MAITLAND GROSSMANN HIGH SCHOOL

iSTEM SCHOOL DEVELOPED BOARD ENDORSED COURSE
STAGE 5 TEACHING AND LEARNING PROGRAM
Year 9 2015

MAITLAND GROSMMANN HIGH SCHOOL
iSTEM TEACHING AND LEARNING PROGRAM

Rationale

Science, technology, engineering and mathematics are fundamental to shaping the future of Australia. They provide enabling skills and knowledge that increasingly underpin many professions and trades and the skills of a technologically based workforce. The iSTEM program utilises these knowledge sources in application to Skills, Technology Engineering and Mechanics.

Australia's graduation rates in science, technology, engineering and mathematics are low by international standards. Yet a high output in these disciplines is seen to be a critical underpinning for the future of innovative economies. Policies are emerging around the world that focus on these fields and seek to grow the supply of graduates with the skills and knowledge developed through a quality education in STEM subjects. The reason is straightforward, the world's dependence on knowledge and innovation will grow and not diminish and to be ahead in the race, a community needs the skills to anticipate rather than follow.

In the United States (U.S.), it is estimated that scientific innovation has produced half of all economic growth in the last 50 years. The science, technology, engineering and mathematics fields and those who work in them are critical engines of innovation and growth, according to one recent estimate, the STEM workforce accounts for more than fifty percent of sustained economic growth in the U.S.

The economic value of STEM cannot be underestimated with 1 in 18, or some 7.6 million workers in the United States being employed in STEM based careers as a technician, technologist, engineer or scientist. Projected growth in STEM based occupations is 17% between 2008 to 2018, compared to 9.8% for non-STEM occupations. STEM workers earn on average 26% higher wages than their non-STEM counterparts and more than two-thirds of STEM workers have at least a University degree, compared to less than one-third of non-STEM workers. A STEM degree means higher wages regardless of what area they are employed.

The recommendations from the report, Mathematics, Engineering & Science, in the National Interest, from the of the Chief Scientist, May 2012, states that "teachers, have the greatest influence on the choices students make and we need to ensure that the school sector maximises interest and provides opportunities for all students to study high quality mathematics and science courses leading to careers in those disciplines and in engineering. i The Smarter Schools National Partnerships, in particular, the National Partnership Agreement on Improving Teacher Quality, both concur with many of the objectives discussed above.

According to the Australia Bureau of Statistics, in Australia the proportion of mathematics and science students in schools still goes down and in universities (as with engineering) it is virtually flat. Albert Einstein's definition of insanity is "doing the same thing over and over again and expecting different results", something different has to be done demanding a paradigm shift in our schools.

There are a number of highly successful STEM based intervention programs in operation across Australia, some international and national programs include; F1inSchools, the ME program, Science and Engineering Challenge, RoboCUP, Electric Vehicle Festival, Solar Car Challenge, Pedal Prix, Science and Technology

Education Leveraging Relevance (STELR) program, and many others. The challenge for schools has been integrating these programs into their existing curriculum.

At Maitland Grossmann High, we are currently involved in the following STEM intervention programs; ME, F1inSchools, the Science and Engineering Challenge, RoboCUP, Electric Vehicle Festival, and STELR. Many of these programs are run partially within, but mainly outside the current school curriculum. The development of the iSTEM course is in part as a result of the need for the school to provide a more structured approach to gaining the most out of these intervention programs. Although components of the Board of Studies NSW, design & technology, graphics technology and industrial technology – engineering, syllabuses can be adapted to accommodate some parts of these STEM programs, none are suitable to implement the full program of study.

The proposed iSTEM program utilises a practical integrated approach with engineering and technology being used to drive interest in science and mathematics, through the development of technical skills and mechanical engineering knowledge. Its purpose is to increase the numbers of students studying STEM based subjects in the senior years and ultimately the number of student matriculating to tertiary study in the STEM areas.

Pure mathematics and science topics are not included in this course proposal, it is not intended as being a vehicle to increase the number of hours in which students study pure science or mathematics in Stage 5. Instead students learn about technological and engineering concepts which by their very nature are scientific and mathematical. Great effort has been taken to ensure that no specific content that appears in the upcoming science or mathematics NSW syllabuses incorporating the Australian Curriculum have been repeated in this course.

In the recent review of Science, Mathematics and Engineering (2012) by the Office of the Chief Scientist of Australia, it was commented that teaching needs to be high quality and inspirational while science and mathematics based content was generally seen as … “irrelevant to life after school.” and “Content based teaching is seen as boring because so much is seen as knowledge transmission of correct answers with neither time nor room for creativity, reflection or offering opinions”.

The development of effective and attractive STEM curricula and teaching methods, - are at the heart of the drive to make STEM studies and careers a more popular option for young learners. Inspiring students to engage with mathematics and science can be best achieved by teachers who are passionate about the subject and have the knowledge and confidence to present the curriculum imaginatively.

According to Sanders the integrative STEM education pedagogical model is best practice when delivered through technology education. In addition over the past two decades, the technology education literature has been heavily populated with articles describing instructional materials designed to integrate technology, science, and mathematics and articles addressing issues associated with the integration of STEM concepts and practices. There is strong evidence to suggest that the approach taken in this course is “best practice” and will lead to advantageous outcomes for students.

This stage 5 iSTEM School Developed Board Endorsed Course is our attempt to provide an innovative and imaginative curriculum which will inspire students to take up the challenge of a career in Technology or Engineering.

School Situation

Maitland Grossmann High School is a coeducational comprehensive High School in the Maitland district located in the lower Hunter Valley. The student enrolment stands at approximately 1300 and has been growing steadily over the past few years. The school has a strong tradition within Maitland being one of the oldest schools in New South Wales.

Resources

The school currently has seven PC based computer labs with an ethernet network and Internet access via broadband line. These labs utilise Windows operating systems, using a large cross section of application software which can be utilised by engineering studies students. The Industrial Arts faculty has a number of mechanical testing devices, a technology lab at the back of A110, a large array of textbooks. Other resources include three 3D printers, a laser cutter, a wind/smoke tunnel, wind tunnel and smoke tunnel, CNC router and two laptop trolley have strengthened the resources to enable improved teaching and learning opportunities. Access to iPAD technologies are also available through a swap deal with the Music faculty. In addition in 2015 we purchased a rocketman bottle rocket launcher and a power anchor aeronautical testing device.

Course Structure

This School Developed Board Endorsed Course covers a number of modules in the fields of technology and engineering, they include; Engineering Fundamentals, Aerodynamics, Motion, Mechatronics and the Major Research Project. These specific modules are not reflected together in any Board Syllabus document.

There are five compulsory modules of which Module 1 is to be completed first as the knowledge and skills developed in this module are applied and enhanced in subsequent modules. Module 2 (50 hours) and Modules 3 and 4 (25-30 hours each) can be taught in any order, however, module 5 (40-50 hours) should be completed concurrently, with module(s) 3 and 4 totalling 50 hours. This is to maximise the use of resources and provide adequate time for students to complete quality work.

Individual modules provide specific content related to CNC, mechatronics, aerodynamics, computer controlled machining, computer integrated manufacture, product modelling and testing which will be developed in the key areas of; Skills, Technologies, Engineering Principles and Processes and Mechanics.

<table>
<tr><th colspan="2">100 Hours</th><th colspan="2">100 Hours</th></tr>
<tr><td>Module 1
Engineering Fundamentals
25 Hours</td><td>Module 2
Aerodynamics
25 Hours</td><td>Module 4
Motion
25 Hours</td><td>Module 5
Mechatronics
25 Hours</td></tr>
<tr><td colspan="2">Module 3
3D CAD/CAM
50 Hours</td><td colspan="2">Module 6
Research Project
50 Hours</td></tr>
</table>

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. Inquiry-based learning assists students to actively pursue and use technological knowledge rather than experience it as pre-packaged and complete – to be accepted and practised. Thus in the course structure there are many points at which students raise questions and explore ideas.

Aims

The aim of the iSTEM course is to promote the areas of science, technology, engineering and mathematics through the study of technology, engineering, skills and mechanics.

Students will learn to use a range of tools, techniques and processes, including relevant technologies in order to develop solutions to a wide variety of problems relating to their present and future needs and aspirations.

iSTEM aims to reverse these lowered participation rates by inspiring and enabling secondary school students to appreciate the role and potential of science, technology, engineering and mathematics in the world in which they live, and to learn from their journey of technological inquiry, the essence of evidence-based critical thinking.

One of the aims of the iSTEM course is to increase the number of students studying physics, chemistry, engineering, design and technology, computing and mathematics subjects at the upper secondary school level. This is to be achieved through an integrative technology and engineering course structure, which give practical relevance to scientific and mathematical concepts.

Secondary aims of the iSTEM course include;

1. Improve the level of technological and engineering literacy and understanding in the community,
2. Prepare students to engage with engineering ideas and be knowledgeable about the way engineers and technologists work,
3. Increase the number of students choosing science and engineering careers to address the shortage of science and engineering graduates,
4. Increase students' awareness of careers in STEM areas including trades,
5. Improve the quality of classroom teaching practices and enable teachers to develop confidence and skills that will assist them in delivering the Australian Curriculum,
6. Improve teaching quality through a cross-curriculum approach to programming and lesson delivery.

Maitland Grossmann High School
Engineering Fundamentals –Module 1

Unit Title: Engineering Fundamentals	**Time:** 25 Hours
Description: This module develops an understanding of the basic principles associated with iSTEM. To satisfy the requirements of this course, students must undertake a range of experimental, group work and inquiry-based learning activities, that occupy the majority of course time. These activities should be used to develop a deep knowledge and understanding of Engineering; Skills, Technologies, Principles & Processes, Mechanics.	
Objectives:	**Outcomes:**
• inquiry-based learning skills appropriate to technological and engineering practice • skills in solving technology based problems using mechanical, graphical and scientific methods • problem-solving skills in a range of technological and engineering contexts	5.1.1 develops ideas and explores solutions to technological and engineering based problems 5.1.2 designs and investigates different approaches in the development of engineered solutions 5.4.1 uses mathematical, scientific and graphical methods related to technology and engineering 5.4.2 develops skills in using mathematical, scientific and graphical methods whilst working as a team 5.6.2 will work individually or in teams to solve problems in technological and engineering contexts

Key:

NUM – Numeracy	ICT – Information and Communication Technologies
LIT – Literacy	AB ED – Aboriginal Education
FOR – Focus on Reading	IBL – Inquiry Based Learning

Quality Teaching Model Key:

Intellectual Quality	*Quality Learning Environment*	*Significance*
DK – Deep Knowledge	EQC – Explicit Quality Criteria	BK – Background Knowledge
DU – Deep Understanding	E – Engagement	CK – Cultural Knowledge
PK – Problematic Knowledge	HE – High Expectations	KI – Knowledge Integration
HOT – Higher-Order Thinking	SS – Social Support	I - Inclusivity
M – Metalanguage	SSR – Students' Self-Regulation	C - Connnectedness
SC – Substantive Communication	SD – Student Direction	N – Narrative

Evidence of Learning - Highlighted in Red **Assessment** - Highlighted in Grey

Assessment

Pre-Assessment: Multiple Intelligences Survey
Progressive Assessment: Inquiry Based Learning activities
Assessment: Engineering Problem Solving Activities

Resources:

Websites

http://www.leansimulations.org/2011/02/lean-lego-game-4-rounds-to-successful.html
http://pbskids.org/designsquad
http://www.sciencefairadventure.com/ProjectDetail.aspx?ProjectID=61
http://www.atse.org.au
http://www.pbs.org/wgbh/buildingbig/lab/forces.html

Texts/Materials

ATSE STELR *Core Program Student Book 2nd Edition*
PBS, *Design Squad guides*
Lynch, B. *Maths In Technology*
Thomson, S. & Forster, I. *Maths In Crime*
Boundy, A. W., (2007) *Engineering drawing.* 7th edition. Published by McGraw Hill Australia, Ryde.
Rochford, J., (2009) *Engineering studies – a student's workbook.* Published by
Multiple Intelligences Survey

Students learn about:	Students learn to:	Level 1	Level 2	Level 3
		Pre-Knowing / Knowing	Understanding / Applying	Evaluating / Creating
SKILLS				
5.1.1 engineering investigations - systematic observation - measurement - experiment - formulation, testing and modification of hypotheses - engineering drawing	- design investigations which produce valid and reliable data - investigate engineering problems using primary and secondary sources - use identified investigative strategies to develop a range of solutions to engineering problems - use AS1100 standards to interpret engineering drawings.	**Measurement** P1: ***Teacher*** to discuss with ***students*** how to design experiments that produce valid and reliable data. **(BK, KI, M)**	**Measurement** U1: ***Students*** analyse a number of experimental designs and identify dependent, independent and controlled variables. **(DU, M)**	**Measurement** E1: ***Students*** evaluate a number of experimental designs and outline improvements that must be made in order for valid and reliable data to be obtained. **(DU, SC, EQC, KI)**
		Experiments Electrical Circuits P2: ***Teacher*** to discuss with ***students*** prior knowledge of electrical circuits and introduce the multimeter as a tool for measuring current, voltage and resistance. ***Teacher*** to discuss multimeter use in everyday applications around the home and in trades. **(BK, KI, C) (ICT)**	**Experiments Electrical Circuits** U2: ***Students*** use the STELR kits to set up electrical circuits and demonstrate that they can use the multimeter to collect data, including voltage, current and resistance. **(DU, M) (ICT)**	**Experiments Electrical Circuits** E2: ***Students*** use the STELR testing station to evaluate which components use the most power. **(HOT, DU, SSR, KI) (ICT)**
		Problem Solving P3: ***Teacher*** to discuss with ***students*** scientific and engineering problem solving: Discussion on; What is an Engineer/Scientist? What do Engineers/Scientists do at work? How do Engineers/Scientist make the world a better place? **(BK, KI)**	**Problem Solving** U3: ***Students*** to develop a flowchart which demonstrates the process to solve engineering based problems? Students to identify the problem, brainstorm, design, build, test, evaluate, redesign and share solutions (See PBS education guide) **(DU, M)**	**Problem Solving** E3: ***Students*** to follow the engineering design process to design and build a table out of newspaper tubes. It must be at least 200mm tall and strong enough to hold a heavy book (See PBS Activity Guide for details) **(BK, C, PK, HOT, IBL)**
		Engineering Drawing P4: ***Teacher*** to led investigations of basic drawing equipment and techniques used in traditional Technical Drawing. Introduction to Australian Standards AS1100. **(BK)**	**Engineering Drawing** U4: ***Students*** to interpret basic AS1100 standards through the completion of basic orthographic sketches. **(DU)**	**Engineering Drawing** C4: ***Students*** to create basic orthographic drawings, accurately calculating spacing's from boards using appropriate numerical techniques. **(HOT, EQC) (NUM)**

Students learn about:	Students learn to:	Level 1		Level 2		Level 3	
		Pre-Knowing	Knowing	Understanding	Applying	Evaluating	Creating
TECHNOLOGIES							
5.1.2 the use of technology in developing engineered solutions to problems - hardware - software - LEAN Manufacturing processes	- describe a range of technologies used to collect, organise and analyse data - use a variety of technologies which assist in investigations into engineered solutions - utilise various hardware and software technologies to solve a broad range of engineering problems - develop an awareness of LEAN manufacturing processes	**Gardner's Multiple Intelligences** P1: ***Teacher*** to introduce Gardner's Multiple Intelligences and associated learning styles. ***Students*** to predict how they feel they learn best based on the evidence presented in the survey. **(SSR, HE)**		**Gardner's Multiple Intelligences** U1: ***Student's*** complete Multiple Intelligences (MI) survey and discover their optimum learning styles. ***Students*** to enter data into a table and create a basic bar graph of the data. **(KI, DU, C) (ICT, LIT, NUM)**		**Assessment** E1: ***Students*** enter their MI data into an appropriate software package and create a series of graphs. ***Students*** use information from Gardner's theory of MI sheets provided to evaluate their own individual strengths and weaknesses. ***Students*** analyse results in Assessment Task 1. **(DU, M, KI, LIT)**	
		Software P2: ***Students*** to learn how to use simulation software to solve engineering problems. ***Teacher*** to demonstrate the use of interactive ICT's to be used by ***students.*** **(DK, E, C) (ICT, LIT)**		**Software** U2: ***Students*** use iPAD's and the simple physics App to learn how to use interactive software. ***Students*** complete tutorials to develop an understanding of the software and problem solving. **(DU, BK) (ICT, IBL)**		**Software** E2: ***Students*** complete a series of problem solving scenarios' and try to bet previous best scores from previous classes. Tree House, staircase, snowy roof, Ferris wheel and windy city. **(PK, HOT) (ICT, IBL))**	
		Simulation Software P3: ***Teacher*** to demonstrate how to use structural analysis software using West Point Bridge Building Software. **(KI, M) (ICT)**		**Simulation Software** U3: ***Students*** use joints and members to design a basic bridge design in the West Point Bridge simulation program. ***Students*** test designs, using the animation feature. **(DU, SSR, BK) (ICT, IBL, NUM)**		**Simulation Software** E3: ***Students*** use one of the scenario's from the software and create a bridge which meets all criteria, which is cost effective and structurally sound. **(C, HOT, KI) (ICT, IBL, NUM)**	
		Lean Manufacturing P4: ***Students*** to investigate the key principles of LEAN thinking. **(DK, KI)**		**Lean Manufacturing** U3: ***Students*** undertake a LEAN simulation using LEGO planes. This initial simulation is designed to fail and demonstrate to student's how inefficient structures cause measureable losses in production. **(E, PK, KI, EQC) (IBL)**		**Lean Manufacturing** E4: ***Students*** evaluate the initial simulation and identify where improvements can be made. These improvements are integrated into the second simulation run. The success of the changes are recorded and students discuss the reasons for the success. **(HOT) (IBL, NUM)**	

Students learn about:	Students learn to:	Level 1		Level 2		Level 3	
		Pre-Knowing	Knowing	Understanding	Applying	Evaluating	Creating
ENGINEERING PRINCIPLES & PROCESSES							
5.1.3 fundamental engineering principles - strength of materials - material properties - fluid mechanics - electricity & magnetism - thermodynamics	- carry out experiments to demonstrate basic engineering principles - determine the properties of materials - use models to demonstrate describe Pascal's Principle - complete basic experiments involving electricity and magnetism - explain basic thermodynamic processes	**Materials** P1: ***Students*** research mechanical properties of materials and define; compression, tension, bending, shear & torsion. **(DK, M, BK)**		**Materials** U1: ***Students*** to use PBS forces lab to experiment with different forces. http://www.pbs.org/wgbh/buildingbig/lab/forces.html. **(DU, C, DK) (ICT)**		**Assessment** E1: ***Students*** to complete a report detailing the different forces and what learning occurred during the activity as part of Assessment 1. **(DU, HOT, KI) (IBL, LIT)**	
		Mechanical Properties P2: ***Teacher*** to discuss the concept of mechanical properties of materials and defines; compression, tension, bending, shear & torsion. **(M, BK)**		**Mechanical Properties** U2: ***Students*** use the PBS Materials lab to test their hypothesis for material strength. **(BK, DU, DK) (ICT)**		**Mechanical Properties** E2: ***Students*** to predict which shape, rectangle, arc or triangle can take the greatest load. ***Students*** use the PBS shapes lab to test their hypothesis for strength of shapes. **(KI, HOT) (ICT)**	
		Fluid Mechanics P3: ***Teacher*** to define Pascal's Principal and to demonstrate practical examples of how it is used. **(DK, M)**		**Fluid Mechanics** U3: ***Students*** to undertake an experiment with in which matchsticks are placed in a bottle of water with a balloon membrane. Pressure is increased and decreased to make the matchsticks move up or down. **(DU, E, KI)**		**Fluid Mechanics** E3: ***Students*** to create a basic lifting device using syringes and rubber tubing. The device must utilise Pascal's law. ***Extension:*** resolve a basic mechanics problem using Pressure = Load/Area. **(DU, PK, HOT, KI) (NUM IBL)**	
		Electricity & Magnetism P4: ***Teacher*** to discuss the use of batteries, turbines, and solar energy. Discussion on the 'Big Ideas' pg. 31, 46 and 61 of STELR. **(DK, DU, PK, M)**		**Electricity & Magnetism** U4: ***Students*** to complete a range of practical activities related to electricity and magnetism. **(DU, KI, SD)**		**Electricity & Magnetism** E4: ***Students*** to work in groups to hypothesize solutions to problems related to electricity and magnetism **(HOT, SSR, KI)**	
		Thermodynamics P5: ***Teacher*** to discuss what is energy and what are the different forms? Three Laws of Thermodynamics: Presentation of the three laws and practical examples discussed from ATSE STELR Renewable Energy Student workbook. **(DK, M)**		**Thermodynamics** U5: ***Students*** to complete experiments from Energy Transformations and Transfers pg. 4-20. STELR ***Students*** to complete experiments on Conservation of Energy and Efficiency pg. 21-27 STELR. **(KI, E, C)**		**Thermodynamics** E5: ***Students*** to complete exercises from 'selecting resources for our energy future'. Resource development activity Pg.28-30 STELR. **(DU, KI, SD, BK) (IBL)**	

Students learn about:	Students learn to:	Level 1		Level 2		Level 3	
		Pre-Knowing	Knowing	Understanding	Applying	Evaluating	Creating
				MECHANICS			
5.1.4 fundamental engineering mechanics - basic units - prefixes - statics - dynamics - modelling	- apply units to concepts of engineering mechanics - utilise metric prefixes related to every day technologies - complete basic calculations related to engineering statics - describe the difference between a static and a dynamic - simulate mathematical problems using appropriate modelling techniques.	**Basic Units** P1: ***Teacher*** to describe the difference between metric and imperial units of measurement and where they are used. **(DK, M) (NUM)**		**Basic Units** U1: ***Students*** choose appropriate units of measurement in a variety of engineering situations**.** **(DU) (NUM)**		**Basic Units** E1: ***Students*** use the length/area/volume of familiar objects to estimate the length/are/volume of larger areas (eg: courts or sporting fields). **(DU, BK, KI) (NUM)**	
		Prefixes and SI Units P2: ***Teacher*** to define the International System of Units (SI units) and are familiar with the list of twenty common prefixes. **(M) (NUM)**		**Prefixes and SI Units** U2: ***Students*** use the metric prefixes to convert between common units of modern technology (eg: kB/MB/ GB computer files). (From 'Maths In Technology' by Barbara Lynch) **(M, DU) (NUM)**		**Prefixes and SI Units** E2: ***Students*** perform calculations in common engineering situations utilising more than one metric prefix (eg: time taken to download 1.8 GB attachments at 512kB/s). **(KI, DU) (NUM)**	
		P3: ***Teacher*** to explain the role mathematics plays in solving problems relating to static engineering systems. **(BK, DU) (NUM)**		U3: ***Students*** utilise different methods (written / technology / software) to solve problems involving simple forces related to static engineering systems. **(DU, PK, KI) (NUM, ICT)**		E3: ***Students*** apply the concepts of force, load and torque to solve problems relating to static engineering systems in two dimensions. **(HOT, M, DU) (NUM)**	
		Dynamics P4: ***Students*** define the terms 'static' and 'dynamic' in an engineering framework. **(NUM, M)**		**Dynamics** A4: ***Students*** to apply knowledge to assess an engineering situation (civil / mechanical / electrical etc…) and describe it as either static or dynamic. **(KI, DU, HOT) (NUM)**		**Dynamics** E4: ***Students*** create a Computer Based presentation highlighting the differences between static and dynamic engineering systems. **(M) (ICT, NUM)**	
		Modelling P5: ***Students*** identify a problem in which mathematics is able to aid in the solution. In small groups ***students*** are able to collaborate on strategies that will lead to an answer. **(SS, SSR, SC) (NUM)**		**Modelling** U5: ***Students*** to work together to solve mathematical problems and communicate their solutions in an appropriate and meaningful manner. (Group work activities that assign each member a role or specific piece of information to be shared with the group) **(SS, SSR, HOT) (NUM, IBL)**		**Modelling** E5: **Students** design their own group work activity (can be modelled on the cards already completed in class) that can be completed by other members of the class. (Examples can be found in 'Maths In Crime' workbook by Sue Thomson & Ian Forster) **(NUM, SS, SSR, SD, HOT, IBL)**	

<table>
<tr><th rowspan="2">Students learn about:</th><th rowspan="2">Students learn to:</th><th colspan="2">Level 1</th><th colspan="2">Level 2</th><th colspan="2">Level 3</th></tr>
<tr><th>Pre-Knowing</th><th>Knowing</th><th>Understanding</th><th>Applying</th><th>Evaluating</th><th>Creating</th></tr>
<tr><td colspan="8">PROBLEM SOLVING & DESIGN</td></tr>
<tr><td rowspan="5">5.1.5 problem solving
- nature of
- strategies to solve
- evaluation
- collaboration</td><td rowspan="5">- identify the nature of engineering problems
- use identified strategies to develop a range of possible solutions to every day engineering problems
- evaluate the appropriateness of different problem solving strategies
- work collaboratively to solve problems
- draw information from a range of sources to aid in the solution of practical everyday problems</td><td colspan="2">Scope and Range of Profession
P1: Students to identify the nature of engineering. Scope and range of work completed by engineers. Students to identify well known engineered solutions.
(C, KI)</td><td colspan="2">Scope and Range of Profession
U1: Students to investigate the scope and range of engineering. Students to research one area of engineering for which they are interested and determine the scope and range of work completed. (KI, SD, DU)</td><td colspan="2">Scope and Range of Profession
E1: Students to evaluate the effects of engineering, both positive and negative, has had on society. Students to complete exercise on engineering disasters. (PK, C, HOT)</td></tr>
<tr><td colspan="2">Strategies to Solve Problems
P2: Teacher to model a range of problem solving strategies. Teacher to demonstrate practical engineering problem solving.
(KI, C, DK)</td><td colspan="2">Marshmallow Challenge
U2: Students to solve a range of engineering problems using a problem solving process. (E.g. Marshmallow Challenge).
(HOT, C, SD, DU) (IBL, NUM)</td><td colspan="2">Collaboration & Assessment
E2: Students to evaluate the results of the highest tower exercise. Students to include results and conclusions of Assessment Task 1. Extension: Add additional problems such as a fan simulating wind conditions.
(HOT, EQC, SD, PK) (IBL, LIT)</td></tr>
<tr><td colspan="2">Collaboration
P3: Teacher to discuss advantages of teamwork vs working as an individual. Advantages and disadvantages of different problem solving techniques discussed.
(DK, C)</td><td colspan="2">Paper Table Challenge
U3: Students to complete an engineering problem solving exercises completed both as an individual than as a group. Paper table challenge.
(HOT, C, DU) (IBL, NUM, LIT)</td><td colspan="2">Collaboration & Assessment
E3: Students to evaluate the success of the group work activities as part of Assessment Task 1.
(HOT, HE, PK) (LIT)</td></tr>
<tr><td colspan="2">Collaboration
P4: Teacher to discuss and model collaborative work practices and discuss their importance in a modern economy.
(KI, C, E)</td><td colspan="2">Hydraulic Lift
U4: Students to complete a collaborative problem solving exercise using syringes to produce a hydraulic lift.
(DU, SD, EQC, HE) (IBL, NUM)</td><td colspan="2">Assessment
C4: Students to record results of problem solving activities using a variety of ICT's and produce a report on its success and the learning involved.
(DU, SD, EQC, HE) (ICT, LIT)</td></tr>
<tr><td colspan="2">Problem Solving
P5: Teacher to discuss engineering problem solving techniques. Students to investigate solutions for set engineering problems using a range of sources.
(DK, KI, HOT)</td><td colspan="2">Egg Drop Challenge
U5: Students demonstrate a range of engineering problem solving using a variety of strategies. Students to utilise skills in the egg drop challenge.
(DU, EQC, HOT, SSR) (IBL)</td><td colspan="2">Evaluation and Assessment
E5: Students to document and evaluate solutions to a range of engineering problems related to everyday practical problems. Assessment Task 1.
(DU, EQC, HE) (IBL, NUM, LIT)</td></tr>
</table>

Maitland Grossmann High School
Aerodynamics –Module 2

Unit Title: Aeronautical Engineering	**Time:** 25 Hours
Description: Select one or more related areas as a theme for an introduction to the engineering concepts related to aerodynamics. Possible examples include: aeronautics, aerospace industries, ***Aeronautical Velocity Challenge, F1inSchools program,*** CO_2 dragsters, Scalectrix cars, kites, motor racing, or sports science. In this module students will utilise inquiry-based learning strategies to develop solutions to aerodynamic problems.	
Objectives:	**Outcomes:**
• inquiry-based learning skills appropriate to technological and engineering practice • knowledge and understanding of scientific and mechanical concepts through investigations of technology and engineering • skills in solving technology based problems using mechanical, graphical and scientific methods • problem-solving skills in a range of technological and engineering contexts	5.1.1 develops ideas and explores solutions to technological and engineering based problems 5.1.2 designs and investigates different approaches in the development of engineered solutions 5.2.1 describe how scientific and mechanical concepts relate to technological and engineering practice 5.4.1 uses mathematical, scientific and graphical methods related to technology and engineering 5.4.2 develops skills in using mathematical, scientific and graphical methods whilst working as a team 5.6.1 selects and uses appropriate problem solving techniques in a range of technological and engineering contexts

Key:

NUM – Numeracy	ICT – Information and Communication Technologies
LIT – Literacy	AB ED – Aboriginal Education
FOR – Focus on Reading	IBL – Inquiry Based Learning

Quality Teaching Model Key:

Intellectual Quality	*Quality Learning Environment*	*Significance*
DK – Deep Knowledge	EQC – Explicit Quality Criteria	BK – Background Knowledge
DU – Deep Understanding	E – Engagement	CK – Cultural Knowledge
PK – Problematic Knowledge	HE – High Expectations	KI – Knowledge Integration
HOT – Higher-Order Thinking	SS – Social Support	I - Inclusivity
M – Metalanguage	SSR – Students' Self-Regulation	C - Connnectedness
SC – Substantive Communication	SD – Student Direction	N – Narrative

Evidence of Learning - Highlighted in Red **Assessment** - Highlighted in Grey

Assessment

Pre-Assessment: Aerodynamics Basics Worksheet
Progressive Assessment: Inquiry Based Learning activities
Assessment: Group Work Project and Folio

Resources:

Websites
Aerodynamics in Racing: http://www.f1technical.net/topics/5
Wind Tunnels How Wind Tunnels Work VideoNASA Link
MIT: http://ocw.mit.edu/courses/mechanical-engineering/2-092-finite-element-analysis-of-solids-and-fluids-i-fall-2009/index.htm
Udemy: https://www.udemy.com/math-is-everywhere-applications-of-finite-math/
Bottle Rocket: https://www.facebook.com/exciteandeducate
SkyPod: http://www.youtube.com/watch?v=2A8DIag7dxw
Project Falcon: http://labs.autodesk.com/utilities/falcon/download_choices
Resources
Skylap Teaching Resource Pack
Rocketman Bottle Rocket Launcher and Power Anchor Testing Device
ATSE STELR *Core Program Student Book 2nd Edition*
VEA, *Flight DVD*
Cham Ltd, *Formula 1 Virtual Wind Tunnel manual*
AutoDESK, *Project Falcon VWT software*

Students learn about:	Students learn to:	Level 1	Level 2	Level 3
		Pre-Knowing / Knowing	Understanding / Applying	Evaluating / Creating
SKILLS				
5.2.1 research and exploration - interpreting and analysing data - quantitative and qualitative research - surveys - interviews - observation - testing & experimenting 	- analyse, interpret and apply research data in the development of aerodynamic projects - complete quantitative and qualitative research - 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 - experiment to optimise solutions for aerodynamics related projects 	**Working Scientifically** P1: ***Teacher*** to explain concepts of scientific method, hypothesis and how Scientist Work in order to analyse, interpret and apply research data introduced. (See notes STERL How do scientists work). **(KI, DK, M, C)**	**Working Scientifically** U1: ***Students*** to complete a range of experiments undertaken to determine how to work scientifically. ***Students*** to complete an investigation planner on each experiment undertaken. Practical Investigation: The Pendulum. **(DU, HOT, KI)**	**Working Scientifically** E1: ***Students*** to evaluate the experiments undertaken. ***Students*** to design experiments related to aerodynamics. **(DU, HOT, KI, SSR) (IBL, ICT)**
		Research P2: ***Teacher*** to introduce different research methods which are used to solve engineering problems. ***Students*** to define quantitative and qualitative research. **(M, KI) (ICT, NUM)**	**Research** U2: ***Students*** to complete a range of scientific experiments in which qualitative and quantitative data is collected & analysed. **(DU, HOT, KI) (ICT, NUM)**	**Research** E2: Qualitative and quantitative data from a range of experiments is evaluated by ***students*** whilst undertaking a range of practical problem solving activities. **(NUM)**
		Research & Exploration P3: ***Students*** to develop knowledge of the scientific method through exposure to a range of experiments related to aerodynamics. **(M, KI, DK)**	**Research & Exploration** U3: ***Students*** to analyse experiments with emphasis on data and statistics. **(DU, KI, SSR) (NUM)**	**Assessment Task** E3: ***Students*** to design their own experiments and produce a poster detailing their findings. **(HOT, PK, SD) (LIT, NUM, IBL)**
		Testing & Experimenting P4: ***Teacher*** to introduce Aeronautical Velocity Challenge. ***Students*** to research requirements of the Bottle Rockets and Skylap challenge. **(DK, E, C, EQC) (ICT)**	***Testing & Experimenting*** U4: ***Students*** form teams and identify learning which needs to be completed in order to compete in set challenges. Individuals assigned to learning tasks and start to complete research on specific areas of the program. **(DU, EQC, SD, SSR) (ICT, IBL)**	***Testing & Experimenting*** E4: ***Student*** to form teams and develop processes to solve set problems related to aerodynamics (i.e. Aeronautical Velocity Challenge). **(HOT, PK, SD) (ICT, IBL)**
		Testing & Experimenting P5: ***Teacher*** to set up and explain a range of experiments and testing processes related to aerodynamic projects. **(KI, DU, HOT)**	***Testing & Experimenting*** U5: ***Students*** to complete and document experiments related to the completion of the BottleRockets and Skylap task. **(DU, PK, HOT) (IBL)**	***Testing & Experimenting*** E5: ***Students*** to evaluate experiments using the bottle rocket launcher and power anchor testing devices. ***Students*** to assess results and make improvements to their designs. **(KI, PK, HOT, SSR, SD) (IBL)**

Students learn about:	Students learn to:	Level 1	Level 2	Level 3
		Pre-Knowing / Knowing	Understanding / Applying	Evaluating / Creating
TECHNOLOGIES				
5.2.2 technologies related to aerodynamics - wind tunnels - smoke tunnels - computational fluid dynamics (CFD)	- describe a range of technologies used in aerodynamics - perform experiments using a range of aerodynamic technologies to solve engineering problems - utilise modelling software to determine optimum aerodynamic conditions using CFD techniques	**Wind and Smoke Tunnels** P1: ***Teacher*** to led discussion on "What are Wind Tunnels? Show an example of a small wind tunnel. ***Students*** watch video on How Wind Tunnels Work. How Wind Tunnels Work Video NASA Link ***Teacher*** to discuss flow visualisation using smoke in a wind tunnel. Aerodynamics of F1 Cars Video ***Students*** to define CFD and how it used. Wikipedia **(M, BK, NUM)**	**Wind and Smoke Tunnels** U1: ***Teacher*** to demonstrate the use of a wind tunnel using a variety of models. ***Teacher*** to use visualisation techniques (Smoke/Vapour) to demonstrate flow lines around a variety of shapes. ***Teacher*** to show video of Paper Plane in smoke tunnel. ***Teacher*** cuts out on a band saw and ***students*** shape a balsa block using a variety of shaping tools. **(DK, DU, KI)**	**Wind and Smoke Tunnels** C1/2: Design Challenge: ***Students*** to design a 3 or 4 wheeled vehicle made from balsa. The vehicle must be at least 100mm long. The vehicle is to be tested in the wind tunnel and the value for drag recoded at a set fan speed. **(EQC, SSR, KI, C) (ICT, IBL)** OR C1: ***Students*** to create a cardboard wind tunnel. See Instruction http://www.instructables.com/id/How-to-make-a-wind-tunnel/ In groups ***students*** construct a wind tunnel using cardboard and a fan. **(EQC, SSR, KI, C) (ICT, IBL)**
		Design - Redesign P2: ***Teacher*** to explain the concept of design and redesign via the use of prototyping. ***Class*** discussion on engineering problems which can be solved using technologies related to aerodynamics. **(BK, HOT)**	**Design - Redesign** A2: ***Students*** to complete a range of pre-designed experiments using technologies related to aerodynamics. Smoke tunnel utilised to show streamline and turbulent flows in aerofoils. Concepts of stall demonstrated in an aerofoil. **(DU, KI)**	
		Computational Fluid Dynamics P3: VWT F1inSchools. Go through introductory notes. ***Teacher*** to demonstrate use of software. OR P3: Project Falcon CFD software. ***Teacher*** to demonstrate use of software. http://labs.autodesk.com/utilities/falcon/download_choices Show skypod video from ME program. **(ICT, C, DK)**	**Computational Fluid Dynamics** A3: ***Student*** to load an F1 car into the VWT software. They then complete the pre-processing of the data. ***Students*** use a variety of post-processing activities. See VWT notes. **(ICT, SSR, KI, C)** OR ***Students*** to upload Skypod.obj file in to the Project Falcon VWT software. ***Students*** to analyse results using applied knowledge of CFD. **(ICT, SSR, KI, C)**	**Computational Fluid Dynamics** C3: ***Students*** to draw Bottle Rocket or Skylap plane in CAD and test in VWT. ***Students*** to test Bottle Rockets and Skylap plane in Wind/Smoke tunnels. OR C3: ***Students*** to use CAD software to upload Skypod file. ***Students*** to modify Skypod to make it more aerodynamic. **(KU, HOT, EQC, E, SD, BK, KI, C)**

<table>
<tr><th rowspan="2">Students learn about:</th><th rowspan="2">Students learn to:</th><th colspan="2">Level 1</th><th colspan="2">Level 2</th><th colspan="2">Level 3</th></tr>
<tr><th>Pre-Knowing</th><th>Knowing</th><th>Understanding</th><th>Applying</th><th>Evaluating</th><th>Creating</th></tr>
<tr><td colspan="8">ENGINEERING PRINCIPLES & PROCESSES</td></tr>
<tr><td rowspan="4">5.2.3 aerodynamics principles
- dynamic, static friction
- lift/drag ratios
- lift, drag, weight, thrust
- Finite Element Analysis (FEA)
- flight</td><td rowspan="4">- explain aerodynamic principles
- describe the effects of lift, drag, weight and thrust
- design, construct or simulate solutions to problems related to friction
- describe how Finite Element Analysis is applied aerodynamic systems.
- construct models for the purpose of solving aerodynamic problems</td><td colspan="2">Aerodynamics Principles
P1: Teacher to define aerodynamics and why it is important for flight and motor sports. Teacher to introduce basic concepts of lift, drag, weight and thrust. Teacher to define Bernoulli's Principle and describe how a venturi works. (See Aerodynamics Notes)
(DK, BK, M) (NUM)</td><td colspan="2">Aerodynamics Principles
U1: Teacher to demonstrate types of airflows using smoke tunnel technologies. Teacher to introduce the use of Reynolds Numbers in describing laminar and turbulent flow.
Students to complete a number of experiments to explain Bernoulli's Principle. See video for examples.
(DU, HOT, C) (NUM)</td><td colspan="2" rowspan="4">Assessment
C1: Option 1: Students to work on F1inSchools program. Students break into groups and design a CO_2 Powered F1 car using CREO 3D CAD software.

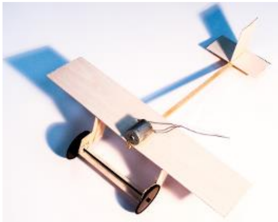
Design criteria is set each year by REA Australia. Students must meet all set criteria. See website for competition criteria. www.rea.org.au F1inSchools car designs are to be aerodynamically designed to reduce drag.

Option 2: Students to design, construct, test and evaluate a bottle rocket and evaluate results. Students to design, construct, test and evaluate a Skylap plane and evaluate results.

All Students need to demonstrate a detailed knowledge of the effects of the four forces of Lift, Drag, Weight and Thrust. Students to complete a portfolio of their work either from F1inSchools or Aeronautical Velocity Challenge.
(DK, DU, PK, HOT, M, EQC, E, SSR, SD, BK, KI, C) (ICT, NUM, IBL, LIT)</td></tr>
<tr><td colspan="2">Lift, Drag, Weight and Thrust
P2: Teacher to describe how an aircraft is able to fly as a result of the balance between all four forces of lift, drag, weight and thrust. Teacher to define parasitic and induced drag.
(DK, M)</td><td colspan="2">Lift, Drag, Weight and Thrust
U2: Teacher to demonstrate the effects of the four forces related to aerodynamics when they are in equilibrium and when they are in dis-equilibrium. Teacher to use a model of an aircraft to demonstrate. Watch Flight video from VEA.
(DU, BK)</td></tr>
<tr><td colspan="2">Dynamic and Static Friction
P3: Teacher to define static and dynamic friction. Teacher to explain concept of coefficient of friction as it relates to surfaces.
(M, BK)</td><td colspan="2">Dynamic and Static Friction
U3: Students to complete a series of experiments related to friction. Use a variety of surfaces and demonstrate how they affect movement.
(DU, SD)</td></tr>
<tr><td colspan="2">Finite Element Analysis
P4: Teacher to define Finite Element Analysis. Teacher to demonstrate use of CREO Simulate 2.0.
(HOT, C) (ICT)</td><td colspan="2">Finite Element Analysis
A4: Students to import files from CREO and apply forces using Finite Element Analysis tools from CREO Simulate. (ICT, NUM, HOT,KI)</td></tr>
</table>

Students learn about:	Students learn to:	Level 1		Level 2		Level 3	
		Pre-Knowing	Knowing	Understanding	Applying	Evaluating	Creating
				MECHANICS			
5.2.4 aerodynamics forces - lift, drag, weight, thrust - simple vectors - efficiency	- determine solutions using vector notation - perform simple calculations related to efficiency - apply mathematical and graphical methods to solve aerodynamic related problems - solve aerodynamic problems related to lift, drag, weight and thrust	**Simple Vectors** P1: ***Teacher*** to define scalar and vector quantities and identify components of vectors. ***Teacher*** to introduce vector terminologies (i.e Terminal and initial points, Co-planner, Co-Linear and Concurrent. **(M, DK) (NUM)**		**Simple Vectors** U1: ***Teacher*** to demonstrate how to add and subtract vector qualities. ***Students*** to solve a number of engineering problems using vector quantities. **(DU) (NUM)**		**Simple Vectors** E1: ***Students*** to identify real life problem which could be resolved using vectors. ***Students*** to design problems related to vectors and produce solutions to such problems. **(DU, SD, HOT, KI, C) (NUM)**	
		Efficiency P2: ***Teacher*** to introduce concepts of simple machines and efficiency. Concept of efficiency demonstrated using practical examples. **(KI, DK, M) (NUM)**		**Efficiency** U2: ***Students*** to complete simple questions related to efficiency. Efficiency related to simple machines, including bikes and gears. **(KI, DU) (NUM)**		**Efficiency** E2: ***Students*** to identify problems related to efficiency of machines. ***Students*** to design problems related to efficiency and produce solutions to such problems. **(DU, SSR, HOT, KI) (NUM)**	
		Lift, Drag, Weight and Thrust P3: ***Teacher*** to define the 4 forces which effect flight. Lift, drag, weight and thrust. Video YouTube ***Teacher*** to define basic vectors **(M, DK, KI) (NUM)**		**Lift, Drag, Weight and Thrust** U3: ***Students*** to apply lift, drag, weigh and thrust as a vector quantity. ***Teacher*** to demonstrate how to add and subtract vectors using a graphical polygon method. **(M, DU, HOT) (NUM)**		**Lift, Drag, Weight and Thrust** E3: ***Students*** to solve a range of basic aerodynamic problems by adding and subtracting vectors using a graphical polygon method. **(M, DU, KI, HOT) (NUM)**	
		Vectors P4: ***Students*** introduced to mathematical methods of solving problems with vectors. ***Students*** given instruction on how to resolve aerodynamic problems related to lift, drag, weight and thrust, using the triangulation method. **(DK) (NUM)**		**Vectors** U3: ***Students*** to solve a range of basic aerodynamic problems using vector arithmetic. **(DU, HOT, PK) (NUM)**		**Vectors** E4: ***Students*** to experiment and evaluate aircraft in terms of lift to drag ratios. ***Students*** to manipulate vectors to determine aerodynamic efficiency. **(KI, HOT) (NUM)**	

<table>
<tr><th rowspan="2">Students learn about:</th><th rowspan="2">Students learn to:</th><th colspan="2">Level 1</th><th colspan="2">Level 2</th><th colspan="2">Level 3</th></tr>
<tr><th>Pre-Knowing</th><th>Knowing</th><th>Understanding</th><th>Applying</th><th>Evaluating</th><th>Creating</th></tr>
<tr><td colspan="8">PROBLEM SOLVING & DESIGN</td></tr>
<tr><td rowspan="3">5.2.5 aerodynamic design solutions


</td><td rowspan="3">- develop engineered solutions to meet detailed specifications
- evaluate results from testing to improve aerodynamic performance of engineered solutions
- uses appropriate design processes and techniques in the context of developing engineered solutions</td><td colspan="2">Rules and Regulations
P1: Students to investigate the rules and regulations for the F1inSchools competition
OR
the Aeronautical Velocity Challenge. General Information and specifications to be reviewed.
(BK, EQC) (ICT)</td><td colspan="2">Rules and Regulations
U1: Students to work in groups to unpack the specifications for the design of the F1 car design, OR bottle rocket and Skylap plane. Using the specifications provided sketch a number of design solutions to the given problem. Students to develop a design portfolio of the work in either F1inSchools or Aeronautical Velocity Challenge.
(DU, EQC) (ICT)</td><td colspan="2">Assessment
C1: Students to use a range of technologies to design solutions to aeronautical problems. E.g. F1inSchools
OR
Aeronautical Velocity Challenge. Students to complete design portfolio of design work.
(DU, HOT) (ICT, LIT, IBL)</td></tr>
<tr><td colspan="2">Design Process
P2: Students to investigate the design processes used for the successful completion of an engineered solution. Students to investigate project management techniques, such as creating gannt charts. Students to develop criteria's to evaluate the success of the engineered solution.
(DK, EQC, M) (ICT, LIT)</td><td colspan="2">Design Process
U2: Students to document the design processes used to develop an engineered solution by producing a comprehensive design portfolio.
(ICT) (EQC, KI)</td><td colspan="2">Design Solutions
E2: Students to use a range of technologies (e.g. 3D printers, Laser Cutter, CNC lathe) and materials to produce creative solutions to engineering problems. E.g. F1inSchools OR Aeronautical Velocity Challenge.
(PK, EQC, E, HE, SSR, BK, KI) (ICT)</td></tr>
<tr><td colspan="2">Design Testing
K3: Students to use an appropriate process to design a Bottle Rocket powered by compressed air which will achieve the longest distance. Student to break into groups and design 2 skylap planes one designed for speed and one designed for altitude.OR Students to design a F1inSchools CO_2 powered car.
(BK, SD) (ICT, IBL)</td><td colspan="2">Design Testing
A3: Students to utilise a range of testing equipment to assess the aerodynamic performance of design solutions. Students to modify design solutions and re-test design to improve performance.
(SSR, DU) (ICT, IBL)</td><td colspan="2">Assessment
E3: Students to complete final testing of solutions to design problems using a range of technologies. Students to evaluate the success of their designs in their portfolio.
(HOT, EQC, E, SSR, KI) (ICT, IBL, LIT)</td></tr>
</table>

Maitland Grossmann High School

Computer Aided Design (CAD) & Computer Aided Manufacture (CAM) –Module 3

Unit Title: Computer Aided Design & Computer Aided Manufacture	**Time:** 50 Hours

Description: Students develop skills in Computer Aided Design (CAD) and Computer Aided Manufacture (CAM). Possible examples of CAD Software include: CREO, CATIA, Google Sketchup, & Solid Works. Possible examples of CAM hardware include: 3D printers, CNC Mills, CNC Routers, CNC Lathes, etc. In this module students will manufacture three dimensional objects for which they have designed.

Objectives:	**Outcomes:**
• inquiry-based learning skills appropriate to technological and engineering practice • skills in solving technology based problems using mechanical, graphical and scientific methods • skills in communicating and critically evaluating • problem-solving skills in a range of technological and engineering contexts	5.1.1 develops ideas and explores solutions to technological and engineering based problems 5.1.2 designs and investigates different approaches in the development of engineered solutions 5.4.1 uses mathematical, scientific and graphical methods related to technology and engineering 5.4.2 develops skills in using mathematical, scientific and graphical methods whilst working as a team 5.5.1 applies a range of communication techniques in the presentation of research and design solutions 5.6.2 will work individually or in teams to solve problems in technological and engineering contexts

Key:

NUM – Numeracy	ICT – Information and Communication Technologies
LIT – Literacy	AB ED – Aboriginal Education
FOR – Focus on Reading	IBL – Inquiry Based Learning

Quality Teaching Model Key:

Intellectual Quality	***Quality Learning Environment***	***Significance***
DK – Deep Knowledge	EQC – Explicit Quality Criteria	BK – Background Knowledge
DU – Deep Understanding	E – Engagement	CK – Cultural Knowledge
PK – Problematic Knowledge	HE – High Expectations	KI – Knowledge Integration
HOT – Higher-Order Thinking	SS – Social Support	I - Inclusivity
M – Metalanguage	SSR – Students' Self-Regulation	C - Connnectedness
SC – Substantive Communication	SD – Student Direction	N – Narrative

Evidence of Learning - Highlighted in Red **Assessment -** Highlighted in Grey

Assessment

Pre-Assessment: Drawing skills, knowledge of skills of CAD/CAM
Progressive Assessment: CREO Drawings, 3D Printed key tag, Laser Cut Items
Assessment: 3D Printed Design Task

Resources:

Websites

http://www.thingiverse.com/
Rapid Prototyping:
http://youtu.be/PDLOmoQj4H0
How Robots will Change the World:
http://www.youtube.com/watch?v=8zP7yP8hdLE
3D Shapes
http://www.learner.org/interactives/geometry/3d.html

Texts/Materials

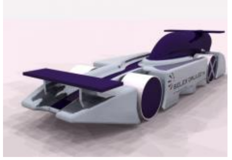
Brotherhood, T. & Haas, A. (2011) *CREO Parametric Primer Education Editions*, PTC
PTC (2012) *Alphabet Soup Assembly*, PTC
Smith, N. & Sleap, S. (2013) Creo Parametric 2.0 An Introduction
PTC How to model almost anything
Boundy, A. W., (2007) *Engineering drawing.* 7th edition. Published by McGraw Hill Australia, Ryde.

Students learn about:	Students learn to:	Level 1		Level 2		Level 3	
		Pre-Knowing	Knowing	Understanding	Applying	Evaluating	Creating
SKILLS							
5.3.1 CAD/CAM - 3D drawing on an x, y & z axis. -basic commands in a 3D CAD package - CAM processes	- use common features in a 3D CAD package to produce parts, products and assemblies in order to design 3D objects use photorealistic rendering techniques to professionally present 3D designs - modify 3D CAD drawings so they can be manufactured using 3D technologies - manipulate Computer Aided Manufacturing processes to produce parts for an assembly	**CREO Introduction** P1: ***Teacher*** to demonstrate the feature first processes for creating 3D CAD drawings using CREO. ***Students*** given an introduction to opening, and navigating through the CREO program. **(KI, DU) (ICT, NUM)**		**CREO** U1: ***Students*** to complete a range of activities from PTC tutorials "How to Model Almost Anything". ***Students*** to work at own pace and complete the units they wish to complete. **(DU, SD) (ICT, NUM)**		**CREO** C1: ***Students*** to create a photo realistic assembly of their name using CREO Parametric.  **(SD, C, E, KI, BK) (ICT, NUM)**	
		Introduction to 3D Printing P2: ***Teacher*** to introduce ***students*** to Makerbot software. ***Teacher*** to demonstrate 3D printing technology. ***Students*** to access http://www.thingiverse.com/ website and investigate objects that can be printed on the Makerbot printer. **(E, SSR) (ICT)**		**Introduction to 3D Printing** U2: ***Students*** to create a personalised key tag using CREO Parametric. Key tag file to be modified by adding student's name. Key tags to be printed using Makerbot 3D Printer. **(DU, SSR, E, KI) (ICT, NUM)**		**3D Printing** C2/3: Students to design and produce of parts for engineering projects. ***Students*** to print out scale models of F1 car designs for testing OR parts for their bottle rockets or skylap planes.  **(DU, E, SSR, KI) (ICT, NUM)**	
		CREO Advanced P3: ***Teacher*** to introduce ***students*** to developing advanced parts and advanced assembly. ***Students*** to open parts for a car and assembly them correctly using x, y and z axis. **(KI, DK) (ICT, NUM)**		**CREO Advanced** U3: ***Students*** to complete F1 R Type CO_2 racer tutorial by Tim Brotherhood or CREO F1Car tutorial by Smith and Sleap. **(SD) (ICT, NUM)**			

Students learn about:	Students learn to:	Level 1		Level 2		Level 3	
		Pre-Knowing	Knowing	Understanding	Applying	Evaluating	Creating
TECHNOLOGIES							
5.3.2 technologies related to CAM - 3D Printers - Computer Numerical Controls - CNC, mills, routers & lathes	- describe a range of technologies used in CAD and CAM processes - perform experiments using a range of CAM technologies to solve engineering problems - use a variety of technologies which assist in the rapid prototyping process - utilise 3D drawing and manufacturing software to produce new products	**CAD/CAM technologies** P1: ***Teacher*** to demonstrate the use of Denford CNC Milling Program. ***Teacher*** to demonstrate the use of the 3D printer. ***Teacher*** to demonstrate the use of Laser Cutter. **(DK, KI) (ICT, NUM)**		**CAD/CAM technologies** U1: ***Students*** to research how 3D printers work. Further investigations into CAM processes; CNC, mills, routers and lathes. ***Students*** use VR CNC Milling program to simulate manufacture of an F1 car. ***Students*** to complete tutorial 'R type F1 Manufacturing Guide'. ***Students*** to utilise QuickCAM 3D program to create CNC file output. **(DU, E, BK, KI) (ICT, NUM)**		**CAD/CAM technologies** C1: ***Students*** to design a CO_2 car using an appropriate CAD package, which meets some basic specifications provided by the teacher. OR Parts for bottle rockets and skylap racers **(DU, PK, HOT, EQC, E, HE, SD, C, KI) (ICT, NUM, IBL)**	
		STL Files P2: STL files explained to ***students*** by ***teacher***. ***Students*** to use a variety of software to produce appropriate STL files for manufacture. E.g. CREO, CATIA, Solidworks, Autodesk 123, Google sketchup, etc. **(DK, KI) (ICT, NUM)**		**STL Files** A2: ***Students*** to experiment with a range of STL files and manufacture simple products which solve basic engineering problems. E.g. ***Students*** to make simple machines for engineering assignments. **(DU, SD, C, KI) (ICT, NUM)**		**CAM** C2: ***Students*** to create a variety of products using CAM technologies which solve engineering problems. **(DU, PK, HOT, EQC, E, HE, SD, C, KI) (ICT, NUM)**	
		Rapid Prototyping P3: ***Teacher*** to show Wired Video: http://youtu.be/PDLOmoQj4H0 3D printing services available and 3D scan technologies. Demonstrate how the milling machine, 3D printer and laser Cutter can be used for rapid prototyping. **(DK, BK, KI) (ICT)**		**Rapid Prototyping** A3: ***Students*** to use a variety of technologies within and outside the school to produce 3D designed products. ***Students*** to use rapid prototyping to design, evaluate and improve products. **(DU, EQC, SD, KI) (ICT, NUM)**		**Rapid Prototyping** C3: ***Students*** to have the opportunity to engage in rapid prototyping process by designing, manufacturing, evaluating and re-manufacturing engineered products which meet an identified need. **(PK, HOT, EQC, E, HE, SD, C, KI)**	
		Mills, Printers & Laser Cutters P4: ***Teacher*** to demonstrate the operation of CAM technologies. Maintenance, loading materials, safe operation, cleaning, etc. **(DU, SD, BK, KI) (ICT)**		**Mills, Printers & Laser Cutters** U4: ***Students*** to be given the opportunity to load materials, upload files, monitor progress and remove final products from the machines. **(DU, E, SSR, KI, BK) (ICT)**		**Mills, Printers & Laser Cutters** C4: ***Students*** to become independent users of CAD/CAM equipment to produce a range of solutions to given problems. **(DU, PK, HOT, EQC, E, HE, SD, C, KI) (ICT)**	

Students learn about:	Students learn to:	Level 1	Level 2	Level 3
		Pre-Knowing / Knowing	Understanding / Applying	Evaluating / Creating
ENGINEERING PRINCIPLES AND PROCESSES				
5.3.3 CAD/CAM operations - Reading and interpreting engineering drawings - rapid prototyping - 3D CAD operations - Computer Aided Manufacturing (CAM) - 3D modelling	- read and interpret basic engineering drawing conventions - explain the operation of CAD/CAM software and hardware - describe how rapid prototyping works - design, construct parts, products or assemblies using CAD software and producing them using appropriate CAM software - produce practical solutions to set problems construct 3D models.	**Engineering Drawing** P1: ***Teacher*** to explain AS1100 standards and basic drafting techniques to be deomonstrated. Pictorial drawing techniques explained. **(DK, KI)**	**Engineering Drawing** U1: ***Students*** to complete a range of pictorial drawing exercises (Isometric and perspective). Exercises using coordinate geometry. **(DU, HOT, EQC, C) (NUM)**	**Engineering Drawing** C1: ***Students*** to take basic 3D objects and produce isometric and perspective drawings and produce 3D CAD drawings. **(DU, HOT, EQC, C) (ICT, NUM)**
		CAD/CAM P2: ***Students*** to investigate different technologies used in Computer Aided Drawing and Computer Aided Manufacturing. Robotics and mechatronic manufacture to be investigated. **(ICT, PK, E, C)**	**CAD/CAM** U2: ***Students*** to research how 3D printers work. Further investigations into CAM processes; CNC, mills, routers, lathes and laser cutters. **(DU, C) (ICT)**	**CAD/CAM** E2: ***Students*** to evaluate the operation of current CAD/CAM systems and predict future trends. ***Students*** to watch You tube Video 'How Robots will Change the World' **(DU, KI, C)**
		Rapid Prototyping P3: ***Teacher*** to explain how rapid prototyping works. **(DK, C)**	**Rapid Prototyping** A3: ***Students*** to use a variety of technologies within and outside the school to produce 3D designed products. **(EQC, HE, SD, KI, C) (ICT, NUM)**	**Rapid Prototyping** C3: ***Students*** to be given many opportunities to engage in rapid prototyping process. **(EQC, HE, SD, KI, C) (ICT, NUM)**
		Product Design P4: ***Students*** to use a variety of software to design products using appropriate CAD software/E.g. CREO, CATIA, Solidworks, Autodesk 123, Google sketchup, etc. **(ICT, DU, HOT, E, SD, KI, EQC)**	**Rapid Prototyping** A4: ***Students*** to manufacture simple products or assemblies from online libraries. **(DU, HOT, EQC, HE, SD, KI, C) (ICT, NUM)**	**Rapid Prototyping** C4/C5: ***Students*** to design, construct parts, products or assemblies using CAD software and producing using appropriate CAM software in Modules 2, 4 and 5. **(DU, HOT, EQC, HE, SD, KI, C) (ICT, NUM)**
		Problem Solving & Product Design P5: ***Teacher*** to introduce product design and revise problem solving processes related to engineering. **(DK, KI)**	**Problem Solving & Product Design** A5: ***Students*** to complete simple problems set which require the design and manufacture of 3D models. **(DU, EQC, HOT)**	

Students learn about:	Students learn to:	Level 1		Level 2		Level 3	
		Pre-Knowing	Knowing	Understanding	Applying	Evaluating	Creating
MECHANICS							
5.3.4 3D environments - vectors - 3D Shapes - Computer Numerical Control - spatial comprehension - 3D Surface Modelling	- apply mathematical and graphical methods to solve questions related to 3D vectors - determine solutions to simple problems using vector notation - manipulate 3D shapes and objects - construct source code for 3D CAM operations.	**Coordinate Geometry** P1: ***Teacher*** to introduce coordinate geometry. Polar, absolute and relative coordinates related to CAD. **(HOT, KI, C) (NUM, ICT)**		**Coordinate Geometry** U1: ***Students*** to solve mathematical problems by plotting x, y and z coordinates. **(HOT, KI, C) (NUM, ICT)**		**Coordinate Geometry** E1: ***Students*** to use a 2D CAD package to produce 3D drawing using Polar, absolute and relative coordinates. **(HOT, C) (NUM, ICT)**	
		Vectors P2: ***Teacher*** to describe how to use vector quantities to solve simple engineering and mathematical problems. Identify components of vectors and introduce vector terminologies (i.e Terminal and initial points, Co-planner, Co-Linear and Concurrent. **(M, DK) (NUM)**		**Vectors** U2: ***Teacher*** to demonstrate how to add and subtract vector qualities. ***Students*** to solve a number of simple engineering problems using vector quantities. Text: Engineering Mechanics by Mullin. ***Students*** to resolve vectors into horizontal and vertical components. **(DU) (NUM)**		**Vectors** E2: ***Students*** to identify real life problems which could be resolved using vectors addition and subtraction. ***Students*** to design problems related to vectors and produce solutions to such problems. **(DU, SSR, HOT, KI) (NUM)**	
		3D Shapes P3: ***Teacher*** to introduce a variety of 3D shapes identified and defined. Polyhedra, Prisms and Pyramids. Glossary of terms, apex, base, congruent, vertex. **(KI, C) (NUM, ICT)**		**3D Shapes** U3: ***Students*** to complete interactive activities from Annenberg Learner web site http://www.learner.org/interactives/geometry/3d.html 3D Shapes, Surface Area & Volume, Euler's Theorem, and Platonic Solids. **(KI, C) (NUM, ICT)**		**3D Shapes Assessment** E3: ***Students*** to complete online test of knowledge and complete exercises related to 3D geometry. **(KI, C) (NUM, ICT)**	
		Computer Numerical Control P4: ***Teacher*** to demonstrate G code programming language. Demonstrate simple G code expressions and what they do on a CNC machine. **(HOT, KI, C) (NUM, ICT)**		**Computer Numerical Control** U4: ***Students*** to complete exercises, construct sequences of G codes which complete simple tasks, such as move in x, y and z axis. **(HOT, KI, C) (NUM, ICT)**		**Computer Numerical Control** E4: ***Students*** to enter G codes into VR milling software or directly into the denford mill and show the operations. **(HOT, KI, C, HE, SD) (NUM, ICT)**	

Students learn about:	Students learn to:	Level 1		Level 2		Level 3	
		Pre-Knowing	Knowing	Understanding	Applying	Evaluating	Creating
PROBLEM SOLVING & DESIGN ALTERNATIVE 1							
5.3.5 CAD/CAM	- design parts, products or assemblies to meet specific criteria - solve problems related to typical Computer Aided Manufacturing issues.	**F1inSchool** P1: F1inSchool competition. Introduce the competition using You Tube clip of 2012 world finals and introduce General Information document. What's it all about, design brief, competition classes, School, Regional, State, National and International progression. Rules and regulations document General regulations, competition procedural regulations, overall F1 car rules, body and side pod rules, nose cone rules, aerofoil rules, wheel rules, wheel support system rules, tether line guide rules, power plant provision rules, race regulations and pit displays. **(DK, DU, PK, HOT, M, EQC, E, SSR, SD, BK, KI, C)**		**F1inSchool** A1: ***Students*** to form teams and assign roles. E.g. Design Engineer, Resources Manager, Manufacturing Engineer, Team Manager, Graphic Designer. ***Students*** to explore management strategies to ensure the completion of a variety of activities which lead to meeting the given rules and regulations. ***Students*** learn how to work cooperatively to ensure the completion of various activities leading to competing in F1inSchools competitions. **(DK, DU, PK, HOT, M, EQC, E, SSR, SD, BK, KI, C)**		**F1inSchool** C1: ***Students*** design a CO_2 Powered F1 car using CREO 3D CAD software. The car is to be tested using Virtual Wind Tunnel or Project Falcon software. Design criteria is set each year by REA Australia. Students must meet all set criteria. See website for competition criteria. www.rea.org.au STL files are to be produced from CREO and converted to machine code using QuickCAM 3D. The Denford Mill is to be setup with a Balsa block and a machining plan chosen. ***Students*** to machine, test, and evaluate their CAM products. Based on rigorous testing the CAD designs should be modified and re-manufactured. Teams to produce various parts for the F1 cars using 3D printing technologies. Teams may design and manufacture wheels, axles, front and rear aerofoils, nose cones, etc. **(DK, DU, PK, HOT, M, EQC, E, SSR, SD, BK, KI, C)** 	
		P2: ***Students*** to develop an understanding of the operation of a typical CNC milling machine. Demonstrate how to configure the software for the denford mill and how to load CNC files. ***Students*** given instruction on how to configure the tooling, run a simulation, homing the CNC mill, moving the machine head, fitting the jig and balsa billet, setting offsets, safely running the program and manipulating CNC files to machine the opposite side of the car. **(DK, DU, PK, HOT, M, EQC, E, SSR, SD, BK, KI, C)**		A2: ***Students*** to upload and run files into VR Milling program. Students to configure software for the denford mill and load CNC files to manufacture F1 cars. Student to configure the tooling, run a simulation, home the CNC mill, moving the machine head, fit the jig and balsa billet, set x, y and z offsets, run the program and manipulate CNC files to machine the opposite side of the car. **(DK, DU, PK, HOT, M, EQC, E, SSR, SD, BK, KI, C)**			

Students learn about:	Students learn to:	Level 1		Level 2		Level 3	
		Pre-Knowing	Knowing	Understanding	Applying	Evaluating	Creating
PROBLEM SOLVING & DESIGN ALTERNATIVE 2							
5.3.5 CAD/CAM	- design parts, products or assemblies to meet specific criteria - solve problems related to typical Computer Aided Manufacturing issues.	**Aeronautical Velocity Challenge SkyLap** P1: Introduce the Aeronautical Velocity Challenge using classroom video DVD from desginability. ***Students*** to be given design parameters; • The fuselage is to be made of balsa wood with a cross section of 6mm x 6mm. • The length of the fuselage is to be between 150mm and 300mm. • The wing length and width is up to you. • The aircraft must have two front wheels so that it can take off and land (the rear can drag on the ground). • The motor can be placed anywhere on the aircraft . **(DK, DU, PK, HOT, M, EQC, E, SSR, SD, BK, KI, C)**		**Aeronautical Velocity Challenge SkyLap** A1: ***Students*** to form teams and assign roles. Students to complete design process; **Construct** the standard aircraft **Test** the aircraft and record results on the test sheets **Modify** your design by varying one of the following: weight, angle of stabiliser, aspect ratio. **Test** the aircraft and record results on the test sheets. **Develop** a theory that explains the change in flight behaviour **Modify** your aircraft to optimise one of the following: lift, speed or payload (weight carried) **Test** the aircraft and record results on the test sheets. **Design and make** an experimental aircraft. **Test** the aircraft and record results on the test sheets. **Make** modifications and do further tests to achieve the results you are after. **Set up** a 'dog fight' with two planes chasing each other around the PowerAnchor. **(DK, DU, PK, HOT, M, EQC, E, SSR, SD, BK, KI, C) (NUM, IBL, ICT)**		**Aeronautical Velocity Challenge Part 1 Skylap** C1: ***Students*** design and make an experimental model aircraft to be tested using the power anchor. It must be able to land and take off so it requires two front wheels. Construction is to be of balsa wood which can be cut with a knife or cut out using a laser cutter and hot glued together. (This project requires you to make modifications to your design so be sure not to use too much hot glue which will also add weight). Because you will be testing your designs using the PowerAnchor your aircraft will not experience roll or yaw. The angle of the stabiliser will however, determine the angle of attack of the front wing. **(DK, DU, PK, HOT, M, EQC, E, SSR, SD, BK, KI, C)**	

<table>
<tr><th rowspan="2">Students learn about:</th><th rowspan="2">Students learn to:</th><th colspan="2">Level 1</th><th colspan="2">Level 2</th><th colspan="2">Level 3</th></tr>
<tr><th>Pre-Knowing</th><th>Knowing</th><th>Understanding</th><th>Applying</th><th>Evaluating</th><th>Creating</th></tr>
<tr><td colspan="8">PROBLEM SOLVING & DESIGN ALTERNATIVE 2</td></tr>
<tr><td>5.3.5 CAD/CAM</td><td>- design parts, products or assemblies to meet specific criteria
- solve problems related to typical Computer Aided Manufacturing issues.</td><td colspan="2">Aeronautical Velocity Challenge Bottle Rockets
P1: Introduce the Aeronautical Velocity Challenge using Youtube clip from the 2014 challenge. Students to be given design parameters;
• For safety reasons, sharp edges or fins are not allowed
• Only use materials from materials list
• Avoid using thin walled bottles; these may explode during the competition due to repeated pressurizations experienced during launches
• Only use 1.25/2 litre bottles
• The maximum number of launches fires per round will be three in total, regardless if the design only achieves a short distance
• 3D printed and/or laser cut objects must be used on the rocket
(DK, DU, PK, HOT, M, EQC, E, SSR, SD, BK, KI, C) (NUM, IBL, ICT)</td><td colspan="2">Aeronautical Velocity Challenge Bottle Rockets
A1: Students to form teams and assign roles. Students use a design process to produce a bottle rocket which meets the;
Construct the standard bottle rocket
Test the bottle rocket and record results on the test sheets
Modify your design by varying fin design or location
Test the bottle rocket and record results on the test sheets.
Develop a theory that explains the flight behaviour of a bottle rocket
Re-Design and make an experimental bottle rocket
Test the bottle rockets at 45, 50, 55, 60,65 and 70 degrees to determine optimum angle
Make modifications and do further tests to achieve the results you are after.
(DK, DU, PK, HOT, M, EQC, E, SSR, SD, BK, KI, C) (NUM, IBL, ICT)</td><td colspan="2">Aeronautical Velocity Challenge Part 1 Skylap
C1: Students compete in teams of 3 – 4 to design, test and evaluate prototype bottle rockets. Groups are required to justify their design and engineering decisions in their design portfolio.

Students in teams will undertake a range of challenges including, designing, producing and launching bottle rockets to achieve maximum velocity whilst travelling a maximum distance. Students will work in teams to design, produce and evaluate their prototypes.

Students must use a CAD/CAM system to produce parts for the rocket.

Students are to use results from the Accelerometer and distance measurements to determine the success of the project.

(DK, DU, PK, HOT, M, EQC, E, SSR, SD, BK, KI, C) (NUM, IBL, ICT)</td></tr>
</table>