TECHNICAL SCIENCE

NEWTON'S LAWS OF MOTION

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.

Contents

2. HOW TO USE THIS STUDY GUIDE

- This book in intended to assist and guide you through the topics. It is complementary to your textbooks, worksheets and other learning materials that you might have. Your efforts to practise and master the concepts outlined will assist you to become confident about the learning and assessments you will do.
- Ensure that you understand all the relevant concepts, formulae, etc.
- Do extra research on your own to get more information on the topics in this booklet. It is important that you discuss your understanding of your findings with fellow learners.
- Work through the examples given in each topic, master them and try to develop more examples yourself. You must work through the examples in your textbooks. There are exercises for you to do at the end of Unit 5 of this study guide. Work through them on your own and compare them with the answers provided in Unit 6.
- When you are 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 it into metres.
- Familiarise yourself with the scientific notations used, e.g. kilo, mega, giga, and write them as 10^x.
- It is important to show SI units in the final answer. This will earn you marks.
- An extract from the examination guidelines is included at the beginning of each topic. You must use these to check what you are expected to master. Revise what you have not yet mastered and do more exercises.

3. STUDY AND EXAMINATION TIPS

3.1 Tips for Technical Sciences Paper One

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 the key words.

USING FORMULAE

- Always use formulae from the formula sheet.
- Common mistakes occur when you change the subject of the formula; thus, it is recommended that you substitute into the given formula and isolate the unknown. However, those of you who are confident with changing the subject of the formula may continue to use this method as it is an efficient method.
- Familiarise yourself with the formula sheet to avoid wasting time during the examination.
- Round off your final answer to a minimum of two decimal places and include the correct unit.

ANSWERING MULTIPLE-CHOICE QUESTIONS

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

The level of difficulty will vary in MCQs. Resorting to guessing may lead to giving incorrect answers.

There are strategies that can be used to maximise your success in answering MCQs. The best way to improve your chances, of course, is to study carefully before the exam and to make sure that you understand your work, instead of just memorising information.

Here are a few tips to help reduce the possibility of making mistakes or of getting confused by distracters that look similar to the correct answer.

Step 1

- Always 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. Rushing through a question may result in misinterpretation.

Step 2

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

Step 3

- Uncover the responses and read them. If you see the response you anticipated or one that closely matches your anticipated response, circle/ mark it and then check the others to make sure none of them is a better response. It is important to read all given responses.
- If your anticipated response is not amongst the given ones, 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 in 1 minute,*
> *skip it and plan to come back to it later.*

3.2 Tips for Newton's Laws

- The topic of Newton's Laws of Motion is assessed in Paper 1.
- Copy the formula as it is written in the data sheet, 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.

Sketching of force and free-body diagrams

- You must be able to distinguish between a free-body and force diagrams.
- The mark allocation 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 arrowheads, and arrows that do not touch the dot (object) will result in lost marks, due to negative marking.
- Label the forces correctly.

4. OVERVIEW OF NEWTON'S LAWS

NEWTON'S FIRST LAW OF MOTION: Consider forces acting on a single object.

An object continues in a state of rest or uniform velocity (moving with a constant velocity), unless it is acted upon by a net (resultant) force.

Object moves at **constant velocity**

Object remains at **rest** OR is **stationary**

F_{net} = 0 N

The object experiences zero acceleration.

Inertia is the property/ tendency of a body to resist any change to its state of rest or state of motion with constant velocity.

- If a car is suddenly set into motion from its rest position, the passenger moves backwards as it tries to maintain its state of rest.

NEWTON'S SECOND LAW OF MOTION: Consider forces acting on a single object.

A (non-zero) net force acting on an object will cause it to accelerate in the direction of the net force.

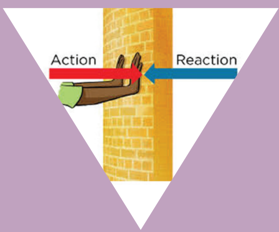
This acceleration is directly proportional to the net force and inversely proportional to the mass.

Mathematical equation:

$F_{net} = ma \qquad a \propto F_{net} \qquad a \propto \frac{1}{mass}$

NEWTON'S THIRD LAW OF MOTION: Two objects exert force on each other.

When object A exerts a force on object B, object B simultaneously exerts an oppositely directed force of equal magnitude on object A.



Two bodies involved:

Force by boy on wall = Force by wall on boy (in the opposite direction)

$\vec{F}_{\text{boy on wall}} = -\vec{F}_{\text{wall on boy}}$

Properties of third law force pair:

- Forces are equal in magnitude.
- Forces act in opposite directions along the same line.
- Forces act at the same time.
- Forces do not cancel each other out (are not balanced).

5. NEWTON'S LAWS OF MOTION

The following is a summary of the concepts that need to be learnt in this topic, as per the examination guidelines.

There are different kinds of forces: weight, normal force, frictional force, applied force (push, pull), tension (strings or cables).

- Weight is described as the gravitational force that the Earth exerts on any object on or near its surface.
- Weight is calculated using the expression $w = mg$.
- Normal force, N, is defined as the perpendicular force exerted by a surface on an object that lies on that surface. (Grade 10)
- Frictional force, F_f, is defined as the force parallel to the surface that opposes the motion of an object and acts in the direction that is opposite to the motion of the object. (Grade 10)
- The static (limiting) frictional force acts between the two surfaces when the object is stationary. It is given by $f_s = \mu_s F_N$. (Grade 11)
- The kinetic (dynamic) frictional force acts between the two surfaces when the object is moving. It is given by $f_k = \mu_k F_N$. (Grade 11)
- Tension, T, is defined as a force acting on a string or rope.
- Distinguish between mass and weight.
- Given a force, F, acting at an angle to the horizontal axis, the force should be resolved into its parallel and perpendicular components (rectangular components). (Grade 11)

Force diagrams, free-body diagrams

- Define a force diagram.
- Define a free-body diagram.
- Draw a force diagram.
- Draw a free-body diagram.
- Draw a force diagram and a free-body diagram for objects that are in equilibrium or accelerating.
- Determine the resultant or net force of two or more forces.

Newton's first, second and third laws

- State Newton's first law: An object continues in a state of rest or uniform (moving with constant) velocity unless it is acted upon by a net (resultant) force.
- Inertia is defined as the property of a body to resist any change in its state of motion or rest.
- Mass is defined as a measure of the inertia of a body.
- Give examples to illustrate Newton's first law.
- Discuss why it is important to wear seatbelts, using Newton's first law.
- Acceleration is defined as the rate of change of velocity.
- State Newton's second law: When a net force is applied to an object of mass, m, it accelerates the object in the direction of the net force.
- Use the equation, $\mathbf{F_{net} = ma}$, to solve problems involving force, mass and acceleration in the content of technology. (Do not include pulley problems and lift problems.)
- Apply Newton's laws to a variety of equilibrium and non-equilibrium problems, including:
  - o A single object:
    - Moving on a horizontal plane with or without friction.
    - Moving in the vertical plane.
  - o Two-body systems (joined by a light inextensible string):
    - Both on a flat horizontal plane with and without friction.
- State Newton's third law: When object A exerts a force on object B, object B simultaneously exerts an oppositely directed force of equal magnitude on object A.
- Identify and give examples of action-reaction pairs.
- List the properties of action-reaction pairs.

REVISION OF GRADE 10 AND 11 CONCEPTS:

Important concepts that you learned in Grades 10 and 11

1. Mass (m) of an object is the amount of matter in that object.

   Weight (w) is the gravitational force that the Earth exerts on any object on or near its surface.

   It is calculated by using the formula **w = mg**.

   e.g. The weight of an object with a mass of 10kg is calculated as follows:

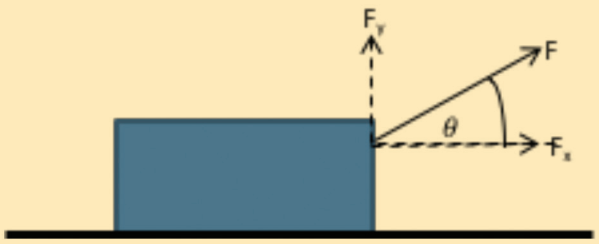
   w = mg where g (gravitational acceleration) is 9.8 $m \cdot s^{-2}$

   = 10 X 9.8

   = 98 N

It is important to note that the mass of the object may be given in grams in a problem. In such a case, the given mass should first be converted to kg.

2. Normal force, N, is the perpendicular force exerted by a surface on an object that lies on that surface. (Grade 10)
3. Frictional force, F_f, is defined as the force parallel to the surface that opposes the motion of an object and acts in the direction that is opposite to the motion of the object. (Grade 10)
4. The static (limiting) frictional force is a force that acts between two surfaces when the object is stationary. It is given by $f_s = \mu_s F_N$. (Grade 11)
5. The kinetic (dynamic) frictional force acts between the two surfaces when the object is moving. It is given by $f_k = \mu_k F_K$. (Grade 11)
6. Tension, T, is defined as a force acting on a string or rope.
7. Given a force (F) acting on an object, at an angle to the horizontal plane, resolve the force into its parallel and perpendicular components. (Grade 11)



F can be resolved into its components, which are F_x and F_y.

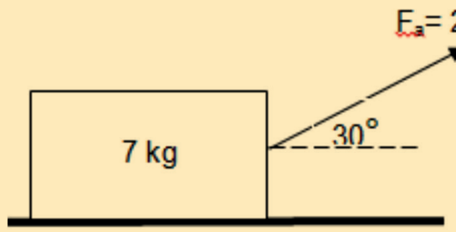
$F_x = F \cos \theta$

$F_y = F \sin \theta$

Force diagrams, free-body diagrams

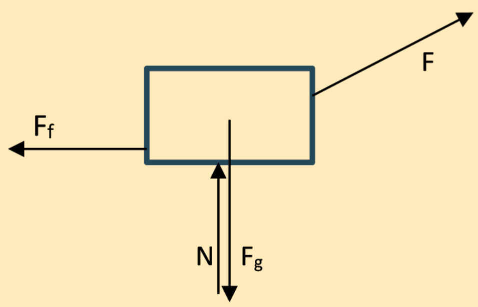
1. A force diagram is a representation of all the forces acting on the object. It is drawn as an arrow.
2. In a free-body diagram, the object is replaced by a point, with all the forces acting on it indicated using arrows.
3. A force of 250 N is applied to a block with a of mass 7kg at an angle of 30^0 to a rough horizontal surface, as illustrated in the diagram below.

Draw a force diagram and a free-body diagram for the object.

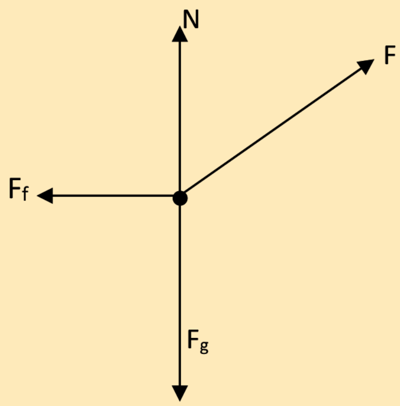


Solution:

Force diagram



Free-body diagram



5.1 Newton's first law of motion

Newton's first law: An object continues in a state of rest or uniform velocity (moving with constant) unless it is acted upon by a net (resultant) force.

Newton's first law of motion is sometimes referred to as the law of **inertia.**

Resultant force = zero

Objects at rest
$v = 0\ m \cdot s^{-1}$
$a = 0\ m \cdot s^{-2}$

Objects in motion
$v \neq 0\ m \cdot s^{-1}$
Objects stay in motion with the same speed and direction (v is constant)
$a = 0\ m \cdot s^{-2}$

- **State of rest** means the object is stationary.
- **Uniform velocity (moving with constant velocity)** means there is no change in velocity.
- **Net (resultant) force** is the vector sum of all forces acting on the object

Definitions

- **Inertia i**s the tendency of an object to resist any change in its state of rest or uniform motion. (Uniform motion is motion with constant velocity)
- The **mass** of an object is the measure of its inertia.
- **Acceleration** is defined as the rate of change of velocity (SI unit for acceleration is $m \cdot s^{-2}$).

$$\text{Acceleration} = \frac{\textit{change in velocity}}{\textit{change in time}}$$

$$a = \frac{\Delta v}{\Delta t}$$

5.1 Test your knowledge

I. What is the net force exerted on a car that is moving at constant velocity?

II. Explain why passengers continue to move forward when a vehicle stops suddenly.

III. Use Newton's first law of motion to explain the importance of safety belts in vehicles.

5.2 Newton's second law of motion

When a **net force** (F_{net}) is applied to an object of mass (m), it accelerates the object in the direction of the net force. The acceleration is **directly proportional** to the net force and **inversely proportional** to the mass of the object.

$F_{net} = ma$

Where mass is in kg:

F_{net} is in **Newton(N)**

and acceleration (a) is in **m·s^{-2}**

- o **The term directly proportional** implies that as the net force increases, the acceleration also increases (and vice versa)
- o **The term inversely proportional** implies that as the mass increases the acceleration decreases (and vice versa).

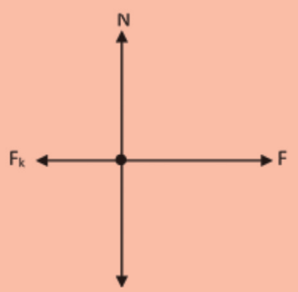
WORKED EXAMPLE:

A 10kg box is placed on a table. A horizontal force of 32 N is applied to the box. A frictional force of 7 N is present between the surface and the box.

a) Draw a free-body diagram indicating all the forces acting on the box.

b) Calculate the acceleration of the box.

Solution:

a.	b. Fnet = ma
	$F_a + F_k = ma$ $32 – 7 = 10a$ $25 = 10a$ $a = 2,5\ m.s^{-2}$

5.2 Test your knowledge

At a construction site, 380kg of rubble should be moved to make way for a new building. A net force of 900 kN is applied by a mechanical grader as it pushes the rubble. Ignore the effects of friction and:

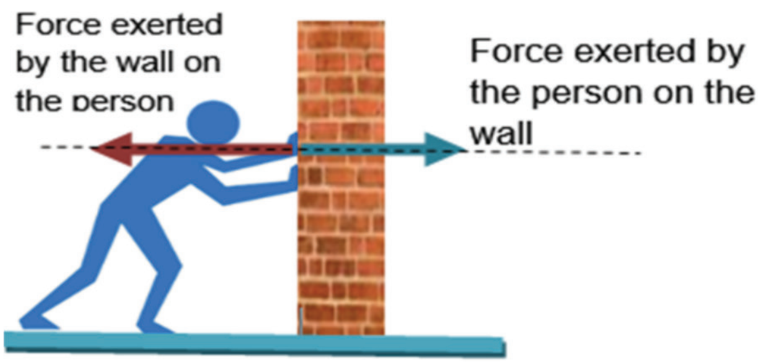
I. **Draw** a force diagram to show all the forces acting on the rubble.
II. **Calculate** the acceleration at which the rubble will be moved.
III. **Determine** how much force the grader would have to apply to move the rubble at the acceleration calcul ated in **II** above, if an average frictional force of 240 kN existed between the rubble and the surface.

5.3 Newton's third law of motion

Newton's third law: When object A exerts a force on object B, object B simultaneously exerts an **oppositely directed** force of **equal magnitude** on object A.

- **Equal magnitude** means the same size / value.

This law can also be stated as follows:
When one body exerts a force on a second body, the second body exerts a force of **equal magnitude** in the **opposite direction** on the first body.



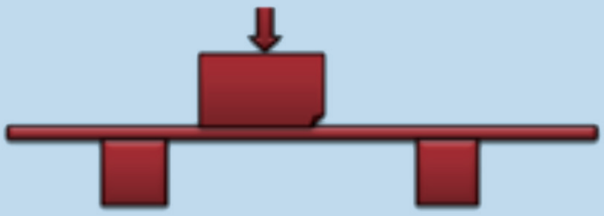
$$\vec{F}_{A\ on B} = -\vec{F}_{B on A}$$

Newton's third law of motion implies that when the person applies a force on the wall, the wall exerts a force of equal magnitude in the opposite direction on that person,

PROPERTIES OF ACTION-REACTION PAIRS

- The two forces of the action and reaction have the **same magnitude,** but act in opposite directions.
- They must **act on different bodies.**
- They must **act along the same line.**
- They must arise from the **same interaction.**
- They must occur **simultaneously.**
- They are **not balanced.** (Even though the forces are equal in magnitude and act in opposite directions, they are not balanced because they act on different objects. Only forces that act onthe same object can be balanced.)

5.3 Test your knowledge



A learner presses a book against a table, as shown in the diagram above.

I. **Draw** a labelled force diagram that indicates all the forces acting on the book.

II. **Identify** and **name** the action-reaction pairs of forces acting in the diagram.

5.4 Application of Newton's laws of motion

Worked examples

Example 1 - *A single object moving on a horizontal plane with or without friction*

A cleaner pushes a 4,5kg laundry cart with a net force of 60 N.

Calculate the magnitude of acceleration of the cart.

Solution:

$F_{net} = ma$ ✓

$60 = 4{,}5\,a$ ✓

$a = 13{,}33\ m{\cdot}s^{-2}$ ✓ (3)

Example 2 - *A single object moving in the vertical plane.*

A crane is used to lift up a 335kg pallet of bricks at an acceleration rate of 3,33 m·s^{-2}. Calculate the net force applied to lift up the bricks.

Solution:

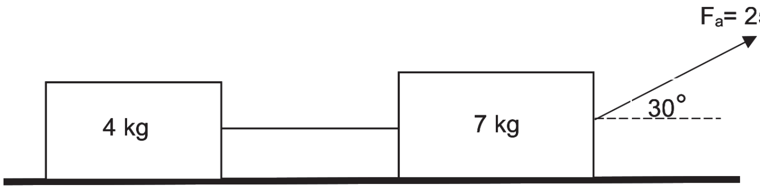
F_{net} = ma ✓

= 335 x 3,33 ✓

= 1115,55 N ✓ (3)

Example 3 - *Two-body systems (joined by a light inextensible string); both on a flat horizontal plane with and without friction.*

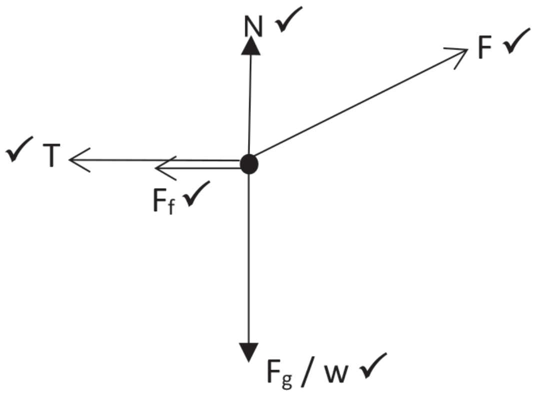
Two blocks weighing 4kg and 7kg are connected by a light inextensible string. A force of 250 N is applied on the 7kg block at an angle of 30° to the horizontal, as shown in the diagram below. The system moves to the east. Each block experiences a frictional force of 45 N.



1. Draw a labelled free-body diagram of ALL the forces acting on the 7kg mass.
2. **Calculate:**
   a) the acceleration of the system.
   b) the tension in the string.

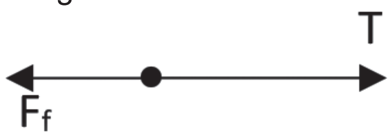
Solution:

1.



(5)

2.a) 4 kg block



$F_{net} = ma$ ✓

$T + F_f = ma$

$T – 45 = 4a$ ✓

$T = 4a + 45$

7 kg block

$F_{net} = F_a \cos 30^0 – (T + F_f) = ma$ ✓

250 x 0,866P – (4a + 45 + 45) ✓ = 7a ✓

216,5 – 90 = 7a + 4a

$a = 11,5\ m.s^{-2}$ ✓ (7)

2.a) 4 kg block

Option 1	Option 2
$F_{net} = ma$ ✓	$F_{net} = ma$ ✓
$T + F_f = ma$	$F_a Cos30^0 – (T + F_f) = ma$ ✓
T – 45 = 4(11,5) ✓	250 x 0,866 – (T+ 45) = 7(11,5) ✓
= 91 N ✓	216,5 – 45 – T = 7 (11,5)
	T = 171,5 – 80,5
	T = 91 N ✓

(3)

EXERCISES:

Question 1: Multiple-choice questions

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number.

1.1 Which of the following statements is correct?

A An object remains in its state of rest unless a resultant/ net force acts on it.
B An object remains in its state of rest or constant velocity unless a resultant/ net force acts on it.
C An object remains in its state of rest or constant velocity unless an external force acts on it.
D An object remains in its state of rest or constant velocity unless a force acts on it. (2)

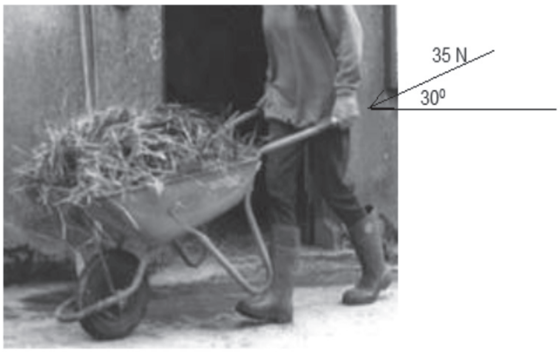
1.2 When a brick is lying on a scaffolding, an upward force is exerted on the brick by the scaffolding. A reaction force to this upward force is the force that the …

A Earth exerts on the brick.
B Earth exerts on the scaffolding.
C brick exerts on the scaffolding.
D scaffolding exerts on the Earth. (2)

1.3 The magnitude of the force exerted by a hammer when it hits a nail is … the magnitude of the force that the nail exerts on the hammer.

A smaller than
B bigger than
C double
D equal to (2)

1.4 The picture below shows a worker pushing a wheelbarrow by applying a force of 35 N at an angle of 30^0 to the horizontal. The wheelbarrow experiences a frictional force of 14 N.

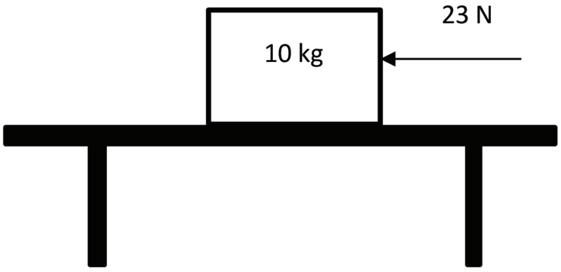


The magnitude of the net force experienced by the wheelbarrow is:

A 49 N
B 21 N
C 16,31 N
D 44,31 N

Question 2

A 10kg tool box is placed on a table. A horizontal force of 23 N is applied on the tool box, to the left.



2.1 State Newton's second law of motion.
2.2 Draw a force diagram indicating all of the forces acting on the tool box.
2.3 Calculate the acceleration of the tool box if friction is ignored.
2.4 Calculate the acceleration of the tool box if it experiences a frictional force of 5 N.

Question 3

A builder pushes a cement block (weighing 150 N) with a constant force of 75 N to the right. The cement block experiences a constant frictional force of 20 N.

3.1 Draw a labelled free-body diagram of all the forces acting on the cement block.
3.2 Determine the acceleration of the cement block.

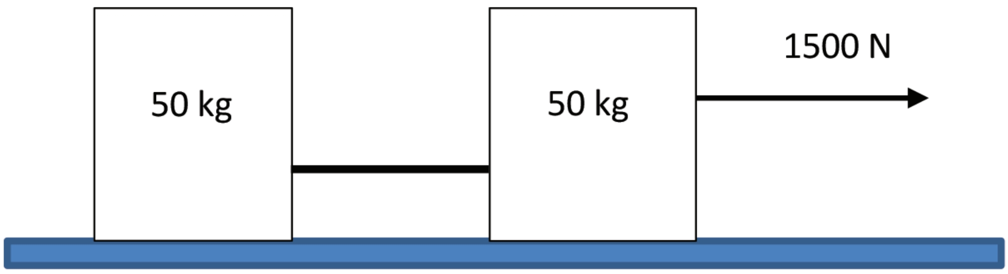
Question 4

A sports car (with a mass of 1000kg) is able to accelerate uniformly from rest to 30 $m \cdot s^{-1}$ in a minimum time of 6 s.

4.1 Calculate the magnitude of the acceleration of the car.
4.2 Calculate the magnitude of the resultant force acting on the car during the 6 s.

Question 5

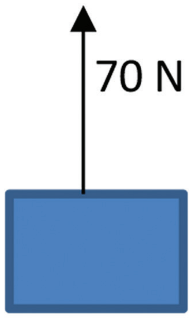
Two crates weighing 50kg are connected with a thick inextensible rope, as illustrated in the diagram below. A force of 1500 N is applied on the crates in an easterly direction. The crates move with an acceleration of 7 $m \cdot s^{-2}$ to the right.



Calculate:
5.1 the magnitude and direction of the frictional force experienced by the crates.
5.2 the magnitude of the tension in the rope.

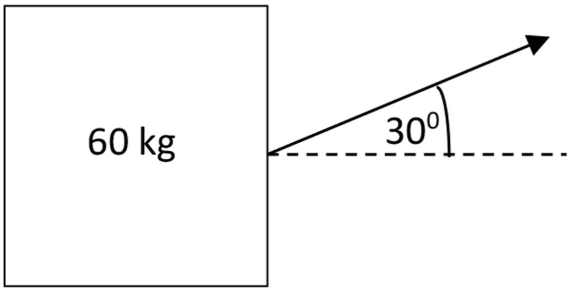
Question 6

A constant force of magnitude 70 N is applied vertically to a block, as shown in the diagram below. The block experiences a force owing to gravity of 49 N. Calculate the acceleration of the block. Ignore the effects of air friction.



Question 7

A force of 190 N is applied to pull a crate with a mass of 60kg, to the right across a floor, as illustrated in the diagram below. The force makes an angle of 30^0 to the horizontal. The crate experiences a constant frictional force.



7.1 Draw a labelled free-body diagram showing all the forces acting on the crate.

Calculate the acceleration of the crate if:

7.2 friction is ignored.

7.3 the crate experiences a frictional force of 28 N.

6. CHECK YOUR ANSWERS

Test your knowledge

6.1 Test your knowledge

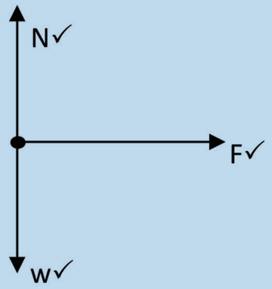
I. Zero ✓

II. Due to inertia, the passengers are resisting a change in their state of motion. ✓✓

III. According to Newton's first law of motion, a passenger will continue to move forward should a vehicle come to a stop suddenly. Safety belts prevent passengers from moving forward and getting injured. ✓✓

6.2

I.



II. $F_{net} = ma$✓

$900 \times 10^3 = 380a$✓

$a = 2368,42\ m{\cdot}s^{-2}$✓

III. $F_{net} = ma$ ✓

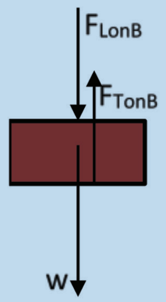
$F + (-F_f) = ma$

$F + (-240 \times 10^3) = 380 \times 2368,42$✓

$F = 1,14 \times 10^6\ N$✓

6.3

I.



II. Force of the table on the book and force of the book on the table.✓✓

Force of the Earth on the book and force of the book on the Earth. ✓✓

Force of the learner on the book and force of the book on the learner. ✓✓

Force of the Earth on the table and force of the table on the Earth. ✓✓

Force of the Earth on the learner and force of the learner on the Earth. ✓✓

ANSWERS AND SOLUTIONS TO EXERCISES

Question 1: Multiple-choice questions

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number

1.1 B ✓✓ (2)

1.2 C ✓✓ (2)

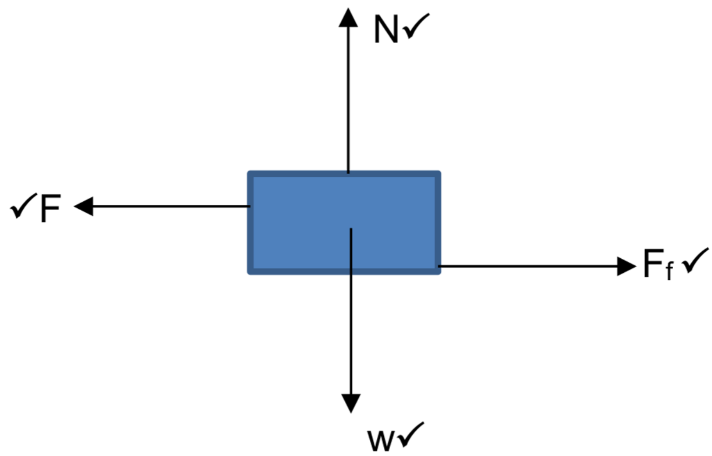
1.3 D ✓✓ (2)

1.4 C✓✓ (2)

Question 2

2.1 When a **net force** (F_{net}) is applied to an object of mass (m), it accelerates the object in the direction of the net force. The acceleration is **directly proportional** to the net force and **inversely proportional** to the mass of the object. ✓✓

2.2



2.3 $F_{net} = ma$ ✓

$23 = 10\,a$ ✓

$a = 2,3\ m\cdot s^{-2}$ ✓ **to the left** ✓

UYJ

2.4 $F_{net} = ma$

$F + F_f = ma$

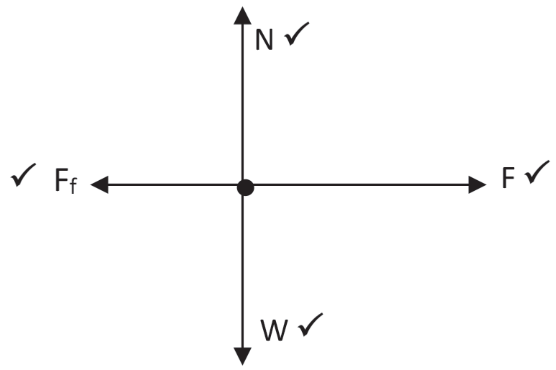
✓ for any one

$23 - 5 = 10\,a$ ✓

$a = 1,8\ m\cdot s^{-2}$ ✓ **to the left** ✓

Question 3

3.1



(4)

3.2 $F_{net} = ma$

$F + F_f = \frac{w}{g}\ a$

$75 - 20 = \frac{150}{9,8}$ ✓ a ✓

a = 3,59 m·s^{-2} ✓ **to the right** ✓ (5)

Question 4

4.1 $a = \frac{\Delta v}{\Delta t}$ ✓

$= \frac{30}{6}$ ✓

= 5 m·s^{-2} ✓ (3)

4.2 Calculate the magnitude of the resultant force acting on the car during the 6 s.

$F_{net} = ma$ ✓

= 1000 x 5 ✓

= 5000 N ✓ / 5 x 10^3 N ✓ (3)

Question 5

5.1 $F_{net} = ma$
$F + F_f = ma$
} ✓ for any one

1500 + F_f = 50 x 2 x 7 ✓

F_f = - 800

= 800 N ✓ **to the left** ✓ (4)

5.2 $F_{net} = ma$
$T + F_f = ma$ } ✓ for any one
$T + (-800) = 50 \times 7$ ✓
$T = 1150$ N ✓ (3)

Question 6

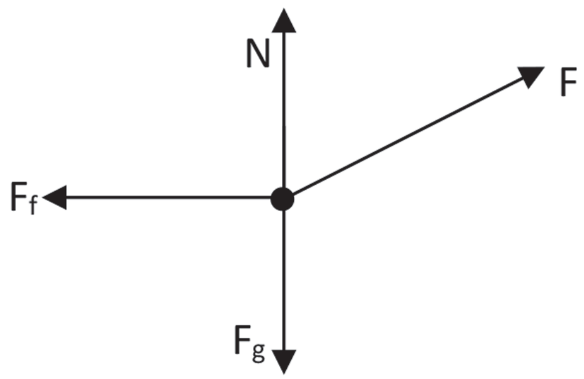
$F_{net} = ma$

$F + F_g = ma$
$70 - 49 = \frac{49}{9,8}a$ ✓

$a = 4,2\ m \cdot s^{-2}$ ✓ **upwards** ✓ (4)

Question 7

7.1



7.2 $F_{net} = ma$
$F_x = ma$
$F \cos \theta = ma$ } ✓ for any one
$190 \cos 30^0 = 60a$ ✓
$a = 2,74\ m \cdot s^{-2}$ ✓**to the right.** ✓ (4)

7.3 $F_{net} = ma$
$F_x + (-F_f) = ma$
$F \cos \theta + (-F_f) = ma$ } ✓ for any one
$190 \cos 30^0 - 28 = 60a$ ✓
$a = 2,28\ m \cdot s^{-2}$ ✓ **to the right.** ✓ (4)

7. MESSAGE TO GRADE 12 LEARNERS FROM THE WRITERS

To be successful in life, you need to go the extra mile, make sure you study, and work hard. I would like to encourage you by referring to Dr John M Tibane who, in his book entitled *Turbo Think*, makes the following statements:

"Always do more than is required of you".
"The number one reason why most people are not wealthy is that they have not decided to be wealthy".

To be successful, you need to decide to be successful and do more than is required of you in order to expedite your success.

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TECHNICAL SCIENCE

NEWTON'S LAWS OF MOTION

GRADE 12

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