1. A wall-sided barge floating in salt-water with a specific volume of 35 ft³/ft³ has a draft of 9 ft, and a center of gravity of 11 ft. (Cg = Cb = Cm = 1.0). The barge is 150 ft long, with a beam of 50 ft, and a depth of 28 ft. Lc = 75 ft, Tc = 0. Determine the following characteristics:
   a. Displacement
   b. Center of Buoyancy
   c. Metacenter radius
   d. longitudinal metacentric radius
   e. Height of the Metacenter
   f. longitudinal height of the metacenter

   a. Displacement
   \[ \Delta = \frac{LBT}{35} \left( \frac{150}{50}(9) \right) \frac{1}{35} = 1.929 \text{ ft}^3 \]

   b. Center of Buoyancy (\( \overline{Y_B} \))
   \[ \overline{Y_B} = \frac{T}{2} - \frac{d}{2} = 9.5 + 4.5 = \overline{Y_B} \]

   c. Metacentric radius (\( \overline{G_M} \))
   \[ \overline{G_M} = \frac{I}{\Delta} - \frac{\beta^2}{12} \cdot \frac{1}{12T} \left( \frac{150}{50} \right) = 2.315 \text{ ft} \cdot \overline{G_M} \]

   d. Longitudinal metacentric radius (\( \overline{G_m} \))
   \[ \overline{G_m} = \frac{I}{\Delta} - \frac{\beta}{12T} \left( \frac{150}{50} \right) = 1.033 \text{ ft} \cdot \overline{G_m} \]

   e. Height of the Metacenter (\( \overline{G} \))
   \[ \overline{G} = 2.5 + 2.315 = 27.15 \text{ ft} \cdot \overline{G} \]

   f. Longitudinal height of the Metacenter (\( \overline{G_m} \))
   \[ \overline{G_m} = \overline{G} + \overline{G_m} = 4.5 + 2.315 = 21.8 \text{ ft} \cdot \overline{G_m} \]
2. The US Census (1870) is at 10 a.m. A train leaves Chicago at 12:30 a.m. and arrives at New York at 3 p.m. Analyze the following questions:

a. What is the train's speed?

b. What is the train's time?

c. What is the average speed of the train?

d. What is the distance traveled by the train?

e. What is the speed of the train at 12:30 a.m.?

f. What is the average speed of the train from Chicago to New York?
\[
C_v = \frac{\Delta P}{\Delta T}
\]

\[
2 = \frac{\Delta P}{\Delta T}
\]

\[
T_v = \frac{v^2}{2} = \frac{v^2}{2} \cdot \frac{1}{2}
\]

\[
\Delta = \frac{v^2}{2}
\]

\[
T_w = \frac{v^2}{2}
\]

\[
\Delta m = \frac{v^2}{2}
\]

\[
D_m = \frac{v^2}{2}
\]

\[
\Delta = \frac{v^2}{2}
\]

\[
\Delta = \frac{v^2}{2}
\]

\[
\Delta = \frac{v^2}{2}
\]
A ship with LCG = 33 ft has the following Bug offset:

<table>
<thead>
<tr>
<th>Side</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>9</th>
<th>AP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 L</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
<td>2.9</td>
<td>3.9</td>
</tr>
</tbody>
</table>

a. What is the area of the Bug?
b. What is the LCG location?

<table>
<thead>
<tr>
<th>Step</th>
<th>Side</th>
<th>2k</th>
<th>k point</th>
<th>3k</th>
<th>4k</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>2</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td>3</td>
<td>0.9</td>
<td>1</td>
<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td>4</td>
<td>1.1</td>
<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
<td>1.5</td>
</tr>
<tr>
<td>5</td>
<td>1.3</td>
<td>1.4</td>
<td>1.5</td>
<td>1.6</td>
<td>1.7</td>
</tr>
<tr>
<td>6</td>
<td>1.5</td>
<td>1.6</td>
<td>1.7</td>
<td>1.8</td>
<td>1.9</td>
</tr>
<tr>
<td>7</td>
<td>1.7</td>
<td>1.8</td>
<td>1.9</td>
<td>2</td>
<td>2.1</td>
</tr>
<tr>
<td>8</td>
<td>1.9</td>
<td>2</td>
<td>2.1</td>
<td>2.2</td>
<td>2.3</td>
</tr>
</tbody>
</table>

\[ A_{lw} = \pi \times \left( \frac{2 \times 1}{2} \right) \times \left( \frac{1}{2} \times 0.5 \right) = 0.875 \text{ ft}^2 \]

b. Compute center of gravity, LCG

\[ \text{LCG} = \left( \frac{8.1/4}{4} \right) = -0.25 \text{ ft} \]

\[ \text{Area} = 2 \times 3.9 \times 0.5 = 7.8 \text{ ft}^2 \]
### Table 1: Water Depth (ft)

<table>
<thead>
<tr>
<th>Station</th>
<th>Water Depth (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6.65</td>
</tr>
<tr>
<td>1</td>
<td>6.61</td>
</tr>
<tr>
<td>2</td>
<td>6.70</td>
</tr>
<tr>
<td>3</td>
<td>6.70</td>
</tr>
<tr>
<td>4</td>
<td>6.70</td>
</tr>
<tr>
<td>5</td>
<td>6.70</td>
</tr>
<tr>
<td>6</td>
<td>6.70</td>
</tr>
<tr>
<td>7</td>
<td>6.70</td>
</tr>
<tr>
<td>8</td>
<td>6.70</td>
</tr>
<tr>
<td>9</td>
<td>6.70</td>
</tr>
<tr>
<td>10</td>
<td>6.70</td>
</tr>
</tbody>
</table>

### Equations
\[
\begin{align*}
\text{Station 1:} & \quad 6.65 \\
\text{Station 2:} & \quad 6.61 \\
\text{Station 3:} & \quad 6.70 \\
\text{Station 4:} & \quad 6.70 \\
\text{Station 5:} & \quad 6.70 \\
\text{Station 6:} & \quad 6.70 \\
\text{Station 7:} & \quad 6.70 \\
\text{Station 8:} & \quad 6.70 \\
\text{Station 9:} & \quad 6.70 \\
\text{Station 10:} & \quad 6.70
\end{align*}
\]
a. Nonlinear Area

\[ \rho_{xx} = \frac{\pi}{4} \left( \frac{L}{2} \right)^2 = \frac{\pi}{4} \left( \frac{4000 \text{ in}}{2} \right)^2 = 31,416 \text{ in}^2 \]

b. Linear Moment of Inertia

\[ I_{xx} = \frac{1}{12} (bh^3) = \frac{1}{12} (20 \text{ in})(20 \text{ in})^3 = 2000 \text{ in}^4 \]

c. Quasi-Static Moment of Area

\[ J_{xx} = \frac{1}{2} (bh^3) = \frac{1}{2} (20 \text{ in})(20 \text{ in})^3 = 1000 \text{ in}^4 \]

d. Complete Moment of Area

\[ J_{xx} = \frac{1}{2} (bh^3) = \frac{1}{2} (20 \text{ in})(20 \text{ in})^3 = 1000 \text{ in}^4 \]

e. Complete Moment of Area with Respect to the Center

\[ J_{xx} = \frac{1}{2} (bh^3) = \frac{1}{2} (20 \text{ in})(20 \text{ in})^3 = 1000 \text{ in}^4 \]

f. Complete Moment of Area with Respect to the Center

\[ \phi = \frac{J_{xx}}{I_{xx}} \]

\[ = \frac{1000 \text{ in}^4}{2000 \text{ in}^4} = 0.5 \]

Note: Moment of Area is in in^2, while Moment of Inertia is in in^4.