Sample assessment task	
Year level	9
Learning area	Technologies
Subject	Design and Technologies: Engineering principles and systems
Title of task	Bridge and lifting device
Task details	
Description of task	Students are required to develop a design solution while investigating the characteristics and properties of structures, combined with force, motion and energy to create engineered solutions. Students design and construct a motor driven lifting device, using equipment and materials available in a studio or workshop.
Type of assessment	Formative or summative
Purpose of assessment	To assess students' knowledge and understanding of the topics of motion, force and energy, and characteristics of materials through research, experimentation and presentation of test results and reports. To assess students' understanding of the design process and technology process in developing a design solution.
Assessment strategy	Students complete the development of the stages of design folio and production model and to observe students in a safe and sensible work practice at all times.
Evidence to be collected	For each student, collect the following: • Task booklet • Electronic and hard copy photograph of finished product.
Suggested time	Approximately 10 hours
Content description	
Content from the Western Australian Curriculum	***Knowledge and understanding*** **Technologies and society** Social, ethical and sustainability considerations that impact on designed solutions Development of products, services and environments, with consideration of economic, environmental and social sustainability **Engineering principles and systems** The characteristics and properties of materials, combined with force, motion and energy, to create solutions ***Processes and production skills*** **Investigating and defining** Identify and define the needs of a stakeholder, to create a brief, for a solution Investigate a selection of components/resources to develop solution ideas, identifying and considering constraints **Designing** Apply design thinking, creativity and enterprise skills Design solutions assessing alternative designs against given criteria, using appropriate technical terms and technology **Producing and implementing** Select, and safely implement and test appropriate technologies and processes, to make solutions **Evaluating** Evaluate design processes and solutions against student-developed criteria

	Collaborating and managing Work independently, and collaboratively to manage projects, using digital technology and an iterative and collaborative approach. Considers time, cost, risk and safety
Task preparation	
Prior learning	Students will have an understanding of the design process, a knowledge of motion, force and energy, ICT skills and fundamental hand and tool skills for production of structures and mechanisms.
Assessment differentiation	Teachers should differentiate their teaching and assessment to meet the specific learning needs of their students, based on their level of readiness to learn and their need to be challenged. Where appropriate, teachers may either scaffold or extend the scope of the assessment tasks.
Assessment task	
Assessment conditions	Individually complete worksheets and a design folio and the construction of the product and evaluation sheet
Resources	• Design task template for folio • Relevant theory and skill demonstrations • Selection of available materials, components, tools and equipment

Instructions for teacher

Knowledge and understanding

1. Introduce students to the characteristics and properties of materials, force, motion and energy, and combinations of these to create solutions
   - introduce bridge building and rigid structures
   - force, motion and energy in bridge structures.

2. Supervise the students' investigation of given websites to find correct responses to the different bridge designs.

3. Instruct students about the fundamental facts in bridge designs and lifting devices, and take notes on:
   - units of measurement
   - compression and tension
   - mechanical advantage and velocity ratio
   - safe working loads (S.W.L.).

This knowledge will be applied to designing and producing an electronic device in the later part of the task.

Part one – Bridge building and testing

1. Students may be paired up or work in groups of three.

2. Start students with a design folio template, and discuss writing a design brief from the following information.

   Design and make a frame (bridge)

   Capable of supporting a MOTORISED LIFTING DEVICE to lift a minimum 2.5 kilograms (kgs) weighted load.
   The structure may be tested to a Safe Working Load of 5kg.
   The bridge model design should:
   - be stable and rigid
   - capable of withstanding a load of 2.5kgs without bending or collapsing, and have a SWL of 5kg
   - designed and built using the minimum amount of materials.

   Requirements and Restrictions
   Materials
   - the Lego dacta technic building materials or similar, a length of string (approximately 500mm), weights for testing (multiples of 100g)
   - two tables or benches will be set about 200mm apart to make the area for the lifting device to operate.

3. Students' sketch concepts
   - Discuss and determine an appropriate concept
   - Annotate a final designed bridge model concept

4. Students then build the bridge model.

5. Students then test the bridge model, using a sling and adding weights up to or beyond 2.5kg:
   - photograph the finished weighted bridge project
   - comment on structure and any deformation.

6. Evaluation: students write a reflection about how the bridge supported the load. Comment on rigidity and the material's ability to withstand the forces applied to the structure. Discuss its success as well as the areas that could be improved or changed.

Part two – Mechanical lifting device and testing

1. Students may continue to work in pairs or groups.
2. Students continue to include notes and drawings into their design folio.

   Design and make a motorised lifting device to lift a minimum 2.5 kilograms (kg) weighted load. A Safe Working Load would be more like 5kg.

   Your device should:
   - be supported on the bridge model
   - rotate at a moderate speed
   - capable of lifting at least 2.5kg without bending or collapsing the structure, or damaging the motor.

   Requirements and Restrictions
   Materials
   - the Lego dacta technic building materials or similar, a length of string (approximately 500mm), weights for testing (multiples of 100 grams)
   - two tables or benches will be set about 200mm apart to make the area for the lifting device to operate
   - your device will need to lift a 2.5kg weight, a vertical distance of 250mm
3. Teach and discuss:
   - gears, shafts and axles, and motor power source
   - gear ratios, compound gearing and mechanical advantage (MA).
4. Students sketch concepts of gear combinations:
   - annotate gear combination concepts
   - discuss and determine the best appropriate concept.
5. Students then build the gear combination:
   - attaching motor drive (input) and lifting string and hook (output)
   - test the unload gear combination, both wind up and unwind.
6. Students then test the lifting device, using a weighted load of 2.5kg:
   - photograph the weighted lifting device on the bridge
   - take notes on the gear mechanism, structure and any deformation.
7. Photograph your finished project.
8. Evaluation: Write a 50 word reflection about how you think your device worked out. Focus on the finished, working product. Explain how it works, and discuss its success as well as the areas that could be improved or changed.

This is a group task and the following must be submitted for assessment with the completed project.

From each student in the group, individual folio notes should be presented for assessment, showing:
- concept sketches/final designs
- manufacture of frame plan and mechanism
- mathematical support for the design and testing of structure
- evaluation of lifting performance.

From the group, a presentation of the completed working project is required.

Task booklet – Part A

Name: _____ Group: _____

Structural and mechanical design problem

"Bridge design over the ages has evolved largely due to the needs of people and the development of new materials and building techniques.
Beam bridges, arch bridges, cantilever bridges and suspension bridges are the four common bridge categories, although combinations of these types of bridge styles can be designed.
Essentially, bridges need to be strong enough to support their own weight and support a load moving from one end to the other."

[Information from: Design Technology Department. (n.d.). *Bridges—Design technology*. Retrieved September, 2014, from www.design-technology.org/bridges.htm]

Research bridges and you will see varieties of styles and different types of traffic.

Click on the web site below to access information on bridges.
http://www.design-technology.org/bridges.htm.

"A mechanism is a device that helps people to carry out tasks more easily." (Slynko, B. 1991)

Common characteristics of mechanisms:

- require an input of effort or energy
- movement or motion occurs
- production of an output
- a task becomes easier.

Simple mechanisms can be coupled together to make complex machines.

Task Management

Prepare a design folio. Start with writing a design brief from the following information.

Design and make a frame (bridge) capable of supporting a MOTORISED LIFTING DEVICE to lift a minimum 2.5 kilograms (kg) weighted load. A safe working load would be more like 5kg.

Your model should:

- be stable
- rotate at a moderate speed
- be capable of lifting at least 2.5kg without bending or collapsing the structure, or damaging the motor.

Requirements and Restrictions

Materials

- the Lego dacta technic building materials or similar
- a length of string (approximately 500mm)
- weights for testing (multiples of 100 grams)

Two tables or benches must be set about 200mm apart to make the area for the lifting device to operate.

Your device will need to lift a 2.5kg weight, a vertical distance of 250mm.

Photograph your finished project.

Design Brief:
In this section, write down your design statement.

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Procedure:

The frame of the bridge

1. Use your knowledge of structures and forces; construct a frame (bridge) capable of supporting a safe working load (S.W.L.) of 5kg applied across the centre. The frame must span an opening of 200mm, between two benches.
2. Use the "A" frame and truss frame strategies and limit the number of pieces to less than 50.
3. Draw a 2D sketch showing beams, bracing members and trusses.
4. Write a statement to support the design:
   - explain the expected compression and tension in the structure, when loaded in the centre with 2.5kg
5. Build the structure.
6. Test the structural strength of the frame by applying force to the central point of the frame. This should be done incrementally with suitable graduated weights, or a spring balance, up to, and then past 2.5kg.
7. Record your observations of the bridge structure when under a 2.5kg load.

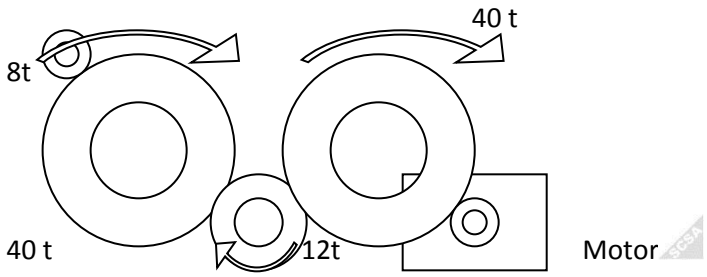
On this page, sketch your ideas before you begin to build the model.

Measure and mark out a 200mm line. Draw your bridge structure, using an appropriate scale.

The lifting mechanism

1. Using information about gearing, gear ratios and combinations, design a geared mechanism to lift the weight.
2. Use simple circles and annotation to explain the drive train and gearing.
3. Draw a pictorial sketch of the complete mechanism. Show the number of teeth for each gear, and the rotation of the gear.

   For example:



   - If the motor rotates at 4000 rpm, calculate the final drive output rpm.

     4000 rpm X ratio of composite gears = final rpm

4. Calculate the RPM of each gear, and the output of the final driven shaft or gear:
   - provide a mathematical answer to support the design.
5. Build the mechanism, ensuring that;
   - gears mesh correctly
   - motor is unpowered during construction
   - string is secured to final drive, and can hang freely below the mechanism
   - mechanism is secure in the bridge frame
6. Attach a battery pack or other power source, with a simple control switch fitted between power supply and the motor.

On this page, sketch your ideas before you begin to build the gearing.

Include motor (4000 rpm), gearing (teeth of each gear and rotation), and then a final output.

Testing the lifting device

1. Test the unloaded running of the mechanism, to check gearing and drive, and the winding of the string.
2. With the lifting mechanism fitted to the frame, the frame is then located in a central position, spanning an opening of 200mm, between two benches.
3. The string should be hanging centrally below the lifting device, and attached by hook or tie to the first of the weights.
4. Power on and test the lifting ability of the device.
5. Increase weight to 2.5kg.
6. Power on and test the lifting ability of the device to lift the 2.5kg a vertical distance of 250mm.
7. Perform three test lifts, and record each performance time in a table, than calculate the average over the three times.
    - Make adjustments, if needed, but record any changes to the lifting device, before re-testing.

Test run	Time to lift 2.5kg a vertical distance of 250mm (seconds)
1	
2	
3	
Average of three runs	

Task booklet – Part B evaluation

Name: _____ Group: _____

Write a reflection about how you think your device worked out. Focus on the finished, working product. Explain how it works, and discuss its success as well as the areas that could be improved or changed.

Refer to the Design Brief and write statements on the performance of your lifting device. Focus on what you have achieved by referring to the questions below:

Was it stable?

Did the structure bend or collapse?

Did your design incorporate an 'A' frame structure?

Did your solution use a limited number of components?

Did it rotate at a moderate speed?

Was it capable of lifting 2.5kg?

How long did it take to lift the weight 250mm?

Do you consider the gear ratios to have the best mechanical advantage?

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Include photo of your completed product from Part A here

Include photo of your completed product from Part B here

Sample marking key

Description	Marks
Technologies and Society	
Demonstrates an extensive understanding of the competing factors and different devices in engineering technologies (e.g. the variety of notes and images)	5
Demonstrates a high level of understanding of the competing factors and different devices in engineering technologies (e.g. the variety of images)	4
Demonstrates a satisfactory level of understanding of the factors and different devices in engineering technologies (e.g. the variety of images)	3
Has limited understanding of the different devices, and requires guidance to arrange and present them ideas and concepts.	2
Has difficulty selecting different devices, and requires assistance to select images to confirm understanding.	1
Subtotal	**5**
Description	**Marks**
Engineering principles and specialisations	
Expresses clear understanding of the characteristics and properties of materials, combined with force, motion and energy to develop a working mechanism. Comprehensively acknowledges the principles behind the operations of a range of mechanical devices and how they function	5
Explains some combinations of the properties of materials, combined with force, motion and energy to develop a working mechanism.	4
Appropriately explains the use of materials with force, motion and energy to develop a working mechanism.	3
Demonstrates limited understanding of the operation and function of a working mechanism.	2
Requires assistance to understand how a mechanical device works.	1
Subtotal	**5**
Description	**Marks**
Investigating and defining	
Clearly identifies and defines the needs of a stakeholder, to create a brief, for a solution. Considers a wide range of components/resources to develop solutions, describing likely constraints.	5
Identifies the needs required to create a brief for a solution. Considers available components/resources to develop solutions, identifying constraints.	4
Creates a suitable brief for a solution. Presents relevant information on a suitable range of components/resources to develop solutions.	3
Provides a brief for a solution. Demonstrates developing research skills. Presents limited information on common components/resources, may not be relevant in developing solutions.	2
Presents incomplete information on a limited range of component/resources/devices.	1
Subtotal	**5**
Description	**Marks**

Designing	
Demonstrates a well-developed understanding of design process, using a range of appropriate technical terms to explain their plans, selection of materials, drawings and design choices. Provides accurately drawn and labelled design for a device. Provides appropriate and correct calculations to confirm the device would function correctly.	5
Applies understanding of the design process and demonstrates a high level of competence when choosing components and materials, which is reflected in the drawing of the device, while using suitable technical terms to explain choices. Provides calculations to support the working device. Drawings reflect accurate detail for the proposed design.	4
Demonstrates a developing understanding of the design process, through labelled, satisfactory drawings of intended device. Attempted calculations to support the working device. Uses some technical terms to explain choices	3
Demonstrates a limited level of understanding of the design process, with limited notes and few steps in the design process completed. Requires assistance to correct inaccuracies in the drawn design.	2
Shows little accuracy in the steps of the design process. Notes are incomplete and lack any detail. Demonstrates limited skills in drawing and does not communicate ideas clearly.	1
Subtotal	**5**
Description	**Marks**
Producing and implementing	
Selects materials appropriate to the construction of the device and accurately plans and follows the procedure. Confidently and safely uses a range of components, equipment and techniques to complete a product, explaining any alterations made.	5
Selects construction materials and tools for making the device and follows a planned procedure. Safely uses a range of components, equipment and techniques to complete a product, explaining any alterations made	4
Demonstrates safe processes using a range of components, equipment and techniques to complete a product, explaining the processes. Identifies changes made.	3
Requires assistance to produce an end product that may not match the design. Attempts to give basic reasons for changes.	2
Finishes with an end product that does not match the design and provides no relevant explanation as to why.	1
Subtotal	**5**
Description	**Marks**
Collaborating and managing	
Demonstrates consistent management skills and processes, managing time, risk and safety appropriately. Works independently and co-operatively to develop ideas and plan production. Works collaboratively when required to assist others to produce designed devices.	5
Demonstrates developing management skills. Works co-operatively to develop ideas and plan production. Works collaboratively when required to produce designed device.	4
Works co-operatively to develop ideas and plan production. Works collaboratively when required to produce designed device.	3

Works co-operatively to produce designed device.	2
Demonstrates little collaboration, and requires assistance to work towards an end product.	1
Subtotal	**5**
Description	**Marks**
Evaluating	
Comprehensively tests and records the end outcomes, and accurately explains performance, and/or any alterations made, justifying why they were made.	5
Provides accurate test results and can explain the performance, and give reasons for any changes made.	4
Records the test results accurately and understands the end result. Lists changes made.	3
Records results of tests attempted. Comments on the performance and changes.	2
End product does not match the design and no explanation is given for why, or the explanation is not relevant to the task's performance.	1
Subtotal	**5**
Total	**35**