Energy Sources & Transfer Of Energy

Energy forms
Major sources of energy
Work
Efficiency
Power

List the different forms of energy with examples in which each form occurs.

Energy Forms

Energy

- **Energy** is defined as the capacity to do work.
- It is a property a body has that helps it move against a force.
- SI unit of energy is the newton-metre (Nm). It is also known as the joule (J).
- Energy is a **scalar** quantity.

Type of Energy

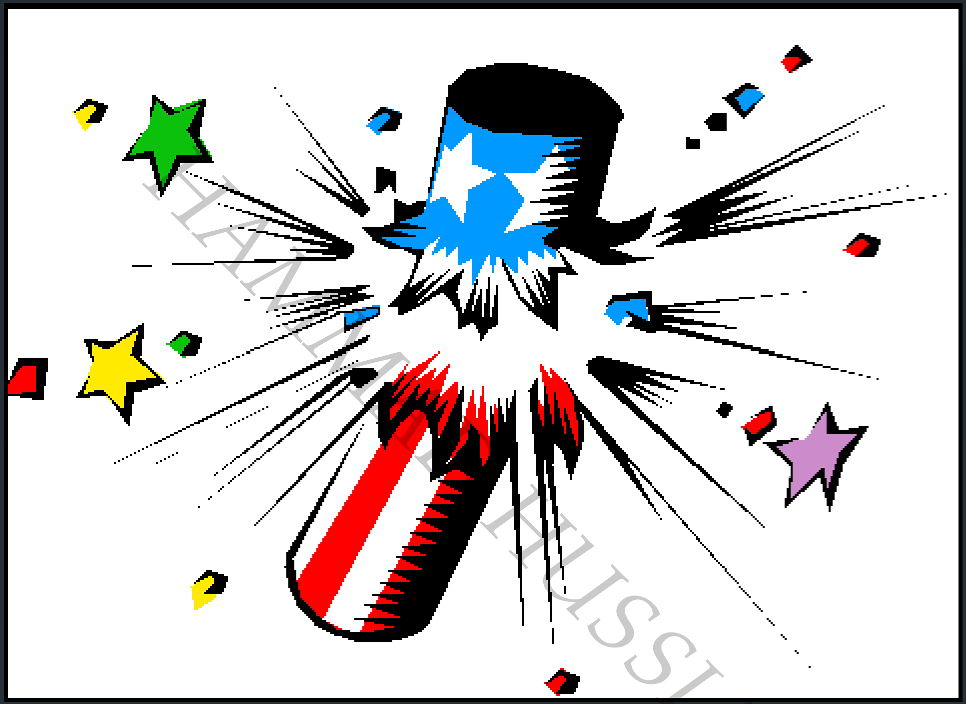
- Kinetic Energy – energy of an object due to its motion
- Gravitational Potential Energy – energy of an object due to its position
- Chemical Energy – energy stored in a substance and released when a chemical reactions take place
- Electrical Energy – energy transferred by an electric current
- Nuclear Energy – energy released when the nucleus of an atom splits or disintegrates
- Internal Energy – energy of an object due to the internal motion and positions of its molecules.
- Heat Energy – energy transfer from a hot object to a cold object
- Sound Energy – energy transfer by sound waves
- Light Energy – energy transfer by light

State the principle of the conservation of energy and apply this principle to the conversion of energy from one form to another.

Energy Forms

Energy Conversion

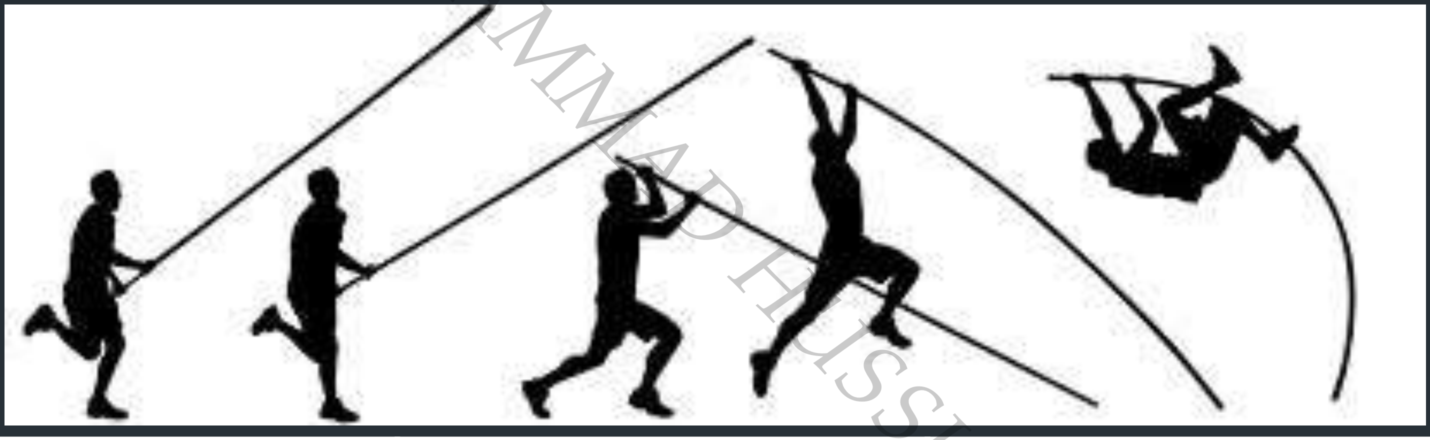
- Energy can change from one form into another.
- The **principle of conservation of energy** states that energy cannot be created or destroyed, but only changes from one form to another.



Chemical → Heat → Sound & Light

Electrical → Kinetic → Sound & Heat

Electrical Energy → Kinetic Energy + Sound Energy + Heat Energy



Chemical Energy → Kinetic Energy + Elastic Energy → Gravitational Potential Energy + Heat Energy + Sound Energy

Gravitational Potential Energy

↓

Kinetic Energy

↓

Heat Energy & Sound Energy

Gravitational Potential Energy

Kinetic Energy + Sound + Thermal Energy

1. Which line in the table gives an example of the stated form of energy?

	form of energy	example
A	gravitational	the energy due to the movement of a train
B	internal	the energy due to the flow of cathode rays in a cathode ray tube
C	kinetic	the energy due to the position of a swimmer standing on a high diving board
D	strain	the energy due to the compression of springs in a car seat

D

2. A child pushes a toy car along a level floor and then lets it go.
3. As the car slows down, what is the main energy change?
   - A. from chemical to heat
   - B. from chemical to kinetic
   - C. from kinetic to gravitational (potential)
   - D. from kinetic to heat

3. Which form of energy do we receive directly from the Sun?
   A. chemical
   B. light
   C. nuclear
   D. sound

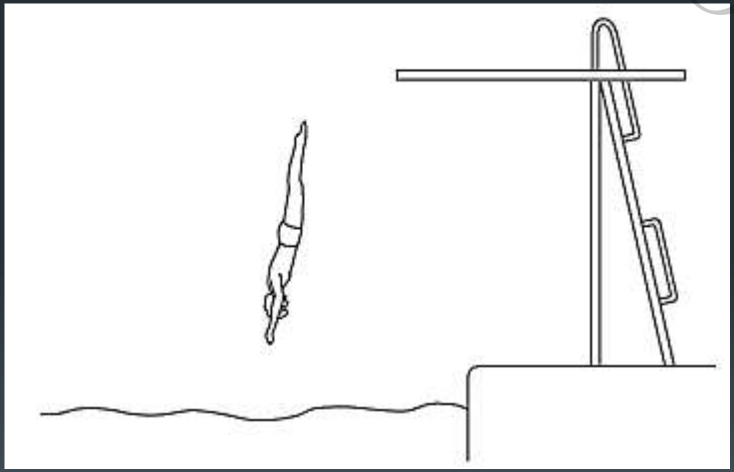
4. What is designed to change electrical energy into kinetic energy?
   A. capacitor
   B. generator
   C. motor
   D. transformer

5. In a car engine, energy stored in the fuel is converted into thermal energy (heat energy) and energy of motion (kinetic energy).

6. In which form is the energy stored in the fuel?

   A. chemical
   B. geothermal
   C. hydroelectric
   D. nuclear

6. The diagram shows a man diving into water.

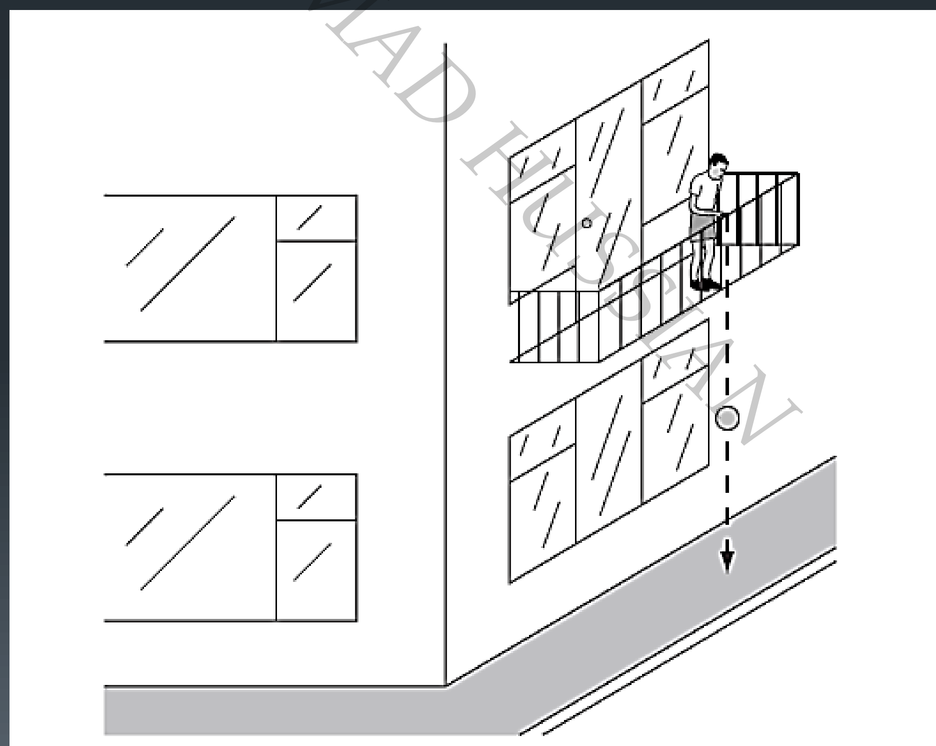


Which form of energy is increasing as he falls?

A. chemical
B. gravitational
C. kinetic
D. strain

7. Which energy changes take place when a pedalling cyclist uses a generator (dynamo) to light his bicycle lamp?
   A. chemical → kinetic → electrical → light
   B. electrical → chemical → kinetic → light
   C. kinetic → chemical → light → electrical
   D. light → electrical → kinetic → chemical

8. A young child holds a ball over the edge of a balcony. The ball has gravitational potential energy.
9. The ball is then released. It falls onto a concrete path below, and bounces back up.



1. Which sequence represents, in the correct order, the transformations of the gravitational potential energy after the ball is released?

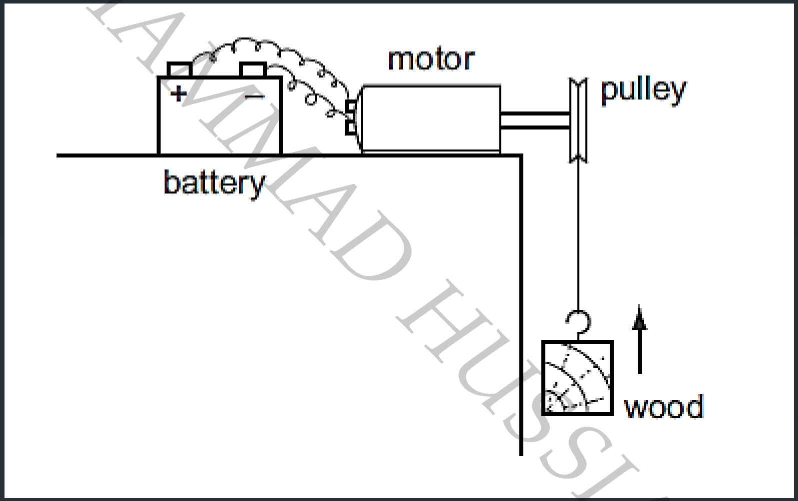
A. → elastic potential energy → kinetic energy → chemical potential energy

B. → elastic potential energy → kinetic energy → gravitational potential energy

C. → kinetic energy → elastic potential energy → kinetic energy

D. → kinetic energy → gravitational potential energy → kinetic energy

9. The diagram shows a battery-operated motor lifting a block of wood at constant speed.



1. What is the overall energy change taking place?

A. chemical → gravitational potential
B. gravitational potential → electrical
C. gravitational potential → kinetic
D. kinetic → gravitational potential

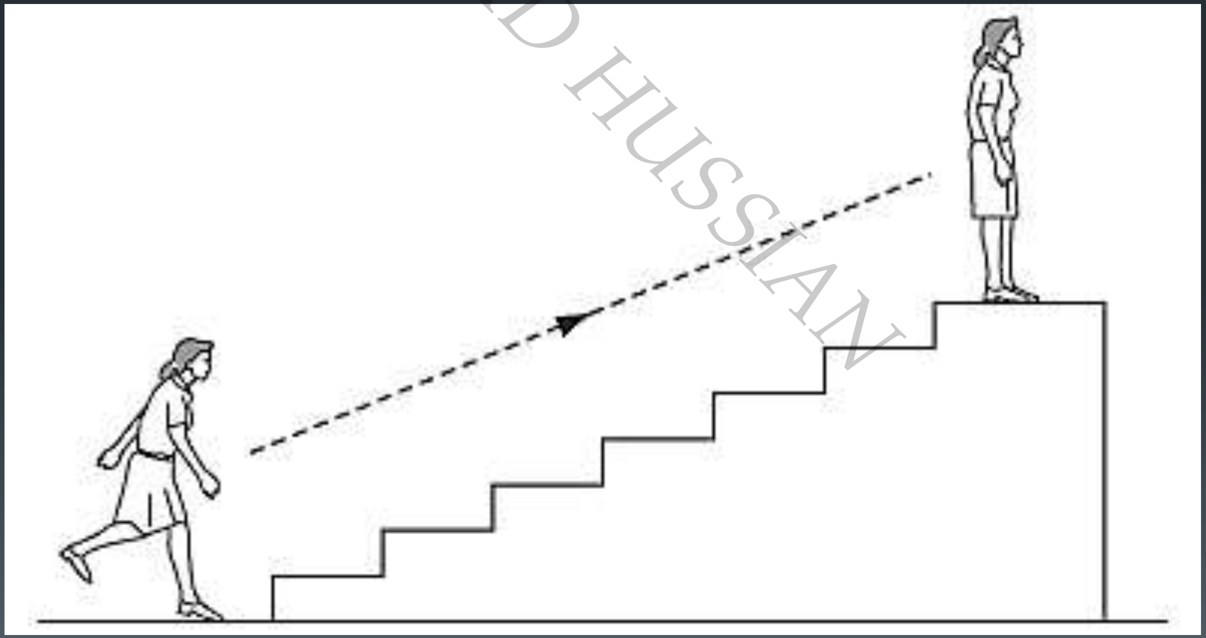
10. A cyclist travels down a hill from rest at point X without pedalling.

The cyclist applies his brakes and the cycle stops at point Y.

Which energy changes have taken place between X and Y?

A. kinetic → internal (heat) → gravitational potential
B. kinetic → gravitational potential → internal (heat)
C. gravitational potential → internal (heat) → kinetic
D. gravitational potential → kinetic → internal (heat)

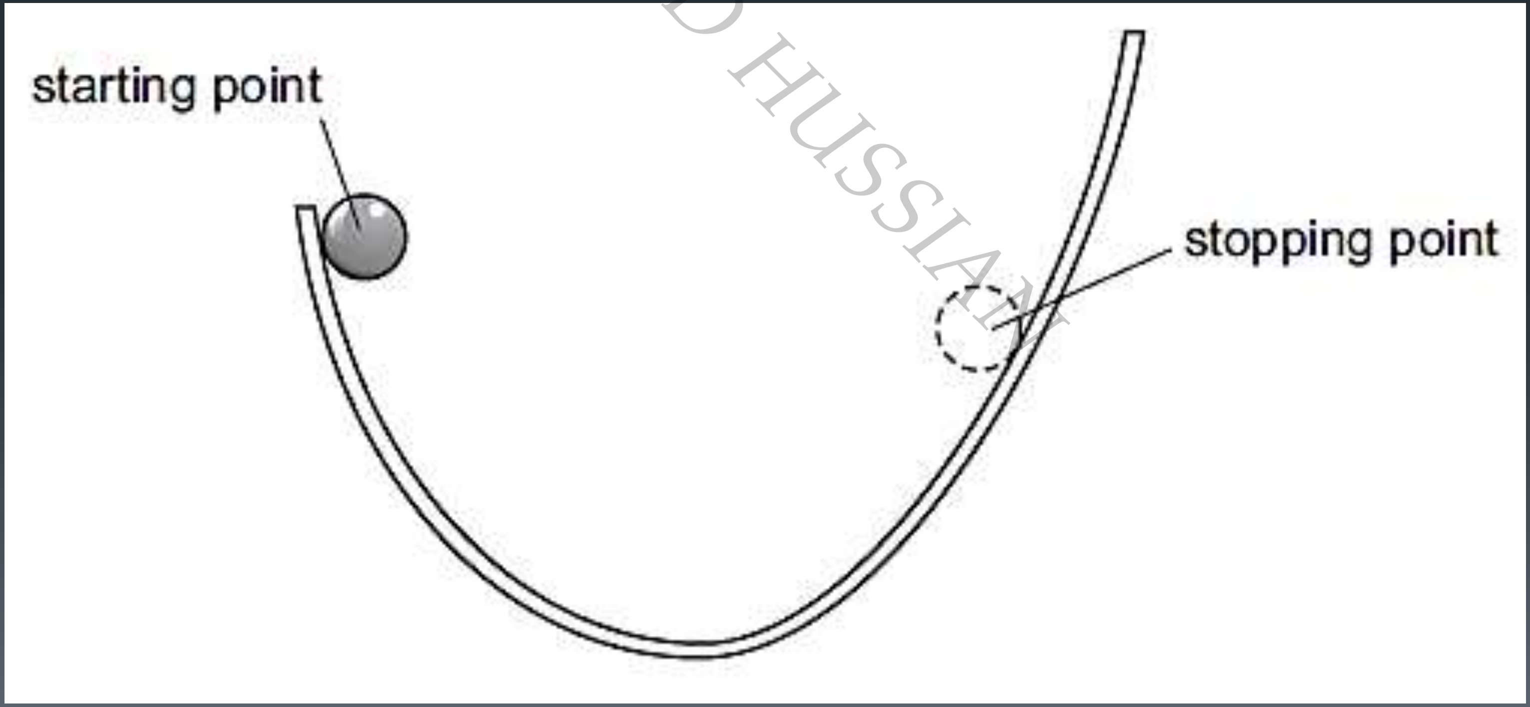
11. A person uses chemical energy to run up some stairs.



1. She stops at the top of the stairs.
2. What has the chemical energy been converted to when she is at the top of the stairs?

A. kinetic energy and gravitational energy
B. kinetic energy and strain energy
C. gravitational energy and heat energy
D. strain energy and heat energy

12. A ball is held at rest on one side of a curved track.



1. The ball is released. It rolls down one side of the track and part of the way up the other side. It then stops, before rolling back down again. The height of the stopping point is less than that of the starting point.
2. What is the sequence of energy changes between starting and stopping for the first time?

A. potential energy → kinetic energy → potential energy + heat

B. potential energy → kinetic energy → heat → potential energy

C. potential energy → heat → kinetic energy → potential energy

D. potential energy → kinetic energy + heat → potential energy + heat

13. The diagram shows a microphone being used in an interview.

1. Which energy change takes place in the microphone?

	input energy	output energy
A	chemical	electrical
B	electrical	chemical
C	electrical	sound
D	sound	electrical

D

State that kinetic energy and that potential energy and use these equations in calculations.

Major Sources of Energy

Kinetic Energy

- **Kinetic energy** is the energy a body possesses due to its motion.
- Any object which is moving has kinetic energy. The kinetic energy E_k of an object of mass m moving with a speed v is defined as

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

Problem Solving

1. What is the kinetic energy of a 6 kg medicine ball travelling at 4.5 ms^{-1}?
2. What is the kinetic energy of a tennis ball of mass 100 g moving with a speed of 2 ms^{-1}?
3. In pushing a frictionless cart from rest on a horizontal surface, 2400 J of work is done. If the mass of the cart is 65 kg, how fast is it then going?
4. What is the mass of a baseball that has 110 J of energy when it is going 22 ms^{-1}?

5. A charging rhinoceros moves at a speed of 15 m/s, and its mass is 750 kg. What is its kinetic energy?
6. A rock of mass 20 kg is travelling in space at a speed of 6 m/ s. What is its kinetic energy?
7. A runner has a mass of 80 kg is moving at 8 m/s. calculate her kinetic energy
8. A ball of mass 0.5 kg has 100 J of kinetic energy. What is the speed of the ball.

Potential Energy

- **Gravitational potential energy** is the energy which body possesses because of its position relative to the ground.
- When an object with mass *m* near the Earth's surface is raised through a height *h*, the change in potential energy is given by

$$PE = mgh$$

Problem Solving

1. In the following examples, is the object gravitational potential energy increasing, decreasing or remain constant?
   a) An apple falls from a tree.
   b) An aircraft flies horizontally at a height of 9000 m.
   c) A sky-rocket is fired into the sky.
2. A man lifts a weight of 300 kg through a distance of 1.8 m. What is the gain in potential energy of the weight?
3. A diver of mass 54 kg jumped from a height of 8.0 m. What was the loss in potential energy of the diver?
4. You lift a 2 kg basketball from the floor, where its gravitational energy is zero. You raise and carry it horizontally to a window and drop it out. It falls 12 m from the bottom of the window. What is its gravitational potential energy loss when it hits the ground?

5. If a 280 kg drop hammer was lifted with 12000 J of work, how high is it above the ground level?
6. A girl weight 500 N climbs on top of a 2 m high wall. By how much does her gravitational potential energy increase?
7. A stone of weight 1 N falls downwards. Its gravitational potential energy decreases by 100 J. how far has it fallen?
8. An object has a mass of 6 kg. what is its gravitational potential energy 6 m above the ground?

Conservation of Energy

- When an object with GPE starts to fall, its GPE is transferred into KE.
- The further the object falls, the less GPE it has and the more KE it has.
- When the object hits the ground, all of its GPE has been transferred into KE.

- Example
  - Calculate how fast a 75 kg rock fall from 4.0 metres above the ground.
- All of the rock's GPE has become KE, so the rock has ______ J of KE when it hits the ground.
- Using the equation for KE, we can calculate how fast it is travelling when it hits the ground.

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

Problem Solving

1. A ball is thrown vertically upwards with an initial velocity of 10 ms^{-1}. What is the maximum height reached by the ball?
2. A stone is thrown vertically upwards and reaches a height of 6 m above the hand of the thrower. What speed was the stone travelling at when it left the person's hand?

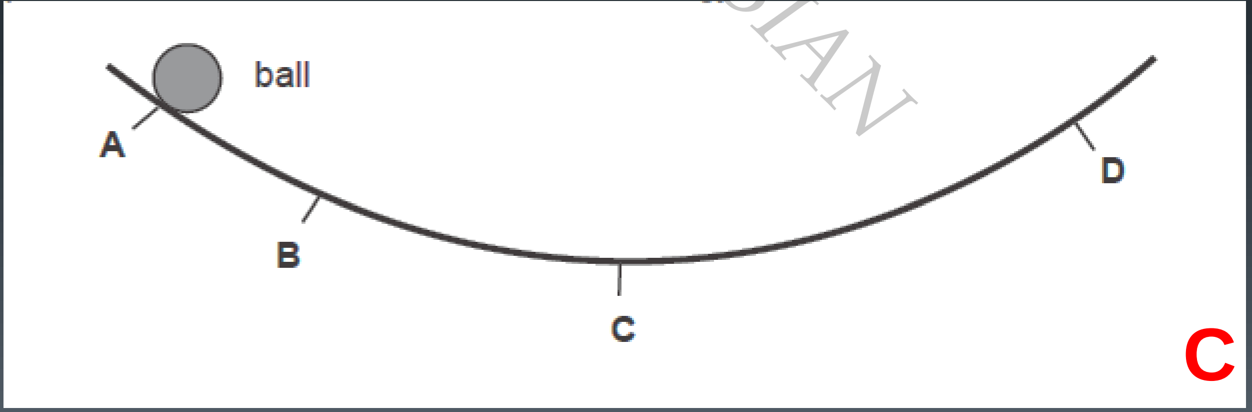
3. A pile driver of mass 100 kg is raised to a height of 8.0 m. It is then dropped through a distance of 6.0 m before striking a pile. Calculate
   a) The work done in raising the pile driver through a height of 8.0 m,
   b) The kinetic gained by the pile driver just before striking the pile,
   c) The speed of the pile driver just before it strikes the pile.

4. A catapult stores a 10 J of strain energy when it is fully stretched. It is used to fire a marble of mass 0.02 kg straight up into the air.
   a) Calculate how high the marble rises.
   b) How fast is the marble moving when it is 30 m above the ground?

Ignore any affects due to air resistance.

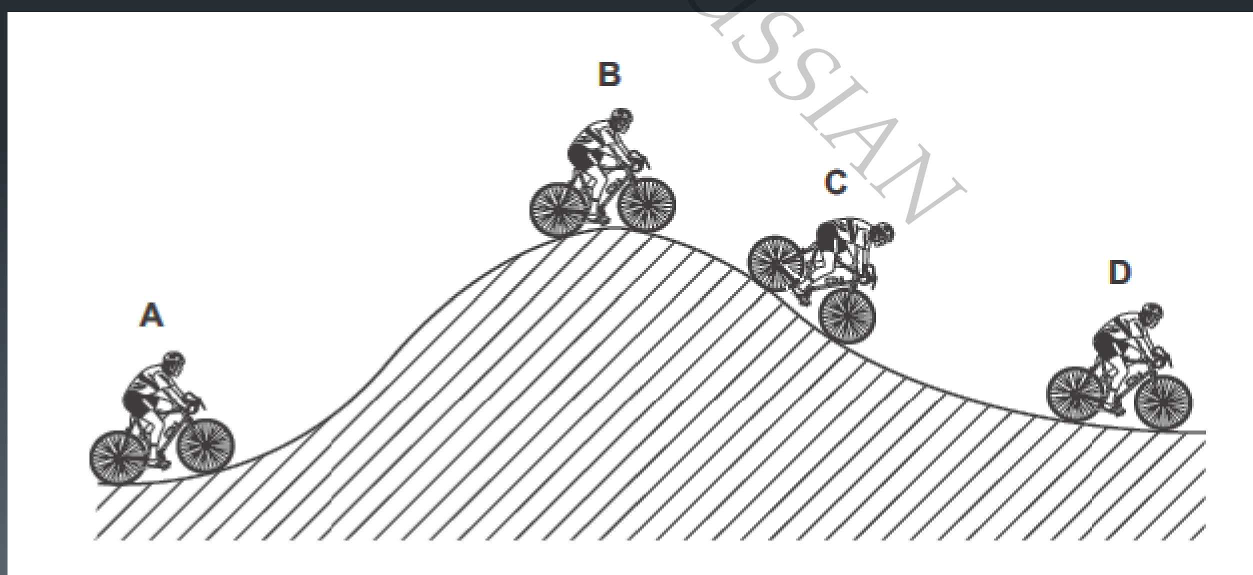
5. A ball has a mass of 0.5 kg. dropped from a cliff top, the ball hits the sea below at a speed of 10 m/s.
   a) What is the kinetic energy of the ball as it is about to hit the sea.
   b) What was the ball's gravitational potential energy before it was dropped?
   c) From what height was the ball dropped?

1. The diagram shows a curved curtain rail that has a steel ball rolling on it. The ball is released at point A.
2. At which point does the ball have maximum kinetic energy?



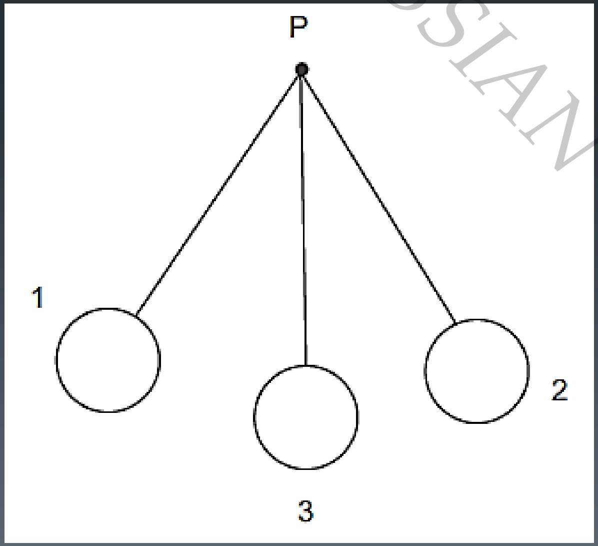
2. The diagram shows a cyclist riding along a hilly road.

At which position does the cyclist have the least gravitational (potential) energy?



A

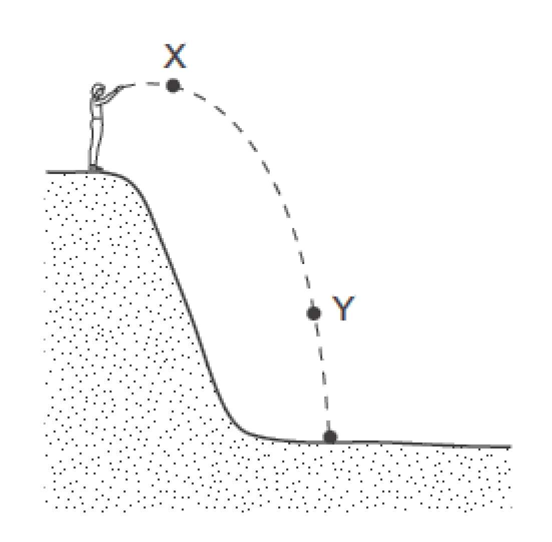
3. A mass hangs on a string fixed at point P. It starts from position 1 and swings to the furthest position on the opposite side, position 2. It then oscillates several times with decreasing amplitude before ending at position 3.



Where does the ball have the most kinetic energy?

A. at position 1
B. at position 2
C. the first time at position 3
D. the last time at position 3

4. A man standing at the top of a cliff throws a stone.



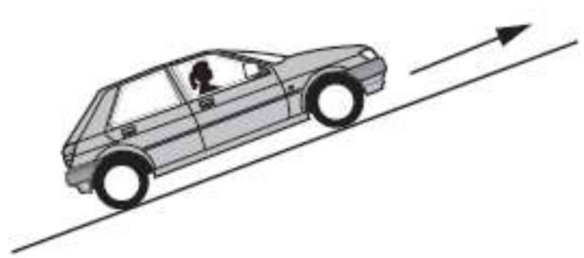
Which forms of energy does the stone have at X and at Y?

	energy at X	energy at Y
A	gravitational only	kinetic only
B	kinetic only	gravitational only
C	gravitational only	gravitational and kinetic
D	gravitational and kinetic	gravitational and kinetic

D

5. A car accelerates along a road as it rises uphill.

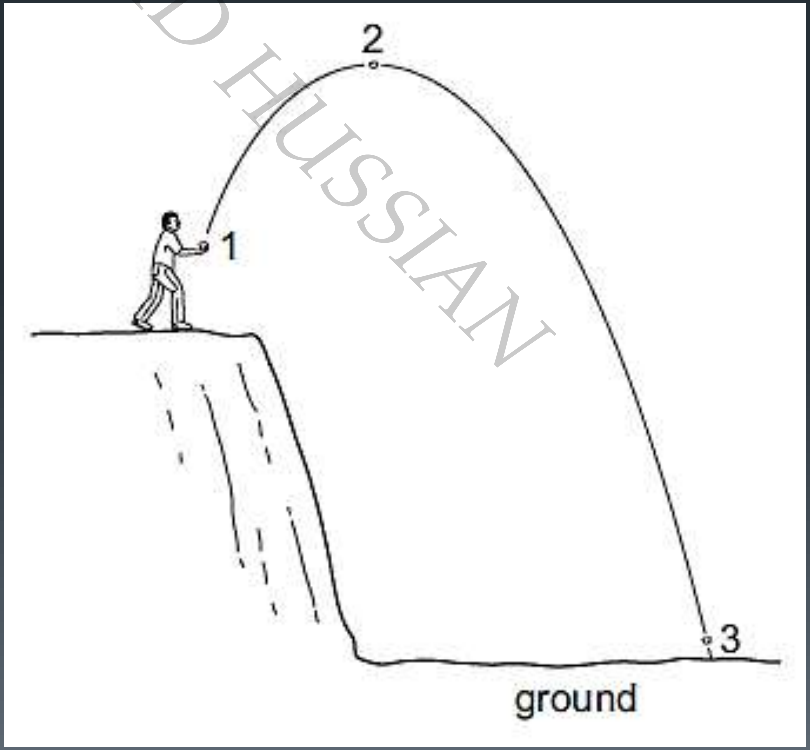
Which energy changes are taking place?



	energy of motion (kinetic energy)	energy of position (gravitational potential energy)
A	decreasing	decreasing
B	decreasing	increasing
C	increasing	decreasing
D	increasing	increasing

D

6. A stone is thrown from the edge of a cliff. Its path is shown in the diagram.

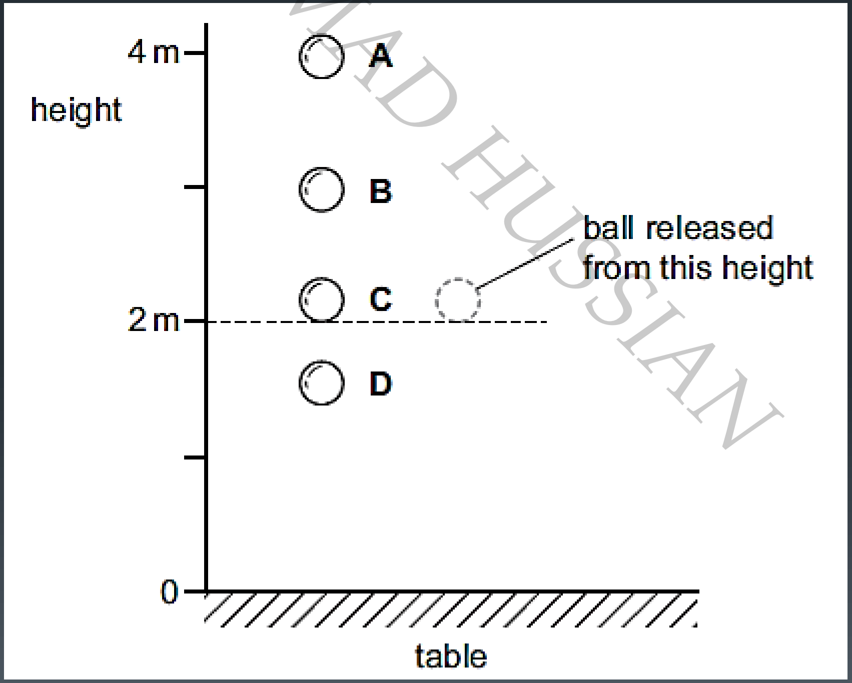


1. In which position does the stone have its greatest kinetic energy and in which position does it have its least gravitational energy?

	greatest kinetic energy	least gravitational energy
A	1	2
B	2	3
C	3	1
D	3	3

D

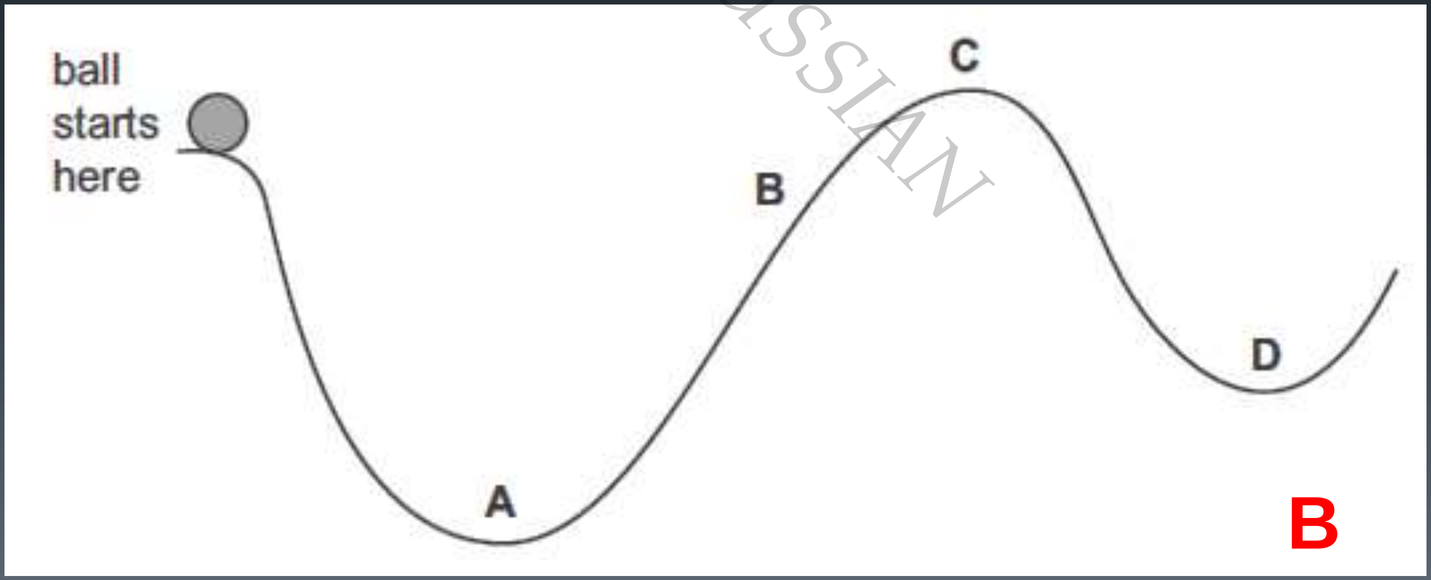
7. A rubber ball is dropped from a height of 2 m on to a table.
8. Whilst in contact with the table, some of its energy is converted into internal energy.
9. What is the highest possible point the ball could reach after bouncing?



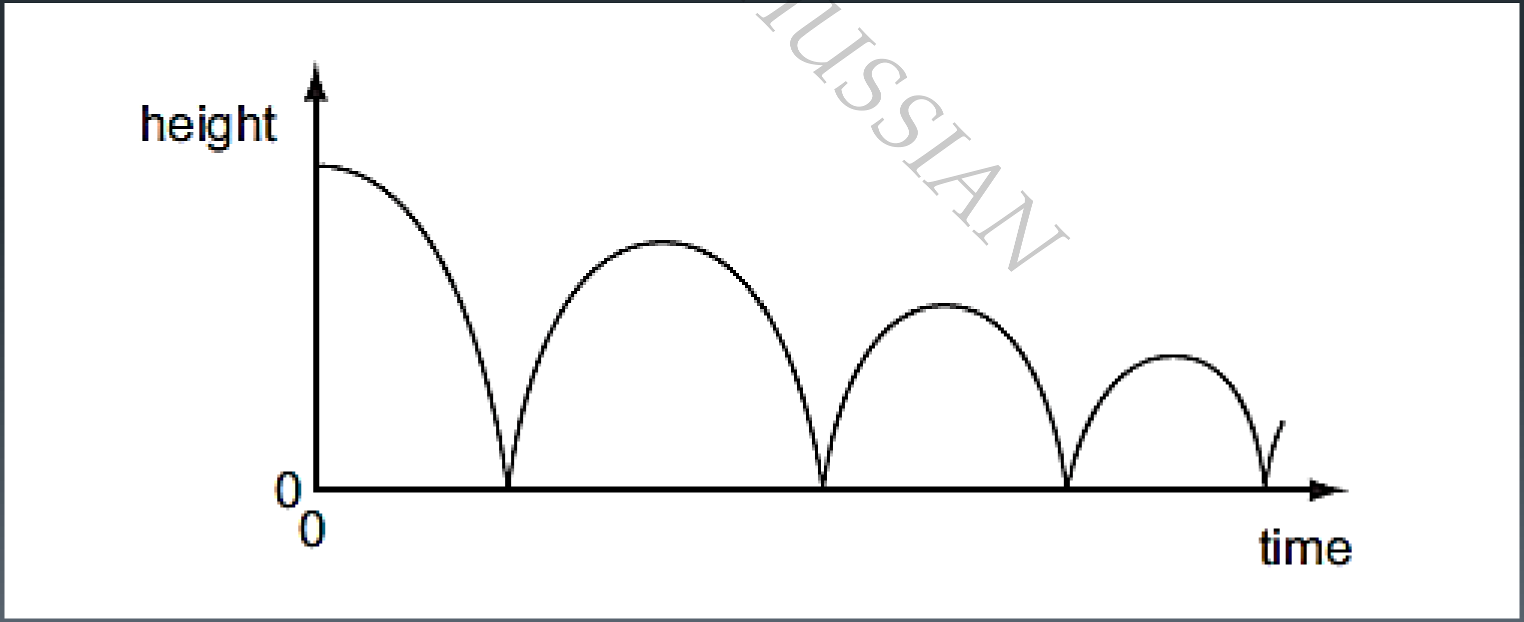
D

8. A ball is released from rest and rolls down a track from the position shown.

What is the furthest position the ball could reach?



9. The graph shows how the height above the ground of a bouncing ball changes with time.

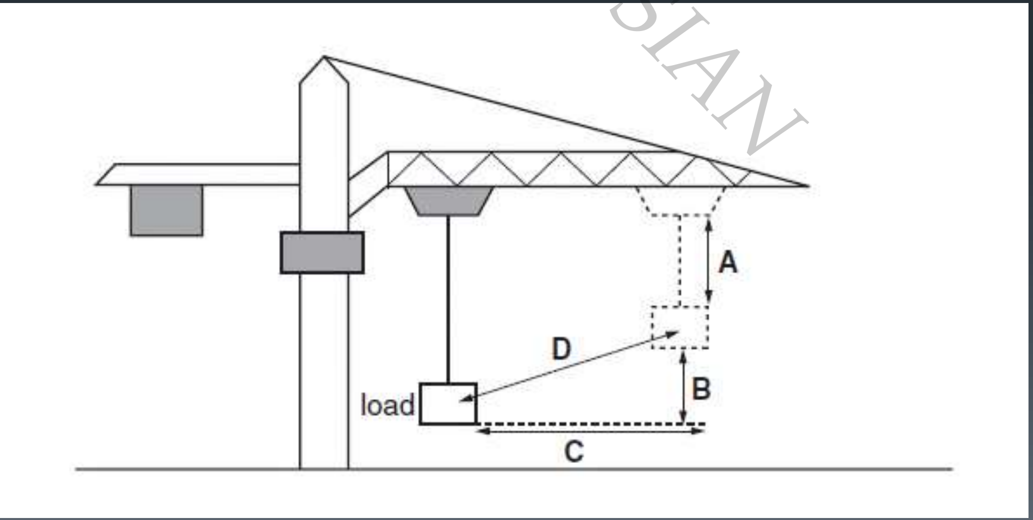


1. Which statement explains why the height of each peak decreases with time?

   A. Kinetic energy is converted to potential energy at each bounce.
   B. Kinetic energy is converted to thermal energy at each bounce.
   C. The ball gains energy on impact with the floor.
   D. The ball is wearing out.

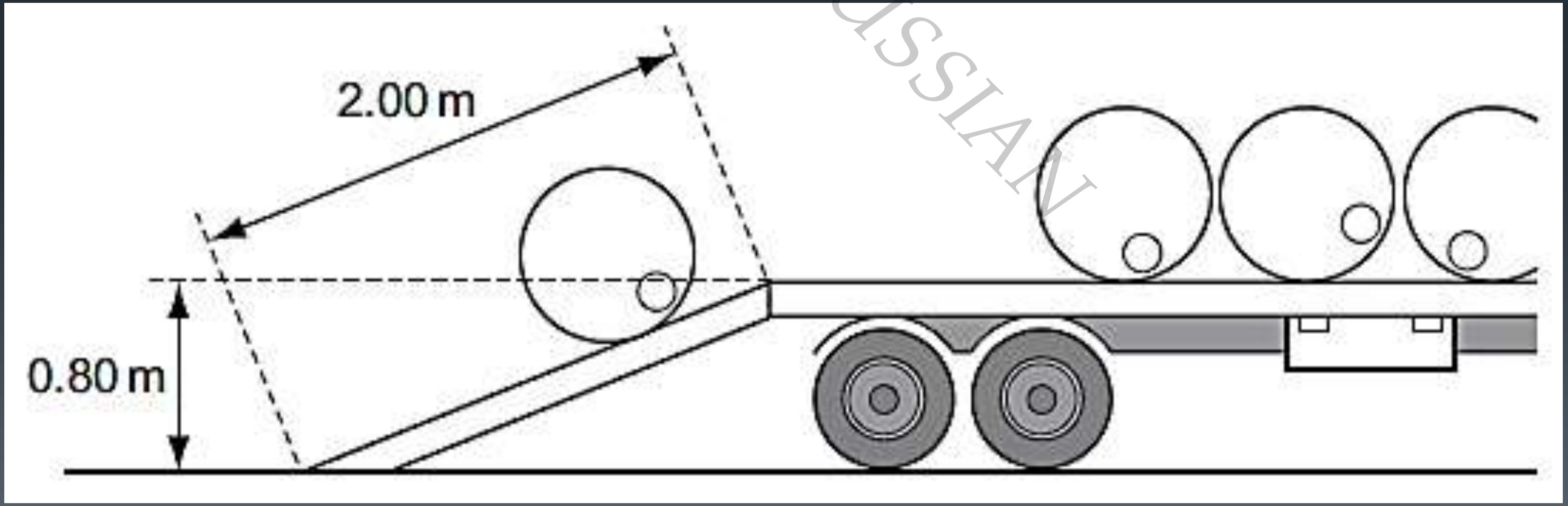
10. A crane moves its load diagonally, as shown.

By which distance must the weight of the load be multiplied in order to find the increase in gravitational potential energy of the load?



B

11. A workman rolls a barrel of weight 2000 N up a plank of length 2.00 m and on to a lorry. The back of the lorry is 0.80 m above the horizontal surface of the road.



1. What is the work done on the barrel against gravity?

A. 1000 J
B. 1600 J
C. 2500 J
D. 4000 J

12. A 2 kg mass is moving at constant speed. The kinetic energy of the mass is 400 J. What is the speed of the mass?

    A. 0.4 m / s
    B. 20 m / s
    C. 200 m / s
    D. 400 m / s

List renewable and non-renewable energy sources.

Major Sources of Energy

RENEWABLE & NON-RENEWABLE

- Non-renewable means that there is only a certain amount of the resource. Once it is used up, it cannot be replaced.
- Renewable means that the resource will not run out.

Non Renewable	Renewable
fossil fuels (coal, oil & gas)	hydroelectric
nuclear power	tidal
	wave
	wind
	solar
	geothermal
	biomass

Describe the process of electricity generation and draw a block diagram of the process from fuel input to electricity output.

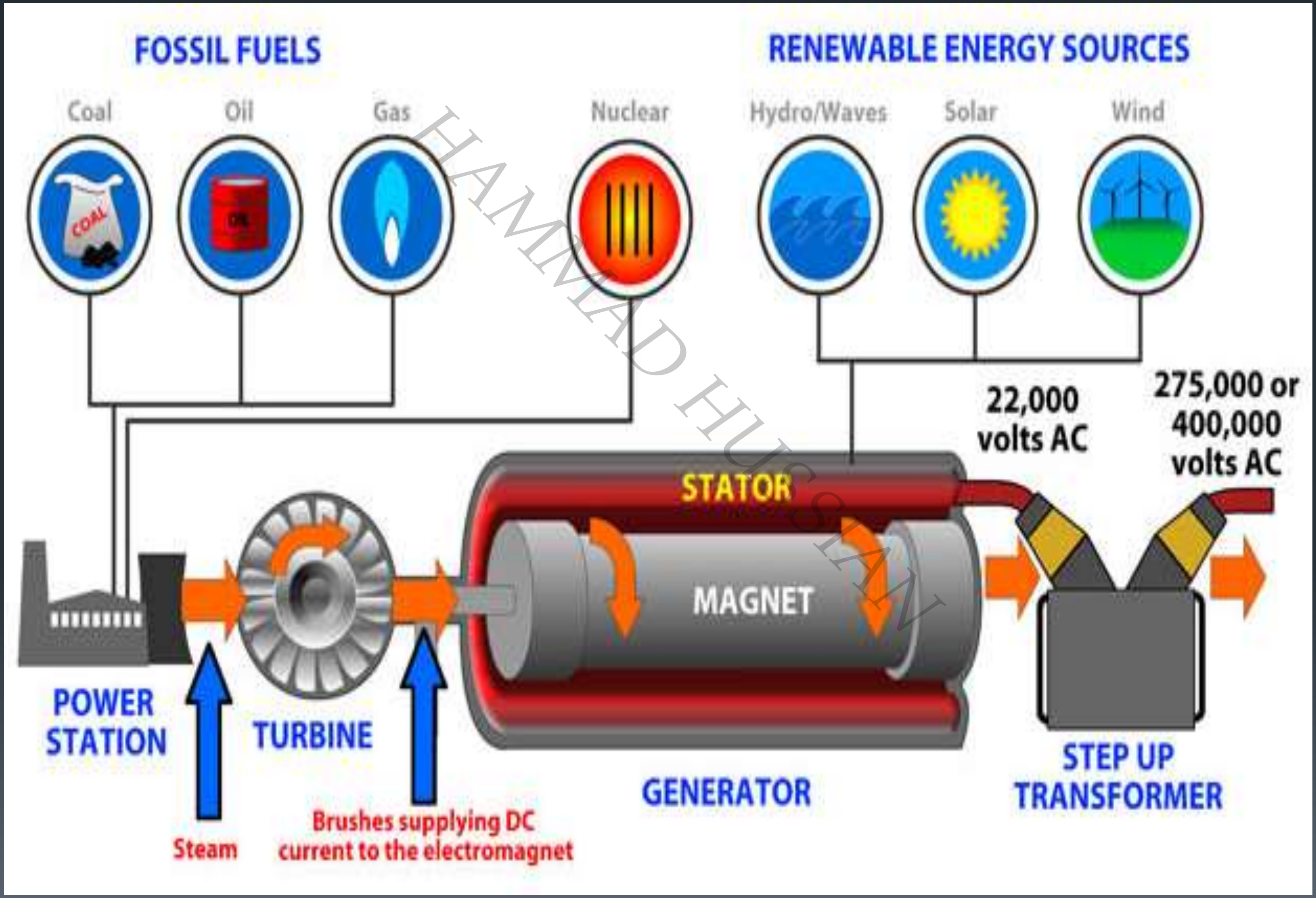
Major Sources of Energy

Discuss the environment issues associated with power generation.

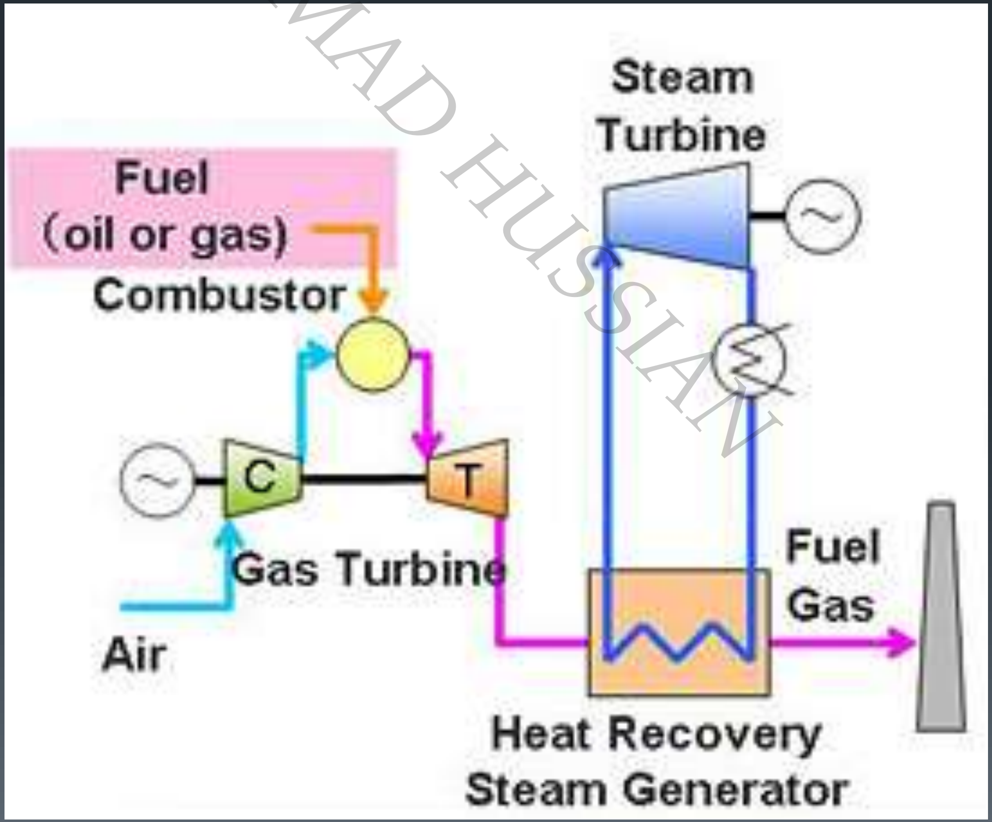
Major Sources of Energy

Power Station

- Power stations convert a **primary energy resource** into electrical energy.
- Electrical energy is called a **secondary energy source**.


FOSSIL FUELS
RENEWABLE ENERGY SOURCES
Coal
Oil
Gas
Nuclear
Hydro/Waves
Solar
Wind
COAL
22,000 volts AC
275,000 or 400,000 volts AC
STATOR
MAGNET
POWER STATION
TURBINE
GENERATOR
STEP UP TRANSFORMER
Steam
Brushes supplying DC current to the electromagnet

Fossil Fuels Power



Chemical → **Heat** → **Kinetic** → **Kinetic** → **Electricity**

- Chemical
  - Fuel
- Heat
  - Fuel Burning
- Kinetic
  - Steam
- Kinetic
  - Turbines
- Electricity
  - Generator

Advantages

1. They give a large amount of energy from a small amount of fuel.
2. They are readily available. If you need more energy, you just burn more fuel.
3. They are relatively cheap.

Disadvantages

1. They are non-renewable. Once you burn them, they are gone.
2. When burned, it gives off atmospheric pollutants, including greenhouse gases.
3. They use water as a coolant and may return warm water into a river. This decreases the amount of dissolved oxygen in the river.

Nuclear Power

Nuclear → Heat → Kinetic → Kinetic → Electricity

- Nuclear
  - Fission of atoms
- Heat
  - Water
- Kinetic
  - Steam
- Kinetic
  - Turbines
- Electricity
  - Generator

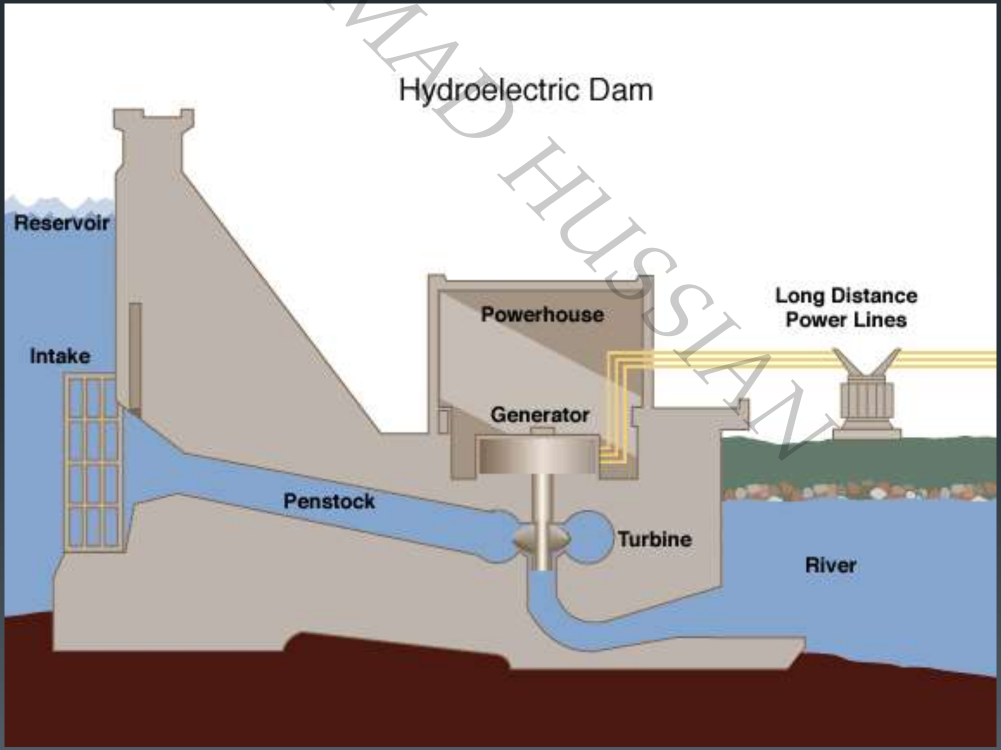
Advantages

1. A small amount of radioactive material produces a lot of energy.
2. Raw materials are relatively cheap and can last quite a long time.
3. It doesn't give off atmospheric pollutants.

Disadvantages

1. Nuclear reactors are expensive to run.
2. Nuclear waste is highly toxic, and needs to be safely stored for hundreds or thousands of years (storage is extremely expensive).
3. Leakage of nuclear materials can have a devastating impact on people and the environment.

Hydroelectric Power



Potential → Kinetic → Kinetic → Electricity

Potential
- Water in dam

Kinetic
- Fast flowing water

Kinetic
- Turbines

Electricity
- Generator

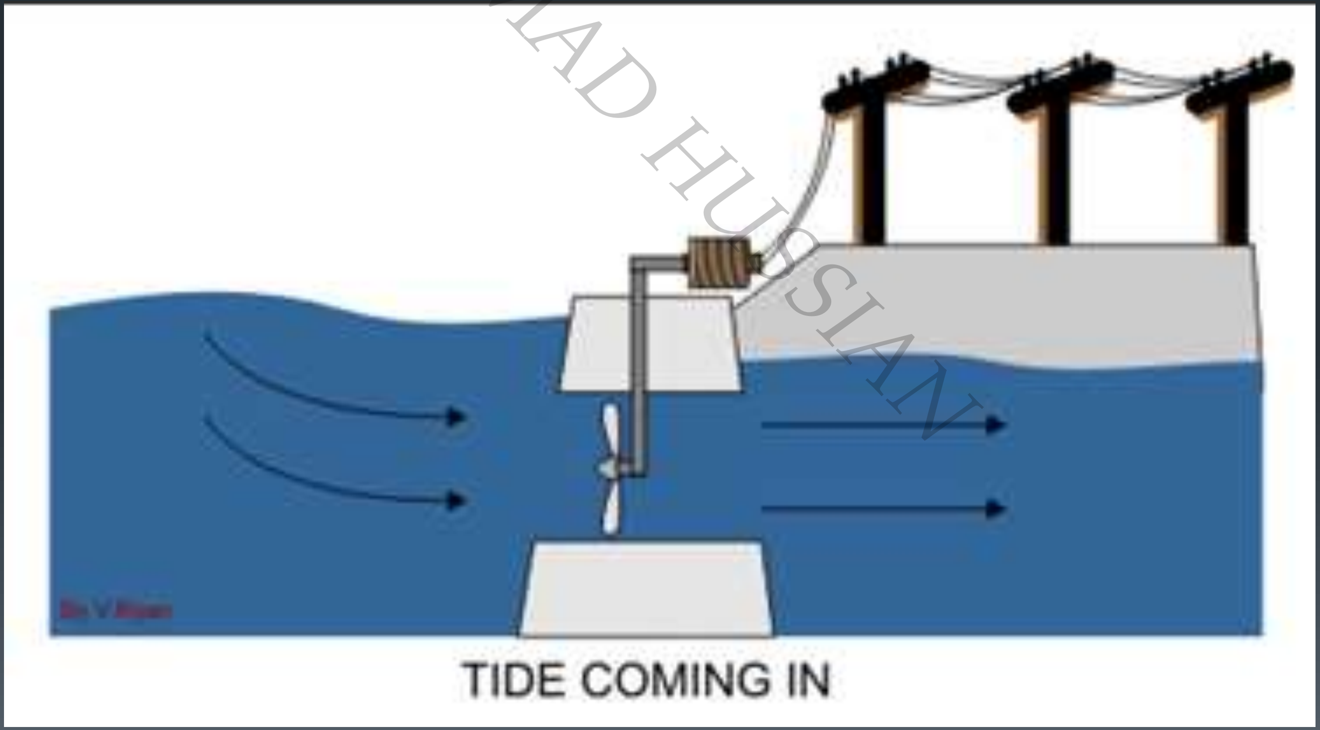
Advantages

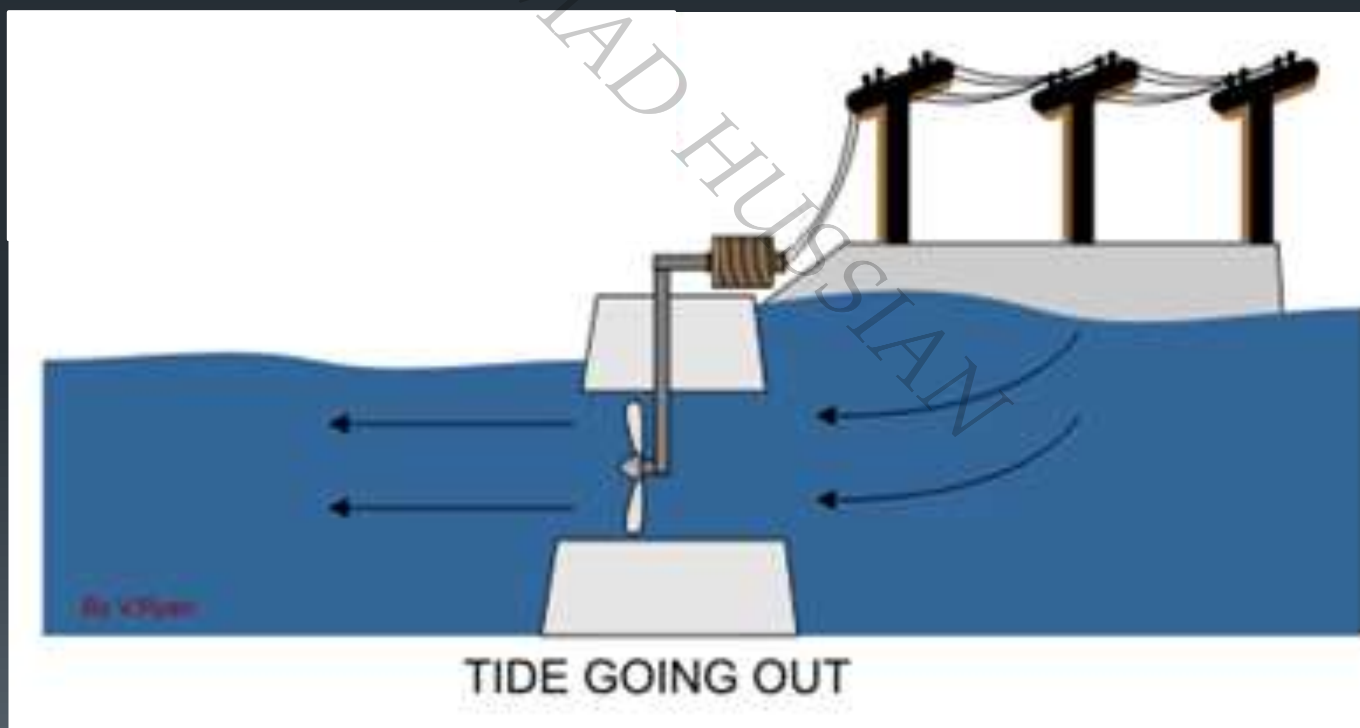
1. It is renewable.
2. It is readily available. If you need more energy, you just let out more water through the turbines.
3. It does not cause pollution.

Disadvantages

1. Costly to build.
2. Can cause the flooding of surrounding communities and landscapes.
3. Dams have major ecological impacts on local hydrology.

Tidal Power




TIDE GOING OUT

Potential → Kinetic → Kinetic → Electricity

Potential
- Water store in barrage

Kinetic
- Flowing water

Kinetic
- Turbines

Electricity
- Generator

Advantages

1. It is reliable.

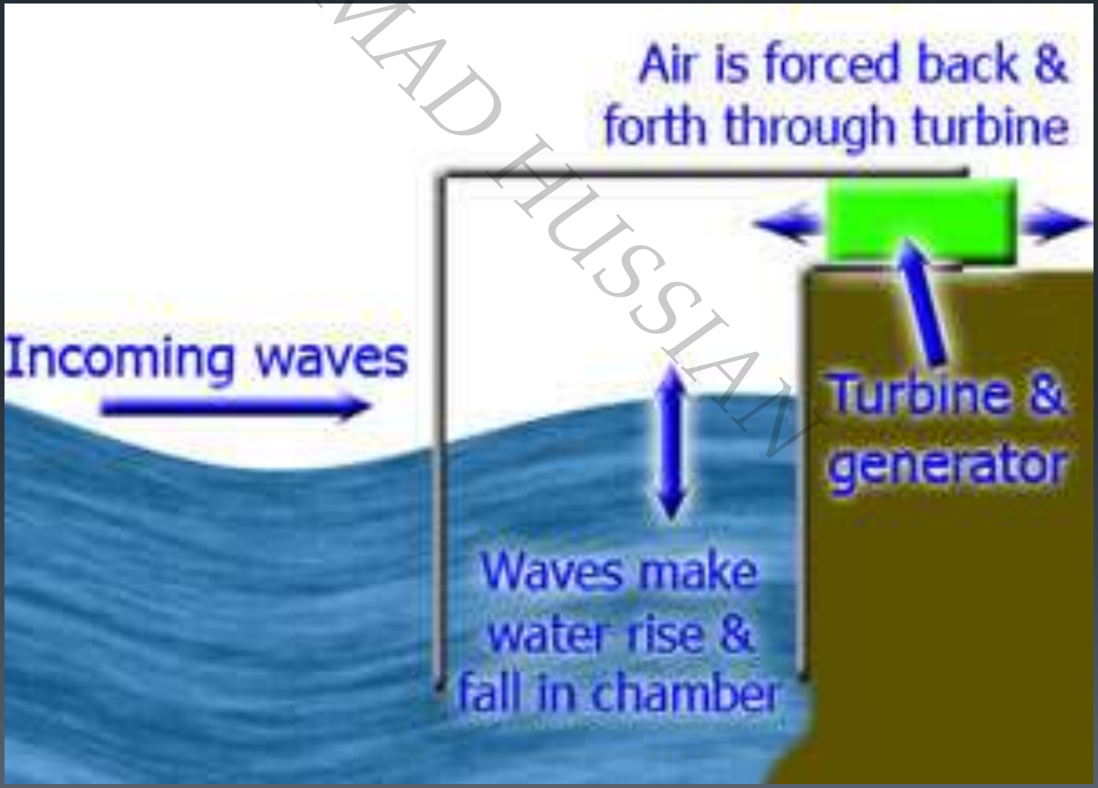
   The tide goes in and out twice a day.

2. Potential to generate a lot of energy.
3. Tidal barrage can double as a bridge, and help prevent flooding.

Disadvantages

1. Construction of barrage is very costly.
2. Only a few estuaries are suitable.
3. Opposed by some environmental groups as having a negative impact on wildlife.
4. May reduce tidal flow and impede flow of sewage out to sea.

Wave Power


Air is forced back &
forth through turbine
Incoming waves
Turbine &
generator
Waves make
water rise &
fall in chamber

Kinetic → Kinetic → Kinetic → Electricity

- Rising water
- Air back & forth
- Turbines
- Generator

Advantages

1. It does not cause pollution.
2. Ideal for an island country.

Disadvantages

1. It is unreliable. When the wind drops, the waves get smaller and less electricity is generated.
2. Construction can be costly.
3. An individual wave power machine does not generate very much electricity. You would need a lot of them to replace one fossil fuel power station.
4. The natural beauty of an area may be spoiled.

Geothermal Power

Heat → Kinetic → Kinetic → Electricity

- Hot rocks
- Steam
- Turbines
- Generator

Advantages

1. It is reliable.
2. It does not cause pollution.

Disadvantages

1. Can be expensive to set up and only works in areas of volcanic activity.
2. Geothermal and volcanic activity might calm down, leaving power stations redundant.
3. Dangerous elements found underground must be disposed of carefully.

Wind Power

Kinetic → Kinetic → Kinetic → Electricity

- Wind
- Propeller
- Turbines
- Generator

Advantages

1. Potentially infinite energy supply.
2. It does not cause pollution (except noise).

Disadvantages

1. It is unreliable. When the wind drops, the turbine turns more slowly and less electricity is generated.
2. An individual wind turbine does not generate very much electricity.
3. Manufacture and implementation of wind farms can be costly.
4. Some local people object to on-shore wind farms, arguing that it spoils the countryside.

Solar Power

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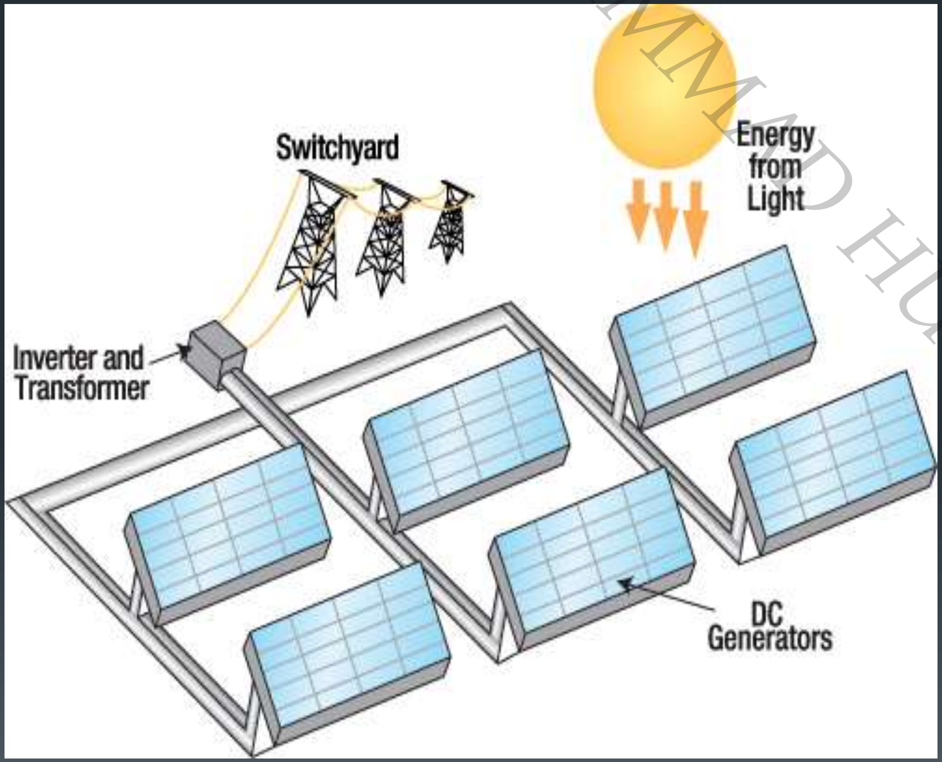
Light → Heat → Kinetic → Kinetic → Electricity

- Sun
- Water
- Steam
- Turbine
- Generator


Switchyard
Energy from Light
Inverter and Transformer
DC Generators

Light → Electricity

- Sun
- Photovoltaic

Advantages

1. Potentially infinite energy supply.
2. It does not cause pollution.

Disadvantages

1. It does not work well when the sky is cloudy. It is does not work at night.
2. It is relatively expensive. The future cost is expected to fall with

1. Hydroelectric, tidal and fossil fuels are three sources of energy.
2. Which of these are renewable energy sources?

	hydroelectric	tidal	fossil fuels
A	no	yes	yes
B	no	no	yes
C	yes	no	no
D	yes	yes	no

D

2. Which represents the main energy changes that take place in a coal-fired power station?
   A. chemical → heat → kinetic → electrical
   B. chemical → heat → light → electrical
   C. chemical → kinetic → electrical → potential
   D. kinetic → heat → light → electrical

3. In a hydroelectric power station, water from a reservoir falls down a long pipe before entering the turbines. The turbines then turn the generator.

What is the overall energy conversion?

A. electrical energy into kinetic energy
B. electrical energy into potential energy
C. kinetic energy into chemical energy
D. potential energy into electrical energy

4. What is the source of the energy converted by a hydro-electric power station?
   - A. hot rocks
   - B. falling water
   - C. oil
   - D. waves

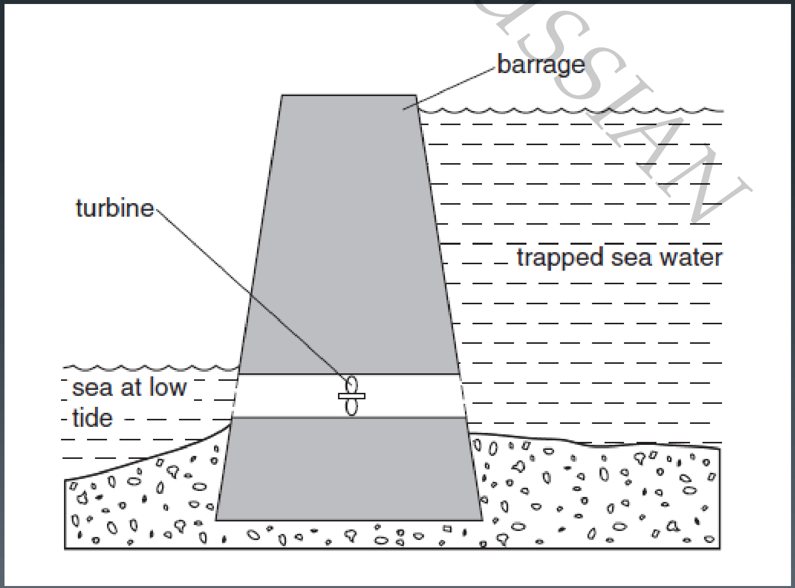
5. Which source of energy uses the production of steam to generate electricity?
   A. hydroelectric
   B. nuclear
   C. tides
   D. waves

6. Which type of power station does not use steam from boiling water to generate electricity?

A. geothermal
B. hydroelectric
C. nuclear
D. oil-fired

7. Which form of energy is used to generate electrical energy in a tidal power station?
   A. chemical energy
   B. gravitational energy
   C. internal energy (thermal energy)
   D. nuclear energy

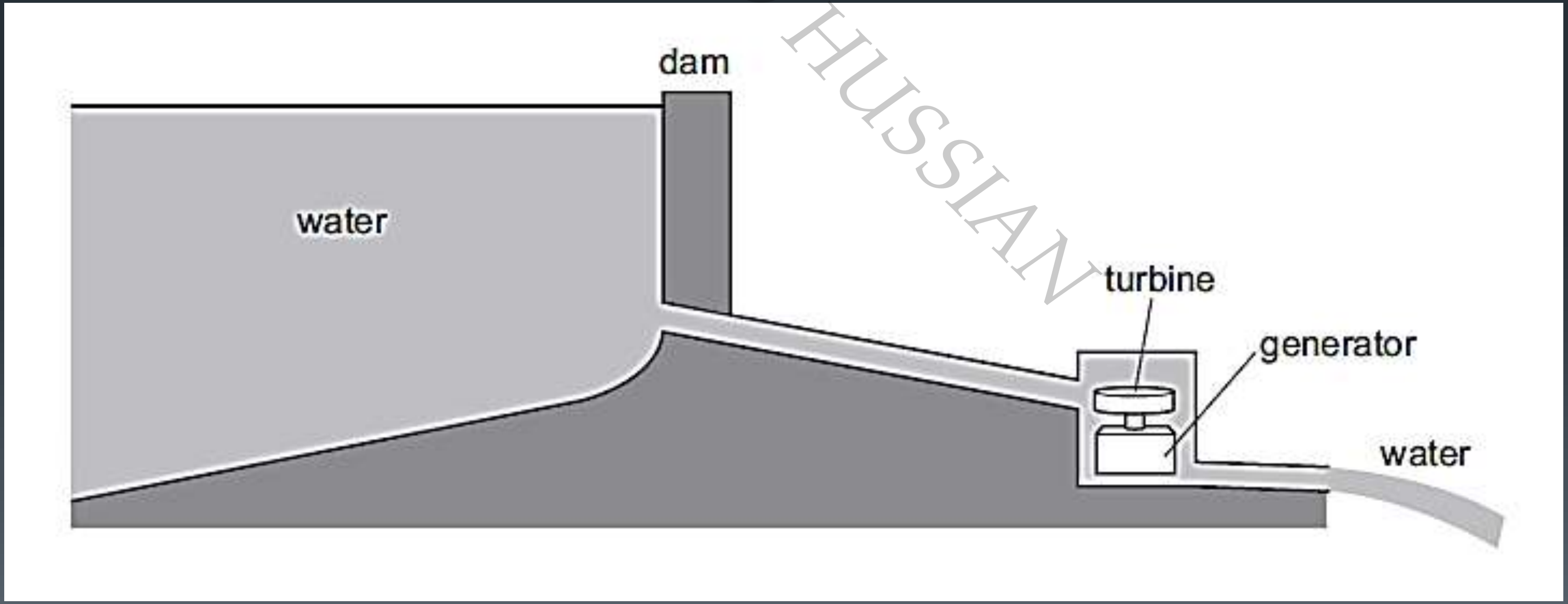
8. A tidal power station is made by building a barrage across the mouth of a river. At high tide the sea water is trapped behind the barrage.



1. At low tide the water is allowed to flow back into the sea through a turbine.
2. What is the useful energy change in a tidal power station?

A. electrical energy → energy of position (potential)
B. electrical energy → energy of motion (kinetic)
C. energy of motion (kinetic) → energy of position (potential)
D. energy of position (potential) → electrical energy

9. The diagram shows water stored behind a dam.



1. The water flows to a turbine and turns a generator.
2. Which sequence for the conversion of energy is correct?

A. gravitational energy → kinetic energy → electrical energy
B. kinetic energy → gravitational energy → electrical energy
C. gravitational energy → electrical energy → kinetic energy
D. kinetic energy → electrical energy → gravitational energy

10. Which process in the Sun produces energy?

A. burning
B. nuclear fission
C. nuclear fusion
D. radiation

11. Electricity can be obtained from different energy resources.

Which energy resource is used to obtain electricity without producing heat to boil water?

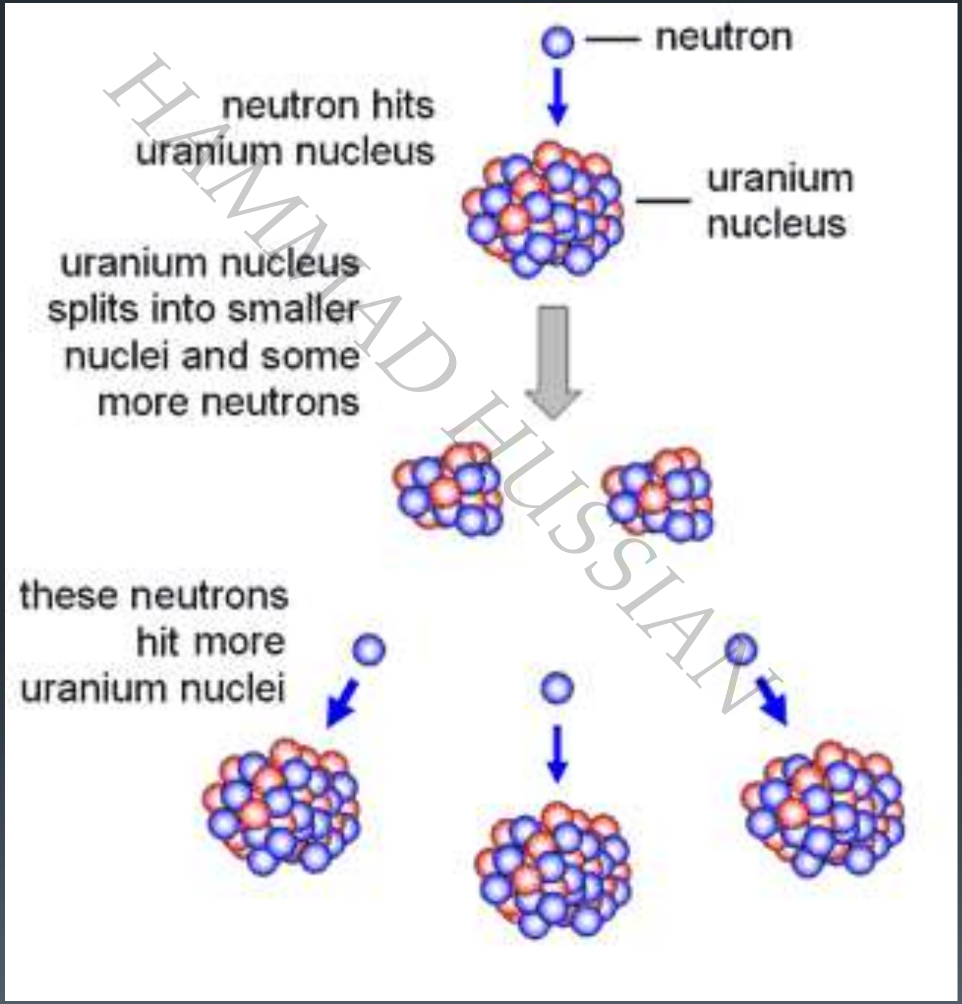
A. coal
B. geothermal
C. hydroelectric
D. nuclear

Explain nuclear fusion and fission in terms of energy-releasing processes.

Major Sources of Energy

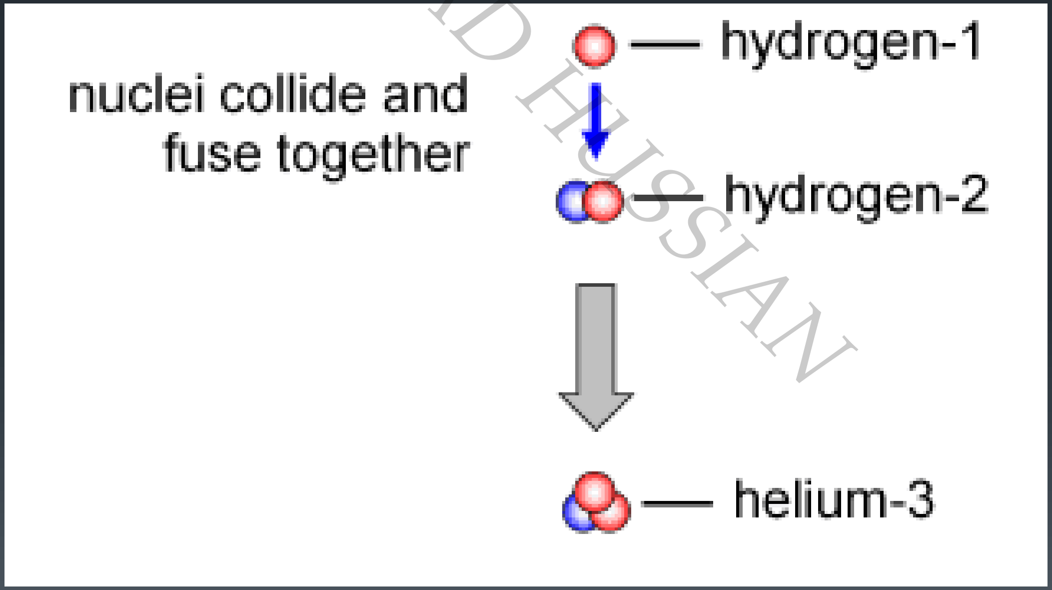
Nuclear Fission

- **Nuclear fission** (atomic fission) is a process whereby the nucleus of an atom splits into two or more smaller nuclei as fission products.
- Fission of heavy elements is an exothermic reaction.
- Fission is useful as a power source.


neutron
neutron hits uranium nucleus
uranium nucleus
uranium nucleus splits into smaller nuclei and some more neutrons
these neutrons hit more uranium nuclei
HAMMAD HUSSIAN

Nuclear Fusion

- In physics and nuclear chemistry, **nuclear fusion** is the process by which multiple nuclei join together to form a heavier nucleus.
- It is accompanied by the release or absorption of energy.


nuclei collide and fuse together
hydrogen-1
hydrogen-2
helium-3

Mass-Energy Calculation

- In physics, **mass-energy equivalence** is the concept that all mass has an energy equivalence, and all energy has a mass equivalence.
- Special relativity expresses this relationship using the mass-energy equivalence formula

$$E = mc^2$$

where

E = the energy equivalent to the mass (in joules),

m = mass (in kilograms), and

c = the speed of light in a vacuum (in meters per second).

Problem Solving

1. How much energy (in J) is generated when 1 g of mass is completely converted into energy?
2. Calculate the energy output when the mass of nuclear fuel decreases by 500 g?
3. Calculate the amount of energy released when 1.8×10^{-30} kg of mass is converted into energy.
4. Calculate the energy produced by a nuclear reactor when the mass of the fuel decreases by 2.0×10^{-6} kg.
5. What is the energy equivalent of the mass of a drop of water that has a mass of about 1×10^{-5} kg?

1. A power station uses nuclear fission to obtain energy. In this process, nuclear energy is first changed into
   - A. chemical energy.
   - B. electrical energy.
   - C. gravitational energy.
   - D. internal energy.

2. Electrical energy may be obtained from nuclear fission. In what order is the energy transferred in this process?
    A. nuclear fuel → generator → reactor and boiler → turbines
    B. nuclear fuel → generator → turbines → reactor and boiler
    C. nuclear fuel → reactor and boiler → generator → turbines
    D. nuclear fuel → reactor and boiler → turbines → generator

3. Which statement about fission or fusion is correct?
   A. During fission, hydrogen converts into helium and releases energy.
   B. During fission, uranium converts into daughter products and releases energy.
   C. During fusion, helium converts into hydrogen and releases energy.
   D. During fusion, uranium converts into daughter products and releases energy.

4. Where is energy released by the fusion of hydrogen atoms to form helium?
   A. in a nuclear power station
   B. in a radioactive isotope
   C. in the core of the Earth
   D. in the core of the Sun

5. How much energy would be released if 1×10^{-20} kg of matter was entirely converted to energy?

(The speed of light is 3×10^{8} m/s.)

A. 3×10^{-12} J
B. 9×10^{-7} J
C. 4.5×10^{-4} J
D. 9×10^{-4} J

6. The speed of light is 3×10^8 m/s.
7. What is the energy equivalent of 2 kg of matter?
   A. $2 \times 3 \times 10^8$ J
   B. $2000 \times 3 \times 10^8$ J
   C. $21 \times 2 \times (3 \times 10^8)^2$ J
   D. $2 \times (3 \times 10^8)^2$ J

7. When a nucleus of Uranium-235 absorbs a neutron, nuclear fission occurs. In a typical reaction the total mass decreases by 3×10^{-28} kg.

8. Given that the speed of light c is 3×10^{8} m/s, approximately how much energy is released?

A. 9×10^{-20} J

B. 2×10^{-13} J

C. 3×10^{-11} J

D. 3×10^{-5} J

Calculate work done from the formula work = force x distance moved in the line of action of the force.

WORK

Work

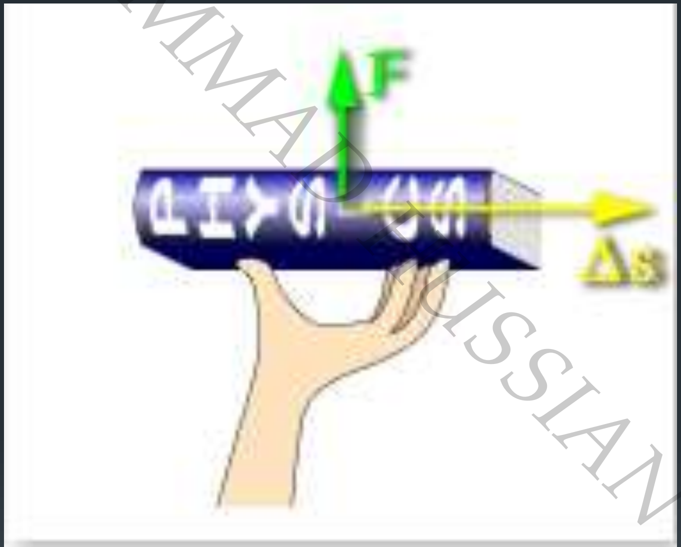
- Work specifies the action and the movement produced by a force.

- Work is **done** when a forces **produces** motion.
- The greater the force and the greater the distance moved, the more work is done.

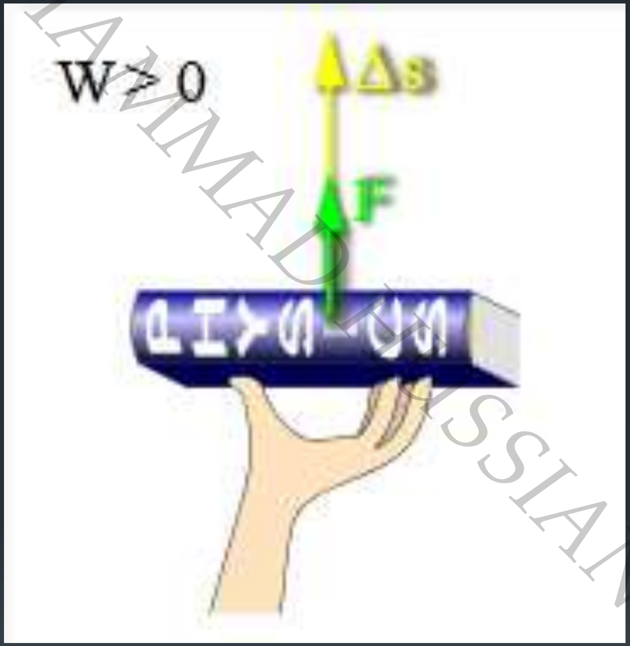
How can you tell if work is being done on an object?

The object may move against a force, for example be raised against gravity, or it may accelerate, or it may get warmer.

No work is done on a textbook when it is held at rest.



No work is done on a textbook when it is carried horizontally at a constant velocity.



Work is done on a textbook when it is raised vertically at a constant velocity.

- Calculating Work

Work =	**Force ×**	**distance moved in the direction of force**

$$\mathbf{W = F \times d}$$

- The SI unit of work is the **joule** (**J**)

1 joule of work is done when a force of 1 Newton (N) moves an object 1 metre in the direction of the force.

- Work is a **scalar** quantity.

Problem Solving

1. In which of the following cases is work being done?
   a) A magnetic force holds magnet on a steel door.
   b) You pedal a cycle along a road
   c) A pulley is used to lift up a load
   d) You hold a 2 kg weight, but without moving it
2. Find the work done against gravity when a man lifts a load of 200 N through a distance of 1.5 m.

3. A boy pushes a wooden block with a constant force of 25 N at a uniform velocity across a floor. What is the work done against friction if the block is pushed through a distance of 5.0 m?
4. How much work is done if a force of 12 N moves an object a distance of 5 m?
5. If you use a 40 N force to lift a bag, and do 20 J of work, how far do you lift it?
6. Calculate the work done in each case below.
   a) You lift a 20 N weight through a height of 2 m.
   b) You drag a 40 kg mass 8 m along a floor using a pull of 80 N.

Calculate power from the formula power = work done/time taken

POWER

Power

- **Power** is defined as ***the rate of doing work***.

$$\textbf{Power} = \frac{\textbf{workdone}}{\textbf{time}}$$

- The SI unit of power is **watt** (W).
- One watt is the same as one joule per second. ($1\ W = 1\ Js^{-1}$)

- One horsepower (1 hp) is equivalent to about 750 W.

Source	Power
Radio	3 W
Light bulb	60 W
Car engine	50 kW
Jet aircraft engine	500 kW
Power station	2000 MW

Problem Solving

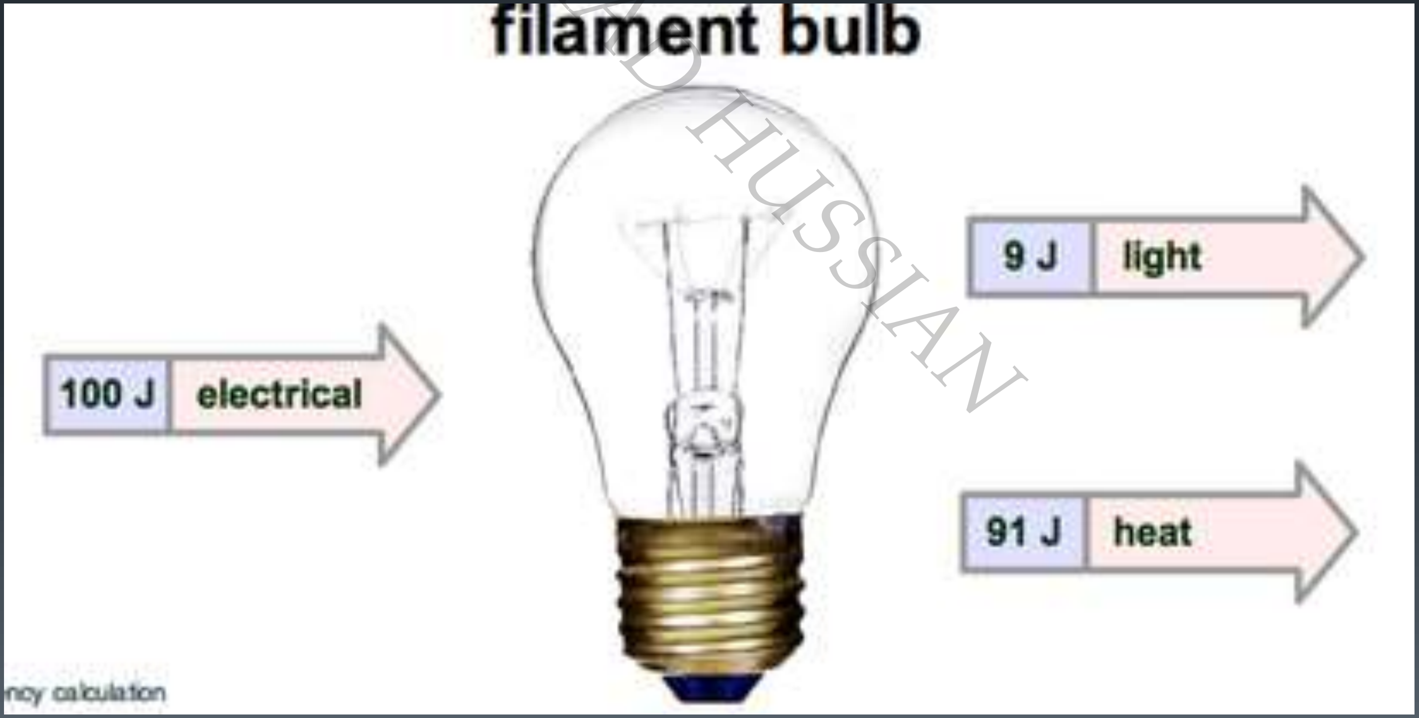
1. If a boy of mass 60 kg takes 10 seconds to run up a flight of stairs of height 3.0 m, what is his average power?
2. A boy has a weight of 500 N and can run up a flight of stairs in 10 s. There are 30 steps and each of them is of height 16 cm. Calculate the boy’s power.

3. A lift in a shopping mall can raise a maximum of 20 people through a height of 10 m in 8 seconds. The lift and its passengers have a total mass of 1600 kg. What is the power of the lift motor?
4. A 50 kg student can climbs a 5 m rope in 20 s. Calculate
   a) the work done,
   b) the power expended by the student.
5. A 60 kg farmer climbs a 5 m tall coconut tree in 5 minutes. How much power has he generated?
6. A boy whose weight is 600 N runs up a flight of stairs 10 m high in 12 s. What is his average power?

7. A light bulb transfers 1000 J of energy in 10 s. what is its power?
8. If an engine does 1500 J of work in 3 seconds, what is its useful power output?
9. A crane lifts a 600 kg mass through a vertical height of 12 m in 18 s.
   a) What weight is the crane lifting?
   b) What is the crane's useful power output?

EFFICIENCY

- Calculate the efficiency of an energy conversion using the formula efficiency = energy converted to the required form/total energy input.
- Discuss the efficiency of energy conversions in common use, particularly those giving electrical output.
- Discuss the usefulness of energy output from a number of energy conversions.


filament bulb
100 J
electrical
9 J
light
91 J
heat
ncy calculation

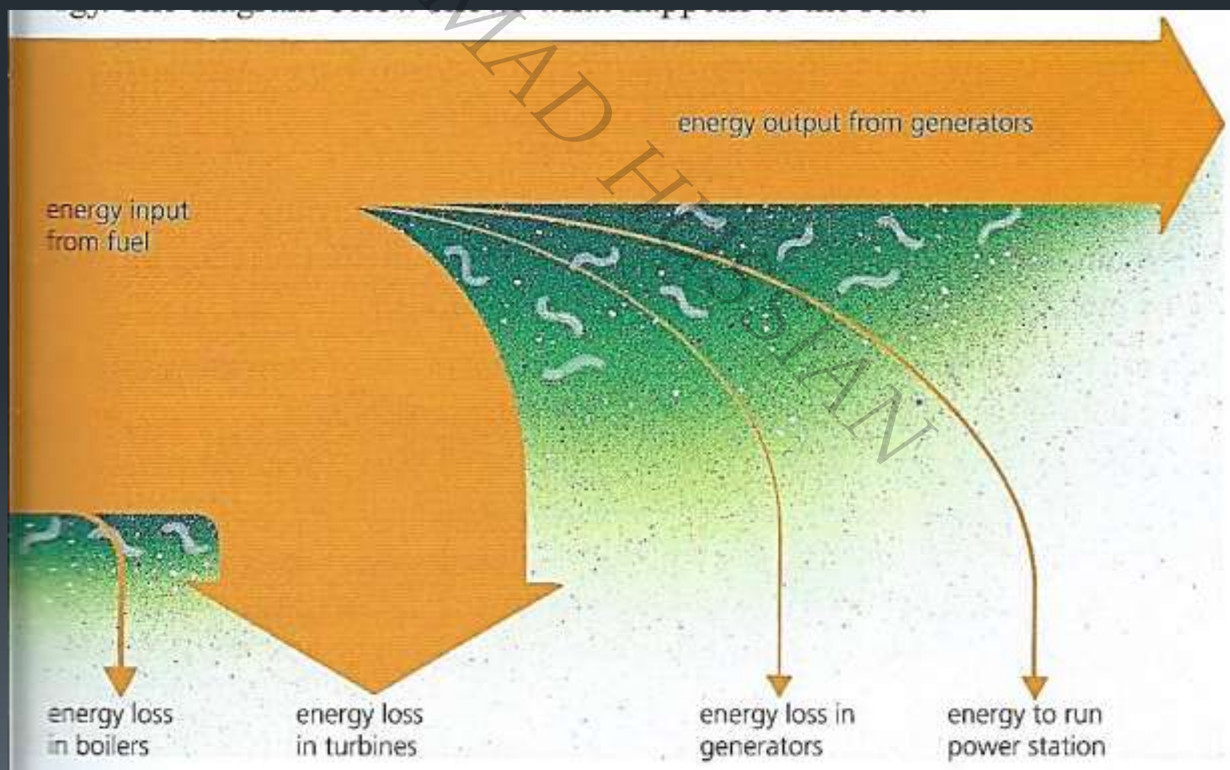
Efficiency

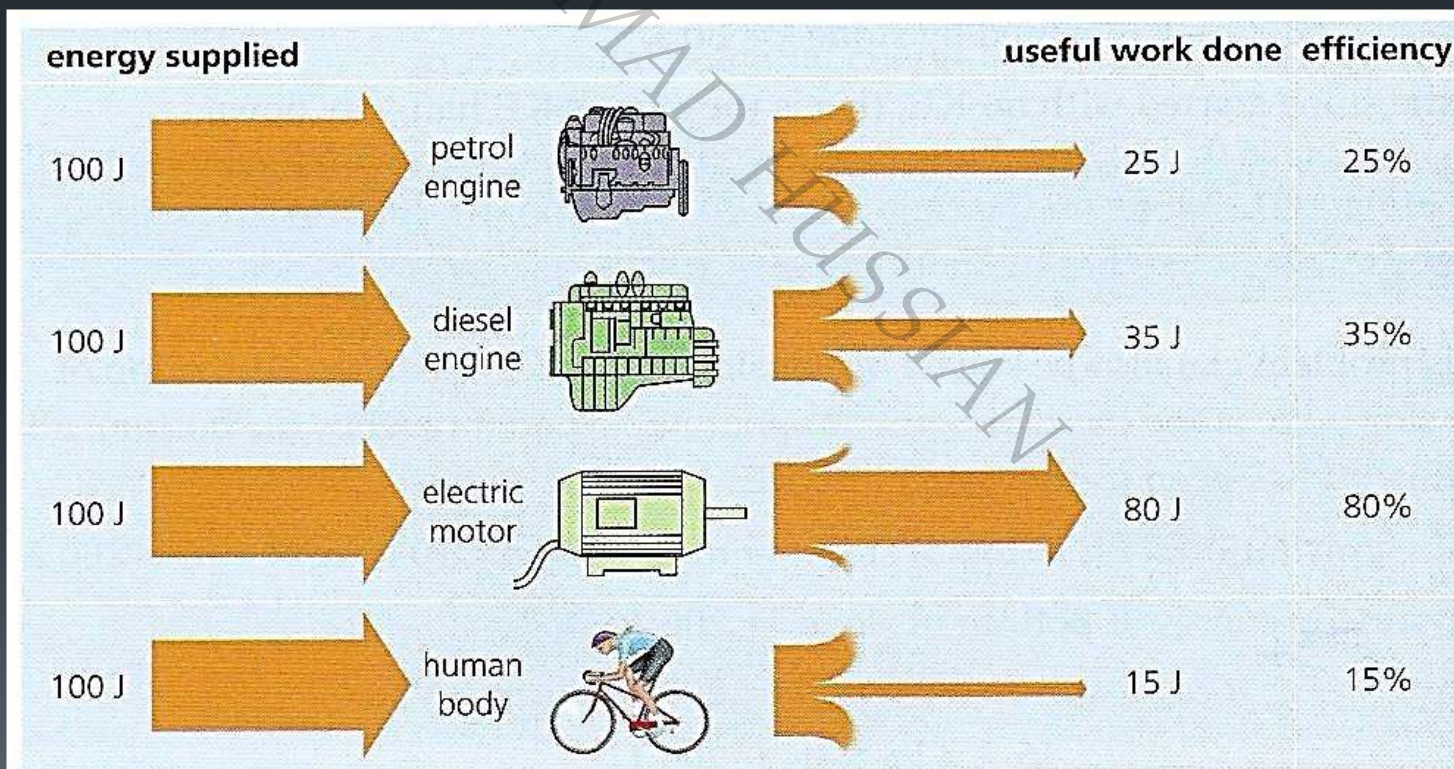
- In any energy transformations, there are always some **non-useful forms** produced.
- In converting one form of energy to another, we sometimes consider the **efficiency of energy conversion** or the **efficiency of a machine**.

$$\text{Efficiency} = \frac{\text{Output Energy}}{\text{Input Energy}} \times 100\%$$

$$\text{Efficiency} = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%$$

- The efficiency of a machine can **never exceed 100%** because **energy can neither be created or destroyed** i.e. energy output can never be greater than energy input, or work output can never be greater than work input.
- If a system is very efficient, its efficiency will be closed to 100%.
- This implies that work output is always less than work put in.


energy output from generators
energy input
from fuel
energy loss
in boilers
energy loss
in turbines
energy loss in
generators
energy to run
power station


energy supplied
useful work done
efficiency
100 J
petrol engine
25 J
25%
100 J
diesel engine
35 J
35%
100 J
electric motor
80 J
80%
100 J
human body
15 J
15%

Problem Solving

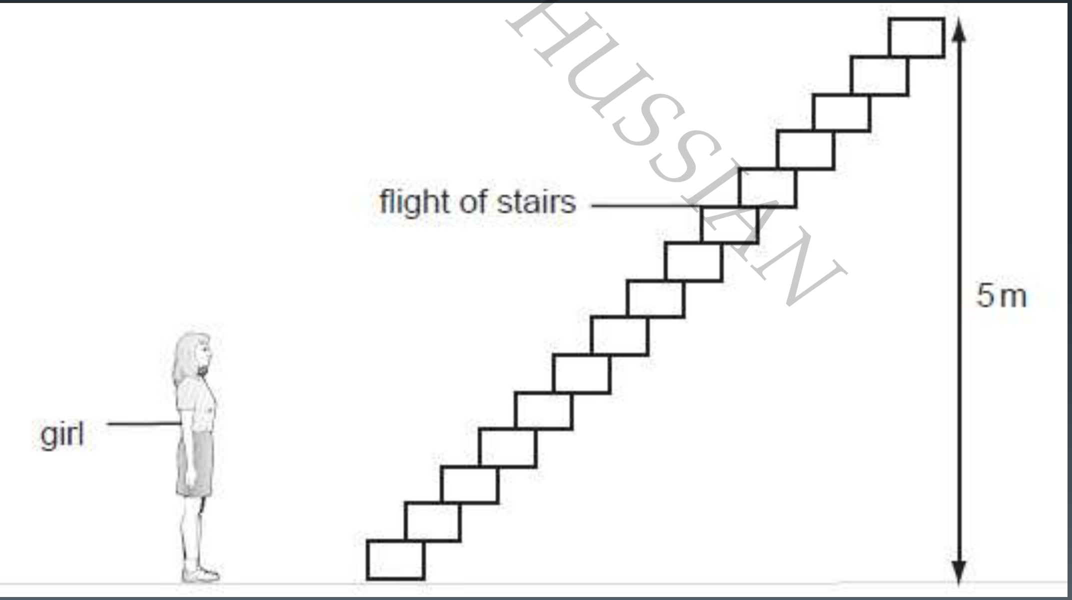
1. A load of 500 N is raised 0.20 m by a machine in which an effort of 150 N moves 1.0 m. What is
   a) the work done on the load,
   b) the work done by the effort,
   c) the efficiency?
2. An effort of 250 N raises a load of 1000 N through 5 m in a pulley system. If the effort moves 30 m, what is
   a) the work done in raising the load,
   b) the work done by the effort,
   c) the efficiency?

3. A crane lifts a load of 450 kg to the height of 90 m in 15 s. What is the efficiency of the motor in the crane if the power input is 38000 W? (g = 10 N/kg)
4. A load with mass of 500 N is raised up to a height of 2.5 m when a force, F is applied over a distance of 4 m. The efficiency of the pulley is 65%. Calculate
   a) the work done by the pulley,
   b) the value of the force, F.

5. An engine does 1500 J of useful work with each 5000 J of energy supplied to it.
   a) What is its efficiency
   b) What happens to the rest of the energy supplied
6. A coal-fired power station produces 100 MJ of electrical energy when it is supplied with 400 MJ of energy from its fuel. Calculate its efficiency.
7. A lamp is 10% efficient. How much electrical energy must be supplied to the lamp each second if it produces 20 J of light energy per second?

1. A large electric motor is used to lift a container off a ship.
2. Which of the following values are enough to allow the power of the motor to be calculated?
   A. the mass of the container and the distance moved
   B. the force used and the distance moved
   C. the current used and the work done
   D. the work done and the time taken

2. A girl of weight 500 N runs up a flight of stairs in 10 seconds. The vertical height of the stairs is 5 m.



1. What is the average power developed by the girl?

A. 50 W
B. 100 W
C. 250 W
D. 1000 W

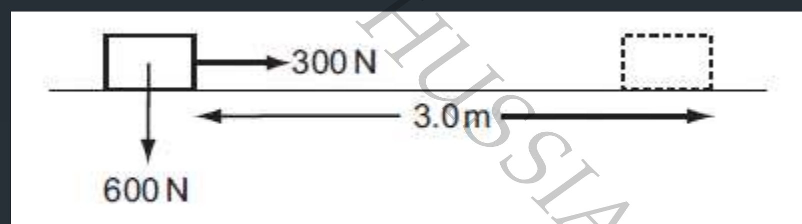
3. Four students exercise in a gym.

4. Which student does the most work?

	exercise time / s	power developed / W
A	50	250
B	100	150
C	200	200
D	250	30

C

4. When a 300 N force is applied to a box weighing 600 N, the box moves 3.0 m horizontally in 20 s.



5. What is the average power?

A. 45 W
B. 90 W
C. 900 W
D. 1800 W

5. A student who weighs 500 N climbs up a flight of stairs 10 metres high in 5 seconds.

What power does she develop?

A $500 \times 10 \times 5$ W

B $\frac{500 \times 10}{5}$ W

C $\frac{500 \times 5}{10}$ W

D $\frac{5}{500 \times 10}$ W

B

6. A man weighs 600 N. He runs up stairs of total height 4 metres in 3 seconds.

7. How much power is exerted by the man?

A. 450 W

B. 800 W

C. 2400 W

D. 7200 W

7. A boy, who weighs 50 N, runs up a flight of stairs 6.5 m high in 7 seconds.

8. How much power does he develop?

A $\frac{6.5}{50 \times 7}$ W

B $\frac{7 \times 6.5}{50}$ W

C $\frac{50}{7 \times 6.5}$ W

D $\frac{50 \times 6.5}{7}$ W

D

8. A rock climber of weight 600 N climbs up a rock face of vertical height 300 m in 3600 s.

What is the average power she generates against gravity during this time?

A. 0.020 W
B. 50 W
C. 1800 W
D. 7200 W

9. The table shows the times taken for four children to run up a set of stairs.

10. Which child's power is greatest?

	mass of child / kg	time / s
A	40	10
B	40	20
C	60	10
D	60	20

C

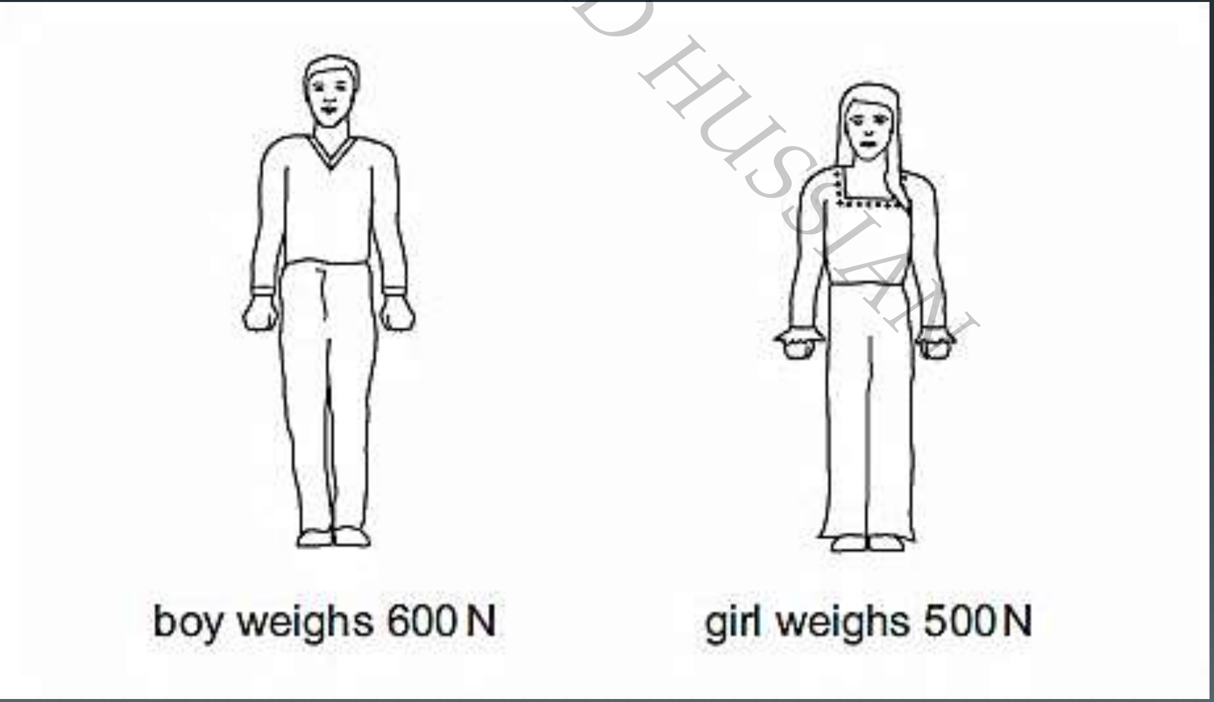
10. A labourer on a building site lifts a heavy concrete block onto a lorry. He then lifts a light block the same distance in the same time.

Which of the following is true?

	work done in lifting the blocks	power exerted by labourer
A	less for the light block	less for the light block
B	less for the light block	the same for both blocks
C	more for the light block	more for the light block
D	the same for both blocks	more for the light block

A

11. A boy and a girl run up a hill in the same time.



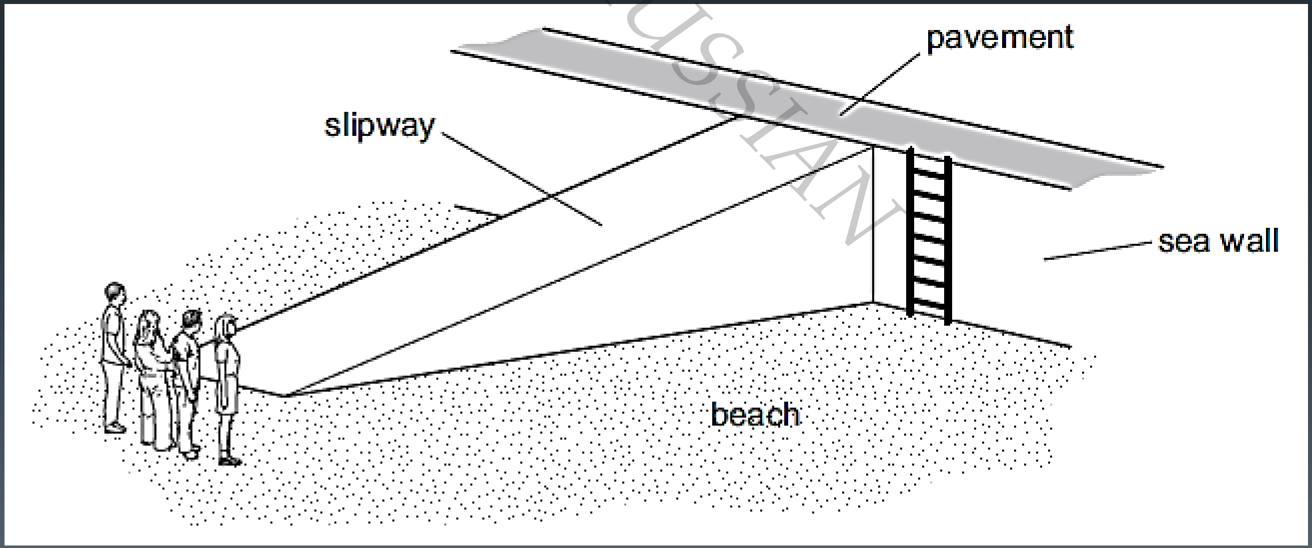
1. The boy weighs more than the girl.
2. Which statement is true about the power produced?

A. The boy produces more power.
B. The girl produces more power.
C. They both produce the same power.
D. It is impossible to tell who produces more power.

12. A worker is lifting boxes of identical weight from the ground onto a moving belt.
13. At first, it takes him 2 s to lift each box. Later in the day, it takes him 3 s.
14. Which statement is correct?

A. Later in the day, less work is done in lifting each box.
B. Later in the day, more work is done in lifting each box.
C. Later in the day, less power is developed in lifting each box.
D. Later in the day, more power is developed in lifting each box.

13. Four people of equal weight on a beach use different routes to get to the top of a sea wall.



1. Which person produces the greatest average power?

person	route	time taken
A	runs across the beach, then climbs the ladder	8s
B	walks across the beach, then climbs the ladder	16s
C	runs up the slipway	5s
D	walks up the slipway	10s

C

14. Which formula gives the efficiency of an energy conversion?

A efficiency = total energy input - useful energy output

B efficiency = useful energy output × total energy input

C $\text{efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}}$

D $\text{efficiency} = \dfrac{\text{total energy input}}{\text{useful energy output}}$

C

15. The input power to a motor is 300 W. In 20 s it lifts a load of 400 N through a height of 6.0 m.

What is the efficiency of the motor?

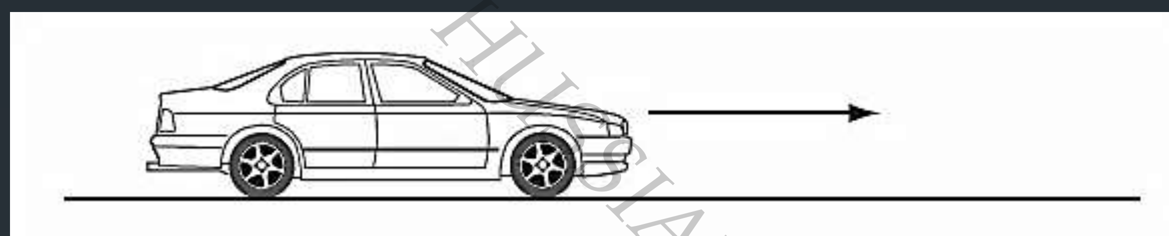
A. 12 %

B. 25 %

C. 40 %

D. 75 %

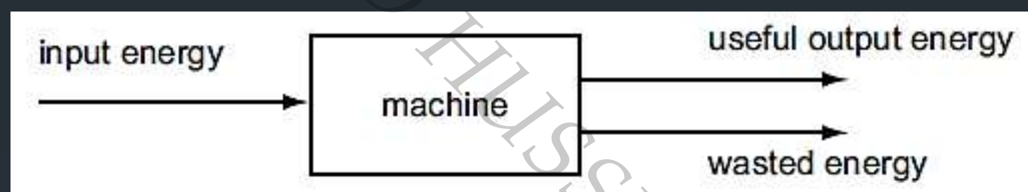
16. A car is driven along a level road. The total energy input from the petrol is 60 kJ, and the car wastes 45 kJ of energy.



17. What is the efficiency of the car?

A. 15 %
B. 25 %
C. 45 %
D. 75 %

17. The diagram shows the energy transfer through a machine.



The machine is 50 % efficient.

19. Which is correct?

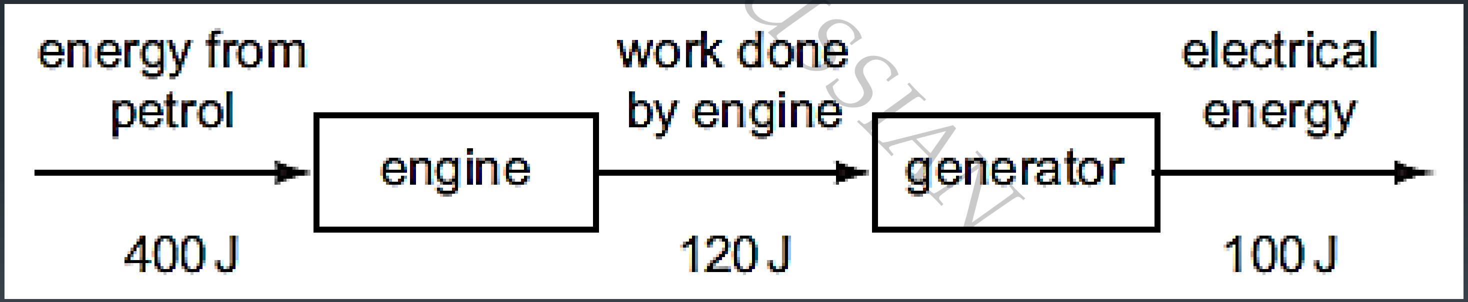
A. input energy = useful output energy
B. useful output energy = input energy + wasted energy
C. wasted energy = input energy + useful output energy
D. wasted energy = useful output energy

18. The efficiency of an electrical generator is 65 %.

Which useful output can be expected if the energy input to the generator is 12 kJ?

A. 4.2 kJ
B. 7.8 kJ
C. 19 kJ
D. 780 kJ

19. Energy from petrol is used to operate an engine. The engine drives a generator, which produces electrical energy.



1. What is the overall efficiency of the process?

A. 25 %
B. 30 %
C. 55 %
D. 83 %

20. A crane lifts a weight of 1000 N through a vertical height of 30 m.

It uses 60 000 J of energy.

What is the efficiency of the crane?

A. 20 %
B. 30 %
C. 40 %
D. 50 %

21. A crane lifts a load of 1000 N through a vertical height of 3.0 m in 10 s. The input power to the crane is 500 J/s.

What is the efficiency of the crane?

A. 0.17
B. 0.50
C. 0.60
D. 0.67