SURNAME:_____ INITIALS ____

STUDENT NUMBER:_____

UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MODULE:	**PHYS0B1**
CAMPUS	**APK**
EXAM	**24 November 2016**

	Student's Mark	Question's Mark
Q 1		10
Q 2		21
Q 3		22
Q 4		28
Q 5		10
Q 6		9
Total		100

EXAMINERS: **DR B.P. DOYLE**

MODERATOR: **MRS. B.S. JACOBS**

DURATION: 150 min **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 PENCIL
NO PROGRAMMABLE CALCULATORS

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Constants

$c = 3\times10^{8}$ m.s^{-1} $h = 6.626\times10^{-34}$ J.s $m_e = 9.1\times10^{-31}$ kg $N_A = 6\times10^{23}$ particle/mol
$q_e = 1.6\times10^{-19}$ C $\varepsilon_0 = 8.85\times10^{-12}$ C^2.(N.m)$^{-2}$ $k = 9.0\times10^{9}$ N.m^2/C^2 $\mu_0 = 4\pi\times10^{-7}$ T.m.A^{-1}

QUESTION 1 [10]

1.1)	
1.2)	
1.3)	
1.4)	
1.5)	

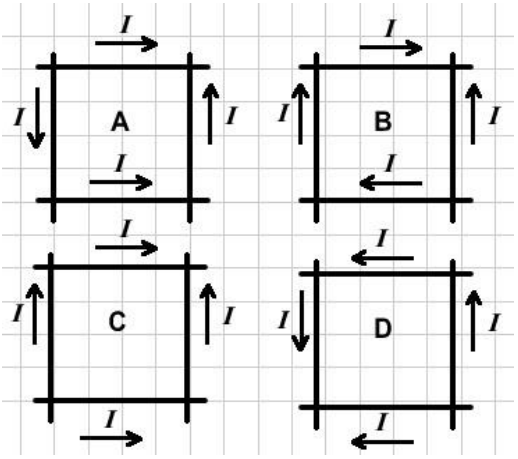
1.1) A positive point charge Q is fixed on a very large horizontal frictionless tabletop. A second positive point charge q is released from rest near the stationary charge and is free to move. Which statement best describes the motion of q after it is released?

A) Its speed will be greatest just after it is released.
B) Its acceleration is zero just after it is released.
C) As it moves farther and farther from Q, its acceleration will keep increasing.
D) As it moves farther and farther from Q, its speed will decrease.
E) As it moves farther and farther from Q, its speed will keep increasing. [2]

1.2) Consider a spherical Gaussian surface of radius R centered at the origin. A charge Q is placed inside the sphere. To maximize the magnitude of the flux of the electric field through the Gaussian surface, the charge should be located

A) at $x = 0$, $y = 0$, $z = R/2$.
B) at the origin.
C) at $x = R/2$, $y = 0$, $z = 0$.
D) at $x = 0$, $y = R/2$, $z = 0$.
E) The charge can be located anywhere, since flux does not depend on the position of the charge as long as it is inside the sphere. [2]

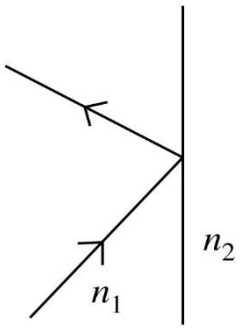
1.3) The figure shows four different sets of insulated wires that cross each other at right angles without actually making electrical contact. The magnitude of the current is the same in all the wires, and the directions of current flow are as indicated. For which (if any) configuration will the magnetic field at the center of the square formed by the wires be equal to zero?



A) A
B) B
C) C
D) D
E) The field is not equal to zero in any of these cases. [2]

1.4) A circular loop of wire lies in the plane of the paper. An increasing magnetic field points out of the paper. What is the direction of the induced current in the loop?
A) counter-clockwise then clockwise
B) clockwise then counter-clockwise
C) clockwise
D) counter-clockwise
E) There is no current induced in the loop. [2]

1.5) A ray of light strikes a boundary between two transparent materials, and there is no transmitted ray, as shown in the figure. What can you conclude about the indices of refraction of these two materials?



A) $n_1 \geq n_2$
B) $n_1 > n_2$
C) $n_1 = n_2$
D) $n_2 \geq n_1$
E) $n_2 > n_1$ [2]

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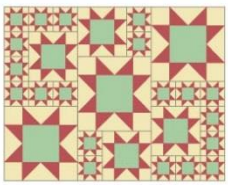
QUESTION 2 [21]

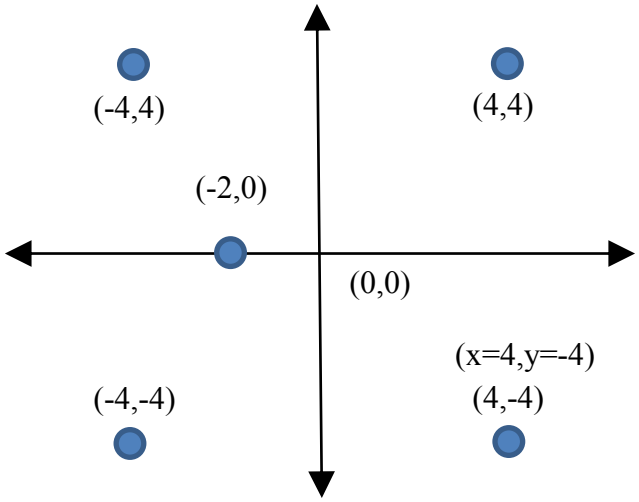
2.1) What symmetries do the following objects have? Do not include translational symmetry or symmetry in time. [3]

(a) 

(b) 

(c) 

2.2) Five equal +4 C charges are arranged as in the figure below. Calculate the value of the electric field at the origin. [3]



2.3) A positively charged rod is brought close to a piece of metal. Explain what is meant by the piece of metal becoming **polarised**. [2]

2.4) Explain what is meant by the **superposition of electric fields**. [2]

2.5) A thin rod of length ℓ carries a uniformly distributed charge q. Calculate the electric field at a point P along a line that is perpendicular to the long axis of the rod and passing through the rod's midpoint. If you are not sure of the geometry, ask! [6]

2.6) Consider a charged sphere of radius R carrying a positive charge q that is uniformly distributed over the volume of the sphere. Calculate the magnitude of the electric field a radial distance $r < R$ from the centre of the sphere. [5]

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QUESTION 3 [22]

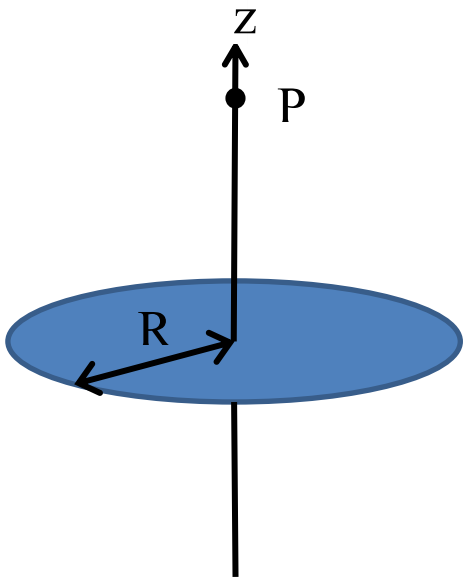
3.1) The electrostatic work done on a charged particle as it moves from one point to another in an electric field is independent of the path taken by the particle. It depends on only the positions of the endpoints of the path. Draw a diagram of this and explain why this is so. [4]

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

$$V(x,y,z) = 8x^2+5yx-4z.$$

Calculate the expression for the electric field. [2]

3.3) A thin disk of radius R carries a uniformly distributed charge. The surface charge density on the disk is σ. Calculate the electrostatic potential due to the disk at point P that lies a distance z from the plane of the disk along an axis that runs through the disk centre and is perpendicular to the plane of the disk as shown in figure below. You do not have to solve the integral. [4]



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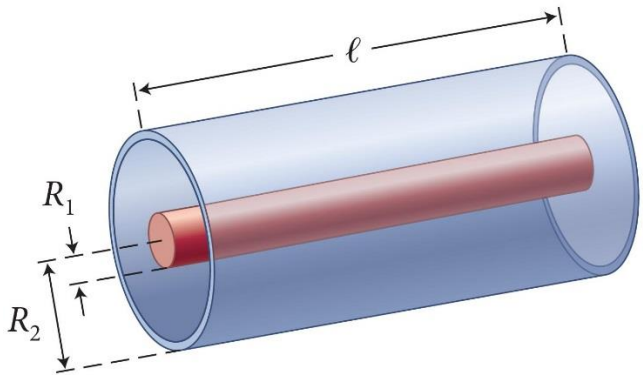
3.4) A capacitor has a plate separation distance d. The plates carry charges $+q$ and $-q$ when the capacitor is connected to a battery that maintains a potential difference V_{batt} between its terminals. An electric field of E is present between the plates. A metal slab of thickness $d/2$ is inserted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

3.5) The figure below shows a coaxial capacitor consisting of two concentric metal cylinders 1 and 2, of radii R_1 and $R_2 > R_1$, and both of length $\ell >> R_2$. Both cylinders are made of metal. Calculate the capacitance of this arrangement. [7]



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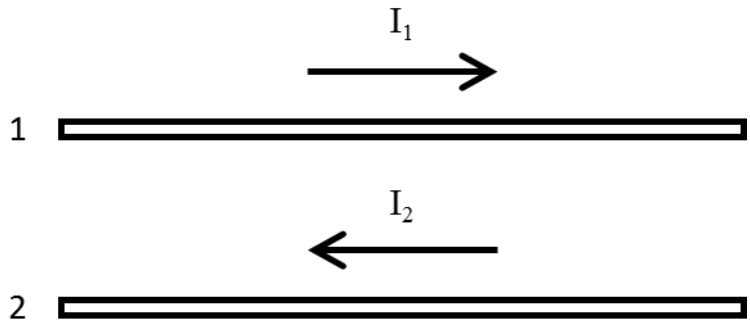
QUESTION 4 [28]

4.1) Two parallel rods carry currents in **opposite directions**. Determine the direction of the magnetic force exerted by each rod on the other rod. Rod 1 is directly above rod 2 as shown in the figure below. [4]



4.2) What three experimentally determined parameters does the magnetic force on a current carrying wire placed in a uniform magnetic field depend on? [3]

4.3) A charged particle is moving with a velocity v in a uniform magnetic field. The velocity of the particle is perpendicular to the magnetic field. Find an expression for the period of the circular path that the particle will follow, in terms of its charge and the magnitude of the magnetic field. [5]

4.4) A large flat metal sheet carries a current. The magnitude of the current per unit of sheet width is K. Calculate the magnitude of the magnetic field a distance d above the sheet. [9]

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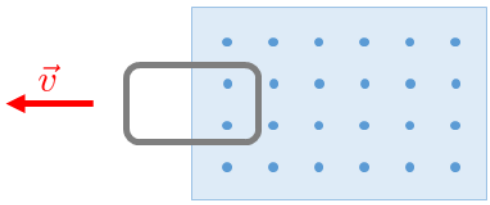
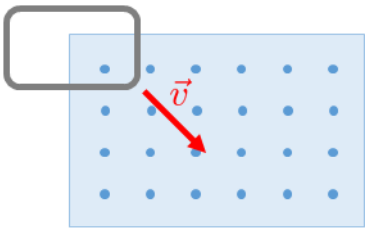
4.5) A conducting loop moves through a magnetic field as shown in the figures (a) to (c) below. Which way does the current run in the loop at the instant shown in each figure? [3]

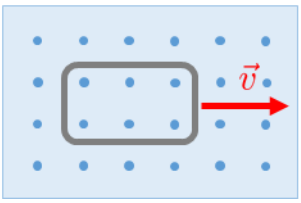
(a)



(b)



(c)

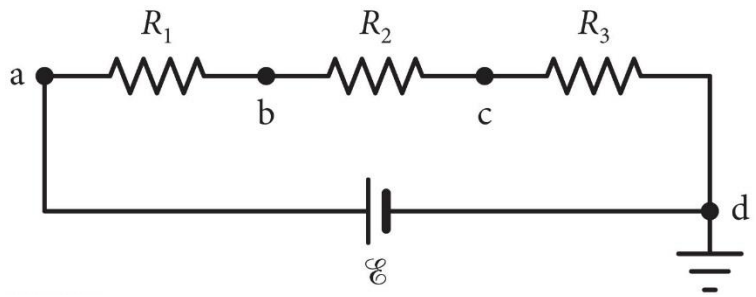


4.6) Show that the potential energy stored in the magnetic field of an inductor when there is current flowing through it is,

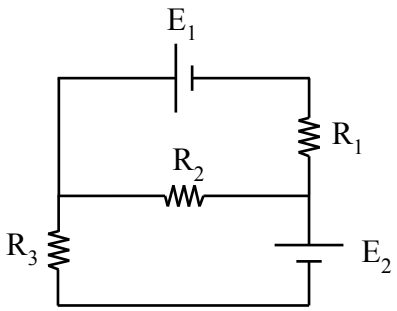
$$U^B = \frac{1}{2}LI^2.$$ [4]

QUESTION 5 [10]

5.1) (a) What is the equivalent resistance of the circuit in the below figure? Use the values R_1 = 10 Ω, R_2 = 60 Ω, and R_3 = 5 Ω. [1]
(b) What is the current in the circuit? Assume E = 15 V. [1]
(c) The electric potential at location *d* is defined to be 0, because the negative terminal of the battery is attached to ground. What is the electric potential at *c*? [2]



5.2) In the circuit below the sources have the values E_1 = 9 V, E_2 = 5 V. The resistors have the values R_1 = 2 Ω, R_2 = 8 Ω and R_3 = 5 Ω. Calculate the currents through the three resistors.



[6]

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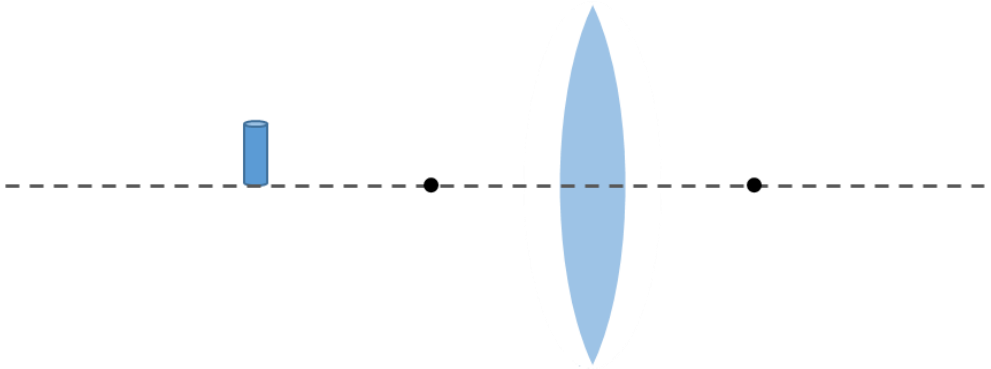
QUESTION 6 [9]

6.1) In the figure below is an object and a converging lens. The foci are marked by the black dots. What happens to the image when the object is shifted to the right? You **must draw** the relevant lens diagram(s). [3]



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6.2) Derive Snel's law. Use an appropriate figure and explain all the steps and symbols used. [6]

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