$e = \frac{\text{what you get out}}{\text{what you pay for}} = \frac{W_{\text{out}}}{Q_H} = 1 - \frac{Q_C}{Q_H}$	definition of efficiency and formula for a heat engine, can also use powers in Watts rather than Joules
$e_{\text{max}} = 1 - \frac{T_C}{T_H}$	the maximum or Carnot efficiency of a heat engine $\Delta S_{\text{system}} = 0$
$\Delta S = \pm\frac{Q}{T} = -\frac{Q_H}{T_H} + \frac{Q_C}{T_C}$	entropy change associated with heat or a heat engine
$k_B = 1.38 \times 10^{-23}$ 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
$E_{th} = \frac{3}{2}Nk_BT$ and $\Delta E_{th} = \frac{3}{2}Nk_B\Delta T$	for a monatomic gas
$\Delta E_{th} = W_{\text{in}} + Q_{\text{in}} = -W_{\text{out}} + Q_{\text{in}}$	1st Law of Thermodynamics, you need to modify the signs if you are talking about a 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
$V_i = V_f$	a constant volume process $W_{\text{out}} = 0$
$T_i = T_f$	an isothermal process $\Delta E_{th} = 0$
$p_iV_i^{\frac{5}{3}} = p_fV_f^{\frac{5}{3}}$	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, 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
$p = p_0 + \rho_f gd$	pressure in a fluid of density ρ_f as a function of depth. p_0 is a "reference pressure" where $d = 0$. This equation also supports *Pascal's principle*: if the pressure changes at one point in the fluid it changes by the same amount at every other point.
$p_t = p_b - \rho_f gh$	If a parcel of fluid with a height of h is in hydrostatic equilibrium then the pressure at the top is lower that the pressure at the bottom.
$F_B = \rho_f V_f g$	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.
$p_{\text{atmos}} = 101.3$ kPa=1 atm	atmospheric pressure

$v_1 A_1 = v_2 A_2$	equation of continuity for an incompressible fluid
$Q = vA = \frac{\Delta V}{\Delta t}$	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.
$\omega = 2\pi f = \frac{2\pi}{T}$	relationship between angular frequency ω, frequency f and period T
$(F_{\text{net}})_x = -kx$	This is for a horizontal, frictionless mass-spring system where x represents displacement from equilibrium. This pattern of a linear restoring force is the same for other examples of simple harmonic motion.
$x(t) = A\cos(\omega t) = A\cos(2\pi t) = A\cos(2\pi \frac{t}{T})$	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). $x_{\text{max}} = A$. 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. $v_{\text{max}} = A\omega$. Substitute in frequency f and period T as necessary.
$a_x(t) = -A\omega^2 \cos(\omega t) = -\omega^2 x(t)$	acceleration as a function of time. Substitute in frequency f and period T as necessary.
$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{g}{L}}$	angular 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
$E = K + U = \frac{1}{2}mv_x(t)^2 + \frac{1}{2}kx(t)^2$	energy relationships in a simple harmonic oscillator
$K_{\text{max}} = U_{\text{max}} = \frac{1}{2}m(v_{\text{max}})^2 = \frac{1}{2}kA^2$	max energies
$y(x,t) = A\cos\left(2\pi\left(\frac{x}{\lambda} - \frac{t}{T}\right)\right)$	sinusoidal wave moving to the right (change to positive sign for wave to the left)
$v = f\lambda = \frac{\lambda}{T} = \frac{"\Delta x"}{\Delta t}$	basic relationship between speed, frequency, period, and wavelength. Use the "quotes" form to relate history and snapshot graphs.
$v_{\text{sound}} = \sqrt{\frac{\gamma k_B T}{m}} = \sqrt{\frac{\gamma R T}{M}}$	speed of sound $\gamma = 3/2$ for monatomic gases, $5/2$ for diatomic
$v_{\text{string}} = \sqrt{\frac{T_s}{\mu}}$	waves on a string, T_s is tension, μ is *linear* density
$v_{\text{light}} = c = 3.00 \times 10^8$ 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*