Creative Design and Innovation

G12 Teacher's Guide

CREATIVE DESIGN
INNOVATION

Term 3 2017-18

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	2			• Introduce key words and learning outcomes for lesson 2	Pg. 30/31	• Define key words • Distinguish between	

			Unit 1: Lesson 2 (Adapting to space vehicles)	• Introduce students steering mechanism and skid steering • Facilitate as pupils complete activities 2.1-2.3 • Introduce students to rocker-bogie suspension system. • Facilitate as student's complete activities 2.4-2.6 • Facilitate and provide feedback as student's model rocker-bogie mechanism in activity 2.7 • Complete Student reflection • Introduce students to unit 2 sustainability, Set homework task to **self-study** this unit for next week. • State importance of sustainability in final project which must include sustainable design.	Pg. 32 Pg.33 Pg. 34-40 Pg. 38-40 Pg. 41 Pg. 42	methods of steering • Understand the operation and advantages of rocker-bogie • Model a rocker-bogie example	
2	1	**Unit 3: Mars Electronics**	**Unit 3: Lesson 1 (Essentials of Arduino)**	• Introduce key words and learning outcomes for lesson 1. • Introduce students to the role of Arduino microcontroller in electronics. • State the importance of the Arduino Leonardo board and Arduino IDE software. • Facilitate as pupil's complete activities 1.1-1.3. • Demonstrate Arduino code structure.	Pg. 60/61 Pg. 62 Pg.63-64 Pg. 63-67 Pg.68	• Define key words • Explain the role of the Arduino microcontroller in electronics. • Identify the main parts of the Arduino board. • Recognise the layout of the	

				• Introduce students to the first program (On-Board LED) • Facilitate as student's complete activity 1.4. • Facilitate and provide feedback as student's go through the Arduino code syntax in activity 1.5. • Complete the final activity and student reflection. State the importance of Arduino programming which must be included in the final project.	Pg. 69-70 Pg. 70 Pg. 71-72 Pg. 86-87	Arduino IDE programming interface. • Explain the Arduino programming structure.	
	2		**Unit 3: Lesson 2 (Analogue and digital signals)**	• Introduce key words and learning outcomes for lesson 2. • Introduce students to digital and analogue signals. • Facilitate as pupil's complete activity 2.1. • State the importance of Arduino functions. • Introduce students to the first most important Arduino function that will be used in their project (digitalWrite). • Facilitate as student's complete digital output-practical work, and activities 2.4-2.5. • Introduce students to the second most important Arduino function that will be used in their project (analogWrite).	Pg. 88/89 Pg. 90-91 Pg.92 Pg. 93 Pg. 99 Pg. 100-102 Pg. 108-109	• Define key words • Differentiate between digital and analogue signals. • Interpret how to generate a digital signal. • Identify how to generate an analogue signal. • Describe the function of PWM signals in electric circuits.	

				• Facilitate and provide feedback as student's complete analogue output-practical work, and activity 2.8. • Complete the student reflection. State the importance of Arduino programming which must be included in the final project.	Pg. 110-112 Pg. 115		
3	1	**Unit 3: Mars Electronics**	**Unit 3: Lesson 3 (Space rover electronics)**	• Introduce key words and learning outcomes for lesson 3. • Introduce students to space rover electronics and DC motors. • Facilitate as pupils complete DC motor- practical work and activities 3.1-3.2. • State the importance of the motor driver parts and functions. • Facilitate as student's complete <u>step 1:</u> Connecting the DC motors to the motor driver. • Introduce students to the importance of controlling the rotation and direction of DC motors. • Facilitate as student's complete <u>step 2:</u> Using Arduino to control the direction and rotation of DC motors and activities 3.3-3.5.	Pg. 116 & Pg. 117 Pg. 118 Pg. 119-122 Pg. 124-125 Pg. 126-128 Pg. 129 Pg. 129-133	• Define Key words • Identify the function of a motor driver. • Assemble electronic components to build a complete circuit of a space rover.	

	2		**Unit 3: Lesson 3 (Space rover electronics)**	• Introduce the Bluetooth module-wireless communication. • Facilitate as student's complete <u>step 3:</u> Connecting the Bluetooth module to the circuit. • Introduce students to a switch case statement. • Facilitate as student's complete activities 3.7-3.8. • Provide feedback as students write the full code for the space rover project. • After completing the circuit and code of the space rover pupils will need to test the space rover. • Complete the student reflection and provide feedback.	Pg. 135-136 Pg. 137-138 Pg. 139-141 Pg. 139-141 Pg. 142 Pg. 143 Pg. 163	• Develop and evaluate an Arduino code using a switch statement. • Use a Bluetooth module between a mobile application and Arduino. • Assemble electronic components to build a complete circuit of a space rover.	
4	1	**Unit 4: Space Rover Project**	**Unit 4: Space rover project:** **Stage 1: Analysis of brief** **Stage 2: Research and investigation**	• Introduce students to the aim and learning outcomes of the project. • Explain key word of project and ensure understanding • Introduce the project brief and mark breakdown • Introduce Stage 1: Analysis of brief	Pg. 165 Pg. 166 / 167 Pg. 168 Pg. 169	• Define Key words • Analyse a brief • Types of research	

			of possible solutions	• Demonstrate methods and key tips for correctly analyzing a brief. • In groups discuss the brief and break down into a mind map • Facilitate as student's complete activities 1.1-1.2 • Introduce students to stage 2: research and investigation • Use LMS resources to demonstrate different research methods • Note students should not begin to research in class yet.	Week 4 LMS resources Pg. 172		
	2		***Stage 3*: Possible solutions** ***Stage 4: Final solution***	• Introduce students to stage 3: possible solutions • Use LMS resources to ensure students understand how to shape possible solutions from research obtained. • Note possible solutions are not sketched at this point, this is knowledge development not application. • Introduce students to stage 4: Final solution • Explore critical thinking and facilitate as students complete Activity 1.5 • Explain the importance of taking positives from possible solutions to create one final	Pg. 175 Pg. 179	• Identify key aspects of possible solutions • Produce a mind map • Recognise research types and methods • Generate research	

				design that will be manufactured. • Facilitate as students use knowledge gained to complete research on research page or mood boards. • At least 2 possible solutions must be produced by EACH PUPIL before week 5 (encourage more than 2 on extra paper if needed) • Stages 2,3 and 4 should be completed for the rest of the lesson and homework. • A final Design must be presented in week 5 • Note encourage students to come for design feedback throughout the week.		• Sketch possible solutions • Generate final solution from possible solutions.	
5	1		***Stage 4: Final solution*** ***Stage 5:*** **Design realisation /** ***manufacture*** **(Electronics)**	• Groups should present their final solution to the class and teacher. • Provide feedback on final designs based on satisfying the brief. • Introduce students to the 3 aspects of design realization. • Facilitate students completing activity 1.6 to reinforce knowledge of manufacturing tools and resources.		• Presentation of final solutions • Identify aspects of design realization. • Assemble electronic components to build a complete circuit of a space rover.	

				• Teacher will facilitate students as they continue to assembly their electronic circuit. • Facilitate as pupils' complete activities 1.7-1.9. • Facilitate as students draw modified circuit diagram for full space rover. • Correct diagrams before facilitating as students build their final circuits in groups. *Going back to the electronics steps:* • Introduce students to step 4: Connecting SPST and DPST switches to the space rover circuit from Unit 3-lesson 3. • Facilitate as pupils' complete activities 3.9-3.10 (Unit 3-lesson 3). • Solder DPST switch to the final circuit. Facilitate as student's program and test the final circuit.	Pg. 185-187 Pg. 146-147 Pg. 147-148 Pg. 147/148 Pg. 206 (Appendix 1)	• Compare between a SPST switch and a DPDT switch. • Solder DPST switches into the final circuit. • Program and evaluate final circuit	
	2		***Stage 5:*** **Design realisation /** ***manufacture (Model and Manufacture***	• Introduce students to model and manufacture stage. • Facilitate as student's complete activities 1.10 and 1.11 to access fusion 360 parts.	Pg. 188 Pg.189 / 190	• Analyse given parts • Demonstrate and develop fusion 360 skills	

				• Facilitate as students create a Fusion 360 model of a complete space rover. • Use TG resources to deliver micro fusion lessons depending on class level. Demonstrate areas that groups are struggling with or areas new to a class. • Incorporate peer teaching if some groups are more proficient in fusion techniques than others. • Facilitate any groups that may still be working on electronics, divide groups to ensure both tasks are being covered. • Continue to facilitate as groups continue to model space rovers on fusion 360.			
6	1-2		***Stage 5:*** **Design realisation / *manufacture* (Model and Manufacture)**	• In this lesson you will facilitate students as they continue to design on fusion 360. • Facilitate those students who are still working on electronics. • Facilitate as students paste images of final model in book. • Recap on 3D printing process and facilitate as groups print space rover parts.	Pg. 191	• Demonstrate and develop fusion 360 skills	
7	1		***Stage 5:*** **Design realisation / *manufacture***	• Introduce students to final assembly of manufactured parts. • Ensure all parts are 3D Printed.	Pg. 194		

			(Assembly)	• Facilitate as groups assemble parts and circuit to complete a Space rover model.			
	2		***Stage 6: Evaluation***	• Introduce students to the evaluation process. • Facilitate as students test and evaluate final space rover.	Pg. 196		
8	1-2		***Summative assessments***	• Teachers carry out summative assessment			
9	1-2		***Project improvement***	• Teachers use this week to allow students finalise and improve their project.			

Lesson Plans:

Unit 1: Technologies in space exploration vehicles

Lesson 1: Vehicle design specifications

Aim:

This lesson aims to introduce you to the function and key principles of vehicle design. You will understand the importance of motor types, power sources, drivetrain methods and suspension systems. You will then analyse and compare this information in relation to the design of a space rover.

Teacher Learning Objectives: Learning objective refers to what you as a teacher will have taught the student by the end of the lesson. Teachers are to tick the box when the they have covered a learning objective.

- ☐ Explain function and operation of a space rover
- ☐ Demonstrate drivetrain types and sample calculations
- ☐ Explain the operation of various suspension systems
- ☐ Present possible power sources and the motor types they can power.

Student Learning Outcomes: Learning outcomes refer to what the student can expect from the lesson, Teachers must share these outcomes with all students. Teachers are to tick the box when the outcome is achieved. Learning outcomes can be assessed using oral questioning and the written activities.

Students should be able to:

- ☐ Define a space rover.
- ☐ Compare possible drivetrains.
- ☐ Complete drivetrain rpm calculations.
- ☐ Recognise and compare various vehicle suspension systems.
- ☐ Differentiate between brushed and brushless motors.
- ☐ Analyse possible power sources.

Keywords	**What are the keywords the students must learn?** • space rover • drivetrain • suspension • combustion • crankshaft • armature • brush • electromagnet • velocity ratio
Resources	**What resources are required?** • textbooks • projector • calculator
Prior Knowledge	• Emirates Mars Mission • Operation of DC motor

Possible Teaching Method(s) or Approach for this lesson

- ☐ Collaborative Teaching (student centred)
- ☐ Instructional / Demonstrative Teaching (teacher centred)
- ☐ Inquiry-based Teaching (student centred)
- ☐ Lecture Style Teaching (teacher centred)
- ☐ Coach Style Teaching (teacher centred)
- ☐ Facilitator Style Teaching (student centred)

Essential and non-essential Sections:

In some lessons it may not be possible to cover every section of the book due to time constraints or lesson variables. Below is a guideline to essential sections for examination and project knowledge.

Topic	Page	
	Essential	**Non-essential/Self Study**
What is a space rover?	Pg. 15	
Power sources and motors	Pg. 15-21	
Drivetrains	Pg. 22-25	
Suspension systems		Pg. 25-28

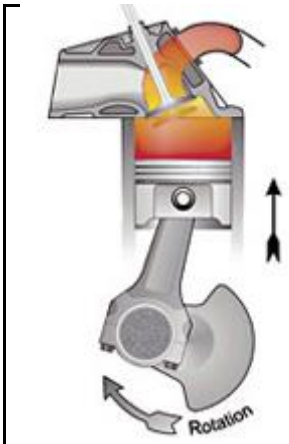
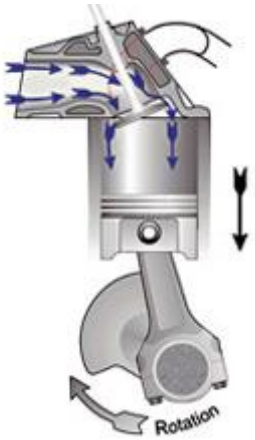
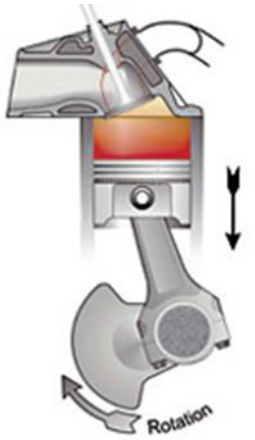
Development [Phases or chunks of learning]:	Notes for differentiation:	Assessment Opportunities:
Note: *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.* **Phase 1 of lesson (Connect)** **Starter** Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Discuss prior knowledge of space rovers and emirates mars mission. Show motivational videos / models to outline the end goal of the term. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.* **Phase 2 of lesson (Activate)** Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. Teacher to explain space rover function from book. Question students on what aspects are new to them when compared to prior knowledge discussion. Teacher to introduce fossil fuels as a power source for internal combustion engine. Teacher to introduce electricity and DC motors as an alternative power source. Teacher to explain Brushed DC motor vs Brushless DC motor. Question students on possible advantages and disadvantages. Teacher to explain the function of drivetrains. Students to explore drivetrain types and complete sample calculations Teacher to introduce suspension types Students to explore and differentiate between the various suspension systems of traditional vehicles. **Teacher Tip:** *Teacher to demonstrate good subject and curriculum knowledge*	***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary through ought the lesson.*	**Questioning.** **Questioning / Mind Map**

Phase 3 of lesson (Engage and Demonstrate) Divide students into groups assigning each group a power source and engine/motor type. Use an "Each on teach one" approach to have groups show their understanding and improve other groups understanding. Teacher to facilitate as peer teaching takes place. Students demonstrate learning by completing activities 1.1-1.5 Divide students into groups assigning each group a drivetrain. Use an "Each on teach one" approach to have groups show their understanding and improve other groups understanding of drivetrains. Teacher to facilitate as peer teaching takes place. Students demonstrate learning by completing activities 1.6 Divide students into groups assigning each group a suspension system. Use an "Each on teach one" approach to have groups show their understanding and improve other groups understanding of suspension systems. Teacher to facilitate as peer teaching takes place. Students demonstrate learning by completing activities 1.7 **Teacher Tip:** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.* **Phase 4 Plenary (Consolidate)** Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete student evaluation Students to complete activities 1.1-1.7 and finish for homework if uncomplete.		**Peer teaching** **Written Activities 1.1-1.5** **Peer teaching** **Written Activity 1.6** **Peer teaching** **Written Activity 1.7** **Oral Assessment** **Student evaluation**

Answer Key/ Resources

QR code links:		
Page	***Topic***	***Link***
18	DC motors	https://www.youtube.com/watch?v=LAtPHANEfQo
27	Shock absorber	https://www.youtube.com/watch?v=vcSH2z706rU

Activity 1.1

			
Exhaust stroke	Intake stroke	Compression stroke	Power stroke

Label the strokes of an internal combustion engine as shown below.

Activity 1.2

In the table below, match the correct stroke to the description.

Stroke:	Description
Compression stroke	The fuel and air mixture is compressed in the cylinder by the piston.
Exhaust stroke	Waste fumes are expelled from the cylinder.
Power stroke	A spark plug ignites the compressed fuel mixture.
Intake stroke	Flammable fuel is fed into the cylinder through the inlet valve.

Activity 1.3

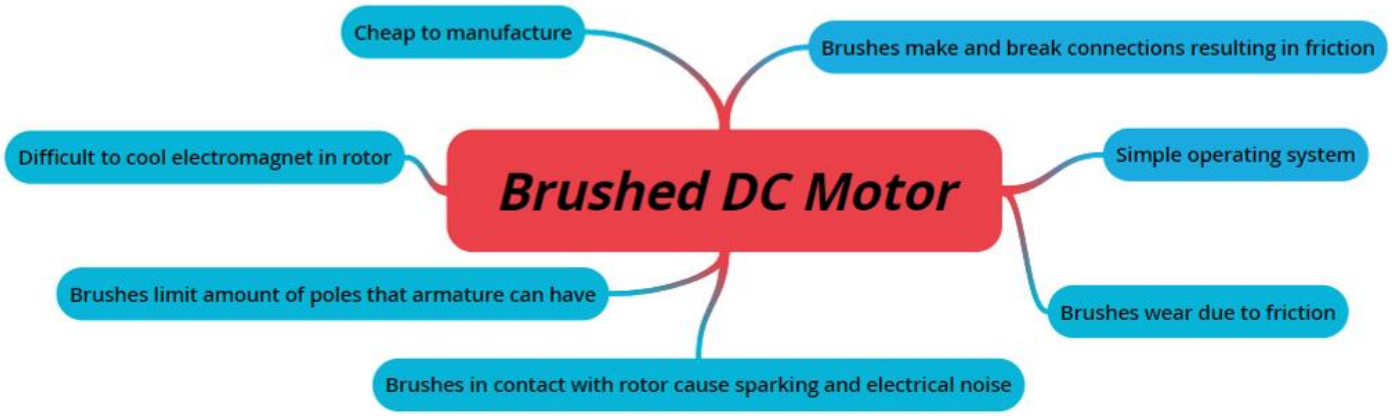


Figure 0.1

Figure 0.1 shows the key features of a brushed DC motor. In the box below, place these features under advantages or disadvantages of a brushed DC motor.

Advantages:	***Disadvantages:***
Cheap to manufacture	Difficult to cool electromagnet in rotor
Simple operating system	Brushes limit amount of poles that armature can have
	Brushes in contact with rotor cause sparking and electrical noise
	Brushes wear due to friction
	Brushes make and break connections resulting in friction

Activity 1.4

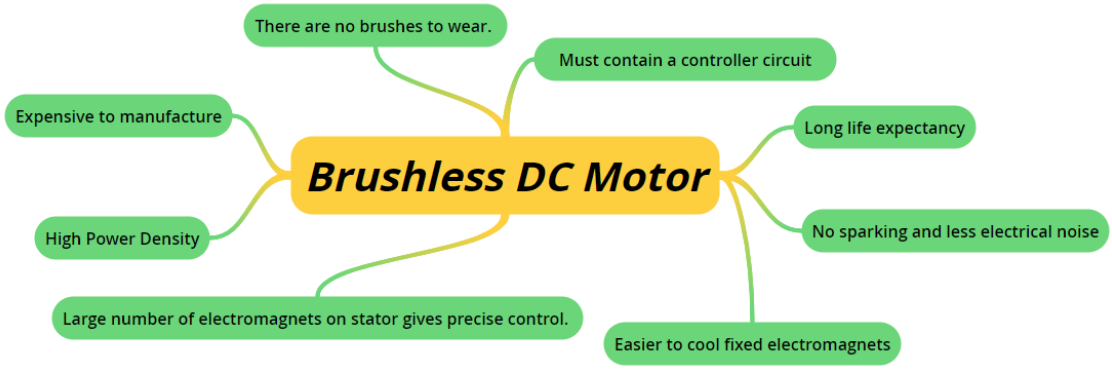


Figure 0.2

Figure 0.2 *shows the key features of a brushless DC motor. In the box below, place these features under advantages or disadvantages of a brushed DC motor.*

Advantages:	***Disadvantages:***
There are no brushes to wear	Expensive to manufacture
High power density	Must contain a controller circuit
Large number of electromagnets on stator gives precise control	
Easier to cool fixed electromagnets	
No sparking and less electrical noise	
Long life expectancy	

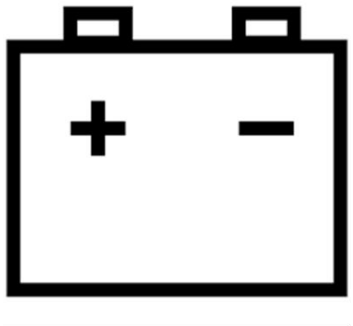
Activity 1.5

Based on your knowledge of power sources and motors, state one advantage and one disadvantage of each of the possible combinations below.

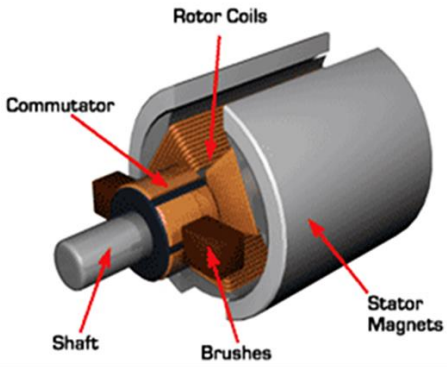
Petrol **Internal combustion engine**

Advantage:
Capable of long distance journeys on one tanks.
One tank of petrol lighter than equivalent battery bank.

Disadvantage:
Petrol is a non-renewable fuel source.
Not sustainable.
Damaging environment.
Price of fossil fuels are increasing.



Battery



Brushed DC Motor

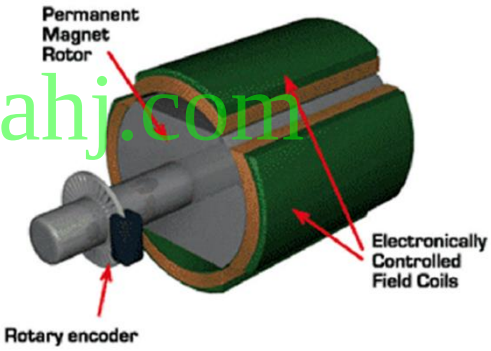
Advantage:

Batteries can be recharged with renewable sources.
Brushed DC motors are cheap to manufacture.
Less impact on the environment than fossil fuel combustion engines.

Disadvantage:

Batteries are expensive to manufacture.
Batteries are heavy and unnecessary weight when discharged.
Brushed DC motors contain brushes that wear out.

Battery



Brushless DC Motor

Advantage:

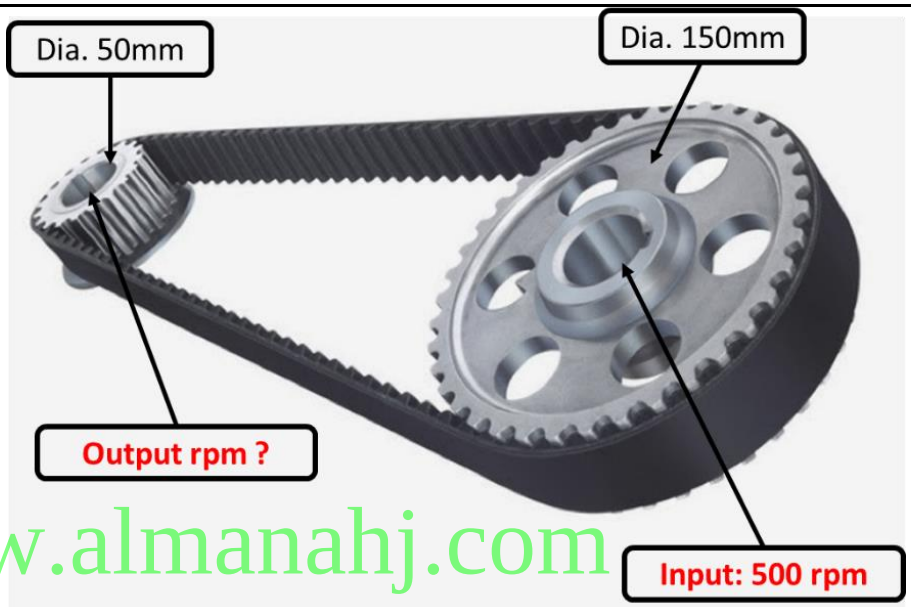
Batteries can be recharged with renewable sources.
Less impact on the environment than fossil fuel combustion engines.
Brushless motors have a long life expectancy
Provide high power density.

Disadvantage:

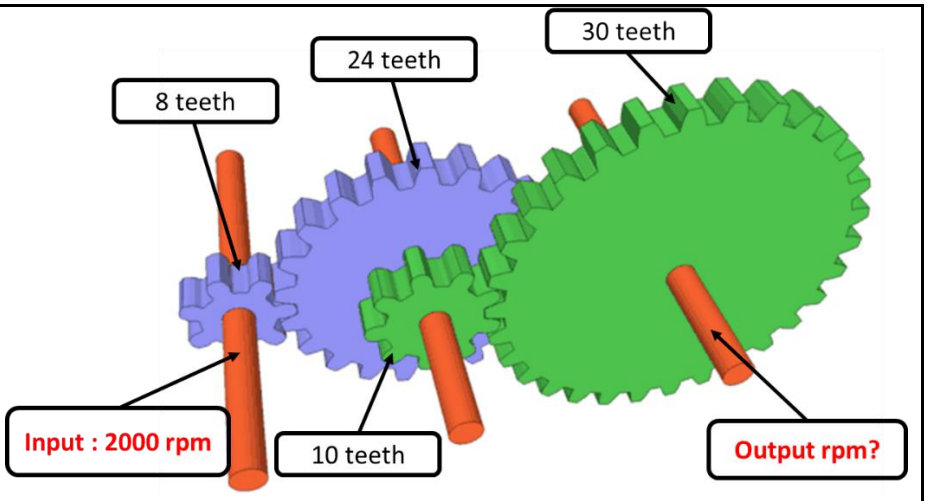
Batteries are expensive to manufacture.
Batteries are heavy and unnecessary weight when discharged.
Brushless DC motors are more expensive than brushed motors

Activity 1.6

Calculate the output rpm of the drivetrain shown.
VR = driver/ driven
VR = 150/50
VR = 3
Output RPM = Input RPM x VR
Output = 500 x 3
Output = 1500rpm



Calculate the output rpm of the drivetrain shown.
First, we need to calculate rpm of the middle or idle shaft.
VR = driver/ driven
VR = 8/24
VR = 1/3
Output RPM = Input RPM x VR
Output = 2000 x 1/3
Output = 666.67 rpm
Now we can calculate the output using this idler rpm and both green gear sizes.
VR = driver/ driven
VR = 10/30
VR = 1/3
Output = 666.67 x 1/3
222.23 rpm



Activity 1.7

- *List two advantages and two disadvantages of leaf springs.*
- **Advantages:**
- Leaf springs are cheap.
- Leaf springs are strong
- Leaf springs can carry heavy loads.
-
- **Disadvantages:**
- Leaf springs can be noisy in motion.
- Ride comfort is limited with leaf springs in comparison to more modern methods.
-
- *List two advantages and two disadvantages of coil springs.*
- **Advantages:**
- Coil springs also offer a higher range of movement.
- Coil springs provide greater comfort.
-
- **Disadvantages:**
- Coils springs are more expensive than leaf springs.
- Coil springs are limited in the load they can carry.

Lesson 2: Adapting to space vehicles

Aim:

This lesson aims to bridge the gap between motor vehicle design and space vehicle design. This lesson will build on prior knowledge of vehicle technologies and help you adapt this knowledge to design a space rover. On completion, you will understand the critical aspects of space rover design.

Teacher Learning Objectives: Learning objective refers to what you as a teacher will have taught the student by the end of the course. Teachers are to tick the box when the they have covered a learning objective.

- ☐ Recap on power sources and motor types
- ☐ Explain the operation of steering mechanisms vs differential steering.
- ☐ Present sample rocker-bogie mechanisms while explaining how they operate

Student Learning Outcomes: Learning outcomes refer to what the student can expect from the course, Teachers must share these outcomes with all students. Teachers are to tick the box when the outcome is achieved. Learning outcomes can be assessed using oral questioning and the written activities.

Students should be able to:

- ☐ Identify suitable motors and power sources for a space rover.
- ☐ Differentiate between steering mechanisms.
- ☐ Understand the operation of a rocker-bogie suspension system.
- ☐ Model a rocker-bogie mechanism.

Keywords	**What are the keywords the students must learn?** • differential • differential steering • torque • rack and pinion • bevel gear • rocker-bogie
Resources	**What resources are required?** • textbooks • projector • calculator
Prior Knowledge	• Motor types used in vehicle design • Leaf versus coil spring suspension • Power sources

Essential and non-essential Sections:

In some lessons it may not be possible to cover every section of the book due to time constraints or lesson variables. Below is a guideline to essential sections for examination and project knowledge.

Topic	Page	
	Essential	Non-essential/Self Study
Steering mechanisms	Pg. 32-33	
Rocker-Bogie suspension	Pg. 34-40	
Rocker-Bogie model	Pg. 41	

Possible Teaching Method(s) or Approach for this lesson

- Collaborative Teaching (student centred)
- Instructional / Demonstrative Teaching (teacher centred)
- Inquiry-based Teaching (student centred)
- Lecture Style Teaching (teacher centred)
- Coach Style Teaching (teacher centred)
- Facilitator Style Teaching (student centred)

Development [Phases or chunks of learning]: ***Note:*** *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.* **Phase 1 of lesson (Connect)** **Starter** Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Recap on previous lesson to assess prior knowledge of motor types, suspension, and drivetrains. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.* **Phase 2 of lesson (Activate)** Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. Teacher to introduce some traditional steering mechanisms before comparing to differential steering. Teacher to introduce rocker-bogie suspension system. Ensure student understanding of all parts of the mechanism. Teacher to demonstrate how rocker-bogie allows vehicle to climb obstacles. Question students on limitations when climbing to ensure understanding.	**Notes for differentiation:** ***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary through ought the lesson.*	**Assessment Opportunities:** **Questioning.** **Questioning** **Questioning**

Teacher to demonstrate how rocker may be attached to chassis using a swivel. Use Fusion 360 model from teacher guide as additional 3D visual aid if required. Fusion link: http://a360.co/2FBfHaE Teacher to introduce students to 2 possible solutions of the issue identified in activity 2.4 Students to explore QR codes and note differences in designs. **Teacher Tip:** *Teacher to demonstrate good subject and curriculum knowledge* **Phase 3 of lesson (Engage and Demonstrate)** Pose a problem to students, suggest a vehicle needs to turn in a tight circle to explore an unknown planet. In groups students should present ideas which method is best suited and why. Teacher should facilitate as students evaluate their decisions and decide the correct method. Students to demonstrate understanding of activities 2.1-2.3 Teacher to facilitate as student's complete activities 2.1-2.3 Use group discussion to allow students to problem solve activity 2.4 Following discussion groups should present any issues they see with this design. Teacher to facilitate as students use information gathered to complete activity 2.4 Students to discuss both possible designs in their groups. Explore Fusion 360 models and videos. Note differences and record advantages and limitations. Use an "Each on teach one" approach to have groups show their understanding of each design. This process should allow all students to fully understand both designs.		**Written Activities 2.1-2.3** **Peer teaching** **Written Activity 2.4** **Peer teaching** **Written Activities 2.5-2.6**

Teacher to facilitate as student's complete activities 2.5-2.6 individually. All students must now demonstrate their understanding by modelling a rocker bogie mechanism in activity 2.7 **Teacher Tip:** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.* **Phase 4 Plenary (Consolidate)** Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete student evaluation Students to complete activities 2.7 and present in next lesson. **Teacher to introduce Unit 2 sustainability for self-study, Students should keep in mind while studying how sustainability can be incorporated into a space rover design.**		**Modelling Activity 2.7** **Oral Assessment** **Student evaluation**

Answer Key/ Resources

Activity 2.1

- *What type of steering mechanism would be most suitable for a space rover that is designed to navigate Mars? Give two reasons for your choice.*
- A skid steer or differential steering system is the most suitable mechanism for a space rover. This system is most suitable for a number of reasons:
- -Skid steer allows vehicles to rotate on the spot when needed in comparison to the wide turning circle of traditional steering mechanisms.
- -Differential steering allows all-wheel drive to be easily incorporated.
- -Differential steering does not contain as many moving parts such as a rack and pinion which may become damaged or worn on rough terrain.
- -Containing less parts is an advantage as these parts cant be easily sourced on Mars as they would on Earth.
-

Activity 2.2

- *Review motor types and power sources from Lesson 1. Which is the most suitable power source and motor system for a space rover that will be used to explore Mars? Give at least two reasons for your choice.*
- A battery bank combined with brushless DC motors is the most suitable system for a space rover.
- Batteries can be recharged using renewable sources such as solar panels.
- Brushless Dc motors are a good option as they provide high power density.
- Brushless DC motors also have a long life expectancy which is important on mars due to a lack of resources.
- The lack of brushes means spare brushes are not needed.

Activity 2.3

List two vehicles that use the steering mechanisms below.

Rack and pinion	**Differential (skid) steering**
Car	Tank
Dunne Buggy	Track Digger

Activity 2.4

- *What issue would attaching both sides on individual swivels (as shown above) cause?*
- Attaching the rockers with single swivels would mean there is nothing to stop the chassis rotating around 360 degrees. This would result in the chassis constantly spinning as the rover drives.

Activity 2.5

- *State one advantage and one disadvantage of using one fixed side method to attach rockers to the chassis.*
- Advantages:
- -This method is its simple to construct.
- -Does not have complicate moving parts
- Disadvantages:
- -Chassis remains parallel to the fixed side and doesn't remain at an average pitch angle depending when travelling over uneven terrain.
-

Activity 2.6

- *State one advantage and one disadvantage of using differential gears to connect rockers.*
- Advantages:
- -Chassis remains at an average pitch angle when travelling over uneven terrain.
- -Gives more even weight distribution of all wheels.
- Disadvantages:
- -More complicated to construct
- -Contains more moving parts

Activity 2.7

- *Based on your knowledge of the rocker-bogie suspension system, you must create a model to show the successful operation of this mechanism. You can create a Fusion 360 model or a physical model using card, lollipop sticks, etc. Paste an image of your assembled model below.*
- *(Note: You only need to create one rocker-bogie with three wheels as preparation for the final project. You are not required to model or assemble a chassis.)*
-

Unit 3: Mars Electronics

Lesson 1: Essentials of Arduino

Aim:

This lesson aims to introduce you to Arduino and explains the basic features of Arduino IDE software. The session starts with a brief introduction to Arduino, and the Arduino board, introducing its various ports and hardware components. This is followed by an explanation of the Arduino IDE software and its key features. A step by step procedure on how to upload a test sketch to the Arduino board will be the final task in this lesson.

Student Learning Outcomes: Learning outcomes refer to what the student can expect from the lesson, Teachers must share these outcomes with all students. Teachers are to tick the box when the outcome is achieved. Learning outcomes can be assessed using oral questioning and the written activities.

Students should be able to:

- ☐ Explain the role of the Arduino microcontroller in electronics.
- ☐ Identify the main parts of the Arduino board.
- ☐ Recognise the layout of the Arduino IDE programming interface.
- ☐ Explain the Arduino programming structure.
- ☐ Explain how to control the LCD screen.
- ☐ Explain how to use Arduino's serial monitor.
- ☐ Configure the Arduino IDE software to work with the Arduino board.
- ☐ Use pseudocode and flowcharts to understand how a program works.

Keywords	**What are the keywords the students must learn?** • microcontroller • Arduino board • pins • power supply • GND • IDE • sketch • serial monitor • LCD • variables
Resources	**What resources are required?** • textbooks • projector • calculator • Arduino board
Prior Knowledge	• Use breadboards for building electronic circuits. • Identify the basic electronic components.

Possible Teaching Method(s) or Approach for this lesson

- Collaborative Teaching (student centred)
- Instructional / Demonstrative Teaching (teacher centred)
- Inquiry-based Teaching (student centred)
- Lecture Style Teaching (teacher centred)
- Coach Style Teaching (teacher centred)
- Facilitator Style Teaching (student centred)

Essential and non-essential Sections:

In some lessons it may not be possible to cover every section of the book due to time constraints or lesson variables. Below is a guideline to essential sections for examination and project knowledge.

Topic	Page	
	Essential	Non-essential/Self Study
What is Arduino?	Pg. 61-65	
Arduino IDE software	Pg. 66-67	
Arduino code structure	Pg. 68	
Example – On-board LED	Pg. 69-70	
Arduino code syntax	Pg. 71-72	
Arduino- LCD and Serial monitor		Pg. 72-81
Pseudocode and flowcharts		Pg. 82-83
Arduino code using pseudocode and flowcharts		Pg.84-85

Notes for differentiation:

All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.

Development [Phases or chunks of learning]:	Assessment Opportunities:
Note: *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.* **Phase 1 of lesson (Connect)** **Starter** Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Discuss prior knowledge of breadboards and basic electronic components. Show motivational videos / models to outline the end goal of the term. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.* **Phase 2 of lesson (Activate)** Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. Teacher to introduce the role of Arduino microcontroller in electronics, while students research the topic. Question students on what aspects are new to them when compared to prior knowledge discussion. Teacher to guide the class discussion about parts of the Arduino board and the IDE software layout. Teacher to introduce the Arduino code structure and allow students to explore their first Arduino program. Teacher to monitor the students' progress throughout the lesson by using the different assessment opportunities. **Teacher Tip:** *Teacher to demonstrate good subject and curriculum knowledge* **Phase 3 of lesson (Engage and Demonstrate)** Task 1: Ask students to find a partner and make a mind map about the advantages, disadvantages, and uses of the Arduino microcontroller. Students to complete Activity 1.1.	**Questioning** **Questioning** **Mind Map**

Teacher to facilitate as peer teaching takes place. <u>Task 2:</u> Divide students into groups and assign each group an Arduino board. Allow students to label the Arduino board as a group. After they finish students will complete activity 1.2. <u>Task 3:</u> Students to be given an IDE software layout, each group to fill out one section. The answers will be given through a class discussion. Students demonstrate learning by completing activity 1.3. <u>Task 4:</u> Students to upload and test their first On-board LED program individually. Students demonstrate learning by completing activity 1.4 in groups. <u>Task 5:</u> Students to study the Arduino code syntax and complete activity 1.5. Teacher to facilitate as collaborative learning takes place. Students demonstrate learning by completing all activities (1.1-1.5). **<u>Teacher Tip:</u>** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.* **<u>Phase 4 Plenary (Consolidate)</u>** Teacher to facilitate as students evaluate learning. Question pupils on what they have learnt. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the final activity and the student evaluation/reflection. Students to complete activities 1.1-1.5 and finish for homework if not completed. *This lesson should be conducted in one lesson (1 period – 45min)*	**Peer teaching** **Written Activities 1.1-1.3** **Written Activity 1.4-1.5** **Oral Assessment** **Student evaluation**

Answer Key/ Resources

QR code links:		
Page	***Topic***	***Link***
63	Various Arduino projects	https://www.youtube.com/watch?v=B7dtdBgOHWM
71	Fritzing	http://fritzing.org/download/?donation=0
71	TinkerCad	https://www.tinkercad.com/#/

Activity 1.1

- Take out your Arduino board and place it in front of you. Can you identify the board model?

  The board is an Arduino Leonardo model.

Activity 1.2

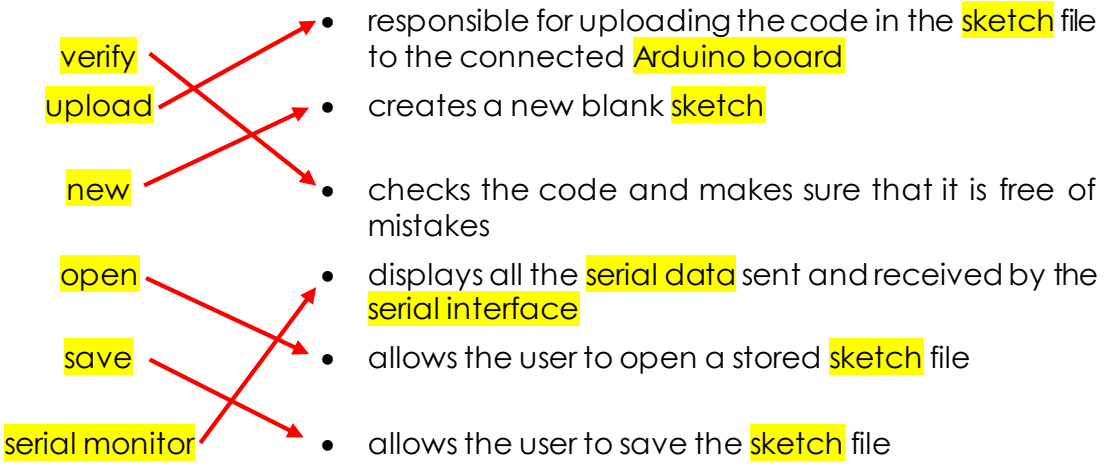
- Identify the four power socket pins and write down their names.
  1. 3.3V pin
  2. 5V
  3. GND pins
  4. VIN pins

- How many analogue pins are there in the Analog IN socket? Name them.
  6 analogue pins. A0, A1, A2, A3, A4, A5.

- How many digital pins are there in the digital socket?
  14 digital pins.

Activity 1.3

- Match the toolbar button to its description.



Activity 1.4

- Check the status of the 'L LED'. What do you observe?

The LED will turn on and off (blink) with a delay of 1 second.

Activity 1.5

- Use the information provided in **Error! Reference source not found.** to answer the following questions:

a. Find the syntax errors in the lines of code below, and then correct them.

```
int variable_$ = 3;

setup(){
pinMode(3, INPUT)
```

Error	Correction	Justify

int variable_$ = 3;	int variable= 3;	the variable name must be meaningful, include no spaces or special characters
pinMode(3, INPUT)	pinMode(3, INPUT);	semicolon is used to end a statement

setup(){
pinMode(3, INPUT)
	setup(){
	pinMode(3, INPUT)
	}
		unbalanced braces will result in a compiler error

b. Mark the lines below as a comment using two different methods.

```
Blink
Turns on an LED on for one second, then off for one second, repeatedly.
```

Method 1:

```
/*
Blink
Turns on an LED on for one second, then off for one second, repeatedly.
*/
```

Method 2:

```
//Blink
//Turns on an LED on for one second, then off for one second, repeatedly.
```


c. Declare the variables below.

declare 'y' as an integer, and set its initial value to 0

```
int y= 0;
```

declare 'age' as a character

```
char age;
```

Activity 1.6

- Write the Arduino code to print the following message on the LCD screen:

Arduino code:

```
void setup() {
  lcd.begin(16, 2);

  lcd.setCursor(2, 0);
  lcd.print("Expo 2020");

  lcd.setCursor(0, 1);
  lcd.print("Dubai, UAE");
}
```

Activity 1.7

- Modify the Arduino example to print your name. Take a picture of the LCD screen and paste it below.

Arduino code:

```
#include <LiquidCrystal.h>

// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(8, 9, 4, 5, 6, 7);

void setup() {
  // set up the LCD's number of columns and rows:
  lcd.begin(16, 2);
  // Print a message to the LCD.
  lcd.print("NAME");
}

void loop() {
  // set the cursor to column 0, line 1
  // (note: line 1 is the second row, since counting begins with 0):
  lcd.setCursor(0, 1);
  // print the number of seconds since reset:
  lcd.print(millis() / 1000);
}
```

Activity 1.8

- Try pressing the Arduino's Reset button a few times. What happens?

  Whenever the reset button is pressed the message is printed once on the serial monitor.

- Now, write the print function inside the loop() function. Verify and upload the code and then observe what happens.

  The message will be displayed on the serial monitor repeatedly.

Activity 1.9

- Write the proper statements for the following statements:

1. Define an integer variable, name it 'count' and give it a value of zero.

```
int count=0;
```

2. Print out an explanation message.

```
Serial.println("Counting integer numbers starting from 0");
```

3. Display the current count.

```
Serial.print("Count = ");
Serial.println(count);
```

4. Implement a procedure to increase the counts.

```
count=count +1;
```

5. Add 100 milliseconds of delay time.

```
delay(100);
```

6. Which one of those steps needs to be done only once?

The counter initialisation and the explanation message.

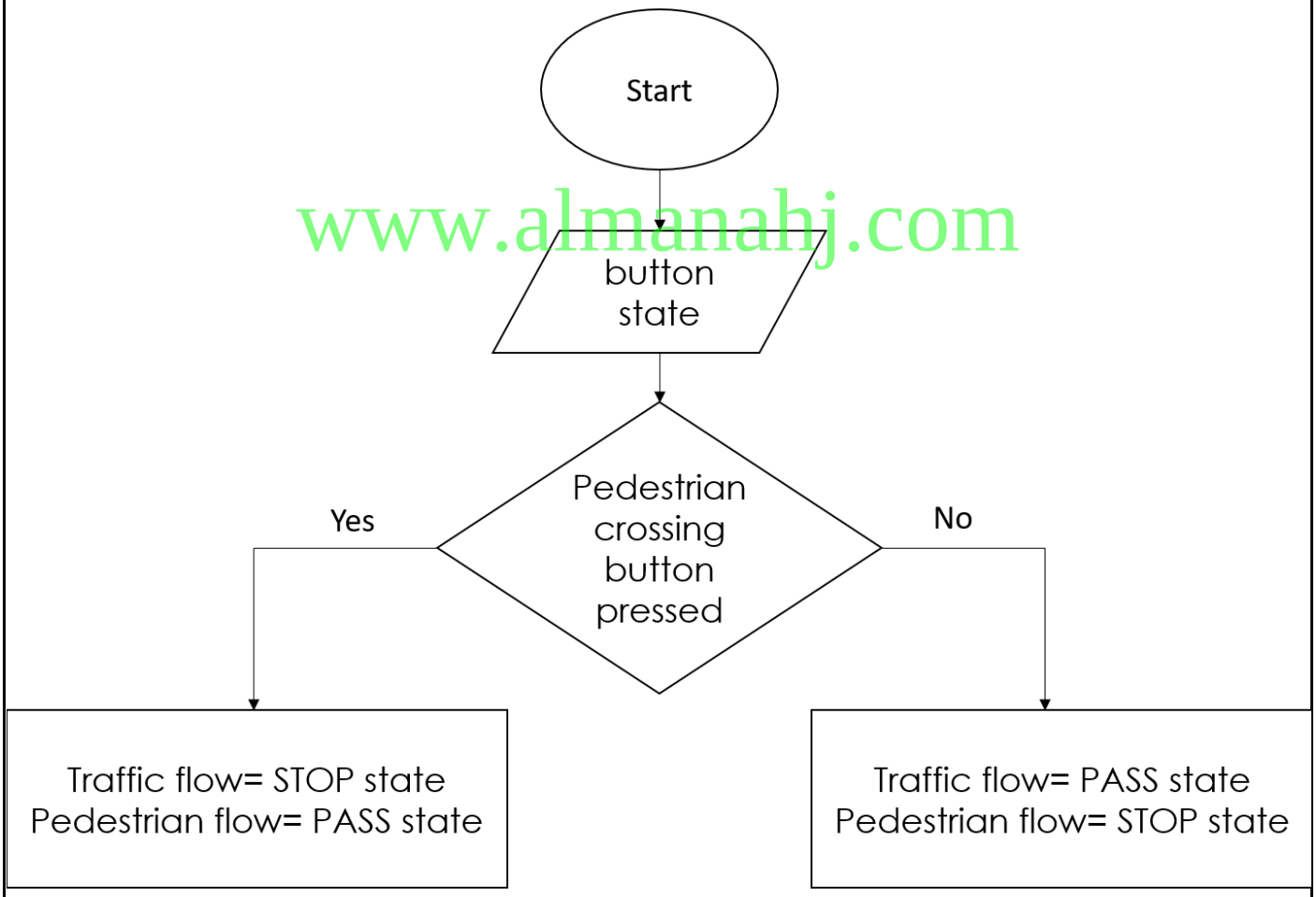
7. Which one of those steps needs to be run continuously in a loop?

Updating the counter and displaying its value.

Activity 1.10

- Using the flowchart diagrams shown in **Error! Reference source not found.**, draw the flowchart for the following traffic system:

1. If the pedestrian crossing button is pressed → change to the **Stop state** for traffic flow, and **Pass state** for pedestrian flow.
2. Otherwise, keep the Pass state for traffic flow and the Stop state for pedestrian flow.



Activity 1.11

- What is a flowchart? Why do I need it?

A flowchart is a visual representation of the sequence of the process. It shows how the code is executed. It also helps you identify the different elements of the process and understand how the different steps are linked together.

- What is a pseudocode? Why do I need it?

Pseudocode is a method to communicate the design problem using English-like statements. It is used to outline the structure of the code, making the process of writing the actual code much easier.

Final activity

- Write an Arduino program to calculate the voltage value in Ohm's law, knowing that the current is 2 mA, and the resistance is 100 Ω.
  Hint: Ohm's law V = I× R

1. Define the variables.

```
float current=0.002;
int resistance=100;
float voltage;
```

2. Print out an explanation message (comment).

```
Serial.println("Calculating the voltage using Ohm's law");
```

3. Implement a procedure to calculate the voltage.

```
voltage= current*resistance;
```

4. Print out the voltage value on the serial monitor.

```
Serial.println("Voltage is:");
Serial.println(voltage);
```

5. Print out the voltage value on the LCD.

```
void setup() {
  lcd.begin(16, 2);

  lcd.setCursor(0, 0);
  lcd.print("Voltage is:");

  lcd.setCursor(0, 1);
  lcd.print(voltage);
}
```

6. Write the complete Arduino code and run the program.

```
#include <LiquidCrystal.h>

float current=0.002;
int resistance=100;
float voltage;

// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(8, 9, 4, 5, 6, 7);

void setup() {
```



```
Serial.begin(9600);
Serial.println("Calculating the voltage using Ohm's law");

}

void loop() {
voltage=current*resistance;

Serial.println("Voltage is:");
Serial.println(voltage);

delay(1000);

  // set up the LCD's number of columns and rows:
lcd.begin(16, 2);

lcd.setCursor(0, 0);
lcd.print("Voltage is:");
lcd.setCursor(0, 1);
lcd.print(voltage);

delay(1000);
}
```

Lesson 2: Analogue and digital signals

Aim:

This lesson aims to introduce you to the world of signals. You will learn how to read the digital signal on Arduino using digital input statements. The content explains in detail the procedure for generating digital signals and reading analogue signals. It also describes how to use pulse width modulation (PWM) to generate analogue signals for simple electrical devices.

Student Learning Outcomes: Learning outcomes refer to what the student can expect from the lesson, Teachers must share these outcomes with all students. Teachers are to tick the box when the outcome is achieved. Learning outcomes can be assessed using oral questioning and the written activities.

Students should be able to:

- ☐ Differentiate between digital and analogue signals.
- ☐ Identify how to read digital signals in Arduino.
- ☐ Interpret how to generate a digital signal.
- ☐ Identify how to read analogue signals in Arduino.
- ☐ Describe the function of PWM signals in electric circuits.

Keywords	**What are the keywords the students must learn?** • digital signal • floating state • analogue signal • PWM • time period • frequency • duty cycle
Resources	**What resources are required?** • textbooks • projector • calculator • Arduino board
Prior Knowledge	• Identify the fundamentals of Arduino programming. • Recognise the structure of LEDs, push-buttons, and potentiometers. • Use breadboards for building electronic circuits. • Identify the basic electronic components.

Possible Teaching Method(s) or Approach for this lesson

- Collaborative Teaching (student centred)
- Instructional / Demonstrative Teaching (teacher centred)
- Inquiry-based Teaching (student centred)
- Lecture Style Teaching (teacher centred)
- Coach Style Teaching (teacher centred)
- Facilitator Style Teaching (student centred)

Essential and non-essential Sections:

In some lessons it may not be possible to cover every section of the book due to time constraints or lesson variables. Below is a guideline to essential sections for examination and project knowledge.

Topic	Page	
	Essential	**Non-essential/Self Study**
What are signals?	Pg. 90-92	
Getting started	Pg. 93	
Digital input		Pg. 94
Read the digital input		Pg. 95
Digital input- practical work		Pg. 96-98
Digital output	Pg. 99	
Digital output- practical work	Pg. 100-102	
Analogue input		Pg.103
Analogue input- practical work		Pg.104-107
Analogue output	Pg. 108-109	
Analogue output- practical work	Pg. 109- 112	

Notes for differentiation:

All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.

Development [Phases or chunks of learning]:	Assessment Opportunities:
Note: *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.* **Phase 1 of lesson (Connect)** **Starter** Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Discuss prior knowledge of Arduino programming and basic electronic components. Show motivational videos / models to outline the end goal of the term. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.* **Phase 2 of lesson (Activate)** Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. Teacher to introduce the topic of digital and analogue signals, while students (think-pair-share) their thoughts. Question students on what aspects are new to them when compared to prior knowledge discussion. Teacher to introduce Arduino functions while students explore these functions through various activities. Teacher to monitor the students' progress throughout the lesson by using the different assessment opportunities. **Teacher Tip:** *Teacher to demonstrate good subject and curriculum knowledge.* **Phase 3 of lesson (Engage and Demonstrate)** Task 1: Students to study the first most important Arduino function (digitalWrite). They will go through digital output-practical work to explore and test this function as groups.	**Questioning.** **Questioning / Mind Map** **Written Activity 2.4-2.5**

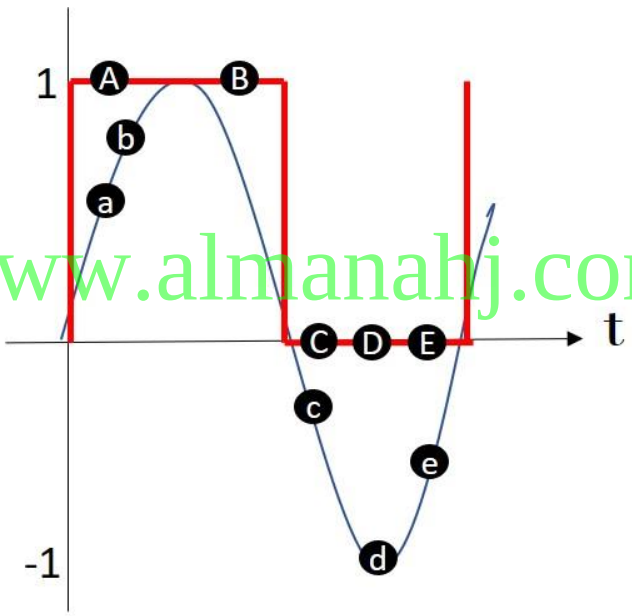
Students demonstrate learning by completing activity 2.4-2.5. Task 2: Students to study the second most important Arduino function (analogWrite). They will go through analogue output- practical work to explore and test this function as groups. Students demonstrate learning by completing activity 2.8. Task 3: Divide students into two groups assigning each group an Arduino function. Use an "Each one teach one" approach to have groups show their understanding and improve other groups understanding of Arduino functions. Teacher to facilitate as peer teaching takes place. **Teacher Tip:** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.* **Phase 4 Plenary (Consolidate)** Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the student evaluation/reflection. Students to complete activities 2.4,2.5,2.8 and finish them for homework if not completed. *This lesson should be conducted in one lesson (1 period – 45min)*	**Peer teaching** **Written Activity 2.8** **Oral Assessment** **Student evaluation**

Answer Key/ Resources

QR code links:		
Page	***Topic***	***Link***
91	Differences between analogue and digital signals	http://qrs.ly/c3690tu
96	Pull up resistor tutorial	https://www.youtube.com/watch?v=wxjerCHCEMg
108	PWM signals	https://www.youtube.com/watch?v=B_Ysdv1xRbA

Activity 2.1

- Using the figure below, find the corresponding values of the labelled letters, and then record their values in the table.



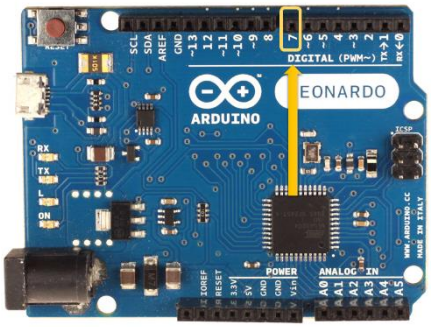
Analogue signal	Digital signal
a = 0.5	A = 1
b = 0.7	B = 1
c = -0.2	C = 0
d = -1	D = 0
e = -0.5	E = 0

Using the recorded values, what is the difference between the analogue and digital signals?

Digital signals have a finite number of values, either 0 or 1.
Analogue signals have an infinite number of values.

Activity 2.2

- The mode for an electronic component connected to Arduino digital pin number **7** is **input**. Write the initialisation statement for this pin using the pinMode function.



pinMode(7, INPUT);

Activity 2.3

- Write a code that prints the status of a push-button on the serial monitor.

  When the push-button is pressed, the serial monitor should display the value 1. When the push-button is released, the serial monitor should display the value 0. Follow the instructions below.

  1. Open the Arduino IDE software, and then click file → new.
  2. In the setup() function, define pin 7 (push-button) as an INPUT.
  3. In the loop() function, print a sentence on the serial monitor to display the signal value using the function → Serial.println(); .
  4. Wait 500 milliseconds before the next loop using the function, delay(500); .
  5. Verify and upload the code to read the value from pin 7.

Arduino code:

```
void setup()
{
Serial.begin(9600);
while (!Serial);
pinMode(7,INPUT);
}

void loop()
{
// print a sentence on the serial monitor
Serial.print("The value of the signal is = ");
Serial.println(digitalRead(7));     // print the signal value
delay(500);       // wait for 500 milliseconds before the next loop

}
```

Activity 2.4

1. Write a code that defines a digital component as an output pin, and write it within the setup() function.


```
Void setup(){
Serial.begin(9600);
pinMode(7,OUTPUT);

    }
```

2. Where do you put the command to turn the digital components ON and OFF for a specific amount of time?

In the loop() function, using the delay command.

Activity 2.5

- Write a full code to flash the LED ON and OFF. Follow the instructions below.

    1. Turn the LED ON.

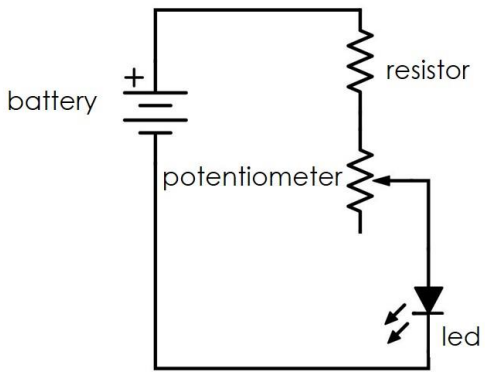
2. Apply a delay of 1 second.
3. Turn the LED OFF.
4. Apply a delay of 1 second.
5. Repeat again.

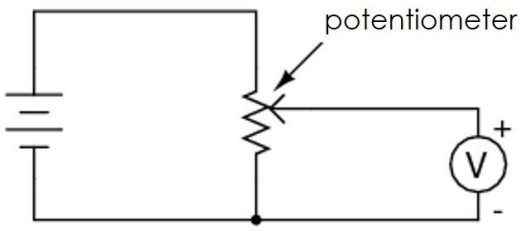
Arduino code:

```
void setup()
{
Serial.begin(9600);
while (!Serial);
pinMode(7,OUTPUT);
}

void loop()
{
digitalWrite(7.HIGH);
delay(1000);
digitalWrite(7,LOW);     // print the signal value
delay(1000);       // wait for 1000 milliseconds before the next loop

}
```

Activity 2.6

- Identify whether the potentiometer in the schematic diagrams below was used as a voltage divider or as a variable resistor.





---

variable resistor

- When only two legs of the potentiometer are connected, the wiper and one of the end terminals, then it acts as a variable resistor.

---

voltage divider

- When all three legs of the potentiometer are connected, and a voltage is applied across the end terminals, then it acts as a voltage divider.

Activity 2.7

- Write a code to read the value of the potentiometer and display it on the serial monitor.

1. Write a statement to define and initialise the variable x as an integer.

```
int x=0;
```

2. Write a statement to display the value of variable x on the serial monitor.

```
Serial.println("The potentiometer value is:");
Serial.println(x);
```

3. Write a statement to execute a delay of 100 milliseconds.

```
delay(100);
```

4. Finalise your code and run it on your Arduino.

Activity 2.8

- Write a code to manipulate the brightness of the LED as detailed below.

1. Define a variable to store the PWM value.
2. Initialise an output pin.
3. Generate the PWM signal using the PWM value.
4. Apply a delay to observe the brightness.
5. Increase the PWM value by 10.
6. Repeat from step 3.

Arduino code:

```
int Brightness = 0;

void setup() {
pinMode(9, OUTPUT); // Define the pin #9 as an output pin.
}
```

```
void loop() {
analogWrite(9, Brightness); // Generate the PWM signal at pin #9
delay(100);     // apply a delay of 100 milliseconds

Brightness = Brightness + 10; // increase the Brightness value by 10

}
```

Final activity

- Find the errors in the Arduino code below. Then, correct the mistakes.
  Hint: There are 10 syntax errors in the code.

```
1.  potentiometer=4;
2.  int LED =  14;
3.  int pushbutton=3;

4.  void setup() {
5.  pinMode(potentiometer, OUTPUT);
6.  pinmode(pushbutton, INTPUT);
7.  }

8.  void loop() {
9.  int val = analogRead(potentiometer);
10. if(pushbutton ==LOW){ //if sensor value is one
11. digitalWrite(LED,HIGH)
12. delay(val); //wait for 2 seconds
13. digitalwrite(LED,LOW);
14. }
15. else{
16. digitalWrite(LED,low);
17. }
```


Line No.	Syntax error	Correction
1	potentiometer=4;	int potentiometer=4;
2	int LED =14;	int LED =10; /*digital I/O pins: 2-13 (pins 0 and 1 are reserved for Tx and Rx)*/

5	pinMode(potentiometer, OUTPUT);	pinMode(LED, OUTPUT); /*the potentiometer is an analogue electronic device, hence, it doesn't need to be defined using the pinMode function. Unlike the push-button and the LED, where both of them are digital components and their pinMode must be defined.*/ /*if you were to define the potentiometer, then it's an input device not an output*/
6	pinmode(pushbutton, INTPUT);	pinMode(pushbutton, INPUT);
10	//if sensor value is one if(push-button ==LOW){	//if sensor value is one if(pushbutton ==HIGH){
11	digitalWrite(LED,HIGH)	digitalWrite(LED,HIGH);

12	//wait for 2 seconds
	delay(val);
		//wait for 2 seconds
		delay(2000);

13	digitalwrite(LED,LOW);	digitalWrite(LED,LOW);
16	digitalWrite(LED,low);	digitalWrite(LED,LOW);

18	curly bracket to close the void loop() function is missing
	Void loop(){
	//commands
	} →the closing bracket is missing
		}

Unit 3: Mars Electronics

Lesson 3: Space rover electronics

Aim:

The aim of this lesson is to set up and program a wireless space rover using various electronic components and an Arduino microcontroller. The space rover will be controlled using a mobile application and Bluetooth module. This lesson introduces a selection control mechanism called a switch statement. This statement will be used in programming the Arduino microcontroller. The electronic circuit will be programmed using various commands from the Arduino Bluetooth mobile application. Once the Bluetooth module communicates with the mobile application, you will be able to control the functions of the space rover.

Student Learning Outcomes: Learning outcomes refer to what the student can expect from the lesson, Teachers must share these outcomes with all students. Teachers are to tick the box when the outcome is achieved. Learning outcomes can be assessed using oral questioning and the written activities.

Students should be able to:

- ☐ Identify the function of a motor driver.
- ☐ Compare between a SPST switch and a DPDT switch.
- ☐ Develop and evaluate an Arduino code using a switch statement.
- ☐ Assemble electronic components to build a complete circuit of a space rover.
- ☐ Use a Bluetooth module between a mobile application and Arduino.

Keywords	**What are the keywords the students must learn?** • L298N motor • Driver • floating state • analogue signal • PWM • time period • frequency • duty cycle
Resources	**What resources are required?** • textbooks • projector • calculator • Arduino board
Prior Knowledge	• Able to generate digital signals using Arduino. • Understand the function of DC motors. • Recognise the mechanism of a rocker-bogie. • Differentiate between steering mechanisms. • Use breadboards for building electronic circuits.

Possible Teaching Method(s) or Approach for this lesson

- ☐ Collaborative Teaching (student centred)
- ☐ Instructional / Demonstrative Teaching (teacher centred)
- ☐ Inquiry-based Teaching (student centred)
- ☐ Lecture Style Teaching (teacher centred)
- ☐ Coach Style Teaching (teacher centred)
- ☐ Facilitator Style Teaching (student centred)

Essential and non-essential Sections:

In some lessons it may not be possible to cover every section of the book due to time constraints or lesson variables. Below is a guideline to essential sections for examination and project knowledge.

Topic	Page	
	Essential	Non-essential/Self Study
Space rover electronics	Pg. 118	
Types of motors	Pg. 118	
DC motor-practical work	Pg.119-122	
Controlling a DC motor		Pg.123
Motor driver	Pg. 124-125	
Step 1: Connecting the DC motors to the motor driver.	Pg. 126-128	
Step 2: Using Arduino to control the rotation and direction of the DC motors.	Pg. 129-133	Pg.134
Bluetooth module- Wireless communication	Pg. 135	
Bluetooth technology	Pg. 135	

How does the Bluetooth module communicate with Arduino?	Pg. 136	
Step 3: Connecting the Bluetooth module to the circuit	Pg. 137-138	
Switch statement- Finalising the code	Pg. 139-141	
Writing the code	Pg. 142	
Testing your space rover	Pg. 143	
Switches		Pg. 144
Types of switches		Pg. 144
Step 4: Connecting SPST and DPST switches to the space rover circuit	Pg.146-148	
Creative problem-solving (Expansion of circuit functions)		Pg.149-156
Obstacle detector		Pg. 157- 162

Notes for differentiation:

All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.

Development [Phases or chunks of learning]:	**Assessment Opportunities:**
Note: *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.* **Phase 1 of lesson (Connect)** **Starter** Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Discuss prior knowledge of DC motors and rocker-bogie mechanisms. Show motivational videos / models to outline the end goal of the term. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.* **Phase 2 of lesson (Activate)** Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. Teacher to introduce students to the new electronic components that will be used to complete the space rover project. Teacher must emphasise the importance of gaining knowledge about these components in order to complete and test the final electronic circuit.	**Questioning.** **Questioning / Mind Map**

Question students on what aspects are new to them when compared to prior knowledge discussion. Teacher to go through the function of DC motors and allow students to practically test them. Teacher to introduce the topic of motor drivers while students explore its use and function. Teacher to explain the use of wireless communication and question students on how the Bluetooth module falls under this category. Teacher to introduce switch case statements and students apply what they have learnt through various activities. **Teacher Tip:** *Teacher to demonstrate good subject and curriculum knowledge.* **Phase 3 of lesson (Engage and Demonstrate)** Task 1: In groups students will go through DC motor-practical work. Students demonstrate learning by completing activities 3.1-3.2. Task 2: Students will use the motor driver module to control the DC motor. They will explore the motor driver parts and connect the DC motor to the motor driver. Students demonstrate learning by completing step 1 of building the circuit. Task 3: Students will complete step 2: Using Arduino to control the direction and rotation of the DC motors. Students will upload and analyse the codes for both direction and rotation. Students demonstrate learning by completing activities 3.3-3.5. Task 4: Students will connect the Bluetooth module to the circuit. Students demonstrate learning by completing step 3 of building the circuit. Task 5: Students will find a partner and start writing the complete code for the project. Students can refer to the previous Arduino lessons if they find difficulty in writing the code.	**Peer teaching** **Written Activities 3.1-3.2** **Peer teaching** **Written Activity 3.3-3.5** **Peer teaching**

Students demonstrate learning by completing activities 3.7-3.8. Task 6: Students need to follow the steps on page 143 to test the function of the electronic circuit. Teacher to facilitate as collaborative learning takes place. **Teacher Tip:** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.* **Phase 4 Plenary (Consolidate)** Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the student evaluation/reflection. Students to complete all the activities and finish in their free time if not completed. *This lesson should be conducted in one double lesson (2 periods – 90min)*	**Written Activity 3.7-3.8** **Oral Assessment** **Student evaluation**

Answer Key/ Resources

QR code links:		
Page	***Topic***	***Link***
125	How to control DC motor with L298N driver and Arduino.	https://www.youtube.com/watch?v=dyZolgNOomk
143	Arduino Bluetooth RC car	http://qrs.ly/gy6akrw

Activity 3.1

- Follow the below steps to check the polarity of a DC motor, and then draw the correct direction for the DC motor in Figure 0..

1. Attach a red wire to the positive terminal of the battery and attach a black wire to the negative terminal of the battery.
2. Attach the wheel to the DC motor shaft and make sure it is firmly fixed.
3. Connect the red (positive) wire of battery to one terminal of the DC motor.
4. Connect the black (negative) wire of the battery to the second terminal, as shown below in Figure 0..

What did you notice about the direction of the DC motor? Did the motor rotate clockwise or counterclockwise?

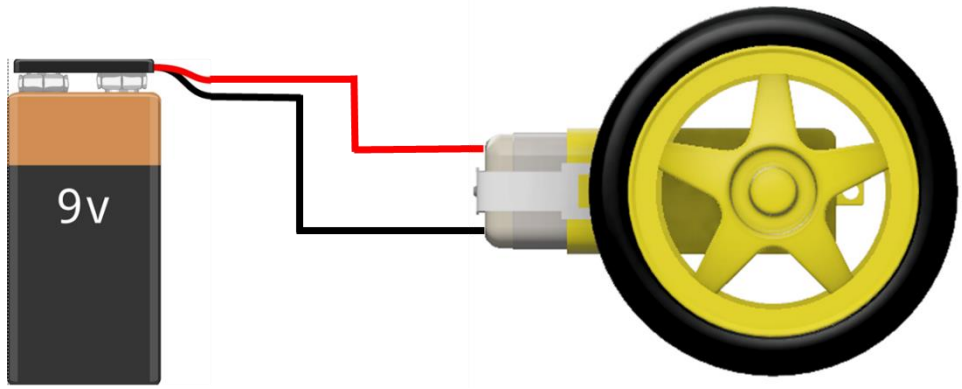


Figure 0.2: DC motor

What is the direction of the wheel rotation? clockwise

Activity 3.2

- Using direction to determine motor polarity:

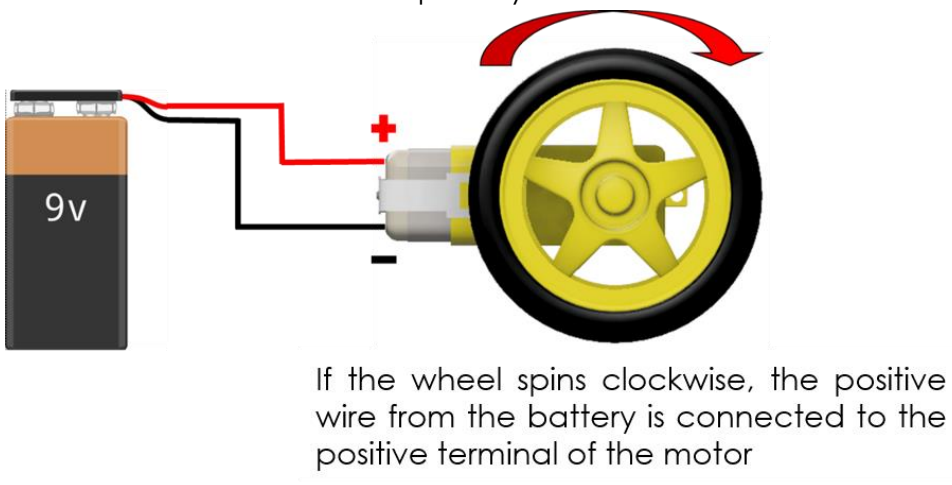


Figure 3.3 Clockwise rotation of a DC motor

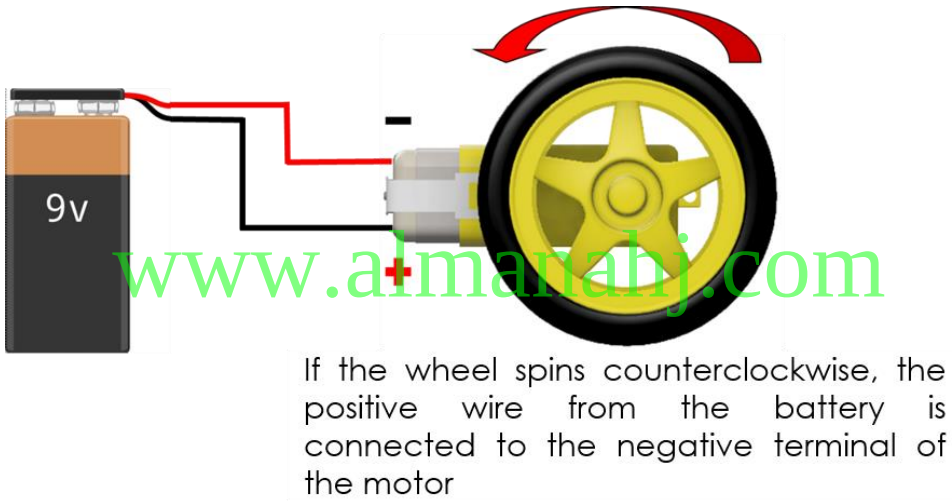


Figure 0.4 : Counter-clockwise rotation of a DC motor

Look at Figure and Figure 0.. Which image matches your circuit? If the wheel rotated clockwise, you should label the pins positive and negative as shown in Figure .

If your wheel rotated counterclockwise, this means you had the positive wire from the battery connected to the negative terminal of motor and should label the positive and negative pins as shown in Figure 0..

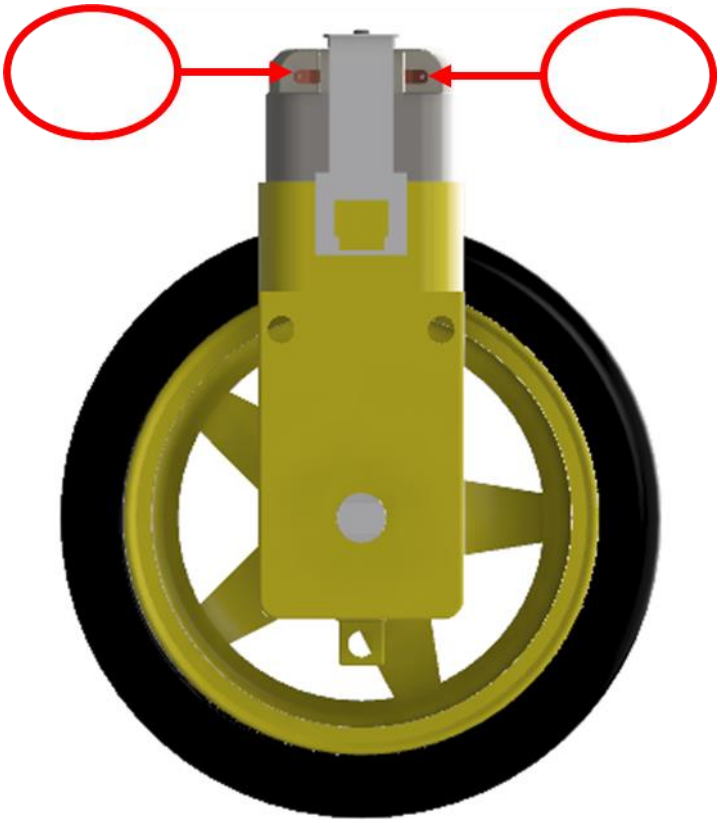
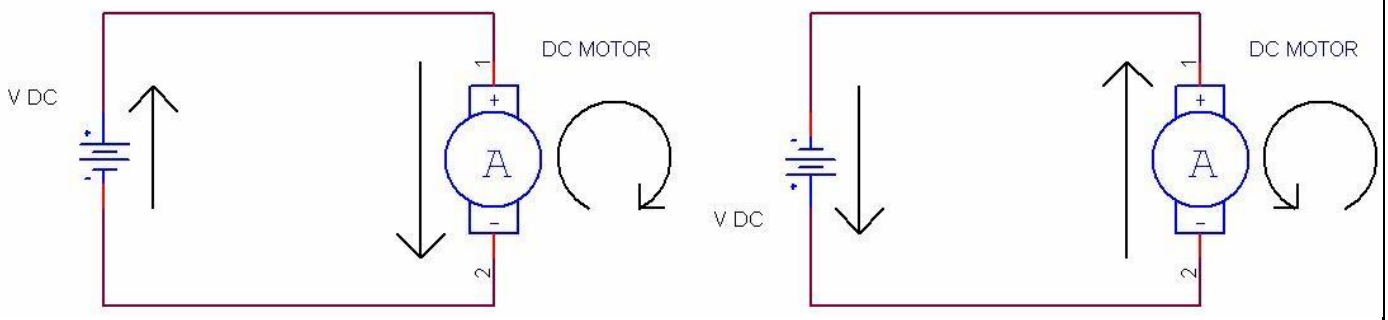


Figure 0.3

Based on your results, you should label the terminals of each motor with a marker or sticker.

As you noticed from the above activity, the direction of the DC motor depends on the polarity. If the red (positive) wire of the DC motor is connected to the negative end of the battery, then the motor will rotate in a counterclockwise direction. If the red (positive) wire of the DC motor is connected to the positive end of the battery, then the motor will rotate in a clockwise direction as shown below.



Activity 3.3

- Analyse the code in Figure 3.10 and document what have you noticed about the direction of the DC motor.
  Note: If the motor does not rotate in the required direction, reverse the connections on the motor driver to correct the rotation. For example, switch the wires entering pins 1 and 2 for motor A or 13 and 14 for motor B.

Since the value for IN1 is HIGH, the value for IN2 is LOW, and the enable pin is given a value, the motor rotates in a clockwise direction.

Activity 3.4

- Modify the code in **Error! Reference source not found.** to rotate the DC motors in the opposite direction.

Arduino code:

```
//speed of motors between 0 and 255, if you like you can change it
int pwm_speedA = 255;
int pwm_speedB = 240;
```



```
void setup() {
Serial1.begin(9600);
//pins for motor controller
pinMode(11, OUTPUT);
pinMode(10, OUTPUT);
pinMode(9, OUTPUT);
pinMode(6, OUTPUT);
pinMode(5, OUTPUT);
pinMode(3, OUTPUT);

}

void loop() {


digitalWrite(10, LOW);
digitalWrite(11, HIGH);
analogWrite(3, pwm_speedB);

digitalWrite(9, LOW);
digitalWrite(6, HIGH);
analogWrite(5, pwm_speedA);

}
```

The value for IN1 needs to be LOW, the value for IN2 needs to be HIGH and the enable pin needs to be given a value to rotate the motor in a counterclockwise direction.

Activity 3.5

- Modify the code in Figure 3.11 to control the DC motors to turn left.
  Hint: Review the skid steering section studied in Unit 1 to understand motor directions for different turns.

Arduino code:

```
//speed of motors between 0 and 255, if you like you can change it
int pwm_speedA = 255;
int pwm_speedB = 240;
void setup() {
Serial1.begin(9600);
//pins for motor controller

pinMode(9, OUTPUT);
pinMode(6, OUTPUT);
pinMode(5, OUTPUT);
pinMode(11, OUTPUT);
pinMode(10, OUTPUT);
pinMode(3, OUTPUT);

}
 void loop() {
//turning left
digitalWrite(9, HIGH);
digitalWrite(6, LOW);
analogWrite(5, pwm_speedA);

digitalWrite(10, LOW);
digitalWrite(11, LOW);
analogWrite(3, 0);

}
```


To turn the motors left, motor A (left-hand side motor) needs to be turned off and motor B (right-hand side motor) need to be turned on.

Activity 3.6

- Get creative
  - You have learned how to program Arduino to turn the DC motors left and right.
  - Taking into consideration the design of the space rover, edit the code in **Error! Reference source not found.** to allow the motors to make a sharp turn, either to the left or right.

    Hint: Review the skid steering section studied in Unit 1 to understand motor directions for different turns.

Arduino code:

```
//speed of motors between 0 and 255, if you like you can change it
int pwm_speedA = 255;
int pwm_speedB = 240;
char command;

void setup() {
Serial1.begin(9600);
//pins for motor controller
pinMode(11, OUTPUT);
pinMode(10, OUTPUT);
pinMode(9, OUTPUT);
pinMode(6, OUTPUT);
pinMode(5, OUTPUT);
pinMode(3, OUTPUT);

}

void loop() {


digitalWrite(10, HIGH);
digitalWrite(11, LOW);


digitalWrite(9, LOW);
digitalWrite(6, HIGH);

analogWrite(3, pwm_speedB);
analogWrite(5, pwm_speedA);

}
```

For the motor to make a sharp turn to the left, motor A needs to rotate counterclockwise while motor B needs to rotate clockwise.

Activity 3.7

- Why do you think you need a switch case statement to write the code for your space rover?

The mobile application has several commands that need to be executed separately when the specific command is used. The switch case statement can switch between different commands by using variables and cases.

- The switch case statements needed for your circuit are shown below. Fill in the blanks with the correct code for each statement. Refer to **Error! Reference source not found.** and **Error! Reference source not found.** for the correct pin connections.

Arduino code:

```
void loop() {
if(Serial1.available() > 0){
command = Serial1.read();
motors_stop();
switch(command){
case 'F':
forward();
break;
case 'B':
backward();
break;
case 'L':
left();
break;
case 'R':
right();
break;
}
 }
  }

// function for driving straight
void forward(){
digitalWrite(10, HIGH);
digitalWrite(11, LOW);

digitalWrite(9, HIGH);
digitalWrite(6, LOW);

analogWrite(5, pwm_speedA);
analogWrite(3, pwm_speedB);




}

//function for reversing
void backward(){


digitalWrite(10, LOW);
digitalWrite(11, HIGH);

digitalWrite(9, LOW);
```

```
digitalWrite(6, HIGH);

analogWrite(5, pwm_speedA);
analogWrite(3, pwm_speedB);



}

//function for turning right
void right(){

digitalWrite(10, HIGH);
digitalWrite(11, LOW);


digitalWrite(9, LOW);
digitalWrite(6, LOW);

analogWrite(3, pwm_speedB);
analogWrite(5, 0);



}

//function for turning left
void left(){

digitalWrite(11, LOW);
digitalWrite(10, LOW);

digitalWrite(9, HIGH);
digitalWrite(6, LOW);

analogWrite(3, 0);
analogWrite(5, pwm_speedA);



}

//function for stopping motors
void motors_stop(){

digitalWrite(11, LOW);
digitalWrite(10, LOW);

digitalWrite(9,LOW);
digitalWrite(6, LOW);

analogWrite(5, 0);
analogWrite(3, 0);
```

```
}
```

Writing the code

1- Define the variables below.

- **pwm_speedA** – Define the variable as an integer and give it a value from 0-255.
- **pwm_speedB** – Define the variable as an integer and give it a value from 0-255.
- **command** – Define the variable as a character.

```
int pwm_speedA=255;
int pwm speedB=240;
char command;
```

2- Void setup

- Start a serial communication to be able to use the serial monitor (Serial1.begin(9600)).
- Define the pins for the motor driver as outputs. Refer to **Error! Reference source not found.** and **Error! Reference source not found.** for the correct pin connections.


```
void setup() {

Serial1.begin(9600);
//pins for motor controller
pinMode(11, OUTPUT);
pinMode(10, OUTPUT);
pinMode(9, OUTPUT);
pinMode(6, OUTPUT);
pinMode(5, OUTPUT);
pinMode(3, OUTPUT);

}
```

3- Void loop

- Refer to Activity 3.8.

Activity 3.9

- Figure 0. shows a DPST switch. Why do you think it is better to use a DPST switch instead of a SPST switch in your circuit?

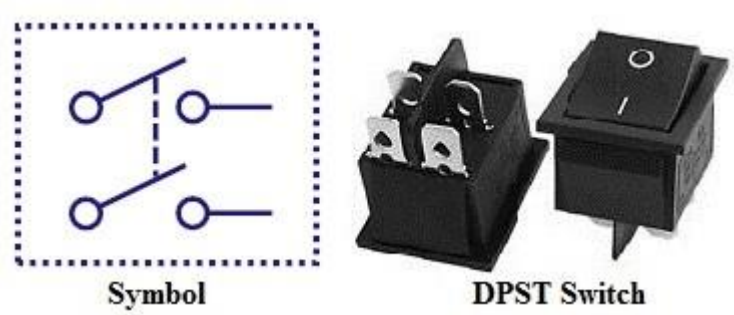


Figure 0.23 : DPST (double-pole single-throw) switch

Instead of using two SPST switches, you can use one DPST switch. A DPST (double-pole single-throw) switch is the combination of two SPST switches.

Activity 3.10

- Add a DPST switch to your circuit. Draw the positive wires and the switch into Figure 0.4. Use the symbol of a DPST switch shown in Figure 0..

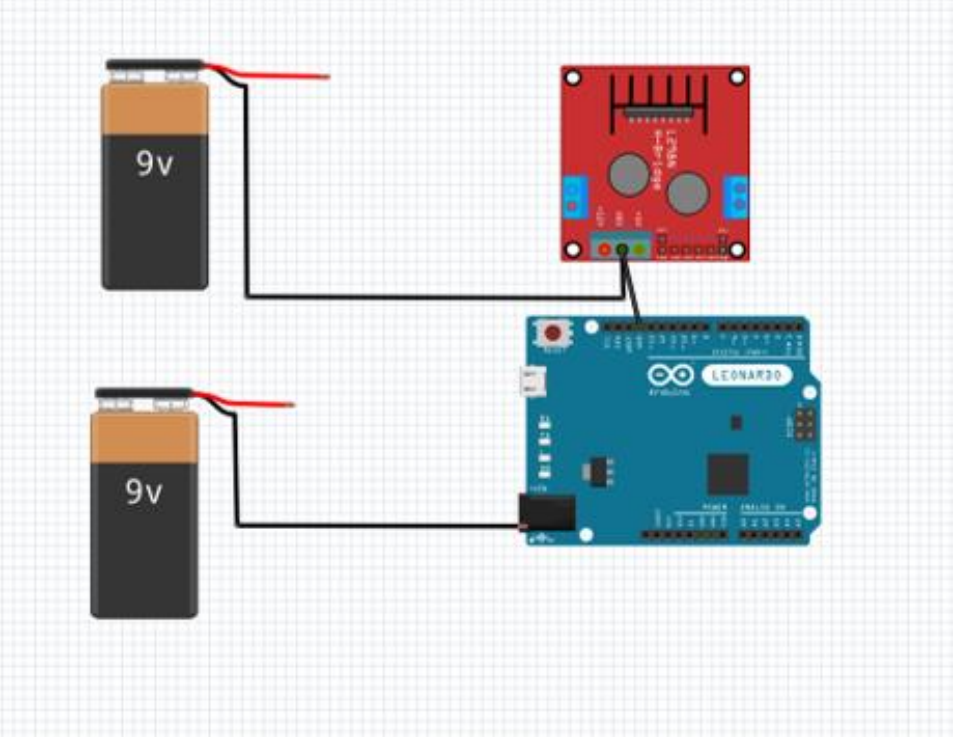


Figure 0.4 Simulation diagram with a DPST switch

Refer to appendix 1

Activity 3.11 – Problem 1

- Your space rover needs to drive and explore Mars at times when there is no light. Do you think adding headlights to your space rover might be efficient? Give it a try.
- Write an Arduino code and build a circuit to add headlights to your space rover. Hint: You will need to add two commands to your switch case statement. The commands will be 'W' to turn the headlights on, and 'w' to turn the headlights off.

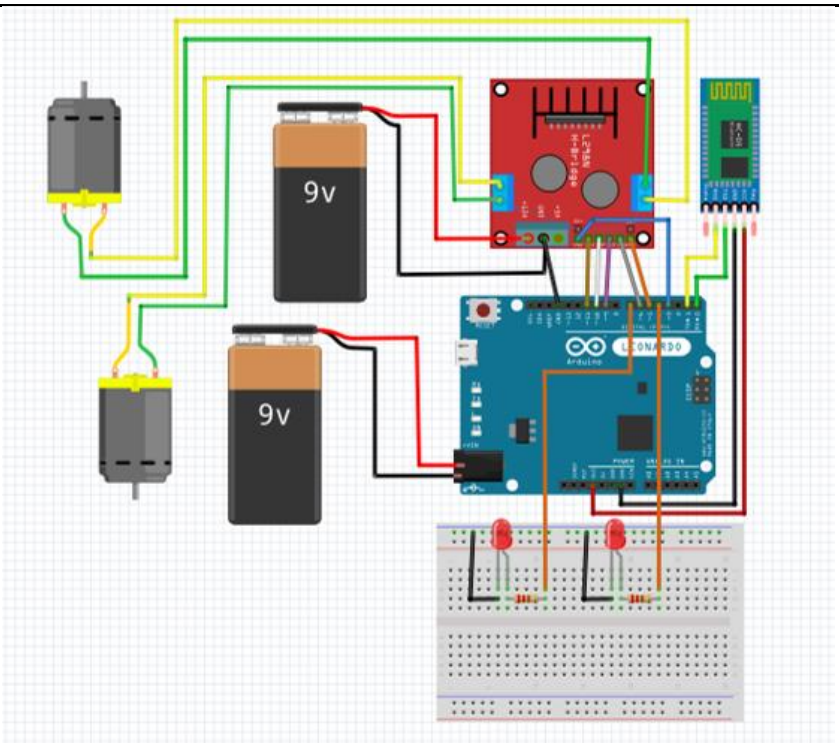


Figure 0.5 Simulation diagram for a space rover with headlights

Arduino code:

```
//speed of motors between 0 and 255, if you like you can change it
int pwm_speedA = 255;
int pwm_speedB = 240;
char command;

void setup() {
Serial1.begin(9600);
//pins for motor controller
pinMode(11, OUTPUT);
pinMode(10, OUTPUT);
pinMode(9, OUTPUT);
pinMode(6, OUTPUT);
pinMode(5, OUTPUT);
pinMode(3, OUTPUT);
pinMode(4,OUTPUT);
pinMode(7,OUTPUT);

}

void loop() {

if(Serial1.available() > 0){
command = Serial1.read();
motors_stop();
switch(command){
case 'F':
forward();
break;
```

```
case 'B':
backward();
break;
case 'L':
left();
break;
case 'R':
right();
break;
case 'W':
LEDon();
break;
case 'w':
LEDoff();
break;
}
}

}

// function for driving straight
void forward(){
digitalWrite(10, HIGH);
digitalWrite(11, LOW);

digitalWrite(9, HIGH);
digitalWrite(6, LOW);

analogWrite(5, pwm_speedA);
analogWrite(3, pwm_speedB);
}

//function for reversing
void backward(){

digitalWrite(10, LOW);
digitalWrite(11, HIGH);

digitalWrite(9, LOW);
digitalWrite(6, HIGH);

analogWrite(5, pwm_speedA);
analogWrite(3, pwm_speedB);
}

//function for turning left
void left(){
digitalWrite(11, LOW);
digitalWrite(10, LOW);

digitalWrite(9, HIGH);
digitalWrite(6, LOW);

analogWrite(3, 0);
```

```
analogWrite(5, pwm_speedA);
}

//function for turning right
void right(){
digitalWrite(10, HIGH);
digitalWrite(11, LOW);


digitalWrite(9, LOW);
digitalWrite(6, LOW);

analogWrite(3, pwm_speedB);
analogWrite(5, 0);

}

void LEDon(){
digitalWrite(4, HIGH);
digitalWrite(7, HIGH);

}
void LEDoff(){
digitalWrite(4, LOW);
digitalWrite(7, LOW);

}
```



```
//function for stopping motors
void motors_stop(){

digitalWrite(11, LOW);
digitalWrite(10, LOW);

digitalWrite(9,LOW);
digitalWrite(6, LOW);

analogWrite(5, 0);
analogWrite(3, 0);
}
```

Activity 3.12 – Problem 2

- What are the advantages of adding a horn to your space rover?
- Write an Arduino code and build a circuit to add a horn to your circuit.
  Hint: You will need to add two commands to your switch case statement. The commands will be 'V' to turn the horn on, and 'v' to turn the horn off.

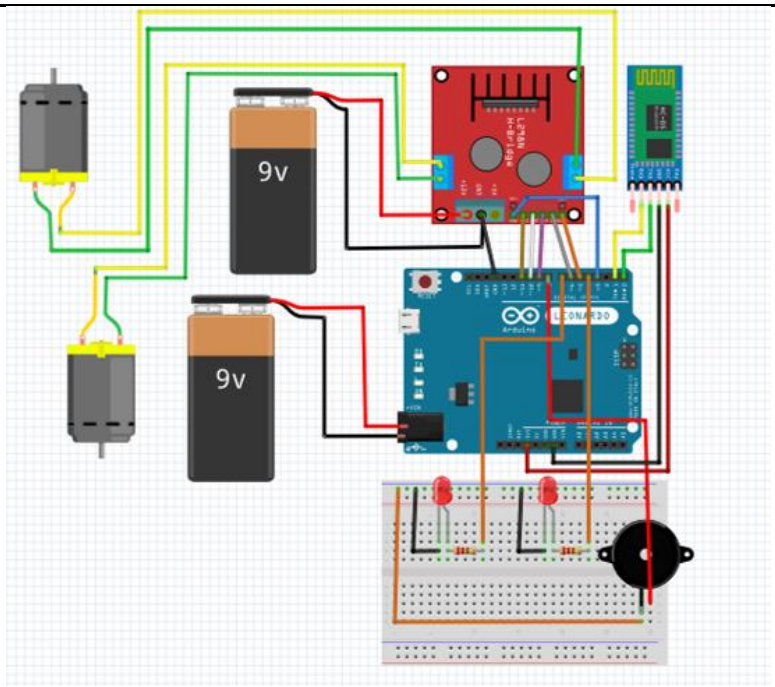


Figure 0.6 Simulation diagram of a space rover with a horn and headlights

Arduino code:

```
//speed of motors between 0 and 255, if you like you can change it
int pwm_speedA = 255;
int pwm_speedB = 240;
char command;
```



```
void setup() {
Serial1.begin(9600);
//pins for motor controller
pinMode(11, OUTPUT);
pinMode(10, OUTPUT);
pinMode(9, OUTPUT);
pinMode(6, OUTPUT);
pinMode(5, OUTPUT);
pinMode(3, OUTPUT);
pinMode(4,OUTPUT);
pinMode(7,OUTPUT);
pinMode(8,OUTPUT);

}

void loop() {

if(Serial1.available() > 0){
command = Serial1.read();
motors_stop();
switch(command){
case 'F':
forward();
break;
case 'B':
backward();
```

```
break;
case 'L':
left();
break;
case 'R':
right();
break;
case 'W':
LEDon();
break;
case 'w':
LEDoff();
break;
case 'V':
hornon();
break;
case 'v':
hornoff();
break;
}
}

}

// function for driving straight
void forward(){
digitalWrite(10, HIGH);
digitalWrite(11, LOW);

digitalWrite(9, HIGH);
digitalWrite(6, LOW);

analogWrite(5, pwm_speedA);
analogWrite(3, pwm_speedB);
}

//function for reversing
void backward(){

digitalWrite(10, LOW);
digitalWrite(11, HIGH);

digitalWrite(9, LOW);
digitalWrite(6, HIGH);

analogWrite(5, pwm_speedA);
analogWrite(3, pwm_speedB);
}

//function for turning left
void left(){
digitalWrite(11, LOW);
digitalWrite(10, LOW);
```

```
digitalWrite(9, HIGH);
digitalWrite(6, LOW);

analogWrite(3, 0);
analogWrite(5, pwm_speedA);
}

//function for turning right
void right(){
digitalWrite(10, HIGH);
digitalWrite(11, LOW);


digitalWrite(9, LOW);
digitalWrite(6, LOW);

analogWrite(3, pwm_speedB);
analogWrite(5, 0);

}

void LEDon(){
digitalWrite(4, HIGH);
digitalWrite(7, HIGH);

}
void LEDoff(){
digitalWrite(4, LOW);
digitalWrite(7, LOW);

}
void hornon(){
digitalWrite(8, HIGH);

}
void hornoff(){
digitalWrite(8, LOW);

}

//function for stopping motors
void motors_stop(){

digitalWrite(11, LOW);
digitalWrite(10, LOW);

digitalWrite(9,LOW);
digitalWrite(6, LOW);

analogWrite(5, 0);
analogWrite(3, 0);
}
```

Writing the code

1. Define the variables.
   - Trig pin of the ultrasonic module is connected to pin12 of the Arduino board.
   - Echo pin of the ultrasonic module is connected to pin13 of the Arduino board.

```
int trigPin = 12;
int echoPin = 13;
char command;
```

2. Void setup
   - Start a serial communication to be able to use the serial monitor.
   - Define the trig_pin as an OUTPUT because it sends out an object detection signal.
   - Define the echo_pin as an INPUT because it receives a signal when an object is detected.

```
void setup() {

Serial1.begin(9600);
pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
pinMode(echoPin, INPUT);


}
```

3. Void loop

   - Define two variables to hold the values of the duration and distance.
   - Set the trig_pin on a LOW state for 2µs to make sure that the trig_pin is clear.
   - Set the trig_pin on HIGH state for 10µs, and then LOW again, to generate the ultrasound wave.
   - Duration is measured using the 'pulseIn' function, which reads the signal's travel time.
     - The 'pulseIn' function takes two variables, the signal pin and its status as high or low.
     - When using it as pulseIn(Echo_pin, HIGH), this means when the echo_pin goes high (a reflected signal is detected) and the timing is started.
   - Calculate the distance where the speed of sound equals to 340m/s (0.034cm/ µs). The distance calculated should be divided by 2, as it represents the forward and backward distances that the signal has travelled. An example is shown in the figure below.

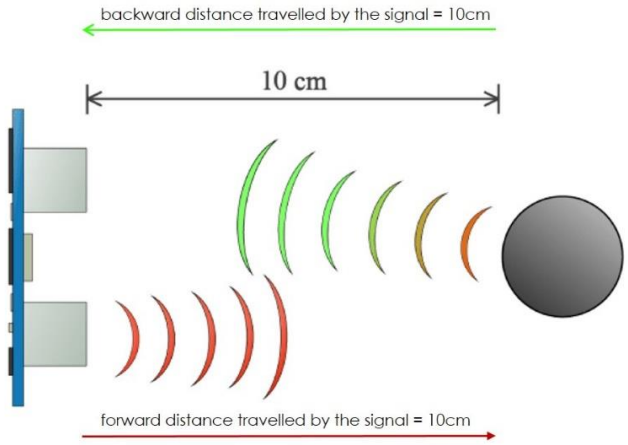


Figure 0.7: Forward and backward distances travelled by the sound wave

- Print the distance value on the serial monitor.

```
void loop() {
  //variables
  long duration, distance;

digitalWrite(trigPin,LOW);
delayMicroseconds(2);

digitalWrite(trigPin, HIGH);
delayMicroseconds(10);

digitalWrite(trigPin, LOW);

duration = pulseIn(echoPin, HIGH);

distance= duration*0.034/2;

  //print the distance value on the serial monitor

Serial.println(distance);

  delay(500);
}
```

Activity 3.13 - Problem 3

- Use the concept of an ultrasonic sensor to write an Arduino code and build a circuit to add an obstacle detector to your space rover. The space rover should stop when it detects an obstacle 20cm away. Figure 0.8 can be used as a guide to help you with connecting the ultrasonic sensor.

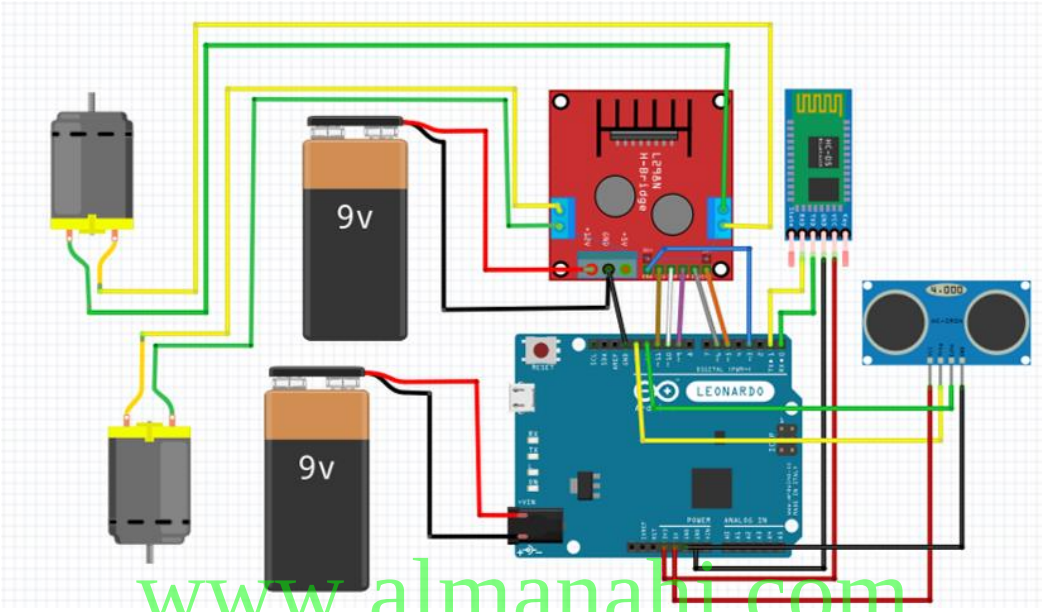


Figure 0.8 Simulation diagram of a space rover with an obstacle detector

Arduino code:

```
int trigPin = 12;
int echoPin = 13;
char command;

long duration;
int distance;
void setup() {
  // put your setup code here, to run once:

Serial1.begin(9600);
pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
pinMode(echoPin, INPUT);

}

void loop() {
  // put your main code here, to run repeatedly:


digitalWrite(trigPin,LOW);
delayMicroseconds(2);

digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
```

```
digitalWrite(trigPin, LOW);

duration = pulseIn(echoPin, HIGH);

distance= duration*0.034/2;

Serial.println(distance);

if (distance<20){

digitalWrite(11, LOW);
digitalWrite(10, LOW);

digitalWrite(9,LOW);
digitalWrite(6, LOW);

analogWrite(5, 0);
analogWrite(3, 0);

}

if (distance>=20){
digitalWrite(11, HIGH);
digitalWrite(10, LOW);

digitalWrite(9,HIGH);
digitalWrite(6, LOW);

analogWrite(5, 255);
analogWrite(3, 240);
}
}
```

Unit 4: Space Rover Project

Lesson 1: Introduction to Space Rover project

Aim:
This lesson aims to introduce students to the space rover project brief. Students will become familiar with the design process. Students will then analyse the brief and carry out research with the aim of creating at least two possible solutions. Students will use these possible solutions to create a final solution to be presented in the following lesson.

Teacher Learning Objectives: Learning objective refers to what you as a teacher will have taught the student by the end of the lesson. Teachers are to tick the box when the they have covered a learning objective.

- ☐ Present the design brief
- ☐ Explain function and demonstrate examples of mind maps
- ☐ Explore and explain different methods of research.
- ☐ Present sketching techniques and facilitate as students sketch designs

Student Learning Outcomes: Learning outcomes refer to what the student can expect from the lesson, Teachers must share these outcomes with all students. Teachers are to tick the box when the outcome is achieved. Learning outcomes can be assessed using oral questioning and the written activities.

Students should be able to:

- ☐ Create a mind map to analyse the brief.
- ☐ Investigate areas of research linked to the space rover and then record your finding through annotations and sketching.
- ☐ Creatively sketch at least two design ideas for possible solutions that meet the requirements of the brief.
- ☐ Sketch one final solution showing all required detail.

Keywords	**What are the keywords the students must learn?** • space rover • drivetrain • suspension
Resources	**What resources are required?** • textbooks • projector • sketching equipment
Prior Knowledge	• Technologies in space exploration • Sustainability • Mars electronics

Possible Teaching Method(s) or Approach for this lesson

- Collaborative Teaching (student centred)
- Instructional / Demonstrative Teaching (teacher centred)
- Inquiry-based Teaching (student centred)
- Lecture Style Teaching (teacher centred)
- Coach Style Teaching (teacher centred)
- Facilitator Style Teaching (student centred)

Essential and non-essential Sections:

In some lessons it may not be possible to cover every section of the book due to time constraints or lesson variables. Below is a guideline to essential sections for examination and project knowledge.

Topic	Page	
	Essential	Non-essential/Self Study
Analysis of brief	Pg. 169-171	
Research and investigation of possible solutions	Pg. 172-174	
Possible solutions	Pg. 175-178	
Final Solution	Pg. 179-182	

Development [Phases or chunks of learning]:	Notes for differentiation:	Assessment Opportunities:
Note: *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.* **Phase 1 of lesson (Connect)** **Starter** Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Teacher to introduce all key words, discuss meaning and ensure understanding before progressing **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.* **Phase 2 of lesson (Activate)** Teacher to present Project brief. Teacher to question students on initial understanding of brief. Teacher to explain function and methods of analysing a brief. Students to discuss and break down the brief in their groups. Teacher to present different methods of research. Students to discuss and decide on appropriate methods of research to be carried out. Teacher to introduce stage 3, Possible solutions. Students to examine design loop diagram on pg. 175 Question students on how well their research satisfies the brief. Are students ready to sketch possible solutions? Teacher to present stage 4 final solution. Students must understand the importance of final design and how it will directly contribute to the design realisation stage. **Teacher Tip:**	***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary through ought the lesson.*	**Questioning.** **Questioning / Mind Map** **Questioning.** **Questioning.** **Questioning.**

Teacher to demonstrate good subject and curriculum knowledge **Phase 3 of lesson (Engage and Demonstrate)** Students to demonstrate understanding of brief by analysing brief. Teacher to facilitate as student's complete activities 1.1 and 1.2 Students to complete extensive research and present their findings in activity 1.3 Teacher to facilitate as student's complete activity Students to analyse their research from activity 1.3. Take positives and negatives and use them to sketch at least two possible solutions that satisfy the design brief. Students demonstrate understanding of brief and research by completing activity 1.4 Teacher to facilitate as student's complete possible solutions Students to discuss positive and negative aspects of their groups possible solutions. Students to combine new fond knowledge to develop one final solution that best satisfies the brief. **Teacher Tip:** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.* **Phase 4 Plenary (Consolidate)** Teacher to facilitate as student's complete activities 1.1-1.5 Question pupils on what they have learned. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete activity 1.5 and present final solution in the next lesson.		**Written Activities 1.1-1.2** **Written Activity 1.3** **Written / sketching Activity 1.4** **Written / sketching Activity 1.5** **Oral Assessment**

Answer Key/ Resources

Stage 1: Analysis of brief:

This section should show evidence of understanding of the given brief. Areas which require solutions should be identified and problems which will be encountered should be recognized.

What is a Design Brief?

A Design brief is a written description that outlines the design or engineering problem being posed to the student. It also highlights the requirements of the student's final solution.

- **Design brief**

- As Creative Design and Innovation students of the UAE, you are expected to contribute to future projects UAE projects. One major ongoing project that is constantly progressing is the Emirates Mars Mission. In this unit you are expected to design a space rover to contribute to this mission. The space rover must contain a rocker-bogie mechanism that is capable of conquering difficult terrain and climbing at least the height of its wheel diameter. The space rover must be controlled wirelessly to allow exploration of Mars without risk to astronauts. The design should showcase knowledge of vehicle design and wireless control as studied earlier in the term. The design should also utilise design skills gained from Term 2.
- Design a model space rover to the specifications outlined below.
- Your design should be unique and innovative, and it should:
- contain an electronic circuit to drive forwards and backwards.
- turn left and right.
- use a maximum of 12 volts to drive the electronic circuit.
- contain a rocker-bogie mechanism.
- contain at least six wheels and be all-wheel drive.
- outline at least one aspect of sustainable design.
- demonstrate wireless control using Bluetooth.
- contain at least one extension to the circuit as studied in Unit 3.
- enclose all electronic components.
- be 3D printed and fully assembled with the electronic circuit.

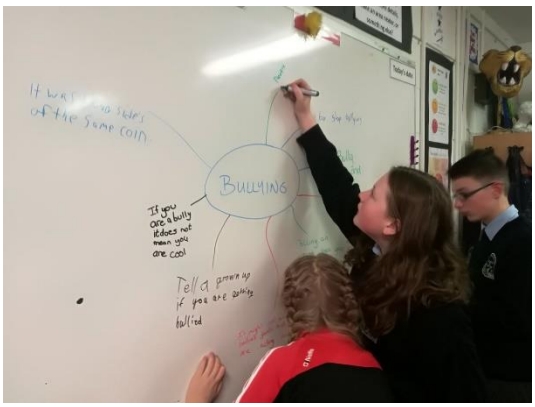
Where do I start?

Explore the brief carefully yourself before you introduce to your students. A good exercise to start is reading the brief with your students and getting them to highlight what they feel are the keywords in the brief. This will help to break down the design one step at a time. The students will fill this into their books, some examples of keywords are shown below:

How will I encourage my student's creativity?

A very useful group exercise at this stage is brainstorming. Brainstorming is a group creativity technique, designed to generate a large number of ideas for solving a problem. Students or the teacher can write the discussed ideas on the board. Throughout the session you should:

- Focus on quantity.
- No criticism is allowed.
- Unusual ideas are welcome.
- There are no wrong answers at this stage.
- Combine and improve ideas



- **Teacher Tip:** The group could be seated in a U direction to encourage discussion. The teacher will act in a facilitating role and can guide the discussion where necessary.

Activity 1.1

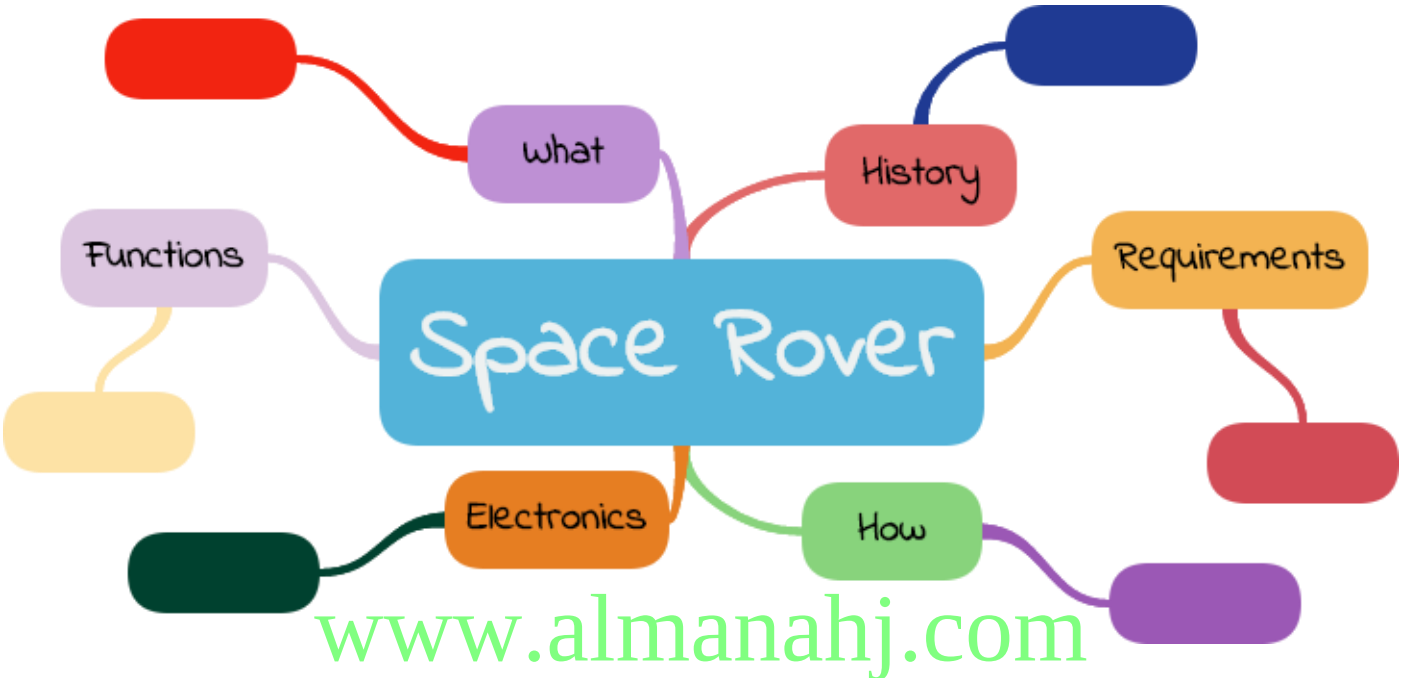
Highlight or circle keywords and phrases in the brief. This will help to break down the design one step at a time. **List five of these keywords below and describe their meaning**.

Keyword	***Meaning***
Space Rover	*a space exploration vehicle designed to move across the surface of a planet or other celestial body*
rocker-Bogie	*A suspension mechanism that allows vehicles to spread weight distribution evenly while traveling over harsh terrain.*
diameter	*a straight line from one edge of a circle or sphere to the other while passing through the centre.*
wireless	*Transmitting messages or signals without the use of wire.*
all wheel drive	*Power delivered from motor to each wheel of the vehicle.*

Activity 1.2

In the space below, create your own unique Mind Map detailing all the requirements of the space rover design: *You may use Figure 4.2 as a starting point for some ideas to discuss.*

Encourage students to really explore every aspect of the brief here. Use as many branches as necessary to demonstrate the brief on a mind map. Use colour to show clarity.



Where can I encourage my students to look for inspiration?

You could do up a powerpoint presentation addressing some of the points below or you could even ask a guest speaker to come into school to speak about design.

When designing a product, designers often look at various areas for inspiration. Some of these include:

- **nature -** The natural patterns and forms found in nature are often used as a starting point for fresh ideas.
- **architecture -** Common shapes or forms can provide inspiration when thinking of creative ideas.
- **design movements -** Design movements such as Art Nouveau, Modernism, Bauhaus, Art Deco, etc. can provide inspiration for new innovative ideas.
- **past and future solutions -** Looking at previous designs of can really help. Most modern-day inventions or designs are an improvement on, or inspired by, an existing product. Futuristic or concept designs can really get creativity flowing.
- **internet and social media –** Google images, Pinterest, YouTube and Instagram can be great assets in gaining inspiration for a design.

- **Teacher Tip:** Put up various images of successful designers work or quotes on your walls to help develop the interest of your students in design.

Stage 2: Research and investigation of possible solutions

What should my students include in this section?

There are two distinct elements to this stage of the process:

1. **Research and investigation:** Students should clearly show the investigation that has been completed. The investigation should display your understanding of the brief. They can use notes, sketches, images from the web, magazine cut outs etc. Avoid having just a collection of information gathered, students should explain why this information is useful.

2. **Possible solutions:** Using the information gathered, sketch a number of possible solutions. You should use a number of sketching techniques.
   Possible solutions will be produced in Stage 3 not here, but students should be thinking about possible solutions when carrying out their research.

What methods of research should the students use?

You could start by introducing students to the two types of research- primary and secondary research.

Primary research involves the observation of associated objects in your immediate environment or locality. For example, students could visit the MOHAMMED BIN RASHID SPACE CENTRE

School tours can be arranged, see link below:

https://mbrsc.ae/en/page/visit-mbrsc

Secondary research involves gathering information from existing sources. You should encourage students to consider the following sources.

- Libraries
- Books
- Magazines
- Catalogues
- Homecare and hardware stores
- Exhibitions
- Websites

Students should take note of any inspiration gathered at any stage of this process as this will be useful for their presentation of investigation. These images can be used in the mood board.

- **Teacher Tip:** Encourage students to use forms of research they might enjoy like capturing and sharing images on Snapchat or Instagram.

What is required of my students in this section?
Each time they carry out research they should be posing questions about their design. Some examples of the questions they may have are listed below:

- What features should my design contain?
- What suspension systems are used?
- What electronic components are required?
- What materials are suitable for my design?
- What size/scale should my design be?
- What features should my design contain?

- **Note:** Students are required to investigate **at least three** essential requirements of their chosen design. These questions will be developed from their brainstorming session and mind mapping in the analysis of brief.

How should my students present their research and investigation?

When presenting their research, they will need to condense it down and give the teacher a clear picture of the research they have carried out. This should all be presented in the Investigation section of their **books page 173-174**. You should encourage students to consider the following:

- **Teacher Tip:** It would be a very good idea to have students get a folder to store all their work. Or have somewhere safe they can store it before its transferred to the book.

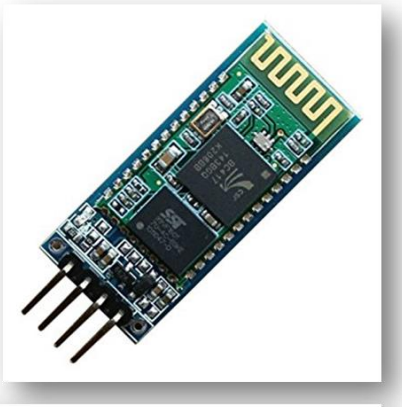
- Using images and freehand sketches is a clever way of presenting investigation.
- A mood board is a great way to represent where students got their inspiration.
- Virtually any conceivable method of presentation can be used to convey the thought process
- Images from books, catalogues and the internet are fine, but they must be accompanied by short notes describing their purpose.
- If your students have prior knowledge of any word processing/desktop publishing software they could use it here.
- Images and annotations together give a distinct representation of the research undertaken.
- Students may include extra pages to accompany their book for this section.
- **Try to be as creative and unique as possible.**

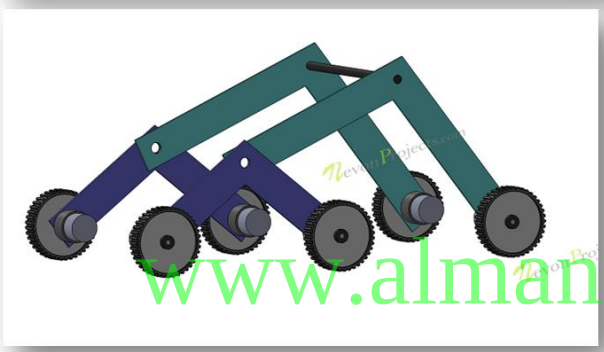
Why are annotations/ notes important to accompany images and sketches throughout this project?
These annotations are where the real 'critical thinking' takes place. They should be found throughout the project. They demonstrate a good understanding for the various design features.

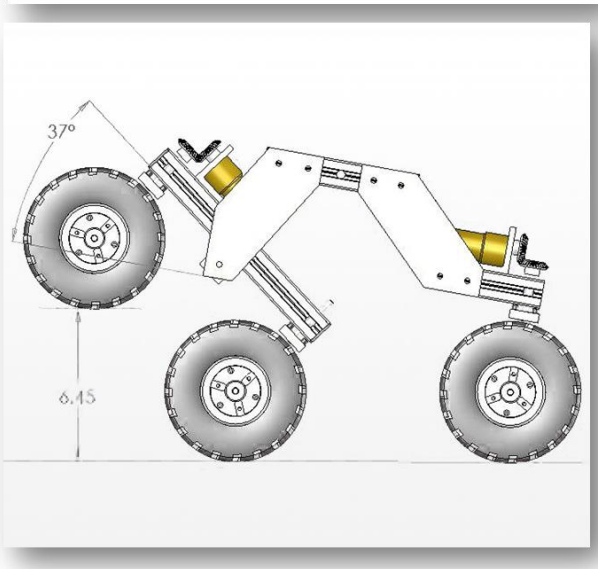
What are mood boards?

As mentioned above a mood board is a great way to represent where students got their inspiration. A mood board is an arrangement of images, materials or text which is used for inspiration for a new design concept. Designers often use mood boards as inspiration for creativity, a good starting point for their design.

- **Example of mood board for Space Rover:**

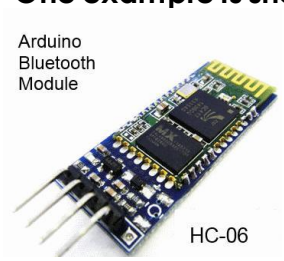






Activity 1.3

- Produce a research page or mood board using both sketches/images and text to explain your research.
- **~~One example is shown~~ below.**



What electronic components are required? One essential component is the HC-06 Bluetooth chip to transfer wireless signals to Arduino.

- Key areas to be researched:
- -Wireless control
- -Motors
- -Materials
- -Skid steer
- -Suspension systems
- -Size and scale
- -Sustainable design

Stage 3: Possible solutions

What is required of my students for possible solutions:

Using the information gathered, students should sketch at least two possible solutions. They can use a number of sketching techniques.

Possible solutions must:

- explain the operation of the design solution.
- state advantages and disadvantages of each solution.
- Show how it meets the brief

What choice do your students have in this section?

1. Students may wish to generate ideas by redesigning the existing products they researched.

OR

2. Communicate their own new design ideas graphically using sketches.

This means that students have the choice to create a possible solution based on an existing products design or they can come up with their own completely new design.

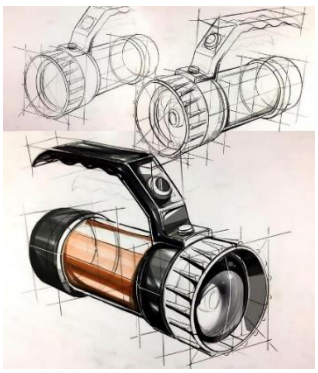
Do my students have to use freehand sketching in this section?

Yes, the student's possible solutions must be represented using freehand sketches. Students should practice sketching their possible solutions before they transfer into book.

- **Teacher Tip:** It would be a good idea to photocopy this section out of book for students to practice on and show you their attempts before they transfer into book.

Sketching- practice makes perfect

When it comes to sketching, the more practice our students get the more they improve as designers. Students should be encouraged to practice their sketching techniques if they get any spare time in school or at home. Youtube is full of videos on sketching techniques, if students wish to practice at home.



- **Teacher Tip:** You could encourage students that like sketching or who are particularly passionate about design to get themselves a sketch pad to store their sketches.

Sketching exercise

You could get students practising how to sketch basic shapes using the video exercise below.

https://www.youtube.com/watch?v=6ZU-ryDOtLw&t=22s

How should my students present their work?

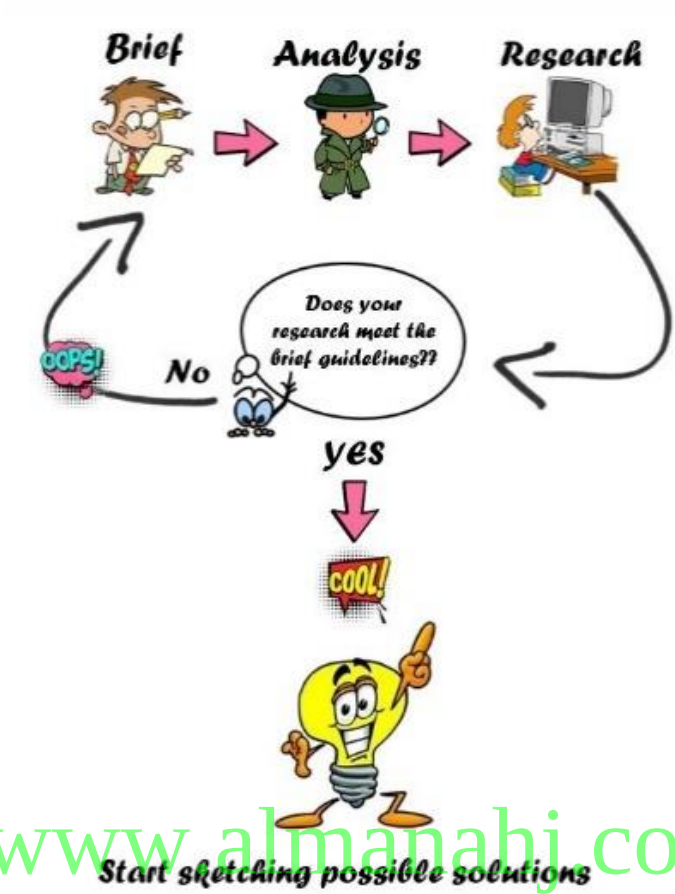
The layout of the sketches is up to the student, they can have a single sketch to present their ideas or a number of sketches. Students should be encouraged to consider the following:

- All sketches should be very neat and tidy. The use of colour and shading is encouraged.
- Students can use a variety of sketching techniques.
- 2D and 3D format are both acceptable, but a combination of both will be a better representation.
- Neat annotations or notes would help in explaining the operation of student designs.
- Students should give at least two advantages and two disadvantages to each design.
- Students may include extra pages to accompany their book for this section.

What guidance can I give my students for possible solutions?

- Look at the details in students research
- pay attention to colour, shape, texture
- what materials are used in my design and what is their pattern.

Use the design process below to help guide your students through preparing for possible solutions.



- **Note:** Does the student's possible solutions meet the criteria of brief? If not give them feedback on areas to change or to come up with another idea

Activity 1.4

Complete at least 2 possible designs. State advantages and disadvantages of each. Encourage rendering or color to enhance designs.

Stage 4: Selection of final solution

What is required of my students for selection of final solution?

In this stage, one final design solution that best fits the brief must be chosen. This solution maybe based on one of the possible solutions or a mixture of possible solutions. It is important that students show the reasons for choosing one solution over another. The way students present their work will be quite similar to the previous section.

What guidance can I give my students for selection of their final design?

Students can follow the diagram below to help guide them in selection of final design: **First and foremost, the final design must meet the criteria of the brief.**

How should my students present their work?

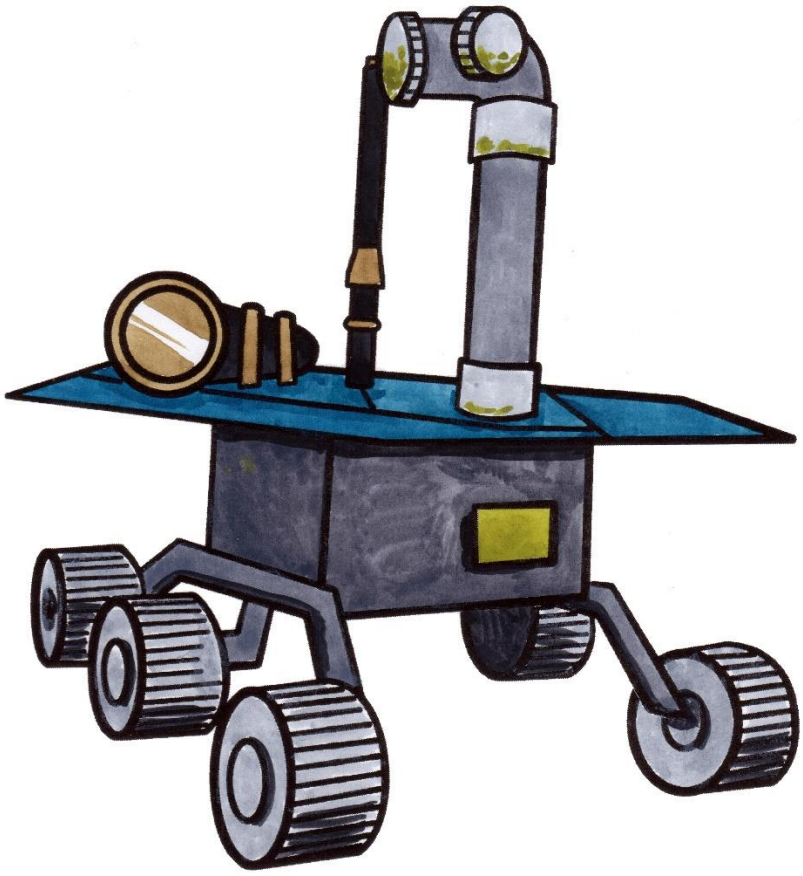
The layout of the sketches is up to the student, they can have a single sketch to present their ideas or a number of sketches. Students should be encouraged to consider the following:

- All sketches should be very neat and tidy. The use of colour and shading is encouraged.
- Students can use a variety of sketching techniques.
- 2D and 3D format are both acceptable, but a combination of orthographic 2D and 3D sketches will be a better representation.
- Neat annotations or notes would help in explaining the operation of student design
- State reasons for choosing this design.
- Select suitable materials for manufacturing and give reasons.
- Students can get creative with how they present their final design.
- Students can include extra pages to accompany their book for this section.

- **Note:** Each student design should be unique and innovative. Encourage students to think outside the box and try to add features that will make their designs unique and stand out against their classmates.

Activity 1.5

Below is sketched example of a unique space rover design, it will give you an idea of the quality that can be expected from students



Unit 4: Space Rover Project

Lesson 2: Design realistaion / manufacture of space rover

Aim:
This lesson aims to finalise space rover design and begin the design realisation process. Students will present their final solution and ensure it satisfies the brief. Students will then become familiar with the 3 main aspects of the design realisation process.

Teacher Learning Objectives: Learning objective refers to what you as a teacher will have taught the student by the end of the lesson. Teachers are to tick the box when the they have covered a learning objective.

- ☐ Give feedback on final design ideas.
- ☐ Recap on Unit 3, Lesson 3: Space rover electronics with pupils.
- ☐ Demonstrate assembly of final circuit.
- ☐ Present fusion 360 micro lessons as needed.

Student Learning Outcomes: Learning outcomes refer to what the student can expect from the lesson, Teachers must share these outcomes with all students. Teachers are to tick the box when the outcome is achieved. Learning outcomes can be assessed using oral questioning and the written activities.

Students should be able to:

- ☐ Present one final solution
- ☐ Create a Bluetooth controlled Arduino circuit
- ☐ Begin to design a 3D space rover model on Fusion 360
- ☐ Apply entrepreneurial attributes throughout the design process.

Keywords	**What are the keywords the students must learn?** • Design realisation • Entrepreneurship • All wheel drive
Resources	**What resources are required?** • textbooks • projector • sketching equipment • Electronics kit • Soldering kit • Fusion 360 • 3D printer
Prior Knowledge	• Fusion 360 • Sustainability • Mars electronics • Soldering

Possible Teaching Method(s) or Approach for this lesson

- Collaborative Teaching (student centred)
- Instructional / Demonstrative Teaching (teacher centred)
- Inquiry-based Teaching (student centred)
- Lecture Style Teaching (teacher centred)
- Coach Style Teaching (teacher centred)
- Facilitator Style Teaching (student centred)

Essential and non-essential Sections:

In some lessons it may not be possible to cover every section of the book due to time constraints or lesson variables. Below is a guideline to essential sections for examination and project knowledge.

Topic- Unit 4	Page	
	Essential	**Non-essential/Self Study**
Design realisation activity 1.6	Pg. 184	
Electronics	Pg. 185-187	
Model and manufacture	Pg. 188-193	

Topic- Unit 3-lesson 3	Page	
	Essential	**Non-essential/Self Study**
Step 4: Connecting SPST and DPST switches to the space rover circuit	Pg.146-148	

Development [Phases or chunks of learning]:	Notes for differentiation:	Assessment Opportunities:
Note: *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.* **Phase 1 of lesson (Connect)** **Starter** Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Teacher to introduce all key words, discuss meaning and ensure understanding before progressing **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.* **Phase 2 of lesson (Activate)** Teacher to organise student groups. Students to present final solution Teacher to give feedback based on how well design meets the brief. Teacher to recap on unit 3 space rover electronics. Students to recall knowledge on Arduino electronics. Teachers to introduce students to step 4: Connecting SPST and DPST switches to the space rover circuit from Unit 3-lesson 3. Teacher to demonstrate assembly of final circuit. Teacher to question students on Arduino code from unit 3. Teacher to introduce model and manufacture stage. Students to explore and discuss given fusion 360 parts and how they will fit into final design. Teacher to present micro Fusion 360 lessons on features as needed by assessing class progress. (see resources for week 5)	***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary through ought the lesson.*	**Questioning.**

Students to explore modelling techniques that will solve their design idea. **Teacher Tip:** *Teacher to demonstrate good subject and curriculum knowledge* **Phase 3 of lesson (Engage and Demonstrate)** Students to demonstrate understanding by completing full circuit diagram. Students to apply knowledge by building final circuit and completing activity 1.8 Teacher to facilitate as circuits are constructed. Facilitate as pupils' complete activities 3.9-3.10 (Unit 3-lesson 3). Teacher to monitor students as the students solder DPST switch to the final circuit. Students to demonstrate understanding by creating final code to control circuit using Bluetooth. Teacher to facilitate as student's complete activity 1.9 and test final code. Students to demonstrate understanding of design and measurement by completing activities 1.10 and 1.11 Students to analyse given fusion 360 models. Students to demonstrate modelling skills on Fusion 360. Students to begin designing a space rover on fusion 360 model using the given motors and wheels. Teacher to facilitate as students work on fusion 360 design. **Teacher Tip:** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.* **Phase 4 Plenary (Consolidate)** Teacher to facilitate as student's complete fusion 360 design Question pupils on what they have learned. Have learning outcomes been met? Has the lesson aim been achieved?		**Written Activity 1.8** **Written Activity 1.9** **Written Activity 3.9-3.10 (Unit 3)** **Written Activity 1.10 / 1.11** **Fusion 360 models in activity 1.12** **Oral Assessment**

All students should have presented a successful final design and began modelling on fusion 360.		

Answer Key/ Resources

Activity 1.6

The images below show various pieces of equipment that may be used to complete the design realisation of the space rover. Name each piece of equipment and what stage of the process it could be used for.

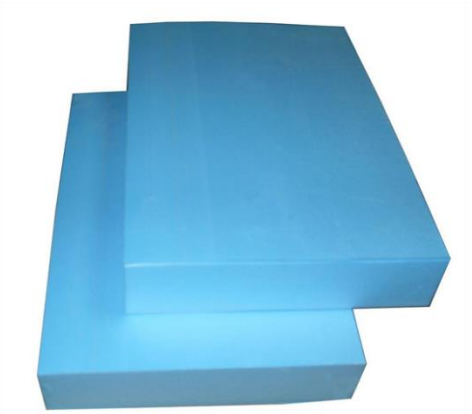
Name: 3D printer
Use: Model and manufacture

Name: Nuts and bolts
Use: Assembly

Name: Super glue
Use: Assembly

Name: Hot glue gun
Use: Assembly

Name: Soldering iron
Use: Electronics



Name: Modeling foam
Use: Model and manufacture

Activity 1.7

Shown below is the circuit diagram you constructed in Unit 2 to control DC motors using Bluetooth.

1) You are required to have six DC motors driving the space rover. Modify the circuit below to control all six motors (three on the left side and three on the right side).

Note: Use your knowledge of parallel circuits to ensure equal power to each motor.

2) You are required to add one expansion task to your space rover circuit. Add one component to the circuit below to be controlled from one of the extra commands from the app as shown in Figure 0.10.

Note: Each command can send a high signal. This can control any component. Be innovative and creative with your choice.

Remember you can refer to appendix 2 for help connecting Bluetooth RC Controller app.

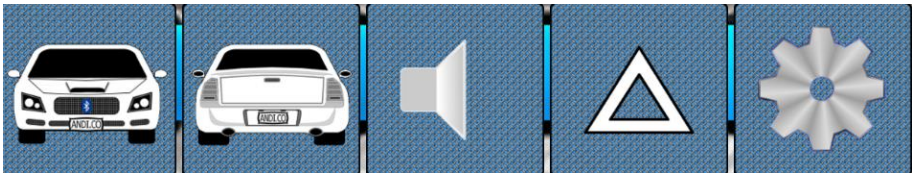
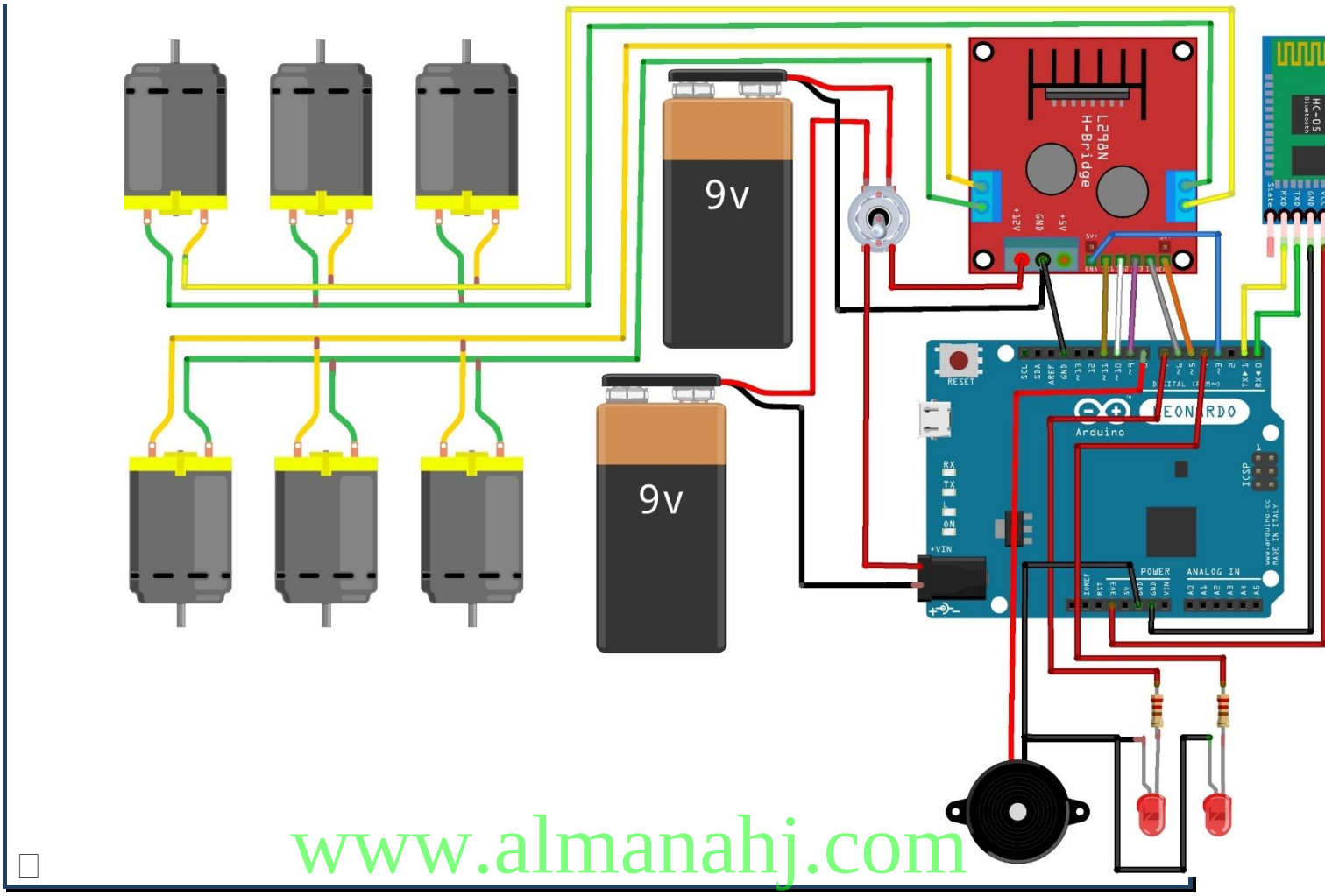


Figure 0.10



Activity1.8

- You must now build the circuit from Activity 7. All motors should be soldered to red and black wires. Leave extra length on these wires to assemble your space rover model and circuit later.
- *Refer to appendix 1: soldering for help soldering motors.*
- When finished, paste a picture of your circuit below.
- Paste a clear image of full circuit ready for coding and testing. Several images showing the circuit progressing is preferred.

Activity 1.9

Arduino code:

```
//speed of motors between 0 and 255, if you like you can change it
int pwm_speedA = 255;
int pwm_speedB = 240;
char command;

void setup() {
Serial1.begin(9600);
//pins for motor controller
pinMode(11, OUTPUT);
pinMode(10, OUTPUT);
pinMode(9, OUTPUT);
pinMode(6, OUTPUT);
pinMode(5, OUTPUT);
pinMode(3, OUTPUT);
pinMode(4,OUTPUT);
pinMode(7,OUTPUT);
pinMode(8,OUTPUT);

}

void loop() {

if(Serial1.available() > 0){
command = Serial1.read();
motors_stop();
switch(command){
case 'F':
forward();
break;
case 'B':
backward();
```

```
        break;
        case 'L':
        left();
        break;
        case 'R':
        right();
        break;
        case 'W':
        LEDon();
        break;
        case 'w':
        LEDoff();
        break;
        case 'V':
        hornon();
        break;
        case 'v':
        hornoff();
        break;
        }
        }

        }

        // function for driving straight
        void forward(){
        digitalWrite(10, HIGH);
        digitalWrite(11, LOW);

        digitalWrite(9, HIGH);
        digitalWrite(6, LOW);

        analogWrite(5, pwm_speedA);
        analogWrite(3, pwm_speedB);
        }
```

```
//function for reversing
void backward(){

digitalWrite(10, LOW);
digitalWrite(11, HIGH);

digitalWrite(9, LOW);
digitalWrite(6, HIGH);

analogWrite(5, pwm_speedA);
analogWrite(3, pwm_speedB);
}

//function for turning left
void left(){
digitalWrite(11, LOW);
digitalWrite(10, LOW);

digitalWrite(9, HIGH);
digitalWrite(6, LOW);

analogWrite(3, 0);
analogWrite(5, pwm_speedA);
}

//function for turning right
void right(){
digitalWrite(10, HIGH);
digitalWrite(11, LOW);


digitalWrite(9, LOW);
digitalWrite(6, LOW);

```

```
        analogWrite(3, pwm_speedB);
        analogWrite(5, 0);

        }

        void LEDon(){
        digitalWrite(4, HIGH);
        digitalWrite(7, HIGH);

        }
        void LEDoff(){
        digitalWrite(4, LOW);
        digitalWrite(7, LOW);

        }
        void hornon(){
        digitalWrite(8, HIGH);
```



```
        }
        void hornoff(){
        digitalWrite(8, LOW);

        }

        //function for stopping motors
        void motors_stop(){

        digitalWrite(11, LOW);
        digitalWrite(10, LOW);

        digitalWrite(9,LOW);
        digitalWrite(6, LOW);
         analogWrite(5, 0);
        analogWrite(3, 0);
        }
```

Activity 1.10

☐ What is the correct name of the suspension system to be used on your space rover?

A) leaf spring B) rocker-bogie C) coil spring D) bogie-rocker

Scan the QR code or follow the link to access the Fusion 360 model of a motor holder. This file can be measured to ensure a snug fit for your motor inside the holder.

Note: Type the correct answer exactly as above to unlock the file.

Figure 0.11: http://a360.co/2sLU3yq

Activity 1.11

Open the motor holder part file from Activity 7. Select the measurement tool and click any line to display its dimension in millimetres. What are the correct measurements of lines 1 and 2?

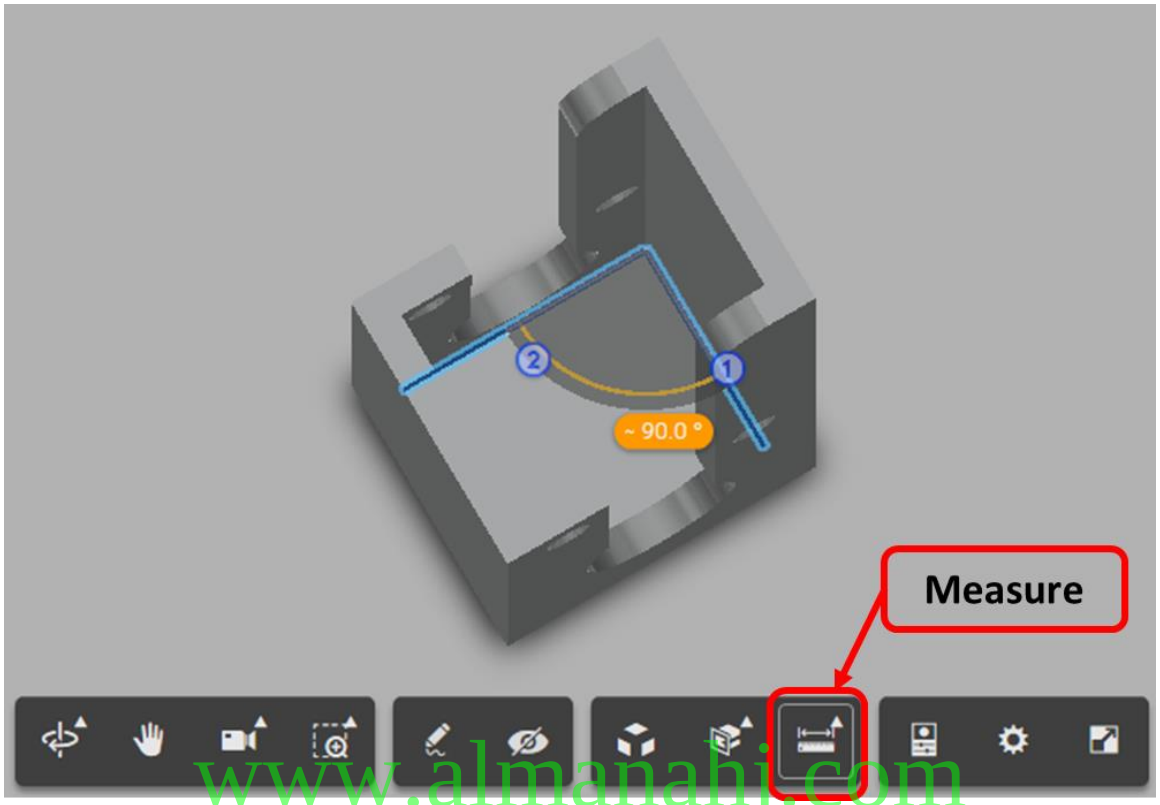


Figure 0.12

A) 1=19mm, 2=23 mm B) 1=20mm, 2=25 mm C) 1=19 mm, 2=24 mm D) 1=20mm, 2=23 mm

Scan the QR code or follow the link to access the Fusion 360 model of a motor and wheels. This file can be downloaded and used as a starting point for your design as parts are to full scale.

Note: Type the correct answer exactly as above to unlock the file.

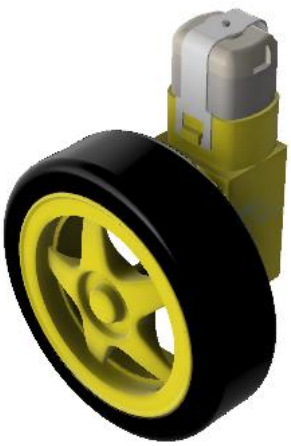
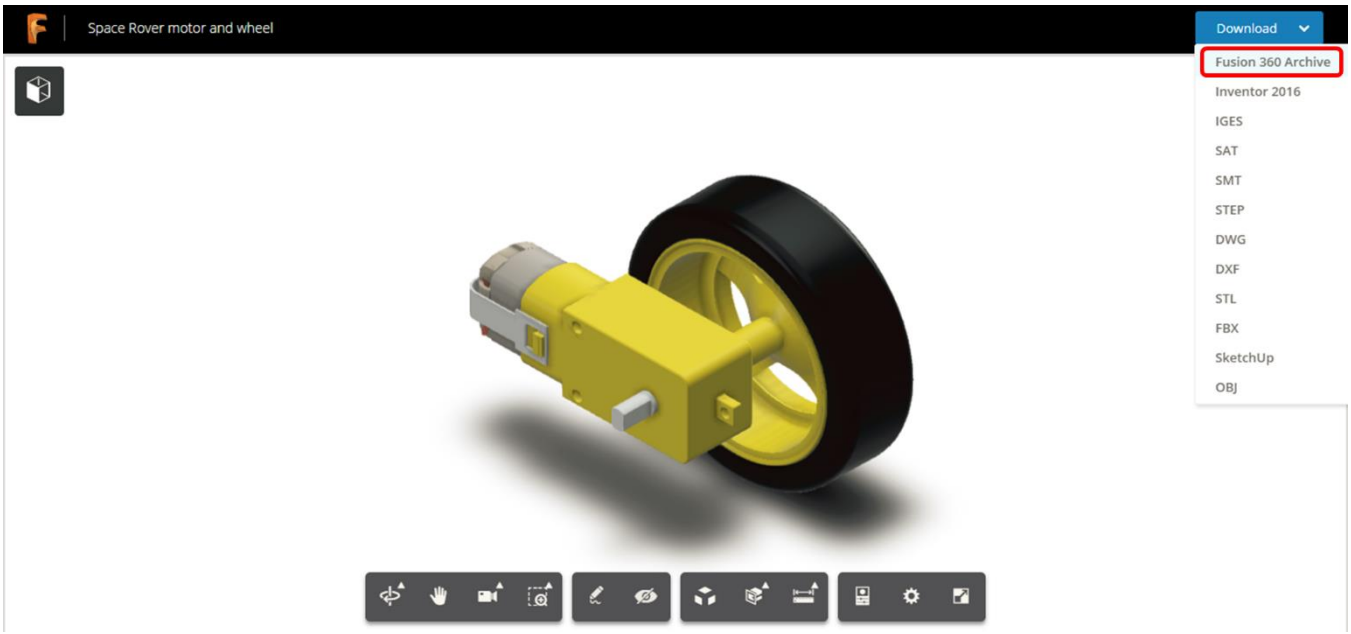


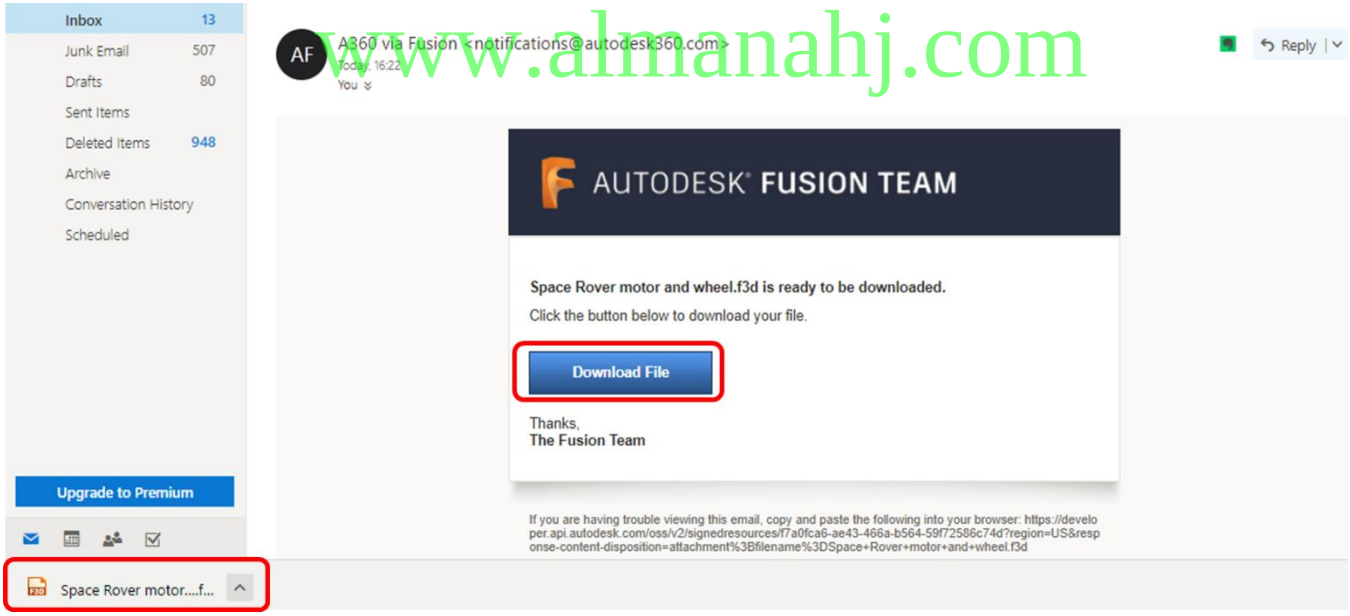
Figure 0.13: http://a360.co/2FhNbeG

Downloading given parts:

- Open the given part in browser.
- Select download > Select Fusion 360 archive



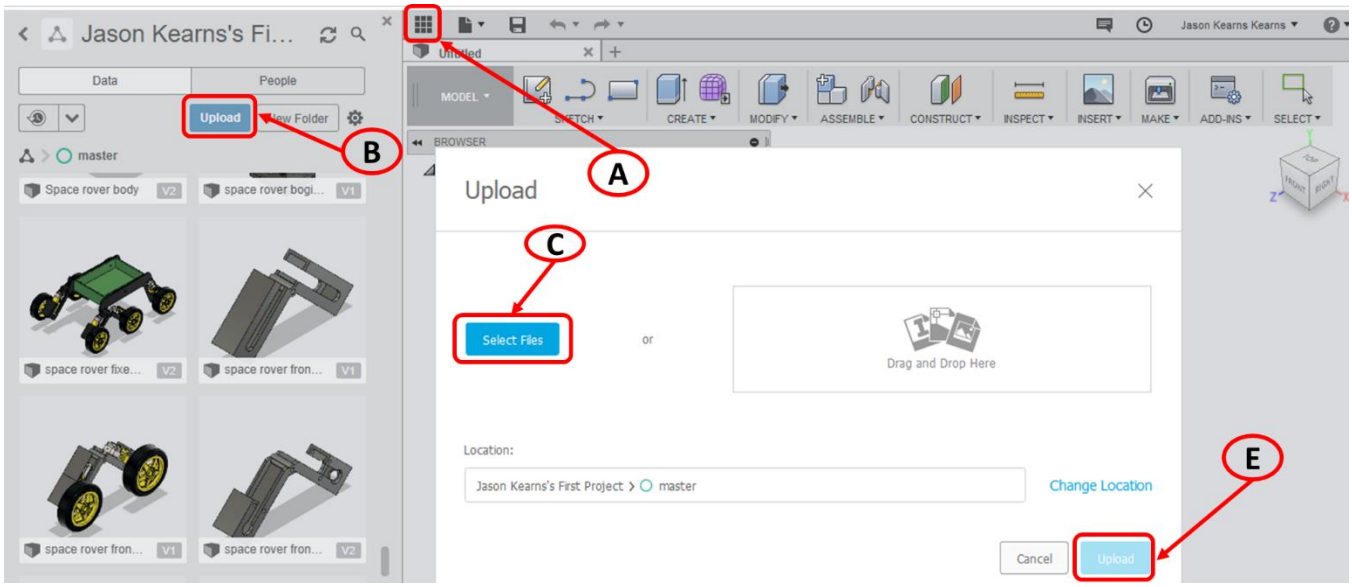
- Enter your email address when requested
- You will receive an email from A360 with a download link.



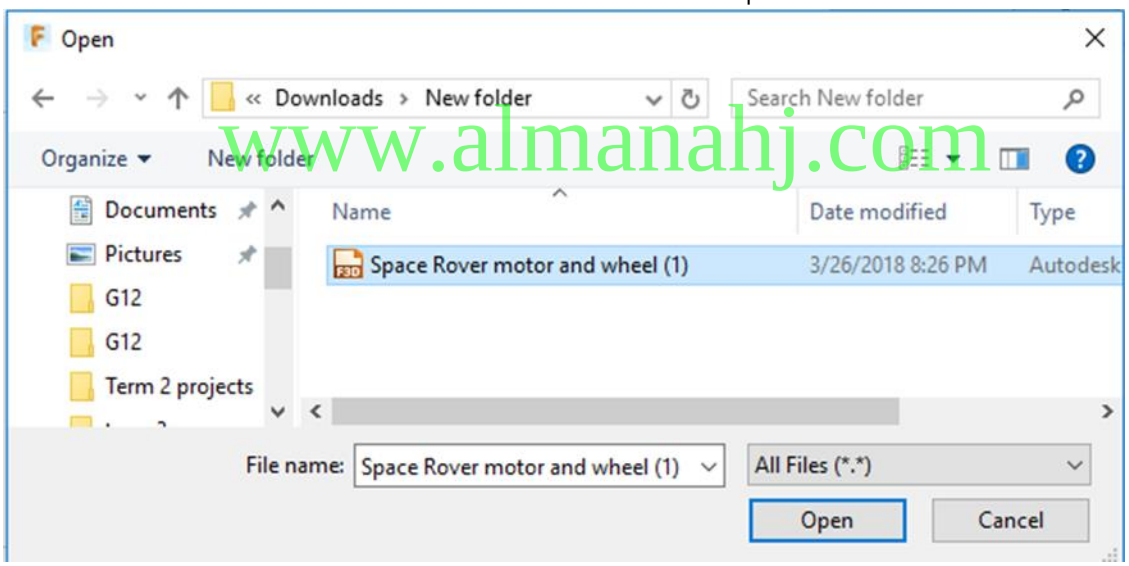
- Select download file and wait until F3D file downloads.

Uploading parts to data panel:

a) Open fusion 360 and select show data panel
b) Select upload
c) Select files



d) Browse to download location and select f3d file to upload



e) Select upload and wait until part has uploaded.
f) The part is now available in your data panel.

Unit 4: Space Rover Project

Lesson 3: Stage 5: Design realistaion / manufacture continued

Aim:
This lesson aims to finalise the 3D Fusion 360 model. Students will begin to 3D print individual parts as they are finalised.

Teacher Learning Objectives: Learning objective refers to what you as a teacher will have taught the student by the end of the lesson. Teachers are to tick the box when the they have covered a learning objective.

- ☐ Give feedback on fusion 360 models
- ☐ Present fusion 360 micro lessons as needed.
- ☐ Recap on 3D printing process

Student Learning Outcomes: Learning outcomes refer to what the student can expect from the lesson, Teachers must share these outcomes with all students. Teachers are to tick the box when the outcome is achieved. Learning outcomes can be assessed using oral questioning and the written activities.

Students should be able to:

- ☐ Design a 3D space rover model on Fusion 360.
- ☐ Apply entrepreneurial attributes throughout the design process.
- ☐ 3D print all models.

Keywords	**What are the keywords the students must learn?** • Design realisation • Entrepreneurship • All wheel drive
Resources	**What resources are required?** • textbooks • projector • sketching equipment • Electronics kit • Soldering kit • Fusion 360 • 3D printer
Prior Knowledge	• Fusion 360 • Sustainability • Mars electronics • Soldering

Possible Teaching Method(s) or Approach for this lesson

- Collaborative Teaching (student centred)
- Instructional / Demonstrative Teaching (teacher centred)
- Inquiry-based Teaching (student centred)
- Lecture Style Teaching (teacher centred)
- Coach Style Teaching (teacher centred)
- Facilitator Style Teaching (student centred)

Essential and non-essential Sections:

In some lessons it may not be possible to cover every section of the book due to time constraints or lesson variables. Below is a guideline to essential sections for examination and project knowledge.

Topic	Page	
	Essential	**Non-essential/Self Study**
Electronics	Pg. 185-187	
Model and manufacture	Pg. 188-193	

Development [Phases or chunks of learning]:	Notes for differentiation:	Assessment Opportunities:
Note: *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.* **Phase 1 of lesson (Connect)** **Starter** Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.* **Phase 2 of lesson (Activate)** Teacher to asses' student progress on fusion model and provide feedback. Students to discuss feedback given in groups. Teacher to present micro Fusion 360 lessons on features as needed by assessing class progress. (see resources for week 5) Students to explore modelling techniques that will solve their design idea. Teacher to recap on 3D printing process **Teacher Tip:** *Teacher to demonstrate good subject and curriculum knowledge* **Phase 3 of lesson (Engage and Demonstrate)** Students to continue designing space rover on fusion 360. Teacher to facilitate as students work on fusion 360 design. Students to save all parts as STL files and export to flash print. **Teacher Tip:**	***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary through ought the lesson.*	**Questioning.** **Fusion 360 models in activity 1.12**

Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's. **Phase 4 Plenary (Consolidate)** Teacher to facilitate as student's complete fusion 360 design Question pupils on what they have learned. Have learning outcomes been met? Has the lesson aim been achieved? All students should present final Fusion 360 model and begin 3D printing.		**Oral Assessment**

Unit 4: Space Rover Project

Lesson 4: Project assembly and evaluation

Aim:
This lesson aims to assemble all 3D printed parts with the electronics

Teacher Learning Objectives: Learning objective refers to what you as a teacher will have taught the student by the end of the lesson. Teachers are to tick the box when the they have covered a learning objective.

- ☐ Demonstrate assembly techniques.
- ☐ Present evaluation questions

Student Learning Outcomes: Learning outcomes refer to what the student can expect from the lesson, Teachers must share these outcomes with all students. Teachers are to tick the box when the outcome is achieved. Learning outcomes can be assessed using oral questioning and the written activities.

Students should be able to:

- ☐ Design a 3D space rover model on Fusion 360.
- ☐ Assemble all parts and electronic components to create a working space rover model.
- ☐ Test and evaluate finished product.

Keywords	**What are the keywords the students must learn?** • Design realisation • Entrepreneurship • All wheel drive
Resources	**What resources are required?** • textbooks • projector • sketching equipment • Electronics kit • Soldering kit • Fusion 360 • 3D printer
Prior Knowledge	• Fusion 360 • Sustainability • Mars electronics • Soldering

Possible Teaching Method(s) or Approach for this lesson

- ☐ Collaborative Teaching (student centred)
- ☐ Instructional / Demonstrative Teaching (teacher centred)
- ☐ Inquiry-based Teaching (student centred)
- ☐ Lecture Style Teaching (teacher centred)
- ☐ Coach Style Teaching (teacher centred)
- ☐ Facilitator Style Teaching (student centred)

Essential and non-essential Sections:

In some lessons it may not be possible to cover every section of the book due to time constraints or lesson variables. Below is a guideline to essential sections for examination and project knowledge.

Topic	Page	
	Essential	Non-essential/Self Study
Assembly of manufactured components	Pg. 194-195	
Evaluation	Pg. 196	
Entrepreneurship task		Pg. 197-198

Development [Phases or chunks of learning]:	Notes for differentiation:	Assessment Opportunities:
Note: *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.* **Phase 1 of lesson (Connect)** **Starter** Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.* **Phase 2 of lesson (Activate)** Teacher to introduce students to assembly techniques. Students to discuss their groups project and what assembly techniques could be used for their project. Teacher to present evaluation questions and ensure understanding. **Teacher Tip:** *Teacher to demonstrate good subject and curriculum knowledge* **Phase 3 of lesson (Engage and Demonstrate)** Students to begin assembling all parts of the space rover. Teacher to facilitate as students assemble 3D printed parts Students to assemble electronic circuit with assembled model. Students to power on and test space rover. Teacher to facilitate and provide feedback as necessary **Teacher Tip:** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.*	***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary through ought the lesson.*	**Questioning.** **Assessment of Final assembled model**

Phase 4 Plenary (Consolidate) Teacher to facilitate as students complete final evaluation Question pupils on what they have learned. Have project learning outcomes been met? Has the project aim been achieved? All students should complete student learning reflection.		**Written evaluation** **Oral Assessment** **Student reflection**

Answer Key/ Resources

Stage 6: Evaluation

Once students have finished 3D printing their project and assembling it with electronic circuit, students should finish by testing and evaluating their work on this project.

Why is evaluation important?

It might be useful to discuss with students why evaluation and self-reflection is an important final stage of their project.

Evaluation affords the opportunity to reflect on the completed project. What went well and what could be improved in the future or what could I do better. It is a worthy learning process for overall improvement of our students in the subject of CDI.

What guidance can I give my students in completing the evaluation?

- Break down the evaluation questions and ensure student understanding of what is being asked.
- Facilitate as student's complete evaluation and submit.
- Encourage students not to just concentrate on the negatives but to really think about the positives, what went well and what are they most proud of.
- Facilitate students as they complete the student reflection section and point out the importance of reflection in all projects they complete.