$e = \frac{\text{what you get out}}{\text{what you pay for}} = \frac{W_{\text{out}}}{Q_H} = 1 - \frac{Q_C}{Q_H}$	definition of efficiency and formula for a heat engine
$e_{\text{max}} = 1 - \frac{T_C}{T_H}$	the maximum or Carnot efficiency of a heat engine $\Delta S_{\text{system}} = 0$
$\Delta S = \pm\frac{Q}{T}$	entropy change associated with heat
$k_B = 1.38 \times 10^{-23}$ J/K $= \frac{R}{N_A}$	Boltzmann's constant and its relationship to the gas constant $R = 8.31$ J/K and Avogadro's Number $N_A = 6.02 \times 10^{23}$
$pV = Nk_BT = nRT$	ideal gas law, N is the number of molecules, n is the number of moles, T is in Kelvin
$E_{th} = \frac{3}{2}Nk_BT$	for a monatomic gas, also works with ΔE_{th} and ΔT
$\Delta E_{th} = W_{in} + Q_{in}$	1st Law of Thermodynamics, you need to modify the signs if you are talking about W_{out} or Q that is "leaving" the system
$\Delta S_{\text{system}} \geq 0$	2nd Law of Thermodynamics for an isolated system, could also say state of disorder increases with time
$v_{rms} = \sqrt{\frac{3k_BT}{m}}$	the average velocity of an atom in a gas at temperature T. Can find m from molecular weight (in kg) divided by $N_A = 6.02 \times 10^{23}$.
$E_{th} = NK_{avg} = N(\frac{1}{2}mv_{rms}^2) = \frac{3}{2}Nk_BT$	for a monatomic gas the thermal energy represents that the total kinetic energy of the molecules which is proportional to v_{rms}^2 and T
$p = \frac{F}{A}$	definition of pressure, units are Pascals (Pa) when F is in Newtons and A is in m^2
$W_{\text{gas, out}} = p\Delta V =$ "area under pV curve"	an *expanding* gas does work on its environment. If the pressure is constant then you may use the simple ΔV expression, otherwise it is the area
$p_iV_i^{\frac{5}{3}} = p_fV_f^{\frac{5}{3}}$	an adiabatic process $Q = 0$ and $\Delta S = 0$
$\frac{p_iV_i}{T_i} = \frac{p_fV_f}{T_f}$	*once you have identified the process* you can use this formula as a second step, a form of the ideal gas law if N is constant
$\rho = \frac{m}{V}$	definition of density, use m in kg and V in m^3. 1 m^3=1000 L=10^6 cm^3=10^6 mL
$p_{\text{atmos}} = 101.3$ kPa=1 atm	atmospheric pressure
$v_1A_1 = v_2A_2$	equation of continuity for an incompressible fluid

$F_B = \rho_f V_f g$	buoyant force directed upward. V_f is the volume of fluid displaced and it equal to the volume of the object *if* the object is submerged. Object will also experience the force of gravity *weight* $w = mg$ directed downward.
$Q = vA = \frac{\Delta V}{\Delta t}$	volume flow rate in m^3/s
$p_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2 = p_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1$	Bernoulli's equation. Often used to find a pressure difference $p_2 - p_1$. If the fluid is low density (like air) and the change in y is small you can drop the $\rho g y$ terms. You can also use it for hydrostatics just set $v = 0$ on both sides.

$\omega = 2\pi f = \frac{2\pi}{T}$	relationship between radial frequency ω, frequency f and period T
$x(t) = A\cos(\omega t) = A\cos(2\pi t) = A\cos(2\pi \frac{t}{T})$	the motion of an object in simple harmonic motion. For vertical mass spring system substitute $y(t)$. For a pendulum either $\theta(t)$ or $s(t)$ (the arc length). $x_{\mathrm{max}} = A$. If you need to calculate an actual x at some time make sure you take the cosine in radians.
$v_x(t) = -A\omega\sin(\omega t)$	velocity as a function of time (it comes from the slope). $v_{\mathrm{max}} = A\omega$. Substitute in frequency f and period T as necessary.
$a_x(t) = -A\omega^2\cos(\omega t) = -\omega^2 x(t) = -\frac{kx}{m}$	acceleration as a function of time. Substitute in frequency f and period T as necessary. I have inserted N2L for a mass-spring system, which gives...
$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{g}{L}}$	radial frequency for mass-spring and pendulum systems
$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{L}{g}}$	period for mass-spring and pendulum systems (just a modification of the previous formula)
$E = K + U = \frac{1}{2}mv(t)^2 + \frac{1}{2}kx(t)^2$	energy relationships in a simple harmonic oscillator, v isn't constant, x isn't constant, E is constant. Look at the next formula.
$K_{\mathrm{max}} = U_{\mathrm{max}} = \frac{1}{2}m(v_{\mathrm{max}})^2 = \frac{1}{2}kA^2$	max energies

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$y(x,t) = A\cos\left(2\pi\left(\frac{x}{\lambda} - \frac{t}{T}\right)\right)$	sinusoidal wave moving to the right (change to positive sign for wave to the left)
$v = f\lambda = \frac{\lambda}{T} = \frac{\text{“}\Delta x\text{”}}{\text{“}\Delta t\text{”}}$	basic relationship between speed, frequency, period, and wavelength. Use the "quotes" form to relate history and snapshot graphs.
$v_{\mathrm{sound}} = \sqrt{\frac{\gamma k_B T}{m}} = \sqrt{\frac{\gamma RT}{M}}$	speed of sound $\gamma = 3/2$ for monatomic gases, $5/2$ for diatomic, m is mass of the molecule
$v_{\mathrm{string}} = \sqrt{\frac{T_s}{\mu}}$	waves on a string, T_s is tension, μ is *linear* density
$v_{\mathrm{light}} = c = 3.00 \times 10^8$ m/s	speed of electromagnetic waves in vacuum (including light, radio waves)

$m\frac{\lambda_m}{2} = L \quad m = 1, 2, 3, \ldots$	waves on string, closed-closed or open-open pipe (draw a picture!), m is the mode number
$m\frac{\lambda_m}{4} = L \quad m = 1, 3, 5, \ldots$	waves in open-closed pipe (draw a picture!) m isn't mode number; it is the number of quarter-wavelengths in the standing wave. Set $m = 1$ for the fundamental, $m = 3$ for 2nd harmonic etc.
$f_m = \frac{v}{\lambda_m}$	changing resonant wavelengths to frequency, this formula works for either open-open or open-closed *with the m in the previous formulas*
$f_{\text{beat}} = \lvert f_1 - f_2 \rvert$	beats arise from a superposition of waves with nearly the same frequency

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$\lvert\vec{F}_{1 \text{ on } 2}\rvert = \lvert\vec{F}_{2 \text{ on } 1}\rvert = \frac{K\lvert q_1\rvert\lvert q_2\rvert}{r_{12}^2}$	magnitude of forces in Coulomb's law, $K = 8.99 \times 10^9$ N m^2/C^2 direction of force is along the line connecting the charges, attractive if charges have unlike signs, repulsive if they have like signs
$\vec{F}_{\text{elec}} = q\,\vec{E}$	force on a charge, if a test charge can define $\vec{E}$
$\vec{E}(x, y, z) = \left(\frac{K\lvert q}{r^2}, \begin{bmatrix} \text{away from } q \text{ if } q > 0 \\ \text{toward } q \text{ if } q < 0 \end{bmatrix}\right)$	electric field of a point charge when distance r from charge
$\vec{E}_{\text{total}} = \vec{E}_1 + \vec{E}_2 + \ldots$	total electric field from several charges, r will be different for each and so will the direction!
$\vec{E} = \left(\frac{Q}{\epsilon_0 A}, \text{from positive to negative}\right)$	electric field in parallel plate capacitor
$\epsilon_0 = \frac{1}{4\pi K} = 8.85 \times 10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2$	
$\tau = qdE \sin\alpha$	torque on an electric dipole with q and $-q$ separated by d. α is the angle between the vector pointing from the negative to the positive charge and $\vec{E}$

$U_{\text{elec}} = qV$	the electric potential energy for a charge q at a location with electric potential V
$V(x, y, z) = \frac{Kq}{r} = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$	electric potential at a point (x, y, z) if a point charge is distance r away (assumes $V = 0$ at infinity) (can also be used for a conducting sphere if $r \geq R$
$V_{\text{total}}(x, y, z) = \sum_i \frac{1}{4\pi\epsilon_0}\frac{q_i}{r_i}$	electric potential is the sum of electric potential for a set of i point charges
$V(x, y, z) = \frac{x}{d}\Delta V_C$	electric potential between plates of a parallel plate capacitor *if* the x direction is normal to the plates and the plate at $x = 0$ is set to $V = 0$
$K_f + qV_f = K_i + qV_i$	kinetic energy for a charged particle moving in a region with an electric potential (no "external" forces)
1 eV$=1.60 \times 10^{-19}$ J	electron-Volt - Joules conversion
$\vec{E} = \left(\frac{\Delta V}{d}, \text{from high to low potenial}\right)$	relationship between electric field and potential
$Q = C\Delta V_C$	definition of capacitance

$C = \frac{\epsilon_0 A}{d}$	capacitance for a parallel plate capacitor
$U_C = \frac{1}{2} C (\Delta V_C)^2$	electrical energy stored in a capacitor
$I = \frac{\Delta q}{\Delta t}$	definition of current. Signs of charge with direction of motion are included in Δq so positive charges going to the right and negative charges going to the left would both contribute to current going to the right.
$\Delta V = IR$	Ohm's law for a resistor, **remember** an ideal wire has $R = 0$ so $\Delta V = 0$ no matter the current
$\Delta V_{\text{battery}} = \mathcal{E}$	a battery provides a constant electric potential difference through its emf. *It does not* provide constant current.
$I_{\text{battery}} = \frac{\Delta V_{\text{battery}}}{R_{\text{equiv}}}$	Current through a battery is determined by the external elements (light bulbs, resistors, and how they are connected).
$\frac{1}{R_{\text{equiv}}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$	resistances in parallel add in this "reciprocal manner". Note: R_{equiv} will end up being smaller than any of the individual resistances. The R values may already be combinations of other resistors. If in parallel the same potential difference must be across all the resistances (or equivalents).
$R_{\text{equiv}} = R_1 + R_2 + \ldots$	resistances in series add. The R values here may already be combinations of other resistors. If in series the same current must go through all the resistances (or equivalents).
$\sum I_i = 0$	Kirchhoff's junction/current law. At any junction if you give currents "in" a positive sign and currents "out" a negative sign then the sum of the currents is equal to zero.
$\sum \Delta V_i = 0$	Kirchhoff's loop/voltage law. For any loop if you look at the sum potential differences around the loop they must be zero.
$P = I\Delta V$	the power dissipated/gained in an electric circuit element
$F_{\text{mag}} = \lvert q \rvert vB \sin\alpha$	magnetic force of charged particle, direction of force is given by right-hand rule: $\vec{B}$ along index finger, $\vec{v}$ along thumb, and force on a *positive* charge is along middle finger when held perpendicular to palm. α is the angle between $\vec{B}$ and $\vec{v}$
$B = \frac{\mu_0}{2\pi} \frac{I}{r}$	magnetic field from a current carrying wire. If current points along the direction of thumb on right hand then the the field points in the direction of the "curled" fingers. $\mu_0 = 4\pi \times 10^{-7}$ T·m/A
$B = \mu_0 \frac{NI}{2R}$	field at the centre of N coils of wire. If current is counterclockwise then $\vec{B}$ points "out of the page" inside the loop and into the page outside of the loop.
$\tau = NIAB \sin\theta = \lvert \vec{m} \rvert B \sin\theta$	the torque on a magnetic dipole moment $\vec{m}$ in magnetic field. A coil of wire has $\lvert \vec{m} \rvert = NIA$. Angle θ is measured between the magnetic field and a line normal to the coil/ parallel to the dipole moment. This allows you to use a compass to find the direction of the magnetic field.