**SENIOR TWO PHYSICS WOR 2020**

**WORK, ENERGY AND POWER:**

**WORK:**

This is the product of force and distance moved in the direction of force. **OR** work is done when the point of application of force moves in the direction of force. The SI unit of work is a joule (J). A **joule** is the work done when a force of 1N moves a body through a distance of 1m in the direction of force.



= F x d

If the body is projected vertically the force acting is the weight of the body



= mgd **Examples:**

1. An object is pulled through a distance of 2m by a force of 55N. Calculate the work done



1. An object is pulled through a distance of 20cm by a force of 1500N. Calculate the work done
2. An object of mass 500g moves through a vertical height of 40cm. Calculate the work done



=

0.25 x 10 x 0.2 x

25

1. A body of mass 250g climbs 25 steps each of height 20cm. Calculate the work done

= 12.5J

ENERGY:

This is the ability to do work. The SI unit of energy is joule (J).

**Forms of energy:**

* **Heat energy.**

This is the form of energy that is transferred from region of high temperature to region of low temperature. This form of energy is produced by burning fuels, electric heaters and radiation from the sun.

* **Sound energy.**

This is a form of energy produced when particles in the medium are set into vibrations.This form of energy is heard by the ear.

* **Electrical energy.**

This is a form of energy due to the flow of charges. This form of energy can be obtained by the conversion of other forms of energy using generators.

* **Light energy.**

This is the form of energy produced by hot bodies and travels in a straight line. This form of energy can be converted into other forms of energy and helps us to see.

* **Chemical energy.**

This is a form of energy that can be converted to heat by burning.

* **Nuclear energy.**

This is form of energy produced when unstable nucleus splits through nuclear fission or two light nuclei fuse together through nuclear fusion.

* **Wave energy.**

This is a form of energy which is transferred from one point to another without causing any permanent displacement of medium itself. This form of energy causes a disturbance through the medium.

**Sources of energy:**

* **The sun.**

The sun produces light energy and heat energy which are used in different ways.

* **Wind.**

Wind is moving air which can drive turbines to produce electrical energy.

* **Fuel.**

Fuels like kerosene and petroleum when burnt produce heat energy and light energy which can be used in different ways.

* **Geothermal.**

Geothermal is a source of electrical energy in power stations.

* **Waterfalls or Dams.**

Waterfalls may be used to turn turbines in hydro-electric power stations.

* **Nuclear.**

When unstable nucleus splits nuclear energy is released.

* **Oceans.**

Ocean currents can be converted into other forms energy like electrical energy.

**Renewable (Non-Exhaustible) sources of energy:**

These are sources of energy which can be re-used to produce energy. Examples are wind, sun (solar), water (hydro-electric).

**Non-Renewable (Exhaustible) source of energy:**

These are sources of energy which cannot be re-used to produce energy. Examples are kerosene, petroleum, coal, and biogas.

##### MECHANICAL ENERGY:

This is divided into two forms of energy namely i) Kinetic energy. ii) Potential energy.

Kinetic energy:

This is the energy possessed by a body due to its motion. It depends on the speed of the body

Kinetic energy = ½ x mass x velocity2

= ½mv2

**Examples**

1. A body of mass 3kg moves with a speed of 30ms-1. Find its kinetic energy

K.E = ½mv2

= ½ x 3 x 302

= ½ x 3 x 900

= ½ x 2700

= 1350J

1. An object of volume 100cm3 and density 8gcm-3 moves with a speed of 10ms-1. Find its kinetic energy

|  |  |
| --- | --- |
| K.E | = ½mv2 |
| m | = ρ x v |
|  | = 8 x 100 |
|  | = 800g |
| K.E | = ½ x 0.8 x 102 |
|  | = ½ x 0.8 x 100 |
|  | = ½ x 80 |
|  | = 40J |

**Potential energy:**

This is the energy possessed by a body by virtue of its position in the gravitational field.

Potential energy = mass x acceleration due to gravity x height

= mgh

**Examples:**

1. Find the potential energy of an object of mass 350g when it is 10m above the ground

P.E = mgh

= 0.35 x 10 x 10

= 35J

1. A 5kg mass falls from a height of 20m. Calculate the potential energy lost

P.E = mgh

= 5 x 10 x 20

= 1000J

The law of conservation of energy:

It states that energy can neither be created nor destroyed but changes from one form to another.

**Energy changes:**

. For a body falling freely the following energy changes take place

1

P.E

P.E + K.E

K.E

sound + heat

**Ground level**

**P.E**

**K.E Sound + heat**

**K.E + P.E**

1. For a freely swinging pendulum the energy changes are

P.E

P.E + K.E

K.E

P.E + K.E

P.E

**P.E +**

**K.E**

**P.E + K.E**

**P.E**

**P.E**

**K.E**

1. When lighting a match box

Chemical energy Heat + Light

1. When a boy compresses the spring

Mechanical energy Elastic potential energy

1. When lighting a lamp connected to a battery

Chemical energy Electrical energy heat + light

1. Catapult pulled by a person to propel a stone

Mechanical energy Elastic potential energy kinetic energy

**N.B:** The following devices can be used to carry out the following energy changes;

1. Electrical energy to mechanical energy ---------Motor

ii) Mechanical energy to electrical energy --------------Dynamo

iii) Electrical energy to sound energy-----------------Loudspeaker

Sound energy to electrical energy---------------------Microphone

1. Heat energy to electrical energy ---------------Thermopile

) Electrical energy to heat energy------------------Electrical heater

1. Electrical energy to light energy------------------Electric lamps

viii) Light energy to electrical energy--------------Photocells

ix) Chemical energy to electrical energy -----------Cell

1. Electrical energy to chemical energy -----------Battery charging

xi) Nuclear energy to heat energy---------------Nuclear reactor

xii) Electromagnetic to electrical energy -----------Aerial

**Note**: For a body falling freely its kinetic energy before impact is equal to potential energy above the ground.

**Examples:**

1. A 200g body falls from a height of 0.2m. Find the kinetic energy just before it hits the ground

K.E gained = P.E lost

= mgh

= 0.2 x 10 x 0.2

= 0.4J

1. A block of mass 2kg falls freely from rest through a height of 20m above the ground. Find

i) The potential energy of the block above the ground ii) The velocity with which the block hits the ground

|  |  |  |
| --- | --- | --- |
| i) | P.E | = mgh |
|  |  | = 2 x 10 x 20 |
|  |  | = 400J |
| ii) | K.E | = P.E |
|  | ½ mv2 | = 400 |
|  | ½ x 2 x v2 | = 400 |
|  | v2 | = 400 |
|  | v | = √400 |
|  | v | = 20ms-1 |

##### POWER:

This is the rate of doing work

|  |  |
| --- | --- |
| Power | = Work done |
|  | Time taken |
|  |  |
| Work done | = Force x distance |
| Power | = Forcex distance |
|  | Time taken |
|  | = Forcex velocity |

The SI unit of power is a watt (W).

**A watt** is the rate of working of one joule per second

Hence 1W = 1Js-1

Other units of power include kilowatt (kW) and megawatt (MW).

1kW =1,000W

1MW = 1,000,000W **Examples:**

1. An engine raises 20kg of water through a height of 50m in 5 seconds. Calculate the power of the engine

Power = work done

Time taken

= F x d t = mg x h

t

= 2 x 10 x 50

5

= 200W

1. What is the power of the crane which can lift a box of mass 1000kg vertically through a height of 15m in 40 seconds?

|  |  |
| --- | --- |
| Power | = work done |
|  | Time taken |
|  | = F x d |
|  | t |
|  | = mg x h |

t

= 1000 x 10 x 15

40

= 3750W

1. A boy whose mass is 60kg can run up a flight of 28 steps each 25 cm high in 56 seconds. Calculate the power developed by the boy

Power = work done

Time taken

= F x d t

= mg x h

t

= 60 x 10 x (28 x 0.25)

56

= 75W

**Trial Exercise 4:**

**Where necessary take acceleration due to gravity, g = 10ms-2**

1. A boy of mass 40kg walks up a flight of 12 steps. If each step is 20cm high, calculate the work done by the boy in climbing up the stairs.
2. An electric motor raises a 50kg load at a constant velocity. Calculate the power of the motor if it takes 40 seconds to raise the load through a height of 24m
3. At what average velocity can a motor rated 200W raise a load of mass 40kg?
4. An object 2.5kg is released from a height of 5m above the ground. Calculate the velocity of the object just before it strikes the ground. What assumption have you made in your calculation?
5. A boy of mass 45kg develops an average power of 250W when running up a flight of stairs. How long does he take to climb up a vertical height of 4m?

1. Water falls through a height of 60m at a rate flow of 1.2 x 104kg per minute. Assuming there are no energy losses, calculate power generated from the base of the water fall.
2. A 30g bullet strikes a tree at a speed of 200ms-1 and leaves it from the opposite side at a speed of

100ms-1. Calculate

i) The kinetic energy of the bullet just before it strikes the tree ii) The kinetic energy of the bullet just before it emerges out of the tree

1. A boy of mass 50kg runs up-flight of stairs in 2 seconds. If each step is 0.2m high and there are 60 steps in the flight. Calculate the boy’s power
2. A crane lifts 4 bricks per minute through a height of 150cm. Find the power that is expended if each brick weighs 100N

1. A boy pulls a toy car by a string which makes an angle of 30oC with the horizontal. If the boy applies a force of 4.8N and a toy moves through a horizontal distance of 8m. Calculate the work done by the boy
2. An object of mass 10kg is released at a height of 25m above the ground. Calculate the kinetic energy with which it hits the ground.
3. Describe the energy transformations that take place in each of the following;
   1. A car battery is used to light a bulb
   2. Coal is used to generate electricity
   3. Water at the top of water fall falls and its temperature rises on reaching the bottom 13. Sometimes work is not done even if there is an applied force. Describe some situations when this is so.

**Multiple-choice Exercise:**

1. Two forces of 3N and 4N act at a point at right angles to each other. The magnitude of their resultant is
   1. 25N B. 7N C. 5N D. 1N
2. The unit of energy is
   1. the joule B. the watt C. the newton D. the newton per metre
3. Forces of 10N, 8N, 4N acts an object as shown in the figure below.

**10N**

**8N**

**4N**

Find the magnitude of the resultant force on the object.

* 1. 10.0N B. 16.1N C. 22.0N D. 100.0N

1. Which of the following sources of energy are exhaustible?

i) Solar energy ii) fossil fuels iii) tidal power

* 1. (i) only correct B. (ii) and (iii) correct

C. (ii) only correct D. (i) and (iii) correct

5 Power is defined as

A. rate of doing work, measured in watts B. ability to do work, measured in joules

C. energy x time, measured in joule time D., measured in joules per hour

1. The forces that hold the molecules in a mercury drop together are called
   1. surface tension B. adhesive forces

C. cohesive forces D. electrostatic forces

1. A pump is rated at 400W. How many kg of water can it raise in one hour through a height of 720m?
   1. 0.8kg B. 5.6kg C. 33.3kg D. 200.0kg
2. A body of mass 2kg was dropped from the top of the building. It has kinetic energy of 900J when it hits the ground, the height of the building was
   1. 450m B. 180m C. 90m D. 45m
3. A mouse of mass 0.03kg climbs through a distance of 2m up a wall in 4 seconds. The power developed in watts is
   1. 0.024 B. 0.15 C. 0.6 D. 2.4
4. A force of 50N moves an object through a distance of 200m in 40 seconds. Find the power developed
   1. 100W B. 250W C. 160W D. 200W
5. A vertical force of 4N and horizontal forces of 6N and 9N were applied on a block as shown blow
6. **4N**



**9N**

**6N**

Find the magnitude of the resultant force on the block

* 1. 3N B. 5N C. 15N D. 19N

1. Two forces of 12N and 5N act on a body of might angles their resultant force is
   1. 7N B. 13N C. 17N D. 169N
2. A newton is defined as the
   1. Unit of force
   2. Force which produces an acceleration of 1ms-2
   3. Force which gives a mass of 1kg an acceleration of 1ms-2
   4. Force which gives any mass an acceleration of 1ms-2.
3. The rate of doing work is measure in
   1. watts B. joules C. newtons D. metres
4. The energy transformation that takes place when a cell is producing electricity is
   1. chemical to electrical B. mechanical to electrical

C. heat to electrical D. electrical to heat

1. The weight of body is defined as the,
   1. Gravitation force on it B. quantity of matter it contain C. Maximum pressure it can exert D. the product of its density and volume.
2. Which of the following have the same units?
   1. energy and power B. energy and work

C. power and work D. kinetic energy and power

1. The weight of a body varies from place to place on the earth’s surface because
   1. of the rotation of the earth
   2. weight acts towards the earth
   3. of the motion of objects in the atmosphere
   4. of the total gravitational force on the body
2. An object of mass 6kg is raised from the ground to height of 4m. The work done is
   1. 100J B. 240J C. 3000J D. 2400J
3. When water spreads on a glass plate, the force between its molecules and glass molecules is due to
   1. surface tension B. adhesion C. cohesion D. viscosity