Structures and Mechanisms

Mechanical Efficiency

Including:

Gaining Leverage
Let's Sell It!
When Push Comes to Shove
Slow Down
Speed, Distance, Force ... Velocity ... Velocity Ratio
How Efficient Is It?
Linking The Systems
Toying With Efficiency

An Integrated Unit for Grade 8

Written by:

The Curriculum Review Team 2005

Length of Unit: approximately: 18 hours

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Unit Context

Catholic Learners are reflective, creative, and holistic thinkers who solve problems and make responsible decisions with informed moral consciences for the common good. They work effectively as interdependent team members. Catholic learners are collaborative contributors who find meaning, dignity, and vocation in work which respects the rights of all and contributes to the common good. They are effective communicators who speak, write, and listen honestly and sensitively, responding critically in light of gospel values.

For this grade 8 Science and Technology unit, students will be using problem-solving strategies as they work in design groups to collaboratively explore each subtask, the successful completion of which leads to a culminating task. The culminating task requires the cooperative efforts of all group members. Students will be expected to communicate effectively, in a way that respects the dignity and rights of all members. Throughout their work, students will be making informed moral choices in light of gospel values, for the common good of all group members.

Efficiency is an important design consideration in the creation of mechanical systems, from economic, social, and environmental points of view. In this unit, students will investigate and describe, in qualitative and quantitative terms, the relationship between force, area, and pressure in relation to liquids and gases. They will also study simple pneumatic and hydraulic systems, describe the mechanical efficiency of mechanical systems in qualitative and quantitative terms, design and construct a mechanical toy device that operates under hydraulic or pneumatic power, and, finally, develop and present a marketing campaign for the product. **It is preferable to have completed the grade 8 "Fluids" unit before beginning this unit, due to its focus on the properties of fluids and the principles involved in fluid mechanics.**

The following questions will be pursued throughout this unit in order for students to develop sufficient background to create a hydraulically or pneumatically-powered device that operates in an efficient manner:

1. What are the three classes of levers and what are their advantages and disadvantages?
2. What are the factors that need to be considered in the manufacturing and marketing of a product?
3. How are forces transferred in fluids?
4. How does pressure on a liquid versus a gas differ in a closed system?
5. What are some forces that affect the movement of an object?
6. What is velocity ratio and how can it be calculated?
7. What is the mechanical advantage associated with the operation of pulley and lever systems?
8. How can simple hydraulic and pneumatic systems be created, in conjunction with levers, to move objects as efficiently as possible?

Unit Summary

Students will explore and demonstrate an understanding of the factors that contribute to the efficient operation of mechanisms and systems (e.g., simple machines, Pascal's Law, forces that affect movement, velocity ratio, hydraulics and pneumatics, consumer needs).

Through the opportunities explored in the subtasks, students will be able to design and make a mechanical toy device, that will move a given object a specified vertical and horizontal distance, and investigate the efficiency of the mechanical device.

Students will be given opportunities to explore and demonstrate understanding of the factors that can affect the manufacturing of a product, including the needs of the consumer. They will then be required to present their mechanical toy devices in light of their findings.

Culminating Task Assessment

Students will participate in this culminating task as members of "Smooth Move Toy Company." Students will be expected to work individually and collaboratively as members of a team. These teams will consist of the same members who had been working together throughout the subtasks. They will work on designing, creating, testing (mechanical efficiency and consumer interest), and marketing a toy product. This toy product must be a mechanical device that is able to move a given object a specified distance through the use of hydraulic or pneumatic power.

An assessment rubric has been provided which focuses on the students' understanding of concepts, design skills, communication skills, and the students' ability to relate science and technology to the world outside the school. The rubric addresses all of the specific criteria set out in the culminating task description and on the blackline master that will be provided to students.

IT IS VERY IMPORTANT THAT YOU TAKE THE TIME NOW TO READ THROUGH THE COMPLETE DESCRIPTION OF THE CULMINATING TASK. THIS WILL HELP TO GIVE YOU A CLEAR SENSE OF WHAT THE SUBTASKS WILL BE LEADING TO AS YOU PROGRESS THROUGH THE UNIT WITH YOUR STUDENTS.

Catholic Graduate Expectations:
CGE 3 - The Catholic Learner is a reflective, creative, and holistic thinker who solves problems and makes responsible decisions with an informed moral conscience for the common good.
CGE 5f - The Catholic Learner exercises Christian leadership in the achievement of individual and group goals.
CGE 5g - The Catholic Learner achieves excellence, originality, and integrity in one's own work and supports these qualities in the work of others.
CGE 2c - The Catholic Learner presents information and ideas clearly and honestly and with sensitivity to others.

Links to Prior Knowledge

It will certainly work to the students' advantage if they have had the opportunity to complete the Structures and Mechanisms units from grades 1 to 7 prior to beginning the "Mechanical Efficiency" unit. Grade 8 students should have had the opportunity to complete the "Fluids" unit in the Matter and Materials strand before beginning this unit.

More specifically, students need to know:
- what the three classes of levers are and how they can be used to reduce the work necessary to move something
- what friction is and how it can be reduced
- the factors that affect the stability of an object
- how to express and respond to a range of ideas and opinions concisely, clearly, and appropriately
- how to contribute and work constructively in groups
- how to use computer applications such as data collection charts, graphs, and Internet search engines

Considerations

Notes to Teacher

General Notes

1. The culminating activity should be introduced to students, along with the assessment rubric, before

beginning the first subtask. This will serve as part of an introduction to the unit and allow students the opportunity to "know where they are going" with regard to what they will be prepared to design, construct, test and market at the end of this unit.

2. This unit does focus on Science and Technology curriculum expectations but it can be linked to other curriculum areas. Links have been made to the Language, Mathematics, and Visual Arts curricula through a number of the subtasks and the culminating task. A couple of Visual Arts applications include the promotional poster or video presentation to be made as part of the culminating task. Mathematics applications include recording of data in different formats and analysis of that data, as well as measurement skills. Language applications include visual and oral communication skills through group work and as part of the culminating task, as well as writing skills in compiling the results of various investigations.

3. Teachers should ensure that all necessary materials have been located and gathered in advance of beginning the unit work. These resources include such items as syringes (20 mL) for Subtask 7 and other for the Culminating Task), tubing, 1 cm square craft wood (e.g., Jinx wood), dowelling, carpenter's glue, hand saws, tape, plastic 2 L pop bottles, a Newton spring scale, and pulleys. Any video material that is available through your Board, related to this topic, should be booked in advance of beginning this unit.

Modifications

The activities in this unit are designed to allow for many learning styles and abilities. Teachers will want to choose small group members carefully to ensure that all students' needs will be met. Individual modifications to the unit should be considered by the classroom teacher.

Some suggested modifications are:

- recognize effort as well as full task completion
- provide immediate feedback
- clarify expectations at the beginning of each lesson and perhaps provide sample responses for some students
- repeat important information (concepts and ideas) or allow students to repeat and rephrase
- use pictures and diagrams whenever possible
- encourage students to question for clarification and additional information before beginning work
- vary resources with regard to reading level, amount of visual information use of oral, written, and visual data
- modify the assignment in terms of: time, quantity of work assigned, nature of the assignment
- stress quality rather than quantity
- provide opportunities for strengths to be used (e.g. artistic abilities could be used to good advantage in groups)
- team students with varying abilities
- help students keep lesson notes consistent and organized
- adjust reading level of student material or tape-record text
- teach note-taking and organizational skills
- provide research material at their reading level, or with relevant information highlighted
- use reading partners
- assign enrichment tasks
- vary assessment strategies

Special Education Adaptations and Accommodations

1. Provide an encouraging and supportive classroom environment.
2. Refer to individual IEPs and accommodation logs of exceptional learners to make meaningful adaptations for these students through consultation with the school's special education and ESL teachers.

3. Whenever possible, consult with parents concerning reinforcement of learning expectations and appropriate working conditions at home.
4. Discuss strategies and objectives with students to ensure that they understand each task, and check often for comprehension of expectations and activities which will ensure maximizing their potential.
5. Pre-teach vocabulary and key concepts as an introduction to each lesson or segment.
6. Provide students with instructional models which illustrate basic concepts.
7. Provide overviews of lessons which include visual organizations schemes, mapping, or webs.
8. Allow opportunities for practice on less complex tasks before undertaking the key lesson objective.
9. Establish rubrics for a variety of data gathering approaches. These can provide references for evaluation based on each student's choice of approach.
10. Allow a variety of reporting options and evaluation rubrics for each approach.
11. Encourage heterogeneous grouping of students where at least one student in each group is a strong reader.
12. Set up group work to meet the needs of all members. Pair students with physical needs, learning and/or developmental challenges and explain expectations of those students to group.
13. Consider extension options which provide students with opportunities to reach beyond the curriculum expectations. This could include expanded research and investigation into related topics and concepts.

Safety

As a matter of good safety practice, please review Ontario Curriculum, Science and Technology document, pages 8, 9, and 71, reproduced below before beginning this unit. Also, the Science Teachers' Association of Ontario's document entitled *Be Safe!* is an excellent safety guide.

In particular, please take careful note of the following, from the Ontario Curriculum, Science and Technology document:

"It is important that students follow established safety practices in designing, constructing, and experimenting with structures and mechanisms. These practices include:
- using tools safely to cut, join, and shape objects;
- 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; gears and pulleys; elevated objects)."

- reprinted from *The Ontario Curriculum, Grades 1-8: Science and Technology, 1998* , page 71

"To carry out their responsibilities with regard to safety, it is important not only that teachers have concern for their own safety and that of their students, but also that they have:
- the knowledge necessary to use the materials, tools, and procedures involved in science and technology safely;
- the skills needed to perform tasks efficiently and safely.

Students demonstrate that they have the knowledge, skills, and habits of mind required for safe participation in science and technology activities when they:
- maintain a well-organized and uncluttered work space;
- follow established safety procedures;
- identify possible safety concerns;
- suggest and implement appropriate safety procedures;
- carefully follow the instructions and example of the teacher; and
- consistently show concern for their safety and that of others."

- reprinted from *The Ontario Curriculum, Grades 1-8: Science and Technology, 1998* , pages 8-9

Please refer to individual subtasks for specific safety considerations.

Background Information

The Particle Theory
Understanding the particle theory will help students comprehend the dynamics of fluids. The particle theory consists of five main points:

1. All forms of matter are made up of particles; these particles are so tiny that they cannot be seen with the naked eye. However, when these small particles move, the movement can be seen.

2. Particles of a pure substance are all identical. Ice, water, and water vapour are all made up of identical particles, no matter what the state.

3. The attractive forces between particles increase with proximity; this simply indicates that the attractive forces (that exist between two particles, which pull the particles towards each other), increase as the particles move closer towards each other. This also explains why solids are harder than liquids or gases; it is because the particles are closer together.

4. The spaces between particles are large compared to the size of the particles themselves.
Actually, the spaces are larger than the size of the particles themselves. The spaces are largest in the gaseous state, which means they can be compressed (e.g., pushing on an inflated balloon) and smallest in solid state.

5. All particles are in constant motion; this may be a difficult concept for students to conceptualize, especially when considering something in the solid state, such as wood or steel. However, it is important for students to know that even though we can not detect movement with the naked eye, the particles within the solid are moving constantly. The speed of the particles is dependent upon temperature. An increase in temperature causes an increase in particle movement.

Fluids
Fluids are described as any materials that can flow, namely gases and liquids. Air (gas) and water (liquid) are two of the most common fluids on our planet. Wind is what we call flowing air. The oceanic tides are an example of flowing water. The study of fluids can take two forms, static and dynamic. Fluid statics involves the study of fluids while stationary (at rest) including, for example, how oil works in a car's engine. On the other hand, dynamic fluids are ones in motion and this area of study includes things such as how an airplane can remain in the air.

Properties of Fluids
Fluids are very interesting because they have some very unique properties. Three areas are of specific note; the shape, volume, and mass of fluids. A can of air freshener contains a highly pressurized fluid, once it is sprayed the fluid vaporizes and spreads throughout the room (due to diffusion from high to low concentration). Fluids do not have a definite shape and will simply take the shape of whatever they are poured into. This applies to both liquids and gases. Whether you fill a glass jar with air or water, it will take the shape of the jar. When considering volume, there is a difference between liquids and gases. Liquids have a definite volume, which is hard to change, meaning a cup of water will take up the same volume, no matter what the shape of the container that it is placed in. In this way, liquids are like solids, meaning they are hard to compress. On the other hand, in the gaseous form, molecules are the farthest apart (refer to Particle Theory), therefore, they can be compressed considerably. Just think about how heavy your propane tank is after it has been filled. The

reason is because the gas has been forced into the can under high pressure, therefore the spaces between the particles have been compressed so more particles can be added. Finally, the mass of a fluid does not change, which intuitively makes sense. If you have a jug of water with a mass of 1 kg, the mass will not change just because you poured it into a larger jug or one with a different shape.

What Is Force and How Is It Measured?
A force is a push or a pull that causes an object to accelerate or decelerate (i.e., a change in speed and direction). It can be applied to an object in two ways. It can be applied directly, through the contact of two objects. For example, when a baseball bat is used to hit a baseball, the bat exerts a force on the ball, causing it to accelerate in the direction it was hit. The second way force can be applied is indirectly, where the contact of two objects is not necessary. An example of this type of force is, after a baseball is hit it will rise to a peak in height and zero velocity, and then will begin to drift back towards the earth, due to the force of gravity. Whether a force is applied directly or indirectly, it results in the acceleration of an object with a direction and magnitude.

Using the international system of measurement, force is measured in newtons (N), named after the English physicist and mathematician Sir Isaac Newton. The students will be doing simplified calculations using measurement in newtons, which will require them to use a spring scale to measure the force of various masses. For our purposes we are ignoring acceleration. It is important that students refer to lifting or raising rather than 'moving' a load. Moving would require them to use calculations of rate of acceleration, in other words, the force of gravity, with which an object falls to earth. The force needed to hold up a mass of 100 g using a spring scale is about 1.0 N. One newton (1 N) refers to the amount of force required to move an object with a mass of 100 g. (against the force of gravity).

Pressure
Anyone who has had to fix a spare tire, fill an air mattress, or any other pool toy knows a little about pressure. When we inflate an object such as an air mattress, we are literally placing air molecules inside the object. If something is underinflated, it is soft and intuitively we know the reason is because there isn't enough air inside. However, in a more scientific way we could say that there are not enough air molecules inside the object to maintain the desired pressure. When we add air to an underinflated object, we increase the number of molecules inside, increasing the forces inside because the air molecules are continually bumping into one another and the walls of the object (exerting a force on the wall). These molecules are free to move about inside the object and exert forces against the entire area of the walls. When something is properly inflated, the air pushes outward with enough force to give the object the shape it needs.

Pressure is defined as the force per unit area of an object. Therefore, the calculation of pressure involves the force and area over which the force is exerted, so pressure equals force divided by area ($P = F/A$) and is expressed in pascals (Pa). When a fluid is acted upon by an external force (pressure), Pascal's law tells us that the force (pressure) is transmitted uniformly throughout the volume of the fluid.

Pressure in Relation to Volume and Temperature of Fluids
The effect of pressure on fluids was hinted at in the properties of fluids section. Pressure has little effect on the volume of a liquid (we say it is resistant to compression). In fact, a huge amount of pressure needs to be applied to even compress a liquid slightly. However, pressure can cause liquids to flow with considerable force. Just consider the power of the Niagara River, which turns huge turbines and provides power to Southern Ontario. Gases, on the other hand, are easy to compress (i.e. change the volume), and like liquids can be quite powerful when pressurized. When a fluid is heated, whether it is a gas or a liquid, the molecules within the container will begin to move more quickly, increasing the collisions that occur, thereby increasing the forces within the container and the pressure. Gases are much more reactive to heating than liquids because the spaces between the molecules expand quite significantly (when compared to the expansion in liquids). For this reason, all pressurized cans contain a warning against exposure to heat and puncture. If a pressurized can of gas was heated, the increase in heat and resulting pressure would eventually cause the

can to explode.

In simplest terms, if you heat a liquid and the volume cannot change (because it is in a container), there will be an increase in pressure. However, if you heat a gas and the volume cannot change, there will be a drastic increase in pressure.

Velocity, Speed, Motion, and Velocity Ratio
To understand the workings of simple machines, you have to understand some of the fundamentals of motion, but there isn't a need for a lot of complicated formulas at this point. Motion is described as the change in location of an object when compared to a specific reference point. The reference point is any stationary point from which motion can be observed or compared. So, you walking down the street, a ball rolling across the floor, or a leaf falling from a tree are all examples of motion. Speed is the measure of how quickly an object is moving and is calculated as the distance covered per unit of time (km/h). Velocity is often confused with speed but is the speed and direction of a moving object. For example, 60 km/h is the speed of a car, while 60 km/h north on Niagara St. is a velocity. The velocity ratio represents the "ideal" mechanical advantage (see below for definition of this term) of a mechanism if friction did not exist. You calculate the velocity ratio by dividing the distance that the effort force moves by the distance that the load force moves.

Lever
In the glossary a lever is defined as "a simple machine that can lift a weight with less effort." This basic definition probably hits on the reason levers were invented, to do more work with less effort. Archimedes, a Greek scientist, lived over 2000 years ago and was the first person to explain how and why levers worked in mathematical terms. One of his famous quotes "With a big enough lever you can move the world!" exemplifies the benefits of using a lever. However, levers had been in existence and used long before Archimedes explained the how and why.

All levers consist of three different parts. These three parts are known as the fulcrum, an effort arm (force applied here), and a resistance arm (where load or weight rests). The fulcrum is the point or pivot where a lever moves. The effort arm is where the force is applied to move the resistance arm (load). If the fulcrum is in the centre of the lever (like in a teeter-totter), then the force applied will be equal to the amount of load you can lift.

Consider another example: Imagine you wanted to lift a box that weighed (exerted a force of) 400 N. RA represents the distance from the fulcrum (F) to the load (R) and is equal to 1 metre. The distance from where the force is applied (E) and the fulcrum (F) is 10 metres. Then you would only have to apply 40 N of force at E to lift the load. This is true because of the rule that E x EA = R x RA. Filling in the formula you see that 40 N times 10 metres = 400 N times 1 metre.

As you can see, the placement of the fulcrum is very important in determining the amount of force needed to move an object using the lever. In general, there are three different types of levers. A first class lever is one in which the fulcrum is between the effort and the load (e.g., hammer, car jack). A second class lever is one in which the fulcrum is at one end of the lever and the load is in the middle (e.g., bottle opener, wheelbarrow). A third class lever is one in which the fulcrum is at one end of the lever and the load is at the other end, with the effort in the middle (e.g., fishing pole). Calculating the mechanical advantage of any lever is simply a matter of dividing the effort arm length by the resistance arm length. Whatever the case, students should be reminded that it is easier to move a load when it is closer to the fulcrum.

Pulley
The pulley is another simple machine used for lifting heavy things. It consists of a chain or rope wrapped around a wheel. The pulley is an example of one of the earliest and simplest wheel devices. Scientist believe the pulley may have been invented in the eighth century B.C.E., in a place that is modern day Syria, where engineers discovered that a rope placed over a small framed wheel made it easier to lift heavy objects. Since

that time, engineers have used the pulley in many construction projects. The pulley can work in two different ways. It can change the direction of a force or it can change the amount of force needed to lift an object. The single pulley does not change the amount of force needed to lift an object, but it does change the direction of the force. Therefore, there is no mechanical advantage to this system. In this case you can use the weight of your body to pull the rope down, while the object on the other end of the rope moves up.

However, the pulley is a special form of a lever which CAN reduce the amount of force needed to lift an object by increasing the distance over which the force is applied. How can this be? The answer is a moveable pulley or pulley system (more than one pulley), also called a block and tackle (when a fixed pulley and moveable pulley are used in one system) which is attached to the object you are trying to move.

For example, pretend you are trying to lift a stone weighing 100 kg. This is much too great of a weight for the average person. Introduce a single fixed pulley and you still have to lift the entire weight, but now the direction of the force has changed. Instead of lifting the stone straight up, you can use your body weight (pulling at an angle). Now try a block and tackle system with one fixed pulley and one moveable pulley, and the force required to lift the stone takes half the effort (50 kg) because there are two ropes supporting the stone, but the distance you have to lift the stone has doubled (remember, gain in force and loss in distance). If the weight is still too much, you could add another pulley and decrease the force needed to lift the stone even further. In these cases the pulley systems result in a mechanical advantage. The mechanical advantage usually equals the number of rope segments supporting the moveable load, minus the segment on which the load rests. In actuality, friction between the rope or chain and the pulleys reduces the mechanical advantage slightly and tends to limit the total number of pulleys used to a maximum of four.

Mechanical Advantage
In general terms, the mechanical advantage is a measurement of the benefit of using a machine versus not using a machine and is the amount of times a machine multiplies a force. The mechanical advantage of any machine can be calculated by dividing the load force (force needed to move an object without use of a machine) by the effort force (force needed to move an object with a machine).

Mech. Advantage = load force/effort force

For example, if you moved a stone with a 600 N force, using only 200 N of force and a lever, then the mechanical advantage would be 600/200 = 3. A mechanical advantage of 3 implies that the use of the machine multiplied the effort force by a factor of 3 or conversely, the person only had to use 1/3 of the force which would be needed to move the object without a lever.

Mechanical Efficiency
Mechanical efficiency is a measure of how well a mechanism runs. This calculation helps us determine if the machine used was worthwhile. More specifically it is calculated as the percent efficiency of a mechanism by dividing the mechanical advantage you previously calculated by its velocity ratio, and multiplying the result by 100.

Whenever a machine is used, it is subjected to frictional forces (which convert energy to heat), therefore, the output of a machine is always lower than 100 per cent. In fact, the greater the frictional forces involved, the less efficient the machine. That's why a pulley system usually is limited to four pulleys, because a number greater than this usually experiences high frictional forces, negating the benefit of extra pulleys.

- reprinted, in part, from *OECTA Teacher Resources - Structures and Mechanisms, Grade 8 (Acknowledgements: Northern Region Catholic Curriculum Cooperative)*

Science and Technology References

Glossary of Terms

block and tackle: A combination of fixed and moveable pulleys used for hoisting heavy objects.
compressible: Able to be squeezed into a smaller volume.
displacement: The amount of fluid displaced by an object that is put into the fluid.
efficiency: The comparison of the useful work or energy provided by a machine or system with the actual work or energy supplied to the machine or system. Efficiency is usually stated as a percentage.
effort: The force supplied to a machine in order to produce an action.
ergonomic: Study of the relationship between work organization and the arrangement, and design of equipment and how it relates to humans.
first-class lever: A simple machine where the fulcrum is between the effort and the resistance, as a seesaw.
fluid: Anything that flows; therefore, liquids and gases are fluids.
force: A push or a pull, in order to move something or to stop something from moving.
friction: The resistance that is caused when one object moves against another.
fulcrum: The pivotal or "resting" point of a lever.
hydraulic power: Power that comes from the pressure of a liquid, usually oil. The liquid is forced through hoses to the area where the force is needed.
hydraulic system: A system that works because of the movement of a liquid or the force of a liquid in a closed system.
hydraulics: The study of pressure in liquids.
lever: A simple machine upon which an effort is applied to gain force, speed, or distance (e.g., less effort force needed).
linkage: A system of levers used to transmit motion.
load: The weight of an object that is moved by a machine, or the resistance to movement that a machine has to overcome.
machine: A device used to make work easier. One of the six basic devices used to do work - inclined plane, lever, pulley, screw, wedge, and wheel and axle.
mechanical advantage: The gain in force obtained by using a machine. Expresed as
mechanical advantage = load force/effort force
Particle Theory of matter: See Notes to Teacher.
Pascal's Law: An external pressure exerted on a fluid is transmitted uniformly throughout the volume of the fluid.
pneumatics: The study of pressure in gases.
pressure: The force acting on a certain area of surface (pressure = force/area).
pulley: A simple machine consisting of a grooved wheel over which a rope passes.
resistance: The force to be overcome by a machine.
second-class lever: A simple machine where the resistance is between the effort and the fulcrum, as in an oar.
survey: A sampling of information, often compiled by asking people questions or interviewing them.
t**hird-class lever:** A simple machine where the effort is between the resistance and the fulcrum, as in a fishing rod.
velocity: Is the distance traveled per unit time in a given direction.
volume: The amount of space occupied by a substance.

Structures and Mechanisms

Mechanical Efficiency An Integrated Unit for Grade 8

1 Gaining Leverage

Students will be engaged in a hands-on activity investigating levers. Teacher will direct a lesson to review the three classes of levers. Students will participate in a hands-on activity using a box of various levers for review of the classes of levers. They will sort these items according to the three classes. Students will begin by working in small groups. They then will participate in a large group-sharing session based on the results of the sorting and classifying work done by each small group. Students will make a table on the computer to record the classification of the items done in the large group. An optional follow-up activity can be done by students, individually, with magazine pictures of a variety of levers that will be part of a collage. These activities will serve as diagnostic assessment tools for the teacher to ascertain the knowledge and skill levels of the class before proceeding with the subsequent subtasks.

Catholic Graduate Expectations:
CGE 5 - The Catholic Learner is a collaborative contributor who finds meaning, dignity, and vocation in work which respects the rights of all and contributes to the common good.
CGE 5a - The Catholic Learner works effectively as an interdependent team member.
CGE 2c - The Catholic Learner presents information and ideas clearly and honestly and with sensitivity to others.

2 Let's Sell It!

Students will explore, through discussion and research, how consumer expectations and needs, as well as economic and environmental factors, affect the development and marketing of many consumer products.

Catholic Graduate Expectations:
CGE 2 - The Catholic Learner is an effective communicator who speaks, writes, and listens honestly and sensitively, responding critically in light of gospel values.
CGE 2a - The Catholic Learner listens actively and critically to understand and learn in light of gospel values.
CGE 2b - The Catholic Learner reads, understands, and uses materials effectively.
CGE 2c - The Catholic Learner presents information and ideas clearly and honestly and with sensitivity to others.

3 When Push Comes to Shove

A) Students will discover the differences in the levels of compressibility between air and water in a closed system. Students will do this by using two plastic bottles, one which is capped and filled with air and the other which is capped and filled with water. Both bottles will be squeezed to demonstrate the differences noted above.

B) Students will investigate the effects of pressure by moving an object using two different sized syringes. They will move liquid and gas from a smaller syringe to a larger and then reverse the syringes to go from larger to smaller. They will be investigating the use of pnuematic and hydraulic systems and the advantages of using a smaller or larger system.

Catholic Graduate Expectations:
CGE 3 - The Catholic Learner is a reflective, creative, and holistic thinker who solves problems and makes responsible decisions with an informed moral conscience for the common good.
CGE 3c - The Catholic Learner thinks reflectively and creatively to evaluate situations and solve problems.
CGE 4f - The Catholic Learner applies effective communication, decision-making, problem-solving, and resource management skills.

4 Slow Down

Students will investigate and measure the force of friction that affects the movement of an object, **which ultimately has an effect upon the mechanical efficiency of that object.** Through hands-on activities, students will explore the concept of friction. An object will be pulled across a variety of different textured surfaces and a Newton scale will be used to measure the frictional forces involved.

Catholic Graduate Expectations:

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CGE 4f - The Catholic Learner applies effective communication, decision-making, problem-solving, and resource management skills.

5 Speed, Distance, Force ... Velocity ... Velocity Ratio

Students will come to an understanding of the term "velocity" and then determine the velocity ratio of various devices. These terms will be defined for students. Students, in groups, will conduct two experiments to find velocity ratio using levers and pulleys. Blackline master worksheets will be provided to students, containing a variety of exercises, to help solidify students' understanding of velocity and velocity ratio.

Catholic Graduate Expectations:
CGE 2 - The Catholic Learner is an effective communicator who speaks, writes, and listens honestly and sensitively, responding critically in light of gospel values.
CGE 2a - The Catholic Learner listens actively and critically to understand and learn in light of gospel values.
CGE 2b - The Catholic Learner reads, understands, and uses materials effectively.

6 How Efficient Is It?

Students will determine mechanical advantage and calculate the efficiency of simple mechanical systems (involving pulleys and levers). Students will investigate this through the use of a simple lever system and then, students will construct a pulley system. Calculations will be made using these systems. The work in this subtask will link back to the knowledge gained about velocity ratio in the previous subtask.

Catholic Graduate Expectations:
CGE 5 - The Catholic Learner is a collaborative contributor who finds meaning, dignity, and vocation in work which respects the rights of all and contributes to the common good.
CGE 5a - The Catholic Learner works effectively as a interdependent team member.
CGE 2c - The Catholic Learner presents information and ideas clearly and honestly and with sensitivity to others.

7 Linking The Systems

Students will construct a lift system, using a set of plans that have been supplied, that incorporates the use of hydraulics. They will incorporate appropriate levers and ways of linking the components of this system into their product. Students will then be required to calculate the mechanical efficiency of the lift system.

Catholic Graduate Expectations:
CGE 3 - The Catholic Learner is a reflective, creative, and holistic thinker who solves problems and makes responsible decisions with an informed moral conscience for the common good.
CGE 3b - The Catholic Learner creates, adapts, evaluates new ideas in light of the common good.

8 Toying With Efficiency

Students will participate in this culminating task as members of "Smooth Move Toy Company." Students will be expected to work individually and collaboratively as members of a team. These teams will consist of the same members who had been working together throughout the subtasks. They will work on designing, creating, testing (mechanical efficiency and consumer interest), and marketing a toy product. This toy product must be a mechanical device that is able to move a given object a specified distance through the use of hydraulic or pneumatic power.

An assessment rubric has been provided which focuses on the students' understanding of concepts, design skills, communication skills, and the students' ability to relate science and technology to the world outside the school. The rubric addresses all of the specific criteria set out in the culminating task description and on the blackline master that will be provided to students.

IT IS VERY IMPORTANT THAT YOU TAKE THE TIME NOW TO READ THROUGH THE COMPLETE DESCRIPTION OF THE CULMINATING TASK. THIS WILL HELP TO GIVE YOU A CLEAR SENSE OF WHAT THE SUBTASKS WILL BE LEADING TO AS YOU PROGRESS THROUGH THE UNIT WITH YOUR STUDENTS.

Catholic Graduate Expectations:
CGE 3 - The Catholic Learner is a reflective, creative, and holistic thinker who solves problems and makes responsible decisions with an informed moral conscience for the common good.
CGE 5f - The Catholic Learner exercises Christian leadership in the achievement of individual and group goals.
CGE 5g - The Catholic Learner achieves excellence, originality, and integrity in one's own work and supports these qualities in the work of others.
CGE 2c - The Catholic Learner presents information and ideas clearly and honestly and with sensitivity to others.

Gaining Leverage

Subtask 1

~ 80 mins

Description

Students will be engaged in a hands-on activity investigating levers. Teacher will direct a lesson to review the three classes of levers. Students will participate in a hands-on activity using a box of various levers for review of the classes of levers. They will sort these items according to the three classes. Students will begin by working in small groups. They then will participate in a large group-sharing session based on the results of the sorting and classifying work done by each small group. Students will make a table on the computer to record the classification of the items done in the large group. An optional follow-up activity can be done by students, individually, with magazine pictures of a variety of levers that will be part of a collage. These activities will serve as diagnostic assessment tools for the teacher to ascertain the knowledge and skill levels of the class before proceeding with the subsequent subtasks.

Catholic Graduate Expectations:
CGE 5 - The Catholic Learner is a collaborative contributor who finds meaning, dignity, and vocation in work which respects the rights of all and contributes to the common good.
CGE 5a - The Catholic Learner works effectively as an interdependent team member.
CGE 2c - The Catholic Learner presents information and ideas clearly and honestly and with sensitivity to others.

Expectations

8s101 A	– use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);
8s87 A	• demonstrate an understanding of the factors that contribute to the efficient operation of mechanisms and systems;
8a26	• define the principles of design (emphasis, balance, rhythm, unity, variety, proportion), and use them in ways appropriate for this grade when producing and responding to works of art;
8s103 A	– communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes and descriptions, charts, graphs, drawings, and oral presentations (e.g., make a display in which they compare the ways in which a closed pneumatic system and a hydraulic system operate the same size of cylinder);

Groupings

- Students Working In Small Groups
- Students Working As A Whole Class
- Students Working Individually

Teaching / Learning Strategies

- Working With Manipulatives
- Note-making
- Classifying
- Brainstorming
- Discussion

Assessment

Teacher can use anecdotal record to record observations of students' abilities to classify levers appropriately and explain their mechanical advantage.

Assessment Strategies

- Classroom Presentation
- Introduction
- Questions And Answers (oral)
- Observation

Assessment Recording Devices

- Rubric
- Anecdotal Record

Teaching / Learning

Activity #1 Teacher directed.

1. Review definitions for lever, effort load, load force, and fulcrum.

2. Students work in small groups of four or five to investigate/review how levers work. Provide students with BLM 1.2 (Gaining Leverage) to lead them through the following activity.

Procedure:

Class 1 Lever (fulcrum in the middle)
i) Place a metre stick with half the length on the desk and the other half extending over the edge. Use the desk's edge as the fulcrum.
ii) Place a book on the end of the load arm (end that is lying on the desk).
iii) Push down on the effort arm (end extended over the edge), trying this with the fulcrum at two or three different distances from the load or effort forces.

Class 2 Lever (load in the middle)
i) Tie the book to the middle of the metre stick, so it is attached below the stick.
ii) Put one end of the metre stick on the desk and hold the other end up with book hanging below.
iii) Try to lift the book using the metre stick while it is hanging at a few different places along the stick.

Class 3 Lever (effort in the middle)
i) Tie the book beneath the far end of the metre stick.
ii) While holding the metre stick's end in place on the desk, try to lift the book with the overhanging extension.

3. Students should be observing the directions of the force associated with the effort and load. (In the class 1 lever, there is a change in direction of force; in the class 2 and 3 levers, there is no change in direction of force.) Students should observe the advantages or disadvantages of where the fulcrum, load, or effort are. (The closer the fulcrum is to the load, the easier it is to lift. This will get them thinking and introduce them to Mechanical Advantage which will be taught in future subtasks.)

4. A note about the three classes of levers is provided for the teacher/students on BLM 1.1 (Notes About Levers).

Activity #2 Students work in small groups.

1. The teacher will have asked the students to bring in different simple machines that are levers or she/he will bring in several him/herself. (Any household items: hammer, stapler, can opener, nut cracker, garlic press, scissors, bottle opener, etc.)
2. Within the small groups of four to five students they discuss the types of levers they have among them and are asked to catagorize them as they wish.
3. The groups each share their groupings and explain their reasoning to the whole class.
4. The teacher will lead the students, if they have not done this already to catagorize their classifications into three classes of levers.
5. The teacher records students' input of suggested levers under each heading on overhead BLM 1.3 (Simple Machines - Levers).
6. The students record these into their own notes and then add other examples that they come up with

themselves.

Activity #3 Homework Assignment

1. i) Make a table on the computer to classify the three classes of levers. Under each class, list examples discussed in class, and add ones (three to five examples) of your own.
ii) On the back of the page, draw and label (fulcrum, load, effort) one of the examples for each class of levers.
OR
2. On a blank poster-size sheet, have three defined areas for each of the three classes of levers and make a collage out of pictures cut from magazines or catalogues.

Adaptations

BLM 1.3 can be used as accommodation for ESL, and learners who need help with organization.

Refer to the Notes to Teacher in the Unit Overview for adaptation ideas for students with learning and/or physical challenges as well as for students identified as ESL.

Resources

Rubric 1 for Gaining Leverage	
BLM 1.2 Gaining Leverage	1.2_Gaining Leverage.cwk
BLM 1.3 Simple Machines - Levers	1.3.cwk
BLM 1.1 Notes About Levers	1.1_notes about levers.cwk
household objects (see teacher notes)	
hardware catalogues	
metre sticks	
book (e.g., dictionary)	
tape or string to tie book to the metre stick	

Notes to Teacher

1. Examples of levers should be collected by the teacher (and students) as soon as possible. Avoid leaving this task to the "night before" these levers are needed.

2. You may want to encourage students to begin collecting pictures from magazines and other sources (for their collage) as part of the introduction to this subtask. They will need some time to collect these resources.

3. Review "Background Information" found in the Overview section, if necessary.

Teacher Reflections

Outline potential changes/improvements you would make to the subtask, or raise questions/concerns for future thought.

Record decisions you wish to pass on in the Subtask Notes; contents of this field are not passed along in the published unit.

Description

Students will explore, through discussion and research, how consumer expectations and needs, as well as economic and environmental factors, affect the development and marketing of many consumer products.

Catholic Graduate Expectations:
CGE 2 - The Catholic Learner is an effective communicator who speaks, writes, and listens honestly and sensitively, responding critically in light of gospel values.
CGE 2a - The Catholic Learner listens actively and critically to understand and learn in light of gospel values.
CGE 2b - The Catholic Learner reads, understands, and uses materials effectively.
CGE 2c - The Catholic Learner presents information and ideas clearly and honestly and with sensitivity to others.

Expectations

8s110 A – identify the kinds of information that assist consumers in making a decision about buying a product (e.g., information on performance, durability, safety, benefits to health);

8s111 A – identify consumer expectations regarding the function and effectiveness of a product, using information collected in a survey they made, and recognize that expectations may change;

8s113 A – identify the personal and societal factors that determine whether a product is used;

8s114 A – evaluate product manuals or help screens (e.g., a manual for a video recorder), focusing on clarity, thoroughness, and general "user-friendliness", and identify ways of making the product easier to use;

8s115 A – assess the impact on the environment of the use and disposal of various products (e.g., motor oil, Freon);

8s116 A – explain the economic, social, and environmental factors that can determine whether a product is manufactured (e.g., costs of materials and equipment, availability of skilled labour, potential harmfulness of the product);

8s102 – compile qualitative and quantitative data gathered through investigation in order to record and present results, using diagrams, flow charts, frequency tables, graphs, and stem-and-leaf plots produced by hand or with a computer (e.g., produce and analyse a quotation to complete a job in the home);

8s103 A – communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes and descriptions, charts, graphs, drawings, and oral presentations (e.g., make a display in which they compare the ways in which a closed pneumatic system and a hydraulic system operate the same size of cylinder);

8s101 A – use appropriate vocabulary, including correct science and technology terminology, to communicate ideas,

Groupings

Students Working As A Whole Class
Students Working Individually

Teaching / Learning Strategies

Research
Discussion
Independent Study
Learning Log/ Journal

Assessment

Assessment Strategies

Questions And Answers (oral)
Essay
Conference
Learning Log
Self Assessment

Assessment Recording Devices

Checklist
Rubric

	procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);
8s107 A	– explain how human weight, height, age, sex, and physical capability affect the design of products (e.g., car seats, snowmobiles, zippers);
8s108 A	– analyse the use of symmetry in the ergonomic design of objects and systems (e.g., office furniture, computer equipment);
8e2 A	• use writing for various purposes and in a range of contexts, including school work (e.g., to write technical instructions, to clarify personal concerns, to explore social issues, to develop imaginative abilities);
8e46 A	• provide clear answers to questions and well-constructed explanations or instructions in classroom work;
8a25 A	• produce two- and three-dimensional works of art that communicate a variety of ideas (thoughts, feelings, experiences) for specific purposes and to specific audiences, using a variety of art forms;
8a26	• define the principles of design (emphasis, balance, rhythm, unity, variety, proportion), and use them in ways appropriate for this grade when producing and responding to works of art;
8e49 A	• express and respond to a range of ideas and opinions concisely, clearly, and appropriately;
8s89 A	• demonstrate understanding of the factors that can affect the manufacturing of a product, including the needs of the consumer.

Teaching / Learning

The focus of this two-part subtask is how consumer expectations and needs, as well as economic and environmental factors, affect the development and marketing of many consumer products.
Factors students may consider during this subtask include:
i) consumer's physical characteristics (e.g., weight, height, gender, body shape, age, etc.)
ii) buying trends (e.g., fashion, toys, electronics, cell phones, etc.)
iii) product's operational efficiency (e.g., how easy to operate, open, close, move up or down, etc.)
iv) ergonomic design (e.g., comfort, effectiveness in meeting consumer needs, etc.)
v) safety (e.g., sharp edges, weight of materials, electric current, easy-to-follow instructions, etc.)
vi) durability (e.g., standing up to wear and tear, strength of material, etc.)
vii) aesthetics (e.g., shape, appearance, texture, colour, patterns, etc.)
viii) material/product costs (e.g., need to stay within a budget, quality versus quantity, etc.)
ix) environmental issues (e.g., potential health benefits, harmfulness of the product, etc.)
x) moral and ethical issues (e.g., Church teachings regarding development and marketing of certain products, etc.)

These factors will be investigated within the context of class discussions and an independent research project.

Activity #1

1. The teacher can introduce this subtask by providing students with the following questions so that they can individually brainstorm some initial written responses in point form, using their learning logs:
i) When a company begins to design a product what are some of the most important factors that they need to consider as part of this design process?
ii) When a consumer is thinking about buying products (possibly more expensive items), what are some of the most important qualities of the products that they might consider before they make their purchases?
Since this is an opportunity to brainstorm ideas, these questions are open-ended. If students need further guidance or assistance, the teacher could provide some categories such as “personal,” “social,” “economic,” “environmental,” “product quality,” to encourage some/greater reflection.

2. The teacher can then lead a whole class discussion of students' ideas and categorize student responses on a chart created on the chalkboard, using some of the categories mentioned above.

3) The teacher could then ask students to reflect on the following:
i) As a Catholic Christian person, reflect on whether or not there are any moral or ethical considerations to be made when certain products are considered for design, production, marketing, or purchase.
ii) Is what is important to a company in their designs of new products the same as/similar to what is important to consumers when they are considering the purchase of new products?
Students can discuss answers to these questions as a class, some or all of this information could be recorded on the chalkboard, and students could then copy the teacher-recorded information into their learning logs.

4. The teacher should then take about 15 minutes to introduce the new concepts of “aesthetics” and “ergonomics” orally. When introducing “aesthetics” (i.e., appreciation of the beauty in something), consider shape, appearance, texture, colour, patterns, and design. “Ergonomics” refers to the study of the mental and physical capacities of persons in relation to the demands made upon them by various kinds of work. When considering the ergonomic design of a product, the producer is looking at ways that the product can be created to operate efficiently, to be comfortable for the consumer, and to be effective in meeting consumer needs. The teacher could then lead a brief class discussion that focuses on the aesthetic value of certain pieces of artwork (pre-selected by the teacher), or the ergonomic design of certain chairs (maybe an office chair that can be found in the school), or computer equipment, in light of the information that the teacher has just provided for students in introducing these two new concepts (i.e., “aesthetics” and “ergonomics”).

5. In order to give students an opportunity to apply what has been shared/learned so far in this subtask, the teacher could have students complete one of these two optional activities:
i) The teacher could supply students with different copies of the "Consumer Report." Ask students to select a consumer product that has been reviewed in one copy of the “Consumer Report” (the version for kids or the one for adults). Students could record in their learning logs what the strengths and weaknesses of their selected product are according to the categories under which the product is reviewed. The teacher could encourage the students to consider some of the categories that were recently discussed in class (e.g., economic, social, personal, environmental, aesthetical, ergonomic design, etc.). “Consumer Report” magazines can be found in local libraries.
ii) Provide students with BLM 2.1 (Comparison Chart) and direct students to complete the chart by comparing the strengths and weaknesses associated with the production and sales of electric cars versus cars with combustion engines, under the categories (previously discussed) listed on the chart. This is an activity that could be completed as a class or independently.

Activity #2

The teacher can then introduce an independent research project to students. Students can select one of the three topics outlined on BLM 2.2 (Research Assignment) to deal with in their research report. Students could be given approximately two weeks to complete this assignment. A conference time could be set up for the teacher to meet with each student after students have had about a week to complete an outline or overview for their report. This would provide the teacher with the opportunity to ensure that students are “on track” with regard to meeting the criteria set out for them. The criteria for this outline and for the overall project is indicated on BLM 2.2 (Research Assignment). Students could also be given an in-class work period during the first week of the assignment and another in-class work period during the second week of the assignment. Once again, this would allow the teacher to monitor student progress during the research reports' development. BLM 2.3 (Student Checklist) can serve as a self-assessment checklist for students as they proceed through their project work.

The teacher should review all three research project options with students and be prepared to answer any questions related to the criteria or timeline which the teacher sets out for them. Review the students checklist (BLM 2.3 - Student Checklist) and the assessment rubrics (BLM 2a and 2b) together to clarify the basis for their evaluation.

Adaptations

Refer to the Notes to Teacher in the Unit Overview for adaptation ideas for students with learning and/or physical challenges as well as for students identified as ESL.

Activity #1, part 5 might serve to provide appropriate options as substitutes for the independent research assignment. The "Consumer Report" activity or the comparison chart for the two types of cars could be completed by those students who require significant program adaptations (in place of the independent research project).

Resources

Rubric 2a for Communication

Rubric 2b for Presentation

BLM 2.3 Student Checklist 2.3_rating scale.cwk

BLM 2.2 Research Assignment 2.2_designing a product.cwk

BLM 2.1 Comparison Chart	2.1_comparison.cwk
Commitment: Faith through Service	Catholic Curriculum Cooperative

Notes to Teacher

1. The issue of consumerism as this relates to social justice, and related Church teachings could be further developed through the Family Life/Religion program.

2. This assignment is being introduced as the second subtask so that students can work on the Activity #2 assignment independently over the course of the completion of the remaining subtasks. This subtask is designed to address a large number of specific expectations under "Relating Science and Technology to the World Outside the School" in a way that provides a balance in class discussion/teacher direction and independent research work.

3. A timeline for Activity #1 and Activity #2 has been suggested throughout the "Teaching/Learning Strategies" section. The teacher should plan additional time for work periods and presentations. Be sure to provide additional time, also, to check with students on their progress throughout their independent research/report writing work.

4. The teacher should introduce the purpose of a **learning log** to the students (if they have had little experience with them in the past). The learning log is an ongoing record by the student of what she/he is doing while working on a particular task or assignment and it makes visible what a student is thinking and/or doing through frequent recordings over time.

5. Students will need time to present the results of their research assignment. Remember to factor in the necessary presentation time as you begin this unit. If there is not enough time for a presentation, students could submit their work for evaluation purposes.

6. A checklist has been provided for student to help them monitor their progress throughout this subtask. Students can use this checklist for self-assessment purposes. Two assessment rubrics can be used by the teacher as formative assessment tools. These rubrics address student efforts during the larger group discussion that precedes the independent research project, and the work done for the research project itself.

Teacher Reflections

Outline potential changes/improvements you would make to the subtask, or raise questions/concerns for future thought.

Record decisions you wish to pass on in the Subtask Notes; contents of this field are not passed along in the published unit.

Description

A) Students will discover the differences in the levels of compressibility between air and water in a closed system. Students will do this by using two plastic bottles, one which is capped and filled with air and the other which is capped and filled with water. Both bottles will be squeezed to demonstrate the differences noted above.

B) Students will investigate the effects of pressure by moving an object using two different sized syringes. They will move liquid and gas from a smaller syringe to a larger and then reverse the syringes to go from larger to smaller. They will be investigating the use of pnuematic and hydraulic systems and the advantages of using a smaller or larger system.

Catholic Graduate Expectations:
CGE 3 - The Catholic Learner is a reflective, creative, and holistic thinker who solves problems and makes responsible decisions with an informed moral conscience for the common good.
CGE 3c - The Catholic Learner thinks reflectively and creatively to evaluate situations and solve problems.
CGE 4f - The Catholic Learner applies effective communication, decision-making, problem-solving, and resource management skills.

Expectations

8s87	• demonstrate an understanding of the factors that contribute to the efficient operation of mechanisms and systems;
8s90 A	– explain how forces are transferred in all directions in fluids (Pascal's law);
8s91	– describe in quantitative terms the relationship between force, area, and pressure;
8s93 A	– compare the effect of pressure on a liquid (e.g., on water in a syringe) with the effect of pressure on a gas (e.g., on air in a syringe);
8s101 A	– use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);
8s103 A	– communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes and descriptions, charts, graphs, drawings, and oral presentations (e.g., make a display in which they compare the ways in which a closed pneumatic system and a hydraulic system operate the same size of cylinder);
8s102 A	– compile qualitative and quantitative data gathered through investigation in order to record and present results, using diagrams, flow charts, frequency tables, graphs, and stem-and-leaf plots produced by hand or with a computer (e.g., produce and analyse a quotation to complete a job in the home);

Groupings
Students Working In Small Groups
Students Working Individually

Teaching / Learning Strategies
Brainstorming
Discussion
Experimenting
Learning Log/ Journal

Assessment
Students will use the learning log to record predictions, observations, reflections, and responses to their conclusions about the compressibility of a liquid and a gas.
They will also draw diagrams, record observations, and, through discussion in their groups, will record in their learning log the outcomes of their investigation of the effects of pressure in enclosed systems.

Assessment Strategies
Learning Log
Observation
Questions And Answers (oral)
Self Assessment

Assessment Recording Devices
Rubric

Teaching / Learning

Activity #1

Have students work in groups of four or five.

1. Have two plastic bottles prepared, one capped and filled with water and another capped and filled with air. Have one of each per group. (Caution is advised that students do not squeeze the bottles until they burst).

2. The teacher leads a discussion of prior knowledge about the particle theory (e.g., attractive forces between particles are stronger in a liquid than in a gas, therefore, particles are closer together and move less in a liquid than they do in a gas). Have the students explain what they know about the particles enclosed in each of the bottles (e.g., both have moving particles, the one with air has more movement and more spaces between the particles).

3. Have the students predict what they think might happen when the bottles are squeezed (e.g., the bottle with air is compressible and the bottle with water is not).

4. Have the students squeeze the bottles to observe the results, let them compare their results.

5. Elicit an explanation as to why the bottle with air is squeezable and the one with water is not (e.g., air is compressible and water is not).

6. Students make an entry in their learning log recording their predictions, observations, and explanation of the outcome.

Activity #2

Review Hydraulic and Pneumatic Systems (see Notes to Teacher following) with the students.
Safety procedures need to be reinforced: proper usage of syringes (not as weapons), clean up any spills immediately, and keep work area organized and tidy. Remind/inform students that 1 cm^3 =1 mL. Therefore a 20 cm^3 syringe = 20 mL.

Students do investigation in small groups of four or five. Distribute copies of BLM 3.1 (Syringe System Setup) and BLM 3.2 (Syringe System Investigation) to students. This will help them with experiment setup and with how to complete the experiment. There is also a checklist for students to aid them in completing the entire task successfully.

1. Experiment setup: (see diagram on BLM 3.1)
i) Clamp a 20 mL syringe to a retort stand.
ii) Using clear plastic tubing connect a 10 mL syringe and tape it to the desk top.
iii) Pull the plunger up fully, filling the syringe with 20 mL of air. Make sure the 10 mL syringe's plunger is totally pushed in.
iv) To the top of the plunger, add a cardboard square to act as a platform for a 200 g mass.
v) In front of the 10 mL syringe, place an object (e.g., small block). Place the 200 g mass on top of the 20 mL syringe and observe. (The plunger will be pushed down by the weight, the air pushes the plunger of the 10 mL

syringe, which pushes the object along the desk's surface.)
vi) Measure the distance the object was moved.

2. Repeat the same experiment but this time clamp the 10 mL syringe to the retort stand and tape the 20 mL syringe to the desk top.

3. Have students record their observations in the learning log. They should reflect on the difference observed between the two systems.

4. Repeat the same experiments, this time filling the clamped syringe with water instead of air.

5. The students again record their observations and as a group, draw conclusions and articulate reasoning to back their conclusions.

6. Calculations could be made to calculate the pressure for each experiment. **(Pressure = Force/Area)** One Newton of force is required to lift a 100 g mass. (See Background Notes on "What Is Force and How It Is Measured?") A 200 g mass is used here, requiring 2 Newtons of force. Students will have to calculate the area of the small syringe and the area of the large syringe by measuring the radius of the larger opening at the top of both of the syringes. Recall that, area = pi (3.14) times radius squared. Pressure should be reported in newtons (N).

Adaptations

Refer to the Notes to Teacher in the Unit Overview for adaptation ideas for students with learning and/or physical challenges as well as for students identified as ESL.

Resources

- **Rubric 3 for Syringe System Investigation**
- **BLM 3.2 Syringe System Investigation** 3.2.cwk
- **BLM 3.1 Syringe System Setup** 3.1_syringesetup.cwk
- **2 L plastic pop bottles**
- **water**
- **cardboard squares (4 cm x 4 cm)**
- **tape**

- **retort stands**
- **20 mL syringes**
- **10 mL syringes**
- **clamps**
- **200 g masses**
- **clear plastic tubing**
- **small wooden blocks**

Notes to Teacher

1. The teacher should become familiar with the following terms: **qualitative data** (information gathered in observations in which no measurement takes place) versus **quantitative data** (data that consists of numbers and/units of measure, obtained through measurement and through mathematical calculations).

2. A review of the **Particle Theory** is recommended as part of Activity #1.

3. The teacher needs to review **Pascal's Law** (Blaise Pascal, a French mathematician who lived 350 years ago, was noted for his intelligence even as a child. He invented the hydraulic press and the syringe. His law states that an enclosed liquid transmits pressure equally in all directions. When force is applied from outside, the confined fluid is still distributed evenly in all directions against the inside surface of the container. The formula for this is **P**ressure = **F**orce / **A**rea.)

4. Discussion should occur in the form of review about their knowledge of hydraulic and pnuematic systems. **Hydraulic systems** use liquid in an enclosed space to transmit force from one place to another, where **pneumatic systems** use compressed gas to transmit forces. Remind them that usually oil is used in hydraulics since it works as a lubricant and non-corrosive. Generally air is used in pneumatics, since air is in abundance and also does not pollute the atmosphere when it is released. A hydraulic system works by having an effort force exerted on a smaller area, which then moves through a system into a bigger area where the force is amplified. Hydraulic systems are used by construction machinery, car brakes, air planes, etc. Pneumatic systems are used when there needs to be a larger force and the area in the system is limited, examples would be the dentist drill, large truck brakes, some tools, etc.

5. Review "Background Information" found in the Overview section, if necessary.

Teacher Reflections

Outline potential changes/improvements you would make to the subtask, or raise questions/concerns for future thought.

Record decisions you wish to pass on in the Subtask Notes; contents of this field are not passed along in the published unit.

Description

Students will investigate and measure the force of friction that affects the movement of an object, **which ultimately has an effect upon the mechanical efficiency of that object.** Through hands-on activities, students will explore the concept of friction. An object will be pulled across a variety of different textured surfaces and a Newton scale will be used to measure the frictional forces involved.

Catholic Graduate Expectations:
CGE 3 - The Catholic Learner is a reflective, creative and holistic thinker who solves problems and makes responsible decisions with an informed moral conscience for the common good.
CGE 3c - The Catholic Learner thinks reflectively and creatively to evaluate situations and solve problems.
CGE 4f - The Catholic Learner applies effective communication, decision-making, problem-solving, and resource management skills.

Expectations

8s95 A – investigate and measure forces that affect the movement of an object (e.g., friction);

8s99 – 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);

8s100 – plan investigations for some of these answers and solutions, identifying variables that need to be held constant to ensure a fair test and identifying criteria for assessing solutions;

8s101 A – use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);

8s102 A – compile qualitative and quantitative data gathered through investigation in order to record and present results, using diagrams, flow charts, frequency tables, graphs, and stem-and-leaf plots produced by hand or with a computer (e.g., produce and analyse a quotation to complete a job in the home);

8s103 A – communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes and descriptions, charts, graphs, drawings, and oral presentations (e.g., make a display in which they compare the ways in which a closed pneumatic system and a hydraulic system operate the same size of cylinder);

Groupings

Students Working In Small Groups
Students Working Individually
Students Working As A Whole Class

Teaching / Learning Strategies

Brainstorming
Collaborative/cooperative Learning
Inquiry
Experimenting
Concept Clarification

Assessment

Student contributions during the brainstorming session are very important as part of the overall process of new learning. The greater the details in the student report, outlining the experiment, the better. Emphasize to students that they are to clearly describe every aspect of their experiments, in detail. Observation, by the teacher, of each group of students is necessary to help keep students on task and so as to easliy address any concerns or questions as soon as they arise.

Assessment Strategies

Questions And Answers (oral)
Performance Task

Assessment Recording Devices

Rubric

Teaching / Learning

1. Begin by having a class discussion about how friction affects the movement of objects across different surfaces. Elicit this information from your students. Introduce the term "mechanical efficiency" (see Background Information section). Ask students to explain the link between mechanical efficiency and friction (e.g., the mechanical efficiency of a moving object is reduced by frictional forces acting on that object).

2. Conduct a teacher-led brainstorming session, with the whole class, about factors that determine how much friction there will be between two surfaces that are rubbed together (see Supplementary Teacher Background Information in Notes to Teacher section). Record this information on the chalkboard.

3. Conduct a second teacher-led brainstorming session about the ways in which friction between two surfaces can be reduced (see Supplementary Teacher Background Information in Notes to Teacher section). Record this information on the chalkboard.

4. Students should record the information gathered from their group discussion into their notebooks.

5. Make enough copies of BLM 4.1 (Slow Down) for each student, including the checklist for each student and the rubric for teacher assessment. Distribute and review each of these handouts together.

6. Have students conduct the investigation outlined on BLM 4.1 (Slow Down).

7. Students use checklist to help them ensure they have covered all necessary parts of the subtask successfully.

8. Provide time for each student to share at least one of the demonstrations that they create in part (d) of BLM 4.1 (Slow Down) with a designated (by the teacher) small group of students.

Adaptations

Refer to the Notes to Teacher in the Unit Overview for adaptation ideas for students with learning and/or physical challenges as well as for students identified as ESL.

Resources

- **Rubric 4 for Investigation of Friction**
- **BLM 4.1 Slow Down** 4.1_slowdown.cwk
- **2" x 4" blocks of wood (with hooks)**
- **8.5" x 11" sheets of coarse sandpaper**
- **Newton spring scales**
- **string**

- **lubricants (e.g., oil, grease, or wax)**
- **rollers (e.g., spools)**
- **ball bearings**
- **wheels**
- **bricks (optional)**
- **text books (optional)**
- **500 g masses**

Notes to Teacher

Supplementary Teacher Background Information
This information may assist you in facilitating the students in their brainstorming sessions.

Possible factors that determine how much friction there will be between two surfaces that are rubbed together are:

1. The amount of friction is affected by the nature of the rubbed materials.

2. The force of friction increases when the force pushing the surfaces together increases.
3. The frictional force is almost independent of the size of the area of contact.

Possible ways in which friction can be reduced:

1. Make the surfaces smoother by sanding and polishing.
2. Use a lubricant such as oil, grease, wax, or graphite.
3. Use rollers, ball bearings, or wheels.
4. Use streamlining, that is, change the shape to reduce air resistance or water resistance.

Teacher Reflections

Outline potential changes/improvements you would make to the subtask, or raise questions/concerns for future thought.

Record decisions you wish to pass on in the Subtask Notes; contents of this field are not passed along in the published unit.

Description

Students will come to an understanding of the term "velocity" and then determine the velocity ratio of various devices. These terms will be defined for students. Students, in groups, will conduct two experiments to find velocity ratio using levers and pulleys. Blackline master worksheets will be provided to students, containing a variety of exercises, to help solidify students' understanding of velocity and velocity ratio.

Catholic Graduate Expectations:
CGE 2 - The Catholic Learner is an effective communicator who speaks, writes, and listens honestly and sensitively, responding critically in light of gospel values.
CGE 2a - The Catholic Learner listens actively and critically to understand and learn in light of gospel values.
CGE 2b - The Catholic Learner reads, understands, and uses materials effectively.

Expectations

8s96 A – distinguish between velocity and speed (i.e., define velocity as speed in a given direction);

8s97 A – 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);

8s101 A – use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);

8s102 A – compile qualitative and quantitative data gathered through investigation in order to record and present results, using diagrams, flow charts, frequency tables, graphs, and stem-and-leaf plots produced by hand or with a computer (e.g., produce and analyse a quotation to complete a job in the home);

Groupings

Students Working As A Whole Class
Students Working In Small Groups

Teaching / Learning Strategies

Experimenting
Problem-solving Strategies

Assessment

Assessment Strategies

Performance Task
Questions And Answers (oral)

Assessment Recording Devices

Rubric

Teaching / Learning

1. Distribute a copy of BLM 5.1 (Velocity) and BLM 5.2 (Velocity Ratio) to each student.

2. Use these sheets as your vehicles for teaching the concepts of velocity and velocity ratio.

3. Have the students complete the work contained on the sheets as you guide students through them.

4. Make sure students understand the concepts involved before having them conduct the investigations which follow. Answers for these blackline masters can be found on BLM 6.8 (Answer Sheet).

5. Group the students based on the availability of materials in your school. Groups of five or six students are suggested.

6. Distribute a copy of BLM 5.3 (Velocity Ratio Using Levers) to each student.

7. Have each group of students set up their materials by following the procedure indicated on the blackline master.

8. Direct the students to conduct the investigation and complete the written work on BLM 5.3 (Velocity Ratio Using Levers).

9. Discuss the results of their investigation as a class. Make sure the students are able to calculate velocity ratio using the data recorded on their observation charts and the formula that is indicated on the blackline master.

10. Distribute a copy of BLM 5.4 (Velocity Ratio Using Pulleys) to each student.

11. Have the groups conduct the investigation of velocity ratio with pulleys, using the materials listed and the instructions provided on BLM 5.4 (Velocity Ratio Using Pulleys).

12. Using the results of their investigation, the students then complete the remainder of BLM 5.4 (Velocity Ratio Using Pulleys).

13. Review the worksheet together to make sure that the students understand the relationship between how far the effort force moves and how far the load force moves. Answers to the questions found in the "Conclusions" section can be found on BLM 6.8 (Answer Sheet).

14. If you feel that additional practice of calculations is required, for any of the students in your class, refer to any of the appropriate Ministry of Education approved Science and Technology textbooks for work samples and examples.

Adaptations

Refer to the Notes to Teacher in the Unit Overview for adaptation ideas for students with learning and/or physical challenges as well as for students identified as ESL. Please see BLM 5.5 (Observations Table).

Resources

Rubric 5 for Velocity Ratio Investigations	
BLM 5.4 Velocity Ratio Using Pulleys	5.4_PulleysVR.cwk
BLM 5.5 Observations Table	5.5_observtable.cwk
BLM 5.1 Velocity	5.1_Velocity.cwk
BLM 5.2 Velocity Ratio	5.2_velocity ratio.cwk
BLM 5.3 Velocity Ratio Using Levers	5.3_Levers VR.cwk
1 cm square craft wood (60 cm in length)	

- pulleys (single)
- heavy string
- 4" x 1/4" bolts and nuts
- tape
- metre sticks
- 500 g masses
- retort stands
- rulers (cm)
- student desks
- ring clamps

Notes to Teacher

1. A machine is a device used to apply or transmit mechanical power. Its function may be to overcome resistance to motion or to change shape or size at one end of an object by applying a force, often at some other point. The multiplication of forces is possible in mechanical devices, enabling work to be performed that human strength could not manage alone. The efficiency and the advantage gained from the use of any machine can be quantified by calculating simple ratios (as outlined in subtasks 5 and 6).

2. The focus for this subtask is "velocity" and "velocity ratio." Velocity can be considered to be speed in a given direction. Velocity ratio is the ratio of the distance the effort force moves to the distance the load force moves. Students need to have a clear understanding of these concepts before beginning the investigations and to help with their understanding of "efficiency" in subtask 6.

3. Your students are asked to create a table, for recording their observations, on BLM 5.3 (Velocity Ratio Using Levers). A sample copy of this table is found on BLM 5.5 (Observations Table). This table could be reproduced for students with special learning needs who may experience great difficulty in trying to produce this table independently.

4. Be sure to caution your students to handle the 500 g masses with care so as not to drop them. Instruct students to use safety glasses throughout the investigation.

5. Answers for the worksheet are found on BLM 6.8 (Answer Sheet).

6. Students' work for this subtask can be assessed using the rubric provided.

Teacher Reflections

Outline potential changes/improvements you would make to the subtask, or raise questions/concerns for future thought.

Record decisions you wish to pass on in the Subtask Notes; contents of this field are not passed along in the published unit.

How Efficient Is It?

Subtask 6

~ 120 mins

Description

Students will determine mechanical advantage and calculate the efficiency of simple mechanical systems (involving pulleys and levers). Students will investigate this through the use of a simple lever system and then, students will construct a pulley system. Calculations will be made using these systems. The work in this subtask will link back to the knowledge gained about velocity ratio in the previous subtask.

Catholic Graduate Expectations:
CGE 5 - The Catholic Learner is a collaborative contributor who finds meaning, dignity, and vocation in work which respects the rights of all and contributes to the common good.
CGE 5a - The Catholic Learner works effectively as a interdependent team member.
CGE 2c - The Catholic Learner presents information and ideas clearly and honestly and with sensitivity to others.

Expectations

8s98 A – predict the mechanical efficiency of using different mechanical systems (e.g., a winch).

8s101 A – use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);

8s102 A – compile qualitative and quantitative data gathered through investigation in order to record and present results, using diagrams, flow charts, frequency tables, graphs, and stem-and-leaf plots produced by hand or with a computer (e.g., produce and analyse a quotation to complete a job in the home);

Groupings

Students Working As A Whole Class
Students Working In Small Groups

Teaching / Learning Strategies

Experimenting
Problem-solving Strategies

Assessment

Assessment Strategies

Performance Task
Questions And Answers (oral)

Assessment Recording Devices

Rubric

Teaching / Learning

1. Keep the student groups the same as for subtask 5.

2. Distribute copies of BLM 6.1 (Mechanical Advantage - Levers).

3. Instruct the students to set up their apparatus similar to the way they did for the velocity ratio experiment using the levers.

4. Have the groups complete BLM 6.1 (Mechanical Advantage - Levers) by following the instructions on the sheet.

5. Review what has been previously discovered about mechanical advantage before proceeding to the investigation of mechanical advantage with pulleys.

6. Distribute a copy of BLM 6.2 (Mechanical Advantage - Pulleys).

7. Instruct the students to set up their apparatus similar to the way they did for the velocity ratio experiment using pulleys.

8. Have students follow the instructions given on BLM 6.2 (Mechanical Advantage - Pulleys) and complete their investigation of mechanical advantage using pulleys.

9. Distribute a copy of BLM 6.3 (VR/MA with Levers) to each student.

10. Work your way through this blackline master with the whole class, having the students complete the worksheet together.

11. Refer to BLM 6.8 (Answer Sheet) for the correct answers and have students check their work as you supply the correct answers, once students' original answers have been completed.

12. Distribute a copy of BLM 6.4 (Summary Sheet (MA/VR)) to each student. Allow them to complete it. Make sure that students have a good understanding of the relationship between mechanical advantage and velocity ratio.

13. Introduce the term "efficiency" to the students. As a group, come up with a definition for "efficiency."

14. Distribute a copy of BLM 6.5 (Efficiency) to each student.

15. Discuss the formula for finding percentage efficiency and complete the problem at the top of the page.

16. Allow the students to answer the remaining questions for BLM 6.5 (Efficiency) in the spaces provided.

17. There is space at the bottom of the page for students to write a definition of efficiency.

18. If you feel that additional practice in calculating mechanical advantage and/or percentage efficiency is required, for any of the students in your class, refer to any of the appropriate Ministry of Education approved Science and Technology textbooks for work samples and examples.

19. Answers for BLM 6.4 (Summary Sheet (MA/VR)) and 6.5 (Efficiency) are found on BLM 6.8 (Answer Sheet).

Adaptations

Refer to the Notes to Teacher in the Unit Overview for adaptation ideas for students with learning and/or physical challenges as well as for students identified as ESL. Please see BLM 6.6 (Observations Tables).

Resources

Rubric 6 for MA/ME Investigations

BLM 6.1 Mechanical Advantage - Levers 6.1_MALevers.cwk

BLM 6.2 Mechanical Advantage - Pulleys 6.2_MAPulleys.cwk

BLM 6.3 VR/MA with Levers	6.3_VRMALevers.cwk
BLM 6.4 Summary Sheet (MA/VR)	6.4_SummarySheet.cwk
BLM 6.5 Efficiency	6.5_Efficiency.cwk
BLM 6.6 Observations Tables	6.6_observtable.cwk
BLM 6.7 Multiple-Choice Test	6.7_MCTest.cwk
BLM 6.8 Answer Sheet	6.8_Answers.cwk

- **4" x 1/4" bolts and nuts**
- **1 cm square craft wood (60 cm lengths)**
- **heavy string**
- **retort stand**
- **ring clamp**
- **ruler (cm)**
- **Newton spring scale**
- **500 g masses**
- **student desks**
- **metre sticks**

Notes to Teacher

1. The focus of this subtask is “mechanical advantage” and “mechanical efficiency.”

2. Mechanical advantage is a number that tells how many times a machine multiplies the effort force. Mechanical advantage is calculated by dividing the load force by the effort force. Be sure that the students have a clear understanding of mechanical advantage before beginning the investigations. Also help with their understanding of “efficiency” (to be looked at later in this subtask).

3. Your students are asked to create a table, for recording their observations on BLMs 6.1 (Mechanical Advantage - Levers) and 6.2 (Mechanical Advantage - Pulleys). Sample copies of these tables are found on BLM 6.6 (Observations Tables). This table could be reproduced for students with special learning needs who may experience great difficulty in trying to produce this table independently. Be sure to caution your students to handle the 500 g masses with care so as not to drop them. Instruct students to use safety glasses throughout the investigation.

4. Mechanical efficiency looks at the relationship between mechanical advantage and velocity ratio. The result is expressed as a percent. To calculate mechanical efficiency, divide the mechanical advantage by the velocity ratio and then multiply the result (quotient) by 100. No machine is 100% efficient. Factors such as friction and gravity reduce the efficiency of machines.

5. Answers for the worksheet are found on BLM 6.8 (Answer Sheet).

6. Students’ work for this subtask can be assessed using the rubric provided.

7. A multiple-choice test can be found as part of the blackline masters for this subtask (BLM 6.7). It is suggested that this test be used as a summative assessment tool at the end of the unit (after completion of the culminating task). Students should be advised to review their learning log entries (from previous subtasks) and the worksheets associated with subtasks 5 and 6 in preparation for this test. Give students notice as soon as possible that there will be a test at the end of this unit so that they have time to prepare themselves to write it.

Teacher Reflections

Outline potential changes/improvements you would make to the subtask, or raise questions/concerns for future thought.

Record decisions you wish to pass on in the Subtask Notes; contents of this field are not passed along in the published unit.

Description

Students will construct a lift system, using a set of plans that have been supplied, that incorporates the use of hydraulics. They will incorporate appropriate levers and ways of linking the components of this system into their product. Students will then be required to calculate the mechanical efficiency of the lift system.

Catholic Graduate Expectations:
CGE 3 - The Catholic Learner is a reflective, creative, and holistic thinker who solves problems and makes responsible decisions with an informed moral conscience for the common good.
CGE 3b - The Catholic Learner creates, adapts, evaluates new ideas in light of the common good.

Expectations

8s94	– explain, using their observations, how the use of appropriate levers and ways of linking the components of fluid systems can improve the performance of the systems (e.g., systems in a steam shovel, in a robot);
8s101 A	– use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);
8s99	– 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);
8s98 A	– predict the mechanical efficiency of using different mechanical systems (e.g., a winch).
8e46	• provide clear answers to questions and well-constructed explanations or instructions in classroom work;
8e47	• listen attentively to organize and classify information and to clarify thinking;
8s104	– design and make a mechanical system that is operated by hydraulic or pneumatic power;
8s105	– select and use appropriate materials and strategies to make a product;
8s102 A	– compile qualitative and quantitative data gathered through investigation in order to record and present results, using diagrams, flow charts, frequency tables, graphs, and stem-and-leaf plots produced by hand or with a computer (e.g., produce and analyse a quotation to complete a job in the home);
8m18	– use estimation when solving problems involving operations with whole numbers, decimals, percents, integers, and fractions, to help judge the reasonableness of a solution;
8m70	– collect and organize categorical, discrete, or continuous primary data and secondary data (e.g., electronic data from websites such as E-Stat or Census At Schools), and display the data in charts, tables, and graphs (including histograms and scatter plots) that have appropriate titles, labels (e.g., appropriate units

Groupings

Students Working Individually
Students Working In Small Groups

Teaching / Learning Strategies

Collaborative/cooperative Learning
Fair Test
Model Making
Problem-solving Strategies

Assessment

Assessment Strategies

Performance Task
Questions And Answers (oral)
Learning Log

Assessment Recording Devices

Anecdotal Record

marked on the axes), and scales (e.g., with appropriate increments) that suit the range and distribution of the data, using a variety of tools (e.g., graph paper, spreadsheets, dynamic statistical software);

Teaching / Learning

Students should be provided with BLMs 7.1 to 7.9. These "Tips," "Assembly Instructions," and schematic drawings provide students with clear directions for constructing a "Hydraulic Test Lever". BLM 7.9 (Instructions for Lever Test) provides students with instructions for testing their device.

Give students time to review the instructions, allowing them to do this independently. Once they have reviewed all of the instructions and schematic drawings, ask each student to write out answers to the following questions in their learning logs:
a) Does this "Hydraulic Test Lever" appear to be of solid, stable construction? What part(s) of the system provide stability and strength? (E.g., the length of the base frame, cross braces)
b) What purpose does the pivot assembly serve? Could this device operate just as effectively without the pivot assembly? (E.g., the syringe is not just moving straight up and down, but through a slightly curved path as well. If the syringe is unable to pivot, the plunger would only extend a short distance before siezing.)
c) What are the advantages of using a lever as part of this device? (E.g., reduces the effort needed to move an object, increases mechanical advantage of the device.)
d) What are the advantages of using a hydraulic assembly as part of this device? (E.g., the forces transmitted are multiplied, an effort force exerted on a small area is transmitted through the system onto a large area where the force is magnified, a large ratio of large piston (supporting piston) to small piston (pushing piston) will multiply the force considerably.)

Accuracy in construction is very important to the overall operation of this device. Instructions should be followed very carefully by students.

Once students have completed the construction of their lift system, have them discuss their answers to the two questions that they wrote answers for related to stability and the pivot assembly. Have them make any necessary additions or changes to their answers (using a different colour ink or marker than was used for their original answers). The teacher then needs to evaluate students' original responses and the additions/changes that students made to their original answers (which indicate the learning that has taken place over the course of the construction work).

Students must then calculate mechanical advantage and calculate the efficiency of the mechanical device. Students should attach a load force of about 200 g to the load end of the boom. They can then test the lift system five times, moving the adjustment pin into a different lever advantage adjustment hole each time (thus changing the location of the effort force on the lever, in relation to the fulcrum, each time). Results could be recorded on a graph of their choice. It can then be determined as to which lever position provides the greatest/least mechanical efficiency. Students can then add a statement to their learning logs that reflects their understanding of how the lever position affects mechanical efficiency.

Refer to “Background Information” under “Lever,” Mechanical Advantage,” and "Mechanical Efficiency” sections:
1. Velocity Ratio = (distance moved by effort force) / (distance moved by load force)
2. Recall the rule that E x EA = R x RA (“E” is effort force, “EA” is distance from where effort force is applied to fulcrum, “R” is load force, and “RA” is distance from load force to fulcrum). Since we know what “R” is (200 g), and we can find “EA” and “RA” by measuring these distances, “E” can then be calculated.
3. Mechanical Advantage can then be calculated: load force / effort force (load force = output force and effort force = input force).
4. Mechanical Efficiency = (mechanical advantage / velocity ratio) x 100, and can be calculated using the data gathered from calculations in steps 1, 2, and 3 above.

The teachers can pool the results of their tests with those of their peers to check for consistency and the level of accuracy of calculations. The teacher may also want to run these same tests in order to come up with an accurate set of answers to be used for comparison purposes with the students' results. The results of their work related to students' calculations becomes the final part of the assessment associated with this subtask.

Adaptations

Refer to the Notes to Teacher in the Unit Overview for adaptation ideas for students with learning and/or physical challenges as well as for students identified as ESL.

Students who experience difficulty with fine motor control or who might find it difficult to follow the detailed schematic drawings might be paired with another student in the class who can more easily manage this activity. If this is not possible, the teacher may have to provide more one-on-one guidance and support for these students.

Resources

Rubric 7 for Hydraulic Test Lever Activity	
BLM 7.1 Hydraulic Test Lever - Tips	tips.pdf
BLM 7.2 Assembly Instructions	7.2_assembly1.pdf
BLM 8_ Assembly Instructions	8_assembly2.pdf
BLM 7.4 Base Frame Design	7.4_base frame.cwk
BLM 7.5 Tower Frame Design	7.5_tower frame.cwk
BLM 7.6 Boom Frame Design	7.6_boom frame.cwk
BLM 7.7 Syringe Assembly	7.7_syringe assembly.cwk
BLM 7.8 Side View / Complete Assembly	7.8_Side View All.cwk

- **BLM 7.9 Instructions for Lever Test** 7.9_testing steps.pdf
- **1 cm square craft wood (Jinx wood)**
- **syringes 10 mL and 20 mL**
- **3/16" doweling**
- **electrical tape**
- **Carpenter's glue or glue guns**
- **hand-powered drills with 13/64" or 7/32" bits**
- **cardboard gussets**
- **steel or plastic squares**
- **mitre boxes**
- **hand saws**
- **cm rulers**
- **200 g masses**

Notes to Teacher

1. The purpose of the question, "Does this 'Hydraulic Test Lever' appear to be of solid, stable construction?" is to check students' background knowledge related to "Stability" (grade 3) and "Structural Strength and Stability" (grade 7). Students should understand the value of cross bracing and the strength associated with triangulation. They also need to understand the value of increasing the length of the base, which would create greater stability for the mechanical device if a heavier load was introduced.

2. Review students' written answers and additions/corrections to the initial two questions related to stabiltiy and the pivot assembly. Students need to understand that stability and the pivot assembly are important to the successful assembly of this mechanical device.

3. Since the performance task does not cover the full design process (e.g., the planning of your design has been provided for you), as part of your assessment you need to focus on whether or not they can successfully make this mechanical device, how well they explain the advantage of the lever and its various positions as part of this device, how well they can explain the advantages of using a hydraulic system to operate this device, whether or not their test results for mechanical efficiency reflect a clear understanding of this concept, and students' accuracy in recording the results of their tests (via their graphs).

4. The 200 g mass that is to be attached to the end of the boom, could be attached with something as simple as tape. No "basket-type" attachment is necessary.

5. Review "Background Information" found in the Overview section, if necessary.

Teacher Reflections

Outline potential changes/improvements you would make to the subtask, or raise questions/concerns for future thought.

Record decisions you wish to pass on in the Subtask Notes; contents of this field are not passed along in the published unit.

Toying With Efficiency

Subtask 8

~ 280 mins

Description

Students will participate in this culminating task as members of "Smooth Move Toy Company." Students will be expected to work individually and collaboratively as members of a team. These teams will consist of the same members who had been working together throughout the subtasks. They will work on designing, creating, testing (mechanical efficiency and consumer interest), and marketing a toy product. This toy product must be a mechanical device that is able to move a given object a specified distance through the use of hydraulic or pneumatic power.

An assessment rubric has been provided which focuses on the students' understanding of concepts, design skills, communication skills, and the students' ability to relate science and technology to the world outside the school. The rubric addresses all of the specific criteria set out in the culminating task description and on the blackline master that will be provided to students.

IT IS VERY IMPORTANT THAT YOU TAKE THE TIME NOW TO READ THROUGH THE COMPLETE DESCRIPTION OF THE CULMINATING TASK. THIS WILL HELP TO GIVE YOU A CLEAR SENSE OF WHAT THE SUBTASKS WILL BE LEADING TO AS YOU PROGRESS THROUGH THE UNIT WITH YOUR STUDENTS.

Catholic Graduate Expectations:
CGE 3 - The Catholic Learner is a reflective, creative, and holistic thinker who solves problems and makes responsible decisions with an informed moral conscience for the common good.
CGE 5f - The Catholic Learner exercises Christian leadership in the achievement of individual and group goals.
CGE 5g - The Catholic Learner achieves excellence, originality, and integrity in one's own work and supports these qualities in the work of others.
CGE 2c - The Catholic Learner presents information and ideas clearly and honestly and with sensitivity to others.

Expectations

8s94	– explain, using their observations, how the use of appropriate levers and ways of linking the components of fluid systems can improve the performance of the systems (e.g., systems in a steam shovel, in a robot);
8s98	– predict the mechanical efficiency of using different mechanical systems (e.g., a winch).
8s101	– use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);
8s103	– communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes and descriptions, charts, graphs, drawings, and oral presentations (e.g., make a display in which they compare the ways in which a closed pneumatic system and a hydraulic system operate the same size of cylinder);

Groupings

Students Working Individually
Students Working In Small Groups

Teaching / Learning Strategies

Case Study
Collaborative/cooperative Learning
Fair Test
Model Making
Problem-solving Strategies

Assessment

1. The design rubric (with the four categories indicated) that has been provided for the overall assessment of students' work is given in this subtask.

8s104 A	– design and make a mechanical system that is operated by hydraulic or pneumatic power;
8s105 A	– select and use appropriate materials and strategies to make a product;
8s106 A	– produce technical drawings and layout diagrams of a structure or a mechanical system that they are designing, using a variety of resources.
8s118 A	– evaluate their own designs against the original need, and propose modifications to improve the quality of the products.
8s117	– make informed judgements about products designed and made by others;
8e1	• communicate ideas and information for a variety of purposes (to evaluate information, to compare points of view) and to specific audiences, using forms appropriate for their purpose (e.g., a survey soliciting opinions on an environmental issue) and features appropriate to the form (e.g., focused questions);
8e46	• provide clear answers to questions and well-constructed explanations or instructions in classroom work;
8e47	• listen attentively to organize and classify information and to clarify thinking;
8e49	• express and respond to a range of ideas and opinions concisely, clearly, and appropriately;
8s87	• demonstrate an understanding of the factors that contribute to the efficient operation of mechanisms and systems;
8s88	• design and make systems of structures and mechanisms, and investigate the efficiency of the mechanical devices within them;
8s89	• demonstrate understanding of the factors that can affect the manufacturing of a product, including the needs of the consumer.
8s112	– recognize the importance of unbiased testing of control samples and independent evaluation of the test results before a product is manufactured;
8s111	– identify consumer expectations regarding the function and effectiveness of a product, using information collected in a survey they made, and recognize that expectations may change;
8m55	• model linear relationships graphically and algebraically, and solve and verify algebraic equations, using a variety of strategies, including inspection, guess and check, and using a "balance" model.
8m70	– collect and organize categorical, discrete, or continuous primary data and secondary data (e.g., electronic data from websites such as E-Stat or Census At Schools), and display the data in charts, tables, and graphs (including histograms and scatter plots) that have appropriate titles, labels (e.g., appropriate units marked on the axes), and scales (e.g., with appropriate increments) that suit the range and distribution of the

2. The need for observation (on the part of the teacher) during students' work is essential in determining students' individual contributions to group's construction work.

3. A brief conference with each student, as she/he is preparing her/his design, would provide the teacher with some insight into how effectively each student is using the background knowledge and experience gained from subtasks 1 to 7.

4. Reviewing students' answers to the questions outlined on BLM 8.3 (page 2), as part of the conference or independent of the conference, will also help the teacher to evaluate each student's individual contributions to this task and her/his understanding of efficiency, "selling features," suggested improvements, and real world applications of hydraulic and pneumatic power.

5. An anecdotal record of the results of each of these conferences could be completed.

Assessment Strategies

Classroom Presentation
Conference
Performance Task
Learning Log

Assessment Recording Devices

Anecdotal Record
Rubric

t tools (e.g., graph paper,

Teaching / Learning

1. Students are presented with the case study outlined on BLM 8.3 (Case Study Outline). Please read, duplicate, and distribute this to students. Time should be taken to carefully review the entire outline together. Review, with students, the rubric being used for the evaluation of students' work for this culminating activity.

2. Set up the timeline dates with students so that they can record them on their copy of BLM 8.3 (Case Study Outline). Students will then have a better idea of how to budget their time most effectively.

3. **Safety Considerations:**
Please refer to safety procedures outlined in the Overview section. Give specific consideration to the safe use of saws, careful use of any hot glue (with cold water available to soothe burns on hands), the need for safety goggles to be worn during construction (e.g., sawing, drilling, and sanding), the pressure that can build up in syringes when they are compressed, and the need for students to stand clear of the moving boom arms on the mechanical device.

Adaptations

1. Refer to the Notes to Teacher in the Unit Overview for adaptation ideas for students with learning and/or physical challenges as well as for students identified as ESL.

2. Students who have special needs may need to verbally articulate a design proposal to you. The two BLMs (8.1 "Shovel Arm Assembly" and 8.2 "Boom Extension Design") could be supplied to students with special needs who might not be able to create technical drawings on their own. These students could then be guided through the rest of the process by her/his team members.

3. There are several alternative tasks that could be incorporated into this culminating activity for those students in need of an additional challenge:

a) The president has indicated that budget guidelines will be provided so that this team's members will be aware of spending limits in preparing a prototype of this new toy. A store needs to be set up with a wide variety of the materials that are listed in the "Resources" section of this subtask. Each of these items needs to have a price attached to it. Some prices have been suggested for your convenience next to each of the materials listed in the "Resources" section. Students then need to be given about **$25** of "Smooth Move" money which can be spent on items they need to construct their mechanical devices. Remind students that they cannot exceed their budgeted amount of money, so they must really plan ahead before construction begins. Students should be given an opportunity to visit the store in advance of their planning work so that they have some idea of the materials that are available to them.
The team must then decide, by way of consensus, what materials (and respective quantities) need to be purchased for construction purposes. Unused materials cannot be returned to the store for refunds. An accurate review/assessment of their plans are critical at this stage. If students are not purchasing materials (since this is optional), they must be able to demonstrate their reasoning related to the quantity and type of materials they require to construct their model. The idea of using an economical approach to obtaining building materials is essential.
All necessary tools need to be made available to students at no "cost." These tools are denoted by the picture of the test tube in the "Resources" section. All materials denoted by the picture of a tube of liquid must be purchased from the store at the given prices.

b) The level of mechanical efficiency of the finished product could be calculated, with students using the background knowledge they have acquired through previous subtasks.

c) Making use of all knowledge gained from the "Let's Sell It!" subtask 2, the toy must be as marketable as

possible. Teams must present their mechanical toys to potential "consumers" (student peers and/or parents) using an effective marketing strategy, with the responsibilities for the presentation shared equally by all group members. Posters, video material, and/or the development of a commercial for their product could be completed.
A survey and an unbiased test should be designed by each student group that identify consumer expectations regarding the function and effectiveness of their mechanical device. When creating the survey and the test, students should consider:
- information that assists consumers in making a decision about whether or not to purchase and/or use a product (e.g., performance, durability, uniqueness, appeal, safety)
- a field test with consideration given to who will be part of the sample and what the sample size will be, as well as an independent evaluation of the test results before the product would actually be mass produced and sold
For students' surveys and product tests, some careful consideration should be given to who will constitute the sample groups of people needed for this task. Allow the students to suggest who could make up the sample groups. The teacher might want to consider pre-arranging access to students and/or teachers in other classes throughout the school to serve as possible sample groups for students' surveys and product tests.

Resources

Rubric 8 for Evaluating Culminating Activity	
BLM 8.1 Shovel Arm Assembly	8.1_shovel arm.pdf
BLM 8.2 Boom Extension Design	8.2_boomextension.cwk
BLM 8.3 Case Study Outline	8.3_casestudy.cwk
1 cm square craft wood	
wood dowels	
craft sticks	
syringes	
plastic tubing	
marbles	
wooden wheels	

- cardboard sheets
- metal jar lids
- petroleum jelly
- jigs (for joining pieces of glued wood)
- Carpenter's glue
- hacksaws
- manually operated hand drills
- pencils
- markers
- hammers
- tape
- rulers
- small metal objects
- paint

Notes to Teacher

1. Review "Background Information" found in the Overview section, if necessary.

2. Two blackline masters have been included (Shovel Arm 8.1 and Boom Extension 8.2) for your convenience but not for reproduction and distribution to students. These are just ideas of possible technical plans for components that could be added to the mechanical device that was previously constructed in Subtask 8. Students must create their own designs of a toy mechanical device that can move a given device the distance outlined in the criteria. These blackline masters are just some added background/idea information for the teacher.

3. A blackline master for students has been included to address design/construction criteria, how the teams will work together, questions for individual reflection, and an overall timeline for this culminating activity. This blackline master should serve as a guide for students to help keep them "on track."

4. Provide students with a product planning sheet on which they create their technical drawings and advise them to include approximate measurements, types of materials to be used in the construction, and labels for the various parts of the device (e.g., boom, base, etc.).

Teacher Reflections

Outline potential changes/improvements you would make to the subtask, or raise questions/concerns for future thought.

Record decisions you wish to pass on in the Subtask Notes; contents of this field are not passed along in the published unit.

Appendices

Structures and Mechanisms

Mechanical Efficiency

Resource List:
Blackline Masters:
Rubrics:
Unit Expectation List and Expectation Summary:
Unit Analysis:

Rubric

- ☐ **Rubric 1 for Gaining Leverage** **ST 1**
  3
- ☐ **Rubric 2a for Communication** **ST 2**
  3
- ☐ **Rubric 2b for Presentation** **ST 2**
  1
- ☐ **Rubric 3 for Syringe System Investigation** **ST 3**
  2
- ☐ **Rubric 4 for Investigation of Friction** **ST 4**
  2
- ☐ **Rubric 5 for Velocity Ratio Investigations** **ST 5**
  2
- ☐ **Rubric 6 for MA/ME Investigations** **ST 6**
  2
- ☐ **Rubric 7 for Hydraulic Test Lever Activity** **ST 7**
  2
- ☐ **Rubric 8 for Evaluating Culminating Activity** **ST 8**
  2
  Toying With Efficiency

Blackline Master / File

- ☐ **BLM 1.1 Notes About Levers** **ST 1**
  1.1_notes about levers.cwk
- ☐ **BLM 1.2 Gaining Leverage** **ST 1**
  1.2_Gaining Leverage.cwk
- ☐ **BLM 1.3 Simple Machines - Levers** **ST 1**
  1.3.cwk
- ☐ **BLM 2.1 Comparison Chart** **ST 2**
  2.1_comparison.cwk
  Factors Affecting the Design and Purchase of Products
- ☐ **BLM 2.2 Research Assignment** **ST 2**
  2.2_designing a product.cwk
- ☐ **BLM 2.3 Student Checklist** **ST 2**
  2.3_rating scale.cwk
- ☐ **BLM 3.1 Syringe System Setup** **ST 3**
  3.1_syringesetup.cwk
- ☐ **BLM 3.2 Syringe System Investigation** **ST 3**
  3.2.cwk
- ☐ **BLM 4.1 Slow Down** **ST 4**
  4.1_slowdown.cwk
- ☐ **BLM 5.1 Velocity** **ST 5**
  5.1_Velocity.cwk
- ☐ **BLM 5.2 Velocity Ratio** **ST 5**
  5.2_velocity ratio.cwk
- ☐ **BLM 5.3 Velocity Ratio Using Levers** **ST 5**
  5.3_Levers VR.cwk
- ☐ **BLM 5.4 Velocity Ratio Using Pulleys** **ST 5**
  5.4_PulleysVR.cwk
- ☐ **BLM 5.5 Observations Table** **ST 5**
  5.5_observtable.cwk
- ☐ **BLM 6.1 Mechanical Advantage - Levers** **ST 6**
  6.1_MALevers.cwk
- ☐ **BLM 6.2 Mechanical Advantage - Pulleys** **ST 6**
  6.2_MAPulleys.cwk
- ☐ **BLM 6.3 VR/MA with Levers** **ST 6**
  6.3_VRMALevers.cwk
- ☐ **BLM 6.4 Summary Sheet (MA/VR)** **ST 6**
  6.4_SummarySheet.cwk
- ☐ **BLM 6.5 Efficiency** **ST 6**
  6.5_Efficiency.cwk
- ☐ **BLM 6.6 Observations Tables** **ST 6**
  6.6_observtable.cwk
- ☐ **BLM 6.7 Multiple-Choice Test** **ST 6**
  6.7_MCTest.cwk

Structures and Mechanisms
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- ☐ **BLM 6.8 Answer Sheet** **ST 6**
  6.8_Answers.cwk
- ☐ **BLM 7.1 Hydraulic Test Lever - Tips** **ST 7**
  tips.pdf
  BLM 7.1
- ☐ **BLM 7.2 Assembly Instructions** **ST 7**
  7.2_assembly1.pdf
- ☐ **BLM 7.4 Base Frame Design** **ST 7**
  7.4_base frame.cwk
- ☐ **BLM 7.5 Tower Frame Design** **ST 7**
  7.5_tower frame.cwk
- ☐ **BLM 7.6 Boom Frame Design** **ST 7**
  7.6_boom frame.cwk
- ☐ **BLM 7.7 Syringe Assembly** **ST 7**
  7.7_syringe assembly.cwk
- ☐ **BLM 7.8 Side View / Complete Assembly** **ST 7**
  7.8_Side View All.cwk
- ☐ **BLM 7.9 Instructions for Lever Test** **ST 7**
  7.9_testing steps.pdf
- ☐ **BLM 8_ Assembly Instructions** **ST 7**
  8_assembly2.pdf
- ☐ **BLM 8.1 Shovel Arm Assembly** **ST 8**
  8.1_shovel arm.pdf
- ☐ **BLM 8.2 Boom Extension Design** **ST 8**
  8.2_boomextension.cwk
- ☐ **BLM 8.3 Case Study Outline** **ST 8**
  8.3_casestudy.cwk

Print

- ☐ **Commitment: Faith through Service** **ST 2**
  Catholic Curriculum Cooperative
  Mid year assessment unit with a focus on social justice and consumerism.
- ☐ **Science and Technology 8** **Unit**
  Carol Glegg, Peter Williams
  ISBN 0-17-607497-4
  Nelson Thomson Learning
  Mechanical Advantage and Efficiency
- ☐ **Science and Technology 8** **Unit**
  Kyn Barker, Steve Campbell, Gary Greenland, Douglas Hayhoe, Doug Herridge, Kathy Kubota-Zarivnij, Shelagh Reading, Lionel Sandner, Beverley Williams
  Pearson Education Canada - Addison Wesley
  Mechanical Efficiency

Media

- ☐ **Efficiency of Energy Conversions** **Unit**
  ACCESS
  Investigates mechanical and biological systems to determine and compare efficiencies of energy conversion. By examining real and toy cars, various types of electrical power generation, and packaging of various foods, students learn to use efficiency calculations.
- ☐ **Fluid Power Technology At Work** **Unit**
  McIntyre Media
  Brings the fluid power industry into your classroom. A broad over view of many applications of hydaulics and pneumatics is summarized.

Website

☐ **A World in Motion** **Unit**
http://www.schoolnet.ca/general/worldinmotion/e/index.html

This is an excellent interactive Canadian site created by SAE, the Society of Automotive Engineers. It contains metric lesson plans, definitions, recording sheets and engineer's links. It is divided into 5 units: Get Moving, Power Up, Slow Down, Move Easy and Airborne.

☐ **Amusement Park Physics** **Unit**
http://www.learner.org/exhibits/parkphysics/
How do physics laws affect amusement park ride design? In this exhibit, you'll have a chance to find out by designing your own roller coaster. Plan it carefully--it has to pass a safety inspection. You can also experiment with bumper car collisions.

☐ **Cantilever Geometry** **Unit**
http://www.sheldonbrown.com/cantilever-geometry.html
You cannot understand bicycle brakes unless you understand mechanical advantage. Go to this site to learn all about tuning your bike's brakes.

☐ **Friction - Science Museum in Minnesota** **Unit**
http://www.smm.org/sln/tf/f/friction/friction.html
Vollis Simpson is an artist who creates kinetic sculptures and whirligigs. He uses bearings in all of his spinning pieces so that they move smoothly. An experiment here is a nice introduction to friction and bearings.

☐ **History of Hydraulics** **Unit**
http://http://www.iihr.uiowa.edu/focusareas/history/hydraulics/
From the Iowa Institute of Hydraulic Research.

☐ **Pascal's Principle and Hydraulics** **Unit**
http://www.lerc.nasa.gov/www/K-12/WindTunnel/Activities/Pascals_principle.html
Pascal's law is explained "that when there is an increase in pressure at any point in a confined fluid, there is any equal increase at every other point in the container."

☐ **Pressure** **Unit**
http://yesican.yorku.ca/home/press1.html
'Pressure' is a term often used in everyday life, for example, we frequently speak of tire pressure, air pressure, blood pressure, water pressure and so on.

☐ **The Pneumatic Tube and the History of Pneumatic Devices** **Unit**
http://inventors.about.com/science/inventors/library/inventors/blpneumatic.htm
A pneumatic device is any of various tools and instruments that generate and utilize compressed air. Visit this site to learn more about pneumatics.

Material

☐ **1 cm square craft wood** **ST 8**
Price: 1 cent/cm
(Jinx wood)

☐ **1 cm square craft wood (60 cm in length)** **ST 5**

☐ **1 cm square craft wood (60 cm lengths)** **ST 6**

☐ **1 cm square craft wood (Jinx wood)** **ST 7**

☐ **2 L plastic pop bottles** **ST 3**

☐ **2" x 4" blocks of wood (with hooks)** **ST 4**
Attach a hook at one end of each block of wood so that a spring scale can be attached.

☐ **3/16" doweling** **ST 7**

☐ **4" x 1/4" bolts and nuts** **ST 5**

☐ **4" x 1/4" bolts and nuts** **ST 6**

☐ **500 g masses** **ST 4**

☐ **500 g masses** **ST 5**

☐ **8.5" x 11" sheets of coarse sandpaper** **ST 4**

☐ **ball bearings** **ST 4**

☐ **book (e.g., dictionary)** **ST 1**

☐ **bricks (optional)** **ST 4**
For student use when designing demonstrations (BLM 4.1 Part d).

☐ **cardboard sheets** **ST 8**
Price: 50 cents/20cmX20cm sheet

☐ **cardboard squares (4 cm x 4 cm)** **ST 3**

☐ **craft sticks** **ST 8**
Price: 1 cent each

☐ **hardware catalogues** **ST 1**

☐ **heavy string** **ST 5**

☐ **heavy string** **ST 6**

☐ **household objects (see teacher notes)** **ST 1**

☐ **lubricants (e.g., oil, grease, or wax)** **ST 4**

☐ **marbles** **ST 8**
Price: 10 cents each

☐ **metal jar lids** **ST 8**
Price: 25 cents each

☐ **metre sticks** **ST 1**

☐ **metre sticks** **ST 5**

☐ **Newton spring scales** **ST 4**

☐ **petroleum jelly** **ST 8**
Price: 20 cents/"squirt"

- ☐ **plastic tubing** — ST 8
  Prices: $1.25/m
  (for syringes)
- ☐ **pulleys (single)** — ST 5
- ☐ **rollers (e.g., spools)** — ST 4
- ☐ **string** — ST 4
- ☐ **syringes** — ST 8
  Prices: 10 CC 75 cents each
  20 CC $1.50 each
  35 CC $2.00 each
  (different size pairs)
- ☐ **syringes 10 mL and 20 mL** — ST 7
- ☐ **tape** — ST 3
- ☐ **tape** — ST 5
- ☐ **tape or string to tie book to the metre stick** — ST 1
- ☐ **text books (optional)** — ST 4
  For student use when designing demonstrations (BLM 4.1 Part d).
- ☐ **water** — ST 3
- ☐ **wheels** — ST 4
- ☐ **wood dowels** — ST 8
  Price: 50 cents/90cm length
- ☐ **wooden wheels** — ST 8
  Price: 40 cents each

Equipment / Manipulative

- ☐ **10 mL syringes** — ST 3
- ☐ **20 mL syringes** — ST 3
- ☐ **200 g masses** — ST 3
- ☐ **200 g masses** — ST 7
- ☐ **500 g masses** — ST 6
- ☐ **cardboard gussets** — ST 7
- ☐ **Carpenter's glue** — ST 8
- ☐ **Carpenter's glue or glue guns** — ST 7
- ☐ **clamps** — ST 3
- ☐ **clear plastic tubing** — ST 3
- ☐ **cm rulers** — ST 7
- ☐ **electrical tape** — ST 7
- ☐ **hacksaws** — ST 8
- ☐ **hammers** — ST 8
- ☐ **hand saws** — ST 7
- ☐ **hand-powered drills with 13/64" or 7/32" bits** — ST 7
- ☐ **jigs (for joining pieces of glued wood)** — ST 8
- ☐ **manually operated hand drills** — ST 8
- ☐ **markers** — ST 8
- ☐ **metre sticks** — ST 6
- ☐ **mitre boxes** — ST 7
- ☐ **Newton spring scale** — ST 6
- ☐ **paint** — ST 8
- ☐ **pencils** — ST 8
- ☐ **retort stand** — ST 6
- ☐ **retort stands** — ST 3
- ☐ **retort stands** — ST 5
- ☐ **ring clamp** — ST 6
- ☐ **ring clamps** — ST 5
- ☐ **ruler (cm)** — ST 6
- ☐ **rulers** — ST 8
- ☐ **rulers (cm)** — ST 5
- ☐ **small metal objects** — ST 8
  (to be lifted by the mechanical device)
- ☐ **small wooden blocks** — ST 3
- ☐ **steel or plastic squares** — ST 7
- ☐ **student desks** — ST 5
- ☐ **student desks** — ST 6

Structures and Mechanisms
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☐ **tape** **ST 8**
(electrical and masking)

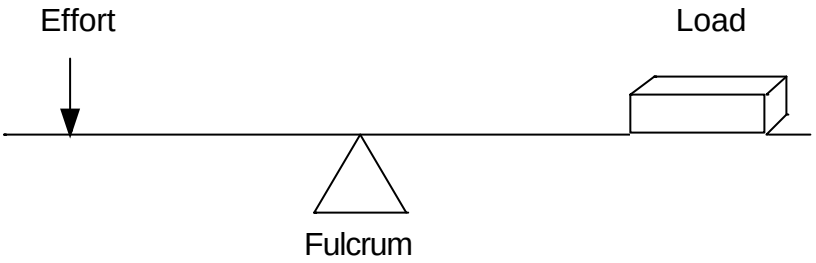
BLM 1.1 Notes About Levers

Levers -are simple machines that make it easier or faster to move something
-all have a fulcrum (pivot point), load force (the force exerted by the load), and effort force (the force required to move the load)

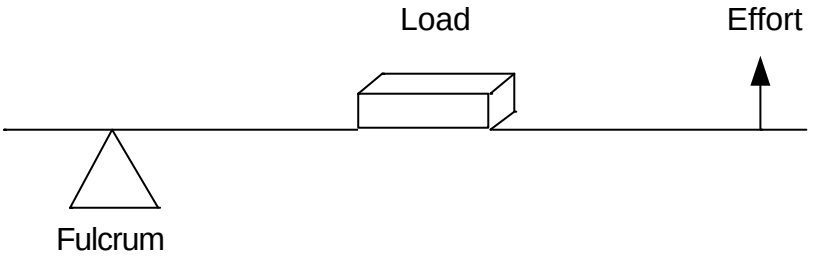
Effort Arm is the distance between the fulcrum and the effort.
Load Arm is the distance between the fulcrum and the load.

Three Classes Of Levers

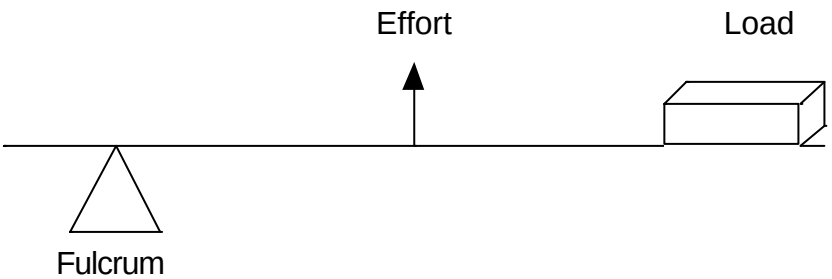
Class 1 -the fulcrum is between the effort and the load
-can be used for power or precision (e.g., scissors, paint can lid opener)



Class 2 -the load is between the effort and the fulcrum
-moves a large load with little effort (e.g., wheelbarrow)



Class 3 -the fulcrum is at one end and the effort is exerted between the load and
fulcrum, as a result the load arm is always longer than the effort arm
-makes movement magnified, not lighter to lift (e.g., hockey stick, fishing
rod)



BLM 1.2 Gaining Leverage (Three Classes of Levers)

Investigation: Investigate the advantages and efficiency of the three classes of levers.

Materials: metre stick, a book (e.g., dictionary), tape, desk top

Procedure:

Class 1 Lever (fulcrum in the middle)

i) Place the metre stick with half the length on the desk and the other half extending over the edge. Use the desk's edge as the fulcrum.
ii) Place the book on the end of the load arm (end that is lying on the desk).
iii) Push down on the effort arm (end extended over the edge).
Try this with the fulcrum at two or three different distances from the load or effort forces.

Class 2 Lever (load in the middle)

i) Tape the book to the middle of the metre stick, so it is attached below the stick.
ii) Put one end of the metre stick on the desk and hold the other end up with book hanging below.
iii) Try to lift the book using the metre stick while it is hanging at a few different places along the stick.

Class 3 Lever (effort in the middle)

i) Tie the book beneath the far end of the metre stick.
ii) While holding the metre stick's end in place on the desk, try to lift the book with the overhanging extension.

Observations:

1. Draw a diagram labelling the location of the load, effort, and fulcrum for each.

2. Record observations for each activity. Be sure to include the direction of force of the effort and load in each activity. Explain observations of the advantages or disadvantages of where the fulcrum, load, and effort are.

Conclusion:

What conclusions are made about the three classes of levers?

BLM 1.3 Simple Machines That Are Levers

First Class Levers	Second Class Levers	Third Class Levers

BLM 2.1 Comparison Chart

Factors Affecting Design/ Purchase of Products	Electric Car	Car with Combustion Engine
moral/ethical		
efficiency		
economic		
environmental		
ergonomic		
social		
aesthetic		
material costs		
safety		
durability		

BLM 2.2 Independent Research Assignment
Factors Affecting the Design, Marketing, and Purchase of Consumer Products

You are required to **select one** of the following three topics and complete a research report to address the issue outlined for you. Please pay close attention to the research and report-writing criteria that is provided with the outline of each topic. A student self-assessment checklist (BLM 2.3) is also being provided to you so that you can use it both during and after your work on this assignment to help to ensure that you are completing/have completed this assignment according the criteria and outline that has been provided for you.

Option A

In a single sentence, define "ergonomics." Use an essay format of at least five paragraphs to describe a product that has some ergonomic design features that take into account the needs and comfort of the potential consumer. In the first paragraph, describe the original design of the product. In subsequent paragraphs, outline ergonomic-related factors such as materials, durability, aesthetics, health issues, safety, efficiency, and physical attributes of the potential consumer, in relation to this product. Suggest modifications that you feel would help to improve the ergonomic design of the product. In your closing paragraph, explain why you think the new design, that you have suggested, is more beneficial to consumers than the original design.

Option B

Develop a marketing plan/strategy for a hypothetical product (cannot be something that has been advertised before), that incorporates some of the important factors that affect the design and purchase of consumer products (that were discussed as a class earlier in this subtask). Use an essay format of at least five paragraphs to describe the hypothetical product and the reasons why a potential consumer would want to purchase it. In the first paragraph, provide a brief desciption of this "new" product and what purpose it could serve in the life of the potential consumer. In subsequent paragraphs, outline the "selling features" of this product. Use appropriate descriptive language and be persuasive. In the concluding paragraph, to reiterate the "strengths" of your product identify what it is that makes your product unique and sets it apart from anything else that is currently available (or not available) on the market, and why they should buy it right away.

Option C

Select a product manual for a product that you have in your home or select a help screen for a particular computer program and read through it thoroughly. Then locate another manual for a different product or another help screen and review it. Set up a comparison chart, using a computer program (e.g., Microsoft Publisher, Microsoft Excel, or Corel WordPerfect), with category headings such as product name, product description, clarity of manuals or help screens, thoroughness, general "user-friendliness," and suggested improvements (to make manuals or help screens easier to use). You should come up with a rating scale (and a legend to explain the scale, which could be added under the chart) that could be used under the category headings of clarity of manuals or help screens, thoroughness, and general "user-friendliness."

After you have completed your work for Option A, B, or C, you will be required to present the results of your work to your classmates. Refer to your self-assessment checklist for specific directions regarding your presentation. You will be required to take notes in your learning log during classmates' presentations to demonstrate what you have learned.

BLM 2.3 Student Self-Assessment Checklist

Student Name: _____

Date: _____

____ A. Participated, regularly, in the class discussion leading up to the research assignment.

____ B. Identified important attributes of consumer products (e.g., personal, environmental, economic, product quality, moral or ethical issues) that should be considered before creating and purchasing such products (orally).

____ C. Demonstrated an understanding of the new concepts of “aesthetics” and “ergonomics” through involvement in class discussion.

____ D. Examined the strengths and weaknesses of a consumer product in a “Consumer Report” or completed a comparison chart for electric cars versus cars with combustion engines according to the criteria provided by the teacher.

____ E. Used a variety of suitable, informative resources to complete research assignment.

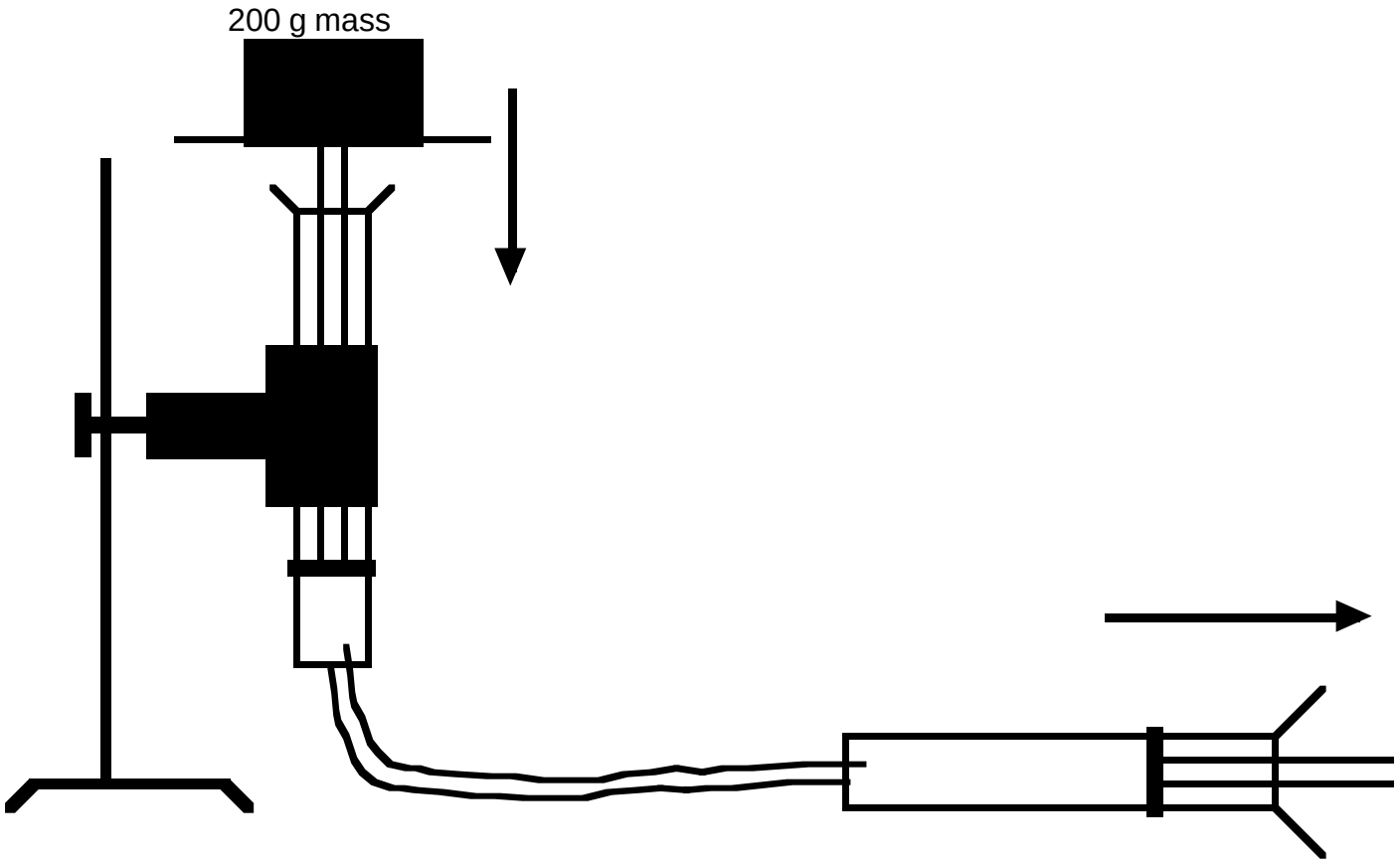
____ F. Used proper essay format, including strong opening and closing paragraphs, and at least five paragraphs that support the topic OR developed a well-designed chart with appropriate headings and a legend, containing relevant information.

____ G. Completed an edit of the essay OR chart, paying particular attention to sentence structure (if applicable), spelling, and overall content.

____ H. Presented the research report to the class in a manner that reflected preparedness, knowledge and understanding of the topic, poise, confidence, and eye contact with the audience.

____ I. Followed instructions carefully and met deadlines.

BLM 3.1 Syringe System Setup



BLM 3.2 Syringe System Investigation

1. Experiment setup:

i) Clamp a 20 mL-syringe to a retort stand.
ii) Using clear plastic tubing connect a 10 mL-syringe and tape it to the desk top.
iii) Pull the plunger up fully, filling the syringe with air. Make sure the 10 mL-syringe's plunger is totally pushed in.
iv) To the top of the plunger add a cardboard square to act as a platform for a 200 g mass.
v) In front of the 10 mL-syringe place an object (e.g. small block). Place the 200 g mass on top of the 20 mL-syringe and observe.
vi) Measure the distance the object was moved.

2. Repeat the same experiment but this time clamp the 10 mL-syringe to the retort stand and tape the 20 mL-syringe to the desk top.

3. Repeat the same experiments, this time filling the clamped syringe with water in the place of the air.

4. Draw a diagram for each experiment and record your observations for each experiment in the learning log. Be sure to include the following:

i) Compare your observations for all four experiments.
ii) What conclusions can be made for the effects of pressure in an closed system?
iii) What advantages are there to a smaller or larger piston?
iv) What comparison is there for a hydraulic system to a pneumatic system?
v) Explain real life situations when and how a hydraulic system or pneumatic system would be used.

BLM 4.1 SLOW DOWN

AN INVESTIGATION INTO THE FORCE OF FRICTION

Procedure:

(a) Take 2 blocks of wood (2" x 4" pieces) and rub one of the smooth surfaces of one block against a smooth surface of the other block repeatedly and quickly for about 15 seconds. Now touch the surfaces with your fingers to get a sense of their temperatures. Record your findings by using a single sentence in the "Observations" section below.

(b) Push one of the blocks of wood over a sheet sandpaper that is lying on a desk top. Now push the same block over the desktop surface. Note how the nature of the surfaces affects friction and record your observations in the "Observations" section below.

(c) Find out whether surface area shared when two objects are in contact with each other affects the amount of force required to overcome friction. Place one of the wooden blocks so that is lying with its largest surface in contact with the same sheet of sandpaper (as in (b) above), with a 500 g mass mounted on top. Attach a spring scale to the hook at one end of the piece of wood and drag the block across the sheet of sandpaper. Record the force required to move the wooden block across the sandpaper. Now tip the block up on its "side" so that a smaller surface area can be slid across the sandpaper. Place the 500 g mass on top of the block. Again measure the force required to move the block by hooking the spring scale onto the wooden block and dragging it across the sandpaper. Record the forces required to move the wooden block under both conditions outlined above in the "Observations" section.

(d) Devise some simple demonstrations for your teacher and classmates to show how the following actions or materials help reduce friction:

(i) polishing (or sanding)
(ii) using a lubricant such as oil, grease, or wax.
(iii) using rollers or ball bearings

Your teacher will supply you with some of the necessary materials to help you set up your demonstrations. You may need to find some other common classroom supplies that will help you put together these demonstrations. Your teacher will ask you to share at least one of the demonstrations that you create with a small group of students (as directed by your teacher).

BLM 4.1 SLOW DOWN (cont'd)

Observations and Conclusions:

Write a brief description of your observations and conclusions from each of the above steps in the procedure, in the space provided. (Attach an extra sheet of paper if necessary.)

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Follow-up Questions

1. State two reasons why it is a good idea to carry a heavy bag of sand in the trunk of your car in the winter.

____

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2. Explain why we often rub our hands together on a cold day.

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BLM 5.1 VELOCITY

The purpose of subtask 5 is for you to gain an understanding of velocity and then be able to calculate velocity ratios of different devices.

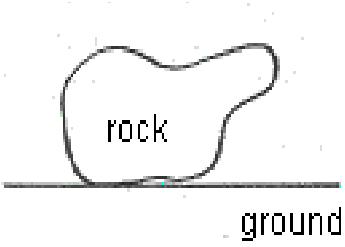
Force, Time, Distance

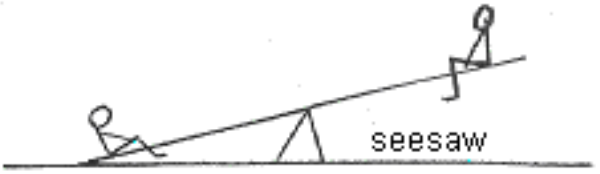
In order to begin our study we need to understand the terms force, distance, time, and speed.

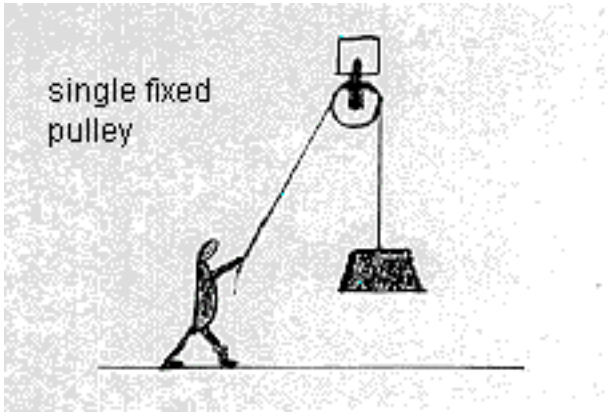
Particle Theory states that all matter consists of tiny particles which are in constant motion. Because these particles are moving a certain distance in a given time, they have speed.

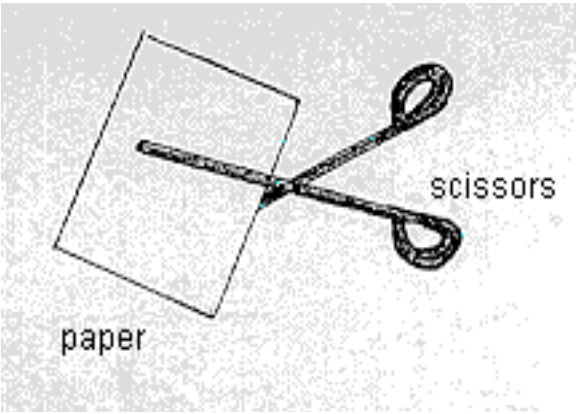
Force is defined as a push or a pull. Forces have both magnitude (size) and direction.

Force diagrams can be drawn to show forces which affect an object. Arrows are used to show these forces. Place arrows on these diagrams to show the forces at play.









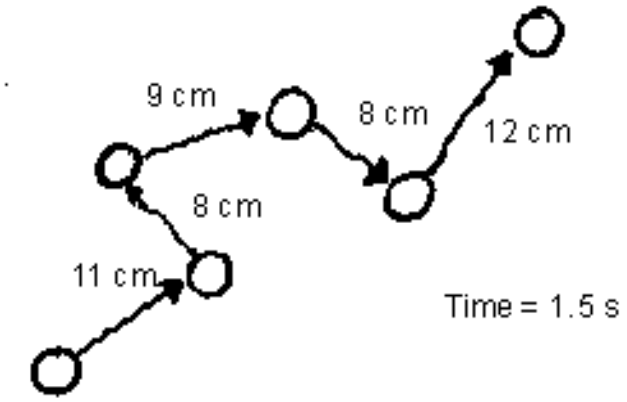
BLM 5.1 VELOCITY (continued)

Time describes how long an action takes place and may be measured in seconds, minutes, hours, etc.

Distance is a measure of how far an object moves when a force is applied. Distance is stated in units of linear measure (cm, m, km, etc.).

Speed is a measure of how far an object moves in a certain period of time.

What would be the speed of this bouncing ball?



Speed = _____ cm/s

Velocity is speed in a given direction.

It is velocity that we will be using in this unit. You will need to be able to calculate this value.

Use the following formula for finding velocity.

$V = D/t$

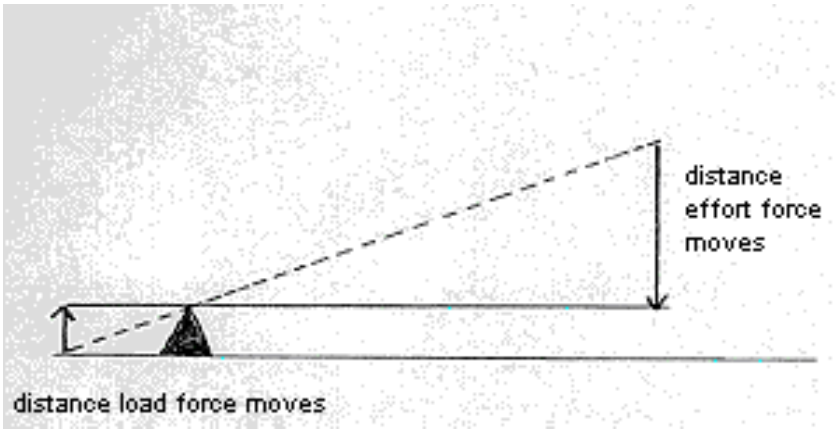
V= velocity
D= distance
t = time

A car travels east, from Toronto, on the 401 for a distance of 120 km. It takes 1 hour and 15 minutes to reach its destination. What is its velocity?

BLM 5.2 VELOCITY RATIO

Velocity Ratio is the comparison of the distance a load force moves with the distance the effort force moves.

To begin our study of velocity ratio let us focus our attention on the lever.



Note:

1. Both the load and the effort move for the same amount of time.
2. The effort moves farther than the load does.

Measure the distance each force moves.
The load force moves _____ cm and the effort force moves _____cm.

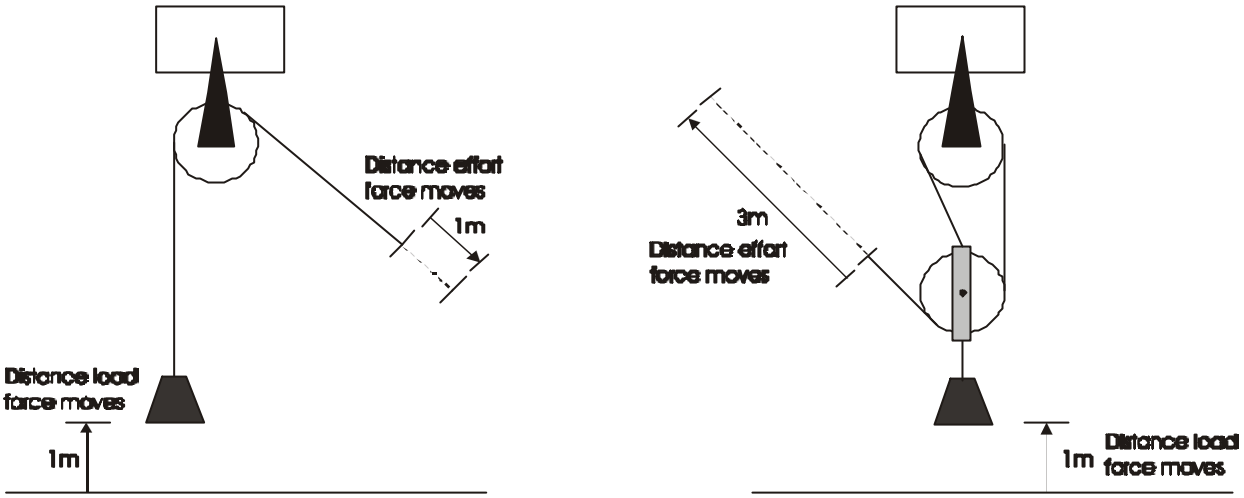
To calculate velocity ratio, divide the distance that the effort force moves by the distance the load force moves. Note: No units are used for velocity ratio (only a number).

$$\text{Velocity Ratio} = \frac{\text{Distance effort force moves}}{\text{Distance load force moves}}$$

Use the formula to find the velocity ratio of the lever. (Do your calculations in the space provided.)

BLM 5.2 VELOCITY RATIO (continued)

Now let's look at the pulley.



SCALE 1 cm = 1 m

Use the distances given in the diagrams to calculate the velocity ratios of the pulleys. (Do your work in the space provided.)

Single Fixed Pulley

Double Fixed Pulley

BLM 5.2 VELOCITY RATIO (continued)

USING PULLEYS

It is time now to gather first hand data using real pulleys.

MATERIALS (per group):

- 1 cm x 60 cm piece of wood
- 2 single pulleys
- 75 to 100 cm heavy string(ie. meat cord)
- metre stick
- 2 desks

METHOD:

1. Place a 1cm x 1cm piece of wood across the space between two desks.
2. Fasten a single fixed pulley to this beam.
3. Tie a weight to one end of a length (75 to 100 cm) of heavy string.
4. Feed the string through the pulley.
5. Place a metre stick behind the pulley.
6. Holding the string between your thumb and index finger, haul the weight up until the bottom of the weight is level with (at same point on the metre stick your thumb is.)
7. Note exactly where this point (benchmark) is on the metre stick and record this point.
8. Haul the weight up from this benchmark by pulling down on the string. (Use the distances indicated in the observations chart.)
9. Carefully observe how far your thumb has moved down from the benchmark and record the values in the observations chart.
10. Fasten a double fixed pulley to the beam and repeat steps 3 - 9.

OBSERVATIONS:

Benchmark Point _____

BLM 5.2 VELOCITY RATIO (continued)

DISTANCE WEIGHT IS HAULED UP (Load Force)	DISTANCE THUMB MOVES DOWN (Effort Force)	
	Single Fixed Pulley	Double Fixed Pulley
5 cm	_____ cm	_____ cm
10 cm	_____ cm	_____ cm
15 cm	_____ cm	_____ cm
Average Distance = _____ cm	Average Distance = _____ cm	Average Distance = _____ cm

ANALYSIS:

Using the average distances the load and effort forces moved, find the velocity ratio for both pulleys.

Single Fixed Pulley

VR = Distance effort force moves / Distance load force moves

VR = _____

VR =

Double Fixed Pulley

VR = Distance effort force moves / Distance load force moves

VR = _____

VR =

CONCLUSIONS:

Look back in the table at the average values. For each pulley note the number of cm the effort force moves in order to move the load force 10 cm.

Why might a velocity ratio equal to one be good?

What advantage might a velocity ratio greater than one have?

As you work your way through subtask 7 look for a relationship between the length of rope you pull and the effort required to lift an object.

BLM 5.3 Velocity Ratio Using Levers

MATERIALS (per group):

- retort stand
- ring clamp
- 4" x 1/4" bolt and nut
- tape
- 30 cm wooden ruler
- 2 metre sticks

PROCEDURE:

1. Fasten a ring clamp to a retort stand.
2. Tape a 1/4” bolt along the top surface of the ring (parallel). Allow part of the bolt to protrude past the edge of the ring (so it “sticks out”), on the side opposite to the retort stand. This will serve as your fulcrum.
3. Ensure that the retort stand is placed on a flat, level surface.
4. Drill 1/4” holes every 2 cm, in both directions, starting from the 15 cm mark of the ruler.
5. Using the bolt as your fulcrum, slide the ruler onto the end of the protruding bolt, through the centre hole of the ruler. This ruler will serve as your lever.
6. Thread the nut onto the bolt and tighten enough to stabilize the lever but not to impede its movement.
7. Level the lever horizontally, as accurately as possible.
8. Hold a metre stick vertically at each end of the levelled lever (to be used as a measuring tool for the movement of the lever). One of two students could hold each metre stick.
9. Move one end of the lever down 6 cm. This is the effort arm.
10. Observe and record how far the other end of the lever moves up.
11. Change the lengths of the arms of the lever by moving the lever to each of the different holes, recording your data as you proceed.
12. Repeat steps 6 to 11 until all holes on the ruler have been used.

OBSERVATIONS:

Create a table to record the results of your investigations. Your table will require 4 columns and at least 4 rows.

BLM 5.3 Velocity Ratio Using Levers (continued)

ANALYSIS:

$$\text{Velocity Ratio} = \frac{\text{Distance Effort Force Moves}}{\text{Distance Load Force Moves}}$$

Calculate the velocity ratio of the lever using the headings in the table below. Data is found in the above table: of observations.

EFFORT ARM LONGER	ARMS EQUAL	EFFORT ARM SHORTER

BLM 5.4 Velocity Ratio Using Pulleys

MATERIALS (per group):

- 1 cm x 60 cm piece of wood
- 2 single pulleys
- 75 to 100 cm heavy string (i.e., meat cord)
- metre stick
- 2 desks
- 500 g mass

METHOD:

1. Place a 1 cm x 1 cm piece of wood across the space between two desks.
2. Fasten a single fixed pulley to this beam.
3. Tie a 500 g mass to one end of a length (75 to 100 cm) of heavy string.
4. Feed the string through the pulley.
5. Place a metre stick behind the pulley.
6. Holding the string between your thumb and index finger, haul the load (500 g mass) up until the bottom of the load is level with (at same point on the metre stick) your thumb.
7. Note exactly where this point (benchmark) is on the metre stick and record this point.
8. Haul the load up from this benchmark by pulling down on the string. (Use the distances indicated in the observations chart.)
9. Carefully observe how far your thumb has moved down from the benchmark and record the values in the observations chart.
10. Fasten a double fixed pulley to the beam and repeat steps 3 to 9.

OBSERVATIONS:

Benchmark Point _____

BLM 5.4 Velocity Ratio Using Pulleys (cont'd)

DISTANCE 500g MASS IS HAULED UP (Load Force)	DISTANCE THUMB MOVES DOWN (Effort Force)	
	Single Fixed Pulley	Double Fixed Pulley
5 cm	_____ cm	_____ cm
10 cm	_____ cm	_____ cm
15 cm	_____ cm	_____ cm
Average Distance = _____ cm	Average Distance = _____ cm	Average Distance = _____ cm

ANALYSIS:
Using the average distances the load and effort forces moved, find the velocity ratio for both pulleys.

Single Fixed Pulley

VR = Distance effort force moves / Distance load force moves

VR = _____

VR =

Double Fixed Pulley

VR = Distance effort force / Distance load force

VR = _____

VR =

CONCLUSIONS:
Look back in the table at the average values. For each pulley, note the number of cm
the effort force moves in order to move the load force 10 cm.

Why might a velocity ratio equal to one be good?

What advantage might a velocity ratio greater than one have?

As you work your way through subtask 6 look for a relationship between the length of
rope you pull and the effort required to lift an object.

BLM 5.5 Observations Table for BLM 5.3 (Adaptation)

LENGTH OF EFFORT ARM	LENGTH OF LOAD ARM	DISTANCE EFFORT FORCE (ARM) MOVES	DISTANCE LOAD FORCE (ARM) MOVES
15 cm	15 cm	6 cm	_____ cm
17 cm	_____ cm	6 cm	_____ cm
13 cm	_____ cm	6 cm	_____ cm

BLM 6.1 Mechanical Advantage Using Levers

MATERIALS (per group):

- retort stand
- ring clamp
- 4" x 1/4" bolt and nut
- 30 cm wooden ruler
- 500 g mass
- Tubular spring scale

METHOD:

1. Follow steps 1 to 6 in the method of the velocity ratio investigation using levers.
2. Hang the 500 g mass on the outside hole of the load arm.
3. Hook the Tubular spring scale to the outside hole of the effort arm.
4. Level the lever.
5. Pull evenly on the spring scale to keep the lever level.
6. Observe and record the effort force.
7. Change the length of the effort arm by moving the lever to different holes. (Test your apparatus with the effort arm length equal to, greater than, and less than the length of the load arm.)
8. Repeat steps 4 to 6.

OBSERVATIONS:

Create a table to record your observations.

BLM 6.1 Mechanical Advantage Using Levers (cont'd)

ANALYSIS:

$$\text{Mechanical Advantage} = \frac{\text{Load force}}{\text{Effort force}}$$

Use the equation and the information in this table to find the mechanical advantage of the lever.

Effort arm longer	Arms of equal length	Effort arm shorter
MA = LF / EF	MA = LF / EF	MA = LF / EF

BLM 6.2 Mechanical Advantage Using Pulleys

MATERIALS (per group):

- 1 cm x 60 cm piece of wood
- 2 single pulleys
- 75 to 100 cm heavy string
- 1 x 500 g mass
- 1 tubular spring scale
- 2 desks

PROCEDURE:

1. Place a piece of 1 cm wood across the space between two desks.
2. Fasten a single fixed pulley to this beam.
3. Tie a 500 g mass to one end of a length (75 to 100 cm) of heavy string.
4. Feed the string through the pulley. Tie the other end of the string to the hook of a tubular spring scale. Zero out the spring scale. (Turn the adjusting nut until the scale reads zero Newtons.)
5. With the load (500 g mass) resting on a surface pull on the spring scale only enough to take the slack out of the string. Make sure the scale is reading zero newtons.
6. Slowly pull on the newton spring scale and cause the load to be raised off the surface on which it is resting.
7. Note the number of newtons of force required to raise the load and record this value in your observation chart.
8. Repeat two more times and record.
9. Tie a double fixed pulley to the beam and repeat steps 3 to 9.

OBSERVATIONS:

Mass of Object = _____ g

Load force = mass (in grams) / 100 = _____ N

***Remember: 10 N of force will lift a 1Kg mass.

Create a table to record your observations.

1. Give the table a title.
2. You will be recording data for a single fixed pulley and a double fixed pulley.
3. Record the results of three trials and an average for each pulley.

BLM 6.2 Mechanical Advantage Using Pulleys (continued)

ANALYSIS:

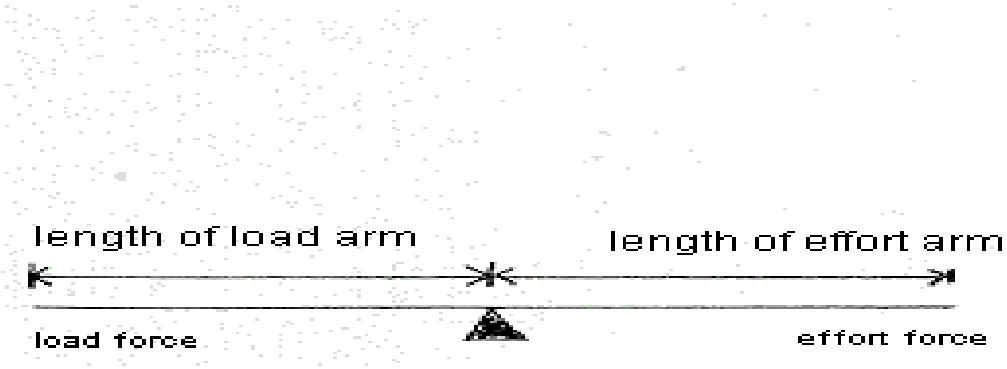
To find the mechanical advantage, divide the load force by the effort force. (Use the average effort force.)

Single Pulley	Double Pulley
MA = LF/EF	MA= LF/EF
MA = _____	MA = _____
MA =	MA =

Note: Mechanical Advantage is just a number. (i.e., MA = 1, not MA = 1 N)

BLM 6.3 Velocity Ratio/Mechanical Advantage With Levers

When looking at levers, we must consider the sizes of the forces and the lengths of the arms of the lever.



When the effort force is less than the load force, the lever has a mechanical advantage (for force). This advantage is gained by using a lever with an effort arm longer than its load arm.

If the two arms are the same length, the forces would also be equal.
That is, it would take an effort of _____ N to move a load of 10 N.

In this example, the mechanical advantage would be equal to 1.

MA = LF/EF
MA = ? ____/ ____
MA = 1

Therefore, if the effort force is less than the load force, the mechanical advantage would be _____ (greater/less) than 1.
If the effort force is greater than the load force, the mechanical advantage would be _____ (greater/less) than 1.

Another way to look at mechanical advantage is to consider the lengths of the load arm and the effort arm.

Levers with effort arms longer than their load arms have a mechanical advantage which is greater than 1.

Therefore, levers with effort arms _____ (longer/shorter) than their load arms have a mechanical advantage less than one.

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

BLM 6.3 Velocity Ratio/Mechanical Advantage With Levers (cont.)

What would be the mechanical advantage of a lever whose effort arm is 90 cm and its load arm is 10 cm?

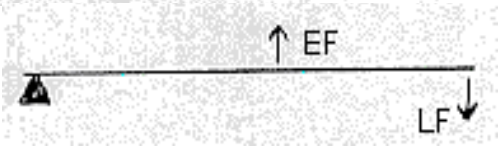
ANSWER: _____

For each lever indicate if the mechanical advantage and velocity ratio is greater than, equal to, or less than 1 by using the appropriate symbol (>, <, =) in the blank. Give the name of a real life example of this lever.

MA ____ 1 VR ____ 1 Example: _____

MA ____ 1 VR ____ 1 Example: _____

MA ____ 1 VR ____ 1 Example: _____



MA ____ 1 VR ____ 1 Example: _____

MA ____ 1 VR ____ 1 Example: _____

Some machines offer an advantage of moving a larger load with less effort. These machines have a _____ (force, velocity) advantage.

Other machines require greater effort to move a smaller load but a movement of the effort force results in a greater movement of the load. These machines have a _____ (force, velocity) advantage.

BLM 6.4 SUMMARY SHEET
Mechanical Advantage/Velocity Ratio

Complete the following organizer by filling each cell with "yes" or "no."

	1st Class Lever	2nd Class Lever	3rd Class Lever	Single Fixed Pulley	Double Fixed Pulley
Mechanical Advantage EF<LF					
Velocity Ratio VR > 1					

Study the organizer. Can you see a relationship between mechanical advantage and velocity ratio? What is it?

You may have heard the expression, "You can't get something for nothing." This is true of machines.
In order to reduce the size of the _____ force needed to move a load, that force must be applied over a greater _____.

BLM 6.5 EFFICIENCY

To determine how efficient a machine is, we divide its mechanical advantage by its velocity ratio. If we multiply this result by 100 we will state our answer as a per cent.

$$\text{Percent Efficiency} = \frac{\text{Mechanical advantage} \times 100}{\text{Velocity ratio}}$$

What would the percentage efficiency of a machine with a mechanical advantage of 3 and a velocity ratio of 3.

PE = MA/ VR x 100
= _____ x 100

= _____ %

No machine is 100% efficient. What is one factor that reduces the efficiency of a machine?

How might this factor be diminished?

BLM 6.6 Observations Table for BLM 6.1 (Adaptations)

Length of Effort Arm (cm)	Length of Load Arm (cm)	Load Force (N)	Effort Force (N)
15			
17			
13			

Observations Table for BLM 6.2 (Adaptations)

Single Fixed Pulley	Double Fixed Pulley
Trial #1 _____ N	Trial #1 _____ N
Trial #2 _____ N	Trial #2 _____ N
Trial #3 _____ N	Trial #3 _____ N
Average _____ N	Average _____ N

BLM 6.7 MULTIPLE-CHOICE TEST

Circle the letter of the most correct response. Select only one response for each question. Refer to the following formulas when doing some of the questions.

1. Effort force x length of effort arm = Load force x length of load arm

2. $VR = \frac{\text{Distance effort force moves}}{\text{Distance load force moves}}$

3. $MA = \frac{\text{Length of effort arm}}{\text{Length of load arm}}$

4. $MA = \frac{\text{Load force}}{\text{Effort force}}$

5. $\text{Percentage Efficiency} = \frac{MA}{VR} \times 100\%$

1. Which of the following is true of first-class levers?

A) The fulcrum is between the effort force and load force.
B) The fulcrum could be placed closer to the effort force giving the lever a velocity advantage.
C) The fulcrum could be placed closer to the load giving the lever a force advantage.
D) All of the above
E) Only A & C

2. An ergonomically designed object

A) is safer for people to use.
B) works more efficiently and easily.
C) is more attractive than functional.
D) Only A & B
E) Only A & C

BLM 6.7 MULTIPLE-CHOICE TEST (continued)

3. When using a single fixed pulley

A) the effort force equals the load force.
B) the effort force is greater than the load force.
C) the effort force is less than the load force.
D) the velocity ratio is >1.
E) None of the above.

4. A double fixed pulley is being used to raise a weight of 60 N. What effort force is required?

A) 60 N
B) 30 N
C) 20 N
D) 15 N
E) None of the above

5. A double fixed pulley is being used to raise a weight of 60 N to a height of 3 m. How many metres of rope must be pulled through the pulley?

A) 3 m
B) 1.5 m
C) 6 m
D) 9 m
E) None of the above

6. What would be the mechanical advantage of a lever with an effort arm 2 metres long and a load arm 0.5 metres long?

A) 4
B) 0.25
C) 2
D) 1
E) None of the above

BLM 6.7 MULTIPLE-CHOICE TEST (continued)

7. The mechanical advantage of a double fixed pulley requiring an effort of 15 N to raise a load of 45 N would be?

A) 2.5
B) 0.34
C) 1.5
D) 3
E) None of the above

8. What would the Percentage Efficiency of a mechanism if its mechanical advantage is 2.7 and its velocity ratio is 3?

A) 90%
B) 87%
C) 100%
D) 88.3%
E) None of the above

9. A liquid, in a closed system,

A) distributes force evenly to the entire inside surface area of the container.
B) is virtually not able to be compressed.
C) is compressible.
D) A & B
E) A & C

10. Which of the following is true about levers?

A) The first-class lever has its fulcrum between its load and the force.
B) A wheelbarrow is an example of a second class lever.
C) The effort in a third-class lever is between the load and the force.
D) All of the above
E) Only A & C

BLM 6.7 MULTIPLE-CHOICE TEST (continued)

11. The third-class lever

A) has a velocity ratio less than 1.
B) has a mechanical advantage greater than 1.
C) uses a large effort force to move a smaller load.
D) All of the above
E) Only A & C

12. A mechanism operated by a hydraulic system has a load arm that is 10 cm long and an effort arm which is 5 cm long. How many N of force will the hydraulic system need to produce to raise an object which has a load force of 50 N?

A) 50 N
B) 500 N
C) 100 N
D) 5 N
E) 2 N

BLM 6.8 ANSWER SHEET

BLM 5.1

ARROWS---------- Rock----------rock down; ground up
Seesaw-------both people down
Pulley----------rope down; weight down; pulley hanger up; pulley down
Scissors------handles together; blades together; paper opposite to blades

BOUNCING BALL---Speed=32 cm/s
CAR---Speed=96 km/h

BLM 5.2

VELOCITY
load force moves (.5 cm); effort force moves (2 cm)
velocity ratio=4

VELOCITY RATIO (Continued)
Single fixed pulley------VR=1
Double fixed pulley-----VR=3
VR= 1 is good because a load which is able to be lifted can be moved more quickly.
VR>1 is good because a load which is too heavy to be lifted without a machine can be lifted.

BLM 6.3

MECHANICAL ADVANTAGE
Effort of 10 N to move a load of 10 N
MA=10/10
Effort<load then MA is (greater) than 1
Effort>load then MA is (less) than 1
Effort arms (shorter) than load arms have MA<1
MA for lever with effort arm 90 cm and load arm 10 cm is (9)
>,=,< ----------lever 1---MA(=)--VR(=)
lever 2---MA(>)--VR(>)
lever 3---MA(>) --VR(>)
lever 4---MA(<)--VR(<)
lever 5---MA(<)--VR(<)
Machines that move larger load with less effort = (force) advantage
Machines that move smaller load a greater distance = (velocity) advantage

BLM 6.8 ANSWER SHEET (continued)

BLM 6.5

EFFICIENCY

PE=MA/VR

=3/3*100

= 100%

Efficiency is reduced by FRICTION

Friction can be diminished by using BEARINGS or LUBRICATION

BLM 6.4

SUMMARY

EF<LF---------yes-----yes-----no-----no-----yes

VR>1----------yes-----yes-----no-----no-----yes

Relationship-------If MA=1 then VR=1

If MA<1 then VR<1

If MA>1 then VR>1

In order to reduce the size of the (effort) force needed to move a load, that force must be applied over a greater (distance).

BLM 6.7

MULTIPLE CHOICE TEST

1--D

2--D

3--A

4--C

5--D

6--A

7--D

8--A

9--D

10--D

11--E

12--C

BLM 7.1 Hydraulic Test Lever (First Class)

This machine is constructed with 1 cm^2 craft wood. 3/16 doweling is used for all pivot points. This unit can be assembled using carpenter's wood glue with gussets. Tape a steel square to the work surface to use when squaring frames. A small plastic square from a geometry set works well to square cross braces.

Tips:

- When working with 1 cm^2 craft wood, 3/16" dowel is easier to work with than 1/4". Make the holes a little larger than the dowel by using a 13/64" (best) or 7/32" drill so that pivot pins can be inserted and removed easily.

- When drilling pivot holes in parallel parts (such as the sides of the boom), do so before assembling. Mark one side, and then tape it securely to the other side with masking tape and drill both at once. This will ensure that all of the holes align properly.

- When drilling holes close to the end of a piece of wood, either drill before cutting or the cut piece extra long, drill the hole, and then trim to correct size. This will prevent the end from splitting.

- Hydraulic or pneumatic cylinders need to be able to pivot slightly on both ends when moving something that arcs (such as a lever) or they will bind.

- Attaching the end of the syringe to a pivot can be difficult. One effective way is to cut the thumb piece off of the plunger and then carefully drill a pivot hole through the middle of the X shaped stem about ½ cm from the end.

- As part of the assembly of these machines, the joints can be further strengthened using gussets fastened with wood glue if so desired.

- The measurements given for the assembly of these machines are based on using a 20 mL syringe. However, the syringe used for the input force in the hydraulic system is a 10 mL syringe.

- If this machine is going to be used to lift heavy loads, extend the sides of the base frame to the rear about 10 cm as shown on the plan. This will accommodate a counterweight.

BLM 7.2 Assembly Instructions

Base Frame
Cut five 8 cm crosspieces and two 25 cm sides (35 cm if you want counter balance supports). Glue together being careful to follow layout instructions. There will be a 1 cm gap left in the center where the tower will be inserted. Make sure the frame is squared and flat as you glue it.

Tower
Cut two 28 cm sides and three 6 cm crosspieces. Also cut two 45^0 angle supports 7 cm long. Tape the side pieces together with masking tape and drill the pivot hole 22 cm from bottom. Glue the bottom horizontal crosspiece first. Then add an angle brace. The next horizontal support is glued at the top and so on. Square each horizontal support as you go.

When the tower is made, glue it into the empty space in the center of the base making sure it is at a 90^0 angle. Add two 45^0 supports on the front end of the tower. They need to reach from the cross brace to the tower.

Boom
Cut two side rails 50 cm long. Tape securely together and mark hole layout as shown on diagram. At the effort end of boom the first hole should be drilled 2 cm from end and then four more at 2 cm intervals. The boom fulcrum hole is drilled 14 cm from effort end. Be careful to drill both holes through the center of the wood or the boom will be tilted to one side. The holes at the load end of the boom are used to change the advantage of the lever as well as adjustment pivot points for later attachments. They also are drilled at 2 cm centers. There are three 2 cm cross braces (note that there is an end brace on the work end only). Make sure the pieces are flat and squared, then glue them. The boom can now be mounted on the tower frame.

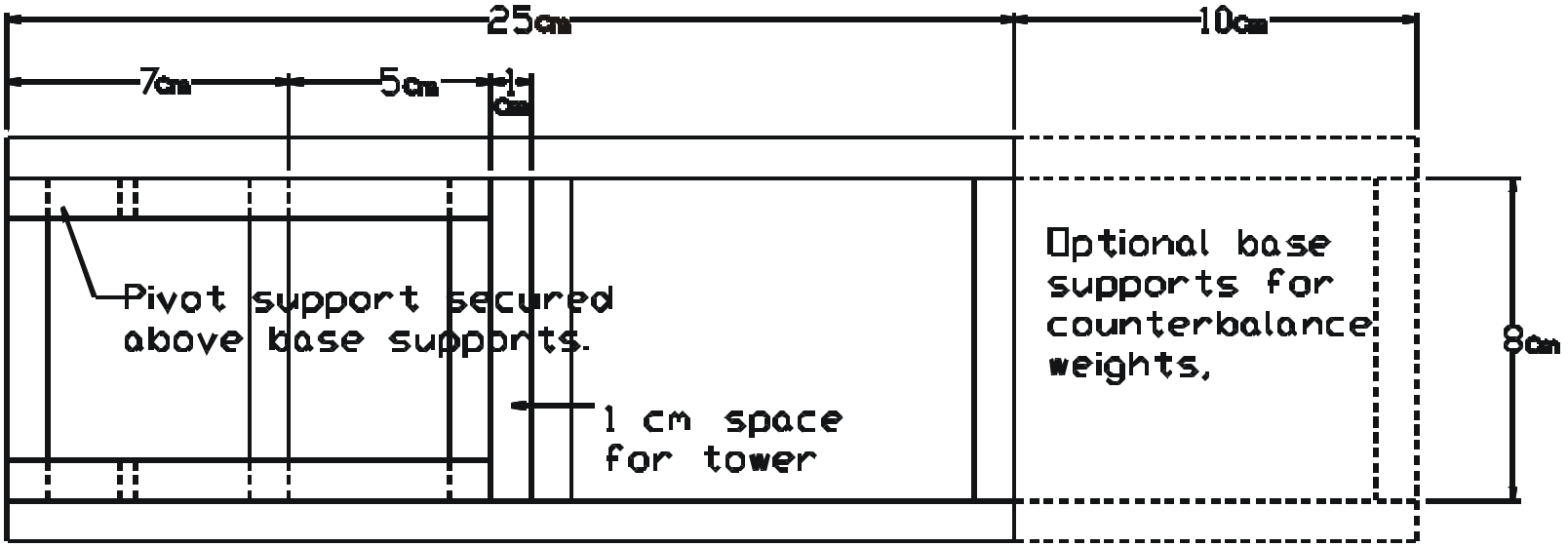
BLM7.3 Assembly Instructions

Hydraulic/Pneumatic Cylinder Assembly

Cut two 14 cm side pieces. Tape together and drill a pivot hole 1 cm from one end. Put one on either side of a 20mL syringe with the two pieces of wood butting against the protruding finger supports of the cylinder. Insert a 3/16" pivot pin through the holes to ensure they align. Wrap with electrical tape near top and bottom of the cylinder. Remove the plunger from the cylinder and carefully use a hacksaw to cut the thumb piece off flush at the end. Drill a pivot hole through the X shaped plunger ½ cm from the end. If this is going to be a hydraulic system, load the syringes and tubing with water now. Cut two 12 cm pieces for the pivot assembly. Tape together and drill a pivot hole 4 cm from the end. Glue in place 1 cm inside base frame (they should line up with the tower uprights). Line up the holes with those on the wooden cylinder supports and insert a pivot pin through the holes. Insert another pivot pin into one set of the boom adjustment holes and through the cut end of the plunger. Your machine is now ready for testing!

BLM 7.4 Base Frame Design

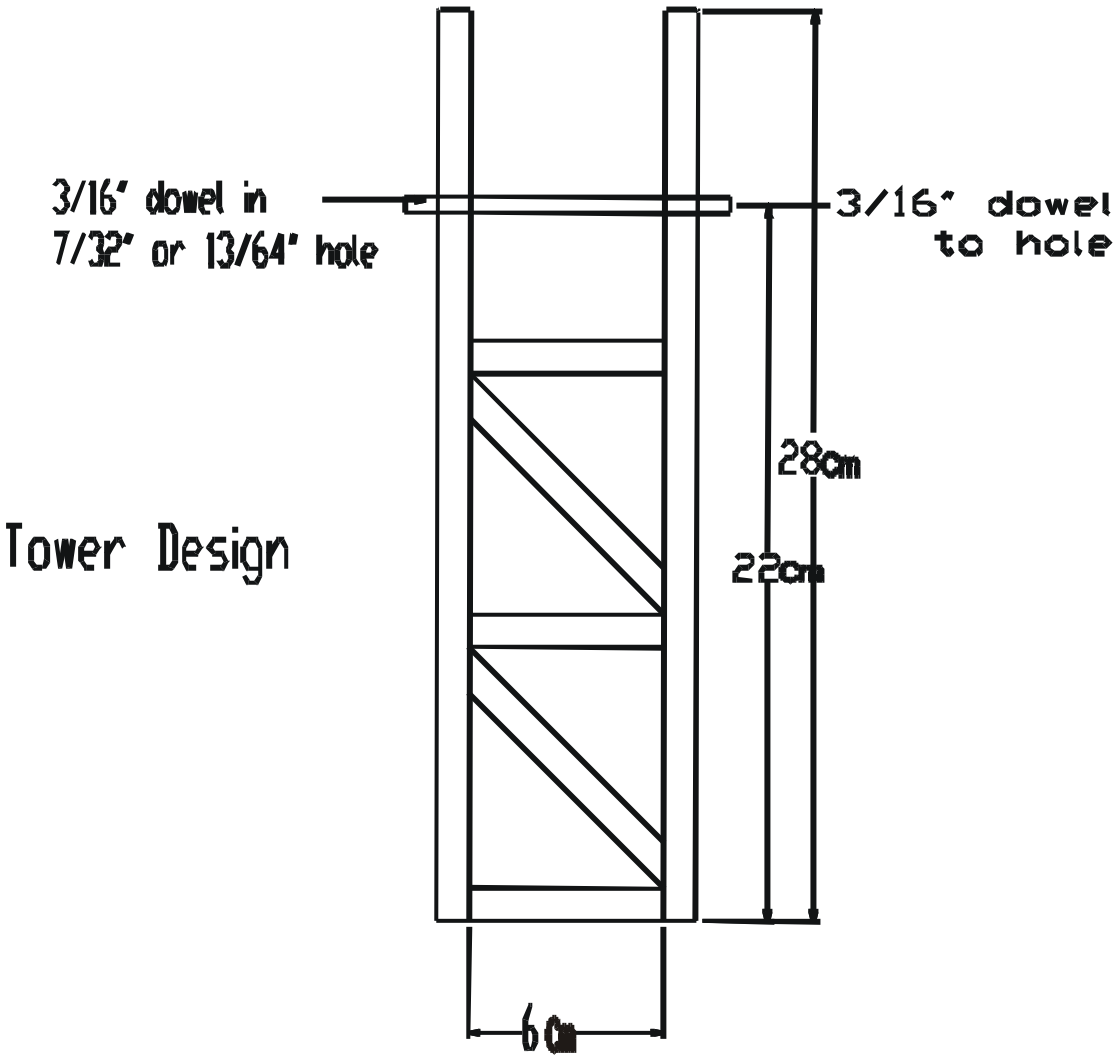
**(Framework uses 1cm x 1cm craftwood.
All dowelling is 3/16" in diameter.)**



Base Design

BLM 7.5 Tower Frame Design

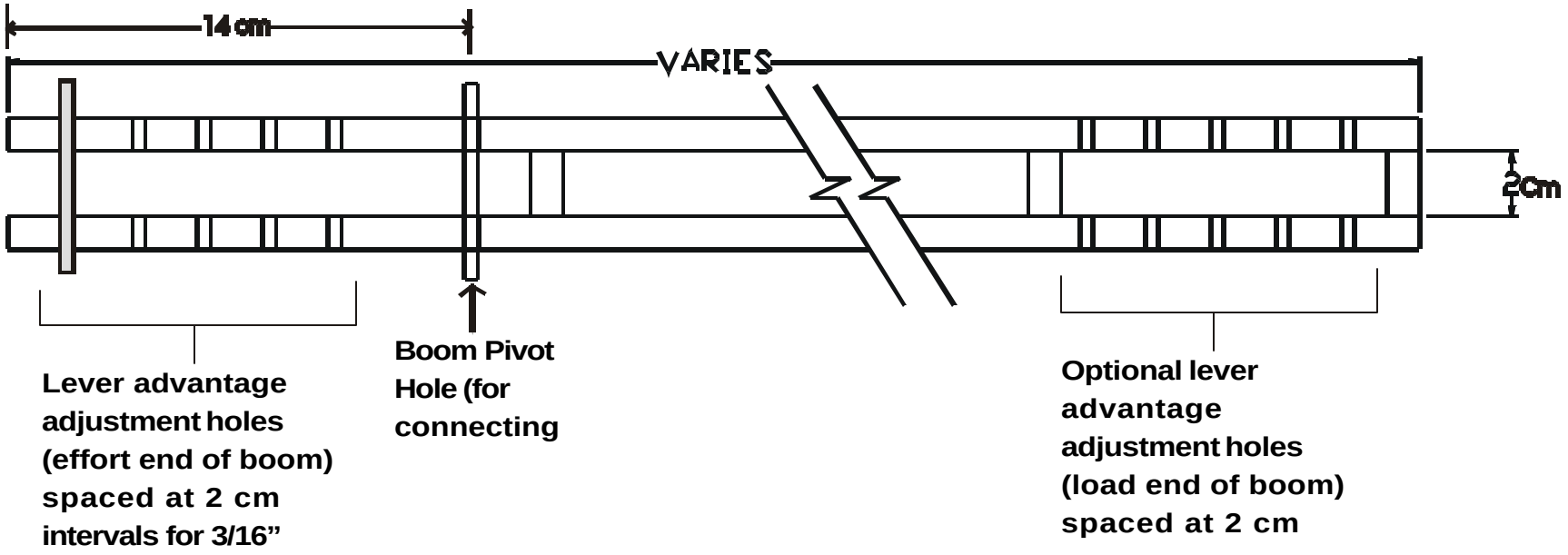
(Framework uses 1 cm x 1 cm craftwood.
All doweling is 3/16” in diameter.)



Tower Design

BLM 7.6 Boom Frame Design

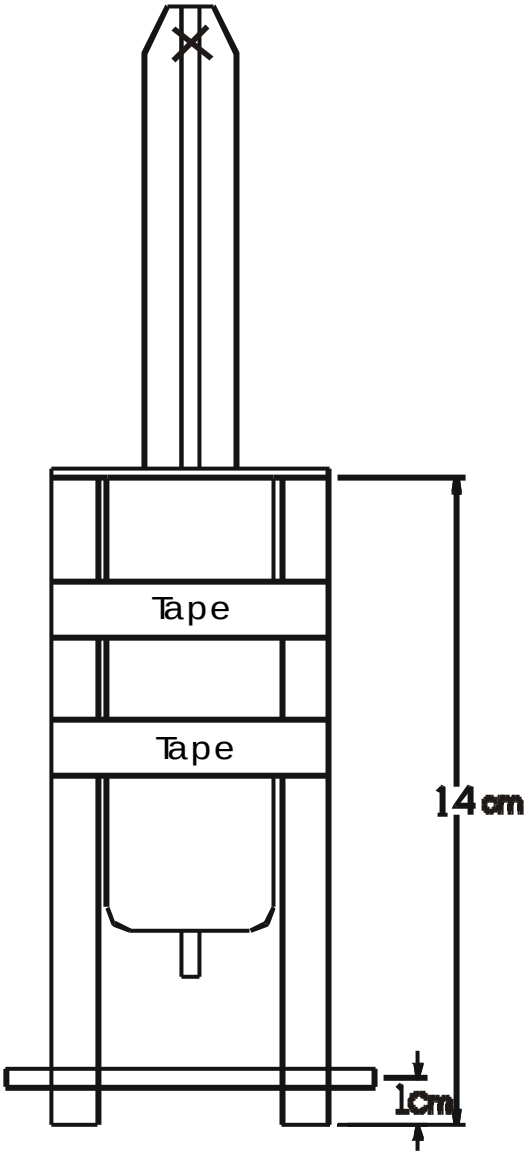
**(Framework uses 1cm x 1cm craftwood.
All doweling is 3/16" in diameter.)**



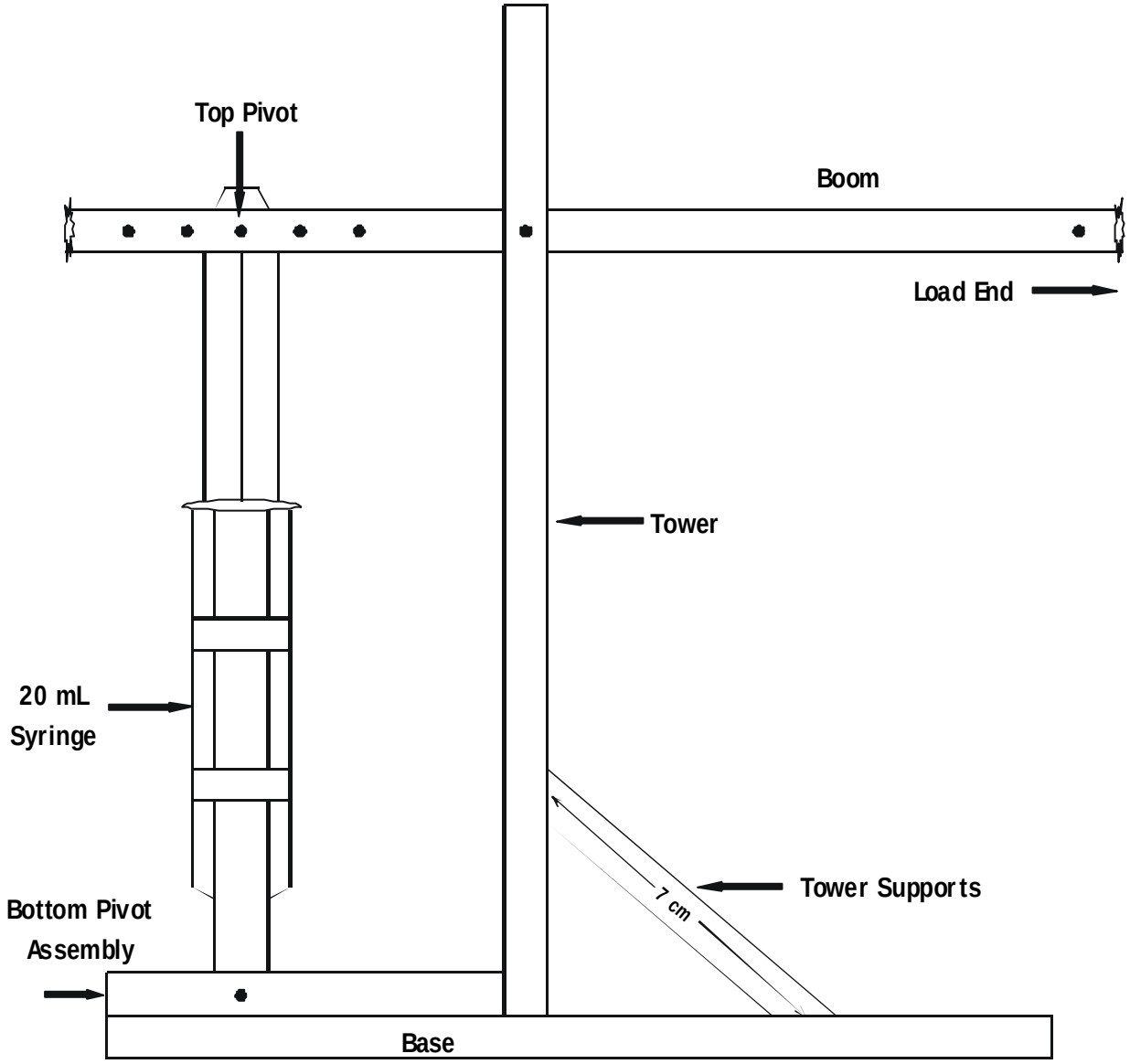
Boom Design

BLM 7.7 Syringe Assembly

Use a 20 mL syringe.
Drill 13/64" or 7/32" holes for 3/16" dowel pin (before making full assembly) 1 cm from the end of each piece of craftwood.
Secure wood to syringe with electrical tape.
Cut thumbpress off of plunger for this syringe only.
Drill 13/64" or 7/32" hole through end of plunger (where "X" is marked).



BLM 7.8 Side View of Complete Assembly



BLM 7.9 Instructions for Testing the Hydraulic Lever

Now that you have completed the construction of your hydraulic lever, it is time to test it!

1/ Create a table or data chart for the information that you will be finding and calculating as part of this testing procedure. Use an appropriate computer program or create the table by hand (according to the instructions of your teacher).
You will be:
a) measuring and recording "EA" (distance from where effort force is applied to fulcrum), and "RA" (distance from the load force to fulcrum), recording "R" (load force), and calculating "E" (effort force by using the formula E x EA = R x RA).
b) calculating and recording Velocity Ratio = $\frac{\text{Distance Effort Force Moves}}{\text{Distance Load Force Moves}}$
c) calculating and recording mechanical advantage (load force / effort force)
d) calculating and recording mechanical efficiency (mechanical advantage/velocity ratio)

2/ Attach a load of 200 g to the load end of the boom. You might want to simply use tape to make the attachment.

3/ Position the adjustment pin into the first set of lever advantage adjustment holes at the effort end of the lever (closest to the end of the boom) once the hole in the top of the syringe assembly is lined up with the lever advantage adjustment holes.

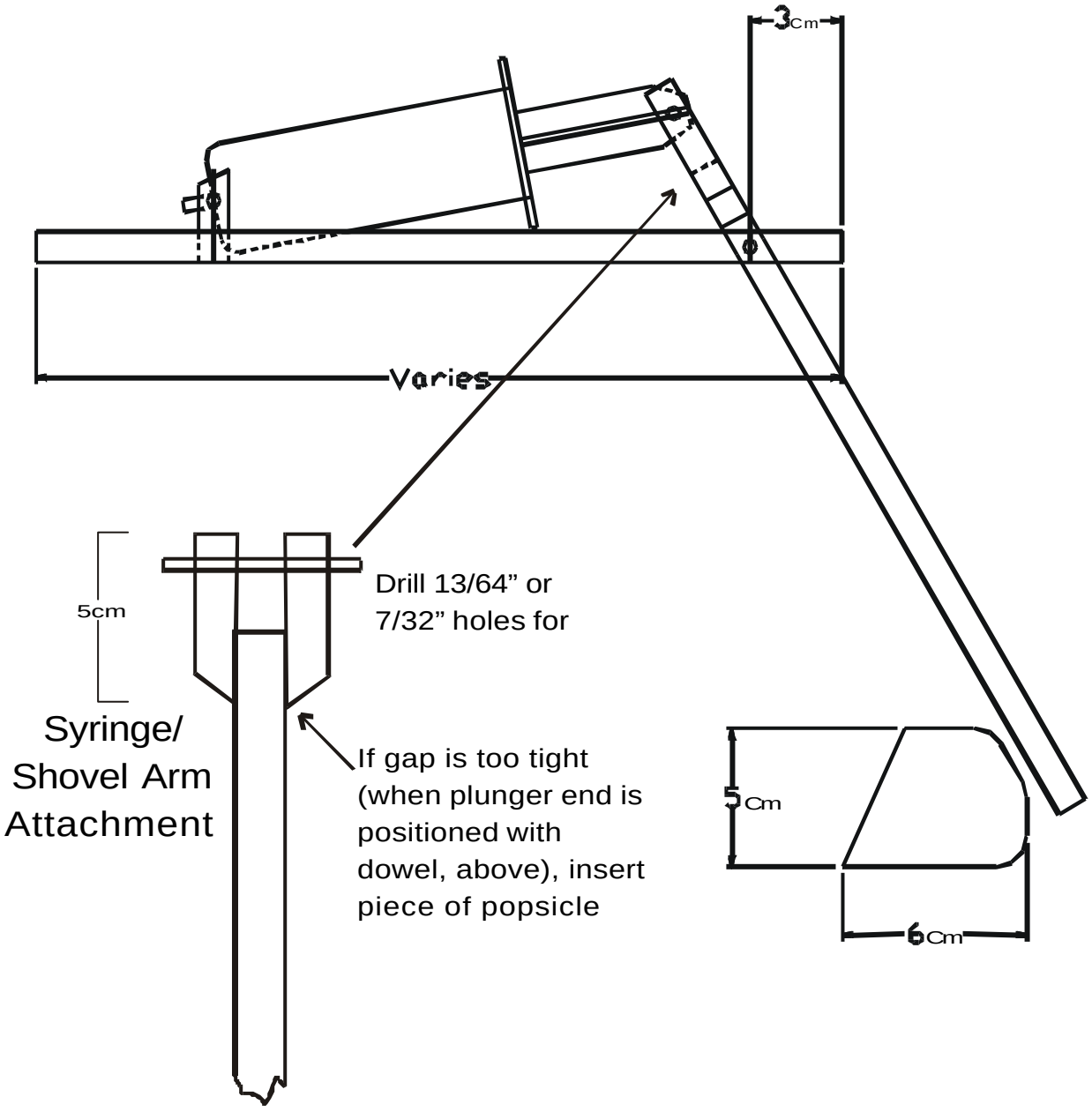
4/ Decide on a set distance through which your 200 g mass should move (in consultation with your teacher and with the rest of your classmates). You and your classmates should all commit to holding this variable (distance the 200 g mass moves) constant throughout your testing procedure.

5/ Move the 200 g mass the required distance (outlined in step 4, above). Then fill in the appropriate part of your table or data chart with the required information.

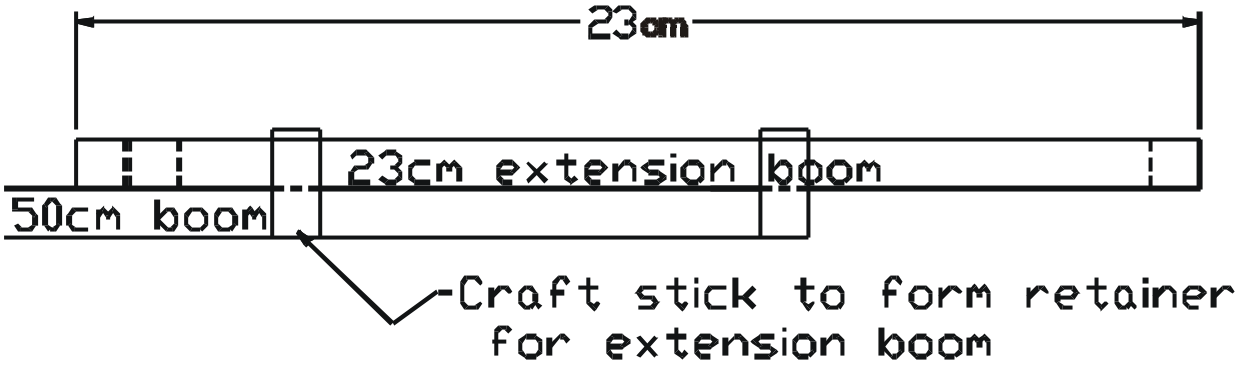
6/ Repeat step 5 a total of 5 times, moving the top of the syringe assembly and the adjustment pin in line with the next closest set of lever advantage adjustment holes each time.

BLM 8.1 Shovel Arm Assembly

Note: These assembly plans based on a 50 cm long boom and a 24 cm long shovel arm. These lengths can vary.



BLM 8.2 Boom Extension Design



Extension Boom Side View

Extension Boom Top View

BLM 8.3 Case Study: Creating, Constructing, and Presenting a Mechanical Toy Device

The president of "Smooth Move Toy Company" has approached a select group of her most trusted and experienced employees to design, construct, test, and market a new mechanical toy. You and other selected classmates (by the teacher) will form that team of employees who will attempt to successfully meet the challenge presented to you by your company president.

As one of these select employees, you must create a technical drawing for your proposed mechanical toy device, remembering to incorporate the following criteria:

1/ The device must be no more than 30 cm in height.

2/ The device must raise a 200 g mass at least 15 cm in a vertical (straight up) direction and at least 15 cm in a horizontal (forward, backward, to the left, or to the right) direction (after raising it up).

3/ The device must use hydraulic or pneumatic power for any of its movement.

4/ The device must incorporate the use of one or more levers.

5/ Pulleys can be incorporated into your device, but use of these is optional.

6/ The device must be as mechanically efficient as possible. Consider ways to reduce frictional forces that are acting on your device.

7/ Technical drawings (similar in format to those supplied to you for subtask 7) must be completed for your device. Remember to include an appropriate title, labels for the various parts of the device, measurements in cm, use of a ruler to draw straight lines, and a materials list.

You will then present your finished technical drawing to your team members. Next, you must work as a team to identify the strengths and weaknesses of each member's drawing. Remember to use a very positive approach to offering constructive criticism! The team will then come up with a group design that "captures the best" of each individual's design.

The team must then decide, by way of consensus, what materials (and respective quantities) are needed for construction purposes. The materials that are available will be reviewed with you by your teacher.

Your team then begins construction, with each group member involved in it.

Once construction is complete, the device needs to be tested to see if it can meet the criteria set out in # 2, above. Modifications may be necessary.

Use of your learning log is important as part of this design process. In your learning log reflect on and write answers to the following questions:

a) What have been all of my contributions to the design and construction of this mechanical toy device?
b) How well has my team worked together (consider strengths and weaknesses)?
b) Does my team's mechanical toy device meet all of the given critieria? Does this newly developed toy device operate efficiently? What supports its efficient operation? How do you know?
c) What are the most important "selling features" of this product (recall some of the work that you completed for subtask 2)?
d) How could your team's mechanical toy be improved to make it more mechanically efficient and, possibly, more appealing to the consumer?
e) In what ways is this type of pneumatic or hydraulic power application used to meet many of the real, every day needs of people?

You and your teammates will now be required to prepare a presentation of your finished product for the president (e.g., your teacher) and the rest of the company executives. Based on your reflections in your learning log, discuss with your teammates the most important "selling features" of your product. Each member of your team should be prepared to share some aspect of your device that will help to ensure that your product is accepted by company executives.

<u>Timeline:</u>

1/ Personally developed technical drawings to be completed by _____.

2/ Team Design to be completed by _____.

3/ Construction of mechanical toy device to be completed by _____.

4/ Reflections in learning log to be completed by _____.

5/ Date of my team's presentation: _____.

Several in-class work periods will be supplied over the next two weeks to complete all of the steps outlined in the timeline, above.

Student Name: _____

Date: _____

Rubric 2b for Presentation

for use with Subtask 2 : Let's Sell It!

from the Grade 8 Unit: **Structures and Mechanisms**

Expectations for this Subtask to Assess with this Rubric:

8e2 • use writing for various purposes and in a range of contexts, including school work (e.g., to write technical instructions, to clarify personal concerns, to explore social issues, to develop imaginative abilities);

8s89 • demonstrate understanding of the factors that can affect the manufacturing of a product, including the needs of the consumer.

8s103 – communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes and descriptions, charts, graphs, drawings, and oral presentations (e.g., make a display in which they compare the ways in which a closed pneumatic system and a hydraulic system operate the...

8s108 – analyse the use of symmetry in the ergonomic design of objects and systems (e.g., office furniture, computer equipment);

8s114 – evaluate product manuals or help screens (e.g., a manual for a video recorder), focusing on clarity, thoroughness, and general “user-friendliness”, and identify ways of making the product easier to use;

Category/Criteria	Level 1	Level 2	Level 3	Level 4
Preparation/Organization	- presentation showed limited organization - student demonstrated limited preparation	- presentation showed some organization - student demonstrated some preparation	- presentation was organized, logical, and interesting - student demonstrated adequate preparation	- presentation was very well-organized, logical, interesting, and lively - student demonstrated a great deal of preparation
Communication/ Presentation	- voice low unclear and monotonous - minimal engagement of audience via eye contact, voice, actions, involvement	- voice sometimes low, some words unclear and somewhat varied - some effort to engage audience	- voice loud enough to be heard easily and most words clear - voice was often varied - spoke at a good pace - considerable success at engaging audience	- voice loud enough to be heard easily and all words clear - voice consistently varied - spoke at an excellent pace - engaged audience by thoroughly integrating into presentation
Content	- small amount of material presented is related to topic - details are random, inappropriate, or barely apparent	- some material presented is not related to topic - details lack elaboration or are repetitious	- almost all material presented is related to topic - details are elaborate and appropriate	- all material presented is related to topic - details are effective, vivid, explicit, and/or pertinent
Report Format	- minimal evidence of use of specified format (e.g., paragraphs or charts)	- some evidence of use of specified format (e.g., paragraphs or charts)	- clear evidence of use of specified format, in an accurate manner (e.g., paragraphs or charts)	- consistent and clear evidence of use of specified format, in a manner that enhances the overall "flow" and understanding of the material (e.g., paragraphs or charts)
Knowledge of Topic	- demonstrated limited understanding of topic - showed significant misconceptions	- demonstrated some understanding of topic - showed minor misconceptions	- demonstrated a good understanding of the topic - showed no significant misconceptions	- demonstrated a very strong understanding of the topic - showed no misconceptions

Student Name: _____

Date: _____

Rubric 3 for Syringe System Investigation

for use with Subtask 3 : When Push Comes to Shove

from the Grade 8 Unit: **Structures and Mechanisms**

Expectations for this Subtask to Assess with this Rubric:

8s90 – explain how forces are transferred in all directions in fluids (Pascal's law);

8s93 – compare the effect of pressure on a liquid (e.g., on water in a syringe) with the effect of pressure on a gas (e.g., on air in a syringe);

8s101 – use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);

8s102 – compile qualitative and quantitative data gathered through investigation in order to record and present results, using diagrams, flow charts, frequency tables, graphs, and stem-and-leaf plots produced by hand or with a computer (e.g., produce and analyse a quotation to complete a job in the home);

8s103 – communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes and descriptions, charts, graphs, drawings, and oral presentations (e.g., make a display in which they compare the ways in which a closed pneumatic system and a hydraulic system operate the

Category/Criteria	Level 1	Level 2	Level 3	Level 4
Carrying out the Plan **-instructions followed** **-safety** **-conducting**	-demonstrated a limited understanding of the instructions -required substantial assistance in approaching and carrying out the task -required continual direction for the use of materials and equipment appropriately	-demonstrated a partial understanding of the instructions -required some assistance in approaching and carrying out the task -required some direction for use of materials and equipment appropriately	-demonstrated understanding of the instructions - with very limited assistance approached and carried out the task -required very limited direction for the use of materials and equipment appropriately	-demonstrated a thorough understanding of the instructions -confidently approached and carried out the task independently -used materials and equipment appropriately without any direction
Recording **-diagrams** **-observations** **-organization**	-diagrams were insufficiently completed and not labelled completely -observations are unorganized and unclear	-diagrams were sufficiently labelled and drawn -observations are adequately recorded in a somewhat organized manner and demonstrate some accuracy of information	-diagrams were clearly drawn and appropriately labelled -observations are sequentially recorded, easy to read, and demonstrate accuracy of information	-diagrams were drawn to scale and labelled clearly -observations are excellently recorded, well-written, and demonstrate insightfulness and good detail
Communication of Understanding **-terminology** **-clarity**	-explanations were unclear, uncertainty of the effects of pressure was shown -terminology used demonstrated uncertainty	-explanations demonstrated some understanding of effects of pressure -used some appropriate terminology in the explanations	-explanations demonstrated understanding of effects of pressure -used appropriate terminology for most of the explanations	-explanations demonstrated clear understanding of effects of pressure -used appropriate terminology for all of the explanations
Connecting/Relating Investigation to the World Around Us	-showed limited understanding about the uses, advantages, disadvantages, and efficiency of pneumatics and hydraulics	-showed some understanding about the uses, advantages, disadvantages, and efficiency of pneumatics and hydraulics	-showed an understanding about the uses, advantages, and efficiency of pneumatics and hydraulics	-confidently showed understanding about the uses, advantages, and efficiency of pneumatics and hydraulics

Student Name: _____

Date: _____

Rubric 4 for Investigation of Friction

for use with Subtask 4 : Slow Down

from the Grade 8 Unit: **Structures and Mechanisms**

Expectations for this Subtask to Assess with this Rubric:

8s95 – investigate and measure forces that affect the movement of an object (e.g., friction);

8s101 – use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);

8s102 – compile qualitative and quantitative data gathered through investigation in order to record and present results, using diagrams, flow charts, frequency tables, graphs, and stem-and-leaf plots produced by hand or with a computer (e.g., produce and analyse a quotation to complete a job in the home);

8s103 – communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes and descriptions, charts, graphs, drawings, and oral presentations (e.g., make a display in which they compare the ways in which a closed pneumatic system and a hydraulic system operate the...

Category/Criteria	Level 1	Level 2	Level 3	Level 4
Carrying out the Plan **-instructions followed** **-safety** **-conducting**	-demonstrated a limited understanding of the instructions -required substantial assistance in approaching and carrying out the task -required continual direction for the use of materials and equipment appropriately and safely	-demonstrated a partial understanding of the instructions -required some assistance in approaching and carrying out the task -required some direction for use of materials and equipment appropriately and safely	-demonstrated understanding of the instructions - with very limited assistance approached and carried out the task -required very limited direction for the use of materials and equipment appropriately and safely	-demonstrated a thorough understanding of the instructions -confidently approached and carried out the task independently -used materials and equipment appropriately without any direction and safely
Recording **-observations** **-organization**	-made few observations -observations are unorganized and unclear	-made observations but they were insufficient to generate data -observations are adequately recorded in a somewhat organized manner and demonstrate some accuracy of information	-made sufficient observations to generate data -observations are sequentially recorded, easy to read, and demonstrate accuracy of information	-made insightful observations -observations are excellently recorded, well-written, and demonstrate good detail
Communication of Understanding **-terminology** **-clarity**	-explanations were unclear, uncertainty of the effects of friction -terminology used demonstrated uncertainty	-explanations demonstrated some understanding of effects of friction -used some appropriate terminology in the explanations	-explanations demonstrated understanding of effects of friction -used appropriate terminology for most of the explanations	-explanations demonstrated clear understanding of effects of friction -used appropriate terminology for all of the explanations
Connecting/Relating Investigation to the World Around Us	-showed limited understanding about the impact of friction on movement in the world outside of the school	-showed some understanding about the impact of friction on movement in the world outside of the school	-showed an understanding about the impact of friction on movement in the world outside of the school	-confidently showed understanding about the impact of friction on movement in the world outside of the school

Rubric 5 for Velocity Ratio Investigations

for use with Subtask 5 : Speed, Distance, Force ... Velocity ... Velocity Ratio

from the Grade 8 Unit: **Structures and Mechanisms**

Student Name: _____

Date: _____

Expectations for this Subtask to Assess with this Rubric:

8s96 – distinguish between velocity and speed (i.e., define velocity as speed in a given direction);

8s97 – 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);

8s101 – use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);

8s102 – compile qualitative and quantitative data gathered through investigation in order to record and present results, using diagrams, flow charts, frequency tables, graphs, and stem-and-leaf plots produced by hand or with a computer (e.g., produce and analyse a quotation to complete a job in the home);

Category/Criteria	Level 1	Level 2	Level 3	Level 4
Carrying out the plan **-instructions followed** **-safety** **-conducting**	-demonstrated a limited understanding of the instructions -required substantial assistance in approaching and carrying out the task -required continual direction for the use of materials and equipment appropriately and safely	-demonstrated a partial understanding of the instructions -required some assistance in approaching and carrying out the task -required some direction for use of materials and equipment appropriately and safely	-demonstrated understanding of the instructions - with very limited assistance approached and carried out the task -required very limited direction for the use of materials and equipment appropriately and safely	-demonstrated a thorough understanding of the instructions -confidently approached and carried out the task independently -used materials and equipment appropriately without any direction and safely
Recording **-tables** **-observations** **-organization**	-tables were insufficiently completed and not labelled completely -observations are unorganized and unclear	-tables were sufficiently labelled and design with some accuracy -observations are adequately recorded in a somewhat organized manner and demonstrate some accuracy of information	-tables were clearly designed and appropriately labelled -observations are sequentially recorded, easy to read, and demonstrate accuracy of information	-tables were designed with great precision and labelled clearly -observations are excellently recorded, well-written, and demonstrate insightfulness and good detail
Understanding Concepts **-clarity** **-terminology**	-explanations/written work were unclear, uncertain of the meaning of velocity and velocity ratio -terminology used demonstrated uncertainty	-explanations/written work demonstrated some understanding of velocity and velocity ratio -used some appropriate terminology as part of explanations	-explanations/written work demonstrated understanding of velocity and velocity ratio -used appropriate terminology for most of the explanations	-explanations/written work demonstrated clear understanding of velocity and velocity ratio -used appropriate terminology for all of the explanations

Student Name: _____

Date: _____

Rubric 6 for MA/ME Investigations

for use with Subtask 6 : How Efficient Is It?

from the Grade 8 Unit: **Structures and Mechanisms**

Expectations for this Subtask to Assess with this Rubric:

8s98 – predict the mechanical efficiency of using different mechanical systems (e.g., a winch).

8s101 – use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);

8s102 – compile qualitative and quantitative data gathered through investigation in order to record and present results, using diagrams, flow charts, frequency tables, graphs, and stem-and-leaf plots produced by hand or with a computer (e.g., produce and analyse a quotation to complete a job in the home);

Category/Criteria	Level 1	Level 2	Level 3	Level 4
Carrying out the plan **-instructions followed** **-safety** **-conducting**	-demonstrated a limited understanding of the instructions -required substantial assistance in approaching and carrying out the task -required continual direction for the use of materials and equipment appropriately and safely	-demonstrated a partial understanding of the instructions -required some assistance in approaching and carrying out the task -required some direction for use of materials and equipment appropriately and safely	-demonstrated understanding of the instructions - with very limited assistance approached and carried out the task -required very limited direction for the use of materials and equipment appropriately and safely	-demonstrated a thorough understanding of the instructions -confidently approached and carried out the task independently -used materials and equipment appropriately without any direction and safely
Recording **-tables** **-observations** **-organization**	-tables were insufficiently completed and not labelled completely -observations are unorganized and unclear	-tables were sufficiently labelled and design with some accuracy -observations are adequately recorded in a somewhat organized manner and demonstrate some accuracy of information	-tables were clearly designed and appropriately labelled -observations are sequentially recorded, easy to read, and demonstrate accuracy of information	-tables were designed with great precision and labelled clearly -observations are excellently recorded, well-written, and demonstrate insightfulness and good detail
Understanding Concepts **-clarity** **-terminology**	-explanations/written work were unclear, uncertain of the meaning of mechanical advantage and mechanical efficiency -terminology used demonstrated uncertainty	-explanations/written work demonstrated some understanding of mechanical advantage and mechanical efficiency -used some appropriate terminology as part of explanations	-explanations/written work demonstrated understanding of mechanical advantage and mechanical efficiency -used appropriate terminology for most of the explanations	-explanations/written work demonstrated clear understanding of mechanical advantage and mechanical efficiency -used appropriate terminology for all of the explanations

Student Name: _____

Date: _____

Rubric 7 for Hydraulic Test Lever Activity

for use with Subtask 7 : Linking The Systems

from the Grade 8 Unit: **Structures and Mechanisms**

Expectations for this Subtask to Assess with this Rubric:

8s98 – predict the mechanical efficiency of using different mechanical systems (e.g., a winch).

8s101 – use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);

8s102 – compile qualitative and quantitative data gathered through investigation in order to record and present results, using diagrams, flow charts, frequency tables, graphs, and stem-and-leaf plots produced by hand or with a computer (e.g., produce and analyse a quotation to complete a job in the home);

Category/Criteria	Level 1	Level 2	Level 3	Level 4
Understanding of Concepts (e.g., stability, force, pressure, mechanical advantage)	- showed understanding of few of the basic concepts - gave explanations showing limited understanding of the concept	- showed understanding of some of the basic concepts - gave partial explanations	- showed understanding of most of the basic concepts - usually gave complete or nearly complete explanations	- showed understanding of all of the basic concepts - always gave complete explanations
Design Skills (e.g., following design plans, using appropriate tools, materials, and strategies)	- could not follow design plans without significant assistance - using tools and materials that required assistance	- followed the design plans with limited assistance - used tools and materials successfully with some assistance	- followed the design plans independently and with accuracy - used tools and materials in ways that reflected good strategy development	- followed the design plans independently, with great attention to detail, and/or made suggestions for improvements - used tools and materials in ways that reflected excellent strategy development
Data Collection Through Investigation (e.g., qualitative and quantitative data related to mechanical efficiency of hydraulic lever)	- completed investigation with significant assistance - table or chart was provided - data collection was incomplete or done with significant assistance	- completed investigation with some assistance - table or chart was created with some assistance - data collection was complete/ almost complete with formulae use being fairly accurate	- completed investigation with occasional assistance - table or chart was created independently and correctly - data collection was complete with formulae use being accurate	- completed investigation independently - table or chart was completely self-designed and accurate - data collection was complete with formulae use demonstrating thorough understanding of data
Communication of Understanding (e.g., how levers and hydraulics affect mechanical efficiency)	- communicated with little clarity and precision - rarely used appropriate science and technology terminology	- communicated with some clarity and precision - sometimes used appropriate science and technology terminology	- generally communicated with clarity and precision - usually used appropriate science and technology terminology	- consistently communicated with clarity and precision - consistently used appropriate science and technology terminology

Student Name: _____

Date: _____

Rubric 8 for Evaluating Culminating Activity

for use with Subtask 8 : Toying With Efficiency

from the Grade 8 Unit: **Structures and Mechanisms**

Expectations for this Subtask to Assess with this Rubric:

8s89 • demonstrate understanding of the factors that can affect the manufacturing of a product, including the needs of the consumer.

8s104 – design and make a mechanical system that is operated by hydraulic or pneumatic power;

8s105 – select and use appropriate materials and strategies to make a product;

8s106 – produce technical drawings and layout diagrams of a structure or a mechanical system that they are designing, using a variety of resources.

8s118 – evaluate their own designs against the original need, and propose modifications to improve the quality of the products.

Category/Criteria	Level 1	Level 2	Level 3	Level 4
Development of Technical Plan - clarity - use of given criteria	- developed a plan that is unclear and incomplete - took into account little or none of the given criteria	- developed a plan that is limited in how appropriate, clear, and complete it is - identified some of the given criteria	- developed a plan that is appropriate clear, and complete - identified most, if not all, of the given criteria	- developed a reproducible plan that is appropriate, efficient, clear, and complete - identified all of the given criteria
Carrying Out of the Plan - use of tools and other materials -safety - performance of model - incorporation of safety criteria	- used tools, equipment, and materials with limited accuracy, and limited respect for safe practices and only with assistance - performance of model did not demonstrate the required function - incorporated few elements of the original plan - addressed very little of the given criteria in the construction	- selected and used tools, equipment, and materials adequately, safely and with some assistance - performance of model demonstrated the required function in a limited way - incorporated some elements of the original plan - addressed some of the given criteria in the construction	- selected and used tools, equipment, and materials effectively, safely and with only occasional assistance - performance of model demonstrated the required function within acceptable limits - incorporated most, if not all, elements of the original plan - addressed most, if not all, of the given criteria in the construction	- selected and used tools, equipment, and materials safely in innovative ways and with little or no assistance - performance of model demonstrated the required function, exceeding expected level - incorporated all elements of the original plan and made any necessary modifications during construction - addressed exact specifications of the given criteria in the construction
Quality of Explanations - planning, construction, finished product - mechanical efficiency - terminology	- communicated her/his understanding of planning and construction, and "strengths" of the finished product, with limited clarity and precision - explanation of device's mechanical efficiency was completely inaccurate - rarely used appropriate terminology	- communicated her/his understanding of planning and construction, and "strengths" of the finished product, with some clarity and precision - explanation of device's mechanical efficiency, although inaccurate, showed a limited understanding of its importance/value - sometimes used appropriate terminology	- generally communicated her/his understanding of planning and construction, and "strengths" of the finished product, with clarity and precision - explanation of device's mechanical efficiency was accurate or very close, showing some understanding of its importance/value - usually used appropriate terminology	- consistently communicated her/his understanding of planning and construction, and "strengths" of the finished product, with clarity and precision - explanation of device's mechanical efficiency was accurate, showing a strong understanding of its importance/value - consistently used appropriate terminology
Connecting Science and Technology and the World Outside the School	- showed little understanding of the following: the value of working as a member of a team, basic marketing strengths of the product (as these reflected real world working strategies), ways of improving mechanical efficiency, identifying real life applications of hydraulics/pneumatics	- showed some understanding of the following: the value of working as a member of a team, basic marketing strengths of the product (as these reflected real world working strategies), ways of improving mechanical efficiency, identifying real life applications of hydraulics/pneumatics	- showed an understanding of the following: the value of working as a member of a team, basic marketing strengths of the product (as these reflected real world working strategies), ways of improving mechanical efficiency, identifying real life applications of hydraulics/pneumatics - demonstrated some leadership skills as a "company employee"	- showed an understanding of the following: the value of working as a member of a team, basic marketing strengths of the product (as these reflected real world working strategies), ways of improving mechanical efficiency, identifying real life applications of hydraulics/pneumatics, as well as their implications - demonstrated leadership skills as a "company employee"

Student Name: _____

Date: _____

Rubric 1 for Gaining Leverage

for use with Subtask 1 : Gaining Leverage

from the Grade 8 Unit: **Structures and Mechanisms**

Expectationsfor this Subtask to Assess with this Rubric:

8s87 • demonstrate an understanding of the factors that contribute to the efficient operation of mechanisms and systems;

8s101 – use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);

8s103 – communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes and descriptions, charts, graphs, drawings, and oral presentations (e.g., make a display in which they compare the ways in which a closed pneumatic system and a hydraulic system operate the

Category/Criteria	Level 1	Level 2	Level 3	Level 4
Communication of Required Knowledge -using terms: load, force, input, output, fulcrum, lever, force, etc.	– communicated with little clarity and precision – rarely used appropriate science and technology terminology and units of measurement	– communicated with some clarity and precision – sometimes used appropriate science and technology terminology and units of measurement	– generally communicated with clarity and precision – usually used appropriate science and technology terminology and units of measurement	– consistently communicated with clarity and precision – consistently used appropriate science and technology terminology and units of measurement
Understanding of Basic Concepts	– showed understanding of few of the basic concepts – demonstrated significant misconception – gave explanations showing limited understanding of the concepts related to lever classes – identify and explain lever classes	– showed understanding of some of the basic concepts – demonstrated minor misconceptions – gave partial explanations related to lever classes	– showed understanding of most of the basic concepts – demonstrated no significant misconceptions – usually gave complete or nearly complete explanations related to lever classes	– showed understanding of all of the basic concepts – demonstrated no misconceptions – always gave complete explanations related to lever classes
Relating of Science and Technology to Each Other and to the World Outside the School -classifies examples according to lever classes	– showed little understanding of connections between science and technology in familiar contexts – showed little understanding of connections between science and technology and the world outside the school	– showed some understanding of connections between science and technology in familiar contexts – showed some understanding of connections between science and technology and the world outside the school	– showed understanding of connections between science and technology in familiar contexts – showed understanding of connections between science and technology and the world outside the school	– showed understanding of connections between science and technology in both familiar and unfamiliar contexts – showed understanding of connections between science and technology and the world outside the school, as well as their implications

Student Name: _____
Date: _____

Rubric 2a for Communication

for use with Subtask 2 : Let's Sell It!

from the Grade 8 Unit: **Structures and Mechanisms**

Expectationsfor this Subtask to Assess with this Rubric:

8e46 • provide clear answers to questions and well-constructed explanations or instructions in classroom work;

8e49 • express and respond to a range of ideas and opinions concisely, clearly, and appropriately;

8s89 • demonstrate understanding of the factors that can affect the manufacturing of a product, including the needs of the consumer.

8s110 – identify the kinds of information that assist consumers in making a decision about buying a product (e.g., information on performance, durability, safety, benefits to health);

8s116 – explain the economic, social, and environmental factors that can determine whether a product is manufactured (e.g., costs of materials and equipment, availability of skilled labour, potential harmfulness of the product);

Category/Criteria	Level 1	Level 2	Level 3	Level 4
Quality of Explanations	- explanations are incomplete, contain little detail, and/or are inaccurate - explanations include limited support to justify conclusions	- explanations are fairly complete, contain some detail, and offer inconsistent accuracy - explanations include some support to justify conclusions	- explanations are generally complete, detailed and accurate - explanations include adequate support to justify conclusions	- explanations demonstrate insight, significant detail, and are always accurate - explanations include strong support to justify conclusions
Reflection/Openness to Change in Thinking in Written and Oral Communication	- identifies a few sources of error - corrections are attempted with limited accuracy	- identifies and explains, in a limited way, a few sources of error - corrections are attempted with some accuracy	- identifies and explains several sources of error - corrections are generally made with accuracy	- identifies and explains all/almost all sources of error - corrections are consistently made with accuracy
Relating Science and Technology to World Outside School	- uses limited grade-appropriate Science and Technology concepts	- uses some grade-appropriate Science and Technology criteria/concepts	- uses grade-appropriate Science and Technology criteria/concepts	- knows grade-appropriate Science and Technology terminology and uses this knowledge to demonstrate a thorough understanding of the topic

Structures and Mechanisms

Mechanical Efficiency An Integrated Unit for Grade 8

		Selected	Assessed
English Language---			
☐ **8e1**	• communicate ideas and information for a variety of purposes (to evaluate information, to compare points of view) and to specific audiences, using forms appropriate for their purpose (e.g., a survey soliciting opinions on an environmental issue) and features appropriate to the form (e.g., focused questions);	1	
☐ **8e2**	• use writing for various purposes and in a range of contexts, including school work (e.g., to write technical instructions, to clarify personal concerns, to explore social issues, to develop imaginative abilities);		1
English Language---Oral and Visual Communication			
☐ **8e46**	• provide clear answers to questions and well-constructed explanations or instructions in classroom work;	2	1
☐ **8e47**	• listen attentively to organize and classify information and to clarify thinking;	2	
☐ **8e49**	• express and respond to a range of ideas and opinions concisely, clearly, and appropriately;	1	1
Mathematics---Mathematical Process Expectations			
☐ **8m5**	• make connections among mathematical concepts and procedures, and relate mathematical ideas to situations or phenomena drawn from other contexts (e.g., other curriculum areas, daily life, current events, art and culture, sports);	1	
Mathematics---Number Sense and Numeration			
☐ **8m18**	– use estimation when solving problems involving operations with whole numbers, decimals, percents, integers, and fractions, to help judge the reasonableness of a solution;	1	
Mathematics---Patterning and Algebra			
☐ **8m55**	• model linear relationships graphically and algebraically, and solve and verify algebraic equations, using a variety of strategies, including inspection, guess and check, and using a "balance" model.	1	
Mathematics---Data Management and Probability			
☐ **8m70**	– collect and organize categorical, discrete, or continuous primary data and secondary data (e.g., electronic data from websites such as E-Stat or Census At Schools), and display the data in charts, tables, and graphs (including histograms and scatter plots) that have appropriate titles, labels (e.g., appropriate units marked on the axes), and scales (e.g., with appropriate increments) that suit the range and distribution of the data, using a variety of tools (e.g., graph paper, spreadsheets, dynamic statistical software);	2	
Science and Technology---Structures and Mechanisms			
☐ **8s87**	• demonstrate an understanding of the factors that contribute to the efficient operation of mechanisms and systems;	2	1
☐ **8s88**	• design and make systems of structures and mechanisms, and investigate the efficiency of the mechanical devices within them;	1	
☐ **8s89**	• demonstrate understanding of the factors that can affect the manufacturing of a product, including the needs of the consumer.	1	1
☐ **8s90**	– explain how forces are transferred in all directions in fluids (Pascal's law);		1
☐ **8s91**	– describe in quantitative terms the relationship between force, area, and pressure;	1	
☐ **8s93**	– compare the effect of pressure on a liquid (e.g., on water in a syringe) with the effect of pressure on a gas (e.g., on air in a syringe);		1
☐ **8s94**	– explain, using their observations, how the use of appropriate levers and ways of linking the components of fluid systems can improve the performance of the systems (e.g., systems in a steam shovel, in a robot);	2	
☐ **8s95**	– investigate and measure forces that affect the movement of an object (e.g., friction);		1
☐ **8s96**	– distinguish between velocity and speed (i.e., define velocity as speed in a given direction);		1
☐ **8s97**	– 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);		1
☐ **8s98**	– predict the mechanical efficiency of using different mechanical systems (e.g., a winch).	1	2
☐ **8s99**	– 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);	2	
☐ **8s100**	– plan investigations for some of these answers and solutions, identifying variables that need to be held constant to ensure a fair test and identifying criteria for assessing solutions;	1	
☐ **8s101**	– use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);	1	7

Structures and Mechanisms

Mechanical Efficiency An Integrated Unit for Grade 8

		Selected	Assessed
☐ **8s102**	– compile qualitative and quantitative data gathered through investigation in order to record and present results, using diagrams, flow charts, frequency tables, graphs, and stem-and-leaf plots produced by hand or with a computer (e.g., produce and analyse a quotation to complete a job in the home);	1	5
☐ **8s103**	– communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes and descriptions, charts, graphs, drawings, and oral presentations (e.g., make a display in which they compare the ways in which a closed pneumatic system and a hydraulic system operate the same size of cylinder);	1	4
☐ **8s104**	– design and make a mechanical system that is operated by hydraulic or pneumatic power;	1	1
☐ **8s105**	– select and use appropriate materials and strategies to make a product;	1	1
☐ **8s106**	– produce technical drawings and layout diagrams of a structure or a mechanical system that they are designing, using a variety of resources.		1
☐ **8s107**	– explain how human weight, height, age, sex, and physical capability affect the design of products (e.g., car seats, snowmobiles, zippers);		1
☐ **8s108**	– analyse the use of symmetry in the ergonomic design of objects and systems (e.g., office furniture, computer equipment);		1
☐ **8s110**	– identify the kinds of information that assist consumers in making a decision about buying a product (e.g., information on performance, durability, safety, benefits to health);		1
☐ **8s111**	– identify consumer expectations regarding the function and effectiveness of a product, using information collected in a survey they made, and recognize that expectations may change;	1	1
☐ **8s112**	– recognize the importance of unbiased testing of control samples and independent evaluation of the test results before a product is manufactured;	1	
☐ **8s113**	– identify the personal and societal factors that determine whether a product is used;		1
☐ **8s114**	– evaluate product manuals or help screens (e.g., a manual for a video recorder), focusing on clarity, thoroughness, and general “user-friendliness”, and identify ways of making the product easier to use;		1
☐ **8s115**	– assess the impact on the environment of the use and disposal of various products (e.g., motor oil, Freon);		1
☐ **8s116**	– explain the economic, social, and environmental factors that can determine whether a product is manufactured (e.g., costs of materials and equipment, availability of skilled labour, potential harmfulness of the product);		1
☐ **8s117**	– make informed judgements about products designed and made by others;	1	
☐ **8s118**	– evaluate their own designs against the original need, and propose modifications to improve the quality of the products.		1

The Arts---Visual Arts

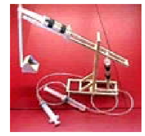
☐ **8a25**	• produce two- and three-dimensional works of art that communicate a variety of ideas (thoughts, feelings, experiences) for specific purposes and to specific audiences, using a variety of art forms;		1
☐ **8a26**	• define the principles of design (emphasis, balance, rhythm, unity, variety, proportion), and use them in ways appropriate for this grade when producing and responding to works of art;	2	

Structures and Mechanisms

Mechanical Efficiency An Integrated Unit for Grade 8

Expectation Summary

Selected **Assessed**



English Language

8e1	1		8e2		1	8e3			8e4			8e5			8e6			8e7			8e8			8e9			8e10		
8e11			8e12			8e13			8e14			8e15			8e16			8e17			8e18			8e19			8e20		
8e21			8e22			8e23			8e24			8e25			8e26			8e27			8e28			8e29			8e30		
8e31			8e32			8e33			8e34			8e35			8e36			8e37			8e38			8e39			8e40		
8e41			8e42			8e43			8e44			8e45			8e46	2	1	8e47	2		8e48			8e49	1	1	8e50		
8e51			8e52			8e53			8e54			8e55			8e56			8e57			8e58			8e59			8e60		
8e61			8e62			8e63			8e64			8e65			8e66			8e67											

Core French

8f1			8f2			8f3			8f4			8f5			8f6			8f7			8f8			8f9			8f10		
8f11			8f12			8f13			8f14			8f15			8f16			8f17											

Mathematics

8m1			8m2			8m3			8m4			8m5	1		8m6			8m7			8m8			8m9			8m10		
8m11			8m12			8m13			8m14			8m15			8m16			8m17			8m18	1		8m19			8m20		
8m21			8m22			8m23			8m24			8m25			8m26			8m27			8m28			8m29			8m30		
8m31			8m32			8m33			8m34			8m35			8m36			8m37			8m38			8m39			8m40		
8m41			8m42			8m43			8m44			8m45			8m46			8m47			8m48			8m49			8m50		
8m51			8m52			8m53			8m54			8m55	1		8m56			8m57			8m58			8m59			8m60		
8m61			8m62			8m63			8m64			8m65			8m66			8m67			8m68			8m69			8m70	2	
8m71			8m72			8m73			8m74			8m75			8m76			8m77			8m78			8m79			8m80		
8m81			8m82																										

Science and Technology

8s1			8s2			8s3			8s4			8s5			8s6			8s7			8s8			8s9			8s10		
8s11			8s12			8s13			8s14			8s15			8s16			8s17			8s18			8s19			8s20		
8s21			8s22			8s23			8s24			8s25			8s26			8s27			8s28			8s29			8s30		
8s31			8s32			8s33			8s34			8s35			8s36			8s37			8s38			8s39			8s40		
8s41			8s42			8s43			8s44			8s45			8s46			8s47			8s48			8s49			8s50		
8s51			8s52			8s53			8s54			8s55			8s56			8s57			8s58			8s59			8s60		
8s61			8s62			8s63			8s64			8s65			8s66			8s67			8s68			8s69			8s70		
8s71			8s72			8s73			8s74			8s75			8s76			8s77			8s78			8s79			8s80		
8s81			8s82			8s83			8s84			8s85			8s86			8s87	2	1	8s88	1		8s89	1	1	8s90		1
8s91	1		8s92			8s93		1	8s94	2		8s95		1	8s96		1	8s97		1	8s98	1	2	8s99	2		8s100	1	
8s101	1	7	8s102	1	5	8s103	1	4	8s104	1	1	8s105	1	1	8s106		1	8s107		1	8s108		1	8s109			8s110		1
8s111	1	1	8s112	1		8s113		1	8s114		1	8s115		1	8s116		1	8s117	1		8s118		1	8s119			8s120		
8s121			8s122			8s123			8s124			8s125			8s126			8s127			8s128			8s129			8s130		
8s131			8s132			8s133			8s134			8s135			8s136			8s137			8s138			8s139			8s140		
8s141			8s142			8s143			8s144			8s145			8s146			8s147			8s148								

Geography

8g1			8g2			8g3			8g4			8g5			8g6			8g7			8g8			8g9			8g10		
8g11			8g12			8g13			8g14			8g15			8g16			8g17			8g18			8g19			8g20		
8g21			8g22			8g23			8g24			8g25			8g26			8g27			8g28			8g29			8g30		
8g31			8g32			8g33			8g34			8g35			8g36			8g37			8g38			8g39			8g40		
8g41			8g42			8g43			8g44			8g45			8g46			8g47			8g48								

History

8h1			8h2			8h3			8h4			8h5			8h6			8h7			8h8			8h9			8h10		
8h11			8h12			8h13			8h14			8h15			8h16			8h17			8h18			8h19			8h20		
8h21			8h22			8h23			8h24			8h25			8h26			8h27			8h28			8h29			8h30		
8h31			8h32			8h33			8h34			8h35			8h36			8h37			8h38			8h39			8h40		
8h41			8h42			8h43			8h44			8h45			8h46			8h47			8h48			8h49			8h50		
8h51			8h52																										

Health and Physical Education

8p1			8p2			8p3			8p4			8p5			8p6			8p7			8p8			8p9			8p10		
8p11			8p12			8p13			8p14			8p15			8p16			8p17			8p18			8p19			8p20		
8p21			8p22			8p23			8p24			8p25			8p26			8p27			8p28			8p29			8p30		
8p31			8p32			8p33			8p34			8p35			8p36			8p37			8p38			8p39			8p40		
8p41																													

The Arts

8a1			8a2			8a3			8a4			8a5			8a6			8a7			8a8			8a9			8a10		
8a11			8a12			8a13			8a14			8a15			8a16			8a17			8a18			8a19			8a20		
8a21			8a22			8a23			8a24			8a25		1	8a26	2		8a27			8a28			8a29			8a30		
8a31			8a32			8a33			8a34			8a35			8a36			8a37			8a38			8a39			8a40		
8a41			8a42			8a43			8a44			8a45			8a46			8a47			8a48			8a49			8a50		
8a51			8a52			8a53			8a54			8a55			8a56			8a57			8a58			8a59			8a60		
8a61			8a62			8a63			8a64			8a65			8a66														

Structures and Mechanisms
Mechanical Efficiency An Integrated Unit for Grade 8

Analysis Of Unit Components

8 Subtasks
73 Expectations
137 Resources
86 Strategies & Groupings

-- Unique Expectations --
5 Language Expectations
3 Mathematics Expectations
30 Science And Tech Expectations
2 Arts Expectations

Resource Types

9 Rubrics
34 Blackline Masters
0 Licensed Software
3 Print Resources
2 Media Resources
8 Websites
43 Material Resources
38 Equipment / Manipulatives
0 Sample Graphics
0 Other Resources
0 Parent / Community
0 Companion Bookmarks

Groupings

5 Students Working As A Whole Class
7 Students Working In Small Groups
6 Students Working Individually

Assessment Recording Devices

3 Anecdotal Record
1 Checklist
7 Rubric

Teaching / Learning Strategies

3 Brainstorming
1 Case Study
1 Classifying
3 Collaborative/cooperative Learning
1 Concept Clarification
3 Discussion
4 Experimenting
2 Fair Test
1 Independent Study
1 Inquiry
2 Learning Log/ Journal
2 Model Making
1 Note-making
4 Problem-solving Strategies
1 Research
1 Working With Manipulatives

Assessment Strategies

2 Classroom Presentation
2 Conference
1 Essay
1 Introduction
4 Learning Log
2 Observation
5 Performance Task
7 Questions And Answers (oral)
2 Self Assessment