Problem Solving, Units and Numerical Accuracy

Problem Solution Method:

1. Inputs
   Outputs
   “Critical Path”

GIVEN: on graph paper

FIND:

SOLUTION

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. GIVEN: Two forces on a particle and a diagram with size and orientation

FIND: The “resultant” of the two forces

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:

   \[
   \text{size of } A^2 + \text{size of } B^2 = \text{size of resultant} \\
   \sin \alpha = \frac{\text{size of } B}{\text{size of } A + B}
   \]

6. Count: Unknowns: 2, magnitude and direction ≤ 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>$Poundal = \frac{lb \cdot ft}{s^2}$</td>
</tr>
<tr>
<td>Technical English</td>
<td>$\text{slug} = \frac{lb \cdot s^2}{ft}$</td>
<td>ft</td>
<td>s</td>
<td>$lb_{force}$</td>
</tr>
<tr>
<td>Engineering English</td>
<td>lb</td>
<td>ft</td>
<td>s</td>
<td>$lb_{force}$</td>
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<td></td>
<td></td>
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<td></td>
<td>$lb_{force} = lb_{(mass)} \times 32.17 \frac{ft}{s^2}$</td>
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</tbody>
</table>

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 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:

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

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