Motors

Teacher Notes for Session 5 Activity C

This activitiy is based upon the use of a LEGO kit. How many of the kits you have available will mainly depend on finance. Ideally there would be one kit per group, but if you have just one it is possible to use it as part of a class activity.

The key aims of this work are to introduce students to the practical uses of motors (e.g. in food mixers, cars and the like) and the use of gears to transfer motion from the motor to the wheels etc. The way this is done is to involve the students in a series of short activities with the LEGO kit. Most of the work is straightforward, but it does require the students to measure, and think! As usual, the idea is that students discuss the tasks, questions etc., with each other in their groups. The notes that follow should be read in conjunction with the student instructions.

Exercise 1

Building the buggy is not too difficult, but there are more parts in the kit than the students need. It would be best to issue the kit with only the parts they need. A convenient way to do this is to put the parts in a good quality sealable freezer bag, or a small plastic lunch box. Note: six AA batteries are needed for each controller box. (The latter can be difficult to open.)

1. There are 24 cogs on the large gear wheel.
2. There are 8 cogs on the small gear wheel.
3. The students might describe this in words and/or with a diagram. Note that the gear wheels in question have identical numbers of cogs.
4. Stable can have several meanings; but the key things are for the students to think about relevant factors. Key ones are: the motor is heavy and is (roughly) in the middle so the weight is fairly evenly distributed; however the motor is quite high, so the centre of gravity will fall outside the base if the buggy tips too much. When you go over their answers it would be useful to stress such factors in the design of cars (for general use and, say, in Formula 1 racing). Needless to say, students will have fun trying out the buggy. How much you can stand of this will depend on you!

Exercise 2

1. Students may suggest many different ways, some of which will not be possible in a lab or class room. However, do let them try out different ways if at all possible. One way that we have tried is to measure out 1m, and time the buggy over that distance. It is necessary to have a timing device that measure to at least 1/10th of a second—many mobile phones have such a facility. Doing that, we observed a time of (about) 1.2seconds, which gives a speed of 100cm/1.2 s = 88.33 cm/s. The accuracy is not that good of course: the main errors are getting accurate times when there is variation in starting and stopping the stop-watch/timer. Probably the inaccuracy is of the order of 30% (possibly more) when short times are being measured. A mechanical device for controlling a time would be best. This could be a possible use of a microswitch attached to the buggy (see the electronics module); but a datalogger would be best.

Motors (continued)

Another point to be aware of is that it take time for the buggy to get to its top speed, so ideally it is best to time it not from a standing start, but when it crosses a mark already moving.

2. One key idea is to repeat measurements, so as to obtain a better estimate. If you are confident with its use, this could be an ideal opportunity to use datalogging equipment to measure the speed of the buggy.

3. The diameter is about 3cm, so the radius is 1.5cm and the circumference is about 9.42 cm.

4. Using our result, the buggy travels 88.33cm in one second, so the number of revolutions is 88.33/9.42, i.e. 9.34 revolutions per second. The number of revolutions per minute is 60 times greater, i.e. 563 revolutions per minute.

Exercise 3
1. The small gear wheel will go round 24/8 = 3 times for each revolution of the large wheel. That is, the wheels will be rotating three times faster than the motor shaft.
2. If the speed were 300 rev/min, then the motor shaft would turn at 100 rev/min.
3. We found a speed of 563 rev/min, so the estimate for the motor speed is 188 rev/min.
4. The result is almost 50% less than the LEGO figure. Reasons for the difference include: errors of timing (see above), slipping of the wheels on the floor/bench, batteries not being at 9V (so motor turns more slowly than stated by LEGO). Note: a datalogger should give a much better estimate, but only if the timing starts when the buggy is at top speed.

More about gears and using motors
Q.1Put the large gear on the wheel shaft, and the small on the motor shaft.
Q.2Easier to move with low gearing; that's why cars start in 1st gear and gradually change up to 4th once the car is moving more rapidly.
Q.3 and 4. The lever is for changing the gears in the mixer. The first setting might be used for mixing dough for bread (thick/heavy and hard to move). The last setting might be used for beating egg whites (light and easy to move)

Follow-up work
The working of a clutch is best explained using diagrams e.g. from auto.howstuffworks.com/clutch.htm. Depending on the nature of the groups, it can be worthwhile asking each group to give a short report to the whole class. The Prius is a car marketed by Toyota (at less than cost price) that uses a combination of electric and petrol motors. The electronics swaps between the two to give the most economical running. The search for a fuel-efficient engine is becoming much more pressing as oil prices rise. Problems remain with making batteries efficient but able to sustain sensible mileages while keeping their weight down. They are not so environmentally friendly as might be thought at first sight—if they are plugged into the mains, then more fuel is used in power stations (more carbon dioxide released etc.).

How students tackle the design issue will vary greatly; but main issues might be the nature of the tasks the mixer is to carry out (distinguish mixers from blenders?); weight and size: the more powerful, the heavier the mixer has to be to remain stable in use; elegance of design (contours, colour etc.).