General College Physics II (PHY 104)

Exam 3

Spring 2025

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Equation Sheet

$$F = k\frac{|qQ|}{r^2} \qquad \text{PE} = k\frac{qQ}{r}$$

$$\mathbf{F} = q\mathbf{E} \qquad \text{PE} = qV$$

$$E = k\frac{|Q|}{r^2} \qquad V = k\frac{Q}{r}$$

$$E = \frac{|\sigma|}{2\epsilon_0} = 2\pi k\,|\sigma| \qquad V = -2\pi k\sigma\,|x|$$

$$\Delta V = Ed \qquad Q = C\Delta V$$

$$C = \epsilon_0\frac{A}{d} \qquad \text{PE} = \frac{1}{2}Q\Delta V = \frac{1}{2}C(\Delta V)^2 = \frac{1}{2}\frac{Q^2}{C}$$

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

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

$$I_{\text{rms}} = \frac{I_0}{\sqrt{2}} \qquad V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

$$R_{\text{eq}} = R_1 + R_2 \qquad R_{\text{eq}} = \frac{R_1R_2}{R_1 + R_2}$$

$$F = \frac{\mu_0}{2\pi}\frac{I_1I_2}{d}l$$

$$B = \frac{\mu_0 I}{2\pi r} \qquad B = \mu_0 NI/l$$

$$F = |q|\,vB\sin\theta \qquad F = IlB\sin\theta$$

$$\Phi_B = BA\cos\theta \qquad \mathcal{E} = -N\frac{\Delta\Phi_B}{\Delta t}$$

$$\Phi_B = BA\cos\omega t \qquad \mathcal{E} = NB\omega A\sin\omega t$$

$$n = \frac{c}{v} \qquad f = \frac{r}{2}$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \qquad \sin\theta_C = \frac{n_2}{n_1}$$

Conventions:

- The focal length f is positive for concave mirrors and converging lenses, and negative for convex mirrors and diverging lenses.
- For a single-lens or single-mirror system, we choose $d_o > 0$.
- A real image has $d_i > 0$, while a virtual image has $d_i < 0$.
- An upright image has $h_i > 0$, while an inverted image has $h_i < 0$.

$$\lambda = \frac{\lambda_0}{n} \qquad v = f\lambda$$

$$\#\lambda\text{s} = \frac{d\sin\theta}{\lambda} \qquad \#\lambda\text{s} = \frac{2tn}{\lambda_0} + \left\{ \begin{array}{c} 1/2 \\ 0 \end{array} \right\} + \left\{ \begin{array}{c} 1/2 \\ 0 \end{array} \right\}$$

$$E = hf \qquad p = \frac{E}{c} = \frac{hf}{c} = \frac{h}{\lambda}$$

$$E_n = -(13.6 \text{ eV})\frac{Z^2}{n^2}$$

$$N = N_0 e^{-\lambda t} \qquad T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

Electron mass	9.11×10^{-31} kg
Proton mass	1.6726×10^{-27} kg
Neutron mass	1.6749×10^{-27} kg
Atomic mass unit (1 u)	1.6605×10^{-27} kg = 931.5 MeV/c^2
Avagadro's number	6.02214×10^{23} u/g
Proton charge	1.602×10^{-19} C
Electrical constant	$k = 8.988 \times 10^{9}$ N·m^2/C^2
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12}$ C^2/N·m^2
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ T·m/A
Gravitational constant	$G = 6.67 \times 10^{-11}$ N·m^2/kg^2
Planck's constant	$h = 6.63 \times 10^{-34}$ J·s
Speed of light in vacuun	$c = 3.00 \times 10^{8}$ m/s

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$$

Material	Resistivity, ρ
Silver	1.59×10^{-8} Ω·m
Copper	1.68×10^{-8} Ω·m
Gold	2.44×10^{-8} Ω·m
Tungsten	5.6×10^{-8} Ω·m

Medium	Index of refraction, n
Vacuum	1.0000
Air (at STP)	1.0003
Water	1.33
Lucite	1.51
Crown glass	1.52

Earth's magnetic field in Annville, Pennsylvania

B_x	20.2 μT	x is North
B_y	−4.1 μT	y is East
B_z	47.4 μT	z is Down
Horizontal Intensity	20.6 μT	
Total Field	51.7 μT	
Inclination (+ D , − U)	66.5°	
Declination (+ E , − W)	−11.4°	

From Giancoli 7th, Appendix B

Atomic Number Z	Element	Symbol	Mass Number A	Atomic Mass†	Half-life (if radioactive)
0	neutron	n	1	1.008665	10.183 min
	electron	e		0.000549	
1	Hydrogen	H	1	1.007825	
	proton	p	1	1.007276	
	Deuterium	${}^2_1H$	2	2.014102	
	Tritium	${}^3_1H$	3	3.016049	12.32 yr
2	Helium	He	3	3.016029	
			4	4.002603	
6	Carbon	C	11	11.011434	20.334 min
			12	12.000000	
			13	13.003355	
			14	14.003242	5730 yr
8	Oxygen	O	15	15.003066	122.24 s
			16	15.994915	
			18	17.999160	
9	Fluorine	F	18	18.000938	109.771 min
			19	18.998403	
11	Sodium	Na	22	21.994437	2.6027 yr
			23	22.989769	
			24	23.990963	14.997 hr
82	Lead	Pb	206	205.974466	
			207	206.975897	
			208	207.976652	
			210	209.984189	22.20 yr
			211	210.988737	36.1 min
			212	211.991898	10.64 h
			214	213.999806	26.8 min
84	Polonium	Po	210	209.982874	138.376 days
			214	213.995202	164.3 μs
85	Astatine	At	218	218.008695	1.5 s

†Masses given are those for the neutral atom, including the Z electrons (except for the electron and proton).

Question 1 (4 points) Object 1 is placed by a concave mirror. A real image will form (a) if the object is inside the focal length, (b) if the object is outside the focal length, (c) regardless of where the object is, or (d) never. Object 2 is placed by a convex mirror. A real image will form (a) if the object is inside the focal length, (b) if the object is outside the focal length, (c) regardless of where the object is, or (d) never. Explain.

Question 2 (4 points) Consider a concave mirror with radius 20 cm. An object is placed 15 cm in front of the mirror. Make a ray diagram that shows where an image would be formed. Is the image real or virtual? Is it inverted or upright?

Question 3 (4 points) Monochromatic red light is incident on a double slit, and the interference pattern is viewed on a screen some distance away. Explain how the fringe pattern would change if the red light source is replaced by a blue light source.

Question 4 (4 points) Consider a pattern of fringes on a screen produced by two-slit interference. If the slit separation is increased, what happens to the spacing between the (bright) fringes? (Does it increase, decrease, or stay the same?) Explain how you know.

Problem 1 (8 points) Light from a lamp 3.0 m above the surface of a pool of water hits the water at an angle 10° above the surface of the water. If the pool is 1.0 m deep, find the total time it takes the light to travel from the lamp to the bottom of the pool. (Hint: First find the distance the light travels in air and the distance it travels in water.)

Problem 2 (8 points) The third-order bright fringe of 610 nm light is observed at an angle of 29° when the light falls on two narrow slits. How far apart are the slits?

Problem 3 (8 points) Consider a thin film of soap on a larger piece of crown glass. Above the soap film is air. Find the two smallest thicknesses of soap film ($n = 1.33$) that will produce destructive interference for light of wavelength 500 nm.