PHYS 1312 Fall 2018 Final Exam: Equation Sheet

Test 1 equations

$$v = f\lambda \qquad \omega = 2\pi f \qquad f = 1/T \qquad v_{\text{sound}} = \left(\frac{\gamma k_B T}{m}\right)^{1/2} \tag{1}$$

$$x(t) = A\cos(\omega t + \phi) \quad v(t) = -A\omega\sin(\omega t + \phi) \quad a(t) = -A\omega^2\cos(\omega t + \phi) \tag{2}$$

$$y(x,t) = A\sin(kx \mp \omega t + \phi_0) = A\sin\varphi \qquad k = 2\pi/\lambda \tag{3}$$

$$\Delta\varphi = \frac{2\pi}{\lambda}\Delta x + \Delta\phi_0 = m2\pi \qquad f_o = f_s\left(\frac{1 \pm v_0/v}{1 \mp v_s/v}\right) \tag{4}$$

$$f_n^{oo} = n\frac{v}{2L} \qquad f_n^{oc} = n\frac{v}{4L} \qquad n = \frac{c}{\text{v}} \qquad n_1\sin\theta_1 = n_2\sin\theta_2 \tag{5}$$

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \qquad \frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R} \qquad \frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \tag{6}$$

$$f = \frac{R}{2} \qquad M = \frac{h'}{h} = \frac{-q}{p} \qquad I \propto \frac{D^2}{f^2} \tag{7}$$

$$f\text{−number} = f/D \qquad P = \frac{1}{f} \qquad m = \frac{\theta}{\theta_0} \qquad m_{\max} = 1 + \frac{25\text{ cm}}{f} \tag{8}$$

$$M_0 = \frac{-L}{f_0} \qquad M = M_0 m_e = -\frac{L}{f_0}\frac{25\text{ cm}}{f_e} \qquad m = -\frac{f_0}{f_e} \tag{9}$$

$$\delta = r_2 - r_1 = d\sin\theta_{\text{bright}} = m\lambda \qquad d\sin\theta_{\text{dark}} = \left(m + \frac{1}{2}\right)\lambda \tag{10}$$

$$y_{\text{bright}} \approx \frac{\lambda L m}{d} \qquad y_{\text{dark}} \approx \frac{\lambda L}{d}\left(m + \frac{1}{2}\right) \qquad I = I_{\max}\cos^2(\phi/2) \tag{11}$$

$$E(t) = E_0\sin(\omega t + \phi) \qquad \phi = \frac{2\pi}{\lambda}\delta \tag{12}$$

Test 2 equations

$$\beta = \frac{2\pi}{\lambda}a\sin\theta \qquad a\sin\theta_{\text{dark}} = m\lambda \qquad I = I_{\max}\left[\frac{\sin(\beta/2)}{\beta/2}\right]^2 \tag{13}$$

$$\theta_{\min} = \frac{\lambda}{a} \qquad \theta_{\min} = 1.22\frac{\lambda}{D} \qquad R = \frac{\lambda_{\text{avg}}}{\Delta\lambda} = Nm \quad \delta = 2d\sin\theta = m\lambda \tag{14}$$

$$\vec{F}_e = \frac{k_e q_1 q_1}{r^2}\hat{r} \qquad k_e = \frac{1}{4\pi\epsilon_0} \qquad \vec{E} = \vec{F}_e/q \tag{15}$$

$$|\vec{E}_{\text{axis}}| \approx \frac{k_e 2qs}{r^3} \qquad |\vec{E}_{\text{perp}}| \approx \frac{k_e qs}{r^3} \qquad \vec{p} = q\vec{s} = \alpha\vec{E} \tag{16}$$

$$|\vec{E}_{\text{induced}}| \approx \frac{k_e^2 2\alpha q_1}{r^5} \qquad \bar{v} = uE_{\text{net}} \tag{17}$$

Test 3 equations

$$\lambda = Q/L \qquad \sigma = Q/A \qquad \rho = Q/V \tag{18}$$

$$\vec{E} = k_e \sum_i \frac{q_i}{r_i^2}\hat{r}_i = k_e \int \frac{dq}{r^2}\hat{r} \qquad E_{x,\text{rod}} = \frac{k_e Q}{a(L+a)} \tag{19}$$

$$\vec{E}_{\text{rod}} = \frac{k_e Q}{r\sqrt{r^2 + (L/2)^2}}\hat{r} \qquad E_{z,\text{ring}} = \frac{k_e Q z}{(R^2+z^2)^{3/2}} \tag{20}$$

$$E_{z,\text{disk}} = \frac{Q/A}{2\epsilon_0}\left[1 - \frac{z}{\sqrt{R^2+z^2}}\right] \tag{21}$$

$$\Delta V = \frac{\Delta U_e}{q} = -\int \vec{E}\cdot d\vec{\ell} \qquad \vec{E} = -\vec{\nabla} V \qquad V = \frac{k_e q}{r} \tag{22}$$

$$V = k_e \int \frac{dq}{r} \qquad \vec{E}_{\text{insulator}} = \vec{E}_{\text{applied}}/K \qquad \Delta V_{\text{insulator}} = \Delta V_{\text{vacuum}}/K \tag{23}$$

$$\text{Energy/volume} = \frac{1}{2}\epsilon_0 E^2 \quad I = |q|nA\bar{v} = |q|i \quad \vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2} \tag{24}$$

$$\Delta\vec{B} = \frac{\mu_0}{4\pi}\frac{I\Delta\vec{\ell}\times\hat{r}}{r^2} \quad B_{z,ring} = \frac{\mu_0}{4\pi}\frac{2\pi R^2 I}{(R^2+z^2)^{3/2}} \quad \vec{B}_{\text{axis}} = \frac{\mu_0}{4\pi}\frac{2\vec{\mu}}{z^3} \tag{25}$$

$$B_{wire} = \frac{\mu_0}{4\pi}\frac{LI}{r\sqrt{(L/2)^2 + r^2}} \qquad \mu = IA \qquad \vec{\mu}_L^e = \mu_{\text{B}}\vec{L}/\hbar \tag{26}$$

$$\vec{\mu}_S^e = 2.0023\mu_{\text{B}}\vec{S}/\hbar \quad L = \sqrt{\ell(\ell+1)}\hbar \quad S = \sqrt{s(s+1)}\hbar \tag{27}$$

Post-Test 3 equations

$$\sum \Delta V_i = 0 \qquad \sum I_{\text{in}} = \sum I_{\text{out}} \qquad I = \int \vec{J}\cdot d\vec{A} \tag{28}$$

$$I = dQ/dt \quad J = I/A \quad \vec{J} = \sigma\vec{E} \quad \sigma = |q|un = \frac{1}{\rho} \tag{29}$$

$$R = \rho\ell/A \quad R_{eq}^s = \sum R_i \quad \frac{1}{R_{eq}^p} = \sum \frac{1}{R_i} \tag{30}$$

$$\Delta V = IR \quad P = \frac{dU}{dt} = I\Delta V = I^2 R = (\Delta V)^2/R \tag{31}$$

$$C = Q/\Delta V \tag{32}$$

Math relations and constants

$$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta = (A_xB_x + A_yB_y + A_zB_z) \tag{33}$$

$$|\vec{A}\times\vec{B}| = |\vec{A}||\vec{B}|\sin\theta \tag{34}$$

$$\vec{A}\times\vec{B} = \Big\langle (A_yB_z - A_zB_y), -(A_xB_z - A_zB_x), (A_xB_y - A_yB_x) \Big\rangle \tag{35}$$

$$\sin(A\pm B) = \sin A\cos B \pm \cos A\sin B \tag{36}$$

$$\cos(A\pm B) = \cos A\cos B \mp \sin A\sin B \tag{37}$$

$$\sin A + \sin B = 2\sin\left(\frac{A+B}{2}\right)\cos\left(\frac{A-B}{2}\right) \tag{38}$$

$$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - ... \qquad \cos x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!}... \tag{39}$$

$$\frac{d}{dx}\left[\frac{u}{v}\right] = \frac{1}{v}\frac{du}{dx} - \frac{u}{v^2}\frac{dv}{dx} \tag{40}$$

$$(1+\epsilon)^n \approx 1 + n\epsilon, \epsilon << 1 \tag{41}$$

$$\int \frac{xdx}{\sqrt{x^2 \pm y^2}} = \sqrt{x^2 \pm y^2} \qquad \int \frac{dx}{\sqrt{x^2 \pm y^2}} = \ln(x + \sqrt{x^2 \pm y^2}) \tag{42}$$

$$\int \frac{xdx}{(x^2 \pm y^2)^{3/2}} = \frac{-1}{\sqrt{x^2 \pm y^2}} \qquad \int \frac{dx}{(x^2 \pm y^2)^{3/2}} = \frac{\pm x}{y^2\sqrt{x^2 \pm y^2}} \tag{43}$$

$$\text{Circumference} = 2\pi r \qquad A = \pi r^2 \qquad V = \frac{4}{3}\pi r^3 \tag{44}$$

$$c = 3\times 10^8 \text{ m/s} \qquad k_e = 8.99\times 10^9 \text{ Nm}^2/\text{C}^2 \qquad \epsilon_0 = 8.854\times 10^{-12} \text{ C}^2/(\text{Nm}^2) \tag{45}$$

$$e = 1.602\times 10^{-19} \text{ C} \qquad m_e = 9.11\times 10^{-31} \text{ kg} \qquad k_B = 1.38\times 10^{-23}\text{J/K} \tag{46}$$

$$\frac{\mu_0}{4\pi} = 1\times 10^{-7} \text{ Tm/A} \qquad m_p = 1.672\times 10^{-27} \text{ kg} \qquad \mu_{\text{B}} = \frac{e\hbar}{2m_e} = 9.274\times 10^{-24}\text{Am}^2 \tag{47}$$