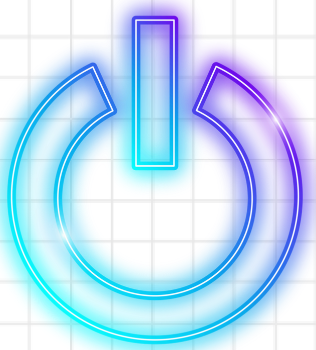
KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

POLITEKNIK MALAYSIA
KUALA TERENGGANU

WORK, ENERGY & POWER



NOR FADZLINA BINTI AINUDDIN

This page intentionally left blank

WORK, ENERGY& POWER

By:
Nor Fadzlina binti Ainuddin
Department of Mathematics, Science & Computer
Politeknik Kuala Terengganu

Nor Fadzlina binti Ainuddin
Department of Mathematics, Science & Computer
Politeknik Kuala Terengganu

Published by:
Politeknik Kuala Terengganu
Jalan Sultan Ismail, 20200 Kuala Terengganu, Terengganu

☎ 09-6204100 09-6204102

Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

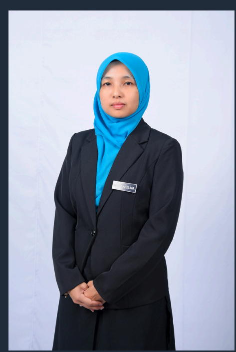
A catalogue record for this book is available from the National Library of Malaysia

eISBN 978-967-2240-54-9

PREFACE

بسم الله الرحمن الرحيم

With sincere appreciation, I would like to express my heartfelt gratitude to all those involved and contributed to the making of this E-book : Work, Energy & Power. The dedication, hard work, and commitment provided by the author, editor, designer, publisher, and all parties involved have been truly remarkable. Without their cooperation and support, this achievement would not have been possible. This e-book provides a detailed overview of work, energy, and power, including their definitions, SI units, and formulas. The content provides a comprehensive understanding of these fundamental concepts and their practical applications. Hopefully, the concepts presented in this e-book are engaging and enjoyable to read, facilitating a deeper understanding of the fundamental principles for both lecturers and students.



Author:
Nor Fadzlina binti Ainuddin

ABSTRACT

The E-book: Work, Energy & Power is to understand the fundamental concepts of work, energy, and power, including their measurement units and formulas, as well as the distinction between renewable and non-renewable energy sources. It emphasizes the importance of conservation of energy and provides examples of renewable and non-renewable energy sources and the importance of efficiency in transforming input energy into useful energy.

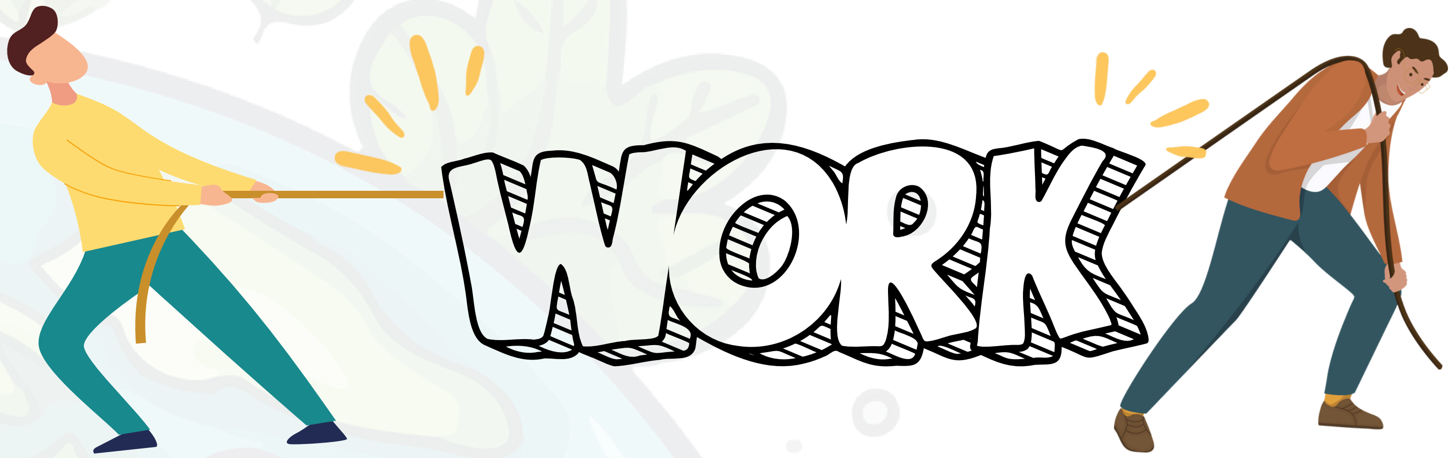
WORK, ENERGY

TABLE OF CONTENTS

& POWER

You will learn:

1. Define work.
2. Formula.
3. Example of the concept and formula of work in solving the related problems.
4. Exercise.



Define Work

The product of an applied force and distance of an object in the direction of the applied force.

S.I Unit

N/m or Joule (J).

Formula

1. $$W = Fd$$

Work, J

Force, N

distance, m

2. $$W = Fd\cos\theta$$

Work, J

Force, N

distance, m

angle, °

3. $$W = mgh$$

Work, J

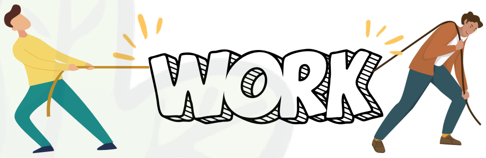
mass, kg

gravity, 9.81m/s

height, m

Interactive video, click below

CLICK



Using formula Work

① $W = Fd$

Work, J Force, N distance, m

② $W = Fd\cos\theta$

Work, J Force, N angle, ° distance, m

③ $W = mgh$

Work, J mass, kg gravity, 9.81m/s height, m

Example

1. A 5kg box is lifted 0.5m into the air by Ali.

Solve

③ $W = mgh$

Work, J mass, kg gravity, 9.81m/s height, m

m = 5kg
h = 0.5m
g = 9.81

$$W = (5)(9.81)(0.5)$$

$$W = 24.525J$$

Example

2. A horse pulls a cart of full coal with 50N of force along 1000m.

Solve

① $W = Fd$

Work, J Force, N distance, m

F = 50N
d = 1000m

$$W = (50)(1000)$$

$$W = 50,000J$$

Example

3. John pull a box with 50N of force along 30m with 30°.

Solve

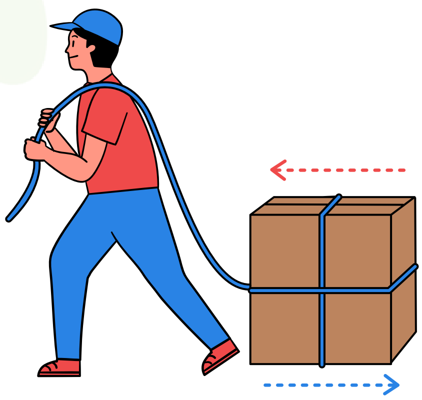
② $W = Fd\cos\theta$

Work, J Force, N angle, ° distance, m

F = 50N
d = 30m
θ = 30°

$$W = (50)(30)cos30$$

$$W = 1299.038J$$



Exercise

01 Answer: 11.25 J

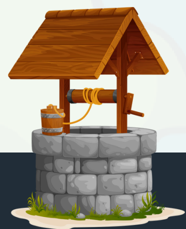
Ahmad pushed a book 1.50 m to the right along a horizontal table with a horizontal force of 7.50 N. If, calculate the work done on the book.

Solve

02 Answer: 2617.070 J

A man is mopping the floor with a mass of 78 kg at an angle of 70°. Calculate the work has the man done after mopping the floor in 10m horizontally.

Solve



03 Answer: 0.765 kg

Mohamad lifted a bucket of with 150 J in 150 seconds out of a well. The bucket was lifted at a height of 20 m. Calculate the mass of the bucket.

Solve

04 Answer: 809.325 J

Amin lifts a 50 kg hiking bag onto his shoulders through a vertical distance of 1.65 m. Calculate the work done.

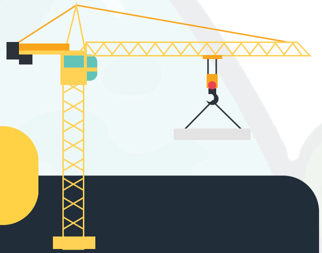
Solve

Exercise

05 Answer: 17781.758 J

Mimi with a mass of 100 kg is climbing up to the top of 20 m stairs with 25° inclined. Calculate the work done.

Solve



06 Answer: 0.437 m

1500 J of work is needed to raise an object vertically. If the mass of the object is 350 kg, calculate the height that can be reached by the object.

Solve

07 Answer: 7003.750 J

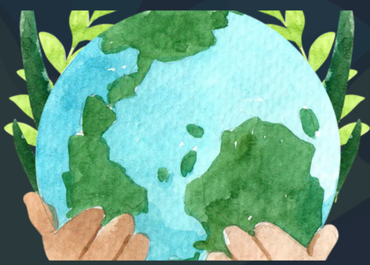
Sheila has just arrived at the airport and is dragging her suitcase to the luggage with a force of 190N at an angle of 35°, displace it 45m to the desk. Determine the work done by Sheila on the suitcase.

Solve

08 Answer: 12.263 J

Calculate the work done against gravity in lifting a 2.5kg object through vertical distance of 50cm.

Solve



RENEWABLE ENERGY

You will learn:

1. Define renewable energy, resources and technologies.
2. Define non-renewable energy, resources and technologies.
3. The advantages of renewable energy.
4. Exercise

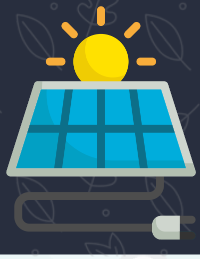
RENEWABLE ENERGY

Define:

Energy generated from natural resources such as sunlight, wind, rain, biofuels, and geothermal heat.

Solar Energy

Energy acquired from the sunlight. There are solar power devices that are used to generate electricity.



Interactive video, click below

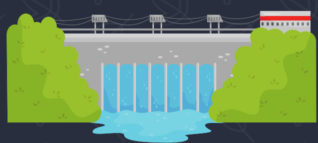
Interactive video, click below

Wind Power

This type of energy originates from windmills and wind corridors.

Hydroelectric Power

Acquired from flowing water. This flow is mostly maintained in the shape of dams



Interactive video, click below

Interactive video, click below

Geothermal Energy

Energy generated from the heat of the earth.

Biofuels

This energy is generated from the fuels of living organisms.

Interactive video, click below

NON-RENEWABLE ENERGY

Define:

Types of energy that cannot be replaced after they have been used.

Coal Energy

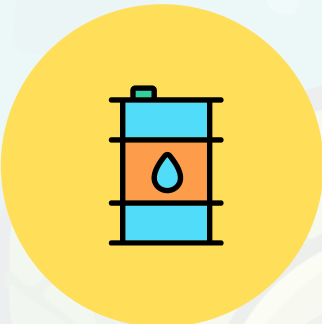
Produced by burning coal to generate heat, which can then be converted into electricity or used for various industrial processes.

Nuclear Energy

Energy released from the process of splitting of atomic nuclei. This process produces an amount of heat, which can be converted into electricity

Natural Gas Energy

It's formed from the remains of ancient plants and animals that have been buried and subjected to heat and pressure over millions of years.



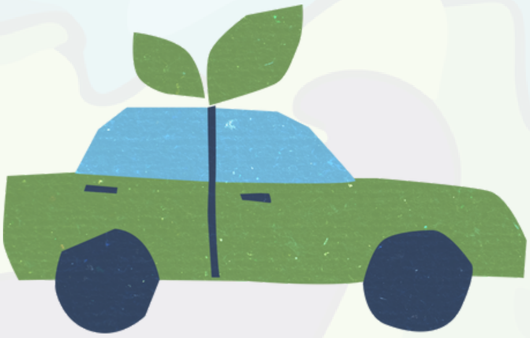
Oil Energy

Energy formed from the remains of prehistoric plants and animals that were buried and subjected to heat and pressure over millions of years.

ADVANTAGES OF RENEWABLE ENERGY

It is safe, abundant, and clean to use when compared to fossil fuels.

Enough sunlight comes down on our planer every day that if we could harvest it with solar panels and other forms of collection, we could power everything for an entire year.



Renewable energy is stable.

When renewables are creating energy, the power produced is stable and usable.

Less global warming.

Most renewable energy sources produce little to no global warming emissions.

Jobs and other economic benefits.

Solar panels need humans to install them; wind farms need technicians for maintenance.

Exercise

RENEWABLE & NON RENEWABLE ENERGY

Circle words in the puzzle below

E	N	E	R	G	Y	N	P	W
S	U	L	O	A	N	A	L	A
O	C	E	I	S	C	L	A	T
L	L	C	L	A	R	S	N	E
A	E	T	O	H	W	O	T	R
R	A	R	M	A	R	I	T	R
R	R	I	C	O	A	L	N	A
Z	G	C	H	E	A	T	Y	D
S	U	N	L	I	G	H	T	W

energy	heat	nuclear	water
solar	coal	plant	electric
wind	gas	sunlight	oil

Exercise

RENEWABLE & NON RENEWABLE ENERGY

Question

Categorize **THREE (3) examples** for renewable energy and non-renewable energy:

Answer:

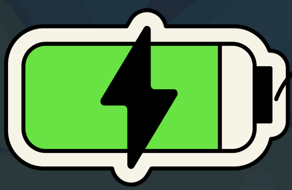
Question

Explain **TWO (2)** the advantages of renewable energy to mankind.

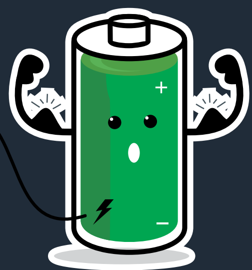
Answer:

1. ....

2. ....



ENERGY



You will learn:

1. Define Energy, Potential Energy and Kinetic Energy.
2. Using the formula of Potential Energy.
3. Exercise of Potential Energy.
4. Using the formula of Kinetic Energy.
5. Exercise of Kinetic Energy.
6. Principle of conservation of energy.
7. Examples of Energy can change from one form to another
8. Example Principle of conservation of energy.
9. Exercise

ENERGY

Define:

Ability to do a work. S.I unit for energy is Joule (J).

$$E_p = M \cdot g \cdot h$$

Potential energy, J

mass, kg

gravity, 9.81 m/s²

height, m

Define Potential energy

Energy of an object due to its position or state.

S.I Unit

Joule (J)

Example

The kid is sitting on swing has potential energy.

The kid stand still before sweeping has potential energy.

The ball has potential energy before it is kicked.

The baby is sleeping without moving has potential energy.

Define Kinetic energy

Energy of an object due to its motion.

S.I Unit

Joule (J)

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

Kinetic energy, J

mass, kg

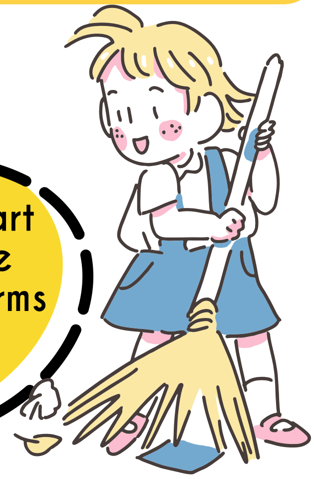
velocity, m/s

Interactive video, click below

Example

Once the swing start swinging, the energy transforms into kinetic energy.

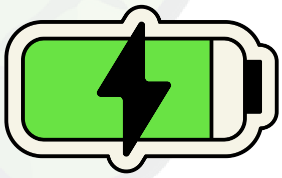
When a kid start sweeping, the energy transforms into kinetic energy.



The mother's voice while humming is kinetic energy in the form of sound.

The ball then transforms into kinetic energy after being kicked.

Using formula of Potential Energy



$$E_p = m \cdot g \cdot h$$

Potential energy, J

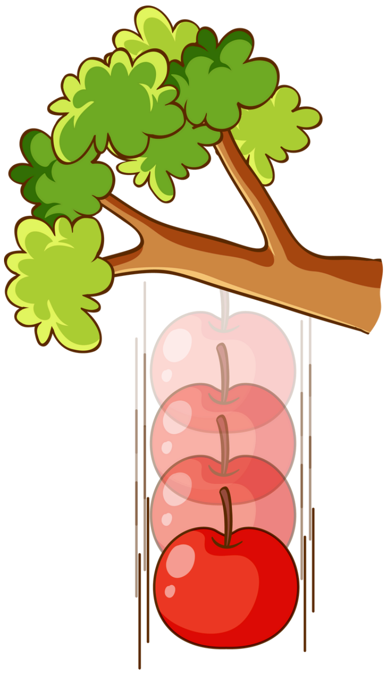
mass, kg

gravity, 9.81 m/s²

height, m

Example

An apple of mass 0.3kg falls from a height of 1.25m. Calculate the gravitational potential energy possessed by the apple.



Solve

$$E_p = m \cdot g \cdot h$$

?

0.3kg

9.81 m/s²

1.25m

$$E_p = 0.3 \times 9.81 \times 1.25$$

$$E_p = 3.679 \text{ J}$$

You need to know!

In the Potential Energy formula, there is the formula **m (mass) x g(gravity)** which means **Weight, W** with S.I unit is Newton (N).

$$W = mg$$

Exercise

Using formula of Potential Energy

$$E_p = M \cdot g \cdot h$$

mass, kg

height, m

Potential energy, J

gravity, 9.81 m/s²

Question 1

1. A man of 60kg climbs to the top of a building which is 40m in height. Calculate the potential energy of the man.

Solve

Answer: 23544 J

Question 2

2. A lift with its passengers has a total mass of 1350 kg. Calculate the gravitational potential energy gained by the lift by moving upwards to a height of 25 m.

Solve

Answer: 33750 J

Exercise

Using formula of Potential Energy

$$E_p = M \cdot g \cdot h$$

Potential energy, J
mass, kg
gravity, 9.81 m/s²
height, m

Question 3

3. A baby carriage is sitting at the top of a hill that is 21 m high. The carriage with the baby weight 12 N. The carriage has potential energy. Calculate it.

Solve

Answer: 252 J

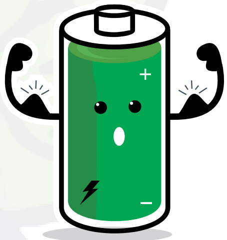
Question 4

4. Calculate the weight of an object fell in the height of 5 m if the gravitational potential energy is 125 J.

Solve

Answer: 25 N

Using formula of Kinetic Energy



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

velocity, m/s

Kinetic energy, J

mass, kg

Example

A car with a mass of 1200kg moves with a velocity of 25m/s. Calculate the kinetic energy possessed by the car.

Solve

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

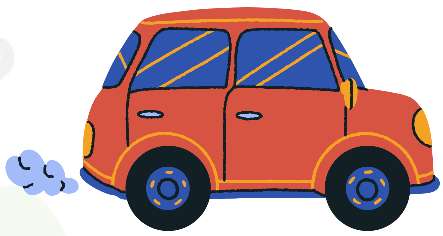
25m/s

?

1200kg

$$E_k = \frac{1}{2}(1200)(25)^2$$

$$E_k = 375000 \text{ J}$$



Exercise

Using formula of Kinetic Energy

$$E_k = \frac{1}{2} m v^2$$

Kinetic energy, J
mass, kg
velocity, m/s

Question 1

1.A 78kg skydiver has a speed of 62m/s at an altitude of 870m above the ground. Calculate kinetic energy.

Solve

Answer: 149916 J

Question 2

2. You serve volleyball with a mass of 2.1 kg. The ball leaves your hand with a speed of 30m/s. The ball has kinetic energy. Calculate it.

Solve

Answer: 945 J

Exercise

Using formula of Kinetic Energy

$$E_k = \frac{1}{2} m v^2$$

velocity, m/s

Kinetic energy, J

mass, kg

Question 3

3. Jacob, the former platform diver for the Jumbo's Circus, had a kinetic energy of 12000 J just prior to hitting the bucket of water. If Jacob's mass is 40 kg, calculate her speed.

Solve

Answer: 24.495m/s

Question 4

4.The kinetic energy of a car is 4000J. Find a velocity of the car if its mass is 1000kg.

Solve

Answer: 2.828 m/s

Exercise

Using formula of Kinetic Energy

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

velocity, m/s

Kinetic energy, J

mass, kg

Question 3

3. Jacob, the former platform diver for the Jumbo's Circus, had a kinetic energy of 12000 J just prior to hitting the bucket of water. If Jacob's mass is 40 kg, calculate her speed.

Solve

Answer: 24.495m/s

Question 4

4.The kinetic energy of a car is 4000J. Find a velocity of the car if its mass is 1000kg.

Solve

Answer: 2.828 m/s

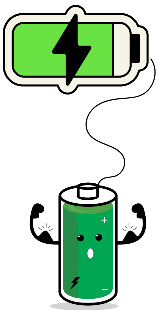
Define Principle of Conservation of Energy

States that energy cannot be created or destroyed but can change from one form to another. This is known as the **Principle of Conservation of Energy.**

S.I Unit

Joule (J)

The total amount of energy in a system is:



the total energy stored before conservation

=

the total energy stored after conservation

$$E_T = E_p + E_K$$

$$E_T = m.g.h + \frac{1}{2}mv^2$$

$$v^2 = 2.g.h$$

Examples of Energy can change from one form to another

Swings

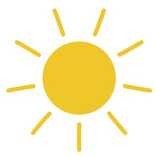
A swing has **potential energy** that converts to **kinetic energy** as the person swings down and then back to potential energy at the highest point of the swing, and the total amount of energy remains constant.

Riding a bike

The food you consume provides **chemical energy** that is converted into **kinetic energy** when you pedal and move forward on a bike.

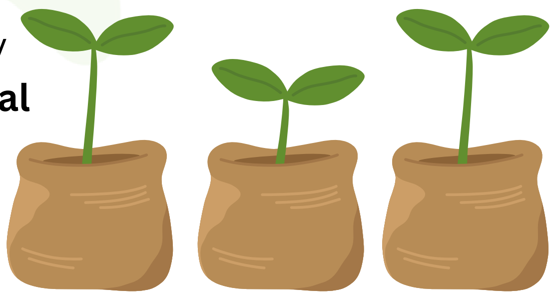
Switch on the radio

When you press the power button, **electrical energy** flows from the power source into the radio converted into **sound energy**. This conversion allows you to hear the audio from the speakers.



Plants are growing

This **solar energy** from the sun is absorbed by the plant's leaves and converted into **chemical energy.** This chemical energy is used for growth, reproduction, and other metabolic processes within the plant.



Using formula of Conservation of Energy

$$E_T = E_p + E_K$$

$$E_T = m.g.h + \frac{1}{2} mv^2$$

$$v^2 = 2.g.h$$

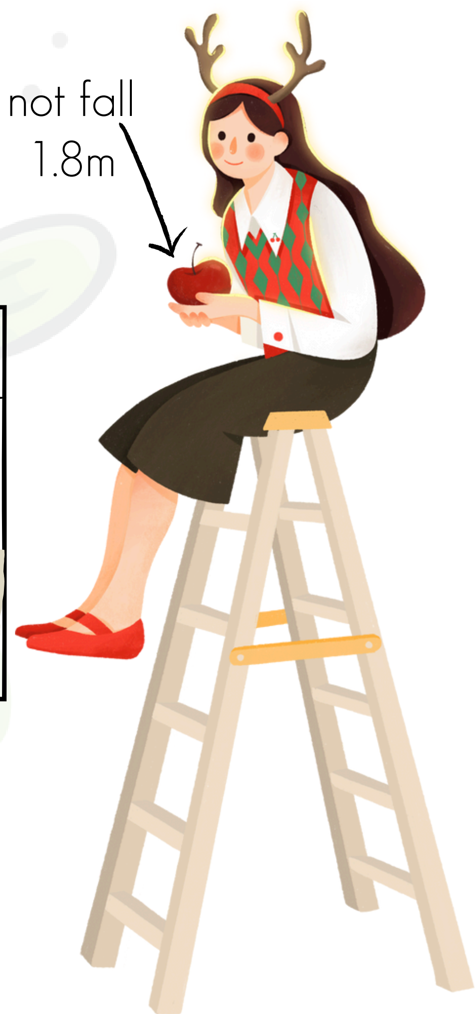
Example

An apple of 0.250 kg mass was lifted as high as 1.8 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

ii) 1 meter under free fall

iii) Right after its touched the ground



Solve i)

i) Before it was let to fall

$E_p = m.g.h$	$E_k = \frac{1}{2} mv^2$	$E_T = E_p + E_k$
$E_p = 0.25 \times 9.81 \times 1.8$ $E_p = 4.415$ J ✓ Not fall	$E_k = \frac{1}{2} \times 0.25 \times 0^2$ $E_k = 0$ J ✓ An apple is not falling yet, so no change in position then the velocity of the object is zero.	$E_T = 4.415 + 0$ $E_T = 4.415$ J ✓ Total Energy, E_T is same for all situations.

Example

An apple of 0.250 kg mass was lifted as high as 1.8 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

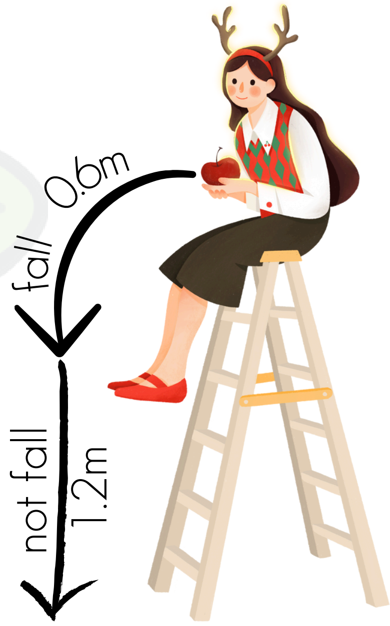
ii) 0.6 meter under free fall

iii) Right after its touched the ground

Solve ii)

ii) 0.6 meter under free fall

$E_p = m.g.h$	$E_k = \frac{1}{2}mv^2$	$E_T = E_p + E_k$
$E_p = 0.25 \times 9.81 \times 1.2$ $E_p = 2.943$ J ✓ Not fall	$E_k = \frac{1}{2} \times 0.25 \times v^2$ Need to find the value An apple is falling, so change in position is 0.6m then the velocity of the object must calculate.	$E_T = 4.415 + 0$ $E_T = 4.415$ J ✓ Total Energy, E_T is same for all situations.



Two (2) ways to solve, both answer is SAME

1 $V^2 = 2.g.h$	2 $E_T = E_p + E_k$
$V^2 = 2 \times 9.81 \times 0.6$ fall $V^2 = 11.772$ Insert the value to formula $E_k = \frac{1}{2} \times 0.25 \times 11.772$ $E_k = 1.472$ J ✓	$E_T = 4.415$ J $E_T = E_p + E_k$ $4.415 = 2.943 + E_k$ $E_k = 4.415 - 2.943$ $E_k = 1.472$ J ✓

Example

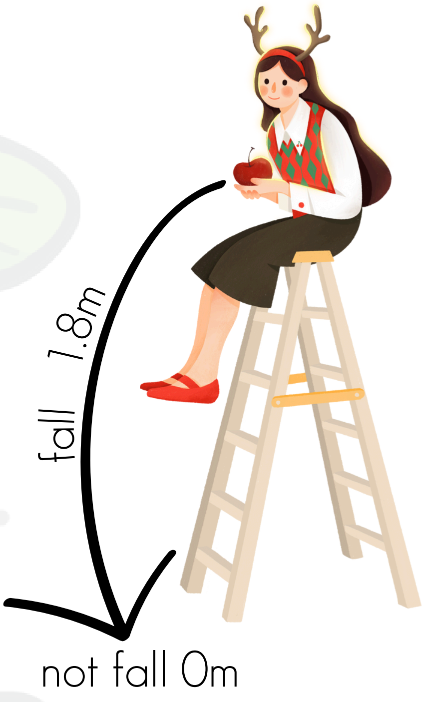
An apple of 0.250 kg mass was lifted as high as 1.8 m from the ground and was let to fall under the gravitational reaction. Calculate the gravitational **potential energy** and the **kinetic energy** possessed by the object under these situations:

i) Before it was let to fall
ii) 0.6 meter under free fall
iii) Right after its touched the ground

Solve iii)

iii) Right after its touched the ground

$E_p = m.g.h$	$E_k = \frac{1}{2} mv^2$	$E_T = E_p + E_K$
$E_p = 0.25 \times 9.81 \times 0$ $E_p = 0$ J Not fall	$E_k = \frac{1}{2} \times 0.25 \times v^2$ Need to find the value An apple is falling, so change in position is 0.6m then the velocity of the object must calculate.	$E_T = 4.415 + 0$ $E_T = 4.415$ J Total Energy, E_T is same for all situations.

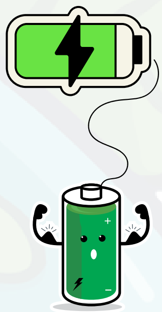


Two (2) ways to solve, both answer is SAME

1 $V^2 = 2.g.h$	2 $E_T = E_p + E_K$
$V^2 = 2 \times 9.81 \times 1.8$ fall $V^2 = 35.316$ Insert the value to formula $E_k = \frac{1}{2} \times 0.25 \times 35.316$ $E_k = 4.415$ J	$E_T = 4.415$ J $E_T = E_p + E_K$ $4.415 = 0 + E_K$ $E_K = 4.415 - 0$ $E_K = 4.415$ J

Exercise

Using formula of Conservation of Energy



$$E_T = E_p + E_k$$

$$E_T = m.g.h + \frac{1}{2}mv^2$$

$$v^2 = 2.g.h$$

Question 1

A cat with mass 2.5kg is trying to jump off a tree which is 3m high from the ground. Calculate the **potential energy** and **kinetic energy** based on the situation below:

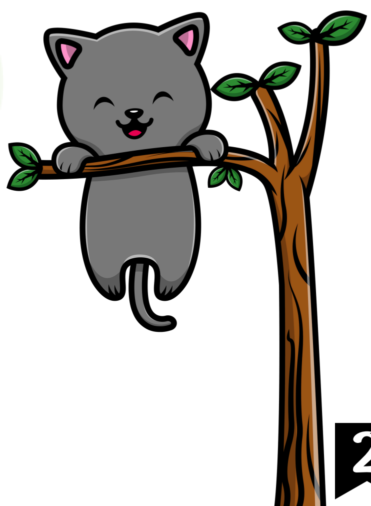
i. While the cat is still on the tree.

ii. When the cat falls 1m from the tree.

iii. When the cat touches the ground.

Answer:
i. Ep = 73.575J , Ek = 0J
ii. Ep = 49.05J, Ek = 24.525J
iii. Ep = 0J, Ek = 73.575J

Solve



Exercise

Using formula of Conservation of Energy

$$E_T = E_p + E_K$$

$$E_T = m.g.h + \frac{1}{2}mv^2$$

$$v^2 = 2.g.h$$

Question 2

A book with 4000 g mass was lifted on a book shell as high as 300 cm from the ground and accidently fall under the gravitational reaction. Calculate the gravitational **potential energ**y and the **kinetic energy** possessed by the object under these situations:

i. before it is falling.

ii. 2.4 meter under free fall

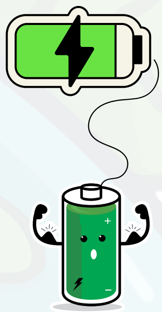
iii. right after it touched the ground.

Answer:
i. Ep = 117.72J , Ek = 0J
ii. Ep = 23.544J, Ek = 94.176J
iii. Ep = 0J, Ek = 117.72J

Solve

Exercise

Using formula of Conservation of Energy



$$E_T = E_p + E_k$$

$$E_T = m.g.h + \frac{1}{2} mv^2$$

$$v^2 = 2.g.h$$

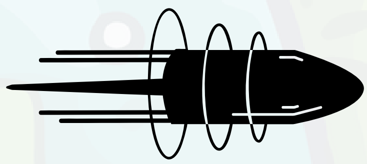
Question 3

A 200g bullet move through the air on 250m high with 150 m/s velocity. Calculate

i. **Potential energy**

ii. **Kinetic energy**

iii. **Total energy**

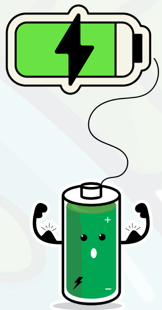


Answer:
i. Ep = 490.5 J
ii. Ek = 2250 J
III. ET = 2740.5 J

Solve

Exercise

Using formula of Conservation of Energy



$$E_T = E_p + E_k$$

$$E_T = m.g.h + \frac{1}{2}mv^2$$

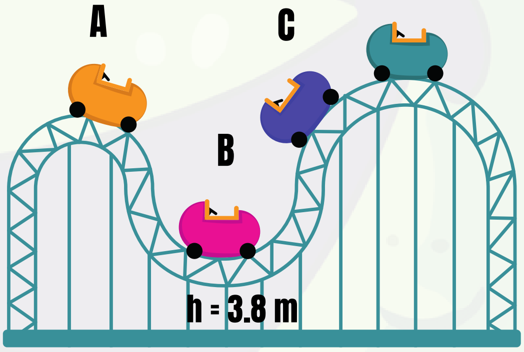
$$v^2 = 2.g.h$$

Question 4

Figure below shows a roller coaster with a mass of 25 kg gliding on a frictionless track which stop at the point R.

i. Find the **total energy** of the roller coaster when reaching the point C.

ii. Calculate the **speed** of the roller coaster at the point B by using **total energy**.

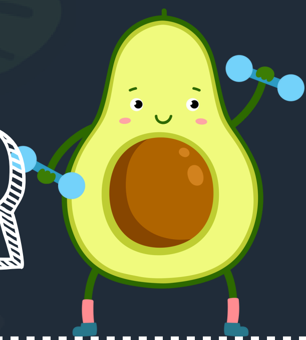


Interactive video, click below

Answer:
i. ET = 5755.5 J
ii. V = 19.644 m/s

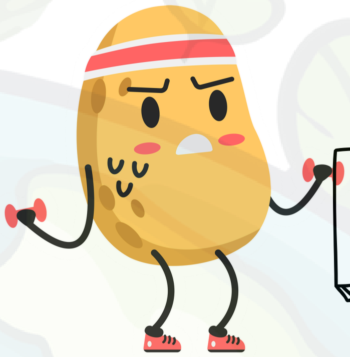
Solve

POWER

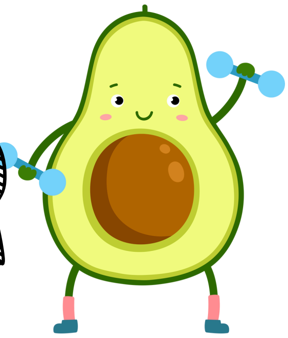


You will learn:

1. Define Power
2. Calculate Power by using formula given.
3. Exercise of Power.
4. Define Efficiency
5. Calculate the efficiency of mechanical system
6. Exercise



POWER



Define Power

as the rate of doing work.

S.I Unit

Joule/second (J/s) or Watt (W).

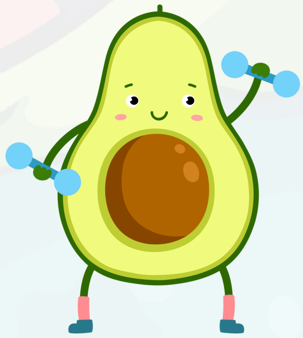
Formula

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

Work, J

Power, Watt

time, s



2. $$P = Fv$$

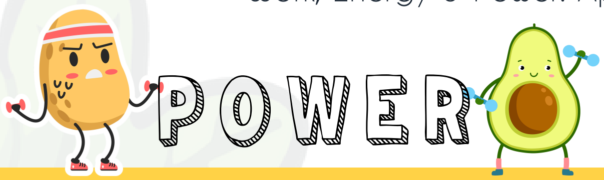
velocity, m/s

Power, Watt

Force, N

Interactive video, click below

CLICK



Using formula Power

① $P = \dfrac{W}{t}$ — P: Power, Watt; W: Work, J; t: time, s

② $P = Fv$ — P: Power, Watt; F: Force, N; v: velocity, m/s

Example

1. A 5kg box is lifted 0.5m into the air by Ali in 3s.

Solve

m = 5kg,
h = 0.5m
g = 9.81
t = 3s

Remember to use formula WORK before calculate the Power!

$W = (5)(9.81)(0.5)$
$W = 24.525J$

① $P = \dfrac{W}{t}$ — P: Power, Watt; W: Work, J; t: time, s → 3 s

$P = \dfrac{24.525}{3}$

P = 8.175W

Example

2. A horse pulls a cart of full coal with 50N with velocity 1.667m/s 10 minutes.

Solve

F = 50N
v = 1.667 m/s

② $P = Fv$ — P: Power, Watt; F: Force, N; v: velocity, m/s

P = 50 x 1.667

P = 83.35 W

Example

3. John pull a box with 50kg of mass along 30m with 30° in 3 minutes

Solve

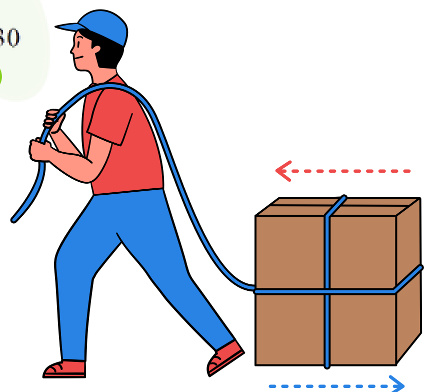
m= 50 kg x 9.81 = 490.5 N
(Use formula W=mg)
d = 30m
θ = 30°
t = 3 minutes x 60 = 180s

$W = (490.5)(30)\cos 30$
$W = 12743.564J$

① $P = \dfrac{W}{t}$ — P: Power, Watt; W: Work, J; t: time, s → 180 s

$P = \dfrac{12743.564}{180}$

P = 70.798 W



Exercise

Using formula of Power

① $P = \frac{W}{t}$

Power, Watt; Work, J; time, s

② $P = Fv$

Power, Watt; Force, N; velocity, m/s

Question 1

Calculate the power is done by Mark by holding a 15 N sack of potatoes while waiting in line about 0.75m at the grocery store for 3 minutes.

Solve

Answer: 0.063 W

Question 2

Mohamad lifted a bucket of 39000 g in 150 seconds out of a well. The bucket was lifted at a height of 20 m. Calculate power.

Solve

Answer: 51.012 W

Exercise

POWER

Using formula of Power

1. $P = \frac{W}{t}$ — P: Power, Watt; W: Work, J; t: time, s

2. $P = Fv$ — P: Power, Watt; F: Force, N; v: velocity, m/s

Question 3

A forklift lifts a 505 kg box at a velocity of 4m/s. Calculate the power.

Solve

Answer: 19816.2 W

Question 4

A boy on a bicycle drags a wagon full of newspapers at 0.80 m/s for 30 min using a force of 40 N. Calculate the power has the boy done.

Solve

Answer: 32 W

Exercise

POWER

Using formula of Power

1. $$P = \frac{W}{t}$$ P: Power, Watt; W: Work, J; t: time, s

2. $$P = Fv$$ P: Power, Watt; F: Force, N; v: velocity, m/s

Question 5

A new conveyor system utilizes a motor-powered mechanical is to exert an average power of 485.455 W to push a large crate that has a distance of 12 meters in 22 seconds. Determine the force required by the motor.

Solve

Answer: 890 N

Question 6

A set of pulleys lifts an 800 N crate 4 meters with the power output is 457.143 W in 7 seconds. Calculate the time was used.

Solve

Answer: 7 s

EFFICIENCY

Define Efficiency

is defined as the percentage of the input energy that is transformed into useful energy.

Unit

%

Formula

1. $$Efficiency = \frac{Power_{output}}{Power_{input}} \times 100\%$$

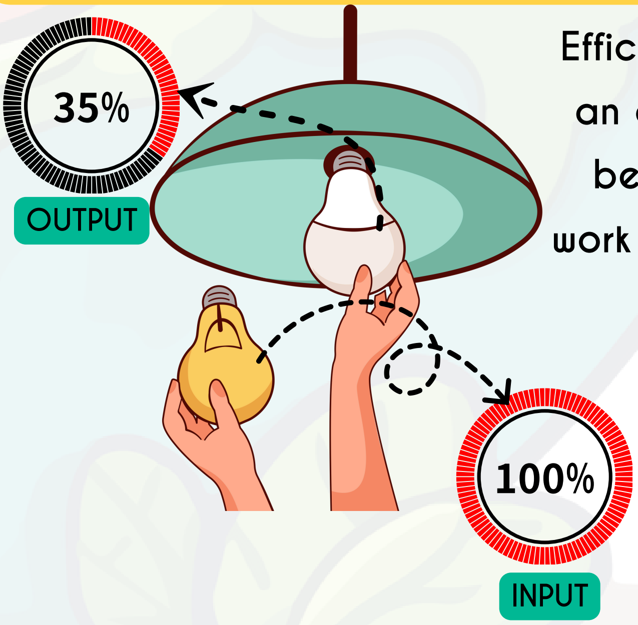
2. $$Efficiency = \frac{Energy_{output}}{Energy_{input}} \times 100\%$$

3. $$Efficiency = \frac{Work_{output}}{Work_{input}} \times 100\%$$

You need to know!

The input value has a GREATER value than the output value.

Example



Efficiency of an ideal machine is 100 % but an actual machine's efficiency will always be less than 100% because some of the work put into the system is transformed (lost) into thermal energy (heat).

Interactive video, click below

CLICK

EFFICIENCY

Formula

1. $$Efficiency = \frac{Power_{output}}{Power_{input}} \times 100\%$$

2. $$Efficiency = \frac{Energy_{output}}{Energy_{input}} \times 100\%$$

3. $$Efficiency = \frac{Work_{output}}{Work_{input}} \times 100\%$$

Example 1

An electric motor has an input power of 120 W. It lifts a 20 kg to a vertical height of 1.5 m in 5 s. Calculate the efficiency of the electric motor.

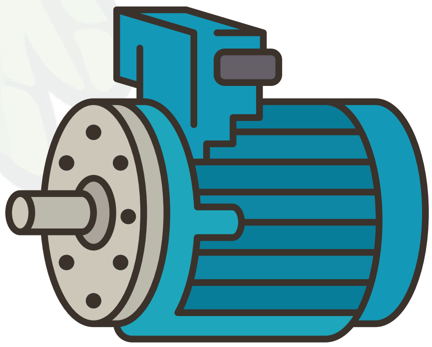
Solve

Keyword : Watt (W), use formula 1

$$Power_{output} = \frac{Work}{time} = \frac{mgh}{time}$$

$$Power_{output} = \frac{(20)\,(9.81)\,(1.5)}{5} = 58.86W$$

$$Efficiency = \frac{58.86}{120} \times 100\% = 49.05\%$$



Example 2

1200 J of electrical energy was supplied to the computer. 200 J of energy are wasted in the form of heat and sound. Calculate the efficiency of this computer.

Solve

Keyword : Joule (J), energy, use formula 2

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

Energy outout = 200 J
Energy input = Greater value = 1200 J

$$Efficiency = \frac{200}{1200} \times 100\% = 16.667\%$$

EFFICIENCY

Formula

1. $$Efficiency = \frac{Power_{output}}{Power_{input}} \times 100\%$$
2. $$Efficiency = \frac{Energy_{output}}{Energy_{input}} \times 100\%$$
3. $$Efficiency = \frac{Work_{output}}{Work_{input}} \times 100\%$$

Example 3

A television that is 83% efficient provides 4 600 J of useful energy. Calculate the energy does it consume.

Solve

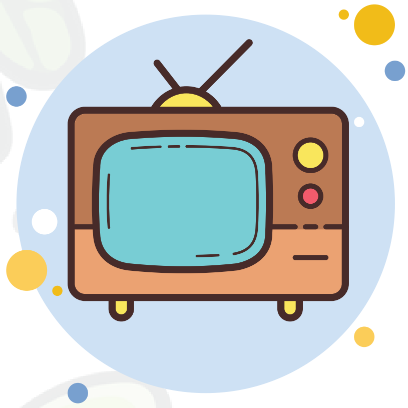
Keyword : Joule (J), energy, use formula 2

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

Energy output = useful energy = 4600 J
Energy input = ?

$$83 = \frac{4600}{Energy_{input}} \times 100\%$$

$$Energy_{input} = \frac{4600}{83} \times 100\% = 5542.169J$$



Example 4

A vehicle with a mass of 250kg is being lifted to a towing truck located 10m above the ground using a system of pulleys and a diesel motor. If efficiency of the pulleys is 85% and the power input is 2000W, calculate the time taken.

Solve

Keyword : Watt (W), use formula 1

$$85 = \frac{Power_{output}}{2000} \times 100\%$$

$$Power_{output} = \frac{85 \times 2000}{100} = 1700W$$

$$Power_{output} = \frac{Work}{time} = \frac{mgh}{time}$$

$$1700 = \frac{(250)(9.81)(10)}{time}$$

$$time = \frac{(250)(9.81)(10)}{1700} = 14.426s$$

Exercise

EFFICIENCY

Using formula of Efficiency

1. $Efficiency = \frac{Power_{output}}{Power_{input}} \times 100\%$
2. $Efficiency = \frac{Energy_{output}}{Energy_{input}} \times 100\%$
3. $Efficiency = \frac{Work_{output}}{Work_{input}} \times 100\%$

Question 1

If a machine takes in 50 kJ for 50 seconds, calculate the energy output if the efficiency of the machine is 80 %

Solve

Answer: 800 W

Question 2

An electric motor lifts an object of 250 kg to a height of 210 meter in 28 second. If the input power of the electric motor is 20000 W, calculate the efficiency of the electric motor.

Solve

Answer: 91.969%

Exercise

EFFICIENCY

Using formula of Efficiency

1. $$Efficiency = \frac{Power_{output}}{Power_{input}} \times 100\%$$
2. $$Efficiency = \frac{Energy_{output}}{Energy_{input}} \times 100\%$$
3. $$Efficiency = \frac{Work_{output}}{Work_{input}} \times 100\%$$

Question 3

The motor of an electric drill is supplied with an input power of 1600Watt. If its efficiency is 85% , calculate output power of electric drill.

Solve

Answer: 1360 W

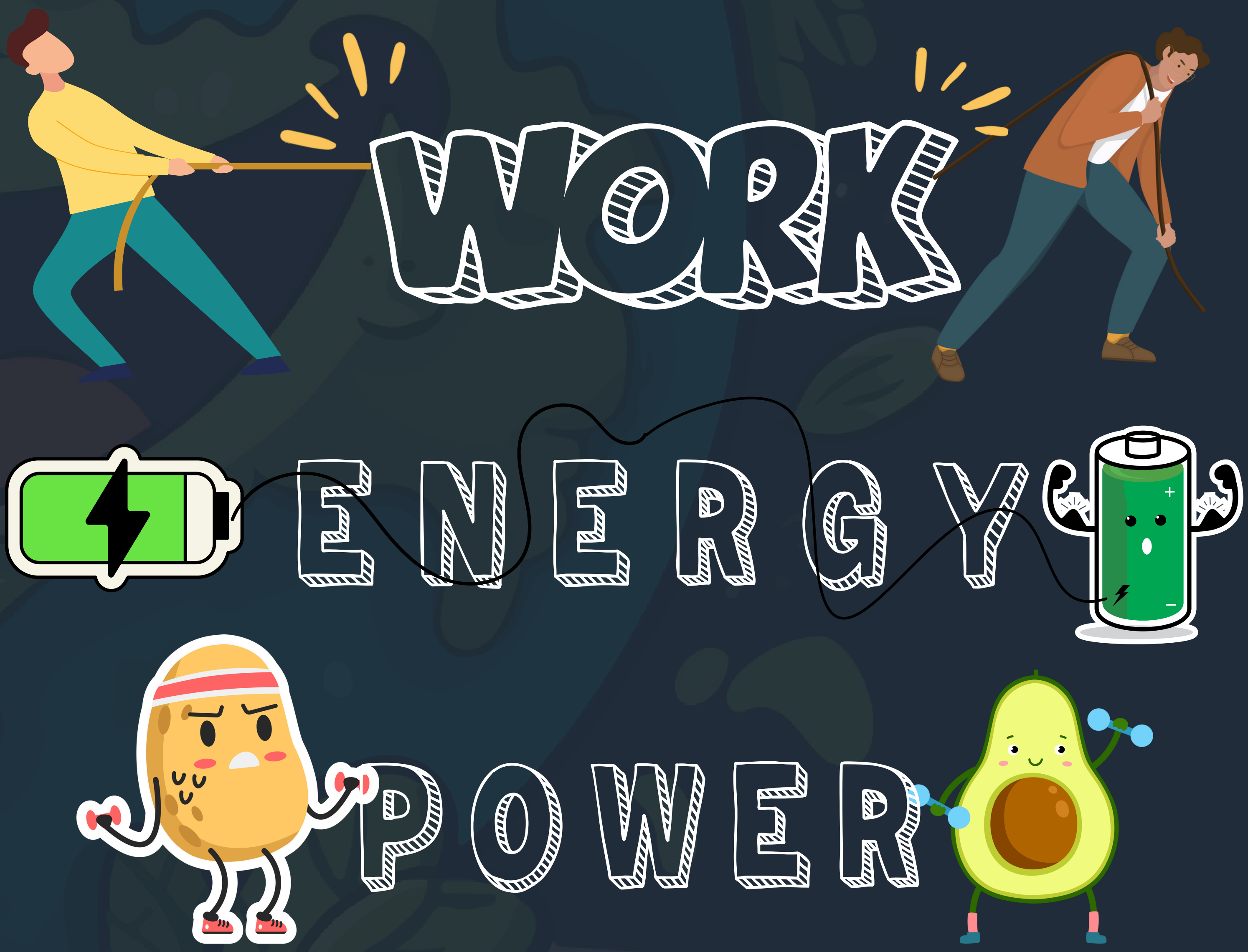
Question 4

An efficiency for the input power of a 1000W electric motor is 85%. Calculate the time taken by the motor to lift an object of mass 150kg at a height of 15m.

Solve

Answer: 25.968s

CARRY OUT AN ACTIVITY RELATED TO WORK, ENERGY AND POWER



SET 1

1. Define work and state the SI unit. [3 marks]

Solve

Answer: Refer Page 1

2. State THREE (3) types of renewable energy sources. [3 marks]

Solve

Answer: Refer Page 5

3. Determine kinetic energy, potential energy and total energy possessed by a ball of mass 5kg with a speed of 14m/s at 7m height from the ground. [6 marks]

Solve

Answer: Ek = 490J, Ep = 343.35 J, ET = 833.35 J

SET 1

4. Calculate work done by a 35kg object that is lifted to a height of 6m from the ground. [4 marks]

Solve

Answer: 2060.1 J

5. An efficiency for the input power of a 2200W electric motor is 55%. Calculate the time taken by the motor to lift an object of mass 80kg at a height of 10m. [9 marks]

Solve

Answer: 6.486s

SET 2

1. Define kinetic energy, potential energy, and state ONE (1) principle of energy conservation. [3 marks]

Solve

Answer: Refer Page 10,11,19

2. State the definition and ONE (1) resource of renewable energy and non-renewable energy [4 marks]

Solve

Answer: Refer Page 5,6

3. Amirul, weighing 80kg, runs upstairs of 30 steps. each of the steps is 0.15m height. Calculate the power generated by Amirul if he takes 22 seconds to reach the top of the stairs. [4 marks]

Solve

Answer: 160.527 W

SET 2

4. An apple falls a height of 13.5m to the ground. Calculate the velocity of the apple right before it hits the ground. ($g = 9.81 m/s^2$)
[6 marks]

Solve

Answer: 16.275m/s

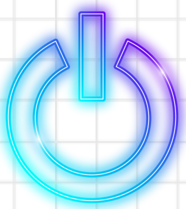
5. A crane's motor can lift a 4.905N weight through a height of 150cm in 10 seconds. If the batteries of the crane deliver a power of 0.8 W to the motor, calculate:

i. The work done by the crane [4 marks]
ii. The efficiency of the crane's motor [4 marks]

Solve

Answer: i. 7.358J, ii. 91.975%

WORK, ENERGY & POWER



"Immerse yourself in 'Work, Energy, and Power' with our interactive eBook designed for learners of all levels. Learn how to calculate work ($W = F \times d$), understand the conservation of energy principle, and apply formulas for kinetic and potential energy. Engage with practical examples such as power and efficiency, and reinforce your understanding through an exercises provided with answers."

By:
Nor Fadzlina binti Ainuddin
Department of Mathematics, Science & Computer
Politeknik Kuala Terengganu

WORK, ENERGY & POWER

e ISBN 978-967-2240-54-9

9 789672 240549

Online