COMPSCI 105: Lecture #15
Units Conversion

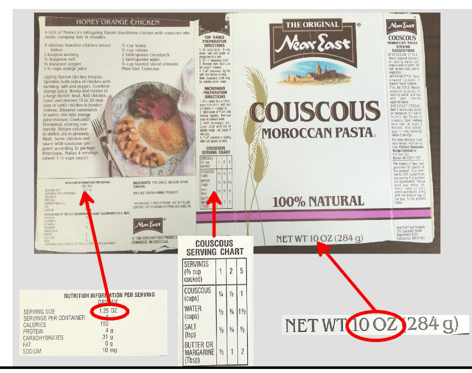
Units Conversion

- 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

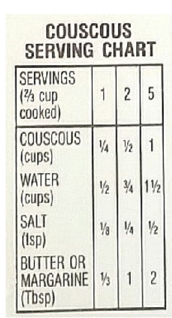
- Couscous is a tasty Moroccan pasta.
- To cook, it needs several things:
  - Dry pasta
  - Water
  - Butter
  - Salt
- How much of each?
- The next slide shows a typical package.

Near East™ Couscous



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!

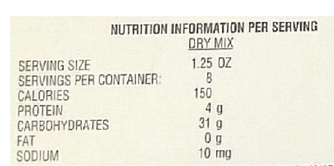


COUSCOUS SERVING CHART

SERVINGS (⅔ cup cooked)	1	2	5
COUSCOUS (cups)	¼	½	1
WATER (cups)	½	¾	1½
SALT (tsp)	⅛	¼	½
BUTTER OR MARGARINE (Tbsp)	⅓	1	2

Near East™ Couscous

- However, in tiny print on the back of the box, you find that there are 1.25 ounces in each serving:



NUTRITION INFORMATION PER SERVING

	DRY MIX
SERVING SIZE	1.25 OZ
SERVINGS PER CONTAINER:	8
CALORIES	150
PROTEIN	4 g
CARBOHYDRATES	31 g
FAT	0 g
SODIUM	10 mg

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:

  (Ounces per Box) × (Ounces per Serving)
  (Ounces per Box) ÷ (Ounces per Serving)
  (Ounces per Serving) ÷ (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:

$$\frac{10\ Ounces}{1\ Box}$$

Option #1: the Multiplication

- $\frac{10\ Ounces}{1\ Box} \times \frac{1.25\ Ounces}{1\ Serving} \rightarrow \frac{10 \times 1.25}{1 \times 1}\ \frac{Ounces^2}{Box\ Serving}$
- 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!
- Bzzzzzzt! Thanks for playing!

Option #2: one of the Divisions

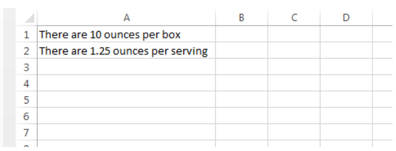
- $\frac{10\ Ounces}{1\ Box} \div \frac{1.25\ Ounces}{1\ Serving} \rightarrow \frac{10 \times 1}{1 \times 1.25}\ \frac{Ounces\ Servings}{Box\ Ounces}$
- Remember that to divide by a fraction you invert and multiply.
- Again, you get a reasonable-looking number: 8
- The ounces ***cancel***.
- Leaving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

Option #3: the other Division

- $\frac{1.25\ Ounces}{1\ Serving} \div \frac{10\ Ounces}{1\ Box} \rightarrow \frac{1.25 \times 1}{1 \times 10}\ \frac{Ounces\ Boxes}{Servings\ Ounces}$
- This time we get 0.125 (one-eighth)
- The ounces again ***cancel***.
- Leaving us with: $\frac{1\ Box}{8\ Servings}$
- This isn't what we want, but it *is* the inverse. If there are 8 servings per box, then there is ⅛ of a box per serving.

Putting the Problem into Excel

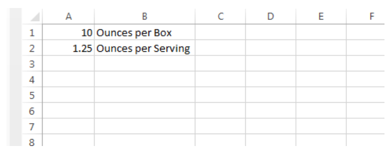
- How NOT to do it:



- 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:



- 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.
- **`=A1/A2`** preferred
- **`=(A1/A2)`** parentheses not necessary
- **`=(1/A2)*A1`** not preferred, inefficient
- $\frac{A1}{A2}$ or **`=A1÷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:
  `=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`)

Here's the Spreadsheet:

	A	B	C	D
1		16	**Ounces per Pound**	
2				
3				
4	**Package #1**		**Package #2**	
5	1.79	**Cost**	2.29	
6	12	**Ounces**	=C7*oz_per_lb	
7	=A6/oz_per_lb	**Pounds**	1	
8				
9	=A5/A6	**$ per ounce**	=C5/C6	
10	=A5/A7	**$ per pound**	=C5/C7	
11				
12				

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 <u>divided by</u> the ounces cell
- **$ per Pound** is the dollars cell <u>divided by</u> the pounds cell
- As stated earlier, "per" means "divided by"

Here are the Results:

	A	B	C	D	E	F
1		16	**Ounces per Pound**			
2						
3						
4	**Package #1**		**Package #2**			
5	$1.79	**Cost**	$2.29			
6	12	**Ounces**	16			
7	0.75	**Pounds**	1			
8						
9	$0.15	**$ per ounce**	$0.14			
10	$2.39	**$ per pound**	$2.29			
11						
12						

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 <u>tell us</u> 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(<u>*question*</u>**,**<u>*true value*</u>**,**<u>*false value*</u>**)**
- The result is either the <u>second parameter</u> or the <u>third parameter</u>, but which one it is depends on the answer to the question.

The **IF** Function

- Here is a sample use of **IF**:
  =IF(A1=0,B17*10,M9+3)
  The result will be either **B17*10** or **M9+3** (numbers); which one it is depends on whether **A1** is zero or not.
- Here is another use of **IF**:
  =IF(SUM(A1:A10)>100,"Frog","Toad")
  The result will be either **Frog** or **Toad** (strings); which one it is depends on whether the sum of ten cells is greater than 100 or not.

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 <u>one</u> **IF**, but we can with <u>two</u>.

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 <u>this</u> 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 **IF**s), write this all on one line :

```
=IF(A1>=90,"A",
  IF(A1>=80,"B",
    IF(A1>=70,"C",
      IF(A1>=60,"D","F"))))
```

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!