Past-paper walk-through

Doppler effect for sound waves ▪ 7.3

eXercise

Questions in this set

- 9702/11 N25 Q27 ▪ 1 mark
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Question 27

9702/11 N25 ▪ Q27 ▪ 1 mark

A dolphin is swimming at a speed of $16.0\ \text{m s}^{-1}$ directly towards a stationary underwater microphone.

The dolphin emits a sound of frequency 122 kHz. The speed of sound in water is $1480\ \text{m s}^{-1}$.

What is the frequency of sound detected by the microphone? **[1]**

A 1300 Hz

B 1330 Hz

C 121 kHz

D 123 kHz

Solution 27

A 1300 Hz

B 1330 Hz

C 121 kHz

D 123 kHz ✓

Why

- The dolphin is approaching, so $f_o = f_s v/(v - v_s) = 122 \times 1480/(1480 - 16.0)$.
- $= 122 \times 1480/1464 = 123$ kHz.
- The shift is small because 16 m s^{-1} is tiny next to the speed of sound in water.

Question 27

9702/12 N25 ▪ Q27 ▪ 1 mark

A moving source emits sound of frequency 1200 Hz.
A stationary observer hears sound of frequency 960 Hz. The speed of the sound is 340 m s^{-1}.
What could be the velocity of the source? **[1]**

A 68 m s^{-1} directly away from the observer

B 68 m s^{-1} directly towards the observer

C 85 m s^{-1} directly away from the observer

D 85 m s^{-1} directly towards the observer

Solution 27

A 68 m s^{-1} directly away from the observer

B 68 m s^{-1} directly towards the observer

C 85 m s^{-1} directly away from the observer ✓

D 85 m s^{-1} directly towards the observer

Why

- The pitch heard is lower than the pitch emitted, so the source is receding.
- $960 = 1200 \times 340/(340 + v_s)$, so $340 + v_s = 425$.
- $v_s = 85$ m s^{-1} directly away from the observer.

Question 27

9702/14 N25 ▪ Q27 ▪ 1 mark

An aircraft flies at a velocity v_s directly away from a stationary observer.
The aircraft emits a sound of constant frequency.
The speed of sound in air is v.
The frequency of the sound heard by the observer on the ground is 500 Hz.
The speed of the aircraft is increased so that it flies away from the observer at a greater velocity.
The observer now hears a sound of frequency 250 Hz.
Which expression gives the new velocity of the aircraft? **[1]**

A $2(v + v_s)$

B $\frac{v+v_s}{2}$

Question 27

C $2v_s + v$

D $2v_s - v$

Solution 27

A $2(v + v_s)$

B $\frac{v+v_s}{2}$

C $2v_s + v$ ✓

D $2v_s - v$

Why

- Write both cases: $500 = f_s v/(v + v_s)$ and $250 = f_s v/(v + v_s')$.
- Dividing one by the other gives $(v + v_s')/(v + v_s) = 2$.
- So $v_s' = v + 2v_s$ – the aircraft must more than double its speed.

Question 24

9702/11 J25 ▪ Q24 ▪ 1 mark

An aircraft produces a sound at a frequency of 30.0 Hz.
The speed of sound in air is 330 m s^{-1}.
The aircraft is directly in front of the stationary observer and travels in a straight line towards or away from the observer.
The observer hears the sound from the aircraft at a frequency of 20.0 Hz.
What is the speed and direction of the aircraft? **[1]**

A 110 m s^{-1} away from observer

B 110 m s^{-1} towards observer

C 165 m s^{-1} away from observer

D 165 m s^{-1} towards observer

Question 24

	speed / m s^{-1}	direction
A	110	away from observer
B	110	towards observer
C	165	away from observer
D	165	towards observer

Solution 24

A $110\ \text{m s}^{-1}$ away from observer

B $110\ \text{m s}^{-1}$ towards observer

C $165\ \text{m s}^{-1}$ away from observer ✓

D $165\ \text{m s}^{-1}$ towards observer

Why

- The pitch heard is lower than the pitch emitted, so the aircraft must be moving away.
- $f_o = f_s v/(v + v_s)$, so $20.0 = 30.0 \times 330/(330 + v_s)$.
- $330 + v_s = 495$, giving $v_s = 165\ \text{m s}^{-1}$ away from the observer.

Question 26

9702/12 J25 ▪ Q26 ▪ 1 mark

A buzzer emitting sound of frequency 846 Hz is attached to a string and rotated in a horizontal circle. The linear speed of the buzzer is 25.0 m s^{-1}.
The speed of sound is 340 m s^{-1}.
What is the maximum frequency heard by the observer? **[1]**

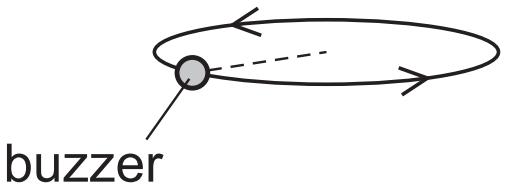
A 783 Hz

B 788 Hz

C 908 Hz

D 913 Hz

Question 26



Solution 26

A 783 Hz

B 788 Hz

C 908 Hz

D 913 Hz ✓

Why

- The pitch is highest when the buzzer is moving directly towards the observer, at its full 25.0 m s^{-1}.
- $f_o = f_s v/(v - v_s) = 846 \times 340/(340 - 25.0)$.
- $= 846 \times 340/315 = 913$ Hz.

Question 22

9702/14 J25 ▪ Q22 ▪ 1 mark

22 A vehicle is moving with a speed of $30.0\,\text{m}\,\text{s}^{-1}$ directly towards a stationary observer. The horn of the vehicle emits sound of frequency 440 Hz. The speed of sound in air is $340\,\text{m}\,\text{s}^{-1}$.

What is the frequency of the sound heard by the observer?

A 401 Hz **B** 404 Hz **C** 479 Hz **D** 483 Hz

Solution 22

Answer: **D**

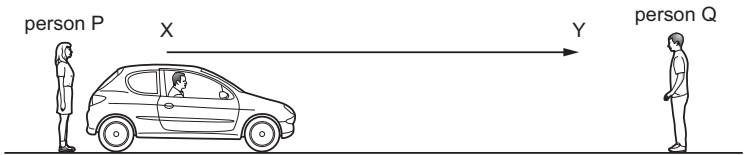
Why

- Moving towards the observer bunches the wavefronts up, so the pitch rises.
- $f_o = f_s v/(v - v_s) = 440 \times 340/(340 - 30.0)$.
- $= 440 \times 340/310 = 483$ Hz; C comes from the moving-*observer* formula, which does not apply here.

Question 24

9702/12 M25 ▪ Q24 ▪ 1 mark

24 The diagram shows a car travelling at a constant speed in a straight line between person P and person Q from point X to point Y.



The car sounds its horn continuously as it travels. The horn emits sound of constant frequency.

Which statements about what person P and person Q hear during the motion of the car are correct?

1 Person P hears a sound of increasing frequency.

Question 24

2 Person Q hears a sound of decreasing frequency.

3 Person Q always hears a sound of higher frequency than person P.

A 1, 2 and 3

B 1 and 2 only

C 3 only

D none of them

Solution 24

Answer: **C**

Why

- The car travels in a straight line at constant speed, directly away from P and directly towards Q.
- With the speed constant and the motion along the line, each listener hears one steady shifted pitch – so 1 and 2 are wrong.
- Q is always being approached and P always left behind, so Q's pitch is always the higher: statement 3 only.