Physical Science: Tables & Formulas

SI Base Units

Base Quantity	Unit Name	Unit Symbol
Amount of substance	mole	Mol
Electric current	ampere	A
Length	meter	M
Luminous intensity	candela	Cd
Mass	kilogram	Kg
Time	second	S
Temperature	Kelvin	K

SI Derived Units

Derived Quantity	Name (Symbol)	Expression in terms of other SI units	Expression in terms of SI base units
Area	Square meter (m^2)		
Volume	Cubic meter (m^3)		
Speed/velocity	Meter per second (m/s)		
Acceleration	Meter per second squared (m/s^2)		
Frequency	Hertz (Hz)		s^{-1}
Force	Newton (N)		$m \cdot kg \cdot s^{-2}$
Pressure, stress	Pascal (Pa)	$N \cdot m^2$	$m^{-1} \cdot kg \cdot s^{-2}$
Energy, work, quantity of heat	Joule (J)	$N \cdot m$	$m^2 \cdot kg \cdot s^{-2}$
Power	Watt (W)	J/s	$m^2 \cdot kg \cdot s^{-3}$
Electric charge	Coulomb (C)	--	$s \cdot A$
Electric potential difference	Volt (V)	W/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-1}$
Electric resistance	Ohm (Ω)	V/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}$

Prefixes used to designate multiples of a base unit

Prefix	Symbol	Meaning	Multiple of base unit	Scientific Notation
tera	T	trillion	1, 000, 000, 000, 000	10^{12}
giga	G	billion	1, 000, 000, 000	10^{9}
mega	M	Million	1, 000, 000	10^{6}
kilo	k	Thousand	1, 000	10^{3}
centi	c	One hundredth	1/100 or .01	10^{-2}
milli	m	One thousandth	1/1000 or .001	10^{-3}
micro	u	One millionth	1/1000000 or .000001	10^{-6}
Nano	n	One billionth	1/1000000000 or .000000001	10^{-9}
pico	p	One trillionth	1/1000000000000 or.000000000001	10^{-12}

In general, when converting from base units (m, l, g, etc) or derived units (m^2,m^3, m/s, Hz, N, J, V, etc) to a multiple greater (kilo, mega, giga, or tera) than the base or derived unit- then divide by the factor. For example: 10m = 10/1000km = 1/100 km = .01km.

When converting from base units or derived units to a multiple smaller (centi, milli, micro, nano) than the base or derived unit- then multiply by the factor. For example: 10m = 10 x 100cm = 1000cm.

Subatomic Particles

Particle	Charge	Mass	Location
Proton	+1	1	nucleus
Neutron	0	1	nucleus
Electron	-1	0	Outside the nucleus

Common Cations

Ion Name (symbol)	Ion Charge
Lithium (Li)	1+
Sodium (Na)	1+
Potassium (K)	1+
Rubidium (Rb)	1+
Cesium (Cs)	1+
Beryllium (Be)	2+
Magnesium (Mg)	2+
Calcium (Ca)	2+
Strontium (Sr)	2+
Barium (Ba)	2+
Aluminum (Al)	3+

Common Anions

Element Name (symbol)	Ion Name (symbol)	Ion Charge
Fluorine	Fluoride	1-
Chlorine	Chloride	1-
Bromine	Bromide	1-
Iodine	Iodide	1-
Oxygen	Oxide	2-
Sulfur	Sulfide	2-
Nitrogen	Nitride	3-

Common Polyatomic Ions

Ion Name	Ion Formula	Ion Name	Ion Formula
Carbonate	CO_3^{2-}	Nitrite	NO_2^-
Chlorate	ClO_3^-	Phosphate	PO_4^{3-}
Cyanide	CN^-	Phosphite	PO_3^{3-}
Hydroxide	OH^-	Sulfate	SO_4^{2-}
Nitrate	NO_3^-	Sulfite	SO_3^{2-}

Prefixes for Naming Covalent Compounds

Number of Atoms	Prefix	Number of Atoms	Prefix
1	Mono	6	Hexa
2	Di	7	Hepta
3	Tri	8	Octa
4	Tetra	9	Nona
5	penta	10	deca

Types of Chemical Reactions

Type of reaction	Generalized formula	Specific Example
Combustion	HC + $\mathbf{O_2}$ → H_2O + CO_2	$2C_2H_6$ + $7O_2$ → $6H_2O$ + $4CO_2$
Synthesis	A + B → AB	2Na + Cl_2 → 2NaCl
Decomposition	AB → A + B	$2H_2O$ → $2H_2$ + O_2
Single Replacement	A + BC → AC + B	2Al + $3CuCl_2$ → 3Cu + $2AlCl_3$
Double Replacement	AX + BY → AY + BX	**$Pb(NO_3)_2$ + K_2CrO_4 → $PbCrO_4$ + $2KNO_3$**

The Effects of Change on Equilibrium in a Reversible Reaction (Le Châtelier's Principle)

Condition	Effect
Temperature	Increasing temperature favors the reaction that absorbs energy (endothermic)
Pressure	Increasing pressure favors the reaction that produces less gas.
Concentration	Increasing conc. of one substance favors reaction that produces less of that substance

Common Acids

Acid	Formula	Strength
Hydrochloric (muriatic) acid	HCl	strong
Nitric acid	HNO_3	strong
Sulfuric acid	H_2SO_4	strong
Acetic acid	CH_3COOH	weak
Citric acid	$C_6H_8O_7$	weak
Formic	HCOOH	weak

Common Bases

Base	Formula	Strength
Potassium hydroxide (potash)	KOH	strong
Sodium hydroxide (lye)	NaOH	strong
Calcium hydroxide (lime)	$Ca(OH)_2$	strong
ammonia	NH_3	weak

pH scale

Strong acids ← more acidic ← weak acids							Neutral	Weak bases → More basic → strong bases						
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Types of Nuclear Radiation

Radiation Type	Symbol	Charge	Nuclear Equation
Alpha particle	${}_{2}^{4}He$	+2	${}_{89}^{225}Ac \rightarrow {}_{87}^{221}Fr + {}_{2}^{4}He$
Beta particle	${}_{-1}^{0}e$	-1	${}_{6}^{14}C \rightarrow {}_{7}^{14}N + {}_{-1}^{0}e$
Gamma	γ	0	n/a

Equations

Density = mass ÷ volume (D = m/v) Units: g/cm^3 or g/mL

Rearranged: mass = Density x Volume Units: grams or
Volume = mass ÷ density Units: cm^3 or mL

Moles = mass (grams) x Molar Mass (grams / mol) Molar Mass = atomic mass in grams

Energy = mass x (speed of light)^2 $E = mc^2$ Units: joules

Speed = distance ÷ time v = d ÷ t Units: meters / second

Rearranged: distance = speed x time Units: meters
time = distance ÷ speed Units: seconds

Momentum = mass x velocity p = m x v Units: kg · m/s

Acceleration = (final velocity - initial velocity) ÷ time a = Δv ÷ t Units: meters / (second)^2

Rearranged: Δv = acceleration x time Units: meters/second
time = Δv ÷ a Units: seconds

Force = mass x acceleration F = m x a Units: kg · m/s^2 or Newtons (N)

Rearranged: mass = Force ÷ acceleration Units: g or kg
acceleration = Force ÷ mass Units: meters / (second)^2

Weight = mass x gravity (9.8 m/s^2) Units: kg · m/s^2 or Newtons (N)

Work = Force x distance W = F x d Units: Joules (J)

Rearranged: Force = Work ÷ distance Units: Newtons
distance = Work ÷ Force Units: meters

Power = Work ÷ time P = W ÷ t Units: J/s or Watts (W)

Rearranged: Work = Power x time Units: Joules (J)
time = Work ÷ Power Units: seconds (s)

Mechanical Advantage = Output Force ÷ Input Force (Resistance Force ÷ Effort Force)

or

Mechanical Advantage = Input Distance ÷ Output Distance (Effort Distance ÷ Resistance Distance)

Gravitational Potential Energy = mass x gravity (9.8 m/s^2) x height GPE = m x g x h Units: Joules

Rearranged: m = GPE ÷ (g · h) h = GPE ÷ (m · g)

Kinetic Energy = ½ mass x $(velocity)^2$ KE = .5 mv^2 Units: Joules

Rearranged: m = 2KE ÷ v^2 v = $\sqrt{2KE \div m}$

Efficiency of a Machine = (Useful Work Output ÷ Work Input) x 100

Temperature Conversions

Celsius-Fahrenheit Conversion:

Fahrenheit temperature = (1.8 x Celsius temperature) + 32.0^0 F = 1.8 (C) + 32^0

Celsius temperature = (Fahrenheit temperature – 32) ÷ 1.8 C = (F – 32) ÷ 1.8

Celsius-Kelvin Conversion:

Kelvin = Celsius + 273 Celsius = Kelvin -273

Specific Heat Equation

Energy = mass x Specific Heat Value x change in temperature $E = m \cdot c \cdot \Delta t$ Units: Joules

Rearranged: mass = Energy ÷ (c x Δ T) Units: kg ΔT = Energy ÷ (c x mass) Units: K or ^{0}C

Wave Speed Equation

Wave's Speed = frequency x wavelength $v = f \times \lambda$ Units: m/s

Rearranged: Frequency = Wave Speed ÷ wavelength $f = v \div \lambda$ Units: Hertz

Wavelength = Wave Speed ÷ frequency $\lambda = v \div f$ Units: meters / second

Speed of light (in a vacuum) = 3.0 x 10^8 m/s (300,000,000 m/s)

Speed of Sound (in air at 25 ^{0}C) = 346 m/s Speed of Sound (in water at 25 ^{0}C) = 1490 m/s

Speed of Sound (in iron at 25 ^{0}C) = 5000 m/s

Ohm's Law Equation

Current = Voltage ÷ Resistance $I = V / R$ Units: Amperes (A)

Rearranged: Voltage = Current x Resistance $V = I \times R$ Units: Volts (V)

Resistance = Voltage ÷ Current $R = V / I$ Units: Ohms (Ω)

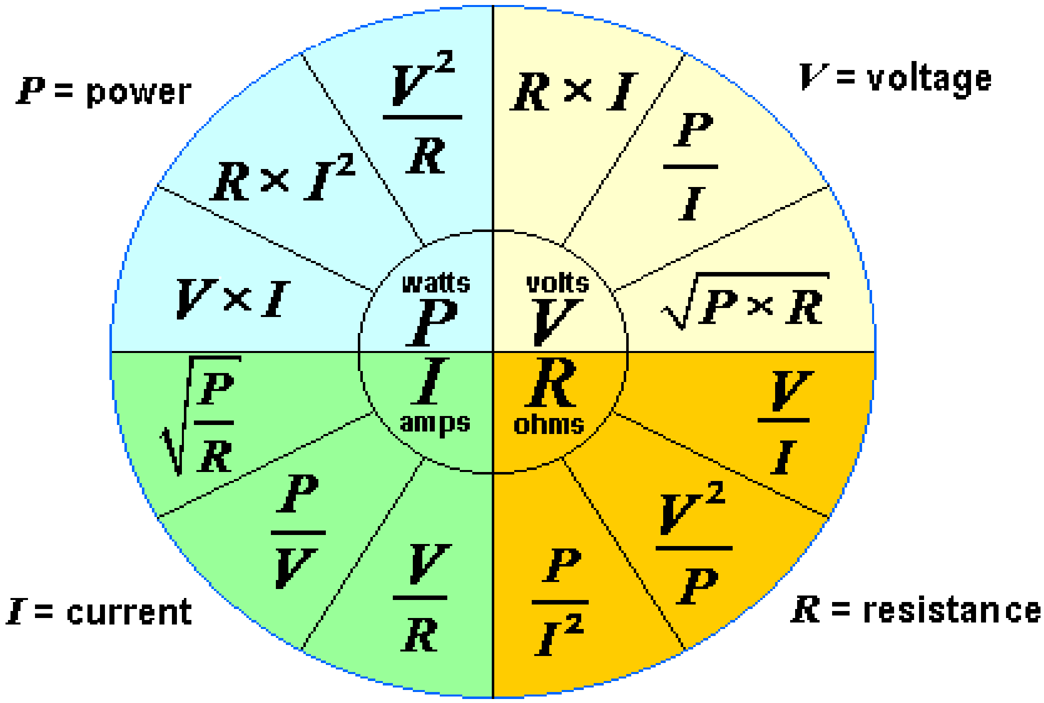
Electric Power Equation

Power = Current x Voltage $P = I \times V$ Units: watts (W) or Kilowatts (kW)

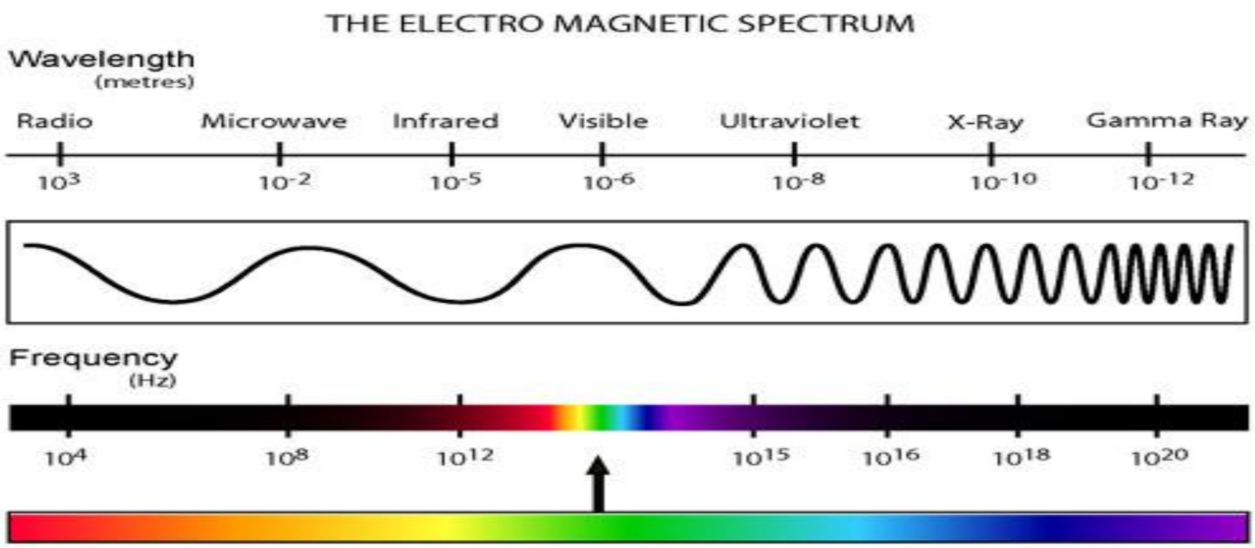
Variations: $P = I^2 \times R$ $P = V^2 / R$

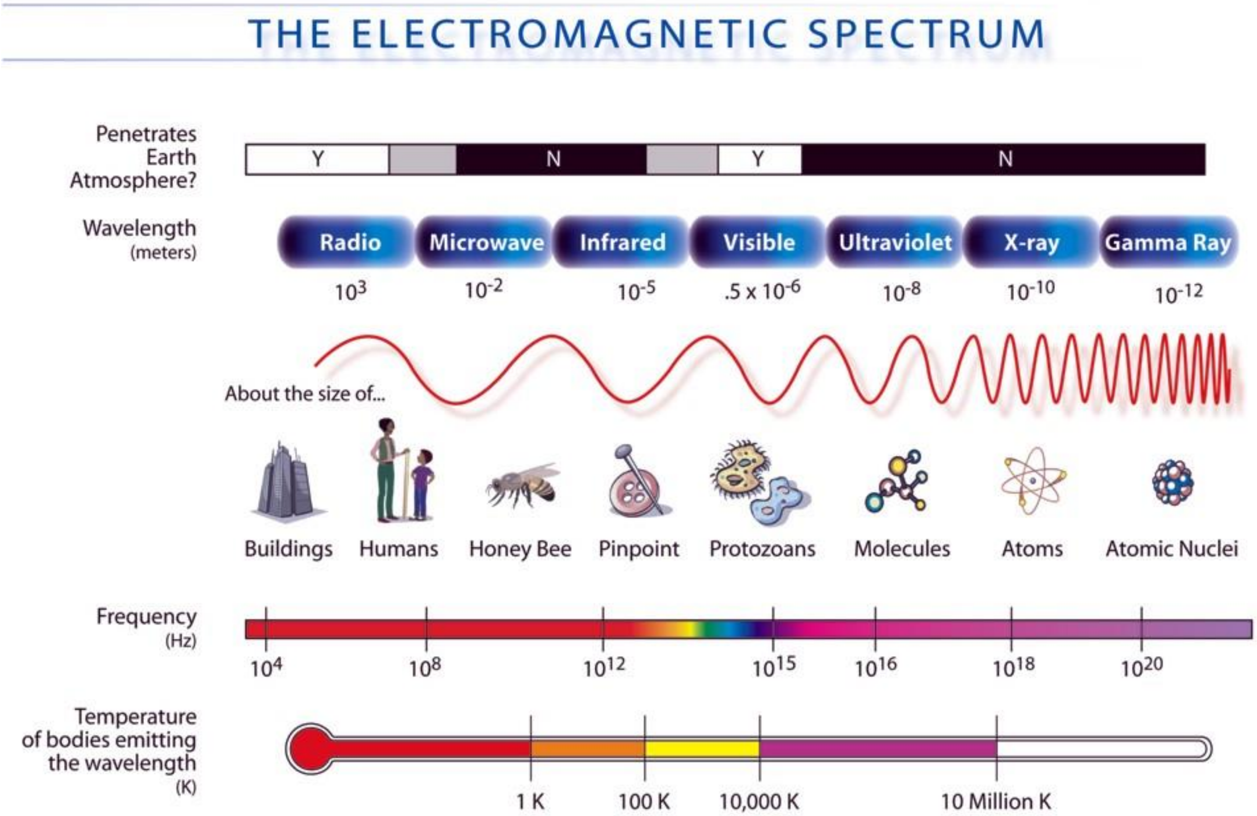
Rearranged: Voltage = Power ÷ Current $V = P \times I$ Units: Volts (V)

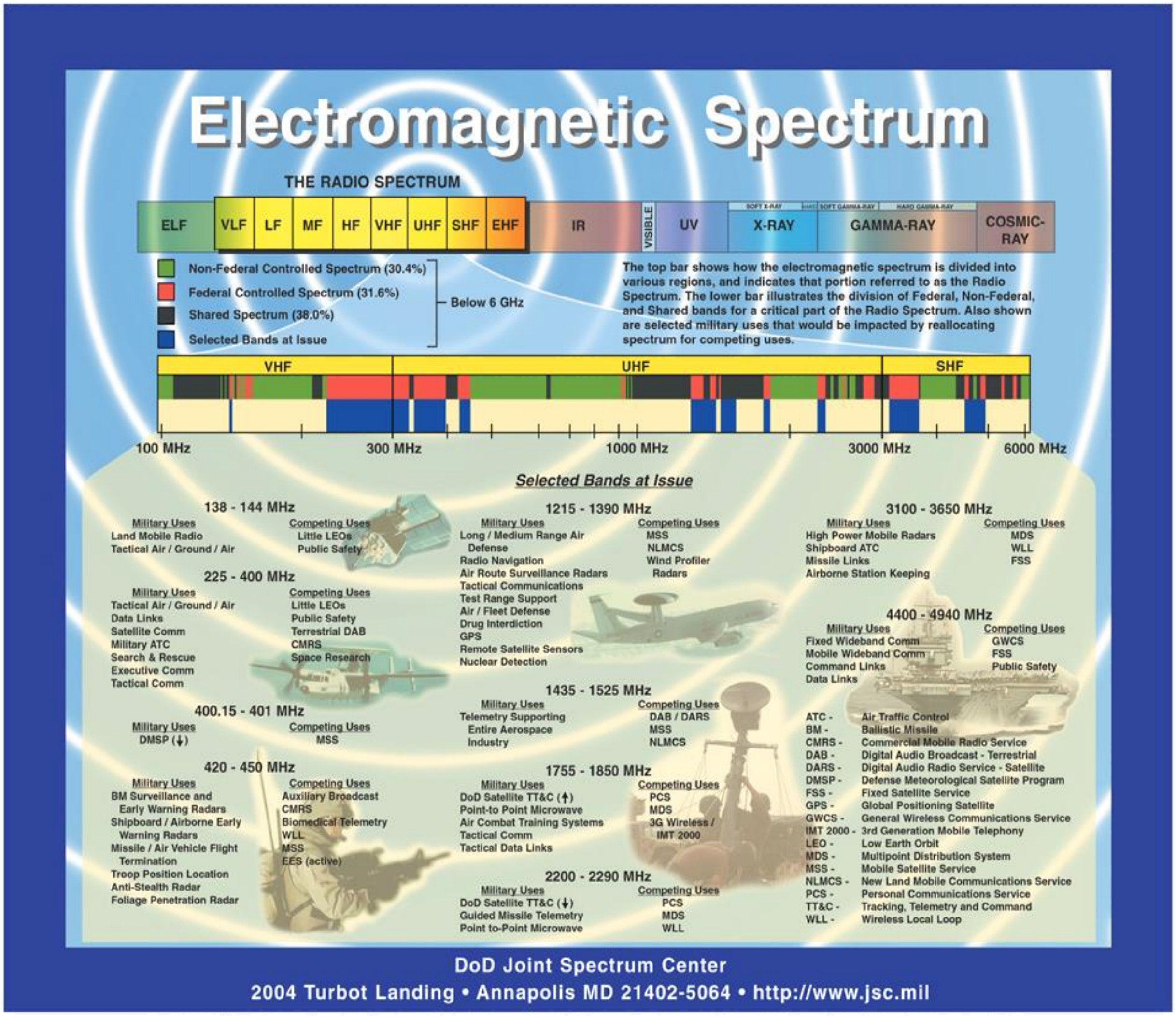
Current = Power ÷ Voltage $I = P \div V$ Units: Amperes (A)



Electromagnetic Spectrum: Relates the energy, frequency and wavelength of various types of electromagnetic waves (radio, TV, micro, infrared, visible, ultraviolet, X-ray, and gamma). As energy and frequency increase the wavelength decreases.




THE ELECTROMAGNETIC SPECTRUM
Penetrates Earth Atmosphere?
Y
N
Y
N
Wavelength (meters)
Radio
Microwave
Infrared
Visible
Ultraviolet
X-ray
Gamma Ray
10^3
10^{-2}
10^{-5}
$.5 \times 10^{-6}$
10^{-8}
10^{-10}
10^{-12}
About the size of...
Buildings
Humans
Honey Bee
Pinpoint
Protozoans
Molecules
Atoms
Atomic Nuclei
Frequency (Hz)
10^4
10^8
10^{12}
10^{15}
10^{16}
10^{18}
10^{20}
Temperature of bodies emitting the wavelength (K)
1 K
100 K
10,000 K
10 Million K



- AM radio - 535 kilohertz to 1.7 megahertz
- Short wave radio - bands from 5.9 megahertz to 26.1 megahertz
- Citizens band (CB) radio - 26.96 megahertz to 27.41 megahertz Television
- FM radio - 88 megahertz to 108 megahertz
- Television stations - 174 to 220 megahertz for channels 7 through 13

- Garage door openers, alarm systems, etc. - Around 40 megahertz
- Standard cordless phones: Bands from 40 to 50 megahertz
- Baby monitors: 49 megahertz
- Radio controlled airplanes: Around 72 megahertz, which is different from...
- Radio controlled cars: Around 75 megahertz
- Wildlife tracking collars: 215 to 220 megahertz
- MIR space station: 145 megahertz and 437 megahertz
- Cell phones: 824 to 849 megahertz
- New 900-MHz cordless phones: Obviously around 900 megahertz!
- Air traffic control radar: 960 to 1,215 megahertz

- Global Positioning System: 1,227 and 1,575 megahertz
- Deep space radio communications: 2290 megahertz to 2300 megahertz