

Chapter 27

1

Current And Resistance

Mustafa Al-Zyout - Philadelphia University

10/5/2025

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Lecture 02

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Electric Power

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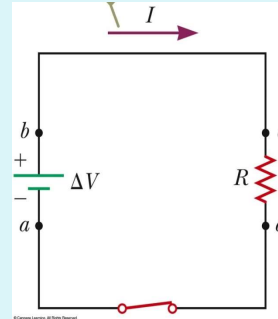
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2

Electrical Power

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- Assume a circuit as shown.
- The entire circuit is the system.
- As a charge moves from a to b , the electric potential energy of the system increases by $q\Delta V$.
- This electric potential energy is transformed into internal energy in the resistor.
- The **power** is the rate at which the energy is delivered to the resistor.



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Electric Power, 2

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- The rate at which the system's potential energy decreases as the charge passes through the resistor is equal to the rate at which the system gains internal energy in the resistor.

$$P = \frac{dU}{dt} = \frac{d}{dt}(Q\Delta V) = Q \frac{d}{dt}(\Delta V) + \Delta V \frac{d}{dt}(Q)$$

$$P = I\Delta V$$

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Electric Power, final

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- Applying $\Delta V = IR$, alternative expressions can be found:

$$P = I\Delta V$$

$$P = I^2 R$$

$$P = \frac{(\Delta V)^2}{R}$$

- Units:

I is in A ,

R is in Ω ,

ΔV is in V , and

P is in W

Power in an Electric Heater

Tuesday, 2 February, 2021 21:07

Lecturer: Mustafa Al-Zyout, Philadelphia University, Jordan.

-   R. A. Serway and J. W. Jewett, Jr., *Physics for Scientists and Engineers*, 9th Ed., CENGAGE Learning, 2014.
-  J. Walker, D. Halliday and R. Resnick, *Fundamentals of Physics*, 10th ed., WILEY, 2014.
-  H. D. Young and R. A. Freedman, *University Physics with Modern Physics*, 14th ed., PEARSON, 2016.
-  H. A. Radi and J. O. Rasmussen, *Principles of Physics For Scientists and Engineers*, 1st ed., SPRINGER, 2013.

An electric heater is constructed by applying a potential difference of 120 V across a Nichrome wire that has a total resistance of $8.00\ \Omega$. Find the current carried by the wire and the power rating of the heater.

SOLUTION

the current in the wire:

$$I = \frac{\Delta V}{R} = \frac{120\text{V}}{8.00\Omega} = 15.0\text{A}$$

Find the power rating using the expression $P = I^2 R$

$$P = I^2 R = (15.0\text{A})^2 (8.00\Omega) = 1.80 \times 10^3\text{W} = 1.80\text{kW}$$

What if the heater were accidentally connected to a 240-V supply?

How would that affect the current carried by the heater and the power rating of the heater, assuming the resistance remains constant?

According to $P = (\Delta V)^2 / R$, the power would be four times larger.

Power, energy and cost

Thursday, 15 April, 2021 23:37

Lecturer: Mustafa Al-Zyout, Philadelphia University, Jordan.

-  R. A. Serway and J. W. Jewett, Jr., *Physics for Scientists and Engineers*, 9th Ed., CENGAGE Learning, 2014.
-  J. Walker, D. Halliday and R. Resnick, *Fundamentals of Physics*, 10th ed., WILEY, 2014.
-  H. D. Young and R. A. Freedman, *University Physics with Modern Physics*, 14th ed., PEARSON, 2016.
-  H. A. Radi and J. O. Rasmussen, *Principles of Physics For Scientists and Engineers*, 1st ed., SPRINGER, 2013.

A $220V$ potential difference is maintained across an electric heater that is made from a nichrome wire of resistance 20Ω .

- Find the current in the wire and
- The power rating of the heater.
- At an estimated price of *JOD* 0.10 per kilowatt-hour of electricity, what is the cost of operating the heater for 5 minutes?

The current is:

$$I = \frac{\Delta V}{R} = \frac{220}{20} = 11A$$

The power rating is:

$$P = \frac{\Delta V^2}{R} = \frac{220^2}{20} = 2420W$$

the cost of operating the heater is:

$$\text{Cost} = \text{energy (in } kWh) \times \text{price}$$

$$\text{Cost} = \text{power (in } kW) \times \text{time(in } h) \times \text{price}$$

$$\text{Cost} = 2.42 \times \frac{5}{60} \times 0.1 = 0.02 \text{ JOD}$$