



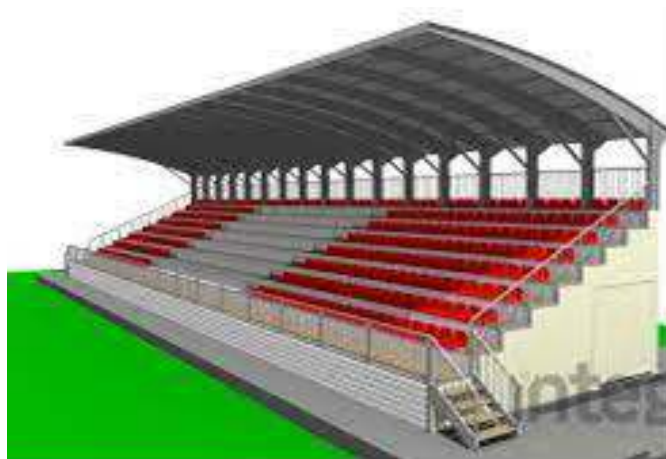
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TECHNOLOGY

GRADE 8

TERM 1: 2023

MEMORANDUM



INVESTIGATION SKILLS: Identify the problem, design brief, specifications, and constraints	____/15
DESIGN SKILLS: Initial Ideas, Evaluation & Choice of the final idea	____/20
MAKING SKILLS: Orthographic Projection / Working Drawing	____/15
MAKING SKILLS: Building the scale model	____/20
TOTAL	____/70

MODERATED BY DEPARTMENTAL HEAD: _____

DATE OF MODERATION: _____

WEEK 1: BASELINE ASSESSMENT

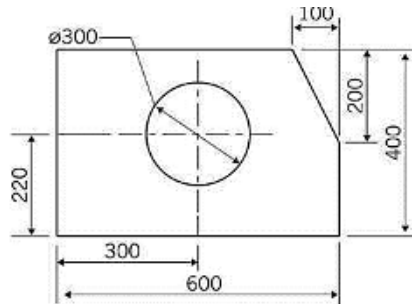
SECTION A: SPECIFIC AIM 1: TECHNOLOGICAL PROCESSES AND SKILLS

ENCIRCLE THE CORRECT ANSWER

1.1 The first response when given the context of a problem or need is to find out about

A	the working drawing	C	the environmental situation
B	the nature of the need	D	both B and C

1.2 The unit of measurement indicated in the 2-Dimensional views (Orthographic) is.....



A	millimetres	C	centimetres
B	meters	D	there is no way of telling

1.3 When you start investigating to solve technological problems the following Technological Process / es can be followed to find information:

A	compare existing products	C	perform practical tests
B	write a design brief	D	both A and C plus collect data.

1.4 To collect data the following could be used as a resource:

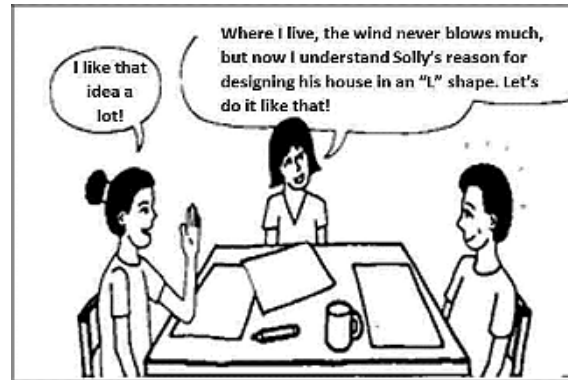
A	speak to or interview people	C	practical investigation and testing of a product
B	find information from any print media	D	A, B and C

1.5 Which of the following questions about existing products will help technologists in creating new solutions?



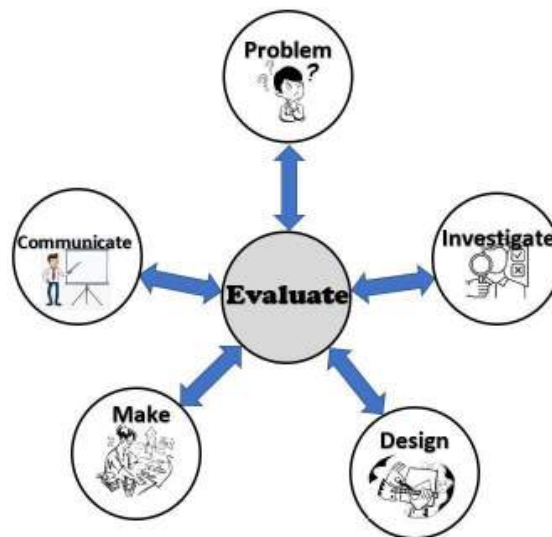
A	Who will use it? What is it used for? What does it look like?	C	Does it impact on the environment?
B	What safety features does it have? How much does it cost?	D	A, B and C.

1.6. The group of learners below are doing a brain storming session that will help them list the



A	Both B and C	C	constraints
B	specifications	D	design brief

1.7 The illustration below can best be described as



A	different stages of a design process	C	steps that follow each other in each sequence when designing
B	a linear representation of the design process	D	the correct order to follow when designing.

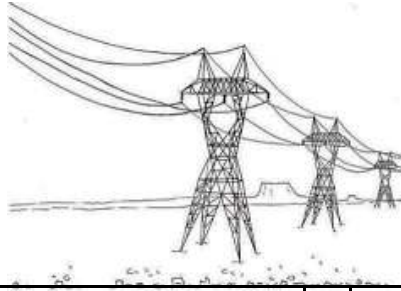
1.8 A technologist collects data and or information during investigation to

A	present the information / data	C	draw conclusions from the information to inform a design idea
B	produce meaningful summaries	D	publish the information / data gained

1.9 A short statement in response to a design situation for the development of a solution that broadly states what a product must do, why it is needed, where it will be used, who will use it and the advantage it will bring, is called a

A	process	C	technological process
B	design brief	D	design Specifications

- 1.10 When you make a 3D drawing that shows things getting smaller in the distance, it is called ...



A	Oblige drawing	C	Isometric drawing
☒ B	Perspective drawing	D	Orthographic drawing

- 1.11 The making of a model (Mock-up) to develop the selected design idea before the actual building of the final product is used by technologists to

A	develop the design idea to see if it will work	☒ C	develop the design idea to see if the proportions of the design are correct
B	improve the product.	D	present a functioning product

- 1.12 A sequence of events or actions presented to show the different steps for making a product is called a



☒ A	flow diagram	C	product
B	portfolio	D	constraint

- 1.13 Measuring, marking out, separating, joining, forming, combining and finishing are all technological processes found in the

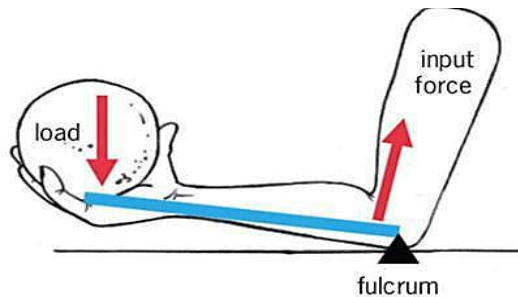
A	investigation stage	C	evaluate stage
B	design stage	☒ D	make stage

- 1.14 Improvements or modifications to a final product are determined by

☒ A	the degree to which the product meets the design brief and specifications	C	the amount of money that could be saved when making the product
B	a feeling!	D	its popularity with the public

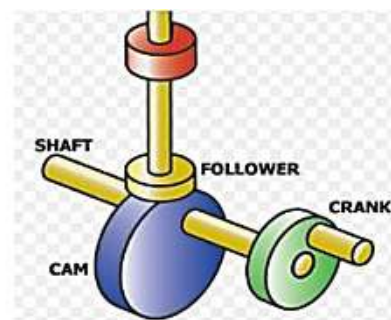
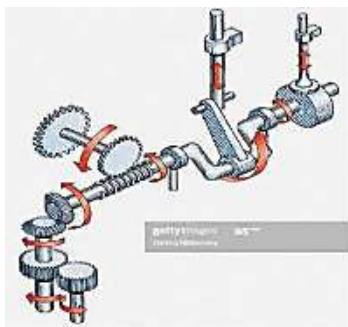
SECTION B: SPECIFIC AIM 2: TECHNOLOGICAL KNOWLEDGE AND UNDERSTANDING

1.15 The following illustration is an example of....



A	First class lever	C	Second class lever
B	Third class lever	D	A and C

1.16 You have been asked to design a mechanical system which changes a circular input motion (rotary) into an output reciprocating motion in a vertical direction. Which of the following mechanical systems could you use?



A	Cam and follower	C	Crank and a cam
B	Eccentric wheel and follower	D	A, B and C

1.17 Shading is used in sketches to enhance a design idea. In the examples below different materials are enhanced to show their



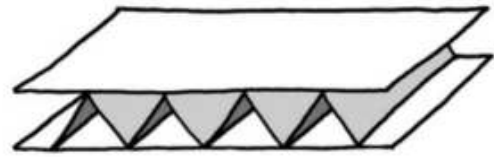
A	colour	C	texture
B	A and C	D	size

1.18 The paper in illustration B will hold a heavier load, because

A.

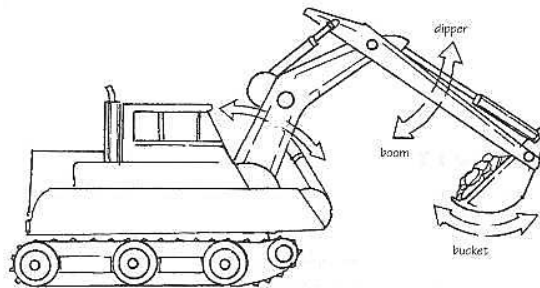


B.



☒ A	the paper in B has been reinforced by corrugation	C	the paper in B has been strengthened by rolled tubes
B	the paper in B has been strengthened by tubing	D	the paper in B has been strengthened by lamination

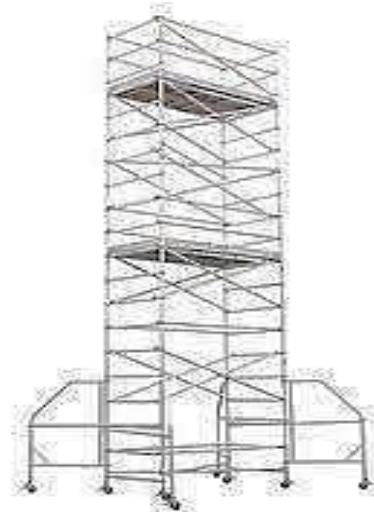
1.19 The workings of the arms in the digger illustrated is best described as follows:



(Illustration from: Technology Today Grade 7 – MML)

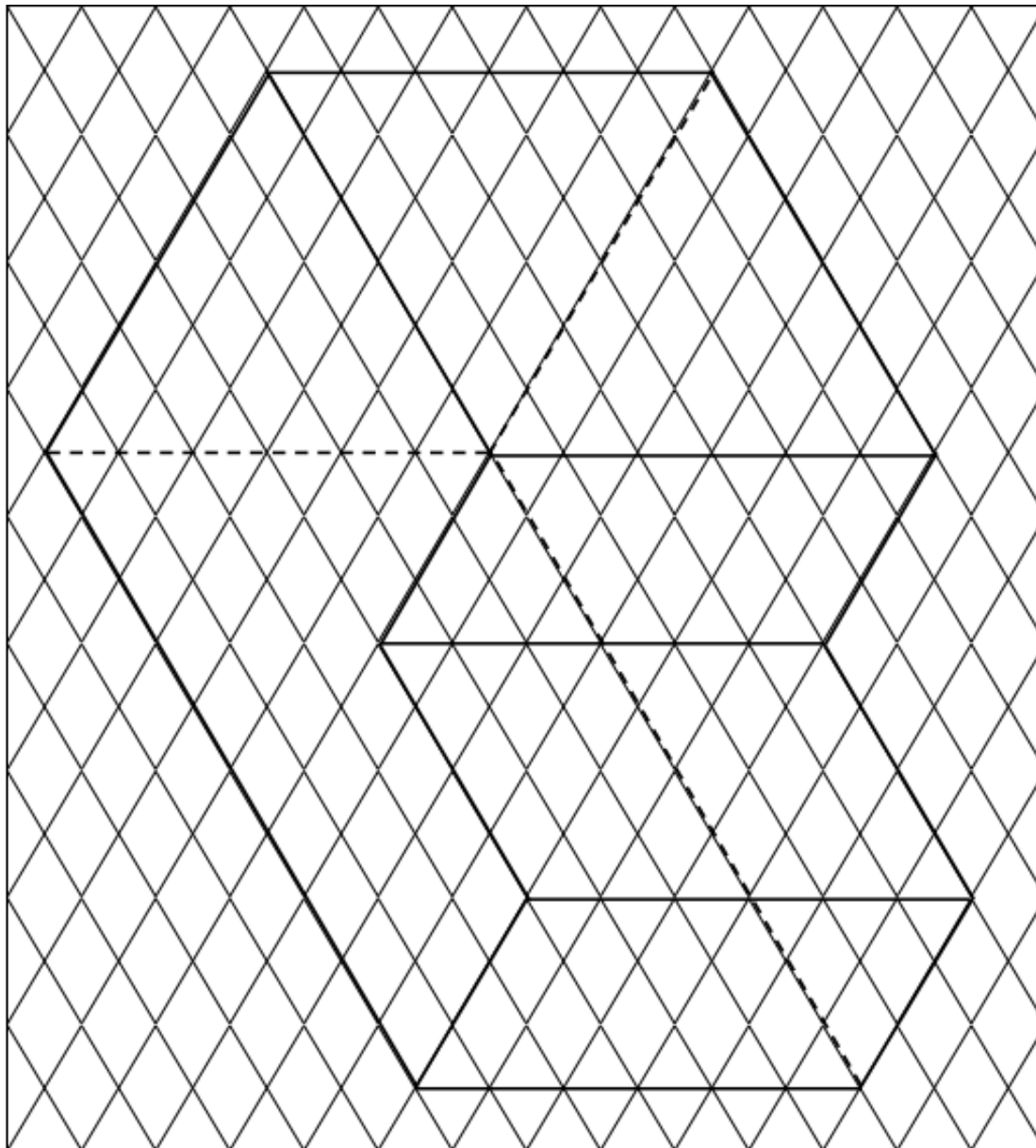
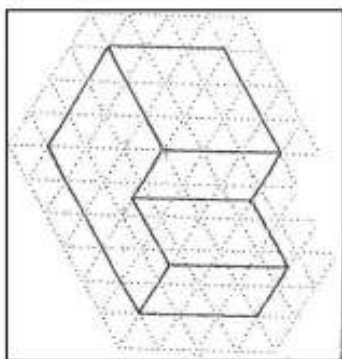
A	Three linked lever systems are used to move the bucket and boom.	C	A hydraulic system is used to move a linked lever system of two levers to move the bucket and the boom.
B	A pneumatic system is used to move a linked lever system of three levers to move the bucket and the boom	☒ D	A hydraulic system is used to move three linked lever systems to move the bucket and the boom.

1.20 The structure below is made stable by



A	the strong joints	C	the steel used to make the structure
☒ B	the wide base	D	triangulation.

1.21 GRAPHIC COMMUNICATION


GRADE 8 - TERM 1
ACTIVITY 1


Redraw the given object on the isometric grid provided. Use the scale 2:1. Show all the hidden detail. Each block on the grid represents 10mm.

Name:

Class:

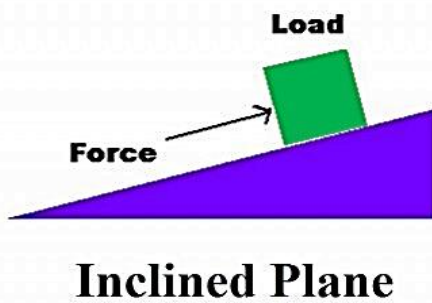
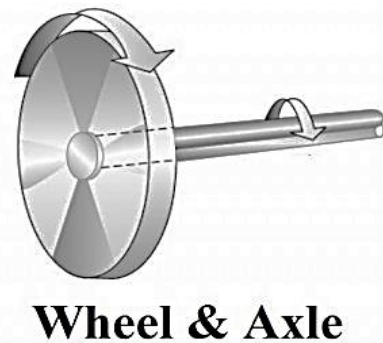
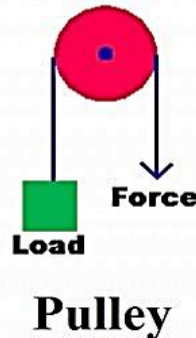
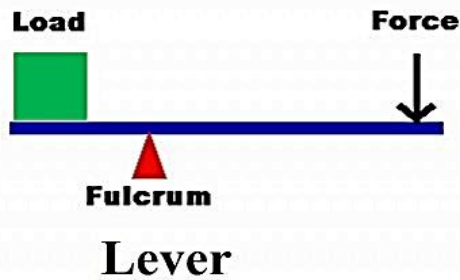
Date:

WEEK 2: COMPLEX MACHINES & MECHANICAL ADVANTAGE

SIMPLE MACHINES

- There are six simple mechanisms that are able to change the strength or direction of a force.

Simple Machines



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- We use **machines to make work easier** and **to do it faster**. For example, we can use a tractor to plough the land instead of digging it over by hand.
- A **machine is a mechanism or group of mechanisms that can do useful work**. Mechanisms are the **working parts of machines**. A mechanism can **change an input force (or motion) into a different output force (or motion)**.
- By **changing one kind of force (or motion) into another kind of force (or motion)**, the mechanism **creates mechanical advantage** that makes our work easier.
- Mechanical advantage is the ability of a machine to multiply effort**. A well-designed machine gives mechanical advantage.
- Machines and mechanisms can be **complex**, but they are actually made up of **combinations of simple mechanisms** such as the inclined plane, wedge, screw, lever, wheel and axle, and pulley.

Machines help us to do work by:

- *changing the effort required to move a load*, e.g. a wheelbarrow
- *changing the speed of output*, e.g. the gears on a bicycle
- *changing the direction of output*, e.g. an egg-beater.

2.1 SIMPLE vs. COMPOUND MACHINES

2.1.1 What makes something a compound machine instead of a simple machine?

Composed of 2 or more simple machines

2.1.2 Label each machine with “S” for simple and “C” for compound.

a. scissors	Compound	d. axe	Simple
b. ramp	Simple	e. bicycle	Compound
c. single fixed pulley	Simple	f. shovel	Simple

2.1.3 List 3 of your own examples of compound machines. (Remember: Machines help make WORK easier.

Bull dozer, wheelbarrow, nail clippers, etc

THE WEDGE, THE WHEEL AND AXLE

A. INCLINED PLANE

An **inclined plane** is the **simplest machine**, because it needs no moving parts to make it **work**. You can use an inclined plane to lift a load from one level to the next level. Instead of using a large force to lift it straight up, the inclined plane (or ramp) allows us to use a **smaller effort over a longer distance to lift/move the load**. The **longer the ramp, the less effort is needed, therefore the greater the mechanical advantage**.

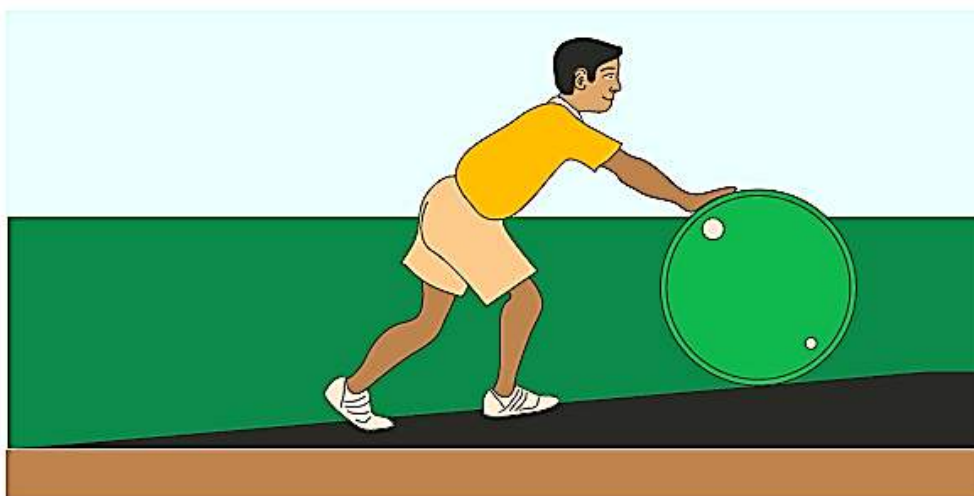


Figure 4 An inclined plane increases the distance but decreases the effort required to do the work.

Key words

- **inclined plane** – a slanting surface connecting a lower level to a higher level; it is used to raise or lower a load
- **wedge** – a double-inclined plane with the two inclined planes facing each other
- **wheel and axle** – a disc that rotates on or around a shaft

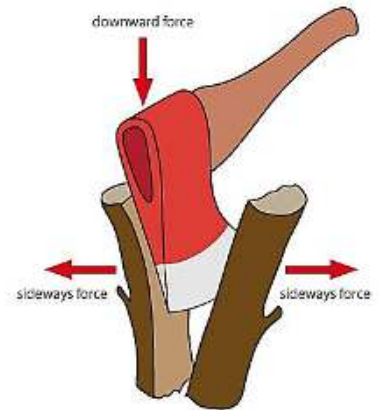
B. THE WEDGE

A **wedge** is like a **double-inclined plane with the two inclined planes facing each other**.



Figure 3.5: A wedge can keep an object in place.

When the **wedge moves forward or downwards**, force is exerted along the length of the sides, perpendicular to the inclined surface, so the wedge is able to push things apart. This action occurs when an axe is used to split logs.



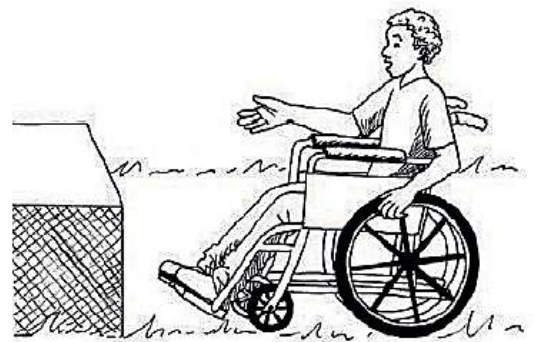
A sharp axe strikes a piece of wood, and the wedge splits the wood.

ANSWER THE FOLLOWING QUESTIONS

2.2. Helping a boy in a wheelchair to get up a step

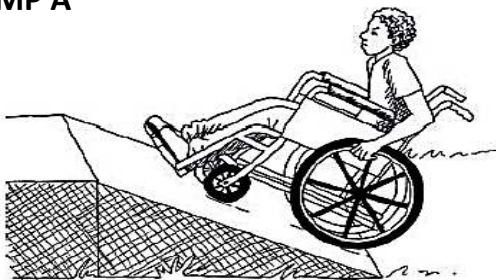
When people **design buildings with steps**, they also have to think about **old people or people in wheelchairs**. These people will struggle to get up steps, like the boy in the wheelchair in the illustration.

To help the boy, you can **build a ramp** to make a **smooth path between the low place on the ground and the higher place**. Two different designs of a ramp are shown below.

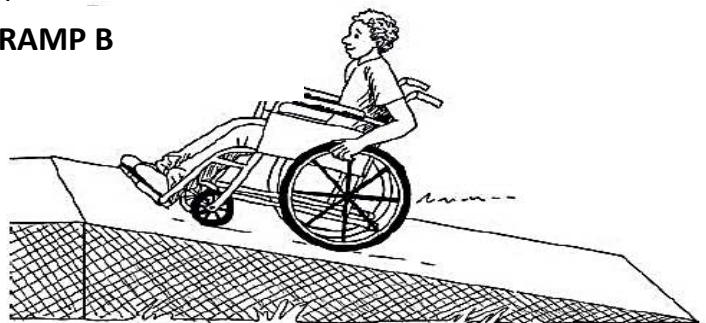


2.2.1 Study the two ramps and answer the questions.

RAMP A



RAMP B



Which design will be the easiest for the boy to get from the ground to the higher place, and why?

Ramp B, because the slope is not so steep.

2.2.2 Will the boy travel the same distance up both ramps A and B, or will he travel a longer distance on one of the ramps? If yes, which one?

Ramp B. It is longer because the slope is not as steep.

2.2.3 Will the force with which the boy has to turn the wheels be the same on both ramps, or will it be greater on one of the ramps? If yes, which one?

The force must be greater for ramp A because it is steeper

2.2.4 Use the following TERMS to write FOUR sentences to explain why it is easier for the boy to go up the one ramp than the other: **input force**, **output force**, **input distance**, and **output distance**.

- The distance the boy travels up ramp A is shorter than the distance he travels against turn off ramp B. This is called the input distance.
- The input power is the power of the son's hands on the wheels. Because ramp A has a greater input distance, it requires a smaller input power.
- The output distance is the height of the step.
- The output force is the force in the vertical direction, directly upwards.
- For both ramps A and B, the output distances and the output powers are respectively same.

2.2.5 Which ramp gives the boy the greatest mechanical advantage?

Ramp B gives the boy the greatest mechanical advantage.

2.3 Axes and knives are examples of a wedge. The wedge changes a small input force into a bigger output force. They use a large input distance to give a small output distance.

Why does an axe make it easier to split wood?

When you cut wood with a wedge-shaped axe, a large input distance downwards causes a small output distance sideways.

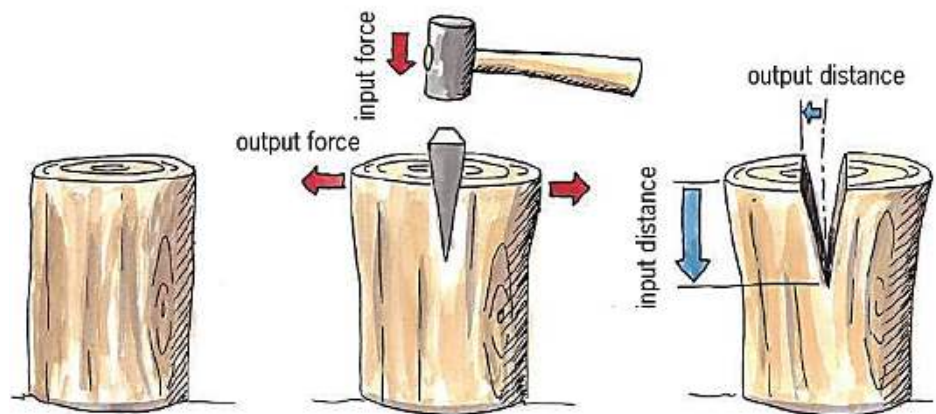


Figure 8: The wedge shape of the head of an axe makes it easier to cut wood.

2.3.1 Is the input force greater or smaller than the output force? Or are they the same?

The input power is the same as the output power.

2.3.2 Does an axe give a mechanical advantage or a distance advantage?

The axe gives a mechanical advantage.

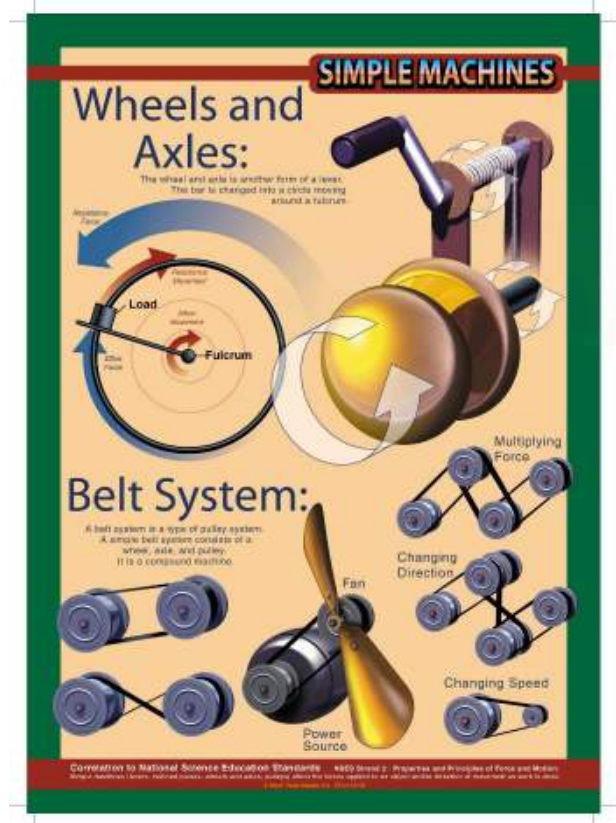
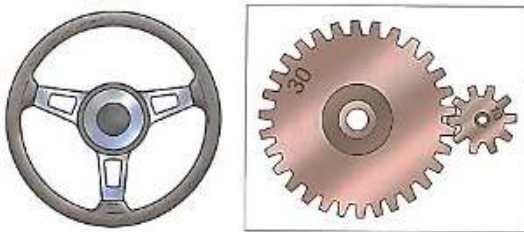
C. THE WHEEL AND AXLE

The **wheel and axle** always work together.

The **advantage** that the **wheel** gives the user is the **ability to move a load easily over a surface**. Each wheel is designed to move a certain load over a certain surface as easily as possible.

There are TWO applications for the wheel and axle:

- A **force multiplier** – can be used to multiply force, such as turning the steering wheel of a car.
- A **distance multiplier** – can be used to cover distance such as the wheels of a car or bicycle.



There are many different types of wheels

- Some wheels are **attached by the axle to a motor**. They are called '**driver**' wheels because they are **used to drive the vehicle forward**. Other wheels move because the vehicle **moves**. They are called '**driven**' wheels.



Figure 6 South African designer Brian Steinhobel's trolley for Woolworths

- some are **fixed to the body and can only go forwards and backwards** (back wheels of a supermarket trolley).

- Some wheels can be **steered (a bicycle)**; some **can move in any direction** (front wheels of a supermarket trolley);



Figure 7 The Hippo Water Roller, designed by Petzer and Jonker, has improved the lives of many South Africans by making it easier to transport water.

- Some wheels are built **to travel over soft or rough surfaces (mountain-bike wheels)** and others are better on hard, smooth surfaces (road-bike wheels).



[This Photo](#) by Unknown Author is

- Some wheels are **designed for high speed and light loads** (motor-bike wheels) whereas others are designed for low speed and heavy loads (tipper trucks)

Key words

- a gear** – a wheel with evenly spaced wedged teeth around its edge
- driver gear** – the gear causing the movement (the input gear)
- mesh** – to link together or engage with another gear
- driven gear** – the gear being moved (the output gear)
- counter-rotation** – two gears that mesh together will turn in opposite directions to each other

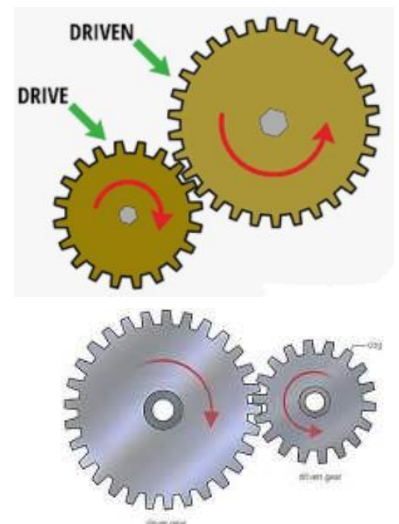
D. GEARS – WHEELS WITH TEETH

DEFINITION

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

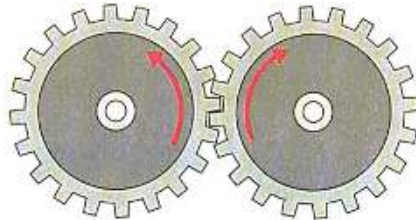
FUNCTION OF GEARS

- 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**.
- To **mesh means to link together**. The gear being turned is called the **driven gear**. The driven gear is attached to the **output axle**.
- 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.
- A gear **attached to an input axle** of a machine is called a **driver gear**. As the axle turns, the driver gear turns with it.
- When **two or more gears are meshed**, they form a **gear train**.



SPUR GEARS AND COUNTER-ROTATION

- A spur gear is a gear with **teeth like spurs on its edge**. This is the **most common type of gear**. When two gears mesh, **they rotate in opposite directions**. This is called **counter-rotation**.
- The cause **transfer of movement, force, and speed**.



Two spur gears mesh, producing counter-rotation.

- 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**.

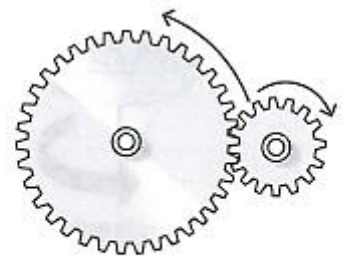


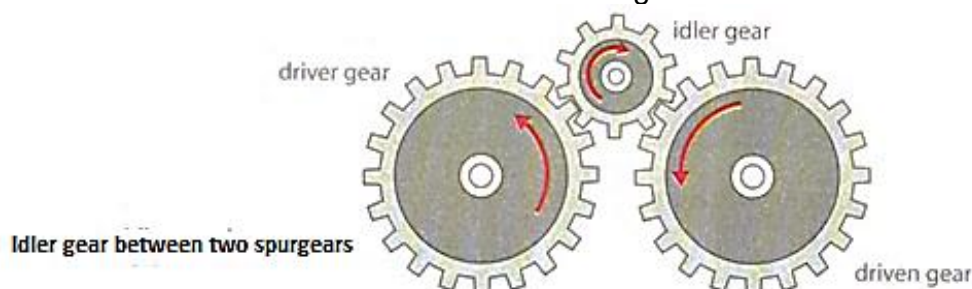
FIGURE 21 Spur gears of unequal size, counter-rotating

IDLER GEARS SYNCHRONISE ROTATION

- An **idler gear** is a gear wheel that is **placed between two larger gears and meshes with both of them**.
- The idler gear makes the **two larger gears rotate in the same direction**. We say that it **synchronises** the direction of rotation of the other two gears.
- An idler gear is **usually small**, so **it rotates more times than the larger gears** it meshes with.
- If it is not lubricated, it might wear out faster than the main gears. Is a possible solution to this problem to use a harder material for the idler gear?

Key words

- idler gear** – a gear wheel placed between two other gear wheels to synchronise their direction of rotation
- synchronise** – when an idler gear causes the input and the output gear to rotate in the same direction at the same time
- gear train** – a chain of gears used to transmit rotary motion from one shaft to another



2.4 MECHANICAL ADVANTAGE AND FORCE RATIO

Mechanical advantage is a concept that is widely used regarding mechanisms and machines.

MECHANICAL ADVANTAGE (MA)	= $\frac{\text{number of teeth on DRIVEN gear}}{\text{number of teeth on DRIVER gear}}$
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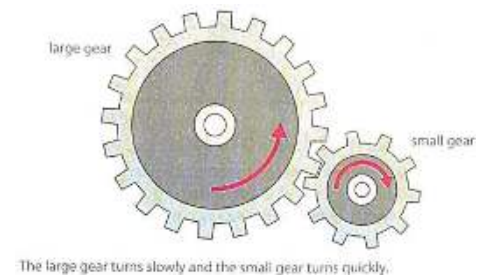
• WHAT IS A FORCE RATIO/ MECHANICAL ADVANTAGE?

A **FORCE** ratio is the relationship between the **TURNING FORCE (TORQUE)** on the driver axle and the turning force of the driven axle.

VELOCITY RATIOS

• WHAT IS A VELOCITY RATIO?

It is the relationship between the SPEED of the driver gear and the speed of the driven gear.



- One full circular movement of the gear wheel is called a **rotation**. We measure the speed at which an axle/gear turns in **rotations (revolutions) per minute (rpm)**.
- If gears of **different sizes are meshed together, they turn at different speeds**. In machines we use this principle to change the speed of rotation of the input axle to a different speed of rotation of the output axle.

FORMULA FOR VELOCITY RATIO:

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

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

Example

If a driver gear has 20 teeth and the driven gear has 10 teeth, what will the velocity ratio be?

Answer

$$\text{velocity ratio} = \frac{\text{number of teeth on driver gear}}{\text{number of teeth on driven gear}} = \frac{20}{10} = 2$$

So for every one rotation of the driver gear, the driven gear will turn twice. in other words, the speed advantage is 2.

VELOCITY RATIO vs FORCE RATIO

if the speed/velocity ratio decreases the force ratio will increase, and vice versa

When we work with gears this relationship is as follows:

- If a small driver gear drives a larger driven gear, the driven gear turns slower, but with greater force.
- If a large driver gear drives a smaller driven gear, the driven gear turns with less force, but faster.

ANSWER THE FOLLOWING QUESTION ON GEARS

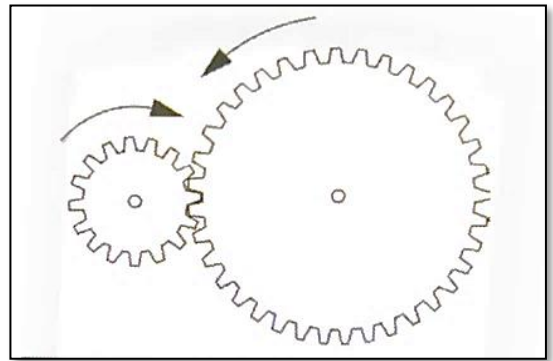
2.4.1 Study the gear train below and answer the questions that follow. The small gear is the driver and has 15 teeth. The big gear is the driven gear and has 45 teeth.

Which gear will turn the slowest?

Big gear / 45 teeth

2.4.2 Calculate the gear ratio of this gear train.

$$\text{Gear ratio} = \frac{\text{Number of teeth driven gear}}{\text{Nuber of teeth driver gear}}$$



$$\text{Gear ratio} = \frac{\text{teeth on driven gear}}{\text{teeth on driver gear}}$$

$$= \frac{45}{15}$$

$$= 3 \therefore$$

Gear ratio is 3:1

2.4.3 Does this gear train provide a force advantage or a speed advantage? Explain your answer.

FORCE ADVANTAGE. Driven gear/output gear is the biggest. It multiply the input force therefore, theres a bigger force at the output/driven gear. Therefore, it has mechanical advantage

2.4.4 What is the mechanical advantage of this gear train?

Mechanical advantage = gear ratio = 3

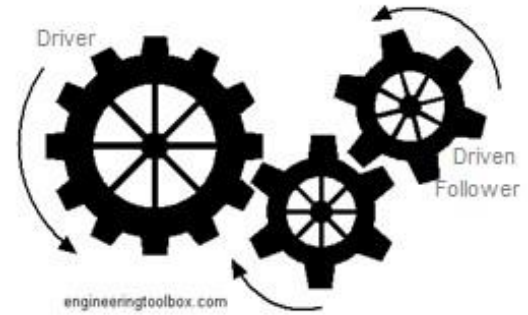
2.4.5 Does this gear train increase or decrease the rotation speed . Explain your answer.

Decreases the rotation speed. Output/driven gear is bigger and turns only once for every three times the driver gear turns.

2.5 A set of three gears that mesh are provided with the gears correctly labelled.

2.5.1 Explain what will happen to the direction the gears turn if the middle gear is removed and the two remaining gears mesh and turn.

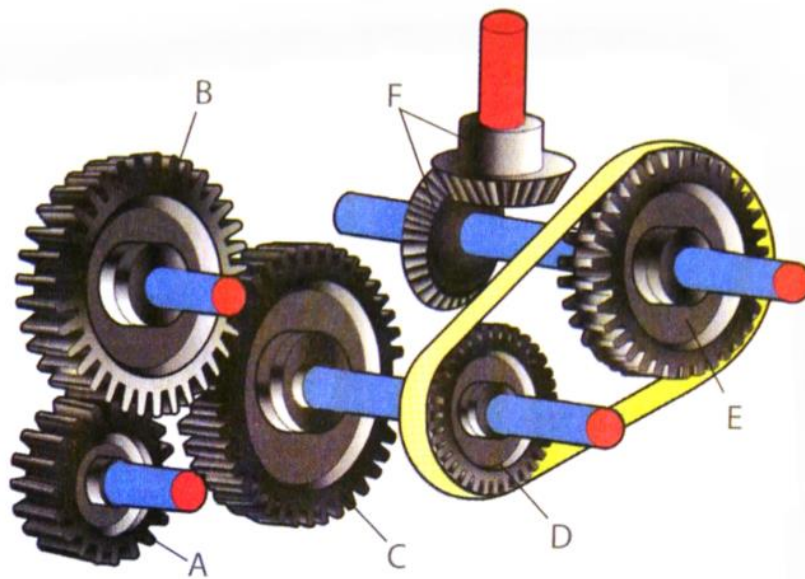
The drive gear and driven gear will rotate in opposite directions.



2.5.2 In relation to the driver will the DRIVEN GEAR turn faster or slower?

Faster. It's smaller and makes more revolutions than the big gear.

2.6 Study the gear train below. Gear a is the driver gear.



2.6.1 What is gear B called in this system? **Idler gear**

2.6.2 What influence does gear B have on the rotation of gear A and C?

Synchronize the movement of gear A and C. (Make them rotate in the same direction)

2.6.3 Gear A is small and rotates fast. Describe the effect this has on gear B, with regard to velocity and force ratio.

Gear B rotates more slowly but has a greater power output.

2.6.4 If gear B is smaller than gear C, does C have mechanical advantage? Explain your answer.

Gear B rotates more slowly but has a greater power output.

2.6.5 Explain the most important difference between gear system F and the rest of the gears in the system.

Gear system F changes the direction of rotation of the input gear through an angle of 90°, while the other gears continue to rotate in the same plane.

WEEK 3: CAMS & CRANKS

MECHANISMS THAT CHANGE THE DIRECTION OF MOTION

- The cam and crank are mechanisms that **change rotary motion into reciprocating motion**.
- Rotary motion is a turning motion** (like a roundabout in a playpark) and **reciprocating motion is an up-and-down or backwards-and-forwards motion** (like a breadknife cutting bread).

E. THE CAM

- A cam is **an unusually shaped wheel on an axle**.

Key words

- cam** – a shaped wheel on an axle
- camshaft** – the axle of a cam
- follower** – a device that follows the shape of the outside edge of the cam
- eccentric wheel** – a wheel where the axle is off-centre
- snail cam** – a cam that has a straight edge cut into the gently curving edge, and that can only rotate in one direction

A cam mechanism usually includes:

- a rotating part (the cam) on an axle
- a stiff rod, called a follower
- a **guide** to ensure that the follower moves straight up and down (or backwards and forwards)
- a **structure to hold all the parts together**

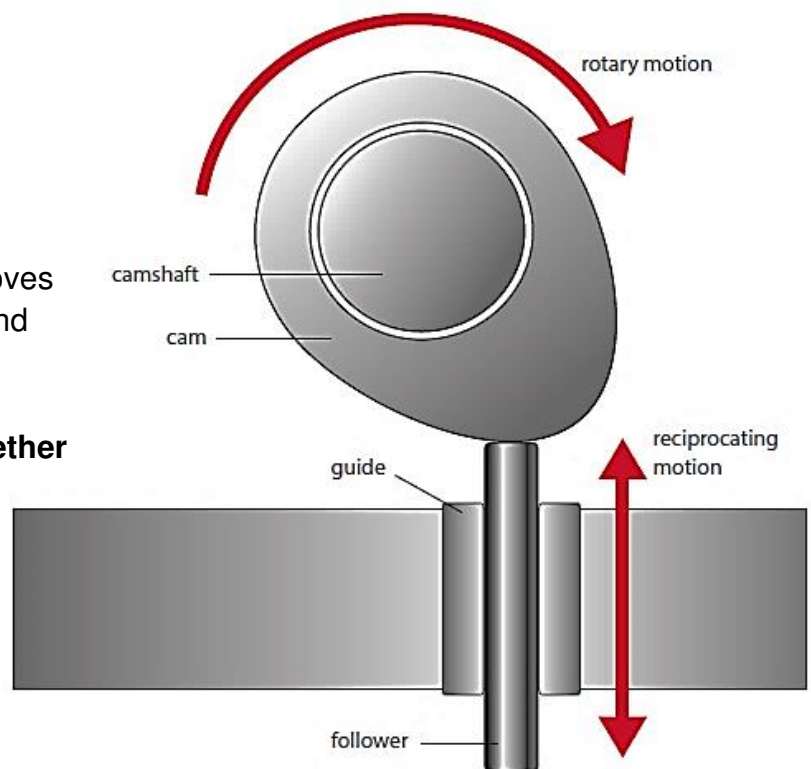
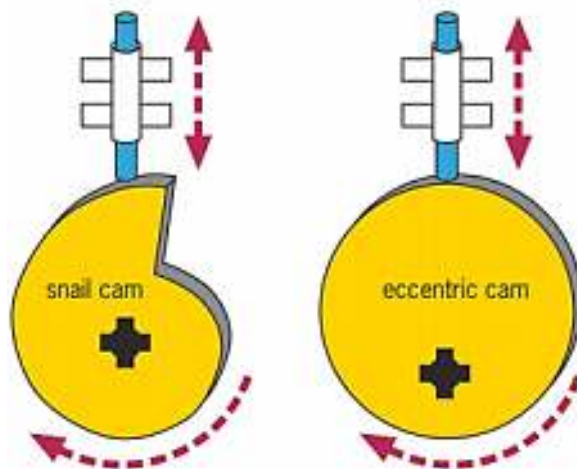


Figure 12 A cam converts rotary motion to reciprocating motion.

- The **axle is called the camshaft**.
- When a **cam turns**, it **converts the rotary motion of its axle into the reciprocating motion** (up and down, or left and right) of a follower.
- The **follower 'follows' the shape of the outside edge of the cam**.

COMPARISON OF AN ECCENTRIC WHEEL AND A SNAIL CAM

- Cams come in many different shapes. Examples include the **eccentric wheel**, **snail cam**.



- An **ECCENTRIC WHEEL** is a wheel with an **axe that is off-centre**
- The **follower resting on the cam will move with a gentle, wavelike motion.**

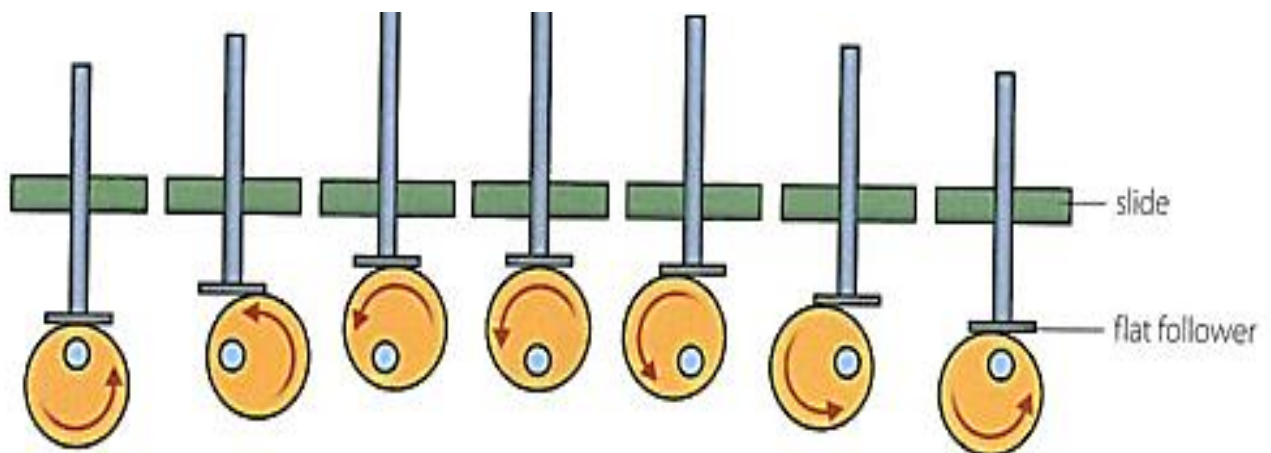
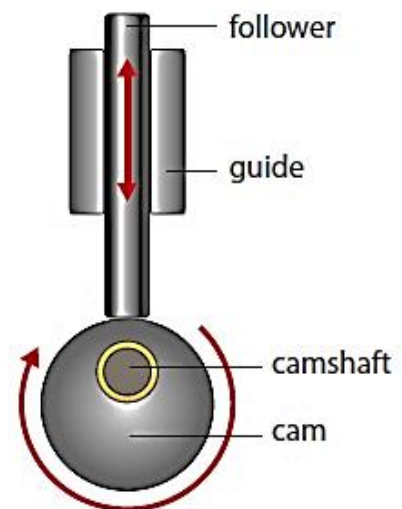


Figure 3.16: Eccentric cam: as the cam turns, the follower rises and drops in a constant steady motion.

- The **SNAIL CAM** has a **straight edge cut into the gently curving edge**.
- It **can only rotate in one direction**.
- The **follower rises slowly** and then **suddenly falls** because of the straight edge.

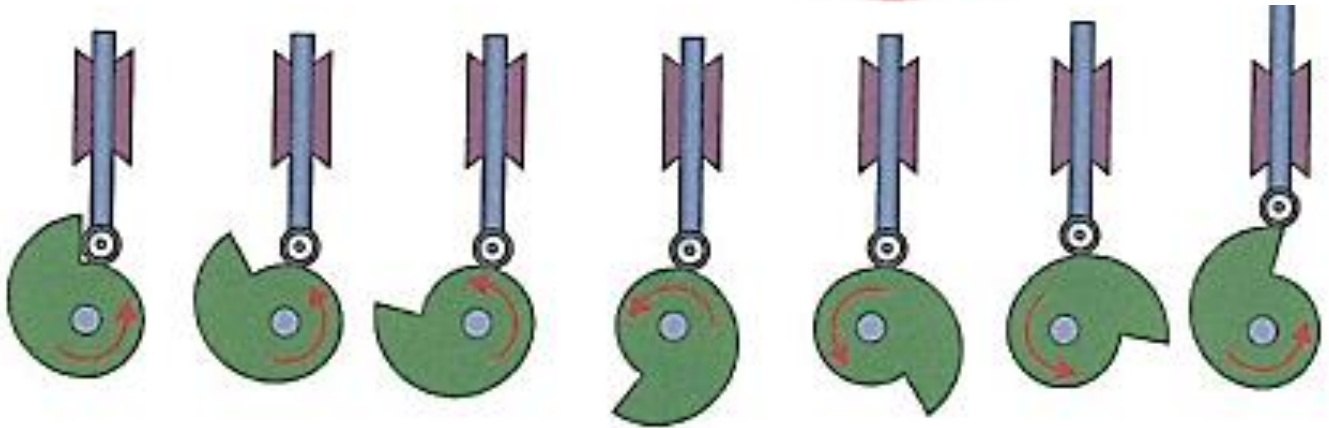
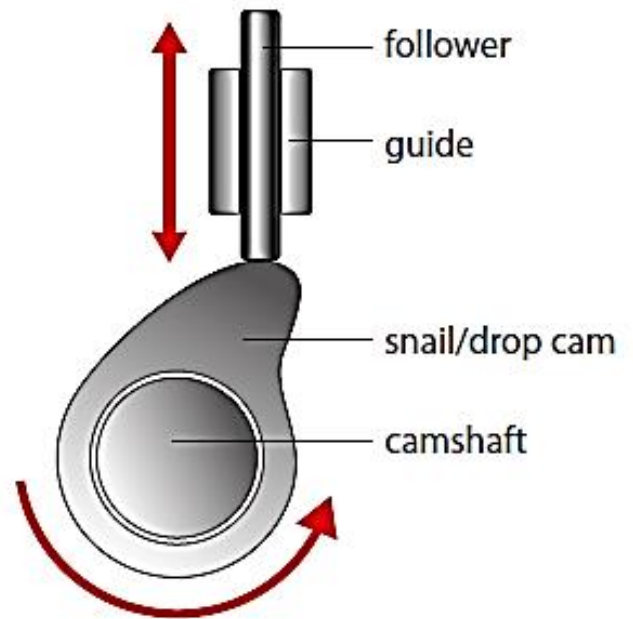


Figure 3.17: Snail or drop cam: as the cam turns, the follower drops in a sudden motion.

F. THE CRANK

- A **crank** is a **mechanism that is used to convert rotary motion into reciprocating motion**.
- For example, they are used in **children's toys and windmill**.

Key word

- **crank** – a lever attached to an axle

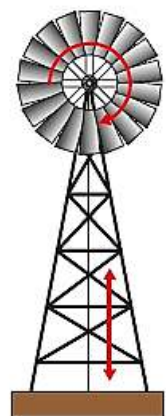
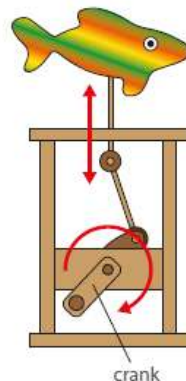
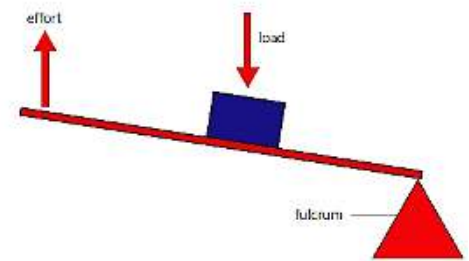


Figure 17 Cranks convert rotary to reciprocating motion.

- A crank is **an adaptation of a second class lever** in which the load is between the pivot and the effort.



HOW A CRANK CONVERTS ROTARY MOTION INTO RECIPROCATING MOTION

A crank mechanism usually includes:

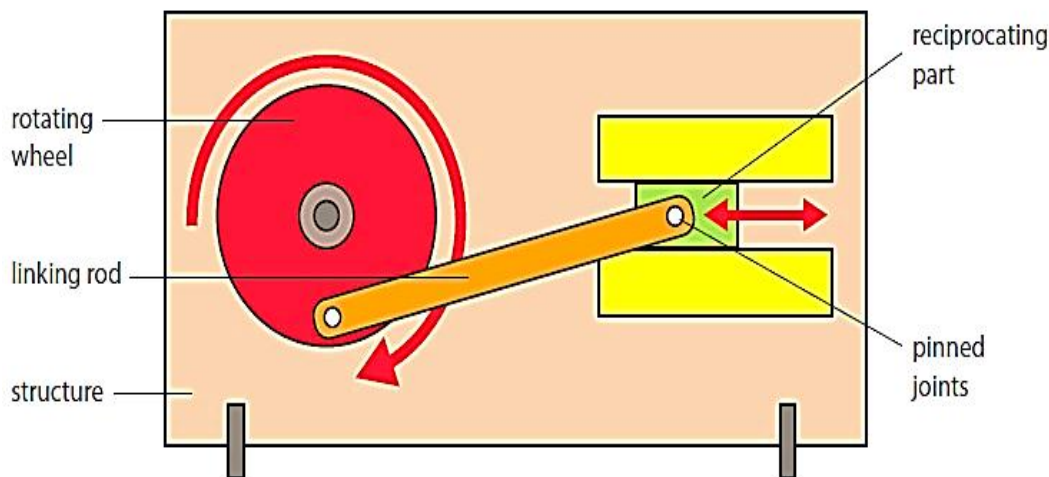
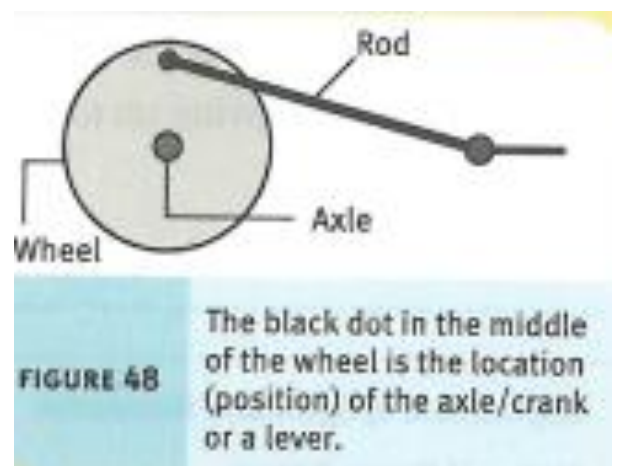


Figure 19 A crank mechanism

- a **rotating part on an axle**, e.g. a wheel
- a **rod** that links the rotating part to the reciprocating part, which **is attached at both ends by pinned joints** that **hold the parts together** but enable them to rotate relative to each other.
- a **reciprocating part**, e.g. a **piston or a slider**.
- a guide to ensure that the reciprocating part moves straight backwards and forwards.
- a **structure to hold all the parts together**.
- When the **wheel rotates**, the **one end of the rod moves around with the wheel** while **the other end move backwards and forwards with the reciprocating part**.



CRANK HANDLES

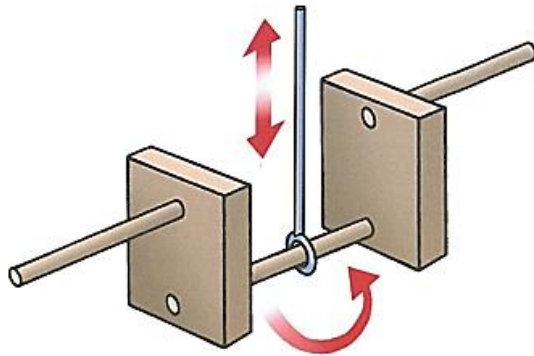


Figure 3.22: As the handle of the crank rotates, the rod attached to the crank move in a reciprocating (up and down) motion.

A crank is an adaptation of a second-class lever in that the load is between the fulcrum or pivot and the effort. You can increase the mechanical advantage of a crank by increasing the distance between the handle and the shaft, thus increasing the turning arc.

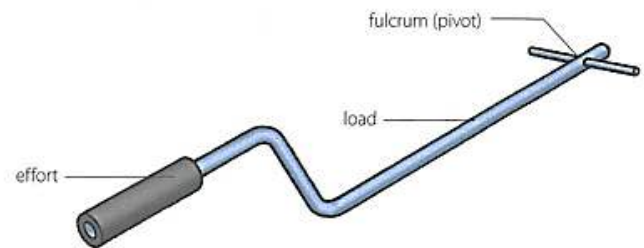


Figure 3.23: A crank is an adaptation of a second-class lever in that the load is between the fulcrum and the effort.

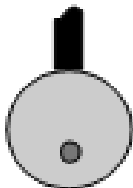
- The pictures below show a **car jack**, a **meat mincer** and a **hand winch**.
- These are all turned by crank handles. **The longer the handle is, the easier it is to turn the axle.**
- Therefore the long handle **gives greater mechanical advantage than a short handle.**



Figure 20 Crank handles on tools

ANSWER THE FOLLOWING QUESTIONS ON CAMS & CRANKS

3.1 Identify the different types of cams

Type of cam: ECCENTRIC CAM	Type of cam: SNAIL CAM
	

3.1.2 Complete the following sentence:

Rotary Cams change rotary motion into reciprocating (backwards and forwards or up-and-down) motion.

3.1.3 Explain in your own words the difference between an eccentric wheel and a snail cam.

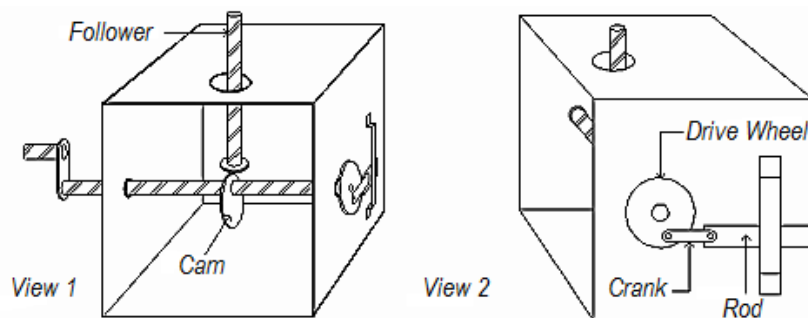
- Eccentric wheels rotate around an object out of its centre (off centre).
- Snail cams rotate about a centre point and have an odd shape.

3.2 Study the picture below and FILL in the missing word from the paragraph.



A cam is a mechanical component that is fixed to an axle. A cam always turns in a circular/rotary motion. A cam always has a follower which moves up and down as it follows the shape of the cam. The toy at the end of the shaft would move in a reciprocating motion. Cams change the direction of movement.

3.3 Carefully examine the two views of the machine below.



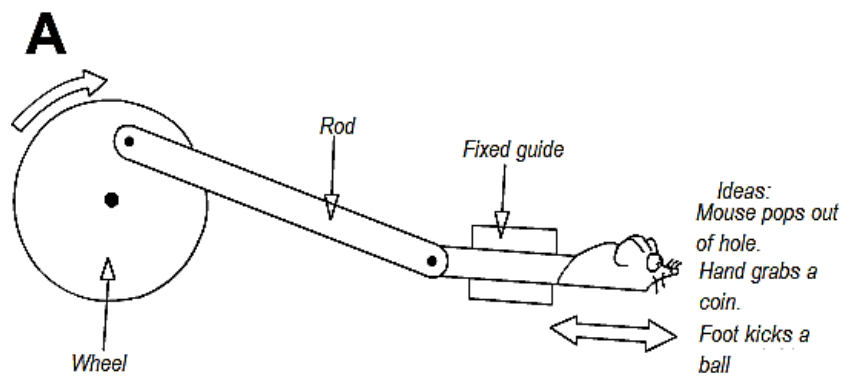
3.3.1 In view 1, you see a simple version of a cam and a cam follower. What do you think happens when the horizontal straw is rotated?

The cam fixed on the straw will rotate and the follower that rests on the cam will move in a reciprocating movement.

3.3.2 In view 2, you see a drive wheel, crank, and rod. What do you think happens when the drive wheel is rotated?

The crank that links the rod to the drive wheel will move horizontally in a reciprocating movement.

3.4 Look carefully at the following diagrams and answer the questions that follow.



3.4.1 What happens to the rod in A when the wheel is turned?

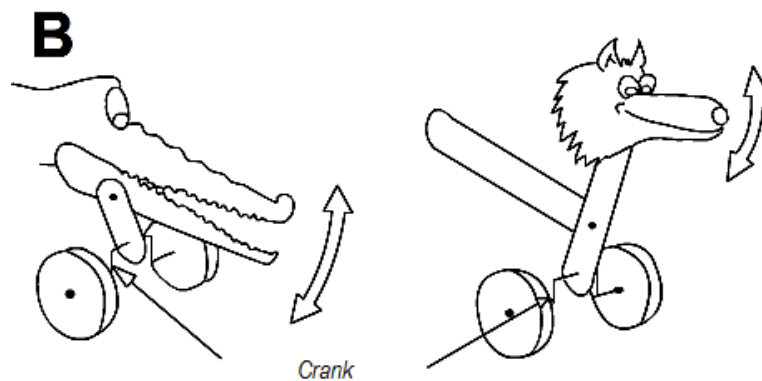
The rod will extend forward.

3.4.2 When the attachment of the rod is in the 3 o'clock position, can the mouse extend any further?

No

3.4.3 What will happen to the mouse when the attachment of the rod is in the 9 o'clock position?

It will withdraw into its hole



3.4.4 In B, the crank is formed by the axle bending. What effect will this have on the mechanism when the wheels rotate?

The fox will go up and down.

3.4.5 In both examples, the rotary movement is changed to which movement?

Reciprocating movement

WEEK 4: SCENARIO

[FORMAL ASSESSMENT]

INSTRUCTION: Read the scenario below and answer the questions.

OVERCOMING THE LIMITATIONS OF STADIUM ROOFS

The local Cricket Stadium will be used for several games during the National Annual Cricket League. The stadium has a grandstand, but it has no roof.

In many instances, a stadium roof makes sound business sense for developers, but these roofs are also a double-edged sword. In large stadiums, where they are mainly used for both sporting and non-sporting events, roofs protect the spectators from environmental effects such as sun, rain, and wind.



You are requested to use your knowledge on structures to design and make a scale model of a roof for the grandstand on stadium.

REQUIREMENTS

1. The roof must extend to cover the entire main grandstand.
2. The roof should provide spectators with protection and a safe unobstructed view of the action on the field of play.
3. The roof must be an **effective, efficient, and dynamic solution** that will enhance the aesthetic appearance of the stadium.
4. The passages on either side of the main grandstand must be modified to prevent any danger of injury to spectators due to crowd pressure. (As it happened tragically before at other stadiums e.g., Ellis Park in 2001).
5. The size of the scale model of the roof should adhere to 600 mm x 250 mm.
6. The construction of the scale model should not exceed R 500.
7. Only local residence should be used for the labour during the construction of the roof.
8. The design of the roof should be strong and stable enough to withstand severe weather conditions and forces acting on the stadium.
9. The design of the roof should include triangulation and internal cross bracing to stabilize the structure

4.1.1 Answer the following questions.

Identify the problem that must be solved? (1)

The local cricket stadium does not have a roof on the grandstand that could protect spectators against wind, sun and rain. ✓

4.1.2 Who will benefit from the final product? (2)

The spectators ✓ as well as the local municipality ✓ will benefit from a roof for the stadium.

4.1.3 Write a design brief for the identified problem.

(3)

Design and make ✓ a scale model of a roof structure ✓ for the grandstand of the local stadium to protect the spectators against rain, sun, and wind. ✓

4.1.4 Identify SIX specifications from the identified problem.

(6)

- The roof must extend to cover the entire main grandstand.
- The roof should provide spectators with protection and a safe unobstructed view of the action on the field of play.
- The roof must be an **effective, efficient, and dynamic solution** that will enhance the aesthetic appearance of the stadium.
- The passages on either side of the main grandstand must be modified to prevent any danger of injury to spectators due to crowd pressure. (As it happened tragically before at other stadiums e.g., Ellis Park in 2001).
- The design of the roof should include triangulation and internal cross bracing to stabilize the structure.
- The design of the roof should be strong and stable enough to withstand severe weather conditions and forces acting on the stadium.

4.1.5 Identify THREE constraints mentioned in the scenario.

(3)

- The size of the scale model of the roof should adhere to 600 mm x 250 mm.
- The construction of the scale model should not exceed R 500.
- Only local residence should be used for the labour during the construction of the roof.

[SUB TOTAL = 15]

ELECTRIC PYLONS



Figure 20 Electrical pylons are frame structures and come in a variety of designs.

- **FUNCTION:** pylons are structures that are **used to support heavy objects**. The most easily recognisable pylons are **electrical pylons**, which **support power lines over great distances**.

VARIETY OF DESIGNS

- Electrical pylons come in **different designs**.
- The **function of a pylon determines** which **design** will be used. Some designs help to reduce the **visual impact** that pylons have on the landscape.
- Some pylons are of **solid material** e.g. concrete, while others need **internal cross-bracing** to keep it rigid.
- However regardless of the design, the **pylons serve the same purpose**.

ELECTRICAL PYLONS

HOW TO ENSURE STURDY, RIGID PYLONS

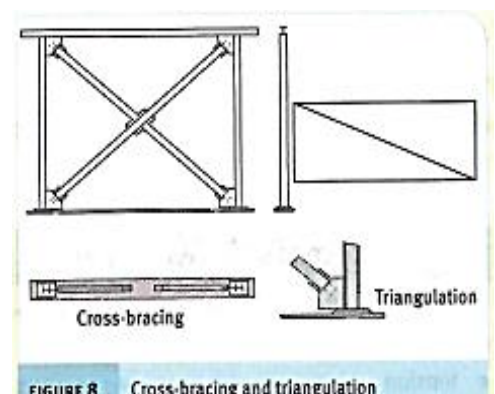
1. Make use of **cross-bracing**,
2. **Triangulation**

INTERNAL CROSS-BRACING

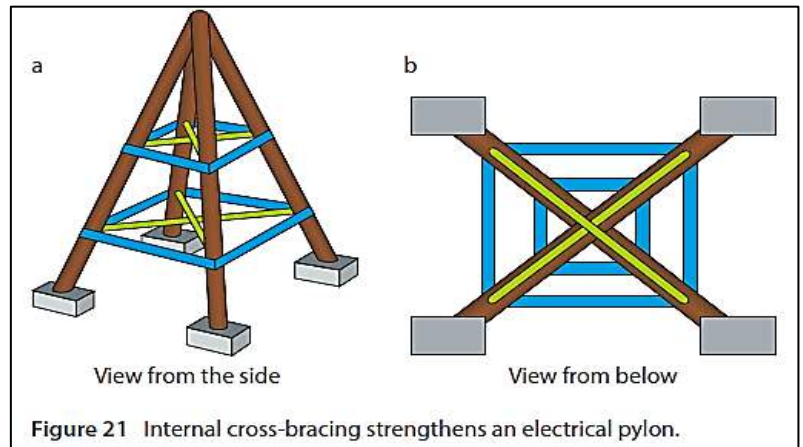
- When **two supporting beams cross each other**, they form an **X shape**.

This is a clever technique that is used to **stabilise a frame structure**.

- Cross-bracing also **increases the load the structure can support**.



- **Cross-bracing** is not just used on the sides of a structure. The illustration on the right shows how the **X shape can be added to the inside of a structure.**
- The X shape helps to **stabilise the structure in high winds.**



- It also keeps it from falling over easily – **wide base**. This is called internal cross-bracing.

TRIANGULATION

- Using **stable triangular shapes to make a frame structure more rigid or stiff** is called triangulation.
- Designers often use triangular shapes to create their structures because a **triangle stays rigid** when force is applied to it.
- The **cross-bracing patterns** are **reinforced** further by **additional struts that form triangular shapes.**

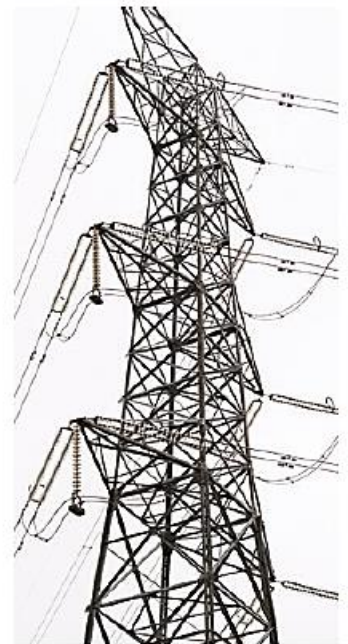


Figure 22 Triangulation is used to make structures more rigid.

IMPACT OF ELECTRICAL PYLONS

- Although electrical pylons give many benefits, **some people are concerned about their negative impact.**
- In **areas where a lot of people live, these structures can be unsafe.** For example, **children often play on or near these structures.**
- They can **fall and hurt themselves** or **loose objects on the structure might fall on them.**
- Many **people think that electricity pylons are ugly** and that they add to **visual pollution.**

CASE STUDY ON ELECTRIC PYLONS

[SPON ON]

ANSWER THE FOLLOWING QUESTION OF PYLONS

4.2 Read the Case Study and answer the questions.

ELECTRIC PYLONS

They are open frame structures. They are made of steel and are exposed to the elements all the time. Electric pylons have to be stable and safe. They are the structures which allow electricity to be supplied across the country over long distances.

In some area the pylons are exposed to strong winds, rain, snow and extreme sun and vast temperature changes. Through all of this, the pylons must remain sturdy and stable.

There are a few ways that the design of pylons can be altered to solve the problems of stability and durability. To ensure stability, base-sized and the centre of gravity of the structure must be considered. To allow the pylon to resist the forces exerted on it, structural members able to withstand these forces must be included. The durability of the pylons depends in part on the strength and stiffness of the structural members. Stiffening and strengthening techniques are used to increase durability.

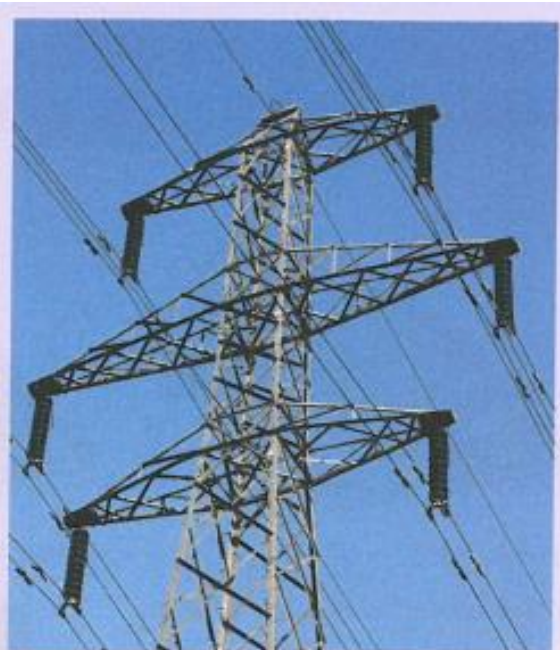
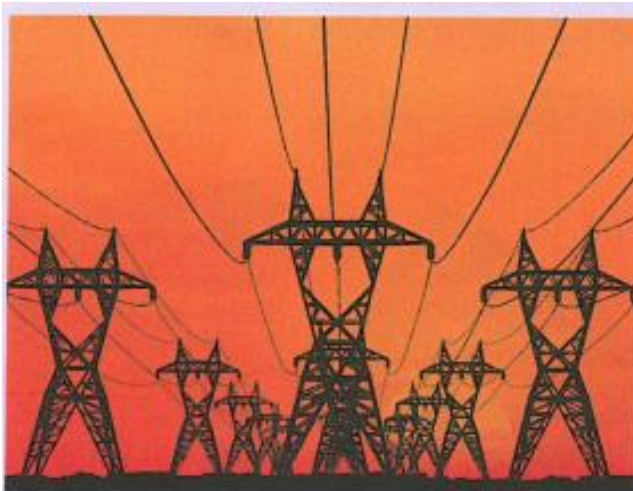


Figure 1.13: Different pylon designs



- 4.2.1 How does the design of each pylon ensure stability? Which factors were considered during the design of the pylons?

Centre of gravity and the wide base-size of the pylons were considered.

- 4.2.2 What structural members can you see in each example which have been included to withstand the forces exerted on the pylon?

Beams, struts

- 4.2.3 List three ways who the electrical pylons have been stiffened.

Triangulation, cross-bracing, strong material e.g. steel, additional struts that form triangular shapes were used in the structure.

- 4.2.4 Give reasons why the different members or components of the structure come under tension and compression.

Pylons are exposed to extreme weather conditions e.g. wind, snow, rain and forces, the weight of the structure itself must be supported, tension of the cables under wind pressure can also contribute to stress to the structure.

- 4.2.5.1 All of the pylons solve the same problem. What is the problem?

Electricity must be supplied across the country over vast/long distances.

- 4.2.5.2 How do they effectively solve this problem?

They support the heavy load of the electrical cables and supply the electricity to the country.

- 4.3 The illustration below is a design for future electric pylons created by French design company Hugh Dutton Associates.

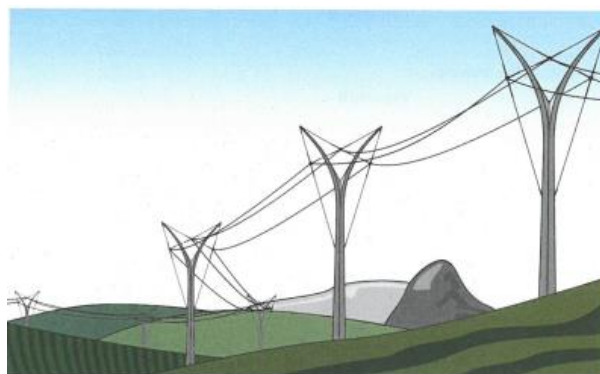


Figure 1.14: Electricity pylons of the future

- 4.3.1 Do you think it would work in South Africa? Motivate your answer

Yes, concrete will be able to withstand most weather conditions.

4.3.2 Do you think the pylons would be able to withstand the forces exerted on them?

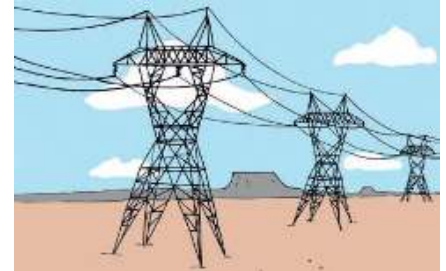
Yes, the concrete used for the pylons will be strong enough to withstand forces if reinforcement with steel rods is used.

4.3.3 Do the pylons have a centre of gravity and base-size which would keep them stable?

Yes, the base of the pylons is solid and strong.

4.3.4 Do you think the pylons create more or less visual pollution than the traditional design as illustrated on the right?

The smooth design of the concrete pylons create less visual pollution than the frame structure of traditional pylons.



WEEK 5: STRUCTURES

DEFINE FRAME STRUCTURES

- A frame structure is made up of **different rigid parts/members**. These parts are joined together to **form a framework**. The parts/members **make the framework stronger**.



FUNCTION/PURPOSE OF *FRAME STRUCTURES*

- It **supports load** and **withstanding or resisting different forces**. A structure must be able to **support its own weight and the load** it has to carry. A load can be a person, an object, or a force.
A **moving load** is known as a **dynamic load**. A **stationary load** is known as a **static load**.
- It **spans a gap**

PURPOSE OF STRUCTURAL MEMBERS (COMPONENTS) IN WOOD AND STEEL ROOF TRUSSES THAT SUPPORT THE LOAD

- Structural members of **steel beam trusses** are supported to add strength. Members supporting a steel roof structure are different from the those of a wooden truss.
- Steel members** have several **advantages** over **wooden members**:
 - It is **stronger**,
 - It can **carry heavier loads**,
 - It is **able to resist strong winds**,

→ Steel members **do not bend or twist easily**.

DISADVANTAGE of steel: it can rust if not treated beforehand by paint, varnish, wax or galvanised steel (coated with zinc).



Larger buildings, such as churches, need many



Steel roof trusses installed in a house

- Frame structures are **fairly easy to design**. They can also be **manufactured cheaply**, and they can be **constructed quickly**. They are often used in the construction industry.

ROOF TRUSSES

WHAT IS A TRUSS?

- A **truss** is a structure **made up of triangles**.
- The **framework for the roofs of most houses and buildings** is made from either wood or steel.
- Roof trusses **support the weight of the roof timbers and roof coverings**.
- The **number of trusses** that are used **depends on the size of the structure**. Larger structures will need more trusses.
- The **members, or components, of a roof truss are nailed, bolted or pegged together to form a strong triangular shape**.

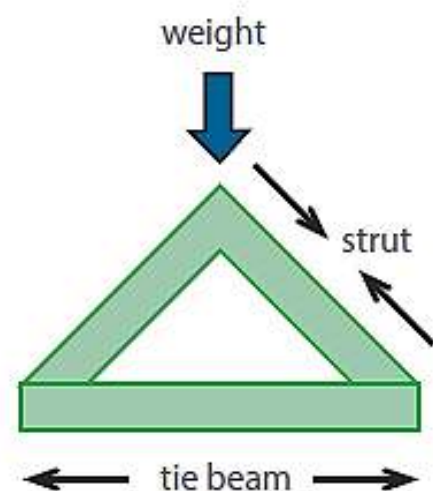
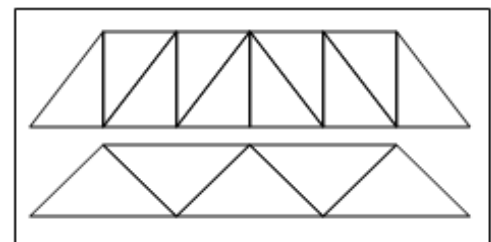
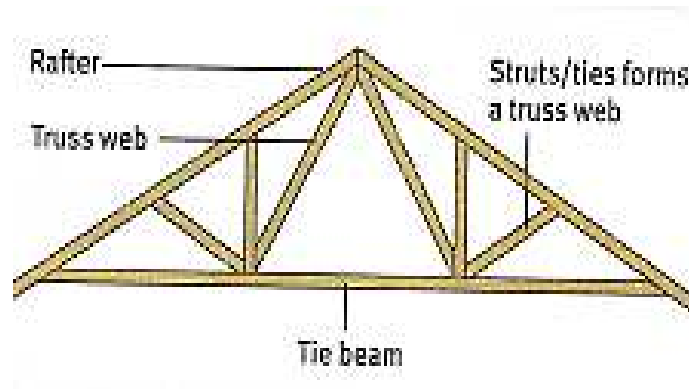


Figure 11 Diagram of a roof truss

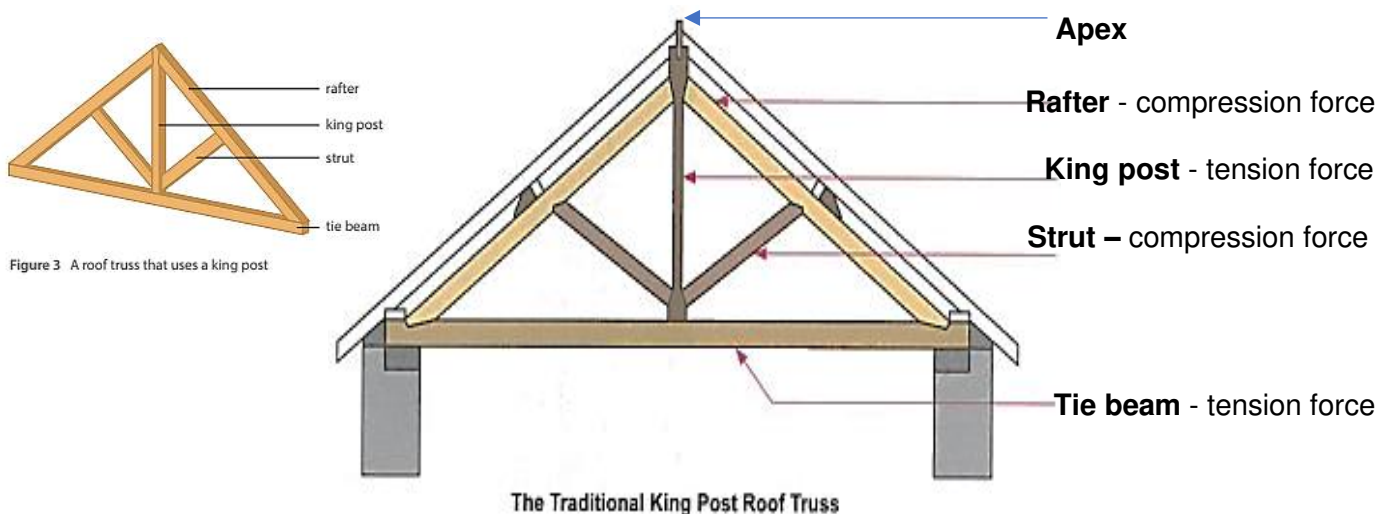
STRUCTURAL MEMBERS OF ROOF TRUSSES:



- A. KING POST** – ONE vertical supporting post attached to the **centre of a tie beam**.
- B. QUEEN POSTS** – TWO supporting posts, it is a **tension** member in a truss designed
 - a. to span longer openings than a king post truss
- C. APEX (TOP)** of the triangle/roof.
- D. RAFTERS** – a Series of parallel beams forming part of the internal framework of a roof.
- E. STRUTS** – rods / bars forming part of a framework and designed to **resist compression**.
- F. TIE BEAM** – horizontal beam which joins two rafters.
- G. TIE** – horizontal beam which withstand tension.

A. KING POSTS roof trusses

- The most common type of roof truss has a **king post**.
- King posts trusses can be used for **roofs and bridges** as it can deal **with compression & tension**.



B. QUEEN POST roof trusses

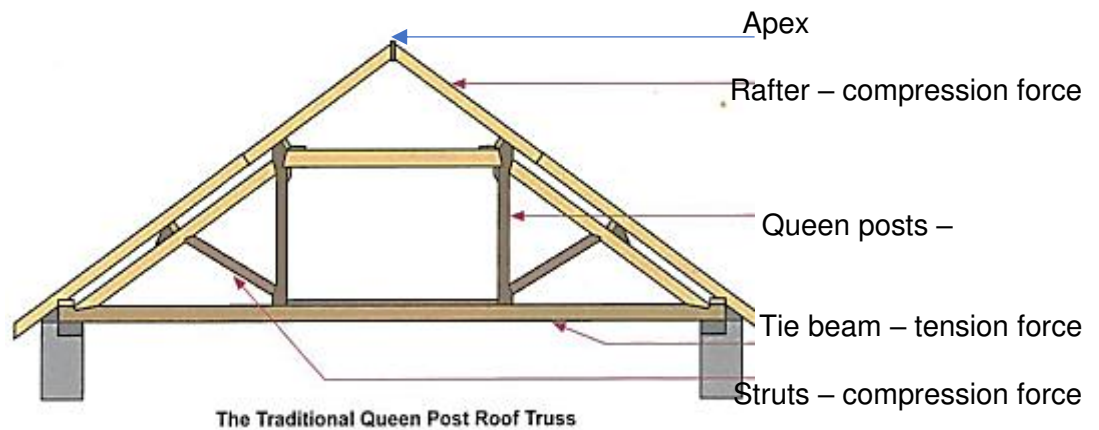


Figure 1.6: Queen truss

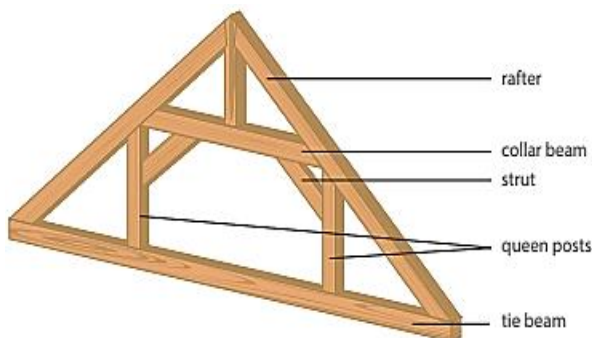
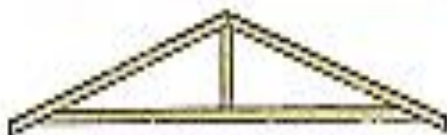


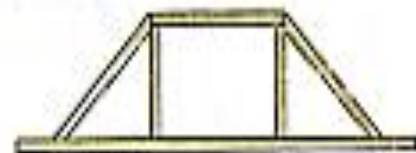
Figure 4 A roof truss that uses queen posts.

- The **vertical beams are evenly spaced** apart.
- The **queen posts are connected at the top by a diagonal collar beam**.
- A queen post roof truss **can span longer distances than a king post roof truss**.
- This means that **larger structures can be built**

MORE EXAMPLES OF ROOF TRUSSES



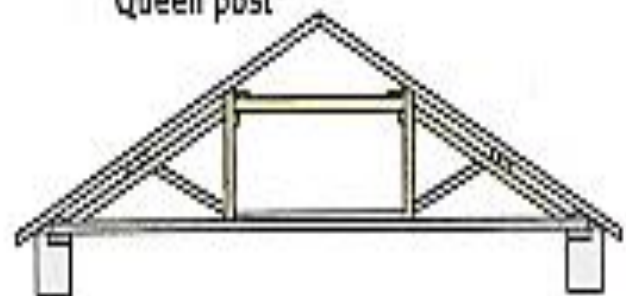
King post



Queen post



Queen post



Traditional queen post roof truss

FIGURE 4 Trusses add to the support of structures.

C. APEX – top of the roof/triangle

D. RAFTERS

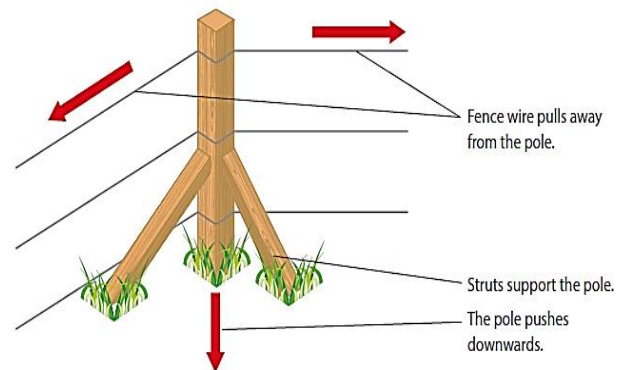
- Rafters **help to shape the roof** and they also **help to support the roof covering and absorb and spread the compression forces on the truss.**



Figure 8 The parallel beams of rafters support and shape the roof structure.

E. STRUTS

- **Hold members of a framework in place by pushing against them.**
- A strut must be **strong enough to keep apart the two components that are pushing against it.**
- A strut is **under a compression force.**
- Placing a **strut across a joint can make a framework stronger.**



F. TIE BEAMS

- A tie beam is a **horizontal beam that rests on two opposite columns.**
- It **joins the two diagonal sides of a triangular structure.**
- A tie beam **usually connects two opposite rafters to form a roof truss.**

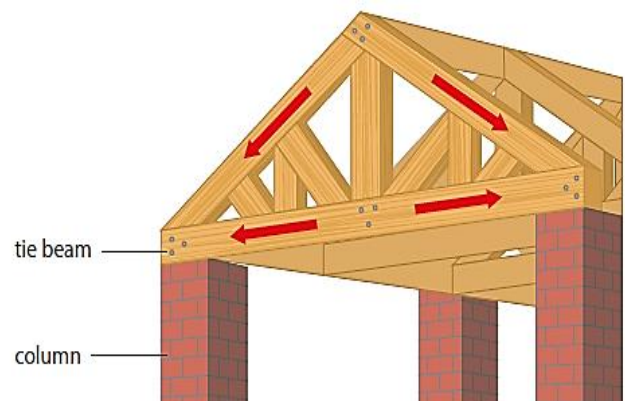


Figure 9 A tie beam rests on two columns.

G. TIES

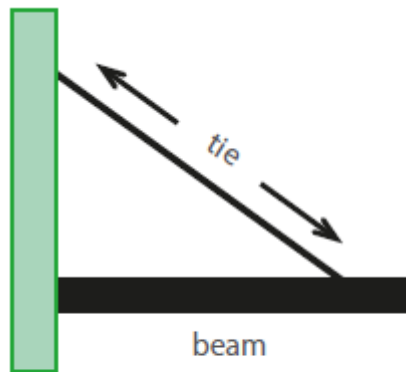
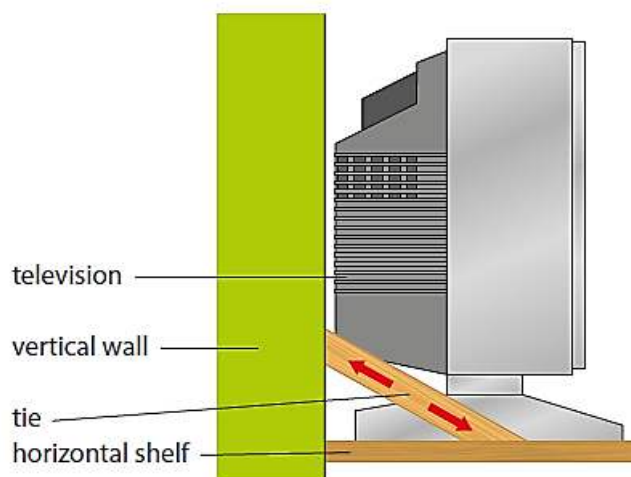


Figure 12 Diagram of a beam hanging from a wall

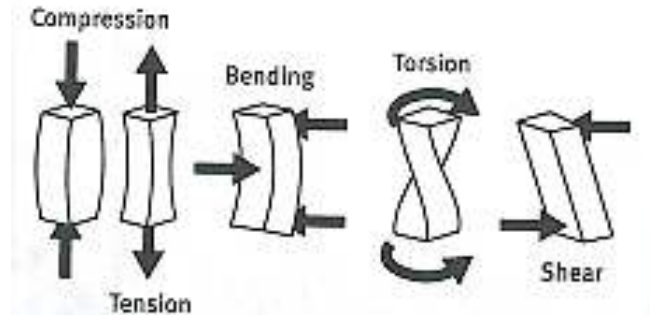
- Hold or **pull two members of a framework together**.
- A tie must be strong enough to hold together **structural members that are pulling away from one another**.
- A framework can be made **stronger by joining the members with a tie**.
- The **two members each pull the tie towards themselves**, so a tie is under a **tension force**. This causes the tie to appear as if it is being stretched in two directions.



- Figure 7 shows a **horizontal shelf** that is joined to a wall. A television rests on the shelf.
 - The **television's weight forces the shelf downwards**.
 - To **stabilise the shelf**, a tie, or diagonal member, is attached to the shelf and the **wall**.
 - The **weight of the television forces the shelf to pull away from the wall**.
 - This creates a **tension force on the tie**.
- Structures **support their own weight** as **well as the weight of the structures they support**.

FORCES ACTING ON FRAME STRUCTURES

- Compression (pushing force)
- Tension (pulling force)
- Bending
- Torsion (twisting force)
- Shearing (tearing force)



INTERNAL SUPPORT

- **TIES & STRUTS** withstand **compression** and **tension** forces, while the **king & queen posts** offer support & **withstand forces of compression**.
- If a structure has **more than one part**, each part of the structure is called a member.

PURPOSE OF STRUCTURAL MEMBERS (COMPONENTS) IN THAT SPAN A DISTANCE.

- A structure may **span a river, a road, or a space**.
- The **support members** of the structure **must be stable and reliable**

STRUCTURAL PARTS / MEMBERS that span a distance can include:

- Arches,
- Beams,
- Buttresses,
- Cantilevers,
- Girders
- Guys,
- Lintels

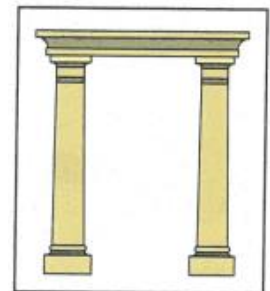


Figure 1.15: A beam supported by columns

A. An ARCH

- Is a **semi-circular structure** that **spans distance and supports a structure** that rests on it.
- In arches made of stone, the **keystone** is in the middle of the arch and this stone supports and keep the rest of the arch together.
- Arches can also be made of **other materials** and the there is no **keystone**.
- Arches are **very sufficient** in bridges that spans valleys because they are then **supported by the slopes of the mountains** on either side.

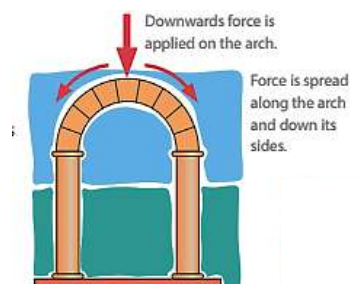


Figure 10 The spread of force down an arch

→ ARCHES IN BUILDINGS

- Arches in buildings **strengthens the structure and increase the space that can be spanned.**



Figure 1.21: An arch is able to withstand compression forces because of its curved shape.



Moses Madiba stadium, KZN

→ ARCHES IN BRIDGES:

Bloukrans bridge (451m long)

- The columns can be further apart because **the arch supports the weight of the traffic on the bridge.**



→ ARCHES IN DAM WALLS:

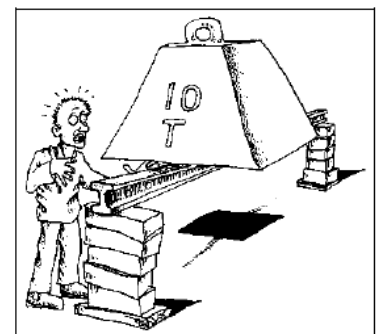
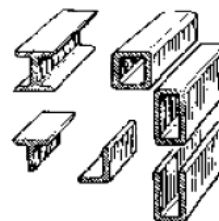
Katse Dam, Lesotho

- The **wall curves into the water** in the dam.
- The dam wall is **able to withstand a great deal of pressure.**



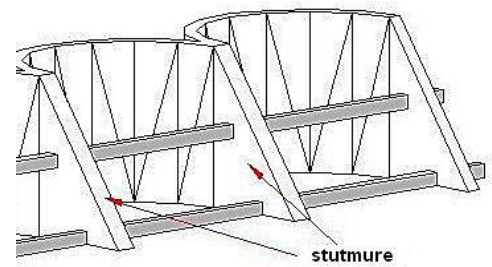
B. BEAMS

- Are **horizontal structural members often made of wood, metal or concrete.**
- Beams often **spread a load across two or more columns.**
- Beams used in larger structures take many **different forms**, some are simply **solid**, some are **hollow**, and others have special **cross-sections to provide strength and rigidity.**



C. BUTTRESSES

- They are built against or projecting from a wall which serves to support or reinforce the wall.

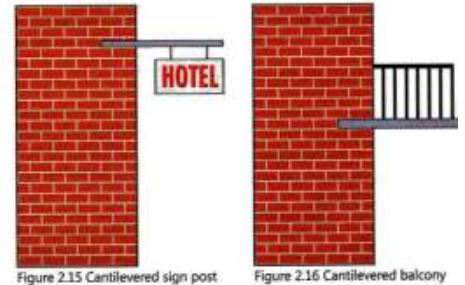


D. CANTILEVERS

- Are beams which are supported at one end only.

→ SIMPLE CANTILEVERS

- A simple cantilever beam can span a gap while it is held in position at one end only.
- As a load is applied to the cantilever, it starts to bend. As you can see in



- Below are examples of simple cantilevers are the wings attached to an aeroplane and some types of buildings and bridges.



The wings of an aeroplane



A room built on to the side of a building



A cantilever bridge, viewed from the air

→ CABLE-STAYED CANTILEVERS

- The cables are in tension, and the deck in compression.
- The cables are of high tensile steel. The columns are often made out of concrete.

Nelson Mandela bridge



E. GRIDERS (STEEL I-BEAM)

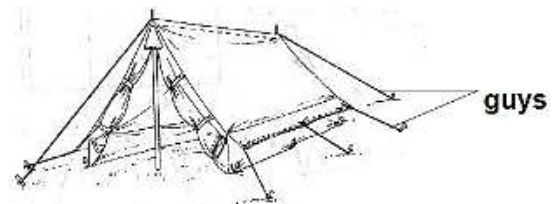
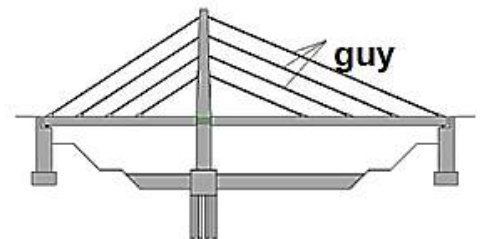
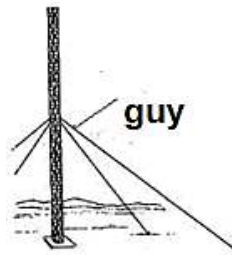
- Usually made of **steel or aluminium**.
- Are **horizontal steel beams** – usually I beams.
- It can also be **box-shaped and Z-shaped**.
- It **often supports other smaller beams around it**.



Figure 5 Steel I-beams being used in the construction of a highway.

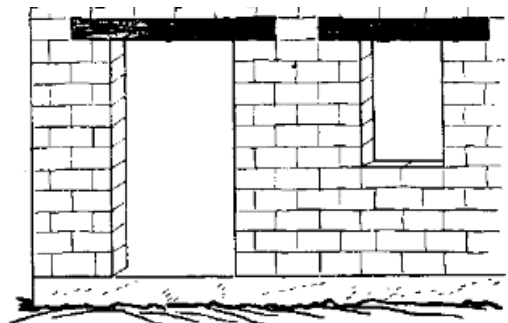
F. GUYS

- Structures like high ROOF STRUCTUREs and tents can also be **made stable by anchoring it to the ground with guys**.
- **Guys** are **ropes, cables or chains** (flexible members) that hold a **structure firmly in place** by **pulling on it**



G. LINTELS

- are **beams** made of **concrete and reinforced with steel bars**.
- They **spread the weight of the structure above the opening of doors and windows** to the structure beside them.
- It **withstands compression force**



Lintel beam placed above a window gap.

Figure 6 A concrete lintel used in the construction of a window

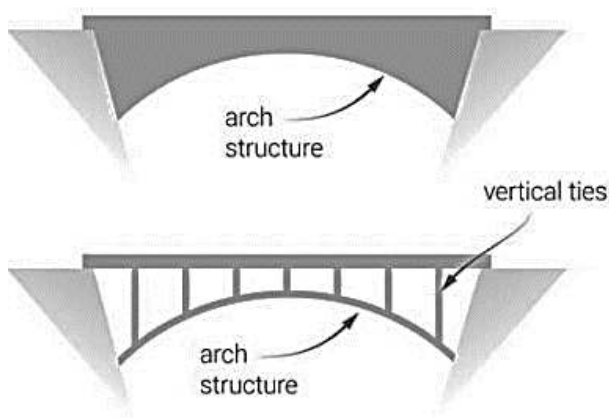
TYPES OF BRIDGES

→ ARCH BRIDGES:

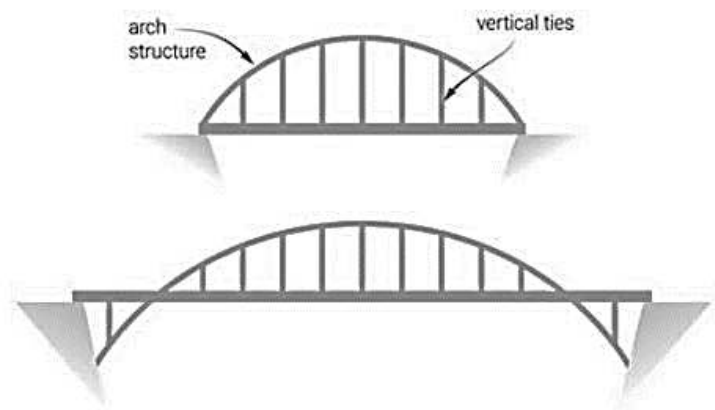
- The columns can be further apart because **the arch supports the weight of the traffic on the bridge.**



Arch Bridge



Tied Arch Bridge



ADVANTAGES OF ARCH BRIDGES

- The bridge is **very strong**.
- Arch bridges **can be very long** because there is no tension in the bridge.

DISADVANTAGES OF ARCHES

- An arch cannot stand until it is complete. **The two halves must be cantilevered using cables.** So, a cable-stayed structure must be built to hold both ends of the arch before it is joined. This is building two structures.

→ BEAM AND COLUMN BRIDGES

- Below are examples of **bridges built across narrow rivers or single carriageways.**

- Such **bridges do not need to be very high.**

- The **horizontal beams are made from concrete.**



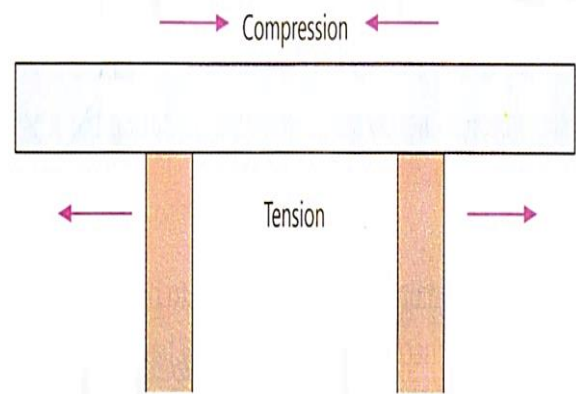
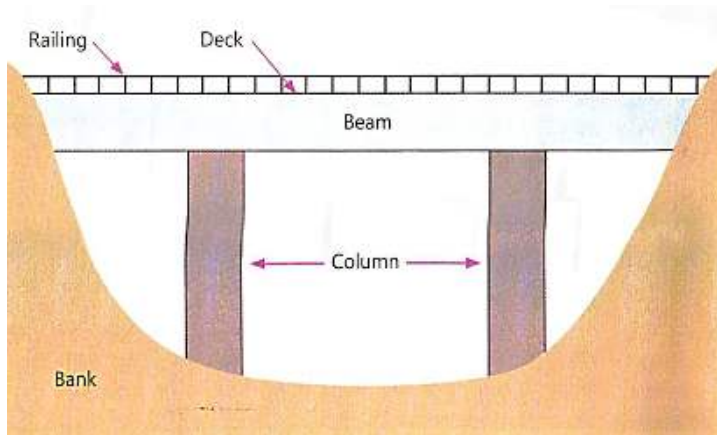
A bridge across a single carriageway



A bridge supported by columns

- The bridges are **supported by concrete columns. Columns are vertical members that support a load. These columns add extra support to the bridges**
- The **beam and column bridge** is the **simplest type of bridge.**
- It is usually straight. The beam is **supported at each end by columns.**
- Columns are designed to **hold the weight of a structure** and in his case the beam bridge.
- There are many **forces that act on a beam and column bridge.**
- The bridge's own weight can put a huge strain on the structure. **For the beam and column bridge to be strong, it must develop compression along the top and tension along the bottom.**





ADVANTAGES OF BEAM AND COLUMN BRIDGES

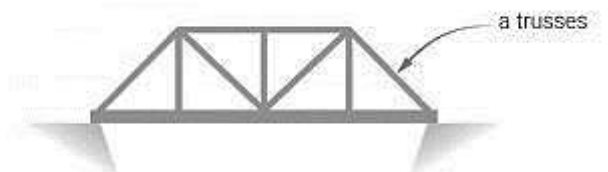
- The beam bridge **rests on simple columns**
- A beam may be **built away from the final position, and lifted swiftly into place with no disruption to the traffic below**

DISADVANTAGES OF BEAM AND COLUMN BRIDGES

- The beam bridge **experiences large forces and therefore has to be a very big size**

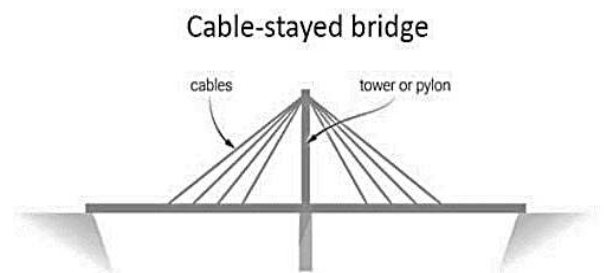
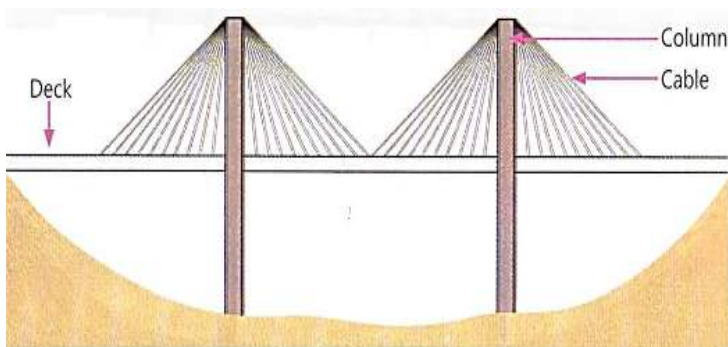
→ TRUSS BRIDGE

- It is **a load-bearing structure** which incorporates a truss in a highly efficient yet very simple design.
- There are different variations of the simple truss bridge **but they all incorporate triangular sections.**
- The role of these **triangular elements** is important because they effectively **absorb tension and compression to create a stressed structure able to accommodate dynamic loads.**
- This mixture of tension and compression ensures the structure of the bridge is maintained and the **decking area remains uncompromised even in relatively strong winds.**



→ CABLE-STAYED BRIDGES

- The **bridge** is held in position by cables that are **connected to a high ROOF STRUCTURE** on one side of the bridge.
- The **cables are in tension**, and the **deck in compression**.
- The **cables are of high tensile steel**. The columns are often made out of concrete.



ADVANTAGES OF CABLE-STAYED BRIDGES

- The **two parts of the bridge** may be cantilevered out from each side.
- **No need for anchorages**.
- They can be **cheaper than suspension bridges**.

DISADVANTAGES OF CABLE-STAYED BRIDGES

- In the longer sizes, the **cantilevered halves can be affected by strong winds during construction**.
- The **cables require careful treatment to protect them from corrosion**.

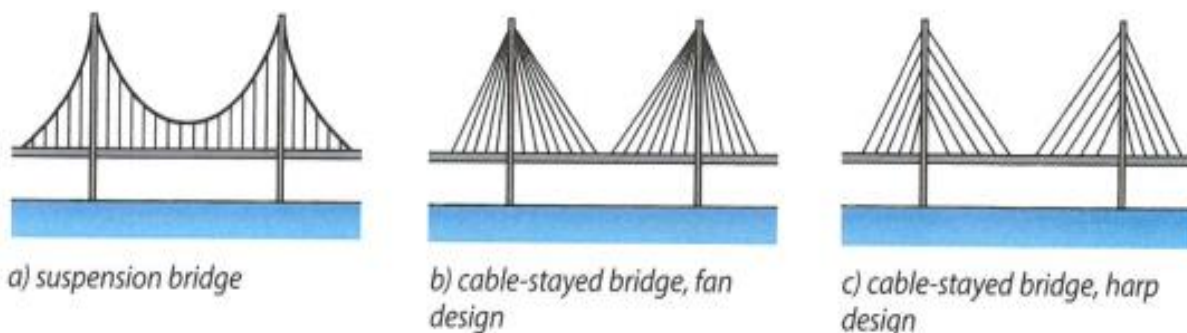
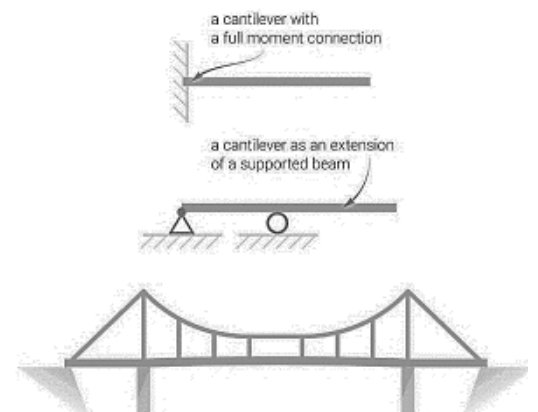


Figure 1.20: Differences between cable-stayed bridges and suspension bridges

→ CANTILEVER BRIDGE

- A cantilever differs from the arch and the beam bridge in that **the attachment points are not at opposite ends. The cantilever projects out into space and the support is at one end only.**
- Most cantilever bridges have **two cantilevers**, with a **beam suspended between their ends.**
- Mostly cantilever bridges are **supported by cables and an anchor at one end of the bridge.**



ADVANTAGES OF CANTILEVER BRIDGES

- Building from each end enables construction to be done with **little disruption to traffic** below.
- the **span can be greater** than that of a simple beam, because a beam can **be added to the cantilever arms.**
- The **support can be simple columns.**

DISADVANTAGES OF CANTILEVER BRIDGES

- Like beams, they **maintain their shape by the opposition of large tensile and compressive forces**, as well as shear, and are therefore **very large and heavy.**

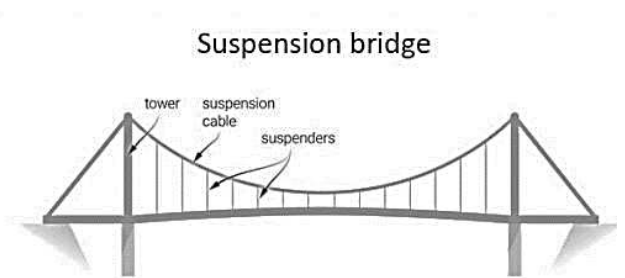
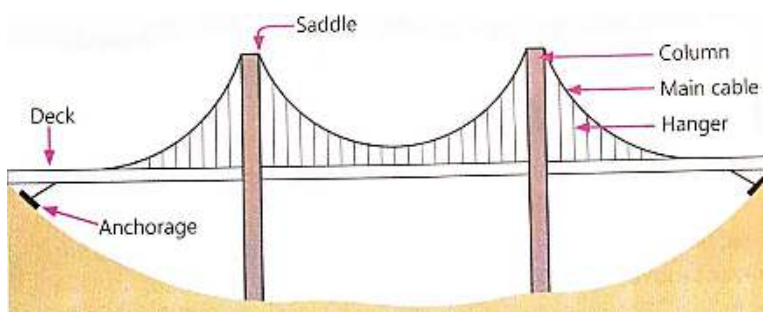
→ SUSPENSION BRIDGES

- Sometimes it is necessary to **design and build a bridge** using supports other than columns, such as a **bridge over deep water or a very deep valley or when the distance to span is very big**.
- Suspension bridges are used in such a case.
- Suspension bridges **hang from cables that run the length of the bridge**.
- The **cables rest on high ROOF STRUCTURES at either end of the bridge**.



Golden Gate bridge - San Francisco

- The cables are **made of wire and able to hold up the heavy beams of the bridge and bear the load of the bridge**.
- The **columns** hold the **main cable** up. The **anchorages** pull the cable outward and downward. The **hangers** connect the deck to the main cable. The **deck** carries the traffic.



ADVANTAGES OF SUSPENSION BRIDGES

- Suspension bridges **can span very long gaps**. The design allows the bridge to be made of very long sections.
- If **one of the hangers fails or breaks, it can be replaced without disruption to the flow of traffic** and **will not have an impact on the stability of the bridge**.
- Suspension bridges do not have to be built along straight channels but **can be designed along curves and arched spaces**.
- Suspension bridges can be built with **double decks for cars and trains**. The strength of the cabling system is sufficient to hold the double decks.

DISADVANTAGES OF SUSPENSION BRIDGES

- Suspension bridges are **very expensive to build**.
- They **take a very long time to build**. It can take up to nine months to connect the main cable to the ROOF STRUCTURES and the anchorages.
- The **concrete ROOF STRUCTURES have to be built in shallow bedrock**.
- The complete **decks can be affected by strong winds**.

STRUCTURAL FAILURE

- A structure is **stable** if it **does not collapse** when a force is pressed against it and it if it **does not topple over** when a force acts on it.
- A **rigid structure** is a structure that **is stiff and not easy to bend or change its shape**.
A non-rigid structure is a structure that is flexible and easy to bend or change. It **collapses easily as there is no reinforcement through triangulation or gussets**.
- **Fracture** is *when an object lacks the strength to resist a force being applied to it and the structure breaks into pieces*.



Key words

- **fracture** – when an object cracks or breaks because too much pressure is placed on it
- **bending** – when the shape of a structure starts to curve because a force is being applied from above
- **buckling** – when the two ends of a structure bend towards each other so that the middle section is under compression
- **flexing** – when the two ends of a structure bend away from each other so that the middle section is under tension
- **toppling over** – when a structure falls over because it is unstable
- **top heavy** – when the top section of a structure carries more weight than the bottom section, making it unstable
- **narrow base** – when the base of a structure is much narrower than its top, making the structure unstable

REASONS WHY STRUCTURES FAIL:

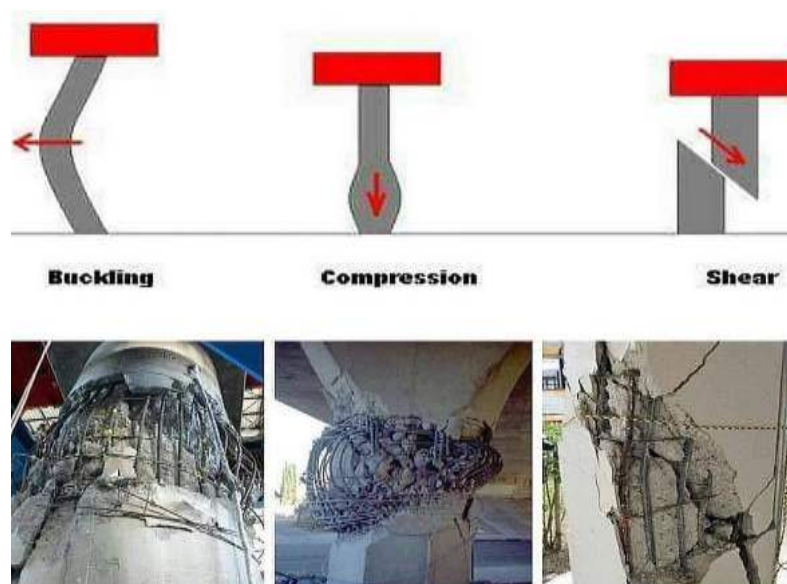
- **Fracture** of a member – due to lack of strength.
- **Bending** (flexing, buckling) – due to lack of stiffness (rigidity)
- **Toppling over** – due to lack of stability (top heavy, narrow base).

EXTERNAL FACTORS THAT CAUSE STRUCTURAL FAILURE:

1. Continuous high temperature
2. Strong winds over a long period of time
3. Excessive weight on the structure
4. Bad design e.g. wrong base size / type of materials
5. Corrosion

REASON FOR STRUCTURAL FAILURE	EXPLANATION	EXAMPLE
FRACTURE	- If a structural member fractures / breaks because it is not strong enough to withstand the forces exerted on it. - It might be caused by the materials used were not correct, - the material was not strong enough, - more force was exerted on the material than was anticipated.	
BENDING	- If the structure bends with more force than its members can sustain, the structure may fall and collapse. - While structures must be able to withstand some torsion forces, if the members are not rigid or stiff enough, the structure will bend too much and fall.	
TOPPLING OVER	- If a structure is not stable or rigid, it will topple over. - This may be caused by the structure that is top-heavy or has a narrow base. A wide base and well-placed centre of gravity can help to prevent this from happening.	

EXAMPLES OF FAILURE IN CONCRETE STRUCTURES



INSTRUCTIONS: ANSWER THE FOLLOWING QUESTIONS ON STRUCTURES**ACTIVITY 5: STRUCTURAL MEMBERS**

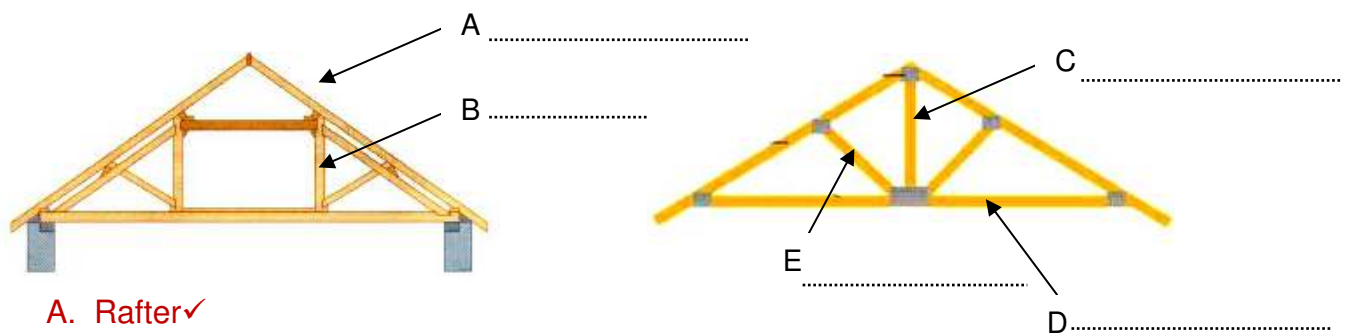
5.1 Define a frame structure.

A frame structure is a number of structural members that have been joined together to form a frame that has a particular shape. ✓

5.2 Name at least 3 structural members of roof trusses.

Strut ✓, king post ✓, tie beam ✓, rafter ✓ (any three relevant answers)

5.3 Identify the roof truss members marked **A – E**.

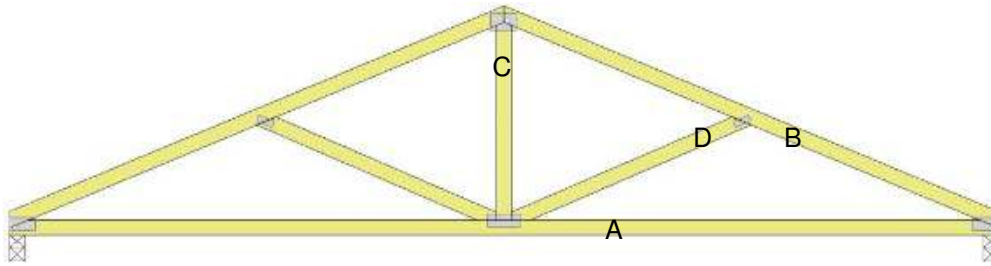


- A. Rafter ✓
 B. Queen post ✓
 C. King post ✓
 D. Tie beam ✓
 E. Strut ✓

5.4 Choose the correct description from column B that goes with the term in column A. Write the correct letter in the Answer column.

COLUMN A	ANSWER	COLUMN B
5.4.1. Frame structure	F	A. The roof truss that has the fewest members
5.4.2 Roof trusses	C	B. A flowerpot hanging from a windowsill by a rope
5.4.3 Rafter	H	C. A roof's covering is supported by these
5.4.4 King post truss	A	D. The bottom, horizontal member of a triangular structure
5.4.5 Queen post truss	G	E. A member that keeps two components separated
5.4.6 Tie	B	F. A structure made up of strong materials that form a rigid frame
5.4.7 Strut	E	G. The roof truss that enables people to construct big halls
5.4.8 Tie beam	D	H. It helps to shape the roof with a series of parallel beams

5.5 Answer the questions underneath based on the roof trusses.



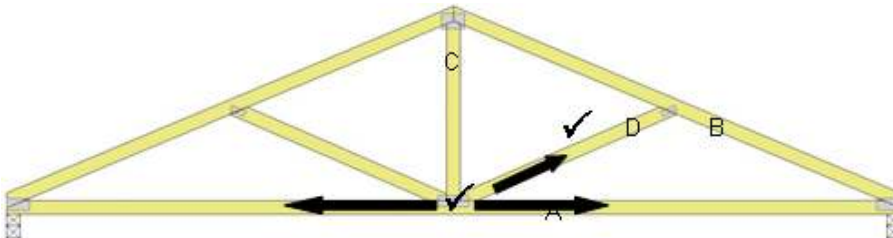
5.5.1 Identify the type of roof trusses in the diagram.

King post roof truss

5.5.2 Name structural member B?

Rafter

5.5.3 Draw arrows on the diagram of the trusses to indicate the direction of the force acting on structural members A and D.

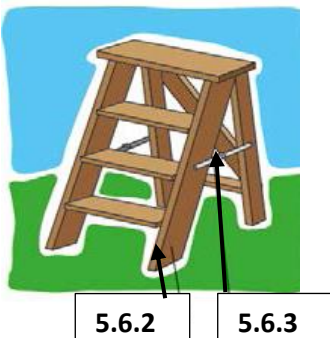
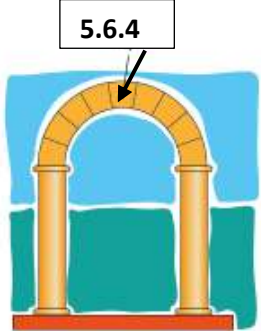


5.5.4 List the forces acting on structural members A and D.

A.: **Tension**

D: **Compression**

5.6 Identify the structural members and the force each one is experiencing in the pictures below.

 5.6.1 Member: Guy✓ Force: Tension✓	 5.6.2 Member: Strut✓ Force: compression✓ 5.6.3 Member: Tie✓ Force: Tension✓	 5.6.4 Member: Arch✓ Force: Compression✓
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5.7 When a force is applied on the structure in Diagram A, the structure is not stable.

Diagram A

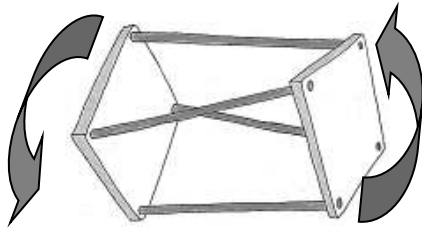
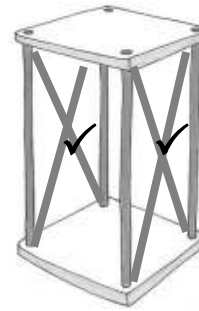


Diagram B



5.7.1 Identify the force applied on the structural members in Diagram A.

Torsion / twisting

5.7.2 Draw reinforcement to stabilise the structure in Diagram B.

5.7.3 Name the type of reinforcement you used to stabilise the structure.

Cross bracing

5.8 Define the following terms:

5.8.1 Tie beam - **Horizontal beam connecting rafters**

5.8.2 Strut – **a solid part of the structure that withstand compression.**

5.8.3 King post - **Upright post from tie- beam to rafter – top.**

5.8.4 Rafter - **Rafters help to shape the roof and they also help to support the roof covering and absorb and spread the compression forces on the truss.**

5.8.5 Queen post - **Two upright timbers between the tie beam and the principal rafters of the roof truss.**

5.9 Fill in the missing words.

5.9.1 We often use struts to support a structure.

5.9.2 This part of a frame structure stands upright and offers support: column

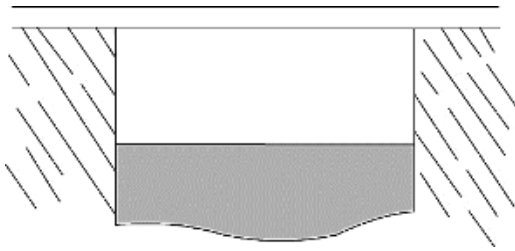
5.9.3 Structures that hold up a roof and give it shape are called roof trusses.

5.9.4 We reinforce building structures with cross-bracing by letting two diagonal supports cross each other.

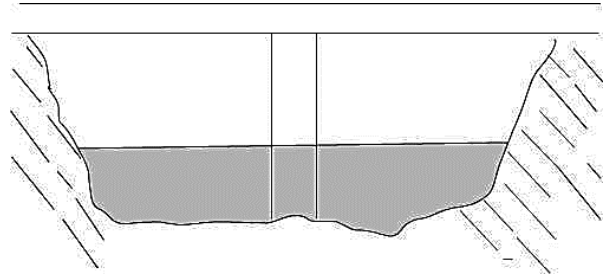
5.9.5 In building construction, the members that are pushed up against columns to keep them in place are called struts.

5.10 Identify the type of each of the following bridges.

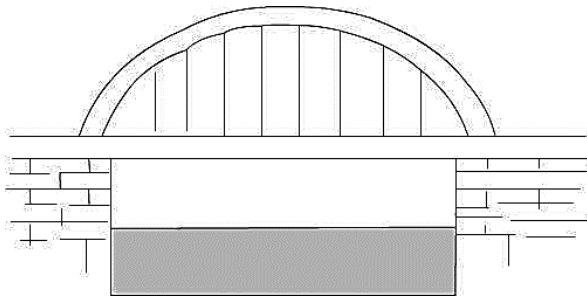
A. Beam bridge



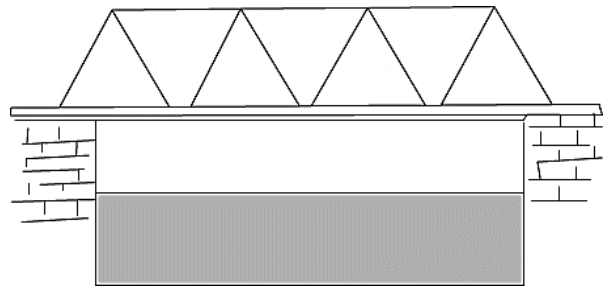
B. Beam bridge with pier / support



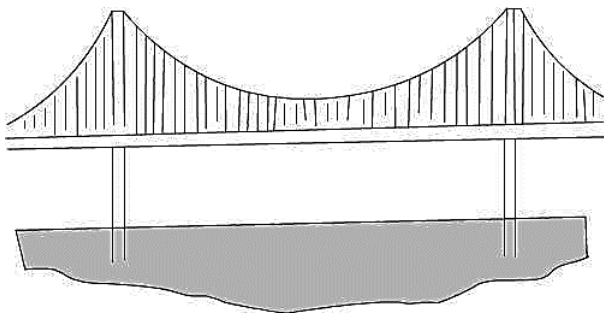
C. Arch bridge



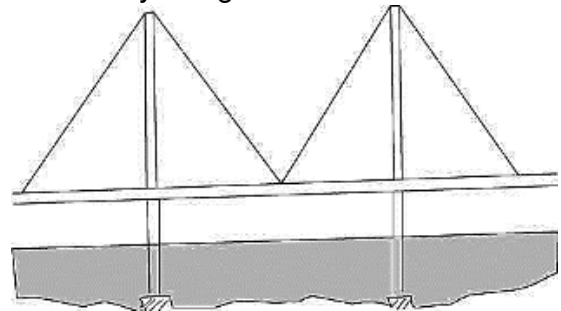
D. Truss bridge



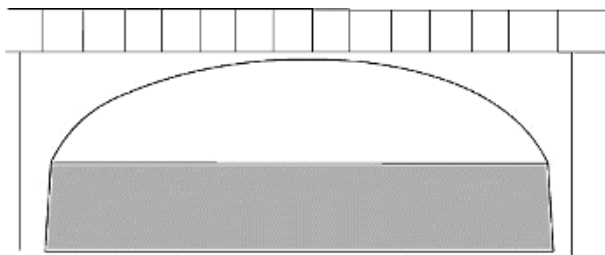
E. Suspension bridge



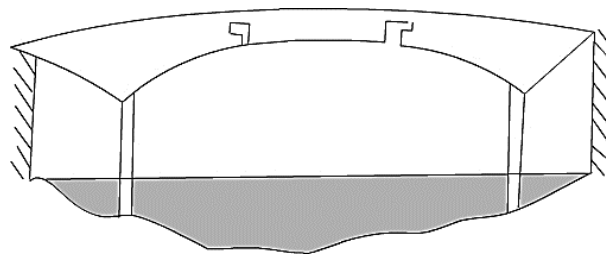
F. Cable stay bridge



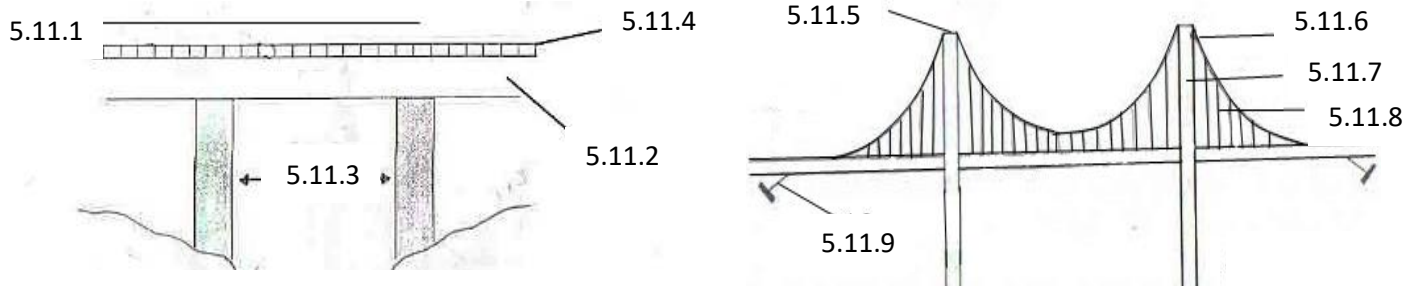
G. Arch bridge



H. Cantilever bridge



5.11 Identify the following parts of the bridges below.



5.11.1 deck

5.11.2 beam

5.11.3 column

5.11.4 railings

5.11.5 saddle

5.11.6 main cable

5.11.7 column

5.11.8 cable hanger

5.11.9 anchorage

5.12 Why do designers make use of arches when designing dam walls?

- It can absorb very strong pressure due to the design.
- This applies downward pressure to the soil and thus improves the strength of the dam.

5.13 Study the illustrations below and answer the questions. The illustrations show different ways that bridges can fail.

Describe how structural failure could be prevented.

5.13.1



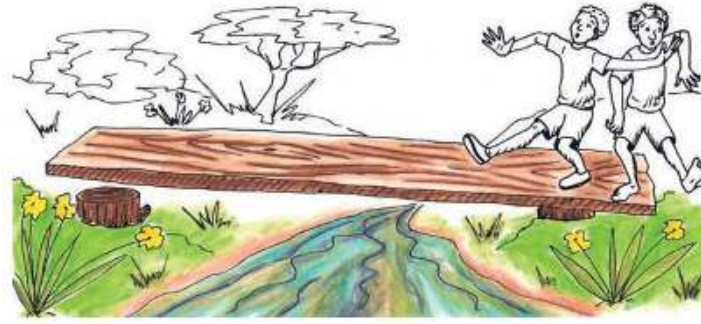
The bridge must have supporting structures to hold it up and that must also be anchored to the riverbank

5.13.2



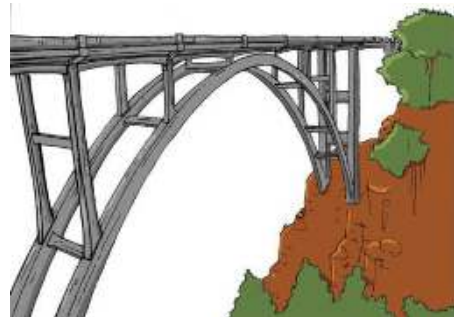
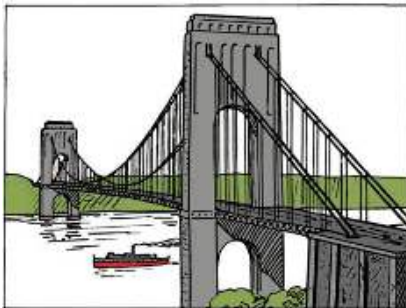
The beam of the bridge must be reinforced with iron bars in the concrete, or it must be provided with an additional supporting column

5.13.3



The supporting structures on each side of the bridge must be wider than the bridge itself and the bridge must be anchored to these structures to prevent distortion

- 5.14 The Figures below show a suspension bridge and an arch bridge. In a suspension bridge, the deck of the bridge hangs from the cables that carry the load. Explain in what way an arch bridge is different from a suspension bridge



With a **SUSPENSION BRIDGE**, the weight is carried by overhead cables. These cables traffic under tension.

With an **ARCH BRIDGE**, the weight from below is carried by the supports struts and arch, which are under compression.

- 5.15 Where are lintels used in houses, and what are their purposes?

Lintels are used for the bricks above windows, doorways and others to support openings in walls.

- 5.16 Name 3 reasons that could cause structural failure.

- Fracturing due the lack of strength
- Bending/buckling
- Toppling over

- 5.17 Name five **EXTERNAL FACTORS THAT CAUSE STRUCTURAL FAILURE**:

- Continuous high temperature
- Strong winds over a long period of time
- Excessive weight on the structure
- Bad design e.g. wrong base size / type of materials
- Corrosion

WEEK 6: DESIGN: GRAPHIC COMMUNICATION

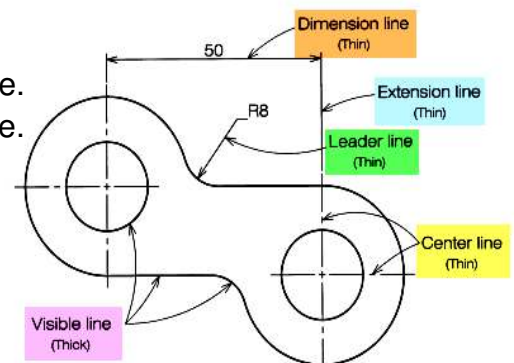
PURPOSE OF GRAPHICS: TO DEVELOP AND COMMUNICATE IDEAS

Graphic communication is **using skills and techniques to record and communicate the shape and size of a product**. Every product we have today (e.g. cars, houses, beds, tables, chairs, desks, appliances and tools) started as an idea. These **ideas were communicated by means of different types of drawings**. These drawings form a universal graphic language that can be understood by anyone, regardless of the country they come from.

RULES OF DRAWING

1. Always use a sharp pencil.
2. HB or 2H pencil is the best type to use when drawing.
3. Always use a ruler to draw straight lines.
4. The horizontal line goes from the left to the right of the page.
5. The vertical line goes from the top to the bottom of the page.
6. Always use a protractor or set square to draw angles.
7. The best way to draw a circle is to use a compass.
8. You also need an eraser (rubber)

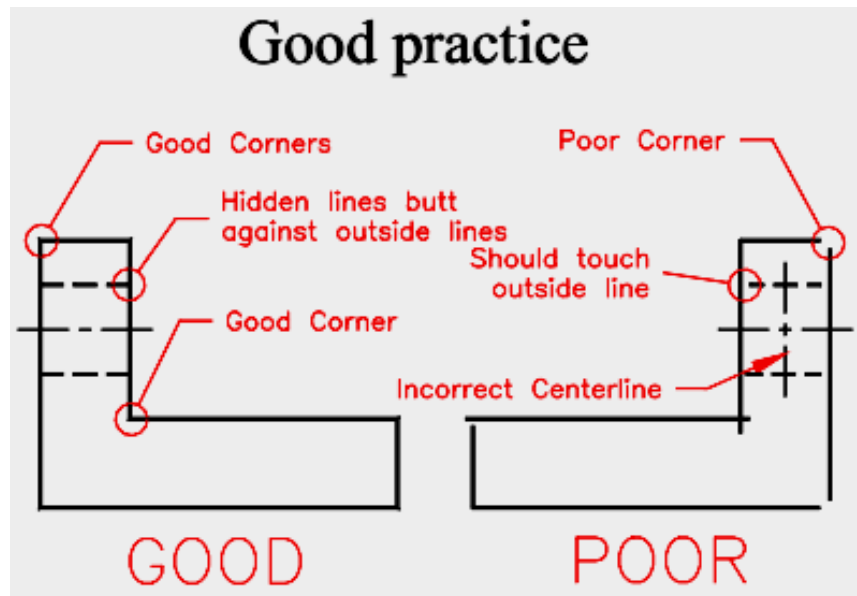
Example : Line conventions in engineering drawing



LINE TYPES

- The correct use of lines and measurements are compulsory to avoid any confusion that might occur during the designing process. The following is an illustration of the types of line used in graphic communication.

LINE TYPE	EXAMPLE	DESCRIPTION
Outline		Visible outlines, visible edges, continuous thick solid line that is used to show the outlines, planes, curved surfaces and the edges of an object and that are visible from the projection plane view.
Construction line		Imaginary lines, projection lines, leader lines. These lines are known as Feint lines. A line that is not more than 0.3 mm. They are thin and used to guide the designer to complete the drawing.
Dashed line		Dashed thick line and is used to show the hidden detail of edges, planes, curved surfaces that are not visible in the projected view.
Centre lines		Chained thin dashed lines that are used to represent symmetry, path of motion, centers of circles, axis of axisymmetric parts (to cut and object in half at the centre) features.
Dimensioning and extension lines		Very thin, feint continuous line with arrowheads on both ends and measurement on top of the line are used to show the dimension of the side.
Curved lines		Represents an area of the object that has been removed to make a clearer or shorten view.



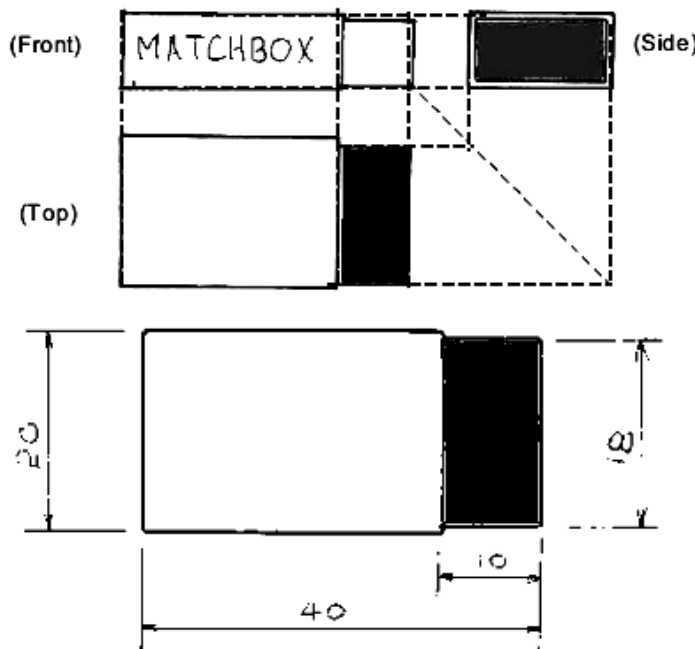
MISTAKES THAT OCCUR WHEN DRAWING

In each example the correct and wrong way are illustrated. Make sure you do not use the wrong method to draw.

DIMENSIONING AND EXTENSION LINES	
<u>CORRECT WAY</u>	<u>INCORRECT / WRONG WAY</u>
A.	OR b. OR c. ALL 3 methods are wrong
B.	
C.	
D.	

DIMENSIONING

- Working drawings are either full size or scaled if they are too big to fit on a page.
- All measurements are placed on the drawing to enable it to be made on the factory floor.
- When we add measurements, we call it dimensioning

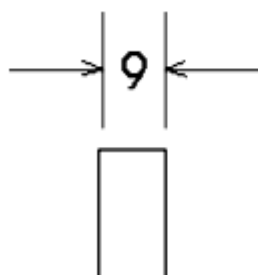
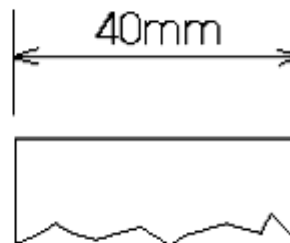


Rules for dimensioning:

- Don't let measurements clutter the drawing.
- All vertical measurements should be read from the right i.e. turn the drawing 90° (clockwise) to read them.
- Do not repeat dimensions if you already have them or they can be worked out from others you have on the drawing.
- Avoid putting dimensions inside a drawing or between the different views.
- Use arrowheads showing exactly where you are measuring from and to.
- Measurements should be in mm.

- It is very important to add dimensions (measurements) when drawing accurate orthographic or working drawings.
- Dimensions can also be applied to simple sketches and designs as they help anyone looking at these to understand the overall size or scale. However, dimensions are usually drawn in a particular way and some examples are shown below.
- **The arrowhead must be sharp but above all the dimensions must be accurate.**

Example of a standard dimension. The dimension is drawn quite faint with the exception of the number and arrow heads.



If a measurement is 9mm or smaller the dimension is drawn in a slightly different way. The arrows point inwards, towards the number.

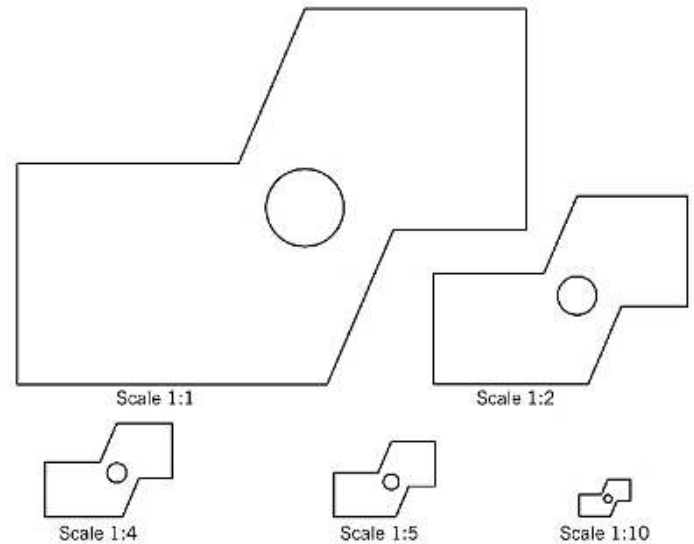
SCALE DRAWINGS

There are mainly three types of scales:

- (1) Full Scale
- (2) Reduced Scale
- (3) Enlarged Scale.

FULL SCALE

- 1:1 means the drawing has to be drawn/are drawn exactly the same size as the real object.
E.g. One circle's radius is 20 mm in data, and you are drawing it of 20 mm in drawing then you are using full scale in drawing.
Example: 1:1, 2:2, 3:3, 4:4, 5:5 etc.



REDUCED SCALE

- Using **reduced** scale means you are **drawing the object SMALLER than the REAL SIZE**.
E.g.: One circle's radius is 20 mm in data, but you are drawing it of 10 mm in drawing then you are using reduced scale in drawing.
Example: 1:2, 1:3, 1:4, 1:5, 1:6 etc.

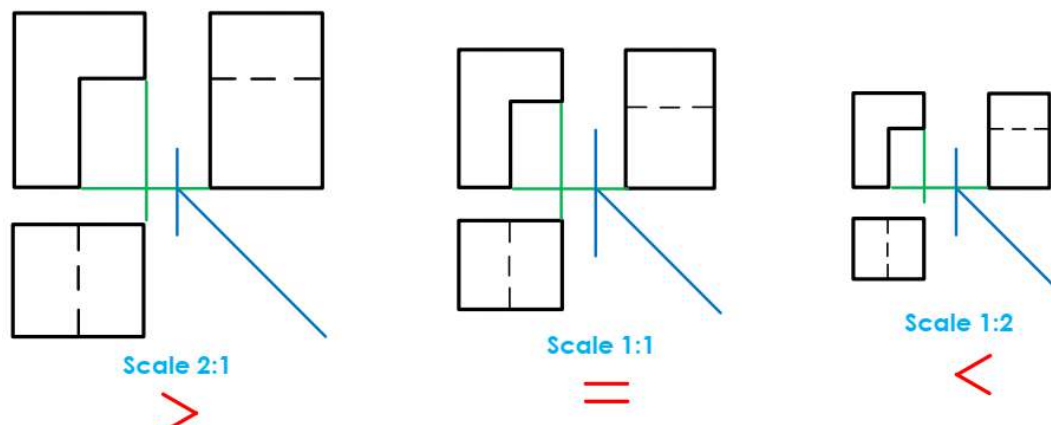
ENLARGED SCALE

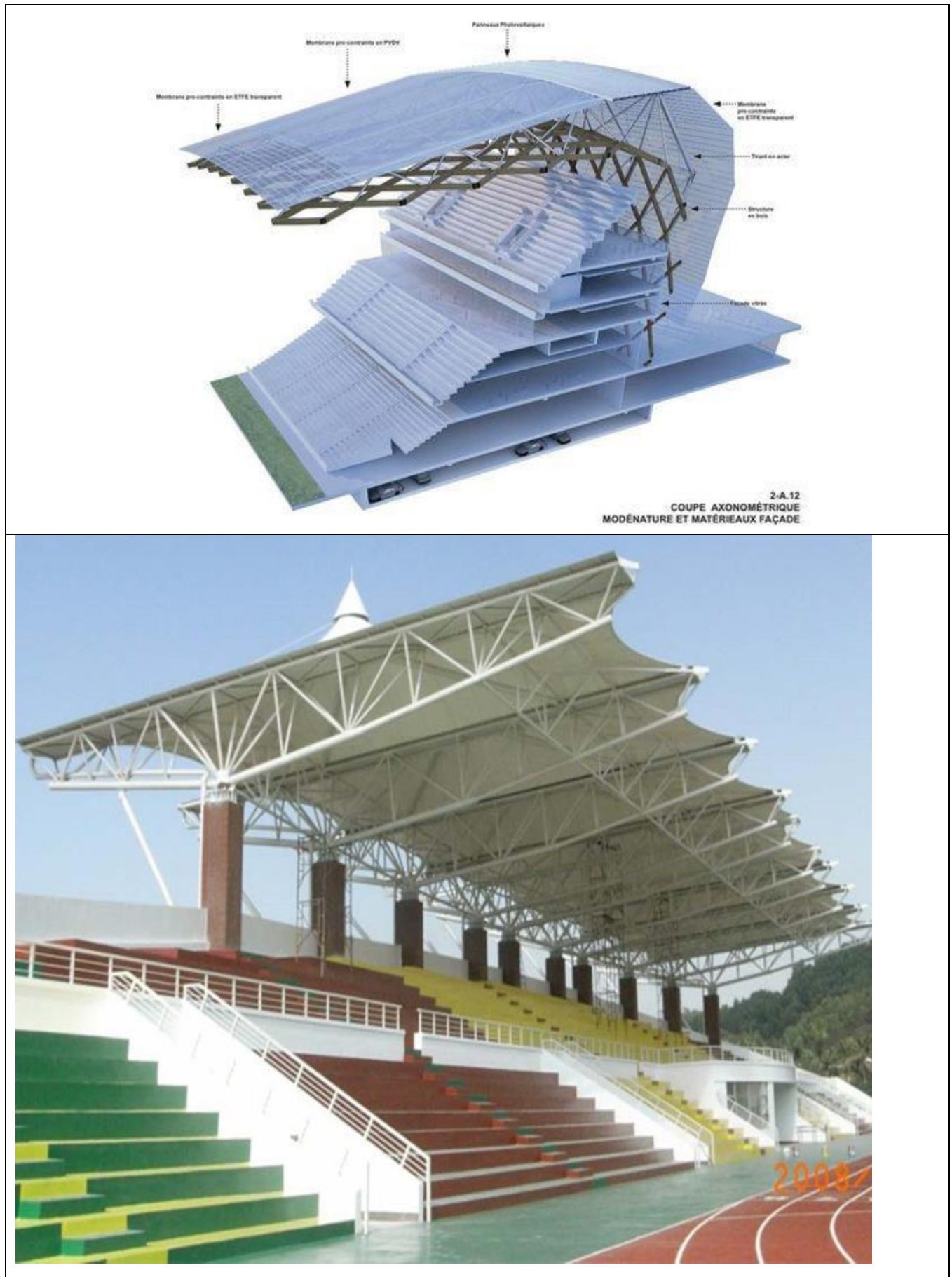
- Using **enlarged scale** means you are drawing the object **BIGGER THAN the REAL SIZE**
- E.g.: One circle's radius is 20 mm in data but you are drawing it of 40 mm in drawing then you are using enlarged scale in drawing. Example: 2:1, 3:1, 4:1, 5:1, 6:1 etc.
- Indicating the scale of the drawing, you write the word "SCALE" followed by the indication of its ratio, as follow

SCALE 1:1	for FULL SCALE / SAME SIZE
SCALE 1:X	for REDUCED SCALE / SIZE
SCALE X:1	for ENLARGED SCALE / SIZE

The ratio normally used is...

1:1, 1:2, 1:5, 1:10, 1:20, 1:50, 1:100, etc.
or
1:1, 2:1, 5:1, 10:1, 20:1, 5:1, 100:1, etc





GROUP WORK

- 6.4 Each member of the group chooses his / her best design idea for the two free hand sketches. As a group, look at all the initial design sketches and evaluate each one using questions like these:

CRITERIA	Member 1:	Member 2:	Member 3:	Member 4:
1. Is the solution an effective solution?	[ANSWERS WILL DIFFER – DEPENDING ON THE DESIGNS]			
2. Does it meet the requirements as stated in the scenario?				
3. What are the problems / weaknesses of this solution?				
4. Do the sketches clearly indicate how the parts will be joined?				

- 6.4.1 After your group has evaluated all the designs, you must choose the most suitable design to make.

We have decided that _____'s design is the most suitable solution to the problem.

- 6.4.2 Motivate your choice in 2.3.1. Give at least 2 reasons for your groups' choice.

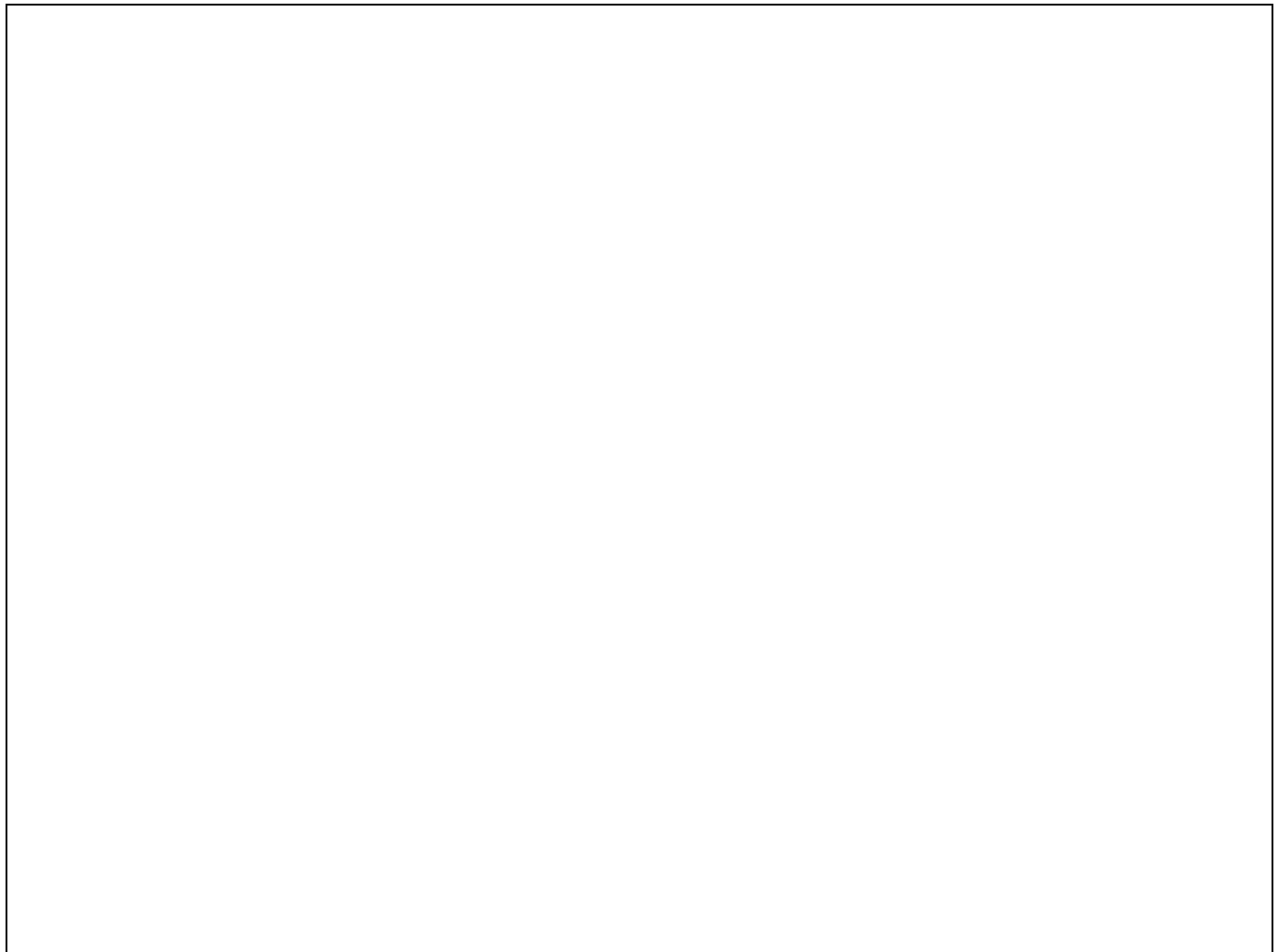
ASSESSMENT GUIDELINES FOR INITIAL IDEAS, EVALUATION & CHOICE OF THE FINAL IDEA

CRITERIA	The learner(s).....	Marks allocated
1.	Sketched TWO FREEHAND ideas – individually (2 marks per drawing)	___/4
2.	Labels and notes were added to the drawings	___/2
3.	Different line types were clearly visible	___/2
4.	Ideas of all group members were evaluated, and a final choice was made	___/3
5.	A final choice from the possible ideas was made	___/1
6.	Indicated possible problems to the different designs	___/4
7.	Made sketches that are neat and complete (2 marks per drawing)	___/4
SUB TOTAL		___/20

6.5 DRAW THE FINAL CHOICE OF ROOF FOR THE STADIUM IN THE SPACE BELOW

Remember to add labels and dimensions.

[INDIVIDUAL WORK]



WEEK 7: MAKE A 2-D WORKING DRAWING OF ONE VIEW OF YOUR DESIGN

7.1 WORKING DRAWING [INDIVIDUAL WORK]

*You must draw a **WORKING DRAWING** of your chosen design showing ONE VIEW OF THE ROOF STRUCTURE WITH DIMENSIONS.*

This drawing should use the correct line types as taught in the graphic communications course.

1. Select the view of your model to draw.
2. Determine the scale and dimensions according to the 3-D drawing done in activity 6.4.
3. Identify different parts of the roof structure.

ANSWERS WILL DIFFER

MARKING GUIDELINES FOR ORTHOGRAPHIC PROJECTION / WORKING DRAWING

Description	Marks allocated
1. ONE view was developed	____/1
2. Labels (2 marks) and annotated notes were used (2 marks)	____/4
3. Parts of the ROOF were identified	____/4
4. Materials were indicated	____/2
5. Line work (consistency in line thickness and line types; neat corners)	____/2
6. Dimensions were indicated (overall length & height)	____/2
TOTAL	____/15

7.2 BUILD A SCALE MODEL OF A ROOF STRUCTURE FOR THE GRANDSTAND OF THE STADIUM

GROUP / INDIVIDUAL WORK

- Before you start working, compare the scale and dimensions of your working drawing with those of the other learners in your group to ensure that the model works out correctly.
- Make a scale model that accurately represents your design of the roof structure. Each member of the team must contribute to this process.
- The model should be made as neatly as possible using suitable materials.
- Use the following criteria to evaluate your model of the roof for the stadium:

	Criteria	Yes / No
1.	Have we managed to sketch a 3D isometric projection with dimensions and to scale?	
2	Have we drawn a 2D working drawing showing one view with dimensions and line types?	
3.	Have we interpreted the working drawing correctly?	
4.	Have we built our roof structure using safe working practices?	
5.	Have we designed the stadium according to the design brief specifications, such as rigidity and stability?	
6.	Does our model show that we have mastered the necessary making skills?	

ASSESSMENT GUIDELINES OF MAKING SKILLS: [20 MARKS]

DESIGN AND MAKE A SCALE MODEL OF A ROOF STRUCTURE FOR THE GRANDSTAND OF THE STADIUM

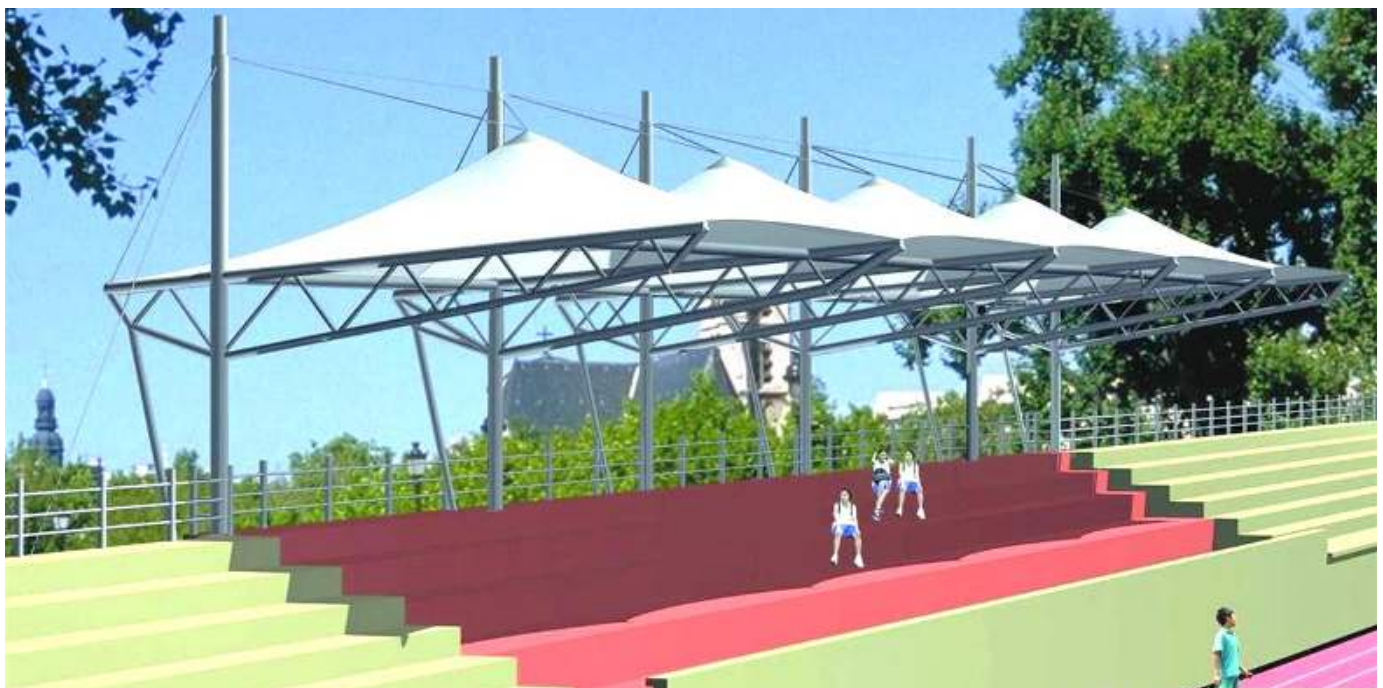
	4 EXCELLENT	3 GOOD	2 ACCEPTABLE	1 UNACCEPTABLE
MAKING SKILLS Make a scale model of a ROOF STRUCTURE FOR THE GRANDSTAND OF THE STADIUM	✓ Shows a VERY GOOD understanding of the making process. ✓ TAKES CARE when working, using tools and materials safely and accurately. ✓ WORKS CONFIDENTLY with others, making a very good contribution. MARKS: 10 – 9	✓ Shows a GENERAL understanding of the making process. ✓ Takes REASONABLE care when working, using tools and materials safely and accurately. ✓ Works EASILY with others, making a very good contribution. MARKS: 8 – 6	✓ Shows UNDERSTANDING of the making process. ✓ Takes SOME care when working, using tools and materials safely and accurately. ✓ Works with others, making a REASONABLE contribution. MARKS: 5 – 3	✓ Shows LITTLE understanding of the making process. ✓ NOT ABLE to use tools and materials safely and accurately. ✓ FINDS it DIFFICULT to work with others, making a very LITTLE or NO contribution. MARKS: 2 – 0
	✓ Produce an EXCELLENT model of a ROOF STRUCTURE. ✓ EXCELLENT usage of triangulation, best usage of available resources and joining techniques. ✓ The ROOF STRUCTURE is VERY STRONG, STABLE and RIGID. ✓ EXCELLENT usage of available resources. MARKS : 10 – 9	✓ Produce a VERY GOOD model of a ROOF STRUCTURE. ✓ VERY GOOD usage of triangulation, good usage of available materials and modern joining techniques. ✓ The ROOF STRUCTURE is VERY STRONG, STABLE and RIGID ✓ VERY GOOD usage of available resources. MARKS : 8 – 6	✓ Produce an ACCEPTABLE model of a ROOF STRUCTURE. ✓ ACCEPTABLE usage of triangulation, reasonable usage of available materials and modern joining techniques. ✓ The ROOF STRUCTURE does not adhere to the specifications of STRENGTH, STABILITY and RIGIDITY. ✓ ACCEPTABLE usage of available resources. MARKS: 5 – 3	✓ Produce and UNACCEPTABLE model of a ROOF STRUCTURE. ✓ UNACCEPTABLE / POOR usage of triangulation, usage of materials and joining techniques. ✓ The ROOF STRUCTURE is NOT AT ALL STRONG, STABLE and RIGID. ✓ VERY FEW materials were used to build the model. MARKS : 2 – 0
SCORE: _____/20				

TOTAL MARKS FOR ASSIGNMENT: 70

WEEK 8: EVALUATE COMPLEX STRUCTURES

1. Evaluate your scale model of the roof structure by identifying the advantages and disadvantages of your model.
2. Use the criteria mentioned in the scenario.

CRITERIA	ADVANTAGES	DISADVANTAGES



WEEK 9: GROUPS PRESENT THEIR PLANS & SCALE MODEL TO THE REST OF THE CLASS

1. PLAN A JOINT STRATEGY TO PRESENT THE TEAM'S WORK GROUP WORK

2. Prepare a five-minute presentation during which you will:

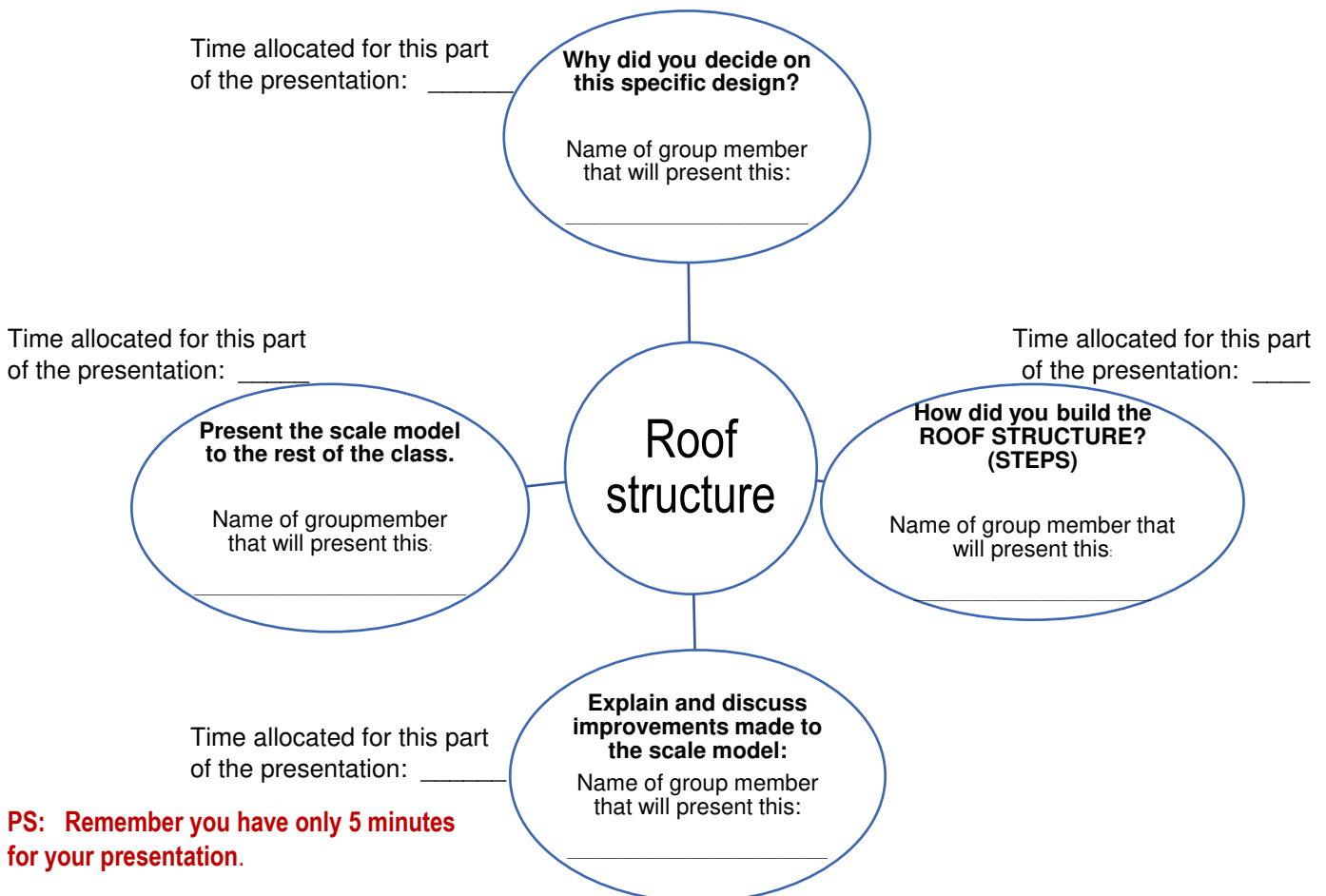
- ❖ show your individual designs sketches;
- ❖ explain the changes you made as a team;
- ❖ show your team's final plans;
- ❖ exhibit (show and explain) your team's model.

3. Each member of the team must speak briefly about the role they played in the following:

- ❖ the development of the design;
- ❖ the making of the scale model;
- ❖ the preparation for the presentation.

4. Use the spider diagram to plan and divide the work amongst the members of the group.

5. Indicate the following concepts/aspects on your diagram:



WEEK 10: MAKE A 3-D ISOMETRIC DRAWING OF THE SCALE MODEL OF THE ROOF STRUCTURE

1. Once you have evaluated the initial sketches and chosen one, you may make changes to the initial sketch to incorporate good ideas from other designs of your group members.
2. Combine the work the members of your group did in activity 2. Use it to make neat drawings of the ROOF OF THE GRANDSTAND.

KEEP THE FOLLOWING IN MIND:

INDIVIDUAL WORK

- decide on the scale to use
- decide which side of the model to use as a front view.

MAKE SURE YOUR DRAWING ADHERES TO THE CRITERIUM

SELF ASSESSMENT FOR THE ISOMETRIC DRAWING

DESCRIPTION	YES	NO
1. Different line types were clearly visible		
2. Labels and notes were used to identify various parts of the bridge and to identify the choice of materials for the bridge.		
3. Dimensions were realistic and clearly visible		
4. Scale of final choice was indicated and drawn to scale		
5. The isometric drawing was neat and complete		



Make a 3-D ISOMETRIC projection. Draw your scale model of the roof to scale in all 3 dimensions

ANSWERS WILL DIFFER FROM GROUP TO GROUP.

NOTE: ALL MEMBERS OF A GROUP SHOULD DRAW THE SAME 3D ISOMETRIC DRAWING OF THE ROOF, BUT INDIVIDUALLY