Nov. 15-17
PHYS2002-1 (Zhang)
PHYS2002-2 (Blackmon)

PHYS2002 Test 3 Formula Sheet

Gravitational constant	$g = 9.8\ \mathrm{m/s^2}$
mass of proton	$m_p = 1.67\times10^{-27}$ kg
mass of electron	$m_e = 9.11\times10^{-31}$ kg
charge on proton	$q_p = +1.602\times10^{-19}$ C
charge on electron	$q_e = -1.602\times10^{-19}$ C
permeability of free space	$\mu_0 = 4\pi\times10^{-7}$ T·m/A
permittivity of free space	$\varepsilon_0 = 8.85\times10^{-12}\ \mathrm{C^2/(N\cdot m^2)}$
Coulomb's Law constant	$k = 8.99\times10^{9}\ \mathrm{N\cdot m^2/C^2} = \frac{1}{4\pi\varepsilon_0}$
Speed of light	$c = 3.00\times10^{8}$ m/s

Point charges

$$F = k\frac{|q_1|\cdot|q_2|}{r^2} \qquad E = k\frac{|q_1|}{r^2}$$

$$EPE = k\frac{q_1 q_2}{r} \qquad V = k\frac{q_1}{r}$$

$$\Delta V = E\cdot\Delta d$$

Joule	= J = N·m
Watt	= W = J/s
Amp	= A = C/s
Volt	= V = J/C
Ohm	= Ω = V/A
Tesla	= T = N·s/(C·m)
Weber	= Wb = T·m²
Henry	= H = V·s/A
Diopter	= D = m⁻¹

Kinematics (e.g. PHYS2001)

$$\sum \vec{F} = m\vec{a} \qquad \vec{p} = m\vec{v} \qquad W = Fd\cos\theta$$

$$x - x_0 = v_{0x}t + \frac{1}{2}a_x t^2 \qquad E_{total} = KE + EPE + GPE + \ldots$$

$$v_x - v_{0x} = a_x t \qquad KE = \frac{1}{2}mv^2 \qquad GPE = mgy$$

$$v_x^2 - v_{0x}^2 = 2a_x(x - x_0) \qquad F_c = \frac{mv^2}{r} = ma_c \qquad T = \frac{2\pi r}{v}$$

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

Ohm's Law $V = IR$

$$R_{series} = R_1 + R_2 + \mathrm{K}$$

$$\frac{1}{R_{||}} = \frac{1}{R_1} + \frac{1}{R_2} + \mathrm{K}$$

$$I_{series} = I_1 = I_2 = \mathrm{K}$$

$$I_{||} = I_1 + I_2 + \mathrm{K}$$

$$V_{series} = V_1 + V_2 + \mathrm{K}$$

$$V_{||} = V_1 = V_2 = \mathrm{K}$$

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

Capacitance

$$q = CV$$

$$C = \frac{\kappa \varepsilon_0 A}{d}$$

$$Energy = \frac{1}{2} C V^2$$

$$E_0 = \frac{\sigma}{\varepsilon_0} = \frac{q}{A \varepsilon_0}$$

$$E = \frac{E_0}{\kappa}$$

$$\frac{1}{C_{series}} = \frac{1}{C_1} + \frac{1}{C_2} + \mathrm{K}$$

$$C_{||} = C_1 + C_2 + \mathrm{K}$$

RC Circuits $\tau = RC$

RC discharging $q = q_0 e^{-t/\tau}$

RC charging $q = q_0 \left(1 - e^{-t/\tau}\right)$

Electric potential energy $\Delta EPE = -W = +q\Delta V$

Forces on charged particle

$F = qE \qquad F = qvB\sin\theta$

Radius of motion of charged particle in uniform field $\Bigg\}\; r = \dfrac{mv}{qB}$

Velocity Filter $E = vB$

Force on a straight wire

$$F = ILB\sin\theta$$

Torque on a coil of wire

$$\tau = NIAB\sin\phi$$

B fields made by currents

Long, straight wire $B = \dfrac{\mu_0 I}{2\pi r}$

At center of coil of wire $B = \dfrac{N\mu_0 I}{2R}$

Solenoid $B = \mu_0 In$

Magnetic Flux $\Phi_M = BA\cos\phi$

Motional EMF $\varepsilon = vBL$

Faraday's Law $\varepsilon = -N\dfrac{\Delta\Phi_M}{\Delta t}$

AC Generator $\varepsilon = NAB\omega\sin\omega t$

Inductance

$$M = \frac{N_S\Phi_S}{I_P} \qquad L = \frac{N\Phi}{I}$$

$$\varepsilon_S = -M\frac{\Delta I_P}{\Delta t} \qquad \varepsilon = -L\frac{\Delta I}{\Delta t}$$

Energy stored $= \dfrac{1}{2}LI^2$

Transformers

$$\frac{V_s}{V_P} = \frac{N_s}{N_P}$$

$$I_S = \frac{V_P}{V_S}I_P$$

Electromagnetic waves

$$E(t) = E_0 \sin \omega t \qquad E_{rms} = \frac{E_0}{\sqrt{2}} \qquad E = cB \qquad c = f \cdot \lambda$$

$$B(t) = B_0 \sin \omega t \qquad B_{rms} = \frac{B_0}{\sqrt{2}} \qquad \omega = 2\pi f \qquad c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$$

Energy density $u = \frac{\varepsilon_0}{2} E^2 + \frac{1}{2\mu_0} B^2 = \varepsilon_0 E^2 = \frac{1}{\mu_0} B^2$

$$\bar{u} = \frac{\varepsilon_0}{2} E_{rms}^2 + \frac{1}{2\mu_0} B_{rms}^2 = \varepsilon_0 E_{rms}^2 = \frac{1}{\mu_0} B_{rms}^2$$

Intensity $S = \frac{P}{A} = \frac{E}{t \cdot A} = cu \qquad \bar{S} = c\bar{u}$

$$S = cu = \frac{c\varepsilon_0}{2} E^2 + \frac{c}{2\mu_0} B^2 = c\varepsilon_0 E^2 = \frac{c}{\mu_0} B^2$$

$$f_o = f_s\left(1 \pm \frac{v_{rel}}{c}\right)$$

$$\frac{\lambda_s}{\lambda_o} = 1 \pm \frac{v_{rel}}{c}$$

Doppler shift

+ if v_{rel} is towards
- if v_{rel} is away

Malus' Law: $S = S_0 \cos^2 \theta$

Mirrors and Lenses

Law of reflection: $\theta_r = \theta_i$

Mirror/lens equation: $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

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

focal length ***f*** $\begin{cases} 0.5 * R \text{ for spherical mirror} \\ - \text{ for convex mirror, diverging lens} \\ + \text{ for concave mirror, converging lens} \end{cases}$

Index of refraction: $n = \frac{c}{v} = \frac{\lambda_{vac}}{\lambda}$

Snell's Law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$

Total Internal reflection (critical angle): $\sin\theta_c = \frac{n_2}{n_1}$

Apparent depth: $d' = d\left(\frac{n_2}{n_1}\right)$ $\begin{cases} n_1 \text{ contains incident ray} \\ n_2 \text{ contains refracted ray} \end{cases}$

Brewster's Angle: $\tan\theta_B = \frac{n_2}{n_1}$ $\begin{cases} n_1 \text{ contains incident ray} \\ n_2 \text{ contains refracted ray} \end{cases}$

Thin film interference

$$2t + shift? = m\lambda$$ Constructive interference

$$2t + shift\ ? = m\lambda + \frac{1}{2}\lambda$$ Destructive interference

Diffraction

Double slit $\boldsymbol{m} = 0, 1, 2, 3, \ldots$

$$d\sin\theta = m\lambda$$ bright fringes (constructive)

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

Single slit $\boldsymbol{m} = 1, 2, 3, \ldots$

$$\sin\theta = \frac{m\lambda}{W}$$ *dark* fringe of order m

Circular aperture - Resolving power - Rayleigh Criterion

$$\sin\theta \approx \theta > 1.22\frac{\lambda}{D}$$

Diffraction grating Principal maxima (bright fringes)

$$\sin\theta = m\frac{\lambda}{d}$$

Small angle approximation $\theta \approx \sin\theta \approx \tan\theta = \frac{s}{H}$