GRADE 12

PHYSICAL SCIENCES

MODULE 1

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- Each matric subject is divided into 12 modules to ensure paced and easy learning.
- You have access to learning material, 24 hours per day and 7 days a week.
- Monitor your progress at the end of each module.
- Each module has exercises based on the topics covered in the module and previous module.
- The questions are based on the type of assessment candidates may expect in the National examination to practice the application of knowledge gained.
- At the end of each module, a compulsory quiz ensures that the candidate has gained the general knowledge required for the topic covered before progress is made to the following module.
- The modules were compiled from multiple resources, both prescribed by the Department of Education and other professionals, to ensure that the topics are covered in detail and from all perspectives.
- Subject specialists with years of experience in teaching their subjects, proof-read all modules and assisted with recommendations to ensure full coverage and easy learning.
- Modules are updated as the curriculum changes to ensure the validity of the learning material.

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EXAMINATION LAYOUT

1.1 Format of question papers

Paper	Types of questions	Time	Total
1	Physics: 10 multiple-choice questions Structured questions	3 hours	150
2	Chemistry: 10 multiple-choice questions Structured questions	3 hours	150

1.2 Topics that will be examined

PAPER 1	PAPER 2
Physics	**Chemistry**
• Newton's laws and application of Newton's laws. • Momentum and impulses • Vertical projectile motion in one dimension (1D) • Work, energy and power • Doppler Effect • Electrostatics • Electric circuits • Electrodynamics • Optical phenomena and properties of materials	• Representing chemical change • Balanced chemical equations • Quantitative aspects of chemical change • Intermolecular Forces • Organic molecules • Energy and change • Rate and extend of reaction • Chemical equilibrium • Acids and bases • Electrochemical reactions • Chemical industry

1.3 General information and information sheets

See attached Addendum A

1.4 Skills needed in Physical Sciences

Skills	Type of skills
Identify and question phenomena	• Formulate an investigative question • List all possible variables • Formulate a testable hypothesis
Design or plan of an investigation	• Identify variables (dependent, independent and controlled) • List appropriate apparatus • Plan the sequence of events
Graphs	• Draw accurate diagrams from given information • Interpret graphs • Draw sketch graphs from given information
Results	• Identify patterns or relationships in data • Interpret results
Conclusions	• Draw conclusions from give information • Evaluate the validity of conclusions
Calculations	• Solve problems using two or more different calculations
Descriptions	• Explain/describe/argue the validity of a statement or event using scientific principles.

UNIT 1: MECHANICS

LEARNING OBJECTIVES

At the end of this unit, you should be able to:

- Explain how a force changes motion.
- Write down Newton's 1st, 2nd and 3rd Laws of Motion.
- Solve problems using the formula FR = ma.
- Identify Newton's 3 pairs.
- Avoid typical mistakes in using Newton's 3rd Law.

You should spend more or less one week on this unit.

1. INTRODUCTION TO MECHANICS

This module is all about forces and motion. Of all the sections in Physics, this can be the easiest and most enjoyable, but most people do not really understand this work, and so this section becomes very difficult.

To help you, we look at these concepts in terms of accelerations, then in terms of change of momentum, but all the time our central thought is FORCES.

We finish the section by looking at how forces are related to work, energy and power.

1.1. Newton's Laws: Force and acceleration

What Newton formulated in the 1680s was a very clear idea about what a force does.

Ask yourself – if a car moves along a road, does it need a force to keep it moving?
If a ball is thrown into the air, what keeps it going up until it turns around and comes down again?

Try this simple experiment
Roll a ball along a smooth surface, like a table. Observe the motion carefully. Now roll the ball along a slightly bumpy surface. Lastly, roll the ball through thick grass.

Now do a second simple experiment
Throw a ball into the air. Note the motion of the ball until you catch it again. Repeat this by throwing the ball into the air again, but this time take careful note of the forces acting on it. Can you decide what caused the ball's motion to change?

If you think about the ball rolling on the table, it did not slow down much. But the ball rolling through thick grass slowed down very quickly.

What was the difference between the two situations?

- In the grass, there is a large force of friction. And what did the large force of friction do? It slowed the ball down – in other words it changed the motion of the ball! Because friction is a force that we do not easily see, we often forget about it. If the grass had a big hand grabbing the ball to slow it down, you would never forget about it. But because the force acts without being easily visible, most people ignore it.
- On the table there is less friction, but there still is a significant force of friction, the ball slowed down less. What would happen if there was no friction at all? The ball would not slow down at all. So, if there is NO FORCE of friction, there is NO CHANGE in motion.

In short, FORCES CHANGE the motion of an object.

Most people think that a force is needed to keep the objects in motion. But they are WRONG! No force is needed to keep things moving BUT a force is always needed to CHANGE the motion.

Why is this so difficult to understand? Because there are forces that we do not observe and so we often miss them.

The ball thrown up into the air, once it has left your hand, effectively only has the force of gravity acting on it. And because the force of gravity acts downwards, the motion of the ball changes from upwards to downwards.

But if a ball is thrown into the air, what keeps it going up until it turns around and comes down again. It is its own upwards motion that keeps it going up. And this upward motion is slowly changed by the FORCE of gravity, until it becomes a downward motion.

1.2. Definitions and laws

- A force is a push or pull upon an object resulting from the object's interaction with another object.
- Gravitational force is the force of attraction that objects exert on other objects in virtue of having mass. It is the force that makes all things fall and causes tides in the ocean. The greater the mass of an object, the greater its gravitational pull.
- The normal force is a perpendicular force that a surface exerts on an object with which it is in contact.
- The resultant (net) force acting on an object is the vector sum of all the forces acting on the object. The vector sum is the sum of all vectors (all the forces added up, taking their directions into account).
- Newton's First Law of Motion: An object will remain at rest or continue moving at a constant velocity (or at constant speed in a straight line) unless acted upon by a non-zero external resultant force.
- Newton's Second Law of Motion: If a resultant net force acts on an object, the object will accelerate in the direction of the resultant force. The acceleration is directly proportional to the resultant force and inversely proportional to the mass of the object.
- Newton's Third Law of Motion: When object A exerts a force on object B, object B simultaneously exerts a force on object A, which is of equal magnitude but opposite in direction.

- Newton's Law of Universal Gravitation: A force of gravitational attraction exists between any two particles or objects anywhere in the universe. The magnitude of this force is directly proportional to the product of the objects' masses and is inversely proportional to the square of the distance between their centers.

1.3. Revision Work

A vector is a quantity that has both magnitude (size) and direction.
We can use bold type to represent a vector, R, or an arrow above the letter $\vec{R}$.

Vectors may be added or subtracted graphically by laying them head to tail / head to head on a set of axes.

Forces

When objects interact with each other, they exert forces on each other.

If a force acts on an object, it can cause a change to the object.

Some of the possible changes are:

- The shape of an object
- The object's state of rest
- The velocity of the object
- The direction in which the object moves
- The object's acceleration.

Force (→F) is a vector quantity. This means it has magnitude and direction.

It may be represented by an arrow in a vector diagram. The length of the arrow shows its magnitude and the angle shows its direction.

It is measured in the SI unit newton (N).

We show the force vector using $\vec{F}$.

F without an arrow represents the size of the force vector only.

Terminology dealing with Force

Repulsion: a force between objects that tends to separate them

Attraction: a force between objects that brings them together

We study these different forces:

1. Gravitational force or weight ($\vec{F}$g or $\overrightarrow{W}$)
2. Normal forces ($\vec{F}$N or $\vec{N}$)
3. Frictional forces ($\vec{F}$f)
4. Applied forces (push or pull)
5. Tension ($\vec{F}$T or $\vec{T}$)

Gravitational force ($\vec{F}$g or $\vec{a}$)

Gravitational force is the force of attraction that the Earth exerts on an object above its surface. Gravitational force acts downwards towards the center of the Earth.

The weight ($\vec{w}$) of an object is the same as the gravitational force ($\vec{F}_g$) on the object, so $\vec{F}_g = \vec{w}$.

The weight of an object is the product of the mass and the gravitational acceleration of the Earth. Thus: $\vec{w}$ = m $\vec{g}$ where m is mass and $\vec{g}$ is the acceleration due to gravity.

∴ $\vec{F}_g = \vec{w}$ = m $\vec{g}$ where $\vec{F}_g$ is gravitational force, $\vec{w}$ is the weight of an object, m $\vec{g}$ is mass × gravitational acceleration.

Normal force ($\vec{F}$N or $\vec{N}$)

When an object rests on a surface, the surface exerts a force on the object, called a normal force.

It is a contact force that acts at a right angle (90°) upwards from the surface.

In a force diagram, you show the object that is experiencing forces. The forces act on the body at its “center of gravity”. In a free body diagram, you do not show the object that is experiencing forces; in other words, you treat the object as a single point.

When an object is resting or moving on a horizontal surface the normal force will have the same magnitude, but an opposite direction to the weight of the object or gravitational force.

When an object is resting or moving on an inclined plane (surface), the normal force will have the same magnitude, but an opposite direction to the perpendicular component of the weight of the object or gravitational force.

Frictional force ($\vec{F}$f or $\vec{f}$)

Frictional force opposes motion. So, it works against the movement of an object.

Frictional force acts in the opposite direction to an object's motion or intended motion.

The rougher the surface, the more friction there is between the object and the surface.

The less rough the surface, the less friction there is between the object and the surface.

This means that the greater the magnitude of the normal force acting on the object, the greater the magnitude of the frictional force. Think of grinding something here. The harder you press, the more "normal" (perpendicular) force there is. Hence, when you are grinding something, e.g. crushing maize for making pap, it experiences strong normal (perpendicular) forces and thus strong frictional forces; hence it is ground up.

If an object is at rest, then there is a static frictional force.

If the object is moving, then there is kinetic frictional force.

The coefficient of friction (μ):

The coefficient of friction depends on the material of the two surfaces that are in contact.

Examples

- Steel on wet ice has a low coefficient of friction (slides easily).
- Rubber on tar has a higher coefficient of friction (more grip, less sliding).
- When an object is at rest on a horizontal surface and no force is applied to it, then there is no static friction.
- When a small force is applied to an object at rest, then the force of static friction increases as the applied force increases. As the force increases, the static friction continues to increase.
- This continues until the static friction reaches a maximum value – it cannot increase further. Eventually maximum static friction force is exceeded, and the object moves.
- The friction then decreases to a smaller value called the kinetic friction ($\vec{f}$k)
- The kinetic friction remains constant while the object moves at a constant speed.
- The kinetic friction remains smaller than the maximum static friction. fs ≤ μsFN and fk = μkFN

When an object moves along a surface inclined at an angle θ, the normal force is multiplied by the kinetic coefficient of friction to find the frictional force.

The kinetic coefficient is calculated using cos θ:$\vec{F}_N = \vec{F}_{g\perp} = m\vec{g}$. cos θ and $f_k = \mu_k \vec{F}_N$

An applied force is a force that a person or object applies to another object.
If a person is pushing a cart along the ground, then there is an applied force acting upon the object.

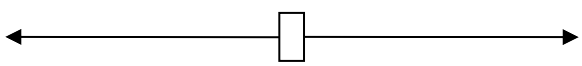
Tension (($\vec{F}$T or $\vec{T}$)

When an object is pulled by a rope (or string or cable), or hanging from a ceiling, the rope applies a force on the object. This force is called tension. It is a contact force and acts in the opposite direction to the 'pull'. If an object hangs from a rope, the direction of the tension is always upwards in the rope. This force complies with Newton's Third Law, in other words it is the reaction to the action of the pulling.

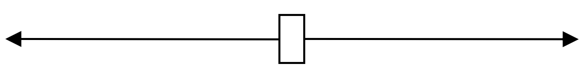
EXERCISE 1

Try the following. You will find the solutions at the end of this unit. In this exercise, forces will be represented by ⟶, as forces are vectors.

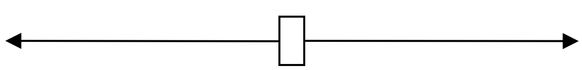
A Two forces act on a stationary object as shown. In which direction will it accelerate?



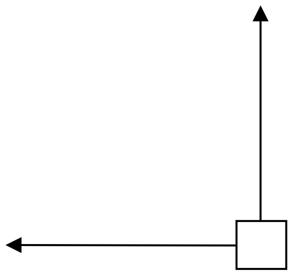
B Two forces, as shown, act on an object moving at 5 m.s^{-1} to the right. In which direction will the object move?



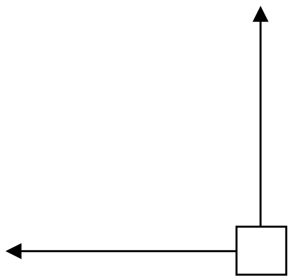
C Two forces, as shown, act on an object moving at 5 m.s^{-1} to the right. In which direction will the object accelerate?



D Two forces, as shown, act on an object moving at 5 m.s^{-1} to the right. In which direction will the object accelerate?

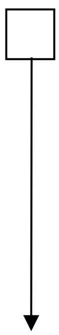


E Two forces, as shown, act on an object moving at 5 $m.s^{-1}$ to the right. In which direction will the object move?



F An object is moving at 5 $m.s^{-1}$ upwards and a force acts on it as shown. In which direction will it accelerate?

G An object is moving at 5 $m.s^{-1}$ upwards and a force acts on it as shown. In which direction will it move?



2. NEWTON'S LAWS DEFINED

Please check your work against the answers at the end of this unit, and then we can start to define Newton's Laws.

2.1. Newton's First Law of Motion (Law of Inertia)

A body at rest or in a state of uniform motion will continue in that state of rest or uniform motion unless acted on by a RESULTANT force.

Inertia is the property of an object that resists any change in the state of rest or uniform motion. If the object is at rest, it resists any change to a state of motion. If it is in motion, it resists any change to the speed and direction of its motion.

Inertia is determined by the object's mass. The greater an object's mass, the greater its inertia.

Example: A box lying in the boot of a car will move forwards when the car brakes. The box's inertia resists the change in movement and allows the box to continue moving in the direction in which the car was moving before it stopped. This is why you must wear seatbelts!

2.2. Newton's Second Law of Motion

When a resultant force acts on a body, that body will accelerate in the direction of the force. This acceleration is directly proportional to the resultant force and inversely proportional to the mass of the body. Thus, this law describes the relationship between the motion of an object and the net force exerted on that object.

It may:

- Start moving (then $\vec{v}_i = 0\ m \cdot s^{-1}$ and $\vec{v}_f \neq 0\ m \cdot s^{-1}$);
- Stop moving (come to rest, then $\vec{v}_f = 0\ m \cdot s^{-1}$);
- Move faster (accelerate); move slower (decelerate); or
- The direction in which it moves will change.

NB!

Newton's 1st and 2nd laws are very similar – in fact they really are the same Law.

Newton's 2nd law deals with the case when there is a resultant force and Newton's 1st law deals with the case when the resultant force is zero.

When stating Newton's 2nd law, you need to talk about the Resultant Force (not just an unbalanced force), the direction of acceleration, that the acceleration is proportional to the force and lastly that the acceleration is inversely proportional to the mass. This can be summarised by the wonderful equation: $F_R = ma$ Use this equation when the mass is constant.

The Equation

$F_R = ma$ (the resultant force is equal to the mass times the acceleration.)

Force has the units of N (newton), mass is in kg and acceleration in $m.s^{-2}$

Hence, 1 N = 1 $kg.m.s^{-2}$. $F_{net} = ma$ only applies to special cases when the mass stays constant. The motion of an object, and therefore its momentum, only changes when a net resultant force is applied on the object. Conversely, a net force causes an object's motion and, therefore, its momentum, to change.

Newton's Second Law in terms of momentum states that the net force acting on an object is equal to the rate of change in momentum of that object.

Thus: $F_{net} = \frac{\Delta p}{\Delta t}$

Example:

A player hits a hockey ball that is moving at $10 m.s^{-1}$ in an easterly direction from behind so that the ball moves at a speed of $12 m.s^{-1}$ in the original direction of motion. If the mass of the ball is 0.3kg, calculate the change in momentum of the ball. The direction stays the same, therefore the signs stay the same ($\rightarrow +$).

$$\Delta \boldsymbol{p} = \Delta(\boldsymbol{mv})$$
$$\Delta \boldsymbol{p} = \boldsymbol{mv_f} - \boldsymbol{mv_i}$$
$$\Delta \boldsymbol{p} = \mathbf{0.3(12) - 0.3(10)}$$
$$\Delta \boldsymbol{p} = \mathbf{0.6}\, \boldsymbol{kg.m.s^{-1}} \textbf{ east}$$

EXERCISE 2

Try the following. You will find the solutions at the end of this unit.

A Complete the following table:

F	**M**	**a**
	3 kg	2 $m.s^{-2}$
	5 kg	25 $m.s^{-2}$
50 N	250 kg	
10 N		0,2 $m.s^{-2}$
	300 g	20 $m.s^{-2}$

B A 2 kg block lies on a table, and Sipho pushes it to the right with a 30 N force. However, there is a 5 N force of friction opposing the motion.

1 What is the resultant force acting on the block?

2 What is the acceleration of the block?

3. DRAWING FREE BODY DIAGRAMS

NB! To draw Free Body/Force Diagrams:

1. Represent the object by a small box or circle.
2. Show each force as an arrow coming out from the object.
3. Each arrow must touch the object.
4. If the forces are meant to be equal, draw the arrows equal lengths, or show them as equal by using a "-" through the equal forces, as shown on the left.
5. If you need to label the forces, use full labels e.g. "tension A" not just T_A.

4. WAIT – WHAT ABOUT WEIGHT?

When we deal with vertical motion, we need to take weight into consideration, after all weight is the gravitational FORCE of attraction between a body and the earth. If the body is moving (or accelerating) horizontally, then the weight will be cancelled by an upward force, such as the force of the table on the book. But if the book is falling, then we need to consider its weight.

EXERCISE 3

Try the following. You will find the solutions at the end of this unit.

A Tshepo pulls a cart along a road, using a rope. He exerts a 1000 N force eastward, but there is a 200 N frictional force opposing the motion.

1) Draw a labelled free body diagram showing all the forces acting on the cart.

2) Calculate the acceleration of the cart.

B A crane lifts a 1000 kg box off the deck of a ship. The crate accelerates at 0,25 $m.s^{-2}$.

1) What is the weight of the box?

2) What is the resultant force acting on the crate?

3) What force does the crane apply to the box?

SOME TRICKIER EXAMPLES

If we consider the interaction of two or three bodies, it is often best to solve them by doing a free body diagram for each. Then the equations can be solved.

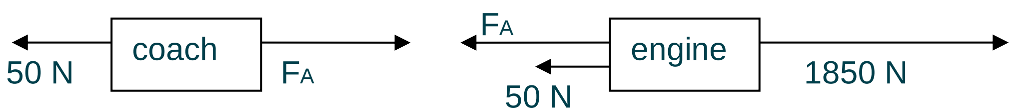
Example: A train engine, mass 2 500 kg, pulls a coach of mass 1 000 kg to the right. The engine can produce 1 850N force. There is a 50 N frictional force between both the engine and the coach and the track.

Draw a free body diagram for the engine and for the coach to show the horizontal forces.

Calculate the acceleration of the engine.

Calculate the force that the engine applies to the coach.

Answer:



Now we apply $F_R = ma$ to each situation

FR = ma

$F_A - 50 = 1000.a$

$F_A = 1000.a + 50$

FR = ma

$1850 - 50 - F_A = 2500.a$

$1800 - F_A = 2500.a$

Solve the simultaneous equations – I will plug the (1000a + 50) into the 2nd equation instead of the F_A.

$1800 - (1000a + 50) = 2500a$

$1800 - 1000a - 50 = 2500a$

$1750 = 3500a$

$a = 0{,}50\ m.s^{-2}$ to the right

We can now solve for F_A

$F_A = 1000.(0{,}50) + 50$

$= 550$ N to the right

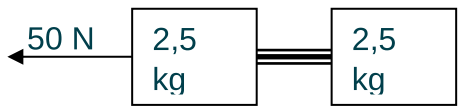
EXERCISE 4

Try the following. You will find the solutions at the end of this unit.

A Two blocks, each 2,5 kg are tied together by a rope on a flat surface, as shown. The block on the left is pulled to the left by a 50 N force.

1) What is the acceleration of the system?

2) What force does the rope exert on the 2nd block?



B If the blocks in question A each have a 5 N friction surface between them and the surface,

1) What is the acceleration of the system?

2) What force does the rope exert on the 2nd block?

MEMORANDUM TO EXERCISES 1 – 4

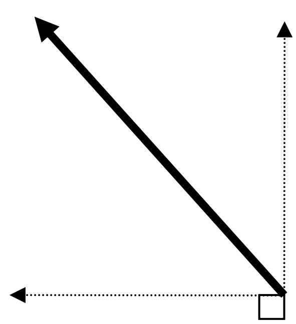
EXERCISE 1

A As the forces are equal, but in opposite directions, there is no resultant force. Hence the object will **not** accelerate.

B Again, the forces are equal, so there is no resultant force and NO acceleration, and so the object continues to move at 5 $m.s^{-1}$ to the right.

C Again, the forces are equal, so there is no resultant force and NO acceleration.

D The object will accelerate in the direction of the resultant force, which is in the direction of the dark, bold line.



E The object will continue to move to the right, but its motion will change in the direction of the resultant force (as shown in D above.) Eventually, the motion will be up and to the left, and increasing in speed in that direction.

F The object will accelerate downwards as the resultant force is downwards.

G The object will continue to move upwards for a while, but eventually will start to move downwards.

EXERCISE 2

A Complete the following table:

F	**m**	**A**
6 N	3 kg	2 $m.s^{-2}$
125 N	5 kg	25 $m.s^{-2}$
50 N	250 kg	**0,2 $m.s^{-2}$**
10 N	**50 kg**	0,2 $m.s^{-2}$
6,0 N	300 g	20 $m.s^{-2}$

B

1 F_R = 25 N to the right

2 $F_R = m.a$

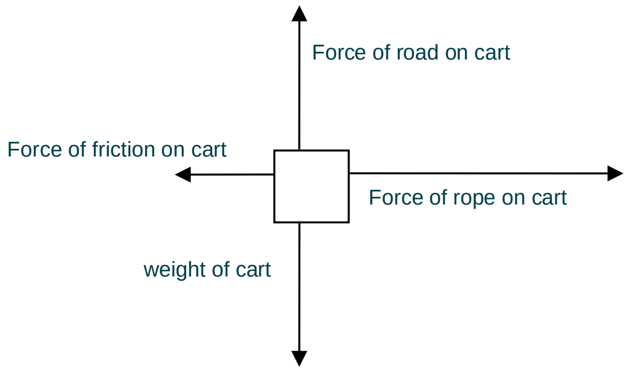
$28 = 2.a$

$a = 14.m.s^{-2}$ to the right

EXERCISE 3

A.

1)



2) $F_R = ma$

(1 000 – 200) = 150.a

a = 5,33 m.s^{-2} eastward

B.

1) Weight = 10 000N

2) $F_R = ma$

= 1 000. 0,25

= 250 N upwards

3) $F_R = F_A$ – Weight

250 = F_A – 1 000

F_A = 1 250 N upwards.

EXERCISE 4

A. 1) 10 m.s.$^{-2}$ left

2) 25 N left

B. 1) 8 $m.s^{-2}$ left

2) 25 N left

5. NEWTON'S THIRD LAW OF MOTION

5.1 Introduction

Imagine that you run into a door headfirst, which then swings closed. The door's motion changed – it was stationary, then it swung closed. So, you must have exerted a force on it.

But your head hurts! That is because the door exerted a force on you (also your motion changed – you were running, then you stopped.) So, you exerted a force on the door and it exerted a force on you. How are these two forces related?

1 The forces act on DIFFERENT objects – one force acted on the door; the other force acted on you!

2 The forces act in opposite directions – you pushed the door the one way (it then swung around on its hinges) and it pushed you the other way.

3 The forces were equal in size. That does not mean that the door was as sore as you, or that you accelerated as much as the door did, but the forces were of equal size. The acceleration of each object depends on the mass of the object and the existence of other forces acting on that object, and how much it hurts depends upon physiology.

Newton considered this type of situation, and in fact any situation where a force acts and discovered his 3rd law.

5.2 Definition: Newton's Third Law

When body A exerts a force on body B, body B exerts an equal but opposite force on body A.

Sometimes this is called the law of action and reaction forces, but this is not a good name – it is not clear enough. Rather call it Newton 3 and use the full statement of the law – it may take a bit longer, but it will help you in the end.

For a third law forces pair:

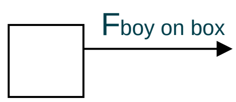
- The forces are equal in magnitude.
- The forces act in the same straight line but in opposite directions on different objects.
- The forces do not cancel each other, as they act on different objects.

6. IDENTIFYING THE NEWTON 3 PAIRS

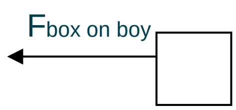
Identifying the correct pair of forces is often a problem that is posed in the exam – but it is easy to solve if you apply the full names of the forces.

Example: A boy pushes on a box with a force of 70 N eastward. What is the Newton 3 pair to this force? Show the forces using relevant, labelled force diagrams.

Solution: The full name of the force on the box is: 70 N force of boy **on** box.



So, the Newton 3 pair is 70 N force of box **on** boy.



The forces act in opposite directions; if the boy on the box is eastward, the box on the boy is westward

EXERCISE 5

Try the following. You will find the solutions at the end of this unit.

Find the Newton 3 Pairs to the following forces:

A The 500 N downward force of Sipho on his chair.

B The 20 N fiction force that the ground exerts on a box, opposite to the direction of the motion of the box.

C The 400 N upward force the ground exerts on Nancy.

D The 70 N force a girl exerts on the ground with her foot, as she pushes off to start running.

E The 600 N weight of Zoleka.

7. OTHER EXAMPLES IN NEWTON 3

A lot of the motion that we observe is easier to describe in terms of Newton's Third Law than any other terms. Take the acceleration of a bullet down the barrel of a gun as an example.

When the gun is fired, the gun powder at the back of the bullet explodes, causing large amount of hot gas, which wants to expand rapidly.

However, the bullet is blocking the path of the expanding gas – it is pushing the gas inwards. So, the gas pushes the bullet outwards, hence there is a (resultant) force on the bullet, and it accelerates.

8. A WARNING

You need to notice that Newton three pairs act on different objects (remember the three statements in the introduction.) And a 10 N force on Joe cannot cancel a 10 N force on Thabo!

This statement is easy but causes a lot of trouble if not properly understood – try the problems below to check yourself out.

EXERCISE 6

Try the following Interesting Problems. You will find the solutions at the end of this unit.

A Explain how a rocket in deep space (where there is no atmosphere) can use its engines to accelerate.

B Explain how a rocket that is taking off from the launch pad can use its engines to accelerate.

C A farmer tied his little cart to his donkey. But the donkey turned around and said to the farmer "This is not going to work! As hard as I try to pull the cart forward, the cart will pull me back with the same force. So, I pull forward and the cart pulls back, and so there will be no resultant force and we will never move. I am not even going to try." Did the donkey really understand Newton's 3rd Law? Explain your answer.

9. A LAST WORD

Often this section on Newton's Laws is used as an integrated section and you must expect to see equations of motion included in typical Newton two problems.

Example: A 2,1 kg block falls off the edge of a wall 2,45 m high. When it strikes the ground, it sinks 3,5 cm into the soil.

With what velocity does the block hit the ground?

What force does the ground apply in stopping the brick?

Solution

When the block is falling:

u = 0 v = ? a = 10 (down) s = 2,45 m = 2,1

$v^2 = u^2 + 2as$

$= 0^2 + 2.(10).(2,45)$

$= 49$

$v = 7\ m.s^{-1}$ downwards

Once it hits the ground:

u = 7 (v from fall) v = 0 a = ? s = 0,035

$v^2 = u^2 + 2as$

$0^2 = 49 + 2.a.0,035$

$a = (-49)/(0,07)$

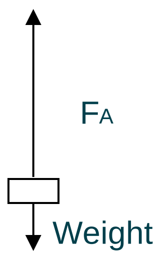
a = 700 N up

So $F_R = ma$

$= 2.\ 700$

$= 1400$ N up

But this is not the final answer – the question did not ask for the resultant force but the applied force – we need a force diagram.



$F_R = F_A - \text{Weight}$

$1400 = F_A - 21$

$F_A = 1421$ N upwards!

This is a very tricky question – you will not get a harder one in the exam. But it shows how they can integrate the sections.

EXERCISE 7

Try the following. You will find the solutions at the end of this unit.

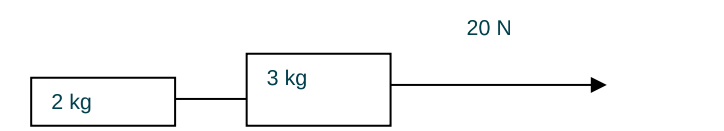
A State Newton's Second Law of Motion

B A marble, mass 100 g, falls from a height of 20m into soft sand. It sinks 15 cm into the sand. Calculate:

1 The velocity of the marble as it hits the sand.

2 The average resultant force acting on the marble in the sand.

C Two blocks are arranged as shown in the diagram below. A 20 N force is applied to the block on the right, and a 5 N frictional force acts on each of the blocks.



Calculate:

1 The tension in the string between the blocks.

2 The acceleration of the blocks.

MEMORANDUM TO EXERCISES 5 - 7

EXERCISE 5

A The 500 N upward force of the chair on Sipho

B The 20 N fiction force that the box exerts on the ground, in the direction of the motion of the box.

C The 400 N downward force Nancy exerts on the ground.

D The 70 N force the ground exerts on the girl’s foot.

E Weight is really the earth’s felt gravitational attraction on an object. Hence 600 N weight is really the 600 N downward force of the earth (not the ground) on Zoleka. So, the Newton 3 pair is “the 600 N upward force of attraction that Zoleka exerts on the earth.”

EXERCISE 6

A As the rocket fires its engines it pushes its exhaust gases backwards. By Newton 3, these gases push the rocket forwards. In the absence of other forces acting on the rocket, it accelerates.

B As the rocket fires its engines it pushes its exhaust gases backwards. By Newton 3, these gases push the rocket forwards. As there are other large forces acting on the rocket (friction and gravity), the force the rocket exerts on the exhaust gases needs to be large, so that the Newton 3 force of gases on rocket will be large, so the rocket will accelerate.

C The donkey is wrong – the force it exerts on the cart CANNOT cancel the force that cart exerts on it – they are acting on different objects! The cart will accelerate so long as the donkey exerts a large enough force on the cart for there to be a resultant force (i.e. he has to overcome friction on the cart) and the donkey will accelerate if there is a resultant force on it (i.e. he has to push on the ground hard enough for the ground's forward push on him to be larger than the cart’s pull on him).

EXERCISE 7

A If a resultant force acts on a body the body accelerates in the direction of the force. This acceleration will be proportional to the resultant force, and inversely proportional to the mass of the body.

B.1 $v_2 = u_2 + 2as$ ✓

$= 0 + 20.20$ ✓

$v = 20\ m.s^{-1}$ ✓ down ✓

B.2 $v^2 = u^2 + 2as$ ✓