Due Date: Two school days after the date at the bottom of this page

Problem Solving – Research

Concepts / Skills: Structure, System, Safety, Analysis, Synthesis, Problem-Solving, Deriving New Concepts from Fundamental Concepts
Grade 12 Technological Design

CONTENTS

1 Expectations: The Student will:

1) **Problem-Solving; Planning / Investigation / Research**
   a) Practice the kinds of thinking that an innovator, such as Thomas Telford, might have used in the development of new technology for the industrial revolution's infrastructure
   b) Begin to extend knowledge of these fundamental concepts from one application (eg truss kind of beam bridge) to a more complex application (eg suspension bridge or a special creative architectural feature)
   c) Output a Version 1 Research Report based on "What I Already Know" (Recall)
   d) Interpret current knowledge in a particular problem-solving situation
   e) Do further research into an assigned product or sub-system design situation
   f) Extract "Requirements" from your research report to carry forward as criteria for your design project.
   g) Analyze the stresses in a truss (Assignment)

2 Research

In the real world, most problems that you will be asked to solve involve doing some research or investigation. How deep you dig will depend on the project and the level of your current knowledge.

2.1 What Do I Already Know?... Version 1 Research Report

So far, in the previous two structures-related files, we've been simplifying a truss problem. These modelling techniques for simplifying a situation are part of "analysis" which, in turn, is part of the research that you must do before you try to design / build something. Before you

design / build, you must first understand and appreciate the system. Again, this takes research, sometimes called the "Inquiry Process" (for example in science class).

"***I already know that***…":

- "Structure" is "*the essential physical or conceptual parts of a product, process, or system, including the way in which the parts are constructed or organized*" (Ontario Tech Educ Curriculum document)
- Geometry is a physical arrangement – a general way to say "frame"
- A force is something that causes a change. There is typically a resistance to such a change, inherent in the properties of the material and / or in the geometry of the structure.
- Tension is a pull (getting longer / stretched)
- Compression is a push (getting shorter)
- Torsion is twisting
- Bending of a member is a combination of tension and compression at the same time
- Deflection is a measured change from a normal position or direction.
- Wood is relatively strong when in only pure tension and when in only pure compression, but weak in bending when laid flat.
    - In general hardwoods are stronger than softwoods. But basswood (classified as a "hardwood") is not as strong as hemlock (a "softwood")
- Some glue types are better than others – for example carpenters glue has better bonding strength than hot glue
- A joint is generally the weak link in a structure
- A triangle is the strongest and most stable structural shape
- An equilateral triangle has three identical sides and three identical interior angles
- An isosceles triangle has two identical sides and two identical interior angles
- A truss bridge is a smartly-made beam bridge, where the material is placed where it is actually needed in order to provide strength
- A suspension bridge uses material types in places where they respond best to the stresses in that particular location.
- A cantilever is rigidly fixed at one end and free at the other end
- Symmetry is a very good design strategy
- Mortar is weak in tension
- Buckling is unrestrained "compression gone wild"
- **Etc… add five more points from your current knowledge that are relevant to your design project subsystem**

Assuming that your current "knowledge" is accurate and you put it all together into a coherent paragraph or three… you now have a rough Version 1 Research Report. This is a set of true facts. But do you yet really understand just how significant these facts are? This will take deeper thinking and more information processing.

2.2 How Can I Interpret My Current Knowledge? --- Synthesize Some Basic Ideas

What can you do by thinking more deeply about your current knowledge?

"***Based on what I already know***":

- We could break down a suspension bridge into sub-systems, each of which is responsible for certain kinds of stress
    - We could design certain parts to resist pure tension
    - We can put parts together to ensure that a component does not go into tension for example
- Good "joining" practices are probably extremely important – we need to limit twisting and slippage at a joint
- Stability is probably extremely important – how to hold parts in a fixed relationship to each other

2.3 Further Research into Structures: Then Improve Your Research Report to V2

Find a relevant video on the internet, for example the "***Understanding Bridges***" series. Or find a good web site about bridges. Or go to the library. Some of this may well be new knowledge.

Now you should use the 80/20 principle and your core thinking skills to integrate the most significant new knowledge with your current knowledge and create an improved version 2 Research Report. You can't start to design until after you've come to at least a modest understanding and appreciation of many of the key concepts and their relationships to each other.

Remember:

- Translate into your own words (by copying, you will not learn – this is plagiarism)
- Interpret: Sort, re-organize, summarize
- Apply: Using the 80/20 principle, select information that is most critical to your project– but you will need to work with this information in your brain first.
- Synthesize: Put it all together into a coherent and valuable version 2 research report

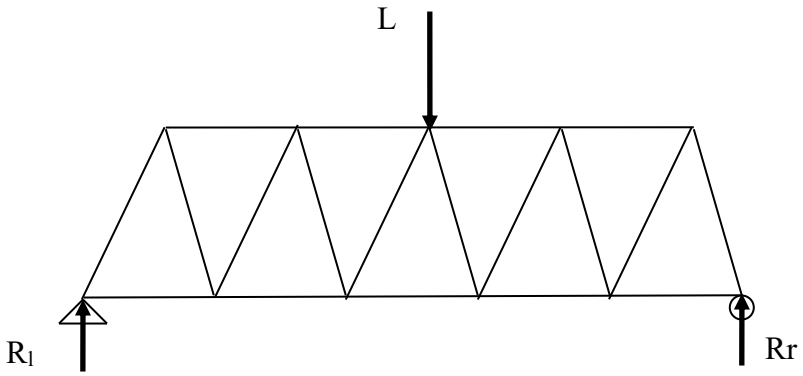
3 Think About This -- Update Research Report & Finalize Requirements Document

1) **Brainstorm. Describe at least one other alternative re-design option. You would add your thoughts to your Sub-system Research Report (say, Version 3).**

2) **You should now have a very solid idea of all of the requirements that your product sub-system must satisfy -- you should have some notes on each of these requirements in your research report. Extract these requirements into one concise list -- your Requirements Document. After review by your QA manager and other team members, you can (depending on the review) start your final design work -- including drawings, specifications, materials and parts list and fabrication plan.**

4 Analysis Assignment: Review / Check Understanding

Problem:
Consider the sketch below of a simple truss. The sketch is not to scale. If the load L is 100 pounds and the height of the truss is 4 inches and the total length of the bottom of the truss is 2.5 feet, calculate the maximum tension force in the bridge. Clearly state all assumptions (for example, "*it is not made of popsicle sticks*")



5 Safety Reminder

Safety is the number one concern in bridge design / construction and this depends greatly on the strength of the bridge. People can die when a bridge fails structurally.

6 Self and Peer Assessment

Inputs / Knowledge / Understanding That I Still Need or Connections that I Want to Make For This Unit: (give each a #)

Assessor's Name and Notes: (Peer Assessor must "make you think". Give the student one clue that will help him or her get a better mark.)