1. A boat is floating on a lake with its huge steel anchor in the water. The boat hoists the anchor into the boat to set sail. What happens to the water level in the lake (with respect to the shore)?
   a. rises  b. drops  c. remains the same  d. depends on the size of the steel anchor

2. Suppose you shake the end of a stretched string to produce a wave. Which of the following will increase the speed of the wave?
   a. move your arm up and down faster  
   b. move your arm a greater distance up and down  
   c. increase the tension in the string  
   d. increase the mass per unit length of the string

3. Which of the following takes the most time?
   a. Raise 1 kg of ice from -100°C to 0°C
   b. Convert 1 kg of ice to water at 0°C
   c. Raise 1 kg of water from 0°C to 100°C
   d. Convert 1 kg of water to steam at 100°C
   e. all times are equal

4. Two copper wires of equal diameter but different lengths are joined end to end and connected to a battery. The current flowing through the connected wires is:
   a. greater in the longer wire  
   b. greater in the shorter wire  
   c. the same in both wires

5. A 12-ft-long, 38 lb ladder leans against a frictionless wall as shown. For $\mu = 0.27$ and $\theta = 52^\circ$, determine the minimum horizontal force at the base of the ladder in addition to friction required to keep the ladder from sliding.

6. A 42 lb container floats in water with 17% of the volume of the container above water. Determine the force required to submerge the container.

   \[ F_{\text{buoyancy}} = 42 \times 0.17 \times \rho_{\text{water}} \times V \]

   \[ F_{\text{buoyancy}} = 42 \times 0.17 \times 1 \times \frac{1}{2} \]

   \[ F_{\text{buoyancy}} = 8.6 \text{ lb} \]

7. On the 2nd floor (elevation 8 m) of Brown Residence Hall, water flows through a 3 cm diameter pipe at a speed of 4.2 m/s and the pressure in the pipe is 160 kPa. The pipe narrows to a 2 cm diameter pipe on the 6th floor (elevation 18 m). Determine the pressure at this point.

   \[ P_1 + \rho \frac{V_1^2}{2} = P_2 + \rho \frac{V_2^2}{2} \]

   \[ P_1 + 100\times 10^3 \times \frac{4.2^2}{2} = P_2 + 100\times 10^3 \times \frac{V_2^2}{2} \]

   \[ P_2 = 26068.75 \text{ Pa} \]
8. (8 pts) A 0.06 kg scooter is connected to an ideal spring (k=54 N/m) and is oscillating on a horizontal, frictionless surface. It is given an initial displacement of +7 cm and an unknown initial velocity. After 6.2 seconds its velocity is +52 cm/s. What was the scooter’s initial velocity?

\[ v_0 = \sqrt{\frac{k}{m}} = \sqrt{\frac{54}{0.06}} = 30 \text{ cm/s} \]

- Use mass * 60 g
- Use k in N/m, cm, no units
- Calculate \( \omega \) in radians
- \( \sin(\omega t) \)
- \( \cos(\omega t) \)
- \( a = r \sin(\omega t) \)
- \( a_x = r \cos(\omega t) \)
- \( a = -\frac{V}{t} \)
- \( V_0 = 6 \text{ cm/s} \)
- \( a_x = 2 \text{ cm/s} \)
- \( v_0 = 3 \text{ cm/s} \)

9. (8 pts) Kevin is standing 13 m away from a 180W speaker and 13 m away from a 120W speaker. What is the sound level (in dB) Kevin hears?

\[ I = \frac{P_A}{4\pi r^2} = \frac{180 + 120}{4\pi (13)^2} \]

\[ I = 141.5 \text{ W/m}^2 \]

\[ \beta = 10 \log \left( \frac{141.5}{10^{-12}} \right) \]

\[ \beta = 111.5 \text{ dB} \]

10. (8 pts) A red car and a green car are blowing identical horns. The red car is at rest and the green car is moving toward the red car at 12 m/s. The driver in the red car hears a beat frequency of 3 Hz. What is the frequency of the horn? Assume speed of sound in air is 343 m/s.

\[ v = 343 \text{ m/s} \]

\[ f' = f_o \left( \frac{v + V}{v - V} \right) \]

\[ f' = f_o \left( \frac{343 + 12}{343 - 12} \right) \]

\[ f' = 6.8 \text{ Hz} \]

- Use 3 Hz as \( f \) or \( f_o \)
- \( f' = f_o \left( \frac{V + v}{V - v} \right) \)
- \( f' = f_o \left( \frac{343 + 12}{343 - 12} \right) \)

\[ f' = 6.8 \text{ Hz} \]

- Use 3 Hz as \( f \) or \( f_o \)

11. (8 pts) The Salvo Cycle is shown. Determine the pressure at B so that 300 J of work will be done during each cycle. Assume the gas is an ideal diatomic gas with \( \gamma = 1.4 \).

\[ \frac{P_B}{P_A} = \frac{V_B}{V_A} \]

\[ P_B = 650 \text{ kPa} \]

- DC as Diabatic (\(-\)) Answer: 1390 kPa
- Area of triangle: \( \frac{1}{2} \text{ kPa} \)
- Diabatic and adiabatic \( \gamma = 1.6 \) Answer: 1880 kPa
- Diabatic and adiabatic \( \gamma = 1.4 \) Answer: 941 kPa

\[ 300 \times 10^{-3} \frac{J}{s} = \frac{1}{2} \left( r_2 \times 2.5 \text{ m} \right) P_B - 150 \times 10^3 \text{ Pa} \]

\[ P_B = 650000 \text{ Pa} \]

12. (8 pts) Calculate the change in entropy of 2.5 kg of liquid water at 0°C when it is frozen at a temperature of 30°C. \( c_p = 0.5 \text{ cal/g°C} \)

\[ \Delta S_{\text{freeze}} = \frac{3}{2} \int_{0}^{T_f} \frac{dS}{T} = \frac{m c_p}{T} \int_{0}^{T_f} \left( \frac{T_f}{T} \right)^{1.5} \frac{dT}{T^2.5} \]

\[ = -3660 \text{ J/K} \]

\[ \Delta S_{\text{water}} = \Delta S_{\text{ice}} + \Delta S_{\text{water}} \]

\[ = -3660 \text{ J/K} + -609.12 \text{ J/K} \]

\[ = -3660.45 \text{ J/K} \]

\[ \Delta S_{\text{water}} = -3660.45 \text{ J/K} \]

or

\[ 728.94 \text{ W/K} + -1455 \text{ W/K} = -876.5 \text{ W/K} \]
13. (8 pts) A 45 nF capacitor has enough stored energy to heat 230 g of water from 22°C to 30°C. What is the potential difference across the plates of the capacitor?

\[ \frac{Q}{\text{V}} = \frac{\text{mC}}{\text{C}} = \frac{45 \times 10^{-9} \text{ C}}{Q_{\text{charge}}} \]

\[ \Delta T = (230 \times (1 - \frac{22}{30}) - 22)^\frac{T}{\text{C}} \]

\[ \Delta H = \frac{7702 \times 24}{4} \]

\[ V = 585.1 \text{ V} \]

14. (8 pts) A charged, 7x10^4 kg dust particle hangs as shown in a uniform electric field, E = 315 N/C. Determine the charge on the dust particle. A separate, complete FBD is required for full credit.

\[ W = 4.89 \times 10^{-9} \text{ N} \]

\[ F_E = 0 \]

\[ F = 7.79 \times 10^{-5} \text{ N} \]

\[ F_E = 3.65 \times 10^{-5} \text{ N} \]

\[ q = \frac{1.159 \times 10^{-3} \text{ C}}{315 \text{ N/C}} \]

15. (8 pts) An electron with a velocity of 5.2x10^6 m/s moves through a magnetic field of (20i - 18j + 16k) T. Determine the acceleration of the electron (\( \mathbf{a} \) in \( \mathbf{k} \) notation).

\[ \mathbf{v} = \begin{pmatrix} -1.76 \times 10^6 \text{ m/s} + 183 \times 10^5 \text{ F} \end{pmatrix} \]

\[ q = -1.6022 \times 10^{-19} \text{ C} \]

\[ \mathbf{F} = q \left( \mathbf{v} \times \mathbf{B} \right) \]

\[ \mathbf{F} = \begin{pmatrix} -0.48 \times 10^{-15} \text{ N} \end{pmatrix} \]

\[ \mathbf{a} = \begin{pmatrix} -1.33 \times 10^{-15} \text{ m/s}^2 \end{pmatrix} \]

16. (8 pts) The power dissipated by the circuit shown is 9 W. Determine the unknown resistance R.

\[ P = \frac{V^2}{R_{\text{total}}} \]

\[ R_{\text{total}} = 16 \Omega \]

\[ R = 23.6 \Omega \]