Creative Design and Innovation

G12 Teacher's Guide

CREATIVE DESIGN
INNOVATION

Term 1 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. This IP can be found on LMS, where some very important resources are attached to each week and need to be downloaded by the teacher.

Note that the IP is divided into weeks, not lessons. The same applies to Lesson Plans. 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 allows 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. Throughout the book, there are several references to the Project Booklet (PB). The PB is another supplementary material aims to provide students with extra projects that they can practice in their own time. It will be shared with teachers through SharePoint throughout the term.

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 sources that eventually feeds into many sciences and fields. Please let your students know this in advance. It will allow them to give a special attention to the subject and will make them interested in exploring more about it. 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 theme with project-based learning and its assessment scheme in details.

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

The authors,

July, 2018

Instructional Planner:

Trimester Planner (Instructional Planner)
Term one for 2018/2019

SUBJECT: Creative Design and Innovation (CDI)

Grade 12

Week	Period	Chapter	Overview	Learning Outcomes
1 2/9	1	1	**Section 1:** • The design process • Trimester Project: Design of Military Vehicle	• Analyse a brief • Distinguish between different types of research • Carry out and present research and investigation • Create neat possible solution sketches • Create an improved final solution design • Evaluate the final project
	2	2	**Section 1:** What is Fusion 360?	• Register for fusion 360 • Open a new design • Save a file • Navigate the toolbar • Open and navigate the data panel • Share work from your data panel • Download files and upload files to your data panel
	3	2	**Section 2:** Introduction to basic modelling	• Identify 2D sketch tools • Identify and distinguish between planes • Create Dimensioned 2D sketch • Create 3D model using extrude too
2 9/9 Islamic New Year 11/9 1 day	1	2	**Section 2 (continued):** Creating first part- tank top cover	• Create Dimensioned 2D sketch • Create 3D model using extrude too • Distinguish between different hole types • Create a hole using the hole tool • Mirror a sketch using mirror tool
	2	2	**Section 3**: Creating model of tank chassis	• Recap on skills from section 1 and 2 • Create and extrude a rectangular base • Shell the extrude to make a hollow model

Week	Period	Chapter	Overview	Learning Outcomes
	3	2		• Create a rib • Advanced sketching- create struts • Create a hole using the hole tool • Mirror a feature using mirror tool
3 16/9	1	2	**Section 4:** Creating model of tank sprocket	• Creating a sprocket to drive the tank • Extruding a circle • Sketch a circular pattern • Using the arc tool
	2	2	**Section 5:** Creating model of tank turret	• Improving sketching skills • Compare a chamfer and a fillet • Create a chamfer
	3	2	**Section 6:** Creating model of tank cannon	• Sketching a profile for a revolve • Improving sketching skills • Use Revolve tool to create 3D model. • Recap on chamfer • Introduction to the fillet tool
4 23/9	1	2	**Section 7:** Creating model of tank cannon holder	• Sketching a profile for the cannon holder • Improving sketching skills • Recap on drawing an arc • Recap on fillet tool
	2	2	**Section 8:** Assembling parts	• Join two parts together using the join tool • Combine two parts for 3D printing • Identify the difference between a rigid joint and a revolute
	3	2	**Section 8 (continued):** Assembling parts	• Complete a full assembly of all your created parts
5 30/9	1	2	**Section 9:** Preparing and 3D printing finished Fusion 360 models	• Save a body as an STL file • Create a new Flashprint project • Import an STL file • Rotate and move models • Add supports for printing • Create a GX file for printing
	2	3	**Section 1**: What is Arduino?	• Explain the applications of the Arduino microcontroller. • Identify the main parts of the Arduino board.

Week	Period	Chapter	Overview	Learning Outcomes
	3			• Recognise the layout of the Arduino ide programming interface. • Explain the Arduino programming structure. • Configure the Arduino IDE software to work with the Arduino board.
6 7/10	1	3	**Section 2**: Arduino display tools	• Explain how to control the LCD screen. • Explain how to use Arduino's serial monitor. • Configure the Arduino IDE software to work with the Arduino board.
	2			
	3		**Section 3**: Pseudocode and flowcharts	• Understand the different types of algorithm description. • Understand the importance of flowcharts and pseudocode in computer programming. • Use flowcharts and pseudocode to understand how a program works.
7 14/10	1	3	**Section 4**: Analogue and digital signals	• Differentiate between digital and analogue signals. • Identify how to read digital signals in Arduino. • Interpret how to generate a digital signal. • Identify how to read analogue signals in Arduino. • Describe the function of PWM signals in electric circuits.
	2			
	3			
8 21/10	1	4	**Section 1:** Military vehicle electronics	• Identify the function of a motor driver. • Identify the different switches types then use an SPST switch to power two circuit boards. • Develop and evaluate an Arduino code using a switch statement. • Assemble electronic components to build a complete circuit of a military vehicle. • Use a Bluetooth module between a mobile application and Arduino.
	2			
	3			
9 28/10	1			
	2			
	3			
10	1	5	**Section 1:**	• Distinguish between Analog and digital signals.

Week	Period	Chapter	Overview	Learning Outcomes
4/11	2		Digital Fundamentals	• Explain signal quantities: amplitude, frequency, pulse width, and period. • Recognize some of digital device and applications. • Learn the basics of the binary system. • Learn the basics features of the oscilloscopes and how to use them. • Learn the conversion from decimal to the binary system.
	3			
11 11/11	1		**Section 2:** Digital Logic Design	• Learn common logic gates and understand their operations. • Understand the concept of truth tables. • Learn the basics of Boolean algebra and its main laws. • Build practical circuits to ensure understanding of digital gates.
	2			
	3			
	self-study	6: G11 Advance ONLY	**Section 1:** Introduction to microelectronics **Section 2:** Semiconductors applications	• Identify what is the semiconductors, microelectronics, and CMOS technology. • Recognise the main steps in the CMOS fabrication process. • Identify some of the popular semiconductor devices and applications. • Learn about the semiconductors technology in UAE. • Learn about the basics of MOSFET and its working principle. • Learn about the main applications of MOSFETs. • Differentiate between the two modes of MOSFETs operating as a switch. • Learn the main features and characteristics of MOSFET's switch modes. • Explain how MOSFETs can operate as a resistor. Build practical circuits to ensure understanding of some of main MOSFET's applications.
12 18/11 Prophets birthday 19/11 1 day	1	**Assessment Revision Week** "Not decide yet. Could be Any week within the 13 weeks. Will be confirmed later by ADU"		
	2			
	3			

Week	Period	Chapter	Overview	Learning Outcomes
13 25/11 Martyrs day 30/11 1 day	1		**Assessment Week** "Not decide yet. Could be Any week within the 13 weeks. Will be confirmed later by ADU"	
	2			
	3			

Lesson Plans:

Week 1 Lesson Plan:

Content	**Grade 12** **Chapter 1: Engineering design** **Chapter 2: Introduction to basic modelling**	**Section 1: The engineering design process** **Section 1: What is Fusion 360** **Section 2: Introduction to basic modelling**
Time allocated 	**3 x 45-minute periods**	

Aim:

In this lesson, you will understand each stage of the design process and why it is important. You will also understand why the design process follows a specific loop and stages cannot be skipped or left out without affecting the finished design. Upon completion of section 1, you will have completed a small design portfolio to design a model of a military tank.
To conclude this week, you will understand what Fusion 360 is capable of as a software. You will understand how to register and download Fusion 360 on your personal computer, as well as a mobile application. You will open a new design and understand how to create a 2D sketch on a chosen plane.

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.

- ☐ Introduce key areas of a brief and the given project brief.
- ☐ Explain different types of research.
- ☐ Introduce sketching techniques.
- ☐ Critique and give feedback on solutions.
- ☐ Introduce fusion 360 download procedure.
- ☐ Demonstrate creating and saving files and navigating all tool bars.
- ☐ Demonstrate the function of data panel, sharing work and downloading files.
- ☐ Explain all sketch tools that will be used.
- ☐ Distinguish between planes and demonstrate a sketch a 2D sketch.

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

Students should be able to:

- ☐ Analyse a brief
- ☐ Distinguish between different types of research
- ☐ Carry out and present research and investigation
- ☐ Create neat possible solution sketches
- ☐ Create an improved final solution design
- ☐ 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.

Keywords	**What are the keywords the students must learn?** • Analysis • Research • Design Realisation • Evaluate • Arduino CAD • Computer Aided • Design) • Autodesk Fusion 360 • data panel • toolbar • 2D Sketch
Resources	**What resources are required?** • textbooks • projector • sketching equipment
Prior Knowledge	• Demonstrate creative ideas through meaningful sketches. • Utilize 3D printers in producing 3D models

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**	**Assessment**
Ch. 1	**Sec. 1**	Analysis of brief	23-26	-	-
		Research and investigation	27-32		
		Possible solutions	33-37		36-37
		Final design solution	38-40		39-40
		Design realisation / Manufacture	41		-
Ch. 2	**Sec. 1**	Installing and registering for Fusion 360	48		
		Opening a new design	49-51		
Ch. 2	**Sec. 1**	Downloading files	-	52	
Ch. 2	**Sec. 2**	2D sketching	55-61		

Learning Phases:

Phase	Development [Phases or chunks of learning] ***Note:*** *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.*	Assessment opportunities	Notes for differentiation ***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.*
Phase 1 of lesson **(Connect) - Starter**	Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Discuss prior knowledge of the engineering design process. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	**Questioning**	
Phase 2 of lesson **(Activate)**	Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. 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 b) Introduce students to different methods of research and design inspiration. Analyse given example mood board c) Introduce the given possible solution	**Oral assessment**	

	Demonstrate correct sketching techniques using isometric paper and crating. d) Introduce assessment sketch and available marks. e) Explain how a final solution is arrived at before introducing the marks for Final design assessment activity. f) Introduce and explain the importance of the design realisation stage. Discuss the skills that will be developed to manufacture the project over the coming weeks. g) 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 h) Facilitate as student's complete activities 1.1.4-1.1.6 to carry out their own unique research. i) Facilitate as students complete sketching activity 1.1.7 j) Provide feedback on first sketch before students complete second possible solution k) Facilitate as students complete an individual and unique final design for assessment sketching activity l) Students to discuss the importance of each skill in the completion of a working military tank model. **<u>Teacher Tip:</u>** *Teacher to demonstrate good subject and curriculum knowledge*	**Activity 1.1.1 -1.1.3** **Written Activity 1.4 -1.1.6** **Sketch 1.1.7** **Official assessment activity 1.1.8** **Official assessment activity 1.1.9** **<u>Note: If struggling for time some of these sketching exercises could be completed at home for homework</u>**	
Phase 3 of lesson **(Engage**	a) Demonstrate the installation of Fusion 360 applications b) Demonstrate opening and navigation Fusion 360 software. Answer any questions students may pose.	**<u>Oral assessment</u>**	

	c) Demonstrate the given MOE CDI file and how it can be downloaded and uploaded to data panel. d) Introduce 2D sketching and all the possible sketching tools. (A visual demonstration on Fusion 360 here can aid the textbook diagram) e) Demonstrate the planes in Fusion 360 and question pupils on correct plane to create cylinder. f) Demonstrate how to sketch and dimension a simple square. g) Students to Access sample file and download to PC. Students should then upload to their own data panel and open and explore the file. h) Students should note all the possible sketch tools and question the purpose of any sketch tools they are unsure of i) Students to complete activity 2.2.1 on plane selection. j) Students to observe and question demonstration. Students then to complete all shapes in activity 2.2.2 **<u>Teacher Tip:</u>** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.*	**Activity 2.2.1** **Activity 2.2.2**	

Phase 4 of lesson - **Plenary (Consolidate)**	Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the official assessment tasks and reflections. Finish Chapter 1 for homework.	**Oral Assessment** **Student evaluation**	

Answer Key

QR code links:		
Page	***Topic***	***Link***
34	Sketching	https://www.youtube.com/watch?v=DY3gqgp6sKg

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 speaker 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:

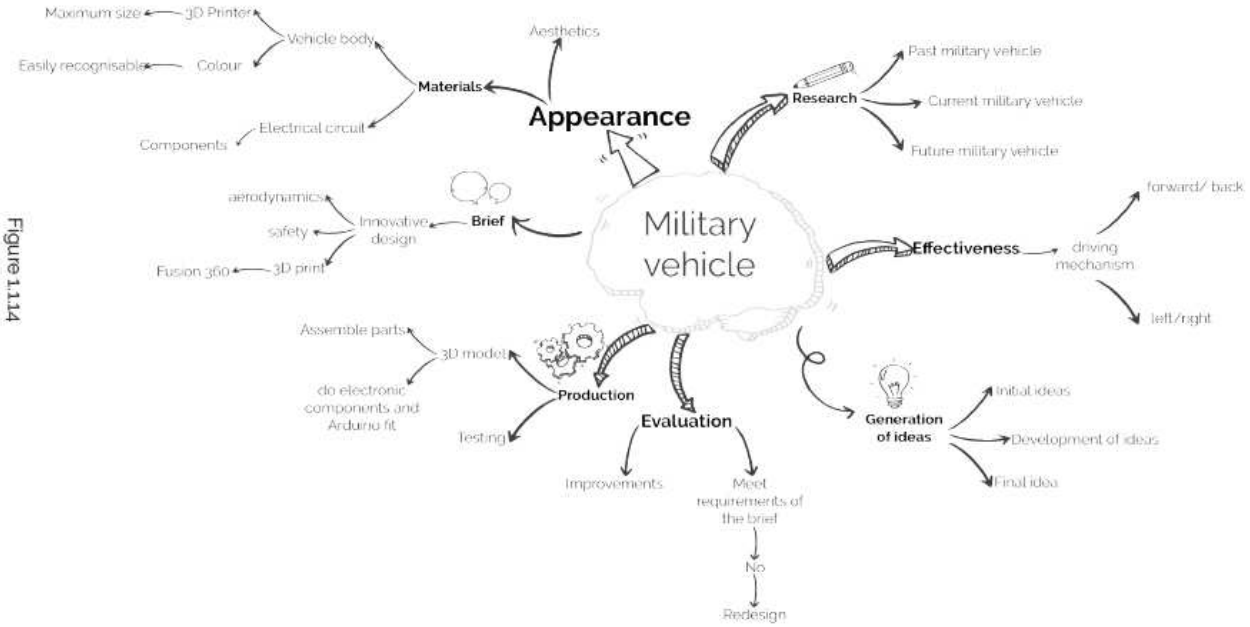


Figure 1.1.14

Activity 1.1.4

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?

Color can affect the first impression of a new product. Eye catching colors can benefit the sales of a product.

2)What style must my design be?

My design must follow a military style.

3) What materials are suitable for 3D printing?

Acrylonitrile butadiene styrene (ABS)

Polylactic Acid (PLA)

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

140mm x 140mm

5)What is the diameter of the speakers provided for the project? How will this affect design?

Measure the given motors, battery pack and Arduino board. Must be at least 140mm long.

Activity 1.1.5

Military tank circuit research

Answer the questions below to help you carry out research on the military tank circuit:

Note: Use the circuit is provided in chapter 4 to help the research.

1) Identify the motor type (DC or AC) that will be used to drive the tank. Justify your answer.

DC motor, because it is powered by a direct current power source (battery).

2) What is the function of the motor driver?

Takes a low current control signal and turn it to a high current signal that can drive a motor. The L298N motor driver allows you to control the speed and direction of two DC motors; it can be used with motors that have a voltage of between 5 and 35V DC.

3) How does the Bluetooth module work? What are the advantages and disadvantages of wireless communication?

Bluetooth module is a hardware component that transfers data wirelessly to a system. Any electronic communication system is made up of three parts; a transmitter, a communication channel and a receiver.

Bluetooth gadgets have built-in radio antennas. Antennas contain both transmitters and receivers to send and receive wireless signals.

Advantages 1) Data can be transmitted faster and with a high speed 2) The cost of maintenance and installation is not high

Disadvantages 1) Wireless signals can be captured by an unauthorized person 2) The wireless network needs to be secured so that the information is not misused by unauthorized users

4) How can you control the direction of the motor's rotation?

By reversing the wire polarities so that each wire is connected to the opposing power supply terminal.

5) What is the function of the Arduino microcontroller?

Arduino acts like a computer. It can be programmed using an easy-to-use software to perform simple or complex tasks. It takes sensory input (from a pushbutton, light sensor, microphone, etc.) and gives a specific output (drive a motor, turn LED on, play music, etc.).

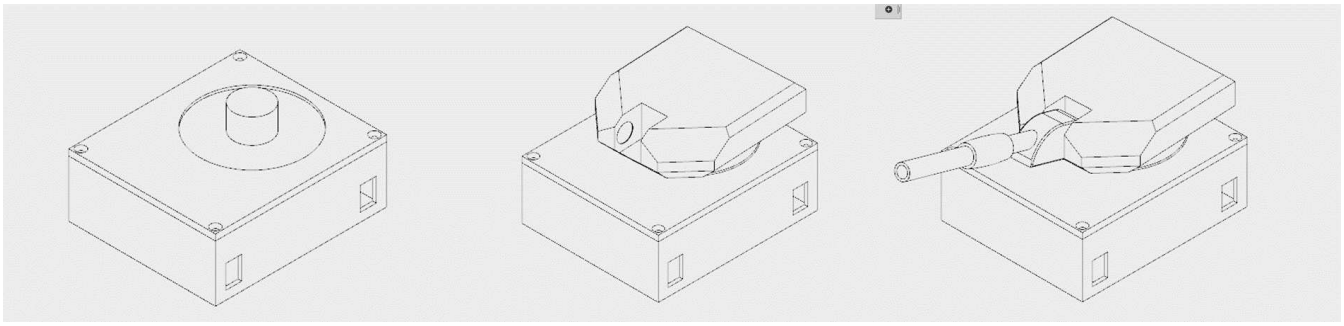
Activity 1.1.6

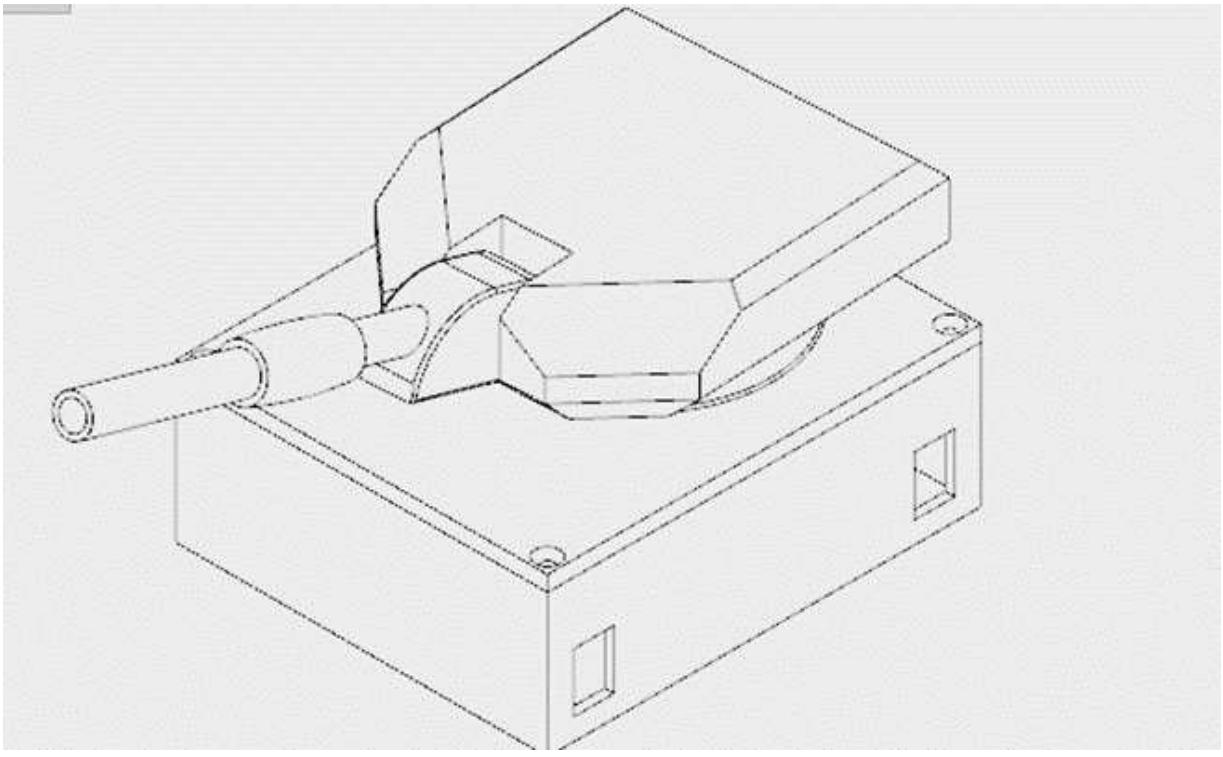
In the space below create a mood board/research page to display the information gathered in activities 1.1.2 – 1.1.5. You must use a combination of images or sketches and notes.

Activity 1.1.7

Sketch the given possible solution

Use the dotted grid to help you create the outline shape before refining your sketch. Sketch the military vehicle design in separate stages as shown below. Sketch the wheel-sprockets of tank freehand. Remember to sketch lightly in pencil then refine.





Advantages:

_____

Disadvantages:

_____

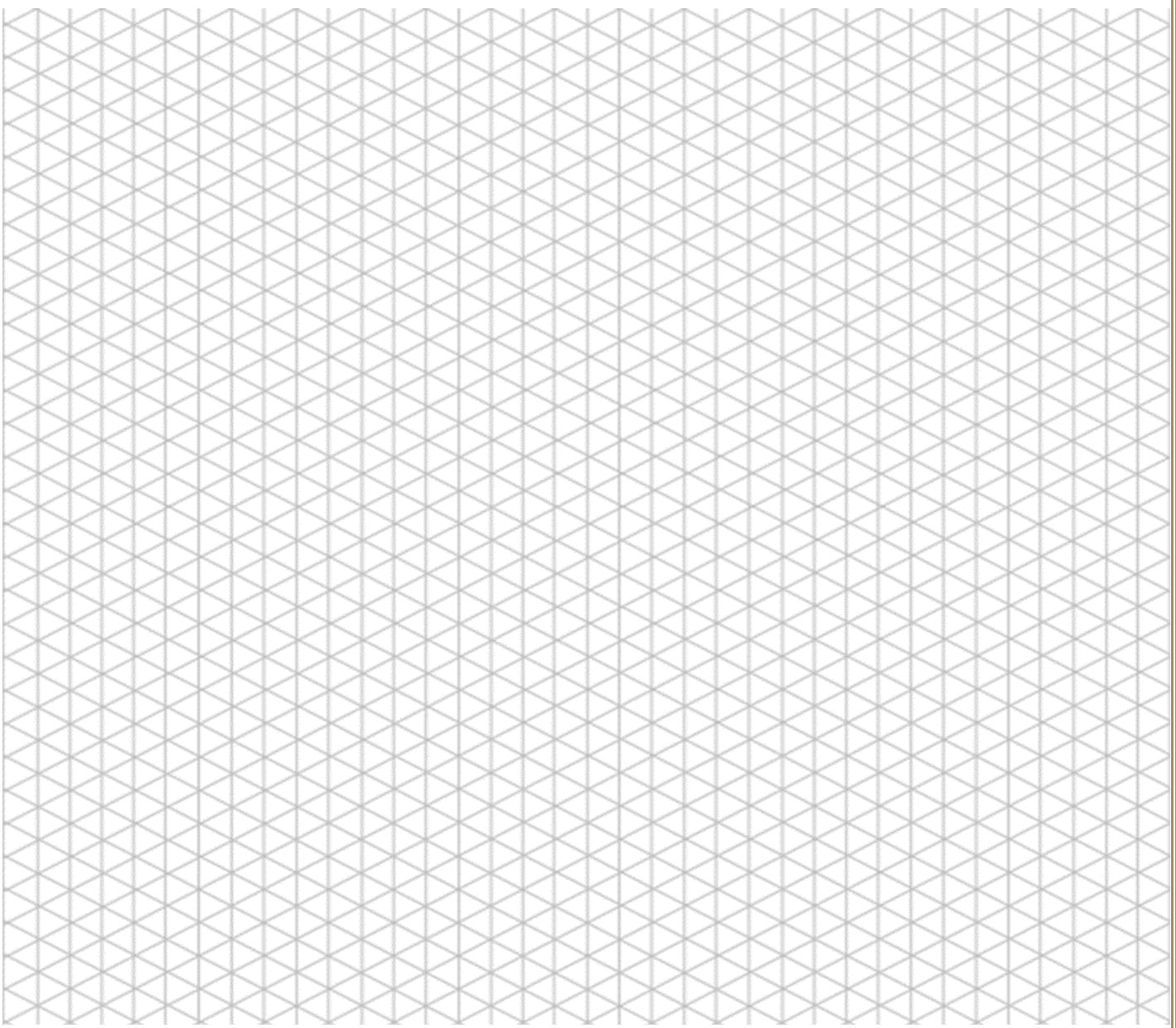
Assessment Task

Possible Solution	Key Skills: 3D sketches, Rendering, Shading

Activity 1.1.8

Sketch a new improved possible solution based on research gathered:

Use the Isometric grid paper as a help if required, if not you may use the blank page.



Advantages:

_____

Disadvantages:

_____

Advantages:

_____

Disadvantages:

_____

Student Grade	Teacher Grade
☆☆	☆☆
Teacher Feedback	
What went well?	**What could be better?**

Assessment Task

Final Solution	Key Skills: 3D sketches, Rendering, Shading, Labelling, Annotations

Activity 1.1.9

Sketch one final design for your military vehicle

- State three reasons for choosing this design.
- Select suitable materials for manufacture.

Student Grade	Teacher Grade
☆☆	☆☆
Teacher Feedback	
What went well?	**What could be better?**

Activity 2.2.1

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

Circle

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

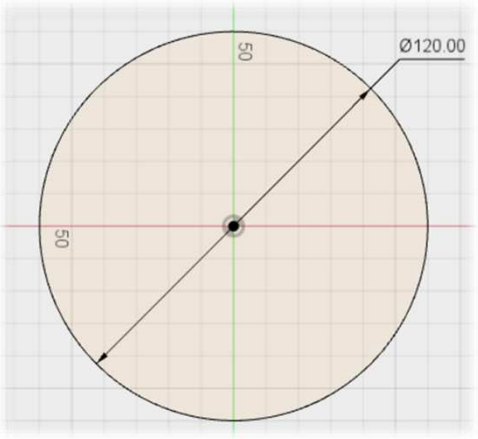
2) XY

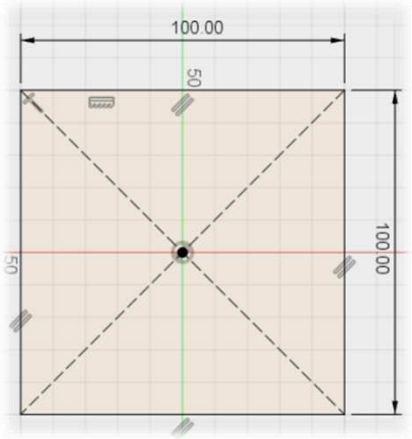
3) YZ

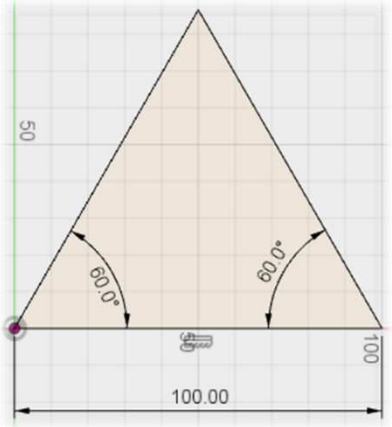
Activity 2.2.2

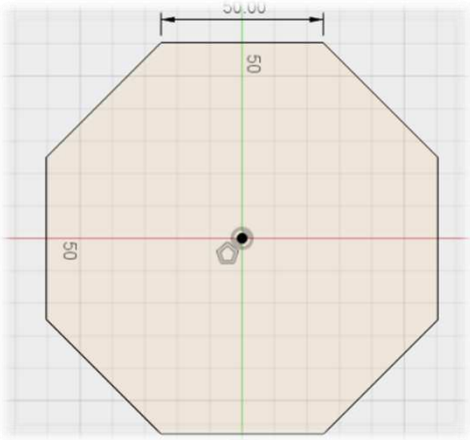
You now understand how to choose a plane for 2d sketching. Open a new design and create a new sketch on the XZ plane as shown below

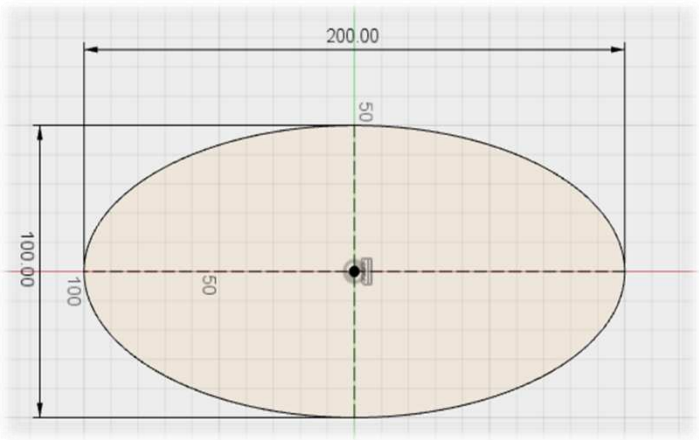
On the XZ plane sketch and dimension the shapes shown below.











Note: Pay attention for correct dimensions and fully defined sketches.

Week 2 Lesson Plan:

Content	**Grade 12** **Chapter 2: Introduction to 3D modelling**	**Section 2b: Introduction to basic modelling- creating the top cover of the tank**
		Section 3: Creating a model of tank chassis
Time allocated 	**3 x 45-minute periods**	

Aim:

Upon completion of this lesson you will have completed sections 2-3, the aim is to create your first part of the the tank on Fusion, the top cover. You will also make the tank chassis this week. You will use the basic skills you have learnt on Fusion to create the top cover. You will recap on the skills of 2D sketching, extruding, extruded cuts and creating holes on the tank chassis. You will also learn the new skills of shelling bodies and creating a rib.

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.

- ☐ Distinguish between planes and demonstrate a sketch a 2D sketch.
- ☐ Demonstrate how to dimension properly
- ☐ Demonstrate the extrude tool.
- ☐ Facilitate as students create extrude for top cover
- ☐ Introduce the mirror tool
- ☐ Explain hole types and demonstrate the hole tool to create these holes.
- ☐ Explain and demonstrate the shell feature.
- ☐ Explain and demonstrate the rib feature

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

Students should be able to:

- ☐ Create dimensioned 2D sketch.
- ☐ Create a 3D model using extrude tool.
- ☐ Duplicate a sketch using the mirror tool.
- ☐ Distinguish between different hole types.
- ☐ Create a hole using the hole tool.
- ☐ Mirror a sketch using mirror tool.
- ☐ Recall basic skills in 3D modelling
- ☐ Create and extrude a rectangular base
- ☐ Shell an extrude to make a hollow model
- ☐ Create a rib

Keywords	**What are the keywords the students must learn?** • extrude • hole • chassis • rib • shell
Resources	**What resources are required?** • textbooks • projector • Fusion 360 • STL file of tank track (check shared resources)
Prior Knowledge	• recognise the user interface of Fusion 360 • use the extrude tool to transform shapes from 2D to 3D • hole tool

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**	**Assessment**
Chapter 2	**Sec 2**	Tank top cover	61-67	-	68
	Sec. 3	Creating tank chassis	70-81		82

Learning Phases:

Phase	Development [Phases or chunks of learning] ***Note:*** *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.*	Assessment opportunities	Notes for differentiation ***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.*
Phase 1 of lesson **(Connect) - Starter**	Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Discuss prior knowledge of Fusion 360 fro last week **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	**Questioning**	

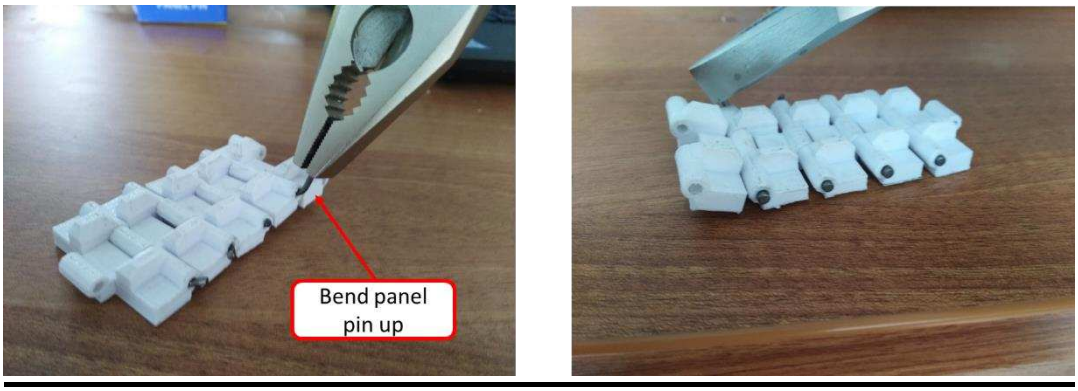
Phase 2 of lesson **(Activate)**	Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. **Section 2b: Introduction to basic modelling- creating the top cover of the tank** Teacher to ensure all students have Fusion downloaded. a) Recap on how to sketch and dimension a simple square. b) Introduce the first part of the project, The Top Cover. Demonstrate the required base sketch and how to extrude to a 3D shape. c) Explain the hole tool and types of holes. d) Introduce the mirror tool e) Demonstrate how to make a countersunk hole in each corner. **Teacher Tip:** *Teacher to demonstrate good subject and curriculum knowledge*	**Oral assessment** **Official assessment task for top cover (Section2)**	
Phase 3 of lesson **(Engage and Demonstrate)**	Introduce students to section 3- creating the tank chassis. Teacher to introduce all keywords, discuss the meaning and ensure understanding before progressing. **Section 3: Creating a model of tank chassis** a) Demonstrate how to create rectangle and extrude for chassis. b) Demonstrate the new skill of shelling a solid model c) Students to use previous skills to create extrude rectangular cuts in the chassis d) Demonstrate the new skill of creating a rib		

	e) Demonstrate how to create motor supports f)Students to make countersunk holes in the supports g) Demonstrate how to mirror features **<u>Teacher Tip:</u>** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.*	**Official assessment task for tank chassis(Section3)**	
Phase 4 of lesson - **Plenary (Consolidate)**	Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the official assessment tasks and reflections	**Oral Assessment** **Student evaluation**	

Answer Key

QR code links:		
Page	***Topic***	***Link***
67	Section 2 video guide: Top cover	https://autode.sk/2KifwGS
81	Section 3 video guide: Tank chassis	https://autode.sk/2KpBDf8

Printing and assembling the tank track



The STL file for the track of the military tank will be provided to you on your online resources. It would be best to **have this printed in week 2 or 3**, to have prepared for the student's assembly stage later in the term. You will need to print 28 of these for each side of the tank so 56 in total per project. You will be able to print multiple track parts on each printing bed. When assembling the track you will slide one of the panel pins provided through each slot. You will then bend upwards, far enough that track remains tightly fastened as shown in the image above. You will then cut the end off panel pin to finish.

Week 3 Lesson Plan:

Content	**Grade 12** **Chapter 2: Introduction to 3D modelling**	**Section 4: Creating a model of tank sprocket**
		Section 5: Creating a model of a tank turret
		Section 6: Creating a model of a tank cannon
Time allocated 	**3 x 45-minute periods**	

Aim:

Upon completion of this lesson, you will be able to create the tank sprocket. To create the sprocket you will learn how to use the pattern tool.
You will then begin to create the turret, this will be your first introduction to both the chamfer and fillet tool. Lastly, you will make the tank cannon, to make the cannon you will learn to use the revolve tool to create a revolved 3D model from a 2D sketch. You will recap on many basic tools throughout such as sketch, dimension, and mirror.

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.

- ☐ Demonstrate how to create a sprocket.
- ☐ Introduce students to the pattern tool.
- ☐ Demonstrate how to sketch an arc
- ☐ Recap on sketching skills
- ☐ Introduce students to the chamfer and fillet tool.
- ☐ Facilitate students as they use the chamfer tool.
- ☐ Explain the revolve tool before revolving the sketch 360 degrees.
- ☐ Demonstrate how to use the fillet tool

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

Students should be able to:

- ☐ Create a sprocket to drive a military tank.
- ☐ Extrude a circle to create shape of sprocket
- ☐ Sketch a circular pattern
- ☐ Use the arc tool to sketch an arc
- ☐ Improve sketching skills
- ☐ Compare a chamfer and a fillet
- ☐ Create a chamfer
- ☐ Create a revolved model using a sketched profile.
- ☐ Use revolve tool to create a 3D model.
- ☐ Improve sketching skills.
- ☐ Recap on chamfer

Keywords	**What are the keywords the students must learn?** • sprocket • sketch pattern • arc • turret • chamfer • fillet • cannon • revolve
Resources	**What resources are required?** • textbooks • projector • Fusion 360
Prior Knowledge	• Demonstrate creative ideas through meaningful sketches. • Applying dimensions to distances and angles in 2D sketches. • Recall basic skills in 3D modelling using Fusion 360 • Use the extrude tool to transform shapes from 2D to 3D • Use mirror tool to duplicate sketches

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**	**Assessment**
Chapter 2	**Sec. 4**	Creating a model of tank sprocket	84-91	-	92
	Sec. 5	Creating a model of a tank turret	94-101		102
	Sec. 6	Creating a model of a tank cannon	104-107		108

Learning Phases:

Phase	Development [Phases or chunks of learning] ***Note:*** *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.*	Assessment opportunities	Notes for differentiation ***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.*
Phase 1 of lesson **(Connect) - Starter**	Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Recap on Fusion 360 skills from previous lesson **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	**Questioning**	
Phase 2 of lesson **(Activate)**	Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. **Section 4: Creating a model of tank sprocket** a) Demonstrate how to extrude a circle. b) Introduce the pattern tool c) Students create a circular pattern d) Demonstrate how to use arc tool e) Students recap on sketching skills	**Oral assessment**	

	f) Students sketch two arcs using the arc tool. **<u>Teacher Tip:</u>** *Teacher to demonstrate good subject and curriculum knowledge*	**Official assessment task for tank sprocket (Section 4)**	
Phase 3 of lesson **(Engage and Demonstrate)**	Teacher to introduce all keywords, discuss the meaning and ensure understanding before progressing. **Section 5: Creating a model of a tank turret** a) Students recap on sketching skills b) Demonstrate how to use the trim tool. c) Introduce students to chamfer and fillet tool d) Students to compare a chamfer to a fillet e) Students to use the chamfer tool to improve the 3D model. f) Students will sketch and extrude a circular hole to hold cannon. **Section 6: Creating a model of a tank cannon** a) Introduce the revolve tool. b) Students sketch a profile for cannon c) Students create a revolve from the sketch profile and center axis. d) Demonstrate how to use fillet tool e) Students use the fillet tool to improved revolved models appearance. f) Students recap on extruded cut **<u>Teacher Tip:</u>** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.*	**Official assessment task for tank turret(Section 5)** **Official assessment task for tank cannon (Section 6)**	

Phase 4 of lesson - **Plenary (Consolidate)**	Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the official assessment tasks and reflections	**Oral Assessment** **Student evaluation**	

Answer Key

QR code links:		
Page	***Topic***	***Link***
91	Section 4 video guide: Creating a model of tank sprocket	https://autode.sk/2lxmkSG
101	Section 5 video guide: Creating a model of a tank turret	https://autode.sk/2K8mRJD
107	Section 6 video guide: Creating a model of a tank cannon	https://autode.sk/2yP5tof

Week 4 Lesson Plan:

Content	**Grade 12** **Chapter 2: Introduction to 3D modelling**	**Section 7: Creating model of tank cannon holder**
		Section 8: Assembling parts
Time allocated 	**3 x 45-minute periods**	

Aim:

Upon completion of this lesson, you will be able to create the cannon holder for the tank. To create you will learn to use the offset cut, you will also learn how to draw a tangent arc. Lastly, you will have to make an assembly of all the parts you have produced so far. You will compare a rigid joint to a revolve joint and learn how to combine two parts for 3D printing.
You will recap on basic tools such as sketch, and fillet throughout.

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.

- ☐ Demonstrate how to sketch profile for cannon holder
- ☐ Demonstrate how to sketch a tangent arc.
- ☐ Introduce students to an offset cut.
- ☐ Demonstrate how to create assemblies in Fusion.
- ☐ Demonstrate how to combine two pars for 3D printing.
- ☐ Explain the difference between a rigid and a revolute joint.
- ☐ Facilitate as students complete the full assembly

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

Students should be able to:

- ☐ Sketching a profile for the cannon holder
- ☐ Improve sketching skills
- ☐ Recap on drawing an arc using Fusion 360
- ☐ Recap on using the fillet tool in Fusion 360
- ☐ Join two parts in Fusion 360 together using the join tool
- ☐ Combine two parts in Fusion 360 for 3D printing
- ☐ Identify the difference between a rigid joint and a revolute
- ☐ Complete a full assembly of all your created parts

Keywords	**What are the keywords the students must learn?** • offset • rigid • revolute • combine
Resources	**What resources are required?** • textbooks • projector • Fusion 360 • Fusion file for motors (page 121)
Prior Knowledge	• Demonstrate creative ideas through meaningful sketches. • Applying dimensions to distances and angles in 2D sketches. • Recall basic skills in 3D modelling using Fusion 360 • Use the extrude tool to transform shapes from 2D to 3D

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**	**Assessment**
Ch. 2	**Sec. 7**	Creating a model of tank cannon holder	110-114	-	115
	Sec. 8	Assembling parts	117-129		130

Learning Phases:

Phase	Development [Phases or chunks of learning] ***Note:*** *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.*	Assessment opportunities	Notes for differentiation ***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.*
Phase 1 of lesson **(Connect) - Starter**	Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Recap on Fusion 360 skills from previous lesson **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	**Questioning**	
Phase 2 of lesson **(Activate)**	Teacher to introduce all keywords, discuss meaning and ensure understanding before progressing. **Section 7: Creating model of tank cannon holder** a) Demonstrate how to sketch profile for cannon holder b) Demonstrate how to sketch a tangent arc. c) students complete profile sketch of cannon holder	**Oral assessment**	

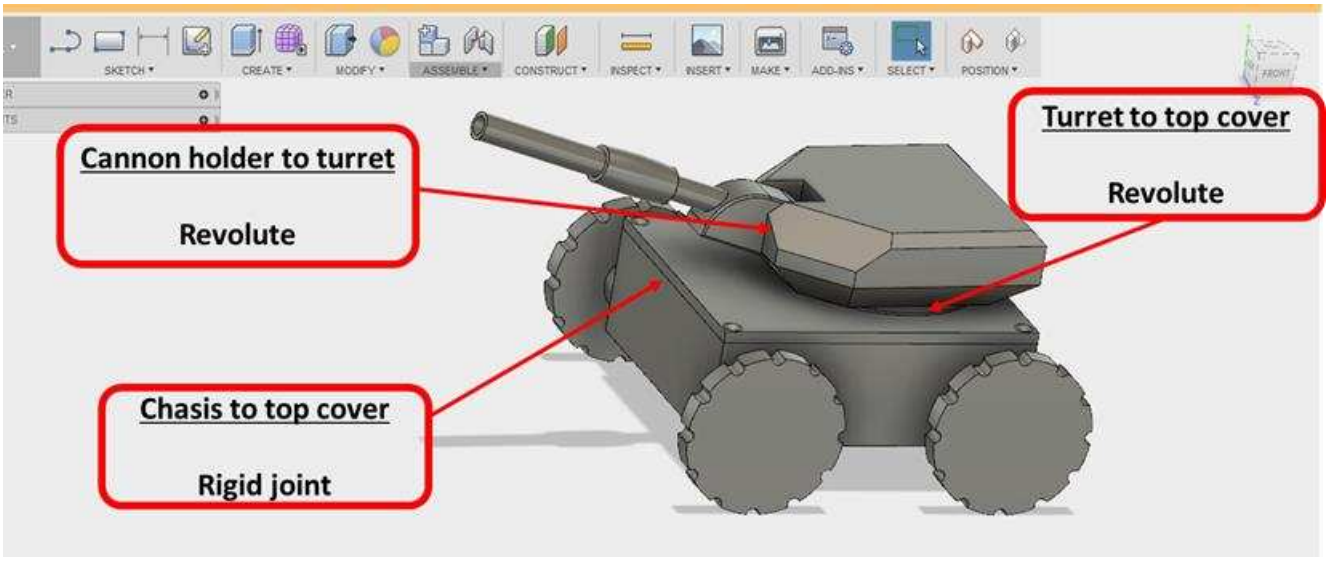
	d) Introduce students to an offset cut. Introduce the revolve tool. e) Students recap on fillet tool **<u>Teacher Tip:</u>** *Teacher to demonstrate good subject and curriculum knowledge*	**Official assessment task for cannon holder (Section 7)**	
Phase 3 of lesson **(Engage and Demonstrate)**	Teacher to introduce all keywords, discuss meaning and ensure understanding before progressing. **Section 8: Assembling parts** a) Teacher to demonstrate how to create assemblies in Fusion. b) Demonstrate how to combine two parts for 3D printing. c) Students to join two parts together in Fusion 360 using the join tool d) Students combine two parts in Fusion 360 for 3D printing e) Students compare the difference between a rigid joint and a revolute f) Students insert components into their design for assembly g) Students use Import motors into their design h) Students use rigid and revoluted joints throughout their assembly i) Students complete a full assembly of all their created parts. **<u>Teacher Tip:</u>** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.*	**Activity 2.8.1** **Official assessment task for assembly (Section 8)**	

Phase 4 of lesson - **Plenary (Consolidate)**	Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the official assessment tasks and reflections	**Oral Assessment** **Student evaluation**	

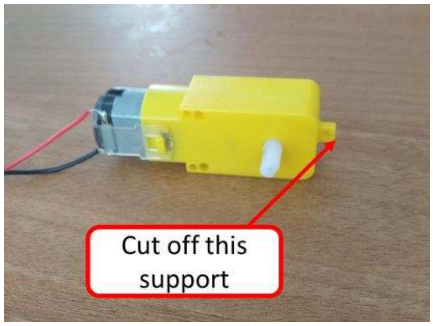
Answer Key

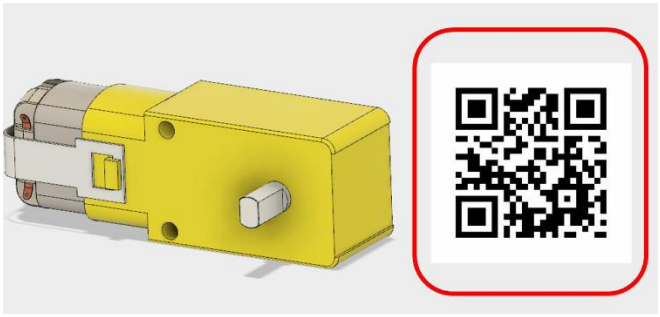
QR code links:		
Page	***Topic***	***Link***
114	Section 7 video guide: Creating a model of tank cannon holder	https://autode.sk/2lAFwiJ
121	Fusion file of the motors for tank	https://a360.co/2JuhMLj 1
129	Section 8 video guide: Assembling parts	https://autode.sk/2lNBG5U

Activity 2.8.1



Inserting the motors





https://a360.co/2JuhMLj 2

As you will see in the Fusion file of the motors provided, the extra support is removed from the end of the motor. This was removed so the motors would fit inside the chassis. During the project assembly stage, this can be easily removed from the actual motors using a snip pliers or a Stanley knife.

Week 5 Lesson Plan 1 of 2:

Content	Grade 12 Chapter 2: Introduction to 3D modelling	Section 9: Preparing and 3D printing finished Fusion 360 parts
Time allocated 	1 x 45-minute periods	

Aim:

Upon completion of this lesson, you will learn how to use FlashPrint 3D printing software to print parts from fusion. You will learn how to save the parts as STL files, import into Flashprint and finally 3D print the parts.

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.

- ☐ Demonstrate how to save separate parts as STL files.
- ☐ Demonstrate how to create a FlashPrint Project and facilitate as students print all parts

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

Students should be able to:

- ☐ Save a body as an STL file.
- ☐ Create a new FlashPrint project.
- ☐ Import an STL file.
- ☐ Rotate and move 3D models in Fusion 360.
- ☐ Add supports to a 3D printed model and understand their importance.
- ☐ Create a GX file for 3D printing.

Keywords	**What are the keywords the students must learn?** • Offset • combine • STL • FlashPrint
Resources	**What resources are required?** • textbooks • projector • Fusion 360 • Flashprint • 3D printers
Prior Knowledge	• Demonstrate creative ideas through meaningful sketches. • Applying dimensions to distances and angles in 2D sketches. • Recall basic skills in 3D modelling using Fusion 360 • Use the extrude tool to transform shapes from 2D to 3D

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.

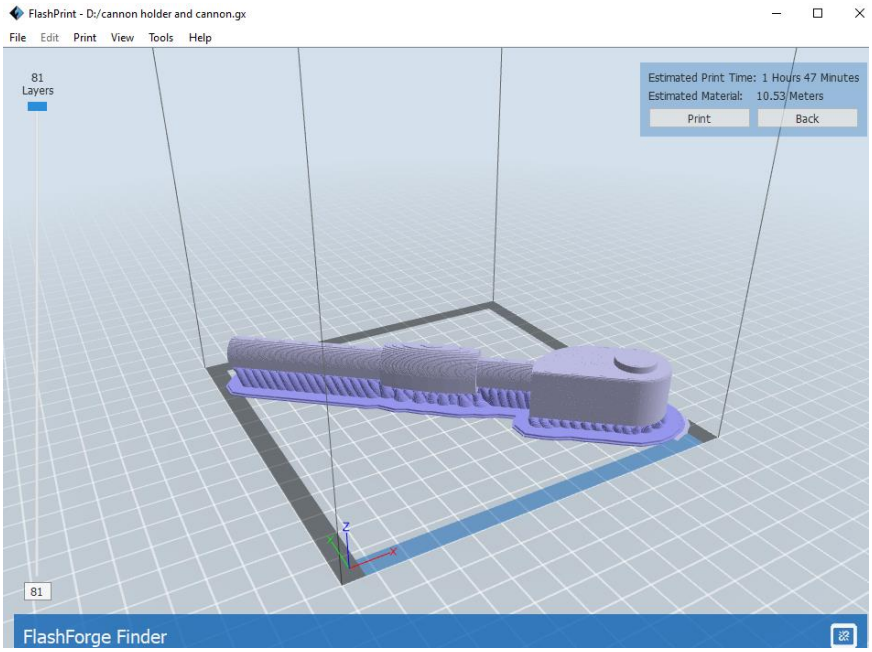
Topic			Page		
Chapter	**Section**	**Focus**	**Essential**	**Non-essential/Self Study**	**Assessment**
Ch. 2	**Sec. 9**	Preparing and 3D printing finished Fusion 360 parts	132-136	-	137

Learning Phases:

Phase	Development [Phases or chunks of learning] ***Note:*** *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.*	Assessment opportunities	Notes for differentiation ***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.*
Phase 1 of lesson **(Connect) - Starter**	Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Recap on Fusion 360 skills from previous lesson **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	**Questioning**	
Phase 2 of lesson **(Activate)**	Teacher to introduce all keywords, discuss meaning and ensure understanding before progressing. **Section 9: Preparing and 3D printing finished Fusion 360 parts** a) Demonstrate how to save a part as an STL file.	**Oral assessment**	

	b) Demonstrate importing STL to FlashPrint and saving as a GX file for 3D printing. c) Students to save all parts as STL files and import into Flashprint. d) Students to 3D print all parts. **Teacher Tip:** *Teacher to demonstrate good subject and curriculum knowledge*	**Official assessment task for 3D printing parts (section 9)**	
Phase 3 of lesson **(Engage and Demonstrate)**	**Teacher Tip:** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.*		
Phase 4 of lesson **- Plenary (Consolidate)**	Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the official assessment tasks and reflections Make sure all parts are printed or left printing for next lesson as will be needed to finish assembly of military tank	**Oral Assessment** **Student evaluation**	

Printing the cannon holder and cannon combined



As stated in the book the cannon holder and cannon must be combined for purposes of 3D printing. You will find that when combined its overall length is more than 140mm wide printing bed. The cannon and holder combined must, therefore, be printed on the diagonal as shown above.

Week 5 Lesson Plan 2 of 2:

Content	Grade 12 Chapter 3: Essentials in Arduino II	Section 1: What is Arduino?
Time allocated 	2 x 45-minute periods	

Aim:

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

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.

- ☐ Explain the applications of the Arduino microcontroller.
- ☐ Identify the main parts of the Arduino board.
- ☐ Recognise the layout of the Arduino ide programming interface.
- ☐ Explain the Arduino programming structure.
- ☐ Configure the Arduino IDE software to work with the Arduino board.

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

Students should be able to:

- ☐ Describe the main features of the Arduino board and software.
- ☐ Write a simple Arduino program and upload it to the Arduino board.
- ☐ Use Arduino programming syntax.

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

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Topic			Page		
Chapter	**Section**	**Focus**	**Essential**	**Non-essential/Self Study**	**Assessment**
Ch. 3	**Sec. 1**	Explore the Arduino board	143-147	-	-
		Explore the Arduino IDE software	148-149		
		Arduino code structure	149-155		
		Arduino code syntax	156-157		

Learning Phases:

Phase	Development [Phases or chunks of learning] ***Note:*** *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.*	Assessment opportunities	Notes for differentiation ***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.*
Phase 1 of lesson **(Connect) - Starter**	Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Discuss prior knowledge of basic electronic components. Show motivational videos / models to outline the end goal of the term. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	**Questioning**	
Phase 2 of lesson **(Activate)**	Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. Teacher to introduce the role of Arduino microcontroller in electronics, while students research the topic. Question students on what aspects are new to them when compared to prior knowledge discussion. Teacher to lead the class discussion about parts of the Arduino board and the IDE software layout.	**Oral assessment**	

	Teacher to introduce the Arduino code structure and allow students to explore their first Arduino program. Teacher to monitor the students' progress throughout the lesson by using the different assessment opportunities. **<u>Teacher Tip:</u>** *Teacher to demonstrate good subject and curriculum knowledge*		
Phase 3 of lesson **(Engage and Demonstrate)**	<u>Task 1:</u> Ask students to find a partner and make a mind map about the advantages, disadvantages and uses of the Arduino microcontroller. Students to complete Activity 3.1.1. Teacher to facilitate as peer teaching takes place. <u>Task 2:</u> Divide students into groups and assign each group an Arduino board. Allow students to label the Arduino board as a group. After they finish students will complete activities 3.1.2 and 3.1.3. <u>Task 3:</u> Students to be given an IDE software layout, each group to fill out one section. The answers will be given through a class discussion. Students demonstrate learning by completing activity 3.1.4. <u>Task 4:</u> Students to learn the basic Arduino code structure. They should be able to use the basic Arduino syntax to blink an LED. And the proper steps to follow to upload their program to the Arduino board. Students demonstrate learning by completing activities 3.1.5 and 3.1.6. <u>Task 5:</u> Students to upload and test the On-board LED program individually. Students demonstrate learning by completing activity 3.1.7.	**Peer teaching** **Written Activities 3.1.1 - 3.1.9**	

	<u>Task 6:</u> Students to study the Arduino code syntax and complete activities 3.1.8 and 3.1.9. Teacher to facilitate as collaborative learning takes place. Students demonstrate learning by completing activities 3.1.1-3.1.9 and finish for homework if incomplete. **<u>Teacher Tip:</u>** *Use group work as appropriate, get to know your class and organise groups to support mixed ability's.*		
Phase 4 of lesson - **Plenary (Consolidate)**	Teacher to facilitate as students evaluate learning. Question pupils on what they have learnt. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the end of section assessment and the student evaluation. This can be given as homework. Students are encouraged to solve the challenge activity on page 159.	**Oral Assessment** **End of section assessment** **Student evaluation**	

Answer Key

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

Activity 3.1.1

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

The board is an Arduino Leonardo model.

Activity 3.1.2

Look at the Arduino board shown in Figure 3.1.4 above. Match each number with its function.

1. microcontroller
2. USB jack
3. power jack
4. reset button
5. LEDs set
6. power socket
7. analog IN socket
8. digital socket

Activity 3.1.3

Identify the four power socket pins and write down their names.

1. 3.3V pin
2. 5V
3. GND pins
4. VIN pins

How many analogue pins are there in the Analog IN socket? Name them.

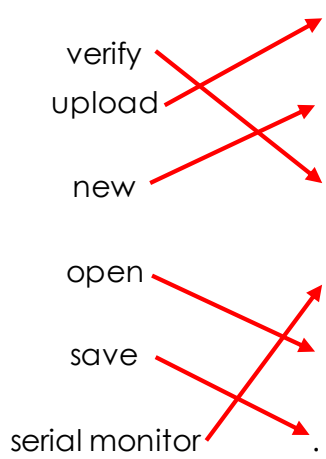
6 analogue pins. A0, A1, A2, A3, A4, A5.

How many digital pins are there in the digital socket?

14 digital pins.

Activity 3.1.4

Match the toolbar button to its description.



responsible for uploading the code in the sketch file to the connected Arduino board

creates a new blank sketch

checks the code and makes sure that it is free of mistakes

displays all the serial data sent and received by the serial interface

allows the user to open a stored sketch file

allows the user to save the sketch file

Activity 3.1.5

How can you make the LED blink (turn off and on)? Write the code, then test your answer and write your observation.

```
digitalWrite(13,HIGH);
delay(1000);
digitalWrite(13,LOW);
```

Note: the delay can be any value

Activity 3.1.6

We now know that using the 'delay' function we can tell the Arduino how many seconds to wait before changing the status of the LED. In other words, the 'delay' function can be used to control how fast or slow an LED blinks.

In which of the following cases does the LED blink faster? Justify.

Case 1:

```
delay(550);
```

The LED will blink faster than in case 2 since the waiting time is less.

Case 2:

```
delay(2000);
```

The LED will blink slower than in case 1 since the waiting time is more.

Activity 3.1.7

Check the status of the 'L LED'. What happens?

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

Activity 3.1.8

Read the syntax explanation written in the table below and try to match it with its corresponding name. The first one is done for you.

2. semicolon
3. block comments
3. line comments
4. variables
5. variable declaration

Activity 3.1.9

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

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

```
int variable_$ = 3;
setup(){
pinMode(3, INPUT)
```

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

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

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

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

Method 1:

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

Method 2:

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

13. Declare the variables below.

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

```
int y= 0;
```

declare 'age' as a character

```
char age;
```

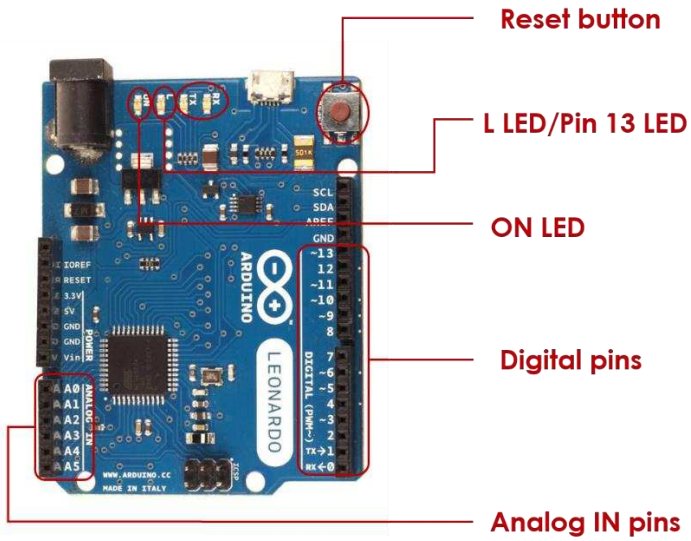
Add the missing curly braces in the following lines of code.

```
int threshold = 10;
int analogPin = 0;
int ledPin = 13;

void loop() {
  int analogValue = analogRead(analogPin);
  if (analogValue > threshold) {
    digitalWrite(ledPin, HIGH);
  }
  else {
    digitalWrite(ledPin, LOW);
  }
}
```

Note: let the students write the code in Arduino and check it for syntax error using the 'Verify' button.

End of section assessment:

1. Label the missing Arduino board parts.



2. Label the name of the buttons in the toolbar menu of the Arduino IDE. Then write its function.

1	verify/compile	• checks the code for syntax errors (like missing semicolons or brackets) • converts the Arduino code into machine code; this is a language that the microcontroller on the Arduino board can understand
2	upload	• sends the code to the Arduino board
3	new	• opens a new code window tab/new sketch
4	open	• opens an existing sketch
5	save	• saves the currently active sketch
6	serial monitor	• opens a window that displays any serial information the Arduino board is transmitting or receiving

3. Write a simple Arduino code to blink an LED connected to pin number 5 fast then slow.

case 1: blinking fast

```
void setup() {
// put your setup code here, to run once:
pinMode(5,OUTPUT);
}
void loop() {
// put your main code here, to run repeatedly:
digitalWrite(5,HIGH);
delay(500);
digitalWrite(5,LOW);
delay(500);
}
```

case 2: blinking slow

```
void setup() {
// put your setup code here, to run once:
pinMode(5,OUTPUT);
}
void loop() {
// put your main code here, to run repeatedly:
digitalWrite(5,HIGH);
delay(5000);
digitalWrite(5,LOW);
delay(5000);
}
```

Challenge activity

Arduino code:

```
int red = 10;
int yellow = 9;
int green = 8;
void setup(){
  pinMode(red, OUTPUT);
  pinMode(yellow, OUTPUT);
  pinMode(green, OUTPUT);
}
void loop(){
  changeLights();
  delay(15000);
}

void changeLights(){
  // green off, yellow on for 3 seconds
  digitalWrite(green, LOW);
  digitalWrite(yellow, HIGH);
  delay(3000);

  // turn off yellow, then turn red on for 5 seconds
  digitalWrite(yellow, LOW);
  digitalWrite(red, HIGH);
  delay(5000);

  // red and yellow on for 2 seconds (red is already on though)
  digitalWrite(yellow, HIGH);
  delay(2000);

  // turn off red and yellow, then turn on green
  digitalWrite(yellow, LOW);
  digitalWrite(red, LOW);
  digitalWrite(green, HIGH);
  delay(3000);
}
```

Week 6 Lesson Plan:

Content	Grade 12 Chapter 3: Essentials in Arduino II	Section 2: Arduino display tools Section 3: Pseudocode and flowcharts
Time allocated 	Section 2: 2 x 45-minute periods Section 3: 1 x 45-minute period	

Aim:

Section 2 aims to introduce you to Arduino's display tools, namely the LCD and the serial monitor. Both serve as useful tools for visualising and monitoring the values sent and received from your Arduino board. The former is a hardware tool, while the latter is a software tool.

Section 3 aims to introduce you to the correct methodology for writing any program. The section introduces algorithm description techniques, such as flowcharts and pseudocodes.

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.

Section 2

- ☐ Explain how to control the LCD screen.
- ☐ Explain how to use Arduino's serial monitor.
- ☐ Configure the Arduino IDE software to work with the Arduino board.

Section 3

- ☐ Understand the different types of algorithm description.
- ☐ Understand the importance of flowcharts and pseudocode in computer programming.
- ☐ Use flowcharts and pseudocode to understand how a program works.

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

Students should be able to:

- ☐ Use the LCD to display messages.
- ☐ Use the serial monitor to display messages.
- ☐ Use the algorithm description techniques to describe any program.
- ☐ Convert a flowchart diagram into a pseudocode and vice versa.

Keywords	**What are the keywords the students must learn?** • Serial monitor • LCD • Variables • algorithm • flowchart • pseudocode
Resources	**What resources are required?** • textbooks • projector • Arduino Leonardo board • LCD shield
Prior Knowledge	• Use breadboards for building electronic circuits. • Identify the basic electronic components. • Arduino code structure.

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**	**Assessment**
Ch. 3	**Sec. 2**	Arduino – LCD	163-168	-	-
		Arduino – Serial monitor	169-174		
	Sec. 3	Flowchart algorithm description	178-179		
		Pseudocode algorithm description	180		
		Representing the Arduino programs using pseudocode and flowcharts	181-182		

Learning Phases: Section 2

Phase	Development [Phases or chunks of learning] ***Note:*** *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.*	Assessment opportunities	Notes for differentiation ***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.*
Phase 1 of lesson **(Connect) - Starter**	Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Discuss prior knowledge of basic electronic components. Show motivational videos / models to outline the end goal of the term. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	**Questioning**	
Phase 2 of lesson **(Activate)**	Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. Teacher to introduce the Arduino display tools – LCD and serial monitor, while students research the topic. Question students on what aspects are new to them when compared to prior knowledge discussion. Teacher to monitor the students' progress throughout the lesson by using the different assessment opportunities.	**Oral assessment**	

	Teacher Tip: *Teacher to demonstrate good subject and curriculum knowledge*		
Phase 3 of lesson **(Engage and Demonstrate)**	Task 1: Divide students into groups and assign each group an Arduino LCD shield. Allow students to label the LCD shield parts as a group. Teacher to facilitate as peer teaching takes place. Task 2: Teacher to demonstrate the Arduino HelloWorld example code. Teacher can show the students the expected message on the LCD shield first, then go through the code with the students' line by line. Students can then test the code themselves by attaching the LCD shield to the Arduino board then uploading the code. Students demonstrate learning by completing activities 3.2.1 and 3.2.2. Task 3: Teacher to introduce the serial monitor display tool and the instructions to use it. Then, divide students into groups and allow them to label the sections of the serial monitor as a group. Task 4: Teacher go through the required functions to setup a serial communication. Then, display a simple message on the serial monitor. Students demonstrate learning by completing activity 3.2.3. Task 5: Students to study how to use the serial monitor to display the result of arithmetic operations. Teacher to explain the code syntax difference between displaying a	**Peer teaching** **Written Activities 3.2.1 - 3.2.4** **Students must complete all activities in their free time if not completed during class time.**	

	message and displaying an arithmetic result. Teacher to introduce variable declaration in coding, explain its importance and code syntax. Teacher to facilitate as collaborative learning takes place. Students demonstrate learning by completing activity 3.2.4 and finish for homework if incomplete. **Teacher Tip:** *Use group work as appropriate, get to know your class and organise groups to support mixed ability's.*		
Phase 4 of lesson - **Plenary (Consolidate)**	Teacher to facilitate as students evaluate learning. Question pupils on what they have learnt. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the end of section assessment and the student evaluation. This can be given as homework.	**Oral Assessment** **End of section assessment** **Student evaluation**	

Answer Key

Activity 3.2.1

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

Arduino code:

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

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

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

Activity 3.2.2

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

Arduino code:

```
#include <LiquidCrystal.h>
// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(8, 9, 4, 5, 6, 7);

void setup() {
  // set up the LCD's number of columns and rows:
  lcd.begin(16, 2);
  // Print a message to the LCD.
  lcd.print("NAME");
}
void loop() {
  // set the cursor to column 0, line 1
  // (note: line 1 is the second row, since counting begins with 0):
  lcd.setCursor(0, 1);
```

```
  // print the number of seconds since reset:
  lcd.print(millis() / 1000);
}
```

Activity 3.2.3

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

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

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

   The message will be displayed on the serial monitor repeatedly.

Activity 3.2.4

Write the proper statements for the following statements:

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

```
Int count=0;
```

15. Print out an explanation message.

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

16. Display the current count.

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

17. Implement a procedure to increase the counts.

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

18. Add 100 milliseconds of delay time.

```
Delay(100);
```

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

    The counter initialisation and the explanation message.

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

    Updating the counter and displaying its value.

End of section assessment

1. Study the following code, then write the expected outcome on the LCD shown below.

2. Write an Arduino code that adds two numbers (3.5 and 7) and then displays the addition result on the serial monitor.

```
//define a variable to hold the value of 3.5
float num_1 = 3.5;
//define a variable to hold the value of 7
int num_2 = 7;
//define a variable to hold the addition result
void setup() {
// put your setup code here, to run once:
Serial.begin(9600);
while (!Serial);
//addition
Serial.print("addition result = ");
Serial.print(num_1+num_2);
}
void loop() {
// put your main code here, to run repeatedly:
}
```

Learning Phases: Section 3

Phase	Development [Phases or chunks of learning] ***Note:*** *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.*	Assessment opportunities	Notes for differentiation ***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.*
Phase 1 of lesson **(Connect) - Starter**	Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Discuss prior knowledge of Arduino code structure. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	**Questioning**	
Phase 2 of lesson **(Activate)**	Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. Teacher to introduce the algorithm description techniques – flowcharts and pseudocodes. Question students on the importance of using such algorithms. Teacher to monitor the students' progress throughout the lesson by using the different assessment opportunities.	**Oral assessment**	

	Teacher Tip: *Teacher to demonstrate good subject and curriculum knowledge*		
Phase 3 of lesson **(Engage and Demonstrate)**	Task 1: Teacher go through the basic flowchart symbols. Students study the symbols and go through the examples with the students. Divide the students into groups and allow them to demonstrate learning by completing activity 3.3.1. Task 2: Teacher explain the pseudocode algorithm description technique. Students demonstrate learning by completing activity 3.3.2. Task 3: Explain how the Arduino code structure can be represented using flowchart and pseudocode. Teacher to facilitate as collaborative learning takes place. Students demonstrate learning by completing activity 3.3.3. **Teacher Tip:** *Use group work as appropriate, get to know your class and organise groups to support mixed ability's.*	**Peer teaching** **Written Activities 3.2.1 - 3.2.4** **Students must complete all activities in their free time if not completed during class time.**	

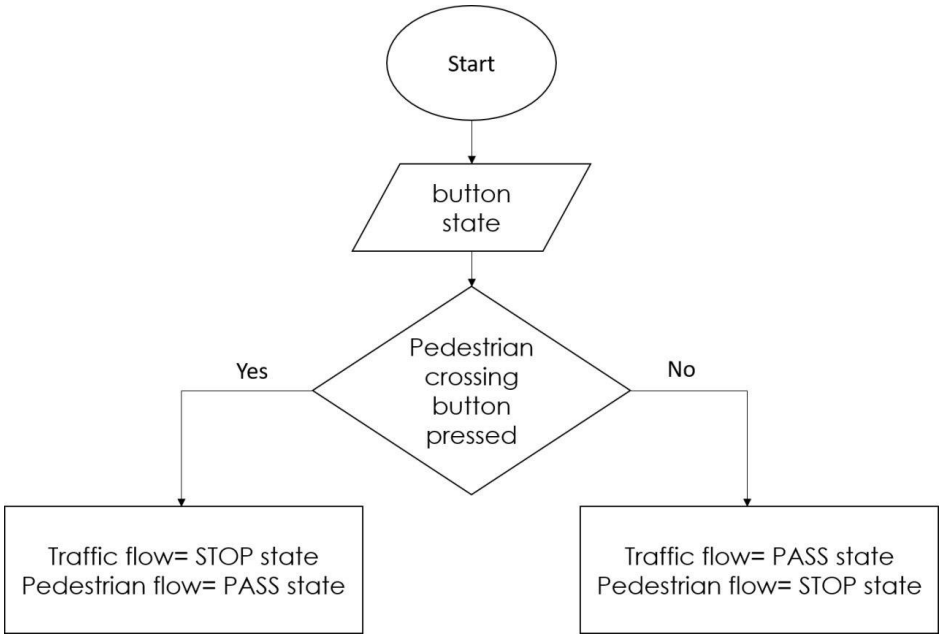
Phase 4 of lesson - **Plenary (Consolidate)**	Teacher to facilitate as students evaluate learning. Question pupils on what they have learnt. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the end of section assessment and the student evaluation. This can be given as homework.	**Oral Assessment** **End of section assessment** **Student evaluation**	

Answer Key

Activity 3.3.1

Using the flowchart diagrams shown in **Error! Reference source not found.**3.1, draw the flowchart for the following traffic system:

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



Activity 3.3.2

Convert the following flowchart into a pseudocode.

1. start the process
2. declare and initialise sum = 0 and count = 0
3. enter 'n'
4. find 'sum + n' and assign it to sum, then increment count by 1
5. is 'count < 5' if YES go to step 3, else print the sum value
6. stop the process

Activity 3.3.3

1. What is a flowchart? Why do I need it?

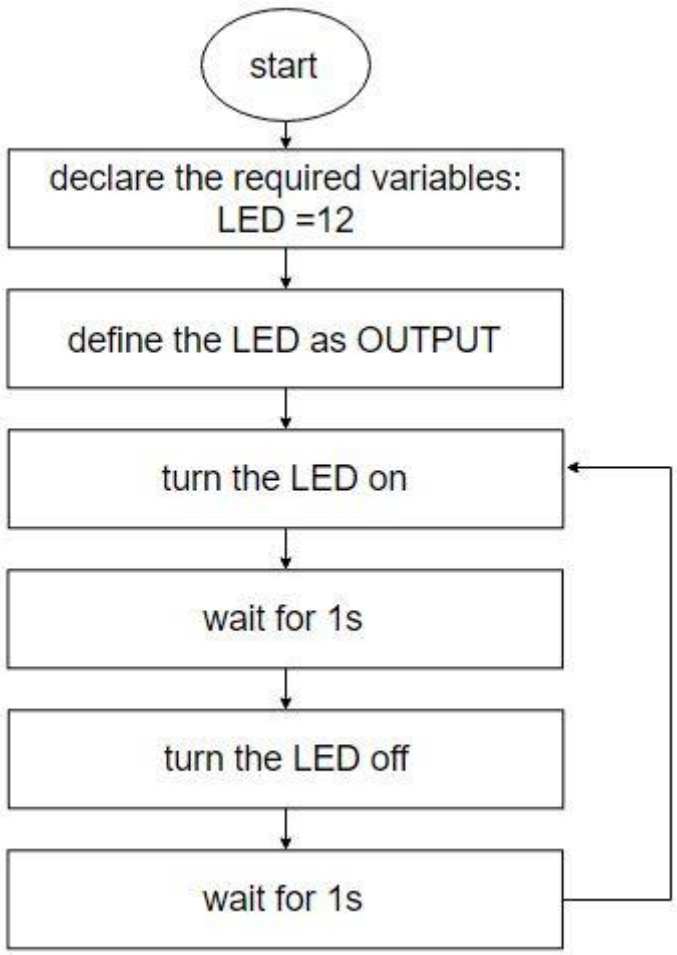
A flowchart is a visual representation of the sequence of the process. It shows how the code is executed. It also helps you identify the different elements of the process and understand how the different steps are linked together.

2. What is a pseudocode? Why do I need it?

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

End of section assessment

1. Study the following Arduino code. Then convert it into a flowchart and pseudocode algorithms?

Flowchart	Pseudocode
	1. start the process 2. declare that the LED is connected to pin number 12 3. define the LED as an OUTPUT device 4. turn the LED on 5. wait for 1s (1000ms) 6. turn the LED off 7. wait for 1s (1000ms) 8. repeat from step 4

Week 7 Lesson Plan:

Content	Grade 12 Chapter 3: Essentials in Arduino II	Section 4: Analogue and digital signals
Time allocated 	3 x 45-minute periods	

Aim:

This lesson aims to introduce you to the world of signals. You will learn how to read the digital and analogue signals on Arduino. The content explains in detail the procedure for generating and reading digital signals. You will also learn how to generate analogue signals using pulse width modulation (PWM) technique.

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.

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

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

Students should be able to:

- ☐ Read digital signals.
- ☐ Generate a digital signal to blink an LED.
- ☐ Read and analogue signal.
- ☐ Generate an analogue signal to control the brightness of an LED.

Keywords	**What are the keywords the students must learn?** • digital signal • floating state • analogue signal • PWM • time period (T) • frequency (f) • duty cycle(D)
Resources	**What resources are required?** • textbooks • projector • Pushbutton • 1kΩ resistor • 10kΩ resistor • 220Ω resistor • LED • Potentiometer • Jumper wires • Breadboard • Arduino board
Prior Knowledge	• Identify the fundamentals of Arduino programming. • Recognise the structure of LEDs, pushbuttons and potentiometers. • Use breadboards for building electronic circuits. • Identify basic electronic 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**	**Assessment**
Ch. 3	**Sec. 4**	What are signals?	187-188	-	-
		Getting started	189		
		Digital signals Digital input	190-195		
		Digital output	196-199		
		Analogue signals Analogue input	200-204		
		Analogue output	205-209		

Learning Phases:

Phase	Development [Phases or chunks of learning] ***Note:*** *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.*	Assessment opportunities	Notes for differentiation ***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.*
Phase 1 of lesson **(Connect) - Starter**	Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Discuss prior knowledge of Arduino programming and basic electronic components. Show motivational videos / models to outline the end goal of the term. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	**Questioning**	
Phase 2 of lesson **(Activate)**	Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. Teacher to introduce the topic of digital and analogue signals, while students (think-pair-share) their thoughts. Question students on what aspects are new to them when compared to prior knowledge discussion. Teacher to introduce Arduino functions while students explore these functions through various activities.	**Oral assessment** **Written Activity 3.4.1**	

	Teacher to monitor the students' progress throughout the lesson by using the different assessment opportunities. **<u>Teacher Tip:</u>** *Teacher to demonstrate good subject and curriculum knowledge.*		
Phase 3 of lesson **(Engage and Demonstrate)**	<u>Task 1:</u> Students to study the Arduino function (digitalRead). They will go through digital input-practical work to explore and test this function as groups. Students demonstrate learning by completing activities 3.4.2 and 3.4.3. <u>Task 2:</u> Students to study the Arduino function (digitalWrite). They will go through digital output- practical work to explore and test this function as groups. Students demonstrate learning by completing activities 3.4.4 and 3.4.5. <u>Task 3:</u> Divide students into two groups assigning each group an Arduino function. Use an "Each one teach one" approach to have groups show their understanding and improve other groups understanding of Arduino functions. Teacher to facilitate as peer teaching takes place. <u>Task 4:</u> Students to study the Arduino function (analogRead). They will go through analogue output- practical work to explore and test this function as groups. Students demonstrate learning by completing activities 3.4.6 and 3.4.7. <u>Task 5:</u> Students to study the Arduino function (analogWrite). They will go through analogue output- practical work to explore and test this function as groups.	**Peer teaching** **Written Activities 3.4.2-3.4.8** **Given as homework if incomplete during class time.**	

	Students demonstrate learning by completing activity 3.4.8. <u>Task 6:</u> Divide students into two groups assigning each group an Arduino function. Use an "Each one teach one" approach to have groups show their understanding and improve other groups understanding of Arduino functions. Teacher to facilitate as peer teaching takes place. **<u>Teacher Tip:</u>** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.*		
Phase 4 of lesson - **Plenary (Consolidate)**	Teacher to facilitate as students evaluate learning. Question pupils on what they have learnt. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the end of section assessment and the student evaluation. This can be given as homework.	**Oral Assessment** **End of section assessment** **End of chapter activity** **Student evaluation**	

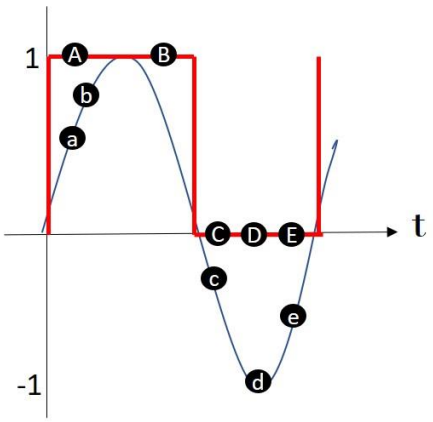
Answer Key

QR code links:		
Page	***Topic***	***Link***
188	Differences between analogue and digital signals	http://qrs.ly/c3690tu
192	Pull up resistor tutorial	https://www.youtube.com/watch?v=wxjerCHCEMg
205	PWM signals	https://www.youtube.com/watch?v=B_Ysdv1xRbA
206	PWM signal that controls the brightness of an LED	http://www.electronicwings.com/public/images/user_images/images/Raspberry Pi/RaspberryPi_PWM/PWM.gif

Activity 3.4.1

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

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

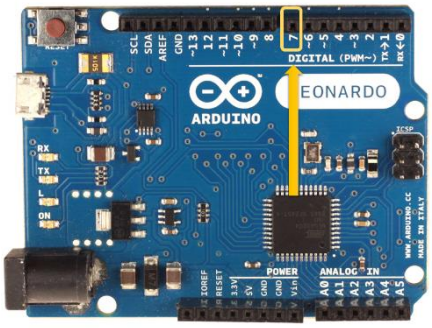


Using the recorded values, what is the difference between the analogue and digital signals?

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

Activity 3.3.2

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




```
pinMode(7, INPUT);
```

Activity 2.3

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

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

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

Arduino code:

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

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

}
```

Activity 3.4.4

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

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

}
```

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

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

Activity 3.4.5

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

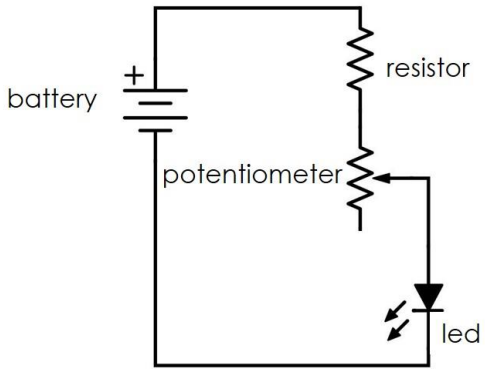
1. Turn the LED ON.
2. Apply a delay of 1 second.
3. Turn the LED OFF.
4. Apply a delay of 1 second.
5. Repeat again.

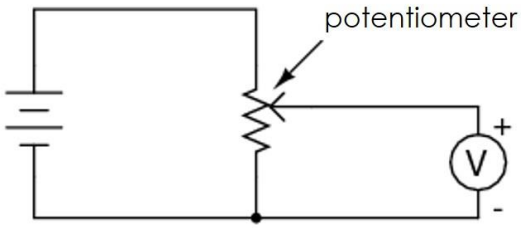
Arduino code:

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

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

}
```

Activity 3.4.6

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





---

variable resistor

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

---

voltage divider

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

Activity 3.4.7

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

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

```
int x=0;
```

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

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

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

```
delay(100);
```

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

```
int x = 0;

void setup() {
Serial.begin(9600);
}
void loop() {
x=analogRead(2);
Serial.println("The potentiometer value is:");
Serial.println(x);
delay(100);
}
```

Activity 3.4.8

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

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

Arduino code:

```
int Brightness = 0;

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

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

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

}
```

End of section assessment

Find the errors in the Arduino code below. Then, correct the mistakes.

Hint: There are 10 syntax errors in the code.

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

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

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

Line No.	Syntax error	Correction
1	potentiometer=4;	int potentiometer=4;
2	int LED =14;	int LED =10; /*digital I/O pins: 2-13 (pins 0 and 1 are reserved for Tx and Rx)*/
5	pinMode(potentiometer, OUTPUT);	pinMode(LED, OUTPUT); /*the potentiometer is an analogue electronic device, hence, it doesn't need to be defined using the pinMode function. Unlike the push-button and the LED, where both of them are digital components and their pinMode must be defined.*/ /*if you were to define the potentiometer, then it's an input device not an output*/
6	pinmode(pushbutton, INTPUT);	pinMode(pushbutton, INPUT);
10	//if sensor value is one if(push-button ==LOW){	//if sensor value is one if(pushbutton ==HIGH){
11	digitalWrite(LED,HIGH)	digitalWrite(LED,HIGH);

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

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

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

End of chapter activity

Final activity

Write an Arduino program to calculate the voltage value in Ohm's law, knowing that the current is 0.9 mA, and the resistance is 10kΩ. Then blink an LED when calculation is complete.
Hint: Ohm's law V = I× R

1. Define the variables.
```
float current=0.9;
int resistance=1000;
float voltage;
```

2. Print out an explanation message (comment).
```
Serial.println("Calculating the voltage using Ohm's law");
```

3. Implement a procedure to calculate the voltage.
```
voltage= current*resistance;
```

4. Print out the voltage value on the serial monitor.
```
Serial.println("Voltage is:");
Serial.println(voltage);
```

5. Print out the voltage value on the LCD.
```
 void setup() {
 lcd.begin(16, 2);

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

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

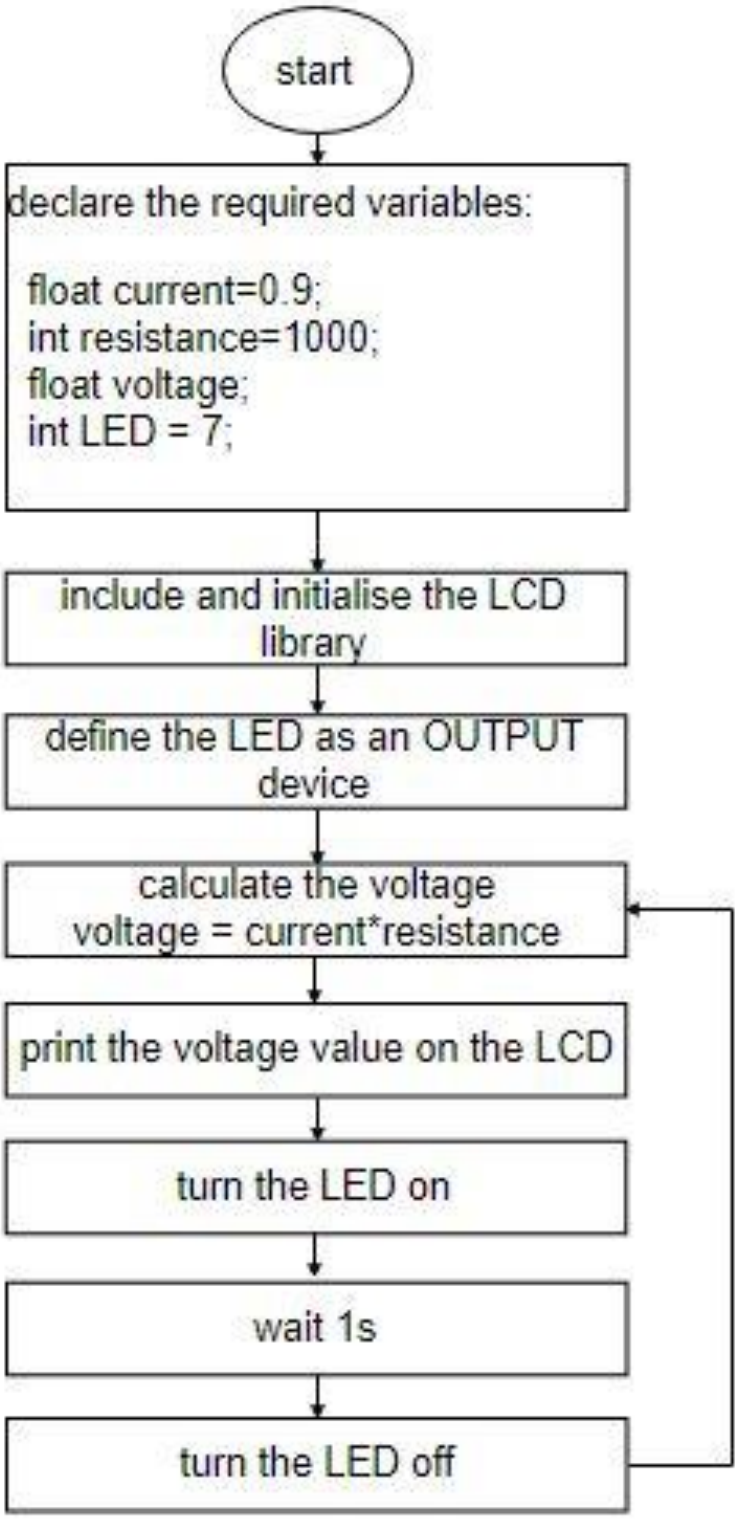
6. Blink an LED on for 1s, then off for 1s.
```
int LED = 7;
void setup() {
pinMode(LED,OUTPUT);
}
void loop() {
digitalWrite(LED,HIGH);
delay(1000);
```

```
digitalWrite(LED,LOW);
delay(1000);
}
```

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

```
#include <LiquidCrystal.h>

float current=0.9;
int resistance=1000;
float voltage;

int LED = 7;

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

void setup() {

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

pinMode(LED,OUTPUT);

}

void loop() {
voltage=current*resistance;

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

delay(1000);

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

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

delay(1000);

digitalWrite(LED,HIGH);
delay(1000);
digitalWrite(LED,LOW);
delay(1000);

}
```

8. Draw the systems flowchart.



Week 8 and week 9 Lesson Plan (this lesson plan extends for two weeks – 6 periods):

Content	**Grade 12** **Chapter 4: Electronics and assembly of a military vehicle model**	**Section 1: Military vehicle electronics**
Time allocated 	**6 x 45-minute periods**	

Aim:

This lesson aims to assemble and program a wireless military vehicle using various electronic components and an Arduino microcontroller. The military vehicle will be controlled using a mobile application and a Bluetooth module. The mobile application will send commands to the Bluetooth module. Accordingly, the electronic circuit will be programmed to react based on these inputs to the Bluetooth module.

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.

- ☐ Identify the function of a motor driver.
- ☐ Identify the different switches types then use an SPST switch to power two circuit boards.
- ☐ Develop and evaluate an Arduino code using a switch statement.
- ☐ Assemble electronic components to build a complete circuit of a military vehicle.
- ☐ Use a Bluetooth module between a mobile application and Arduino.

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

Students should be able to:

- ☐ Differniate between DC and AC motors.
- ☐ Program the Arduino microcontroller to control the rotation and direction of 4 DC motors.
- ☐ Use the Bluetooth module to communicate with a mobile application.
- ☐ Assemble the tank military vehicle.

Keywords	**What are the keywords the students must learn?** • L298N motor driver • Bluetooth module • wireless communication • antenna • electromagnetic radio waves • transmitter • receiver • switch statement
Resources	**What resources are required?** • textbooks • projector • Pushbutton • 9V battery • 9V battery pack • 1.5V battery • DC motor • Tack sprocket (wheels) • L298N motor driver • Bluetooth module • SPST switch • Jumper wires • Arduino board • 3D printed top cover • 3D printed chassis • 3D printed sprocket • 3D printed turret • 3D printed cannon and cannon holder (combined)
Prior Knowledge	• Able to generate digital signals using Arduino. • Understand the function of DC motors. • Use breadboards for building electronic circuits.

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**	**Assessment**
Ch. 4	**Sec. 1**	Military vehicle electronics	219	-	-
		Types of motors	219-224		
		Motor driver	225-235		
		Bluetooth module- Wireless communication	236-239		
		Switch statement- Finalising the code	240-243		
		Testing your military vehicle	244		
		Switches	245-248		
		Assembling the tank military vehicle	249-250		
		Creative problem solving (expansion of circuit functions)	-	251	
		Assessment task page		-	254-255

Learning Phases:

Phase	Development [Phases or chunks of learning] ***Note:*** *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.*	Assessment opportunities	Notes for differentiation ***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.*
Phase 1 of lesson **(Connect) - Starter**	Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Discuss prior knowledge of DC motors. Show motivational videos / models to outline the end goal of the term. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	**Questioning**	
Phase 2 of lesson **(Activate)**	Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. Teacher to introduce students to the new electronic components that will be used to complete the military vehicle project. Teacher must emphasise the importance of gaining knowledge about these components in order to complete and test the final electronic circuit. Question students on what aspects are new to them when compared to prior knowledge discussion.	**Oral assessment**	

	Teacher to go through the function of DC motors and allow students to practically test them. Teacher to introduce the topic of motor drivers while students explore its use and function. Teacher to explain the use of wireless communication and question students on how the Bluetooth module falls under this category. Teacher to introduce switch case statements and students apply what they have learnt through various activities. **Teacher Tip:** *Teacher to demonstrate good subject and curriculum knowledge.*		
Phase 3 of lesson **(Engage and Demonstrate)**	Task 1: In groups students will go through DC motor-practical work. Students demonstrate learning by completing activities 4.1.1 and 4.1.2. Task 2: Students will use the motor driver module to control the DC motor. They will explore the motor driver parts and connect the DC motor to the motor driver. Students demonstrate learning by completing step 1 of building the circuit. Task 3: Students will complete step 2: Using Arduino to control the direction and rotation of the DC motors. Students will upload and analyse the codes for both direction and rotation. Students demonstrate learning by completing activities 4.1.3 - 4.1.6. Task 4: Students will connect the Bluetooth module to the circuit.	**Peer teaching** **Written Activities 4.1.1 - 4.1.8** **Students to complete all the activities and finish in their free time if not completed.**	

	Students demonstrate learning by completing step 3 of building the circuit. <u>Task 5:</u> Students will find a partner and start writing the complete code for the project. Students can refer to the previous Arduino lessons if they find difficulty in writing the code. Students demonstrate learning by completing activities 4.1.7 and 4.1.8. <u>Task 6:</u> Students need to follow the steps on page 244 to test the function of the electronic circuit. Teacher to facilitate as collaborative learning takes place. <u>Task 7:</u> Students will learn about the different types of switches. Students demonstrate learning by completing step 4 of building the circuit. <u>Task 8:</u> Students will assemble the military vehicle parts. **<u>Teacher Tip:</u>** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.*		

Phase 4 of lesson - **Plenary (Consolidate)**	Teacher to facilitate as students evaluate learning. Question pupils on what they have learnt. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the student evaluation.	**Oral Assessment** **Student evaluation**	

Answer Key

Answer Key/ Resources

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

Activity 4.1.1

- Follow the below steps to check the polarity of a DC motor, and then draw the correct direction for the DC motor in Figure4.1.2.

1. Attach a red wire to the positive terminal of the battery and attach a black wire to the negative terminal of the battery.
2. Attach the wheel to the DC motor shaft and make sure it is firmly fixed.
3. Connect the red (positive) wire of battery to one terminal of the DC motor.
4. Connect the black (negative) wire of the battery to the second terminal, as shown below in Figure4.1.2.

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

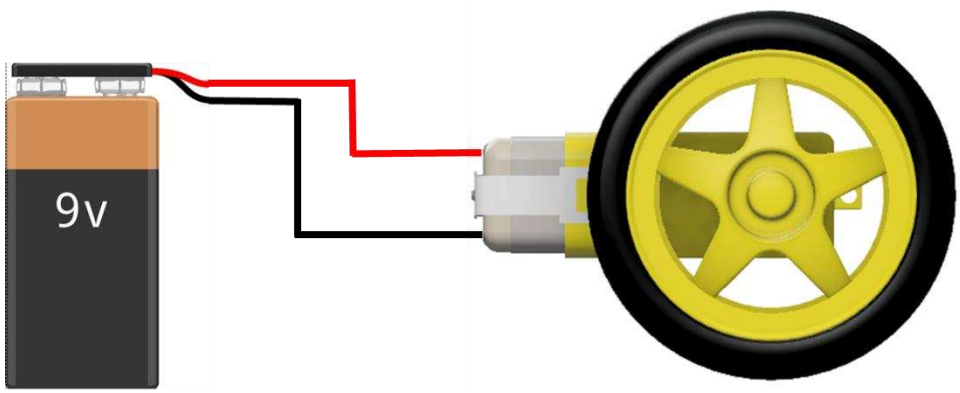


Figure 4.1.2: DC motor

What is the direction of the wheel rotation? clockwise

Activity 4.1.2

- Using direction to determine motor polarity:

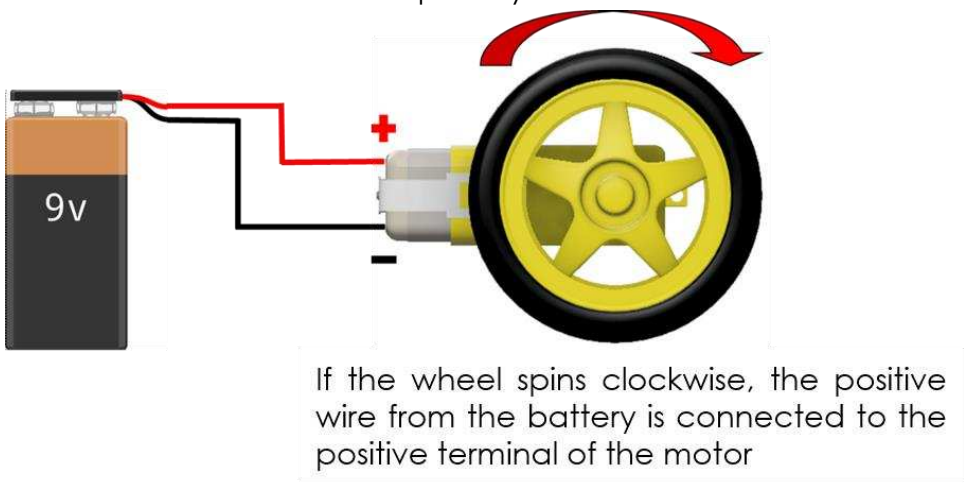


Figure 4.1.3 Clockwise rotation of a DC motor

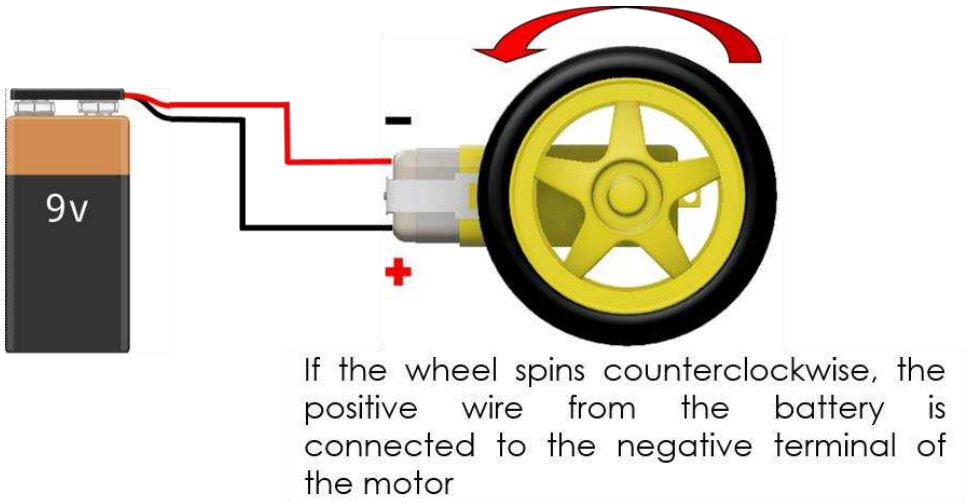


Figure4.1.4 : Counter-clockwise rotation of a DC motor

Look at images Figure 4.1.3 and Figure 4.1.4. Which image matches your circuit. If the wheel rotated clockwise, you should label the pins positive and negative as shown in Figure 4.1.3.

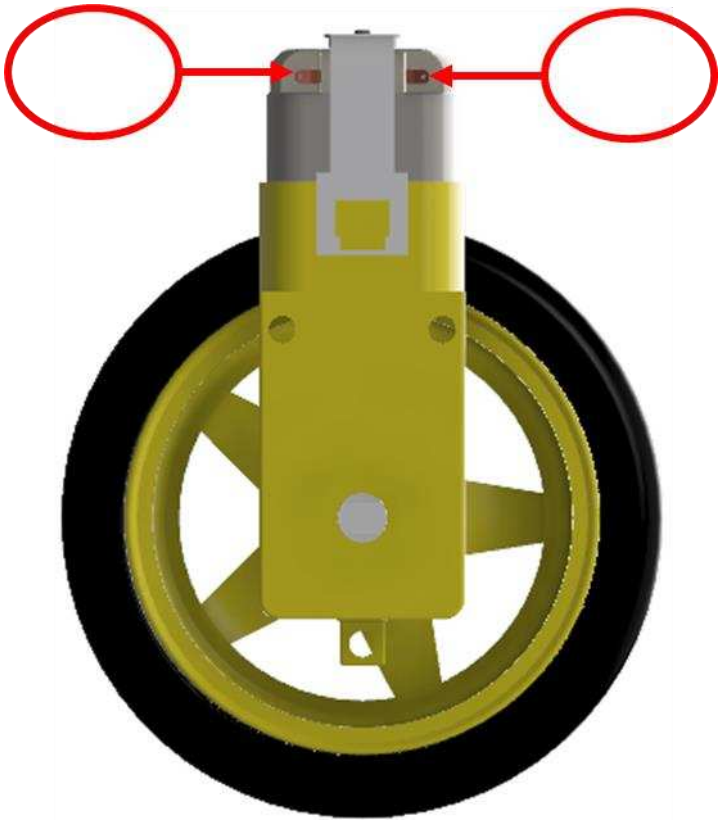
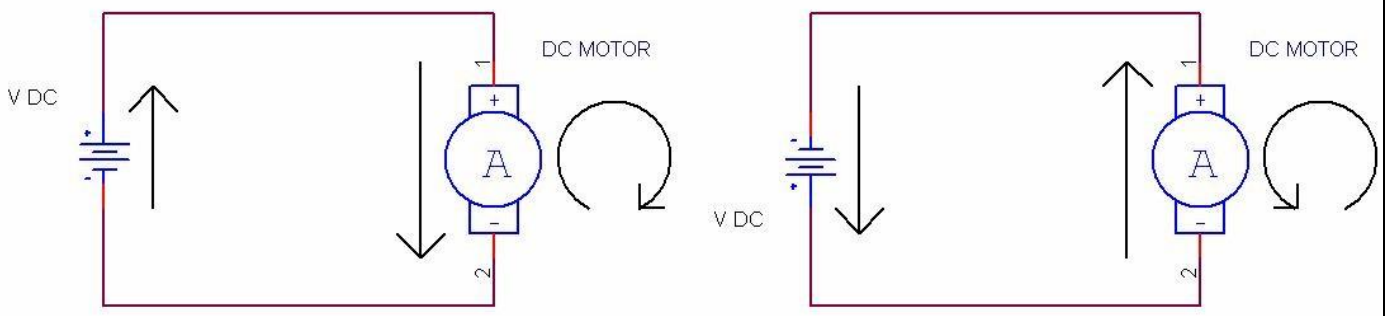


Figure 4.1.1

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

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



Activity 4.1.3

- Analyse the code in Figure 4.1.10 and document what have you noticed about the direction of the DC motor.
  Note: If the motor does not rotate in the required direction, reverse the connections on the motor driver to correct the rotation. For example, switch the wires entering pins 1 and 2 for motor A or 13 and 14 for motor B.

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

Activity 4.1.4

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

Arduino code:

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

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

}

void loop() {

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

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

}
```

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

Activity 4.1.5

- Modify the code in Figure 4.1.11 to control the DC motors to turn left.

Arduino code:

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

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

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

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

}
```

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

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

Arduino code:

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

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

}

void loop() {


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


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

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

}
```

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

Activity 4.1.7

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

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

Activity 4.1.8

- The switch case statements needed for your circuit are shown below. Fill in the blanks with the correct code for each statement. Refer to **Error! Reference source not found.**4.1.4 and **Error! Reference source not found.**4.1.5 for the correct pin connections.

Arduino code:

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

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

digitalWrite(9, HIGH);
```

```
digitalWrite(6, LOW);

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



}

//function for reversing
void backward(){


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

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

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



}

//function for turning right
void right(){

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


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

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



}

//function for turning left
void left(){

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

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

analogWrite(3, 0);
```

```
analogWrite(5, pwm_speedA);

}

//function for stopping motors
void motors_stop(){

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

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

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



}
```

Writing the code

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

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

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

```
void setup() {

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

}
```

3. Void loop

- Refer to Activity 4.1.8.

Creative problem solving (expansion of circuit functions)

Activity 4.1.11

- Your space rover needs to drive and explore Mars at times when there is no light. Do you think adding headlights to your space rover might be efficient? Give it a try.

- Write an Arduino code and build a circuit to add headlights to your space rover. Hint: You will need to add two commands to your switch case statement. The commands will be 'W' to turn the headlights on, and 'w' to turn the headlights off.

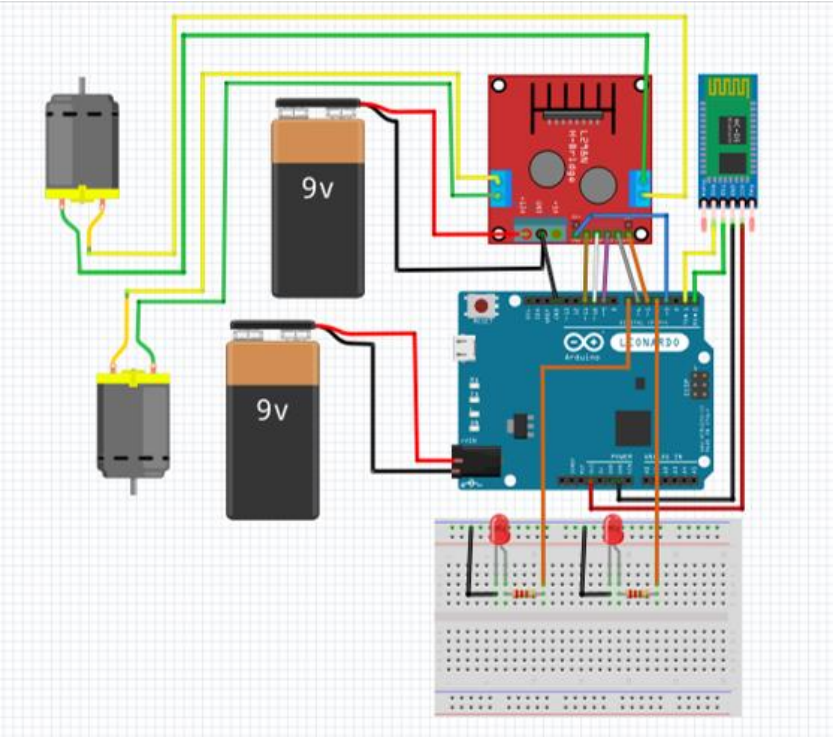


Figure 4.1.27: Simulation diagram for a space rover with headlights

Arduino code:

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

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

```
}

void loop() {

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

}

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

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

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

//function for reversing
void backward(){

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

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

analogWrite(5, pwm_speedA);
```

```
analogWrite(3, pwm_speedB);
}

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

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

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

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


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

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

}

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

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

}

//function for stopping motors
void motors_stop(){

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

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

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

Week 10 Lesson Plan:

Content	Grade 12 Chapter 5: Digital electronics	Section 1: Digital fundamentals
Time allocated 	3 x 45-minute periods	

Aim:

The aim of this lesson is to introduce you to the digital fundamentals and ensure that you can differentiate between analogue and digital signals. You will also learn the main features of two main measuring instruments which are the multimeter and the oscilloscope. At the end of the lesson, you will be introduced to the number systems especially the binary system. Also, you will learn how to convert a binary number to a decimal.

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.

- ☐ Introduce the key vocabulary of the digital fundamentals.
- ☐ Elucidate the differences between analogue and digital signals.
- ☐ Explain the characteristics of analogue signals (amplitude and frequency).
- ☐ Explain the characteristics of digital signals (frequency, period, amplitude, pulse width, and duty cycles).
- ☐ Introduce the main properties of analogue and digital systems.
- ☐ Present some of the digital applications.
- ☐ Explain digital pulse definitions (amplitude, rise time, fall time, width, and other characteristics).
- ☐ Introduce the two measuring instruments (multimeter and oscilloscope) and explain their features.
- ☐ Introduce number systems and concentrate on the binary system.
- ☐ Explain binary conversions and solve some examples.

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

Students should be able to:

- ☐ Distinguish between analogue and digital signals.
- ☐ Explain signal quantities: amplitude, frequency, pulse width, and period.
- ☐ Recognize some digital device and applications.
- ☐ Learn the basics of the binary system.
- ☐ Learn the basics features of the oscilloscopes and how to use them.
- ☐ Learn the conversion from decimal to the binary system.

Keywords	**What are the keywords the students must learn?** • analogue • digital • binary • pulse • bit • amplitude • frequency • PWM
Resources	**What resources are required?** • textbooks • projector
Prior Knowledge	• basic knowledge about digital devices. • basic mathematics skills.

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			Pages
Chapter	**Section**		
Ch. 1	**Sec. 1**	**All topics in this section are essential**	**259 - 275**

Learning Phases:

Phase	Development [Phases or chunks of learning] ***Note:*** *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.*	Assessment opportunities	Notes for differentiation ***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.*
Phase 1 of lesson **(Connect) - Starter**	Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Discuss prior knowledge of the digital world by asking students to give examples of digital devices which they use daily. **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	**Questioning**	
Phase 2 of lesson **(Activate)**	Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. a) Teacher to explain the two different ways of sending and receiving information which are analogue and digital. b) Ask students to give examples of analogue and digital values in the real world. c) Explain the basic differences between analogue and digital signals shown in figure 5.1.2.	**Oral assessment**	

	d) Explain the important characteristics of analogue signals (amplitude and frequency). e) show the difference between the low and the high frequency signals. f) Explain the characteristics of digital signals (frequency, period, amplitude, pulse width, and duty cycles). **<u>Teacher Tip:</u>** *Teacher to demonstrate good subject and curriculum knowledge*		
Phase 3 of lesson **(Engage and Demonstrate)**	a) Reexplain the difference between high and low frequency signals before asking students to solve activity 5.1.1. b) Facilitate as students complete activity 5.1.1. c) Draw an example of an analogue signal which has a frequency of 4 Hz and an amplitude of 3 V, then ask students to do the second part of the activity 5.1.1. d) Provide feedback on activity 5.1.1. e) Motivate students to view the videos provided in the lesson using the QR codes in their leisure time. f) Introduce the main properties of analogue and digital systems. g) Explain the example shown in figure 5.1.9 as it represents a good example of how digital and analogue systems interact with each other. h) Discuss features of analogue and digital systems shown in table 5.1.1. i) Ask students to complete activity 5.1.2 as a homework. j) Students to solve activity 5.1.3. k) Explain some of the digital applications and ask students to do activity 5.1.4.	**Activity 5.1.1** **Activity 5.1.2** **Activity 5.1.3** **Activity 5.1.4**	

	l) Explain digital pulse definitions (amplitude, rise time, fall time, width, and other characteristics). m) Students to complete activity 5.1.5. n) Introduce the two measuring instruments (the multimeter and the oscilloscope). o) Explain the number systems and focus on binary system conversions. p) Explain one conversion example then ask students to solve activity 5.1.6. q) Divide students into groups to discuss entrepreneurship and entrepreneur examples. Students to further study entrepreneurship at home. **<u>Teacher Tip:</u>** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.*	**Activity 5.1.5** **Activity 5.1.6**	
Phase 4 of lesson - **Plenary (Consolidate)**	Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the official activities tasks and reflections	**Oral Assessment** **Student evaluation**	

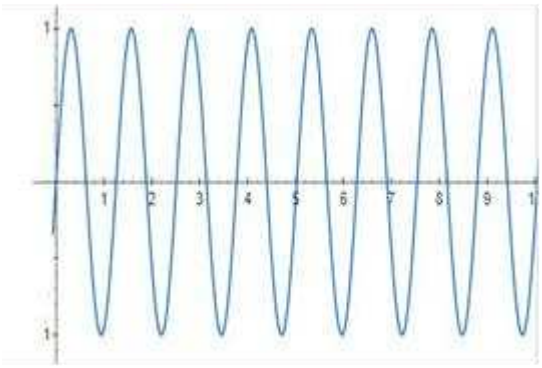
QR Code Links

QR code links:		
Page	***Topic***	***Link***
264	analogue and digital - 1	https://www.youtube.com/watch?v=WxJKXGugfh8
264	analogue and digital - 2	https://m.youtube.com/watch?v=btgAUdbj85E
269	PWM for controlling LED brightness	https://www.youtube.com/watch?v=Qgoe3KbEvTI
272	how to Use an Oscilloscope	https://m.youtube.com/watch?v=u4zyptPLIJI
273	binary Numbers and Base Systems	https://www.youtube.com/watch?v=LpuPe81bc2w
274	binary to decimal conversions	https://www.youtube.com/watch?v=LFmlStBx6nw

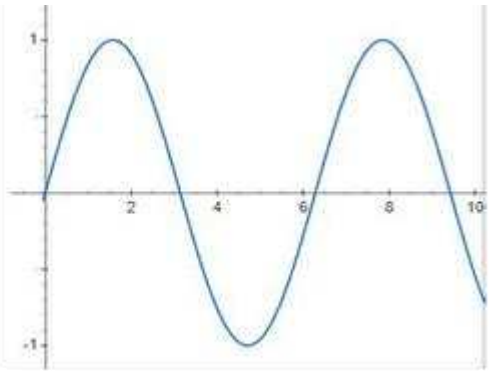
Answer Key

Activity 5.1.1

You learned the difference between high and low frequencies. Now write down which signal from the followings is a high-frequency signal and which is a low-frequency signal.

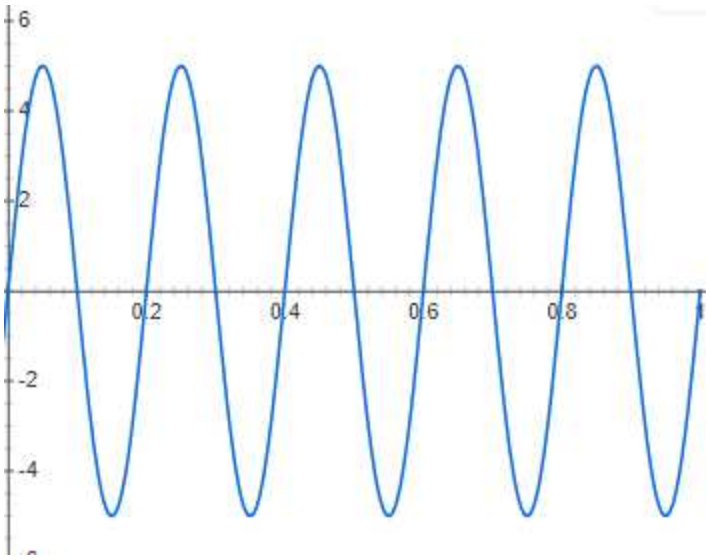


High frequency



Low frequency

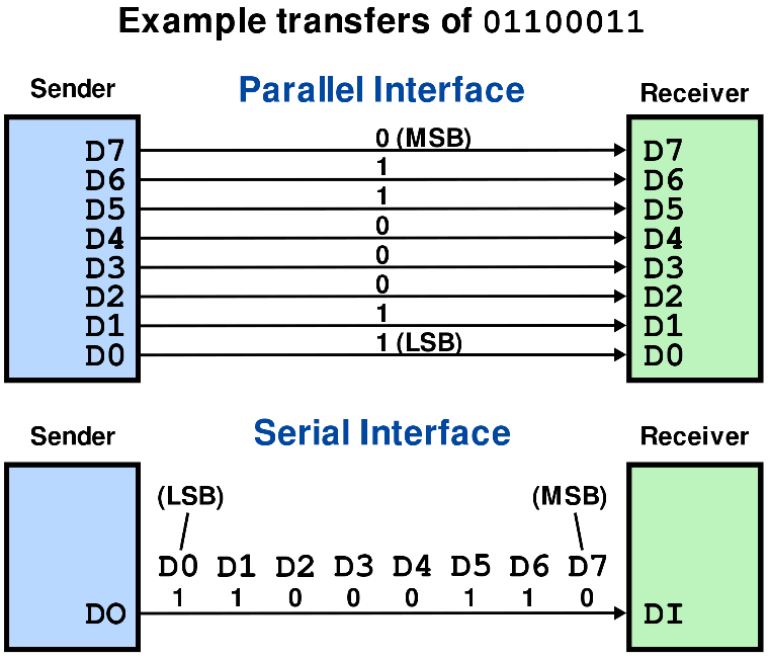
2. Draw an Analogue signal which has a frequency of 5 Hz and an amplitude of 5 V.



<u>Note:</u> Student can draw any periodical wave instead of the shown sine wave. It is important that the amplitude equals 5 and has a frequency of 5 Hz.

Activity 5.1.2

Search for the main features of both parallel and serial communication interface and write it down.

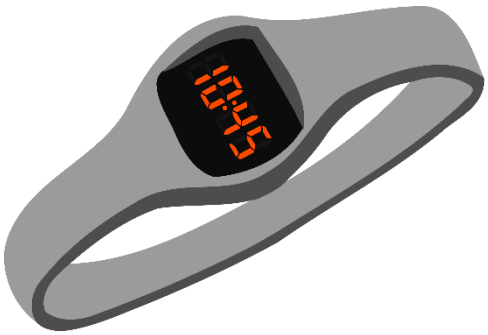


In digital devices, the information is transferred using two different forms. The first one as shown in the previous figure is the parallel transfer in which all information is transferred at the same time between the sender and the receiver. In the serial interface, the information is transferred in sequence one after the other. The student is required to search for at least two features of these communication interfaces.

Activity 5.1.3

Classify the following devices to Analog or Digital

Analogue



Digital

Analogue

Digital

Digital

Analogue

Activity 5.1.4

Mention three examples of digital application and specify their functions.

Digital technology is used in various fields such as communication, computing, control, and automobiles. In this activity, the student is required to mention three examples of a device or a system which is based on the digital technology. For example, the student can mention digital cameras and its advantages over the previous generations of cameras which depended on analog technology.

Activity 5.1.5

Answer the following questions:

1. b
2. a
3. a
4. a

Activity 5.1.6

Convert the following binary numbers to decimals:

A. 101110 = $1x2^5 + 0x2^4 + 1x2^3 + 1x2^2 + 1x2^1 + 0x2^0 = 46$

B. 100101 = $1x2^5 + 0x2^4 + 0x2^3 + 1x2^2 + 0x2^1 + 1x2^{0=37} = 37$

C. 111001 = $1x2^5 + 1x2^4 + 1x2^3 + 0x2^2 + 0x2^1 + 1x2^0 = 57$

Week 11 Lesson Plan:

Content	Chapter 5: Assembly of speaker model	Section 1: Assembling, programming and testing speaker model
Time allocated 	3 x 45-minute periods	

Aim:

Upon completion of this lesson, you will understand how to assemble the 3D printed model of your speaker with the electrical components. This will include mounting the speakers with hot glue, soldering the LED Matrix into the 3D printed holder, gluing the LED matrix into place and soldering the speakers to the PCB board. You will also mount the power switch, the volume potentiometer and the 3.5mm audio jack in the holes created. When you are finished, you should have a fully assembled and functioning portable smart speaker

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.

- ☐ Demonstrate gluing speakers to 3D printed model.
- ☐ Demonstrate soldering speakers to PCB
- ☐ Facilitate as student's glue

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

Students should be able to:

- ☐ Mount speakers to a 3D printed model.
- ☐ Solder speakers to PCB board.
- ☐ Use glue or nuts to assemble electronic components to a 3D printed model
- ☐ Assemble LED matrix.
- ☐ Use Arduino microcontroller to program an LED matrix pattern.

Keywords 	**What are the keywords the students must learn?** • assemble • to solder/soldering
Resources 	**What resources are required?** • textbooks • projector • Fusion 360
Prior Knowledge 	• Solder the components of an electronic circuit into a a copper PCB • Recognizes the basic Arduino microcontroller software and hardware applications

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**	**Assessment**
Ch. 5	**Sec.1**	Adding power supply and potentiometer	301-302	-	307
		Adding speakers	303-304		
		Assembly of switch, volume potentiometer and audio jack	304-306		

Learning Phases:

Phase	Development [Phases or chunks of learning] ***Note:*** *All lessons start with Phase 1, Lessons can move back and forth between phases 2 and 3 as content is covered and then students engage. All lessons must finish with phase 4 to evaluate learning.*	Assessment opportunities	Notes for differentiation ***Note:*** *All lessons can be different depending on ability and success of previous lesson. Place additional notes or activities to cater for differentiation where necessary throughout the lesson.*
Phase 1 of lesson **(Connect) - Starter**	Teacher to introduce students to the lesson aim. Teacher to place all student learning outcomes on the board and ensure student understanding of aims and outcomes. Assess progress of pupil's assembly and 3D printed parts **Teacher Tip:** *Teacher to set high expectations which inspire, motivate and challenge pupils.*	**Questioning**	
Phase 2 of lesson **(Activate)**	Teacher to introduce all key words, discuss meaning and ensure understanding before progressing. a) Demonstrate adding power supply, toggle switch and potentiometer to circuit. b) Demonstrate gluing and soldering speakers in place. c) Facilitate as students assemble all components inside the speaker base. **Teacher Tip:** *Teacher to demonstrate good subject and curriculum knowledge*	**Oral assessment**	
Phase 3 of	a) Student to solder power supply, switch and potentiometer to circuit		

	b) Student to glue speaker into model before soldering speaker wires to PCB c) Students to assemble all components inside speaker base and mount bottom cover. **<u>Teacher Tip:</u>** *Use groupwork as appropriate, get to know your class and organise groups to support mixed ability's.*	**Official assessment task for assembling**	
Phase 4 of lesson - **Plenary (Consolidate)**	Teacher to facilitate as students evaluate learning. Question pupils on what they have learned. Have learning outcomes been met? Has the lesson aim been achieved? All students must complete the official assessment tasks and reflections Students to return to Chapter one and complete project evaluation.	**Oral Assessment** **Student evaluation**	