PHYS 111-01 STARTING EQUATIONS - WAVES, SOUND, THERMAL PHYSICS

The equations given below may be used as starting points for solving problems on the final.

**WAVES AND SOUND**

Waves:
\[ v_w = \lambda f \quad \text{f} = (1/T) = \omega/2\pi \]
\[ v_w = \sqrt{\frac{F}{m/L}} \quad (\text{stretched string}) \]

Sound:
\[ f_n = (n/2L)v \quad \text{normal modes - stretched string or open tube} \]
\[ f_n = (n/4L)v \quad \text{normal modes - tube with only one end open} \]
\[ I = P/A \quad I(r) = P/4\pi r^2 \quad (\text{spherical sound wave}) \]

Doppler Shift – Easy versions
\[ f' = f\left[\frac{v_w}{v_w \pm u_0}\right] \quad \text{moving source} \quad f' = f\left[\frac{(v_w \pm u_0)/v_w}\right] \quad \text{moving observer (Top signs, approaching)} \]

Doppler Shift – Textbook versions
\[ f' = \left(1 \pm \frac{u_o}{v_w}\right) f \quad \text{Moving Observer} \quad f' = \left(\frac{1}{1 \pm \frac{u_s}{v_w}}\right) f \quad \text{Moving Source (Top signs, approaching)} \]

**TEMPERATURE AND HEAT**

\[ \Delta L = \alpha L_0 \Delta T \quad \Delta V = \beta V_0 \Delta T \quad Q = mc\Delta T \quad Q = mL \]

Ideal Gas
\[ PV = NkT = nRT \quad U = (3/2) NkT = (3/2)nRT \quad \text{Monatomic Ideal Gas} \]

Thermodynamics, Thermal Conduction, Thermal Radiation:
\[ Q = kA\Delta T/L \quad P = eA\sigma T^4 \]
\[ \Delta U = Q_{\text{in}} - W_{\text{by}} \quad W = P\Delta V \quad \Delta S = Q/T \quad \Delta S_{\text{universe}} \geq 0 \]

Heat Engines
\[ e = W/Q_h \quad e_{\text{max}} = 1 - (T_c/T_h) \]

<table>
<thead>
<tr>
<th>QUANTITY</th>
<th>SYMBOL</th>
<th>UNIT OR VALUE</th>
<th>COMMENTS</th>
</tr>
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<tbody>
<tr>
<td>Period</td>
<td>T</td>
<td>s</td>
<td>Hz = sec^{-1}</td>
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<tr>
<td>Frequency</td>
<td>f</td>
<td>Hz</td>
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<tr>
<td>Wavelength</td>
<td>\lambda</td>
<td>m</td>
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<tr>
<td>Wave velocity</td>
<td>v or v_w</td>
<td>m/s</td>
<td>v_w = 343 m/s, sound in 20°C air</td>
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<tr>
<td>Intensity</td>
<td>I</td>
<td>W/m^2</td>
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<tr>
<td>Temperature</td>
<td>T</td>
<td>K or °C</td>
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<tr>
<td>Linear expansion coefficient</td>
<td>\alpha</td>
<td>K^{-1} or °C^{-1}</td>
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<tr>
<td>Volume expansion coefficient</td>
<td>\beta</td>
<td>K^{-1} or °C^{-1}</td>
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<tr>
<td>Specific Heat</td>
<td>c</td>
<td>J/(kg-K) or J/(kg-°C)</td>
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<tr>
<td>Heat</td>
<td>Q</td>
<td>J</td>
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<tr>
<td>Latent Heat</td>
<td>L</td>
<td>J/kg</td>
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<tr>
<td>Thermal Conductivity</td>
<td>k</td>
<td>J/(m-C°)</td>
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<tr>
<td>Stefan-Boltzmann Constant</td>
<td>\sigma</td>
<td>5.67 x 10^{-8} W/(m^2-K^4)</td>
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<tr>
<td>Boltzmann Constant</td>
<td>k</td>
<td>1.38 x 10^{-23} J/K</td>
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<tr>
<td>Gas Constant</td>
<td>R</td>
<td>8.31 J/(mol-K)</td>
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<tr>
<td>Number of moles</td>
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<tr>
<td>Entropy</td>
<td>S</td>
<td>J/K</td>
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<tr>
<td>Internal Energy</td>
<td>U</td>
<td>J</td>
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