Delta Science Education

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HKDSE Physics

Core 3: Wave Motion

Chapter 7: Sound

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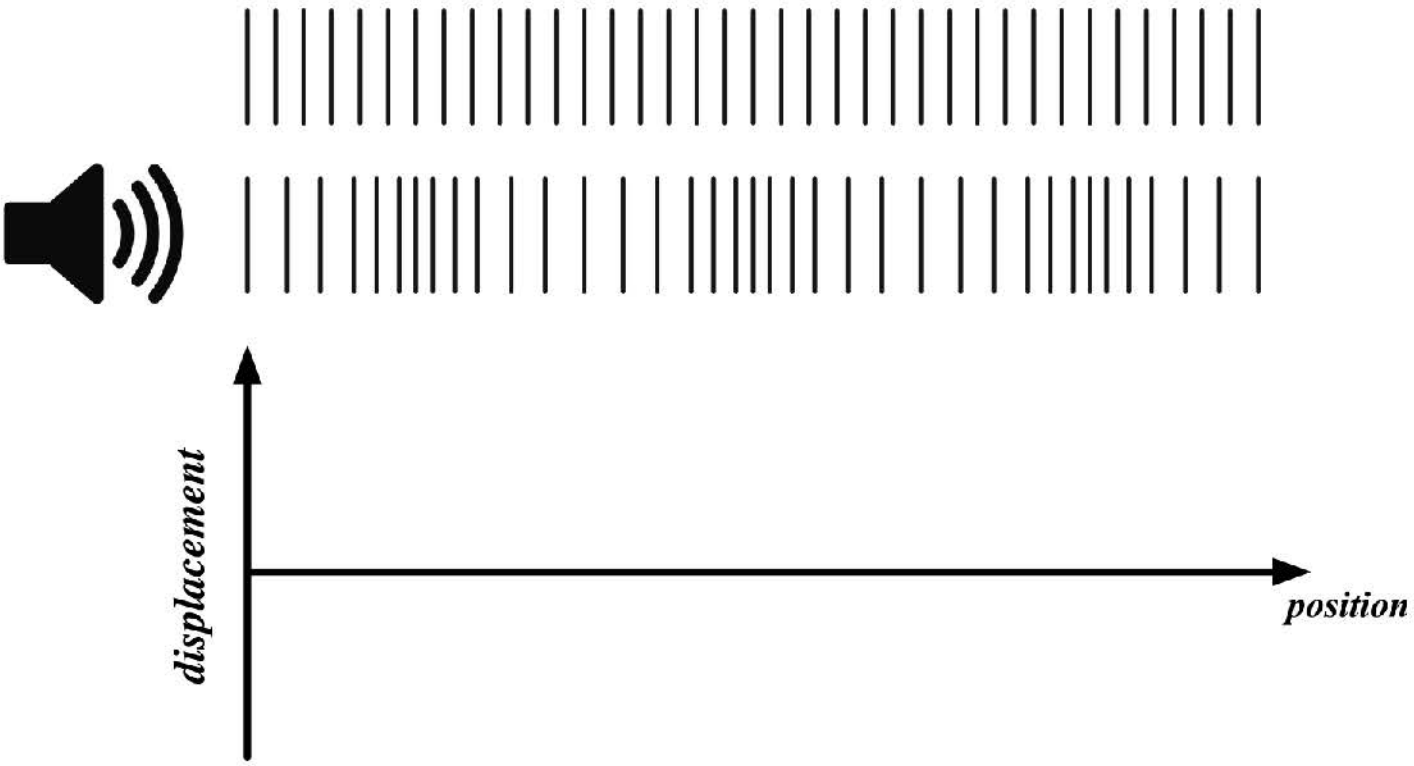
1. Nature of Sound waves

(1) Propagation of sound wave

- **Sound wave** is a kind of [ ] **wave**.
- The transmission of sound wave consists of propagation of **compression and rarefaction**.



- Sound waves **would not be deflected by Electric field of Magnetic field**.
- Sound wave is a **mechanical wave** which **requires a material medium** for travelling.

Examples that you must fully understand

1. How two astronauts on the Moon communicate?

Since there is [ ] on the Moon, the two astronauts cannot communicate by sound wave. Thus, they cannot talk directly to each other. Instead, one astronaut speaks to a [ ] inside the spacesuit which converts the sound signal to [ ] and transmits to the other astronaut. A [ ] in inside the spacesuit converts the received radio wave signal to sound wave.

2. A ringing electric bell is placed inside a glass jar. As air is then pumped out of the jar, we can no longer hear the sound of the bell. Which of the following can explain this?

(1) The electric bell cannot function in vacuum.
(2) Sound waves are internally reflected by the glass of the gas jar.
(3) Sound waves cannot travel in vacuum.

3. Suggest an experiment to demonstrate that sound wave is a longitudinal wave.

Place a candle flame in front of a loudspeaker. When the loudspeaker is turned on, the candle flame [ ], [ ] to the propagation of sound wave.

(2) Speed of sound wave

- Speed of sound wave depends on the medium:

	How speed of sound differs in different medium?
Sound wave	$Solid > Liquid > Gas$ $High\ temperature > Low\ temperature$

- At room temperature, the speed of sound in air is about 330 m s^{-1}, which is much lower than the speed of light in air, 3 x 10^8 m s^{-1}.

Examples that you must fully understand

4.

(a) During a thunderstorm, we see lightning before we hear the thunder because:

(1) Light has a greater frequency than sound.

(2) Light has a greater amplitude than sound.

(3) Light has a greater speed than sound.

(b) Joey sees a flash of lightning in the sky. After 6 s, she hears the thunder. How far away is she from the thunderstorm? You can assume the speed of sound in air to be 320 m s^{-1}. State one more assumption in your calculation.

Assumption: The time taken for the light wave of the lightning to travel to Joey can be _____.

5. In a 100 meter race, a starter at the starting point uses a horn to release a sound signal of frequency 625 Hz to notify John to start running. A time keeper standing at the end of the race track presses a stop watch to record the time when he hears the sound signal as shown in the figure below.

Given that the speed of sound in air is 330 m s^{-1}.

(a) If the average running speed of John is 9.2 m s^{-1}, find the time recorded by the time keeper.

(b) As the time keeper cannot record the actual time, it takes time *t* for the sound signal to travel form the starter to the time keeper, Ann suggests the following ways to reduce the time delay, *t*:

(i) using a horn emitting sound of higher frequency;

(ii) lowering a flag instead of using a horn to notify the time keeper.

Explain whether each of the above suggestions can work.

(i) It _____ ***since the speed of sound will*** _____.

(ii) It _____ ***since the speed of light is*** _____ ***and the time delay can then be neglected.***

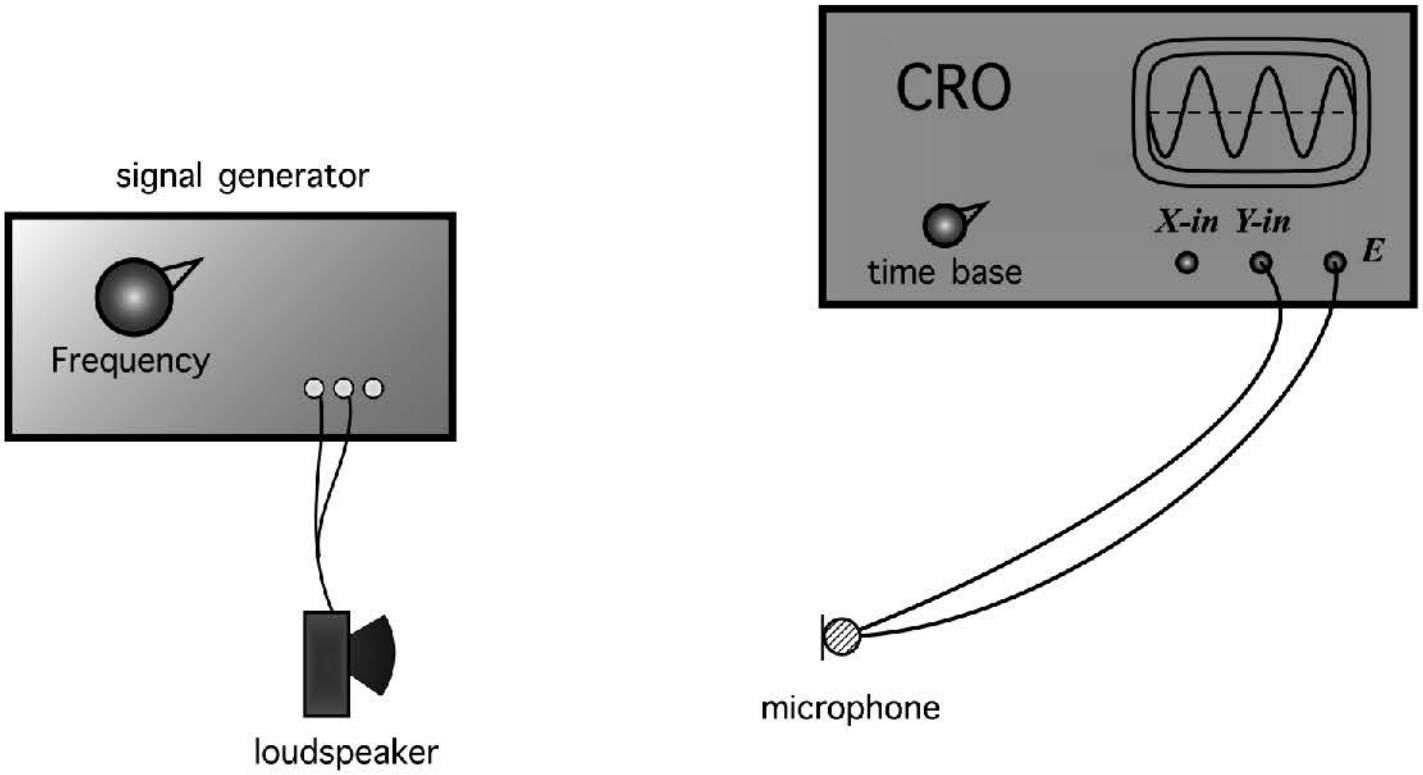
(3) Comparison between sound and light wave

Sound wave	Light wave
• Sound is a **mechanical** wave. • Sound is a **longitudinal** wave. • Sound **cannot travel in vacuum**.	• Light is an **electromagnetic** wave. • Light is a **transverse** wave. • Light **can travel in vacuum**.

• Sound travels **fastest in solid**:
  ✦ *Speed in solid (4 000 – 6 000 m s^{-1}) > Speed in liquid (1 000- 1 500 m s^{-1}) > Speed in gas (300 – 1000 m s^{-1})*
	• Light travels **fastest in air or vacuum**:
	  ✦ *Speed in air/vacuum (3 x 10^8 m s^{-1}) > Speed in water > Speed in glass*

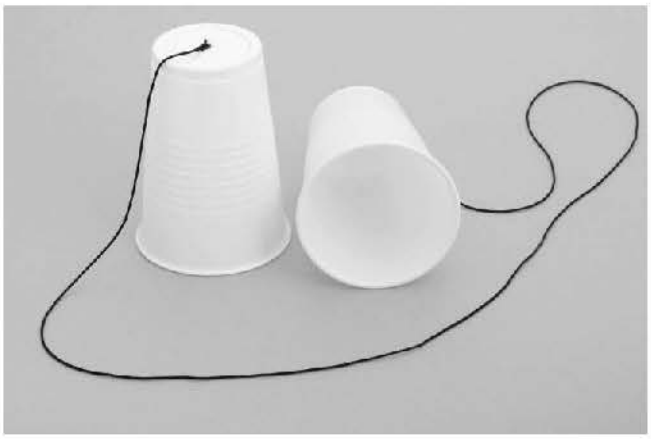
(4) Uses of CRO to visualize sound wave

- A microphone connected to a Cathode Ray Oscilloscope (CRO) can display the waveform on the screen.
- The CRO shows the **displacement-time graph** of the signal **at a specific point**.
- A CRO can show the [ ] and [ ] of the sound wave.



Examples that you must fully understand

6. Carmen and Claire talk with each other by using a handmade device as shown below. Which of the following statements is/are correct?



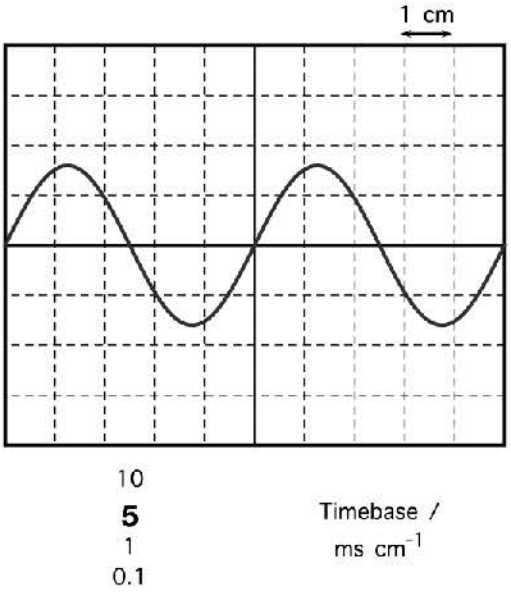
(1) Sound waves are transmitted through the string.

(2) The sound waves transmitted along the string are transverse waves.

(3) The speed of the sound waves along the string is faster than that in the air.

(4) The device demonstrates that sound can be transmitted through solid.

7. A sound note is displayed on a CRO as shown. The speed of sound is 340 m s^{-1}.



(a) Find the period and frequency on the sound note.

(b) Find the wavelength of the sound note.

(c) Sketch the graph showing the variation of reciprocal of wavelength with frequency.

2. Phenomena of sound waves

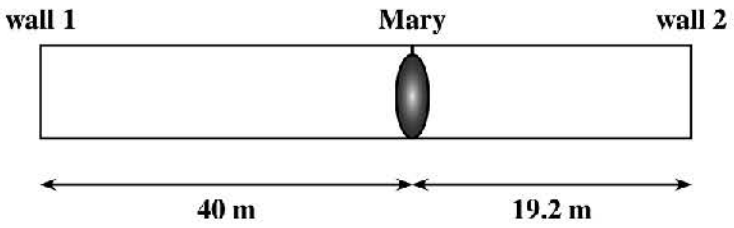
(1) Reflection, refraction and diffraction

- **Echo** is produced when sound is [ ] from a mountain, a cliff or a wall.
- **Refraction** of sound occurs when sound travels from one medium to another with different speed.
- Sound has a **very large degree** of diffraction as its [ ].

Examples that you must fully understand

8. John stands **250 m** in front of a cliff. He claps her hands continuously with regular interval such that each echo is coincident with the next clap. He finds that the time interval between the first clap and the fifth clap is **5.1 s**. What is the speed of sound in air?

9. Mary stands between two walls inside a tunnel and she claps her hands once. If the speed of sound in air is **320 m s^{-1}**, what will be the time interval between the first two echoes?



10. The wavelength and speed of a sound note in air are **25 cm** and **320 m s^{-1}** respectively. When it enters water, its wavelength becomes **100 cm**.

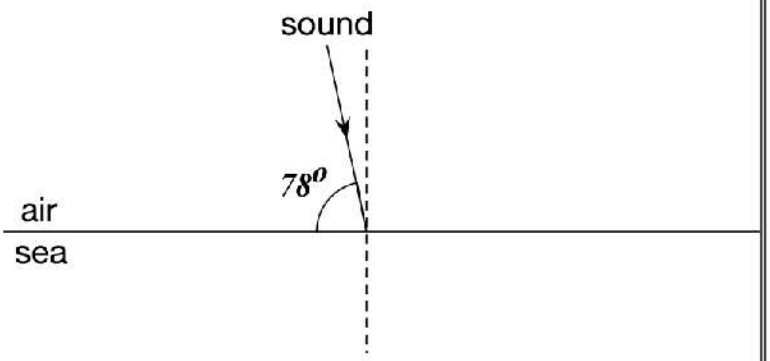
(a) What is the phenomenon and what will be the frequency of the sound note in water?

[ ]. ***The frequency will be*** [ ].

(b) Find the speed of the sound note in water.

Examples that you must fully understand

11. The figure shows a sound wave travelling from air to sea water. Given that the speed of sound in air is $340\ m\ s^{-1}$ and that in sea water is $1\ 500\ m\ s^{-1}$.



(a) Find the angle of refraction in water.

(b) Which of the following statements is/are correct?

(1) The wavelength increases.

(2) The sound wave bends away from the normal.

(3) Total internal reflection may occur if the incident angle is large enough.

(c) Calculate the critical angle that total internal reflection can just occur.

12. The figure shows an ordinary loudspeaker with two units, a unit with big cone and a unit with small cone. Suppose the loud speaker will emit low and high frequency sounds, which unit is suitable to emit low frequency sound and which unit is suitable to emit high frequency sound? Explain your answer.

The unit with small cone is more suitable for emitting* [ ] *sounds. Since the* [ ] *of* [ ] *is* [ ]*, it has* [ ]*.

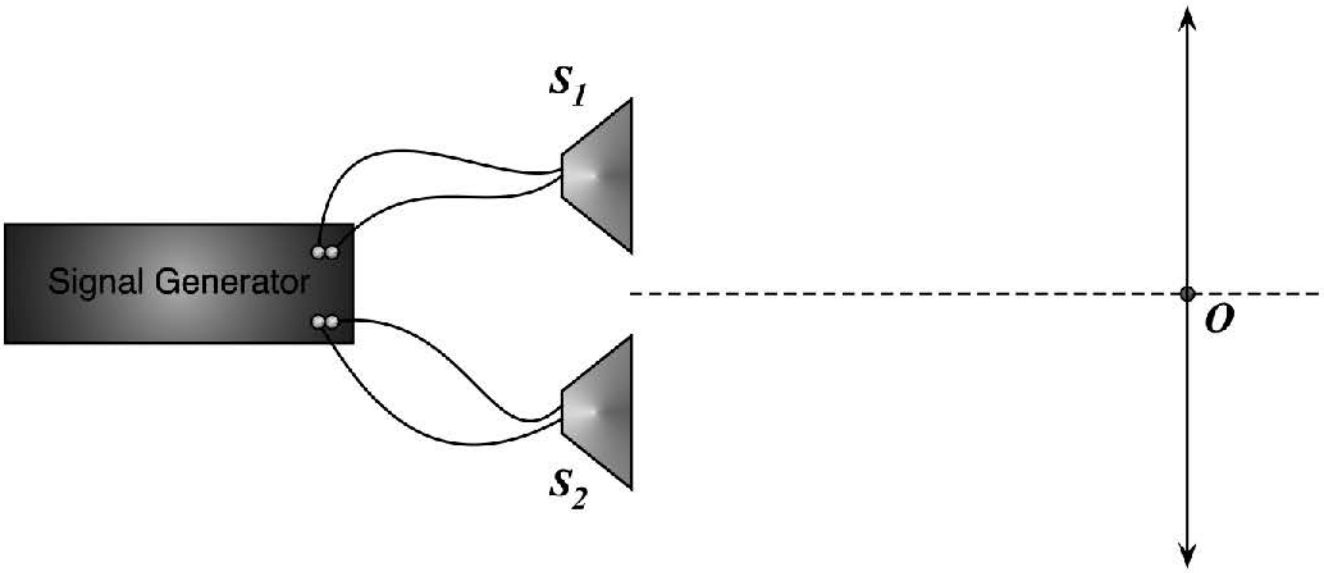
Thus, a smaller cone is suitable to* [ ]*.

13. Sometimes, when we are outside a room playing musics, we can only hear the base sound. Why?

Since the base sound has a* [ ]*, its* [ ] *is* [ ] *and it has a* [ ] *than sound of higer frequencies.

(2) Interference

- To demonstrate the interference of sound, connect **2 loudspeakers to the same signal generator** to become **2** [ ] **sources**.



- Walk along **the line in front of and** [ ] **to the line joining the two loudspeakers**.
- Alternative **loud and soft sound** can be heard. A loud sound represents point of **constructive** interference while a soft sound represents point of **destructive** interference.
- The variation of sound intensity can also be found by using a microphone connected to a CRO.

Examples that you must fully understand

14. Two identical loudspeakers X and Y are connected in parallel to a signal generator. A microphone connected to a CRO detects a maximum when it is 0.3 m from X and 1.5 m from Y. It detects a minimum when it is 1.1 m from X and 0.2 m from Y. What is/are the possible wavelength(s) of the sound wave?

(1) 0.2 m

(2) 0.4 m

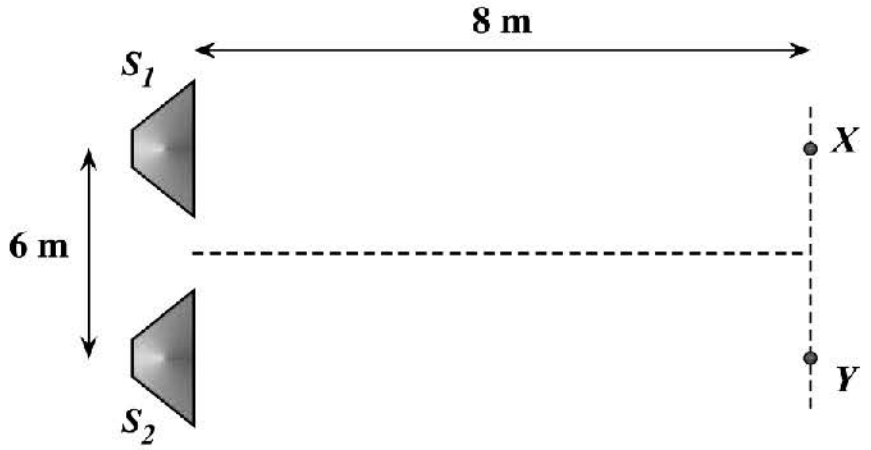
(3) 0.6 m

15. Why is there no interference of the sound emitted by the two loudspeakers connected to a TV set.

As the sound emitted by the two loudspeakers are having [ ]***, the two loudspeakers are not*** [ ]***. Thus no intereference pattern can be produced by the two loudspeakers.***

Examples that you must fully understand

16. In the figure, two loudspeakers are connected to signal generators emitting sound wave of wavelength 2 m.



(a) Sketch the graph showing the variation fo sound intensity I along the line XY if the signal generators are in phase (solid line) and in opposite phase (dotted line).

(b) Explain why the intensity is non-zero at minimum point.

There are [ ]. ***There is*** [ ] ***of sound from the surrounding walls. The*** [ ] ***is*** [ ] ***since the two sound waves have not exactly the*** [ ] ***due to different path lengths. The microphones detect sound within a finite region.***

(c) State the effect on the separation between two points of loud sound if

(i) the frequency of sound is increased; [ ]

(ii) the amplitude of sound is increased; [ ]

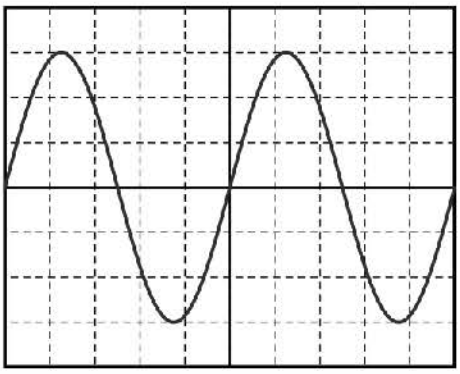
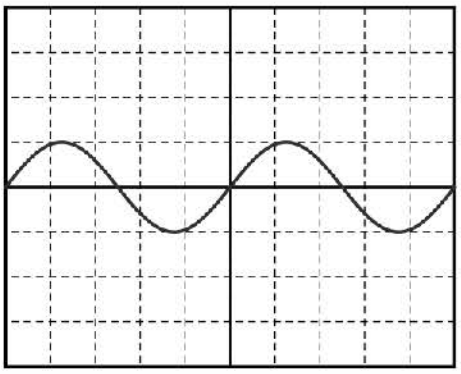
(iii) the separation between the two loudspeakers is increased; [ ]

(iv) the temperature of air is increased. [ ]

3. Properties of Sound

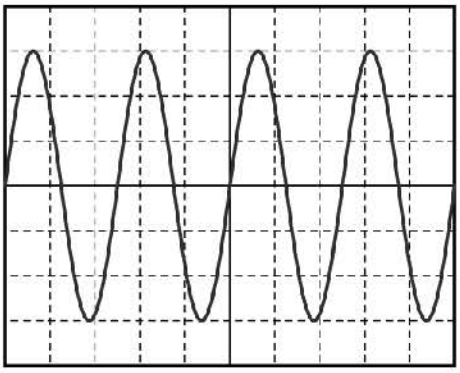
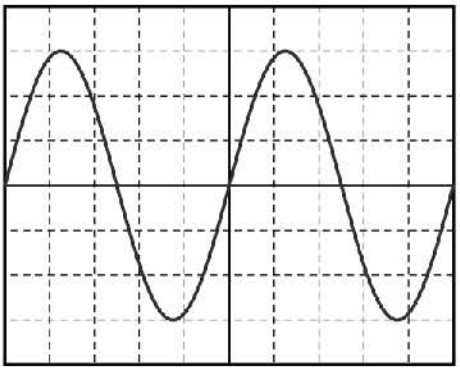
(1) Loudness

- **Loudness** of sound dependents on the **sound** [ ] which depends on the [ ].
- The **greater the amplitude**, the **greater the loudness** is the sound.
- **Speed** of sound is [ ] affected by the sound's loudness.

Greater loudness	Lower loudness
	

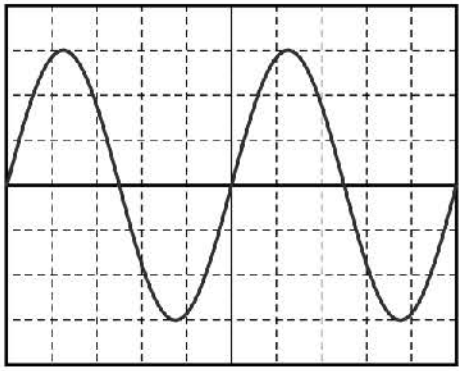
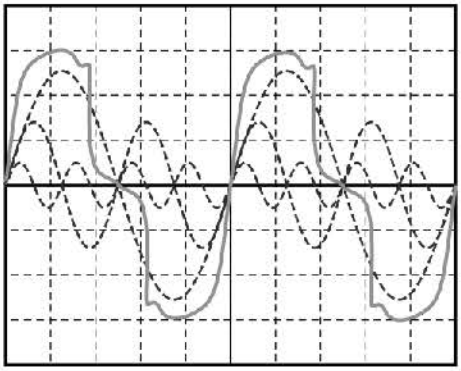
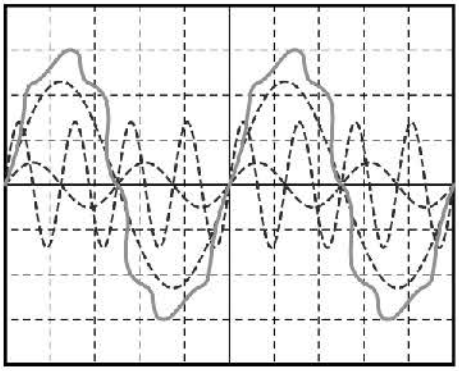
(2) Pitch

- **Pitch** of a musical note depends on the [ ] of the sound.
- The **greater the frequency**, the **greater the pitch** is the sound.
- **Speed** of the sound is [ ] affected by the pitch.
- When the **frequency is doubled**, the **pitch will increase by one octave**.

Greater pitch	Lower pitch
	

(3) Quality

- **Quality** of sound depends on the [ ] of it.
- **Different musical instruments** emit sound note with **different waveform** to give sound of **different quality / timbre.**
- Different sound sources can be distinguished by the quality of sound.

Tuning fork	Violin	Erhu
		
		

Examples that you must fully understand

17. Which of the following statements concerning the properties of sound is/are correct?

(1) A louder sound travels faster than a soft sound in air.

(2) A sound of higher pitch travels faster than a sound of lower pitch in air.

(3) When two notes of the same frequency of 256 Hz are sounded together, a note of 512 Hz will be heard.

(4) Loudness of a sound is independent with its frequency.

(5) Discounting the loudness, a note produced by a 256 Hz tuning fork is exactly the same as the note produced by a violin at 256 Hz.

Examples that you must fully understand

18. The frequencies of two musical notes X and Y are 256 Hz and 512 Hz respectively. If X and Y have the same amplitude, which of the following statements is/are correct?

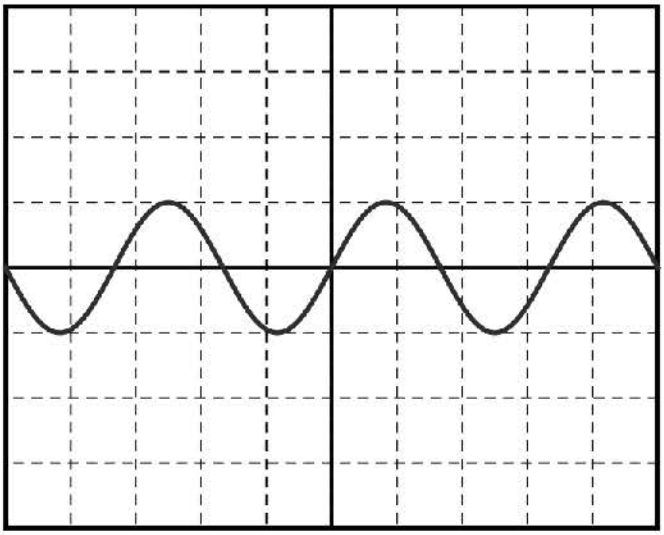
(1) The pitch of Y is higher than that of X.

(2) The loudness of Y is larger than that of X.

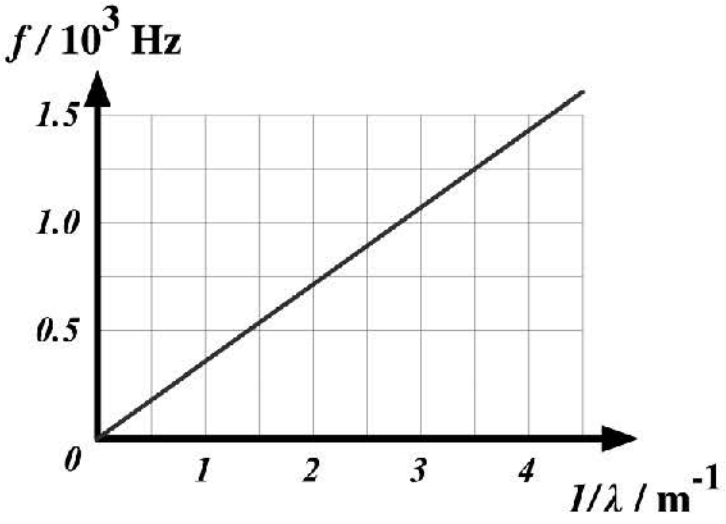
(3) The speed of Y is the same as that of X.

(4) The wavelength of Y is longer than that of X.

19. Below shows a sound note detected by a CRO. Draw, on the same figure (i) a sound note with higher pitch but softer (mark as X) and (ii) a sound note with lower pitch but louder.



20. The firgure shows the variation of the frequency f of sound waves with the reciprocal of the wavelength lamda.



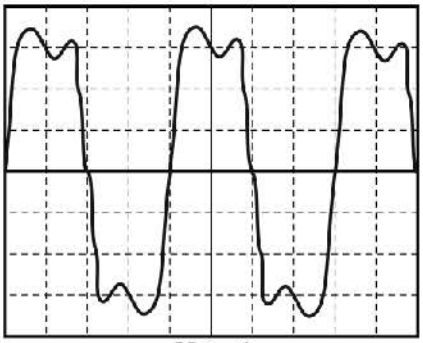
(a) Find the speed of the sound.

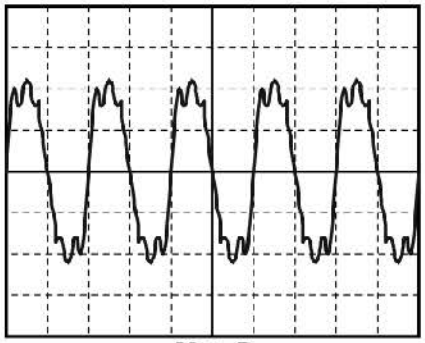
(b) Judy said that the speed of sound increaes when the frequenct increases. Comment the statement with the use of the graph.

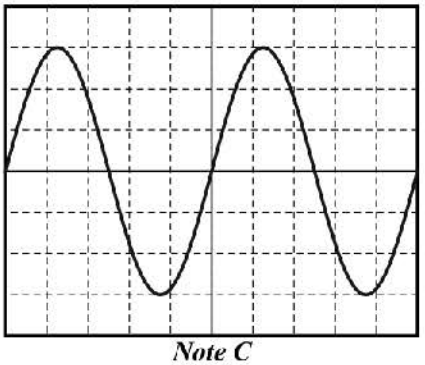
She is not correct since the [ ] of the graph which represents the speed of the sound waves which is [ ]. Thus, the speed of the sound wave is [ ].

Examples that you must fully understand

21. The figure below shows the waveforms of three notes, A, B and C displayed on an oscilloscope. One note is produced by a tuning fork, another note is produced by a viola and the other note is produced by a flute.


Note A


Note B


Note C

(a) Which one is produced by a tunning fork?

[ ]

(b) Among the three notes, which one:

(i) has the highest pitch:

[ ]

(ii) has the lowest pitch:

[ ]

(iii) is the loudest:

[ ]

(iv) is the softest:

[ ]

(c) Which of the following statements concerning the above three notes is/are correct?

(1) The three notes have different quality.

(2) The three notes travel with different speed in air.

(3) The three notes have different wavelengths.

(4) The three notes are transverse waves.

22. Which of the following statements concerning sound is/are correct?

(1) Loudness increases with the amplitudes of the sound wave.

(2) Pitch decreases with the wavelength of the sound wave.

(3) A note emitted by a violin sounds different from the note produced by a piano.

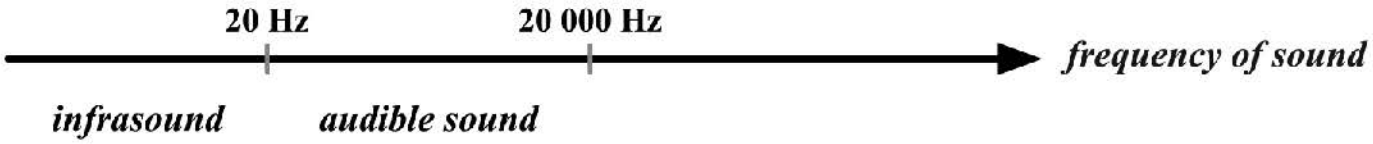
(4) The sound produced by different people can be distinguished due to the quality.

(5) The musical notes emitted by a guitear string through air consist of transverse waves.

4. Ultrasound

(1) Definition of Ultrasound

- Our ears can only hear sound of frequency between **20 Hz to 20 000 Hz**.
- **Ultrasounds (ultrasonic waves)** are sound waves with frequency **higher than 20 000 Hz**.



(2) Properties of Ultrasound

- Ultrasound cannot be heard by human ears but can be heard and/or produced by some animals.

- Ultrasound travels with the [ ] as audible sound in the same medium.
- As ultrasound has higher frequency, its **wavelength is** [ ]. Thus, ultrasound has [ ] **diffraction.**
- Energy can be concentrated in a beam and ultrasound can thus travel in **a straight line** for a longer distance.

Examples that you must fully understand

23. Which of the following statements concerning ultrasound is/are correct?

(1) Ultrasound does not diffract.

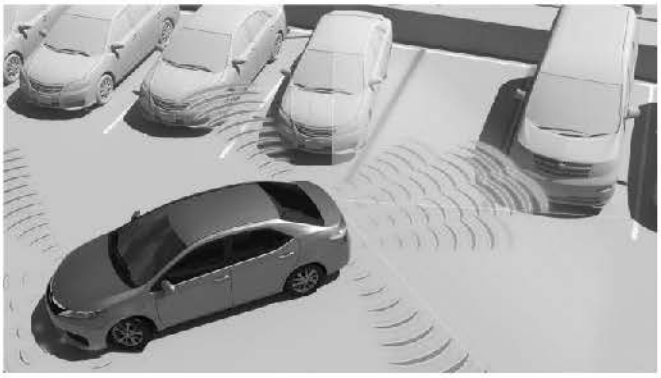
(2) Ultrasound travels faster than common sound.

(3) Ultrasound travels faster in waver than in air.

(4) Ultrasound is an EM wave.

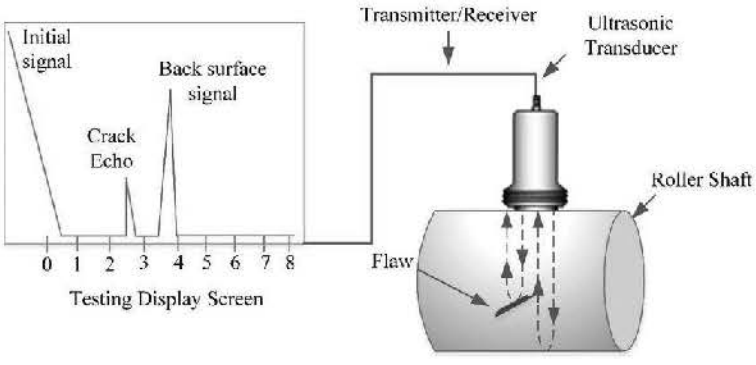
(3) Applications of Ultrasound

- **Sonar**
  - Similar to radar, but ultrasonic wave is used instead of the [ ].
  - Sonar is common to be used in water since [ ] **cannot travel a long distance in** [ ].
  - Distance to objects under water or depth of seabed is found by **measuring the** [ ] **the echo is received.**



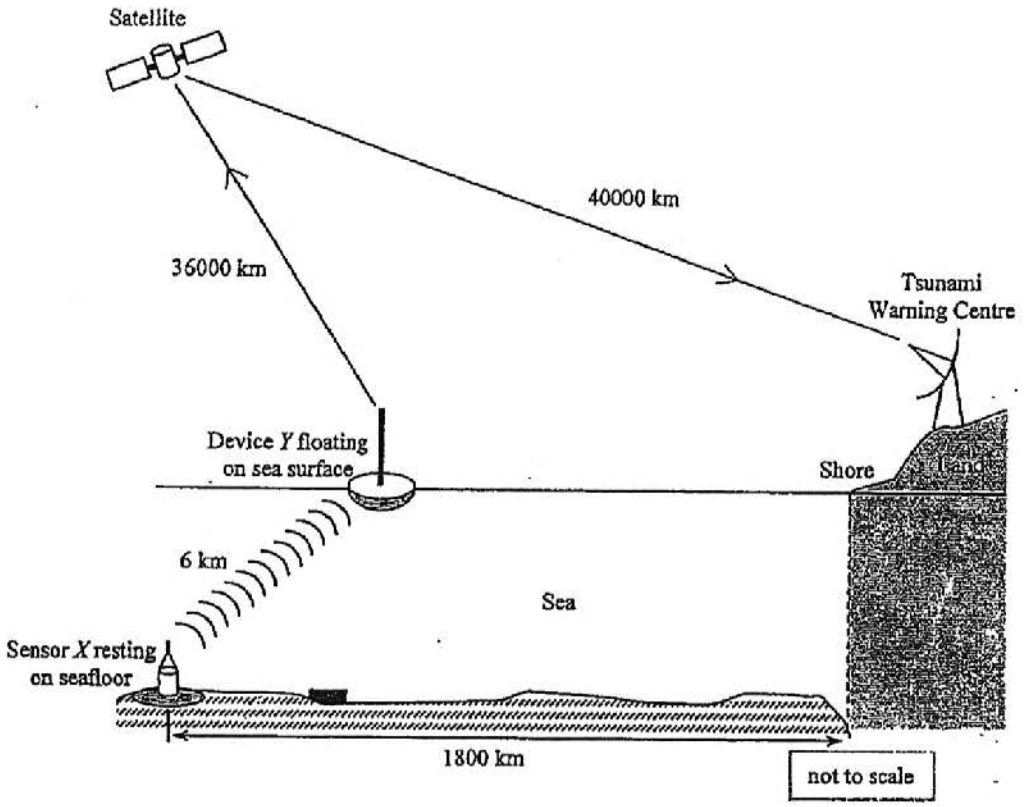
  - Ultrasonic wave, not audible sound, is used as ultrasonic wave has [ ] and thus [ ]. Therefore, ultrasonic wave can be **reflected by tiny objects** and thus the objects can be detected by sonar.

- **Auto-focusing in camera**
- **Ultrasonic cleaner**
- **Ultrasonic scanner**
- **To smash kidney and bladder stones**
- **To detect cracks in railway or machines**



Examples that you must fully understand

24. A tsunami is a kind of large-scale water wave that is commonly generated by earthquakes. The figure below shows a simplified tsunami detection system. Sensor X on the seafloor can detect earthquakes and tsunamis. When a tsunami is detected, an ultrasound signal will be sent from Sensor X to Device Y on the sea surface. Device Y will immediately transmit a microwave signal to a satellite and the satellite will send the microwave signal to the Tsunami Warning Centre on land.



(a) What is ultrasound?

Ultrasound is sound wave of frequency [ ].

(b) Why is ultrasound, instead of radio wave used in sending the signal from the Sensor X on seafloor to the Device Y on sea surface?

Radio wave (EM wave) cannot travel [ ].

(c) John said that ultrasound is used instead of audiable sound because ultrasound travels faster. Comment.

He is [ ] ***since ultrasound and audiable sound travel*** [ ].

(d) Explain why ultrasound is not used to transmit signals from the satellite to the Tsunami Warning Centre.

Ultrasound [ ] ***travel in*** [ ] ***/ outer space.***

(e) Given:

Distance from Sensor X to the shore $= 1\,800$ km

Distance from Sensor X to Device $Y = 6$ km

Distance from Device Y to the satellite $= 36\,000$ km

Distance from the satellite to the Tsunami Warning Centre $= 40\,000$ km

Speed of ultrasound in water $= 1\,500$ m s^{-1}

Speed of microwave $= 3 \times 10^8$ m s^{-1}

Average speed of tsunami on the sea surface $= 250$ m s^{-1}

Can the Tsunami Warning Centre receive the signal one hour before the arrival of tsunami to the shore? Show your calculations. (Assume that when a tsunami arrives at the water surface vertically above Sensor X, X sends a signal to Device Y.)

(f) After receiving the signal from the satellite, the Tsuami Warning Centre will send a warning signal to the alarm stations in neighbouting cities. John suggests using ultrasound to transmit the warning signal, while Peter suggests using radio wave to transmit the warning signal. Explain which suggestion is more appropriate.

The [ ] ***of*** [ ]. ***Therefore,*** [ ] ***suggestion is more appropriate.***

25. Figure (1) shows a car travelling with a uniform speed along a straight road away from a stationary ultrasound generator and detector at Y. When the car is 64 m from Y, the generator emits an ultrasound pulse towards the car. The pulse is then reflected back to the detector at Y and displayed on a CRO as shown in Figure (2). Estimate the speed of the car. Given the speed of ultrasound in air is 340 m s^{-1}.

Figure (1)

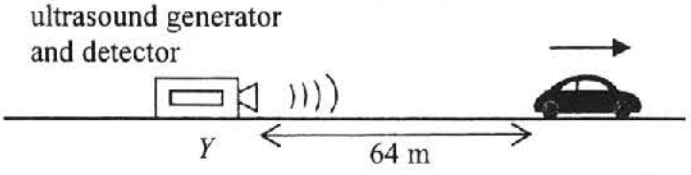
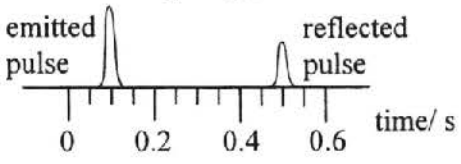
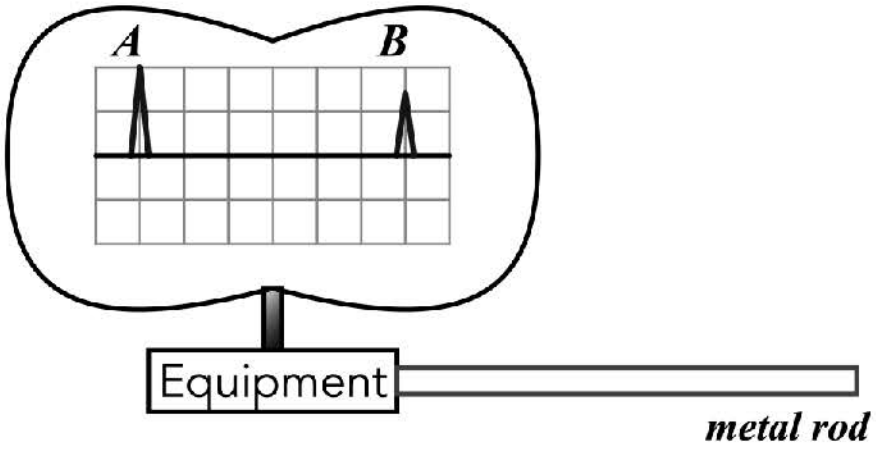


Figure (2)



Examples that you must fully understand

26. The set-up shown is used to measure the length of a metal rod. A transmitter emits an ultrasonic pulse of frequency 5 MHz through the rod and the reflected pulse is received. The two pulses A and B are recorded on the CRO. Speed of sound in the metal is known as $3\,800\ \text{m s}^{-1}$.



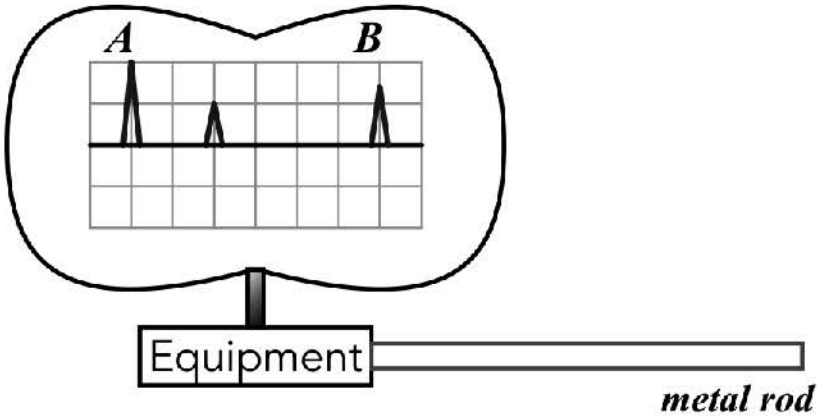
(a) Which pulse repersents the reflected pulse?

[ ] ***is the reflected pulse since its*** [ ].

(b) What is the wavelength of the ultrasound transmitted in the metal rod?

(c) If each division of the CRO represents 20 muis, what is the length of the metal rod?

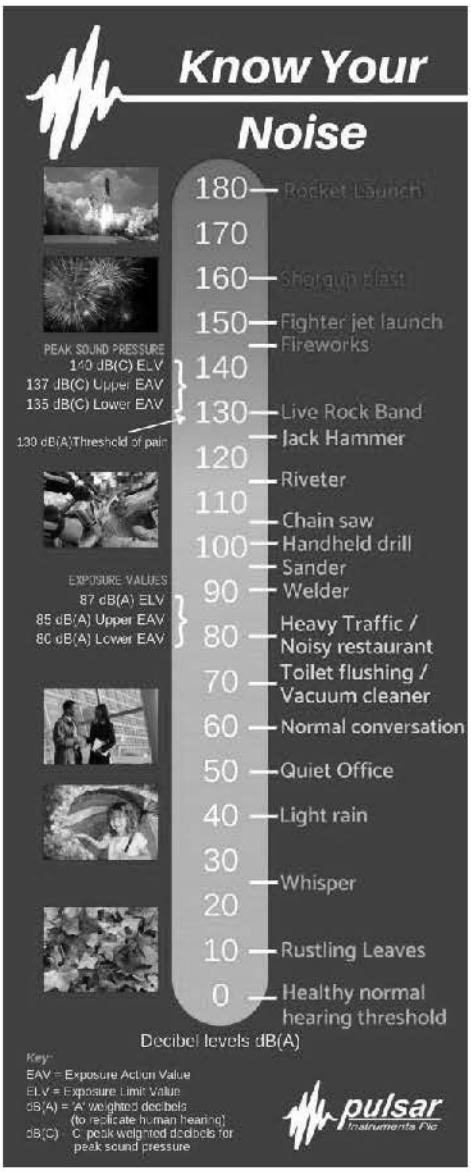
(d) On anotehr day of measurement, the test result is shown below. There is one more pulse appearing on the CRO. Give a possible reason why there is aone more pulse appearing on the display.



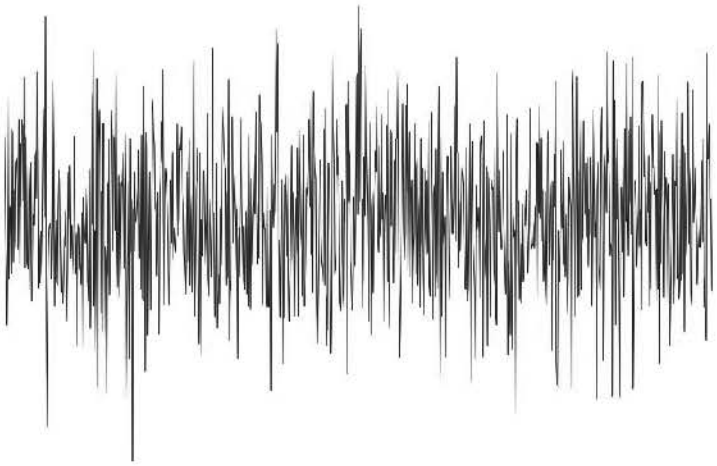
There may be a [ ] ***inside the metal rod. The extra pulse is*** [ ].

5. Noise

(1) Noise pollution



- All of the **unwanted** sounds are **noises**.
- Usually, noises consist of [ ] waveforms.



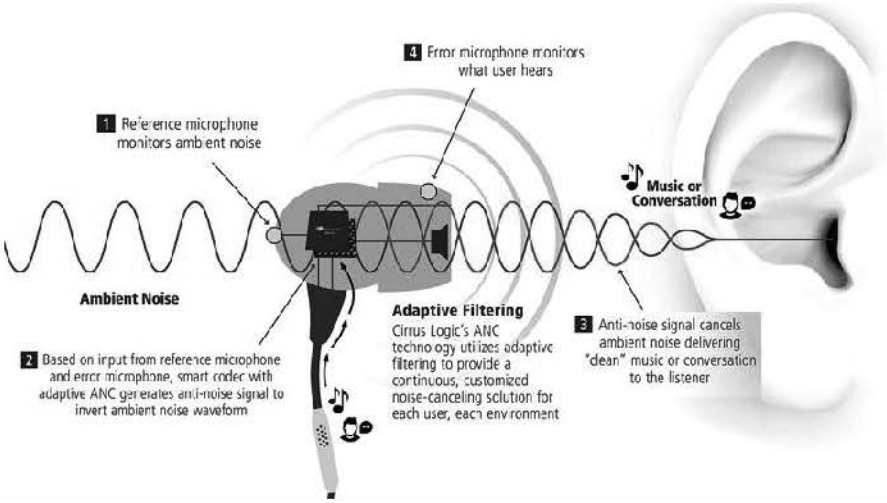
- **Source of noises:**
  - Motor vehicles, machines, electronic appliances, aircraft….
- **Psychological effect of noise:**
  - Nervousness and loss of concentration
- **Physiological effect of noise:**
  - Raised blood pressure and deafness

(2) Sound intensity level

- **Sound intensity level** indicates [ ] of sound or noise, measured in **decibels (dB)**.
- A **sound intensity level meter** is used for the measurement.
- Note that an increase of **3 dB** means [ ] times of the original intensity while an increase of **10 dB** is [ ] times of the original intensity.

(3) Noise control

- **Targeting the source:**
  - Install silencer in vehicles to absorb the noise generate from engines
  - Well lubricate the moving parts in machines to reduce friction
- **Targeting the path:**
  - Use noise barriers to reflect and absorb the noise generated from traffic in highway
  - Use noise absorbing materials or noise isolating materials to enclose the source of noise
  - Use double glazed windows
- **Targeting the receiver:**
  - Put on ear protector in noisy environment
  - Use headphone with active noise cancellation



Examples that you must fully understand

27. Noise barriers built along highways are used to block the noise generated by road traffic. Which of the following statements correctly explain how the noise barriers can block the noise?

(1) The nosie from vehicles is reflected.

(2) The noise is absorbed by the noise barriers.

(3) The noise is diffracted at the top edge of the noise barriers.