Phys 2326 Equation Sheet

$\mathbf{a} \cdot \mathbf{b} = ab\cos(\theta)$ $|\mathbf{a} \times \mathbf{b}| = ab\sin(\theta)$
$V_{\text{sphere}} = \frac{4}{3}\pi R^3$ $V_{\text{cylinder}} = \pi R^2 h$
$A_{\text{sphere}} = 4\pi R^2$ $A_{\text{cylinder}} = 2\pi Rh + 2\pi R^2$
$K_i + U_i = K_f + U_f$ $K = \frac{1}{2}mv^2$
$F_{cent} = \frac{mv^2}{r}$ $v^2 = v_0^2 + 2a\Delta x$

Electrostatics

$|\mathbf{F}| = \frac{k|q_1||q_2|}{r^2}$ $|\mathbf{E}| = \frac{k|q|}{r^2}$
$\mathbf{E} = \mathbf{F}/q$ $\mathbf{E} = \int \frac{k\ dq}{r^2}\ \hat{r}$
$\Phi_E = \int \mathbf{E} \cdot d\mathbf{A}$ $\oint \mathbf{E} \cdot d\mathbf{A} = Q_{encl}/\varepsilon_0$ $\mathbf{E} = -\nabla V$
$U_f - U_i = -W_{i\to f} = -\int_i^f \mathbf{F} \cdot d\boldsymbol{\ell}$ $\Delta V = \Delta U/q_0$
$V_a - V_b = \int_a^b \mathbf{E} \cdot d\boldsymbol{\ell}$ $V = \int \frac{k\ dq}{r}$
$V = \frac{kq}{r}$ (point charge) $V = |\mathbf{E}|d$ (parallel plates)
$C = Q/V$ $C_0 = \varepsilon_0 A/d$ (parallel plates)
$\frac{1}{C_{\text{eq}}} = \sum_i \frac{1}{C_i}$ (series) $C_{\text{eq}} = \sum_i C_i$ (parallel)
$U = Q^2/2C = CV^2/2 = QV/2$ $u_E = \frac{1}{2}\varepsilon_0 E^2$
$C = \kappa C_0$ $\varepsilon = \kappa\varepsilon_0$
$E = \frac{\sigma}{\varepsilon}$ $\oint \mathbf{E} \cdot d\mathbf{A} = \frac{Q_{encl,free}}{\varepsilon}$

$k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9\ \text{Nm}^2/\text{C}^2$ $\epsilon_0 = 8.854 \times 10^{-12}\ \text{C}^2/(\text{Nm}^2)$ $q_e = 1.6 \times 10^{-19}\ \text{C}$

Electrodynamics

$I = \frac{dQ}{dt}$ $J = I/A$
$I = nAv_d|q|$ $\mathbf{J} = nq\mathbf{v}_d$
$\rho = |\mathbf{E}|/|\mathbf{J}|$ $R = \rho\ell/A$
$V = IR$ $P = IV = I^2R = V^2/R$
$R_{\text{eq}} = \sum_i R_i$ (series) $\frac{1}{R_{\text{eq}}} = \sum_i \frac{1}{R_i}$ (parallel)
$\sum I_{in} = \sum I_{out}$ $\sum V = 0$
$q = C\mathcal{E}(1 - e^{-t/(RC)})$ (charging RC circuit) $q = Q_0 e^{-t/(RC)}$ (discharging RC circuit)
$\tau = RC$ (RC circuit) $\mathcal{E} = V_{\text{bat}} + Ir = IR + Ir$ (batteries)

Magnetism and Induction

$\mathbf{F} = q\mathbf{v} \times \mathbf{B}$

$\mathbf{F} = I\boldsymbol{\ell} \times \mathbf{B}$

$R = \frac{mv}{|q|B}$

$\boldsymbol{\mu} = I\mathbf{A}$

$\mathbf{B} = \frac{\mu_0}{4\pi} \frac{q\mathbf{v}\times\hat{\mathbf{r}}}{r^2}$

$d\mathbf{B} = \frac{\mu_0}{4\pi} \frac{Id\boldsymbol{\ell}\times\hat{\mathbf{r}}}{r^2}$

$\oint \mathbf{B} \cdot d\boldsymbol{\ell} = \mu_0 I_{encl}$

$F = \frac{\mu_0 I_1 I_2 L}{2\pi r}$

$B = \frac{\mu_0 I}{2\pi r}$(long straight wire)

$B = \frac{\mu_0 N I}{2a}$ (center of N circular loops)

$B = \mu_0 n I$ (solenoid)

$B = \frac{\mu_0 N I}{2\pi R}$ (toroidal solenoid)

$\oint \mathbf{B} \cdot d\mathbf{A} = 0$

$\Phi_B = \int \mathbf{B} \cdot d\mathbf{A}$

$\varepsilon_{ind} = -N d\Phi_B/dt = \oint \mathbf{E} \cdot d\mathbf{l}$

$\varepsilon = B\ell v$

$\varepsilon = NBA\omega \sin(\omega t)$

$L = N\Phi_B/i$

$\varepsilon = -L di/dt$

$i = \frac{\varepsilon}{R}\left(1 - e^{-t/\tau}\right)$ (RL circuit)

$\tau = L/R$ (RL circuit)

$\omega = \sqrt{\frac{1}{LC}}$ (LC circuit)

$I_{max} = Q_{max}/\sqrt{LC}$

$U = \frac{1}{2}LI^2$

$u_B = \frac{1}{2\mu_0}B^2$

$$\mu_0 = 4\pi \times 10^{-7} \text{ Tm/A}$$

EM waves

$E = E_{max}\cos(kx - \omega t)$

$c^2 = \frac{1}{\mu_0 \epsilon_0}$

$k = 2\pi/\lambda$

$\omega = 2\pi f$

$v = f\lambda$

$E = cB$

$\mathbf{S} = \frac{1}{\mu_0}\mathbf{E} \times \mathbf{B}$

$E_{max} = \sqrt{2}E_{rms}$

$I = S_{\text{av}} = \frac{P}{A} = \frac{1}{2}\epsilon_0 c E_{\text{max}}^2$

$$c = 3.00 \times 10^8 \text{ m/s}$$

Optics, Interference, and Diffraction

$v_n = c/n$

$\lambda_n = \lambda/n$

$\theta_r = \theta_i$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$\sin\theta_c = n_2/n_1$

$\tan\theta_p = n_2/n_1$

$I = I_0 \cos^2\theta$ (polarizer)

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

$M = h_i/h_o = -d_i/d_o$

$f = \pm R/2$ (spherical mirrors)

$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Double Slit maxima: $d\sin\theta = m\lambda$

Double Slit minima: $d\sin\theta = (m + \frac{1}{2})\lambda$

Single Slit minima: $a\sin\theta = M\lambda$

Thermodynamics

$T_F = \frac{9}{5}T_C + 32^\circ$ $\qquad$ $T_K = T_C + 273.15$

$\Delta L = \alpha L_0 \Delta T$ $\qquad$ $\Delta V = \beta V_0 \Delta T$ $\qquad$ $F/A = -Y\alpha\Delta T$

$Q = \pm mL$

$Q = mc\Delta T$ $\qquad$ $Q = nC_V\Delta T$ (isochoric) $\qquad$ $Q = nC_p\Delta T$(isobaric)

$P = dQ/dt$ $\qquad$ $P = kA(T_H - T_C)/L$ $\qquad$ $P = Ae\sigma T^4$

$pV = nRT = Nk_BT$ $\qquad$ $nR = Nk_B$ $\qquad$ n=m/M

$K_{\text{trans}} = \frac{3}{2}nRT$ $\qquad$ $K_{ave} = \frac{1}{2}m(v^2)_{av} = \frac{3}{2}k_BT$ $\qquad$ $v_{rms} = \sqrt{3RT/M}$

$$C_V = \begin{cases} 3R/2 & \text{monatomic} \\ 5R/2 & \text{diatomic} \end{cases}$$

$\Delta U = Q - W$ $\qquad$ $W = \int_{V_o}^{V_f} pdV$

$W = p\Delta V$ (isobaric) $\qquad$ $W = nRT\ln(V_2/V_1)$ (isothermal) $\qquad$ $W = \frac{p_0V_0 - p_fV_f}{\gamma - 1}$ (adiabatic)

pV^γ =constant (adiabatic) $\qquad$ $pT^{\gamma-1}$ =constant (adiabatic)

$\gamma = C_p/C_V$ $\qquad$ $\gamma = \frac{5}{3}(monatomic)$ $\qquad$ $\gamma = \frac{7}{5}$ (diatomic)

cyclic: $|Q_H| = |W| + |Q_C|$ $\qquad$ $e = \frac{W}{Q_H} = 1 - \frac{|Q_C|}{|Q_H|}$ $\qquad$ $e = 1 - \frac{T_C}{T_H}$ (Carnot)

$\Delta S = \int_1^2 \frac{dQ}{T}$ $\qquad$ $\Delta S = \Delta Q/T$ (isothermal)

$R = 8.31$ J/(mol K)=0.0821 L atm/mol K $\qquad$ $k_B = 1.38 \times 10^{-23}$ J/(molecule K)

$N_A = 6.02 \times 10^{23}$ $\qquad$ 1 L $= 1 \times 10^{-3}$ m^3

$\sigma = 5.67 \times 10^{-8}$ W/m^{2}K^4

For H_2O:

$L_v = 2.26 \times 10^6$ J/kg $\qquad$ $L_f = 33.5 \times 10^4$ J/kg

$c_{water} = 4190$ J/kg K $\qquad$ $c_{steam} = 2010$ J/kg K $\qquad$ $c_{ice} = 2090$ J/kg K