Leaving Cert Physics Long Questions 2018 - 2002

7. *Static Electricity and Capacitance*

Please remember to photocopy 4 pages onto one sheet by going A3→A4 and using back to back on the photocopier

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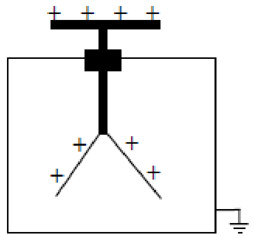
Static electricity: ordinary level questions

2013 Question 12 (c) [Ordinary Level]

(i) State Coulomb's law of force between electric charges.
(ii) The diagram shows a positively-charged electroscope.
Give a use for an electroscope.
(iii)How can an electroscope be given a positive charge?
(iv)What is observed if you touch the cap of the electroscope with your finger?
(v) Explain why this happens.

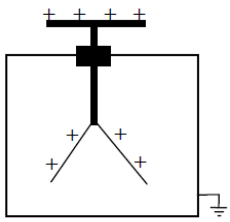


2010 Question 9 (a) [Ordinary Level]

(i) State Coulomb's law of force between electric charges.
(ii) How would you detect the presence of an electric field?
(iii)What is the unit of electric charge?
(iv)How does the lightning conductor prevent damage to the building?
(v) Suggest a suitable material for a lightning conductor.

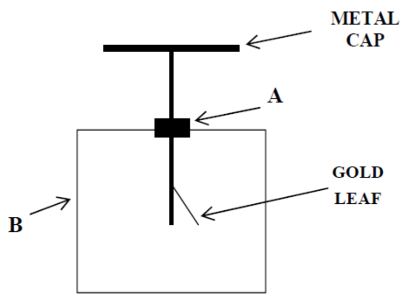
2007 Question 9 (a) [Ordinary Level]

(i) State Coulomb's law of force between charges.
(ii) The diagram shows a positively charged gold leaf electroscope.
Describe how an electroscope is given a positive charge.
(iii)What is observed when the cap of an electroscope is earthed?
(iv)Why does this happen?
(v) How is the cap of the electroscope earthed?



2005 Question 12 (c) [Ordinary Level]

The diagram shows a gold leaf electroscope.
(i) Name the parts labelled A and B.
(ii) Give one use of an electroscope.
(iii)Explain why the gold leaf diverges when a positively charged rod is brought close to the metal cap.
(iv)The positively charged rod is held close to the electroscope and the metal cap is then earthed.
Explain why the gold leaf collapses.

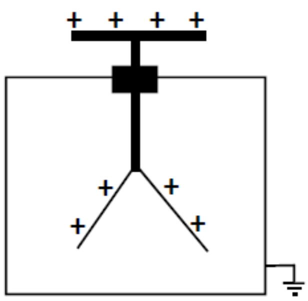


2003 Question 12 (c) [Ordinary Level]

(i) What is the unit of electric charge?
(ii) Describe, with the aid of a labelled diagram, how you would charge a conductor by induction.
(iii)The build-up of electric charge can lead to explosions. Give two examples where this could happen.
(iv)How can the build-up of electric charge on an object be reduced?

2018 Question 9 (a) [Ordinary Level]

The diagram shows a positively charged gold leaf electroscope.
(i) State Coulomb's law of force between charges.
(ii) State one use of an electroscope.
(iii)How can an electroscope be given a positive charge?
(iv)What is observed when the cap of a charged electroscope is earthed?
(v) Explain this observation.
(vi)How could the cap of the electroscope be earthed?



Static electricity: higher level questions

2011 Question 9 (b) [Higher Level]

(i) Draw a labelled diagram of an electroscope.
(ii) Why should the frame of an electroscope be earthed?
(iii) Describe how to charge an electroscope by induction.

2011 Question 9 (c) [Higher Level]

(i) How does a full-body metal-foil suit protect an operator when working on high voltage power lines?
(ii) Describe an experiment to investigate the principle by which the operator is protected.

2002 Question 11 [Higher Level]

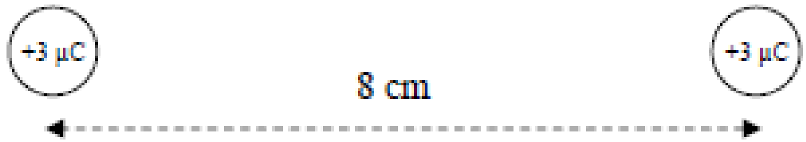
Read the following passage and answer the accompanying questions.
Benjamin Franklin designed the lightning conductor. This is a thick copper strip running up the outside of a tall building. The upper end of the strip terminates in one or more sharp spikes above the highest point of the building. The lower end is connected to a metal plate buried in moist earth. The lightning conductor protects a building from being damaged by lightning in a number of ways.
During a thunderstorm, the value of the electric field strength in the air can be very high near a pointed lightning conductor. If the value is high enough, ions, which are drawn towards the conductor, will receive such large accelerations that, by collision with air molecules, they will produce vast additional numbers of ions. Therefore the air is made much more conducting and this facilitates a flow of current between the air and the ground. Thus, charged clouds become neutralised and lightning strikes are prevented. Alternatively, in the event of the cloud suddenly discharging, the lightning strike will be conducted through the copper strip, thus protecting the building from possible catastrophic consequences.
Raised umbrellas and golf clubs are not to be recommended during thunderstorms for obvious reasons.
On high voltage electrical equipment, pointed or roughly-cut surfaces should be avoided.
(Adapted from “Physics – a teacher’s handbook”, Dept. of Education and Science.)

(a) Why is a lightning conductor made of copper?
(b) What is meant by electric field strength?
(c) Why do the ions near the lightning conductor accelerate?
(d) How does the presence of ions in the air cause the air to be more conducting?
(e) How do the charged clouds become neutralised?
(f) What are the two ways in which a lightning conductor prevents a building from being damaged by lightning?
(g) Why are raised umbrellas and golf clubs not recommended during thunderstorms?
(h) Explain why pointed surfaces should be avoided when using high voltage electrical equipment.

Electric fields / electric field strength (all higher level)

2013 Question 12 (c) [Higher Level]

(i) Define the unit of charge, the coulomb.
(ii) State Coulomb's law.
(iii)Calculate the force of repulsion between two small spheres when they are held 8 cm apart in a vacuum (each sphere has a positive charge of +3 μC).



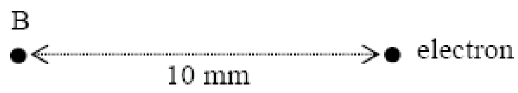
(iv)Copy the diagram above and show on it the electric field generated by the charges.
(v) Mark on your diagram a place where the electric field strength is zero.

2003 Question 12 (c) [Higher Level]

(i) State Coulomb's law of force between electric charges.
(ii) Define electric field strength and give its unit.
(iii)How would you demonstrate an electric field pattern?
(iv)The diagram shows a negative charge – *Q* at a point X.
Copy the diagram and show on it the direction of the electric field strength at Y.

2005 Question 10 [Higher Level]

(i) Define electric field strength.
(ii) State Coulomb's law of force between electric charges.
(iii)Why is Coulomb's law an example of an inverse square law?
(iv)Give two differences between the gravitational force and the electrostatic force between two electrons.
(v) Describe an experiment to show an electric field pattern.
(vi)Calculate the electric field strength at the point B, which is 10 mm from an electron.



(vii) What is the direction of the electric field strength at B?
(viii) A charge of 5 μC is placed at B. Calculate the electrostatic force exerted on this charge.
(permittivity of free space = 8.9×10^{-12} F m^{-1}; charge on the electron = 1.6×10^{-19} C)

2010 Question 12 (d) [Higher Level]

(i) Define electric field strength and give its unit of measurement.

(ii) Copy the diagram into your answerbook and show on it the direction of the electric field at point P.

(iii) Calculate the electric field strength at P.

(iv) Under what circumstances will point discharge occur?

(permittivity of free space = 8.9 × 10–12 F m^{-1})

2007 Question 8 [Higher Level]

(i) Define electric field strength and give its unit of measurement.

(ii) Describe how an electric field pattern may be demonstrated in the laboratory.

(iii) The dome of a Van de Graff generator is charged.
The dome has a diameter of 30 cm and its charge is 4 C.
A 5 μC point charge is placed 7 cm from the surface of the dome.
Calculate the electric field strength at a point 7 cm from the dome

(iv) Calculate the electrostatic force exerted on the 5 μC point charge.

(v) All the charge resides on the surface of a Van de Graff generator's dome. Explain why.

(vi) Describe an experiment to demonstrate that total charge resides on the outside of a conductor.

(vii) Give an application of this effect.

(permittivity of free space = 8.9×10^{-12} F m^{-1})

2015 Question 8 [Higher Level]

(i) Define electric field strength.

(ii) Both Van de Graaff generators and gold leaf electroscopes are used to investigate static electricity in the laboratory.

Draw a labelled diagram of a gold leaf electroscope.

(iii) Describe how it can be given a negative charge by induction.

(iv) A Van de Graaff generator can be used to demonstrate point discharge.
Explain, with the aid of a labelled diagram, how point discharge occurs.

(v) Describe an experiment to demonstrate point discharge.

(vi) The polished spherical dome of a Van de Graaff generator has a diameter of 40 cm and a charge of +3.8 μC.
What is the electric field strength at a point 4 cm from the surface of the dome?

2011 Question 9 (a) [Higher Level]

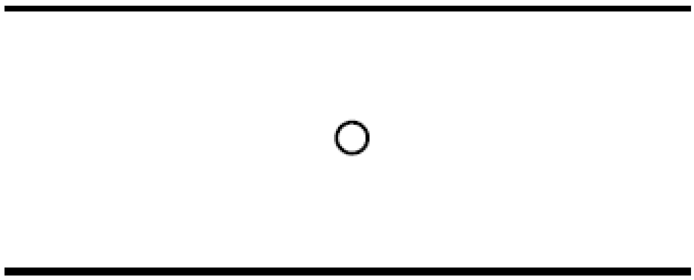
(i) State Coulomb's law.

(ii) Two identical spherical conductors on insulated stands are placed a certain distance apart.
One conductor is given a charge Q while the other conductor is given a charge $3Q$ and they experience a force of repulsion F.
The two conductors are then touched off each other and returned to their original positions.
What is the new force, in terms of F, between the spherical conductors?

2016 Question 12 (b) [Higher Level]

In 1909 Robert Millikan determined the charge on an electron by experiment.

A tiny drop of oil was placed between two horizontal plates, one directly above the other as shown. The oil drop was ionised by X-rays so that it became negatively charged. An electric field was applied between the plates until the drop no longer moved up or down.



(i) Define electric field strength.

(ii) In your answer book, sketch the electric field pattern between two oppositely charged parallel plates.

(iii) Draw a diagram to show the forces acting on the drop of oil when it is stationary.

(iv) The electric field strength between the plates was 3.6×10^4 V m^{-1} when the drop of oil was stationary, and the mass of the drop was 2.4×10^{-15} kg.

Calculate the charge of the drop.

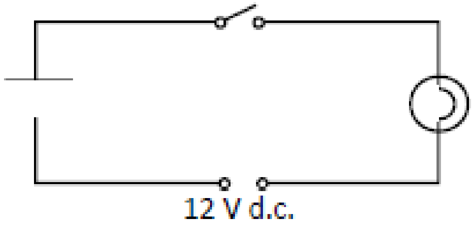
(v) How many excess electrons are on this drop?

(acceleration due to gravity = 9.8 m s^{-2})

Capacitance: ordinary level questions

2017 Question 12 (d) [Ordinary Level]

(i) State Coulomb's law of force between electric charges.

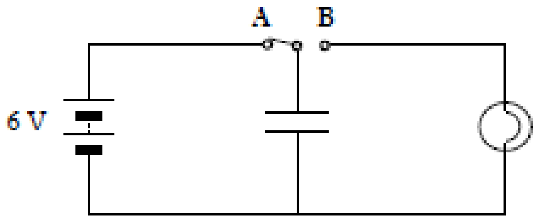


A capacitor can be used to store electric charge.
A discharged capacitor with a capacitance of 6×10^{-2} F is connected in a circuit with a bulb, a switch and a 12 V d.c. power supply as shown.

(ii) What is observed when the switch is closed?
(iii) What would be observed if a 12 V a.c. power supply had been used instead?
(iv) Calculate the charge stored on the capacitor when it is connected to the 12 V d.c. power supply.
(v) State one application of a capacitor.

2012 Question 12 (d) [Ordinary Level]

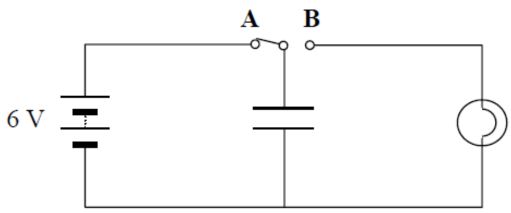
A capacitor is connected to a switch, a battery and a bulb as shown in the diagram.
When the switch is changed from position A to position B, the bulb lights briefly.



(i) What happens to the capacitor when the switch is in position A?
(ii) Why does the bulb light when the switch is in position B?
(iii) Why does the bulb light only briefly?
(iv) The capacitor has a capacitance of 200 μF. Calculate its charge when connected to a 6 V battery.
(v) Give a use for a capacitor.

2007 Question 9 (b) [Ordinary Level]

A capacitor is connected to a switch, a battery and a bulb as shown in the diagram. When the switch is moved from position A to position B, the bulb lights briefly.



(i) What happens to the capacitor when the switch is in position A?
(ii) Why does the bulb light when the switch is in position B?
(iii) When the switch is in position A the capacitor has a charge of 0.6 C, calculate its capacitance.
(iv) Give a use for a capacitor.

2002 Question12 (c) [Ordinary Level]

(i) Define capacitance.
(ii) Diagram A shows a capacitor connected to a bulb and a 12 V a.c. supply.
Diagram B shows the same capacitor connected to the bulb, but connected to a 12 V d.c. supply.
What happens in each case when the switch is closed?
Explain your answer.
(iii) Describe an experiment to demonstrate that a capacitor can store energy.

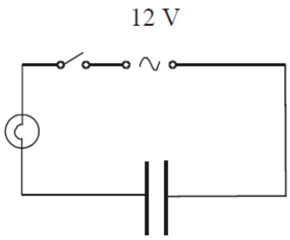


diagram A

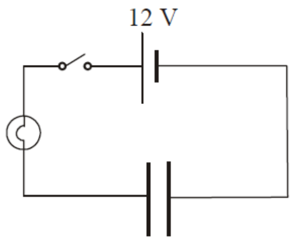
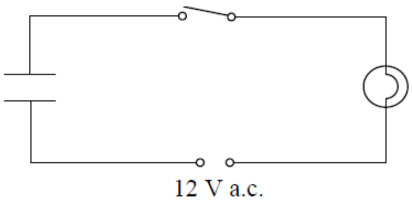


diagram B

2015 Question 8 [Ordinary Level]



(i) Define capacitance. Name the unit of capacitance.

(ii) The diagram shows a circuit with a bulb, switch, capacitor and a 12 V a.c. power supply.
What is observed when the switch is closed?

(iii) What would be observed if a 12 V d.c. supply were used instead of the a.c. supply?

(iv) What do these observations tell us about capacitors?

(v) The capacitor has a charge of 0.8 C when connected to the 12 V d.c. supply. Calculate its capacitance.

(vi) Describe an experiment to show that energy is stored in a charged capacitor.

(vii) The photographs show a radio and a camera flash. Each of these devices makes use of a property of capacitors. Name the property used in each case.

Capacitance: higher level questions

2014 Question 9 [Higher Level]

Most modern electronic devices contain a touchscreen.
One type of touchscreen is a capacitive touchscreen, in which the user's finger acts as a plate of a capacitor.
Placing your finger on the screen will alter the <u>capacitance</u> and the <u>electric field</u> at that point.

(i) Explain the underlined terms.
(ii) Describe an experiment to demonstrate an electric field pattern.
(iii) Two parallel metal plates are placed a distance *d* apart in air.
The plates form a parallel plate capacitor with a capacitance of 12 μF. A 6 V battery is connected across the plates.
Calculate the charge on each plate
(iv) Calculate the energy stored in the capacitor.
(v) While the battery is connected the distance *d* is increased by a factor of three.
Calculate the new capacitance.
(vi) A capacitor and a battery are both sources of electrical energy.
State two differences between a capacitor and a battery.
(vii) Touchscreens also contain two polarising filters. What is meant by polarisation of light?
(viii) Give one application of capacitors, other than in touchscreens.

2008 Question 12 (d) [Higher Level]

(i) Define capacitance.
(ii) Describe how an electroscope can be charged by induction.
(iii) How would you demonstrate that the capacitance of a parallel plate capacitor depends on the distance between its plates?

2006 Question 12 (b) [Higher Level]

(i) List the factors that affect the capacitance of a parallel plate capacitor.
(ii) The plates of an air filled parallel plate capacitor have a common area of 40 cm^2 and are 1 cm apart.
The capacitor is connected to a 12 V d.c. supply. Calculate the capacitance of the capacitor.
(iii) Calculate the magnitude of the charge on each plate.
(iv) What is the net charge on the capacitor?
(v) Give a use for a capacitor.
(permittivity of free space = 8.85×10^{-12} F m^{-1})

2009 Question 9 [Higher Level]

(i) Define potential difference.

(ii) Define capacitance.

(iii) A capacitor stores energy.
Describe an experiment to demonstrate that a capacitor stores energy.

(iv) The ability of a capacitor to store energy is the basis of a defibrillator. During a heart attack the chambers of the heart fail to pump blood because their muscle fibres contract and relax randomly. To save the victim, the heart muscle must be shocked to re-establish its normal rhythm. A defibrillator is used to shock the heart muscle.
A 64 μF capacitor in a defibrillator is charged to a potential difference of 2500 V.
The capacitor is discharged through electrodes attached to the chest of a heart attack victim.
Calculate the charge stored on each plate of the capacitor.

(v) Calculate the energy stored in the capacitor.

(vi) Calculate the average current that flows through the victim when the capacitor discharges in a time of 10 ms.

(vii) Calculate the average power generated as the capacitor discharges.

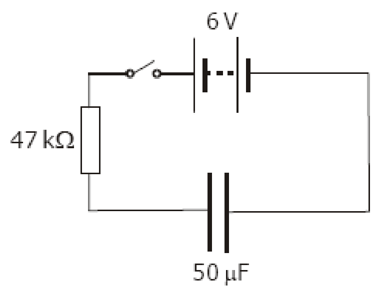
2004 Question 8 [Higher Level]

{you should have the *Resistance* chapter covered before trying the maths part of this question}

(i) Define potential difference.

(ii) Define capacitance.

(iii) Describe an experiment to demonstrate that a capacitor can store energy.



(iv) The circuit diagram shows a 50 μF capacitor connected in series with a 47 kΩ resistor, a 6 V battery and a switch.
When the switch is closed the capacitor starts to charge and the current flowing at a particular instant in the circuit is 80 μA.
Calculate the potential difference across the resistor and hence the potential difference across the capacitor when the current is 80 μA.

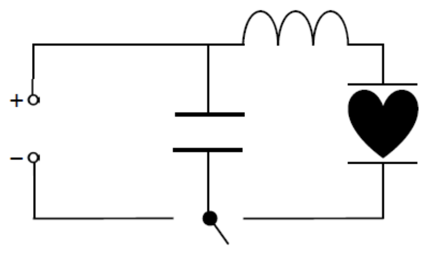
(v) Calculate the charge on the capacitor at this instant.

(vi) Calculate the energy stored in the capacitor when it is fully charged.

(vii) Describe what happens in the circuit when the 6 V d.c. supply is replaced with a 6 V a.c. supply.

2018 Question 12(c) [Higher Level]

(i) Define capacitance and state its unit.



A capacitor is an important component of a defibrillator.
A simple defibrillator circuit is shown.
Each plate of a parallel plate capacitor in a defibrillator stores a charge of 0.11 C when a potential difference of 4.0 kV is applied across it.

(ii) Calculate the energy stored in the capacitor.

(iii) What is the net charge of the capacitor when it stores this energy?

(iv) The capacitor discharges in a time of 15 ms.
Calculate the average current flowing as the capacitor discharges.

(v) Draw a diagram of the electric field between the charged plates of a parallel plate capacitor.

Solutions to higher level questions

2018 Question 12 (c)

(vi)**Define capacitance and state its unit.**
Capacitance is the ratio of charge to potential.
The unit is the farad.

(vii) **Calculate the energy stored in the capacitor.**

$$C = \frac{Q}{V} = \frac{0.11}{4000}$$

C = 2.75×10^{-5} farads

E = ½ CV^2
E = ½ $(2.75 \times 10^{-5})(4000)^2$

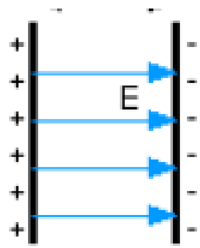
E = 220 J

(viii) **What is the net charge of the capacitor when it stores this energy?**
0 coulombs

(ix)**Calculate the average current flowing as the capacitor discharges.**

$$I = \frac{Q}{t} = \frac{0.11}{0.015} = 7.3\text{ A}$$

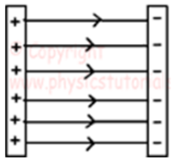
(x) **Draw a diagram of the electric field between the charged plates of a parallel plate capacitor.**
See diagram



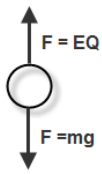
2016 Question 12 (b)

(i) Define electric field strength.
E = force per unit charge // *F/Q* (notation required)

(ii) In your answer book, sketch the electric field pattern between two oppositely charged parallel plates.
Parallel field lines from + to –



(iii)Draw a diagram to show the forces acting on the drop of oil when it is stationary.
See diagram



(iv)Calculate the charge of the drop.
Force up = Eq, Force down = mg
Force up = Force down
Eq = mg $\qquad q = \frac{mg}{E}$

E = 3.6×10^{4} V m^{-1}, Mass of the drop = 2.4×10^{-15} kg

$q = \frac{2.4 \times 10^{-15}(9.8)}{3.6 \times 10^{4}}$ q = 6.53×10^{-19} C

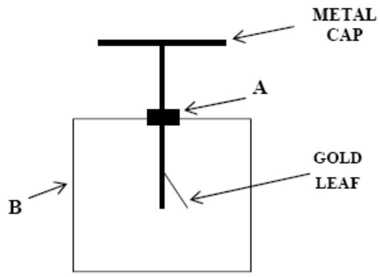
(v) How many excess electrons are on this drop?
An electron has a charge of 1.6×10^{-19} C, so 6.53×10^{-19} C is approximately equal to the charge of four electrons.
Answer: 4

2015 Question 8

(i) Define electric field strength.

E = force per unit charge

(ii) Draw a labelled diagram of a gold leaf electroscope.



A = insulated joint, B = metal case

Marking scheme:

Metal cap attached to gold leaves

Metal case (and glass window)

Both the cap and the leaves are insulated from the case

(iii)Describe how it can be given a negative charge by induction.

1. Bring a positively-charged rod close to the cap of the electroscope.
2. Keeping the charged rod in place, earth the conductor by touching it with your finger.
3. Remove your finger, then *and only then* remove the rod.

(iv)Explain, with the aid of a labelled diagram, how point discharge occurs.

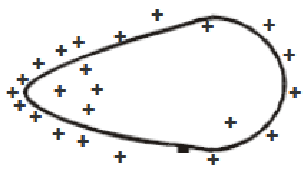


Diagram with concentration of charge at point

Air/gas near the point is ionised (by large electric field)

Opposite charges neutralise the charge at the point

- On a pear-shaped conductor, most charge accumulates on the pointed end as seen on the diagram.
- If the build-up of charge at the pointed end is sufficiently large, it can attract nearby positive ions from the air and cause them to accelerate towards the pointed end.
- En route, these ions are likely to crash off other molecules, causing these to become ionised.
- Newly formed ions with opposite charge to that on the point move towards this end and neutralise the charge on it.
- Ions with the same charge move away from this end.

(v) Describe an experiment to demonstrate point discharge.

Attach a nail to the surface of a Van der Graff generator.

Bring up a candle and notice that the flame moves away from the Van der Graff. This is because of the 'wind' generated by point discharge.

(vi)What is the electric field strength at a point 4 cm from the surface of the dome?

The 'distance' in relation to electric field strength corresponds to the distance to the centre of the dome (similar to centre of gravity of a planet being in the middle of the planet).

d = 4 + 20 = 24 cm = 0.24 m

$$E = \frac{Q}{4\pi\varepsilon d^2}$$

$$E = \frac{3.8 \times 10^{-6}}{(4)(\pi)(8.9 \times 10^{-12})(0.24)^2}$$

$E = 5.9 \times 10^5$ N C^{-1} away from the centre of the dome

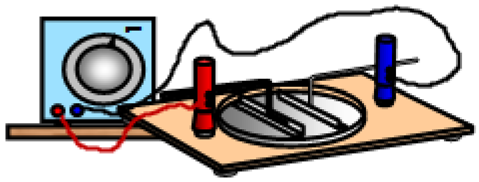
2014 Question 9

(i) Explain the underlined terms.

Capacitance is the ratio of charge (on a capacitor) to the potential difference across it.

An *electric field* is a region (of space) where electrostatic forces are experienced / forces experienced by charged particles

(ii) Describe an experiment to demonstrate an electric field pattern.



1. Place two electrodes in a petri-dish.
2. Pour some oil into the petri-dish and sprinkle on some semolina powder.
3. Connect a high voltage source (about 2,000 volts) to the metal electrodes.
4. Result: The semolina lines up in the direction of the field, showing the electric field.

(iii) Calculate the charge on each plate

$C = \frac{Q}{V}$ $Q = CV = (12\times10^{-6})(6) = 72\times10^{-6}$ C

(iv) Calculate the energy stored in the capacitor.

$E = \frac{1}{2}CV^2 = \frac{1}{2}(12\times10^{-6})(6)^2 = 216\times10^{-6}$ J

(v) Calculate the new capacitance.

$C \propto \frac{1}{d}$

So if the distance increases by a factor of 3 then the capacitance decreases by a factor of 3.

So new capacitance is 3 times smaller = 4 μF

(vi) State two differences between a capacitor and a battery.

Capacitor discharges faster than a battery / capacitor stores (electrostatic) potential energy while a battery stores chemical energy / battery gives a constant current / battery stores more energy

{I would have struggled to give anything beyond the first one}

(vii) Touchscreens also contain two polarising filters. What is meant by polarisation of light?

Vibration of a wave is in one plane only.

(viii) Give one application of capacitors, other than in touchscreens.

e.g. flash of a camera / tuning circuits / defibrillator

2013 Question 12 (c)

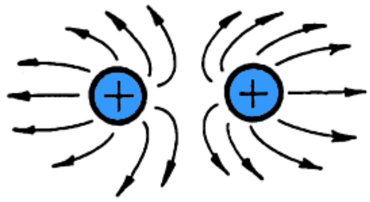
(i) Define the unit of charge, the coulomb.
The coulomb is the amount of charge that passes when one Amp flows for one second.

(ii) State Coulomb's law
Coulomb's Law states that the force between two point charges is proportional to the product of the charges and inversely proportional to the square of the distance between them.

(iii) Calculate the force of repulsion between two small spheres when they are held 8 cm apart in a vacuum.

$F = \frac{1}{4\pi\varepsilon}\frac{Q_1Q_2}{d^2}$ $F = \frac{1}{(4)(\pi)(8.9\times10^{-12})}\frac{(3\times10^{-6})(3\times10^{-6})}{0.08^2}$ $F = 12.64\text{ N}$

(iv) Copy the diagram above and show on it the electric field generated by the charges.
See diagram – curved deviation of the field lines needs to be clearly evident



(v) Mark on your diagram a place where the electric field strength is zero.
Neutral/null point marked halfway between charges

2011 Question 9 (a)

(i) State Coulomb's law.

The force between two charges is proportional to the product of the charges and inversely proportional to the square of the distance between them.

(ii) What is the new force, in terms of *F*, between the spherical conductors?

$F = \frac{(Q)(3Q)}{4\pi\varepsilon d^2}$ $\qquad F' = \frac{(2Q)(2Q)}{4\pi\varepsilon d^2}$

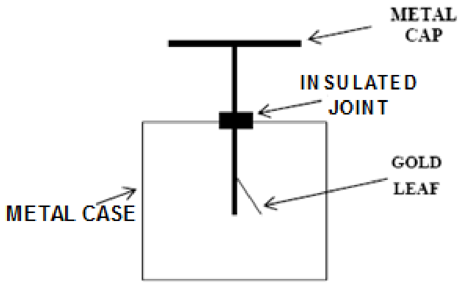
$F = \frac{3Q^2}{4\pi\varepsilon d^2}$ $\qquad F' = \frac{4Q^2}{4\pi\varepsilon d^2}$

$\frac{\boldsymbol{F'}}{\boldsymbol{F}} = \frac{\mathbf{4}}{\mathbf{3}}$ $\qquad F' = \frac{4}{3}F$

(b)

(i) Draw a labelled diagram of an electroscope.

See diagram



(ii) Why should the frame of an electroscope be earthed?

If the frame was charged it would affect the degree of deflection of the leaf.

(iii) Describe how to charge an electroscope by induction.

1. Bring a charged rod near the electroscope.
2. Keeping the charged rod in place, earth the cap by touching it with your finger.
3. Remove your finger, then *and only then* remove the rod.

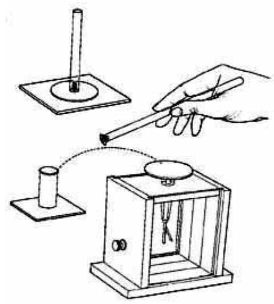
(c)

(i) How does a full-body metal-foil suit protect an operator when working on high voltage power lines?

Even if the operator touches a live wire all charges will reside on the *outside* of the conducting suit so he won't get shocked.

(ii) Describe an experiment to investigate the principle by which the operator is protected.

1. Charge a hollow conductor (a metal can will do fine).
2. Using a proof plane, touch the inside of the can and bring it up to the GLE. Notice that there is no deflection.
3. Touch the proof plane off the outside of the can and bring it up to the GLE. Notice that there is a deflection.
4. Conclusion: charge resides on outside only



2010 Question 12 (d)

(i) Define electric field strength and give its unit of measurement.
Electric field strength is defined as force per unit charge.
Its unit is the N C^{-1} (or V m^{-1})

(ii) Copy the diagram into your answerbook and show on it the direction of the electric field at point P.

(iii) Calculate the electric field strength at P.
The electric field strength at P is the sum of the electric fields acting on P from the other two charges.
The electric field strength is towards the left in both cases (attracted to the negative charge and repelled from the positive charge).
Because both electric fields are in the same direction (towards the left) the individual field strengths can simply be added together.

$$E = \frac{q_1}{4\pi\varepsilon d^2} + \frac{q_2}{4\pi\varepsilon d^2}$$

$$E = \frac{2 \times 10^{-6}}{4\pi\varepsilon(0.1)^2} + \frac{5 \times 10^{-6}}{4\pi\varepsilon(0.15)^2}$$

$E_{total} = 3.77 \times 10^6$ N C^{-1}

(iv) Under what circumstances will point discharge occur?
High charge density at a point / large electric field strength /potential at a point

2009 Question 9

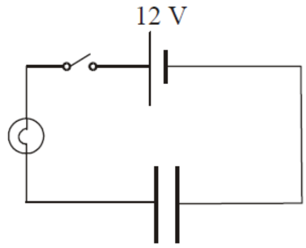
(i) Define potential difference

Potential difference is the work done in moving unit charge from one place to another.

(ii) Define capacitance

The capacitance of a conductor is the ratio of the charge on the conductor to its potential.

(iii) Describe an experiment to demonstrate that a capacitor stores energy.



1. Set up as shown.
2. Close the switch to charge the capacitor.
3. Remove the battery and connect the terminals together to 'short' the circuit.
4. The bulb will flash as the capacitor discharges, showing that it stores energy.

(iv) Calculate the charge stored on each plate of the capacitor.

$C = \frac{Q}{V}$ Q = CV ⇒ Q = $(64 \times 10^{-6})(2500)$ ⇒ Q = 0.16 C

(v) Calculate the energy stored in the capacitor.

$E = \frac{1}{2} CV^2 = \frac{1}{2}(64 \times 10^{-6})(2500)^2 = 200$ J

(vi) Calculate the average current that flows through the victim when the capacitor discharges in a time of 10 ms.

$I = \frac{Q}{t}$ $= \frac{0.16}{10 \times 10^{-3}}$ = 16 A

(vii) Calculate the average power generated as the capacitor discharges.

$Power = \frac{Work}{time}$ $= \frac{200}{10 \times 10^{-3}}$ = 20000 W

2008 Question 12 (d)

(i) Define capacitance.

The capacitance of a conductor is the ratio of the charge on the conductor to its potential.

(ii) Describe how an electroscope can be charged by induction.

1. Bring a negatively charge rod near the electroscope
2. Keeping the charged rod in place, earth the electroscope by touching the cap with your finger.
3. Remove your finger, then *and only then* remove the rod.
   The conductor will now be positively charged.

(iii) How would you demonstrate that the capacitance of a parallel plate capacitor depends on the distance between its plates?

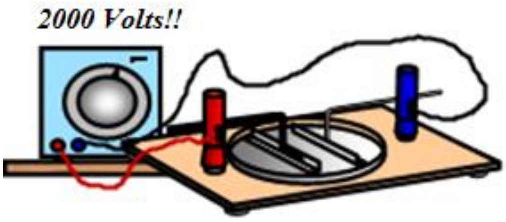
Connect the two parallel plates to a digital multi-meter (DMM) set to read capacitance.
Note the capacitance.
Increase the distance between them – note that the capacitance decreases.

2007 Question 8

(i) Define electric field strength and give its unit of measurement.

Electric field strength at a point is the force per unit charge at that point.
The unit is the N C^{-1}

(ii) Describe how an electric field pattern may be demonstrated in the laboratory.



1. Place two electrodes in a petri-dish.
2. Pour some oil into the petri-dish and sprinkle on some semolina powder.
3. Connect a *high voltage* source (about 2,000 volts) to the metal electrodes.
4. Result: The semolina lines up in the direction of the field, showing the electric field.

(iii)Calculate the electric field strength at a point 7 cm from the dome.

{the distance in this case corresponds to the distance from a point 0.07 m (7 cm) outside to dome to the centre of the dome (charge is spread all over the dome but we can treat it as a point situated in the middle). Therefore d = 0.07 + 0.15 = 0.22 m}

$$E = \frac{1}{4\pi\varepsilon}\frac{Q}{d^2}$$

$$E = \frac{1}{4\pi(8.9\times10^{-12})}\frac{4}{(0.22)^2} \qquad E = 7.39 \text{ x } 10^{11} \text{ N C}^{-1}$$

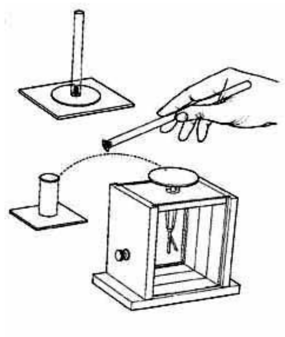
(iv)Calculate the electrostatic force exerted on the 5 μC point charge.

$F = Eq$
$F = (7.39 \times 10^{11})(5 \times 10^{-6})$ $F = 3.69 \times 10^{6}$ N

(v) All the charge resides on the surface of a Van de Graff generator's dome. Explain why.

Like charges repel and the charges are a maximum distance apart on the outside surface of dome.

(vi)Describe an experiment to demonstrate that total charge resides on the outside of a conductor.



1. Charge the conductor (a metal can will do fine).
2. Using a proof plane, touch the *inside* of the can and bring it up to the gold leaf electroscope (GLE).
3. Notice that there is no deflection.
4. Touch the proof plane off the *outside* of the can and bring it up to the GLE.
5. Notice that there is a deflection.
6. Conclusion: charge resides on outside only

(vii) Give an application of this effect.

Electrostatic shielding / co-axial cable / TV (signal) cable / to protect persons or equipment, enclose them in hollow conductors /Faraday cages (there is no electric field inside a closed conductor), etc.

2006 Question 12 (b)

(i) List the factors that affect the capacitance of a parallel plate capacitor.
Common area of plates, distance apart, permittivity of dielectric between plates.

(ii) Calculate the capacitance of the capacitor.
{There are 10,000 (1×10^4) cm^2 in a m^2. Therefore 1 cm^2 $=1\times10^{-4}$ m^2 40 cm^2 $=40\times10^{-4}$ m^2}

$C = \frac{\varepsilon A}{d}$ $C = \frac{(8.85 \times 10^{12})(40\times10^{-4})}{0.01}$ C = 3.54×10^{-12} F

(iii) Calculate the magnitude of the charge on each plate.
$C = \frac{Q}{V}$ Q = CV   Q = (3.54×10^{-12})(12) = 4.25×10^{-11} C

(iv) What is the net charge on the capacitor?
{this seems like a trick question, but it is actually testing whether or not you understand how a capacitor works. When charged, there will be equal amounts of positive charge on one plate and negative charge on the second plate. So total net charge is zero.}
Answer: Zero

(v) Give a use for a capacitor.
Flash guns for cameras / locks d.c. /smoothing /tuning circuits / timing circuits /

2005 Question 10

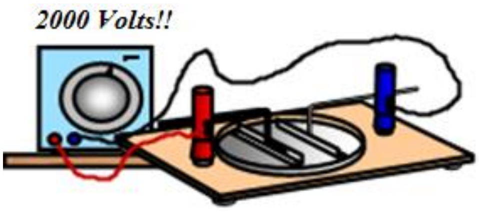
(i) Define electric field strength.
Electric field strength is defined as force per unit charge.

(ii) State Coulomb's law of force between electric charges.
The force between two charges is proportional to the product of the charges and inversely proportional to the square of the distance between them.

(iii) Why is Coulomb's law an example of an inverse square law?
Because the force is inversely proportional to the distance squared.

(iv) Give two differences between the gravitational force and the electrostatic force between two electrons.
Gravitational force is much smaller than the electrostatic force.
Gravitational force is attractive, electrostatic force (between two electrons) is repulsive.

(v) Describe an experiment to show an electric field pattern.



1. Place two electrodes in a petri-dish.
2. Pour some oil into the petri-dish and sprinkle on some semolina powder.
3. Connect a high voltage source (about 2,000 volts) to the metal electrodes.

Result: The semolina lines up in the direction of the field, showing the electric field.

(vi) Calculate the electric field strength at the point B, which is 10 mm from an electron.
$E = \frac{Q}{4\pi\varepsilon d^2}$ $E = \frac{1.6 \times 10^{-19}}{4\pi(8.9\times10^{-12})(0.01)^2}$ E = 1.4×10^{-5} N C^{-1}

(vii) What is the direction of the electric field strength at B?
Towards the electron / to the right

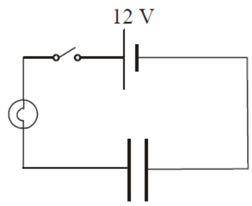
(viii) A charge of 5 μC is placed at B. Calculate the electrostatic force exerted on this charge.
$E = \frac{F}{Q}$ $F = Eq$ $F = (1.4 \times 10^{-5})(5 \times 10^{-6})$ $F = 7.2 \times 10^{-11}$ N
Towards the electron

2004 Question 8

(i) Define potential difference.
The potential difference (p.d.) between two points is the work done in bringing a charge of 1 Coulomb from one point to the other.

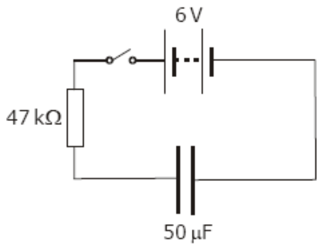
(ii) Define capacitance.
The capacitance of a conductor is the ratio of the charge on the conductor to its potential.

(iii)Describe an experiment to demonstrate that a capacitor can store energy.



1. Set up as shown.
2. Close the switch to charge the capacitor.
3. Remove the battery and connect the terminals together to ‘short’ the circuit.
4. The bulb will flash as the capacitor discharges, showing that it stores energy.

(iv)Calculate the potential difference across the resistor and hence the potential difference across the capacitor.



$V_{\text{across 47 k}\Omega\text{ resistor}} = (80 \times 10^{-6})(47 \times 10^{3}) = 3.76$ V
{Total potential difference (provided by the battery) = potential difference across the resistor plus potential difference across the capacitor}
$V_{\text{across the capacitor}} = 6 - 3.76 = 2.24$ V

(v) Calculate the charge on the capacitor at this instant.
$C = \frac{Q}{V}$ □ $Q = CV$ $Q = (50 \times 10^{-6})(2.24)$ $Q = 1.12 \times 10^{-4}$ C

(vi)Calculate the energy stored in the capacitor when it is fully charged.
$E = ½ CV^2$ $E = ½ (50 \times 10^{-6})(6)^2$ $E = 9 \times 10^{-4}$ J

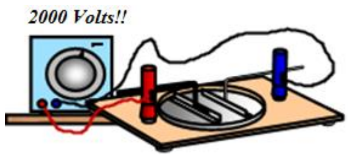
(vii) Describe what happens in the circuit when the 6 V d.c. supply is replaced with a 6 V a.c. supply.
The current will flow continually.

2003 Question 12 (c)

(i) State Coulomb’s law of force between electric charges.
Coulomb’s law states that the force between two point charges is proportional to the product of the charges and inversely proportional to the square of the distance between them.

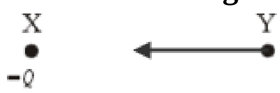
(ii) Define electric field strength and give its unit.
Electric field strength at a point is the force per unit charge at that point.
The unit of electric field strength is the Newton per Coulomb (NC^{-1}).

(iii)How would you demonstrate an electric field pattern?



1. Place two electrodes in a petri-dish.
2. Pour some oil into the petri-dish and sprinkle on some semolina powder.
3. Connect a high voltage source (about 2,000 volts) to the metal electrodes.
Result: The semolina lines up in the direction of the field, showing the electric field.

(iv)Copy the diagram and show on it the direction of the electric field strength at Y.
Arrow towards X



2002 Question 11

(a) Why is a lightning conductor made of copper?
It is a good conductor.

(b) What is meant by electric field strength?
Electric field strength is defined as force per unit charge. $E = \frac{F}{Q}$

(c) Why do the ions near the lightning conductor accelerate?
They experience a large force due to the high density of charge on the conductor

(d) How does the presence of ions in the air cause the air to be more conducting?
The ions act as charge carriers.

(e) How do the charged clouds become neutralised?
Electrons flow to or from the ground through the air.

(f) What are the two ways in which a lightning conductor prevents a building from being damaged by lightning?
It neutralises charged clouds
It conducts charges to earth.

(g) Why are raised umbrellas and golf clubs not recommended during thunderstorms?
Because they act as lightning conductors.

(h) Explain why pointed surfaces should be avoided when using high voltage electrical equipment.
Sparking is more likely to occur from these points due to point discharge.