Exam IV Details:
Exam IV will take place in rooms HECC-108 on November 30th, 2023 from 7:00pm – 9:00pm. It is a common exam, all sections of PHYS 201 will take the same exam at this given time and location. Please arrive at least 10 minutes early to get settled; we would like to begin exactly on time. If you have any questions during the exam, you may call over one of the proctors monitoring the exam.

Chapters to be covered on exam 4 :12, 13.1-13.3, 14, 15, 16

Items to bring:

- Pencil and eraser
- Scientific Calculator (up to a Ti-84 is allowed)
- Yourself

Items *not* to bring:

- Your own formula sheet (one will be provided on exam)
- Scantron (one will be provided on exam)
- Computerized Calculator (example: Ti-nspire with touchpad keyboard)
- A laptop, tablet, or phone (all computer devices should be kept powered off and left in your bag for the duration of the exam)
- Any other prohibited item

Concepts to review:

- Waves
  - Wave types
    - Transverse
      - Waves where the amplitude is at a right angle (aka transverse) to the direction of travel. Ex. Ocean wave
    - Longitudinal
      - Wave where the amplitude is along the line (aka longitudinal) to the direction of travel. Ex. Sound wave
  - Description of a wave
    - Amplitude(A): Distance from peak of wave to center of wave (or from dip to center).
    - Wavelength(λ): Distance from peak to peak of wave (or dip to dip).
    - Frequency(f): Number of wavelengths per unit of time
    - Wave speed(v): Distance a single wavelength travels in a given amount of time ($v=f*\lambda$)
  - Interference
    - Constructive
      - When waves add together.
      - $|d_2-d_1|=m\lambda$ (not on formula sheet)

        - Destructive
            - When waves cancel each other.
            - $|d_2-d_1|=(m+1/2)\lambda$ (not on formula sheet)
    - Standing waves: Special wave type which do not appear to stand in the same location. Requires at least one "boundary" (think rope tied to wall)
        - Nodes
            - Stationary part of the wave.
        - Anti-node
            - Peak (or dip) location of the wave.
        - Harmonics
            - Fundamental: The longest (lowest frequency, f_1) wave possible. n=1
            - n'th Harmonic: the wave with $n*f_1$ frequency.
        - Overtones
            - All harmonics above the fundamental (i.e., n>1)
            - Note: the first overtone is the second harmonic.
        - Resonance
            - Both harmonics and overtones are a type of resonance.

- Fluid Statics
    - Density of a liquid
        - ρ = mass/volume
    - Pressure
        - P=Force/Area
            - Pressure is the (normal) force divided across the area the force is applied to.
        - $P_0=P_{atm} + \rho gh$
            - The stationary pressure on any vertical part of liquid is the atmospheric pressure + the weight (ρg) of the liquid above that point (h).
    - Buoyancy
        - $F=\rho_{fluid}V_{displaced}g$
            - Buoyancy force depends on the density of the liquid, and the volume of liquid displaced by the object.

- Thermodynamics
    - Temperature
    - Expansion & Heat
    - Phase Changes
        - Enthalpy of formation
    - Thermal Transfer
        - Conduction
        - Convection
        - Radiation
    - Ideal Gas Law

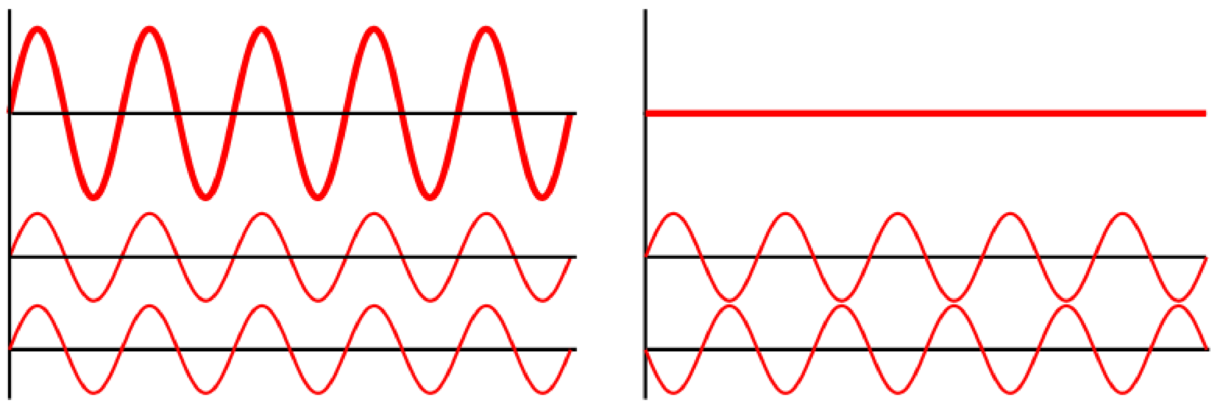
    - PV=nRT
- Laws of Thermodynamics (Chap. 15, 16)
- Processes & Cycles (Chap. 16)
    - PV graph
    - Isothermal
    - Isochoric
    - Isobaric
    - Adiabatic
- Engines
    - Carnot
    - Heat engine/refrigerator

Useful Review

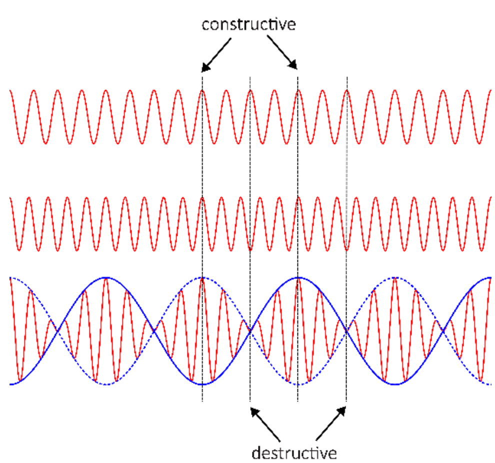
Constructive and Destructive interference

Constructive interference is when two waves peaks and dips (crest and troughs) overlap with each other, causing them to add together into a stronger wave. For waves which have different starting locations (but same wavelength), the formula to determine at what distance they constructively interfere is $|d_2\text{-}d_1|=m\lambda$. m represents every instance where they interfere, starting at the closest spot, m=0 (the m=0 case is when the waves have the same starting location).

Destructive interference is when the peak from one wave overlap with another waves dip, causing them to cancel out. For waves which have different starting locations (but same wavelength), the formula to determine at what distance they destructively interfere is $|d_2\text{-}d_1|=(m+1/2)\lambda$. m represents every instance where they interfere, starting at the closest spot, m=0 (the m=0 case is the shortest starting distance two identical waves can have).

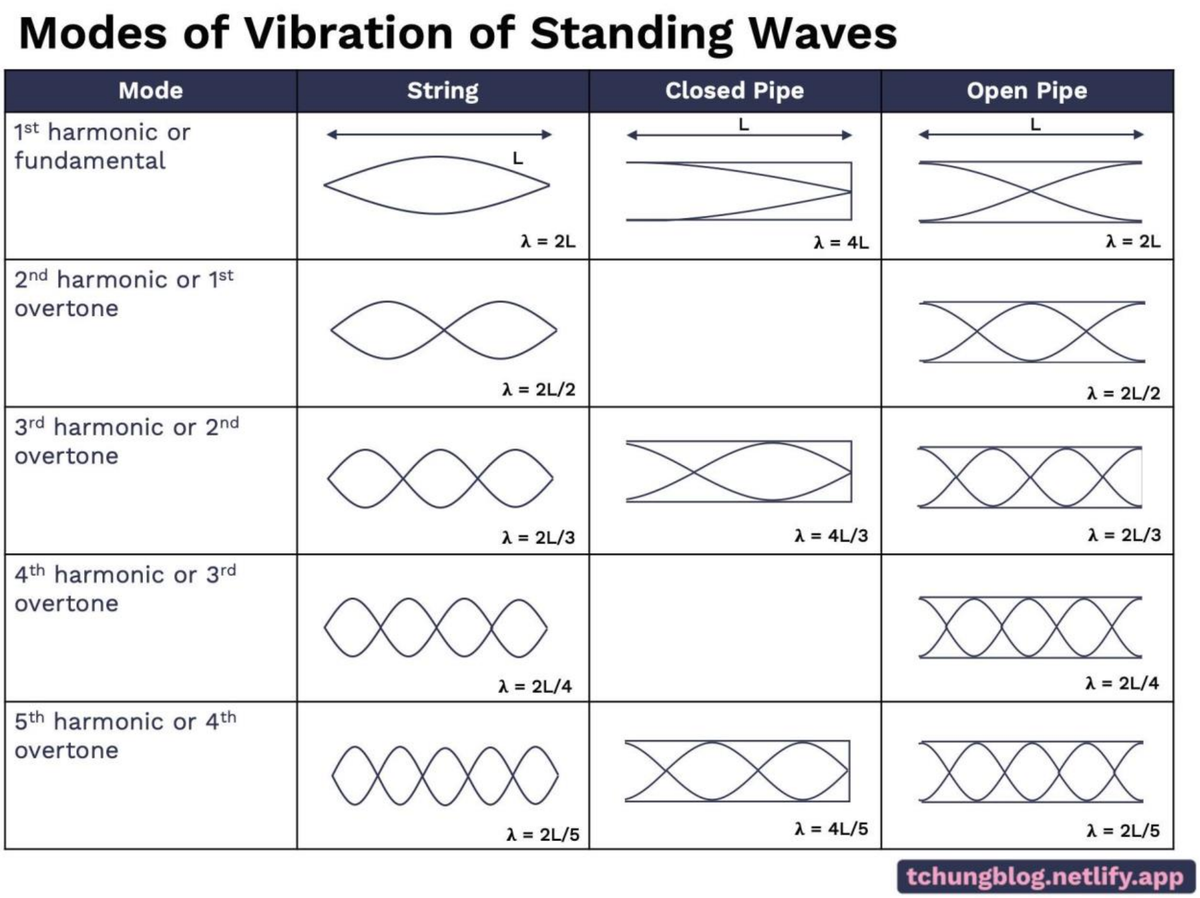


Note: Waves with the same frequency can perfectly overlap or fully cancel each other out. Waves with different frequencies will have both constructive and destructive interference, and form a type of combined wave called a **beat**. The beat can have its own repeating pattern, with a beat frequency: $f_{beat}=f_{wave\ 2}\text{-}f_{wave\ 1}$.



Harmonics and Overtones of pipes

Standing waves can have harmonics, which are a type of constant wave shape in a closed or semi-closed boundry. The first harmonic (n=1) is also called the **Fundamental**. Standing waves exist in 3 types of situations, commonly called fixed string, closed pipe, and open pipe. Any standing waves which exist above the fundamental (n>1) are called **Overtones** (Note: what might be an overtone for one type of standing wave might not exist for another type of standing wave).



Modes of Vibration of Standing Waves

Mode	String	Closed Pipe	Open Pipe
1st harmonic or fundamental	L; λ = 2L	L; λ = 4L	L; λ = 2L
2nd harmonic or 1st overtone	λ = 2L/2		λ = 2L/2
3rd harmonic or 2nd overtone	λ = 2L/3	λ = 4L/3	λ = 2L/3
4th harmonic or 3rd overtone	λ = 2L/4		λ = 2L/4
5th harmonic or 4th overtone	λ = 2L/5	λ = 4L/5	λ = 2L/5

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For Strings, allowed frequencies are: $f_n = n(\frac{v}{2L})$, with n = 1,2,3,4,5,6,… (i.e. all whole numbers)

For Closed Pipes, allowed frequencies are : $f_n = n(\frac{v}{4L})$, with n = 1,3,5,… (i.e. all odd numbers)

For Open Pipes, allowed frequencies are : $f_n = n(\frac{v}{2L})$, with n = 1,2,3,4,5,6,… (i.e. all whole numbers)

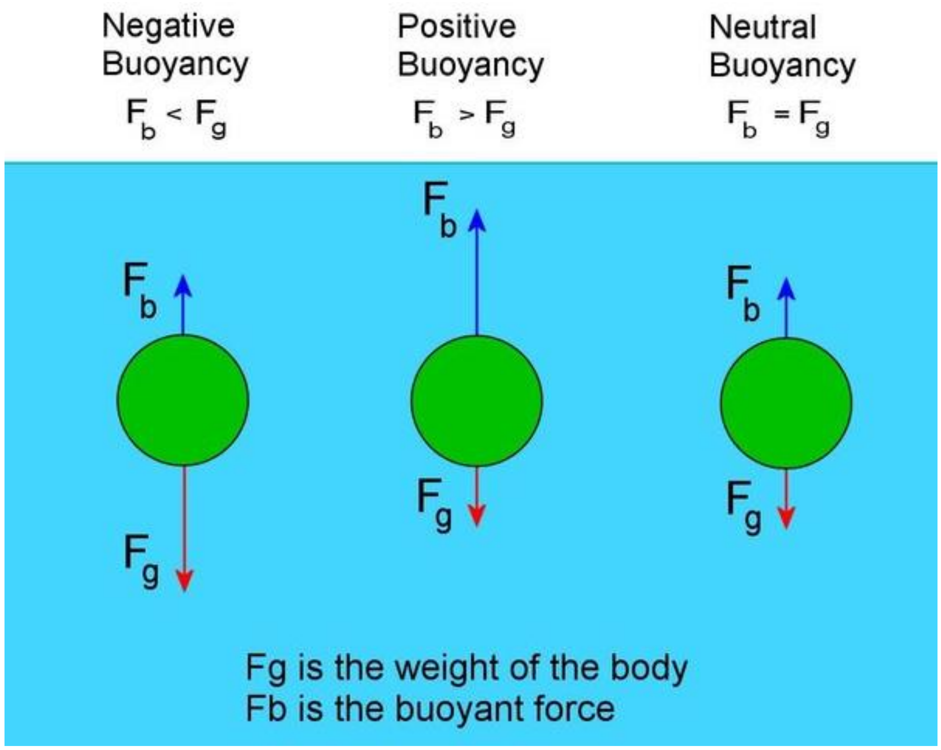
(Note: for Open Pipes, the waves are inverted from Strings)

(Note: v is the speed of the wave)

(Note: L is the length of the string or pipe)

Bouyancy

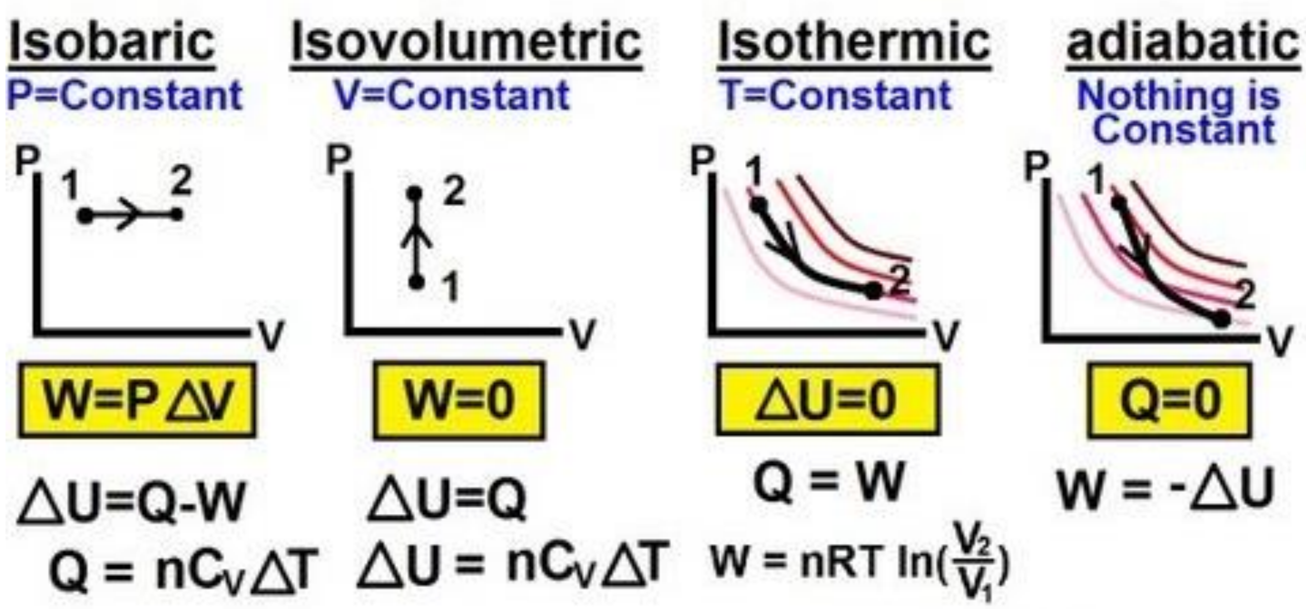
The bouyancy force is the upward force exerted by a liquid on an object. The bouyancy for is equal to the weight of the liquid displaced by an object (i.e. moved to make room for the object). It is given by the equation: $F_b = \rho_{liquid} * V_{displaced\ liquid} * g$. (Note: ρ_{liquid} is the density of the liquid. $V_{displaced\ liquid}$ is the displaced volume of the liquid). An object can have positive bouyancy (its weight is smaller than the bouyancy force), neutrally bouyant (its weight is equal to the bouyancy force), or negative bouyancy (its weight is larger than the bouyancy force).



This can also be described in terms of density. An object can be floating (its density is smaller than the density of the liquid), neutrally bouyant (its density is equal to the density of the liquid), or sinking (its density is larger than the density of the liquid).

Processes

(Note: Isovolumetric is also called <u>Isochoric)</u>



Heat Flow & Phase Change

When calculating the amount of energy needed to change the temperature of an object (or to create a phase change such as melting or freezing), compare heat sources with heat consumption, i.e.:

$$Q_{lost} = Q_{recieved}$$

or,

$$Q_{exothermic} = Q_{endothermic}$$

An object changing temperature will gain or lose temperature with a gain or loss of heat.

An object melting requires it to gain heat.

An object freezing requires it to lose heat.

The total heat transfer than looks like:

$$Q_{T\ decrease} + Q_{freezing} = Q_{T\ increase} + Q_{melting}$$

Example of formula sheet provided on exam:

Chapters 12 --16 (Exam 4)

$v = f\lambda \qquad v = \sqrt{\frac{F_T}{\mu}} \qquad y(x,t) = A\sin\left[2\pi f\left(t - \frac{x}{v}\right)\right] = A\sin\left[2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)\right]$

path difference = $n\lambda$, $n = 0, \pm1, \pm2, \ldots$ constructive

path difference = $\left(n + \frac{1}{2}\right)\lambda$, $n = 0, \pm1, \pm2, \ldots$ destructive

$f_n = n\left(\frac{v}{2L}\right), n = 1,2,3,\ldots \qquad f_n = n\left(\frac{v}{4L}\right), n = 1,3,5,\ldots$

$I = \frac{P}{4\pi r^2} \qquad \beta = (10\text{ dB})\log\left(\frac{I}{I_0}\right) \qquad f_{\text{beat}} = f_1 - f_2 \qquad f_L = \left(\frac{v+v_L}{v+v_S}\right)f_S$

$\rho = \frac{m}{V} \qquad p = \frac{F_\perp}{A} \qquad p_0 = p_{\text{atm}} + \rho g h \qquad F_B = \rho_{\text{fluid}} V_{\text{displ}} g$

$T_F = \frac{9}{5}T_C + 32^\circ \qquad T_C = \frac{5}{9}(T_F - 32^\circ) \qquad T_K = T_C + 273.15^\circ \qquad 1\ C^\circ = \frac{9}{5}\ F^\circ$

$\Delta L = \alpha L_0 \Delta T \qquad \Delta V = V_0 \beta \Delta T \qquad \frac{F}{A} = -Y\alpha\Delta T$

$Q = mc\Delta T \qquad Q = \pm mL \quad H = kA\frac{T_H - T_C}{L} \qquad H = Ae\sigma T^4$

For ice, $c_{\text{ice}} = 2010$ J/(kg/K) and for liquid water $c_{\text{water}} = 4190$ J/(kg/K)
For water $L_f = 3.34 \times 10^5$ J/kg and $L_v = 2.256 \times 10^6$ J/kg
$\sigma = 5.67 \times 10^{-8}\ \text{W}/(m^2 \cdot K^4) \quad N = 6.022 \times 10^{23}$ molecules/mol $\quad m_{\text{total}} = nM$

$pV = nRT \qquad \rho = \frac{pM}{RT} \qquad R = 8.314\ \text{J}/(\text{mol}\cdot K)$

$k = 1.381 \times 10^{-23}$ J/molecule $\cdot K$

$K_{tr} = \frac{3}{2}nRT \qquad K_{av} = \frac{1}{2}m(v^2)_{av} = \frac{3}{2}kT \qquad pV = NkT \quad v_{rms} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3RT}{M}}$

$Q = nC\Delta T \quad W = p\Delta V \qquad W = nRT\ln\left(\frac{V_2}{V_1}\right) \qquad \Delta U = Q - W$

$C_p = C_V + R \qquad p_1V_1^\gamma = p_2V_2^\gamma \qquad T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1} \qquad \gamma = C_p/C_V$

For a monatomic ideal gas $C_V = 3R/2, C_p = 5R/2$

$W = Q = |Q_H| - |Q_C| \qquad e = \frac{W}{Q_H} = 1 - \left|\frac{Q_C}{Q_H}\right| \qquad K = \frac{Q_C}{|W|} = \frac{|Q_C|}{|Q_H| - |Q_C|}$

Carnot: $\frac{Q_C}{Q_H} = -\frac{T_C}{T_H} \qquad e_{\text{Carnot}} = 1 - \frac{T_C}{T_H} \qquad \Delta S = \frac{Q}{T}$