Part I: Multiple Choice Questions

1. What are the units of the following quantities?

(10 pts)
- Sound intensity I = \( \text{W/m}^2 \)
- Decibel = \text{dimensionless}
- Heat of vaporization = \( \text{J/kg} \)
- Specific heat capacity \( c \) = \( \text{J/(kg K)} \)
- Heat of fusion = \( \text{J/kg} \) or \( \text{cal/kg} \) or \( \text{btu/lb} \)
- Tensile strain = \text{dimensionless}
- Emissivity \( e \) = \text{dimensionless}
- Tensile stress = \( \text{N/m}^2 \)
- Thermal conductivity \( k \) = \( \text{W/m}^2 \text{K} \)

2. A piece of iron has a temperature of 37\(^\circ\)C. A second identical piece of iron is twice as hot. What is the temperature of the second piece of iron? Give this temperature in \(^\circ\)C.

\[
\begin{align*}
273 + 37 &= 310 \text{ K} \\
2 \times 310 &= 620 \text{ K} \\
620 - 273 &= 347 \text{ K}
\end{align*}
\]
3. A standing wave is oscillating at 270 Hz on a string, as shown in Figure 12.3. What is the wave speed?

(a.) 108 m/s
(b.) 160 m/s
(c.) 81 m/s
(d.) 54 m/s

4. If you wanted to know how much the temperature of a particular piece of material would rise when a known amount of heat was added to it, which of the following would be the most helpful to know?

(a.) Initial temperature
(b.) Specific heat
(c.) Density
(d.) Coefficient of linear expansion
(e.) Thermal conductivity
**Part II. Short problems:**

5. A glass flask has a volume of 900 ml at a temperature of 20 °C. The flask contains 893 ml of mercury at an equilibrium temperature of 20 °C. The temperature is raised until the mercury reaches the 900 ml reference mark. The coefficients of volume expansion of mercury and glass are $18 \times 10^{-5} \text{K}^{-1}$ and $2.0 \times 10^{-5} \text{K}^{-1}$, respectively. What is the temperature at which this occurs, in °C?

\[
\Delta V_m = \beta_m V_{om} \Delta T
\]
\[
\Delta V_f = \beta_f V_{of} \Delta T
\]
\[
\Delta V_m - \Delta V_f = (\beta_m V_{om} - \beta_f V_{of}) \Delta T
\]
\[
\frac{7}{0.1427} = (18 \times 10^{-5} \times 893 - 2 \times 10^{-5} \times 900) \Delta T
\]
\[
\Delta T = \frac{7}{0.1427} = 49.05 \text{ K} \Rightarrow 49 \text{ °C}
\]

6. Stress on a mountaineer’s rope. A nylon rope used by mountaineers elongates 1.10 m under the weight of a 65.0 kg climber. If the rope is 45.0 m in length and 7.0 mm in diameter, what is Young’s modulus for this nylon?

\[
A = \pi r^2 = \pi (3.5 \times 10^{-3} \text{m})^2 = 3.85 \times 10^{-5} \text{m}^2
\]

\[
P = 65 \text{ kg} \times 9.8 \text{ m/s}^2 = 637 \text{ N}
\]

\[
Y = \frac{P}{A \cdot \Delta L} = \frac{45 \text{ m} \times 637 \text{ N}}{(3.85 \times 10^{-3} \text{ m}^2) \times 1.10 \text{ m}} = 6.77 \times 10^8 \text{ Pa}
\]
7. A certain transverse wave is described by the equation.

\[ y(x, t) = (10.5 \text{ mm}) \sin 2\pi \frac{c}{0.360 \text{ m}} - \frac{x}{0.180 \text{ m}} \]

Determine this wave's (a) amplitude, (b) wavelength, (c) frequency, (d) speed of propagation, and (e) direction of propagation.

\[ A = 10.5 \text{ mm} \]
\[ \lambda = 0.180 \text{ m} \]
\[ T = 0.360 \text{ s} \]
\[ f = \frac{1}{T} = 2.77 \text{ Hz} \]
\[ v = \frac{c}{\lambda} = 0.5 \text{ m/s} \]

propagate to \( +x \) direction

8. (a) While vacationing in Europe, you feel sick and are told you have a temperature of 41°C. Should you be concerned? What is your temperature in °F? (b) The morning weather report in Sydney predicts a high temperature of 2°C. Will you need to bring a jacket? What is this temperature in °F? (c) A friend has suggested that you go swimming in a pool having water of temperature 350 K. Is this safe to do? What would this temperature be on the Fahrenheit and Celsius scales?

\[ (a) \quad T_F = \left(\frac{9}{5} T_C + 32\right) = \frac{9}{5} \times 41 + 32 = 105.8 \text{ °F} \]
\[ (b) \quad T_F = \left(\frac{9}{5} \times 2 + 32\right) = 35.6 \text{ °F} \]
\[ (c) \quad T_C = 350 - 273 = 77 \text{ °C} \]
\[ T_F = \frac{9}{5} \times 77 + 32 = 170.6 \text{ °F} \]
10. (20 pts) If the air temperature is the same as the temperature of your skin (about 30°C), your body cannot get rid of heat by transferring it to the air. In that case, it gets rid of the heat by evaporating water (sweat). During bicycling, a typical 70 kg person's body produces energy at a rate of about 500 W due to metabolism, 80% of which is converted into heat. (a) How many kilograms of water must the person's body evaporate in an hour to get rid of this heat? The heat of vaporization of water at body temperature is 2.42 x 10^6 J/kg. (b) The evaporated water must, of course, be replenished, or the person will dehydrate. How many 750mL bottles of water must the bicyclist drink per hour to replenish the lost water? (Recall that the mass of a liter of water is 1.0 kg)

(a) In 1 hour, heat generated = 500 W · 3600 s · 80%

= 1.44 x 10^6 J

Need water \[ \frac{1.44 \times 10^6 J}{2.42 \times 10^6 J/kg} = 0.595 kg \]

(b) \[ \frac{0.595}{0.750} = 0.8 \text{ bottle} \]