

In showing work, these formulas may be used without derivation.

CONSTANTS

$$v = 343 \text{ m/s} \quad c = 2.998 \times 10^8 \text{ m/s}$$

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$m_e = 9.11 \times 10^{-31} \text{ kg}$$

$$m_p = 1.67 \times 10^{-27} \text{ kg}$$

$$k = 8.99 \times 10^9 \text{ Nm}^2/\text{C}^2$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$$

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

MATH

$$\text{sphere:} \quad 4\pi R^2 \quad \frac{4}{3}\pi R^3$$

$$\text{cylinder:} \quad 2\pi RL \quad \pi R^2 L$$

$$\frac{d}{dx}(x^n) = nx^{n-1}$$

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

$$\int x^n dx = \frac{x^{n+1}}{n+1} \quad \int \frac{dx}{x} = \ln x$$

$$\int \sin(kx) dx = -\frac{1}{k} \cos(kx)$$

$$\int \frac{dx}{\sqrt{x^2 + a^2}} = \ln(x + \sqrt{x^2 + a^2})$$

$$\int \frac{xdx}{\sqrt{x^2 + a^2}} = \sqrt{x^2 + a^2}$$

$$\int \frac{dx}{(x^2 + a^2)^{3/2}} = \frac{x}{a^2(x^2 + a^2)^{1/2}}$$

$$\int \frac{x dx}{(x^2 + a^2)^{3/2}} = \frac{-1}{(x^2 + a^2)^{1/2}}$$

MECHANICS

$$x(t) = x_0 + v_0 t + \frac{1}{2}at^2$$

$$v(t) = v_0 + at$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

WAVES

$$y(x, t) = y_m \sin(kx - \omega t + \phi_0)$$

$$k = \frac{2\pi}{\lambda} \quad f = \frac{\omega}{2\pi} = \frac{1}{T}$$

$$v = \frac{\omega}{k} = \lambda f \quad v = \sqrt{\frac{\tau}{\mu}}$$

$$P_{\text{avg}} = \frac{1}{2} \mu v \omega^2 y_m^2$$

$$\frac{\Delta \phi}{2\pi} = \frac{\Delta L}{\lambda} = \frac{\Delta t}{T}$$

$$\Delta \phi = 2m\pi \quad \Delta \phi = (2m + 1)\pi$$

$$y' = \left[2y_m \cos\left(\frac{\phi_0}{2}\right) \right] \sin\left(kx - \omega t + \frac{\phi_0}{2}\right)$$

$$y' = [2y_m \sin kx] \cos \omega t$$

$$f = \frac{n}{2L} \sqrt{\frac{\tau}{\mu}} \quad f = \frac{v}{2L} n \quad f = \frac{v}{4L} n$$

SOUND

$$v = \sqrt{\frac{B}{\rho}} \quad \Delta p = \Delta p_m \sin(kx - \omega t)$$

$$I = \frac{P}{A} \quad I = \frac{P}{4\pi r^2} \quad I = \frac{1}{2} \rho v \omega^2 s_m^2$$

$$\beta = (10 \text{ dB}) \log \frac{I}{I_0} \quad I_0 = 10^{-12} \text{ W/m}^2$$

$$f' = f \left(\frac{v \pm v_D}{v \pm v_S} \right)$$

LIGHT

$$v = \frac{c}{n} \quad \lambda_n = \frac{\lambda}{n}$$

$$N_2 - N_1 = \frac{L}{\lambda} (n_2 - n_1) \quad y_m = \frac{m\lambda D}{d}$$

$$d \sin \theta = m\lambda \quad d \sin \theta = \left(m + \frac{1}{2} \right) \lambda$$

$$\frac{2L}{\lambda_n} = m \quad \frac{2L}{\lambda_n} = m + \frac{1}{2}$$

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ELECTROSTATICS

$$\vec{F} = k \frac{q_1 q_2}{r^2} \hat{r} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} \hat{r}$$

$$\vec{F} = q_0 \vec{E} \quad \vec{E} = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \hat{r}$$

$$\vec{p} = q\vec{d} \quad \vec{E} = -k \frac{\vec{p}}{x^3} \quad \vec{E} = 2k \frac{\vec{p}}{z^3}$$

$$\vec{\tau} = \vec{p} \times \vec{E} \quad U = -\vec{p} \cdot \vec{E}$$

$$\lambda = \frac{Q}{L} \quad \sigma = \frac{Q}{A} \quad \rho = \frac{Q}{V}$$

$$\Phi = \vec{v} \cdot \vec{A} = vA \cos \theta$$

$$\Phi = \int \vec{E} \cdot d\vec{A}$$

$$\epsilon_0 \Phi = \epsilon_0 \oint \vec{E} \cdot d\vec{A} = q_{\text{enc}}$$

$$E = \frac{\sigma}{\epsilon_0} \quad E = \frac{\sigma}{2\epsilon_0}$$

CIRCUIT ELEMENTS

$$q = C \Delta V \quad \Delta V = Ed$$

$$E = \frac{q}{\kappa\epsilon_0 A} \quad C = \kappa\epsilon_0 \frac{A}{d}$$

$$C_{\text{eq}} = C_1 + C_2 + C_3 + \dots$$

$$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots$$

$$U = \frac{q^2}{2C} \quad U = \frac{1}{2} C \Delta V^2$$

$$i = \frac{dq}{dt} \quad q = \int i dt$$

$$J = \frac{i}{A} \quad i = \int \vec{J} \cdot d\vec{A} \quad \vec{J} = qn\vec{v}_d$$

$$\Delta V = iR \quad P = i \Delta V = i^2 R = \frac{\Delta V^2}{R}$$

$$\vec{E} = \rho \vec{J} \quad R = \rho \frac{L}{A}$$

POTENTIAL

$$V_f - V_i = - \int_i^f \vec{E} \cdot d\vec{s}$$

$$V = \frac{1}{4\pi\epsilon_0} \frac{q}{r} \quad V = k \frac{p \cos \theta}{r^2}$$

$$W_{\text{app}} = -W = U_f - U_i$$

$$\Delta V = V_f - V_i = \frac{U_f}{q_0} - \frac{U_i}{q_0} = \frac{\Delta U}{q_0}$$

$$V = \frac{U}{q_0} \quad U = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r_{12}}$$

$$E_s = -\frac{\partial V}{\partial s} \quad E_x = -\frac{\partial V}{\partial x}$$

$$E_y = -\frac{\partial V}{\partial y} \quad E_z = -\frac{\partial V}{\partial z}$$

MAGNETIC FIELD

$$\vec{F} = q (\vec{v} \times \vec{B}) \quad \vec{F} = i\vec{L} \times \vec{B}$$

$$r = \frac{mv}{|q|B} \quad f = \frac{|q|B}{2\pi m} \quad n = \frac{Bi}{Vle}$$

$$|\vec{\mu}| = NiA \quad \vec{\tau} = \vec{\mu} \times \vec{B} \quad U = -\vec{\mu} \cdot \vec{B}$$

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{id\vec{s} \times \hat{r}}{r^2}$$

$$B = \frac{\mu_0 i}{4\pi R} \left[\frac{z}{\sqrt{z^2 + R^2}} \right]_a^b$$

$$B = \frac{\mu_0 i}{2\pi R} \quad B = \frac{\mu_0 i}{4\pi R} \phi$$

$$F_{ba} = \frac{\mu_0 L i_a i_b}{2\pi d} \quad \oint \vec{B} \cdot d\vec{s} = \mu_0 i_{\text{enc}}$$

$$B = \mu_0 i n \quad \vec{B} = \frac{\mu_0}{2\pi} \frac{\vec{\mu}}{z^3}$$

MAGNETIC INDUCTION

$$\mathcal{E} = -N \frac{d\Phi_B}{dt} \quad \Phi_B = \oint \vec{B} \cdot d\vec{A}$$

$$\mathcal{E} = Blv \quad P = Fv = \frac{B^2 l^2 v^2}{R}$$

MATH

circle: $2\pi R$ πR^2

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

$$ds = r d\theta$$

$$\vec{A} \cdot \vec{B} = A_x B_x + A_z B_z + A_z B_z = AB \cos(\theta)$$

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

Right Hand Rule

$$\int \cos(kx) dx = \frac{1}{k} \sin(kx)$$

MECHANICS

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

WAVES

transverse velocity from $u = \frac{dy}{dt}$

$$\mu = \frac{m}{L} \quad \rho = \frac{m}{V}$$

$$f_{\text{beat}} = |f_1 - f_2|$$

**Supplied if Necessary,
Need NOT Memorize**

$$\vec{A} \times \vec{B} = (A_y B_z - A_z B_y) \hat{i} + (A_z B_x - A_x B_z) \hat{j} + (A_x B_y - A_y B_x) \hat{k}$$

Any electric field or electric potential that can be obtained by integration, unless the question is intended to test your ability to perform that integration.