WORK, ENERGY AND POWER

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ABSTRACT

Work is defined as a force acting upon an object to cause a displacement. Work is defined as a force acting upon an object to cause a displacement. Amount of work done depends on the force and displacement. The greater the distance, or force, the greater the work done. Energy is often defined as the ability or capacity to do work. The energy transferred to an object by the work of moving it a distance of one meter against a force of one newton. The common energy are kinetic energy and potential energy. Kinetic energy is also called as the energy of motion. The faster an object moves, the more kinetic energy it has. Conservation of energy states that energy is neither created nor destroyed, it is converted from one form to another. This principle implies that the total amount of energy in a closed system remains constant. Power is the rate at which work is done or rate of energy transformed. It is simply energy exchanged per unit time, or how fast you get work done.

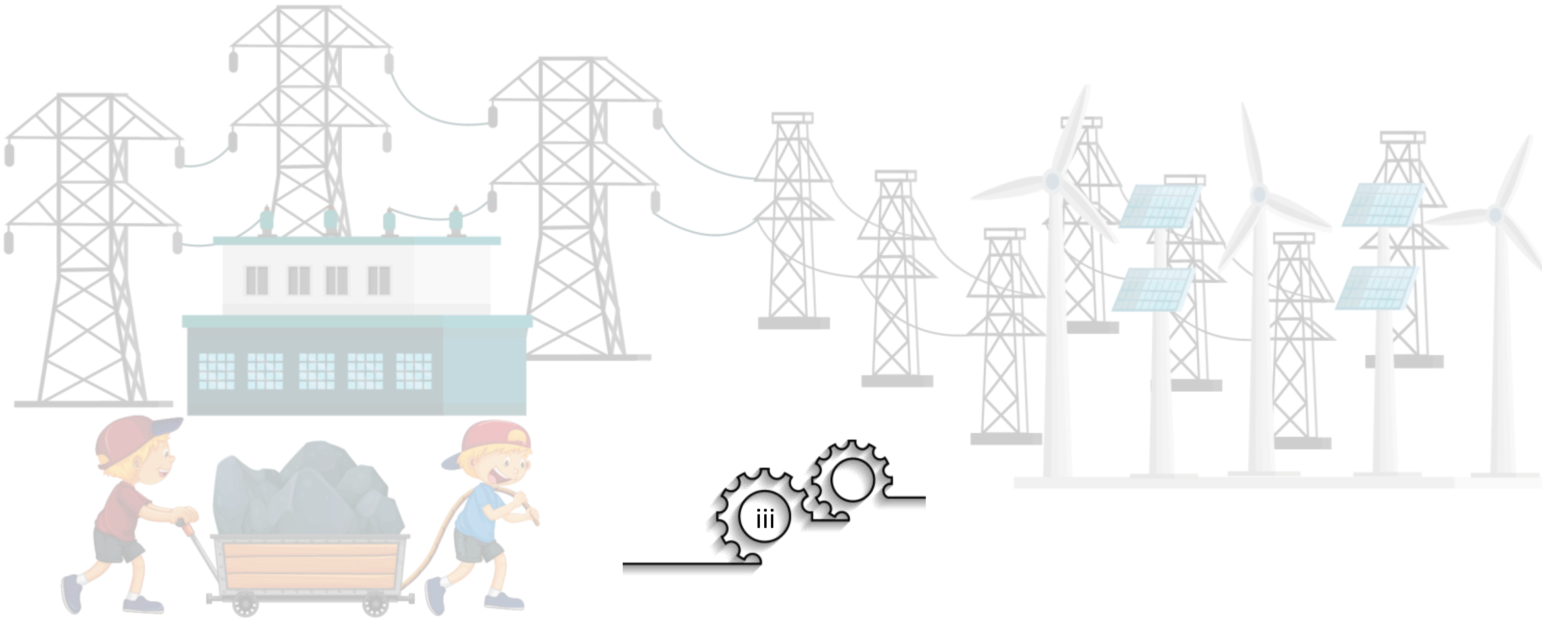


TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURE

1.0 INTRODUCTION OF WORK, ENERGY AND POWER

Work is defined as a force acting upon an object to cause a displacement. In science, work is done only when a force produces a motion and no work is done when a force is applied but no displacement occurs. The concepts of work and energy are closely tied to the concept of force because an applied force can do work on an object and cause a change in energy. The work energy principle states that an increase of the kinetic energy of an object is caused by an equal amount of positive work done on the object by the resultant force acting on that object. Conversely, a decrease in kinetic energy is caused by an equal amount of negative work done by the resultant force.

Energy is often defined as the ability or capacity to do work. The energy transferred to an object by the work of moving it a distance of one meter against a force of one newton. The common energy are kinetic energy and potential energy. Kinetic energy is also called as the energy of motion. The faster an object moves, the more kinetic energy it has. Potential energy is energy that is stored in an object because of its position or state. Potential energy that is dependent on height is called gravitational potential energy. The sum of translational and rotational kinetic energy and potential energy within a system is referred to as mechanical energy. Energy can be transformed between different forms at various efficiencies and it stated in the principle of conservation of energy. Conservation of energy states that energy is neither created nor destroyed, it is converted from one form to another. This principle implies that the total amount of energy in a closed system remains constant. Power is the rate at which work is done or rate of energy transformed. It is simply energy exchanged per unit time, or how fast you get work done.

Power is the rate at which work is done or rate of energy transformed. It can also be defined as the quantity of force needed to cause a unit displacement. For the same amount of work, power and time are inversely proportional. Therefore, a more powerful machine does the same amount of work in less time. A human also has a *power rating*. Some people are more power full than others, meaning that they are capable of doing the same amount of work in less time or more work in the same amount of time. The integral of power over time defines the work performed.

1.1 Work

Work is defined as a force acting upon an object to cause a displacement. Amount of work done depends on the force and displacement. The greater the distance, or force, the greater the work done. The International System of Units (SI) unit of work is the Joule (J). Mathematically, work can be expressed by the following equation.

$$W = F \times d$$

Where:

W = Work, (Nm or Joule)

F = Force, (N)

d = distance moved in the direction of the force (meter, m)

As we can see from the work equation, that there is no work done, if there is no displacement, irrespective of how large the force is. We can say that there is no work done when;

i. the displacement is zero

ii. the force is zero

iii. the force and displacement are mutually perpendicular to each other.

Figure 1.1 show the examples of work done in change of position/displacement, speed/direction and shape/size.

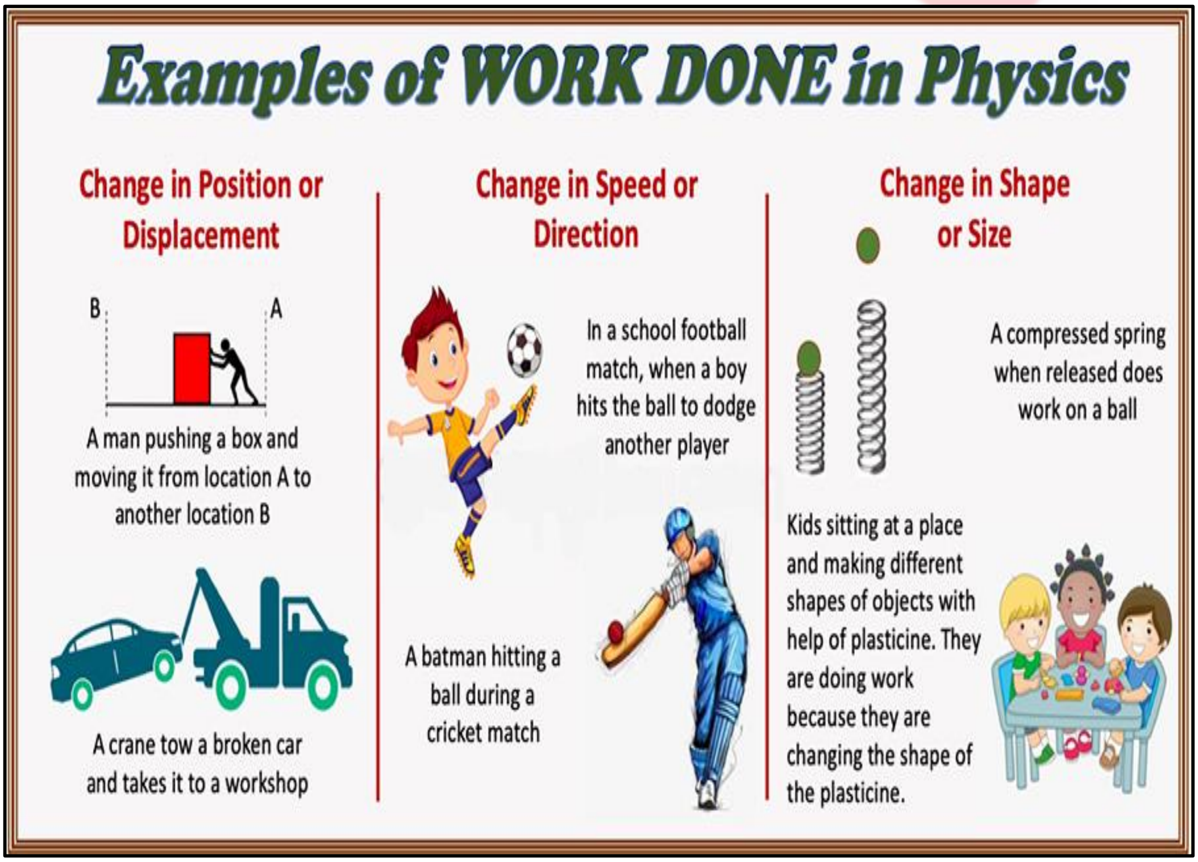


Figure 1.1 Example of Work done in Physics

There are two types of work which are positive work and negative work. Positive work means the force is acting in the same direction as the motion of the object. Positive work means an increase in speed. Negative work means the force is acting in the opposite direction as the motion of the object. Negative work means a decrease in speed.

Figure 1.2 shows about positive and negative work done.

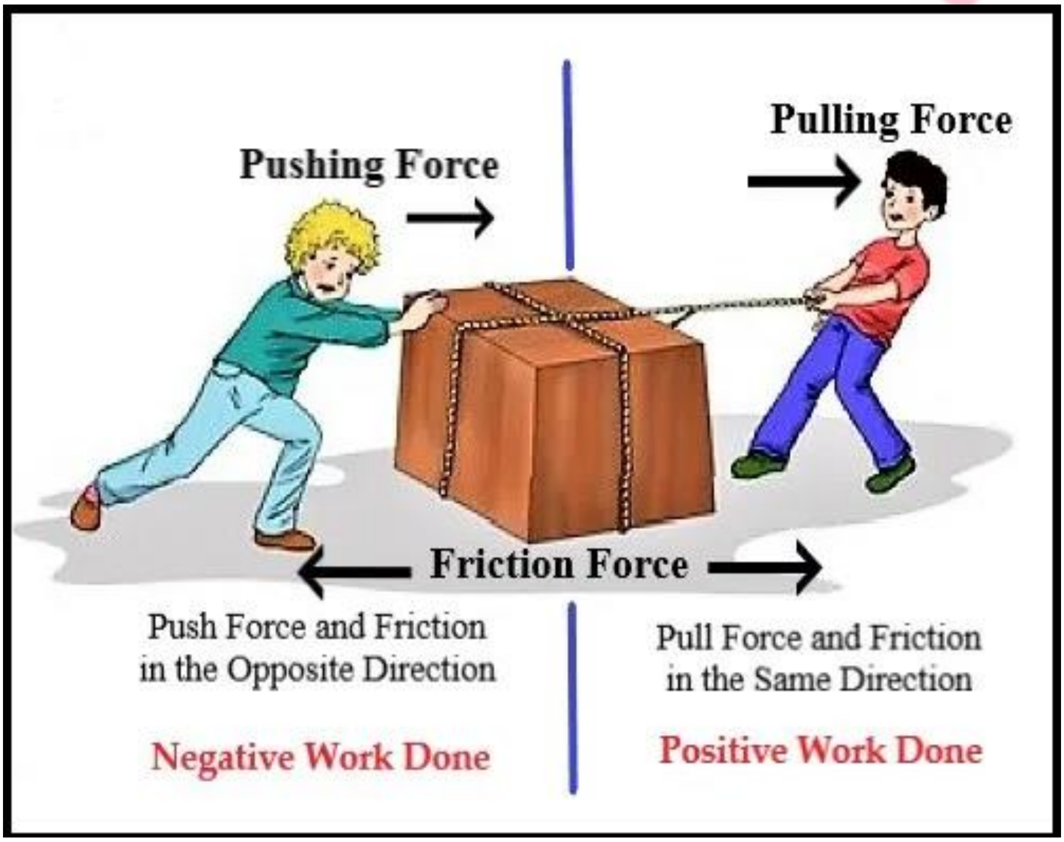


Figure 1.2 Example of Positive and Negative Work

There are four different situations that can describe the suitable formula to find work done.

i. Work done by a constant force on a point that moves a displacement in a straight line (horizontal) in the direction of the force.

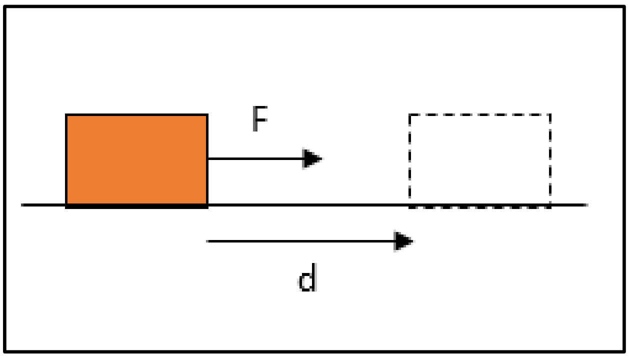


Figure 1.3 Force moves in a straight horizontal line

W = F x d

ii. Work done by gravity depends only on the vertical movement of the object and on the object by its weight.

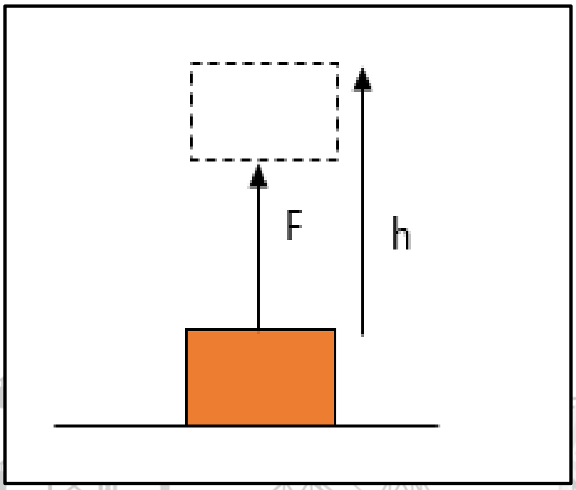


Figure 1.4 Force moves in a vertical straight line

W = mg x h

iii. Work done by a constant force in a straight line (horizontal) and the angle between the force and the displacement is θ.

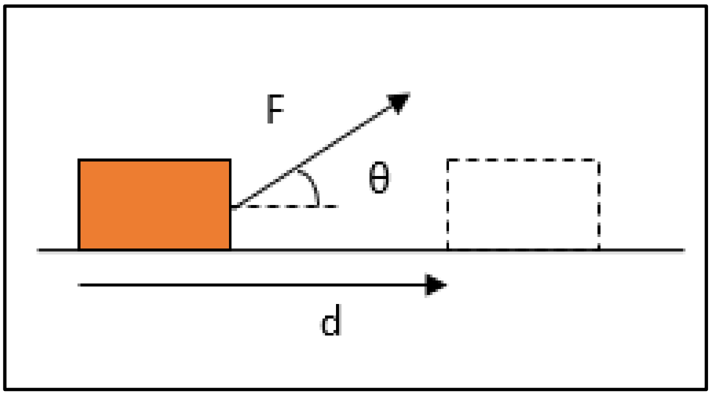


Figure 1.5 Angle between force and displacement is θ

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

iv. Work done by a force and displacement up a slope with angle θ.

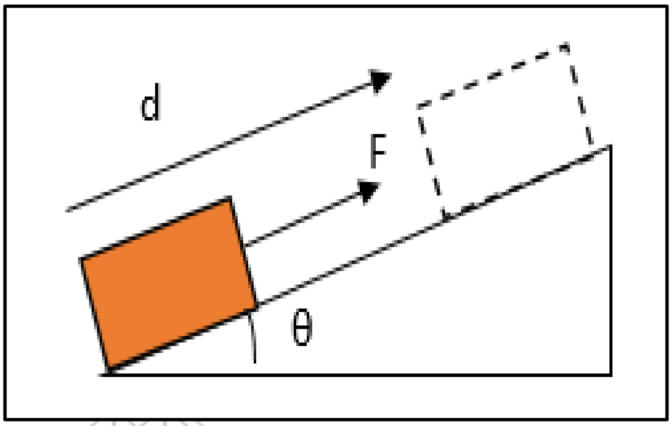


Figure 1.6 Force and displacement up a slope with angle θ

$$W = mg \sin \theta \times d$$

Examples Of Work

Example 1.1

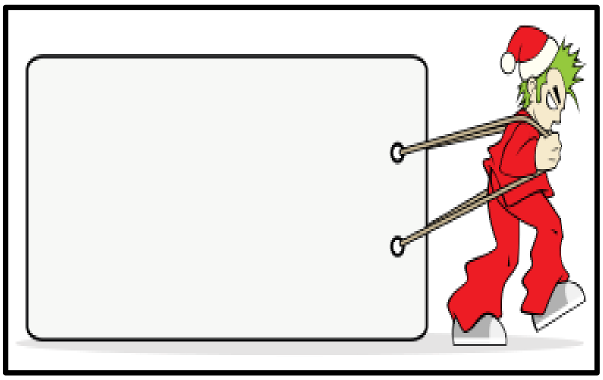
A boy pulls a box with 745N for a distance of 9m. How much work that has he done?

Solution;

W = F x d

= (675 N) (9m)

= 6075 Nm @ 6.075 kJoule



Example 1.2

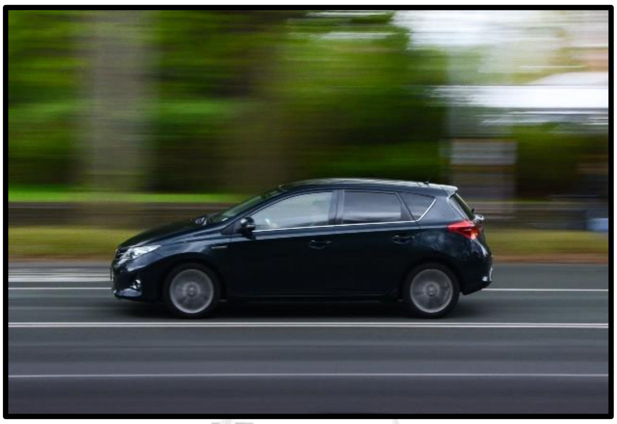
How much work is done on a small car if a 3150N force is exerted to move it 75.5m to the side of the road?

Solution;

W = F x d

= (3150 N) (75.5m)

= 237825 Nm @ 237.825 kJoule



Example 1.3

Figure 1.7 shows that a force of 0.4Kn acting at 70^{0} above the horizontal in pulling a block 800cm along a horizontal surface in 9 seconds. Calculate work done to pull a block.

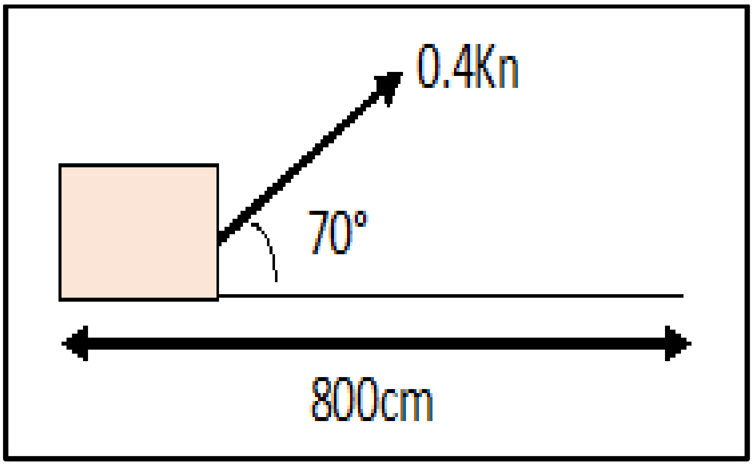


Figure 1.7

Solution;

F = 0.4kN = 400N   d = 800cm = 8m

W = F cos θ d

= (400) (cos 70) (8)

= (400) (0.342) (8)

= 1094.46Nm

Example 1.4

A man lifts 8kg box through a vertical distance of 1.5m as shown in Figure 1.8. What is the work done by the man? ($g = 9.81\ ms^{-2}$)

Figure 1.8

Solution;

W = F x d

= mg x d

= (8) (9.81) (1.5)

= 14.72 Nm

Example 1.5

A crane is being lifted into a truck. If it is moved with a 2470N force and 3650J of work is done, then how far is the crane being lifted?

Solution;

W = F x d

d = W/F

$= \frac{3650}{2470}$

= 1.48 m

Example 1.6

If 16700J of work is done to shoot the human cannonball down a 3.05m barrel, then how much
force is applied to the person to fire them out the cannon?

Solution;

$$W = F \times d$$

$$F = W/d$$

$$= \frac{16700}{3.05}$$

$$\mathbf{= 5475.41\ N}$$

Exercise Of Work

1. A boy pushes a wall with a 400N force. What is the work done? **(Ans : 0Nm)**

2. A box is pulled with a force of 25 N to produce a displacement of 15 m. If the angle between the force and displacement is 30^o, find the work done by the force.

(Ans : 324.76Nm)

3. A man pulls a trolley with 680N for a distance 9m. How much work that has he done? **(Ans : 6120Nm)**

4. A students lifts a 5 kg bag onto his shoulders through a distance of 1.3m. What is the work done by the students? **(Ans : 63.77Nm)**

5. A 10kg block is pulled 720cm along a frictionless plane by a 98N force that acts at 28^o above the horizontal. What is the work done by the force of the block? (Assume g = $10 m/s^2$) **(Ans : 331.26Nm)**

6. A man drags a 5kg bag at constant speed along a horizontal surface through a distance of 3m. The student does this by exerting a force of 50N with an angle of 45^o. Find the work done by the student. **(Ans : 106.07Nm)**

2.0 Energy

Energy is often defined as the ability or capacity to do work. The unit of measurement in the International System of Units (SI) of energy is the Joule, J.

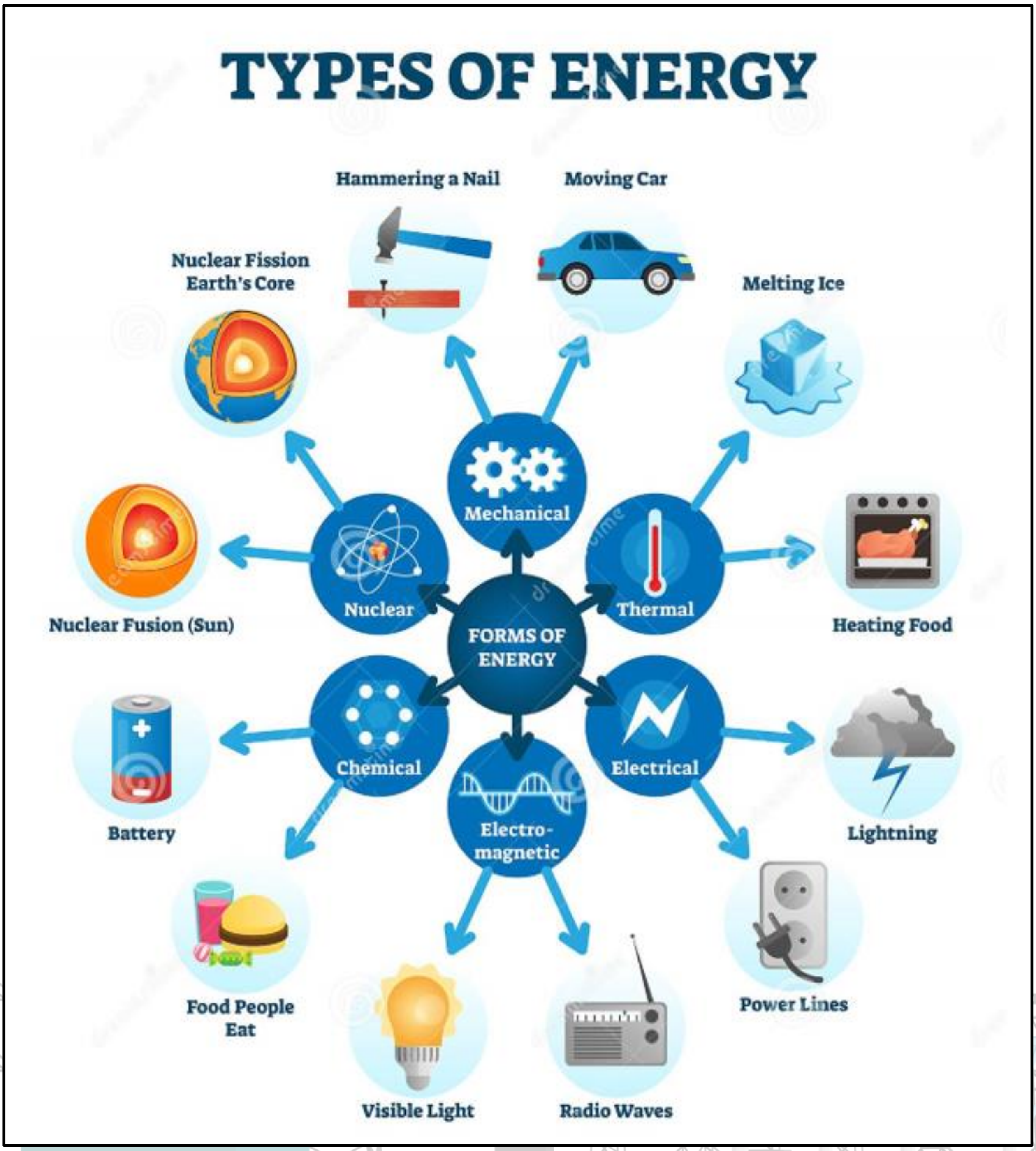


Figure 2.1 Types of Energy

2.1 Energy Resources

Energy resources can be categorized into two types:

i. Renewable Energy

ii. Non-renewable Energy

2.1.1 Renewable Energy

Renewable energy, often referred to as clean energy, comes from natural sources or processes that are constantly replenished and over relatively short periods of time.

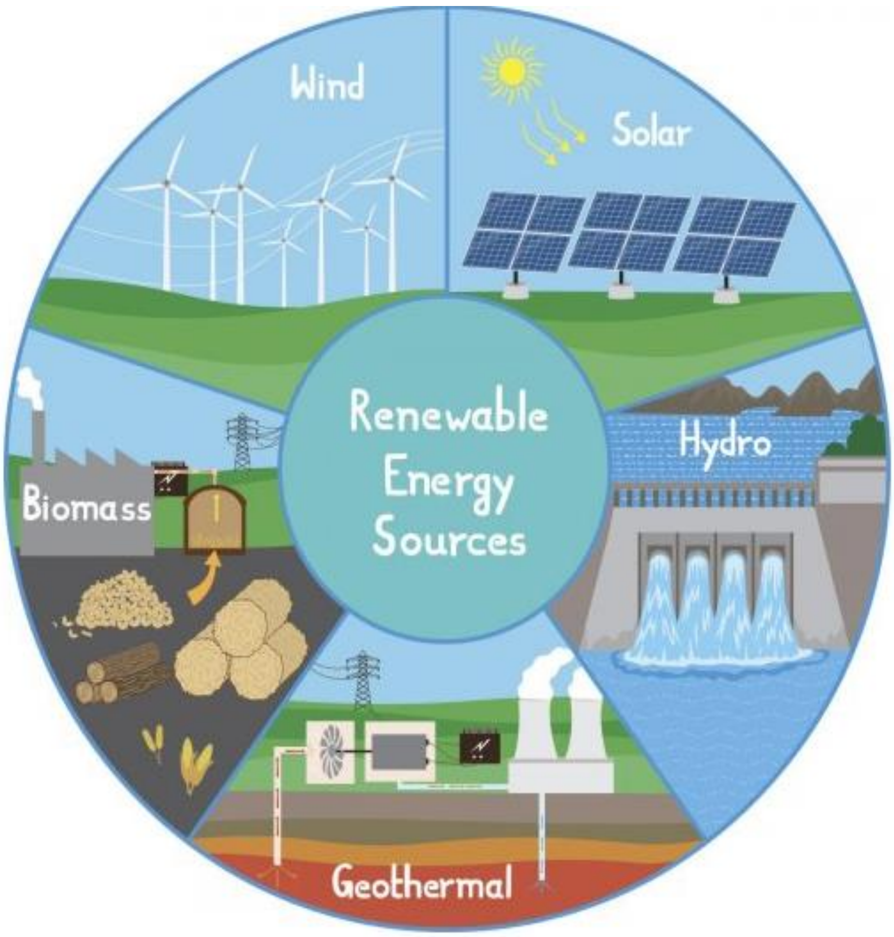


Figure 2.2 : Types of Renewable Energy

2.1.2 The 5 primary renewable energy resources

i. Solar Energy

The amount of sunlight that strikes the earth's surface in an hour and a half is enough to handle the entire world's energy consumption for a full year. Solar technologies convert sunlight into electrical energy either through photovoltaic (PV) panels or through mirrors that concentrate solar radiation. This energy can be used to generate electricity or be stored in batteries or thermal storage.

ii. Wind Energy

Wind turbines use blades to collect the wind's kinetic energy. Wind flows over the blades creating lift (similar to the effect on airplane wings), which causes the blades to turn. The blades are connected to a drive shaft that turns an electric generator, which produces (generates) electricity.

iii. Water (hydro) Energy

Hydroelectric energy, also called hydroelectric power or hydroelectricity, is a form of energy that harnesses the power of water in motion—such as water flowing over a waterfall—to generate electricity.

iv. Biomass Energy

Biomass energy is energy generated or produced by living or once-living organisms. The most common biomass materials used for energy are plants, such as corn and soy, above. The energy from these organisms can be burned to create heat or converted into electricity.

v. Geothermal Energy

By harnessing the natural heat below the earth's surface, geothermal energy can be used to heat homes directly or to generate electricity. Although it harnesses a power directly below our feet, geothermal energy is of negligible importance in the UK compared to countries such as Iceland, where geothermal heat is much more freely available

2.1.3 Application of Renewable Energy

There are many application of renewable energy such as :

i. Used for heating, transportation, lighting, and more.

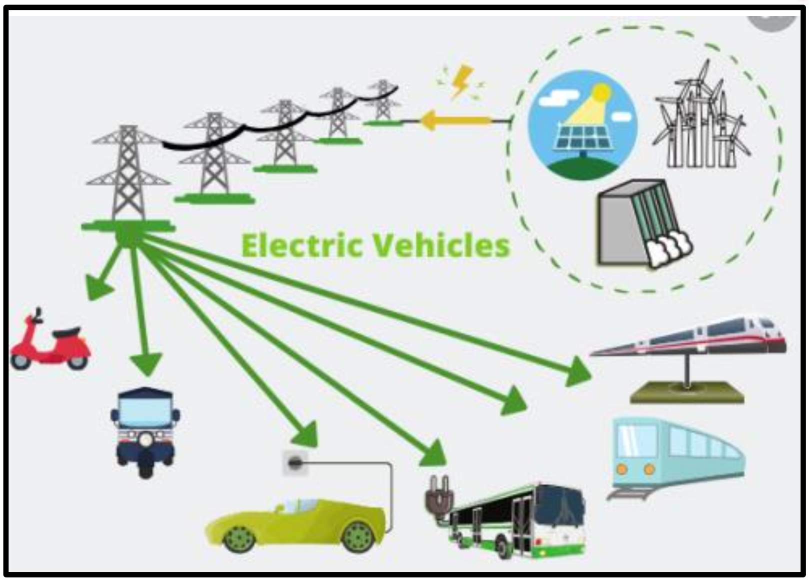


Figure 2.3 Renewable energy, hydroelectric for transportation

ii. Wind has powered the boats to sail at the seas

Figure 2.4 Renewable energy, wind to power the boats sail

iii. Build the rooftop solar panels at homes

Figure 2.5 Renewable energy, solar as solar panels at home

2.1.4 Advantages of Renewable Energy

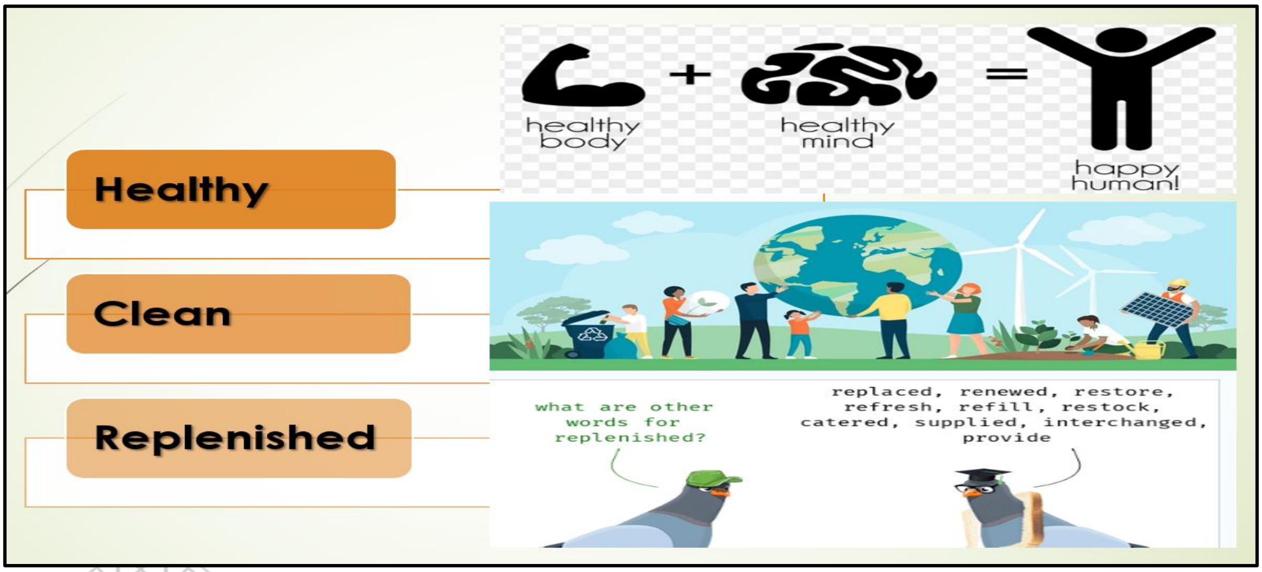


Figure 2.6 Advantages of renewable energy

The advantages of renewable energy are :

i. For healthy body and healthy mind

ii. For clean environment

iii. Easy to replenished.

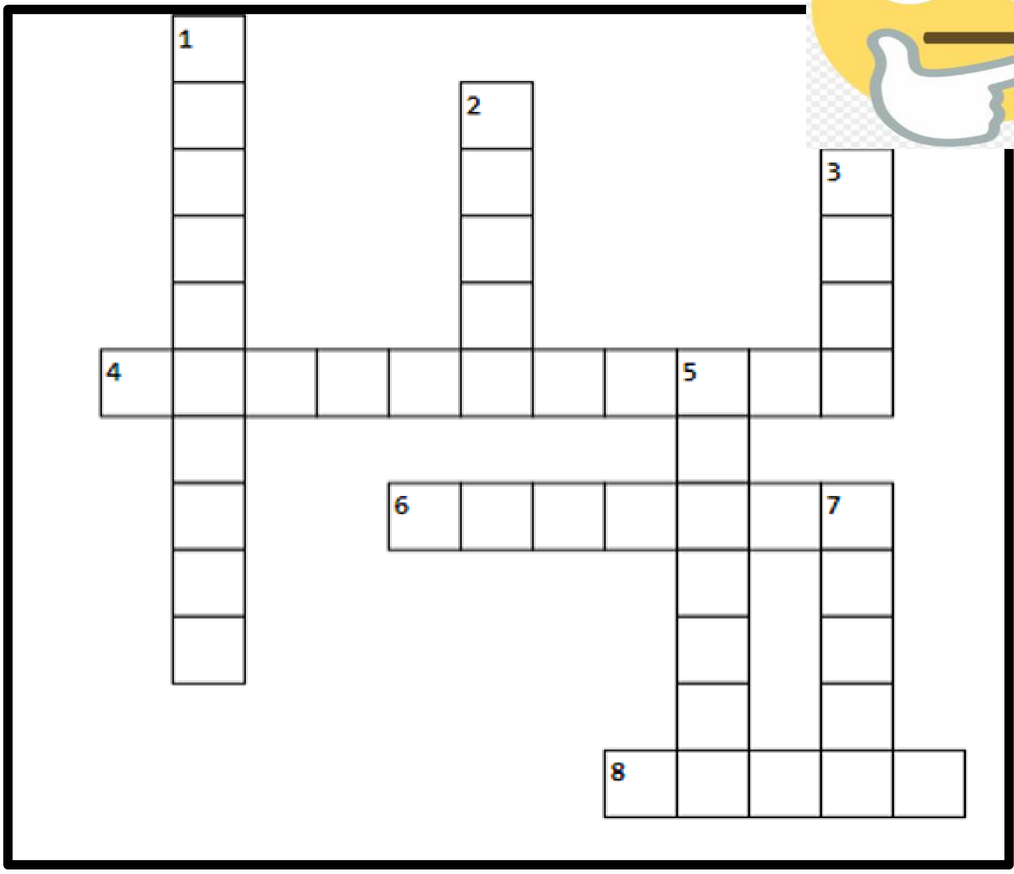
2.1.5 Non Renewable Energy

Nonrenewable energy also known as ‘dirty’ energy. The sources of energy only available in limited supplies and takes a long time to replenish. Nonrenewable energy includes fossil fuels such as oil, gas, coal and nuclear.

These are the disadvantages of non renewable energy to mankind:

i. Can endanger the environment such as oil drilling can cause fracking and thus can cause the earthquake and water pollution and coal power plants can foul the air.
ii. Can effect human health.
iii. Can contribute to global warming.

CROSSWORLD PUZZLE – RENEWABLE ENERGY



Across

4. Advantages of renewable energy of green technology

6.Energy generated or produced by living or once-living organisms

8.A form of energy that harnesses the power of water in motion.

Down

1.Renewable energy source because heat is continuously produced inside the earth.

2.Advantages of renewable energy to environment

3.Flows over the blades creating lift (similar to the effect on airplane wings) which causes the blades to turn

5.Advantages of renewable energy to human

7.Convert sunlight into electrical energy either through photovoltaic (PV) panels

3.0 Potential Energy, Kinetic Energy & Principle of Conservation Energy

There are several different forms of energy, including kinetic, potential, thermal, elastic, electromagnetic, chemical and nuclear. Mechanical energy is the sum of the kinetic and potential energies possessed by an object.

Mathematically, mechanical energy can be expressed by the following equation.

Total Mechanical Energy = Potential energy + Kinetic energy

$$\Sigma E = mgh + \frac{1}{2} mv^2$$

3.1 Potential Energy, PE

Potential energy is energy that is stored in an object because of its position or state. Potential energy that is dependent on height is called gravitational potential energy. It is maximum at the maximum height. Mathematically, kinetic energy can be expressed by the following equation.

$$PE = mgh$$

Where;

PE = Potential Energy (J)

m = mass (kg)

g = gravity acceleration (m/s^2)

h = height (m)

3.2 Kinetic Energy, KE

Kinetic Energy is the energy of motion. The faster an object moves and the greater the mass of a moving object, the more kinetic energy it has. Kinetic energy depends on both mass and velocity. Mathematically, kinetic energy can be expressed by the following equation.

$$KE = \frac{1}{2} mv^2$$

Where;

KE = Kinetic Energy (J)

m = mass (kg)

v = velocity (m/s)

3.3 Principle of Conservation Energy

The principle of conservation of energy states that:

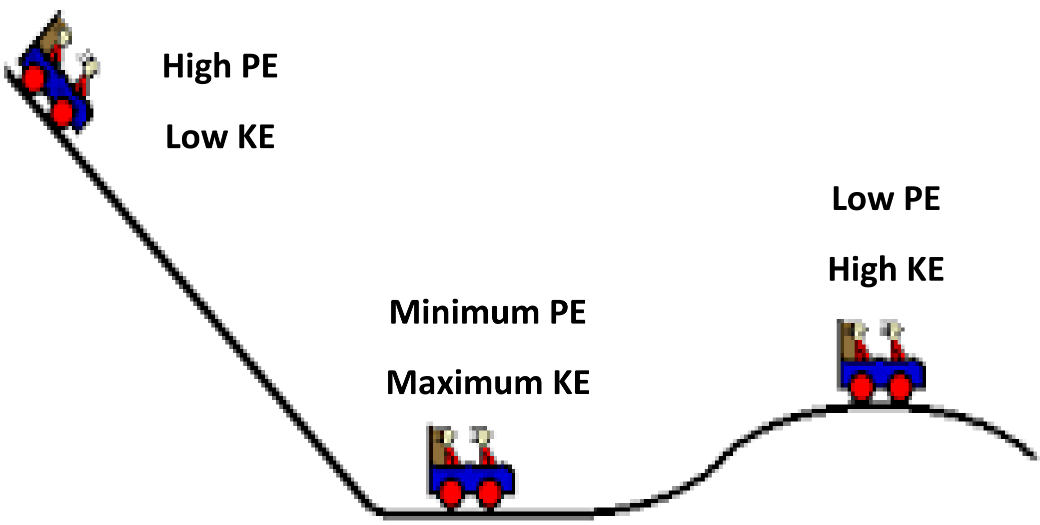
i. Energy is neither created nor destroyed. It is converted from one form to another.

ii. This principle implies that the total amount of energy in a closed system remains constant.

The most common conservation of energy involves the changing of potential energy into kinetic energy or vice-versa.

At the top, an object has its maximum potential energy. (Potential Energy = Max), (Kinetic Energy = 0).

At the bottom its potential energy has been converted into kinetic energy so that it now has its maximum kinetic energy. (Kinetic Energy =Max), (Potential Energy = 0)



As a coaster car loses height, it gains speed, Potential Energy (PE) is transformed into Kinetic Energy (KE).

As a coaster car gains height it loses speed Kinetic Energy (KE) is transformed into Potential Energy (PE).

The sum of the Kinetic Energy (KE) and Potential Energy (PE) is constant.

Figure 3.1 Comparison of Potential Energy and Kinetic Energy

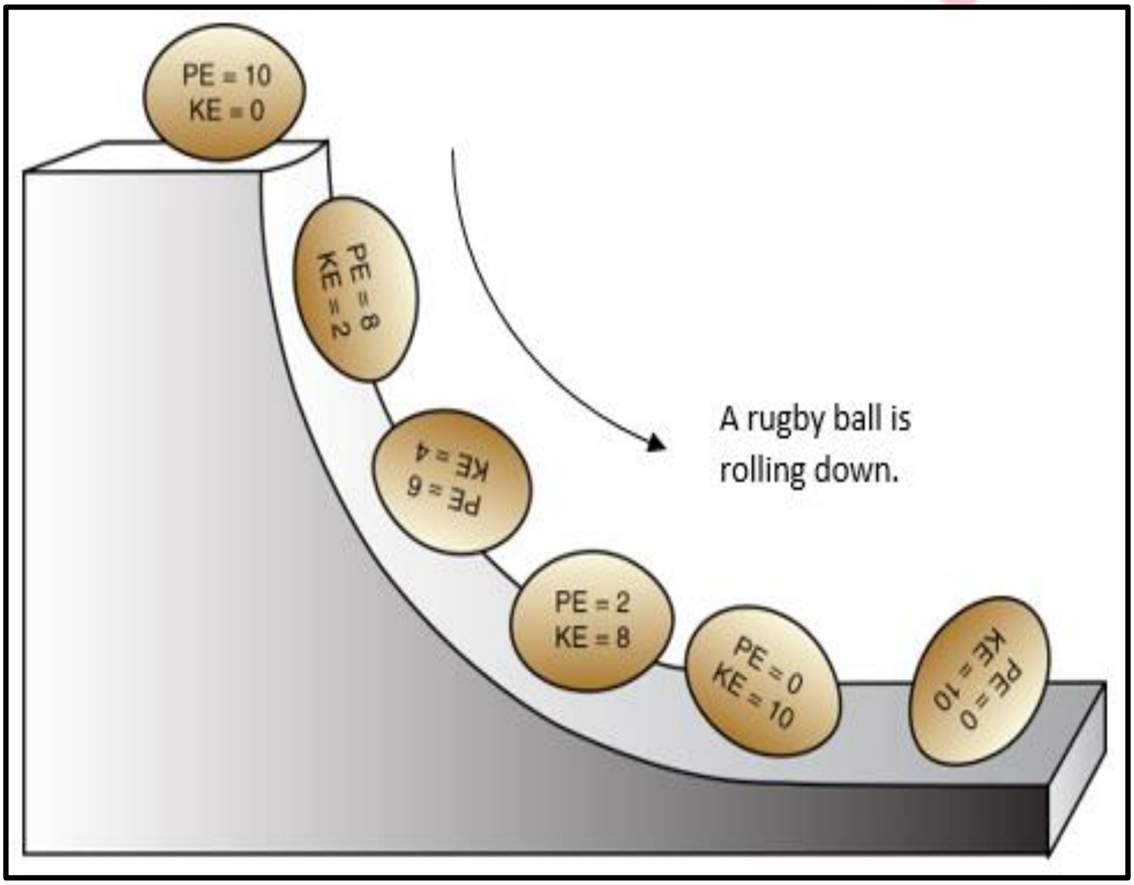


Figure 3.2 Principle of Conservation Energy

Examples of Energy

Example 3.1

Calculate the kinetic energy of 1500 kg car moves down the freeway at 30 m/s.

Solution :

Given : m = 1500 kg v = $30ms^{-1}$

Kinetic Energy = $\frac{1}{2} mv^2$

= $\frac{1}{2} (1500)(30)^2$

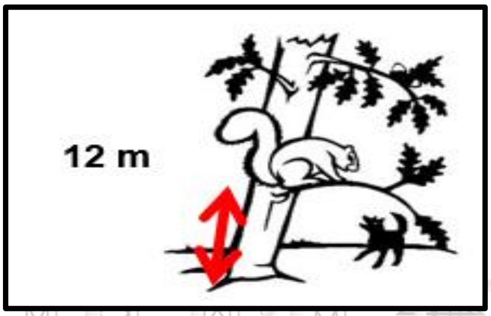
= 675 kJ

Example 3.2

An 700 g squirrel climbs up a 12 m tree. What is its potential energy gained?

Solution :

Given : m = 700 g = 0.7 kg h= 12.0 m g= 9.81 ms^{-2}



Potential Energy = mgh

= (0.7)(9.81)(12)

= 82.404 Joule

Example 3.3

Table 3.1 shows the masses and velocities of two boys, Arif and Ben. Which of the boys has greater kinetic energy?

Boy	Mass (kg)	Velocity (ms^{-1})
Arif	95	4.8
Ben	48	9.5

Table 3.1

Solution :

Kinetic Energy Ariff = ½ mv^2

= ½ (95) $(4.8)^2$

= **1094.4 Joule**

Kinetic Energy Ben = ½ mv^2

= ½ (48) $(9.5)^2$

= 2166 Joule

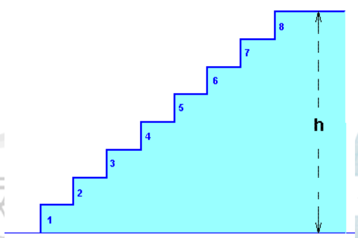
So Ben has more kinetic energy

Example 3.4

A 60 kg boy runs up a flight of stairs. There are 8 stairs and each of them is 14 cm high. What is the potential energy gained by the boy?

Solution :

Given : m = 60 kg   h = 0.14 x 8 = 1.12 m   g= 9.81 ms^{-2}



Potential Energy = mgh

= (60)(9.81)(1.12)

= 659.232 Joule

Example 3.5

A 78kg skydiver has a speed of 62m/s at an altitude of 870m above the ground. Determine :

i. The kinetic energy possessed by the skydiver

ii. The potential energy possessed by the skydiver

iii. The total energy possessed by the skydiver.

Solution :

m = 78 kg v = $62\ ms^{-1}$ h= 870 m g= $9.81\ ms^{-2}$

i. The kinetic energy possessed by the skydiver:

Kinetic Energy = ½ mv^2

= ½ (78) $(62)^2$

= 149 916 Joule

ii. The potential energy possessed by the skydiver:

Potential Energy = mgh

= 78 (9.81) (870)

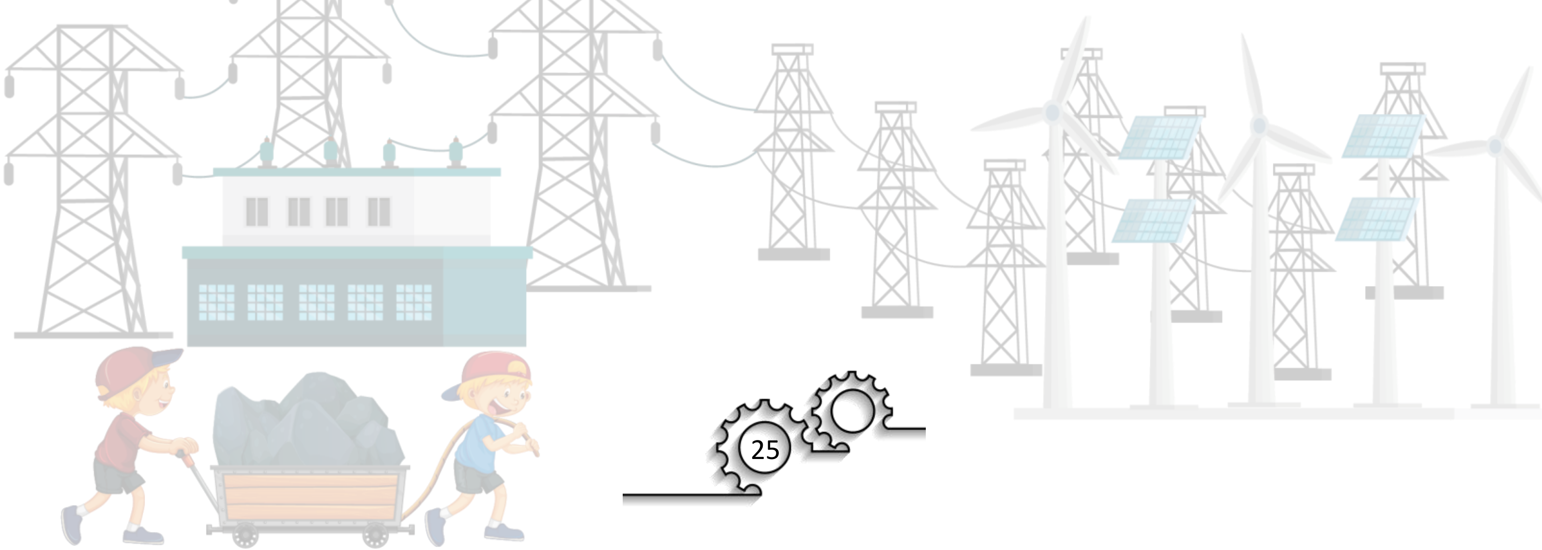
= 665 706.6 Joule

iii. The total energy possessed by the skydiver.

Total Energy = Potential Energy + Kinetic Energy

= 149 916 Joule + 665 706.6 Joule

= 815 622.6 Joule



Example 3.6 :

An apple with mass 150 g drop from tree with height 20 m. Find:

a. Potential energy before it drops

b. The velocity when it drop 15 m from ground

c. Kinetic energy when its reach ground.

Solution :

a. Potential energy before it drops

$$PE = mgh$$

$$= (0.15)(9.81)(20)$$

$$\mathbf{PE = 29.43\ J}$$

b. The velocity when it drop 15 m from ground

$$v^2 = u^2 + 2\ a\ s$$

$$= 0^2 + 2\ (9.81)\ (5)$$

$$\mathbf{V = 9.905\ m/s}$$

c. Kinetic energy when its reach ground.

$$KEmax = PE\ max$$

$$= mgh$$

$$= (0.15)(9.81)(20)$$

$$\mathbf{KE\ max = 29.43\ J}$$

Example 3.7

A ball with a mass of 800g is dropped from a height of 5.0m and rebounds to a height of 3.8 m. The air resistance is negligible. Calculate:

i. The kinetic energy of the ball just before the impact

ii. The initial rebound speed of the ball

iii. The energy transferred to the ground during the impact

Solution :

Given : m=0.8 kg h_1 = 5.0 m h_2 = 3.8 m g= 9.81 ms^{-2}

i. The kinetic energy of the ball just before the impact

Final kinetic energy = loss of potential energy

Kinetic Energy = mgh

= (0.8) (9.81) (5.0)

= 39.24 Joule

ii. The initial rebound speed of the ball, v

Potential Energy = mgh

= (0.8) (9.81) (3.8)

= 29.82 Joule

Potential Energy = Kinetic Energy = ½ mv^2

29.82 Joule = ½ (0.8) v^2

V^2 = (29.82 x 2) / 0.8

V = √74.55

V = 8.63 ms^{-1}

iii. The energy transferred to the ground during the impact

Energy transferred = $PE_{\text{before rebound}} - PE_{\text{after rebound}}$

= 39.24 Joule – 29.82 Joule

= **9.42 Joule**

Exercise of Energy

1. A 50g stone is dropped freely from a height of 45m. what is the speed just before it touches the ground?

   Answer : V=29.71 ms^{-1}

2. A man is carrying a trolley of a mass of 6 kg and having kinetic energy of 40 Joule. Calculate its velocity with which is he is running?

   Answer : V= 3.65 ms^{-1}

3. An object of 30 kg mass was lifted as high as 3 m from the ground and was let to fall under the gravitational reaction. Calculate the gravitational potential energy and the kinetic energy possessed by the object under these situations:

   i. before it was let to fall — Answer : **(PE = 882.9 J, KE=0J)**

   ii. 1 meter under free fall — Answer : **(PE = 588.6 J, KE= 294.3 J)**

   iii. right after its touched the ground — Answer: **(PE=0J, KE=882.9 J)**

4. Jane is the tallest player in South's Varsity volleyball team. She is in spiking position when Suzie gives her the perfect set. The 226g volleyball is 2.29m above the ground and has a speed of 1.06m/s. Jane spikes the ball, doing 9.98 J of work on it.

   Determine :

   i. The potential energy of the ball before the spike. **Answer: 5.078 Joule**

   ii. The kinetic energy of the ball before the spike. **Answer: 0.127 Joule**

   iii. The total energy of the ball before the spike. **Answer : 5.025 Joule**

   iv. Determine the total energy of the ball upon hitting the floor on the opponent's side.

      a. **Answer : 15.095 Joule**

   v. Determine the speed of the ball upon hitting the floor on the opponent's side of the net.

      a. **Answer : 11.56 ms^{-1}**

4.0 POWER

Power is the rate at which work is done or rate of energy transformed. Power is simply energy exchanged per unit time or how fast a work done. The standard metric unit of power is the Watt @ J/s @ Nm/s. The same amount of work done faster, will produce more power. Mathematically, kinetic energy can be expressed by the following equation.

$$P = W/t$$

Where :

P = Power (Watt @ J/s @ Nm/s)

W = Work, (Nm or Joule)

t = time, s

4.1 Efficiency

Efficiency is the percentage of the input energy that is transformed to a useful form of output energy. Efficiency also defined as the ratio of the useful output energy to the total energy put into the machine.

$$\text{Efficiency} = \frac{\text{Work output}}{\text{Work input}} \times 100\%$$

$$\text{Efficiency} = \frac{\text{Energy output}}{\text{Energy input}} \times 100\%$$

$$\text{Efficiency} = \frac{\text{Power output}}{\text{Power input}} \times 100\%$$

Examples of Power
Example 4.1

Define power and state its SI unit.

Solution:

Power is defined as the rate at which work is done or rate of energy transformed. Power is simply energy exchanged per unit time, or how fast the work is done.

The SI unit for power is Watt @ J/s @ Nm/s

Example 4.2

A cat with 2kg mass climbs up a 10 m rambutan tree in 15s. Calculate the power done by the cat. (Given the acceleration of gravity as 9.81m/s^2)

Solution:

$$\text{Work, } W = mgh$$

$$W = 2 \times 9.81 \times 10$$

$$= 196.2 \text{ Nm or J}$$

$$\text{Power, } P = \frac{\text{Work}}{\text{time}}$$

$$P = \frac{W}{t}$$

$$= \frac{196.2 \text{ Nm}}{15 \text{ s}}$$

$$= \mathbf{13.08 \text{ Nm/s @W}}$$

Example 4.3

Aminah went to Kuala Lumpur International Airport by carrying a luggage with 5kg with an angle 30° with horizontal surface. She pulls a luggage for 500m to the ticket counter in 5 minutes. Calculate the power done by Aminah. (Given the acceleration of gravity as 9.81m/s^2)

Solution:

$$\text{Work, } W = F \cos\theta \times d$$

$$W = (5 \times 9.81) \cos 30^\circ \times (500/1000)$$

$$= (49.05) \cos 30^\circ (0.5)$$

$$= 21.85 \text{ Nm or J}$$

$$\text{Power, } P = \frac{\text{Work}}{\text{time}}$$

$$P = \frac{W}{t}$$

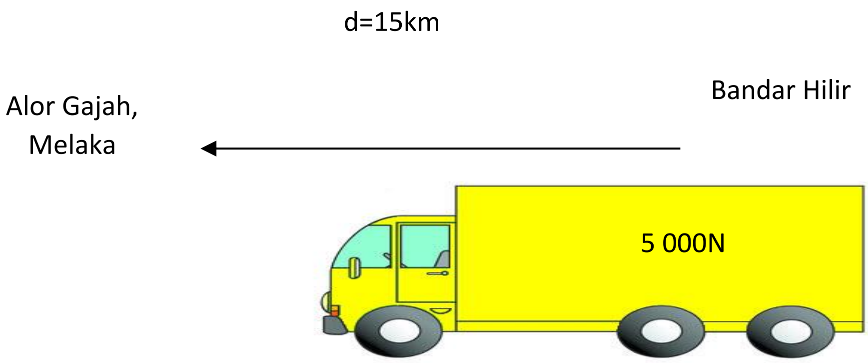
$$= \frac{21.85 \text{ Nm}}{(5 \times 60) \text{ s}}$$

$$= \frac{21.85 \text{ Nm}}{300 \text{ s}}$$

$$\mathbf{= 0.07 \text{ Nm/s @W}}$$

Example 4.4

The lorry moves from Bandar Hilir, Melaka to Alor Gajah, Melaka to transfer the goods. It took 50 minutes for lorry to reach Alor Gajah. Calculate the power done.



Solution:

Work, W = Force x displacement

W = F x d

= 5000 x 15 000 m

= 75, 000, 000 Nm or J

Power, P = $\frac{\text{Work}}{\text{time}}$

P = $\frac{W}{t}$

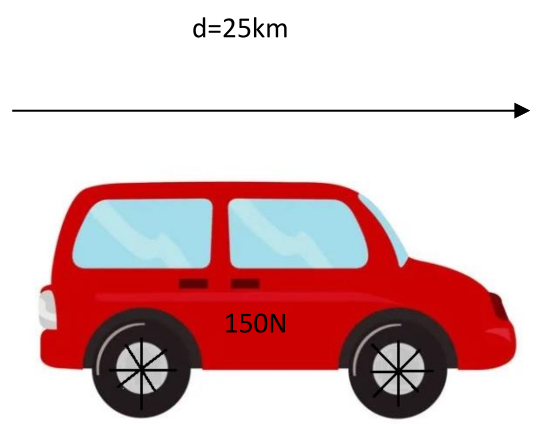
= $\frac{75000000 \text{ Nm}}{(50 \times 60) \text{ s}}$

= $\frac{75000000 \text{ Nm}}{3000\text{s}}$

= **25000 Nm/s @W**

Example 4.5

Ali drives from Malacca Town to Jasin to fetch his children. It tooks 1 hour for driver to reach Jasin. Calculate the power done.



Solution:

Work, W = Force x displacement

$$W = F \times d$$

$$= 150 \times 25\,000 \text{ m}$$

$$= 3,750,000 \text{ Nm or J}$$

$$\text{Power, } P = \frac{\text{Work}}{\text{time}}$$

$$P = \frac{W}{t}$$

$$= \frac{3\,750\,000 \text{ Nm}}{(1 \times 3600) \text{ s}}$$

$$= \frac{3750000 \text{ Nm}}{3600\text{s}}$$

= **1041.67 Nm/s @W**

Example 4.6

A 280W electric motor raised a 15 kg mass through a vertical distance of 20m in 12 s. Find the efficiency of the motor? [acceleration of gravity, g = 10 m/s^2]

Solution:

Mass, m = 15 kg, height, h = 20m, time, t = 12 s & Input power = 165 W

$$\text{Output power} = \frac{\text{work done}}{\text{time}}$$

$$= \frac{m\,g\,h}{t}$$

$$= \frac{15 \times 10 \times 20}{12}$$

$$= 250\ \text{W}$$

$$\text{Efficiency} = \frac{\text{output power}}{\text{input power}} \times 100\ \%$$

$$= \frac{250}{280} \times 100\ \%$$

$$= \mathbf{89.29\ \%}$$

Example 4.7

A DC electric motor is supplied with a voltage input of 250 V and 2A current to raise a load of 650 N. Determine the time taken to raise the load through a height of 10m?

Solution :

$$\text{Power} = VI$$

$$= 250\,(2)$$

$$= 500W$$

Given W=mg= 650N

$$\text{Power} = \frac{\text{work done}}{\text{time}}$$

$$500 = \frac{mgh}{t}$$

$$= \frac{650 \times 10}{t}$$

$$t = \frac{650 \times 10}{500}$$

$$= \mathbf{13s}$$

Example 4.8

The efficiency of electric motor is 76% to pull up load with 200N in 20s. Determine the height of the load is pulled up if the input power of the electric motor is 220W.

Solution:

Efficiency = 76%, W=mg=200N, t=20s, Input Power =220W

$$\text{Efficiency} = \frac{\text{output power}}{\text{input power}} \times 100\ \%$$

$$76\% = \frac{P_{out}}{220} \times 100\ \%$$

$$P_{out} = 167.2\text{W}$$

$$\text{Output power} = \frac{\text{work done}}{\text{time}}$$

$$167.2 = \frac{200\ h}{20}$$

$$h = \frac{167.2 \times 20}{200}$$

$$= \mathbf{16.72m}$$

Exercise of Power

1. A squirrel climbs up a 13m rambutan tree in 45s. Calculate the power by squirrel?
(Given the acceleration of gravity as 9.81m/s^2)

Mass of squirrel = 8kg

(Answer: 22.67W)

2. Zara go back to to hostel by carrying a luggage with 4kg with an angle 35° with horizontal surface. She pulls a luggage for 300m to the hostel gate in 6 minutes. Calculate the power done by Zara. (Given the acceleration of gravity as 9.81m/s^2)

(Answer: 26.79W)

3. An object is pulled by the force of 60N along a horizontal floor at an angle of 55^0 for 16 m. Calculate the work done to the object and the power produced by the object if the time taken to pull the object is 15s.

(Answer: 550.63J; 36.71W)

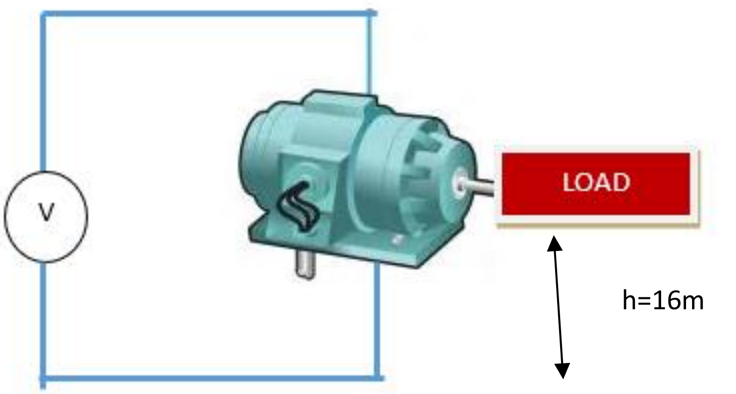
4. The lorry with 2000N load moves from Melaka to Kuala Lumpur to transfer the goods. It took 2 hours for lorry to reach Kuala Lumpur. Calculate the power done if the distance form Melaka to Kuala Lumpur is 55km.

(Answer: 15277.78W)

5. A 200W motor pump is used to raise water into a tank with a high of 10m. Determine the mass of water that has been raised into a tank in 0.5 hours.

(Answer: 3669.72kg)

6. An electric motor is supplied with a DC voltage of 240 V and 2 A current to raise a load of 1000 N. Determine the time taken to raise the load.



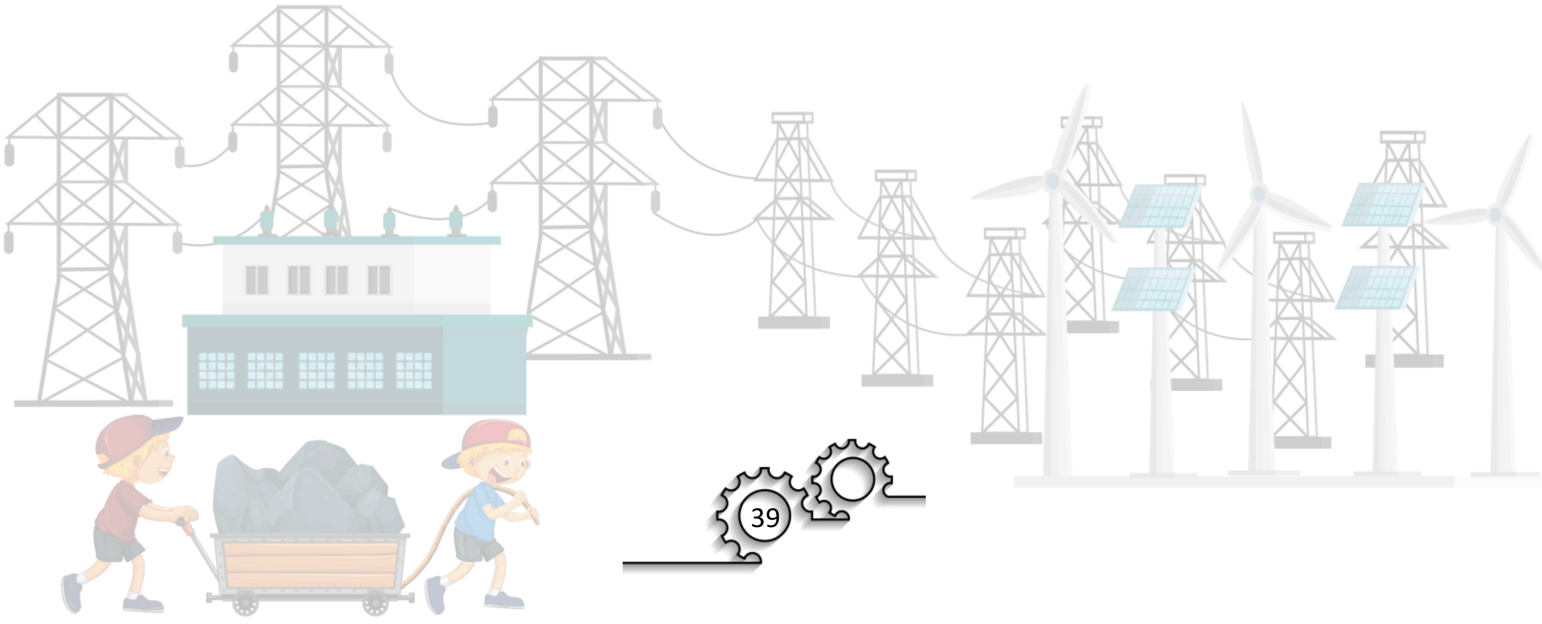
(Answer: 33.33s)

7. A crane lifts a load of 500 kg to a height of 120 m in 2 minutes. If the input power of the crane is 5500 W, calculate the efficiency of the crane's motor. (Given the acceleration of gravity as 9.81m/s)

(Answer: 89.19%)

8. A 300 W electric pump is 75% efficient. What is the time taken for it to pump up 40kg of water into a tank that is 18 m high.

(Answer: 30.18s)



Exercises of Work, Power and Energy

1. A box in figure 4.14 is pulled with a force of 25 N to produce a displacement of 15 m. If the angle between the force and horizontal surface is 30^0, find the work done by the force. **(Ans : 324.76Nm)**

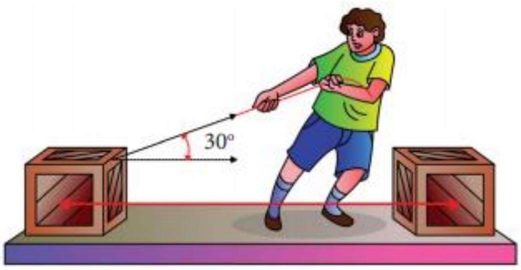


Figure 4.14

2. A man pulls a trolley with 680N for a distance 9m. How much work that has been done?

(Ans : 6120Nm)

3. A students lifts up a 5 kg bag onto his shoulders through a height of 1.3m. What is the work done by the students? **(Ans : 63.77Nm)**
4. A 10kg block is pulled 720cm along a frictionless plane by a 98N force that acts at 28^0 above the horizontal surface. What is the work done by the force of the block? (Assume $g = 10m/s^2$)

(Ans : 331.26Nm)

5. A student drags a 5kg bag at constant speed along a horizontal surface through a distance of 3m. The student does this by exerting a force of 50N with an angle of 45^0. Find the work done by the student. **(Answer : 106.07Nm)**
6. A ball with a mass of 800g is dropped from a height of 5.0m and rebounds to a height of 3.8 m. The air resistance is negligible. Calculate the kinetic energy of the ball just before the impact. **(Answer : 39.24 Joule)**
7. A 65kg man is carrying a trolley of a mass of 6 kg and having kinetic energy of 40 Joule. The man ran when he saw a dog chase over him. Calculate his velocity during running?

(Answer : $V = 1.06\ ms^{-1}$)

8. An object of 30 kg mass was lifted as high as 3 m from the ground and was let to fall under the gravitational reaction. Calculate the gravitational potential energy and the kinetic energy possessed by the object 1 meter under free fall.
   (Answer : PE = 588.6 J, KE= 294.3 J)

9. A squirrel with a mass 800g climbs up a 13m rambutan tree in 45s. Calculate the power done by squirrel? (Given the acceleration of gravity as $9.81 m/s^2$) **(Answer: 2.267W)**

10. A crane lifts a load of 500 kg to a height of 120 m in 2 minutes. If the input power of the crane is 5500 W, calculate the efficiency of the crane's motor. (Given the acceleration of gravity as 9.81m/s) **(Answer: 89.19%)**

FUN ACTIVITY

POP QUIZ

Word Search

F	Y	R	M	Y	H	P	C	C	X	F	V	D	Z	X	E	G	E	W	G	S	O	M	T
T	A	Z	K	C	R	H	C	G	P	T	X	Y	X	Q	B	C	V	H	F	Q	K	Y	T
I	T	L	N	B	E	O	E	C	W	T	R	Q	F	T	R	B	U	G	Q	N	J	F	B
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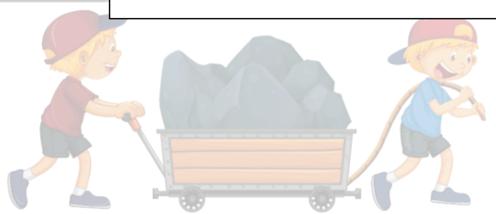
S	B	V	L	C	M	D	A	A	R	N	O	I	T	O	M	F	O	Y	G	R	E	N	E

1. velocity
2. heat energy
3. stored energy
4. spring energy
5. watt
6. potential
7. time
8. power
9. mass
10. nuclear energy
11. energy of motion
12. instantaneous power
13. force
14. kinetic
15. displacement
16. work
17. newton
18. chemical
19. electrical
20. Average power
21. joule
22. mechanical
23. energy



REVIEW QUESTION

1. A coconut with a mass 200g fall from a tree with a height 20m, calculate:

   i. Potential energy for a coconut just before it falls.

   ii. Kinetic energy for the coconut 3m under free fall.

   iii. Velocity for the coconut just before it reaches the ground.

2. Julia is the tallest player in North's Varsity volleyball team. She is in spiking position when Hana gives her the perfect set. The 232g volleyball is 2.19m above the ground and has a speed of 1.03m/s. Julia spikes the ball, doing 9.85J of work on it. Determine:

   i. The potential energy of the ball before the spike.

   ii. The kinetic energy of the ball before the spike.

   iii. The total energy of the ball before the spike.

   iv. Determine the total energy of the ball upon hitting the floor on the opponent's side.

   v. Determine the speed of the ball upon hitting the floor on the opponent's side of the net.

3. A tractor is pulled by another tractor as far as 10m from point A to point B. The amount of force needed to pull the tractor is 10000N. It takes 2 minutes for the tractor to reach point B from point A. Calculate:

   i. Power done

   ii. Efficiency of the power, if the power input is 900W.

4. A machine is used to lift a 250kg engine vertically from the ground at a constant velocity. If the machine does 6000J of work, calculate:

   i. The final height of the engine above the ground?

   ii. How much power is required to lift the engine in 2.5 minutes?

   iii. What is the efficiency if power input for the machine is 90W?

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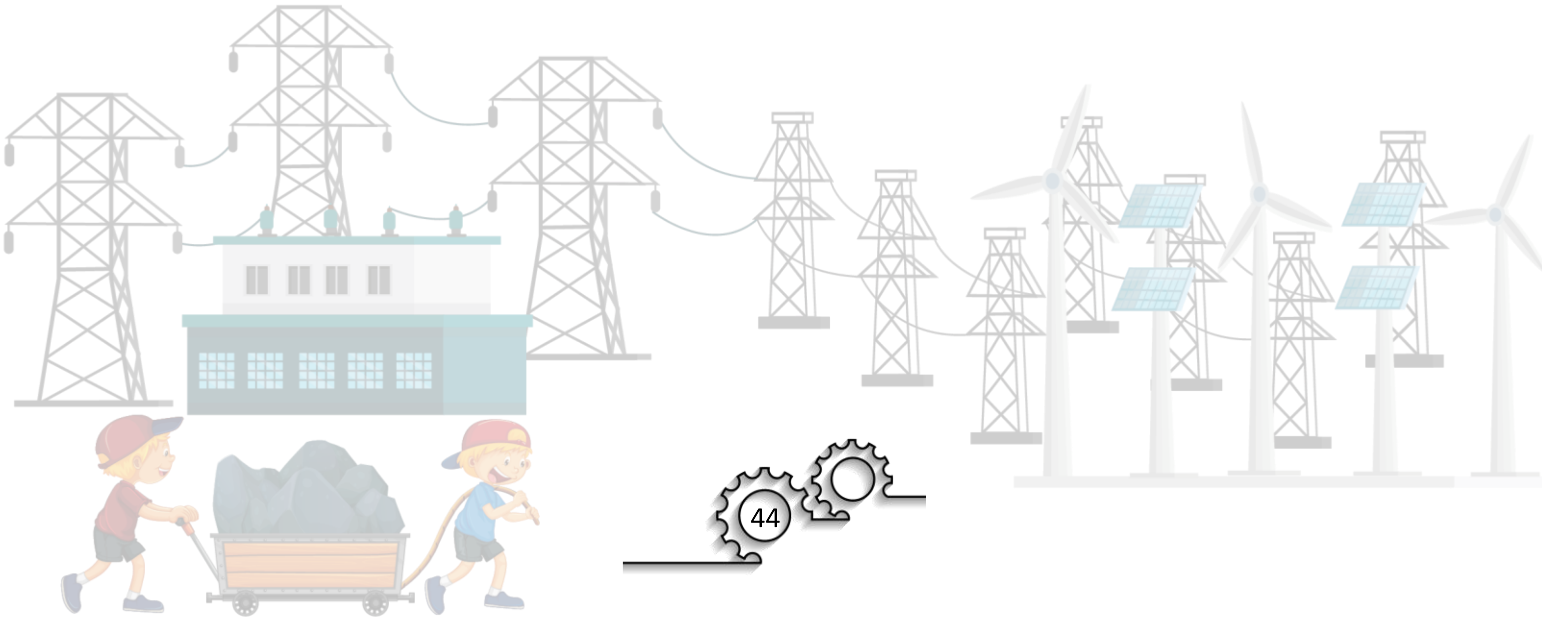

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