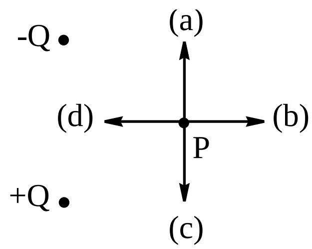
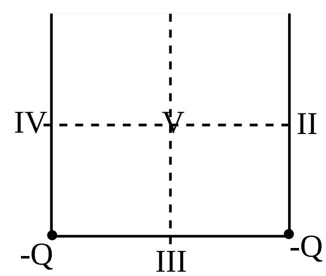
Part I

1. Which of the arrows indicates the direction of the electric field at point P due the stationary charges $+Q$ and $-Q$?



2. Four charges are arranged on the four corners of a square as shown in the diagram.
If the electric potential is defined to be zero at infinity then it is also zero at



   (a) point V only.
   (b) points II and IV and V.
   (c) points I and III.
   (d) none of the labeled points.

3. A point charge Q_1 exerts an electrostatic force F on a point charge Q_2 when they are 3.0 cm apart. If the charges are placed 6.0 cm apart, the magnitude of the electrostatic force Q_1 exerts on Q_2 will be

   (a) $4F$ (b) $2F$ (c) $F/2$ (d) $F/4$

4. A suitable unit for electric field strength is

   (a) Coulombs per metre squared.
   (b) Volts per Coulomb.
   (c) Volts per metre.
   (d) Joules per Coulomb.

5. Two light bulbs both operate from 110 V, but one has a power rating of 40 W whereas the other has a rating of 75 W. Which of the following statements is true about the bulbs

   (a) The 40 W bulb has greater resistance and draws a greater current.
   (b) The 40 W bulb has a greater resistance and draws a smaller current.
   (c) The 40 W bulb has a smaller resistance and draws a greater current.
   (d) The 40 W bulb has a smaller resistance and draws a smaller current.

6. Two wires of equal length are made of the same material. Wire A has twice the diameter of wire B. It follows that

   (a) Wire A has one quarter the resistance of wire B

   (b) Wire A has half the resistance of wire B

   (c) Wire A has twice the resistance of wire B

   (d) Wire A has four times the resistance of wire B

7. When a charged particle moves horizontally through a vertical magnetic field the effect of the field can lead to a change in

   (a) velocity.

   (b) kinetic energy.

   (c) speed.

   (d) all of the above.

8. A long straight horizontal wire vertical wire carries a steady current in the upward direction. At a point due north of the wire, what is the direction of the magnetic field that the wire produces?

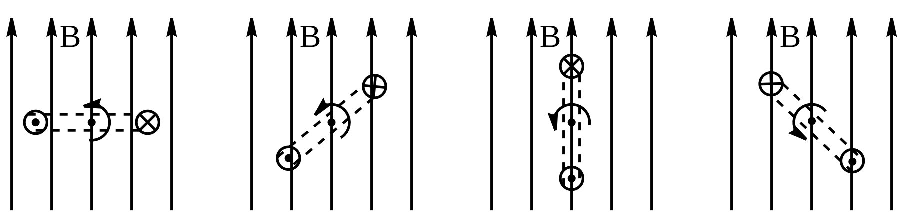
   (a) North.

   (b) South.

   (c) East.

   (d) West.

9. In which of the following positions will the coils of a generator produce the maximum voltage?



(a) (b) (c) (d)

10. Consider the following situations.

    I. A wire loop around a long straight wire carrying a steady current.

    II. A wire loop with a magnet moving uniformly through it.

    III. A wire loop with a stationary charge at its center.

    In which case is there an induced current in the wire loop?

    (a) All 3 cases (b) I and II only (c) II only (d) None of the cases.

Part II

1. Answer the following questions about the nature of the electromagnetic interaction. Clearly explain your reasoning for all your answers and under what conditions your answers are valid.

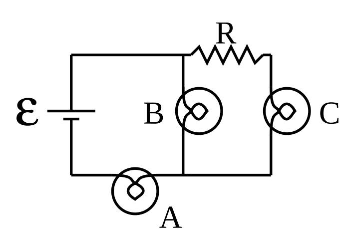
   (a) Is it possible for a charged particle to move through a magnetic field without experiencing a force?

   (b) Is it possible for a charged particle to move without accelerating in the simultaneous presence of a magnetic and an electric field?

   (c) Is it possible for such a particle to be at rest in the presence of both fields alone?

   (d) Is it possible for a current loop in a uniform magnetic field to remain at rest?

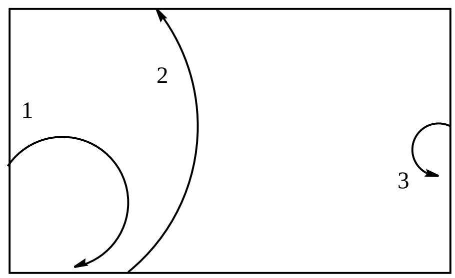
2. The following circuit has three identical light bulbs A, B and C connected with a non zero resistor R to an ideal battery with $\mathcal{E}mf\ \mathcal{E}$.



   (a) Rank the bulbs in order of their brightness explaining your reasoning clearly.

(b) If bulb C is unscrewed (hence breaking the circuit at that point) what happens to the brightness of the other two bulbs. Which bulb, if any, is brighter?

3. Charged particles passing through a bubble chamber leave tracks consisting of small hydrogen gas bubbles. These bubbles make visible the particles trajectories. In the following figure, the magnetic field is directed into the page and has value 2.0 Tesla and the particle follow tracks in the plane of the page in the directions indicated by the arrows.



(a) Which of the tracks correspond to a positively charged particle?

(b) If all particles have the same mass and charges of equal magnitude, which is moving the most slowly?

(c) If all particles are moving with the same speed and have charges of equal magnitude, which has the greatest mass?

(d) Suppose particle 1 has charge e and its radius of curvature is 20.0 cm. Find the momentum of the particle.

Please work independently on this take home test. It is due Monday, May 24th at 10:30 am.

1. (a) A hollow conducting sphere of radius 1.0 cm is fixed at the origin of a Cartesian coordinate system and carries a charge of 0.80 μC.

   (i) What is the potential at the surface of the sphere?

   (ii) Draw a graph of potential as a function of position along the x-axis. Include the interior of the sphere in your graph.

   (b) A second hollow conducting sphere with the same radius but charge 0.20 μC is moved from a great distance until its centre lies on the x-axis at $x = 10.0$ cm

   (i) How much work is required to bring the sphere to this position?

   (ii) How much force is required to keep it in this position?

   (iii) Draw a graph of electric field strength as a function of position along the x-axis due to both spheres. Include the interior of both the spheres on your graph.

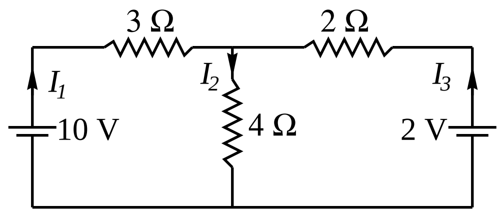
(iv) Draw a diagram showing the electric field lines of the two charges in this configuration.

(v) On the same diagram show the equipotential surfaces, clearly indicating which is which.

(c) The second sphere is now moved until it touches the first sphere. What is the charge on each sphere after they have touched

(d) To what position should the sphere be moved in order that the force between the two spheres is the same as it was in part (b)(ii)?

2. The following questions apply to the circuit shown below



(a) Write down one equation relating the three different currents in the circuit.

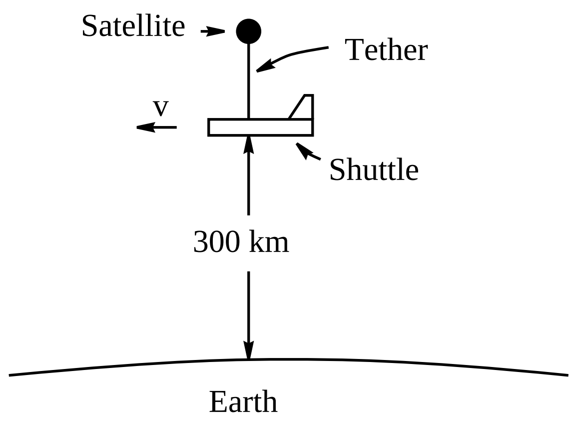
(b) Write down two equations relating the potential drops across that occur in two of the loops in the circuit.

(c) Solve this these equations to find the current in each part of the circuit.

3. (a) It is desired to produce a magnetic field strength of 2.0×10^{-3} T along the axis of a long solenoid. If the solenoid is 0.15 m long and has 200 turns per centimetre, what current in the solenoid will produce this field?

(b) Suppose the solenoid is uncoiled into a long straight wire and carries the same current. At what distance from the wire will the magnetic field strength be the same as it was inside the solenoid in part (a).

4. The Tethered Satellite System was an experiment conducted on the space shuttle in order to create a potential difference to generate electric power. While the shuttle was orbiting 300 km above the equator the astronauts reeled out a satellite attached to the shuttle by a long conducting tether to a position 20 km above the shuttle as shown.



(a) Explain how a potential difference could be generated in this experiment.

(b) Assuming the diagram above shows a view from the north looking south

(i) indicate the direction of the magnetic field on the diagram.

(ii) indicate the polarity of the induced potential difference between the satellite and the shuttle.

(c) If the magnetic field in the vicinity of the shuttle was 0.33×10^{-4} Tesla and the shuttle was moving at 7.7 km/s, find the potential difference between the satellite and the shuttle.

(d) This potential difference was used to generate a current through the ionosphere. The current was then used to provide power for experiments on the shuttle. What, ultimately would be the source of the consumed energy?