Engineering Notation

The standards for radio and electrical technologies are set by radio engineers and electric engineers. They both like to use what is called engineering notation. This approach is describe below and contrasted with scientific notation that you may have heard of before.

Engineering vs Scientific Notation

Engineers and scientist are always slightly jealous of each other. Scientist have some thing called scientific notation. This notations for decimal numbers uses a decimal number that is between 1 and 9 followed by a decimal point and possible a decimal fraction. This number is followed by 10 to some power so the number retains it correct value. As an example consider the decimal number 912.3765. If we move the decimal value two places to the left we are effectively dividing the number by 100 or 10 x 10 = 10^2. The exponent counts the number of times the 10 is repeated. Therefore 912.3765 = 9.123765 x 10^2. If the exponent is negative that is the number of tenths. As an example 1/10 = 10^{-1}, 1/10 x 1/10 = 1/100 = 10^{-2}, etc.

Engineers like the power of the exponent to be divisible by 3 such as 3 in this case. Now 912.3765 = 0.9123765 x 10^3. The International Systems of Units (SI) has names for exponents of 10 that are divisible by 3. These names are shown in the table below.

Text	Symbol	Factor	Power
exa	E	1 000 000 000 000 000 000	10^{18}
pea	P	1 000 000 000 000 000	10^{15}
tera	T	1 000 000 000 000	10^{12}
giga	G	1 000 000 000	10^{9}
mega	M	1 000 000	10^{6}
kilo	k	1 000	10^{3}
(none)	(none)	1	10^{0}
milli	m	0.001	10^{-3}
micro	μμ	0.000 001	10^{-6}
namo	n	0.000 000 001	10^{-9}
pico	p	0.000 000 000 001	10^{-12}
femto	f	0.000 000 000 000 001	10^{-15}
atto	a	0.000 000 000 000 000 001	10^{-18}

In terms of radio frequencies we are interested in terahertz (or THz), gigahertz (or GHz), megahertz (or MHz), kilohertz (or kHz) and hertz (or Hz). These are shaded in yellow. When dealing with components such as capacitors and instructors we are often interested in milli (or m), micro (or µ), nano (or n) and pico (or p). Note with micro the lower case m is already used for milli and the upper case M for mega. So the Greek lowercase m or mu (µ) is used for micro. Note µ looks much like a lowercase u which is often used on an English keyboard.

The Decimal Point Boogie Woogie

Now we must learn to dance about the decimal point. By moving the decimal point to the right by one-position, the value has increased its value by ten. As an example 9.00 becomes 90.0. Therefore we must divide the new number by 10, multiply by 1/10 or 10^{-1} to retain its correct value. Therefore 9.00 = 90.0 x 10^{-1}.

In a similar manner if we move the decimal point to the left, we are dividing the number by 10. Therefore we must multiply the number by 10 to retain the value. 9.00 becomes 0.900 x 10 or 0.900 x 10^1.

If the number is originally in engineering notation, to retain engineering notation we must move the decimal point by 3, 6, 9 or 12 positions to the right or left.

Examples from Question Pool

Below are some examples of how one would keep results in engineering notation drawn for the 2014 to 2018 Technician Class Question Pool.

```
+T5B01
How many milliamperes is 1.5 amperes?
   A. 15 milliamperes
   B. 150 milliamperes
   C. 1,500 milliamperes
   D. 15,000 milliamperes
```

Since all the answers are in the units of milliamperes, convert 1.5 amperes to milliamperes. 1.5 ampere is 1.5 x 10^0 amperes. If you move the decimal point three places to the right and subtract 3 from the exponent you obtain 1.500 x 10^0 = 1500 x $10^{(0-3)}$ = 1500 x 10^{-3} = 1500 milliamperes. Therefore the answer is C or 1,500 milliamperes

```
=T5B02
What is another way to specify a radio signal frequency of 1,500,000 hertz?
   A. 1500 kHz
   B. 1500 MHz
   C. 15 GHz
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```
   D. 150 kHz
```

The answers are in kHz, MHz, and GHz. Let's mover the decimal point to the left 3 places and adjust the units from kHz to MHz to GHz for each 3 places moved. After we perform the move we will check to see if answer is present in list. 1,500,000 Hz = 1,500.000 kHz. There it is the first iteration. The answer is A or 1500 kHz.

```
=T5B03 (C)
How many volts are equal to one kilovolt?
   A. One one-thousandth of a volt
   B. One hundred volts
   C. One thousand volts
   D. One million volts
```

All the answers are in volts. Therefore we will start with 1 kilovolt and change kilo to 1 x 10^3 volts = 1 x 1000 volts = 1,000 volts. Therefore C or One thousand volts is the correct answer.

```
=T5B04
How many volts are equal to one microvolt?
   A. One one-millionth of a volt
   B. One million volts
   C. One thousand kilovolts
   D. One one-thousandth of a volt
```

Let's start with 1 microvolt which is 1 x 10^{-6} volts. 1 x 10^{-6} volts = 1 x 0.000 001 = 0.000 001 or one one-millionth of a volt. Therefore the answer is A or one one-millionth of a volt.

```
=T5B05 (B)
Which of the following is equivalent to 500 milliwatts?
   A. 0.02 watts
   B. 0.5 watts
   C. 5 watts
   D. 50 watts
```

Since all the answers are in the units of watts, convert 500 milliwatts to watts. 500-milliwatts is 500 x 10^{-3} watts. If you move the decimal point three places to the left and add 3 to the exponent you obtain 500 x 10^{-3} = 0.500 x $10^{(-3+3)}$ = 0.500 x 10^0 = 0.500 x 1 = 0.500 watts. There for the answer is B or 0.5 watts.

```
=T5B06 (C)
If an ammeter calibrated in amperes is used to measure a 3000-milliampere current,
what reading would it show?
   A. 0.003 amperes
   B. 0.3 amperes
   C. 3 amperes
   D. 3,000,000 amperes
```

Since all the answers are in the units of amperes, convert 3000-milliamperes to amperes. 3000-milliampere is 3000 x 10^{-3} amperes. If you move the decimal point three places to the left and add 3 to the exponent you obtain 3000 x 10^{-3} = 3.000 x $10^{(-3+3)}$ = 3.000 x 10^{0} = 3.000 x 1 = 3.000 amperes. There for the answer is C or 3 amperes

```
=T5B07
If a frequency readout calibrated in megahertz shows a reading of 3.525 MHz, what
would it show if it were calibrated in kilohertz?
   A. 0.003525 kHz
   B. 35.25 kHz
   C. 3525 kHz
   D. 3,525,000 kHz
```

One way to work this problem is to move the decimals point to the left and right by three positions and look at the results. Remember to subtract and add respectively to retain the same value. 3.525 MHz = 3.525 x 10^{6} Hz. Now lets move the decimal point 3 places to the left. We must add three to the exponent to retain the same value. 3.525 x 10^{6} = 0.003525 x 10^{9} or 0.003525 GHz. Answer A is 0.003535 kHz which is not 0.003525 GHz. Let move the decimal point 3 places to the right and subtract 3 from the exponent to retain the value. 3.525 x 10^{6} = 3525.0 x 10^{3} or 3525 kHz. Therefore the answer is C or 3535 kHz. Understand and remember the method not that the answer is C.

```
=T5B08
How many microfarads are 1,000,000 picofarads?
   A. 0.001 microfarads
   B. 1 microfarad
   C. 1000 microfarads
   D. 1,000,000,000 microfarads
```

One way to work this problem is to convert 1,000,000 picofarad and then to microfarads because all answers are in microfarads. 1,000,000 picofarads = 1.0 x 10^{6} x 10^{-12} farads. The 10^{6} came from the one-million and the 10^{-12} from the pico. To combine the two exponents to one exponent we add them. Therefore 1.0 x 10^{6} x 10^{-12} farads = 10^{-6} farads, since +6-12 = -6. From the table milli is 10^{-3}, micro is 10^{-6}, nano is 10^{-9} and pico is 10^{-12}. Therefore 1.0 x 10^{-6} is 1 microfarad or B. Again understand and remember the method and not that the answer is B.

```
=T5B12
Which of the following frequencies is equal to 28,400 kHz?
   A. 28.400 MHz
   B. 2.800 MHz
   C. 284.00 MHz
   D. 28.400 kHz
```

Again one way to work this problem is to move the decimal point to the left and right by three positions and look at the results. Remember to subtract and add respectively to retain the same value. 28,400 kHz = 28,400 x 10^{3} Hz. Now lets move the decimal point 3 places to the left. We must add three to the exponent to retain the same value. 28,400 x 10^{3} = 28.400 x 10^{6} or 28.400 MHz. In this case moving the decimal point to the left gave us the correct answer.

By moving to the right we get 28,400 kHz = 28,400,000 x 10^3 x 10^{-3} = 28,400,000 x 10^0 = 28,400,000 x 1 = 28,400,000 or 28,400,000 Hz. None of the answers are in Hertz, they are all in kHz or MHz.

```
T5B13
If a frequency readout shows a reading of 2425 MHz, what frequency is that in GHz?
   A. 0.002425 GHZ
   B. 24.25 GHz
   C. 2.425 GHz
   D. 2425 GHz
```

MHz is 10^6 Hz and GHz is 10^9 Hz. To add 3 to the exponent we must move the decimal point to the left to retain the value. Let's perform this operation. 2425 x 10^6 = 2.425 x 10^9 or 2.425 GHz. Therefore C is the correct answer. Understand and remember the method not the specific answer.

Conclusion

Working the problems with SI prefixes is not that complex. One just needs to stay calm and move the decimal point left or right and adjust the exponent on the power of 10. One only needs to learn the prefixes, there symbols, there value and associated exponents for those shaded in either yellow or green.

At this point you don't need to know anything about the units just the prefixes. You don't care what a Farquaad is just how to convert a farquaad to a kilofarquaad or a millifarquaad etc.