Phys2426-Fall16 Final Exam Topics

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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 23-24, Charges, Electric Field, Gauss's Law
- Chap 25-26, Electrostatic Potential, Capacitors
- Chap 27-28, DC Current, Ohm's Law, Series/Parallel, Kirchoff's Laws

Part II - Magnetism, Electromagnetic Induction, and AC Circuits

- Chap 29-30, Magnetic Field Sources, Magnetic Force, Magnetic Torque
- Chap 31-32, Induced Voltages and Inductors
- Chap 33, AC Circuits

Part II - Waves and Optics

- ## Chap 15 - Oscillations
  - Oscillations, Amplitude, Frequency, Angular Frequency

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

  - (Sec 15.2) Harmonic Oscillator, Energy of Harmonic Oscillator

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

  - (Sec 15.5) Pendulum

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

- **Chap 16 - Waves**
  - (Sec 16.2) Sinusoidal Wave Speed:
  $$v = f\lambda$$
  - (Sec 16.3) Wave on a String:
  $$v = \sqrt{F_T/\mu}$$
- **Chap 17 - Sound Waves**
  - (Sec 17.2) Speed of Sound:
  $$v \approx 340\text{m/s}$$
  - (Sec 17.3) Intensity and Decibels
  $$I = \frac{\text{Power}}{\text{Area}} \qquad I = I_{\text{ref}} 10^{\beta/10}$$
  - 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 17.4) Doppler Effect - Frequency shifts up when moving toward each other.
  $$\frac{\Delta f}{f} = \frac{v_{\text{rel}}}{v_{\text{wave}}}$$
- **Chap 18 - 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 18.3) Standing wave with nodes at each end,
  $$L = \lambda_1/2 \qquad f_1 = \frac{v}{\lambda_1} = \frac{v}{2L}$$
  $$f_n = nf_1, \quad n = 1, 2, 3, \ldots$$
  - (Sec 18.5) Standing wave with node at one end and peak at other end,

$$L = \lambda_1/4 \qquad f_1 = \frac{v}{\lambda_1} = \frac{v}{4L}$$
$$f_n = nf_1, \quad n = 1, 3, 5, \ldots$$

- **Sec 38.6 - Polarization**
  - A polarizer works by absorbing some energy from a light wave. When unpolarized light passes through, half of the intensity is absorbed.
    $$I = \tfrac{1}{2}I_0$$
  - A polarizer also works by zeroing out a component of the electric field of the light wave (hence the cos(θ)). 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 34-35 - 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: $c = 3 \times 10^8 \mathrm{m/s}$
  - Speed of Light in a Medium is a little slower: $v = c/n$
  - Air is almost the same as a vacuum: $n_{\mathrm{air}} \approx 1.0003$
  - (Sec 35.4) Reflection: $\theta_1' = \theta_1$
  - (Sec 35.5) Refraction: $n_1 \sin\theta_1 = n_2 \sin\theta_2$
  - Total Internal Reflection: When refraction tries to make $\sin\theta_2 > 0$, which is impossible. Therefore there is no refraction, only reflection.
- **Chap 36 - Images**
  - 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.
      $$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$
    - 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.
- Flat (plane) mirror: $f = \infty$ so $d_i = -d_o$.
- 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.
- 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 36 - Optics Instruments

- (Sec 36.7) 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 36.8) 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.

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

  - 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 36.9) 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 36.10) 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 37 - Interference**
    - Measuring Angles:

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

    - Diffraction Grating: Spots produced

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

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

    - Two-slit Interference: Bright fringes produced

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

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

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