Machine

1. **What is Machine?**
   Ans. A machine is a device by which we can either overcome a large resistive force (or load) at some point by applying a small force (or effort) at a convenient point and in a desired direction or by which we can obtain again in speed.

2. **What are the functions of a Simple Machine?**
   Ans. The various functions of machines are·. useful to us in the following four ways:
   a. In lifting a heavy load by applying less effort.
   b. In changing the point of application of effort to a convenient point.
   c. In changing the direction of effort to a convenient direction.
   d. For obtaining a gain in speed (i.e., a greater movement of load by a smaller movement of effort)

3. **What is Load?**
   Ans. The resistive or opposing force to be overcome by a machine is called load (L).

4. **What is Effort?**
   Ans. The force applied on the machine to overcome the load is called effort (E).

5. **What is Mechanical Advantage?**
   Ans. The ratio of load. to effort is called the mechanical advantage of the machine.

   Mechanical Advantage (M.A) = Load (L) / Effort (E)

   - While using a machine to overcome a certain load, if the effort needed is less than the load, the machine has mechanical advantage greater than 1.
     A machine having mechanical advantage greater than I. acts as a Force Multiplier.
   - While if it needs an effort greater than the load, it has mechanical advantage less than 1.
     While a machine having mechanical advantage less than 1, gives gain in speed.
   - A machine has mechanical advantage equal to 1, if the effort needed; is, equal to the load.
     The machine having mechanical advantage equal to I, is generally used to change the direction of effort as there is no gain in force or speed.

     Since mechanical advantage is the ratio of two similar quantities (forces). so, it has no unit.

6. **What is Velocity Ratio?**
   Ans. The ratio of the velocity of effort to the velocity of load; is called the velocity ratio of machine.
   i.e., **Velocity Ratio (V.R) = Velocity of effort (V_E) / Velocity of Load (V_L)**
   If d_L and d_E are the distance moved in the same time t by the load and the effort respectively, then
   - Velocity of Load (V_L) = d_L/t
   - Velocity of effort (V_E) = d_E/t
   - Or **V.R. = d_L / d_E**

   Thus, velocity ratio is also defined as the ratio of the displacement of effort to the displacement of load.
   Since velocity ratio is al o the ratio of two similar quantities (distance so it has no unit

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7. **What is Work Input?**
   Ans. The work done on the machine by the effort, is catted Work Input (W_{Input})
   Work input = Work done by the effort

8. **What is Work Output?**
   Ans. The work done by the machine on the load, is called Work Output (W_{Output})
   Work output =work done on the load.

9. **What is Efficiency?**
   Ans. Efficiency of a machine is the ratio of the work done the the load by the machine to the work done on the machine by the effort.
   In other words, efficiency is the ratio of work output to work input.
   It is denoted by the symbol (ŋ)

   Efficiency (ŋ) = Work Output (W_{Output}) / Work Input (W_{Input})

   Efficiency (ŋ) $= \dfrac{\textbf{Work Output } (W_{Output})}{\textbf{Work Input } (W_{Input})} \times 100\%$
   It has no unit since it is also the ratio of two similar quantities (i.e., work).

10. **What is Effort Point and Load Point of Machine?**
    Ans. The point at which energy is supplied to a machine by applying effort is called the Effort Point of the Machine.
    The point where energy is obtained by overcoming the load, is called the Load Point.

11. **What is Ideal Machine?**
    Ans. An Ideal Machine is that in which there is no loss of energy in any manner. Here the work output is equal to the work input
    i.e., the efficiency of an ideal machine is 100%

12. **What is Actual Machine?**
    Ans. In an actual machine, the output energy is always less than the input energy i.e., there is always some loss of energy during its operation.

13. **The loss of energy in a machine is depends on which factors?**
    Ans. The loss of energy in a machine is due to the following three reasons:
    a. the moving parts in it are neither. weightless nor smooth (or frictionless).
    b. The string, in it (if any) is not perfectly elastic, and
    c. Its different parts are not perfectly rigid.

14. **Why the moving parts of the machine heated?**
    Ans. The most prominent loss in energy is in overcoming the force of friction between the moving parts of a machine. The energy so lost appears as heat due to which the moving parts of the machine get heated.

15. **The efficiency of a machine is 80%. What is it means?**
    Ans. If a machine is 80% efficient, it implies that at 80% of the total energy supplied to the machine at the effort point is obtained as useful energy at the Load point.
    The remaining 20% of the energy supplied is lost in overcoming the force of friction etc. and it appears as heat energy in its different parts due to which they get heated up.

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16. **Determine the relation between Efficiency (ŋ), Mechanical Advantage (M.A) and Velocity Ratio (V.R).**
Ans. Let a machine overcomes a load L by the application of effort E. Let the displacement of effort be d_E and the displacement of the load be d_L in time t.
Work input = effort × displacement of effort
$= E \times d_E$
Work output = load × displacement of load
$= L \times d_L$
Efficiency **η = work output / work input**
$\eta = (L \times d_L) / (E \times d_E)$
$= L / E \times d_L / d_E$
$= L / E \times 1 / (d_E / d_L)$
But L / E = M.A.
d_E / d_L = V.R.
η = M.A. / V.R.
M.A. = V.R. × η
Hence, the mechanical advantage of a machine is equal to the product of its efficiency and velocity ratio.

17. **How is the mechanical advantage related to the velocity ratio for an actual machine? State whether the efficiency of such a machine is equal to 1, less than 1 or more than**
Ans. For an actual machine, the mechanical advantage is equal to the product of its efficiency and velocity ratio.
M.A. = V.R. × **η**
The efficiency of such a machine is always less than 1

18. **State one reason why is mechanical advantage less than the velocity ratio for an actual machine.**
Ans. For an actual machine, the output work is always less than the input work, so the efficiency is always less than 1 because there is a loss of energy due to friction.

19. **What is a lever?**
Ans. A lever is a rigid, straight or bent bar which is capable of turning about a fixed axis.

20. **State the Principle of a Lever?**
Ans. A lever works on the principle of moments. For an ideal lever, it is assumed that the rod is weightless and there is no friction at the fulcrum. In the equilibrium position of the lever, by the principle of moments,
Moment of load about the fulcrum = Moment of the effort about the fulcrum

21. What is Mechanical Advantage of Liver?
Ans. The mechanical advantage of a lever is equal to the ratio of the length of its effort arm to the length of its load arm.

22. Livers are how many types?
Ans. Depending upon the relative positions of effort, load and fulcrum, there are following three types of levers
(1) Class I levers,
(2) Class II levers, and
(3) Class II levers.

23. **Name the three classes of levers and state how are they distinguished. Give two examples of each class.**
Ans. The following are the three classes of levers
(i) **Class I levers:** In this type of the levers, the fulcrum F is in between the effort E and the load L.
For class I levers, the mechanical advantage and velocity ratio can·. have any value either greater than 1, equal to 1 or less than 1.
Example: claw hammer, a beam of a physical balance, crowbar, a seesaw

(ii) **Class II levers:** In these types of levers, the load L is in between the effort E and the fulcrum F. Thus, the effort arm is always longer than the load arm.
The mechanical advantage and velocity ratio of Class II levers are always more than 1.
In other words, a class II lever always acts as a force multiplier.
Example: a wheelbarrow, a paper cutter, a door, a nutcracker

(iii) **Class III levers:** In these types of levers, the effort E is in between the fulcrum F and the load L. Thus, the effort arm is always smaller than the load arm.
The mechanical advantage and velocity ratio of class Ill levers are always less than 1.
Example: fire tongs, knife, fishing rod, sugar tongs

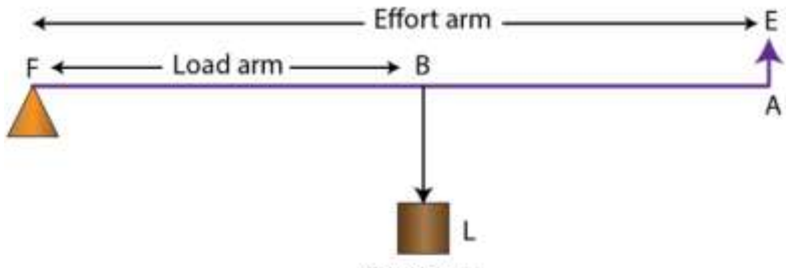
24. **Give one example each of a class I lever where the mechanical advantage is (a) more than 1, and (b) less than 1.**
Ans. (a) For more than one mechanical advantage: shears used for cutting the thin metal sheets.
(b) For less than one mechanical advantage: a pair of scissors whose blades are longer than its handles.

25. **What is the use of lever if its mechanical advantage is (a) more than 1, (b) equal to 1, and (c) less than 1?**
Ans. (a) When the mechanical advantage is more the 1, the lever serves as force multiplier means it enables us to overcome a large resistive force by a small effort.
(b) When the mechanical advantage is equal to 1, the lever has effort arm and load arm of equal lengths.
(c) When the mechanical advantage is less than 1, the levers are used to obtain the gain in speed. This implies that the displacement of load is more as compared to the displacement of effort.

26. **Explain why scissors for cutting cloth may have blades longer than the handles, but shears for cutting metals have short blades and long handles.**
Ans. A pair of scissors which is used to cut a piece of cloth has blades longer than the handles so that the blades move longer on the cloth when the handles are moved a little. Shears used for cutting metals have short blades and long handles because it enables us to overcome large resistive force by a small effort.

27. **Which type of lever has a mechanical advantage always more than 1? What change can be made in this lever to increase its mechanical advantage?**
Ans. The mechanical advantage of Class II levers is always more than 1
We can increase the length of effort arm in this lever to increase its mechanical advantage.

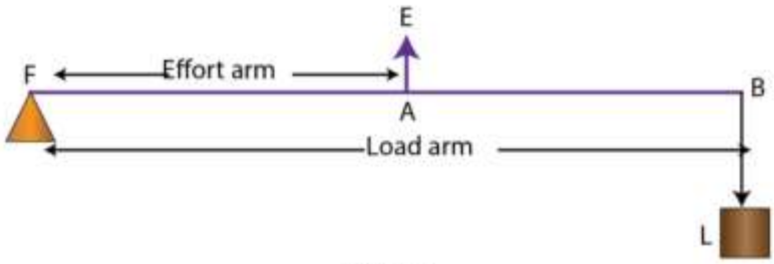
28. **Draw a diagram of a lever which is always used as a force multiplier. How is the effort arm related to the load arm in such a lever?**
Ans.



(b) Class II

In this type of lever, the effort arm is longer than the load arm.

29. **State the kind of lever which always has the mechanical advantage less than 1. Draw a labelled diagram of such a lever.**
Ans. The mechanical advantage of Class III levers is always less than 1.



Class III

30. **Explain why the mechanical advantage of the class III lever is always less than 1.**
Ans. In Class III lever, the effort E is in between the fulcrum F and the load L. So, the effort arm is always smaller than the load arm. Hence, M.A. < 1.

31. **Give an example of each class of lever in a human body.**
Ans. The examples of each class of lever in a human body are as follows
(i) The action of nodding of the head is a Class I lever. Here the spine acts as the fulcrum, load is at its front part and effort is at its rear part.
(ii) Raising the weight of the body on toes is a Class II lever. Here the fulcrum is at toes at one end, the load is in the middle and effort by muscles is at the other end.
(iii) Raising a load by forearm is a Class III lever. Here the elbow joint acts as fulcrum at one end, biceps exert the effort in the middle and a load on the palm is at the other end.

32. **What is Pulley?**
Ans. It is a metallic (or wooden) disc with a grooved rim. A string or rope is passed around the groove at the rim. The disc rotates about an axle passing through its centre. The axle is fixed rigidly to a frame by means of nails.

33. **How can we use a Single Pulley?**
Ans. A single pulley can be used in two ways· :
(1) as a fixed pulley by keeping its axis of rotation stationary i.e., keeping its frame fixed in position, and
(2) as a movable pulley by changing its axis of rotation i.e., keeping the whole frame movable.

34. **What is a Single Fixed Pulley? State its one use.**
Ans. A pulley which has its axis of rotation stationary in position, is called a fixed pulley.
A fixed pulley is used only to change the direction of effort to be applied, i.e., with its use, the effort can be applied in a more convenient direction.
This type of pulley is used lifting a small load such as a water bucket.

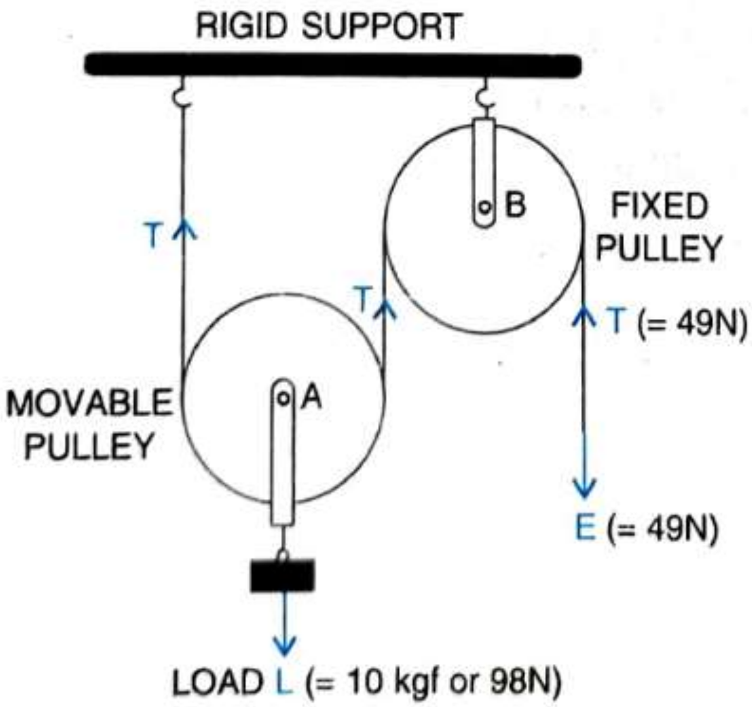
35. **What is the ideal mechanical advantage of a single fixed pulley? Can it be used as a force multiplier?**
Ans. The mechanical advantage of a single fixed pulley is 1.
No, it cannot be used as a force multiplier.

36. **What is Mechanical Advantage, Velocity Ratio and Efficiency of Single Fixed Pulley?**
Ans: Mechanical Advantage = Load L / Effort E = 1
Velocity Ratio = 1
Efficiency = 1 or 100%

37. **What is Single Movable Machine?**
Ans. A pulley whose axis of rotation is movable (i.e., not fixed in position) is called a Movable Pulley.

38. **What is Mechanical Advantage, Velocity Ratio and Efficiency of Single Movable Pulley?**
Ans. Mechanical Advantage = 2
Velocity Ratio = 2
Efficiency = 1 or 100%

39. **How can we change the direction of effort by using a movable pulley?**
Ans. With a single movable pulley, the effort is to be applied in upward direction. However, it is inconvenient to apply effort in an upward direction, therefore a movable pulley A is used along with a fixed pulley; B to change the direction of effort as· shown. in Fig. The load is attached to the axle of the movable pulley A and the effort is applied in the downward direction at the free end of the string passing over the fixed pulley B. One can also use his own weight as effort which will be quite convenient.



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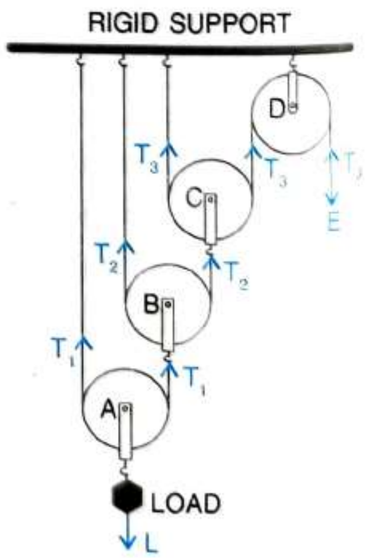
40. **State four differences between a single fixed pulley and a single movable pulley.**
Ans.

Single fixed pulley	Single movable pulley
It is fixed to a rigid support	It is not fixed to a rigid support
Its ideal mechanical advantage is 1	Its ideal mechanical advantage is 2
Its velocity ratio is 1	Its velocity ratio is 2
The weight of pulley itself does not affect its mechanical advantage	The weight of pulley itself reduces its mechanical advantage
It is used to change the direction of effort from upwards to downwards	It is used as a force multiplier

41. **How can we make a Combination of Pulleys?**
Ans. The combination of Pullies can be made in two ways:
a. using one fixed pulley and several movable pulleys attached to the same rigid support.
and
b. using· several pulleys in two blocks (of which lower block is movable and upper block is fixed known as block and tackle system.)

42. **How can we make a Combination Pulleys by using one fixed Pulley and other movable pulley?**
Ans. This figure shows a system of three movable pulleys A, B and C used with a fixed pulley D. Each movable pulley is sus pended with a separate string around its rim. The tension is
same in one string but it is different in different strings.



- __Mechanical Advantage:__
  The pulley is in equilibrium
  Effort $E = T_3$ ....(i)
  The two segments of the string passing over the pulley A supports the load L, therefore tension T_1 is in this string given as:
  $2T_1=L$
  Or $T_1=L/2$
  Similarly, two segments of the string passing over the pulley B supports the tension T_1, so tension T_2 in this string given as
  $2T_2=T_1$
  Or $T_2=T_1/2=L/2^2$
  Similarly, tension T_3 in the string passing over the pulley C is given as:
  $2T_3=T_2$
  Or $T_3=T_2/2=L/2^3$ .... (ii)

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So from the eq. (i) and (ii) we get

$E=L/2^3$

Now Mechanical Advantages

MA = Load (L) / Effort (E)
$MA= 2^3\times T_3/T_3$
$MA=2^3$

In general, if there are n movable pulleys with one fixed pulley, the mechanical advantage is then,

$MA= 2^n$

- <u>Velocity Ratio</u>

As one end of each string passing over a movable pulley is fixed, so the other end of the string moves up twice the distance moved by the axle of the movable pulley. If the load L attached to the pulley A moves up by a distance x i.e. $d_L = x$, the string connected to the axle of pulley B moves up by a distance $2\times x = 2x$, the string connected to the axle of pulley C moves up by a distance $2\times 2x = 2^2x$ and the end of the string passing over the fixed pulley D moves up by a distance $2\times 2^2x = 2^3x$, i.e. the effort E moves by a distance 2^3x or $d_E = 2^3x$.

So,
Velocity Ratio V.R
= distance moved by the effort d_E / distance moved by the load d_L
$=2^3x/x = 2^3$

In general, if there are n movable pulleys connected to a fixed pulley, then velocity ratio is

$V.R = 2^n$

Efficiency= $MA / VR = 2^n / 2^n = 1$ or 100%

43. **How can we make a Combination Pulleys by using several pullies in two blocks?**
Ans. In this system of pulleys, two blocks of pulleys are used. One block (upper) having several pulleys is attached to a rigid support (i.e .. fixed) and the other block (lower) having several pulleys is movable. This arrangement is called the block and tackle system.
For the convenience of applying effort in downward direction, the number of pulleys in the movable lower block is kept either equal to or one less than the number of pulleys in the fixed upper block. A strong inextensible string (or rope) of negligible mass passes around all the pulleys. One end of the string is attached to the hook of the lower block or or it is attached to the hook of the upper block so as to apply the effort in downward direction.
The load L is attached to the movable lower block and the effort E is applied at the free ·end of the string. The tension along the entire · length of the string is the same and is denoted as T.

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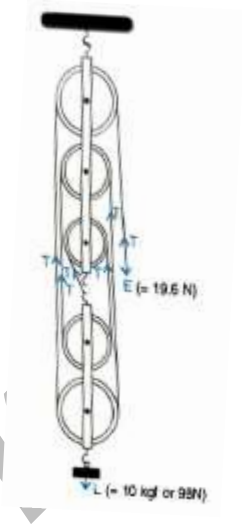
- **Mechanical Advantage:**
  In tension in the five segment of the string supports the load L. therefore
  L = 5T and E = T
  So E = L/5

  And M.A = L/E = 5T/T = 5

  In general, if the total number of pulleys used in both the blocks is n and the effort is applied in downward direction, then the tension in the n segments of the string supports the load, therefore,
  L = nT and E = T

  So E = L/n

  And **M.A = L/E = nT/T = n**

  MA = Total Number of pulleys in both the block

- **Velocity Ratio**
  In a system of n pulley if the load moves up through a distance each segment of the string supporting the load is loosened by a length d, so the effort end moves through a distance nd, i.e.,
  if $d_L = d$,
  $d_E = nd$.

  Velocity Ratio= $d_E / d_L = nd/d = n$

  Efficiency η **=M.A / V.R = n/ n =1 or 100%**

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Numerical

1. **A crowbar of length 120 cm has its fulcrum situated at a distance of 20 cm from the load. Calculate the mechanical advantage of the crowbar.**
   Solutions:
   Given
   Total length of a crowbar = 120 cm
   Load arm = 20 cm
   Effort arm = 120 – 20
   = 100 cm
   Mechanical advantage M.A. = Effort arm / Load arm
   M.A. = 100 / 20
   = 5
2. **A pair of scissors has its blades 15 cm long, while its handles are 7.5 cm long. What is its mechanical advantage?**
   Solutions:
   Given
   Effort arm = 7.5 cm
   Load arm = 15 cm
   Mechanical advantage M.A = Effort arm / Load arm
   = 7.5 / 15
   = 0.5

3. **A force of 5kgf is required to cut a metal sheet. A shears used for cutting the metal sheet has its blades 5 cm long, while its handle is 10 cm long. What effort is needed to cut the sheet?**
   Solutions:
   Given
   Effort arm = 10 cm
   Load arm = 5 cm
   Mechanical advantage M.A. = Effort arm / Load arm
   = 10 / 5
   = 2
   To find effort, we have
   Effort = Load / M.A
   = 5 / 2
   = 2.5 kgf

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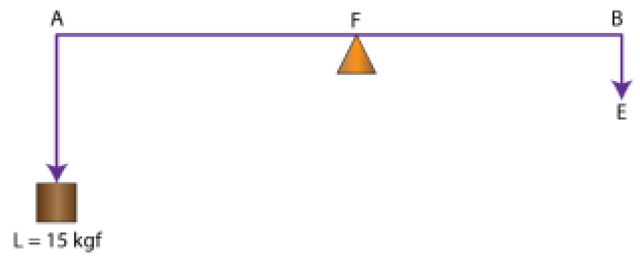
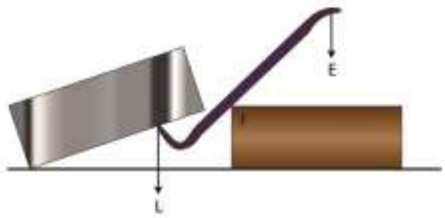
4. The diagram below shows a lever in use.
(a) To which class of lever does it belong?
(b) If AB =1 m, AF= 0.4 m, find its mechanical advantage.
(c) Calculate the value of E.



Solutions:
(a) This belongs to a Class I lever
(b) Given AB = 1m
AF = 0.4 m
BF = 0.6 m
Mechanical advantage M.A = BF / AF
= 0.6 / 0.4
= 1.5
(c) Given Load = 15 kgf
Effort = Load / M.A
= 15 / 1.5
= 10 kgf

5. A man uses a crowbar of length 1.5 m to raise a load of 75kgf by putting a sharp edge below the bar at a distance 1 m from his hand. (a) Draw a diagram of the arrangement showing the fulcrum (F), load (L) and effort (E) with their directions. (b) State the kind of lever. (c) Calculate: (i) load arm, (ii) effort arm, (iii) mechanical advantage, and (iv) the effort needed.

Ans. Crowbar is a class I lever
Given
(i) Total length of crowbar = 1.5 m
Effort arm = 1 m
Load arm = 1.5 – 1
= 0.5 m
(ii) Effort arm = 1 m
(iii) Mechanical advantage M.A. = Effort arm / Load arm
= 1 / 0.5
= 2
(iv) The effort needed
Effort = Load / M.A.
= 75 / 2
= 37.5 kgf



6. **A pair of scissors is used to cut a piece of a cloth by keeping it at a distance 8.0 cm from its rivet and applying an effort of 10 kgf by fingers at a distance 2.0 cm from the rivet.**
   (a) Find: (i) the mechanical advantage of scissors and (ii) the load offered by the cloth.
   (b) How does the pair of scissors act: as a force multiplier or as a speed multiplier?

   Solutions:
   Effort arm = 2 cm
   Load arm = 8.0 cm
   Given effort = 10 kgf
   (i) Mechanical advantage M.A. = Effort arm / Load arm
   = 2 / 8
   = 0.25
   (ii) Load = M.A. × effort
   = 0.25 × 10
   = 2.5 kgf
   The pair of scissors acts as a speed multiplier since the mechanical advantage is less than 1 i.e M.A < 1

7. **A 4 m long rod of negligible weight is to be balanced about a point 125 cm from one end and a load of 18 kgf is suspended at a point 60 cm from the support on the shorter arm.**
   (a) If a weight W is placed at a distance of 250 cm from the support on the long arm, Find W.
   (b) If a weight 5 kgf is kept to balance the rod, find its position.
   (c) To which class of lever does it belong?

   Solutions:
   Given
   Total length of rod = 4 m = 400 cm
   (a) 18 kgf load is placed at 60 cm from the support.
   W kgf weight is placed at 250 cm from the support.
   According to the principle of moments
   18 × 60 = W × 250
   W = 4.32 kgf
   (b) Given W = 5 kgf
   18 kgf weight is placed at 60 cm from the support.
   Let 5 kg of weight is placed at d cm from the support.
   According to the principle of moments
   18 × 60 = 5 × d
   d = 216 cm from the support on the long arm
   (c) It belongs to class I lever

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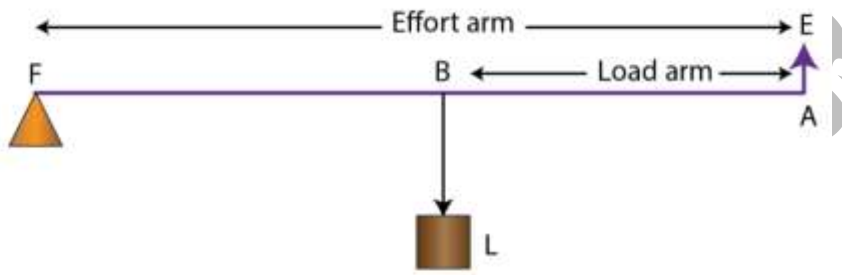
8. A lever of length 9 cm has its load arm 5 cm long and the effort arm is 9 cm long. (a) To which class does it belong? (b) Draw diagram of the lever showing the position of fulcrum F and directions of both the load L and effort E. (c) What is the mechanical advantage and velocity ratio if the efficiency is 100%? (d) What will be the mechanical advantage and velocity ratio if the efficiency becomes 50%?

Solutions:
(a) Length of the lever is equal to the effort arm. The effort arm is also more than the load arm. Hence this is a class II lever.
(b)

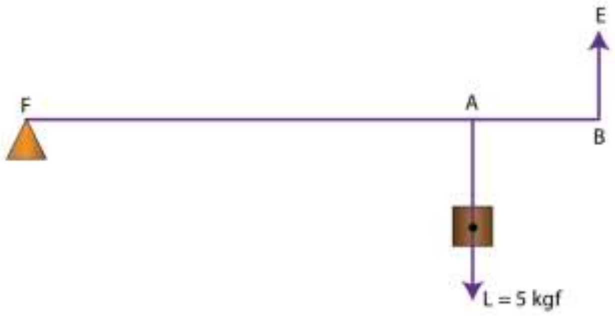


(b) Class II

(c) Mechanical advantage is
M.A. = Effort arm / Load arm
= 9 cm / 5 cm
M.A. = 1.8
Relation between mechanical advantage, efficiency and velocity ratio is
M.A. = $\eta \times$ V.R.
M.A.= V.R. (η = 100% = 1)

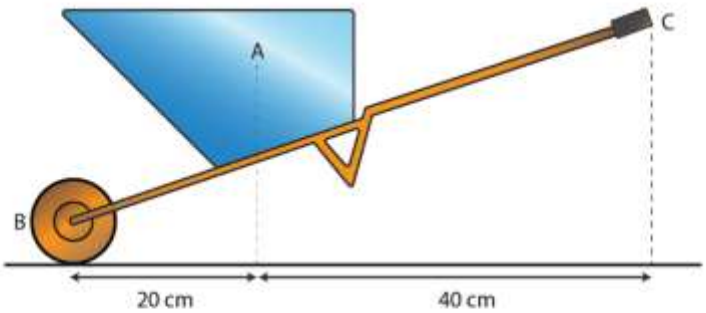
(d)When efficiency reduces, its mechanical advantage reduces and velocity ratio remains the same. So, when efficiency becomes 50%, M.A. = 0.9 and V.R. = 1.8

9. The diagram below shows a lever in use.
(a) To which class of lever does it belong?
(b) If FA = 80 cm, AB = 20 cm, find its mechanical advantage.
(c) Calculate the value of E.



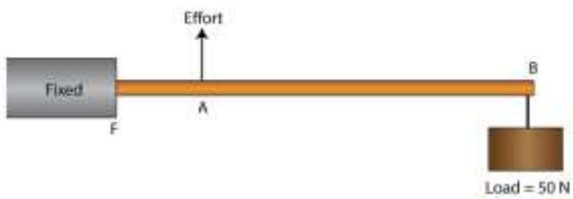
Solutions:
(a) It belongs to class II lever.
(b) Given FA = 80 cm
AB = 20 cm
BF = FA + AB
= 100 cm
Mechanical advantage M.A. = BF / AF
= 100 / 80
= 1.25
(c) Effort (E) = Load (L) / M.A.
= 5 / 1.25
= 4 kgf

10. The figure shows a wheelbarrow of mass 15 kg carrying a load of 30 kgf with its centre of gravity at A. The points B and C are the centre of wheel and tip of the handle such that the horizontal distance AB = 20 cm and AC = 40 cm.
Find: (a) the load arm, (b) the effort arm, (c) the mechanical advantage, and (d) the minimum effort required to keep the leg just off the ground.



Solutions:
(a)
(i) Load arm AF = 20 cm
(ii) Effort arm CF = 60 cm
(iii) Mechanical advantage M.A. = CF / AF
= 60 / 20
= 3
(iv) Total load = 30 + 15
= 45 kgf
Effort = Load / M.A
= (30 + 15) / 3
= 15 kgf

11. The diagram below shows the use of a lever.
(a) State the principle of moments as applied to the above lever.
(b) To which class of lever does it belong? Give an example of this class of lever.
(c) If FA = 10cm, AB = 490cm, calculate: (i) the mechanical advantage, and (ii) the minimum effort required to lift the load (= 50N).



Solutions:
(a) According to the principle of moments
Moment of the load about the fulcrum = moment of the effort about the fulcrum
load × FB = Effort × FA
(b) It belongs to Class III lever. The example of this lever is a knife.
(c) Given FA = 10 cm
AB = 490 cm
BF = 490 + 10
= 500 cm
The mechanical advantage
M.A= AF / BF
= 10 / 500
= 1 / 50
The minimum effort required to lift the load
Effort = Load / M.A
= 50 / 1 / 50
= 50 × 50
= 2500 N

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12. **A fire tongs has its arms 20 cm long. It is used to lift a coal of weight 1.5kgf by applying an effort at a distance 15 cm from the fulcrum. Find: (i) the mechanical advantage of fire tongs and (ii) the effort needed.**
Solutions:
Given
Fire tongs has its arms = 20 cm
Effort arm = 15 cm
Load arm = 20 cm
(i) Mechanical advantage M.A. = Effort arm / Load arm
= 15 / 20
= 0.75
(ii) Effort = Load / M.A
= 1.5 / 0.75
= 2.0 kgf
13. **A woman draws water from a well using a fixed pulley. The mass of the bucket and water together is 6 kg. The force applied by the women is 70 N. calculate the mechanical advantage. (Take g = 10 m s^{-2}).**
Solutions:
Given
The force applied by the woman is = 70 N
The mass of bucket and water together is = 6 kg
Total load = 6 × 10
= 60 N
Mechanical advantage M.A = load / effort
= 60 / 70
= 0.857
14. **A fixed pulley is driven by a 100 kg mass falling at a rate of 8.0 m in 4.0 s. It lifts a load of 75.0 kgf. Calculate:**
(a) The power input to the pulley taking the force of gravity on 1 kg as 10 N.
(b) the efficiency of the pulley, and
(c) the height to which the load is raised in 4.0 s.
Solutions:
(a) Effort driving the pulley is,
E = mg
= 100 × 10
= 1000 N
Input power is,
P_{in} = 2000 W
(b) Load pulley by the pulley is,
L = 75 × 10
= 750 N
Hence, M.A is,
M.A = L / E
= 750 / 1000
= 0.75
When the effort moves by a distance d downwards, the load moves by the same distance upwards. Thus,
V.R = 1
Therefore efficiency is,
η = M.A. / V.R.
= 0.75 / 1
= 0.75
= 75%
(c) The load moves by the same distance upwards when the effort moves by a distance d downwards. So, height to which the load moves is 8 m.

15. **A single fixed pulley and a movable pulley both are separately used to lift a load of 50 kgf to the same height. Compare the efforts applied.**
Solutions:
In case of a single fixed pulley, the effort i.e E_f needed to lift a load is equal to the load itself.
Hence, $E_f = L$
$E_f = L$
The effort needed to lift a load is equal to half the load
$E_m = 50$ kgf / 2
= 25 kgf
Hence, the ratio of efforts applied by the respective pulley is
$E_f / E_m = 2 / 1$
Therefore $E_f : E_m = 2: 1$

16. **In a block and tackle system consisting of 3 pulleys, a load of 75 kgf is raised with an effort of 25 kgf. Find: (i) the mechanical advantage, (ii) the velocity ratio, and (iii) the efficiency.**
Solutions:
Given,
Load = 75 kgf
Effort = 25 kgf
n = 3
M.A. = Load / Effort
= 75 / 25
= 3
M.A. = n = 3
Velocity V.R. = n = 3
Efficiency η = M.A. / V.R.
= 3 / 3
= 1 or 100%

17. **A block and tackle system has 5 pulleys. If an effort of 1000 N is needed in the downward direction to raise a load of 4500 N, calculate:**
(a)The mechanical advantage,
(b)The velocity ratio and,
(c)The efficiency of the system.
Solutions:
Given,
A block and tackle system has 5 pulleys (n = 5)
Effort = 1000 N
Load = 4500 N
(a) The mechanical advantage
M.A. = Load / Effort
= 4500 / 1000
= 4.5
(b) The velocity ratio = n = 5
(c) The efficiency of the system η = M.A. / V.R
= 4.5 / 5
= 0.9
= 90%