Physics 201 Equations v.2.3

May 9, 2018

Constants:

$k = \frac{1}{4\pi\epsilon_0} = 8.988 \times 10^9$ Nm^2/C^2

$\epsilon_0 = 8.854 \times 10^{-12}$ C^2/(N m^2)

$e = 1.602 \times 10^{-19}$ C

$\mu_0 = 1.2566 \times 10^{-6}$ T m/A

$h = 6.63 \times 10^{-34}$ J s

$k_B = 1.3806 \times 10^{-23}$ J/K $= 8.625 \times 10^{-5}$ eV/K $= 0.0020$ kcal/(mol-K)

1 eV $= 1.602 \times 10^{-19}$ J

$N_A = 6.022 \times 10^{23}$ particles/mol

$R = N_A k_B = 8.314$ J/(mol-K)

1 atm $= 1.013 \times 10^5$ Pa (pressure)

$v = 343$ m/s (v sound in air)

Useful Mechanics Equations:

$\Sigma\vec{F} = m\vec{a}$

$\vec{F} = d\vec{p}/dt$

$\vec{p} = m\vec{v}$

Electromagnetism:

$|\vec{F_E}| = k\frac{|q_1 q_2|}{r^2}$

$|\vec{E}| = k|q|/r^2$

$U = \frac{kq_1q_2}{r}$

$V = kq/r$

$\rho = Q/V$

$\sigma = Q/A$

$\lambda = Q/L$

$\vec{F} = q'\vec{E}$

$U = q'V$

$\oint \vec{E} \cdot \vec{da} = Q_{in}/\epsilon_0$

$V = \int \frac{k\ dq}{r}$

$\vec{E} = \int \frac{k\ dq}{r^2}\hat{r}$

$F_x = \frac{-dU}{dx}\hat{x}$

$E_x = \frac{-dV}{dx}\hat{x}$

$\Delta V = -\int \vec{E} \cdot \vec{dl}$

$\Delta U = -\int \vec{F} \cdot \vec{dl}$

Circuits:

$Q = CV$

$C = \epsilon A/d$

$1/C_{ser} = 1/C_1 + 1/C_2 + 1/C_3 + ...$

$C_{par} = C_1 + C_2 + C_3 + ...$

$U = 1/2CV^2$

$V = RI$

$I = \frac{dQ}{dt}$

$J = I/A$

$P = IV = I^2R$

$R = \rho l/A$

$R_{ser} = R_1 + R_2 + R_3 + ...$

$1/R_{par} = 1/R_1 + 1/R_2 + 1/R_3 + ...$

$\Sigma V = 0$

$I_{in} = I_{out}$

$V(t) = V_o(1 - e^{-t/\tau})$

$V(t) = V_o e^{-t/\tau}$

$\tau = RC$

$\epsilon = K\epsilon_o$

Magnetism:

$\vec{F} = I\vec{l} \times \vec{B}$

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

$\int \vec{B} \cdot \vec{dl} = \mu_0(I)$

$V = -\frac{d}{dt}\Phi_B$

$\Phi_B = \int \vec{B} \cdot \vec{da}$

Inductor Circuits:

$L = \frac{\mu_0 N^2 A}{l}$

$L = \frac{N\Phi_B}{I}$

$V = -L\frac{dI}{dt}$

$\tau = L/R$

$B_{sol} = \mu_0 NI/l$

AC Circuits:

$V = XI$

$X_R = R$

$X_L = \omega L$

$X_C = \frac{1}{\omega C}$

$\omega = 2\pi f$

$V = ZI$

$Z = \sqrt{(R^2 + (X_L - X_C)^2)}$

Waves:

$v = f\lambda$

$\frac{d^2y(x,t)}{dt^2} = v^2\frac{d^2y(x,t)}{dx^2}$

$y(x,t) = A\sin(kx - \omega t + \phi)$

$k = 2\pi/\lambda$

$\omega = 2\pi f = 2\pi/T$

$d\sin(\theta) = n\lambda$

$n = 0, \pm1, \pm2, ...$

$a\sin(\theta) = p\lambda$

$p = \pm1, \pm2, \pm3, ...$

$f' = f\frac{1 \pm v_o/v}{1 \pm v_s/v}$

Optics:

$1/f = 1/d_i + 1/d_o$

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

Thermal Physics

$Q = cm\Delta T$

Ideal Gasses

$PV = nRT$

$P = F/A$

$n = N/N_A$

$PV = Nk_BT$

Thermal Expansion

$L(T) = L_O(1 + \alpha\Delta T)$

$V(T) = V_O(1 + \beta\Delta T)$

Statistical Physics

$E_{Kavg} = 1/2mv^2 = 3/2k_BT$

$S = k_B \ln N_s$

$P \propto \exp(-E/(k_BT))$

$G = E - TS$

$P \propto \exp(-G/(k_BT))$

Two level systems:

$P_a + P_b = 1$

$P_a = \frac{1}{1+\exp(-\Delta E/(k_BT))}$

where: $\Delta E = E_b - E_a$

$P_a = \frac{1}{1+\exp(-\Delta G/(k_BT))}$

where: $\Delta G = G_b - G_a$

$Z = \Sigma_i \exp\left(-E_i/(k_BT)\right)$

$Z = \Sigma_i \exp\left(-G_i/(k_BT)\right)$

$P = \exp(-E/(k_BT))/Z$

$P = \exp(-G/(k_BT))/Z$

Geometry:

Sphere: $A = 4\pi r^2$ and $V = \frac{4}{3}\pi r^3$

Cylinder: $A = 2\pi r^2 + 2\pi rH$ and $V = \pi r^2 H$

Circle: $A = \pi r^2$ and circumfrence $= 2\pi r$

Trig:

sine = opp/hyp

cosine = adj/hyp

tanget = opp/adj

Vectors:

$\vec{A} \cdot \vec{B} = AB\cos\theta$

$|\vec{A} \times \vec{B}| = AB\sin\theta$

Calculus:

$\frac{d}{dx}Ax^n = Anx^{n-1}$

$\frac{d}{dx}A\sin(kx) = Ak\cos(kx)$

$\frac{d}{dx}A\cos(kx) = -Ak\sin(kx)$

$\frac{d}{dx}Ae^{kx} = Ake^{kx}$

$\frac{d}{dx}f(g(x)) = f'(g(x)) \times g'(x)$

$\frac{d}{dx}f(x)g(x) = f'(x)g(x) + f(x)g'(x)$

Metric Prefixes:

tera (T) 10^{12}

giga (G) 10^9

mega (M) 10^6

kilo (k) 10^3

deci (d) 10^{-1}

centi (c) 10^{-2}

mili (m) 10^{-3}

micro (μ) 10^{-6}

nano (n) 10^{-9}

pico (p) 10^{-12}

femto (f) 10^{-15}

atto (a) 10^{-18}

Units:

A = ampere; C=coulomb; s=second; V=volt; J=joule; N=newton; kg=kilogram; T=tesla; F=farad; H=henry; Pa = pascal; kg=kilogram; m=meter; Ω = ohm

A = 1C / s

V = Ω C / s = Ω A

V = J/C = m^2 kg / (s^3 A)

Ω = m^2 kg / (s^3 A^2)

Ω = H/s = s/F

J = N m = kg m^2/s^2

N = kg m / s^2

T = kg / (s^2 A) = N / (A m)

T = kg / (s C) = (N s) / (C m) = N / (C m/s)

F = C/V = A s/ V = s^4 A^2 / (m^2 kg) = C^2/J

H = T m^2/A = s^2/F = kg m^2/(s^2 A^2)

Pa = N/m^2

Symbols:

into the page $\otimes$

out of the page $\odot$