Task

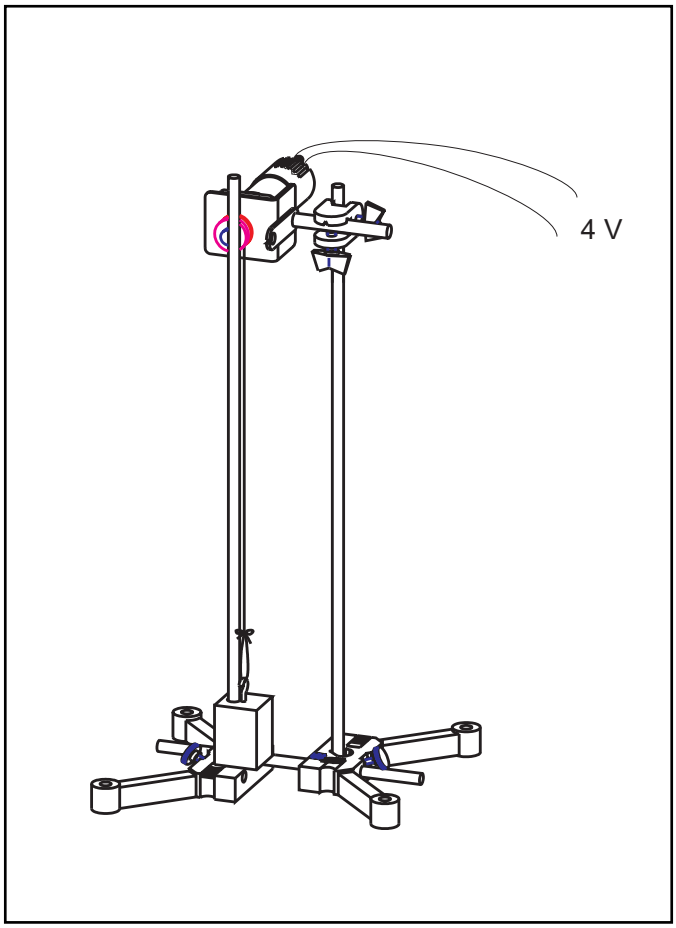
To observe the lifting up of a weight by an electric motor and the conversion of mechanical energy to electrical energy by a generator.

To determine the efficiency of an electric motor in lifting up a weight.

Equipment

Plug-in board	06033.00	1
Wire building block	39120.00	5
Changeover switch	39169.00	
Lamp holder E10	17049.00	1
Connecting cable, 50 cm, red	07314.01	2
Connecting cable, 50 cm, blue	07314.04	2
Connecting cable, 25 cm, red	07313.01	2
Connecting cable, 25 cm, blue	07313.04	2
Filament lamp, 6V/0.5 A, E10, 1 pc.	35673.03	(1)
Multi-range meter	07028.01	2
Power supply, 0...12 V-,6 V~, 12 V~	13505.93	1
Weight with hole	02245.00	1
Supporting material:		
Motor with gearing, 12 VDC	11610.00	1
Support base variable	02001.00	1
Rod, stainless steel, 250 mm	02031.00	1
Support rod, stainless steel, 600 mm	02037.00	2
Bosshead	02043.00	1
Fish line, need approx. 60 cm	02089.00	(1)

Fig. 1



Stopwatch (03071.01)
Measuring tape (09936.00)
Adhesive tape or spongy plastic

Set-Up

— Prepare the mechanical set-up as shown in Fig.1.
— Separate the two parts of the support base and connect them together, laterally displaced, with a short support rod.
— Fix the motor at the top of one of the two long support rods with a bosshead, and align it so that its cord pulley is directly alongside the second long support rod.
— Fasten the weight to the hook at the end of the fish line and slide the weight down the second support rod as shown in Fig. 1.
— Lead the other end of the fish line from behind through the bore hole in the cord pulley, tie it tight with a knot and lead it over the cord pulley with the smallest diameter.
— Wrap adhesive tape, spongy plastic or similar at a height of about 5 cm above the lower end of the support rod. This is to act as a brake to the weight, and so prevent it from falling on the support base, should the fish line break.
— Connect the motor up electrically as shown in Fig. 2. **Important!** The voltage on the motor must only be approx. 4 V.
— Select the 10 V- and 3 A- measurement ranges.
— First flip the changeover switch to position 2 (motor off).
— Set the power supply to 0 V.

Procedure

First Experiment: Motor and generator

— Switch on the power supply, adjust the power supply voltage to 4 V-, the current strength to 2 A-.
— Move the weight to the lowest position (the fish line should be slightly taut).
— Flip the changeover switch to position 1 (motor on).
— Hold the weight tight when it bumps against the motor above it and flip the changeover switch to position 2.
— Let go of the weight and observe the weight and the filament lamp.
— Repeat this procedure several times and note your observations under (1) and (2).

Second Experiment: Efficiency of the motor

— Make the following measurements when the weight is being drawn up: The voltage U, the current strength I; and the time t which the motor needs to draw the weight up to the top stop (motor casing). (We recommend that the lifting procedure be carried out several times, and only one quantity be observed in each run. Average values can also be determined.)
— Measure the height h which the motor lifts the weight up.
— Note the measured values under (3).

Observations and Measurement Results

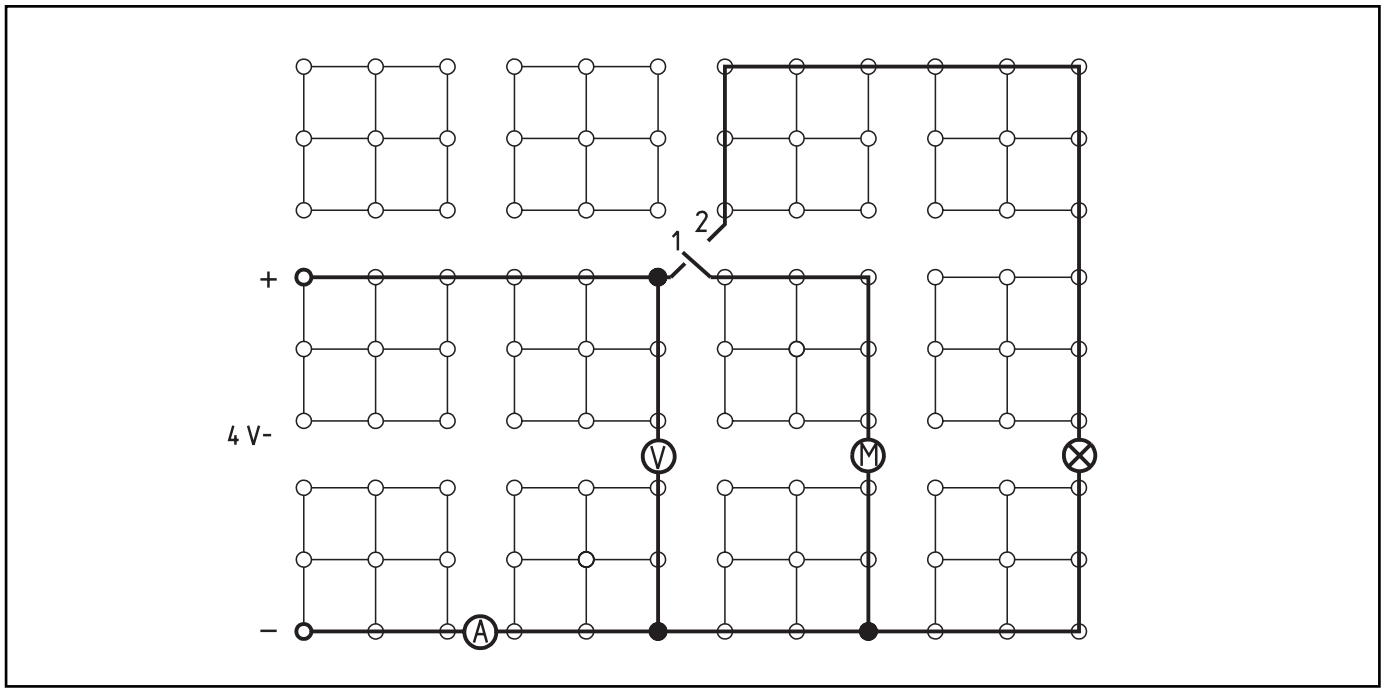
(1) What happens when the motor is switched on?

(2) What happens when the weight falls down?

(3) The efficiency of the motor:

I	=	A
U	=	V
t	=	s
h	=	m

Fig. 2



Evaluation

1. Describe the processes observed, using the terms “electrical energy” and “potential energy” in doing so.

2. Calculate the electrical energy taken up by the motor during the time t
   $E_{el} = U \cdot I \cdot t$.

3. Calculate the increase in the potential energy of the weight brought about by the motor
   $E_{pot} = m \cdot g \cdot h$.
   The weight has a mass of m = 0.8 kg, the value of the acceleration due to gravity is g = 9.81 N/kg

4. What was the efficiency of the energy conversion process?

5. How much electrical energy was not converted to potential energy in the weight? What happened to it?

Room for notes

(How can electrical energy be converted to mechanical energy?)

In the first part of the experiment, the qualitative observation of the energy conversion process is of primary interest. It is a common everyday occurrence to see a motor lifting up a load. The distinctive feature of this set-up is, that the directly subsequent “falling down” of the weight re-generates electrical energy, as can be seen by the lighting up of a lamp.
In the second part of the experiment, the efficiency of the electric motor is to be determined. This set-up has the advantage, that potential energy is the form of energy which can be most simply calculated.

Notes on Set-Up and Procedure
When the experiment is being set up, ensure that the two parts of the support base are laterally displaced and then connected together with a short support rod. The pulley of the motor can then be aligned directly alongside the second long support rod. The fish line holding the weight should be slightly tautened prior to each experiment.
For the quantitative measurement, the experiment should be repeatedly carried out in order to practice reading a displayed value in the very short time of approx. 2 seconds.

Observations and Measurement Results
(1) The motor lifts up the weight.
(2) When the weight falls down, it turns the pulley of the motor/generator. The filament lamp lights up and extinguishes again, when the weight comes to rest.
(3) The efficiency of the motor:
I = 1.7 A
U = 4.0 V
t = 1.9 s
h = 0.40 m

Evaluation
1. The motor requires electrical energy to lift up the weight. The weight has a greater potential energy after it has been lifted up. When the weight “falls down” and operates the generator in doing so, then the potential energy is converted back to electrical energy.
2. The electrical energy taken up by the motor during the time t is:
$E_{el} = 4.0\ V \cdot 1.7\ A \cdot 1.9\ s = 12.9\ Ws$.
3. The increase in the potential energy of the weight is:
$E_{pot} = 0.8\ kg \cdot 9.81\ N/kg \cdot 0.40\ m = 3.1\ Nm$.
4. The efficiency of the energy conversion process is:
$\eta = E_{pot} / E_{el} = 3.1\ Nm / 12.9\ Ws = 0.24 = 24\%$.
5. 9.8 Ws of the electrical energy was not converted to potential energy. This energy was converted to heat by friction both in the motor and in the set-up, and as direct electrical heating of the winding in the motor.

Remarks
Only 4 V- voltage must be placed on the motor.
The experiment should not be carried out without the braking wrapping around the lower end of the rod, as otherwise, when the line breaks, fingers could be squashed between the support base and the weight.

(How can electrical energy be converted to mechanical energy?)

Room for notes