GPN1-QA7

Problem 1

Please match the SI units of the following items with the physical quantities in the questions below. Enter the number of the item you pick up for each one.

1=N; 2=rad/m; 3=W; 4=kg.m^2; 5=N.m; 6=W/m^2; 7=m/s^2; 8=kg.m/s; 9=Hz; 10=rad/s; 11=s; 12=J; 13=m/s; 14=N.m^2; 15=kg/m. (10小題)

(a)energy=_____ (Enter the number of the above items you pick up.)

01: **ANS:=12**

(b)frequency=_____

02: **ANS:=9**

(c)moment of inertia=_____

03: **ANS:=4**

(d)torque=_____

04: **ANS:=5**

(e)period=_____

05: **ANS:=11**

06: **ANS:=6**

(g)linear mass density(μ)=_____

07: **ANS:=15**

(h)momentum=_____

08: **ANS:=8**

(i)angular speed=_____

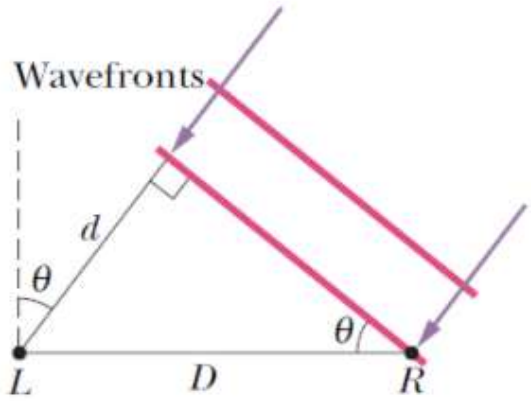
09: **ANS:=10**

(j)wave number=_____

10: **ANS:=2**

Problem 2

One clue used by your brain to determine the direction of a source of sound is the time delay Δt between the arrival of the sound at the ear closer to the source and the arrival at the farther ear. Assume that the source is distant so that a wavefront from it is approximately planar when it reaches you, and let D represent the separation between your ears. (a) If the source is located at angle $\theta = 60^\circ$ in front of you (see figure), what is Δt in terms of D and the speed of sound v in air? (b) If you are submerged in water and the sound source is directly to your right, what is Δt in terms of D and the speed of sound v_w in water? (c) Based on the time-delay clue, your brain interprets the submerged sound to arrive at an angle θ from the forward direction. Evaluate θ for fresh water at 20°C. $D = 20$ cm, $v_{air} = 343$ m/s, $v_{water} = 1482$ m/s.



大腦用來確定聲源方向的一條線索是聲音到達靠近聲源的耳朵與到達遠處耳朵之間的時間延遲 Δt。 假設源很遠，因此當它到達您時，來自它的波前近似為平面，並讓 D 代表您的耳朵之間的間隔。 (a) 如果源位於你面前的角度 $\theta = 60^\circ$（見圖），就 D 和 空氣中的聲速v？ (b) 如果你被淹沒在水中並且聲源直接在你的右邊，那麼就 D 和水中聲速 v_w 而言 Δt 是多少？ (c) 根據時間延遲線索，你的大腦將淹沒的聲音解釋為從正向到達一個角度 θ。 對 20°C 的淡水評估 θ。 $D = 20$ cm, $v_{air} = 343$ m/s, $v_{water} = 1482$ m/s。 (03小題)

(a)Δt=_____ s

11: **ANS:=5.05E-4**

(b)Δt=_____ s

12: **ANS:=1.35E-4**

(c)θ=_____ degree

13: **ANS:=13**

(a)Δt=_____ s

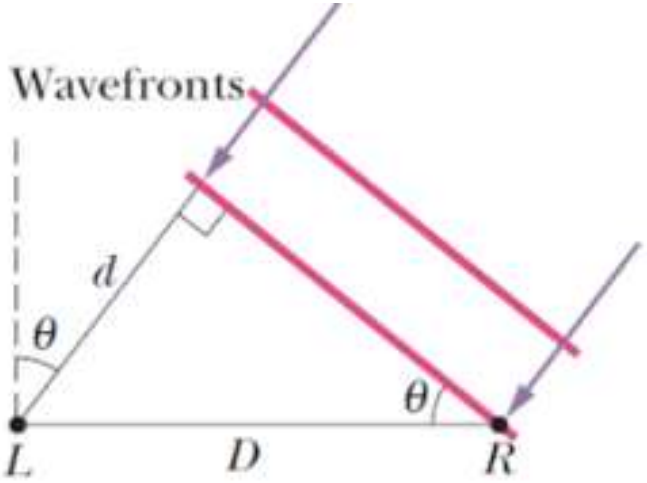
11: **ANS:=5.05E-4**

(b)Δt=_____ s

12: **ANS:=1.35E-4**

(c)θ=_____ degree

13: **ANS:=13**



(a) From the figure, we find $\Delta t = \frac{d}{v} = \frac{D \sin\theta}{v}$.

(b) Since the speed of sound in water is now v_w, with $\theta = 90°$, we have

$$\Delta t_w = \frac{D \sin 90°}{v_w} = \frac{D}{v_w}.$$

$$\Delta t = \frac{D \sin\theta}{v} = \frac{D}{v_w}. \qquad v_w = 1482 \text{ m/s}$$

$$\theta = \sin^{-1}\left(\frac{v}{v_w}\right) = \sin^{-1}\left(\frac{343 \text{ m/s}}{1482 \text{ m/s}}\right) = \sin^{-1}(0.231) = 13°$$

Problem 3

Suppose that the sound level of a conversation is initially at an angry 70 dB and then drops to a soothing 50 dB. Assuming that the frequency of the sound is 500 Hz, determine the (a) initial and (b) final sound intensities and the (c) initial and (d) final sound wave amplitudes.

假設談話的音量最初是憤怒的 70 dB，然後下降到舒緩的 50 dB。 假設聲音的頻率為 500 Hz，確定 (a) 初始和 (b) 最終聲音強度以及 (c) 初始和 (d) 最終聲波振幅。 (04小題)

(a)initial sound intensity=_____ (SI unit)

14: **ANS:=10E-6**

(b)final sound intensity=_____ (SI unit)

15: **ANS:=0.1E-6**

(c)initial sound wave amplitude=_____ m

16: **ANS:=70E-9**

(d)final sound wave amplitude=_____ m

17: **ANS:=7E-9**

Thus we find that for a $\beta = 70$ dB level we have a high intensity value of $I_{\text{high}} = 10\ \mu\text{W/m}^2$.

(b) Similarly, for $\beta = 50$ dB level we have a low intensity value of $I_{\text{low}} = 0.10\ \mu\text{W/m}^2$.

(c) $I = \frac{1}{2}\rho v \omega^2 s_m^2$ the relation between the displacement amplitude and I. Using the values for density and wave speed, we find $s_m = 70$ nm for the high intensity case.

(d) Similarly, for the low intensity case we have $s_m = 7.0$ nm.

We note that although the intensities differed by a factor of 100, the amplitudes differed by only a factor of 10.

Problem 4

One of the harmonic frequencies of tube A with two open ends is 325 Hz. The next-highest harmonic frequency is 390 Hz. (a)What is the fundamental frequency of tube A? (b) What harmonic frequency is next highest after the harmonic frequency 195 Hz? (c) What is the number n of this next-highest harmonic?

One of the harmonic frequencies of tube B with only one open end is 1080 Hz. The next-highest harmonic frequency is 1320 Hz. (d)What is the fundamental frequency of tube B? (e) What harmonic frequency is next highest after the harmonic frequency 600 Hz? (f) What is the number of this next-highest harmonic?

具有兩個開口端的管 A 的諧波頻率之一是 325 Hz。 次高諧波頻率是 390 Hz。 (a)A 管的基頻是多少？ (b) 在諧波頻率 195 Hz 之後，次高的諧波頻率是什麼？ (c) 這個次高次諧波的數 n 是多少？

只有一個開口的B管的諧波頻率之一是1080赫茲。 次高諧波頻率是 1320 Hz。 (d) B 管的基頻是多少？ (e) 諧波頻率 600 Hz 之後的次高諧波頻率是多少？ (f) 次高次諧波的次數是多少？

For tube A,

(a)the fundamental frequency, f_1=_____ Hz

18: **ANS:=65**

(b)next higher freqency after 195 Hz=_____

19: **ANS:=260**

(c)the number ($f = nf_1$) of the frequency of (b), n=_____

20: **ANS:=4**

(d)**For tube B,**

(a)the fundamental frequency, f_1=_____ Hz

21: **ANS:=120**

(e)next higher freqency after 600 Hz=_____

22: **ANS:=840**

(f)the number ($f = nf_1$) of the frequency of (e), n=_____

23: **ANS:=7**

具有兩個開口端的管 A 的諧波頻率之一是 325 Hz。 次高諧波頻率是 390 Hz。 (a)A 管的基頻是多少？ (b) 在諧波頻率 195 Hz 之後，次高的諧波頻率是什麼？ (c) 這個次高次諧波的數 n 是多少？

只有一個開口的B管的諧波頻率之一是1080赫茲。 次高諧波頻率是 1320 Hz。 (d) B 管的基頻是多少？ (e) 諧波頻率 600 Hz 之後的次高諧波頻率是多少？ (f) 次高次諧波的次數是多少？

Since the difference between consecutive harmonics is equal to the fundamental frequency (see section 17-6) then $f_1 = (390 - 325)$ Hz = 65 Hz. The next harmonic after 195 Hz is therefore (195 + 65) Hz = 260 Hz.

Since $f_n = nf_1$ then $n = 260/65 = 4$.

Only *odd* harmonics are present in tube *B* so the difference between consecutive harmonics is equal to *twice* the fundamental frequency in this case

$$f_1 = \frac{1}{2}(1320 - 1080) \text{ Hz} = 120 \text{ Hz}.$$

The next harmonic after 600 Hz is consequently [600 + 2(120)] Hz = 840 Hz.

Since $f_n = nf_1$ (for n odd) then $n = 840/120 = 7$.

Problem 5

A stationary motion detector sends sound waves of frequency 0.150 MHz toward a truck approaching at a speed of 45.0 m/s. What is the frequency of the waves reflected back to the detector?
靜止運動檢測器向以 45.0 m/s 的速度接近的卡車發送頻率為 0.150 MHz 的聲波。 反射回探測器的波的頻率是多少？ (01小題)

---

the frequency of the waves reflected back to the detector=_____ Hz

24: **ANS:=0.195E6**

We are combining two effects: the reception of a moving object (the truck of speed u = 45.0 m/s) of waves emitted by a stationary object (the motion detector), and the subsequent emission of those waves by the moving object (the truck) which are picked up by the stationary detector. This could be figured in two steps, but is more compactly computed in one step as shown here:

$$f_{\text{final}} = f_{\text{initial}}\left(\frac{v+u}{v-u}\right) = (0.150\,\text{MHz})\left(\frac{343\,\text{m/s} + 45\,\text{m/s}}{343\,\text{m/s} - 45\,\text{m/s}}\right) = 0.195\,\text{MHz}.$$

Problem 5

The explosion of a firecracker in the air at a height of 40 m produces a 100 dB sound level at the ground below. What is (a)the intensity of the sound on the ground and (b)the instantaneous total radiated power, assuming that it radiates as a point source?

鞭炮在 40 m 高度的空氣中爆炸，在下面的地面產生 100 dB 的聲級。 (a) 地面上的聲音強度和 (b) 瞬時總輻射功率是多少，假設它作為點源輻射？ (02小題)

(a)intensity=_____ SI unit

25: **ANS:=0.01**

(b)the instantaneous total radiated power=_____ W

26: **ANS:=201**

$100\ \text{dB} = 10\log(I_2/I_o) = \log I_2 + 12$, thus $\log I_2 = -2$ and $I_2 = 10^{-2}\ \text{W/m}^2$; $P = IA = (10^{-2}\ \text{W/m}^2)(4\pi r2) = 201\ \text{W}$.

Problem 6

A sound source A and a reflecting surface B move directly toward each other. Relative to the air, the speed of source A is 29.9 m/s, the speed of surface B is 65.8 m/s, and the speed of sound is 329 m/s. The source emits waves at frequency 1200 Hz as measured in the source frame. In the reflector frame, what are the (a) frequency and (b) wavelength of the arriving sound waves? In the source frame, what are the (c) frequency and (d) wavelength of the sound waves reflected back to the source?

聲源A和反射面B直接朝向彼此移動。 相對於空氣，源A的速度為29.9 m/s，B面的速度為65.8 m/s，聲速為329 m/s。 源發射頻率為 1200 Hz 的波，如在源坐標系中測量的那樣。 在反射器框架中，到達聲波的 (a) 頻率和 (b) 波長是多少？ 在源坐標系中，反射回源的聲波的 (c) 頻率和 (d) 波長是多少？ (04小題)

In reflector frame,(a)frequency=____ Hz

25: **ANS:=1.58E3**

(b)wavelength=_____ m

26: **ANS:=0.208**

In source frame,(c)frequency=____ Hz

27: **ANS:=2.168E3**

(d)wavelength=_____ m

28: **ANS:=0.152**

聲源A和反射面B直接朝向彼此移動。 相對於空氣，源A的速度為29.9 m/s，B面的速度為65.8 m/s，聲速為329 m/s。 源發射頻率為 1200 Hz 的波，如在源坐標系中測量的那樣。 在反射器框架中，到達聲波的 (a) 頻率和 (b) 波長是多少？ 在源坐標系中，反射回源的聲波的 (c) 頻率和 (d) 波長是多少？ (04小題)

with $f = 1200$ Hz and $v = 329$ m/s.

(a) In this case, $v_D = 65.8$ m/s and $v_S = 29.9$ m/s, and we choose signs so that f' is larger than f:

$$f' = f\left(\frac{329\ \text{m/s} + 65.8\ \text{m/s}}{329\ \text{m/s} - 29.9\ \text{m/s}}\right) = 1.58\times10^3\ \text{Hz}.$$

(b) The wavelength is $\lambda = v/f' = 0.208$ m.

(c) The wave (of frequency f') "emitted" by the moving reflector (now treated as a "source," so $v_S = 65.8$ m/s) is returned to the detector (now treated as a detector, so $v_D = 29.9$ m/s) and registered as a new frequency f'':

$$f'' = f'\left(\frac{329\ \text{m/s} + 29.9\ \text{m/s}}{329\ \text{m/s} - 65.8\ \text{m/s}}\right) = 2.16\times10^3\ \text{Hz}.$$

(d) This has wavelength $v / f'' = 0.152$ m.