GPN1-L11

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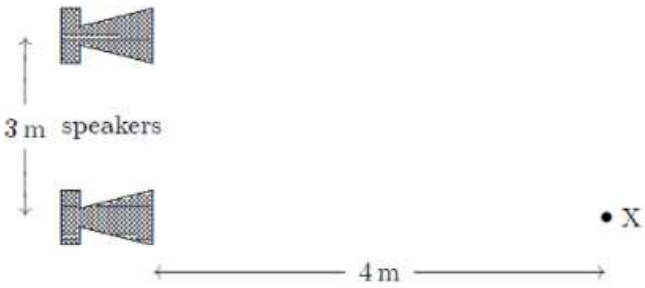
Problem 1

Answer the following questions: (05小題)

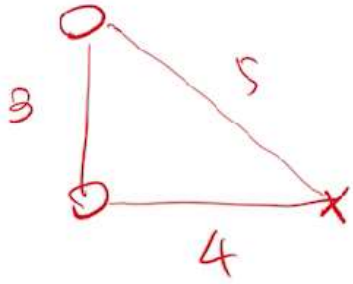
(a) Two small identical speakers are connected (in phase) to the same source. The speakers are 3 m apart and at ear level. An observer stands at X, 4 m in front of one speaker as shown in the figure. If the amplitudes are not changed, the sound he hears will be least intense if the wavelength=_____ m



01: **ANS:=2**

(b)following (a), the sound he hears will be most intense if the wavelength=_____ m

02: **ANS:=1**



$d = 5 - 4 = 1$

$d = \frac{\lambda}{2}$ → destructive

$\lambda = 2d = 2$ ← least intensive

$d = \lambda \Rightarrow$ constructive

$\lambda = 1$ ← most intensive

(c)A whistle emits a tone of frequency=170 Hz. Take the speed of sound in air to be 340m/s. The wavelength of this sound is _____ m.

$v = \lambda f$

$340 = \lambda (170) \Rightarrow \lambda = 2$

03: **ANS:=2**

(d)The sound intensity 5.0 m from a point source is 0.50 W/m^2. The power output of the source = _____ W

$P = I(4\pi r^2) = (0.5)(4\pi)(0.5)^2 = 157.1$

04: **ANS:=160**

(e)A piano wire has a length of 81 cm and a mass of 2:0 g. If its fundamental frequency is to be 394Hz, its tension=_____ N

05: **ANS:=63**

$v = \sqrt{\frac{\tau}{\mu}} \quad \tau = \mu v^2$

$v = \lambda f \quad \lambda = \frac{L}{2} = \frac{0.81}{2} = 0.405$

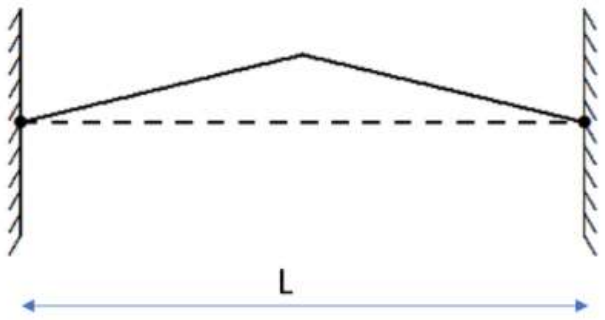
$v = (0.405)(394) = 159.6$

$\mu = \frac{0.082}{0.81} = 2.47 \times 10^{-3}$

$\tau = \mu v^2 = (2.47 \times 10^{-3})(159.6)^2 = 62.89$

Problem 2

A stretched wire of length 1.0 m is clamped at both ends. It is plucked at its center as shown. Find the three longest wavelengths in the wire. (03小題)



(a)longest, λ_1=_____ m

06: **ANS:=2**

(b)the 2nd long, λ_2=_____ m

07: **ANS:=0.667**

(3)the 3rd long, λ_3=_____ m

08: **ANS:=0.4**

兩端夾著一根長度為 1.0 m 的拉伸絃線。 如圖所示，它在其中心被撥絃。找出絃中三個最長的波長。

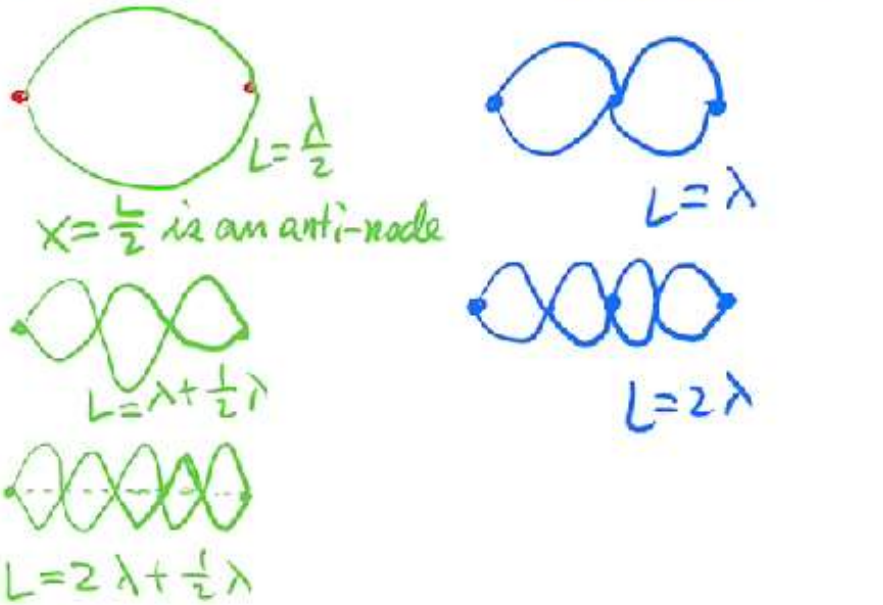
兩端固定之駐波：

$\lambda_1 = 2L$

$\lambda_1 = 2L = 2$

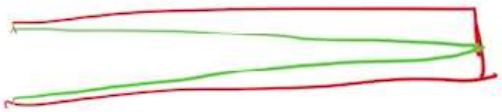
$\lambda_2 = \frac{2}{3}L = \frac{2}{3} = 0.667$

$\lambda_3 = \frac{2}{5}L = \frac{2}{5} = 0.4$



Problem 3

Answer the following questions: (05小題)



$L=\frac{1}{4}\lambda=0.425$

$\lambda=1.7$

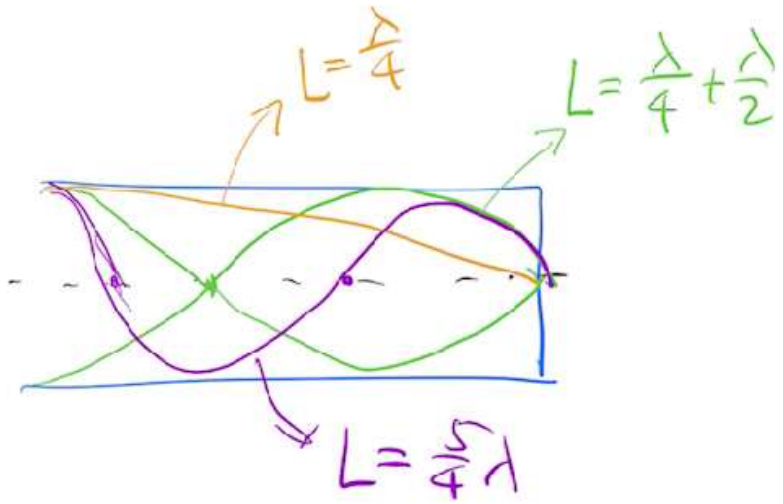
(a)A column of argon is **open at one end and closed at the other**. The shortest length of such a column that will resonate with a 200 Hz tuning fork is 42.5 cm. The speed of sound in argon=_____ m/s

09: **ANS:=340**

$v=\lambda f=1.7(200)=340$

(b)A 1024 Hz tuning fork is used to obtain a series of resonance levels in a gas column of variable length, **with one end closed and the other open**. The length of the column changes by 20 cm from resonance to resonance. From this data, the speed of sound in this gas=_____ m/s

10: **ANS:=410**



$L=\frac{\lambda}{4}+n\left(\frac{\lambda}{2}\right)$

$L_0=\frac{\lambda}{4}$

$L_1=\frac{3}{4}\lambda$

$L_2=\frac{5}{4}\lambda$

$\lambda=\frac{340}{1024}$

$=332\,cm$

$\Delta L=\frac{\lambda}{2}=0.2$

$\lambda=0.4$

$v=\lambda f=0.4(1024)$

$=409.6$

(c)If the speed of sound is 340 m/s, find the length of the shortest **closed** pipe that resonates at 218 Hz. length=_____ m

11: **ANS:=0.39**

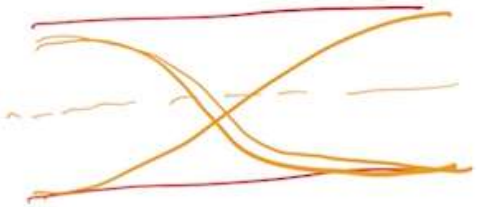
$L=\frac{\lambda}{4}=\frac{1}{4}\frac{v}{f}=\frac{1}{4}\cdot\frac{340}{218}=0.39\,(m)$

(d)The lowest tone produced by a certain organ comes from a 3.0 m pipe with **both ends open**. If the speed of sound is 340 m/s, the frequency of this tone=_____ Hz

12: **ANS:=57**

(e)When listening to tuning forks of frequency 256 Hz and 260 Hz, how many beats does one hear per second? Ans.=_____

13: **ANS:=4**



$L = \frac{\lambda}{2}$, $\lambda = 2L = 2(3) = 6$

$f = \frac{v}{\lambda} = \frac{340}{6} = 56.7$

$S(t) = (2 S_m \cos \omega' t) \cos \omega t$

$\omega' = \frac{1}{2}(\omega_1 - \omega_2)$, $\omega_1 \approx \omega_2$, $\omega_1 > \omega_2$

$\omega = \frac{1}{2}(\omega_1 + \omega_2)$

$\omega_{beat} = 2\omega'$

$f' = \frac{1}{2}(f_1 - f_2) = \frac{1}{2}(260 - 256) = 2$

$f_{beat} = 2f' = 4$

Problem 4

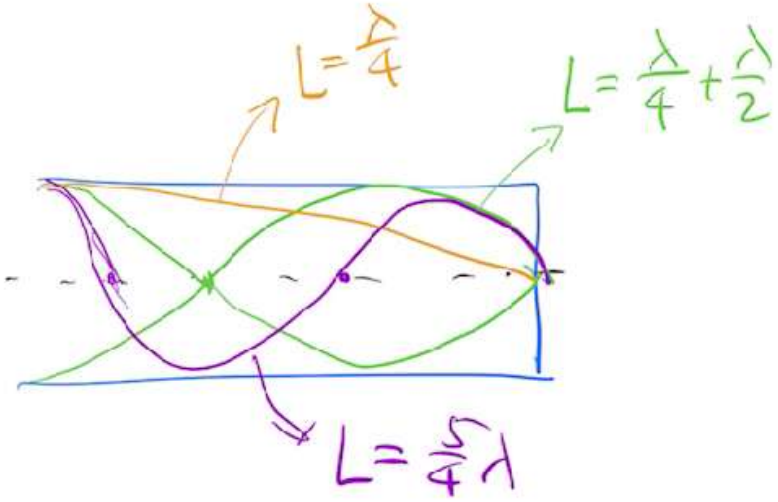
If the speed of sound is 340 m/s, find the two lowest frequencies of an 0.5 m organ pipe, closed at one end. (02小題)

(a)the lowest frequency=_____ Hz

14: **ANS:=170**

(b)the 2nd lowest frequency=_____ Hz

15: **ANS:=510**



lowest f → longest λ

$\lambda_1 = 4L \rightarrow f_1 = \frac{v}{\lambda_1} = \frac{340}{2} = 170$

$= 4(0.5)$

$= 2$

$\lambda_2 = \frac{4}{3}L = \frac{4}{3}(0.5)$ $f_2 = \frac{340}{\frac{2}{3}} = 170\times 3 = 510$

$L = \frac{\lambda}{4} + n(\frac{\lambda}{2})$

$L_0 = \frac{\lambda}{4}$

$L_1 = \frac{3}{4}\lambda$

$L_2 = \frac{5}{4}\lambda$

$\lambda = \frac{340}{1024}$

$= 332\,cm$

$\Delta L = \frac{\lambda}{2} = 0.2$

$\lambda = 0.4$

$v = \lambda f = 0.4(1024)$

$= 409.6$

Problem 5

The Doppler Effect

$$f' = f\frac{v \pm v_D}{v \pm v_S}$$

Answer the following questions: (04小題)

(a)A stationary source generates 5.0 Hz water waves whose speed is 2.0 m/s. A boat is approaching the source at 10 m/s. Find the frequency of these waves as observed by a person in the boat. frequency=_____ Hz

16: **ANS:=30**

$$f' = 5 \times \frac{v + v_D}{v} = 5 \cdot \frac{2+10}{2} = 30$$

(b)A stationary source emits a sound wave of frequency f. If it were possible for a man to travel toward the source at the speed of sound, he would observe the emitted sound to have a frequency=_____ f

17: **ANS:=2**

$$f' = f \cdot \frac{v+v}{v} = 2f$$

(c)A source emits sound with a frequency of 1000 Hz. It and an observer are moving toward each other, each with a speed of 100 m/s. If the speed of sound is 34 0m/s, the observer hears sound with a frequency=_____ Hz

18: **ANS:=1830**

$$f' = 1000 \cdot \frac{340+100}{340-100} = 1833.3$$

(d)A tuning fork of unknown frequency makes 3.00 beats per second with a standard fork of frequency 384 Hz.The beat frequency decreases when a small piece of wax is put on a prong of the first fork.What is the frequency of this fork? Ans.=_____ Hz

19: **ANS:=387**

未知頻率的音叉用頻率為 384 Hz 的標準音叉每秒產生 3.00 拍。當在第一個音叉的叉頭上放一小塊蠟時，拍頻會降低。這個音叉的頻率是多少？

Wax會使音叉頻率下降 $\omega = \sqrt{\frac{k}{m}}$ $m\uparrow, \omega\downarrow$

$f_{beat} = f_1 - f_2 \Rightarrow f_{unknown} = 381$ or 387

$3 = 384 - f_2$ 若 wax 在 381 上，$f\downarrow \Rightarrow f_{beat}\uparrow$

$= f_1 - 384$ 題意不合 $\Rightarrow f_{unk} = 387$

Problem 6

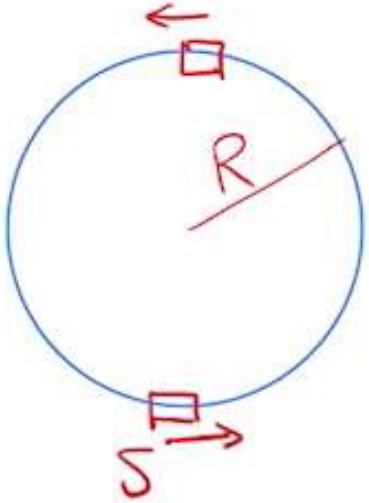
A whistle of frequency 540 Hz moves in a circle of radius 60.0 cm at an angular speed of 15.0 rad/s.What are the (a) lowest and (b) highest frequencies heard by a listener a long distance away, at rest with respect to the center of the circle? (02小題)

(a)lowest frequency=_____ Hz

20: **ANS:=526**

(b)highest frequency=_____ Hz

21: **ANS:=555**



X
D

$v_s = R\omega$

$= 0.6(15)$

$= 9$

$f' = f\dfrac{v}{v \pm v_s}$

$= 540\left(\dfrac{340}{340 \pm 9}\right)$

$= \begin{cases} 526 \\ 555 \end{cases}$