شركة تدريب هندسي

E.CAMP

الطريق الدائري بجوار المدرسة المعمارية

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PHYSICS 1

2021 - 2022 No.18

"Molar specific Heat"

الحرارة النوعية المولية للغازات (C_v , C_p)

A specific heat at constant Volume:

$$\boxed{Q = n C_v \Delta T}$$ $C_v \rightarrow J/mol.K$

* Is the amount heat required to heat one mole of a gas $1\,\mathring{c}$, When its Volume is kept Constant.

هي كمية الحرارة اللازمة لرفع درجة حرارة مول واحد من الغاز $1\,\mathring{c}$ عند ثبات الحجم.

B specific heat at constant pressure:

$$\boxed{Q = n C_p \Delta T}$$

* Is the amount of heat required to heat one mole of a gas $1\,\mathring{c}$, When the pressure is kept Constant.

* The relation between C_v, C_p:

(i) If the tempreture increased ΔT at constant volume

$$\Delta Q = n C_v \Delta T \quad , \quad W = 0$$

$$\because \Delta E_{int} = n C_v \Delta T$$

(ii) If the tempreture increased ΔT at constant pressure

$$\therefore \Delta Q = n C_p \Delta T \quad , \quad \Delta W = -P dV$$

$$\because \Delta E_{int} = \Delta Q + \Delta W$$

$$\therefore n C_v \Delta T = n C_p \Delta T - P \Delta V$$

$$\therefore \cancel{n} C_v \cancel{\Delta T} = \cancel{n} C_p \cancel{\Delta T} - \cancel{n} R \cancel{\Delta T}$$

$$\therefore C_v = C_p - R$$

$$\therefore \boxed{C_p = C_v + R}$$

Note: "هام"

(1) $C_p = C_v + R$ $\therefore C_p > C_v$

(2) The ratio $\gamma = \frac{C_p}{C_v} > 1$

(3) $R \longrightarrow 8.317$ J/mol.K

$\boxed{4}$

	C_v	C_p	γ
هام← Monatomic غاز أحادي الذرة	1.5R	2.5R	1.67
Diatomic غاز ثنائي الذرة	2.5R	3.5R	1.4
Polyatomic غاز متعدد الذرات	3R	4R	1.33

"CH. 9 : Sound - Waves"

1 Waves Velocity: سرعة الموجات

(a) Speed of sound: سرعة الصوت

حفظ

$$\boxed{v_{air} = 343\ m/s}$$

* سرعة الصوت في الهواء ثابتة

* سرعة الصوت في أي وسط غير صلب

حفظ

liquid
gas

$$\boxed{v = \sqrt{\frac{B}{\rho}}}$$

$$v = \sqrt{\frac{\text{elastic property}}{\text{intertia property}}}$$

$B \rightarrow$ Bulk modulus $\left(B = \frac{-\Delta P}{\Delta V / V} \right)$

$\rho \rightarrow$ medium denisty كثافة الوسط

Types of sound waves

- infrasonic — الموجات تحت الصوتية — $f < 20\ Hz$
- Hearing waves — الموجات المسموعة — $20 < f < 20\ kHz$
- ultrasonic — الموجات فوق الصوتية — $f > 20\ kHz$

EX.1: Using dimensional analysis Derive a relation between the speed of the sound wave and bulk modulus in a medium with denisty (ρ).

- answer -

$$v \propto B^{x} \rho^{y}$$

$$v = K B^{x} \rho^{y} \qquad B = \frac{F}{A} = \frac{MLT^{-2}}{L^{2}}$$

$$LT^{-1} = (ML^{-1}T^{-2})^{x} (ML^{-3})^{y} \qquad = ML^{-1}T^{-2}$$

$$M^{0} L^{1} T^{-1} = M^{x+y} L^{-x-3y} T^{-2x}$$

$$-1 = -2x \Rightarrow x = \frac{1}{2}$$

$$0 = x + y \Rightarrow y = \frac{-1}{2}$$

$$v = K B^{\frac{1}{2}} \rho^{-\frac{1}{2}} \Rightarrow \boxed{v = K\sqrt{\frac{B}{\rho}}}$$

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* **Wavelength (λ):** الطول الموجي

$$\boxed{\lambda = \frac{v}{f}}$$

السرعة / التردد

حبل

(b) Speed of wave traveling in rope:

حفظ

$$\boxed{v = \sqrt{\frac{F}{\mu}}} \quad m/s$$

$F \rightarrow$ tension force (τ)

$\mu \rightarrow$ mass per unit length $\left(\mu = \frac{m}{L}\right)$

EX: Derive a relation between the speed of transverse wave in a string (خيط) with the tension force and the string mass per unit length.

- answer -

$v \propto F^{x} \mu^{y}$

$v = K F^{x} \mu^{y}$

$L T^{-1} = (M L T^{-2})^{x} (M L^{-1})^{y} = M^{x+y} L^{x-y} T^{-2x}$

$\therefore -1 = -2x \Rightarrow x = \frac{1}{2}$ & $y = \frac{-1}{2}$

$\therefore v = K F^{\frac{1}{2}} \mu^{\frac{-1}{2}} \Rightarrow \boxed{v = K\sqrt{\frac{F}{\mu}}}$

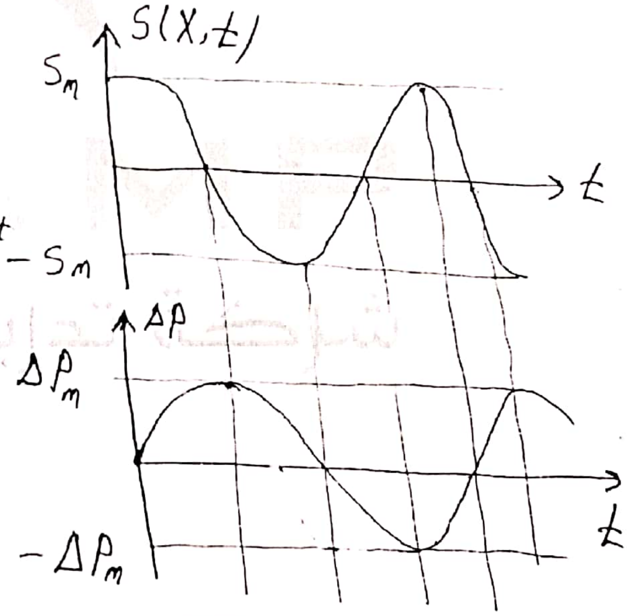
(c) Sound Waves equations:

(1) Displacement: الإزاحة

$$\boxed{S(X,t) = S_m \cos(KX - \omega t)}$$

(2) Pressure:

$$\boxed{\Delta P(X,t) = \Delta P_m \sin(KX - \omega t)}$$



Where:

$S_m \rightarrow$ maximum displacement (Amplitude)

$\Delta P_m \rightarrow$ maximum Pressure (Amplitude)

$$\boxed{K = \frac{2\pi}{\lambda}}$$ angular wave number

$$\boxed{\omega = 2\pi f}$$

$$\boxed{\Delta P_{max} = \rho \omega v S_m}$$

$\rho \rightarrow$ density

$v \rightarrow$ Velocity

(+)

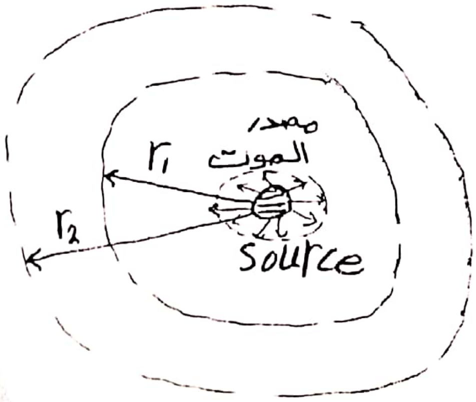
2 Sound intenisty : شدة الصوت

حفظ

$$\boxed{I = \frac{Power}{area}} \quad W/m^2$$

حفظ

$$\boxed{I_1 = \frac{P}{4\pi r_1^2}}$$



$$\boxed{I_2 = \frac{P}{4\pi r_2^2}}$$

مساحة سطح الكرة $4\pi r^2$

$$\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$$

$$\therefore \boxed{I \propto \frac{1}{r^2}}$$

inverse-square law

قانون التربيع العكسي

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* Threshold intenisty (I_0) :

حفظ

$$\boxed{I_0 = 10^{-12}\ W/m^2}$$

أقل شدة صوت يمكن أن يسمعها الإنسان

* Intenisty in decibels: الديسيبل

$(\pm)$

$$\boxed{\beta = 10 \log\left(\frac{I}{I_0}\right) \text{ dB}}$$

هامي

$I_0 \rightarrow 10^{-12}$

EX.1: If you place your alarm clock 3 times closer to your bed, how many times the sound intenisty will be greater?

قلل مسافة المنبه ٣ مرات
$3^2 = 9$

~answer~

$I \propto \frac{1}{r^2}$ $\quad r_2 = \frac{1}{3} r_1 \Rightarrow \boxed{I_2 = 9 I_1}$

EX.2: Find the sound level in dB

(a) $I = 10^{-5}$ W/m² $\quad$ (b) $I_0 = 10^{-12}$ W/m²

~answer~

(a) $\beta = 10 \log\left(\frac{I}{I_0}\right) = 10 \log\left(\frac{10^{-5}}{10^{-12}}\right) = \boxed{70 \text{ dB}}$

(b) $\beta = 10 \log\left(\frac{I}{I_0}\right) = 10 \log\left(\frac{10^{-12}}{10^{-12}}\right) = \boxed{0 \text{ dB}}$

threshold intenisty

3 Doppler equation: تأثير دوبلر

* يحدث تأثير دوبلر في حالة تحرك مصدر الصوت أو المستمع أو كلاهما.

* ينتج عنه تغير في تردد الموجات الصوتية.

$$\boxed{f_L = f_s \left[\frac{v \pm v_L}{v \mp v_s} \right]}$$

هام جداً

التردد الذي يصل للمستمع

$F_L \rightarrow$ Frequency as heard by a listener

التردد الخارج من المصدر

$F_s \rightarrow$ Frequency as produced by the source

$v \rightarrow$ speed of sound in medium

$v_L \rightarrow$ speed of the listener

$v_s \rightarrow$ speed of the source

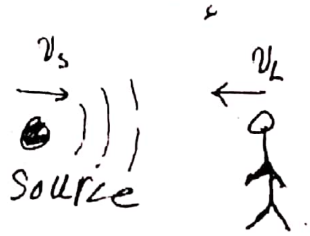
* الإشارات

المستمع يقترب ← (+)

(−) → المستمع يبتعد

المصدر يقترب ← (−)

(+) → المصدر يبتعد



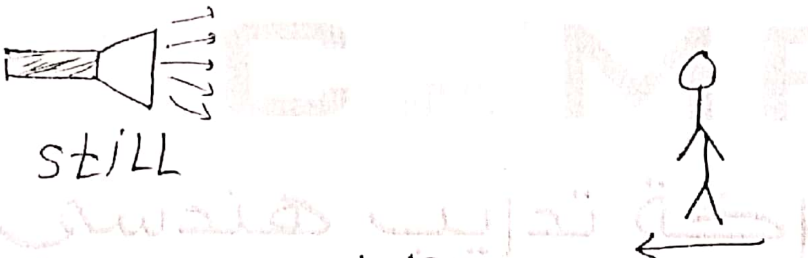
نقية يولد ميكروفون

EX.1: The horn is producing a pure 1000Hz tone (نغمة), the speed of sound in air is 343 m/s. Find

The frequency as heared by the listner in various motion scenarios.

(a)

(b)



"answer"

$$(a)\quad F_L = F_s\left(\frac{v+\cancelto{0}{v_L}}{v-v_s}\right) = 1000\left(\frac{343}{343-10}\right) = \boxed{1030Hz}$$

$$(b)\quad F_L = F_s\left(\frac{v+v_L}{v-\cancelto{0}{v_s}}\right) = 1000\left(\frac{343+10}{343}\right)$$

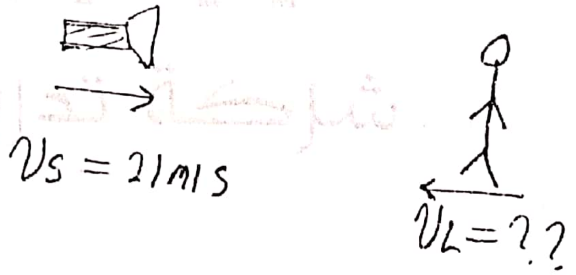
$$= \boxed{1029Hz}$$

EX.2: A man drives at 21 m/s and toots his horn, His horn sounds at 650 Hz, a girl hears the horn at 750 Hz, when they are heading toward each other, How fast should she drive.

→ The speed of sound is 343 m/s

~ answer ~

$$F_L = F_s \left(\frac{V + V_L}{V - V_s} \right)$$



$$\therefore 750 = 650 \left(\frac{343 + V_L}{343 - 21} \right)$$

$$\therefore \boxed{V_L = 28.5 \text{ m/s}}$$

هام جداً

الخلاصة

"Sound-Waves"

1 Speed of sound:

$\boxed{v_{air} = 343\ m/s}$, liquid / gas $\boxed{v = \sqrt{\frac{B}{\rho}}}$, solids $\boxed{V = \sqrt{\frac{Y}{\rho}}}$

$B \rightarrow$ Bulk Modulus $\quad Y \rightarrow$ Young Modulus

2 in string:

$\boxed{v = \sqrt{\frac{\tau}{\mu}}}$ $\quad \tau \rightarrow$ tension

$\boxed{\mu = \frac{m}{L}}$ mass per unit length

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3 Displacement:

$s(t) = s_{max} \cos(kx - wt)$

4 Pressure:

$\Delta P = \Delta P_{max} \sin(kx - w)$

where $\boxed{\Delta P_{max} = \rho v w s_{max}}$, $k = \frac{2\pi}{\lambda}$, $w = 2\pi f$

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5 Sound intensity:

$I = \frac{Power}{area} = \frac{1}{2} \rho v (w s_{max})^2$

6 Sound Level:

$\beta = 10 \log\left(\frac{I}{10^{-12}}\right)$ dB

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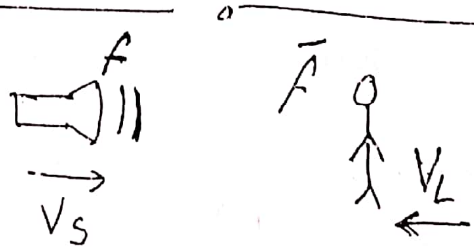
7 Doppler effect:



$$\boxed{\bar{f} = f\ \frac{V \pm V_L}{V \mp V_s}}$$

المستمع يقترب

المصدر يقترب

Sound Waves

Please Choose the Correct Answer

1. The speed of a sound wave is determined by:
A) its amplitude B) its intensity C) its pitch D) number of harmonics present
E) the transmitting medium

2. Take the speed of sound to be 340 m/s. A thunder clap is heard about 3 s after the lightning is seen. The source of both light and sound is:
A) moving overhead faster than the speed of sound B) emitting a much higher frequency than is heard C) emitting a much lower frequency than is heard D) about 1000 m away E) much more than 1000 m away

* 3. A sound wave has a wavelength of 3.0 m. The distance from a compression center to the adjacent rarefaction center is:
A) 0.75 m B) 1.5 m C) 3.0 m D) need to know wave speed
E) need to know frequency

4. The velocity of sound in sea water is 1533 m/s. Find the bulk modulus (in N/m^2) of sea water if its density is 1.025×10^3 kg/m^3.
A) 2.6×10^9 B) 2.2×10^9 C) 2.0×10^9 D) 2.4×10^9 E) 2.8×10^9

5. A sculptor strikes a piece of marble with a hammer. Find the speed of sound through the marble (in km/s). (The Young's modulus is 50×10^9 N/m^2 and its density is 2.7×10^3 kg/m^3.)
A) 5.1 B) 4.3 C) 3.5 D) 1.3 E) 1.8

6. The Young's modulus for aluminum is 7.02×10^{10} N/m^2. If the speed of sound in aluminum is measured to be 5.10 km/s, find its density (in kg/m^3).
A) 11.3×10^3 B) 7.80×10^3 C) 2.70×10^3 D) 29.3×10^3 E) 1.40×10^3

7. Calculate the pressure amplitude (in N/m^2) of a 500 Hz sound wave in helium if the displacement amplitude is equal to 5×10^{-8} m. ($\rho = 0.179$ kg/m^3, $v = 972$ m/s.)
A) 3.5×10^{-2} B) 1.6×10^{-2} C) 2.7×10^{-2} D) 4.2×10^{-2}
E) 2.0×10^{-2}

8. Determine the intensity (in W/m^2) of a harmonic longitudinal wave with a pressure amplitude of 8×10^{-3} N/m^2 propagating down a tube filled with helium. ($\rho = 0.179$ kg/m^3, $v = 972$ m/s.)
A) 3.7×10^{-7} B) 1.8×10^{-7} C) 9.2×10^{-8} D) 4.6×10^{-8}
E) 1.5×10^{-9}

10. Calculate the intensity level in dB of a sound wave that has an intensity of 15×10^{-4} W/m^2.

A) 20 B) 200 C) 92 D) 9 E) 10

* 11. A jet plane has a sound level of 150 dB. What is the intensity in W/m^2?

A) 1 B) 100 C) 10 D) 1000 E) 10000

* 12. Which one of the following statements is true?

A) Both the intensity level (in dB) and the sound intensity can never be negative.
B) The intensity level (in dB) obeys an inverse-square distance law, but the sound intensity does not.
C) Both intensity level (in dB) and sound intensity obey inverse-square distance laws.
D) The sound intensity can never be negative, but the intensity level (in dB) can be negative.
E) Both the intensity level (in dB) and the sound intensity can be negative.

* 13: When a rocket is traveling toward a mountain at 100 m/s, the sound waves from this rocket's engine approach the mountain at speed V. If the rocket doubles its speed to 200 m/s, the sound waves from the engine will now approach the mountain at speed

A) $4V$. B) $2V$. C) $\sqrt{2}\,V$. D) V.

* 14. A plane flies toward a stationary siren at 1/4 the speed of sound. Then the plane stands still on the ground and the siren is driven toward it at 1/4 the speed of sound. In both cases, a person sitting in the plane will hear the same frequency of sound from the siren.

A) True B) False

15. A stone is thrown into a quiet pool of water. With no fluid friction, the amplitude of the waves falls off with distance r from the impact point as

A) $1/r^3$ B) $1/r^2$ C) $1/r^{3/2}$ D) $1/r^{1/2}$ E) $1/r$