YORK/SENECA INSTITUTE FOR SCIENCE, TECHNOLOGY AND EDUCATION

YSISTE

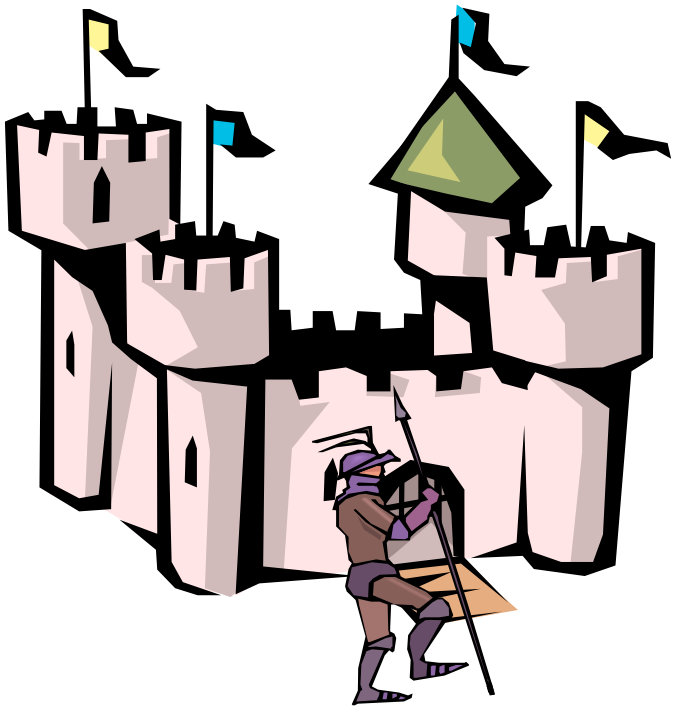
ASSESSMENT OF SCIENCE AND TECHNOLOGY ACHIEVEMENT PROJECT (ASAP)

Science and Technology Exemplars

Grade 4: Structures and Mechanisms – Pulleys and Gears

Exemplar Task (4SMPT01/Mar 26, 2001)

Defending the Castle



Preface

This task is one of a series developed by the Assessment of Science and Technology Achievement Project (ASAP) which is being used for the ASAP Science and Technology Exemplars Project.

This task is organised in three parts:

A. Task Overview
B. Student task sheet – designed to be photocopied for the students
C. Teacher Information – providing essential information relating specifically to this task

For further information, contact the ASAP office at 416-736-5269 or email: asap@edu.yorku.ca

Task Overview

Description of the Task:

This is a culminating activity designed to assess a cluster of expectations for this grade and strand. Students should have been taught the concepts and skills required to perform this task prior to attempting it.

Students are asked to design, build and explain systems that would supply a castle with water and defend it with a catapult and a drawbridge. They are asked to use pulleys and gears in their systems.

Materials and Equipment Required:

pieces of wood, string, glue, glue guns, gloves, saws, rulers, scissors, pulley wheel gears, elastics, screws, nails, screwdrivers, hammers, cardboard, safety glasses, small yoghurt containers, popsicle sticks, egg cartons, tape, or found materials

Suggested Timeline:

Series of 3-5 on task sessions each of 45 minutes in duration

Suggested Grouping:

- task activities to be completed in cooperative groups of 4
- written report to be completed individually

SAFETY ASPECTS IN THE DESIGN PROCESS

It is important that all students follow established safety practices when designing, constructing, and experimenting with structures and mechanisms. These practices include:

- Using tools safely to cut, join, and shape objects
- Handling molding clay correctly, and washing one's hands after using it
- Following proper procedures when comparing mechanical systems and their operation
- Using care when observing and working with objects in motion (e.g., objects that are spinning, swinging, bouncing, vibrating)
- Using care with gears and pulleys and with elevated objects

The following are minimum safety standards, that all students should know:

- Use all tools **below waist** level. (Ideally, tools should be used while standing instead of sitting)
- Ensure your tools are in **good repair** before you begin. Broken tools must be fixed or discarded

- Store tools in a **safe place**
- Always **walk** when carrying tools
- Wear **safety goggles** for protection
- Ensure **workspaces** are set up in low-traffic areas
- Use the **appropriate tool** for the task
- When **exploring materials**, ensure that students are not exposed to hot, sharp, or easily breakable tools or objects
- Special care should be taken when using materials made of **plastic** (e.g., cellophane bags that could obstruct breathing)

Pulleys and Gears

- Use caution when lifting **heavy objects**
- Be careful not to get **fingers, clothes, and hair** caught when using any mechanical device, such as pulleys or gears
- Make sure that pulley systems are securely attached to a **firm structure** and are tested to be secure before using
- Use materials only for their **intended purpose** (e.g., spring scales are only to be used to measure force)
- Be careful not to get **fingers, clothes, and hair** caught when using any mechanical device or system
- Exercise extreme caution when using the test bicycle – turn the pedal slowly, and be careful not to get anything caught in the spokes, gears, or chain. Use only pedal to spin the wheel; do no use hands or feet.

ASSESSMENT OF SCIENCE AND TECHNOLOGY ACHIEVEMENT PROJECT (ASAP)

Science and Technology Exemplars Project

Grade 4: Structures and Mechanisms – Pulleys and Gears

Exemplar Task (4SMPT01/Mar 26, 2001)

Defending the Castle

Student Task Sheets

Defending the Castle

You are a team of castle engineers building devices to protect your castle. Each member of your team will use pulley and/or gears to design and construct one of the following:

- a device to get water from the river which fills the moat around the castle
- a catapult to protect themselves from their enemies
- a drawbridge that opens and closes

In your collection of devices you must use at least one pulley system and one gear system.

In case of death all team members must know how to operate each device. You will be required to describe the construction and operation of your device.

Design and build:

1. A device to get water from the river

Draw your device. Explain how the pulleys and gears help your device to work in the space provided below.

2. A catapult:

Draw your device. Explain how the pulleys and gears help you device to work.

3. A drawbridge that can open and close.

Draw your device. Explain how the pulleys and gears help your device to work.

4. How would your device (drawbridge, catapult or water device) be different if you were given only paper and string to build it?

5. How do pulleys and gears make the raising and lowering of your device easier than doing it by hand?

6. Explain why the pulleys and gears that move your device would have to be fixed to the wall of the castle.

7. How could you change the pulleys and gears of the device to improve it?

8. What material would you use to build a real catapult or drawbridge?

9. Why would you use those materials?

ASSESSMENT OF SCIENCE AND TECHNOLOGY ACHIEVEMENT PROJECT (ASAP)

Science and Technology Exemplars Project

Grade 4: Structures and Mechanisms – Pulleys and Gears

Exemplar Task (4SMPT01/Mar 26, 2001)

Defending the Castle

Teacher Information Sheets

SPICE Model

The second goal of Science and Technology Education encourages students to develop the skills, strategies, and habits of mind for scientific inquiry and technological design. As students' design, construct and test devices to solve problems through the technological design approach, it is important that they accommodate the attributes of the design process similar to the SPICE Model as follows:

S – Situation –	The situation or context provides an opportunity for something to be designed. It is the setting of the problem. Observe the scene and question.
P – Problem –	The problem defines what is going to be solved using the phrase "Design and Make a …" This statement tells us clearly what is going to be built
I – Investigation –	This step requires the problem to be brainstormed. Several different ideas should be explored. Identify the requirements, the available resources and the restrictions. Sketches are an effective way of brainstorming.
C - Construction –	The construction step requires the problem's solution in the form of a model to be built from real materials. List of materials can be generated and procedures established. Plan adequately and make the model safely
E – Evaluation –	The evaluation is the testing and inspection of the model to see if it works to solve the problem. Look back at the problem and reflect on the achievements. Consider any improvement

By permission of Geoff Day

This task addresses the following cluster of expectations. Expectations assessed by the rubric are highlighted in bold.

Understanding Basic Concepts

- **describe, using their observations, the functions of pulley systems and gear systems (e.g., they make changes in direction, speed, and force possible)**

Developing Skills of Inquiry, Design and Communication

- formulate questions about and identify needs and problems related to structures and mechanism in their environment, and explore possible answers and solutions (e.g., test the effort required by different gear systems to lift the same load
- use appropriate vocabulary, including correct science and technology terminology, to describe their investigations (e.g., use terms such as *block and tackle* in describing pulley systems and *gear train* in describing gear systems)
- **communicate the procedures and results of investigation for specific purposes and to specific audiences, using media works, written notes descriptions, drawings, charts, and oral presentations (e.g., draw a diagram of a proposed object and a diagram of the finished product)**
- **design, make, and use pulley system that performs a specific task (e.g., a pulley system that closes a door or carries an object from one place to another)**
- **design and make a system of pulleys and /or gears for a structure (e.g., a potter's wheel) that moves in a prescribed and controlled way (e.g., fast, straight) and performs a specific function**
- **manipulate pliable and rigid materials (e.g., modeling clay, wood) as required by a specific design task**

Relating Science and Technology to the World Outside the School

- demonstrate awareness that most mechanical systems are fixed and dependent on structures (e.g., elevators)
- **identify and make modifications to their own pulley and gear systems to improve the way they move a load (e.g., change the size of pulleys or gears used; use gears that change direction through a right angle)**

Prior Knowledge Required:
Before attempting this task students should have been taught the following:

- describe, using their observations, the function of pulley systems and gear systems (e.g., they make changes in direction, speed, and force possible)
- describe, using their observations, how rotary motion in one system (e.g., a system of pulleys of different sizes) is transferred to rotary motion in another (e.g., a system of various gears) in the same structure
- describe, using their observations, how gears operate in one plane (e.g., crown, bevel, or worm gears)
- demonstrate an awareness of the concept of mechanical advantage by using a variety of pulleys and gears

Students should be familiar with the following science and technology terminology:

- pulley, gear, pulley system, gear system, gear train, mechanical advantage

Prior Skills Required:
Before attempting this task students should have experience of the following:

- test the effort required by different gear systems to lift the same load

Suggested Introductory Activities:
The following activities are suggested to introduce this task to the students:

- demonstrate an understanding of the characteristics of pulleys and gears;
- design and make pulley systems and gear systems, and investigate how motion is transferred from one system to another;
- identify ways in which different systems function, and identify appropriate criteria to be considered when designing and making such systems

Cross-strand Links:

Every strand in the Science and Technology document has common set of expectations clustered under the title ***Developing Skills of Inquiry, Design and Communication.*** This task is therefore appropriate to assess and evaluate these skills for every Grade 4 strand

Cross-curricular Links:

This task provides a cross-curricular link with t*he Ontario Curriculum, Social Studies, Grades 1-6:* (Heritage and Citizenship: Grade 4 – Medieval) on their ability to work cooperatively as part of a group. Students should be made aware that this will be an integral part of the evaluation and they should have prior experience of working with a group before being assessed. This provides a cross-curricular link with *The Ontario Curriculum Grades 1-8 Language,* Grade 4: Oral and Visual Communication

Reading and Writing Skills:

This task has been constructed to take into account the possible limited reading and writing skills of some students at this grade level. At the end of Grade 4 students are expected to be able to write a sentence (See MET Writing Exemplars 1999). Depending on the achievement level of the children in the class and the time in the school year that this task is administered, teachers will need to take into account the diverse abilities in their classes. The task could be presented orally and evaluated through teacher/student conferences. Teachers could use the questions on the student task sheet to guide their conferences. Students could make oral presentations about their investigation to the class. Their presentation could be based on the questions outlined in the student task sheet. Grade 5/6 students could act as reading/writing buddies to read out questions. A peer buddy system could be introduced

Considerations for Combined Grade Classes:

Appropriate strategies are as follows:

- Teach one grade while the other completes the task which does not require active teacher guidance
- Create separate learning centers for student investigation specific to each grade topic and strand. The methods of science and technology (inquiry and communication) would provide the whole class focus
- Introduce self-directed student activities connected to specific expectations
- Reorganize students into grade groupings for the purposes of teaching a given topic
- Teach specific grade expectations when part of the class in working with another teacher

- Teach the common topics in a strand between the combined grades (e.g., Structures and Mechanisms in Grades 4-5: Pulleys and Gears in Grade 4 and Forces Acting on Structures and Mechanisms in Grade 5)
- Make thematic connections by clustering the overall expectations around a unifying organizer such as “Form and Function”.
- Invite students from other classes (or schools) to present connection work from their own program to a class (or part of a class) studying a similar topic (e.g., Grade 5, Forces present to Grade 4, Pulleys and Gears)

RUBRIC FOR GRADE 4: DEFENDING THE CASTLE

Category/Criteria	Level 1	Level 2	Level 3	Level 4
Understanding of Basic Concepts • describes functions of pulley and gear systems	**The Student:** • shows limited understanding of the basic concepts of pulley and gear systems, gear trains, and/or mechanical advantage	**The Student:** • shows understanding of some of the basic concepts of pulley and gear systems, gear trains, and/or mechanical advantage	**The Student:** • shows understanding of most of the basic concepts of pulley and gear systems, gear trains, and/or mechanical advantage	**The Student:** • shows understanding of all of the basic concepts of pulley and gear systems, gear trains, and/or mechanical advantage
Design skills • designs, constructs and tests pulley and gear systems • manipulates materials to perform a task	**The Student:** • applies few of the required skills and strategies related to the use of pulleys and/or gears and appropriate tools • shows little awareness of the safety procedures related to the use of pulleys and gears and appropriate tools • uses tools, equipment, and materials correctly only with assistance	**The Student:** • applies some of the required skills and strategies related to the use of pulleys and/or gears and appropriate tools • shows some awareness of safety procedures related to the use of pulleys and gears and appropriate tools • uses tools, equipment, and materials correctly with some assistance	**The Student:** • applies most of the required skills and strategies related to the use of pulleys and/or gears and appropriate tools • usually shows awareness of safety procedures related to the use of pulleys and gears and appropriate tools • uses tools, equipment, and materials correctly with only occasional assistance	**The Student:** • applies all skills related to the use of pulleys and/or gears and appropriate tools • consistently shows awareness of safety procedures related to the use of pulleys and gears and appropriate tools • uses tools, equipment, and materials correctly with little or no assistance
Communication of required knowledge • communicates results and procedures	**The Student:** • communicates understanding of concepts with little clarity and precision • rarely uses science & technology terminology correctly	**The Student:** • communicates with some clarity and precision • sometimes uses science & technology terminology correctly	**The Student:** • generally communicates with clarity and precision • usually uses science & technology terminology correctly	**The Student:** • consistently communicates with clarity and precision • consistently uses science & technology terminology correctly
Relating Science and Technology • makes modifications to improve function	**The Student:** • suggests in a very limited way, any modification for their device to improve its function	**The student:** • suggests only superficial modifications which do not improve the function of the device	**The Student:** • suggests modifications which improve the function of their device	**The Student:** • suggests modifications which improve the function of their device, and clearly explains the improvement

*Written using the **Ontario Curriculum Unit Planner** (March 2001)*