SIMPLE MACHINES

LEARNING OBJECTIVES:

* Introduction
* Mechanical Advantage Ideal mechanical advantage (IMA),
  Actual mechanical advantage (AMA).
* Types of simple Machines
  Lever,Wheel and axle ,Pulley,Inclined plane,Wedge ,Screw
* Center of gravity:
* Location of Centre of gravity (CG)
* Determination of CG of irregular shape
* Stable equilibrium
* Unstable equilibrium
* Neutral equilibrium

Real life applications:

* Levers are used in door handles,the claws of hammer for removing nails, crowbars, light switches, bottle openers and hinges.
* Wheels are used in an electric fan, a motor, a revolving door, a merry go round and any wheel on the car, on your skate board, on a bicycle.
* pulleys are used in window blinds and drapery to move them up and down or back and forth, on ships to raise and lower sails, in elevators to move the car up and down from floor to floor, on cranes for use in moving construction equipment.

IMPORTANT FORMULE:-

1. $\text{MA} = \frac{\text{Output Force}}{\text{Input Force}} = \frac{\text{Load(L)}}{\text{Effort(E)}}$

2. $\text{IMA} = \frac{D_E}{D_R}$

3. $\text{AMA} = \frac{R}{E_{actual}}$

4. $M = Fd$

5. Load x load arm = effort x effort arm

$$\therefore \text{MA} = \frac{\text{MO}}{\text{NO}} = \frac{\text{effort arm}}{\text{load arm}}$$

6. Work done by load = work done by effort

M.A. = radius of wheel / radius of axle

7. $M.A. = \frac{l}{h} = \frac{\text{length of Inclined plane}}{\text{height of Inclined plan e}}$

8. M.A =length of the inclined surfaceof wedge / thickness of wedge

9. Px2 $\prod$ d = wxh

10. M.A. = 2 $\prod$ d/h

11. velocity ratio $V.R = \frac{displacement\ of\ the\ power}{displacement\ of\ the\ load}$

12. Efficiency= $\frac{M.A}{V.R}$

13. Percentage of Efficiency= $\frac{M.A}{V.R} X 100$

Introduction

1. A simple machine is a mechanical device that changes the direction or magnitude of a force.
2. In general, they can be defined as the simplest mechanisms that use mechanical advantage (also called leverage) to multiply force.
3. Simple machine uses a single app

The ratio of the output to the input force is called the mechanical advantage.

$$MA = \frac{\text{Output Force}}{\text{Input Force}} = \frac{\text{Load(L)}}{\text{Effort(E)}}$$

Here the force applied to a machine is called ***effort***. The force overcome by a machine in response to the effort is called ***load or resistance***.

Types: There are two types of mechanical advantage, ideal mechanical advantage (IMA) and actual mechanical advantage (AMA).

Ideal or perfect machine : A machine in which no part of the work done on the machine is wasted,is called an ideal or perfect machine.thus for an idel machine work out put =work input(efficiency is 1or 100%)

Ideal mechanical advantage: The *ideal mechanical advantage* (IMA), or *theoretical mechanical advantage*, is the mechanical advantage of an ideal machine. It is calculated using physics principles because no ideal machine actually exists.

The IMA of a machine can be found with the following formula: IMA = $\frac{D_E}{D_R}$

where D_E equals the 'effort distance' (for a lever, the distance from the fulcrum to where the effort is applied)

D_R equals the load distance (for a lever, the distance from the fulcrum to where the resistance is encountered)

Actual mechanical advantage: The *actual mechanical advantage* (AMA) is the mechanical advantage of a real . Actual mechanical advantage takes into consideration real world factors such as energy lost in friction.

The AMA of a machine is calculated with the following formula:AMA = $\frac{R}{E_{actual}}$

where R = resistance force obtained from the machine,

E_{actual} = actual effort force applied to the machine

Types of simple Machines

Usually Simple machines refers to the six classical simple machines which are

1. Lever , 2.Wheel and axle , 3 Pulley 4. Inclined plane , 5. Wedge , 6. Screw

Simple machines fall into two classes; those dependent on the vector resolution of forces (inclined plane, wedge, screw) and those in which there is an equilibrium of torques (lever, pulley, wheel).

1. LEVER :

In physics, a **lever** is a rigid object that is used with an appropriate fulcrum or pivot point to multiply the mechanical force (effort) that can be applied to another object (load). A lever is one of the six simple machines.

1. "*Give me a place to stand, and I shall move the earth with a lever*" is a remark of Archimedes.

2. It is assumed that in ancient Egypt, constructors used the lever to move and uplift obelisks weighting more than 100 tons.

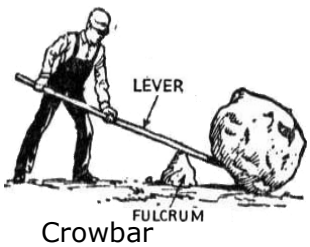
Force and levers

1. The force applied (at end points of the lever) is proportional to the ratio of the length of the lever arm measured between the fulcrum (pivoting point) and application point of the force applied at each end of the lever.
2. Mathematically, this is expressed by $M = Fd$, where F is the force, d is the distance between the force and the fulcrum, and M is the turning force known as the moment or torque.

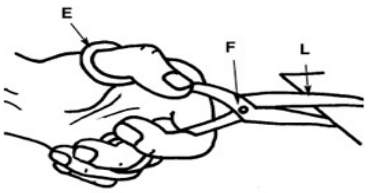
Classes of Levers

There are three classes of levers representing variations in the relative locations of the fulcrum, the load and the force.

Class 1: The fulcrum is located between the applied force and the load. Example:



Crowbar

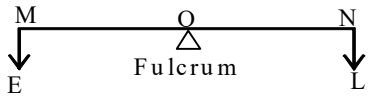


pair of scissors


seesaw

The below figure shows a class 1 lever under equilibrium. The fulcrum acts at point 'O' such that Load x load arm = effort x effort arm

that is L x ON = E x MO $\Rightarrow \frac{L}{E} = \frac{MO}{NO}$ $\therefore MA = \frac{MO}{NO} = \frac{\text{effort arm}}{\text{load arm}}$



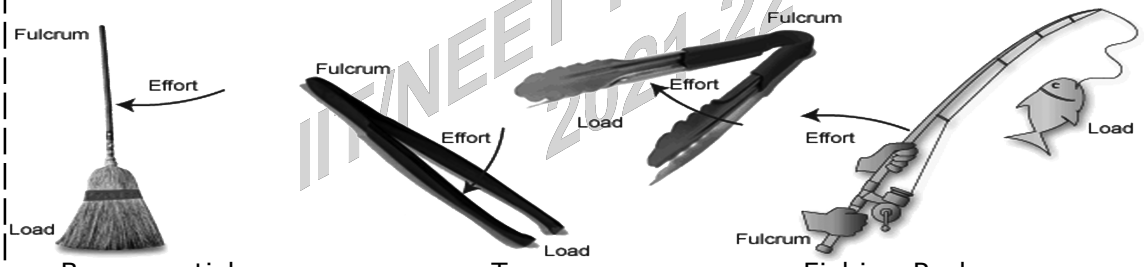
Thus, the mechanical advantage of a lever depends on the ratio of the lenghts of the effort arm to the load arm.

Class 2: The load is situated between the fulcrum and the force.

A nut cracker Lemon squasher A mango cutter A wheel barrow

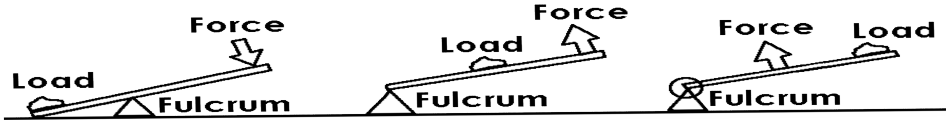
In class 2 levers, the effort arm is always greater than the load arm. Therfore the M.A. is always greater than one. Thus by using a class 2 lever, a greater load can be lifted with a lesser effort i.e., class 2 levers are used as force multipliers.

Class 3: The force is applied between the fulcrum and the load. Examples



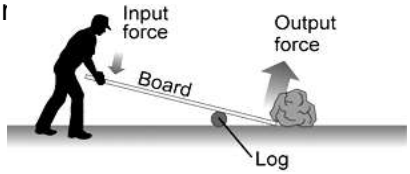
Brooms stick Tongs Fishing Rod

In class 3 levers, the length of load arm is always greater than that of effort arm. Therfore the M.A. is always less than one. Hence it can not be used as force multiplier. Insted class 3 levers are used as speed multipliers.



Class 1 Lever Class 2 Lever Class 3 Lever

Example 1: A construction worker uses a board and log as a lever to lift a heavy rock. If the input arm is 3 meter long and the output arm is 0.75 meterslong, what is the mechanical advantage of the lever?



Solution: $\text{M.A.} = \frac{input\ arm\ length}{output\ arm\ length} = \frac{3\ \text{m}}{0.75\ \text{m}} = 4$

Example 2: The mechanical advantage of a mechine is 4 and its velocity ratio is 5. what is its percentage efficiency?

Solution $\text{Percentage of Efficiency} = \frac{M.A}{V.R} X100$ $\text{Efficiency} = \frac{M.A}{V.R}$

$$\text{Efficiency} = \frac{4}{5} = 0.8$$

$$\therefore percentage\ of\ efficency = 80\%$$

Example 3: A machine is operated by a power of 50 N and the power has a downward displacement of 0.25 m in raising a load of mass 100N through 10 cm. calculate M.A., V.R. and efficiency.

Solution: $M.A = \frac{\text{Load(L)}}{\text{Effort(E)}} = \frac{Load}{power} = \frac{100}{50}$

M.A=2

$$V.R = \frac{displacement\ of\ the\ power}{displacement\ of\ the\ load}$$

$$V.R = \frac{0.25}{0.1} = 2.5$$

$$\text{Efficiency} = \frac{M.A}{V.R} = \frac{2}{2.5} = 0.8$$

Example 4: A lever used to lift a heavy box has an input arm of 24 meters and an output arm of 6 meters. What is the mechanical advantage of the lever?

Solution: $\text{M.A.} = \frac{input\ arm\ length}{output\ arm\ length} = \frac{24}{6} = 4$

Example 5: The mechanical advantage of a liver is 2. load applied by the person on liver is 20N.what is the effort on it?

$$M.A = \frac{\text{Load(L)}}{\text{Effort(E)}}$$

Solution : $Effort = \frac{\text{Load}}{M.A} = \frac{20N}{2} = 10N$

TEACHING TASK

I. Single Correct Answer Type:

1. The mechanical advantage of machine is 5 and its efficiency is 80% it is used with a load 200kgf to height of 20m .calculate the effect required ?

   A) 40kgf B) 80kgf C) 95kgf D) 10kgf

2. A lever is used to lift a heavy box has an input arm of 4m and an output arm of 0.8m what is the mechanical advantage ?

   A) 4 B) 0.4 C) 5 D) 0.2

3. What is the mechanical advantage of lever that has an input arm of 3m and an output on arm's lenth is 2m

   A) 1.5 B) 0.4 C) 2 D) 0.2

4. A lever is held so that its input arm is 0.4 meters and its output arm is 1.0 meters. What is the mechanical advantage of the lever?

   A) 4 B) 0.4 C) 2 D) 0.2

5. A broom with an input arm length of 0.4 meters has a mechanical advantage of 0.5. What is the length of the output arm?

   A)8 B)20 C)2 D)0.8

6. A child's toy is held so that its output arm is 0.7 meter. If the mechanical advantage is 0.3, what is the input arm length?

   A)1.8 B) 0.21 C) 0.42 D) none

7. A crow bar ,of length 120cm as fulcrum situatued at a distance of 20cm from theload calculate the mechanical advantge of the crowbar?

   A) 2.2 B) 5 C) 0.85 D) 3.4

8. A boy 's toy rake is held so that its output arm is 90 meters. If the mechanical advantage is 0.30, what is the input arm length?

   A)27 B) 27.5 C) 37 D) 300

9. If 20m is the displacement caused by an effort in the time t ,such that 5m is thedisplacment caused by the load in the same time then velocity ratio is ?

   A)100 B) 40 C) 4 D) 1/4

10. Agirl's toy with the lenth of its output arm is 20 meters. If the mechanical advantage is 0.5, what is the input arm length?

    A)100 B) 40 C) 4 D) 10

Multiple option type:

11. Simple machines is dependent on in these vector resolution of forces

    a)inclined plane b) wedge c) screw d) lever

    A) a, b correct B) b , c correct C) a , b , c correct D) b , c , d correct

12. The M.A. is always less than one in case of

    a)Crowbar b) Tongs c) Pair of scissors d) Fishing rod

    A) a, b correct B) b , c correct C) a , b , c correct D) b , d correct

Fill in the blanks:

13. The ratio of the output to the input force is called .....
14. The IMA of a machine can be found with the ,.....
15. ..... is a rigid object that is used with an appropriate fulcrum to multiply themechanical force applied to another object .
16. The length of load arm is always greater than that of effort arm. then the M.A. is .....
17. The effort arm length is always greater than the load arm length .then the M.A. is .....

Assertion - A and Reason - R:

A) Both A and R are true and R is correct explanation of A

B) Both A and R are true and R is not correct explanation of A

C) A is true but R is false D)A is false but R is true

18. A: In class 3 levers,the length of load arm is always greater than that of effort arm
R:class 3 levers are used as speed multipliers.
19. A: In class 2 levers,the length of load arm is always greater than that of effort arm
R:class 2 levers are used as force multipliers.

Match the following:

20.

Column A	***Column B***
A. Human fore arm	1. MA
B. Load/effort	2. 3 rd class lever
C. Bread knife	3. 1 st class lever
D. Chistel	4. 2 nd class lever

A) A-3, B-4, C-1 D-2 B)A-4, B-3, C-2, D-1

C) A-3, B-1 C-2, D-4 D) A-3, B-2, C-4, D-1

Comprehention type:

21. A construction worker uses a board and log as a lever to lift a heavy rock. If the input arm is 4 meters long and the output arm is 0.5 meter slong

i) which type of lever they are used?

A) Class 1 lever B) Class 2 lever C) Class 3 lever D) none

ii) what is the mechanical advantage of the lever?

A) 2 B) 4 C) 6 D) 8

Key:-1) A, 2) C, 3) A , 4) B, 5) D, 6) B, 7) B,8) A , 9)C, 10) D 11) C, 12) D, 13) The mechanical advantage , 14) IMA = D_E / D_R ,15) a lever, 16) always less than one, 17) always greater than one, 18) A, 19) D, 20) C, 21) i) A , ii) D

LEARNER'S TASK

BEGINNERS (Level - I)

Choose the correct option:

1. The stair case used by the airline passengers is a modified form of

   A) lever B) Wedge C) inclined plane D) pulley

2. In the first order lever, by keeping the load constant the effort decreases if

   A) the fulcrum is moved towards the load

   B) the fulcrum is moved away from the load

   C) the fulcrum is moved towards the effort

   D) Both B and C

3. Which of the following are correct examples of first, second and third class levers?

	First class Lever	***Second class Lever***	***Third class Lever***
I	Scissors	Wheel Barrow	Broom
II	Ice tongs	Tweezer	Paper cutter
III	Pliers	Nut cracker	Fishing rod

   A) I and II only B) II and III only C) III and I only D) I, II and III

4. Choose the correct inthe case of hammer and nut cracker

   I. Both are simple machines

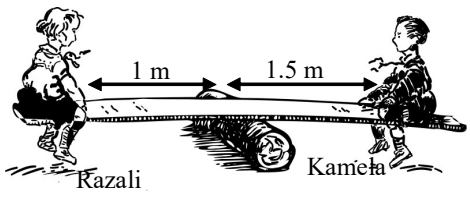
   II. Both are second class levers

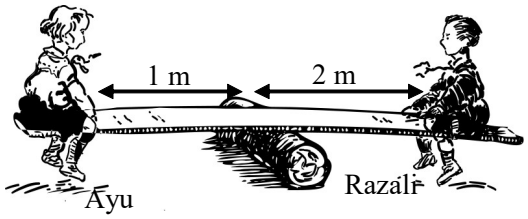
   III. Both have a fulcrum between load and force

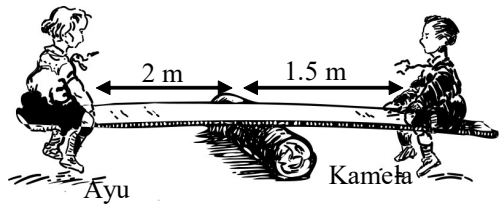
   A) I and II only B) II and III only C) I and III only D) I, II and III

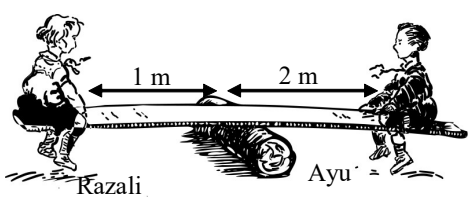
5. Table shows the weights of three students sitting on see-saw.

Student	Razali	Ayu	Kamela
Weight	800 N	400 N	400 N

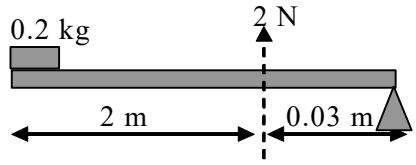
A) 

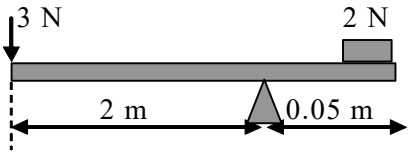
B) 

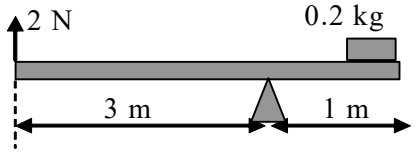
C) 

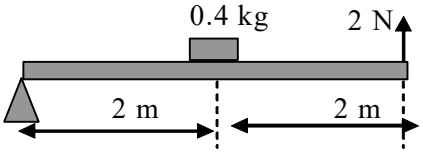
D) 

6. Which of the following levers are in equilibrium?

A) 

B) 

C) 

D) 

7. Which is not simple machine?

A)switches B) a drill C) screw D)scissors

8. Which is not first order lever?

A)switches B) scissors C) screw D) bicycle

9. Write a relation expression of the mechanical advantge of a lever ?

A) $\frac{effortarm}{loadarm}$ B)effort arm X load arm C) $\frac{loadarm}{effortarm}$ D) none

10. the ratio between work output and work input is called.....?

A) Fulcrum B)efficiency C)MA D) none

11. velocity ratio is.....

A) $\frac{velocityofeffort}{velocityofload}$ B) $\frac{effortarm}{loadarm}$ C) MA D) none

ACHIEVERS (Level - II)

Multiple option type:

12. Levers are used in

a)switches b) a drill c) bottle openers d) escalators

A) a, b correct B) a , c correct C) a , b , c correct D) b , c , d correct

13. Mechanical advantage = ...

a) *M*A= *Fd*, b) load by effort c) MA = $\frac{R}{E_{actual}}$ d) $MA = \frac{Effortarm}{Loadarm}$

A) a, b correct B) a , c correct C) a , b , c correct D) b , c , d correct

Fill in the blanks:

14. A wheel barrow is an example of .....

15. In a second order lever, the effort arm is always ..... than load arm.

16. Third class levers acts as ..... multipliers

17. A bottle opener is an example of .....

Assertion - A and Reason - R:

A) Both A and R are true and R is correct explanation of A

B) Both A and R are true and R is not correct explanation of A

C) A is true but R is false D)A is false but R is true

18. A: The force is applied between the fulcrum and the load in third class lever

R: the load acts in the middle of effort and fulcsurm in third class lever.

19. A: length of effort arm of meter scale is 75cm and length of load arm meter scale is 25cm then its MA=3

R: $\text{M.A.} = \frac{input\ arm\ length}{output\ arm\ length}$

Match the following:

20

Column A	***Column B***
a) Work done on the machine by effort	1) Effort
b) Force applied on the machine to overcome the load	2) Mechanical advantage
c) Ratio of load to effort	3) Work input
d) Work done by the machine on the load	4) work output

A) a-3,b-4,c-1,d-2 B) a-3,b-1,c-2,d-4 C) a-3,b-4,c-2,d-1 D) a-3,b-2,c-4,d-1

Comprehention type:

21. Sometimes levers are used to multiply distance. For a broom, your upper hand is the fulcrum and your lower hand provides the input force in 0.5 m long and the load arm is 2 meter.

i) which type of lever they are used?

A) Class 1 lever B) Class 2 lever C) Class 3 lever D) none

ii) what is the mechanical advantage of the broom?

A) 0.25 B) 4 C)1 D) 8

EXPLORERS (Level - III)

22. A lever used to lift a heavy box has an input arm of 0.4 meters and an output arm of 4 meters. What is the mechanical advantage of the lever? (Ans:0.1)

23. What is the mechanical advantage of a lever that has an input arm of 4.8 meters and an output arm of 2 meters? (Ans:2.4)

24. A lever with an input arm of 2.5 meters has a mechanical advantage of 2. What is the output arm's length? (Ans:1.25)

25. A lever with an output arm of 1.2 meter has a mechanical advantage of 4. What is the length of the input arm? (Ans:4.8)

Level -4

26. A rake is held so that its input arm is 1.5 meters and its output arm is 3.0 meters. What is the mechanical advantage of the rake? (Ans:0.5)

27. A broom with an input arm length of 1.4 meters has a mechanical advantage of 0.2. What is the length of the output arm? (Ans:7)

28. A child's toy rake is held so that its output arm is 1.7 meters. If the mechanical advantage is 0.5, what is the input arm length? (Ans:0.85)

Key:-1 - C , 2 - A , 3 - C , 4 - B , 5 - D , 6 - D , 7 - B ,8 -D,9- A,10 - B , 11-A 12-B 13-D 14- 2 nd order lever , 15-greater, 16- Speed , 17- second order lever , - 18 - C, 19 - A 20.B 21) i - C, ii - A

2. Wheel and axle: It is a simple machine and is used to lift heavy loads. It has a wheel of larger radius (**R**) and an axle of smaller radius (**r**) fixed on the same shaft. Wheel and axle are free to rotate about its shaft.

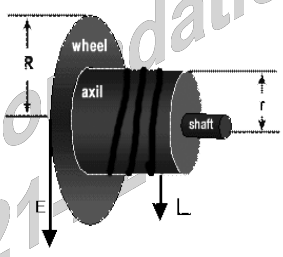
Mechanical Advantage : The effort is applied to the rim of the wheel and the load is raised by a rope wound around the axle. In one rotation wheel covers a distance of $2\pi R$ In one rotation load is raised by a distance of $2\pi r$ If we neglect force of friction, Work done by load = work done by effort

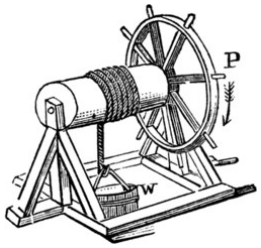
$L \times 2\pi r = E \times 2\pi R \Rightarrow \frac{L}{E} = \frac{2\pi R}{2\pi r} \Rightarrow \frac{L}{E} = \frac{R}{r}$.

$\left[\text{since} \frac{L}{E} = M.A.\right]$ $M.A. = \frac{R}{r}$

OR

M.A. = radius of wheel / radius of axle





This expression indicates that in order to increase the mechanical advantage Radius of wheel must have a large value, radius of axle must be smaller than that of wheel.

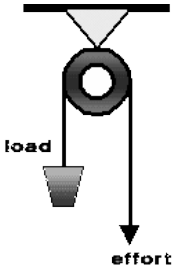
In villages wheel and axle is used for lifting water from a well. This form consists of a wheel that turns an axle, which turns a rope, which converts the rotational motion to linear motion for the purpose of lifting.

Examples: Gears, Bicycle wheels, Ferris wheels , automobiles, blenders, clocks, escalators, golf carts, helicopters, jet, lawn mowers, microwaves, propellers.

3. Pulley: A pulley is a simple machine. It consists of a wheel mounted on an axis which is fixed to a frame called block. The wheel is free to rotate. With the help of pulley we can lift heavy loads very easily by applying little force and also change the direction of force.

Types of Pulleys:

a) Fixed Pulley: If the block of the pulley is fixed to a strong beam or ceiling, the pulley will not move and is called a "Fixed Pulley".



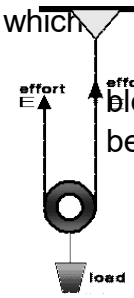
Mechanical Advantage: In fixed pulley, the effort 'E' is applied which is equal to the load 'L', if we ignore weight of rope and force of friction between rope and pulley then :

effort = load that is E = L (or) L/E = 1,

Hence **M.A = 1** This shows that fixed pulley can only change the direction of force but it will

lift load equal to the effort applied on it.

b) Movable Pulley: In a moveable pulley, one end of the rope which passes around the pulley is tied to a firm support 'O' and effort 'P' is applied to the other end. The load is hung from the hook of the block. As the load is applied by two segments of rope, the effort becomes twice of the applied value i.e.



Mechanical Advantage: In equilibrium condition we have

Load = Effort, L = 2E that is L/E = 2

Hence **M.A. = 2** This shows that a moveable pulley can lift a load double the effort.

c) Compound Pulley: A *compound pulley* is a combination of a fixed and a movable pulley system.

4. Inclined Plane: Any smooth plane surface which makes an angle q with the horizontal surface is called an "Inclined plane". Where $0^o < q < 90^o$ or values of q lies between 0^o and 90^o.

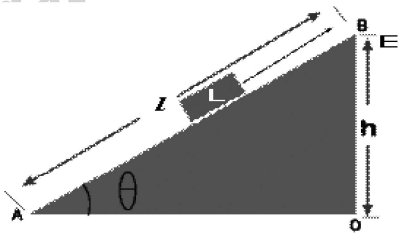
Mechanical Advantage: In the figure AB is an inclined plane which makes an angle θ with the horizontal plane. A load 'L' is being raised from A to B by applying an effort 'E'. If we neglect the force of friction between load and inclined plane

Work done by load = Work done by effort

$\Rightarrow$ Weight x height = effort x distance

L x h = E x $l \Rightarrow \frac{L}{E} = \frac{l}{h}$

$$M.A. = \frac{l}{h} = \frac{\text{length of Inclined plane}}{\text{height of Inclined plan e}}$$



Use: It is a simple machine and is used to raise heavy loads by applying little effort.

5. Wedge:

Wedge is also a type of simple machines. It is used in levers as a fulcrum. It is also used for splitting the wood in to small pieces. It is used as an Axe.

A wedge is made of two inclined planes joined together. The effort 'P' is applied on the top of the wedge placed over a wood log. The wedge enters the wood and splits it. The reaction forces **R1** & **R2** are acting perpendicular on the inclined planes of the wedge. These forces and resultant frictional forces are responsible for keeping the wedge inside the wood firmly.

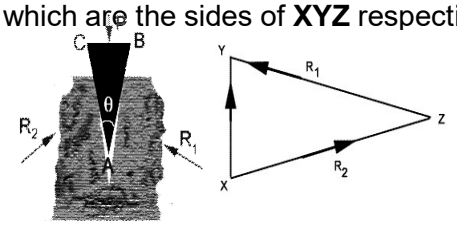
Mechanical Advantage: Let us consider that the wedge is in equilibrium under the action of forces three forces **R_1, P** and **R_2** and neglecting frictional forces. According to figure below the forces P, R_1 and R_2 are represented by the sides of **XYZ** such that effort P the reaction R_1 and R_2 are represented by **XY, YZ, ZX** which are the sides of **XYZ** respectively.

For equal sides of wedge i.e. = $R_1 = R_2 = R$

M.A. = R/P

M.A = ZX/XY Triangle ABC and triangle XYZ are similar, therefore, ZX=AC and XY=BC

M.A. = AC/BC



Mechanical advantage = length of inclined surface of wedge/thickness of wedge From above expression it is clear that if the thickness of the wedge is decreased the mechanical advantage of the wedge will increase & if the wedge is more sharper , then the mechanical advantage will increase.

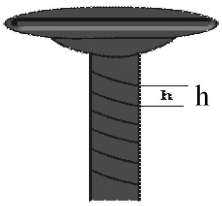
6) Screw:

Screw is one of the most important machines. It is used to hold different parts of machines together. It has vast applications in our daily life plus in industries. It is used in every type of device.

It simply consists of a threaded rod with a head known as "**Screw head**". It has a number of threads. The **perpendicular distance between two adjacent threads is known as pitch of screw.** The thread of screw can be regarded as a continuous inclined plane wrapped round a cylinder of radius **d** .

Mechanical Advantage: If we apply an effort 'P' on the head of screw then it turns one revolution and at the same time the screw moves forward in to the wood or wall through a distance equal to its pitch "h". The effort 'P' moves through a distance 2π d. The screw remains in the wood due to frictional forces between the screw and the wood. A large amount of energy changes in to heat energy during the process of screwing.

Let us assume an ideal case when there is no loss of energy then;in this condition



Output = input that is **P x** $\underline{2\Pi d}$ **= W x h** (or) **W/P =** $\underline{2\Pi d}$**/h**

Hence, the mechanical advantage of the screw will be. **M.A. =** $\underline{2\Pi d}$**/h**

The mechanical advantage of the screw depends upon the following factors.

PITCH: In order to increase mechanical advantage of screw we must use a screw of small pitch.

RADIUS OF SCREW: Larger is the radius of screw head, greater is the mechanical advantage.

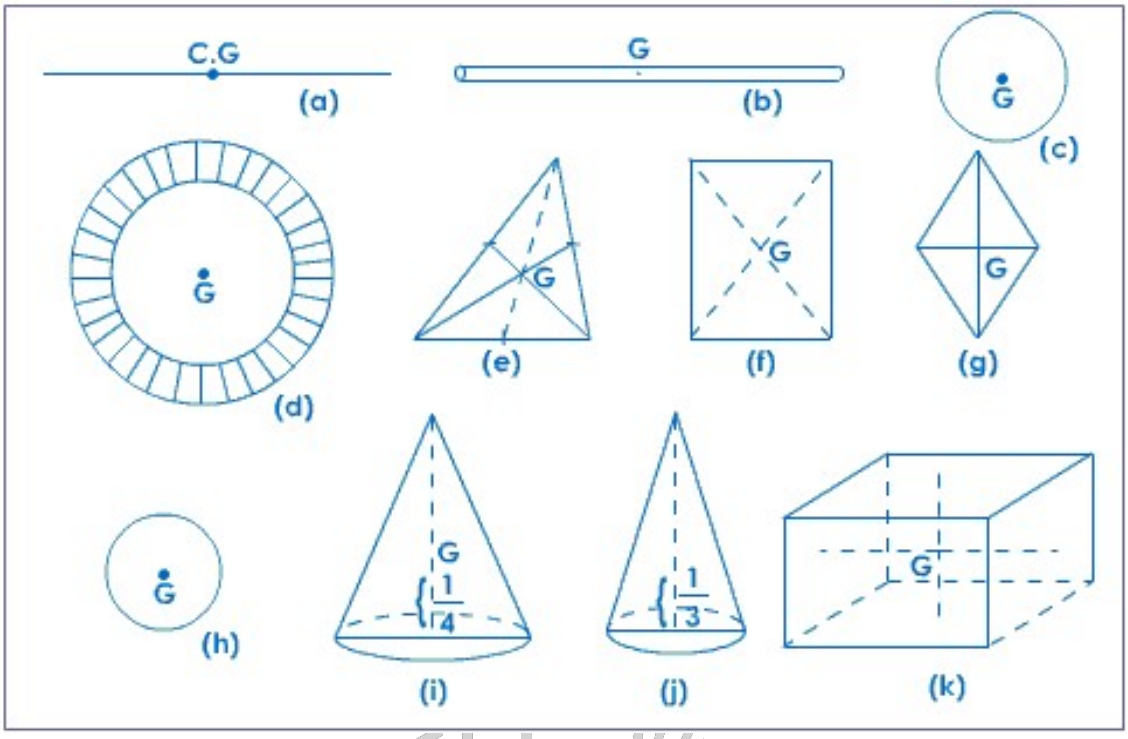
Center of gravity:

Center of gravity of body is defined as a point of application of the resultant force due to the earth's attraction on it.

1. The center of gravity is a geometric property of any object.
2. The center of gravity is the average location of the weight of an object.
3. We can completely describe the motion of any object through space in terms of the translation of the center of gravity of the object from one place to another, and the rotation of the object about its center of gravity if it is free to rotate.
4. A kite, on the other hand, rotates about the bridle point. But the trim of a kite still depends on the location of the center of gravity relative to the bridle point,because for every object the weight always acts through the center of gravity.

Location of Centre of gravity (CG):

The centre of gravity of some objects are given below in table below

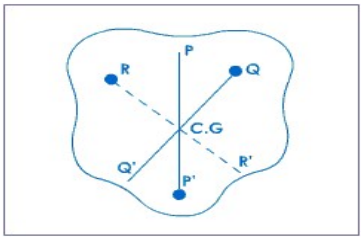


Determination of CG of irregular shape:

Aim : To determine the centre of gravity of an irregularly shaped lamina using a plumb line.

Procedure :

1. Make three holes near the edge of the lamina so that the lamina swings freely when pivoted from each hole.
2. Hang the lamina about one of its holes on a pin clamped on a retard stand.



3. Suspend a plumb line from P and mark the position PP' on the lamina.
4. Repeat the experiment by suspending the lamina from Q and R and similarly mark the plumb line positions QQ' and RR'.
5. All the three lines, PP', QQ' and RR' intersect at one point. This point of intersection of these lines is the centre of gravity of the lamina.

Stable equilibrium: A body is said to be in stable equilibrium, if it regains its original position when slightly disturbed.

Ex: 1) a bottle standing on its base

2) a cone lying on its base

3) funnel resting on its mouth.

Unstable equilibrium: If body does not regain its original position after being slightly disturbed, the equilibrium is said to be unstable.

Ex: 1) a bottle is standing on its mouth

2) a cone is erect on its vertex

3) a funnel perched on its stem.

Neutral equilibrium: If, after being slightly disturbed, a body changes its position without change in equilibrium, the equilibrium is said to be neutral.

Ex: 1) a bottle lying on its side

2) a cone lying on its curved surface

3) a funnel lying on its side.

EXAMPLES

Example 1: To pull a weed out of a garden, you can apply a force of 20 N to the shovel. The shovel applies a force of 180 N to the weed. What is the mechanical advantage of the shovel?

solution: $$M.A = \frac{\text{Output Force}}{\text{Input Force}} = \frac{180N}{20N} = 9$$

Example 2: To lift a refrigerator, you can apply a force of 20 N to the wedge. The wedge applies a force of 180 N to the weed. What is the mechanical advantage of the wedge?

Solution : $$M.A = \frac{\text{Output Force}}{\text{Input Force}} = \frac{180N}{20N} = 9$$

Example 3: A brick has is dimensions 36 cm x 24 cm x 6 cm. Find the ratio of its heights of centres of gravity, when it have maximum stability and minimum stability

Solution : lowest height of the Brick gives maximum stability.

i.e, lowest height of the Brick=6cm

height of centre of gravityh_{Max}=6cm/2=3cm

heighest height of the Brick gives minimum stability.

i.e,heighest height of the Brick=36cm

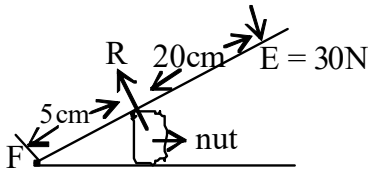
height of centre of gravityh_{min}=36cm/2=18cm.

The ratio of its heights of centres of gravity=3cm:18cm =1:6

Example 4: A cylinder of height 14 cm and diameter 4 cm. The decrease in height of its C.G when its position is changed

Solution: minimum height of C.G=4cm/2=2cm

Example 5: In the diagram shown below. The resistance (R) offered by the nut when an effort of 30N is applied.



Solution: Load x load arm = effort x effort arm

loadx5cm=30Nx25cm

load=150N

The resistance (R) offered by the nut=150N

TEACHING TASK-2

Choose the correct option:

1. To pull a weed out of a garden, you can apply a force of 50 N to the shovel. The shovel applies a force of 600 N to the weed. What is the mechanical advantage of the shovel?

   A) 12 B) 10 C) 8 D) 15

2. To pry a nail out of a wall, you can apply a force of 50 N to the hammer. The hammer applies a force of 650 N to the nail. What is the mechanical advantage of the hammer?

   A) 15 B) 10 C) 13 D) 11

3. To lift a block on a movable pulley, you can apply a force of 50 N to a rope. The rope applies a force of 700 N to the block. What is the mechanical advantage of the rope?

   A) 18 B) 10 C) 16 D) 14

4. To pull apart two pieces of wood, you can apply a force of 50 N to the lever. The lever applies a force of 650 N to the weed. What is the mechanical advantage of the lever?

   A) 15 B) 13 C) 17 D) 11

5. To lift a refrigerator, you can apply a force of 50 N to the wedge. The wedge applies a force of 550 N to the weed. What is the mechanical advantage of the wedge?

   A) 18 B) 9 C) 13 D) 11

6. To pry open a sodacan lid, you can apply a force of 50 N to a car key. The car key applies a force of 390 N to the lid. What is the mechanical advantage of the car key?

   A) 6 B) 8 C) 10 D) 12

7. To lift a bookshelf, you can apply a force of 50 N to a wedge. The wedge applies a force of 800 N to the bookshelf. What is the mechanical advantage of the wedge?

   A) 20 B) 18 C) 16 D) 22

8. To pry a wooden board off of a treehouse, you can apply a force of 50 N to a lever. The lever applies a force of 750 N to the weed. What is the mechanical advantage of the lever?

   A) 15 B) 18 C) 12 D) 13

9. To lift a television, you can apply a force of 50 N to a wedge. The wedge applies a force of 480 N to the weed. What is the mechanical advantage of the wedge?

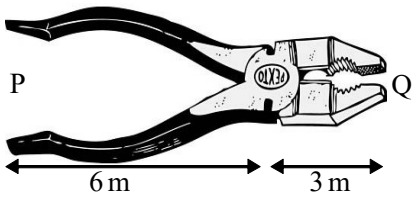
   A) 12 B) 10 C) 15 D) 22

10. To pull a tree out of a yard, you can apply a force of 50 N to the shovel. The shovel applies a force of 900 N to the weed. What is the mechanical advantage of the shovel?

    A) 20 B) 12 C) 18 D) 16

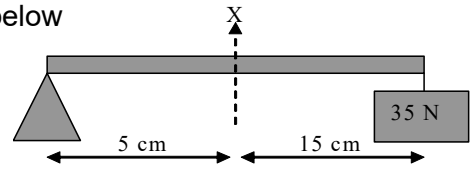
11. Based on the figure what could be the force P and Q?

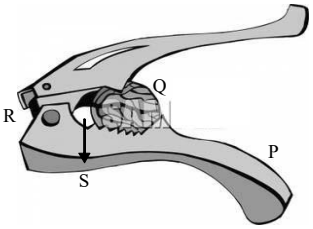
I. P=3 N, Q=6 N
II. P=6 N, Q=12 N
III. P= 9 N, Q=15 N
A) I and II only B) II and III only
C) I and III only D) I, II and IIII



12. Calculate the value of X in the figure given below

A) 140 N B) 105 N
C) 99 N D) 70 N

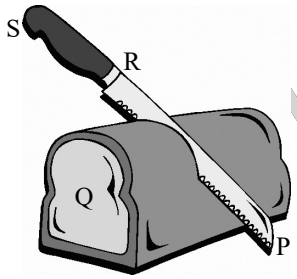


13. 

The diagram shows a lever in action.
Where is the fulcrum of the lever?
A) P B) Q C) R D) S

14. Which of the following are first class levers

I. Wheel Barrow II. Pliers III. Scissors
A) I and II only B) I and III only C) II and III only D) I, II and III

15. 

Which of the following matches its Load (L), Ful crum (F) and effort (E) correctly? For the figure shown

	L	F	E
A)	P	Q	S
B)	P	R	S
C)	Q	P	S
D)	Q	P	R

16. If a person siting in a cradle stands up

A) CG moves up B) CG moves down
C) No change in the position of CG D) may or may not change depending of person

Multiple option type:

17. A screw is preferred over a nail to insert into wood because

a) screw holds more firmly than a nail b) Less force is needed to insert a screw
c) tip of a screw has more area of contact than nail
d) fulcrum, of the screw is at its head
A) a, b correct B) b , c correct C) a , b , d correct D) b , c , d correct

18. A simple machine is a device that makes work easier by

a) multiplying force b) multiplying speed
c) applying force at a convenient point d) applying force in a convenient direction
A) a, b correct B) b , c correct C) a , b , d correct D) a, b , c , d correct

19. The effort moves through a larger distane than the load by applying a small force. identify the example of devices from the following using the type of lever described.

A) pliers B) diving board C) nut cracker D) ice tongs

A) a, b ,c correct B) b , c correct C) a , b , d correct D)a, b , c , d correct

Fill in the blanks:

20. ..... is used to seperate two objects into pieces.

21. A flat plank can be used as an .....

22. ..... is used to pull water from a well.

23. An external force applied to a simple machine to over come the load is .....

24. An egg beater is an example of .....

Assertion - A and Reason - R:

A) Both A and R are true and R is correct explanation of A

B) Both A and R are true and R is not correct explanation of A

C) A is true but R is false D)A is false but R is true

25. A: Mechanical advantge of wheel is the ratio of radius of wheel to radius of axle

R:radius of wheel 2π r

26. A: by moving the fulcurm towards load, the the mechanical advantge can be increased

R: by keeping load constant.

Match the following:

27.

Column A	***Column B***
A. Wheel and axle	1. Nut and bolt
B. Inclined Plane	2. Axe
C. Screw	3. Door knob
D. Wedge	4. Ramp

A) a-3, b-4, c-1 d-2 B) a-3, b-1, c-2, d-4

C) a-3, b-4, c-2, d-1 D) a-3, b-2, c-4, d-1

Comprehention type:

28 A simple machine is used to lift heavy load 50 N. It has a wheel of larger radius (R = 21 cm) and an axle of smaller radius (r = 14 cm) fixed on the same shaft. Wheel and axle are free to rotate about its shaft. Work done by load = work done by effort

i) The work done by load is

A) 44 J B) 22 J C) 66 J D) 33 J

ii) what is the mechanical advantage of the wheel?

A) 15 B) 1.5 C) 0.66 D) 6.6

Key: 1) A , 2) C , 3) D, 4) B, 5) D, 6) B, 7) C, 8) A , 9) B, 10) C, 11) A , 12) A , 13) C, 14) C, 15) C, 16) A , 17) C, 18) D, 19) A, 20) wedge, 21) inclined plane, 22) wheel and axle, 23) effort, 24) third order lever, 25) C, 26) A, 27) A, 28) i) A, ii) B

LEARNER'S TASK

BEGINNERS (Level - I)

Choose the correct option:

1. Where does the center of gravity of the atmosphere of the earth lie?
   A) at geometric centre of earth B) at north pole
   C) at south pole D) on equator of earth
2. A road roller is in
   A) stable equilibrium B) unstable equilibrium
   C) Neutral equilibrium D) none of the above
3. If water leaks out from a hole at the bottom of a hallow sphere full of water then
   A) CG shifts downwards B) CG moves upwards
   C) no change in the position of CG
   D) CG first shifts downwards then rises up to original position
4. The CG of uniform circular lamina and CG of an annular ring of same radius
   A) coincide B) do not coincide C) may or may not coincide D) can't say
5. The CG of a regular cuboid is
   A) at the centre of the large face B) at the centre of a small face
   C) at one of the corners D) at the point of intersection of body diagonals
6. Where will be CG of a triangle lies
   A) at one of the vertex B) at centroid C) at mid point of its one of the side D) none
7. As the inclination of the screw increases, the distance between the threads
   A) increases B) decreases C) remains the same D) may increase or decrease
8. Distance between two succsive threads of a screw is called
   A) arm length B) principle of screw C) pitch of screw D) least count
9. Example of wheel and axle is
   A) egg beaters B) egg whiskers C) clocks D) electric saw
10. Screw is a/an
    A) lever B) gear C) inclined plane D) wheel
11. Modified inclined plane is a
    A) lever B) wheel C) screw D) axle
12. mechanical advantage of wheel and axle is (R = radius of the wheel, r = radius of the axle
    A) R + r B) R/r C) r/R D) R - r

ACHIEVERS (Level - II)

Multiple option type:

13. Which of the following statements is correct ?
    a) In a first order lever, the fulcrum is placed between the effort and the load
    b) The mechanical advantage of a second class levers is greater than 1 as load is situated in between to effort and fulcrum
    c) An inclined plane in a hospital, helps in pushing a wheel chair easily
    d) A crow bar is an example of second class lever
    A) a, b correct B) b , c correct C) a , b , d correct D) a, b , c , correct

14. Which of the follwing devices have the fulcrum between the load and the effort ?
    a) seaSaw b) Screw c) Scissors d) Crane
    A) a, b correct B) b , c correct C) a ,c correct D)a , c , d correct

15. Which of these devices have the load between the fulcrum and effort ?
    a) nut cutter b) Scissors c) fishing rod d) wheel barrow
    A) a, b correct B) b , c correct C) a , d correct D)a, b , c , d correct

Fill in the blanks:

16. In villages ---------- is used for lifting water from a well.
17. A pulley consists of a wheel mounted on an axis which is fixed to a frame is called ---
18. ..... is used for splitting the wood in to small pieces

Assertion - A and Reason - R:

A) Both A and R are true and R is correct explanation of A
B) Both A and R are true and R is not correct explanation of A
C) A is true but R is false D)A is false but R is true

19. A: fulcurm is in between load and effort in class 1 lever
    R: fulcurm is used find the mechinical advantge
20. A: by moveing the fulcurm towards load, the the mechanical advantge can be increased
    R: Length of the effort arm is increased

Match the following:

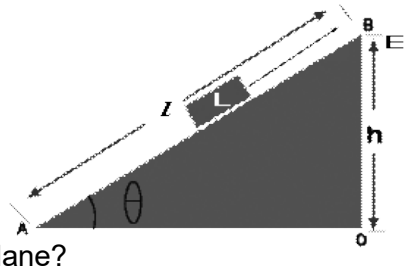
21.

Column A	*Column B*
a. Wheel and axle	1. M.A = 1
b. *Fixed Pulley*	2. $M.A = \frac{\text{length of inclined surface}}{\text{thickness}}$
c. *Movable Pulley*	3.M.A. = 2
d. Wedge	4. M.A. = radius of wheel / radius of axle

A) a-3, b-4, c-1 d-2 B) a-3, b-1, c-2, d-4 C) a-3, b-4, c-2, d-1 D) a-4, b-1, c-3, d-2

Comprehention type:

22. In the figure AB is an inclined plane which makes an angle 45° with the horizontal load is 40 N being raised from A to B by applying an effort 'E'. If we neglect the force of friction between load and inclined plane, AB=2 m



i) Find the height of the incined plane OB

A) $\sqrt{2}$ m B) 4 m C) 1 m D) 6 m

ii) what is the mechanical advantage of the inclined plane?

A) 2 B) 4 C) $\sqrt{2}$ D) 6

Key: 1) A, 2) C, 3) D, 4) A, 5) D, 6) B, 7) B, 8) C, 9) C, 10) C, 11) C, 12) B, 13) D, 14) C, 15) C,16) wheel and axle, 17) block, 18) Wedge 19) A , 20) A, 21) D, 22) i)A , ii) C

EXPLORERS (Level - III)

1. The distance of CG from one of the corner of a lamina in the form of a square of length 10 cm is

A) $5\sqrt{2}$ cm B) $\sqrt{2}$ cm D) 10 cm D) 5 cm

2. A brick has is dimensions 16 cm x 8 cm x 4 cm. Find the ratio of its base areas , when it has maximum stability and minimum stability

A) 4 : 1 B) 1 : 4 C) 1 : 2 D) 2 : 1

RESEARCHERS (Level - IV)

3. A brick has is dimensions 16 cm x 8 cm x 4 cm. Find the ratio of its heights of centres of gravity, when it have maximum stability and minimum stability

A) 1 : 4 B) 2 : 3 C) 1 : 2 D) 2 : 1

4. A cylinder of height 12 cm and diameter 5 cm. The decrease in height of its CG when its position is changed

A) 6 cm B) 3.5 cm C) 2.5 cm D) 2 cm

Key: 1) A, 2) A, 3) A ,4) C,

Archieves:

1. A screw is essentially a lan:

A) wheel and axle B) lever C) pulley D) inclined plane

2. The pulley and lever uses mechanical energy to move an object.The pulley and lever are examples of [NSO-2010]

A) circuits B) magnets C) measurement tools D) simple machines