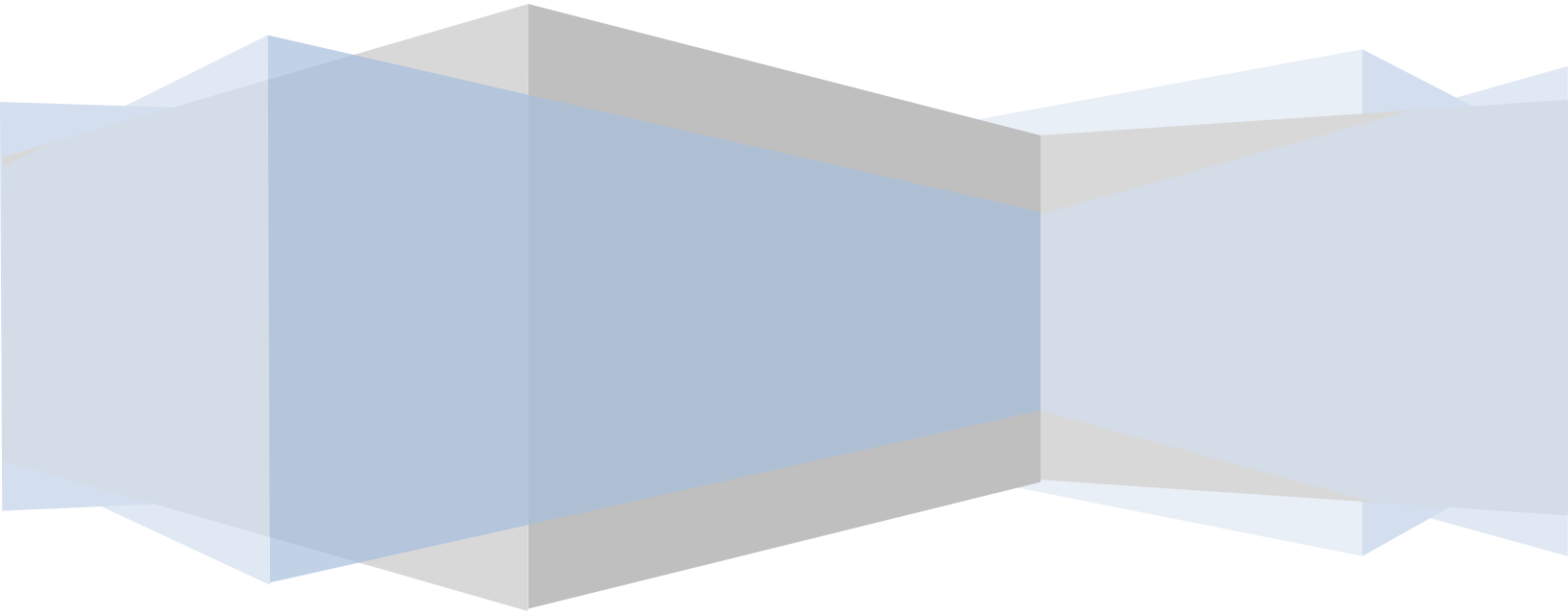
Electric Fields and Electricity

Problems by Topic



June 2005

6 Two parallel metal plates P and Q are situated 8.0 cm apart in air, as shown in Fig. 6.1.

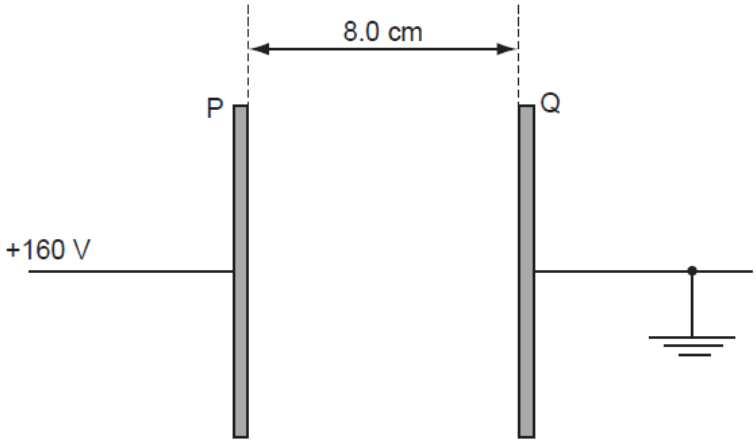


Fig. 6.1

Plate Q is earthed and plate P is maintained at a potential of +160 V.

(a) (i) On Fig. 6.1, draw lines to represent the electric field in the region between the plates. [2]

(ii) Show that the magnitude of the electric field between the plates is $2.0 \times 10^3 \text{ V m}^{-1}$.

[1]

(b) A dust particle is suspended in the air between the plates. The particle has charges of $+1.2\times10^{-15}$ C and -1.2×10^{-15} C near its ends. The charges may be considered to be point charges separated by a distance of 2.5 mm, as shown in Fig. 6.2.

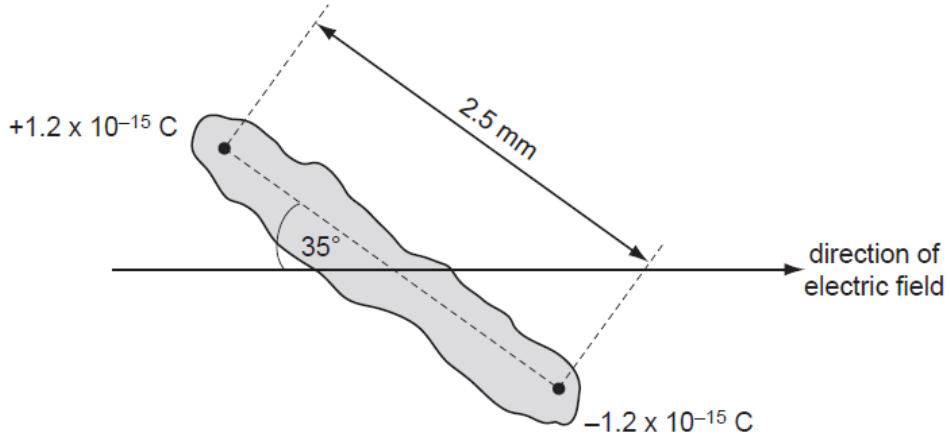


Fig. 6.2

The particle makes an angle of 35° with the direction of the electric field.

(i) On Fig. 6.2, draw arrows to show the direction of the force on each charge due to the electric field. [1]

(ii) Calculate the magnitude of the force on each charge due to the electric field.

force = ... N [2]

(iii) Determine the magnitude of the couple acting on the particle.

couple = ... N m [2]

(iv) Suggest the subsequent motion of the particle in the electric field.

.....

.....

.....[2]

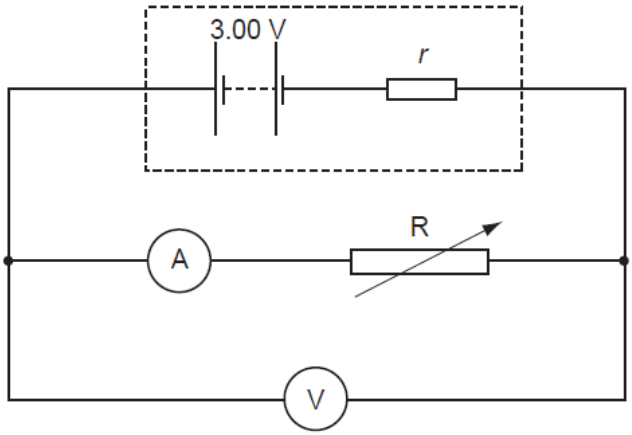
7 **(a)** Define the *resistance* of a resistor.

June 2005

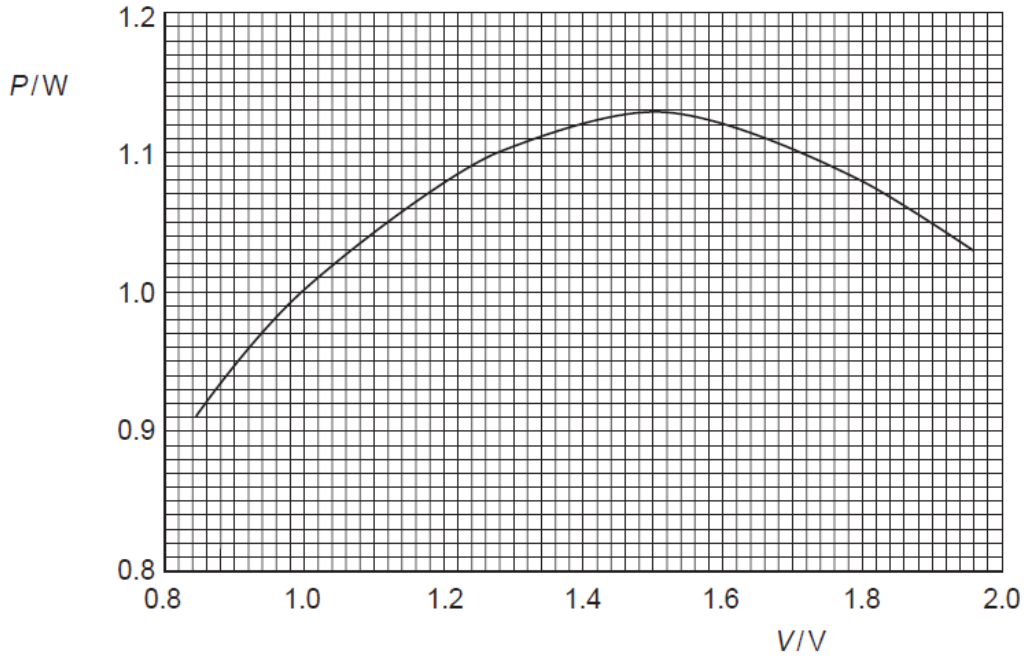
.....

.....[1]

(b) In the circuit of Fig. 7.1, the battery has an e.m.f. of 3.00 V and an internal resistance *r*. R is a variable resistor. The resistance of the ammeter is negligible and the voltmeter has an infinite resistance.



The resistance of R is varied. Fig. 7.2 shows the variation of the power *P* dissipated in R with the potential difference *V* across R.



(i) Use Fig. 7.2 to determine

1. the maximum power dissipation in R,

maximum power = ... W

2. the potential difference across R when the maximum power is dissipated.

potential difference = ... V
[1]

(ii) Hence calculate the resistance of R when the maximum power is dissipated.

resistance = ... Ω [2]

(iii) Use your answers in **(i)** and **(ii)** to determine the internal resistance r of the battery.

r = ... Ω [3]

(c) By reference to Fig. 7.2, it can be seen that there are two values of potential difference V for which the power dissipation is 1.05 W.
State, with a reason, which value of V will result in less power being dissipated in the internal resistance.

.....

.....

.....

.....[3]

7 A circuit contains three similar lamps A, B and C. The circuit also contains three switches, S_1, S_2 and S_3, as shown in Fig. 7.1.

June 2006

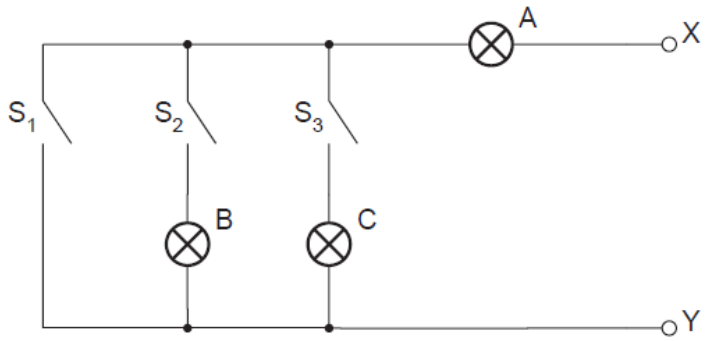


Fig. 7.1

One of the lamps is faulty. In order to detect the fault, an ohm-meter (a meter that measures resistance) is connected between terminals X and Y. When measuring resistance, the ohm-meter causes negligible current in the circuit.

Fig. 7.2 shows the readings of the ohm-meter for different switch positions.

switch			meter reading
S_1	S_2	S_3	/ Ω
open	open	open	∞
closed	open	open	15 Ω
open	closed	open	30 Ω
open	closed	closed	15 Ω

(a) Identify the faulty lamp, and the nature of the fault.

faulty lamp: .....

nature of fault: ..... [2]

(b) Suggest why it is advisable to test the circuit using an ohm-meter that causes negligible current rather than with a power supply.

.....

..... [1]

(c) Determine the resistance of one of the non-faulty lamps, as measured using the ohm-meter.

resistance = ... Ω [1]

(d) Each lamp is marked 6.0 V, 0.20 A.

Calculate, for one of the lamps operating at normal brightness,

(i) its resistance,

resistance = ... Ω [2]

(ii) its power dissipation.

power = ... W [2]

(e) Comment on your answers to **(c)** and **(d)(i)**.

.....

.....

.....[2]

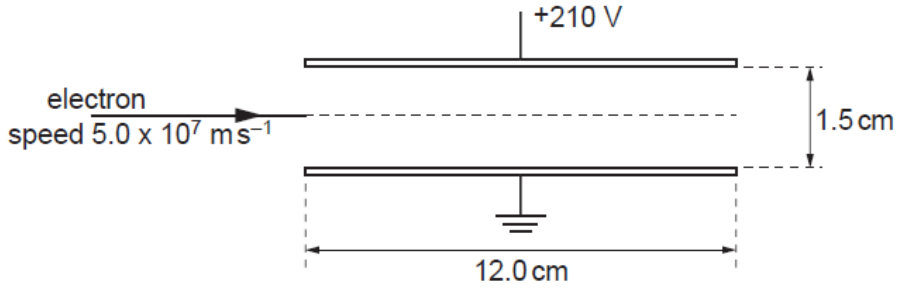
June 2007

2 **(a)** Define *electric field strength*.

.....

.....[1]

(b) Two flat parallel metal plates, each of length 12.0 cm, are separated by a distance of 1.5 cm, as shown in Fig. 2.1.



The space between the plates is a vacuum.
The potential difference between the plates is 210 V. The electric field may be assumed to be uniform in the region between the plates and zero outside this region.
Calculate the magnitude of the electric field strength between the plates.

field strength = ...N C^{-1} [1]

(c) An electron initially travels parallel to the plates along a line mid-way between the plates, as shown in Fig. 2.1. The speed of the electron is 5.0×10^7 m s^{-1}.

For the electron between the plates,

(i) determine the magnitude and direction of its acceleration,

acceleration = ... m s^{-2}

direction .....[4]

(ii) calculate the time for the electron to travel a horizontal distance equal to the length of the plates.

time = ... s [1]

(d) Use your answers in **(c)** to determine whether the electron will hit one of the plates or emerge from between the plates.

[3]

6 A car battery has an internal resistance of 0.060 Ω. It is re-charged using a battery charger having an e.m.f. of 14 V and an internal resistance of 0.10 Ω, as shown in Fig. 6.1.

June 2007

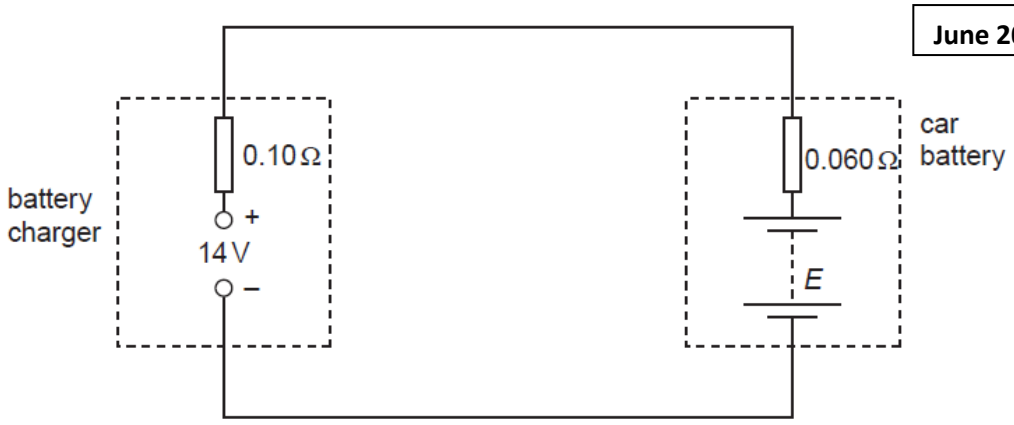


Fig. 6.1

(a) At the beginning of the re-charging process, the current in the circuit is 42 A and the e.m.f. of the battery is *E* (measured in volts).

(i) For the circuit of Fig. 6.1, state

1. the magnitude of the total resistance,

resistance = ... Ω

2. the total e.m.f. in the circuit. Give your answer in terms of *E*.

e.m.f. = ... V

[2]

(ii) Use your answers to **(i)** and data from the question to determine the e.m.f. of the car battery at the beginning of the re-charging process.

e.m.f. = ...V [2]

(b) For the majority of the charging time of the car battery, the e.m.f. of the car battery is 12V and the charging current is 12.5A. The battery is charged at this current for 4.0 hours. Calculate, for this charging time,

(i) the charge that passes through the battery,

charge = ... C [2]

(ii) the energy supplied from the battery charger,

energy = ... J [2]

(iii) the total energy dissipated in the internal resistance of the battery charger and the car battery.

energy = ... J [2]

(c) Use your answers in **(b)** to calculate the percentage efficiency of transfer of energy from the battery charger to stored energy in the car battery.

efficiency = ... % [2]

June 2008

6 An electric heater consists of three similar heating elements A, B and C, connected as shown in Fig. 6.1.

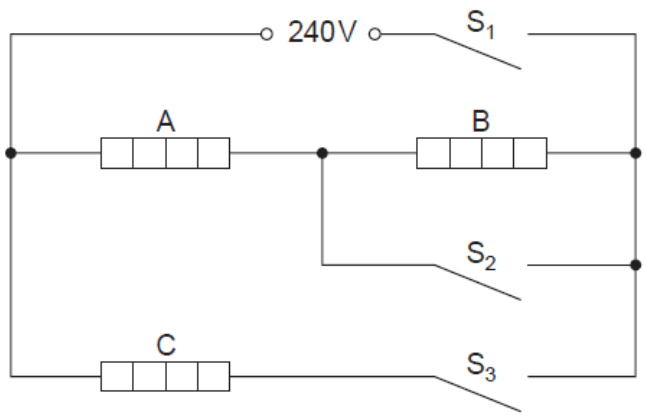


Fig. 6.1

Each heating element is rated as 1.5kW, 240V and may be assumed to have constant resistance.
The circuit is connected to a 240V supply.

(a) Calculate the resistance of one heating element.

resistance = ... Ω [2]

(b) The switches S_1, S_2 and S_3 may be either open or closed.

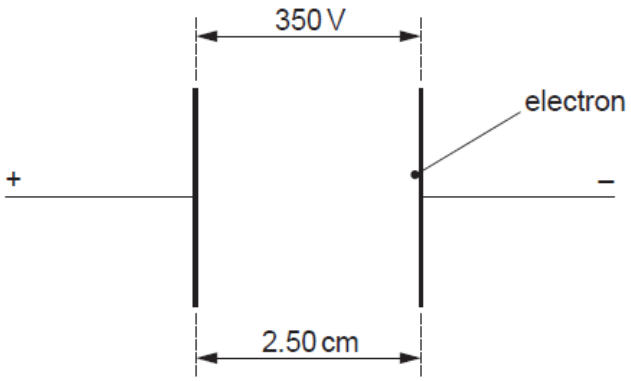
Complete Fig. 6.2 to show the total power dissipation of the heater for the switches in the positions indicated.

S_1	S_2	S_3	total power / kW
open	closed	closed	.....
closed	closed	open	.....
closed	closed	closed	.....
closed	open	open	.....
closed	open	closed	.....

[5]

6 Two vertical parallel metal plates are situated 2.50 cm apart in a vacuum. The potential difference between the plates is 350 V, as shown in Fig. 6.1.

June 2009



An electron is initially at rest close to the negative plate and in the uniform electric field between the plates.

(a) (i) Calculate the magnitude of the electric field between the plates.

electric field strength = ... NC^{-1} [2]

(ii) Show that the force on the electron due to the electric field is 2.24×10^{-15} N.

[2]

(b) The electron accelerates horizontally across the space between the plates. Determine

(i) the horizontal acceleration of the electron,

acceleration = ... $m\,s^{-2}$ [2]

(ii) the time to travel the horizontal distance of 2.50 cm between the plates.

time = ... s [2]

(c) Explain why gravitational effects on the electron need not be taken into consideration in your calculation in **(b)**.

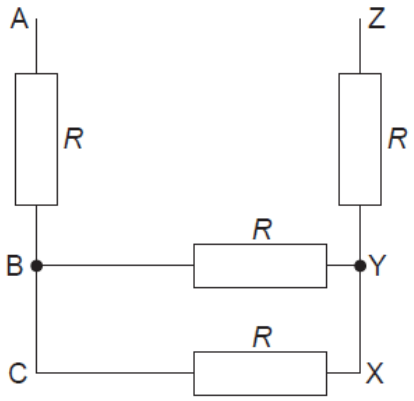
.....

.....

..... [2]

June 2008

7 A network of resistors, each of resistance R, is shown in Fig. 7.1.



(a) Calculate the total resistance, in terms of R, between points

(i) A and C,

resistance = ... [1]

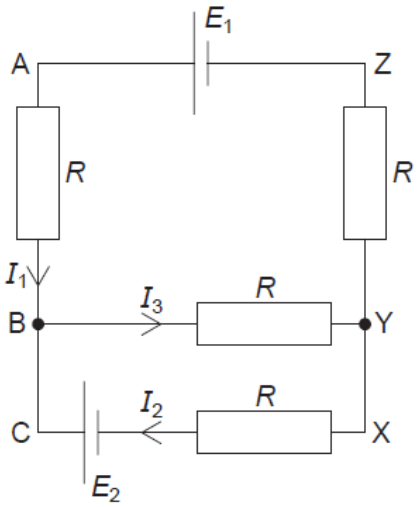
(ii) B and X,

resistance = ... [1]

(iii) A and Z.

resistance = ... [1]

(b) Two cells of e.m.f. E_1 and E_2 and negligible internal resistance are connected into the network in **(a)**, as shown in Fig. 7.2.



The currents in the network are as indicated in Fig. 7.2.

Use Kirchhoff's laws to state the relation

(i) between currents I_1, I_2 and I_3,

..... [1]

(ii) between E_2, R, I_2 and I_3 in loop BCXYB,

..... [1]

(iii) between E_1, E_2, R, I_1 and I_2 in loop ABCXYZA.

..... [1]

6 Two vertical parallel metal plates are situated 2.50 cm apart in a vacuum. The potential difference between the plates is 350 V, as shown in Fig. 6.1.

June 2009/22

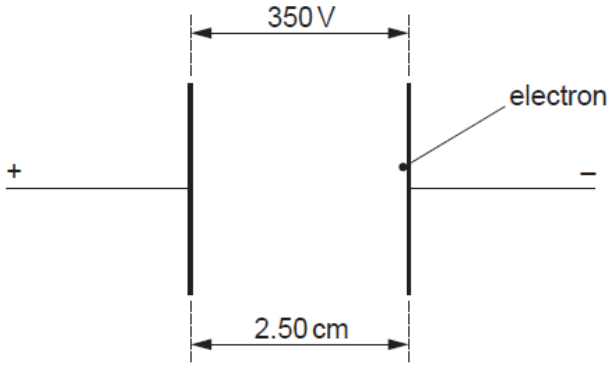


Fig. 6.1

An electron is initially at rest close to the negative plate and in the uniform electric field between the plates.

(a) (i) Calculate the magnitude of the electric field between the plates.

electric field strength = ... NC^{-1} [2]

(ii) Show that the force on the electron due to the electric field is 2.24×10^{-15} N.

(b) The electron accelerates horizontally across the space between the plates. Determine

(i) the horizontal acceleration of the electron,

acceleration = ... $m\,s^{-2}$ [2]

(ii) the time to travel the horizontal distance of 2.50 cm between the plates.

time = ... s [2]

(c) Explain why gravitational effects on the electron need not be taken into consideration in your calculation in **(b)**.

.....

.....

..... [2]

7 **(a)** A network of resistors, each of resistance *R*, is shown in Fig. 7.1.

June 2009/22

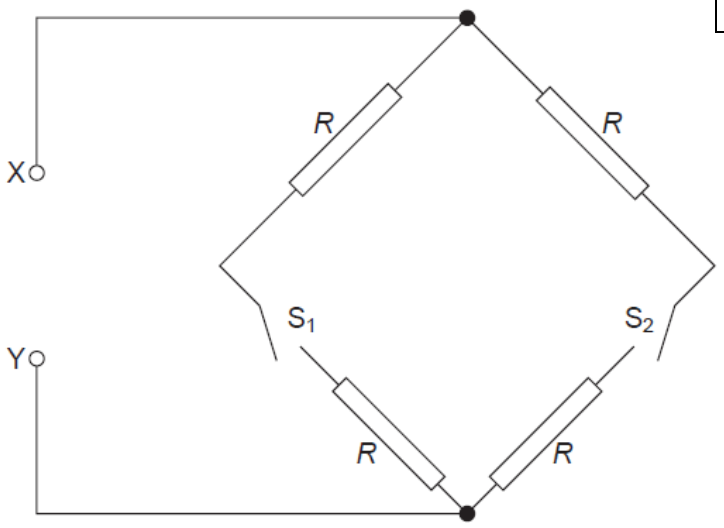


Fig. 7.1

Switches S_1 and S_2 may be 'open' or 'closed'.

Complete Fig. 7.2 by calculating the resistance, in terms of *R*, between points X and Y for the switches in the positions shown.

switch S_1	switch S_2	resistance between points X and Y
open	open	.....
open	closed	.....
closed	closed	.....

Fig. 7.2

[3]

(b) Two cells of e.m.f. E_1 and E_2 and negligible internal resistance are connected into a network of resistors, as shown in Fig. 7.3.

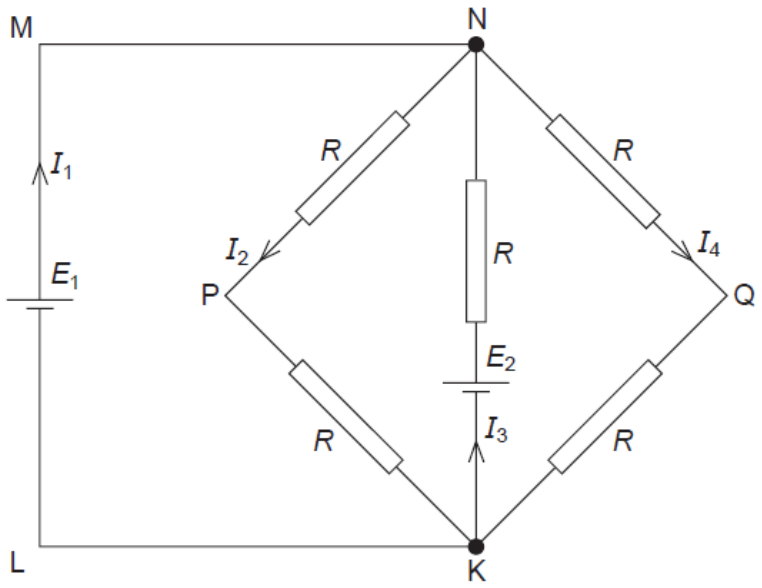


Fig. 7.3

The currents in the network are as indicated in Fig. 7.3.

Use Kirchhoff's laws to state the relation

(i) between currents I_1, I_2, I_3 and I_4,

.....[1]

(ii) between E_1, E_2, R, and I_3 in loop NKLMN,

.....[1]

(iii) between E_2, R, I_3 and I_4 in loop NKQN.

.....[1]