PHYS 1511 Discussion Section: Week 14

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Review

Chapter 15: Thermodynamics

-Thermal Processes (Isobaric, Isothermal, Isochoric, adiabatic)

Chapter 16: Waves and Sound

-The Nature of Waves

-Periodic Waves

-Speed of a wave on a string

-The mathematical description of a wave

-Sound/Speed of sound

-Sound intensity

-Decibels

-The doppler Effect

Review (cont.)

Chapter 17: The principle of linear superposition and interference phenomena

- -Principle of Linear Superposition in Waves
- -Constructive and Destructive interference of sound waves
- -Beats
- -Transverse standing waves
- -Longitudinal standing waves
- -Complex Sound Waves

Equations

Chapter 15:

$$W = P\Delta V \qquad \text{(Work done in Isobaric Process)} \qquad (1)$$

$$W = nRT \ln\left(\frac{V_f}{V_i}\right) \qquad \text{(Work done by Ideal Gas - Isothermal)} \qquad (2)$$

$$W = \frac{3}{2}nR(T_i - T_f) \qquad \text{(Work done by idea gas - adiabatic)} \qquad (3)$$

Equations

Chapter 16:

$$f = \frac{1}{T} \qquad \text{(Definition of frequency)} \tag{4}$$

$$v = f\lambda \qquad \text{(\textbf{General} equation for wave velocity)} \tag{5}$$

$$y = A\sin\left(2\pi tf \pm \frac{2\pi x}{\lambda}\right) \qquad \text{(Wave equation with } \pm \text{ directionality)} \tag{6}$$

Equations

Speed of Sound in a medium:

$$v = \sqrt{\frac{F}{m/L}} \qquad \text{(Speed of wave on a string)} \tag{7}$$

$$v = \sqrt{\frac{\gamma k T}{m}} \qquad \text{(In ideal gas for } \gamma = C_p/C_V\text{)} \tag{8}$$

$$v = \sqrt{\frac{B_{ad}}{\rho}} \qquad \text{(In liquid for adiabatic bulk modulus } B_{ad}\text{)} \tag{9}$$

$$v = \sqrt{\frac{Y}{\rho}} \qquad \text{(In solid for Young's Modulus Y)} \tag{10}$$

Equations

$$\mathrm{I} = \frac{P}{A} = \frac{P}{4\pi r^2} \qquad \text{(Sound Intensity for spherical radiation)} \qquad (11)$$

$$\beta = (10dB)\log_{10}\left(\frac{\mathrm{I}}{\mathrm{I_o}}\right) \qquad \text{(Sound Intensity)} \qquad (12)$$

(Generally use threshold for hearing, $\mathrm{I}_o = 10^{-12} W/m^2$, for reference.)

$$f_o = f_s\left(\frac{1 \pm \frac{v_o}{v}}{1 \mp \frac{v_s}{v}}\right) \qquad \text{(Doppler Effect)} \qquad (13)$$

Note on Doppler shift:
Numerator: (+) if observer moving towards source (-) if observer moving away from source
Denominator: (-) if source moving towards observer (+) if source moving away from observer

Equations

Chapter 17:

$$\sin\theta = \frac{\lambda}{D} \qquad \text{(General Diffraction)} \tag{14}$$

*θ corresponds to the first minimum Intensity

$$\sin\theta = 1.22\frac{\lambda}{D} \qquad \text{(Diffraction Circular Opening)} \tag{15}$$

$$f_b = |f_1 - f_2| \qquad \text{(Beat Frequency)} \tag{16}$$

$$f_n = n\left(\frac{v}{2L}\right), n = 1, 2, 3\ldots \qquad \text{(Standing Waves [Transverse])} \tag{17}$$

$$f_n = n\left(\frac{v}{2L}\right), n = 1, 2, 3\ldots \qquad \text{(Longitudinal Standing Waves (Open))} \tag{18}$$

$$f_n = n\left(\frac{v}{4L}\right), n = 1, 3, 5\ldots \qquad \text{(Longitudinal Standing Waves (1/2 closed))} \tag{19}$$

Question #1

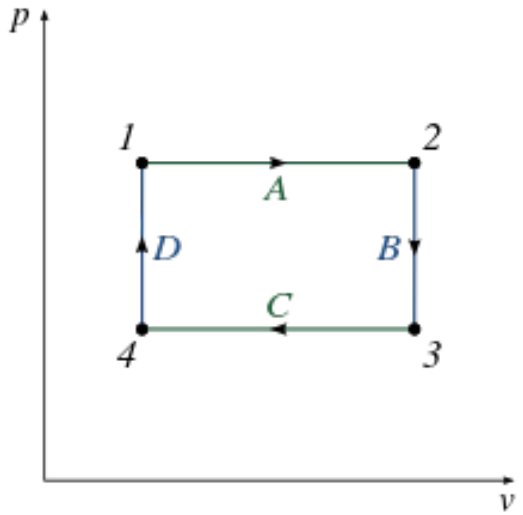
Static Physics

For the P-V diagram below, answer the following:

(1) For each path (A-D) name the type of thermodynamic process

(2) Consider path C. If at point 3 the pressure was 130,000 Pa and volume $0.226923 m^3$, what is the work done on the system if at point 4 the volume is $0.15 m^3$?

(3) What is the work done on the system in path D?



Question #2

A light physics problem

Light is an electromagnetic wave and travels at a speed (in space) of **exactly** 299,792,458 m/s. The human eye is most sensitive to yellow-green light, which has a wavelength of $5.45 \times 10^{-7} m$. What frequency of light is this?

Double trouble

The middle C string on a piano is under a tension of 944N. The period and wavelength of a wave on this string are 3.82ms and 1.26m, respectively. Find the linear density of the string.

Question #3

Every Hawkeye Game

When one person shouts at a football game, the sound intensity level at the center of the field is 60.0 dB. When all the people shout together, the intensity level increases to 109 dB. Assuming that each person generates the same sound intensity at the center of the field:

(a) How many people are at the game? (round up)

(Note: dB are **not** on a linear scale i.e. 2 people scream at 2 dB does **not** imply 4 people scream at 4 dB)

(b) What is the total power emitted from the stadium 1.1 mile away in terms of the reference intensity I_o?
(assuming negligible loss of power due to buildings, air etc)

1 mile = 1.609344 km

Question #4

Thermal Sound

Sound exits a diffraction horn loudspeaker through a rectangular opening like a small doorway. Such a loudspeaker is mounted outside on a pole. In winter, when the temperature is $273^{\circ}K$, the diffraction angle θ has a value 15.0°. What is the diffraction angle for the same sound on summer day when the temperature is $311^{\circ}K$.

Question #4

Thermal Sound

Sound exits a diffraction horn loudspeaker through a rectangular opening like a small doorway. Such a loudspeaker is mounted outside on a pole. In winter, when the temperature is $273^{\circ}K$, the diffraction angle θ has a value 15.0°. What is the diffraction angle for the same sound on summer day when the temperature is $311^{\circ}K$.

Hint: Assume air to be an ideal gas and that frequency of the waves doesn't change.

Question #5

Air Physics

The fundamental frequencies of two air columns are the same. Column A is open at both ends, while column B is open at only one end. The length of column A is 0.7m. What is the length of column B? (The figure below is not directly related to the problem but helps you see waves in a pipe)