THE EMPEROR OF PHYSICS

KINGS

PHY 102

ELECTROMAGNETISM

SIMPLIFIED EDITION

FOR FIRST YEARS AND PREDEGREES

WITH **LECTURE NOTE, PAST QUESTIONS AND ANSWERS ON**

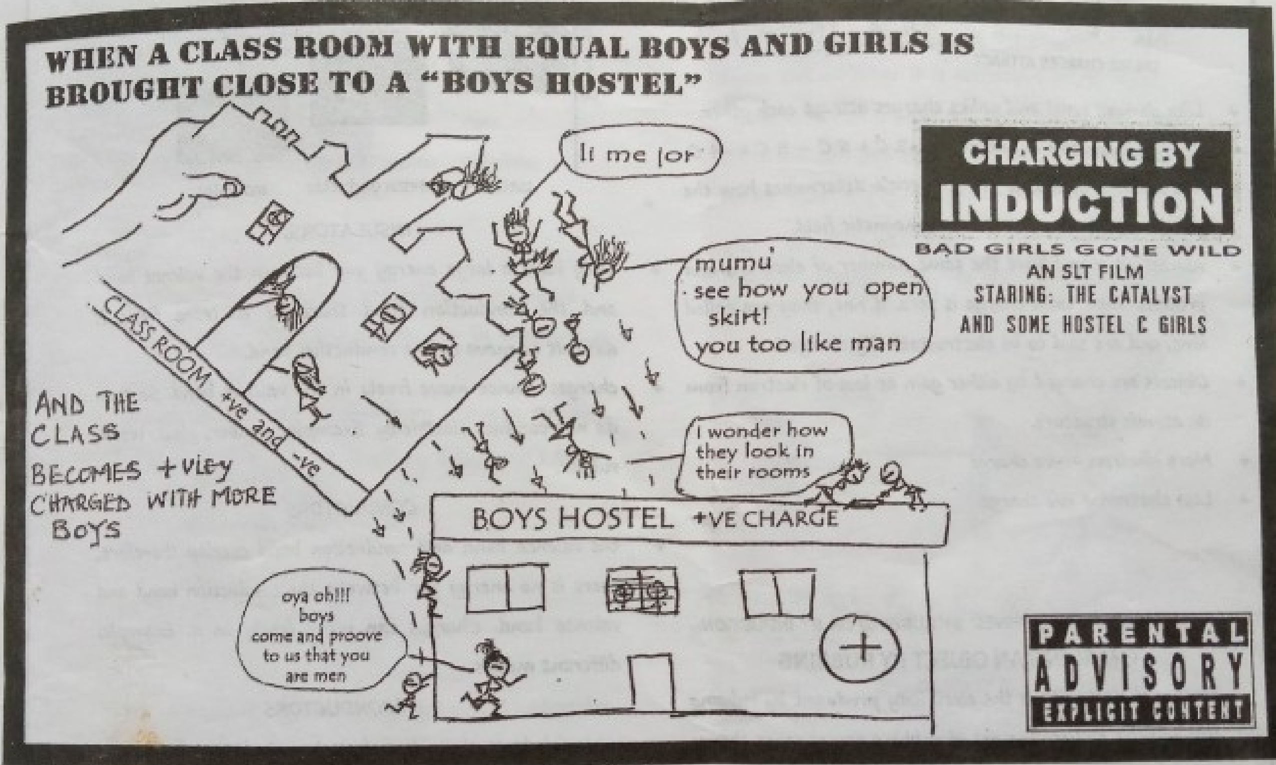
2017, 2016, 2015, 2014, 2013, 2012, 2011, 2010, 2009 EXAMS AND TESTS

PREPARE TO BLOW YOUR MINDS

AN LFX PRODUCTION

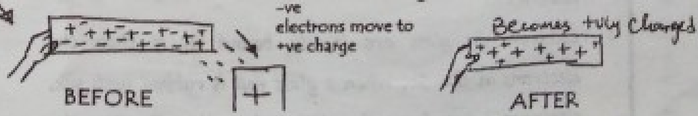
TABLE OF CONTENT

ELECTRIC CHARGE



WARNING ! that is not the diagram for Charging by Induction

This is The diagram for Charging by Induction



CHARLES AUGUSTINE DE COULOMB
A FRENCH MAN IN THE FIELD OF PHYSIC, HE WORKED ON THE FORCES BETWEEN CHARGES.
HE IS KNOWN FOR COULOMBS LAW

ALL FORMULARS NEEDED IN THIS TOPIC

* force between two Charges: $F = \frac{KQ_1Q_2}{r^2}$

$$K = \frac{1}{4\pi\varepsilon_0}$$

* Total Charge: $Q = \pm ne$

* Vector force on a Charge: $= \frac{KQ_1Q_2}{\left[\text{distance b/w the two Charges}\right]^2} \times \frac{\left[\text{Position of the Charge feeling the force}\right] - \left[\text{Position of the Charge Causing the force}\right]}{\left[\text{distance b/w the two Charges}\right]}$

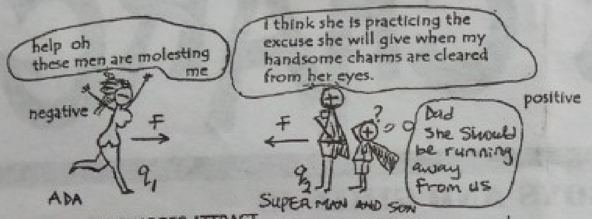
CONSTANTS

* Electron Charge = ($-$ve 1.60×10^{-19} C)
* Proton Charge = (+ve 1.60×10^{-19} C)
* $K = 9 \times 10^9 \ N \cdot m^2/C^2$
* $\varepsilon_0 = 8.85 \times 10^{-12} \ C^2/N \cdot m^2$
* mass of electron $= 9.11 \times 10^{-31}$ KG

ELECTRIC CHARGE

SUMMARY IN AN 'ALL YOU NEED TO KNOW' STYLE

- Electrostatics is the study of electrical phenomena that are associated with charges and charged systems at rest.
- Charge is a fundamental physical scalar quantity. Its unit is the Coulomb (C)
- There exists only two types of charges, namely positive and negative.



UNLIKE CHARGES ATTRACT

- Like charges repel and unlike charges attract each other.
- Charge is additive in nature. eg. $+2\ C + 5\ C - 3\ C = +4\ C$
- The amount of charge on a particle determines how the particle reacts to electrical and magnetic field.
- Almost all atoms have the same number of electrons and protons. Their total charge is zero. If not, they are called ions, and are said to be electrostatically charged.
- Objects are charged by either gain or loss of electron from its atomic structure.
- More electron = -ve charge
- Less electron = +ve charge

CHARGING CAN BE ATCHIVED BY RUBBING OR BY INDUCTION.

CHARGING AN OBJECT BY RUBBING

Frictional electricity is the electricity produced by rubbing two suitable bodies. The act of rubbing causes some charge to be transferred from one material to another.

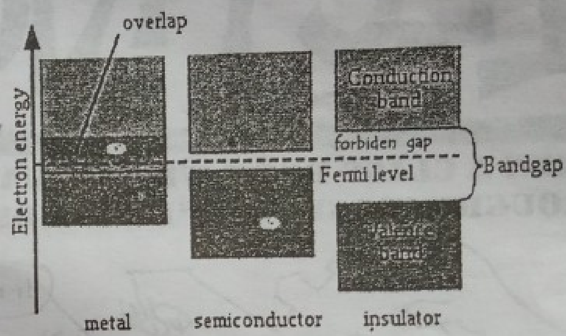
EXAMPLE;

- Electrons in glass are loosely bound in it than the electrons in silk. So, When a glass rod is rubbed with silk, electrons moves from the glass rod to the silk, then the glass rod becomes positively charged while the silk becomes negatively charged
- Similarly;

  Rubber + fur → (rubber -ve) + (fur +ve)
- The law of conservation of electric charges states that the net amount of electric charge produced in any process is zero.

BAND THEOREM AND CONDUCTION

- In the electronic arrangement of any object, electrons could either be in the valence band or the conduction band when excited.
- Electrons freely conducts electricity in the conduction band.
- The gap between the valence band and the conduction band for any material determines the electrical conductive nature of the material.



INSULATORS;

- They have a large energy gap between the valence band and the conduction band therefore electrons finds it difficult to move to the conduction band.
- charges cannot move freely in the valence band. So they do not conduct electricity. Examples; amber, glass, wood, rubber.

CONDUCTORS

- the valence band and conduction band overlap therefore, there is no energy gap between the conduction band and valence band. Charges can move freely on it. Example; different metals.

SEMICONDUCTORS

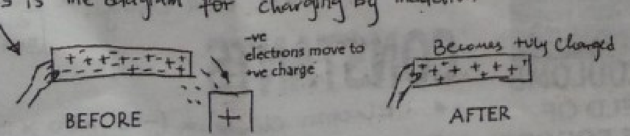
- materials have properties of electric conduction between insulator and conductor. There is a small energy gap between the valence band and the conduction band. Electrons or charges can get excited and jump to the conduction band.

QUANTIZATION OF CHARGES

- Electric charge exists in discrete packets rather than in continuous amount.

This is The diagram for charging by Induction

charging by induction is like charging by friction, but this time, the two objects does not touch each other



- It can be expressed in integral multiples fundamental electronic charge
- ($e = 1.6 \times 10-19$ C)
- Electron charge = (-ve 1.60×10^{-19} C)
- Proton charge = (+ve 1.60×10^{-19} C)
- Total charge $Q = \pm ne$ where $n = 1, 2, 3, \ldots\ldots\ldots$
- Where n = number of electron or proton
- e = charge of on electron or proton (1.60×10^{-19} C)

ELECTRIC FORCES AND COULOMB'S LAW

CHARLES-AUGUSTIN DE COULOMB

Born	14 June 1736 Angoulême, Angoumois, France
Died	23 August 1806 (aged 70) Paris, France
Nationality	French
Fields	Physics
Known for	Coulomb's law

- Electric force can be either attractive or repulsive (assume two charged particles can be modeled as point particles)
- The magnitude of the electric force between the two electric charges q_1 and q_2 is given by Coulomb's law.

$$\boxed{|F| = k\frac{q_1 q_2}{r^2}}$$

Since $k = \frac{1}{4\pi\varepsilon_0}$

$$\boxed{|F| = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}}$$

The constant $k = 9 \times 10^9$ N.m²/C²

$\varepsilon_0 = 8.85 \times 10^{-12}$ C²/N.m²

This force is repulsive for like charges and attractive for unlike charges.

EXAMPLE

Find the force of repulsion between the two charges.

Solution

$$F = \frac{kq_1q_2}{r^2} \quad \text{or} \quad F = \frac{q_1q_2}{4\pi\varepsilon_0 r^2}$$

$$= \frac{(9\times10^9)\times 5\times6}{4^2}$$

$$= 1.69\times10^{10}\ N$$

OK Now lets be less playful and more realistic.

$q_1 = 3\mu C$ ⊖ ← 2m → ⊕ $q_2 = 4\mu C$

Find the force of attraction between the $3\mu c$ and $4\mu c$ charges with a distance 2m between them.

Solution

$$F = \frac{kq_1q_2}{r^2}$$

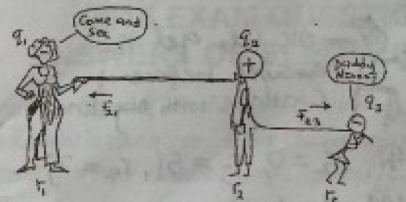
$$= \frac{(9\times10^9)\times(3\times10^{-6})\times(4\times10^{-6})}{2^2}$$

$$= 0.027N$$

VECTOR FORCE

the coulomb – law gives us the magnitude of the force and whether it is attractive or repulsive, but it does not give us the direction of the force. Only this can not be helpfull when there are forces from many charges on one charge.

OK, To describe vector force, lets use a positive charge q_2, in between two negative charges q_1 and q_3, with their positions r_1, r_2 and r_3.



Net force on $q_2 = F_{21} + F_{23}$ (Vector Sum)

$$F_{21} = \text{Force on } q_2 \text{ due to } q_1 = \frac{kq_2q_1}{(\text{dist b/w } q_2 \text{ and } q_1)^2} \times \left(\frac{\text{Position of } q_2 \text{ (Feeling)} - \text{Position of } q_1 \text{ (Causing)}}{\text{(dist b/w } q_2 \text{ and } q_1)}\right)$$

OR Simply

$$F_{21} = \frac{kq_2q_1}{(r_{21})^2} \times \frac{r_2 - r_1}{r_{21}}$$

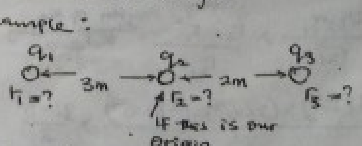
$$F_{23} = \text{Force on } q_2 \text{ due to } q_3 = \frac{kq_2q_3}{(\text{dist b/w } q_2 \text{ and } q_3)^2} \times \left(\frac{\text{Position of } q_2 \text{ (Feeling)} - \text{Position of } q_3 \text{ (Causing)}}{\text{(dist b/w } q_2 \text{ and } q_3)}\right)$$

OR $$F_{23} = \frac{kq_2q_3}{(r_{23})^2} \times \frac{r_2 - r_3}{r_{23}}$$

Before we solve an example problem, lets get a better understanding of position.

- $\hat{i}$ ⇒ means x axis
- $\hat{j}$ ⇒ means y axis
- The position is the distance from a selected origin.

Example:

① 

$r_1 = -3\hat{i}$ (position of q_1)

$r_2 = 0$ (Position of q_2)

$r_3 = 2\hat{i}$ (position of q_3)

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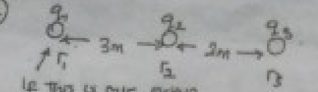
②



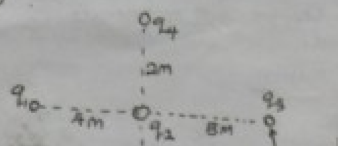
If this is our origin

$r_1 = 0$

$r_2 = 3i$

$r_3 = 5i$ ..... (3+2) from the origin.

③



$r_1 = -9i$

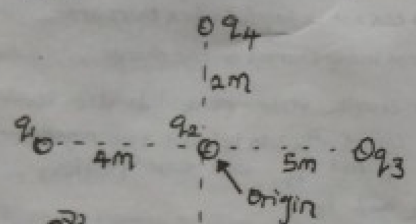
$r_2 = -5i$

$r_3 = 0$

$r_4 = (-5i + 2j)$

confused?....... go take a cup of cold smirnoff ice

Finally, try this on your own



— OK, lets get the answer before I Continue with my dinner

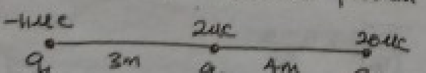
$r_1 = -4i,\ r_2 = 0,\ r_3 = 5i,\ r_4 = 2j$

Mind you, I'm holding a spoon with a hot food content not a stick of nush!!!

WEEDITES WILL UNDERSTAND

Any where you choose as your origin, following the positioning correctly, you will get your answer correctly.

OK now lets solve this problem



Find the net force on q2

Solution

$F_{2total} = F_{21} + F_{23}$

I want my origin to be at q_1

$$F_{21} = \frac{kq_2q_1}{r_{21}^2} \times \frac{r_2 - r_1}{r_{21}}$$

(r_2: position of the feeling; r_1: position of the charge causing the force)

$$F_{21} = \frac{(9\times10^9)\times(2\times10^{-6})\times(-11\times10^{-6})}{3^2} \times \frac{3i - 0}{3}$$

$= -0.022 \times i$

$= -0.022i$

$$F_{23} = \frac{kq_2q_3}{r_{23}^2} \times \frac{r_2 - r_3}{r_{23}}$$

$$= \frac{(9\times10^9)\times(2\times10^{-6})\times(20\times10^{-6})}{4^2} \times \frac{3i - 7i}{4}$$

$= 0.0225 \times -i$

$= -0.0225i$

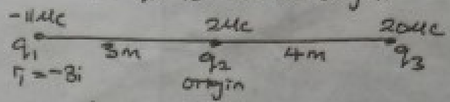
$F_2 = F_{21} + F_{23}$

$= (-0.022i) + (-0.0225i)$

$= -0.0445i\,N$

OK lets try if we would get a different answer;

lets choose q_2 to be the origin.



$F_2 = F_{21} + F_{23}$

$$F_{21} = \frac{kq_2q_1}{r_{21}^2} \times \frac{r_2 - r_1}{r_{21}}$$

$$= \frac{(9\times10^9)\times(2\times10^{-6})\times(-11\times10^{-6})}{3^2} \times \frac{0 - (-3i)}{3}$$

$= -0.022 \times i$

$= -0.022i$

$$F_{23} = \frac{kq_2q_3}{r_{23}^2} \times \frac{r_2 - r_3}{r_{23}}$$

$$= \frac{(9\times10^9)\times(2\times10^{-6})\times(20\times10^{-6})}{4^2} \times \left(\frac{0 - 4i}{4}\right)$$

$= 0.0225 \times i$

$= -0.0225i$

$F_2 = F_{21} + F_{23}$

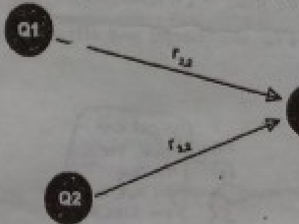
$= (-0.022i) + (-0.0225i)$

$= -0.0445i\,N$

Same answer. ☺

Try choosing r_3 as your origin.

Example; to find the total force on charge Q3



$F_{31} = k\frac{Q_3Q_1}{r_{31}^2} \cdot \frac{r_3 - r_1}{r_{31}}$

$F_{32} = k\frac{Q_3Q_2}{r_{32}^2} \cdot \frac{r_3 - r_2}{r_{32}}$

- Calculate the individual forces F_{31} and F_{32}
- Total them up using vector addition → $F_{3\,total}$

Make sure to watch the signs!

From the equation above,

F_{31} = force on Q3 due to Q1

F_{32} = force on Q3 due to Q2

r_{31} = distance between Q3 and Q1

r_{32} = distance between Q3 and Q2

r_1 = position of Q1

r_2 = position of Q2

r_3 = potision of Q3

remember, direction for the force can be understood as;

$$\frac{\text{(the position of feeler} - \text{position of the causer of the force)}}{\text{distance between them}}$$ (kings terms)

FUTO PAST QUESTION ON ELECTRIC CHARGE 2016 - 2009

THIS TOPIC WILL BE UNDERSTOOD BETTER AFTER GOING THROUGH THE SOLUTIONS TO THESE ELECTRIC CHARGE PAST QUESTIONS

2016 EXAM QUESTION AND ANSWERS ON ELECTRIC CHARGE

32. What is the magnitude of the electrostatic force of attraction between an α-particle and an electron 10^{-14}m apart? A. 2.30×10^{-16}N B. 2.30×10^{-2}N C. 4.61N D. 4.61×10^{-14}N E. 4.61×10^{-2}N

In this question, we are looking for magnitude alone, so we do not need the vector formular.

From the question.

q_1 = Charge of an α particle = 3.2×10^{-19}C

q_2 = Charge of an electron = -1.6×10^{-19}C

$$F = \frac{Kq_1q_2}{r^2}$$

$$= \frac{(9\times10^9)\times(3.2\times10^{-19})(1.6\times10^{-19})}{(10^{-14})^2}$$

← we ignore the -ve sign for the charge of the electron bcos we are looking for magnitude alone

$$= 4.61\text{N}$$

46. Which of these is not true? i) In a conductor electrons move about freely. ii) A hot conductor conducts electrons more feely than one at normal temperature. iii) Both electrons and holes are involved in conducting current in a semiconductor. iv) The energy bandgap in a conductor is wider than that of insulators. A. i) only B. ii) and iv) C. ii) and iii) D. iii) only E. iv) only

46) E

47. A neutral body can be charged by ... i) induction. ii) friction. iii) conduction. iv) heating. A. i) and iii) only B. i) and ii) only C. ii) only D. i), ii) and iii) E. ii) and iv) only

47) A

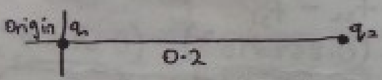
48. Two positive charges of magnitudes $q_1=1.6\times10^{-19}$C and $q_2=3.2\times10^{-19}$C are located a distance of 20cm apart along the x-axis, with q_1 at the origin. Find the force on q_1 due to q_2. A. -1.15×10^{-24}Ni B. -2.3×10^{-26}Ni C. 1.15×10^{-30}Ni D. -2.3×10^{-29}Nj E. 4.6×10^{-28}Nj

48) From the question

$q_1 = 1.6\times10^{-19}$

$q_2 = 3.2\times10^{-19}$

$d = 20\text{cm} = 0.2\text{m}$



$$F_{12} = \frac{Kq_1q_2}{d^2}\times\frac{r_1-r_2}{d}$$

$$= \frac{(9\times10^9)(1.6\times10^{-19})(3.2\times10^{-19})}{(0.2)^2}\times\frac{0i-0.2i}{0.2}$$

$$= 1.152\times10^{-26}\text{N}\times(-i)$$

$$= -1.152\times10^{-26}\text{N}\,i$$

49. If the distance between two point charges is doubled, the force between them is decreased by ... A. 2 times B. 9 times C. 4 times D. 8 times E. 6 times

49) $F = \frac{Kq_1q_2}{r^2}$

when the distance is doubled

$$F = \frac{Kq_1q_2}{(2r)^2} = \frac{1}{4}\frac{Kq_1q_2}{r^2}$$

$$= \frac{1}{4}F$$

= decreased by 4 times

50. How many electrons must be removed from a neutral body to leave a net charge of 0.5μC? A. 3.13×10^{12} B. 8×10^{18} C. 1.6×10^{-19} D. 9.1×10^{-32} E. 1.6×10^{19}

Solution

$Q = ne$

$n = Q/e$

$$= \frac{0.5\times10^{-6}}{1.6\times10^{-19}}$$

$$= 3.13\times10^{12}$$

51. The energy gap between the bottom of the conduction band and top of the valence band in semiconductors is ... A. less than that in conductors B. greatest in all solids C. greater than in conductors D. equal to that in conductors E. equal to that in insulators

51) C

2015 TEST QUESTION ON ELECTRIC CHARGE

1) An α particle has mass of 6.6×10^{-27} kg and charge of 3.2×10^{-19}C. Find the ratio of the magnitudes of the electric repulsion and the gravitational attraction between two α particles.

D Electric Force $(F_E) = \frac{Kq_1q_2}{r^2}$

Gravitational Force $(F_G) = \frac{GM_1M_2}{r^2}$

$$\text{Ratio} = F_E/F_G = \left[\frac{Kq_1q_2}{r^2}\right]\Big/\left[\frac{GM_1M_2}{r^2}\right] = \frac{Kq_1q_2}{GM_1M_2}$$

$$= \frac{(9\times10^9)\times(3.2\times10^{-19})\times(3.2\times10^{-19})}{(6.67\times10^{-11})\times(6.6\times10^{-27})\times(6.6\times10^{-27})}$$

$$= 3.17\times10^{35}$$

2015 EXAM QUESTION AND ANSWERS ON ELECTRIC CHARGE

6. One of the following is the fundamental law of electrostatics A. Unlike charges look similar in appearance B. Like Charges repel each other C. Like charges attract each other D. Unlike charges repel each other E. Line of force cross each other

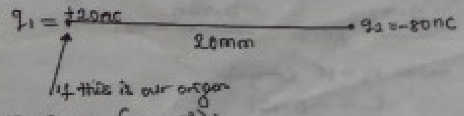
ANS= B

10. Which of the following statements is not true?
A. Two unlike charges attract each other B. Charges can always be created C. A plastic rod rubbed with a fur and a glass rod rubbed with a silk will attract each other when brought close to each other D. When a plastic rod is rubbed with a fur, both objects acquire a net charge, and their net charges are always equal in magnitude and opposite in sign E. Two like charges repel each other

ans.....B

41. Two point charges q1 = +20nC and q_2 = -80nC are separated by a distance of 20mm. Find the magnitude and direction of the electric force that q_1 exerts in q_2. A. 0.036N directed towards q_1 along the line joining the charges B. 0.036N directed away from q_2 C. 0.720N directed towards q_1 along the line joining the two charges D. 0.720N directed away from q_1 E. 0.360N directed towards q_2 along the line joining the two charges.

41]



$r_1 = 0,\; r_2 = (20\times10^{-3})i$

$$F_{21} = \frac{Kq_1q_2}{r^2}\left(\frac{r_2-r_1}{r}\right)$$

$$F_{21} = \frac{(9\times10^9)\times(20\times10^{-9})\times(-80\times10^{-9})}{(20\times10^{-3})^2}\times\left[\frac{(20\times10^{-3})i-0}{(20\times10^{-3})}\right]$$

$$= 0.036\times i$$

$$= -0.036i$$

or 0.036N, directed towards q_1 along the line joining the charges - - - - Ans A//

46.Two point charges $q_1 = +25nC$ and $q_2 = -75nC$ are separated by a distance r = 3.0cm. Find the magnitude of the electric force that q_1 exerts on q_2 A. 0.019N B. 0.19N C. 0.0019N D. 1.90N E. 19.0N

TRY THIS ON YOUR OWN

NOTE: WE ARE LOOKING FOR JUST THE MAGNITUDE SO THE -VE SIGN CAN BE IGNORED

ANS........ A

57. Which of these is correct when two glass rods are charged by vigorously rubbing them with silk cloths and are brought close to each other? i) The two rods repel themselves ii) They possess negative charges iii) they attract themselves iv) They possess positive charges A. I only v B. i and iv only C. i and ii only D. iii only E. i and iii only **ans......B**

2014 EXAM QUESTION AND ANSWERS ON ELECTRIC CHARGE

2013 / 2014 QUESTIONS ON ELECTRIC CHARGE

1. What is the force exerted by a charge 2.3×10^{-19} C on another charge -2.3×10^{-15}C at a distance 2×10^{-10}m away? A. -1.19×10^{-8}N B. 1.19×10^{-8}N C. 11.9×10^{-8}N D. -11.9×10^{-8}N E. -11.9×10^{-7}N

SOLUTION

FROM THE PARAMETERS GIVEN,

1) $Q_1 = 2.3\times10^{-19}c$

$Q_2 = -2.3\times10^{-19}c$

$r = 2\times10^{-10}m$

$K = 9\times10^{9}$

$$F = \frac{KQ_1Q_2}{r^2} = \frac{(9\times10^{9})\times(2.3\times10^{-19})\times(2.3\times10^{-19})}{(2\times10^{-10})^2}$$

Note: we ignored the -ve sign in Q_2 cos we are not dealing with vector force.

$$= \underline{1.19\times10^{-8}N} \text{ ------(B)}$$

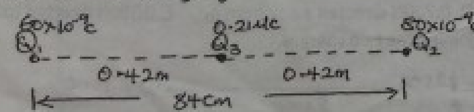
9. Which of these is not correct? A. In conduction band the electrons can move freely B. There is no forbidden band in insulators C. current is due to motion of holes and electrons in semiconductors D. valence band and conduction band overlap in conductors E. The total current in conductors is simply a flow of electrons.

9) Solution

(B)-------(There is no forbidden band in insulators)

11. A charge of 60 X10^{-9}C is 84cm from a charge of 80 X 10^{-9}C. What force will these charges exert on a charge of 0.21μC placed half way between then? A. 63.3 X 10^{-5}N B. 85.7 X 10^{-5}N C. 150 X 10^{-5}N D. 75.0 X 10^{-5}N E. 42.8 X 10^{-5}N

This is one way you can solve this question



let's take $r_3 = 0$ (origin)

$r_1 = -0.42i$

$r_2 = 0.42i$

$$F_{31} = \frac{KQ_1Q_3}{r_{31}^2} \times \frac{r_3 - r_1}{r_{31}}$$

$$= \frac{(9\times10^{9})(60\times10^{-9})(0.21\times10^{-6})}{(0.42)^2} \times \left[\frac{0-(-0.42i)}{0.42}\right]$$

$$= 0.64\times10^{-3} \times i$$

$$= 0.64\times10^{-3}iN$$

$$F_{32} = \frac{KQ_3Q_2}{r_{32}^2} \times \frac{r_3 - r_2}{r_{32}}$$

$$= \frac{(9\times10^{9})(0.21\times10^{-6})(80\times10^{-9})}{(0.42)^2} \times \frac{0-0.42i}{0.42}$$

$$= 0.857\times10^{-3} \times -i$$

$$= -0.857\times10^{-3}i\,N$$

Total $F_3 = F_{31} + F_{32}$ (algebraic sum)

$$= (0.64\times10^{-3}i) + (-0.857\times10^{-3}i)$$

$$= -0.217\times10^{-3}i$$

magnitude $= \underline{0.217\times10^{-3}N}$

this is another way to solve that same question

11. A charge of 60 X10^{-9}C is 84cm from a charge of 80 X 10^{-9}C. What force will these charges exert on a charge of 0.21μC placed half way between then? A. 63.3 X 10^{-5}N B. 85.7 X 10^{-5}N C. 150 X 10^{-5}N D. 75.0 X 10^{-5}N E. 42.8 X 10^{-5}N

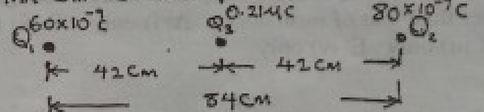
11) Solution

$Q_1 = 60\times10^{-9}C$

$Q_2 = 80\times10^{-9}C$

$q_3 = 0.21\mu C = 0.21\times10^{-6}$

This can be drawn as:



42cm = 0.42m

$$F_{31} = \frac{KQ_1Q_3}{r^2} = \frac{(9\times10^{9})\times(60\times10^{-9})\times(0.21\times10^{-6})}{(0.42)^2}$$

$F_{31} = 0.64\times10^{-3}N$ to the right

$$F_{32} = \frac{KQ_3Q_2}{r^2} = \frac{(9\times10^{9})\times(0.21\times10^{-6})\times(80\times10^{-9})}{(0.42)^2}$$

$F_{32} = 0.857\times10^{-3}N$ to the left

Since they are 2 opposite forces, we subtract the smaller force from the bigger one

$$= F_{32} - F_{31}$$

$$= (0.857\times10^{-3}) - (0.64\times10^{-3})$$

$$= \underline{0.217\times10^{-3}N}$$ (no right option)

This is another way of finding net force without using unit vector. you have to understand the direction of forces and how to resolve forces

14. The ratio of electric force to the force of gravity between electrons and protons in an atom of radius r = 5.3 x 10^{-11}m is A. 8.2 X 10^{-8} B. 3.7 X 10^{-47} C. 11.9 X 10^{-8} D. 2.2 X 10^{39} E. 11.9 X 10^{47}

SOLUTION

the values for charges of proton and electron and their masses will be given to you in the instruction of the question paper

14) $$\left[\frac{KQ_1Q_2}{r^2}\right] \Big/ \left[\frac{GM_eM_p}{r^2}\right] = \frac{KQ_1Q_2}{GM_eM_p}$$

$$= \frac{(9\times10^{9})\times(1.6\times10^{-19})(1.6\times10^{-19})}{(6.67\times10^{-11})\times(9.11\times10^{-31})\times(1.67\times10^{-27})}$$

$$\cdot\ \underline{2.27\times10^{39}} \text{ ---------(D)}$$

22. When the distance between charges is halved, the electrical force between them ___? A. Quadruples B. Doubles C. halves D. reduces to one fourth E. None of the above

SOLUTION

22) $F = \frac{KQ_1Q_2}{(r/2)^2} = \frac{4KQ_1Q_2}{r^2}$

= Quadruples .... (A)

23. Two equally charged pith balls are 3cm apart and repel each other with a force of $4X10^{-5}$ N. Compute the charge on each ball. A. $3 X 10^{-9}$C B. $3 X 10^{9}$C C. $2 X 10^{-9}$C D. $2 X 10^{9}$C E. 18.6C

23) Solution

$r = 3cm = 0.03m$

$F = 4\times10^{-5}N$

from the formular,

$F = \frac{Kq_1q_2}{r^2}$

$F = \frac{Kq^2}{r^2}$ .... $(q_1 = q_2)$

$q = \sqrt{\frac{Fr^2}{K}} = \sqrt{\frac{(4\times10^{-5}) \times 0.03^2}{9\times10^9}}$

$= 2\times10^{-9}C$ .... (C)

24. How many electrons must be removed from a neutral object to leave a net charge of 0.500μC? A. $1.6 X 10^{-19}$ B. $3.13 X 10^{12}$ C. $8 X 10^{13}$ D. $5 X 10^{6}$ E. $1.25 X 10^{10}$

SOLUTION

24) from $Q = \pm nq$

$n = \frac{Q}{q} = \frac{0.5\times10^{-6}}{1.6\times10^{-19}}$

$= 3.13\times10^{12}$ .... (B)

2012 / 2013 QUESTIONS ON ELECTRIC CHARGE

1) The electronic properties of solid which explains the conduction of conductors, insulators and semiconductors is the (A) Valence theory (B) Electron theory (C) group theory (D) band theory (E) conduction theory

1) Band theory (D)

2) Two equal point charges are situated in vacuum 50cm apart in a straight line. If they repel each other with a force of 0.1N what is the magnitude of each charge (A) 1.7μC (B) 17.0μC (C) 0.17μC (D) 1.7C (E)none of the above

2) This is a question on Scalar force (Position of Charge not given)

Using the formular:

$F = \frac{Kq_1q_2}{r^2}$

$q_1 = q_2$ .... (two equal Point Charge)

$k = 9\times10^9$ ..... (Same in vaccum and free air)

$r = 50cm = 0.5m$

$F = 0.1N$

$F = \frac{Kq^2}{r^2}$ .... (q^2 since $q_1 = q_2$)

Making q subject of the formular

$q = \sqrt{\frac{Fr^2}{K}}$

$q = \sqrt{\frac{0.1 \times 0.5^2}{9\times10^9}}$

$= 1.7\times10^{-6}C$

$= 1.7\mu C$ KING'S ANS

3) Which of the following statement is correct (A) electrostatics is the study of electrical phenomenon that is associated with charges and charge system at rest (B) electrostatics is the study of electrical phenomenon that are associated with charges and charge system in motion (C) electrostatics is the study of electrical phenomenon that is associated with charges and charge system partially in motion (D) all of the above (E) none of the above

3) Electrostatics is the study of electrical Phenomenon that is associated with charges and charge System at rest.

(A)

4) In experiment on static electricity, the standard for obtaining positive charge to avoid damping is by rubbing (A) glass rod with fur (B) ebonite rod with silk (C) glass rod with silk (D) glass rod with cellulose acetate (E) ebonite rod with fur

4) glass rod with silk (C)

5) Two charges Q1=400 μC and Q2 =200μC are located on the XY plane at the positions r1=3j *m* and r2 =4i *m*. find the force exerted on Q1 (A) (17.28i +23.04j)N (B) (-17.28j + 23.04i)N (C) (-23.04i + 17.28j)N (D) (-23.04I – 17>28j)N (E) (-23.04i + 17.28j)N

SOLUTION

5) Now let's get a better understanding of vector force.

The formular states;

$\text{Force (vector)} = \left[\text{Coulombs law for Force}\right] \times \left[\text{Unit Vector}\right]$

$= \frac{KQ_1Q_2}{\left[\text{distance b/w the two Charges}\right]^2} \times \left[\frac{\left[\text{Position of the Charge Feeling the Force}\right] - \left[\text{Position of the Charge Causing the Force}\right]}{\left[\text{distance b/w the two Charges}\right]}\right]$

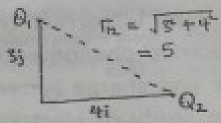
Since from the question, Q_1 is feeling the Force (The Force exerted on Q_1)

The formular Could be Shortened to

$F_{12} = \frac{KQ_1Q_2}{r_{12}^2} \times \left[\frac{r_1 - r_2}{r_{12}}\right]$

where: r_1 = Position of Q_1 (feeling)
r_2 = Position of Q_2 (causing)
F_{12} = Force on Q_1 due to Q_2
r_{12} = distance b/w Q_1 and Q_2

Now in diagram form:
3j ⇒ 3 units in the j or y axis } Positions of
4i ⇒ 4 units in the i or x axis } Q_1 and Q



Subst. back to formular

$$F_{12} = \frac{(9\times10^9)\times(400\times10^{-6})\times(200\times10^{-6})}{5^2} \times \left[\frac{3j-4i}{5}\right]$$

$$F_{12} = 28.8 \times [0.6j - 0.8i]$$

$$= 17.28j - 23.04i$$

writing i before j, we have

$$F_{12} = \underline{-23.04i + 17.28j} \quad (C)$$

6) The only sure test for the sign of a charge on abody in a gold leaf experiment is to obtain (A) a decrease in divergence (B) an increase in divergence (C) both increase and decrease in divergence (D)no deflection (E) none of the above

6) An increase in divergence only (B)

The gold leaf electroscope consists of two strips of gold leaves which are movable. The leaves are connected by a metal rod to a metal knob outside the case. The rod is insulated from the case. When a charged glass rod is brought near the metal knob, a separation of charge takes place. The two leaves become positively charged and repel each other. When the charging glass is removed, the charges in the conductor no longer remain separated and the leaves collapse. If we now touch the metal knob with the charging rod, the whole apparatus become charged by conduction and the leaves diverge. The angular divergence of the leaves is proportional to the quantity of charge on the leaves.

32) Which of the following statement is not true? (A) a semiconductor can conduct electricity (B) an insulator has a smaller band gap than a semiconductor (C) an insulator has a larger band gap than a semiconductor (D) a semiconductor is a perfect insulator at 0K (E) none of the above

32) "An insulator has a smaller band gap than a semi conductor" is not true (B)

33) Two identical positive ion separate by a distance of 5×10^{-10}m has a force of 3.7N between them. The charge on each ion is (A) 3.2×10^{-19}C (B) 2.89×10^{-19}C (C) 1.01×10^{-18}C (D) 8.33×10^{-18}C (E) 3.2×10^{19}c

33) from the question, we use the equation

$$F = \frac{Kq_1q_2}{r^2}$$

$$F = \frac{Kq^2}{r^2} \quad \left(\begin{matrix}\text{since } q_1 = q_2 \text{ ie identical} \\ q_1q_2 = q^2\end{matrix}\right)$$

making q subject of the formular

$$q = \sqrt{\frac{Fr^2}{K}}$$

from the question
$r = 5\times10^{-10}m$
$F = 3.7nN \equiv 3.7\times10^{-9}N$
and $K = 9\times10^9\ Nm^2C^{-2}$ ...... (For free space and vacuum)

$$q = \sqrt{\frac{(3.7\times10^{-9})(5.0\times10^{-10})^2}{9\times10^9}}$$

$$= \underline{3.2\times10^{-19}C} \ \ldots\ldots\ A$$

2011 / 2012 QUESTIONS ON ELECTRIC CHARGE

1. Three point charges located at the corners of a triangle where q1 = q3 = 5.0 μC,qz = - 0.20 μC are seperated by a distance b = 0.20 m. Find the magnitude of force exerted on q3 by q1 ________

1) Solution

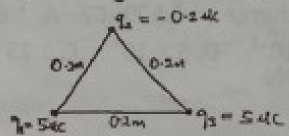
From the question, the given parameters are:

$q_1 = q_3 = 5.0\mu C = 5\times10^{-6}C$

$q_2 = -0.20\mu C = -0.2\times10^{-6}C$

$F_{31} = ?$ .... (Force on Q_3 due to Q_1)

representing with diagram, we have.



To find F_{31} we use the formular

$$F_{31} = \frac{Kq_3q_1}{r^2} \quad \ldots\ldots$$ (we are not using the unit vector because we are told to find magnitude only and positions are not given)

$$= \frac{(9\times10^9)\times(5\times10^{-6})\times(5\times10^{-6})}{(0.2)^2}$$

$$= \underline{5.625N}$$

2. Which of the solid matter has overlapping band structure? ____________

2) ANSWER ⇒ Conductors

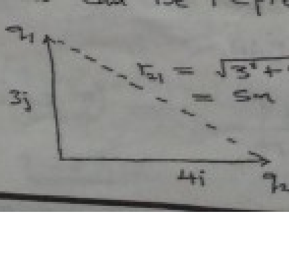
3. Two charges Q1 = 500 μC and Q2 = 100 μC are located on the XY planee at the positions r1 = 3J m and r2 = 4I m. Find the force exerted on Q2 ____________

3) Solution

From the question
$Q_1 = 500\mu C \equiv 500\times10^{-6}C$
$Q_2 = 100\mu C \equiv 100\times10^{-6}C$
$r_1 = 3j$ (position of q_1)
$r_2 = 4i$ (position of q_2)

$F_{21} = ?$

This can be represented as:



Using the formular

$$F_{21} = \frac{Kq_1q_2}{r_{21}^2} \cdot \frac{r_2 - r_1}{r_{21}} \longrightarrow \text{Note } \frac{\left(\begin{smallmatrix}\text{Position} \\ \text{of} \\ \text{Feeling}\end{smallmatrix}\right) - \left(\begin{smallmatrix}\text{Position} \\ \text{of} \\ \text{Cause}\end{smallmatrix}\right)}{\left(\begin{smallmatrix}\text{distance b/w} \\ \text{Charges}\end{smallmatrix}\right)}$$

$$F_{21} = \frac{9\times10^9 \times 500\times10^{-6} \times 100\times10^{-6}}{5^2} \cdot \frac{4i - 3j}{5}$$

$$= 18 \cdot (0.8i - 0.6j)$$

$$= (14.4i - 10.8j)\,N$$

2010 / 2011 QUESTIONS ON ELECTRIC CHARGE

1. Object A repels object B and attracts object C. Object C repels object D. If D is positively charged, what kind of charge does B have?

① Solution

$\overset{-}{(A)} \longleftrightarrow \overset{-}{(B)} \qquad \overset{+}{(C)} \longleftrightarrow \overset{+}{(D)}$

Note: Like charges repel while unlike charges attract

If D is positively charged and repels C then C is positively charged

If C attracts A, then A is negatively charged

If A repels B, then B is negatively charged

B = Negative charge

2. A plastic rod is rubbed against a wool shirt, thereby acquiring a charge of -0.8μC. How many electrons are transferred from the wool shirt to the plastic rod?

2) Solution

From the question

$Q = -0.8\mu C = -0.8\times10^{-6}\,C$

$q = -1.6\times10^{-19}$ ...... (Charge of an electron)

$n = ?$ .... (number of electron)

Using Quantization formular

$Q = \pm nq$ (or $Q = \pm ne$)

Making n subject of the formular

$$n = \frac{Q}{q}$$

$$= \frac{-0.8\times10^{-6}}{-1.6\times10^{-19}}$$

$= 4.99\times10^{12}$ electrons

3. Which of the following solid matters have no overlapping bands? (I) Conductors (ii) semiconductors (iii) insulators?

3) Solution

Semiconductors and insulators have no overlapping band. Only conductors have overlapping band.

∴ Answer = (ii) and (iii)

4. The mathematical statement of Coulomb's law for two charged particles in vacuum is............

4) Ans

The mathematical statement of Coulomb's law for two charged particles in a vacuum is:

$$F = \frac{Kq_1q_2}{r^2}$$

8. Three charges Q_1=6.0μC, Q_2=-6.0μC and Q_3=4.0μC are located at -0.6î, 0.6î and 0.8ĵ respectively. Find the (vector) force on Q_3 due to Q_1

8) Solution

From the question

$Q_1 = 6.0\mu C = 6\times10^{-6}C$

$Q_2 = -6.0\mu C = -6\times10^{-6}C$

$Q_3 = 4.0\mu C = 4\times10^{-6}C$

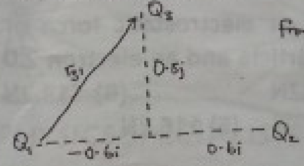
$r_1 = -0.6i$

$r_2 = 0.6i$

$r_3 = 0.8j$

$F_{31} = ?$

This can be drawn as:



From the diagram

$r_{31} = \sqrt{0.8^2 + (-0.6)^2}$

$= 1$

We now use the formular

$$F_{31} = \frac{KQ_3Q_1}{r_{31}^2} \times \frac{r_3 - r_1}{r_{31}} \longrightarrow \frac{\left(\begin{smallmatrix}\text{Position} \\ \text{of Feel}\end{smallmatrix}\right) - \left(\begin{smallmatrix}\text{Position of} \\ \text{Cause}\end{smallmatrix}\right)}{\left(\begin{smallmatrix}\text{distance b/w} \\ \text{Them}\end{smallmatrix}\right)}$$

Note for the last time. This is a warning ☺

$$F_{31} = \frac{9\times10^9 \times 6\times10^{-6} \times 4\times10^{-6}}{1^2} \times \frac{0.8j - (-0.6i)}{1}$$

notice how the position of q_1 (r_1) still carries -ve sign

$F_{31} = 0.216 \times (0.8j + 0.6i)$

$= 0.17j + 0.13i$

Which can be arranged alphabetical as

$F_{31} = (0.13i + 0.17j)\,N$

2009 / 2010 QUESTIONS ON ELECTRIC CHARGE

41. Which of the following is not true? (A) In solids, electrons have energies restricted to only certain levels (B) the energy level in solids are confined to bands (C) In conductors there are no energy gaps between bands (D) In semi- conductors, the energy gaps between the filled and empty bands are energetically close.

41) Solution

"In solids, electrons have energies restricted to only certain levels" is not correct because electrons can jump from one energy level to another with respect to energy gained or lost.

eg: when electrons gains energy, it jumps from the valence band to the conduction band where the material can now conduct electricity

Ans. (A) is not correct.

42. The magnitude of the electrostatic force between two identical ions that are separated by a distance of 5 x 10^{-10} m is 3.7 x 10^{-9} N. What is the charge on the ion? (A) 1.03 x 10^{-37}C (B) 3.2 x 10^{-19}C (C) 2.0 x 10^{-19} C (D) 18.5 x 10^{-19}C

42) Solution

From the question:

$r = 5\times10^{-10}m$

$F = 3.7\times10^{-9}N$

$q = ?$

notice the difference b/w vector force questions and normal force questions

We use the formula

$$F = \frac{Kq_1q_2}{r^2}$$

Since q_1 and q_2 are identical

$$F = \frac{Kq^2}{r^2}$$

making q the subject of the formular

$$q = \sqrt{\frac{Fr^2}{K}}$$

$$= \sqrt{\frac{(3.9\times10^{-7})\times(5\times10^{-10})^2}{(9\times10^9)}}$$

$$= \underline{3.2\times10^{-19}C} \quad \ldots\ldots \ (B)$$

43. What is the magnitude of electrostatic force of attraction between an α – particle and an electron 2.0 x 10-15 m apart? (A) 112.2N (B) 113.2N (C) 114.2N (D) 115.2N (E) 116.2N

43) Solution

from the question we have:

alpha particle (α) $= +2e = [2\times(1.6\times10^{-19})]$

electron (e) $= -e = -1.6\times10^{-19}$

distance b/w (r) $= 2.0\times10^{-15}$

$F = ?$

in solving the question, we are going to ignore negative signs. Cas it is not a vector force quest

$$F = \frac{Kq_1q_2}{r^2}$$

$$= \frac{K(2e)(e)}{r^2}$$

$$= \frac{9\times10^9\times(2\times1.6\times10^{-19})\times(1.6\times10^{-19})}{(2\times10^{-15})^2}$$

$$= \underline{115.2\,N} \ \ldots\ldots (D)$$

45. Two charges Q_1 = 500μC and Q_2 = 100μC are located on the xy plane at the positions r_1 = 3jm and r_2 = 4.0im. Find the force exerted on Q_2. (A) (4.2i +18j) N (B) (2.2i – 10j) N (C) (4.0i – 3.0j)N (D) (14.4i – 10j) N (E) (16.2i + 98j) N.

45) Solution

From the question

$Q_1 = 500\mu C = 500\times10^{-6}C$

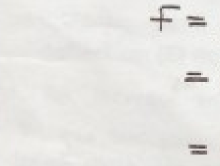
$Q_2 = 100\mu C = 100\times10^{-6}C$

$r_1 = 3j$ (position of q_1)

$r_2 = 4i$ (position of q_2)

$F_{21} = ?$

This can be represented as:



Using the formular

$$F_{21} = \frac{Kq_1q_2}{r_{21}^2}\cdot\frac{\bar{r}_2-\bar{r}_1}{r_{21}} \longrightarrow \text{Note } \frac{(\text{Position of Feeling}) - (\text{Position of Cause})}{(\text{distance b/w Charges})}$$

$$F_{21} = \frac{9\times10^9\times500\times10^{-6}\times100\times10^{-6}}{5^2}\cdot\frac{4i-3j}{5}$$

$$= 18 \cdot (0.8i - 0.6j)$$

$$= (14.4i - 10.8j)\,N.$$

46. How many electrons would have to be removed from a coin to leave it with a charge +1.0 x 10^{-7}C? (A) 6.25 x 10^{11} (B) 2 (C) 900 (D) 7.9 x 10^5 (E) 1

46) Solution

From the question

electron (e) $= 1.6\times10^{-19}$

$+1.0\times10^{-7} \rightarrow -1.0\times10^{-7}$

Number of electrons removed = number of proton that results to $+1.0\times10^{-7}C$

So, finding the number of protons, we use

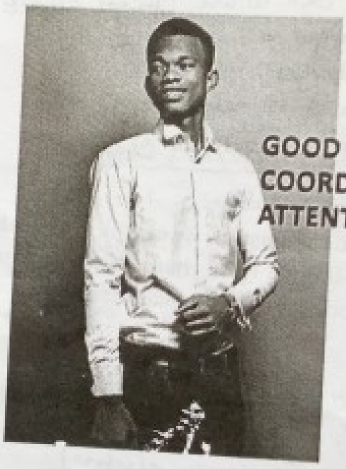
$$Q = \pm nq$$

$$n = Q/q = \frac{1.0\times10^{-7}}{1.6\times10^{-19}}$$

$$= 6.25\times10^{11} \text{ Protons}$$

$$= \underline{6.25\times10^{11} \text{ electrons}} \ \ldots\ldots A$$

BEFORE WE CONTINUE, LET'S RECOGNIZE SOME IMPORTANT INDIVIDUALS THAT CAUGHT OUR ATTENTION



PHYSIOLOGY COURSE REPRESENTATIVE

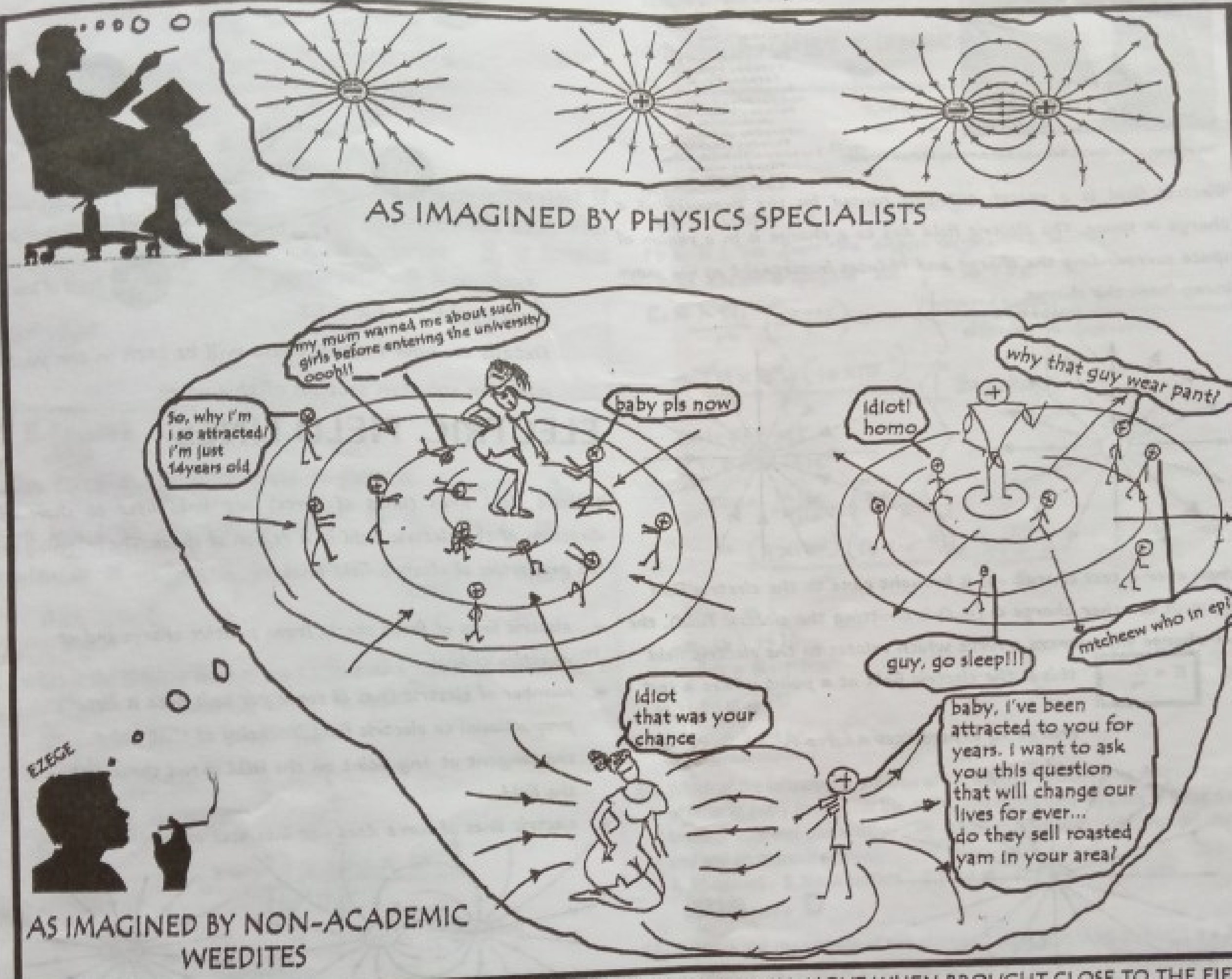
GOOD LEADERSHIP QUALITY, WELL COORDINATED, AND HIGHLY ATTENTIVE TO DETAILS

BMT COURSE REPRESENTATIVE

GENTLE, RESERVED AND WELL ARTICULATED. HE IS A GREAT REP. FROM A GREAT DEPT.

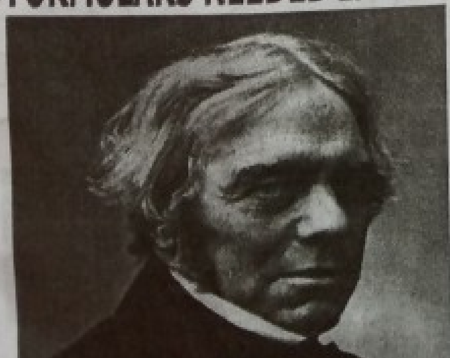
MEET NKECHI..............
SORRY THERE WAS A MIX UP SOMEWHERE..... THIS MUST BE A PICTURE I'M ADMIRING ONLINE......... HOW WAS IT PASTED HERE!!!!!! PLS IGNORE THIS PICTURE!!!!!!!!

ELECTRIC FIELD



ELECTRIC FIELD LINES SHOWS THE DIRECTION A POSITIVE TEST CHARGE WILL MOVE WHEN BROUGHT CLOSE TO THE FIELD

ALL FORMULARS NEEDED IN THIS TOPIC



MICHAEL FARADAY WAS AN ENGLISH SCIENTIST WHO CONTRIBUTED TO THE STUDY OF ELECTRIC FIELD LINES (A NON-SMOKER ACTUALLY)

* Electric field due to a Charge Q : $E = \frac{KQ}{r^2}$
* Vector Electric field : $E = \frac{KQ}{r^2} \times \frac{r_p - r_Q}{r}$
* dipole moment: $P = 2lq$
* Torque: $= PE\sin\theta$
* max torque: $= PE$
* Electric field from a dipole : $E = \frac{KP}{r^3}$
* Another formular for Electric field : $E = F/q$
* Relationship b/w Electric field, mass, acceleration and charge : $E = \frac{ma}{q}$

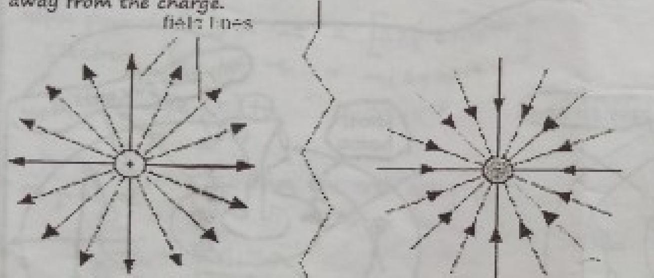
ELECTRIC FIELD

MICHAEL FARADAY, 1842

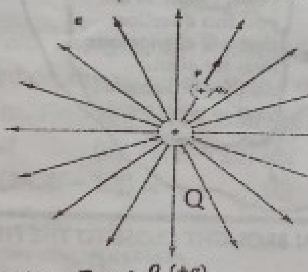
Born	22 September 1791 Newington Butts, England
Died	25 August 1867 (aged 75) Hampton Court, Middlesex, England
Residence	United Kingdom
Nationality	English
Fields	Physics and Chemistry
Institutions	Royal Institution
Known for	Faraday's law of induction, Electrochemistry, Faraday effect, Faraday cage, Faraday constant, Faraday cup, Faraday's laws of electrolysis, Faraday paradox, Faraday rotator, Faraday-efficiency effect, Faraday wave, Faraday wheel, Lines of force

The concept of an electric field was introduced by Michael Faraday

Electric field is a vector quantity caused by the presence of a charge in space. The electric field due to a charge is in a region of space surrounding the charge and reduces in strenght as we move away from the charge.



When ever a test charge $+q_o$ is brought close to the electric field region of another charge Q (ie Q is emitting the electric field), the test charge experiences a force which relates to the electric field as; $\boxed{E = \frac{F}{+q}}$ this is the electric field at a point where a test charge +q experiences a force F.



But since $F = k\frac{Q\cdot(+q)}{r^2}$

$$E = \frac{k\frac{Q\,(+q)}{r^2}}{+q}$$

$\boxed{E = k\frac{Q}{r^2}}$ this is the electric field at a point p, caused by Q at a distace r From Q.

VECTOR ELECTRIC FIELD

To find the vector electric field at a point p due to a charge Q, we use; $\boxed{E_{QP} = k\frac{Q}{r_{PQ}}\cdot\frac{r_P - r_Q}{r_{PQ}}}$

E_{PQ} = field at p due to Q

r_{PQ} = distance between Q and p

r_P = position of p

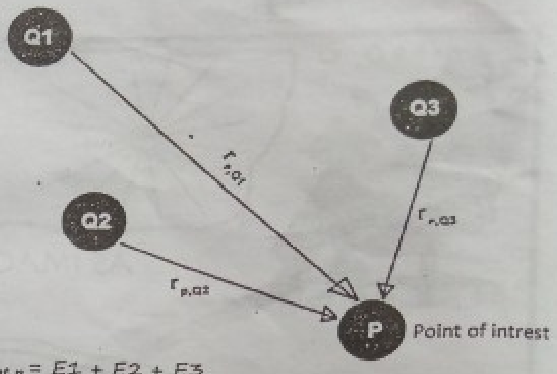
r_Q = position of Q

Note that we just multiplied the magnitude of the electric field with a unit vector in other to get the vector electric field at that point.

The unit vector can be explained as;

$$\frac{(\text{the position of feeler} - \text{position of the causer of the field})}{\text{distance between them}}$$

When the electric field is caused by many electric charges, we find the vector electric field at the point of intrest from each electric charge, and add them up in vector form



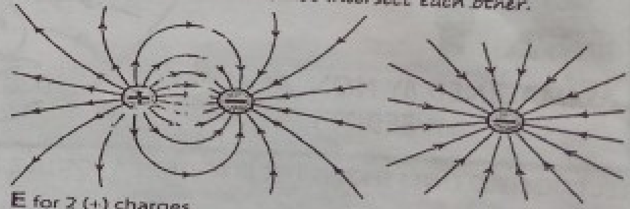
$E_{total\ at\ p} = E1 + E2 + E3$

Details on how to add these will be seen in the past question solution section of this work.

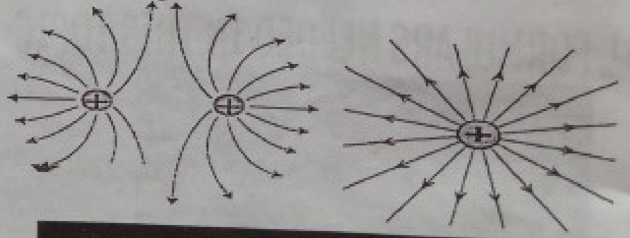
ELECTRIC FIELD LINES

Electric field lines (lines of force) are lines used to show the direction of the electric field in a region of space. The following are tbe properties of electric field lines

- electric lines of force starts from positive charge end at negative charge .
- number of electric lines of force per unit area is directly proportional to electric field intensity at that point
- the tangent at any point on the field shows the direction of the field
- electric lines of force does not intersect each other.



E for 2 (+) charges



FUTO PAST QUESTION ON ELECTRIC FIELD 2016 - 2009

2016 EXAM QUESTION AND ANSWERS ON ELECTRIC CHARGE

52. Which of the following statements is correct about the electric field?
A. It points inwards from a positive charge B. It depends only on the values and locations of the external charge C.It depends on the test charge D. It is always uniform in space E. It is always zero in space

52) B

53. What is the magnitude of the electric field intensity at a point in an electric field such that an electron placed there experiences an electric force equal to its weight? A. $2.5\times10^{-11}NC^{-1}$ B. $4.0\times10^{-11}NC^{-1}$ C. $5.0\times10^{-11}NC^{-1}$ D. $5.6\times10^{-11}NC^{-1}$ E. $6.0\times10^{-11}NC^{-1}$

53) mass of electron $= 9.11\times10^{-31}$

weight of electron $(mg) = (9.11\times10^{-31})\times9.8$

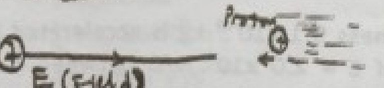
$$E = F/q$$

$$= \frac{(9.11\times10^{-31})\times9.8}{1.6\times10^{-19}}$$

$$= \underline{5.6\times10^{-11}\ NC^{-1}}$$

54. Electric field in a certain region of space points from left to right. If a proton moving in the opposite direction encounters this field, what happens to the proton's speed? A. It increases B. It remains constant C. It decreases D. It equals zero E. It oscillates

54) Solution



Electric field originates from a positive charge. When a Proton moves in opposite direction to the field, it experiences a repelling force and decreases in Speed.

Ans C

55. What is the electric field at the surface of a proton of radius 10^{-15}m? A. $1.4\times10^{6}NC^{-1}$ B. $1.4\times10^{-6}NC^{-1}$ C. $1.4\times10^{-21}NC^{-1}$ D. $1.4\times10^{21}NC^{-1}$ E. $5.6\times10^{15}NC^{-1}$

55) Solution

$$E = kq/r^2$$

$$= \frac{(9\times10^{9})\times(1.6\times10^{-19})}{(10^{-15})^2}$$

$$= \underline{1.4\times10^{21}\ NC^{-1}}$$

56. What maximum torque does an external field of $10^{5}NC^{-1}$ exert on an electric dipole each with a charge of 10^{-6}C and separated by a distance of 2cm? A. 2×10^{-3}Nm B. 2×10^{-1}Nm C. 4×10^{-3}Nm D. 4×10^{-1}Nm E. 2×10^{-6}Nm

56) $\tau = PE$

$$= (2lq)E$$

$$= \left[2\times(0.02)(10^{-6})\right]\times10^{5}$$

$$= \underline{4\times10^{-3}}\ Nm$$

2015 EXAM QUESTION AND ANSWERS ON ELECTRIC FIELD

5. What force will an electric field of 4.6×10^{7}N/C exert on a charge of magnitude q = 20μC? A. 2.3×10^{3}N B. 9.2×10^{6}N C. 2.3×10^{11}N D. 9.2×10^{8}N E. 9.2×10^{2}N

$q = 20\mu C = 20\times10^{-6}C$

$E = 4.6\times10^{6}N/C$

⇒ using the formula $E = F/q$

$\therefore F = Eq$

$= 20\times10^{-6}\times4.6\times10^{9}$

$F = 920N = 9.2\times10\ N$ ..... E

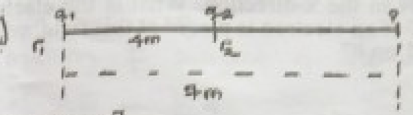
Ans $= 9.2\times10\ N$ //

12. Which of these is not true of electric field lines? A. Electric field lines are imaginary lines B. Electric field lines show the direction of E vector at each point. C. The spacing of electric field lines gives an idea of the magnitude of E at each point D. Electric field lines do not intersect each other E. None of the above

ans.....E

17. A positive charge q1 = +10nC is at the origin, and a second positive charge q2 = 16nC is on the x axis at x = 4m. Find the net electric field at a point P(x = 7m) on the x-axis.
A. 17.0N/C B. 17.84 IN/C C. 15.84 N/C D. 1.84 IN/C E. 16.0 IN/C

17]



$r_1 = 0$ [origin]

$r_2 = 4\hat{i}$ [from the positive axis]

$r_p = 7\hat{i}$ [7m from the origin to the +ve axis]

net electric field at $p = E_1 + E_2$

$E_1 = \frac{kQ_1}{r^2}\left(\frac{r_p - r_1}{r}\right)$ ← Position feeling − position causing / distance between

$= \frac{(9\times10^{9})(10\times10^{-9})}{7^2}\left[\frac{7\hat{i} - 0}{7}\right]$

$= 1.837\times\hat{i}$

$= 1.837\hat{i}\ N/C$

$E_2 = \frac{kQ_2}{r^2}\left(\frac{r_p - r_2}{r}\right)$

$= \frac{(9\times10^{9})(16\times10^{-9})}{3^2}\times\frac{7\hat{i} - 4\hat{i}}{3}$

$= 16\times\hat{i}$

$= 16\hat{i}\ N/C$

$E_p = E_1 + E_2$

$= 1.836\hat{i} + 16\hat{i}$

$= \underline{17.8\hat{i}\ N/C}$ Ans D//

42. Which of the following is/are true of electric field lines: i) The tangent to the lines of force at every point gives the magnitude of the field ii) Lines of force do not touch or intersect one another iii) Lines of force start from negative charges and end on positive charges.
A. All correct B. None correct C. i and iii D. ii only E. iii only

ans.... D

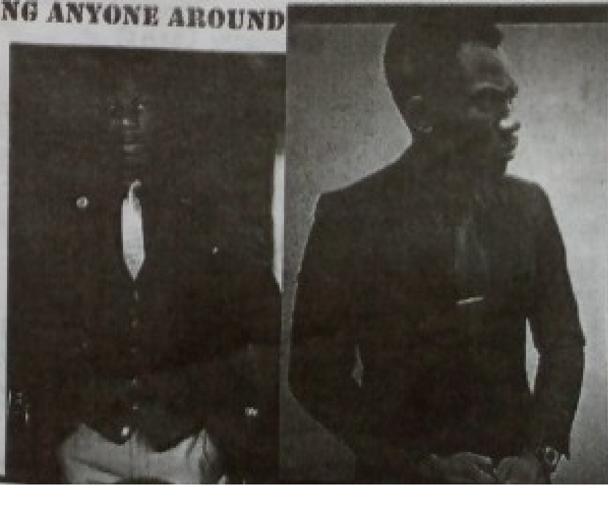
56. What is the magnitude of the electric field 50mm from a charge q = 40μC?
A. 720N/C ft. 1.44×10^{8}N/C C. 400N/C D. 7.2×10^{6}N/C E. 144000N/C

TRY THIS ON YOUR OWN.

USE.......... $E = Kq/r^2$

correct ans = 1.44×10^{8}N/C

STILL ON RECOGNITION.
THIS IS DOMINIC, FROM GEOLOGY DEPT.
HE HAS BEEN SPOTTED WITH A DEDICATED LEADERSHIP SPIRIT. ONE WITH INTENTION OF HELPING ANYONE AROUND HIM



2015 TEST QUESTION AND ANSWERS ON ELECTRIC FIELD

THIS TOPIC WILL BE UNDERSTOOD BETTER AFTER GOING THROUGH THE SOLUTIONS TO THESE ELECTRIC FIELD PAST QUESTIONS

2) When a 10μC charge is placed at a certain point it experiences a force of 2×10^{-4}N in the x-direction. What is the electric field E at that point? If an electron is placed at this field, what force will be exerted on it?

2) $\oplus \rightarrow$

$10\mu C = 10\times10^{-6}C$

$F = 2\times10^{-4}N$

$E = F/q = \frac{2\times10^{-4}}{10\times10^{-6}} = 20NC^{-1}$

Force experienced by electron

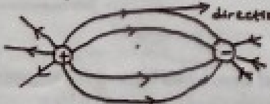
$F = Eq = 20\times(1.6\times10^{-19})$

$= 3.2\times10^{-18}N$

2013 / 2014 QUESTIONS ON ELECTRIC FIELD

2. One of the following is a property of lines of force A. The cosine to the lines of force at every point gives the direction of the field B. The sine to the lines of force at any point gives the direction of the field C. the tangent to the lines of force at any point gives the direction of the field D. all of the above E. None of the above

2) C ---- (The tangent to the Lines of force at any point gives the direction of the field)

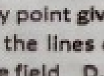


10. one of these is not true about electric field A. Electric field lines originate from a positive charge and terminate at a negative charge. B. The lines of electric field are imaginary. C. The lines of electric field beyond themselves. D. The lines of force are continuous E. A test charge experiences a force when placed in an electric field.

10) (C) ------ (The Lines of electric Field Cross themselves)

15. A point charge -20μC is placed at the centre of sphere of radius 5cm. The electric field intensity on the surface of the sphere is? A. $-7.2 \times 10^{4}NC^{-1}$ B. $3.6 \times 10^{3}NC^{-1}$ C. $36 NC^{-1}$ D. $-7.2 \times 10^{9}NC^{-1}$ E. $7.2 \times 10^{13}NC^{-1}$

15) Solution



$Q = 20\times10^{-6}C$ (20μC)

$r = 0.05m$ (5cm)

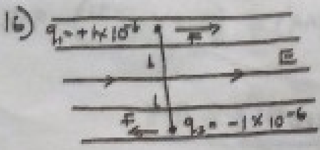
$E = \frac{kQ}{r^2} = \frac{(9\times10^{9})\times(20\times10^{-6})}{(0.05)^2}$

$= 7.2\times10^{7}NC^{-1}$

No option

16. The maximum torque an electric field $E = 1.0\times10^{5}NC^{-1}$ exerted on a dipole with charge $q = 1.0 \times 10^{-6}$ C separated by distance, d = 2.0cm is? A. 0.2Nm B. 2.0×10^{-3}Nm C. 2.0×10^{3}Nm D. 1.5Nm E. 1.5×10^{-3}Nm

16)



$2L = 2cm = 0.02m$

$E = 1\times10^{5}NC^{-1}$

torque = $PE\sin\theta$

Max torque = PE

P = dipole moment

$= 2Lq$

$= 0.02\times(1\times10^{-6})$

$\tau = 0.02\times(1\times10^{-6})\times(1\times10^{5})$

$= 2.0\times10^{-3}Nm$ ...... (B)

no. 50, of 2009/ 2010 question

50. An electron of mass 9.1×10^{-31} kg is accelerated in the uniform field of $E = 2.0 \times10^{4}$ N/C between two parallel charged plates. Determine the acceleration of the electron. (A) $1.0 \times 10^{7} m/s^2$ (B) $3.2 \times 10^{-15} m/s^2$ (C) $3.5 \times10^{15} m/s^2$ (D) $8.9 \times10^{30} m/s^2$

50) Solution

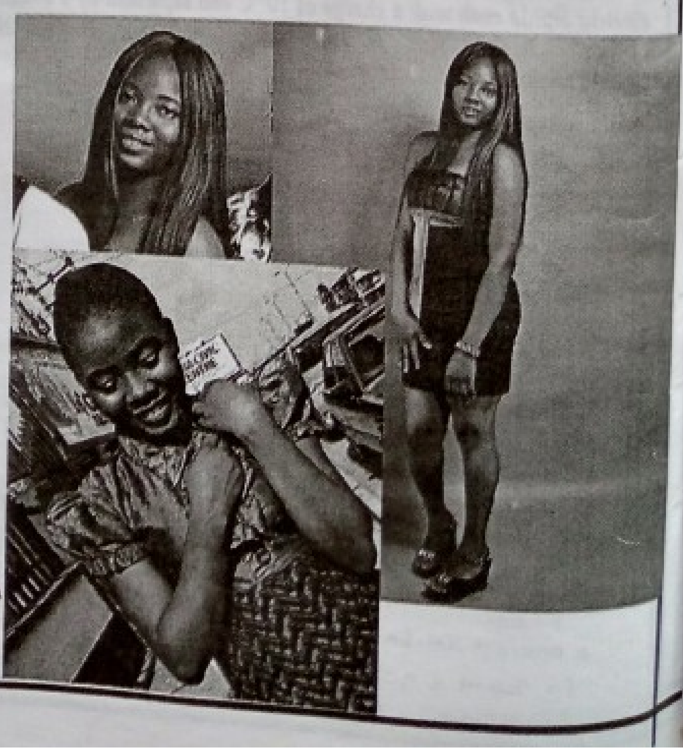
$E = F/q$

$E = ma/q$

$a = \frac{Eq}{m}$

$= \frac{(2\times10^{4})\times(1.6\times10^{-19})}{(9.1\times10^{-31})}$

$= 3.5\times10^{15} m/s^2$



THIS IS STEPH, A YOUNG, HARD-WORKING AND INTELLIGENT ASSISTANT REPRESENTATIVE FROM A DEPARTMENT WITH THE SMARTEST MINDS (PHYSICS DEPARTMENT)

25. A point charge q = 4.00 X 10^{-9}C is placed on the x axis at the origin. What is the electric field produced at x = 25.0cm? A. 5.76 X 10^{2}NC^{-1} B. 3.6 X 10^{4}NC^{-1} C. 5.76 NC^{-1} D. 5.76 X 10^{-2}NC^{-1} E. 5.76 X 10^{3}NC^{-1}

25) Solution

$Q = 4 \times 10^{-9}$

$x = r = 25cm = 0.25m$

$$E = \frac{KQ}{r^2} = \frac{(9\times10^9)\times(4\times10^{-9})}{0.25^2}$$

$$= 5.76\times10^2 NC^{-1} \text{ .... (A)}$$

30. If the magnitude of the electric field at a point p is 6.3 x 10^{9}NC^{-1} and if an electron is placed at rest at p and then released, what will be its initial acceleration? A. 1.1 x 10^{20} ms^{-2} B. 11.1 x 10^{21} ms^{-2} C. 1.1 x 10^{-20} ms^{-2} D. 11.1 x 10^{-21} ms^{-2} E. -11.1 x 10^{21} ms^{-2}

30) Solution

$E = 6.3\times10^{8} NC^{-1}$

$m_e = 9.11\times10^{-31}$

$q = 1.6\times10^{-19}$

From the Force formular.

$F = ma$

$\therefore \; Eq = m_e a$

$$a = \frac{Eq}{m_e} = \frac{(6.3\times10^8)\times(1.6\times10^{-19})}{9.11\times10^{-31}}$$

$$= 1.1\times10^{20} m/s^2 \text{ .... (A)}$$

57. An object having a net charge of 24μC is placed in a uniform electric field of 610NC^{-1} directed vertically. What is the mass of this object if it floats in the field? A. 15kg B. 1.5x 10^{-3}kg C. 1.45x10^{-4}kg D. 1.5 x 10^{-2}kg E. 0.015Kg

57) Solution

For it to float, weight = Electric force

ie $mg = Eq$

$$m = \frac{Eq}{g}$$

$$= \frac{610\times(24\times10^{-6})}{9.81}$$

$$= 1.5\times10^{-3} kg \text{ .... (B)}$$

2012 / 2013 QUESTIONS ON ELECTRIC FILED

7) What force will an electric field of 6.8x10z N/C exert on a charge of 10μC (A) 6.8 μN (B) 68N (C) 3.8N (D) 42N (E) 56N

7) Solution

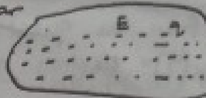
from The question,

Field $(E) = 6.8\times10^6 N/c$

Charge $(q) = 10\mu C = 10\times10^{-6}c$

force $(F) = ?$

Using the field formular force on a charge in a field



$$E = \frac{F}{q}$$

making F subject of the formular

$$F = Eq$$

$$= (6.8\times10^6)\times(10\times10^{-6})$$

$$= 68N \text{ ..... (B)}$$

8) A water molecule is placed in uniform electric field. If the dipole moment of the water molecules is 6.1x10^{-30}C.m at a distance Of 10 cm, calculate the magnitude of the electrical field (A) 5.49x10^-17 N^{-1}C (B) 2.47x10^-17 NC^{-1} (C) 3.16x10^-16 NM^{-1} (D) 3.83x10^{-17} NC^{-1} (E) 5.17x10^{-16} NC^{-1}

8) Solution

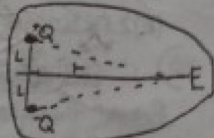
from the question,

dipole moment $p = 6.1\times10^{-30}$

distance $r = 10cm = 0.1m$

Field $E = ?$

From the dipole formular for field



$$E = \frac{KP}{r^3}$$

We have that

$$E = \frac{(9\times10^9)\times(6.1\times10^{-30})}{(0.1)^3}$$

$$E = 5.49\times10^{-17} NC^{-1} \text{ .... (A)}$$

9) Find the electrical field at a point 30 cm from a charge of 20uC (A) 2.2x10^{6}N/C (B) 2.0x10^{6} N/C (C) 3.4x10^{5}N/C (D) 3.83x10^{-17} (E) 2.7x10^{2}

9) Solution

from The question

$r = 30cm = 0.3m$

$Q = 20\mu C = 20\times10^{-6}c$

Using the formular of the field from a charge (Q) at a distance (r)

$$E = \frac{KQ}{r^2}$$

We have

$$E = \frac{(9\times10^9)\times(20\times10^{-6})}{0.3^2}$$

$$= 2\times10^6 N/c \text{ .... (B)}$$

34) What is magnitude of the electric field intensity at a point in an electric field such that an electron placed at the point experiences an electric force equals to its weight? (A) $4.0\times10^{-11}NC^{-1}$ (B)$5.0\times10^{-11}NC^{-1}$(C) $2.5\times10^{-11}NC^{-1}$ (D)$5.6\times10^{-11}NC^{-1}$(E) $6.0\times10^{-11}NC^{-1}$

34) Solution

From the question,

Charge (q) = electron = 1.6×10^{-19} ...... (I ignored the sign cos its not a vector quest)

Force (F) = Weight of electron $= Mg$

$= [(9.11\times10^{-31})\times(9.81)]$

Field $(E) = ?$

Using the formular for force felt by a charge in a field regim

$E = F/q$, we have that

$$E = \frac{[(9.11\times10^{-31})\times(9.81)]}{1.6\times10^{-19}}$$

$\simeq 5.6\times10^{-11}$ N/c ....(D)

35) An electron projected into an electric field of strength $3.2\times10^{5}NC^{-1}$ calculate the acceleration of the electron in the field (A)$5.6\times10^{16}ms^{-2}$ (B)$5.2\times10^{18}ms^{-2}$ (C)$3.1\times10^{18}ms^{-2}$ (D)$2.5\times10^{18}ms^{-2}$ (E)$2.0\times10^{18}ms^{-2}$

35) Solution

from the question,

electron $e = 1.6\times10^{-19}C = (q)$

Field $E = 3.2\times10^{5}$ N/c

Mass of $e = 9.11\times10^{-31}$

Force = Mass x accel

$\therefore a = F/M$

but $F = Eq$

$$a = \frac{Eq}{M} = \frac{(3.2\times10^{5})\times(1.6\times10^{-19})}{9.11\times10^{-31}}$$

$= 5.6\times10^{16}\ m/s^2$ ....(A)

39) Which of the following is not true of electric line of forces? (A) lines of force due to positive point charge radiate outward (B) lines of force due to negative point charge radiate inward (C) lines of force runs from negative to positive (D) lines of forces from two negative point charges repel each other (E) there is neutral point between line of force from two positive point charges

39) Solution

Lines of force run from negative to Positive point charges ....(C)

2011 / 2012 QUESTIONS ON ELECTRIC FILED

4. A positive charge $q1 = 10\ \mu C$ s at the origin and a second positive charg, $q2 = 14\ \mu C$ is on the x-axis at x = 10 m. Find the net electric field at the point p on the x = 20 m __________

4) Solution

This is a vector electric field question

from the question,

$q_1 = 10\mu c = 10\times10^{-6}c$

$r_1 = 0$ ......(at the origin)

$q_2 = 14\mu c = 14\times10^{-6}c$

$r_2 = 10i$ .... (10m on the x axis)

r_p (Position of point where electric field is felt) $= 20i$ ... (20m on x axis)

$q_1 = 10\mu c$ $q_2 = 14\mu c$ P

0i   10i   20i

Total electric field at $P = E_1 + E_2$

$E_P = E_{P,1} + E_{P,2}$

$$E_{P,1} = \frac{kq_1}{r_{P,1}^2}\times\frac{(r_P - r_1)}{r_{P,1}}$$

$$= \frac{(9\times10^{9})\times(10\times10^{-6})}{(20)^2}\times\frac{20i - 0}{20}$$

$= 225 \times i$

$= 225i$

$$E_{P,2} = \frac{kq_2}{r_{P,2}^2}\times\frac{(r_P - r_2)}{r_{P,2}}$$

$$= \frac{(9\times10^{9})\times(14\times10^{-6})}{10^2}\times\frac{(20i - 10i)}{10}$$

$= 1260 \times i$

$= 1260i$

$E_{P Total} = E_1 + E_2$

$E_{P Total} = 225i + 1260i$

$= 1485i$

5. Electric field intensity is defined as __________

5) Electric field intensity is defined as the Force per unit charge acting on a positive test charge placed at a point in an electric field.

6. An electron is accelerated from rest by a uniform of magnitude 10^5 N/C, how long does it take to attain 0.1c, where $c = 3.0\times10^8$ m/s is the speed of light

6) Solution

from the question

$E = 10^5$

$V = 0.1c = [0.1 \times (3\times10^8)]$

$u = 0$

$t = ?$

we are going to relate this to uniform accel motion with the equation

$V = u + at$

Where

$u = 0$

$a = \left(\frac{F}{m}\right) = \left(\frac{Eq}{m}\right)$

$$[0.1\times(3\times10^8)] = 0 + \left(\frac{Eq}{m}\right)t$$

$$t = \frac{[0.1\times(3\times10^8)]}{(Eq/m)}$$

$$= \frac{[0.1\times(3\times10^8)]}{\left(\frac{10^5\times1.6\times10^{-19}}{9.11\times10^{-31}}\right)}$$

$$= \underline{1.708\times10^{-9}s}$$

5. What is the magnitude of the electric field in which the force due to an electron is equal in magnitude to the weight of the electron (take mass of electron to be 9.11 x 10^{-31} kg)?

5) Solution

given that

F = weight of electron = mg $= (9.11\times10^{-31}\times9.8)$

q = electron = 1.6×10^{-19}

$$E = \frac{F}{q}$$

$$= \frac{(9.11\times10^{-31}\times9.8)}{1.6\times10^{-19}}$$

$$= \underline{5.6\times10^{-11}\ N/c}$$

9. The electric force on a +4.20μC charge is F=(7.22 x 10^{-4}N)j. What is the electric field at the position of this charge?

9) Solution

given that

$F = 7.22\times10^{-4}j$

$q = 4.2\times10^{-6}$

$$E = F/q = \frac{7.22\times10^{-4}j}{4.2\times10^{-6}}$$

$$= 1.72\times10^2 j\ N/c$$

10. Which of these is/are true of the electric lines of force? (i) They originate from the negative charge and terminate at the positive charge (ii) They never cross one another (iii) They originate from the positive charge and terminate at the negative charge.

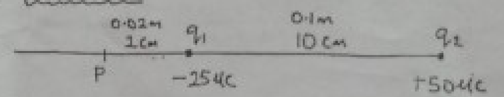
10) Solution

(ii) and (iii)

2009 / 2010 QUESTIONS ON ELECTRIC FILED

47. Two point charges are separated by a distance of 10.0cm. One has a charge -25μC and the other +50μC. Determine the magnitude of the electric field at a point 2.0cm from the negative charge. (A) 4.9 x10^8 N/C (B) 6.3 x 10^8 N/C (C) 1.3 x 10^8 N/C (D) 3.4 x 10^8 N/C (E) 7.1 x10^8 N/C

47) Solution



Total electric field at $P = E_1 + E_2$

Note: This method is not really a vector method cos we are just working with magnitude.

$$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9\times(-25\times10^{-6})}{(0.02)^2}$$

$$= -562500000$$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9\times(50\times10^{-6})}{(0.12)^2}$$ ......(0.1 + 0.02)

$$= 31250000$$

$$E_1 + E_2 = -562500000 + 31250000$$

$$= \underline{5.3\times10^8 N/c}$$ ← Since the question wants just the magnitude, the final sign is not necessary.

48. The ammonia molecule has a permanent electric dipole moment of 5.0 x10^{-30}C.m. if this arises from the net charges of +e and –e of two regions of the molecule, what is the distance of one of the charge from the center of the dipole? (A) 3.125 x 10^{-11} m (B) 5.0 x 10^{-11} m (C) 1.5625 x10^{-11} m (D) 1.6 x10^{-11} m.

48) Solution

given that

dipole moment $(P) = 2lQ = 5.0\times10^{-30}$

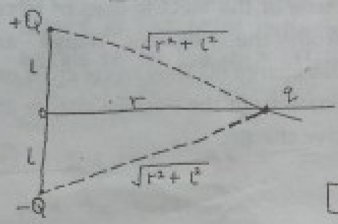
$$2lQ = 5.0\times10^{-30}$$

$$l = \frac{5\times10^{-30}}{2Q}$$

$$= \frac{5\times10^{-30}}{2\times(1.6\times10^{-19})}$$

$$= \underline{1.5625\times10^{-11}\ m}$$

DIPOLE



An electric dipole is a pair of point charges with equal magnitudes but opposite signs separated by a distance L. [+Q and -Q is the dipole]

Force on a charge due to a dipole

To find the force on a charge (q) from a dipole +Q and -Q, we find the vector force from each charge from the dipole and sum the forces up.

ie: $F_{qQ^+} + F_{qQ^-}$ = Force on q due to dipole.

$$F_{qQ^+} = \frac{KqQ}{(\text{dist b/w them})^2} \times \left[\frac{(\text{Position of } q) - (\text{Position of } q+Q)}{(\text{dist b/w them})}\right]$$

$$= \frac{KqQ}{\left[\sqrt{r^2+L^2}\right]^2} \times \frac{ri - Lj}{\sqrt{r^2+L^2}}$$

$$= \frac{KqQ}{(r^2+L^2)^{3/2}} \times ri - Lj$$

For the force on q due to $-Q$

$$F_{qQ^-} = \frac{Kq(-Q)}{(\text{dist b/w them})^2} \times \left[\frac{(\text{Position of } q) - (\text{Position of } q-Q)}{(\text{dist b/w them})}\right]$$

$$= \frac{Kq(-Q)}{\left(\sqrt{r^2+L^2}\right)^2} \times \frac{ri-(-Lj)}{\sqrt{r^2+L^2}}$$

$$= \frac{KqQ}{(r^2+L^2)^{3/2}} \times \left[-(ri+Lj)\right]$$

← Watch closely what we did with the signs. If confused, call Kings 08138722407

Sum the 2 forces.

$$= F_{qQ^+} + F_{qQ^-}$$

$$= \left[\frac{KqQ}{(r^2+L^2)^{3/2}} \times ri - Lj\right] + \left[\frac{KqQ}{(r^2+L^2)^{3/2}} \times \left[-(ri+Lj)\right]\right]$$

$$= \frac{KqQ}{(r^2+L^2)^{3/2}} \times -2Lj$$

$$= \frac{-2KqLQ}{(r^2+L^2)^{3/2}}\, j$$

but dipole moment

$= 2LQ$

$= P$

we have $\frac{-KPq}{(r^2+L^2)^{3/2}}\, j$

If r is far greater than L and L becomes neglected, we have

$$\frac{-KPq}{(r^2)^{3/2}}\, j$$

$$= \frac{KPq}{r^3} \text{ in the } -\text{ve } j \text{ direction}$$

Electric field due to a dipole

If Force (F) due to a dipole $= \frac{KPq}{r^3}$

and field $= F/q$

Field due to a dipole $= \left(\frac{KPq}{r^3}\right)/q$

$$= \frac{KP}{r^3}$$

49. Two charges $q_1 = 2.1 \times 10^{-8}$ C and $q_2 = -4q_1$ are placed 50cm apart. Find the point along the straight line passing through the two charges at which the electric field is zero. (A) 0.5m (B) 0.3m (C) -0.3m (D) 0.6m (E) 1m.

49) Solution

x $\quad q_1 = 2.1\times10^{-8} \quad$ 50cm = 0.5m $\quad q_2 = -4(2.1\times10^{-8})$

We are looking for the point where

$$E_{Total} = E_1 + E_2 = 0$$

$$\frac{Kq_1}{x^2} + \frac{-K4q_1}{(0.5+x)^2} = 0$$

$$Kq_1\left[\frac{1}{x^2} - \frac{4}{(0.5+x)^2}\right] = 0$$

dividing by Kq_1, we have

$$\frac{1}{x^2} - \frac{4}{(0.5+x)^2} = 0$$

$$\frac{1}{x^2} = \frac{4}{(0.5+x)^2}$$

finding square root of both sides

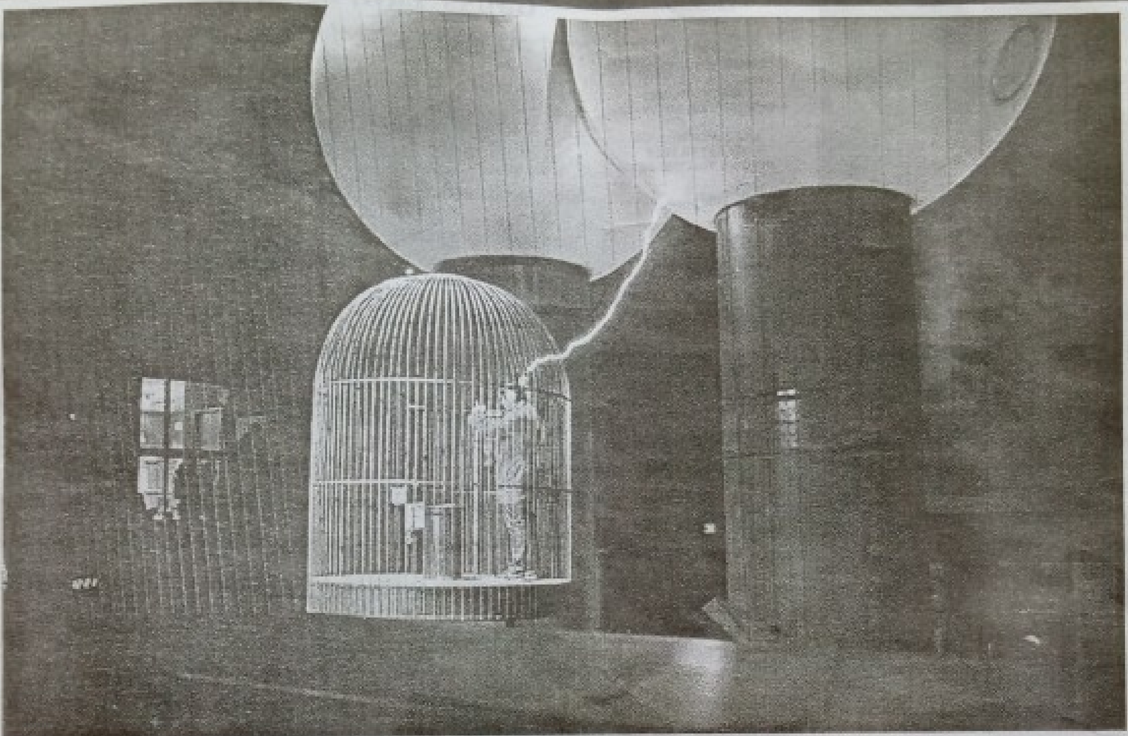
$$\frac{1}{x} = \frac{2}{0.5+x}$$

$$0.5 + x = 2x$$

$$2x - x = 0.5$$

$$x = 0.5\text{m}$$

GAUSS LAW



THIS IS THE LAW THAT HELPS US FIND THE ELECTRIC FIELD FROM DIFFERENT SHAPES OF CHARGE

ALL FORMULARS NEEDED IN THIS TOPIC

* Due to a point charge: $E = \frac{Q}{4\pi \varepsilon_0 r^2}$
* Outside a solid sphere of charge ,,
* Outside a spherical shell of charge ,,
* inside a spherical shell of charge $E = 0$
* inside a solid sphere of charge $(r \leq R)$ $E = \frac{Qr}{4\pi \varepsilon_0 R^3}$
* Near an infinite line of charge λ = linear charge density $E = \frac{\lambda}{2\pi \varepsilon_0 r}$
* Outside a cylinder of charge density ρ = volume charge $E = \frac{R^2 \rho}{2\varepsilon_0 r}$
* Inside a solid cylinder $E = \frac{r\rho}{2\varepsilon_0}$
* Inside a cylindrical shell $E = 0$
* Near an infinite charged plane σ = Area charge density $E = \frac{\sigma}{2\varepsilon_0}$
* Just outside a charged conductor $E = \frac{\sigma}{\varepsilon_0}$

where R = radius of the charged geometry

r = radius of the gaussian surface

* $\Phi = \frac{Q}{\varepsilon_0} = EA$
* Electric flux: $\Phi = EA$
* Electric flux with θ: $\Phi = EA\cos\theta$

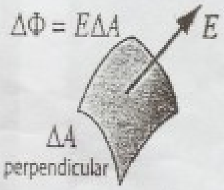
GAUSS LAW / THEOREM

CARL FRIEDRICH GAUß (1777–1855), PAINTED BY CHRISTIAN ALBRECHT JENSEN

JOHANN CARL FRIEDRICH GAUSS
BORN
30 APRIL 1777
BRUNSWICK, DUCHY OF BRUNSWICK-WOLFENBÜTTEL, HOLY ROMAN EMPIRE
DIED
23 FEBRUARY 1855 (AGED 77)
GÖTTINGEN, KINGDOM OF HANOVER
RESIDENCE
KINGDOM OF HANOVER
NATIONALITY
GERMAN
FIELDS
MATHEMATICS AND PHYSICS
INSTITUTIONS
UNIVERSITY OF GÖTTINGEN
LFX KINGS WILL GO AN EXTRA MILE TO GIVE YOU THE BEST

Gauss's Law

The total of the electric flux out of a closed surface is equal to the charge enclosed divided by the permittivity.



The sum of the flux is proportional to the total charge enclosed.

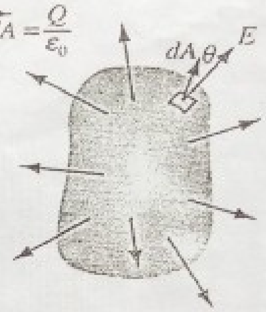
$$\Phi_{electric} = \frac{Q}{\varepsilon_0}$$

The electric flux through an area is defined as the electric field multiplied by the area of the surface projected in a plane perpendicular to the field. Gauss's Law is a general law applying to any closed surface. It is an important tool since it permits the assessment of the amount of enclosed charge by mapping the field on a surface outside the charge distribution. For geometries of sufficient symmetry, it simplifies the calculation of the electric field.

Gauss' Law, Integral Form

The area integral of the electric field over any closed surface is equal to the net charge enclosed in the surface divided by the permittivity of space.

$$\oint \vec{E}\cdot d\vec{A} = \frac{Q}{\varepsilon_0}$$



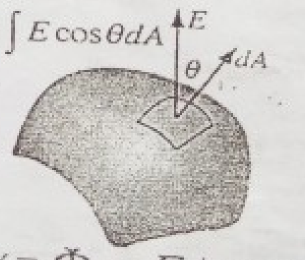
Gauss' law permits the evaluation of the electric field in many practical situations by forming a symmetric Gaussian surface surrounding a charge distribution and evaluating the electric flux through that surface.

Electric Flux

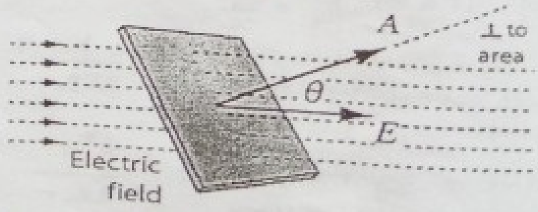
The concept of electric flux is useful in association with Gauss' law. The electric flux through a planar area is defined as the electric field times the component of the area perpendicular to the field. If the area is not planar, then the evaluation of the flux generally requires an area integral since the angle will be continually changing.

Electric flux:

$$\Phi = \int E\cos\theta dA$$



$$\text{flux} = \Phi = EA\cos\theta$$



THIS IS SNOW, ONE OF SMATS' MOST ACTIVE ASSISTANT COURSE REPRESENTATIVE. SHE IS DILIGENT, HARD-WORKING, WELL CALCULATED AND STABLE. SHE IS IN PMT DEPT.

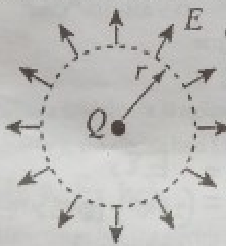
When the area A is used in a vector operation like this, it is understood that the magnitude of the vector is equal to the area and the direction of the vector is perpendicular to the area.

Applications of Gauss' Law

Gauss' law is a powerful tool for the calculation of electric fields when they originate from charge distributions of sufficient symmetry to apply it.

Electric field of point charge

The electric field of a point charge Q can be obtained by a straightforward application of Gauss' law. Considering a Gaussian surface in the form of a sphere at radius r, the electric field has the same magnitude at every point of the sphere and is directed outward. The electric flux is then just the electric field times the area of the sphere.

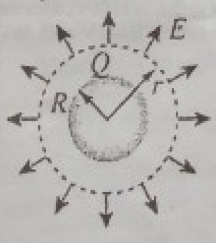


$$\Phi = EA = E4\pi r^2 = \frac{Q}{\varepsilon_0}$$

The electric field at radius r is then given by:

$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

Electric Field of Conducting Sphere (hollow spherical shell)



$$\Phi = EA = E4\pi r^2 = \frac{Q}{\varepsilon_0}$$

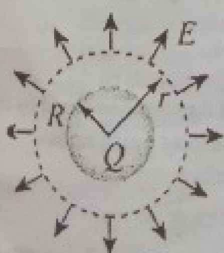
For $r > R$ (outside the shell)

$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

For $r < R$ (inside the shell)

$E = 0$

Electric Field: Sphere of Uniform Charge (solid sphere)

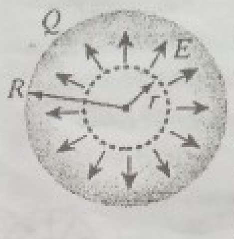


$$\Phi = EA = E4\pi r^2 = \frac{Q}{\varepsilon_0}$$

For $r > R$ (outside the solid sphere)

$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

Inside a Sphere of Charge (solid sphere)



The electric field inside a sphere of uniform charge is radially outward (by symmetry), but a spherical Gaussian surface would enclose less than the total charge Q. The charge inside a radius r is given by the ratio of the volumes:

$$\frac{Q'}{Q} = \frac{\frac{4}{3}\pi r^3}{\frac{4}{3}\pi R^3} \quad \text{or} \quad Q' = Q\frac{r^3}{R^3}$$

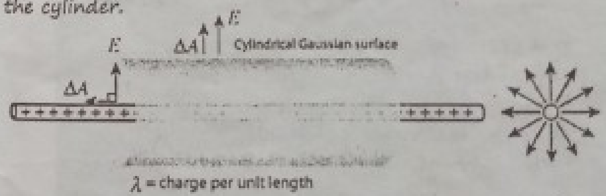
The electric flux is then given by $\Phi = E4\pi r^2 = \dfrac{Qr^3}{\varepsilon_0 R^3}$

and the electric field is; $E = \dfrac{Qr}{4\pi\varepsilon_0 R^3}$

Note that the limit at r= R agrees with the expression for r >= R. The spherically symmetric charge outside the radius r does not affect the electric field at r. It follows that inside a spherical shell of charge, you would have zero electric field.

Electric Field of Line Charge

The electric field of an infinite line charge with a uniform linear charge density λ can be obtained by a using Gauss' law. Considering a Gaussian surface in the form of a cylinder at radius r, the electric field has the same magnitude at every point of the cylinder and is directed outward. The electric flux is then just the electric field times the area of the cylinder.



$$\Phi = E2\pi rL = \frac{\lambda L}{\varepsilon_0}$$

$$E = \frac{\lambda}{2\pi r\varepsilon_0}$$

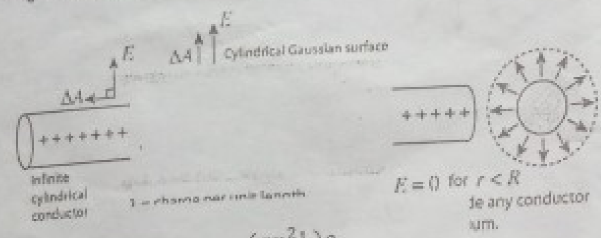
This expression is a good approximation for the field close to a long line of charge.

Electric Field:Inside a Conducting Cylinder (thin cylnder shell)

electric field, $E = 0$

Electric Field: Inside a Cylinder of charge

The electric field inside a Cylinder of charge with a uniform volume charge density ρ can be obtained by a using Gauss' law. Considering a Gaussian surface in the form of a cylinder at radius r, the electric field has the same magnitude at every point of the cylinder and is directed outward. The electric flux is then just the electric field times the area of the cylinder. Note that $\rho = Q/vol$ therefore $Q = \rho.vol$

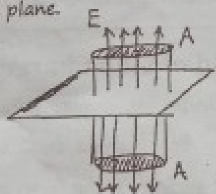


$$\Phi = E(2\pi rL) = \frac{(\pi r^2 L)\rho}{\varepsilon_0}$$

$$E = \frac{r^2\rho}{2\varepsilon_0}$$

Electric Field: near an infinite charged plane

In an infinite charged plane situation, the electric field moves upwards and downward the plane and the best gaussian surface for this are 2 cylinderical areas above and below the plane.



$$\Phi = EA = \frac{Q}{\varepsilon_0}$$

$$= E(2A) = \frac{Q}{\varepsilon_0}$$

$$E = \frac{Q}{2A\varepsilon_0}$$

Since $\sigma = Q/A$

$$E = \frac{\sigma}{2\varepsilon_0}$$

in summary;

Due to a point Charge: $E = \frac{Q}{4\pi\varepsilon_0 r^2}$

Outside a solid sphere of Charge ,,

Outside a Spherical shell of charge ,,

inside a Spherical shell of Charge $E = 0$

inside a Solid sphere of Charge $(r \leq R)$ $E = \frac{Qr}{4\pi\varepsilon_0 R^3}$

near an infinite line of Charge λ = linear Charge density $E = \frac{\lambda}{2\pi\varepsilon_0 r}$

Outside a cylinder of Charge ρ = Volume Charge density $E = \frac{R^2\rho}{2\varepsilon_0 r}$

Inside a solid cylinder $E = \frac{r\rho}{2\varepsilon_0}$

Inside a Cylindrical Shell $E = 0$

near an infinite charged plane σ = Area charge density $E = \frac{\sigma}{2\varepsilon_0}$

Just Outside a charged Conductor $E = \frac{\sigma}{\varepsilon_0}$

Where R = radius of the charged geometry

r = radius of the gaussian surface

learn how to prove these formulars and if you cant, try to memorize them before going into the test or Exam hall.

FUTO PAST QUESTION ON ELECTRIC FIELD 2016 - 2009

2016 EXAM QUESTION AND ANSWERS ON GAUSS LAW

31. What is the surface charge density on the ground directly below a thunder cloud if the E-field is $2x10^4$N/C? A.$2.3x10^{15}$C/m^2 B. $4.4x10^{16}$C/m^2 C. $2.3x10^{-15}$C/m^2 D. $4.4x10^{-16}$C/m^2 E. $1.8x10^{-7}$C/m^2

31) Solution

$E = \sigma/\varepsilon_0$

Area Charge density $\sigma = E\varepsilon_0$

$= (2\times10^4)\cdot(8.85\times10^{-12})$

$= 1.77\times10^{-7}$

$= 1.8\times10^{-7}$ C/m^2

38. A uniform electric field with a magnitude $5x10^2$N/C is directed parallel to the positive x-axis. If the potential at x=5m is 2500V, then the potential at x=2m is ...A. lkV B. 1.5kV C. 2kV D. 4kV E. 5kV

38) Solution

From the formular

$E = \sigma/\varepsilon_0$

$\sigma = E\varepsilon_0$

$Q/A = E\varepsilon_0$

$Q = AE\varepsilon_0$

$= \left(\frac{610}{100\times100}\right)\times(2\times10^5)\times(8.85\times10^{-12})$

$= 1.08\times10^{-7}$ C

58. The electric flux through a closed surface depends on the ...
A. shape of the surface B. position of the charge enclosed by the surface C. magnitude of the charge enclosed by the surface D. area of the surface E. size of the surface

58) C, $\Phi = Q/\varepsilon_0$

59. A thin spherical shell of radius R possesses a total charge Q that is uniformly distributed on it. What is the electric field at points inside the shell? A. E=kQ/R B. E=kQ/R^2 C. E=kQ/R^3 D. E=Q/ε_0 E. E=0

59) E

60. Two charges Q_1=100μC and Q_2=-120μC are within a spherical surface of radius 10cm. What is the flux through the surface? A. $1.1x10^6$Nm^2/C B. $1.4x10^6$Nm^2/C C. $120x10^6$Nm^2/C D. $2.26x10^6$Nm^2/C E. $126.5x10^6$Nm^2/C

60) Solution

$$\phi = Q/\varepsilon_0$$

$$= \frac{[100 + (-120)]}{8.85\times10^{-12}}$$

$$= \frac{-20\times10^{-6}}{8.85\times10^{-12}}$$

$$= 2.26\times10^{6}\ Nm^2/C$$

2015 EXAM QUESTION AND ANSWERS ON GAUSS LAW

39. A positive point charge q = 3.0u.C is surrounded by a sphere with radius 0.20m centered on the charge. Find the electric flux through the sphere due to this charge. A. $4.3\times10^5 Nm^2/C$ B. $3.4\times10^5 Nm^2/C$ C. $5.4\times10^{5} Nm^2/C$ D. $7.8\times10^6 Nm^2/C$ E. $8.6\times10^5 Nm^2/C$

$$\varnothing = \frac{Q}{\varepsilon_0} = \frac{3.0\times10^{-6}}{8.85\times10^{-12}}$$

= 338983.051

= $3.4\times10^5 Nm^2/C$

43. When a solid sphere of radius R is uniformly charged with a constant volume density ρ, the electric field E inside the sphere for r < R is? A. $\frac{Q}{4\pi\varepsilon_0 R^3}$ B. $\frac{3Q}{4\pi R^3}$ C. $\frac{Q}{4\pi r^2}$ D. $\frac{Qr}{4\pi\varepsilon_0 r^2}$ E. $\frac{Q}{4\pi R^2}$ **ans....A**

48. Using Gauss law, the electric field outside a charged infinite plane with surface charge density σ can be written as?

A. $E=\frac{\sigma}{2\varepsilon_0}$ B. $E=\frac{\sigma}{4\varepsilon_0}$ C. $E=\frac{\sigma}{\varepsilon_0}$ D. $E=\frac{\sigma}{4\pi\varepsilon_0 r}$ **ans.....A**

50. A 10μC charge is at the centre of a cube 10m. What is the total flux through the cube? A. $54\times10^4 Nm^2/C$ B. $54\times10^6 Nm^2/C$ C. $216\times10^4 Nm^2/C$ D. $600\times10^5 Nm^2/C$ E. $24\times10^3 Nm^2/C$

2015 TEST QUESTION ON GAUSS LAW

3) State Gauss's law in its mathematical forms.

3) For gauss law,

$$\phi = EA = \frac{Q}{\varepsilon_0}$$

2013 / 2014 QUESTIONS ON GAUSS LAW

4. Given a conducting sphere of radius 2m with a uniform charge distribution, what will be the magnitude of the charge within a Gaussian sphere of radius 2.1m from the centre of the sphere if the electric field is $8\times10^7 NC^{-1}$? A. 0.039C B. 3.9C C. 39C D. 0.39C E. 390C

4) Solution

gaussian surface

R = 2m

r = 2.1m

E = $8\times10^7 NC^{-1}$

Electric field outside a conducting sphere

$$E = \frac{kQ}{r^2}$$

$$\therefore Q = \frac{Er^2}{K} = \frac{(8\times10^7)\times2.1^2}{9\times10^9}$$

= 0.039C --------(A)

5. What is the area of a conducting plane sheet if the electric field due to the plane is $400NC^{-1}$ and the charge contained by the sheet is 50×10^{-9} C? A. $1.41m^2$ B. $14.1 m^2$ C. $141 m^2$ D. $0.141 m^2$ E. $141 m^3$

5) E = 400NC $\varepsilon_0 = 8.85\times10^{-12}$

q = 50×10^{-9}C

Gauss law for plane sheet can be stated as

$$EA = \frac{Q}{\varepsilon_0}$$

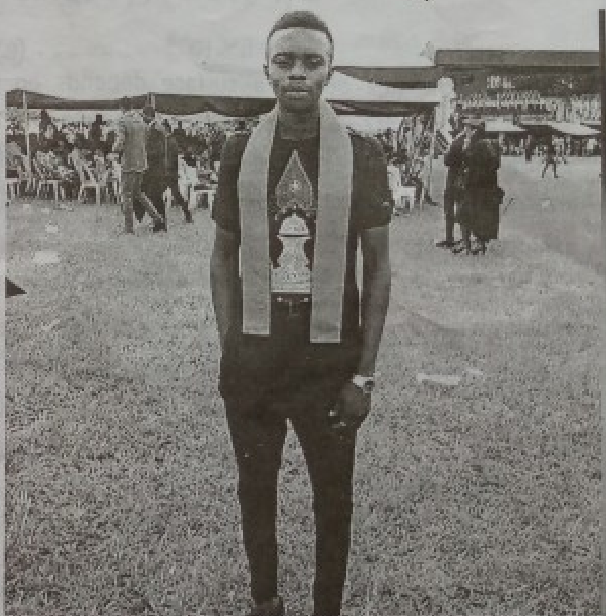
$$A = \frac{Q}{E\varepsilon_0}$$

$$= \frac{50\times10^{-9}}{400\times(8.85\times10^{-12})}$$

= $14.1m^2$ --------(B)

17. Gauss theorem can be expressed as _? A. $\Phi_E = \frac{\varepsilon_0}{q}$ B. $\oint Eds = \frac{q}{\varepsilon_0}$ C. $\Phi_E = \frac{\oint Edv}{s}$ D. $\oint Eds = \frac{\varepsilon_0}{q}$ E. None

17) B --------- ($\oint Eds = q/\varepsilon_0$)



THIS IS ONE OF THE MOST RESPECTED COURSE REPRESENTATIVE IN THE SCHOOL OF ENVIRONMENTAL SCIENCE. FROM THE DEPARTMENT OF EVT, HE IS SHEDRACK, HE IS YOUNG, SMART AN HAS A VERY GOOD LEADERSHIP SPIRIT.

18. Gauss' law cannot be used to: A. Calculate E of an isolated point charge B. Determine E of a charged solid sphere C. deduce E just outside a charged conductor of arbitrary shape D. evaluate E of a very long cylinder E. Obtain the potential difference across a current carrying wire

18) E - - - - - - - (Obtain the potential diff. across a current carrying wire)

26. The total electric flux from a cubical box of side 28cm is 1.84×10^3 Nm^3C^{-1}. What charge is enclosed by the box?
A. 4.6×10^{-8}C B. 1.6×10^{-8}C C. 5.71×10^{-8}C D. 1.84×10^{-3}C E. 51.52 C

26) Solution
From the formular, $\Phi = \frac{Q}{\varepsilon_0}$

$$Q = \Phi \times \varepsilon_0$$

$$= (1.84 \times 10^3) \times (8.85 \times 10^{-12})$$

$$= 1.6 \times 10^{-8} \text{ - - - - - - - (B)}$$

27. The electric flux out of a surface depends on the following except? A. The strength of the field B. The surface area C. the relative orientation of the field and surface D. the electric dipole moment on the surface E. None of the above.

27) D - - (The electric dipole moment on the surface)

2012 / 2013 QUESTIONS

11) Gauss' law can be expressed in form (A) $\int E.\,ds = q\varepsilon_o$ (B) $\int E.\,ds = \varepsilon_o/q$ (C) $\int E.\,ds = q/\varepsilon_o$ (D) $\int E.\,ds = \varepsilon_o$ (E) $\int E.ds = q$

11) Solution

$$\int E.\,ds = \frac{Q}{\varepsilon_0} \text{ .... (C)}$$

12) The proof of coulombs law from gauss law is possible only if the surface is a (A)triangle (B) sphere (C) rectangle (D) square (E) trapezium

12) Solution
Sphere .... (B)

13) A thin spherical shell of radius r_o possesses a total net charge Q that is uniformly distributed on it. What is the electric field inside the shell (A) $1/4\pi\varepsilon_o.Q/r^2$ (B) 0 (C) $1/4\pi\varepsilon_o.Q/r^2$ (D) $Q/2\pi\varepsilon_o r$ (E) none of the above

13) The electric field inside any shell of charge = 0 .... (B)

36) A very uniform conducting wire has a linear charge density of λcm^{-2} in vacuum. The electric field intensity at a point a small distance y from the wire is (A)$2\pi\lambda/E_0y$ (B)$E_0\lambda/2\pi y$ (C)$\lambda/2\pi E_0y$ (D)$y\lambda/2\pi E_0$ (E)$2\pi E_0/y\lambda$

36) Solution

$$E_y = \frac{\lambda}{2\pi\varepsilon_0 y} \text{ . . . . (C)}$$

2011 / 2012 QUESTIONS

7. State Gauss' law________________

7) Solution
Gauss' law states that the total electric flux crossing a closed area varies directly as the net electric charge enclosed by the surface.

8. At each point on a flat rectangular surface of sides 20 cm by 15 cm, the electric field has a magnitude of 350 N/C and makes an angle of 50° with the unit vector *n*. Calculate the electric flux for the surface.

8) Solution
given that;

$$\text{Area} = 20\,\text{cm} \times 15\,\text{cm}$$
$$= (0.2 \times 0.15)\,m^2$$
$$E = 350\,N/C$$
$$\theta = 50^\circ$$
$$\text{flux } \phi = EA\cos\theta$$
$$= 350 \times (0.2 \times 0.15) \times \cos 50$$
$$= 6.75\,\frac{Nm^2}{C}$$

9. A Gaussian surface encloses a charge of 20 μC, determine the fux through the surface.

9) Solution

$$\text{flux } \phi = \frac{q}{\varepsilon_0}$$
$$= \frac{20 \times 10^{-6}}{8.85 \times 10^{-12}}$$
$$= 2.26 \times 10^6\,NM^2C^{-1}$$

2010 / 2011 QUESTIONS

6. The net flux out of a cylindrical enclosure is 3.14 N.m²/C. What is the charge enclosed by the cylinder?

6) Solution
From gauss theorm

$$\text{flux } \phi = \frac{Q_{net}}{\varepsilon_0}$$
$$Q_{net} = \varepsilon_0 \phi$$
$$= (8.85 \times 10^{12}) \times (3.14)$$
$$= 2.78 \times 10^{11}\,C$$

7. A rectangle 10cm by 20cm is immersed in a uniform electric field of 200 N/C at an angle of 30^0 to the vertical. Calculate the electric flux through the rectangle surface.

7) Solution

$$\text{Area} = (10\text{cm} \times 20\text{cm}) = (0.1 \times 0.2)\text{m}^2$$

$$E = 200\text{N/C}$$

$$\theta = 30^\circ$$

$$\text{flux } \phi = EA\cos\theta = 200 \times (0.1 \times 0.2) \times \cos 30^\circ = 3.46\ \text{Nm}^2\text{C}^{-1}$$

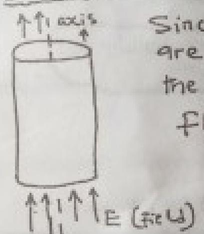
11. A thin spherical shell of radius R has a total charge Q uniformly distributed on it. Find the electric field at a radius r inside the shell.

11) Solution

Electric field inside a Shell $= \underline{\underline{0}}$

12. A Gaussian surface in the form of a cylinder of radius R is immersed in a uniform electric field E with the cylinder axis parallel to the field. What is the electric flux through the curved surface of the cylinder?

12) Solution



Since the field lines are not cutting through the curved surface,

$$\text{flux} = EA = E \times 0 = \underline{\underline{0}}$$

2009 / 2010 QUESTIONS

1. A non- conducting sphere has a uniform charge density throughout. How does the magnitude of the electric field vary inside with distance from the center? (A) The electric field is zero throughout. (B) The electric field is constant but non- zero throughout (C) The electric field is linearly increasing from the center to the outer edge (D) The electric field is exponentially increasing from the center to the outer edge (E) The electric field increases quadrically from the center to the outer edge

1) Solution

for a non- conducting sphere (Solid Sphere)

$$E = \frac{Qr}{4\pi\varepsilon_0 R^3}$$

where r = distance of the Electric field point from the center inside the solid sphere.

R = radius of the Sphere.

$\therefore E \propto r$ (electric field is linearly increasing from the center to the outer edge)

Ans $\Rightarrow$ (C)

2. A rectangle 10cm by 20cm is placed in a uniform electric field of magnitude 200 N/C. if the perpendicular to the plane of the rectangle makes an angle of 30^0 with the electric field, calculate the electric flux through the rectangle (A) 3.5 $N.m^2/C$ (B) 4.0 $N.m^2/C$ (C) 3.0 $N.m^2/C$ (D) 4.5 $N.m^2/C$

2) Solution

$$\text{flux } \phi = EA\cos\theta = 200 \times (0.1 \times 0.2) \times \cos 30^\circ = \underline{\underline{3.5\,\text{N.m}^2/\text{C}}}$$

3. An electric charge Q is distributed uniformly throughout a non- conducting sphere of radius r_0, the electric field E inside the sphere at $r < r_0$ is given by (A) $Qr/4\pi\varepsilon_0 r_0^3$ (B) $Qr/4\pi\varepsilon_0 r_0$ (C) $Q/4\pi\varepsilon_0 r_0^3$ (D) $Qr^2/4\pi\varepsilon_0 r_0^3$ (E) $Qr^2/4\pi\varepsilon_0 r_0$

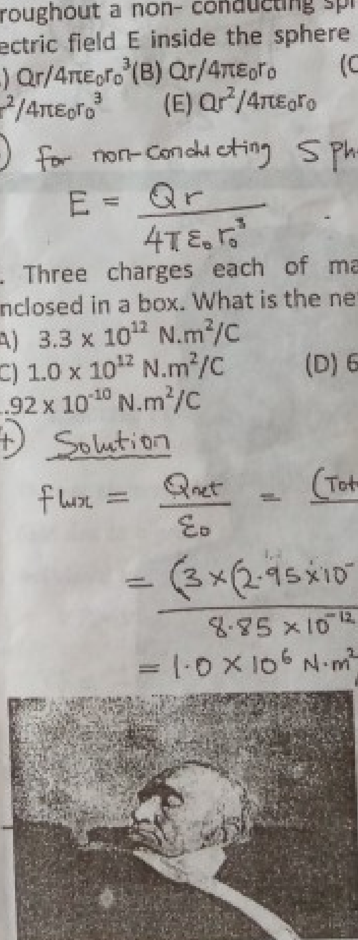
3) for non-conducting Sphere (inside $r<r_0$)

$$E = \frac{Qr}{4\pi\varepsilon_0 r_0^3} \quad \ldots\ldots\ (A)$$

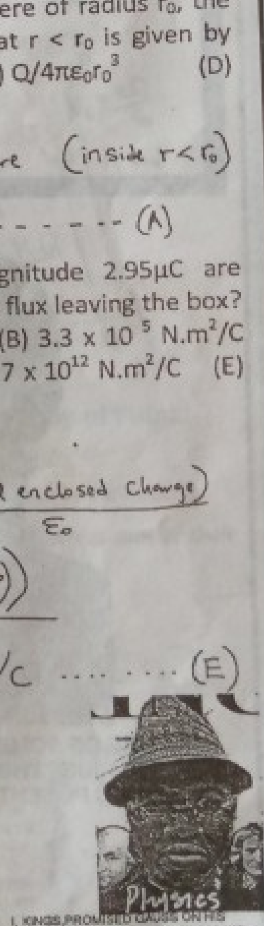
4. Three charges each of magnitude 2.95μC are enclosed in a box. What is the net flux leaving the box? (A) 3.3×10^{12} $N.m^2/C$ (B) 3.3×10^5 $N.m^2/C$ (C) 1.0×10^{12} $N.m^2/C$ (D) 6.7×10^{12} $N.m^2/C$ (E) 1.92×10^{-10} $N.m^2/C$

4) Solution

$$\text{flux} = \frac{Q_{net}}{\varepsilon_0} = \frac{(\text{Total enclosed Charge})}{\varepsilon_0} = \frac{(3 \times (2.95 \times 10^{-6}))}{8.85 \times 10^{-12}} = 1.0 \times 10^6\ \text{N.m}^2/\text{C} \quad \ldots\ldots\ (E)$$



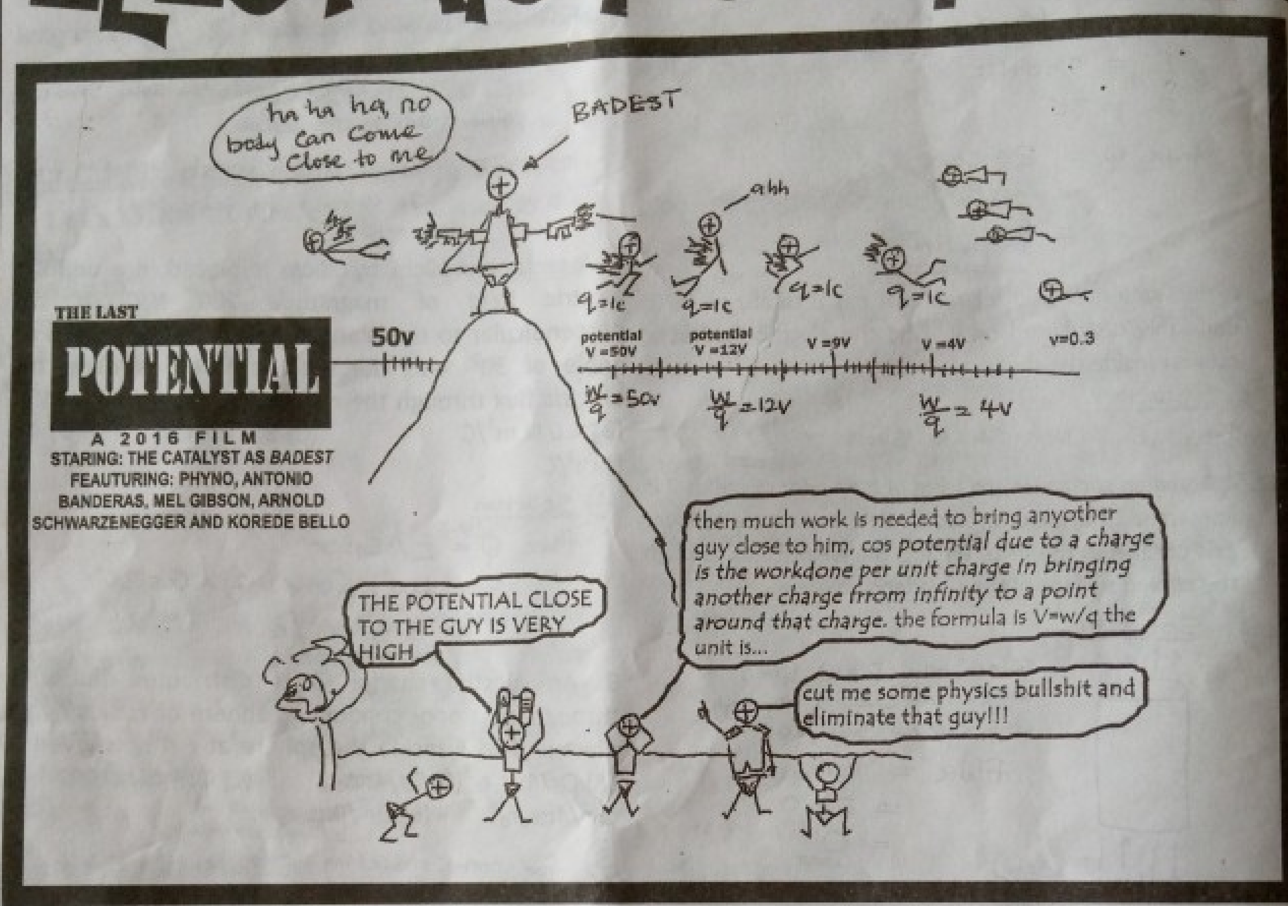
Daguerreotype of Gauss on his deathbed, 1855

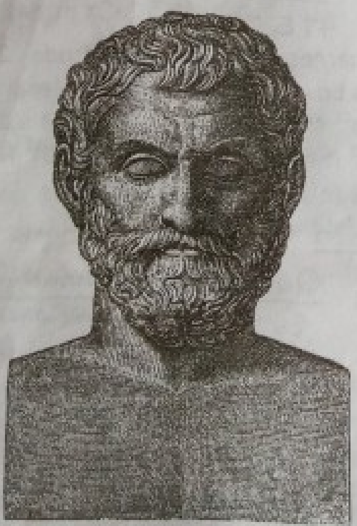


I, KINGS, PROMISED GAUSS ON HIS DEATHBED IN 1855, THAT I WILL MAKE SURE ALL FUTO STUDENT UNDERSTAND THE DREAMS HE PURSUED. SO HELP ME GOD.

ACTUALLY, I WROTE THAT TO TRICK YOU TO COME FOR LFX TUTORIALS IF YOU DONT UNDERSTAND THIS TOPIC. HOPE IT WORKS.

ELECTRIC POTENTIAL





PICTURE OF SOMEONE I FOUND ONLINE AND LOVED. I JUST WISH HE ALSO WORKED ON ELECTRIC POTENTIAL.

ALL FORMULARS NEEDED IN THIS TOPIC

* Potential: $V = \frac{W}{q}$
* Potential: $V = \frac{KQ}{r}$
* Potential: $V = Er$
* potential difference: $(V_B - V_A) = \frac{W}{q}$
* potential difference between B and A: $(V_B - V_A) = KQ\left[\frac{1}{r_B} - \frac{1}{r_A}\right]$
* Total potential at a point: $V_p = K\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2} \ldots\ldots \frac{Q_n}{r_n}\right]$
* Potential due to a dipole: $V = \frac{KP\cos\theta}{r^2}$
* Electric field: $E = \frac{-dV}{dr}$
* Electric Potential Energy for 2 Charges: $U = \frac{K\,Q_1Q_2}{r}$
* for 3 Charges: $U = K\left[\frac{Q_1Q_2}{r_{12}} + \frac{Q_1Q_3}{r_{13}} + \frac{Q_2Q_3}{r_{23}}\right]$

ELECTRICAL POTENTIAL

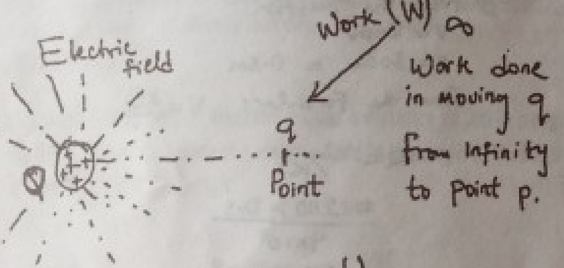
Electric potential is a physical quantity which determines the flow of charges from one body to another.

It is a physical quantity that determines the degree of electrification of a body.

Electric Potential at a point in the electric field is defined as the work done in moving (without any acceleration) a unit positive charge from infinity to that point against the electrostatic force irrespective of the path followed.

$$V = \frac{W}{q}$$

- Electric potential at a point is one volt if one joule of work is done in moving one coulomb charge from infinity to that point in the electric field.



$$\text{Potential } (V) = \frac{W}{q}$$

Electric Potential difference between two points in the electric field is defined as the work done in moving a unit positive charge between the two points or the energy gained by the unit charge after movement.

$$(V_B - V_A) = \frac{WORK}{q}$$
$$= \frac{ENERGY}{q}$$

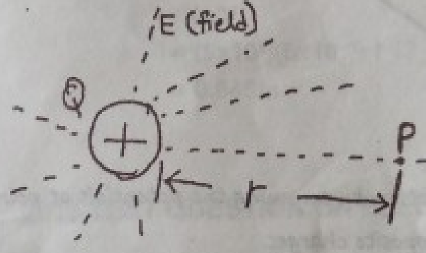
$(V_B - V_A)$ is also = Ed

- SI unit of electric potential is volt (V) or J C-1 or Nm C-1.
- unit of work/energy = joules or electron volt (eV)
- 1 electron volt (eV) = 1.6×10^{-19} j
- Electric potential and potential difference are scalar quantities.
- Electric potential at infinity is zero.
- Electric potential near an isolated positive charge ($q > 0$) is positive
- That near an isolated negative charge ($q < 0$) is negative.

Electric Potential due to a Single Point Charge

The electric potential V at a distance r from a single point charge Q can be stated as;

$$V = \frac{KQ}{r} = -\int E.dr$$
$$= Er$$



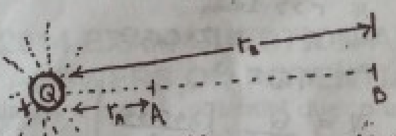
V at Point P $= \frac{KQ}{r}$

OR

$V = Er$

Electric potential difference between two points due to a point charge is the difference between the point with the larger potetial and the point with the lower potential

Electric potential between point A and B in the field of charge Q



$$V_A = \frac{KQ}{r_A} \qquad V_B = \frac{KQ}{r_B}$$

Potential difference b/w A and B

$$\Delta V = V_A - V_B$$
$$= \left[\frac{KQ}{r_A} - \frac{KQ}{r_B}\right]$$
$$\Delta V = KQ\left[\frac{1}{r_A} - \frac{1}{r_B}\right]$$

Electric Potential due to a Group of Point Charges

The net electrostatic potential at a point in the electric field due to a group of charges is the algebraic sum of their individual potentials at that point.

$$V P = V1 + V2 + V3 + V4 + \ldots\ldots\ldots + Vn$$

$$V_P = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2} + \frac{Q_3}{r_3} + \frac{Q_4}{r_4} \cdots + \frac{Q_n}{r_n}\right]$$

Signs of the charges will be taken into consideration.

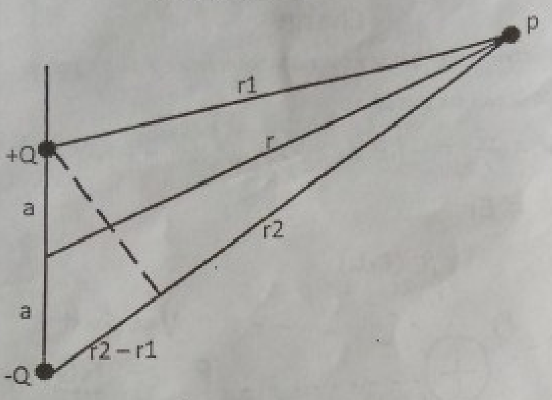
AN ELECTRIC POTENTIAL (ALSO CALLED THE ELECTRIC FIELD POTENTIAL OR THE ELECTROSTATIC POTENTIAL) IS THE AMOUNT OF ELECTRIC POTENTIAL ENERGY THAT A UNITARY POINT ELECTRIC CHARGE WOULD HAVE IF LOCATED AT ANY POINT IN SPACE, AND IS EQUAL TO THE WORK DONE BY AN ELECTRIC FIELD IN CARRYING A UNIT POSITIVE CHARGE FROM INFINITY TO THAT POINT.

SOURCED FROM WIKIPEDIA

YOU SEE HOW I'M TRYING HARD TO GET YOU MORE INFORMATION. LATER YOU'LL SAY I'M PROUD. WHO EVEN STARTED THAT PROUD ISSUE

PRE DEGREES . . . I OWE YOU GUYS SOME PUNCHES. FRIENDLY PUNCHES ANYWAY, THAT COULD FRIENDLY INJURE YOU.

Electric potential due to a dipole



This can be gotten by summing the potentials at point p from the 2 opposite charges.

$$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q}{r_1} + \frac{-Q}{r_2}\right]$$

$$= \frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

$$= \frac{Q}{4\pi\varepsilon_0}\left[\frac{r_2 - r_1}{r_2 r_1}\right]$$

If $r >> 2a$

Then $r_2 - r_1 \equiv 2a\cos\theta$

and $r_1 r_2 \equiv r^2$

$$V = \frac{Q}{4\pi\varepsilon_0}\cdot\left[\frac{2a\cos\theta}{r^2}\right]$$

$$= \frac{P\cos\theta}{4\pi\varepsilon_0 r^2}$$

where $P = 2aQ$ = dipole moment

- *Electric field can be gotten by differentiating electric potential with respect to time*

$$E = \frac{-dV}{dr}$$

In terms of three - dimentional Unit vector,

$$E = -\left(\frac{dV}{dx}i + \frac{dV}{dy}j + \frac{dV}{dz}k\right)$$

Electric potential energy

Electric potential energy of a system of two charges can be stated as;

$$U = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r_{1,2}}$$

For a system of three charges

$$U = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1Q_2}{r_{1,2}} + \frac{Q_1Q_3}{r_{1,3}} + \frac{Q_2Q_3}{r_{2,3}}\right]$$

For a system of 4 charges.

$$U = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1Q_2}{r_{12}} + \frac{Q_1Q_3}{r_{1,3}} + \frac{Q_1Q_4}{r_{1,4}} + \frac{Q_2Q_3}{r_{2,3}} + \frac{Q_2Q_4}{r_{2,4}} + \frac{Q_3Q_4}{r_{3,4}}\right]$$

For a system of n charges

$$U = \frac{1}{4\pi\varepsilon_0}\sum_{pairs}\frac{Q_i Q_j}{r_{ij}}$$

2016 EXAM QUESTIONS ON POTENTIAL

34. Twelve electrons each of charge -e are equally spaced and fixed around a circle of radius R. Which of the following is/are correct? i) The potential at the centre of the circle is V=-12ke/R ii) The potential at the centre of the circle is V=-ke/R iii) The electric field at the centre of the circle is E=-ke/R iv) The electric field at the centre is E=12ke/R^2 v) Electric field at the centre is E=0 A. i) and v) only B. i) and iv) only C. ii) only D. ii) and iii) only. E. iv) only

34) Solution

All the potentials add up at the middle to give $\frac{-12ke}{R}$

And all the Electric fields repel at the middle give zero.

Ans: A

35. The electric potential of an isolated charge is +200V at a distance 30cm from the charge. What is the magnitude of the charge? A. 1.6x10-^{19}C B. 3.2x10-^{9}C C. 9.11x10-^{31}C D. 6.67x10-^{9}C E. 1.6xl0-^{9}C

35) From the question

$V = 200V$

$r = 30cm = 0.3m$

From the formular: $V = \frac{kQ}{r}$

$$Q = Vr/k$$

$$= \frac{200 \times 0.3}{9\times10^9}$$

$$= 6.67\times10^{-9}C$$

36. What is the electric potential a distance of 5.3nm from a proton? (Take V at ∞=0) A. 2.72xlO-^{10} B.2.72xlO-^{5}V C. 2.72xl0-^{3}V D. 27.2V E. 2.72V

36) $V = ?$

$r = 5.3nm = 5.3\times10^{-9}$

Q = proton $= 1.6\times10^{-19}$

$$V = kQ/r$$

$$= \frac{(9\times10^9)\times(1.6\times10^{-19})}{5.3\times10^{-9}}$$

$$= 0.27V$$

37. Calculate the potential energy of an electron at a distance of 3A from the electron. A-7.68xl0-^{9}J B. 7.68xlO-^{19}J C. -7.68J D. 7.68J E. 4.8J

37) Solution

from the question

$Q = -1.6\times10^{-19}$

$r = 3\mathring{A} = 3\times10^{-10}$

$$U = kqq/r = \frac{(9\times10^9)(1.6\times10^{-19})(1.6\times10^{-19})}{(3\times10^{-10})}$$

$$= 7.68\times10^{-19}J$$

38. A uniform electric field with a magnitude 5x10^{2}N/C is directed parallel to the positive x-axis. If the potential at x=5m is 2500V, then the potential at x=2m is ...A. IkV B. 1.5kV C. 2kV D. 4kV E. 5kV

38) Solution

$$V = Er$$

$$= (5\times10^2)\times2$$

$$= 1000V$$

$$= 1kV$$

39. What is the electric potential due to a dipole whose dipole moment is 9.6×10^{-30}Cm at a point 10^{-9}m away if this point is along the axis of the dipole? A. 0.040V B. 0.031V C. 0.172V D. 5.421V E. 0.086V

39) Solution

potential due to a dipole: $V = \frac{KP\cos\theta}{r^2}$

When it is acting along the axis of the dipole $V = KP/r^2$

$$V = \frac{(9\times10^9)(9.6\times10^{-30})}{(10^{-9})^2}$$

$= 0.0864$

$= 0.086V$

2015 EXAM QUESTION AND ANSWERS ON POTENTIAL

7. Which of these are/is correct for equipotential surfaces? I) They are surfaces having the same electric potential at all points II) At each point of the equipotential surface, the direction of the electric field is perpendicular to the surface III) The lines of force are orthogonal to the equipotential surfaces A. I, II and III B. I only C. III only D. II only E. I and II only

ans....A

13. The work done when an electron moves a distance of 2m in a region with electric field E is 100eV. Calculate the electric field in the region. A. 8.0×10^{-16}N/C B. 50eV C. 50V D. 200N/C E. 50N/C

$$V = \frac{W}{q}$$

$$Er = \frac{W}{q}$$

$$E = \frac{W}{qr}$$

$$E = \frac{100\,(1.6x10^{-19})}{1.6x10^{-19}\,x\,2}$$

$$E = 50N/c$$

21. f the electric potential difference between points A and B is equal to 64V, the work done by an external agent in carrying a charge $q_o = 5.0\times10^{-5}$C from A to B at a constant speed is? A. 2.1×10^{-3}J B. 3.2×10^{-3}J C. 3.2×10^{7}J D. 2.1×10^{3}J E. None of the above

$$VB - VA = 64V$$

$$q_O = 5.0x10^{-5}C$$

$$VB - VA = \frac{W}{q_O}$$

$$W = (VB - VA)Xq_O$$

$$= 64X\,5.0X10^{-5}$$

$$= 3.2X10^{-3}J$$

23. The eleectric potential due to a dipole is given by which of the following, (symbols have their usual meaning)? A. $\frac{p\cos\theta}{4\pi\varepsilon_0 r^2}$ B. $\frac{p\sin\theta}{4\pi\varepsilon_0 r^2}$ C. $\frac{p\cos\theta}{2\pi\varepsilon_0 r^2}$ D. $\frac{p\sin\theta}{2\pi\varepsilon_0 r^2}$ E. $\frac{p\cos\theta}{4\pi\varepsilon_0 r^3}$

ans....A

24. A point charge $q = 8.0\times10^{-8}$C is located at the origin of a coordinate system. Calculate the value of the electric potential at the point r = 4.0im? A. 180V B. 7.2V C. 1.8×10^{-15}V D. 1.8×10^{18}V E. 18V

$$V = \frac{kq}{r}$$

$$= \frac{(9X10^9)X(8.0X10^{-8})}{4.0}$$

$$V = 180V$$

51. The potential due to an isolated point charge at a point 20cm from the charge is 400V. Calculate the magnitude of the charge. A. 8.80×10^{-9}C B. 8.90×10^{-9}C C. 8.85×10^{-12}C D. 8.9×10^{-7}C E. 8.90×10^{-10}C

from the formula V=Kq/r

q= Vr/K

where r = 20cm = 0.2m

V= 400v

K= 9×10^9

q = (400 x 0.2) / (9×10^9)

= 8.9×10^{-9}C

52. A point charge has a charge of 6×10^{-11}C. At what distance from the point charge is the electric potential 12.0V? A. 0.045m B. 0.45m C. 0.0045m D. 4.5mm E. 45cm

using V= Kq/r

r=Kq/V

= (9×10^9)(6×10^{-11}) / 12

= 0.045m

2015 TEST QUESTION ON ELECTRIC POTENTIAL

4) Find the electric potential due to a point charge = -2nC at a point 2.0cm from the charge.

4) Potential due to a point charge

$V = \frac{kq}{r}$

But $q = -2nC = -2\times10^{-9}C$

$r = 2cm = 0.02m$

$$V = \frac{(9\times10^9)(-2\times10^{-9})}{0.02}$$

$= -900V$

2014 EXAM QUESTION AND ANSWERS ON POTENTIAL

13. Calculate the electric potential due to a dipole whose dipole moment is 5×10^{-10}Cm at a point 10^{-5}m away if this point is along the axis of the dipole nearer thepositive charge. A. 4.5×10^{4}V B. 2.25×10^{10}V C. 3.90×10^{10}V D. 2.25×10^{6}V E. 4.5×10^{10}V

13) Solution

$P = 5\times10^{-10}$ C·m

$r = 10^{-5}$m

from the formular for potential due to dipole $V = \frac{KP\cos\theta}{r^2}$

Since there is no θ

$$V = \frac{KP}{r^2} = \frac{(9\times10^9)\times(5\times10^{-10})}{(10^{-5})^2}$$

$= 4.5\times10^{10}$ V -------(E)

19. How much electrical potential energy does a proton loose as it falls through a potential drop of 5KV? A. 0.8×10^{-16}J B. 80×10^{-16}J C. 0.8×10^{16}J D. 8.0×10^{-16}J E. 8.0×10^{-15}J

19) Solution

q = Proton = 1.6×10^{-19}

V = 5kV = 5000V

from the formular

$V = \frac{U}{q}$

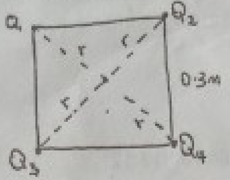
$U = qV$

$= (1.6\times10^{-19})\times5000$

$= 8\times10^{-16}$ ....(D)

21. Four point charges (each +2.0 μC) are placed at the four corners of a square that is 30cm on each side. Find the potential at the centre of the square. A. 1.7×10^5 V B. 1.2×10^6 V C. 3.4×10^5 V D. 2.5×10^5 V E. 2.4×10^5 V

21)



$30cm = 0.3m$

$r = \frac{\sqrt{0.3^2 + 0.3^2}}{2}$

$= 0.212m$

$P = \frac{KQ}{r}$, since all charges are equal,

$P_{Total} = \frac{4KQ}{r}$

$= \frac{4 \times (9 \times 10^9) \times (2 \times 10^{-6})}{0.212}$

$= 3.34 \times 10^5 v$ .... (C)

28. What is the electric potential at a distance $r = 0.53 \times 10^{-10}$ m from a proton if $V(\infty) = 0$? A. 27.2×10^{-10}V B. 272V C. 27.2V D. 51.2×10^{-2} V E. 27.2×10^{-3}V

28) Solution

$Q = \text{Proton} = 1.6 \times 10^{-19}$

$r = 0.53 \times 10^{-10}$

$V = \frac{KQ}{r} = \frac{(9 \times 10^9)(1.6 \times 10^{-19})}{(0.53 \times 10^{-10})}$

$= 27.2V$ .... (C)

29. Which of the following may be given as joules/Coulomb? A. Amps B. Ohms C. Volts D. Watts E. Newton

29) $J/_C$ = Volts .... (C)

ie $V = \frac{U}{q} = \frac{J}{C}$

2012 / 2013 QUESTIONS ON ELECTRIC POTENTIAL

10) The electrical potential due to a dipole is given by (A) $V = p\cos\theta/4\pi\varepsilon_o r^2$ (B) $V = p\sin\theta/4\pi\varepsilon_o r^2$ (C) $V = p\cos\theta/4\pi\varepsilon_o r^2$ (D) $V = p\sin\theta/4\pi\varepsilon_o r^2$ (E) $V = p\cos^2\theta/4\pi\varepsilon_o r^2$

10) Solution

$V = \frac{P\cos\theta}{4\pi\varepsilon_o r^2}$ .... (A)

14) The potential at a point r distance from a charge q in an E-field is (A) $-\int E.\,dr$ (B) $\int E.\,dr$ (C) $q/4\pi\varepsilon_o r^2$ (D) $q^2/4\pi\varepsilon_o r$ (E) $q^2/4\pi\varepsilon_o r^2$

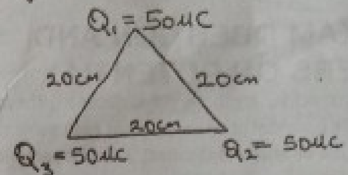
14) Answer

Potential $= -\int E.dr$

15) Three identical charges each of 50 μC are located at the vertices of an equilateral triangle of side 20 cm. calculate the electrical potential energy (A) 500 j (B) 475 j (C) 245.5 j (D) 337.5j (E) 3372 j

15) Solution

This question can be represented as:



The electric potential energy for the system of the 3 charges:

$= \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1 Q_2}{r_{12}} + \frac{Q_1 Q_3}{r_{13}} + \frac{Q_2 Q_3}{r_{23}}\right]$

Where $r_{12} = r_{13} = r_{23} = 20cm$
$= 0.2m$

and $Q_1 = Q_2 = Q_3 = 50\mu C$
$= 50 \times 10^{-6}$

Substituting these into the equation

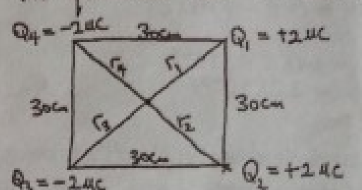
$= k\left[\frac{(50 \times 10^{-6})^2}{0.2} + \frac{(50 \times 10^{-6})^2}{0.2} + \frac{(50 \times 10^{-6})^2}{0.2}\right]$

$= 337.5J$ .... (D)

16) Four point charges are placed at the four corner of a square that is 30 cm on each side, find the potential at the center of the square if two of the four charges +2.0μC and two are -2.0μC . (A) 3.4×10^5V (B) 34.0×10^5V (C) 0 (D) 3.4×10^{-3}V (E) none

16) Solution

The question can be drawn as:



Where:

$2\mu C = 2 \times 10^{-6} C$

$30cm = 0.3m$

Using pythagoras theorem, $(r_1 + r_2) = \sqrt{0.3^2 + 0.3^2}$
$= 0.424m$

$r_1 = r_2 = \frac{0.424}{2} = 0.212m$

$r_3 = r_4 = 0.212m$

Total electric potential a center

$V_E = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2} + \frac{Q_3}{r_3} + \frac{Q_4}{r_4}\right]$

factorizing r .... $(r_1 = r_2 = r_3 = r_4)$

$= \frac{1}{4\pi\varepsilon_0 r}\left[Q_1 + Q_2 + Q_3 + Q_4\right]$

$= \frac{1}{4\pi\varepsilon_0 r}\left[2\mu c + 2\mu c + (-2\mu c) + (-2\mu c)\right]$

$= 0v$ C

17) If the electrical potential difference between point A and B is equal to 52V, find the work done by an external agent in carrying a chae q_o =5.0x10^{-5}C from A to B at a constant speed(A)2.6x10^{-3}j (B) 3.6x10^{3} j(C)2.6x10^{-4} j(D) 5.0x10^{-3} j(E)2.0x10^{-3} j

17) Solution

From the question,

Potential difference $(V_B - V_A) = 52V$

Charge $q_0 = 5\times10^{-5}C$

Work done $W = ?$

Using the formular

$$V_B - V_A = \frac{W}{q_0}$$

$$W = (V_B - V_A)q_0$$

$$= 52 \times (5\times10^{-5})$$

$$= 2.6\times10^{-3}J \text{ .... A}$$

37) Calculate the work required to transfer 200μC from a point at infinity to a point 20 cm from the origin of X--Y plane (A) 2x10^5 j (B) 3x10^6 j (C) 3.7x10^6 j (D) 7x10^5 j (E) 9x10^6 j

37) Solution

given that:

$Q = 200\mu C = 200\times10^{-6}C$

$r = 20cm = 0.2m$

Using the potential formular

$$V = \frac{KQ}{r}$$

$$= \frac{(9\times10^9)\times(200\times10^{-6})}{0.2\,m}$$

$$= 9\times10^6\,JC^{-1} \text{ ....(E)}$$

38) What must the magnitude of an isolated positive point charge be for the electrical potential at 10 cm for the charge to be 100V (A) 2.5x10^{-9}C (B)1.5x10^{-9}C (C) 1.8x10^{-9}C (D) 1.1x10^{-9} C (E) 2.0x10^{-9} C

38) Solution

Given that

$V = 100v$

$r = 10cm = 0.1m$

we use the formular

$$V = \frac{KQ}{r}$$

making Q subject of the formular

$$Q = \frac{Vr}{K} = \frac{100\times0.1}{9\times10^9}$$

$$= 1.1\times10^{-9}c \text{ ....(D)}$$

40) How far should a 20μF and a 30μF b placed such that the potential energy in the configuration is 7.2x10^6 j (A) 1.25μm (B) 2.4μm (C) 0.5μm (D) 0.45μm (E) 0.75μm

40) Solution

From the relation of energy for 2 charges

$$U = \frac{KQ_1Q_2}{r}$$

$$r = \frac{KQ_1Q_2}{U} = \frac{9\times10^9\times(20\times10^{-6})\times(30\times10^{-6})}{7.2\times10^6}$$

$$= 5\times10^{-7}m$$

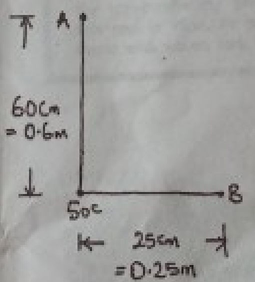
$$= 0.5\mu m \text{ .... (C)}$$

2011 / 2012 QUESTIONS ON ELECTRIC POTENTIAL

10. A charge f 50 C is placed at the origian of an XY plane. Calculate the poteneial difference between two points A= 60 cm and B = 25ncm in the Y and X directions respectively. ______________

10) Solution

The question can be represented as shown



Potential at A $(V_A) = \frac{KQ}{r_A}$

Potential at B $(V_B) = \frac{KQ}{r_B}$

Potential difference $= (V_B - V_A)$

$$(V_B - V_A) = \frac{KQ}{r_B} - \frac{KQ}{r_A}$$

$$= KQ\left[\frac{1}{r_B} - \frac{1}{r_A}\right]$$

$$= \left[9\times10^9\times50\left(\frac{1}{0.25} - \frac{1}{0.6}\right)\right]$$

$$= 1.05\times10^{12}\,V$$

11. The electric potential at a point is defined as

11) The electric Potential at a Point is defined as The work done in moving a unit charge from infinity to that point.

12. If the elec tric potential difference between two points is 30 v, find the work done by an external agent in carrying a charge, q0 = 5 x10^{-5} C between the points. ______________

12) Solution

from the question,

Potential diff $(\Delta V) = 30V$

Charge $q_0 = 5\times10^{-5}C$

Work $W = ?$

$$\Delta V = W/q_0$$

$$W = \Delta V\, q_0$$

$$= 30\times(5\times10^{-5})$$

$$= 1.5\times10^{-3}J$$

2010 / 2011 QUESTIONS ON ELECTRIC POTENTIAL

13. Calculate the electric potential due to a dipole whose moment is 4.8×10^{-30}C. M at a point 10^{-9}m away if this point is 45° above the dipole axis.

13) Solution

from the formular for electric potential

$$V = \frac{KP\cos\theta}{r^2}$$

$K = 9\times10^9$
$P = 4.8\times10^{-30}$
$r = 10^{-9}$
$\theta = 45°$

$$V = \left(\frac{(9\times10^9)\times(4.8\times10^{-30})\times(\cos 45)}{(10^{-9})^2}\right)$$

$= 0.031$ V ANS

14. Two metal plates are 2.0cm apart in vacuum and the upper is maintained at a positive potential relative to the lower so that the field strength between them is 2.5×10^5 V/m. What is the potential difference of the plates?

14) Solution

given that:
$E = 2.5\times10^5$
$d = 2.0$cm $= 0.02$m
we use the formular

$V = Ed$
$= (2.5\times10^5)\times(0.02)$
$= 5000$ V

15. A charge Q_1=2μC is located at the origin and a second charge Q_2=4μC is located on the x-axis at 0.5m. Calculate the electric potential energy of this pair of charges?

15) Solution

$q_1 = 2\times10^{-6}$c
$q_2 = 4\times10^{-6}$c
$r = 0.5$
electric Potential energy

$$U = \frac{Kq_1q_2}{r}$$

$$= \frac{(9\times10^9)\times(2\times10^{-6})\times(4\times10^{-6})}{0.5}$$

$= 0.144$J

2009/2010 QUESTIONS ON POTENTIAL

5. The electric potential difference between discharged points during a particular thunderstorm is 1.2×10^9 V. What is the electric potential energy of an electron that moves between these points? (A)1.52×10^{-10}j (B) 1.65×10^{-10}j (C)1.72×10^{-10}j (D) 1.88×10^{-10}j (E) 1.92×10^{-10}j

5) Solution

given that:
$q = 1.6\times10^{-19}$
$V = 1.2\times10^9$ V
$U = ?$
From $V = \frac{U}{q}$

$U = Vq$
$= (1.2\times10^9)\times(1.6\times10^{-19})$
$= 1.92\times10^{-10}$J .... (E)

6. A charge q_1 = 9μC is located at the origin and a second charge q_2 = 1μC is located at the x-axis at x = 0.7m. Calculate the electric energy due to the pair of charges. (A) 0.116j (B) 0.7j (C) 0.118j (D) 0.191j (E) 1.15j

6) Solution

$q_1 = 9.0\times10^{-6}$
$q_2 = 1.0\times10^{-6}$
$r = 0.7$m

$$U = \frac{Kq_1q_2}{r}$$

$$= \frac{(9\times10^9)\times(9\times10^{-6})\times(1\times10^{-6})}{0.7}$$

$= 0.116$J .... (A)

7. The electric potential of an isolated positive point charge is +200V at a distance 30cm from the charge. What is the magnitude of the charge? (A) 1.6×10^{-19}C (B) 3.2×10^9C (C) 9.11×10^{-31}C (D) 6.67×10^{-9}C

7) Solution

From the question,
$V = 200$V
$r = 30$cm $= 0.3$m,
using the equation for potential,

$$V = \frac{KQ}{r}$$

$$Q = \frac{Vr}{K} = \frac{200\times0.3}{9\times10^9}$$

$= 6.67\times10^{-9}$C .... (D)

9. Suppose an electron in a cathode ray tube is accelerated from rest through a potential difference +5000V, what is the change in electric potential energy of the electron? (A) -1.6×10^{-19}j (B) $+1.6 \times 10^{-16}$j (C) $+3.2 \times 10^{-16}$j (D) -3.2×10^{-19}j (E) -8.0×10^{-16}j

CAPACITANCE AND DIELECTRICS

9) Solution

given that:

Charge $q = -1.602 \times 10^{-19} C$

Potential diff. $\Delta V = +5000V$

we use the Formular:

$\Delta V = \frac{\Delta U}{q}$

$\Delta U = \Delta V \times q$

$= 5000 \times (-1.602 \times 10^{-19})$

$= -8.0 \times 10^{-6} J$ .... E

Our answer carries sign in potential because of the additive nature of charge.

10. What minimum work must be done by an external force to bring a charge q = 3.00μC from infinity to a point 0.5m from a charge Q = 20μC? (A) 1.08J (B) 0.50J (C) 3.0J (D) 1.0J (E) 2.16J

10) Solution

from the quest:

$r = 0.5m$

$Q = 3.0 \times 10^{-6}$

$q = 3.0 \times 10^{-6}$

$U = ?$

$U = \frac{KQq}{r}$

$= \frac{9 \times 10^{9} \times 3 \times 10^{-6} \times 3 \times 10^{-6}}{0.5}$

$= 1.08J$ ..... A

11. calculate the electric potential due to a dipole whose moment is 4.8×10^{-9}m away if this point is along the axis of the pole nearer the positive charge. (A)23.0V (B)0.55V (c)40.6V (D)0.023 (E)0.043V

11) Solution

given the Parameters:

dipole moment $P = 4.8 \times 10^{-30}$ C.m

$r = 1.0 \times 10^{-9} m$

electric potential due to a dipole

$V = \frac{KP}{r^2} = \frac{(9 \times 10^{9}) \times (4.8 \times 10^{-30})}{(1.0 \times 10^{-9})^2}$

$= 0.043V$ ....(E)

VON KLEIST AND THE LEYDEN JAR 71

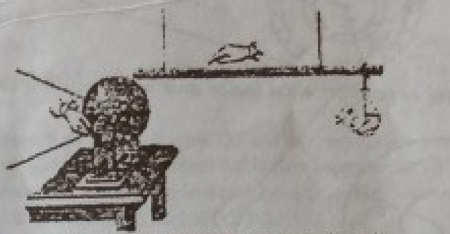
CHAPTER V

VON KLEIST AND THE LEYDEN JAR

"I would not take a second shock for the Kingdom of France."—MUSSCHENBROECK, in a letter to Reaumur.

TOWARD the close of 1745, Von Kleist, Bishop of Pomerania, desiring to isolate electricity, conceived the idea of leading a charge from an electric machine into a glass bottle, arguing, in all probability, that he might in this manner be able to

Von Kleist's invention of the Leyden jar.

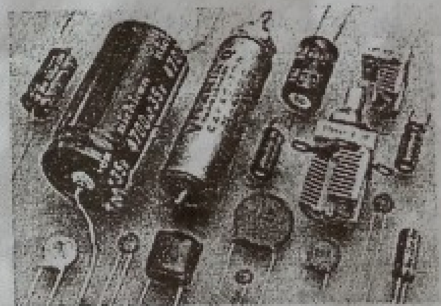


[illegible]—Von Kleist's discovery of the Leyden jar. Note the [illegible] sharp angles and edges of the prime conductor. This was before the discharging power of points or sharp edges was known.

fill the bottle with electricity, since he imagined the electricity would not be able to escape on account of the non-conducting property of the glass. With this end in view, he partially filled a small glass bottle with water, and, holding it in one hand, con-

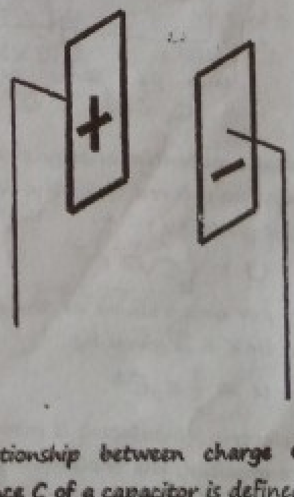
Ewald Georg von Kleist From Wikipedia, the free encyclopedia

the first man that tried to store charge in a jar and in the process he created the capacitor



Summary adapted from the school textbook

A capacitor is a device for storing electrical charge and energy. It consists of two conductors, closely spaced but insulated from each other, carrying equal but opposite charges.



- **The relationship between charge Q, potential V and capacitance C of a capacitor is defined by;**

$$Q = CV$$

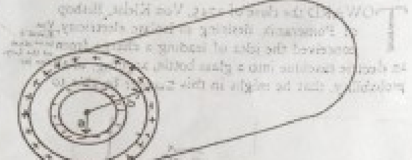
- the unit of capacitance is farads (F)
- capacitance depends only on the geometrical arrangement of the conductors and not on the charge or the potential difference.
- A parallel plate capacitor has a capacitance given by

$$C = \frac{\varepsilon_0 A}{d}$$

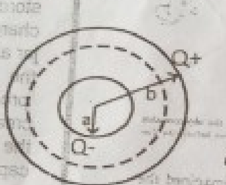
Where A is the area of the plates and d is the distance between the plates.

- For cylindrical capacitor

$$C = \frac{2\pi\varepsilon_0 l}{ln\left(\frac{b}{a}\right)}$$

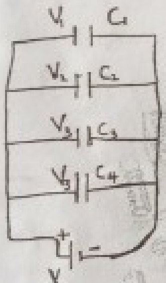


- For spherical capacitor with inner and outer radii a and b



$$C = \frac{4\pi\varepsilon_0 ab}{b-a}$$

- When capacitors are connected in parallel, the equivalent capacitance C is given by;

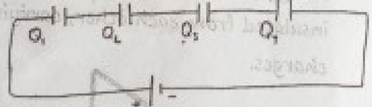


$$C = C_1 + C_2 + C_3 + C_4$$

And NOTE
P.d across each Capacitor in Parallel is the Same
ie
$V = V_1 = V_2 = V_3 = V_4$

- When capacitors are arranged in series, the equivalent capacitance C is given by;

$$C = \frac{1}{\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4}\right]}$$



Note, For Series arrangement
$Q_1 = Q_2 = Q_3 = Q_4$

- The electrostatic potential energy stored in a capacitor, which can also be refered to as the work done in charging it, is given by ;

$$U = \frac{1}{2}CV^2$$

- The energy per unit volume or the energy density in the electric field E is given by;

$$u = \frac{1}{2}\varepsilon_0 E^2$$

- When a dielectric (insulator) is inserted between the plate of a capacitor, the molecules in the dielectric becomes polarized and the electric field within the dielectric is weakened. If E_o is the field without the dielectric, E the field with the dielectric and E_{ind} the field induced by the dielectric, then;

$$E = E_o - E_{ind}$$

$$E = E_o/K$$

Where K is called dielectric constant. The decrease in the electric field leads to an increase in the capacitance by factor K;

$$C = C_o K$$

Where C_o is the capacitance without the dielectric. The permittivity of a dielectric ε is defined as;

$$\varepsilon = K\varepsilon_o$$

We also have that

$$Q_{ind} = Q(1 - 1/K) \text{ and}$$

$$E_{ind} = E_o(1 - 1/k)$$

- Capacitors are used in many devices because of the storage capability. They also find use when a.c. is being converted to d.c. other applications include use in tuning circuits of radio and television receivers.

FUTO PAST QUESTION ON CAPACITANCE 2016 - 2009

2016 EXAM QUESTION AND ANSWERS ON CAPACITANCE

40. Which of these is not correct about inclusion of dielectric material of dielectric constant K in a capacitor?
A. The potential energy of the capacitor is increased B. The potential difference between the plates of the capacitor is increased C. The charge stored in the capacitor will increase D. The electric field within the capacitor is reduced E. The capacitance is increased

40) B

41. If the area of a parallel plate capacitor separated by a 6.5mm air gap is $3x10^3m^2$, what is the capacitance of the capacitor/
A.2.08µF B. 4.08µF C. 6.5µF D. 3.0µF E. 6.0µF

41) from the Capacitance formular

$$C = \frac{\varepsilon_o A}{d}$$

$$C = \frac{(8.85\times10^{-12})(3\times10^3)}{(6.5\times10^{-3})}$$

$$= 4.08\times10^{-6}\,F$$

$$= 4.08\mu F$$

42. A dielectric K=2 is inserted between the plates of a 20uF capacitor. Its capacitance will become.. A.10µf B.18µF C. 20µF D.40µF E. 80µF

42) $C_F = C_o k$
$= 20\mu F \times 2$
$= 40\mu F$

43. What voltage must be applied across the terminals of a capacitor of capacitance 10µf in order to store an energy of 5 J in it? A. 5kV B.2.5kV C. 1.5kV D. 1kV E. 0.5kV

43) $u = \frac{1}{2}CV^2$

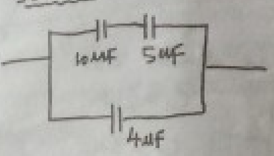
$5 = \frac{1}{2}(10\times10^{-6})V^2$

$V = \sqrt{\frac{5}{\frac{1}{2}(10\times10^{-6})}} = 1000V$

$= 1kV$

44. Two series capacitors of capacitances 10μf and 5μF respectively are made parallel with another capacitor of capacitance 4μF. What is their effective capacitance? A. 0.30μF B. 3.16μF C. 3.33μF D. 7.33μF E. 19.00μF

44) Solution



$$C_{eq} = \left[\frac{1}{(1/10)+(1/5)}\right] + 4$$

$$= 7.33\mu F$$

45. A parallel plate capacitor has plates of area $250cm^2$ and separation 2mm. What is the capacitance of the capacitor if there is no dielectric inserted into it? A. 0 B.111pF C. 56.5pF D. 70.8pF E. 4.4nF

45) Solution

$$A = 250cm^2 = \left[\frac{250}{100 \times 100}\right] m^2$$

$$d = 2mm = 2 \times 10^{-3}$$

$$C = \varepsilon_0 A/d$$

$$= \frac{(8.85 \times 10^{-12})\left(\frac{250}{100 \times 100}\right)}{(2 \times 10^{-3})}$$

$$= 1.106 \times 10^{-10} F$$

$$\approx 111pF$$

20. The plates of a parallel plate capacitor separated by a distance of 5.00mm have a potential difference of 3.0×10^4V applied across them. When the space between them is filled with a dielectric, the electric field within the dielectric is found to be 1.5×10^6 V/m. Calculate the dielectric constant of the material. A 50 B. 4.0 C. 0.25 D. 0.4 E. 5.0

20] for original electric field, E_0

$$E_0 = \frac{V_0}{d} = \frac{3 \times 10^4}{5 \times 10^{-3}}$$

$$= 6 \times 10^6$$

final electric field after dielectric has been placed $E = 1.5 \times 10^6$

dielectric constant $k = E_0/E$

$$= \frac{6 \times 10^6}{1.5 \times 10^6}$$

$k = 4$ ...... B//

27. The capacitance of a 8mm x 5mm parallel plate capacitor is 20μF. If the charge on the plates is 40μC, the energy stored in it is? A. 45μJ B. 25μJ C. 60μJ D. 20μJ E. 40μJ

27] from the question

$C = 20\mu F$

$Q = 40\mu C$

But Energy stored on a capacitor is given by

$$U = \frac{Q^2}{2C} = \frac{(40)^2}{2 \times 20}$$

$$U = \frac{1600}{40} = 40$$

Ans $U = 40\mu J$ --- E//

49. Two capacitors of capacitances 2μF and 4μF respectively are connected in parallel. A third capacitor of capacitance 3μF is then connected in series with the combination. Calculate the resultant capacitance of the entire combination. A. 9.00μF B. 4.33μF C. 0.92μF D. 2.00μF E. 2.22μF

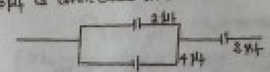
49] Solution 2μF and 4μF in parallel

$C_{eq} = C_1 + C_2$ (in parallel)

$C_{eq} = 2\mu F + 4\mu F = 6\mu F$

6μF is connected in series with 3μF

i.e



$$C_{eq} = \frac{1}{\frac{1}{6} + \frac{1}{3}}$$

$= 2\mu F \therefore C = 2\mu F$ .... D

2015 EXAM QUESTION AND ANSWERS ON CAPACITANCE

1. Find the capacitance of a parallel plate capacitor 5.00m apart with an area of $2.0m^2$ if a potential difference of 10.0kV is applied across the capacitor. A. 5.4×10^{-16}F B. 2.7×10^{-6}F C. 4.35×10^{-6}F D. 3.54×10^{-12}F E. 3.54×10^{-6}F

1] $d = 5.00m$

$A = 2.0m^2$

$V = 10.0kV = 0.01V$

$C = ?$

The formula for a parallel plate capacitor is given by

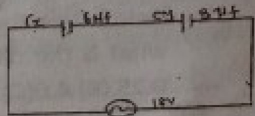
$C = \frac{E_0 A}{d}$ $E_0 = 8.85 \times 10^{-12}$

$$C = \frac{8.85 \times 10^{-12} \times 2.0}{5.0} = \mathbf{3.54X10^{-12}F}$$

3. If two capacitors X and Y with respective capacitance $C_x = 6\mu F$ and $C_y = 3\mu F$ are arranged in series, find the charge Q_x and Q_y on each of the capacitors if a potential of 18V is applied between the terminals of the arrangement. A. Q_x = 108μC, Q_y = 54μC B. Q_x = 108μC, Q_y = 108μC C. Q_x = 36μC, Qy = 54μC D. Q_x = 54μC, Q_x = 36μC E. Q_x = 36μC, Qy = 36μC

3] Since they are in series, the charge on both of them must be equal.

first we find the capacitance



$$C_{eq} = \frac{1}{(\frac{1}{6}) + (\frac{1}{3})}$$

$= 2\mu F$

$Q = CV$

$= 2 \times 18$

Ans $= 36\mu C$ ---- E//

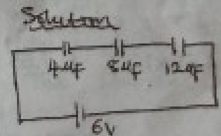
4. Which of these is incorrect when a dielectric material with dielectric constant K is introduced between the space of a parallel plate capacitor? A. The capacitance of the capacitor increases by a factor of K B. The potential difference for a given charge Q is reduced by a factor of K C. The electric filed between the plates of the capacitor is reduced by the factor K D. The energy density u in the electric field increases by a factor of K E. None of the above

ans.... E

2015 TEST QUESTION ON CAPACITANCE

5) Three capacitors of capacitance 4uF, 8uF and 2uF are connected in series and a potential difference of 6 volts is supplied. Calculate the equivalent capacitance.

5) Solution



equivalent Capacitor in Series

$$= \frac{1}{\left(\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}\right)} = \frac{1}{\left(\frac{1}{4}+\frac{1}{8}+\frac{1}{12}\right)}$$

$= 2.18uF$

2013 / 2014 QUESTIONS ON CAPACITANCE.

8. What energy is stored in a capacitor 2μF if it is connected across a DC supply 12v for 5minutes and it is fully charged? A. 144×10^{-4}J b. 1.44×10^{-4}J C. 14.4×10^{-4}J D. 1.44×10^{-3}J E. 1.88×10^{-2}J

8) $C = 2uF = 2 \times 10^{-6}F$

$V = 12v$

$U = ?$

$$\text{Energy } (U) = \tfrac{1}{2}CV^2$$

$$= \tfrac{1}{2}(2 \times 10^{-6}) \times (12)^2$$

$$= 1.44 \times 10^{-4}J \text{ .... (B)}$$

20. Calculate the area of the plate of a 1.00 F parallel plate capacitor with an air gap of 0.05mm. A. $1.77 \times 10^3 m^2$ B. $5.56 m^2$ C. $450 m^2$ D. $1.75 \times 10^9 m^2$ E. $5.56 \times 10^6 m^2$

20) Solution

$C = 1F$

$d = 0.05\,mm = 0.05 \times 10^{-3}$

$A = ?$

From the Formular $C = \frac{A\varepsilon_0}{d}$

$$A = \frac{Cd}{\varepsilon_0}$$

$$= \frac{1 \times (0.05 \times 10^{-3})}{8.85 \times 10^{-12}}$$

$$= 5.6 \times 10^6 \text{ ------- E}$$

31. What is the energy density of a parallel plate capacitor of capacitance 2μF if the electric field is $4 \times 10^6 NC^{-1}$? A. $708\ Jm^{-3}$ B. $70.8\ Jm^{-3}$ C. $7.08\ Jm^{-3}$ D. $0.708\ Jm^{-3}$ E. $7.08 \times 10^{-2}\ Jm^{-3}$

31) Solution

Energy density $= \frac{1}{2} E \varepsilon_0$

$E = 4 \times 10^6\ NC^{-1}$

$\varepsilon_0 = 8.85 \times 10^{-12}$

$$u = \tfrac{1}{2} \times (4 \times 10^6) \times (8.85 \times 10^{-12})$$

$$= 70.8\ Jm^{-3} \text{ ------ (E)}$$

43. A parallel plate capacitor has a charge $Q = 8.9 \times 10^{-7}C$. what will be the induced charge Q_{ind} if dielectric material of dielectric constant K = 7.14 is inserted between the plates? A. $6.65 \times 10^{-7}C$ B. $2.65 \times 10^{-7}C$ C. $3.65 \times 10^{-7}C$ D. $4.65 \times 10^{-7}C$ E. $7.65 \times 10^{-7}C$

43) Solution

$$Q_{ind} = Q_0 (1 - 1/K)$$

$$= 8.9 \times 10^{-7}\left(1 - \frac{1}{7.14}\right)$$

$$= 7.65 \times 10^{-7}C \text{ ------ (E)}$$

2012 / 2013 QUESTIONS ON CAPACITANCE

18) Two capacitors 4μF and 12μF are connected in series. Calculate the equivalent capacitance (A)24μF (B)2.18μF (C)1.31μF (D)15μF (E) 0μF

18) Solution

from the question,

$C_1 = 4\mu F$

$C_2 = 12\mu F$

$C_{equiv} = ?$

for Capacitors Connected in Series

$$C_{equiv} = \frac{1}{\left(\frac{1}{C_1}\right) + \left(\frac{1}{C_2}\right)}$$

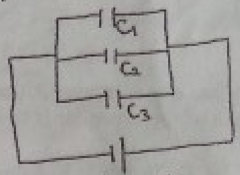
$$= \frac{1}{\left(\frac{1}{4}\right) + \left(\frac{1}{12}\right)}$$

$$= 3\mu F$$

19) Three capacitors of 2μF 3μF and 4μF are connected in parallel and a p.d of 6V is maintained across each capacitors. Find the charge on the 2μF capacitor (A)2.4x 10^{-5}C (B) 5.4×10^{-5} C (C) 1.2×10^{-5} C (D) 4.8×10^{-5} C (E) 1.8×10^{-5}

19) Solution

This question can be drawn as:



$C_1 = 2\mu F$

$C_2 = 3\mu F$

$C_3 = 4\mu F$

$V = 6v$

Since the Capacitors are arranged in parallel, V is Same for all Capacitors, $V = V_1 = V_2 = V_3$ but Total Charge $Q = Q_1 + Q_2 + Q_3$

and $Q_1 = C_1V_1$, $Q_2 = C_2V_2$, $Q_3 = C_3V_3$

$$\therefore Q_1 = 2\mu F \times 6V$$

$$= 12\mu C$$

$$= 1.2 \times 10^{-5} C$$

20) A 3.0F capacitor is desired. What should the area of the plates be if they are to be separated by a 4.5 mm air gap? (A) 2.5×10^9 (B)1.52×10^9 (C) 1.63×10^7 (D) 1.52×10^{-7} (E) none of the above

20) From the question,

$C = 3F$

$d = 4.5mm = 4.5 \times 10^{-3}$

$\varepsilon_0 = 8.85 \times 10^{-12}$ (free Space)

we use the Formular

$$C = \frac{\varepsilon_0 A}{d}$$

making A Subject of the formular

$$A = \frac{Cd}{\varepsilon_0}$$

$$= \frac{3 \times (4.5 \times 10^{-3})}{8.85 \times 10^{-12}}$$

$$= 1.52 \times 10^9 m^2 \text{ .... (B)}$$

41) The plates of a parallel plate capacitor separated by a distance of 5.0mm have a potential difference of $3.0 \times 10^4 V$ applied across them. When the space between them is filled with a dielectric, the electric field within the dielectric Is found to be $1.5 \times 10^6 Vm^{-1}$ what is the dielectric constant of the material? (A) 0.25 (B) 4.0(C) 0.4 (D) 50 (E) 5.0

41) Solution

for Original electric field, E_0

$$E_0 = \frac{V_0}{d} = \frac{3 \times 10^4}{5 \times 10^{-3}}$$

$$= 6 \times 10^6$$

Final electric field after dielectric has been placed $E = 1.5 \times 10^6$

dielectric Constant $K = E_0/E$

$$= \frac{6 \times 10^6}{1.5 \times 10^6}$$

$$= 4 \text{ .... B}$$

42) Which of the following is not true of a capacitor (A) the charges on the conductors of the capacitors are equal and opposite (B) there is a finite potential difference between the two conductors of the capacitors (C) the two parallel conductors of a capacitors may be in a capacitor may be in direct contact with each other (D) the unit of the capacitance of a capacitor is the farad (E) None of the above

42) Solution

Option C is not Correct

43) A parallel plate capacitor has a plate of dimension 20 cm by 20 cm separated by 2mm. the dielectric constant of the material between the plate is 5.0 and the p.d between the plate is 500V. calculate the magnitude of the charges on each plate (A) 4.4×10^{-8}C (B) 4.4×10^{-7} C (C) 4.4×10^{-6}C (D) 2.2×10^{-8}C (E) 2.2×10^{-7}

43) Solution

from the question, $d = 2mm = 2\times10^{-3}m$

$$\text{Area} = 20cm \times 20cm = (0.2\times0.2)m^2 = 0.04m^2$$

Potential diff $V = 500V$

$$K = 5$$

With K present in the capacitor

$$C = CK = \frac{A\epsilon_0}{d}\times K$$

but $Q = CV$

$$= \frac{A\epsilon_0 K V}{d} = \left[\frac{0.04\times(8.85\times10^{-12})\times5}{2\times10^{-3}}\right]$$

$$Q = 4.4\times10^{-7}C \text{ ...... B}$$

44) The capacitance of a capacitor depends on the following factor except (A) the area of the plate (B) the distance between the plate (C) the p.d between the plate (D) the material nature of the plate (E) the dielectric material between the plate

44) Option C.

2011/2012 QUESTIONS ON CAPACITANCE

13. A receiver contains a capacitor of 10 µF, charged to a potential difference of 20 kv. Calculate the potential energy stored the capacitor. ________

Question 1 Solution

Formular for energy (U) stored in a capacitor $= \frac{1}{2}CV^2$

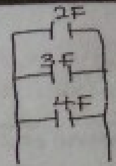
$$C = 10F$$

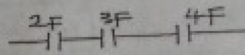
$$V = 20kV = 20\times10^3 V$$

$$U = \frac{1}{2}CV^2 = \frac{1}{2}\times10\times(20\times10^3)^2 = 2\times10^9 J$$

KINGS ANSWER

14. Three capacitors of capacitance 2,3,4 µF are connected in parallel and then connected inseries. Find the resultant of each arrangment





Parallel

$$C_{eq} = C_1 + C_2 + C_3 = 2+3+4 = 9F$$

Series

$$C_{eq} = \frac{1}{\left(\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}\right)} = \frac{1}{\left(\frac{1}{2}+\frac{1}{3}+\frac{1}{4}\right)} = 0.92F$$

KINGS ANSWER

15. State the factors that affect the capacitance of a parallel plate capacitor. ________

(3) Factors that affects the Capacitance are:

1. Area of plates
2. Distance between the plates
3. permittivity between the plates.

KINGS ANSWER

29. Write down two areas of application of capacitors. ________

Radio Systems

Transmitters

Power storage etc

KINGS ANSWER

30. A capacitor of capacitance 20 µF has a dielectric constant 2.8 between the plates. If the capacitor is fully charged from 24 V source, calculate the energy stored in thee capacitor. ________

from the parameters given in the Question.

$$C = 20\mu F$$

$$K = 2.8$$

$$V = 24V$$

energy $(U) = \frac{1}{2}CV^2$

But if there is a dielectric material

$$U = \frac{1}{2}KCV^2 = \frac{1}{2}\times2.8\times20\times10^{-6}\times24^2 = 0.016J$$

2010/2011 QUESTIONS ON CAPACITANCE

16. If the original field, E_O and the induced field E_{ind} of a capacitor are given as 10^7N/C and 8.8 x 10^6N/C respectively, find the dielectric constant of the material used in the capacitor.

Original Field $E_O = 10^7$ N/c

Induced Field $E_{ind} = 8.8\times10^6$ N/c

dielectric Constant (K) = ?

From the formular

$$E_{ind} = E_o\left(1-\frac{1}{K}\right)$$

making K subject of the formular

$$K = \frac{1}{\left[1-\frac{E_{ind}}{E_o}\right]}$$

$$K = \frac{1}{\left[1 - \frac{8.8\times10^{6}}{10^{7}}\right]}$$

$K = 8.33$ [KINGS ANSWER]

17. A 2.0µF capacitor was charged by a 12V battery. What is the energy stored in the capacitor?

$Q = 2.0\mu C$

$V = 12V$

energy $(u) = ?$

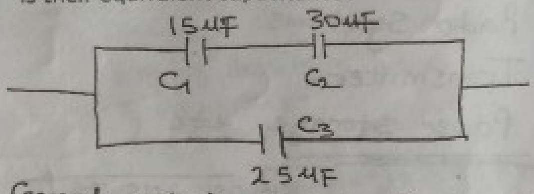
The energy formular involving Q and V is:

$u = \frac{1}{2}QV$ Kings will prove it in the class.

$u = \frac{1}{2}\times 2\times10^{-6}\times 12$

$= 1.2\times10^{-5} J$ KINGS ANSWER

18. Two capacitors in series C_1=15µF and C_2 =30µF are in parallel connection with a third capacitor C_3=25µF. What is their equivalent capacitance?



General method; we look for any series or parallel arrangement and compress them, until we get to the final answer

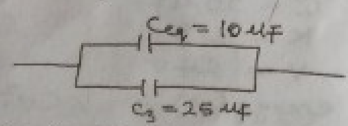
C_1 and C_2 ⇒ Series.

$$C_{eq} = \frac{1}{\left[\left(\frac{1}{C_1}\right) + \left(\frac{1}{C_2}\right)\right]}$$

$$= \frac{1}{\left(\frac{1}{15}\right) + \left(\frac{1}{30}\right)}$$

$= 10\mu F$

New diagram



Adding the two in Parallel

$C = C_{eq} + C_3$

$= 10 + 25$

$= 35\mu F$ KINGS ANSWER

19. The two plates of a capacitor hold +2800µC and -2800µC of charge respectively, when the potential difference across the plates is 930V. What is the capacitance?

From Capacitance formular

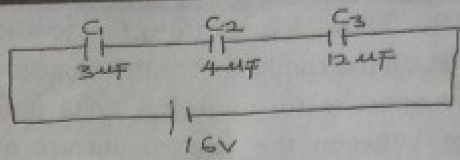
$Q = CV$

$C = \frac{Q}{V}$

$= \frac{2800\times10^{-6}}{930}$

$= 3\times10^{-6}F$ KINGS ANSWER

20. Three capacitors of capacitances 3µF,12µF, and 4µF are connected in series and a potential difference of 16V is applied to the whole combination. Calculate the net charge stored by the capacitor.



$Q = CV$

$$C = \frac{1}{\frac{1}{3} + \frac{1}{4} + \frac{1}{12}}$$

$= 1.5\mu F$

$Q = 1.5\times16$

$= 24\mu C$ [KINGS ANSWER]

2009/2010 QUESTIONS ON CAPACITANCE

12. how many 0.5µF capacitors must be connected in parallel to store a charge of 10C with a potential of 50V across the capacitors. (A)400000 (B)9999 (C)Infinity (D)50000 (E)400999

First find the capacitance of the system.

$C = \frac{Q}{V}$

$= \frac{10}{50}$

$= 0.2F$

Now to find how many $0.5\mu F$ (0.5×10^{-6}) Capacitors makes 0.2F, we divide:

$$\frac{0.2}{0.5\times10^{-6}}$$

$= 400,000$ KINGS ANSWER

Option B

13. if the area of a parallel plate capacitor separated by a 6.5mm air gap is $3.0\times10^{3}m^2$, what is the capacitance of the capacitor? (A)2.08µF (B)4.08µF (C)6.5µF (D)3.0µF

Another Capacitance formular for Parallel plate

Make sure you memorize all of them

$$C = \frac{A\varepsilon_o}{d}$$

$$= \frac{(3\times10^{3})\times(8.85\times10^{-12})}{(6.5\times10^{-3})}$$

$= 4.08\times10^{-6}$

$= 4.08\mu F$ [KINGS ANSWER]

14. A parallel plate capacitor has plate dimension, 8cm by 8cm separated by a distance of 3mm. calculate the capacitance if a glass of dielectric constant 5 fills the space between the plates. (A)141.5PF (B)25.14PF (C)690.30PF (D)41.6PF

$$C = \frac{A\varepsilon_0}{d}$$

But with the presence of a dielectric material,

$$C = \frac{KA\varepsilon_0}{d}$$

$$A = 8cm \times 8cm = (8\times10^{-2})m \times (8\times10^{-2})m = 6.4\times10^{-3}m^2$$

$$d = 3mm = 3\times10^{-3}m$$

$$C = \frac{5\times(6.4\times10^{-3})\times(8.85\times10^{-12})}{(3\times10^{-3})}$$

$$= \underline{9.44\times10^{-11}}\ F$$ Kings Answer

No Right option

15. A capacitor has charges +q on one plate and −q on the other plate. Which is true? (A)the potential difference between the plate is qc (B)the energy stored is 1/2qΔ (C)the energy stored is $1/2q^2\Delta v$ (D) the pd across the plates is $q^2/2c$

Option B is True Kings Answer

16. an air-filled plate capacitor has capacitance of 2.4pf. the separation of the plates is tripled and wax inserted between them. The new capacitance is 4.8pf. find the dielectric constant of the wax (A)4 (B)2 (C)8 (D)6 (E)12

hmm... this question seems kind of freaky. But dont get fooled.

dielectric constant $K = \frac{C_{Final}}{C_{original}}$

but 4.8 as C_{Final} was gotten after Triplicating d (distance between plates) To remove that effect, we multiply C_{Final} by 3

$$C_{Final} = \frac{A\varepsilon_0}{(\cancel{3}d)} \times \cancel{3}$$

I Know NASA Student will not understand this. DONT JUST THINK! again, meet KINGS

$$= 4.8\times3$$

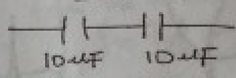
Normal $C_{Final} = \underline{14.4}PF$

$$K = \frac{14.4}{2.4} = \underline{6}$$ KINGS ANSWER

Option D

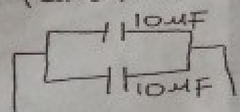
17. Consider two identical capacitors $C_1=C_2=10\mu f$. what are the minimum and maximum capacitances that can be obtained by connecting these in series or parallel combination? (A)0.2μf, 5.0μf (B)0.2μf,10.0μf (C)0.2μf,20.0μf (D)5.0μf,10.0μf

Series



$$C = \frac{1}{\frac{1}{10}+\frac{1}{10}} = 5uF$$

Parallel

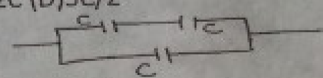


$$C = 10 + 10 = 20uF$$

Min and Max = 5uF and 20uF Not in the option

KINGS ANSWER

18. Two capacitor $C_2$and C_3 in parallel are in series with a third capacitor C_1. Determine the equivalent capacitance of this combination if $C_1=C_2=C_3=C$ (A)3C (B)2C/3 (C)2C (D)3C/2



$$\left[\frac{1}{\frac{1}{c}+\frac{1}{c}}\right] + C = \tfrac{1}{2}C + C = 3C/2$$ option D

KINGS ANSWER

19. What is the net field within a dielectric if the original field E_0 and the induced field E_{ind} are 1.0×10^7 N/C and 8.6×10^6 respectively? (A)1.4×10^6 N/C (B)8.6×10^6 N/C (C)2.4×10^6 N/C (D)1.2×10^5 N/C

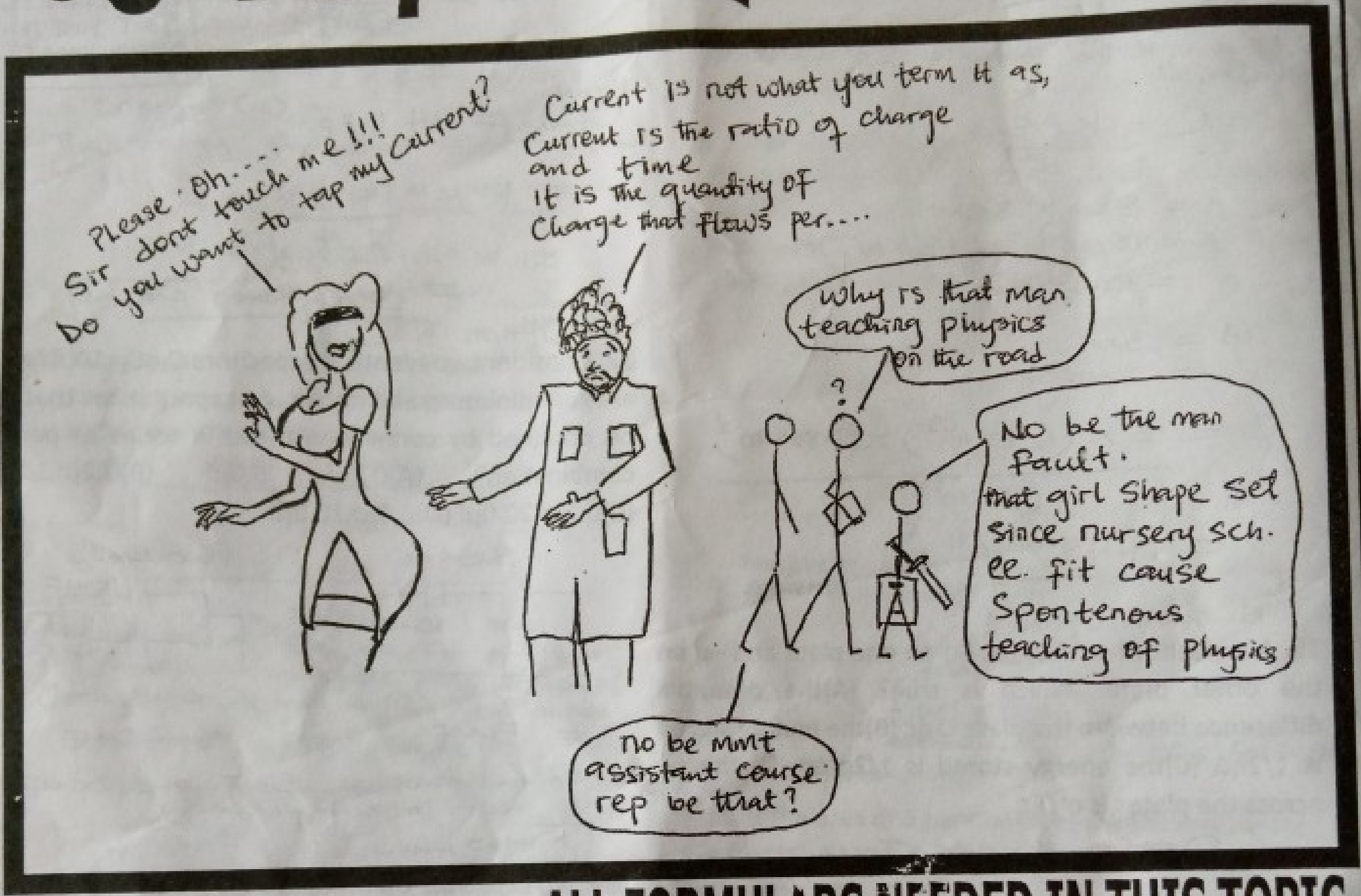
Net electric Field:

$$E = E_0 - E_{ind} = (1\times10^7) - (8.6\times10^6) = 1400,000 = \underline{1.4\times10^6 N/c}$$

option (a)

KINGS ANSWER

CURRENT ELECTRICTY



ALL FORMULARS NEEDED IN THIS TOPIC

SIR GEORG SIMON OHM. A GERMAN THAT WORKED ON THE FLOW OF ELECTRIC CURRENT AND CAME UP WITH THE 'OHMS LAW'

- Current: $I = Q/t$
- Current: $I = qnAV_d$
- Current density: $j = I/A$
- Current density: $j = qnV_d$
- Resistance: $R = V/I$
- Resistance: $R = \rho L/A$
- Conductivity: $\sigma = 1/\rho$
- Resistivity: $\rho = \frac{RA}{L}$
- Power: $P = IV$
- Energy: $E = Pt$
- Internal resistance: $r = E/I - R$

Georg Simon Ohm

Born	16 March 1789 Erlangen, Brandenburg-Bayreuth (present-day Germany)
Died	6 July 1854 (aged 65) Munich, Kingdom of Bavaria
Residence	Brandenburg-Bayreuth, Bavaria
Nationality	German
Fields	physics (electricity)
Institutions	University of Munich
Alma mater	University of Erlangen
Doctoral advisor	Karl Christian von Langsdorf
Known for	Ohm's law Ohm's phase law Ohm's acoustic law
Notable awards	Copley Medal (1841)

ELECTRIC CURRENT

- Electric current in a conductor is the charge passing through a cross- sectional area per unit time.

$I = dQ/dt$ or $I = Q/t$

- In terms of the charge carrying particles in the wire, current can also be given as;

$I = qnAv_d$ where $q = 1.6x10^{-19}C$
n= electron density
A= cross sectional area of the wire
V_d= drift velocity of the charges

- Current density $j = I/A$ and can also be stated as $j = qnv_d$
- The resistance of a wire across which there is a potential drop V is given by $R = V/I$ where I is the current flowing along the wire. This is known as ohms law.
- A given material obeys ohms law if its resistance is independent of the applied voltage. Materials which obey ohms law are said to be ohmic (eg metals) while those that do not obey it are non-ohmic (eg transistors)
- The resistance of a wire is proportional to the lenght and inversely proportional to the cross-sectional area

$R = \rho L / A$

- The reciprocal of resistivity ρ is known as conductivity, σ

$\sigma = 1/\rho$

- The power supplied to a segment of a circuit equals the product of the current and the voltage drop across the segment. $P = IV$ the unit of power is the watt or joule per second.
- Energy consumption or electrical energy can be stated as the product of power and time Pt
- The relationship between resistivity and increase in temperature can be stated as $\rho_T = \rho_o [1 + \alpha(T - T_o)]$.
- Super conductors are materials for which the resistivity is zero below the critical temperature T_c.

points on battries and cell would be gotten from the solutions to past questions

FUTO PAST QUESTION ON ELECTRIC CURRENT 2016 - 2009

BETTER UNDERSTANDING OF THIS TOPIC WILL BE GOTTEN AFTER GOING THROUGH THESE QUESTIONS

16. A current density of $2x10^5 A/m^2$ in a cylindrical wire of radius R=2mm is uniform across a cross-section of the wire. What is the current through the portion of the wire between the radial distance R/2 and R? A. 2.51A B. 0.63A C. 1.88A D. 188A E. 0

16) Solution
from the formular for current density

$j = I/A$

$I = jA$

$= (2 \times 10^5) \times \pi R^2$

$= (2 \times 10^5) \times \pi (2 \times 10^{-3})^2$

$= 2.51A$ .... A

17. What voltage difference is required to send a current of 2A through 50cm of silver wire that has a $3.1mm^2$ cross-sectional area? (Resistivity = $1.6x10^{-8}\Omega$-m) A. 0.52V B. 5.2V C. $5.2xlO^{-7}$V D. $5.2xlO^{-5}$V E. $5.2x10^{-3}$V

17) Solution

$V = ?$

$I = 2A$

$L = 50cm = 0.5m$

$A = 3.1mm^2 = \left(\frac{3.1}{1000 \times 1000}\right)m^2$

$\rho = 1.6 \times 10^{-8}$

$V = IR$

But $R = \frac{\rho L}{A}$

$= \frac{(1.6 \times 10^{-8}) \times 0.5}{\left(\frac{3.1}{1000 \times 1000}\right)}$

$= 2.58 \times 10^{-3}\Omega$

$V = IR$

$= 2 \times (2.58 \times 10^{-3})$

$= 5.2 \times 10^{-3} V$

18. A carbon block has dimensions 2cmx2cmx60cm. Determine the resistance measured between the two square end' if the resistivity of carbon is 3.5x10-5ft-m. A. $6.5x10^{-4}\Omega$ B. $5.3xl0^{-2}\Omega$ C. $7.6xlQ^{-2}\Omega$ D. $4.4x10^{-4}\Omega$ E. $3.2xl0^{-3}\Omega$

18) $R = \frac{\rho L}{A}$

$$= \frac{(3.5 \times 10^{-5}) \times 0.6}{0.02 \times 0.02}$$

$$= 53 \times 10^{-2}\,\Omega$$

21. A copper wire has 5mm diameter and carries a current of 10A. Determine the current density in the wire. A. 5.1×10^{5}A/m^2 B. 5.1×10^{2}A/m^2 C. 7.1×10^{5}A/m^2 D. 7.1×10^{2}A/m^2 E. 4.1×10^{2}A/m^2

21) Solution

Current density $j = I/A$

from the question: $I = 10A$

$d = 5mm = 0.005m$

$$j = \frac{I}{\left(\frac{\pi d^2}{4}\right)} = \frac{10}{\left(\frac{\pi (0.005)^2}{4}\right)}$$

$$= 5.1 \times 10^{5}\ A/m^2$$

2015 EXAM QUESTIONS AND ANSWERS ON CURRENT

14. Which of these is not a vector quantity?
A. Current B. Dipole Moment C. Electric Field D. Torque E. Force

ans....A

28. The Current density of a 5.0mm diameter Copper wire which carries a current of 10μA is given as? A 0.2×10^{-6}Am^2 B. 0.2Am^2 C. 50.91Am^2 D. 5.091×10^{6}Am^2 E. 0.51Am^2

28] $D = 0.5mm = 5\times10^{-4}m$

$I = 10\mu A = 10\times10^{-6} A$

$j = ?$

$A = \pi r^2$

$r = \frac{D}{2} = \frac{5\times10^{-4}}{2}$

$= 2.5\times10^{-4}$

$\therefore A = (3.142) \times (2.5\times10^{-4})^2$

$= 1.964\times10^{-7}$

$\therefore J = \frac{I}{A} = \frac{10\times10^{-6}}{1.964\times10^{-7}}$

$J = 50.9 \simeq 51Am^2$

Ans = 51Am - - - C

29. The resistance of a metal wire of diameter 0.2mm and length 5m is 20Ω, what is the diameter of the same metal of length 2.5m and resistance 40Ω? A. 0.02mm B. 0.2mm C. 0.4mm D. 0.01mm E. 0.1mm

30. A potential difference of 6V is found to produce a current of 0.14A in a 2.6m length of conductor having uniform radius of 0.3cm. Calculate the resistivity of the material. A. 7.78×10^{-5} Ωm B. 4.66×10^{-4} Ω m C. 1.2×10^{-3} Ω m D. 6.52×10^{-5} Ω m E. 1.86×10^{-3} Ω m

$$hint \ldots\ldots use\ \rho = \frac{RA}{L}$$

$$where\ R = \frac{V}{I}\ and\ A = \pi r^2$$

NOW DO IT YOUR SELF

31. A Carbon block at 20°C has dimensions 2.0cm x 2.0cm x 50cm. Given that the resistivity of carbon at 20°C is 3.5×10^{-5}Ωm Determine the resistance measured between the two square ends of the Carbon block A. 2.2×10^{-2} Ω B. 1.8×10^{-3} Ω C. 2.2 Ω D. 4.4×10^{-2} Ω E. 4.4 Ω

31] Given that

$A = 2.0 \times 2.0 = 4.0 cm^2$

$= 4\times10^{-4} m^2$

$l = 50cm = 0.5m$

but $R = \frac{\rho l}{A}$

$= \frac{(3.5\times10^{-5})\times(0.5)}{4\times10^{-4}}$

$R = 0.0437 \simeq 0.044$

$R = 4.4\times10^{-2}$ - - - - D//

32. Which of these statements is Incorrect?
A. ...esistivity of a perfect conductor is zero B. The resistivity of a perfect ...or is infinite C. The resistivity of insulators are lower than those of metals D. ...esistivity of a semiconductor decreases with increasing temperature E. The resistivity of a metal increases with increasing temperature

ans.....C

45. Which of the following statements about current electricity is false? A. The resistivity of metals increases with increase in temperature B. The fuse in the household appliances burns when the current exceed a certain value C. The electric power can be determined when the resistance and the applied potential are known D. The resistivity is directly proportional to the conductivity E. The resultant resistance of three resistors in parallel is smaller than the least resistance of the three **ans....D**

FUTO PAST QUESTIONS ON CURRENT
2013 / 2014 - 2009 / 2010

THIS TOPIC WILL BE UNDERSTOOD BETTER AFTER GOING THROUGH THE SOLUTIONS TO THESE ELECTRIC CHARGE PAST QUESTIONS

2013 / 2014 QUESTIONS ON CURRENT ELECTRIC

33. Calculate the resistivity of a 50.0m long conductor of 0.5mm radius if it carries a current of 1.0A when a potential difference of 2.0V is applied across its lenght. A 3.142×10^{-8}Ωm B. 3.142×10^{8}Ωm C. 3.142×10^{0}Ωm D. 3.142×10^{3}Ωm E. 3.142×10Ωm

33) $\rho = \frac{RA}{L}$

$R = \frac{V}{I} = \frac{2}{1} = 2$

$A = \pi r^2 = \pi (0.5\times10^{-3})^2$

$A = 0.79\times10^{-6}$

$L = 50$

$\rho = \frac{2\times(0.79\times10^{-6})}{50}$

$= 3.142\times10^{-8}\,\Omega m$ - - - - - - - (A)

35. A steady current of 2.5A exist in a wire for 4.0 minutes. Calculate the total charge that passed through a given point in the wire during the 4.o minutes A. 500C B. 600C C. 700C D. 200C E. 300C

35) $I = Q/t$

$\therefore Q = It$

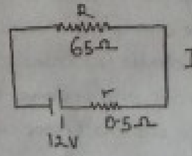
$I = 2.5A$

$t = (4\times60)s$ 4min

$Q = 2.5\times(4\times60)$

$= 600C$ - - - - - - - - -(B)

36. A 65.0Ω resistor is connected to the terminals of a battery whose emf is 12.0 v and resistance is 0.5 Ω calculate the power dissipated in the battery's internal resistance. a. 0.03W b. 2.18W c. 0.13W d. 0.02W e. 0.04W

36) 

R and r are in Series.

$I = \frac{V}{(R+r)}$

$= 12/(65+0.5)$

$I = 0.183$

Power at internal resistance

$P = I^2 r$

$= (0.183)^2 \times 0.5$

$= 0.02W$ - - - - - - - (D)

38. A 1.63mm diameter wire carries a current of 2.09 A. calculate the current density. a. $2.086 \times 10^{6}\ AM^{-2}$ b. $2.0 \times 10^{6}\ AM^{-2}$ c. $1.0 \times 10^{6}\ AM^{-2}$ d. $2.00 \times 10^{-6} AM^{-2}$

Current density = current / cross sectional area

$j = I/A$

but $A = (\pi D^2)/4 = (\pi \times (1.63\times10^{-3})^2)/4$

and I = 2.09A

$j = 2.09/ [(\pi \times (1.63\times10^{-3})^2)/4] =$

$= 1.0 \times 10^{6} Am^{-2}$

45. If the power rating of a fan is equal to 0.44 KM, determine the cost of operating the fan for 720 hr if electric energy costs N10 per KWh. a. N31.68k b. N44.00k c. N720.00k d. N10.00k e. N88.00k

45) Solution

P = 0.44KW

t = 720hr

Energy cost = # per KWhr

Energy = Pt

= 0.44 x 720

= 316.8 KWH

IF 1KwH = #10

316.8 KWH = #[316.8 x 10]

= #3168 ---- (A)

49. A copper of diameter 4mm and length 2m has a resistance of 25Ω. What will be the length of the wire if it is drawn into a 2mm diameter conductor of resistance 50 Ω? A. 30m B. 2.5m C. 5.0m D. 8.0m E. 4.5m

49) Solution

Resistivity is constant for same wires

$$\rho = \frac{R_1A_1}{L_1} = \frac{R_2A_2}{L_2}$$

$$L_2 = \frac{R_2A_2L_1}{R_1A_1}$$

$$L_2 = \frac{R_2\left(\frac{\pi D^2}{4}\right)_2 L_1}{R_1\left(\frac{\pi D^2}{4}\right)_1}$$

$$= \frac{R_2 D_2^2 L_1}{R_1 D_1^2}$$

$$= \frac{50(2\times10^{-3})^2\times 2}{25\times(4\times10^{-3})^2}$$

= 1 m (no option)

53. An X- ray tube takes a current of 7.0 m A and operates at a potential difference of 80 KV, what power is dissipated? A. 560W B. 500W C. 460W D. 920W E. 550W

53) Solution

$I = 7\times10^{-3}$ A (7mA)

$V = 80\times10^{3}$ V (80KV)

P = IV

$= (7\times10^{-3}) \times (80\times10^{3})$

= 560 Watt (A)

54. Electric current I can simply be defined as A. $\frac{dy}{dt}$ B. $\frac{dQ}{dt}$ C. $\frac{dR}{dt}$ D. $\frac{dE}{dt}$ E. $\frac{dl}{dt}$

54) Solution

$I = \frac{dQ}{dt}$ (B)

55. What is the conductivity of a copper wire of lenght 20m and diameter 1.5mm, if the wire has a resistance of 2.5Ω? A. $0.22 X 10^{-6}\ \Omega^{-1}m^{-1}$ B. $4.6 X 10^{6}\ \Omega^{-1}m^{-1}$ C. 46 $X 10^{-6}\ \Omega^{-1}m^{-1}$ D. $4.6 X 10^{6}\ \Omega^{-1}m^{-1}$ E. $2.2 X 10^{6}\ \Omega^{-1}m^{-1}$

55) Solution

Conductivity = $\frac{1}{\text{resistivity}}$

$$\sigma = \frac{1}{\rho}$$

$$\rho = \frac{RA}{L}$$

where: L = 20

$A = \frac{\pi(1.5\times10^{-3})^2}{4} = 1.77\times10^{-6} m^2$

R = 2.5

$$\rho = \frac{2.5\times(1.77\times10^{-6})}{20} = 2.21\times10^{-6}$$

$$\sigma = \frac{1}{\rho} = \frac{1}{2.21\times10^{-6}}$$

$= 4.6\times10^{6}\ \Omega^{-1}m^{-1}$

2012 / 2013 QUESTIONS ON CURRENT ELECTRIC

22) A copper wire has a diameter of 1.5m and a resistance of 8Ω. Calculate the corresponding length if the resistivity of copper is 1.7×10^{-8} Ωm (A) 196.38m (b) 20.40m (C) 8.0m (D) 318.75m (E) none of the above

22) Solution

from the question

Resistivity (ρ) = 1.7×10^{-8} Ωm

Resistance R = 8Ω

Diameter D = 1.5m

Using the formula $R = \frac{\rho L}{A}$

and $A = \left(\frac{\pi D^2}{4}\right)$

$$R = \frac{\rho L}{\left(\frac{\pi D^2}{4}\right)}$$

(d) ---- making L the Subject of the Formular

$$L = \frac{R\pi D^2}{4\rho} = \frac{8\times\pi\times(1.5)^2}{4\times(1.7\times10^{-8})}$$

$= 1.04\times10^{8}$M

23) The quantity of current passing through a unit cross sectional area of a wire is (A) current density (B) electromotive force (C) current (D) energy (E) none of the above

23) Current density .... (A)

25) A cell has an E M F of 60 V and is connected to a resistance of 15Ω if a current of 3A flows through the circuit, calculate the internal resistance of the cell (A) 20Ω (B)35Ω (C)45Ω (D)5Ω (E) 10Ω

25) From the question,

External resistance $R = 15\Omega$

Cell emf $E = 60V$

Current $I = 3A$

we use the formular $E = I(R+r)$

we make r (internal resistance) subject of the formular:

$r = \frac{E}{I} - R$

$\therefore r = \frac{60}{3} - 15$

$= 5\Omega$ .... (D)

45) A steady current of 2.5mA flows through a conductor for 5minutes.calculate the quantity of charge transferred within the period (A) 0.75C (B) 12.5C (C) 150C (D) 300C (E)250C

45) Given the parameters

time = 5min = 5×60

= 300 s

Current (I) = 2.5mA

= 2.5×10^{-3}

Q = ?

from the formular $I = \frac{Q}{t}$

$Q = It$

$= (2.5 \times 10^{-3}) \times 300$

$= 0.75C$ ...... (A)

46) An electric oven has the rating (2000W, 240V)calculate the resistance of the element of the oven (A) 0.120Ω (B) 8.33Ω (C) 6.44Ω (D) 28.8Ω (E) 3.58Ω

46) From the question,

Power $P = 2000W$

Voltage $V = 240V$

from the relation $P = \frac{V^2}{R}$

$R = \frac{V^2}{P}$

$= \frac{(240)^2}{2000} = 28.80\Omega$ .... (D)

47) The following are sources of emf except (A) dry cell (B) accumulator (C) photo cell (D) thermistor (E) dynamos

47) Thermistor is a resistor

$\therefore$ Thermistor ...... (D)

49) A copper wire 3.2 mm in diameter carries a current of 5A. What is the current density in the wire? (A) 2.22x10^5 A/M^2 (B)3.42x10^5 A/M^2 (C) 4.22x10^5 A/M^2 (D) 5.42x10^{5}A/M^2(E) 6.22x10^{5}A/M^2

49) Solution

From the question,

Current $I = 5A$

Diameter (D) = 3.2mm = 3.2×10^{-3} m

we use the formular for current density

$J = I/A$

$= I / \left(\frac{\pi D^2}{4}\right)$

$= 5 / \left(\frac{\pi \times (3.2 \times 10^{-3})^2}{4}\right)$

$= 6.22 \times 10^5 A/m^2$ .... (E)

50) What is the drift velocity of electron in copper wire of cross sectional area 1cm^2 in which the current, 200 A is passed? Take the number of free electron per unit volume of copper as 8.4 x 10^{26}m^3. A. 1.5 x 10^{-4}m/s B. 6.3 x 10^{8}m/s C. 1.64 x 10^{31}m/s D. 4.2 x 10^{26}m/s E. 2.32 x 10^{-27}m/s.

50) Solution

From the question

electron density (n) = 8.4×10^{28}

Area (A) = $1cm^2 = 1 \times 10^{-4} m^2$

Current $I = 200A$

Using the current formular

$I = qnAV_d$

Where $q = 1.6 \times 10^{-19}$

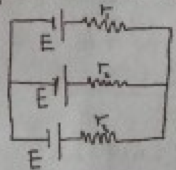
$V_d = \frac{I}{qnA} = \frac{200}{(1.6 \times 10^{-19}) \times (8.4 \times 10^{28}) \times (1 \times 10^{-4})}$

$= 1.5 \times 10^{-4} ms^{-1}$ ..... (A)

51) Three cells of emf 2 V each andinternal resistance 3 Ω are connected in parallel. The effective emf and internal resistance of the conbintion are: A. 6 V, 9 Ω B. 2 V, 1 Ω C. 2 V, 1 Ω D. 6 V, 1 Ω E. 6V, 3 Ω

51) Solution

The question can be drawn as



when ever cells are arranged in parallel, the net emf = one of the emf

the net internal resistance

$r = \frac{1}{\left(\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}\right)}$

$= \frac{1}{\left(\frac{1}{3} + \frac{1}{3} + \frac{1}{3}\right)} = 1\Omega$

$\therefore$ net E and net r = 2V, 1Ω .... (C)

52) Which of the follwing is not true? A. A seat of emf maintains a Pd between two points to which they are connected B. A seat of emf must be able to do work on charge carrier that enters it C. The seat of emf maintains its upper terminal negative and its lower terminal positive D. the unit of emf is Joule/Coulomb E. None of the above

52) Solution .... (C)

2011 / 2012 QUESTIONS ON CURRENT ELECTRIC

16. What is the resistivity of a 20.0 m alength of wire 1.5 mm in diameter which has a resistance of 2.5Ω? ______________

16) Solution

from the question,

$D = 1.5mm = 1.5 \times 10^{-3} m$

$R = 2.5\Omega$

$l = 20m$

we use the formular

$\rho = \frac{RA}{l} = \frac{R}{l}\left(\frac{\pi D^2}{4}\right)$

$= \frac{2.5}{20}\left[\frac{\pi (1.5 \times 10^{-3})^2}{4}\right]$

$= 2.2 \times 10^{-7} \Omega \cdot m$

17. A 1.63 mm diameter wire carries a current of 2.09 A. Calculate the current dentity. ______________

17) Solution

from the question,

$I = 2.09$

$D = 1.63 \times 10^{-3}$

from the current density equation

$j = I/A = \frac{I}{\left(\frac{\pi D^2}{4}\right)}$

$= \frac{2.09}{\left(\frac{\pi \times (1.63 \times 10^{-3})^2}{4}\right)}$

$= 1.0 \times 10^6 Am^{-2}$

18. The current in a conductordepends on time as I (t) = $5t^2 - 3t + 10$ where t is in seconds. What quantity of charge moves across a section through theconduction during the interval t = 1s to t = 2s. ______________

18) Solution

from the question, $I = 5t^2 - 3t + 10$

but integration of current = Charge

$\int_1^2 (5t^2 - 3t + 10)dt = Q$

$\left[\frac{5t^3}{3} - \frac{3t^2}{2} + 10t\right]_1^2$

$= \left[\frac{5(2)^3}{2} - \frac{3(2)^2}{2} + 10(2)\right] - \left[\frac{5(1)^3}{3} - \frac{3(1)^2}{2} + 10(1)\right]$

$= 17.17A$ Ans

19. A 60 Ω resistor is connected to the terinal of a battery whose emf is 24 V and internal resistance is 1.0 Ω. Calculate the terminal voltage of the battery. ______________

19) from the question

$E = 24V$

$R = 60\Omega$

$r = 1\Omega$

we use the formular

$E = I(R + r)$

making I subject of the formular

$I = \frac{E}{R + r}$

$= \frac{24}{(60 + 1)} = 0.393A$

$V = IR = 0.393 \times 60 = 23.60V$

20. A 76 Ω resistor is connected to a 12V battery. If 150 mA current flows in the circuit, what is the internal resistance of the battery? ______________

20) Solution

from the parameters given,

$I = 150mA = 0.15A$

$R = 76\Omega$

$E = 12V$

$r = ?$

we use the formular

$E = I(R + r)$

$\therefore r = \left(\frac{E}{I}\right) - R$

$= \left(\frac{12}{0.15}\right) - 76 = 4\Omega$

2010 / 2011 QUESTIONS ON CURRENT ELECTRIC

21. A 20.0cm length wire 1.50mm in diameter has a resistance of 2.5Ω. What is the resistance of a 35.0m length of wire 3.0mm in diameter made of the same material?

21) Solution

from the question,

$L_1 = 20cm = 0.2m$

$D_1 = 1.5mm = 1.5 \times 10^{-3}m$

$R_1 = 2.5\Omega$

$L_2 = 35m$, $D_2 = 3mm = 3 \times 10^{-3}m$

$R_2 = ?$

we use the relation,

$\rho = \frac{R_1 L_1}{A_1} = \frac{R_2 L_2}{A_2}$ .... (Resistivity is constant)

$R_2 = \frac{A_2 R_1 L_1}{A_1 L_2}$ .... (making R_2 subject of the formula)

$= \frac{\left(\frac{\pi D_2^2}{4}\right) R_1 L_1}{\left(\frac{\pi D_1^2}{4}\right) L_2}$

$= \frac{D_2^2 R_1 L_1}{D_1^2 L_2}$

$= \frac{(1.5 \times 10^{-3})^2 \times 2.5 \times 35}{(3 \times 10^{-3})^2 \times 0.2}$ ...

$= 109.375\Omega$

22. Power dissipated when an x-ray tube takes a current of 7.0mA and operates at a potential difference of 80Kv is

22) Solution

$P = IV$

$= (7\times10^{-3}) \times (80\times10^{3})$

$= 560W$

23. If charge Q (t) is given as $t^3 + 2t$, calculate the current I at t = 2s.

23) Solution

If $Q = t^3 + 2t$ then

$I = \frac{dQ}{dt} = \frac{d}{dt}(t^3 + 2t)$

$I = 3t^2 + 2$

when $t = 2$,

$I = 3(2)^2 + 2$

$= 14A$

24. A 4 μF capacitor is charged to 24 V and then connected across a 200 Ω resistor. Find the initial current 24v and then connected across a 200 Ω resistor. ____________

24) Solution

$\text{conductivity} = \frac{1}{\text{resistivity}}$

$\sigma = \frac{1}{\rho}$

$= \frac{1}{1.7\times10^{-8}}$

$= 5.88\times10^{7}\Omega^{-1}m^{-1}$

26. An electron travels at 8.0×10^{7} m/s in a plane perpendicular to a uniform 0.005 T magnetic field. Calculate the radius of the path traced by the elecron. ____________

26) Seat of emf (Source of emf)
= Batteries and generators

2009 / 2010 QUESTIONS ON CURRENT

20. A copper wire and iron wire of the same length have the same potential difference applied to them. What must be the ratio of their radii if the current is to be same? (assume resistivity of copper $1.7\times10^{7}\Omega$.m and resistivity of iron= $1.0\times10^{+7}\Omega$m (A)1:1 (B)5:1 (C)17:10 (D)4:1 (E)3:1

20) Solution

from the question,

$\rho_{copper} = 1.7\times10^{-8}$

$\rho_{iron} = 1.0\times10^{-7}$

$L_{iron} = L_{copper}$

$V_I = V_c$

$I_I = I_c$

$\frac{r_c}{r_I} = ?$ ..... (ratio of radius)

From the formular.

$\rho = \frac{RA}{L}$ and $R = \frac{V}{I}$

$A = \frac{\rho L}{R}$

$\pi r^2 = \frac{\rho L}{R}$

$r = \sqrt{\frac{\rho L}{\pi R}} = \sqrt{\frac{\rho L}{\pi (V/I)}}$

$\frac{r_c}{r_I} = \frac{\sqrt{\frac{\rho_c L_c}{\pi (V_c/I_c)}}}{\sqrt{\frac{\rho_I L_I}{\pi (V_I/I_I)}}}$

dividing and removing equal quantities

$= \frac{\sqrt{\rho_c}}{\sqrt{\rho_I}}$

$= \sqrt{\frac{1.7\times10^{-8}}{1.0\times10^{-7}}}$

$= 0.412$

$= \frac{4}{10} = \frac{2}{5}$

21. A 10m length of aluminum wire has diameter of 1.5mm. it carries a current of 12A. find the current density. (A)1.602×10^{-19}A/m^2 (B)18.95×10^{7} A/m^2 (C)45.5×10^{3} A/m^2 (D)6.79×10^{6} A/m^2 (E)4.66×10^{4} A/m^2

21) Solution

from the question,

$D = 1.5mm = 1.5\times10^{-3}m$

$I = 12A$

Current density $J = I/A$

$= I/\left(\frac{\pi D^2}{4}\right) = \frac{4I}{\pi D^2}$

$= \frac{4\times12}{\pi (1.5\times10^{-3})^2}$

$= 6.79\times10^{6}$ A/m ....

22. Which is a unit of energy? (A)$A^2\Omega$ (B)V.A (C)V.C (D)Ω.m (E)N.m/V

22) Solution

electrical energy (U) = qV

= C.V

or

V.C (volt . Coulombs)

23. In many real circuit, wires are connected to a common conductor that provides continuity. This common conductor is called. (A)anode (B)battery (C)cathode (D)ground

23) D

24. How does a resistance of a piece of conducting wire change if both its length and radius are doubled? (A)remains the same (B)4 times as much (C)1/2 as much (D)2 times as much (E)1/4 as much

24) Solution

From $R = \frac{\rho L}{A}$

$= \frac{\rho L}{\pi r^2}$

If length and radius are doubled

$R = \frac{\rho (2L)}{\pi (2r)^2}$

$= \frac{2\rho L}{4\pi r^2}$

$= \frac{1}{2}\frac{\rho L}{\pi r^2} = \frac{1}{2}R$

1/2 as much ------- D

28. in a parallel circuit ,the section with the lowest resistance has th: (A)the greatest voltage drop (B)smallest voltag drop (C)highest current (D)smallest heating effect (E)smallest current

28) Solution

from ohm's law,

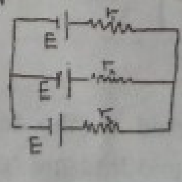
$R = \frac{V}{I}$

This means that the section with the lowest resistance will have the highest current ------- (C)

29. Three cells of EMF 2V and internal resistance 3Ω each are connected in parallel. The effective emf and internal resistance Of the combination are respectively: (A)6Vand 9Ω (B) 6V and 1Ω (C)2V and 9Ω (D)6Vand 3Ω (E)2V and 1Ω

29) Solution

The question can be drawn as



when ever cells are arranged in parallel, the net emf = one of the emf

the net internal resistance

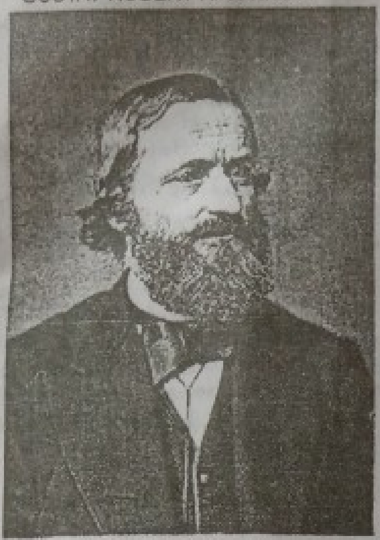
$r = \frac{1}{\left(\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}\right)}$

$= \frac{1}{\left(\frac{1}{3} + \frac{1}{3} + \frac{1}{3}\right)} = 1\Omega$

∴ net E and net r = 2V, 1Ω .... (E)

DC CIRCUITS

GUSTAV ROBERT KIRCHHOFF



BORN
12 MARCH 1824
KÖNIGSBERG, KINGDOM OF PRUSSIA
(PRESENT-DAY RUSSIA)

DIED
17 OCTOBER 1887 (AGED 63)
BERLIN, PRUSSIA, GERMAN EMPIRE
(PRESENT-DAY GERMANY)

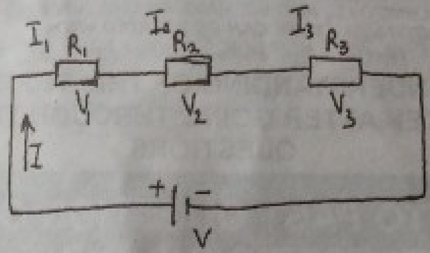
RESIDENCE
PRUSSIA/GERMAN EMPIRE

NATIONALITY
PRUSSIAN

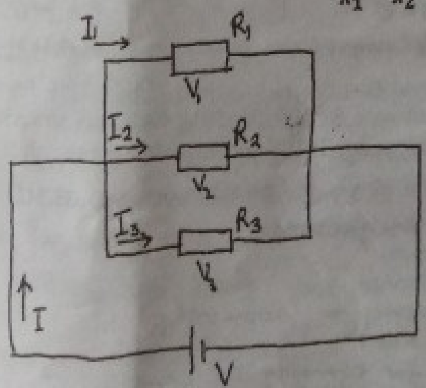
FIELDS
PHYSICS, CHEMISTRY

INSTITUTIONS
UNIVERSITY OF BERLIN
UNIVERSITY OF BRESLAU
UNIVERSITY OF HEIDELBERG

- The equivalent resistance of a number of resistors connected in series is given by R = R1 + R2 + R3 +.....



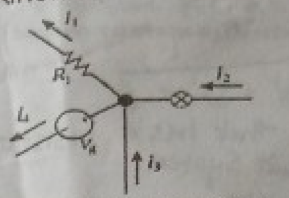
- In series connection, the current in each resistor is the same ie, $I = I_1 = I_2 = I_3$
- The main voltage is splited to fit all the resistors $V = V_1 + V_2 + V_3$
- The equivalent resistance of a number of resistors connected in parallel is given by $R = \dfrac{1}{(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3})}$



- In parallel arrangement of resistors, the voltage in each resistor is the same ie $V = V_1 = V_2 = V_3$
- The main current is divided into all the resistors which can be stated as $I = I_1 + I_2 + I_3$

KIRCHHOFF'S CIRCUIT LAWS

KIRCHHOFF'S CURRENT LAW (KCL)



The current entering any junction is equal to the current leaving that junction. $i_2 + i_3 = i_1 + i_4$

THIS LAW IS ALSO CALLED KIRCHHOFFS FIRST LAW, KIRCHHOFF'S POINT RULE, OR KIRCHHOFF'S JUNCTION RULE (OR NODAL RULE).

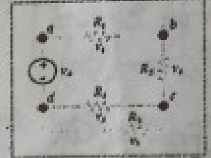
AT ANY NODE (JUNCTION) IN AN ELECTRICAL CIRCUIT, THE SUM OF CURRENTS FLOWING INTO THAT NODE IS EQUAL TO THE SUM OF CURRENTS FLOWING OUT OF THAT NODE

OR EQUIVALENTLY

THE ALGEBRAIC SUM OF CURRENTS IN A NETWORK OF CONDUCTORS MEETING AT A POINT IS ZERO.

THE LAW IS BASED ON THE CONSERVATION OF CHARGE

KIRCHHOFF'S VOLTAGE LAW



The sum of all the voltages around the loop is equal to zero. $v_1 + v_2 + v_3 - v_4 = 0$

THIS LAW IS ALSO CALLED KIRCHHOFF'S SECOND LAW, KIRCHHOFF'S LOOP (OR MESH) RULE, AND KIRCHHOFF'S SECOND RULE.

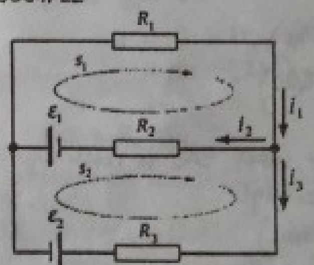
THE DIRECTED SUM OF THE ELECTRICAL POTENTIAL DIFFERENCES (VOLTAGE) AROUND ANY CLOSED NETWORK IS ZERO, OR:

MORE SIMPLY, THE SUM OF THE EMFS IN ANY CLOSED LOOP IS EQUIVALENT TO THE SUM OF THE POTENTIAL DROPS IN THAT LOOP, OR:

THE ALGEBRAIC SUM OF THE PRODUCTS OF THE RESISTANCES OF THE CONDUCTORS AND THE CURRENTS IN THEM IN A CLOSED LOOP IS EQUAL TO THE TOTAL EMF AVAILABLE IN THAT LOOP.

THIS LAW USES THE THE PRINCIPLE OF CONSERVATION OF ENERGY

EXAMPLE



ASSUME AN ELECTRIC NETWORK CONSISTING OF TWO VOLTAGE SOURCES AND THREE RESISTORS.
ACCORDING TO THE FIRST LAW WE HAVE

$$i_1 - i_2 - i_3 = 0$$

The second law applied to the closed circuit s_1 gives

$$-R_2 i_2 + \mathcal{E}_1 - R_1 i_1 = 0$$

The second law applied to the closed circuit s_2 gives

$$-R_3 i_3 - \mathcal{E}_2 - \mathcal{E}_1 + R_2 i_2 = 0$$

Thus we get a linear system of equations in i_1, i_2, i_3:

$$\begin{cases} i_1 - i_2 - i_3 & = 0 \\ -R_2 i_2 + \mathcal{E}_1 - R_1 i_1 & = 0 \\ -R_3 i_3 - \mathcal{E}_2 - \mathcal{E}_1 + R_2 i_2 & = 0 \end{cases}$$

Assuming

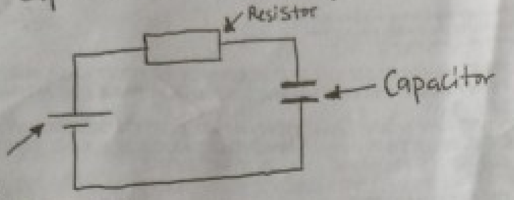
$R_1 = 100,\ R_2 = 200,\ R_3 = 300$ (ohms); $\mathcal{E}_1 = 3,\ \mathcal{E}_2 = 4$ (volts)

the solution is

$$\begin{cases} i_1 = \frac{1}{1100} \\ i_2 = \frac{4}{275} \\ i_3 = -\frac{3}{220} \end{cases}$$

i_3 has a negative sign, which means that the direction of i_3 is opposite to the assumed direction (the direction defined in the picture).

RC Circuit is a circuit that has a resistor and a capacitor in a circuit system.



Q_0 = equilibrium charge in the capacitor
sometimes written as (CV_0) or (CE)

I_0 = equilibrium current in the circuit
can be written as (V_0/R) or (E/R)

V_0 = equilibrium potential from the cell

V = Potential at a time t

I = Current at a time t

Q = Charge in the capacitor at a time t

<u>CHARGING</u>

During charging, the charge and the voltage in the capacitor continue to increase from zero until it reaches an equilibrium charge and voltage Q_0 and V_0

The charge (Q) and potential (V) at any time can be gotten with

$$Q = Q_0(1 - e^{-t/RC})$$
$$V = V_0(1 - e^{-t/RC})$$

RC = time constant, it takes 5RC to reach equilibrium.

In percentage

$$x\%\, Q_0 = Q_0(1 - e^{-t/RC})$$
$$x\%\, V_0 = V_0(1 - e^{-t/RC})$$

During charging, the current in the circuit (I) and the potential (V) from the cell reduces from equilibrium value I_0 and V_0 down to zero.

The current (I) and potential (V) at any time can be gotten with

$$I = I_0 e^{-t/RC} \quad \text{and} \quad V = V_0 e^{-t/RC}$$

In percentage

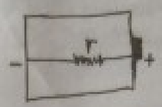
$$x\%\, I_0 = I_0 e^{-t/RC} \quad \text{and} \quad x\%\, V_0 = V_0 e^{-t/RC}$$

<u>DISCHARGE</u>

During discharges the capacitor now acts as a potential source. The current (I), potential (V), and charge (Q) in the circuit reduces from equilibrium value down to zero

$$Q = Q_0 e^{-t/RC}$$
$$I = I_0 e^{-t/RC}$$
$$V = V_0 e^{-t/RC}$$

<u>CELL</u>



When a cell is produced, it has a voltage or potential (V) which is called the Emf (E).

But,

Due to the fact that the cell has internal resistance (r) the potential V reduces to:

$$V = E - Ir$$

V = the terminal voltage (the voltage and external load will get from the cell)

$$IR = E - Ir$$

or

$$E = IR + Ir$$
$$E = I(R + r)$$

POTENTIOMETER

FOR A POTENTIOMETER, ASSUMING WE HAVE A KNOWN EMF, E_s, RESISTANCE R_s, LENGTH L_s AND WE HAVE AN UNKOWN EMF, E_x RESISTANCE R_x, LENGTH L_x, THEY CAN BE RELATED WITH

$$(E_x/E_s) = (R_x/R_s) = (L_x/L_s)$$

BETTER UNDERSTANDING OF THIS TOPIC WILL BE GOTTEN AFTER GOING THROUGH THESE QUESTIONS

FUTO PAST QUESTION ON ELECTRIC CURRENT 2016 - 2009

2016 EXAM QUESTIONS AND ANSWERS ON CURRENT

1. How many time constants must elapse before a capacitor in an RC circuit is charged to 10% of its equilibrium charge?:
A. 2.3RC B. 4.6RC C. 6.9RC D. 9.2RC E. 1.7RC

1) $Q = CE(1 - e^{-t/RC})$

$0.1CE = CE(1 - e^{-t/RC})$

$0.1 = 1 - e^{-t/RC}$

$e^{-t/RC} = 1 - 0.1$

$e^{-t/RC} = 0.9$

$t/RC = -\ln(0.9)$

$t = -RC\ln(0.9)$

$= \underline{0.11RC}$

no of time constant = 0.11

2. For a circuit with R=20Ω, V=50V, C=100μF in series, calculate the charge on the capacitor 3×10^{-3} seconds after the switch is closed.

A. 0.78C B. 3.9×10^{-3}C C. 3.9C D. 38.8C E. 3900C

2) From the question

$R = 20\Omega$

$V = 50V$

$C = 100\mu F = 100\times10^{-6} F$

$t = 3\times10^{-3}$

Using the for charging RC circuit

$$Q = CE(1 - e^{-t/RC})$$
$$= (100\times10^{-6})\times 50\left(1 - e^{-\frac{(3\times10^{-3})}{20\times100\times10^{-6}}}\right)$$
$$= \underline{3.9\times10^{-3}C}$$

3. A fully charged capacitor of capacitance 2.02μF and voltage 20V is connected to discharge through a resistor. If the current decreased to 50% of its initial value in 40μs, determine the value of R. A. 20.8Ω B. 57Ω C. 28.6Ω D. 82.6Ω E. 38.2Ω

3) for discharging of RC circuit

$$x\%\, Q_0 = Q_0 e^{-t/RC}$$
$$50\%\, Q_0 = Q_0 e^{-t/RC}$$

$0.5 = e^{-t/RC}$

$t/RC = -\ln(0.5)$

$R = \dfrac{t}{[-\ln(0.5) \times C]}$

$= \dfrac{(40 \times 10^{-6})}{(-\ln(0.5)) \times (2.02 \times 10^{-6})}$

$= \underline{28.6\,\Omega}$

28\. A resistor with resistance of 10MΩ is connected in series with a capacitor with capacitance of 1μF and a battery with emf of 12 V. What is the time constant of the circuit? A. 10^6s B. 10^4s J C. 10^3s D. 10^2s E. 10s

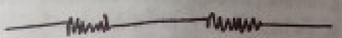
28) time Constant $(\tau) = R \times C$

$= (10 \times 10^6) \times (1 \times 10^{-6})$

$= \underline{10\,s}$

19\. A resistance of 9985Ω is in series in a circuit with a 15Ω wire. If the potential difference across the latter is 0.075V, then the total potential difference across the resistances is... A. 49.0V B. 49.8V C. 49.9V D. 50.0V E. 51.0V

19)



A: 9985Ω, $V_A = ?$

B: 15Ω, $V_B = 0.075$V

Since they are in series,

$I_A = I_B$

$I_B = \dfrac{V_B}{R_B} = \dfrac{0.075}{15} = 5 \times 10^{-3}$A

$\therefore I_A = 5 \times 10^{-3}$A

$V_A = I_A R_A$

$= (5 \times 10^{-3}) \times (9985)$

$= 49.925$V

Total potential for the series Arrangement $= V_A + V_B$

$= 49.925 + 0.075$

$= \underline{50\,V}$

20\. Suppose the resistance of a copper wire is 1.05 Ω at 20°C. Find the resistance at 0°C if the temperature coefficient of copper is 0.0039/°C. A. 1.078Ω B. 1.1319 Ω C. 1.8362 Ω D. 0.968.Ω E. 2.1560Ω

20) Solution

Using the formular

$R = R_{ref}[1 + \alpha(T - T_{ref})]$

where R = Conductor resistance at temperature T

R_{ref} = Conductor resistance at reference temperature = 1.05 Ω

α = Temperature Coefficient of resistance for the Conductor material = 0.0039

T = Conductor temp. in °C = 0°

T_{ref} = Reference temp that α is specified

$R = 1.05[1 + 0.0039(0 - 20)]$

$= \underline{0.9681\,\Omega}$

22\. Which of these statements is/are correct? According to Kirchhoff's rules: (i) ΣV=0 at a junction (ii) ΣI=0 at a junction (iii) ΣV=ΣI at a junction A. (i) only B.(i)and(ii) C. (ii) only D. (ii) and (iii) E. (iii) only

22) C

it is called the Kirchhoff junction rule

23\. Three cells of emf 2V each and internal resistance 3Ω are connected in parallel. What is the effective emf and internal resistance of the combination? A. 6V, 9Ω B. 2V, 9Ω C. 2V, 1Ω D. 6V, 1Ω E. 6V, 3Ω

23) Solution

when resistors are Connected in parallel V is Same for all resistors = 2V

$R = \dfrac{1}{1/R_1 + 1/R_2 + 1/R_3} = \dfrac{1}{1/3 + 1/3 + 1/3}$

$= \underline{1\,\Omega}$

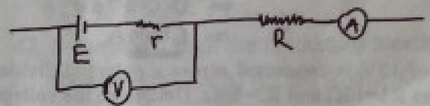
Ans = C, 2V, 1Ω

24\. A battery of emf 12V and internal resistance 2Ω supplies current to a gadget of resistance 4Ω. What are the readings on a voltmeter connected across the cell and an ammeter connected in series with the gadget?

A. 2V, 8A B. 8V,2A C. 12V, 2A D. 4V, 6A E. 12V, 8A

24) Solution

The Circuit will look like this



First, the Current in the gadget is equal to the total current in the Series Circuit.

from $E = V + Ir$

$E = IR + Ir$

$E = I(R + r)$

$I = \dfrac{E}{R + r}$

$= \dfrac{12}{(4 + 2)}$

$= 2A$

Voltage across the Cell with Internal resistance = terminal Voltage

from $E = V + Ir$

$V = E - Ir$

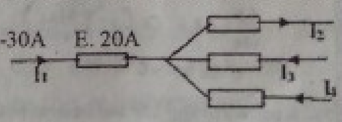
$= 12 - (2 \times 2)$

$= 8V$

Ans = B, 8V, 2A

25\. Determine the value of I3 in the shown circuit if I1=20A, I2=50A and I4=60A.

A. 90A B. -90A C. 30A D.-30A E. 20A



25) Solution

Using The Kirchhoff's junction rule:

Sum of Current into a junction = Sum of Current out of the junction

$I_1 + I_3 + I_4 = I_2$

$\therefore I_3 = I_2 - I_1 - I_4$

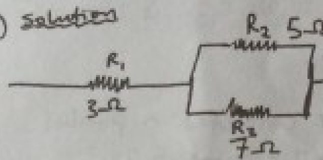
$= 50 - 20 - 60$

$= \underline{-30A}$

26\. Three resistors are arranged such that resistor 1 with resistance of 3Ω is connected in series with a parallel arrangement of resistors 2 and 3, with resistances 5Ω and 7Ω respectively. What is the equivalent resistance of the arrangement?

A. 15Ω B. 3.3428Ω. C. 5.9167Ω D. 1.4788Ω E. 2.4Ω

26) Solution



$$R_{eq} = R_1 + \frac{1}{1/R_2 + 1/R_3}$$

$$= 3 + \frac{1}{[1/5 + 1/7]}$$

$$= 5.9167\,\Omega$$

27. A 100Ω resistor is connected to a battery of 6V emf and 1/5Ω internal resistance. Calculate the current in the circuit. A. 60mA B. 69mA C. 50mA D. 59mA E. 40mA

27) $E = IR + Ir$
$E = I(R+r)$, $\quad I = E/(R+r)$

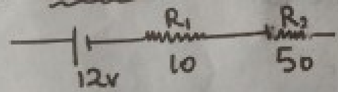
$$= \frac{6}{100 + (1/5)}$$

$$= 0.05988$$

$$= 60mA$$

30. A voltage source of 12V is connected across a potential divider comprising two resistors R1=10Ω and R2=50Ω. Determine the voltage across R_2. A. 10V B. 8V C. 11V D. 9V E. 6V

30) Solution



$V = I(R_1 + R_2)$
$12 = I(10 + 50)$

$$I = \frac{12}{(10+50)}$$

$$= 0.2A$$

$V_{R_2} = IR_2$
$= 0.2 \times 50$
$= 10V$

2015 EXAM QUESTIONS AND ANSWERS ON DC

11. A 20Ω resistor was connected in series with a 6μC capacitor to be charged by 12V battery. How long will it take to charge the capacitor to 63% of its final value? A.10u.s B. 120μs C. 4x10^7s D. 1.67s E. 0.5ns

11] R = 20Ω
$C = 6\mu C = (6 \times 10^{-6})C$
$Q = CE(1 - e^{-t/RC})$ at 100%
at → 63% charge.

$\frac{63}{100} CE = CE(1 - e^{t/RC})$

$0.63 = 1 - e^{-t/RC}$

$e^{t/RC} = 1 - 0.63$
$e^{t/RC} = 0.37$
$t = -RC \cdot \ln(0.37)$
$= -20 \times (6 \times 10^{-6}) \ln(0.37)$
$= 0.000119$
Ans. = 120 μC

33. A battery of Emf 12V and internal resistance 2 Ω is connected in series with an external resistor of resistance 4 Ω. If a voltmeter is connected across the battery and an ammeter connected in series with the external resistance, what are the voltmeter and ammeter readings? A. 8V and 2A B. 8V and 3A C. 12V and 3A D. 12V and 2A E. None of the above

33] E.m.f = 12V
r = 2Ω, R = 4Ω
Recall $E = I(R+r)$
Make I the subject of formula.
$I = \frac{E}{R+r} = \frac{12}{4+2} = \frac{12}{6} = 2$

I = 2A
from ohms Law
V = IR
V = 2×4 = 8
8V and 2A - - - A

35. Three resistors of resistances R_1, R_2 and R_3 are connected in parallel. The effective resistance of the network is_? A. $\frac{R1R2+R1R3+R2R3}{R1R2R3}$ B. $\frac{1}{R1+R2+R3}$ C. $\frac{R1R2R3}{R1R2+R1R3+R2R3}$ D. $R1+R2+R3$ E. $\frac{R1+R2+R3}{R1R2+R1R3+R2R3}$ **ans....C**

34. A battery of Emf 150V has a terminal potential difference (pd) of 1.25V when a resistor of 25 Ω is joined to it. Compute the internal resistance r and the terminal potential difference V when a resistor of 10 Ω replaces the 25 Ω resistor. A. r = 6 Ω, V = 0.8v B. r = 5 Ω, V = 1v C. r = 6 Ω, V = 1v D. r = 5 Ω, V = 0.5v E. r = 6 Ω, V = 0.5v

37. A cell of Emf 1.08V is in series with a resistor of 80 Ω. A high resistance voltmeter put across the cell registers 0.8V. What is the internal resistance of the cell? A. 2.35 Ω B. 0.01 Ω C. 28 Ω D. 100 Ω E. 1.0 Ω

using the formula.
$E = I(R+r)$
make r the subject of formula.
$r = \frac{E}{I} - R$

$= \left(\frac{1.08}{0.01}\right) - 80$
$r = 108 - 80$
$r = 28\,\Omega$ - - - - C

44. Kirchoff's junction rule states that A. The algebraic sum of the potential differences in any loop equals zero B. The algebraic sum of the currents at any junction in a circuit is zero C. The total current in any circuit must be equal to the potential difference D. The algebraic sum of potential difference in any loop must be greater than zero E. The algebraic sum of the currents at any junction in a circuit must be less than zero **ans......B**

53. In an RC circuit, the charging current i through the resistor at any time t can b written as? A. $i = \frac{E}{R}e^{-t/RC}$ B. $i = IRe^{-t/RC}$ C. $i = \frac{E}{R}e^{t/RC}$ D. $i = \frac{E}{R}e^{-1/RC}$ E. $i = \frac{E}{R}e^{-T/RC}$ **ans.......A**

54. An ammeter can be produced from a galvanometer by which of the following configuration?
A. Connecting a shunt resistor in series B. Connecting a shunt resistance in parallel C. Connecting two galvanometers in series D. Connecting two galvanometers in parallel E. None of the above
ans.......B

58. A 2.5μF capacitor is charged by a battery of Emf 4V through a device of resistance 200KΩ. What is the time constant? A. 0.5s B. 5s C. 20s D. 10s E. 2.5s

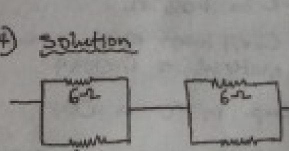
time constant = RC
$= (200 \times 10^3) \times (2.5 \times 10^{-6})$
$= 0.5s$

59. A galvanometer has an internal resistance of 20Ω and deflects full scale for a 50μA current, how do you use this galvanometer to make a voltmeter to give a full scale deflection of 1000V? A. 2 x 10^7 Ω connected in parallel with the galvanometer B. 2 x 10^7 Ω connected in series with the galvanometer C. 2 x 10^-7 Ω connect in series with the galvanometer D. 2 x 10^8 Ω connected in series with the galvanometer . E. 2 x 10^8 Ω connected in parallel with the galvanometer

2013 / 2014 QUESTIONS ON DC CIRCIUT

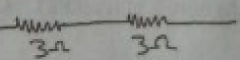
34. A combination of two resistors in parallel each of resistance 6Ω is in series with another combination of two resistors in parallel each having a resistance of 6Ω. What is the equialent resistance of the network? A. 3Ω B. 24Ω C. 0.67Ω D. 6Ω E. 12Ω

34) Solution



$$R_{eq(A)} = \frac{1}{(1/6) + (1/6)} = 3\,\Omega \qquad R_{eq(B)} = \frac{1}{(1/6) + (1/6)} = 3\,\Omega$$

The new Connection becomes

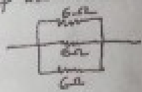


$R_{eq} = 3 + 3$
$= 6\,\Omega$ .... (D)

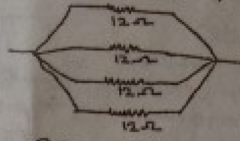
Note: For Solving Speed

When the resistors are equal in parallel, divide one of the resistance with the number of resistors

eg



$R_{eq} = 6/3$
$= 2\Omega$



$R_{eq} = 12/4$
$= 3\Omega$

37. An RC circuit has V_s = 12V, R= 20 KΩ and C= 0.3μF, what is the time constant of this circuit? a. 6.0×10^{-3} b. 2.0×10^{4} s c. 6.2×10^{3} s d. 7.2×10^{2} s e. 3.0×10^{-7} s

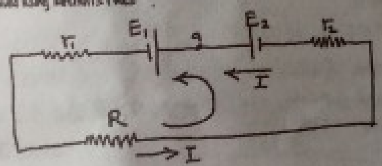
37) Solution

$V_s = 12V$
$R = 20k\Omega = 20{,}000\Omega$
$C = 0.3\mu F = 0.3 \times 10^{-6} F$
$\tau = RC$
$= 20{,}000 \times (0.3 \times 10^{-6})$
$= 6.0 \times 10^{-3} s$ -------- A

39. Two sources of emf (in series and opposite in direction) E1 and E2 are connected across a 5.0Ω resistor (R). If E1= 2.0 v with internal resistance r1= 1.0Ω and E2 = 4.0 v with internal resistance r2= 2.0Ω. What current flows in the current? A. 4.0 A B. 0.25 A C. 0.75 A D. 0.4 A E. 1.2 A

Solution

this can be solved using kirchoff's rules



following the direction of the curved arrow

$-IR - Ir_2 + E_2 - E_1 - Ir_1 = 0$
$-I(5) - I(2) + 4 - 2 - I(1) = 0$
$-8I + 2 = 0$
$I = 2/8 = 0.25A$

40. Which of the following is true of Kirchhoff loop rule? A. If a resistor is traversed in the direction of the current, the change is potential is negative. B. If a resistor is traversed opposite the current, the change in potential is positive C. if a seat of emf is traversed in the direction of emf, the change in potential is positive D. if a seat of emf is traversed opposite the direction of the emf, the change in potential is negative. E. All of the above

solution.

the correct answer is E

41. A 6V battery of negligible internal resistance is used to charge a 2μF capacitor through a 100Ω resistance. Find the final charge on the capacitor. A. 3μC B. 0.33 μC C. 12C D. 12 μC E.3C

Solution

41) $Q = CV$
$V = 6V$
$C = 2\mu F = 2 \times 10^{-6} F$
$Q = (2 \times 10^{-6}) \times 6$
$= 12 \times 10^{-6} C$
$= 12\mu C$

42. A 4 μF capacitor is charged to 24V and then connected across a 200Ω resistor. Find the initial current through the resistor. A. 0.12A B. 8.33A C. 83.3A D. 12A E. 0.833A

42) Solution

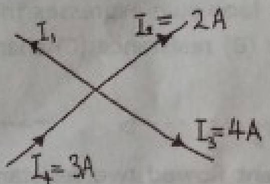
for the RC circuit

$C = 4\mu F$
$V = 24V$
and $Q = CV$
for the original current,
$I_0 = \frac{Q}{RC}$
$= \frac{CV}{RC}$
$= \frac{(4 \times 10^{-6}) \times 24}{200 \times (4 \times 10^{-6})}$
$= 0.12A$

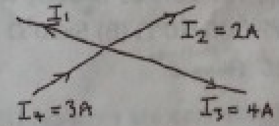
46. Kirchhoff's first law is simply a convenient application of the of conservation of _? a. Charge b. Mass c. Power d. Voltage e. Momentum

46) A ------ Charge

47. Determine I_1 from the conductors meeting at a point A shown below. A. -1 A B. 3 A C. -2 A D. 2 A E. -3 A



47) Solution



Total current entering equals Total current leaving

$I_4 = I_1 + I_2 + I_3$
$\therefore I_1 = I_4 - I_2 - I_3$
$= 3 - 2 - 4$
$I_1 = -3A$ -------- (E)

48. A galvanometer has an internal resistance of 30Ω and deflects full scale for a 6μA current. Determine the resistance R required to use this galvanometer to make a voltmeter to give a full scale deflection of 3000V. A. $1 \times 10^7\Omega$ B. $2 \times 10^7\Omega$ C. $3 \times 10^7\Omega$ D. $4 \times 10^7\Omega$ E. $5 \times 10^7\Omega$

48) Solution

$r = 30\Omega$
$I_m = 6\mu A = 6 \times 10^{-6} A$
$V = 3000V$
$R = ?$
for the resistance required to use galvanometer:
$R = \frac{V}{I_m} - r$

$= \frac{3000}{6\times10^{-6}} - 30$

$= 5\times10^{7}\,\Omega$ ------ (E)

59. A 15M Ω resistor is connected in series with a capacitor of capacitance 0.47 μF and a battery of emf 24.0V. what is the time constant of the circuit? A. 7.1s B. 7.1x10^{-6}s C. 7.1x10^{6}s D. 71s E. 0.71s

59) Solution

Time constant $\tau = RC$

$= (15\times10^{6})\times(0.47\times10^{-6})$

$= 7.05\,s$

$= 7.1\,s$ .... (A)

2012 / 2013 QUESTIONS ON DC CIRCIUT

24) The function of a resistor in a given circuit is to (A) limit the flow of charge (current) in a circuit (B) stop the flow of electrical energy in a circuit (C) short circuit the path of current (D) none of th above (E) all of the above

24) Solution

limit the flow of charge in the circuit -------- (A)

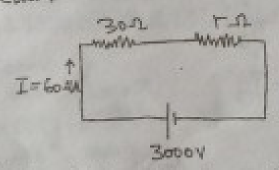
26) Kirchhoff's loop rule expresses the conservation of (A) voltage (B) resistance (C) charge (D) energy (E) current

26) Energy ------ D

27) 60μA current flowed two resistances connected in series when 3000V was connected across their two ends. If one of the resistances is 30Ω, what is the value of the other? (A)5x10^{5}Ω (B) 5x10^{9}Ω (C)5x10^{7}Ω (D)5x10^{-5}Ω (E) 5x10 Ω

27) Solution

This question can be represented as shown below:



$r = ?$

for the total resistance of the circuit we use

$R = \frac{V}{I} = \frac{3000}{60\times10^{-6}}$

$= 5\times10^{7}\,\Omega$

for resistors in series, $5\times10^{7} = 30 + r$ .... $(R = r_1 + r_2)$

$r = 5\times10^{7} - 30$

$= 5\times10^{7}\,\Omega$ .... (C)

28) Kirchhoff's voltage rule states that(A)∑E=0 (B) ∑(E + IR) (C) ∑IR=0 (D) ∑R+C=0 (E) none of the above

28) $\Sigma(E + IR) = 0$

48) In other to measure accurately the emf of a cell, a standard cell and the cell are connected in turn in a potentiometer circuit if the balanced length produced are 60 cm and 80 cm respectively, and the emf of the standard cell is 1.5 V. the emf of the cell is ? (A) 1.5V (B) 1.6V (C) 1.8V (D) 2.0V (E) 2.2 V

48) Solution

From the question,

$E_s = 1.5V,\ L_s = 60cm,\ L_x = 80cm$

For potentiometer,

$\frac{E_x}{E_s} = \frac{R_x}{R_s} = \frac{L_x}{L_s}$ ...... (s ⇒ Standard Emf, Resistance, length; x ⇒ unknown ", ", ")

$\therefore E_x = \left(\frac{L_x}{L_s}\right)E_s$

$E_x = \left(\frac{80}{60}\right)(1.5) = 2.0V$ ..... D

53) The current flowing in an RC circuit: A. Increases linearly with time B. Increases exponentially with time C. decreases linearly with time D. decreases exponentially with time E. Remains constant with time

53) ----- D

54) A series RC circuit has a resistor of resistance 3 x10^{6} Ω and a capacitor of capacitance 1μF. If the potential applied in the circuitt is 4V, calculate the rate at which the charge of the capacitor is

54) Solution

From the question,

$R = 3\times10^{6}\,\Omega$

$t = 1s$

$Emf = 4V$

$C = 1\mu F = 1\times10^{-6}F$

we use the formular $I = \frac{E}{R}e^{(-t/RC)}$ for rate at which the charge of the capacitor is increasing.

$I = \frac{4}{3\times10^{6}}e^{(-1/3)}$

$= 0.96\times10^{-6}\,C/s$ .... A

55) In an AC circuit having 10 Ω resistor and 100μF capacitor in series and supplied from 240v source. The constant of the circuit is A. 10^{3}s B. 10^{5} s C. 10^{-3}s D. 10^{-5} E. 10^{-6}s

55) Solution

from the question,

$R = 10\Omega$

$C = 100\mu F = 100\times10^{-6}F$

time constant

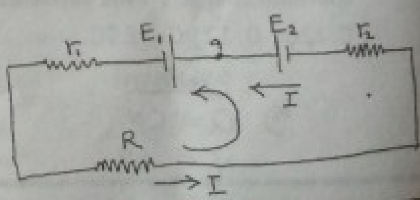
$\tau = RC = 10\times(100\times10^{-6}) = 10^{-3}s$ C

56) Which of the following can be used to measurean unknown emf of a cell? A. Wheatstone bridge B. Meter bridge C. Voltmeter D. Potentiometer E. None of the above.

56) Potentiometer -------- D

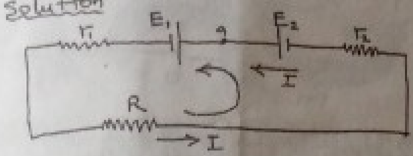
2011 / 2012 QUESTIONS ON DC CIRCIUT

21.



In the figure above, let E1 = 2.0 V, E2 = 4.0 V, r1 Ω = 1, r2 = 2Ω and R = 5.0 Ω . what current flows in the circuit? ____________

21) Solution



Following the direction of the curved arrow

$-IR - Ir_2 + E_2 - E_1 - Ir_1 = 0$

$-I(5) - I(2) + 4 - 2 - I(1) = 0$

$-8I + 2 = 0$

$I = 2/8 = \underline{0.25A}$

22. A slide-wire potentiometer is balanced against 3.0 V standard cell when the side wire is set at 50.2 cm out of a total length of 100.0 cm. For an unknown source, the setting is 21.9 cm. What is the emf of theunknown cell? ____________

22) Solution

given that:

$L_x = 21.9\,cm$

$l_s = 50.2\,cm$

$E_s = 3V$

We use the formular

$E_x = \left(\frac{L_x}{L_s}\right) \cdot E_s$

$= \left(\frac{21.9}{50.2}\right)(3) = \underline{1.3V}$

23. A 60 μF capacitor is charged to 100 V and connected across a 35 kΩ resistor. Calculate the time constant of theRC circuit? ____________

23) Solution

$R = 35 \times 10^3 \Omega$

$C = 60 \times 10^{-6} F$

time constant $\tau = RC$

$= (35 \times 10^3) \times (60 \times 10^{-6})$

$= \underline{2.1\,s}$

24. A 4 μF capacitor is charged to 24 V and then connected across a 200 Ω resistor. Find the initial current 24v and then connected across a 200 Ω resistor. ____________

24) for Charging of Capacitor/Resistor Circuit

$I = \frac{E}{R} e^{-t/RC}$

Where $E = 24$

$R = 200$

$t = 0$ ... (initial time)

$I = \frac{E}{R} e^0 = \frac{E}{R}$

$= \frac{24}{200} = \underline{0.12A}$

28. A 25 μF capacitor and a 15 MΩ resistor are connected in series with a 12 V battery so as to charge the capacitor. How much time would have elapsed before the capacitor reaches 75% to its final equilibrum value. ____________

28) Solution

from the quest. $R = 15M\Omega = 15 \times 10^6 \Omega$

$C = 25\mu f = 25 \times 10^{-6} F$

for Charging of R.C.

$Q = CE(1 - e^{-t/RC})$

at 100% charge, $Q = \frac{100}{100} CE$

at 75% charge, $Q = \frac{75}{100} CE$

$\frac{75}{100} CE = CE(1 - e^{-t/RC})$

$0.75 = 1 - e^{-t/RC}$

$e^{-t/RC} = 1 - 0.75$

$e^{-t/RC} = 0.25$

$t = -RC \ln(0.25)$

time elapsed b/4 it reaches 75% of its final equilibrium value

$t = -(15 \times 10^6 \times 25 \times 10^{-6}) \ln(0.25)$

$= \underline{519.9\,s}$

2010 / 2011 QUESTIONS ON DC CIRCIUT

25. Calculate the terminal voltage of a battery whose emf is 12V and internal resistance is 0.5Ω if the current in the circuit is 0.183A

25) Solution

From the question:

$r = 0.5\Omega$

$E = 12V$

$I = 0.183A$

using the formular

$E = I(R + r)$

$E = IR + Ir$

$E = V + Ir$

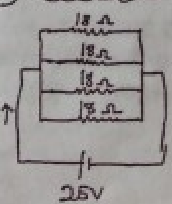
Terminal Voltage, $V = E - Ir$

$= 12 - (0.183 \times 0.5)$

$= \underline{11.9\,V}$

27. Four 18Ω resistors are connected in parallel across a 25V battery. What is the current in the circuit?

27) Solution



$R_{eff} = \frac{1}{\frac{1}{18} + \frac{1}{18} + \frac{1}{18} + \frac{1}{18}}$

$= 18/4 = 4.5\Omega$

$I = \frac{V}{R} = \frac{25}{4.5}$

$= \underline{5.56A}$

28. That the sum of the charges in potential around any closed loop of a circuit is zero is known as .... law/rule.

28) Kirchhoff Voltage Law/rule

29. A 6V battery of negligible internal resistance is used to charge a 2μf capacitor through a 100Ω resistor. Find the final charge on the capacitor..........

29) Solution

For Charging of an RC, capacitor

$Q = CE(1 - e^{-t/RC})$

The final time for Charging $t = \infty$

$$Q = CE\left(1-e^{-\frac{\infty}{RC}}\right)$$
$$= CE(1-0) = CE$$
$$= 6 \times 2\mu F$$
$$= \underline{12\mu C}$$

30. A 50µF capacitor is charged to 100V and connected across a 25kΩ resistor. Its time constant is ....

30) Solution

$R = 25 \times 10^3 \Omega$

$C = 50\mu F = 50 \times 10^{-6} F$

time constant $\tau = RC$

$= (25 \times 10^3) \times (50 \times 10^{-6})$

$= \underline{1.25s}$

31. How much time constant must elapse for an initially uncharged capacitor in an RC series circuit to be charged to 99% of its equilibrium charge?..........

31) Solution

for 99% of its final charge, we have

$Q = \frac{99}{100} CE$

$\frac{99}{100} CE = CE\left(1-e^{-t/RC}\right)$

$0.99 = 1-e^{-t/RC}$

$e^{-t/RC} = 1-0.99$

$e^{-t/RC} = 0.01$

$t = -RC \ln(0.01)$

$t = 4.6RC$

no of time Const. $= \underline{4.6}$

32. What is an RC circuit? ....

32) Solution

An RC circuit is one which has both resistor and capacitor Connected in Series with a battery supplying the difference in potential that Charges the Capacitor.

2009 / 2010 QUESTIONS ON DC CIRCIUT

25. In figure I below. A is a junction in an electric current (A)$I_1+I_2=I_3+I_4$ (B)$I_1=I_2+I_3+I_4$ (C)$I_4+I_1=I_2+I_3$ (D)$I_1+I_3=I_4+I_2$

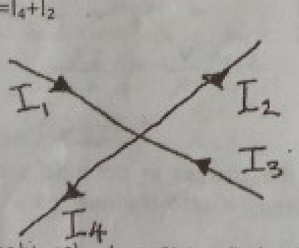


Fig 1

25) kirchhoff's law States That, the Sum of the Current entering a node equals the Current Leaving.

$(I_1+I_3) = (I_2+I_4)$ ....(D)

26. in fig 2, if $R_1=R_1=2\Omega$, $E_1=2V$, $E_2=4V$ and $E_3=4V$, the current I_1 and I_2 are respectively (A)2A and 1/4A (B)2/3A and 1/3A (C) 1A and 1/3A (D)1/4A and 4A (E)2/3A and 5/6 A

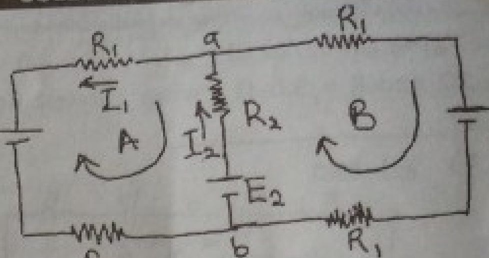


Fig2

27. In fig. 2, if $R_1=R_1=2\Omega$, $E_1=2V$ and, $E_2=4V$ and $E_3=4V$, the potential between the a and b that is V_{ab} is (A)4V(B)5V (C)3V (D)3.33V (E)2V

30. a side wire potentiometer is balanced against a 2.182V standard cell when the wire is set at 33.6cm out of a total length of 100.0cm. for an unknown source, setting is 45.8cm. what is the emf of the unknown cell? (A)1.388V(B)1.1601V(C)2.974V (D)3.678V(E)4.164V

30) Solution

from the question,

$L_x = 45.8cm$

$l_s = 33.6cm$

$E_s = 2.182V$

Using the potentiometer formular

$E_x = \frac{L_x}{l_s} E_s$

$= \frac{45.8}{33.6} \times 2.182$

$= \underline{2.974}$ C

31. a resistance $R=1.0M\Omega$, capacitance $C=2.0\mu f$ and a switch S are in series. A battery of emf 20V is connected such that the positive terminal is connected to the resistor and the negative terminal to the switch. If the the switch is closed at t=0, at what time t will the voltage will the voltage across the capacitor be 15V? (A)0 (B)2.0s (C)0.5s (D)2.77s (E)1.55s

31) Solution

From the question,

$E = 20V$

$R = 1M\Omega = 1\times10^6\Omega$

$C = 2\mu F = 2\times10^{-6}F$

$V = 15V$

$RC = (1\times10^6)\times(2\times10^{-6}) = \underline{2s}$

from the formular.

$Q = CE\left(1-e^{-t/RC}\right)$

$\frac{Q}{C} = E\left(1-e^{-t/RC}\right)$

$V = E\left(1-e^{-t/RC}\right)$

$15 = 20\left(1-e^{-t/2}\right)$

$e^{-t/2} = 1-\frac{15}{20}$

$e^{-t/2} = 0.25$

$t = -2\ln(0.25)$

$= \underline{2.77s}$ C

32. the electric current in an RC circuit is given by : (A)$[E/RC]e^{-t/RC}$ (B)$[E/R]^{-t/c}$ (C)$[E/R]e^{-t/RC}$(D)V/R

32) $I = \left(\frac{E}{R}\right)e^{-t/RC}$ .... (C)

33. the time constant of an RC circuit is the time required for a capacitor to reach .... Of it full charge (A)100% (B)73% (C)50% (D)63% (E)33%

33) 63% ....(D)

MAGNETISM

ALL FORMULARS NEEDED IN THIS TOPIC

* Magnetic force on a moving charged particle : $F = q\vec{v} \times \vec{B}$ or $F = qvB\sin\theta$
* Force on a wire carrying current : $F = \vec{IL} \times \vec{B}$ or $F = BIL\sin\theta$
* radius of a circular orbit moved by a charge : $r = \frac{mv}{qB}$
* Period of cyclotron : $T = \frac{2\pi m}{qB}$
* Hall emf : $V_H = \frac{IB}{neh}$
* Drift velocity : $V_d = \frac{V_H}{Bd}$
* Frequency of cyclotron : $f = \frac{qB}{2\pi m}$
* Ampere's law : $\oint B \cdot dl = \mu_0 I$
* Magnetic field : $B = \frac{\mu_0 I}{2\pi d}$
* Hall coefficient : $R_H = \frac{V_H h}{IB}$
* Force per unit length : $F/L = \frac{\mu_0 I^2}{2\pi d}$

All magnetic fields are caused by charges in motion. When a charge q moves with velocity v in a magnetic field B, it experiences a fore $F = q\vec{v} \times \vec{B}$

The SI unit of magnetic field is tesla (T).

A particle of mass m and charge q moving with speed v in a plane perpendicular to a magnetic field moves in a circular orbit of radius r given by $r = \frac{mv}{qB}$

The cyclotron period $T = \frac{2\pi m}{qB}$

$Frequency = \frac{qB}{2\pi m}$

A wire of length L carrying current I when placed in a magnetic field B experiences force $\vec{F} = \vec{IL} \times \vec{B}$

Torque on a current loop is given by $\tau = \vec{\mu} \times \vec{B}$

At any given place on the earth, we can define 3 magnetic elements: the angle of declination, the angle of dip, and horizontal component of earth's magnetic field (see text for definitions).

WHEN THEY SAY HALL EFFECT, DO THEY MEAN AFTER TAKING WEED IN THE HALL, YOU GO AROUND HARASSING PEOPLE?

O O . .

BETTER UNDERSTANDING OF THIS TOPIC WILL BE GOTTEN AFTER GOING THROUGH THESE QUESTIONS

FUTO PAST QUESTION ON MAGNETISM 2016 - 2009

2016 EXAM QUESTIONS AND ANSWERS ON DC

4. What is cyclotron frequency?
A. Frequency of any particle moving in the earth's magnetic field
B. Frequency with which a charged particle moves in the earth's magnetic field
C. Frequency with which two charged particles move relative to each other D. Frequency of the earth's magnetic field relative to the sum. E. Frequency of a charged particle moving perpendicular to the direction of a uniform magnetic field.

4) Cyclotron frequency or gyrofrequency is the frequency of a charged particle moving perpendicular to the direction of a uniform magnetic field.

Solution: E

5. Assuming the symbols have their usual meanings, the cyclotron frequency f is given by...
A. f=qB/(2πm) B. f=2πm/(qB) C. f=mv²/R D. f=mv/(qB) E. f=2πR/v

5) A

6. Determine the force on and ion of charge 10^{-19}C and speed 10^{-2}m/s moving in a magnetic field of 2.2T if the ion moves in a direction perpendicular to the field. A. 2.2×10^{-21}N B. 3.3×10^{-28}N C. 1.9×10^{-21}N D. 1.2×10^{-25}N E. 4.2×10^{9}N]

6) $F = ?$
$Q = 10^{-19}C$
$V = 10^{-2}$ m/s
$B = 2.2T$
Force on a charge moving in a magnetic field
$F = qVB$
$= 10^{-19} \times 10^{-2} \times 2.2$
$= 2.2 \times 10^{-21}N$ .... A

7. A magnetron in a microwave oven emits microwaves with frequency of 2450MHz. What magnetic field strength is required for electrons to move in circular paths with this frequency? A. 0.0877T B. 0.000877T C. 0.8770T D. 1.7530T E. 0.01753T

7) Solution

$f = 2450 \times 10^6$

$B = ?$

using the formular, $f = \frac{qB}{2\pi m}$

$B = \frac{2\pi m f}{q}$

$= \frac{2\pi \times 9.11 \times 10^{-31} \times 2450 \times 10^6}{1.6 \times 10^{-19}}$

$= 0.0877T$ .... A

8. A long copper strip 2.8cm wide and 2mm thick is placed in a 1.2T magnetic field. When a 15A current passes through it, the Hall emf is measured to be 1.06uV. Determine the drift velocity of the electrons. A. 2.3×10^{-5}m/s B. 3.5×10^{-5}m/s C. 3.2×10^{-5}m/s D. 5.3×10^{-6}m/s E. 2.3×10^{-6}m/s

8) From the hall effect formular for drift velocity

$V_d = V_H / Bd$

From the question

$V_H = 1.06 \times 10^{-6}$ V

$B = 1.2T$

$d = 2.8 \times 10^{-2}$

$V_d = \frac{(1.06 \times 10^{-6})}{(1.2) \times (2.8 \times 10^{-2})}$

$= 3.2 \times 10^{-5}$ m/s C

9. A straight conductor carries a current of 50A in a horizontal direction in a region where the magnetic field is in the direction 30° north with magnitude 2. IT. Find the magnitude and direction of the force on a 50cm length of the conductor. A. 2.625N, out of the paper B. 262.5N, into the paper C. 26.26N, into the paper D. 26.25N, out of the paper E. 26.25N, towards the x-axis

9) From the question

$I = 50A$ $B = 2.1T$

$\theta = 30°$ $L = 50cm = 0.5m$

$F = BIL\sin\theta$

$= 2.1 \times 50 \times 0.5 \times \sin 30°$

$= 26.25$ out of the paper ..... D

10. Electric current may be generated by rotating a loop of wire between the poles of a magnet. The induced current is greatest when the plane of the loop ... A. is parallel to B B. is perpendicular to B C. makes an angle of 45° with B D. makes an angle of 60° with B E. is off the B-field

10) A

11. Ampere's circuital law for any closed path about any configuration of current-carrying conductor in vacuum is given by ... A. $\oint B.dl = \mu_0 / I$ B. $\oint B.dl = I/\mu_0$ C. $\oint B.dl = \mu_0 I$ D. $\int B.dl = \mu_0 I$ E. $\int B.dl = \mu_0$

11) C

12. Two parallel wires of equal length of 20m are 5mm apart and carry a current of 8A each. Calculate the force one exerts on the other if the currents are in opposite directions. A. 1.5×10^{-3}N B. 8.5×10^{-3}N C. 6.1×10^{-4}N D. 3.1×10^{-3}N E. 5.1×10^{-3}N

12) $L = 20m$

$R = 5mm = 5 \times 10^{-3}$

$I = 8A$

$F = ?$

Force between two parallel conductors in opposite direction:

$F = \frac{\mu_0}{2\pi} \frac{I_1 I_2}{R} L$

$= \frac{4\pi \times 10^{-7}}{2\pi} \times \frac{8 \times 8}{5 \times 10^{-3}} \cdot 20$

$= 0.0512N$

$= 5.1 \times 10^{-2}N$

13. A magnetic field of 1.4×10^{-3}T exists at the centre of a circular coil of radius 20cm, having 15 closely wound turns. Find the current in the coil. A. 3000A B. 300A C. 30A D. 3A E. 0.3A

13) From the question

$B = 1.4 \times 10^{-3}$ T

$R = 20cm = 0.2m$

$N = 15$

Using the formular for magnetic field due to a current loop

$B = \frac{\mu_0 N I}{2R}$

$I = \frac{2RB}{\mu_0 N}$

$= \frac{2 \times 0.2 \times 1.4 \times 10^{-3}}{(4\pi \times 10^{-7}) \times 15}$

$= 30A$

14. Which statement is correct? According to Lenz's law, ... A. the induced emf opposes change in magnetic flux producing it B. the induced current attracts the change in magnetic flux producing it C. no emf is produced when the magnetic flux changes D. no current is produced when the magnetic flux changes. E. electrons are produced when the magnetic flux changes.

14) A

15. A coil of 600 turns is threaded by a flux of 8×10^{-5}Wb. If the flux is reduced to 3×10^{-5}Wb in 0.015s, find the average induced emf. A. -2V B. -2×10^{-5}V C. 0.012V D. 0.018V E. 0.015V

15) Solution

Induced emf $(\varepsilon) = -N\frac{d\phi_B}{dt}$

$= -600 \times \frac{(8 \times 10^{-5}) - (3 \times 10^{-5})}{0.015}$

$= -2V$

2015 EXAM QUESTIONS AND ANSWERS ON MAGNETISM

8. A 32cm long Solenoid, 1.2cm in diameter is to produce 0.20T magnetic field at its center. If a maximum current is 3.7A, find the number of turns in the solenoid. A. 7.2×10^4 loops B. 4.3×10^4 loops C. 2.7×10^4 loops D. 1.4×10^4 loops E. 5.2×10^4 loops

9. A circular coil of wire has a diameter of 20.0cm and contains 10 loops. The current in each loop is 3.0A, and the coil is placed in a 2.0T external field. Determine the magnetic dipole moment of the coil. A. 1.04 Am^2 B. 2.04 Am^2 C. 0.29m^2 D. 4.29Am^2 E. 0.94Am^2

15. An electron travels at 2.0×10^7m/s in a plane perpendicular to a uniform 0.01T magnetic field. Determine the radius of curvature of its path. A. 1.8×10^{-4}m B. 1.1×10^{-4} C. 1.2m D. 1.8×10^{-23}m E. 1.1×10^{-2}m

15) $v = 2.0 \times 10^7$ m/s

$B = 0.01T$

$q_e = 1.6 \times 10^{-19}C$ [charge of electron]

$m_e = 9.1 \times 10^{-31}$ kg [mass of electron]

using the equation for the radius path

$r = \frac{mv}{q_e} = \frac{(9.1 \times 10^{-31}) \times (2.0 \times 10^7)}{(1.6 \times 10^{-19}) \times (0.01)}$

$r = \frac{1.82 \times 10^{-23}}{1.6 \times 10^{-21}} = 0.01137$

Ans $= 1.1 \times 10^{-2}$ m - - F//

16. An electron enters a region of uniform magnetic field of induction 0.5T at right angles to it. Calculate the Cyclotron frequency for the electron. A. 14GHz B. 4.46GHz C. 7.0GHz D. 552GHz E. 139.7GHz

16) $B = 0.5T$
$q_e = 1.6 \times 10^{-19}$
$m_e = 9.1 \times 10^{-31}$ kg
using the frequency formula
$f = \frac{qB}{2\pi m} = \frac{(1.6\times10^{-19})\times(0.5)}{2(3.142)\times(9.1\times10^{-31})}$

$f = \frac{8\times10^{-20}}{5.72\times10^{-30}}$

Ans. $f = 14$GHz - - - A//

18. A wire carrying a 30A current has a length l = 16cm between the pole faces of a magnet at an angle θ = 60°. If the magnetic field is uniform at 0.90T, what is the magnitude of the force on the wire? A. 3.7×10^2N B. 3.7N C. 2.8×10^2N D. 2.8N E. 2.5×10^4N

18) $I = 30A$
$l = 16cm = 0.16m$
$\theta = 60°$
$B = 0.90T$
using the formular for force on a current - carrying wire
$F = BIl\sin\theta$
$= (0.90)\times(30)\times(0.16)\sin 60$
$= 4.32 \times 0.866$
ans $F = 3.7N$ - - - - B//

19. A magnetic field of 1.4×10^{-3}T exist at the center of a circular coil of radius 20cm having 15 closely wound turns. Find the current in the coil A. 1.4×10^{-3}A B. 30A C. 15A D. 20A E. 40A

25. A straight conductor carries a 1.0A current. At what distance from the axis of the conductor does the resulting magnetic *field have* magnitude $B = 0.5 \times 10^{-4}$T?
A. 40mm B. 0.04mm C. 0.4mm D. 4mm E. 0.004mm

25) $I = 1.0A$, $B = 0.5\times10^{-4}$T
$a = ?$ $B = \frac{\mu_0 I}{2\pi a}$
Make a subject of formula.

$a = \frac{\mu_0 I}{2\pi B} = \frac{(4\pi\times10^{-7})\times(1.0)}{2\times0.5\times10^{-4}\times\pi}$

$a = \frac{4\times10^{-7}}{1\times10^{-4}} = 4\times10^{-3}$m.

Ans $= a = 4mm$ - - - D//

26. Two straight parallel superconductors 4.5mm apart carry equal currents of 15,000A in opposite directions. What force per unit length does each wire exert on the other?
A. 1.0×10^{4}N/m B. 1.0×10^{4}N/m C. 1.0×10^{3}N/m D. 1.0×10^{3}N/m E. 1.0×10^{6}N/m

47. In a Hall Effect experiment, a sample of metal 15mm thick is placed in a uniform magnetic field of induction 1.8T. If a Hall voltage of 0.122μV is produced in the sample when carrying a current of 12A. Calculate the number density of electrons in the metal. A. 87.3×10^{28} m^{-3} B. 7.23×10^{28} m^{-3} C. 2.28×10^{28} m^{-3} D. 7.38×10^{28} m^{-3} E. 4.1×10^{28} m^{-3}

47) from the question
h = 15mm = 0.015m
B = 1.8T
$V_H = 0.122\mu V = 0.122\times10^{-6}$V
I = 12A

$V_H = \frac{IB}{neh}$

$n = \frac{IB}{V_H eh}$

$= \frac{(12)\times(1.8)}{(0.122\times10^{-6})\times(1.6\times10^{-19})\times(15\times10^{-3})}$

Ans = 7.38×10^{28} - - - - - D.

55. The direction of induced Emf is deduced from two laws, which of these laws are correct or is? i) The Flemings - Right hand rule ii) The Flemings - Left hand rule iii) The Lenz law iv) Faraday's first law
A. i and ii only B. iii and iv C. i and iv only D. ii and iii only E. i and iii only

60. Which law in electromagnetic induction does this statement represent? The magnitude of the induced Emf is proportional to the rate of change of flux - linkage?
A. Faraday's first law B. Faraday's third law C. Faraday's second law D. Maxwell's law E. Lenz's law

2013 / 2014 QUESTION ON DC CIRCIUT

60. The magnetic force on a moving charged particle is given by A. $\vec{F} = \mu\vec{V}\times\vec{E}$ B. $\vec{F} = q\vec{V}\times\vec{B}$ C. $\vec{F} = q\vec{V}\times\vec{E}$ D. $\vec{F} = \mu\vec{V}\times\vec{B}$ E. $\vec{F} = q\vec{V}\times\mu\vec{B}$

60) B - - - - - $F = q\vec{V}\times\vec{B}$

2012 / 2013 QUESTION ON DC CIRCIUT

59) The magnitude of the magnetic force on a current carrying conductor in a magnetic field doesnot depend on one of the following A. Magnitude of current B. Magnitu of magnetic induction C. length of the conductor D. diameter of the conductor E. Angle between the conductor and the magnetic field

59) - - - - D

60) In a effect experiment, a sample of metal 15 mm thick is placed in a uniform magnetic field of induction 1.8 T. If a hall voltage of 0.122μV is produced in the sample when carrying a current of 12 A, what is the electron density in the metal? A. 7.38×10^{29} B. 2.28×10^{28} C. 4.1×10^{28} E. 2.28×10^{-28}

60) Solution
from the question,
$I = 12A$
$V_H = 0.122\mu V = 0.122\times10^{-6}V$
$B = 1.8T$
$h = 15mm = 15\times10^{-3}m$
Using the hall emf formula
$V_H = \frac{IB}{neh}$

$n = \frac{IB}{V_H eh}$

$= \frac{12\times1.8}{(0.122\times10^{-6})\times(1.6\times10^{-19})\times(15\times10^{-3})}$

$= 7.38\times10^{28}$ - - - - - - - D

2012/2013 QUESTIONS ON MAGNETISM

29) A wire carrying 30 A current has a length l=12 cm between the pole faces of a magnet at an angle θ=60°. The magnetic field is approximately uniformed at 0.90T (ignore the field beyond the pole faces), what is the magnitude of the force on the wire (A) 2.8N (B) 5.6N (C) 1.4N (D) 3.2N (E) 3.0N

29) Solution
from the question,
$L = 12cm = 0.12m$
$\theta = 60°$
$B = 0.90T$
$I = 30A$

Using the formular for force on a current-carrying wire:

$F = BIL\sin\theta$
$= 0.9 \times 30 \times 0.12 \times \sin 60^\circ$
$= 2.8N$ ..... A

30) A long copper trip 1.8 cm wide and 1.0 mm thick is placed in a 1.2 T magnetic field. When a steady current 1.5 A passes through it, the hall emf is measured to 1.02 μV. Determine the drift velocity of the electrons (A) 7.4×10^{14}m/s (B) 4.7×10^{-5}m/s (C) 7×10^{5}m/s (D) 4.7×10^{5}m/s (E) 4×10^{-5}m/s

30) Solution
from the question:
$I = 1.5A$
$h = 1mm = 1\times10^{-3}m$
$B = 1.2T$
$d = 1.8cm = 1.8\times10^{-2}$
$V_H = 1.02\mu V = 1.02\times10^{-6}V$
using the formular for hall emf
$V_H = V_d B d$
$V_d = \frac{V_H}{Bd} = \frac{1.02\times10^{-6}}{1.2\times(1.8\times10^{-2})}$
$= 4.7\times10^{-5} ms^{-1}$ .... B

31) A uniform field of magnetic induction B point horizontally from south to north, its magnitude is webers/meter square. If a 50eV proton moves vertically downward through this field, what force will act on it ? take $1eV=1.6\times10^{-19}$J (A) 74×10^{-12}N (B) 7.4×10^{-12}N (C) 0.74×10^{-12}N (D) 7.4×10^{-14} (E) nOne of the above

31) From the parameters given,
$KE = 5eV = 5\times(1.6\times10^{-19})$
$= 8\times10^{-19}J$

$B = 1.5 webers/m^2$
Proton mass $M = 1.67\times10^{-27}kg$
Charge $q = 1.6\times10^{-19}c$
we use the formular, $F = qVB$
but from K.E formular ($KE = \frac{1}{2}mv^2$)
$V = \sqrt{\frac{2KE}{m}}$
$\therefore F = q\left(\sqrt{\frac{2KE}{m}}\right)B$
$= (1.6\times10^{-19})\left(\sqrt{\frac{2\times(8\times10^{-19})}{1.67\times10^{-27}}}\right)\times1.5$
$= 7.4\times10^{-15}N$

57) A Sodium ion of mass 3.84×10^{-26} kg and charge 1.6×10^{-19} C is shot perpendicularly into a magnetic field of induction 0.02 T with a speed of 3.0×10^{4} m/s. The radius of the circular path traced by the ion is A. 36cm B. 72cm C. 36cm D. 18cm E.7.2cm

57) From the question,
$q = 1.6\times10^{-19}c$
$B = 0.02T$
$V = 3\times10^{4} m/s$
$m = 3.84\times10^{-26}kg$

For radius of Path:
$r = \frac{mv}{qB}$
$= \frac{(3.84\times10^{-26})\times(3\times10^{4})}{(1.6\times10^{-19})\times0.02} = 0.36m$
$= 36cm$ .... (A)

58) An electron enters a region of uniform magnetic field of induction 0.5 at right angles to it. Determine the cyclotron frequency of the electron A. 14 GHz B. 4.46 GHz C. 7.0 GHz D. 552GHz E. 138 GHz

58) Solution
given that:
$B = 0.5T$
$q = 1.6\times10^{-19}c$
$m = 9.11\times10^{-31}$
we use the frequency formular:
$f = \frac{qB}{2\pi m}$
$= \frac{(1.6\times10^{-19})\times0.5}{2\pi\times(9.11\times10^{-31})}$
$= 13.98\times10^{9}$
$= 14GHz$ A

2010/2011 QUESTIONS ON MAGNETISM

33. Which of the following is true? The force F_B acting on a charged particle moving with velocity v through a magnetic field B is [(i) parallel (ii) perpendicular (iii) at angle 30°] to v and B..............

33) Perpendicular

34. Calculate the magnetic force on a 240m length of wire stretched between two towers carrying a 150A current. The earths magnetic field of 5×10^{-5}T makes an angle of 30° with the wire. ....

34) Solution
$\theta = 30^\circ$
$I = 150A$
$L = 240m$
$B = 5\times10^{-5}T$

$F = BIL\sin\theta$
$= [(5\times10^{-5})\times150\times240\times\sin30^\circ]N$
$= 0.9N$

35. Which of the following is not a unit of magnetic field? (i) N.s/C.m (ii) N/A.m (iii) m^2/N.s.......

35) $m^2/N.s$

36. A long copper strip 1.8 cm wide is placed in a 1.2 T magnetic field such that the magnetic field is perpendicular to it. If the hall emf is 1.02μV, determine the drift velocity. ....

36) Solution
from the question:
$B = 1.2T$
$d = 1.8cm = 1.8\times10^{-2}$
$V_H = 1.02\mu V = 1.02\times10^{-6}V$
using the formular for hall emf
$V_H = V_d B d$
$V_d = \frac{V_H}{Bd} = \frac{1.02\times10^{-6}}{1.2\times(1.8\times10^{-2})}$
$= 4.7\times10^{-5}ms^{-1}$ .... B

37. Write out the equation known as ampere's law ....

37) $\oint B \cdot dl = \mu_0 I$

38. Name at least one source of magnetic field ....

38) wire Carrying Current, moving Charge.

39. A long straight wire carries a current of 20A. determine the magnetic field due to the current at a distance of 4mm from the wire. ....

39) Solution

From the question,

$\mu_0 = (4\pi \times 10^{-7})\ T \cdot mA^{-1}$

$I = 20A$

$a = 4mm = 4 \times 10^{-3}$

we use the formular

$B = \frac{\mu_0 I}{2\pi a} = \frac{(4\pi \times 10^{-7}) \times 20}{2 \times \pi \times (4 \times 10^{-3})}$

$= 1 \times 10^{-4}\ T$

40. A point charge of magnitude q = 4.5nC is moving with speed v = 3.6×10^7 m/s parallel to the x axis along the line y = 3m. find the magnetic field at the origin produced by this charge when it is at the point x = -4m . ...

2011/2012 QUESTIONS ON MAGNETISM

25. A region of space is said to be the site of a magnetic field if a test charge moving in the regoin experiences a force due to its motion. Give the mathematical expression of the force. ____________

25) $q\vec{v} \times \vec{B}$

26. An electron travels at 8.0×10^7 m/s in a plane perpendicular to a uniform 0.005 T magnetic field. Calculate the radius of the path traced by the elecron. ____________

26) Solution

From the question

$m = 9.11 \times 10^{-31}\ kg$

$q = e = 1.6 \times 10^{-19}\ C$

$B = 0.005T$

$v = 8 \times 10^7\ m/s$

radius of path $(r) = \frac{mv}{qB}$

$= \frac{(9.11 \times 10^{-31}) \times (8 \times 10^7)}{(1.6 \times 10^{-19}) \times 0.005}$

$= 9.11 \times 10^{-2}\ m$

27. A cyclotron for acceratng protons has a magneticfield to 2.5 T and a maximum radius of 0.8 m. What is the cyclotron frequency? ____________

27) Solution

given the parameter

$B = 2.5T$

$e = 1.6 \times 10^{-19}\ C$

$m = 1.67 \times 10^{-27}\ kg$

we use:

$f = \frac{qB}{2\pi m}$

$= \frac{1.6 \times 10^{-19} \times 2.5}{2\pi (1.67 \times 10^{-27})}$

$= 3.81 \times 10^7\ Hz$

2009/2010 QUESTIONS ON MAGNETISM

34. a section of a conductor 0.4×10^{-2}m in thickness is use as the experimental specimen in a hall effect measurement. If a hall voltage of 35×10^{-6}V is measured for a current 21A in a magnetic field of 1.8T, calculate the hall coefficient for the conductor. (A) $1.2 \times 10^{-9} M^3/C$ (B) $1.3 \times 10^{-9} M^3/C$ (C) $3.7 \times 10^{-9} M^3/C$ (D) $3.5 \times 10^{-9} M^3/C$

34) Solution

From the question,

Current $I = 21A$

Hall emf $V_H = 35 \times 10^{-6}\ v$

magnetic field $B = 1.8T$

thickness $h = 0.4 \times 10^{-2}\ m$

Hall Coefficent $R_H = ?$

Using the formular

$V_H = R_H \frac{IB}{h}$

$R_H = \frac{V_H h}{IB} = \frac{(35 \times 10^{-6}) \times (0.4 \times 10^{-2})}{21 \times 1.8}$

$= 3.7 \times 10^{-9}\ m^3/c$ ......(C)

35. an electron experiences the greatest force as it travels at 3.9×10^5 m/s in a magnetic field when it is moving westward. The force is upward and the magnitude 8.2×10^{-13}N. what is the magnitude of the electric field

35) Solution

$F = 8.2 \times 10^{-13}$

$q = 1.6 \times 10^{-19}$

$V = 3.9 \times 10^5$

$B = ?$

From the formular:

$F = qVB$

$B = \frac{F}{qV} = \frac{8.2 \times 10^{-13}}{(1.6 \times 10^{-19}) \times (3.9 \times 10^5)}$

$= 13.14T$ ....D

37. Two long parallel wire are separated by 10cm. They carry the same current in the same direction. If the force per unit length between the wires is 2×10^{-4} Nm^{-1}. Determine the current carried by the wires. (A) 100A (B) 40.5A (C) 10A (D) 12A (E) 15A.

37) $\mu_0 = 4\pi \times 10^{-7}\ T \cdot m/A$

$L = 1m$

$d = 10cm = 0.1m$

$F/L = 2 \times 10^{-4}\ N/m$

From the Formular

$\frac{F}{L} = \frac{\mu_0 I^2}{2\pi d}$

$I = \sqrt{\frac{2\pi d}{\mu_0} \times \frac{F}{L}}$

$I = \sqrt{\frac{2\pi \times 0.1}{4\pi \times 10^{-7}} \times 2 \times 10^{-4}}$

$I = 10A$ C

38. A long copper strip 1.8cm wide and 1.0mm thick is placed in a 1.2T magnetic field. When a steady current of 15A passes through it, the Hall emf is measured to be 1.02μv. Determine the drift velocity of the electrons. (A) 4.7×10^{-5} m/s (B) 7.05×10^{4} m/s (C) 1.5×10^{-4} m/s (D) 6.8×10^{-5} m/s (E) 3.0×10^{-8} m/s

38) $B = 1.2T$

$d = 1.8cm = 1.8 \times 10^{-2}$

$V_H = 1.02\mu V = 1.02 \times 10^{-6}\ V$

using the formular for hall emf

$V_H = V_d B d$

$V_d = \frac{V_H}{Bd} = \frac{1.02 \times 10^{-6}}{1.2 \times (1.8 \times 10^{-2})}$

$= 4.7 \times 10^{-5}\ ms^{-1}$ ......(A)

39. A magnetic field B is defined in terms of the force F acting on a test charge Q moving through the field with velocity V. (A) F = qB x v (B) F = qv x B (C) F = B x qv (D) F = q2B x v

39) $F = qv \times B$ .... (B)

40. A long straight wire carries a current of 20A. Determine the magnetic field due to the current at a distance of 4mm from the wire. (A) 0.001 T (B) 10.0 T (C) 0.10 T (D) 2.1T (E) 11.0T .

40 Solution

From the question,

$\mu_0 = (4\pi \times 10^{-7})\ T \cdot mA^{-1}$

$I = 20A$

$a = 4mm = 4 \times 10^{-3}$

we use the formular

$B = \frac{\mu_0 I}{2\pi a} = \frac{(4\pi \times 10^{-7}) \times 20}{2 \times \pi \times (4 \times 10^{-3})}$

$= 1 \times 10^{-4}\ T$

PAST TEST QUESTIONS

FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI SCHOOL OF PHYSICAL SCIENCES DEPARTMENT OF PHYSICS

2015 TEST

2014/2015 RAIN SEMESTER TEST Date: 22/07/15

PHY 102: GENERAL PHYSICS Time- 40 minutes

Constants: Permittivity of free space, $\varepsilon_0 = 8.854 \times 10^{-12}$ Wm²; Coulomb's constant, K = 9.0×10^9 = Nm²C-²; Gravitation constant, G = 6.67 x 1Cr¹¹Nm²Kg-¹; Acceleration due to gravity, g = 9.8ms-f **Instruction:** Use all the available space in this paper answer all the questions.

Surname Other Names

Reg. No.: ______________________ Dept.: ______________ Manual No.:

1) An α particle has mass of 6.6×10^{-27} kg and charge of 3.2×10^{-19}C. Find the ratio of the magnitudes of the electric repulsion and the gravitational attraction between two α particles. **ANSWER: CHECK PAGE 5**
2) When a 10μC charge is placed at a certain point it experiences a force of 2×10^{-4}N in the x-direction. What is the electric field E at that point? If an electron is placed at this field, what force will be exerted on it? **ANSWER: CHECK PAGE 14**
3) State Gauss's law in its mathematical forms. **ANSWER: CHECK PAGE 23**
4) Find the electric potential due to a point charge = -2nC at a point 2.0cm from the charge. **ANSWER: CHECK PAGE 29**
5) Three capacitors of capacitance 4uF, 8uF and 2uF are connected in series and a potential difference of 6 volts is supplied. Calculate the equivalent capacitance. **ANSWER: CHECK PAGE 35**

PHY 102 TESTS 2014

ANSWER ALL QUESTIONS COMPLETE ANSWERS ARE PREFERED TO FRAGMENTS

INSTRUCTIONS: show all working take $m_e = 9.11 \times 10^{-31}$kg, e = 1.60×10^{-19}C. ε_0=8.85xl0-12C²NM²

1(a) state coulombs law of electrostatics and write its mathematical form_

(b) Three point charges lie on a straight line as shown in the figure below find the resultant force on Q3

2(a) list any two properties of lines of force
(I)..
(II)..

2(b) what magnitude of electric field is required to give an electron of mass m_e and charge e an acceleration of $3.00 \times 10^8 m/s^2$

3(a) state gauss law _..........................

3(b) A spherical body of radius R has a charge q uniformly distributed throughout its volume, obtain an expression for the electric field E at a point r (i.e r<R) from the center of the sphere_..........................

4(a) Define electric potential difference between two point in an electric field

4(b) three identical particles each having a charge of 30μC are located at the vertices of an equilateral triangle that is 10cm along each side. Calculate the electric potential energy in it.

5(a) state the mathematical formulas for energy stored in a capacitor._..........................

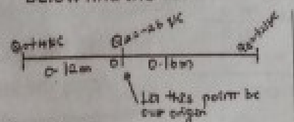
5(b) four capacitors are connected as shown below, find the equivalent capacitance

ANSWERS

1] Columb's Law states that the force of attraction or repulsion exerted by two charges is directly proportional to the product of the charges and inversely proportional to the square of the distance between them.

Mathematically $F = \frac{kQ_1Q_2}{r^2}$

(b) Three point charges lie on a straight line as shown in the figure below find the resultant force on Q3



Resultant force on Q_3

f_3 total = $f_{31} + f_{32}$

where f_{31} = force on Q_3 due to Q_1

f_{32} = force on Q_3 due to Q_2

for our positions

$r_1 = -0.12\hat{i}$ [distance from the origin on the -ve $\hat{i}$ direction]

$r_2 = 0$ [the point we chose as our origin]

$r_3 = 0.16\hat{i}$ [distance from the origin in the +ve $\hat{i}$ direction]

$f_{31} = \frac{kQ_1Q_3}{r^2}\left[\frac{r_3 - r_1}{r}\right]$

$f_{31} = \frac{(9\times10^9)(14\times10^{-6})(21\times10^{-6})}{(0.12+0.16)^2} \times \left[\frac{0.16\hat{i}-(-0.12\hat{i})}{(0.12+0.16)}\right]$

$= 33.75 \times \hat{i}$

$= 33.75\hat{i}$ N//

$f_{32} = \frac{kQ_3Q_2}{r^2}\left[\frac{r_3 - r_2}{r}\right]$

$= \frac{(9\times10^9)\times(21\times10^{-6})(-26\times10^{-6})}{(0.16)^2}\left[\frac{0.16\hat{i}-0}{0.16}\right]$

$= -191.95 \times \hat{i}$

$= -191.96\hat{i}$

Net force $f_3 = f_{31} + f_{32}$

$= 33.75\hat{i} + [-191.96\hat{i}]$

$= -158.21\hat{i}$N

or 158.21N towards the negative x direction

2a] Lines of force originates from a positive charge and terminates at the negative charge.

2aii] Lines of force do not intersect.

6b] from the question
charge of electrons 1.6×10^{-19}
mass of electrons 9.11×10^{-31}
acceleration $= 8.00\times10^{8}$
$E = ?$

We use the Electric field formula
$E = \frac{ma}{e}$
$= \frac{(9.11\times10^{-31})\times(8\times10^{8})}{(1.6\times10^{-19})}$
$= \underline{1.91\times10^{-3}\ N/c}$

5] Gauss's law states that the total number of the flux out of a closed surface is equal to the charge enclosed divided by the permittivity.

Mathematically $\phi = Q/\varepsilon_0$ or $\oint E\cdot dA = Q/\varepsilon_0$ //

5b] from $\phi = EA = Q/\varepsilon_0$
charge inside a solid sphere
$Q' = Q\, r^3/R^3$

Area of gaussian surface $A = 4\pi r^2$

We have that $E(4\pi r^2) = (Qr^3/R^3)/\varepsilon_0$
$\therefore E = \frac{Qr}{4\pi\varepsilon_0 R^3}$

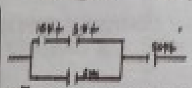
See Kings lecture note for better explanation

4a] Electric potential can be defined as the work done in carrying a positive test charge from one point to the other in an electric field.

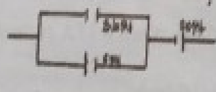
4b] Total potential energy.
$U = U_{12} + U_{13} + U_{23}$
$= \left[\frac{kQ_1Q_2}{r_{1,2}} + \frac{kQ_1Q_3}{r_{1,3}} + \frac{kQ_2Q_3}{r_{2,3}}\right]$
$U = k\left[\frac{Q_1Q_2}{r_{1,2}} + \frac{Q_1Q_3}{r_{1,3}} + \frac{Q_2Q_3}{r_{2,3}}\right]$

$= 9\times10^{9}\left[\frac{(20\times10^{-6})\times(20\times10^{-6})}{0.1} + \frac{(20\times10^{-6})\times(20\times10^{-6})}{0.1} + \frac{(20\times10^{-6})\times(20\times10^{-6})}{0.1}\right]$
$= \underline{\underline{0.108\,J}}$

5a] Energy $(U) = \frac{1}{2}CV^2$



5b] for the capacitors in series
$C_{eq} = \frac{1}{(1/15 + 1/3)}$
$= 5/2\ \mu f$
The diagram becomes.



for the two capacitors in parallel
$C_{eq} = (5/2) + 6$
$= \underline{8.5\ \mu f}$

The diagram becomes

for the two capacitors in series.
$C_{eq} = \frac{1}{\left(\frac{1}{8.5}\right) + \left(\frac{1}{20}\right)}$
$= \underline{\underline{5.9\ \mu f}}$

(2) State two ways which a natural body could be charged

2] * A natural body could be charged by friction.
* A natural body could be charged by induction.

(3) A proton of charge 10μC is released from rest in a uniform electric field of intensity 4×10^{5}N/C, calculate the acceleration of the charge

3] from the formular $E = \frac{ma}{q}$
Where $q = 10\mu C = 10\times10^{-6}$
$m = 1.67\times10^{-27}$ ... (mass of proton)
$E = 4\times10^{5}$ N/c
$a = ?$

$a = \frac{Eq}{m}$
$= \frac{(4\times10^{5})(10\times10^{-6})}{1.67\times10^{-27}}$
$a = 2.40\times10^{27}\ m/s^2$ // Ans

(4) Two protons are separated by a distance 10μm, calculate the electric field intensity at a point mid way between the charges.

4]

The electric field intensity at midpoint between two equal charges is zero
See Kings material for vectorial method of solving it.

(5) A non conducting sphere has a uniform charge density throughout how does the magnitude of the electric field vary

5] for a non-conducting sphere [solid sphere]
$E = \frac{Qr}{4\pi\varepsilon_0 R^3}$

See Kings material for better explanation.

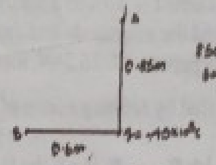
(6) A line charge has a linear charge density of 60μc/m calculate the electric field intensity at a point 10μm above the line charge.

6] using the formular.
$E = \frac{\lambda}{2\pi\varepsilon_0 r}$
where λ (charge density) $= 60\mu c/m = 60\times10^{-6}$
$\varepsilon_0 = 8.85\times10^{-12}$
r (distance) $= 10\mu m = 10\times10^{-6}$ m

$E = \frac{60\times10^{-6}}{2\pi(8.85\times10^{-12})(10\times10^{-6})}$
$\underline{\underline{E = 1.08\times10^{11}}}$ N/C Ans.

(7) A point A is 85cm north of a point charge -45×10^{3}C and a point B is 60cm west of the charge calculate the potential difference $V_B - V_A$

7]



85cm = 0.85m
60cm = 0.6m.

$V_B - V_A = \left(\frac{kq}{r_B}\right) - \left(\frac{kq}{r_A}\right)$
$= \left(\frac{(9\times10^{9})\times(-45\times10^{3})}{0.6}\right) - \left(\frac{(9\times10^{9})\times(-45\times10^{3})}{0.85}\right)$
$= 1.99\times10^{14}$ V // Ans.

9

DEPARTMENT OF PHYSICS RAIN SEMESTER

2013 PHY 102 TEST

Attempt all questions Date: 09/06/13
Constants permittivity of free space, $\varepsilon_0 = 8.85\times10^{-12}cm^2/N$, coulombs constant, K = $9.0\times10^{9}N/cm^2$
SURNAME OTHER NAMES
REG DEPARTMENT

(1) Two charges Q_1 = 500μC and Q_2 = 100μC are located on the XY plane at the position n=3jm and 4im find the force exerted on Q_1

1]

using pythagoras
$r = \sqrt{3^2 + 4^2}$
$= 5$

$F_{12} = \frac{kQ_1Q_2}{r^2}\left[\frac{\vec{r}}{r}\right]$ — unit vector — coulomb's force.
$= \frac{(9\times10^{9})(500\times10^{-6})(100\times10^{-6})}{5^2}\left[\frac{3j - 4i}{5}\right]$
$= 18 \times (0.6j - 0.8i)$
$= [10.8j - 14.4i]$ N
$= [-14.4i + 10.8j]$ N //

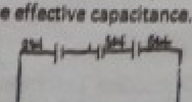
(8) A camera flash unit stores energy in 150μF capacitor from a 200V source. How much electric energy can be stored?

8] $C = 150\mu f$
$V = 200V$
$U = ?$
from the formular
$U = \frac{1}{2}CV^2$
$U = \frac{1}{2}\times(150\times10^{-6})\times(200)^2$
U = dont be lazy, get me the answer......

10

(9)Three capacitors of capacitance 2μF, 3μF and 5μF are connected in series, calculate the effective capacitance.

9]



$C_{eq} = \frac{1}{1/2 + 1/3 + 1/5}$
$= 0.968\ \mu f$

(10) Write down to factors affecting the capacitance of a capacitor.

10] Solution.
i] Area of the plates. ii] distance between the plates.

FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI SCHOOL OF PHYSICAL SCIENCES: DEPARTMENT OF PHYSICS
RAIN SEMESTER EXAMINATIONS, 2015/2016 SESSION

PHY 102: GENERAL PHYSICS II Date: 17/09/16 Type: D Time: 2.5 hrs

Surname		Reg. No.			
Other name(s)		Manual No.		Dept.	

MOBILE PHONES ARE NOT ALLOWED IN THE EXAMINATION HALL, WHETHER ON OR OFF

Instructions: Do all. Do not detach the optical mark sheet (OMS) from the question paper. Fill in your particulars on both the question paper and the OMS. Shade clearly (with pencil) the alphabet bearing your chosen answer on the answer sheet (OMS).

TOPICS

Some useful constants: $g = 9.8\ m/s^2$; $e=1.6\times10^{-19}$ C; $m_e=9.1\times10^{-31}$ kg; $\varepsilon_0=8.85\times10^{-12}$F/m; $k=9\times10^9\ Nm^2/C^2$; $\mu_0=4\pi\times10^{-7}$H/m

DC 1. How many time constants must elapse before a capacitor in an RC circuit is charged to 10% of its equilibrium charge?:
A. 2.3RC B.4.6RC C. 6.9RC D. 9.2RC E 1.7RC

DC 2. For a circuit with R=20Ω, V=50V, C=100μF in series, calculate the charge on the capacitor 3×10^{-3} seconds after the switch is closed.
A. 0.78C B. 3.9×10^{-3}C C. 3.9C D. 38.8C E. 3900C

DC 3. A fully charged capacitor of capacitance 2.02μF and voltage 20V is connected to discharge through a resistor. If the current decreased to 50% of its initial value in 40μs, determine the value of R. A. 20.8Ω B. 57Ω C. 28.6Ω D. 82.6Ω E. 38.2Ω

MAGNET 4. What is cyclotron frequency? A. Frequency of any particle moving in the earth's magnetic field
B. Frequency with which a charged particle moves in the earth's magnetic field
C. Frequency with which two charged particles move relative to each other D. Frequency of the earth's magnetic field relative to the sun. E. Frequency of a charged particle moving perpendicular to the direction of a uniform magnetic field.

MAGNET 5. Assuming the symbols have their usual meanings, the cyclotron frequency f is given by...
A. $f=qB/(2\pi m)$ B. $f=2\pi m/(qB)$ C. $f=mv^2/R$ D. $f=mv/(qB)$ E. $f=2\pi R/v$

MAGNET 6. Determine the force on and ion of charge 10^{-19}C and speed 10^{-2}m/s moving in a magnetic field of 2.2T if the ion moves in a direction perpendicular to the field. A. 2.2×10^{-21}N B. 3.3×10^{-21}N C. 1.9×10^{-21}N D. 1.2×10^{-25}N E. 4.2×10^{6}N]

MAGNET 7. A magnetron in a microwave oven emits microwaves with frequency of 2450MHz. What magnetic field strength is required for electrons to move in circular paths with this frequency? A. 0.0877T B. 0.000877T C. 0.8770T D. 1.7530T E. 0.01753T

MAGNET 8. A long copper strip 2.8cm wide and 2mm thick is placed in a 1.2T magnetic field. When a 15A current passes through it, the Hall emf is measured to be 1.06uV. Determine the drift velocity of the electrons.
A. 2.3×10^{-5}m/s B. 3.5×10^{-5}m/s C. 3.2×10^{-5}m/s D. 5.3×10^{-6}m/s E. 2.3×10^{-6}m/s

MAGNET 9. A straight conductor carries a current of 50A in a horizontal direction in a region where the magnetic field is in the direction 30° north with magnitude 2.1T. Find the magnitude and direction of the force on a 50cm length of the conductor. A. 2.625N, out of the paper B. 262.5N, into the paper C. 26.26N, into the paper D. 26.25N, out of the paper E. 26.25N, towards the x-axis

MAGNET 10. Electric current may be generated by rotating a loop of wire between the poles of a magnet. The induced current is greatest when the plane of the loop ... A. is parallel to B B. is perpendicular to B C. makes an angle of 45° with B D. makes an angle of 60° with B E. is off the B-field

MAGNET 11. Ampere's circuital law for any closed path about any configuration of current-carrying conductor in vacuum is given by ... A. $\oint B.dl = \mu_0/I$ B. $\oint B.dl = I/\mu_0$ C. $\oint B.dl = \mu_0 I$ D. $\int B.dl = \mu_0 I$ E. $\int B.dl = \mu_0$

MAGNET 12. Two parallel wires of equal length of 20m are 5mm apart and carry a current of 8A each. Calculate the force one exerts on the other if the currents are in opposite directions. A. 1.5×10^{-3}N B. 8.5×10^{-3}N C. 6.1×10^{-4}N D. 3.1×10^{-3}N E. 5.1×10^{-3}N

MAGNET 13. A magnetic field of 1.4×10^{-3}T exists at the centre of a circular coil of radius 20cm, having 15 closely wound turns. Find the current in the coil. A. 3000A B. 300A C. 30A D. 3A E. 0.3A

MAGNET 14. Which statement is correct? According to Lenz's law, ... A. the induced emf opposes change in magnetic flux producing it B. the induced current attracts the change in magnetic flux producing it C. no emf is produced when the magnetic flux changes D. no current is produced when the magnetic flux changes. E. electrons are produced when the magnetic flux changes.

MAGNET 15. A coil of 600 turns is threaded by a flux of 8×10^{-5}Wb. If the flux is reduced to 3×10^{-5}Wb in 0.015s, find the average induced emf. A. -2V B. -2×10^{-3}V C. 0.012V D. 0.018V E. 0.015V

CURRENT 16. A current density of 2×10^{5}A/m^2 in a cylindrical wire of radius R=2mm is uniform across a cross-section of the wire. What is the current through the portion of the wire between the radial distance R/2 and R? A. 2.51A B. 0.63A C. 1.88A D. 188A E. 0

CURRENT 17. What voltage difference is required to send a current of 2A through 50cm of silver wire that has a 3.1mm^2 cross-sectional area? (Resistivity = 1.6×10^{-8}Ω-m) A. 0.52V B. 5.2V C. 5.2×10^{-2}V D. 5.2×10^{-3}V E. 5.2×10^{-3}V

CURRENT 18. A carbon block has dimensions 2cmx2cmx60cm. Determine the resistance measured between the two square end' if the resistivity of carbon is 3.5×10^{-5}Ω-m. A. 6.5×10^{-4}Ω B. 5.3×10^{-2}Ω C. 7.6×10^{-2}Ω D. 4.4×10^{-4}Ω E. 3.2×10^{-3}Ω

DC 19. A resistance of 9985Ω is in series in a circuit with a 15Ω wire. If the potential difference across the latter is 0.075V, then the total potential difference across the resistances is... A. 49.0V B. 49.8V C. 49.9V D. 50.0V E. 51.0V

DC 20. Suppose the resistance of a copper wire is 1.05 Ω at 20°C. Find the resistance at 0°C if the temperature coefficient of copper is 0.0039/°C. A. 1.078Ω B. 1.1319 Ω C. 1.8362 Ω D. 0.968 Ω E. 2.1560Ω

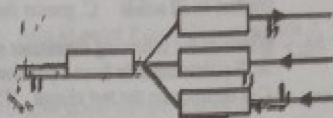
CURRENT 21. A copper wire has 5mm diameter and carries a current of 10A. Determine the current density in the wire. A. 5.1×10^5 A/m² B. 5.1×10^3 A/m² C. 7.1×10^5 A/m² D. 7.1×10^2 A/m² E. 4.1×10^2 A/m²

DC 22. Which of these statements is/are correct? According to Kirchhoff's rules: (i) ΣV=0 at a junction (ii) ΣI=0 at a junction (iii) ΣV=ΣI at a junction A. (i) only B.(i)and(ii) C. (ii) only D. (ii) and (iii) E. (iii) only

DC 23. Three cells of emf 2V each and internal resistance 3Ω are connected in parallel. What is the effective emf and internal resistance of the combination? A. 6V, 9Ω B. 2V, 9Ω C. 2V, 1Ω D. 6V, 1Ω E. 6V, 3Ω

DC 24. A battery of emf 12V and internal resistance 2Ω supplies current to a gadget of resistance 4Ω. What are the readings on a voltmeter connected across the cell and an ammeter connected in series with the gadget?
A. 2V, 8A B. 8V,2A C. 12V, 2A D. 4V, 6A E. 12V, 8A

DC 25. Determine the value of I3 in the shown circuit if I1=20A, I2=50A and I4=60A.
A. 90A B. -90A C. 30A D.-30A E. 20A



DC 26. Three resistors are arranged such that resistor 1 with resistance of 3Ω is connected in series with a parallel arrangement of resistors 2 and 3, with resistances 5Ω and 7Ω respectively. What is the equivalent resistance of the arrangement?
A. 15Ω B. 3.3428Ω, C. 5.9167Ω D. 1.4788Ω E. 2.4Ω

DC 27. A 100Ω resistor is connected to a battery of 6V emf and 1/5Ω internal resistance. Calculate the current in the circuit. A. 60mA B. 69mA C. 50mA D. 59mA E. 40mA

DC 28. A resistor with resistance of 10MΩ is connected in series with a capacitor with capacitance of 1μF and a battery with emf of 12 V. What is the time constant of the circuit? A. 10^6s B. 10^4s J C. 10^3s D. 10^2s E. 10s

DC 29. Which of the following statements is not true about the ammeter-voltmeter method of measuring resistance? A. All voltmeters pass some current B. All ammeters have some resistance C. It is more precise than the Wheatstone bridge D. It requires the use of two calibrated meters E. Current passed by the voltmeter is only negligible if the voltmeter resistance is far greater than R_x

DC 30. A voltage source of 12V is connected across a potential divider comprising two resistors R1=10Ω and R2=50Ω. Determine the voltage across R_2. A. 10V B. 8V C. 11V D. 9V E. 6V

GAUSS 31. What is the surface charge density on the ground directly below a thunder cloud if the E-field is 2×10^4N/C? A. 2.3×10^{15}C/m² B. 4.4×10^{16}C/m² C. 2.3×10^{-15}C/m² D. 4.4×10^{-16}C/m² E. 1.8×10^{-7}C/m²

CHARGE 32. What is the magnitude of the electrostatic force of attraction between an α-particle and an electron 10^{-14}m apart? A. 2.30×10^{-16}N B. 2.30×10^{-2}N C. 4.61N D. 4.61×10^{-14}N E. 4.61×10^{-2}N

GAUSS 33. A cylindrical imaging drum of a photocopier is to have an electric field just outside its surface of 2×10^5N/C. If the drum has a surface area of 610cm², what total quantity of charge must reside on the surface of the drum? A. 1.08×10^{-3}C B. 1.08×10^3C C. 1.08×10^{-7}C D. 1.08×10^7C E. 1.08C

POTENTIAL 34. Twelve electrons each of charge -e are equally spaced and fixed around a circle of radius R. Which of the following is/are correct? i) The potential at the centre of the circle is V=-12ke/R ii) The potential at the centre of the circle is V=-ke/R iii) The electric field at the centre of the circle is E=-ke/R iv) The electric field at the centre is E=12ke/R² v) Electric field at the centre is E=0 A. i) and v) only B. i) and iv) only C. ii) only D. ii) and iii) only. E. iv) only

POTENTIAL 35. The electric potential of an isolated charge is +200V at a distance 30cm from the charge. What is the magnitude of the charge? A. 1.6×10^{-19}C B. 3.2×10^{-9}C C. 9.11×10^{-31}C D. 6.67×10^{-9}C E. 1.6×10^{-9}C

POTENTIAL 36. What is the electric potential a distance of 5.3nm from a proton? (Take V at ∞=0)
A. 2.72×10^{-10} B. 2.72×10^{-5}V C. 2.72×10^{-2}V D. 27.2V E. 2.72V

POTENTIAL 37. Calculate the potential energy of an electron at a distance of 3A from the electron. A. -7.68×10^{-9}J B. 7.68×10^{-19}J C. -7.68J D. 7.68J E. 4.8J

POTENTIAL 38. A uniform electric field with a magnitude 5×10^2N/C is directed parallel to the positive x-axis. If the potential at x=5m is 2500V, then the potential at x=2m is ...A. 1kV B. 1.5kV C. 2kV D. 4kV E. 5kV

POTENTIAL 39. What is the electric potential due to a dipole whose dipole moment is 9.6×10^{-30}Cm at a point 10^{-9}m away if this point is along the axis of the dipole?
A. 0.040V B. 0.031V C. 0.172V D. 5.421V E. 0.086V

CAPACITOR 40. Which of these is not correct about inclusion of dielectric material of dielectric constant K in a capacitor? A. The potential energy of the capacitor is increased B. The potential difference between the plates of the capacitor is increased C. The charge stored in the capacitor will increase D. The electric field within the capacitor is reduced E. The capacitance is increased

CAPACITOR 41. If the area of a parallel plate capacitor separated by a 6.5mm air gap is 3×10^3m², what is the capacitance of the capacitor/
A. 2.08μF B. 4.08μF C. 6.5μF D. 3.0μF E. 6.0μF

CAPACITOR 42. A dielectric K=2 is inserted between the plates of a 20uF capacitor. Its capacitance will become.. A. 10μf B. 18μF C. 20μF D. 40μF E. 80μF

CAPACITOR 43. What voltage must be applied across the terminals of a capacitor of capacitance 10μf in order to store an energy of 5 J in it? A. 5kV B. 2.5kV C. 1.5kV D. 1kV E. 0.5kV

CAPACITOR 44. Two series capacitors of capacitances 10μf and 5μF respectively are made parallel with another capacitor of capacitance 4μF. What is their effective capacitance? A. 0.30μF B. 3.16μF C. 3.33μF D. 7.33μF E. 19.00μF

CAPACITOR 45. A parallel plate capacitor has plates of area 250cm² and separation 2mm. What is the capacitance of the capacitor if there is no dielectric inserted into it? A. 0 B. 111pF C. 56.5pF D. 70.8pF E. 4.4nF

CHARGE 46. Which of these is not true? i) In a conductor electrons move about freely. ii) A hot conductor conducts electrons more feely than one at normal temperature. iii) Both electrons and holes are involved in conducting current in a semiconductor. iv) The energy bandgap in a conductor is wider than that of insulators. A. i) only B. ii) and iv) C. ii) and iii) D. iii) only E. iv) only

CHARGE 47. A neutral body can be charged by ... i) induction. ii) friction. iii) conduction. iv) heating. A. i) and iii) only B. i) and ii) only C. ii) only D. i), ii) and iii) E. ii) and iv) only

CHARGE 48. Two positive charges of magnitudes $q_1=1.6\times10^{-19}C$ and $q2=3.2\times10^{-19}C$ are located a distance of 20cm apart along the x-axis, with q_1 at the origin. Find the force on q_1 due to q_2. A. $-1.15\times10^{-24}Ni$ B. $-2.3\times10^{-26}Ni$ C. $1.15\times10^{-30}Ni$ D. $-2.3\times10^{-29}Nj$ E. $4.6\times10^{-28}Nj$

CHARGE 49. If the distance between two point charges is doubled, the force between them is decreased by ... A. 2 times B. 9 times C. 4 times D. 8 times E. 6 times

CHARGE 50. How many electrons must be removed from a neutral body to leave a net charge of 0.5μC? A. 3.13×10^{12} B. 8×10^{18} C. 1.6×10^{-19} D. 9.1×10^{-32} E. 1.6×10^{19}

CHARGE 51. The energy gap between the bottom of the conduction band and top of the valence band in semiconductors is ... A. less than that in conductors B. greatest in all solids C. greater than in conductors D. equal to that in conductors E. equal to that in insulators

FIELD 52. Which of the following statements is correct about the electric field?
A. It points inwards from a positive charge B. It depends only on the values and locations of the external charge
C.It depends on the test charge D. It is always uniform in space E. It is always zero in space

FIELD 53. What is the magnitude of the electric field intensity at a point in an electric field such that an electron placed there experiences an electric force equal to its weight? A. $2.5\times10^{-11}NC^{-1}$ B. $4.0\times10^{-11}NC$'1 C. $5.0\times10^{-11}NC^{-1}$ D. $5.6\times10^{-11}NC^{-1}$ E. $6.0\times10^{-11}NC^{-1}$

FIELD 54. Electric field in a certain region of space points from left to right. If a proton moving in the opposite direction encounters this field, what happens to the proton's speed? A. It increases B. It remains constant C. It decreases D. It equals zero E. It oscillates

FIELD 55. What is the electric field at the surface of a proton of radius $10^{-15}m$? A. $1.4\times10^{6}NC^{-1}$ B. $1.4\times10^{-6}NC^{-1}$ C. $1.4\times10^{-21}NC^{-1}$ D. $1.4\times10^{21}NC^{-1}$ E. $5.6\times10^{13}NC^{-1}$

FIELD 56. What maximum torque does an external field of $10^{5}NC^{-1}$ exert on an electric dipole each with a charge of $10^{-6}C$ and separated by a distance of 2cm? A. $2\times10^{-3}Nm$ B. $2\times10^{-1}Nm$ C. $4\times10^{-3}Nm$ D. $4\times10^{-1}Nm$ E. $2\times10^{-6}Nm$

GAUSS 57. A uniform charged insulating rod of 10cm length is bent into the shape of a semicircle. If the rod has a total charge of-18μC, find the magnitude of the electric field at the centre of the semicircle. A. $-101.6\times10^{6}N/C$ B. $-50.8\times10^{6}N/C$ C. $50.8\times10^{6}N/C$ D. $-16.2\times10^{6}N/C$ E. $5\times10^{12}N/C$

GAUSS 58. The electric flux through a closed surface depends on the ... A. shape of the surface B. position of the charge enclosed by the surface C. magnitude of the charge enclosed by the surface D. area of the surface E. size of the surface

GAUSS 59. A thin spherical shell of radius R possesses a total charge Q that is uniformly distributed on it. What is the electric field at points inside the shell? A. $E=kQ/R$ B. $E=kQ/R^2$ C. $E=kQ/R^3$ D. $E=Q/\mathcal{E}_0$ E. $E=0$

GAUSS 60. Two charges $Q_1=100\mu C$ and $Q_2=-120\mu C$ are within a spherical surface of radius 10cm. What is the flux through the surface? A. $1.1\times10^{6}Nm^2/C$ B. $1.4\times10^{6}Nm^2/C$ C. $120\times10^{6}Nm^2/C$ D. $2.26\times10^{6}Nm^2/C$ E. $126.5\times10^{6}Nm^2/C$

2017 EXAM

SCHOOL OF PHYSICAL SCIENCES
DEPARTMENT OF PHYSICS
2016/2017 RAIN SEMESTER EXAMINATION
PHY 102 – GENERAL PHYSICS II

TYPE B

Instruction: where needed, use the following constant; $\varepsilon_o = 8.85\times10^{-12}\,CNm^{-2}$, electron charge = 1.6×10^{-19} C. do not detach this question paper from th OMR sheet, both are to be submitted together as presented to you

1. A 1.63mm diameter copper wire carries a current of 1A. determine the current density. a. $1.63\times10^{-3}Am^{-2}$ b. $6.13\times10\ Am^{-2}$ c. $6.13\times10^{-3}\ Am^{-2}$ d. $4.7\times10^{6}\ Am^{-2}$ e. $4.7\times10^{5}\ Am^{-2}$
2. suppose the resistance of a copper wire is 1.05Ω at 20°C. what is the resistance at 0°C. Take the temperature coefficient of resistivity to be $3.93\times10^{-3}(°C)^{-1}$ for copper a. 2.00 Ω b. 0.09 Ω c. 0.97 Ω d. 1.97 Ω e. 1.23 Ω
3. what is the equivalent capacitance of a combination of a series connection of $6\mu F$ and $3\ \mu F$ capacitors in parallel with a $5\ \mu F$ capacitor a. $3.2\ \mu F$ b. $1.5\ \mu F$ c. $7.0\ \mu F$ d. $14\ \mu F$ e. $55\ \mu F$
4. calculate the power dissipated by a 65 Ω resistor connected to a battery whose emf is 12.0V and internal resistance is 0.5 Ω. a. 6.5w b. 2.2w c. 3.2w d. 4.5w e. 5.2w
5. A solid metal sphere of radius 3.0m carries a total charge of $5.5\mu C$ if the magnitude of the electric field at point P outside the sphere is 7.7×10^{2} N/C, find the distance of P from the centre of the metal sphere. a. 5.0m b. 3.0m c. 8.0m d. 12.0m e. 10.0m
6. What is the change in the electric potential energy of an electron if it is accelerated from rest through a potential difference of +7,000V a. -2.12×10^{-15} b. -3.12×10^{-15}J c. -5.12×10^{-15}J d. -7.12×10^{-15}J e. -1.12×10^{-15}J
7. Find the charge in a $1.5\mu F$ capacitor connected in series with a 2M Ω resistor and a 6.0V battery of negligible internal resistance at a time t = RC a. $3.79\ \mu C$ b. $0.63\ \mu C$ c. $5.69\ \mu C$ d. $4.52\ \mu C$ e. $3.9\ \mu C$
8. A spherical Gaussian surface of radius 2.0m has three charges q1 = +6 μC, q2 = -9 μC and q3 = +3 μC enclosed by it. Determine the net flux through the sphere. a. $0.0Nm^{3}C^{-1}$ b. $3.0\ Nm^{3}C^{-1}$ c. $1.0\ Nm^{3}C^{-1}$ d. $4.0\ Nm^{3}C^{-1}$ e. $20\ Nm^{3}C^{-1}$
9. A spherical metal shell of radius 4.0m carries a total charge of 1.5nC, what is the magnitude of the electric field at a point 3.0m from the center of the sphere. a. 1.0N/C b. 2.0 N/C c. 3.0 N/C d. 0.0 N/C e. 40 N/C
10. If the work done in moving a charge of 5.0×10^{-5} C from point A to B is 2.1×10^{-3} J, what is the potential difference between A & B a. 42V b. 12V c. 52V d. 32V e. 72V
11. Which of the following statements is/are true: i. An ammeter is used to measure current and voltage iii. A voltmeter ideally has a zero resistace. iv. The wheatstone bridge is used to decide a. (ii) and (iii) b. (iii) and (iv) c. (ii) and (iv) d. (i) and (iii)
12. A fully charged capacity of capacitance C = 2.5 μF and V_o = 20 V is connected to discharge through a resistor R. the current I is observed to decrease to 50% of its initial value in 60 μS. Find the resistance of the resistor R. a. 34.6Ω b. 24.6Ω c. 54.6Ω d. 14.6Ω e. 64.6Ω
13. What is the resistance measured between the terminals of a 10m long wire of 4mm diameter at room temperature? The resistivity of the wire at room temperature is $3.5\times10^{-5}\Omega m$. a. 28Ω b. 35Ω c. 15Ω d. 5Ω e. 10Ω
14. Which of the following is/are seats of emf in electrical circuits i. resistors ii. Batteries iii. Capacitors iv. Electric generator a. (i) and (iii) b. (ii) and (iv) c. (ii) and (iii) d. (iii) only e. (i) and (ii)
15. A cell of emf 1.08V is connected across a resistor of 80Ω resistance. A high resistance voltmeter put across the cell measures 0.8V what is the internal resistance of the cell? a. 0.01Ω b. 100Ω c. 2.35Ω d. 1.0Ω e. 28Ω
16. Which of the following is/are not true of what happens to a bar magnet cut into two equal halves: i. the magnetic field is destroyed. ii. A north pole magnet and a south pole magnet are formed. iii. Two magnets each having north and south poles are formed. a. (ii) only b. (i) and (ii) c. (iii) Only d. (i) and (iii) e.(i) only
17. A wire carrying a 30A current has a length L = 12cm between the pole faces of a 0.90T magnet at an angle of 60°. what is the magnitude of the force on the wire? a. 5.8N b. 1.8N c. 10.8N d. 2.8N e. 3.8N
18. Four point charges of values 5.0μC each are placed at the four corners of a square, what is the electric potential at the center of the square if the distance from this centre to the corners is 3cm. a. 3.0×10^{6}V b. 6.0×10^{6}V c. 4.0×10^{6}V d. 5.0×10^{6}V e. 8.0×10^{6}V
19. Calculate the capacitance of a parallel plate capacitor made with two square metal sheets of side 1.3m, separated by a distance of 0.027m a. 5.5×10^{-10} F b. 2.5×10^{-10} F c. 3.5×10^{-10} F d. 1.5×10^{-10} F e. 7.5×10^{-10} F
20. If an atom loses an electron, it becomes which of the following a. neutron b. cation c. conductor d. anion e. proton
21. Two current I_1 and I_2 flow to a junction and two other current I_3 and I_4 flow away from the junction. If I_1, I_2 and I_3 = 1A, 6A and 4A, respectively, find I_4. a. 21A b. 6A c. 3A d. 5A e. 1A
22. A circuit segment from junction A to B comprises a 12V battery with the positive terminal connected to junction A and 10Ω resistor connected between the negative terminal of the battery and junction B. if a 2A current flows from B to A, determine V_{AB} a. 10V b. 20V c. 16V d. 24V e. 8V
23. A parallel plates capacitor has a capacitance of 2.8nF when no dielectric material is present in the separation between the plates. If a material of dielectric constant K = 3.4 is now introduced and the capacitor is charged to a voltage of 100V, calculate the energy stored in the capacitor. a. 4.8×10^{-2}J b. 4.8×10^{-4}J c. 4.8×10^{-6}J d. 4.8×10^{-5}J e. 4.8×10^{-2}J
24. Three resistors of equal resistance R are connected in parallel, what is the effective resistance of the network? a. 3/R b. 1/3R c. 3R d. 1/R e. R/3
25. A parallel plate capacitor has circular plates of radius 8.2cm, and 1.3mm separation, what is its capacitance? a. 1.4×10^{-10}F b. 4.4×10^{-10}F c. 3.4×10^{-10}F d. 5.4×10^{-10}F e. 2.4×10^{-10}F
26. What is the electric potential energy of two charges q1= 15nC and q2 = 75μC, if their separation is 5.0cm ? a. 8.20J b. 4.2J c. 0.20J d. 2.20J e. 1.20J
27. A gold leaf electroscope is charge by bringing its nob in contact with a positively charged object. If a negatively charged object is now brought near the bob, the separation of the leaves........... a. decreases b. remains unchanged c. becomes elastic d. increases e. becomes inelastic
28. A 12V battery is connected to charge a 100nF capacitor through a 60Ω resistor for 20 seconds. Find the time constant of the circuit a. 12.0μS b. 20.0 μS c. 6.0 μS d. 2.0 μS e. 3.0 μS
29. Which of the following statements is/are true of RC circuits: I. they are applied in delay circuits they produce ...... in the current-time graph. III. They are applied in multivibrator circuits. A.(ii)only B.(i) and (iii) C.(ii) and(iii) D.(i) and (ii) E.(i)only

30. If the separation between the plates of a parallel plate capacitor increases, its capacitance.......................... a. increases b. remains c. vanishes d. decreases e. goes to infinity
31. An 8cm long cylindrical capacitor consists of a copper cylinder of 0.5cm radius surrounded by a coaxial cylindrical shell of radius 2.5cm. determine the capacitance of the capacitor. a. 2.8Pf b. e.8Pf c. 7.8Pf d. 0.8Pf e. 1.8pF
32. A resistive load dissipates 220W when connected to a 12V battery. Determine the current drawn by resistive load.
a. 5.3A b. 18.3A c. 27.3A d. 13.3A e. 2.3A
33. A cubical non conducting box encloses a net charge of $3.8\mu C$, if the electric field on the surface of this box is 2.8×10^3 NC, find the surface area of the box. a. $6.5 \times 10^2 m^2$ b. $1.5 \times 10^2 m^2$ c. $0.5 \times 10^2 m^2$ d. $3.5 \times 10^2 m^2$ e. $2.5 \times 10^2 m^2$
34. Which of the following options is true if x, y and z are the energy band gaps of conductors, insulators and semiconductors respectively.
a. x=0, y>z b. x>y>z c. x=0, y<z d. x=y=z e. x<y<z
35. Determine the potential difference required to give a helium nucleus of charge $q = 4.2 \times 10^{-19}$ C, a kinetic energy of 6.8×10^4 GJ.
a. 1.61×10^{23}V b. 4.59 X $\times 10^4$V c. 7.59 X $\times 10^4$V d. 2.59 X $\times 10^4$V e. 9.59 X $\times 10^4$V
36. Which of these statement is / are correct about an equipotential surface? i) A surface that contains points at the same potential ii) The surface of the conductor and the Earth are good examples of Equipotential surface iii) Electric field line are always perpendicular to the Equipotential surface iv) The lines of force are always parallel to Equipotential surface. a. (i),(ii) and (iii) b. (iii) only c. (ii) and (iii) d. (i) (ii) and (iv) e. (i) only
37. A metal object can be made to acquire some charge by which of the following methods; i. evaporation, ii. Conduction iii. Induction iv. Condensation. A. (iii) and (iv) b. (i),(ii) and (iii) c. (ii) and (iii) d.(iii) and (iv) e. (i) and (ii)
38. A 6V battery of negligible internal resistance is used to charge a $2\mu F$ capacitor through a 100Ω resistor. Find the final charge of the capacitor. a. $6\mu C$ b. 2C c. 10C d. $20\mu C$ e. $12\mu C$
39. How many time constants must be elapse for an initially uncharged capacitor in an RC series circuit to be charged to 99% of its equilibrium charge?
a. 2.6 b. 6.4 c. 4.6 d. 9.0 e. 1.0
40. How much charge is in a 1F capacitor which has a potential difference of 110V.
a. 150C b. 110C c. 10C d. 230C e. 210C
41. When a $7.0\mu C$ test charge is placed at a certain point, it experiences a force of 3.0×10^{-4}N, the electric field at that point is?
a. 4.3×10^{-4}N/C b. 4.3×10^{1}N/C c. 4.3×10^{6}N/C d. $4.3 \times \times 10^{6}$N/C e. 4.3×10^{4}N/C
42. Which of the following statements are true of lines of force; i. they intersect to indicate high electric field, ii. They emanate from negative charges and terminate on positive charges. iii. They emanate from positive charges and terminate on negative charges, iv. The electric field is proportional to the number of lines crossing a unit cross sectional area. a. (ii), (iii) and (iv) b. (iii) and (iv) c. (i) and (ii) d. (i) and (iv) e. (i), (ii) and (iv)
43. A positive charge q1 = +20nC is at the origin, and a second positive charge q_2 =+12nC is on the x-axis at x =6m. Find the net electric field At a point P (x =9m) on the x-axis. a. 14.22 ℓN/C b. 12.22ℓN/C c. 2.33ℓN/C d. 10.33ℓN/C e. 6.22ℓN/C
44. Determine the linear charge density of an infinitely long line of charge that has 1.6×10^{6}N/C electric field at 0.1m from the material
a. 4.9×10^{18}C/m b. 6.9×10^{18}C/m c. 5.9×10^{18}C/m d. 1.9×10^{18}C/m e. 8.9×10^{-6}C/m
45. What is the dipole moment of a dipole comprising two charges q1 = +8.0nC and q2 = - 8.0nC with 100mm separation?
a. 4.0×10^{-10} Cm b. 2.0×10^{-4}Cm c. 5.0×10^{-4}Cm d. 1.9×10^{-4}Cm e. 8.9×10^{-4}Cm
46. The electric field between the plates of a cathode-ray oscilloscope is 1.2×10^4 N/C, what deflection will an electron experience if it enters at right angle to the field with a kinetic energy of 3.2×10^{-16} J, the deflecting assembly is 1.5 cm long.
a. 2.4×10^{-4}m b. 6.4×10^{-4}m c. 1.4×10^{-4}m d. 8.4×10^{-4}m e. 3.4×10^{-4}m
47. Two series resistors R1 = 60Ω and R2 = 20Ω are connected as potential divider across a 12.0V voltage source. Determine the output voltage taken across R2.
a. 4.0V b. 8.0V c. 3.0V d. 9.0V e. 5.0V
48. Determine the z component of the electric field if the electric potential is given as $V(x, y, z) = (3Vm^{-2})x^2 + (8V\, m^{-3})\, y^2z + (2Vm^{-2})z^2$,
a. $-(8V\, m^{-3})y^2 - (4Vm^{-2})z$ b. $-(8Vm^{-3})y^2 - (2Vm^{-2})z$ c. $-(16Vm^{-3})yz$ d. $(2V\, m^{-2})z^2$ e. $(3Vm^{-2})x^2$
49. Emeka plugged in three electrical devices with power consumption of 1000W, 1200W and 2000W to a mains socket with power rating of 1000W, this is dangerous because.....
a. the current drawn by the load is too high b. the voltage across the load is too high c. the emf is too high
d. the capacitance is too high e. the total load resistance is too high
50. A uniformly charged semi-circular rod of radius 10cm has a total charge of $+9.0\mu C$, find the total electric field at the center of the semi-circular rod.
a. 2.5×10^{6} N/C b. 5.1×10^{6} N/C c. 4.1×10^{6} N/C d. 6.1×10^{6} N/C e. 1.5×10^{6} N/C
51. Two parallel thin plates of surface charge density $2.0nC/m^2$ are separated by 2.0mm distance, find the magnitude of the electric field in the region between the plates
a. 1.3×10^2 N/C b. 4.3×10^2 N/C c. 5.3×10^2 N/C d. 0.3×10^2 N/C e. 2.3×10^2 N/C
52. If the net electric flux passing through a spherical closed surface is $75Nm^2C^{-1}$, determine the net electric charge inside the closed surface. a. 2.64×10^{-10}C b. 8.64×10^{-10}C c. 1.64×10^{-10}C d. 6.64×10^{-10}C e. 5.64×10^{-10}C
53. Three capacitors of equal capacitance C are connected in series, what is the effective capacitance of the capacitor?
a. 3C b. $3C^2$ c. 3/C d. C/3
54. What is the magnitude of the electric force of attraction between the nucleus (with charge q = +26e) of an atom and its outermost electron, if the distance between them is 1.5×10^{-12} m?
a. 1.6×10^{-4}N b. 6.1×10^{-4}N c. 7.2×10^{-5}N d. 3.4×10^{-5}N e. 2.5×10^{-4}N
55. How many electrons make up a charge of $-38.0\mu C$?
a. 5.23×10^{14} b. 2.38×10^{14} c. 3.52×10^{14} d. 6.38×10^{14} e. 123×10^{14}
56. A battery of emf 1.50V has a terminal potential difference of 1.25V when a resistor of 25Ω is connected to it, calculate the current flowing in the circuit when a resistor of 10Ω replaces the 25Ω resistor.
a. 0.10A b. 0.50A c. 0.15A d. 0.30A e. 1.50A
57. If a neutral metal rod is touched with a positively charged object, the rod becomes ....
a. negatively charged b. hot c. cold d. positively charged e. none
58. Calculate the electric flux through a rectangular surface of dimension 40cm by 70cm, if the electric field is uniform at 30N/C and makes an angle of 30° with the rectangular surface.
a. 7.3 Nm^2C^{-1} b. 47 Nm^2C^{-1} c. 56 Nm^2C^{-1} d. 63 Nm^2C^{-1} e. 31 Nm^2C^{-1}
59. A small 12V heater draws 2A current. How much energy will it consume when it runs for 5 minutes?
a. 30J b. 1,800J C. 7,200J d. 120J e. 3200J
60. A 1.0Ω resistor and a 2.0 Ω resistor are connected in series across a 12V d.c supply. What is the current in the circuit ?
a. 6.0A b. 4.0A c. 7.0A d. 10.0A e. 0.5A

TOPIC BY TOPIC SOLUTION TO 2017 EXAM

ELECTRIC CHARGE

20. If an atom loses an electron, it becomes which of the following
a. neutron b. cation c. conductor d. anion e. proton

20) b

27. A gold leaf electroscope is charge by bringing its nob in contact with a positively charged object. If a negatively charged object is now brought near the bob, the separation of the leaves.......... a. decreases b. remains unchanged c. becomes elastic d. increases e. becomes inelastic

SOLUTION: a

34. Which of the following options is true if x, y and z are the energy band gaps of conductors, insulators and semiconductors respectively. a. x=0, y>z b. x>y>z c. x=0, y<z d. x=y=z e. x<y<z

SOLUTION: a

37. A metal object can be made to acquire some charge by which of the following methods; i. evaporation, ii. Conduction iii. Induction iv. Condensation. A. (iii) and (iv) b. (i),(ii) and (iii) c. (ii) and (iii) d.(iii) and (iv) e. (i) and (ii)

SOLUTION: c

54. What is the magnitude of the electric force of attraction between the nucleus (with charge q = +26c) of an atom and its outermost electron, if the distance between them is 1.5 x 10^{-12} m?
a. 1.6 x 10^{-4}N b. 6.1 x 10^{-4}N c. 7.2 x 10^{-5}N d. 3.4 x 10^{-5}N e. 2.5 x 10^{4}N

54) Solution

using the formular :

$F = \frac{kq_1q_2}{r^2}$

where $q_1 = 26C$

$q_2 = 1.6\times10^{-19}$ (charge of electron)

$r = 1.5\times10^{-12}$ (distance between them)

$F = \frac{(9\times10^9)(26)(1.6\times10^{-19})}{1.5\times10^{-12}}$

$= 24960N$

$= 2.5\times10^4 N$

55. How many electrons make up a charge of -38.0μC ?
a. 5.23 x 10^{14} b. 2.38 x 10^{14} c. 3.52 x 10^{14} d. 6.38 x 10^{14} e. 123 x 10^{14}

55) Solution

using the quantization formular

$Q = ne$ (we ignored the -ve sign cos we are looking for n)

$n = Q/e$

$= \frac{38.0\times10^{-6}}{1.6\times10^{-19}}$

$= 2.38\times10^{14}$

57. If a neutral metal rod is touched with a positively charged object, the rod becomes ....
a. negatively charged b. hot c. cold d. positively charged e. none

SOLUTION: a

ELECTRIC FIELD

41. When a 7.0μC test charge is placed at a certain point, it experiences a force of 3.0 x 10^{-4}N, the electric field at that point is?
a. 4.3x 10^{-4}N/C b. 4.3 x 10^{1}N/C c. 4.3 x 10^{6}N/C d. 4.3 x x 10^{6}N/C e. 4.3 x 10^{4}N/C

41) from the question

$q = 7.0\mu C = 7\times10^{-6}C$

$F = 3.0\times10^{-4}N$

$E = ?$

using the formular for Electric field

$E = F/q$

$= \frac{3.0\times10^{-4}}{7\times10^{-6}}$

$= 42.85$

$= 4.3\times10^1 N/C$

42. Which of the following statements are true of lines of force; i. they intersect to indicate high electric field, ii. They emanate from negative charges and terminate on positive charges. iii. They emanate from positive charges and terminate on negative charges, iv. The electric field is proportional to the number of lines crossing a unit cross sectional area. a. (ii), (iii) and (iv) b. (iii) and (iv) c. (i) and (ii) d. (i) and (iv) e. (i), (ii) and (iv)

SOLUTION: b

43. A positive charge q1 = +20nC is at the origin, and a second positive charge q_2 =+12nc is on thex-axis at x =6m. Find the net electric field At a point P (x =9m) on the x-axis. a. 14.22 ẑN/C b. 12.22ẑN/C c. 2.33ẑN/C d. 10.33ŷN/C e. 6.22ẑN/C

43) •- - - 6m - - - -|- - 3m - - -| P

$q_1 = +20nC$ $q_2 = +12nC$

electric field at $P = E_1 + E_2$

$E_1 = \frac{kq_1}{r^2} \times \frac{F-C}{r}$

$= \frac{9\times10^9\times20\times10^{-9}}{9^2} \times \frac{9i-0i}{9}$

$= 2.22 \times i$

$= 2.22i$

$E_2 = \frac{kq_2}{r^2} \times \frac{F-C}{r}$

$= \frac{9\times10^9\times12\times10^{-9}}{3^2} \times \frac{9i-6i}{3}$

$= 12 \times i$

$= 12i$

$P = E_1 + E_2$

$= 2.22i + 12i$

$= 14.22i$

$= \underline{14.22\hat{x}\ N/C}$

GAUSS

5. A solid metal sphere of radius 3.0m carries a total charge of $5.5\mu C$ if the magnitude of the electric field at point P outside the sphere is 7.7×10^2 N/C, find the distance of P from the centre of the metal sphere.
a. 5.0m b. 3.0m c. 8.0m d. 12.0m e. 10.0m

5) Electric Field outside a Charged Sphere;

$E = \frac{Q}{4\pi\varepsilon_0 r^2}$ or $E = \frac{KQ}{r^2}$

from the question.

$Q = 5.5\mu C = 5.5\times10^{-6}$ (the charge of the sphere)

$E = 7.7\times10^2 N/C$

the distance from the sphere wher the electric field is felt.

$r = \sqrt{\frac{KQ}{E}}$

$= \sqrt{\frac{(9\times10^9)(5.5\times10^{-6})}{7.7\times10^2}}$

$= 8.017m$

$= \underline{8.0m}$

8. A spherical Gaussian surface of radius 2.0m has three charges $q1 = +6\ \mu C$, $q2 = -9\ \mu C$ and $q3 = +3\ \mu C$ enclosed by it. Determine the net flux through the sphere.
a. $0.0Nm^3C^{-1}$ b. $3.0\ Nm^3C^{-1}$ c. $1.0\ Nm^3C^{-1}$ d. $4.0\ Nm^3C^{-1}$ e. $20\ Nm^3C^{-1}$

8) Solution

q_1, q_2, q_3 from the formular for flux,

$\text{flux} = \frac{\text{total enclosed Charge}}{\varepsilon_0}$

$\phi = \frac{q_{enclosed}}{\varepsilon_0}$

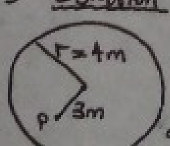
$= \frac{6\mu C + (-9\mu C) + 3\mu C}{8.85\times10^{-12}}$

$= \frac{0}{8.85\times10^{-12}}$

$= \underline{0Nm^3C^{-1}}$

9. A spherical metal shell of radius 4.0m carries a total charge of 1.5nC, what is the magnitude of the electric field at a point 3.0m from the center of the sphere.
a. 1.0N/C b. 2.0 N/C c. 3.0 N/C d. 0.0 N/C e. 40 N/C

9) Solution



electric field inside any Shell = 0

Since the radius = 4m and the point = 3m from the center

It is inside the Sphere.

$\therefore\ E = \underline{0N/C}$

33. A cubical non conducting box encloses a net charge of $3.8\mu C$. If the electric field on the surface of this box is 2.8×10^3 NC, find the surface area of the box.
a. $6.5\times10^2m^2$ b. $1.5\times10^2m^2$ c. $0.5\times10^2m^2$ d. $3.5\times10^2m^2$ e. $2.5\times10^2m^2$

33) from the flux formular

$\phi = EA = q/\varepsilon_0$

$A = \frac{q}{\varepsilon_0 E}$

$= \frac{3.8\times10^{-6}}{(8.85\times10^{-12})\times(2.8\times10^3)}$

$= 153.35$

$= \underline{1.5\times10^2m^2}$

44. Determine the linear charge density of an infinitely long line of charge that has 1.6×10^6N/C electric field at 0.1m from the material
a. 4.9×10^{18}C/m b. 6.9×10^{18}C/m c. 5.9×10^{18}C/m d. 1.9×10^{18}C/m e. 8.9×10^{-6}C/m

44) Solution

For Infinite Line of Charge

$E = \frac{\lambda}{2\pi\varepsilon_0 r}$

$\lambda = E(2\pi\varepsilon_0 r)$

$= 1.6\times10^6\times2\pi\varepsilon_0\times0.1$

$= 0.00000889699$

$= \underline{8.9\times10^{-6}\ C/m}$

51. Two parallel thin plates of surface charge density $2.0nC/m^2$ are separated by 2.0mm distance, find the magnitude of the electric field in the region between the plates
a. 1.3×10^2 N/C b. 4.3×10^2 N/C c. 5.3×10^2 N/C d. 0.3×10^2 N/C e. 2.3×10^2 N/C

51) Electric Field b/w two plate or Capacitor

$E = \sigma/\varepsilon_0$

$= \frac{2.0\times10^{-9}}{8.85\times10^{-12}}$

$= 225.99$

$= \underline{2.3\times10^2\ N/C}$

52. If the net electric flux passing through a spherical closed surface is $75Nm^2C^{-1}$, determine the net electric charge inside the closed surface. a. 2.64×10^{-10}C b. 8.64×10^{-10}C c. 1.64×10^{-10}C d. 6.64×10^{-10}C e. 5.64×10^{-10}C

52) Solution

$\text{Flux} = \frac{Q_{enclosed}}{\varepsilon_0}$

$\phi = Q/\varepsilon_0$

$Q = \phi\varepsilon_0$

$= 75\times8.85\times10^{-12}$

$= \underline{6.64\times10^{-10}\ C}$

58. Calculate the electric flux through a rectangular surface of dimension 40cm by 70cm, if the electric field is uniform at 30N/C and makes an angle of 30° with the rectangular surface.
a. $7.3\ Nm^2C^{-1}$ b. $47\ Nm^2C^{-1}$ c. $56\ Nm^2C^{-1}$ d. $63\ Nm^2C^{-1}$ e. $31\ Nm^2C^{-1}$

LFX KINGS

58) Solution

$\phi = EA\cos\theta$

$= 30 \times [(40\times10^{-2})\times(70\times10^{-2})]\cos 30^\circ$

$= 7.3\,Nm^2C^{-1}$

POTENTIAL

6. What is the change in the electric potential energy of an electron if it is accelerated from rest through a potential difference of +7,000V a. -2.12×10^{-15} b. -3.12×10^{-15}J c. -5.12×10^{-15}J d. -7.12×10^{-15}J e. -1.12×10^{-15}J

POTENTIAL

6) From the question.

$V = 7000V$ (electric potential)

$q = -1.6\times10^{-19}$ (charge)

$U = ?$ (potential energy)

From the Formular

$V = U/q$

$U = qV$

$= -1.6\times10^{-19} \times 7000$

$= -1.12\times10^{-15}\,J$

10. If the work done in moving a charge of 5.0×10^{-5} C from point A to B is 2.1×10^{-3} J, what is the potential difference between A & B a. 42V b. 12V c. 52V d. 32V e. 72V

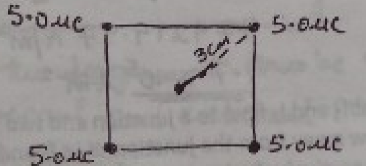
10) From the formular; potential = $\frac{\text{work}}{\text{charge}}$

$V = W/q$

$V_{a\to b} = \frac{2.1\times10^{-3}}{5.0\times10^{-5}}$

$= 42V$

18. Four point charges of values 5.0μC each are placed at the four corners of a square, what is the electric potential at the center of the square if the distance from this centre to the corners is 3cm. a. 3.0×10^6V b. 6.0×10^6V c. 4.0×10^6V d. 5.0×10^6V e. 8.0×10^6V



$r = 3cm = 0.03m$

$V_{total} = 4KQ/r$

$= \frac{4\times9\times10^9\times5\times10^{-6}}{0.03}$

$= 6\times10^6\,V$

26. What is the electric potential energy of two charges q1= 15nC and q2 = 75μC, if their separation is 5.0cm? a. 8.20J b. 4.2J c. 0.20J d. 2.20J e. 1.20J

26) Solution

Potential energy $E = \frac{KQ_1Q_2}{r}$

$Q_1 = 15nc = 15\times10^{-9}C$

$Q_2 = 75\mu C = 75\times10^{-6}C$

$r = 5cm = 5\times10^{-2}m$

$= \frac{(9\times10^9)\times(15\times10^{-9})(75\times10^{-6})}{(5\times10^{-2})}$

$= 0.2025J$

$= 0.20J$

35. Determine the potential difference required to give a helium nucleus of charge $q = 4.2\times10^{-19}$ C, a kinetic energy of 6.8×10^4 GJ. a. 1.61×10^{23}V b. $4.59\times X\,10^4$V c. $7.59\times X\,10^4$V d. $2.59\times X\,10^4$V e. $9.59\times X\,10^4$V

35) Solution

$V = U/q$

$V = \frac{6.8\times10^4}{4.2\times10^{-19}}$

$= 1.61\times10^{23}\,V$

36. Which of these statement is / are correct about an equipotential surface? I) A surface that contains points at the same potential ii) The surface of the conductor and the Earth are good examples of Equipotential surface iii) Electric field line are always perpendicular to the Equipotential surface iv) The lines of force are always parallel to Equipotential surface. a. (i),(ii) and (iii) b. (iii) only c. (ii) and (iii) d. (i) (ii) and (iv) e. (i) only

36) a

48. Determine the z component of the electric field if the electric potential is given as $V(x, y, z) = (3Vm^{-2})x^2 + (8V\,m^{-3})\,y^2z + (2Vm^{-2})z^2$. a. $-(8V\,m^{-3})y^2 - (4Vm^{-2})z$ b. $-(8Vm^{-3})y^2 - (2Vm^{-2})z$ c. $-(16Vm^{-3})yz$ d. $(2V\,m^{-2})z^2$ e. $(3Vm^{-2})x^2$

48) Solution

$E = -dV/dr$

If $V(x,y,z) = (3Vm^{-2})x^2 + (8Vm^{-3})y^2z + (2Vm^{-2})z^2$

from the question,

r is in the z direction

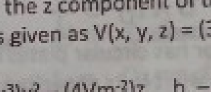
$E = \frac{-dV}{dz} = -8Vm^{-3}y^2 - 4Vm^{-2}z$

CAPACITOR

3. what is the equivalent capacitance of a combination of a series connection of 6μF and 3 μF capacitors in parallel with a 5 μF capacitor a. 3.2 μF b. 1.5 μF c. 7.0 μF d. 14 μF e. 55 μF

3) Solution

This is the diagram to the question



C_{eq} for Series $= \left[\frac{1}{1/6 + 1/3}\right] + 5$

$= 7.0\mu F$

19. Calculate the capacitance of a parallel plate capacitor made with two square metal sheets of side 1.3m, separated by a distance of 0.027m a. 5.5×10^{-10} F b. 2.5×10^{-10} F c. 3.5×10^{-10} F d. 1.5×10^{-10} F e. 7.5×10^{-10} F

For parallel plate Capacitors,

Capacitance; $C = \frac{A\varepsilon_0}{d}$

LFX KINGS

$$= \frac{(1\cdot 3^2) \times 8\cdot 85\times10^{-12}}{0\cdot 027}$$

$$= \underline{5\cdot 5\times10^{-10}F}$$

23. A parallel plates capacitor has a capacitance of 2.8nF when no dielectric material is present in the separation between the plates. If a material of dielectric constant K = 3.4 is now introduced and the capacitor is charged to a voltage of 100V, calculate the energy stored in the capacitor. a. 4.8×10^{-2}J b. 4.8×10^{-4}J c. 4.8×10^{-6}J d. 4.8×10^{-5}J e. 4.8×10^{-2}J

23) Solution

From the question,

Capacitance; $C = 2\cdot 8nF = 2\cdot 8\times10^{-9}F$

dielectric constant; $K = 3\cdot 4$

$V = 100V$

Energy stored in a capacitor $E = \frac{1}{2}CV^2$

But when there is a dielectric material, $E = \frac{1}{2}CKV^2$

$$E = \frac{1}{2}\times(2\cdot 8\times10^{-9})\times3\cdot 4\times 100^2$$

$$= 0\cdot 0000476$$

$$= \underline{4\cdot 8\times10^{-5} J}$$

25. A parallel plate capacitor has circular plates of radius 8.2cm, and 1.3mm separation, what is its capacitance? a. 1.4×10^{-10}F b. 4.4×10^{-10} F c. 3.4×10^{-10} F d. 5.4×10^{-10} F e. 2.4×10^{-10} F

Solution

For paralel plate Capacitor,

$$C = \frac{A\epsilon_0}{d}$$

But $A = \pi r^2$

and $r = 8\cdot 2cm = 8\cdot 2\times10^{-2}m$

$\therefore A = \pi(8\cdot 2\times10^{-2})^2$

$d = 1\cdot 3mm = 1\cdot 3\times10^{-3}$

$$C = A\epsilon_0/d$$

$$= \frac{\pi(8\cdot 2\times10^{-2})^2(8\cdot 85\times10^{-12})}{1\cdot 3\times10^{-3}}$$

$$= \underline{1\cdot 4\times10^{-10}F}$$

30. If the separation between the plates of a parallel plate capacitor increases, its capacitance.......................... a. increases b. remains c. vanishes d. decreases e. goes to infinity

30) d

31. An 8cm long cylindrical capacitor consists of a copper cylinder of 0.5cm radius surrounded by a coaxial cylindrical shell of radius 2.5cm. determine the capacitance of the capacitor. a. 2.8Pf b. e.8Pf c. 7.8Pf d. 0.8Pf e. 1.8pF

For cylindrical Capacitors,

$$C = \frac{2\pi\epsilon_0 L}{\ln(b/a)}$$

From the question

$L = 8cm = 8\times10^{-2}$

$b = 2\cdot 5cm = 2\cdot 5\times10^{-2}$

$a = 0\cdot 5cm = 0\cdot 5\times10^{-2}$

$$C = \frac{2\pi\times(8\cdot 85\times10^{-12})\times(8\times10^{-2})}{\ln\left(\frac{2\cdot 5\times10^{-2}}{0\cdot 5\times10^{-2}}\right)}$$

$$= 2\cdot 764\times10^{-12}$$

$$= \underline{2\cdot 8\,pF}$$

40. How much charge is in a 1F capacitor which has a potential difference of 110V. a. 150C b. 110C c. 10C d. 230C e. 210C

40) Solution

From the Formular

$Q = CV$

$Q = 1\times110$

$= \underline{110C}$

CURRENT

1. A 1.63mm diameter copper wire carries a current of 1A. determine the current density. a. $1.63\times10^{-3}Am^{-2}$ b. $6.13\times10\ Am^{-2}$ c. $6.13\times10^{-3}\ Am^{-2}$ d. $4.7\times10^{6}\ Am^{-2}$ e. $4.7\times10^{5}\ Am^{-2}$

1) from the question

diameter $= 1\cdot 63mm = 1\cdot 63\times10^{-3}m$

Current $= 1A$

Formular for current density;

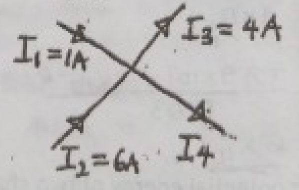
$$j = \frac{\text{Current}}{\text{Cross Sectional Area of wire}} = \frac{I}{\left(\frac{\pi d^2}{4}\right)}$$

$$= \frac{1}{\left[\frac{\pi\times(1\cdot 63\times10^{-3})^2}{4}\right]}$$

$$= 479219\cdot 97\ A/m^2$$

$$= \underline{4\cdot 7\times10^{5}\ Am^{-2}}$$

21. Two current I_1 and I_2 flow to a junction and two other current I_3 and I_4 flow away from the junction. If I_1, I_2 and I_3 = 1A, 6A and 4A, respectively, find I_4. a. 21A b. 6A c. 3A d. 5A e. 1A



From kirchoff Current rule,

Total current into a Junction = Total current out of the Junction

$$I_1+I_2 = I_3+I_4$$

$$\therefore I_4 = I_1+I_2-I_3$$

$$= 1+6-4$$

$$= \underline{3A}$$

DC CIRCUIT

2. suppose the resistance of a copper wire is 1.05Ω at 20°C. what is the resistance at 0°C. Take the temperature coefficient of resistivity to be $3.93 \times 10^{-3} (^{\circ}C)^{-1}$ for copper a. 2.00 Ω b. 0.09 Ω c. 0.97 Ω d. 1.97 Ω e. 1.23 Ω

From the question,

R at 20°C = 1.05 Ω

R at 0°C = ?

α (coefficient of resistivity) = 3.93×10^{-3}

Using the formular

$R = R_{ref}[1 + \alpha(T - T_{ref})]$

where R = Conductor resistance at reference temperature = 1.05 Ω

α = Temperature Coefficient of resistance for Conductor material = 3.93×10^{-3}

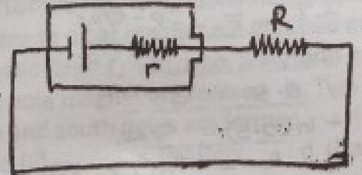
T = Conductor temperature for which R would be found (°C) = 0°

T_{ref} = Reference temp that α is specified

$R = 1.05(1 + 3.93 \times 10^{-3}(0 - 20))$

$= \underline{0.97 \Omega}$

4. calculate the power dissipated by a 65 Ω resistor connected to a battery whose emf is 12.0V and internal resistance is 0.5 Ω.
a. 6.5w b. 2.2w c. 3.2w d. 4.5w e. 5.2w



From the diagram, it can be seen that the internal and external resistance are in series.

$\therefore R_{eq} = (R + r)$

$\text{Power} = \frac{V^2}{R} = \frac{(Emf)^2}{(R+r)}$

$= \frac{(12)^2}{65 + 0.5}$

$= 2.1984\,W$

$= \underline{2.2W}$

13. What is the resistance measured between the terminals of a 10m long wire of 4mm diameter at room temperature? The resistivity of the wire at room temperature is $3.5 \times 10^{-5}\Omega m$.
a. 28Ω b. 35Ω c. 15Ω d. 5Ω e. 10Ω

From the question, for resistivity

$R = \rho L / A$

and from the question,

L = 10m

$d = 4mm = 4 \times 10^{-3}$

$\rho = 3.5 \times 10^{-5} \Omega m$

$\text{Area} = \frac{\pi d^2}{4} = \frac{\pi \times (4 \times 10^{-3})^2}{4} = 1.26 \times 10^{-5}$

$R = \frac{3.5 \times 10^{-5} \times 10}{1.26 \times 10^{-5}}$

$= 27.852 \Omega = \underline{28 \Omega}$

14. Which of the following is/are seats of emf in electrical circuits
i. resistors ii. Batteries iii. Capacitors iv. Electric generator
a. (i) and (iii) b. (ii) and (iv) c. (ii) and (iii) d. (iii) only e. (i) and (ii)

14) b

15. A cell of emf 1.08V is connected across a resistor of 80Ω resistance. A high resistance voltmeter put across the cell measures 0.8V what is the internal resistance of the cell?
a. 0.01Ω b. 100Ω c. 2.35Ω d. 1.0Ω e. 28Ω

Using the formular

$E = IR + Ir$

Where E = emf = 1.08V

I = current

R = Resistor = 80 Ω

r = Internal resistance = ?

Before we can find r, we need to find I (current)

But from the question, the Voltmeter measures the terminal voltage (IR)

$IR = 0.8V$

$I = 0.8/R$

$= 0.8/80 = 0.01A$

$\therefore$ from $E = IR + Ir$

$r = \frac{E - IR}{I}$

$= \frac{1.08 - (0.01 \times 80)}{0.01}$

$= \underline{28 \Omega}$

24. Three resistors of equal resistance R are connected in parallel, what is the effective resistance of the network? a. 3/R b. 1/3R c. 3R d. 1/R e. R/3

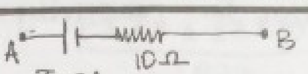
$R = \frac{1}{1/R + 1/R + 1/R}$

$= \frac{1}{(3/R)}$

$= \underline{R/3}$

22. A circuit segment from junction A to B comprises a 12V battery with the positive terminal connected to junction A and 10Ω resistor connected between the negative terminal of the battery and junction B. If a 2A current flows from B to A, determine V_{AB} a. 10V b. 20V c. 16V d. 24V e. 8V

RC CIRCUIT



$I = 2A$

$V = IR$

$= 2 \times 10$

$= 20V$

32. A resistive load dissipates 220W when connected to a 12V battery. Determine the current drawn by resistive load.
a. 5.3A b. 18.3A c. 27.3A d. 13.3A e. 2.3A

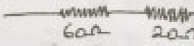
Power $= IV$

$I = \frac{Power}{V}$

$= \frac{220}{12}$

$= 18.3A$

47. Two series resistors R1 = 60Ω and R2 = 20Ω are connected as potential divider across a 12.0V voltage source. Determine the output voltage taken across R2.
a. 4.0V b. 8.0V c. 3.0V d. 9.0V e. 5.0V



From $V = IR_1 + IR_2$

$I = \frac{V}{R_1 + R_2} = \frac{12}{60+20}$

$= 0.15A$

$V_2 = IR_2$

$= 0.15 \times 20$

$= 3V$

49. Emeka plugged in three electrical devices with power consumption of 1000W, 1200W and 2000W to a mains socket with power rating of 1000W, this is dangerous because.....
a. the current drawn by the load is too high b. the voltage across the load is too high c. the emf is too high d. the capacitance is too high e. the total load resistance is too high

Solution

e

59. A small 12V heater draws 2A current. How much energy will it consume when it runs for 5 minutes?
a. 30J b. 1,800J C. 7,200J d. 120J e. 3200J

Energy $= P \times t$

$= (IV) \times (5 \times 60)$

$= (2 \times 12) \times (5 \times 60)$

$= 7{,}200$

60. A 1.0Ω resistor and a 2.0 Ω resistor are connected in series across a 12V d.c supply. What is the current in the circuit ?
a. 6.0A b. 4.0A c. 7.0A d. 10.0A e. 0.5A

$V = I(R_1 + R_2)$

$I = \frac{V}{(R_1 + R_2)}$

$= \frac{12}{2+1}$

$= 4A$

7. Find the charge in a 1.5μF capacitor connected in series with a 2M Ω resistor and a 6.0V battery of negligible internal resistance at a time t = RC
a. 3.79 μC b. 0.63 μC c. 5.69 μC d. 4.52 μC e. 3.9 μC

from the question

$C = 1.5\mu F = 1.5 \times 10^{-6} F$

$R = 2M\Omega$

$V = 6.0V$

$t = RC$

from the charging formular for RC circuit

$Q = CE(1 - e^{-t/RC})$

But since $t = RC$

$Q = CE(1 - e^{-1})$

$= (1.5 \times 10^{-6}) \times 6[1 - e^{-1}]$

$= 0.0000056 89C$

$= 5.69\mu C$

12. A fully charged capacity of capacitance C = 2.5 μF and V_o = 20 V is connected to discharge through a resistor R. the current i is observed to decrease to 50% of its initial value in 60 μS. Find the resistance of the resistor R.
a. 34.6Ω b. 24.6Ω c. 54.6Ω d. 14.6Ω e. 64.6Ω

from the question

$C = 2.5\mu F$ $t = 60\mu C$

$V_o = 20V$

$\% = 50\%$

From the current discharge formular relating percentage.

$x\% I_o = I_o e^{-t/RC}$

$50\% I_o = I_o e^{-t/RC}$

$0.5 = e^{-t/RC}$

$-\ln(0.5) = t/RC$

$R = \frac{t}{[-\ln(0.5)] \times C}$

$= \frac{60 \times 10^{-6}}{[-\ln(0.5)] \times [2.5 \times 10^{-6}]}$

$= 34.6\Omega$

28. A 12V battery is connected to charge a 100nF capacitor through a 60Ω resistor for 20 seconds. Find the time constant of the circuit
a. 12.0μS b. 20.0 μS c. 6.0 μS d. 2.0 μS e. 3.0 μS

Time Constant $\tau = RC$

from the question,

$R = 60\Omega$

$C = 100nF = 100 \times 10^{-9} F$

$\tau = 60 \times (100 \times 10^{-9})$

$= 0.000006 s$

$= 6 \times 10^{-6} s$

$= 6\mu s$

29. Which of the following statements is/are true of RC circuits: i. they are applied in delay circuits they produce ...... in the current-time graph. Iii. They are applied in multivibrator circuits. A.(ii)only B.(I) and (iii) C.(ii) and(iii) D.(i) and (ii) E.(i)only

38. A 6V battery of negligible internal resistance is used to charge a $2\mu F$ capacitor through a 100Ω resistor. Find the final charge of the capacitor. a. $6\mu C$ b. 2C c. 10C d. $20\mu C$ e. $12\mu C$

38) Solution

for Charging of RC

$Q = Q_0(1 - e^{-t/RC})$

final charge of the capacitor

$Q = Q_0$

$= CV$

$= 2uF \times 6V$

$= (2\times10^{-6}) \times 6$

$= 12\times10^{-6}$

$= 12uC$

39. How many time constants must be elapse for an initially uncharged capacitor in an RC series circuit to be charged to 99% of its equilibrium charge?

a. 2.6 b. 6.4 c. 4.6 d. 9.0 e. 1.0

$99\% Q_0 = Q_0(1 - e^{-t/RC})$

$0.99 = 1 - e^{-t/RC}$

$e^{-t/RC} = 1 - 0.99$

$e^{-t/RC} = 0.01$

$t/RC = -\ln(0.01)$

$t/RC = 4.605$

$t = 4.605RC$

$= 4.6\tau$

MAGNETIZM

16. Which of the following statements is/are not true of what happens to a bar magnet cut into two equal halves: i. the magnetic field is destroyed. ii. A north pole magnet and a south pole magnet are formed. iii. Two magnets each having north and south poles are formed. a. (ii) only b. (i) and (ii) c. (iii) Only d. (i) and (iii) e.(i) only

16) b

17. A wire carrying a 30A current has a length L = 12cm between the pole faces of a 0.90T magnet at an angle of 60°. what is the magnitude of the force on the wire?

a. 5.8N b. 1.8N c. 10.8N d. 2.8N e. 3.8N

From the question,

Current; $I = 30A$

Length; $L = 12cm = 0.12m$

magnetic Field; $B = 0.90T$

Angle $= 60°$

Force = ?

we use the formular

$F = BIL\sin\theta$

$= 0.90 \times 30 \times 0.12 \times \sin 60$

$= 2.8N$

2017 TEST

FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI SCHOOL OF PHYSICAL SCIENCES DEPARTMENT OF PHYSICS 2016/2017 RAIN SEMESTER TEST PIIY 102-GENERAL PHYSICS II

Instruction. Use all the available space on this paper to attempt all questions. Fill up the frontpage before using the **Where needed, use the following constants:** $\varepsilon_0 = 8.85 \times 10^{-12}$, **electron charge = 1.6×10^{-19} C**

1 . a) Using fully labelled energy band diagrams only, differentiate between conductor, insulator and semiconductor b) Two point charges = $+25uC$ and $q_2 = -75nC$ are separated by a distance r = 3.0cm. Find the force q1 exerts on q_2.

2. a) List four properties of lines of force.

b) Find the electric field strength at a distance of 50cm from a -2uC charge placed at the origin,

3. a) State Gauss's law.

b) A point charge of 1.0×10^{-6} C is at the centre of a cubical Gaussian surface 0.50 m on edge. What is the net electric flux *through* the surface?

4. a) Define the electric potential difference between two points A and B in an electric field.

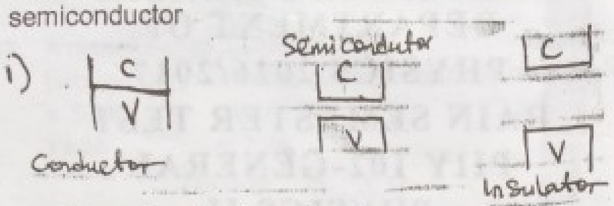
b) Calculate the potential difference between two plates if an electron accelerated between the plates with a kinetic energy *of* 4.6×10^{-17} J.

5 *a)* List three factors *upon* which the capacitance of a parallel plates capacitor depend, b) The flash unit of a camera stores energy in a 200uF capacitor at 300V. How much energy can this unit store?

2017 TEST SOLUTION

1 . a) Using fully labelled energy band diagrams only, differentiate between conductor, insulator and semiconductor

i)



C = Conduction band

V = Valence band.

b) Two point charges = $+25uC$ and $q_2 = -75nC$ *are* separated by a distance r = 3.0cm. Find the force q1 exerts on q_2.

b) $F = \frac{Kq_1q_2}{r^2}$

$= \frac{9\times10^9 \times (25\times10^{-6})(75\times10^{-9})}{(3\times10^{-2})^2}$

$= 18.75\,N$

2. a) List four properties of lines of force.

- *electric lines of force starts from positive charge end at negative charge .*
- *number of electric lines of force per unit area is directly proportional to electric field intensity at that point*
- *the tangent at any point on the field shows the direction of the field*
- *electric lines of force does not intersect each other.*

b) Find the electric field strength at a distance of 50cm from a -2uC charge placed at the origin,

$E = \frac{Kq}{r^2}$

$= \frac{(9\times10^9)(-2\times10^{-6})}{(50\times10^{-2})^2}$

$= -72000\,N/C$

3. a) State Gauss's law.

The electric flux through a planar

a is defined as the electric field times the component of the area perpendicular to the field.

$$\Phi = \int E\cos\theta dA$$

b) A point charge of 1.0 x 10^{-6} C is at the centre of a cubical Gaussian surface 0.50 m on edge. What is the net electric flux *through* the surface?

b) Solution

$\text{Flux} = \frac{q}{\varepsilon_0}$

$= \frac{1.0\times10^{-6}}{8.85\times10^{-12}}$

$= 112994.4\,Nm^2C^{-1}$

4. a) Define the electric potential difference between two points A and B in an electric field.

Electric potential difference between two points due to a point charge is the difference between the point with the larger potetial and the point with the lower potential

Potential difference b/w A and B

$\Delta V = V_A - V_B$

b) Calculate the potential difference between two plates if an electron accelerated between the plates with a kinetic energy *of* 4.6 x 10^{-17} J.

4b) $V = \frac{U}{q}$

$V = \frac{4.6\times10^{-17}}{1.6\times10^{-19}}$

$= 287.5\,V$

5 *a)* List three factors *upon* which the capacitance of a parallel plates capacitor depend,

(5a) i) Area of the plate

ii) distance b/w the plate

iii) Material b/w the plate

b) The flash unit of a camera stores energy in a 200uF capacitor at 300V. How much energy can this unit store?

5b) $E = \frac{1}{2}CV^2$

$= \frac{1}{2}\times(200\times10^{-6}) \times 300$

$= 0.03J$