Units Conversion

- Also known as Dimensional Analysis.
- Allows for reasoning about quantities.
- Just because you get a number from a calculation it doesn’t mean the number makes any sense!
- NOT supported directly by Excel, but should be. (That’s a later rant by Dr. Bill!)
- We have to manually analyze data to verify the computed numbers make sense.

Example #1

- Couscous is a tasty Moroccan pasta.
- To cook, it needs several things:
  - Dry pasta
  - Water
  - Butter
  - Salt
- How much of each?
- The next slide shows a typical package.

Near East™ Couscous

- There are 10 ounces (oz) of dry pasta in the box,
- But the serving chart on the side of the box measures the dry pasta in servings or cups,
- Nowhere does it say how to fix the entire box!
How do we make the whole box?

- There are:
  - 10 ounces per box, and
  - 1.25 ounces per serving.
- How many servings are there per box?
  - Turns out there are 8 servings per box,
  - The chart shows only 1, 2, or 5 servings!
  - Do you quadruple the 2 serving numbers?
  - Do you add the 1, 2, and 5 serving numbers?
  - They’re different!

Meanwhile...

- The water is boiling,
- The dog is barking,
- The kids are yelling,
- The dinner guests are arriving,
- You don’t have time for all this!
- To be fair, Near East changed their packaging so you can now fix the whole box.

Let’s break down the problem

- We have: 10 Ounces per Box
- We have: 1.25 Ounces per Serving
- We need: Servings per Box
- How do we compute this?
- There are only three possibilities:
  - \(\text{Ounces per Box} \times \text{Ounces per Serving}\)
  - \(\text{Ounces per Box} \div \text{Ounces per Serving}\)
  - \(\text{Ounces per Serving} \div \text{Ounces per Box}\)

Which is correct?

- Only one will be correct.
- If it is the multiplication, then both the divisions will be bogus,
- If it is one of the divisions, then the multiplication will be bogus, but the other division will be the inverse of what we want.

Note

- The word “per” means “divided by”
- So, 10 Ounces per Box really means: \(\frac{10 \text{ Ounces}}{1 \text{ Box}}\)

Option #1: the Multiplication

- \(\frac{10 \text{ Ounces}}{1 \text{ Box}} \times \frac{1.25 \text{ Ounces}}{1 \text{ Serving}} \rightarrow \frac{10 \times 1.25 \text{ Ounces}^2}{1 \text{ Box Serving}}\)
- Computationally, you get a reasonable-looking number: 12.5
- But the units don’t make sense!
- What is a square ounce?
- Just because the number looks reasonable doesn’t mean it is correct!
- Bzzzzzt! Thanks for playing!
Option #2: one of the Divisions

- \[ \frac{10 \text{ Ounces}}{1 \text{ Box}} \div \frac{1.25 \text{ Ounces}}{1 \text{ Serving}} = \frac{10 \times 1 \text{ Ounces Servings}}{1 \times 125 \text{ Box Ounces}} \]
- Remember that to divide by a fraction you invert and multiply.
- Again, you get a reasonable-looking number: 8
- The ounces cancel.
- Leaving us with: \( \frac{8 \text{ Servings}}{1 \text{ Box}} \)
- This is what we want! Yay!

Option #3: the other Division

- \[ \frac{1.25 \text{ Ounces}}{1 \text{ Serving}} \div \frac{10 \text{ Ounces}}{1 \text{ Box}} = \frac{1.25 \times 1 \text{ Ounces Boxes}}{1 \times 10 \text{ Servings Ounces}} \]
- This time we get 0.125 (one-eighth)
- The ounces again cancel.
- Leaving us with: \( \frac{1 \text{ Box}}{8 \text{ Servings}} \)
- This isn’t what we want, but it is the inverse. If there are 8 servings per box, then there is \( \frac{1}{8} \) of a box per serving.

Putting the Problem into Excel

- How NOT to do it:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>There are 10 ounces per box</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>There are 1.25 ounces per serving</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- These are text cells. You cannot get to the numbers. Might as well have said “My dog has fleas” for all the good it will do.

Putting the Problem into Excel

- This is much better:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10 Ounces per Box</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.25 Ounces per Serving</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Numbers are in cells by themselves, descriptive text is next door out of the way.

Putting the Problem into Excel

- Now that A1 contains ounces per box, and A2 contains ounces per serving, we can write the formula to compute servings per box.
  - \( = \frac{A1}{A2} \) preferred
  - \( = (A1/A2) \) parentheses not necessary
  - \( = (1/A2) \times A1 \) not preferred, inefficient
  - \( \frac{A1}{A2} \) or \( = A1+\frac{1}{A2} \) marked off on a quiz!
  - It isn’t valid Excel!

Putting the Problem into Excel

- You may also name cells or ranges and use the names in formulae.
  - Give A1 the range name oz_per_box
  - Give A2 the range name oz_per_serving
  - Then the formula becomes: \( \frac{oz\_per\_box}{oz\_per\_serving} \)
  - Give the result cell the range name: \( =servings\_per\_box \)
  - Use range names instead of cell addresses to reduce confusion!
Example #2

• You go to the supermarket to get something, but there are two sizes of packages for that item,
  • One is $1.79 for 12 ounces,
  • The other is $2.29 for a pound.
• Which is the better unit price?
• To figure this out you need a conversion factor of 16 ounces per pound (range name oz_per_lb in cell B1)

Notice:

• Cell B1 has range name oz_per_lb, and all formulae that need it use the range name instead of the cell address.
• $ per Ounce is the dollars cell divided by the ounces cell
• $ per Pound is the dollars cell divided by the pounds cell
• As stated earlier, “per” means “divided by”

Interpreting the Results

• We can clearly see that Package #2 is the better buy:
  – $0.14 per ounce instead of $0.15 per ounce
  – $2.29 per pound instead of $2.39 per pound
  – They differ by only the conversion factor (16 ounces per pound)
  – We could not tell that from the original pricing ($2.29/lb or $1.79/12 ounces)

What if...

• Maybe the supermarket has a sale on one of the packages,
• How do we get the spreadsheet to tell us which is the better buy?
• We need to use a new Excel function called IF
### The IF Function

- The IF function is a way for the spreadsheet to ask a question and return one of two values depending on the answer to the question.
- The format is: `IF(question, true value, false value)`
- The result is either the second parameter or the third parameter, but which one it is depends on the answer to the question.

#### Back to the Packages

- Cell A9 contains $/oz for Package #1, and C9 contains $/oz for Package #2 (we could also use the $/pound cells).
- We need to determine three things:
  - Is Package #1 a better buy than Package #2? A9 < C9
  - Is Package #2 a better buy than Package #1? A9 > C9
  - Are they the same? A9 = C9
- There are three possibilities not two, so we can’t do this with one IF, but we can with two.

#### What do we Write?

- The first part is easy:
  - IF(A9 < C9, "Buy Package #1", __________)
- But what about the empty slot?
- A second question goes there!
  - IF(A9 > C9, "Buy Package #2", __________)
- But what about this empty slot?
- Since A9 is neither less than nor greater than C9, the empty slot is returned if the packages are the same! We know this by default, and need not ask explicitly if A9 = C9!

#### The Final Formula

- You would write this all on one line:
  - `=IF(A9<C9, "Buy Package #1", IF(A9>C9, "Buy Package #2", "They are the same price"))`

#### The IF function in General

- If you have N possible return values, you’ll need (N-1) IF functions.
- To determine a letter grade for an exam score in A1 for example (five values, four IFs), write this all on one line:
In Lab #7 and #8

- In Lab #7 and #8 you will use the **IF** function extensively.
- In Lab #8 you will use unit conversions to compute the number of kilometers in a mile (around 1.6) using **only** five provided units (in/ft, ft/mi, cm/in, cm/m, and m/Km), along with multiplication and division. You may **not** use any built-in conversion functions!