

# ***TECHNOLOGY***

*Systems and Control  
(Mechanisms)*

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District D15**

***2009***

***Grade 8***

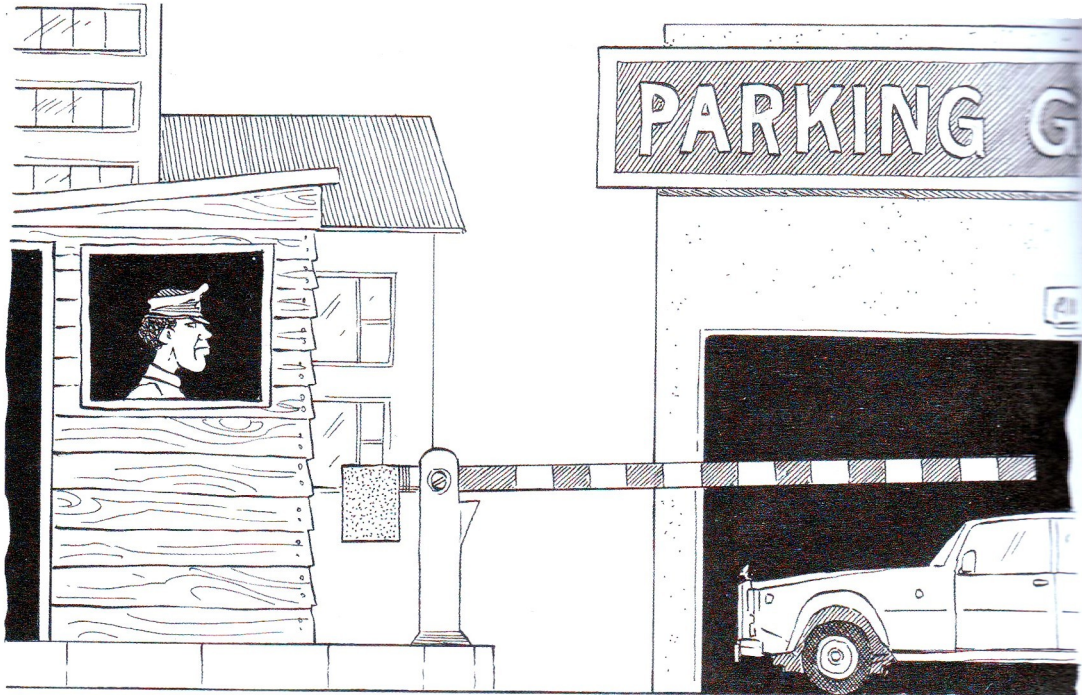
*Learner* \_\_\_\_\_

*Teacher* \_\_\_\_\_

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## CAPABILITY TASK

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In this module you are going to make a mechanism to help a disabled boom operator open and close the boom from within his security box. You will use the knowledge you will obtain about mechanisms in order to comply with the given specifications.

### Given Specifications:

- use hydraulics
- levers
- give a mechanical advantage
- you have to use syringes
- leftover wood and dowels

To help you with your capability task you will complete various activities.

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## INVESTIGATE

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Most manufactured products can be thought of as **systems**.

*A system is a group of **components** connected so that they work together to perform a task.*

The component parts may be ordered steps in a procedure or organizational structure but we need only concern ourselves with physical components each of which has its own contribution to make to the overall operation of a system.

All systems consist of at least three clearly identifiable sections. The **input** stage is where energy or information is fed into the system. The **process** stage is where energy or information is processed or converted. The **output** stage causes something to happen. The flow of information or energy from input through the process stage to the output is often called a **signal**.



The **energy source** for the system will determine which type of component is required at each stage. If the energy source is compressed air the components will need to be pneumatic components and these will combine to produce a pneumatic system. If the energy source is electricity the components will need to be electrical or electronic and these will combine to produce an electronic or electrical system. The energy input into a system can be:

- Movement** - (mechanical systems),
- Oil/water under pressure** - (hydraulic systems),
- Air under pressure** - (pneumatic systems),
- Electricity** - (electrical or electronic systems).

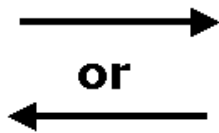
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## MECHANICAL SYSTEMS

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### MOVEMENT

There are four basic kinds of motion, or movements:



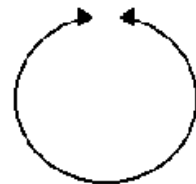
**Linear motion**  
movement in a straight line and in one direction



**Reciprocating motion**  
movement backwards and forwards in a straight line



**Oscillating motion**  
a swinging back and forth



**Rotary motion**  
a circular motion.

### GEARS

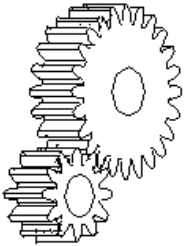
Gears are wheels with teeth. Gears can be used to slow things down or speed things up, change direction and/or control several things at once. Gears are wheels whose perimeter is made up of evenly sized and spaced teeth. The teeth of one gear mesh with those of an adjoining one and transmit rotary motion between the two gear. The driven gear always rotates in an opposite direction to the driving gear. If both gear have the same number of teeth, they will rotate at the same speed, however if they have different numbers of teeth then the gear with fewer teeth will rotate more quickly. A gear system is a combination of two or more gears working together. Two gears connected together turn in opposite directions; the gear upon which the effort force is being

applied is the DRIVER gear and the other gear is the FOLLOWER (driven gear). By placing a gear (IDLER) between the driver and the follower gear, you can make the driver and follower gear turn in the same direction. The smaller driver gear connected to a larger follower gear, results in slower speed, but greater force in the follower gear (gearing down). A larger driver gear, connected to a smaller follower gear results in faster speed, but less force in the follower gear (gearing up).

There are different types of gears: spur gear, bevel gear, worm gear, rack and pinion.

## **Types of gears**

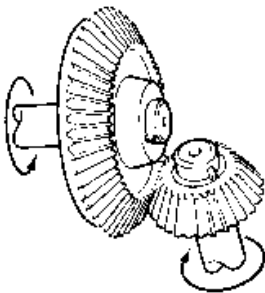
### **Spur gears**



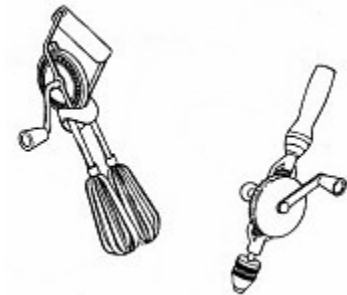
Multiple gears can be connected together to form a gear train. If there are an odd number of gears, the output rotation will be the same direction as the input. If there are an even number, the output will rotate in the opposite direction to the input. Note that for the simple type of gear train shown, the number of teeth on the intermediate gears does not affect the overall velocity ratio which is governed purely by the number of teeth on the first and last cog.



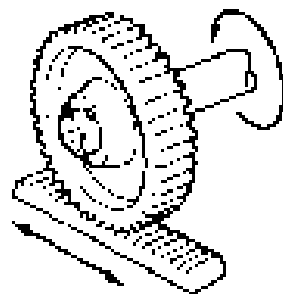
### **Bevel gears**



Bevel gears are used to change rotational movement through an angle of 90°. Bevel gears will provide some mechanical advantage or increase in velocity ratio.



### **Rack-and-spur gears**

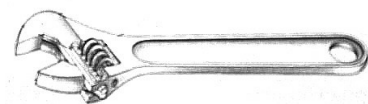


The rack-and-spur gear is used to convert between rotary and linear motion. Often the spur rotates in a fixed position and the rack is free to move - this arrangement is used in the steering mechanism of most cars. Alternatively, the rack may be fixed and the spur rotates moving up and down the rack. This latter arrangement is used on two-handled corks-pullers.

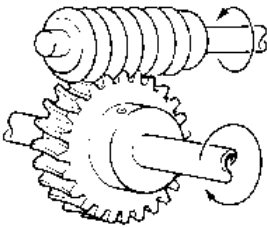


### **Rack-and-worm gears**

The rack-and-worm gear changes rotational movement into linear movement. In a shifting spanner, the rack-and-worm system is used to adjust the position of the jaw of the spanner—to make the gap wider or narrower. The worm is turned to adjust the position of the spanner. So for each revolution of the worm, the rack advances the distance between two consecutive teeth on the rack.



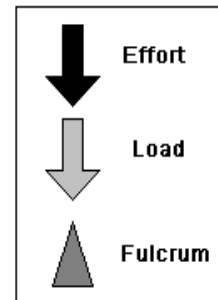
## Worm-and-spur gears



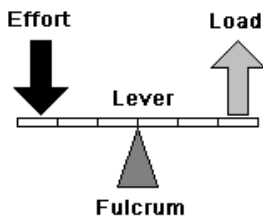
A worm-and-spur gear is often used when a large speed reduction is required and not much power is needed. Unlike ordinary gears, the motion is not reversible, a worm can drive a gear to reduce speed but a gear cannot drive a worm to increase it. The velocity ratio of two adjacent cogs can be calculated by dividing the number of teeth on the driven gear by the number of teeth on the driving gear. The velocity ratio of a worm-and-spur gears is easily calculated because the worm has only one tooth. The worm gear is always the drive gear. For example, if the wheel gear has 60 teeth and the worm gear has 1 tooth, then the velocity ratio is  $1/60 = 1:60$

## LEVERS

A lever helps you do more work with the strength you already have. A lever is a simple machine. All tools are combinations of the simple machines. Simple machines are things like: a wheel, a screw, an incline, a pulley or a lever. All levers have 3 parts, or 3 things we can find on them. The fulcrum, the load, the effort and of course the lever, itself.



Here's the key to these different kinds of levers:



The fulcrum (FULL-krum) is the place a lever rocks back and forth. You could call it a pivot. When it's right in the middle of the lever, the amount of effort you push down equals exactly the amount of load you can lift with the other end.

<p><b>First Class Lever</b></p> <p>L      △      E</p> <p>Pound a nail almost all the way into some wood. Use your fingers to pull it out. Now try pulling it out with the hammer. It's a lot easier. The claw on a hammer is a lever. We call this kind of lever a first-class lever. It does not mean it's a better lever - just that it's the first kind of lever.</p>	
	<p><b>Second Class Lever</b></p> <p>△      L      E</p> <p>Use your first finger and thumb to pop off a metal cap from a soda bottle. Don't twist it off, pry it off. Now try a bottle opener. Much easier, right? A bottle opener is a second-class lever, which means the fulcrum is at the end of the lever and the load is in the middle.</p>
<p>L      E      △</p> <p><b>Third Class Lever</b></p> <p>A third-class lever has its fulcrum at one end and the load at the other end, with the work you do in the middle. It's how a fishing pole works. You lift just a short distance at the handle, but the end of the pole pops up several feet - hopefully with dinner on the line.</p>	

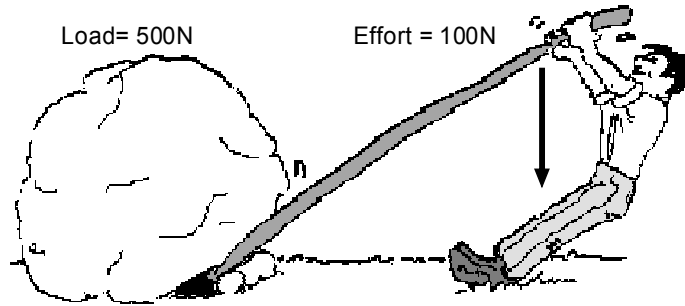
**Mechanical Advantage (MA)**

The unit in which force is measured is Newton (N). A force of 10 N is necessary to lift a mass of 1 kg. (100 g = 1 Newton)

$$MA = \frac{\text{Load}}{\text{Effort}}$$

$$MA = \frac{500 \text{ N}}{100 \text{ N}}$$

$$= 5$$

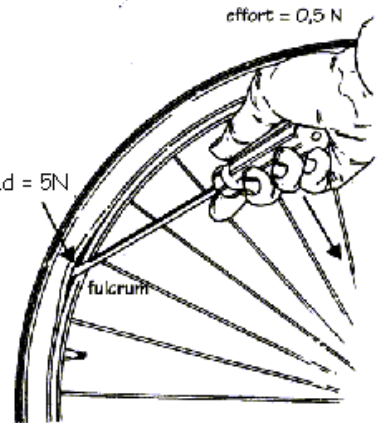
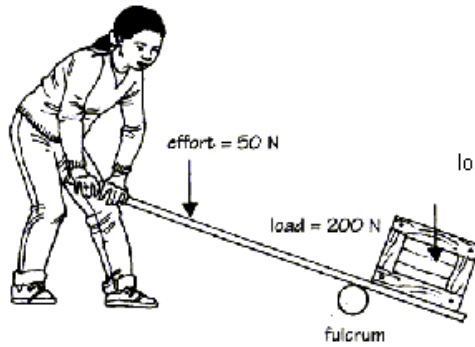
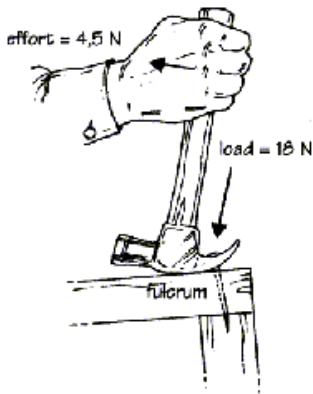


The greater the mechanical advantage, the more help the lever gives you.

**Activity 1**

**Date:** \_\_\_\_\_

Determine the mechanical advantage of each lever below.



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_____	_____	_____
_____	_____	_____
_____	_____	_____

Assessment					
Aspect	Level 7 (Mastered excellently)	Level 6 (Meritoriously mastered)	Level 4 (Adequately mastered)	Level 2 (Elementary mastered)	Mark
		Level 5 (Substantially mastered)	Level 3 (Moderately mastered)	Level 1 (Not mastered)	
<b>Activity 1</b>	Assignments completed and correct. Obvious effort.	Assignments completed and correct. Some effort.	Assignments completed haphazardly. Hardly any effort.	Assignments incomplete. No effort.	9

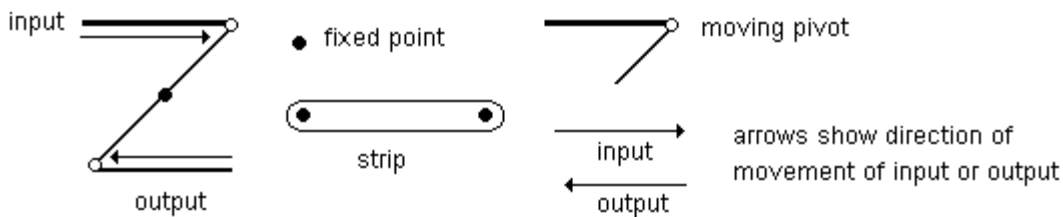
## Linking levers

Sometimes a number of different levers are connected together to do certain jobs. A mechanism that is made by connecting levers is called a linkage. A linkage is a system of levers that is used to transmit motion (e.g., nail clippers, back-hoe, and pedal garbage can).

The levers in a linkage are connected at fixed pivots or moving pivots. (Remember, a pivot is another word for fulcrum.) A fixed pivot is one which turns around one point. A moving pivot is one which can move away from its original position.

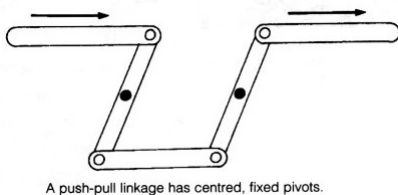
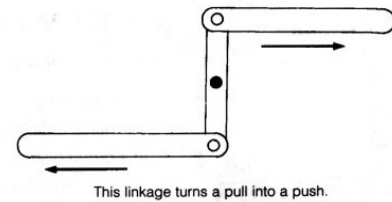
Linkages are often used to change the direction of force or movement: a push can be changed to a pull, or a pushing movement can be changed to a turning movement. Linkages can also change the distance of movement.

## How to draw linkages



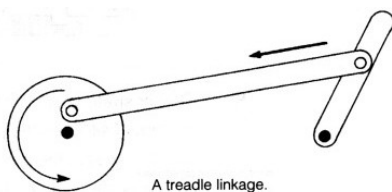
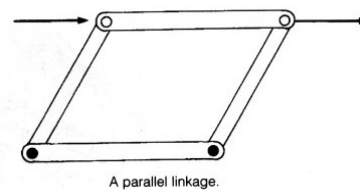
## Different kinds of linkages

Reversing linkages, reverse the direction of a force or movement. A **push-pull linkage** is used to get an output movement which is in the same direction as the input movement. This type of linkage connects two rods with two fixed pivots. The linkage makes sure that both levers move at the same time in the same direction.



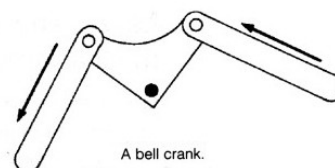
Linkages can also be used to make objects move together in a line at a fixed distance apart, or to make objects stay parallel to each other.

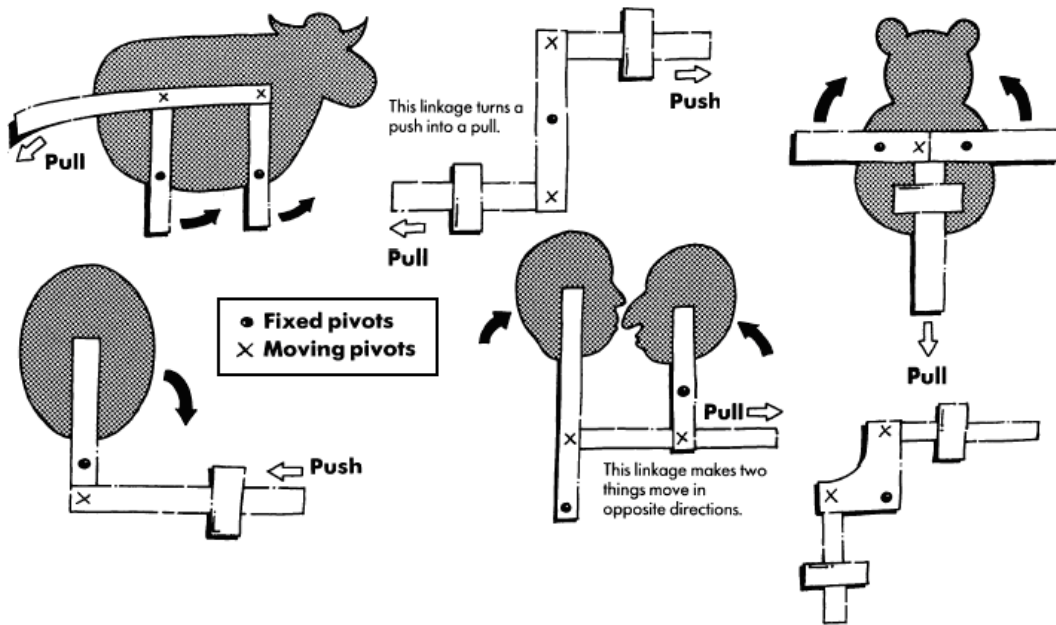
Parallel linkages are used in things such as a tool box. Parallel linkages can also be used to copy or repeat movement, for example folding security doors.



Some linkages change rotary movement into a to-and-fro movement. Treadle linkages can also change a to-and-fro movement into a rotary movement. Rotary describes something that turns in a circle around a centre point.

Another linkage which rotates around a fixed pivot is a bell crank. A bell crank changes the direction of movement through 90°.





**Activity 2:**

Use cardboard strips and split pins and make your OWN moving toy using linkages. Do not copy the toys in the examples above !!!  
 Make a drawing of your toy and clearly indicate the moving and fixed pivots using these symbols:

- Key ● fixed pivot  
 ○ loose pivot

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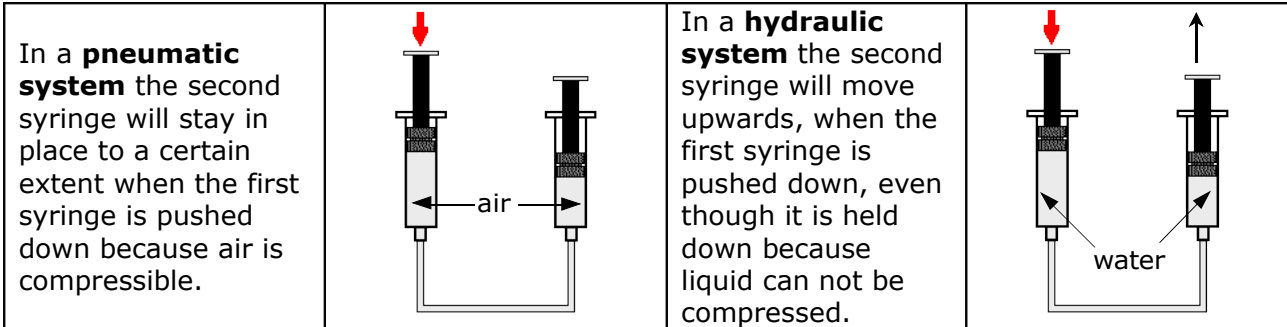
Assessment					
Aspect	Level 7 (Mastered excellently)	Level 6 (Meritoriously mastered)	Level 4 (Adequately mastered)	Level 2 (Elementary mastered)	Mark
		Level 5 (Substantially mastered)	Level 3 (Moderately mastered)	Level 1 (Not mastered)	
Activity 2	Assignments completed and correct. Obvious effort.	Assignments completed and correct. Some effort.	Assignments completed haphazardly. Hardly any effort.	Assignments incomplete. No effort.	10



# HYDRAULICS AND PNEUMATICS

Hydraulics and pneumatic systems basically work in the same way. The only difference is that **hydraulic** systems use an **incompressible liquid** to operate, while **pneumatic** systems use **compressed air** to operate.

## How do these two systems really work?



## Pneumatic systems

Any machine that uses compressed air to do work is a pneumatic system. Compressed air is air that has been forced into a small space. You compress air every time you pump up a bicycle tyre or blow up a balloon. In industry, air is compressed by machines called compressors.

**Bus doors** are opened and closed using a pneumatic system. The piston in the system moves in and out in a straight line, but is connected to a lever system that makes the door swing open and closed. The hissing sound you hear when the doors open and close is the movement of compressed air. **Car hoists** that lift cars in workshops are also operated by pneumatic systems. **Pneumatic wheel spanners** and **jackhammers** are also examples of pneumatic systems.

### Components of a pneumatic system:

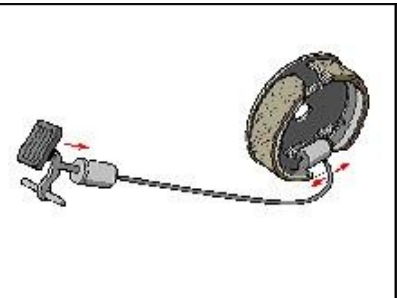
- ◆ A supply of compressed air, usually from a compressor
- ◆ Air lines containing the compressed air
- ◆ Cylinders with pistons for producing force and movement
- ◆ Valves that control the flow of compressed air

## Hydraulic systems

### Principles of hydraulics

Hydraulics is based on the principle that a force is transmitted through a liquid. This means that if a liquid, such as water or oil, is in a cylinder or tube, a force applied to the liquid at one end will be passed through the liquid. The force will then be exerted by the liquid at the other end. This happens because a liquid cannot be compressed.

**Brakes** on many vehicles make use of hydraulic systems. To slow down the car, the driver steps on the brake pedal. This pedal pushes a piston into the hydraulic system, which is filled with brake fluid, this causes pressure in the brake fluid. The force is then transmitted equally to all the wheels. This exerts a force on the brake pads in each wheel which press against the rotating disc inside the car's wheels. The wheel slows down and the car eventually stops.



**Activity 3**

**Date:** \_\_\_\_\_

**You need**

Two plastic syringes of the same size (without needles);  
a piece of plastic tube that fits tightly over the end of each syringe; water.

**You do**

Connect the two syringes with the plastic tube as shown in the illustration.  
Fill the system with water by holding it under water. Make sure there is no air in the system! Press one plunger down while the other plunger is completely out. As soon as the plunger is pressed in, press the other plunger in.  
Remove from the water. Slowly apply force to the one plunger by pressing it in.

The syringe to which the force is applied is called the input syringe while the other syringe is called the output syringe.

**What happened?**

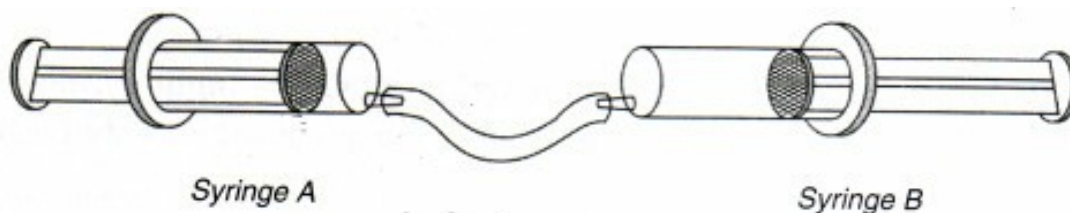
1. What distance in mm was the input syringe pressed? \_\_\_\_\_
2. What distance in millimeters did the output syringe move? \_\_\_\_\_
3. Was the force with which the input syringe was pressed the same as the force that the output syringe experienced? \_\_\_\_\_
4. Why do you think this is the case? \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

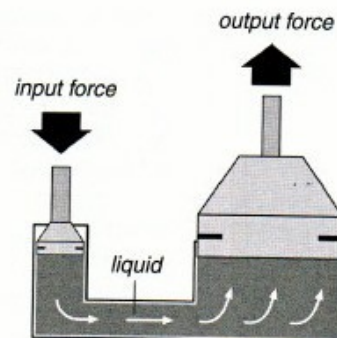


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Assessment					
Aspect	Level 7 (Mastered excellently)	Level 6 (Meritoriously mastered)	Level 4 (Adequately mastered)	Level 2 (Elementary mastered)	Mark
		Level 5 (Substantially mastered)	Level 3 (Moderately mastered)	Level 1 (Not mastered)	
<b>Activity 3</b>	Answers were logically planned and well structured and provide in-depth information	Answers planned that provide information to suit the aim of the task	Some answers were given but not all are applicable to the aim of the task	Incomplete or could not answer questions	<u>5</u>

## Syringes of different sizes

If the area of the disc of the output piston or pistons is the same size as the area of the input piston, then the output force is equal to the input force. But if the area of the output pistons is larger (say three times larger) than the input piston, then the output force is also larger (in this case three times larger). If the area of the output piston is half of the area of the input piston, then the output force is half of the input force.

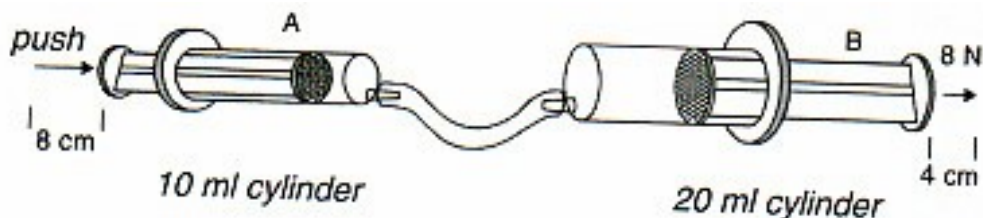


### Activity 4

Date: \_\_\_\_\_

You will now repeat the previous practical test, but with a small syringe at A and a bigger syringe at B. Use a 10 ml syringe and a 20 ml syringe.

1. Again determine the length that syringe A is pressed in. \_\_\_\_\_
2. Also determine the length syringe B moved. \_\_\_\_\_
3. What is the ratio between the distance the output syringe and the input syringe moved?  
\_\_\_\_\_
4. What is your conclusion based on this activity? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



(5)

Assessment					
Aspect	Level 7 (Mastered excellently)	Level 6 (Meritoriously mastered)	Level 4 (Adequately mastered)	Level 2 (Elementary mastered)	Mark
		Level 5 (Substantially mastered)	Level 3 (Moderately mastered)	Level 1 (Not mastered)	
Activity 4	Answers were logically planned and well structured and provide in-depth information	Answers planned that provide information to suit the aim of the task	Some answers were given but not all are applicable to the aim of the task	Incomplete or could not answer questions	<u>5</u>

**Activity 5****Date:**  
\_\_\_\_\_**Two output syringes vs. one input syringe**

What will be the effect if two output syringes of the same size were connected to one input syringe of the same size, as in the figure?

With what can the two output syringes be replaced in order to obtain the same effect as in 1?

Do the following experiment to see whether you were right.

Connect a 20 ml cylinder to two 10 ml cylinders, as in the illustration.

1. Determine the distance each cylinder moved. \_\_\_\_\_
2. The 20 ml cylinder moved \_\_\_\_\_ mm and the 10 ml cylinder moved \_\_\_\_\_ mm.
3. The ratio between the two distances is \_\_\_\_\_.
5. What is your conclusion based on this activity? \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

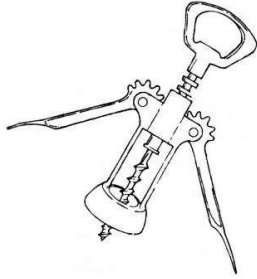
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<b>Assessment</b>					
<b>Aspect</b>	<b>Level 7 (Mastered excellently)</b>	<b>Level 6 (Meritoriously mastered )</b>	<b>Level 4 (Adequately mastered)</b>	<b>Level 2 (Elementary mastered)</b>	<b>Mark</b>
		<b>Level 5 (Substantially mastered)</b>	<b>Level 3 (Moderately mastered)</b>	<b>Level 1 (Not mastered)</b>	
<b>Activity 5</b>	Answers were logically planned and well structured and provide in-depth information	Answers planned that provide information to suit the aim of the task	Some answers were given but not all are applicable to the aim of the task	Incomplete or could not answer questions	<u>6</u>

**Activity 6**

**Date:** \_\_\_\_\_

Identify at least 3 mechanisms in each system and draw a systems diagram for each system.



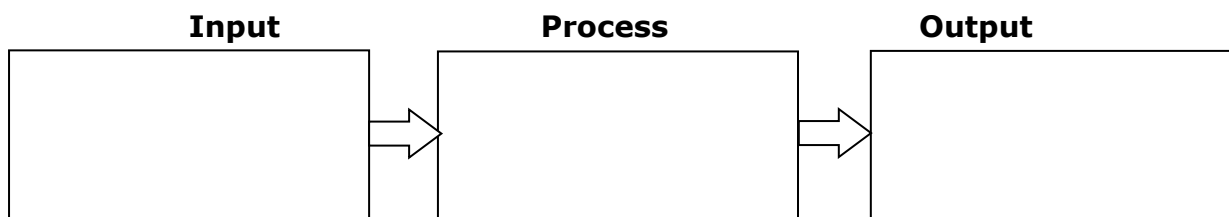

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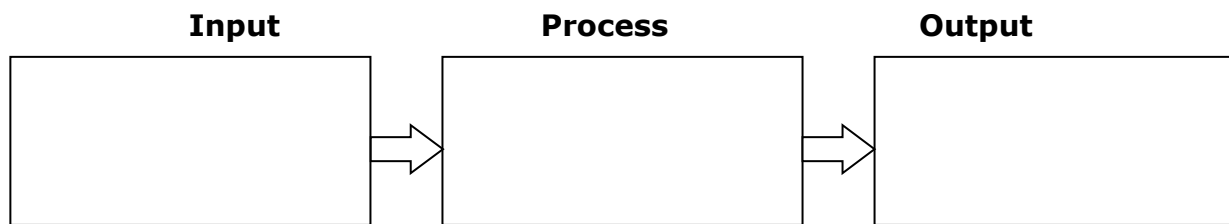

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Assessment					
Aspect	Level 7 (Mastered excellently)	Level 6 (Meritoriously mastered )	Level 4 (Adequately mastered)	Level 2 (Elementary mastered)	Mark
		Level 5 (Substantially mastered)	Level 3 (Moderately mastered)	Level 1 (Not mastered)	
<b>Activity 6</b>	Assignments completed and correct. Obvious effort.	Assignments completed and correct. Some effort.	Assignments completed haphazardly. Hardly any effort.	Assignments incomplete. No effort.	<u>15</u>

## DESIGN

**Design Brief**

**Date:** \_\_\_\_\_

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Assessment					
Aspect	Level 7 (Mastered excellently)	Level 6 (Meritoriously mastered )	Level 4 (Adequately mastered)	Level 2 (Elementary mastered)	Mark
		Level 5 (Substantially mastered)	Level 3 (Moderately mastered)	Level 1 (Not mastered)	
<b>Design Brief</b>	Formulation of problem solving is clear and comprehensible.	Formulation of problem solving is reasonably clear	Formulation of problem solving is vague	Formulation of problem solving is incomplete and not relevant	<u>5</u>

**Specifications**

**Date:** \_\_\_\_\_

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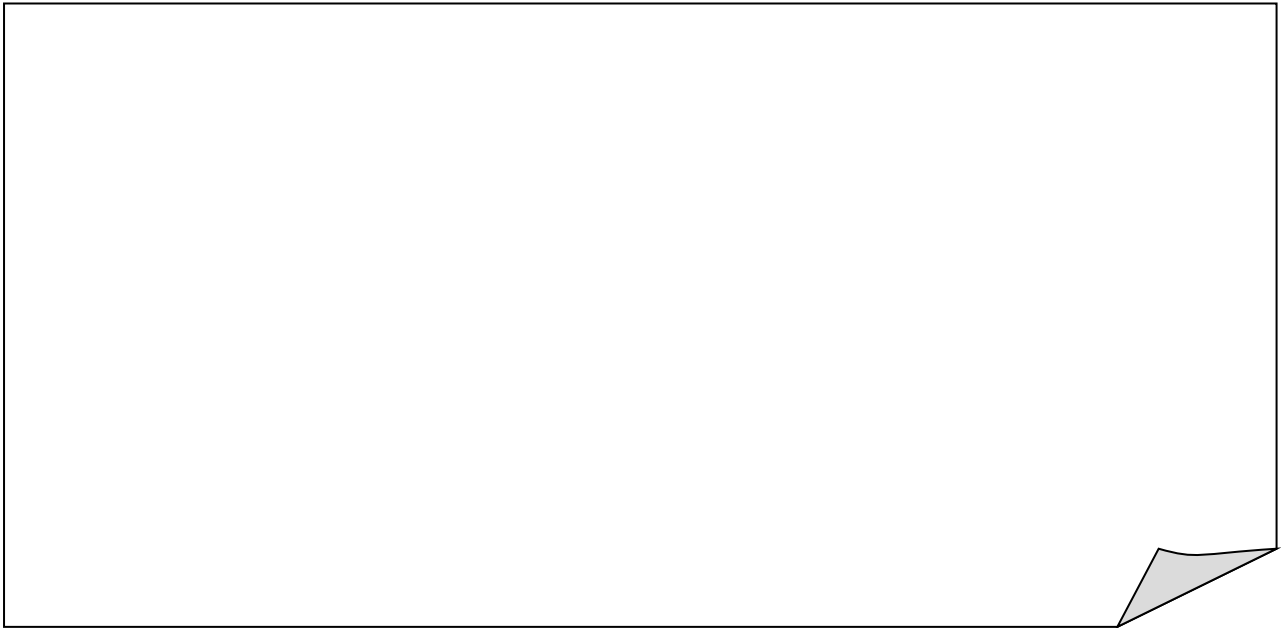
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Assessment					
Aspect	Level 7 (Mastered excellently)	Level 6 (Meritoriously mastered )	Level 4 (Adequately mastered)	Level 2 (Elementary mastered)	Mark
		Level 5 (Substantially mastered)	Level 3 (Moderately mastered)	Level 1 (Not mastered)	
<b>Specifications</b>	List of specifications complete and relevant.	Specifications complete	A few specifications were given	Specifications incomplete	<u>5</u>

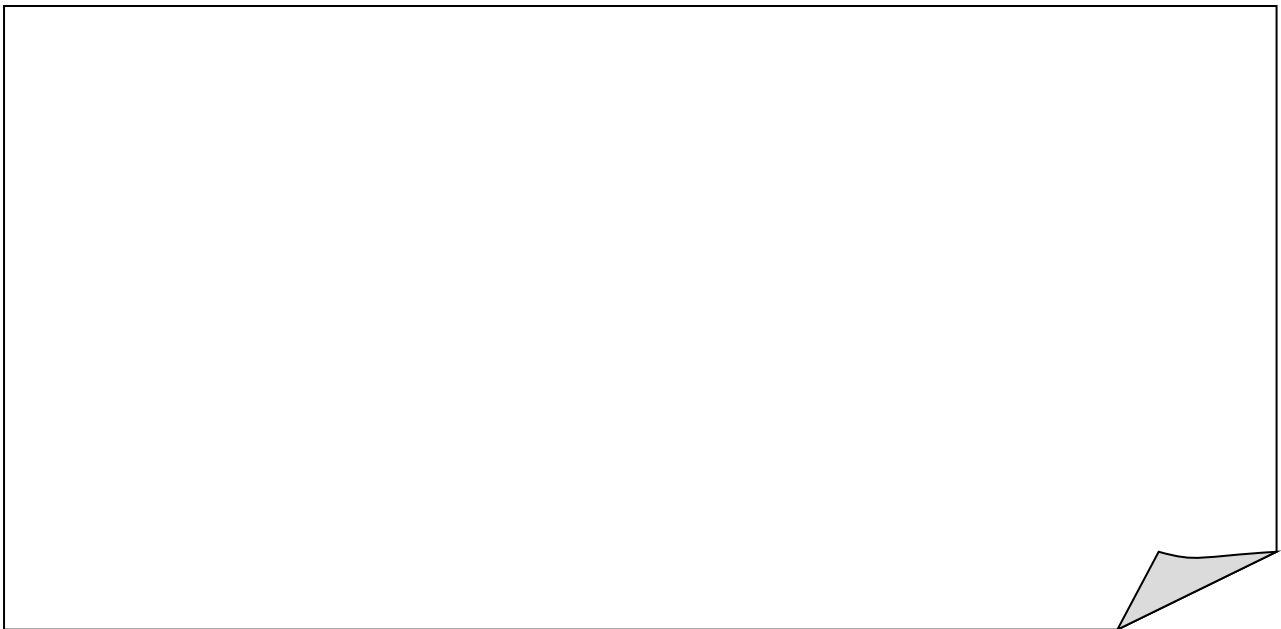
**Possible ideas**

**Date:** \_\_\_\_\_

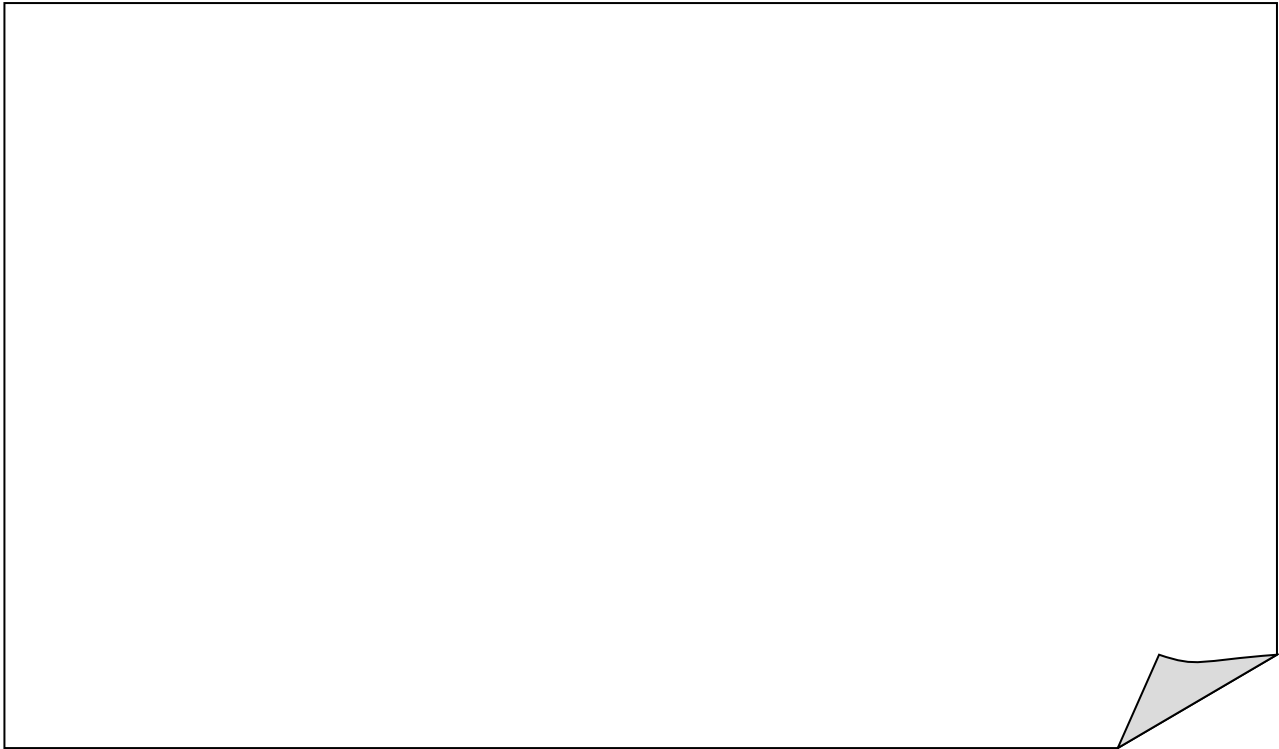
Draw freehand 3-D representations of 3 possible solutions for the problem and briefly give pros and cons for each idea.



**Pros and Cons:** \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



**Pros and Cons:** \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



**Pros and Cons:** \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Assessment					
Aspect	Level 7 (Mastered excellently)	Level 6 (Meritoriously mastered )	Level 4 (Adequately mastered)	Level 2 (Elementary mastered)	Mark
		Level 5 (Substantially mastered)	Level 3 (Moderately mastered)	Level 1 (Not mastered)	
<b>Possible ideas</b>	Ideas very neatly drawn, labels added. All pros and cons mentioned. Chosen idea very well motivated.	Ideas reasonably neatly drawn, labels added. Pros and cons mentioned. Chosen idea motivated.	Ideas not neatly drawn labels added. Few pros and cons mentioned. Chosen idea not clearly motivated.	Incomprehensible drawings of ideas. Pros and cons incomplete. Weak motivation of chosen idea.	10

**Final Design** **Date:** \_\_\_\_\_

Give final information regarding your product and make the required drawings.

\_\_\_\_\_

\_\_\_\_\_

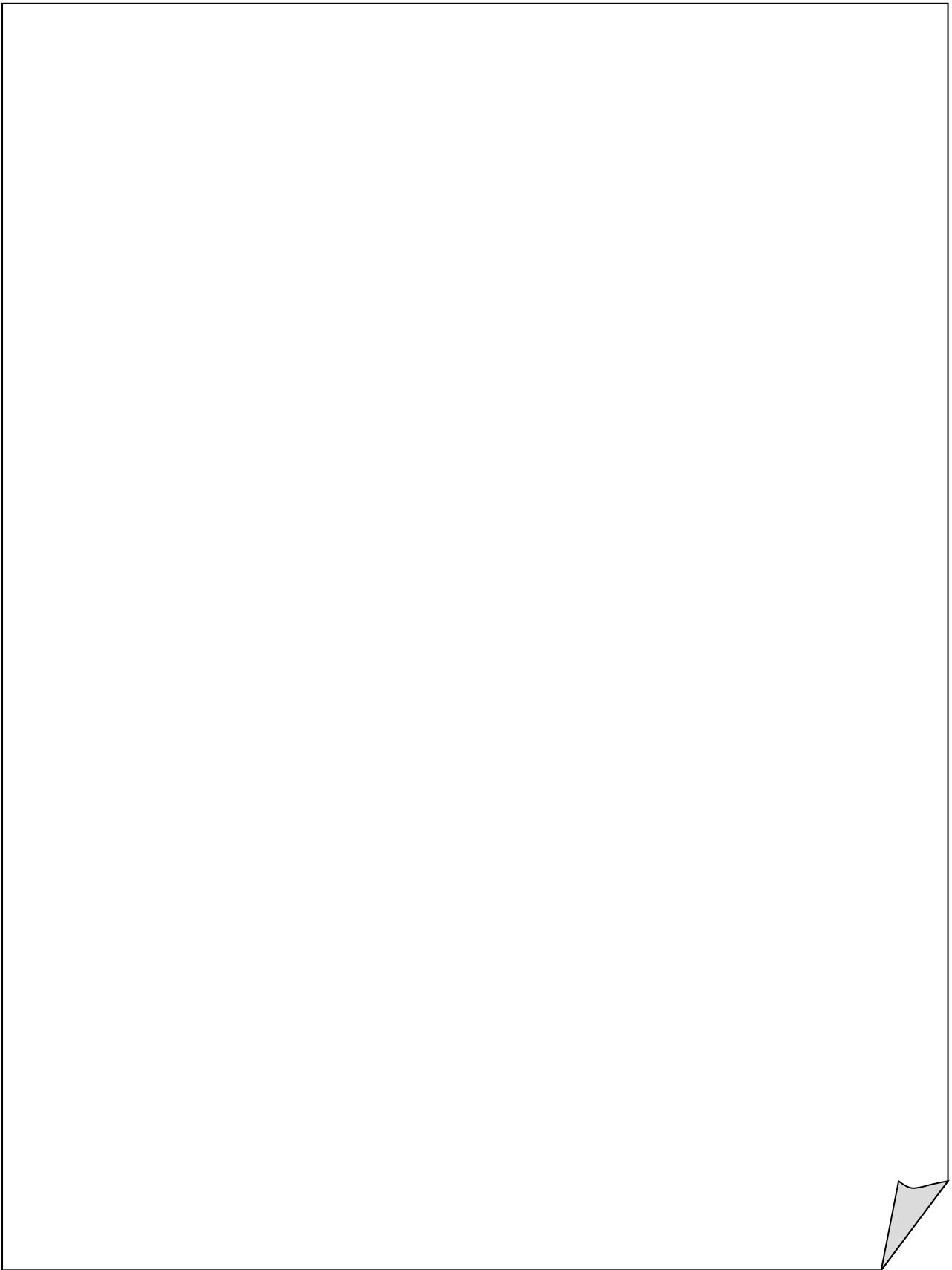
\_\_\_\_\_

\_\_\_\_\_

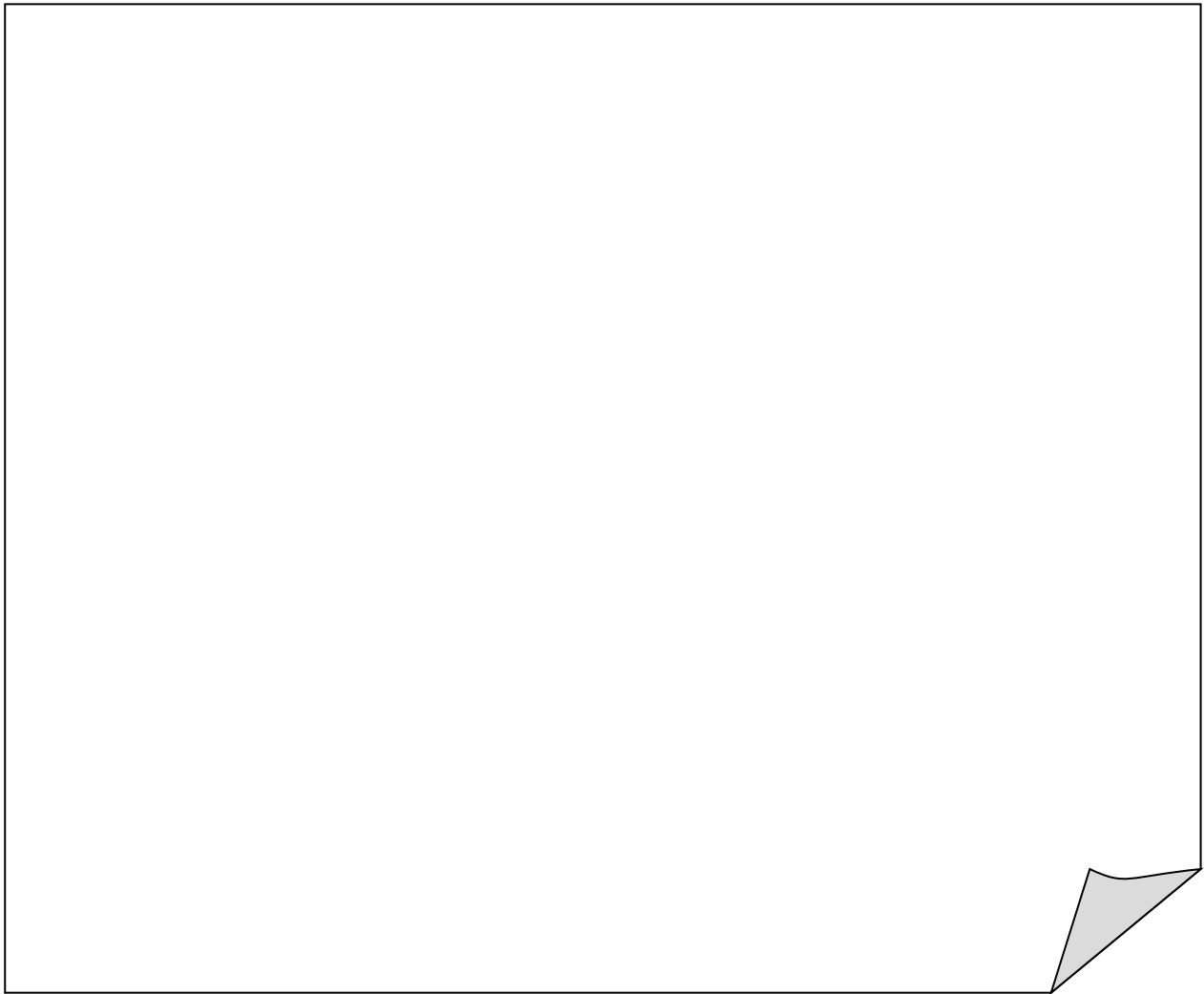
\_\_\_\_\_



Make a first angle orthographic drawing of your product and indicate dimensions.



Draw 3-D representations of your product. Make use of exploded drawings and labeling to explain your idea in detail.



Assessment					
Aspect	Level 7 (Mastered excellently)	Level 6 (Meritoriously mastered )	Level 4 (Adequately mastered)	Level 2 (Elementary mastered)	Mark
		Level 5 (Substantially mastered)	Level 3 (Moderately mastered)	Level 1 (Not mastered)	
<b>Final design</b>	Working drawing and 3-D drawing is done and labeled.	Parts of the working drawing and 3-D drawing have been omitted.	Working drawing and 3-D drawing are incomplete.	Working drawing and 3-D drawing are neat and is labeled.	____ 10

# MAKE

## Flow diagram

Date: \_\_\_\_\_

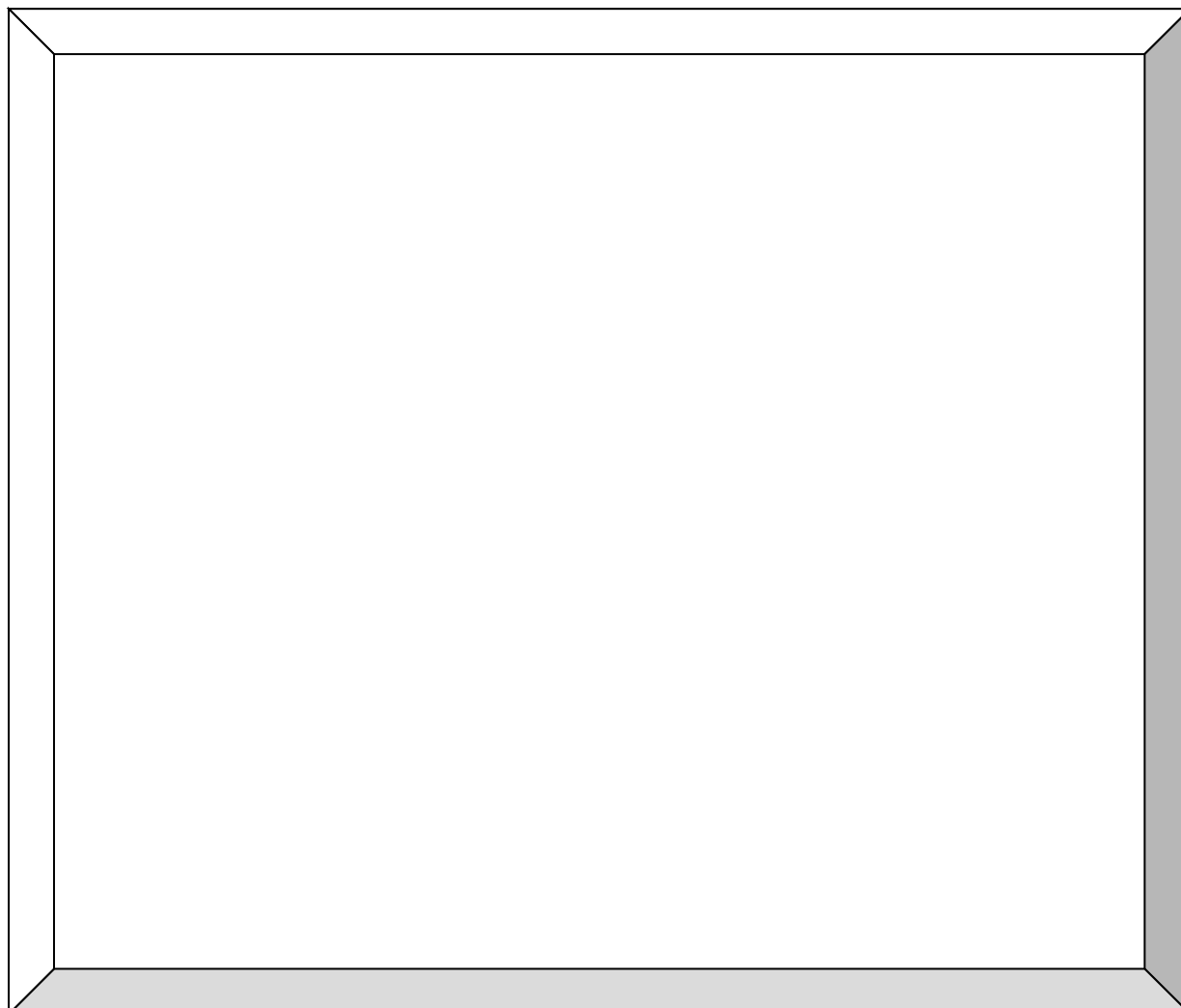
Draw a flow diagram to show your work method, time, tools equipment and materials.

Assessment					
Aspect	Level 7 (Mastered excellently)	Level 6 (Meritoriously mastered )	Level 4 (Adequately mastered)	Level 2 (Elementary mastered)	Mark
		Level 5 (Substantially mastered)	Level 3 (Moderately mastered)	Level 1 (Not mastered)	
<b>Flow diagram</b>	List of tools and materials is detailed Flow diagram is logical and comprehensible.	List of tools and materials is complete Flow diagram is logical and but a bit sketchy.	List of tools and materials is not quite complete Flow diagram is not logical or comprehensible.	List of tools and materials is incomplete Flow diagram is incomprehensible.	<u>    </u> 10

**Project**

**Date:** \_\_\_\_\_

Paste a picture of your project here:



<b>Assessment</b>					
<b>Aspect</b>	<b>Level 7 (Mastered excellently)</b>	<b>Level 6 (Meritoriously mastered )</b>	<b>Level 4 (Adequately mastered)</b>	<b>Level 2 (Elementary mastered)</b>	<b>Mark</b>
		<b>Level 5 (Substantially mastered)</b>	<b>Level 3 (Moderately mastered)</b>	<b>Level 1 (Not mastered)</b>	
<b>Project</b>	The project is strong, can withstand forces, will have an increased lifespan. Documents will be kept neat and dry. The size is at least 350 x 250 x 60 mm. Was made of recycled paper/cardboard.	The project is reasonably strong, can withstand forces, will have an increased lifespan. Documents will be kept neat. The size is at least 350 x 250 x 60 mm. Was made of recycled paper/cardboard.	The project is not very strong, can withstand forces to a certain extent, will not have an increased lifespan. Documents will be kept neat. The size is not at least 350 x 250 x 60 mm. Was not made of recycled paper/cardboard.	The project was not done or is incomplete. The measurements does not comply to the specifications. Documents can not be kept neatly in the folder.	<u>35</u>

# EVALUATION

**Evaluation**

**Date** \_\_\_\_\_

**Weak vs Strong points**

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**Possible changes and modifications**

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Assessment					
Aspect	Level 7 (Mastered excellently)	Level 6 (Meritoriously mastered )	Level 4 (Adequately mastered)	Level 2 (Elementary mastered)	Mark
		Level 5 (Substantially mastered)	Level 3 (Moderately mastered)	Level 1 (Not mastered)	
<b>Evaluation</b>	Relevant evaluation criteria. Useful ideas to improve product.	Reasonable evaluation criteria and ideas to improve product.	Evaluation criteria unclear. Ideas to improve product irrelevant.	No evaluation criteria. Ideas to improve product incomplete.	<u>10</u>