Extra-Class License Course

Math Review

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K0NK
1/10/2026

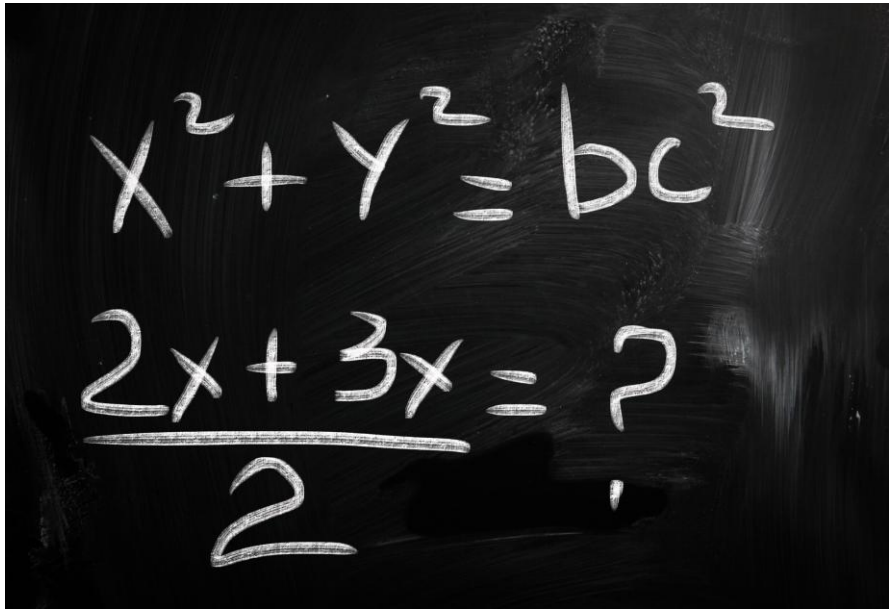
What we will look at:

- **General Class Math**
- Metric system & powers of 10
- Adding or removing zeros
  - 1230.45 = 00001230.450000
- Equations
  - Variables and constants
  - Math operators (+ -- x ÷)
  - Squaring and square roots
  - Logarithms
- Numbers expressed as fractions or decimal
- Negative numbers

- **Extra Class Math**
  - Other Operators < >
  - Pi π
  - Absolute Values
  - Imaginary numbers
  - Trigonometry
    - Sine, cosine, tangent
  - Deeper look at equations

A Look Back

Let's take a look back at the math that was used in the General Class study



The Metric System

Table 2-1

International System of Units (SI)—Metric Units

Prefix	*Symbol*	*Multiplication Factor*
Tera	T	$10^{12} = 1{,}000{,}000{,}000{,}000$
Giga	G	$10^{9} = 1{,}000{,}000{,}000$
Mega	M	$10^{6} = 1{,}000{,}000$
Kilo	k	$10^{3} = 1000$
Hecto	h	$10^{2} = 100$
Deca	da	$10^{1} = 10$
Deci	d	$10^{-1} = 0.1$
Centi	c	$10^{-2} = 0.01$
Milli	m	$10^{-3} = 0.001$
Micro	μ	$10^{-6} = 0.000001$
Nano	n	$10^{-9} = 0.000000001$
Pico	p	$10^{-12} = 0.000000000001$

A Quick Look at the Metric System

- **The metric system is a shorthand for expressing numbers, particularly useful for:**
  - Very large numbers
  - Very small numbers
- Examples:
  - 1 meter = 1 m
  - 1000 meters = 1 kilometer = 1 km
  - 16000 meters = 16 kilometers = 16 km
  - 1,000, 000 meters = 1 Megameters = 1 Mm
- kilo is like multiplying by 1000
- Mega is like multiplying by 1,000,000

The Important Ones

Prefix - Symbol	Meaning	Number	Power of Ten
Giga - **G**	One billion	1,000,000,000	10^{9}
Mega - **M**	One million	1,000,000	10^{6}
Kilo - **k**	One thousand	1,000	10^{3}
Hecta-	One hundred	100	10^{2}
Deca	Ten	10	10^{1}
(none)	One	1	10^{0}
Deci-	One tenth	0.1	10^{-1}
Centi-	One hundredth	0.01	10^{-2}
Milli - **m**	One thousandth	0.001	10^{-3}
Micro - **u**	One millionth	0.000001	10^{-6}
Nano - **n**	One billionth	0.000000001	10^{-9}
Pico – **p**	One trillionth	0.000000000001	10^{-12}

Moving the Decimal Point

* All numbers have decimals points
* 3 = 3. = 3.0 = 3.00 = 3.000000 = 000000003.
* The Metric System lets us move the decimal point to the left or to the right make the number easier to write.

➢ 4000. = 4.000k = 4.k = 4k

➢ **k** means we moved the decimal point 3 places to the left

➢ 6,000,000. = 6M

➢ **M** means we moved the decimal point 6 places to the left

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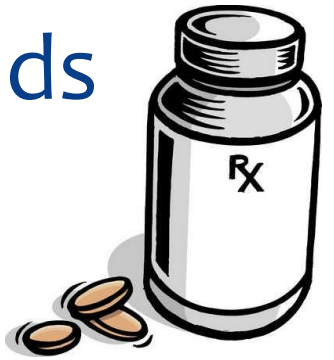
G M k -- m u n p

Good **M**en **k**now -- **m**any **u**seful **n**ational **p**roverbs

Metric System Usage

- Very large numbers (300 million meters)
- Very small numbers (2 millionths of a second)

- Common Units of Measure: Meter, gram, liter
- Electronics: Hertz, Ohm, Farad, Henry, seconds



Moving the Decimal Point
- Very Large Numbers -

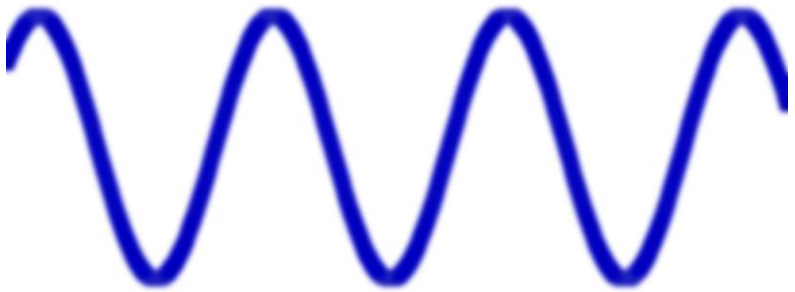
- 6,000,000. = 6000k = 6M
- 6,450,000. = 6.45M

- Hertz (Hz) is a unit of measure for frequency
  - 14.2 **M**Hz
  - = 14,200 **k**H
  - = 14,200,000 Hz

Moving the Decimal Point
- Very Small Numbers -

- Light travels at the speed of 300,000,000 meters every second.
  - Or 186000 miles per second

  How long does it take a radio signal to travel 300m (about 1000 ft)?
- A radio wave will travel a distance of about 300m in about one millionth of a second.
- Expressed mathematically:
  - 0.000001 s
  - Moving the decimal point to the right 6 places
  - 0.000001. s → u
  - 1us



Powers of Ten

* $10^1 = 10$
* $10^2 = \mathbf{10 \times 10} = 100$
* $10^3 = \mathbf{10 \times 10 \times 10} = 1000$
* $10^6 = \mathbf{10 \times 10 \times 10 \times 10 \times 10 \times 10} = 1{,}000{,}000$
* $10^{-2} = \frac{1}{\mathbf{10 \times 10}} = \frac{1}{100}$ or .01 or divide by 100
* 10^{-3} = .001 or divide by 1000
* 10^{-6} = .000001 or divide by 1000000

Ten to the third power

$5 \times 10^3 = 5000$

$5 \times 10^6 = 5{,}000{,}000$

$5 \times 10^{-2} = 0.05$

$5 \times 10^{-3} = 0.005$

$5 \times 10^{-6} = 0.000005$

13000

Adding or Removing Zeros

* 3 = 3. = 3.0 = 3.00 = 3.000000 = 000000003.

* 1230.45 = 000001230.45 = 1230.4500000 = 00001230.4500000
* 00001230.4500000
  * **We can not add or remove zeros within the significant figures**

Significant Figures

* 67800.0 The Decimal point can be thought of as part of the significant figure
  * **We can not add or remove zeros within the significant figures**

Significant Figures

0.0987

Significant Figures

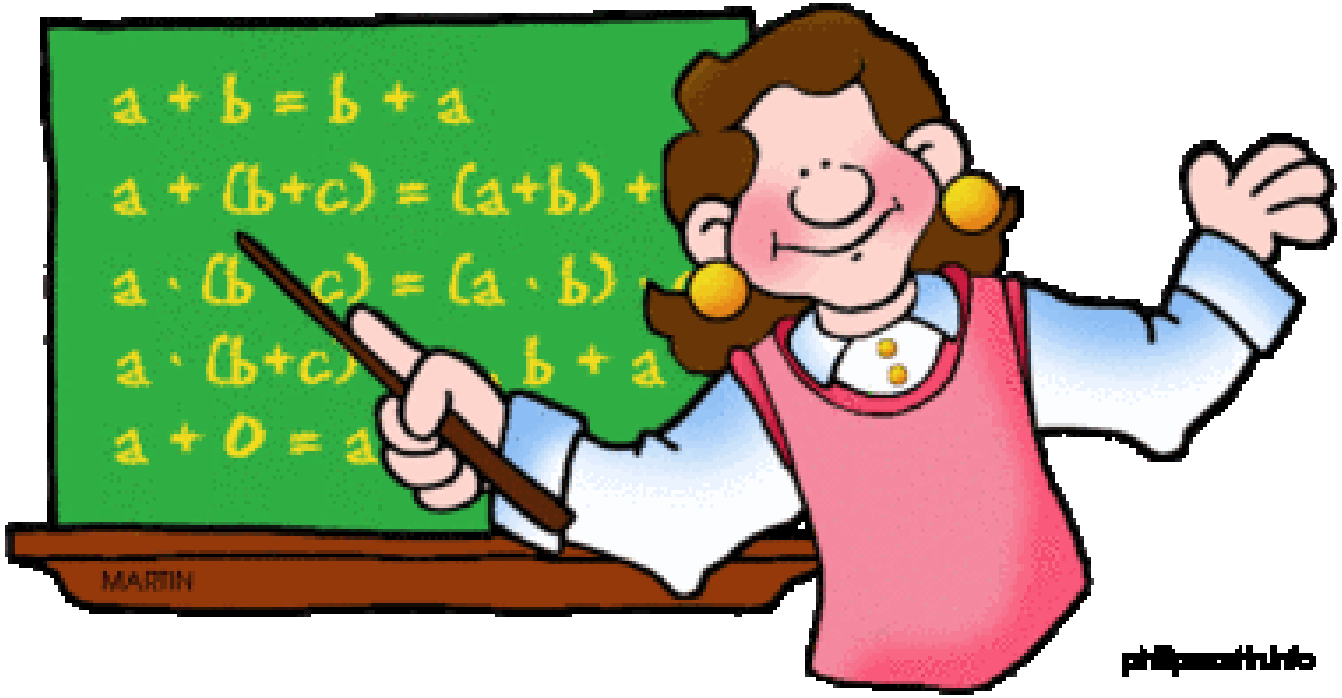
Remember your school days?

English Class!

Nouns, Verbs Adjectives …

Math class!

Numbers, Multiplication, Equations …



Making Simple Equations

* The people participating in this class are made up of the students and the instructors.

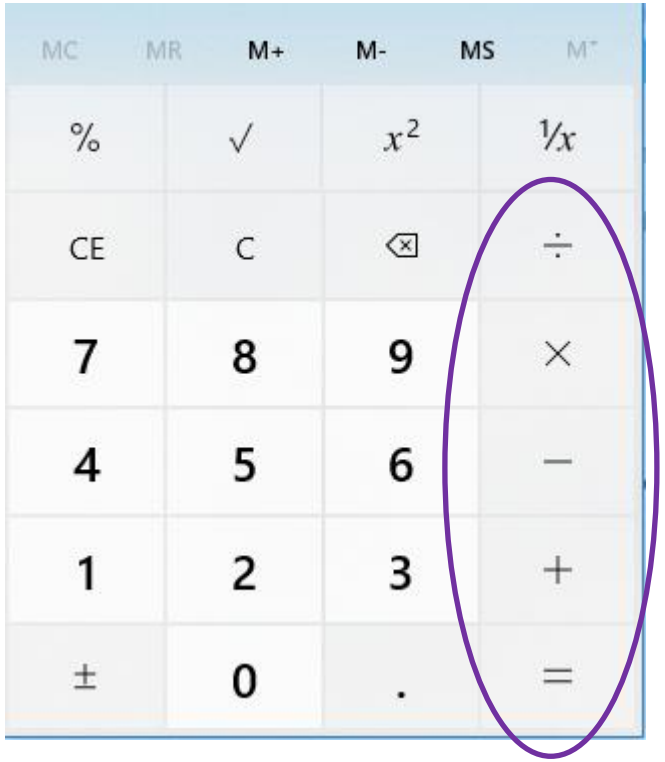
* People = students + instructors
* P = S + I
* P = 12 + 5
* P = 17

Variables

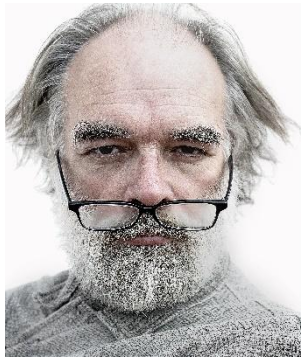
* An **equation** (or **formula**) is simply a mathematical sentence

Math Vocabulary (Operators)

* Addition: **+**
  * Example: 5 + 3
* Subtraction: **-**
  * Example: 5 - 3
* Multiplication: **x ; * ; R1 R2; R1(R2)**
  * Examples: 5 x 3 ; 5 * 3; 5(3)
* Division: **÷** ; **/** ; $\frac{}{}$
  * Examples: 5 ÷ 3 ; 5/3 ; $\frac{5}{3}$
* Equal: **=**
  * Example: 5 = 5



Let's Make Another Simple Equation



Old Man

Young Lady

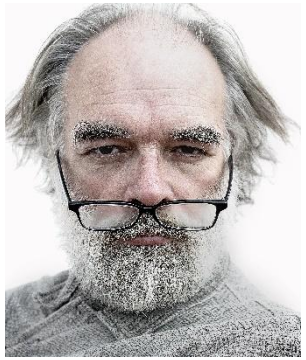
* Total Participants = OM students + YL students + Instructors

* $P_T = S_{OM} + S_{YL} + I$

Subscript

Variables

Let's Plug Numbers in for the Variables



Old Man

Young Lady

$P_T = S_{OM} + S_{YL} + I$

$P_T = 8 + 4 + 5$

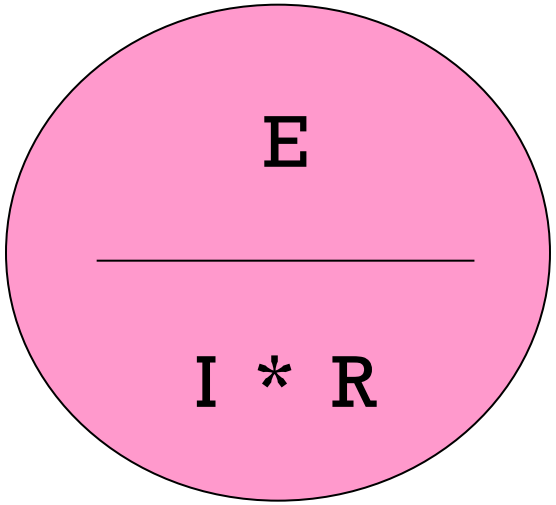
$P_T = 17$

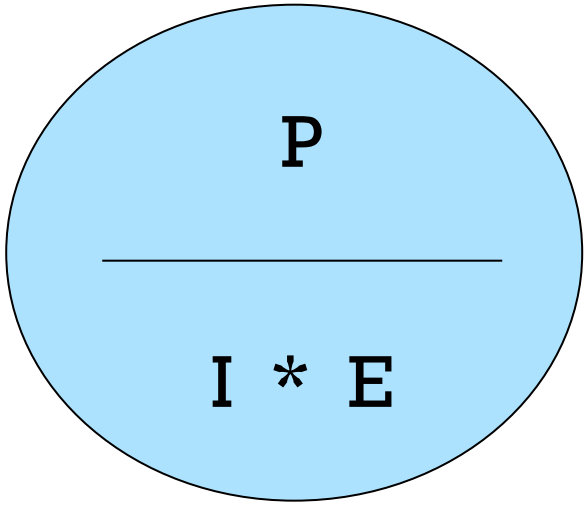
Equations, Equations and More Equations

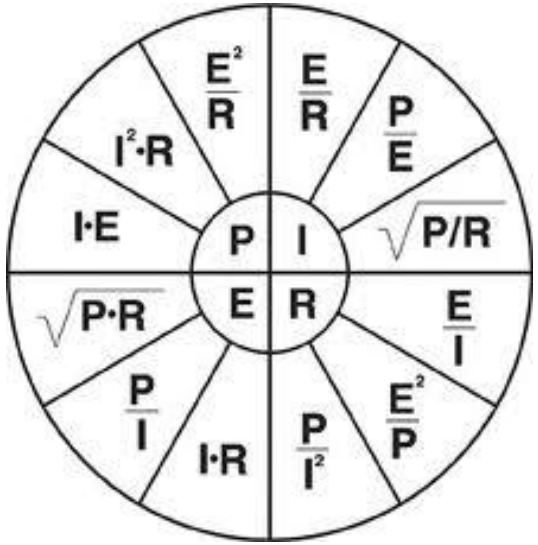
Tech and General

- **Ohm's Law: E(voltage) = I(current) * R(resistance)**
- **Power equation: P(power) = I(current) * E(voltage)**

  Both sides of the equation are equal. This allows us to use the substitution process to find a value. If we know any two of the variables then we can calculate the third variable.







Variables and Constants

* λ = c/f
* λ = 300 / f
* λ = 300 / 146 MHz
* λ = 2.05 meters

The formula for determining wavelength when we know the frequency

- λ (Lamda) is the wavelength (Distance in meters covered by 1 cycle)
- c (constant). The speed of light is 300 million meters per second
- f is s variable, in this case the frequency expressed in MHz

Let's do some math!

Resistors in Series

$$R_1 + R_2 + R_3 + R_N = R_T$$

$$R_1 + R_2 + R_3 + R_4 = R_T$$

* Simple addition

* $R_1, R_3 = 50\ \Omega$
* $R_2 = 200\ \Omega$
* $R_4 = 300\ \Omega$

$50 + 200 + 50 + 100 = R_T$

$R_T = 400$

Let's do some math!

Resistors in Parallel

$$\frac{R_1 R_2}{R_1 + R_2} = R_T$$

* Multiply R_1 times R_2
  * Write the number down
* Add R_1 and R_2
  * Write the number down
* Divide the first number by the second to find the answer.

Let's do some math!

Resistors in Parallel

$$\frac{R_1 R_2}{R_1 + R_2} = R_T$$

* $R_1 = 50\ \Omega$
* $R_2 = 200\ \Omega$

* $R_1 * R_2 = ?$
  - $50 * 200 = 10{,}000$
* $R_1 + R_2 = ?$
  - $50 + 200 = 250$
* $10{,}000 / 250 = 40$
* $R_T = 40$

More Math Vocabulary

* **Square: E^2**
  * This means: E x E
* Example: E = 5

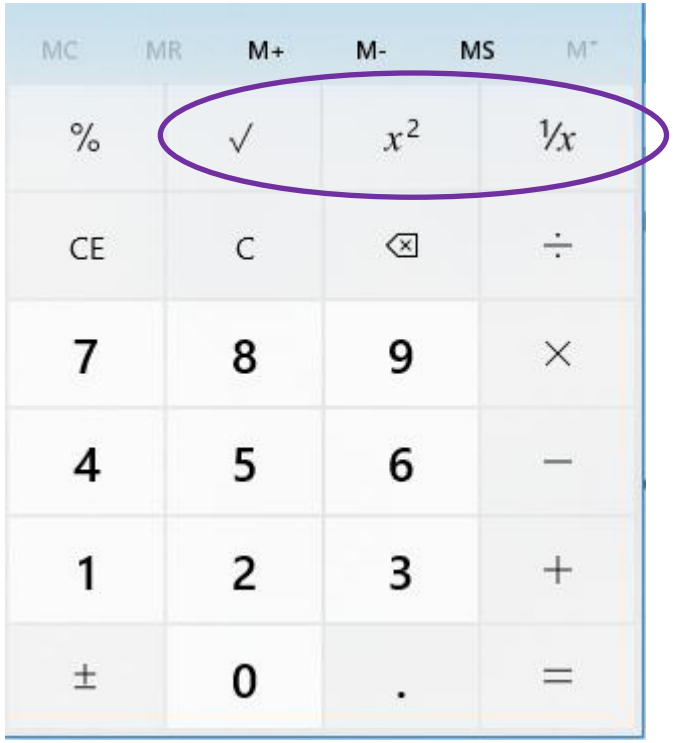
5^2 Five squared
Five to the second power

  * Example: 5 x 5 = 25

* **Square root : $\sqrt{E}$**
* Examples: E = 9
* $\sqrt{9} = 3$
* 9 = 3 x 3

Reciprocals:

$\frac{1}{E}$ $E = 10$ $\frac{1}{10} = 0.1$



Let's do some math!

Resistors in Parallel

$$\frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_N}} = R_T$$

$R_T = 1/(1/R1 + 1/ R2 + 1/R3 + 1/R_N)$

- Do each fraction in the denominator in turn
  - Hint: Use the reciprocal function on your calculator
  - Write the number down
- Add all fraction results together.
  - Write the number down
- Divide 1 by the sum of the fractions.
  - Hint: Use the reciprocal function on your calculator

Let's do some math!
The Power Formula

$$P = \frac{E^2}{R}$$

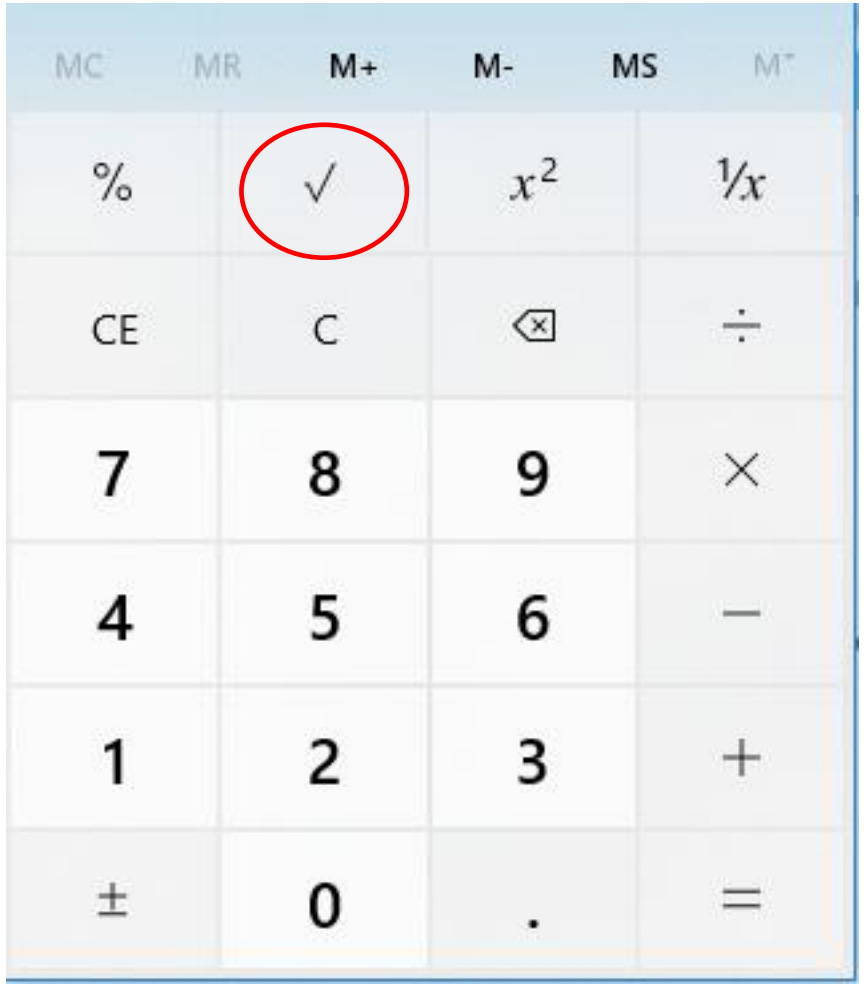
* E = 300 Volts
* R = 450 Ohms

* E^2 = ? (square E)
  - 300^2 = 90,000
* 90,000/R = ?
  - 90000/450 = 200
  - 200 Watts

Square Roots

- $\sqrt{9} = x$
  - What two numbers multiplied together would equal 9?
- $\sqrt{9} = 3$ (3 x 3 = 9)

- $\sqrt{20} = x$
- $\sqrt{20} = 4.47$



Using Square Roots!

Transformer impedance and turns ratio

$$\sqrt{\frac{Z_P}{Z_S}} = \frac{N_P}{N_S}$$

* What is the ratio of N_P to N_S?
* Divide Z_P by Z_S.
* Take the square root of the result.

Logs!

* **Logarithms** (logs for short) are math techniques for handling very large and very small numbers within the same formula without losing resolution.
* **Logs are not trivial math techniques** and it is going to take some thought, patience, and practice to master the use of logarithms.

$$\log_{10} N = L$$

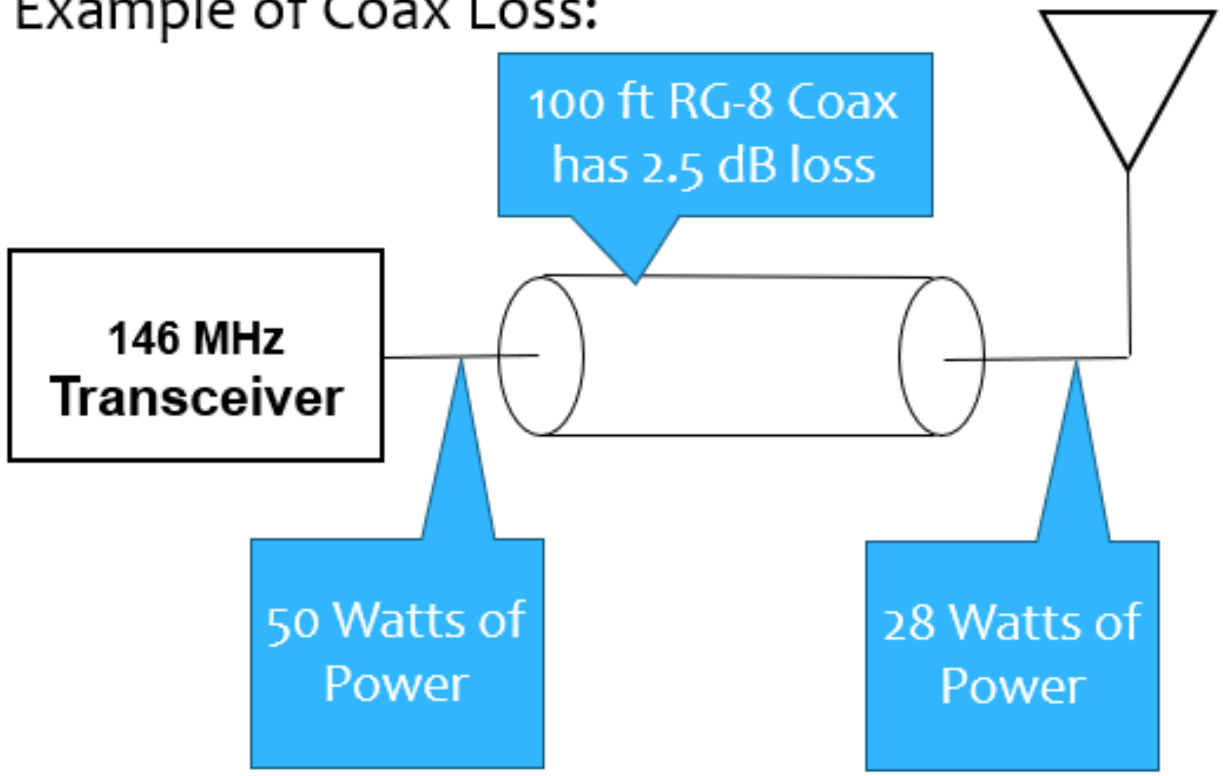
Scientific Calculator

Practical Uses of Log Functions

Decibel	Change in Power
1 dB	About 20%
3 dB	Factor of 2
6 dB	Factor of 4
10 dB	Factor of 10
15 dB	Factor of 32
20 dB	Factor of 100
30 dB	Factor of 1000

$$dB = 10 \log (P_{out} / P_{in}) = 10 \log (28 / 50) = 2.518 \text{ dB}$$

Example of Coax Loss:



Finding Logarithms & Anti-logs with a **Scientific** Calculator

* Basic log formula:

$$\log_{10} N = L$$

$$\log 20 = 1.30$$

* Anti-log formula

$$N = 10^{L}$$

$$\mathrm{N} = \log^{-1}(1.3) = 20$$

Anti-log

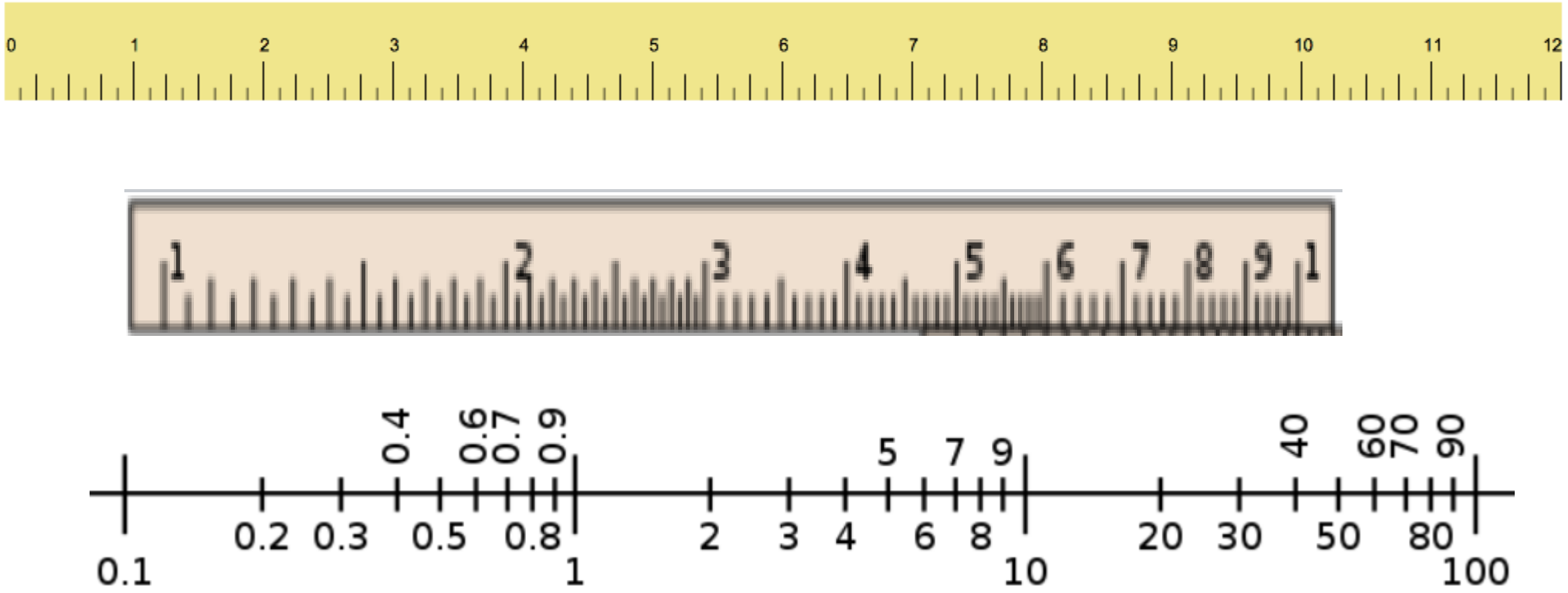
Practice on the calculator:

* Take the Log of 20
  * The answer should be about 1.3

The anti-log is the reverse or opposite of the log

* Take the Anti-log of 1.3
  * The answer should be about 20
* On most calculators, press SHIFT then 10^x for anti-log

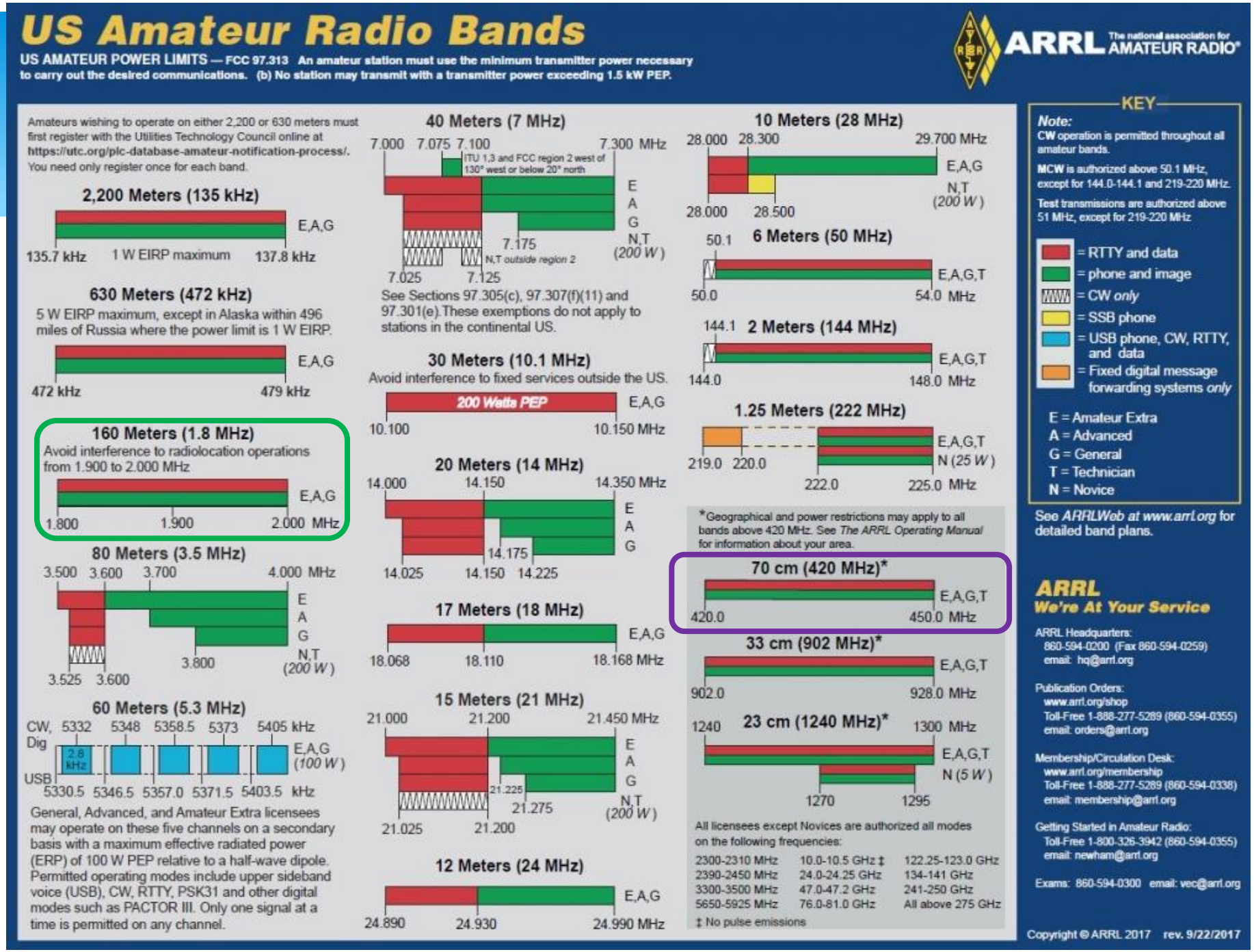
Linear vs. Logarithmic Scale



Band Chart

200 KHz

300 MHz



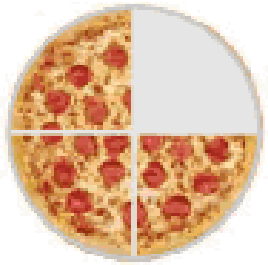
Decimal Numbers

Decimal numbers tend to be used in electronics:

- Fraction: ½
- Decimal: **.5** or **0.5**
- ½ = **.5 or 0.5**

¼ = 0.25

¾ = 0.75



3 ← Numerator

4 ← Denominator

Decimal Numbers

It is common for a rain gauge to divide each inch up into 10 sections, with each division the same size.

* Each division represents 1/10 (0.1) of an inch
* The green arrow marks five 0.1” divisions, or **0.5**”
* The purple arrow marks two full inches plus four 0.1” divisions, or **2.4** inches.

Decimal Numbers

Although the rain gauge may be divided into 0.1” divisions, many people will use their eye and their mind to subdivide each 0.1 division into 10 additional divisions. These smaller “imagined” divisions represent 0.01 inches, or 1/100th of an inch.

* The red arrow marks one full inch plus about 85 of the 0.01” divisions, or about **1.85** inches.

Decimal Numbers

1.850000

Full units

Tenths

Hundredths

Thousandths

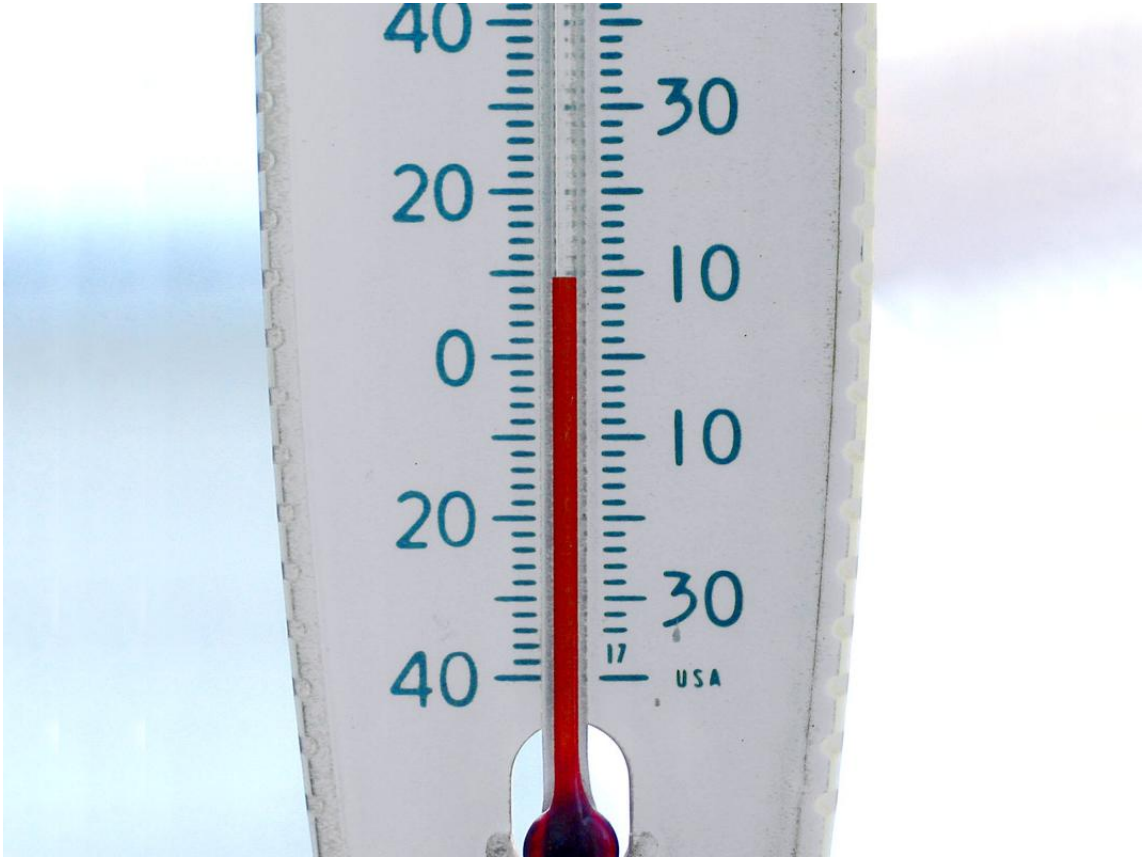
Ten Thousandths

Hundred Thousandths

Millionths

Positive and Negative Numbers

* Positive counting: 1, 2, 3, 4, 5, 6, …
* Negative counting: -1, -2, -3, -4, -5, -6, …



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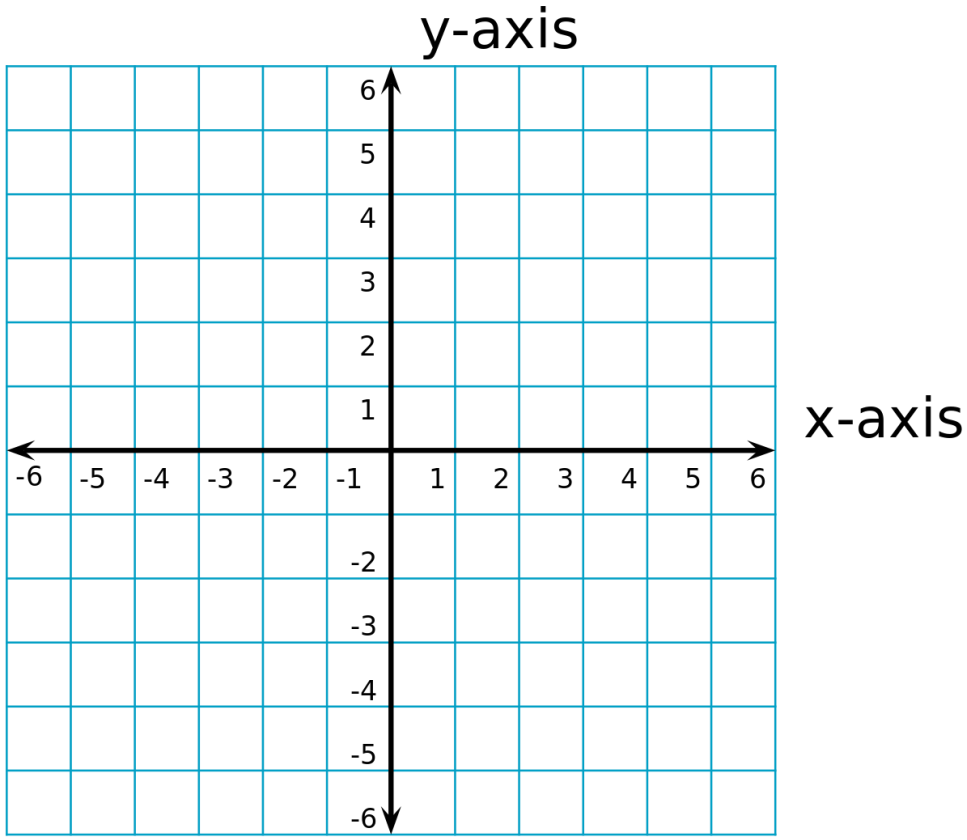
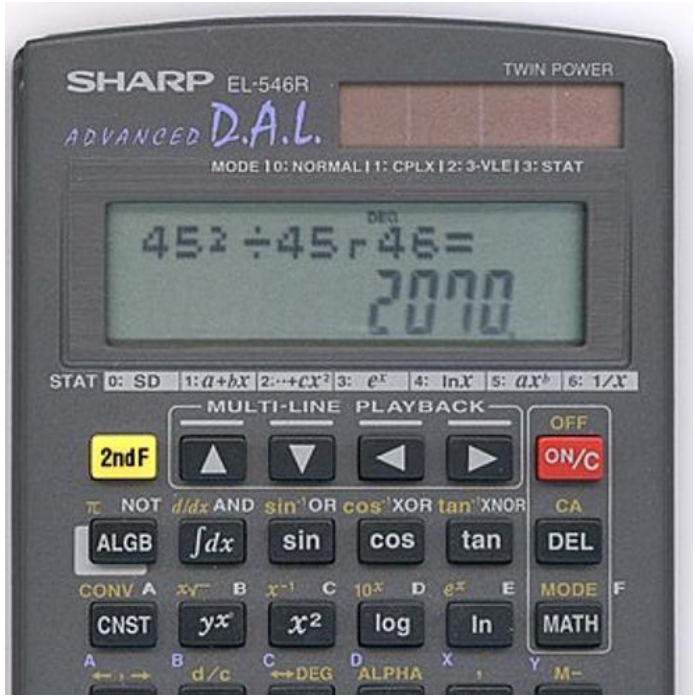
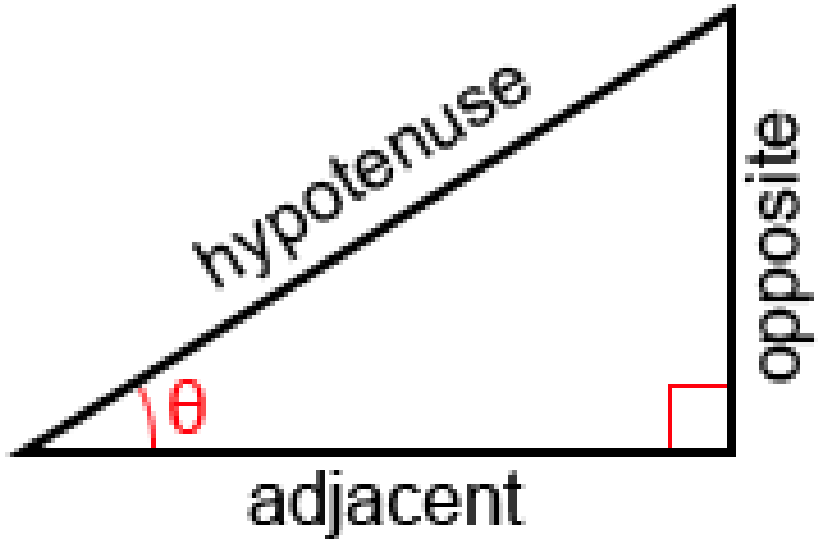


A Look Forward

Let's take a look forward at the math that will be used in the Extra Class study



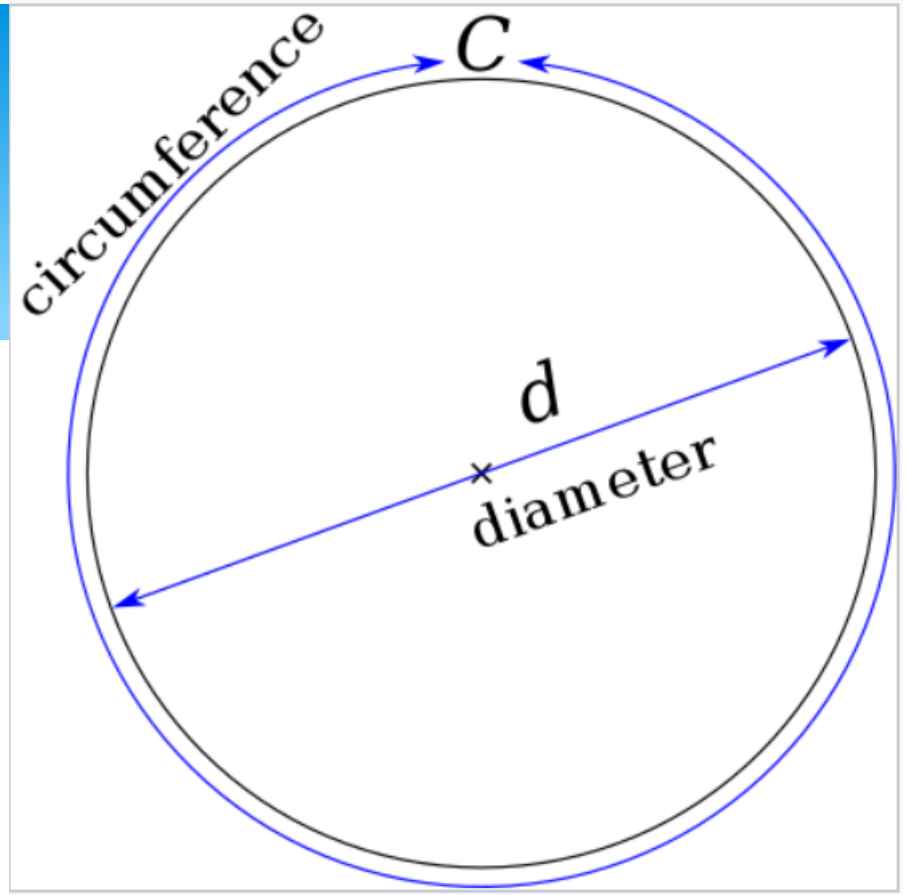


Other Math Operators

* Greater than: **>** **a > 0**
* Less than: **<** **b < 100**
* Greater than or equal to: **≥** **a ≥ 0**
* Less than or equal to: **≤** **b ≤ 100**
* Approximately equal to: **≈** **c ≈ 10**
* Not equal to: **≠** **a ≠ b**

Pi π

* Pi is simply a constant that is commonly used in math, geometry and electronics
* **Pi = 3.14**, or more precisely 3.1415926535
* Pi is the ratio of the circumference of a circle to its diameter
* The normal symbol for pi is **π**

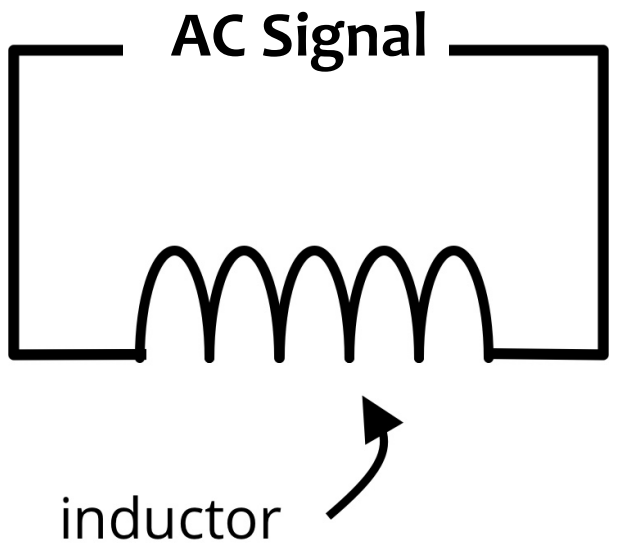


$C = \pi \times d$

A common use of Pi π

* What is the impedance of an inductor?

* **$X_L = 2\pi fL$**
* Where:
  * X_L is the impedance (inductive reactance)
  * π is always 3.14
  * f is the frequency in MHz
  * L is the value of the inductor in uH



Absolute Value

* The absolute value of a number is always a positive number
* A positive number and the equivalent negative number result in the same absolute value
* The symbol for absolute value is **| a |**
* Example:
  * **| 5 | = 5**
  * **| -5 | = 5**

Square Roots & Imaginary Numbers

Simple Square Roots:

$$\sqrt{16} = 4$$

$$\sqrt{9} = 3$$

$$\sqrt{1} = 1$$

Not-so-Simple Square Roots:

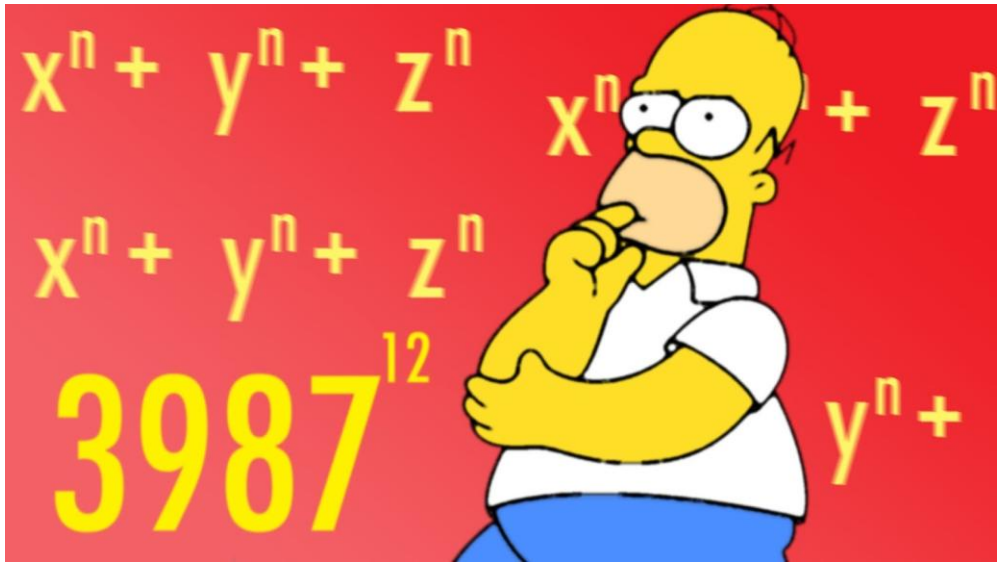
$\sqrt{-1}$ = Error

$\sqrt{-1}$ = ***i***

i *means* ***imaginary***

In electronics, ***j*** is substituted for ***i***

$$\sqrt{-1}$$



Practical application: 10Ω + **j**17Ω

Trigonometric Functions

*If you know the angle, you can determine the **length ratios:***

Sine (sin): opposite / hypotenuse

Cosine (cos): adjacent / hypotenuse

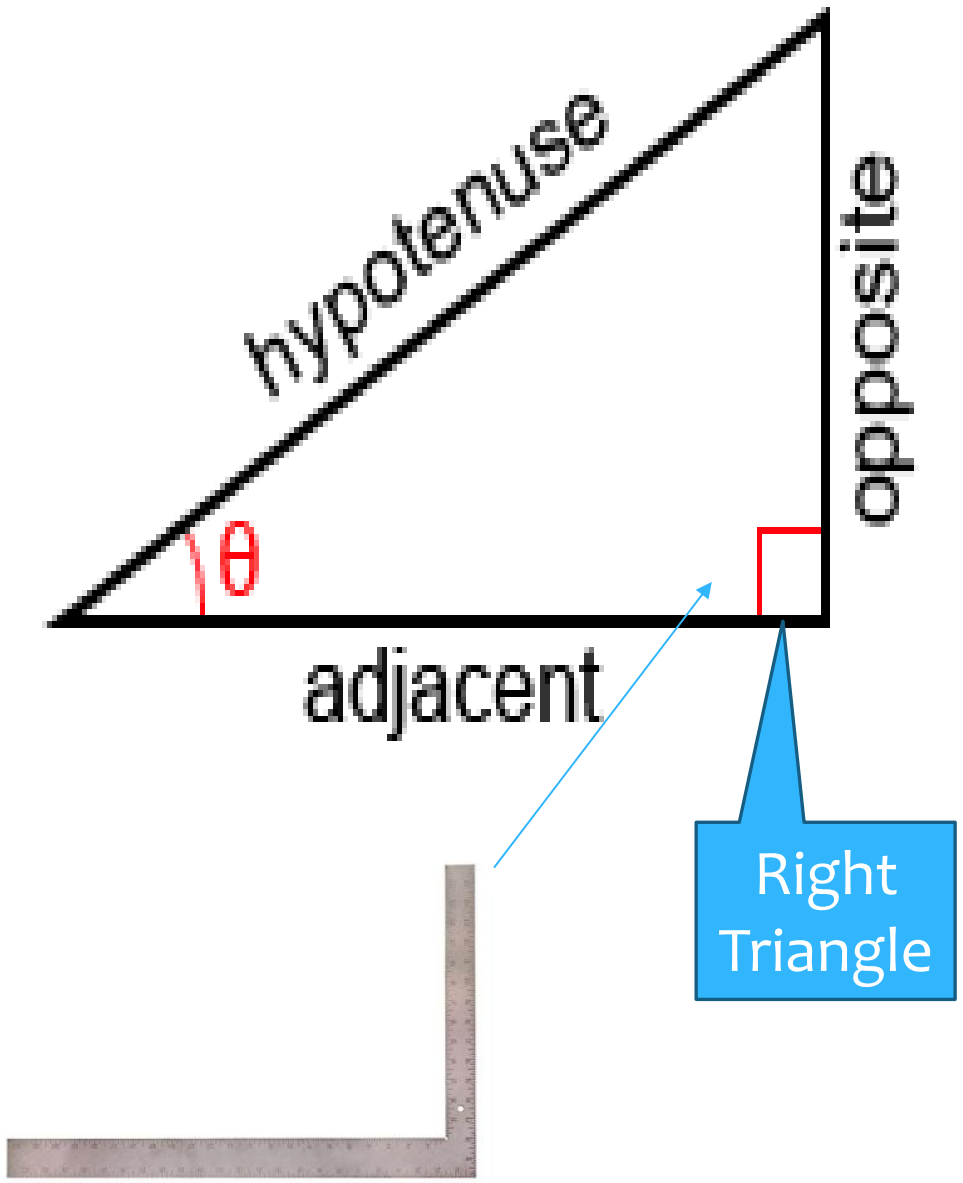
Tangent (tan): opposite / adjacent

*If you know the lengths, you can determine the **angle:***

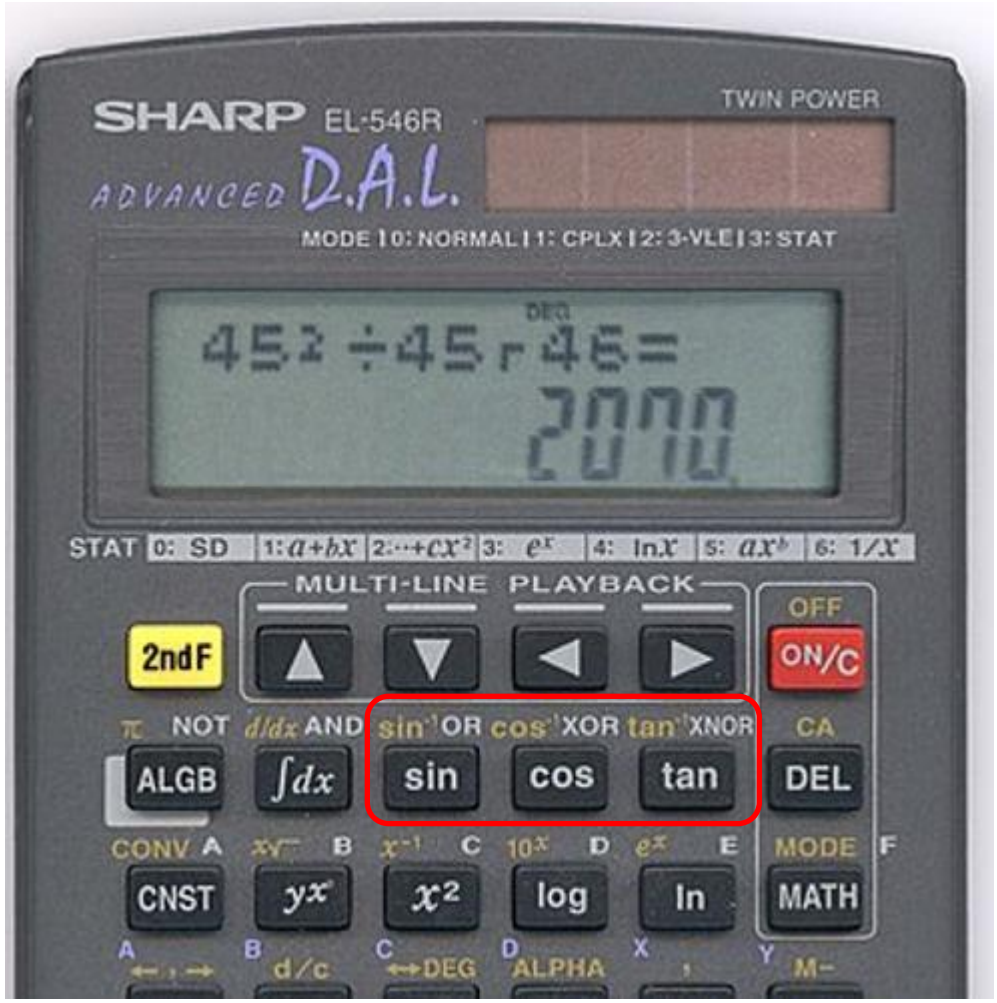
Arcsine ($\sin^{-1}$)

Arccosine ($\cos^{-1}$)

Arctangent ($\tan^{-1}$)



A Scientific Calculator is very useful when working with Trigonometric Functions



If you have a Scientific calculator, bring it to class next week.

Main button functions:

Sine (sin)

Cosine (cos)

Tangent (tan)

Secondary button functions:

Arcsine ($\sin^{-1}$)

Arccosine ($\cos^{-1}$)

Arctangent ($\tan^{-1}$)

Shift or 2nd F

If you want to experiment with sin, cos & tan

Use your calculator to take the:

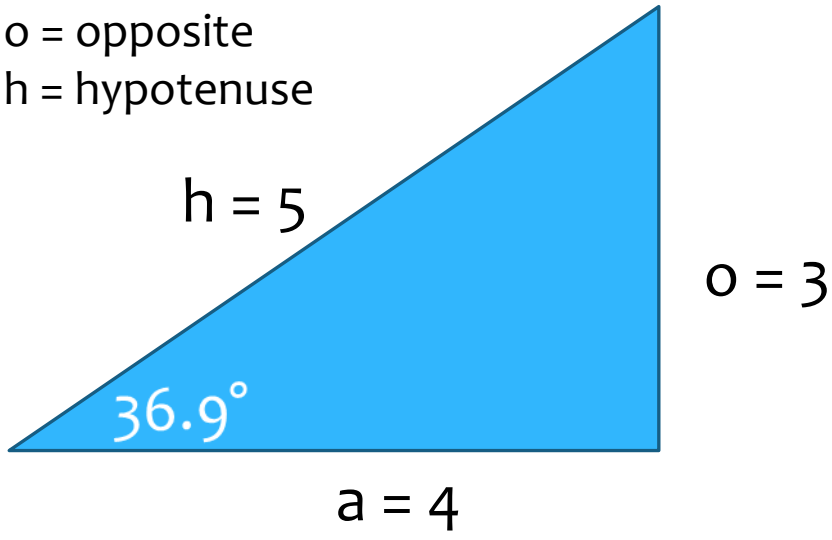
- sin of the angle = sin 36.9° = 0.6
  - You get the ratio of o/h [0.6 x 5 = 3]
- cos of the angle = cos 36.9° = 0.8
  - You get the ratio of a/h [0.8 x 5 = 4]
- tan of the angle = tan 36.9° = 0.75
  - You get the ratio of o/a [0.75 x 4 = 3]

or

Use your calculator to take the arc function:

- $\sin^{-1}$ of o/h = $\sin^{-1}$ 3/5 = 36.9°
- $\cos^{-1}$ of a/h = $\cos^{-1}$ 4/5 = 36.9°
- $\tan^{-1}$ of o/a = $\tan^{-1}$ 3/4 = 36.9°

a = adjacent
o = opposite
h = hypotenuse



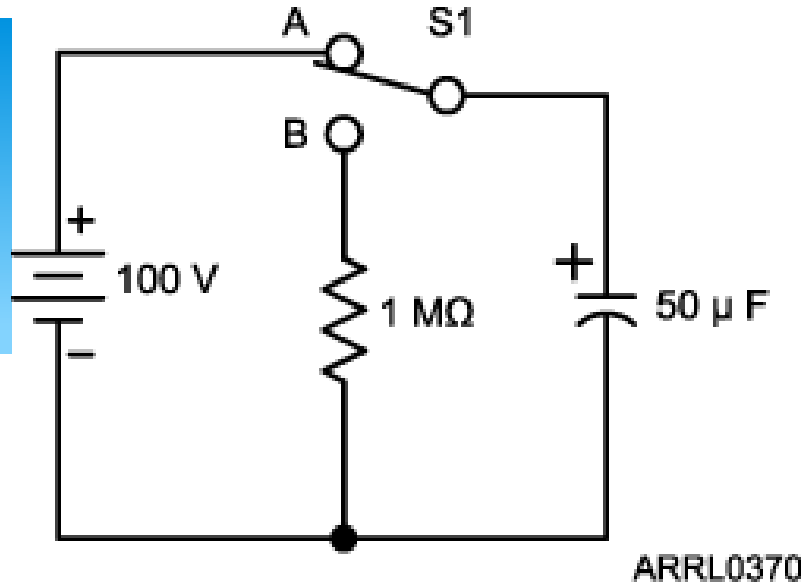
$$a^2 + o^2 = h^2$$

$$4^2 + 3^2 = h^2$$

$$16 + 9 = 25$$

$$h = \sqrt{25} = 5$$

Don't be Intimidated by Odd-Looking Equations



Equation 4.5 on Pg 4-12; Time Constant

$$I(t) = \frac{E}{R}(1 - e^{-t/\tau})$$

where:

I(t) is the current in amperes at time t.
E is the applied voltage.
R is the circuit resistance in ohms.
t is the time in seconds after the switch is closed.
τ is the time constant for the circuit in seconds.

Tau

e = 2.7182, another constant and another button on your scientific calculator e^x

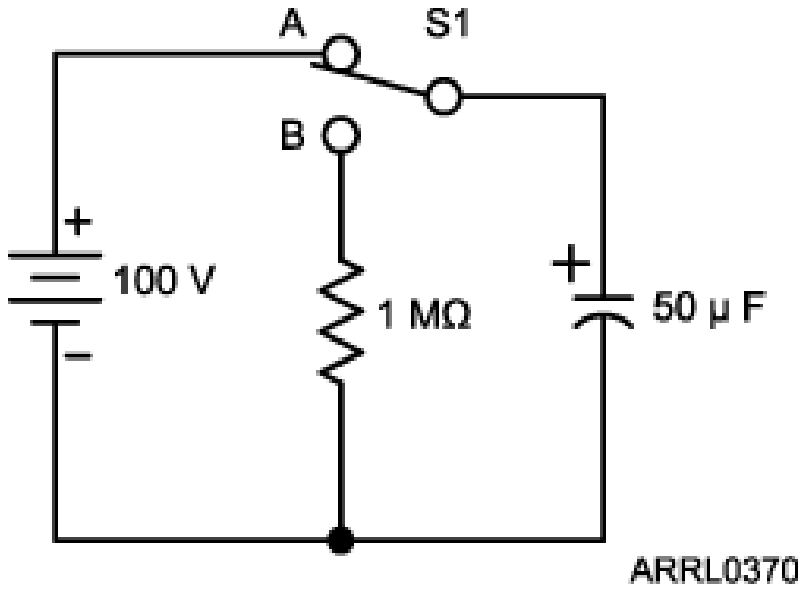
Steps to solving for **I(t)**:

* **t** would be provided
* Equation 4.1 says: τ = RC
* Divide **t** by **τ**
* Take **e** to the *negative* **t/τ** power
* Subtract the above value from 1
* Multiply the above value by E/R

Find the Time Constant τ

Find the time constant of the circuit to the right

* τ = RC
* R = 1 MΩ or 1 x 10^6
* C = 50 uF or 50 x 10^{-6}
* **τ = (1 x 10^6) x (50 x 10^{-6})**
* **τ = 50 sec**



Amateur Extra License Class

- **Goal – Extra Class License**
- **You are 2/3 of the way already. You passed Technician and General Class tests.**
- **Take your time on the test.**
- **Magic number is 37/50 or 74%.**
- **Learning is an ongoing process that will continue long after you have passed the Extra Class test.**

Have a Good Day