The transformation of electrical energy into mechanical energy and back again (Item No.: P1396800)

Curricular Relevance

Area of Expertise: Physics

Education Level: Age 14-16

Topic: Electricity

Subtopic: Electrical energy, power and work

Experiment: The transformation of electrical energy into mechanical energy and back again

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

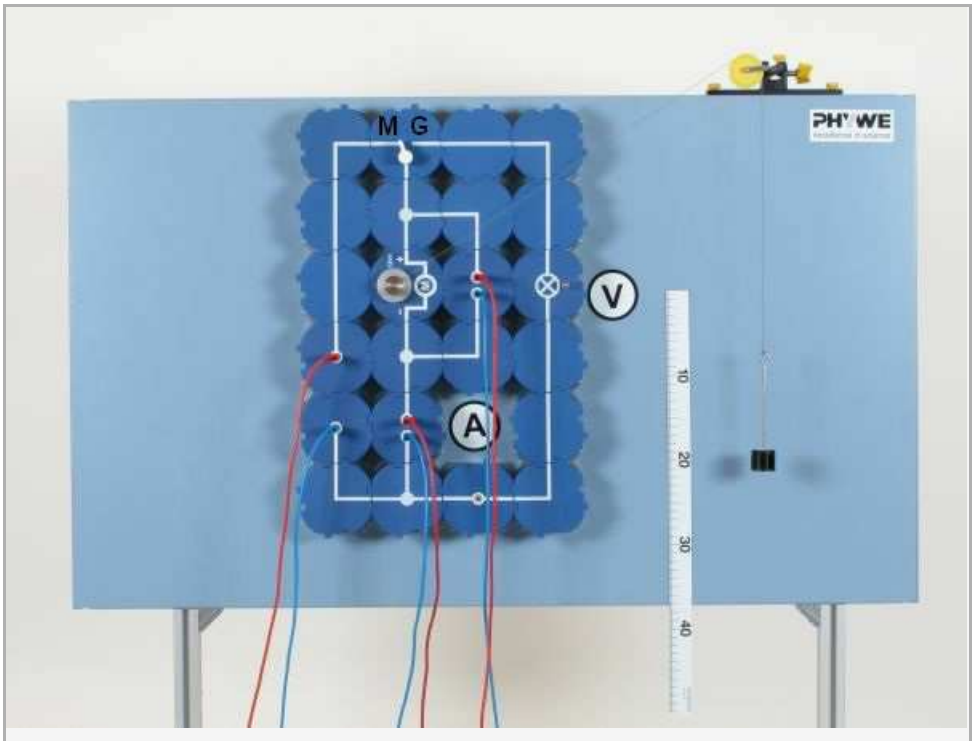
Experiment Variations:

Keywords:

Principle and equipment

Principle

An electric motor is to be used, first as a motor and then as a generator, to qualitatively demonstrate the energy transformations stated above. The efficiency of each energy transformation is to be subsequently determined.



Experimental set-up

Equipment

Position No.	Material	Order No.	Quantity
1	Multimeter ADM2, demo., analogue	13820-01	2
2	PHYWE power supply, universal DC: 0...18 V, 0...5 A / AC: 2/4/6/8/10/12/15 V, 5 A	13500-93	1
3	Demo Physics board with stand	02150-00	1
4	Stop clock, demo.; diam. 13 cm	03075-00	1
5	Motor 12 V, module DB	09475-01	1
6	Switch, change-over, module DB	09402-02	1
7	Clamp on holder	02164-00	1
8	Socket for incandescent lamp E10 ,module DB	09404-00	1
9	Connector interrupted, module DB	09401-04	3
10	Junction, module DB	09401-10	2
11	Electr.symbols f.demo-board,12pcs	02154-03	1
12	Connector, straight, module DB	09401-01	6
13	Connector, angled, module DB	09401-02	6
14	Connector, T-shaped, module DB	09401-03	3
15	Connect.straight w.socket,mod. DB	09401-11	1
16	Fish line, l. 100m	02090-00	1
17	Rod for pulley	02263-00	1
18	Scale for demonstration board	02153-00	1
19	Filament lamps 4V/0.04A, E10, 10	06154-03	1
20	Weight holder for slotted weights	02204-00	1
21	Pulley,movable,dia.40mm,w.hook	03970-00	1
22	Slotted weight, black, 10 g	02205-01	2
23	Slotted weight, silver bronze, 10 g	02205-02	2
24	Slotted weight, silver bronze, 50 g	02206-02	1
25	Connecting cord, 32 A, 1000 mm, red	07363-01	2
26	Connecting cord, 32 A, 1000 mm, blue	07363-04	2
27	Connecting cord, 32 A, 500 mm, red	07361-01	1
28	Connecting cord, 32 A, 500 mm, blue	07361-04	1

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Set-up and procedure

1st. Experiment

- Set up the experiment as shown in Fig. 1.
- Move the demo board to the edge of the table, screw the clamp-on holder to the table edge on the right; use it to hold the rod and movable pulley.
- Fasten the fishing line to the belt pulleyof the motor; wind the line around the grooved rim until the groove is filled, then lead the line over the rod-held pulley and down to floor level, cut it off there.
- Load the slotted weight holder (to a total mass= 80 g), hook it onto the end of the line and stand it on the floor.
- Turn the rod-held pulley so that the line runs parallel to the board.
- Select the 1 0 V- and 3 A- measurement ranges.
- Turn the switch to position G, switch on the power supply and adjust the voltage to approx. 3 V-
- Turn the switch to position G and watch the weight on the line.
- As soon as the weight is close to the rod-held pulley, turn the switch to position G and at the same time hold the weight.
- Let go of the weight and observe the filament lamp.
- Hold the weight at the height of the table top; place it there.
- Switch off the power supply and note your observations (1).

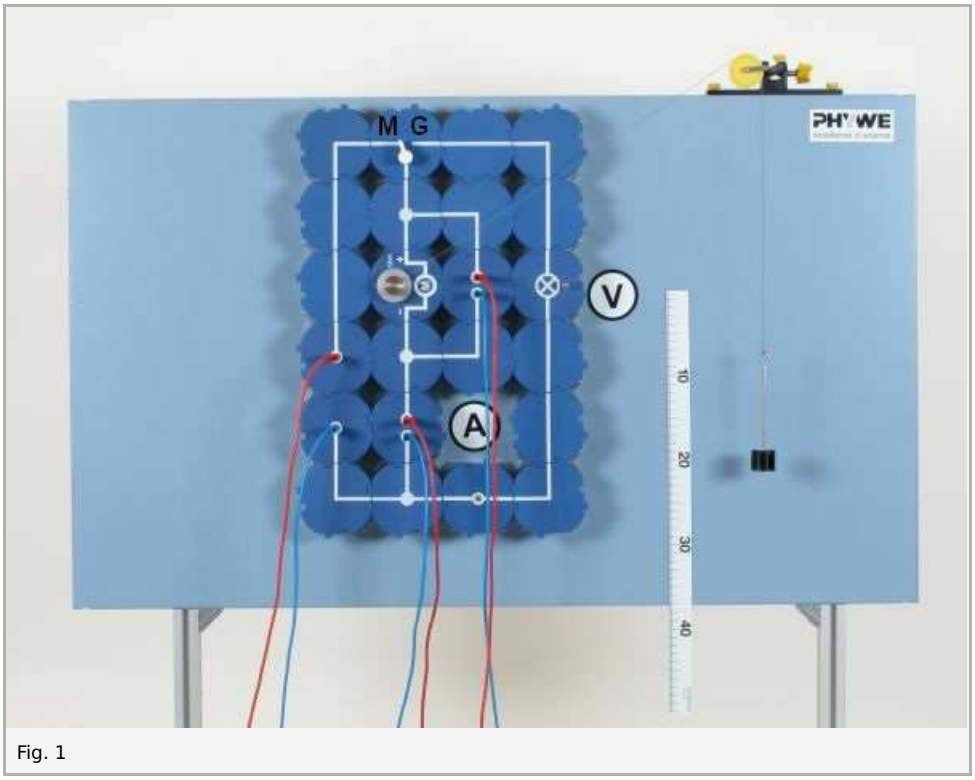

Fig. 1

2nd. Experiment

- Increase the mass of the weight to 1 00 g (50 g + 4 x 1 0 g on the weight holder); stand the weight on the floor and slightly tauten the line.
- Switch on the power supply and set the voltage to approx. 4 V.
- Turn the switch to position M and start the stopwatch at the same time, measure voltage and current.
- Turn the switch to position G as soon as the weight has reached the wanted lifting height (e.g. hits against the rod-held pulley) and at the same time stop the stopwatch; place the weight on the table.
- Repeat this experiment several times if possible; take the average of the measured values and note it in Table 1, line 1.

3rd. Experiment

- Reduce the mass of the weight to 70 g (50 g + 1 0 g on the weight holder); stand the weight on the floor and tauten the line
- Switch on the power supply and set the voltage to approx. 3 V-; turn the switch to position M

- Turn the switch to position G as soon as the weight touches the rod-held pulley and hold the weight at this position (*h*); reverse the polarity of the voltmeter
- Let go of the weight and at the same time stop the stopwatch; Measure U and I and determine the time taken for the weight to hit the floor
- Repeat this experiment several times if possible; take the average of the measured values and note it in Table 1, line 2

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Observation and evaluation

Observation

1. The motor lifts the weight up. The filament lamp lights up when the weight drops down.

Tabelle 1

Experiment no.	m/g	h/m	U/V	I/A	t/s
2	100	1.55	4.0	0.40	3.06
3	70	1.55	1.3	0.13	2.87

Evaluation

The motor needs electrical energy to be able to lift the weight up. A motor can convert electrical energy to mechanical energy. The lighting up of the lamp demonstrates that a generator enables mechanical energy to be converted to elecrical energy In all such processes, friction in the motor and heating up of the coil in the motor generate heat, whic results in the loss of part of the energy supplied. Their efficiency η is therefore partly far lower than 1 00%.

For the 2nd experiment we have:

$E_{\mathrm{el}} = U \cdot I \cdot t = 4{,}0\ \mathrm{V} \cdot 0{,}40\ \mathrm{A} \cdot 3{,}06\ \mathrm{s} = 4{,}9\ \mathrm{Ws}$;

$E_{\mathrm{mech}} = E_{\mathrm{pot}} = m \cdot g \cdot h = 0{,}1\ \mathrm{kg} \cdot 9{,}81\ \mathrm{kgms}^{-2} \cdot 1{,}55\ \mathrm{m} = 1{,}52\ \mathrm{Nm} = 1{,}52\ \mathrm{Ws}$;

$\eta = E_{\mathrm{mech}} / E_{\mathrm{el}} = 1{,}52 / 4{,}9 = 31$.

For the 3rd experiment we have:

$E_{\mathrm{el}} = U \cdot I \cdot t = 1{,}3\ \mathrm{V} \cdot 0{,}13\ \mathrm{A} \cdot 2{,}87\ \mathrm{s} = 0{,}49\ \mathrm{Ws}$;

$E_{\mathrm{mech}} = E_{\mathrm{el}} = m \cdot g \cdot h = 0{,}07\ \mathrm{kg} \cdot 9{,}81\ \mathrm{kgms}^{-2} \cdot 1{,}55\ \mathrm{m} = 1{,}06\ \mathrm{Nm} = 1{,}06\ \mathrm{Ws}$;

$\eta = E_{\mathrm{el}} / E_{\mathrm{mech}} = 0{,}94 / 1{,}06 = 46$.

Remarks

We recommend that before repeating the 2nd experiment you lead the weight (slotted weight holder with added weights) down by hand, so that it does not strike the floor. As several measured values must be read at almost the same time, it is suggested that, in the several repeats of the 2nd and 3rd experiments, you first determine the average values for U and I, and after that the value fort. Neither a voltmeter nor an ammeter is required in the 1st experiment. At first, therefore, the voltmeter need not be connected, and the sockets for the connection of the ammeter can be bridged with a short connecting lead.

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