# Singleton High School
## Integrated STEM unit — Rollercoasters
## Year 8

**Design Situation:**

Design and problem solving skills are vital for the careers of the future. Students will need the ability to resolve issues through experimentation and testing. Design is not undertaken alone and is quite often most effective when applied in collaboration.

Motion is embedded into our everyday lives, so much so that its intricacies and nuances are largely ignored or taken for granted. However, the understanding of motion and how it can be applied and manipulated is vital in a 21st Century world.

Mathematics is everywhere. It gives us the theory behind why things are the way they are and makes everyday situations more predictable.

**Design Brief:**

Working as a part of a collaborative team complete the following:

Design, produce, promote and evaluate a rollercoaster mainly constructed from paper that allows a ball bearing (supplied) to move from start to finish in the slowest time possible. The track needs to be of a predetermined length and contain mandated elements. A starting gate of your own design must be used to begin the balls motion from the beginning of the rollercoaster without the ball being touched.

**Limitations:**

- The Rollercoaster must stand completely on the board you are provided with that is 1200mm x 600mm
- The length of the rollercoaster must be 2000mm
- The ball must be released from a start gate of your own design, produced using the 3D printer.
- Construction may only use the materials provided
- It must contain a straight section of 500mm in length at an angle of 30°
- The track must contain at least two changes of direction

**Common Assessment**

Each team will produce a design folio documenting the design, ongoing evaluation, research, experimentation, production and evaluation.

- Design – sketches, design modification, justification of design decisions and final design
- Ongoing evaluation– will be established early in the project and be used as an ongoing evaluation tool to monitor progress and determine success. Includes justifications of decisions made to meet the need identified in the design brief
- Research – motion, energy transfer and technological innovation
- Experimentation- kinetic and potential energy, energy transfer, factors affecting motion, tools, materials and construction techniques, design ideas
- Production – folio documenting the process from initial ideas to final product (videos, photos, drawings, log book )

| OUTCOME MAPPING FOR ROLLERCOASTERS | | |
|---|---|---|
| **Science** | **TAS** | **Mathematics** |
| SC4-5WS collaboratively and individually produces a plan to investigate questions and problems<br><br>SC4-6WS follows a sequence of instructions to safely undertake a range of investigation types both collaboratively and individually<br><br>SC4-7WS processes and analyses data from first hand investigation and secondary sources to identify trends, patterns and relationships, and draw conclusions<br><br>SC4-9WS Presents science ideas, findings and information to a given audience using appropriate scientific language, text types and representations<br><br>SC4-10PW Describes the action of unbalanced forces in everyday situations<br><br>SC4-11PW Discusses how scientific understanding and technological developments have contributed to finding solutions to problems involving energy transfer and transformation | 4.1.1 Applies design processes that respond to needs and opportunities in each design project<br><br>4.1.2 Describes factors influencing the design in the area of Built Environments<br><br>4.2.1 generates and communicates creative design ideas and solutions<br><br>4.2.2 Selects, analyses, presents and applies research and experimentation from a variety of sources<br><br>4.3.2 Demonstrates responsible and safe use of a range of tools, materials and techniques in each design project<br><br>4.5.2 produces quality solutions that respond to identified needs and opportunities in each design project<br><br>4.6.1 applies appropriate evaluation techniques throughout the design process | MA4-1WM: a student communicates and connects mathematical ideas using appropriate terminology, diagrams and symbols-communicating<br><br>MA4-2WM: a student applies appropriate mathematical techniques to solve problems- problem solving<br><br>MA4-3WM: a student recognises and explains mathematical relationships using reasoning- reasoning<br><br>MA4-7NA: operates with ratios and rates and explores their geographical representation<br><br>MA4-15MG: performs calculations of time that involve mixed units<br><br>MA 4.18MG: identifies and uses angle relationships<br><br>MA4-19SP collects, represents and interprets single sets of data, using appropriate statistical displays<br><br>MA4-20SP analyses single sets of data using measures of location and range<br><br>MA4-11NA creates and displays number patterns; graphs and analyses linear relationships |

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/

**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

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/

Learning experiences include:

| LITERACY | NUMERACY | ICT CAPABILITY | CRITICAL AND CREATIVE THINKING | ETHICAL BEHAVIOUR | PERSONAL AND SOCIAL CAPABILITY | ASIA AND AUSTRALIA'S ENGAGEMENT WITH ASIA | SUSTAINABILITY |
|---|---|---|---|---|---|---|---|
| Write scientific reports<br><br>Write explanatory notes<br><br>Communicate using scientific ideas<br><br>Communicate using Metalanguage<br><br>Write procedural texts<br><br>Write evaluation<br><br>Read and follow instructions | Make measurements<br><br>Analyse data to identify trends<br><br>Construct graphs to represent data<br><br>Derive equations from graphical data | Use smart devices to gather experimental data<br><br>Use spreadsheets as a tool to perform calculations and create graphs<br><br>Create using a 3D Printer | Use thinking skills to complete group activities and open ended tasks<br><br>Solve problems in order to complete a design brief | Consider how design can influence safety of the user of any devise<br><br>Consider how the built environment can affect the people living in the location or area | Work together to participate in science investigations<br><br>Work together to participate in designing<br><br>Work together to participate in learning experiences | Research and evaluate rollercoasters throughout the Asia/ Australia region | Debate how emerging technologies improve sustainability of resources |

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**Stage 4 Technology Mandatory**

**Area of Study – Built Environment**

**Design Specialisation — Structural Design**

| OUTCOME | STUDENTS LEARN ABOUT: | STUDENTS LEARN TO: | TEACHING AND LEARNING STRATEGIES | RESOURCES | CCC | REG |
|---|---|---|---|---|---|---|
| 4.1.2 | Factors affecting design: function, aesthetics, environmental resources | Examine factors affecting design in the area of the built environment. | • Introduction to STEM, organisation, expectations and roles.<br>• Introduce the concept by examining rollercoasters in Asia/Australia region and evaluating their design, function and aesthetics | Letters to parents | **ASIA AND AUSTRALIA'S ENGAGEMENT WITH ASIA**  | |
| 4.1. | Effective Group Work<br><br>The construction of a sample rollercoaster using set plans and materials | Follow instructions for the construction of sample project in group work situation.<br><br>Allocate roles and responsibilities within groups<br><br>Complete project with resources and necessary equipment supplied. | • Roles and responsibilities within groups discussed<br>• Students work together following set instructions and using stated materials to construct a standard rollercoaster. | paperrollercoasters.com | **LITERACY**  Read and follow instructions<br><br>**PERSONAL AND SOCIAL CAPABILITY**  Work in groups to complete a task | |
| | | | **DESIGN BRIEF INTRODUCED AND EXPLAINED** | Design Brief Document | | |

| OUTCOME | STUDENTS LEARN ABOUT: | STUDENTS LEARN TO: | TEACHING AND LEARNING STRATEGIES | RESOURCES | CCC | REG |
|---|---|---|---|---|---|---|
| 4.2.2<br><br>SC4-9WS<br><br>SC4-10PW<br><br>SC4-11PW<br><br>SC4-6WS<br><br>SC4-7WS<br><br>SC4-5WS<br><br>MA4-1WM<br><br>MA4-2WM<br><br>MA4-3WM<br><br>MA4-7NA<br><br>MA4-15MG<br><br>MA 4.18MG<br><br>MA4-19SP<br><br>MA4-20SP<br><br>MA4-11NA | Research and experimentation methodologies<br><br>Scientific theories and laws surrounding:<br>- Types of Energy<br>- Energy transformation<br>- Efficient energy transfer<br>- Unbalanced forces<br>- Describing motion<br>- Factors affecting motion<br>- Calculations the motion of objects<br><br>Mathematical terminology and concepts including:<br>- Solving problems involving speed with and without the use of digital technologies<br>- Interpreting and calculating ratios involving more than two numbers | Design valid experiments, present reliable results, analyse trends and patterns in data collected.<br><br>To complete a scientific report using conventions<br><br>Design, perform and analyses valid and reliable experiments to test a range of theories and ideas including<br>- Types of Energy<br>- Energy Transformation<br>- The efficient transfer of energy<br>- Unbalanced force<br>- Factors affecting motion of an object<br>- Calculations of motion<br>Design variations to experimental situations and analyse results including:<br>- Solve problems involving speed with and without the use of digital technologies | **What is Energy?**<br><br>Students recognise that all objects contain energy and that energy can be divided into kinetic, chemical, heat, sound, light, electric, elastic and gravitational. Use video of rollercoasters to complete a table identifying these types of energies in the rollercoaster they are watching.<br><br>Introduce the concept of energy transformation using simple demonstrations and experiments including:<br>- Motor mouse (elastic to kinetic)<br>- Tuning forks (sound to motion)<br>- Thermo-generators (heat to electric and light)<br>- Food Combustion (chemical to heat)<br>Students use flow charts to describe the energy transformation occurring and start taking simple measurements to test relationships between variables.<br><br>Students use a diagram to analyse the energy transformations that occur in a rollercoaster<br><br>Use flowcharts to examine both visually and numerically the efficiency of energy transfer in everyday situations. For example in a light bulb, toaster or a car. Using the basic model they built students discuss the factors that may affect how efficiently energy is transferred in a rollercoaster.<br><br>**What are balanced and unbalanced forces?**<br><br>Students are given everyday situations; discuss the forces that are operating on objects and produce diagrams to describe these forces eg car at traffic lights, car slowing down, car speeding up, car at constant speed. Classify each of these situations as involving balanced or unbalanced forces. | YouTube Videos<br><br>Kinetic to Potential Energy worksheet<br><br>SCIENCE FOCUS 1<br><br>SCIENCE FOCUS 4 | **LITERACY AND NUMERACY**<br>Communicate using scientific ideas | |

| OUTCOME | STUDENTS LEARN ABOUT: | STUDENTS LEARN TO: | TEACHING AND LEARNING STRATEGIES | RESOURCES | CCC | REG |
|---|---|---|---|---|---|---|
| | - Solving real life problems involving ratio and rates<br>- Converting of units of speed<br>- The language and conventions of geometry<br>- Defining and labelling angles<br>- Measurement of angles | - Interpret and calculate ratios involving more than two numbers<br>- Solve real life problems involving ratio and rates<br>- Convert of units of speed<br>- Apply the conventions of geometry to real life situations<br>- Manipulate angles to achieve a desired outcome<br>- Measure angles in real life situations | **Describing and Analysing Motion**<br><br>Introduce terminology used to describe motion; speed, velocity, acceleration, deceleration and constant speed.<br><br>Perform simple calculations of speed, acceleration and deceleration using correct units. Practice unit conversion such as m/s to km/hr.<br><br>Describe and label angles according to distinguishing features. Practice the measurement of angles.<br><br>Describe Newtons Laws of Motion in everyday situations and relate them to the design and movement of a rollercoaster.<br><br>Students learn to manipulate and analyse the factors that affect the motion of an object by completing the following experiments, data collected using conventional and digital technologies, presented in graphical form.<br><br>1. The effect of angle of a ramp on the speed of an object. Use trigonometry to calculate angles of the ramp and apply to everyday situations<br>2. The effect of surface on the speed of an object. Students calculate speeds from collected data using the formula<br>$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$<br>3. The effect of object shape and mass on its speed. Students practice unit conversions using collected data. Students perform calculations of time and speed that involve mixed units. | Science Equipment<br><br>Ramp, stopwatch, protractor, calculator, bubble wrap, aluminium foil, plasticine<br><br>Paper roller coaster experimental worksheets | **NUMERACY**<br>Make measurements<br><br>Analyse data to identify trends<br><br>Construct graphs to represent data<br><br>**CRITICAL AND CREATIVE THINKING**<br><br>Use thinking skills to complete group activities and open ended tasks<br><br>**LITERACY**<br><br>Write scienctific reports<br><br>Write evaluation | |

| OUTCOME | STUDENTS LEARN ABOUT: | STUDENTS LEARN TO: | TEACHING AND LEARNING STRATEGIES | RESOURCES | CCC | REG |
|---|---|---|---|---|---|---|
| 4.3.2 | Work place health and safety issues around experimentation and in the workshop | Use and demonstrate safety with a range of tools, equipment and technologies | The safe usage of a range of tools and resources are explained before they are used. Expectations are clearly defined. | | | |
| 4.2.1 | Experimentation with ideas to create a solution to a problem operating within set limitations and guidelines.<br><br>Technology based skills introduced<br>- 3D printer<br>- Using video for results, analysis and as a presentation tool<br>- Use of camera to calculate speed | Work in groups to create solutions<br><br>Use technologies such as 3D Printers and video for calculation and presentation of their work. | Groups collaborate, experiment and critically analyse results to develop the plan of their rollercoaster.<br><br>Use 3D printer to design and produce a start gate | Camera<br>Video Recorder<br>3d Printer | **ICT CAPABILITY**<br><br>Create using 3D Printer | |
| 4.6.1<br><br>4.5.2 t | | | Students begin construction of their final design. Groups evaluate progress consistently and modify plans as needed.<br><br>Final rollercoaster is produced and tested against other groups to assess which design best meets the requirements of the design brief. | Resource Box provided containing objects described in design brief. | **PERSONAL AND SOCIAL CAPABILITY**<br>Work together to participate in designing<br><br>**CRITICAL AND CREATIVE THINKING**<br>Solve problems in order to complete a design brief | |

# Assessment

**PORTFOLIO** – 100% of Assessment, a Grade of A – E will be awarded

- Every student is required to submit an individual portfolio that documents the learning journey involved in the Rollercoaster unit.
- The portfolio may be A3 in size
- The portfolio is to include:
  - Documentation of the design process used, sketches, ideas, modification and justifications, evidence of ongoing evaluation
  - Evidence of Research and Experimentation - Science and Mathematical theory
  - Information regarding the safe use of equipment and techniques
  - Step by step documentation of the Production Process
  - Visual representation of the Design Process
  - Evaluation of the final product
  - Evaluation of performance of all group members throughout the project
  - The final product and its compliance with the design brief
  - Time management skills throughout the projcet
  - The ability to work safely in the practical component
  - Success of collaboration within the group , work and responsibilities shared
  - Use of technology to complete and present the project
  - Creativity of design

| **SUMMARY OF RESULTS : ROLLERCOASTERS** | **Grade Recieved** |
|---|---|
| Portfolio | |

Teacher Comment:

## *Marking Rubric: ROLLERCOASTERS*

| Grade | Area | Criteria |
|---|---|---|
| A | **Science** | Demonstrates deep knowledge of the scientific principles underlying motion and energy transfer and applies this to problem solving situations.<br>Clearly identifies all components of the scientific method. Analyses data from experiments and clearly presents findings using tables and graphs<br>Uses scientific understanding to justify decisions made to design and evaluates these decisions. |
| | **Mathematics** | Demonstrates deep knowledge of the mathematical principals underlying ratios and rates, time calculations angle relationships and data<br>Clearly identifies communicates and connects all of the mathematical ideas using appropriate terminology, diagrams and symbols<br>Demonstrates expert knowledge of the appropriate mathematical techniques to solve problems.<br>Provides deep explanations of mathematical relationships using reasoning |
| | **Technology** | Describes relevant areas of investigation.<br>Establishes and Analyses appropriate criteria to evaluate success.<br>Formulates and Evaluates well documented Action and Time plans.<br>Demostrates the substantial application of Creativity.<br>Undertakes, Evaluates and Applies a range of appropriate research, experimentation and testing and applies conclusions drawn from research and experiementation.<br>Succinctly demonstrates a range of appropriate communication and presentation techniques. Applies a range of high quality practical skills.<br>Critically evaluates aspects of the project throughout development. |
| B | **Science** | Demonstrates good knowledge of the scientific principles underlying motion and energy transfer.<br>Clearly identifies most components of the scientific method. Analyses data from experiments and clearly presents findings using tables and graphs<br>Uses scientific understanding to justify decisions made to design and evaluates. |
| | **Mathematics** | Demonstrates good knowledge of the mathematical principals underlying ratios and rates, time calculations angle relationships and data<br>Clearly identifies communicates and connects most of the mathematical ideas using appropriate terminology, diagrams and symbols<br>Demonstrates good knowledge of the appropriate mathematical techniques to solve problems and provides good explanations of mathematical relationships using reasoning |
| | **Technology** | Describes some relevant areas of invetigation.<br>Describes appropriate criteria to evaluate success.<br>Formulates Action and Time plans and shows some evidence of their application.<br>Demontrates an application of creativity.<br>Undertakes, Evaluates and Applies appropriate research, experimentation and testing and demonstrates some application of conclusions drawn<br>Demonstrates varied and appropriate communication and presentation techniques.<br>Applies a range of sound practical skills.<br>Evaluates some aspects of the project throughout development. |

| Grade | Area | Criteria |
|---|---|---|
| C | **Science** | Demonstrates sound knowledge of the scientific principles underlying motion and energy transfer.<br>Clearly identifies some components of the scientific method. Analyses data from experiments and clearly presents findings using tables and graphs<br>Uses some scientific understanding to make decisions relating to design and attempts to evaluate |
| | **Mathematics** | Demonstrates some knowledge of the mathematical principals underlying ratios and rates, time calculations angle relationships and data<br>Clearly identifies communicates and connects some of the mathematical ideas using appropriate terminology, diagrams and symbols<br>Demonstrates some knowledge of the appropriate mathematical techniques to solve problems<br>Provides some explanations of mathematical relationships using reasoning |
| | **Technology** | Identifies areas of investigation.<br>Briefly describes criteria to evaluate success.<br>Formulates action and/or timeplans<br>Demonstrates some creativity.<br>Undertakes, Evaluates and Applies some appropriate research, experimentation and testing and demontrates some selective application of conclusions Demonstrates appropriate communication and presentation techniques.<br>Applies sound practical skills.<br>Judges the success of some aspects of the project through stages of development. |
| D | **Science** | Demonstrates basic knowledge of the scientific principles underlying motion and energy transfer and applies this to problem solving situations.<br>Clearly identifies some components of the scientific method. Attempts to analyse data from experiments and attempts to present findings using tables and graphs<br>Basic justifcation of decisions and a basic evaluation |
| | **Mathematics** | Demonstrates basic knowledge of the mathematical principals underlying ratios and rates, time calculations angle relationships and data<br>Clearly identifies communicates and connects a few of mathematical ideas using appropriate terminology, diagrams and symbols<br>Demonstrates basic knowledge of the appropriate mathematical techniques to solve problems<br>Provides basic explanations of mathematical relationships using reasoning |
| | **Technology** | Lists areas of investigation.<br>Briefly discribes criteria to evaluate success, most of which is appropriate.<br>Some evidence of the application of action and/or timeplan<br>Provides some evidence of idea generation<br>Evaluates and/or applies limited research and/or experimentation and/or design testing and demonstrates limited application of conclusions.<br>Demonstrates a limited range of communication and presentation techniques.<br>Applies basic practical skills.<br>Describes, with little justification, the success of aspects of the project along the way. |

| Grade | Area | Criteria |
|---|---|---|
| E | **Science** | Demonstrates limited knowledge of the scientific principles underlying motion and energy transfer.<br>Clearly identifies some components of the scientific method. Shows limited analysis of data from experiments.<br>Shows limited justification of decisions |
| | **Mathematics** | Demonstrates limited knowledge of the mathematical principals underlying ratios and rates, time calculations angle relationships and data<br>With guidance identifies, communicates and connects a few of mathematical ideas using appropriate terminology, diagrams and symbols<br>Demonstrates limited knowledge of the appropriate mathematical techniques to solve problems and recognises<br>Provides limited explanations of mathematical relationships using reasoning |
| | **Technology** | Names of an area of investigation.<br>List criteria, some of which may be innapropriate to evaluate success.<br>Action and time planning not evident.<br>Provides limited idea generation.<br>Minimal evidence of appropriate research and/or experimentation and/or design solution testing.<br>Demonstrates minimal application of conclusions<br>Demonstrates minimal communication and presentation techniqes.<br>Applies minimal practical skill.<br>Describes, without justification, the success of an aspect of the project<br>Does not clearly relate the project to the criteria for success. |