Physics 7B

DLM 14 Overview

Model/Approach: Energy-Density Model

Act-6.2.6 Equivalent Resistance and Power Ratings DLM-13 FNTs (~ 70 min)

Learning Goals:
- Practice using the construct of equivalent resistance in simple parallel and series circuits
- Understand household wiring in terms of the basic concepts
- Understand the parallel nature of household circuits and why this leads to “constant” voltage
- Develop a deeper understanding of electrical power and power in general
- Develop an understanding of electrical power in household circuits
- Practice finding equivalent parallel and series resistance

AC-6.2.7 Power and Household Circuits (~ 60 min)

Learning Goals:
- Understand household wiring in terms of the basic concepts.
- Understand the parallel nature of household circuits and why this leads to “constant” voltage.
- Develop a deeper understanding of electrical power and power in general.
- Develop an understanding of electrical power in household circuits.

Start on the FNT if you finish early

Announcements

- **Reading Assignment** - Read Unit 7 through page 86.

- You should be use the resources on the web page to improve your understanding of the course materials, in particular playing with the circuits applet will help with this unit’s concepts and prepare you for the exams and the final.

Equivalent Resistance and Power Ratings (DLM-13 FNTs)

A) Wrap up 6.2.5

If you did not do so last time, put on the board your answers to part B of AC 6.2.5 and be prepared to share with the whole class. In addition, be prepared to be called on to answer any question from part A, if your TA desires.

B) Equivalent Resistance

In your small group

FNT 1

Share your individual responses to FNT 1 with the other members of your group.

Then, draw **on the board** the circuit that results **after** replacing resistor #2 and #3 with their equivalent resistor. Indicate the value of this equivalent resistor on your diagram. Call this equivalent resistor #4.

Next, draw **on the board** the circuit that results **after** replacing resistor #1 and #4 with their equivalent resistor. Indicate the value of this equivalent resistor on your diagram. Call this equivalent resistor #5.

1) Use your second diagram (the one with resistor #5) and the energy-density equation taken around the entire circuit to determine the current "drawn from" the battery. Is this also the value of the current in resistors #1and #4 in your second diagram? Explain.
2) Use your first diagram (the one with resistors #1 and #4) and the energy-density equation taken around the entire circuit to determine the voltage drop across resistor #1 and #4 and write these next to the resistors on your first diagram.
3) What does knowing the voltage drop across #4 tell you about the voltage across #2 and #3? Why?
4) Use the results of (2) and (3) to determine the currents in resistors #2 and #3. What must be the relation of these two currents to the current through the battery you determined in (1)? Why?

FNT 2

1) Share your individual responses to FNT 2 with the other members of your group.
2) Does your answer depend on the value of either resistor #2 or #3?
3) Describe in simple terms what it means for an element to be short circuited.

C) Power: FNTs 3-7

In your small group:

Share your individual responses to FNTs 3-7 with the other members of your group. Come to a consensus on the answers to each FNT **as well as** the reasons behind your answer..

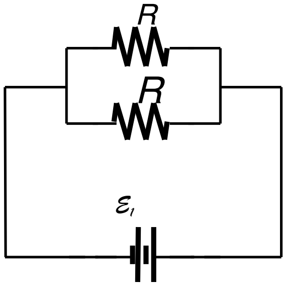
Put up **on the board** any of these FNTs your DL instructor tells you to.

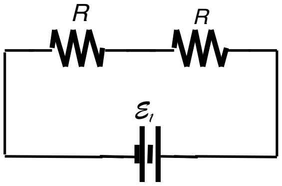
Be prepared to explain the correct response for each FNT if called upon in the whole class discussion, ***AS WELL AS*** the reasons for your response.

Power and Household Circuits (finish as FNT)

In Your Small Group:

A) How are house circuits wired up?





Suppose the resistors shown in the diagram at right represent two different small appliances which are plugged into two different electrical outlets in a room of your house. We can imagine $\mathcal{E}$ as being the 120 V that is present on the metal prongs of the outlet. If each appliance is to always have 120 volts applied across its plug, which way would they need to be wired up (left or right diagram)? Explain your thinking using the steady-state energy density model. How many "current carrying" wires have "to run" to each electrical outlet in your house. Show "a run" with five outlets wired up from one source of 120 V. Put this on the board.

B) How are holiday light strings wired up?

You know that a single holiday light bulb is bright with about 3 volts across it (two 1.5 B batteries is series). How is it possible to plug strings of holiday lights into a 120 V household outlet without burning them all out? **Make a diagram**. How many lights should there be in a single string if there are only two wires total and each light has the proper brightness with 3 volts across it?

C) Power used by an electrical appliance

Discuss in your small group:

1) Consider a variety of different light bulbs connected in the normal way in your house. Which of the following quantities is the same for all of these bulbs: the voltage across them, the current in them, or the power used by them? Explain.

2) What ***physical*** feature of a light bulb determines the power it "consumes"?

Put your responses on the board.

D) Power Limitations

Discuss in your small group:

Imagine you have a small thermally insulated thermos bottle that has a built in electrical heater. The thermos holds one-liter of fluid. What is the least amount of time required to raise the temperature of one liter of water in this thermos to a boil (starting at 20˚C) if it is plugged into a standard 20 amp, 120 volt household electrical outlet.

1) What is the limiting factor that to heating the water as quickly as you wish?

2) Calculate the time required under the optimum conditions.

3) What should the resistance of the heating element of this thermos be to achieve the shortest heating time?

Physics 7B

Exit Handout

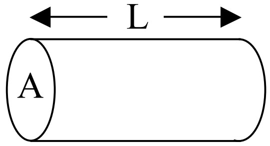
DLM 14

FNT

1) Read pages 79-82 of the course notes. In these pages you will find a short discussion of the linear transport model. You have already seen this model in the two specific cases of fluid flow and electrical charge flow. In this question, we ask you to connect the ideas of the linear transport model to the two flow problems that you already understand and then extend the ideas to two more flow problems that you know a little about from your own experience and from previous science classes.

a) The linear transport model is always concerned with something being transported from one location to another. Since it is a flow problem, we are concerned with the amount being transported per second (i.e. the current). Apply this general model to the problems you have studied so far.

- i) In a fluid circuit, name the stuff that is being transported. Is this stuff being transported actual matter or is it something else?
- ii) In an electrical circuit, name the stuff that is being transported. Is this stuff matter or is it something else?
- iii) When a hot object is put near enough to a cold object, the hot object cools down and the cold object gets hotter. Name what is being transported from the hot object to the cold object. Is this stuff matter or is it something else?
- iv) Some time after a container of a strong smelling substance (like ammonia) is opened on one side of a room, a person on the other side of the room will smell it. Name the stuff that is transported from the container to the other side of the room. Is this stuff matter or is it something else?



b) In the linear transport model, the current is carried a distance, L, through an area, A, as shown in the picture to the right. In this model, we don't actually use the current, I, alone. Instead, we define the "flux", j, of the stuff being transported as the current per unit area so that $j = I / A$. The flux is essentially a measure of the current density (if we force the same current through a smaller area then the flux is larger).

- i) In a fluid circuit, what are the SI units for the **flux** of stuff being transported?
- ii) In an electrical circuit, what are the SI units for the **flux** of stuff being transported?
- iii) In a heat flow problem, what are the SI units for the **flux** of stuff being transported?
- iv) In an ammonia diffusion problem, what are the SI units for the **flux** of stuff being transported?

c) In the linear transport model, there is always a physical quantity that ***decreases*** along the direction of the flow. When there is a change in a quantity from one location to another, we say that there is a "gradient" of this quantity. This gradient causes the flow (the gradient "drives" the flow).

- i) In a fluid circuit, what quantity changes from point to point to cause the flow?
- ii) In an electrical circuit, what quantity changes from point to point to cause the flow?
- iii) In a heat flow problem, what quantity changes from point to point to cause the flow?
- iv) In an ammonia diffusion problem, what quantity changes from point to point to cause the flow?

d) In the linear transport model there is always something that resists the flow.

- i) In a fluid circuit, what resists the flow?
- ii) In an electrical circuit, what resists the flow?
- iii) In a heat flow problem, what resists the flow?
- iv) In an ammonia diffusion problem, what resists the flow?