To provide an idea about what this book contains, only few pages taken randomly from the book are shown here.

KEY•POINTS SERIES

ABOUT PHYSICS KEY•POINTS

This book covers the newly revised syllabus for GCE 'O' LEVEL PHYSICS. Aiming to provide students with an effective yet easy-to-follow guide, each chapter in this book consists of following learning skills:

ABOUT KEY SYMBOLS

i. To unlock the contents in the OVERVIEW OF THE TOPIC.

OR

ii. To search for next subject.

Learning Objectives

Learning objectives based on the latest syllabus are given in this part. Students should make sure they are able to meet all the expectations before taking the examinations.

Useful Websites

Some useful websites are listed for students' reference and further research. The Java Applets and animations in some websites can be helpful in understanding concepts.

Overview Of The Topic

Overview of the topic gives students a full picture of the topic. The table shows the structure and all the key areas of the chapter.

Key Points

This part is featured by concise study notes. All key concepts and formulae are presented to help students consolidate their knowledge learnt in class.

ExamTips

ExamTips summarizes all of students' common mistakes, weaknesses and misconceptions shown in the past examinations. Some important reminders are also listed here.

Stop & Think

These are useful exam-type MCQs provided after each sub-topic to help students identify and enhance the learning of key concepts.

Challenging Questions With Solutions & Explanations

Exam-type structured questions provided at the end of each chapter enable students to apply what they have learnt.

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CONTENTS

TOPIC 7 ENERGY, WORK AND POWER

LEARNING OBJECTIVES

Candidates should be able to:

🕮	Show understanding that kinetic energy, elastic potential energy, gravitational potential energy and chemical potential energy are examples of different forms of energy
🕮	State the principle of the conservation of energy
🕮	Apply the principle of the conservation of energy to new situations or to solve related problems
🕮	State that kinetic energy $E_k = ½\, mv^2$ and gravitational potential energy $E_p = mgh$ (for potential energy changes near the Earth's surface)
🕮	Apply the relationships for kinetic energy and potential energy to new situations or to solve related problems
🕮	Recall and apply the relationship *work done* = *force* × *distance moved in the direction of the force* to new situations or to solve related problems
🕮	Recall and apply the relationship *power* = *work done* / *time taken* to new situations or to solve related problems

USEFUL WEBSITES

- ☐ http://www.glenbrook.k12.il.us/gbssci/phys/Class/energy/u5l1a.html
  (Definition and Mathematics of work)
- ☐ http://www.glenbrook.k12.il.us/gbssci/phys/Class/energy/u5l1aa.html
  (Calculating the amount of work done by a force)
- ☐ http://www.glenbrook.k12.il.us/gbssci/phys/Class/energy/u5l1b.html#elastic
  (Potential energy)
- ☐ http://www.glenbrook.k12.il.us/gbssci/phys/Class/energy/u5l1c.html
  (Kinetic energy)
- ☐ http://www.glenbrook.k12.il.us/gbssci/phys/Class/energy/u5l1d.html
  (Mechanical energy)
- ☐ http://www.glenbrook.k12.il.us/gbssci/phys/Class/energy/u5l1e.html
  (Power)
- ☐ http://www.glenbrook.k12.il.us/gbssci/phys/Class/energy/u5l2a.html
  (Work - energy Theorem)
- ☐ http://www.bbc.co.uk/schools/ks3bitesize/science/physics/energy_transfer_intro.shtml
  (Revision notes and quizzes on energy resources and energy transfer)

OVERVIEW OF THE TOPIC

ENERGY, WORK AND POWER *3 key areas*	ENERGY	• Different forms of energy
		• Kinetic Energy
		• Gravitational Potential Energy
		• Conservation of energy
	WORK	
	POWER	

ENERGY

Different Forms of Energy

☑ | Definition | Energy is the ***capacity to do work***. |

☑ ENERGY HAS THE ABILITY TO CHANGE FROM ONE FORM TO ANOTHER.

☑ It has no direction so it is a scalar.

☑ **SI unit of energy:** joule (J)

☑ Everything around us has energy which exists in different forms.

☑ *Forms of energy:*

	Forms of energy	Some common examples
①	Chemical energy	Fuels (oil, coal, petrol), electric cells, food, explosives.
②	Electrical energy	The energy associated with the current in an electric drill, electric motors, an immersion heater and electrical appliances.
③	Mechanical energy ❶ Kinetic energy (K.E.) ❷ Potential energy (P.E.) (i) Gravitational potential energy (ii) Elastic potential energy	 All objects in motion have kinetic energy, e.g. a moving car, a flying aeroplane. (i) a waterfall, raised objects (ii) compressed or stretched springs or rubber bands
④	Nuclear energy	The energy released from nuclear reactions like fission and fusion.

STOP & THINK

[Q] Which example best illustrates the conversion of electrical energy to chemical energy?

A melting a fuse

B charging an accumulator

C starting a car

D generating hydro-electric power

[Ans] **B** Charging an accumulator is to convert the electrical energy from the power source to the chemical energy stored inside the accumulator.

ExamTip

Accumulator is a kind of battery.

Kinetic Energy

☑ All moving objects have ENERGY OF MOTION called kinetic energy.

☑ Kinetic energy is the energy about movement. When an object is AT REST, it has NO kinetic energy.

☑

Take note	Kinetic energy depends on an object's MASS and SPEED.

e.g. **A running elephant has more kinetic energy than a running man because it has more mass. A racing car has more kinetic energy than a family car because it has a higher speed.**

☑ To measure kinetic energy, apply the following equation:

Equation	K.E. $= \frac{1}{2}mv^2$	where K.E.: kinetic energy (in J) m: mass (in kg) v: speed (in $m\,s^{-1}$)

Gravitational Potential Energy

☑ The ENERGY OF POSITION is called potential energy.

☑ When an object is lifted to a higher position, it gains gravitational potential energy.

☑ This is stored energy which can be converted to kinetic energy when the object falls down.

e.g. **Water stored behind a dam. A pole-vaulter at his maximum height.**

☑

Take note	Potential energy depends on an object's MASS and HEIGHT.

☑ To measure potential energy, apply the following equation:

Equation	P.E. $=$ mgh	where P.E.: potential energy (in J) m: mass (in kg) g: gravitational field strength (in $N\,kg^{-1}$) h: height (in m)

ExamTip

Potential energy is the energy about position. When we calculate potential energy, there must be a reference level. It is very often that we use the ground level for P.E. = 0.

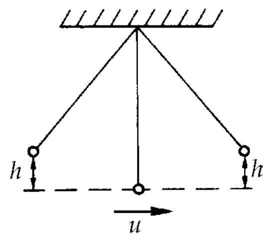
STOP & THINK

[Q] A pendulum bob of mass m, attached to a light string, is released from rest at a height *h* above its lowest point. The speed of the bob at its lowest point is *u*.

What will be the kinetic energy of the bob when it reaches a height *h* on the other side?

A zero   C $\frac{1}{2}mu^2$

B mgh   D mu^2



[continued]

[Ans] **A** At the highest point, the bob is momentarily at rest and so the kinetic energy is zero.

ExamTip

Kinetic energy is the energy of motion. There is no kinetic energy if the object is at rest. It is potential energy at h.

CONSERVATION OF ENERGY

☑ ***When energy changes from one form to another, the total amount of energy always stays the same.***

☑ We say it is conserved. This fact is known as the Principle of Conservation of Energy.

☑

Principle of Conservation of Energy	**Energy can be changed from one form to another, but it can neither be created nor destroyed.**

An example:

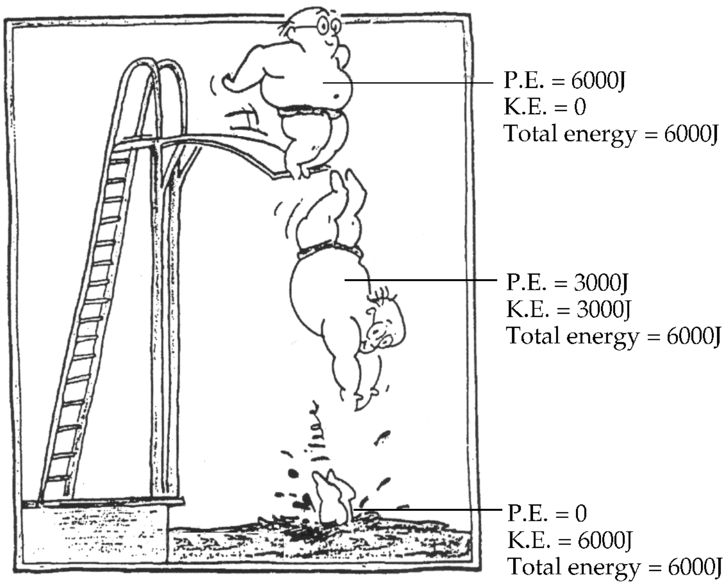
We assume that a diver has 6000 J of gravitational potential energy before the dive. There is no kinetic energy yet. Total energy is 6000 J.

As the diver takes off, there is only one direction, i.e. downwards, so he loses potential energy and gains kinetic energy.

At midway, if potential energy is assumed to drop to 3000 J, kinetic energy must be increased to 3000 J. The total amount of energy is still 6000 J.

At ground level (water surface), potential energy becomes 0 J. Kinetic energy is 6000 J.

The form of energy has changed, but there is no change in the total amount of energy throughout his action.



STOP & THINK

[Q] A car accelerates up a hill. What happens to its kinetic energy and to its potential energy?

	kinetic energy	potential energy
A	decreases	increases
B	increases	decreases
C	increases	increases
D	unchanged	decreases

[Ans] **C** The speed of the car increases and so the kinetic energy is increasing. Accelerating up a hill implies an increase in vertical height and so the potential energy increases.

ExamTip

In some questions, the potential energy increases when kinetic energy decreases so that the total energy is conserved. However it does not apply to this question as the car engine continues to supply energy to the car.

WORK

☑ If you exert a FORCE on an object and make it MOVE in the SAME DIRECTION as the applied force, we say WORK IS DONE on the object. ***(Energy is converted during the process.)***

Definition	The amount of work done by a constant force is the ***product of the force and the distance moved in the direction of the force***.

Equation	$W = F \times s$	where W: work done by a constant force (in J) F: force (in N) s: distance moved in the direction of the force (in m)

☑ **SI unit of work done:** newton metre (N m) or joule (J)

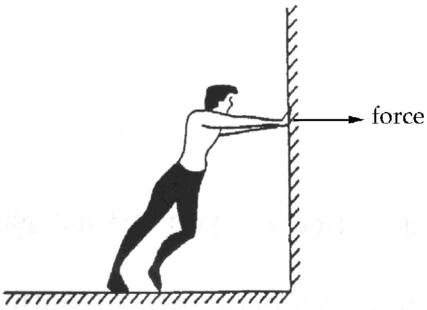
☑ $1\ J = 1\ N\,m$

ExamTip

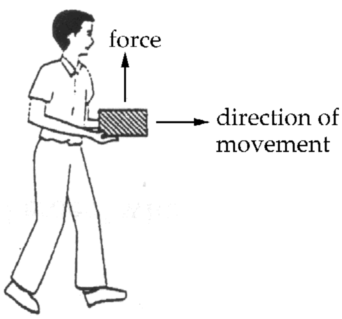
No work is done when:

(a) The force is applied on the object but the object does not move.

(b) The direction of the applied force and the direction in which the object moves are perpendicular to one another.



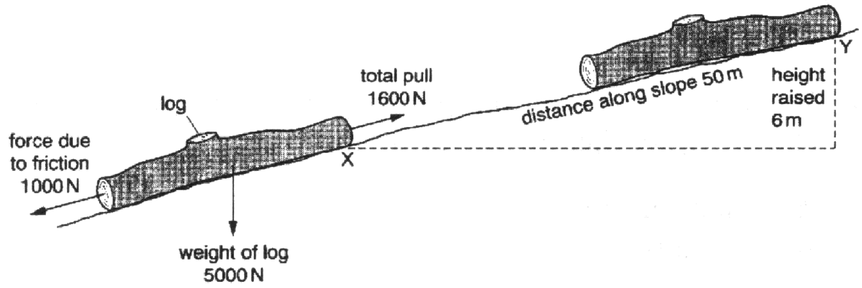
No work done because wall remains at rest



No work done because force is perpendicular to direction of movement

STOP & THINK

[Q] The diagram shows a log being pulled up an earth slope from X to Y. How much work is done against friction?



A 6000 J **B** 9600 J **C** 50000 J **D** 80000 J

[Ans] **C** Work done against friction $= \text{friction} \times \text{distance moved}$
$= 1000 \times 50$
$= 50000\ \text{J}$

ExamTip

Work done against friction is the energy used to overcome friction. It is equal to the work done by the friction.

POWER

☑ If two cars of the same weight climb up the same hill, they have same amount of WORK DONE. But if car A climbs the hill in a shorter TIME than car B, we say it has a greater POWER.

☑

Definition	Power is the ***rate of work done (or rate of converting energy)***.

☑ Hence, $\text{power} = \dfrac{\text{work done}}{\text{time taken}} = \dfrac{\text{energy converted}}{\text{time taken}}$

☑

Equation	$P = \dfrac{W}{t} = \dfrac{E}{t}$	where P: power W: work done (in J) E: energy converted (in J) t: time taken (in s)

☑ **SI unit of power:** joule per second ($J s^{-1}$) or watt (W)

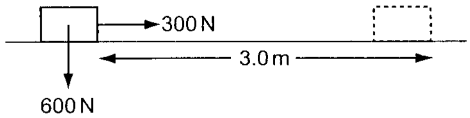
☑ $1\ W = 1\ J s^{-1}$

ExamTip

Power is not energy. Many candidates misuse the term 'Power' when they describe changes in energy. Power is not a thing that can be transferred like energy. It is merely a rate.

STOP & THINK

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



What is the average power?

A 45 W

B 90 W

C 900 W

D 1800 W

[Ans] **A** $P = \frac{\text{work done}}{\text{time}}$

$= \frac{300 \times 3}{20}$

$= 45\ W$

ExamTip

Work done is the force × distance moved in the direction of force. 600 N is the weight of the box which is a vertical force. It is not included in the calculation of work done by the 300 N force.

STOP & THINK

[Q] A windmill is used to raise water from a well. The depth of the well is 5 m. The windmill raises 200 kg of water every day. What is the useful power extracted from the wind? (g = 10 N/kg)

A $\frac{200 \times 10 \times 4}{5}$ W

B $\frac{200 \times 10 \times 5}{24 \times 60 \times 60}$ W

C $\frac{200 \times 10}{5 \times 24}$ W

D $\frac{200 \times 5}{24 \times 60}$ W

[Ans] **B** Power $P = \frac{E}{t}$

$P = \frac{F \times s}{t}$

$= \frac{200 \times 10 \times 5}{24 \times 60 \times 60}$

ExamTip

Candidates need to convert 1 day to 24 × 60 × 60 seconds. The force is the weight of the water 200 × 10 N.