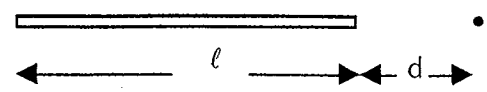
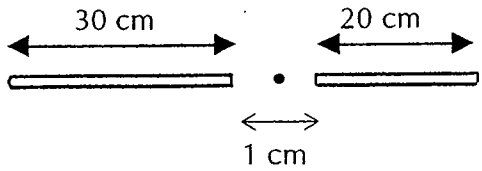
QUESTION 1

[Marks 15]

(a) Derive an expression for the electric field at a distance d from one end of a thin uniformly charged rod, length ℓ, on which the total charge is Q.



(b)

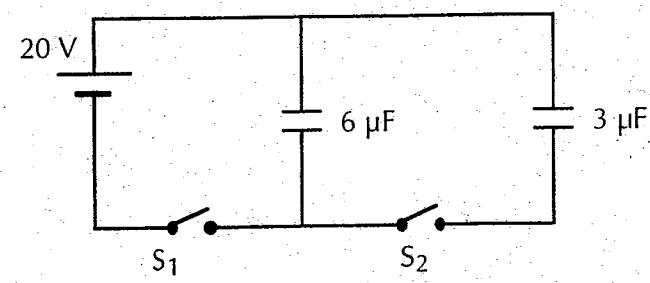


The rod is 50 cm long and carries a total charge of 20 μC. It is then cut at 20 cm from one end, forming two pieces. These are placed 1 cm from each other. Calculate the electric field in the middle of the 1 cm gap.

QUESTION 2

[Marks 16]

In the circuit shown both switches are initially open and the capacitors are uncharged. S1 is then closed so that the 6μF capacitor is charged up. S1 is then opened and S2 closed.



(a) After S2 has been closed, calculate the charges on each of the two capacitors and the potential differences across each.

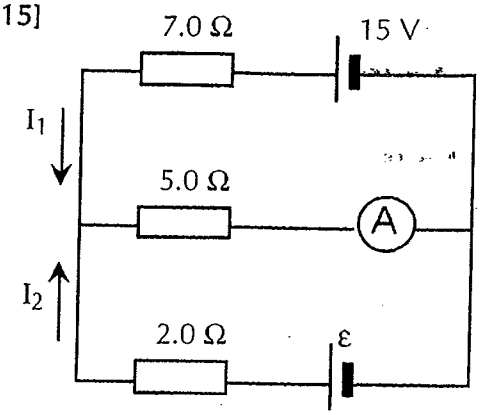
(b) The 3 μF is a parallel plate capacitor and a piece of teflon, with dielectric constant of 2.0, is inserted to completely fill the space between the plates (previously filled with air). Calculate the potential difference across this capacitor after the insertion of the dielectric.

(c) Compare the total energy stored in the two capacitors before and after the insertion of the teflon and account for any change.

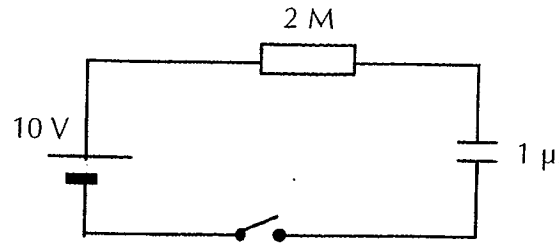
QUESTION 3

[Marks 15]

(a) In the circuit shown, the ammeter reads 2 amps.
Calculate the value of the emf $\mathcal{E}$.



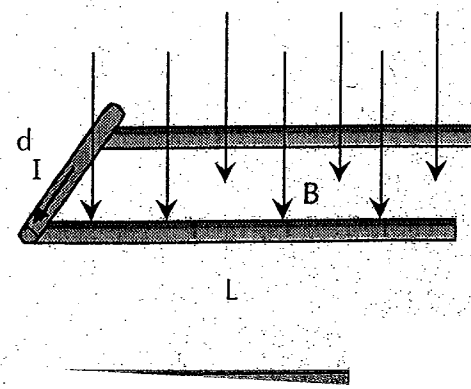
(b) A 1 μF capacitor, initially uncharged, and a 2 Megohm resistor are connected in series with a 10V battery as shown. At a time 10 seconds after the switch is closed calculate:
(i) the charge on the capacitor, and
(ii) the current flowing.



QUESTION 4

[Marks 5]

A rod of mass *m* and radius *R* rests on two parallel rails that are a distance *d* apart and have a length *L*. The rod carries a current *I* in the direction shown and rolls along the rails without friction. A magnetic field *B* is directed perpendicular to the rod and the rails. If the rod starts from rest, derive an expression for the velocity of the rod after it has travelled to the right a distance *L* to the end of the rails.

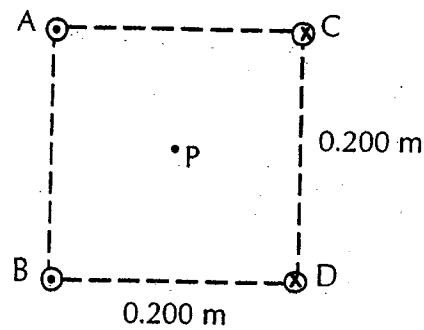


QUESTION 5

[Marks 12]

Four long parallel conductors are located at the corners of a square and run perpendicular to the plane of the page. Each conductor carries a current of 5 A with the current directed outwards at A and B and inwards at C and D.

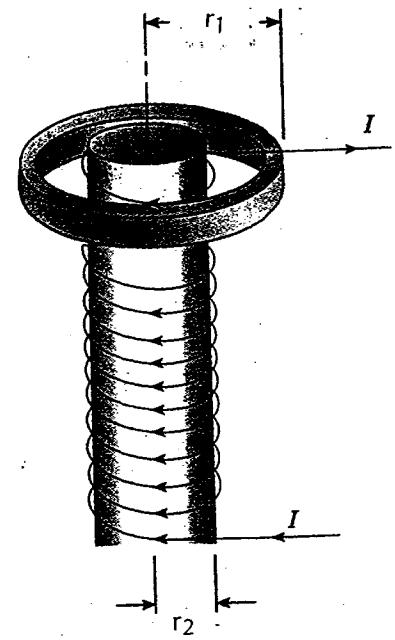
Calculate the total magnetic field at the point P at the centre of the square.



QUESTION 6

[Marks 17]

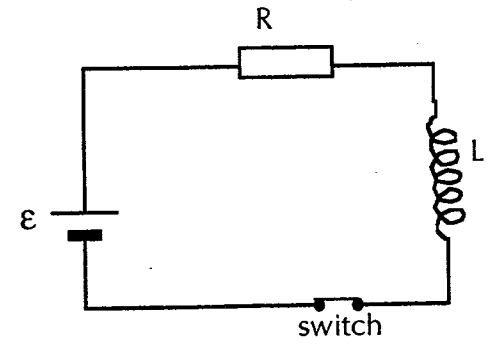
(a) An aluminium ring of radius r_1 and resistance R is placed at the top of a long solenoid with n turns per metre and radius r_2. At the location of the ring the magnetic field due to the current in the solenoid is one half of that at the centre of the solenoid and is confined within the solenoid. If the current in the solenoid is increasing at a rate $\frac{dI}{dt}$,



(i) what are the magnitude and direction of the induced current in the ring?

(ii) What is the magnitude and direction of the magnetic field produced by the current in the ring at the centre of the ring?

(b) (i) The switch in the circuit shown in the diagram has been closed for a long time. Why does a spark appear at the switch contacts at the instant that the switch is opened?



(ii) How does the current in the circuit vary with time after the switch has been opened?