On which quantities are electric power and electric work dependent?

EEP 3.1 | S

Task

To investigate the dependence of electric power on current strength and voltage by connecting filament lamps in series and in parallel.

Equipment

Plug-in board	06033.00	1
On/off switch	39139.00	1
Wire building block	39120.00	4
Lamp holder E10	17049.00	2
Connecting cable, 25 cm, red	07313.01	1
Connecting cable, 25 cm, blue	07313.04	1
Connecting cable, 50 cm, red	07314.01	2
Connecting cable, 50 cm, blue	07314.04	2
Filament lamp, 4V/0.04 A, E10, 1 pc.	06154.03	(2)
Multi-range meter	07028.01	2
Power supply, 0...12 V-,6 V~, 12 V~	13505.93	1

Set-Up and Procedure

— Connect up the circuit as shown in Fig. 1, with the switch open.
— Select the 10 V- and 300 mA- measurement ranges.
— Set the power supply to 0 V and switch it on.
— Slowly increase the power supply voltage until the voltmeter across lamp L_1 shows exactly 4 V.
— Measure the current strength I and note this value under I in Table 1.
— Close the switch and thereby connect lamp L_2 in parallel with lamp L_1.
— Measure the current strength I (after previously adjusting the voltage to exactly 4 V) and obseve the brightness of each of the lamps.
— Note the measured value for I and your observations under (1).
— Change the experimental set-up. Remove wire building block 1 and replace it with lamp L_2, whereby this is connected in series with lamp L_1. Also remove wire building blocks 2 and 3, as well as the on/off switch.
— Increase the power supply voltage until the current strength has the value 0.04 A; measure the voltage required for this and note it in column 2 of Table 2.
— Adjust the power supply to 0 V and switch it off.

Observations and Measurement Results

Table 1

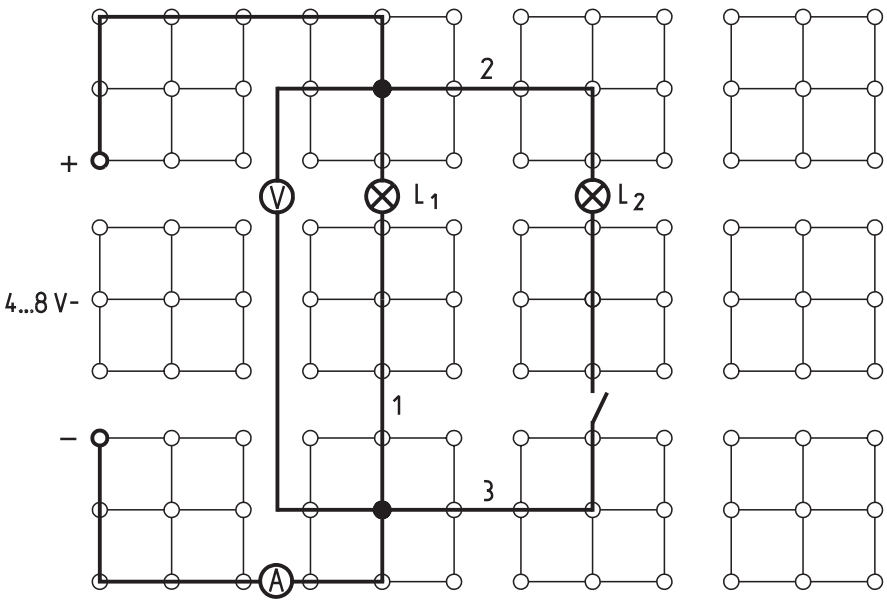
Number of lamps	U / V	I / A	Lamp performance
1	4		normal
2 (parallel)	4		

Table 2

Number of lamps	U / V	I / A	Lamp performance
1		0.04	normal
2 (in series)		0.04	

(1)

Fig. 1



Evaluation

1. Enter the values for the voltage U and the current strength I which were measured for lamp L_1 at the start of the experiment and noted in the first line of Table 1 in the first line of Table 2.
2. Complete the second lines of Tables 1 and 2 with a statement on the total lighting performance of the lamps.
3. Take a close look at Tables 1 and 2 and supplement Tables 3 and 4.

Table 3

Number of lamps	$\frac{U}{V}$	$\frac{I}{A}$	Lamp performance
3 (parallel)	4		
4 (parallel)	4		

Table 4

Number of lamps	$\frac{U}{V}$	$\frac{I}{A}$	Lamp performance
3 (in series)		0.04	
4 (in series)		0.04	

4. Express the relationships between the electric power P and the current strength I and the voltage U mathematically and in words.

5. These relationships can be summed up as:
   $P \sim U \cdot I$ or $P = U \cdot I$,
   when the unit 1 V · 1 A = 1 W (Watt) is taken for power. When a lamp shines with a power of P for a time of t, then the electric work is obtained by multiplication:
   $W_{el} = P \cdot t = U \cdot I \cdot t$.
   Calculate the electric work performed by the lamps used in the experiment when they lit up for 5 minutes.

(On which quantities are electric power and electric work dependent?)

The power of an electrical appliance can be qualitatively estimated from its brightness, the heat radiated, loudness etc..
In this experiment, the light emitted from filament lamps is used as a measure of electric power. The students can easily understand that two identical lamps together have a doubled power, when they each have the same brightness, and n lamps correspond to n times the power of one. The experiment consists of two parts, because of $P \sim U$ for I = constant and $P \sim I$ for U = constant.

Notes on Set-Up and Procedure
The values of the resistances of the filament lamps are naturally subject to some variation. It is therefore advisable to give each group two lamps which are as equal as possible (prior to the experiment, match pairs of lamps which have the same current strength at 4.0 V).
The circuit is not difficult to connect up.

Observations and Measurement Results
Table 1

Number of lamps	$\frac{U}{V}$	$\frac{I}{A}$	Lamp performance
1	4	0.04	normal
2 (parallel)	4	0.08	double

(1) The two lamps light up equally bright (have the same lighting power).

Table 2

Number of lamps	$\frac{U}{V}$	$\frac{I}{A}$	Lamp performance
1	4	0.04	normal
2 (in series)	8	0.08	double

Evaluation
1. Refer to the first line of Table 2.
2. Refer to column 4 of Tables 1 and 2.
3. Refer to Tables 3 and 4.

Table 3

Number of lamps	$\frac{U}{V}$	$\frac{I}{A}$	Lamp performance
3 (parallel)	4	0.12	triple
4 (parallel)	4	0.16	fourfold

Table 4

Number of lamps	$\frac{U}{V}$	$\frac{I}{A}$	Lamp performance
3 (in series)	12	0.04	triple
4 (in series)	16	0.04	fourfold

4. $P \sim I$ for U = constant. Electric power is proportional to the current strength (at constant voltage).
   $P \sim U$ for I = constant. Electric power is proportional to the voltage (at constant current strength).
5. $P = 4\ V \cdot 0.04\ A \cdot 5 \cdot 60\ s = 0.16\ W \cdot 300\ s = 48\ Ws$

Remarks
When the question is asked, what is the electric power dependent on, most students generally answer spontaneously with current strength.
Th recognition of the dependence of power on voltage requires much didactic work. As example, one can point out that although a currents of comparable strength (0.5 A and 0.43 A) flow through a 6 V / 0.5 A filament lamp and a 6 V / 0.5 A intended for mains connection, they have very different powers of illumination.

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Room for notes