Cherrybrook Technology High School
Stage 4 Integrated STEM project

Project Name: *Solaris Potestas*	**School**: Cherrybrook Technology High School

Coordinator:
Eddie Woo

Teachers:	**Position:**
Evan Kennedy	Technology
Yetsum Yang	Science
Eddie Woo	HT Maths
Geroge An	Science

Project outline

Students are to design, make and evaluate a land based vehicle to be powered by solar energy with the objective of travelling to deliver water to rural and remote communities (in model form for the project). The project will be centred on the design process utilising critical and creative problem solving skills, providing opportunities for students to develop scientific and mathematical concepts during research. Both the Science and Mathematics key learning areas will develop activities aimed at constructively challenging their understanding of the engineering concepts in order to develop a vehicle that need to be charged and moved using solar energy.
Students are encouraged to think creatively and develop ideas that are informed solutions to the problem presented. They are not limited to a 'car' solution and will need to complete extensive primary and secondary research to develop a suitable solution

Justify your choice of project as suitable for a STEM project

"Integrative STEM education refers to Technological/Engineering design-based learning approaches that intentionally integrate the concepts and practices of science and/or mathematics education with the concept practices of technology and engineering education (Sanders & Wells, 2006).

As such, the use of the design process to solve the above mentioned solar vehicle problem requires the extrapolation of science and mathematical concepts in order for students to develop an informed, functional and justified design solution.

Technology:

Tools: 3D printer, laser cutter, vac former, milling machine
Materials: polymers; ABS, PLA, HIPS, PMMA, solar panels
ICT: Video and audio creation and editing software dependent on individual BYO devices. 3D modelling software

Describe the structure for your project:

2 Terms, 20 weeks
6x 57 minute periods per 2 week cycle
Timetabled in Technology Mandatory (year 8) subject addressing the focus areas: Electronics, Polymers and Media
STEM team meeting every 2 weeks plus additional Staff interest group meetings twice/ term
Timetabled into a computer room for 4 of 6 periods and a workshop for 2 of the 6 periods.

Professional Learning: identify professional learning to be accessed in order to complete the project?

Professional Learning	Who	How
Solar transfer of energy	Eddie	Spend time with Science developing resources for the class
Use of CAM machinery	Eddie, Yetsum and George	Spend time with Andrew making sample projects
Documenting design processes	Eddie, Yetsum and George	Complete an example documentation process with Andrew
Generating 'integrated STEM' marking criteria	Whole team	Research and PD with BOSTES and ACARA
Understanding relevant mathematical concepts within the project restraints	George and Yetsum	Spend time with Eddie developing resources / Wootube

Sharing project activity and learning with whole school staff:

How and when will the project plan be promoted/ to the whole school staff?

Whole school STEM promotion commenced at the beginning of 2015 at CTHS. This has been done through several newsletter articles and updates of current Stage 5 trial STEM class.
Technology Education key learning area was introduced to the concept of STEM and the trial program at the Term 2, week 4 KLA meeting by Alesha with a 15 minute presentation.
KLA head teacher meeting was held on 18/6/15 where the ideas, concepts and plan for the stage 4 STEM program were tabled by the STEM team to the 2x TAS KLA head teachers, 1x Science head teacher, 1x Computing head teacher and 2x Mathematics head teacher as well as the principal and 1x Deputy (not the one that attended the STEM conference). The CTHS STEM team also held a STEM project presentation evening on the 9/6/15 where the concepts of STEM education were presented to DEC, BOSTES, ACARA, P&C, KLA Head teachers, senior executive, parents and local community by Stage 5 students. The development of the Stage 4 program was also discussed.

What PL will be provided to staff and when will it happen?
The up skilling of Technology, Science and Mathematics staff will happen progressively over the coming 3 years. There will potentially be a taster at the end of term 4 2015 with the 3 KLA's. However at CTHS the 3 KLA's alone consists of 65 staff members (total full time staff 140).
The proposed taster would likely happen in an afternoon or a SDD. This would consist of small practical activities to demonstrate the interconnectedness. It is critical for us to develop programs that we are comfortable with and provide evidence of best practice before distributing to all appropriate KLA members.

Timeline for planning and implementation			
Term 2 2015 1. Develop scaffold/planning document (this one). 2. Hold KLA HT meeting 3.Identify outcomes	**Term 3 2015** 1. Develop stage 4 program inclusive of content 2. research relevant project components 3.Develop sample projects to trial and test concept 4.Flag timetable requirements with timetable developer	**Term 4 2015** 1.Develop applicable resources 2.Introduction for relevant KLA's 3.Purchase necessary resources 4.Identify students in 2016 class and send home correspondence re new course	**2016** 1. Trial 1 (possibly 2x year 8 Technology mandatory classes) semester 1. 2.Evaluate semester 1 3. Trial 1 (possibly 2x year 8 Technology Mandatory classes) semester 2. 4.Evaluate semester 2

Syllabus Outcomes

The outcomes used in this document are from the Board of Studies Teaching and Educational Standards (BOSTES) NSW.
http://www.boardofstudies.nsw.edu.au/syllabus_sc/

Science Outcomes	How the outcomes will be met in the project
SC4-4WS identifies questions and problems that can be tested or researched and makes predictions based on scientific knowledge	Linked with TAS (4.1.1)
SC4-5WS collaboratively and individually produces a plan to investigate questions and problems	Linked with TAS (4.5.1)
SC4-6WS follows a sequence of instructions to safely undertake a range of investigation types, collaboratively and individually	Linked with TAS (4.3.2)
SC4-7WS processes and analyses data from a first-hand investigation and secondary sources to identify trends, patterns and relationships, and draw conclusions	Linked with Maths (MA4-11NA)
SC4-10PW describes the action of unbalanced forces in everyday situations	Define electric fields and the application of forces on charges to cause movement of electrons.
SC4-11PW discusses how scientific understanding and technological developments have contributed to finding solutions to problems involving energy transfers and transformations	Explain the scientific knowledge of the energy transfers and transformations. Use diagrams to aid explanations. Define an electric current as a flow of electrons that transfers energy in the circuit. Construct simple circuits and diagrams and outline the energy transformation for relevant applications.
SC4-17CW explains how scientific understanding of, and discoveries about, the properties of elements,	Research task: investigate the range of materials that were used in vehicles over time (metals-->plastics) and relate the properties to their uses.

compounds and mixtures relate to their uses in everyday life	

Technology Outcomes	**How the outcomes will be met in the project**
4.1.1 applies design processes that respond to needs and opportunities in each design project	Students will utilise the process to document and scaffold the problem solving process
4.2.1 generates and communicates creative design ideas and solutions	This is done is the idea generation and planning components of the design process
4.2.2 selects, analyses, presents and applies research and experimentation from a variety of sources	Students complete research that is relative to the projects then apply their findings
4.3.1 applies a broad range of contemporary and appropriate tools, materials and techniques with competence in the development of design projects	polymers (range of: HIPS, PLA, ABS, Perspex) electronics (circuits, capacitors, resistors) tools (vac former, mill, 3D printer, laser, 3D modeling) Solar panels traditional tools
4.3.2 demonstrates responsible and safe use of a range of tools, materials and techniques in each design project	Mandatory- WHS & PPE etc.
4.4.1 explains the impact of innovation and emerging technologies on society and the environment	Investigated in relation to sustainable and renewable energy and link back to the tools we are using in the development of the project
4.5.2 produces quality solutions that respond to identified needs and opportunities in each design project	Mandatory- Project solutions respond to the design brief and is informed by relevant research throughout the problem solving process
4.6.1 applies appropriate evaluation techniques throughout each design project	ongoing evaluation of experimentation and testing to inform design solution Critical final evaluation referring to criteria to evaluation success
4.6.2 identifies and explains ethical, social,	see 4.4.1

environmental and sustainable considerations related to design projects	

Strand	Mathematics Outcomes	How the outcomes will be met in the project
Working Mathematically	• **MA4-1WM: communicating** - students communicate and connect mathematical ideas using appropriate terminology, diagrams and symbols • **MA4-2WM: problem solving** – students apply appropriate mathematical techniques to solve problems • **MA4-3WM: reasoning** – students recognise and explain mathematical relationships using reasoning	• **Communicating** - students use mathematical language and visual representations to inform the design process and justify their chosen solution for the solar vehicle • **Problem solving** - students choose and apply strategies to generate mathematically sound responses to the constraints and obstacles encountered during the project's design, iteration, construction and evaluation phases of the vehicle • **Reasoning** - students identify mathematical relationships between energy consumption, material costs, vehicle speed and other relevant quantities/rates
Number + Algebra	• **MA4-5NA: fractions, decimals and percentages** – compares, orders and calculates with integers, applying a range of strategies to aid computation • **MA4-7NA: ratios and rates** - operates with ratios and rates, and explores their graphical representation • **MA4-10NA: solving equations** – uses algebraic techniques to solve simple linear and quadratic equations • **MA4-11NA: patterns and graphs** – creates and displays number patterns; graphs and analyses	• **Fractions, decimals and percentages** - able to make accurate computations with decimals and percentages that arise from scientific observations related to vehicle testing and evaluation • **Ratios and rates** - operates with rates such as energy generation, energy usage, and velocity; understands ratios such as those related to energy efficiency or construction costs • **Solving equations** - understands and employs techniques for solving equations related to the physical quantities

	linear relationships; and performs transformations on the Cartesian plane	• **Patterns and graphs** - construct and analyse relationships between quantities as mentioned above
Strand	**Mathematics Outcomes**	**How the outcomes will be met in the project**
Measurement + Geometry	• **MA4-13MG: area** – uses formulas to calculate the areas of quadrilaterals and circles, and converts between units of area • **MA4-14MG: volume** – uses formulas to calculate the volumes of prisms and cylinders, and converts between units of volume • **MA4-15MG: time** – performs calculations of time that involve mixed units, and interprets time zones	• **Area** - solar panels and energy generation • **Volume** - 3D-printed components • **Time** - see MA4-7NA above
Statistics + Probability	• **MA4-19SP: data collection, representation and interpretation** – collects, represents and interprets single sets of data, using appropriate statistical displays • **MA4-20SP: data analysis** – analyses single sets of data using measures of location and range	• **Data collection, representation and interpretation** - illustrate statistical data and patterns • **Data analysis** - uses measures of central tendency to compare data sets and make data-driven choices

General Capabilities: (See Teaching and Learning Program to identify links to General Capabilities*)*

Learning Across the curriculum used in this document are from the Board of Studies Teaching and Educational Standards (BOSTES) NSW http://syllabus.bostes.nsw.edu.au/mathematics/mathematics-k10/learning-across-the-curriculum/

The cross-curriculum priorities:

- Aboriginal and Torres Strait Islander histories and cultures
- Asia and Australia's engagement with Asia
- Sustainability

The general capabilities:

- Critical and creative thinking
- Ethical understanding
- Information and communication technology capability
- Intercultural understanding
- Literacy
- Numeracy
- Personal and social capability

Other learning across the curriculum areas:

- Work and enterprise

Outcome and Content	Teaching, learning and assessment	Resources
Science: SC4-4WS (b), SC4-5WS (5.1ac,5.2a,5.3a) SC4-6WS (b, d, e) SC4-7WS (7.1ab,7.2b) SC4-10PW A student describes the action of unbalanced forces in everyday situations PW1 Change to an object's motion is caused by unbalanced forces acting on the object Students: a. identify changes that take place when particular forces are acting b. predict the effect of unbalanced forces acting in everyday situations PW2 The action of forces that act at a distance may be observed and related to everyday situations Students: c. describe the behaviour of charged objects when they are brought close to each other SC4-11PW discusses how scientific understanding and technological developments have contributed to finding solutions to problems involving energy transfers and transformations PW3 Energy appears in different forms including movement, heat and potential energy, and causes change within systems Students: a. identify objects that possess energy because of their motion (kinetic) or because of other properties (potential) SC4-17CW explains how scientific understanding of, and discoveries about, the properties of elements, compounds and mixtures relate to their uses in everyday life CW4 In a chemical change, new substances are formed, which may have specific properties related to their uses in everyday life.	**CLASS ACTIVITY** *Introduction to electricity and energy* Recall different types of forces. List examples of unbalanced forces such as gravitational force on different objects and describe the action of this force on these objects. Use demonstrations of discharges tubes to demonstrate the action of unbalanced forces on electrons. Discussion on the nature of electricity. Students brainstorm the different types of energy that exist. Discuss the concept of Law of conservation of energy: sources of energy, energy transfer and transformations in circuits and devices. Proposed timing: Term 1, Week 1 **INVESTIGATION** *Students plan and conduct simple, teacher-selected first-hand investigations relating to the solar car. Possible practical experiences could include:* - Construct simple series and parallel circuits and use multimeters to measure voltage and current across different components. - Investigate the output voltage and current of solar panels in series and parallel configurations. - Investigate the relationship between solar panel surface area and output voltage and current. - Investigate the relationship between angle of the solar panel to the output voltage and current. Critical and creative thinking Information and communication technology capability - Determine the average speed of solar cars. - Investigate the relationship between mass and the average speed of the solar car. Critical and creative thinking For each investigation students record in their portfolios the purpose, method used, results obtained and, based on the data collected, an explanation of how their findings relate to the function of a solar car. Proposed timing: Term 1, Weeks 5-6 **RESEARCH TASK** Students research the different types of materials currently used in vehicles. They are to outline the changes in material in a timeline (e.g. metals-->plastics) and relate the properties to their intended uses. Students research new materials that would be potentially replace existing materials. Literacy Information and communication technology capability	DEMO: Discharge tubes Experiment:1: Globes in series and 3 globes in parallel. page

	Proposed timing: Term 1, Week 2	

MATHEMATICS

A student:

MA4-2WM
applies appropriate mathematical techniques to solve problems

MA4-5NA
operates with fractions, decimals and percentages

MA4-20SP
analyses single sets of data using measures of location and range

MA4-13MG
uses formulas to calculate the areas of quadrilaterals and circles, and converts between units of area

MA4-7NA
operates with ratios and rates, and explores their graphical representation

MA4-15MG
performs calculations of time that involve mixed units

MA4-14MG
uses formulas to calculate the volumes of prisms and cylinders, and converts between units of volume

MA4-3WM
recognises and explains mathematical relationships using reasoning

MA4-11NA
creates and displays number patterns; graphs and analyses linear relationships; and performs transformations on the Cartesian plane

'MA4-1WM
communicates and connects mathematical ideas using appropriate terminology, diagrams and symbols

MA4-19SP
collects, represents and interprets single sets of data, using appropriate statistical displays

MA4-10NA
uses algebraic techniques to solve simple linear and quadratic equations

MA4-4NA
compares, orders and calculates with integers, applying a range of strategies to aid computation

Class Activity

Representing and interpreting data

- Students take the numerical data produced by the experiments conducted and select the appropriate mathematical strategies for interpreting and making decisions based on this data (MA4-2WM). Proposed timing: Term 2, Week 1
- Students explore a variety of representations for this data and come to conclusions about the suitability of fractions, decimals and percentages for various quantities that have been generated during the data collection process (MA4-5NA), and then make accurate statistical calculations to draw reasonable conclusions from the data (MA4-20SP). Proposed timing: Term 2, Week 2

Projecting for future designs

- Students take measurements on the solar cells and their power-generating area (MA4-13MG), and correlate these with the quantity of electricity being produced over time (MA4-7NA, MA4-15MG).
  Proposed timing: Term 1, Week 8

- Students then draw together their understanding of energy generation and consumption, velocity, and material costs (MA4-14MG) to make predictions about the maximise size of a vehicle that could be constructed and remain economically viable over the long term (MA4-3WM). Proposed timing: Term 1, Week 9

Critical and creative thinking

Formative Assessment

- Students must research the quantitative design constraints related to their solar vehicle and develop the mathematical concepts used to understand and work within these constraints (MA4-2WM, MA4-11NA). Proposed timing: Term 2, Week 5
- In groups, students present their findings and explain the optimal solution they have identified with mathematical justification, selecting appropriate verbal, graphical or symbolic representations to make their case (MA4-1WM, MA4-19SP). Proposed timing: Term 3, Week 4

Personal and social capability

Summative Assessment

- Students sit a formal quiz that assess their fluency and understanding with regard to constructing, solving and interpreting equations of the forms that have arisen during prior class activities and problem solving tasks, such as linear equations (MA4-10NA) involving multiple representations of quantities that are non-integer (MA4-5NA) or directed (MA4-4NA). Proposed timing: Term 4, Week 2

TEC		
4.4.1 explains the impact of innovation and emerging technologies on society and the environment 4.6.2 identifies and explains ethical, social, environmental and sustainable considerations related to design projects 4.1.1 applies design processes that respond to needs and opportunities in each design project	**Innovation** **Examples of innovation in solar powered vehicles** Students research and discuss innovations that have occurred in the development of alternative powered vehicles, in particular solar energy and the impact they have had on society *Information and communication technology capability* *Literacy* Proposed timing: Term 1, Weeks 2-3	Internet Stimulus images
4.1.1 applies design processes that respond to needs and opportunities in each design project 4.6.1 applies appropriate evaluation techniques throughout each design project 4.2.2 selects, analyses, presents and applies research and experimentation from a variety of sources 4.6.2 identifies and explains ethical, social, environmental and sustainable considerations related to design projects 4.2.1 generates and communicates creative design ideas and solutions 4.6.1 applies appropriate evaluation techniques throughout each design project 4.5.2 produces quality solutions that respond to identified needs and opportunities in each design project 4.2.1 generates and communicates	**The Design Folio** **The Engineering Process** Explain the components of the design process and how it is used in industry Proposed timing: Term 1, Week 3 **The Design Brief** Discuss the context of the design brief giving clear parameters and direction Proposed timing: Term 1, Week 4 **Analysis of the Design Brief** Students analyse the design brief to determine the requirements and limitations of the project *Critical and creative thinking* Proposed timing: Term 1, Week 4 **Research and Investigation** Students research relevant information to assist in the designing of their vehicle. This may include, existing designs, tools materials, techniques and new technologies in the field. Proposed timing: Term 1, Weeks 7-10 **Idea Generation**	Student workbook drawing equipment Solar kits

creative design ideas and solutions 4.5.2 produces quality solutions that respond to identified needs and opportunities in each design project 4.6.1 applies appropriate evaluation techniques throughout each design project 4.2.1 generates and communicates creative design ideas and solutions 4.2.2 selects, analyses, presents and applies research and experimentation from a variety of sources 4.3.1 applies a broad range of contemporary and appropriate tools, materials and techniques with competence in the development of design projects 4.6.1 applies appropriate evaluation techniques throughout each design project 4.6.1 applies appropriate evaluation techniques throughout each design project 4.3.1 applies a broad range of contemporary and appropriate tools,	Students generate a range of possible solutions to the design brief, evaluating the suitability of each Proposed timing: Term 1, Weeks 1-2 **Final Idea** After evaluating all ideas students select the most suitable solution, justifying their choice. *Critical and creative thinking* Proposed timing: Term 1, Week 3 **Planning Drawing** Students complete detailed working drawings that can be followed to construct the design. Proposed timing: Term 1, Week 5 **Steps in Construction** Students are guided in the development of a plan that can be followed to build the vehicle. Proposed timing: Term 1, Week 8 **Realisation** Students build/construct their design project following the drawings and steps in construction they have developed. Proposed timing: Term 2, Weeks 2-10 **Final Evaluation** Students evaluate their design throughout the entire process and complete a final evaluation upon completion in relation to the parameter set in the Design Brief and at the analysis stage of the process Proposed timing: Terms 2-3	

materials and techniques with competence in the development of design projects 4.6.1 applies appropriate evaluation techniques throughout each design project	Practical Applications The following is a general overview of the skills that students will need to complete the design project. The teacher will demonstrate each of the skills and techniques and monitor student application. It should be noted that this is not an exhaustive list and some student designs may require additional skills that will need to be demonstrated. Basic electronics Marking Out Working with a range of materials Finishing Techniques Assembly techniques	
4.3.2 demonstrates responsible and safe use of a range of tools, materials and techniques in each design project	**Safety** All students will need to have the correct PPE for every practical lesson and complete all safety test requirements prior to commencing any practical work. Outcome: 4.3.2 demonstrates responsible and safe use of a range of tools, materials and techniques in each design project	Solar kits Appropriate tools, materials and equipment Online safety tests PPE