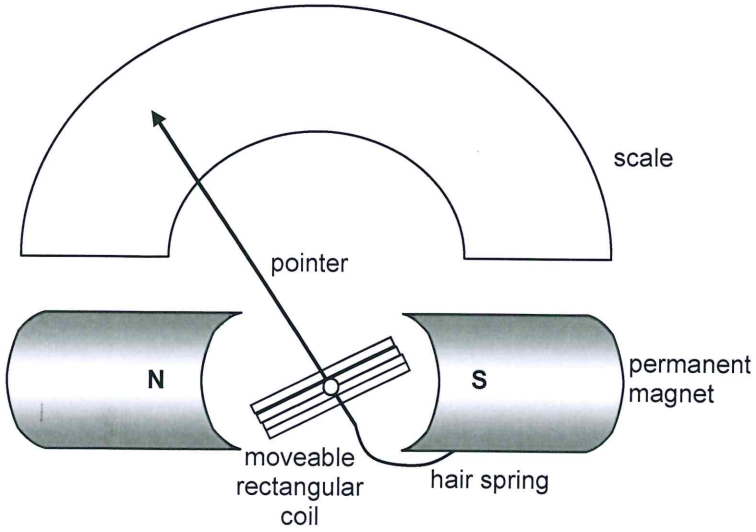
Exam Question
Chapter 5.4 - Electric Motors
Question 1: 2010:2:16

(13 marks)

Analogue meters, like the one shown in the diagram below, have many applications: for example, in pool chlorination systems. The interaction of the electric current in the coil and the permanent magnet creates a torque. A fine spring (hair spring) provides a restoring torque.



(a) When a current flows in the rectangular coil, a force is produced on each side of the coil that interacts with the magnetic field. Explain the reason for this force and comment on its direction. You must draw a diagram to illustrate your explanation. (3 marks)

(b) The coil has a length of 0.100 m and a width of 0.0800 m and has 50.0 turns. There is a current of 4.00 A in the coil and it is in a uniform magnetic field of 0.0100 T.

(i) Calculate the force on one of the long sides of the coil. (4 marks)

(ii) Hence determine the torque acting on the coil. (3 marks)

(c) Why will the coil rotate? (2 marks)

(d) The loosely-coiled spring provides a torque that opposes the coil's rotation. When the coil is stationary, with a current flowing in it, state the relationship between the torque acting on the coil because of the magnetic field, and the torque provided by the spring. (1 mark)

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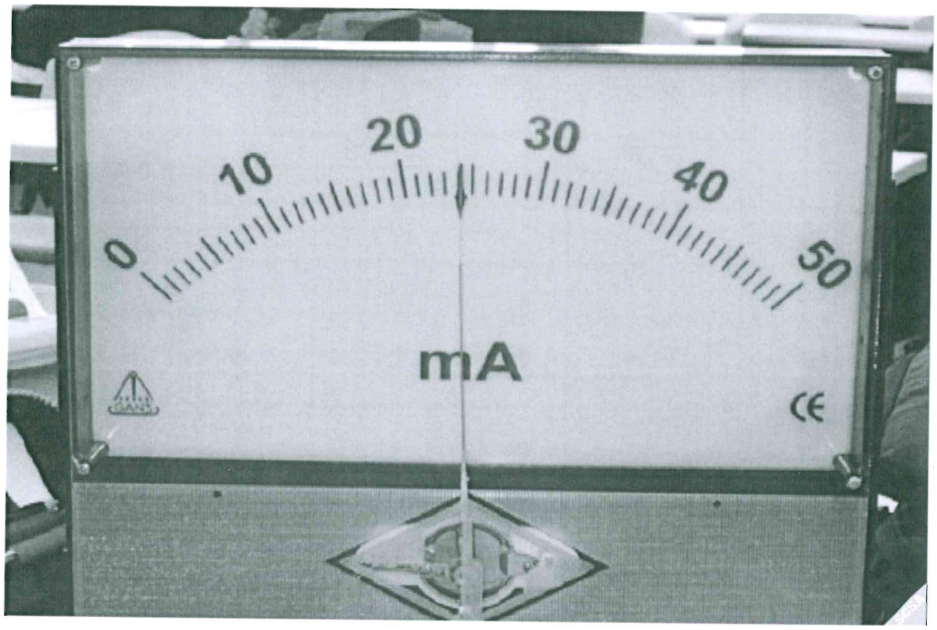
Question 2 2013:2:14

(16 marks)

An ammeter is a device that is used to determine the magnitude of an electric current. The unknown current is passed through a coil of wire in a magnetic field. The turning effect of the current-carrying coil is balanced by a spring and a corresponding value is read from the meter.

(a) Use the photograph below of an ammeter's scale to determine the magnitude of the current passing through it, as well as the absolute and relative uncertainty for this value. (3 marks)

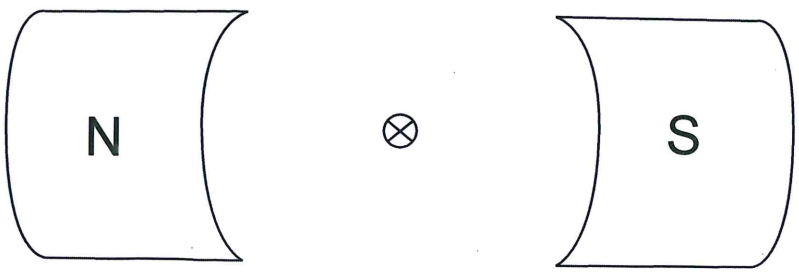


Current: _____mA

Absolute uncertainty: _____

Relative uncertainty: _____

(b) A simplified diagram representing one current-carrying wire of the ammeter's coil between two magnets, is shown below. Draw at least **five** field lines to show the resultant magnetic field between the magnets. (4 marks)



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Question 2 continued

(c) Calculate the magnitude of the force, in newtons, acting on the wire carrying a current of 1.45 A in the simplified diagram on page 14, given that the magnetic field strength is 4.25×10^{-2} T and the length of the wire in the field is 2.50×10^{-2} m. (2 marks)

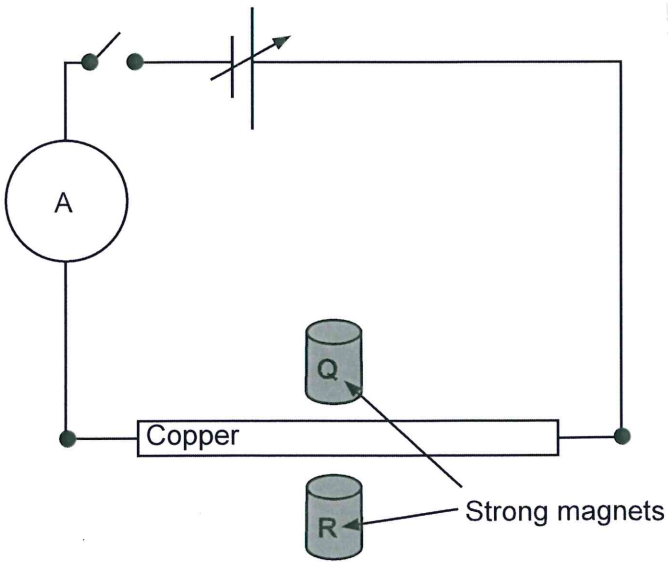
(d) The actual ammeter shown has 250 turns of wire that form a square coil with sides of 3.20×10^{-2} m. Determine the magnitude of the current in amperes, given that the spring provides a restoring torque of 2.65×10^{-2} N m in the magnetic field strength of 4.25×10^{-2} T. (4 marks)

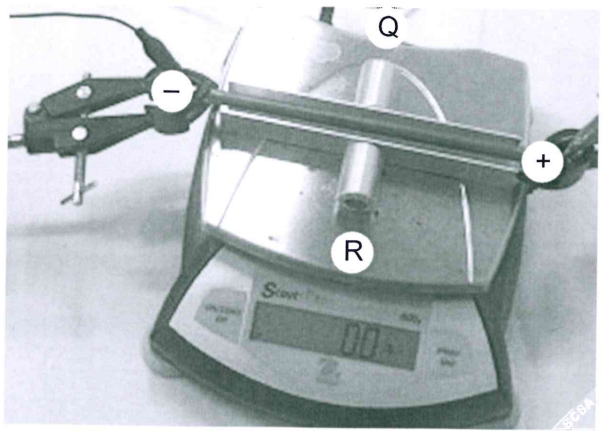
(e) When the ammeter is disconnected, the spring rotates the coil so that the marker needle returns to zero. This causes a change in flux of 2.18×10^{-5} Wb to occur in the coil in 0.115 s. Determine the average potential difference induced in the coil during this change. Include the units in your answer. (3 marks)

Question 3 2014:2:20

(18 marks)

Jake wanted to determine the strength of a magnetic field by conducting an investigation. In this investigation, two identical cylindrical permanent magnets, each 2.0 cm in diameter, were placed opposite each other on either side of an aluminium channel. A current was passed along a 20 cm copper rod, which in turn was placed perpendicularly in the magnetic field. The interaction between the permanent magnets and the current-carrying wire produced a downward force acting on the magnets which was measured using a digital balance. Photographs of the equipment are shown below, as is a schematic diagram of the circuit.





Close up of magnets and copper rod on digital balance

(a) Using the photograph above, for magnets labelled Q and R, write either 'North' or 'South' in the space below to indicate which pole the magnet would need to have next to the channel to provide the magnets with a force directed downward (into the pan of the balance). (2 marks)

For magnet Q, the _____ pole would be next to the channel.

For magnet R, the _____ pole would be next to the channel.

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Question 3 continued

(b) A table of results for this investigation is shown below:

Potential difference (V)	Current (A)	Scale reading (g)	Force (N)
0.00	0.00	0.00	0.0
2.0	0.94	0.30	
4.0	1.81	0.70	6.9×10^{-3}
6.0	2.67	0.90	
8.0	3.66	1.3	1.3×10^{-2}
12	5.30	1.9	1.9×10^{-2}

(i) Complete the last column in the table above with values expressed to **two** significant figures. (2 marks)

(ii) Use the data from the table to plot a straight line graph on the grid provided, demonstrating the relationship between the current and force. (4 marks)

(iii) Use your graph to determine the force that should be measured when a current of 4.0 A flows through the copper rod. Express your answer using appropriate significant figures. (3 marks)

(iv) Determine the gradient of your line of best fit. Include units in your answer. (3 marks)

(v) Use your gradient to determine the experimental value of the magnetic field strength. Include units in your answer. Show **all** workings. (4 marks)