UNITED ARAB EMIRATES
MINISTRY OF EDUCATION

YEAR OF
ZAYED

CREATIVE DESIGN & INNOVATION

Teacher Guide

Grade 12
Advance

Volume
1 2 3

Creative Design and Innovation

G12 Advance Teacher's Guide

CREATIVE DESIGN
INNOVATION

Term 2 2018-19

Volume 01

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Introduction:

This Teacher's Guide aims to provide the teachers of Creative Design and Innovation with a set of teacher support materials. This includes the Instructional Planner (IP), the Lesson Plans (LPs) and Answer Keys.

The Instructional Planner aims to provide teachers with the scope and sequence during the term. Teachers will be able to have a detailed idea of when to teach each section of the book and accordingly organise their work during the entire term in advance. The Instructional Planner also highlights the material that will not be assessed throughout the term (self-study), where the details are in the lesson plans in the next section of the Teacher's Guide. The Lesson Plans can be also found on LMS for you reference.

Note that the IP is divided into weeks containing three periods, the same applies to Lesson Plans. These may be organised as double and single or all single periods depending on school timetables. Assessment weeks will be confirmed by ADU throughout the term and the current distribution of weeks might need to be slightly tweaked by the teacher accordingly.

The Lesson Plans provide a model teaching strategy for Creative Design and Innovation teachers. It highlights the core points that allow teachers to support the progress of their students and it divides the lesson into phases to allow an optimum comprehension of the lessons for students. It also provides a plenty of advices for the teachers to follow in class promoting various teaching methodologies, practices and strategies. It contains answer keys for all the questions and activities within the book, in order to provide teachers with model answers that guarantee a moderate and consistent level for answers across the country.

As a CDI teacher for Grade 12 students, you have a great responsibility of enlightening your students with the available opportunities in their higher education studies. CDI is a very important and rich subject that eventually feeds into many science engineering and design fields. Please demonstrate this importance at the beginning and throughout the term. This will allow students to give extra attention to the subject and motivate students to explore the subject outside the classroom. Also, as G12 students are seeking high grades for their university acceptance, it is extremal important to draw their attention to the assessment approach in G12. This can be achieved through familiarising them with project-based learning and its assessment scheme in details.

Please note that the Summative Assessment for this term requires the use of students' laptops **OR** computer lab with **Autodesk Fusion 360 installed**. Hence, make sure the needed facilities are well prepared ahead of **week 10**, as per the instructional planner.

Wishing you a very successful and fruitful term with your creative and innovative students!

The authors,

January 2019

Instructional Planner:

Trimester Planner (Instructional Planner)
Term two 2018/2019

SUBJECT: Creative Design and Innovation (CDI)

Grade 12 Advance

Note: All **blue** Learning outcomes are from Chapter 1: the design process but completed throughout the term as further chapters are studied. All learning outcomes are essential unless highlighted in **green**, they are not directly assessed but contribute to project assessment.

Week	Period	Chapter	Overview	Learning Outcomes
1 13/01	1	1	**Chapter 1 - Section 1:** The design process: Design of a space rover	• **Analyse a brief.** • **Distinguish between different types of research.** • **Present research and investigation techniques.**
	2	2	**Chapter 2- Section 1:** Vehicle design specifications	• **Carry out and present research and investigation.** • 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.
	3	2	**Chapter 2 - Section 2:** Adapting to space vehicles	• **Carry out and present research and investigation** • Identify suitable motors and power sources for a space rover. • Differentiate between steering mechanisms. • Understand the operation of a rocker-bogie suspension system. • Design a rocker-bogie mechanism.
2 20/01	1 2 3	3	**Chapter 3 - Section 1**: Electric vehicle components	• **Carry out and present research and investigation** • Differentiate between motor types. • Identify the function of a motor driver.

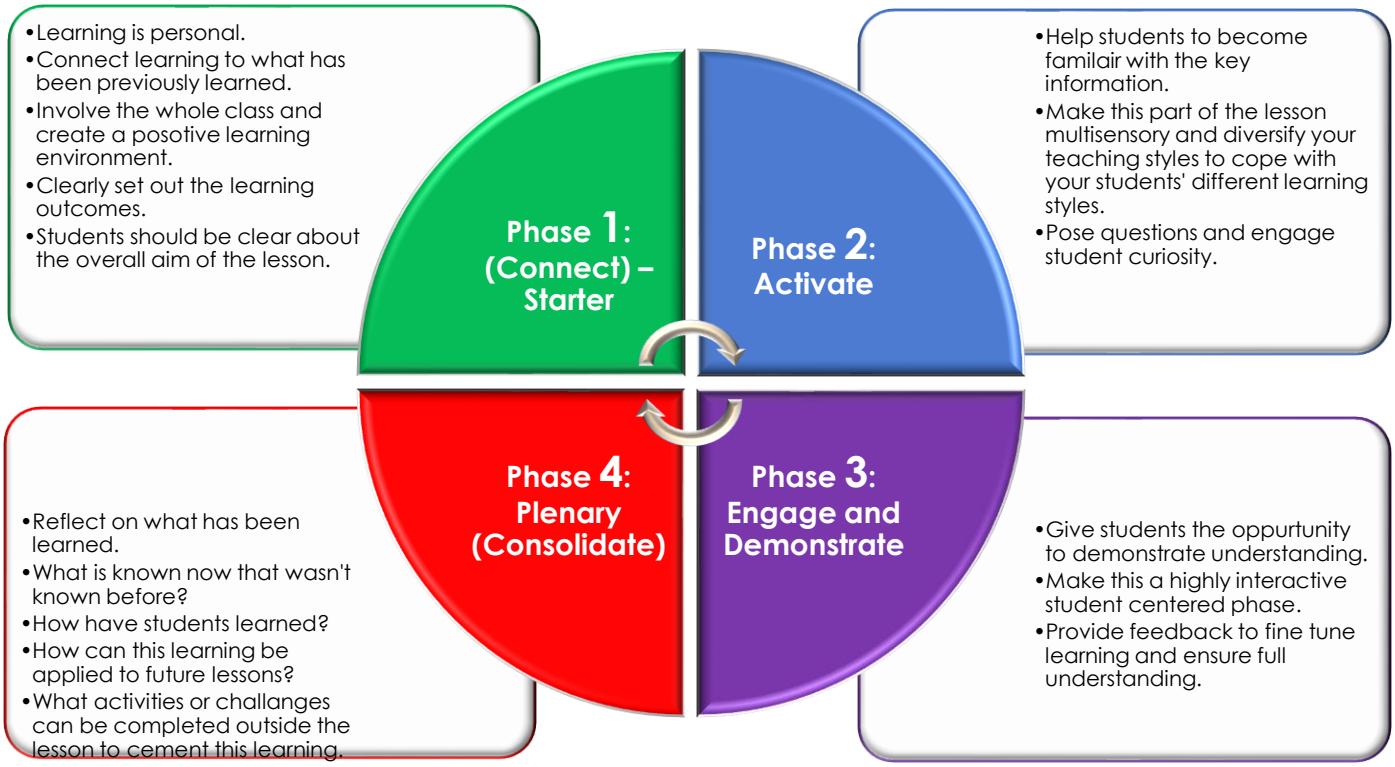
				• Compare between different switch types. • Identify and compare integrated circuits, microprocessors and microcontrollers. • Identify methods of wireless control. • Catagorise inputs, controllers and outputs of an electrical circuit. • Design a circuit to drive DC motors from a Bluetooth device. • Build and test a circuit to drive DC motors from a Bluetooth device.
3 27/01	1	3	**Chapter 3 - Section 2:** Space rover control	• **Carry out and present research and investigation** • Complete a circuit diagram to solve the design brief. • Identify all components needed to complete the circuit. • Build the circuit. • Modify and create a new Arduino code to programme the circuit.
	2	1	**Chapter 1 - Section 1:** The design process: Design of a space rover (Stage 4: Possible solutions)	• **Create neat possible solution sketches.**
	3	1	**Chapter 1 - Section 1:** The design process: Design of a space rover (Stage 5: Final Solutions)	• **Create an improved final solution design.**
4 03/02	1	4	**Chapter 4 - Section 1:** Fusion 360 recap **Chapter 4 - Section 2:** Introduction to basic modelling *Note: The amount of time spent on section 1 and 2 should be determined by your classes level and previous experience on fusion 360 but shouldn't be more than 1-2 periods.*	• Register for Fusion 360. • Open a new design in Fusion 360. • Save a file in Fusion 360. • Navigate the toolbar. • Open and navigate the data panel. • Share work from your data panel. • Download files and upload files to your data panel. • Identify 2D sketch tools. • Identify and distinguish between planes. • Create dimensioned 2D sketch. • Create a 3D model using extrude tool.
	2 3	4	**Chapter 1 - Section 1:** The design process: Design of a space rover (Stage 6: Design realisation) **Chapter 4 - Section 3:** Creating the space rover chassis	• Identify the required chassis type and size. • Create the required 2D sketch. • Extrude a 2D sketch. • Shell required parts of the chassis. • Add fillets to improve chassis appearance and function.

				• Create holes to mount components and top body to chassis.
5 10/02	1 2 3	4	**Chapter 4 - Section 4:** Assemblies and Multiple body design	• Understand how to model different bodies and components in one design. • Use combine tool to create one body or component. • Save separate components as parts. • Insert an existing part into a design. • Differentiate between joint types. • Create an assembly using all joint types. • Apply joint limits to moving joints. • Assemble all electric components within the chassis.
6 17/02	1 2 3	4	**Chapter 4 - Section 5:** Modelling the rocker-bogie mechanism	• Identify and read a working drawing. • Create the required 2D rocker sketch. • Create the required bogie sketch. • Extrude 2D sketches to form 3D profiles. • Use extruded cuts to create motor mounts. • Add fillets to improve rocker and bogie strength and appearance. • Create holes to join components.
7 24/02	1 2	4	**Chapter 4 - Section 5:** Modelling the rocker-bogie mechanism	• Identify and read a working drawing. • Create the required 2D rocker sketch. • Create the required bogie sketch. • Extrude 2D sketches to form 3D profiles. • Use extruded cuts to create motor mounts. • Add fillets to improve rocker and bogie strength and appearance. • Create holes to join components. • Assemble the rocker-bogie mechanism to the chassis using suitable joints • Add motion links and joint limits to simulate realistic motion
	3		**Chapter 4 - Section 6**: Space rover top body	• Create offset planes. • Create sketch profiles. • Create a lofted profile. • Create a swept profile. • Use the hole tool to match existing mount points.
8 03/03	1 2	4	**Chapter 4 - Section 6**: Space rover top body (Activity 4.6.5)	• Create a unique top body model.

	3		**Chapter 5 - Section 1:** Manufacturing and assembly of a space rover	• Convert 3D models to STL files. • Insert and set up STL files for 3D printing in FlashPrint. • 3D print all space rover components. • Assemble all parts using suitable joining methods.
9 10/03	1	5	**Chapter 5 - Section 1:** Manufacturing and assembly of a space rover	• Convert 3D models to STL files. • Insert and set up STL files for 3D printing in FlashPrint. • 3D print all space rover components. • Assemble all parts using suitable joining methods. • Fully assemble the electronic circuit.
	2		**Chapter 1 - Section 1:** The design process: Design of a space rover (Stage 7)	• **Evaluate the final project.**
	3			
10 17/03	1	-	**Summative Assessment Preparation** "Not decide yet. Could be a different week and will be confirmed later by ADU"	
	2			
	3		**Summative Assessment** "Not decide yet. Could be a different week and will be confirmed later by ADU"	
11 24/03	1	5	**Chapter 5 - Section 1:** Manufacturing and assembly of a space rover	• Modify the circuit to add a buzzer. • Modify the program to vary speed, turning circle etc. (this is an opportunity for students to explore and improve without being assessed or fearing failure).
	2			
	3			

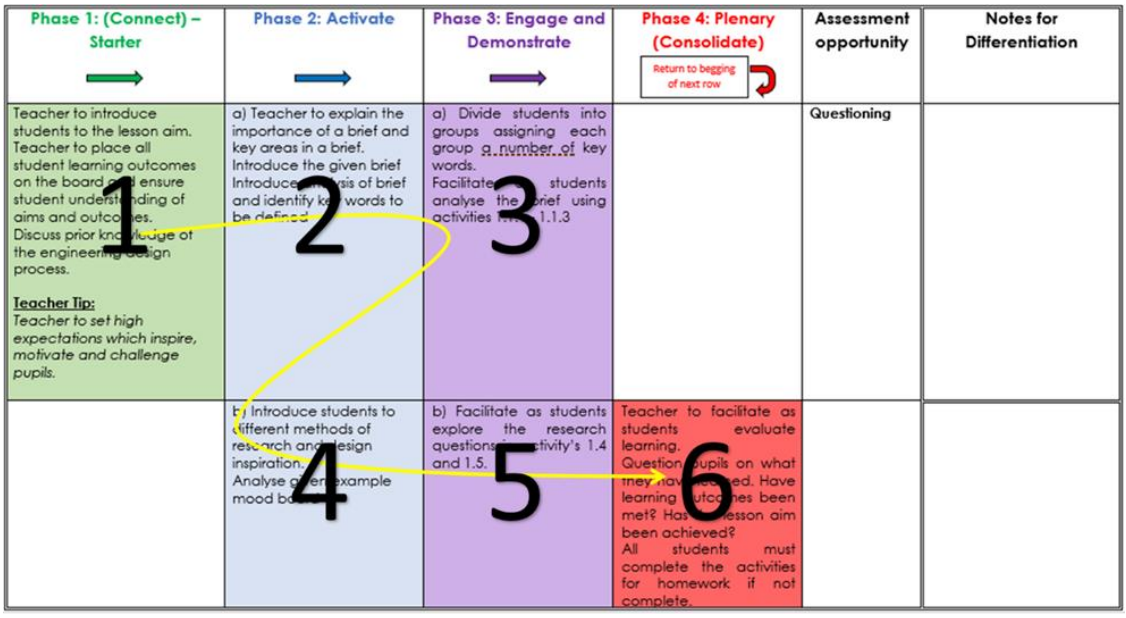
Using the provided lesson plans

Lesson plans are provided to work with the instructional planner. The lesson plan contains 4 key learning phases. The generic lesson progression is demonstrated below, please follow the phases (clockwise).



When following the lesson plan work from left to right, completing each phase in that row before moving to the next row (see the figure below). The lesson should always begin with the **connect** phase and end with the **plenary** phase; however, the lesson may move between phases several times throughout the period.

The example figure below explains this flexibility of moving between phases for Period 1.



Notes should be made by the teacher on activities or tasks to cater for differentiation specific to your class group.

Lesson Plans:

Week 1 Lesson Plan:

<table>
<tr><td rowspan="3">Content</td><td colspan="2">Grade 12 Advance</td></tr>
<tr><td>Chapter 1: Engineering design</td><td>Section 1: The design process: Design of a space rover</td></tr>
<tr><td rowspan="2">Chapter 2: Technologies in space exploration Vehicles</td><td>Section 1: Vehicle design specifications</td></tr>
<tr><td>Section 2: Adapting to space vehicles</td></tr>
<tr><td>Time allocated</td><td colspan="2">3 x 45-minute periods</td></tr>
<tr><td>Keywords</td><td colspan="2">What are the keywords the students must learn?</td></tr>
<tr><td></td><td colspan="2">• analysis
• aesthetics
• research
• design realisation
• evaluate
• Arduino
• space rover
• drivetrain
• suspension
• combustion
• crankshaft
• armature
• brush
• electromagnet
• velocity ratio
• differential
• differential steering
• torque
• rack and pinion
• bevel gear
• rocker-bogie</td></tr>
<tr><td>Resources</td><td colspan="2">What resources are required?
• textbooks
• projector
• sketching equipment</td></tr>
<tr><td>Prior Knowledge</td><td colspan="2">• Sketching
• Fusion 360
• Basic electronics
• 3D printing</td></tr>
</table>

Aim:

In this lesson, students will understand each stage of the design process and why it is important. Students should also understand why the design process follows a specific loop and stages cannot be skipped or left out without affecting the finished design. You will be present students with a design brief to be solved. They must analyse this brief and show understanding of the problem to be solved. Stage 3 involves research and investigation to solve the brief. You will learn present types of research before moving onto chapters 2 and 3 to aid students research and understanding of vehicle technologies and space rovers.

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 they have covered a learning objective.

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.

Teacher should: *(tick as you complete)*	***Students should:*** *(tick as students complete)*
☐ Introduce the given brief.	☐ Analyse a brief.
☐ Introduce different types and techniques of research and investigation	☐ Distinguish between different types of research.
	☐ Carry out and present research and investigation.
☐ Explain the functions of a space rover.	☐ Define a space rover.
☐ Demonstrate possible drivetrains.	☐ Compare possible drivetrains.
☐ Demonstrate sample rpm calculations.	☐ Complete drivetrain rpm calculations.
☐ Explain various vehicle suspension systems.	☐ Recognise and compare various vehicle suspension systems.
☐ Introduce brushed and brushless motors	☐ Differentiate between brushed and brushless motors.
☐ Demonstrate possible power sources.	☐ Analyse possible power sources.
	☐ Identify suitable motors and power sources for a space rover.
☐ Explain possible steering mechanisms.	☐ Differentiate between steering mechanisms.
☐ Explain the operation of a rocker-bogie suspension system.	☐ Understand the operation of a rocker-bogie suspension system.
☐ Facilitate and give feedback as students design a rocker-bogie mechanism.	☐ Design a rocker-bogie mechanism.
☐ Remind students of the relevant research questions to be answered from Chapter 2	☐ **Carry out and present research and investigation**

Possible teaching method(s) or approach for this lesson

(teacher to tick the relevant method)

- ☐ 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	
Chapter	**Section**	**Focus**	**Essential**	**Non-essential/Self Study**
1	1	The design process	Pg. 15 - 30	
2	1	Vehicle design specifications	Pg. 51-71	
2	2	Adapting to space vehicles	Pg. 72 - 87	

Learning Phases - Week 1: Period 1

Phase 1 of lesson (Connect) – Starter	Phase 2 of lesson (Activate)	Phase 3: (Engage and Demonstrate)	Phase 4: Plenary (Consolidate) Return to begging of next row	Assessment opportunity	Notes for Differentiation
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. Introduce all key words for the lesson. Discuss prior knowledge of the engineering design process. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	a) Teacher to explain the importance of a brief and key areas in a brief. Introduce the given brief Introduce analysis of brief and identify key words to be defined	a) Divide students into groups assigning each group a number of key words. Facilitate as students analyse the brief using activities 1.1.1 - 1.1.3		**Oral Questioning** **Written Activity 1.1.1 – 1.1.3**	
	b) Introduce students to different methods of research and design inspiration. Analyse given example mood board	b) Facilitate as students explore the research questions in activity's 1.4 and 1.5. *(Studying chapters 2 and 3 in the following lessons will aid students in answering these questions so it is important they explore and understand each question)*	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 activities for homework if not complete.	**Written Activity 1.1.4 - 1.1.5** **Student reflection**	

Learning Phases - Week 1: Period 2

Phase 1 of lesson (Connect) – Starter	Phase 2 of lesson (Activate)	Phase 3: (Engage and Demonstrate)	Phase 4: Plenary (Consolidate) Return to begging of next row	Assessment opportunity	Notes for Differentiation
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. Introduce all key words for the lesson. Discuss prior knowledge of space rovers and vehicle design specification. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	a) Teacher to explain the operation and functions of a space rover.	a) Students to contribute with any existing knowledge they have on space rovers.		**Oral Questioning**	
	b) Teacher to introduce pupils to vehicle chassis.	b) Facilitate and provide feedback as student's complete activity 2.1.1		**Written activity 2.1.1**	
	b) 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.	b) 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.		**Oral Questioning** **Written activity 2.1.2 - 2.1.6**	

		Students demonstrate learning by completing activities 2.1.2 - 2.1.6. Teacher to facilitate and provide feedback.			
	c) Teacher to explain the function of drivetrains and complete sample calculations	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. Students demonstrate learning by completing activity 2.1.7. Teacher to facilitate and provide feedback.		**Oral Questioning** **Written activity 2.1.7**	
	d) Teacher to introduce suspension types. Pose questions to students on any known suspension types. Use examples of everyday life such as Dune buggy's, 4x4 vehicles etc.	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 activity 2.1.8	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 activities for homework if not complete.	**Oral Questioning** **Written activity 2.1.8** **Student reflection**	

Learning Phases - Week 1: Period 3

Phase 1 of lesson (Connect) – Starter	Phase 2 of lesson (Activate)	Phase 3: (Engage and Demonstrate)	Phase 4: Plenary (Consolidate) Return to begging of next row	Assessment opportunity	Notes for Differentiation
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. Introduce all key words for the lesson. Discuss prior knowledge of vehicle design and how it may adapt to space vehicles. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	a) Teacher to introduce and explain different types of steering mechanisms.	a) Students to discuss advantages and disadvantages of each type. Students demonstrate learning by completing activity 2.2.1 - 2.2.3 Teacher to facilitate and provide feedback.		**Questioning** **Written activities 2.2.1 - 2.2.3**	
	b) Teacher to introduce the rocker-bogie suspension system. Clearly explain the different parts of the rocker bogie and question pupils on its suitability for space exploration.	b) Students to explore various 3D models of rocker bogie assemblies using the provided QR codes. Students demonstrate learning by completing activity 2.2.4 - 2.2.7 Teacher to facilitate and provide feedback.			
	c) Teacher to introduce activity 2.2.8	b) Students to demonstrate learning as they design and sketch their own rocker bogie in activity 2.2.8. Teacher to facilitate and provide constructive feedback to improve design.	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 activities		

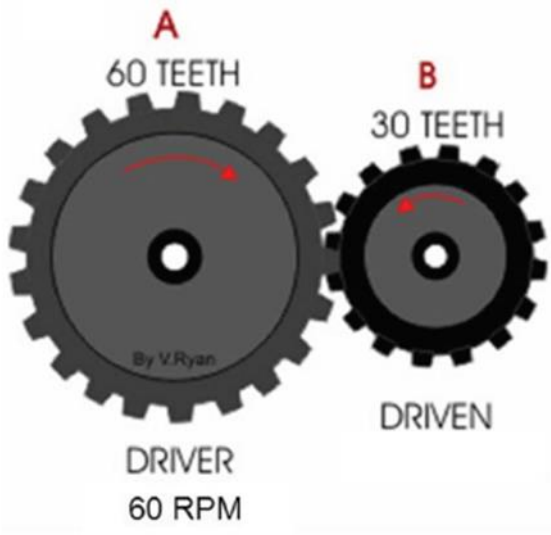
			for homework if not complete.		

Answer Key

QR code links:		
Page	***Topic***	***Link***
12	Introduction	https://www.youtube.com/watch?v=aVSZJDSRdOM&feature=youtu.be
32	Sketching	https://www.youtube.com/watch?v=OezMavBqWXc
59	DC motors	https://www.youtube.com/watch?v=LAtPHANEfQo
69	Shock absorber	https://www.youtube.com/watch?v=vcSH2z706rU

Note there is a typo on Pg. 65 in the example calculation.

The motor rpm is 300 rpm and should read: 300 rpm x 2 = 600rpm



VR = Driver/Driven
VR = 60/30
VR = 2
If this motor rotates at 300 rpm what speed will the wheel rotate at?
Motor rpm x VR = **Wheel rpm**
600 rpm x 2 = 600 rpm

Figure 2.1.20

Activity 1.1.1

Keyword	Meaning:
Fusion 360	A computer software for 3D modelling.
Arduino	An open-source electronics platform or board and the software used to program it.
Assemble	To join parts together to create a finished product.
Enclose	To insert or contain items inside an object
Bluetooth	Is a wireless technology standard for exchanging data over short distances from fixed and mobile devices
Innovative	Introducing new ideas; original and creative in thinking.

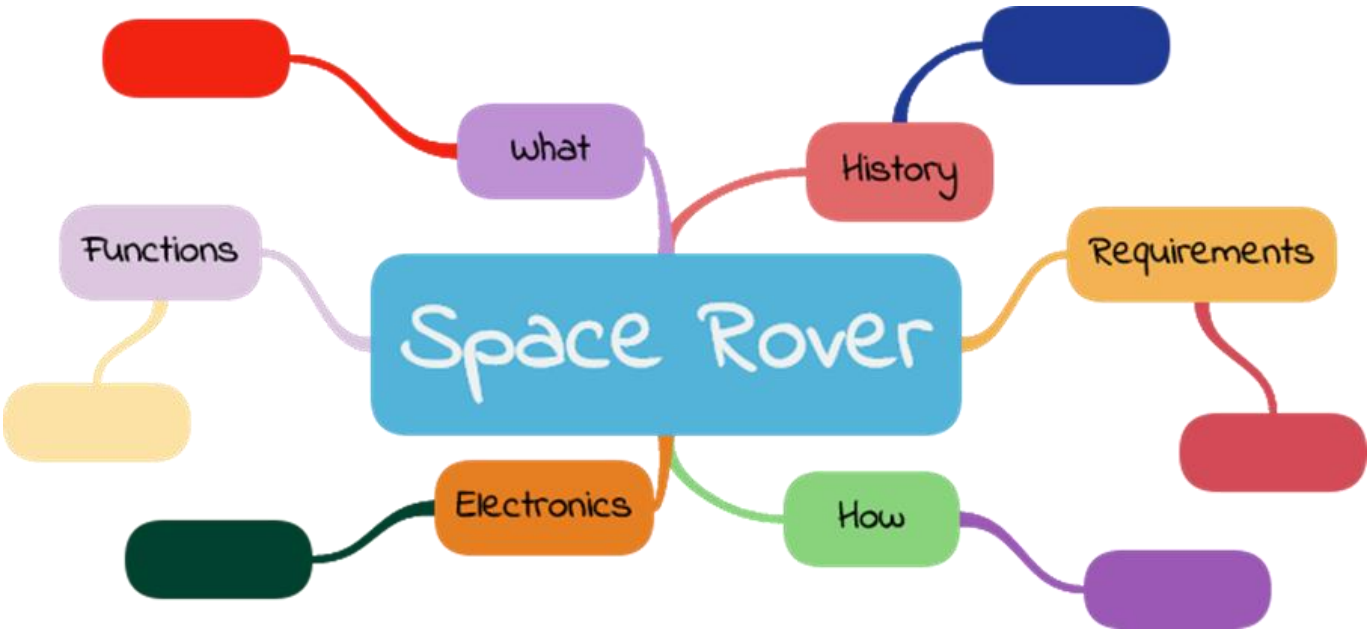
Activity 1.1.2

Key areas of brief:	Possible Questions	Explain the key areas in Military Tank brief
Aims and objectives	What is the overall aim? What steps will you take to meet this aim?	The overall aim is to design and manufacture a model of a military tank. The tank must be able to drive forward/ backwards and left/right. I must also be controlled through Bluetooth
		I will complete the military tank circuit and further my electronic and soldering skills
		I will improve my Arduino knowledge to control the tank.
		I will develop a 3D model on Fusion 360 and 3D print the model.
		I will assemble all parts
Budget and schedule	Do you have a budget? When must your project be completed?	The tank must be completed with the given materials.
		The tank must be completed by the last week of term 1
Target Audience	Who do you think might purchase this military vehicle?	Governments who visit The International Defence Exhibition & Conference, to buy military products.
Materials	What restrictions will you have to deal with when choosing materials for manufacture?	3D printers can print PLA or ABS
Style or theme	Is there a style or theme required for the military vehicle?	It must stick to a military theme and also consider camouflage.

Activity 1.1.3

In the space below, create your own Mind Map. Add key information you have taken from activity 1.1.2.

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 3: Research and investigation of possible solutions

What should my students include in this section?
Students should clearly show the investigation that has been completed. The investigation should display your understanding of the brief. Students can use images, notes, and sketches. They should avoid having just a collection of information gathered. There is little value in reproducing material gathered from the internet, magazines, books, etc. Students should research and analyse all aspects of space rovers

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. Activity 1.1.4 and 1.1.5 show suitable research questions.

Activity 1.1.4

You should present these questions to students before moving on to Chapter 2 which will help students research and answer these questions.

Design research

Answer the questions below to help you carry out design research:

1) Will the colour of your design affect the finished product? How?

Some colours will retain or reflect heat, Bright colours may attract attention to interest buyers,

(any relevant point to justify colour selection.)

2)What mechanisms must my design include?

The space rover must include a rocker bogie suspension system.

3)What type of steering mechanisms are suitable for a space rover?

The steering should operate using a skid steer mechanism.

4) What materials are suitable for 3D printing?

PLA and ABS. Aluminium can now be 3D printed with advancing printing methods.

5)What is the maximum 3D printing area of the 3D printer in your classroom?

140mm x 140mm

6)What are the dimensions of the 12v DC motors supplied for this project? How will this affect design?

Activity 1.1.5

You should present these questions to students before moving on to Chapter 3 which will help students research and answer these questions.

Space rover control circuit research

Answer the questions below to help you carry out research on the space rover circuit:

1) What control boards can be used to control the circuit?

Arduino, raspberry pi.

2) How can the control board be controlled wirelessly?

Bluetooth, WIFI, infrared.

3) What voltage is needed to drive the circuit?

9-12V.

4)What type of power supply is needed to adequately power the space rover?

A battery bank of AA batteries will provide greater capacity at 9/12V

5) What other components are needed to complete the wireless control circuit?

DC motors, Bluetooth module, motor driver, toggle switch, Power supply, Arduino Leonardo, Jumper wires.

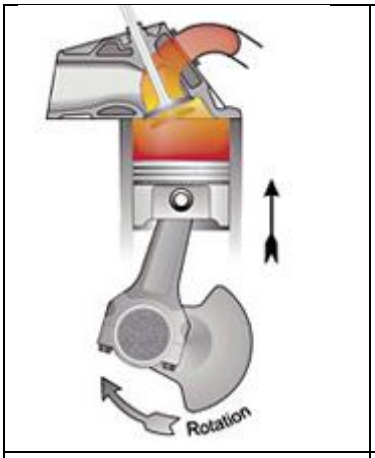
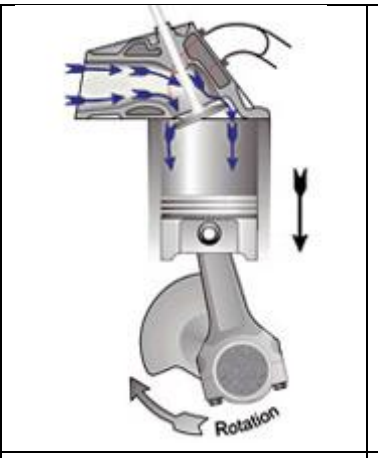
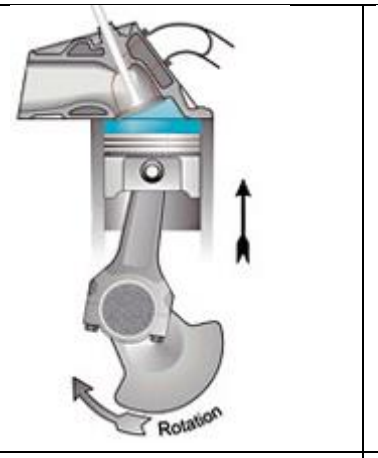
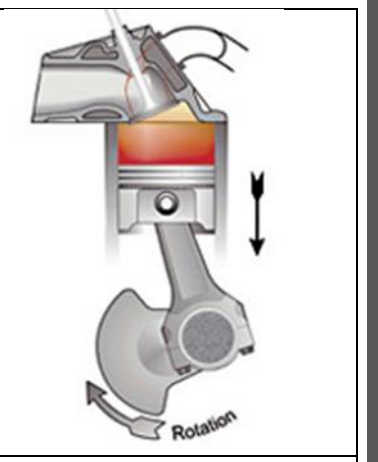
Activity 2.1.1

The image below shows a body on frame chassis vs a unibody chassis. List the advantages and disadvantages of each type in the space below.

Body on frame	**Unibody**
Advantages	***Advantages***
High load capacity	*Lightweight*
Easy to design	*More comfortable / less rattles*
Easy to manufacture	*Better performance / handling*
Strong and safe	*Better economy*
Easy to repair	
Disadvantages	***Disadvantages***
Heavy	*Not as strong*
Lower performance	*Lower load capacity*
Lower Economy	*More easily damaged*
	Difficult to repair

Activity 2.1.2

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

			
Exhaust stroke	Intake stroke	Compression stroke	Power stroke

Activity 2.2.3

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 2.1.4

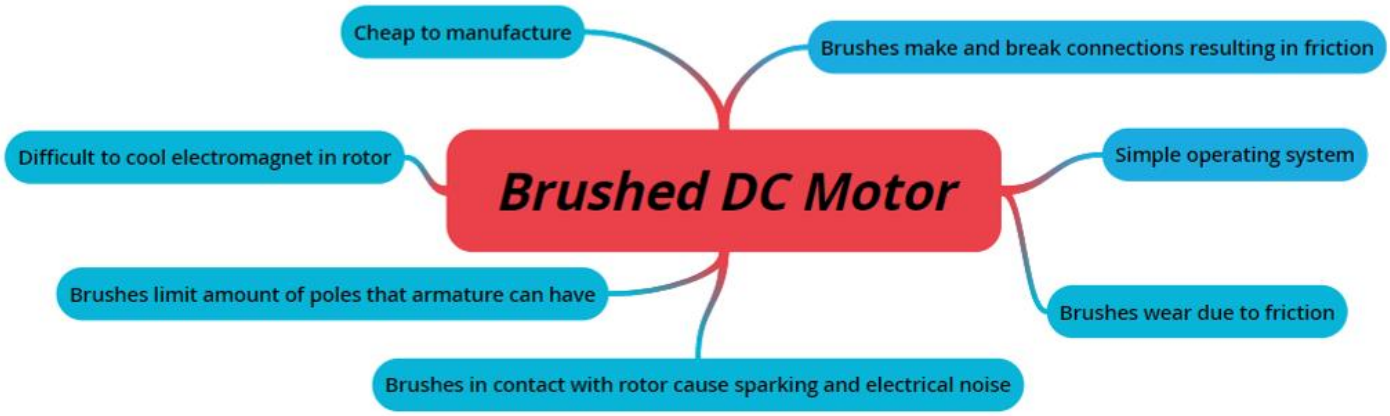


Figure 2.1.11 shows the key features of a brushed DC motor. In the box below, place these features under advantages or disadvantages of a brushed DC motor.

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 2.1.5

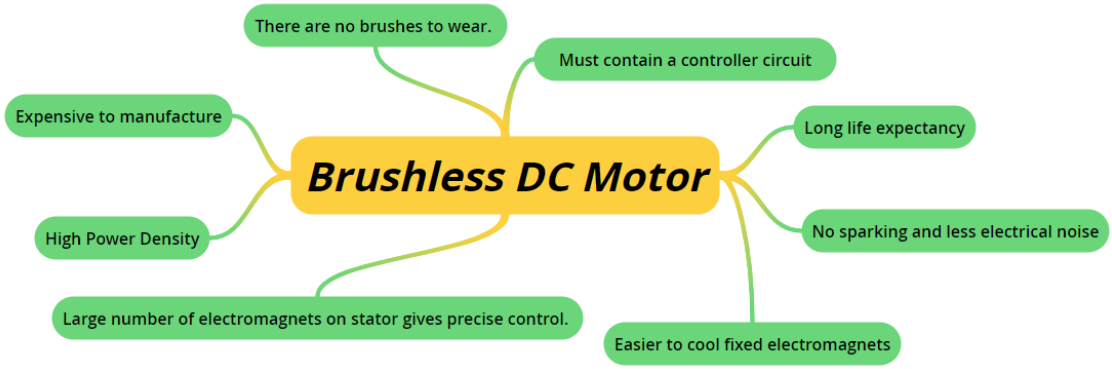


Figure 2.1.12 shows the key features of a brushless DC motor. In the box below, place these features under advantages or disadvantages of a brushed DC motor.

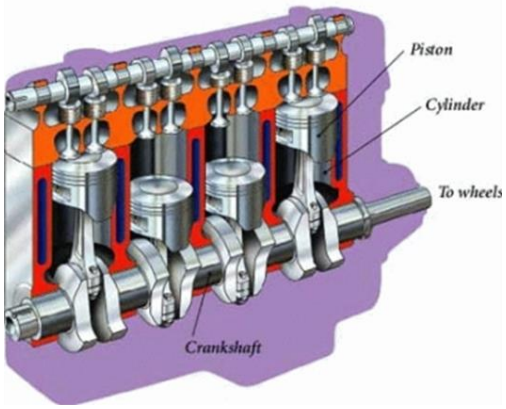
Advantages:	***Disadvantages:***
There are no brushes to wear	Expensive to manufacture
High power density	Must contain a controller circuit

Large number of electromagnets on stator gives precise control	
Easier to cool fixed electromagnets	
No sparking and less electrical noise	
Long life expectancy	

Activity 2.1.6

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

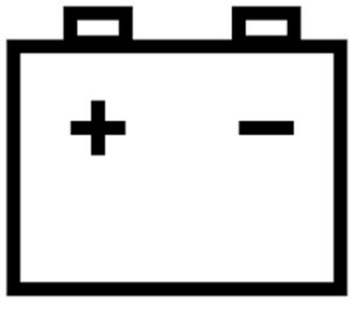
Petrol



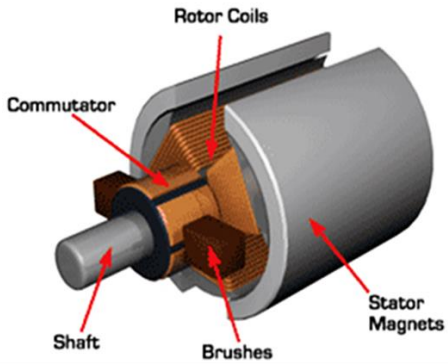
Internal combustion engine

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

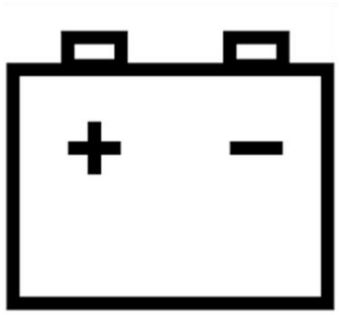


Brushed DC Motor

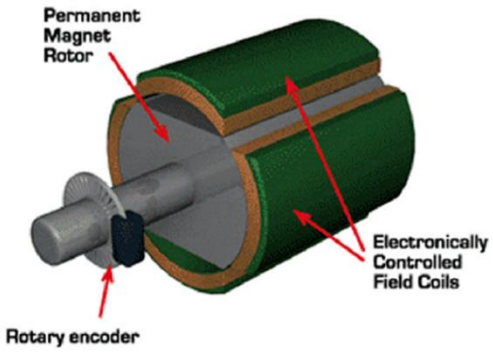
Advantage:
Batteries can be recharged with renewable sources.
Brushed DC motors are cheap to manufacture.
Less impact on the environment than fossil fuel combustion engines.

Disadvantage:

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



Battery

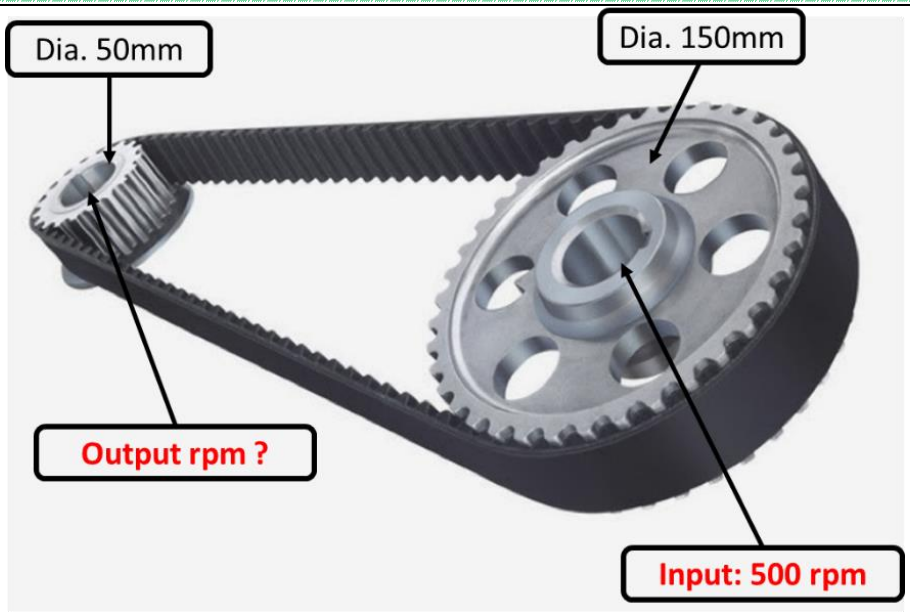


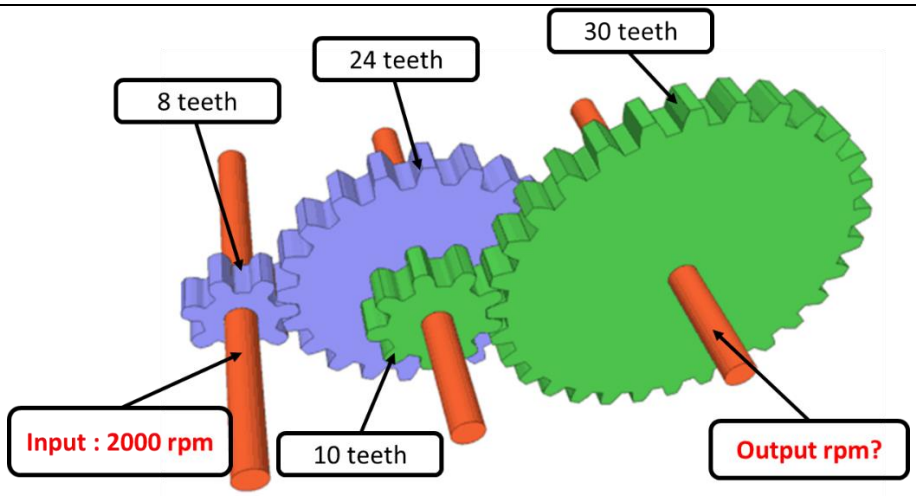
Brushless DC Motor

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 2.1.7

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 2.1.8

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.

Activity 2.2.1

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 2.2.2

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 2.2.3

List two vehicles that use the steering mechanisms below.

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

Activity 2.2.4

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 2.2.5

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 2.2.6

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 2.2.7

State one advantage and one disadvantage of using a differential bar 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 2.2.8

Based on your knowledge of the rocker-bogie suspension system, you must sketch a design for a rocker-bogie mechanism. Clearly show using detailed sketches of how you will stabilise the chassis. Based on the supplied wheels of 65mm diameter create the sketch to a suitable scale and include overall dimensions.

(Note: You can turn the page to landscape or use extra paper for more room)

-Sketches should be in pencil.

-Use colour and shading.

-Label all parts.

-Sketches should be to a suitable scale.

Week 2 Lesson Plan:

<table>
<tr><td rowspan="2">Content</td><td colspan="2">Grade 12 Advance</td></tr>
<tr><td>Chapter 3: Electronics for the mission to Mars</td><td>Section 1: Electric vehicle components</td></tr>
<tr><td>Time allocated
  </td><td colspan="2">3 x 45-minute periods</td></tr>
<tr><td rowspan="2">Keywords
  </td><td colspan="2">What are the keywords the students must learn?</td></tr>
<tr><td colspan="2">• torque
• Mains electricity (wall power)
• Ripple voltage
• microcontroller
• Arduino board
• pins
• power supply
• GND
• IDE
• (Integrated
• Development
• Environment)
• sketch
• serial monitor
• variables</td></tr>
<tr><td>Resources
  </td><td colspan="2">What resources are required?
• textbooks
• projector
• sketching equipment</td></tr>
<tr><td>Prior Knowledge
  </td><td colspan="2">• Understand the function of DC motors.
• Introduction to Arduino.
• Use breadboards for building electronic circuits.</td></tr>
</table>

Aim:

In this lesson, students will develop a full understanding of the basic electronic components that are needed for creating an electric vehicle. Students will learn about the different types of components and their functions. Upon completion of the section, students should be able to fully understand the functions of an electric vehicle's components. Students will then research further how these can be applied to create a circuit capable of controlling a wireless 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 they have covered a learning objective.

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.

Teacher should: *(tick as you complete)*	***Students should:*** *(tick as students complete)*
☐ Introduce motor types	☐ Differentiate between motor types.
☐ Explain the function of a motor driver	☐ Identify the function of a motor driver.
☐ Introduce and explain different switch types	☐ Compare between different switch types.
☐ Explain the functions of ICS, microprocessors and microcontrollers	☐ Identify and compare integrated circuits, microprocessors and microcontrollers.
☐ Introduce various methods of wireless control	☐ Identify methods of wireless control.
☐ Facilitate as students categorise electrical components	☐ Catagorise inputs, controllers and outputs of an electrical circuit.
☐ Facilitate as students design and build a circuit to drive DC motors	☐ Design a circuit to drive DC motors from a Bluetooth device.
	☐ Build and test a circuit to drive DC motors from a Bluetooth device.
☐ Remind students of the relevant research questions to be answered from Chapter 3	☐ **Carry out and present research and investigation**

Possible teaching method(s) or approach for this lesson

(teacher to tick the relevant method)

- ☐ 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	
Chapter	**Section**	**Focus**	**Essential**	**Non-essential/Self Study**
3	**1**	Electric vehicle components	Pg.89 - 136	

Learning Phases - Week 2: Period 1,2 and 3.

Phase 1 of lesson (Connect) – Starter	Phase 2 of lesson (Activate)	Phase 3: (Engage and Demonstrate)	Phase 4: Plenary (Consolidate) Return to begging of next row	Assessment opportunity	Notes for Differentiation
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. Introduce all key words for the lesson. Discuss prior knowledge of the electric vehicle components **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	a) Teacher to introduce and explain DC motor types Teacher to ensure student understanding of torque by relating to real life examples.	a) Students to explore QR codes. Facilitate and provide feedback as student's complete activity 3.1.1		**Oral Questioning** **Written Activity 3.1.1**	
	b) Teacher to explain the operation of a power supply	b) Students to contribute any knowledge they may have on parts of a power supply such as a transformer or rectifier from previous exposure to electronics.			
	c) Teacher to introduce power banks as portable power supplies. Clearly explain the difference in connecting battery's in parallel and series.	c) students to demonstrate understanding of connecting battery's in parallel and series. ***Using practical tasks such as connecting cells and measuring voltage with a multimeter is a suitable activity*** Facilitate and provide feedback as student's		**Written Activity 3.1.2 - 3.1.3**	

		complete activity 3.1.2 – 3.1.3			
	d)Introduce and distribute the parts needed for DC motor practical work.	d)Facilitate as students explore the effect of polarity on motor direction and complete activity 3.1.4 and 3.1.5		**Activity 3.1.4 - 3.1.5**	
	e) Teacher to introduce and explain electric components needed to complete the circuit. Switches, LEDs and Buzzers.	e) Facilitate and provide feedback as student's complete activity 3.1.6 - 3.1.8		**Activity 3.1.6 - 3.1.8**	
	f) Introduce the problem to be solved in activity 3.1.9.	f) Divide students into groups. Student groups to demonstrate understanding of electronic components by designing and building the required circuit		**Activity 3.1.9**	
	g) Introduce and explain different electronic controllers.	g) Students to Explore different types of controllers and development boards		**Oral Questioning**	
	h) Explain the function of motor drivers. Demonstrate connecting a L298N motor driver to the Arduino and DC motors	h) Facilitate and provide feedback as students complete the circuit diagram in activity 3.1.10		**Activity 3.1.10**	
	i) Explain the Arduino code to control DC motor rotation and direction.	i) Facilitate and provide feedback as student's program and test the circuit in activities 3.1.11 - 3.1.14		**Activity 3.1.11 – 3.1.14**	

	j) Introduce Bluetooth as a method of wireless control for Arduino. Demonstrate how to connect the Arduino and Bluetooth module correctly	j) Facilitate and provide feedback as student's complete activities 3.1.15 - 3.1.16		**Activity 3.1.15 - 3.1.16**	
	k) Introduce switch statements and the Bluetooth RC controller application.	Students to demonstrate understanding by completing activity 3.1.17 and activity 3.1.18. Teacher to facilitate and provide feedback to fine tune circuits and program to ensure DC motor control from the Bluetooth app.		**Activity 3.1.17 - 3.1.18**	
			Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Relate questions to research questions in chapter 1 Have learning outcomes been met? Has the lesson aim been achieved? Students should return to Chapter one and add to their research based on the knowledge gained from the lesson.		

Answer Key

QR code links:		
Page	***Topic***	***Link***
92	Tesla drag race	https://www.youtube.com/watch?v=Jv6FvfKm9FI
113	Motor Driver	https://www.youtube.com/watch?v=dyZolgNOomk
131	RC App	https://play.google.com/store/apps/details?id=braulio.calle.bluetoothRCcontroller&hl=en

Activity 3.1.1

Is torque important in the design of a space rover? Based on this, what type of motor do you think is suitable for a space rover?

Yes, torque is important to ensure the space rover has the power to climb steep hills and uneven terrain. For this reason, a DC motor with high torque and lower speed would be suitable. The motor shown in figure 3.1.5 would be a suitable choice.

Activity 3.1.2

6 AA batteries are shown below. They have a capacity of 2000mAh. Draw positive and negative wires to arrange them in a series. What are the output voltage and total capacity?

Output voltage:_____9v_____

Total capacity:_____2000mAh_____

Figure 3. 1. 1

Now draw positive and negative wires to arrange them in parallel. What are the output voltage and total capacity?

Output voltage:___1.5V___

Total capacity:_12000mAh_____

Figure 3. 1. 2

Activity 3.1.3

Shown below are two 9v power supplies. A 9v ppv battery and a 9v power bank made from AA batteries. Which do you think would be most suitable for driving a DC motor in a project and why?

A power bank of AA batteries would be more suitable as it has a higher capacity. Storing more amps would mean it would power the motors for longer.

Activity 3.1.4

- Follow the below steps to check the polarity of a DC motor and draw the correct direction for the DC motor in Figure 3.1.20.

1. Attach a red wire to the positive terminal of the battery. 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 from the 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 3.1.20.

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

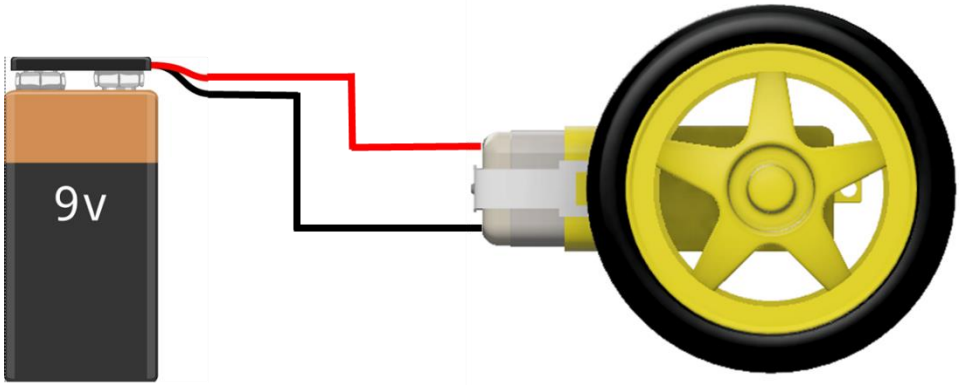


Figure 3. 1. 3

Direction of wheel rotation = Note direction when looking at the front of the motor/wheel

Activity 3.1.5

- Using direction to determine motor polarity:

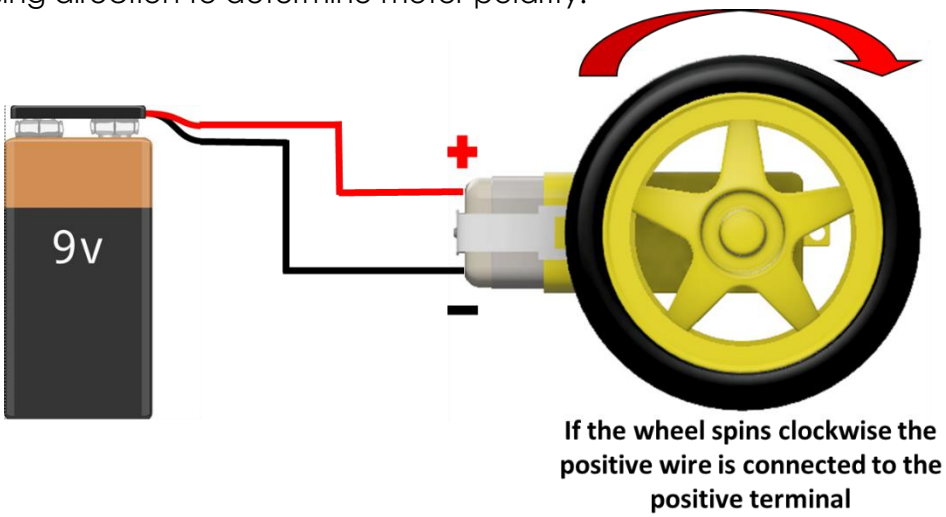


Figure 3. 1. 4

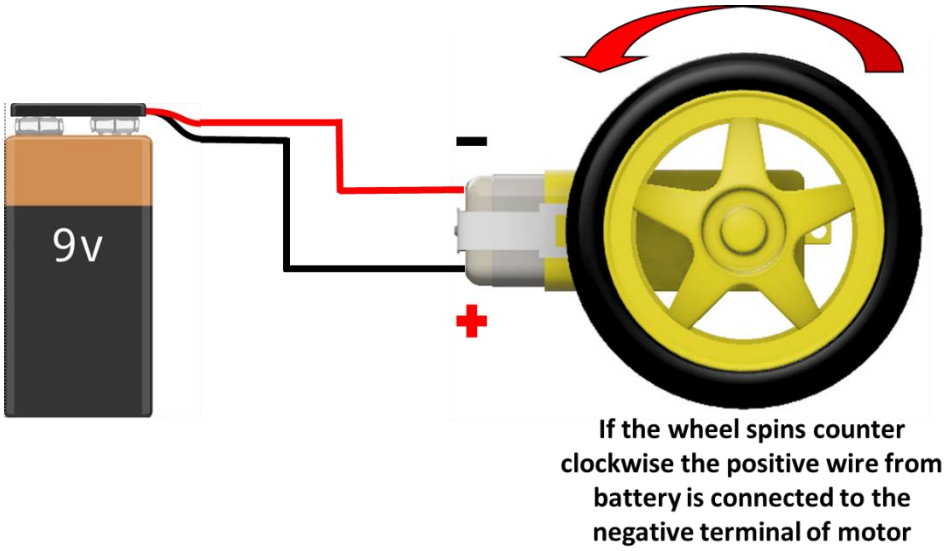


Figure 3. 1. 5

Look at images Figure 3.1.21 and Figure 3.1.21. Which image matches your circuit. If the wheel rotated clockwise, you should label the pins positive and negative as shown in Figure 3.1.21.

If your wheel rotated counterclockwise, you had the positive from the battery connected to the negative terminal. Label the positive and negative pins as shown in Figure 3.1.22.

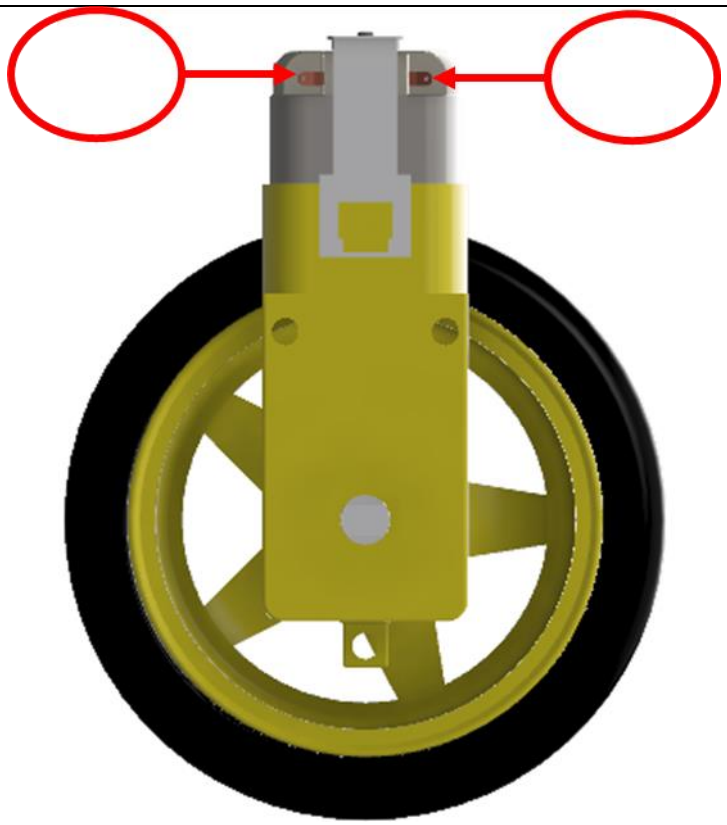


Figure 3. 1. 6

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

Note there is no right or wrong answer. The polarity can be different on various motors which is why this activity is important to get the correct direction and polarity.

Activity 3.1.6

How is light produced in an LED bulb?

Light is produced by the movement of electrons in a semiconductor material.

Activity 3.1.7

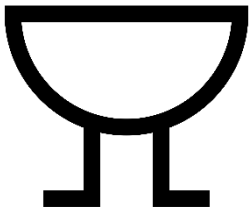
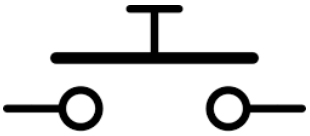
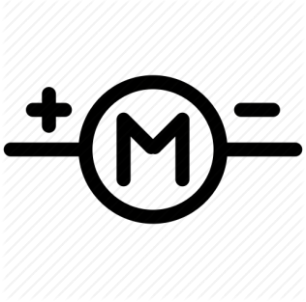
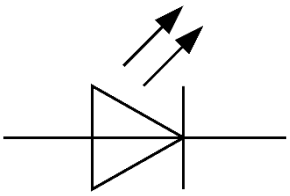
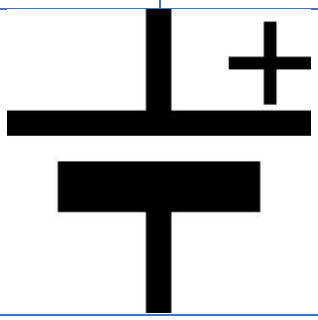
Dubai glow gardens contain thousands of LED lights to create unique displays. Why do you think LEDs were used? In the boxes below state at least three advantages and disadvantages of LEDs.

Figure 3. 1. 7

Advantages:	**Disadvantages:**
Have a long lifespan	*Can be more expensive*
White light	*Voltage sensitive*
Many colours available	*LEDs are polarised*
Can be cycled without damage	*Not suitable where heat is needed from light*
Low power consumption	
Can be very small	
Little heat produced.	

Activity 3.1.8

Label the electric component symbols shown below:

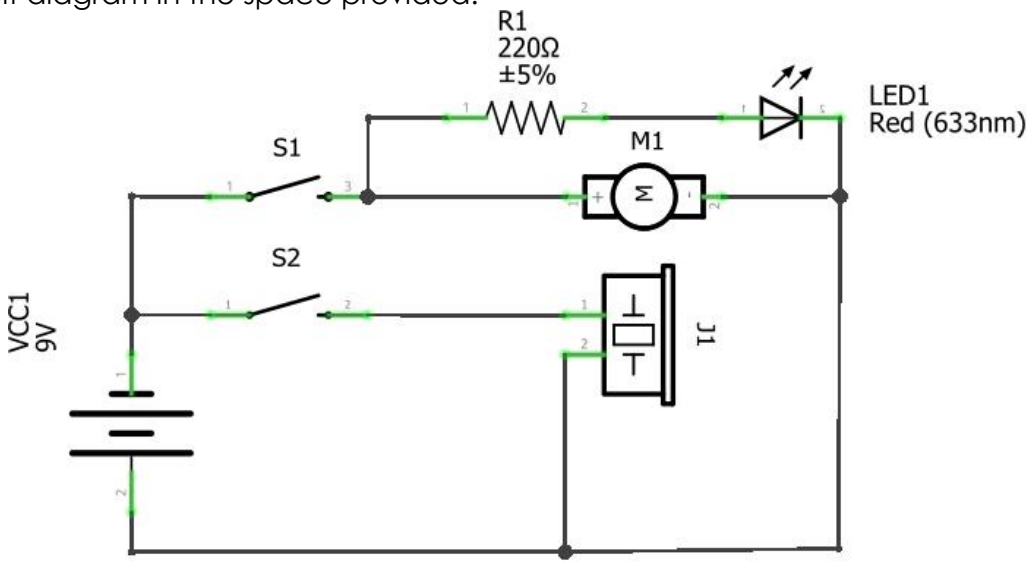
			
Toggle Switch	Buzzer	Push to make switch	Motor
			
LED	Battery / Cell		

Activity 3.1.9

Based on your study of electronics so far, create a simple circuit below to satisfy the following:

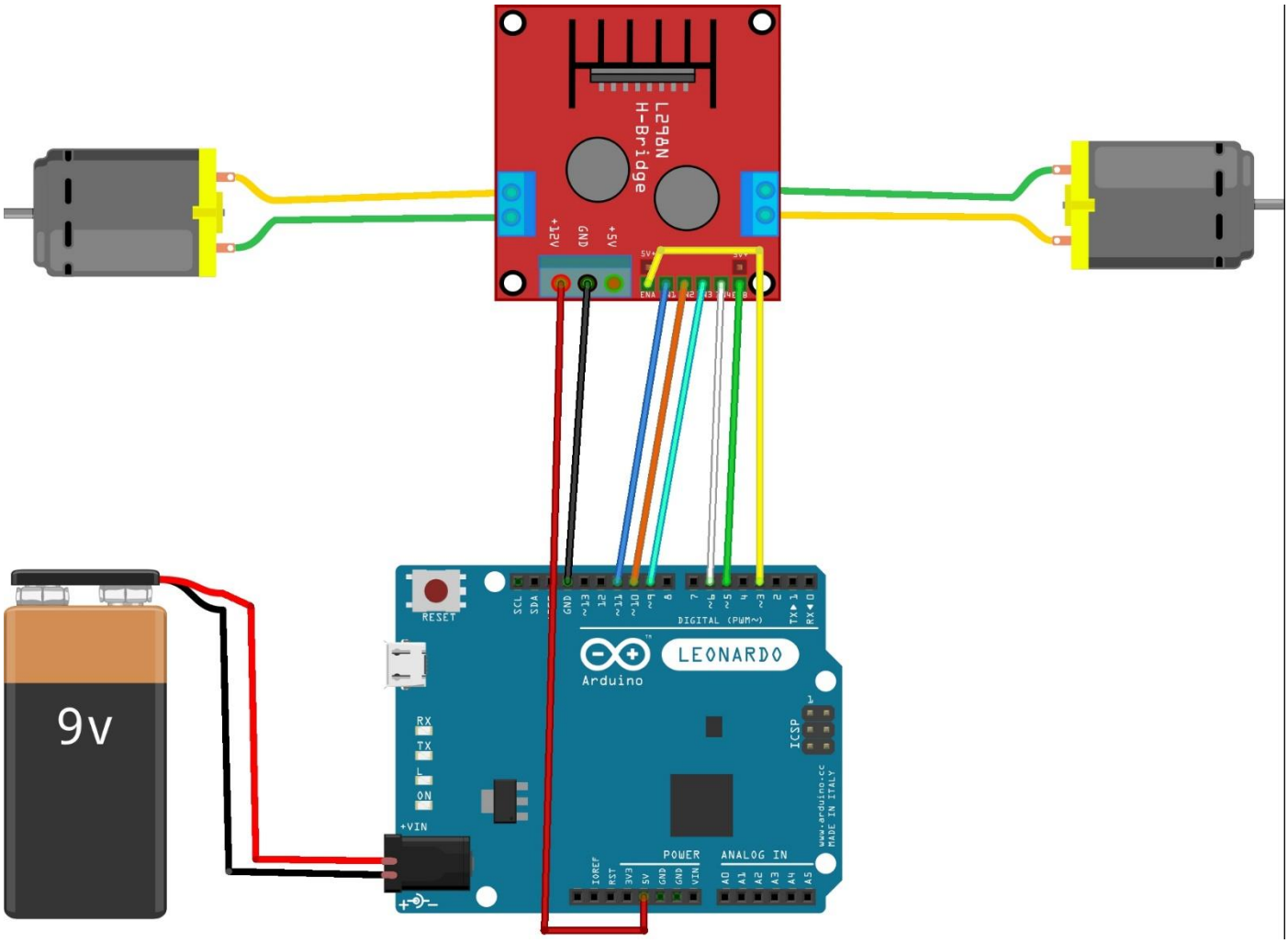
-Powered by a 9V battery
-Turn a motor on and off using a simple push or toggle switch
-Light an LED while the motor is turning
-Sound a buzzer when a separate push button is pressed (to replicate a vehicle horn)

1)Draw a circuit diagram in the space provided.



Activity 3.1.10

Complete the circuit below to show how two DC motors can be controlled by Arduino using an L298N motor driver.



Activity 3.1.11

- Analyse the code in **Error! Reference source not found.** and document what you have noticed about the direction of the DC motors.
  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 wires entering pins 1 and 2 for Motor A or 13 and 14 for Motor B.

The motor rotates in a clockwise direction.

Activity 3.1.12

- Modify the code in Figure 3.1.47 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);

}
```

Activity 3.1.13

- Modify the code in **Error! Reference source not found.** to control the DC motors to turn left.
  Hint: Recap on skid steer 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);

}
```

Activity 3.1.14

- Get creative
  - You have learned how to program Arduino to turn the DC motors left and right.

  - Taking into consideration the design space rover, edit the code in Figure 3.1.48 to allow the motors to make a sharp turn, either to the left or right.

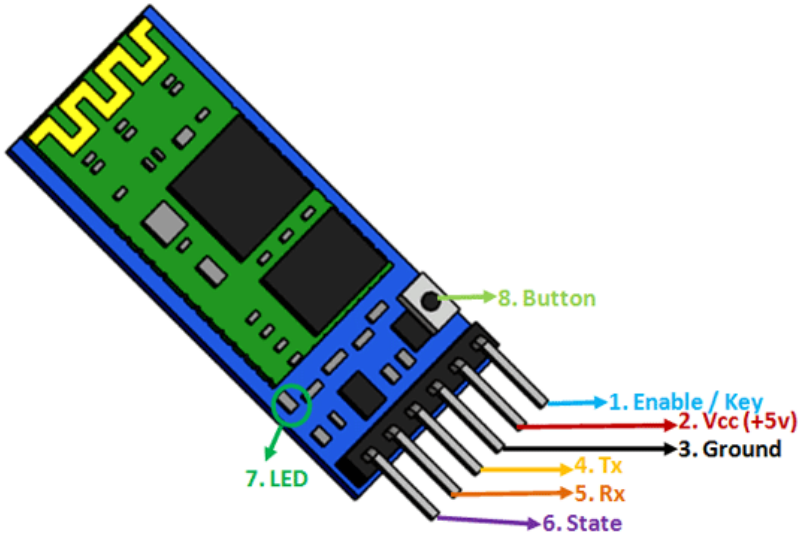
    Hint: Recap on skid steer section studied in Chapter 2 to understand motor directions for different turns.

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);

}
```

Activity 3.1.15

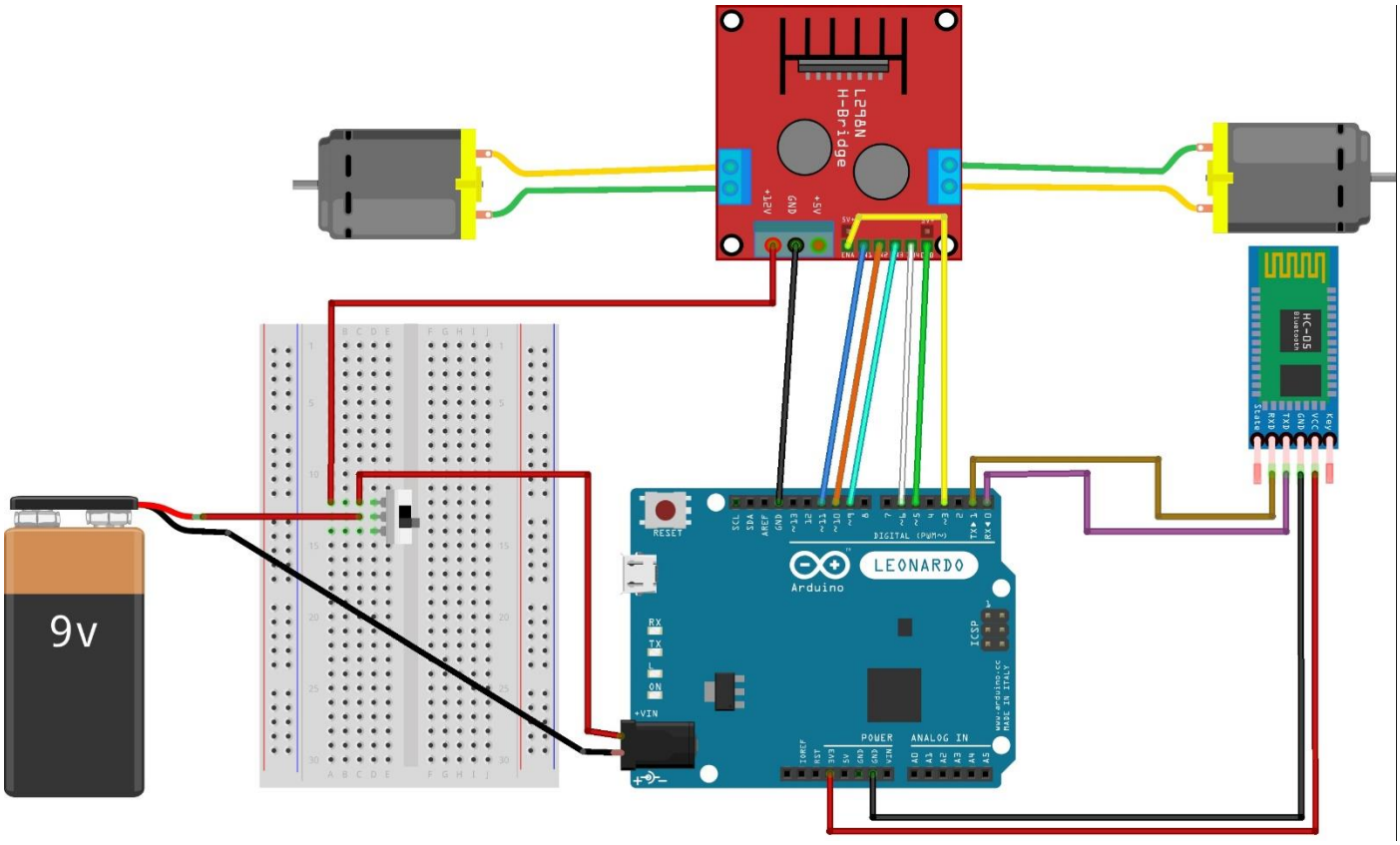
Match the correct Arduino pins to the Bluetooth module pins



Arduino pins		Bluetooth pins
RX (Pin 0)	→	Tx
TX (Pin1)	→	Rx
3.3V	→	Vcc
GND	→	Ground

Activity 3.1.16

You must create a circuit to drive two DC motors through Bluetooth using Arduino and a motor driver. Your circuit must also include a switch to isolate power to the motor driver and Arduino.



Activity 3.1.17

- Why do you need a switch case statement to write the code controlling DC motors using Bluetooth?

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 the uses of variables and cases.

Activity 3.1.18

- The switch case statements needed for your circuit are shown below. Fill in the blanks with the correct code for each statement. Refer to Table 3.1.4**Error! Reference source not found.** and Table 3.1.5 for the correct pin connections.

```
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);

}

//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 Table 3.17 and Table 3.18 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

```
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);



}
```

Week 3 Lesson Plan:

<table>
<tr><td rowspan="3">Content</td><td colspan="2">Grade 12 Advance</td></tr>
<tr><td>Chapter 3 - Electronics for the mission to Mars</td><td>Section 2 - Electric vehicle design</td></tr>
<tr><td>Chapter 1 - Engineering Design</td><td>Section 1 - The design process: Design of a space rover
-Stage 4: Possible solutions
-Stage 5: Final design solution</td></tr>
<tr><td>Time allocated</td><td colspan="2">3 x 45-minute periods</td></tr>
<tr><td rowspan="2">Keywords</td><td colspan="2">What are the keywords the students must learn?</td></tr>
<tr><td colspan="2">• Aspect</td></tr>
<tr><td>Resources</td><td colspan="2">What resources are required?
• textbooks
• projector
• sketching equipment</td></tr>
<tr><td>Prior Knowledge</td><td colspan="2">• Understanding the function of DC motors
• Can use Arduino boards in electronic projects
• Using breadboards for building electronic circuits
• Controlling DC motors through Bluetooth
• Operation of LED bulbs
• Operation of buzzers
• Sketching</td></tr>
</table>

Aim:

In this lesson, students will electronic components and how inputs, controllers and outputs are used to create a functioning circuit. In this case, the circuits function is to solve the design brief. Upon completion of this section, students will have designed, built and tested a circuit to satisfy the design brief. Students will then return to Chapter one to continue the design process. All research should be presented using a mood board. Students will then sketch possible solutions. You will provide feedback to the students before they create an improved final solution.

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 they have covered a learning objective.

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.

Teacher should: *(tick as you complete)*	***Students should:*** *(tick as students complete)*
☐ Recap on the brief and aid students identify key points to be met.	☐ Complete a circuit diagram to solve the design brief.
☐ Facilitate as students complete and test the circuit	☐ Identify all components needed to complete the circuit.
	☐ Build the circuit.
	☐ Modify and create a new Arduino code to programme the circuit.
	☐ Complete a circuit diagram to solve the design brief.
☐ Introduce the isometric crating method for design 1	☐ **Create neat possible solution sketches.**
☐ Facilitate and give feedback as student's complete designs.	☐ **Create an improved final solution design.**

Possible teaching method(s) or approach for this lesson

(teacher to tick the relevant method)

- ☐ 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	
Chapter	**Section**	**Focus**	**Essential**	**Non-essential/Self Study**
3	**2**	Final Circuit	Pg. 137 - 142	
1	**1**	Stage 4 – Possible solutions	Pg. 33-39	
1	**1**	Stage 5 – Final design solution	Pg. 41-42	

Learning Phases - Week 3: Period 1 (Ch. 2: Section 2)

Phase 1 of lesson (Connect) – Starter	Phase 2 of lesson (Activate)	Phase 3: (Engage and Demonstrate)	Phase 4: Plenary (Consolidate) Return to begging of next row	Assessment opportunity	Notes for Differentiation
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. Introduce all key words for the lesson. Discuss prior knowledge of the electric circuit from chapter 3, section 1. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	a) Teacher to recap on the brief.	a) Students to identify key areas to be solved. Teacher to facilitate as student's complete activity 3.2.1		**Oral Questioning** **Written Activity 3.2.1**	
	b) Teacher to introduce activity 3.2.2 "the final circuit diagram"	b) Students to complete and test the final circuit by completing activities 3.2.2 – 3.2.4		**Written Activity 3.2.2 -3.2.4**	
		c) Facilitate and provide feedback as student's complete activity 3.2.2-3.2.4	Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Relate questions to research questions in chapter 1 Have learning outcomes been met? Has the lesson aim been achieved?.	**Visual inspection of working circuit.** **Student evaluation**	

Learning Phases - Week 3: Period 2 + 3 (Ch. 1: Section 1)

Phase 1 of lesson (Connect) – Starter	Phase 2 of lesson (Activate)	Phase 3: (Engage and Demonstrate)	Phase 4: Plenary (Consolidate) Return to begging of next row	Assessment opportunity	Notes for Differentiation
Teacher to recap on aim of chapter one. Recap on stage 3 (research) Discuss how chapters 2 and 3 have influenced research. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	a) Teacher to recap on activities 1.1.4 – 1.1.6	a) Students to complete all research questions and develop a research page / mood board to display all ideas. Facilitate and provide feedback as student's complete activity 1.1.4-1.1.6		**Oral Questioning** **Written Activity 1.1.4 -1.1.6**	
	b) Teacher to introduce stage 4 – possible designs. Demonstrate isometric crating techniques.	b) Facilitate and provide feedback as student's complete activity 1.1.7 – 1.1.8		**Sketching Activity 1.1.7 - 1.1.8**	
	c) Teacher to introduce stage 5 – Final design solution	c) Facilitate and provide feedback as student's complete activity 1.1.9	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? ***Students should be encouraged to continue and improve designs in their own time***	**Visual inspection finished sketches**	

Answer Key

QR code links:		
Page	***Topic***	***Link***
32	sketching	*https://www.youtube.com/watch?v=OezMavBqWXc*

Activity 3.2.1

Design Brief: Mars Rover

Introduction:

As Creative Design and Innovation students of the UAE, you are expected to contribute to future projects of the UAE. One major ongoing project that is constantly progressing is the Emirates Mars mission. You are expected to design a space rover based around the Emirates Mars mission theme. The space rover must contain a rocker-bogie mechanism that is capable of conquering difficult terrain. It must also be able to climb at least the height of its own wheel diameter. You must use Fusion 360 to model and 3D print the space rover. The space rover must be controlled wirelessly using Arduino to allow exploration of Mars without risk to astronauts. The design should showcase an understanding of vehicle design and wireless control. The design should also utilise design and sketching skills gained in previous CDI terms.

Design a model space rover to the specifications outlined below:

Your design should be unique, innovative and should:

- contain an electronic circuit to drive forwards and backwards.
- turn left and right.
- use a maximum of 12v 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 functional front and rear lights that can be controlled through Bluetooth.
- be capable of sounding a warning noise remotely.
- be 3D printed and fully assembled with an electronic circuit.
- enclose all electronic components.

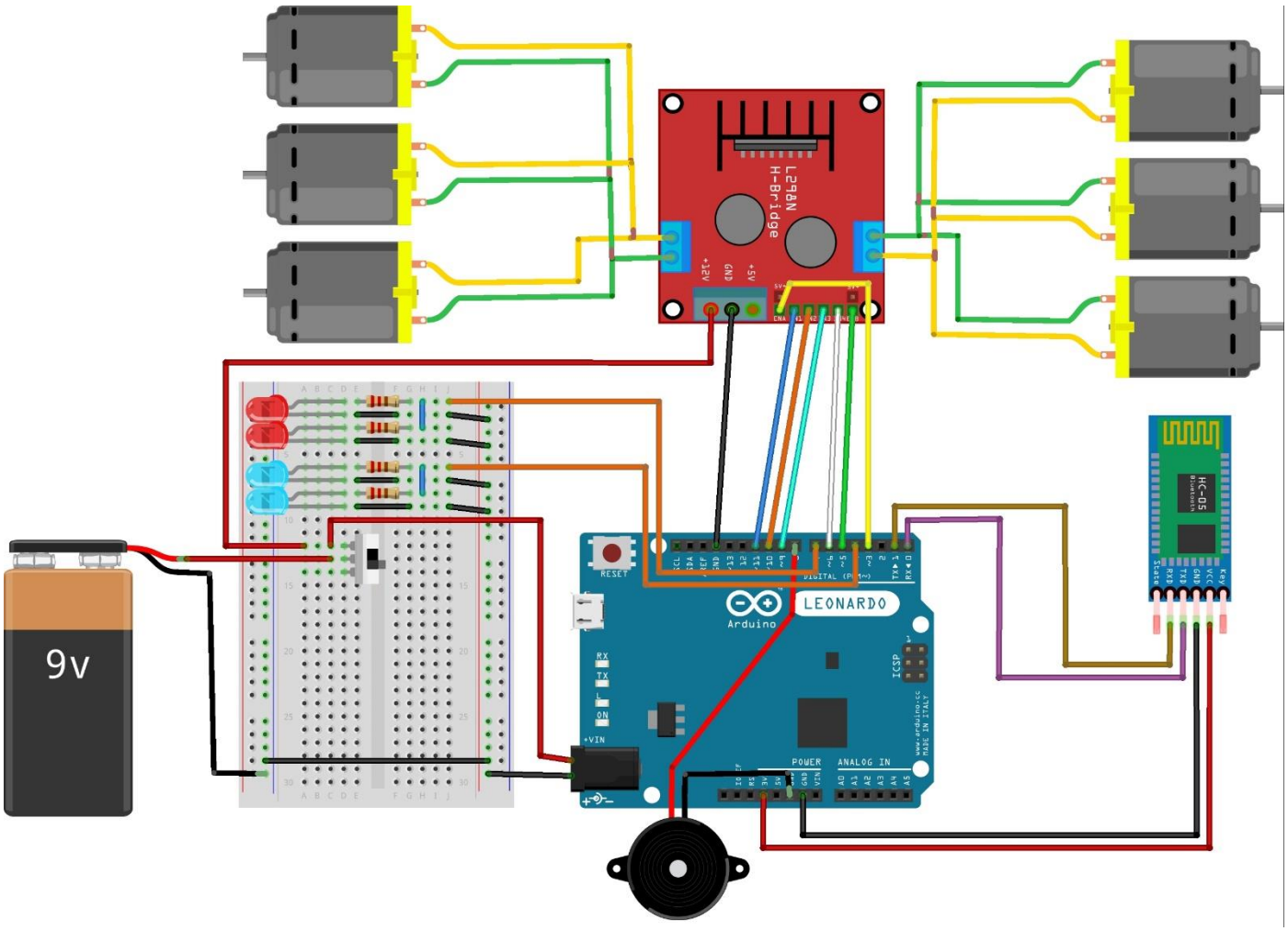
In the space below, list required functions of the space rover circuit:

All electronic functions identified in red

Activity 3.2.2

In the space below you must design a circuit to satisfy the brief. Refer to activity 3.2.1 and make sure all key points are satisfied.

The Arduino board, breadboard, Bluetooth module and motor driver are shown. All other components and wires must be neatly sketched. Use rulers and colours to represent wires.



Activity 3.2.3

Now that you have designed a circuit to fully satisfy the brief you must build and test the circuit using all the required components and a breadboard.

Paste a picture of your completed circuit below.

Paste a picture of fully assembled circuit on breadboard

Activity 3.2.4

Test your circuit and modify the Arduino code as needed to satisfy the brief. Paste your final Arduino code below.

```
//speed of motors between 0 and 255, if you like you can change it
int pwm_speedA = 255;
int pwm_speedB = 255;
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':
LEDfronton();
break;
case 'w':
LEDfrontoff();
break;
case 'V':
hornon();
break;
case 'v':
hornoff();
break;
case 'U':
LEDbackon();
break;
case 'u':
LEDbackoff();
break;
case 'X':
Hazardon();
break;
```

```
case 'x':
Hazardoff();
break;
}
}

}

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

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

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

//function for reversing
void backward(){
digitalWrite(11, LOW);
digitalWrite(10, HIGH);

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

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

//function for turning left
void left(){
```

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


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

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

}

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

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

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

void LEDfronton(){
digitalWrite(4, HIGH);

}
void LEDfrontoff(){
digitalWrite(4, LOW);


}
void LEDbackon(){
```

```
digitalWrite(7, HIGH);

}
void LEDbackoff(){
digitalWrite(7, LOW);

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

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

}
void Hazardon(){
digitalWrite(7, HIGH);
digitalWrite(4, HIGH);

}
void Hazardoff(){
digitalWrite(7, LOW);
digitalWrite(4, 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);
}
```

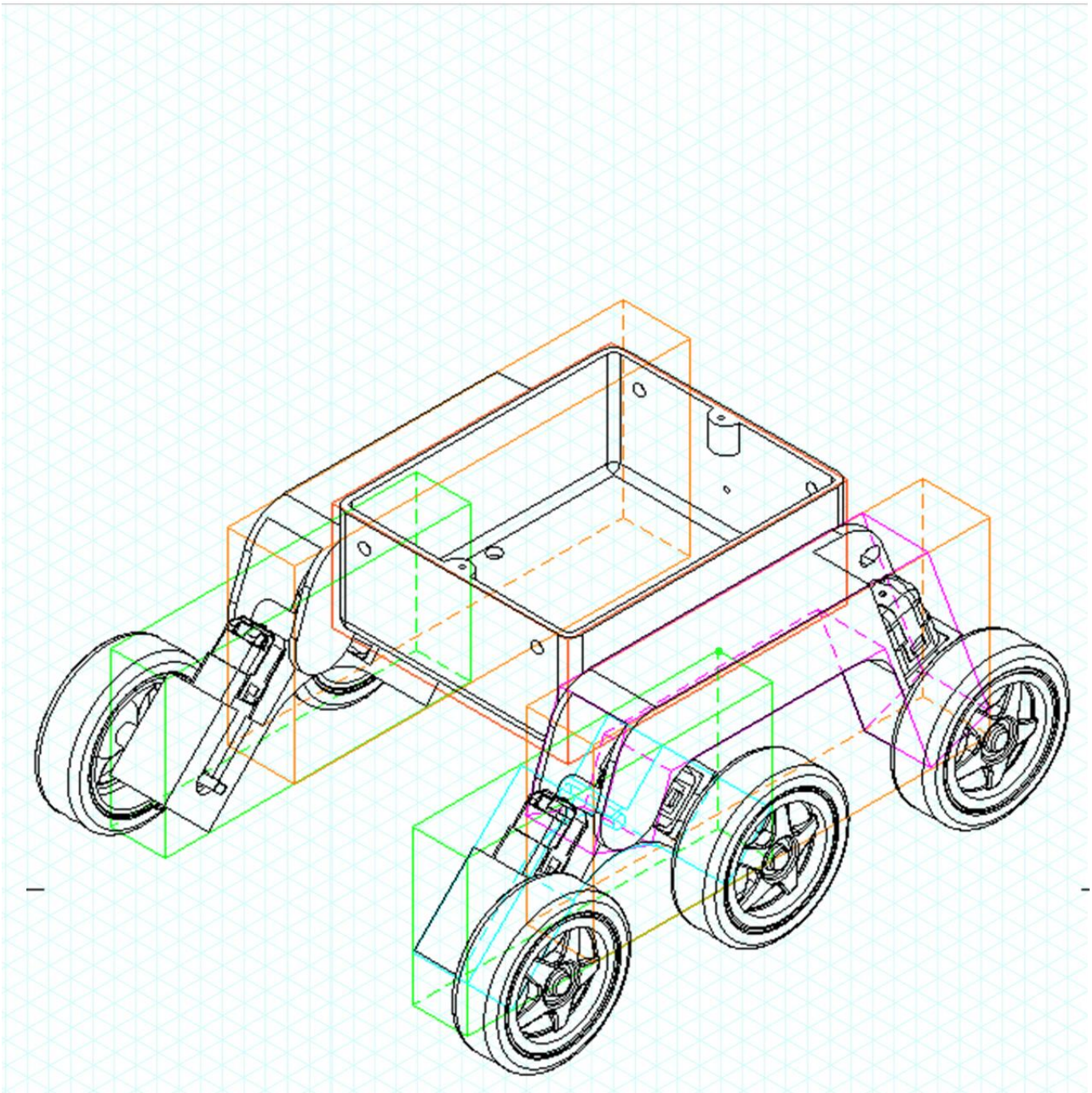
Added command to turn on all LEDs with hazard button. Encourage students to try

Activity 1.1.7

Sketch the given possible solution

Use the isometric grid to sketch the space rover. The coloured points outline shape using the "crating" technique. Crating involves sketching very light isometric boxes that aid you to create more complex shapes inside them. Sketch the space rover design in separate stages as shown below. Remember to sketch lightly in pencil then refine the sketch with heavy lines where needed. All coloured lines are light construction sketches. Black lines represent final visible edges.

Complete the outline with a darker pencil, Add wheels and motors to the design.
Hint: create small crates the size of the wheels to help sketch uniform circles.
Sketch a top body to be attached to the chassis, this can be sketched on the same sketch or as a detailed sketch in the extra space provided.



Activity 1.1.8

Sketch a new improved possible solution based on research gathered:

-Sketches should be neat and in pencil.
-Construction lines should be light.
-Sketches should be proportional.
-Sketches should satisfy key points of the brief and reflect research.
-Shading / colouring should be used.

Activity 1.1.9

Sketch one final design for your space rover
- State three reasons for choosing this design.
- Select suitable materials for its manufacture.

-Final sketches should be neat and in pencil.
-Construction lines should be light.
-Sketches should be proportional.
-Sketches should satisfy key points of the brief and reflect research.
-Shading / colouring should be used.

Week 4 Lesson Plan:

<table>
<tr><td rowspan="4">Content</td><td colspan="2">Grade 12 Advance</td></tr>
<tr><td>Chapter 1 - Engineering Design</td><td>Section 1 - The design process: Design of a space rover
-Stage 6: Design Realisation</td></tr>
<tr><td rowspan="3">Chapter 4 – 3D Modelling</td><td>Section 1 – What is Fusion 360</td></tr>
<tr><td>Section 2 – Introduction to basic modelling</td></tr>
<tr><td>Section 3 – Creating the space rover chassis</td></tr>
<tr><td>Time allocated</td><td colspan="2">3 x 45-minute periods</td></tr>
<tr><td rowspan="2">Keywords</td><td colspan="2">What are the keywords the students must learn?</td></tr>
<tr><td colspan="2">• CAD
• Fusion 360
• data panel
• toolbar
• 2D Sketch
• Extrude
• Chassis</td></tr>
<tr><td>Resources</td><td colspan="2">What resources are required?
• textbooks
• projector
• sketching equipment</td></tr>
<tr><td>Prior Knowledge</td><td colspan="2">• Sketching
• 3D Printing</td></tr>
</table>

Aim:

In this lesson, students will complete sections 1-3 of the 3D modelling chapter. You should spend an adequate amount of time on sections 1 and 2 depending on student ability and prior knowledge / exposure to Fusion 360 in previous terms. The outlined time in the IP is a maximum time for recap. If students show good knowledge during recap move along to section 3: Creating the space rover chassis. In this section students will measure the electronic components from chapter 3 and determine the required chassis dimensions based on this. Accuracy of measurement is critical here so that all components fit inside the finished chassis.

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 they have covered a learning objective.

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.

Teacher should: *(tick as you complete)*	***Students should:*** *(tick as students complete)*
☐ Introduce Lesson aim and outcomes. ☐ Introduce Design realisation stage of chapter 1. ☐ Recap on Fusion 360 as a 3D modelling solution.	☐ Register for Fusion 360.
	☐ Open a new design in Fusion 360.
	☐ Save a file in Fusion 360.
	☐ Navigate the toolbar.
	☐ Open and navigate the data panel.
	☐ Share work from your data panel.
	☐ Download files and upload files to your data panel.
☐ Recap on creating 2D sketches and extruding to 3D.	☐ Identify 2D sketch tools.
	☐ Identify and distinguish between planes.
	☐ Create dimensioned 2D sketch.
	☐ Create a 3D model using extrude tool.
☐ Introduce the aim of section 3, Facilitate as students measure and record component sizes to determine chassis dimensions.	☐ Identify the required chassis type and size.
☐ Facilitate as students sketch the chassis base sketch and extrude to 3D.	☐ Create the required 2D sketch.
	☐ Extrude a 2D sketch.
☐ Recap on the shell, fillet and hole features as needed.	☐ Shell required parts of the chassis.
	☐ Add fillets to improve chassis appearance and function.
☐ Demonstrate creating holes to later mount top body.	☐ Create holes to mount components and top body to chassis.

Possible teaching method(s) or approach for this lesson

(teacher to tick the relevant method)

- ☐ 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	
Chapter	**Section**	**Focus**	**Essential**	**Non-essential/Self Study**
4	**1**	What is fusion 360		Pg. 145 - 152
4	**2**	2D sketching and 3D modelling	Pg. 153 - 161	
4	**3**	Section 3: Creating the space rover chassis	Pg.162 - 180	

Learning Phases - Week 4: Period 1-3 (Ch. 4: Section 1-3)

Phase 1 of lesson (Connect) – Starter	Phase 2 of lesson (Activate)	Phase 3: (Engage and Demonstrate)	Phase 4: Plenary (Consolidate) Return to begging of next row	Assessment opportunity	Notes for Differentiation
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. Introduce all key words for the lesson. Discuss prior knowledge of design realization from previous terms. Discuss prior knowledge of Fusion 360 from previous terms. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	a) Teacher to recap what is Fusion 360.	a) Students to show level of understanding through answers and fusion 360 tasks.		**Oral Questioning**	
	b) Teacher to recap on basic 3D modelling.	b) Students to complete revision activities 4.2.1 - 4.2.3		**Activity 4.2.1 -4.2.3**	

		c) Facilitate and provide feedback as student's complete activity 4.2.1-4.2.3			
	d) Introduce students to the chassis to be modelled. Recap on the electronic components to be used from chapter 3 and provide students with the circuits for reference and measurements.	d) Facilitate as students measure components and use this information to determine the correct chassis dimensions through Activity 4.3.1-4.3.4.		**Activity 4.3.1 - 4.3.4**	
		e) Facilitate as students use the information gathered to model the chassis. Provide constructive feedback on models as they are created. If there are issues, engage students in troubleshooting and correcting errors using the timeline in Fusion 360.			

	f) Demonstrate adding holes and mount points to the chassis. Clearly demonstrate the function of the mount points and holes and the importance of extents when modelling.	f) Facilitate and provide feedback as students add mount points and complete activity 4.3.6		**Activity 4.3.6**	
			Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Relate questions to Fusion 360 features used. Have learning outcomes been met? Has the lesson aim been achieved?.	**Visual inspection of Fusion model** **Student evaluation**	

Answer Key

QR code links:		
Page	**Topic**	**Link**
145	What is Fusion 360?	https://www.youtube.com/watch?v=beebJ6fgVPo
148	Using data panel	https://help.autodesk.com/videos/YxdDhhbjqwuccpnsqjraCEnee5N-l_Ln/video.webm
150	Motor 3D model	http://a360.co/2FhNbeG
162	Space rover 3D model	https://a360.co/2Qcprx4

Activity 4.2.1

What 2D shape would you sketch to create a 3D cylinder?

Circle.

What plane would you select to create cylinder 2 and 3?

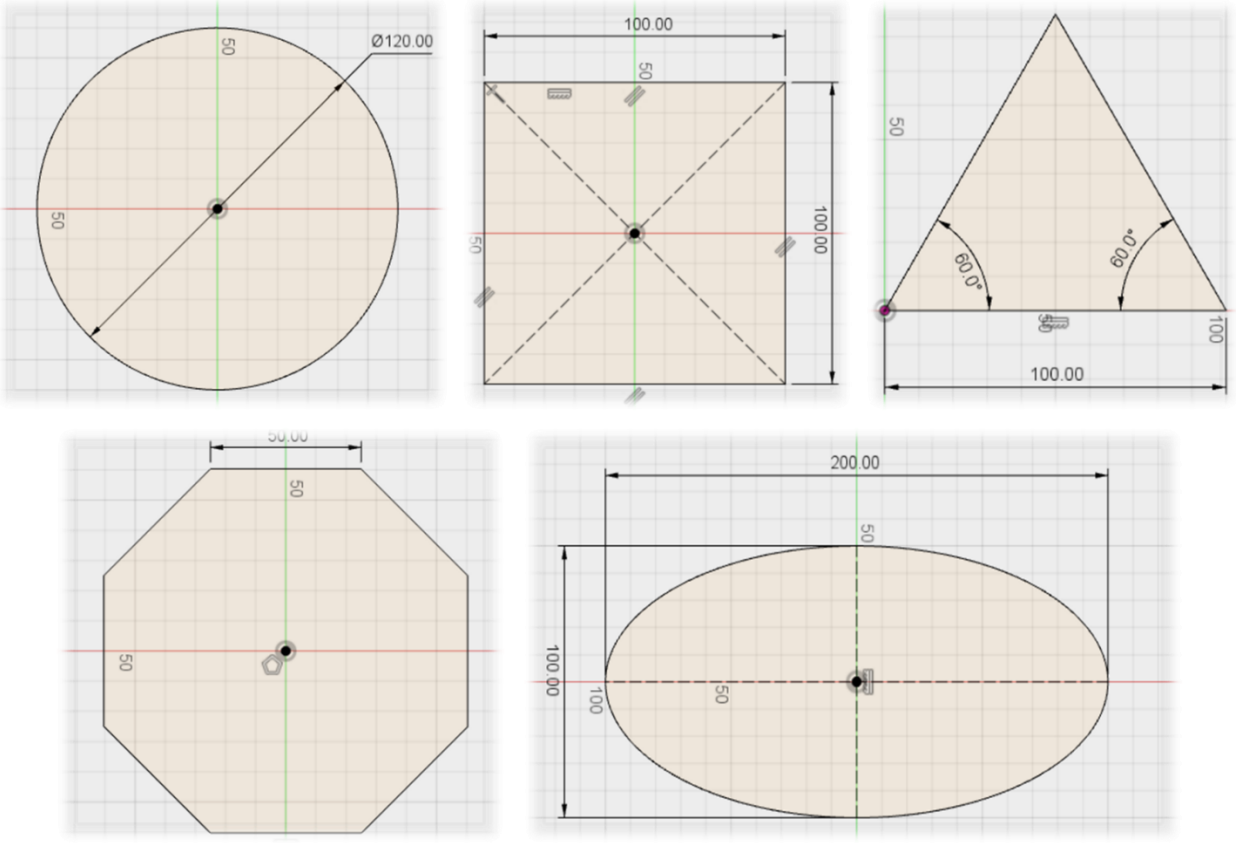
2) XY plane.

3) YZ plane.

Activity 4.1.2

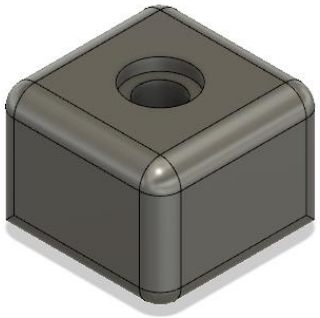
You now understand how to choose a plane for 2D sketching. Open a new design and create a new sketch on the XZ plane as shown below.

On the XZ plane sketch and dimension the shapes are shown below.



Activity 4.1.3

Recap the basic modelling skills studied in Term 1. Extrude the above 40x40mm square into a 30mm tall cuboid. Add a 5mm round to all sides and cut a diameter 10mm hole through center of the top face.



What tool is used to create a 5mm round on edges?

Modify > Fillet.

Name the hole shown.

Counterbore.

What tool is used to create a hole as shown?

Create > hole

Activity 4.3.1

Do you think this chassis would be classed as a body on a frame chassis or a unibody chassis? Why?

Body on frame Chassis as there is a separate body to be mounted on top of the chassis

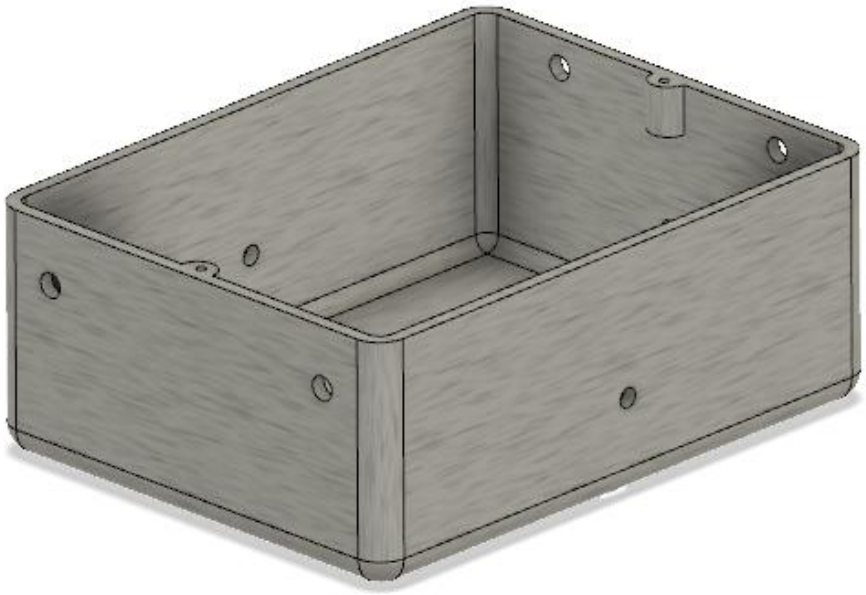


Figure 0.1

List the features and tools you will use to create the chassis shown above:

-Sketch

-Extrude

-Fillet

-Shell

-Hole

-Mirror

Activity 4.3.2

The image below shows all the required electronic components you used to create and test the circuit in Chapter 3. Measure and dimension each component's actual length, width and height. Fill in the dimensions in the boxes below. ***(Do not measure drawings shown. They are not to scale)***

Measure given components to ensure accuracy

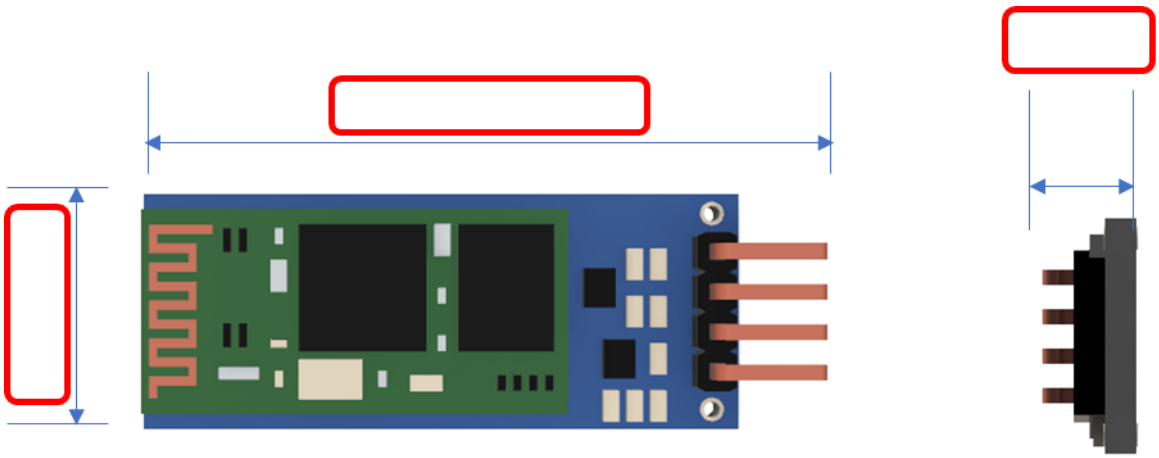


Figure 0.2

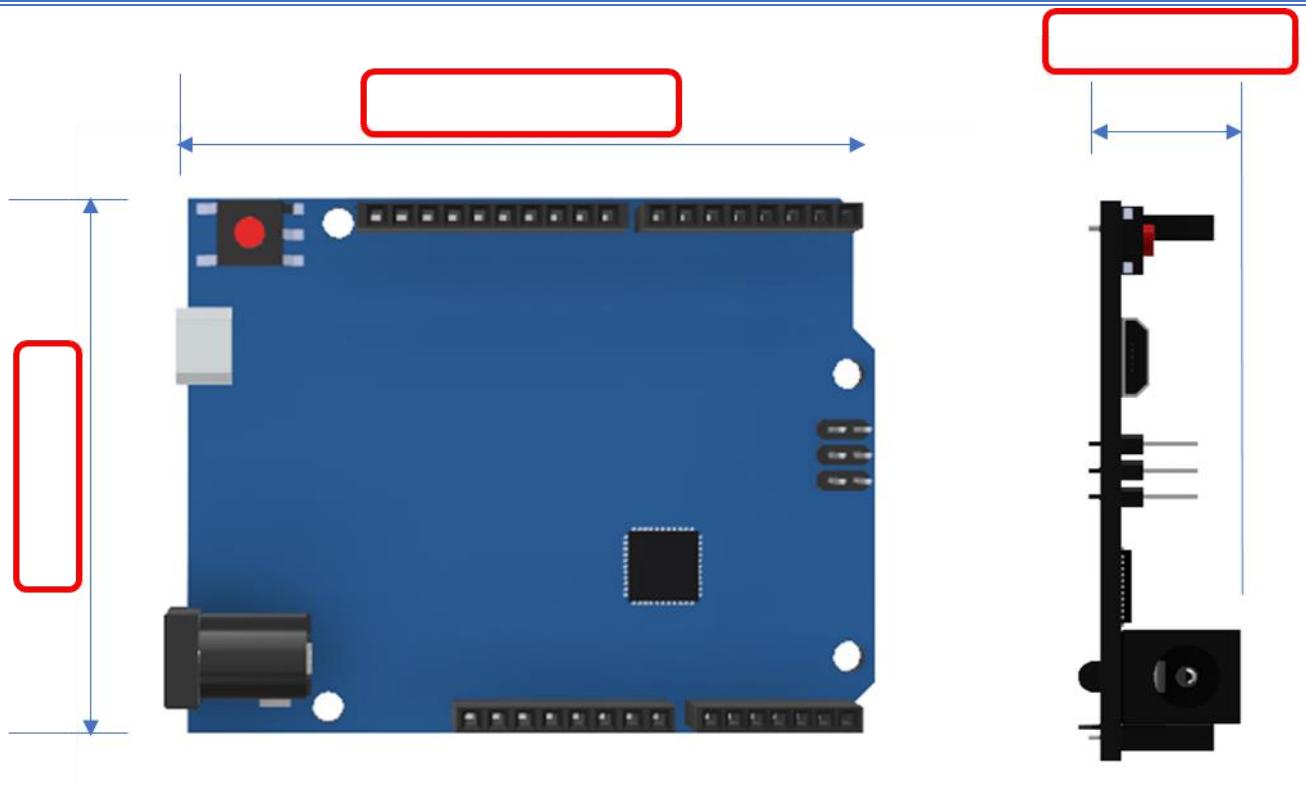


Figure 0.3

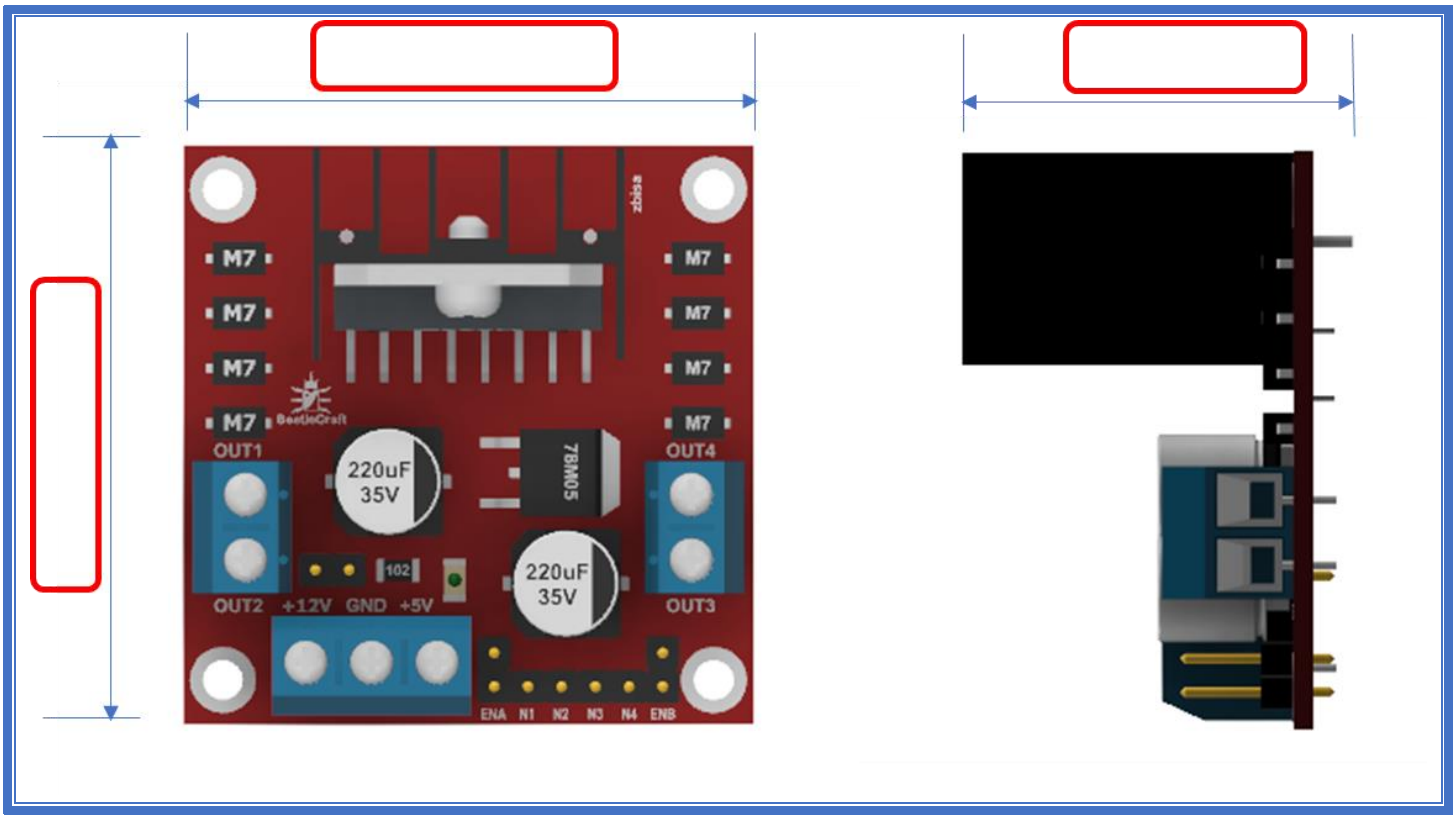


Figure 0.4

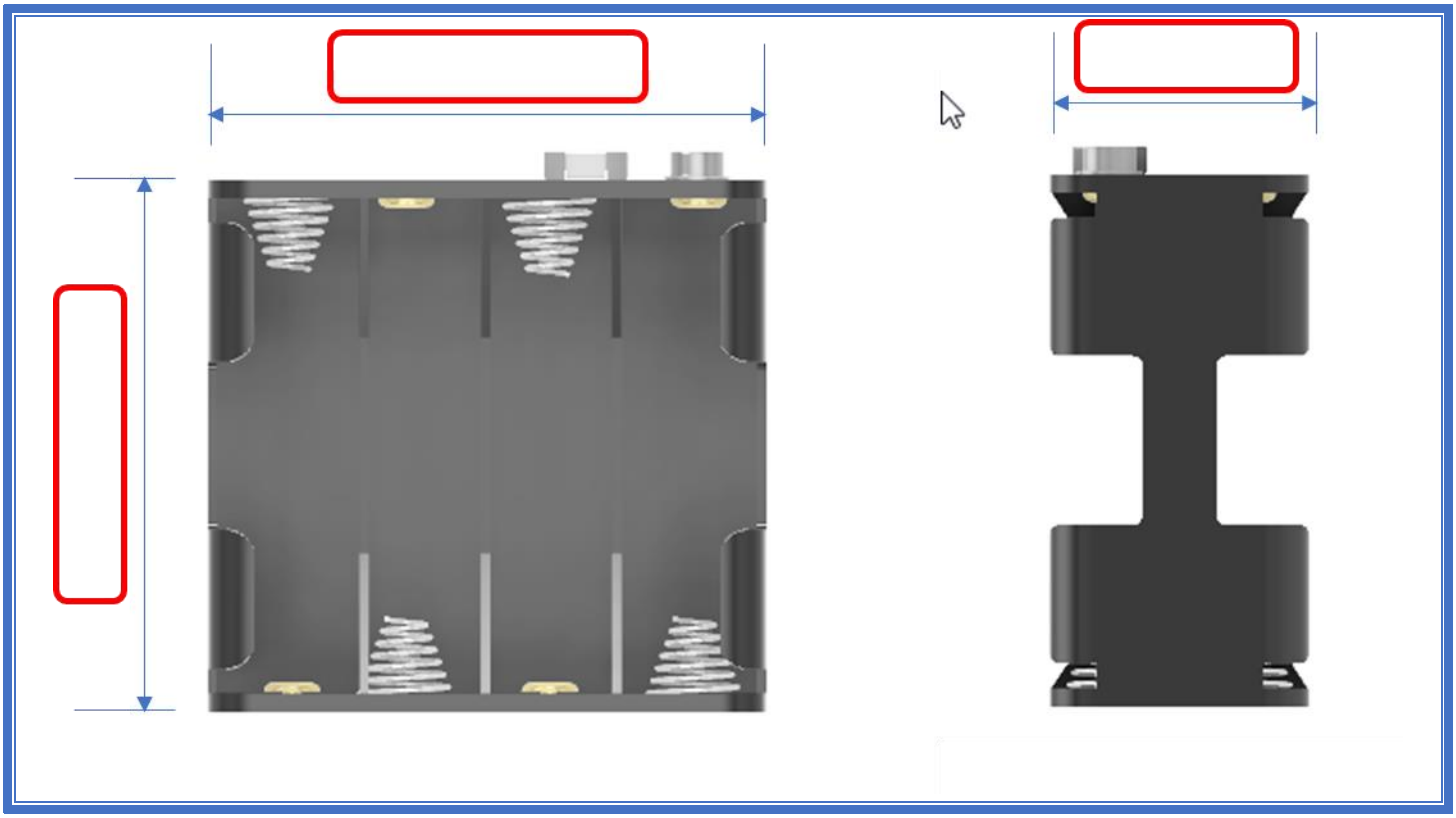
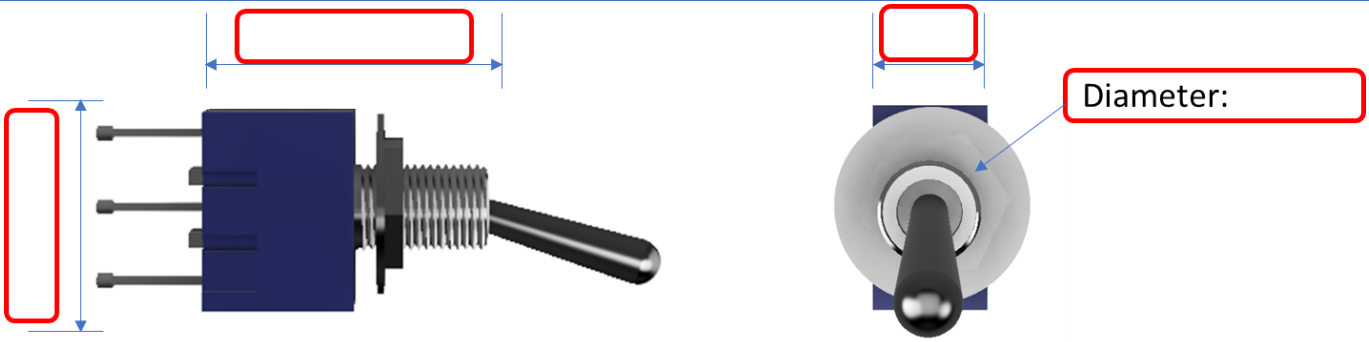
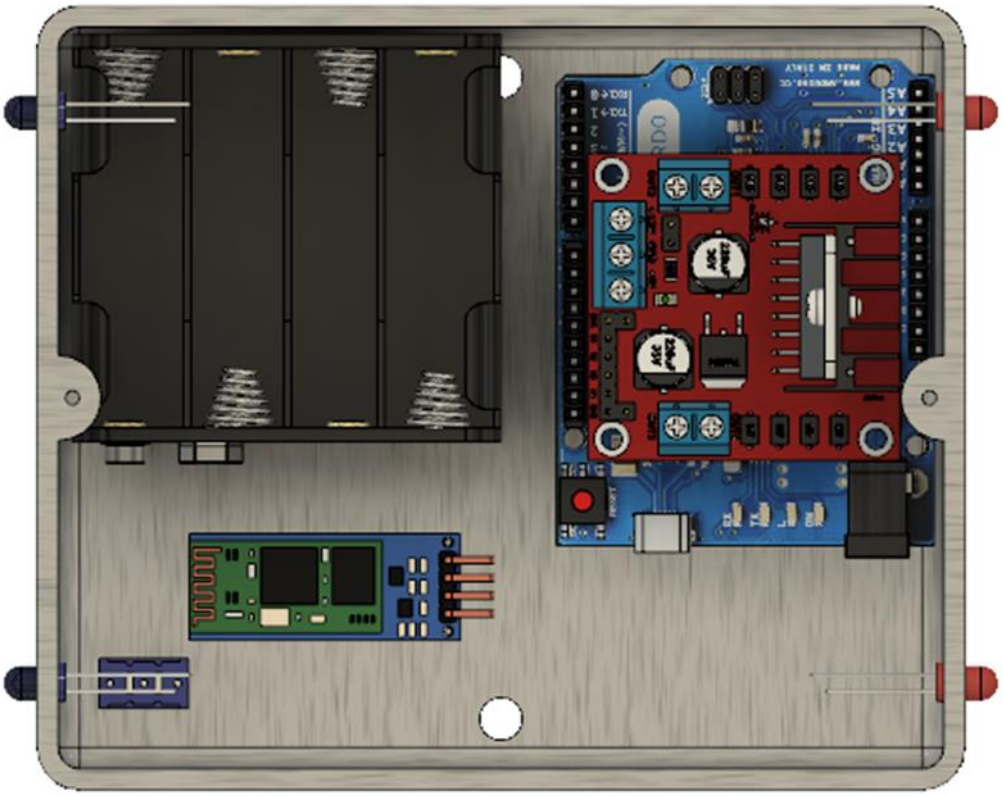


Figure 0.5



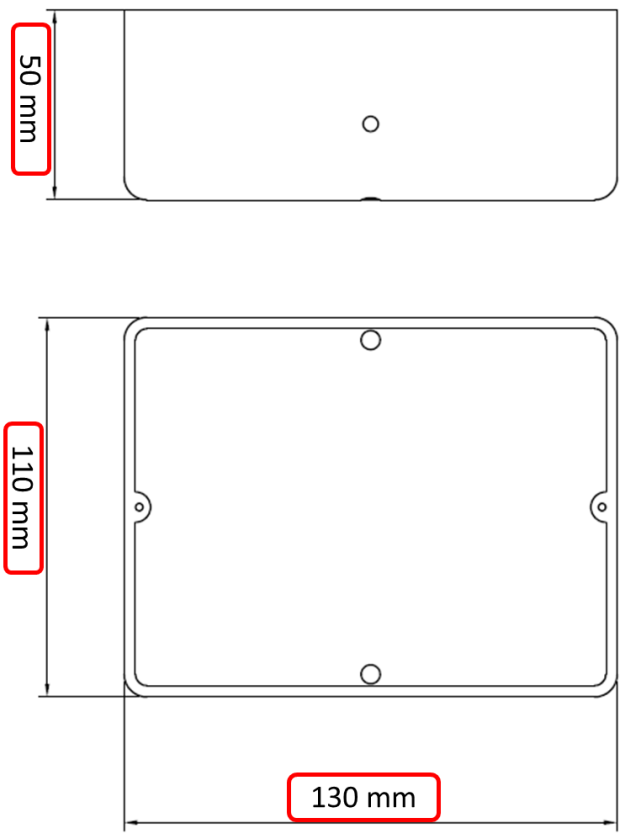
Activity 4.3.3

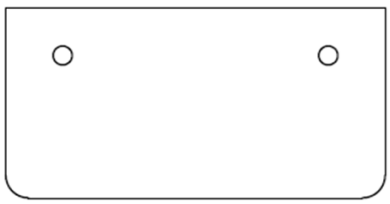
Using the measurements from Activity 4.3.2, create a full-sized sketch of how you would arrange the components inside the chassis. Include a hole to mount the switch through the bottom surface. ***(Remember that 140mm is the maximum printing length.)***

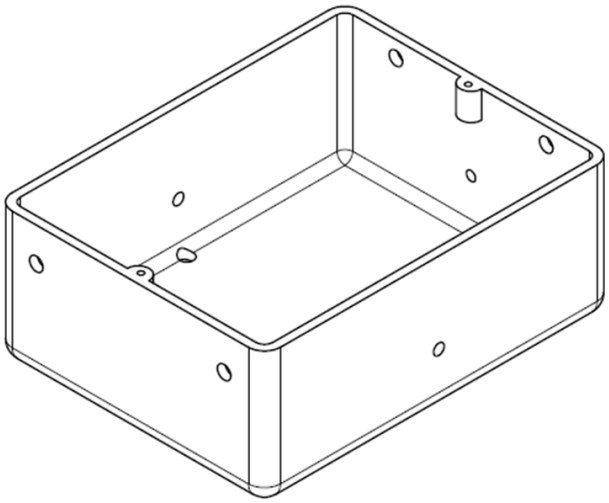


Activity 4.3.4

Based on your full-scale sketch from Activity 4.2.3 add dimensions to the chassis shown below. ***(Note, the motors will be attached to the rocker-bogie mechanism, all other components must be mounted inside.)***







Basic modelling of the chassis

Activity 4.3.5

You should now have determined the required size for the space rover chassis. List and explain the correct steps and create the chassis as shown below.

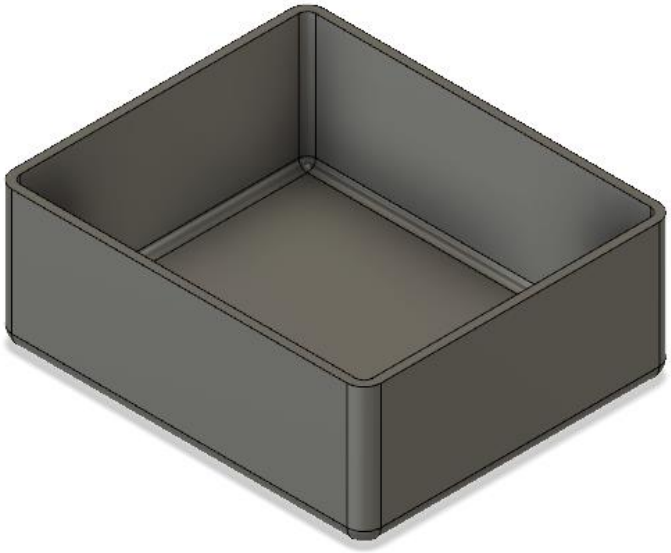


Figure 0.6

Step 1: Create 2D sketch on top plane

Step 2: Extrude rectangle 50mm

Step 3: Add fillets to edges

Step 4: Shell the chassis

Activity 4.3.6

You should now have finished the chassis with holes to mount the top body, switches and LEDs. In the space below, list the features used to create the chassis from start to finish in the correct order.

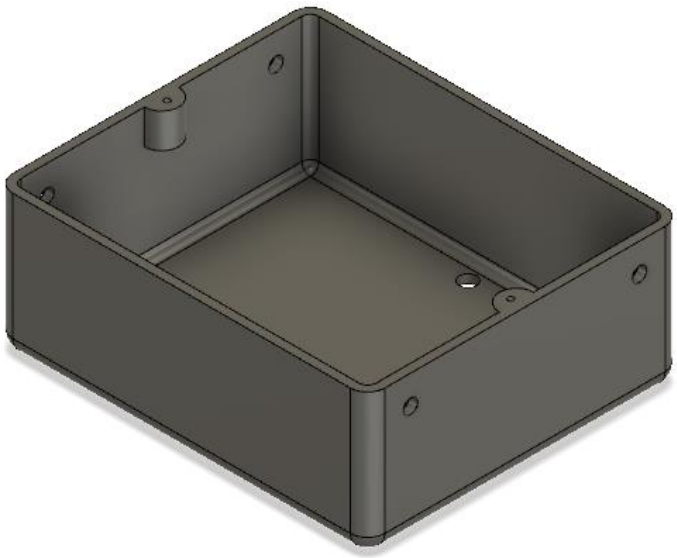


Figure 0.7

Sketch the rectangle.

Extrude the rectangle.

Fillet the edges.

Shell the chassis.

Sketch hole center points.

Create holes for LEDs.

Sketch hole center points.

Create holes for switch and wires.

Sketch mount profile.

Extrude mount.

Create a hole.

Mirror features

Week 5 Lesson Plan:

Content	Grade 12 Advance	
	Chapter 4 – 3D Modelling	**Section 4 – Assemblies and multibody design**
Time allocated 	**3 x 45-minute periods**	
Keywords 	**What are the keywords the students must learn?**	
	• 2D sketch • extrude • assemble • joint • translate • gimbal	
Resources 	**What resources are required?** • textbooks • projector • sketching equipment	
Prior Knowledge 	• sketching tools • create tools • modify tools • creating bodies	

Aim:

In this lesson, students will complete section 4: Assemblies and multibody design. Upon completion of this section students should understand how to model various components within one design and define their movement by adding joints. This knowledge will then be used to assemble all the electronic components within the chassis to verify it is the correct size. This knowledge will also be used in section 5 to create and assemble the rocker bogie mechanism.

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 they have covered a learning objective.

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.

Teacher should: *(tick as you complete)*	***Students should:*** *(tick as students complete)*
☐ Demonstrate multibody design and creating components.	☐ Understand how to model different bodies and components in one design.
	☐ Use combine tool to create one body or component.
	☐ Save separate components as parts.
☐ Demonstrate inserting and defining a parts motion using joints. ☐ Demonstrate all joint types and their uses.	☐ Insert an existing part into a design.
	☐ Differentiate between joint types.
	☐ Create an assembly using all joint types.
	☐ Apply joint limits to moving joints.
☐ Demonstrate assembling the switch into the chassis and facilitate as students assemble other components.	☐ Assemble all electric components within the chassis.

Possible teaching method(s) or approach for this lesson

(teacher to tick the relevant method)

- ☐ 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	
Chapter	**Section**	**Focus**	**Essential**	**Non-essential/Self Study**
4	**4**	Assemblies and multibody design	Pg. 181 - 225	

Learning Phases - Week 5: Period 1-3 (Ch. 4: Section 4)

Phase 1 of lesson (Connect) – Starter	Phase 2 of lesson (Activate)	Phase 3: (Engage and Demonstrate)	Phase 4: Plenary (Consolidate) Return to begging of next row	Assessment opportunity	Notes for Differentiation
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. Introduce all key words for the lesson. Discuss prior knowledge of assemblies from previous terms. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	a) Teacher to introduce and explain joint types.	a) Students to show level of understanding through answers and previous use of joints.		**Oral Questioning**	
	b) Teacher to introduce multibody design and its uses.	b) Students to create the cube, joint rectangle and pin for the joints exercise as multi bodies in one design.		**Oral Questioning**	
		c) Facilitate and provide feedback as student's complete activity 4.4.1		**Activity 4.4.1**	

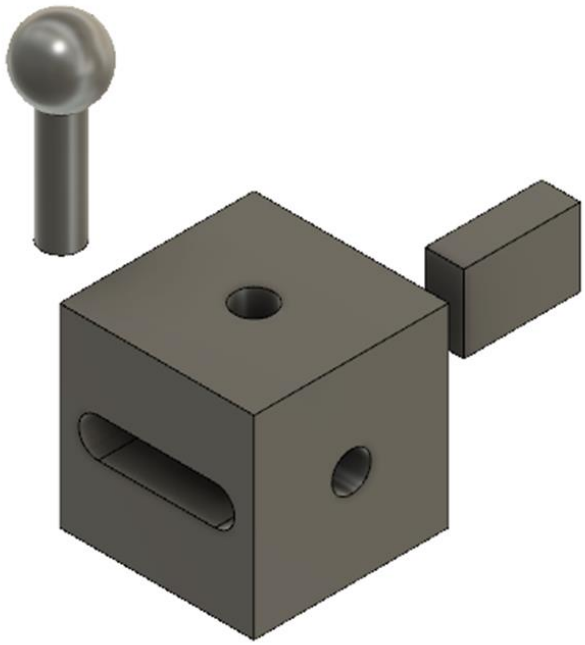
	d) Teacher to demonstrate all the joint types using the joint cube, rectangle and pin.	d) Facilitate as students complete all the joint types.		**Visual inspection**	
	e) Teacher to demonstrate creating an as built joint	e) Facilitate as students complete an as built joint in Activity 4.4.2		**Activity 4.4.2**	
	f) Teacher to demonstrate uploading switch to data panel and assembling switch into chassis.	f) Facilitate and provide feedback as students assemble all electronic components into place in activity 4.4.3		**Activity 4.4.3**	
			Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Relate questions to Fusion 360 joints used. Have learning outcomes been met? Has the lesson aim been achieved?	**Visual inspection of Fusion model** **Student evaluation**	

Answer Key

QR code links:		
Page	***Topic***	***Link***

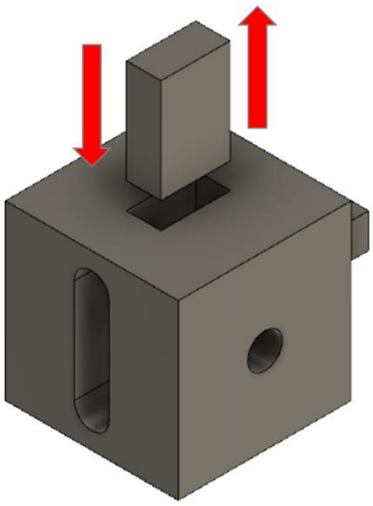
Activity 4.4.1

Create a new component from the body to create the joint pin component. Also, save it to your data panel. You should then have three separate components in your data panel: the joint cube, the rectangle cuboid and the joint pin. ***Save this design as a copy and name it 'cube with components.'***



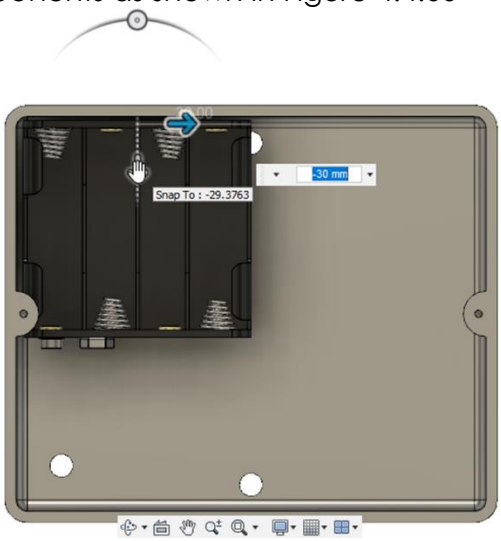
Activity 4.4.2

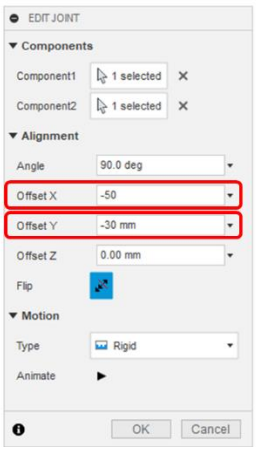
You have now created an 'as built joint' between the pin and cube using the original created position. You must now create an 'as built slider joint' between the cuboid component and the joint component as shown below.



Activity 4.4.3

Import all the electric components to your data panel. Insert and assemble using rigid joints to position the components as shown in Figure 4.4.60





Hint: Create a joint between the bottom face of the component and the chassis floor. Then use the triad to offset and position component as required.

Paste a picture of your assembled chassis including a timeline view of the joints used.

Position of LEDs and switch must be exact. Position of other components can vary as long as they fit correctly

Week 6 Lesson Plan:

Content	Grade 12 Advance	
	Chapter 4 – 3D Modelling	**Section 5 – Modelling the rocker-bogie mechanism**
Time allocated 	**3 x 45-minute periods**	
Keywords 	**What are the keywords the students must learn?**	
	• 2D sketch • extrude • joint • rocker-bogie	
Resources 	**What resources are required?** • textbooks • projector • sketching equipment	
Prior Knowledge 	• sketching • extrude tool • hole tool • fillet tool • creating chassis • multibody design • joints and assemblies	

Aim:

In this lesson, students will complete section 5: Modelling the rocker-bogie mechanism. Upon completion of this section students should understand how to create parts using dimensioned 2D working drawings. These drawings will be used as reference to create 2D sketches. Students will extrude these profiles into 3D before positioning the motors using their knowledge of joints. Students will then create extrudes, cuts and holes to finalise the rocker and bogie so they can hold the motors. Students will convert the bodies to components and assemble using joints to simulate real life operation of the mechanism.

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 they have covered a learning objective.

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.

Teacher should: *(tick as you complete)*	***Students should:*** *(tick as students complete)*
☐ Present working drawings	☐ Identify and read a working drawing.
☐ Facilitate as students create 2D sketches	☐ Create the required 2D rocker sketch.
	☐ Create the required bogie sketch.
☐ Facilitate as students extrude sketches to 3D	☐ Extrude 2D sketches to form 3D profiles.
☐ Demonstrate creating cuts for motor mounts	☐ Use extruded cuts to create motor mounts.
☐ Facilitate as students create fillets and holes in the rocker model.	☐ Add fillets to improve rocker and bogie strength and appearance.
	☐ Create holes to join components.

Possible teaching method(s) or approach for this lesson

(teacher to tick the relevant method)

- ☐ 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	
Chapter	**Section**	**Focus**	**Essential**	**Non-essential/Self Study**
4	**5**	Assemblies and multibody design	Pg. 226 - 241	

Learning Phases - Week 6: Period 1-3 (Ch. 4: Section 5)

Phase 1 of lesson (Connect) – Starter	Phase 2 of lesson (Activate)	Phase 3: (Engage and Demonstrate)	Phase 4: Plenary (Consolidate) Return to begging of next row	Assessment opportunity	Notes for Differentiation
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. Introduce all key words for the lesson. Discuss prior knowledge of features needed to create the rocker. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	a) Teacher to present working drawing of rocker.	a) Facilitate as students fill in all dimensions and create 2D sketch for rocker.		**Activity 4.5.1**	
		b) Facilitate as student extrude the 2D sketch to 3D		**Oral Questioning Visual inspection**	
	c)Teacher to demonstrate inserting and positioning motor using joints. Demonstrate all cuts and holes to create the motor mount	c) Facilitate and provide feedback as insert motor and create all cuts and holes to finalise the rocker model.		**Activity 4.5.2-4.5.3**	

			Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Relate questions to Fusion 360 features used. Have learning outcomes been met? Has the lesson aim been achieved?	**Visual inspection of Fusion model** **Student evaluation**	

Answer Key

QR code links:		
Page	***Topic***	***Link***

Activity 4.5.1

In Section 4, you learned how to create multiple-body designs and then create and assemble components in one design. Using an 'as built joint' allows us to define degrees of freedom between components in the position they were created. For this reason, it makes sense to create the rocker in its intended position, on the side of the chassis. From previous lessons, you know a 2D sketch must first be created before extruding the profile to 3D.

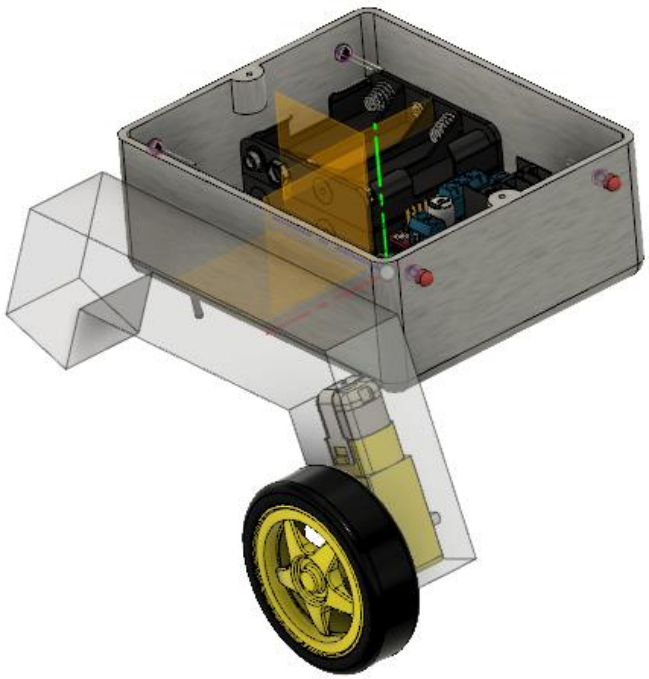
This section will contain many blank spaces in the steps, these spaces must be filled in with correct measurements, features, joint types, etc.

ALL blanks to be filled with correct measurements from working drawing.

Activity 4.5.2: Mounting the motor

You should have now created a basic 3D model of the rocker. This model must now be modified to hold the motors. You must also create points to mount to the chassis and to join the bogie. In order to ensure the motor fits correctly, we will insert the motor to our design and utilise our knowledge of multi-body design. Changing the opacity level of the rocker will allow you to see through it and view the motor inside.

Motor mounted correctly to leave 3mm wall from outside edge



Activity 4.5.3 Creating mounts for the chassis and bogie

You should now have modelled a complete rocker as shown below. List the steps and features/tools used to create the bogie.

Figure 0.1

Sketch rocker profile.
Extrude the rocker.
Insert a motor.
Sketch sidecut profiles.
Extrude cuts.
Sketch motor profile.
Extrude cut to mount the motor.
Cut a hole through the bottom.
Create mounting holes for chassis and bogie.

Week 7 Lesson Plan:

<table>
<tr><td rowspan="3">Content</td><td colspan="2">Grade 12 Advance</td></tr>
<tr><td rowspan="2">Chapter 4 – 3D Modelling</td><td>Section 5 – Modelling the rocker-bogie mechanism</td></tr>
<tr><td>Section 6 – Space rover top Body</td></tr>
<tr><td>Time allocated</td><td colspan="2">3 x 45-minute periods</td></tr>
<tr><td>Keywords</td><td colspan="2">What are the keywords the students must learn?</td></tr>
<tr><td></td><td colspan="2">• 2D sketch
• extrude
• joint
• rocker-bogie
• Loft
• Sweep</td></tr>
<tr><td>Resources</td><td colspan="2">What resources are required?
• textbooks
• projector
• sketching equipment</td></tr>
<tr><td>Prior Knowledge</td><td colspan="2">• sketching
• extrude tool
• hole tool
• fillet tool
• creating chassis
• multibody design
• joints and assemblies</td></tr>
</table>

Aim:

In this lesson, students will complete section 5: Modelling the rocker-bogie mechanism. Upon completion of this section students should understand how to create parts using dimensioned 2D working drawings. These drawings will be used as reference to create 2D sketches. Students will extrude these profiles into 3D before positioning the motors using their knowledge of joints. Students will then create extrudes, cuts and holes to finalise the rocker and bogie so they can hold the motors. Students will convert the bodies to components and assemble using joints to simulate real life operation of the mechanism. Students will the create a sample top body for the space rover while learning 3 new features, the loft, sweep and pipe features.

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 they have covered a learning objective.

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.

Teacher should: *(tick as you complete)*	***Students should:*** *(tick as students complete)*
☐ Present working drawings	☐ Identify and read a working drawing.
☐ Facilitate as students create 2D sketches	☐ Create the required 2D rocker sketch.
	☐ Create the required bogie sketch.
☐ Facilitate as students extrude sketches to 3D	☐ Extrude 2D sketches to form 3D profiles.
☐ Demonstrate creating cuts for motor mounts	☐ Use extruded cuts to create motor mounts.
☐ Facilitate as students create fillets and holes in the rocker model.	☐ Add fillets to improve rocker and bogie strength and appearance.
	☐ Create holes to join components.
☐ Demonstrate assembling rocker and bogie to chassis	☐ Assemble the rocker-bogie mechanism to the chassis using suitable joints
☐ Demonstrate motion links and joint limits to simulate realistic motion	☐ Add motion links and joint limits to simulate realistic motion
☐ Demonstrate offset planes	☐ Create offset planes.
☐ Demonstrate creating profiles and lofts	☐ Create sketch profiles.
	☐ Create a lofted profile.
☐ Demonstrate the sweep feature	☐ Create a swept profile.
☐ Demonstrate using the hole tool to match existing holes.	☐ Use the hole tool to match existing mount points.

Possible teaching method(s) or approach for this lesson

(teacher to tick the relevant method)

- ☐ 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	
Chapter	**Section**	**Focus**	**Essential**	**Non-essential/Self Study**
4	**5**	Assemblies and multibody design	Pg. 241-262	
4	**6**	Space Rover top body	Pg. 263 - 276	

Learning Phases - Week 7: Period 1-2 (Ch. 4: Section 5)

Phase 1 of lesson (Connect) – Starter	Phase 2 of lesson (Activate)	Phase 3: (Engage and Demonstrate)	Phase 4: Plenary (Consolidate) Return to begging of next row	Assessment opportunity	Notes for Differentiation
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. Introduce all key words for the lesson. Recap on the skills used to create the rocker in the previous lesson. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	a) Teacher to present working drawing of bogie	a) Facilitate as students fill in all dimensions and create 2D sketch for bogie		**Activity 4.5.1**	
		b) Facilitate as students extrude the 2D sketch to 3D		**Activity 4.5.4**	

	c)Teacher to demonstrate inserting and positioning motor using joints. Demonstrate all cuts and holes to create the motor mounts	c) Facilitate and provide feedback as students insert motor and create all cuts and holes to finalise the bogie model		**Activity 4.5.5**	
	d) Demonstrate creating components from the rocker and bogie bodies. Demonstrate assembling these components to the chassis.	d) Facilitate and provide feedback as students create and assemble rocker and bogie components.		**Activity 4.5.6**	
	e) Demonstrate creating the differential bar to connect the rockers. Demonstrate applying realistic motion joints between the rockers and the differential.	e) Facilitate and provide feedback as students create and assemble the differential bar.		**Activity 4.5.7 -4.5.9**	
			Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Relate questions to Fusion 360 features used. Have learning outcomes been met? Has the lesson aim been achieved?	**Visual inspection of Fusion model** **Student evaluation**	

Learning Phases - Week 7: Period 3 (Ch. 4: Section 6)

Phase 1 of lesson (Connect) – Starter	Phase 2 of lesson (Activate)	Phase 3: (Engage and Demonstrate)	Phase 4: Plenary (Consolidate) Return to begging of next row	Assessment opportunity	Notes for Differentiation
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. Introduce all key words for the lesson. Discuss the new features to be used to create a top body. Will any previously used features be used again? **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	a) Teacher to present example top body to class. Introduce the loft feature and sample shapes that can be created.	a) Students to discuss possible uses of the loft feature.		**Oral questioning**	
	b) Demonstrate the loft feature to the class	b) Facilitate as students complete the loft feature of the top body		**Activity 4.6.1**	

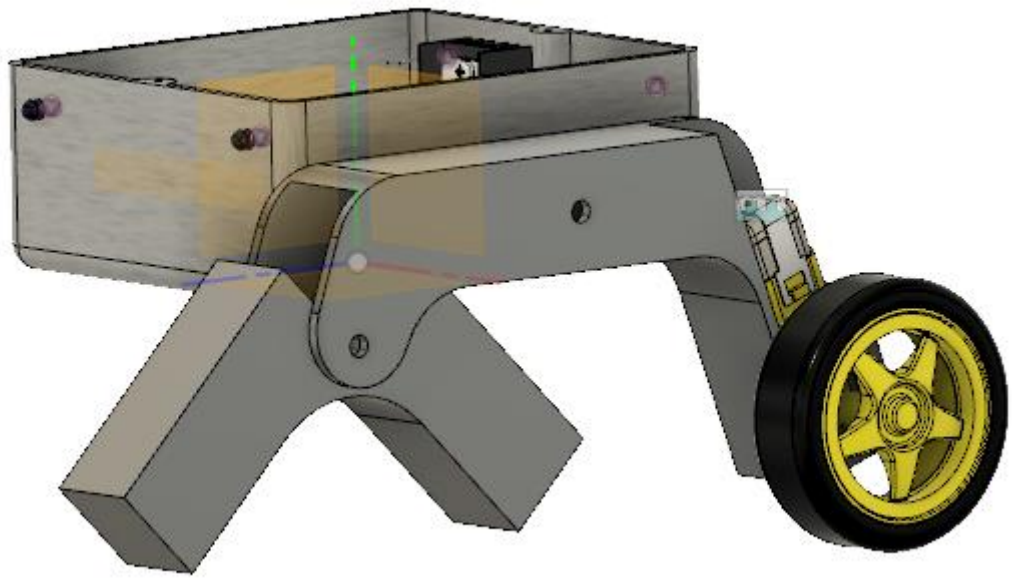
	c)Teacher to demonstrate the sweep and pipe features. Cleary explain the difference between these two tools.	c) Facilitate and provide feedback as students complete the sweep and pipe features of the top body.		**Activity 4.6.2 – 4.6.3**	
	d) Demonstrate creating holes to match the mounting holes of the chassis.	d) Facilitate and provide feedback as students create holes to assemble the top body to the chassis.		**Activity 4.6.4**	
			Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Relate questions to Fusion 360 features used. Have learning outcomes been met? Has the lesson aim been achieved?	**Visual inspection of Fusion model** **Student evaluation**	

Answer Key

QR code links:		
Page	***Topic***	***Link***

Activity 4.5.4 Extruding the bogie

Students should sketch the bogie to the correct dimensions and extrude the bogie to the correct width as per the working drawing



Activity 4.5.5 Modifying the extrude

You should now have modelled a complete rocker and bogie as shown below. List the steps and features/tools used to create the bogie.

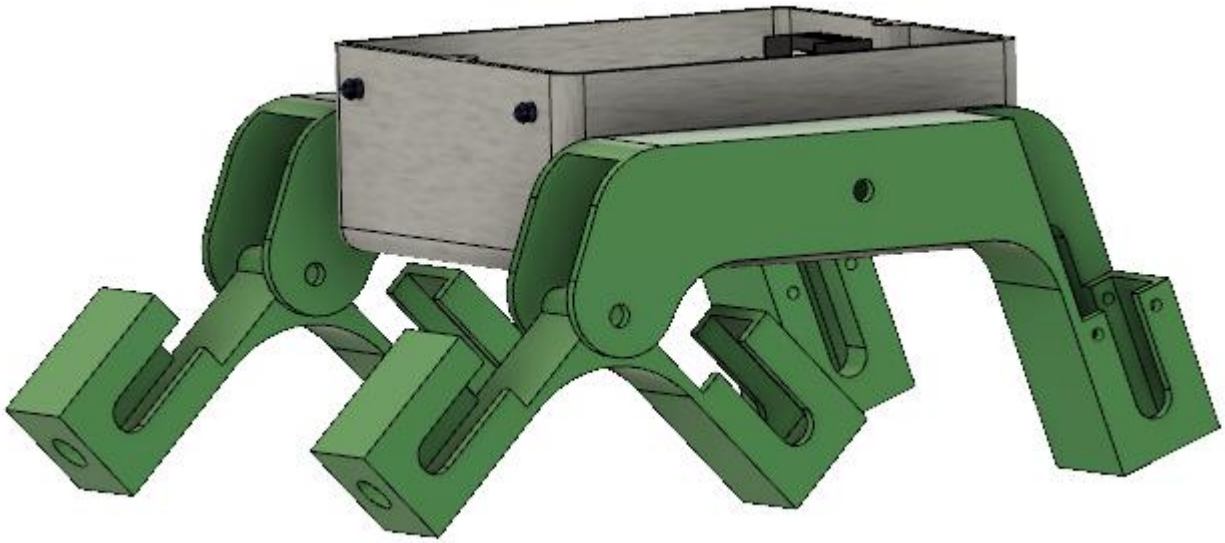
Figure 0.1

Sketch bogie profile.
Extrude the bogie.
Insert a motor.
Sketch sidecut profiles.
Extrude cuts.
Sketch motor profile.
Extrude cut to mount the motor.
Cut a hole through the bottom.
Mirror all features to the second side.

Image clearly showing steps completed in timeline and student name.

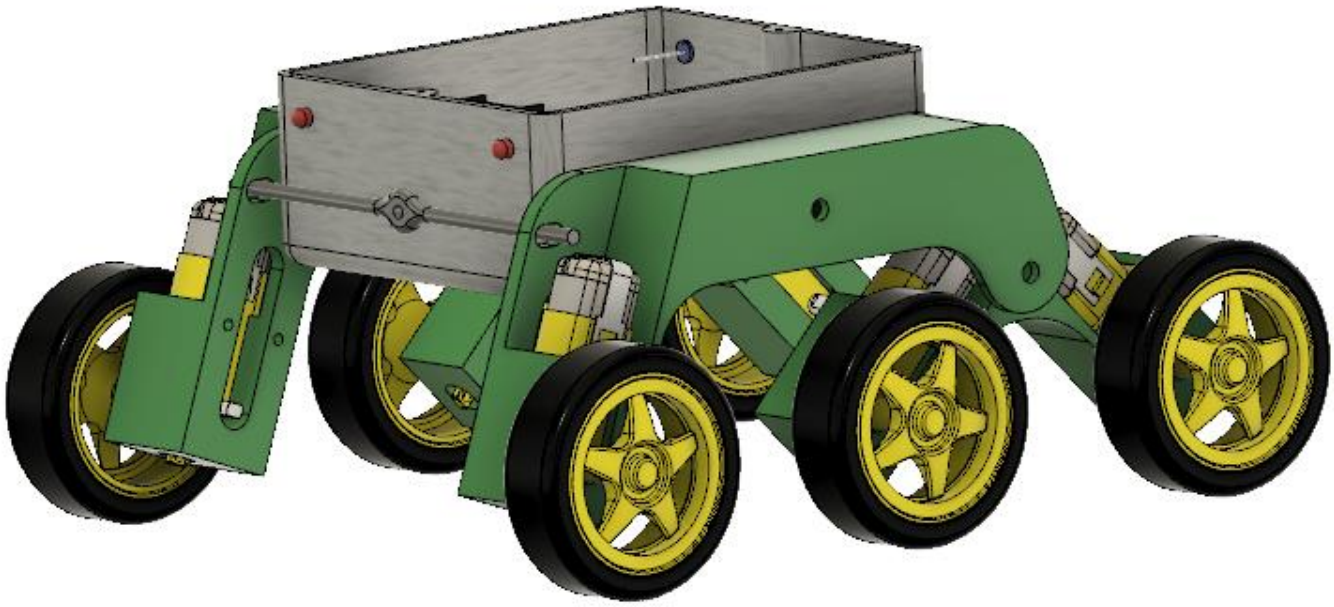
Activity 4.5.6 Creating and assembling components

Students should have created components and assembled all parts of the rocker-bogie mechanism



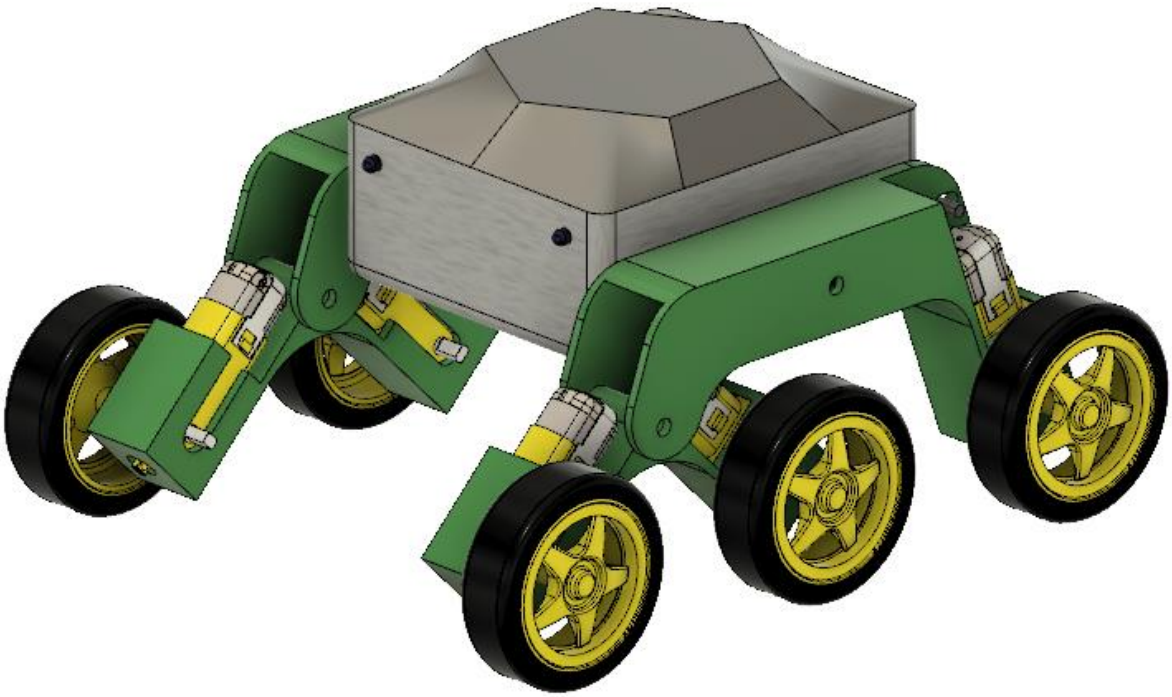
Activity 4.5.7-4.5.9

At this point students should have created the differential bar and applied joints to simulate realistic motion of the rocker-bogie mechanism.



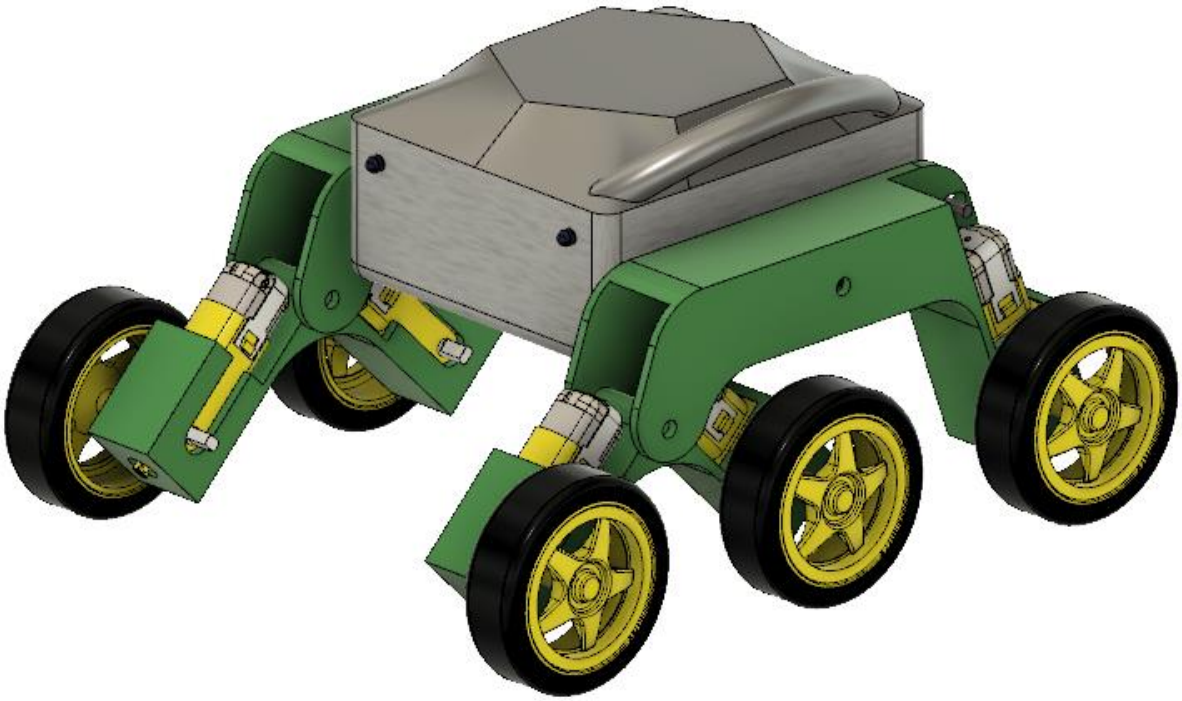
Activity 4.6.1

Students should create the shown loft.



Activity 4.6.2

Students should create the swept profile as shown.

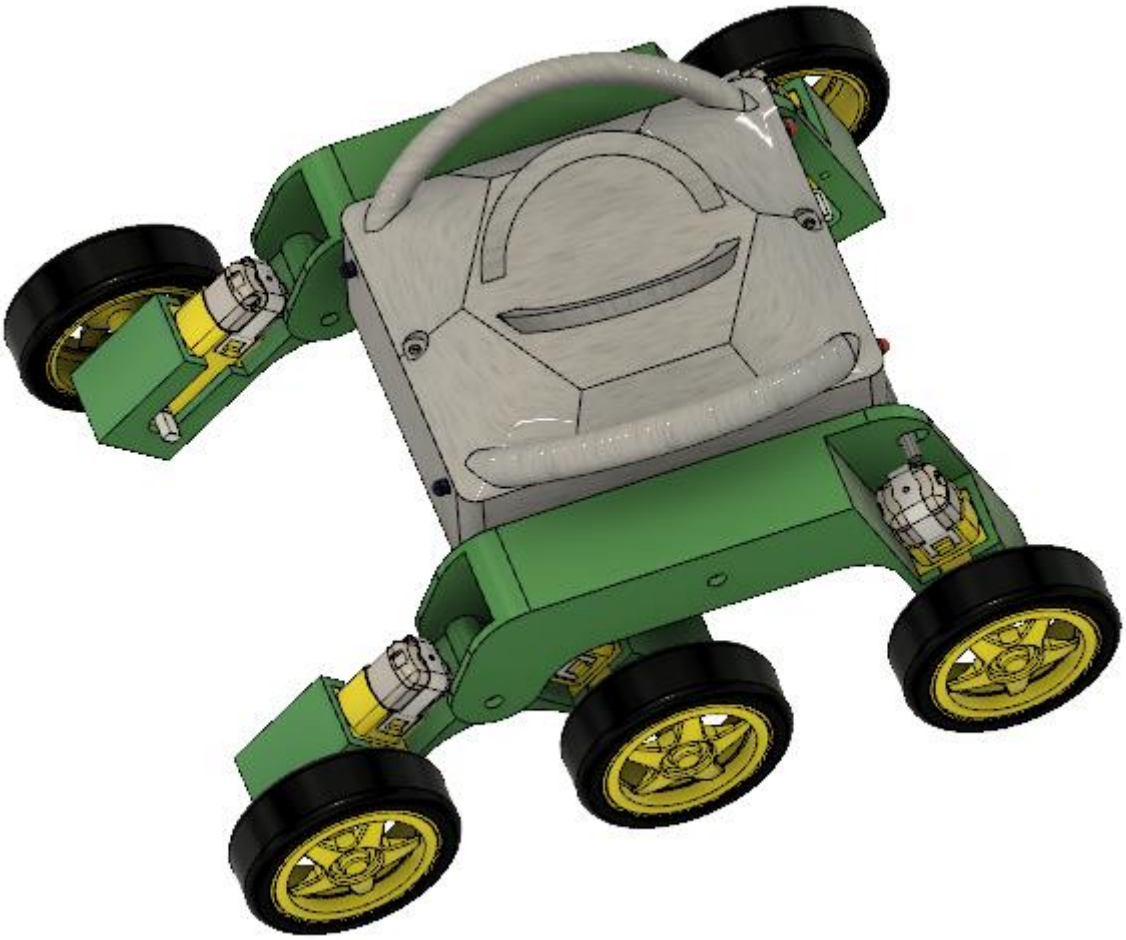


Activity 4.6.3

Students should create pipe as shown and mirror features across the centre plane.

Activity 4.6.4

Students should complete the sample top body by adding the mounting holes



Week 8 Lesson Plan:

Content	**Grade 12 Advance**	
	Chapter 4 – 3D Modelling	**Section 6 – Space rover top body**
	Chapter 5 – Design realisation	**Section 1 – Manufacturing and assembly of a space rover**
Time allocated 	**3 x 45-minute periods**	
Keywords 	**What are the keywords the students must learn?**	
	• CAM • CNC • FlashPrint	
Resources 	**What resources are required?** • textbooks • projector • sketching equipment	
Prior Knowledge 	• Design process • Vehicle technologies • Wireless Arduino control • Fusion 360 modelling	

Aim:

In this lesson, students will create their own unique top body using the skills learned throughout the term. Students will then begin manufacturing the space rover components. These parts will be manufactured using the 3D printing process. Students will then assemble all the parts using suitable joining methods. Finally, Students will assemble all electronic components with the 3D printed model to complete the space rover. Students will program and test the project before evaluating its performance.

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 they have covered a learning objective.

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.

Teacher should: *(tick as you complete)*	***Students should:*** *(tick as students complete)*
☐ Facilitate and provide feedback on student designs.	☐ Create a unique top body model.
☐ Recap on the 3D printing process.	☐ Convert 3D models to STL files.
	☐ Insert and set up STL files for 3D printing in Flash Print.
	☐ 3D print all space rover components.
☐ Demonstrate assembly of the space rover parts	☐ Assemble all parts using suitable joining methods

Possible teaching method(s) or approach for this lesson

(teacher to tick the relevant method)

- ☐ 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	
Chapter	**Section**	**Focus**	**Essential**	**Non-essential/Self Study**
4	**6**	Space Rover top body	Pg. 277-279	
5	**1**	Manufacturing and assembly of a space rover	Pg. 281 - 302	

Learning Phases - Week 8: Period 1-2 (Ch. 4: Section 6)

<table>
<tr><th>Phase 1 of lesson (Connect) – Starter</th><th>Phase 2 of lesson (Activate)</th><th>Phase 3: (Engage and Demonstrate)</th><th>Phase 4: Plenary (Consolidate)
Return to begging of next row</th><th>Assessment opportunity</th><th>Notes for Differentiation</th></tr>
<tr><td rowspan="2">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.

Introduce all key words for the lesson.

Recap on the skills used to create the top body in the previous lesson.

<u>Teacher Tip:</u>

Teacher to set high expectations which inspire, motivate and challenge pupils.</td><td>a) Teacher to present activity 4.6.5 and ensure understanding of the task.</td><td>a) Facilitate and provide feedback on designs as students model their own unique top body.

Encourage students to consider logistics of 3D printing in design.</td><td></td><td>Activity 4.6.5</td><td rowspan="2"></td></tr>
<tr><td></td><td></td><td>Teacher to facilitate as students evaluate learning.

Question pupils on what they have learned. Relate questions to Fusion 360 features used.

Have learning outcomes been met? Has the lesson aim been achieved?</td><td>Visual inspection of Fusion model

Student evaluation</td></tr>
</table>

Learning Phases - Week 8: Period 3 (Ch. 5: Section 1)

Phase 1 of lesson (Connect) – Starter	Phase 2 of lesson (Activate)	Phase 3: (Engage and Demonstrate)	Phase 4: Plenary (Consolidate) Return to begging of next row	Assessment opportunity	Notes for Differentiation
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. Introduce all key words for the lesson. Discuss previous knowledge of 3D printing and assembling **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	a) Teacher to present how CAD is used for CAM. Recap on the 3D printing process	a) Students to save all parts as STL files and begin 3D printing.		**Oral questioning** **Inspection of 3D printed parts** **Activity 5.1.1**	
	b) Demonstrate assembling the 3D printing parts using nuts and bolts.	b) Facilitate as students assemble the printed parts. ***(note you can move onto the next lesson if waiting on parts to be printed)***	Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Relate questions to Fusion 360 features used. Have learning outcomes been met? Has the lesson aim been achieved?	**Activity 5.1.2** **Oral questioning**	

Answer Key

QR code links:		
Page	***Topic***	***Link***

Activity 4.6.5

Top body should be unique.

Should incorporate lofts, sweeps and pipe feature.

Should be realistic and printable.

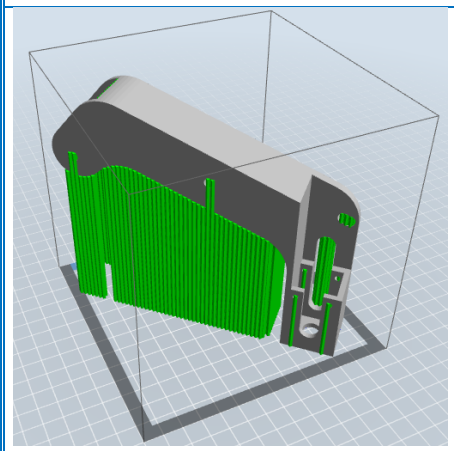
Should be the correct size to fit the chassis.

Mounting holes should match the chassis.

Activity 5.1.1

You must print all components of the space rover. Figure 5.1.14 ***Error! Reference source not found.*** *shows how to position the rockers as they are longer than 140mm. Paste a picture of all the printed parts in the space below.*

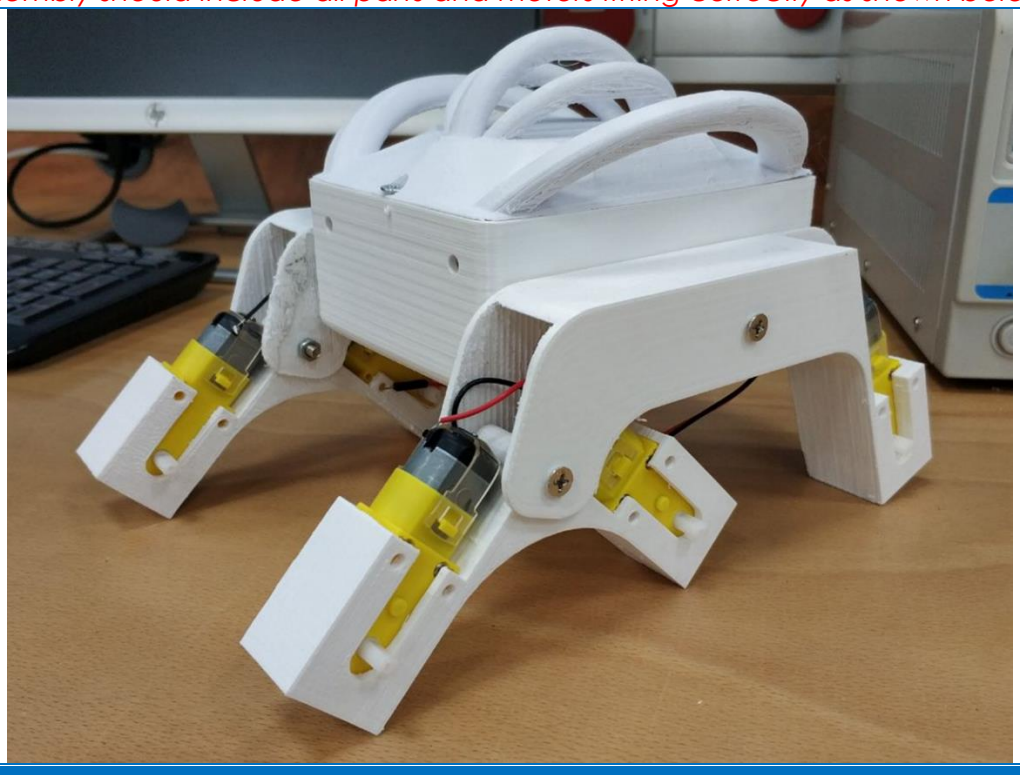
Rocker



Show all 3D printed parts

Activity 5.1.2

Assemble all the 3D printed parts and the motors as shown.
Students assembly should include all parts and motors fitting correctly as shown below.



Week 9 Lesson Plan:

Content	**Grade 12 Advance**	
	Chapter 4 – 3D Modelling	**Section 6 – Space rover top body**
	Chapter 5 – Design realisation	**Section 1 – Manufacturing and assembly of a space rover**
Time allocated 	**3 x 45-minute periods**	
Keywords 	**What are the keywords the students must learn?**	
	• CAM • CNC • FlashPrint	
Resources 	**What resources are required?** • textbooks • projector • sketching equipment	
Prior Knowledge 	• Design process • Vehicle technologies • Wireless Arduino control • Fusion 360 modelling	

Aim:

In this lesson, students will continue manufacturing the space rover components. These parts will be manufactured using the 3D printing process. Students will then assemble all the parts using suitable joining methods. Finally, Students will assemble all electronic components with the 3D printed model to complete the space rover. Students will program and test the project before evaluating its performance.

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 they have covered a learning objective.

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.

Teacher should: *(tick as you complete)*	***Students should:*** *(tick as students complete)*
☐ Continue facilitating 3D printing and assembling if needed	☐ Convert 3D models to STL files.
	☐ Insert and set up STL files for 3D printing in FlashPrint.
	☐ 3D print all space rover components.
	☐ Assemble all parts using suitable joining methods.
☐ Demonstrate the assembly of the final electric circuit	☐ Fully assemble the electronic circuit.
☐ Facilitate and provide feedback as students evaluate.	☐ **Evaluate the final project.**

Possible teaching method(s) or approach for this lesson

(teacher to tick the relevant method)

- ☐ 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	
Chapter	**Section**	**Focus**	**Essential**	**Non-essential/Self Study**
5	**1**	Manufacturing and assembly of a space rover	Pg. 281 - 302	
1	**1**	Evaluation	Pg. 47	

Learning Phases - Week 9: Period 1-3 (Ch. 4: Section 6)

Phase 1 of lesson (Connect) – Starter	Phase 2 of lesson (Activate)	Phase 3: (Engage and Demonstrate)	Phase 4: Plenary (Consolidate) Return to begging of next row	Assessment opportunity	Notes for Differentiation
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. Introduce all key words for the lesson. Recap on 3D printing and asses what point each group is at. Organise printing if more parts need to be printed. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	a) Teacher recap on printing and ensure all parts are printed.	a) Facilitate and provide feedback as students continue printing and assembling parts.		**Activity 4.6.5**	
	b) Demonstrate the assembly and soldering of the final electric circuit	b) Facilitate and provide feedback as students assemble and solder the electric circuit.		**Visual inspection circuit**	

		c)Facilitate and provide feedback as students finalise the circuit and code.		**Visual inspection of finished project** **Activity 5.1.3**	
	d) Present the evaluation questions to students	d) Facilitate and provide constructive feedback as students reflect on and evaluate the	Teacher to facilitate as students evaluate learning. Question pupils on what they have learned from the project. What would they do differently Have learning outcomes been met? Has the brief been satisfied?	**Activity 1.1.10** **Student evaluation**	

Answer Key

QR code links:		
Page	**Topic**	**Link**
282	5 axis machining	https://www.youtube.com/watch?v=RnIvhlKT7SY
282	Additive manufacturing	https://www.youtube.com/watch?v=R-W3y_gX_Mo

Activity 5.1.3

Add a 5V buzzer to your circuit. It must sound when you press the horn button on the mobile application. Paste an image of your fully assembled space rover and final Arduino program below.
Note the addition of a buzzer won't be assessed and can be added in week 11.

Code	**Space rover with circuit visible**
Full tested and working code should be pasted below *As in activity 3.2.4 or with modifications to add buzzer etc.* *Correct as long as:* *-All driving functions operate as per commands on the app (motors forward when forward command sent etc)* *-LEDs are controlled on/off using the app*	*Paste an image of the assembled circuit*

Fully assembled space rover with top body

Paste an image of the finished model.

Week 10 Lesson Plan:

Content	Grade 12 Advance
	Summative Assessment
Time allocated 	3 x 45-minute periods

Week 11 Lesson Plan:

Content	Grade 12 Advance
	Adding Buzzer and modifying code
Time allocated 	3 x 45-minute periods

Aim:

This lesson is not assessed and should be treated as a week for exploring without the fear of failure. Students should be encouraged to add a buzzer (or another electrical device to be controlled.)

Students should be encouraged to modify the code and experiment with motor speeds, turning circles and more. Use this time to reflect on the project and apply any ideas students have without affecting the assessed project.