STEAMING SCHEMATICS

LEVEL

Year 11

VCE: Systems Engineering

ACTIVITY DESCRIPTION

A steam locomotive, such as Puffing Billy Railway, is a machine that uses steam power to perform mechanical work through the agency of heat. Steam engines in locomotives convert thermal energy into mechanical energy, heating water until it converts to steam to drive the pistons and turn the wheels. These mechanical systems have been used for over a century and have slowly been replaced by more innovative, economical and sustainable systems such as internal combustion engines and electrical motors.

After their excursion to the Railway, students will design, construct and assemble their own integrated and controlled aspect of an operational mechanical system for Puffing Billy Railway. Students will solve a system-based problem, need, opportunity or situation by applying technological, mathematical and scientific principles. Students will plan, test, record and evaluate this system while performing risk assessments and safely using materials, tools, equipment, components and machines. Students will use engineering processes, creative thinking and technical skills to document this progression, test and modify their system to achieve optimum performance and success, whilst highlighting the factors that influenced the creation of their system.

NOTE: This resource can be used for students' assessment task for Systems Engineering, Unit 1: Mechanical Systems.

SUBJECT AREA

Systems Engineering Unit 1: Mechanical Systems

Area of Study 2- Producing and evaluating mechanical systems

MATERIALS REQUIRED

- "Steaming Schematics" Authentication Record Form – for teachers
- Devices with access to the internet to conduct research
- "Steaming Schematics" Task sheet
- Steaming Systems workbook notes
- Devices with access to multimedia presentation programs
- Any tools, materials, equipment required to develop prototype in systems engineering workshop
- Safety briefs/risk assessments for workshop tools, materials and equipment to be used
- Pens, paper and textas for those students developing a brochure or written report and/or for those who wish to create a folio to document their process.
- Access to photography equipment to photograph students' progress for folios.

INSTRUCTIONS

1. Prior to visiting Puffing Billy Railway teachers will pre-emptively prepare students to document their system engineering processes whilst producing and creating a mechanical system. Teachers will set students up to develop a mechanical system back at school using all the knowledge gained in the subject.

HINT: Speak to students about the mechanical system that is a steam locomotive. Brainstorm some mechanical systems used at the Railway. Speak to students about problems, needs or opportunities they think the railway may have for mechanical systems.

2. Prior to the excursion teachers can choose to showcase 2023 Systems Engineering final designs on display at Melbourne Museum. You can view them online here: https://museumsvictoria.com.au/melbournemuseum/learning/top-designs-2024/systems-engineering/

REMINDER: At this point in their learning students are developing a mechanical system not an electrotechnological system, although their design can have some electronic elements.

3. Throughout their excursion to Puffing Billy Railway teachers reiterate to students the need to take notes and develop a design brief to create a mechanical system back at school. Teachers to remind students that everything they see at the railway and hear from the staff and volunteers could help them with developing their mechanical system. Students need to solve a system-based problem, need, opportunity or situation by applying design principles. "What mechanical system does Puffing Billy Railway need? And why?"
4. On return to school, after visiting Puffing Billy Railway, brainstorm with students some ideas of mechanical systems they could create to help and support Puffing Billy Railway to achieve success. Students create a design brief and research, design and plan a mechanical system to help and support Puffing Billy Railway. Students consider relevant factors that influence the creation and use of their system and document their findings and processes. Social, ethical and sustainability considerations, in the development of technologies and designed solutions to meet community needs for economic, environmental and social sustainability.
5. Students' assessment is based on the documentation of their systems engineering process using one or more of:
   a. A multimedia/simulation presentation
   b. An electronic portfolio
   c. A brochure
   d. A poster
   e. A written report

Students' assessment is also based on the production work to create a mechanical system and their development and creation of a prototype in the workshop and classroom.

HINT: Some suggested projects for mechanical systems at the railway can be found in the Background Information.

SUGGESTIONS FOR ASSESSMENT

Ability to take notes on excursion and use these notes to define a brief for a mechanical system to be used at Puffing Billy Railway. Student documentation (creation of a folio) of their system engineering process and production work to create a mechanical system. Students' ability to develop a prototype of their mechanical system. Completion of "Scheming Schematics" Authentication Form by teacher and student. .

CURRICULUM LINKS

SYSTEMS ENGINEERING

Unit 1: Mechanical Systems

Area of Study 2 – Producing and evaluating mechanical systems

Outcome 2

On completion of this unit the student should be able to produce, test, diagnose and evaluate a mechanical system using the systems engineering process.

BACKGROUND INFORMATION

SYSTEMS ENGINEERING

The definition of a system is “a set of interrelated components working together toward some common objective”. It is an integrate composite of people, products and processes that provide a capability to satisfy a stated need or objective.

A system can be natural or engineered. An example of a natural system is our solar system. Engineered systems are designed and built to satisfy human needs eg. Wireless telephone network, power generation plants, highways, etc. From a functional viewpoint systems have inputs, processes, outputs and boundaries.

Engineered systems can be non-complex or complex.

NON-COMPLEX SYSTEM – engineered system which does not involve many disciplines of engineering. Eg. Washing machine, refrigerator, dishwasher and vacuum cleaner.

COMPLEX SYSTEM – engineered system that involves many engineering disciplines eg. Weather satellite system and air traffic control system.

TABLE 1.1. Examples of Engineered Complex Systems: Signal and Data Systems

System	Inputs	Process	Outputs
Weather satellite	Images	• Data storage • Transmission	Encoded images
Terminal air traffic control system	Aircraft beacon responses	• Identification • Tracking	• Identity • Air tracks • Communications
Track location system	Cargo routing requests	• Map tracing • Communication	• Routing information • Delivered cargo
Airline reservation system	Travel requests	Data management	• Reservations • Tickets
Clinical information system	• Patient ID • Test records • Diagnosis	Information management	• Patient status • History • Treatment

TABLE 1.2. Examples of Engineered Complex Systems: Material and Energy Systems

System	Inputs	Process	Outputs
Passenger aircraft	• Passengers • Fuel	• Combustion • Thrust • Lift	Transported passengers
Modern harvester combine	• Grain field • Fuel	• Cutting • Threshing	Harvested grain
Oil refinery	• Crude oil • Catalysts • Energy	• Cracking • Separation • Blending	• Gasoline • Oil products • Chemicals
Auto assembly plant	• Auto parts • Energy	• Manipulation • Joining • Finishing	Assembled auto
Electric power plant	• Fuel • Air	• Power generation • Regulation	• Electric AC power • Waste products

Reference: System Engineering, Dr. S.S.Thankur

STEAM LOCOMOTIVES

A steam engine uses a coal fire as its source of energy to boil water and make steam. The hot gases from the burning coal in the firebox are passed through the boiler in "Fire tubes" before leaving the engine via the smoke box and chimney.

As the water boils, the hot "wet" steam rises, and is collected from the steam dome on top of the boiler through the regulator valve, which the driver uses to control the locomotive speed.

From the regulator, steam is piped to the cylinders, and is admitted alternatively via the valve-chests, pushing the piston in the cylinder back and forth as the piston is connected to the driving wheels via the "connecting rod" and "crank", the to and for motion of the piston turns the driving wheels.

MORE INFORMATION:
https://www.trains.com/trn/train-basics/abcs-of-railroading/how-a-steam-locomotive-works/

EXAMPLES OF MECHANICAL SYSTEMS

SUGGESTED THEMES	SUGGESTED PROJECTS
Home	• Strength multiplier, for example: – can opener – heavy object-lifting device – model crane or weight-moving device • Cooking or baking device, for example: – mechanical whisk – egg timer
Industrial	• Assistance device, for example: – crane • Automation, for example: – process, such as conveyor system with mechanical drive – access, such as automatic door closer or opener, swing or lifting bridge
Entertainment	• Pull-along toy using mechanical principles • Steering mechanisms for use with building systems

REFERENCE:
https://www.vcaa.vic.edu.au/curriculum/vce/vce-study-designs/systemsengineering/advice-for-teachers/Pages/develop.aspx

MECHANICAL SYSTEMS AT THE RAILWAY

SUGGESTED PROJECTS

- **TORQUE MULTIPLIER** - Removal of wash out plugs in hard-to-reach locations on a train, or in generally for the use of removal fixtures and fittings that are stuck on tight or rusted.
  (https://norbaraustral ia.com.au/torque-multipl iers/torque-multiplier-1300-n%C2%B7m-51-3-4-square-drive-handtorque-ht3/).
- **CONVEYOR BELT** - Shift the ash from the ash pit into the ash bin without manual labour. Currently the ash is shovelled into wheelbarrows and then tipped into a pile. The machine then loads it into the bin.
  Could it be automated?
- **PRESS TOOLING** - To remanufacture diaphragms and seals that are no longer available for purchase (eg. DH radiator thermos switch).
- **A PURPOSE-BUILT TROLLEY** that holds specific parts, so they all have a space and don't go missing when removed from the train (think kanban systems).
- **CARRIAGE DOOR MONITORING SYSTEM** - includes an electrical component.
- **WHEELCHAIR RAMP /ACCESS** lifts as carriages are higher than platforms and there isn't enough space to get the ramp.
- **A JIG** that allows the rapid testing of leaf springs.
- **A PRESS** that can help press biomass into burnable fuel sized pellets (alternative fuel source).

STEAMING SCHEMATICS TASK SHEET

You will develop a design brief to solve a system-based problem, need or opportunity at Puffing Billy Railway. You will plan, test, record, evaluate and create a prototype of a mechanical system.

1. Prepare a design folio; start with writing a design brief. Consider:
   a. Your observations on excursion to Puffing Billy Railway
   b. Puffing Billy Railways needs and opportunities
   c. Social, ethical and sustainability considerations, in the development of technologies and designed solutions to meet community needs for economic, environmental and social sustainability.
   HINT: Use any notes you made on excursion to Puffing Billy Railway.
2. Below is a page for a mind map. Brainstorming or mind mapping are simple methods for collection and sorting of ideas and thoughts. Group your thoughts into input actions and output results.
3. In your folio:
   a. List the steps required to build your mechanical system.
   b. Highlight your design limitations.
   c. Determine your materials, tools and equipment needed.
   d. Carefully follow a planned set of production steps to collaboratively and safely use tools and equipment in the workshop to produce and test the completed device.
   e. Draw working designs for your mechanical system.
   f. Complete the assembly and/or testing of your prototype
   g. Photograph your final design. **REMEMBER**: To take photographs throughout the design and building process.
   h. Evaluation: Write a 100-word reflection about how the mechanical system functioned and if it satisfied the brief. Discuss the successes and areas that could be improved or changed.

MIND MAP

STEAMING SCHEMATICS AUTHENTICATION RECORD FORM
VCE SYSTEMS ENGINEERING UNIT 1: MECHANICAL ENGINEERING

This form must be completed by the class teacher. It provides a record of the monitoring of students' work in progress for authentication purposes.

Assessment criteria for School-assessed Task	Indicators	Date observed/ submitted	Authentication issues/comments	Teacher's initials	Student's initials
1. Investigation of a problem/situation/ opportunity/need at Puffing Billy Railway and develop a design brief for a mechanical system, including evaluation criteria	• identifies problem/situation/ opportunity/need for Puffing Billy Railway				
	• develops design brief for a mechanical system				
	• develops evaluation criteria				
	• responds to design brief				
	• references factors that influence the creation and use of the mechanical system				
2. Researching, devising, designing and modelling design options	• conducts research including heritage railway components, modelling of components, subsystems, systems		(Note: all resources must be acknowledged)		
	• generates design ideas				
	• produces feasible design options				

Assessment criteria for School-assessed Task	Indicators	Date observed/ submitted	Authentication issues/comments	Teacher's initials	Student's initials
3. Planning the creation of the system	• devises workplan (timeline, sequence of steps and associated mechanical equipment, components, materials, and processes)				
	• references materials, components and processes				
	• describes safety and risk assessment for materials, components and processes				
4. Use of tools, equipment and machines to make the system	• implements work plan				
	• complies with OH&S requirements				

Assessment criteria for School-assessed Task	Indicators	Date observed/ submitted	Authentication issues/comments	Teacher's initials	Student's initials
5. Realisation of a mechanical system	• produces a mechanical system		(Note: all outsourced processes must be recorded. At least three observations need to be recorded)		
6. EXTENSION. Use of diagnostic test procedures and interpreting test data	• identifies diagnostic tests				
	• provides reason for diagnostic tests				
	• explains how to set up diagnostic tests				
	• conducts tests				
	• generates and uses test data				
	• manages production of system				

Assessment criteria for School-assessed Task	Indicators	Date observed/ submitted	Authentication issues/comments	Teacher's initials	Student's initials
7. Project management to realise the preferred option	• documents decision-making, modifications and justifications				
8. Evaluating the use of the systems engineering process, including finished mechanical system/ prototype	• evaluates design				
	• evaluates production (materials, tools, processes)				
	• tests and evaluates prototype/ mechanical system				

REFERENCE: *https://www.vcaa.vic.edu.au/*