TAS Year 9/Stage 5 (iSTEM) – 2020

Programmed Unit of Work: "Aerodynamics" (Module 5)

Teacher: Dave Bonzo Class: Year 9 iSTEM1 Timing: Terms 3 & 4

Preamble:

There are several students in Year 9, who have a diagnosed disability/imputed disabilities and/or significant difficulties with learning (diagnosed learning disorder), who require adjustments to ensure they are able to demonstrate what they know and can do in relation to syllabus outcomes and content. Consultation with parents has occurred during the consultative/ collaborative process during Individual Plan meetings. All curriculum adjustments are annotated in pink in this program. Please refer to the Summary Table of Adjustments link below for a list of students and their adjustments.

Teaching & Learning	Assessment - Disability Provisions	Literacy	Numeracy	Social Skills	Environment:	Resources:	Extra Curricular

Adjustments appear in pink within this program

Rationale

This unit addresses Module 5 (Aerodynamics)

During Term 3, students are introduced to a range of aerodynamic concepts and encouraged to undertake inquiry-based learning practical activities to experiment with, and formulate conclusions about, aerodynamic engineering principles. Learning activities will support the development an engineering design project, an aerodynamic Formula-1 style CO2 powered model dragster. This project will incorporate the design, development and testing of the race car, and will be defined by a number of criteria common to the *Formula One in Schools* competition. Technologies utilised will include, but are not limited to, the use of CAD software for design and manufacture, wind tunnel testing, 3D printing of components and/or race car bodies, testing of designs through the use of aerodynamic simulation programs, and a range of workshop tools and equipment required for manufacture. For students involved in the optional *Formula One in Schools* external STEM competition, a CNC machined balsa dragster will be produced. The generation of a CAD-design and 3D printed dragster (as well as a CNC machined dragster) will preview components of Module 8 (CAD/CAM-2). All students will utilise appropriate experimentation to analyse and validate design decisions. Documentation of the design process, and the analysis of results, will be in the form of an Engineering Report. Students will work in teams to capitalise on their respective strengths. Pedagogical practice will emphasise the “explore before explain” model of independent learning.

Opportunities for extension are provided through participation in the *F1 in Schools STEM Challenge*.

Aim:

The aim of this unit is to introduce students to the principles and practices utilized in aerodynamics.

Christian Perspective:

Ps 121:1 states “I will lift my eyes up to the hills, from where my help comes”. This scripture refers to our God-given need for assistance in this life. God often places us in situations where we need His help, so that we can develop our prayer life, by seeking His wisdom and understanding. The nature of the engineering design project for this unit will stretch student’s abilities, and may even challenge their confidence. Students will regularly be encouraged to invite God to intervene, after all, He is the origin of all wisdom. God desires to build us up into stronger and wiser people. Learning to talk to Him when we discover the limits of our “engineering wisdom”, will develop in us the confidence to trust Him for other matters in life.

SPCC Leaning Framework

Term 3:

Domain: Managing

Habit: ***Revising***

How addressed: Throughout the term, students undertake activities that require them to build upon their knowledge of aerodynamics. Learning is (revised and) applied in development of the CO2 race car project.

Domain: Discovering

Habit: ***Taking Risks***

How addressed: The CO2 race car project encourages students to "push the envelope" in terms of aerodynamic design and weight reduction, in order for them to optimize their racing result during the testing heats.

Objectives

Knowledge, Understanding and Skills

Students will develop:

1. inquiry based learning skills appropriate too technological and engineering practice;
2. knowledge and understanding of scientific and mechanical concepts through investigations of technology and engineering;

3. knowledge and understanding of technological and engineering principles and processes;

4. skills in solving technology based problems using mechanical, graphical and scientific methods;
5. skills in communicating and critically evaluating;

6. problem solving skills in a range of technological and engineering contexts.

Values and Attitudes

Students will develop:

7. an appreciation of the role and potential of science, technology, engineering and mathematics in the world in which they live.
8. an understanding of the contribution of STEM disciplines to the economic well- being of nations

Syllabus Requirements – *see page 7 in syllabus*

- Inquiry-Based Learning: "*To satisfy the requirements of the course students must undertake a range of inquiry-based learning activities which occupy the majority of course time*".
- The Stage 5 course contains 5 Modules. This unit addresses the Module 5 (Aeronautics) and secondary components of Module 3* (CAD/CAM-2).

Term 3, Week 1-2: Mechanics: Review SI units & prefixes; Statics vs Dynamic; Friction; Efficiency

Outcomes A Student:	**Students learn about:**	**Students learn to:**	**Strategies, activities**	**Resources**	**Evidence of Learning**	**Feedback**
5.1.4 (fundamental engineering mechanics)	**Fundamental engineering mechanics** - basic units - prefixes - modelling	- apply units to concepts of mechanics - complete basic calculations related to statics - apply units to concepts of engineering mechanics - utilise metric prefixes related to every day technologies 	<u>Measurement units</u> Thought questions: 1. What is the difference between a meter and a yard? (metric vs imperial) 2. How were they developed? (the need to standardise measurement for trade … inch = length of a thumb, foot = length of a man's shoe, yard = length between your nose and your outstretched fingertip tip; cup = how much water you could hold in your hand; a pound = the weight of a throwing stone) 3. What is the metric system based on? (units of 10 ... easier for calculations/trade) 4. Which county still uses the imperial system? (USA) 5. What are the <u>S.I base units</u> in the metric system? (length→metre, mass→kilogram, volume→litre) <u>Prefixes</u> When thinking of computer memory, it is divided into units called "bits" (0 or 1 charge). These are then bundled into units of 8 called "bytes". Because computing power continues to grow, we no longer measure capacity in "bytes". We now commonly use kB, MB, and GB. Activity: Create a table of at least 6 commonly used metric prefixes (both in multiples of the SI units and in fractions of them); include their index (power of 10). Activities: 1. Students choose appropriate units of measure for a variety of engineering situations: (eg. Volume of a swimming pool/reservoir = Litre; Width of a road = Meter; Weight of a bridge = Kg) 2. Students use the length/area/volume of familiar objects (meter stick or maximum stride) to estimate the length/area/volume of larger areas (eg: courts or sporting fields; volume of a rainwater tank, length of the classroom)	*Measurement: Thought Questions* Worksheet Meter stick Litre bottle Kilogram Students correctly estimate the size objects	Monitor progression of student understanding of *Measurement Thought Questions* worksheet Students produce a table containing at least 3 prefixes greater than the base SI unit, and 3 smaller. Students accurately estimate the approximate size of the item being measured, using the most appropriate prefix.	Reinforce the use of both the prefix and the index. Check to see that students use the most appropriate prefix. (i.e. limiting the unit using a prefix)

5.3.1 applies a knowledge and understanding of STEM principles and processes	**Aerodynamic forces** - simple vectors	- describe the difference between a static and a dynamic - apply units to concepts of - complete basic calculations related to engineering statics engineering mechanics - determine solutions using vector notatio - complete basic calculations related to engineering statics - simulate mathematical problems using appropriate modelling techniques. - describe the difference between a static and a dynamic - apply mathematical and graphical methods to solve aerodynamic related problems - determine solutions using vector notation	<u>Statics</u> Statics = the study of object at rest (when all forces are in **<u>equilibrium)</u>** **Force** is calculated in **Newtons** (1/10th of a kilogram … the force gravity exerts on a 1kg weight … on earth). Vectors: A <u>force</u> exerts pressure on an object to encourage <u>movement</u> in a particular <u>direction</u>. Vectors describe the <u>direction</u> and intensity of the force. Activities: (to be checked by another class member) 1. Calculate the vertical force that your chair must exerting to support you while sitting in it (i.e. to achieve equilibrium). [Your mass in kg x 10]. Answer in Newtons! 2. Calculate the force on a rope used to pull a boat out of the water when four of your friends use their full body weight to pull it. Will the rope break???? 3. Optional: Calculate the force the floor must exert on the chair. 4. Calculate the force required to counteract a 100MN force caused by wind blowing against a building. (100MN) 5. SIMULATION→ Calculate the RESULTING force from a tug of war between 6 students. ***<u>(Illustrate this graphically using scaled lines for forces)</u>*** *<u>Extension:</u>* Force does not have to be linear. Rotational force is used to propel your bicycle wheels and move your car. Rotational force is commonly referred to as “torque”. <u>Dynamics</u> If the applied force is sufficient, movement will occur. Systems in which movement occurs are no longer static (still), but “dynamic”. The greater the rate of movement, the greater the force. In dynamic systems, the <u>rate of movement</u> must be included. Example: A car travelling on the M1 to Sydney is limited to 110km/hr; a sprinter in a bicycle race may be travelling 60km an hour, light travels at 299,792,458 metres/ second. Ask students to write a definition of statics and dynamics <u>in one sentence</u>. Activity: In groups of 2 students generate one (vector) statics problem each and work out a solution; answers are cross-checked. (Suggest one easier and one more complex.) The problems are then written out and given to another group to solve. Answers are checked against the original solution for accuracy. Discrepancies are to be resolved.	Scale - to weigh students. *Statics: Thought Questions* Worksheet Calculators	Students arrive at correct calculations. (Checked by at least one other class member) Monitor progression of student understanding of Statics worksheet Ask several students to read out their own definition. Try to arrive at a concise, one-sentence answer. Generation of suitable static problems with worked solutions.	Ensure students remember to express their answer in Newtons… and with an appropriate direction. (↑, ↓, →, ←) Assist students to arrive at a concise, one-sentence answer by having them consolidate the various definitions. Reinforce the necessity to cross check answers in real world situations. Errors occur!

	Aerodynamic Principles - dynamic & static friction	- explain aerodynamic principles	<u>Friction:</u> Illustrate the difference between static and dynamic friction by having students shift a table across the carpet. *Question: Why does it require less force to keep the table moving, rather than to get it moving? (static vs dynamic friction; inertia)* Then, have students move the table with someone sitting on it. *Question: Why does it require more force to move the table? (Greater frictional force due to increased weight)* Aircraft must overcome friction from air resistance to gain speed to fly; we call this Drag. *Question: When do we WANT friction on an aircraft? (Braking when landing)*	Table and carpeted floor	Students engagement with concepts	
	- Lift/drag ratios - lift, drag, weight, thrust	- describe the effects of lift, drag, weight and thrust	Which force works to counteract the drag created by air resistance? (Thrust from the engines) Which force works to counteract the effect of gravity (weight)? (Lift from the wings)	Model airplane to illustrate forces		
5.7.1 demonstrates an appreciation of the value of STEM in the world in which they live		- apply mathematical and graphical methods to solve aerodynamic related problems	Draw a simple Force Diagram for an airplane to illustrate the relationship between the 4 forces of flight. Assign each one a value and direction (vector). Provide students with a simple problem to solve using these 4 vectors. (i.e. "Will the airplane ascend or descend?" "Will the airplane maintain its present speed?") Following this, use Trigonometry to isolate the vertical & horizontal components of each vector. Illustrate that these can be combine mathematically to calculate the exact resultant force.		Student mastery of simple force calculations	Students check their work against each other's answers.
	- efficiency	- perform simple calculations related to efficiency	Introduce concept of mechanical efficiency. (The relationship between inputted "effort" and outputted "work".) Provide a simple example of 2kg (20N) of force required to open a paint tin lid using a screw driver, which would normally require 6kg (60N) of force. Efficiency is 300%.	Examples of screw driver & pliers (levers)	Student calculation of efficiency.	

Term 3, Weeks 3-4: CO2 Dragster Project: Research & Seminar

Outcomes A Student:	Students learn about:	Students learn to:	Strategies, activities	Resources	Evidence of Learning	Feedback
5.2.1 describe how scientific and mechanical concepts relate to technological and engineering practice 5.2.2 Applies and transfers acquired scientific knowledge and mechanical knowledge to subsequent learning experiences in a variety of contexts 5.5.1 applies a range of communication techniques in the presentation of research and design solutions 5.3.1 applies a knowledge and understanding of STEM principles and processes 5.3.2 identifies and uses a range of technologies in the development of solutions to STEM based problems 5.7.1 demonstrates an appreciation of the value of STEM in the world in which they live 5.5.2 critically evaluates innovative, enterprising and creative solutions	**Research and exploration** - interpreting and analysing data - quantitative and qualitative research **Aerodynamic principals** - dynamic, static friction - lift/drag ratios - lift, drag, weight, thrust - Finite Element Analysis (FEA) - flight **Technologies related to aerodynamics** - wind tunnels - smoke tunnels - computational fluid dynamics (CFD)	- use research techniques to develop design ideas by testing and experimenting - select and use a variety of research methods to inform the generation, modification, and development of aerodynamic projects. - explain aerodynamic principles - describe the effects of lift, drag, weight and thrust - describe how Finite Element Analysis is applied aerodynamic systems - analyse, interpret and apply research data in the development of aerodynamic projects - complete quantitative and qualitative research	<u>**CO2 Dragster Project**</u> • Introduce task and explain parameters (one hand-shaped balsa dragster and one CAD designed 3D printed dragster) • Students to select a partner to undertake the project with • Students research & evaluate existing designs <u>**Seminar Task: "Aerodynamics" (C/T)**</u> Working in groups of two, students to research and present information on a range of topics relating to aerodynamic principles. Assessment will focus on ability of students to: 1) adequately research their nominated topic 2) effectively communicate their information to the class 3) effectively summarise their information on paper This task is to be conducted as "home learning" with only limited time provided during class sessions for consultation with other students and the teacher. Time allocation is 2 weeks. 	Project task sheet Aerodynamics Seminar task sheet	Teacher observation during research sessions. Presentation of Seminar Task	Appropriate feedback provided to student questions Seminar presentation marked and feedback provided to students

5.3.2
identifies and uses a range of technologies in the development of solutions to STEM based problems
 	
5.6.1
selects and uses appropriate problem solving and decision making techniques in a range of STEM contexts
	- Aerodynamic design solutions
	
	Technologies related to aerodynamics
	- wind tunnels
	- smoke tunnels
	
	Research and exploration
	- testing and experimentation
	- observation
		- construct models for the purpose of solving aerodynamic problems.
		
		- evaluate results from testing to improve aerodynamic performance of engineered solutions
		- select and use a variety of research methods to inform the generation, modification, and development of aerodynamic projects
		
		-utilise 3D drawing and manufacturing software to produce new products
		
		- develop engineered solutions to meet detailed specifications
		
		- uses appropriate design processes and techniques in the context of developing engineered solutions.
			• Preliminary sketches of design ideas (isometric)
			
			• Modelling of "balsa dragster":
			  ○ conversion of iso→ortho
			  ○ form shape using "magic sand" and determine frontal area by projecting a shadow of the front view onto the whiteboard.
			  ○ Shaping of foam model and testing using wind/smoke tunnel (video results). Evaluate results to improve design.
			
			• Use of CAD software to commence designing F1 dragster
				Sketching paper for isometric
				Drawing boards orthogonal
				
				Modelling foam and tools
				
				Magic Sand
				
				Wind tunnel
				Smoke generator
				
				CAD software (AutoDESK Fuzion 360)
					Production of 2 isometric sketches of designs
					
					Foam model
					Determination of frontal area.
					Video of wind tunnel testing
					Students observe the airflow patterns generated by their cars. Pressure sensor data is logged and recorded, Data is then graphed using MS EXCEL.
					
					Some CAD designing commenced
						Incidental advice in the form of thought questions on level of progress.

Term 3, Weeks 5-8: CO2 Dragster Project: Construction of balsa dragsters; CFD testing and 3D Printing of F1 racers

Outcomes A Student:	Students learn about:	Students learn to:	Strategies, activities	Resources	Evidence of Learning	Feedback
5.2.1 Describes how scientific and mechanical concepts relate to technological and engineering practice 5.3.2 identifies and uses a range of technologies in the development of solutions to STEM based problems 5.6.1 selects and uses appropriate problem solving and decision making techniques in a range of STEM contexts	**Technologies** - computational fluid dynamics (CFD) **CAD/CAM operations** - 3D CAM operations	- experiment to optimise solutions for aerodynamics related projects - evaluate results from testing to improve aerodynamic performance of engineered solutions the purpose of solving aerodynamic problems - Utilise modelling software to determine optimum aerodynamic conditions using CFD techniques. - uses appropriate design processes and techniques in the context of developing engineered solutions - design, construct parts, products or assemblies using CAD software and producing them using appropriate CAM software	**<u>CO2 Dragster Project (continued)</u>** • Complete CAD drawing of F1 dragster and import into *AutoDesk FLOW Design* software to perform CDF testing. Evaluate results and modify design as indicated. • Applying the results of wind tunnel testing, construct the balsa racer using tools and equipment in the workshop. • Fabricate the F1 dragster by importing the CAD file to the 3D printer.	AutoDesk FLOW program Balsa block, axles and wheels 3D printers	Students run simulation in *AutoDesk FLOW* and record coefficient of drag data. Several screen shots are also taken for use in the Engineering Report. Construction of balsa dragsters. Fabrication of 3D printed F-1 dragsters using 3D printers.	Incidental feedback provided students on the gathering and interpretation of data. As required.

Term 3, Week 9-10: Finishing & Painting of Dragsters; Testing of dragsters

Outcomes A Student:	**Students learn about:**	**Students learn to:**	**Strategies, activities**	**Resources**	**Evidence of Learning**	**Feedback**
5.1.2 demonstrated initiative, entrepreneurship, resilience and cognitive flexibility through the completion of practical STEM based activities 5.3.2 identifies and uses a range of technologies in the development of solutions to engineering problems 5.5.1 applies a range of communication techniques in the presentation of research and design solutions 5.3.1 applies a knowledge and understanding of STEM principles and processes	**Problem solving** and design – aerodynamic design solutions	- develop engineered solutions to meet detailed specifications - evaluate the results from testing to improve aerodynamic performance of engineered solutions	**CO2 Dragster Project (continued)** Students to apply an appropriate finish to their dragsters (sand smooth, seal, spray paint and decorate) Students may use the label maker and/or vinyl cutter to print stickers **Testing** of CO2 dragsters (balsa and 3D printed F-1) in the form of heats using a 20 meter racetrack. (Testing to determine the fastest dragsters in each category) If time remains, allow students to re-test their dragsters in one final competition, allowing them to further improve/modify their design (while staying within the task parameters), Prizes (medals) to be awarded in each category for fastest overall time, best decorated, and most improved.	Workshop Sand paper Spray putty Spray primer Spray paints (variety of colours) Pin-striping tape Sticker maker Vinyl cutter Race track and timing device CO2 canisters	Application of an appropriate finish to the dragsters Use of sticker maker and/or vinyl cutter machines to create decorations/logos Record results of heats.	Ask students to reflect on how their racing went. What could be improved?

Term 3, Week 10 – Submission of Engineering Report for CO2 Dragster Project;

Outcomes A Student:	**Students learn about:**	**Students learn to:**	**Strategies, activities**	**Resources**	**Evidence of Learning**	**Feedback**
5.5.1 applies a range of communication techniques in the presentation of research and design solutions		**Problem solving and design** - develop engineered solutions to meet detailed specifications - evaluate results from testing to improve aerodynamic performance of engineered solutions	Students document their design process in the form of an Engineering Report, containing a range of communication methods (text, sketches, drawings, and photographs) and submit it for marking. The report is to be formatted in a technical writing style (i.e. concise, yet precise, with a minimum of text). 	Aerodynamics Engineering Report template.	Submission of completed Engineering Report	Engineering reports marked and returned.