# Telematic Schools Project

# 2022 SUBJECT WORKBOOK
# Grade 12

## PHYSICAL SCIENCES

A joint initiative between the Western Cape Education Department and Stellenbosch University.

Western Cape Government
Education

Stellenbosch
UNIVERSITY
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## BROADCAST SESSIONS

| Session | Date | Time | Topic |
|---|---|---|---|
| **1** | **28 FEBRUARY 2022** | **16H00 – 17H00** | **MOMENTUM** |
| 2 | 19 JULY 2022 | 15H00 – 16H00 | ACIDS AND BASIS |

# INTRODUCTION AND TOPICS

**TOPICS**

MOMENTUM

ACIDS AND BASIS

| Topics | Description |
|---|---|
| **TOPIC** | **MOMENTUM AS A VECTOR** |
| TOPIC | MOMENTUM AND IMPULSE |
| **TOPIC** | **CONSERVATION OF MOMENTUM** |
| TOPIC | CONJUGATE ACID – BASE PAIRS |
| **TOPIC** | **NEUTRALIZATION** |

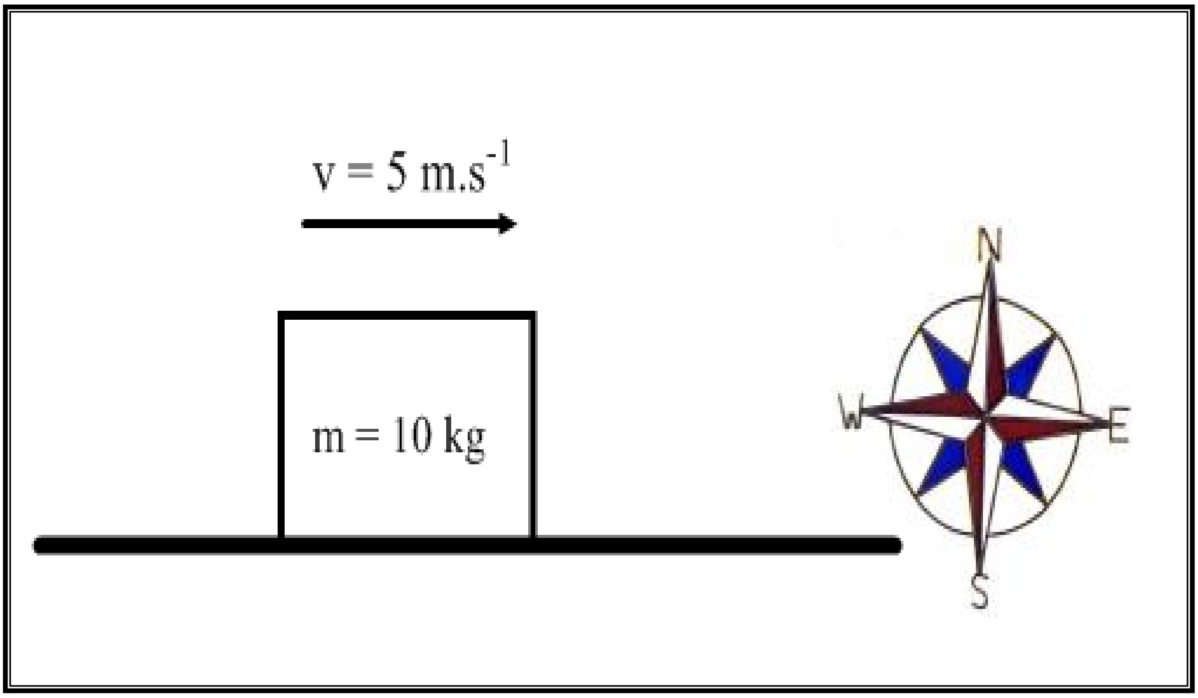
## TERMINOLOGY

| Term | Definition |
|---|---|
| **Define momentum.** | |
| **Definition of Impulse** | |
| **Principle of conservation of linear momentum** | |
| **Definition of an elastic collision** | |
| **Definition of an inelastic collision** | |
| **Newton's Second law in terms of change in momentum** | |
| **Newton's Third Law of motion** | |

**TAKE NOTE**

Momentum is defined as the product of the mass and velocity of an object.
p - momentum
m – mass
v – velocity
p = mv

Example: An object, mass 10 kg, moves with a constant velocity of 5 m.s-1 due east as shown in the sketch below.




The momentum of the object is calculated as follows.
P = mv
= 10 x 5
= 50 kg.m.s-1 east

NOTE: Momentum is a vector quantity and the direction must be indicated.

## TAKE NOTE

The change in momentum is equal to the impulse of the object.

Impulse is defined as the product of the force and contact time of the force. If the above collision of the ball with the wall lasts 0.1 s, then we can calculate the force that the wall exerts on the ball as follows:

FnettΔt = Δp ……………(1)
Fnett x 0.1 = -5
Fnett = -50 N ( ie 50 N to the left or away from the wall.

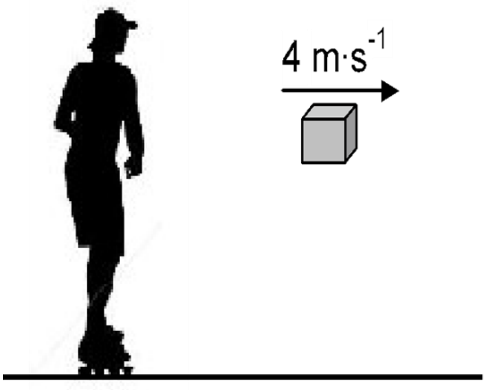
Rearranging equation 1 we get: Fnet = $\frac{\Delta P}{\Delta t}$ … (2)

State Newton's second law in terms of momentum:
The net force acting on an object is equal to the rate of change of momentum.

**TAKE NOTE**

**QUESTION 1**

Initially a girl on roller skates is at rest on a smooth horizontal pavement. The girl throws a parcel, of mass 8 kg, horizontally to the right at a speed of 4 m·s-1. Immediately after the parcel has been thrown, the girl-roller-skate combination moves at a speed of 0,6 m·s-1. Ignore the effects of friction and rotation.




1.1 Define the term momentum in words.
(2)

1.2 Will the girl-roller-skate combination move TO THE RIGHT or TO THE LEFT after the parcel is thrown?
NAME the law in physics that can be used to explain your choice of direction. (2)

The total mass of the roller skates is 2 kg.

1.3 Calculate the mass of the girl. (5)

1.4 Calculate the magnitude of the impulse that the girl-roller-skate combination is experiencing while the parcel is being thrown. (3)

1.5 Without any further calculation, write down the change in momentum experienced by the parcel while it is being thrown.
(2)

[14]

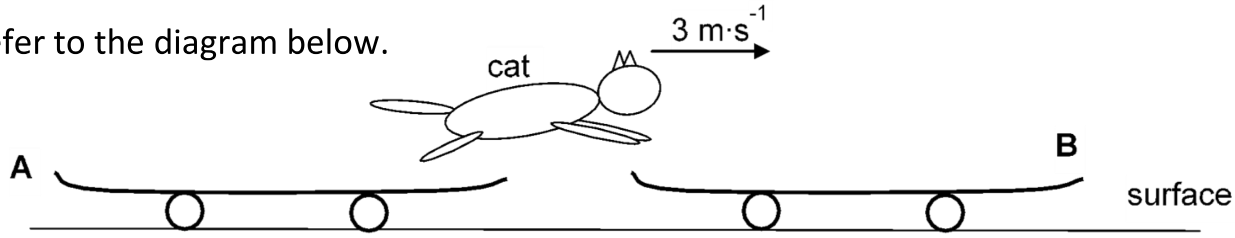
**QUESTION 2**

The diagram below shows two skateboards, **A** and **B**, initially at rest, with a cat standing on skateboard **A**. The skateboards are in a straight line, one in front of the other and a short distance apart. The surface is flat, frictionless and horizontal.


2.1 State the *principle of conservation of linear momentum* in words. (2)

EACH skateboard has a mass of 3,5 kg. The cat, of mass 2,6 kg, jumps from skateboard **A** with a horizontal velocity of 3 $m \cdot s^{-1}$ and lands on skateboard **B** with the same velocity of 3 $m \cdot s^{-1}$.

Refer to the diagram below.




2.2 Calculate the velocity of skateboard **A** just after the cat has jumped from it. (5)

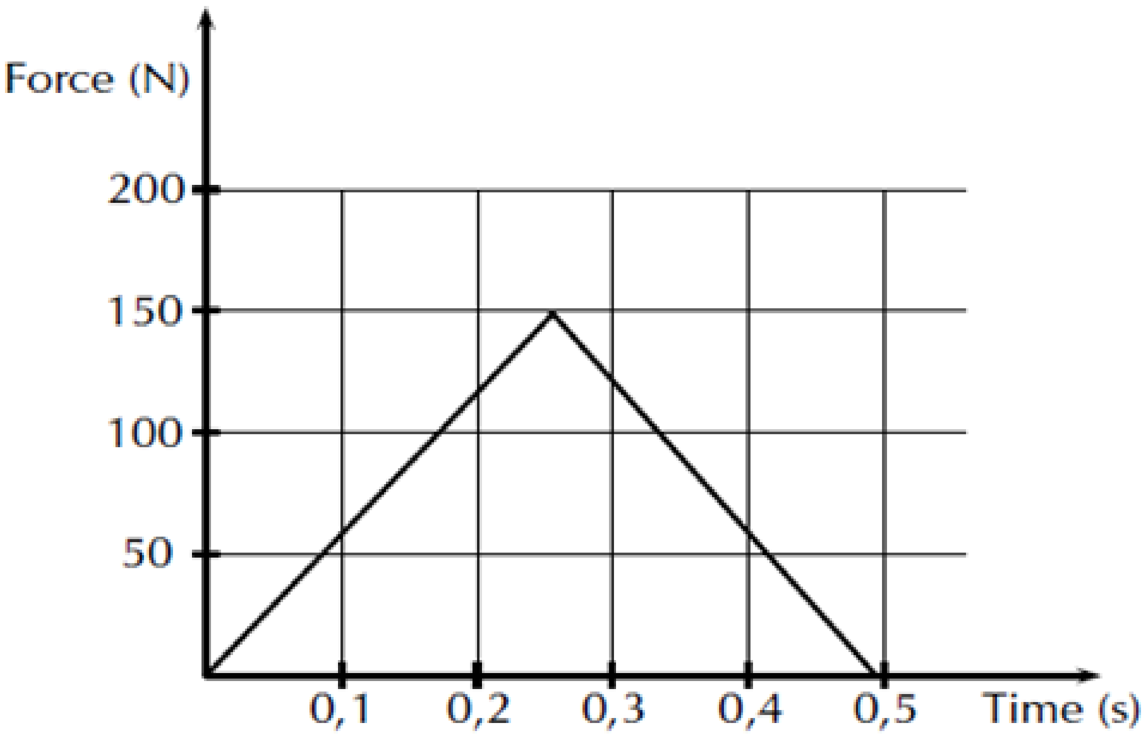
Immediately after the cat has landed, the cat and skateboard **B** move horizontally to the right at 1,28 $m \cdot s^{-1}$.

2.3 Calculate the magnitude of the impulse on skateboard **B** as a result of the cat's landing. ((3)

**[10]**

## Question 3

During a game of hockey, a player strikes a stationary ball of mass 150 g. The graph below shows how the force of the ball varies with the time.




3.1 What does the area under this graph represent?

3.2 Calculate the speed at which the ball leaves the hockey stick.

3.3 The same player hits a practice ball of the same mass, but which is made from a softer material. The hit is such that the ball moves off with the same speed as before. How will the area, the height and the base of the triangle that forms the graph, compare with that of the original ball?

## TAKE NOTE

### Momentum

- Define momentum as… the product of an object's mass and its velocity.
- Describe linear momentum as …. a vector quantity with the same direction as the velocity of the object.
- Calculate the momentum of a moving object using p = mv.
- Describe the vector nature of momentum and illustrate it with some simple examples.
- Draw vector diagrams to illustrate the relationship between the initial momentum, the final momentum and the change in momentum for each of the cases above.

### Newton's second law in terms of momentum

- State Newton's second law of motion in terms of momentum: The net (or resultant) force acting on an object is equal to the rate of change of momentum of the object in the direction of the net force.
- Express Newton's second law of motion in symbols: $F_{net} = \Delta P/\Delta t$
- Explain the relationship between net force and change in momentum for a variety of motions.
- Calculate the change in momentum when a resultant/net force acts on an object and its velocity:
    - Increases in the direction of motion, e.g. 2nd stage rocket engine
    - fires
    - Decreases, e.g. brakes are applied
    - Reverses its direction of motion, e.g. a soccer ball kicked back in the direction it came from

**Impulse**

- Define *impulse* as the product of the resultant/net force acting on an object and the time the net force acts on the object.
- Use the impulse-momentum theorem, $F_{net}\Delta t = m\Delta v$, to calculate the resultant/net force exerted, the time for which the force is applied and the change in momentum for a variety of situations involving the motion of an object in one dimension.
- Explain how the concept of impulse applies to safety considerations in everyday life, e.g. airbags, seatbelts and arrestor beds.

**Conservation of momentum and elastic and inelastic collisions**

- Explain what is meant by a *system* (in Physics).
- Explain (when working with systems) what is meant by *internal* and *external forces*.
- Explain what is meant by *an isolated system* (in Physics), i.e. a system on which the net external force is zero. (An isolated system excludes external forces that originate outside the colliding bodies, e.g. friction. Only internal forces, e.g. contact forces between the colliding objects, are considered.)
- State the principle of conservation of linear momentum: The total linear momentum of an isolated system remains constant (is conserved).
- Apply the conservation of momentum to the collision of two objects moving in one dimension (along a straight line) with the aid of an appropriate sign convention.
- Distinguish between *elastic collisions* and *inelastic collisions* by calculation.

## TERMINOLOGY

| Term | Definition |
| --- | --- |
| **Define *acids* and *bases* according to Arrhenius and Lowry-Brønsted:** | Arrhenius theory: An acid is a substance that produces hydrogen ions ($H^+$)/hydronium ions ($H_3O^+$) when it dissolves in water. A base is a substance that produces hydroxide ions ($OH^-$) when it dissolves in water.<br>Lowry-Brønsted theory: An acid is a proton ($H^+$ ion) donor.<br>A base is a proton ($H^+$ ion) acceptor. |
| **Distinguish between *strong acids* and *weak acids* with examples.** | Strong acids ionise completely in water to form a high concentration of $H_3O^+$ ions. Examples of strong acids are hydrochloric acid, sulphuric acid and nitric acid.<br>Weak acids ionise incompletely in water to form a low concentration of $H_3O^+$ ions. Examples of weak acids are ethanoic acid and oxalic acid. |
| **Distinguish between *strong bases* and *weak acids* with examples.** | Strong bases dissociate completely in water to form a high concentration of $OH^-$ ions. Examples of strong bases are sodium hydroxide and potassium hydroxide.<br>Weak bases dissociate/ionise incompletely in water to form a low concentration of $OH^-$ ions.<br>Examples of weak bases are ammonia, calcium carbonate, potassium carbonate, calcium carbonate and sodium hydrogen carbonat |
| **Distinguish between *concentrated acids/bases* and *dilute acids/bases*.** | Concentrated acids/bases contain a large amount (number of moles) of acid/base in proportion to the volume of water. Dilute acids/bases contain a small amount (number of moles) of acid/base in proportion to the volume of water. |

**QUESTION 1**

1.1 The balanced equation below represents the first step in the ionisation of sulphuric acid (H2SO4) in water:

H2SO4(ℓ) + H2O(ℓ)    H3O+(aq) + HSO 4▯ (aq)

1.1.1 Write down the FORMULAE of the TWO bases in the equation above.

(2)

1.1.2 Is sulphuric acid a STRONG or a WEAK acid?
Give a reason for the answer. (2)

1.2 Learners use the reaction of a 0,15 mol·dm-3 sulphuric acid solution with a sodium hydroxide solution in two different experiments.

The balanced equation for the reaction is:

H2SO4(aq) + 2NaOH(aq) → Na2SO4(aq) + H2O(ℓ)

1.2.1 They use 24 cm3 of H2SO4(aq) in a titration to neutralise 26 cm3 of NaOH(aq).

Calculate the concentration of the NaOH(aq).
(5)

1.2.2 In another experiment, 30 cm3 of the H2SO4(aq) is added to 20 cm3 of a 0,28 mol·dm-3 NaOH solution in a beaker.

Calculate the pH of the final solution. (8)

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**QUESTION 2**

2.1 Ethanoic acid ($CH_3COOH$) is an ingredient of household vinegar.

2.1.1 Is ethanoic acid a WEAK acid or a STRONG acid? Give a reason for the answer. (2)

2.1.2 An ethanoic acid solution has a pH of 3,85 at 25 °C. Calculate the concentration of the hydronium ions, $H_3O^+(aq)$, in the solution. (3)

2.1.3 Sodium ethanoate, $CH_3COONa(aq)$, forms when ethanoic acid reacts with sodium hydroxide.

2.1.4 Will the pH of a sodium ethanoate solution be GREATER THAN 7, LESS THAN 7 or EQUAL TO 7?

(1)

2.1.5 Explain the answer to QUESTION 7.1.3 with the aid of a balanced chemical equation.

(3)

2.2 Household vinegar contains 4,52% ethanoic acid, $CH_3COOH$ by volume.
A 1,2 g impure sample of calcium carbonate ($CaCO_3$) is added to 25 $cm^3$ household vinegar. On completion of the reaction, the EXCESS ethanoic acid in the household vinegar is neutralised by 14,5 $cm^3$ of a sodium hydroxide solution of concentration 1 $mol \cdot dm^{-3}$. The balanced equation for the reaction is:

$$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(\ell)$$

2.2.1 Calculate the number of moles of the unreacted ethanoic acid. (3)

Calcium carbonate reacts with ethanoic acid according to the following balanced equation:

$$CaCO_3(s) + 2CH_3COOH(aq) \rightarrow (CH_3COO)_2Ca(aq) + H_2O + CO_2(g)$$

2.2.2 Calculate the percentage calcium carbonate in the impure sample if 1 $cm^3$ of household vinegar has a mass of 1 g.

(8)

**[20]**

## Acid-base reactions

- Write down the reaction equations of aqueous solutions of acids and bases. Examples:
  $HC\ell(g) + H_2O(\ell) \rightarrow H_3O^+(aq) + C\ell^-(aq)$ ($HC\ell$ is a monoprotic acid.)

  $NH_3(g) + H_2O(\ell) \rightarrow NH_4^+(aq) + OH^-(aq)$

  $H_2SO_4(aq) + 2H_2O(\ell) \rightarrow 2H_3O^+(aq) + SO_4^{2-}(aq)$ ($H_2SO_4$ is a diprotic acid.)

- Identify conjugate acid-base pairs for given compounds.
- Describe a substance that can act as either acid or base as ampholyte. Water is a good example of an ampholyte substance. Write equations to show how an ampholyte substance can act as acid or base.
- Write down neutralisation reactions of common laboratory acids and bases.

Examples: $HC\ell(aq) + NaOH(aq)/KOH(aq) \rightarrow NaC\ell(aq)/KC\ell(aq) + H_2O(\ell)$

$HC\ell(aq) + Na_2CO_3(aq) \rightarrow NaC\ell(aq) + H_2O(\ell) + CO_2(g)$

$HNO_3(aq) + NaOH(aq) \rightarrow NaNO_3(aq) + H_2O(\ell)$

$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(\ell)$

$(COOH)_2(aq) + NaOH(aq) \rightarrow (COO)_2Na_2(aq) + H_2O(\ell)$

$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(\ell)$

**NOTE:** The above are examples of equations that learners will be expected to write from given information. However, any other neutralisation reaction can be given in the question paper to assess, e.g. stoichiometry.

**Hydrolysis**

- Define hydrolysis as the reaction of a salt with water.

- Determine the approximate pH (equal to, smaller than or larger than 7) of salts in salt hydrolysis.
  - o Hydrolysis of the salt of a weak acid and a strong base results in an alkaline solution, i.e. the pH > 7. Examples of such salts are sodium ethanoate, sodium oxalate and sodium carbonate. o Hydrolysis of the salt of a strong acid and a weak base results in an acidic solution, i.e. the pH < 7. An example of such a salt is ammonium chloride. o The salt of a strong acid and a strong base does not undergo hydrolysis and the solution of the salt will be neutral, i.e. pH = 7.

**Acid-base titrations**

- Motivate the choice of a specific indicator in a titration. Choose from methyl orange, phenolphthalein and bromothymol blue.

- Define the equivalence point of a titration as: the point at which the acid/base has completely reacted with the base/acid.

Define the endpoint of a titration as:

- the point where the indicator changes colour.

- Perform stoichiometric calculations based on titrations of a strong acid with a strong base, a strong acid with a weak base and a weak acid with a strong base. Calculations may include percentage purity.

- For a titration, e.g. the titration of oxalic acid with sodium hydroxide:

o List the apparatus needed or identify the apparatus from a diagram.
o Describe the procedure to prepare a standard oxalic acid solution.
o Describe the procedure to conduct the titration.
o Describe safety precautions.
o Describe measures that need to be in place to ensure reliable results.
o Interpret given results to determine the unknown concentration.