Annotated Equation Sheet:

Linear kinematics (1-D):

$\Delta x = v_0 t + \frac{1}{2}at^2$ $\quad v = v_0 + at$ $\quad v^2 = v_0^2 + 2a\Delta x$

Δx represents the change in position
v_0 represents the velocity of the object at the start of the time interval under consideration
a represents the acceleration of the object during the time interval under consideration
v represents the velocity of the object at some general time t during the time interval under consideration.
t represents the time (assumed starting from time = 0)

Mechanics:

$\sum \vec{F} = m\vec{a}$ $\quad F_{fric} \le \mu F_N$ $\quad F_g = G\frac{m_1 m_2}{r^2}$

$\sum \vec{F}$ represents the (vector) net (or total) force acting on some object
m represents the mass on which the force acts
$\vec{a}$ represents the (vector) acceleration of the object

$F_{fric} \le \mu F_N$ is a general expression used for both static and kinetic friction… the equality can be used for both the expression of kinetic friction or for the case that the maximum static friction is used.
F_{fric} represents the friction force acting
F_N represents the normal force acting from the surface of contact
μ represents the coefficient of friction between object and surface

$F_g = G\frac{m_1 m_2}{r^2}$ is Newton's Universal Law of Gravitation in which there are two point masses (m_1, m_2) separated by a distance of r. G is the gravitational constant found on the constants page.

$F_g = mg$ is the gravitational force acting on a object close to the Earth's surface where g is the magnitude of the acceleration due to gravity near the surface. Starting in 2010, this value will be taken as $g = 9.8 \, {}^{m}\!/_{s^2}$

$\vec{p} = m\vec{v}$ is the expression for the vector linear momentum $(\vec{p})$ of an object of mass (m) moving with velocity $(\vec{v})$.

$a = v^2/r$ is the expression for the centripetal acceleration acting on a particle which is changing direction. The quantity v represents the tangential speed of the object while r represents the radius of the circular arc associated with the motion of the particle

Rotational motion:

$v_t = r\omega$ $\qquad\qquad$ $a_t = r\alpha$

r represents the radius of the arc associated with the motion
ω represents the angular speed associated with the motion
α represents the angular acceleration associated with the motion
v_t represents the tangential speed associated with the motion
a_t represents the tangential acceleration associated with the motion

$\tau = RF\sin\theta = R_\perp F = RF_\perp$ represents how one calculates the torque from a force using the general expression, the moment-arm approach, and the force component perpendicular to the length pointing from the axis of rotation to the point of force application

$\sum \vec{\tau} = I\vec{\alpha}$ is Newton's Second Law in rotational form with (I) representing the moment of inertia and $(\vec{\alpha})$ is the angular acceleration for the net torque $(\vec{\tau})$

Energy:

$KE = \frac{1}{2}mv^2$ is the kinetic energy associated with the translational motion of an object with mass (m) moving with speed (v)

$\Delta PE_g = mg\Delta y$ is the change in the gravitational potential energy of the system comprised of the Earth and an object of mass (m) that change vertical position by Δy near the surface of the Earth.

$W = Fd\cos\theta = F_{\parallel}d = Fd_{\parallel}$ is the work done by a force applied to an object where d represents the magnitude of the displacement, $F_{\parallel}$ is the component of force parallel to the displacement, and $d_{\parallel}$ is the component of displacement parallel to the applied force. Note that components can be negative, thereby producing negative work

$PE_s = \frac{1}{2}kx^2$ is the potential energy associated with a mass-spring system, treating the potential energy at the equilibrium point as zero. The spring constant is (k) and the displacement from equilibrium (1D) is given as (x).

$P = W/\Delta t$ is the expression for the *average* power computed as the total work (W) divided by the time interval (Δt) during which one does the work. Instantaneous power is computed as $P = Fv\cos\theta$

Oscillation:

$\vec{F} = -k\vec{x}$ is Hooke's Law where the spring constant is (k) and the displacement from equilibrium is given as $(\vec{x})$

$T = 2\pi\sqrt{\frac{m}{k}}$ is the period of a mass-spring system with period (T), the spring constant is (k), and the mass is (m)

$T = 2\pi\sqrt{\frac{L}{g}}$ is the period of a simple pendulum in the small-angle approximation where the period is (T), the acceleration due to gravity (on Earth) is (g), and the pendulum length is (L).

Fluids/Gases/Thermodynamics:

$\rho = m/V$ is the relation for mass density with the density represented as (ρ), the mass is (m), and the volume is (V)

$F_{buoy} = \rho g V$ is a statement of Archimedes' Principle where (F_{buoy}) is the size of the buoyant force, (ρ) is the density of fluid displaced, and (V) is the volume of fluid displaced.

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

is a statement of Bernoulli's Principle at a point on a streamline in which (P) is the pressure, (ρ) is the fluid density, (v) is the speed of the fluid, and (y) is the vertical position of the fluid in a gravitational field

$P = F/A$ is the relation for pressure (P)as related by force (F) per unit area (A)

$PV = nRT = Nk_BT$ is the ideal gas equation with

P representing the absolute pressure
V representing the volume
T representing the absolute temperature
n representing the number of moles
N representing the number of particles
R representing the Universal gas constant (see constants sheet)
k_B representing Boltzmann's constant (see constants sheet)

$\Delta U = Q + W_{on\ system}$ is the statement of the First Law of Thermodynamics where we are using the convention of computing the internal energy change of the system (ΔU) is written in terms of the energy transferred to the system from the surroundings (heat : (Q)) and the work done ON the system by the surroundings $\left(W_{on\ system}\right)$. With this prescription, one writes for constant pressure processes $W_{on\ system} = -P\Delta V$ on the standard PV diagrams.

$Q = mc\Delta T$ is the relation for the change in temperature of a sample when energy is added to it. Here, heat is (Q), the sample mass is (m), the specific heat of the sample is (c) and the temperature difference is (ΔT)

$Q = \pm mL$ is the relation for phase changes. Here, heat is (Q), the sample mass is (m), the latent heat is (L) and the $\pm$ deals with whether the system gains or loses the energy

$\Delta S = \frac{Q}{T}$ is the relation for the entropy change at constant temperature. Here the entropy change is (ΔS), the reversible heat is (Q), and the temperature is (T)

Waves/Optics:

$v = f\lambda$ is the basic wave equation relating the wave speed (v) to the wave's frequency (f) and wavelength (λ)

$f_o = f_s\left(\frac{v_{snd} \pm v_{obs}}{v_{snd} \mp v_{src}}\right)$ is the expression for the 1D Doppler Shift in a still medium for sound… here

f_o is the observed frequency
f_s is the source frequency
v_{obs} is the observer's speed
v_{src} is the source's speed
v_{snd} is the speed of sound

$n = {}^{c}\!/_{v}$ is the relation for the index of refraction (n) as the speed of light in vacuum (c) divided by the speed of light in the medium (v)

$n_1 \sin\theta_1 = n_2 \sin\theta_2$ is Snel's Law. (see a recent AJP commentary about how Snel is the proper spelling of "Snell"… C.F. Bohren, "Physics textbook writing: Medieval, monastic mimicry," Am. J. Phys., **77**(2), 101-103 (2009).). Here, the 1 subscript refers to medium "1" and the 2 subscript refers to medium 2. The angles are those measured from the normal to the surface and relate the incident angle to the refracted angle.

$m\lambda = d\sin\theta$ This expression can be used either for finding bright spots in a double slit experiment where (m) refers to the order of the bright region, (λ) is the wavelength of the light, (d) is the spacing between slits, and $(\Theta)$is the angle from the central maximum to the location of the bright spot.
Alternatively, one *could* use this expression to locate the dark regions for single slit diffraction where (m) refers to the order of the dark region and (d) is the slit thickness

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$ is the lens maker equation for thin lenses where (f) is the focal length of the lens, (d_o) represents the object distance from the lens and (d_i) represents the image distance from the lens

$m = -\frac{d_i}{d_o}$ is the expression for the lateral magnification. Here, (d_o) represents the object distance from the lens and (d_i) represents the image distance from the lens, while (m) is the magnification.

Electricity:

$F_e = k\frac{q_1 q_2}{r^2}$ is Coulomb's Law in which there are two point charges (q_1, q_2) separated by a distance of (r). (k) is the Coulomb constant found on the constants page.

$\vec{E} = \frac{\vec{F}}{q}$ is the relation for the electric field $(\vec{E})$ defined as the force $(\vec{F})$ on a charge divided by the charge (q)

$V = \frac{kq}{r}$ is the relation for the electric potential associated with a point charge in which (V) is the electric potential (assuming the potential is zero at infinity), (k) is the Coulomb constant found on the constants page, (r) is the distance from the charge (q) to the point at which the potential is to be determined.

$V = {W}/{q}$ is a relation that can be used is several ways… for example, it could mean the potential difference (V) is the work done by an external agent (W) per unit charge (q), or it could represent the emf (V) is work per unit charge

$\Delta V = -Ed\cos\theta = -E_{\parallel}d = -Ed_{\parallel}$ is the relation between potential difference (ΔV) and the conservative electric field (E) associated with it through some magnitude of displacement (d). Note that this expression is similar to the work equation earlier in the sheet except for the minut sign.

$PE_e = \dfrac{kq_1q_2}{r}$ is the relation for the potential energy associated with the system of two point charges where (PE_e) is the electric potential energy, and the two point charges (q_1, q_2) are separated by a distance (r). (k) is the Coulomb constant found on the constants page.

Circuits:

$Q = CV$ is the relation for the charge on a capacitor (Q) with capacitance (C) and associated potential difference V

$PE = \dfrac{1}{2}CV^2$ is the potential energy stored in the field between the capacitor plates. Here, the capacitance is (C), the potential difference is (V), and the potential energy is (PE).

$V = RI$ is Ohm's Law for simple resistors with potential difference (V), resistance (R), and current (I).

$P = IV$ is one of the relations for the power associated with a current element where (P) is the energy transfer rate (power), the current is (I), and the voltage is (V)

Magnetism:

$F = qvB\sin\theta = qvB_{\perp}$ is the relation for the magnitude of the force (F)on a charged particle (q) moving with speed (v) in a magnetic field of magnitude (B)

$B = \dfrac{\mu_0 I}{2\pi r}$ is the relation for the magnetic field strength outside of a long straight wire. Here, the field strength is (B), the current in the wire is (I), and the distance from the wire is (r). The permeability of free space (μ_0) is on the constant sheet.

$B = \mu_0 nI$ is the expression for the magnetic field strength interior to an ideal solenoid in which the permeability of free space (μ_0) is on the constant sheet, the current in the wire is (I), and the number of turns per unit length is (n)

$F = ILB\sin\theta = ILB_{\perp}$ is the relation for the magnitude of the force (F) on a wire with current (I) and length (L) in a magnetic field of magnitude (B)

Modern Physics:

$E = \gamma m_0 c^2 = mc^2$ is the Einstein relation relating energy and mass where (E) is the energy, (c) is the speed of light in vacuum (found on the Constants page), (m_0) is the rest mass of the object, γ is the Lorentz factor equal to $\gamma = \frac{1}{\sqrt{1-\left(v^2/c^2\right)}}$. The quantity $m = \gamma m_0$ is the so-called relativistic mass.

$E = hf$ is the relationship between the energy of light (E) to its frequency (f) by Planck's constant (h) which is on the constants sheet

$p = \frac{h}{\lambda}$ is the deBroglie relation for momentum (p) and wavelength (λ) by Planck's constant (h) which is on the constants sheet

Moments of Inertia:

Solid disk or cylinder for a perpendicular axis through its center: $I = \frac{1}{2} MR^2$

Thin rod about the center, perpendicular to rod: $I = \frac{1}{12} MR^2$

Solid sphere about a diameter: $I = \frac{2}{5} MR^2$

For each of the moments of inertia, the moment is given as (I), the mass of the object is (M), and the associated length (or radius) of the object is (R)