Can an electric current be generated by moving a conductor?

Task

To investigate if the process in which a current-carrying conductor is deflected in a magnetic field, i.e. in which electrical energy is converted to mechanical energy, is reversible.

Equipment

Plug-in board	06033.00	1
Bar magnet, l = 72 mm	07823.00	1
Coil, 400 turns	07829.01	2
Yoke	07833.00	1
Galvanometer movement	07875.00	1
Galvanometer scale	07876.00	1
Notch bearing with plug	07877.00	1
Connecting cable, 50 cm, red	07314.01	2

Set-Up and Procedure

— Assemble the galvanometer model as shown in Fig. 2, and position it back right on the plug-in board (↗ is the symbol for the galvanometer).

— Connect up the circuit as shown in Fig. 1; position the coil as far as possible away from the galvanometer in front of the board.

— Successively carry out the following steps of the procedure, at each step observe the deflection of the galvanometer pointer and note your observation in Table 1.

Note: The movements in steps 1 to 4 and 6 and 7 should be carried out as quickly as possible.

1. Move the magnet with the North pole into the coil.
2. Move the magnet out of the coil.
3. Move the magnet with the South pole into the coil.
4. Move the magnet out of the coil.
5. Move the magnet more quickly into the coil and out.
6. Move the coil to the magnet.
7. Move the coil away from the magnet.
8. Rest the magnet in the coil.
9. With the magnet in the coil, tip it a little to turn it a little from its longitudinal axis, without otherwise shifting it.

Fig. 2

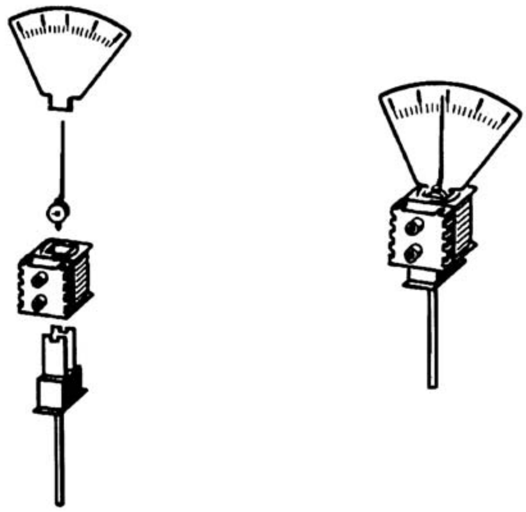
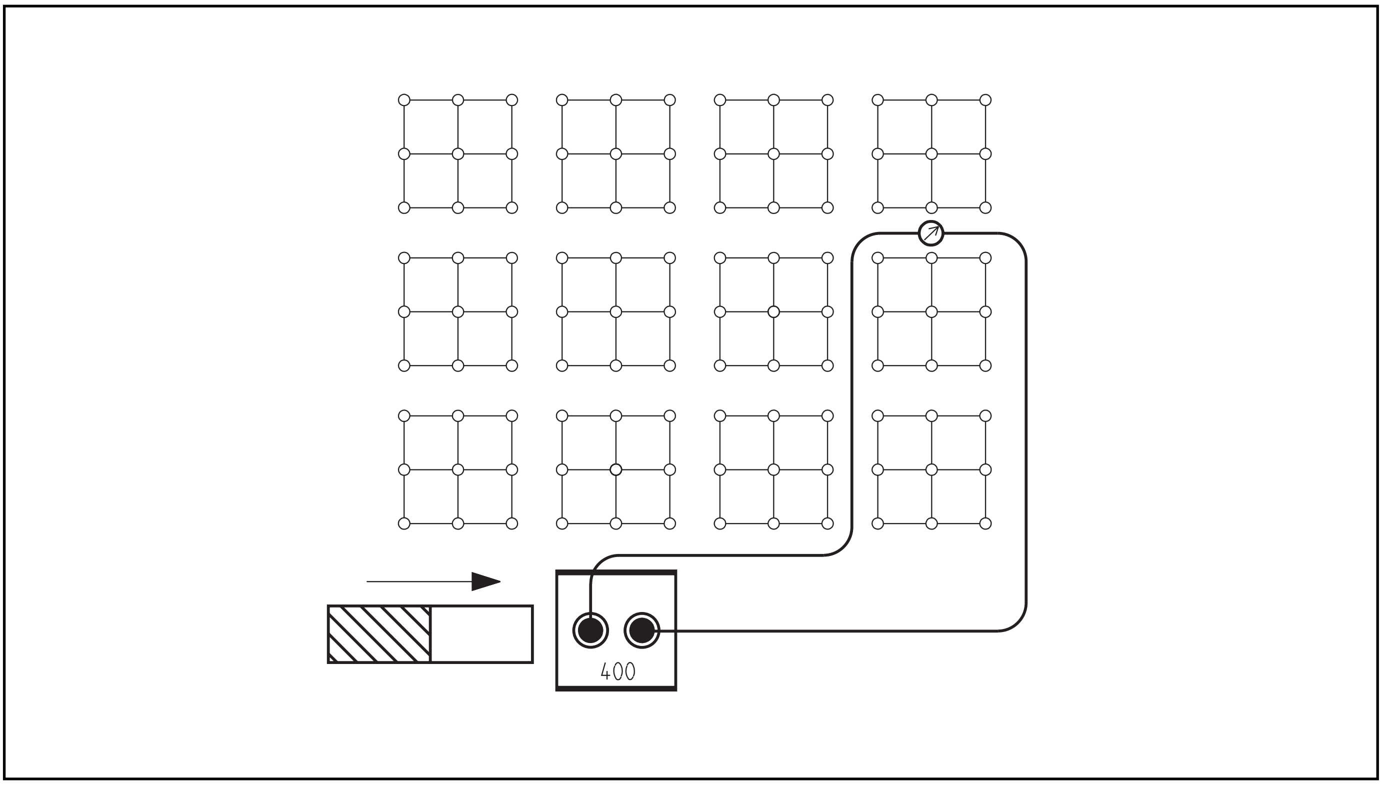


Fig. 1



Observations

Table 1

Movement	Pointer deflection (to the left/right; more/less)
1. North pole into the coil	
2. North pole out of the coil	
3. South pole into the coil	
4. South pole out of the coil	
5. Quicker movement of the magnet	
6. Coil to the magnet	
7. Coil away from the magnet	
8. Magnet rests in the coil	
9. Magnet turned in the coil longitudinally	

Evaluation

1. The voltage which the galvanometer showed in this experiment is called the induction voltage; the process in which it is generated is called electromagnetic induction.

   a). What is the direction of the induction voltage dependent on (refer to the results from steps 1 to 4)?

   b) What is the height of the induction voltage dependent on (refer to the results from step 5 and also formulate your reply with “The ... the ...).

2. Which conclusion can you draw from the comparison of steps 1 to 4 with steps 6 and 7?

3. During the movement of the magnet and the coil (the induction coil) relative to each other, the magnetic field surrounding the coil changes. In steps 8 and 9 it apparently does not change. Now answer the question: Under which conditions is a voltage induced?

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The students know that a current-carrying conductor is surrounded by a magnetic field which can cause mechanical movement in interaction with another magnetic field. They should demonstrate the reversal of this phenomenon, i.e. demonstrate that electrical energy can be generated by mechanical movement. They should come to recognize, that a voltage is only induced, when the magnetic field which is contained by a coil (or conductor loop) changes.

Notes on Set-Up and Procedure
The galvanometer has the advantage over the multi-range meter, that it can deflect to either side and therefore allows differently directed current to be indirectly observed.
Quantitative statements on induction voltage are not strived for in this experiment.
As the galvanometer movement includes a permanent magnet, it must be ensured that the bar magnet used in this experiment is not moved about in the direct vicinity of the galvanometer, otherwise the sensitive movement will react to the magnet and falsify the measured values by induction.
(To make clear that the bar magnet should be kept as far from the galvanometer during handling, it is shown in Fig. 1 at the far front left.)

Evaluation
1. a).The direction of the induction voltage is dependent on whether the movement of the magnet is into or out of the coil, and on which pole of the magnet is pointing towards the coil.
   b). The height of the induction voltage is dependent on the speed of the movement. The quicker the movement, the greater the induction voltage.
2. For the generation of the induction voltage, there is no difference between bringing the magnet to the coil or bringing the coil to the magnet.
3. A voltage is induced, as long as the magnetic field which is contained by the induction coil changes.

Remarks
During the last steps of the experiment, it should become clear to the students – if necessary with the teacher's help – that the relative movement of the coil and permanent magnet to each other is, although a necessary condition for the generation of an induction voltage, not alone sufficient for it. The movement must be so made that it causes the magnetic field contained by the core to change.

Observations
Table 1

Movement	Pointer deflection (to the left/right; more/less)
1. North pole into the coil	To the right*
2. North pole out of the coil	To the left
3. South pole into the coil	To the left
4. South pole out of the coil	To the right
5. Quicker movement of the magnet	More
6. Coil to the magnet	To the left
7. Coil away from the magnet	To the right
8. Magnet rests in the coil	No deflection
9. Magnet turned in the coil longitudinally	No deflection

* The entries for the direction of the pointer deflection in Fig. 1 are only meant as examples. The movement to the left or right is dependent on the connection of the two coils.

Generation of an induction voltage with permanent magnets

(Can an electric current be generated by moving a conductor?)

Room for notes