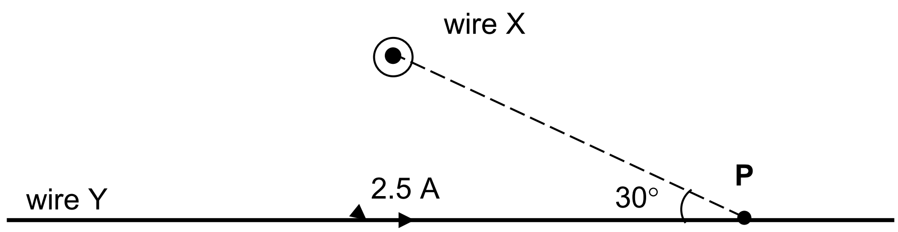
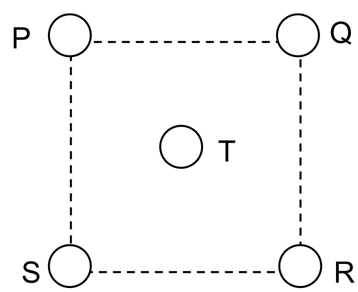
H2 Physics Revision – Electromagnetism

1 Two long straight current-carrying wires X and Y, are placed perpendicular to each other as shown. The directions of current flow in the two wires are indicated in the figure below.



The magnetic flux density at point P due to the magnetic field produced by wire X is 0.10 mT, and 2.5 A of current flows through wire Y. Calculate the magnitude and state the direction of the force per unit length acting on wire Y at point P.

2 In the following figure, P, Q, R, S and T are cross sections of conductors carrying equal magnitudes of currents. P, Q, R and S are fixed at the four corners of a square while T is placed loosely at the intersection of its diagonals.

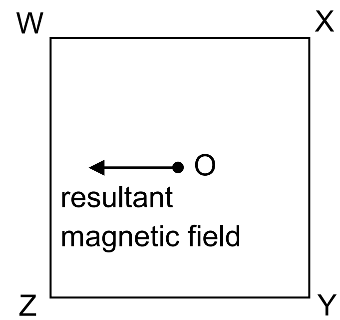


T experiences no net electromagnetic force due to the other four conductors. Given that P and Q carry currents in opposite direction, which one of the following statements provides a possible description of the directions of current in R, S and T?

	R	**S**	**T**
A	Same as Q	Same as P	Independent of P, Q, R, S
B	Same as P	Same as Q	Independent of P, Q, R, S
C	Same as Q	Same as P	Dependent on P, Q, R, S
D	Same as P	Same as Q	Dependent on P, Q, R, S

3 Four parallel conductors, carrying equal currents, pass vertically through the four corners of a square WXYZ. In two conductors, the current is directed into the page and in the other two, it is directed out of the page.

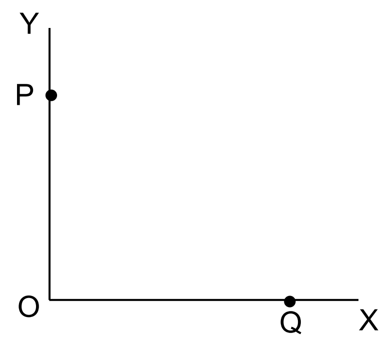
State the directions of the currents at each corner if a resultant magnetic field is to be produced at O in the direction shown.



4 The diagram shows a flat surface with lines OX and OY at right angles to each other.

Which current in a straight conductor will produce a magnetic field at O in the direction OX?

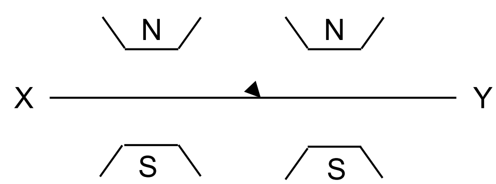
A At P into the plane of the diagram.
B At P out of the plane of the diagram.
C At Q into the plane of the diagram.
D At Q out of the plane of the diagram.



5 A straight wire carrying a steady current from X to Y lies between the poles of two similar permanent magnets, each of which produces a uniform field in the direction NS at right angles to the wire.

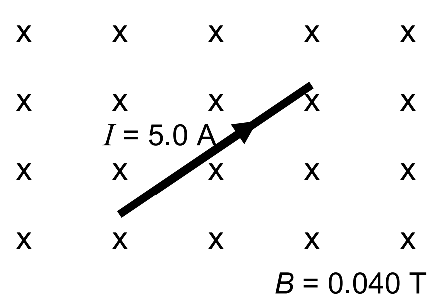
The wire experiences

A A force in the direction XY.
B A force in a direction at right angles to XY and NS.
C No resultant force
D A couple tending to rotate the wire about an axis parallel to NS.

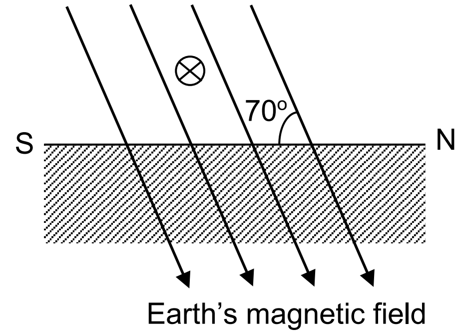


6 A wire of length 3.0 cm is placed on the plane of the paper as shown. A magnetic field of flux density 0.040 T acts into the plane of the paper.

The wire carries a current of 5.0 A. Calculate the magnitude of the force which the field exerts on the wire.



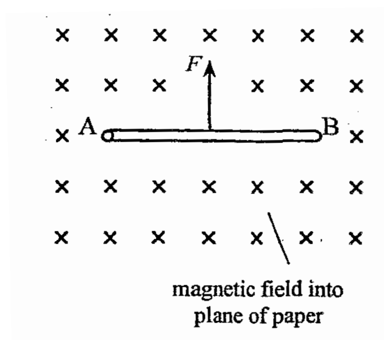
7 A horizontal power cable carries a steady current in an east-to-west direction i.e. into the plane of the diagram. Sketch, on the diagram, the direction of force on the cable caused by the Earth's magnetic field, in a region where this field is at 70° to the horizontal.



8 A wire of mass 4.5 g and length 0.57 m is placed at right angles to a uniform magnetic field of flux density 1.8×10^{-3} T as shown.

The wire has a resistance of 0.050 Ω.

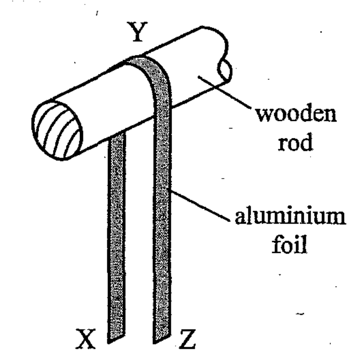
A potential is applied between the ends of the wire so that there is a magnetic force *F* acting on the wire, as shown.



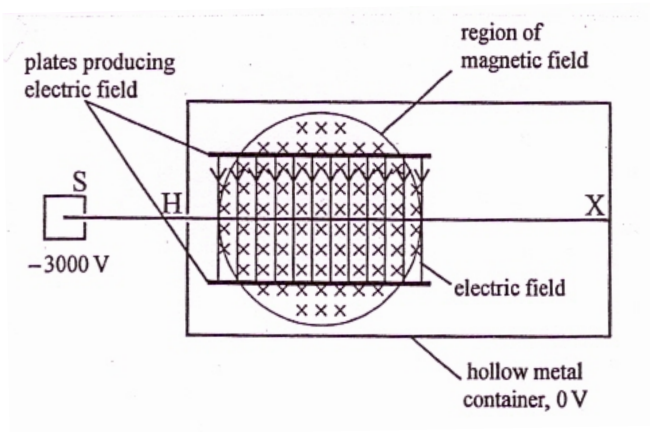
(a) State the direction of the current in the wire.
(b) Calculate the potential difference required between the ends of the wire for the magnetic force on the wire to equal its weight.
(c) Given that the horizontal component of the Earth's magnetic field is 1.8×10^{-5} T, explain why, in practice, current-carrying wires are not seen floating in the air.

9 The given diagram shows a long length of aluminium foil XYZ hung over a wooden rod. A large current is momentarily passed through the aluminium foil in the direction XYZ, and the foil moves (the foil is not damaged).

State and explain the directions in which XY and YZ will move.



10 The given diagram illustrates a section of a mass spectrometer, which is in a vacuum. At the source S, which is kept at a potential of -3000 V, negative ions of mass 2.84×10^{-26} kg and charge -1.60×10^{-19} C are generated.



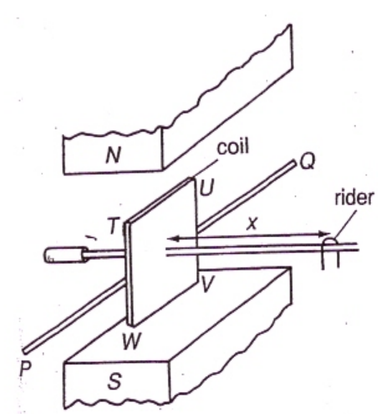
The ions accelerate in a narrow beam from S towards H, which is a hole in a hollow metal casing. The casing is kept at zero potential.

Upon entering the casing, the negative ions enter a region in which a magnetic field of flux density 0.83 T and an electric field of field strength E are applied at right angles to each other. The negative ions continue moving with constant velocity in a straight line through the fields.

(a) Determine the velocity of the ions when they reach H.
(b) With the aid of a sketch, describe how it is possible for the ions not to be deflected in the fields.
(c) Determine the electric field strength E.
(d) When the electric field is switched off, describe, without calculation, what would happen to the path of the negative ions.

11 **(a)** Write down the equation defining magnetic flux density in terms of F, the force it produces on a long, straight conductor of length L carrying a current I at an angle θ to the field. Draw a clear diagram to illustrate the direction of the force relative to the current and magnetic field.

A small square coil of N turns has sides of length L and is mounted so that it can pivot freely about a horizontal axis PQ, parallel to one pair of sides of the coil, through its centre. The coil is situated between the poles of a magnet which produces a uniform magnetic field of flux density B. The coil is maintained in a vertical plane by moving a ride of mass M along the coil. When a current I flows through the coil, equilibrium is restored by placing the rider a distance x along the beam from the coil.



(b) Starting from the definition of magnetic flux density, show that B is given by the expression $B = \dfrac{Mgx}{IL^2N}$.

(c) The current is supplied by a battery of constant e.m.f. and negligible internal resistance. Discuss the effect on *x* when the coil is replaced by one wound with similar wire but having

(i) sides of length *L* with 2*N* turns.

(ii) *N* turns with sides of length *L*/2

12 An electron moves in a circular path in a vacuum, under the influence of a magnetic field. The radius of the path is 10^{-2} m and the flux density is 10^{-2} T. Given that the specific charge of the electrons is -1.76×10^{11} C kg^{-1}, calculate

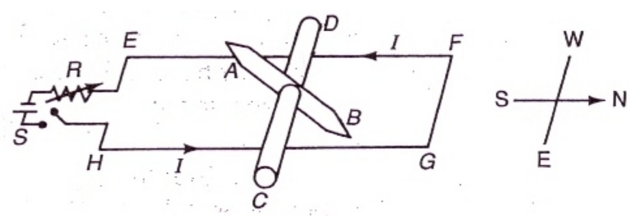
(a) the period of its orbit,

(b) the period if the electron had only half as much energy.

13 An electron is projected in vacuum along the axis of a current-carrying solenoid. Describe and explain its motion.

14 The magnetic flux density at the end of a long solenoid is *B*. State the flux density at the centre of the solenoid. Explain your reasoning.

15 A magnet AB is pivoted at its centre of gravity on a freely moving non-conducting rod CD, supported midway between two long straight conducting wires EF and GH, as shown in the diagram.



The wires are parallel, in the same horizontal plane, and lie in the North-South direction. With the switch S open, the magnetic field of the Earth causes the magnet to dip as shown. When the switch is closed, the resistor *R* can be adjusted so that the field due to the current I causes the magnet to set horizontally in the same plane as EFGH. This happens when the field due to the wires neutralizes the vertical component of the Earth's magnetic field.

(a) Calculate the vertical component of the flux density of the Earth's magnetic field. I = 3.0 A and EH = FG = 0.50 m. [Magnetic flux density due to long straight current-carrying conductor is $B = \frac{\mu_0 I}{2\pi r}; \mu_0 = 4\pi \times 10^{-7}$ H m^{-1}]

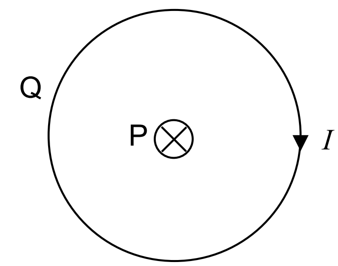
(b) Discuss what would happen to the pivoted magnet if the current I were increased to a very large value

(i) in the same direction as shown in the diagram,

(ii) in a direction opposite to that shown.

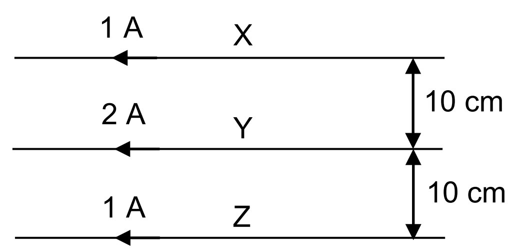
16 In the diagram below, Q is a circular coil of wire carrying a clockwise current I as shown. P is a long, straight wire carrying a current perpendicularly into the plane of the paper through the centre of the coil.

State and explain the direction of the force acting on each part of the wire Q.



17 Three long, parallel, straight wires X, Y and Z are placed in the same plane in a vacuum as shown in the diagram.

The force per unit length between two long, parallel, straight wires placed 10 cm apart, each carrying a current of 1 A is 2 × 10^{-6} N m^{-1}. Determine the net force per unit length acting on Z.



[Magnetic flux density due to long straight current-carrying conductor is $B = \frac{\mu_0 I}{2\pi r}$]

Answer Key:

1	2.17 x 10^{-4} N m^{-1}	**2**	B	**3**	-
4	B	**5**	B	**6**	0.0060 N
7	-	**8(b)**	2.2 V	**9**	-
10(a)	1.84 x 10^{5} m s^{-1}	**10(c)**	1.53 × 10^{5} N C^{-1}	**11**	-
12(a)	3.6 × 10^{-9} s	**12(b)**	3.6 × 10^{-9} s	**13**	-
14	-	**15(a)**	4.8 x 10^{-6} T	**16**	-
17	9.0 × 10^{-6} N m^{-1}				