



education

DEPARTMENT: EDUCATION
MPUMALANGA PROVINCE

GERT SIBANDE DISTRICT



GRADE 12

PHYSICAL SCIENCES TOPIC TEST

TOPIC: DOPPLER EFFECT

APRIL 2023

Stanmorephysics.com

MARKS: 50

TIME: 1 hour

This question paper consists of 8 pages including the data sheet

INSTRUCTIONS AND INFORMATION

1. This question paper consists of FOUR questions. Answer ALL the questions in the ANSWER BOOK.
2. Start EACH question on a NEW page in the ANSWER BOOK.
3. Number the answers correctly according to the numbering system used in this question paper.
4. Leave ONE line between two sub questions, for example between QUESTION 2.1 and QUESTION 2.2.
5. You may use a non-programmable calculator.
6. You are advised to use the attached DATA SHEETS.
7. Show ALL formulae and substitutions in ALL calculations.
8. Round off your final numerical answers to a minimum of TWO decimal places.
9. Write neatly and legibly.

QUESTION 1

Four options (A – D) are given as possible answers to the following questions. Choose the answer and write only the letter (A – D) next to the question number (1.1 – 1.5).

1.1 An astronomer, viewing light from distant galaxies, observes a shift of spectral lines towards the red end of the visible spectrum. This shift provides evidence that ...

- A. the universe is expanding.
- B. the galaxies are moving closer towards Earth.
- C. earth is moving towards the distant galaxies.
- D. the temperature of Earth's atmosphere is increasing. (2)

1.2 The hooter of a truck travelling at a constant speed towards a stationary observer, produces sound waves of frequency 500 HZ. Which one of the following frequencies is most likely to be heard by the observer?
The effects of wind are being ignored.

- A. 500 HZ
- B. 450 HZ
- C. 0 HZ
- D. 570 HZ (2)

1.3. Which ONE of the following CANNOT be explained using the Doppler effect?

- A. Emission of electrons from a metal surface
- B. Determination of the speed of rotation of the sun
- C. Red spectral lines from distant stars being shifted
- D. Observed frequency of light from moving bodies being higher. (2)

1.4 A stationary observer is listening to the sound coming from a sound source. The listener hears a sound of a lower pitch when compared to that produced by the source. This indicates that.....

- A. The source is at rest.
- B. The source is moving towards the listener.
- C. The source is moving away from the listener.
- D. There is an obstacle between the source and the listener

(2)

1.5 An ambulance is travelling towards a stationary observer at constant velocity. Which one of the following describes how the observed frequency and wave length differ from that of the ambulance?

OBSERVED WAVELENGTH	OBSERVED FREQUENCY
A. Greater than	Greater than
B. Less than	Less than
C. Greater than	Less than
D. Less than	Greater than

(2)
[10]

QUESTION 2

The diagram below shows an ambulance vehicle moving on a high way.

The siren of the ambulance emits sound waves of frequency 433, 64 Hz, while the wavelength of the sound waves from the ambulance detected by the nearby STATIONARY observer is 0, 72 m. The speed of sound in air is 340 m.s^{-1}



2.1 Define the term *Doppler effect* in words. (2)

2.2 Doppler effect has various practical applications in different fields of life.

State ONE such applications in the field of transport. (1)

2.3 Calculate the frequency of the sound waves detected by the observer. (3)

2.4 Is the ambulance moving TOWARDS or AWAY from the observer?

Give a reason **basing** on the answer in QUESTION 2.3. (2)

2.5 Calculate the speed at which the ambulance is moving. (4)

2.6 If the ambulance moves at a lower constant speed, how will this affect the

frequency detected by the bird? Write down INCREASE, DECREASE or REMAIN THE SAME. (1)

[13]

QUESTION 3

In the diagram below, a car produces sound as it moves at a constant velocity TOWARDS a bird resting on a nearby tree. The frequency of sound detected as the car approaches the bird is 2 600 Hz, while the frequency of sound detected as the car moves away from the bird is 1 750 Hz.

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

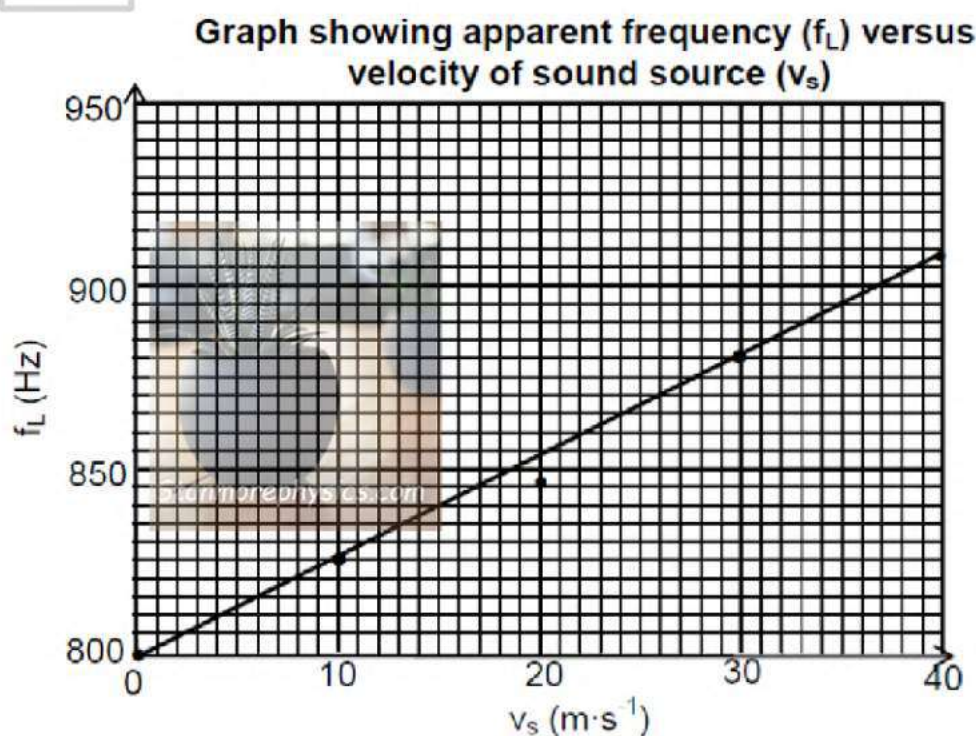


- 3.1 Name the phenomenon that is observed by the bird. (1)
- 3.2 State ONE practical application of the phenomenon in QUESTION 3.1
In the field of medicine. (1)
- 3.3 Calculate the speed at which the car is moving. (6)
- 3.4 Will the observed frequency INCREASE, DECREASE or REMAIN THE SAME if the velocity of the car increased as it:
 - 3.4.1 Moves towards the bird? (1)
 - 3.4.2 Moves away from the bird? (1)
- 3.5 Draw the diagram to show the advancing wave fronts that are produced by the car when it is moving TOWARDS the bird. Indicate the position of the bird with "O". (2)

[12]

QUESTION 4

An investigation was carried out to determine the relationship between the different velocities of a moving sound source TOWARDS a **stationary** listener and the frequencies detected by the listener for each velocity. The data obtained was plotted on the graph below. The effect of wind was ignored in this investigation.



4.1 For this investigation, write down:

4.1.1 The dependent variable. (1)

4.1.2 The investigative question. (1)

4.2 Use the information in the graph to calculate the speed of sound in air. (5)

4.3 Sketch a graph of apparent frequency (f_L) versus the velocity (V_s) of the sound source, if the source was moving AWAY from the listener. Numerical values should not be indicated on the graph. (2)

- 4.4 The evidence for the expanding of our universe is obtained by studying the distances of galaxies relative to the earth. The table below shows the wavelengths and frequencies of two galaxies **A** and **B** obtained during a study of their distances relative to the earth.

Experiment number	1	2	3	4
Wavelength of Galaxy A (m)	420	550	670	790
Frequency of galaxy B (HZ)	840	865	884	910

- 4.4.1 What is meant by the term '*red shift*' in relation to Doppler effect? (2)
- 4.4.2 Which galaxy **A** or **B** exhibit the red shift?
Give a reason for the answer. (2)
- 4.4.3 State the type of the spectrum observed for the galaxy **A**. (1)
- 4.4.4 Will the wave length of light observed from the galaxy **B** be
INCREASING, DECREASING or REMAINING THE SAME? (1)

[15]

TOTAL: 50

TABLE OF FORMULAE

WAVES, SOUND AND LIGHT

$v = f\lambda$	$T = \frac{1}{f}$	$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$
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MARKING GUIDELINES

MARKS: 50

These marking guidelines consist of 5 pages

QUESTION 1

- 1.1 A ✓✓ (2)
- 1.2 D ✓✓ (2)
- 1.3 A ✓✓ (2)
- 1.4 C ✓✓ (2)
- 1.5 D ✓✓ (2)

[10]

QUESTION 2

2.1 The change in the observed 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. ✓✓ **[2 or 0 mk]** (2)

2.2 Used in speed traps to calculate the speed of the moving vehicle. ✓

Used by blind persons to detect the moving vehicles/ obstacles

Used by flying bats/animals at night to detect the obstacles. **[Any one]** (1)

2.3 $V = f \times \lambda$ ✓

$340 = f \times 0,72$ ✓

$f = 472,22\text{HZ}$ ✓ (3)

2.4 POSITIVE MARKING FROM Q 2.3

Towards. ✓

The frequency of sound waves detected by the observer is greater than the frequency of sound waves emitted by the ambulance/ observed frequency

is greater than 433,64HZ ✓ (2)

2.5 POSITIVE MARKING FROM Q 2.3



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

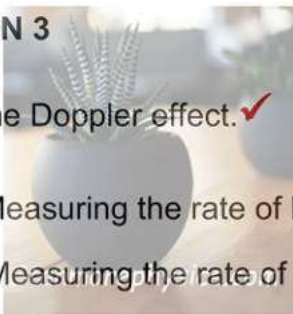
$$472,22 = \frac{340}{(340 - v_s)} \times 433,64$$

$$v_s = 27,78 \text{ m} \cdot \text{s}^{-1} \quad (4)$$

2.6 DECREASES (1)

[13]

QUESTION 3



3.1 The Doppler effect. (1)

3.2 Measuring the rate of blood flow. (1)

- Measuring the rate of heart beat of a foetus (1)
- OR/** Ultrasound (scanning) [Any one]

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

$$2600 = \frac{340}{(340 - v_s)} f_s$$

3.3

$$340f_s = 2600 (340 - v_s) \text{ ----- eq 1}$$

$$1750 = \frac{340}{(340 + v_s)} f_s$$

$$340f_s = 1750 (340 + v_s) \text{ ----- eq 2}$$

$$\text{eq 1} = \text{eq 2}$$

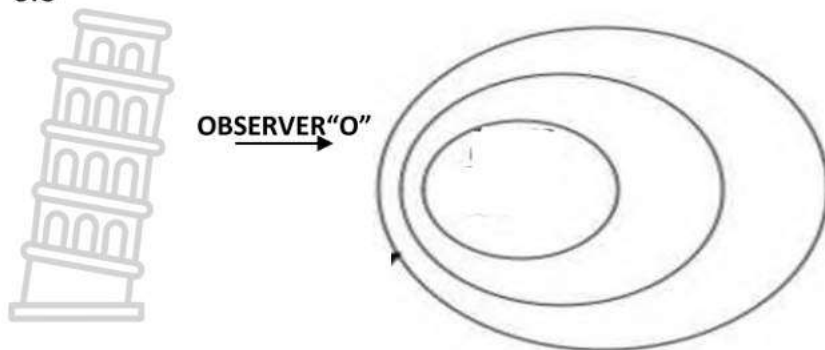
$$2600(340 - v_s) = 1750(340 + v_s)$$

$$v_s = 66,44 \text{ m} \cdot \text{s}^{-1} \quad (6)$$

3.4.1 INCREASE (1)

3.4.2 DECREASE (1)

3.5



Marking criteria Q 3.5	
Correct shape	✓
Indicating of "O" for observer	✓

(2)

[12]

QUESTION 4

4.1.1 Frequency (of sound detected by the listener/observer) ✓ (1)

4.1.2 What is the relationship between the (different) velocities of a moving sound source and the frequencies detected by the listener?(1)

4.2 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ OR $f_L = \frac{v}{v - v_s} f_s$

$$825 \checkmark = \frac{v}{v - 10} (800) \checkmark$$

$$(1,03125)(v - 10) \checkmark = v$$

$$v = 330 \text{ m.s}^{-1} \checkmark$$

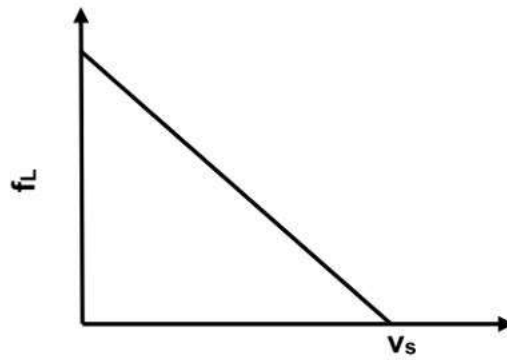
(5)

NOTE 1: Other answers of v can be obtained by using alternative points from the graph, as shown in the table below.

Vs (m.s ⁻¹)	Frequencies(V(m.s ⁻¹)
Vs = 20	850	310
Vs = 20	845	375,56
Vs = 30	880	330
Vs = 40	910	331

NOTE 2: No penalization if zero substitution in the formula is omitted.

4.3



CRITERIA FOR MARKING THE GRAPH

Straight line with a negative gradient
(frequency decreases linearly)

✓✓
(2 or 0 mark)

4.4.1 Is the shift in the spectra of distant stars/galaxies towards the longer wave length of the red end of the spectrum. ✓✓ [2 or 0 mark] (2)

4.4.2 A ✓ Increasing wave lengths ✓ (2)

4.4.3 Absorption (spectrum) ✓ (1)

4.4.4 DECREASING ✓ (1)

[15]

TOTAL: 50