHYS1B1**

CAMPUS **APK**

EXAM/SUPPL/SPEC

	Question's Mark	Student's Mark
Q 1	20	
Q 2	15	
Q 3	15	
Q 4	15	
Q 5	15	
Q 6	20	
Total	100	

EXAMINER: **DR P. MOHANTY**

MODERATOR: **DR B.S. JACOBS**

DURATION: 2.5 HRS **MARKS: 100**

THIS PAPER CONSISTS OF 19 PAGES INCLUDING THE COVER PAGE

INSTRUCTIONS: **Answer ALL questions IN SPACES PROVIDED**
If you need more space write on the back of the page.
NO PENCILS ALLOWED

Do not write in the margin

Constants and integrals

$c = 3 \times 10^8$ m.s^{-1} $h = 6.626 \times 10^{-34}$ J.s $m_e = 9.1 \times 10^{-31}$ kg $m_p = 1.67 \times 10^{-27}$ kg
$N_A = 6 \times 10^{23}$ particle/mol $q_e = 1.6 \times 10^{-19}$ C $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2.(N.m)$^{-2}$
$k = 9.0 \times 10^9$ N.m^2/C^2 $\mu_0 = 4\pi \times 10^{-7}$ T.m.A^{-1}

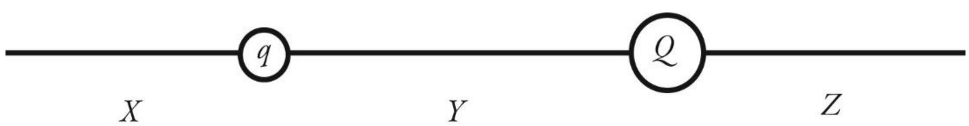
$$\int \frac{dx}{(a^2+x^2)^{3/2}} = \frac{x}{a^2\sqrt{a^2+x^2}};\ \int \frac{dx}{\sqrt{(a^2+x^2)}} = \ln\left(x + \sqrt{a^2+x^2}\right);\ \int \frac{x\,dx}{\sqrt{(a^2+x^2)}} = \sqrt{a^2+x^2}$$

QUESTION 1 [20]

1.1)		1.2)		1.3)		1.4)		1.5)	
1.6)		1.7)		1.8)		1.9)		1.10)	

1.1) Two identical small, charged spheres are a certain distance apart, and each one initially experiences an electrostatic force of magnitude F due to the other. With time, charge gradually leaks off of both spheres. When each of the spheres has lost half its initial charge, the magnitude of the electrostatic force will be
A) 1/16 F.
B) 1/8 F.
C) 1/4 F.
D) 1/2 F.
E) None of the above.

1.2) The figure shows two unequal point charges, q and Q, of opposite sign. Charge Q has greater magnitude than charge q. In which of the regions X, Y, Z will there be a point at which the net electric field due to these two charges is zero?

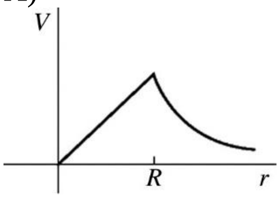


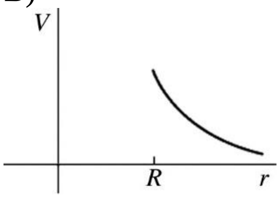
A) only regions X and Z
B) only region X
C) only region Y
D) only region Z
E) all three regions

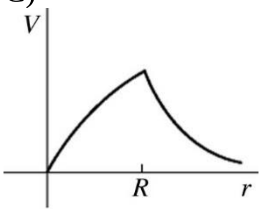
1.3) Two very large parallel sheets a distance d apart have their centers directly opposite each other. The sheets carry equal but opposite uniform surface charge densities. A point charge that is placed near the middle of the sheets a distance $d/2$ from each of them feels an electrical force F due to the sheets. If this charge is now moved closer to one of the sheets so that it is a distance $d/4$ from that sheet, what force will the charge experience?

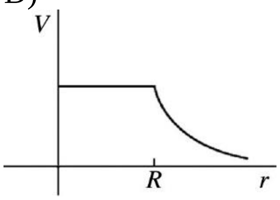
A) $4F$
B) $2F$
C) F
D) $F/2$
E) $F/4$

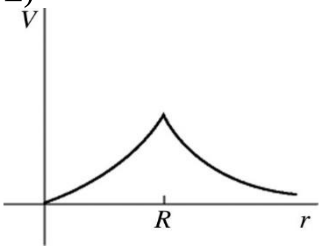
1.4) A conducting sphere of radius R carries an excess positive charge and is very far from any other charges. Which one of the following graphs best illustrates the potential (relative to infinity) produced by this sphere as a function of the distance r from the center of the sphere?

A)


B)


C)


D)


E)


Do not write in the margin

1.5) The electric field between square the plates of a parallel-plate capacitor has magnitude E. The potential across the plates is maintained with constant voltage by a battery as they are pulled apart to twice their original separation, which is small compared to the dimensions of the plates. The magnitude of the electric field between the plates is now equal to
A) $4E$.
B) $2E$.
C) E.
D) $E/2$.
E) $E/4$.

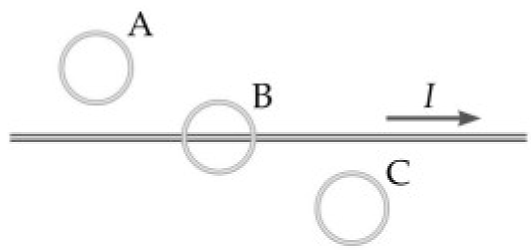
1.6) A horizontal wire carries a current straight toward you. From your point of view, the magnetic field at a point directly below the wire points
A) directly away from you.
B) to the left.
C) to the right.
D) directly toward you.
E) vertically upward.

1.7) An electron, moving toward the west, enters a uniform magnetic field. Because of this field the electron curves upward. The direction of the magnetic field is
A) towards the north.
B) towards the south.
C) towards the west.
D) upward.
E) downward.

1.8) Two long parallel wires placed side-by-side on a horizontal table carry identical size currents in opposite directions. The wire on your right carries current toward you, and the wire on your left carries current away from you. From your point of view, the magnetic field at the point exactly midway between the two wires
A) points upward.
B) points downward.
C) points toward you.
D) points away from you.
E) is zero.

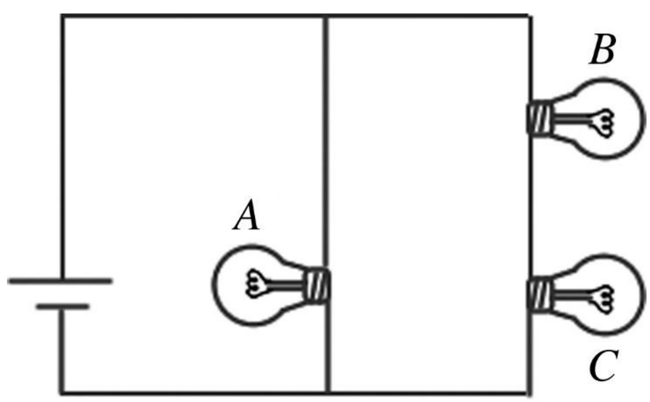
Do not write in the margin

1.9) The long straight wire in the figure carries a current I that is decreasing with time at a constant rate. The circular loops A, B, and C all lie in a plane containing the wire. The induced emf in each of the loops A, B, and C is such that



A) no emf is induced in any of the loops.
B) a counterclockwise emf is induced in all the loops.
C) loop A has a clockwise emf, loop B has no induced emf, and loop C has a counterclockwise emf.
D) loop A has a counter-clockwise emf, loop B has no induced emf, and loop C has a clockwise emf.
E) loop A has a counter-clockwise emf, loops B and C have clockwise emfs.

1.10) In the circuit shown in the figure, all the lightbulbs are identical. Which of the following is the correct ranking of the brightness of the bulbs?

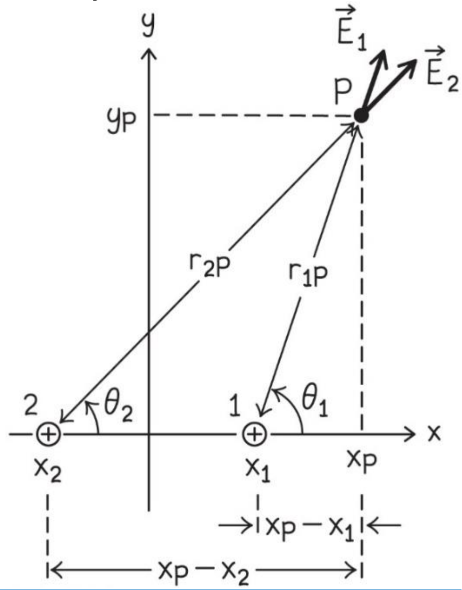


A) B and C have equal brightness, and A is the dimmest.
B) A and B have equal brightness, and C is the dimmest.
C) A is brightest, C is dimmest, and B is in between.
D) A is the brightest, and B and C have equal brightness but less than A.
E) All three bulbs have the same brightness.

QUESTION 2 [15]

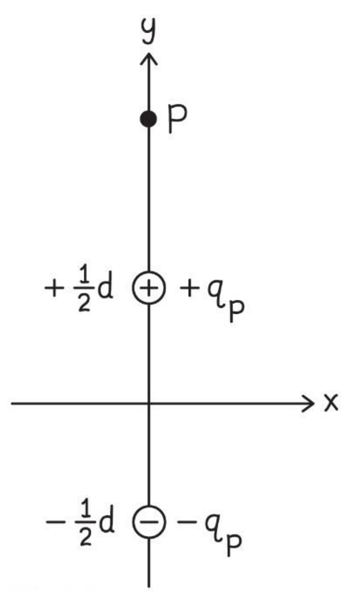
2.1) Explain why a charged strip of tape attracts a neutral piece of paper. [2]

2.2) A point P is located at Xp = 2.0 m, Yp = 3.0 m . Calculate the magnitude and direction of the electric field at point Pdue to a particle 1 carrying a charge a charge q_1= 10 µC and located at x_1 = 1.0m, y_1=0 and a particle 2 carrying charge q_2 = +20 µC and located at x_2= −1.0 m, y_2 =0 [8]



Do not write in the margin

2.3) A permanent dipole consists of a particle carrying a charge $+q_p at\ x = 0, y = +\frac{1}{2}d$ and another particle carrying a charge $-q_p\ at\ x = 0, y = -\frac{1}{2}d$. Use the electrostatic potential at a point P on the axis of the dipole to determine the electric field at that point. [5]



Do not write in the margin

QUESTION 3 [15]

3.1) The electrostatic potential in a particular *xyz* coordinate system is given by

$$V(x,y,z) = 6x^2+3yx-2z.$$

Calculate the expression for the electric field. [2]

Do not write in the margin

3.2) A capacitor has a plate separation distance d. The plates carry charges $+q$ and $-q$ when the capacitor is connected to a battery that maintains a potential difference V_{batt} between its terminals. An electric field of E is present between the plates. A metal slab of thickness $d/2$ is inserted midway between the plates while the battery remains connected.

(a) What happens to the magnitude of the electric field between the plates? [3]

(b) What is the charge on the plates now? [2]

Do not write in the margin

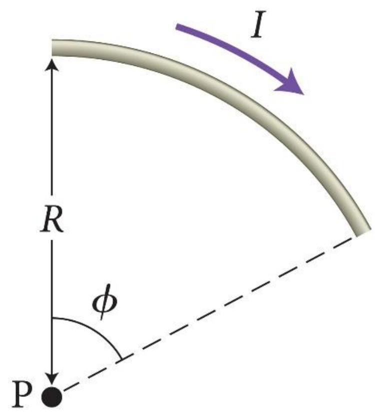
3.3) An infinitely long thin rod carries a positive charge per unit length λ. Use Gauss's law to calculate the electric field magnitude a radial distance r from the axis. [8]

Do not write in the margin

QUESTION 4 [15]

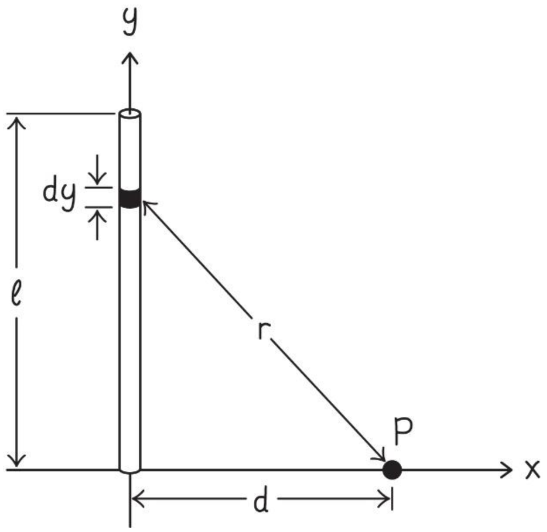
4.1) State Ampere's law. [1]

4.2) A wire bent into a circular arc of radius R subtending an angle ϕ carries a current of magnitude I as shown in the figure below. Derive an expression for the magnitude and direction of the magnetic field produced at point P, located at the centre of the arc. [6]



Do not write in the margin

4.3) A thin rod of length *l* carries a uniformly distributed charge *q*. Calculate the potential *V*p at point P a distance *d* along a line that runs perpendicular to the long axis of the rod and passes through one end of the rod?. [8]



Do not write in the margin

Do not write in the margin

QUESTION 5 [15]

5.1) Calculate the capacitance of a spherical capacitor consisting of two concentric conducting spherical shells of radii R_1 and $R_2 > R_1$? [10]

Do not write in the margin

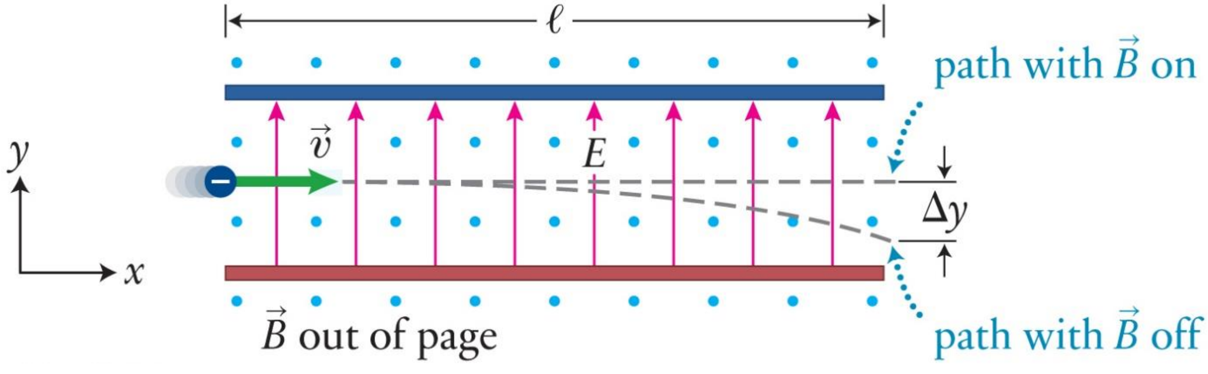
5.2) Explain by drawing a necessary diagram that suggests the insertion of dielectric material inside the parallel plate capacitor increases the amount of free charges on the plates (provided the electric field inside the capacitors is maintained by the use of a battery). [2+3]

QUESTION 6 [20]

6.1) Two parallel rods 1 and 2 carry currents in same direction. Determine the direction of the magnetic force exerted by each rod on the other rod. Begin with a neat sketch. [5]

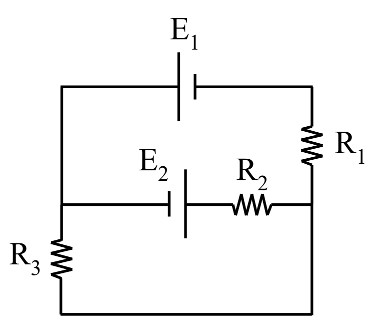
Do not write in the margin

6.2) Figure below shows schematically part of the apparatus used in 1897 by J. J. Thomson to determine the charge-to-mass ratio of the electron. A beam of electrons, all moving at the same speed v enters a region of electric and/or magnetic fields. When an electric field of magnitude 1.0 kV/meters and a magnetic field of magnitude 1.2×10^{-4} T are turned on, the electrons go through the device undeflected. When the magnetic field is turned off, the electrons are deflected by 3.2 mm in the negative y direction after traveling the length l = 0.05 m of the apparatus. Given that the charge of the electron is $e = -1.6\times10^{-19}$ C calculate the mass of each electron. [10]



Do not write in the margin

6.3) In the circuit below the sources have the values E_1 = 6 V, E_2 = 4 V. The resistors have values R_1 = 7 Ω, R_2 = 5 Ω and R_3 = 12 Ω. Calculate the currents through the three resistors. [5]



Do not write in the margin

Space For Rough Work

-----End of paper----