### LESSON SUMMARY FOR:  DATE STARTED:  DATE COMPLETED:

**LESSON OBJECTIVES**

At the end of this lesson learners should know:

- The meaning of frame of reference

The following results will be the outcome of this lesson:

- Learners must be able to define a frame of reference
- Learners must be able to give examples of the importance of specifying the frame of reference
- Learners must be able to define relative velocity

### TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED
---|---|---|---
1. **TEACHING METHOD USED IN THIS LESSON**
- Question and answer, Explanation

2. **LESSON DEVELOPMENT**

#### 2.1 Introduction

- Pre-knowledge
  - Position, displacement, velocity

- Baseline questions
  - Describe position
  - Define displacement
  - Define velocity

#### 2.2 Main Body (Lesson presentation)

- Lesson starts with the educator asking the learners the baseline questions.
- Educator and learners discuss the following answers to the baseline questions:
  - Position is the place where one finds an object. The position of an object can only be described if there is a second point that can be used as a reference
  - Displacement is defined as a straight line distance from start to finish
  - Velocity is the rate of change of displacement.
- Educator discuss and explain the following to the learners:

1. Learners answer the baseline questions.
2. Learners take notes from the board.
3. Learners write the classwork

**Classwork**

1. Explain the following terms
   - a) frame of reference
   - b) relative velocity
2. John sits in a train which is moving north at $5 \text{m}\cdot\text{s}^{-1}$. On another train on the next track, Sue is walking South at $2 \text{m}\cdot\text{s}^{-1}$ relative to the floor of the coach. Sue’s train is moving north at $6 \text{m}\cdot\text{s}^{-1}$. To John it would seem as though

**TIMING**

5 min 30 min 15 min

**RESOURCES NEEDED**

Chalkboard
Frame of reference

- A frame of reference is a set of reference points that allows us to give the position or velocity of an object at any given point.
- In other words, the direction of an object must be compared to some fixed point and this point is called the point of reference.
- For example, when it is said that a bird flies at 4 m/s, it is implied that the earth is stationary and the bird flies at 4 m/s relative to the earth.
- The frame of reference, however, may not always be stationary.

Frames of reference in displacement

- Consider an object travelling at a constant velocity as shown by the arrows in the diagram below:

  ![Diagram](image)

  - Distance from A to B = distance from A to C = 100 m
  - The point of reference (starting point) is point A.
  - The displacement, with reference to A, when the object is
    - moving from A to B – increasing to the right
    - at B – 100 m to the right
    - at A – zero
    - moving from A to C – decreasing to the left
    - at C – 100 m to the left

Frames of reference in velocity

If you consider a passenger sitting in a car that is moving at 60 km/h, this means that the passenger is moving at 60 km/h relative to the earth. The passenger is not moving, relative to the car.

Example

Sipho is travelling in a train and he decides to walk towards the back of the train at 2 m/s.

<table>
<thead>
<tr>
<th>Question</th>
<th>Option A</th>
<th>Option B</th>
<th>Option C</th>
<th>Option D</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Consider an object being thrown upwards and reaches a maximum height of 10 m. What is the displacement of the object halfway downwards?</td>
<td>5 m downwards</td>
<td>5 m upwards</td>
<td>15 m upwards</td>
<td>15 m downwards</td>
</tr>
<tr>
<td>4. The velocity of a moving motorboat as observed from a moving jet ski is called its</td>
<td>relative velocity</td>
<td>associated velocity</td>
<td>differential velocity</td>
<td>comparative velocity</td>
</tr>
<tr>
<td>5. When car A, is travelling at 20 m/s, approaches car B, travelling at 18 m/s in the opposite</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
The train moves forward at 15 m\(\cdot\)s\(^{-1}\). How fast is Sipho travelling relative to

- the train
- the ground

**Solution**

- He is travelling at 2 m\(\cdot\)s\(^{-1}\) toward the back of the train (the train is taken as stationary relative to his movement)
- He is travelling at 13 m\(\cdot\)s\(^{-1}\) (15 - 2 = 13) in the direction of the train (the ground is taken as stationary and the algebraic sum of the vector is taken)

**2.3 Conclusion**

- Ask learners about the main aspects of the lesson i.e. frame of reference.
- Give learners classwork
<table>
<thead>
<tr>
<th>SOLUTIONS</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
</tr>
<tr>
<td>a) It is a point of origin or zero point with a set of directions.</td>
</tr>
<tr>
<td>b) When velocities are measured relative to frame of reference</td>
</tr>
<tr>
<td>2. A</td>
</tr>
<tr>
<td>3. B</td>
</tr>
<tr>
<td>4. A</td>
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<tr>
<td>5. A</td>
</tr>
<tr>
<td>6. D</td>
</tr>
<tr>
<td>7. D</td>
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</table>

Reflection/Notes:

Name of Teacher:  

HOD:  

Sign:  

Sign:  

Date:  

Date:
## Lesson Plan

### Lesson Objectives
At the end of this lesson learners should know
- The meaning of frame of reference

The following results will be the outcome of this lesson
- Learners must be able to define a frame of reference
- Learners must be able to give examples of the importance of specifying the frame of reference
- Learners must be able to define relative velocity
- Learners must be able to specify the velocity of an object relative to different frames of reference
- Learners must be able to use vectors to find the velocity of an object that moves relative to something else that is itself moving

### Teacher Activities

<table>
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<td>Question and answer, Explanation</td>
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### Lesson Development

#### 2.1 Introduction
Pre-knowledge
- Frame of reference, relative velocity

Baseline questions
- Define frame of reference
- Define relative velocity

#### 2.2 Main Body (Lesson presentation)
- Lesson starts with the educator asking the learners the baseline questions.
- Educator and learners discuss the following answers to the baseline questions
  - It is a point of origin or zero point with a set of directions
  - When velocities are measured relative to a frame of reference.
- Educator give learners the following consolidation exercise
- Consolidation exercise
  1. A train moves at 50 km\(\cdot\)h\(^{-1}\). Susan wants to buy sweets and walks to the front of the train at 14.4 m\(\cdot\)s\(^{-1}\), past Alice who is sitting quietly.
  1.1 What is Susan’s velocity to the train in km\(\cdot\)h\(^{-1}\)?

### Learner Activities

<table>
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<tr>
<td>1. Learners answer the baseline questions.</td>
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<tr>
<td>2. Learners write the consolidation exercise</td>
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### Timing

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<tr>
<td>5 min</td>
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<tr>
<td>35 min</td>
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</tbody>
</table>

### Resources Needed
- Chalkboard
1.2 What is Susan’s velocity relative to Alice in km•h⁻¹?
1.3 What is Susan’s velocity to the ground?
1.4 After having bought sweets, Susan walks to her seat at the same velocity.
   What is her velocity relative to the ground now?
2. John and Peter, who are a distance apart on a straight road, starts moving
   towards each other. John walks at a speed of 1 m•s⁻¹ and Peter at a speed
   of 2m•s⁻¹.
   2.1 What is John’s velocity relative to Peter?
   2.2 What is Peter’s velocity relative to John?
3. A girl sitting in a train which is moving eastward at 100 km•h⁻¹. An aeroplane
   flying in a westerly direction at 300 km•h⁻¹ flies over the train. Calculate the velocity
   of the aeroplane relative to the girl in the train.
4. The water in the river flows from east to west at a velocity of 1 m•s⁻¹ relative to the
   ground. A boat moves upstream (from west to east) at a velocity of 5 m•s⁻¹ relative
   to the water. A man walks alongside the river at a velocity of 2 m•s⁻¹, relative to the
   ground. Calculate the velocity of the boat relative to the ground.
   * Educator and learners discuss the solutions of the consolidation exercise

**SOLUTIONS**

1. Convert 14.4 m•s⁻¹ to km•h⁻¹: 14.4 x 3.6 = 51.84 km•h⁻¹
   1.1 51.84 km•h⁻¹ in the direction of the train
   1.2 51.84 km•h⁻¹ in the direction of the train

1.3 \( \vec{v}_{gf} = 51.84 \text{ km•h}^{-1} \)
   \( \vec{v}_{tg} = 50 \text{ km•h}^{-1} \)
   \( \vec{v}_{gs} = \vec{v}_{gf} + \vec{v}_{tg} \)
   \( = 101.84 \text{ km•h}^{-1} \) in the direction of the train
1.4 \( v_{ST} = -51.84 \text{ km}\cdot\text{h}^{-1} \)

\( v_{TG} = 50 \text{ km}\cdot\text{h}^{-1} \)

\( v_{SG} = v_{ST} + v_{TG} \)

\( = -51.84 + 50 \)

\( = -1.84 \text{ km}\cdot\text{h}^{-1} \)

\( \therefore v_{SG} \) is 1.84 km•h\(^{-1}\) in the opposite direction to the train’s direction

2. Let the direction of John be positive

2.1 \( v_{JG} = 1 \text{ m}\cdot\text{s}^{-1} \)

\( v_{PG} = -2 \text{ m}\cdot\text{s}^{-1} \), thus \( v_{GP} = +2 \text{ m}\cdot\text{s}^{-1} \)

\( v_{JP} = v_{JG} + v_{GP} \)

\( = 1 + 2 \)

\( = 3 \text{ m}\cdot\text{s}^{-1} \) in the original direction of John

2.2 \( v_{PJ} = - v_{JP} \)

\( = -3 \text{ m}\cdot\text{s}^{-1} \)

\( \therefore 3 \text{ m}\cdot\text{s}^{-1} \) opposite to John’s original direction

3. Choose west as positive

\( v_{Ground} = v_{GirlGround} = -100 \text{ km}\cdot\text{h}^{-1} \)

\( v_{GroundGirl} = 100 \text{ km}\cdot\text{h}^{-1} \)

\( v_{AGround} = 300 \text{ km}\cdot\text{h}^{-1} \)

\( v_{AGirl} = v_{Aground} + v_{GroundGirl} \)

\( = 300 - (-100) = 400 \text{ km}\cdot\text{h}^{-1} \) west

4. Let East be positive

\( v_{WL} = -1 \text{ m}\cdot\text{s}^{-1} \)

\( v_{BW} = 5 \text{ m}\cdot\text{s}^{-1} \)

\( v_{ML} = 2 \text{ m}\cdot\text{s}^{-1} \)

\( v_{BM} = v_{BW} + v_{WL} + v_{LM} \)

\( = 5 + (-1) + (-2) \)

\( = 2 \text{ m}\cdot\text{s}^{-1} \) east

2.3 Conclusion

- Ask learners about the main aspects of the lesson i.e. frame of reference.
At the end of this lesson learners should know
- The meaning of projectile motion
The following results will be the outcome of this lesson
- Learners must be able to explain that projectiles
  - fall freely with gravitational acceleration “g”
  - accelerate downwards with a constant acceleration whether the projectile is moving upward or downward.
  - have zero velocity at their greatest height
  - take the same time to reach their greatest height from the point of upward launch as the time they take to fall back to the point of launch.
  - can have their own motion described by a single set of equations

### TEACHER ACTIVITIES

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<th>1. TEACHING METHOD USED IN THIS LESSON</th>
<th>LEARNER ACTIVITIES</th>
<th>TIMING</th>
<th>RESOURCES NEEDED</th>
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</thead>
<tbody>
<tr>
<td>• Question and answer, Explanation</td>
<td>1. Learners answer the baseline questions.</td>
<td>15 min</td>
<td>Chalkboard</td>
</tr>
<tr>
<td>2. LESSON DEVELOPMENT</td>
<td>2. Learners take notes from the board.</td>
<td>30 min</td>
<td></td>
</tr>
<tr>
<td>2.1 Introduction</td>
<td>3. Learners write the classwork</td>
<td>10 min</td>
<td></td>
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<tr>
<td>Pre-knowledge</td>
<td></td>
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<tr>
<td>• Vectors and scalars</td>
<td><strong>CLASSWORK</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline questions</td>
<td>One word/term items</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Define and give the unit for the following</td>
<td>1. The force that acts on a body in free fall.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Distance</td>
<td>2. Motion of an object near the surface of the earth under the influence of the earth’s gravitational force alone.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Displacement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Speed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Velocity</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>• Acceleration</td>
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</tbody>
</table>

### LEARNER ACTIVITIES

1. Learners answer the baseline questions.
2. Learners take notes from the board.
3. Learners write the classwork.
• Distance is the actual path length covered. **Unit: m**
• Displacement is defined as a straight line distance from start to finish. **Unit: m and direction**
• Speed is defined as a rate of change in distance. **Unit: m•s⁻¹**
• Velocity is defined as the rate of change in displacement. **Unit: m•s⁻¹ and direction**
• Acceleration is defined as the rate of change in velocity. **Unit: m•s⁻² and direction**
• Distance: **scalar**. Symbol: d
• Displacement: **vector**. Symbol: Δx-horizontal or Δy-vertical
• Speed: **scalar**. Symbol: v
• Vector: **vector**. Symbol: v
• Acceleration: **vector**. Symbol: a

Educator discuss and explain the following to the learners:

**Vertical Projectile Motion**

• Vertical projectile motion deals with objects that fall straight down, objects that get thrown straight up, and the motion of an object as it goes straight up and then down.
• An object is in free fall when the only force acting on the object is the gravitational force of the earth pulling it downwards.
• The acceleration of this object due to gravity is called **gravitational acceleration, g**, and is equal to **9,8 m•s⁻²** on earth.
• An object falling straight down from rest
  • Consider an object dropped from the top of a building.
  • It accelerates at 9,8 m•s⁻² and this is always downwards.
  • The object has an initial velocity, **v₀**, of 0 m•s⁻¹.
  • The displacement, Δy, of the object is equal to the height from which it falls.
  • The object reaches maximum velocity, **v_f**, on impact with the ground.
• An object projected vertically upwards
  • Consider an object that is thrown vertically upward.

### Multiple Choice

3. Which of the following is a correct statement? Gravitational force is __________
   A. applicable only in our solar system
   B. both an attractive and repulsive force
   C. directly proportional to the product of the masses involved.
   D. Directly proportional to both the masses and the radius of the earth.

4. A golf ball is hit vertically upwards. What is the acceleration of the ball at the highest point? Ignore the effects of friction.
   A. 9,8 m•s⁻² upwards
   B. 9,8 m•s⁻² downwards
   C. 0 m•s⁻²
   D. 6,8 m•s⁻² downwards

### Long question

5. A stone is thrown vertically upwards at an initial velocity of 24 m•s⁻¹. It reaches its maximum height after 2s.

5.1 Describe the motion of the stone in terms of velocity and acceleration.
• As it get higher and higher, it slows down until it stops momentarily at its highest point.
• It has an initial velocity, \( v_i \), with which it was projected i.e. \( v_i \) is not 0 m\( \cdot \)s\(^{-1} \)
• The acceleration is 9.8 m\( \cdot \)s\(^{-2} \) downward.
• At the highest point the object stops and therefore its final velocity \( v_f = 0 \) m\( \cdot \)s\(^{-1} \), but the acceleration is still 9.8 m\( \cdot \)s\(^{-2} \).
• The object speeds up as it ascends.
• The time taken for an object to reach its maximum height is the same as the time it takes to come back.

2.3 Conclusion
• Ask learners about the main aspects of the lesson i.e. projectile motion
• Give learners classwork

5.2 How long from the time it is thrown upward, will it take to come back into the thrower’s hand?
5.3 What is the velocity of the stone at the turning point?
5.4 What is the acceleration of the stone at the turning point?

SOLUTIONS
1. Gravitational force/weight
2. Free fall
3. C
4. B
5.
5.1 Initially the stone has a velocity of 24 m\( \cdot \)s\(^{-1} \) upwards. Throughout the motion it experiences a constant downward acceleration of 9.8 m\( \cdot \)s\(^{-2} \). Its velocity decreases to zero at the turning point. There its direction of motion changes and the velocity increases while moving downwards.
5.2 4s
5.3 0 m\( \cdot \)s\(^{-1} \)
5.4 9.8 m\( \cdot \)s\(^{-2} \)
### Lesson Summary
At the end of this lesson learners should know:
- That the gravitational acceleration is a constant.
- That the velocity of an object is 0 m•s\(^{-1}\) at the maximum height.

The following results will be the outcome of this lesson:
- Learners must be able to do calculations, using equations of motion for projectile motion:
  - greatest height reached, given the velocity with which the projectile is launched upward (initial velocity)
  - time at which a projectile is at a particular height, given its initial velocity
  - height relative to the ground of the position of a projectile shot vertically upward at launch, given the time for the projectile to reach for the ground

### Teacher Activities

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<tr>
<th>TEACHING METHOD USED IN THIS LESSON</th>
<th>LEARNER ACTIVITIES</th>
<th>TIMING</th>
<th>RESOURCES NEEDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Question and answer, Explanation</td>
<td>1. Learners answer the baseline questions.</td>
<td>10 min</td>
<td></td>
</tr>
<tr>
<td>2. LESSON DEVELOPMENT</td>
<td>2. Learners take notes from the board.</td>
<td>25 min</td>
<td></td>
</tr>
<tr>
<td>2.1 Introduction</td>
<td>3. Learners write the classwork.</td>
<td></td>
<td>Chalkboard</td>
</tr>
</tbody>
</table>

### Learner Activities

1. A ball is thrown vertically upwards and returns to the thrower's hand 4s later. Calculate:
   - the height reached by the ball (a)
   - the velocity with which the ball left the thrower's hand (b)

### Classwork

- Pre-knowledge:
  - Projectile motion, equations of motion

- Baseline questions:
  - What is the initial velocity of an object falling from rest?
  - What is its acceleration?
  - An object is thrown upwards and comes back after 6s. How long did it take for the object to reach its maximum height? What is the velocity of the object at the maximum height?

- Main Body (Lesson presentation):
  - Lesson starts with the educator asking the learners the baseline questions.
  - Educator and learners discuss the following answers to the baseline questions:
    - 0 m•s\(^{-1}\)
    - 9.8 m•s\(^{2}\)
• Educator discuss and explain the following to the learners:

Equations of motion
• Projectiles can have their own motion described by a single set of equations for the upward and downward motion.
• Acceleration
  ▪ At any point during the journey the acceleration of the object is equal to the gravitational acceleration, \( g \).
  ▪ \( g \) is equal to \( 9.8 \text{ m}\cdot\text{s}^{-2} \) downwards.
  ▪ \( g \) is independent of the mass of an object.
• Use equations of motion
  ▪ \( v_f = v_i + g \Delta t \)
  ▪ \( \Delta y = v_i \Delta t + \frac{1}{2} g \Delta t^2 \)
  ▪ \( v_f^2 = v_i^2 + 2g\Delta y \)
  ▪ \( \Delta y = \frac{(v_f + v_i) \cdot \Delta t}{2} \)
• Tips to help you use the equations of motion for the projectile motion
  ▪ Choose a direction as positive.
  ▪ Write down the values of the known \( v_i \); \( v_f \); \( g \); \( \Delta y \) and \( \Delta t \)
  ▪ If an object is released or dropped by a person that is moving up or down at a certain velocity the initial velocity of an object equals the velocity of that person.
  ▪ Identify which formula to use.
  ▪ Substitute into the equation.
  ▪ Interpret the answer.

Apply your knowledge

A bullet is fired vertically upwards with a velocity of \( 200\text{ m}\cdot\text{s}^{-1} \) to reach its maximum height. Ignore the effects of air resistance and calculate

a) the maximum height reached

Take up as positive

\( v_i = +200\text{ m}\cdot\text{s}^{-1} \)

c) the velocity with which the ball returned to the thrower's hand.

2. A grade 12 learner wants to determine the height of the school building. He projects a stone vertically upward so that it reaches the top of a building. The stone leaves a learner’s hand at a height of 1.25m above the ground, and he catches the stone again at a height of 1.25m above the ground. He finds the total time the stone is in the air is 2s. Calculate the height of the school building if air resistance is ignored.

SOLUTIONS

1.

a) \( \Delta y = v_i \Delta t + \frac{1}{2} g \Delta t^2 \)

\[ = 0 (2) + \frac{1}{2} (9.8)(2)^2 \]

\[ = 19.6 \text{ m} \]
\[ v_f = 0 \text{ m/s} \]
\[ g = -9.8 \text{ m/s}^2 \]
\[ \Delta y = ? \]
\[ v_f^2 = v_i^2 + 2g\Delta y \]
\[ 0^2 = (200)^2 + 2(-9.8)\Delta y \]
\[ \Delta y = 2040.82 \text{ m} \]

b) At what height will it be moving at 100 m/s upwards?

Take up as positive
\[ v_i = 200 \text{ m/s} \]
\[ v_f = 100 \text{ m/s} \]
\[ g = 9.8 \text{ m/s}^2 \]
\[ \Delta y = ? \]
\[ v_f^2 = v_i^2 + 2g\Delta y \]
\[ (100)^2 = (200)^2 + 2(-9.8)\Delta y \]
\[ \Delta y = 1530.61 \text{ m} \]

2.3 Conclusion
- Ask learners about the main aspects of the lesson i.e. equations of motion.
- Give learners classwork

Reflection/Notes:
### Lesson Summary

At the end of this lesson learners should know:
- The graphs of projectile motion

The following results will be the outcome of this lesson:
- Learners must be able to draw position vs. time; velocity vs. time; acceleration vs. time graphs for projectile.
- Learners must be able to give equations for positions vs. time and velocity vs. time for the graphs of motion of particular projectiles and vice versa.

### Teacher Activities

1. Teaching Method Used in This Lesson
   - Question and answer, Explanation

2. Lesson Development
   2.1 Introduction
   - Pre-knowledge
     - Equations of motions, graphs of motion
   2.2 Main Body (Lesson presentation)
     - Educator discuss and explain the following to the learners:
       - Graphs of projectile motion
         - Equations of motion are equations that are used to determine the motion of a body while experiencing a force as a function of time.
         - These equations apply only to bodies moving in one dimension/straight line with a constant acceleration.
         - The body’s motion is considered between two time points: that is, from one initial point and its final point in time.
         - Motion can be described in different ways:
           - Words
           - Diagrams
           - Graphs

### Learner Activities

1. Learners take notes from the board.
2. Learners write the classwork on page 5.

### Timing

- 30 min
- 20 min

### Resources Needed

- Chalkboard
We use three different graphs
  - velocity – time graph
  - acceleration – time graph
  - position – time graph

**Worked example**

An object is dropped from a hot air balloon which is ascending at a constant speed of 2\(\text{m/s}^{-1}\). Ignore the effects of air resistance.

a) Calculate how far below the point of release the object will be after 4s.

b) Draw velocity vs time and acceleration vs time graphs for the motion of the object from the moment it is dropped from the balloon until it hits the ground.
Solution

a) Take up as positive

\[ g = -9.8 \text{ ms}^{-1} \]

\[ \mathbf{v}_i = 2 \text{ ms}^{-1} \]

\[ \Delta t = 4 \text{ s} \]

\[ \Delta y = ? \]

\[ \Delta y = \mathbf{v}_i \Delta t + \frac{1}{2} g \Delta t^2 \]

\[ = (2)(4) + \frac{1}{2} (-9.8)(4)^2 \]

\[ = 70.4 \text{ m} \]

\[ a) \quad \text{Velocity – time graph} \]

\[ 2 \]

\[ \mathbf{v} (\text{m•s}^{-1}) \]

\[ 0 \]

\[ -2 \]

\[ \text{t (s)} \]

\[ \text{Acceleration – time graph} \]

\[ -9.8 \]

\[ a \ (\text{m} \cdot \text{s}^{-2}) \]

\[ 0 \]

\[ \text{t (s)} \]

2.3 Conclusion

- Ask learners about the main aspects of the lesson i.e. graphs of motion
- Give learners classwork
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<td>Date:</td>
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CLASSWORK

QUESTION 1

A hot-air balloon is rising vertically at constant velocity. When the balloon is at a height of 88 m above the ground, a stone is released from it. The displacement-time graph below represents the motion of the stone from the moment it is released from the balloon until it strikes the ground. Ignore the effect of air resistance.
Use information from the graph to answer the following questions:

1.1 Calculate the velocity of the hot-air balloon at the instant the stone is released.

1.2 Draw a sketch graph of velocity versus time for the motion of the stone from the moment it is released from the balloon until it strikes the ground. Indicate the respective values of the intercepts on your velocity-time graph.

SOLUTION

QUESTION 1

1.1 For complete motion of stone

Upward motion negative

\[ \Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2 \]

\[ \therefore 88 = v_i(6) + \frac{1}{2} (9.8)(6)^2 \]

\[ v_i = -14.7 \text{ m/s} \]

\[ \therefore 14.7 \text{ m/s} \text{ upwards} \]
1.2

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Velocity (m·s⁻¹)</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1,5</td>
<td>-14,7</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
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</table>

Upward motion as negative:

Downward motion as negative:
At the end of this lesson learners should know
- The meaning of projectile motion

The following results will be the outcome of this lesson
- Learners must be able to explain that projectiles
  o fall freely with gravitational acceleration “g”
  o accelerate downwards with a constant acceleration whether the projectile is moving upward or downward.
  o have zero velocity at their greatest height
  o take the same time to reach their greatest height from the point of upward launch as the time they take to fall back to the point of launch.
  o can have their own motion described by a single set of equations

**TEACHING METHOD USED IN THIS LESSON**
- Question and answer, Explanation

**LESSON DEVELOPMENT**

2.1 Introduction
Pre-knowledge
- Vertical projectile motion
Baseline questions
- What is the velocity of an object at the maximum height?
- Which force acts on an object during free fall?
- If it takes 4s for an object to reach the maximum height, how long will it take for it to come back to the thrower’s hand?

2.2 Main Body (Lesson presentation)
- Lesson starts with the educator asking the learners the baseline questions.
- Educator and learners discuss the following answers to the baseline questions
  - 0 m•s⁻¹
  - Weight
  - 4 s

**SOLUTIONS TO THE CONSOLIDATION EXERCISE**
1. Let up be positive
   a) 0 m•s⁻¹
   b) -9,8 m•s⁻²
   c) \( v_f = v_i + g \Delta t \)
   \[ 0 = 4 + (-9,8) \Delta t \]
   \[ \Delta t = 0,41 \text{ s} \]
   d) \( v_f = v_i + g \Delta t \)
   \[ = 4 + (-9,8)(1,8) \]
   \[ v_i = -13,64 \text{ m•s}⁻¹ \]
• Educator discuss the following with the learners:

**Consolidation of vertical projectile motion**

**Important Points to Remember and exam tips**

- If an object is dropped, its initial velocity is zero, but if it is thrown or projected its initial velocity will not be zero.
- When a projectile reaches maximum height above the ground, its velocity is momentarily zero until it starts dropping down.
- If you have a choice, it is usually easiest to take up as positive.
- Units must always be written next to the final answer. Do not write units within your calculation.

**Consolidation exercise**

1. A boy stands on a roof and kicks a ball from a position 5 m above the ground. The ball goes vertically into the air with an initial velocity of 4 m•s\(^{-1}\). The ball lands on the ground after 1.8 s.
   
   a) What is the velocity of the ball at the highest height?
   
   b) What is the acceleration of the ball at this height?
   
   c) How long does it take for the ball to reach the maximum height?
   
   d) What is the velocity of the ball just before it strikes the ground?
   
   e) Draw a velocity vs. time graph.

2. A ball is dropped from a height of 2.5 m and after bouncing it reaches a height of 1.5 m. It then bounces for a second time reaching a height of 0.6 m. Let up be positive.
   
   a) Write down the initial velocity of the ball as it is dropped.
   
   b) What is the final velocity of the ball just before it strikes the ground?
   
   c) What is the final velocity of the ball when it reaches the height of 1.5 m after bouncing?
   
   d) What is the velocity of the ball when it strikes the ground for the first time?

3. A hot air balloon rises vertically at constant velocity. When it is 80 m up in the air a ball is released (not thrown).
   
   e) \( v_i = 13.64 \text{ m•s}^{-1} \text{ down} \)

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<table>
<thead>
<tr>
<th>( v(t) ) (m•s(^{-1}))</th>
<th>( t ) (s)</th>
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</thead>
<tbody>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>-13.6</td>
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2.

a) 0 m•s\(^{-1}\)

b) \( v_f^2 = v_i^2 + 2g\Delta y \)

\[ v_f^2 = 0^2 + 2(-9.8)(-2.5) \]

\( \therefore v_f = -7 \text{ m•s}^{-1} \)

c) 0 m•s\(^{-1}\)

d) \( v_f^2 = v_i^2 + 2g\Delta y \)

\[ 0^2 = v_i^2 + 2(-9.8)(1.5) \]

\( \therefore v_i = 5.42 \text{ m•s}^{-1} \)
The ball rises briefly then drops to the Earth as shown in the displacement vs. time graph. Use the graph to answer the questions.

When it is released it continues to rise but slows down due to gravity and after 1 second it stops rising and starts to drop back to Earth.

d) Taking the downward movement B to C:

\[ \begin{align*}
vi &= 0 \text{ m}\cdot\text{s}^{-1} \\
\Delta y &= -5 \text{ m} \\
g &= -9.8 \text{ m}\cdot\text{s}^{-2} \\
\Delta y &= vi \Delta t + \frac{1}{2} g \Delta t^2 \\
-5 &= 0 + \frac{1}{2} (-9.8) \Delta t^2 \\
\therefore \Delta t &= 1.01 \text{ s} \\
e) &= -9.8 \text{ m}\cdot\text{s}^{-2} \\
f) \text{ Up is positive} \\
vf &= vi + g \Delta t \\
0 &= vi + (-9.8)(1.01) \\
\therefore vi &= 9.9 \text{ m}\cdot\text{s}^{-1}
\end{align*} \]

4. a) If two objects of different mass but similar are dropped at the same time they will reach the ground at the same time if the effects of air resistance are ignored.
b) Mass
c) Take up as positive

g) Galileo Galilei (1564 – 1642) was an Italian astronomer and physicist. His discoveries amazed and sometimes infuriated other scientists and churchmen of the time. Galileo formulated the Law of Uniform Acceleration of Falling Bodies, which predicted that any two bodies falling from the same height would hit the ground at the same time. Legend has it that he demonstrated this by dropping objects of different mass simultaneously from the top of the leaning tower of Pisa, which is 55 m high.
a) Write a possible hypothesis for Galileo’s experiment.
b) Write down the independent variable in his experiment.

Galilean Galilei
c) Suppose one of his critics had thrown a similar object from the same spot 1 second after Galileo and both objects hit the ground at the same time. At what velocity would the critic have thrown the object?

Note:
- Investigative question: What I want to find out
- Hypothesis: What I think will happen
- Conclusion: What I found out and why it happened
- Controlled variable: must not be allowed to change
- Independent variable: values and changes controlled by me
- Dependent variable: values and changes controlled by the independent variable

2.3 Conclusion
- Ask learners about the main aspects of the lesson.

\[ \Delta y = v_i \Delta t + \frac{1}{2} g \Delta t^2 \]
\[ -55 = 0 + \frac{1}{2} (-9.8) \Delta t^2 \]
\[ \therefore \Delta t = 3.32 \text{ s} \]

The second object took 1 s less to reach the ground \( \therefore \Delta t = 2.32 \text{ s} \)

\[ \Delta y = v_i \Delta t + \frac{1}{2} g \Delta t^2 \]
\[ -55 = v_i (2.32) + \frac{1}{2} (-9.8)(2.32)^2 \]
\[ v_i = -12.34 \text{ m/s} \]

The initial velocity of the second object was

12.34 m/s. 

Reflection/Notes:
At the end of this lesson learners should know

- The meaning of momentum
- Learners must be able to do simple calculations of momentum and the change in momentum

### LESSON DEVELOPMENT

1. **Introduction**
   - Preknowledge
     - Mass, velocity
   - Baseline questions
     - Is mass a scalar or vector quantity?
     - Is velocity a scalar or vector?

2. **Main Body (Lesson presentation)**
   - Lesson starts with the educator asking the learners the baseline questions.
   - Educator and learners discuss the following answers to the baseline questions
     - Scalar
     - Vector
   - Educator discuss and explain the following to the learners:

   **Momentum**
   - The product of mass and velocity of an object is called the momentum of the object.
   - Momentum: \( \mathbf{p} = \mathbf{m} \times \mathbf{v} \)
   - Unit: kg\( \cdot \)m\( \cdot \)s\(^{-1}\)
   - Momentum is a vector quantity.

### CLASSWORK

1. Calculate the momentum of a body if its mass is 5 kg and its velocity is 25 m\( \cdot \)s\(^{-1}\) due east.
2. A 1100 kg car accelerates along a straight road and its velocity increases from 10 m\( \cdot \)s\(^{-1}\) to 20 m\( \cdot \)s\(^{-1}\). Calculate its change in momentum.
3. The brakes of a 1500kg car are applied and its velocity decreases from 10 m\( \cdot \)s\(^{-1}\) to 2 m\( \cdot \)s\(^{-1}\). Calculate its change in momentum.
Momentum calculations

- When doing calculations concerning momentum we must keep the vector nature of momentum in mind.
  A 5000kg bus moves due west at 10 m•s\(^{-1}\). Find its momentum.
  \[ p = mv \]
  \[ = 5000 \times 10 \]
  \[ = 50000 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1} \]

Change in momentum

- If a non-zero net force acts on an object, then its velocity changes and so does its momentum.
- The change in momentum of a body is the difference between its final and its initial momentum.
- We calculate the change in momentum of a body with the equation:
  \[ \Delta p = m\Delta v = m(v_f - v_i) \]

Worked example

- A batsman hits a 160g cricket ball approaching him at 30 m•s\(^{-1}\) so that it moves in the opposite direction at 40 m•s\(^{-1}\). Calculate the change in momentum of the ball.
  Take approach as positive
  \[ m = 0.16 \text{ kg} \]
  \[ v_i = 30 \text{ m} \cdot \text{s}^{-1} \]
  \[ v_f = -40 \text{ m} \cdot \text{s}^{-1} \]
  \[ \Delta p = m(v_f - v_i) \]
  \[ = 0.16 \times (-40 - 30) \]
  \[ = -11.2 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1} \]
  \[ = 11.2 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1} \] away from the batsman

2.3 Conclusion

- Ask learners about the main aspects of the lesson i.e. momentum and change in momentum.
- Give learners classwork

| 4. A 440 g soccer ball approaches a goalkeeper at 8 m•s\(^{-1}\) and he kicks it in the opposite direction at 10 m•s\(^{-1}\). |
| SOLUTIONS |
| 1. \[ p = mv \]
  \[ = (5)(25) \]
  \[ = 125 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1} \] east |
| 2. \[ \Delta p = m\Delta v \]
  \[ = m(v_f - v_i) \]
  \[ = 1100 \times (20 - 10) \]
  \[ = 11000 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1} \] |
| 3. \[ \Delta p = m(v_f - v_i) \]
  \[ = 1500 \times (2 - 10) \]
  \[ = -12000 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1} \]
  \[ = 12000 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1} \] in the opposite direction to the motion of the car. |
| 4. \[ \Delta p = m(v_f - v_i) \]
  \[ = 0.44 \times (-10 - 8) \]
  \[ = -7.92 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1} \]
  \[ = 7.92 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1} \] in the opposite direction |
### Reflection/Notes:

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### Lesson Plan: Momentum and Impulse

#### Lesson Summary

**Objective:**
- Learners should know the meaning of impulse.
- Learners must be able to define impulse – delivered by the force $F \Delta t = \Delta p$.
- Learners must be able to do calculations of momentum and impulse.

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#### Lesson Objectives

- At the end of this lesson learners should know:
  - The meaning of impulse.

The following results will be the outcome of this lesson:

- Learners must be able to define impulse – delivered by the force $F \Delta t = \Delta p$.
- Learners must be able to do calculations of momentum and impulse.

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#### Teacher Activities

1. **Teaching Method Used in this Lesson**
   
   - Question and answer, Explanation

2. **Lesson Development**

   **2.1 Introduction**
   
   *Pre-knowledge*
   
   - Newton’s second law of motion and change in momentum

   **Baseline questions**
   
   - Write Newton’s second law equation.
   - What is the equation for the determination of the change in momentum?

   **2.2 Main Body (Lesson presentation)**
   
   - Lesson starts with the educator asking the learners the baseline questions.
   - Educator and learners discuss the following answers to the baseline questions:
     - $F_{net} = ma$
     - $\Delta p = m\Delta v$
   - Educator discuss and explain the following to the learners:

   **Impulse**
   
   - Isaac Newton realised that the larger the change of momentum and the shorter the time that it takes place in, the larger the force that is necessary to bring it about.
   - In terms of Newton’s Second Law of Motion:

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#### Learner Activities

1. Learners answer the baseline questions.
2. Learners take notes from the board.
3. Learners write the classwork.

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#### Classwork

1. A rubber ball with a mass 80g, is thrown horizontally and collides perpendicularly with a wall at a velocity of 7 m•s$^{-1}$. The ball rebounds in the opposite direction at 6 m•s$^{-1}$.
   
   a) Calculate the magnitude and state the direction, of the change in momentum of the ball during the collision.
   b) If the collision lasts for 0.02s, calculate the magnitude of the force the ball experiences during the collision.

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#### Resource Needs

- Chalkboard

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The rate of change of momentum of a body is directly proportional to the net force acting on it and the change of momentum is in the direction of the force.

Net force = change of momentum
change of time

\[ F_{\text{net}} = \frac{\Delta p}{\Delta t} \]

Rearranging, \( F_{\text{net}}\Delta t = \Delta p \)

The product \( F_{\text{net}}\Delta t \) is called the impulse.

Impulse has the unit N•s

**Worked example**

The driver of a car of mass 1200 kg travelling at 20 m•s\(^{-1}\) along a straight road, slows down uniformly for 4s. The brakes apply a net force of 4800 N.

a) Calculate the impulse exerted by the brakes.

\[ \text{Impulse} = F_{\text{net}}\Delta t \]
\[ = -4800 \times 4 \]
\[ = -19200 \text{ N•s} \]

b) What is the change in momentum of the car?

Change in momentum = impulse = -19200 kg•m•s\(^{-1}\)

c) Calculate the velocity, \( v_f \), of the car after 4s.

\[ F_{\text{net}}\Delta t = m(v_f - v_i) \]
\[ -19200 = 1200(v_f - 20) \]
\[ v_f = 4 \text{ m•s}^{-1} \]

**2.3 Conclusion**

- Ask learners about the main aspects of the lesson i.e. impulse and change in momentum.
- Give learners classwork

2. A body with a mass of 8 kg is moving with an initial velocity of 4.5 m•s\(^{-1}\). A net force accelerates it, and after 9s its velocity is 22.5 m•s\(^{-1}\). Calculate the force accelerating the car.

3. After a rain storm in Bloemfontein, a student of mass 75 kg driving a car of mass 1000 kg at 72 km•h\(^{-1}\) skidded on the wet road and hit a tree. The collision took 0.5 s (that is the time from when he hit the tree until the car came to a stop).

a) Determine the force exerted by the tree on the car.

b) The car was fitted with airbags so, for the driver, the collision time increased to 1.5s. Determine the force exerted by the airbags on the driver.

c) If there had been no airbags, determine the force exerted on the driver by the windscreen (assume he is not wearing a seatbelt).

**SOLUTIONS**

1. Take towards the wall as positive

a) \( \Delta p = m(v_f - v_i) \)
\[ = 0.08(-6 - 7) \]
\[ = -1.04 \text{ kg•m•s}^{-1} \]
\[ \Delta p = 1.04 \text{ kg}\cdot\text{ms}^{-1} \text{ away from the wall.} \]

b) \( F_{\text{net}} \Delta t = \Delta p \)
\[ F_{\text{net}}(0.02) = -1.04 \]
\[ F_{\text{net}} = -52 \text{ N} \]
\[ \therefore F_{\text{net}} = 52 \text{ N away from the wall} \]

2. \( F_{\text{net}} \Delta t = m(v_f - v_i) \)
\[ F_{\text{net}}(0.02) = 8(22.5 - 4.5) \]
\[ F_{\text{net}} = 16 \text{ N} \]

3. Take towards the tree as positive
   
   a) \( m(\text{car + driver}) = 1075 \text{ kg} \)
   \( v_i = \frac{72}{3.6} = 20 \text{ m}\cdot\text{s}^{-1} \)
   \( v_f = 0 \text{ m}\cdot\text{s}^{-1} \)
   \[ F_{\text{net}} \Delta t = m(v_f - v_i) \]
   \[ F_{\text{net}}(0.5) = 1075(0 - 20) \]
   \[ F_{\text{net}} = -43000 \text{ N} \]
   \[ \therefore F_{\text{net}} = 43000 \text{ N away from the tree.} \]
   
   b) \( F_{\text{net}} \Delta t = m(v_f - v_i) \)
   \[ F_{\text{net}}(1.5) = 75(0 - 20) \]
   \[ F_{\text{net}} = -1000 \text{ N} \]
   \[ \therefore F_{\text{net}} = 1000 \text{ N away from the tree.} \]
   
   c) \( F_{\text{net}} \Delta t = m(v_f - v_i) \)
   \[ F_{\text{net}}(0.5) = 75(0 - 20) \]
   \[ F_{\text{net}} = -3000 \text{ N} \]
   \[ \therefore F_{\text{net}} = 3000 \text{ N away from the tree.} \]
**LESSON SUMMARY FOR:**

At the end of this lesson learners should know
- The meaning of impulse

The following results will be the outcome of this lesson
- Learners must be able to apply impulse to safety consideration in everyday life e.g. airbags, seatbelts, arrestor beds

**LESSON OBJECTIVES**

**TEACHER ACTIVITIES**

1. **TEACHING METHOD USED IN THIS LESSON**
   - Question and answer, Explanation

2. **LESSON DEVELOPMENT**

2.1 **Introduction**

Pre-knowledge
- Impulse, principle of conservation of momentum, types of collisions, vertical projectile motion

Baseline questions
- In the equation $F_{net} = \frac{\Delta p}{\Delta t}$, what is the relationship between $F_{net}$ and $\Delta t$?
- State the principle of conservation of momentum

2.2 **Main Body (Lesson presentation)**

- Lesson starts with the educator asking the learners the baseline questions.
- Educator and learners discuss the following answers to the baseline questions
  - $F_{net}$ is inversely proportional to $\Delta t$
  - The total linear momentum in an isolated system is constant in both magnitude and direction.
- Educator discuss and explain the following to the learners:
  - The impulse, conservation of momentum and projectile motion questions are not usually asked in isolation.
  - They are normally asked in one question.

**LEARNER ACTIVITIES**

1. Learners answer the baseline questions.
2. Learners write the class exercise.
3. Learners take notes from the board

**TIMING**

5 min
35 min
10 min

**RESOURCES NEEDED**

Chalkboard
• The following questions will try to show how questions are normally asked.

Class exercise

1. The roof of a tall building is 25 m above the ground. A rigid ball of mass 0.3 kg falls freely when dropped from the roof. It strikes the concrete floor on the ground with velocity \( v_1 \). It bounces to a maximum vertical height of 6 m.
   
   1.1 Calculate the velocity \( v_1 \) when the ball first hits the floor.
   
   1.2 Calculate the impulse of the ball as a result of the collision.
   
   1.3 Calculate the magnitude of the net force exerted on the ball.

2. Two shopping trolleys, X and Y, are both moving to the right along the same straight line. The mass of trolley Y is 12 kg and its kinetic energy is 37.5 J.

2.1 Calculate the speed of trolley Y.

* Trolley X of mass 30 kg collides with trolley Y and they stick together on impact. After the collision the combined speed of the trolleys is 3.2 m\( \cdot \)s\(^{-1} \). (Ignore the effects of friction)

2.2 Calculate the speed of trolley X before the collision.

2.3 Calculate the magnitude of the force that trolley X exerts on trolley Y.

Solutions

1. Take up as positive

1.1 \( v_1^2 = v_0^2 + 2g\Delta y \)

\[ v_0^2 = 0^2 + 2(-9.8)(25) \]

\[ \therefore v_0 = 22.13 \text{ m}\( \cdot \)s\(^{-1} \) or 22.13 m\( \cdot \)s\(^{-1} \) down
1.2 \( v_f^2 = v_i^2 + 2g\Delta y \)
\[
0^2 = v_i^2 + 2(-9,8)(6)
\]
\[
\therefore v_i = 10,84 \text{ m/s}{}
\]
**Impulse** = \( \Delta p \)
\[
= m(v_f - v_i)
\]
\[
= 0,3[10,84 - (-22,13)]
\]
\[
= 9,89 \text{ N s upwards}
\]

1.3 \( F_{net}\Delta t = \Delta p \)
\[
F_{net}(0,9) = 9,89
\]
\[
\therefore F_{net} = 10,99 \text{ N}
\]

2. **Take to the right as positive**

2.1 \( E_k = \frac{1}{2}mv^2 \)
\[
37,5 = \frac{1}{2}(12)v^2
\]
\[
\therefore v = 2,5 \text{ m/s}{}
\]

2.2 \( \Sigma p\) before = \( \Sigma p\) after
\[
m_1v_1 + m_2v_2 = (m_1 + m_2)v_f
\]
\[
30v_1 + (12 \times 2,5) = (30 + 12)(3,2)
\]
\[
\therefore v_1 = 3,48 \text{ m/s}{}
\]

2.3 \( F_{net}\Delta t = m\Delta v \)
\[
F_{net}(0,2) = 30(3,2 - 3,48)
\]
\[
F_{net} = -42 \text{ N}
\]
\[
\therefore \text{magnitude } F_{net} = 42 \text{ N}
\]

- Educator and learners discuss the above questions and solutions.
- Educator discuss the following with the learners

**Impulse and Motor Vehicle Safety**
- During a collision in which a car is brought to rest, the people in the car must also be brought to rest.
- From the impulse equation \( F_{net}\Delta t = \Delta p \) we can see that if \( \Delta t \) increases, the net force acting on the people to bring about the required decrease in momentum is smaller.
Thus injury is reduced.

- During a front-end collision the front of the car is designed to crumple. While the front crumples the strong central cab, with the people in it, is able to move for a little longer while slowing down. This increases $\Delta t$ thus decreasing the force.
- When an airbag is deployed, it begins to exert a retarding force on the person. As the air in the airbag compresses it is able to exert this force over a period of time thus decreasing the required force.

### 2.3 Conclusion
- Ask learners about the main aspects of the lesson i.e. impulse and conservation of momentum.

### Reflection/Notes:

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LESSON OBJECTIVES
At the end of this lesson learners should know
- That the momentum of a system is conserved when no external forces act on it.
The following results will be the outcome of this lesson
- Learners must be able to apply the conservation of momentum to collisions of two objects moving along a straight line.

TEACHER ACTIVITIES
1. **TEACHING METHOD USED IN THIS LESSON**
   - Question and answer, Explanation

2. **LESSON DEVELOPMENT**
   2.1 **Introduction**
   Pre-knowledge
   - Momentum, vectors
   Baseline questions
   - Define momentum

   2.2 **Main Body (Lesson presentation)**
   - Lesson starts with the educator asking the learners the baseline questions.
   - Educator and learners discuss the following answers to the baseline questions
     - Momentum is the product of mass and velocity
   - Educator discuss and explain the following to the learners:
     Conservation of momentum
     - The principle of conservation of momentum states: the total linear momentum in an isolated system remains constant in both magnitude and direction.
     - In other words, in an isolated system the total linear momentum before the collision is equal to the total linear momentum after the collision.
     - Isolated system- means no external forces acting.

   **CLASSWORK**
   1. A 9 kg mass travelling eastwards at 4 m•s⁻¹ collides with a 3 kg mass travelling westward at 8 m•s⁻¹. After collision the 9 kg mass is moving westward at 1 m•s⁻¹. Calculate the velocity of the 3 kg mass after collision.
   2. A railway truck with a mass of 5000 kg and a velocity of 6 m•s⁻¹ collides with the second truck. The second truck has a mass of 4000 kg, and before the collision, it had a velocity of 3 m•s⁻¹ in the same direction as the first truck. The two trucks separate after the collision. The new velocity of the second truck is 5 m•s⁻¹ in the same direction as before. Calculate the new velocity of the first truck.

LEARNER ACTIVITIES
1. Learners answer the baseline questions.
2. Learners take notes from the board.
3. Learners write the classwork

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<tr>
<td>5 min</td>
<td>Chalkboard</td>
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<tr>
<td>10 min</td>
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<tr>
<td>15 min</td>
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</table>
In simple language, the vector sum of the momenta of all parts after collision is equal to the momenta of all parts after the collision i.e. if one object loses momentum, the other gains that momentum.

In simple terms:

\[ \sum p_{\text{before}} = \sum p_{\text{after}} \]

\[ m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f} \]

**Worked Example (Objects that separate after collision)**

A ball with mass of 1 kg is moving eastward with a speed of 2 m/s. It collides head-on with a second ball. The second ball has a mass of 1.5 kg and is moving with a speed of 1.5 m/s in the opposite direction. After the collision, the first ball bounces back with a velocity of 2.05 m/s. Calculate the velocity of the second ball after the collision.

**Solution**

Take east as positive

\[ \sum p_{\text{before}} = \sum p_{\text{after}} \]

\[ m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f} \]

\[ (1 \times 2) + (1.5 \times -1.5) = (1 \times -2.05) + (1.5 \times v_f) \]

\[ v_f = 1.2 \text{ m/s} \text{ east} \]

**2.3 Conclusion**

- Ask learners about the main aspects of the lesson i.e. principle of conservation of momentum
- Give learners classwork

3. Two toy cars are approaching each other. Car 1, with mass 0.8 kg, has a velocity of 5 m/s to the right. Car 2, has a mass of 1 kg and a velocity of 5 m/s to the left. After the collision, car 2 is stationary. Calculate car 1's velocity after the collision.

**SOLUTIONS**

1. **Take east as positive**

\[ \sum p_{\text{before}} = \sum p_{\text{after}} \]

\[ m_{1i} v_{1i} + m_{2i} v_{2i} = m_{1f} v_{1f} + m_{2f} v_{2f} \]

\[ (9 \times 4) + (3 \times -8) = (9 \times -1) + (3 \times v_f) \]

\[ \therefore v_f = 7 \text{ m/s} \text{ east} \]

2. **Let the direction of the initial velocity be positive.**

\[ \sum p_{\text{before}} = \sum p_{\text{after}} \]

\[ m_{1i} v_{1i} + m_{2i} v_{2i} = m_{1f} v_{1f} + m_{2f} v_{2f} \]

\[ (5000 \times 6) + (4000 \times 3) = (5000 \times v_{1f}) + (4000 \times 5) \]

\[ \therefore v_{1f} = 4.4 \text{ m/s} \text{ in the same direction as the initial velocity.} \]

3. **Take right as positive**

\[ \sum p_{\text{before}} = \sum p_{\text{after}} \]

\[ m_{1i} v_{1i} + m_{2i} v_{2i} = m_{1f} v_{1f} + m_{2f} v_{2f} \]

\[ (0.8 \times 5) + (1 \times -5) = 0.8 \times v_{1f} + (1 \times 0) \]

\[ \therefore v_{1f} = -1.25 \text{ m/s} \text{ to the left.} \]
<table>
<thead>
<tr>
<th>LESSON SUMMARY FOR:  DATE STARTED:</th>
<th>LESSON OBJECTIVES</th>
<th>DATE COMPLETED:</th>
</tr>
</thead>
<tbody>
<tr>
<td>At the end of this lesson learners should know</td>
<td>• That the momentum of a system is conserved when no external forces act on it.</td>
<td></td>
</tr>
<tr>
<td>The following results will be the outcome of this lesson</td>
<td>• Learners must be able to apply the conservation of momentum to collisions of two objects moving along a straight line.</td>
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<table>
<thead>
<tr>
<th>LESSON DEVELOPMENT</th>
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<tr>
<td>2.1 <strong>Introduction</strong></td>
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<tr>
<td>Pre-knowledge</td>
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<tr>
<td>• Conservation of momentum</td>
</tr>
<tr>
<td>Baseline questions</td>
</tr>
<tr>
<td>• State the principle of conservation of momentum.</td>
</tr>
<tr>
<td>• An object of 4 kg moving to the right at $2 \text{ m} \cdot \text{s}^{-1}$ collides with a stationary object with a mass of 6 kg. After collision the 4 kg mass moves at $1,5 \text{ m} \cdot \text{s}^{-1}$ to the left. Calculate the velocity of the 6 kg after collision.</td>
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<tr>
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<tbody>
<tr>
<td>2.2 <strong>Main Body (Lesson presentation)</strong></td>
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<tr>
<td>• Lesson starts with the educator asking the learners the baseline questions.</td>
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<tr>
<td>• Educator and learners discuss the following answers to the baseline questions</td>
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<tr>
<td>$\Sigma p \text{ before} = \Sigma p \text{ after}$</td>
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<thead>
<tr>
<th>CLASSWORK</th>
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<tbody>
<tr>
<td>1. A 30 g bullet is shot horizontally with a certain velocity, into a wooden block of mass 1,47 kg, which is standing on a smooth surface. After the impact the bullet gets embedded in the wood and they move off together with a horizontal velocity of $4 \text{ m} \cdot \text{s}^{-1}$. Calculate the initial velocity of the bullet.</td>
</tr>
<tr>
<td>2. The driver of a 1800 kg car stops the car when he sees that the robot he is approaching turns red. A smaller car, whose driver tries to ‘beat’ the red light, collides into the back of the stationary car and the two cars become entangled during the collision. If the smaller car, of mass 900 kg, was moving at $20 \text{ m} \cdot \text{s}^{-1}$ when it hit the stationary car, calculate the velocity of the entangled wreckage after the collision.</td>
</tr>
</tbody>
</table>
Educator discuss and explain the following to the learners:

**Worked example 1: Bodies that stick together after a collision**

A railway truck with a mass of $2 \times 10^3$ kg is moving at a speed of $5 \text{ m/s}^{-1}$. It collides with a stationary truck which has a mass of $3 \times 10^3$ kg. If the two trucks couple together during the collision, what is their combined velocity after the collision?

**Solution**

Take the direction of the truck as positive.

\[ \sum p_{\text{before}} = \sum p_{\text{after}} \]

\[ m_1v_1 + m_2v_2 = (m_1 + m_2)v_f \]

\[ (2 \times 10^3)(5) + (3 \times 10^3)(0) = (2 \times 10^3 + 3 \times 10^3)v_f \]

\[ v_f = 2 \text{ m/s}^{-1} \]

**Worked example 2: An explosion**

A bullet with a mass of 100 g is fired from a rifle. The bullet’s velocity as it leaves the barrel of the rifle is 300 m/s. If the mass of the rifle is 5 kg, calculate its recoil velocity. (This is an example of an explosion. The total momentum before the rifle is fired is zero.)

**Solution**

\[ \sum p_{\text{before}} = \sum p_{\text{after}} \]

\[ 0 = m_1v_1 + m_2v_2 \]

\[ 0 = (0.1 \times 300) + (5)v_f \]

\[ v_f = -6 \text{ m/s}^{-1} \]

2.3 Conclusion

- Ask learners about the main aspects of the lesson i.e. conservation of momentum.
- Give learners classwork.
\[ \Sigma p_{\text{before}} = \Sigma p_{\text{after}} \]
\[ 0 = m_1v_1 + m_2v_2 \]
\[ 0 = (0.05 \times 400) + 3v_f \]
\[ \therefore v_f = -6.67 \text{ m/s} \]
\[ \therefore v_f = 6.67 \text{ m/s} \text{ in the opposite direction of the velocity of the bullet.} \]
### Lesson Summary for:  
**Date Started:**  
**Date Completed:**

#### Lesson Objectives
At the end of this lesson learners should know
- The types of collision i.e. elastic and inelastic collisions

The following results will be the outcome of this lesson
- Learners must be able to distinguish between elastic and inelastic collisions

### Teacher Activities

<table>
<thead>
<tr>
<th><strong>Teaching Method Used in this Lesson</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Question and answer, Explanation</td>
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</table>

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<tr>
<th><strong>Lesson Development</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2.1 Introduction</strong></td>
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</tbody>
</table>

### Lesson Development

#### Pre-knowledge
- Kinetic energy, conservation of momentum

**Baseline questions**
- Give the formula for the calculation of kinetic energy
- In what units is kinetic energy measured in?*
- A stone of mass 500 g is thrown at a velocity of 2 m/s. Calculate the kinetic energy of the stone.
- A ball with mass of 1 kg is moving eastward with a speed of 2 m/s. It collides head-on with a second ball. The second ball has a mass of 1.5 kg and is moving with a speed of 1.5 m/s in the opposite direction. After the collision, the first ball bounces back with a velocity of 2.05 m/s and the second ball bounces back at 1.2 m/s.

**Classwork**

1. At rush hour in Johannesburg vehicle A (2000 kg) stopped as the robot turned red. Vehicle B (2400 kg) speeding behind A, was unable to stop and crashed into the back of A at 12 m/s. Vehicle A was pushed into the intersection and B slowed down to 5 m/s.

   **a)** Assume that momentum was conserved and calculate the speed of A immediately after the collision.
   
   **b)** Determine by calculation whether this was an elastic or inelastic collision.

2. A toy car of mass 0.5 kg travelling at 2 m/s collides with a stationary lorry of mass 0.8 kg. The lorry is pushed ahead at 0.5 m/s. What is the final velocity of the car? Prove that the collision is inelastic.

### Learner Activities

<table>
<thead>
<tr>
<th><strong>Learner Activities</strong></th>
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</thead>
<tbody>
<tr>
<td>1. Learners answer the baseline questions.</td>
</tr>
<tr>
<td>2. Learners take notes from the board.</td>
</tr>
<tr>
<td>3. Learners write the classwork</td>
</tr>
</tbody>
</table>

### Timing

<table>
<thead>
<tr>
<th><strong>Timing</strong></th>
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<tbody>
<tr>
<td>5 min</td>
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<tr>
<td>5 min</td>
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<tr>
<td>20 min</td>
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</table>

### Resources Needed

- Chalkboard
2.2 Main Body (Lesson presentation)

- Lesson starts with the educator asking the learners the baseline questions.

- Educator and learners discuss the following answers to the baseline questions
  - $E_k = \frac{1}{2} mv^2$
  - Joules (J)
  - a) Total kinetic before = $\frac{1}{2} m_1v_{1i}^2 + \frac{1}{2} m_2v_{2i}^2$
    
    $$= \frac{1}{2} (1)(2)^2 + \frac{1}{2} (1.5)(1.5)^2$$
    
    $$= 3.69 \text{ J}$$
  - b) Total kinetic after = $\frac{1}{2} m_1v_{1f}^2 + \frac{1}{2} m_2v_{2f}^2$
    
    $$= \frac{1}{2} (1)(2.05)^2 + \frac{1}{2} (1.5)(1.2)^2$$
    
    $$= 3.18 \text{ J}$$

- Educator discuss and explain the following to the learners:
  - Elastic and inelastic collisions
    - Elastic collision: Kinetic energy is conserved. Total kinetic energy before collision is equal to total kinetic energy after the collision. This is unlikely to happen in everyday occurrences.
    - Inelastic collision: Kinetic energy is not conserved. Total kinetic energy before is not equal to total kinetic energy after.
    - To determine whether a collision is elastic or inelastic use $E_k = \frac{1}{2} mv^2$ to calculate the total kinetic energy before and after the collision.
    - Momentum is always conserved in a collision in an isolated system but kinetic energy is not usually conserved.
    - In a collision, the ‘lost’ kinetic energy is transformed into heat and sound.

2.3 Conclusion

- Ask learners about the main aspects of the lesson i.e.
- Give learners classwork

3. A bullet of mass 2g is fired horizontally into a stationary wooden block of mass 1 kg. The bullet strikes the wooden block at a velocity of 490 m•s$^{-1}$. The impact causes the block-bullet system to slide a distance of 20 cm before coming to rest.

a) Name and state the law that can be used to calculate the velocity of the bullet-block system after collision.

b) Calculate the velocity of the block-bullet system immediately after collision.

c) Is this collision elastic or inelastic?

**SOLUTIONS**

1.

a) $\Sigma p_{\text{before}} = \Sigma p_{\text{after}}$

$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$

$(2000 \times 0) + (2400 \times 12) = 2000v_{1f} + (2400 \times 5)$

$\therefore v_{1f} = 8.4 \text{ m}\cdot\text{s}^{-1}$

b) $E_k_{\text{before}} = \frac{1}{2}(2000)(0)^2 + \frac{1}{2} (2400)(12)^2$

$$= 1,73 \times 10^5 \text{ J}$$

$E_k_{\text{after}} = \frac{1}{2}(2000)(8.4)^2 + \frac{1}{2} (2400)(5)^2$

$$= 1,01 \times 10^5 \text{ J}$$

$\therefore$ Collision is inelastic since $E_k_{\text{before}}$ is not equal to $E_k_{\text{after}}$. 

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2. 
\[ \Sigma p_{\text{before}} = \Sigma p_{\text{after}} \]
\[ m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f} \]
\[ (0.5 \times 2) + (0.8 \times 0) = 0.5v_{1f} + (0.8 \times 0.5) \]
\[ \therefore v_{1f} = 1.2 \text{ m/s in direction of car} \]
\[ \Sigma E_{\text{before}} = \frac{1}{2}(0.5)(2)^2 + \frac{1}{2}(0.8)(0)^2 \]
\[ = 1 \text{ J} \]
\[ \Sigma E_{\text{after}} = \frac{1}{2}(0.5)(1.2)^2 + \frac{1}{2}(0.8)(0.5)^2 \]
\[ = 0.46 \text{ J} \]
Thus collision is inelastic since \( E_k \) before is not equal to \( E_k \) after.

3. 
   a) Law of conservation of momentum
   The total linear momentum of an isolated system is constant in both magnitude and direction.
   b) 
   \[ \Sigma p_{\text{before}} = \Sigma p_{\text{after}} \]
   \[ m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f \]
   \[ (0.02 \times 490) + (1 \times 0) = 1.02v_f \]
   \[ \therefore v_f = 0.97 \text{ m/s} \]
   c) 
   \[ \Sigma E_{\text{before}} = \frac{1}{2}(0.02)(490)^2 + \frac{1}{2}(1)(0)^2 \]
   \[ = 2401 \text{ J} \]
   \[ \Sigma E_{\text{after}} = \frac{1}{2}(1.02)(0.97)^2 \]
   \[ = 0.48 \text{ J} \]
   Collision is inelastic since \( E_k \) before is not equal to \( E_k \) after.
### LESSON SUMMARY

**Lesson Objective:**

1. **LEARN OBJECTIVES**
   
   **1.** Learners will be TAUGHT and LEARN the following:
   
   - Definition of work done on an object by a force.
   - How to calculate net work done on an object by using the formula \( W = F \Delta x \cos \Theta \).
   - Give examples of when an applied force does and does not do work on an object.
   - Positive net work done on a system will increase the energy of the system and negative net work done on the system will decrease the energy of the system.

2. **LESSON OUTCOMES** – At the end of the lesson learners should be able to:
   
   - To define the scientific meaning of work in physics use.
   - Use the formula of work to calculate work done on an object by applied force.
   - Give examples of when an applied force does and does not do work on an object.
   - Know that work is a scalar quantity and is measured in joules (J)
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<th>LEARNER ACTIVITIES</th>
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<tr>
<td><strong>1. TEACHING METHODS USED IN THIS LESSON:</strong> Explanations, illustrations, Demonstrations and questions and answer methods</td>
<td><strong>1. Baseline Assessment:</strong></td>
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<td>Worksheet</td>
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<td><strong>2. Lesson Development</strong></td>
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<td>Chalkboard summary</td>
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<td><strong>2.1 Introduction</strong></td>
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<tr>
<td>a) Pre-knowledge required.</td>
<td>1. What is the scientific meaning of “work done”? <strong>Work is done on an object when a force exerted in an object, moves that object in the direction of the force.</strong> 2. Which unit is used to calculate work? <strong>Joule (J)</strong> 3. What is a simple definition of 1 Newton of force? <strong>A force of 1 Newton can accelerate a mass of 1 kg by 1 m·s⁻²</strong> 4. How much work is done when the force is perpendicular to the object’s displacement? <strong>Zero (0 J)</strong> 5. How does friction “know” in which direction to act? <strong>If the object is moving towards the east, then friction will counter this motion by acting in the opposite direction.</strong></td>
<td>± (15 min)</td>
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<td>2. Learners will discuss their solution (the teacher will discuss the solution with the learners)</td>
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</table>
Under frictionless conditions, no work is done when the object is moving at a **uniform velocity**, since no resultant force is applied.

There must be resistance of some kind to the object’s motion, otherwise the force would not be necessary.

When a resultant force is applied and causes a displacement in the direction of the force, work is done.

- The teacher will introduce the concept of “friction force” to the learners.

\[
W = F_{\text{res}} \times \Delta x \quad \text{But} \quad F_{\text{res}} = m \cdot a
\]

Therefore \[ W = m \cdot a \cdot \Delta x \]

### Demonstration Method

**Instructional** – the teacher will demonstrate a billiard ball being struck by a cue.

- The ball moves with uniform velocity:
  \[ F = 0 \text{ N}, \quad W = 0 \text{ N} \]

### HOMEWORK ACTIVITY

Learners will *solve the problems on the worksheets* given to them by the teacher and will discuss and present their solutions.

1. A 30 N force is applied to a box. There is a frictional force of 5 N between the floor and the box. The box slides for 10 m along the floor.

   \[
   W = F_{\text{res}} \times \Delta x
   \]

   \[
   F = 0 \text{ N}, \quad W = 0 \text{ N}
   \]

### Demonstration and Explanation

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**Illustrations and Explanation**

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<th>± 15 – 20 minutes</th>
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</table>

1.1 Calculate the work done to move the box.

1.2 Calculate the work done against friction.

2. A force of 20 N is applied horizontally to a box to slide it 5 m along the floor. Calculate the work done in sliding the box.

3. Tsepiso wants to move a concrete block of mass 4 kg a distance of 12 m to the right by applying a force of 16 N to the block. There is a frictional force of 2 N which acts against the block due to the rough surface.

3.1 Draw a rough sketch showing the forces acting on the block.

3.2 Calculate the work done by the 16 N forces.

3.3 Calculate the work done by the frictional force.

3.4 What do you think happens to the work done by

### Charts/ or available resources

<table>
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<tr>
<th>Relevant equipments/ or other available resources</th>
</tr>
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Grade 12 Physical Sciences Lesson Plans

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- Take note that no work is done after the player has broken contact with the ball. The ball then moves on due to its own inertia and momentum.

- Work is only done to move the box vertically. There is no resistance horizontally.

- As the crate is moving forward, work is done by the horizontal component only. The vertical component does not lift the crate. Therefore no work is done in this direction.

\[ W = F \cos \Theta \times s \]

\[ F = 16 \text{ N} \]

\[ \text{Friction} = 2 \text{ N} \]

\[ M = 4 \text{ kg} \]

\[ W = F \times \Delta x \times \cos 0^\circ \]

\[ W = 16 \times 12 \times \cos 0^\circ \]

\[ W = 192 \text{ J} \]

\[ W = \text{friction} \times \Delta x \times \cos 180^\circ \]

\[ W = 2 \times 12 \times -1 \]

\[ W = -24 \text{ J} \]

Work done is 24 J opposite to the direction of motion.

3.4 It would be converted into heat energy.
3. **Lesson Development:**

**RECALLING:**
- Drawing a force diagram showing all forces that act on an object. Force due to friction

![Force Diagram](image)

- Calculate the resultant force.
- Calculate the net work done on an object.

**EXPLANATION:**
- Work and energy (all forms) are equivalent and have the unit, **joule**.
- There must be a resistance to the force applied – no resistance – no work.
- If there is no movement then \( W = 0 \) J
- If movement is perpendicular to force then \( W = 0 \) J
4. **LESSON SUMMARY (CONCLUSION):**

5.1 **Summarise on the lesson on the chalkboard**

- Work is done when the *force displaces* the object in the direction of the force.
- The SI units of work is Joule (J) which is equivalent to (N·m)
- Work is a scalar quantity with magnitude only, i.e. No direction
- 1 joule of work done when a force of 1 N acts through a distance of 1 m.
- Under *frictionless conditions*, no work is done when the object is moving at a *uniform velocity*, since no resultant force is applied.

- If force is applied on an object, and there is no movement the magnitude of work = 0 J

5.3 The teacher can give more problems to learners in order to practice during free time.
<table>
<thead>
<tr>
<th>Reflection/Notes:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Name of Teacher:</th>
<th>HOD:</th>
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</thead>
<tbody>
<tr>
<td>Sign:</td>
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<td>Date:</td>
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</tbody>
</table>
1. **Learners will be TAUGHT and LEARN the following:**
   - Calculate the work done by an object when a force $F$ applied at an angle $\Theta$ to the direction of motion causes the object to move a distance $d$, using $W = Fd \cos \Theta$.
   - The work done by an external force on an object/system equals the change in kinetic energy of the object/system.
   - How to calculate work done on an object on an incline plane.

2. **The outcomes of the lesson - at the end of the lesson learners should be able:**
   - To calculate the work done by an object using $W = Fd \cos \Theta$
   - To find the component of the applied force that is parallel to the motion does work on an object.
   - Draw a force diagram of an object on an incline and find the component of force parallel to motion of an object.
   - To state work energy theorem in words.
   - Solve problems using the work energy theorem, i.e. the work done on an object is equal to the change in its kinetic energy: $W = \Delta E_k = E_{kf} - E_{ki}$
<table>
<thead>
<tr>
<th>TEACHER ACTIVITIES</th>
<th>LEARNER ACTIVITIES</th>
<th>TIMING</th>
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</thead>
<tbody>
<tr>
<td><strong>1. Teaching Methods:</strong></td>
<td><strong>Learners will write Baseline Assessment:</strong></td>
<td></td>
<td>Worksheet</td>
</tr>
<tr>
<td>Explanations, illustrations, Demonstrations and questions and answer methods</td>
<td>Calculate the vertical and horizontal components of the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$F = 200 \text{ N}$</td>
<td>Baseline assessment:</td>
<td></td>
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<tr>
<td></td>
<td>$F_{\text{vertical}} = 200 \text{ N} \times \sin 45^0$</td>
<td>$\pm (15 \text{ min})$</td>
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<td></td>
<td>$= 141.42 \text{ N}$</td>
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<td>$F_{\text{horizontal}} = 200 \text{ N} \times \cos 45^0$</td>
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<td>$= 141.42 \text{ N}$</td>
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<td>$F = 150 \text{ N}$</td>
<td>Feedback: provide correct answers</td>
<td>Chalkboard summary</td>
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<tr>
<td></td>
<td>$F_{\text{vertical}} = 150 \text{ N} \times \sin 50^0$</td>
<td>$\pm (15 \text{ min})$</td>
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<td>$= 114.91 \text{ N}$</td>
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<td></td>
<td>$F_{\text{horizontal}} = 150 \text{ N} \times \cos 50^0$</td>
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<td></td>
<td>$= 96.42 \text{ N}$</td>
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<tr>
<td>2. Lesson Development</td>
<td>3 When does a force perform work?</td>
<td></td>
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<tr>
<td>2.1 Introduction</td>
<td><strong>When the object is displaced in the direction of the force.</strong></td>
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<tr>
<td>a) Pre-knowledge required.</td>
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<tr>
<td>The teacher will introduce the lesson by giving learners baseline assessment.</td>
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<td>OR</td>
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<tr>
<td>Using question and answer method illustrated on the board.</td>
<td></td>
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<tr>
<td>2.2 Discussion and Explanation Method (the teacher will clears any misconceptions that the learners may have)</td>
<td>When the object is displaced in the direction of the force.</td>
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</tbody>
</table>
3. **Lesson Development**

**Illustration Method**
- **Instructional** – The teacher will illustrate to learners work done by forces acting at an angle to the horizontal by using an example.

**Example 1**

The Inuit man pulling the sledge exerts a force of 200 N and moves the sledge 20 m along the level ground. The rope is inclined at an angle of 30° to the horizontal. Determine the work done by the man, while he moves the pengines.

---

4. When there is no resultant force acting on an object, but it keeps on moving, what is keeping it moving?

   **Its inertia and momentum**

5. How are work and energy related?

   **Measured in the same units (joules)**

6. What is meant by kinetic energy?

   **Energy an object has due to its motion**

**Individual Work:**

A 1 020 kg car moves at a constant speed on an incline road that makes an angle of 60° with the horizontal. A constant friction force of 1 000 N acts on the car.

(i) What is the applied force exerted by the road on the tyres if the car is moving up the slope?

If the car moves up, friction acts down the slope. Friction opposes linear motion.

Weight $F_g = mg = (1 020,41)(9,8) = 10 000$ N

The component of the car’s weight that pulls it down parallel to the slope is $F_{gl}$.

---

**Demonstration and Explanation**

± 15 minutes

OR

**Illustrations and Explanation**

± 15 – 20 minutes

**Charts/ or available resources**

**Relevant equipments/ or other available resources.**
Solution:

Work done = \( F_{\text{horizontal}} \times \Delta x \)

Work done = 200 \( \times \) Cos 30 \( \times \) 20

Work done = 3464.10 J

1. Lesson Development:
   - Introduce the lesson to calculate force on incline plane.

A 2 kg object is released at A – the top of an incline plane as follows:

\( F_{\parallel} = \frac{m}{g} \cos 30^\circ = (10,000)(\cos 30^\circ) = 8,660 \) N

Constant speed motion means the net force is zero

\[ F_{\text{net}} = 0 = F_{\text{applied}} + F_{\parallel} + F_{\text{friction}} \]

\[ F_{\text{applied}} = 9,660 \) N up the slope

INFORMAL ASSESSMENT: HOME WORK

QUESTION 1

A box of mass 60 kg starts from rest at height \( h \) and slides down a rough slope of length 10 m, which makes an angle of 25° with the horizontal. It undergoes a constant acceleration of magnitude 2 m\( \cdot \)s\(^{-2} \) while sliding down the slope.

1. State the work-energy theorem in words.

State that Net work done on an object is equal to a change in kinetic energy of an object.
3. **Lesson Presentation**

**EXPLANATION:**

Only the component of the applied force that is parallel to the motion does work on an object.

Positive net work done on a system will increase the energy of the system and negative net work done on the system will decrease the energy of the system.

Very often the applied force on an object is not in the same direction as the direction of movement that is, it is applied at an angle to the movement.

Rem: One of the important things about work is that the force must be in the same direction as the change in position.

**CONCLUSION:**

- The horizontal component of the force is moving the object in the horizontal direction and therefore the work done by this force.
- Friction on an incline does negative work extracting energy from the system.
- The equation: \( E = \text{Heat} = F_r \cdot \Delta x \cdot \cos 180^\circ \)
- If an object moves at a constant speed, then the two forces acting on it are equal in magnitude but opposite in direction.
- Work Energy Theorem: The work done by a resultant force on an object is equal to the change in its kinetic energy.

- Formula: \( W_{\text{net}} = \Delta E_k = F_{\text{res}} \cdot \Delta x \cdot \cos \theta \)

---

2. **The box reaches the bottom of the slope.**

**Calculate the following:**

2.1 The kinetic energy of the box, using the equations of motion

\[
\begin{align*}
\nu_f^2 &= \nu_i^2 + 2a\Delta x \\
\nu_f^2 &= 0^2 + 2(2)(10) \\
\nu_f^2 &= 40 \, \text{m}^2/\text{s}^2
\end{align*}
\]

\(\Delta K = \frac{1}{2} (60)(40)\)

\(\Delta K = 1200 \, \text{J}\)

2.2 The work done on the box by the gravitational force

\[
W_g = w// \Delta x \cos \theta
\]

\[
= mgsin 25^\circ (10) (\cos 0^\circ)
\]

\[
= (60)(9,8)sin25^\circ 10(1)
\]

\(= 2485 \, \text{J}\)

2.3 The work done on the box by the frictional force, using the work-energy theorem

\[
W_{\text{net}} = W_g + W_f
\]

\[
m \cdot a \cdot \Delta x = W_g + W_f
\]

\[
(60)(2)(10) = 2485 + W_f
\]

\[
W_f = -1285 \, \text{J}
\]


<table>
<thead>
<tr>
<th>W_{\text{net}} = E_{k,\text{final}} - E_{k,\text{initial}}</th>
</tr>
</thead>
</table>

Provide Homework to learners that they can do and discuss the solution the following lesson.

**MORE EXERCISES:**

The teacher will provide learners with extra exercise to practice on their own OR work in groups. Learners will provide their solutions to the rest of classmates.

1. A woman pulling her suitcase along the ground exerts a force of 100 N on the handle of the trolley as she moves.

   1.1 Draw a force diagram of all force on the trolley

   1.2 If the angle between the applied force and the horizontal is 60°, find the horizontal and vertical component of force applied.

2. A boy of mass 40kg is traveling at 8 m/s on a skateboard when he reaches a ramp of height 1.2m and of length 5m. A constant force of friction of 16N acts between the skateboard and the surface of the ramp.

   Calculate his velocity when he reaches the top of the ramp.

<table>
<thead>
<tr>
<th>2.4 The magnitude of the frictional force acting on the box</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ W_{\text{friction}} = F_f \Delta x \cos \theta ]</td>
</tr>
<tr>
<td>[ -1285 = f(10)\cos 180° ]</td>
</tr>
<tr>
<td>[ F_f = 128.5 \text{ N} ]</td>
</tr>
</tbody>
</table>

**ATTACHMENTS:**

Power point slides present.
Ek at the bottom of the ramp = ½ mv²
Ek = ½ x 40 x (8)² = 1280J

This is the total amount of energy at the beginning
Ep gained during journey up ramp = mgh
Ep gain = 40 x 10 x 1.2 = 480J

Energy lost due to friction = F·s = 16 x 5 = 80J
Ek remaining = 1280 – (480 + 80) = 720J

720 = ½ mv²
720 = ½ x 40 x v²
v = 6 m·s⁻¹
### LESSON OBJECTIVES

1. **Learners will be TAUGHT and LEARN the following:**
   - The work done by larger potential energy has a greater capacity to do work.
   - Calculations of work done by an object.
   - Define the principle of mechanical energy.

2. **LESSON OUTCOMES - At the end of the lesson learners should be able to:**
   - Describe work done by an object that has a greater capacity to do work at different height.
   - Apply the principle of mechanical energy to calculate work done by an object.
   - Define the principle of mechanical energy.
<table>
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<td><strong>Baseline Assessment:</strong></td>
<td></td>
<td>Worksheet</td>
</tr>
<tr>
<td>Explanations, illustrations, Demonstrations and questions and answer methods</td>
<td>a. What is the definition of energy?</td>
<td>± (15 min)</td>
<td>Chalkboard summary</td>
</tr>
<tr>
<td></td>
<td>Capacity to do work</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Define what is kinetic energy?</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Energy that the object has due to its state of motion.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Define Work – energy theorem</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Work done on an object is equal to the change in its kinetic energy as a result of this acceleration.</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>d. Derive the formula of mechanical energy?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$U_{(top)} + K_{(top)} = U_{(bottom)} + K_{(bottom)}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>e. Define conservation law of energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total mechanical energy of a particle in an isolated system is conserved.</td>
<td></td>
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</tbody>
</table>

| **2. Lesson Development** | **Baseline assessment:** | | |
| | a) Pre-knowledge required. | | |
| | • The teacher will introduce the lesson by giving learners baseline assessment. | | |
| | OR | | |
| | • Using question and answer method? | | |
| | ✓ Define what is kinetic energy? | | |
| | ✓ What are the SI units of energy? | | |
| | ✓ Define what is potential energy | | |
| | ✓ What are the SI units? | | |
| | ✓ What is the principle of mechanical energy? | | |
Discussion and Explanation Method (the teacher will clear any misconceptions that the learners may have)

- **Mechanical energy** of an object is the sum of its **kinetic and gravitational potential energy**.
- **Mechanical energy is conserved** provided the sum of the kinetic energy and gravitational potential energy \((E_p + E_k)\) stays constant.
- The *work done by an external force* on an object equals the change in mechanical energy of the object or system.

Demonstration Method

- Demonstration – the teacher will prepare a PENDULUM to demonstrate to learners the concepts of mechanical energy \((E_k + E_p)\)

Problem Solving

- Problem solving – the teacher will use simple examples to show how to calculate energy.

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<thead>
<tr>
<th>Grade 12 Physical Sciences Lesson Plans</th>
<th>Term 1 Page 64</th>
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</table>

<table>
<thead>
<tr>
<th>1. Drop a 50 kg rock off a vertical cliff that is 45, 92 m high. Calculate its speed when 25, 51 m above the ground</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Diagram of a rock falling from a cliff]</td>
</tr>
<tr>
<td>(A (v = 0))</td>
</tr>
<tr>
<td>(B)</td>
</tr>
<tr>
<td>(45, 92 \text{ m})</td>
</tr>
<tr>
<td>(25, 51 \text{ m})</td>
</tr>
<tr>
<td>(U + K \text{ (at A)} = U + K \text{ (at B)})</td>
</tr>
<tr>
<td>(mgh + 0 \text{ (at A)} = mgh + \frac{1}{2} \cdot m \cdot v^2 \text{ (at B)})</td>
</tr>
<tr>
<td>(9, 8 \times 45, 92 = 9, 8 \times 25, 51 + \frac{1}{2} v^2)</td>
</tr>
<tr>
<td>(v^2 = 400)</td>
</tr>
<tr>
<td>(v = 20 \text{ m.s}^{-1})</td>
</tr>
</tbody>
</table>

| Assume a 1 kg bead at A is sliding down a 2 m length of wire to point B and experiences a constant frictional force of 6 N as it slides down |
| ![Diagram of a bead sliding down a wire] |
| \(A\) |
| \(3 \text{ m} \cdot \text{s}^{-1}\) |
| \(6 \text{ m}\) |
| \(2 \text{ m}\) |
| \(4 \text{ m}\) |
| \(B\) |

Demonstration and Explanation

\[\pm 15 \text{ minutes}\]

OR

Illustrations and Explanation

\[\pm 15 - 20 \text{ minutes}\]

Relevant equipments/ or other available resources.

Charts/ or available resources.
2.2 Attention focussing

2.2.1 Example

\[ E_p = mgh \]
\[ E_k = 0 \ J \]
\[ E_p = mgh \]
\[ E_k = 0 \ J \]

3. Pre - Knowledge:
- Define the concept **conservation of energy**.
- What are the SI units of both \( E_p \) and \( E_k \)?
- Explain the concept **closed system**.
- Define the concepts \( E_p \) and \( E_k \).

4. Lesson Presentation

Conducting Demonstration on PENDULUM:
- The teacher will conduct a demonstration to explain the principle of mechanical energy.
- **The sum of potential energy and kinetic energy at the different position of the pendulum.**

\[ U + K_{(at \ A)} - W_{friction} = U + K_{(at \ B)} \]
\[ m \ g \ h + \frac{1}{2} \ m \ v^2_{(at \ A)} - F_{\Delta x} = m \ g \ h + \frac{1}{2} \ m \ v^2_{(at \ B)} \]
\[ 1 \times 9.8 \times 6 + \frac{1}{2} (1)(3)^2 - (6 \times 2) = 1 \times 9.8 \times 4 + \frac{1}{2} (1) v^2_{(at \ A)} \]
\[ 58.8 + 4.5 - 12 = 39.2 + \frac{1}{2} v^2 \]
\[ 51.3 = 39.2 + \frac{1}{2} v^2 \]
\[ v^2 = 24.2 \]
\[ v = 4.92 \ m \ s^{-1} \]

The mechanical energy decreases due to friction. The “lost” energy becomes thermal energy.

**GROUP WORK ACTIVITY**

Learners will work in groups to find solutions:

If a 10 kg object falls from rest above the ground at point A to B:

- **A** 16 m
- **B** 12 m
- **C** 8 m
- **D** 4 m
- **E** 0 m

(1) **Using the conservation of mechanical energy, calculate the U and K at each position from A to E.**
**EXPLANATION:**

A and C – sphere at rest, B – sphere at lowest point and moving fastest.
Height at A and C equal – $E_m$ is conserved. At B all potential energy is converted into kinetic energy and at A and C all kinetic energy has been converted into potential energy.

- Energy cannot be created nor destroyed. It can only be converted from one form to another.
- During free fall, total mechanical energy remains constant, since the potential is transferred into kinetic energy.

3. **Lesson Development:**

**DERIVE FORMULA:**

Mechanical Energy = potential energy + kinetic energy

$$E_m = E_k + E_p$$

**A to E.**

<table>
<thead>
<tr>
<th>Point</th>
<th>Potential Energy</th>
<th>Kinetic Energy</th>
<th>Total Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>At A</td>
<td>$U_A = mgh_A$</td>
<td>$K_A = 0 J$</td>
<td>$313.6 J$</td>
</tr>
<tr>
<td>At B</td>
<td>$U_B = mgh_B$</td>
<td></td>
<td>$235.2 J$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$K_B = 78.4 J$</td>
<td></td>
</tr>
<tr>
<td>At C</td>
<td>$U_C = mgh_C$</td>
<td></td>
<td>$156.8 J$</td>
</tr>
<tr>
<td>At D</td>
<td>$U_D = mgh_D$</td>
<td></td>
<td>$78.4 J$</td>
</tr>
</tbody>
</table>

*At A:* $U_A = (2)(9.8)(16) = 313.6 J$

*At B:* $U_B = (2)(9.8)(12) = 235.2 J$

*At C:* $U_C = (2)(9.8)(8) = 156.8 J$

*At D:* $U_D = (42)(9.8)(4) = 78.4 J$
**Definition:**

- States that: in an isolated (closed) system in the absence of air friction, the sum of the gravitational potential energy and the kinetic energy of a body (in vertical plane) remains constant.

\[
U_{\text{max}} = m \cdot g \cdot h
\]

\[
K_{\text{max}} = 0 \text{ J} = \frac{1}{2} \cdot m \cdot v^2
\]

\[
K_B = 235, 2 \text{ J}
\]

At E: \( U_B = m \cdot g \cdot h_{(E)} \)

\[
=(2)(9, 8)(0)
\]

\[= 0 \text{ J} \]

\[
(U + K)_E = (U + K)_A
\]

\[
313, 6 + 0 = 0 + K_E
\]

\[
K_E = 313, 6 \text{ J}
\]

(2) Now determine the velocity of the ball at each position from A to E.

At A: \( K_A = 0 \text{ J}, \quad V_A = 0 \text{ m/s} \)

At B: \( K_B = 73, 6 \text{ J}, \quad 73, 6 = \frac{1}{2} \times 2 \times v^2 \)

\[V_B = 8, 85 \text{ m/s} \]

At C: \( K_C = 156, 8 \text{ J}, \quad 156, 8 = \frac{1}{2} \times 2 \times v^2 \)

\[V_C = 12, 52 \text{ m/s} \]

At D: \( K_D = 235, 2 \text{ J}, \quad 235, 2 = \frac{1}{2} \times 2 \times v^2 \)

\[V_D = 15, 34 \text{ m/s} \]

At E: \( K_E = 235, 2 \text{ J}, \quad 313, 6 = \frac{1}{2} \times 2 \times v^2 \)

\[V_E = 17, 71 \text{ m/s} \]

(3) Thus we can say that as the ball loses 3.1 it will now gain 3.2 according to the principle of conservation energy.
**TEACHING – LEARNING ACTIVITY**

**ACTIVITY ONE:**

**Cliff Problem**

Drop a 50 kg rock off a vertical cliff that is 45.92 m high. Calculate its speed at the bottom of the cliff.

A, Top \( (v = 0) \) object is stationary at A

B, bottom \( (h = 0) \)

\[ U + K_{\text{bottom}} = U + K_{\text{top}} \]

\[ 45.92 \times 9.8 \times 50 + 0 \, \text{J} = 0 + \frac{1}{2} \times 50 \times v^2 \]

\[ v = 30 \, \text{m/s} \]

**ACTIVITY TWO:**

Given a 0.1 kg bead at A sliding along a frictionless surface. Determine its speed at B if it slides up the frictionless ramp.

A, Top \( (v = 0) \) object is stationary at A

B, bottom  \( (h = 0) \)

\[ U + K_{\text{bottom}} = U + K_{\text{top}} \]

\[ 45.92 \times 9.8 \times 50 + 0 \, \text{J} = 0 + \frac{1}{2} \times 0.1 \times v^2 \]

\[ v = 4.05 \, \text{m/s} \]

**3.1 Potential energy**

**3.2 Kinetic energy**

**HOME WORK**

**QUESTION 1**

A player throws a cricket ball with a mass of 300 g vertically up into the air and it rises to a height of 15 m above the player.

1.1 Before throwing the ball, the player held the ball motionless. What was its mechanical energy at that stage?

   **Answer:** zero

Before throwing the ball:

1.2 Now consider the ball from the time that the player starts to throw it.

   1.2.1 Explain how the ball came to gain mechanical energy.

   As the ball rises its potential energy increase relative to the ground and its kinetic energy at maximum height become zero

   1.2.2 Calculate the gravitational potential energy of the ball at its maximum height relative to the player. **Answer:** \( 44.1 \, \text{J} \)

1.2.3 Assuming that air friction is negligible, what is the mechanical energy of the ball? **Answer:** \( 44.1 \, \text{J} \)

1.2.4 What was the kinetic energy of the ball when it left the player's hand? **Answer:** \( 44.1 \, \text{J} \)
**ACTIVITY 3**

A pendulum of mass 800 g swings to a maximum height of 50 cm.

![Diagram of a pendulum with points A, B, and C, each 50 cm apart.]

a. Calculate the maximum potential energy at point A

\[ U = m g h \]
\[ = 0.8 \times 9.8 \times 0.5 \]
\[ = 3.92 \text{ J} \]

b. Calculate its velocity at the lowest point of its swing

\[ 3.92 = \frac{1}{2} \times 0.8 \times v^2 \]
\[ v^2 = 9.8 \]
\[ v = 3.13 \text{ m/s} \]

**CONCLUSION:**

- The equation of total mechanical energy can be used to calculate the velocity of the object at its final position.
- Mechanical energy is always conserved if there is no friction.

The SI units is Joule (J) or N·m.

---

1.2.5 How much work did the player do on the ball?

**Answer:** (44 J)

1.2.6 Calculate the speed with which the ball left the player's hand. **Answer:** (17 m·s⁻¹)

1.2.7 What is the kinetic energy of the ball at one quarter of its maximum height?

**Answer:** 33.08 J
### Reflection/Notes:

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## Grade 12 Physical Sciences Lesson Plans

**Term 1 Page 71**

### Lesson Plan

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1. **Learners will be TAUGHT and LEARN the following:**
   - The net work done by an external/ resultant force on an object/ system equals the change in kinetic energy of the object or system (the work-energy theorem)
   - Solve problems using the work-energy theorem, i.e. the work done on an object is equal to the change in its kinetic energy.

\[ W = \Delta E_k = E_{kf} - E_{ki} \]

2. **LESSON OUTCOMES – At the end of the lesson learners should be able to:**
   - To define the work – energy theorem.
   - Apply the work-energy theorem to objects on horizontal and incline planes (frictionless and rough)
   - Explain how different height will produce potential energy when object is lifted above the ground.

Define potential energy of the object.
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| 1. **Teaching Methods:**  
  Explanations, illustrations, Demonstrations and questions and answer methods | | | |
| 2. **Lesson Development** | | | |
| 2.1 Introduction | | | |
| a) Pre-knowledge required. | | | |
| • The teacher will introduce the lesson by giving learners **baseline assessment**. | | | |
|  | OR | | |
|  | • Using question and answer method? | | | |
|  | ✓ Define what is kinetic energy? | | | |
|  | ✓ What are the SI units of energy? | | | |
|  | ✓ Define what is potential energy | | | |
|  | ✓ What are the SI units? | | | |
|  | ✓ Is energy a scalar or vector? Explain your answer. | | | |
|  | ✓ How does energy relate with work? | | | |
| | 1. **Baseline Assessment:** | | | |
|  | a. Define what is acceleration? | | | |
|  | The rate of change in velocity, it is vector quantity. | | | |
|  | b. What are the **SI units** of acceleration? (m·s⁻²) | | | |
|  | c. Define Work – energy theorem | | | |
|  | Work done on an object is equal to the change in its kinetic energy as a result of this acceleration. | | | |
|  | d. Derive the formula | | | |
|  | \( W = \Delta E_k = E_{mf} - E_k \) | | | |
|  | e. What is energy? | | | |
|  | **Energy is capacity to do work** | | | |
Discussion and Explanation Method (the teacher will clear any misconceptions that the learners may have)

- The net force acting on a body, therefore, changes its kinetic energy.
- \[ W_{\text{NET}} = \Delta E_K \text{ final} - \Delta E_K \text{ Initial} \]
  Where \( W_{\text{net}} \) is the work done by the net force
- Newton's second law of motion tells us that a net force brings about a change of velocity of an object.
- The object must move in the direction of the force that is applied i.e. Displacement must be in the same direction.

Demonstration Method

- Instructional – the teacher will use examples to illustrate this concept.

Example:

Jabu pushes a small cart of mass 5 kg with a speed of 1 m·s\(^{-1}\). She suddenly increases the force acting on the cart to move at 2 m·s\(^{-1}\) for distance of 50 m. Calculate

1. The initial kinetic energy
2. The final kinetic energy
3. The work done on the cart
4. The force causing the cart to speed up
5. The acceleration of the cart

HOMEWORK ACTIVITY

Learners will solve the problems on the worksheets given to them by the teacher and will discuss and present their solutions.

1. A 4 kg block initially at rest, is pulled to the right along a rough horizontal surface by a constant horizontal force of 12 N. The coefficient of dynamic friction is 0.15. Using the work energy theorem, calculate the speed of the block after it has moved a distance of 3 m

   \[ \text{Rem: Friction} = \mu \cdot m \cdot g \]

   \[ F_F = \mu \cdot m \cdot g \]
   \[ F_F = 0.15 \times 4 \times 9.8 \]
   \[ F_F = 5.88 \text{ N left} \]
   \[ F_{\text{net}} = 12 \text{ N} - 5.88 \text{ N} \]
   \[ F_{\text{net}} = 6.12 \text{ N} \]
   \[ W_{\text{net}} = F \cdot \Delta x \cdot \cos \Theta \]
   \[ W_{\text{net}} = 6.12 \times 3 \times 1 \]
   \[ W_{\text{net}} = 18,36 \text{ J} \]
   \[ W_{\text{NET}} = \Delta E_{K \text{ final}} - \Delta E_{K \text{ Initial}} \]
   \[ W_{\text{NET}} = \frac{1}{2} \times 4 \times (v_f)^2 - \frac{1}{2} \times 4 \times (0)^2 \]
   \[ 18,36 = \frac{1}{2} \times 4 \times (v_f)^2 \]
   \[ v_f = 3.03 \text{ m} \cdot \text{s}^{-1} \]

2. On a horizontal road a 2 400 kg vehicle is braked from 20 m·s\(^{-1}\) to rest by a net force of 9 600 N. How far does it move as it slows?

Demonstration and Explanation ± 15 minutes

Illustrations and Explanation ± 15 – 20 minutes

Charts/ or available resources

Relevant equipment s/ or other available resources.
Solution:

1. \( K_{\text{initial}} = \frac{1}{2} mv^2 \)
   \[ = \frac{1}{2} (5)(1)^2 \]
   \[ = 2.5 \text{ J} \]

2. \( K_{\text{initial}} = \frac{1}{2} mv^2 \)
   \[ = \frac{1}{2} (5)(2)^2 \]
   \[ = 10 \text{ J} \]

3. Work – Energy Theorem
   \[ W = \Delta E_k = E_{kf} - E_{ki} \]
   \[ = 10 - 2.5 \]
   \[ = 7.5 \text{ J} \]

4. \( W = F \cdot \Delta x \cdot \cos \Theta \)
   \[ 7.5 = F \times 50 \times \cos 0 \]
   \[ F = 0.15 \text{ N} \]

5. \( F_{\text{net}} = ma \)
   \[ 0.15 = 5 \times A \]
   \[ a = 0.03 \text{ m/s}^2 \]

3. **Lesson Development:**

**EXPLANATION**

✓ The amount of kinetic energy produced by resultant force depend on the mass of the object and the velocity (speed) at which it is moving.

✓ There must be resultant force acting on object in order to change its velocity.

✓ Work done = energy transferred.
Work is done when an external force acts on an object.

If this external force results in the object undergoing acceleration, then we would expect the amount kinetic energy to get bigger as the velocity increases due to the acceleration.

Resultant force always produces acceleration: $F = ma$.

### 4. LESSON SUMMARY (CONCLUSION):

#### 5.1 Summarise on the lesson on the chalkboard
- Work – Energy theorem, the net work on an object by the net force is equal to the change in the object’s change in kinetic energy.
- Kinetic energy is the energy due to the motion of an object.
- Energy is a scalar quantity with magnitude only, i.e. No direction

- We use the square of the velocity in the equation to calculate K.
- The work done by the total force acting on a particle is equal to the change in the kinetic energy of the particle.
- The SI unit for work and energy is the joule.
- Both work and energy are scalar quantities.

#### 5.2 The teacher will use examples from previous question paper to increase the level of understanding of learners.

#### 5.3 Question on incline where frictional force is part of the system will be included as part exercise.

### Question 2

A cyclist pedals such that a net force of 20 N accelerates the bicycle from rest.

1. Use the work-energy theorem to calculate the kinetic energy of the bicycle and cyclist after moving 50 m.

   $W_{net} = F_{net} \cdot \Delta x \cdot \cos \theta$

   $W_{net} = 20 \cdot 50 \cdot 1 = 1000 \text{ J}$

2. If the combined mass of bicycle and cyclist is 50 kg, calculate their velocity after moving 50 m.
Here the teacher can give learners different question to work in groups and discuss their solution to the class.

\[ \Delta K = 1000 \text{ J} \]
\[ 1000 = \frac{1}{2} \times 50 \times (v_f^2 - 0) \]
\[ 1000 = 25 v_f^2 \]
\[ v_f = 6,33 \text{ m} \cdot \text{s}^{-1} \]

3. If, instead of starting from rest, the bicycle was already moving at 2 m \cdot s^{-1} when the resultant force was applied, what is its velocity after moving 50 m?

\[ 1000 = \frac{1}{2} \times 50 \times (v_f^2 - 2^2) \]
\[ 1000 = 25 v_f^2 - 100 \]
\[ v_f = 6 \text{ m} \cdot \text{s}^{-1} \]

HOME WORK

If a 20 kg object falls for 5 s from rest and hits the ground at 40 m \cdot s^{-1}.

1. Calculate the work done to overcome air friction

\[ W = U = m \times g \times h \]
\[ U = 20 \times 9,8 \times 81,63 \]
\[ U = 16000 \text{ J} \]

2. What average force stops the box if it makes a 40 cm dent in the ground?

\[ W_{\text{net}} = F \Delta x \]
\[ 16000 \text{ J} = F \times 0,4 \]
\[ F = 40000 \text{ N} \]
## Work, Power and Energy:

1. **Power** = The rate at which work is done or energy is transferred.
2. **Efficiency** = \( \frac{\text{Energy Output}}{\text{Energy Input}} \)

### Lesson Objectives

1. **Learners will be TAUGHT and LEARN** the following concepts:
   - Define power as the rate at which work is done or energy is expended.
   - Calculate the power involved when work is done.
   - Understand the average power required to keep an object moving at a constant speed along a rough horizontal surface or a rough incline plane and do calculations using: \( P_{av} = F \cdot v_{av} \)
   - Apply to real life example, e.g. the minimum power required of an electric motor to pump water from a borehole of a particular depth at a particular rate, the power of different kinds of cars operating under different conditions.

2. **LESSON OUTCOMES** – At the end of the lesson learners should be able to:
   - To define the power involved when work is done.
   - Calculate the power involved when work is done.
   - Calculate the power when an object is moving with constant velocity.
   - Apply to real life situation.
### TEACHER ACTIVITIES

1. **Teaching Methods:**
   - Explanations, illustrations, Demonstrations and questions and answer methods

2. **Lesson Development**

   2.1 **Introduction**

   a) **Pre-knowledge required.**
   - The teacher will introduce the lesson by giving learners **baseline assessment.**
   - OR
   - Using question and answer method?
     - What is the scientific meaning of power?
     - Which unit is used to calculate power? **(Watt (J·s⁻¹))**
     - Is power a scalar or a vector? Explain your answer.
     - Define the term “rate”.
     - What is the formula used to calculate power?
     - Derive the formula:  \( P = F\overline{v} \)
     - What is different between the two formulae?

### LEARNER ACTIVITIES

1. **Baseline Assessment:**
   a. What is the scientific meaning of power?
   - The rate at which energy or work is done on an object.
   b. Which unit is used to calculate power? **Watt (J·s⁻¹)**
   c. Define the unit Watt.
   - **One watt is the rate of working or energy transfer of one joule per second**
   d. Write down the formula.
   - \( P = \frac{W}{\Delta t} \)

### GROUP WORK ACTIVITY

1. A car moves at a constant speed of 20 m·s⁻¹. Thus the frictional force equals the driving force. Determine the frictional force \( F \) if it has an 88 kW motor.
   - \( W = F \Delta x \) if you divide both sides by \( \Delta t \)
   - \( P = F \overline{v} \)
   - \( \frac{88 000}{\Delta t} = F \times 20 \)
   - \( F = 4 400 \text{ N} \)

2. A 100 W electric motor takes 1 minute to lift a 50 kg mass vertically through 6m at constant speed. Calculate the efficiency of the motor.

### TIMING

Baseline assessment: ± (15 min)

Feedback: provide correct answers ± (15 min)

### RESOURCES NEEDED

- **Worksheet**
- **Chalkboard summary**
Discussion and Explanation Method (the teacher will clear any misconceptions that the learners may have)

- Power measures how quickly the work is done.
- By Definition:
  Power is equal to the work done or energy transferred divided by the time interval over which the work is performed.
  It is simply: the rate of performing work or transferring energy. (\( P = \frac{W}{\Delta t} \))
  - The SI unit of power is Watt.

(The teacher will explain the concept power in relation to electricity)

- The concept of power is also useful when dealing with electricity.
- Imagine an electric current with a resistor. A certain amount of work must be done to move charge through the resistor.
- To move charge more quickly through the resistor – or in other words, to increase the current flowing through the resistor – more power is required.
- Show application to real life: electric motor, power of different kinds of cars

Demonstration Method

- Instructional – the teacher will use examples to illustrate this concept.

\[
W = P \Delta t = 100 \times 60 = 6000 \text{ J}
\]
\[
W = \Delta U = mg \Delta h = 50 \times 9.8 \times 6 = 3000 \text{ J}
\]

Efficiency = \( \frac{\text{work done on mass}}{\text{work done by motor}} \times 100 \)
\[
\frac{3000}{6000} \times 100 = 50\%
\]

The greater the power of motor, the faster it can perform work.

3. An electric motor of 1500 W of power is used to pull in a 70 kg crate of fish up a very slippery loading ramp at a constant speed. The ramp is inclined 31° to the horizontal. Determine the speed of the crate. (Ignore friction.)

A. 1.9 m/s⁻¹
B. 2.1 m/s⁻¹

Chairs/ or available resources

Demonstration and Explanation
± 15 minutes

OR

Illustrations and Explanation
± 15 – 20 minutes

Relevant equipments/ or other available resources.
**Example 1:**

A car with a mass of 1 200 kg accelerates from rest at 5 m/s² across a horizontal road. Calculate the average power of the engine if the car accelerates for 5 s.

**Solution:**

The acceleration is constant and motion equations can be used to calculate the final velocity of the car:

\[ v_f = v_i + a\Delta t = 0 \text{ m/s} + (5 \text{ m/s}^2)(5 \text{ s}) = 25 \text{ m/s} \]

The average velocity of the car:

\[ \bar{v} = \frac{v_i + v_f}{2} = \frac{0 \text{ m/s} + 25 \text{ m/s}}{2} = 12.5 \text{ m/s} \]

The average power of the car:

\[ P = F\bar{v} = ma \bar{v} = (1 200 \text{ kg})(5 \text{ m/s}^2)(12.5 \text{ m/s}) = 7.5 \times 10^4 \text{ W} \]

**Example 2**

During a canoe race each of two different teams, A and B, exerts a net force of 80 N to pull their canoes across a distance of 70 m. Team A takes 100 s and Team B takes 95 s. Determine the power of each team.

**Solution**

\[ P_A = \frac{W}{\Delta t} = \frac{F\Delta x}{\Delta t} = \frac{(80 \text{ N})(70 \text{ m})}{100 \text{ s}} = 56 \text{ W} \]

4. How much work is required to raise a 4,0 \( \times \) 10³ kg object to an altitude of 5,0 \( \times \) 10⁶ m above the earth’s surface?

A. 1.1 \( \times \) 10¹¹ J  
B. 1.4 \( \times \) 10¹¹ J  
C. 2.0 \( \times \) 10¹¹ J  
D. 2.5 \( \times \) 10¹¹ J

**Answer:** A

**HOME WORK ACTIVITY**

Learners will work individually to find solutions:

**QUESTION 1**

1.1

A force of 100 N is required to keep a canoe moving at 2 m·s⁻¹. What power must be produced to keep the canoe moving at this speed?

\[ P = Fv \]  
\[ P = 100 \times 2 \]
\[
PB = \frac{W}{\Delta t} = \frac{F\Delta x}{\Delta t} = \frac{(80 \text{ N})(70 \text{ m})}{95 \text{ s}} = 58.9 \text{ W}
\]

### 3. Lesson Development:

**EXPLANATION**

- The amount of power produced depends on the amount of energy or work done on an object at a certain period of time.
- The formula to calculate power: \( PB = \frac{W}{\Delta t} = \frac{F\Delta x}{\Delta t} \)

**Alternatively:**

Suppose a car moves along an even horizontal road at a constant velocity. The driving force of the engine is equal in size and opposite in direction to the frictional force and the car does not experience any acceleration.

Distance that the car moves in time, \( t \): \( \Delta x = v \Delta t \)

Work done by the driving force: \( W = F\cos\theta \Delta x = Fv \Delta t \)

Power produced by the engine: \( P = \frac{W}{\Delta t} = \frac{Fv\Delta t}{\Delta t} = Fv \)

- The SI units: watt (W)
- Power is a scalar quantity – it has no direction

---

**1.2**

In gold mines, the miners are lowered into the mine using elevator. The elevator is able to hold 14 miners, each of an average mass of 70 kg and lowers them down the mine shaft a distance of 300 m in 100 seconds. If the mass of the lift is 1500 kg, then calculate the power that the elevator engine must generate.

\[
\begin{align*}
M_{\text{miners}} &= 14 \times 17 \quad \text{m}_{\text{total}} = m_{\text{miners}} + m_{\text{lift}} \\
&= 980 \text{ kg} \quad = 980 + 1500 \\
M_{\text{lift}} &= 1500 \text{ kg} \quad = 2480 \text{ kg} \\
F_{\text{applied}} &= F_g = mg \\
P &= \frac{W}{t} \\
W &= mg \Delta y \\
P &= \frac{7291200}{100} \\
W &= (2480)(9.8)(300) \\
P &= 72912 \text{ W} \\
W &= 7291200 \text{ J}
\end{align*}
\]
Efficiency tells us how much of our input energy actually did useful work. The rest was dissipated as heat.

The greater the power of a motor, the faster it can work.

4. LESSON SUMMARY (CONCLUSION):

4.1 Summarise on the lesson on the chalkboard

- Power is the rate at which work is done or energy is transferred.
- The unit of power is joule per second, or J/s, also called a watt (W)
- 1 watt is the power delivered when 1 joule of work is done in 1 second.
- Power is a scalar quantity with magnitude only, i.e. No direction,
- F and v act along the same straight line and v is the average or constant velocity.
- Apply to real life example, e.g. the minimum power required of an electric motor to pump water from a borehole of a particular depth at a particular rate, the power of different cars operating under different conditions

The teacher will use examples from previous question papers to increase the level of understanding of learners
### Lesson Summary

At the end of this lesson learners should know:

- The meaning of scattering

The following results will be the outcome of this lesson

- Learners must be able to explain why the sky is blue.

### Lesson Objectives

1. The meaning of scattering
2. Learners must be able to explain why the sky is blue.

### Teaching Methods Used in This Lesson

- Question and answer
- Demonstration
- Investigate
- Explain

### Lesson Development

#### 2.1 Introduction

- Introduce the lesson by giving learners the following scenario:
  
  Parallel light rays falling onto a smooth surface are reflected parallel and evenly in a new direction. Some surfaces however are rough and the reflected rays scatter in various directions. What is the reflection off a rough surface called?

#### Pre-knowledge

- Light as a wave, reflection, refraction, spectrum of light, electronic properties of matter.

### Learner Activities

1. Learners observe and record the colour of light on the screen and in the glass of water, water and few teaspoons of milk
2. Learners answer baseline questions.
3. Learners and educator discuss questions and answers on the baseline questions.
4. Learners copy the observations and discussion from the demonstration
5. Learners copy notes from the board.
6. Learners copy the following homework:

   1. Light from many sources, such as sunlight, appears white. When white light passes through a prism, however, it separates into a spectrum of varied colours. The methods used for colour specification today consist of accurate scientific measurements based on the wavelengths of each colour as given in the table below:

### Timings

- Learners observe and record the colour of light on the screen and in the glass of water, water and few teaspoons of milk: 5 min
- Learners answer baseline questions: 10 min
- Learners and educator discuss questions and answers on the baseline questions: 15 min
- Learners copy the observations and discussion from the demonstration: 5 min
- Learners copy notes from the board: 15 min
- Learners copy the following homework: 15 min

### Resources Needed

- A clear, straight sided glass jar or drinking glass;
- water; milk; torch; and
darkened room
Baseline assessment
- Educator write questions on the board (or prepare a worksheet) to find out the level of understanding of the learners’ prior knowledge

Baseline questions
- How does light travel?
- What is reflection of light?
- When light travels from a less dense medium to a more dense medium, what happens to the light ray?
- Which colour of light has the lowest frequency?
- Which colour of light has the highest frequency?
- Which colour of light has the longest wavelength?
- Which colour of light has the shortest wavelength?
- What is the relationship between frequency and wavelength?

2.2 Main Body (Lesson presentation)
- Lesson starts with a scenario given to learners and the phrases reflection and scattering mentioned
- Experimental demonstration of scattering demonstration

<table>
<thead>
<tr>
<th>Colour</th>
<th>Wavelength (nm)</th>
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<tr>
<td>Red</td>
<td>780 - 622</td>
</tr>
<tr>
<td>Orange</td>
<td>622 - 597</td>
</tr>
<tr>
<td>Yellow</td>
<td>597 - 577</td>
</tr>
<tr>
<td>Green</td>
<td>577 - 492</td>
</tr>
<tr>
<td>Blue</td>
<td>492 - 455</td>
</tr>
<tr>
<td>Indigo</td>
<td>455 - 430</td>
</tr>
<tr>
<td>Violet</td>
<td>430 - 390</td>
</tr>
</tbody>
</table>

a) What is meant by the “spectrum” of light?
b) Name one similarity and one difference between the different colours of the spectrum.
c) What assumptions can be made if two rays of light have the same wavelength?
d) Name the colour which is refracted the most.
e) What colour is associated with the frequency $4.9 \times 10^{14}$ Hz?

2. Explain why an apple appears to be red in white light.

SOLUTIONS
1.
(a) A spectrum is the rainbow-like series of colours, produced by splitting light into its component colours.

Learn more from the glass of milk

As the number of particles suspended in the glass increases, the amount of light that passes through the liquid decreases.
Note:
- The image on the screen appears red
- The milk appears blue
- The red wavelengths are scattered less and travel through the milk to form the image.
- The blue wavelengths are scattered more than the red wavelengths so the milk in the glass appears blue.

- Educator gives learners the following answers to the baseline questions:
  - Light travels in straight lines when it is not passing through a medium.
  - Reflection of light is the change in direction of a wavefront at an interface between two different media so that the wavefront returns into the medium from which it originated.
  - It bends—or more accurately, changes direction—when it travels from one medium to another.
  - Red
  - Violet
  - Red
  - Violet
  - The wavelength and frequency of light are closely related. The higher the frequency, the shorter the wavelength.

(b) Different colours of light are similar in consisting of electromagnetic radiation. They differ in having different frequencies and wavelengths.

(d) Violet

(e) \( c = f \lambda \)

\[
3 \times 10^8 = 4.9 \times 10^{14} \lambda \\
\lambda = \frac{3 \times 10^8}{4.9 \times 10^{14}} \\
= 6.12 \times 10^{-7} \text{ m} \\
= 612 \text{ nm}
\]

2. The apple consists of atoms whose electrons have the same frequency as all the colours of the light, except red. All the colours except red will be absorbed. The red light will be reflected, and therefore the apple will appear red in colour under white light.
- Educator discusses answers to the baseline questions.
- Write the observations on the demonstration.
- Discuss scattering
  - When light passes through the atmosphere it is scattered by the dust particles in the air and the water droplets in clouds.
  - The degree of scattering depends on:
    - The size of the particles
    - The wavelength of the light
  - Scattering by particles that are smaller than the wavelength of light is called Raleigh Scattering.
  - Short wavelengths—the blue end of the spectrum—are scattered far more than red wavelengths.
  - The sky appears blue because the shorter blue wavelengths are scattered perpendicular to the sun’s rays and reach our eyes.
  - At sunrise and sunset the rays have to pass through more of the atmosphere to reach our eyes. Most of the blue wavelengths have been scattered away and so the sunlight appears red.

### 2.3 Conclusion
- Learners asked about the important aspects of the lesson i.e. the scattering of light, why the sky is blue.
- Give learners homework.
**LESSON OBJECTIVES**

At the end of this lesson learners should know:
- The interaction of light with materials.
- The following results will be the outcome of this lesson
  - Learners must be able explain the interaction of UV and visible radiation with
    - Metals: reflect (absorb and re-emit)
    - In terms of the interaction with the electromagnetic radiation

**TEACHER ACTIVITIES**

1. **TEACHING METHODS USED IN THIS LESSON**
   - Question and answer, Explanation

2. **LESSON DEVELOPMENT**
   2.1 **Introduction**
   - Introduce the lesson with the baseline questions
     - Pre-knowledge
     - Electronic properties of matter
   
   **BASELINE ASSESSMENT**
   - Baseline questions
     - On what does the electrical conductivity of metals depend?
     - Why do metals conduct electricity?

   2.2 **Main Body (Lesson presentation)**
   - Lesson starts with the educator asking the learners the baseline questions.
   - Educator and learner discuss the following answers to the baseline questions
     - Electrons
     - According to the Band Theory the conduction and valence bands of metals are close together. This makes it easy for excited electrons to move with ease between the bands.
     - Educator explain and discuss with learners the following:

**LEARNER ACTIVITIES**

1. Learners answer the baseline question
2. Learners and educator discuss the questions and answer of the baseline assessment.
3. Learners copy notes from the board
4. Learners write the classwork

**CLASSWORK**

1. Explain the following terms
   - (a) Transmission of light
   - (b) Absorption of light
   - (c) Reflection of light

2. Which phenomenon will occur in each of the following instances? Choose from reflection, transmission and absorption.
   - (a) The frequency of the incident light on an object is equal to the natural frequency of the electrons in the atoms of the object.

**TIMING**

- 10 min
- 30 min

**RESOURCES NEEDED**

- Chalkboard for notes, discussions and classwork.
The interaction between light and materials

- As light strikes a material, it interacts with the electrons in the atoms of the material.
- Light is energy, and on striking the material, this energy is transferred to the electrons in the atoms.
- The amount of energy transferred depends on the material.
- Since the energy levels in metals are close together, almost all frequencies of light can be absorbed, exciting electrons into higher available energy levels.
- When the frequency of the light is different to the natural energies of the electrons in the atom material, the light passes through and therefore transmitted.
- In terms of non-metals such as insulators, energy gaps between conduction bands and the valence bands are large. Thus for an electron to move into empty energy level in the conduction band requires a lot of energy.
- When light is absorbed, the greatest transfer of energy takes place.
- When light is scattered, very little energy transfer takes place.
- The absorbed energy is converted into internal energy, making the object hot.
- If no light is reflected or transmitted, the object will appear black.
- The colour of an object is determined by the frequency of the light it transmits.

2.3 Conclusion

- Learners questioned on main aspects of the lesson.

(b) The frequency of the incident light on an object is higher than the natural frequency of the electrons in the atoms of the object.

(c) The frequency of the incident light on the object is slightly lower than the natural frequency of the electrons in the atoms of the object.

3. A beam of white falls onto one side of each of three rectangular blocks: a carbon block that looks black, a copper block that looks reddish-orange and aluminium block that looks silvery.

(a) Which block absorbs the most energy from the beam of light?

(b) Which block absorbs least energy from the beam light? Explain your answer.

(c) Why does the copper block appear reddish-orange?

SOLUTIONS

1. (a) Transmission of light describes the situation in which light passes through a substance virtually unchanged.

(b) Absorption of light occurs when the light striking a surface is neither transmitted nor reflected, but rather absorbed by the material and the electrons use the energy and start to vibrate more energetically.
(c) Reflection of light occurs when light beams hit the surface of certain materials and do not operate into the material but rather “bounce” off.

2. (a) reflection
   (b) transmission
   (c) absorption

3. (a) The carbon. Because it is black no colour will be seen as all the frequencies are absorbed and more re-emitted.
   (b) The aluminium because most frequencies are re-emitted and therefore not absorbed.
   (c) Only the red and orange frequencies are transmitted, the rest are absorbed.
At the end of this lesson learners should know:

- The meaning of photoelectric effect
- The meaning of work function
- The meaning of threshold frequency

The following results will be the outcome of this lesson

- Learners must be able to explain photoelectric effect in terms of photons and work function.
- Learners must be able to recall, use and explain the significance of \( hf = W_0 + \frac{1}{2} mv^2 \)
- Learners must be able to give the significance of the photoelectric effect:
  - it establishes the quantum theory
  - it illustrates the particle the nature of light

### LESSON DEVELOPMENT

#### 2.1 Introduction
- Introduce the lesson with the baseline questions
- Pre-knowledge
  - Energy as the ability to do work, Kinetic energy, Electroscope, Intensity and frequency of waves, Electromagnetic spectrum (Visible light and ultraviolet light), Flow of charge, Delocalised electrons of metals

#### BASELINE ASSESSMENT

Baseline questions

- How do metals bond? What do we call the bond between two metal atoms? - Allude to delocalised electrons
- What keeps the delocalised electrons in the metallic lattice?
- Is it possible to remove one delocalised electron from a metal surface?

<table>
<thead>
<tr>
<th>TEACHER ACTIVITIES</th>
<th>LEARNER ACTIVITIES</th>
<th>TIMING</th>
<th>RESOURCES NEEDED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TEACHING METHODS USED IN THIS LESSON</strong></td>
<td>Question and answer, Explanation</td>
<td></td>
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<tr>
<td><strong>LESSON DEVELOPMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 <strong>Introduction</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Introduce the lesson with the baseline questions</td>
<td>1. Learners answer the baseline questions</td>
<td>10 min</td>
<td>Chalkboard for notes, discussions and classwork.</td>
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<tr>
<td>- Pre-knowledge</td>
<td>2. Learners and educator discuss the questions and answers of the baseline assessment</td>
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<td>- Energy as the ability to do work, Kinetic energy, Electroscope, Intensity and frequency of waves, Electromagnetic spectrum (Visible light and ultraviolet light), Flow of charge, Delocalised electrons of metals</td>
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<tr>
<td><strong>BASELINE ASSESSMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline questions</td>
<td>3. Learners take notes from the board/transparencies.</td>
<td>15 min</td>
<td></td>
</tr>
<tr>
<td>- How do metals bond? What do we call the bond between two metal atoms? - Allude to delocalised electrons</td>
<td>4. Learners discuss their conclusions with the educator</td>
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<td></td>
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<tr>
<td>- What keeps the delocalised electrons in the metallic lattice?</td>
<td>5. Learners take notes of the formal conclusions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Is it possible to remove one delocalised electron from a metal surface?</td>
<td>6. Learners copy notes from the board</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- How does the gold leaf work in an electroscope?
- Does visible light or ultraviolet light have a higher frequency?
- Do you think there is any relationship between frequency and energy of a wave?
- Why is energy needed to remove the electrons from the metal surface?
- Do you think light has energy?

**2.2 Main Body (Lesson presentation)**

- Lesson starts with the educator asking the learners the baseline questions.
- Educator and learners discuss the following answers of the baseline assessment:
  - Metals bond when the electrostatic forces between the delocalised electrons, gathered in an "electron sea" and the positively charged metal ions.
  - The metal is held together by the strong forces of attraction between the positive nuclei and the delocalised electrons
  - Yes
  - A gold-leaf electroscope is a simple device which is used to identify the electric charge present in a body. If a charged body (positively or negatively charged) is brought and touched to the metallic disk of the gold-leaf electroscope, it attains the same charge as that of the charged body touched to the metallic disk by the property of transmission of charges from one charged substance to another substance.
  - Yes
  - The metal will somehow be “reluctant” to surrender an electron and energy will be needed to. This energy is called ionization energy.
  - Light has energy

- Educator explain and discuss with learners the following

### APPLY YOUR KNOWLEDGE

1. To eject electrons from the surface of a given metal the incident radiation must have a minimum
   - A. Intensity
   - B. Amplitude
   - C. Speed
   - D. Frequency

2. The photoelectric effect is the
   - A. emission of protons from a substance under the action of light
   - B. emission of electrons from a substance under the action of light
   - C. emission of neutrons from a substance under the action of light
   - D. emission of nucleons from a substance under the action of light

3. A photon’s energy can be calculated by the formula
   - A. \( E = hf \)
   - B. \( E = h/f \)
   - C. \( E = f/h \)
   - D. \( E = hf^2 \)

4. Mention one way in which the wave model of light fails to explain the photoelectric effect.
A negatively charged zinc plate placed on a negatively charged electroscope discharges in the presence of ultraviolet light.

Increased intensity of UV light discharges the electroscope quicker.

A positively charged zinc plate on an electroscope is not discharged by UV light.

Visible light, even at high intensity, is not able to discharge a zinc plate that has been negatively charged.

Educator asks learners to write the conclusions they can make from the results of this experiment.

Educator and learners discuss the conclusions.

Educator formalises the conclusion on the board.

Shining light onto the charged plate can cause electrons to be ejected from the plate.

Only light of sufficiently high frequency can eject electrons from the plate.

5. Calculate the energy of a photon of frequency $2.2 \times 10^{14}$ Hz. Will this radiation be able to eject an electron from a piece of metal with a work function of $1.6 \times 10^{-19}$ J?

6. The photoelectric threshold frequency of copper is $9.4 \times 10^{14}$ Hz.

6.1 What is the work function of copper?

6.2 With what maximum kinetic energy will electrons be ejected when light of frequency $2 \times 10^{15}$ Hz is shone onto copper?

SOLUTIONS

1. D
2. B
3. A

4. The wave model cannot account for the emission of photoelectrons only after the frequency of the incident light passes a certain threshold value.
This minimum frequency is called **threshold frequency** ($f_0$).

- Increasing the intensity of the ultraviolet light causes more electrons to be ejected per second.
- This effect of releasing electrons from the metal surface is called **photoelectric effect**.
- The ejected electron is called the **photo-electron**.

Explaining the results- Max Planck’s contribution

- Vibrating particles radiate energy. This energy is not continuous but is emitted in small packages called quanta.
- The quantity energy in each package is directly proportional to the frequency of the vibration.
- $E \propto f$ or $E = hf$ where $h$ is Planck’s constant $= 6.63 \times 10^{-34}$ J$\cdot$s
- Quanta are indivisible

Explaining the results- Einstein contribution

- Energy is needed to remove an electron from a metal. For any metal, a minimum amount of energy, called the **work function** ($W_0$) is needed to remove the electron.
- The energy of the photon must be equal or greater than the work function before electrons will be ejected.
- Work function = $h \times$ threshold frequency
- $W_0 = hf_0$
- The kinetic energy of the ejected electrons can be determined:
  - Energy of the photon = work function $\times$ kinetic energy
  - $hf = W_0 + \frac{1}{2}mv^2$
- The dual nature of light
  - Light undergoes refraction and diffraction and this demonstrates its wave nature
  - The photoelectric effect demonstrates the particle nature of light
  - Electromagnetic radiations consists of packages of transverse waves
  - The wave nature predominates during propagation of radiation

5. $E = hf$
   
   $= (6.63 \times 10^{-34})(2.2 \times 10^{14})$
   
   $= 1.46 \times 10^{19}$ J

   It will be able because, $E > W_0$

   $6.1 \ W_0 = hf_0$
   
   $= (6.63 \times 10^{-34})(9.4 \times 10^{14})$
   
   $= 6.23 \times 10^{19}$ J

   $6.2 \ E = hf$
   
   $= (6.63 \times 10^{-34})(2 \times 10^{15})$
   
   $= 1.33 \times 10^{18}$ J

   $E = W_0 + E_k$
   
   $1.33 \times 10^{18} = 6.23 \times 10^{19} + E_k$

   $E_k = 7.03 \times 10^{19}$ J
- The particle nature predominates during interaction with matter
- Give learners classwork

### 2.2 Conclusion
- Learners questioned on main aspects of the lesson i.e. the meaning of photoelectric effect, threshold frequency, work function, photons, photo-electrons.
- Give learners the attached worksheet. Annexure A

**Reflection/Notes:**

<table>
<thead>
<tr>
<th>Name of Teacher:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HOD:</td>
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<tr>
<td>Sign:</td>
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<tr>
<td>Sign:</td>
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<tr>
<td>Date:</td>
<td></td>
</tr>
<tr>
<td>Date:</td>
<td></td>
</tr>
</tbody>
</table>
### Lesson Summary

At the end of this lesson learners should know:

- The meaning of continuous emission spectrum
- The meaning of line emission spectrum
- The meaning of line absorption spectrum

The following results will be the outcome of this lesson:

- Learners must be able to explain the source of atomic emission spectra (cf discharge tubes) and their unique relationship to each element.
- Learners must be able to relate the lines on the atomic spectrum to electron transition between energy levels.
- Learners must be able to explain the difference between atomic absorption and emission spectra.
- Learners must be able to use $E = hf$, to determine the energy of photons of UV and visible light to atomic absorption spectra.

### Teacher Activities

**Teaching Methods Used in this Lesson**

- Question and answer, Explanation

**Lesson Development**

2. **Introduction**

   - Introduce the lesson with the baseline questions
   - Pre-knowledge
     - Energy as the ability to do work, Kinetic energy, Electroscope, Intensity and frequency of waves, Electromagnetic spectrum (Visible light and ultraviolet light), Flow of charge, Delocalised electrons of metals

**Baseline Assessment**

Baseline questions

- What is meant by “spectrum of light”?
- Which wavelength of light is reflected the most?
- Which wavelength of light is reflected the least?
- Give the formula for calculating the energy of the photon.

### Learner Activities

1. Learners answer the baseline questions
   - Timing: 10 min
   - Resources Needed: Chalkboard for notes, discussions and classwork.

2. Learners and educator discuss the questions and answer of the baseline assessment
   - Timing: 5 min

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2.2 Main Body (Lesson presentation)

- Lesson starts with the educator asking the learners the baseline questions.
- Educator and learners discuss the following answers to the baseline questions:
  - A spectrum of light is the rainbow-like series of colours, produced by splitting light into its component colours.
  - Violet
  - Red
  - \( E = hf \)
- Educator explains and discusses with learners the following:
  - There are three different types of spectra upon which we need to focus. They are:
    - Continuous emission spectra
    - Line emission spectrum
    - Line absorption spectrum

When does a continuous emission spectrum form?
- When an object is heated the particles begin to vibrate. The vibrating protons and electrons in the atoms emit electromagnetic radiation.

3. Learners take notes from the board/transparencies
4. Learners copy notes from the board
5. Learners write the following classwork

APPLY YOUR KNOWLEDGE
1. The wavelength of the indigo line in a hydrogen spectrum is roughly 434 nm. Calculate the energy of a photon of indigo light.
2. Explain how the following are obtained
   2.1 continuous emission spectrum
   2.2 line emission spectrum
   2.3 line absorption spectrum

SOLUTIONS
1. \( c = f \lambda \)
   \[
   3 \times 10^8 = f(434\times10^{-9})
   \]
   \[
   f = 3 \times 10^8
   \]
   \[
   4.34 \times 10^9
   \]
   \[
   = 6.91\times10^{16} \text{ Hz}
   \]
   \[
   W_o = hf_o
   \]
   \[
   = (6.63\times10^{-34})(6.91\times10^{16})
   \]
   \[
   = 4.58\times10^{-17} \text{ J}
   \]
<table>
<thead>
<tr>
<th>When does a line emission spectrum form?</th>
<th>When a single element is heated until it emits light, the light emitted forms a line emission spectrum when passed through a prism, instead of a continuous spectrum.</th>
<th>Line spectra and internal energy of atoms</th>
<th>In 1905 Einstein suggested that electromagnetic radiation, which includes monochromatic light can be seen as a stream of particles which he called photons or quanta, with the energy for each photon as: $E = hf$</th>
</tr>
</thead>
<tbody>
<tr>
<td>When an electric current is passed through a gas such as neon light, the gas will emit light of specific frequencies. This spectrum is called the line emission spectrum.</td>
<td></td>
<td>When does a line absorption spectrum form?</td>
<td>A line absorption spectrum is formed when white light is passed through a cold gas before being shone through a prism or a diffraction grating. The black lines represent wavelength of light that have been absorbed by the gas.</td>
</tr>
<tr>
<td>2.1 Continuous emission spectrum</td>
<td>When an object is heated the particles begin to vibrate. The vibrating protons and electrons in the atoms emit electromagnetic radiation. Initially red light with the lowest frequency in the visible part of the spectrum is emitted. The object appears to be red hot.</td>
<td></td>
<td>When the object is white hot, the atoms are vibrating at all possible frequencies and emit light of all frequencies in the visible spectrum. The object appears to be white hot.</td>
</tr>
<tr>
<td></td>
<td>As the object gets hotter the particles vibrate faster and emit light of higher frequencies.</td>
<td></td>
<td>If this light is passed through a prism, a full continuous emission spectrum is observed.</td>
</tr>
<tr>
<td></td>
<td>When the object is white hot, the atoms are vibrating at all possible frequencies and emit light of all frequencies in the visible spectrum. The object appears to be white hot.</td>
<td></td>
<td>When an object is heated the particles begin to vibrate. The vibrating protons and electrons in the atoms emit electromagnetic radiation. Initially red light with the lowest frequency in the visible part of the spectrum is emitted.</td>
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<tr>
<td></td>
<td>If this light is passed through a prism, a full continuous emission spectrum is observed.</td>
<td></td>
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</tr>
</tbody>
</table>
If the involved atoms in the discharge tube emits photons having only certain specific energies, it implies that the internal energy of the atom will only increase or decrease in steps, or that the internal energy of an atom is distinctive by certain discreet energy levels. When an atom gains internal energy, the internal energy jumps between energy level increases. When an atom loses internal energy, it emits energy as a photon that contains energy.

\[ E = E_2 - E_1 \]

where, \( E \) is the energy of the photon
\( E_2 - E_1 \) is the total internal energy between two energy levels which energy jump took place.

**Example**

The energy level diagram of an element is shown. \( E_1 \) represents the ground state.

For the electron transfer from energy level \( E_3 \) to \( E_2 \) calculate

(a) the energy of a released light photon
(b) the frequency of the emitted light

**2.2 Line emission spectrum**

- When a single element is heated until it emits light, the light emitted forms a line emission spectrum when passed through a prism, instead of a continuous spectrum.
- When an electric current is passed through a gas such as neon light, the gas will emit light of specific frequencies. This spectrum is called the line emission spectrum.

**2.3 Line absorption spectra**

- A line absorption spectrum is formed when white light is passed through a cold gas before being shone through a prism or a diffraction grating.

Notes on emission and absorption spectra (pg 250- pg 253, Physical Sciences, A Olivier)
The black lines represent wavelength of light that have been absorbed by the gas.
At the end of this lesson learners should know
- The meaning of hydrocarbons
- The meaning of alkanes, alkenes or alkynes.

The following results will be the outcome of this lesson
- Learners must be able to explain the term saturated and unsaturated
- Learners must be able to give condensed structural formulae and structural formulae for the alkanes, alkenes and the alkynes.

### TEACHER ACTIVITIES

<table>
<thead>
<tr>
<th>Lesson Development</th>
<th>Learner Activities</th>
<th>Timing</th>
<th>Resources Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Teaching Methods Used in This Lesson</td>
<td>Q&amp;A, Explanation</td>
<td></td>
<td>Chalkboard for notes, discussions and classwork.</td>
</tr>
<tr>
<td>2. Lesson Development</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 Introduction</td>
<td>1. Learners answer the baseline questions</td>
<td>5 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Learners and educator discuss the questions and answers of the baseline assessment</td>
<td>10 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Learners take notes from the board/transparencies.</td>
<td>15 min</td>
<td></td>
</tr>
</tbody>
</table>
It generally occurs between two non-metals.

- Intermolecular forces refer to forces that exist between molecules and hold them together.
- The valency of carbon is 4.
- Carbon has 4 valence electrons.
- The ability of carbon to form long chains is called catenation.

**Educator explain and discuss with learners the following:**

**ORGANIC COMPOUNDS**

HYDROCARBONS - COMPOUNDS of CARBON and HYDROGEN only.

- ALIPHATIC HYDROCARBONS - straight chain structures
  - ALKANES - single bonds
  - ALKENES - double bonds
  - ALKYNES - triple bonds

- AROMATIC HYDROCARBONS - which have benzene ring structures – with double bonds

**Some terminology**

- **Saturated hydrocarbons** these molecules have only single bonds between carbon atoms.
- **Unsaturated hydrocarbons** compounds with double or triple bonds between carbon atoms

**Test for saturated and unsaturated compounds**

- Add a few drops bromine water, which is orange-brown, to the compound to be tested as an unsaturated hydrocarbon. Shake the solution.
- If the solution discolours immediately without having to put it in sunlight then the solution is an unsaturated hydrocarbon (an alkene or alkyne).
- If the orange-brown colour does not disappear immediately, then the solution is a saturated hydrocarbon (an alkane).

Hydrocarbons can be represented by:
- a molecular formula
  $\text{C}_2\text{H}_6$
- a condensed structural formula
  $\text{CH}_3\text{CH}_3$
- a structural formula

![Structural formula of ethane](image)

### THE ALKANE HOMOLOGOUS SERIES

<table>
<thead>
<tr>
<th>Alkane name</th>
<th>No of C</th>
<th>Molecular Formula</th>
<th>Condensed structural formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>1</td>
<td>$\text{CH}_4$</td>
<td>$\text{CH}_4$</td>
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<tr>
<td>Ethane</td>
<td>2</td>
<td>$\text{C}_2\text{H}_6$</td>
<td>$\text{CH}_3\text{CH}_3$</td>
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<td>Propane</td>
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<td>$\text{C}_3\text{H}_8$</td>
<td>$\text{CH}_3\text{CH}_2\text{CH}_3$</td>
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<td>Pentane</td>
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<td>Nonane</td>
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<td>Decane</td>
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</tr>
</tbody>
</table>

4. Learners do the exercise

30 min
- Educator asks learners to do the following exercise:
  - Create a similar table for the alkenes. Replace one of the C-C bond with a double C=C bond
  - Create a similar table for the alkynes. Replace one of the C-C bond with a triple C≡C bond
  - Draw structural formulae for each molecule represented in the tables
### Lesson Summary for: Date Started:

**Date Completed:**

**Lesson Objectives**

At the end of this lesson learners should know:
- The meaning of homologous series
- The meaning functional group

The following results will be the outcome of this lesson
- Learners must be able to apply the IUPAC name when given the formula
- Learners must be able to draw structural formulae
- Learners must be able to identify functional groups

### Teacher Activities

1. **Teaching Methods Used in This Lesson**
   - Question and answer, Explanation

2. **Lesson Development**

   2.1 Introduction
   - Introduce the lesson with the baseline questions
   - Pre-knowledge
     - Hydrocarbons

   **Baseline Assessment**
   - Baseline questions
     - Draw the structural formulae of saturated hydrocarbon with 4 carbons.
     - Draw the structural formulae of the unsaturated hydrocarbon with 4 carbons which has one double bond
     - Draw the structural formulae of the unsaturated hydrocarbon with 4 carbons which has one triple bond

3. **Learner Activities**

   1. Learners answer the baseline questions
   2. Learners and educator discuss the questions and answers of the baseline assessment
   3. Learners take notes from the board/transparencies.
   4. Learners write the following classwork:

   **Classwork**
   - Identify the functional groups in each of the following cases.
     - i) \( \text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3 \)
     - ii) \( \text{HCOOH} \)
     - iii) \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CHO} \)
     - iv) \( \text{CH}_3\text{CH}_2\text{COCH}_3 \)
     - v) \( \text{CH}_3\text{COOC}_2\text{H}_5 \)

### Timing

<table>
<thead>
<tr>
<th>Activity</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learners answer the baseline questions</td>
<td>10 min</td>
</tr>
<tr>
<td>Learners and educator discuss the questions and answers of the baseline assessment</td>
<td>25 min</td>
</tr>
<tr>
<td>Learners take notes from the board/transparencies.</td>
<td>25 min</td>
</tr>
<tr>
<td>Learners write the following classwork:</td>
<td>25 min</td>
</tr>
</tbody>
</table>

**Resources Needed**
- Chalkboard for notes, discussions and classwork.
2.2 Main Body (Lesson presentation)

- Lesson starts with the educator asking the learners the baseline questions.

- Educator and learners discuss the following answers of the baseline assessment:
  - Butane
  - But-1-ene
  - But-1-yne

- Educator explain and discuss with learners the following:
  - Distinguish between the hydrocarbons using the general formulae

<table>
<thead>
<tr>
<th>Hydrocarbon</th>
<th>General formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkane</td>
<td>( \text{C}<em>n\text{H}</em>{2n+2} )</td>
</tr>
<tr>
<td>Alkene</td>
<td>( \text{C}<em>n\text{H}</em>{2n} )</td>
</tr>
<tr>
<td>Alkyne</td>
<td>( \text{C}<em>n\text{H}</em>{2n-2} )</td>
</tr>
</tbody>
</table>

- Straight and branched chained hydrocarbons
  - The hydrocarbons represented in the alkane homologous series are all straight chain hydrocarbons.
  - Carbon chains can be branched which means that one of the hydrogen atoms is replaced by an alkyl group

2. Draw the structural formulae of:
   i) propene
   ii) but-2-yne

3. Name the following according to the IUPAC naming system:
   (a)
   (b)
   (c)

SOLUTION
1. (i) alcohol
   (ii) carboxylic acid
2-methylbutane

### Naming alkyl groups

<table>
<thead>
<tr>
<th>Alkyl group structure</th>
<th>Alkyl name</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₃⁻</td>
<td>Methyl</td>
</tr>
<tr>
<td>CH₃CH₂⁻</td>
<td>Ethyl</td>
</tr>
<tr>
<td>CH₃CH₂CH₂⁻</td>
<td>Propyl</td>
</tr>
<tr>
<td>CH₃CH₂CH₂CH₂⁻</td>
<td>Butyl</td>
</tr>
</tbody>
</table>

### FUNCTIONAL GROUP

- alkane
- alkene
- alkyne
- phenyl
- alkyl halide
- amine
- alcohol
- ether
- aldehyde
- ketone
- carboxylic acid
- ester
- amide

### Rules for naming organic compounds (IUPAC Rules)

- Identify the functional group of the molecule – this determines the ending of the name, for example only single bonds end in –ane

2.

(i) propene

ii) but-2-yne

3. (a) 2-methylpropan-2-ol
   (b) 3,3-dimethylbut-1-ene
   (c) 3-methylpentane
- Find the longest continuous carbon chain and allocate its prefix according to the number of carbon atoms in the chain (see table for prefixes)

<table>
<thead>
<tr>
<th>No of C atoms</th>
<th>Prefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Meth-</td>
</tr>
<tr>
<td>2</td>
<td>Eth-</td>
</tr>
<tr>
<td>3</td>
<td>Prop-</td>
</tr>
<tr>
<td>4</td>
<td>But-</td>
</tr>
<tr>
<td>5</td>
<td>Pent-</td>
</tr>
<tr>
<td>6</td>
<td>Hex-</td>
</tr>
<tr>
<td>7</td>
<td>Hept-</td>
</tr>
<tr>
<td>8</td>
<td>Oct-</td>
</tr>
</tbody>
</table>

- Number the carbon atoms in the chain. Number them so that the functional group is on the carbon with the lowest possible number. Double and triple bonds take preference over side chains.
- Name the branched group according to the number of carbon atoms it has and give it a number according to the carbon atom it is attached to.
- If there is more than one branched group of the same kind, use the Greek prefixes di, tri, tetra, penta and so on to indicate this.
- If a halogen atom is attached to the carbon chain, it is treated as an alkyl group.
- The prefixes: fluoro-; chloro-; bromo-; iodo-; are used, for example tetra-chloro methane CCl₄
- For alcohols, the name ending –ol is used e.g. ethanol.
- For carboxylic acids, the name ending –oic acid is used e.g. ethanoic acid.
• Apply the rules

Longest chain - 4 carbon atoms - prefix: but-
Functional group - alkane = -ane
Alkyl group on C₂ = 2-methyl
Name: 2-methylbutane

• Give learners the classwork.
### LESSON SUMMARY FOR:

**DATE STARTED:**

**DATE COMPLETED:**

### LESSON OBJECTIVES

At the end of this lesson learners should know:

- The meaning of isomers
- The structure and physical property relationship

The following results will be the outcome of this lesson

- Learners must be able to recognise and apply to particular examples the relationship between:
  - Physical properties and intermolecular forces
  - Physical properties and number and type of functional groups
  - Physical properties and chain length
  - Physical properties and branched chains

### TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED
--- | --- | --- | ---
1. **TEACHING METHODS USED IN THIS LESSON**
   - Question and answer, Explanation
2. **LESSON DEVELOPMENT**
   2.1 **Introduction**
   - Introduce the lesson with the baseline questions
   - Pre-knowledge
     - Intermolecular forces, covalent bonds, microscopic and macroscopic properties of matter
1. Learners answer the baseline questions
2. Learners and educator discuss the questions and answers of the base
3. Learners answer the questions
4. Learners take notes from the board
5. Learners write the following classwork

5 min | Chalkboard for notes, discussions and classwork.
### Baseline Assessment

Baseline questions
- Mention the three main types of intermolecular forces.
- Which intermolecular forces are found between polar molecules?
- What type of bonds are Hydrogen bonds and between which molecules are they formed?

### Classwork

1. The table shows the boiling points of the first alkanes and the first six alcohols.

<table>
<thead>
<tr>
<th>Alkane</th>
<th>Boiling point (°C)</th>
<th>Alcohol</th>
<th>Boiling point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>-164</td>
<td>Methanol</td>
<td>65</td>
</tr>
<tr>
<td>Ethane</td>
<td>-89</td>
<td>Ethanol</td>
<td>79</td>
</tr>
<tr>
<td>Propane</td>
<td>-42</td>
<td>Propan-1-ol</td>
<td>97</td>
</tr>
<tr>
<td>Butane</td>
<td>-0.5</td>
<td>Butan-1-ol</td>
<td>117</td>
</tr>
<tr>
<td>Pentane</td>
<td>36</td>
<td>Pentan-1-ol</td>
<td>138</td>
</tr>
<tr>
<td>Hexane</td>
<td>69</td>
<td>Hexan-1-ol</td>
<td>156</td>
</tr>
</tbody>
</table>

1. Explain, referring to the type of intermolecular forces, why the boiling points of alcohols are higher than the boiling points of alkanes.
2. Consider the following organic compounds
   - A HCOOH
   - B CH₃COOH
   - C HCOOCH₂CH₃
   - D CH₃CH₂COOH
   - E CH₃CH₂CH₂OH

2.1 Write down the IUPAC name for an isomer of E.
2.2 Write down the functional group of C.

3. Knowledge of boiling points can be used to identify chemical compounds. The boiling points of four organic compounds, represented by the letters A, B, C and D are given in the table below
of hydrogen and a small electronegative element. Hydrogen bonds are found between water, hydrogen fluoride and ammonia molecules.

- Educators explain and discuss with learners the following:
  
  **PROPERTIES OF ORGANIC MOLECULES**
  
  - **Isomerism**
    - Isomers are molecules with the same molecular formula but different structural formulae.
  
  - **Structural isomers**
    - The properties of isomers that belong to the same homologous series are usually quite similar, but with difference in melting and boiling points.
    - Structural isomers can also belong to different homologous series.
    - Questions
      - ✓ The atoms in the hydrocarbon with formula C₄H₁₀ can be arranged in two

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Propane</td>
<td>-42</td>
</tr>
<tr>
<td>B</td>
<td>Pentane</td>
<td>36</td>
</tr>
<tr>
<td>C</td>
<td>2-methylbutane</td>
<td>27.8</td>
</tr>
<tr>
<td>D</td>
<td>Penta-1-ol</td>
<td>137</td>
</tr>
</tbody>
</table>

3.1 Define the term boiling point.
3.2 Which one of A or B has a higher vapour pressure?
3.3 B and C are structural isomers
3.3.1 Define the term structural isomer.
3.3.2 Explain why B has a higher boiling point than C.

**SOLUTIONS**

1.1 Hydrogen bonds between alcohol molecules are stronger than the Van der Waals forces between the molecules of alkanes. Thus more energy is needed to break the hydrogen bonds than the weaker Van Der Waals forces so therefore the boiling point is higher for the alcohols.
2.1 propan-2-ol

\[
\begin{align*}
\text{O} & \\
\text{C} & \\
\text{C} & \\
\text{O} & \\
\end{align*}
\]

2.2

3.1 The temperature at which the vapour pressure of a liquid is equal to the external (atmospheric) pressure.
3.2 A
3.3.1 Compounds with the same molecular formula, but different structural formulae.
3.3.2 Compound C is more branched and so has weaker intermolecular forces. As a result less energy is needed to overcome the intermolecular forces. Thus, it will have a lower boiling point.
different ways to form the structural isomers butane and 2-methylpropane. Draw the structure for the two isomers.

✓ But-1-ene; but-2-ene; and methylpropene are structural isomers with the molecular formula C₄H₈. Draw the structures of these isomers.

- **Physical properties**
  - The spatial structure of organic molecules determines their physical properties, e.g. melting and boiling points, viscosity and vapour pressure.
  - These factors determine spatial structure:
    - Intermolecular forces
    - Chain length
    - Branched chains
    - Number and type of functional groups
**Intermolecular forces**

- Weak **Van der Waals** forces act between non-polar molecules, such as hydrocarbons.
- Stronger **hydrogen bonds** exist between a hydrogen atom of one molecule and oxygen, nitrogen or fluorine atom on another molecule, for example in alcohols and carboxylic acids.
- **Vapour pressure** is an indication of the ease of evaporation of a liquid. A substance with a high vapour pressure is referred to as volatile. Weaker forces between molecules result in lower boiling points. Molecules can evaporate more easily and vapour pressures are higher at a given temperature. (weak forces low $\rightarrow$ boiling points $\rightarrow$ high vapour pressure)
- **Viscosity** is a measure of the resistance of a liquid to flow.

  Strong intermolecular forces between molecules in a liquid will prevent the molecules from gliding past one another and the viscosity of the liquid will be higher.

- Viscosity tends to decrease as the temperature increases, i.e. the hotter a liquid is, the runnier it is.
  - (strong forces $\rightarrow$ high boiling points $\rightarrow$ high viscosity)

- **Chain length**
  - As the length of the molecules increases, the surface area in contact between adjacent molecules increases and there are more opportunities for Van der Waals forces to form weak bonds.
  - Large molecules usually have stronger forces than small molecules- melting and boiling
points increase with molecular mass.

- **Branched chains**
  - Straight-chained molecules can get closer to one another and there are more points of contact for intermolecular forces to form.
  - Branched chains form more spherical molecules with fewer points of contact for intermolecular force. Melting and boiling points are lower for branched-chain molecules with the same number of carbon atoms.

- Number and type of functional groups
  - Alcohols and carboxylic acids contain \(-\text{OH}\) groups and hydrogen bonds exist between their molecules.
  - Hydrogen bonds are stronger than Van der Waals forces. Melting and boiling points of alcohols and carboxylic acids are generally higher than similar-sized hydrocarbons.
2.3 Conclusion
- Ask learners questions about the main aspects of the lesson i.e. isomers, physical properties
- Give learners the classwork.

<table>
<thead>
<tr>
<th>Reflection/Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Name of Teacher:**

**HOD:**

**Sign:**

**Sign:**

**Date:**

**Date:**
### LESSON SUMMARY FOR: LESSON STARTED:

At the end of this lesson learners should know:
- The different types of organic molecules
- The properties of organic molecules in a homologous series

The following results will be the outcome of this lesson:
- Learners must be able to explain the terms functional group, hydrocarbons, saturated, unsaturated, homologous series
- Learners must be able identify the organic molecules

### LESSON OBJECTIVES

**LEARNER ACTIVITIES**

1. Learners answer the baseline questions
2. Learners and educator discuss the questions and answers of the baseline assessment
3. Learners take notes from the board
4. Learners answer the questions

### TEACHING METHODS USED IN THIS LESSON

- Question and answer
- Explanation

### LESSON DEVELOPMENT

2.1 Introduction

- Introduce the lesson with the baseline questions
- Pre-knowledge
  - Hydrocarbons, IUPAC naming

**BASELINE ASSESSMENT**

Baseline questions
- Mention the three types of hydrocarbons?
- Differentiate between saturated and unsaturated hydrocarbons.
- What is a homologous series?

2.2 Main Body (Lesson presentation)

- Lesson starts with the educator asking the learners the baseline questions.
- Educator and learners discuss the answers to the baseline questions
- Educator explain and discuss with learners the following

**HOMOLOGOUS SERIES**
- Hydrocarbons: alkanes

**CLASSWORK**

1. What is a functional group?
2. Give the general formula for a mono-halogen derivative of an alkane.
Alkanes are non-polar molecules containing only carbon and hydrogen atoms.
- They are hydrocarbons with single bonds between the carbon atoms.
- They are saturated because no further atoms can be added to the molecules of these compounds.
- Alkanes are the most important fuels (fossil fuels)
- Boiling points increase with molecular mass.
- The general formula for the alkanes is C\(_n\)H\(_{2n+2}\), where n is the number of carbon atoms present.

Cycloalkanes

- Cycloalkanes are hydrocarbons with single bonds that form a ring structure.
- They show similar physical and chemical properties as the alkanes, but have higher melting and boiling points.
- Naming is the same as for alkanes, except that the prefix cyclo- is added.

Hydrocarbon: alkenes

- Alkenes are non-polar hydrocarbons
- They contain at least one double bond between two carbon atoms.
- They are unsaturated, because during a reaction the weaker bond of the two of the two in the double bond can break to allow more atoms to be added onto the molecule.
- Alkenes with one double bond have the general formula C\(_n\)H\(_{2n}\).

What is the functional group of the alkenes?

Give the structural formula for tetrachloromethane

What is a diene?

SOLUTIONS

1. A functional group is an atom or group of atoms which gives a compound its particular characteristics.
2. C\(_n\)H\(_{2n+1}\)X
3. C=C
4. 
   \[\text{Cl} \quad \text{Cl} \quad \text{Cl}\]
5. A diene is a compound that contains two double bonds.
The simplest alkene must contain two carbon atoms to allow for the C=C, and is called ethene.

\[
\begin{array}{c}
\text{H} \\
\text{C} = \text{C} \\
\text{H} \\
\text{H}
\end{array}
\]

The boiling points of the alkenes increase with molecular mass.

- **Dienes**
  - When a molecule contains two double bonds, a diene is formed.
  - In a conjugated diene, the double bonds are separated by a single bond.
    \[
    \begin{array}{c}
    \text{CH}_2 = \text{CH} - \text{CH} = \text{CH}_2 \\
    \text{1,3-Butadiene}
    \end{array}
    \]
  - In a cumulated diene, two double bonds form to one carbon atom.
    \[
    \begin{array}{c}
    \text{H}_2 \text{C} = \text{C} - \text{CH}_2 \\
    \text{1,2-Propadiene or Allene}
    \end{array}
    \]
  - In an isolated diene, there are one or more saturated carbon atoms between the double bond.
    \[
    \begin{array}{c}
    \text{H}_2 \text{C} = \text{CH} - \text{CH} = \text{CH}_2 \\
    \text{1,4-Pentadiene}
    \end{array}
    \]

- **Cycloalkenes**
  - Cycloalkanes are hydrocarbons with double bonds that form a ring structure.
  - They show the same physical and chemical properties as the alkenes.
  - Naming is the same as for alkenes, except that the prefix cyclo- is added.

- **Hydrocarbons: alkynes**
  - Alkynes are hydrocarbons that contain C≡C triple bond.
The simplest member is ethyne, \( \text{C}_2\text{H}_2 \), a highly reactive colourless gas also known as acetylene. The combustion of ethyne is strongly exothermic and gives an extremely hot flame. It is used in the oxyacetylene torch to weld metals.

- Alkynes are unsaturated.
- They have the general formula \( \text{C}_n\text{H}_{2n-2} \)

### Alkyl Halides (Halo-alkanes)

- The formula is \( \text{R-X} \), where \( \text{R} \) is an alkyl group and \( \text{X} \) is a halogen atom.
- Simple haloalkanes with one halogen atom attached to the carbon chain have the general formula \( \text{C}_n\text{H}_{2n+1}\text{X} \), where \( \text{X} \) is \( \text{F, Cl, Br, or I} \).
- Haloalkanes are generally volatile liquids that do not mix with water.
- Haloalkenes contain double bonds and can be polymerised to form useful polymers. Poly(chloroethene) also known as PVC, and poly(tetrafluoroethane), abbreviated as PTFE, are used in many domestic products.
- CFCs such as dichlorodifluoromethane have been used as refrigerants, aerosol propellants and blowing agents to produce foamed polymers. They are very stable molecules that can move to the upper layers of the atmosphere to break down ozone molecules.
- Other well-known haloalkanes include trichloromethane (carbon tetrachloride), used as a dry-cleaning solvent up to the early 1950s.

### 2.3 Conclusion

- Ask learners about the main aspects of the lesson i.e. alkanes, alkenes, alkynes and alkyl halides.
<table>
<thead>
<tr>
<th>Reflection/Notes:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Name of Teacher:</th>
<th>HOD:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sign:</td>
<td>Sign:</td>
</tr>
<tr>
<td>Date:</td>
<td>Date:</td>
</tr>
</tbody>
</table>

Term 1 Page 124  © Gauteng Department of Education (ver.1)
**LESSON SUMMARY FOR: DATE STARTED:**

At the end of this lesson learners should know:
- The different types of organic molecules
- The properties of organic molecules in a homologous series

The following results will be the outcome of this lesson
- Learners must be able to identify the hydrocarbons derivatives

**LESSON OBJECTIVES**

- The different types of organic molecules
- The properties of organic molecules in a homologous series

**TEACHER ACTIVITIES**

1. **TEACHING METHODS USED IN THIS LESSON**
   - Question and answer, Explanation

2. **LESSON DEVELOPMENT**

2.1 **Introduction**
   - Introduce the lesson with the baseline questions
   - Pre-knowledge
   - Hydrocarbons, IUPAC naming, Functional groups

**BASELINE ASSESSMENT**

Baseline questions
- Give the functional groups of the following:
  - Alcohols
  - Carboxylic acids
  - Aldehydes
  - Ketones
  - Esters

2.2 **Main Body (Lesson presentation)**

- Lesson starts with the educator asking the learners the baseline questions.
- Educator and learners discuss the questions and answers of the baseline assessment.

**LEARNER ACTIVITIES**

1. Learners answer the baseline questions
2. Learners and educator discuss the questions and answers of the baseline assessment
3. Learners take notes from the board
4. Learners write the classwork

**CLASSWORK**

1. Which one of the following pairs of reactions
   - A. ethane and methanoic acid
   - B. methanol and ethanoic acid
   - C. ethanol and methanol
   - D. ethane and methanol
2. Write the functional group of carboxylic acids.
3. How are esters formed?
4. How are esters named?

**TIMING**

- 5 min
- 30 min
- 20 min

**RESOURCES NEEDED**

- Chalkboard for notes, discussions and classwork.
• Educator explain and discuss with learners the following

HOMOLOGOUS SERIES

• Alcohols
  • The functional group is as follows
    \[ R - O - H \]
  • Alcohols contain at least one hydroxyl (-OH) group.
  • They form hydrogen bonds between molecules.
  • Alcohols with one hydroxyl group have the general formula
    \[ C_nH_{2n+1}OH \]
  • Most alcohols have polar molecules.
  • The simplest member of the group, methanol, contains one carbon atom and is commonly known as methyl alcohol.
  • Ethanol has two carbon atoms. It is the product of the fermentation process of fruits and other plant material. Ethanol is used in alcoholic beverages.
  • The strong hydrogen bonds in alcohols result in alcohols having higher melting and boiling points than similar sized hydrocarbons.
  • Alcohols are classified according to the position of the hydroxyl group on the carbon chain
    - Primary alcohol
      \[ R - C - OH \]
    - Secondary alcohol

5. Millions of organic compound compounds are known to date. Four of these compounds are represented by the letters.
   P methanol
   Q
   R
   S

5.1 Write down the following

5.1.1 Structural formula of the functional group of P.

5.1.2 Homologous series to which Q belongs.

5.1.3 Structural formula of an isomer of Q.

5.1.4 The IUPAC name of R
Aldehydes and ketones contain the carbonyl functional group C=O.

- **Aldehydes**
  - The functional group is \( R - \text{H} \)
  - A hydrogen atom is bonded to the carbonyl group.
  - Aldehydes names end in the suffix –al.
  - The simplest aldehyde is methanol, also known as formaldehyde (\( \text{H}_2\text{C}=\text{O} \)).

- **Ketones**
  - The functional group is \( R - \text{O} - R' \)
  - The carbon atom in the carbonyl group is bonded to a carbon on both sides.
  - Ketones names end in –one.
  - The simplest ketone is propanone (acetone). This is a pleasant-smelling liquid used mainly as a solvent for organic compounds and an active ingredient in nail polish removers.

5.2 \( S \) represents an alcohol. Classify this alcohol as primary, secondary or tertiary.

6. Nico heats some **ethanoic acid** and **ethanol** in the presence of a catalyst in a test tube. Two products, of which one is an ester, are formed in this reaction.

6.1 Write down the **NAME** of the other product.

6.2 Write down the **NAME** of the catalyst.

6.3 Write down the structural formula of the ester.

6.4 Write down the IUPAC (systematic) name of the ester.

**SOLUTIONS**

1. C
2. \( R - \text{O} - R' \)
3. Esters are formed by reacting an alcohol with a carboxylic
Aldehydes are more reactive than ketones. Aldehydes and ketones contribute to the distinctive smells of foods and plants.

### Carboxylic acids
- The functional group is \[
\text{C} - \text{O} - \text{H}
\]
- They have a general formula \( C_nH_{2n+1}COOH \).
- All organic acids are carboxylic acids.
- They all contain the functional group \(-\text{COOH}\).
- Methanoic acid is a liquid found in stinging nettles and ants.
- Ethanoic acid is the sour component of vinegar.
- Butanoic acid gives the unpleasant smell to rancid butter.
- Carboxylic acids names end in \(-\text{oic acid}\).

### Esters
- The functional group is
\[
\text{C} - \text{O} - \text{C}
\]
- Esters have pleasant smells and they are largely responsible for the flavours and scents of fruits and flowers.
- The form from alcohols and carboxylic acids in an esterification reaction
- The name of the ester consists of two parts: the first party is derived from the parent alcohol and the second part is derived from the the carboxylic acid. The name has the suffix \(-\text{oate}\). An example is methanol that reacts with propanoic acid to form the ester methyl propanoate.

### 2.3 Conclusion
- Give learners the classwork

### 4. The first part is derived from the parent alcohol and the second part is derived from the carboxylic acid. The name has the suffix \(-\text{oate}\).

5.1.1

5.1.2 ketones

5.1.3

5.1.4 1-bromo-2-chlorocyclopentane

5.2 tertiary

6.1 water

6.2 sulphuric acid

6.3

6.4 ethyl ethanoate
### Lesson Summary

At the end of this lesson learners should know:

- The different types of organic molecules
- The properties of organic molecules in a homologous series

The following results will be the outcome of this lesson

- Learners must be able to give structural formulae or give the IUPAC name for benzene rings.

### Lesson Objectives

- The different types of organic molecules
- The properties of organic molecules in a homologous series

### Teacher Activities

1. **Teaching Methods Used in This Lesson**
   - Question and answer, Explanation

2. **Lesson Development**
   2.1 **Introduction**
      - Introduce the lesson with the baseline questions
      - Pre-knowledge
      - Dienes, hydrocarbons
   
     **Baseline Assessment**
     - Baseline questions
      - What is a diene?
      - What is a conjugated diene?
   
   2.2 **Main Body (Lesson presentation)**
      - Lesson starts with the educator asking the learners the baseline questions.
      - Educator and learners discuss the following answers to the baseline questions:
        - When a compound contains two double bonds, a diene is formed.
        - A conjugated diene is formed when the double bonds are separated by a single bond.
      - Educator explain and discuss with learners the following

### Learner Activities

1. Learners answer the baseline questions
2. Learners and educator discuss the questions and answers of the baseline assessment
3. Learners take notes from the board
4. Learners write the classwork

### Classwork

Give the systematic (IUPAC) name of the following

(a)
Benzene

- Benzene, \( \text{C}_6\text{H}_6 \), is an excellent solvent organic solvent but it will not mix with water.
- It belongs to the family of aromatic hydrocarbons.
- It can be made from oil by catalytic reforming.
- In the presence of a catalyst (Pt or Molybdenum(IV) oxide) rearrange their molecules producing a variety of aromatic hydrocarbons including benzene.
- Benzene is one of the chemicals added to unleaded petrol to boost its octane ring.
- There was a lot of uncertainty about the structure of the benzene molecule.
- Molecular mass measurements showed that its formula is \( \text{C}_6\text{H}_6 \), while X-ray diffraction studies suggested that the molecule is planar.
- The formula 1,2,4,5-tetrahexene (\( \text{CH}_2=\text{C}=\text{CH}-\text{CH}=\text{C}=\text{CH}_2 \)) is therefore a possible structure but the following factors need to be taken into account:
  - Benzene does not undergo the addition reactions that alkenes do.
  - X-ray diffraction shows that all the carbon-carbon bonds in benzene are the same length.
  - The heat of reaction given out when benzene reacts with hydrogen is just under 60% of the expected value.
  - Benzene is therefore clearly more stable than the 1,2,4,5-tetrahexene.
  - The following is the structure of benzene.

The resonance structures for benzene are as follows:
The extra stability of benzene and the fact that its bonds are all of equal length can be explained by the idea of conjugated double bonds. The last structure above illustrates that the three double bonds are conjugated. Some well known aromatic compounds like toluene, phenol and benzoic acid include a benzene ring.

2.3 Conclusion
- Ask learners questions about the main aspects of the lesson.
- Give learners the classwork.

SOLUTIONS
(a) 1-methyl-2-ethylbenzene
(b) Dimethylbenzene
(c) Propylbenzene
(d) 1,3-dimethylbenzene
(e) 2-bromo-1,3-dimethylbenzene
(f) 1-bromo-2-chlorocyclopentane
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**Lesson Objectives**

At the end of this lesson learners should know:

- The different types of organic compounds reactions

The following results will be the outcome of this lesson:

- Learners must be able to identify the type of reactions that hydrocarbons undergo
- Learners must be able to explain what happens during each type of reaction
- Learners must be able to compare the reactivity of different hydrocarbons

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**Teacher Activities**

1. **Teaching Methods Used in this Lesson**
   - Question and answer, Explanation

2. **Lesson Development**

   2.1 **Introduction**
   - Introduce the lesson with the baseline questions
     - Pre-knowledge
     - Chemical reactions

   **Baseline Assessment**
   - Baseline questions
     - Give the types of chemical reactions

   2.2 **Main Body (Lesson Presentation)**
   - Lesson starts with the educator asking the learners the baseline questions.
   - Educator and learners discuss the following answers to the baseline question:
     - Substitution reaction
     - Elimination reaction
     - Addition reaction
     - Acid-base reaction

---

**Learner Activities**

1. Learners answer the baseline questions
2. Learners and educator discuss the questions and answers of the baseline assessment
3. Learners take notes from the board
4. Learners write the classwork

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**Classwork**

1. Study the following reactions and state whether it is a substitution, addition or elimination reaction.
   a) \( \text{CH}_2\text{Cl} \rightarrow \text{CH}_2\text{Cl} + \text{HCl} \)
   b) \( \text{CH}_2 = \text{CH}_2 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} \rightarrow \text{CH}_2\text{Cl} \)
   c) \( \text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{CH}_2 = \text{CH}_2 + \text{H}_2\text{O} \)
   d) \( \text{C}_2\text{H}_6 \rightarrow \text{CH}_2 = \text{CH}_2 + \text{H}_2 \)

2. The process of reacting an alkene with oxygen is known as

   A. Hydrolysis
Educator explain and discuss with learners the following

- Organic compounds reactions
- Alkanes
  - Alkanes undergo
    - Combustion (oxidation) reactions
    - Elimination reactions
    - Addition reactions
  - Combustion (oxidation) reactions
    - Alkanes react with oxygen in the air and forms carbon dioxide and water.
    - This reaction is exothermic and a great deal of energy is released.
    - Methane burns with a blue flame.
      \[ \text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{energy} \]
    - Propane is the gas in Bunsen burners in the laboratory
      \[ \text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O} + \text{energy} \]
  - Elimination reactions
    - During these reactions an unsaturated molecule is formed as well as a second small molecule e.g. H\(_2\) or H\(_2\)O
    - Cracking (heating at high temperature) produces unsaturated products:
      \[ \text{CH}_3\text{CH}_3 \rightarrow \text{CH}_2=\text{CH}_2 + \text{H}_2 \]
  - Substitution reactions
    - During these reactions a hydrogen atom is replaced by a halogen atom, forming a halo-alkane molecule.

3. Write down an equation for the reaction which take place when butane burns in excess oxygen

4. Consider the following formulae of organic compounds:
   - A: C\(_2\)H\(_4\)
   - B: C\(_2\)H\(_6\)
   - C: C\(_3\)H\(_2\)
   - D: HCC\(_3\)

4.1 Write down the equation, using condensed structural formulae, for the reaction of compound A with bromine.

4.2 Compound B does not react with bromine as easily as compound A. Explain why this is so.

4.3 To which group (class) of compounds does compound D belong?

4.4 Write down the IUPAC name for compound D.

SOLUTIONS

1. (a) elimination
   (b) addition
   (c) elimination
   (d) elimination

2. B

3. \[ 2\text{C}_4\text{H}_10 + 13\text{O}_2 \rightarrow 8\text{CO}_2 + 10\text{H}_2\text{O} \]
Activation energy in the form of sunlight or heat is needed to start the reaction.

\[ \text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{HCl} \]

Substitution reactions where a hydrogen is replaced with a halogen is called halogenation.

- **Alkenes**
  - Alkenes undergo:
    - Combustion reaction
    - Addition reactions
      - Hydrohalogenation
      - Halogenation
      - Hydration
      - Hydrogenation
  - Combustion reactions
    - Alkenes undergo combustion the same way alkanes do by forming carbon dioxide and water.
  - Addition reactions
    - Hydrohalogenation
    - Addition reactions in which an alkene reacts with a hydrogen halide \((HX \text{ where } X \text{ is Cl, Br or I})\) is called hydrohalogenation
    - \[ \text{CH}_2=\text{CH}_2 + \text{HCl} \rightarrow \text{CH}_3\text{-CH}_2\text{Cl} \]
    - Reaction conditions: HX is added to alkene; no water must be present.
    - During addition of HX to an alkene, the H atom attaches to the C atom already having the greater number of H atoms. The X atom attaches to the more substituted C atom.

- 4.1 \[ \text{CH}_2=\text{CH}_2 + \text{Br}_2 \rightarrow \text{CH}_2\text{Br}-\text{CH}_2\text{Br} \]
- 4.2 Compound B is a saturated hydrocarbon and thus requires more energy to break the bonds. Therefore it does not react easily.
- 4.3 Halo-alkane
- 4.4 trichloromethane
• Halogenation
  o Addition reactions in which an alkene reacts \( X_2 \)
    (where \( X \) is Cl or Br) is called halogenations
  o \( \text{CH}_2\text{=CH}_2 + \text{Cl}_2 \rightarrow \text{CH}_2\text{Cl}-\text{CH}_2\text{Cl} \)
  o Reaction conditions: Cl and Br added to alkene

• Hydration
  o Addition of water to an alkene is called hydration
  o \( \text{CH}_2\text{=CH}_2 + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{CH}_2\text{OH} \)
  o Reaction conditions: H\(_2\)O in excess and a small amount
    of HX or other strong acid (H\(_3\)PO\(_4\)) as a catalyst.
  o During addition of H\(_2\)O to unsaturated hydrocarbons, the
    H atom attaches to the C atom already having the
    greater number of H atoms. The OH group attaches to
    the more substituted C atom.

• Hydrogenation
  o Addition of hydrogen to alkenes
  o \( \text{CH}_2\text{=CH}_2 + \text{H}_2 \rightarrow \text{CH}_3\text{-CH}_3 \)
  o Reaction conditions: alkene dissolved in a non-polar
    solvent with the catalyst (Pt, Pd or Ni) in an H\(_2\)
    atmosphere.

• Alkynes
  x Alkynes undergo
    ✓ Combustion reactions
    ✓ Addition reactions
  o Combustion reactions
  o Alkynes undergo combustion reactions like alkanes and
    alkenes by reacting with oxygen and form carbon dioxide
    and water.
  o Addition reaction
    o Hydrogenation
    o Addition of hydrogen to alkynes
    o \( \text{CH}_≡\text{CH} + \text{H}_2 \rightarrow \text{CH}_3\text{-CH}_3 \)
    o Reaction conditions: alkene dissolved in a non-polar
      solvent with the catalyst (Pt, Pd or Ni) in an H\(_2\)
      atmosphere.
### 2.3 Conclusion
- Ask learners questions about the main aspects of the lesson i.e. types of reactions
- Give learners the classwork.

### Reflection/Notes:

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### Lesson Summary
At the end of this lesson learners should know:
- The different types in alcohols and alkyl halides
- The following results will be the outcome of this lesson
- Learners must be able to identify the organic molecules reactions

### Lesson Objectives
- The different types in alcohols and alkyl halides
- The following results will be the outcome of this lesson
- Learners must be able to identify the organic molecules reactions

### Teacher Activities
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<td>Give the types of reactions found in alkanes, alkenes and alkynes</td>
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<td>Educator explain and discuss with learners the following</td>
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<td>Alkyl halides</td>
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### Baseline Assessment
- Give the types of reactions found in alkanes, alkenes and alkynes

### Learner Activities
1. Learners answer the baseline questions
2. Learners and educator discuss the questions and answers of the baseline assessment
3. Learners take notes from the board
4. Learners write the classwork (Annexure A)

### Timing
- 5 min
- 20 min
- 30 min

### Resources Needed
- Chalkboard for notes, discuss
• Elimination
  - The elimination of HX (X is Cl, Br or I) from a haloalkane is called dehydrohalogenation.
  - CH₂Cl-CH₂Cl → CH₂=CHCl + HCl
  - Reaction conditions: heat under reflux (vapour condensate and return to reaction vessel during heating) in a concentrated solution of NaOH or KOH in pure ethanol as the solvent i.e. hot ethanoic NaOH/KOH.
  - If more than one elimination product is possible, the major product is the one where the H atom is removed from the C atom with the least number of H atoms.

• Substitution
  - Haloalkane with bases to produce alcohols.
  - This substitution reaction is called hydrolysis.
  - C(CH₃)₃X + KOH → C(CH₃)₃OH + KX
  - Reaction conditions: Haloalkanes dissolved in ethanol before treatment with aqueous sodium hydroxide and warming the mixture; the same hydrolysis reaction occurs more slowly without alkali, i.e. H₂O added to the haloalkane dissolved in ethanol

• Alcohols
  - Alcohols undergo the following reactions
    - Elimination (Dehydration of alcohols)
    - Substitution reaction
  - Substitution
    - Alcohols react with Hydrogen halides (HX; X= Cl,Br) to produce haloalkanes.
    - Reaction conditions:
      - Tertiary alcohols are converted into haloalkanes using HBr or HCl at room temperature
      - e.g C(CH₃)₃OH + HBr → C(CH₃)₃Br + H₂O
- Primary and secondary alcohols: Treat primary and secondary alcohols with concentrated H2SO4 and solid NaBr (or KBr). The H2SO4 and solid NaBr react to form HBr:
  \[ \text{H}_2\text{SO}_4 + \text{NaBr} \rightarrow \text{HBr} + \text{NaHSO}_4 \]
- The HBr reacts with the alcohol to form the bromoalkane:
  \[ \text{e.g. CH}_3\text{CH}_2\text{OH} + \text{HBr} \rightarrow \text{CH}_3\text{CH}_2\text{Br} + \text{H}_2\text{O} \]

2.3 Conclusion

- Ask learners questions about the main aspects of the lesson i.e. isomers, physical properties
- Give learners the classwork.