ECE1240 - Unit Conversion Module

There are 3 steps to converting between units:

1) Identify what you have and a fraction that equals "1" containing what you want
2) Multiply (or divide) all numbers and maintain all units in numerator and denominator
3) Look for and cancel out any units that appear in both numerator and denominator

Examples: Convert 40.3mA to A

Step 1: $(40.3\,mA)\left(\frac{1\,A}{1000\,mA}\right)$

Step 2: $\left(\frac{40.3}{1000}\right)\left(\frac{mA \cdot A}{mA}\right) \Rightarrow \frac{(0.043)(mA \cdot A)}{mA}$

Step 3: $\frac{(0.043)(\cancel{mA} \cdot A)}{\cancel{mA}} \Rightarrow 0.043\,A$

Convert 7.46mF to μF

* Note: If less confusing for you, first convert to F, then to μF

Step 1: $(7.46\,mF)\left(\frac{1\,F}{1000\,mF}\right)$

Step 2: $\left(\frac{7.46}{1000}\right)\left(\frac{mF \cdot F}{mF}\right) \Rightarrow \frac{(0.00746)(mF \cdot F)}{mF}$

Step 3: $\frac{(0.00746)(\cancel{mF} \cdot F)}{\cancel{mF}} \Rightarrow 0.00746\,F$

Now repeat steps 1-3 for converting 0.00746 F to μF

Step 1: $(0.00746\ F)\left(\frac{1{,}000{,}000\ \mu F}{1\ F}\right)$

Step 2: $\frac{(0.00746)(1{,}000{,}000)}{1} \cdot \left(\frac{F \cdot \mu F}{F}\right)$

$\Rightarrow (7460)\left(\frac{F \cdot \mu F}{F}\right)$

Step 3: $(7460)\left(\frac{\cancel{F} \cdot \mu F}{\cancel{F}}\right) \Rightarrow 7460\ \mu F$

Therefore $7.46\ mF = 7460\ \mu F$

Alternate Solution:

Step 1: $(7.46\ mF)\left(\frac{1000\ \mu F}{1\ mF}\right)$

Step 2: $\frac{(7.46)(1000)}{1} \cdot \frac{mF \cdot \mu F}{mF} \Rightarrow (7460)\left(\frac{mF \cdot \mu F}{mF}\right)$

Step 3: $(7460)\left(\frac{\cancel{mF} \cdot \mu F}{\cancel{mF}}\right) \Rightarrow 7460\ \mu F$

* Note: Remember when converting to a smaller unit (like $mF \rightarrow \mu F$) your final answer should be a larger number because there are more of them.

Example: There are more mini MnM's that take up the space of 10 regular MnM's.

Now we'll repeat the previous example using scientific notation: Convert 7.46 mF to μF

Step 1: $7.46\,mF = 7.46\times10^{-3}\,F$

$1\,F = 1\times10^{6}\,\mu F$

$\Rightarrow (7.46\times10^{-3}\,F)\left(\frac{1\times10^{6}\,\mu F}{1\,F}\right)$

Step 2: $(7.46\times10^{-3})(1\times10^{6})\left(\frac{F\cdot\mu F}{F}\right)$

* See scientific notation handout

Step 1: $(7.46)(1) = 7.46$

Step 2: $-3+6 = 3$

Step 3: 7.46×10^{3}

Step 3: $(7.46\times10^{3})\left(\frac{\cancel{F}\cdot\mu F}{\cancel{F}}\right) = 7.46\times10^{3}\,\mu F$

Multiple unit conversion example:

Calculate $V = IR$ if $I = 40.0\,mA$

$R = 7.36\,k\Omega$

Step 1: unit for volts will be $A\cdot\Omega$

$1\,A = 1\times10^{3}\,mA \Rightarrow \frac{1\,A}{1\times10^{3}\,mA}$

$1\,\Omega = 1\times10^{-3}\,k\Omega \Rightarrow \frac{1\,\Omega}{1\times10^{-3}\,k\Omega}$

$\Rightarrow V = \underbrace{\left[(40.0\,mA)\left(\frac{1\,A}{1\times10^{3}\,mA}\right)\right]}_{I}\underbrace{\left[(7.36\,k\Omega)\left(\frac{1\,\Omega}{1\times10^{-3}\,k\Omega}\right)\right]}_{R}$

Step 2: $\frac{(40.0)(7.36)}{(1\times10^{3})(1\times10^{-3})}\left(\frac{mA\cdot A}{mA}\right)\left(\frac{k\Omega\cdot\Omega}{k\Omega}\right)$

$$\Rightarrow \frac{294}{[(1)(1)] \times 10^{3+(-3)}} \left(\frac{mA \cdot A}{mA}\right)\left(\frac{k\Omega \cdot \Omega}{k\Omega}\right)$$

Step 3: $\frac{2.94 \times 10^2}{1 \times 10^0} \left(\frac{\cancel{mA} \cdot A}{\cancel{mA}}\right)\left(\frac{\cancel{k\Omega} \cdot \Omega}{\cancel{k\Omega}}\right)$

$$\Rightarrow \frac{2.94 \times 10^2}{1} \; A \cdot \Omega = 2.94 \times 10^2 V$$

* 3 digits of accuracy since both I & R have 3 digits.

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Real-world Example

Suppose I want to impress someone by showing off my culinary skills. However, I'm also wondering if it's cheaper to eat out. I have a $20 budget and the food items will cost $18.27. I need to determine the cost for electricity to make the following:

1) Baking a roast in an electric oven at low temp (215°F) for 6 hours
2) Heating green beans in the microwave for 4 minutes
3) Frying potatoes on an electric stovetop for 20 min

To remain under budget, the cost for electricity must be less than $1.73

Solution: Rocky Mountain Power charges the following rates:

9.28¢ for 0-20 kiloWatt Hours (kWh)
11.97¢ for 20.01-40 kiloWatt Hours (kWh)

The stickers on my appliances show the following wattages:

1) Electric Oven - 2400 W

Note: This is a maximum value for high temperatures. Since I will be baking at a low temp, I will assume 1500 W

2) Microwave - 1000 W

3) Stovetop - 3000 W

Note: This is also a max value. I will assume 2000 W for med/hi heat

A watt is a unit of power. A joule is a unit of energy.

$$1 \text{ Watt} = \frac{1 \text{ Joule}}{\text{sec}}$$

Using unit conversions: $1 \text{ W} \cdot \text{sec} = 1 \text{ Joule}$ which is energy. $\Rightarrow$ Rocky Mountain Power is selling units of energy, not power.

To convert to kWh:

$$(1 \cancel{\text{W}} \cdot \cancel{\text{sec}})\left(\frac{1 \text{ kW}}{1000 \cancel{\text{W}}}\right)\left(\frac{1 \text{ hour}}{3600 \cancel{\text{sec}}}\right) = \frac{1}{(1000)(3600)} \text{ kW} \cdot \text{h}$$

$$\Rightarrow 1 \text{ Joule} = 2.78 \times 10^{-7} \text{ kWh}$$

Now, let's calculate specific energy use for each appliance:

1) $(1500 \cancel{\text{W}})\left(\frac{1 \text{ kW}}{1000 \cancel{\text{W}}}\right)(6 \text{ h}) = 9 \text{ kWh}$

2) $(1000\,\cancel{W})\left(\frac{1\,kW}{1000\,\cancel{W}}\right)\left(4\,\cancel{min}\right)\left(\frac{1\,h}{60\,\cancel{min}}\right)$

$\Rightarrow \left(\frac{\cancel{1000}\cdot 4}{\cancel{1000}\cdot 60}\right) kWh = 0.067\,kWh$

3) $(2000\,\cancel{W})\left(\frac{1\,kW}{1000\,\cancel{W}}\right)\left(20\,\cancel{min}\right)\left(\frac{1\,h}{60\,\cancel{min}}\right)$

$\Rightarrow \left(\frac{2000\cdot 20}{1000\cdot 60}\right) kWh = 0.667\,kWh$

Total energy (kWh) to make the meal:

$(9 + 0.067 + 0.667)\,kWh = 9.73\,kWh$

Total energy cost to make the meal:

$(9.73\,kWh)\left(\frac{\$0.0928}{kWh}\right) = \$0.903$

Total cost for the meal:

$\$18.27 + \$0.903 = \$19.17$

My meal cost is under budget and much nicer than what I can buy for $20 if eating out!