Coordinator Notes:

Module 4.3: Electronics - Motors

This session explores the electronics of motors. Students build on their knowledge of energy, and circuits, and explore how:

- Electric motors transform electrical energy into mechanical energy
- Magnets play a role in electric motors
- Two different types of electrical current are harnessed by motors, direct current (DC) and alternating current (AC).

Students learn how to differentiate between DC and AC and what each form is used for. Students will use their knowledge to construct a DC motor powered car as this module's challenge. Students are encouraged to experiment with different materials, test, and refine their car designs. This challenge helps to further develop teamwork and critical thinking.

Session Length:

This Module can be presented in different session durations per your needs.

Lesson plans are provided for:

- A 120 minute session, or, 2 x 60 minute sessions
- 45 minute, 75 minute, and 90 minute sessions

Technology:

PowerPoint: If you do not have access to a data projector and cannot display the PowerPoint presentation, we recommend that you print the most important slides before the session, and either enlarge them onto cardboard to use in place of slides, or create a booklet that students can share in small groups.

The session can be conducted without slides, however they offer important visual aid in explanation of circuit components and symbols used for circuit diagrams.

Videos links: The suggested links to online videos within the session can be helpful with explanation. Notes have been included in the slides if there is an essential component to a video which the facilitator should discuss or demonstrate, if the video cannot be played.

Video files: A video file for each Module has been provided to aid explanation and instruction for some experiments and challenges. It is recommended coordinators view video files prior to delivering sessions, if the experiments and challenge activities are unfamiliar.

Please read the Module 4 Risk Assessment before proceeding with the activity

Contents	Page

Module 4.3: Electronics - Motors

Overview

This session builds on modules 4.1 and 4.2, where we introduced energy types, storage, transformation and electrical circuit design. In this session, we explore the concept of motors as a component in an electrical circuit.

Students build on their understanding of electrical currents in circuits, and explore both direct current and alternating current. They use this knowledge to build a simple DC motor powered vehicle.

Content overview:

Concept / Activity	Session Duration (minutes)			
	120	90	75	45
Motors: What are they, where are they found?	*	*	*	*
Motors and Magnets. Magnetic fields, poles, flux lines. Permanent Magnets, Electromagnets.	*	*	*	-
Activity 4.3.2: Magnetic Car. Exploring magnets, an important component of electric motors.	*	*	*	-
Activity 4.3.3: Electromagnet. Creating an electromagnet, exploring magnetism and de-magnetism.	*	*	-	-
Introduction to DC (Direct Current) and AC (Alternating Current).	*	*	*	-
Activity 4.3.1: Simple Motor. Exploring the construction of a simple DC motor using a magnet and an electromagnet.	*	*	*	-
Challenge 4.3: X-Racer Challenge. Designing, constructing and testing self-powered cars. Using DC motors and / or other concepts (e.g. rubber bands as springs) to power small cars.	*	*	*	*

Slides:

PowerPoint Slides are available to support the delivery of this module. Slides explain concepts visually, and include short, engaging videos relevant to the topic.

A full list of slides and recommended inclusions for each session duration are provided in the table below. Appropriate slides are also noted in lesson plans for each duration.

PowerPoint Presentation: 'M 4.3 - Master Slides 120 minute Session Duration'		**Session Duration (minutes)**			
Slide	**Content**	**120**	**90**	**75**	**45**
1	Introductory title page for Module 4.3	*	*	*	*
2	Discussion prompt: What is a motor?	*	*	*	*
3	Motors and Magnets. **Activity 4.3.2: Magnetic Car**	*	*	*	-
4	Overview: Motors and Magnets. Magnetic fields, poles, flux lines. Permanent Magnets, Electromagnets.	*	*	*	-
5	Electromagnets. **Activity 4.3.3: Electromagnet.**	*	*	-	-
6	Overview: Magnetic Fields and Forces.	*	*	-	-
7	**Activity 4.3.1: Simple Motor**	*	*	*	-
8	Overview: Types of Motors - AC and DC	*	*	*	*
9	Interactive slide: Identifying AC and DC on a graph	*	*	*	*
10	Interactive slide: Identifying AC and DC pictorially	*	*	*	-
11	Discussion prompt: Usage of AC and DC	*	*	-	-
12	Introductory page for **Challenge 4.3: X-Racer**	*	*	*	*
13	Overview: Challenge 4.3 X-Racer outline	*	*	*	*
14	Examples videos	*	*	*	*
15	Rules for Challenge 4.3 X-Racer	*	*	*	*
16	Materials for Challenge 4.3 X-Racer	*	*	*	*
17	References & Resources	*	*	*	*

Module 4.3 Electronics - Motors

Lesson Plan

120 minute session or 2 x 60 minute sessions

High Tech: Use PowerPoint Presentation 'M4.3 - Master Slides'

Key Learning Area Physics			**Topic** Motors, Magnets, Electricity
Timing	**Running Time (hh:mm)**	**Procedure**	**Materials**
3 min	00:03	**Lesson Introduction** Welcome! Brief recap energy transformation, circuits, switches. Discussion: what is a motor, where are motors found?	M4.3 PowerPoint (Slides 1-2)
		Body of Lesson (Lesson 1, 2 x 60 minute sessions)	
10 min	00:13	Motors and Magnets. Activity 4.3.2 Magnetic Car.	M4.3 PowerPoint (Slide 3) AA batteries, disc magnets, aluminium foil
3 min	00:16	Introduction to magnets, magnetic fields, poles, flux lines. Introduction to permanent magnets and electromagnets.	M4.3 PowerPoint (Slide 4)
10 min	00:26	Activity 4.3.3 Electromagnet.	M4.3 PowerPoint (Slide 5) Iron nails, D batteries, insulated copper wire, wire strippers, electrical tape
2 min	00:28	Discussion, magnetic fields, forces, how motors work.	M4.3 PowerPoint (Slide 6)
22 min	00:50	Activity 4.3.1 Simple Motor.	M4.3 PowerPoint (Slide 7) AA batteries, paper clips, copper wire, disc batteries
5 min	00:55	Types of motors, introduction to Alternating and Direct Current	M4.3 Power Point (Slides 8 – 11)

		(Break for 2 x 60 minute sessions)	
		(Lesson 2, 2 x 60 minute sessions)	
5 min	00:05/ 01:05	Introduce Challenge 4.3 and outline rules, materials, scoring.	M4.3 PowerPoint (Slides 13-16)
3 min	00:08/ 01:08	Watch videos to prompt design ideas. If videos unable to be played, ensure the coordinator watches prior to the session.	
7 min	00:15/ 01:15	Design planning time. Form groups and review materials, draw design ideas.	Planning sheet 4.3, pens / pencils.
30 min	00:45/ 01:45	Construct X-Racers, time trial tests.	Score sheets 4.3, plastic bottles, lids, cardboard, paper, rubber bands, straws, paddle-pop sticks, skewers, DC motors toothpicks, foam trays, wire, hot glue gun, scissors, sticky tape / masking tape, blue tack, 9V batteries, battery clips, stop-watch, race area
10 min	00:55/ 01:55	Individual and group races.	Score sheets 4.3 Stop-watch
		Lesson Conclusion	
5 min	01:00/ 02:00	Discussion, questions, clean up.	

Activity 4.3.1: Simple Motor

Aim: To construct and observe a simple DC motor

Equipment (per group):

- 1 x AA battery
- Thin copper wire, approx. 40cm length (note: wire > 1mm diameter will not work)
- 2 small disc magnets
- 2 paperclips
- Electrical tape
- Thick pen / small glue stick

Procedure:

1. Form into groups of 2 – 4 students.
2. Wrap the wire around the pen / glue stick 5 to 10 times to make a coil shape. Ensure you leave a few centimetres of straight wire on each side.
3. Wind the sides around the coil once or twice on either side to secure the coil, again ensuring a few centimetres of straight wire remain on each side.
4. Bend each of the paperclips to make a long straight end and an end with a loop. Tape the straight end of each paperclip onto either end of the battery.
5. Hook the straight ends of the wire coil into the paperclip loops.
6. Place a magnet between the battery and the coil.
7. Observe.

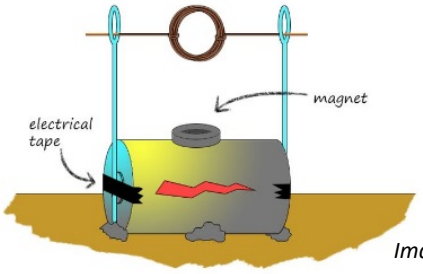

Image source: www.makeprojects.com

Expected Result: The coil will spin when the magnet is between the battery and the coil.

Explanation:
Simple DC motors work due to Faraday's Law of Induction. When current runs through a wire loop, a magnetic field is created. If a magnet is placed near the wire, the two magnetic fields interact, causing a mechanical force to be applied to the wire. We call this twisting force torque. This process converts the electrical energy of the current into the mechanical energy, or torque, of the spinning wire loop.

Notes:
The wire will begin to warm up and will become hot if left to spin for an extended time.
If the wire coil does not spin:

- Push the coil slightly to get it started
- Adjust the coil to be more evenly shaped
- Add additional magnets.
- Ensure the battery has a charge / is not flat.

Activity 4.3.2: Magnetic Car

Aim: To build a simple magnetic car and observe a motor

Materials (per group):

- One AA battery
- Two circular magnets
- Aluminium foil square (approx. 30cm x 30cm)

Procedure:

1. Form into groups of 2 – 3 students
2. Lay a square of aluminium foil on a table
3. Attach a magnet to each end of the AA battery, so they look like wheels (the magnets will stick to the battery, no glue/tape needed).
4. Place the battery with its "wheels" (magnets) on top of the aluminium foil.
5. Observe!

Expected result:
The magnets will stick to both ends of the battery. If they don't, turn them around.
When the magnets are stuck to the battery like wheels, and the battery is placed on the foil, the device will act like a self-powered toy car and "drive" forwards.

Explanation:
An electric motor turns because of the forces of attraction and repulsion (push and pull) between a permanent magnet, and an electromagnet.

Magnets produce a magnetic field, which attracts some materials and can attract (draw towards) or repel (push away) other magnets.

Permanent magnets: Some materials, including the metals iron, nickel, and cobalt, are "ferromagnetic". These can be magnetized by an electric current, or by stroking another magnet. Once magnetised, these magnets stay magnetic, unless they become demagnetized by a shock, excess heat, or variable magnetic field.

Electromagnets: Magnets are not the only sources of magnetic fields. An electric current flowing through a conductor produces a circular magnetic field at right angles to the conductor. The current creates an electromagnet – a device that is extremely useful since its magnetism can be controlled and switched on and off. The poles of an electromagnet will be reversed if the direction of the current is reversed.

The stored electricity in the battery creates a magnetic field. The aluminium foil acts as a conductor (a carrier of electricity) and, when the conductor is placed in the magnetic field, because of the positioning of the battery and the magnets, it creates "torque" (it makes the magnets spin). This is called the "Lorentz force".

Activity 4.3.3: Electromagnet

Aim: To build and observe a simple electromagnet

Materials (per group):

- 3-4 metres of insulated copper wire (1 spool)
- Wire strippers
- An iron nail (8cm or more in length)
- 1 large D-size battery
- Paper clips
- Electrical tape

Procedure:

1. Form into groups of 2 – 4 students.
2. With the assistance of your supervisor, using the wire strippers, remove one centimetre of insulation from each end of the wire.
3. Leave 3 – 4 centimetres of wire trailing at each end, tightly wrap the wire around the nail, starting at one end and leaving no gaps. Ensure you wind the wire in the same direction the entire way along the nail.
4. Ensure you leave the head of the nail and a part of the nail's point uncovered.
5. Holding an insulated part of the coiled wire, touch one end of the exposed wire to the positive terminal of the battery (the + side). Attach with electrical tape.
6. Holding an insulated part of the wire, touch the other end of the wire to the battery's negative terminal.
7. The nail should now become magnetised! Test this by trying to pick up a paperclip using the head of the nail, or point of the nail.
8. When you release the wire from the negative terminal, the nail should no longer be magnetic. Test this by trying to pick up a paperclip with the nail.
9. See how many paperclips your electromagnet can pick up at the same time.

Expected result:
When the wire is connected to both battery terminals, the nail will become magnetised and attract the metal paperclips. When the wire is not connected to both terminals, the nail will lose its magnetic charge.

Explanation:
When the wire is connected to both battery terminals, an electrical current flows through the wire. The flowing electrical current produces a small magnetic field, which is amplified by having the wire wound tightly around the nail. This makes the nail magnetic. When the battery is disconnected, the electrical current flow stops, and the magnetic field stops as a result.

Challenge 4.3: X-Racer Challenge

Coordinator notes

Scoring:
A scoring mechanism is included so that the element of 'competition' may challenge all students to participate to their fullest. You may remove the scoring system all together if it does not work with your group of students.

When scoring, it is important to only announce who the winning team is. Consider asking how the students might approach the task differently if asked to do it again, or how they might teach the same things they learned during the club to a younger student. It is important to highlight the good strategies of each team.

Scores in this challenge are awarded based on time taken for the X-Racer to drive from the start line to finish line.

Activity notes:

- Students must construct a race car using the materials provided!
- Teams of 2 to 4 should be encouraged.
- Teams will be given a DC motor and a battery. They may choose to use just the DC powered motor to power their car, or, come up with another idea to help move the car forward, using the materials provided, e.g. rubber bands.
- Straight wheels, good placement of the motor, and the shape of the vehicle will each impact how fast it travels - and whether it goes in a straight line!
- Set up a race track with a distinct starting and finishing line before the Challenge. Use masking tape or chalk to define the lines. Ensure the race path is at least 1m wide, obstacle free, relatively flat, and a minimum of 2m long. The race path should be no more than 10m long.
- Encourage students to minimise use of materials and conserve resources.
- Ensure each group draws and plans their design before starting on construction.
- Students may need assistance with planning their car. The videos included in the slide notes give some ideas.
- The DC motor needs to be connected to a moving part of the car (e.g. axel, wheel) in order to use the mechanical energy provided.
- Ensure a coordinator is available for timing throughout the activity to assist students test / time trial their car. Time trials should be recorded in each group's score sheet.
- The supervisor should place holes in the plastic bottles for wheels axels, and use the hot glue gun when it is required, to minimise risk of injury.
- A final group race should be performed at the end of the session. You may choose to award the winner 10 bonus points.

Rules:

- Each car can only use one DC motor and 1 battery.
- Teams can use as many other materials as they choose, however discourage wastage through allowing time for design planning, and encourage conservative use through noting light cars will likely travel faster than heavy cars.
- Cars need to travel over the race track as quickly as possible. Times are calculated from when the car is released to when it has completely crossed the finish line.
- Before the final race teams can test their cars in up to 3 time trials. Their best time trial will contribute to their final score.

Materials:

- Plastic bottles & lids
- Cardboard
- Bottle lids
- Rubber bands
- Straws
- Paper
- Paddle pop sticks
- Skewers
- Toothpicks
- Foam trays
- Insulated wire
- Wire strippers
- Hot glue guns
- Scissors
- Sticky tape
- Blue tack
- 9V battery
- Battery clips
- DC Motor
- Stop watch

Challenge 4.3: X-Racer Planning Sheet

Take a look at the materials available, and draw your ideas!

Consider:

- Will the DC motor be used, if so, where will it be located in your design?
- What other ways could you power your X-Racer using the material supplied…
- How many wheels will your racer have, does it need 4? More? Less? Where will the wheels be positioned?
- Will you build your racer using a plastic bottle, or other materials?
- How much will your design weigh when it is constructed?

Image Source: https://youtu.be/36IEEvsEYVg

Challenge 4.3: X-Racer Challenge Score Sheet

Team Name	
POINTS AVAILABLE:	**POINTS SCORED**
Design ideas drawn prior to construction (20 points)	
X-Racer drives! (20 points)	
X-Racer completes the race track from the start line to the finish line (20 points)	
Time trial 1: (seconds) Time trial 2: (seconds) Time trial 3: (seconds) **Fastest trial x 10 = (A)**	**Points = 100 – (A)** **=**
Official test time: (seconds) **Official time x 10 = (B)**	**Points = 100 – (B)** **=**
Winner of group race: Receive 10 bonus points!	
Final Score:	

Team Name	
POINTS AVAILABLE:	**POINTS SCORED**
Design ideas drawn prior to construction (20 points)	
X-Racer drives! (20 points)	
X-Racer completes the race track from the start line to the finish line (20 points)	
Time trial 1: (seconds) Time trial 2: (seconds) Time trial 3: (seconds) **Fastest trial x 10 = (A)**	**Points = 100 – (A)** **=**
Official test time: (seconds) **Official time x 10 = (B)**	**Points = 100 – (B)** **=**
Winner of group race: Receive 10 bonus points!	
Final Score:	

Module 4.3 Electronics - Motors

Lesson Plan

90 minute session

High Tech: Use PowerPoint Presentation 'M4.3 - Master Slides'

Key Learning Area Physics			**Topic** Motors, Magnets, Electricity
Timing	**Running Time (hh:mm)**	**Procedure**	**Materials**
3 min	00:03	**Lesson Introduction** Welcome! Brief recap energy transformation, circuits, switches. Discussion: what is a motor, where are motors found?	M4.3 PowerPoint (Slides 1-2)
		Body of Lesson	
8 min	00:11	Motors and Magnets. Activity 4.3.2 Magnetic Car.	M4.3 PowerPoint (Slide 3) AA batteries, disc magnets, aluminium foil
3 min	00:14	Introduction to magnets, magnetic fields, poles, flux lines. Introduction to permanent magnets and electromagnets.	M4.3 PowerPoint (Slide 4)
8 min	00:22	Activity 4.3.3 Electromagnet.	M4.3 PowerPoint (Slide 5) Iron nails, D batteries, insulated copper wire, wire strippers, electrical tape
2 min	00:24	Discussion, magnetic fields, forces, how motors work.	M4.3 PowerPoint (Slide 6)
16 min	00:40	Activity 4.3.1 Simple Motor.	M4.3 PowerPoint (Slide 7) AA batteries, paper clips, copper wire, disc batteries
4 min	00:44	Types of motors, introduction to Alternating and Direct Current	M4.3 Power Point (Slides 8 – 11)

6 min	00:50	Introduce Challenge 4.3 and outline rules, materials, scoring. Watch videos to prompt design ideas. If videos unable to be played, ensure the coordinator watches prior to the session.	M4.3 PowerPoint (Slides 13-16)
5 min	00:55	Design planning time. Form groups and review materials, draw design ideas.	Planning sheet 4.3, pens / pencils.
25 min	01:20	Construct X-Racers, time trial tests.	Score sheets 4.3, plastic bottles, lids, cardboard, paper, rubber bands, straws, paddle-pop sticks, skewers, DC motors toothpicks, foam trays, wire, hot glue gun, scissors, sticky tape / masking tape, blue tack, 9V batteries, battery clips, stop-watch, race area
7 min	01:27	Individual and group races.	Score sheets 4.3 Stop-watch
		Lesson Conclusion	
3 min	01:30	Discussion, questions, clean up.	

Module 4.3 Electronics - Motors

Lesson Plan

75 minute session

High Tech: Use PowerPoint Presentation 'M4.3 - Master Slides'. Hide slides 5, 6 and 11.

Key Learning Area Physics			**Topic** Motors, Magnets, Electricity
Timing	**Running Time (hh:mm)**	**Procedure**	**Materials**
3 min	00:03	**Lesson Introduction** Welcome! Brief recap energy transformation, circuits, switches. Discussion: what is a motor, where are motors found?	M4.3 PowerPoint (Slides 1-2)
8 min	00:11	**Body of Lesson** Motors and Magnets. Activity 4.3.2 Magnetic Car.	M4.3 PowerPoint (Slide 3) AA batteries, disc magnets, aluminium foil
3 min	00:14	Introduction to magnets, magnetic fields, poles, flux lines. Introduction to permanent magnets and electromagnets.	M4.3 PowerPoint (Slide 4)
16 min	00:30	Activity 4.3.1 Simple Motor.	M4.3 PowerPoint (Slide 7) AA batteries, paper clips, copper wire, disc batteries
4 min	00:34	Types of motors, introduction to Alternating and Direct Current	M4.3 Power Point (Slides 8 – 10)
6 min	00:40	Introduce Challenge 4.3 and outline rules, materials, scoring. Watch videos to prompt design ideas. If videos unable to be played, ensure the coordinator watches prior to the session.	M4.3 PowerPoint (Slides 13-16)

5 min	00:45	Design planning time. Form groups and review materials, draw design ideas.	Planning sheet 4.3, pens / pencils.
25 min	01:05	Construct X-Racers, time trial tests.	Score sheets 4.3, plastic bottles, lids, cardboard, paper, rubber bands, straws, paddle-pop sticks, skewers, DC motors toothpicks, foam trays, wire, hot glue gun, scissors, sticky tape / masking tape, blue tack, 9V batteries, battery clips, stop-watch, race area
7 min	01:12	Individual and group races.	Score sheets 4.3 Stop-watch
		Lesson Conclusion	
3 min	01:15	Discussion, questions, clean up.	

Module 4.3 Electronics - Motors

Lesson Plan

45 minute session

High Tech: Use PowerPoint Presentation 'M4.3 - Master Slides'. Hide slides 3, 4, 5, 6, 7, 10 and 11.

Key Learning Area Physics			**Topic** Motors, Magnets, Electricity
Timing	**Running Time (hh:mm)**	**Procedure**	**Materials**
3 min	00:03	**Lesson Introduction** Welcome! Brief recap energy transformation, circuits, switches. Discussion: what is a motor, where are motors found?	M4.3 PowerPoint (Slides 1-2)
2 min	00:05	**Body of Lesson** Types of motors, introduction to Alternating and Direct Current	M4.3 Power Point (Slides 8 – 9)
5 min	00:10	Introduce Challenge 4.3 and outline rules, materials, scoring. Watch videos to prompt design ideas. If videos unable to be played, ensure the coordinator watches prior to the session.	M4.3 PowerPoint (Slides 13-16)
25 min	00:35	Form groups and review materials, draw design ideas. Construct X-Racers, time trial tests.	Planning sheet 4.3, pens / pencils. Score sheets 4.3, plastic bottles, lids, cardboard, paper, rubber bands, straws, paddle-pop sticks, skewers, DC motors toothpicks, foam trays, wire, hot glue gun, scissors, sticky tape / masking tape, blue tack, 9V batteries, battery clips, stop-watch, race area

7 min	00:42	Individual and group races.	Score sheets 4.3 Stop-watch
3 min	00:45	**Lesson Conclusion** Discussion, questions, clean up.	

Module 4.3 - References

Electromagnets & Electric motors

https://science.howstuffworks.com/electromagnet.htm

https://www.bbc.co.uk/education/guides/zryj6sg/revision

https://www.livescience.com/53509-faradays-law-induction.html

https://study.com/academy/lesson/electromagnet-science-fair-project.html

https://www.britannica.com/science/Lorentz-force

http://www.physics4kids.com/files/elec_faraday.html

http://www.bbc.co.uk/schools/gcsebitesize/science/edexcel_pre_2011/electricityworld/thecostofelectricityrev1.shtml

http://www.rohm.com/web/global/electronics-basics/motors/what-is-a-motor/

http://www.instructables.com/id/Simple-DC-Motor/

https://electronics.howstuffworks.com/motor7.htm

AC/DC current

https://www.bbc.co.uk/education/guides/zddp34j/revision/3

https://learn.sparkfun.com/tutorials/alternating-current-ac-vs-direct-current-dc

X-Racer Ideas:

4-wheeler with propeller: https://youtu.be/UnxNe_XjlWg

3-wheeler: https://youtu.be/36IEEvsEYVg

Rubber band power (instead of battery / DC motor)

https://www.youtube.com/watch?v=9xhEXDrMMLg

https://diy.org/rabinovitch/63115

https://www.youtube.com/watch?v=2ts7R__2gAE

Module 4.3 - Required Materials

- Pens, pencils and writing paper are generally required every session.
- Students may like to bring a note pad to record their observations and ideas.
- A group usually refers to 2 - 4 students.

Activity	Material	Amount	Where can I find it?
All sessions	PowerPoint Slides* (digital, or printed)	1 per coordinator	Coordinator Package
All sessions	Printed PowerPoint* Slide Notes	1 per coordinator	Coordinator Package
All sessions	Printed Lesson Plan	1 per coordinator	Coordinator Package
All sessions	Printed Module 1 Risk Assessment	1	Coordinator Package
All sessions	Computer, Data Projector, Screen	1	Venue
Activity 4.3.1 Simple Motor All sessions except 45 minute duration	AA Battery	1 per group	Supermarket, hardware store
	Electrical tape	2 rolls per session	
	Thin copper wire <1mm diameter	~40cm per group	Hardware store, online, electronics store
	Small disc magnets	2 per group	stationary store, online
	Thick pen / small glue stick	1 per group	Recycled, supermarket
	Paper clips	2 – 3 per group	Supermarket, stationary store
Activity 4.3.2 Magnetic Car All sessions	AA battery	1 per group	Supermarket, hardware store
	Aluminium foil	30cm square per group	
	Small disc magnets	2 per group	stationary store, online
Activity 4.3.3 Electromagnet 120 minute, 2 x 60 minute, and 90 minute session	D Battery	1 per group	Supermarket, hardware store
	Insulated copper wire	3-4 metres per group	Hardware store, online, electronics store
	Wire strippers	1 – 2 pairs	
	Iron nail (min 8cm long)	1 per group	Hardware store

Materials List continues on next page

* PowerPoint Slides have been provided as a Master Slide Set for a 120 minute (or 2 x 60 minute) session duration. Hide/ omit slides as noted in lesson plans for delivery of shorter session durations.

Note: Materials used in Activities overlap, and can be recycled for use in Challenge 4.3. Review materials used in module 4.2 and reuse for module 4.3 where practical.

Activity	Material	Amount	Where can I find it?
Challenge 4.3 X-Racer Challenge All sessions	9V Battery	1 per group	Supermarket, hardware store
	9V Battery clip	1 per group	Online, electronics store
	Insulated Wire	20cm per group	Online, electronics store, hardware store
	Electrical tape	2 rolls	Hardware store
	cardboard	30cm x 30cm per group	Recycled
	Rubber bands	6 per group	Supermarket, stationary store
	straws	4 per group	supermarket
	paper	1 A4 sheet per group	Recycled, supermarket, stationary store
	Planning sheet	1 – 2 per group	Coordinator notes
	Paddle pop sticks	6 per group	Craft / catering / stationary store
	skewers	2 per group	supermarket
	Plastic bottles	1 per group	Recycled
	Plastic bottle lids	4 per group	recycled
	Bottle lids (metal)	optional	recycled
	toothpicks	4 per group	Supermarket
	Foam trays	1 per group, optional	Catering store, supermarket, recycled
	scissors	1 pair per group	Supermarket, stationary store
	Sticky tape / masking tape	3 rolls for the session, managed by the supervisor	Supermarket, stationary store
	DC motor (9V)	1 per group	Online, electronics store
	Hot glue guns	1 - 2 for the session, managed by supervisor	Hardware store, craft / stationary store
	blue tack	1 strip per group	Supermarket, stationary store

Online Shopping Links:

Copper Wire, insulated and non-insulated:
https://www.jaycar.com.au/0-5mm-enamel-copper-wire-spool/p/WW4016
https://core-electronics.com.au/enameled-copper-magnet-wire-11-meters-0-1mm-diameter.html
https://core-electronics.com.au/stranded-wire-black-26-awg-70-feet.html

Battery Clips (from $0.65):
https://core-electronics.com.au/9v-battery-clip.html
https://www.jaycar.com.au/9v-battery-snap-high-quality/p/PH9232

DC Motors (from $3.50):
https://core-electronics.com.au/dc-toy-hobby-motor-130-size.html
https://www.jaycar.com.au/6v-9-000-rpm-dc-electric-motor/p/YM2712