

EXERCISE 2(A)



**Solutions:**

When the force applied on a body makes the body move, then the work is said to be done. It is a scalar quantity.

**Solutions:**

(i) Work done when force is in direction of displacement,

$$W = F \times S$$

(ii) Work done when force is at an angle to the direction of displacement,

$$W = F S \cos \theta$$

**Solutions:**

(a) Work done when force is at an angle  $\theta$  to the direction of displacement,

$$W = F S \cos \theta$$

(b) (i) The angle between force and displacement should be  $90^\circ$  as  $\cos 90^\circ = 0$  for zero work done.

$$W = F S \cos 90^\circ$$

$$= FS \times 0$$

(ii) The angle between force and displacement should be  $0^\circ$  as  $\cos 0^\circ = 1$  for maximum work done.

$$\text{Then, } W = FS \cos 0^\circ$$

$$= FS$$

**Question: 4**

**A body is acted upon by a force. State two conditions when the work done is zero.**

**Solutions:**

When the work done is zero, the two conditions are:

- (i) When there is no displacement,  
 $S = 0$  and
- (ii) To the direction of force when the displacement is normal,  
 $\theta = 90^\circ$

**Solutions:**

- (i) The work done is positive, if the body's displacement is in the direction of force,  
Therefore  $W = F \times S$

Example: When the coolie raises the load up against the force of gravity, then the work done by coolie on the load. Both the displacement and the force exerted by coolie are in upward direction.

- (ii) The work done is negative, if the body's displacement is in the direction opposite to the force,

Therefore  $W = - F \times S$

Example: The force of friction between the body and the surface is in direction opposite to the motion of the body, when a body moves on a surface and hence work done by the force of friction is negative.

**Question: 6**

**A body is moved in a direction opposite to the direction of force acting on it. State whether the work is done by the force or work is done against the force.**

**Solutions:**

Work is done against the force when a body is moved in a direction opposite to the direction of force acting on it.

**Question: 7**

**When a body moves in a circular path, how much work is done by the body? Give reason.**

**Solutions:**

No work is done when a body moves in a circular path, since the force on the body is directed towards the centre of circular path (the body is acted upon by the centripetal force), while at all instants the displacement is along the tangent to the circular path, i.e normal to the direction of force.

**Question: 8**

A satellite revolves around the earth in a circular orbit. What is the work done by the satellite? Give reason.

**Solutions:**

As the force of gravity acting on the satellite is perpendicular to the displacement of the satellite, we get that,

Work done by the force of gravity is zero

**Question: 9**

State whether work is done or not by writing yes or no, in the following cases?

(a) A man pushes a wall.

(b) A coolie stands with a box on his head for 15 min.

(c) A boy climbs up 20 stairs.

**Solutions:**

(a) No, work is done by a man

(b) No, work is not done by a coolie

(c) Yes, work is done by a boy climbing up a stairs

**Question: 10**

A coolie X Carrying a load on his head climbs up a slope and another coolie Y carrying the identical load on his head move the same distance on a frictionless horizontal platform. Who does more work? Explain the reason.

**Solutions:**

The capacity to do work is energy and the energy spent is equal to the work done. The coolie X will do more work as the work done by him will involve a change in potential energy, kinetic energy and loss of energy due to friction whereas the work done by the coolie Y carrying the load in horizontal frictionless surface does not involve change in potential energy and work done by the friction is also zero.

**Question: 11**

The work done by a fielder when he takes a catch in a cricket match, is negative. Explain.

**Solutions:**

The work done by a fielder is negative when he takes a catch because the force applied by the fielder is in opposite direction of displacement of ball.

**Question: 12**

Give an example when work done by the force of gravity acting on a body is zero even though the body gets displaced from its initial position.

**Solutions:**

The displacement is in the horizontal direction when a coolie carries a load walking on a ground while the force of gravity acts vertically downward. Hence the work done by the force of gravity is zero.

**Question: 13**

**What are the S.I. and C.G.S. units of work? How are they related? Establish the relationship.**

**Solutions:**

The S.I unit of work is Joule and C.G.S unit of work is erg

Relation between joule and erg:

$$1 \text{ joule} = 1\text{N} \times 1\text{m}$$

But  $1 \text{ N} = 10^5 \text{ dyne}$  and  $1 \text{ m} = 10^2 \text{ cm}$

Therefore  $1 \text{ joule} = 10^5 \text{ dyne} \times 10^2 \text{ cm}$

$$= 10^7 \text{ dyne} \times \text{cm}$$

$$= 10^7 \text{ erg}$$

$$\therefore 1 \text{ joule} = 10^7 \text{ erg}$$

**Question: 14**

**State and define the S.I. unit of work.**

**Solutions:**

The S.I unit of work is Joule. When a force of 1 newton displaces a body through a distance of 1 metre in its own direction then 1 joule of work is said to be done.

**Question: 15**

**Express joule in terms of erg.**

**Solutions:**

$$1 \text{ joule} = 1\text{N} \times 1\text{m}$$

But  $1 \text{ N} = 10^5 \text{ dyne}$  and  $1 \text{ m} = 10^2 \text{ cm}$

Therefore  $1 \text{ joule} = 10^5 \text{ dyne} \times 10^2 \text{ cm}$

$$= 10^7 \text{ dyne} \times \text{cm}$$

$$= 10^7 \text{ erg}$$

$$\therefore 1 \text{ joule} = 10^7 \text{ erg}$$

**Question: 16**

**A body of mass  $m$  falls down through a height  $h$ . Obtain an expression for the work done by the force of gravity.**

**Solutions:**

Let a body of mass  $m$  falls down through a height  $h$  either vertically or inclined plane.

For example: a hill, slope or staircase. The force of gravity on the body is  $F = mg$  acting vertically downwards and the vertical displacement in the direction of force is  $S = h$ . Therefore the work done by the force of gravity is

$$W = FS = mgh$$

**Question: 17**

A boy of mass  $m$  climbs up a stairs of vertical height  $h$ .

(a) What is the work done by the boy against the force of gravity?

(b) What would have been the work done if he uses a lift in climbing the same vertical height?

**Solutions:**

Let a boy of mass  $m$  climb up through a vertical height  $h$  either through a staircase or using a lift.  $F = mg$  is the force of gravity acting vertically downwards and the vertical displacement in the direction opposite to the force is

$$S = -h$$

Therefore the work done by the force of gravity on a boy is

$$W = FS = -mgh \text{ or}$$

The work  $W = mgh$  is done by a boy against the force of gravity.

**Question: 18**

Define the term energy and state its S.I unit.

**Solutions:**

The term energy is defined as 'the energy of a body is its capacity to do work'. The S.I unit of energy is Joule.

**Question: 19**

What physical quantity does electron volt (eV) measure? How is it related to the S.I. unit of that quantity?

**Solutions:**

The energy of atomic particles is measured in electron volt (eV)

$$1 \text{ eV} = \text{charge on an electron} \times 1 \text{ volt}$$

$$= 1.6 \times 10^{-19} \text{ coulomb} \times 1 \text{ volt}$$

$$= 1.6 \times 10^{-19} \text{ J}$$

**Question: 20**

Complete the following sentence:

(a)  $1 \text{ J} = \underline{\hspace{2cm}}$  calorie.

(b)  $1 \text{ kWh} = \underline{\hspace{2cm}}$  J.

**Solutions:**

(a)  $1 \text{ J} = 0.24 \text{ calorie}$

(b)  $1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$

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**Question: 21**

**Name the physical quantity which is measured in calorie. How is it related to the S.I unit of that quantity?**

**Solutions:**

Heat energy is measured in calorie.

$$1 \text{ calorie} = 4.18 \text{ joule}$$

**Question: 22**

**Define a kilowatt hour. How is it related to joule?**

**Solutions:**

The energy spent (or work done) by a source of power 1 kW in 1 h is known as kilowatt hour.

$$1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$$

**Question: 23**

**Define the term power. State its S.I. unit.**

**Solutions:**

The term power is defined as the rate of doing work. The S.I unit of power is watt (W)

**Question: 24**

**State two factors on which power spent by a source depends. Explain your answer with examples.**

**Solutions:**

The power spent by a source depends on two factors

(i) The amount of work done by a source and

(ii) The time taken by the source to do the said work.

For example:

If a coolie A takes 1 minute to lift a load to the roof of a bus and a coolie B takes 2 minutes to lift a load to the roof of a same bus. The work done by both the coolies remain same, but the power spent by the coolie A is twice the power spent by the coolie B because coolie A does the work faster than B.

**Question: 25**

**Differentiate between work and power.**

**Solutions:**

## Class 10 Chapter 2 Work, Energy and Power

Work	Power
Work done by a force is equal to the product of force and the displacement in the direction of force.	Power of a source is the rate of doing work by it.
Work done does not depend on time	Power spent depends on the time in which work is done.
S.I unit of work is joule (J)	S.I unit of power is watt (W)

### Question: 26

**Differentiate between energy and power.**

**Solutions:**

Energy	Power
Energy of a body is its capacity to do work.	Power of a source is the rate at which energy is supplied by it
Energy spent does not depend on time	Power depends on the time in which energy is spent
S.I unit of energy is joule (J)	S.I unit of power is watt (W)

### Question: 27

**State and define the S.I unit of power.**

**Solutions:**

The S.I unit of power is watt (W)

The power spent is said to be 1 watt, if 1 joule of work is done in 1 second.

### Question: 28

**(a) Name the physical quantity measured in terms of horse power.**

**(b) How is horse power related to the S. I. unit of power?**

**Solutions:**

(a) The physical quantity measured in terms of horse power is Power.

(b) It is related to the S.I unit watt as given below

$$1 \text{ horse power} = 746 \text{ watt}$$

### Question: 29

**Differentiate between watt and watt hour.**

**Solutions:**

The unit of power is watt (W) while the unit of work is watt hour (Wh)

$$\text{Since power} \times \text{time} = \text{work or energy}$$

**Question: 30**

Name the quantity which is measured in

- (a) kWh
- (b) kW
- (c) Wh
- (d) eV

**Solutions:**

- (a) Energy is measured in kWh
- (b) Power is measured in kW
- (c) Energy is measured in Wh
- (d) Energy is measured in eV

**Question: 31**

Is it possible that no transfer of energy takes place even when a force is applied to a body?

**Solutions:**

Yes, if the body is acted upon by the force normal to the displacement, there is no transfer of energy. The force is normal to the displacement when the body is moving in a circular path and the work done is zero. Hence, there is no transfer of energy.

### **MULTIPLE CHOICE TYPE**

**Question: 1**

One horse power is equal to:

- a. 1000 W
- b. 500 W
- c. 764 W
- d. 746 W

**Solutions:**

One horse power is equal to 746 W

**Question: 2**

kWh is the unit of:

- a. Power
- b. Force
- c. Energy
- d. None of these

**Solutions:**

kWh is the unit of energy

**NUMERICALS****Question: 1**

A body, when acted upon by a force of 10 kgf, gets displaced by 0.5 m. Calculate the work done by the force, when the displacement is

- (i) in the direction of force,
- (ii) at an angle of  $60^\circ$  with the force, and
- (iii) normal to the force. ( $g = 10 \text{ N kg}^{-1}$ )

**Solutions:**

$$\begin{aligned} \text{Force acting on the body} &= 10 \text{ kgf} \\ &= 10 \times 10 \text{ N} \\ &= 100 \text{ N} \end{aligned}$$

$$\text{Displacement, } S = 0.5 \text{ m}$$

Work done = force  $\times$  displacement in the direction of force

$$(i) W = F \times S$$

$$\begin{aligned} W &= 100 \times 0.5 \\ &= 50 \text{ J} \end{aligned}$$

(ii) Work = force  $\times$  displacement in the direction of force

$$W = F \times S \cos \theta$$

$$W = 100 \times 0.5 \cos 60^\circ$$

$$W = 100 \times 0.5 \times 0.5 \quad [\cos 60^\circ = 0.5]$$

$$W = 25 \text{ J}$$

(iii) Normal to the force

Work = force  $\times$  displacement in the direction of force

$$W = F \times S \cos \theta$$

$$W = 100 \times 0.5 \cos 90^\circ$$

$$W = 100 \times 0.5 \times 0 \quad [\cos 90^\circ = 0]$$

$$W = 0$$

**Question: 2**

A boy of mass 40kg climbs up the stairs and reaches the roof at a height 8m in 5 s.

**Calculate:**

- (i) The force of gravity acting on the boy,
  - (ii) The work done by him against gravity,
  - (iii) The power spent by boy.
- (take  $g = 10 \text{ ms}^{-2}$ )

**Solutions:**

Given

Mass of a boy = 40 kg

Vertical height moved by a boy,  $h = 8$  m

Time taken by a boy,  $t = 5$  s

(i) Force of gravity acting on the boy

$$\begin{aligned} F &= mg \\ &= 40 \times 10 \\ &= 400 \text{ N} \end{aligned}$$

(ii) Work done by a boy against the force of gravity while climbing,

Work done by a boy = Force  $\times$  distance moved in the direction of force

$$\begin{aligned} W &= F \times S \\ W &= 400 \times 8 \\ W &= 3200 \text{ J} \end{aligned}$$

(iii) Power spent = (work done / time taken)

$$\begin{aligned} &= 3200 / 5 \\ &= 640 \text{ W} \end{aligned}$$

### Question: 3

A man spends 6.4 kJ energy in displacing a body by 64 m in the direction in which he applies force, in 2.5 s. Calculate: (i) the force applied and (ii) the power spent (in H.P) by the man.

#### Solutions:

Given

Work done by man = 6.4 kJ

Distance moved,  $S = 64$  m

(i) Work done by the man = Force  $\times$  distance moved in direction of force

$$\begin{aligned} \text{Work, } W &= F \times S \\ 6.4 \times 10^3 &= F \times 64 \\ F &= (6.4 \times 10^3) / 64 \\ F &= 100 \text{ N} \end{aligned}$$

(ii) Power spent =  $(6.4 \times 10^3) / 2.5$

$$\begin{aligned} &= 2560 \text{ W} \\ 1 \text{ H.P} &= 746 \text{ W} \\ 1 \text{ W} &= 1 / 746 \text{ H.P} \\ 2560 \text{ W} &= 2560 / 746 \text{ H.P} \\ &= 3.43 \text{ H.P} \end{aligned}$$

### Question: 4

A weight lifter lifted a load of 200 kgf to a height of 2.5 m in 5 s. Calculate: (i) the work done, and (ii) the power developed by him. Take  $g = 10 \text{ N/kg}^{-1}$ .

**Solutions:**

$$\begin{aligned} \text{Force} &= mg \\ &= 200 \times 10 \\ &= 2000 \text{ N} \end{aligned}$$

$$\text{Distance, } S = 2.5 \text{ m}$$

$$\text{Time, } t = 5 \text{ s}$$

$$(i) \text{ Work done, } W = FS$$

$$W = 2000 \times 2.5 \text{ m}$$

$$W = 5000 \text{ J}$$

$$(ii) \text{ Power developed} = (\text{work done}) / (\text{time taken})$$

$$= 5000 \text{ J} / 5 \text{ s}$$

$$= 1000 \text{ W}$$

**Question: 5**

**A machine raises a load of 750N through a height of 16m in 5 s. Calculate:**

**(i) the energy spent by the machine.**

**(ii) the power of the machine if it is 100% efficient.**

**Solutions:**

$$(i) \text{ Energy spent by machine or work done} = FS$$

$$\text{Work, } W = 750 \times 16$$

$$W = 12000 \text{ J}$$

$$(ii) \text{ Power spent} = \text{work done} / \text{time taken}$$

$$= 12000 \text{ J} / 5\text{s}$$

$$= 2400 \text{ W}$$

**Question: 6**

**An electric heater of power 3 kW is used for 10 h. How much energy does it consume?**

**Express your answer in**

**(i) kWh**

**(ii) joule.**

**Solutions:**

$$\text{Energy consumed} = \text{power} \times \text{time}$$

$$(i) \text{ Energy} = 3 \text{ kW} \times 10 \text{ h}$$

$$= 30 \text{ kWh}$$

$$(ii) 1 \text{ kilowatt hour (kWh)} = 3.6 \times 10^6 \text{ J}$$

$$30 \text{ kWh} = 30 \times 3.6 \times 10^6 \text{ J}$$

$$= 1.08 \times 10^8 \text{ J}$$

**Question: 7**

A water pump raises 50 litres of water through a height of 25m in 5 s. Calculate the power of the pump required.

(Take  $g = 10 \text{ N kg}^{-1}$  and density of water  $= 1000 \text{ kg m}^{-3}$ ).

**Solutions:**

$$\begin{aligned} \text{Volume of water} &= 50 \text{ L} \\ &= 50 \times 10^{-3} \text{ m}^3 \end{aligned}$$

$$\text{Density of water} = 1000 \text{ kg m}^{-3}$$

$$\begin{aligned} \text{Mass of water} &= \text{Volume of water} \times \text{density of water} \\ &= 50 \times 10^{-3} \times 1000 \end{aligned}$$

$$= 50 \text{ kg}$$

Work done in raising 50 kg water to a height of 25 m against the force of gravity is

$$W = mg \times h$$

$$W = mgh$$

$$\text{Power } P = (\text{work done}) / (\text{time taken})$$

$$= mgh / t$$

$$= 50 \times 10 \times 25 \text{ J} / 5 \text{ s}$$

$$= 2500 \text{ W}$$

**Question: 8**

A pump is used to lift 500kg of water from a depth of 80m in 10s. Calculate:

(a) The work done by the pump,

(b) The power at which the pump works, and

(c) The power rating of the pump if its efficiency is 40%. (Take  $g = 10 \text{ m s}^{-2}$ ).

**Solutions:**

Work done in raising a 500 kg mass to a height of 80 m against the force of gravity is:

$$(a) W = mg \times h = mgh$$

$$W = 500 \times 10 \times 80$$

$$= 4 \times 10^5 \text{ J}$$

$$(b) \text{ Power at which pump works} = \text{work done} / \text{time taken}$$

$$= mgh / t$$

$$= (500 \times 10 \times 80 \text{ J}) / 10 \text{ s}$$

$$= (4 \times 10^5) / 10$$

$$= 40 \text{ kW}$$

$$(c) \text{ Efficiency} = \text{useful power} / \text{power input}$$

$$\text{Efficiency} = 40 \%$$

$$= 0.4$$

$$0.4 = 40 \text{ kW} / \text{power input}$$

$$\text{Power input} = 40 \text{ kW} / 0.4$$

$$= 100 \text{ kW}$$

**Question: 9**

An ox can apply a maximum force of 1000N. It is taking part in a cart race and is able to pull the cart at a constant speed of  $30\text{m/s}^{-1}$  while making its best effort. Calculate the power developed by the ox.

**Solutions:**

Given

$$\text{Force} = 1000 \text{ N}$$

$$\text{Velocity} = 30 \text{ m/s}$$

$$\text{Power, } P = \text{force} \times \text{velocity}$$

$$P = 1000 \times 30$$

$$= 30,000\text{W}$$

$$= 30 \text{ kW}$$

**Question: 10**

The power of a motor is 40kW. At what speed can the motor raise a load of 20,000 N?

**Solutions:**

Given

$$\text{Power} = 40 \text{ kW}$$

$$\text{Force} = 20,000 \text{ N}$$

$$\text{Power} = \text{force} \times \text{velocity}$$

$$\text{Velocity} = \text{power} / \text{force}$$

$$= 40 \text{ kW} / 20,000$$

$$= 40,000 / 20,000$$

$$= 2 \text{ m / s}$$

$$= 2 \text{ ms}^{-1}$$

**Question: 11**

Rajan exerts a force of 150 N in pulling a cart at a constant speed of  $10 \text{ m s}^{-1}$ . Calculate the power exerted.

**Solutions:**

Power exerted by Rajan due to force is

$$P = Fv$$

$$P = 150 \times 10$$

$$P = 1500 \text{ W}$$

**Question: 12**

A boy weighing 350 N climbs up 30 steps, each 20 cm high in 1 minute. Calculate:

- (i) the work done, and  
 (ii) the power spent.

**Solutions:**

$$\begin{aligned} \text{Total distance covered in 30 steps, } S &= 30 \times 20 \text{ cm} \\ &= 600 \text{ cm} \\ &= 6 \text{ m} \end{aligned}$$

Work done by the boy in climbing = Force  $\times$  distance moved in direction of force

$$\begin{aligned} \text{Work, } W &= F \times S \\ &= 350 \times 6 \\ &= 2100 \text{ J} \end{aligned}$$

$$\begin{aligned} \text{Power developed} &= \text{work done} / \text{time taken} \\ &= 2100 \text{ J} / 60 \text{ s} \\ &= 35 \text{ W} \end{aligned}$$

**Question: 13**

It takes 20 s for a person A of mass 50 kg to climb up the stairs, while another person B of same mass does the same in 15 s. Compare the

- (i) work done and  
 (ii) power developed by the persons A and B.

**Solutions:**

(i) The work done by two persons A and B is independent of time. Hence both will do the same amount of work. Hence,

$$\begin{aligned} \text{Work done by A} / \text{work done by B} \\ &= 1 / 1 \\ &= 1: 1 \end{aligned}$$

(ii) The power developed by the persons A and B is calculated as shown below:

A takes 20 s to climb the stairs while B takes 15 s to do the same work. Hence, B does the work at a faster rate than A. Therefore more power is spent by B.

$$\begin{aligned} \text{Power developed} &= 1 / \text{time} \quad (\text{amount of work done by A and B is same}) \\ \text{Power developed by A} / \text{Power developed by B} &= 15 / 20 \\ &= 3 / 4 \\ &= 3: 4 \end{aligned}$$

**Question: 14**

A boy of weight 40 kgf climbs up the 15 steps, each 15 cm high in 10 s and a girl of weight 20 kgf does the same in 5 s. Compare :

- (i) the work done, and  
 (ii) the power developed by them. Take  $g = 10 \text{ N kg}^{-1}$ .

**Solutions:**

(i) Work done is

$$W = Fs = mgh$$

$$(\text{Weight of boy}) / (\text{weight of girl}) = 40 / 20$$

$$= 2 / 1$$

$$= 2: 1$$

(ii) Power developed is

$$P_{\text{boy}} / P_{\text{girl}} = [(m_{\text{boy}}gh) / t] / [(m_{\text{girl}}gh) / t]$$

$$= (40 / 10) / (20 / 5)$$

$$\text{Thus } P_{\text{boy}} / P_{\text{girl}} = (40 / 10) \times (5 / 20)$$

$$= 1: 1$$

**Question: 15**

A man raises a box of mass 50kg to a height of 2m in 20s, while another man raises the same box to the same height in 50s.

(a) Compare: (i) the work done, and (ii) the power developed by them.

(b) Calculated: (i) the work done, and (ii) the power developed by each man. Take  $g = 10 \text{ N kg}^{-1}$ .

**Solutions:**

(a) (i) Work done to raise the box of mass 50 kg is same for both

(ii) Power = work done / time taken

The power taken by the first man is less. Hence power developed is more.

(b) (i) Work done =  $50 \times 10 \times 2$

$$= 1000 \text{ J}$$

(ii) Power developed by first man =  $1000 / 20$

$$= 50 \text{ W}$$

Power developed by second man =  $1000 / 50$

$$= 20 \text{ W}$$

**Question: 16**

A boy takes 3 minutes to lift a 20 litre water bucket from a 20 m deep well, while his father does it in 2 minutes. (a) Compare: (i) the work, and (ii) power developed by them. (b) How much work each does? Take density of water =  $10^3 \text{ kg m}^{-3}$  and  $g = 9.8 \text{ N kg}^{-1}$ .

**Solutions:**

(a) (i) Both the people carry same weight of water to the same height. So, work done is same for both. Hence, Work = 1: 1

(ii) Power developed is

$$P_{\text{boy}} / P_{\text{father}} = [(W / t_{\text{boy}}) / (W / t_{\text{father}})]$$

$$\begin{aligned} &= t_{\text{father}} / t_{\text{boy}} \\ \therefore P_{\text{boy}} / P_{\text{father}} &= 2 / 3 \\ &= 2:3 \end{aligned}$$

(b) Mass of water lifted by both is

$$\begin{aligned} m_w &= \rho \times V \\ &= 10^3 \text{ kg / m}^3 \times 20 \times 10^{-3} \text{ m}^3 \\ &= 20 \text{ kg} \end{aligned}$$

So, the work done is

$$\begin{aligned} W &= m_w g h \\ &= 20 \times 9.8 \times 20 \end{aligned}$$

$$W = 3920 \text{ J}$$

$$W = 3.92 \text{ kJ}$$