STATIC ELECTRICITY & CAPACITANCE: Higher Level Long Questions:

Static Electricity

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]

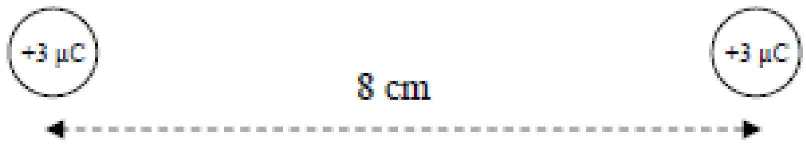
Read the following passage and answer the accompanying questions.
Benjamin Franklin designed the lightning conductor. This is a thick copper strip running up the outside of a tall building. The upper end of the strip terminates in one or more sharp spikes above the highest point of the building. The 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

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).



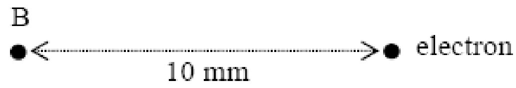
(iv) Copy the diagram above and show on it the electric field generated by the charges.
(v) Mark on your diagram a place where the electric field strength is zero.

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 3*Q* 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?

Capacitance

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 capacitance and the electric field 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.

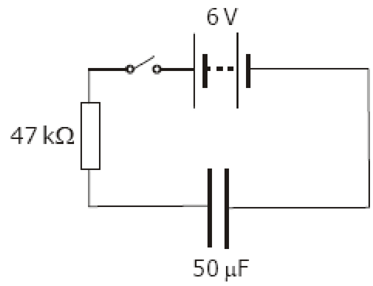
2004 Question 8 [Higher Level]

{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.