TECHNICAL SCIENCE

WORK ENERGY AND POWER

GRADE 12

basic education
Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

Read to Lead
A Reading Nation is a Leading Nation

2030 NDP

Foreword

In order to improve learning outcomes the Department of Basic Education conducted research to determine the specific areas that learners struggle with in Grade 12 examinations. The research included a trend analysis by subject experts of learner performance over a period of five years as well as learner examination scripts in order to diagnose deficiencies or misconceptions in particular content areas. In addition, expert teachers were interviewed to determine the best practicesto ensure mastery of thetopic by learners and improve outcomes in terms of quality and quantity.

The results of the research formed the foundation and guiding principles for the development of the booklets. In each identified subject, key content areas were identified for the development of material that will significantly improve learner's conceptual understanding whilst leading to improved performance in the subject.

The booklets are developed as part of a series of booklets, with each bookletfocussing onlyon one specific challenging topic. The selected content is explained in detail and include relevant concepts from Grades 10 - 12 to ensure conceptual understanding.

The main purpose of these booklets is to assist learners to master the content starting from a basic conceptual level of understanding to the more advanced level. The content in each booklets is presented in an easy to understand manner including the use of mind maps, summaries and exercises to support understanding and conceptual progression. These booklets should ideally be used as part of a focussed revision or enrichment program by learners after the topics have been taught in class. The booklets encourage learners to take ownership of their own learning and focus on developing and mastery critical content and skills such as reading and higher order thinking skills.

Teachers are also encouraged to infuse the content into existing lesson preparation to ensure in-depth curriculum coverage of a particular topic. Due to the nature of the booklets covering only one topic, teachers are encouraged to ensure learners access to the booklets in either print or digital form if a particular topic is taught.

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2. How to use this study guide

- This book in intended to assist and guide you through the topics. It is complimentary to your textbooks, worksheets and other learning materials. Your efforts to practice and master the concepts outlined will assist you to be confident in the learning and assessments that you will do.
- Ensure you understand all the relevant concepts, formulae, etc.
- Do extra research on your own to obtain more information on the topics in this booklet. It is important that you share and discuss your understanding of your findings with fellow learners.
- Work through the examples given in each topic, master them and try to provide more examples yourself. You must go through the examples in your textbooks. At the end of Unit 5, there are exercises for you to do. Work through them on your own and compare them with the answers in Unit 6.
- When doing calculations, take note of all the information given: it is intended to help you. Read the given information with the intention of understanding what you must do with it. Always look for action verbs in order to answer correctly, e.g. determine, explain, discuss, calculate, list, compare, etc.
- If you are given measurements in millimetres (mm), convert them into meters.
- Familiarise yourself with the scientific notations used, e.g. kilo, mega, giga and write them as 10x.
- It is important to show SI units in the final answer. This will earn you a mark.
- An extract from the examination guidelines is included at the beginning of each topic. You must use this to check what you are expected to master. Revise what you have not mastered and do more exercises.

3. Study and Examination Tips

Format of question papers

PAPER	QUESTION TYPE	DURATION	TOTAL
1	• 10 multiple choice questions – 20 marks • Structured questions – 130 marks	3 hours	150
2	• 10 multiple choice questions – 20 marks • Structured questions – 130 marks	3 hours	150

Format of question papers

P1 Content			P2 Content		
Content	**Marks**	**%**	**Content**	**Marks**	**%**
Mechanics	108	72	**Organic molecules**	54	36
Electricity and Magnetism	42	28	**Electrochemistry**	42	28
			Light	54	36

Laws, definitions and principles

Study and understand the laws, definitions, concepts and principles stated in the examination guidelines. Careful attention must be paid to keywords.

Using formulae

- Always use formulae from the formula sheet.
- Common mistakes occur when changing the subject of the formula, therefore it is recommended that you substitute into the given formula and isolate the unknown.

- Familiarise yourself with the formula sheet.
- Round off your final answer to a minimum of two decimal places and include the correct unit.

Some tips to approaching the examinations

How to answer multiple-choice questions

Multiple choice questions (MCQ) ask a learner to recognize a correct answer from among a set of options that include 3-4 wrong answers (called distracters).

The level of difficulty will vary in MCQ. Sometimes resorting to guessing may lead to an incorrect answer being given.

There are strategies that can be used to maximize your success in answering MCQs. The best way to improve your chance of success is to study carefully before the exam and make sure you understand your work, instead of just memorizing it.

An MCQ consists of a phrase or stem, followed by 3-4 options from which to select the correct answer. Here are a few tips to help reduce the chance of making a mistake or getting confused by distracters that look very similar to the correct answer.

Step 1

- Cover the possible options given with a piece of paper or your hand while you read the stem or body of the question.
- Read carefully and make sure you understand what you are required to do. Many a time, rushing through the question results in misinterpretation of questions.

Step 2

- Try to anticipate the correct answer before looking at the given options.

Step 3

- Uncover and read the responses, if you see the response you anticipated or one that closely matches your anticipation circle/ mark it and then check the others to make sure none provides a better response. It is important to read all given responses.
- If your anticipated response is not amongst those given or if you are not able to anticipate an answer, read the given options and eliminate those you know are wrong.
- By eliminating wrong options, you will be left with fewer options from which to select your answer. This makes it easier to look for the correct option.

Step 4

- Look at the remaining options, compare them for differences and then refer to the stem of the question to find the correct answer.

If you cannot answer a question within a minute or less, skip it and plan to come back to it later.

EASY MARKS

TOPIC	EASY TO SCORE	COMMENTS
Work, energy and power	• Defining work • Defining energy • Defining power	• Use the definitions as they appear in the examination guidelines. Careful attention must be paid to the keywords.
	• Draw a free body diagram	• Distinguish between a free body and force diagrams. • The number of marks is a guide to the number of forces required in the diagram, e.g. for 4 marks, 4 labelled forces should be drawn. Extra forces, leaving out the arrow heads and if the arrows do not touch the dot (object) result in lost marks due to negative marking. • Make sure that you are in a position to identify forces that do positive or negative work and forces that do no work on the object.
	• Using the appropriate formula work, potential, kinetic mechanical energy	• Copy the formula as it is written in the datasheet, without attempting to manipulate it. • Ensure that all values are in SI units, i.e. carry out the necessary conversion • Show all substitutions. • Include the correct unit for the answer.

4. Overview of Work Energy Power

WORK, ENERGY AND POWER

WORK

Work (W) is the product force (F) acting on an object and the displacement (Δx) in the direction of the force. Work is a scalar.

SI unit: joule (J) 1 J = 1 N m

Formulae: $W = F\Delta x\cos\theta$

When does a force do work on an object?

- A force must be in a direction, which is parallel to the direction of displacement.

Work is NOT done on an object by a force, when:

- No force is applied.
- The object is not displaced.
- The force and the displacement are perpendicular to each other.

ENERGY

Energy (E) is the ability to do work (W).

Potential energy (E_P) is the energy of an object due to its position in a gravitational field.

Kinetic energy (E_K) is the energy of an object due to its motion.

The mechanical energy (M_E) of an object is the sum of its potential and kinetic energy.

Energy is a scalar quantity.

$E_P = m.g.h$ $E_K = \frac{1}{2}mv^2$ $M_E = E_K + E_P$

SI unit: Joule **(J)**

The law of conservation of mechanical energy states that total mechanical energy of a =n isolated system is conserved (remains constant).

Thus, between any two points (A and B) in an isolated system, mechanical energy is equal.

$M_{E(A)} = M_{E(B)}$ $(E_K + E_P)_A = (E_K + E_P)_B$

POWER

Power (P) is the rate at which work is done.

Power is a scalar quanity.

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

$P = Fv$ (where v is constant)

SI Unit: Watt ***(W)***

$1\ W = 1\ J.s^{-1}$

A Watt of power is when a joule of work is done per second.

OR

When a joule of energy is transferred per second.

Practical units in technology

1 ***kW*** = 1000 ***W***

1 ***hp*** = 746 ***W***

5. Work Energy Power

5.1 Summary: Work, Energy And Power

The following is a summary of the concepts that need to be covered as per the examination guidelines:

Work

- Define the work done as the product of the applied on an object and the displacement in the direction of the force.
- Work is a scalar quantity (as it is the product of two vector quantities).
- Use the equation $W = F\Delta x\cos\theta$ to solve problems involving force, work done and displacement (where a force (F) and the displacement, Δx, are at an angle, θ, to each other).
- Explain that no work is done when a force acts at right angles to the direction of motion.
- Draw a force diagram and free body diagram.
- Calculate the net work done on an object using the equation $W_{net} = F_{net}\Delta x\cos\theta$.
- Define energy as the ability to do work.
- Emphasise that both work and energy are scalar quantities that have a SI unit, joule (J).

Conservation of energy

- State the principle of conservation of mechanical energy: The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. A system is isolated when the net external force (excluding the gravitational force) acting on the system is zero.
- Solve conservation of energy problems using the equation: $M_E = E_k + E_p$ (where: ME is mechanical energy; Ek is kinetic energy; Ep is potential energy).
- Use the above equation to solve problems involving kinetic energy, potential energy and velocity in one dimension only.

Power

- Define power as the rate at which work is done or energy is expended.

In symbols: $P = \frac{W}{\Delta t}$, where: P is power, W is work done and Δt is change in time or time taken. Also, $P = \frac{E}{\Delta t}$, where E is energy.

- Power has the SI unit, watt (W).
- Calculate the power involved when work is done.
- Practical units of power in technology:
  - o kW = 1000 W.
  - o horsepower (hp) = 746 W.
- Solve problems involving work, power and time, with the emphasis on conversion of the practical units.
- Perform calculations using P = Fv when an object moves at a constant speed.
- Calculate the power output for a pump that lifts a mass (e.g. lifting water through a height at constant speed).
- Solve problems involving power, force and velocity, with the emphasis on conversion of the practical units.

5.2 Summary of concepts on work

Important concepts from grade 10 and 11:
Vectors and scalars
A vector is a physical quantity with both magnitude and direction.
A scalar is a physical quantity with magnitude only.
The table below shows some of the quantities we already know and their classification.

Vectors	Scalars
♦ Displacement ♦ Velocity ♦ Acceleration ♦ Force	♦ Distance ♦ Time ♦ Speed

Terminology

Rate is the change in a physical quantity in time.

Displacement is the change of position of an object in a straight line.

Work is defined as the product of the force acting on an object and the displacement in the direction of the force.
Force ***(F)*** and displacement ***(Δx)*** are both vector quantities; thus, work is a scalar quantity.

For work done:

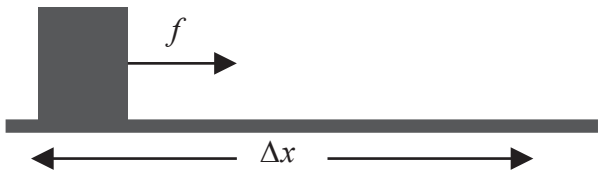
$$W = F\Delta x\cos\theta$$

SI units of measurement
Work is measured in joules.
Force (F) is measured in Newtons (N).
Displacement (Δx) is measured in metres (m).

$$1\ J = 1\ N{\cdot}m$$

A joule of work is done when a force of 1N acts on an object and causes displacement of 1m in the direction of the force.

Determining the amount of work done in different scenarios.
When is work done on an object?
• The force doing work on the object and the displacement can be in the same direction: $\theta = 0^o$. This is positive work.

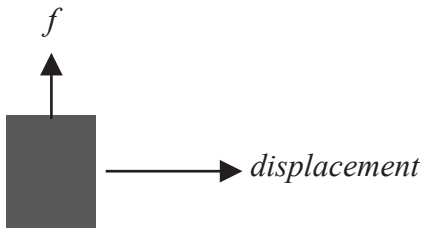


Force ***(F)*** and the displacement ***(Δx)*** of the object have the same direction

• The force doing the work and the displacement are in opposite directions, ***θ = 180°.*** Then the force (F) is doing negative work.

Force ***(F)*** and the displacement ***(Δx)*** of the object are in opposite directions.

• If the force is perpendicular to direction of the displacement, NO work is done on the object by the force: ***θ = 90°***.



Force ***(F)*** and the displacement ***(Δx)*** of the object are perpendicular.

• Work is also done when energy is transferred from one form to another.

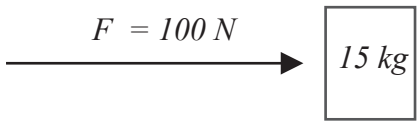
The main steps involved in problem-solving are:
• Identify the force(s) acting on the object.
• Draw a free body or force diagram and identify the force(s) that do positive and negative work.
• Copy the formula ($W = F\Delta x\cos\theta$) from the data sheet.
• The angle θ is between the force and displacement of the object.
• Ensure that all quantities substituted in the formula are in SI units, otherwise carry out the necessary conversions.

Example
In each of the following cases, identify if work is done? Justify in each case.
1.1 A worker at a construction site is lifting a concrete beam off the ground.
1.2 A mechanic is walking across the workshop holding a toolbox.
1.3 A boy is supporting a huge column to prevent it from falling.
1.4 Paramedics are lifting an injured player onto a stretcher.
1.5 Themba pushes a crate by applying a constant force of 400N towards a wall that is 1,8m away.

Solutions
1.1 Work is done on the beam: an applied force acts on the beam and displaces it upwards.
1.2 No work is done on the toolbox: the applied force and the displacement of the toolbox are perpendicular.
1.3 No work is done: there is zero displacement of the column.
1.4 Work is done: an applied force acts on the stretcher and displaces it upwards.
1.5 Work is done: an applied force acts on the crate and displaces it horizontally.

Example
Work done by a force in the direction parallel to that of displacement of the object.

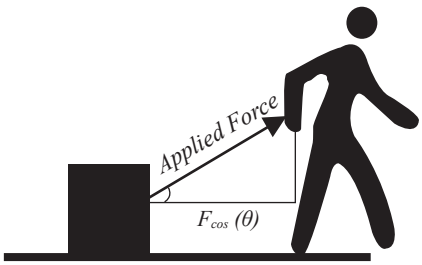
A constant force F of magnitude 100 N acts on a block of mass 15kg that is resting on a surface. A constant frictional force of 20 N acts on the block and the block moves a distance of 80cm.



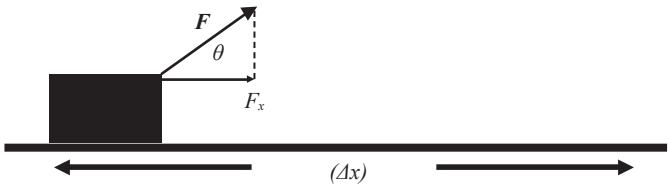
Calculate:
a. The work done on the block by force F.
Solution
W = FΔxcos θ
W = 100(0,8)cos0°
W = 80 J (Force F does work in the direction of displacement)

b. The work done on the block by frictional force.
Solution
W = fΔxcos θ
W = 20(0,8)cos180°
W = - 16 J (Frictional force does work in the opposite direction of displacement.)
Work done on an object by a force acting at an angle to the horizontal

Consider a crate being pulled along a smooth horizontal surface by an applied force.



The displacement of the object is horizontal; hence the horizontal component of the applied force is actually doing work on the crate.



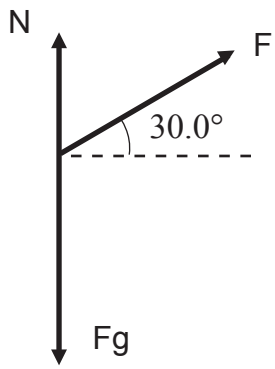
From trigonometrical ratios:
Fx = FAcosθ
Fy = FAsinθ

Note that in the above case, the horizontal component is actually doing work, thus work done on the object:
W = FxΔxcos θ

Example
A man cleaning a frictionless floor pulls a vacuum cleaner with a force F of magnitude 50 N at an angle of 30° with the horizontal.

a. Draw a labelled free body diagram showing all the forces that act on the vacuum cleaner.

Solution



b. What is the magnitude of the work done by the weight of the vacuum cleaner? Explain briefly.

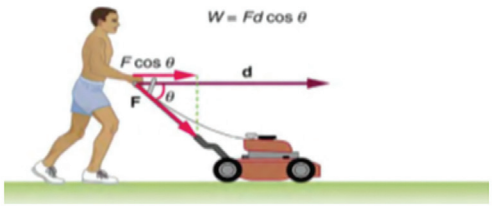
Solution
0 J – the weight is acting perpendicular to the displacement of the vacuum cleaner; therefore, no work is done.

c. Calculate the work done by the force F on the vacuum cleaner as the vacuum cleaner is displaced 3 m to the right.

Solution
$W = F\Delta x\cos\theta$
$W = (50)(3{,}0)\cos 300$
$W = 129{,}9$ J

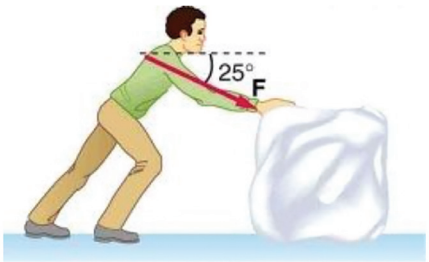
Test your knowledge

Question 1
In the diagram below, how much work is done on the lawnmower by the person if: he exerts a constant force of 75 N at an angle 35º below the horizontal; and pushes the mower 25m on level ground?



A. 1,875 ×100 J
B. 1,875 ×101 J
C. 1,54 ×102 J
D. 1,54 ×103 J (2)

Question 2
A worker pushes a wooden block by applying a force ***F,*** which acts at an angle of 25° to the horizontal.



Which one of the following about the magnitude and direction of **the horizontal component** of force **F** is **CORRECT?**

A. Fsin25° to the right.
B. Fsin25° to the left.
C. Fcos25° to the right.
D. Fcos25° to the left. (2)

Question 3
Which one of the following is equivalent to **horsepower**?

A. 1 kW
B. 1 $J.s^{-1}$
C. 1 N.m
D. 746 $J.s^{-1}$ (2)

Question 4

Which one of the following is equivalent to the SI unit of energy?

A. A mass of 1 kg falls for 1m.

B. A force of 1 N moves an object 1m in its direction.

C. A joule of work is done per second.

D. An applied force of 1 N acts on a stationary object (2)

Question 5

A constant horizontal force F displaces a box by Δx over a rough horizontal surface. Study the

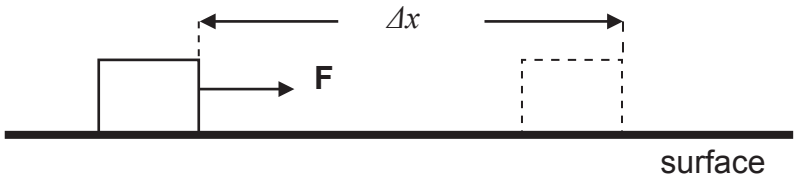


diagram below.

The normal force acting on the box does NO work on the box during the motion, because it is …

A. perpendicular to the displacement of the box.

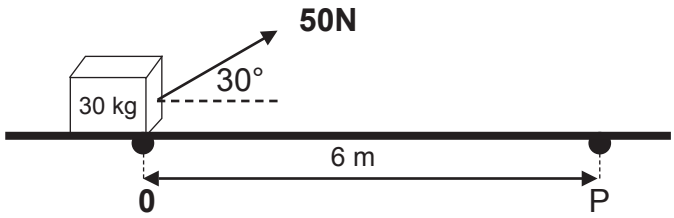
B. perpendicular to the applied force.

C. equal and opposite to the weight of the box.

D. equal to the applied force. (2)

Question 6

A worker pulls a crate with a mass of 30kg from rest along a horizontal floor, by applying a constant force of magnitude 50 N at an angle of 30° to the horizontal. A frictional force of



magnitude 20 N acts on the crate whilst it is moving along the floor.

6.1 Define the term work. (2)

6.2 Draw a labelled force diagram that shows all the forces that act on the block. (4)

6.3 Calculate the:

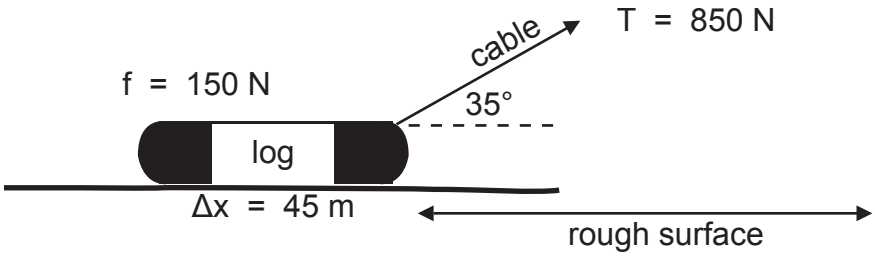
6.3.1 magnitude of the horizontal component of the applied force. (3)

6.3.2 work done by the horizontal component of the applied force. (3)

6.3.3 work done due to the frictional force acting on the box. (3)

Question 7

In the diagram below, an inextensible cable of negligible mass is used to drag a log on a rough horizontal surface. The tension in the cable is **850 N** and it acts at an angle of 35° to the horizontal. The log is dragged over a distance of **45m.** The frictional force experienced by the



log is **150 N.**

7.1 Define the term work. (2)

7.2 Calculate the net work done on the log. (5)

5.3 ENERGY

5.3.1 Mechanical Energy

Definitions

Energy is the capacity to do work.

In order for work to be done, energy must be transferred from one form to another.

Energy is a scalar quantity.

SI unit: joule (J)

Terminology

A system is isolated when the net external force (excluding the gravitational force) acting on the system is zero.

When work is done on a system, energy is transferred to the system. The two types of energy that we focus on are: gravitational potential energy and kinetic energy.

Potential energy is the energy of an object due to its position in a gravitational field.

$$E_p = mgh$$

Relationship between an object's potential energy and height.

$$E_P \alpha h$$

Kinetic energy is the energy of an object due to its motion.

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

The faster the object moves, the greater its kinetic energy.

Relationship between object's mass, kinetic energy and velocity:

$$E_K \alpha v^2$$

The mechanical energy of an object is the sum of its potential and kinetic energy.

Thus $M_E = mgh + \frac{1}{2} mv^2$

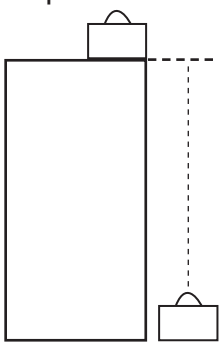
5.3.2 Conservation of mechanical energy

The principle of conservation of mechanical energy states:

Total mechanical energy (the sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. Energy is a scalar quantity and it is measured in joules **(J)**.

Remember that a system is isolated when the resultant/ net external force acting on the system is zero.

Let's say that a suitcase falls off a cupboard. Consider the mechanical energy of the suitcase at the top and at the bottom. We can say:



The total mechanical energy ($E_{M1} = E_{K1} + E_{P1}$) at the top.

The total mechanical energy will remain constant throughout the motion.

The total mechanical energy ($E_{M2} = E_{K2} + E_{P2}$) at the bottom.

$$E_{M1} = E_{M2}$$

$$E_{K1} + E_{P1} = E_{K2} + E_{P2}$$

$$\frac{1}{2}mv_1^2 + mgh_1 = \frac{1}{2}mv_2^2 + mgh_2$$

$$M_E = E_k + E_P$$

Example

A technician at a construction site accidentally drops a concrete block with a mass of 8kg from a scaffold, which is 10m above the ground. Ignore the effects of air resistance.

a) Calculate the mechanical energy of the block.

Solution

When the block drops, it starts from rest, that is, its speed is 0m/s; therefore, its kinetic energy just before it falls, is zero:

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

$ME = 8(9,8)10 + 0$

$ME = 784$ J

b) Calculate how much gravitational potential energy the block possesses when it is has fallen half the distance.

Solution

$E_p = mgh$

$E_p = 8(9,8)5$

$E_p = 392$ J

c) Calculate the speed of the block when it reaches the ground.

Solution

$M_{E(top)} = M_{E(bottom)}$

$784 = mgh + \frac{1}{2}mv^2$

$784 = 0 + \frac{1}{2}(8)v^2$

$v = 14 m \cdot s^{-1}$

Test Your Knowledge

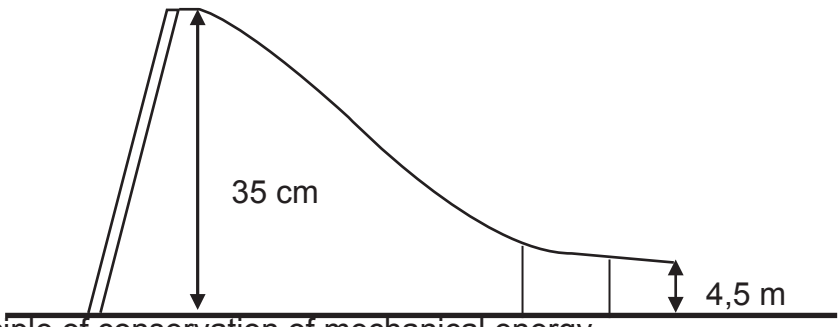
Question 1
The mechanical energy of an object is given by:

A. mgh
B. $\frac{1}{2}mv^2$
C. $E_k + E_p$
D. $E_{ki} + E_{pi} = E_{kf} + E_{pf}$

Question 2
Which one of the following is equivalent to a watt?

A. N•m
B. $N \cdot m^{-2}$
C. J.s
D. $N \cdot m \cdot s^{-1}$

Question 3
A learner with a mass of **65kg** slides down a slope that is **4,5m** high and **35cm** from the ground, as shown in the diagram below. Assume that the frictional force is negligible.



3.1 State the principle of conservation of mechanical energy.
3.2 Calculate the learner's velocity at the end of the slope.

5.4 POWER

Power is the rate at which work is done.

$$P = \frac{W}{\Delta t} \qquad P = \frac{\Delta E}{\Delta t}$$

SI unit of power is the watt **(W).**

Necessary conversions of units must be done when doing calculations:

- ♦ Work or energy must be in joules (J).
- ♦ Time must be in seconds (s).

1 watt = 1 J.s^{-1}

When an object travels at a constant velocity: $P = F.v$

Practical units of power in technology are:

1**kW** = 1000 **W**

1 horsepower **(hp)** = 726 **W**

Because work is energy transfer, power is also the **rate at which energy is expended.**

A 100-W light bulb, for example, expends 60J of energy per second.

Great power means a large amount of work or energy is developed in a short time. For example, when a powerful car accelerates rapidly, it does a large amount of work and consumes a large amount of fuel in a short time.

Example

1 If a motor is rated at 5.60kW, how much work can it do in 20 minutes?

2. A tow-truck is pulling a trailer up a steep hill. If it has a 5hp engine, how much work does the truck do in a minute?

Solution

1.

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

$$5{,}6 \times 1000 = \frac{W}{20 \times 60}$$

$$W = 6720 \text{ kJ}$$

2.

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

$$5 \times 746 = \frac{W}{60}$$

$$W = 223{,}8 \text{ kJ}$$

Test Your Knowledge

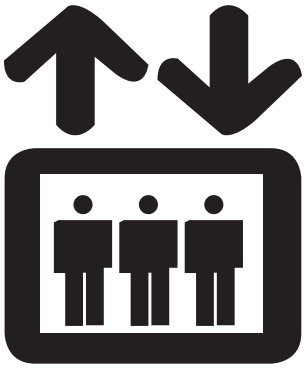
Question 1
Power is:

A. The rate at which work is done.
B. Work in progress.
C. The sum of all kinetic energies.
A. Work done on an object. (2)

Question 2
If a motor is rated at 5,6 kW, work done in 20 minutes is equal to:

A. 4,55 J
B. 6,72 x 106 J
C. 4,55 x 103 J
D. 6,72 J (2)

Question 3
A lift with a mass of 800kg has a maximum load of 600kg. At full capacity, the lift cable pulls it 30m up, at a constant speed of 5 m/s. Ignore air resistance.



3.1 Define the term power. (2)
3.2 The weight of the lift is doing negative work on the lift. Briefly explain. (2)
3.3 Calculate the average power of the motor as it lifts the elevator 30m upwards. (4)

Question 4
A racing motorbike has a mass of 450kg. At most, it has a maximum power output of 3 hp.

4.1 Convert the power output of the motorbike to watts. (2)
4.2 Calculate the work done by the engine if the motorbike moves for 5 seconds at maximum power output. (3)

Question 5

The following drawing shows an elevator that has a mass of 1 000kg and carries passengers having a combined mass of 800kg. A constant frictional force of 4 000 N reduces its motion upward.

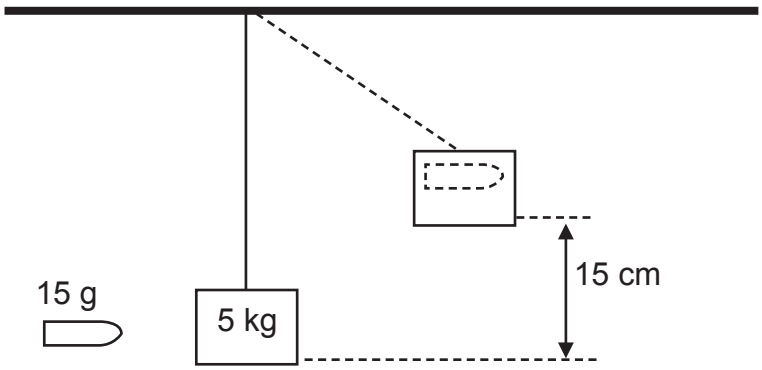
5.1 Draw a labelled free body diagram showing all the forces that act on the lift. (3)

5.2 Determine the power delivered by the motor to lift the elevator car at a constant speed of 3 $m \cdot s^{-1}$? (5)

5.4 EXERCISES

Question 1

A bullet with a mass of 15g is fired into a stationary wooden block with a mass of 5 kg that is suspended from a long strong cord.
The bullet remains stuck in the block and the block-bullet system swings to a height of 15cm above the equilibrium position.

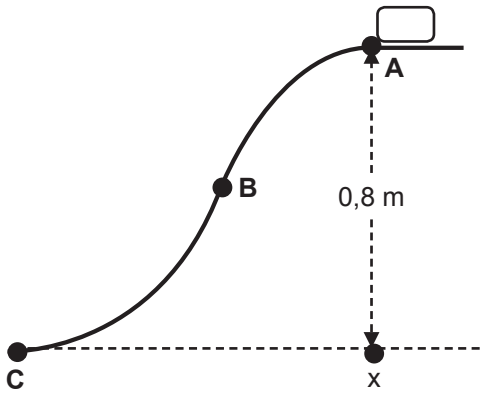


The effects of friction and mass of the cord may be ignored.

1.1 State the law of conservation of mechanical energy, in words. (2)
1.2 USING ENERGY PRINCIPLES ONLY, calculate the magnitude of the block-bullet system immediately after the bullet strikes the block. (5)
1.3 A learner with a mass of 60kg runs up a flight of stairs in 5 seconds.
The height of the stairs is 300cm.
1.3.1 Is work a vector or scalar quantity? (1)
1.3.2 Calculate the work done by the learner. (4)
1.3.3 Define the term, power. (2)
1.3.4 Calculate the power output of the learner, in horsepower (hp). (5)

Question 2

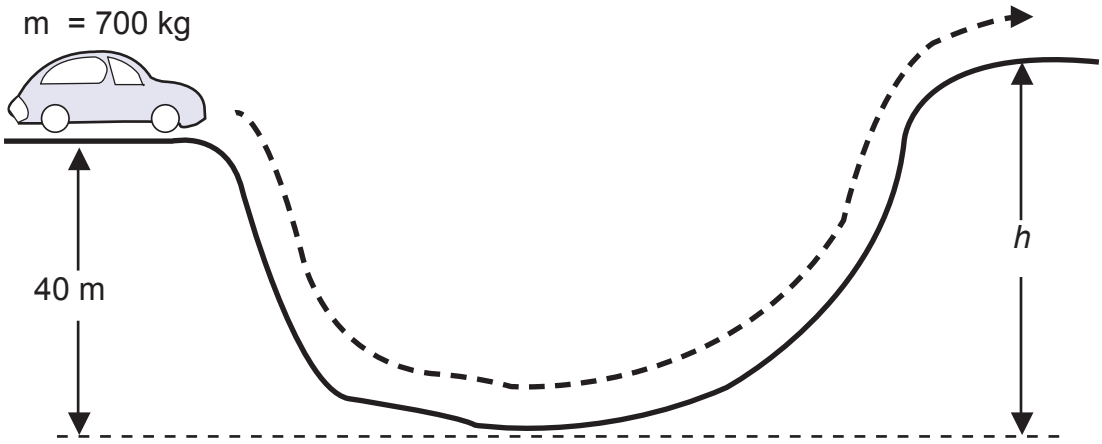
An object of mass of 200g is released at point A and moves along a frictionless track (AC).
The vertical height of point A above point X on the ground is 0,8m, as shown below.



2.1 Write down, in words, the principle of conservation of mechanical energy. (2)
2.2 Calculate the gravitational potential energy of the object at point A, just before release. (3)
2.3 At point B, the speed of the object is 3 m•s-1. Use the principle of conservation of mechanical energy to calculate the vertical height of point B above the ground. (6)

Question 3

Nomsa is driving home from work. Her car runs out of petrol just as it reaches the top of a hill that is 40m high. She is driving at a constant speed of 21,67 m•s–1 when it reaches the top. It coasts down the hill, without friction, coming to rest at a height of h at the top of the next hill, as shown in the diagram below. Nomsa has a mass of 50kg and the car has a mass of 650kg.



3.1 What is the total mass of Nomsa and the car? (1)

3.2 Calculate the total mechanical energy (in kJ) of the car at the top of the first hill. (5)

3.3 Choose the correct word in brackets. Write only the word in each case.

3.3.1 The potential energy of the car at the bottom of the hill will be at a (MINIMUM / MAXIMUM) value. (1)

3.3.2 The kinetic energy of the car at the top of the second hill where it comes to rest will be at a (MINIMUM / MAXIMUM) value. (1)

3.4 If mechanical energy is conserved, calculate the height at which the car comes to rest at the top of the second hill. (4)

Question 4

A forklift at a warehouse moves at a constant speed of 36 km•h-1. A constant frictional force of 800 N acts on the forklift.

4.1 Define the term, friction force. (2)

4.2 Calculate the power output of the forklift. (3)

4.3 Convert the power calculated in Question 4.2 to horsepower. (2)

1. CHECK YOUR ANSWERS

6.1 WORK - Test your knowledge

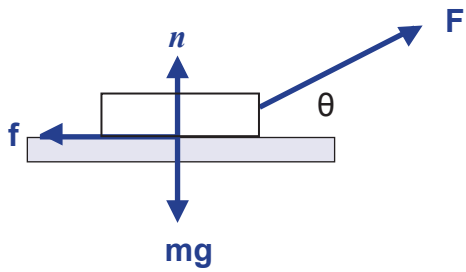
Multiple choice

D ✓✓
C ✓✓
D ✓✓
B ✓✓
A ✓✓

Question 6

6.1 The product of force and displacement of the object in the direction of the force. ✓✓

6.2



Criterion	Marks
Correct label and direction	✓

6.3.1 $F_x = F_A\cos\theta$ ✓
$F_x = 50\cos 30^o$ ✓
$F_x = 43{,}3$ N ✓

6.3.2 $W = F_x \bullet \Delta x \bullet \cos\theta$ ✓
$W = 43{,}3(6)\cos 0^o$ ✓
$W = 259{,}81$ J ✓

Question 7

7.1 The product of force and displacement of the object in the direction of the force. ✓✓

7.2 $W_{net} = W_{friction} + W_{T(horizontal)}$ ✓
$= f\,\Delta x \cos\theta + T\cos 35°\Delta x\cos\theta$ } Any one

$= (150)(45)(\cos 180°) + (850)(\cos 35°)(45)(\cos 0°)$ ✓
$= 24582.56$ J ✓

6.2 ENERGY - Test your knowledge

1. C ✓✓

2. D✓✓

3.1 The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. ✓✓

3.2 $\mathbf{M_E \text{ at } A = M_{E \text{ at } B}}$

$$\mathbf{(E_k + E_p)\text{at } A = (E_k + E_p)\text{at } B}$$

$$\mathbf{\tfrac{1}{2} mv_A^2 + mgh_A = \tfrac{1}{2} mv_B^2 + mgh_B}$$

$$(\tfrac{1}{2})(65)(0)^2 + (65)(9{,}8)(4{,}5) = \tfrac{1}{2}(65)v^2 + (65)(9{,}8)(0.35)$$

$$v^2 = 9.01 \text{ m•s}^{-2}$$

6.3 POWER - Test your knowledge

1. A✓✓
2. B✓✓

3.1 Work done per unit of time / rate of doing work. ✓✓

3.2 The weight acts in the opposite direction of the displacement of the elevator. ✓✓

3.3

Pave = F•v ✓
Pave = (1400)(9,8)(30) ✓
Pave = 411 600 W✓

Question 4

4.1 1hp = 746 W
3 hp = 3 x 746 = 2238 W ✓✓

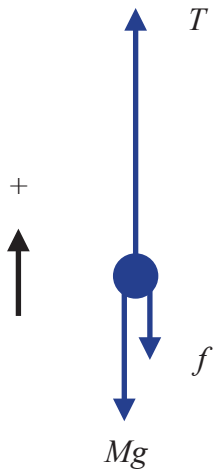
4.2 $P = \frac{W}{\Delta t}$ ✓ ✓

2238 = W5 ✓

W = 11 190 J ✓

Question 5

5.1



Criterion	Marks
Correct label and direction	✓

5.2 From Newton's first law, we obtain:

$F_{net} = 0$

$T - W - f = 0$ ✓

$T - Ff - Mg = 0$

$T = F_f + Mg$

Where **M** is the total mass of the system (elevator plus passengers), equal to 1 800 kg. Therefore:

$T = 4000 + (1800 \times x9{,}8)$

$T = 2{,}16 \times 10^4$ N

$P = Fv$

$P = 2{,}16 \times 10^4 \times 3{,}00$

$P = 6{,}48 \times 10^4$ W

6.1 Answers to exercises

Question 1

1.1 The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. ✓✓

1.2 $M_{E\ at\ A} = M_{E\ at\ B}$

$(E_k + E_p)$at A = $(E_k + E_p)$at B

$\frac{1}{2} mv_A^2 + mgh_A = \frac{1}{2} mv_B^2 + mgh_B$

$\frac{1}{2}(5 + 0{,}015)v^2$ ✓ = $(5 + 0{,}015)(9{,}8)(0{,}15)$ ✓

$V = 1{,}71\ m.s^{-1}$ ✓

1.3.1 Scalar (quantity)

1.3.2 $W = Fx \cdot \Delta x \cdot \cos\theta$ ✓

$W = m \cdot g \cdot h \cdot \cos\theta$

$= (60)(9{,}8)$ ✓ $(300/100)$ ✓ cos0o

$= 1764{,}00$ J

1.3.3 Work done per unit of time / rate of doing work. ✓✓

1.3.4 $P = \frac{w}{\Delta t}$ ✓

$= \frac{1764}{5}$ ✓

$= 352{,}80$ W ✓

Question 2

2.1 The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. ✓✓

2.2 $Ep = mgh$ ✓

$= (0{,}2)(9{,}8)(0{,}8)$ ✓

$= 1{,}568$ J ✓

2.3 $M_{E\ at\ A} = M_{E\ at\ B}$

$(Ek + Ep)$at A $= (Ek + Ep)$at B

$\frac{1}{2} mv_A^2 + mgh_A = \frac{1}{2} mv_B^2 + mghB$

$(0{,}2)(9{,}8)h$ ✓ $+ \frac{1}{2}(0{,}2)(3)^2$ ✓ $= (0{,}2)(9{,}8)(0{,}8)$ ✓ $+ \frac{1}{2}(0{,}2)(0)^2$ ✓

$h = 0{,}34$ m ✓

Question 3

3.1 700 kg ✓

3.2 $ME = \frac{1}{2} mv^2 + mgh$ ✓

$= \frac{1}{2}(700)(21{,}67)^2 + (700)(9{,}8)(40)$ ✓✓

$= 438\ 756{,}12$ J ✓

$= 438{,}756$ kJ ✓

3.3.1 Minimum ✓

3.3.2 Maximum ✓

3.4 $Ep = mgh$ ✓

438 756,12 J ✓ = ✓

$h = 63{,}96$ m ✓

Question 4

4.1 The force parallel to the surface that acts in the opposite direction of motion. ✓✓

4.2 The movement of the forklift at constant velocity suggests that the net force acting on the forklift is zero.
Thus, friction force is equal to the applied force of the engine of the force applied by the engine.

$P = F \cdot v$ ✓
$= 800 \left(\frac{36}{3,6}\right)$ ✓
$= 8\ 000$ W ✓

4.3 1 hp = 746 W
Therefore: horsepower $= \frac{8000}{746}$ ✓
$= 10,72$ hp ✓

7 Message to Grade 12 Learners from the Writers

Obtaining the National Senior Certificate with a pass in Technical Sciences opens doors for you. You need to study hard to ensure that you pass. Use this document to prepare yourself thoroughly for the examination. We encourage you to pursue further studies at tertiary level in your field of interest. South Africa remains a country with a technical skills shortage. Obtaining a pass in Technical Sciences will undoubtedly pave the way for you to become a key economic contributor.

Best wishes.

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TECHNICAL SCIENCE

WORK ENERGY AND POWER

GRADE 12

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