1. An ambulance travels down a highway at a speed of 75.0 mi/h, its siren emitting sound at a frequency of 400 Hz. What frequency is heard by a passenger in a car traveling at 55.0 mi/h in the opposite direction as the vehicles approach each other? Use the speed of sound as 345 m/s. (20)

2. A family ice show is held in an enclosed arena. The skaters perform to music playing at a level of 85.0 dB. The intensity is too loud for your baby, who cries at 80.0 dB. What is the combined sound level in dB? (20)

3. A mass of 0.5 kg hangs from a spring with a spring constant 50 N/m. The mass is pulled downward to a displacement of 20 cm and released from rest.
   a. What is the maximum speed of the mass in its oscillation? (10)
   b. What is the period of its oscillation? (10)

4. An explosion occurs near the surface of a lake. A diver at some distance hears the explosion and immediately surfaces. He hears the explosion 5 s later through the air. How far away was the explosion? Assume the air temperature is 20°C. (15)

5. The human ear canal can be thought of resembling an organ pipe, closed at one end, that resonates at a fundamental frequency of 3300 Hz. What is the length of the canal? Assume the air temperature in the canal is the same as body temperature, 37°C. (15)

6. Derive an equation giving the difference in decibel level levels $\beta_2 - \beta_1$ of a sound source as measured at two distances $r_1$ and $r_2$. (15)

7. Explain what a standing wave is and how is it formed. (5)
Mechanics

\[ v_f - v_i = v_e \ln \left( \frac{M_i}{M_f} \right) \]  
(rocket) \hspace{1cm} a_e = \frac{v^2}{r} = r \omega^2 \hspace{1cm} I = mr^2 \hspace{1cm} T^2 = \left( \frac{4\pi^2}{GM} \right) r^3

Newtonian gravity

\[ F = G \frac{m_1 m_2}{r^2} \hspace{1cm} PE = -G \frac{m_1 m_2}{r} \]

Bernoulli’s Equation

\[ P + \rho v^2/2 + \rho g y = \text{constant} \]

Thermal Expansion

\[ \Delta L = \alpha L_0 \Delta T \hspace{1cm} V = 3 \alpha V_0 \Delta T \]

Heat and energy

\[ \Delta U = Q + W \hspace{1cm} W = -P \Delta V \]

\[ U = \frac{3}{2} nRT \hspace{1cm} Q = mc \Delta T \hspace{1cm} Q = nC_v \Delta T \hspace{1cm} Q = nC_p \Delta T \hspace{1cm} C_p = C_v + R \]

\[ e = \frac{W_{\text{eng}}}{|Q_h|} = 1 - \frac{|Q|}{|Q_h|} \hspace{1cm} e_c = 1 - \frac{T_c}{T_h} \hspace{1cm} \Delta S = \frac{Q}{T} \]

Spring

\[ T = \frac{1}{f} = \frac{1}{2\pi \omega} = \sqrt{\frac{m}{k}} \hspace{1cm} KE = \frac{1}{2} kx^2 \]

Speed of sound

\[ v = (331 \text{ m/s}) \sqrt{\frac{T}{273K}} \hspace{1cm} \text{water} \hspace{1cm} 1490 \text{ m/s} \]

Doppler Effect

\[ f_o = f_s \left( \frac{v + v_o}{v - v_s} \right) \hspace{1cm} v = f \lambda \]

Sound Intensity

\[ \beta (dB) = 10 \log \left( \frac{I}{I_0} \right), \hspace{1cm} I_0 = 1 \times 10^{-12} \text{ W/m}^2 \hspace{1cm} \frac{I_1}{I_2} = \frac{r_2^2}{r_1^2} \]