PHY302L Useful Formulae

Electricity

Couloumb's Law
$\vec{\mathbf{F}}_{12} = k\frac{q_1 q_2}{r^2}\hat{\mathbf{r}}_{12}$

Electric Field of a point charge q:
$\vec{\mathbf{E}} = \frac{\vec{\mathbf{F}}}{q_2} = k\frac{q}{r^2}\hat{\mathbf{r}}$

Electric field inside a conductor in electrostatic equilibrium:
$\vec{\mathbf{E}} = 0$

Electric potential near a point charge:
$V = k\frac{q}{r}$

Definition of capacitance: $C = Q/V$

Parallel plate capacitance: $C = \epsilon_0 \frac{A}{d}$

Energy stored in a capacitor:
$U = \frac{QV}{2} = \frac{CV^2}{2} = \frac{Q^2}{2C}$

Resistance of a wire of length L and cross section A:
$R = \rho\frac{L}{A}$

Temperature dependence of Resistivity :
$\rho - \rho_0 = \rho_0 \alpha (T - T_0)$

Electric power dissipation:
$P = IV = I^2R = V^2/R$

Transient behavior in an RC circuit, charging:
$Q(t) = Q_0\left(1 - \exp^{-t/RC}\right)$

Transient behavior in an RC circuit, discharging:
$Q(t) = Q_0 \exp^{-t/RC}$

Magnetism

Magnetic Force on a moving charged particle
$\mathbf{F}_B = qvB\sin\theta$

Magnetic Force on a current carrying wire
$\mathbf{F}_B = iLB\sin\theta$

Magnetic dipole moment $\mu = NiA$

Torque on a magnetic dipole: $\tau = \mu B \sin\theta$

Uniform circular motion of a charged particle in a magnetic field, radius
$r = \frac{mv}{qB}$

Uniform circular motion of a charged particle in a magnetic field, frequency
$\omega = 2\pi\nu = \frac{qB}{m}$

Magnetic field of a long straight wire:
$B = \frac{\mu_0 i}{2\pi R}$

Flux of the magnetic field: $\Phi_B = BA\cos\theta$

Faraday's law of induction:
$E = -N\frac{\Delta\Phi_B}{\Delta t}$

Transformer equation: $\frac{V_s}{V_p} = \frac{N_s}{N_P}$

Wave equation relating speed, frequency and wavelength: $v = \lambda\nu$

Energy density in electromagnetic waves (peak):
$u = \epsilon_0 E^2 = \epsilon_0 cEB = B^2/\mu_0$

Energy density in electromagnetic waves (average):
$u = \frac{\epsilon_0 E^2}{2} = \frac{\epsilon_0 cEB}{2} = \frac{B^2}{2\mu_0}$

Power transported in electromagnetic waves (average):
$\bar{S} = \frac{\epsilon_0 cE_0^2}{2} = \frac{E_0 B_0}{2\mu_0} = \frac{cB_0^2}{2\mu_0}$

Power dissipated in an electrical circuit:
$P = I^2R = \frac{V^2}{R} = VI$

Optics

Index of refraction
$n = \frac{c}{v}$

Snell's law of refraction
$n_1 \sin\theta_1 = n_2 \sin\theta_2$

Critical angle for total internal reflection
$\sin\theta_c = \frac{n_2}{n_1}$

Spherical mirror in air
$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} = \frac{2}{r}$

Thin lens equation
$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

Constructive interference in Young's double slit
$d \sin\theta = m\lambda$

Einstein-Planck photon energy
$E = h\nu$

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de Broglie wavelength
$\lambda = h/p$

Heisenberg uncertainty principle
$\Delta p \Delta x \geq \hbar \qquad \Delta E \Delta t \geq \hbar$

Constants and Conversion factors:

Magnetic permeability, $\mu_0 = 1.26\text{x}10^{-6}$ T·m/A

Couloumb's law constant: $k_e = \frac{1}{4\pi\epsilon_0} = 8.89\text{x}10^9$ N·m^2/C^2

1 eV = 1.602 x 10^{-19} J

Proton mass, m_p = 1.67 x 10^{-27} kg

Electron mass, m_e = 9.11 x 10^{-31} kg

Electron charge, e = 1.60 x 10^{-19} C

Speed of light in vacuum, c = 3.0 x 10^8 m/s