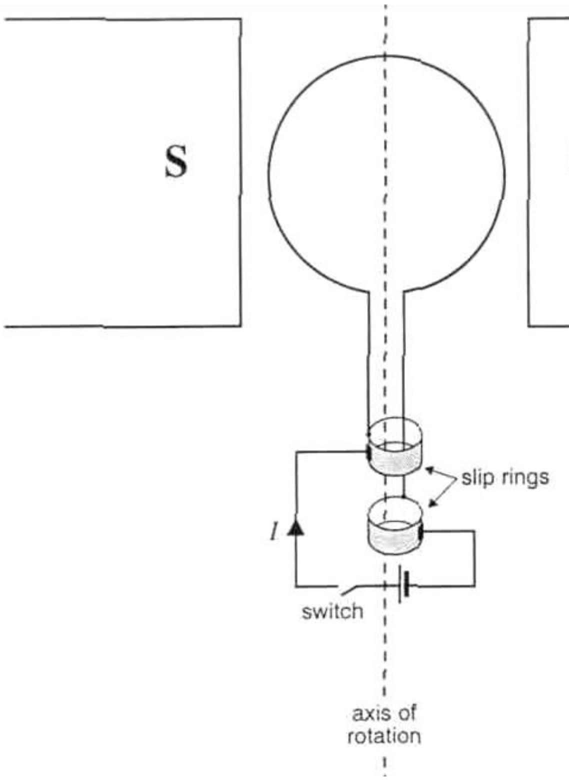
Multiple choice questions

The coil is initially set with its plane parallel to the magnetic field as shown, and the switch is open so that no current flows.



Example 1 2000 Question 13, 2 marks

The switch is closed. Which **one** of the statements (**A - D**) best describes the situation after current begins to flow?

A. The coil begins to rotate, but stops after turning through 90°.

B. The coil begins to rotate and, after rotating one half turn, rotates back to its original position. It then continues to oscillate in this way.

C. The coil does not move.

D. The coil rotates continuously.

Example 2 2000 Question 14, 2 marks

If the slip rings were replaced with a commutator, which **one** of the statements (**A - D**) best describes the situation after the switch is closed, and the current begins to flow?

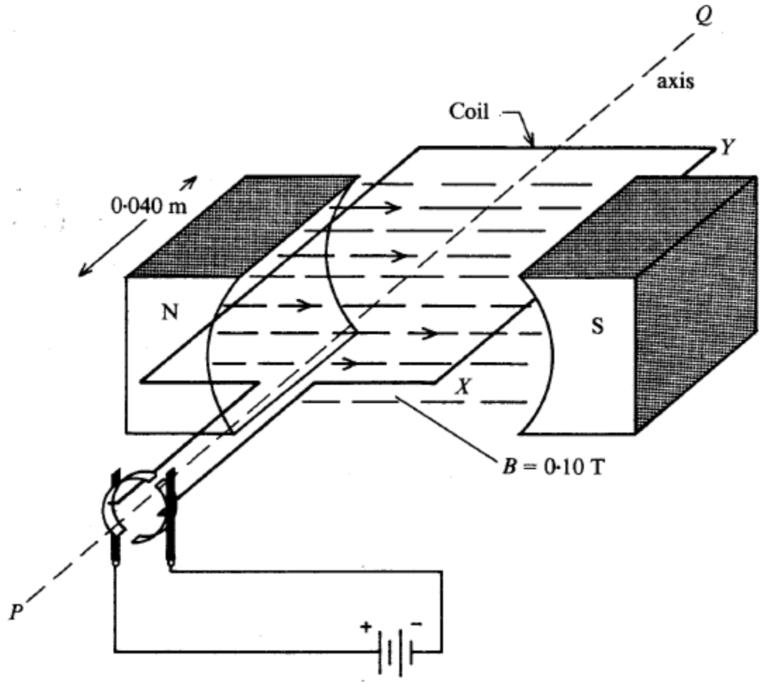
A. The coil begins to rotate, but stops after turning through 90°.

B. The coil begins to rotate and, after rotating one half turn, rotates back to its original position. It then continues to oscillate in this way.

C. The coil does not move.

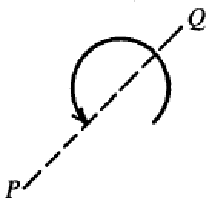
D. The coil rotates continuously.

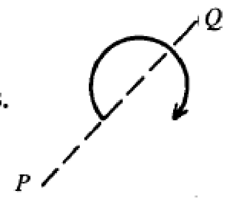
The essential features of a small, DC electric motor are shown in the diagram below. The rotating coil of the motor is connected to a DC supply whose polarity is marked on the diagram. The direction of the magnetic field is also shown on the diagram.



Example 3 1986 Question 69, 1 mark

With the coil in the position shown in the diagram which of the following (**A - C**) shows the direction of rotation of the coil?

A. 

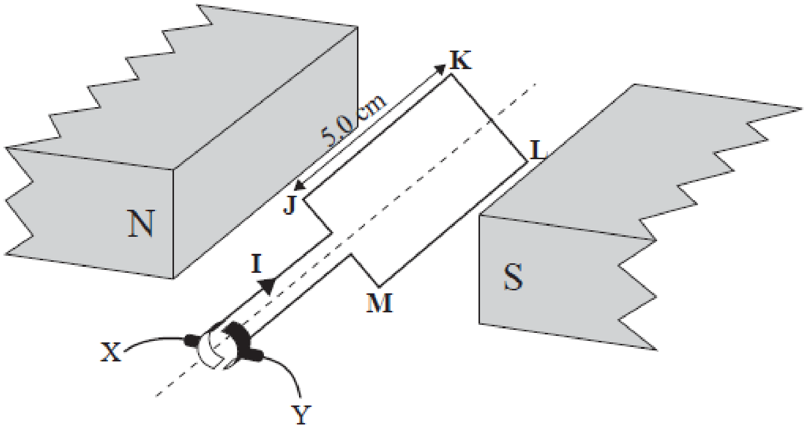
B. 

C. Will not rotate

Extended questions

Use the following information to answer Questions 3-5.

The figure below shows a schematic diagram of a DC electric motor. The motor has a rectangular coil, JKLM, of 50 turns. The permanent magnets provide a magnetic field of 0.30 T in the region of coil JKLM. The commutator with contacts X and Y is connected to a source of constant DC current.



Example 4 2011 Question 3, 3 marks

Explain the role of the commutator in the operation of the motor.

Example 5 2011 Question 4, 1 mark

A current, I, is flowing through the rectangular coilin the direction shown.
When the coil is in the position shown in the diagram, draw an arrow on side JK to show the direction of the magnetic force on side JK.

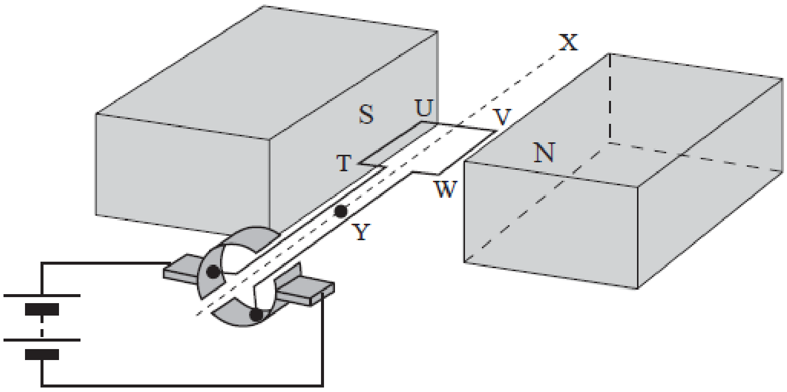
Example 6 2011 Question 5, 2 marks

A current of 6.0 amp is flowing in the 50-turn rectangular coil. The length of side JK is 5.0 cm. Calculate the magnitude of the magnetic force acting on side when it is in the position as shown.

The following information relates to Questions 5 – 8.

The figure below shows a diagram of a simple DC motor. The single square loop coil **TUVW**, of side 0.0090 m, is free to rotate about the axis XY. Current is supplied from a battery via the split-ring commutator.

The two permanent magnets provide a uniform magnetic field **B** of magnitude 0.25 T in the region of the coil. The current flowing in the coil is 2.0 amp.



Example 7 2009 Question 5, 2 marks

Indicate with an arrow the direction of the force on side **TU** of the coil above.

Example 8 2009 Question 6, 2 marks

Calculate the magnitude of the force on the side **TU** of the coil. Show your working.

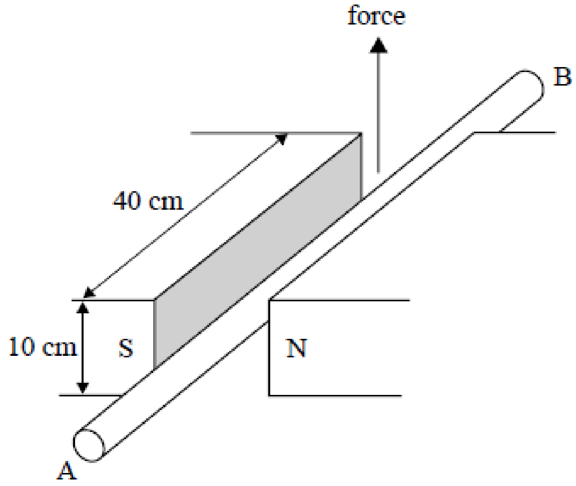
Example 9 2009 Question 7, 2 marks

What is the magnitude of the force acting on side **UV** of the coil when in the position shown above?

Example 10 2009 Question 8, 3 marks

Explain the purpose of the split-ring commutator.

The figure shows a magnet with pole pieces that are each 40 cm × 10 cm.
The uniform magnetic field strength between the poles is 2.0×10^{-3} T, and zero outside the poles.
A conducting wire, AB, carrying a current of 5.0 A, is placed between the poles as shown.
The force on the wire is upwards.



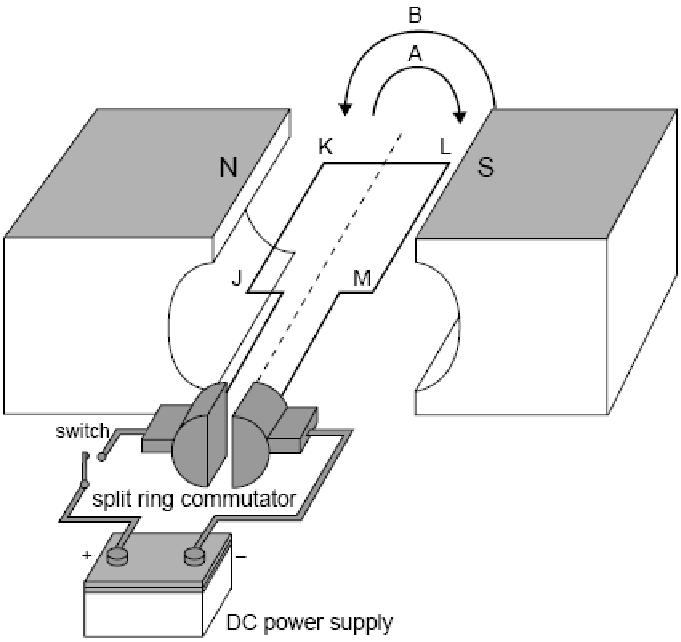
Example 11 2008 Question 2, 2 marks

In which direction, AB or BA, is the current flowing in the wire?

Example 12 2008 Question 3, 2 marks

What is the magnitude of the force on the wire?
Show working.

The figure shows a schematic diagram of a DC motor.



Example 13   2007 Question 4, 1 + 2 marks

The motor is initially stationary as shown above.

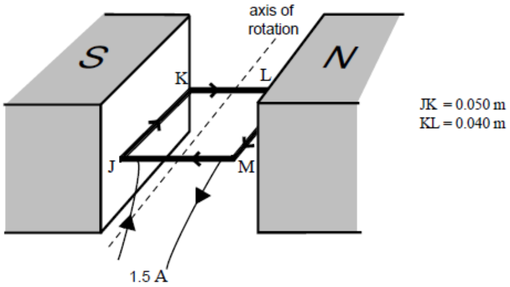
a. In which direction, A (clockwise) or B (anticlockwise), will the motor rotate when the switch is closed?

b. Explain your answer.

Example 14   2007 Question 5, 3 marks

Why is the split ring commutator necessary for the motor to operate correctly? Explain the operation of the commutator.

Two physics students set up a **50-turn coil** (JKLM), which is free to rotate about the axis shown as the dashed line in the figure below. The loop is placed between the poles of a magnet, in a uniform magnetic field of 0.040 T. The current in the coil is 1.5 A.



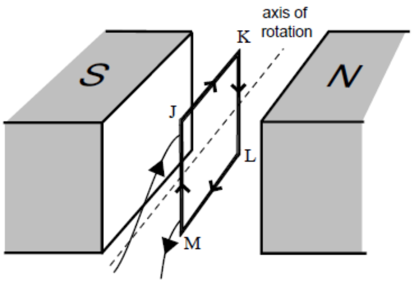
Example 15 1999 Question 4, 2 marks

What is the magnitude of the magnetic force on **side JK** (length = 0.050 m) of the 50-turn coil, when oriented as shown above?

Example 16 1999 Question 5, 2 marks

What is the magnitude of the magnetic force on **side KL** (length = 0.040 m) of the 50-turn coil, when oriented as shown above?

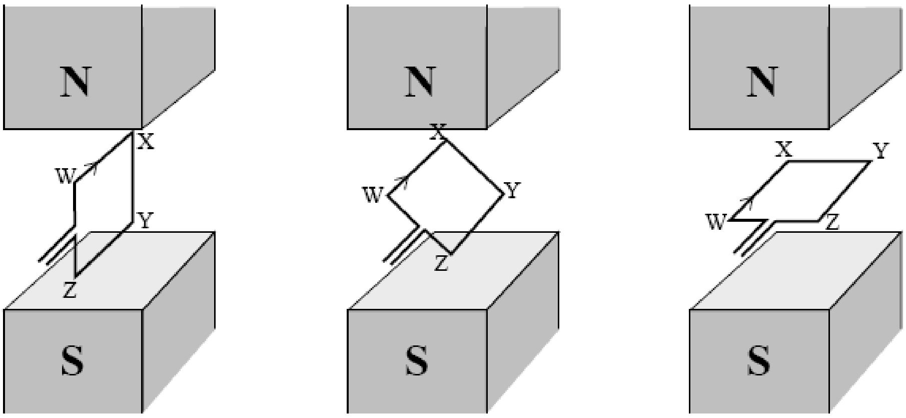
Two physics students set up a **50-turn coil** (JKLM), which is free to rotate about the axis shown as the dashed line. The loop is placed between the poles of a magnet, in a uniform magnetic field of 0.040 T. The current in the coil is 1.5 A.
The students now turn off the current and set the coil at rest, oriented as shown below. They then turn the current on again.



Example 17 1999 Question 6, 4 marks

What happens to the coil after the current is turned on? Explain your answer.

The figure below shows a single loop of wire in a uniform magnetic field. The loop can rotate, and is shown at three different orientations. In each case there is a current flowing around the coil from W to X to Y to Z.



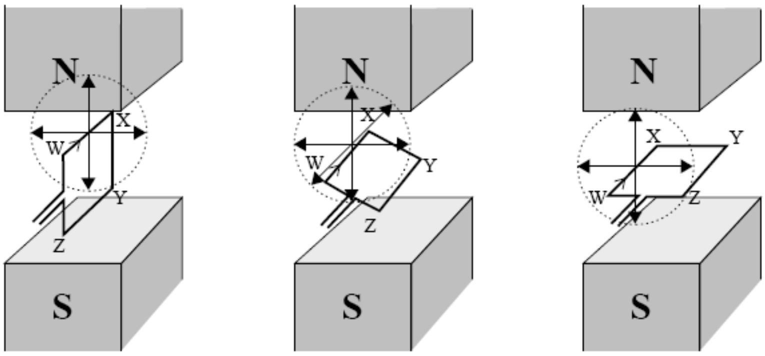
orientation (a) orientation (b) orientation (c)

Example 18 1998 Question 6, 2 marks

The magnetic field is 0.10 T, and the current in the loop is 0.30 A. With the loop in orientation (a) of Figure 4, what is the magnitude of the force acting on side WX of the coil? The length of side WX is 0.030 m. Show your working.

Example 19 1998 Question 7, 2 marks

In the figure below, the arrows indicate possible directions of the force on **side WX** of the loop in the three orientations (a), (b) and (c). The arrows in **each** orientation are in a plane perpendicular to the axis of rotation of the loop.
For **each** orientation, circle the **head of the arrow** which best represents the **direction** of the **magnetic force on side WX** of the coil. If there is no force on the side, write **NF** under the diagram.

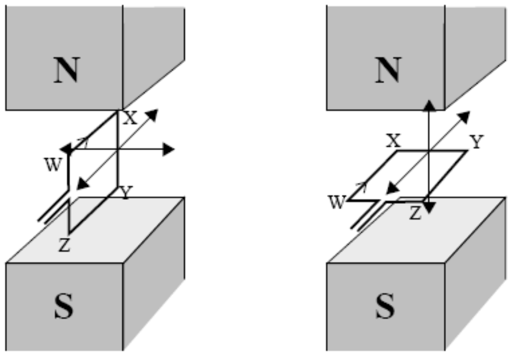


orientation (a) orientation (b) orientation (c)

In the figure below, the arrows indicate possible directions of the force on **side XY** for the loop in orientations (a) and (c).

Example 20 1998 Question 8, 2 marks

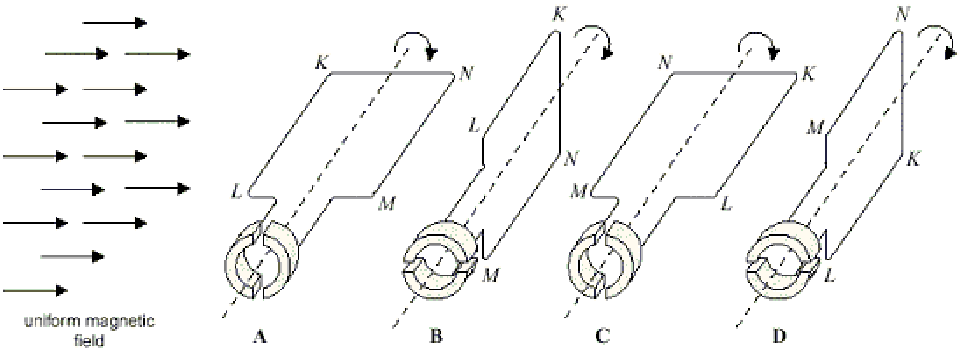
For **each** of the two orientations, circle the head of the arrow which best represents the **direction** of the **magnetic force on side XY** of the coil. If there is no force on the side, write **NF** under the diagram.



orientation (a) orientation (c)

The figure below shows four positions (A, B, C, D) of the coil of a DC motor. The coil can be assumed to be a single wire which is in a uniform magnetic field parallel to the coil when in the orientation shown in diagram A.

It rotates in the direction indicated, about the axis which passes through the middle of sides *LM* and *N*K. The coil is attached to a commutator, to which current is passed by brushes (not shown in the figure).



Example 21 1997 Question 9, 1 mark

For the coil as shown in orientation **A** above, in which direction is the current flowing in the side *K*L? Explain your answer.

Side *KL* of the coil is 0.10 m long, and a magnetic force of 0.60 N acts on it.

Example 22 1997 Question 10, 1 mark

If the magnetic field has a magnitude of 1.5 T, what is the magnitude of the current in the coil?

Example 23 1997 Question 11, 1 mark

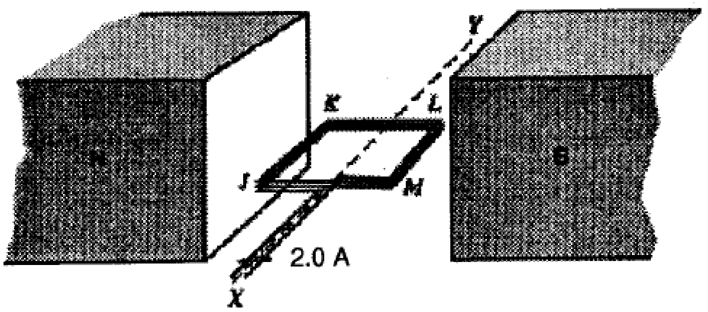
Consider **two** cases:

a. The coil is at rest with the orientation shown in diagram **A** above.

b. The coil is at rest with the orientation shown in diagram **B** above.

Explain what would happen, in each case, if current is allowed to flow in the coil. Your answer should discuss the forces on each side of the coil, and their net effect.

A student has pulled apart a small DC motor to observe how it operates. Although the motor looks complicated, the motor can be drawn in simple form as shown below. In this simple model the square coil, attached to the commutator, rotates in a uniform magnetic field of strength 0.50 T.
A current of 500 mA flows through the coil. Each side of the coil is 3.0 cm long.
A DC electric motor is illustrated below.



The permanent magnet shown above produces a uniform magnetic field of 3.0×10^{-2} T between the pole pieces. The coil JKLM, wound on a square armature of side 0.05 m, consists of 20 turns of wire. There is a current of 2.0 A in each turn of the coil. The armature can rotate about the axis XY.

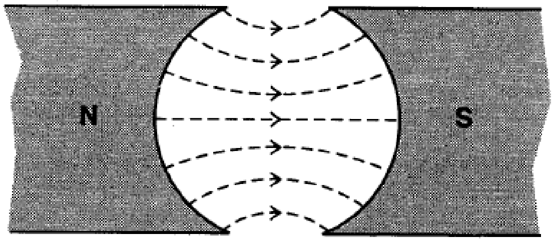
Example 24 1996 Question 7, 1 mark

For the coil oriented horizontally, as shown above, calculate the magnitude of the total force exerted on the 20 turns of side JK.

Example 25 1996 Question 8, 1 mark

For the coil oriented horizontally, as shown above, calculate the magnitude of the total force exerted on the 20 turns of side KL.

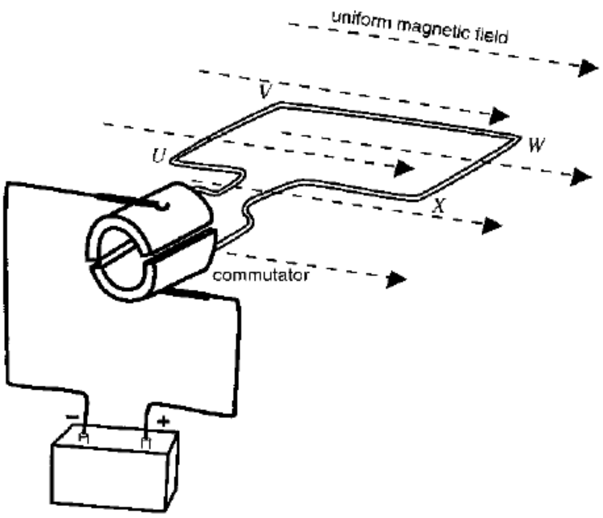
Curving the pole pieces of a magnet produces the magnetic field shown below. The maximum value of this field is 3.0×10^{-2} T. This magnetic field will provide a greater average torque on coil JKLM, with the same coil current, than the magnetic field shown above.



view as seen looking along axis XY

Example 26 1996 Question 9, 2 marks (This is not specifically on the course)

Explain why such pole pieces lead to a greater average torque on the coil.



Example 27 1995 Question 9, 1 mark

With the coil oriented as shown above, what is the magnitude of the force on side VW of the coil?

Example 28 1995 Question 10, 3 marks

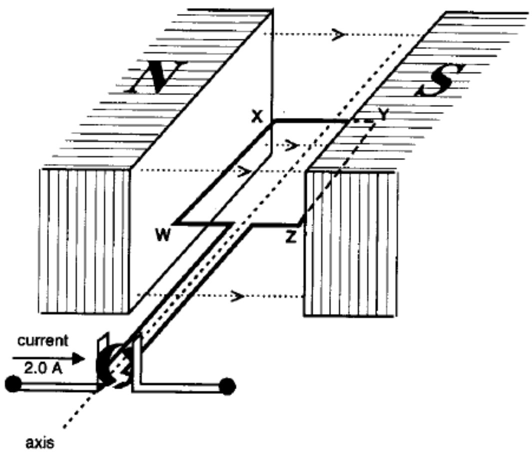
Describe the principles of operation of the simple motor shown above. In your answer discuss the direction of rotation, the purpose of the commutator, and the way the twisting effects of the forces depends on the coil orientation.

Example 29 1995 Question 11, 3 marks

In the motor above, calculate the force on side UV of the coil.

A student built a model DC motor. The motor is shown below. The arrows show the direction of the magnetic field. The coil of the motor was formed from 50 turns of wire. Each turn was rectangular having length 0 .050 m (sides WX and YZ) and width 0.030 m (sides XY and WZ). The magnetic field can be assumed to be uniform and have a value of 0.048 T.

The student mounted the coil to allow it to rotate freely and placed it between the poles of the magnet. When the terminals of the coil were connected to a battery the coil began to rotate.



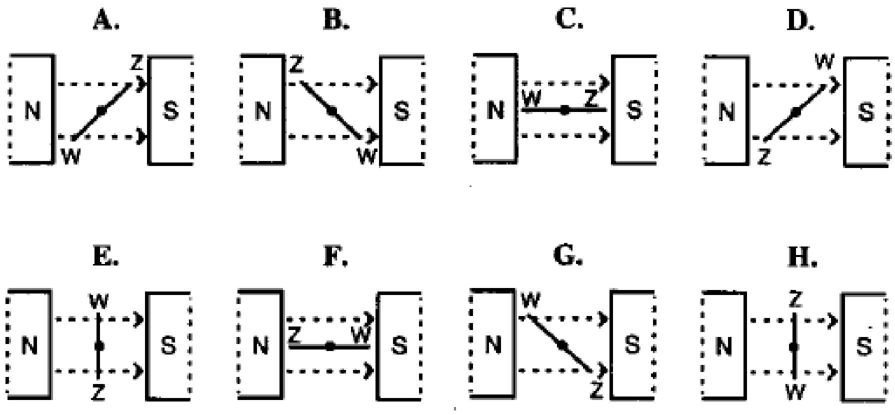
Example 30 1994 Question 1, 1 mark

Draw arrows on the diagram to show the direction of the force on sides WX and XY of the coil when the plane of the coil is parallel to the magnetic field and the current direction is as shown. If the force on either side is zero, then label that side 'zero force

Example 31   1994 Question 2, 1 mark

What is the magnitude of the force on the side YZ of the 50-turn coil when the coil is in the orientation shown, and the current in the coil is 2.0 A?

Several orientations of the coil, as viewed along the axis, are shown



Example 32   1994 Question 3, 2 marks

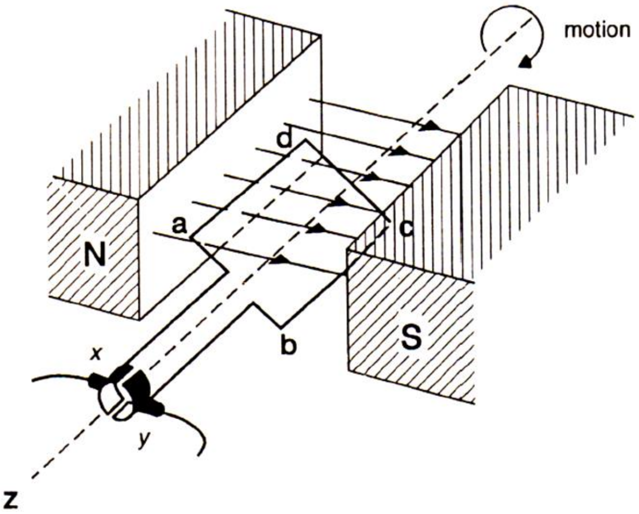
In which one or more orientations (**A - H** above) does the magnitude of the torque experienced by the coil have its maximum value? Justify your answer. You may find it helpful to draw diagrams to assist your explanation.

You are asked to design another motor, of the same type, in which the coil will experience a greater maximum torque. You may make any changes you wish.

Example 33   1994 Question 4, 2 marks

Describe two changes you would make and explain why each of these changes would increase the maximum torque on the coil.

The diagram below shows a model motor, with a split-ring commutator.



A battery is connected between X and Y, (see figure above). The coil then rotated continuously in one direction.

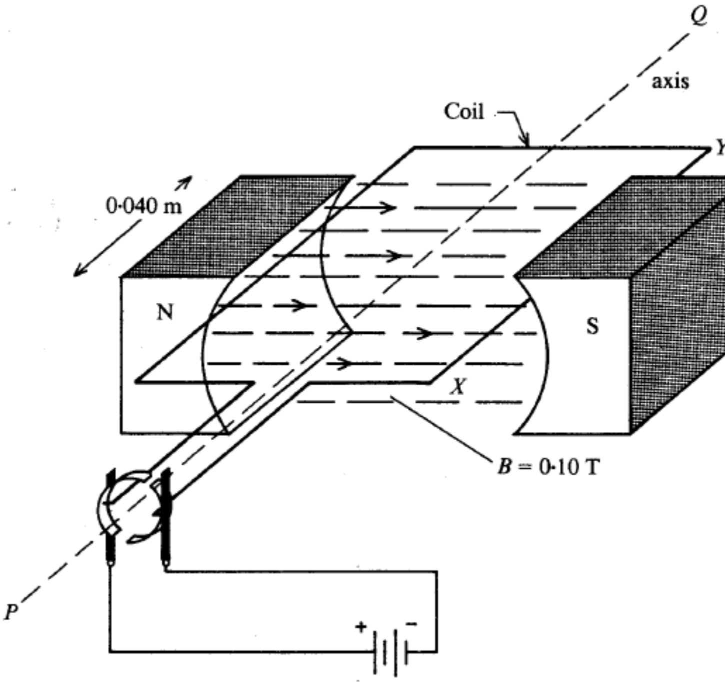
Example 34 1993 Question 4, 2 marks

Explain how the split-ring commutator enables the motor to rotate always in the same direction.

Example 35 1993 Question 5, 1 mark

How should the terminals of the battery be connected to X and Y to make the coil rotate clockwise as viewed from Z?

The essential features of a small, DC electric motor are shown in the diagram below. The rotating coil of the motor is connected to a DC supply whose polarity is marked on the diagram. The direction of the magnetic field is also shown on the diagram.



The strength of the motor's magnetic field is 0.1 T and the length of the conductors in the field is 0.040 m.

Example 36 1986 Question 70, 1 mark

What is the maximum force that will act on the segment, XY (marked on the diagram), if a current of 5.0 A flows in the coil?

Example 1 1993 Question 4

The split-ring commutator reverses the direction of the current every half cycle, as the coil moves through the position where its plane is perpendicular to the field.
This reversal of current reverses the direction of the force acting on both wires.
This allows the loop to continue to rotate in the one direction.

Example 2 1993 Question 5

The field is from left to right.
To get the coil to rotate clockwise the force on 'ad' needs to be up.
Therefore the current is from 'd' to 'a'
This means that Y needs to connect to the positive terminal of the battery.

Example 3 1986 Question 70)

The force on XY is given by

$F = nBiL$

$\therefore F = 1 \times 0.1 \times 5.0 \times 0.04$

Question 16 (6 marks)

A diagram of a DC motor is shown in Figure 21.

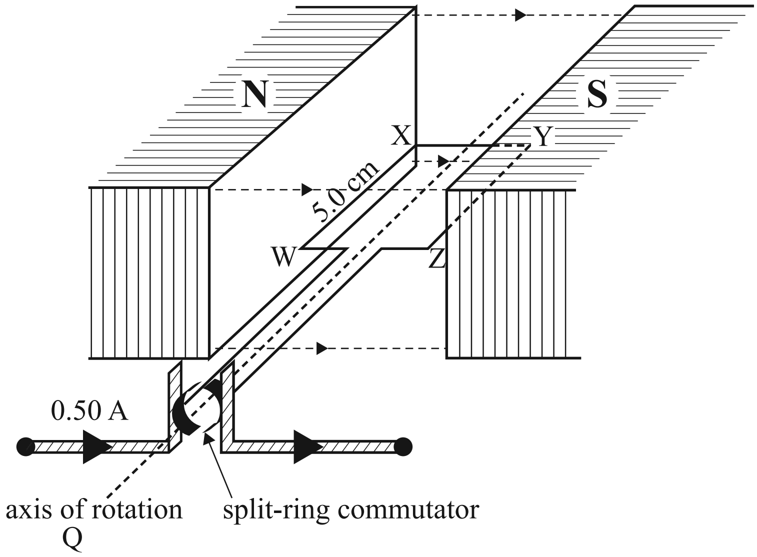


Figure 21

a. The motor is operating and the rectangular coil is rotating about the axis of rotation. Mary views the operating motor from point Q.

Is the direction of rotation clockwise or anticlockwise? Give a reason for your answer. 2 marks

b. While in the position shown in the diagram, a current of 0.50 A is flowing in the rotating coil. The coil has 20 turns and the magnetic field at the side labelled WX has a strength of 500 mT. The side WX has a length of 5.0 cm.

Calculate the magnitude of the force on the side WX. 2 marks

N

c. There is a split-ring commutator fitted to the motor. Mary suggests that the split-ring commutator causes a lot of friction on the motor, and that the motor would rotate faster if the split-ring commutator were removed and, instead, slip-rings were used to connect the input DC current to the rotating coil.

Would this change improve the operation of the motor? Give reasons for your answer. 2 marks

Question 17 (11 marks)

Students conduct an experiment that is shown in Figure 22. An aluminium ring is made to oscillate vertically between point A and point B. Point C is the midpoint between A and B. A strong, small bar magnet is fixed at the centre of the oscillation, as shown in Figure 22.

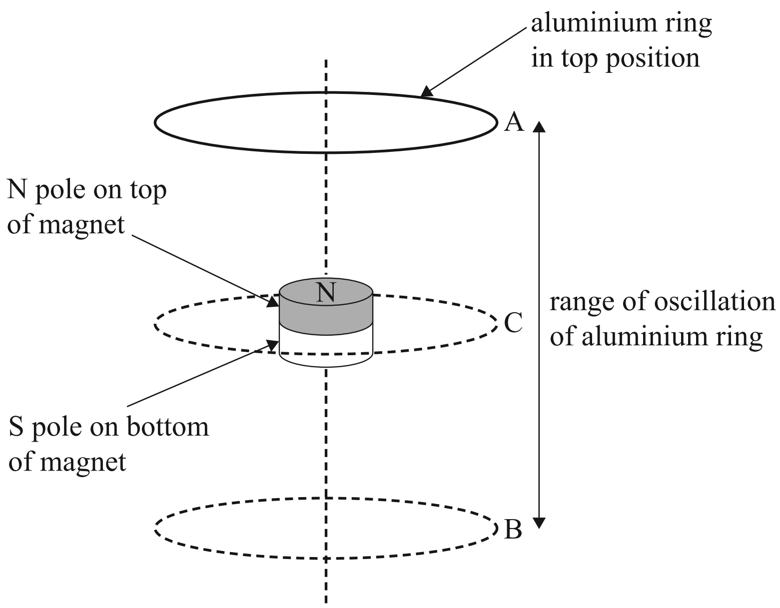


Figure 22

The vertical dashed line goes through the centre of the aluminium ring and also through the centre of the bar magnet in the diagram.

Question 14 (5 marks)

Students build a simple electric motor, as shown in Figure 18.

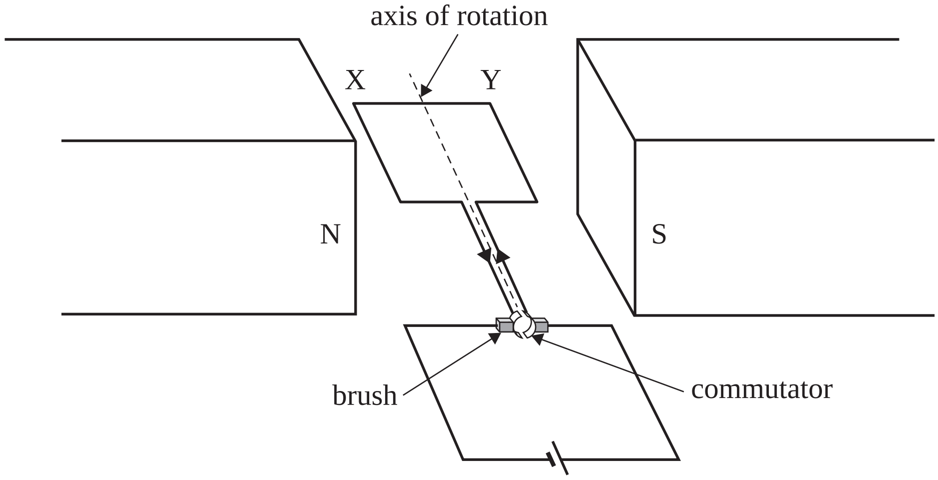


Figure 18

a. At what position(s) (**A.–D.**) of the rotating coil is the magnetic force on the side XY zero? One or more answers may be selected. 1 mark

A. horizontal with the current as shown in Figure 18

B. horizontal with the current in the opposite direction to that shown in Figure 18

C. vertical

D. at all orientations of the coil

b. The students discover that the motor starts moving more easily with the coil in some orientations than in others.

Explain the best orientation(s) for starting the motor to move from rest. 2 marks

c. To increase the speed of rotation of the motor, the students suggest a number of improvements.

Which suggested improvement(s) (**A.–D.**) is likely to increase the speed of rotation of the coil? One or more answers may be selected. Explain your answer. 2 marks

A. increase the battery voltage

B. replace the single coil of the motor with several turns

C. increase the resistance of the coil

D. reverse one of the poles of the permanent magnets

Question 13 (6 marks)

Students build a simple electric motor consisting of a single coil and a split-ring commutator, as shown in Figure 21.

The magnetic field between the pole pieces is a constant 0.02 T.

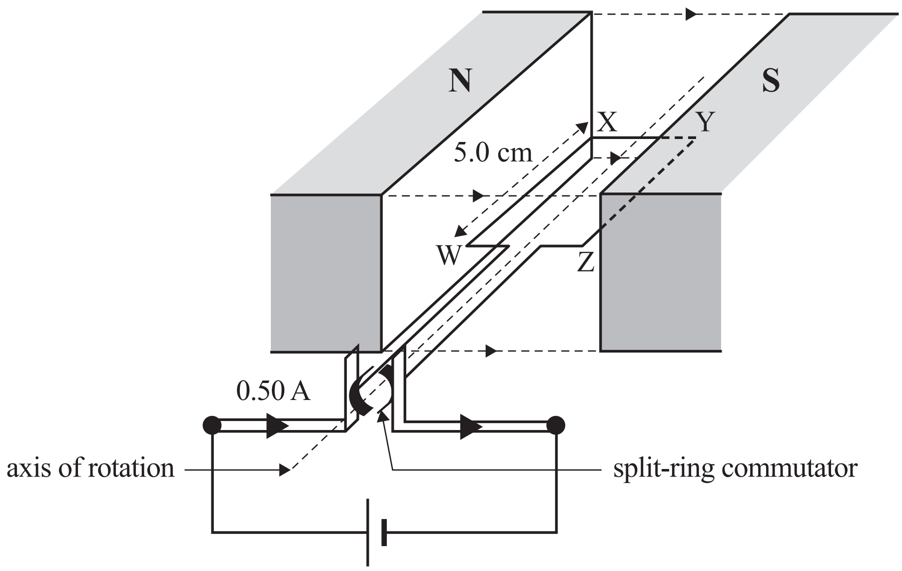


Figure 21

a. Calculate the magnitude of the force on the side WX. 2 marks

N

b. Will the coil rotate in a clockwise or anticlockwise direction as seen by an observer at the split-ring commutator? Explain your answer. 2 marks

c. Explain the role of the split-ring commutator in the operation of the electric motor. 2 marks

✓ **Question 3** (5 marks)

Figure 2 shows a schematic diagram of a simple DC motor.

It consists of two magnets, a single 9.0 V DC power supply, a split-ring commutator and a rectangular coil of wire consisting of 10 loops.

The total resistance of the coil of wire is 6.0 Ω.

The length of the side JK is 12 cm and the length of the side KL is 6.0 cm.

The strength of the uniform magnetic field is 0.50 T.

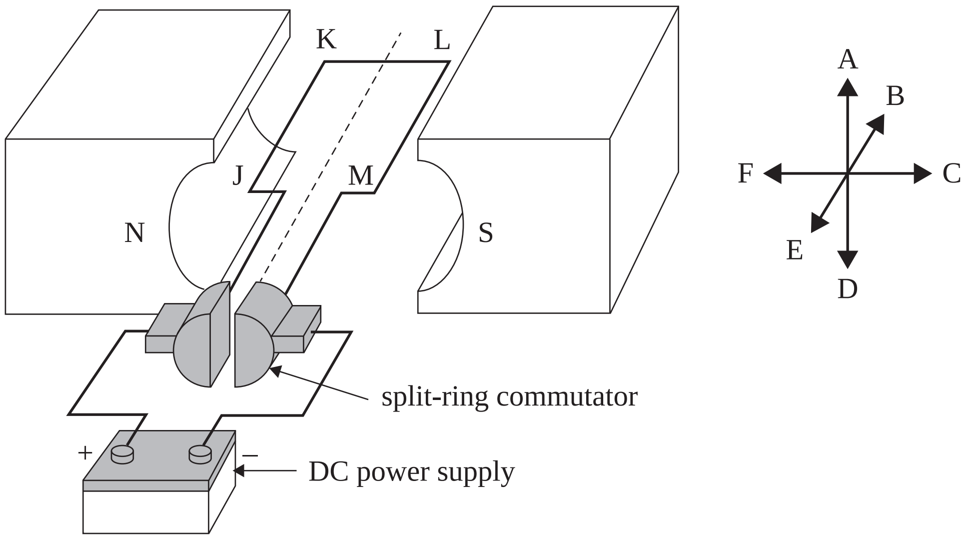


Figure 2

a. Determine the size and the direction (A–F) of the force acting on the side JK. 3 marks

N	Direction

b. What is the size of the force acting on the side KL in the orientation shown in Figure 2? Explain your answer. 2 marks

N

Question 3 (5 marks)

Students build a model of a simple DC motor, as shown in Figure 3.

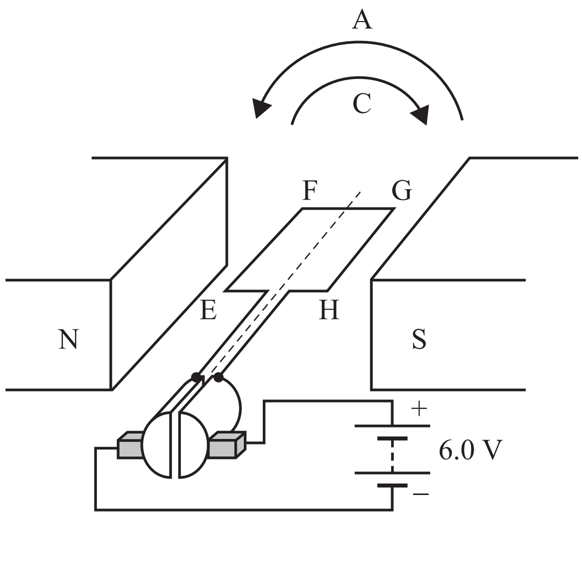


Figure 3

a. The motor is set with the coil horizontal, as shown, and the power source is applied.

Will the motor rotate in a clockwise (C) or anticlockwise (A) direction? Explain your answer. 3 marks

b. One student suggests that slip rings would be easier to make than a commutator and that they should use slip rings instead.

Explain the effect that replacing the commutator with slip rings would have on the operation of the motor, if no other change was made. 2 marks

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.
Where an answer box is provided, write your final answer in the box.
If an answer box has a unit printed in it, give your answer in that unit.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
Take the value of g to be 9.8 m s^{-2}.

Question 1 (5 marks)

Figure 1 shows four positions (1, 2, 3 and 4) of the coil of a single-turn, simple DC motor. The coil is turning in a uniform magnetic field that is parallel to the plane of the coil when the coil is in Position 1, as shown.

When the motor is operating, the coil rotates about the axis through the middle of sides *LM* and *NK* in the direction indicated. The coil is attached to a commutator. Current for the motor is passed to the commutator by brushes that are not shown in Figure 1.

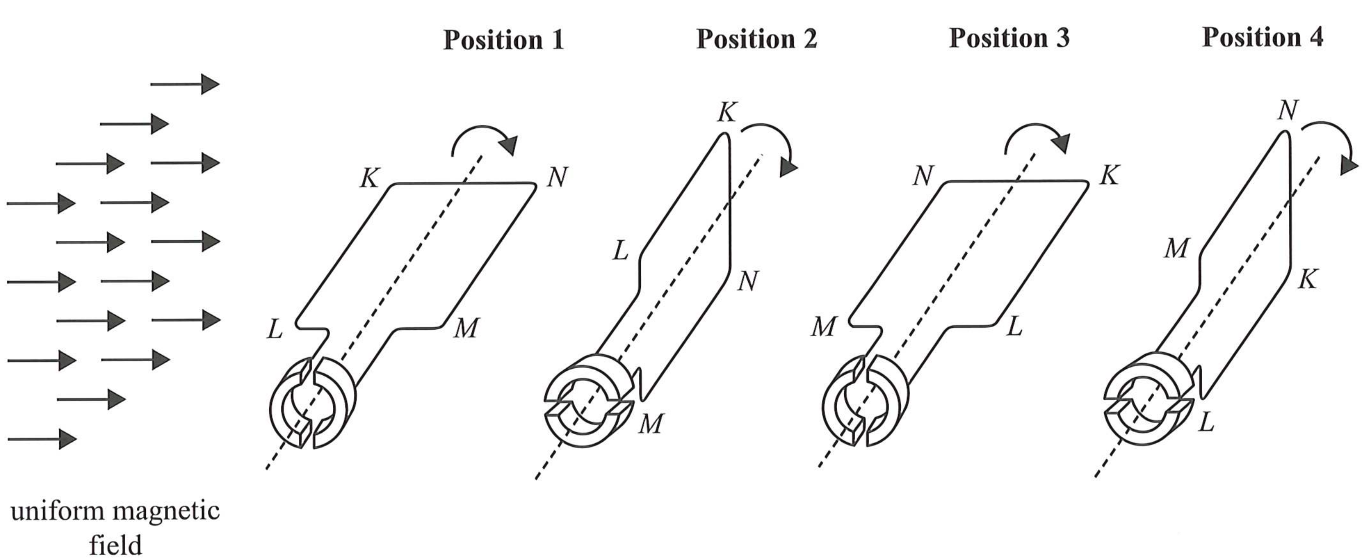


Figure 1

a. When the coil is in Position 1, in which direction is the current flowing in the side *KL* – from *K* to *L* or from *L* to *K*? Justify your answer. 2 marks