Brisbane Adventist College

Student name:	**Student number:**
Teacher name: Luke Martin	
Date handed out: 29/3/21	**Date due:** 31/5/21

Subject	Engineering
Technique	Three parts: Structure model, Lego Winch, Individually written folio.
Unit	The Built Environment - Structures
Topic	Lifting Structure - Design challenge (35%)

Conditions			
Time	7 weeks of class time		
Mode	- Written / Graphically presented. - Physical Model consisting of two parts	**Length**	- Part A: 6–7 single-sided A3 pages - Part B: 2–3 single-sided A4 pages - Must include: cover page, table of contents and references.
Individual/ group	Individual	**Other**	the cover page, table of contents and reference list are not included in the page count
Resources	The workshop, Laser cutter, 3D Printer, printers, scanners. Graphics room materials. SketchUp.		

Context/Situation

A new heavy lifting company in Brisbane is seeking design submissions for a new medium-lift, high reach crane to support the growing demand for the high rises in the city.

You have been hired by the Longreach Engineering Company to design and build a scale model of a lifting structure capable of meeting the specific parameters (details below) This design will be tested to meet the minimum requirements, but the desire is for a design that will outperform the criteria.

Task:

You will be required to follow the Problem-Solving Process (listed out below) in Engineering to find a solution to this problem. Details of this process are on pages 6 and 7.

Folio Submission details:

In Engineering, a folio involves you documenting the application of the problem-solving process in response to the engineering problem you have been given. Your response will include the following folio and referencing conventions:

- Headings that organise and communicate your thinking through the phases of the problem-solving process in Engineering
- A table of contents page
- A reference list and in-text referencing based on the APA 6th style.

Prototype Specifications:

1. The lifting structure model must be capable of lifting a 1000gm – 1kg weight.
2. The overall height the weight must be raised needs to be 800mm or higher.
3. The lifting structure must be capable of lifting the load no closer than 400mm from the base.
4. Must lift the weight to the specified height within 60 seconds.

Model Constraints:

The school will supply all materials:

1. The lifting structure model may be based on any type of structure (e.g. truss type, girder, web, etc.)
2. 5mm^2 timber will be provided for the fabrication. No other materials will be allowed.
3. The structure can be assembled with hot glue only.
4. The weld material (glue) can only be used on joints - NOT to reinforce the frame structure.
5. The structure must have a powered winch system to demonstrate the workability of the design. LEGO Technics Kits will be provided for this purpose.
    a. *A point system will be awarded for the overall weight of the lifting structure. The heavier the lifting structure the lower the corresponding points will be relative to the lifting capacity of the structure.*
        i. *The weight of the LEGO Winch will not be considered.*
        ii. *The Lifting structure will be used to lift the weight as per the above specifications before being put through a test to fail assessment. This is where pressure is applied to the structure until it breaks.*
        iii. *The overall weight the structure held (in Newtons 'N') will be divided by the weight of the structure and supplied base before a result is given.*

Specific instructions for the task:

You will be required to follow the Problem-Solving Process in Engineering to find a solution to this problem. Details of this process are on pages 6 and 7.

Folio Submission details

The folio will be in two parts and include the following:

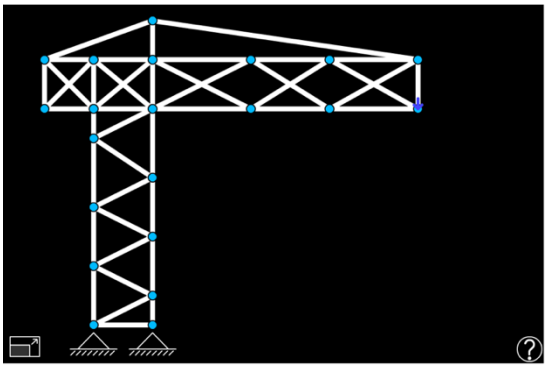
<u>Part A- the development of an engineered solution</u> (6–7 single-sided A3 pages or equivalent digital media)

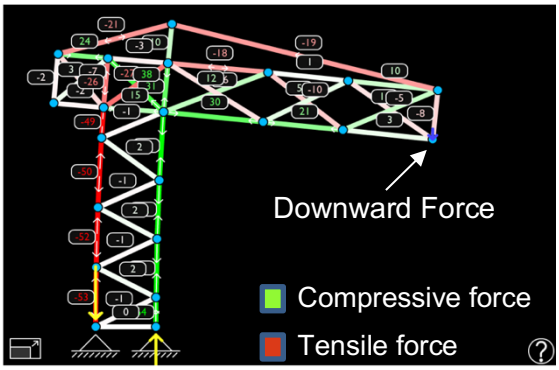
1.0 Explore the Problem

- Investigate the most important aspects of the problem from a theoretical perspective. Your research should focus on **engineering mechanics** and **materials available** relating to the engineering problem you have been given.
- List down:
    - Important **Design Criteria** – *these are elements of your design that need to be adhered to in order to meet the clients needs/requests. 3-4x*
    - Critical **Design Factors** to be considered. – *refer to prototype specifications*
    - **Design Constraints** that you must consider. – *refer to model constraints*

2.0 Develop Ideas

- You will need to develop **four** different solutions to the problem outlined above. Each design can be done on an A3 page using the front and back of the page.
    - You will need to firstly hand sketch (only side views are required) your design ideas.
    - Add annotations explaining your design ideas.
    - You must use software to simulate different ideas. See, for example; http://ivanmarkov.com/truss-simulator.html These are vital to the development of design ideas for your structure. These may be printed and glued to the A3 page along with their necessary annotations.
    - Your drawings need to indicate where you think the members are either under compression or tension.
    - The front and back of the page maybe be used for each design.





- Sketch out a winch system that will incorporate LEGO Technics parts as the building material. This will need to take the rotational speed of the motor and reduce it to a usable speed. This also needs to consider the need to increase the pulling power required to lift the weight. You can calculate the rotational speed from the gear rotations if you want to. You may use the following calculator to find the information, http://gears.sariel.pl
    - You will be required to explain your winch design in the terms of the gear

selection and allocation. This will be taught as a lesson.

- Evaluate each of your four ideas using a PMI (Positive, Minus [Negatives], Interests) table. See example to the right. This file is available in both .pdf and .docx form on the resource section of the lifting structure assessment in SEQTA.

PMI Chart

A PMI is an effective reflection tool to allow students to look at the whole picture of an event. It allows you to look at the positives, the minuses and what are some interesting factors. You could use a PMI individually, with a partner, small groups or in whole class discussions. This procedure could be implemented after Literacy Teams, after playing team games, after reading an information book or at the end of an integrated topic

Plus	Minus	Interesting

- Select a previously developed engineering Solution- Synthesise and refine your design ideas:
  - Resketch the design that appears to solve the problem most effectively. Describe why this was chosen as the solution using annotations.
  - Refine your design idea- explore the details and make improvements. This should include engineering elements and principals. Any information you acquire needs to be referenced. This could include drawings and prototyping. Ensure that you document this process well.
  - Finally, produce either by hand drawing or using digital solutions a to scale drawing consisting (possibly a 3:1 – 3cm of you design would equal 1cm on your page) of at least a side view with the dimensions that you will use to construct your structure.
  - Include a drawing of the final winch system that you chose to use as well. This needs to include the gearing ratios at each stage (refer to the following Lego gear calculator link http://gears.sariel.pl). This should also include the following:
    - The total final gear ratio.
    - The rotational speed of the final gear shaft (where the cable would be attached to).
    - The theoretical output speed (cable speed will need to be calculated)
    - The estimated time it will take to lift the weight to the specified height.
    - The theoretical output torque (in Newton meters Nm)
    - The theoretically expected lifting ability in mass (M)

This section should refer back to the specifications, criteria and constraints identified earlier, as well as any engineering principles that have influenced your final design. Your sketches should show depth or fine detail such as how you intend to join the members etc. and any other fabrication techniques you might use etc.

3.0 Generate Solution

- Produce a model of your lifting structure using SketchUp or a similar software. Extract the following drawings from the model:
  - Orthographic Drawing - front and top view, scaled, dimensioned, title block.
  - Isometric Sketch - rendered a 3-D sketch.
- In a group of 2-3 classmates, produce a physical model of the lifting structure and test it.

- Take photographs/videos of your lifting structure before, during and after testing. Include them with annotations in your folio.

4.0 Evaluate and Refine your chosen design solution

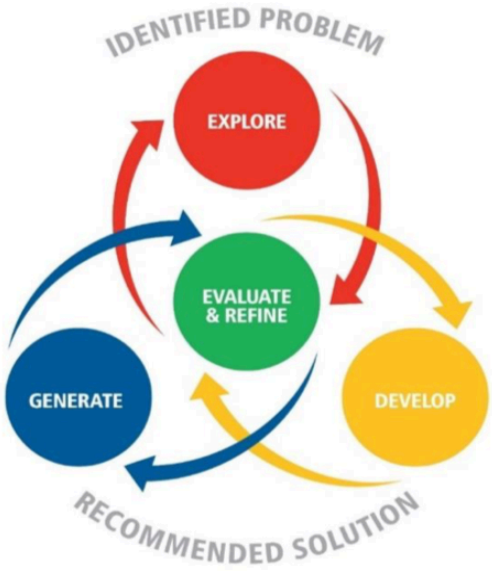
- Explain why your model did or why it didn't perform as expected with sketches and notes. Where possible, comment on its points of strength and weaknesses are and how to improve the deficiencies. Vertical stability and how to further improve this element, force distribution throughout the structure, compression and tension in members, the mounting supporting of winch system you have designed, the difficulty of construction, etc. Use photos and notes to illustrate and add positive comments as well as negative ones.
- Suggest ways in which you could improve the design or construction of the lifting structure.

Part B- A Summary Report (2–3 single-sided A4 pages or equivalent digital media)

Write a summary of your project from Part A for the client as per the 'suggested' outline below:

- Introduction - a succinct overview of the summary report content/ what the report will provide the client for their consideration (40 words).
- Background - succinctly explain the background of the engineering project and a summary of the specifications, constraints and other critical background information.
- Project Objectives - Outline the project objectives which includes the criteria of success (4x) that you hope to achieve.
- Options Considered - Include key pictures, tables, graphs, sketches and drawings that provide a concise account of the preferred solution to the structural problem including any key features.

The problem-solving process in Engineering



Problem-solving process in Engineering

The problem-solving process in Engineering involves four phases which require you to:

1. explore the problem
2. develop ideas for prototyping
3. generate a prototype solution for testing
4. test, evaluate and refine the prototype solution.

To **explore** the problem, you need to:

- recognise and describe the characteristics of the problem and determine their importance
- analyse the problem and associated engineering technology information

  - identify the elements, components and features, and their relationship to the structure of the problem
- research and investigate similar problem situations or solutions to understand the nature of the problem (i.e. best engineering practice)
- recognise the science, technology, engineering and mathematics knowledge known and unknown in relation to the problem
- test and/or calculated to understand the engineering fundamentals of the problem
- determine solution success criteria (i.e. needs and constraints, or requirements) considering the identified elements, components and features, and their relationship to the structure of the problem.

To **develop** ideas, you need to:

- evaluate idea development using solution success criteria
- brainstorm and discuss ideas with colleagues through teamwork and collaboration
- sketch ideas
- calculate to determine the limits for prototype solution development
- test materials and processes to support idea development
- synthesise ideas
- prototype ideas for testing and refinement
- review solution success criteria
- predict a solution.

To **generate solutions**, you need to:

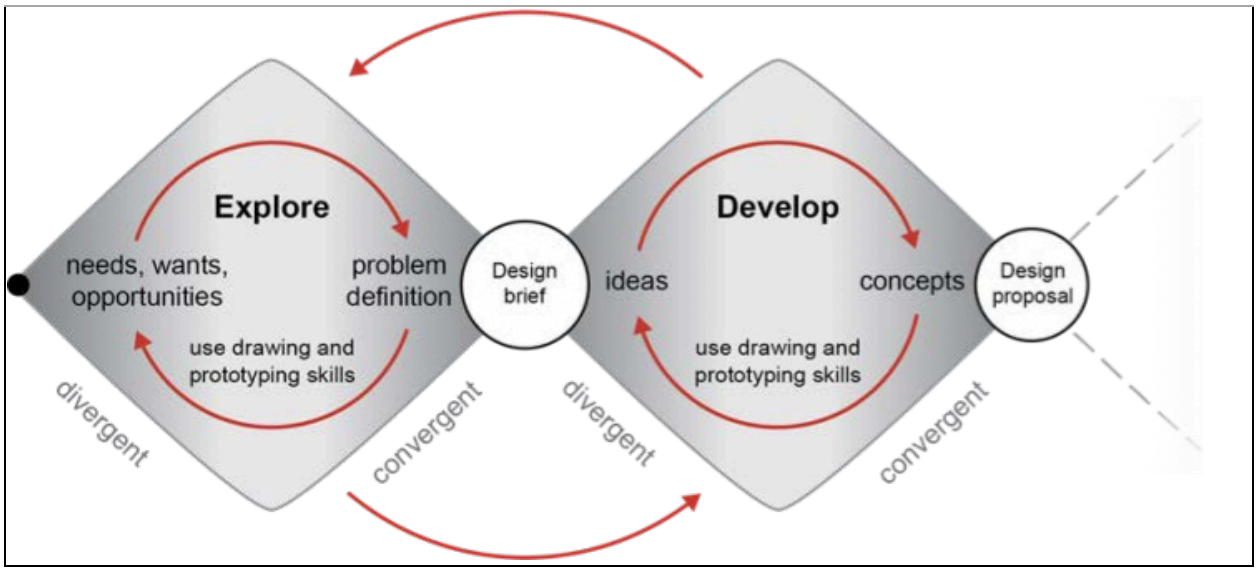
- project manage the generation of the prototype solution
- create drawings that demonstrate an understanding of the Australian standards for engineering drawings — either manual or using computer-aided drafting (CAD) — to facilitate generation of a prototype solution
- communicate the processes proposed to generate the prototype solution
- calculate to predict prototype solution performance and communicate data for an audience using diagrams, tables and spreadsheets
- resolve uncertainties to refine the prototype solution
- generate the prototype solution using processes including 3D printing, laser cutting, hand and/or machine manufacture and virtual production.

To **evaluate and refine** you need to:

- perform testing of the prototype solution, including destructive and non-destructive testing, substitution and simulation to provide performance data
- evaluate the prototype solution using solution success criteria and performance data
- reanalyse test results
- consider sustainability and reliability issues
- make and justify recommendations to improve prototype solution performance.

Checkpoints
☐ Term 2 Week 3: Teacher check in on student progress to ensure crane is nearing completion in the workshop
☐ Term 2 Week 5: Submit draft 21th May 2019
☐ Term 2 Week 6: Submit Final assessment 31th May 2019

Marking Criterion	**Marks allocated**	**Result**
Retrieving and comprehending	5	
Analysing	7	
Communicating	4	
Synthesising and evaluating	9	
Total	**25**	
Authentication strategies		
• Students must acknowledge all sources.		
• The teacher will collect copies of the student response and monitor at key junctures.		
• The teacher will conduct interviews or consultations with each student as they develop the response.		



Instrument-specific marking guide (ISMG)

Instrument-specific marking guide (ISMG)– Lifting Structure Design (25%)

Criterion: Retrieving and comprehending
Assessment objectives
1. recognise and describe the structural problem, engineering technology knowledge, and mechanics and materials science concepts and principles in relation to structures
2.symbolise and explain ideas and a solution in relation to structures

The student work has the following characteristics		
• **accurate** and **discriminating** recognition and **discerning** description of the structural problem, engineering technology knowledge, and mechanics and materials science concepts and principles in relation to structures • **adept** symbolisation and **discerning** explanation of ideas and a solution in relation to structures with sketches, drawings, diagrams, graphs, tables and/or schemas.	4-5	

• **accurate** recognition and **appropriate** description of the structural problem, engineering technology knowledge, and some mechanics and materials science concepts and principles in relation to structures • **competent** symbolisation and **appropriate** explanation of some ideas and a solution in relation to structures with sketches, drawings, diagrams, graphs, tables and/or schemas.	2-3	
• **variable** recognition and **superficial** description of aspects of the structural problem, concepts or principles in relation to structures, variable symbolisation or superficial explanation of aspects of ideas or a solution in relation to structures.	1	
• does not satisfy any of the descriptors above.	0	

Criterion: Analysing

Assessment objectives

3. analyse the structural problem, and information in relation to structures

4. determine solution success criteria for the structural problem

The student work has the following characteristics:		
• **insightful** analysis of the structural problem, and **relevant** engineering mechanics, materials science, technology and research information in relation to structures, to identify the relevant elements, components and features, and their relationship to the structure of the problem • **astute** determination of **essential** solution success criteria for the structural problem.	6-7	
• **considered** analysis of the structural problem, and relevant engineering mechanics, materials science, technology and research information in relation to structures, to identify the relevant elements, components and features, and their relationship to the structure of the problem • **logical** determination of **effective** solution success criteria for the structural problem.	4-5	
• **appropriate** analysis of the structural problem, and engineering mechanics, materials science, technology and research information in relation to structures, to identify some of the elements, components or features of the problem • **reasonable** determination of some solution success criteria for the structural problem.	2-3	
• statements about the structural problem, or information in relation to structures • **vague** determination of some solution success criteria for the structural problem.	1	
• does not satisfy any of the descriptors above.	0	

Criterion: Communicating

Assessment objective

8. make decisions about and use mode-appropriate features, language and conventions to communicate development of the prototype solution

The student work has the following characteristics relating to written and visual features to communicate about a solution, language for a technical audience, grammatically accurate language structures, folio and referencing conventions.		
• **discerning** decision-making about, and fluent use of, - written and visual features to communicate about a solution - language for a technical audience - grammatically accurate language structures - folio and referencing conventions.	3-4	
• **variable** decision-making about, and inconsistent use of, - written and visual features - suitable language - grammar and language structures - folio or referencing conventions.	1-2	
• does not satisfy any of the descriptors above.	0	

Criterion: Synthesising and evaluating

Assessment objectives

5. synthesise information and ideas to predict a possible structural solution

6. generate a structural prototype solution to provide data to assess the accuracy of predictions

7. evaluate and refine ideas and a solution to make justified recommendations

The student work has the following characteristics:		
• **coherent** and **logical** synthesis of relevant engineering mechanics, materials science, technology and research information, and ideas to predict a possible structural solution • **purposeful** generation of a structural prototype solution to provide valid performance data to critically assess the accuracy of predictions •**critical** evaluation and discerning refinement of ideas and a solution using success criteria to make astute recommendations justified by data and research evidence.	8-9	
• **logical** synthesis of relevant engineering mechanics, materials science, technology and research information, and ideas to predict a possible structural solution, • **effective** generation of a structural prototype solution to provide valid performance data to effectively assess the accuracy of predictions • **reasoned** evaluation and **effective** refinement of ideas and a solution using success criteria to make considered recommendations justified by data and research evidence.	6-7	
• **simple** synthesis of engineering mechanics, materials science, technology and research information, and ideas to predict a possible structural solution, • **adequate** generation of a structural prototype solution to provide relevant performance data to assess the accuracy of predictions •**feasible** evaluation and **adequate** refinement of ideas and a solution using some success criteria to make fundamental recommendations justified by data and research evidence.	4-5	
• **rudimentary** synthesis of partial engineering mechanics, materials science, technology or research information, or ideas to predict a structural solution, • **partial** generation of a structural prototype solution to provide elements of performance data to partially assess the accuracy of predictions • **superficial** evaluation of ideas or a solution using some success criteria to make elementary recommendations.	2-3	
• **unclear** combinations of information or ideas, • generation of elements of a structural prototype solution • identification of a change about an idea or the solution.	1	
• does not satisfy any of the descriptors above	0	