Tutorials on Mathematics

The following web links are a compilation of online resources organized by topic. Many of the tutorials listed below are part of the Interactive Mathematics website (**www.intmath.com**), a free, online system of tutorials. The system begins with basic number concepts and progresses all the way through introductory calculus. The lessons referenced here are those of most use to a student of radio electronics.

1 Basic Numbers & Formulas

Order of Operations — **www.intmath.com/Numbers/3_Order-of-operations.php**

Powers, Roots, and Radicals — **www.intmath.com/Numbers/4_Powers-roots-radicals.php**

Scientific Notation —**www.intmath.com/numbers/6-scientific-notation.php**

Ratios and Proportions — **www.intmath.com/Numbers/7_Ratio-proportion.php**

Geometric Formulas — **www.equationsheet.com/sheets/Equations-4.html**

2 Metric System and Conversion of Units

Metric System Overview — **en.wikipedia.org/wiki/Metric_system**

MetricEnglish — **en.wikipedia.org/wiki/Metric_yardstick**

Conversion Factors — **https://brownmath.com/bsci/convert.htm**

Tables of Conversion Factors —**en.wikipedia.org/wiki/Conversion_of_units**

3 Fractions

Equivalent Fractions — **www.intmath.com/factoring-fractions/factoring-fractions-intro.php**

Multiplication and Division — **www.intmath.com/Factoring-fractions/6_Multiplication- division-fractions.php**

Adding and Subtracting — **www.intmath.com/Factoring-fractions/7_Addition-subtraction- fractions.php**

Equations Involving Fractions — **www.intmath.com/Factoring-fractions/8_Equations- involving-fractions.php**

4 Graphs

Basic Graphs — **www.intmath.com/Functions-and-graphs/Functions-graphs-intro.php**

Polar Coordinates — **www.intmath.com/Plane-analytic-geometry/7_Polar-coordinates.php**

Exponents & Radicals — **www.intmath.com/Exponents-radicals/Exponent-radical.php**

Exponential & Logarithmic Functions — **www.intmath.com/Exponential-logarithmic- functions/Exponential-log-functionsintro.php**

5 Algebra and Trigonometry

Basic Algebra—**www.intmath.com/Basic-algebra/Basic-algebra-intro.php**

Basic Trig Functions — **www.intmath.com/Trigonometric-functions/Trig-functions- intro.php**

Graphs of Trig Functions —**www.intmath.com/trigonometric-graphs/trigo-graph-intro.php**

6 Complex Numbers

Complex Numbers — **www.intmath.com/Complex-numbers/imaginary-numbers-intro.php**

Polar-Rectangular Conversion — **www.intmath.com/Complex-numbers/4_Polar-form.php**

7 Quadrature Signals

Quadrature Signal Tutorial — **www.dsprelated.com/showarticle/192.php**

Quadrature (I-Q) Modulation — **www.fourier-series.com/IQMod**

Digital Modulation — **complextoreal.com/wp-content/uploads/2013/01/mod1.pdf**

Radio Math Cheat Sheet

Here are many formulas and constants that are frequently used in Amateur Radio. You can save this on your smartphone or tablet or print it out and keep it in your toolbox or on the bench. No guessing required!

CONSTANTS

$e = 2.71828$; $1/e = 0.36788$
$\pi = 3.14159$; $2\pi = 6.28318$; $4\pi = 12.5664$; $\pi/2 = 1.5708$; $\pi/4 = 0.785398$
$\log_{10} = 2.303 \times \ln$ (or $\log_e$); $\ln = \log_{10} / 2.303$

Time constants — charging
$\tau = 1/e = 0.632$; $2\tau = 0.865$; $3\tau = =0.95$; $4\tau = 0.982$; $5\tau = 0.993$

Time constants — discharging
$\tau = 1 = 1/e = 0.368$; $2\tau = 0.135$; $3\tau = =0.05$; $4\tau = 0.018$; $5\tau = 0.007$

TABLE OF CONVERSION FACTORS FOR SINUSOIDAL AC VOLTAGE OR CURRENT

Conversion Factors for Sinusoidal AC Voltage or Current

From	To	Multiply By
Peak	Peak-to-Peak	2
Peak-to-Peak	Peak	0.5
Peak	RMS	$1/\sqrt{2}$ or 0.707
RMS	Peak	$\sqrt{2}$ or 1.414
Peak-to-Peak	RMS	$1/(2 \times \sqrt{2})$ or 0.35355
RMS	Peak-to-Peak	$2 \times \sqrt{2}$ or 2.828
Peak	Average	$2/\pi$ or 0.6366
Average	Peak	$\pi/2$ or 1.5708
RMS	Average	$(2 \times \sqrt{2})/\pi$ or 0.90
Average	RMS	$\pi/(2 \times \sqrt{2})$ or 1.11

Note: These conversion factors apply only to continuous pure sine waves.

Ohm's Law and Power Circle

During the first semester of my *Electrical Power Technology* program, one of the first challenges issued by our dedicated instructor — Roger Crerie — to his new freshman students was to identify and develop 12 equations or formulas that could be used to determine voltage, current, resistance and power. Ohm's Law is expressed as $R = E / I$ and it provided three of these equation forms while the basic equation relating power to current and voltage ($P = I \times E$) accounted for another three. With six known equations, it was just a matter of applying mathematical substitution for his students to develop the remaining six. Together, these 12 equations compose the *circle* or *wheel* of voltage (E), current (I), resistance (R) and power (P) shown in **Figure A**. Just as Roger's previous students had learned at the Worcester Industrial Technical Institute (Worcester, Massachusetts), our Class of '82 now held the basic electrical formulas needed to proceed in our studies or professions.

As can be seen in Figure A, we can determine any one of these four electrical quantities by knowing the value of any two others. You'll probably be using many of these formulas as the years go by — this has certainly been my experience.
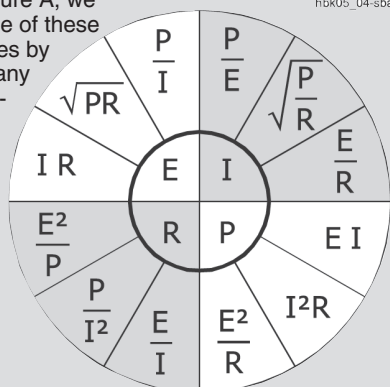— *Dana G. Reed, W1LC*

Figure A — Electrical formulas

REACTANCE

$$X_C = \frac{1}{2\pi fC} \text{ and } X_L = 2\pi fL$$

POLAR-RECTANGULAR CONVERSION

To convert from rectangular ($a + jb$) to polar form ($r \angle \theta$):

$$r = \sqrt{(a^2 + b^2)} \text{ and } \theta = \tan^{-1}\left(\frac{b}{a}\right)$$

To convert from polar to rectangular form:
$a = r \cos \theta$ and $b = r \sin \theta$

DECIBELS

$dB = 10 \log (P/ P_{REF}) = 20 \log (V / V_{REF})$
Power ratio = $\log^{-1} (dB/10)$ and Voltage ratio = $\log^{-1} (dB/20)$
$dB = 10 \log$ (percentage of power / 100) = $20 \log$ (percentage of voltage / 100)
Percentage of power = $100\% \times \log^{-1} (dB/10)$
Percentage of voltage = $100\% \times \log^{-1} (dB/20)$
dBm: $P_{REF} = 1$ mW; dBW: $P_{REF} = 1$ W; dBµW: $P_{REF} = 1$ µW
dBV: $V_{REF} = 1$ V; dBµV: $V_{REF} = 1$ µV
$dBd = dBi - 2.15$ and $dBi = dBd + 2.15$
1 µW = -30 dBm; 1 mW = 0 dBm; 1 W = 30 dBm
100 W = 50 dBm; 1 kW = 60 dBm

Common dB Values For Ratios of Power and Voltage

P2/P1	dB	V2/V1	dB
0.1	-10	0.1	–20
0.25	-6	0.25	–12
0.5	-3	0.5	–6
1	0	0.707	–3
2	3	1	0
4	6	1.414	3
10	10	2	6
		4	12
		10	20

PARALLEL AND SERIES COMPONENTS

How components in series and parallel are combined into a single equivalent value. For two resistors or inductors in parallel or for two capacitors in series use the simplified formula

$$\text{Equivalent value} = \frac{\text{Value1} \times \text{Value2}}{\text{Value1} + \text{Value2}}$$

$R = R_1 + R_2 + R_3$

$R = \dfrac{1}{\dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}}$

$C = \dfrac{1}{\dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3}}$

$C = C_1 + C_2 + C_3$

$L = L_1 + L_2 + L_3$

$L = \dfrac{1}{\dfrac{1}{L_1} + \dfrac{1}{L_2} + \dfrac{1}{L_3}}$

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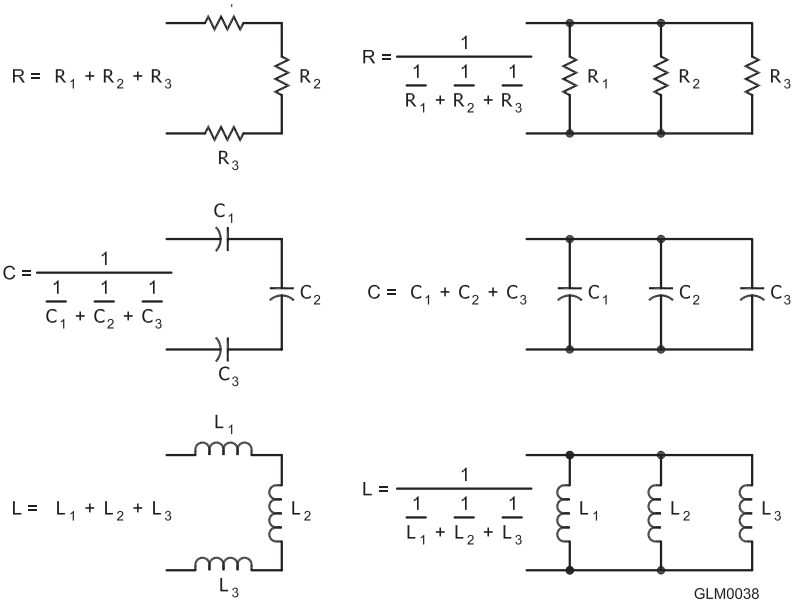
PEAK ENVELOPE POWER

$$PEP = \frac{\left[\dfrac{0.707 \times V_{Pk-Pk}}{2} \right]^2}{R_{LOAD}} = \frac{V_{RMS}^{\,2}}{R_{LOAD}}$$

FREQUENCY-WAVELENGTH CONVERSION

Frequency (in Hz) = 3×10^8 / Wavelength (in m)
Wavelength (in m) = 3×10^8 / Frequency (in Hz)
Frequency (in MHz) = 300 / Wavelength (in m)
Wavelength (in m) = 300 / Frequency (in MHz)
Half-wavelength in free space (in feet) = 492 / Frequency (in MHz)
Quarter-wavelength in free space (in feet) = 246 / Frequency (in MHz)

LENGTH CONVERSION

Multiply meters by 3.28 to get feet
Multiply meters by 39.4 to get inches
Multiply meters by 1.09 to get yards
Multiply yards by 0.914 to get meters
Multiply feet by 0.305 to get meters
Multiply inches by 2.54 to get centimeters
Multiply feet by 30.5 to get centimeters
Multiply centimeters by 0.0328 to get feet
Multiply centimeters by 0.394 to get inches

TRIGONOMETRY AND ANGLES

1 radian (rad) = 57.3 degrees; 2π radians in a circle
1 degree = 0.0174 radians; 360 degrees in a circle
$45° = \pi/4$ rad; $90° = \pi/2$ rad; $180° = -180° = \pi$ rad
$270° = -90° = 3/\pi/2$ rad $= -\pi/2$ rad
1 revolution = 360°; 2 rev = 720°; 3 rev = 1080°

$\text{Sin}(\theta) = -\sin(-\theta) = \cos(\theta - 90°)$ or $\cos(\theta - \pi/2 \text{ rad})$
$\text{Cos}(\theta) = \cos(-\theta) = \sin(\theta + 90°)$ or $\sin(\theta + \pi/2 \text{ rad})$

$\text{Sin}(90°) = \sin(\pi/2 \text{ rad}) = \cos(0) = 1$
$\text{Sin}(45°) = \sin(\pi/4 \text{ rad}) = \cos(45°) = \cos(\pi/4 \text{ rad}) = 0.707$
$\text{Sin}(30°) = \cos(60°) = 0.5$

$\text{Sin}(0) = \cos(90°) = \cos(\pi/2 \text{ rad}) = 1$
$\text{Sin}(180°) = \sin(\pi \text{ rad}) = 0$; $\cos(180°) = \cos(\pi \text{ rad}) = -1$
$\text{Sin}(270°) = \sin(3\pi/2 \text{ rad}) = -1$; $\cos(270°) = \cos(3\pi/2 \text{ rad}) = 0$

$\text{Tan}(\theta) = \sin(\theta) / \cos(\theta) = $ height of structure / distance to structure base

Height of a structure = distance to base of structure $\times$ tan (angle to top of structure)

Length of a guy wire =

$$\sqrt{(\text{distance to guy point})^2 + (\text{height of guy attachment})^2}$$