4. Energy

- When we are pushing a wall we are not doing any work as the position of wall is not change i.e. wall has not moved in the direction of force.
- WORK: “is said to be done if on applying force on a body, the body moves (or changes it position) from it place in the direction of force. W = F × d
  Or
  “Work is said to be done by a force applied on a body, if it changes its size or shape.”
- FACTORS AFFECTING THE AMOUNT OF WORK DONE : W = F × d
  (i) Magnitude of force applied.
  (ii) Distance moved by the body in the direction of force.
  UNIT OF WORK : W = F × d
  s.i unit W= 1N × 1m = Nm = joule (J)
  1 kgf = 9.8 N is force on 1 kg ∴ F = mg
  Work done – 1 kgf × m = 9.8 N m = 9.8 J = 10 J nearly
- A cooli standing with a box on his head, does no work as distance moved is zero.
  ~
- A cooli with a box on his head and walking is doing no work as force is acting vertically downward and direction of motion is at right angle.
- ENERGY: “is capacity of doing work.”
  Or
  “The work done on a body in changing its state is called energy.”
  s.1. unit of energy = S.I. unit of work = (J)
- JOULE: “A body is said to possess a energy of one joule. If a force of 1 Newton moves the body by a distance of 1 metre in the direction of force.”
- MECHANICAL ENERGY: “The energy possessed by a body due to its state of rest or state of motion is called mechanical energy.
- Potential energy and kinetic energy are mechanical energies.
- POTENTIAL Energy (P.E.) : “Is energy possessed by body due to its state of rest or position.” P.E. = mgh
- KINETIC Energy (K.E.) : “Is energy possessed by body due to its motion.”
  K.E. = 1/2 M V^2
- GRAVITATIONAL POTENTIAL ENERGY: “When a stone or water is raised (lifted) from ground to a height, work is done against the force of gravity. This work is stored in the stone or water in the form of GRAVITATIONAL POTENTIAL ENERGY.”
- A stretched bow, due to change in position possesses potential energy. When stretched bow is relreased the arrow comes in motion and due to motion possesses the kinetic energy and hits the body on which it strikes.
- When a body at a hight, it possess P.E. = mgh. When it falls, height decreases and speed increases
  ∴ its P.E. decreases and K.E. increases.

- Powder : “Rate of doing work”. P = W/t

$$\text{S.I. unit of power} = \frac{w \longrightarrow \text{is}}{t \longrightarrow \text{is}} \quad \frac{\text{J}}{\text{Sec}} = \text{JS}^{-1} = \text{watt}$$

Test your self

A.Objective Questions

1. Write true or false for each statement

(a) A coolie does no work against the force of gravity while carrying a luggage on a road.
Answer. True.

(b) The energy stored in water of a dam is the kinetic energy.
Answer. False.
The energy stored in water of a dam is the potential energy.

(c) The energy of a flying kite is kinetic energy.
Answer. True.

(d) Work done by a boy depends on the time in which he does work.
Answer. False.

(e) Power spent by a body depends on the time for which it does work.
Answer. True.

2. Fill in the blanks

(a) Work is said to be done by a forte only when **the body moves.**
(b) Work done = Force × **distance moved in direction of force.**
(c) The energy of a body is its capacity to do **work.**
(d) The S.I. unit of energy is **joule.**
(e) The potential energy of a body is due to its **state of rest or position** and kinetic energy of body is due to its **state of motion.**
(f) Gravitational potential energy U = mass × force of gravity on unit mass × **height.**
(g) Kinetic energy = 1/2 × mass × **(speed)**^{2}
(h) Power P=**work done**/time taken.
(i) The S . i. unit of power is **watt**
(j) I H.P. = **746 W**

3. Match the following

Column A	Column B
(a) A stone at a height	**(i) power**
(b) A moving ball	**(ii) joule**
(c) Energy	**(iii) work done in 1 s**
(d) Power	**(iv) potential energy**
(e) watt	**(v) kinetic energy**

Column A	Column B
(a) A stone at a height	(iv) potential energy
(b) A moving ball	(v) kinetic energy
(c) Energy	(ii) joule
(d) Power	(iii) work done in 1 s
(e) watt	(i) power

4. Select the correct alternative

(a) The S.I. unit of work is

1. second
2. metre
3. **joule**
4. newton

(b) No work is done by a force if the body

1. moves in direction of force
2. **does not move**
3. moves in opposite direction
4. none of the these

(c) Two coolies A and B do some work in time 1 minute and 2 minute respectively. The power spent is

1. same by both coolies
2. **is more by coolie A than by B**
3. is less by coolie A than by B
4. nothing can be said.

(d) The expression of power P is

1. P = mgh
2. P = P = 1/2 Mv^2
3. P = F × d
4. **P = F × d/t**

(e) I H.P. ¡s equal to

1. 1 W
2. 1 J
3. 746 J
4. 746 W

(f) When a boy doubles his speed, his kinetic energy becomes

1. half
2. double
3. **four times**
4. no change

(g) A boy lifts a luggage from height 2 m to 4 m. The potential energy will become

1. half
2. **double**
3. one-third
4. one-fourth

B. Short/Long Answer Questions

Question 1.
Define work.
Answer:
WORK “When a force is applied on a body and there is displacement of the body, work is said to be done.”

Question 2.
When does a force perform work ?
Answer:
Work is said to be done only when the force applied on a body i. makes the body more (/. e. there is a displacement of the body).

Question 3.
State two conditions when no work is done by a force.

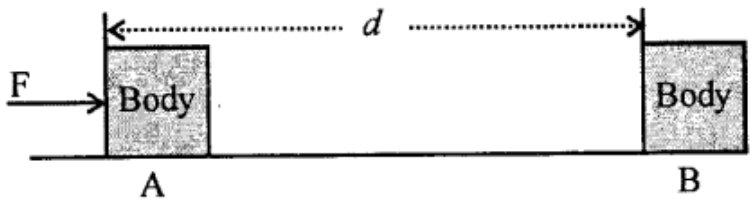
Answer:
Two conditions are :
(i) There should be no displacement i.e. S = 0
(ii) The displacement is NORMAL to the direction of FORCE
i.e. – θ = 90°

Question 4.
In which of the following cases is work being done :
(a) A boy pushing a rock
(b) A boy climbing up the stairs
(c) A coolie standing with a box in his head
(d) A girl moving on the road.
Answer:
(b) A boy climbing up the stairs
(d) A girl moving on the road.

Question 5.
A coolie is moving on a road with a luggage on his head. Does he perform work against the force of gravity ? Give reason for your answer.
Answer:
A coolie carrying a luggage on his head moving on ground does i no work against the force of gravity as displacement is normal to the direction of force of gravity.

Question 6.
The moon is revolving around the earth in a circular path. How much work is done by the moon ?
Answer:
No work is done, since displacement is NORMAL to the direction | of force on the body. The force is CENTRIPETAL.

Question 7.
Write the expression for work done by a force,
Answer:
Work done by applying force F is the product of force applied on the body and distance moved by the body in the direction of force , work done = Force x distance moved in the direction of force.
W = F × d



Question 8.
State the S.I. unit of work and define it.
Answer:
S.I. unit of work is Joule
Joule “Is that much work done when a force of IN displaces the body through a distance of lm in the direction of force.”

Question 9.
State two factors on which the work done on a body depends.
Answer:
Two factors are :
(i) Magnitude of force applied (F).
(ii) Distance moved by the body in the direction of force (d) or (5)

Question 10.
Define the term energy.
Answer:
ENERGY : “Capacity of doing work” is called ENERGY

Question 11.
State the S.I. unit of energy.
Answer:
S.I unit __ is Joule (J).

Question 12.
Define 1 joule of energy.
Answer:
Joule “is the capacity of a body to work of 1 J irrespective of time taken.”

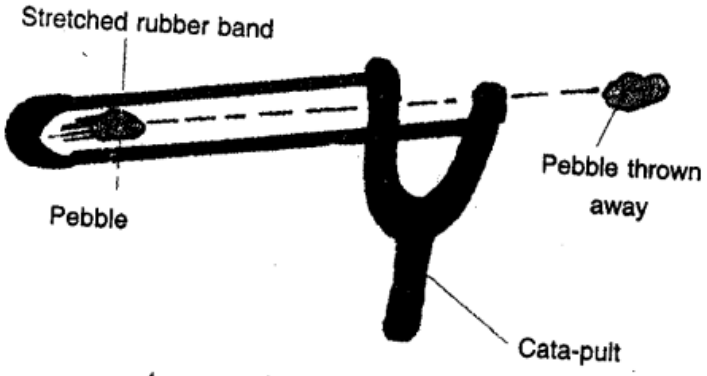
Question 13.
How is work related to energy ?
Answer:
RELATION BETWEEN WORK AND ENERGY : “Energy is the capacity of doing work”
Every form of energy → is work.
i.e. work done on body is STORED IN THE FORM OF ENERGY. ENERGY is spent when a body does work.
Thus to do more amount of work-more energy is needed.

Question 14.
What are the two kinds of mechanical energy ?
Answer:
Two KINDS OF MECHANICAL ENERGY :
(i) The Potential energy (P.E.)

(ii) The Kinetic energy (K.E.)
(ii) The Kinetic energy (K.E.)

Question 15.
What is potential energy ? State its unit.
Answer:
POTENTIAL ENERGY : (P.E. or U)
"The energy possessed by a body due its position above the ground . or change in state."
UNIT : Unit of P.E. = S.I. UNIT OF ENERGY = Joule (J)

Question 16.
Give one example of a body that has potential energy, in each of the following :
(a) due to its position at a height,
(b) due to its elongated stretched state.
Answer:
(a) P.E. due to its position at a height :
Water at a height has P.E. stored in it. Falling water from a height can be used to do work like turning a wheel,
(b) P.E. due to its elongated stretched state :
A stretched rubber band (elongated state) has potential energy. It does work in restoring itself to its original state. A pebble placed on the stretched rubber catapujt, is thrown away when it is released to restore its original state.



A stretched rubber catapult has the potential energy

Question 17.
State two factors on which the potential energy of a body at a certain height above the ground depends.
Answer:
Potential energy = mgh
∴ P.E. = m × h × g '
g' is constant depends upon m and h
Two factors on which P.E. depends :

(i) Mass : greater the mass, greater is P.E.
(ii) HEIGHT ABOVE THE GROUND : Higher the height of body, greater is the P.E.

Question 18.
Two bodies A and B of masses 10 kg and 20 kg respectively are at the same height above the ground. Which of the two has greater potential energy ?
Answer:

Body A	Body B
$P.E_1 = m_1gh$	$P.E_2 = m_2gh$
$P.E_1 = 10 \times gh$	$P.E_2 = 20 \times gh$

As g is constant and h is same in both the cases
Pe_2 is greater than PE.
Hence, Potential energy of body B (more mass) is greater than the P.E. of body A.
Or
As height of body A and is same and 'g' is constant, the body with greater mass i.e. body B has greater potential energy.

Question 19.
A bucket full of water is on the first floor of your house and another identical bucket with same quantity of water is kept on the second floor. Which of the two has greater potential energy ?
Answer:
As 'g' is constant in both cases and quantity of water (m) is same in both cases potential energy depends on height. Since height of second bucket kept at second floor is greater. Hence, second bucket at second floor has greater P.E.

Question 20.
Write the expression for the gravitational potential energy explaining the meaning of the symbols used.
Answer:
EXPRESSION FOR GRAVITATIONAL POTENTIAL ENERGY: P.E. = U = mgh
Where U is gravitational potential energy m is the mass of body.
g is___ force of gravity on mass of 1 kg
mg___ is the force acting on body
h___ is the distance or height moved above the ground level.

Question 21.
A body of mass m is moved from ground to a height h. If force of gravity on mass of 1 kg is g newton, find : (a) the force needed to lift the body, (b) the work done in lifting the body and (c) the potential energy stored in the body.
Answer:
(a) When a body of mass m at A on ground is raised above ground through height h at

B force is applied. This force applied = weight ofbody
Force on mass m = F = m g
Where ‘g’ is the force of gravity on a mass of 1 kg.
(b) Work done in lifting the body = Force × displacement h W = mg × h
(c) This work done W is stored in body in the form of Potential energy
P.E. mgh

Question 22.
Define the term kinetic energy. Give one example of a body which possesses kinetic energy.
Answer:
KINETIC ENERGY:
“The energy possessed by a body by virtue of its motion is called KINETIC ENERGY.”
Example : A bullet moving at high speed through has small mass, possesses kinetic energy and can penetrate the body.
Or
When a stretched bow is released the potential energy of arrow changes into kinetic energy and makes the arrow to move.

Question 23.
State two factors on which the kinetic energy of a moving body depends.
Answer:
The energy possessed by a body by virtue of its motion is defined as kinetic energy.
The factors on which it depends are
(i) mass of the body.
(ii) velocity of the body.

Question 24.
Two toy-cars A and Bof masses 200 g and 500 g respectively are moving with the same speed. Which of the two has greater kinetic energy ?
Answer:

CAR A

mas = 200 g

$= \frac{200}{1000} = \frac{1}{5}$ kg

$= 0.2$ kg

$K.E. = \frac{1}{2} mv^2$

$K.E. = \frac{1}{2} \times 0.2 \times v^2$

$= 0.1\ v^2$

CAR B

mass = 500 g

$= \frac{500}{1000} = 0.5$ kg

$\because$ speed of both cars is same

$K.E.\ of\ B = \frac{1}{2} \times 0.5 \times v^2$

$= 0.25\ v^2$

$0.25\ v^2$ is greater than $0.1v^2$

∴ K.E. of car B is greater.

Or

Since speed of both cars is same

∴ The speed of car having greater mass (i.e. of car B), the K.E. is greater

∴ Kinetic energy of car B having greater mass is greater.

Question 25.

A cyclist double his speed. How will his kinetic energy change: increase, decrease or remain same ?

Answer:

As Kinetic energy K.E. = 1/2 Mv_2

Since speed is doubled, its square will become 4 times

∴ K.E. increases i.e. becomes 4 times.

Or

K.E j = Mv_2

When speed is doubled New speed $v_1 = (2\ v)$

$$\text{New K.E}_2 = \frac{1}{2}\ mv_1^{\ 2}$$

$$\therefore \quad \text{New K.E}_2 = \frac{1}{2}\ m\ (2v)^2$$

$$\text{K.E}_2 = \frac{1}{2}\ m\ 4v^2 = 4\left[\frac{1}{2} m\ v^2\right]$$

(ii) ÷ (i)

$$= \frac{\text{KE}_2}{\text{KE}_1} = \frac{4\left[\frac{1}{2} m\ v^2\right]}{\left[\frac{1}{2} m\ v^2\right]} = \frac{4}{1}$$

$$= \frac{\text{KE}_2}{\text{KE}_1}$$

$\text{New K.E.}_2 = 4$ times K.E_1

Question 26.
Write the expression for the kinetic energy of a body explaining the meaning of the symbols used.
Answer:
Kinetic energy =1/2 Mv^2
Where m is the mass of body v is the speed of body.

Question 27.
A ball of mass m is moving with a speed v. What is its kinetic energy ?
Answer:
Kinetic energy of a ball of mass m and moving with speed v is K.E. = 1/2 Mv^2

Question 28.
Name the form of energy stored in a wound up spring of a watch.
Answer:
It possesses Potential energy.

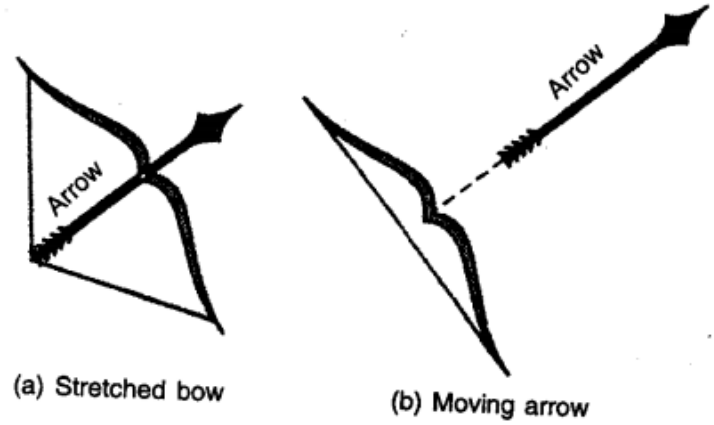
Question 29.
Can a body possess energy even when it is not in motion ? Explain your answer with an example.
Answer:

Yes, a body not in motion can possess energy.
Example: Water stored in dam through not in motion possess potential energy.
Or
A stone at rest on the top of a building possesses P.E.

Question 30.
Name the type of energy (kinetic or potential) possessed by the following:
(a) A moving cricket ball.
(b) A stone at rest on the top of a building.
(c) A compressed spring.
(d) A moving bus.
(e) A bullet fired from a gun.
(f) Water flowing in a river.
(g) A stretched rubber band.
Answer:
(a) AMOVING BALL due to motion possesses KINETIC ENERGY.
(b) A stone at rest on the top of a building possesses POTENTIAL ENERGY, ∴ Due to height above ground.
(c) A compressed spring possesses potential energy due to changed position of spring.
(d) A moving bus possesses kinetic energy due to motion.
(e) A bullet fired from a gun possesses kinetic energy due to motion.
(f) WATER FLOWING IN A RIVER possesses kinetic energy due to its motion.
(g) A STRETCHED RUBBER BAND possesses potential energy due to changed position.

Question 31.
Give an example to show the conversion of potential energy to kinetic energy when put in use.
Answer:
A stretched bow has the potential energy because of its stretched position. When the stretched bow is released the potential energy of the bow changes into its kinetic

energy.



Potential energy of a stretched bow changes into its kinetic energy

Question 32.
State the energy changes that occur in a watch spring while it unwinds.
Answer:
A wound up watch spring has P.E. stored ¡n ¡t due to it wound up state.
A the spring UNWINDS itself, the potential energy changes into KINETIC ENERGY with which it moves the arms of the watch.

Question 33.
Give reasons for the following:
(a) No work is done ¡fa man ¡s pushing against a wall.
(b) Hammer drives a nail into the wood only when it ¡s lifted up and then struck.
(c) A horse and a dog are running with the same speed. Which one of them has more kinetic energy than the other.
(d) A teacher moving around in the class is doing work but a child standing and reading a book is not doing any work.
Answer:
(a) As wall does not move from its placc.-distance moved is zero. Hence, no work is done.
(b) On lifting the Hammer, its potential energy is stored in the hammer on striking the nail with hammer this energy is used in driving the nail
into the wood. .
(c) A horse has more mass than dog. As both are running with the same speed.
M_1 of horse is greater than M_2 of dog
∴ K.E. of horse is more than K.E. of dog
(d) A child reading a book while standing is not moving from its place i.e. displacement is zero. Hence product of force and displacement ¡s zero
W=F × S
W = mg × O = O

Hence, child is not doing any work. Where as teacher is moving from its place is doing work.

Question 34.
State the energy changes in the following while ¡n use.
(a) An electric bulb (b) An electric oven
(c) A loud speaker (d) A microphone
(e) An electric motor
Answer:
(a) An electric bulb — Electrical to light energy
(b) An electric oven — Electrical to heat energy
(c) A loud speaker — Electrical to sound energy
(d) A microphone — Electrical to sound energy
(e) An electric motor — Mechanical to'aHcaI energy

C. Numericals

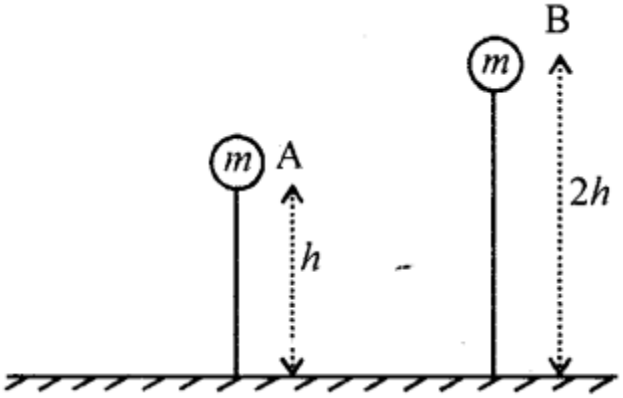
Question 1.
A force of 30 N acts on a body and moves it through a distance of 5 m ip the direction of force. Calculate the work done by the force.
Answer:
F = 30 N
d= 5m
Work done = w = F × d
W = 30 × 5= 150 J

Question 2.
A man lifts a mass of 20 kg to a height of 2.5 m. Assuming that the force of gravity on 1 kg mass is 10 N, find the work done by the man.
Answer:
Mass = 20 kg h = 2.5 m
Force of gravity on a mass of 1 kg = 10 N
Force of gravityona mass of 20kg
F = mg = 20 × 10 = 200 N
Work done in lifting the mass to height h = 20 m is
W = F × h
= 200 N × 2.5 m
= 200 × 25/10 =500 J

Question 3.
A body when acted upon by a force of 10 kgf moves to a distance 0.5 m in the direction of force.Find the work done by the force. Take 1 kgf = 10 N.
Answer:
F= 10 kgf = 10 × 10N= 100 N,

Displacement S = 0.5 m
Work done
(i) When displacement is in the direction of force
W = F × S
W= 100 × 0.5 = 50 J

Question 4.
Two bodies of same masses are placed at heights h and 2h. Compare their gravitational potential energy.
Answer:
Gravitational pot. energy of A / Gravitational pot. energy of B
mgh / mg2h = 1/2 = 1 : 2



Question 5.
Find the gravitational potential energy of 2.5 kg mass kept at a height of 15 m above the ground. The force of gravity on mass 1 kg is 10 n.
Answer:
Mass m = 2.5 kg
Gravitational potential energy is the work done against force of gravity ¡s stored in the body at a height h.
P.E = U = mgh
U = 2.5 × 10 × 15
U = 25/10 × 10 × 15 = 375 j

Question 6.
The gravitational potential energy stored in a box of weight 150 kgf is 1.5 x 104 J. Find the height of the box. Take l kgf = 10 N.
Answer:
Gravitational potential energy U = mg x h
1.5×10^4 J = (150 kgf) × h
1.5×10^4 J=(150 × IO N) × h

$$h = \frac{1.5 \times 10^4}{1500} = \frac{15}{10} \times \frac{10000}{1500} = 10 \text{ m}$$

Question 7.
The potential energy of a body of mass 0.5 kg increases by 100 J when it is taken to the top of a tower from ground. If force of gravity on 1 kg is 10 N, what is the height of the tower ?

Answer:
K.E. = Force × height
Potential energy = (m g) h
100 J = (0.5 × 10) N × h

$$h = \frac{100}{0.5 \times 10} = \frac{100}{\frac{5}{10} \times 10} = 20 \text{ m}$$

Question 8.
A body of mass 60 kg is moving with a speed 50 m s_1. Find its kinetic energy.

Answer:
m = 60 kg
Speed v = 50 m S^{1}
K.E = 1/2 MV^{2}
1/2 × 60 × 50 × 50 = 75000
K.E = 75/10 × 1000 × 10 = 7.5 × 10^{4} J

Question 9
A truck of mass 1000 kg, increases its speed from 36 km h^{-1} to 72 km h^{-1}. Find the increase is its kinetic energy.

Answer:

Weight of truck = Force = 1000 kgf

$$\therefore \text{ Mass of truck } = \frac{1000 \text{ kg} \times \text{g}}{\text{g}} = 1000 kg$$

$$\text{Initial speed } u = 36 \text{ km } h^{-1} = 36 \times \frac{5}{18} = 10 \text{ ms}^{-1}$$

$$\text{Final speed } v = 72 \text{ km } h^{-1} = 72 \times \frac{5}{18} = 20 \text{ ms}^{-1}$$

Work done = Increase in energy

$$= \frac{1}{2} mv^2 - \frac{1}{2} mu^2 = \frac{1}{2} m [(v + u) (v - u)]$$

$$= \frac{1}{2} \times 1000 (20 + 10) (20 - 10) = \frac{1}{2} \times 1000 \times 30 \times 10$$

Work done W = 150000 J = $1.5 \times 10^5 J$

t = 2 minutes = 2 × 60 = 120s.

$$\therefore \text{ Power of Engine } = \frac{w}{t} = \frac{150000}{120} = 1250 \text{ W}$$

$$= \frac{1250}{100} \times 100 = \frac{125}{100} \times 10^3 = 1.25 \times 10^3 W$$

Question 10.

A car is moving with a speed of 15 km h^{-1} and another identical car is moving with a speed of 30 km h^{-1}. Compare their kinetic energy.

Answer:

Two identical cars means, they have equal mass

K.E = 1/2 mv^2

Let m be the mass of each car

$$\text{Kinetic energy of car A} = \frac{1}{2} \text{ m} \times (15)^2 = \frac{225}{2} \text{ m}$$

$$= 112.5 \text{ m J}$$

Kinetic energy of car B = 1/2 M $(30)^2$

=450 M J

$$\frac{\text{K.E. of A}}{\text{K.E. of B}} = \frac{225\ \text{m}}{2 \times 450\ \text{m}} = \frac{1}{4} = 1 : 4$$

K.E. of car B is 4 times K.E. of car A.

Question 11.

A pump raises water by spending 4 × 105 J of energy in 10 s. Find the power of pump.

Answer:

Energy spent = w = 4×10^5 J Time taken = 10 s

Power = Energy / Time

$$P = \frac{4 \times 10^5}{10} = 4 \times 10^4\ \text{W}$$

Question 12.

It takes 20 s for a girl A to climb up the stairs while girl B takes 15 s for the same job. Compare : (i) the work done and (ii) the power spent by then.

Answer:

(i) As height is same for both girls A and B, work done is same (irrespective of time)

∴ Work done by A : Work done by B = 1 : 1

$$\text{(ii) Power} = \frac{\text{Work done}}{\text{Time taken}} = \frac{\text{Energy}}{\text{Time}}$$

$$= \frac{\text{Power of A}}{\text{Power of B}} = \frac{\frac{\text{Energy}}{t_1}}{\frac{\text{Energy}}{t_2}} = \frac{1}{t_1} \cdot \frac{t_2}{1} = \frac{15}{20}$$

$$= \frac{3}{4} = 3 : 4$$