



Western Cape
Government

**CURRICULUM FET
PHYSICAL SCIENCES
LEARNER BOOK TERM 2**



**BACK ON TRACK PROGRAMME
GRADE 12**



Western Cape
Government

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SESSION 1: Organic Chemistry – PHYSICAL PROPERTIES

Examination Guidelines 2021

Structure and physical properties (boiling point, melting point, vapour pressure) relationships.

For a given example, explain the relationship between physical properties and:

- o Strength of intermolecular forces (Van der Waal's forces), i.e. hydrogen bonds, dipole-dipole forces, London forces (induced dipole forces).
- o Type of functional groups
- o Chain length
- o Branched chains

Terms In Science Investigations:

Dependent variable:	This is the variable that is being measured in an experiment. It forms the vertical axis of a graph.
Independent variable:	This is the variable that is manipulated or changed in an experiment. It usually forms the horizontal axis of a graph.
Control variable:	This is the variable that is kept constant so that the relationship between the independent and dependent variables can be found.
Investigative question:	It is a relationship between the independent and dependent variables. It is phrased as a question with a question mark.
Hypothesis:	It is a prediction about what the relationship between the independent and dependent variables actually are. It is a statement, not a question. It is also an assumption that can be proved right or wrong by doing an investigation.
Fair test:	This is an experiment (or investigation) in which there is only one independent variable.

- **Boiling point:** The temperature at which the vapour pressure of a substance equals atmospheric pressure.
 - The stronger the intermolecular forces, the **higher** the boiling point.
- **Melting point:** The temperature at which the solid and liquid phases of a substance are at equilibrium.
 - The stronger the intermolecular forces, the **higher** the melting point.
- **Vapour pressure:** The pressure exerted by a vapour at equilibrium with its liquid in a closed system.
 - The stronger the intermolecular forces, the **lower** the vapour pressure.

Pre-Test:

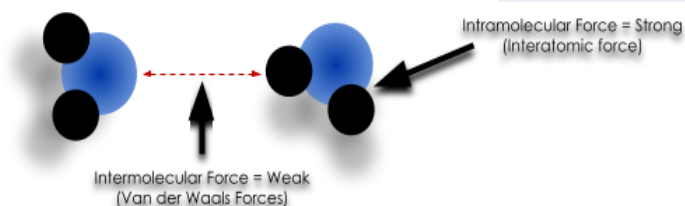
Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A–D) next to the question number (1.1–1.5), for example 1.6. D

1. The boiling point of a compound is the ...
 - A. minimum temperature at which it boils.
 - B. temperature at which its vapour pressure equals atmospheric pressure.
 - C. maximum temperature at which it boils.
 - D. average temperature at which it boils across all possible atmospheric pressures.
2. Which ONE of the following compounds has the highest melting point?
 - A. CH_3CH_3
 - B. $\text{CH}_3\text{CH}_2\text{CH}_3$
 - C. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
 - D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
3. A scientist investigates a factor which influences the boiling points of alkanes. He determines the boiling points of the first six straight chain alkanes.
Which ONE of the following is the independent variable in this investigation?
 - A. Chain length
 - B. Boiling point
 - C. Branching
 - D. Functional group
4. Which ONE of the following isomers has the LOWEST boiling point?
 - A. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
 - B. $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{CH}_3$
 - C. $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
 - D. $\text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)_2\text{CH}_3$
5. Which ONE of the following compounds has the HIGHEST vapour pressure?
 - A. CH_3CHO
 - B. $\text{CH}_3\text{CH}_2\text{OH}$
 - C. HCOOH
 - D. $\text{CH}_3\text{CH}_2\text{CH}_3$

5x2=[10]

Intermolecular Forces (IMF) Grade 11 Revision

Electrostatic attraction force
between a δ^- charge and a δ^+
charge



Intramolecular forces

Ionic bonds

Covalent bonds

Intermolecular forces

London forces	Due to uneven distribution of electrons around the nucleus of adjacent atoms.
Dipole-dipole forces	Due to charge obtained by an atom due to the position of bonded electron pairs in a covalent bond. The atom with the greatest electronegativity is δ^-
Hydrogen bonds	Due to strong dipole-dipole force when a H-atom (Hydrogen) is covalently bonded to a small but highly electronegative atom e.g. N, O, or F.

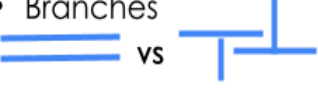
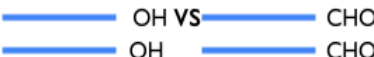
Intermolecular Forces

DISPERSION FORCES (LONDON FORCES)	DIPOLE-DIPOLE FORCES	HYDROGEN BONDS
Alkanes Alkenes Alkynes	Aldehydes Ketones Haloalkanes Esters	Alcohols (1 place) Carboxylic acids (2 places)

INCREASING STRENGTH OF INTERMOLECULAR FORCES

Alkanes	Alkenes	Alkynes	Aldehydes	Ketones	Halo- alkanes	Esters	Alcohols	Carboxylic acids
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Explanations:

Structural factors (Independent variable)	Intermolecular Forces (IMF) (Van Der Waals Forces)	Physical Property (Dependent variable)
- Chain length (molecular mass)  (Constant: Homologous Series) Increase in chain length = increase in IMF - Branches  (Constant: Homologous Series) Less branched = increase in IMF - Functional group (specify IMF)  (Constant: Molecular mass)	- Hydrogen bonds - Carboxylic acids (2 places) - Alcohols (1 place) - Dipole-dipole forces - haloalkanes, ketones, Aldehydes, esters - London (Induced dipole) - all organic molecules (alkanes, alkenes, alkynes)	- Boiling point Def: Temperature at which the vapour pressure = atmospheric pressure - Melting point The temperature at which the solid and liquid phases of a substance are at equilibrium. - Vapour pressure Def: The pressure exerted by a vapour at equilibrium with its liquid in a closed system. Explanation: - Identify structural factor and IMF - Explain and compare strength of IMF - Energy needed to overcome IMF - Compare BP/MP/VP



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COMPOUNDS	BOILING POINT
Methane	-162 °C
Ethane	- 89 °C
Propane	- 42 °C
Butane	-1 °C
Pentane	36 °C

COMPARE

Constant Variable

- Same homologous series

Independent Variable

- Chain length
- Molecular mass of the compound

Dependent Variable

- Boiling point



Scientific Conclusion

The boiling points of the compounds increase as the chain length (Molecular mass) increases.

- 1 Difference between **COMPOUNDS & IMF**
- 2 Compare strength of **IMF**
- 3 **ENERGY** needed to overcome **IMF (not bonds)**
- 4 Explain the difference in **PHYSICAL PROPERTIES**

1. Methane and butane are both alkanes with London forces. Butane has a longer chain length than methane.
1. Butane has stronger IMF than methane.
1. More energy is needed to overcome the intermolecular forces of butane.
1. Therefore, the boiling point of butane is higher than the boiling point of methane.

COMPOUNDS	Mr	BOILING POINT
Butane	58	- 0,5 °C
Propanal	58	49 °C
Propanone	58	56 °C
Propan-1-ol	60	97 °C
Ethanoic acid	60	118 °C

COMPARE

Constant Variable

- Same molecular mass

Independent Variable

- Different functional groups

Dependent Variable

- Boiling point

Scientific Conclusion

The boiling points of the compounds increase as the strength of the intermolecular forces increases.



- 1 Difference between **COMPOUNDS & IMF**
- 2 Compare strength of **IMF**
- 3 **ENERGY** needed to overcome **IMF (not bonds)**
- 4 Explain the difference in **PHYSICAL PROPERTIES**

1. Propanal is an aldehyde with dipole-dipole forces and ethanoic acid is a carboxylic acid with hydrogen bonds.
1. Hydrogen bonds are stronger than dipole-dipole forces.
1. More energy is needed to overcome the intermolecular **forces** of ethanoic acid.
1. Therefore, the boiling point of ethanoic acid is higher than the boiling point of propanal.

COMPOUNDS	BOILING POINT
Propan-1-ol	97 °C
Butan-1-ol	118 °C
Pentan-1-ol	138 °C
Hexan-1-ol	157 °C
Heptan-1-ol	175 °C

COMPARE

Constant Variable

- Same homologous series

Independent Variable

- Chain length (Mr)

Dependent Variable

- Boiling point

Scientific Conclusion

The boiling points of the compounds increase as the chain length increases.



- 1 Difference between **COMPOUNDS & IMF**
- 2 Compare strength of **IMF**
- 3 **ENERGY** needed to overcome **IMF**
- 4 Explain the difference in **PHYSICAL PROPERTIES**

1. Butan-1-ol and hexan-1-ol are both alcohols with hydrogen bonds. Hexan-1-ol has a longer chain length than butan-1-ol.
1. Hexan-1-ol has stronger IMF than butan-1-ol.
1. More energy is needed to overcome the intermolecular **forces** of hexan-1-ol.
1. Therefore, the boiling point of hexan-1-ol is higher than the boiling point of butan-1-ol.

COMPOUNDS	BOILING POINT
Hexane	69 °C
Pentan-1-ol	138 °C
Butanoic acid	164 °C

COMPARE

Constant Variable

- The same molecular mass

Independent Variable

- Different functional groups

Dependent Variable

- Boiling point

Scientific Conclusion

The boiling points of the compounds increase as the strength of the intermolecular forces increases.



- 1 Difference between COMPOUNDS & IMF
- 2 Compare strength of IMF
- 3 ENERGY needed to overcome IMF
- 4 Explain the difference in PHYSICAL PROPERTIES

1. Pentan-1-ol is an alcohol with hydrogen bonds and butanoic acid is a carboxylic acid with hydrogen bonds.
1. The intermolecular forces of butanoic acid are stronger than those of pentan-1-ol because the butanoic acid has **two sites** for hydrogen bonds and pentan-1-ol has only **one site** for hydrogen bonds.
1. More energy is required to overcome the intermolecular forces of butanoic acid.
1. Therefore, the boiling point of butanoic acid is higher than the boiling point of pentan-1-ol.

Worked Example:

QUESTION 3 (SC 2018) – PHYSICAL PROPERTIES

The boiling points of straight-chain alkanes and straight-chain alcohols are compared in the table below.

NUMBER OF CARBON ATOMS	BOILING POINTS OF ALKANES (°C)	BOILING POINTS OF ALCOHOLS (°C)
1	-162	64
2	-89	78
3	-42	98
4	-0,5	118

- 3.1 Explain the increase in boiling points of alkanes, as indicated in the table. (3)

- 3.2 Explain the difference between the boiling points of an alkane and an alcohol, each having THREE carbon atoms per molecule, by referring to the TYPE of intermolecular forces. (4)

- 3.3 Does the vapour pressure of alcohols INCREASE or DECREASE with an increase in the number of carbon atoms? (1)

- 3.4 How will the boiling point of 2-methylpropane compare to that of its chain isomer? Write down HIGHER THAN, LOWER THAN or EQUAL TO. Give a reason for the answer by referring to the structural differences between the two compounds. (2)
[10]

- 3.1 BP increases from 1 to 4:
The chain length/molecular mass/surface area increases
Increase in strength of IMF/London/Van der Waals forces.
More energy needed to overcome IMF

- 3.2 Alkanes have London forces.
Alcohols have hydrogen bonding.
Hydrogen bonding are stronger than London forces.
Alcohols have higher boiling points than alkanes.

- 3.3 Decrease (when BP increases, VP will decrease)

- 3.4 Lower than
2-methylpropane is more branched/has a smaller surface area (than butane/chain isomer)

QUESTION 3 (SC 2021) – PHYSICAL PROPERTIES

Learners use compounds A, B and C to investigate one of the factors that influences the VAPOUR PRESSURE of organic compounds.

A	Butan-1-ol
B	Butan-2-one
C	Propanoic acid

- 3.1 Define the term vapour pressure. (2)
- 3.2 Write down the independent variable for this investigation. (1)
- 3.3 Which compound, A or B, has the higher vapour pressure? (1)
- 3.4 Fully explain the answer to QUESTION 3.3. Include the TYPES OF INTERMOLECULAR FORCES in your explanation. (4)

3.1 The pressure exerted by a vapour at equilibrium with its liquid in a closed system. (2)

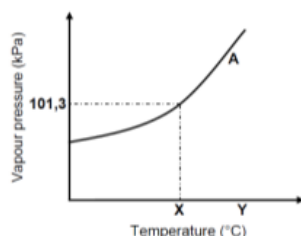
3.2 Functional group/Type of intermolecular forces/Homologous series (1)

3.3 B (1)

- 3.4
- Compound A/butan-1-ol has hydrogen bonding (dipole-dipole and London forces) between molecules.
 - Compound B/butan-2-one has dipole-dipole forces (and London forces) between molecules.
 - Intermolecular forces in compound A/butan-1-ol are stronger than intermolecular forces in compound B/butan-2-one. (4)

QUESTION 3 (SC 2021) – PHYSICAL PROPERTIES

3.5 The graph below represents the relationship between vapour pressure and temperature for compound A at sea level. X and Y represent different temperatures.

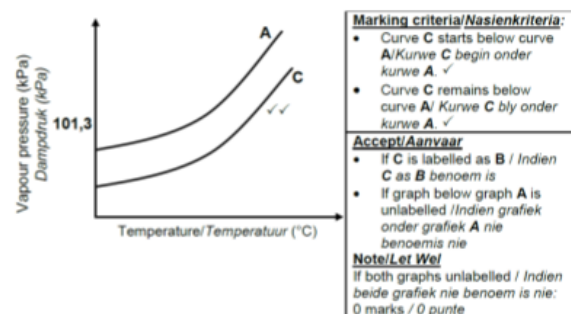


- 3.5.1 Write down the term for the temperature represented by X. (1)
- 3.5.2 State the phase of compound A at temperature Y. Choose from GAS, LIQUID or SOLID. (1)
- 3.5.3 Redraw the graph above in your ANSWER BOOK. On the same set of axes, sketch the curve that will be obtained for compound C. Clearly label curve A and curve C. (2)

3.5.1 Boiling point (of compound A/butan-1-ol) (1)

3.5.2 Gas (1)

3.5.3



Marking criteria/Nasienkriteria:

- Curve C starts below curve A/Kurwe C begin onder kurwe A. ✓
- Curve C remains below curve A/ Kurwe C bly onder kurwe A. ✓

Accept/Aanvaar

- If C is labelled as B / Indien C as B benoem is
- If graph below graph A is unlabelled /Indien grafiek onder grafiek A nie benoem is nie

Note/Let Wel
If both graphs unlabelled / Indien beide grafiek nie benoem is nie: 0 marks / 0 punte

(2)
[12]

Exam revision:

QUESTION 1

- 1.1 Give a reason why alkanes are *saturated* hydrocarbons. (1)
- 1.2 Write down the structural formula of:
- 1.2.1 The functional group of alcohols (1)
- 1.2.2 A tertiary alcohol that is a structural isomer of butan-1-ol (2)
- 1.3 Learners investigate factors that influence the boiling points of alkanes and alcohols. In one of the investigations they determine the boiling points of the first three alkanes.
- 1.3.1 Write down an investigative question for this investigation. (2)
- 1.3.2 Fully explain why the boiling point increases from methane to propane. (3)
- 1.4 The learners find that the boiling point of propan-1-ol is higher than that of propane. Explain this observation by referring to the TYPE of INTERMOLECULAR FORCES present in each of these compounds. (3)
- [12]

QUESTION 2

Learners use compounds A to C, shown in the table below, to investigate a factor which influences the boiling point of organic compounds.

A	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
B	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
C	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$

- 2.1 Which ONE of the compounds (A, B or C) has the highest boiling point? (1)
- 2.2 For this investigation, write down the:
- 2.2.1 Independent variable (1)
- 2.2.2 Dependent variable (1)
- 2.3 Write down the name of the type of Van der Waals force that occurs between the molecules of compound B. (1)
- 2.4 How will the vapour pressure of 2-methylpentane compare to that of compound C? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

The learners now compare the boiling points of compounds D and E, shown in the table below.

D	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
E	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$

- 2.5 How does the boiling point of compound D compare to that of compound E? Write down HIGHER THAN, LOWER THAN or EQUAL TO. Fully explain the answer. (4)
- [9]

QUESTION 3

The table below shows five organic compounds represented by the letters A to E.

A	CH ₄
B	CH ₃ CH ₃
C	CH ₃ CH ₂ CH ₃
D	CH ₃ CH ₂ CH ₂ CH ₃
E	CH ₃ CH ₂ OH

- 3.1 Is compound B SATURATED or UNSATURATED? Give a reason for the answer. (2)

Consider the boiling points of compounds A to E given in random order below and use them, where applicable, to answer the questions that follow.

0 °C	- 162 °C	- 42 °C	- 89 °C	78 °C
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- 3.2 Write down the boiling point of:
- 3.2.1 Compound C (1)
- 3.2.2 Compound E (1)
- 3.3 Explain the difference in boiling points of compounds C and E by referring to the TYPE of intermolecular forces present in EACH of these compounds. (3)
- 3.4 Does vapour pressure INCREASE or DECREASE from compounds A to D? Fully explain the answer. (4)
- 3.5 How will the vapour pressure of 2-methylpropane compare to the vapour pressure of compound D? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)
- [12]

QUESTION 4

Four compounds of comparable molecular mass are used to investigate the effect of functional groups on vapour pressure. The results obtained are shown in the table below.

	COMPOUND	VAPOUR PRESSURE (kPa at 20 °C)
A	Butane	204
B	Propan-2-one	24,6
C	Propan-1-ol	2
D	Ethanoic acid	1,6

- 4.1 Define the term *functional group* of an organic compound. (2)
- 4.2 Which ONE of the compounds (A, B, C or D) in the table has the:
- 4.2.1 Highest boiling point
(Refer to the vapour pressures in the table to give a reason for the answer.) (2)
- 4.2.2 Weakest intermolecular forces (1)
- 4.3 Refer to the type of intermolecular forces to explain the difference between the vapour pressure of compound A and compound B. (3)
- 4.4 The vapour pressures of compounds C and D are much lower than those of compounds A and B. Name the type of intermolecular force in A and B that is responsible for this difference. (1)
- 4.5 Briefly explain the difference in vapour pressure between compound C and compound D. (2)
- 4.6 During a combustion reaction in a closed container of adjustable volume, 8 cm³ of compound A (butane) reacts in excess oxygen according to the following balanced equation:

$$2\text{C}_4\text{H}_{10}(\text{g}) + 13\text{O}_2(\text{g}) \rightarrow 8\text{CO}_2(\text{g}) + 10\text{H}_2\text{O}(\text{g})$$
 If the initial volume of the oxygen in the container was 60 cm³, calculate the TOTAL volume of the gases that are present in the container at the end of the reaction. All the gases in the container are at the same temperature and pressure. (5)
- [16]

QUESTION 5

5.1 Define the term *boiling point*. (2)

5.2 What is the relationship between strength of intermolecular forces and boiling point? (1)

The relationship between strength of intermolecular forces and boiling point is investigated using four organic compounds from different homologous series. The compounds and their boiling points are given in the table below.

COMPOUND		BOILING POINT (°C)
A	Propane	- 42
B	Propan-2-one	56
C	Propan-1-ol	97
D	Propanoic acid	141

5.3 Refer to the TYPE and the STRENGTH of intermolecular forces to explain the difference in boiling points between:

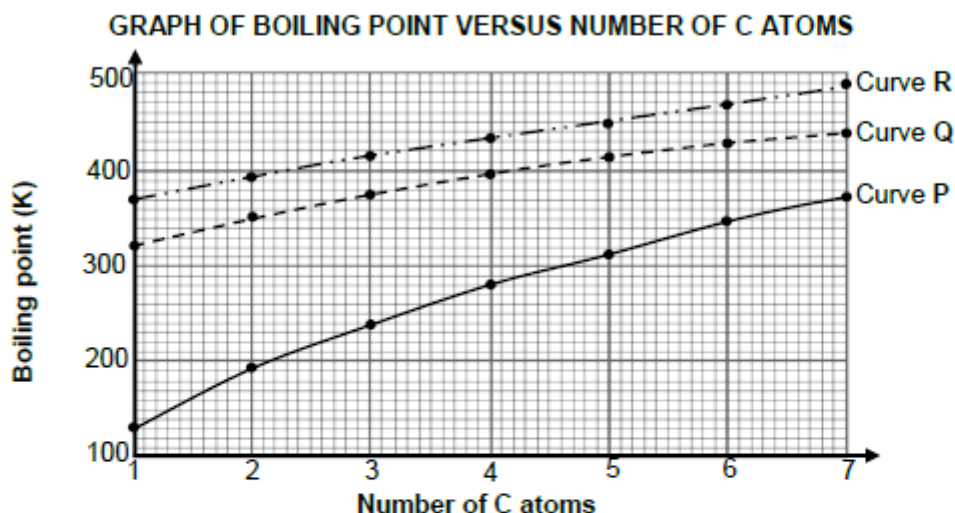
5.3.1 Compounds A and B (3)

5.3.2 Compounds C and D (3)

5.4 Is compound B a GAS or a LIQUID at room temperature? (1)
[10]

QUESTION 6

The relationship between boiling point and the number of carbon atoms in straight chain molecules of alkanes, carboxylic acids and alcohols is investigated. Curves P, Q and R are obtained.



6.1 Define the term *boiling point*. (2)

6.2 For curve P, write down a conclusion that can be drawn from the above results. (2)

6.3 Identify the curve (P, Q or R) that represents each of the following:

6.3.1 Alkanes (1)

6.3.2 Carboxylic acids (1)

6.4 Explain the answer to QUESTION 6.3.2 by referring to the:

- Types of intermolecular forces present in alkanes, carboxylic acids and alcohols
- Relative strengths of these intermolecular forces
- Energy needed

(5)
[11]

Post-Test:

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A–D) next to the question number (1.1–1.5), for example 1.6. D

1. The boiling point of a compound is the ...
 - A. minimum temperature at which it boils.
 - B. temperature at which its vapour pressure equals atmospheric pressure.
 - C. maximum temperature at which it boils.
 - D. average temperature at which it boils across all possible atmospheric pressures.
2. Which ONE of the following compounds has the highest melting point?
 - A. CH_3CH_3
 - B. $\text{CH}_3\text{CH}_2\text{CH}_3$
 - C. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
 - D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
3. A scientist investigates a factor which influences the boiling points of alkanes. He determines the boiling points of the first six straight chain alkanes.
Which ONE of the following is the independent variable in this investigation?
 - A. Chain length
 - B. Boiling point
 - C. Branching
 - D. Functional group
4. Which ONE of the following isomers has the LOWEST boiling point?
 - A. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
 - B. $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{CH}_3$
 - C. $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
 - D. $\text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)_2\text{CH}_3$
5. Which ONE of the following compounds has the HIGHEST vapour pressure?
 - A. CH_3CHO
 - B. $\text{CH}_3\text{CH}_2\text{OH}$
 - C. HCOOH
 - D. $\text{CH}_3\text{CH}_2\text{CH}_3$

5x2=[10]

SESSION 2: WORK, ENERGY & POWER

ATP (Annual Teaching Plan) 2023/24

- Define the work done on an object.
- Draw force diagram & free-body diagrams.
- Calculate the net work done on an object.
- Distinguish between positive work and negative net work done on the system.
- State the work-energy theorem.
- Apply the work-energy theorem on horizontal, vertical and inclined planes.
- Define conservative and non-conservative forces and give examples.
- State the principle of conservation of mechanical energy.
- Solve problems using the equation: $W_{nc} = \Delta E_k + \Delta E_p$
- Show that E_M is conserved in the absence of non-conservative forces.
- Define power and calculate the power involved when work is done.
- Perform calculations using $P_{average} = Fv_{average}$ when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane.
- Calculate the minimum power required of an electric motor to pump water from a borehole of a particular depth at a particular rate using $W_{nc} = \Delta E_k + \Delta E_p$

Examination Guideline 2021

(This section must be read in conjunction with the CAPS, p.117 – 120)

Work

- Define the work done on an object by a constant force F as $F\Delta x \cos\theta$, where F is the magnitude of the force, Δx the magnitude of the displacement and θ the angle between the force and the displacement. (Work is done by a force – the use of the term 'work is done against a force', e.g. work done against friction, must be avoided.)
- Draw a force diagram and free-body diagrams.
- Calculate the net work done on an object.
- Distinguish between *positive net work done* and *negative net work done* on the system.

Conservation of energy with non-conservative forces present

- Define a *conservative force* as a force for which the work done in moving an object between two points is independent of the path taken. Examples are gravitational force, the elastic force in a spring and electrostatic forces (coulombic forces).
- Define a *non-conservative force* as a force for which the work done in moving an object between two points depends on the path taken. Examples are frictional force, air resistance, tension in a chord, etc.
- State the principle of conservation of mechanical energy: The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. **NOTE:** A system is isolated when the net external force (excluding the gravitational force) acting on the system is zero.
- Solve conservation of energy problems using the equation: $W_{nc} = \Delta E_k + \Delta E_p$
- Use the relationship above to show that in the absence of non-conservative forces, mechanical energy is conserved.

Power

- Define *power* as the rate at which work is done or energy is expended.
- In symbols: $P = \frac{W}{\Delta t}$
- Calculate the power involved when work is done.
- Perform calculations using $P_{average} = Fv_{average}$ when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane.
- Calculate the power output for a pump lifting a mass (e.g. lifting water through a height at constant speed).

Formulae

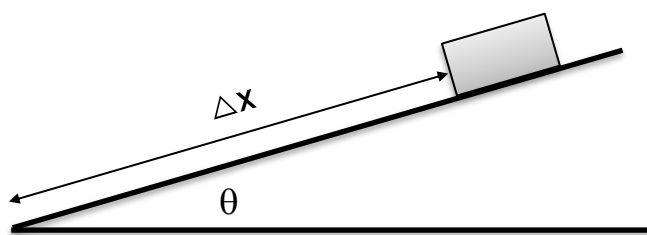
$E_p = mgh$ <u>or</u> $U = mgh$	$E_k = \frac{1}{2}mv^2$ <u>or</u> $K = \frac{1}{2}mv^2$
$W = F\Delta x \cos\theta$	$W_{net} = \Delta E_k$ of $W_{net} = \Delta K$
$W_{nc} = \Delta E_k + \Delta E_p$ <u>or</u> $W_{nc} = \Delta K + \Delta U$	$\Delta E_k = E_{kf} - E_{ki}$
$P = \frac{W}{\Delta t}$	$P_{average} = Fv_{average}$

PRE-TEST

QUESTION 1 (MULTIPLE-CHOICE)

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A–D) next to the question number (1.1–1.5), for example 1.6. D

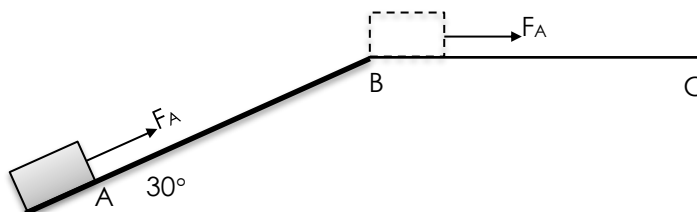
- 1.1 A block with mass **m** slides down a smooth FRICTIONLESS inclined plane that makes an angle of θ with the horizontal. The block moves over a distance of Δx as indicated in the sketch. (2)



The WORK done on the block is:

- A $W_{\text{net}} = \Delta E_k + \Delta E_p$
- B $W_{\text{net}} = w \sin \theta \cdot \Delta x \cdot \cos 0^\circ$
- C $W_{\text{net}} = w \cos \theta \cdot \Delta x \cdot \cos 0^\circ$
- D $W_{\text{net}} = w \cos \theta \cdot \Delta x \cdot \cos 180^\circ$
- 1.2 Which ONE of the following equations represents the principle of conservation of mechanical energy? (2)
- A $\Delta E_k = \Delta E_p$
- B $\Delta E_k + \Delta E_p = 0$
- C $W_{\text{nc}} = \Delta E_k + \Delta E_p$
- D $W_{\text{nc}} = \Delta E_k - \Delta E_p$

- 1.3 An object (0,5 kg) is pulled with a CONSTANT FORCE (F_A) from point A to point C. AB = BC. AB is a frictionless inclined plane that makes an angle of 30° with the horizontal. A frictional force of 3N acts against the object on BC. (2)

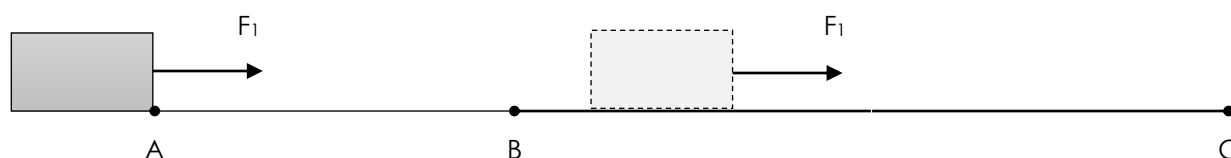


Which one of the following statements regarding the NET WORK done on the object is true?

- A $W_{\text{net}(AB)} = W_{\text{net}(BC)}$
- B $W_{\text{net}(AB)} > W_{\text{net}(BC)}$
- C $W_{\text{net}(AB)} < W_{\text{net}(BC)}$
- D $W_{\text{net}(AC)} = 0$

- 1.4 A box (5kg) is pulled from point A to C with a CONSTANT horizontal force (F_1). The surface between point A and B is frictionless, but a constant friction acts on the box between point B and C. (2)

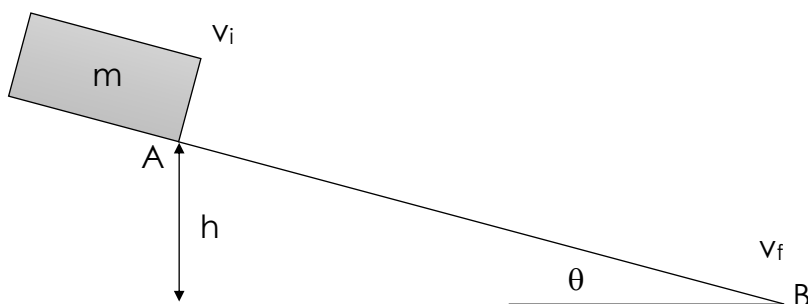
$$2AB = BC$$



The net work done on the box between point A and C is:

- A $W_{\text{net}} = (3F + 2f) \Delta x$
- B $W_{\text{net}} = (3F - 2f) \Delta x$
- C $W_{\text{net}} = (2F + 3f) \Delta x$
- D $W_{\text{net}} = (2F - 3f) \Delta x$

- 1.5 A box slides down a frictionless incline from point A to point B. There are four equations that can be used to calculate the box's final velocity (v_f) at point B. (2)



Which one may NOT be used if the examiner clearly states that only WORK-ENERGY PRINCIPLES may be used?

- A $W_{\text{net}} = \Delta E_K$
- B $W_{\text{nc}} = \Delta E_K + \Delta E_P$
- C $E_{M(A)} = E_{M(B)}$
- D $v_f^2 = v_i^2 + 2a\Delta x$

[10]

LONGER QUESTIONS

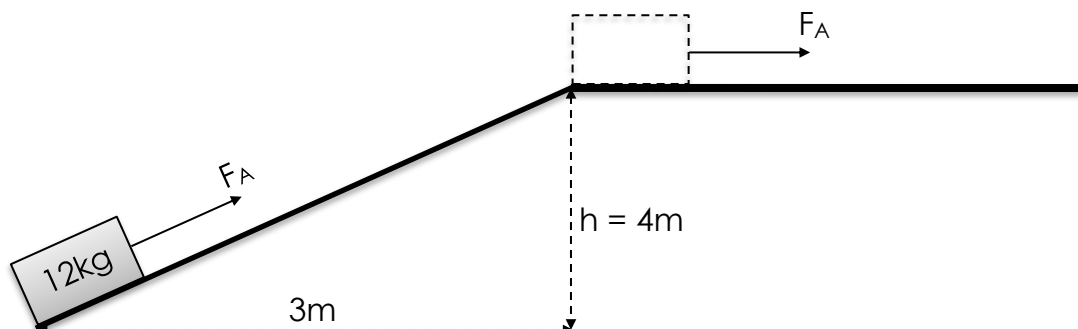
QUESTION 2

- 2.1 State the WORK-ENERGY PRINCIPLE in words. (2)

- 2.2 Define the term: NON-CONSERVATIVE FORCES (2)

An object with mass 12kg is pulled from rest by a constant force (F_A) from A to C in the following illustration. The distance $AB = BC$.

The magnitude of the frictional forces that opposes the motion of the object is 2N on surface AB and 4N on surface BC. The object moves at $6 \text{ m}\cdot\text{s}^{-1}$ at point B.



You may only use WORK-ENERGY PRINCIPLES to answer this question.

2.3 Calculate the magnitude of the constant applied force (F_A). (6)

[Tip: Use the formula for non-conservative forces]

2.4 Calculate the nett work done on the horizontal surface (BC). (4)

2.5 Calculate the velocity of the object at point C. (3)
[17]

QUESTION 3

3.1 State the WORK-ENERGY THEOREM in words. (2)

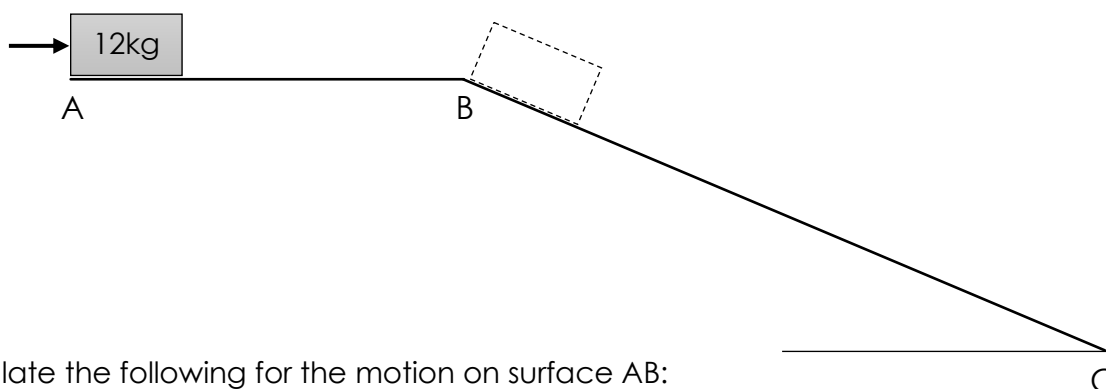
3.2 Define the term: CONSERVATIVE FORCE (2)

A block with a mass of 12 kg accelerates from rest from A to B on a horizontal surface when a force F (300N) acts on it parallel with the surface.

The block moves under the influence of its own weight alone from B to C down an inclined plane that makes an angle of 30° with the horizontal. The constant kinetic friction acting on the block between A and B is 3N and the friction acting on the block between B and C is 1N.

AB = 12 m and BC = 20 m.

Only use WORK-ENERGY principles to answer this question!



3.3 Calculate the following for the motion on surface AB:

5.3.1 Net work done (3)

5.3.2 Velocity of the block at point B (4)

3.4 NAME the CONSERVATIVE FORCE acting on the object on BC. (2)

3.5 Calculate the following for the motion on surface BC:

3.5.1 Net work done (3)

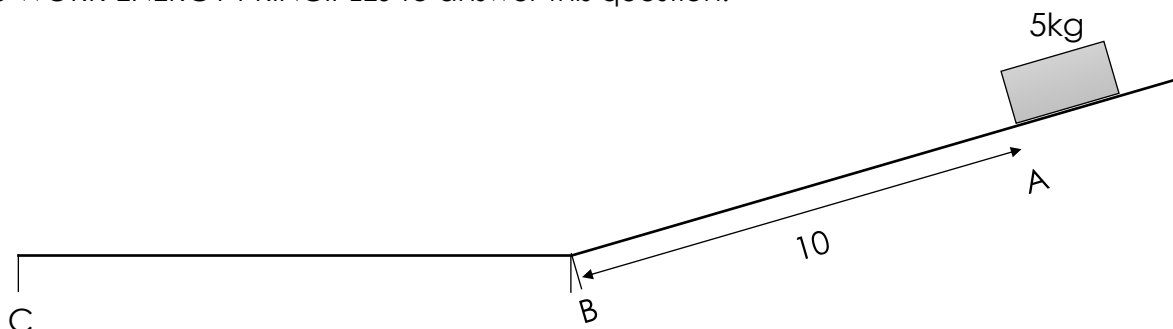
3.5.2 Velocity of the block at point C (4)

[20]

QUESTION 4

A box with mass 5kg slides from rest down on a FRICTIONLESS inclined plane over a distance of 10m. The angle between the inclined plane and the horizontal is 30° . It hits a rough horizontal surface at point B with a frictional force of 12N acting against the motion of the box. The box stops at point C.

Use WORK-ENERGY PRINCIPLES to answer this question.



Calculate:

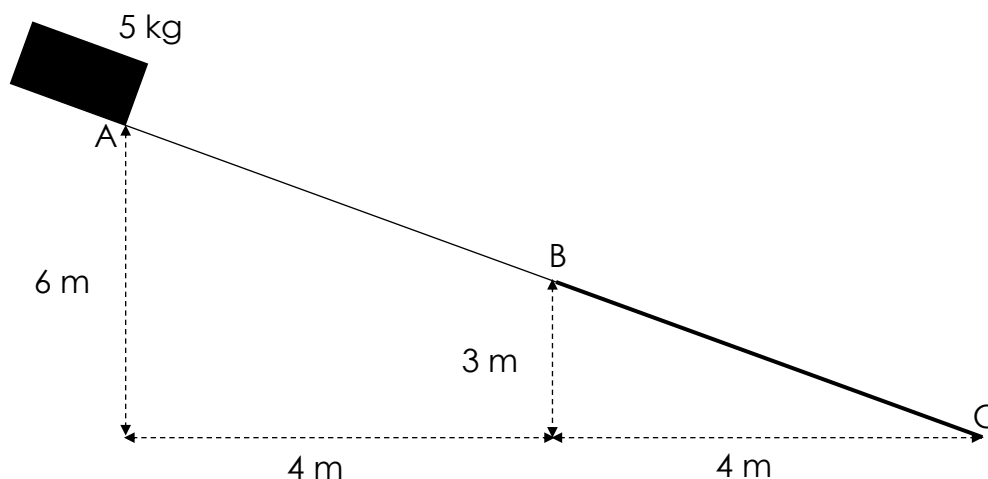
- 4.1 The parallel component ($w_{\parallel}$) of the weight of the box. (3)
 - 4.2 The velocity of the box at point B. (6)
 - 4.3 The work done by the frictional force on the box between point B and C. (4)
 - 4.4 The distance between point B and C. (5)
- [18]

QUESTION 5

- 5.1 State the WORK-ENERGY THEOREM into words. (2)

A box (5 kg) slides from rest down an inclined plane from point A to point C. On the inclined plane AB is frictionless and the frictional force acting on the block on BC is 1,2 N.

Only use WORK-ENERGY PRINCIPLES to answer this question.



5.2 NAME an example of the following forces acting on the box:

5.2.1 Conservative force during part AB. (1)

5.2.2 Non-conservative force during part BC. (1)

5.3 Calculate the box's velocity at:

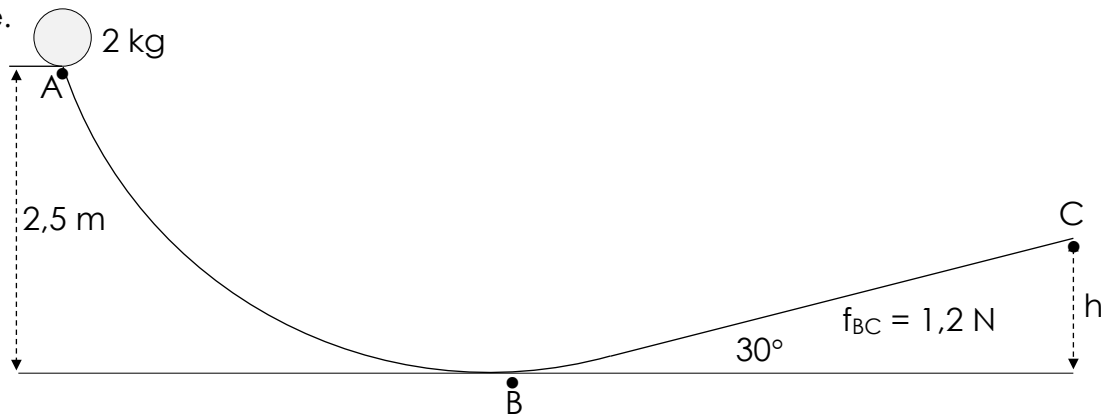
5.3.1 Point B (4)

5.3.2 Point C (4)
[12]

QUESTION 6

6.1 State the WORK-ENERGY theorem into words. (2)

A ball (mass 2 kg) rolls from rest from point A down a frictionless curve to point B and up again on an inclined plane where it comes to rest at point C. Assume that BC is a straight line. The ball experiences a frictional force of 1.2 N as it rolls up the inclined plane.



Only use WORK-ENERGY principles to answer this question.

6.2 Which ONE of the levels (AB or BC) is considered a closed system? (2)
Give a reason for your answer.

6.3 Calculate the speed of the ball at point B. (3)

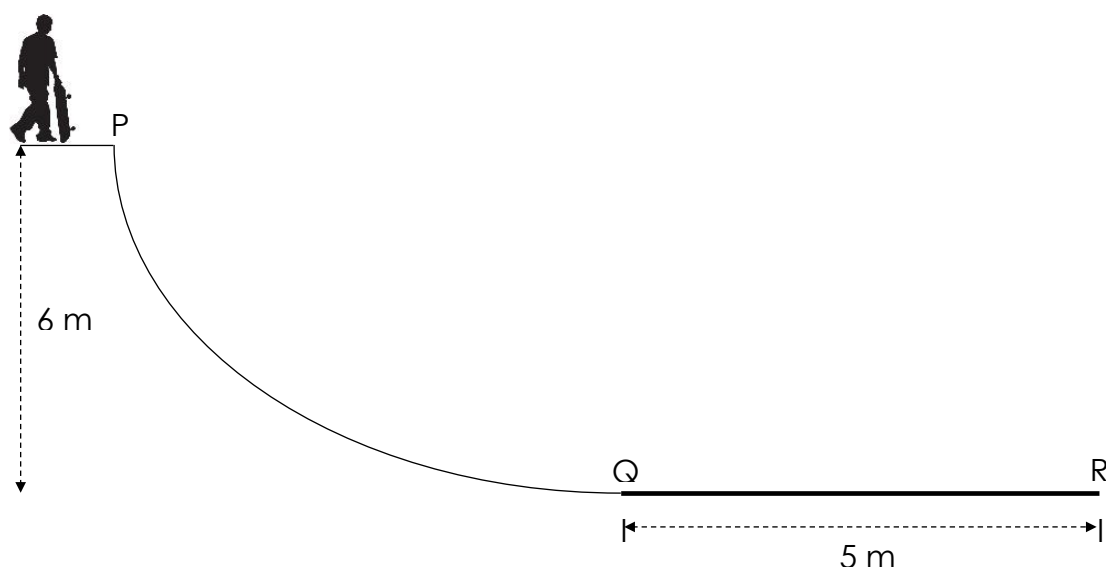
6.4 Calculate the distance (BC) **AND** the height (h) where the ball comes to rest. (5)
[12]

QUESTION 7

7.1 State the WORK-ENERGY theorem into words. (2)

A boy skates from rest with a skateboard from point P to point Q down a frictionless curve and over a rough horizontal surface to point R.

The boy and the skateboard together weigh 65 kg. The coefficient of kinetic friction (μ_k) between the skateboard and the horizontal surface between Q and R is 0.2



You may only use ENERGY PRINCIPLES to answer this question.

Calculate

7.2 The speed of the boy at point Q. (4)

7.3 The speed of the boy at point R. (5)

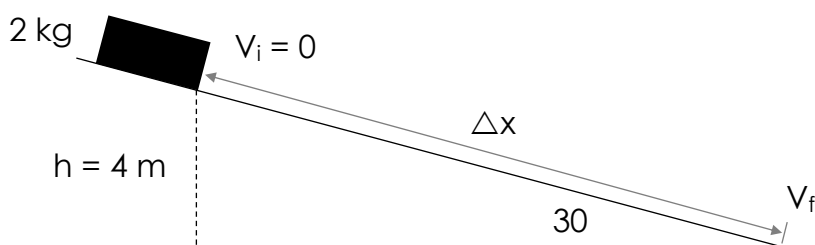
7.4 The change in kinetic energy of the boy between Q and R. (3)
[14]

POST-TEST

QUESTION 8 (MULTIPLE-CHOICE)

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A–D) next to the question number (8.1–8.5), for example 8.6. D

8.1 A box slides down a FRICTIONLESS inclined plane. Which ONE of the following formulas can NOT be used to calculate the final velocity of the box? (2)



A $f\Delta x \cos\theta = \Delta E_k + \Delta E_p$

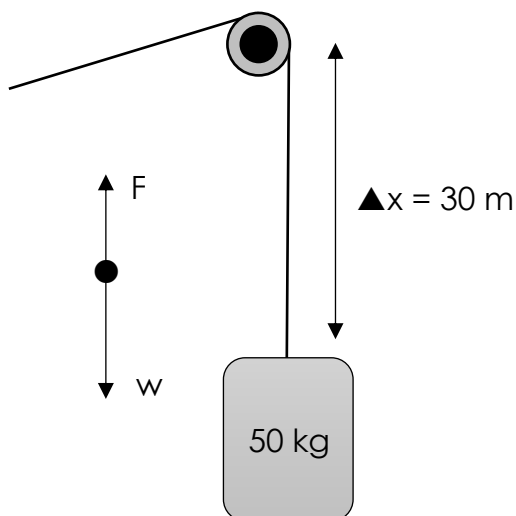
B $0 = \Delta E_k + \Delta E_p$

C $W_{\text{net}} = \Delta E_k$

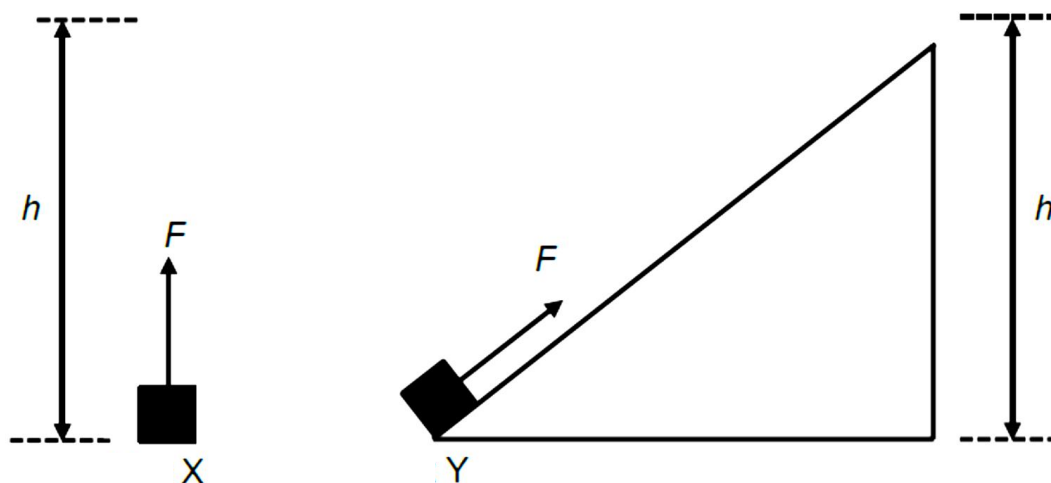
D $\frac{1}{2}mg\Delta x \cos\theta = \Delta E_k$

- 8.2 An electric motor is used to lift an object (50 kg) vertically to a height of 30 m. Calculate the power delivered by the motor if the object is being lifted at a CONSTANT SPEED of 0.1 m.s^{-1} . (2)

- A $P = 49 \text{ W}$
 B $P > 49 \text{ W}$
 C $P < 49 \text{ W}$
 D $P = 0 \text{ W}$



- 8.3 Two boxes **X** and **Y** have the same mass. Box **X** is lifted through a vertical height **h** by a force of magnitude **F**. Box **Y** is pulled up a slope by a force of the same magnitude to reach the same vertical height, as shown. (2)



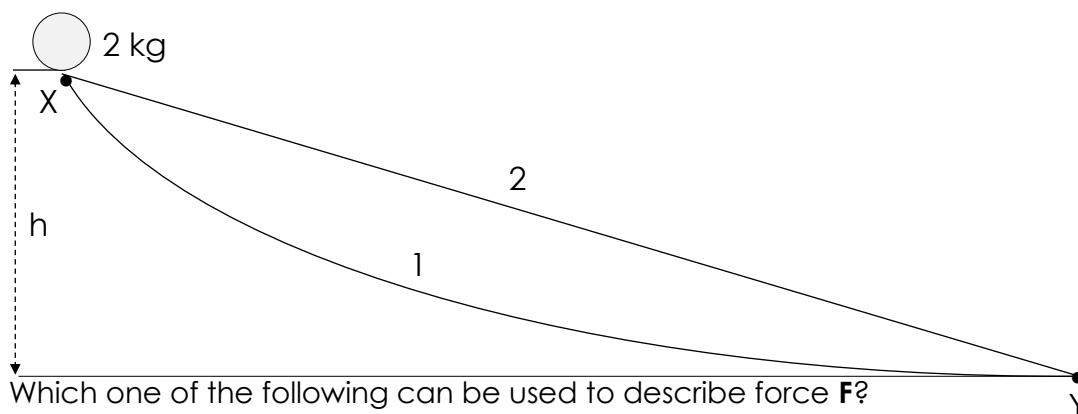
Which combination regarding the change in gravitational potential energy and work done is correct?

	Change in gravitational potential energy of the boxes	Amount of work done by F
A	Is less for box Y than for box X	Is less for box Y than for box X
B	Is more for box Y than for box X	Is more for box Y than for box X
C	Is the same for box X and box Y	Is the same on X and Y
D	Is the same for box X and box Y	Is more for box Y than for box X

8.4 The net work done on an object to increase its speed from rest to $\mathbf{v}$, is $\mathbf{W}$. What must the net work done on the same object be to increase its speed from $\mathbf{v}$ to $\mathbf{2v}$? (2)

- A $\mathbf{W}$
- B $\mathbf{2W}$
- C $\mathbf{3W}$
- D $\mathbf{4W}$

8.5 A force $\mathbf{F}$ moves an object P from point X to point Y along two different paths, 1 and 2, as shown below. The work done by $\mathbf{F}$ in moving the object is the same for both paths. (2)



- A Normal force
- B Gravitational force
- C Friction
- D Tension

SESSION 3: THE DOPPLER EFFECT

1.1 EXAMINATION GUIDELINES

The following points are summarized from the Exam Guidelines and ATP. This section must be read in conjunction with the CAPS, p. 134-135.

Prior knowledge:

- Properties of waves as summarized in grade 10 (frequency, period, wavelength, amplitude & wave speed)
- Properties of sound waves (pitch & loudness of sounds)
- Diffraction of waves as summarized in grade 11 (wave fronts & Huygens' Principle)

With sound and ultrasound

- Write down the Doppler effect as the change in frequency (or pitch) of the sound perceived by a listener because the sound source and the listener have different speeds relative to the medium in which the sound is propagated.
- Explain the change in pitch observed when a source moves toward or away from a listener.
- Solve problems using the equation $f_L = \frac{v \pm v_L}{v \pm v_b} f_b$ when EITHER the listener OR the source moves.
- Name applications of the Doppler effect.

With sound and ultrasound

- Explain redshifts and blueshifts.
- Use the Doppler effect to explain applications such as the use of ultrasound waves in medicine.

1.2 Prior knowledge

PROPERTIES OF WAVES:

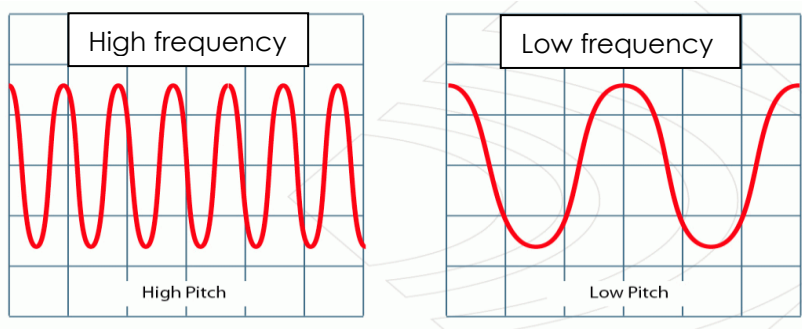
- 1) **Amplitude** → is the maximum distance of the wave from its resting position and is measured in meters (m).
- 2) **Wavelength** (λ , the Greek letter lambda) → is the distance between two consecutive points that are in phase and is measured in meters (m).
- 3) **Frequency (f)** → The number of wave pulses per second and is measured in hertz (Hz).
- 4) **Period (T)** → The time it takes for one complete wave pulse and is measured in seconds.
- 5) The relationship between frequency and period, $f = \frac{1}{T}$ and $T = \frac{1}{f}$, to solve problems.

- 6) **Wave speed (v)** → is the distance a point on the wave moves per unit time. Use the wave equation $v = f\lambda$ to solve problems involving waves.

PROPERTIES OF SOUND WAVES:

Sound waves are longitudinal waves that result from the vibration of an object. The vibration is parallel to the direction of propagation and causes compressions and dilutions. The speed of sound increases with an increase in temperature. At 0 °C the speed of sound in air is 331 m·s⁻¹; at 20 °C the speed increases to 343 m·s⁻¹.

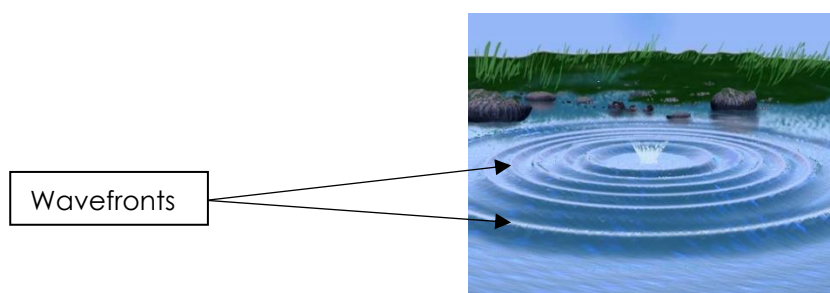
pitch → The pitch refers to how low or how high the note of a sound is. The pitch of a note depends on its frequency.



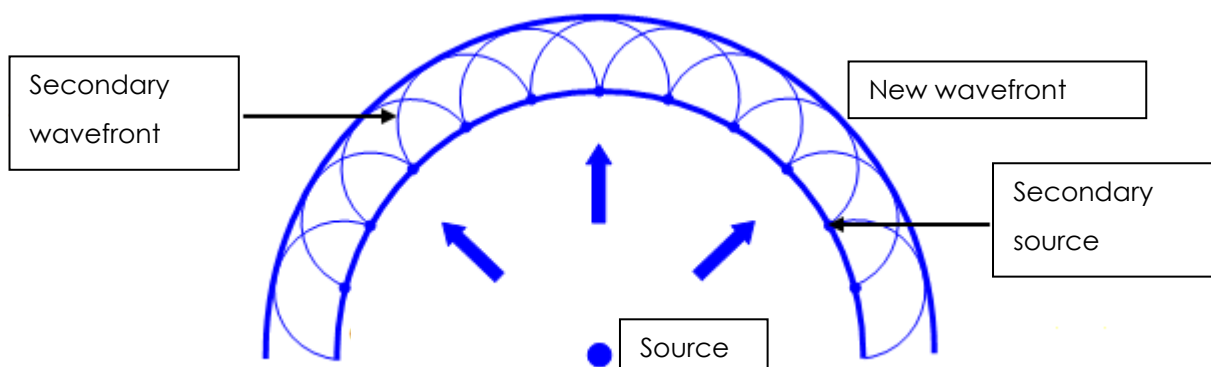
Loudness of sounds → The loudness of sounds is related to the intensity of the wave, which is a measure of the amount of energy carried by a wave. The loudness of sounds depends on the size of the wave/pulse's amplitude.

WAVEFRONTS & HUYGENS' PRINCIPLE:

Wavefronts → are imaginary lines that we draw between adjacent points in phase, meaning all the particles in a wave that have the same motion at the same time. Wavefronts are used to show the movement of a wave.



Huygens' Principle → Huygens developed a technique to predict the future position of a wave front when a previous position is known. Each point on the wavefront is a source of a new small wave that propagates forward. A new wave front forms when all the small waves overlap on the outside.



Huygens' Principle states: Each point on a wavefront act as the source of secondary wavelets that propagate forward at the same speed as the wave. The new wavefront is determined by constructing the surface tangent to the secondary wavelets.

1.3 THE DOPPLER EFFECT

State the Doppler effect as the change in frequency (or pitch) of the sound detected by a listener, because the sound source and the listener have different velocities relative to the medium of sound propagation.

The Doppler effect equation:

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$$

$f_L \rightarrow$ frequency of the listener (Hz)

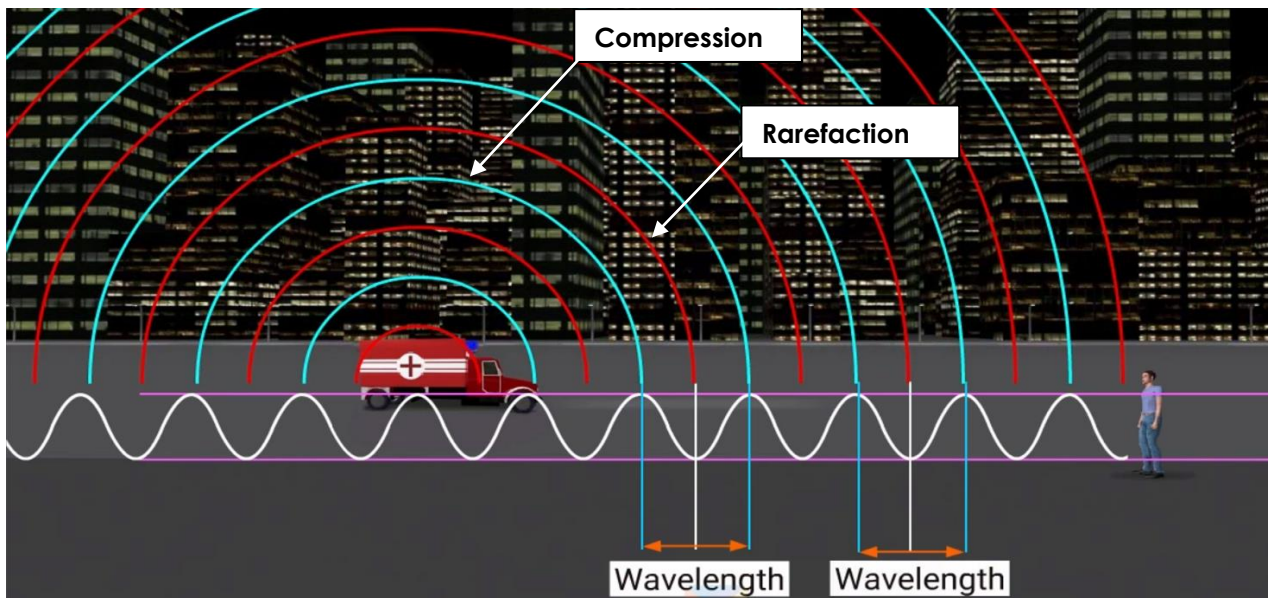
$f_s \rightarrow$ frequency of the source (Hz)

$v \rightarrow$ speed of sound in air ($\text{m}\cdot\text{s}^{-1}$)

$v_L \rightarrow$ velocity of the listener ($\text{m}\cdot\text{s}^{-1}$)

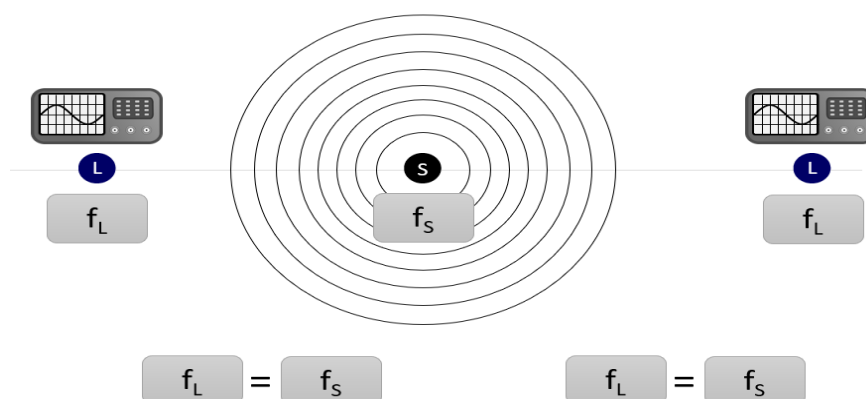
$v_s \rightarrow$ velocity of the source ($\text{m}\cdot\text{s}^{-1}$)

Observation of frequencies: When both the source and listener are stationary.



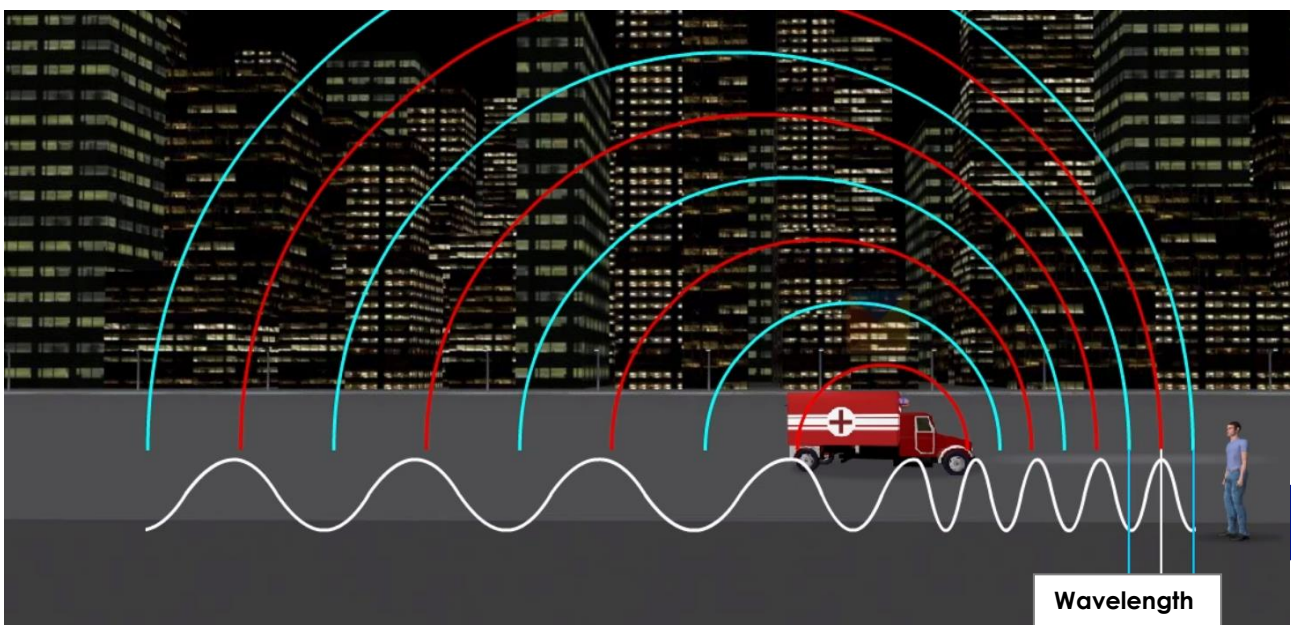
Frequency of the Source = Frequency of the Listener

$$f_s = f_L$$



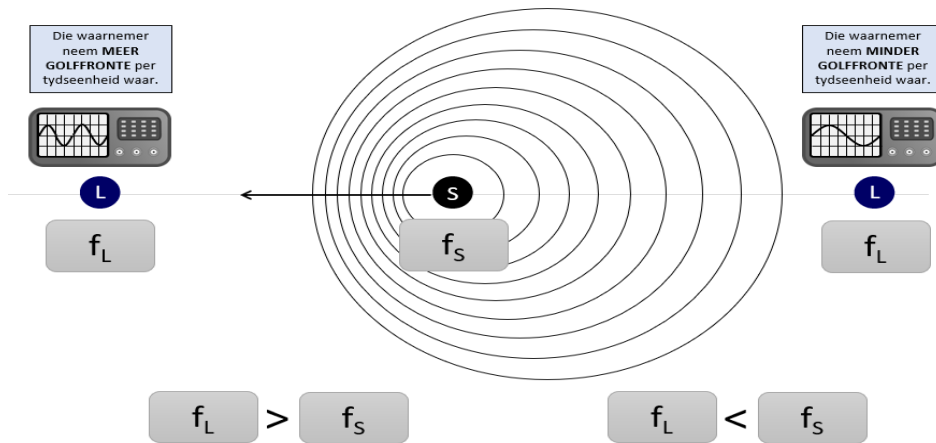
Observation of frequencies:

*The listener is stationary and the source moves **TOWARDS** the listener:*



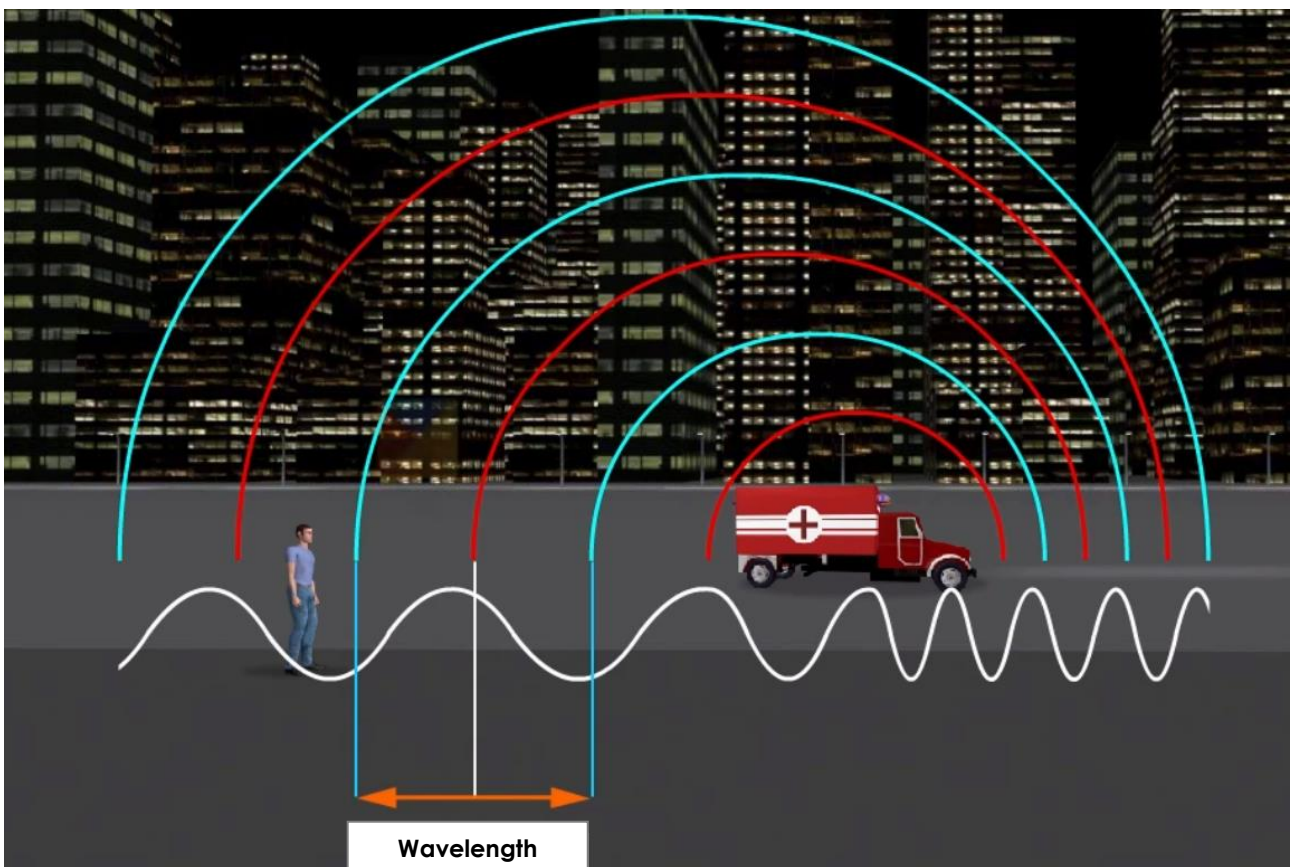
Frequency of the Source > Frequency of the Listener

$$f_s < f_L$$



Observation of frequencies:

*The listener is stationary, and the source is moving **AWAY** from the listener:*



Frequency of the Listener < Frequency of the Source

$$f_L < f_s$$

Source moves TOWARDS the listener	Source moves AWAY from the listener
$f_L = \frac{v + v_L}{v - v_b} f_b$	$f_L = \frac{v - v_L}{v + v_b} f_b$

1.4 EXERCISES:

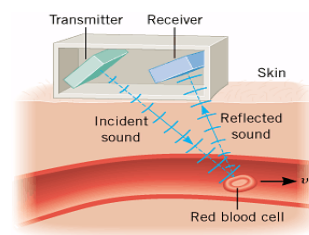
- 1.4.1) A conductor stands on a platform at a train station. A train passes and moves away from the conductor at $22 \text{ m}\cdot\text{s}^{-1}$. The train driver blows the horn, which has a frequency of 250 Hz . What frequency does the conductor hear? Take the speed of sound in air as $340 \text{ m}\cdot\text{s}^{-1}$. (4)
- 1.4.2) A man sails his yacht at $35 \text{ km}\cdot\text{h}^{-1}$ on a dam, passing a stationary boat. On the boat is a child playing a harmonica, which emits a note with a frequency of 150 Hz . As the man on the yacht sails away from the stationary boat, he notices that the sound of the harmonica changes.
- (a) Calculate the frequency of the note he hears as he moves closer to the stationary boat. Assume the speed of sound in air to be $340 \text{ m}\cdot\text{s}^{-1}$. (4)
- (b) Is the note he heard as he sailed away higher or lower than the note, he heard as he sailed closer to the stationary boat? (1)
- 1.4.3) An ice cream truck emits a signal at a frequency of 225.78 Hz as it approaches a group of stationary children who want to buy ice cream. The children hear the sound at a frequency of 240.5 Hz . Take the speed of sound as $340 \text{ m}\cdot\text{s}^{-1}$ and determine the speed of the ice cream truck. (4)
- 1.4.4) A flying bat emits beeping sounds at a frequency of 80 MHz . If a stationary observer hears the frequency of the beeps at 78 MHz ,
- (a) is the bat moving towards or away from the observer? (1)
- (b) what is the velocity of the bat if the speed of sound in air is $340 \text{ m}\cdot\text{s}^{-1}$. (4)

1.5 APPLICATIONS OF THE DOPPLER EFFECT

Ultrasound is sound waves with a frequency above human hearing (greater than 20kHz). High frequency means short wavelengths. Therefore, it can be reflected and refracted by very small objects. A high wavelength will easily travel over such small objects.

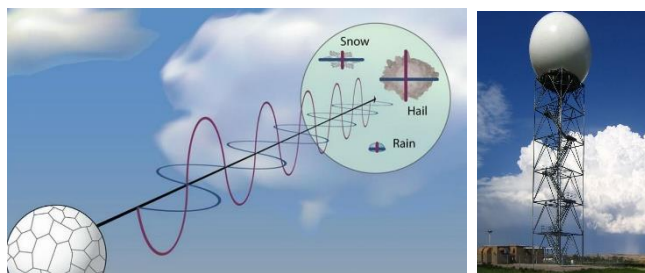
1.5.1) The **Doppler flowmeter** Medical scientists use this device to measure the speed of blood cells using ultrasound waves.

- The doppler flowmeter consists of a transmitter and a scope that is placed directly on the skin.
- The transmitter emits sound waves which then bounce back off a moving red blood cell. The frequency of the reflected wave is measured and compared with the frequency of the emitted wave.
- The doppler flowmeter can therefore determine the speed of the blood cell because of the Doppler effect, blood flowing in the direction of the meter will increase the frequency of the sound wave while blood flowing away from the meter will decrease the frequency.



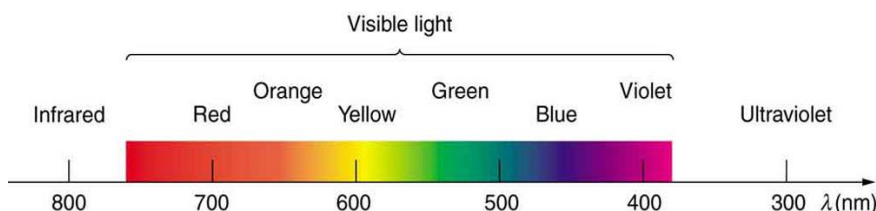
1.5.2) The **Doppler radar**

The Doppler radar is used in weather stations to determine precipitation's speed and direction.



- Radar uses pulses of radio waves emitted by the transmitter.
- The radio waves are reflected back by moving raindrops or hail.
- The frequencies of the reflected waves are analyzed and compared with the frequencies of the transmitted waves.
- To determine the speed and direction of the precipitation and associated storm.

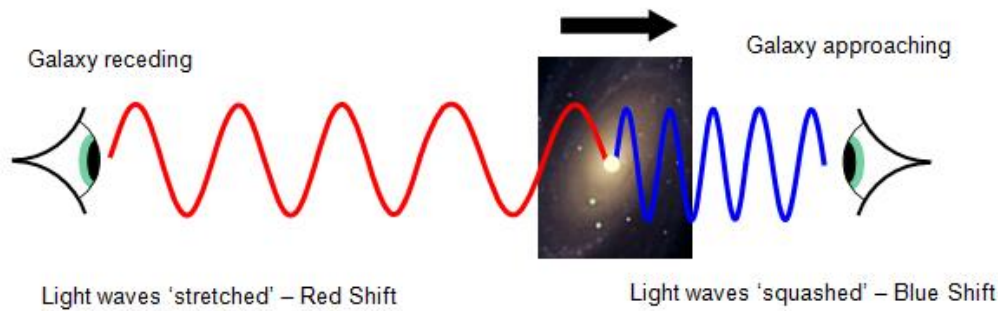
1.5.3) The Doppler effect and **light**



In the spectrum of light:

- the red side corresponds to smaller frequencies and longer wavelengths.
- the blue side corresponds to higher frequencies and smaller wavelengths.

The movement of a light source changes the frequencies and then the Doppler effect takes place.



- If a star moves towards the earth → the frequency of light increases. The phenomenon is called the **blue shift**.
- If a star moves away from Earth → decrease the frequency of light. The phenomenon is called the **redshift**.
- Certain galaxies do move in our direction, but more slowly as the distance between us and them increases.

1.6 Exercises on the Application of the Doppler effect

1.6.1) A light from a distant galaxy is observed from Earth and shows that it undergoes a blue shift. So this proves that this galaxy is...

- (A) moving away from Earth
- (B) revolving around the Milky Way.
- (C) moving towards the Earth.
- (D) revolving around the Sun.

(2)

1.6.2) The diagram below shows the spectral lines of an element.



Which ONE of the diagrams below represents the spectral line of the element as the light observed from a star moves away from the Earth.

- A)

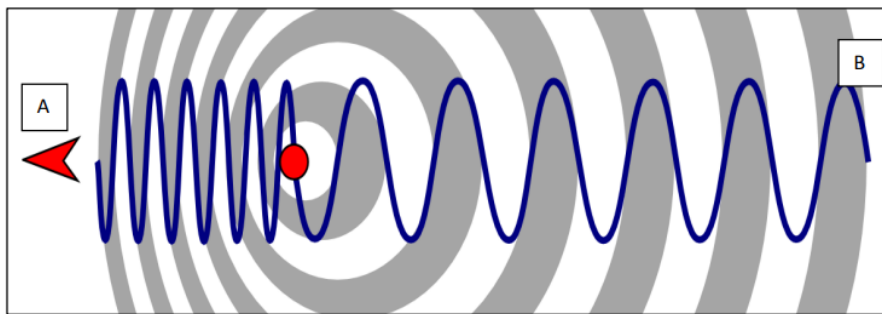
B)

C)

D)

(2)

1.6.3) Consider the diagram below and answer the questions that follow:



- (i) Which side (A or B) of the diagram shows a star moving towards Earth? (1)
- (ii) Which side (A or B) of the diagram shows a star moving away from Earth? (1)
- (iii) Redshift is represented by which side? Give a reason for your answer. (2)

1.6.4) Study the sketch below and answer the questions that follow:



- (i) Which galaxy or planet is moving at the same speed as the nearby star? (1)
- (ii) Which galaxy or planet is moving away from the nearby star? (1)
- (iii) Is the Andromeda galaxy undergoing a red or blue shift? (1)
- (iv) Name the galaxy or planet that moves the slowest away from the nearby star? (1)

QUESTION 1

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A–D) next to the question number (1.1–1.10) in the ANSWER BOOK.

- 1.1 Which one of the following is NOT an application of the Doppler effect? (2)

- A Redshift of a star moving away from the observer.
- B Reflection of EM waves from a vehicle back to a speed camera.
- C The doppler flowmeter to measure the flow of blood.
- D Reflection of sound waves from a cliff.

- 1.2 The siren of a fire truck has a frequency of 400 Hz. (2)

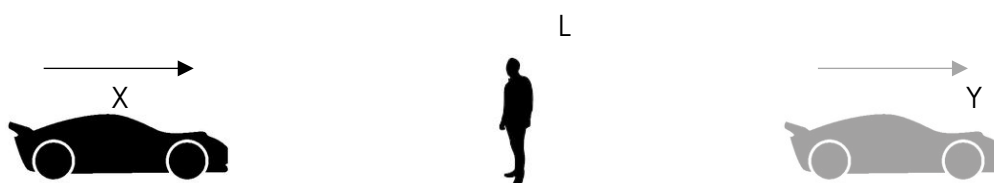
The fire truck moves from left to right past a stationary observer at a speed of $20 \text{ m}\cdot\text{s}^{-1}$.

Let the speed of sound in air be $340 \text{ m}\cdot\text{s}^{-1}$.

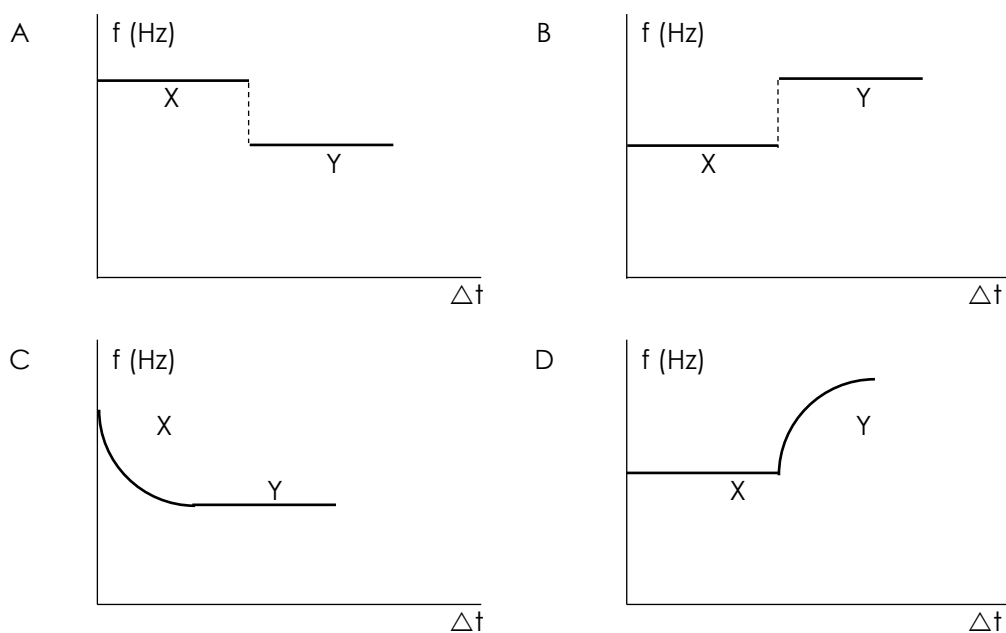
What will the difference in observable frequency (Δf_L) be, rounded to the nearest whole number, as the fire truck passes him?



- A 45 Hz
 - B 47 Hz
 - C 50 Hz
 - D 55 Hz
- 1.3 A vehicle's horn is pressed while traveling at a CONSTANT SPEED moving from left to right on a straight horizontal path as indicated in the diagram below. (2)
A stationary listener (L) observes the change in frequency.



Which one of the following graphs shows the apparent change in frequency?

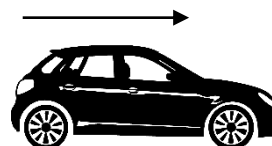


- 1.4 Which ONE of the following physical properties of waves remains constant during the observation of the Doppler effect? (2)

- A Frequency
- B Wavelength
- C Amplitude
- D Speed

- 1.5 A car drives past a factory when the end of shift siren goes off with a frequency of f_s and the driver hears a frequency of f_L . (2)

The road in front of the factory has a speed limit of $90 \text{ km}\cdot\text{h}^{-1}$.
Let the speed of sound in air be $340 \text{ m}\cdot\text{s}^{-1}$.



Which one of the following frequencies will the driver observe if he breaks the speed limit?

- A $f_L = 0,926 f_s$

B $f_L < 0,926 f_s$

C $f_L = 1,07 f_s$

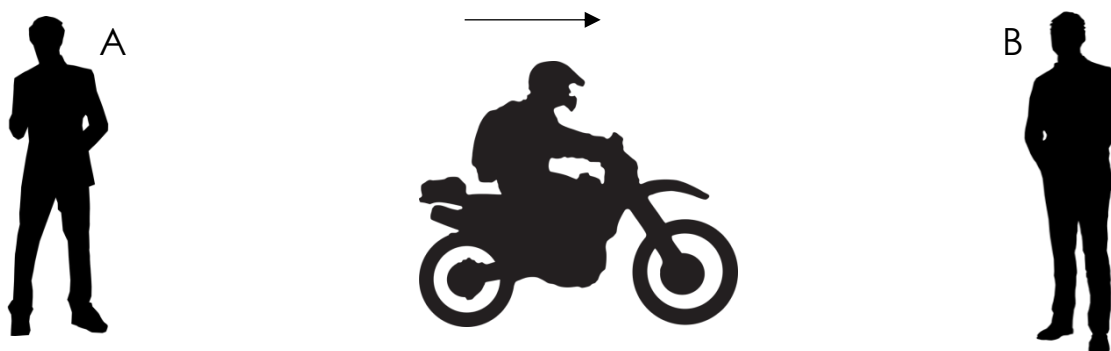
D $f_L > 1,07 f_s$

QUESTION 2

2.1 Define the term: DOPPLER EFFECT

(2)

A motorcycle drives from left to right past two stationary observers. The two observers hear a sound of 120 Hz and 130 Hz made by the motorcycle's engine. Let the speed of sound in air be 340 m.s^{-1} .



2.2 Which one of the observers (A or B) hears the frequency 130 Hz? Give a reason for your answer.

(2)

2.3 Calculate the constant velocity of the motorcycle.

(5)

2.4 Write your answer in question 6.3 in km.h^{-1}

(2)

2.5 Calculate the frequency of the motorbike's engine (f_s).

(2)

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EXEMPLAR QUESTIONS

QUESTION 1

1.1 Define the term: DOPPLER EFFECT

(2)

1.2 A wave source (**S**) moves at a constant speed AWAY from a stationary observer (**L**).

Briefly explain what **L** would observe if the type of waves generated by the source were the following:

1.2.1 Sound waves

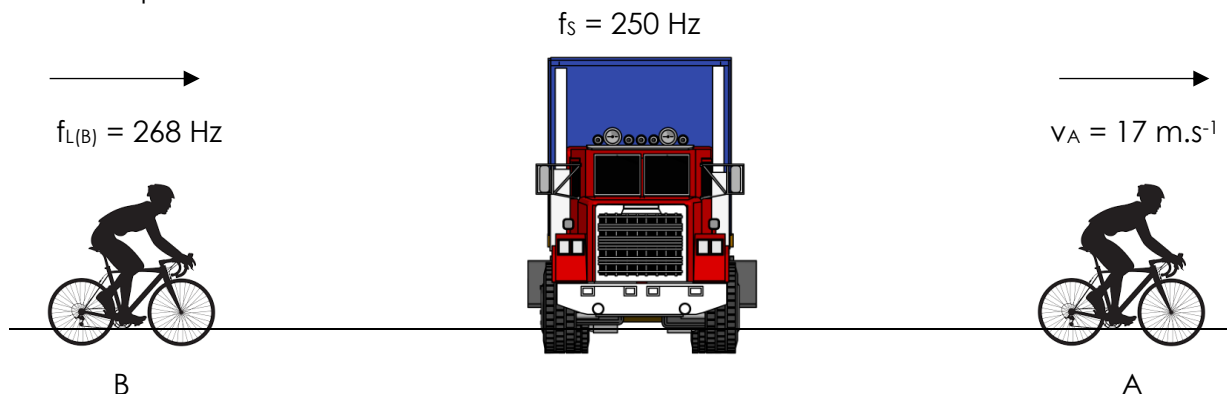
(2)

1.2.2 Light waves

(2)

Two cyclists are driving along a straight road past a stationary truck that is blowing its horn, with a frequency of 250 Hz, for the cyclists. Cyclist A moves AWAY from the truck and cyclist B moves TOWARDS the truck.

Let the speed of sound in air be 340 m.s^{-1} .

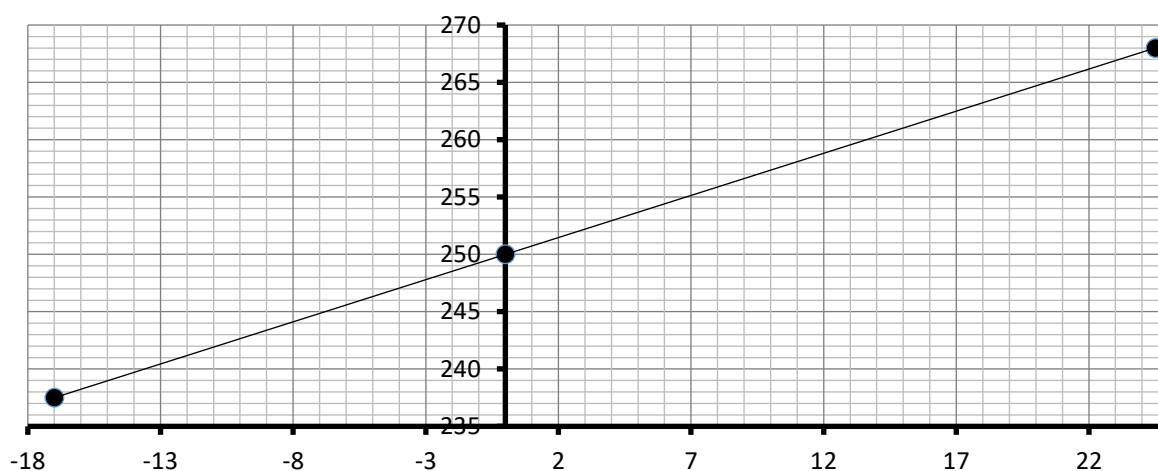


1.3 Calculate:

1.3.1 The frequency that cyclist A observes when riding at 17 m.s^{-1} . (4)

1.3.2 The speed of cyclist B if he observes a frequency of 268 Hz. (4)

The following graph illustrates all the frequencies and speeds used in this question.



1.4 Label the following axes:

1.4.1 Vertical axis (1)

1.4.2 Horizontal axis (1)

Use the data on the graph to answer the following questions without showing any calculations. Round your answers to the nearest whole number.

1.5 What will the observable frequency be if:

1.5.1 A cyclist rides TOWARDS the truck at 7 m.s^{-1} ? (2)

1.5.2 A cyclist is riding at 7 m.s^{-1} AWAY from the truck? (2)

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QUESTION 2

2.1 Define the term: DOPPLER EFFECT

(2)

During an air show, an airplane flies from left to right (A to B) past a crowd of people at a constant speed. The crowd observes two frequencies during the flyby, 351 Hz and 277 Hz.

Let the speed of sound in air be 340 m.s^{-1} .



2.2 Calculate:

2.2.1 The speed of the plane.

(6)

2.2.2 The frequency of the engine of the aircraft.

(2)

2.3 Write the speed of the plane (as calculated in question 6.2.1) in km.h^{-1}

(2)

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QUESTION 3

3.1 Define the term: DOPPLER EFFECT

(2)

A man is standing next to a race track when a Formula One race car speeds past him from point A to point B at a constant speed from left to right. The man observes two frequencies: 850 Hz and 1200 Hz.

Let the speed of sound in air be 340 m.s^{-1} .



Calculate:

3.2 The speed of the racing car.

(5)

3.3 The frequency of the engine of the racing car.

(1)

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QUESTION 4

A bird, flying at a constant speed, emits a sound with a frequency of 90 Hz.

A stationary observer hears the sound the bird makes at 88 Hz. Take the speed of sound in air as 340 m.s^{-1} .

- 4.1 Define the term: DOPPLER EFFECT (2)
- 4.2 Is the bird moving TOWARDS or AWAY from the observer? (1)
- 4.3 Calculate the magnitude of the velocity at which the bird flies. (5)

The velocities of galaxies relative to Earth can be determined by studying the redshift in the systems' spectra. The table below shows the velocities of three galaxies, **D**, **E** and **F**, relative to Earth:

GALAXY	D	E	F
SPEED ($\times 10^7$) m.s^{-1}	0,15	1,52	2,44

- 4.4 What is meant by the term: RED SHIFT? (2)
- 4.5 Name the TYPE OF SPECTRUM observed for the various galaxies. (1)
- 4.6 Which ONE of the galaxies shows the greatest redshift? (2)
Give a reason for your answer.

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QUESTION 5

- 5.1 State the DOPPLER EFFECT in words. (2)
- 5.2 Name the change that an observer will observe during the Doppler effect if the wave in question...
- 5.2.1 is a SOUND WAVE. (1)
- 5.2.2 is a LIGHT WAVE. (1)

Two racing cars (**A** and **B**) race past a finish line during the Grand Prix car race.



Car **A** races past the finish line at a speed of 284.4 km.h^{-1} while its engine emits a sound of 1200 Hz. Take the speed of sound in air as 340 m.s^{-1}

- 5.3 Write the speed of racing car **A** (284.4 km.h^{-1}) in m.s^{-1} (1)
- 5.4 Calculate the observable frequency of car **A** if it races past the finish line at an official. (4)
- 5.5 Racing car **B**'s engine emits a sound with a frequency of 1170 Hz. (4)
Calculate the speed at which racing car **B** races past the winning pole if the official hears a frequency of 1600 Hz.

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QUESTION 1

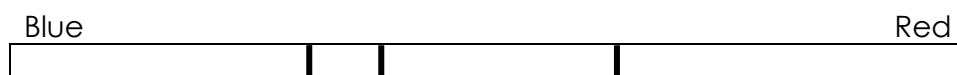
Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A–D) next to the question number (1.1–1.10) in the ANSWER BOOK.

- 1.1 A girl moves AWAY from a stationary ambulance at a speed of 20 m.s^{-1} . She observes a frequency of 960 Hz. Take the speed of sound in air as 340 m.s^{-1} . (2)

The girl now stops and the ambulance moves AWAY from her at the same constant speed of 20 m.s^{-1} .

What will the frequency that the girl now observes (rounded to the nearest whole number) be?

- A 963 Hz
B 957 Hz
C 960 Hz
D 970 Hz
- 1.2 Which ONE of the following observations shows that the source of a wave is moving TOWARDS a stationary observer? (2)
- A $f_L = f_s$
B $\lambda_L < \lambda_s$
C $f_L < f_s$
D $\lambda_L > \lambda_s$
- 1.3 The absorption spectrum of an element observed in a laboratory on Earth is shown in the diagram below: (2)



Which ONE of the following diagrams shows the absorption spectrum of the same element from a distant star moving TOWARDS the earth?

- A
- B
- C
- D

- 1.4 Four cyclists taking part in a bicycle race were riding past a factory when the siren of the factory went off and released a sound wave with a frequency of 1000 Hz. The cyclists observe different frequencies. Let the speed of sound in air be 340 m.s^{-1} . Which cyclist rides the fastest? (2)

- A 1150 Hz
- B 1100 Hz
- C 900 Hz
- D 840 Hz

- 1.5 A sound source moves away from a stationary observer. How do the perceived wavelength (λ_L), frequency (f_L) and pitch change? (2)

	Wavelength (λ_L)	Frequency (f_L)	Pitch
A	INCREASE	DECREASE	DECREASE
B	INCREASE	INCREASE	DECREASE
C	DECREASE	INCREASE	INCREASE
D	DECREASE	DECREASE	INCREASE

QUESTION 2

- 2.1 State the Doppler effect in words. (2)

A veteran car's horn has a frequency of 500 Hz. During a test, the car drives at a constant speed of 54 km.h^{-1} towards a sound recorder (L) which registers the frequency of the sound wave.

Let the speed of sound in air be 340 m.s^{-1} .



- 2.2 Calculate the wavelength of the horn's sound wave. s (3)
- 2.3 Write the speed of the car (54 km.h^{-1}) in m.s^{-1} (1)
- 2.4 Calculate the frequency of the sound wave that the sound recorder registers. (3)
- 2.5 The test is repeated and the sound recorder records a frequency 35 Hz LOWER than the original frequency of the horn. Calculate the speed at which the car is traveling. (3)

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