# Teacher Package

## Science and Technology Exemplar Task
## Grade 8

## Teacher Package

**Title:** Rescuing Whales

**Time Requirements:** 245 minutes (over several class periods)

*Introductory activities*
- Pre-task 1: 40 minutes
- Pre-task 2: 45 minutes
- Pre-task 3: 40 minutes

*Exemplar task:* 120 minutes (the amount of time needed for each of the five parts to be determined by the individual teacher, depending on the particular needs of each class)

### Description of the Task

Students will use their knowledge and understanding of simple machines and mechanical advantage (MA) to design and construct a lifting mechanism that will achieve a mechanical advantage of at least 4 to facilitate the rescue and release of stranded whales.

Students will complete the worksheets provided in this package and submit selected worksheets for assessment. Each student will also make a four-minute oral presentation describing and demonstrating how his/her model works, and these presentations will be videotaped. The videotapes will also be used for assessment purposes.

### Scenario and Instructions for Students

For the scenario and instructions that should be presented to students, see Appendix 5: "Scenario: 'Whales Forever' Design Competition".



## Curriculum Expectations Addressed in the Task

Note that the codes that follow the expectations relate to the Ministry of Education's *Curriculum Unit Planner* (CD-ROM).

*Students will:*

1. demonstrate an understanding of the factors that contribute to the efficient operation of mechanisms and systems (8s87);
2. design and make systems of structures and mechanisms, and investigate the efficiency of the mechanical devices within them (8s88);
3. determine the velocity ratio of devices with pulleys and gears (i.e., divide the distance that a load moves by the distance covered by the force [effort] required to move it) (8s97);
4. formulate questions about and identify needs and problems related to the efficient operation of mechanical systems, and explore possible answers and solutions (e.g., test a device at each stage of its development and evaluate its performance in relation to specific criteria) (8s99);
5. produce technical drawings and layout diagrams of a structure or a mechanical system that they are designing, using a variety of resources (8s106);
6. describe how the components and subsystems of a product used by humans enable the product to function (8s109);
7. evaluate their own designs against the original need, and propose modifications to improve the quality of the products (8s118).

### "Big Ideas"

Based on the expectations being assessed, the following "big ideas" have been identified for this task:
- Machines are a way to transfer energy.
- Design influences the efficiency of machines.
- Designs for machines arise from a need to solve problems.

## Teacher Instructions

### Prior Knowledge and Skills Required

Before attempting the task, students should have had experience related to the following:
- the design process (see Appendix 4): identifying the problem/need, making the plan, executing and evaluating the plan, and communicating the solution
- the functions of simple machines (e.g., levers, pulleys, gears)
- calculations involving mechanical advantage
- ways of combining various structural components to create structures and mechanisms
- the safe and appropriate use of tools

**The Rubric**

The rubric* provided with this exemplar task is to be used to assess students' work. The rubric is based on the achievement levels outlined on page 13 of *The Ontario Curriculum, Grades 1-8: Science and Technology, 1998.*

Introduce the task-specific rubric to students at least one day before administering the task. Copy the rubric for students or create a transparency to use with the class. You may find it useful to rephrase the rubric for students to help them in their work.

Review the elements of the rubric with students to ensure that they understand the criteria and the descriptions for achievement at each level. Allow ample class time for a thorough reading and discussion of the assessment criteria outlined in the rubric.

**Accommodations**

Accommodations that are normally provided in the regular classroom for students with special needs should be provided in the administration of the exemplar task.

**Classroom Set-up**

- Ensure that students have a suitable work space for their design processes.
- Review the safe use of tools with all students.
- Keep low-temperature glue guns away from the regular flow of student traffic.
- Allow students easy access to materials (although you should emphasize the economical use of the materials) and tools (with safe storage provided).
- Provide students with a generic support device for their mechanisms, such as a retort stand and ring, a metre stick placed across an open space between chairs or tables, or some other method of supporting their lifting device.
- Consider providing a suitable location for the lift test (one for the class).

**Materials Needed**

- pulleys (hooked on both ends): a single axle/single wheel; double axle/double wheel
- 4 mm (1/8 in.) dowels (to be used for axles and levers)
- gears (assorted sizes: 50, 40, 30, 20, and 10), all bevel-toothed
- cranks (to fit on gears)
- 1 cm x 1 cm x 60 cm wood (to be used for levers or gear-and-pulley frames)
- low-temperature glue guns (10 W)
- low-temperature glue sticks
- paper gussets (for reinforcing corners of structures; these could be cut from file folders)
- 4 mm (1/8 in.) drill bits (to create snug axle holes)
- 5 mm (9/64 in.) drill bits (to create loose axle holes)
- Newton meter spring scales (0 – 10 N)
- sandpaper
- miter box
- clamps (to hold material to be drilled or glued)



- carpenter's glue
- miscellaneous wood scraps (to be used for levers and other components)
- 300 m of string, fishing line, or thread appropriate to students' mechanisms
- resealable plastic bag (to be used for the skin of the "whale")
- sand to represent at least 500 g of whale mass (only one "whale" is required per class)
- handsaw
- hand drill or an electric drill (See the safety considerations that follow.)
- selection of hooked masses (1 kg, 500 g)
- other found materials (e.g., cardboard, empty spools, small pieces of cloth)

*Note:* Many of these materials (e.g., pulleys, gears) can be reused after the presentations have been shared and assessed.

**Safety Considerations**

Before attempting this task, it is important for both you and your students to be familiar with the following safety considerations:

- Students should use only those tools for which they have been given instructions for safe use.
- The work area should be kept neat and well organized.
- The floor and walkways should be kept clear of debris.
- Students should use only mini- or low-temperature glue guns to reduce the risk of burns.
- Students should be aware that most burns result not from the glue guns themselves but from contact with melted glue. If hot glue comes in contact with skin, it should be removed as quickly as possible by immersing the affected area in cold water. A bucket of water should be available for this purpose.
- Students must wear closed-toe shoes to reduce the possibility of injury from dropped materials.
- Students should wear protective aprons to protect synthetic clothing from heat, as this type of material will melt when subjected to intense heat such as that generated by glue guns.
- Extension cords and power-tool cords must be situated in such a way that they do not pose a tripping hazard.
- When students use power tools such as drills, they must clamp their work securely in place.
- When working with hand tools, power tools, and glue guns, students must use CSA-approved eye protection.
- When using power tools, students must tie back any long hair that could be caught or tangled in a machine and should remove jewellery and long scarves and roll up their sleeves to avoid the risk of entanglement.

*Note:* Check your board regulations regarding the need for any additional qualifications when using power tools with students.



**The rubric is reproduced on pages 52–53 of this document.*

## Task Instructions

**Introductory Activities**

The pre-tasks are designed to ensure that students have the prior knowledge and skills required to complete the exemplar task. These activities review and reinforce the skills and concepts that students will be using in the exemplar task, but are not assessed on the rubric.

***Pre-task 1: Setting the Scene***

1. Introduce and discuss the student scenario with the class. Discuss and clarify the task-specific assessment rubric, perhaps displaying it on an overhead as you discuss it. (This will take about 15 minutes.)
2. Review with students the types of simple machines (e.g., levers, gears, pulleys) through discussions or using a video such as *Eureka* (TVO, No. 60164). (This will take about 25 minutes.)

***Pre-task 2: Calculating Mechanical Advantage***

1. Have students work at centres (with partners or in groups) using gears, pulleys, and levers to experience and review how to calculate the mechanical advantage of various systems in more than one way. Set up the centres as follows:
   - *Gear centre.* Set up the three gear combinations shown in Appendix 1 on Styrofoam, cardboard, or wooden bases. See also “Set-up for Gear Centre” in Appendix 9.
   - *Pulley centre.* Set up the pulley combinations shown in Appendix 2 by suspending them on string from the ceiling or from a pre-made support. See also “Set-up for Pulley Centre” in Appendix 9.
   - *Lever centre.* Set up levers as outlined in “Set-up for Lever Centre” at the end of Appendix 9.
2. Distribute the student worksheets “Gears”, “Pulleys”, and “Levers” (see Appendices 1-3) and have students move through each of the three centres. Ask them to spend fifteen minutes at each centre measuring and recording the effort and load forces for three different circumstances. The forces measured will be used to calculate mechanical advantage. The worksheets also show students how to estimate mechanical advantage in a variety of ways. If time allows, the use of wheels and axles can also be discussed.
3. With the class, consolidate students’ understanding of calculating and estimating mechanical advantage. Clarify any misunderstandings.

***Pre-task 3: Understanding the Design Process***

1. Spend about fifteen minutes reviewing the design process with the class using the student worksheet (see Appendix 4).
2. Challenge students to work through the design process with the following task: Support one science and technology textbook 10 cm above the desk using only two sheets of letter-size paper. With the class, consolidate students’ understanding of the design process as they have applied it to this challenge. Clarify any misunderstandings.



**Exemplar Task**

The completed student worksheets “Making the Plan”, “Executing/Evaluating the Plan”, and “Reflection” (see Appendices 6-8) are to be submitted for marking.

***Part 1: Identifying and Rephrasing Design Needs***

1. Distribute the student scenario (see Appendix 5) to students and review it with the class. Clarify that only the lifting mechanism is to be constructed; classroom materials can be used for a supporting structure. For example, a metre stick between two desks or a retort stand with a clamp can be used to support a lifting device. If their time and skill level permit, students may choose to create an appropriate alternative support structure, but this will add considerably to the time required for the task and is not assessed in the rubric.
2. Give students a chance to discuss possible solutions as a group and to ask questions for clarification.

***Part 2: Making the Plan***

1. Distribute the student worksheet “Making the Plan” (see Appendix 6) to students.
2. Have students individually rephrase the need in part 1 of the worksheet.
3. Ask students individually to record several different ideas as sketches with suggested dimensions in part 2 of the worksheet.
4. Have each student complete part 3 of the worksheet, choosing one of the possible solutions from part 2 of the worksheet and explaining the reasons for his or her choice.
5. Ask students to create a design sketch in part 4 of the worksheet, labelling the dimensions, the materials, the simple machines used, and the location of the load and effort forces.
6. Have students outline the steps necessary to complete their plans in part 5 of the worksheet. These steps should include the construction only of the lifting mechanism, not the supporting structure. If you like, allow students to construct the supporting device, but this is not required or assessed in the rubric.

***Part 3: Executing and Evaluating the Plan***

1. Have students gather the materials they will require to follow their plans.
2. Instruct them to construct their lifting mechanisms safely and within the allotted time.
3. Have students test their solutions and make the necessary revisions to meet the task criteria.
4. Ask students to observe and record data and make the necessary calculations on their worksheets (see Appendix 7) to verify that their mechanisms are able to generate a mechanical advantage of at least 4.

***Part 4: Reflection***

Have students evaluate the strengths and weaknesses of their models and suggest possible improvements using the "Reflection" worksheet (see Appendix 8).

***Part 5: Presentation to the Board of Directors of Whales Forever***

1. Have each student prepare a four-minute oral presentation that communicates a summary of his or her design process and demonstrates clearly how his or her mechanism meets the task criteria. Students can use their completed Appendices 6, 7, and 8 to plan their oral presentations.
2. Ask students to demonstrate the effectiveness of their mechanisms (in lifting the "whale" 10 cm and lowering it 5 cm) to the "board of directors" (portrayed by peers sitting around a board table, other classes, outside experts, or parent volunteers).



## Appendix 1

### Gears


**Steps**

1. Note the names of each gear in the above diagram.
2. Using the gear sample with only two gears, turn the driver and record the direction that the follower turns.
3. Using the gear sample with three gears (as in the above diagram), turn the driver and record the direction that the follower turns.
4. What effect does adding an idler gear have on the direction that the follower turns?
5. When a small driver gear turns a larger follower gear a mechanical advantage is gained. The mechanical advantage can be found by completing the following steps:
   - Find the force required to lift a mass straight up (*load force*), using a Newton spring scale (N).
   - Using something like tape, string, or a dowel, fasten the mass to the outside edge of the follower gear.
   - Now fasten a Newton spring scale to the driver gear and note the force required to move the mass (*effort force*).
   - Calculate the mechanical advantage by using the formula MA = load force ÷ effort force. For example: It requires 20 N to raise a mass unaided (the load force). When the mass is connected to a gear system, the force required to raise it is 5 N (the effort force).

$$MA = \frac{\text{load force}}{\text{effort force}} = \frac{20\text{ N}}{5\text{ N}} = 4$$

   - To estimate the mechanical advantage for gears:

$$MA = \frac{\text{number of teeth on follower}}{\text{number of teeth on driver}}$$

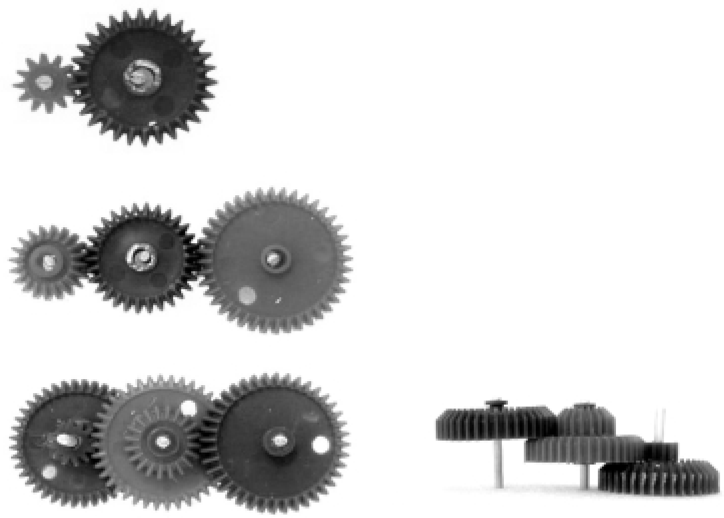
For example, a gear of 10 teeth driving a follower of 30 teeth produces an MA of 3:

$$MA = \frac{30 \text{ teeth}}{10 \text{ teeth}} = 3$$

- Another way of estimating mechanical advantage is by using the radius of the gears:

$$MA = \frac{\text{radius of the follower}}{\text{radius of the driver}}$$

6. Determine the MA for each of the gear systems shown in the photograph below or for gear systems provided by your teacher.



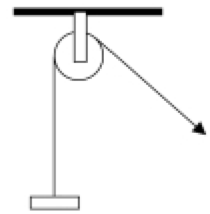


## Appendix 2

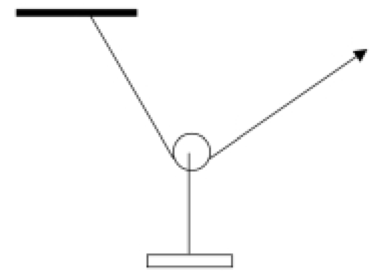
### Pulleys

Using the pulleys set up by your teacher, investigate the changing effort required when the number of pulleys is changed. Use the Newton meter for observation and record the effort required to lift the load. Calculate the mechanical advantage of each pulley system.

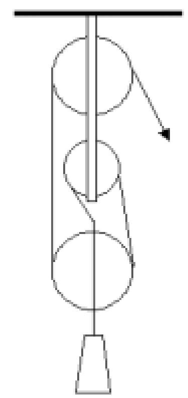
**Single Fixed Pulley – Set-up 1**



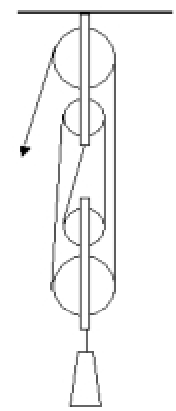
**Single Movable Pulley – Set-up 2**



**Single Fixed Double Movable Pulley – Set-up 3**

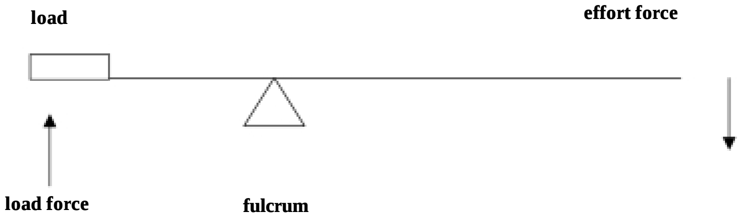


**Four-Pulley System – Set-up 4**



## Appendix 3

### Levers




**Steps**

1. Study the diagram and note the parts of a lever.
2. Using the Newton spring scale, measure the force required to lift the mass provided.
3. For each of the three lever set-ups provided by your teacher:
   a) measure and record the force required to lift the mass without using the lever (load force);
   b) measure and record the force required to lift the mass using the lever (effort force).

   Note that the load force does not change; it is the same for each lever set-up.
4. Calculate the mechanical advantage (MA) for each of the three lever set-ups by dividing the load force by the effort force:

$$MA = \frac{\text{load force}}{\text{effort force}}$$

5. Measure and record the length of the load arm (the arm extending from the load to the fulcrum) and that of the effort arm (the arm extending from the effort force to the fulcrum) for each of the levers.
6. Based on your data from step 5, propose a relationship between the ratio of the effort arm to the load arm and mechanical advantage.

Show your work in the space below and on the back of this page.



## Appendix 4

### The Design Process

**Identifying the Problem/Need**

- Provide a description of the problem/need.
- Ask questions to clarify the criteria for developing a plan.
- Brainstorm a variety of solutions to the problem/need.

**Making the Plan**

- Select a solution from the alternative solutions while considering criteria.
- Outline the steps to be followed using appropriate vocabulary and units of measurement (and labelled sketches if required).
- Select and record the materials, equipment, and tools that you will require.
- Make a reasonable timeline for completion.

**Executing and Evaluating the Plan**

- Construct a solution that represents the plan and meets the design criteria.
- Demonstrate appropriate construction techniques.
- Use the most appropriate materials, equipment, and tools.
- Test the solution and make the revisions necessary to meet the design criteria.
- Follow the timeline and meet the deadline.

**Communicating the Solution**

- Communicate the solution concisely and accurately.
- Communicate the solution using the appropriate method/format.
- Use appropriate vocabulary.

## Appendix 5

### Scenario: "Whales Forever" Design Competition

Throughout the world, whales get stranded on seaside beaches from time to time. Whales Forever, an environmental group, is concerned about the low survival rate of beached whales. They know that beached whales must be able to swim in open water within a short time or they will perish. Whales Forever has announced a design competition for students to create a prototype device that can safely lift a stranded whale onto a hovercraft to allow for both medical attention and release.

In your role as a designer, you are challenged to design and construct a lifting mechanism that:

- achieves a mechanical advantage (MA) of at least 4;
- uses one of the types of simple machines (e.g., lever, pulley, gear) or a system combining two or more simple machines.

You will make a four-minute presentation to the Whales Forever board of directors demonstrating your model's effectiveness in lifting the "whale" (simulated by a resealable plastic bag filled with sand) a height of 10 cm and lowering it 5 cm onto a simulated hovercraft platform. Since only the lifting mechanism is involved in the design competition, you may hand-position your "whale" in whatever harness you decide to use. It is recommended that, wherever possible, you use readily available materials (e.g., desks, tables, stools, retort stands) as the supports for your lifting device. If time and your skill level permit, you may be given permission to create a support structure that works best with your solution.

Your presentation must also include the following:

- exploratory sketches and a labelled sketch of your chosen design, with measurements, indicating the critical components
- mechanical advantage measurements, calculations, estimations, explanations, and verifications
- a written reflection on the strengths and weaknesses of your design
- suggestions for improving your solution



## Appendix 6

### Making the Plan

**1. Restate the Need.**

**2. Exploring Ideas. (Use the space below to illustrate your ideas.)**

3. **Select** your preferred solution and **explain why** you've made your choice.

4. **Design Sketch** (draw a clearly labelled design sketch of your solution on the back of this sheet or on graph paper).

5. **Outline the design process steps** followed in constructing, testing, and revising your solution. These steps should only include the lifting mechanism construction, **not** the supporting structure.



## Appendix 7

### Executing/Evaluating the Plan

Observe and record data that show that your mechanism generates a mechanical advantage (MA) of at least 4. Show how you have applied MA calculations with an explanation. Show evidence verifying your results.

## Appendix 8

### Reflection

1. Provide an **evaluation** of the strengths and weaknesses of your mechanism.
   a) Strengths:

   b) Weaknesses:

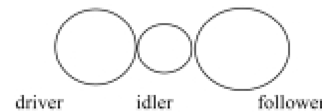
2. Explain **how** your design could be improved.



## Appendix 9

### Teacher's Background Information

**Gears**




A gear is a toothed-wheel device. A group of two or more gears in contact with each other is called a gear train. The *driver gear* is the part of the mechanism that is turned by an external force such as a crank or a motor. The *follower gear* turns as a result of its contact with the driver gear. When the driver gear is turned, the follower gear will turn in the opposite direction. Adding an *idler gear* in between the two gears has the effect of making the driver gear and the follower gear turn in the same direction.

A small gear driving a larger follower gear produces more force (mechanical advantage is gained) but decreases the speed. A large gear driving a smaller follower gear produces less force but increases the speed. The relationship of the amount of force involved with gears can be used to calculate mechanical advantage (MA).*

There are two ways to determine mechanical advantage (MA) for gears.

1. *Experimentally*
   - Use a Newton spring scale to find the force required to lift a mass straight up (load force).
   - Using something like tape, string, or a dowel, fasten the mass to the outside edge of the follower gear.
   - Fasten the Newton spring scale to the driver gear and note the force required to move the mass (effort force).
   - Calculate mechanical advantage by using the formula

   $$MA = \frac{\text{load force}}{\text{effort force}}$$

   For example, it requires 20 N to raise a mass unaided (load force). When the mass is connected to a gear system, the force required to raise it is 5 N (effort force):

   $$MA = \frac{\text{load force}}{\text{effort force}} = \frac{20\text{ N}}{5\text{ N}} = 4$$

**Note:* Mechanical advantage is numerical and does not involve any units of measurement. The greater the number, the greater the mechanical advantage.

2. *Using a Formula*

- To estimate mechanical advantage for gears:

$$MA = \frac{\text{number of teeth on follower}}{\text{number of teeth on driver}}$$

For example, a gear of 10 teeth driving a follower of 50 teeth produces an approximate MA of 5:

$$MA = \frac{50}{10} = 5$$

- Mechanical advantage can also be estimated using the radius of the gears:

$$MA = \frac{\text{radius of the follower}}{\text{radius of the driver}}$$

*Set-up for Gear Centre (for Pre-task 2)*

Set up gears as outlined in Appendix 1. Styrofoam provides a good, easy-to-work-with base or background for the gears. Nails or wooden skewers can be used to fasten the gears to the Styrofoam. Alternatively, you may prefer to make more permanent samples by using nails for shafts and scraps of wood for the base. Use a marker or pen to identify which gears are the driver and follower gears. Driver gears are on the left of the illustrations at the end of Appendix 1.

*Answers to Student Questions (see Appendix 1)*

Question 2. The driver and follower turn in opposite directions.

Question 3. The idler gear makes the driver and follower gears turn in the same direction.

Question 4. Adding an idler gear causes the follower gear to turn in the same direction as the driver gear.

Question 6. Answers will vary depending on the gear system used. If the gear systems shown in the photograph are used, the answers are as noted in the following table:

| Set-up | Mechanical Advantage |
|---|---|
| 1 | 30 ÷ 12 = 2.5 |
| 2 | 30 ÷ 20 = 1.5 |
| 3 | 40 ÷ 12 = 3.3 |



**Pulleys**

A pulley is a wheel with a grooved outer rim with a string or rope running in the groove around the rim. It is similar to a lever.

| *Lever* | *Pulley* |
|---|---|
| bar | rope |
| fulcrum | axle |
| effort and load arms | sides of the pulley |

Pulleys can be positioned so that they are attached (fixed) or so that they move as the rope or string is pulled (movable).

A single fixed pulley does not give a mechanical advantage. It simply changes the direction of the motion and can make the movement more convenient (e.g., a fixed pulley at the top of a flagpole used to raise and lower the flag).

When fixed and movable pulleys are combined to form a pulley system, they form a block and tackle, which can provide a significant mechanical advantage.

There are two ways to determine mechanical advantage for pulleys.

1. *Experimentally*
   - Use a Newton spring scale to find the force required to lift a mass (load force).
   - Fasten the mass to the pulley system.
   - Attach the Newton spring scale to the pulley system and record the force required to raise the mass.
   - Calculate the MA, which is $\frac{\text{load force}}{\text{effort force}}$

   For example, with a load force of 6 N and an effort force of 3 N:

$$MA = \frac{\text{load force}}{\text{effort force}} = \frac{6N}{3N} = 2$$

2. *By Estimation*
   The MA for pulleys can also be estimated by counting the number of rope sections supporting the load. A pulley with two rope sections supporting the load has a mechanical advantage of approximately 2, and a pulley system with three rope sections supporting the load has a mechanical advantage of approximately 3, and so on.

*Set-up for Pulley Centre (for Pre-task 2)*

Set up the pulley arrangements as shown in Appendix 2. To support the pulley arrangements, use metre sticks with table or desk supports, retort stands, or strings attached to the ceiling.

*Answers to Pulley Questions (see Appendix 2)*

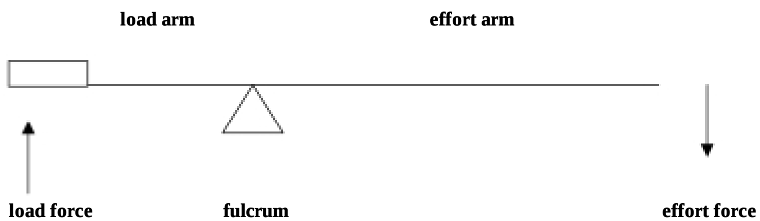
Set-up 1: MA = 1 (with one rope supporting the load)

Set-up 2: MA = 2 (with two ropes supporting the load)

Set-up 3: MA = 3 (with three ropes supporting the load)

Set-up 4: MA = 4 (with four ropes supporting the load)

**Levers**




There are two ways to determine mechanical advantage (MA) for levers.

1. *Experimentally*
   - Attach a Newton spring scale to a mass and record the force required to lift the mass straight up (load force).
   - Place the same mass on the load end of the lever and place the Newton spring scale on the effort end of the lever. Exert force on the Newton spring scale and record the force required to lift the mass using the lever (effort force).
   - Calculate the mechanical advantage by dividing the load force by the effort force.
   - For example, to lift a sample mass straight up requires a force of 10 N. Using a lever, the force required is 5 N.

$$MA = \frac{\text{load force}}{\text{effort force}} = \frac{10N}{5N} = 2$$



2. *Using a Formula*
   The MA for levers can be estimated by comparing the length of the effort arm to the length of the load arm. Thus,

$$MA = \frac{\text{length of effort arm}}{\text{length of load arm}}$$

For example, for a length of effort arm of 50 cm and a length of load arm of 10 cm:

$$MA = \frac{50\text{ cm}}{10\text{ cm}} = 5$$

To have a mechanical advantage of 5 with a lever, the effort arm must be five times longer than the load arm. (*Note:* If students add harnesses or similar devices to hold the "whale" on the ends of their levers, they will be adding more mass to the load arm, which will affect their MA calculations.)

*Set-up for Lever Centre (for Pre-task 2)*

To facilitate the use of the lever centre for Pre-task 2, the six to nine levers (two or three sets of levers with three set-ups in each set) should already have been constructed and be available for student use. This will focus student time on concept exploration rather than on lever construction. To create the levers for this centre, use metre sticks (as levers), pencils (as fulcrums), and tape to secure the pencils to the metre sticks. Since the levers must be somewhat above the desk to work, the lever mechanisms can be supported on a pile of textbooks. You will require the following set-ups:

- Set-up 1: with the fulcrum at the 50 cm mark on the metre stick, halfway between the load and the effort
- Set-up 2: with the fulcrum at 25 cm from the load
- Set-up 3: with the fulcrum at 75 cm from the load

*Answers to Lever Activities (see Appendix 3)*

Question 2. Answers will vary depending on the mass used.

Question 3. Answers will vary depending on the mass used.

Question 4. Answers will vary depending on the mass used, but final answers will be close to those in number 5.

Question 5. Set-up 1: $MA = \frac{50\ \text{cm}}{50\ \text{cm}}$

$= 1$

Set-up 2: $MA = \frac{75\ \text{cm}}{25\ \text{cm}}$

$= 3$

Set-up 3: $MA = \frac{25\ \text{cm}}{75\ \text{cm}}$

$= 0.33$

Question 6. Students should generalize that the approximate mechanical advantage for a lever is obtained by dividing the length of the effort arm by the length of the load arm.