Electricity and Magnetism: Teaching and Learning Issues 05

Contents

This is the ‘Teaching and Learning Issues’ that explains the particular challenges. To develop your expertise in the episode, work with the ‘Physics Narrative’ and the ‘Teaching Approaches’. Navigate to any part of the topic using the Topic Menu, or use the tabs below to stay within this episode. .

Some challenges to be met

- Challenge 1: Power; connections to the everyday
- Challenge 2: Power brings together the current and voltage stories
- Challenge 3: Is the power output of an electrical appliance fixed?

These challenges reflect research carried out into alternative conceptions.

Challenge 1: Power; connections to the everyday

Thinking about the learning

Many pupils will have already come across the unit of power, the watt, outside school. This may have been buying light bulbs at the supermarket, choosing an amplifier for a music system, or switching to the correct power setting for a microwave oven when heating up a snack.

These everyday experiences are likely to fit in with the science idea that the power output of an electrical device is a measure of the amount of energy it transfers each second.

For example, many pupils will be familiar with the fact that light bulbs come in all shapes and sizes and are sold according to their "wattage".

Thus, their bed-side light may use a 40 watt bulb and provide a relatively subdued light (transferring 40 joule of energy per second). In comparison, the main light in their room might use a 100 watt bulb and be much brighter in comparison (transferring 100 joule of energy per second).

Making such links to familiar domestic appliances can help pupils to come to understand what is meant by electrical power.

Challenge 1: Power; connections to the everyday

Thinking about the teaching

Start with familiar electrical appliances. To introduce the idea of electrical power, you might demonstrate various electrical appliances with different power outputs and explain that the amount of energy each device gives out per second is called its electrical power.

Desk lamp
Transfers 100 joule of energy per second as it heats up and gives out light.

Microwave oven
Transfers 850 joule of energy per second as it cooks food.

Kettle
Transfers 2500 joule of energyper second as it heats up water.

By making comparisons between the appliances, the important idea to get over is that, for example, the kettle transfers energy 25 times more quickly than the desk lamp (2500 to 100).

The important images to develop are:

- The energy store is being emptied 25 times more quickly with the kettle.
- The household electricity supply meter spins around 25 times more quickly.
- The costs builds up 25 times more quickly.

Thank goodness it only takes a matter of minutes to boil a kettle!

Appliances with different power outputs

It is a very useful exercise for pupils to investigate the power outputs of electrical appliances in and around the home. By collecting the figures and grouping them according to size, pupils can find out that appliances with the biggest power outputs are those which have some kind of heating function.

For example, an electric fan heater might have a power output of 2000 watt or 2 kilowatt (2 kW). The heater transfers 2000 joule of energy per second.

Microwave ovens often have high and low power output settings:

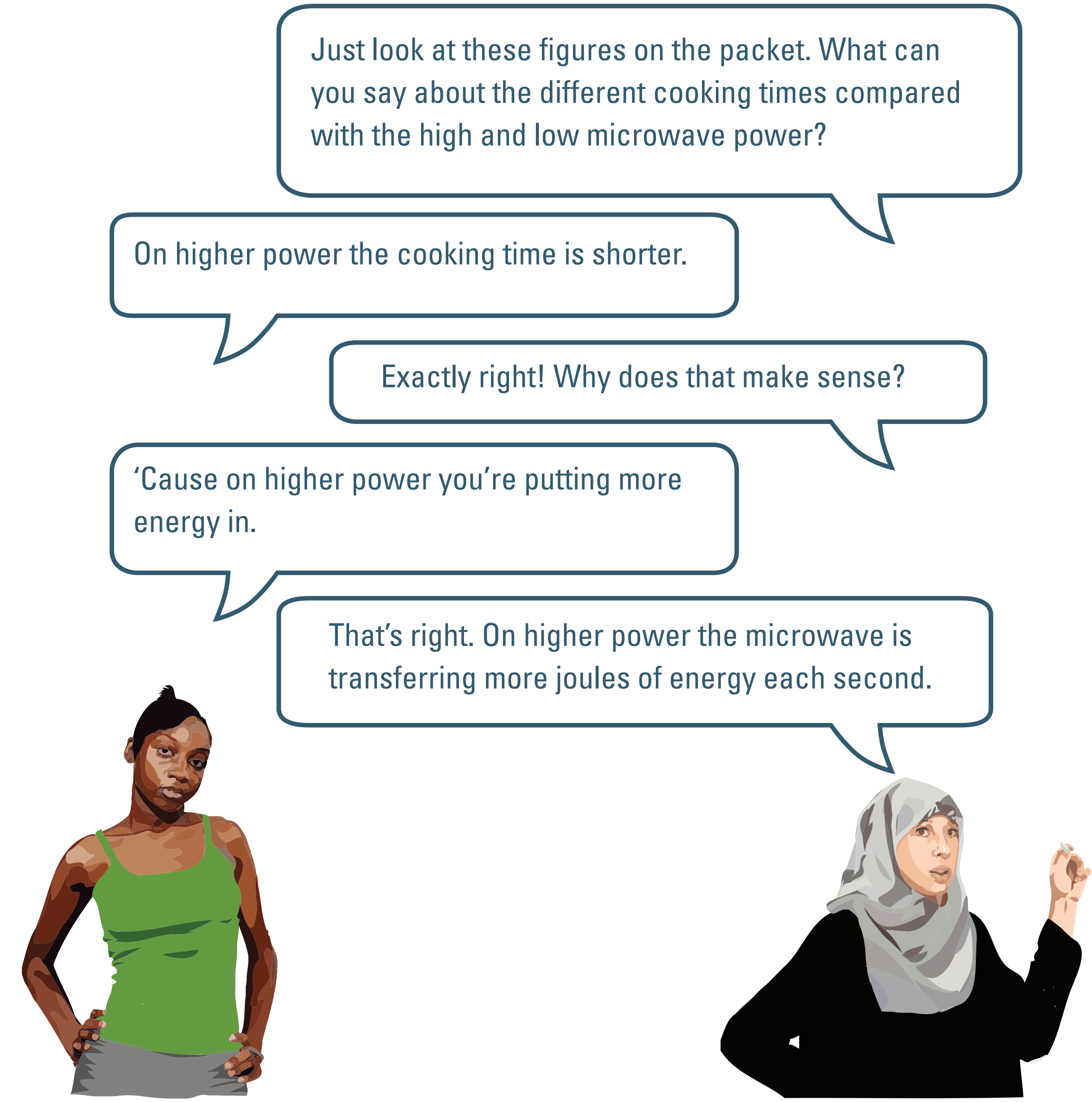
Microwave low power	Microwave high power
650 watt	750 watt

The directions on the microwave food packet provide details for cooking times. For example, for a bolognese sauce:

Microwave power output cooking time

- 650 watt, 4.5 minutes
- 750 watt, 3.5 minutes

Use sets of figures such as these to help pupils grasp the idea that high power electrical devices can transfer a lot of energy in a shorter period of time:



Paying the electricity bill

It is also interesting and instructive to talk about the relative costs involved in running different electrical appliances. The first thing to establish here is what it is that you are actually paying the electricity board for. The straight answer is energy.

For example, a two bar electric fire operates at 2 kW and transfers:

- 2000 joule of energy each second
- 20 000 joule of energy every 10 seconds
- 200 000 joule of energy every 100 seconds

As soon as the fire is switched on, the electricity meter starts spinning around more quickly as the fire heats up the surroundings. The meter keeps a record of the total amount of energy transferred by all of the electrical appliances in the house.

It is instructive to make some direct comparisons between the costs of using different electrical appliances. It's not too difficult to bring these matters close to the pupils' own interests!

I remember when I was a young lad (!), I used to play my hi-fi record player all of the time. My mother would get fed up with this, and when the electricity bill came would blame me for the size of the bill, saying, "Look at this bill! No wonder we have to pay so much for electricity with you listening to that record player all the time".

Now, my mother didn't know too much about science. Was she right about the electricity bill? Do you think I was really to blame? Has anybody here had a similar sort of experience?

The kilowatt hour

Find out more about what you pay for!

The bill from your electricity company is not set out in terms of joules of energy transferred. As you can see from the example of the two bar electric fire, this would very quickly give rise to some rather big numbers! Instead the unit of energy is taken as the kilowatt hour.

1 kilowatt hour is the amount of energy transferred when a 1 kilowatt device is left running for 1 hour (note that the kilowatt hour is a unit of energy, just like the joule). The electricity companies refer to one kilowatt hour as a “unit” of energy, and charge according to the number of units transferred or shifted by the household.

For example:

- A 2 kilowatt electric fire left running for 3 hours transfers 6 kilowatt hours of energy (or 6 units of energy).
- A 100 watt light bulb (0.1 kilowatt) left on for 60 hours transfers 6 kilowatt hours of energy (or 6 units of energy).

Introducing the kilowatt hour offers useful extension work for some pupils.

Challenge 2: Power brings together the current and voltage stories

Thinking about the learning

The idea of electrical power brings together the moving charges (current) part of the electric circuit story along with the energy shifted (voltage) part. As such, pupils often find this a satisfying step to make as they draw on their knowledge of current and voltage and see how this leads to an understanding of electrical power.

Thinking about the teaching

From current and voltage to power

For those pupils who are able to follow the line of argument, we would recommend following through the "working from first principles" approach, which is set out in the Physics Narrative.

Start with the definitions of current as coulomb/second and voltage as joule/coulomb and move from these to power in terms of joule/second. Such an approach is made easier in the classroom by referring to a particular circuit (as we did in the narrative) and working with specific figures for current and voltage (for example: 2 ampere and 12 volt). Having developed the idea of power for a specific case, you can then introduce the general definition.

All too often, pupils know that power can be calculated by multiplying together current and voltage, but have little understanding either of why this should be the case or what the electrical power actually means in practice.

Challenge 3: Is the power output of an electrical appliance fixed?

Wrong track: If a car headlamp bulb has a power rating of 24 watt, this means that it always gives out 24 joule of heat and light energy each second.

Right lines: If a car headlamp bulb has a power rating of 24 watt, this means that it is designed to transfer 24 joule of energy per second at its normal operating voltage of 12 volt. However, if the voltage is reduced (say to 6 volt) then the power output will fall below 24 watt and the bulb will be dimmer than normal.

Challenge 3: Is the power output of an electrical appliance fixed?

Thinking about the learning

The key point to understand here is that an electrical device such as a light bulb can have a full range of power outputs depending on the operating conditions. If the supply voltage falls, then so too will the current and the power output of the bulb will be reduced.

Household light bulbs are rated and sold in terms of their power output, but you need to bear in mind that figures of 100 watt or 60 watt apply for the normal 240 volt supply.