Problem Solving, Units and Numerical Accuracy

Problem Solution Method:

1. Inputs
   Outputs
   “Critical Path” \( \rightarrow \) \( \text{GIVEN:} \) \( \text{FIND:} \)

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. \( \text{GIVEN:} \) Two forces on a particle and a diagram with size and orientation

2. \( \text{FIND:} \) The “resultant” of the two forces

3. \( \text{SOLUTION:} \)

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:

6. Count:

\[
\text{sizeof } A^2 + \text{sizeof } B^2 = \text{sizeof resultant}
\]

\[
\sin \alpha = \frac{\text{sizeof } B}{\text{sizeof } A + B}
\]

Unknowns: 2, magnitude and direction \( \leq \) Equations: 2 \( \therefore \) 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 = \frac{kg \cdot m}{s^2})</td>
</tr>
<tr>
<td>Absolute English</td>
<td>lb</td>
<td>ft</td>
<td>s</td>
<td>(\text{Poundal} = \frac{lb \cdot ft}{s^2})</td>
</tr>
<tr>
<td>Technical English</td>
<td>(\text{slug} = \frac{lb \cdot s^2}{ft})</td>
<td>ft</td>
<td>s</td>
<td>(\text{lb}_{\text{force}})</td>
</tr>
<tr>
<td>Engineering English</td>
<td>lb</td>
<td>ft</td>
<td>s</td>
<td>(\text{lb}_{\text{force}})</td>
</tr>
</tbody>
</table>

\[\text{lb}_{\text{force}} = \text{lb}_{\text{mass}} \times 32.17 \frac{ft}{s^2}\]

gravitational constant

\[g_c = 32.17 \frac{ft}{s^2} \quad \text{(English)}\]
\[g_c = 9.81 \frac{m}{s^2} \quad \text{(SI)}\]

conversions

\[1 \text{ in} = 25.4 \text{ mm}\]
\[1 \text{ lb} = 4.448 \text{ N}\]

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 \quad \text{the number of significant digits}\n
accuracy \quad \text{the possible error}\n
Relative error measures the degree of accuracy:

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

For engineering problems, accuracy \textit{rarely} is less than 0.2%.