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GRADE 9: _____

TECHNOLOGY ACTIVITIES – 2023

TERM 2

NAME: _____

MECHANICAL SYSTEMS & CONTROL



WEEK 1

- ✓ **Mechanisms** are the **moving parts in machines** that use energy to **transmit force and motion to do work**.
- ✓ Machines that are designed well help us **work faster and with less effort**. **Simple mechanisms are used together to make complex mechanical systems**.



Figure 3.5 A systems diagram shows how a system works.

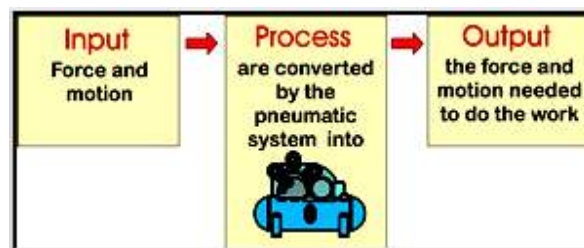
- ✓ **Complex mechanical systems** have **several parts**. Each part is a mechanical system that is part of a bigger system. Each part of a complex mechanical system is called a **sub-system**.
- ✓ Each sub-system performs a **specific function** needed to make the machine work. **All systems use energy to work**, whether it be human, mechanical, electrical, or chemical energy.

We can also use the energy created by using gases or fluids under pressure:

- ✓ **Pneumatic systems** use **air under pressure**.
- ✓ **Hydraulic systems** use **liquids under pressure**

A. PNEUMATIC SYSTEMS

- ✓ A mechanical system that gives us **mechanical advantage** using **enclosed / compressed gas** is called a pneumatic system.



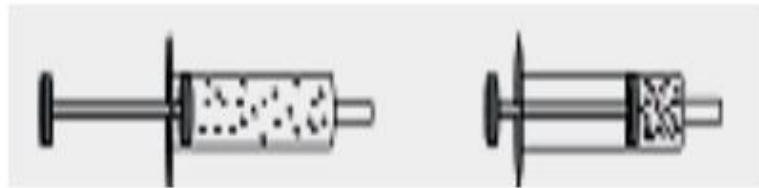
- ✓ **Pneumatic systems** change a small force into a bigger force by transferring it through a compressed gas.
- ✓ A gas has so much space between its particles that these particles can be forced together under compression.
- ✓ Pneumatic systems **use the potential energy of compressed air to make machines and tools work**.

Examples of machines that use pneumatic systems:

- **bicycle pumps, car tyres,**
- industrial tools like **jackhammers,**
- A **dentist's drill,**
- **air brakes** on heavy vehicles such as buses, trucks, and trains, and
- a **pneumatic drill**
- **aerosol cans** and spray bottles



To compress means to make something smaller – e.g. when you press the plunger of a syringe in while keeping the outlet closed, you will compress the air inside the syringe. That means you forced air molecules to move closer together.



ADVANTAGES AND DISADVANTAGES OF PNEUMATIC SYSTEMS

ADVANTAGES	DISADVANTAGES
✓ cheaper than hydraulic systems	✓ pneumatic systems are not suitable for machines where precise, controlled movement is needed.
	✓ Compressed air can be very dangerous because it is unpredictable, and kickback can occur

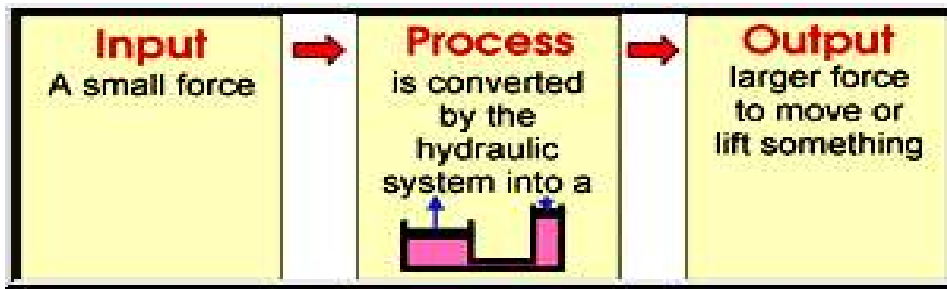
B. HYDRAULIC SYSTEMS

TYPES OF HYDRAULIC SYSTEMS

An **open hydraulic system** contains a liquid that is placed under pressure, for example water and a garden hose with a pressure nozzle.

A **closed hydraulic system**: This consists of a **sealed unit** containing **two pistons** that are connected to each other by means of a pipe or reservoir.

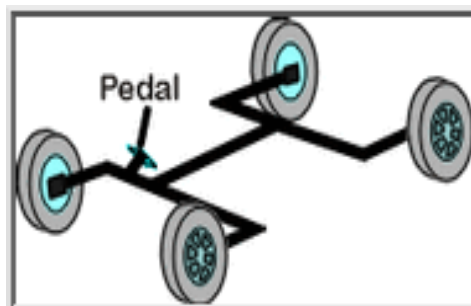
SYSTEM DIAGRAM OF A HYDRAULIC SYSTEM



- ✓ Hydraulic systems use **liquids** (oil / water) under pressure to transmit force and motion in a machine.
- ✓ The **liquids** used in hydraulic systems are **incompressible**. This makes the pressure in hydraulic machines predictable and results in an accurate and immediate output movement.
- ✓ Oil is a lubricant. It **reduces friction and does not freeze as easily as water**.
- ✓ A hydraulic system **can transfer forces evenly throughout a system** using **fluid that is under pressure**.
- ✓ Hydraulic systems can be **very powerful** and are used in several industries.
- ✓ Hydraulic systems are used to **give mechanical advantage** in systems/machines. **A small input force is converted into a big output force**
- ✓ A **liquid or fluid** has no shape of its own and **changes shape according to its container**.
- ✓ A liquid **transmits the pressure applied to it in all directions and therefore provides great increase in work force.**

Examples of machines that use hydraulic systems are:

- **Hydraulic jack**
- compression mechanisms on **tipper trucks**,
- **digger loaders**,
- **bulldozers** and
- **car brake systems**



ADVANTAGES AND DISADVANTAGES

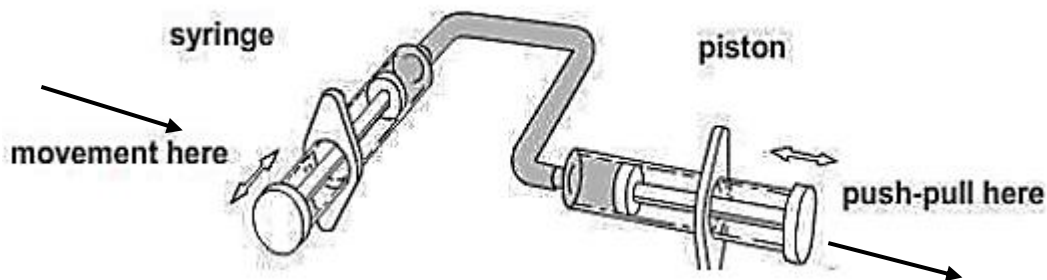
ADVANTAGES	DISADVANTAGES
✓ A hydraulic system is effective since the pressure in the system is constant ✓ Force is transferred directly and immediately. ✓ The system is efficient because oil reduces friction. ✓ It is not affected by change of load. ✓ Low cost to operate	✓ Oil leaks are messy ✓ Hydraulic machines are expensive to build ✓ Parts of a hydraulic system must be extremely strong to withstand the high forces generated by the system

COMPONENTS OF A PNEUMATIC / HYDRAULIC SYSTEM

You will use **syringes to represent the pneumatic or hydraulic system**. Make sure that you know how the different parts of a syringe work.

INPUT: MASTER CYLINDER

The cylinder where the **action starts**



OUTPUT: SLAVE CYLINDER

Where the **force is transferred to**, and the **outcome is noticeable**

PRACTICAL ACTIVITY 1: FORCE BETWEEN TWO EQUAL SYRINGES FILLED WITH AIR & LIQUID

DEMONSTRATION BY TEACHER

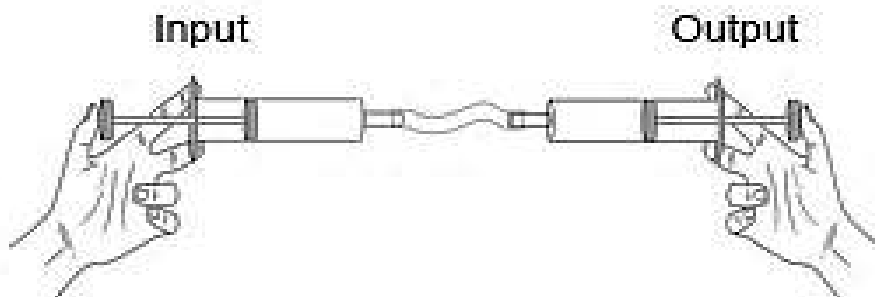
INVESTIGATE FORCE TRANSFER BETWEEN TWO EQUAL SYRINGES FILLED WITH

(1) AIR and

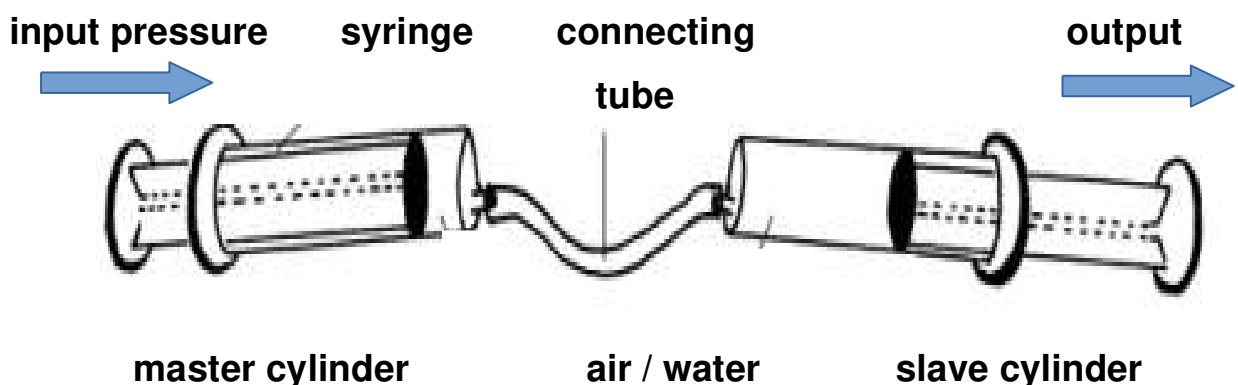
(2) WATER

Follow the instructions / steps then answer the questions.

1. Push in the plunger of the input syringe.
2. Note what happens to the output syringe.
3. Repeat the experiment, but this time apply some pressure to the output plunger.
4. Note what happens with the plunger of the output syringe.



NB: Do the above-mentioned experiment with the pneumatic system as well as the hydraulic system.



Did you know?

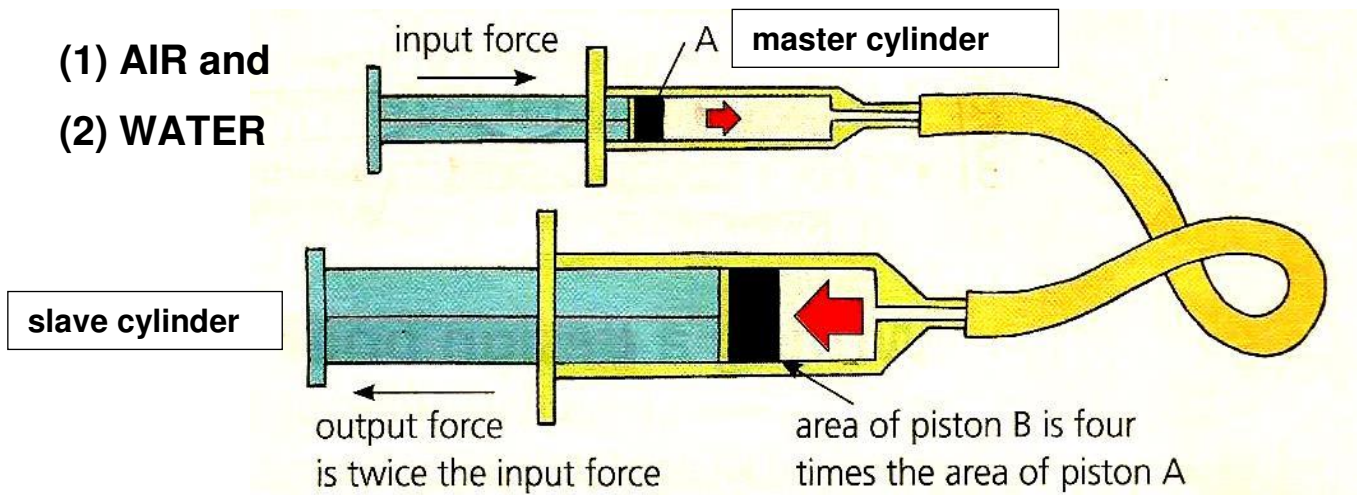
Hydraulics and pneumatics are called fluid mechanics, because liquids and gases are not solid substances and they can both move in a system.

PRACTICAL ACTIVITY 2: FORCE BETWEEN TWO EQUAL SYRINGES FILLED WITH AIR & LIQUID

DEMONSTRATION BY TEACHER

INVESTIGATE FORCE TRANSFER BETWEEN TWO UNEQUAL SYRINGES FILLED WITH

- (1) AIR and
- (2) WATER



Follow the instructions / steps listed, then answer the questions.

1. Push in the plunger of the input syringe.
2. Note what happens to the output syringe.
3. Repeat the experiment, but this time apply some pressure to the output plunger.
4. Note what happens with the plunger of the output syringe.

Revision

Less distance results in more force ($MA > 1$).

More distance results in less force ($MA < 1$).

NB: Do the above-mentioned experiment with the pneumatic system as well as the hydraulic system.

Look at the conclusion below. Did you reach the same conclusion?

- If the area of the output piston is larger than the area of the input piston, then the output force is larger than the input force.
- E.g., if the output piston is 3 times larger than the input piston, then the output force will also be 3 times larger than the input force.
- Air can be compressed.
- Liquid is in-compressible

[30]

(1)

(3)

1.3 Tabulate the differences between pneumatics and hydraulics below based on your observation during the demonstration of the two systems. (4)

PNEUMATIC SYSTEMS (LIST TWO)	HYDRAULIC SYSTEMS (LIST TWO)

- 1.4 What *similarities* do you notice about the working of the pneumatic and hydraulic system? (2)

- 1.5 What advantage does a hydraulic system have over a pneumatic system? (1)

- 1.6 TRUE or FALSE. If the answer is false, you must give the correct answer to correct the statement. (3)

- 1.6.1 When the area / surface of the output piston is the same as the area / surface of the input piston, the output force is greater than the input force.

- 1.6.2 Mechanical advantage is when a small input force is converted into a large output force.

- 1.7 Underline the correct word in the brackets. (2)

- 1.7.1 Liquid is (compressible / incompressible).

- 1.7.2 The force transfer in a hydraulic system is (greater than / less than) the force transfer in a pneumatic system.

- 1.8 Name four examples of the use of hydraulics in everyday life. (4)

- 1.9 Fill in the missing words. (4)

- 1.9.1 In a hydraulic system with **two equal syringes**, you get _____ distance and _____ force between the two syringes.

- 1.9.2 In a hydraulic system where movement is from a **small syringe to a larger syringe**, the output distance is _____, and the output force is bigger.

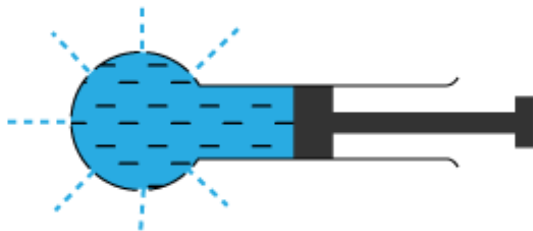
- 1.9.3 When the output force is increased by the force transfer from the input force, we call this _____.

1.10 Match **COLUMN A** with **COLUMN B**. Write only the letter of the alphabet (A – F) in the **ANSWER** column: (6)

COLUMN A	ANSWER	COLUMN B
1.10.1 Pneumatic system		A. It can be compressed to take up less space.
1.10.2 Hydraulic system		B. It can also be called master cylinder or input cylinder
1.10.3 Driver cylinder		C. It cannot be pressed to take less space.
1.10.4 Driven cylinder		D. It is a tube and syringe filled with a liquid (water or oil).
1.10.5 Compressible		E. The output cylinder or the slave cylinder
1.10.6 Incompressible		F. It is a tube and syringes filled with air.

WEEK 2

A. PRINCIPLE OF HYDRAULICS – PASCAL'S LAW



Pascal's Principle

Pressure causes movement to occur in a closed hydraulic system. When you squeeze an input piston, the build-up of pressure will cause the fluid to push the output piston out.

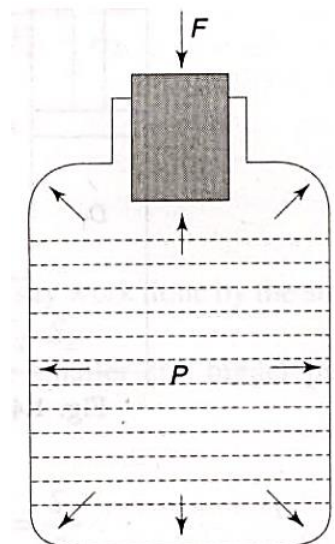
When we apply **pressure anywhere to a fluid in a closed container, the force is transmitted equally in all directions.**

This happens throughout the fluid and onto the walls of the container

Pressure applied on one part of a hydraulic system will be transferred equally, without any loss, in all directions to other parts of the closed system.

Revision

Newton is the unit that we use to measure force. This unit of measurement is named after the famous scientist, Sir Isaac Newton.

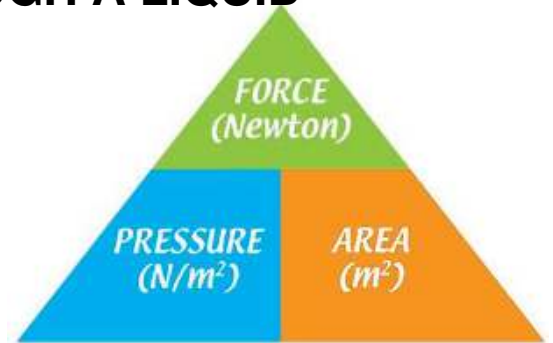


PRESSURE TRANSFERRED THROUGH A LIQUID

Using the pressure equation triangle on the right, pressure is defined as the force applied per unit area:

$$\text{PRESSURE} = \frac{\text{FORCE}}{\text{AREA}}$$

We can reason that force = pressure × area.



This means that a smaller area will result in a larger pressure.

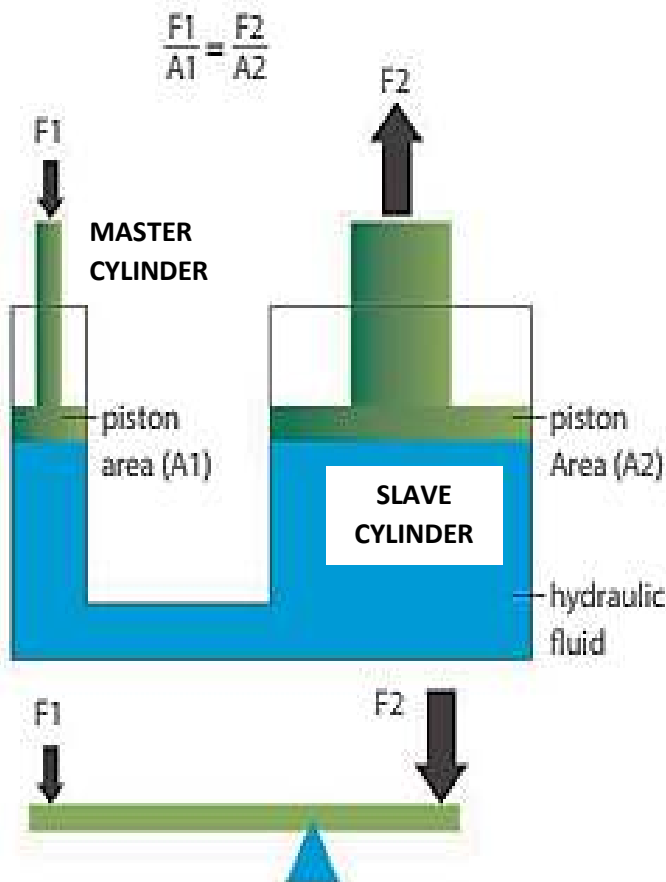


Figure 3.15 Force increases with hydraulics

at piston F2.

Figure 3.15 (on the left) shows how a smaller surface area (A_1) exerts more pressure over a larger surface area (A_2) to give a greater force.

- Pascal's principle states that **when a force is applied to a liquid in a closed system the pressure is applied evenly throughout the liquid in all directions.**

- It shows how the **pressure in a closed hydraulic system is the same in the whole system.** If piston F1 is pushed down, a force is exerted on the surface area of the liquid.

- According to Pascal's principle this **pressure will be transferred equally** in all directions to piston F2.

- At piston F2 a pressure is applied to a large area, producing a force. The force exerted on F2 will be pressure multiplied by the area of the large piston. The force will be multiplied

- Figure 3.15 shows how **a small force is applied to a small piston, producing a large force on a large piston.**
- When a **small piston drives a larger piston, force is multiplied and there is mechanical advantage of more than 1 ($MA > 1$).**

ACTIVITY 2: Answer the questions on Pascal's Law

[30]

2.1 Underline the correct word in the brackets.

(1)

2.1.1 According to Pascal's principle "when pressure is applied to a fluid, the force is transmitted (equally / unequally) in all directions".

2.2 Fill in

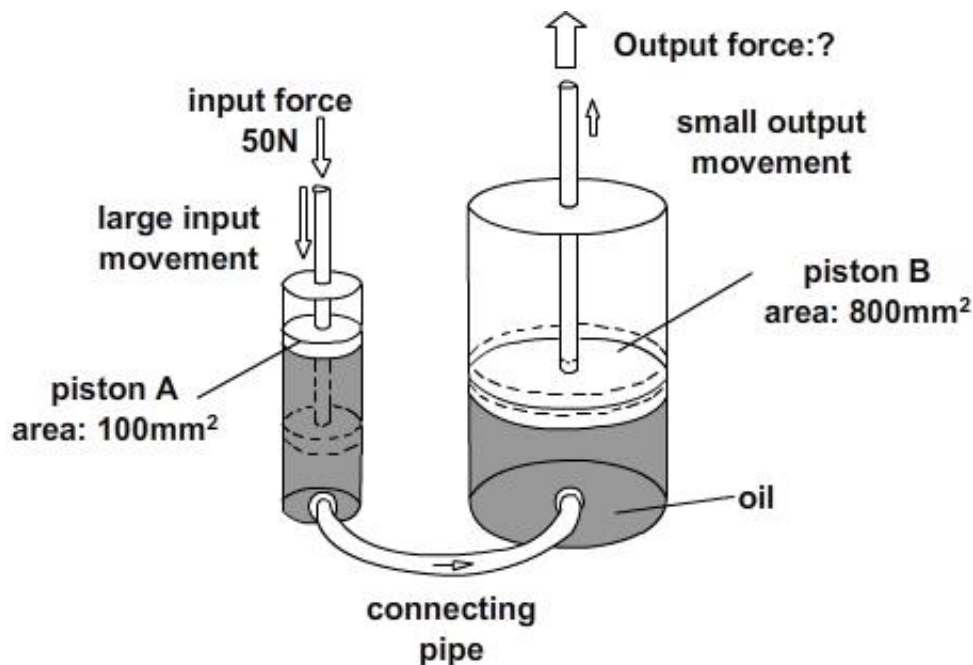
(4)

2.2.1 Newton is the unit in which _____ is measured in a hydraulic system with two equal syringes, we get **equal** distance and **equal** force between the two syringes.

2.2.2 In a hydraulic system where movement is from a small syringe to a larger syringe, the output distance is _____ and the output force is _____.

2.2.3 When the output force is increased by the force transfer from the input force, we call this _____.

2.3 Study the hydraulic system below and answer the questions that follow.

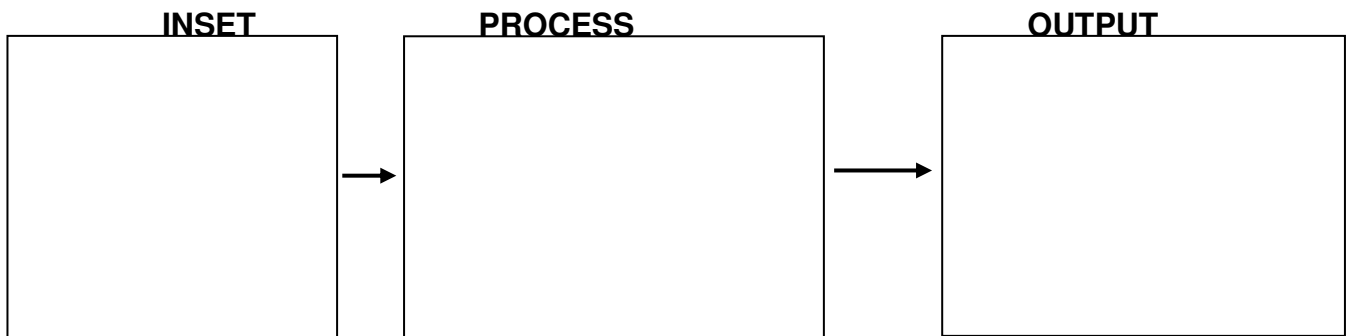


2.3.1 Use the picture above to explain how forces within a hydraulic system are transferred.

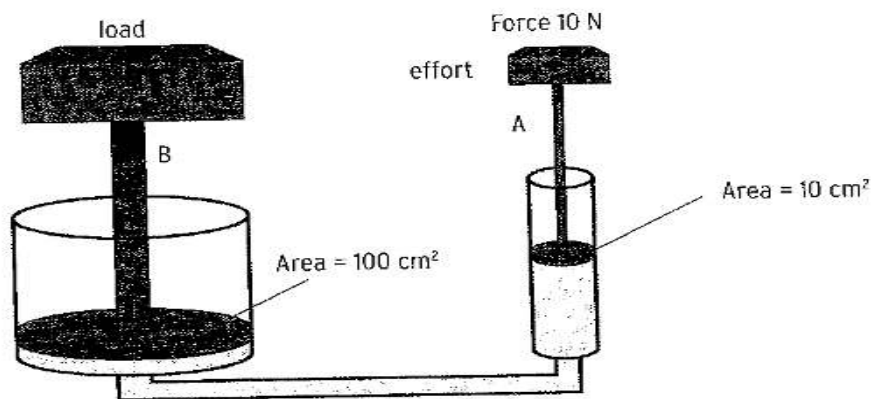
(3)

2.3.2 Calculate the output force, if the input force is 50N, the input piston's area is 100mm^2 and the output piston's area is 800mm^2 . (3)

2.3.3 Draw a systems diagram for the above hydraulic system. (3)



2.4 In the hydraulic press below; a force of 100 N is applied to piston A and it moves down 10 cm.



2.4.1 Calculate the work done by both pistons. (3)

2.4.2 Calculate the pressure of the fluid. (3)

2.4.3 Calculate the maximum force that is exerted on the load by piston B. (3)

2.4.4 Calculate the distance travelled by piston B. (3)

2.4.5 Calculate the mechanical advantage of the system. (3)

2.5 Name the type of mechanical advantage that is achieved when a small syringe drives a larger syringe. (1)

TOTAL = 30

WEEK 3: THE HYDRAULIC PRESS

- Hydraulic systems are **used to crush or compact objects**.
- Hydraulic components such as **pumps, valves and plates are combined to apply a crushing power**.
- In machines they are usually **called hydraulic presses**.
- A hydraulic press **uses pressurised liquid to create a large amount of force**. It is used for **punching, bending, and forming metals into different shapes**.
- The hydraulic press is based on Pascal's principle, which states that pressure is constant throughout a closed system.
- An **example of the hydraulic press** is **equipment used to raise a car to look underneath or at the tyres**.

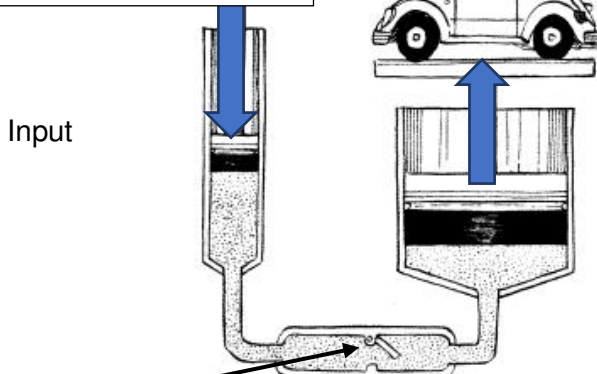


Figure 4.3 A hvdraulic car press crushes a car.

CONTROL MECHANISMS IN HYDRAULIC SYSTEMS

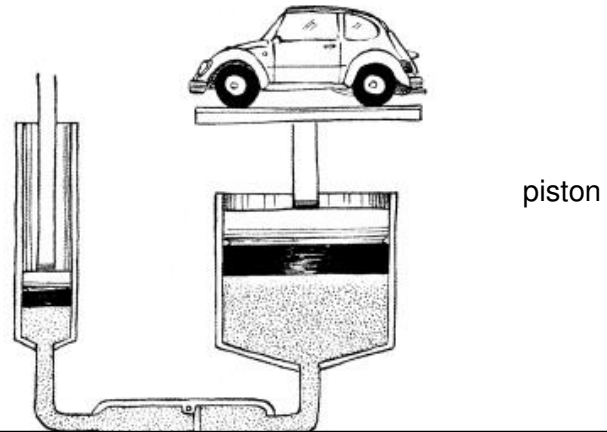
The control mechanism in the hydraulic system **allow you to direct the flow of fluid to your advantage.**

The input piston pushes fluid causing output piston to rise and lift the car.



Input

One way valve allows fluid through to the output piston



piston

One way valve **closes** and stops the hydraulic fluid from flowing back by closing the passage in the cylinder.

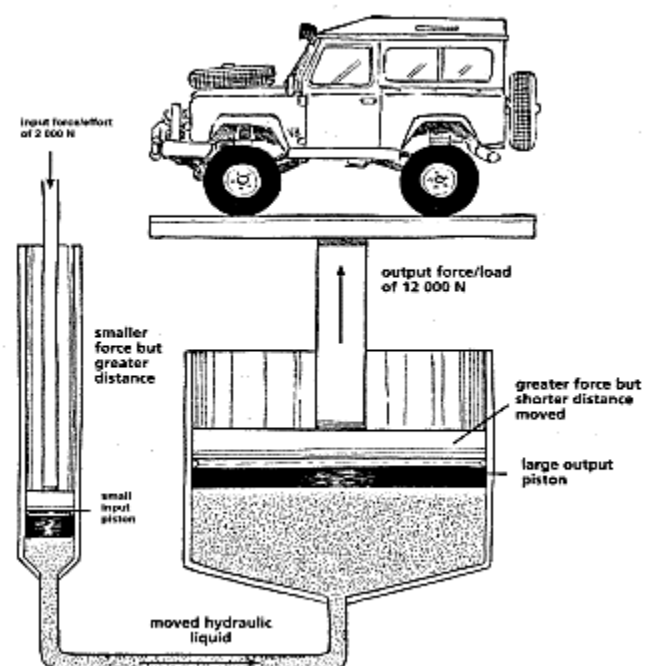
When the car has been fully raised, what prevents the output piston from dropping and returning to its original position?

ACTIVITY 3

ANSWER THE FOLLOWING QUESTIONS ON THE HYDRAULIC PRESS

3.1 The diagram shows a hydraulic system in a car lift. The force applied to the input piston is 2 000N. The output piston lift the car with a force of 12 000 N.

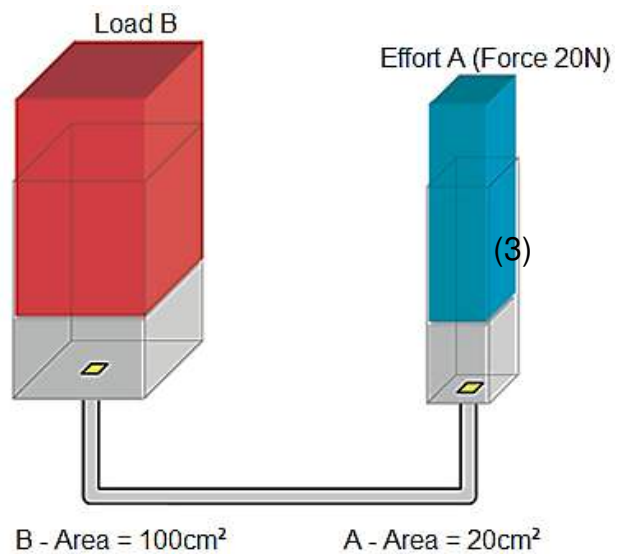
3.1.1 Calculate the mechanical advantage



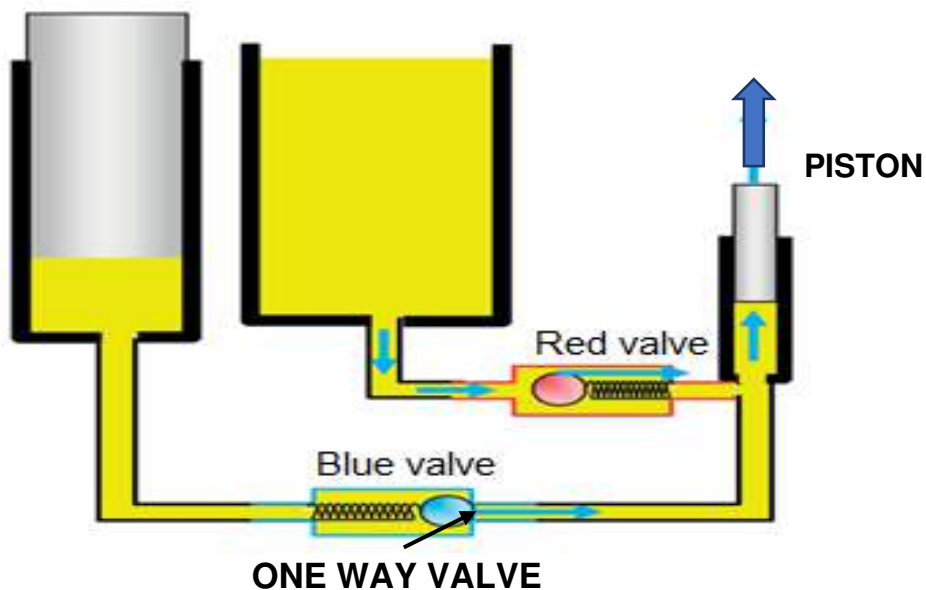
- 3.2 In the hydraulic press below a force of 20N is applied to piston A. Answer the questions that follow.



- 3.2.1 Calculate the pressure of the fluid.



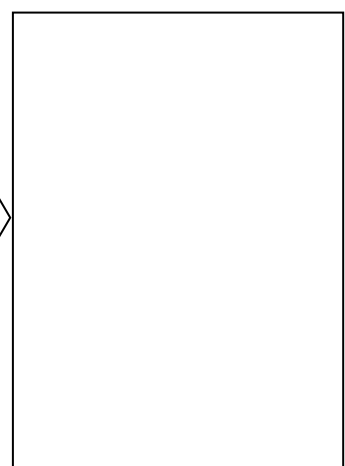
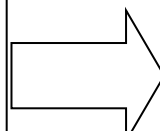
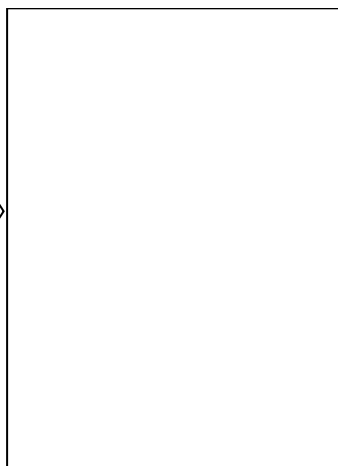
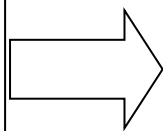
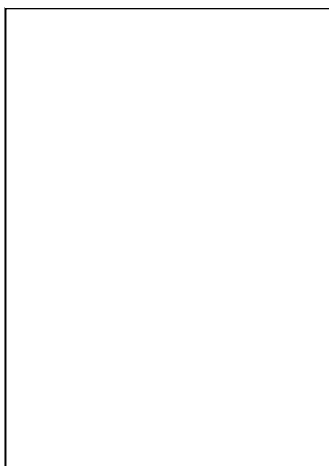
- 3.3 Complete the system diagram for the hydraulic system below when the piston is pulled upwards.



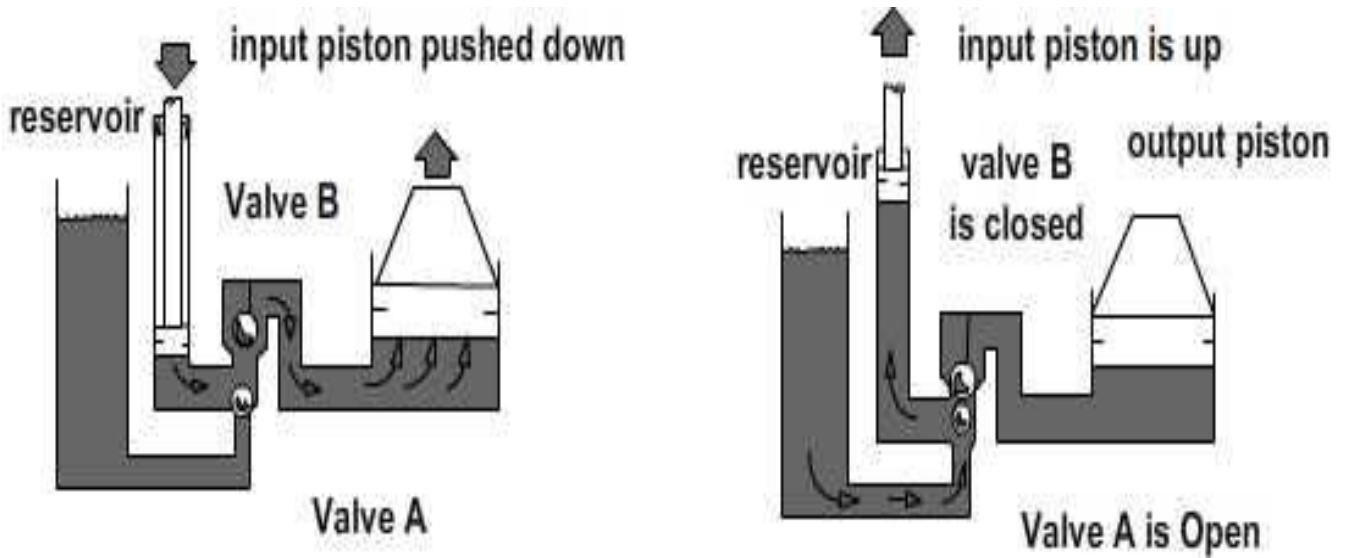
INPUT

PROCESS

OUTPUT



3.4 Answer the questions about the two hydraulic systems below.



3.4.1 What is the function of the reservoir in these hydraulic systems?

3.4.2 Explain how the reservoir and the two valves help to increase the movement of the output piston.

THE HYDRAULIC JACK

The hydraulic jack is **like a hydraulic press**.

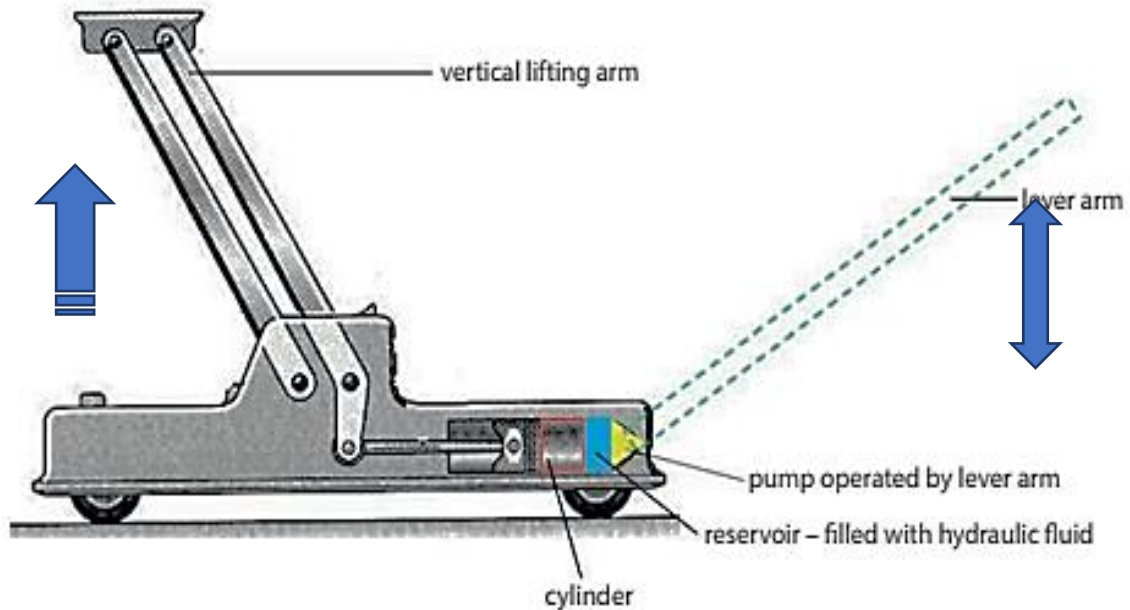
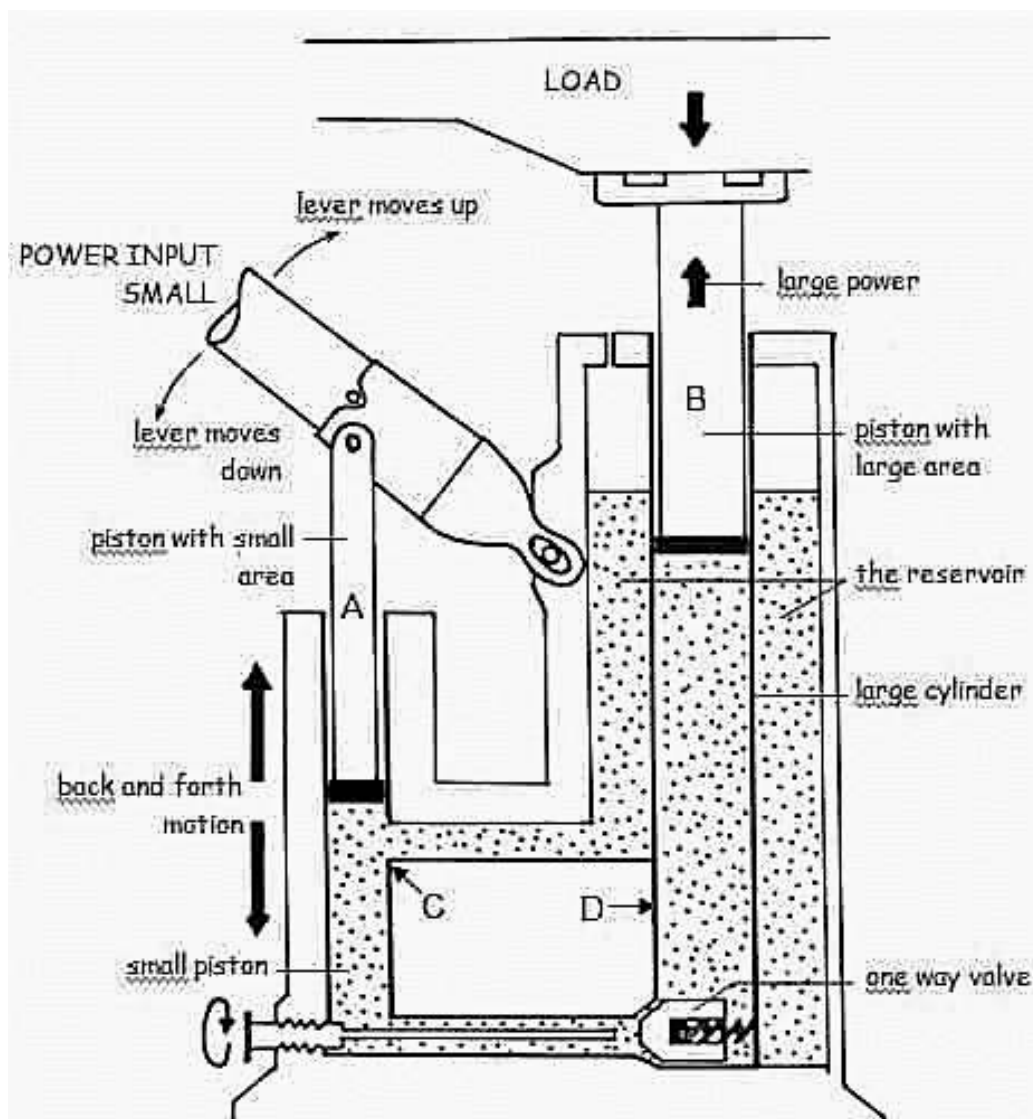


Figure 4.7 A diagram of a cross-section of a hydraulic car jack



PARTS OF THE HYDRAULIC JACK

- The hydraulic jack (Figure 4.7) is a very simple machine. Its design includes a **pump**, a **reservoir**, a **cylinder**, and a **one-way valve**. It works with **hydraulic fluid** and has a **vertical arm** that lifts the load.
- **PUMP** – **Power source** of the hydraulic jack. It is usually **hand powered** by a person pushing the lever up and down. The lever is **attached to the pump**
- **RESERVOIR** – contains the **hydraulic fluid**. When the **jack's pump is activated**, it **applies pressure on the hydraulic fluid and fills the cylinder**.
- **CYLINDER** – **hydraulic fluid is pump into the cylinder** through a **one-way valve**, which applies **pressure on the lifting arm**.
- **A ONE-WAY VALVE** – **allows hydraulic fluid through** to the cylinder in **ONE DIRECTION** (but does not allow it to pass back).
- **LIFTING ARM** – the build-up of **fluid causes pressure in the cylinder and pushes the arm to lift out**.
- The **one-way valve is released** when the job is done. The **weight of the load forces the hydraulic fluid out of the jack's cylinder into the reservoir**. This releases the pressure of the jack.
- **Safety valves** are often built into hydraulic systems to release some liquid if the pressure gets too high. This **prevents the system from bursting**



SYSTEM DIAGRAM OF THE HYDRUALIC JACK

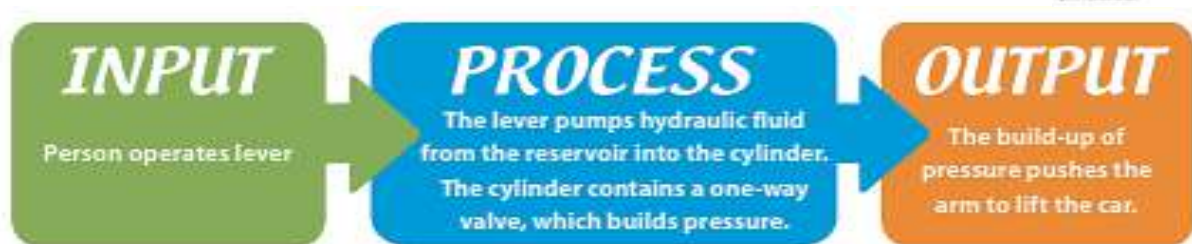


Figure 4.10 A systems diagram showing the use of a car jack

INVESTIGATE: DESIGN CONSIDERATION OF HYDRAULIC JACK

An engineer must **design** a machine that is good enough to do the job for which it was intended.

INSTRUCTION: EVALUATE THE HYDRAULIC JACK TO DETERMINE THE FITNESS-FOR-PURPOSE

- ✓ **Products are evaluated by asking questions such as:**
Who is it for? What is it for? Will it do the job? What should it be made of? What should it cost? Is it cost effective? Does it look good (aesthetics)? Is it safe and easy for the end user to use (ergonomics)?
- ✓ The hydraulic car jack shown in the photo in Figure 4.8 is **manufactured to be able to lift heavy loads with the least amount of effort.**
- ✓ Smaller jacks can **lift to three tons** of weight, which makes them very fit-for-purpose.
- ✓ For this jack to last and **remain sturdy, strong materials** like metal were used for its casing.
- ✓ The **cost** of this jack must **compare well with its competitors** to make it as **cost-effective** as possible.
- ✓ ***Aesthetics*** is about ***how good a product looks.***
The hydraulic jack in Figure 4.8 has bright yellow and black colours to make it look attractive. These jacks are generally very reliable and easy to use.
- ✓ ***Ergonomics*** deals with ***the way a product was designed to increase its productivity while reducing the operator's discomfort.***
- ✓ On the car jack we are evaluating, the **operating lever is a long pole with a rubber handle to protect the operator's hand.**
- ✓ **Wheels** have been added to **speed up movement,** and the jack's assembly is neat.



ANSWER THE FOLLOWING QUESTIONS

3.5 The South African Bureau of Standards (SABS) is the national standardisation institution in South Africa.

All tools and machinery must be approved by this body before they can be made or sold to the public.

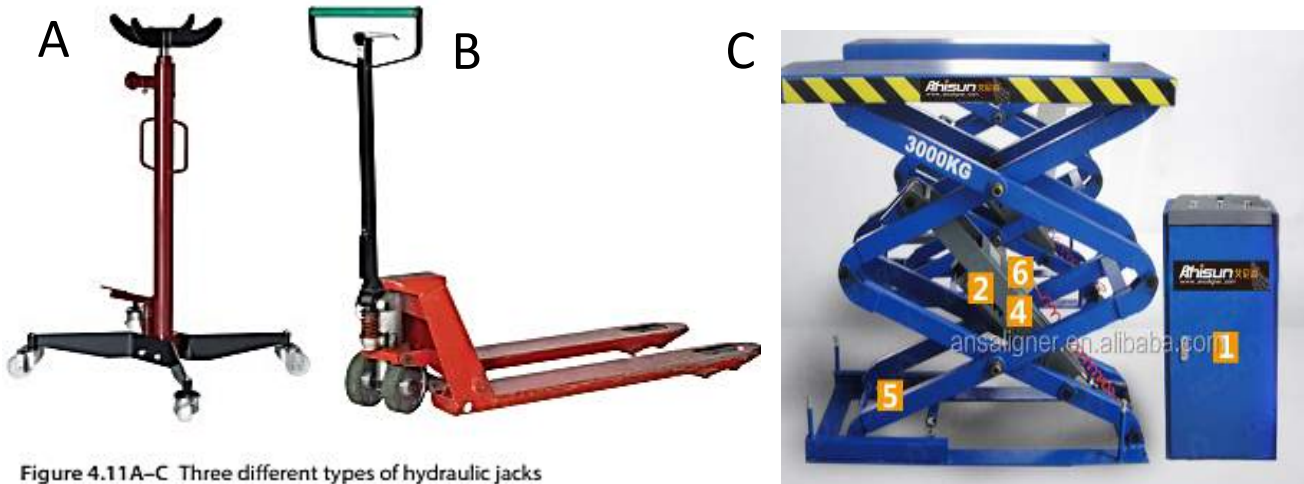


Figure 4.11 A–C Three different types of hydraulic jacks

3.5.1 Complete the table below. Compare the three hydraulic jacks shown in Figure 4.11 A–C above.

	Jack A	Jack B	Jack C
Who do you think would use this hydraulic jack?			
What is the purpose of the hydraulic jack?			
Will it do the job?			
What materials should it be made of?			
Is it cost effective?			
Is it attractive (aesthetics)?			
Is it safe/easy for the end user to use (ergonomics)?			

3.6 Draw a systems diagram to describe the way a hydraulic jack works.

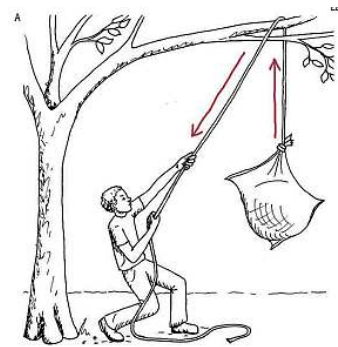
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WEEK 4

MECHANICAL SYSTEMS & CONTROL

PULLEYS

- Pulleys **help to lift heavy loads** and are **often used in lifts and cranes**.
- Pulleys, like all machines, ***make physical work easier*** by taking the effort needed to complete a task and using the effort in a more efficient way.



DEFINITION OF PULLEYS

- A pulley is a **grooved wheel with either a rope, or a chain, and a steel cable or belt which lies in the groove**.
- The **load is attached to the rope, which passes around one or more pulleys**.
*As you **pull the rope** on the side of the wheel, the **wheel turns**, **pulling the rope on the other side of the wheel in the opposite direction**.*

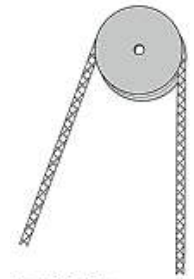


Figure 4: A pulley

USES OF A PULLEY SYSTEM

- They are used to **lift loads**
- Used to **transmit power**
- Used to **change direction of the force**

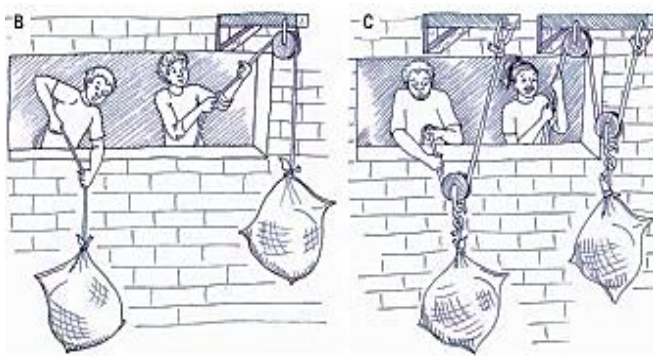


Figure 2: Which way of hoisting a heavy bag is the easiest?

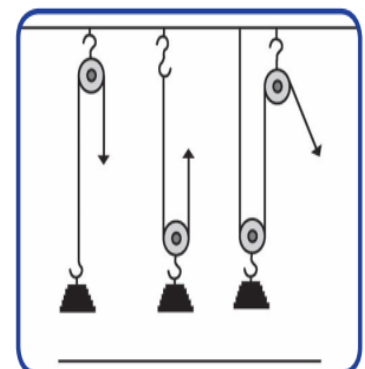


Figure 5.2B The three classes of pulleys

TYPES OF PULLEYS

1. **SINGLE FIXED PULLEY**: a single pulley has **one wheel**.

- The pulley is attached to a support such as beam or frame and is called a fixed pulley.
- It does make it easier **to lift a load by changing the direction of force and effort**.



Key word

- **single wheel fixed pulley** – a single wheel with a groove in its rim for a belt to run in; pulley changes the direction of force needed and multiplies force

- The **effort needed to lift an object is about the same as the weight of the object**.
- This pulley **does not give a mechanical advantage**, $MA=1$
- It **does not decrease the amount of work** you have to do because the:
 - force** you must pull with is the **same** as the weight of the object
 - distance** you must pull the rope down to raise a weight up to the same height is **the same**. The object moves the same distance as the rope moves down.

2. A **MOVABLE PULLEY** consists of a rope attached to some surface.
- The **wheel directly supports the load**, and the **effort comes from the same direction as the rope attachment**.
- A movable pulley **reduces the effort required to lift a load**. Moveable pulleys do provide a mechanical advantage.

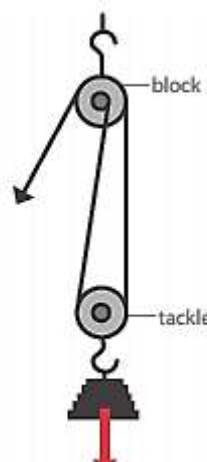


Key word

- **moveable pulley** – a pulley that is not fixed in place but supports a load; a moveable pulley reduces the amount of effort needed to lift and move a load

3. **COMPOUND PULLEY: BLOCK-AND-TACKLE** is a system of ropes and pulleys, used to lift heavy loads.

- As the pulley becomes **more complex**, the **total lifting effort decreases**.
- For example, a system consisting of a **fixed pulley and a movable pulley** would **reduce the workload by a factor of two** because the **two pulleys combine to lift the load**.

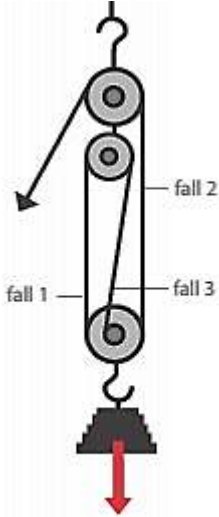


Key word

- **block and tackle** – a system of multiple pulleys; because the pulley rope winds around them many times, the number of falls reduces the effort needed to lift heavy loads

MECHANICAL ADVANTAGE OF PULLEYS

- Like a lever, it provides a **mechanical advantage in lifting a heavy load**. There is a **direct relationship between the number of ropes that form the pulley** and its resulting advantage.



- Greater mechanical advantage is gained by **increasing the number of pulleys** in the system.
- Doubling the number of pulleys halves the amount of force, because two pulleys each share the weight.
- But the **distance you need to pull** is twice as far as the **distance the load is lifted**.
- So, in a **double pulley system** the **MA = 2**
- The **effort needed to raise a load** is **reduced** according to the **number of falls (ropes)** supporting the load.

- When you use a compound pulley, the **effort needed to lift the load is the weight of the object divided by the number of falls**.

- The rope must be pulled the distance which the object is lifted multiplied by the number of falls.

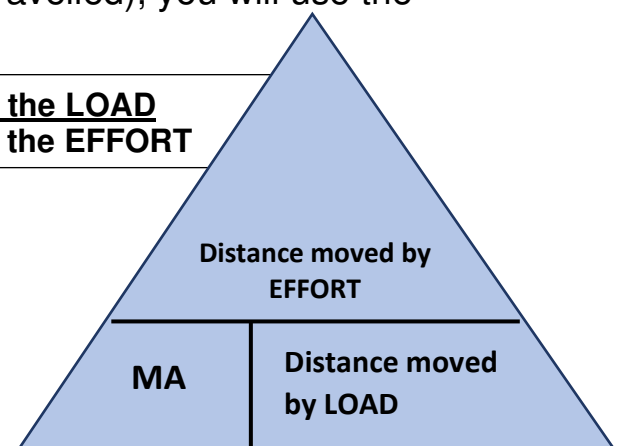
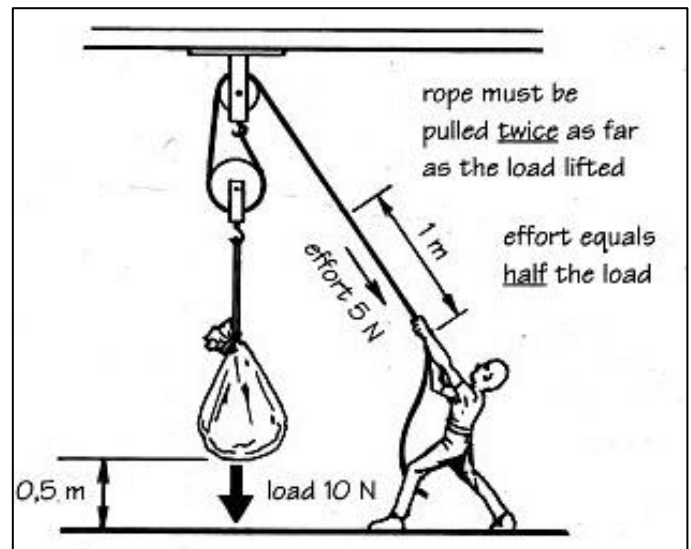
- One Newton (N) is the force** exerted by gravity on a mass of 0,1 kg
100 g = 1 Newton

- When you must determine the movement ratio (distance the effort or load travelled), you will use the formula below:

MECHANICAL ADVANTAGE = $\frac{\text{Distance moved by the LOAD}}{\text{Distance moved by the EFFORT}}$

$$MA = \frac{1 \text{ m}}{0,5 \text{ m}}$$

$$MA = 0,5 \text{ meter}$$



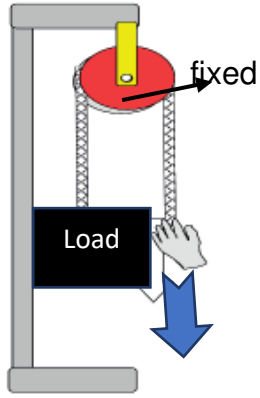
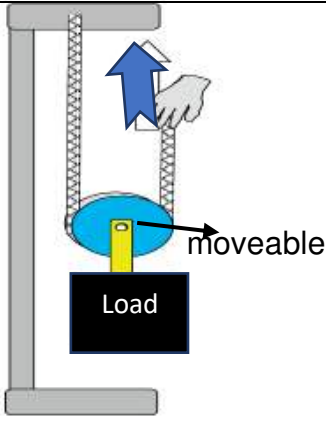
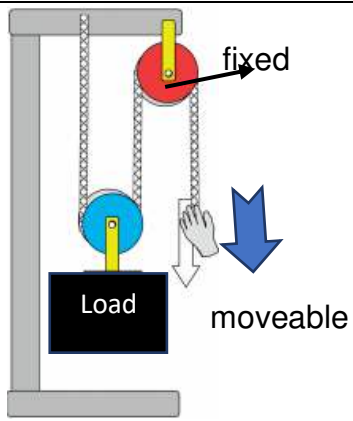
ACTIVITY 4: ACTION RESEARCH: PRACTICAL INVESTIGATION

HOW DOES THE NUMBER OF PULLEYS USED IN A PULLEY SYSTEM AFFECT MECHANICAL ADVANTAGE?

TEACHER DEMONSTRATION

You will be investigating factors that might influence the actual mechanical advantage of pulley systems.

4.1.1 Look carefully at the three diagrams in illustration below, showing different ways in which pulleys can be used when lifting an object with a rope.

A. Fixed pulley system	B. Moveable pulley system	C. Block-and-tackle system
		
a. If the rope in the fixed pulley system is pulled down by 50 cm, will the load also move 50 cm? _____ _____	b. If the rope of the moveable pulley system is pulled up by 50 cm, will the load also move up by 50 cm? _____ _____	c. If the rope of the block and tackle system is pulled down 50 cm, will the load move up 50 cm? _____ _____

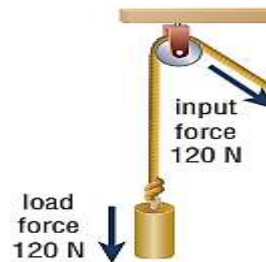
4.1.2 When will you do more work, when you pull the rope in A down by 50 cm, or when you pull the rope in C down by 50 cm?

In pulley systems such as these, the purpose of the fixed pulleys, is to change the direction of the rope, so that you can pull down to lift an object up. It is easier for your body to pull a rope downwards than to pull it upwards.

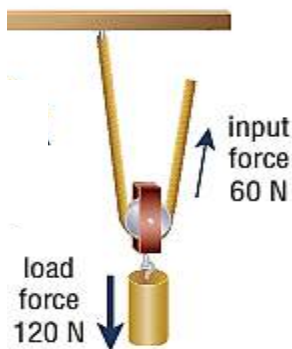
4.1.3 In what way do the moveable pulleys, help to make it easier to lift the load?

4.2 Calculate the **mechanical advantage** of the following systems:

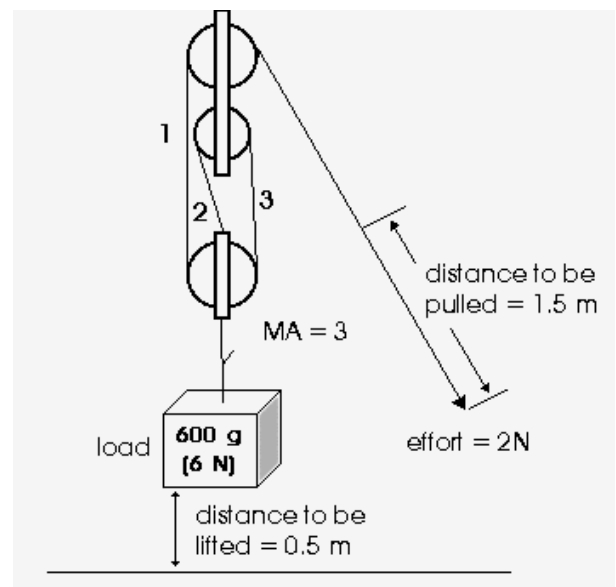
4.2.1



4.2.2



4.2.3



To determine the weight of the load you will use the formula below.

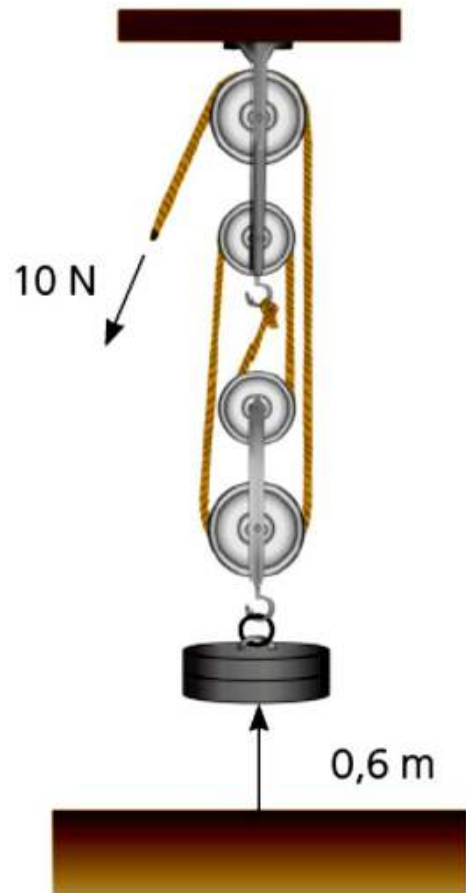
Load = Effort x Number of Falls (MA)

4.3 Consider the following diagram of a block and tackle mechanism.

a) Determine the **mechanical advantage**,

b) distance the **load is pulled** and

c) output force.



WEEK 5: MECHANICAL CONTROL SYSTEMS

When machines and mechanical devices are used, it must be possible for the people who use them to control them easily and use them safely. **We shall investigate the following control systems:**

- **Ratchet and pawl**
- **Disc brake**
- **Bicycle brake**
- **Cleat**

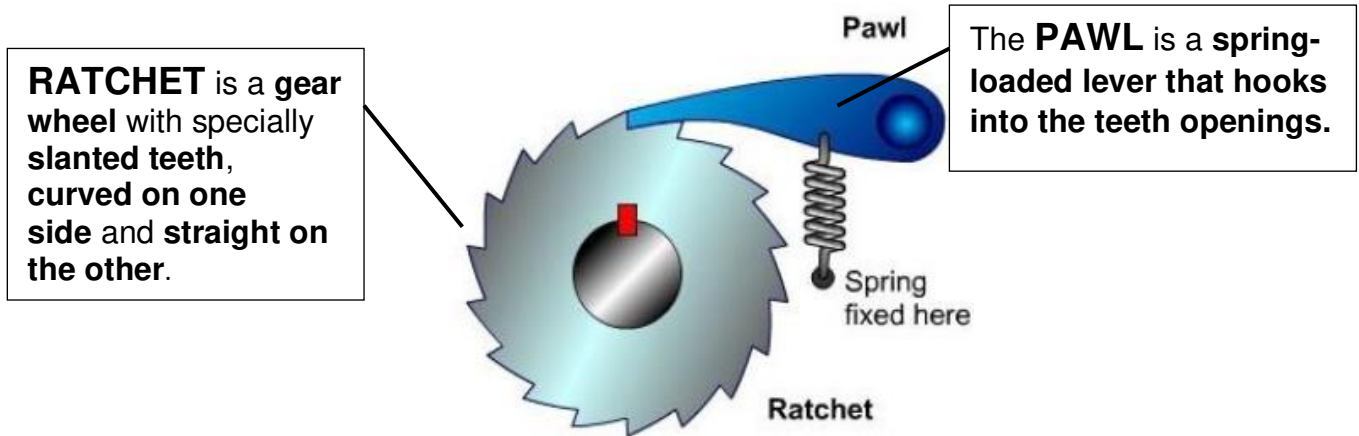
Key words

- **ratchet and pawl** – a gear mechanism that can lock to prevent a load from rolling backwards
- **winch** – a mechanism that winds up a rope or cable

A. RATCHET AND PAWL

FUNCTION

- A ratchet and pawl is a device that is used to **allow movement in one direction**, while **preventing movement in the opposite direction** (study the illustration below)



HOW DOES A RATCHET AND PAWL WORK?

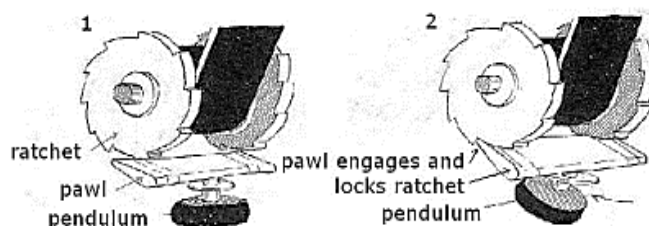
- When the ratchet is **rotated in one direction** by the axle, the **pawl slides up or 'climbs' the curved edge of the teeth**.
- As the pawl **passes over the tip of each tooth**, it **falls down the flat edge of the tooth into the dip** and a spring clicks it into a locking position.
- The **gear cannot slip backwards** as the **straight edge and the spring-loaded pawl block the motion of the gear**, allowing rotation to occur only once the ratchet axle turns in the correct way again.

USES

- Ratchets are **used in machines that lift or pull, to lock the motion and prevent reverse rotation when the input force is removed**.

Rachets are very useful in devices such as:

- mechanical jacks** used to lift vehicles for tyre changes
- a **winch in a water well**
- tightening mechanisms** used in **mountain climbing**
- fairground rollercoasters**
- safety belts in vehicles



A ratchet adjusts the mechanical jack.



The ratchet in a winch is used to collect water from the well.

B. DISC BRAKES

- Nowadays, **most cars have brakes on all four wheels to stop the vehicle more effectively.**
- The most common type of brake system is a **disc brake system**, where the car is ***slowed down by applying friction to a disc or rotor in the wheel of the car***

HOW A DISC BRAKE SYSTEM WORKS

Look at Figure 6.7. A disc brake system of a car is a combination of mechanical, electrical and hydraulic systems:

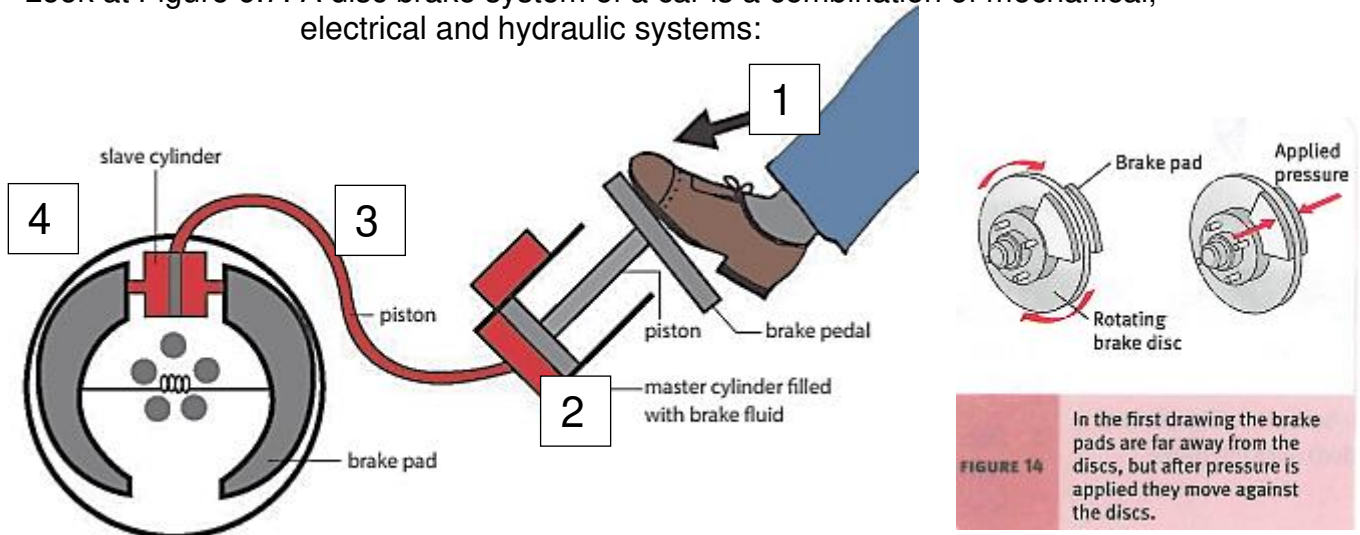


Figure 6.7 Cross-section of a disc brake system of a car

- Disc **brake system** consists of a **brake disc**, a **caliper**, **brake pads** and a **hydraulic input and output cylinders**.
1. When the **driver presses on the brake pedal**, the small input on the brake pedal exerts pressure on the brake fluid in the whole system.
 2. The **brake fluid from the master cylinder forces an equal pressure** through the whole system into the **pistons on each wheel**.
 3. The **piston** in turn **squeezes two brake pads** mounted on the calipers against the disc, which is mounted on the wheel.
 4. **Friction between the pads and the disc slows the car**, causing the **wheels to slow down**, and the car eventually stops.

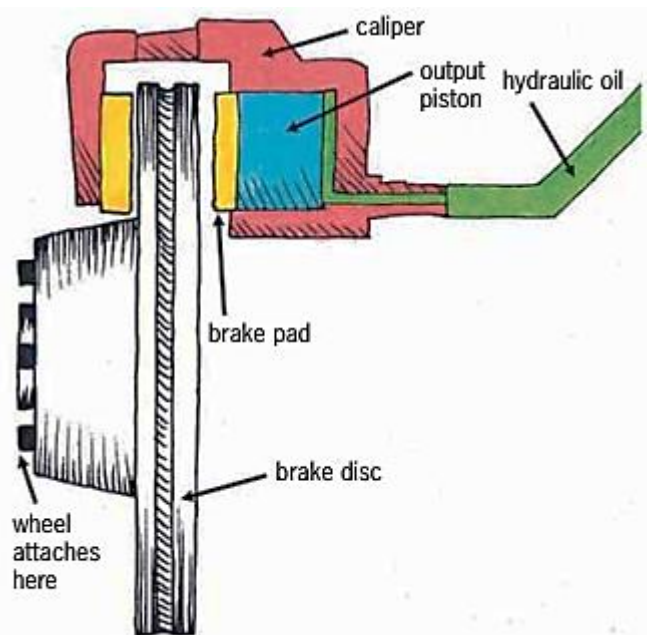


Figure 20: The parts of a car disc brake

C. BICYCLE BRAKES

FUNCTION

- Bicycle brakes are **used to slow down or stop a bicycle**.
- Bicycle **brakes reduces the speed of a bicycle or prevents it from moving** which is a critical function for our safety.



Key word

- **rim brakes** – brakes that use brake blocks or brake shoes made of rubber, cork or leather to apply friction to the rim of a bicycle wheel, causing it to slow down and come to a stop

- Most brakes systems slow the bicycle by **applying pressure to the rim**, making the rim part of the braking system.
- Rim brakes are **cheap, easy to maintain and mechanically simple**, but are nevertheless a very effective control system.
- The brake system on a bicycle uses several sub-systems:

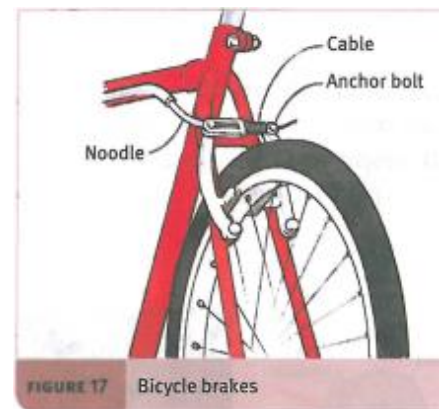


FIGURE 17 Bicycle brakes

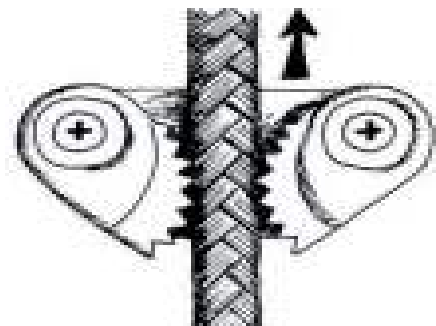
HOW THE BRAKES WORK

1. When **brake handles are pulled** towards handlebars, the **cable pulls up**
2. The brake pads / calipers **pull together and clamp onto front wheel**
3. This **action restricts the wheel from rotating/turning**.

D. CLEATS

FUNCTION

- A cleat is a **safety device used to control the movement of the rope used in a pulley**.
- A cleat **secures a rope by pinching it between or locking it around two pieces of metal or plastic**.



USES

- Cleats are used to **secure ropes on blinds**
- On **secure ropes** on **sailing ships** and
- To **secure ropes** on **mountain climbing equipment**

ACTIVITY 5: CONTROL MECHANISMS

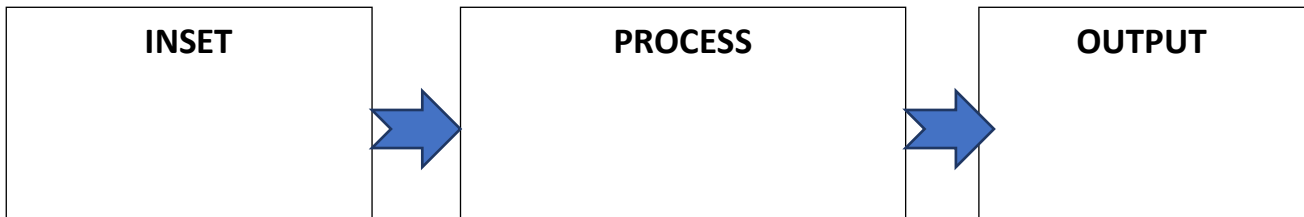
ANSWER THE FOLLOWING QUESTIONS ON CONTROL MECHANISMS

5.1 Study the picture of the bicycle below and answer the questions that follow.



5.1.1 Draw a system diagram that will present the **sequence of events** that happen **which enable the bicycle to move forward**.

(3)



5.1.2 Explain the sequence of events that happen when the **brake handle is pulled to enable the bicycle to slow down and/or come to a stop**.

(3)

5.2 Compare the different mechanical control systems and answer the questions that follow:

5.2.1 Complete the table below with relevant information regarding the illustrated mechanisms.

(12)

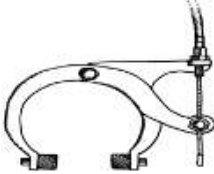
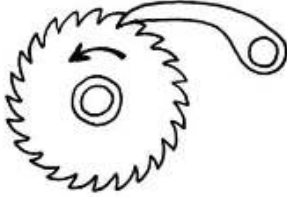
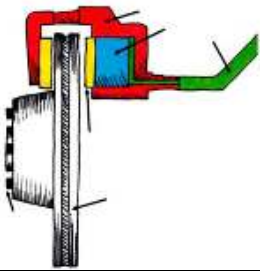
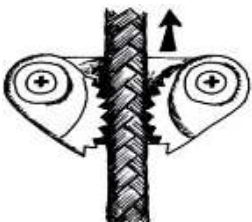
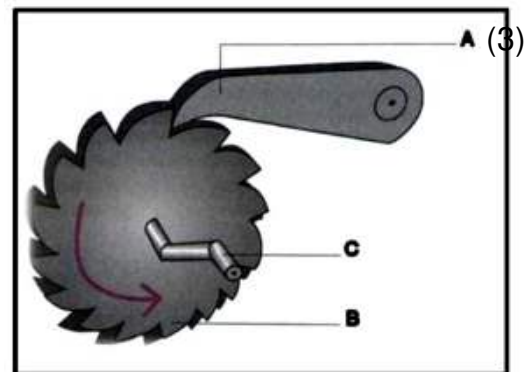
	Illustration	Name of control mechanism	Uses	Function
A				
B				

	Illustration	Name of control mechanism	Uses	Function
C				
D				

5.3 Answer the questions on the control mechanism below.

5.3.1 Identify parts A – C .

- A. _____
 B. _____
 C. _____



5.3.2 What is the function of C in the mechanism above?

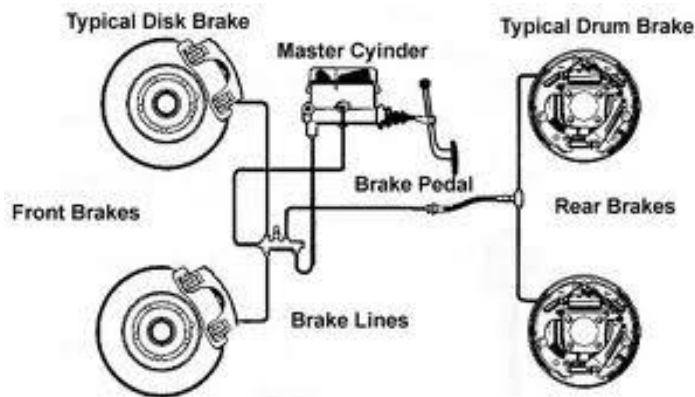
(1)

5.3.3 Explain how this system controls movement.

(3)

- 5.4 Most bikes use brakes where the braking force is applied to the rim of the wheel rim. Give any benefit from these types of brakes (1)
-

- 5.5 Study the drawing of the **brake system of a car** below and answer the questions that follow:



- 5.5.1 How is this system activated? (1)
-

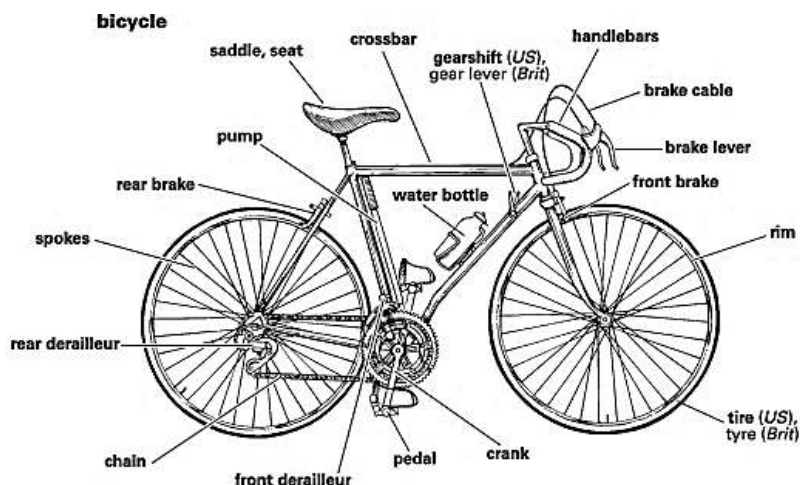
- 5.5.2 Identify the input cylinder in this system. (1)
-

- 5.5.3 Name the two brake systems in a car. (2)
-

- 5.5.4 What is the OUTPUT of this system? (1)
-

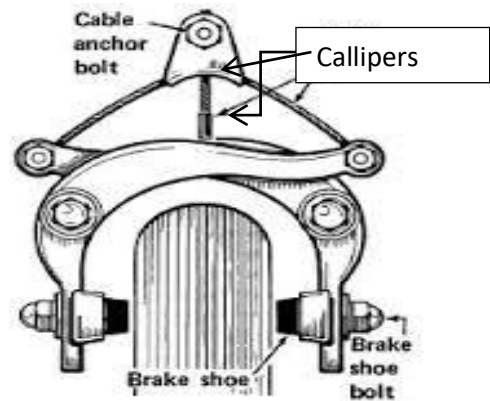
- 5.6 The bicycle makes use of a **RIM-BRAKE system**. The brake system on a bicycle uses several sub-systems.

Below is a picture of a bicycle, the bicycle brakes, and its parts. **Select the parts which play a role when the brakes are activated.**



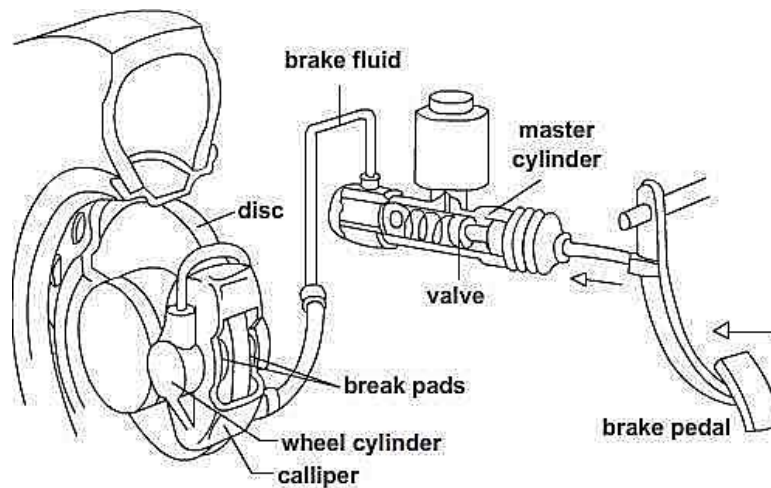
5.6.1 List the parts of the sub-systems – from activating the brakes until the bicycle has stopped. (5)

- a)
b)
c)
d)
e)



5.7 Study the illustration of the mechanical control system below and answer the questions that follow:

5.7.1 With the aid of the diagram below, **summarise what would happen in the system which controls the brakes, when the driver depresses/pushes the brake pedal of a car.** (4)



[TOTAL = 40]

WEEK 6: REVISE GEARS

DEFINITION

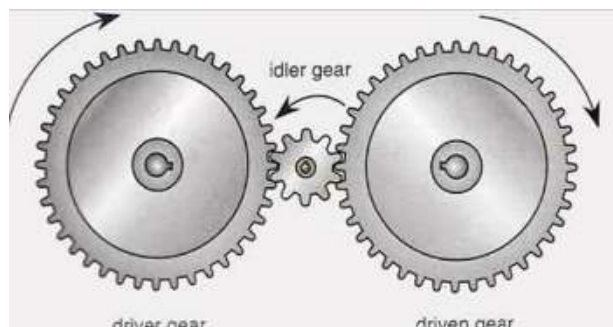
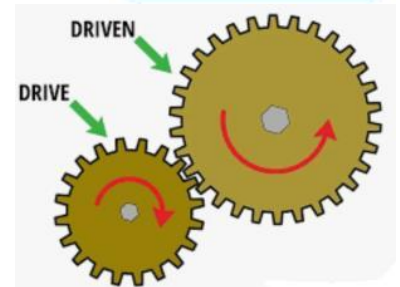
- Gears are wheels with evenly spaced teeth around their outer rim. They are attached to an axle.

FUNCTION OF GEARS

- increase or decrease speed
- change the direction of motion
- multiply or increase turning forces.
- When **teeth from two different gears** are **interlocked**, we say that they are meshed.
- When **two or more gears are meshed**, they form a gear train.
- When two gears are meshed, **they turn in opposite direction** to each other. This is known as a counter-rotation. The cause transfer of movement, force, and speed.
- The **INPUT** gear is called the **driver** gear.
- The **OUTPUT** gear that meshes with the driver is called the **driven gear** as it turns into the opposite direction.
- When you want the driver gear and the driven to rotate in the same direction. You can do this by using a third gear called idler gear.

Key words

- spur gear** – a wheel with teeth around its edge
- in-line systems** – when gears act in the same plane and direction
- gearing down** – when the output gear rotates more slowly than the input gear
- torque** – a turning force
- gear ratio** – the ratio of the speed of the driven gear relative to the speed of the driver gear
- gear trains** – sets of gears that transmit when two or more gears are meshed together



MECHANICAL ADVANTAGE (MA)

= number of teeth on DRIVEN gear
number of teeth on DRIVER gear

TYPES OF GEARS

A. SPUR GEARS



- **SPUR GEARS** are the ***simplest*** and most common type of gears.
- They have **straight teeth and are oriented parallel to shafts**.
- They are used in industrial mechanisms to transfer mechanical motion as well as to control speed and torque

→ **SPUR GEARS of equal size counter-rotating**

- When **two equal sized spur gears touch**, the teeth mesh and cause the gears to **rotate in opposite directions and move in counter-rotation**.
- If two gear wheels are **the same size**, they **turn at the same speed or rpm** (rotations per minute).



FIGURE 20 Spur gears of equal size, counter-rotating

→ **SPUR GEARS of unequal size counter-rotating**

- When two spur gears of **different sizes mesh**, they **counter-rotate at different speeds**.
- The smaller gear turns faster than the bigger gear.
- The difference in the speed of the two gears depends on the number of teeth on each gear wheel.

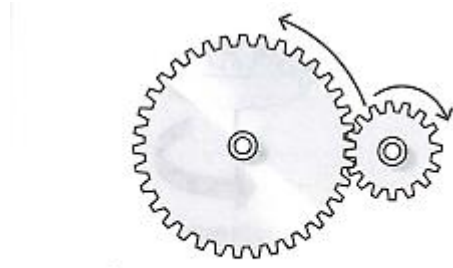


FIGURE 21 Spur gears of unequal size, counter-rotating

- Big gears have more teeth than small gears. We call the **relationship between the speeds of the two gears the velocity ratio**.
- **FORMULA FOR VELOCITY RATIO:**

VELOCITY RATIO (VR)	= $\frac{\text{number of teeth on DRIVEN gear}}{\text{number of teeth on DRIVER gear}}$
----------------------------	---

The abbreviation **rpm** is often used for “revolutions per minute”.

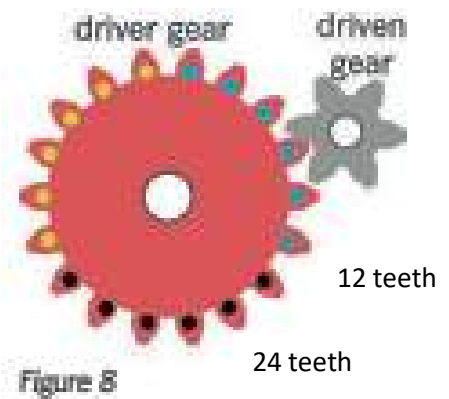
EXAMPLE

- If the smaller driven gear has 12 teeth and the larger driver gear has 24 teeth, we calculate the velocity ratio as follows:

VELOCITY RATIO = $\frac{\text{number of teeth on DRIVEN gear}}{\text{number of teeth on DRIVER gear}}$

$$= \frac{12}{24}$$

$$= 1 : 2$$



- This means that the **driven gear turns twice** for each **time the driver gear turns**. This is called **gearing down**.
- The turning speed of a gear will affect **how much force it can transmit**. The **faster the gear turns, the less force it transmits**.
- The **turning force or torque** can be **increased** when the **driven gear is larger**. It turns more slowly than the driver but with greater force.
- The **greater the distance from the axle to the circumference of the wheel**, the **greater the torque or turning speed of the gear**. We call this the gear ratio. This is called **gearing UP**
- When a gear with **many teeth drives** a gear with **fewer teeth**, the **driven gear turns faster, but with a smaller turning force than the driver gear**.
- When a gear with **few teeth drives** a gear with **many teeth**, the **driven gear turns slower, but with a bigger turning force than the driver gear**.

GEAR RATIO IS DEFINED AS FOLLOWS:

- Gear ratio is defined as follows:

$$\begin{aligned} \text{Gear ratio} &= \frac{\text{rotational speed of input axle}}{\text{rotational speed of output axle}} = \frac{\text{turning force on output axle}}{\text{turning force on input axle}} \\ &= \frac{\text{number of teeth on output gear}}{\text{number of teeth on input gear}} \end{aligned}$$

Formula:

$$\text{Mechanical Advantage} = \frac{\text{number of teeth on driven gear}}{\text{number of teeth on driver gear}} \quad \text{OR} \quad \frac{\text{diameter of driven gear}}{\text{diameter of driver gear}}$$

→ SPUR GEARS using an idler to synchronise rotation.

- An **idler gear** is a **third gear wheel** that is **placed between two spur gears** to **synchronise the rotation of the two outer gears**.
- By using an idler gear, the **direction of the output driven gear will move in the same direction as the input driver gear**.

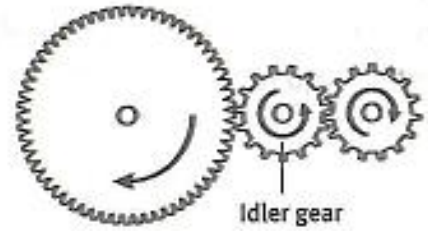


FIGURE 22

Spur gears using an idler gear to synchronise rotation.

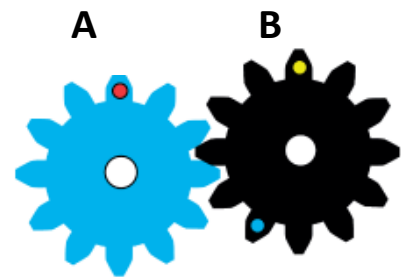
ACTIVITY 6

6.1 Answer the following question on gears

6.1.1 How many teeth do each of these gears have?

Gear A: _____

Gear B: _____



6.1.2 Say gear B turns clockwise. In what direction will gear A turn?

6.2 In the gear train on the right, gear A is the driver. If gear A is turned clockwise, in which direction will the driven turn?

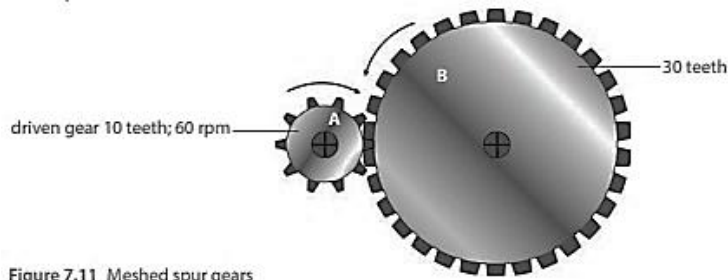


6.3 Answer the following question.

6.3.1 In which direction will Gear B move? Explain your answer.



6.4 Answer the questions on the following gear train.



6.4.1 Calculate the velocity ratio.

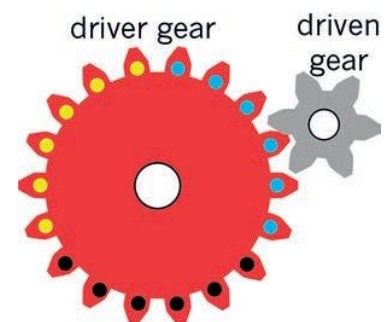
6.4.2 State whether this gear system is gearing up or gearing down. Explain your answer.

6.4.3 What is the speed of Gear B?

6.4.4 What is Gear B called? _____

6.5 Suppose the driver has **18 teeth** and the driven has **6 teeth**.

6.5.1 If the driver gear makes one full revolution anti-clockwise, how many revolutions will the driven gear make, and in which direction?

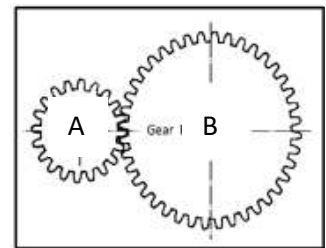


6.5.2 How many revolutions should the DRIVEN gear make if the **driver gear makes 8 full revolutions?**

6.5.3 How many revolutions should the DRIVER gear make if the **driven gear makes 12 revolutions?**

6.6 The diagram below shows a typical gear train. Gear **A** is connected to a motor. Study the diagram and answer the questions that follow.
(When gear **A** rotates 10 times, gear **B** rotates 5 times)

6.6.1 Identify the DRIVEN gear.

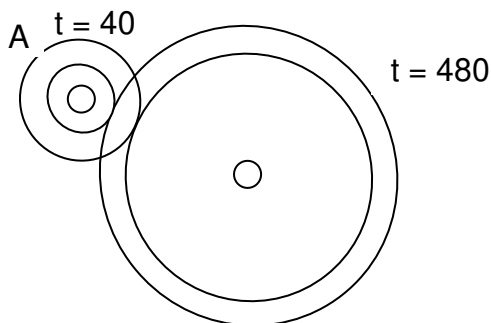


6.6.2 Give a reason for your answer in question 6.6.1.

6.6.3 Gear A rotates in a clockwise direction. In which direction will gear B rotate?

6.7 Study the drawing of a simple gear train and answer the questions that follow.

'A' is the driver gear and **'t'** is the number of teeth on each gear.



6.7.1 If gear A turns anti-clockwise, in which direction will the driven gear turn?

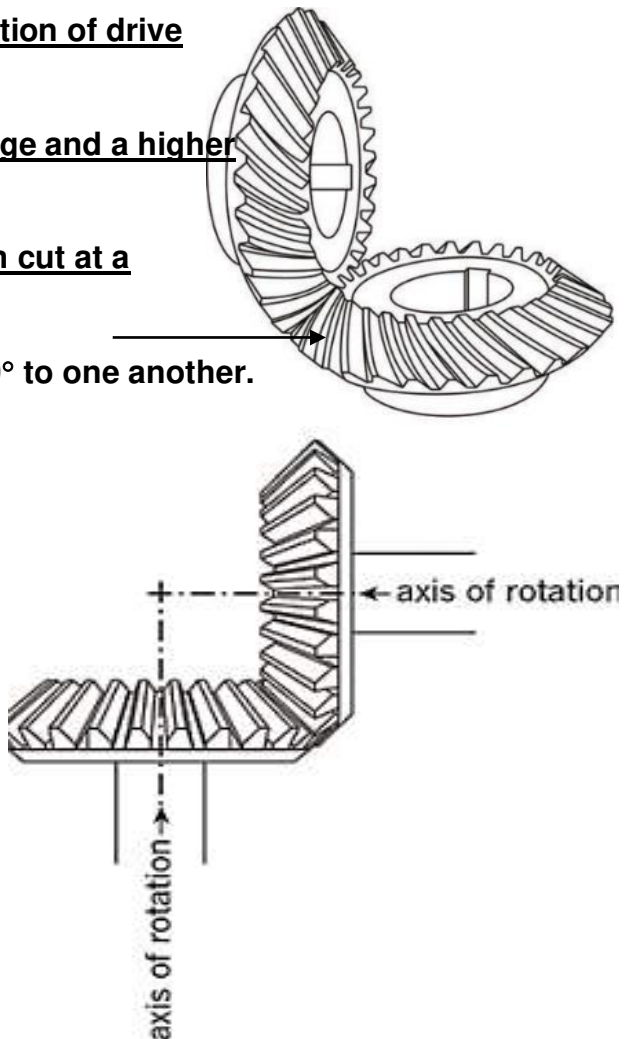
6.7.2 Calculate the mechanical advantage of this gear train.

6.7.3 How much faster or slower is the driven gear than the driver gear?

B. BEVEL GEARS

→ **BEVEL GEARS OF EQUAL SIZE – axis of rotation 90°**

- Bevel gears are used to change the direction of drive in a gear system by 90°
- Bevel gears have a mechanical advantage and a higher velocity ratio
- Bevel gears are cone-shaped, with teeth cut at a 45° angle.
- The gears are mounted at an angle of 90° to one another.
- One bevel gear turns *vertically* on an axis and *meshes* with another gear that turns *horizontally*. In this way, the *movement changes through 90° from horizontal to vertical. The axis of rotation is 90°*



→ **BEVEL GEARS OF UNEQUAL SIZE – axis of rotation 90°**

- In bevel gears of unequal size, the **smaller gear turns quicker than the larger gear**.
The **velocity ratio of the gears** gives **mechanical advantage** in that **one turn of the larger gear results in more than one turn of the smaller gear**.
- But the **smaller gear transmits less force** as it turns faster.
- The **force can be increased when the driven gear is larger**. It turns more slowly than the driver gear but with greater force.



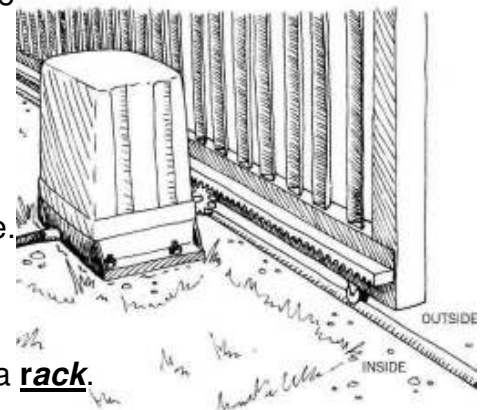
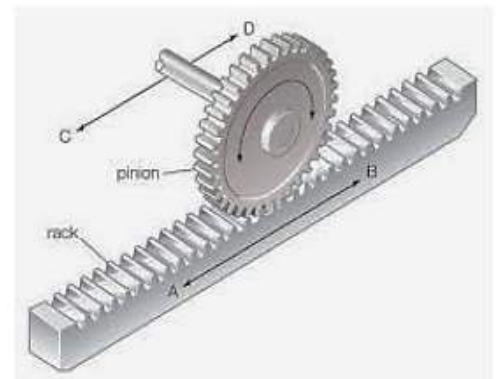
EXAMPLES OF BEVEL GEARS

- Hand drill
- Hand blender



C. RACK AND PINION GEARS

- Rack and pinion gears **change rotational movement into linear movement**.
- A rack and pinion gear system consists of a gear, called a **pinion**, which **meshes with a strip of metal** with corresponding teeth on the top, called a **rack**.
- The **rack** is just like **a gear, but in one long strip**. As the **pinion turns**, the rack **moves sideways in a straight line**. Either the rack or the pinion can be fixed, allowing the other to move freely.
- If the rack is mounted in a sliding carriage to allow it to move freely in one direction and then back again, the output movement is linear.
 - For example, in an **automatic gate**
 - The **gate is powered by a motor**, which has a rotating axle.
 - The **axle** is attached to a **spur or pinion gear**.
 - The **pinion meshes with a flat strip of gear teeth**, called a **rack**.
 - The rack **changes rotary motion into linear motion**.



- An example of a rack and pinion that moves up and down is a corkscrew.
- The rack and pinion is also used in microscopes, pillar drills and camera tripods and the steering mechanism of a vehicle.

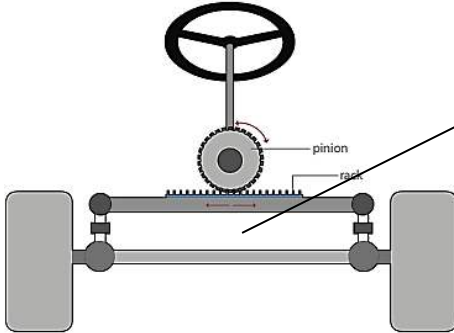
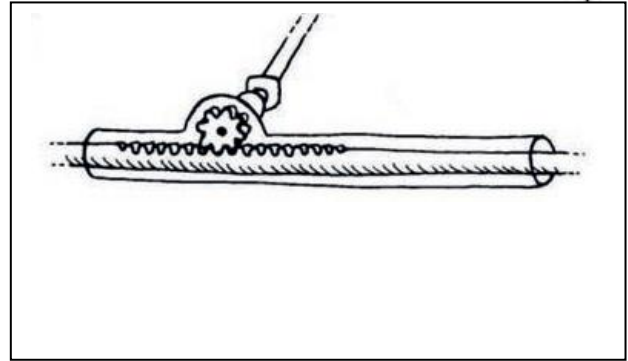
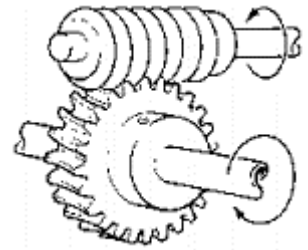


Figure 7.14 In the steering mechanism of most cars, the pinion rotates in a fixed position and the rack is free to move.



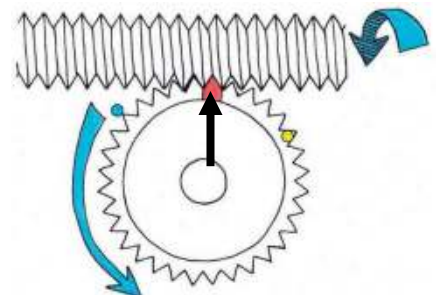
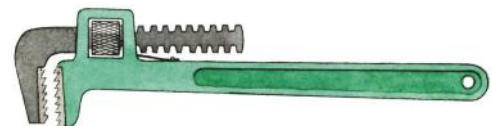
D. WORM GEAR SYSTEM

- Worm gears' teeth is one continuous screw thread(**cylinder**).
- When the **worm turns**, it **slowly pushes the wheel round and round**.
- The **worm (DRIVER)** meshes with a spur gear called a **worm wheel (DRIVEN)**, which transmits a **turning force, torque, and rotary motion through a right angle**.
- It produces a **90° change in rotational movement**.
- The slowing down creates a **large turning force or torque** in the **driven gear**.



➔ GEARS REDUCE OUTPUT SPEED AND INCREASE FORCE

- Worm gears slows down the speed of movement but has an increase in force.
- Worm gears are comm only found **monkey wrenches** (on the right).
- Many **toys** are driven with small electric motors that spin at very fast speeds, like those used in model trains or cars. The speed must be reduced to provide increased force for the toy to move.
- In illustration on the right can see that the **worm driver touches three of the wheel's teeth**.
- For **each full revolution of the worm**, the worm wheel rotates by one tooth.



WEEK 7: SCENARIO

INSTRUCTION: Read the scenario below and answer the questions.

FREE STATE LANDFILL SITES ARE IN A SHAMEFUL STATE AND DO NOT ADHERE TO NATIONAL STANDARDS

BY AFRIFORUM | MAY 28, 2019, JUNE 22, 2020

After an audit of 135 landfill sites in all nine provinces it came to light that the Free State did not adhere to national standards as indicated in the National legislation and regulations, including the National Environmental Management: Waste Act, 2008 (Act no. 59 of 2008) where a landfill site must adhere to standards.

Findings of the audit include: “Most landfill sites are in a poor condition. This can be ascribed mainly to poor management by municipalities, as well as regulations and laws that are not followed. In some cases, certain sites are not maintained at all, while garbage lay around the site for kilometres as well as medical waste which was illegally dumped on the landfill site.”

The audit report has been submitted to the Green Scorpions for further investigation and action against non-compliant municipalities.



<https://afriforum.co.za/en/free-state-landfill-sites-do-not-adhere-to-national-standards>

A tender was rewarded to Maria's company to clean the dumping cite from all the rubbish that filled the area. Maria's company **is going to need a big tip truck to remove all the waste from the landfill site.**

You are therefore requested to design a scale model of a tip truck that could be used to load and remove the waste from the landfill site.

REQUIREMENTS:

- The load/waste must not fall off when the load back is horizontal.
- It should also not allow any waste to fall out when the load is lifted.
- The tip truck must have four strong wheels and a cab for the driver.
- The load bed should have a bed that lift at an angle of 30° or more than 30° .
- The load bed should be able to carry a load of 250grams.
- The load bed should have a door at the back that will be able to open on its own to let the waste out.
- The tip truck must have pivots and axles for wheels.
- The tip truck should have a hydraulic system to raise the load bed.
- The tip truck needs to have warning lights and beepers so that everyone will know when the load bed is being lifted.
- I have two weeks to design a scale model of the tip truck.
- Materials to be used: cardboard and other recycled materials for the body of the tip truck.
- Height of the tip truck should not exceed 300 mm.



bed

**INVESTIGATE EXISTING HYDRAULIC MACHINES**

The machine in the photo on the right is called a mini-loader, and it is used to move materials around on sites.

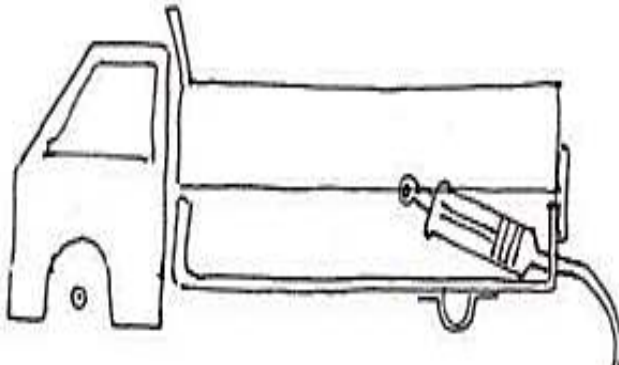
It has a scoop in the front, which the driver pushes into a pile of waste.

Then the arms of the loader lift the load of waste into the air.

It uses diesel fuel in the engine as its source of energy. The engine turns a powerful pump that pumps hydraulic oil through hoses and pistons.



7.4 Identify TWO CONSTRAINTS (the things that you may or may not do) when designing the tip truck.



THE DIFFERENT PARTS OF A TIP TRUCK

The information below will show you the different parts of a model tip truck.

Look at the photograph of a tip truck on the right.



A. HOW TO ATTACH THE LOAD BED TO THE BODY OF THE TRUCK

Waste is loaded in the load bed of the truck. The load bed and the body of the truck should be joined in such a way that the load bed can lift, as in the photo.

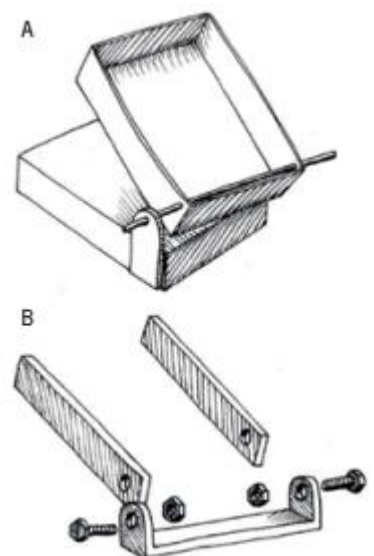
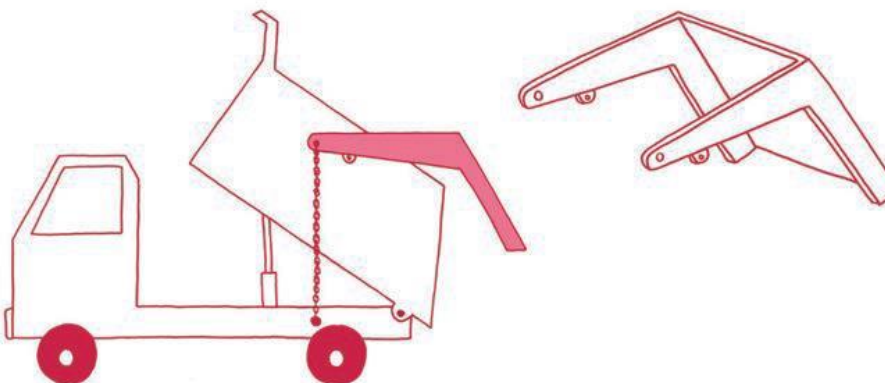
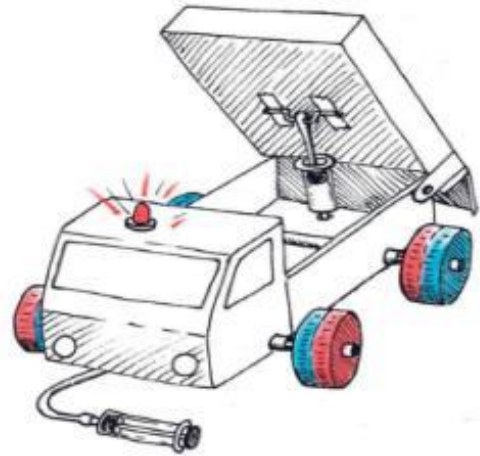


Figure 4

You can make this out of two boxes. The drawings on the right show different ways in which this can be done.

Join the **top box to the bottom box with two hinges**, so that the box can lift at one end.

Doors and windows have hinges to allow them to open and close.



B. HOW TO USE A HYDRAULIC SYSTEM TO TILT UP THE LOAD BED

When a tip truck unloads, the one side of the load bed lifts, but the other side of the load bed remains at the same height.

Another way to say this is that the load bed tilts up at an angle.

The drawing on the right shows you how to make something tilt upwards by using a hydraulic system.

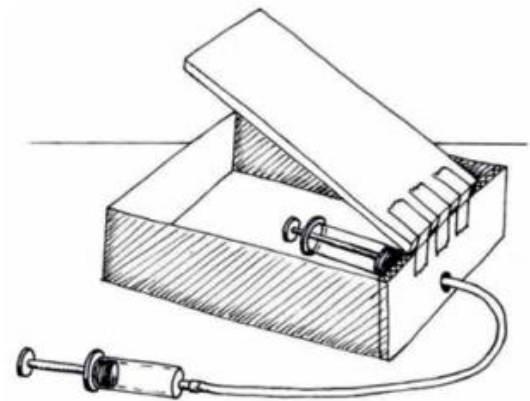


Figure 5

ANSWER THE FOLLOWING QUESTIONS

Your hydraulic system must give you a mechanical advantage. In other words, the output force must be greater than the input force.

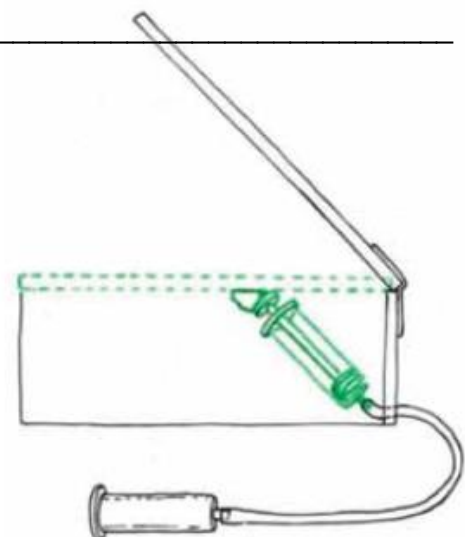
7.5.1 Should the driven piston under the load bed be wider than the driver piston, the same size, or narrower?

7.5.2 Give a reason for your answer.

7.5.3 Complete the drawing on the right.

The dashed lines indicates where the driven piston is when the load bed is horizontal (in it's normal position)

Now draw the output piston on this same drawing. Show its position when it unloading a load at an angle of 30°.



C. HOW TO PUT A DOOR ON THE LOAD BED SO THAT IT SWINGS OPEN BY ITSELF WHEN THE LOAD BED TILTS UP

Study the tip truck on the right and answer the questions.

The door does not have any handles or locks to keep it shut, it should stay shut by itself.

Think how you can make a door like this for the truck.

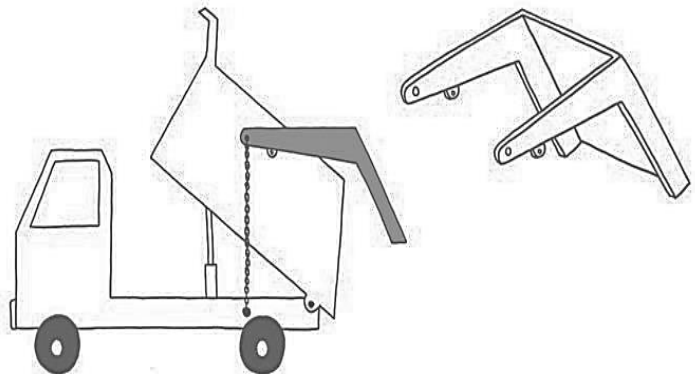
When the load bed tilts up at 30° , the waste including medical waste should fall out. But when the truck is on the road, the door must keep the waste in.

7.4.1 Look at the position of the hinge around which the door swings. Why is the hinge placed there?



7.4.2 Look at the chains going down from the arms of the door to the body of the truck.

What is the purpose of these chains?



D. DESIGN THE PARTS OF YOUR TIP TRUCK

INDIVIDUAL WORK



7.5.1 Draw **TWO free hand designs** on the following page.

7.5.2 Give a **title for each drawing**, to show what the drawing is about.

7.5.3 Also **use labels** to show what the different parts of a drawing are.

7.5.4 Use your ruler and show measurements of the parts on your drawing.

The measurements are important because the part or parts you make must fit into the parts that other people are making.

IDEA 1

IDEA 2

E. EVALUATE YOUR INITIAL IDEAS

7.6.1 The **chosen solution or best idea** will be the one that **best satisfies** the **design brief, specifications** and **constraints**.

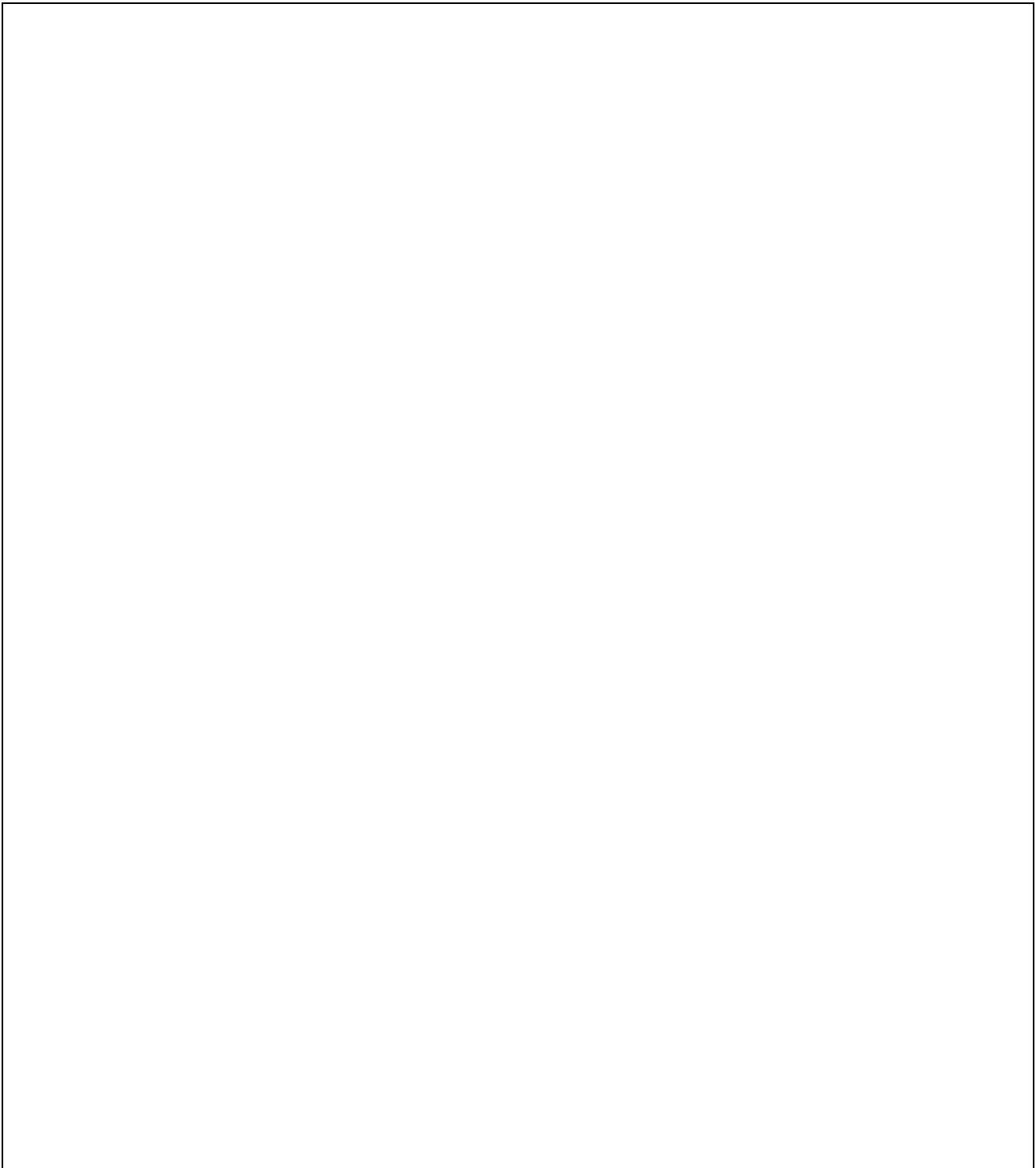
7.6.2 Use the **evaluation instrument** in a **table below to evaluate** your **design ideas** and choose your **best idea** or **final idea**.

CRITERIA	Idea 1 (Yes / No)	Idea 2 (Yes / No)
1. Did you indicate the heading of the drawing?		
2. Did you indicate labels on the drawings to explain design details?		
3. Does the tip truck have 4 wheels and a cab for the driver?		
4. Does the load bed have a door at the back that will be able to open on its own to let the waste out?		
5. Does the tip truck have pivots and axles for wheels?		
6. Does the tip truck have a load bed that lift at an angle of at least 30°?		
7. Does your tip truck have a hydraulic system to raise the load bed?		
8. Will the load/waste not fall off when the load back is horizontal?		
9. Did you indicate the warning lights and beepers on your design?		
10. Materials indicate cardboard and other recycled materials		

7.6.3 Select the best choice from your two designs based on your findings above.

7.6.4 Suggest any changes that you could make to your chosen idea to make it even better to meet the specifications and constraints.

7.6.5 Draw your final choice below. Make changes if necessary.



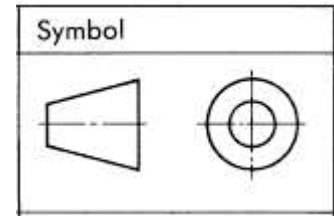
WEEK 8: MAKE A WORKING DRAWING

8.1 Make a 1st Angle Orthographic drawing of your chosen idea:

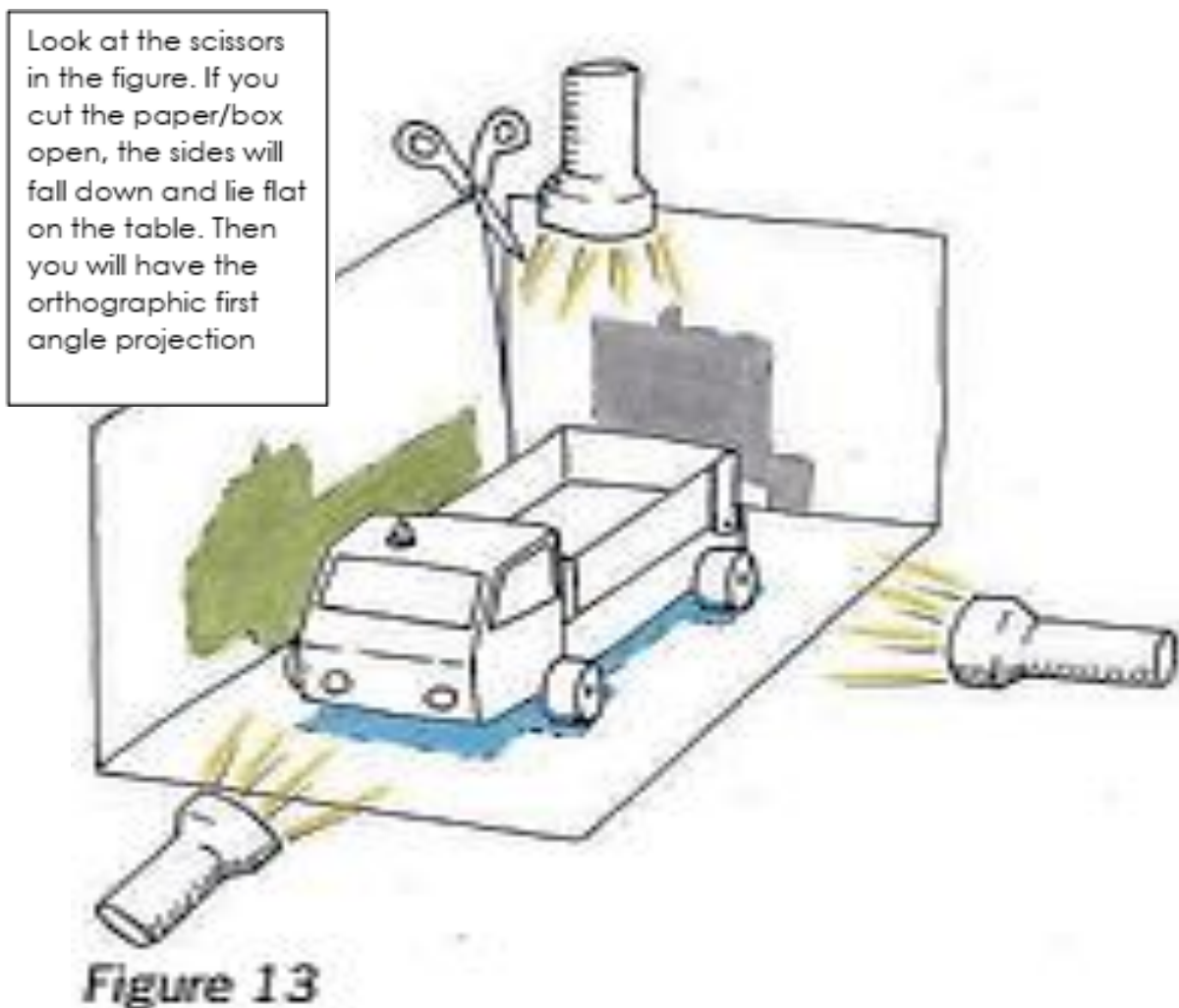
By sketching a **first angle Orthographic working** drawing of your best idea, it should **include all details** needed for making the tip truck.

Details include:

- Indicate instructions,
- Show dimensions (indicated in millimeters)
- Notes on the materials, etc.
- Indicate the front view, side view and
- top view.
- Bold / dark outlines of the drawing must be used.

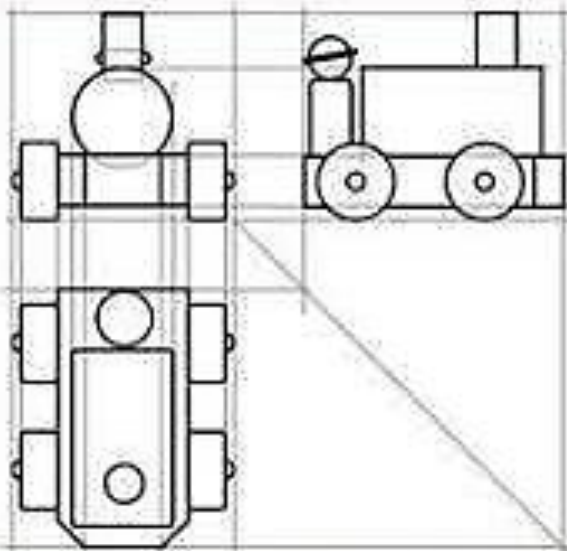
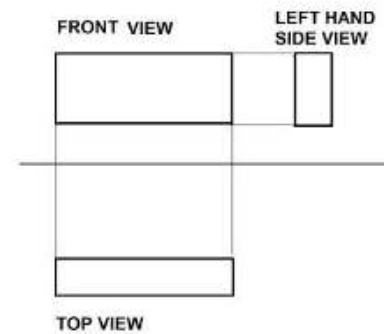


The idea below shows how the model is projected onto the paper/card, to draw an “orthographic first angle projection”

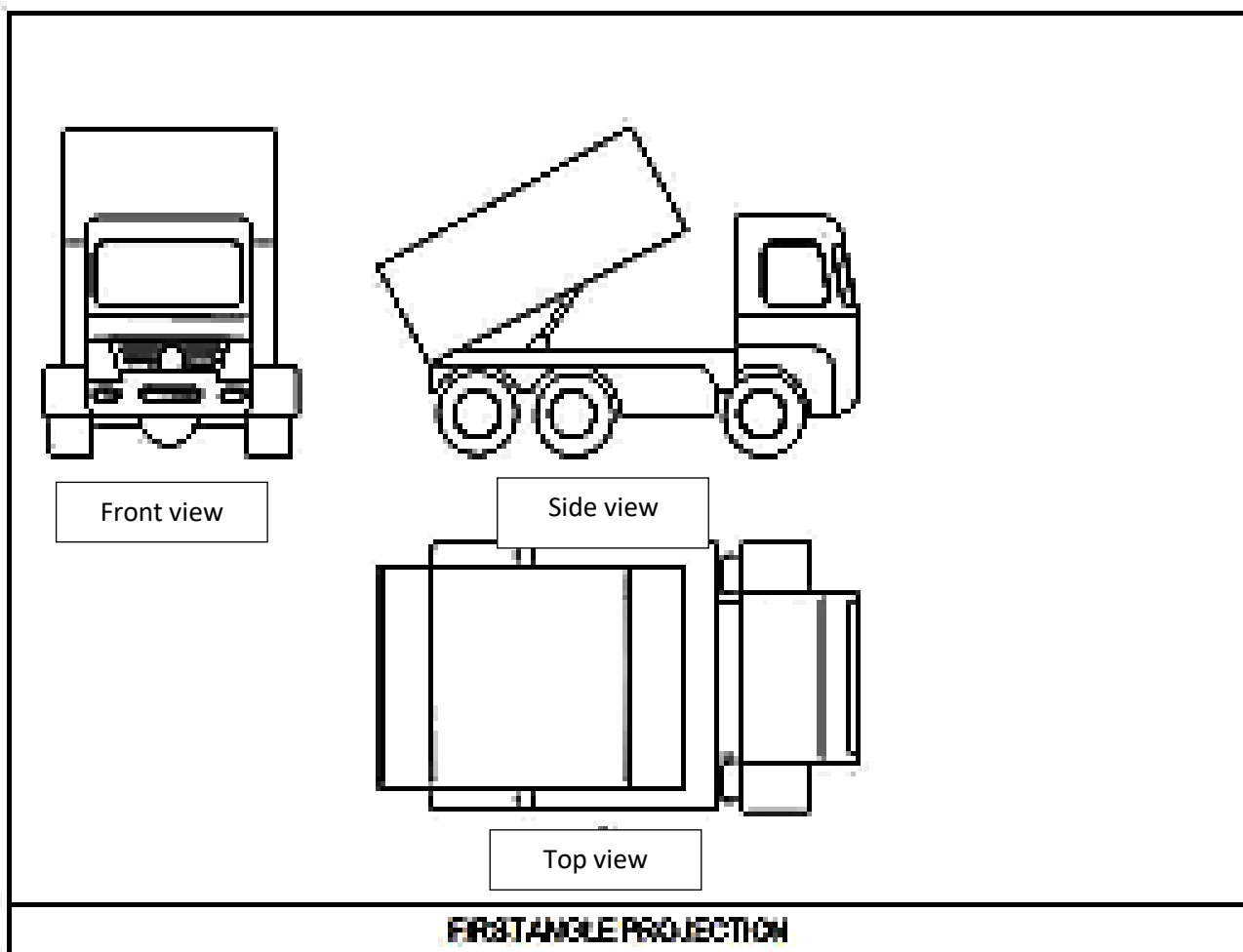


EXAMPLE OF AN ORTHOGRAPHIC DRAWING

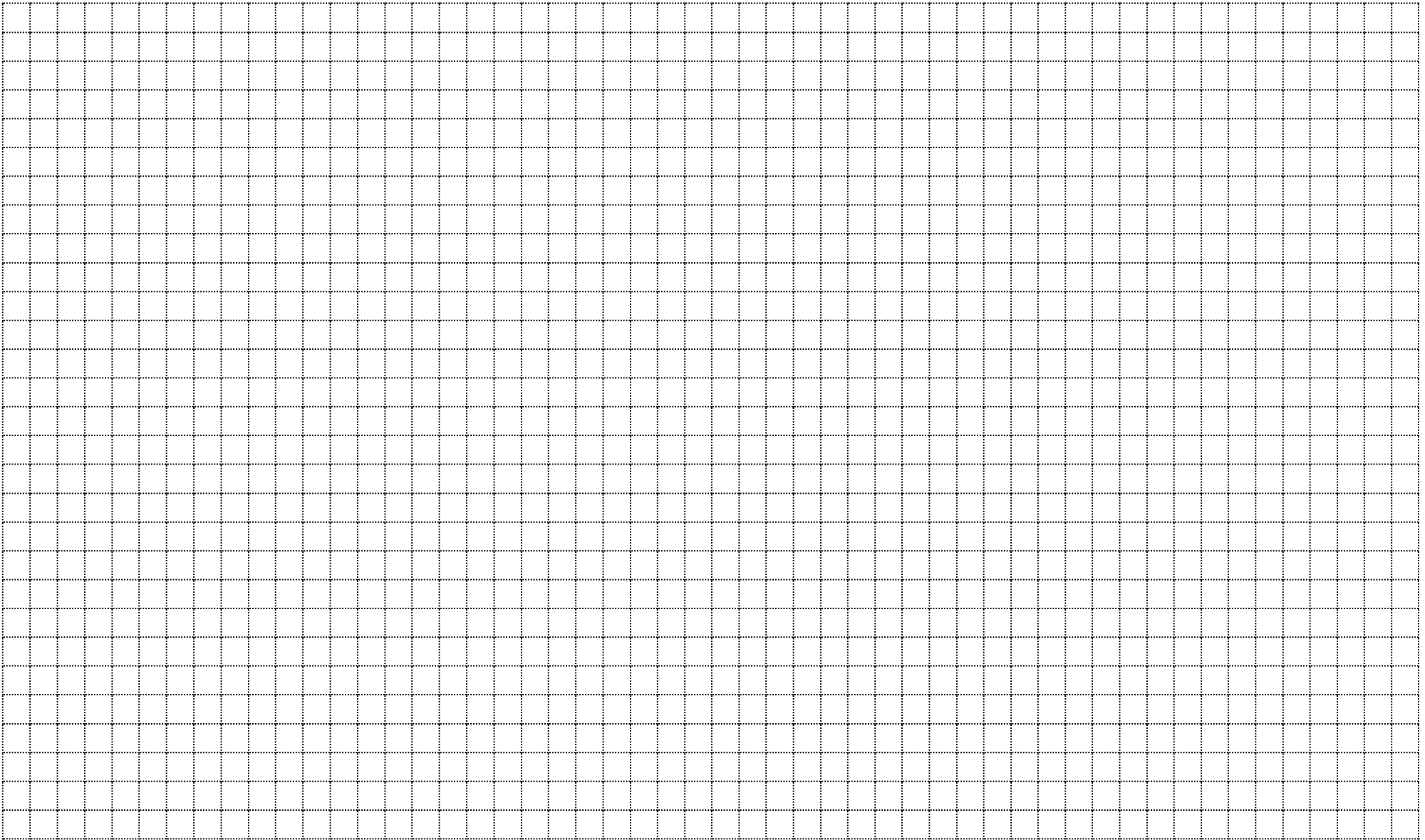
Study these examples of 1st angle orthographic projections, **front view, side view and top view**, provided to assist you.

1st Angle

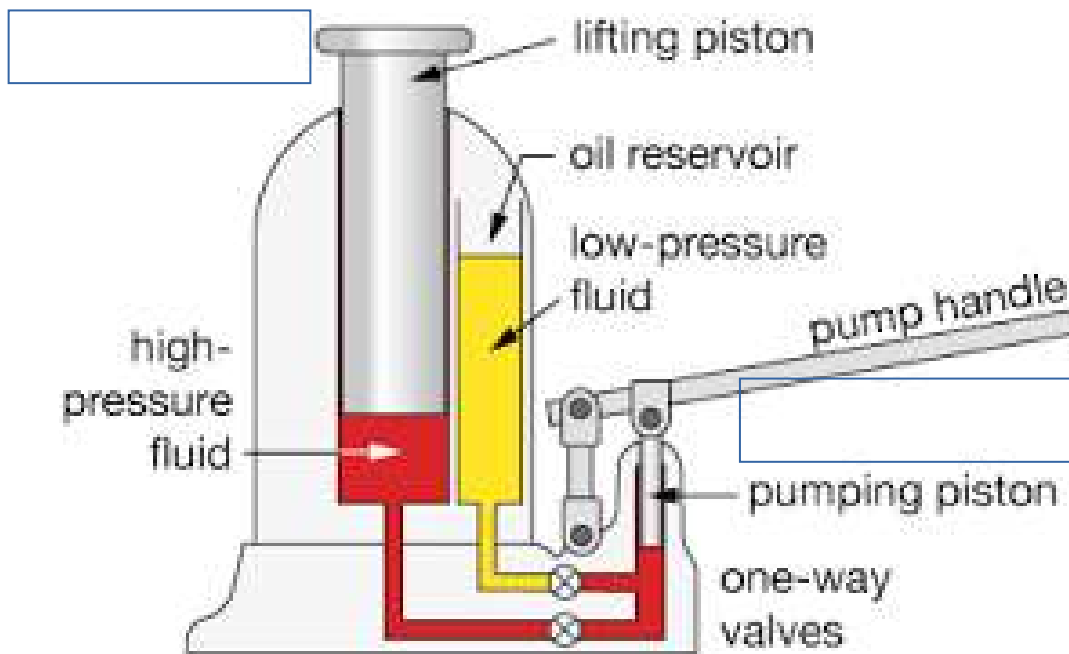
NOTE: (You may use these examples to practice, but not as your final orthographic working drawing)



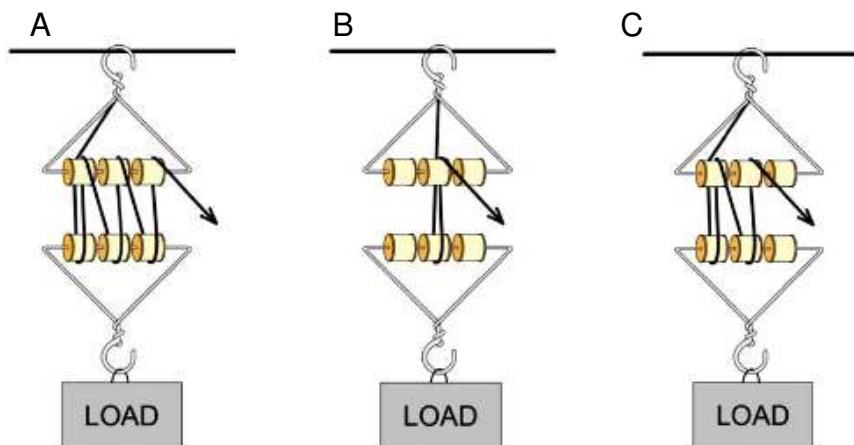
Make a working drawing of your chosen idea in 1st angle orthographic projection on the provided grid



9.2 Indicate the master and slave piston / cylinders of the hydraulic jack.



9.3 Investigate the pictures of different block and tackle systems.



9.3.1 For each of the diagrams A, B and C, predict how easy it will be to lift the load. Arrange the letters in order of increasing ease with which the load can be lifted.

9.3.2 Determine the mechanical advantage of the system in each diagram.

A: _____

B: _____

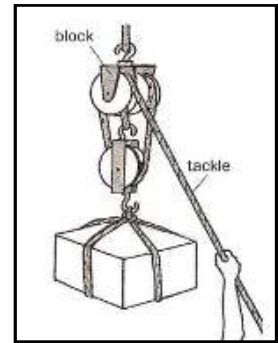
C: _____

9.4 The following questions are based on the pulley system.

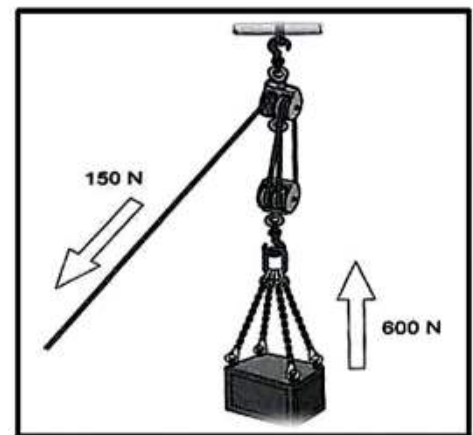
9.4.1 What is the mechanical advantage of the compound pulley shown on the right?

UNDERLINE the correct answer and cross the letter of your choice.

- A. 1
B. 3
C. 4
D. 2



9.5 Calculate the mechanical advantage of the pulley below.

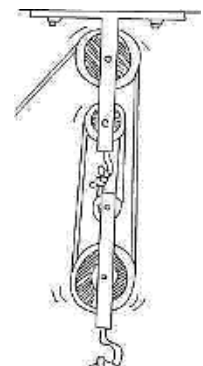


9.6 The figure below represents the use of a block and tackle to remove the engine from a car for repairs.

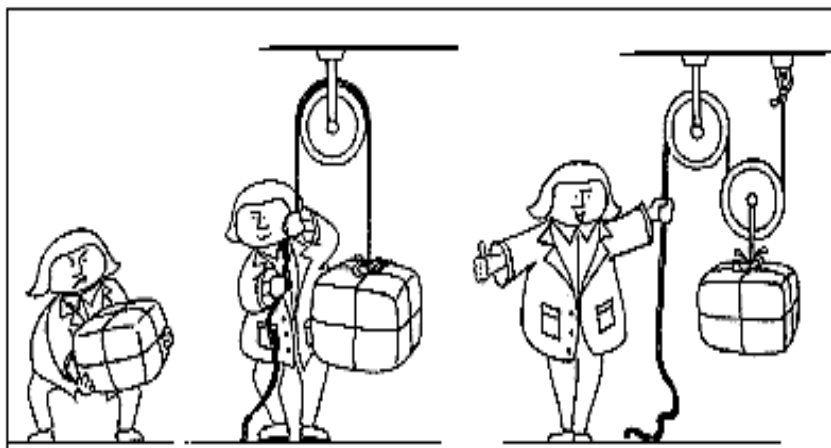
9.6.1 What is the mechanical advantage of this pulley system?

9.6.2 How much effort is needed to lift the motor car engine?

9.6.3 What is the distance moved by the effort if this load is lifted 4m?



4 000 N

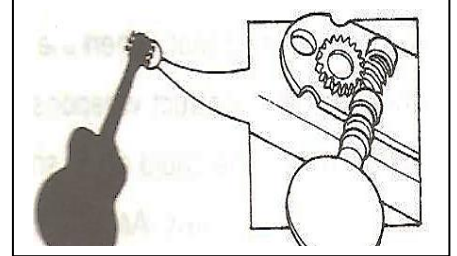


MORE QUESTIONS ON GEARS

10.1 Underline the correct answer in the questions below.

10.1.1 The mechanism for tuning the guitar is an example of which type of a gear system?

- A. Spur gear
- B. Bevel gear
- C. Rack and worm gear
- D. Worm and spur gear

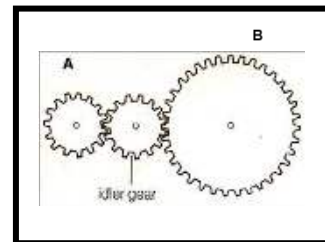


10.1.2 This type of gear system is used to change the orientation of rotational movement through 90° .

- A. Spur gear
- B. Bevel gear
- C. Rack and worm gear
- D. Worm and spur gear

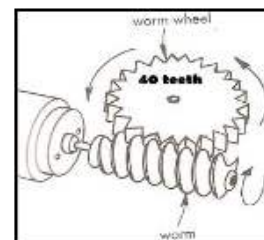
10.1.3 In the gear train system below ...

- A. The idle gear changes the gear ratio.
- B. Gears A and B rotates in different directions.
- C. The idle gear has no effect on the gear ratio.
- D. None of the above.



10.1.4 How many times should the worm turn for the worm wheel to make one complete revolution?

- A. 40
- B. 80
- C. 5
- D. 0.2



10.2 What is the purpose of the gear collection at the back wheel of the bicycle illustration? Complete the sentence below.

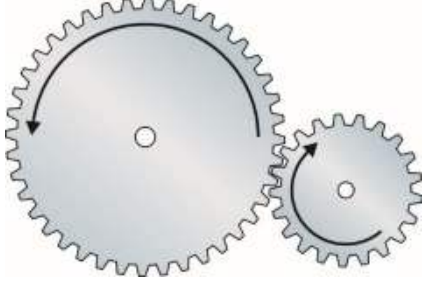


It will allow the cyclist to _____ ratios

whenever the circumstances occur where _____

_____ is required.

10.3 Complete the table below with relevant answers

		
_____	PROCESS Gear mechanism	OUTPUT
Force movement	_____ _____	Desired _____
GEAR SYSTEM: MA 1:2		
_____ on driven gear 20 teeth.	FULCRUM in the middle around an _____ MOVES AROUND AN AXLE.	_____: Driver gear with 40 teeth.

10.4.1 Use a compass and draw two unequal size spur gears. No teeth must be shown only 2 circles per gear will be necessary.

10.4.2 Indicate the rotation of the two gears.

10.5 State the uses of the following gears?

10.5.1 Driver gear: _____

10.5.2 Driven gear: _____

10.5.3 Idler gear: _____

10.5.4 Gear ratio: _____

10.6 Match the description in COLUMN A to those in COLUMN B. Write only the correct letter of the alphabet in the ANSWER column.

COLUMN A		ANSWER	COLUMN B
10.6.1	Wheels with teeth that mesh with each other. They change the speed and direction of a rotating shaft		a) Bevel gears
10.6.2	These gears work on the screw principle. A rotation on the screw wheel causes a much slower rotation on the toothed wheel. The input and output shafts are also at 90° to each other		b) Spur gears
10.6.3	A gear wheel and a toothed bar to change a rotary movement into a linear movement		c) Rack and pinion
10.6.4	These gears change the direction of rotation through 90°. The teeth are angled at 45°, so the gears fit together at right angles		d) Worm gear

10.7 QUESTIONS ABOUT BEVEL GEARS

10.7.1 Do you think bevel gears can also be used to change the speed of rotation?

10.7.2 Explain your answer with examples.

10.8 In a particular bevel gear set, the gear ratio is 1 to 12.

10.8.1 The driven gear in this gear set has 8 teeth. How many teeth does the driver gear have?

10.8.2 How many revolutions will the driver gear make if the driven gear makes 60 revolutions?

10.8.3 How fast should the driver gear turn to make the driven gear turn at 36 rpm?

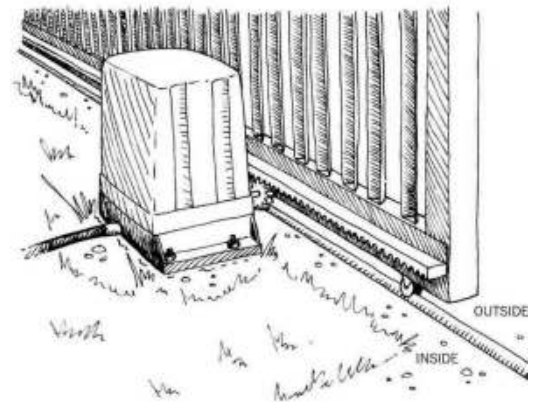
10.9 Suppose you want to buy a food mixer to help you mix ingredients when you bake a cake.

10.9.1 Which food mixer would require the biggest force to turn when you mix: the mixer with a ratio of 1:3 or a mixer with a gear ratio of 1:30? Explain your answer.

10.10 QUESTIONS ABOUT RACK-AND-PINION GEARS

In the illustration on the right, you can see a shell structure that is bolted to the ground on the inside of the gate.

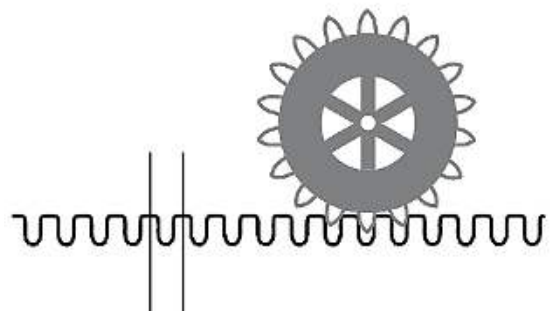
10.10.1 What do you think is inside the shell structure, and why is it there?



10.10.2 Which part of a rack-and-pinion gear set rotates?

10.10.3 Which part of a rack-and-pinion gear set moves in a straight line?

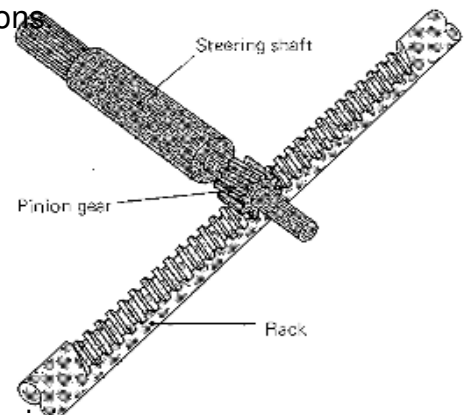
10.11 If the distance between two teeth on the rack is 3 cm, and the pinion has 18 teeth, how far will the rack move if the pinion gear makes one full revolution?



10.12 Read the following information and answer the questions

A model of a SLIDING DOOR is driven by a rack-and-pinion.

The pinion has 20 teeth, and the rack has 5 teeth per centimetre. The pinion shaft rotates at 24 revolutions per minute. The door must move 8 cm to fully open or close.



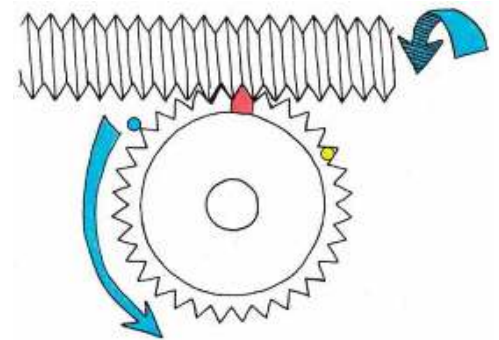
10.12.1 Determine the distance moved per revolution by the pinion.

10.12.2 How long does it take to complete one revolution?

10.12.3 How long will it take for the door to open or close?

10.13 QUESTIONS ABOUT WORM GEARS

10.13.1 If the wheel on the right has 32 teeth, how many revolutions will the worm have to make for the wheel to make one full revolution?



10.13.2 Does the toothed wheel turn faster or slower than the worm?

10.13.3 If there are 18 teeth on the wheel, how fast should the worm be turned to make the wheel turn at 3 rpm?

