FORMULÆ
Physics 1020 Final Exam

Waves, Acoustics, and Constants

$$F = -kx$$

$$x(t) = A\cos(\omega t + \delta)$$

$$\text{Spring}: \quad \omega = \sqrt{\frac{k}{m}}; \quad T = 2\pi\sqrt{\frac{m}{k}}$$

$$\text{Pendulum}: \quad \omega = \sqrt{\frac{g}{L}}; \quad T = 2\pi\sqrt{\frac{L}{g}}$$

$$K = \frac{1}{2}mv^2; \quad U = \frac{1}{2}kx^2; \quad E = \frac{1}{2}kA^2$$

$$y(x,t) = A\cos(\kappa x - \omega t + \delta)$$

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

$$f_n = n\frac{v}{2L} \qquad (n = 1, 2, 3, \ldots)$$

$$v_{\text{snd}} \approx (331 + 0.60T_c)\ \text{m/s}$$

$$v = \sqrt{\frac{F_T}{m/L}}$$

$$\beta = 10\log_{10}\frac{I}{I_0}; \qquad I_0 = 10^{-12}\ \text{W/m}^2$$

$$I = \frac{P}{A} = \frac{P}{4\pi r^2}$$

$$f' = f\left(\frac{v_{\text{snd}} \pm v_{\text{obs}}}{v_{\text{snd}} \mp v_{\text{source}}}\right);$$

top sign : toward; bottom sign : away

$$x = vt$$

Circle:

$$C = 2\pi r = \pi d$$
$$A = \pi r^2 = \tfrac{\pi}{4}d^2$$

Sphere:

$$A = 4\pi r^2 = \pi d^2$$
$$V = \tfrac{4}{3}\pi r^3 = \tfrac{\pi}{6}d^3$$

Constants:

$$c = 2.99792458 \times 10^8\ \text{m/s}$$
$$e = 1.602176565 \times 10^{-19}\ \text{C}$$
$$g = 9.80\ \text{m/s}^2$$
$$v_{\text{snd}} = 343\ \text{m/s}$$
$$n_{\text{air}} = 1.00$$
$$n_{\text{water}} = 1.33$$
$$\varepsilon_0 = 8.85418781762038985\ldots \times 10^{-12}\ \text{F/m}$$
$$\mu_0 = 4\pi \times 10^{-7}\ \text{N/A}^2$$
$$k_c = 1/(4\pi\varepsilon_0) = 8.9875517873681764 \times 10^9\ \text{m/F}$$
$$m_e = 9.10938291 \times 10^{-31}\ \text{kg} \qquad \text{(electron mass)}$$
$$m_p = 1.672621777 \times 10^{-27}\ \text{kg} \qquad \text{(proton mass)}$$

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Electricity and Magnetism

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

$$\mathbf{E} = \frac{\mathbf{F}}{q_0}$$

$$\Phi_E = \mathbf{E}\cdot\mathbf{A} = EA\cos\theta$$

$$\Phi_E = \frac{q_{\text{encl}}}{\varepsilon_0}$$

$$R = \rho\frac{L}{A}$$

$$\rho = \rho_0[1 + \alpha(T - T_0)]$$
$$R = R_0[1 + \alpha(T - T_0)]$$

$$R_s = R_1 + R_2 + R_3 + \cdots$$
$$R_p = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots\right)^{-1}$$

$$V = IR$$

$$P = IV = I^2R = \frac{V^2}{R}$$

$$C = \frac{Q}{V}$$

$$C = K\,\frac{\varepsilon_0 A}{d} \qquad \text{(parallel plate cap.)}$$

$$C_s = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots\right)^{-1}$$
$$C_p = C_1 + C_2 + C_3 + \cdots$$

$$U = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$$

$$\tau = RC$$

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

$$B = \mu_0 nI \qquad \text{(solenoid)}; \qquad n = N/\ell$$

$$\mathbf{F} = q(\mathbf{E} + \mathbf{v}\times\mathbf{B})$$

$$r = \frac{mv_\perp}{|q|B} \qquad \text{(gyroradius)}$$

$$\omega = \frac{|q|B}{m} \qquad \text{(gyrofrequency)}$$

$$\frac{F}{\ell} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{d} \qquad \text{(two parallel wires)}$$

$$\mathcal{E} = -N\frac{\Delta\Phi_B}{\Delta t}$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$c = f\lambda$$

Resistivities and temp. coeffs. (at $T_0 = 20°\text{C}$)

Material	Resistivity ρ (Ω m)	Temp. coeff. α $(°\text{C})^{-1}$
Silver	1.59×10^{-8}	0.0061
Copper	1.68×10^{-8}	0.0068
Gold	2.44×10^{-8}	0.0034
Aluminum	2.65×10^{-8}	0.00429
Tungsten	5.6×10^{-8}	0.0045
Platinum	10.6×10^{-8}	0.003927

Dielectric constants

Material	Dielectric const.
Vacuum	1.0000
Air (1 atm)	1.0006
Paraffin	2.2
Polystyrene	2.6
Paper	3.7
Quartz	4.3

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Optics and Modern Physics

Indices of Refraction

Material	Index of refraction
Vacuum	1.0000
Air (STP)	1.0003
Water	1.33
Ethyl alcohol	1.36
Lucite	1.51
Sodium chloride	1.53
Diamond	2.42

Sign convention for mirrors and lenses:

Variable	+	−
d_o	real object	virtual object
d_i	real image	virtual image
h_o	always	—
h_i, m	upright image	inverted image
f	converging mirror/lens	diverging mirror/lens
R_1, R_2	convex surface	concave surface

$$f = \frac{R}{2}$$

$$\frac{1}{f} = \left(\frac{n_{\text{lens}}}{n_{\text{air}}} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

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

$$m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$\theta_i = \theta_r$$

$$n = \frac{c}{v}$$

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

$$\sin\theta_c = \frac{n_2}{n_1} \qquad (n_1 > n_2)$$

$$I = \frac{\Phi}{\Omega} \quad (\Phi = \text{lum. flux (lm)};\ \Omega = \text{solid angle (sr)})$$

$$E = \frac{\Phi}{A} = \frac{\Phi}{4\pi r^2} \quad (E = \text{illuminance (lx)})$$

$$d \sin\theta = m\lambda \quad (m = 0, 1, 2, 3, \ldots) \quad \text{(interference, bright)}$$

$$a \sin\theta = m\lambda \quad (m = 1, 2, 3, \ldots) \quad \text{(diffraction, dark)}$$

$$\Delta\theta = \begin{cases} 1.22\,\dfrac{\lambda}{D} & \text{(circular aperture)} \\ \dfrac{\lambda}{D} & \text{(rectangular aperture)} \end{cases}$$

$$I = I_0 \cos^2\theta$$

$$\tan\theta_p = \frac{n}{n_{\text{air}}}$$

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

$$\Delta t = \gamma \Delta t_0$$

$$L = \frac{L_0}{\gamma}$$

$$w = \frac{v - u}{1 - uv/c^2}$$

$$E_0 = mc^2$$