Livingston's Physics Formulas

Kinematics (8)

★ Velocity Definition - $v_{\text{avg}} = \frac{\Delta x}{\Delta t}$

★ Acceleration Definition - $a_{\text{avg}} = \frac{\Delta v}{\Delta t}$

★ Displacement - $\Delta x = v_o t + \frac{1}{2} a t^2$

★ No-Time Kinematic - $v^2 = v_o^2 + 2a\Delta x$

★ Projectile Range - $R = \frac{v_o^2 \sin 2\theta}{g}$

★ Projectile Height - $H = \frac{v_o^2 \sin^2 \theta}{2g}$

★ Projectile Time of Flight - $t = \frac{2v_o \sin \theta}{g}$

★ Escape Velocity - $v = \sqrt{\frac{2GM}{R}}$

Dynamics/Energy (11)

★ Parallel Gravity Ramp Component - $F_{g\parallel} = F_g \sin \theta$

★ Perpendicular Gravity Ramp Component - $F_{g\perp} = F_g \cos \theta$

★ Frictional Force - $f = \mu N$

★ Spring Force - $F_s = -kx$

★ Kinetic Energy - $K = \frac{1}{2} m v^2$

★ Gravitational Potential Energy - $U_g = mgh$

★ Elastic Potential Energy - $U_s = \frac{1}{2} k x^2$

★ Thermal/Frictional Energy - $E_{\text{th}} = d\mu F_N$

★ Work-Kinetic Energy Theorem - $W = \Delta K$

★ Power Definition - $P = \frac{W}{t} = Fv$

★ Pressure Definition - $P = \frac{F}{A}$

Angular Motion (12)

★ Centripetal Force - $F_c = \frac{mv^2}{r}$

★ Point Mass Moment of Inertia - $I = mr^2$

★ Parallel Axis Theorem - $I = I_{\text{cm}} + md^2$

★ Torque - $\tau = Fr \sin \theta = I\alpha$

★ Angular Momentum - $L = pr = I\omega$

★ Rotational Kinetic Energy - $K = \frac{1}{2} I \omega^2$

★ Angular-Linear Velocity Relationship - $v = \omega r$

★ Angular-Linear Acceleration Relationship - $a = \alpha r$

★ Frequency-Period Relationship - $f = \frac{1}{T}$

- ★ Angular Frequency - $\omega = 2\pi f$
- ★ SHM Position - $x = A\cos\omega t$
- ★ SHM Velocity - $v = -A\omega\sin\omega t$
- ★ SHM Acceleration - $-A\omega^2\cos\omega t$

Waves/Oscillations (21)

- ★ Period of a Spring-Mass System - $T = 2\pi\sqrt{\frac{m}{k}}$
- ★ Period of a Simple Pendulum - $T = 2\pi\sqrt{\frac{l}{g}}$
- ★ Period of a Physical Pendulum - $T = 2\pi\sqrt{\frac{I}{mgd}}$
- ★ Frequency of Open-Open Apparatus - $f = \frac{nv}{2L}$
- ★ Frequency of Closed-Closed Apparatus - $f = \frac{nv}{4L}$
- ★ Velocity-Tension Relation -$v = \sqrt{\frac{T}{\mu}}$
- ★ Velocity of a Wave - $v = f\lambda$
- ★ Doppler Shift - $f = f_0\frac{v+v_o}{v+v_s}$
- ★ Velocity of Sound - $v = 331\sqrt{1+\frac{T}{273}}$
- ★ Intensity Definition - $I = \frac{P}{A}$
- ★ Decibel Definition - $\beta = 10\log\left(\frac{I}{10^{-12}}\right)$
- ★ Perfect Absorber Radiation Pressure - $P = \frac{I}{c}$
- ★ Perfect Reflector Radiation Pressure - $P = \frac{2I}{c}$
- ★ Energy of Light - $E = \frac{hc}{\lambda}$
- ★ deBrogile Wavelength - $\lambda = \frac{h}{p}$
- ★ Velocity of Light in Medium - $v = \frac{c}{n}$
- ★ Snell's Law - $n_1\sin\theta_1 = n_2\sin\theta_2$
- ★ Malus' Law - $I = \frac{I_o\cos^2\theta}{2}$
- ★ Compton Scattering - $\Delta\lambda = \frac{h}{mc}(1-\cos\theta)$
- ★ Single Slit Diffraction - $a\sin\theta = m\lambda$
- ★ Wein's Law - $T = \frac{0.0029}{\lambda}$

Relativity (7)

- ★ Lorentz Factor - $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$
- ★ Relativistic Time Dilation - $t = \gamma t_0$
- ★ Relativistic Length Contraction - $L = \frac{L_0}{\gamma}$
- ★ Relativistic Mass Dilation - $m = \gamma m_0$
- ★ Relativistic Energy - $E = \sqrt{(pc)^2 + (mc^2)^2}$
- ★ Relativistic Kinetic Energy - $K = (\gamma - 1)mc^2$

★ Relativistic Velocity Addition - $u = \frac{u' + v}{1 + \frac{u'v}{c^2}}$

Electromagnetism (36)

★ Coulomb's Law - $F_E = \frac{kq_1q_2}{r^2}$

★ Electrostatic Force - $F_E = qE$

★ Point Charge Electric Field - $E = \frac{kq}{r^2}$

★ Electric Potential - $V = \frac{kq}{r}$

★ Electric Potential Energy - $U_e = qV = \frac{kq_1q_2}{r}$

★ Electric Field Across Potential Difference - $E = \frac{V}{d}$

★ Gauss' Law - $EA = \frac{Q}{\varepsilon_0}$

★ Resistance - $R = \frac{\rho L}{A}$

★ Conductance - $G = \frac{1}{R}$

★ Conductivity - $\sigma = \frac{1}{\rho}$

★ Ohm's Law - $V = IR$

★ Electrical Power - $P = VI$

★ Capacitance - $C = \frac{\kappa\varepsilon_0 A}{d} = \frac{Q}{V}$

★ Capacitor Energy - $U_e = \frac{1}{2}QV = \frac{1}{2}CV^2$

★ Voltage with Charging Capacitor - $V = V_0\left(1 - e^{-\frac{t}{RC}}\right)$

★ Current Transformer Ratio - $n_pI_p = n_sI_s$

★ Voltage Transformer Ratio - $\frac{V_p}{V_s} = \frac{N_p}{N_s}$

★ Power Transformer Ratio - $V_pI_p = V_sI_s$

★ Ampere's Law - $Bs = \mu_0 I$

★ Coil Magnetic Field - $B = \frac{\mu_0 I}{2R}$

★ Faraday's Law of Induction - $\varepsilon = -N\frac{\mathrm{d}\Phi}{\mathrm{d}t} = -M\frac{\mathrm{d}I}{\mathrm{d}t}$

★ Magnetic Flux - $\Phi = \vec{B} \cdot \vec{A}$

★ Magnetic Field Force on Charged Particle - $F_B = q\left(\vec{v} \times \vec{B}\right)$

★ Magnetic Field Force on a Current-Carrying Wire - $F = I\left(\vec{I} \times \vec{B}\right)$

★ EMF Induced in a Moving Rod - $\varepsilon = Blv$

★ Poynting Vector (Intensity) Magnitude - $\langle S \rangle = \frac{EB}{2\mu_0}$

★ Electric/Magnetic Field Relation - $v = \frac{E}{B}$

★ Force Between Wires - $F = \frac{\mu_0 I_1 I_2 L}{2\pi r}$

★ Inductor Energy - $U_e = \frac{1}{2}LI^2$

★ Solenoid Magnetic Field - $\mu\frac{n}{l}I$

★ Ampere-Maxwell Equation - $Bs = \mu_0\varepsilon_0\frac{\mathrm{d}\Phi_E}{\mathrm{d}t}$

Alternating Current (AC) Circuits (7)

★ Impedance Magnitude - $|Z| = \frac{V}{I} = \sqrt{R^2 + (X_L - X_C)^2}$

★ Resistance - $R = |Z| \cos \phi$

★ Reactance - $X = |Z| \sin \phi$

★ Inductive Reactance - $X_L = 2\pi f L$

★ Capacitive Reactance - $X_C = \frac{1}{2\pi f C}$

★ Resonance Frequency - $f = \frac{1}{2\pi} \sqrt{\frac{1}{LC}}$

★ Power Factor - $\text{PF} = \cos \phi$

Solids, Gases, and Liquids (15)

★ Volumetric Flow Rate - $Q = Av$

★ Ideal Gas Law - $PV = nRT$

★ Work Done on Gas (Isobaric) - $W = -P\Delta V$

★ Work Done on Gas (Isothermal) - $W = nRT \ln\left(\frac{V_f}{V_i}\right)$

★ Heat Flow (Isovolumetric) - $Q = nC_v\Delta T$

★ Heat Flow (Isobaric) - $Q = nC_p\Delta T$

★ Equipartition Theorem - $U = \frac{fnRT}{2}$

★ Constant Volume Molar Heat Capacity - $C_V = \frac{f}{2}R$

★ Constant Pressure Molar Heat Capacity - $C_P = C_V + R$

★ Adiabatic Index Definition - $\gamma = \frac{C_P}{C_V}$

★ Adiabatic Process - $P_1V_1^\gamma = P_2V_2^\gamma$

★ Buoyant Force - $F_B = \rho g V$

★ Bernoulli's Law - $P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$

★ Linear Thermal Expansion - $\Delta L = \alpha L_0 \Delta T$

★ Volumetric Thermal Expansion - $\Delta V = \beta V_0 \Delta T$

Lenses (5)

★ Lens Equation = $\frac{1}{f} + \frac{1}{d_i} + \frac{1}{d_o}$

★ Lens Power Definition - $D = \frac{1}{f}$

★ Magnification Definition - $m = -\frac{d_i}{d_o}$

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

★ Surface Image Formation - $\frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R}$

Miscellaneous (10)

★ Heat Engine Efficiency - $\eta = \frac{W}{Q_{\text{in}}} = \frac{Q_{\text{in}} - Q_{\text{out}}}{Q_{\text{in}}}$

★ Carnot Efficiency - $\eta = 1 - \frac{T_c}{T_h}$

- ⋆ Heisenberg's Uncertainty Principle - $\Delta E \Delta t = \Delta x \Delta p \geq \frac{h}{4\pi}$
- ⋆ Entropy - $\Delta S = \frac{Q}{T}$
- ⋆ Quantum Probability Definition - $P(a \leq x \leq b) = \int_a^b |\psi(x,t)|^2 \ \mathrm{dx}$
- ⋆ Normalization Constant Definition - $\int_{-\infty}^{\infty} |\psi(x)|^2 \mathrm{dx} = 1$
- ⋆ Quantum Expectation Value - $\langle x \rangle = \int_{-\infty}^{\infty} x |\psi(x)|^2 \mathrm{dx}$
- ⋆ Root-Mean-Square (RMS) Definition - $\mathrm{RMS} = \sqrt{\frac{\int_a^b (f(x))^2 \ \mathrm{dx}}{T}}$
- ⋆ Additive/Subtractive Error Propagation - $\Delta Q = \sqrt{(\Delta A)^2 + (\Delta B)^2}$
- ⋆ Multiplicative/Divisive Error Propagation - $\frac{\Delta Q}{Q} = \sqrt{\left(\frac{\Delta A}{A}\right)^2 + \left(\frac{\Delta B}{B}\right)^2}$