Formula Sheet (Final)

$f = \frac{1}{T}$; $v = \lambda f$; $v = \sqrt{\frac{F}{m/L}}$ (String); $v = \sqrt{\frac{\gamma k T}{m}}$ (Ideal gas);

$v = \sqrt{\frac{B_{ad}}{\rho}}$ (Liquid); $v = \sqrt{\frac{Y}{\rho}}$ (Solid); $y = A\sin\left(2\pi f t \mp \frac{2\pi x}{\lambda}\right)$ (Wave function);

$I = \frac{P}{A}$ (Sound intensity); $\sin\theta = \frac{\lambda}{D}$ [rectangular Slit] & $\sin\theta = 1.22\frac{\lambda}{D}$ [circular] (Diffraction);

$f_o = f_s\left(\frac{1}{1 \pm \frac{v_s}{v}}\right)$ (Moving source), $\begin{cases} - \text{ toward} \\ + \text{ away} \end{cases}$; $f_o = f_s\left(1 \pm \frac{v_o}{v}\right)$ (Moving observer), $\begin{cases} + \text{ toward} \\ - \text{ away} \end{cases}$;

$f_{beat} = |f_1 - f_2|$ (Beat frequency); $f_n = n\left(\frac{v}{2L}\right)$ $n = 1,2,3,\ldots$ (String fixed at both ends);

$f_n = n\left(\frac{v}{2L}\right)$ $n = 1,2,3,\ldots$ (Tube open at both ends); $f_n = n\left(\frac{v}{4L}\right)$ $n = 1,3,5,\ldots$ (Tube open at only one end);

$\Delta s = n\lambda$ $n = 0,1,2,3\ldots$ (Constructive interference)

$\Delta s = \left(n + \frac{1}{2}\right)\lambda$ $n = 0,1,2,3\ldots$ (Destructive interference)

$N = \frac{q}{e}$ (Number of charge); $F = \frac{kq_1q_2}{r^2}$ but [k =8.99×10^{9}N·m^2/C^2] (Coulomb's law);

$F = q_0E$; $E = \frac{kq}{r^2}$ but [k =8.99×10^{9}N·m^2/C^2] (Point charge);

$E = \frac{q}{\varepsilon_0 A} = \frac{\sigma}{\varepsilon_0}$ but [ε_0 =8.85×10^{-12}C^2/(N·m^2)] (Parallel plate capacitor);

$V = \frac{EPE}{q_0}$; $\Delta(EPE) = -W_{AB}$; $V = \frac{kq}{r}$ but [k =8.99×10^{9}N·m^2/C^2]; $E = -\frac{\Delta V}{\Delta s}$;

$q = CV$ (Capacitor); $\frac{1}{2}mv_i^2 + EPE_i = \frac{1}{2}mv_f^2 + EPE_f$ (Energy conservation);

$C = \frac{\kappa\varepsilon_0 A}{d}$ (Parallel plate capacitor filled with a dielectric) but [ε_0 =8.85×10^{-12}C^2/(N·m^2)];

$E = \frac{1}{2}CV^2$ (Energy storage in a capacitor);

$I = \frac{\Delta q}{\Delta t}$ (Definition of current); $V = IR$ (Ohm's law);

$R = \rho\frac{L}{A}$ (Resistance and resistivity); $\frac{R_1}{R_2} = \frac{I_2}{I_1}$ (In a parallel circuit)

$\rho = \rho_0[1 + \alpha(T - T_0)]$; and $R = R_0[1 + \alpha(T - T_0)]$ (Temperature dependence of resistance)

$P = IV$ (Electric power); $V = V_0 \sin 2\pi ft$ and $I = I_0 \sin 2\pi ft$ (Alternating current);

$V_{rms} = \frac{V_0}{\sqrt{2}}$ and $I_{rms} = \frac{I_0}{\sqrt{2}}$ (Root mean square); $R_{eq} = R_1 + R_2 + \cdots$ (Series)

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$ (Parallel); $V_T = Emf - Ir$ and $I = \frac{Emf}{R_{total} + r}$ (Internal resistance)

$C_{eq} = C_1 + C_2 + \cdots$ (Parallel); $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$ (Series);

$q = q_0 [1 - \exp(-t/(RC))]$ (Capacitor charging); $q = q_0 \exp(-t/(RC))$ (Capacitor discharging);

$\tau = RC$ (Time constant);

$F = q_0 vB \sin\theta$ (Lorentz force); $F = IB\ell \sin\theta$ (Ampere's force);

$B = \frac{\mu_0 I}{2\pi r}$ (Long, straight wire); $B = N\frac{\mu_0 I}{2R}$ (Center of a circular loop);

$B = \mu_0 nI$ (Interior of a long solenoid); $\tau = NIAB \sin\phi$ (Torque on the current-carrying coil)

$V_{emf} = v\ell B$ (Motional emf); $\Phi = BA\cos\phi$ (Magnetic flux);

$V_{emf} = NAB\omega \sin\omega t$ (Emf induced in a rotating planar coil) where $\omega = 2\pi f$;

$V_{emf} = v(2\ell)B$ (Motional emf due to a rotating planar coil);

$V_{emf} = -N\frac{\Delta\Phi}{\Delta t}$ (Faraday's law); $V_{emf\_s} = -M\frac{\Delta I_p}{\Delta t}$ (Emf due to mutual inductance);

$V_{emf} = -L\frac{\Delta I}{\Delta t}$ (Emf due to self-inductance); $E = \frac{1}{2}LI^2$ (Energy stored in an inductor);

$\frac{V_s}{V_p} = \frac{N_s}{N_p}$, $\frac{I_s}{I_p} = \frac{N_p}{N_s}$ (Transformer equations); $c = f\lambda = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$ (Speed of light);

$u = \frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2\mu_0}B^2 = \varepsilon_0 E^2 = \frac{B^2}{\mu_0}$ (Total energy density);

$E = cB$ (Relation between E and B); $E_{rms} = \frac{1}{\sqrt{2}}E_0$, & $B_{rms} = \frac{1}{\sqrt{2}}B_0$ (Root mean square);

$S = \frac{P}{A} = cu$ (Intensity); $f_o = f_s\left(1 \pm \frac{v_{rel}}{c}\right) \begin{cases} - & \text{away} \\ + & \text{toward} \end{cases}$ (Doppler effect);

$\overline{S} = \overline{S}_0 \cos^2\theta$ (Malus' law); $n = \frac{c}{v}$ (Index of refraction); $n_1 \sin\theta_1 = n_2 \sin\theta_2$ (Snell's law);

$\frac{n_2}{n_1} = \frac{d'}{d}$ (Apparent depth); $\sin\theta_c = \frac{n_2}{n_1}$ $(n_1 > n_2)$ (Critical angle);

$\tan\theta_B = \frac{n_2}{n_1}$ (Brewster's law);

$f = \frac{1}{2}R$ (Focal length of a concave mirror); $f = -\frac{1}{2}R$ (Focal length of a convex mirror);

$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ (Mirror & lens equation);

$m = \frac{\text{Image height, } h_i}{\text{Object height, } h_o} = -\frac{d_i}{d_o}$ (Magnification equation for mirrors & lenses);

$\sin\theta = m\frac{\lambda}{d}$ $m = 0,1,2,3\ldots$ (Bright fringes of a double slit);

$\sin\theta = \left(m + \frac{1}{2}\right)\frac{\lambda}{d}$ $m = 0,1,2,3\ldots$ (Dark fringes of a double slit);

$\lambda_{film} = \frac{\lambda_{vacuum}}{n}$ (Wavelength in a film); $2t + \frac{1}{2}\lambda_{film} = \begin{cases} n\lambda_{film}\ (n = 1,2,3\ldots)\ [\text{constructive}] \\ (m + \frac{1}{2})\lambda_{film}\ (m = 0,1,2\ldots)\ [\text{destructive}] \end{cases}$

$\sin\theta = m\frac{\lambda}{W}$ $m = 0,1,2,3\ldots$ (Dark fringes for single-slit diffraction);

$\sin\theta = m\frac{\lambda}{d}$ $m = 0,1,2,3\ldots$ (Principal maxima of a diffraction grating);

Constants

$\varepsilon_0 = 8.85\times10^{-12}\,C^2/(N\cdot m^2)$ (Permittivity of free space); $\mu_0 = 4\pi\times10^{-7}$ T·m/A (Permeability of free space);

$c = 3.00 \times 10^8$ m/s (Speed of light in vacuum).

Appendix

$F = kx$ (Spring motion); $E = Pt$ (Energy–Power); $F = ma$ (Newton's equation)
Area of sphere = $4\pi r^2$, Area of circle = πr^2

k (kilo)	$\times 10^3$	μ (micro)	$\times 10^{-6}$
m (milli)	$\times 10^{-3}$	n (nano)	$\times 10^{-9}$

Right- and Left-Hand Laws