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DPP – 4 (Sound Wave)

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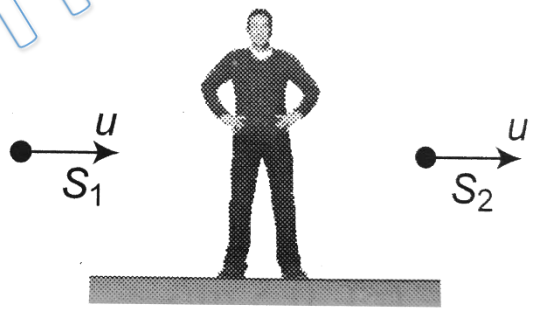
Q 1. Two sound sources are moving in opposite directions with velocities v_1 and v_2 ($v_1 > v_2$). Both are moving away from a stationary observer. The frequency of both the sources is 900 Hz. What is the value of $v_1 - v_2$ so that the beat frequency observed by the observer is 6 Hz? Speed of sound $v = 300$ m/s. [Given that v_1 and $v_2 \ll v$]

(a) 1 m/s (b) 2 m/s (c) 3 m/s (d) 4 m/s

Q 2. A sound wave of frequency n travels horizontally to the right with speed c. It is reflected from a broad wall moving to the left with speed v. The number of beats heard by a stationary observer to the left of the wall is

(a) zero (b) $\frac{n(c+v)}{c-v}$ (c) $\frac{nv}{c-v}$ (d) $\frac{2nv}{c-v}$

Q 3. Two sources S_1 and S_2 of same frequency f emits sound. The sources are moving as shown with speed u each. A stationary observer hears that sound. The beat frequency is (v = speed of sound)



(a) $\frac{2u^2 f}{v^2-u^2}$ (b) $\frac{2v^2 f}{v^2-u^2}$ (c) $\frac{2uvf}{v^2-u^2}$ (d) $\frac{2uf}{v}$

Q 4. A man moving towards a vertical cliff at a constant velocity of u m/s, fires a gun and hears the echo after t seconds. If he was at a distance of d meters from the cliff when he fired the gun, then the velocity of sound in air in m/s is

(a) $\frac{2d}{t}$ (b) $\frac{2d}{t} + u$ (c) $\frac{2d}{t} - u$ (d) $\frac{d}{t}$

Q 5. A sound source is moving with speed 50m/s towards a fixed observer. Frequency observed by observer is 1000Hz. Find out apparent frequency observed by observer when source is moving away from observer (Speed of sound = 350 m/s)
(a) 750 Hz (b) 950 Hz (c) 550 Hz (d) 350 Hz

Q 6. With what velocity an observer should move relative to a stationary source so that he hears a sound of double the frequency of source
(a) Velocity of sound towards the source
(b) Velocity of sound away from the source
(c) Half the velocity of sound towards the source
(d) Double the velocity of sound towards the source

Q 7. A motor cycle starts from rest and accelerates along a straight path at 2 m/s^2. At the starting point of the motor cycle, there is a stationary electric siren. How far has the motor cycle gone when the driver hears the frequency of the siren at 94% of its value when the motor cycle was at rest?
(Speed of sound =330 m/s)
(a) 49 m (b) 98 m (c) 147 m (d) 196 m

Q 8. An observer standing at station observers frequency 219 Hz when a train approaches and 184 Hz when train goes away from him. If velocity of sound in air is 340 m/s, then velocity of train and actual frequency of whistle will be
(a) 15.5 m/s, 200 Hz (b) 19.5 m/s, 205 Hz
(c) 29.5 m/s, 200 Hz (d) 32.5 m/s, 205 Hz

Q 9. A bus driving at 39.6 km/h is approaching a person who is standing at the bus stop, while honking repeatedly at an interval of 30 seconds. If the speed of the sound is 330 m/s, at what interval will the person hear the horn?
(a) 31 sec (b) 29 sec
(c) 30 sec (d) interval depends on distance between bus & passenger

Q 10. A source of light emitting wavelength λ = 600nm is moving away from the observer at a speed close to 1/5th the speed of light in vacuum. When observed, what will be wavelength perceived for the source?
(a) 490 nm (b) 735 nm (c) 684 nm (d) 637 nm

Q 11. An observer is revolving in a circular orbit of a radius r with time period T. A sound source is at a distance d from the center of circle. If the velocity of the sound is x m/s, then the difference between the maximum & minimum frequencies received by this observer (n is original frequency)
(a) $\frac{2\pi nr}{xT}$ (b) $\frac{2\pi nrx}{T}$ (c) $\frac{4\pi nx}{rT}$ (d) $\frac{4\pi nr}{xT}$

Q 12. An engine is moving on a circular path of radius 100 meter with a speed of 20 meter per second. The frequency observed by an observer standing stationary at the center of circular path when the engine blows a whistle of frequency 500 Hz is
(a) More than 500 Hz (b) Less than 500 Hz

(c) 500 Hz (d) no sound is heard

Q 13. A supersonic jet is moving with a velocity twice that of sound, the angle of conical wave front produced by the jet will be
(a) 120° (b) 90° (c) 60° (d) 30°

Q 14. A source and an observer move away from each other with a velocity of 10 m/s with respect to ground. If the observer finds the frequency of sound coming from the source as 1950 Hz, then actual frequency of the source is (velocity of sound in air = 340 m/s)
(a) 1950 Hz (b) 2068 Hz (c) 2132 Hz (d) 2486 Hz

Q 15. A jet plane flies through air with a velocity of 2 Mach. While the velocity of sound is 332 mis, the air speed of the plane is
(a) 166 m/s (b) 66.4 m/s (c) 332 m/s (d) 664 m/s

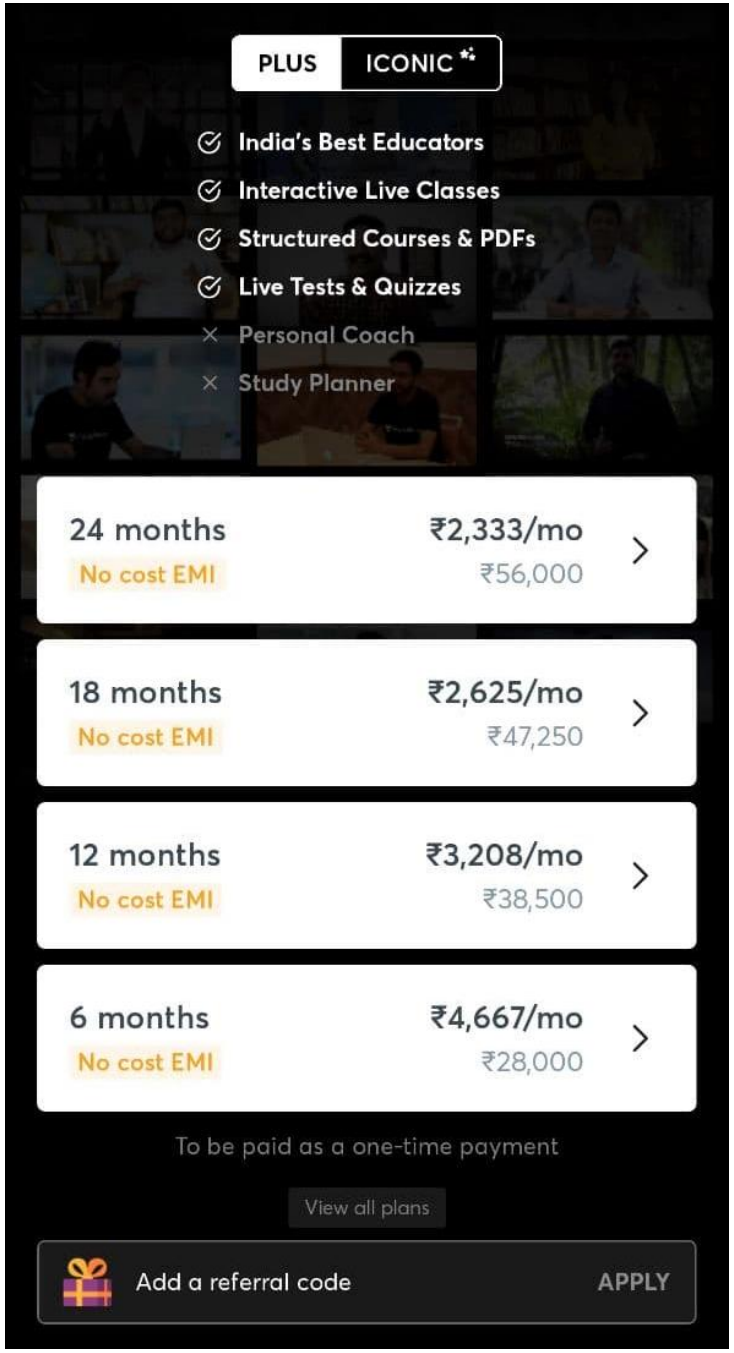
Q 16. A star is moving away from an observer with a speed of 500 km/s. Calculate the Doppler shift if the wavelength of light emitted by the star is 6000Å.
(a) 6 Å (b) 5 Å (c) 30 Å (d) 10 Å

Q 17. The apparent wavelength of light from a star moving away from earth is observed to be 0.01% more than its real wavelength. The velocity of star is
(a) 120 km/s (b) 90 km/s (c) 60 km/s (d) 30 km/s

Q 18. Earth is moving towards a fixed star with a velocity of 30km/s. An observer on earth observes a shift of 0.58Å in wavelength of light coming from star. What is the actual wavelength of light emitted by star?
(a) 5800 Å (b) 8500 Å (c) 6300 Å (d) 7800 Å

Answer Key

Q.1 b	**Q.2 d**	**Q.3 c**	**Q.4 c**	**Q.5 a**
Q.6 a	**Q.7 b**	**Q.8 c**	**Q.9 b**	**Q.10 b**
Q.11 d	**Q.12 c**	**Q.13 d**	**Q.14 b**	**Q.15 d**
Q.16 d	**Q.17 d**	**Q.18 a**		



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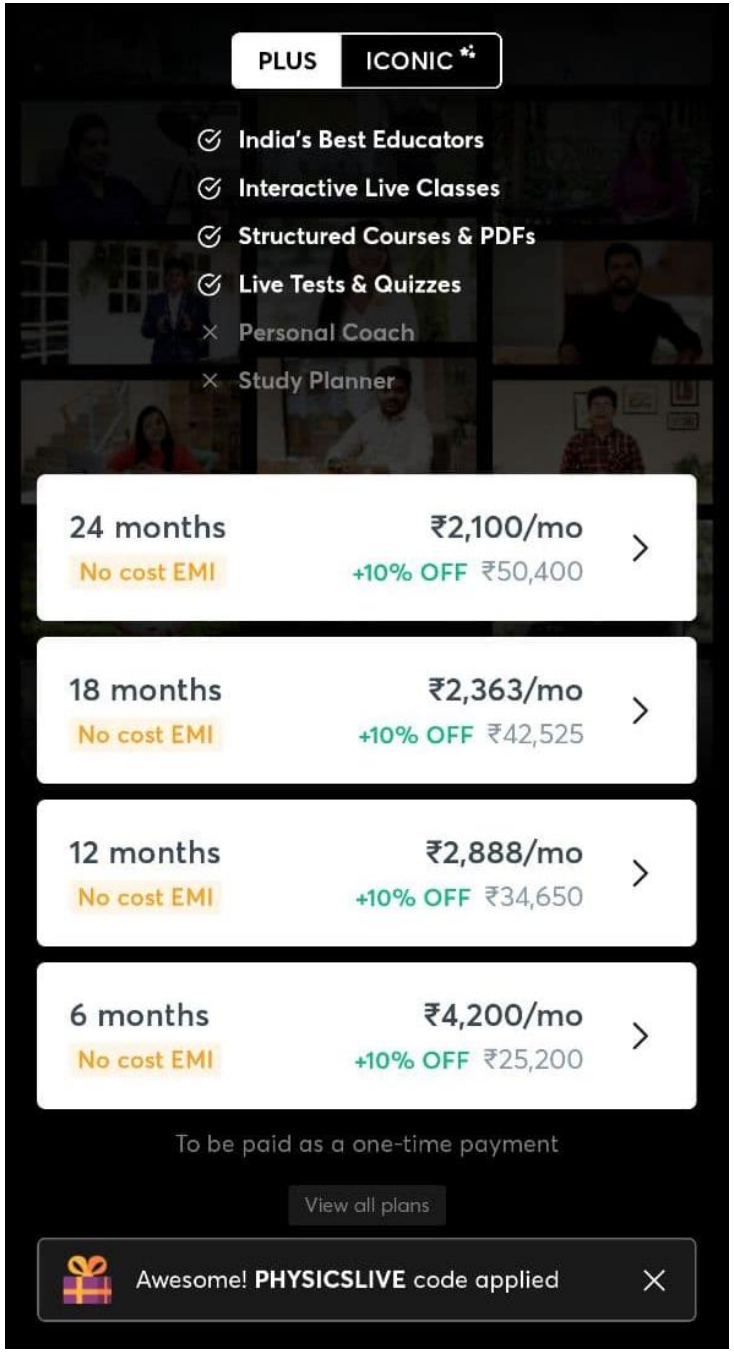
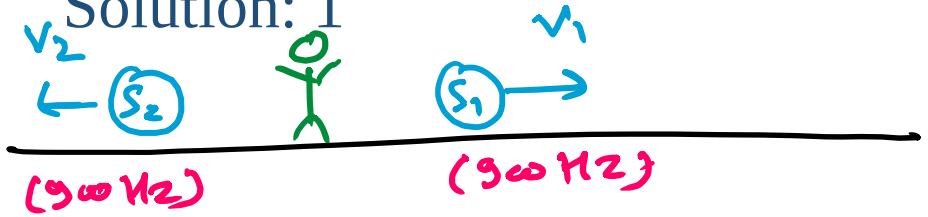


Written Solution

DPP-4 Sound Wave: Doppler's Effect

By Physicsaholics Team

Solution: 1



Apparent frequency of S_1 heard $= f_1 = \left(\frac{300+0}{300+v_1}\right) \times 900 = \left(\frac{300}{300+v_1}\right) 900$

Apparent frequency of S_2 heard $= f_2 = \left(\frac{300+0}{300+v_2}\right) \times 900 = \left(\frac{300}{300+v_2}\right) 900$

Your text here

$\therefore v_1 > v_2$ so, $f_1 < f_2$

& given ; $\Delta f = f_2 - f_1 = 6$

$\Rightarrow \left(\frac{300}{300+v_2}\right) 900 - \left(\frac{300}{300+v_1}\right) 900 = 6$

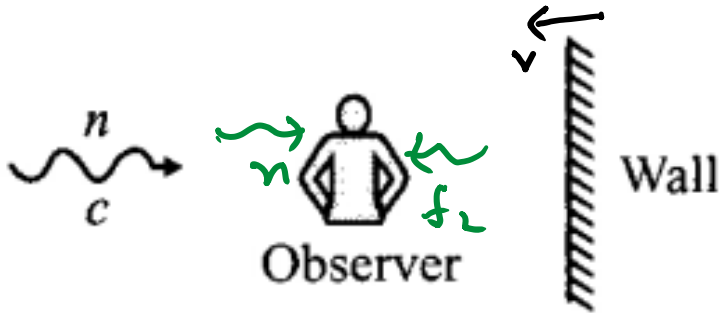
$\Rightarrow (300 \times 900)\left(\frac{300+v_1-300-v_2}{(300+v_1)(300+v_2)}\right) = 6$

as given; [v_1 & v_2 << v or 300 m/s]

so, $300 \times 900 \left(\frac{v_1 - v_2}{(300)(300)}\right) = 6 \Rightarrow \boxed{v_1 - v_2 = 2 \text{ m/s}}$ Ans

Ans. b

Solution: 2



initially wall behaves like approaching observer. so; apparent freq.

$$f_1 = \left(\frac{c+v}{c-0}\right)n = \left(\frac{c+v}{c}\right)n$$

Now wall will behave like a moving source. so;

$$f_2 = \left(\frac{c+0}{c-v}\right)f_1 = \left(\frac{c}{c-v}\right)f_1$$

$$f_2 = \left(\frac{c}{c-v}\right)\cdot\left(\frac{c+v}{c}\right)n$$

$$\Rightarrow \boxed{f_2 = \left(\frac{c+v}{c-v}\right)n}$$

So; beat frequency $= \Delta f = f_2 - n$

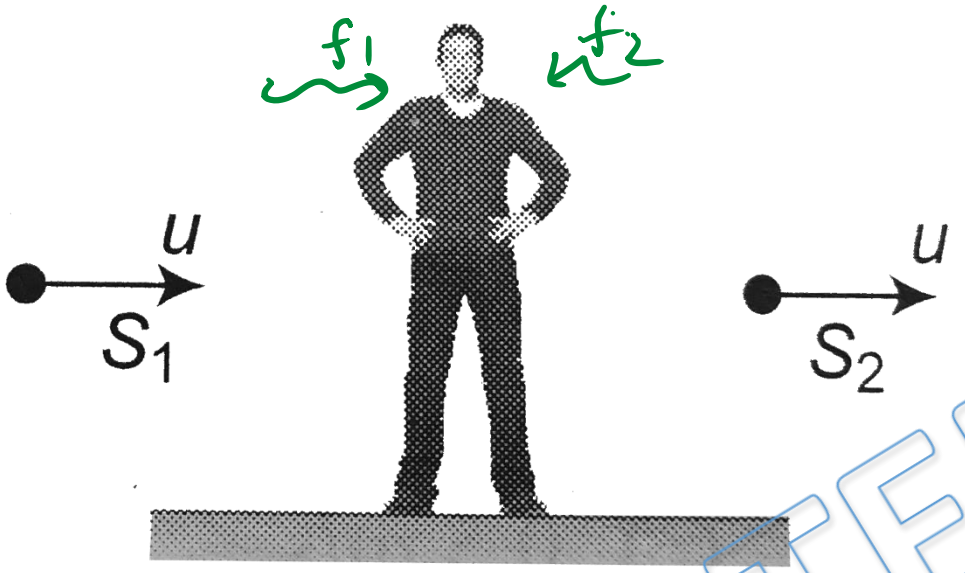
$$\Delta f = \left(\frac{c+v}{c-v}\right)n - n = n\left[\frac{c+v}{c-v} - 1\right]$$

$$= n\left[\frac{c+v-c+v}{c-v}\right]$$

$$\boxed{\Delta f = \frac{2nv}{c-v}}$$ Ans

Ans. d

Solution: 3



apparent frequencies heard :

$$f_1 = \left(\frac{v+0}{v-u}\right) f = \left(\frac{v}{v-u}\right) f$$

$$f_2 = \left(\frac{v+0}{v+u}\right) f = \left(\frac{v}{v+u}\right) f$$

beat frequency $= \Delta f = f_1 - f_2$

$$\Delta f = \left(\frac{v}{v-u}\right) f - \left(\frac{v}{v+u}\right) f$$

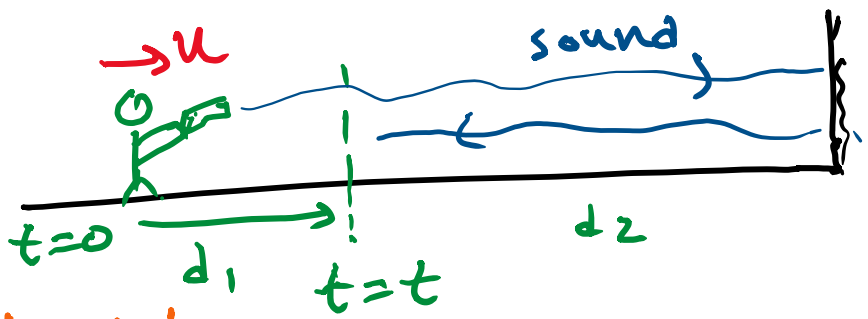
$$= vf \left[\frac{v+u-v+u}{(v-u)(v+u)}\right]$$

$$= vf \left[\frac{2u}{v^2-u^2}\right]$$

$$\boxed{\Delta f = \frac{2uvf}{v^2-u^2}}$$ Ans

Ans. c

Solution: 4



$d_1 = ut$

(in time t)

distance traveled by man $= d_1$

but, distance traveled by sound $= d_1 + d_2 + d_2$

$= d_1 + 2d_2$

let speed of sound $= v$

then, $t = \frac{d_1}{u} = \frac{d_1 + 2d_2}{v}$

$\therefore d_1 + d_2 = d$ [given]

$\boxed{d_2 = d - d_1}$

so, $\frac{d_1}{u} = \frac{d_1 + 2(d - d_1)}{v}$

$\frac{ut}{u} = \frac{ut + 2(d - ut)}{v}$

$t = \frac{ut + 2d - 2ut}{v}$

$v = \frac{2d - ut}{t}$

$\boxed{v = \frac{2d}{t} - u}$ Ans

Ans. c

Solution: 5

Source is moving towards observer

$V_s = 50$ m/s

$V_o = 0$ [$\because$ fixed observer]

apparent frequency $= f' = 1000$ Hz

Let; original frequency of source $= f_0$

then; $f' = \left(\frac{V}{V-50}\right) f_0 = 1000$ Hz — (1)

Now; when source is moving away from observer;

$f'' = \left(\frac{V}{V+50}\right) f_0$ — (2)

(1) / (2) $\Rightarrow \frac{1000}{f''} = \frac{\left(\frac{V}{V-50}\right) f_0}{\left(\frac{V}{V+50}\right) f_0}$

$\frac{1000}{f''} = \frac{V+50}{V-50} = \frac{350+50}{350-50}$

$\frac{1000}{f''} = \frac{400}{300} = \frac{4}{3}$

$f'' = 750$ Hz Ans.

Ans. a

Solution: 6

Let; frequency of source = f_0

velo. of observer = V_0

given; vel. of source = 0 m/s

& apparent frequency = $f' = 2f_0$ [$\because f' > f_0$; observer should move towards source]

so; $f' = 2f_0 = \left(\frac{V + V_0}{V + 0}\right) f_0$

$2 = \frac{V + V_0}{V}$

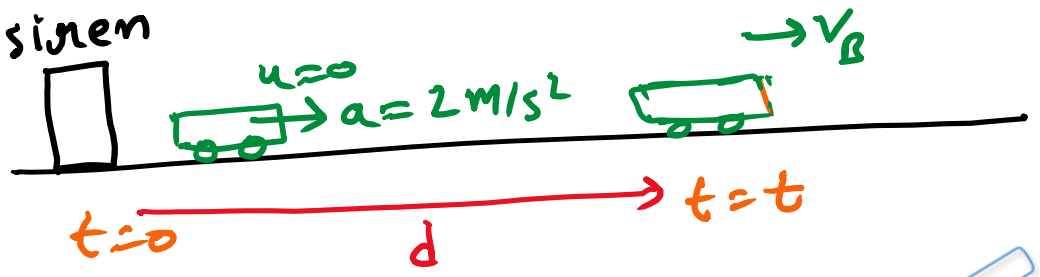
$2V = V + V_0$

$\boxed{V_0 = V}$ Ans.

And here; V = vel. of sound.

Ans. a

Solution: 7



$\therefore v^2 - u^2 = 2as$

$v_B^2 - 0 = 2(2)d$

$v_B^2 = 4d$

$\boxed{v_B = 2\sqrt{d} \text{ m/s}}$

Let; frequency of siren $= f_0$

then; heard frequency $= 94\%$ of f_0

$= 0.94 f_0$

so; $f = \left(\frac{330 - 2\sqrt{d}}{330 + 0}\right) f_0$

$0.94 f_0 = \left(\frac{300 - 2\sqrt{d}}{330}\right) f_0$

$330 - 2\sqrt{d} = 0.94 \times 330 = 310.2$

$2\sqrt{d} = 19.8$

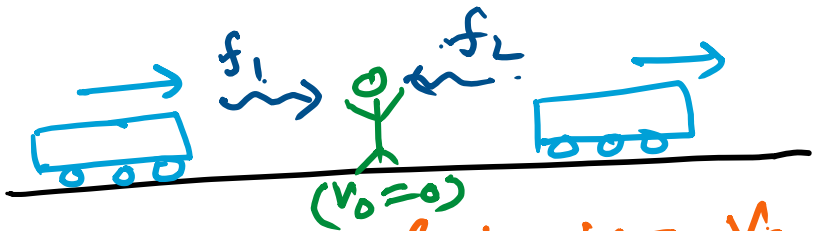
$\sqrt{d} = 9.9$

$d = 98.01 \text{ m}$

so $\boxed{d \simeq 98 \text{ m}}$ Ans

Ans. b

Solution: 8



Let; velocity of train = v_s

and freq. of train horn = f_0

So; $f_1 = 219\ Hz = \left(\frac{340+0}{340-v_s}\right) f_0$ — (1)

$f_2 = 184\ Hz = \left(\frac{340+0}{340+v_s}\right) f_0$ — (2)

$\frac{(1)}{(2)} \Rightarrow \frac{219}{184} = \frac{\left(\frac{340}{340-v_s}\right) f_0}{\left(\frac{340}{340+v_s}\right) f_0} = \frac{340+v_s}{340-v_s}$

$219(340) - 219 v_s = 184(340) + 184 v_s$

$v_s(219+184) = 340(219-184)$

$v_s = 340 \times \frac{35}{403}$

$\boxed{v_s = 29.5\ m/s}$

Put v_s in eq^n (1)

$f_0 = 219 \times \left(\frac{340-29.5}{340}\right)$

$\boxed{f_0 \simeq 200\ Hz}$

Ans. c

Solution: 9

frequency of source $= \frac{1}{30}$ Hz

speed of source towards observer $=$ speed of bus $= V_B = 39.6$ km/h $= 11$ m/s

speed of sound $= V = 330$ m/s

Let observed frequency $= f$

then $f = \left(\frac{330+0}{330-11}\right) \times \frac{1}{30}$

$f = \frac{11}{319}$

so; time period of horn heard $= \frac{1}{f} = \frac{319}{11}$ sec

$T = 29$ sec Ans

Ans. b

Solution: 10

speed of light in vacuum = $c = 3\times10^8$ m/s.

so; speed of source away from observer $= v_s = \frac{c}{5} = \frac{3}{5}\times10^8$ m/s

$\therefore$ distance btwn observer & source is increasing.

so; $f' = \left(\sqrt{\frac{c-v}{c+v}}\right) f$

$\because v = f\lambda \Rightarrow f \propto \frac{1}{\lambda}$

so; $\lambda' = \left(\sqrt{\frac{c+v}{c-v}}\right)\lambda$

$\Rightarrow \lambda' = \left(\sqrt{\frac{c+c/5}{c-c/5}}\right) 600\ nm$

$\lambda' = \left(\sqrt{\frac{6}{4}}\right)\times 600\ nm$

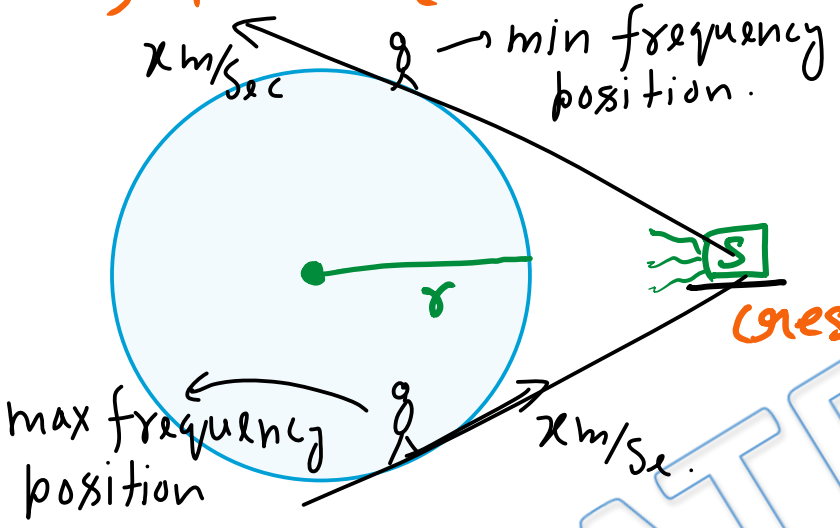
$\lambda' = \frac{\sqrt{6}}{2}\times 600\ nm$

$= \sqrt{6}\times 300\ nm$

$\boxed{\lambda' \simeq 735\ nm}$ Ans

Ans. b

Solution: 11



Let; n = freq. of source.

vel. of observer; $v_o = \frac{2\pi r}{T}$

vel. of source = $v_s = 0$

vel. of sound = $v = x$ m/s

so; max freq. heard = when source is moving in the dirn of observer (A)

so; $f_{max} = \left(\frac{x + \frac{2\pi r}{T}}{x}\right) n$ —①

so; min. freq. heard = when moving away (B)

$f_{min} = \left(\frac{x - \frac{2\pi r}{T}}{x}\right) n$ —②

① − ② ⇒ $f_{max} - f_{min} = \Delta f$

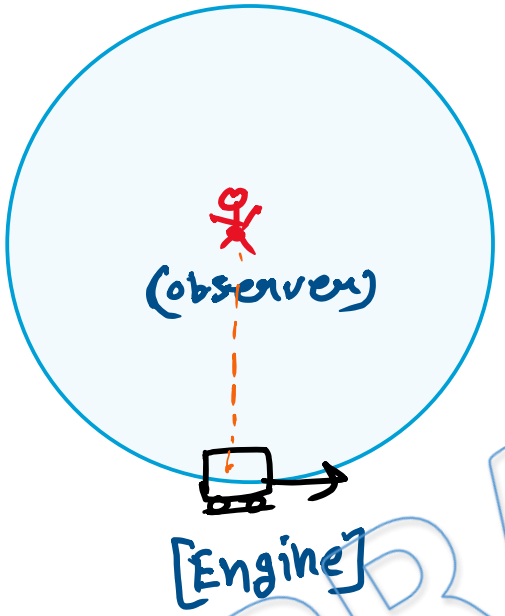
$\Delta f = \left(\frac{x + \frac{2\pi r}{T}}{x}\right) n - \left(\frac{x - \frac{2\pi r}{T}}{x}\right) n$

$\Delta f = \left(\frac{x + \frac{2\pi r}{T} - x + \frac{2\pi r}{T}}{x}\right) n$

$$\boxed{\Delta f = \frac{4\pi r n}{xT}} \text{ Ans}$$

Ans. d

Solution: 12



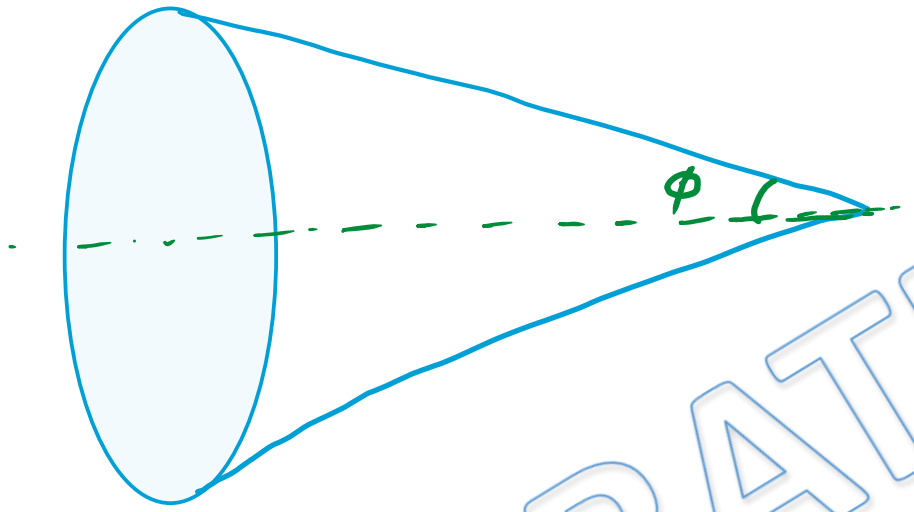
f = original frequency = 500 Hz

f' = Apparent frequency heard.

As; vel. of source/engine is always perpendicular to the dirⁿ of source. so; $\boxed{f' = f = 500\ Hz}$ Ans

Ans. c

Solution: 13



$\sin\phi = \frac{c}{v}$

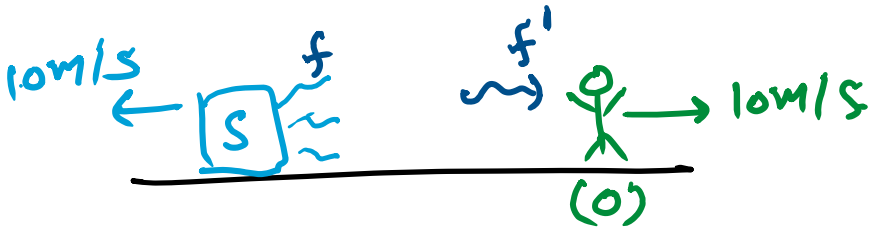
[$\because v = 2c$; given]

so; $\sin\phi = \frac{c}{2c} = \frac{1}{2}$

$\phi = 30°$

Ans. d

Solution: 14



$$\therefore f' = \left(\frac{340 - 10}{340 + 10}\right) f$$

$$1950 = \left(\frac{330}{350}\right) f$$

$$f = 1950 \times \frac{350}{330}$$

$$\boxed{f \simeq 2068 \text{ Hz}} \quad \text{Ans}$$

Ans. b

Solution: 15

Vel. of Jet ; $v = 2$ mach.

$= 2 \times$ speed of sound

$= 2 \times 332$

$= 664$ m/s

So $\boxed{v = 664 \text{ m/s}}$ Ans

Ans. d

Solution: 16

$$\Delta\lambda = \left(\frac{v}{c}\right)\lambda$$

$$= \left(\frac{500 \times 10^3 \text{ m/s}}{3 \times 10^8 \text{ m/s}}\right) \times 6000\ A^\circ$$

$$= \left(\frac{5 \times 10^5}{3 \times 10^8}\right) \times 6000\ A^\circ$$

$$= \frac{5 \times 6 \times 10^8}{3 \times 10^8}\ A^\circ$$

$$\boxed{\Delta\lambda = 10\ A^\circ}$$

Ans. d

Solution: 17

Given: $\lambda' = \lambda + (0.01\%)\lambda$

$= \lambda + \frac{0.01}{100}\lambda$

$\lambda' = \lambda + 10^{-4}\lambda$

$\lambda' - \lambda = 10^{-4}\lambda$

$$\boxed{\Delta\lambda = 10^{-4}\lambda}$$

$\therefore \Delta\lambda = \left(\frac{v}{c}\right)\lambda$

So; $\frac{v}{c} = 10^{-4}$

$v = c \times 10^{-4} = 3 \times 10^8 \times 10^{-4} = 3 \times 10^4$ m/s

$$\boxed{v = 30 \text{ km/s}}$$ Ans

Ans. d

Solution: 18

$V = 30\ km/h = 3\times10^{4}\ m/s$

$\Delta\lambda = 0.58\ A^{\circ}$

$\therefore \quad \Delta\lambda = \left(\frac{V}{c}\right)\lambda$

So; $\lambda = (\Delta\lambda)\times\frac{c}{V}$

$= 0.58\times\frac{3\times10^{8}}{3\times10^{4}}\ A^{\circ}$

$= 0.58\times10^{4}\ A^{\circ}$

$\boxed{\lambda = 5800\ A^{\circ}}$ Ans

Ans. a

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