CBSE

WAVES WS 3

Class 11 - Physics

Section A

1. The equation of a wave is represented by $y = 10^{-4}\sin\left(100t - \frac{x}{10}\right)$ m, then the velocity of wave will be: **[1]**

   a) 10 m/s
   b) 100 m/s
   c) 1000 m/s
   d) 4 m/s

2. If the intensity level of a sound wave is increased by factor 20, the corresponding change in decibels level of the sound would be **[1]**

   a) 7 dB
   b) 19 dB
   c) 27 dB
   d) 13 dB

3. A balloon is filled with hydrogen. For sound waves, this balloon behaves like **[1]**

   a) a concave mirror
   b) a diverging lens
   c) a converging lens
   d) a convex mirror

4. Velocity of sound waves in air is 330 m/s. For a particular sound in air, a path difference of 40 cm is equivalent to a phase difference of 1.6π. The frequency of the wave is: **[1]**

   a) 660 Hz
   b) 165 Hz
   c) 330 Hz
   d) 150 Hz

5. The speed (v) of ripples on the surface of water depends on surface tension (σ), density (μ) and wavelength (λ). The square of speed (v) is proportional to **[1]**

   a) $\rho\lambda\sigma$
   b) $\frac{\lambda}{\sigma\rho}$
   c) $\frac{\sigma}{\rho\lambda}$
   d) $\frac{\rho}{\sigma\lambda}$

6. If a star emitting orange light moves away from the earth, it's color will: **[1]**

   a) appear yellow
   b) remain the same
   c) turns gradually blue
   d) appear red

7. Speed of sound wave in air **[1]**

   a) is independent of temperature
   b) increases with increase in humidity
   c) increases with pressure
   d) decreases with increase in humidity

8. The phase velocity (v_p) of a travelling wave is **[1]**

   a) $v_p = \frac{\omega}{k}$
   b) $v_p = \frac{c}{v_g}$
   c) $v_p = \frac{d\omega}{dk}$
   d) v_p = c

9. If density of oxygen is 16 times that of hydrogen, what will be their corresponding ratio of velocity of sound? **[1]**

a) 4 : 1

b) 1 : 16

c) 2 : 1

d) 1 : 4

10. The wave described by y = 0.25 sin (10πx - 2πt), where x and y are in meters and t in seconds, is a wave travelling along the: **[1]**

a) +ve X-direction with frequency n Hz and wavelength λ = 0.2 m

b) -ve X-direction with frequency 1 Hz

c) +ve X-direction with frequency 1 Hz and wavelength λ = 0.2 m

d) -ve X-direction with amplitude 0.25 m and wavelength λ = 0.2m

11. **Assertion (A):** Sound waves travel faster in solids than in gases. **[1]**
Reason (R): Solids possess greater density than gases.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

12. **Assertion (A):** Bats navigate and search out prey by emitting and the detecting reflections of ultrasonic waves. **[1]**
Reason (R): Relative motion between the source and observer causes a change in the frequency of the sound wave as heard by the observer.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

13. **Assertion (A):** Sound waves cannot propagate through a vacuum but light waves can. **[1]**
Reason (R): Sound waves cannot be polarised but light waves can be polarised.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

14. **Assertion (A):** The quality of sound depends on the number of overtones produced by the instrument. **[1]**
Reason (R): The pitch of a sound depends on the fundamental frequency of the sound.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

15. **Assertion (A):** Sound would travel faster on a hot summer day than on a cold winter day. **[1]**
Reason (R): Velocity of sound is directly proportional to the square of its absolute temperature.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

16. **Assertion (A):** At a fixed temperature and pressure sound travels fastest in monatomic gases as compared to polyatomic gases. **[1]**
Reason (R): Opposition to the wave propagation is more in polyatomic gases.

a) Both A and R are true and R is the correct

b) Both A and R are true but R is not the

explanation of A.

correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

17. **Assertion (A):** The velocity of sound increases with increase in humidity. **[1]**

Reason (R): Velocity of sound does not depend upon the medium.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

18. **Assertion (A):** The basic of Laplace correction was that, exchange of heat between the region of compression and rarefaction in the air is not possible. **[1]**

Reason (R): Air is a bad conductor of heat and the speed of sound in air is large.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

19. **Assertion (A):** Sound waves travel faster in moist air. **[1]**

Reason (R): The density of moist air is less than the density of dry air.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

20. **Assertion (A):** Two arms of a tuning fork vibrate in same phase. **[1]**

Reason (R): Each arm has the same frequency of vibration.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

21. The frequency of the vibrating string is 200 Hz. If the tension is doubled, the frequency will be approximately _____. **[1]**

a) 400.8 Hz

b) 240.4 Hz

c) 320.6 Hz

d) 282.8 Hz

22. Explain why sound travels faster in warm air than cool air? **[1]**

23. What is the difference between wave velocity and particle velocity? **[1]**

24. What determines the quality of sound? **[1]**

25. How do wave Velocity and particle Velocity differ from each other? **[1]**

26. Why explosions on other planets cannot be heard on the earth? **[1]**

27. If the pressure of a gas at constant temperature is increased four times, how the velocity of sound in the gas will be affected? **[1]**

28. What types of waves are used in a SONAR? **[1]**

29. What is the wavelength range of audible sound and visible light? **[1]**

30. What characteristics of a medium determine the speed of sound waves through it? **[1]**

31. Why does sound travel faster in solids than in gases? **[1]**

Section B

32. A copper wire is held at the two ends by rigid supports. At 30° C, the wire is just taut with negligible tension. Find the speed of transverse waves in the wire at 10° C. $\left(\alpha = 1.7 \times 10^{-5} {}^{\circ}\mathrm{C}^{-1}, Y = 1.4 \times 10^{11} \mathrm{Nm}^{-2} \text{ and } \rho = 9 \times 10^{3} \text{ kg} m^{-3}\right)$ **[2]**

33. At normal temperature and pressure, 4 g of helium occupies a volume of 22.4 litres. Determine the speed of sound in helium. For helium, γ = 1.67 and 1 atmospheric pressure = 10^5 Nm^{-2}. **[2]**

34. If c is r.m.s. speed of molecules in a gas and v is the speed of sound waves in the gas, show that c/v is constant and independent of temperature for all diatomic gases. **[2]**

35. For a travelling harmonic wave, y = 2.0 cos (10t - 0.0080 x + 0.18) where x and y are in cm and t is in seconds. What is the phase difference between two points separated by **[2]**

    i. a distance of 0.5 m and

    ii. a time gap of 0.5 s?

36. A steel wire has a length of 12.0 m and a mass of 2.10 kg. What should be the tension in the wire so that the speed of a transverse wave on the wire equals the speed of sound in dry air at 20°C (is equal to 343 ms^{-1})? **[2]**

37. Two monoatomic ideal gases 1 and 2 of molecular masses m_1 and m_2 respectively are enclosed in separate containers kept at the same temperature. What is the ratio of the speed of sound in gas 1 to that in gas 2? **[2]**

38. At what temperature will the velocity of sound in hydrogen be the same as in oxygen at 100°C? Density of oxygen is 16 times the density of hydrogen. **[2]**

39. An aluminium rod of length 90 cm and of mass 'm' is clamped at its mid-point and is set into longitudinal vibrations by stroking it with resined cloth. Assume that the rod vibrates in its fundamental mode of vibration. The density of aluminium is 2.6 g/cm^3 and its Young's modulus is 7.80 $\times$ 10^{10} N/m^2. Find the speed of the sound in aluminium. If the wavelength is 180 m then, find frequency of vibration. **[2]**

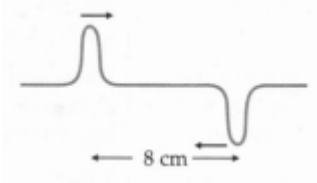
40. A well with vertical sides and water at the bottom resonates at 7 Hz and at no other lower frequency. The air in the well has density 1.10 kg m^{-3} and bulk modulus of 1.33 $\times$ 10^5 Nm^{-2}. How deep is the well? **[2]**

41. The speed of a wave in a medium is 960 m s^{-1}. If 3600 waves are passing through a point in the medium in 1 minute, then calculate the wavelength. **[2]**

42. A wave-pulse is travelling on a string of linear mass density 1.0 g cm^{-1} under a tension of 1 kg wt. Calculate the time taken by the pulse to travel a distance of 50 cm on the string. Given g = 10 ms^{-2}. **[2]**

43. A body sends waves 100 mm long through medium A and 0.25 m long in medium B. If the velocity of waves in medium A is 80 cm s^{-1}, calculate the velocity of waves in medium B. **[2]**

44. Two pulses in a stretched string whose centres are initially 8 cm apart are moving towards each other as shown in the Fig. The speed of each pulse is 2 cm/s. After 2 seconds, what will be the nature of the total energy of the pulses? **[2]**



45. On the basis of dimensional considerations, write the formula for the speed of transverse waves on a stretched string. **[2]**

46. The longitudinal wave, starting from a ship return from the bottom of the sea to the ship after 2.64 s. If the bulk modulus of water be 220 kg mm^{-2} and the density 1.1 $\times$ 10^3 kg m^{-3}, calculate the depth of the sea. Take g = 9.8 **[2]**

N kg^{-1}.

47. Calculate the speed of sound in dry hydrogen at NTP, assuming its density at NTP conditions as 0.089 kg m^{-3} and γ = 1.41. **[2]**

Section C

48. **State True or False:** **[3]**

(a) The speed of the wave along a stretched ideal string depends only on the tension and the linear mass density of the string and also depends on the frequency of the wave. **[1]**

(b) A balloon is filled with hydrogen gas. For sound waves it acts as a convex lens. **[1]**

(c) For a given string under a tension, the frequency of the vibrating string is directly proportional to the vibrating length of the string. **[1]**

49. Define wave velocity or phase velocity. Deduce its relation with angular frequency co and propagation constant k. **[3]**

50. Use the formula $v = \sqrt{\frac{\gamma P}{\rho}}$ to explain why the speed of sound in air **[3]**

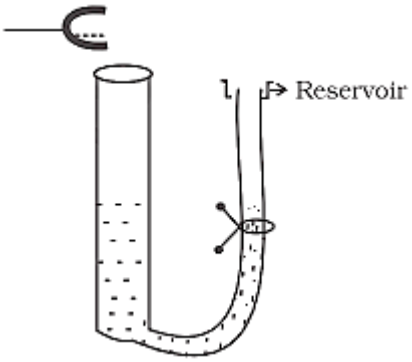
a. is independent of pressure,

b. increases with temperature,

c. increases with humidity.

51. A bat is flitting about in a cave, navigating via ultrasonic beeps. Assume that the sound emission frequency of the bat is 40 kHz. During one fast swoop directly toward a flat wall surface, the bat is moving at 0.03 times the speed of sound in air. What frequency does the bat hear reflected off the wall? **[3]**

52. A tuning fork vibrating with a frequency of 512Hz is kept close to the open end of a tube filled with water (Figure). The water level in the tube is gradually lowered. When the water level is 17cm below the open end, maximum intensity of sound is heard. If the room temperature is 20° C, calculate **[3]**



a. speed of sound in air at room temperature

b. speed of sound in air at 0° C

c. if the water in the tube is replaced with mercury, will there be any difference in your observations?

53. A simple harmonic wave train of amplitude 1 cm and frequency 100 vibrations is travelling in positive x-direction with velocity 15 ms^{-1}. Calculate the displacement y, the particle velocity, and particle acceleration at x = 180 cm from the origin at t = 5 s. **[3]**

54. A source and an observer are approaching one another with the relative velocity 40 ms^{-1}. If the true source frequency is 1200 Hz, deduce the observed frequency under the following conditions: **[3]**

i. All velocity is in the source alone.

ii. All velocity is in the observer alone.

iii. The source moves in air at 100 ms^{-1} towards the observer, but the observer also moves with the velocity v_0 in the same direction.

55. A railway engine and a car are moving on parallel tracks in opposite directions with speed of 144 kmh^{-1} and 72 kmh^{-1} , respectively. The engine is continuously sounding a whistle of frequency 500 Hz. The velocity of sound is 340 ms^{-1}. Calculate the frequency of the sound heard in the car when **[3]**

i. the car and the engine are approaching each other,

ii. the two are moving away from each other.

56. A wire of length 108 cm produces a fundamental note of frequency 256 Hz, when stretched by a weight of 1 kg. By how much its length should be increased so that its pitch is raised by a major tone, if it is now stretched by a weight of 4 kg? **[3]**

57. A source of frequency 250Hz produces sound waves of wavelength 1.32 m in a gas at STP. Calculate the change in the wavelength, when temperature of the gas is 40°C. **[3]**

58. When an engine goes away from a stationary observer, the frequency of the engine appears $\frac{6}{7}$ times the real frequency. Calculate the speed of the engine. Speed of sound in air = 330 ms^{-1}. **[3]**

Section D

59. Write Newton's formula for the speed of sound in gases. Why and what correction was applied by Laplace in this formula? Also deduce modified formula for speed of sound. **[5]**

60. Find the temperature at which sound travels in hydrogen with the same velocity as in oxygen at 1000°C. The density of oxygen is 16 times that of hydrogen. **[5]**

61. A gas is a mixture of two parts by volume of hydrogen and one part by volume of nitrogen. If the velocity of sound in hydrogen at 0°C is 1300 ms^{-1}, find the velocity of sound in the gaseous mixture at 27° C. **[5]**

62. A machine gun is mounted on an armored car. The gun can point (a) in the direction of motion or against the direction of motion of the car. The muzzle speed of the bullet equals the speed of sound in still air i.e., 340 ms^{-1}. If the car moves with a speed of 20 ms^{-1}, find out the sign and magnitude of the time difference between the bullet's arrival (t_b) and the arrival of the sound of firing (t_s) at a target 500 m away from the car at the instant of firing in each case. **[5]**

63. For the travelling harmonic wave **[5]**
$y(x, t) = 2.0 \cos 2\pi (10t - 0.0080x + 0.35)$ where x and y are in cm and t in s. Calculate the phase difference between oscillatory motion of two points separated by a distance of

a. 4 m

b. 0.5 m

c. $\frac{\lambda}{2}$

d. $\frac{3\lambda}{4}$

64. For a traveling harmonic wave $y = 2.0 \cos (10t - 0.0080x + 0.35)$ where x and y are in cm and t in s. What is the phase difference between oscillatory motion at two points separated by a distance of **[5]**

i. 4 m,

ii. 0.5 m,

iii. $\frac{\lambda}{2}$

iv. $\frac{3\lambda}{4}$?

65. Derive Newton's formula for speed of sound in an ideal gas. What is Laplace correction? **[5]**

Section E

66. **Fill in the blanks:** **[8]**

(a) The velocity of sound in a gas is directly proportional to the _____ of its absolute temperature. **[1]**

(b) The speed of a traverse wave through a string depends on _____ and _____ of the string and not on the _____ of the wave. **[1]**

(c) The velocity of a transverse wave is a 150 cm long wire of mass 5 g subjected to a tension of 1200 N is _____ ms^{-1}. **[1]**

(d) If the pressure of a gas at constant temperature is increased four times, the velocity of sound in the gas will _____. **[1]**

(e) The waves of wavelengths 1 m and 1.01 m produce 24 beats in 6 s in a gas. The speed of sound in the gas is _____ ms^{-1}. **[1]**

(f) At constant pressure, the speed of sound in a gas is _____ proportional to the _____ of its density. **[1]**

(g) A body vibrating with a certain frequency sends waves of wavelength 15 cm in a medium A and 20 cm in medium B. If the velocity of waves in A is 120 ms^{-1}, that in B will be _____ ms^{-1}. **[1]**

(h) Speed of sound in air is _____ of its frequency. **[1]**