1 While playing golf, players use different golf clubs, depending on the distance the ball needs to travel. Different golf clubs produce different launch angles for the ball.

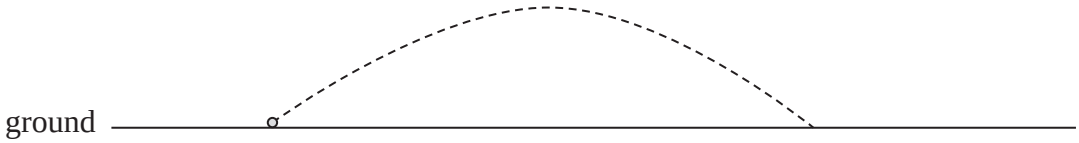
(a) A golf club strikes a ball. The ball leaves the golf club at an angle of 26° to the horizontal and at a speed of 35 m s^{-1}.

(i) Calculate the horizontal distance that the golf ball should travel before reaching the ground.

(4)

Horizontal distance =

(ii) The path of the golf ball in (i) is shown below.



Add to the diagram to show the path the ball would have taken had it left the golf club, at the same speed, at an angle of 42° to the horizontal.

(1)

(b) The actual horizontal distance travelled by the ball is affected by air resistance and an upwards force caused by the spin of the ball as it moves through the air.

Explain how each of these forces would have affected the distance calculated in (a)(i) had they been considered.

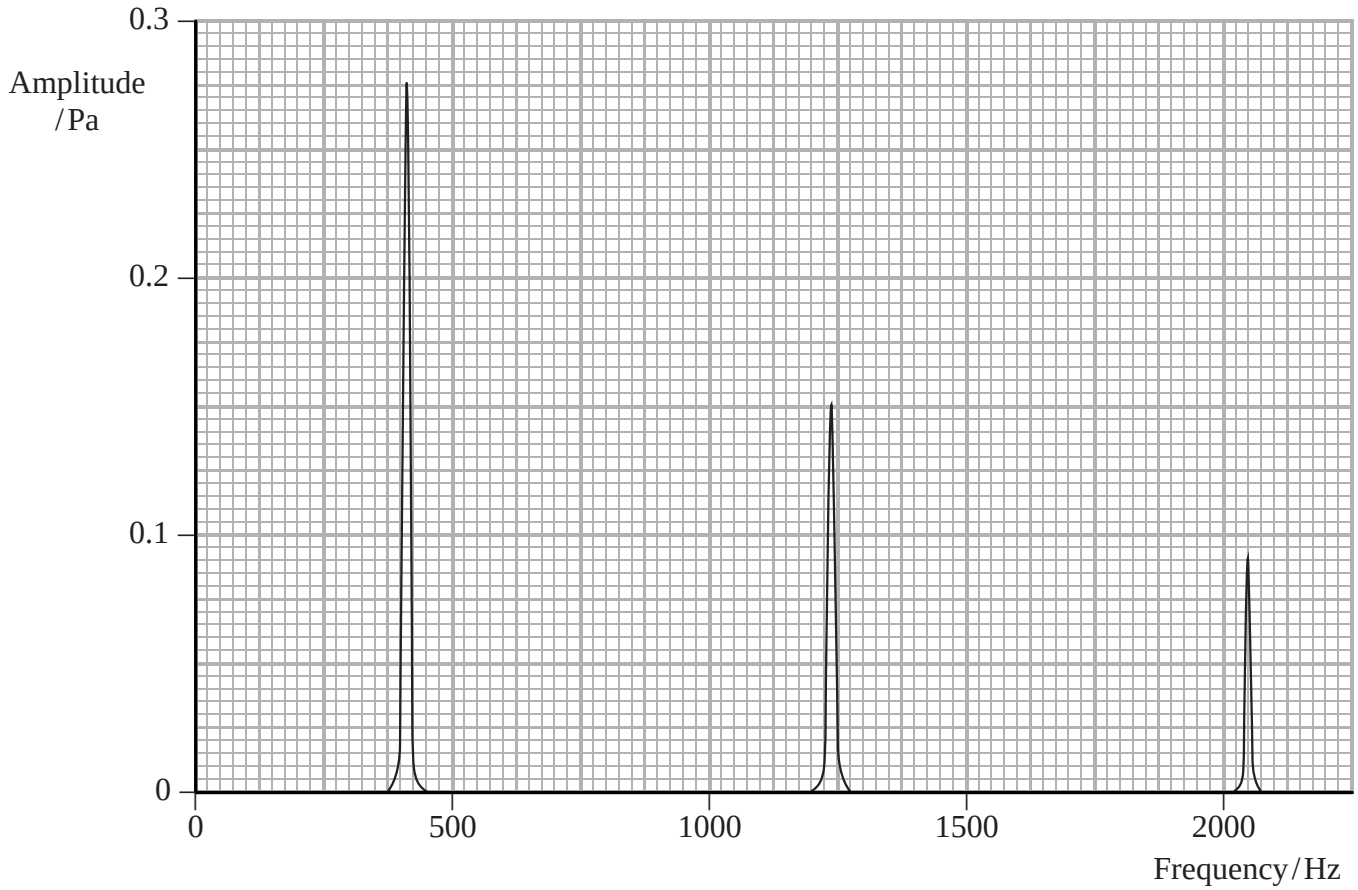
(4)

Air resistance

Upwards force

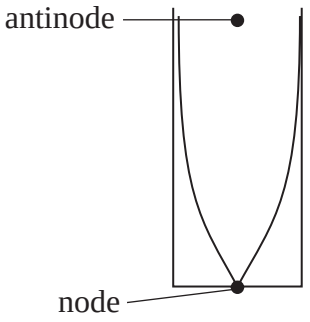
(Total for Question = 9 marks)

2 A sound is created by blowing across the top of a tube which is open at one end.
The sound is recorded and displayed on a graph of amplitude against frequency.



Several frequencies of sound are observed. Each frequency corresponds to a different standing wave in the tube. The loudest, at 410 Hz, is the fundamental frequency. The higher frequencies observed are known as overtones.

(a) The diagram below shows the standing wave created at the fundamental frequency.
The positions of a node and an antinode are shown.

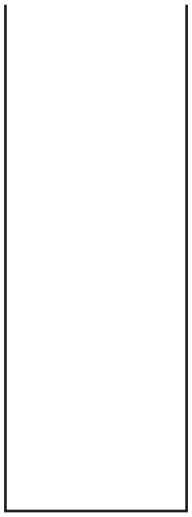


(i) Explain how this standing wave is formed.

(3)

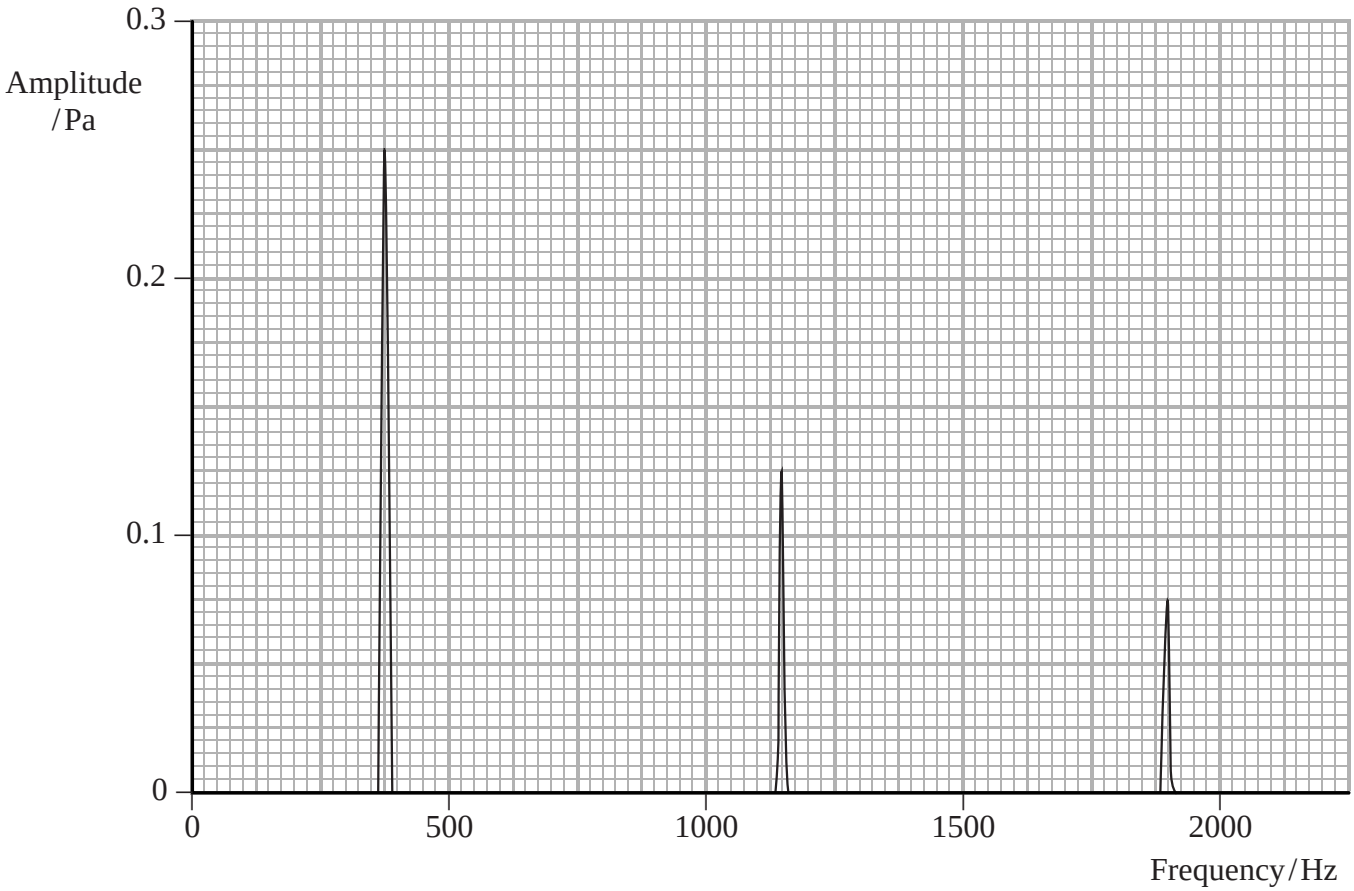
(ii) Add to the diagram below to show the standing wave pattern for an overtone and state its frequency.

(3)



Frequency =

(b) Carbon dioxide is poured into the tube and the sound of the standing waves for the tube is recorded again. The frequencies seen are lower than with air.



Determine a value for the speed of sound in carbon dioxide.
length of tube = 20.3 cm

(4)

Speed of sound in carbon dioxide =

(Total for Question = 10 marks)

3 Bats emit pulses of ultrasound to find the positions of objects using echolocation.

(a) The time between a bat emitting a pulse towards a building and the echo being detected is 0.045 s.
Calculate the distance from the bat to the building.
speed of sound in air = 340 m s^{-1}

(3)

Distance =

(b) When a bat is closer to its prey the following changes take place:

- the ultrasound emitted by the bat becomes higher in frequency;
- the pulses become shorter in duration;
- the pulses are separated by a shorter time interval.

Explain why these changes are made.

(6)

(c) Some bats can detect changes in frequency between the emitted pulse and the echo.

Suggest how this helps the bats in hunting their prey.

(3)

(Total for Question = 12 marks)

4 An ultrasonic distance estimator can be used to measure the length of a room.

The estimator is held against one wall. It emits pulses of ultrasound and detects them when they return after reflection by the opposite wall.

(a) Explain why the ultrasound must be emitted in pulses.

(1)

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.....

(b) The shortest distance the estimator can measure is 40 cm.
Calculate the longest pulse duration that would allow this distance to be measured.

speed of ultrasound in air 330 m s ^{1}

(3)

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.....

Pulse duration .....

(c) When the estimator is pointed at a sloping wall, as shown in the photograph, it is unable to measure this distance.

Suggest why the estimator is unable to measure the distance to the sloping wall.

(1)

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(Total for Question 5 marks)

5 In February 2013 the largest known meteor for a century exploded over the Ural region of Russia.

The explosion was detected by stations monitoring infrasound, a type of sound with a frequency too low for humans to hear.

Describe how infrasound travels through the air.

(3)

(Total for Question = 3 marks)

6 Meteorologists use radar to monitor rain.

Radar uses pulses of microwaves. The emitted pulses are directed horizontally towards rain. The pulses are reflected from the rain and detected. The time taken for the reflected pulses to return, their intensity and frequency are all measured.

*(a) Explain how these measurements can be used to determine the distance to the rain, the relative speed of the rain towards the detector and the amount of rain falling.

(6)

(b) (i) Explain why pulses of microwaves are used rather than a continuous beam.

(1)

(ii) Calculate the maximum pulse duration which would enable distances between 5 km and 200 km to be measured.

(3)

Maximum pulse duration =

(Total for Question = 10 marks)

7 (a) Some radio signals have a frequency of 218.6 MHz.

Calculate their wavelength.

(2)

Wavelength =

(b) State what is meant by:

(i) frequency

(1)

(ii) wavelength.

(1)

(Total for Question = 4 marks)

8 Ultrasonic testing can be used for detecting corrosion inside metal pipes.

(a) Describe how the ultrasound travels through a metal.

(3)

(b) A steel pipe was manufactured with a wall thickness of 4.0 cm.

After several years of use this pipe is tested for corrosion. A pulse of ultrasound is sent into the steel from the outer surface and the reflection from the inner surface is detected after a time of 5.1×10^{-6} s.

Determine whether the steel is corroded at this point.

speed of sound in steel = 5900 m s^{-1}

(4)

(c) In this technique the ultrasound is emitted as pulses.

Explain why pulses are used rather than a continuous wave and how the duration of the pulse affects the thickness of the pipe wall that can be accurately measured.

(3)

(Total for Question = 10 marks)