SA-STUDENT

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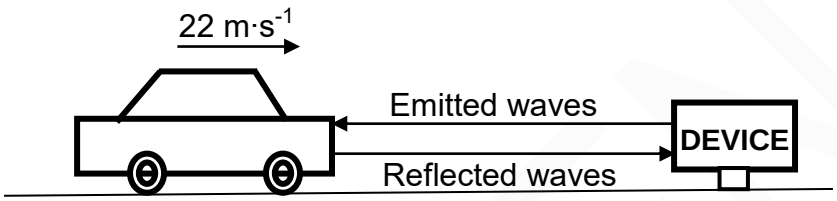
QUESTION 6 (Start on a new page.)

6.1 A car moves at a constant velocity of 22 $m \cdot s^{-1}$ on a straight horizontal road TOWARDS a stationary device, which can both emit and detect sound waves.

The device emits sound waves with a frequency of 24 000 Hz. These sound waves are reflected off the car and the reflected sound waves are then detected by the device, as shown in the diagram below.



6.1.1 State the *Doppler effect* in words. (2)

6.1.2 If the speed of sound in air is 340 $m \cdot s^{-1}$, calculate the frequency of the reflected sound waves detected by the device. (6)

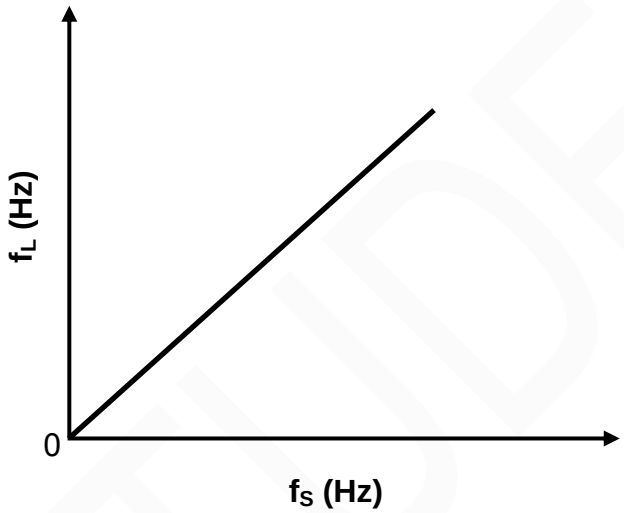
6.2 The spectral lines observed for a distant star show that the star is moving away from Earth. Explain, by referring to frequency, how one can deduce that the star is moving away from Earth. (2)
[10]

QUESTION 6 (Start on a new page.)

A learner investigates the relationship between the observed frequency and the frequency of sound waves emitted by a stationary source.

The learner moves towards the source at a constant velocity and records the observed frequency (f_L) for a given source frequency (f_S) . This process is repeated for different frequencies of the source, with the learner moving at the same constant velocity each time.

The graph below shows how the observed frequency changes as the frequency of sound waves emitted by the source changes.



6.1 Name the phenomenon illustrated by the graph. (1)

6.2 Name ONE application in the medical field of the phenomenon in QUESTION 6.1. (1)

6.3 Write down the type of proportionality that exists between $\mathbf{f_L}$ and $\mathbf{f_S}$, as illustrated by the graph. (1)

6.4 The gradient of the graph obtained is found to be 1,06.

If the speed of sound in air is 340 $m \cdot s^{-1}$, calculate the magnitude of the velocity at which the learner approaches the source. (5)

The investigation is now repeated with the learner moving at a HIGHER constant velocity towards the sound source.

6.5 Copy the graph above in your ANSWER BOOK and label it as **A**. On the same set of axes, sketch the graph that will be obtained when the learner is moving at the HIGHER velocity. Label this graph as **B**. (2)

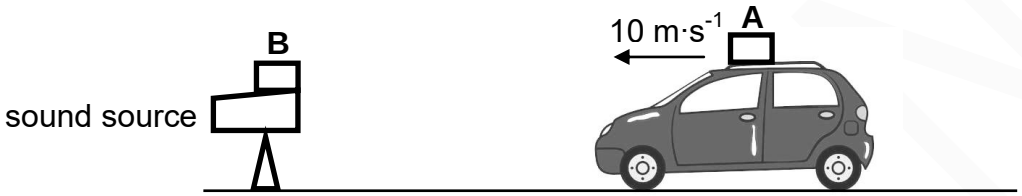
[10]

QUESTION 6 (Start on a new page.)

A car moves at a constant speed of 10 $m \cdot s^{-1}$ TOWARDS a stationary sound source. The sound source emits sound waves of frequency 880 Hz.

A sound detector **A** is attached to the car and another sound detector **B** is attached to the sound source. Detector **B** detects the sound waves reflected from the car.

The speed of sound in air is 340 $m \cdot s^{-1}$.

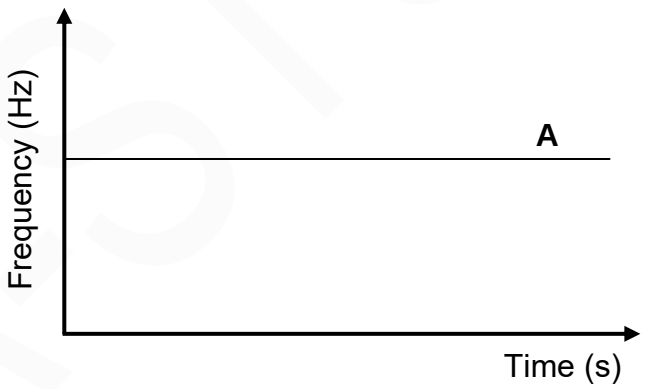


6.1 State the Doppler effect in words. (2)

6.2 Calculate the wavelength of the sound waves emitted by the source. (3)

6.3 Calculate the frequency of the sound waves detected by detector **A**. (4)

The sketch graph below shows the frequency recorded by detector **A**.



6.4 Redraw the graph above for detector **A** in your ANSWER BOOK. On the same set of axes, sketch the graph of the frequency recorded by detector **B**. Label this graph as B. (2)

[11]

QUESTION 6 (Start on a new page.)

The siren of a stationary ambulance emits sound waves at a constant frequency of 680 Hz. A man is standing with a detector that records the wavelength of the sound emitted by the siren, as shown in the diagram below.

The speed of sound in air is 340 $m \cdot s^{-1}$.

6.1 Calculate the wavelength of the detected sound. (3)

The ambulance now moves at a constant speed along the road TOWARDS the man. The detector now records the wavelength of the sound, which differs from the previous reading by 0,05 m.

6.2 State the Doppler effect. (2)

6.3 How would EACH of the following have changed when the ambulance approached the detector compared to when the ambulance was stationary?

Choose from INCREASED, DECREASED or NO CHANGE.

6.3.1 Distance between the wave fronts (1)

6.3.2 Frequency of the detected waves (1)

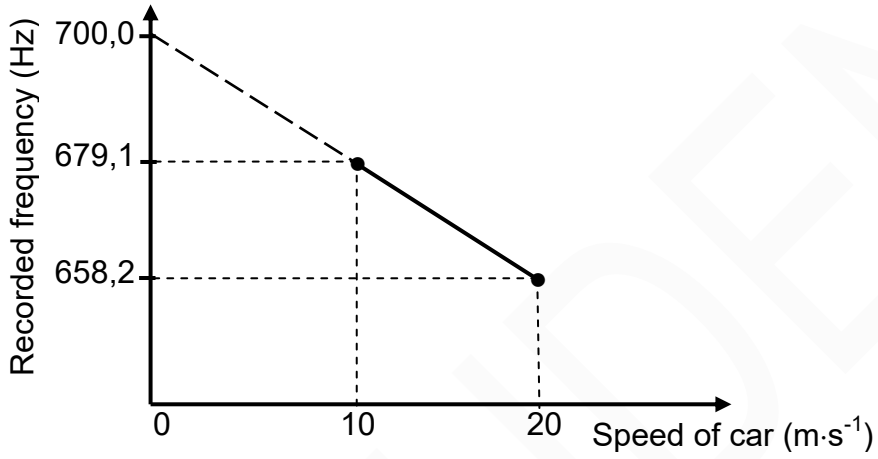
6.4 Calculate the speed of the ambulance. (5)
[12]

QUESTION 6 (Start on a new page.)

A learner in a car, moving at a constant speed of 10 $m \cdot s^{-1}$ along a straight horizontal road, records the frequency of sound emitted by a distant stationary source.

The learner then repeats the recording of the frequency of the sound when the car travels at a new constant speed of 20 $m \cdot s^{-1}$.

The graph below, not drawn to scale, is obtained from the results.



6.1 State the *Doppler effect*. (2)

6.2 Use the graph to answer the following questions.

6.2.1 Write down the frequency of the sound emitted by the stationary source.

Give a reason for the answer. (2)

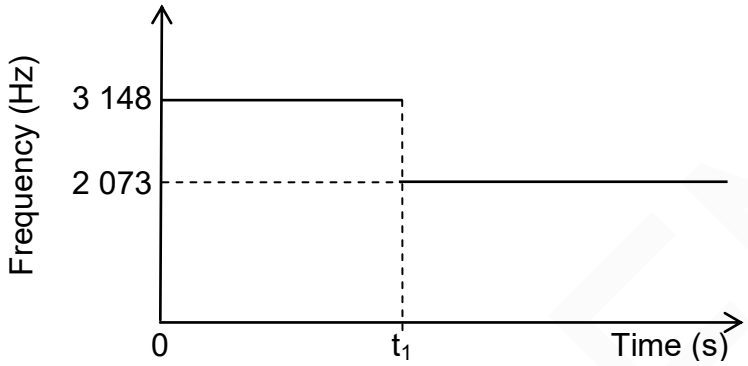
6.2.2 In which direction is the car moving relative to the source? Choose from TOWARDS or AWAY.

Give a reason for the answer. (2)

6.2.3 Calculate the speed of sound in air. (5)
[11]

QUESTION 6 (Start on a new page.)

The siren of a train, moving at a constant speed along a straight horizontal track, emits sound with a constant frequency. A detector, placed next to the track, records the frequency of the sound waves. The results obtained are as shown in the graph below.



6.1 State the Doppler effect in words. (2)

6.2 Does the detector record the frequency of 3 148 Hz when the train moves TOWARDS the detector or AWAY from the detector? (1)

6.3 Calculate the speed of the train. Take the speed of sound in air as 340 $m \cdot s^{-1}$. (6)

6.4 The detector started recording the frequency of the moving train's siren when the train was 350 m away.

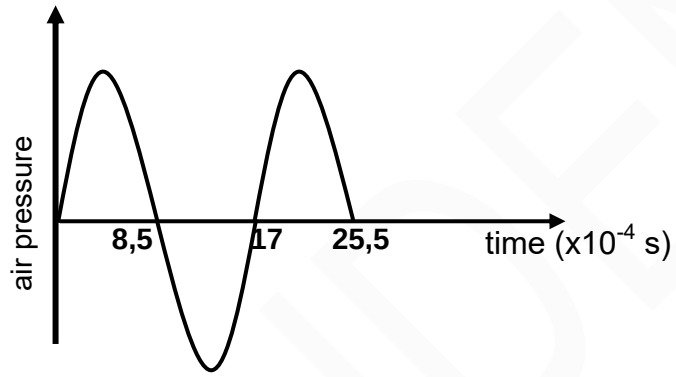
Calculate time t_1 indicated on the graph above. (2)
[11]

QUESTION 6 (Start on a new page.)

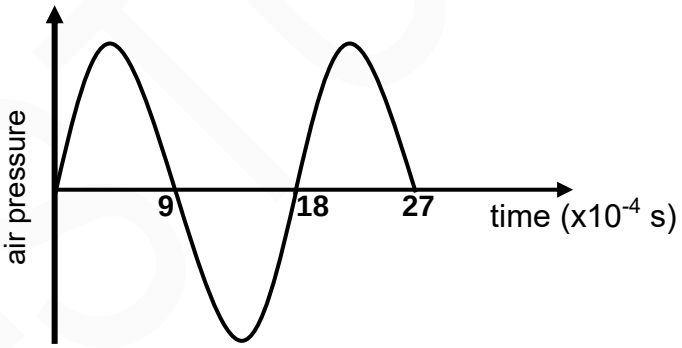
The siren of a police car, which is travelling at a constant speed along a straight horizontal road, emits sound waves of constant frequency. Detector **P** is placed inside the police car and detector **Q** is placed next to the road at a certain distance away from the car. The two detectors record the changes in the air pressure readings caused by the sound waves emitted by the siren as a function of time.

The graphs below were obtained from the recorded results.

GRAPH A: AIR PRESSURE VS TIME RECORDED BY DETECTOR P IN THE CAR



GRAPH B: AIR PRESSURE VS TIME RECORDED BY DETECTOR Q NEXT TO THE ROAD



6.1 Different patterns are shown above for the same sound wave emitted by the siren. What phenomenon is illustrated by the two detectors showing the different patterns? (1)

The police car is moving AWAY from detector **Q**.

6.2 Use the graphs and give a reason why it can be confirmed that the police car is moving away from detector **Q**. (1)

6.3 Calculate the frequency of the sound waves recorded by detector **P**. (3)

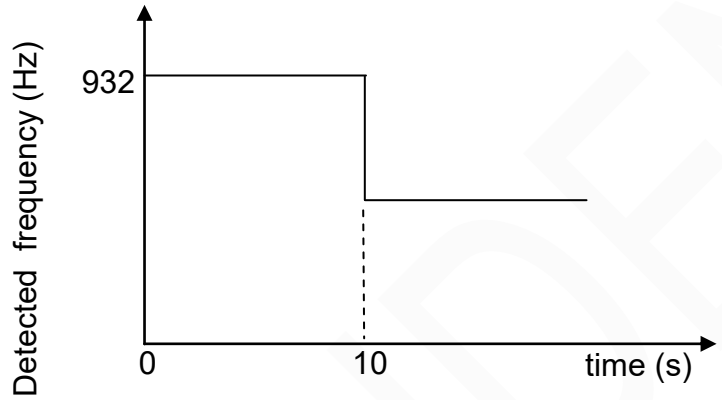
6.4 Use the information in the graphs to calculate the speed of the police car. Take the speed of sound in air as 340 $m \cdot s^{-1}$. (6)
[11]

QUESTION 6 (Start on a new page.)

6.1 A patrol car is moving at a constant speed towards a stationary observer. The driver switches on the siren of the car when it is 300 m away from the observer.

The observer records the detected frequency of the sound waves of the siren as the patrol car *approaches*, *passes* and *moves away* from him.

The information obtained is shown in the graph below.



6.1.1 Calculate the speed of the patrol car. (2)

6.1.2 State the Doppler effect. (2)

6.1.3 The detected frequency suddenly changes at t = 10 s. Give a reason for this change. (2)

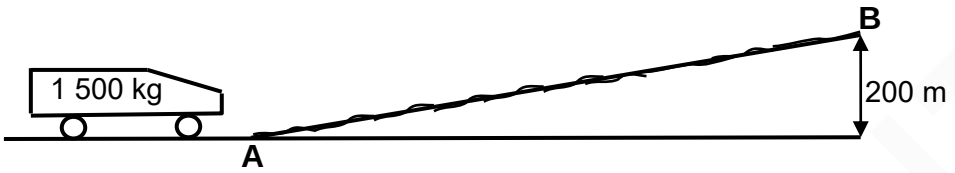
Take the speed of sound in air as 340 $m \cdot s^{-1}$.

6.1.4 Calculate the frequency of the sound emitted by the siren. (4)

6.2 State TWO applications of the Doppler effect. (2)
[12]

QUESTION 5 (Start on a new page.)

The diagram below, not drawn to scale, shows a vehicle with a mass of 1 500 kg starting from rest at point **A** at the bottom of a rough incline. Point **B** is 200 m vertically above the horizontal.



The total work done by force **F** that moves the vehicle from point **A** to point **B** in 90 s is $4{,}80 \times 10^6$ J.

5.1 Define the term *non-conservative force*. (2)

5.2 Is force **F** a conservative force? Choose from: YES or NO. (1)

5.3 Calculate the average power generated by force **F**. (3)

The speed of the vehicle when it reaches point **B** is 25 $m \cdot s^{-1}$.

5.4 State the work-energy theorem in words. (2)

5.5 Use **energy principles** to calculate the total work done on the vehicle by the frictional forces. (5)
[13]

QUESTION 6 (Start on a new page.)

The alarm of a vehicle parked next to a straight horizontal road goes off, emitting sound with a wavelength of 0,34 m. A patrol car is moving at a constant speed on the same road. The driver of the patrol car hears a sound with a frequency of 50 Hz **lower than** the sound emitted by the alarm. Take the speed of sound in air as 340 $m \cdot s^{-1}$.

6.1 State the Doppler effect in words. (2)

6.2 Is the patrol car driving TOWARDS or AWAY FROM the parked vehicle? Give a reason for the answer. (2)

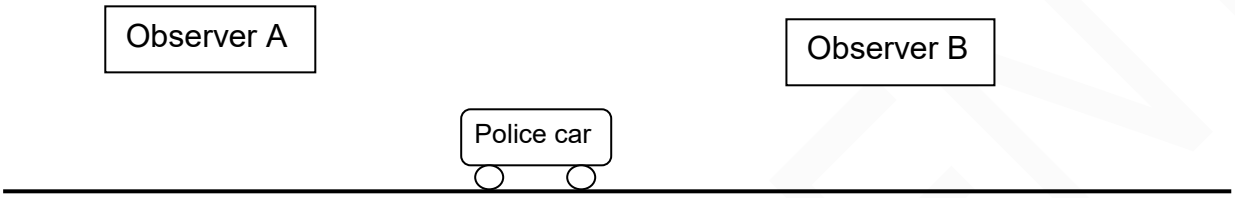
6.3 Calculate the frequency of the sound emitted by the alarm. (3)

6.4 The patrol car moves a distance of *x* metres in 10 seconds. Calculate the distance *x*. (6)
[13]

QUESTION 6 (Start on a new page.)

A police car is moving at a constant speed on a straight horizontal road. The siren of the car emits sound of constant frequency.
EACH of two observers, **A** and **B**, standing some distance apart on the same side of the road, records the frequency of the detected sound.

Observer **A** records a frequency of 690 Hz and observer **B** records a frequency of 610 Hz.



6.1 State the Doppler Effect in words. (2)

6.2 In which direction is the car moving? Choose from TOWARDS A or AWAY FROM A. Give a reason for the answer. (2)

6.3 Determine the speed of the police car. Take the speed of sound in air as 340 $m.s^{-1}$. (6)

6.4 Name ONE application of the Doppler effect. (1)
[11]

QUESTION 6 (Start on a new page.)

A sound source, moving at a constant speed of 240 $m \cdot s^{-1}$ towards a detector, emits sound at a constant frequency. The detector records a frequency of 5 100 Hz.

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

6.1 State the Doppler effect. (2)

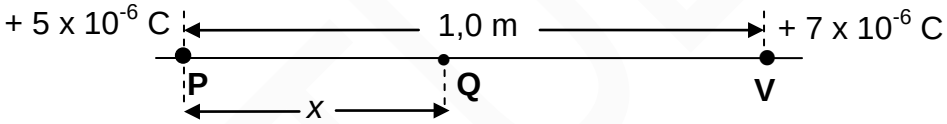
6.2 Calculate the wavelength of the sound emitted by the source. (7)

Some of the sound waves are reflected from the detector towards the approaching source.

6.3 Will the frequency of the reflected sound wave detected by the sound source be EQUAL TO, GREATER THAN or SMALLER THAN 5 100 Hz? (1)
[10]

QUESTION 7 (Start on a new page.)

A particle, **P**, with a charge of + 5 x 10^{-6} C, is located 1,0 m along a straight line from particle **V**, with a charge of +7 x 10^{-6} C. Refer to the diagram below.



A third charged particle, **Q**, at a point *x* metres away from **P**, as shown above, experiences a net electrostatic force of zero newton.

7.1 How do the electrostatic forces experienced by **Q** due to the charges on **P** and **V** respectively, compare with each other? (2)

7.2 State Coulomb's law in words. (2)

7.3 Calculate the distance *x*. (5)
[9]

QUESTION 8 (Start on a new page.)

A small metal sphere **Y** carries a charge of + 6 x 10^{-6} C.

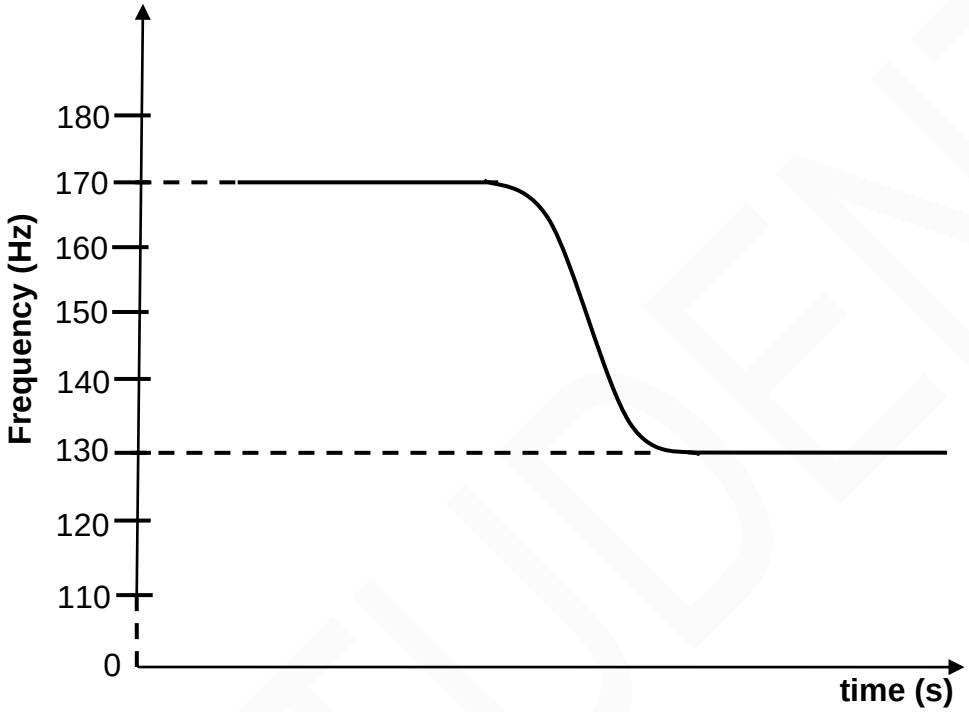
8.1 Draw the electric field pattern associated with sphere **Y**. (2)

8.2 If 8 x 10^{13} electrons are now transferred to sphere **Y**, calculate the electric field at a point 0,5 m from the sphere. (7)
[9]

QUESTION 6 (Start on a new page.)

A police car moving at a constant velocity with its siren on, passes a stationary listener.

The graph below shows the changes in the frequency of the sound of the siren detected by the listener.



6.1 State the Doppler Effect in words. (2)

6.2 Write down the frequency of the sound detected by the listener as the police car:

6.2.1 Approaches the listener (1)

6.2.2 Moves away from the listener (1)

6.3 Calculate the speed of the police car. Take the speed of sound in air to be 340 $m \cdot s^{-1}$. (6)
[10]

QUESTION 6 (Start on a new page.)

6.1 A sound source is moving at constant velocity past a stationary observer. The frequency detected as the source approaches the observer is 2 600 Hz. The frequency detected as the source moves away from the observer is 1 750 Hz.

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

6.1.1 Name the phenomenon that describes the apparent change in frequency detected by the observer. (1)

6.1.2 State ONE practical application of the phenomenon in QUESTION 6.1.1 in the field of medicine. (1)

6.1.3 Calculate the speed of the moving source. (6)

6.1.4 Will the observed frequency INCREASE, DECREASE or REMAIN THE SAME if the velocity of the source increased as it:

(a) Moves towards the observer (1)

(b) Moves away from the observer (1)

6.2 Spectral lines of star **X** at an observatory are observed to be *red shifted.*

6.2.1 Explain the term *red shifted* in terms of wavelength. (2)

6.2.2 Will the frequency of the light observed from the star INCREASE, DECREASE or REMAIN THE SAME? (1)
[13]

QUESTION 6 (Start on a new page.)

6.1 An ambulance is moving towards a stationary listener at a constant speed of 30 $m \cdot s^{-1}$. The siren of the ambulance emits sound waves having a wavelength of 0,28 m. Take the speed of sound in air as 340 $m \cdot s^{-1}$.

6.1.1 State the Doppler effect in words. (2)

6.1.2 Calculate the frequency of the sound waves emitted by the siren as heard by the ambulance driver. (3)

6.1.3 Calculate the frequency of the sound waves emitted by the siren as heard by the listener. (5)

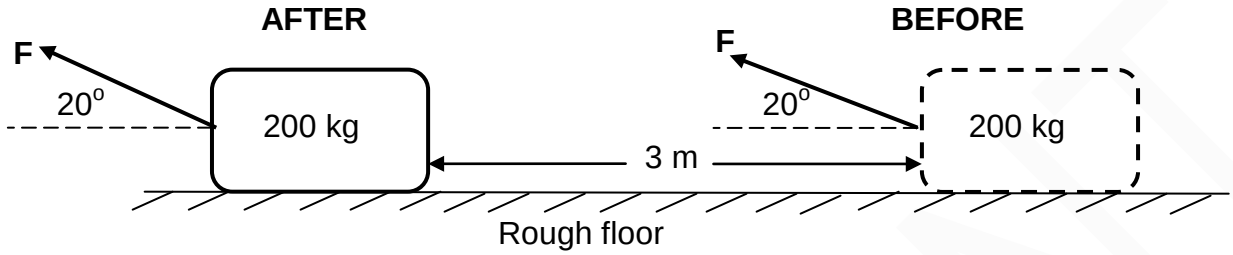
6.1.4 How would the answer to QUESTION 6.1.3 change if the speed of the ambulance were LESS THAN 30 $m \cdot s^{-1}$? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

6.2 An observation of the spectrum of a distant star shows that it is moving away from the Earth.

Explain, in terms of the frequencies of the spectral lines, how it is possible to conclude that the star is moving away from the Earth. (2)
[13]

QUESTION 5 (Start on a new page.)

A constant force **F**, applied at an angle of 20^o above the horizontal, pulls a 200 kg block, over a distance of 3 m, on a rough, horizontal floor as shown in the diagram below.



The coefficient of kinetic friction, μ_k, between the floor surface and the block is 0,2.

5.1 Give a reason why the coefficient of kinetic friction has no units. (1)

5.2 State the work-energy theorem in words. (2)

5.3 Draw a free-body diagram indicating ALL the forces acting on the block while it is being pulled. (4)

5.4 Show that the work done by the kinetic frictional force (W_{fk}) on the block can be written as W_{fk} = (-1 176 + 0,205 **F**) J. (4)

5.5 Calculate the magnitude of the force **F** that has to be applied so that the net work done by all forces on the block is zero. (4)
[15]

QUESTION 6 (Start on a new page.)

Reflection of sound waves enables bats to hunt for moths. The sound wave produced by a bat has a frequency of 222 kHz and a wavelength of 1,5 x 10^{-3} m.

6.1 Calculate the speed of this sound wave through the air. (3)

6.2 A stationary bat sends out a sound signal and receives the same signal reflected from a moving moth at a frequency of 230,3 kHz.

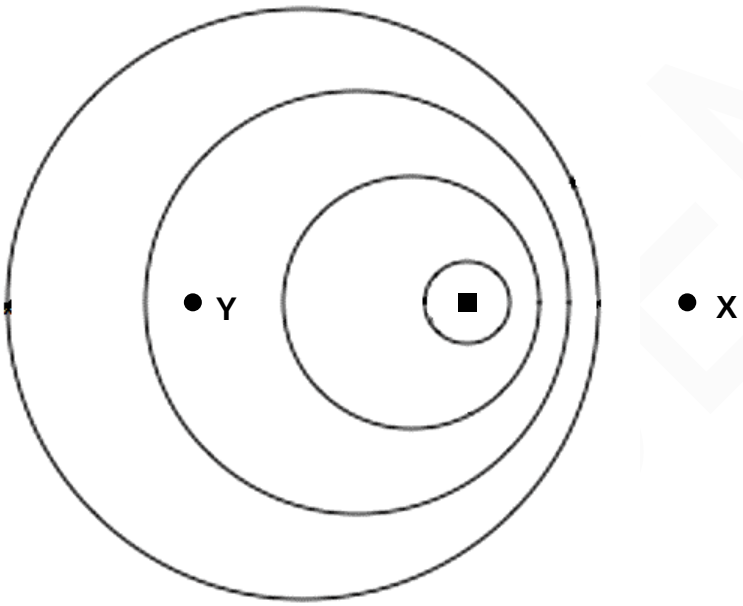
6.2.1 Is the moth moving TOWARDS or AWAY FROM the bat? (1)

6.2.2 Calculate the magnitude of the velocity of the moth, assuming that the velocity is constant. (6)
[10]

QUESTION 6 (Start on a new page.)

An ambulance is travelling towards a hospital at a constant velocity of 30 $m \cdot s^{-1}$. The siren of the ambulance produces sound of frequency 400 Hz. Take the speed of sound in air as 340 $m \cdot s^{-1}$.

The diagram below shows the wave fronts of the sound produced from the siren as a result of this motion.



6.1 At which side of the diagram, **X** or **Y**, is the hospital situated? (1)

6.2 Explain the answer to QUESTION 6.1. (3)

6.3 Calculate the frequency of the sound of the siren heard by a person standing at the hospital. (5)

6.4 A nurse is sitting next to the driver in the passenger seat of the ambulance as it approaches the hospital. Calculate the wavelength of the sound heard by the nurse. (3)
[12]

QUESTION 6 (Start on a new page.)

6.1 The data below was obtained during an investigation into the relationship between the different velocities of a moving sound source and the frequencies detected by a stationary listener for **each** velocity. The effect of wind was ignored in this investigation.

Experiment number	1	2	3	4
Velocity of the sound source ($m \cdot s^{-1}$)	0	10	20	30
Frequency (Hz) of the sound detected by the stationary listener	900	874	850	827

6.1.1 Write down the dependent variable for this investigation. (1)

6.1.2 State the Doppler effect in words. (2)

6.1.3 Was the sound source moving TOWARDS or AWAY FROM the listener? Give a reason for the answer. (2)

6.1.4 Use the information in the table to calculate the speed of sound during the investigation. (5)

6.2 The spectral lines of a distant star are shifted towards the longer wavelengths of light. Is the star moving TOWARDS or AWAY FROM the Earth? (1)
[11]

QUESTION 6 (Start on a new page.)

The Doppler effect is applicable to both sound and light waves. It also has very important applications in our everyday lives.

6.1 A hooter on a stationary train emits sound with a frequency of 520 Hz, as detected by a person standing on the platform. Assume that the speed of sound is 340 $m \cdot s^{-1}$ in still air.

Calculate the:

6.1.1 Wavelength of the sound detected by the person (2)

6.1.2 Wavelength of the sound detected by the person when the train moves towards him/her at a constant speed of 15 $m \cdot s^{-1}$ with the hooter still emitting sound (6)

6.2 Explain why the wavelength calculated in QUESTION 6.1.1 differs from that obtained in QUESTION 6.1.2. (2)

6.3 Use your knowledge of the Doppler effect to explain *red shifts.* (2)
[12]

QUESTION 6 (Start on a new page.)

6.1 The siren of a stationary ambulance emits a note of frequency 1 130 Hz. When the ambulance moves at a constant speed, a stationary observer detects a frequency that is 70 Hz **higher** than that emitted by the siren.

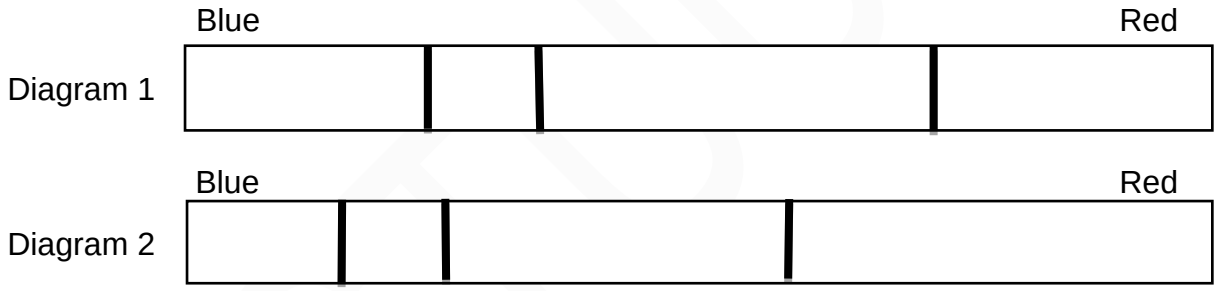
6.1.1 State the Doppler effect in words. (2)

6.1.2 Is the ambulance moving *towards* or *away from* the observer? Give a reason for the answer. (2)

6.1.3 Calculate the speed at which the ambulance is travelling. Take the speed of sound in air as 343 $m \cdot s^{-1}$. (5)

6.2 A study of spectral lines obtained from various stars can provide valuable information about the movement of the stars.

The two diagrams below represent different spectral lines of an element. Diagram **1** represents the spectrum of the element in a laboratory on Earth. Diagram **2** represents the spectrum of the same element from a distant star.



Is the star moving *towards* or *away from* the Earth? Explain the answer by referring to the shifts in the spectral lines in the two diagrams above. (2)
[11]

QUESTION 6 (Start on a new page.)

A sound source on a car produces sound waves of frequency 850 Hz. A stationary observer measures the emitted frequency using a detector which can measure a maximum frequency of 800 Hz. He finds that the detector only registers a reading whilst the car is moving. (Ignore the effects of wind.)

6.1 Must the car move TOWARDS or AWAY from the observer for the detector to register a reading?

Explain the answer by referring to frequency or wavelength. (3)

6.2 Calculate the minimum speed at which the car must move for the detector to register the maximum reading. Take the speed of sound in air as 340 $m \cdot s^{-1}$. (5)

6.3 State ONE use of the Doppler effect in medicine. (1)
[9]

QUESTION 6 (Start on a new page.)

The siren of a stationary police car emits sound waves of wavelength 0,55 m.

With its siren on, the police car now approaches a stationary listener at constant velocity on a straight road. Assume that the speed of sound in air is 345 $m \cdot s^{-1}$.

6.1 Will the wavelength of the sound waves observed by the listener be GREATER THAN, SMALLER THAN or EQUAL TO 0,55 m? (1)

6.2 Name the phenomenon observed in QUESTION 6.1. (1)

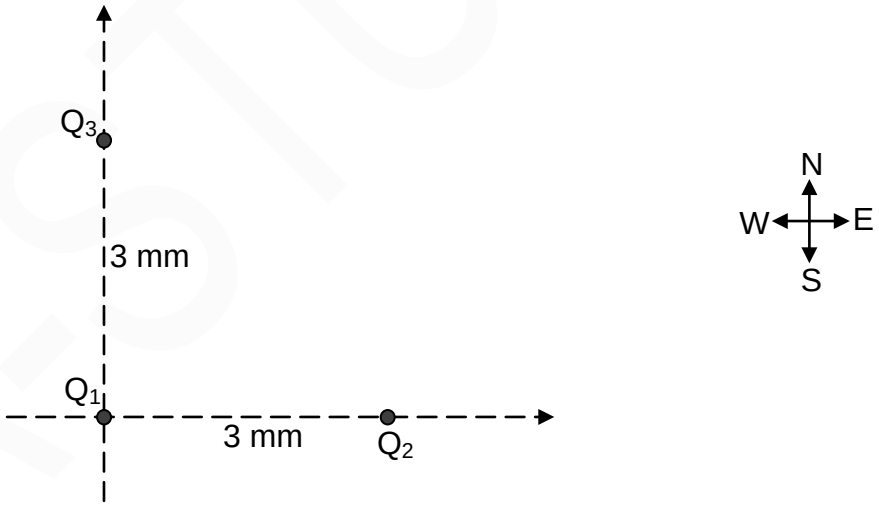
6.3 Calculate the frequency of the sound waves observed by the listener if the car approaches him at a speed of 120 $km \cdot h^{-1}$. (7)

6.4 How will the answer in QUESTION 6.3 change if the police car moves away from the listener at 120 $km \cdot h^{-1}$? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

[10]

QUESTION 7 (Start on a new page.)

Three small, identical metal spheres, Q_1, Q_2 and Q_3, are placed in a vacuum. Each sphere carries a charge of – 4 µC. The spheres are arranged such that Q_2 and Q_3 are each 3 mm from Q_1 as shown in the diagram below.



7.1 State Coulomb's law in words. (2)

7.2 Draw a force diagram showing the electrostatic forces exerted on Q_1 by Q_2 and Q_3. (2)

7.3 Calculate the net force exerted on Q_1 by Q_2 and Q_3. (8)

[12]

QUESTION 6 (Start on a new page.)

An ambulance approaches a stationary observer at a constant speed of 10,6 $m \cdot s^{-1}$, while its siren produces sound at a constant frequency of 954,3 Hz. The stationary observer measures the frequency of the sound as 985 Hz.

6.1 Name the medical instrument that makes use of the Doppler effect. (1)

6.2 Calculate the velocity of sound. (5)

6.3 How would the wavelength of the sound wave produced by the siren of the ambulance change if the frequency of the wave were higher than 954,3 Hz? Write down only INCREASES, DECREASES or STAYS THE SAME. (1)

6.4 Give a reason for the answer to QUESTION 6.3. (2)
[9]

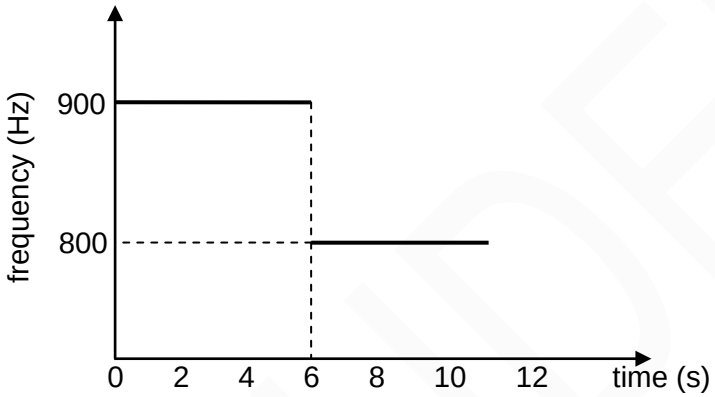
QUESTION 6 (Start on a new page.)

The siren of a stationary ambulance emits sound waves at a frequency of 850 Hz.

An observer, travelling in a car at a constant speed in a straight line, begins measuring the frequency of the sound waves emitted by the siren when he is at a distance *x* from the ambulance.

The observer continues measuring the frequency as he approaches, passes and moves away from the ambulance.

The results obtained are shown in the graph below.



6.1 The observed frequency suddenly changes at t = 6 s. Give a reason for this sudden change in observed frequency. (1)

6.2 Calculate the:

6.2.1 Speed of the car
(Take the speed of sound in air as 340 $m \cdot s^{-1}$.) (5)

6.2.2 Distance *x* between the car and the ambulance when the observer BEGINS measuring the frequency (3)
[9]

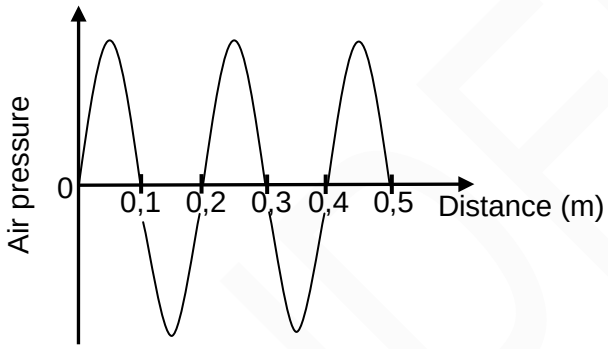
QUESTION 6 (Start on a new page.)

A bird flies directly towards a stationary birdwatcher at constant velocity. The bird constantly emits sound waves at a frequency of 1 650 Hz. The birdwatcher hears a change in pitch as the bird comes closer to him.

6.1 Write down the property of sound that is related to pitch. (1)

6.2 Give a reason why the birdwatcher observes a change in pitch as the bird approaches him. (1)

The air pressure versus distance graph below represents the waves detected by the birdwatcher as the bird comes closer to him. The speed of sound in air is 340 $m \cdot s^{-1}$.



6.3 From the graph, write down the wavelength of the detected waves. (1)

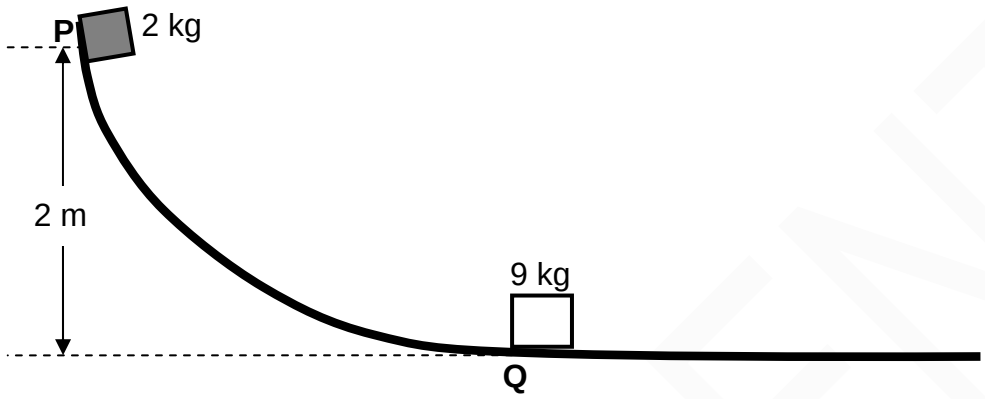
6.4 Calculate the:

6.4.1 Frequency of the waves detected by the birdwatcher (3)

6.4.2 Magnitude of the velocity at which the bird flies (5)
[11]

QUESTION 5 (Start on a new page.)

A wooden block of mass 2 kg is released from rest at point **P** and slides down a curved slope from a vertical height of 2 m, as shown in the diagram below. It reaches its lowest position, point **Q**, at a speed of 5 m·s^{-1}.



5.1 Define the term *gravitational potential energy*. (2)

5.2 Use the work-energy theorem to calculate the work done by the average frictional force on the wooden block when it reaches point **Q**. (6)

5.3 Is mechanical energy conserved while the wooden block slides down the slope? Give a reason for the answer. (2)

5.4 The wooden block collides with a stationary crate of mass 9 kg at point **Q**. After the collision, the crate moves to the right at 1 m·s^{-1}.

5.4.1 Calculate the magnitude of the velocity of the wooden block immediately after the collision. (4)

5.4.2 The total kinetic energy of the system before the collision is 25 J. Use a calculation to show that the collision between the wooden block and the crate is inelastic. (5)

[19]

QUESTION 6 (Start on a new page.)

An ambulance approaches an accident scene at constant velocity. The siren of the ambulance emits sound waves at a frequency of 980 Hz. A detector at the scene measures the frequency of the emitted sound waves as 1 050 Hz.

6.1 Calculate the speed at which the ambulance approaches the accident scene. Use the speed of sound in air as 340 m·s^{-1}. (4)

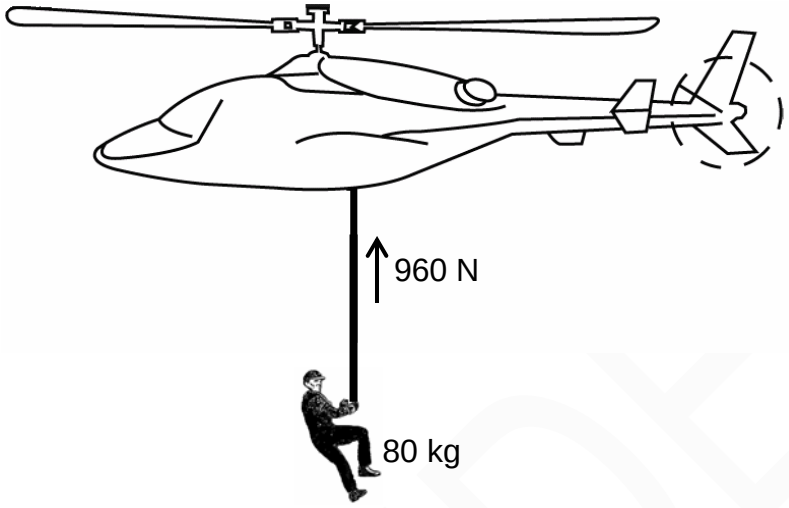
6.2 Explain why the measured frequency is higher than the frequency of the source. (2)

6.3 The principle of the Doppler effect is applied in the Doppler flow meter. State ONE positive impact of the use of the Doppler flow meter on humans. (2)

[8]

QUESTION 5 (Start on a new page.)

A rescue helicopter is stationary (hovers) above a soldier. The soldier of mass 80 kg is lifted vertically upwards through a height of 20 m by a cable at a CONSTANT SPEED of 4 $m \cdot s^{-1}$. The tension in the cable is 960 N. Assume that there is no sideways motion during the lift. Air friction is not to be ignored.



5.1 State the work-energy theorem in words. (2)

5.2 Draw a labelled free-body diagram showing ALL the forces acting on the soldier while being lifted upwards. (3)

5.3 Write down the name of a non-contact force that acts on the soldier during the upward lift. (1)

5.4 Use the WORK-ENERGY THEOREM to calculate the work done on the soldier by friction after moving through the height of 20 m. (5)
[11]

QUESTION 6 (Start on a new page.)

A train approaches a station at a constant speed of 20 $m \cdot s^{-1}$ with its whistle blowing at a frequency of 458 Hz. An observer, standing on the platform, hears a change in pitch as the train approaches him, passes him and moves away from him.

6.1 Name the phenomenon that explains the change in pitch heard by the observer. (1)

6.2 Calculate the frequency of the sound that the observer hears while the train is approaching him. Use the speed of sound in air as 340 $m \cdot s^{-1}$. (4)

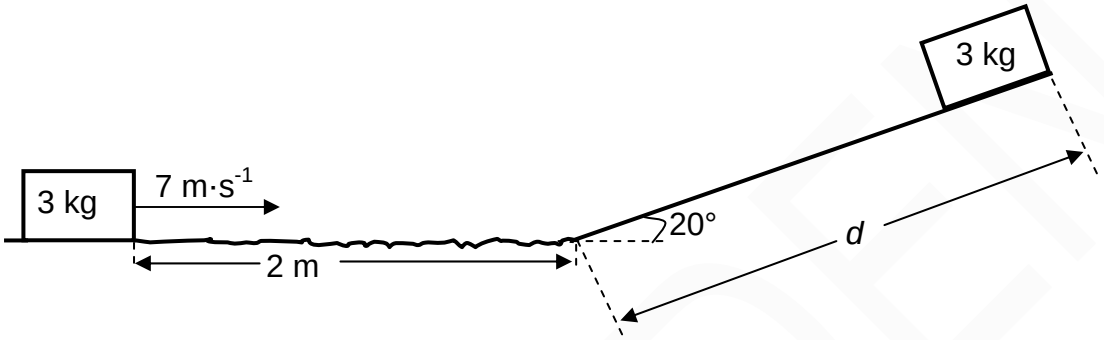
6.3 How will the observed frequency change as the train passes and moves away from the observer? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

6.4 How will the frequency observed by the train driver compare to that of the sound waves emitted by the whistle? Write down only GREATER THAN, EQUAL TO or LESS THAN. Give a reason for the answer. (2)
[8]

QUESTION 5 (Start on a new page.)

A 3 kg block slides at a constant velocity of 7 m·s^{-1} along a horizontal surface. It then strikes a rough surface, causing it to experience a constant frictional force of 30 N. The block slides 2 m under the influence of this frictional force before it moves up a frictionless ramp inclined at an angle of 20° to the horizontal, as shown in the diagram below.

The block moves a distance *d* up the ramp, before it comes to rest.



5.1 Show by calculation that the speed of the block at the bottom of the ramp is 3 m·s^{-1}. (5)

5.2 Draw a free-body diagram to show all the forces acting on the block in a direction parallel to the incline, whilst the block is sliding up the ramp. (2)

5.3 Calculate the distance, *d*, the block slides up the ramp. (5)
[12]

QUESTION 6 (Start on a new page.)

A man of mass 87 kg on roller skates, moving horizontally at constant speed in a straight line, sees a boy of mass 22 kg standing directly in his path. The man grabs the boy and they both continue in a straight line at 2,4 m·s^{-1}.

6.1 Calculate the man's speed just before he grabs the boy. Ignore the effects of friction. (4)

6.2 Is the collision elastic? Use a calculation to support your answer. (6)

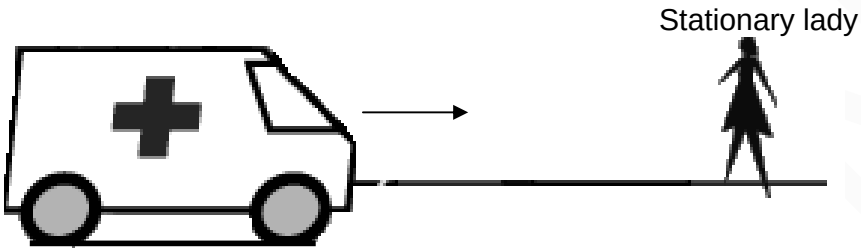
6.3 After grabbing the boy, they both continue at a velocity of 2,4 m·s^{-1} along a straight line until they arrive at a loose gravel surface near the end of the path. They now move at constant acceleration in a straight line through the loose gravel for 2 m before coming to rest.

Calculate the magnitude of the force exerted by the gravel surface on the man and the boy. (5)
[15]

QUESTION 8

An ambulance travelling down a road at constant speed emits sound waves from its siren. A lady stands on the side of the road with a detector which registers sound waves at a frequency of 445 Hz as the ambulance approaches her.

After passing her, and moving away at the same constant speed, sound waves of frequency 380 Hz are registered.



Assume that the speed of sound in air is 343 $m \cdot s^{-1}$.

8.1 Name the phenomenon that describes the change in the frequency observed by the lady. (1)

8.2 Calculate:

8.2.1 The speed at which the ambulance is moving (7)

8.2.2 The frequency at which the siren emits the sound waves (3)
[11]

QUESTION 9

A helium-neon laser emits red light that passes through a single slit. A diffraction pattern is observed on a screen some distance away from the slit.

9.1 Define the term *diffraction.* (2)

9.2 If the wavelength of red light is 644,4 nm and the slit width is 3 437 nm, calculate the angle at which the third minimum occurs. (3)

9.3 Briefly describe the diffraction pattern that will be observed on the screen. (2)

The single slit is replaced with a double slit.

9.4 Name ONE similarity and ONE difference in the pattern observed when the single slit is replaced with a double slit. (2)

9.5 Will this pattern be observed if the laser is replaced with a light bulb? Give a reason for your answer. (2)
[11]