Work And Energy

Assess Yourself

Q. 1. Calculate the work done when a force of 15 N moves a body by 5 m in its direction.

Answer: Work done = Force × Displacement

Given

Force = 15 N

Displacement = 5 m

Work done = 15×5 = 75 J

The work done is 75 Joule

Q. 2. What is power? Write its SI unit.

Answer: Power is defined as the rate of doing work. It is the ratio of the work done (W) and the time taken (t).

Power (P) = $\frac{\text{Work(W)}}{\text{TIme(t)}}$

The S.I unit of the power is Watt (W) in honour of the physicist James Watt.

Q. 3. To what height should a body of mass 5 kg be raised so that its potential energy is 490 J? [g = 9.8 m/s^2]

Answer: The potential energy due to gravitation is given by

P.E = mgh

Where, m = Mass,

G = acceleration due to gravity,

H = height,

Given

Mass = 5 Kg,

P.E = 490 J,

G = 9.8m/s^2.

H =?

490 = 5 × 9.8 × h

$$\Rightarrow h = \frac{490}{9.8 \times 5} = \frac{490}{49} = 10 \text{ m}$$

Hence the body should be raised to 10 m

Q. 4. State the SI unit of work and power.

Answer: SI unit of work is Joule. It is the scalar quantity. It is defined as the Work done by force of 1 N to move an object by 1 m.

SI unit of Power is Watt denoted by W.

Q. 5. Relate watt to joule.

Answer: 1 watt is the power of an agent which does the work at the rate of 1 joule per second.

1W = 1 j/s

Q. 6. Find the energy possessed by an object of mass 10 kg when it is at a height of 6m above the ground. [g = 9.8 ms^{-1}]

Answer: Given

Mass of object (m) = 10 Kg.

Height (h) = 6 m.

Acceleration due to gravity (g) = 9.8m/s^2

Potential Energy of Object = mgh

= 10×9.8×6 = 98×6

= 588 J

Energy possessed by an object is 588 Joule.

Q. 7. A boy of mass 80 kg is running at 10 m/s. Find the work done by him.

Answer: Work done = Kinetic Energy possessed by a body.

Kinetic Energy = $\frac{mv^2}{2}$

Given

Mass (m) = 80 Kg;

Velocity (v) = 10 m/s;

Kinetic Energy = $\frac{80 \times 10^2}{2}$

$$\Rightarrow \text{Kinetic Energy} = \frac{8000}{2} = 4000 \text{ J}$$

Hence the work done is 4000 J.

Q. 8. Define kinetic energy and potential energy.

Answer: Kinetic Energy ⇒ The energy possessed by an object in motion is called as the kinetic Energy. It is given by

Kinetic Energy = $\frac{mv^2}{2}$

Where m = mass of body;

V = velocity of body.

Example = Earth revolving around the sun, you walking down the street etc.

Potential Energy⇒ When the object is at rest the energy possessed by an object is called as the potential energy.

Potential Energy = mgh

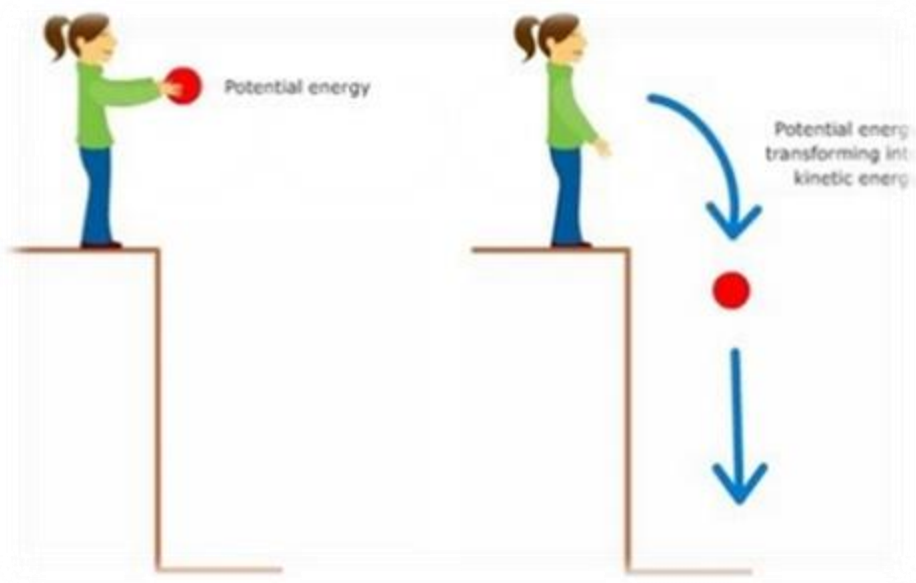
Where m = mass of body,

H = height at which body is kept

G = acceleration due to gravity = 9.8 m/s^2.

Example = A ball kept at a certain height.

The figure below illustrates the Kinetic and potential energy in more detail.



Q. 9. A boy of mass 50 kg runs up a staircase of 45 steps in 9s. If the height of each step is 15 cm, find his power. (Take g = 10 ms^{-2})

Answer: Given

Mass of Body (m) = 50 Kg,

Time (t) = 9s,

Height of each step = 15 cm,

Acceleration due to gravity (g) = 10 m/s^2.

Now

Weight = mg = 50×10 = 500N

Height of staircase = $45 \times \frac{15}{100} = 6.75 \text{ m}$

(∵ 1 m = 100 cm)

$$\text{Power} = \frac{\text{Work}}{\text{Time}} = \frac{\text{mgh}}{\text{t}}$$

$$\Rightarrow \text{Power} = \frac{500 \times 6.75}{9} = \frac{3375}{9}$$

Power = 375 Watt

Q. 10. An electric bulb of 60 W is used for 6 h per day. Calculate the 'units' of energy consumed in one day by the bulb.

Answer: Given

Power = 60 W = $\frac{60}{1000} = 0.06$ Kw

(∵ 1Kw = 1000 W).

Time (t) = 6 hours.

Now

Power = $\frac{\text{Energy Consumed}}{\text{Time taken}}$

⇒ Energy Consumed = Power × Time taken

= 0.06 × 6 = 0.36kWh

Hence 0.36 unit of electricity is consumed by a bulb in one day.

Q. 12. Mention the commercial unit of energy. Express it in terms of joules. Calculate the energy in joule consumed by a device of 60 W in 1 hour.

Answer: Commercial unit of Energy is Kilo Watt per hour denoted by kWh.

1kWh = 3600000 Joules

Energy Consumed in 1 hour

60 W = 60 j/s

1 hour = 60×60 seconds

⇒ Energy consumed in 1 hour = 60 × 60 × 60 = 216000 j

216000 Joules of energy is consumed in 1 hour.

Q. 13. (a) State and define SI unit of power.

(b) A person carrying 10 bricks each of mass 2.5 kg on his head moves to a height 20 m in the 50s. Calculate power spent in carrying bricks by the person (g = 10 m/s2)

Answer: (a) The rate of doing work is called as the power. The SI unit of power is Watt denoted by W.

1 Watt is the power of appliances that consume the energy at the rate of 1 joule per second.

(b) Given

Mass of brick = 2.5 kg

⇒ Weight = mg = 2.5×10 = 25 N

Weight of 10 bricks = 25×10 = 250 N

Height (h) = 20 m

Time (t) = 50 s

$$\text{Power} = \frac{\text{Work done}}{\text{Time taken}}$$

$$\Rightarrow \text{Power} = \frac{mgh}{t} = \frac{250 \times 20}{50}$$

$$= \frac{5000}{50} = 100 \text{ W}$$

Power spent in carrying bricks is 100 Watt.

Q. 14. Two bulbs of 40W each are lighted for eight hours daily. Find the cost of electrical energy consumed by them in one week at Rs. 3 per unit.

Answer: Given

Power = 40W

Time = 8 hours

Now

$$\text{Power} = \frac{\text{Energy}}{\text{Time}}$$

$$\Rightarrow 40 = \frac{\text{Energy}}{8}$$

$$\Rightarrow \text{Energy} = 40 \times 8 = 320$$

Energy consumed by 2 bulbs in 1 week = 320×2×7 = 4480 Wh = 4.48 kW

(∵ 1kWh = 1000Wh)

Total units = 4.48 units

Now

Cost of 1 unit = Rs 3

Total cost = 4.48 ×3 = Rs13.44

Total cost for 1 week is Rs 13.44

Q. 15. A man whose mass is 50 kg moves up 15 steps each of height 15 cm in 45 seconds of time. Calculate the power used in climbing those stairs. (g = 10 m/s^2)

Answer: Given

Mass of Body (m) = 50 Kg,

Time (t) = 45s,

Height of each step = 15 cm,

Acceleration due to gravity (g) = 10 m/s^2.

Now

Weight = mg = 50×10 = 500N

$$\text{Height of staircase} = 15 \times \frac{15}{100} = 2.25 \text{ m}$$

$$(\because 1 \text{ m} = 100 \text{ cm})$$

$$\text{Power} = \frac{\text{Work}}{\text{TIme}} = \frac{\text{mgh}}{\text{t}}$$

$$\Rightarrow \text{Power} = \frac{500 \times 2.25}{45} = \frac{1125}{45} = 25$$

Power = 25 Watt

Power used in climbing stairs = 25 W

Q. 16.A. A battery lights a bulb. Describe the energy change involved in the process.

Answer: When the bulb is connected to the battery the chemical energy of the battery is converted into the electrical energy. When bulb receives this electrical energy it converts it into light and heat energy. The figure below shows the energy transformation in more descriptive way.

Chemical Energy → Electrical Energy → Light Energy + Heat Energy

Q. 16.B. Calculate the amount of work needed to stop a car of 500 kg, moving at a speed of 36 km/h.

Answer: Given

Mass of car = 500 Kg

Initial speed = 36 km/h = 10m/s

(∵ 1 km/h = 5/18 m/s)

Now

Work done = Change in Kinetic Energy.

= Final kinetic Energy – Initial Kinetic Energy.

$$= \frac{m(v^2-u^2)}{2}$$

$$= \frac{500(0-10^2)}{2}$$ (Final velocity = 0, because the car is at rest).

$$= 250 \times -100 = -25000 \text{ J}.$$

The magnitude of work required is 25000 Joule.

Q. 17. Rashmi was playing on a swing in a park. To increase her speed when her swing was at its lowest position during its oscillations she pushed the ground hard with her feet. She enjoyed it but could not understand the mechanism. Her elder brother Pankaj explained her the reason, when she asked him.

(i) What type of energy was possessed by Rashmi while swinging? On what factors does it depend?

(ii) Why did the swing's speed increase on pushing the ground harder with feet?

(iii) Why and what did Rashmi ask Pankaj?

Answer: (i) At the extreme position of the swing she will have potential energy. At the mean position of the swing, she will have kinetic energy. These energies keep interchanging during the motion of the swing.

The kinetic energy depends on the velocity of the mass so it will be greatest at the bottom and, zero at the top. The gravitational potential energy depends on the height. It will be maximum at the top of the swing and minimum at the bottom.

(ii) On pushing ground harder with the feet, force is applied on the swing. As a result of it the swing starts moving with the greater speed and the speed of the swing increases.

(iii) Rashmi asked her brother pankaj that why on pushing the ground with the feet the speed of the swing increases. She asked so because she is curious to know that why the speed of the oscillations was increasing on pushing the ground when at the lowest position.

Q. 18. Roma enjoys to ride fastly on a swing. So Rano stands behind the swing every time Roma rides it and pushes her. However, Rano also gets scared of Roma riding too fast and keeps yelling out to her to be careful. However, Roma refrains from being slow.

(a) What energy conversion takes place on a swing?
(b) Muscular energy of Rano converts to which energy on pushing the swing?
(c) Compare the qualities of Roma and Rano.

Answer: (a) The energy conversion which takes place is the change of the potential energy of the Rano while standing on the swing into the kinetic energy of the swing due to which the speed of the swing increases.

(b) The muscular energy of Rano is not converted into the specific form of the energy but it is imparted as the additional kinetic energy to the swing which makes the swing fast.

(c) Roma is adventurous and courageous while Rano is timid and fearful. Also, Roma is risk-taking and Rano is very careful.