Problem Solving, Units and Numerical Accuracy

Problem Solution Method:

1. Inputs
   Outputs
   “Critical Path” \rightarrow \begin{align*}
   \text{GIVEN:} & \quad \text{on graph paper} \\
   \text{FIND:} \quad & \end{align*}

2. Draw simple diagram of body/bodies & forces acting on it/them.

3. Choose a reference system for the forces.

4. Identify key geometry and constraints.

5. Write the basic equations for force components.

6. Count the equations & unknowns.

7. SOLVE

8. “Feel” the validity of the answer. (Use common sense. Check units…)

Example: Two forces, A & B, act on a particle. What is the resultant?

1. \textbf{GIVEN:} Two forces on a particle and a diagram with size and orientation

   \textbf{FIND:} The “resultant” of the two forces

   \textbf{SOLUTION:}

2. Draw what you know (the diagram, any other numbers in the problem statement that could be put on the drawing…)

3. Choose a reference system. What would be the easiest? Cartesian, radian?

4. Key geometry: the location of the particle as the origin of all the forces
   Key constraints: the particle is “free” in space

5. Write equations:
   \begin{align*}
   \text{size of } A^2 + \text{size of } B^2 &= \text{size of resultant} \\
   \sin \alpha &= \frac{\text{size of } B}{\text{size of } A + B}
   \end{align*}

6. Count: Unknowns: 2, magnitude and direction \leq \text{Equations: 2} \quad \therefore \text{can solve}

7. Solve: graphically or with equations

8. “Feel”: Is the result bigger than A and bigger than B? Is it in the right direction? (like A & B)
Units

<table>
<thead>
<tr>
<th>Units</th>
<th>Mass</th>
<th>Length</th>
<th>Time</th>
<th>Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI</td>
<td>kg</td>
<td>m</td>
<td>s</td>
<td>N = Kg·m/s²</td>
</tr>
<tr>
<td>Absolute English</td>
<td>lb</td>
<td>ft</td>
<td>s</td>
<td>Poundal = lb·ft/s²</td>
</tr>
<tr>
<td>Technical English</td>
<td>slug</td>
<td>ft</td>
<td>s</td>
<td>lb_{force}</td>
</tr>
<tr>
<td>Engineering English</td>
<td>lb</td>
<td>ft</td>
<td>s</td>
<td>lb_{force}</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(\text{lb}<em>{\text{force}} = \text{lb}</em>{\text{mass}} \times 32.17 \frac{\text{ft}}{s^2})</td>
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<tr>
<td>gravitational constant</td>
<td>(g_c = 32.17 \frac{\text{ft}}{s^2}) (English)</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>(g_c = 9.81 \frac{\text{m}}{s^2}) (SI)</td>
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</tbody>
</table>

conversions

| (pg. vii) | 1 in = 25.4 mm |
|           | 1 lb = 4.448 N |

Numerical Accuracy

Depends on
1) accuracy of data you are given
2) accuracy of the calculations performed

The solution CANNOT be more accurate than the less accurate of #1 and #2 above!

DEFINITIONS: precision the number of significant digits
accuracy the possible error

Relative error measures the degree of accuracy:

\[
\text{relative error} \times 100 = \text{degree of accuracy (\%)}
\]

For engineering problems, accuracy rarely is less than 0.2%.