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For Part I and Part II, use the equation sheet, homeworks, prelabs, and exams as a cue to what you are supposed to know.

Part I - Electrostatics and DC Circuits

Chap 15-18

- Chap 15, Charges, Electric Field, Gauss's Law
- Chap 16, Electrostatic Potential, Capacitors
- Chap 17-18, DC Current, Ohm's Law, Series/Parallel, Kirchoff's Laws

Part II - Magnetism, Electromagnetic Induction, and AC Circuits

Chap 19-21

- Chap 19, Magnetic Field Sources, Magnetic Force, Magnetic Torque
- Chap 20, Induced Voltages and Inductors
- Chap 21, AC Circuits

Part II - Waves and Optics

• Chap 13 - Oscillations

- Oscillations, Amplitude, Frequency, Angular Frequency

$$\omega = 2\pi f \quad T = \frac{1}{f}$$

- (Sec 13.3-13.4) Harmonic Oscillator, Energy of Harmonic Oscillator

$$f = \frac{1}{2\pi} \sqrt{\frac{k}{m}} \quad E = \frac{1}{2}kA^2 = \frac{1}{2}mv_{\max}^2$$

- (Sec 13.5) Pendulum

$$f = \frac{1}{2\pi} \sqrt{\frac{g}{L}}$$

● **Chap 13 - Waves**

- (Sec 13.8) Sinusoidal Wave Speed:

$$v = f\lambda$$

- (Sec 13.9) Wave on a String:

$$v = \sqrt{F_T/\mu}$$

● **Chap 14 - Sound Waves**

- (Sec 14.3) Speed of Sound:

$$v \approx 340\text{m/s}$$

- (Sec 14.4) Intensity and Decibels

$$I = \frac{\text{Power}}{\text{Area}} \quad I = I_{\text{ref}}10^{\beta/10}$$

- As intensities are multiplied (or divided), decibel levels are added (or subtracted).
- Important Decibel Levels

Level β	Ratio = $10^{\beta/10}$
-10 dB	0.1
0 dB	1
3 dB	2
5 dB	≈ 3
7 dB	5
10 dB	10
20 dB	100

- (Sec 14.6) Doppler Effect - Frequency shifts up when moving toward each other.

$$\frac{\Delta f}{f} = \frac{v_{\text{rel}}}{v_{\text{wave}}}$$

● **Chap 14 - Standing Waves**

- The wave speed is determined by the type of wave (string, sound, light).
- The wavelength is determined by the size of the cavity (string, pipe, or antenna) and which harmonic is being analyzed.
- The frequency is determined once the speed and wavelength are known.
- (Sec 14.8) Standing wave with nodes at each end,

$$L = \lambda_1/2 \quad f_1 = \frac{v}{\lambda_1} = \frac{v}{2L}$$

$$f_n = nf_1, \quad n = 1, 2, 3, \dots$$

- (Sec 14.10) Standing wave with node at one end and peak at other end,

$$L = \lambda_1/4 \quad f_1 = \frac{v}{\lambda_1} = \frac{v}{4L}$$

$$f_n = nf_1, \quad n = 1, 3, 5, \dots$$

● Sec 24.9 - Polarization

- A polarizer works by absorbing some energy from a light wave. When unpolarized light passes through, half of the intensity is absorbed.

$$I = \frac{1}{2}I_0$$

- A polarizer also works by zeroing out a component of the electric field of the light wave (hence the $\cos(\theta)$). This affects light that has a well-defined direction of the electric field, and this is called polarized light.
- Since the intensity is related to the electric field squared, when polarized light goes through a polarizer, it brings in a factor of $\cos^2(\theta)$.

$$I = I_0 \cos^2(\theta)$$

- Light reflected at an angle tends to be polarized parallel to the surface. For example, light glaring off of water tends to be polarized horizontally. This allows vertically-polarized sunglasses to absorb that glare.

● Chap 21-22 - Light

- Types of "light" - Radio, Microwave, Infrared, Visible, UV, X-Rays, Gamma Rays
- Visible Light - wavelength between 400 and 750 nm.
- Speed of Light in a Vacuum: $c = 3 \times 10^8 \text{ m/s}$
- Speed of Light in a Medium is a little slower: $v = c/n$
- Air is almost the same as a vacuum: $n_{\text{air}} \approx 1.0003$
- (Sec 22.2) Reflection: $\theta'_1 = \theta_1$
- (Sec 22.3) Refraction: $n_1 \sin \theta_1 = n_2 \sin \theta_2$
- Total Internal Reflection: When refraction tries to make $\sin \theta_2 > 1$, which is impossible. Therefore there is no refraction, only reflection.

● Chap 23 - Images, Mirrors, and Lenses

- We see objects or images when rays of light are coming from a common point.
 - Nearby objects have rapidly diverging rays.
 - Far objects have weakly diverging rays.
 - Infinitely far objects (the sun) have parallel rays.
- A lens or mirror creates an image from an object. When looking at the lens or mirror, we see the image, not the object.
 - The location of the image is calculated relative to the lens/mirror.

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

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- The size of the image is calculated from the location:

$$\frac{h_i}{h_o} = M = -\frac{d_i}{d_o}$$

- A real image is formed when the rays of light coming from a lens/mirror actually cross. A piece of paper placed at that location will allow us to see the real image. This occurs whenever d_i is positive.
- A virtual image is formed when the rays of light coming from a lens/mirror diverge from each other. When looking at the lens/mirror, these rays appear to be coming from a common point, and that common point is the image. This occurs whenever d_i is negative.
- (Sec 23.1) Flat (plane) mirror: $f = \infty$ so $d_i = -d_o$.
- (Sec 23.2, 23.6) Converging lens/mirror: f is positive.
 - Infinitely-far object ($d_o = \infty$): solar cooker
Results: $d_i = f$, which is positive. $M = 0$ (huge sun focused to tiny point).
 - Nearby object ($d_o < f$): magnifying glass
Results: d_i is negative, M is positive and big ($M > 1$)
 - Far object ($d_o > f$): projector
Results: d_i is positive, M is negative and could be big or small.
- (Sec 23.3, 23.6) Diverging lens/mirror: f is negative
 - Infinitely-far object ($d_o = \infty$): sun glare from curved surface
Results: $d_i = f$, which is negative (virtual image). $M = 0$
 - Real object: your reflection from a convex mirror
Results: d_i always negative and smaller than d_o .
 M always positive and small ($0 < M < 1$).

● Chap 25 - Optics Instruments

- (Sec 25.2) The Eye
 - Near point is closest distance. Want 25 cm.
 - Far point is furthest distance. Want ∞ .
- Angular Size - Angle between edges of feature, as measured from the eye. With small angles, we can measure in radians and approximate that $\tan \theta = \theta$.

$$\theta \approx \frac{h}{d_{\text{eye}}}$$

- (Sec 25.3) Simple Magnifier
 - Without lens, can place object at near point.

$$\theta_0 = \frac{h}{25 \text{ cm}}$$

- With lens, for “relaxed” viewing, can place object at lens focal point.

$$\theta = \frac{h}{f}$$

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- Angular Magnification compares these:

$$m = \frac{\theta}{\theta_0} = \frac{25 \text{ cm}}{f}$$

- If you bring the image up to the near point, the object can be even closer with the lens. This leads to:

$$m = 1 + \frac{25 \text{ cm}}{f}$$

- (Sec 25.4) Compound Microscope

- The object is placed just outside the objective lens's focal point. So it acts as a magnifying projector to create the intermediate image. The distance to this is the tube length L . It creates a linear magnification of:

$$M_o \approx -\frac{L}{f_o}$$

- The eyepiece is used as a simple magnifier to view the intermediate image. It creates an angular magnification of:

$$m_e = \frac{25 \text{ cm}}{f_e}$$

- Multiply the two magnifications to find the overall angular magnification.

- (Sec 25.5) Telescope

- The object has a fixed angular size θ_0 .

- The object is infinitely far away from the objective. So it acts as a reducing projector to create the intermediate image. Its height is:

$$h' = \theta_0 f_o$$

- The eyepiece acts as a simple magnifier to view the intermediate image. The angular size of the intermediate image is:

$$\theta = h' / f_e$$

- Together, the objective and eyepiece create an angular magnification of:
\$\$ m = \frac{\theta}{\theta_0} = -\frac{f_o}{f_e} \$\$

● Chap 24 - Interference

- Measuring Angles:

$$y = L \tan(\theta)$$

- (Sec 24.8) Diffraction Grating: Spots produced

$$m\lambda = d \sin(\theta)$$

$$d = \frac{1}{\text{Grating Density}}$$

- (Sec 24.2) Two-slit Interference: Bright fringes produced

$$m\lambda = d \sin(\theta)$$

- (Sec 24.7) Single-slit Diffraction: Dark fringes produced (except $m=0$):

$$m\lambda = a \sin(\theta)$$