E&M Review Sheet

Note: Appendix E of Conte & MacKay contains some other useful stuff.

Speed of light in vacuum: $c = 299792458$ m/s $\simeq 30$ cm/ns
Fields (See Chapter 9 of Conte & MacKay):

$$\vec{D} = \epsilon\vec{E} \qquad \vec{B} = \mu\vec{H} \qquad \epsilon = \epsilon_r\epsilon_0 \qquad \mu = \mu_r\mu_0$$

For free space (vacuum): $\epsilon_r = \mu_r = 1$

$$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{Tm/A}, \quad \epsilon_0 = \frac{1}{\mu_0 \mathrm{c}^2} \simeq 8.85 \times 10^{-12}\ \mathrm{C/V/m^2}$$

Maxwell's Equations:

$\nabla \cdot \vec{D} = \rho$	$\nabla \cdot \vec{B} = 0$	$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$	$\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$
$\iint_{\partial V} \vec{D} \cdot \cdot d\vec{S} = \iiint_V \rho\, dV$	$\iint_{\partial V} \vec{B} \cdot d\vec{S} = 0$	$\oint E \cdot d\vec{\ell} = \frac{\partial}{\partial t} \iint \vec{B} \cdot d\vec{S}$	$\oint H \cdot d\vec{\ell} = \iint \vec{J} \cdot d\vec{S} + \frac{\partial}{\partial t} \iint \vec{D} \cdot d\vec{S}$

Steady-state boundary conditions between two media:

$$(\vec{D}_2 - \vec{D}_1) \cdot \hat{n} = \rho_{\mathrm{surface}}$$

$$(\vec{B}_2 - \vec{B}_1) \cdot \hat{n} = 0$$

$$(\vec{E}_2 - \vec{E}_1) \times \hat{n} = 0$$

$$(\vec{H}_2 - \vec{H}_1) \times \hat{n} = -\vec{J}_{\mathrm{surface}}$$

Fields in terms of potentials:

$$\vec{E} = -\nabla\Phi - \frac{\partial \vec{A}}{\partial t}$$

$$\vec{B} = \nabla \times \vec{A}$$

Coulomb's law:

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

Biot-Savart law:

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

Lorentz force:

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

Energy density:

$$u = \frac{1}{2}(\vec{D} \cdot \vec{E} + \vec{H} \cdot \vec{B})$$

Momentum density:

$$\vec{g} = \frac{\vec{E} \times \vec{H}}{c^2}$$

Poynting vector (energy flow):

$$\vec{S} = \vec{E} \times \vec{H}$$

Some trig identities and other useful stuff:

$$e^{ix} = \cos x + i \sin x \qquad e^{x} = \cosh x + \sinh x$$

$$\sin x = \frac{e^{ix} - e^{-ix}}{2i} \qquad \sinh x = \frac{e^{x} - e^{-x}}{2}$$

$$\cos x = \frac{e^{ix} + e^{-ix}}{2} \qquad \cosh x = \frac{e^{x} + e^{-x}}{2}$$

$$\sin(\theta + \phi) = \sin\theta\cos\phi + \cos\theta\sin\phi \qquad \sinh(\theta+\phi) = \sinh\theta\cosh\phi + \cosh\theta\sinh\phi$$

$$\cos(\theta + \phi) = \cos\theta\cos\phi - \sin\theta\sin\phi \qquad \cosh(\theta+\phi) = \cosh\theta\cosh\phi + \sinh\theta\sinh\phi$$

$$\cos^2\theta = \tfrac{1}{2}(1 + \cos 2\theta)$$

$$\sin^2\theta = \tfrac{1}{2}(1 - \cos 2\theta)$$

$$\sin\frac{\theta}{2} = \pm\sqrt{\frac{1-\cos\theta}{2}}$$

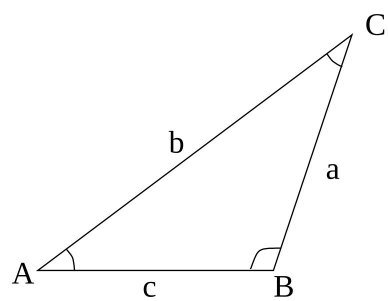
$$\cos\frac{\theta}{2} = \pm\sqrt{\frac{1+\cos\theta}{2}}$$

$$\tan\frac{\theta}{2} = \pm\sqrt{\frac{1-\cos\theta}{1+\cos\theta}} = \frac{\sin\theta}{1+\cos\theta} = \frac{1-\cos\theta}{\sin\theta}$$

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

$$c^2 = a^2 + b^2 - 2ab\cos C$$

$$\frac{a+b}{a-b} = \frac{\tan\left(\frac{A+B}{2}\right)}{\tan\left(\frac{A-B}{2}\right)}$$



$$\int \frac{dx}{1+x^2} = \tan^{-1} x$$

$$\frac{1}{\sqrt{2\pi}\sigma}\int_{-\infty}^{\infty} e^{-\frac{x^2}{2\sigma^2}}\,dx = 1$$

$$\frac{1}{\sqrt{2\pi}\sigma}\int_{-\infty}^{\infty} x^2 e^{-\frac{x^2}{2\sigma^2}}\,dx = \sigma^2$$

Fourier transforms:

$$\hat{f}(\omega) = \int_{-\infty}^{\infty} e^{-i\omega t} f(t)\,dt$$

$$f(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} e^{-i\omega t}\hat{f}(\omega)\,d\omega$$

$$\sum_{n=-\infty}^{\infty} \delta(t - n\tau) = \frac{1}{\tau}\sum_{m=-\infty}^{\infty} e^{i\frac{m2\pi t}{\tau}}$$

Parseval's theorem:

$$h(t) = \int f(t')g(t-t')dt' \quad \Leftrightarrow \quad \hat{h}(\omega) = \hat{f}(\omega)\hat{g}(\omega)$$