7. Waves

7.3 Doppler effect for sound waves

Paper 1

Question Paper

1 The siren of a moving police car emits a sound wave with a frequency of 440 Hz. A stationary observer hears sound of frequency 494 Hz. The speed of sound in the air is 340 $m\,s^{-1}$.

What could be the speed and the direction of movement of the car?

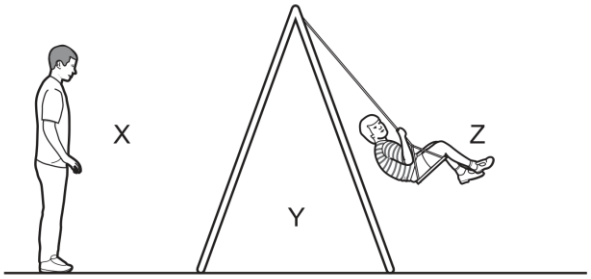
A 37 $m\,s^{-1}$ directly away from the observer

B 37 $m\,s^{-1}$ directly towards the observer

C 42 $m\,s^{-1}$ directly away from the observer

D 42 $m\,s^{-1}$ directly towards the observer

2 A man stands stationary in front of a swing. A child sits and swings.



The child blows a whistle that emits a sound at a constant frequency.

The man observes the frequency of the sound when the swing is at positions X, Y and Z.

When will the man hear the highest frequency?

A when the swing is at X

B when the swing is at Y and moving away from the man

C when the swing is at Y and moving towards the man

D when the swing is at Z

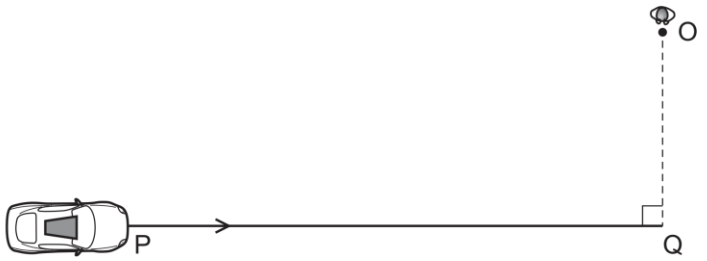
3 A source of sound emits waves of a constant frequency. The source moves at a constant speed in a straight line relative to a stationary observer.

Which velocity of the source gives the smallest observed frequency?

	speed / m s^{-1}	direction
A	5	away from observer
B	10	away from observer
C	15	towards observer
D	20	towards observer

4 A car travels at a constant speed along a straight line PQ.

A loudspeaker attached to the car emits sound of constant frequency *f*. A stationary observer is at point O.



What does the observer hear as the car moves from P towards Q?

A a frequency less than *f* that decreases as the car moves from P towards Q

B a frequency less than *f* that increases as the car moves from P towards Q

C a frequency more than *f* that decreases as the car moves from P towards Q

D a frequency more than *f* that increases as the car moves from P towards Q

5 A source X emits a sound wave of constant frequency *f*.

The wave is subsequently received at a stationary detector Y.

The frequency of the wave that is detected by Y is less than *f*.

What could be the reason for this?

A Between X and Y, the wave undergoes diffraction.

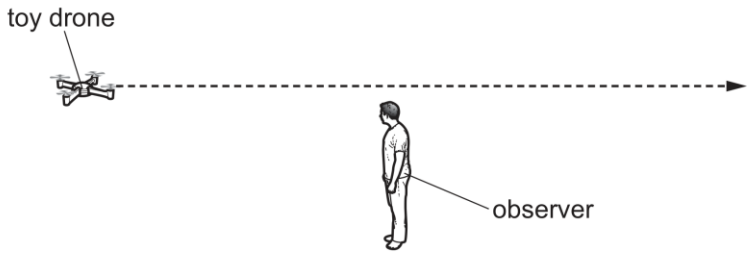
B Between X and Y, the wave undergoes reflection.

C X is moving away from Y.

D X is moving towards Y.

6 A toy drone emits a sound of constant frequency 800 Hz. The speed of the sound in the air is $330\,m\,s^{-1}$.

The drone moves along a straight path directly towards an observer and then continues in a straight line directly away from the observer. The speed of the drone is constant.



What is the velocity of the drone when the frequency of the sound heard by the observer is 850 Hz?

	magnitude of velocity / $m\,s^{-1}$	direction of velocity
A	19	away from the observer
B	21	away from the observer
C	19	towards the observer
D	21	towards the observer

7 A source of sound waves is moving at a constant speed directly towards a stationary observer.

The sound waves have a speed of $340\,m\,s^{-1}$ and a frequency of 480 Hz. The observer hears sound waves of frequency 650 Hz.

What is the speed of the source?

A $89\,m\,s^{-1}$ **B** $120\,m\,s^{-1}$ **C** $250\,m\,s^{-1}$ **D** $340\,m\,s^{-1}$

8 A car is travelling at a constant velocity directly towards a man standing in the middle of the road.

The driver sounds the car's horn as a warning. The horn emits a sound wave of constant frequency.

The frequency of the sound heard by the man is different from the frequency of the sound emitted by the horn.

Which statement is correct?

A The frequency of the sound emitted by the horn is greater than the frequency of the sound heard by the man.

B The frequency of the sound heard by the man depends on the distance between the car and the man.

C The sound waves continually accelerate as they move from the horn to the man.

D The wavelength of the sound heard by the man is less than the wavelength of the sound emitted by the horn.

9 A source emits a sound wave of a single frequency. The Doppler effect causes a different frequency of sound to be heard by a stationary observer.

What is a requirement for the Doppler effect to occur?

A a source that is moving as it produces the sound wave

B a source that produces a polarised sound wave

C a source that produces a sound wave of changing amplitude

D a source that produces a sound wave of changing frequency

10 A jet aircraft travels at a speed of $0.80v$, where v is the speed of sound. The aircraft directly approaches a stationary observer. The frequency of sound emitted by the aircraft is 100 Hz.

Which frequency does the observer hear?

A 56 Hz **B** 180 Hz **C** 400 Hz **D** 500 Hz

11 A miniature loudspeaker, initially at rest, falls vertically from a window in a high building. When the speaker has fallen a distance of 10.0 m, it emits a very short pulse of sound of constant frequency 256 Hz in all directions. The pulse of sound, travelling at a speed of 330 m s^{-1}, is heard by a person leaning out of the window.

Air resistance is negligible.

What is the frequency of the pulse of sound heard by the person?

A 246 Hz **B** 249 Hz **C** 267 Hz **D** 313 Hz

12 An ambulance has a siren that emits sound of a constant frequency. The ambulance is moving directly towards a stationary observer.

The ambulance decelerates as it is approaching the observer and then accelerates after it has passed the observer.

How does the frequency of the sound heard by the observer change as the ambulance is approaching and as it is moving away from the observer?

	approaching observer	moving away from observer
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

13 A person stands at the side of a straight railway track. A train moves towards the person and emits sound from its whistle. The person hears a sound of frequency 1690 Hz as the train approaches him.

The person then hears sound of frequency 1500 Hz as the train moves away from him. The speed of sound in air is 340 $m\,s^{-1}$.

What is the speed of the train?

A 20 $m\,s^{-1}$ **B** 38 $m\,s^{-1}$ **C** 41 $m\,s^{-1}$ **D** 43 $m\,s^{-1}$

14 With which waves can the Doppler effect be observed?

A all waves including sound and light

B light waves only

C sound and light waves only

D sound waves only

15 A train travels in a straight line at a constant speed of 30 $m\,s^{-1}$. The train's horn continuously emits sound of frequency 2400 Hz.

A stationary observer stands next to the train track. The train approaches the stationary observer, passes him and then moves away.

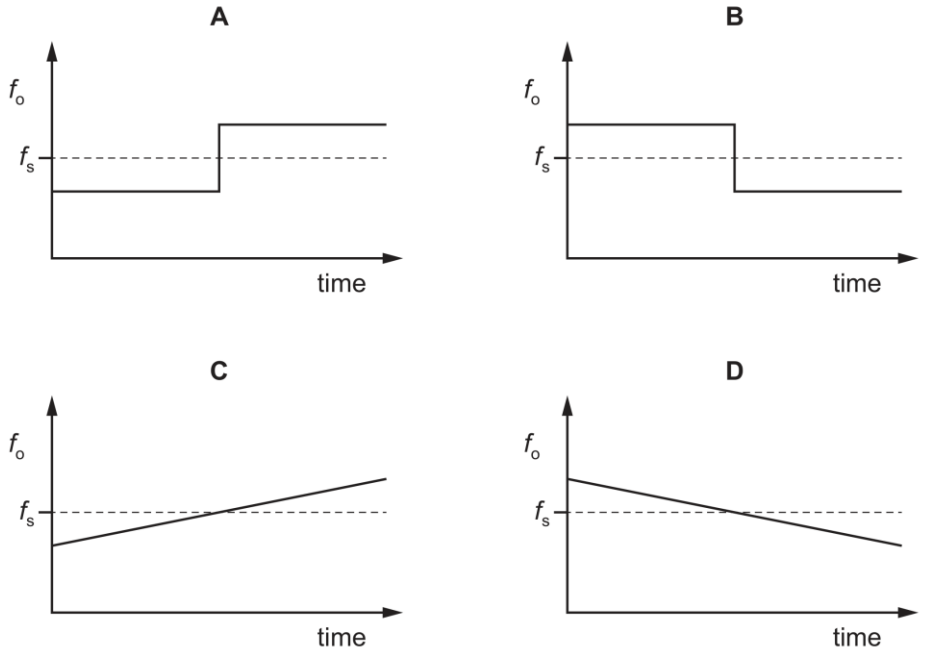
The speed of sound is 340 $m\,s^{-1}$.

What is the maximum difference in the frequencies of the sound heard by the stationary observer?

A 190 Hz **B** 230 Hz **C** 430 Hz **D** 460 Hz

16 A source emitting sound of a single frequency f_s travels at constant speed directly towards an observer. The source then passes the observer and continues to move directly away from the observer. The velocity of the source remains constant.

Which graph represents the variation with time of the frequency f_o of the sound heard by the observer?



17 A stationary person measures the speed and wavelength of the sound from a horn on a stationary vehicle. The person then repeats the measurements when the vehicle is approaching at a constant speed.

Which row describes the measured wavelength and the measured speed of the sound wave from the moving vehicle when compared with the sound wave from the stationary vehicle?

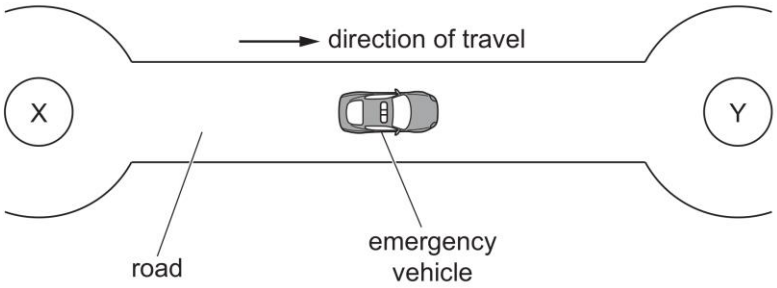
	wavelength of the sound wave	speed of the sound wave
A	longer	greater
B	shorter	greater
C	longer	same
D	shorter	same

18 A source of sound of frequency 1000 Hz directly approaches a stationary observer. The observer measures the frequency of the received sound to be 1500 Hz. The speed of sound in still air is $330\,m\,s^{-1}$.

What is the speed of the source of sound?

A $110\,m\,s^{-1}$ **B** $165\,m\,s^{-1}$ **C** $220\,m\,s^{-1}$ **D** $330\,m\,s^{-1}$

19 An emergency vehicle sounds its siren as it accelerates along a straight road between two points X and Y, as shown in the diagram.



The frequency of the sound emitted by the siren is 750 Hz.

A person stands at X and another person stands at Y.

What describes the sounds heard by the people at X and at Y as the vehicle accelerates?

	sound heard by person at X	sound heard by person at Y
A	higher than 750 Hz, increasing in frequency	lower than 750 Hz, decreasing in frequency
B	higher than 750 Hz, decreasing in frequency	lower than 750 Hz, increasing in frequency
C	lower than 750 Hz, decreasing in frequency	higher than 750 Hz, increasing in frequency
D	lower than 750 Hz, increasing in frequency	higher than 750 Hz, decreasing in frequency

20 A stationary insect on the surface of water creates circular waves with its legs, as shown in diagram 1. The insect begins to travel to the right as shown in diagram 2.

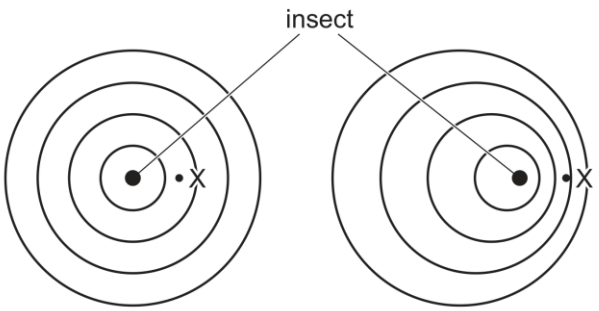


diagram 1 diagram 2

Which row describes the change to the waves at X caused by the movement of the insect?

	frequency	wave speed
A	decreases	increases
B	decreases	stays the same
C	increases	increases
D	increases	stays the same

21 A toy motorboat moving with constant velocity v vibrates up and down on the surface of a pond. This causes the boat to act as a source of circular water waves of frequency 2.0 Hz. The speed of the waves is 1.5 m s^{-1}.

A man, standing at the edge of the pond, observes that the waves from the boat approach him with a frequency of 3.0 Hz.

The formula for Doppler effect calculations with sound waves may also be used for water waves.

What is a possible value of v?

	speed / m s^{-1}	direction
A	0.50	directly away from the man
B	0.50	directly towards the man
C	0.75	directly away from the man
D	0.75	directly towards the man

22 In one of the first experiments to demonstrate the Doppler effect, a train was filled with trumpeters all playing a note of frequency 440 Hz. The difference in observed frequency of the note as the train directly approached a stationary observer was 22 Hz. The speed of sound was 340 $m\,s^{-1}$.

At which speed was the train moving?

A 15.4 $m\,s^{-1}$ **B** 16.2 $m\,s^{-1}$ **C** 17.0 $m\,s^{-1}$ **D** 17.9 $m\,s^{-1}$

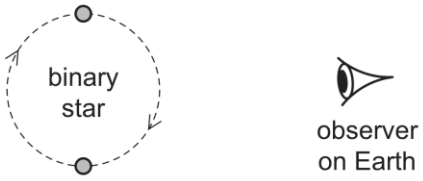
23 A loudspeaker emitting a constant frequency of 2000 Hz is swung in a horizontal circle with a speed of 15.0 $m\,s^{-1}$.

A stationary observer is level with the loudspeaker and situated a long distance from the loudspeaker. The observer hears a sound of varying frequency. The maximum frequency heard is 2097 Hz.

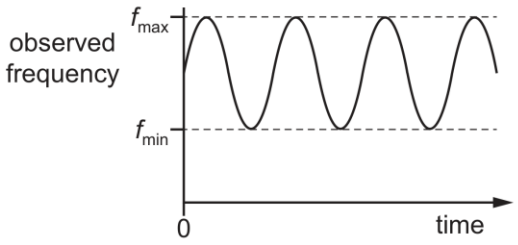
What is the speed of the sound in the air?

A 294 $m\,s^{-1}$ **B** 309 $m\,s^{-1}$ **C** 324 $m\,s^{-1}$ **D** 330 $m\,s^{-1}$

24 A binary star consists of two stars rotating around a common centre. Light from one of the stars is observed on the Earth.



The observed frequency of the light varies between a minimum frequency f_{min} and a maximum frequency f_{max}, as shown.



The rate of rotation of the binary star increases.

What is the change to f_{max} and the change to f_{min}?

	f_{max}	f_{min}
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

25 An astronomer observes the light from a star that is moving away from the Earth.

For the observed light, what has been increased due to the star's motion?

A amplitude

B frequency

C speed

D wavelength

26 A police car has a two-tone siren emitting sound of frequencies of 700 Hz and 1000 Hz.

The police car is travelling at a speed of 40.0 m s^{-1} towards a stationary observer. The speed of sound in the air is 340 m s^{-1}.

What is the difference between the two frequencies of the sound that is heard by the observer?

A 268 Hz **B** 300 Hz **C** 335 Hz **D** 340 Hz