# November 24th

Review for midterm 3

# Schedule for rest of term

- Nov. 25 (Tues) - no class - Midterm-3 at 6pm
- Nov. 26 (Wed) – 8am midterm-3 make-ups
- Nov. 26 (Wed) – class – finish Chpt. 36
- Dec. 1-2 (Mon-Tues) – cover Chpt. 37
- Dec. 3-5 (Wed-Fri) – Review for final
- Dec. 3 (Wed) – HW set #12 due
- Dec. 8 (Mon) – Corrections #3 due
- Dec. 8 (Mon) – 5:45-7:45 pm Final Exam
  - N130 BCC (Business College) for section 1
  - 158 NR (Natural Resources) for section 2

# Midterm-3

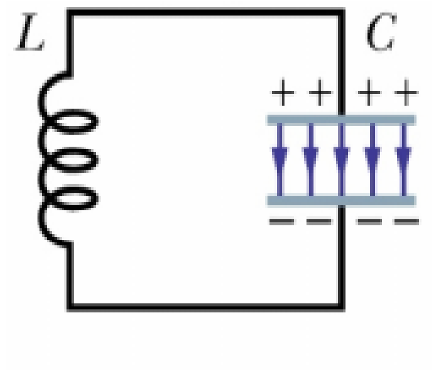
- Tuesday November 25 at 6pm
  - Section 1 – N100 BCC (Business College)
  - Section 2 – 158 NR (Natural Resources)
- Allowed one sheet of notes (both sides) and calculator
- Covers Chapters 32-35 (HW sets 9,10, and 11)
- Need photo ID
- Send me an email if you have another class on Tuesday night - tell me which class it is - makeup will be on Wednesday morning.
- Use the help-room to prepare

# Elements of RLC circuits

| | Resistor | Inductor | Capacitor |
|---|---|---|---|
| Energy stored | $U = 0$ | $U_B = \frac{1}{2} L i^2$ | $U_E = \frac{1}{2}\frac{q^2}{C}$ |
| Voltage change | $V = iR$ | $V = -L\frac{di}{dt}$ | $V = \frac{q}{C}$ |
| Power lost | $P = i^2 R$ | $P = 0$ | $P = 0$ |

# LC Circuits

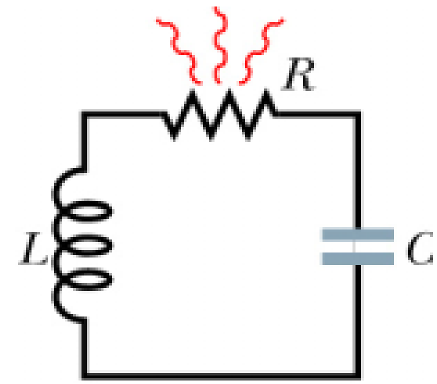
- Charge $$q = Q\cos(\omega t)$$
- Current $$i = \frac{dq}{dt} = -Q\omega\, sin(\omega t)$$
- Angular frequency $$\omega = \sqrt{\frac{1}{LC}}$$
- No power loss



# RLC circuits

- Charge on capacitor

$$q = Qe^{-Rt/2L}\cos(\omega' t)$$




- Angular frequency

$$\omega' = \sqrt{\omega^2 - (R/2L)^2}$$

- Natural frequency $\omega = \sqrt{\dfrac{1}{LC}}$

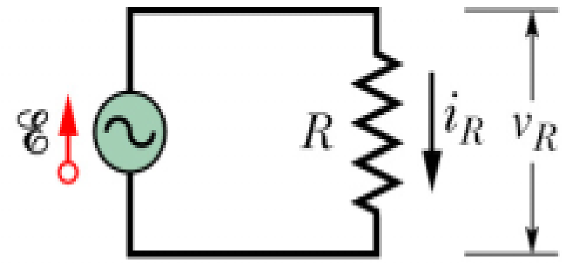
# AC circuits

$$\mathcal{E} = \mathcal{E}_m \sin\omega_d t, \quad \omega_d = \text{driving frequency}$$

$$V_x = \mathcal{E}_m, \quad x = R, C, L$$

Resistive load

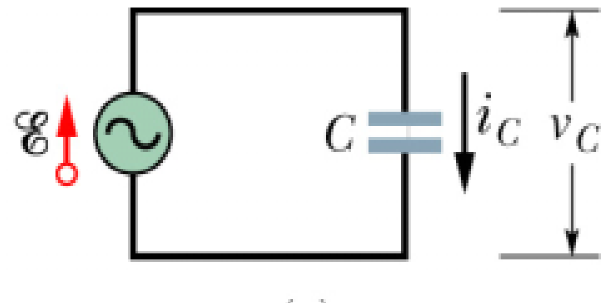
$$I_R = \frac{V_R}{R}$$




Capacitive load

$$I_C = \frac{V_C}{X_C}$$

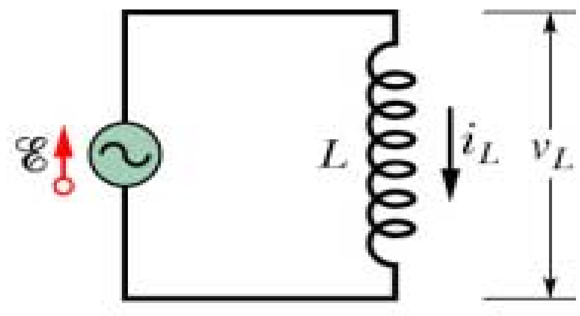
$$X_C = \frac{1}{\omega_d C}$$




Inductive load

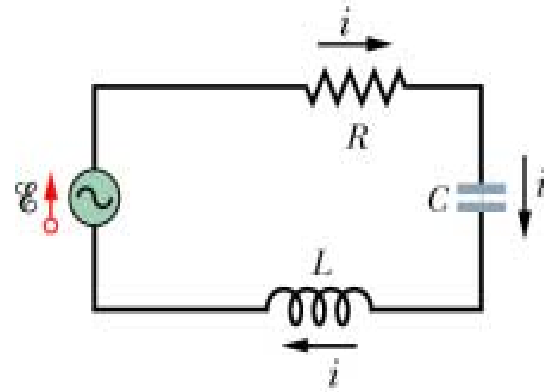
$$I_L = \frac{V_L}{X_L}$$

$$X_L = \omega_d L$$




$X$ is the reactance

# AC circuits



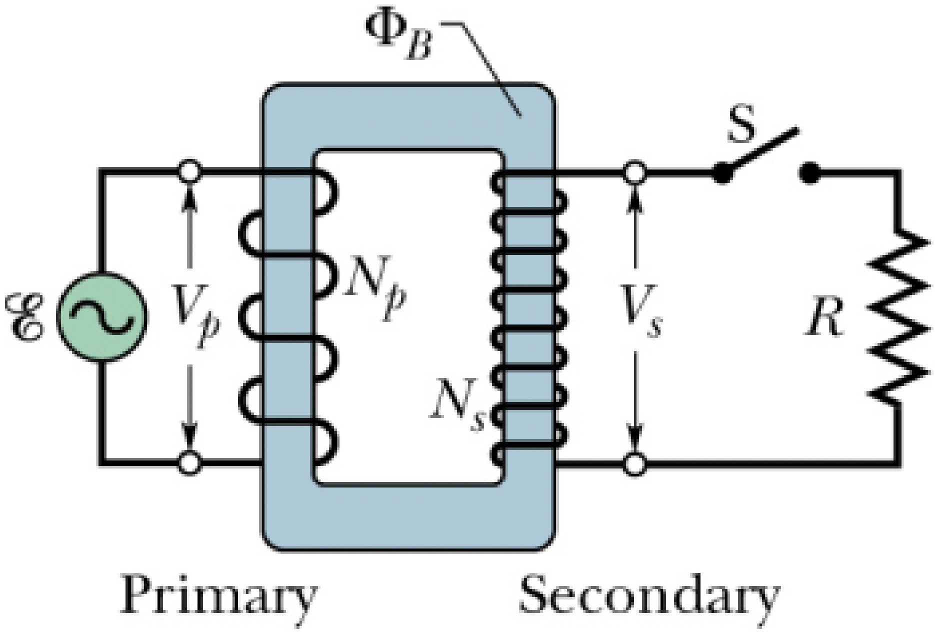

- Current (same everywhere) $i = I\sin(\omega_d t - \phi)$
- Solution $I = \frac{\mathcal{E}_m}{Z}$ $\tan\phi = \frac{X_L - X_C}{R}$ $\frac{X_L}{X_C} = \frac{(\omega_d)^2}{\omega^2}$
- Z is the impedance $Z = \sqrt{R^2 + (X_L - X_C)^2}$
- I is maximum on resonance where

$$X_L = X_C \qquad Z = R \qquad \omega_d = \omega$$

# Transformer

$$I_S = I_P \frac{N_P}{N_S}$$

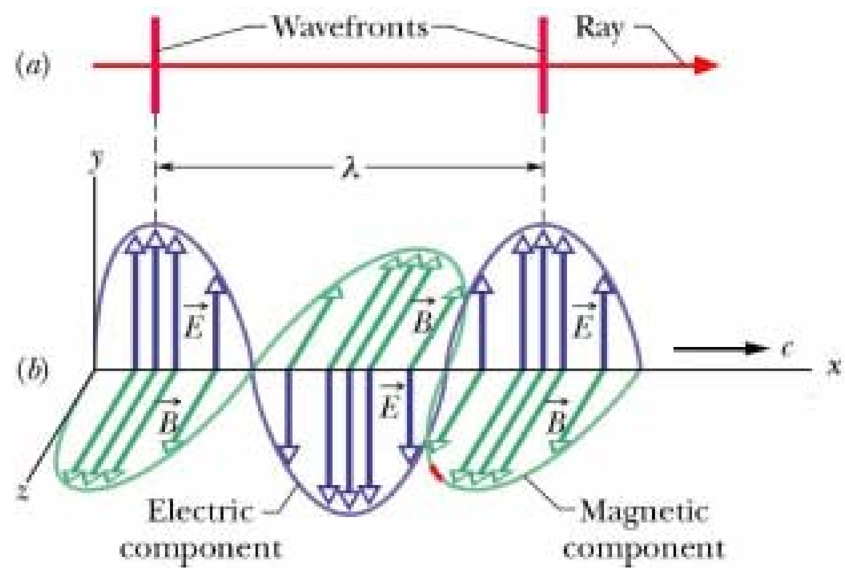
$$V_S = V_P \frac{N_S}{N_P}$$



# EM Waves

$$E = E_m \sin(kx - \omega t)$$

$$B = B_m \sin(kx - \omega t)$$




$$c = \frac{E}{B} = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3\times 10^8 \text{ m/s}$$

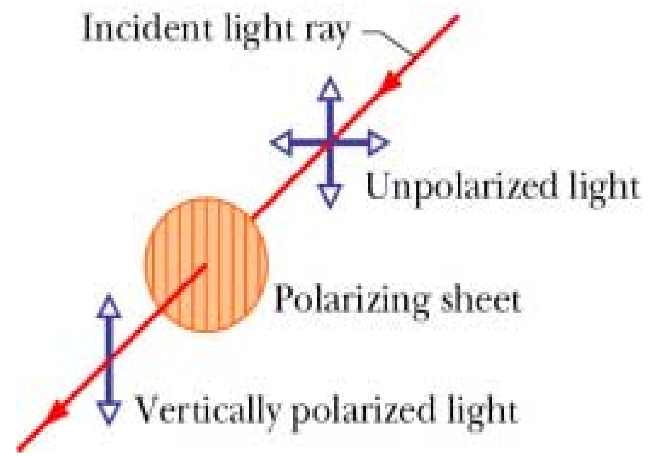
Direction and power per unit area $$\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$$

Intensity $$I = \frac{1}{\mu_0 c} E_{rms}^2$$

Pressure $$p_r = \frac{I}{c}$$ absorption $$p_r = \frac{2I}{c}$$ reflection

# Polarization

- Polarization is the direction of the *E* field




- Intensity of unpolarized light with intensity $I_0$ after hitting a polarizing sheet

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

- Intensity of polarized light with intensity $I_0$ after hitting a polarizing sheet

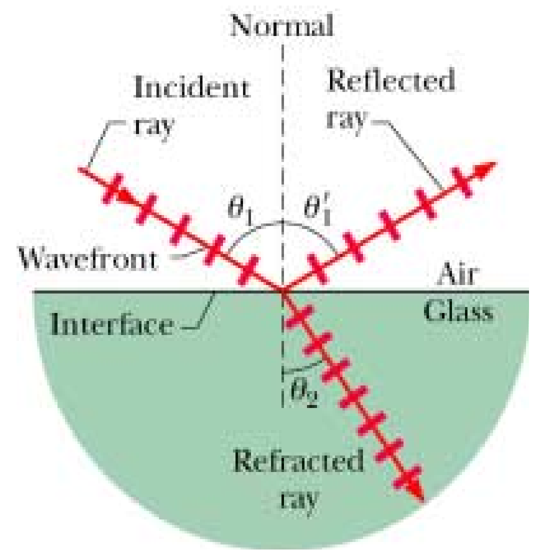
$$I = I_0 \cos^2 \theta$$

# Reflection & Refraction (Fig. 34-17)

- Reflection: $\theta_1' = \theta_1$

- Refraction (Snell's law)

$$n_2 \sin\theta_2 = n_1 \sin\theta_1$$




- Index of refraction

$$n = \frac{\text{speed in vacuum}}{\text{speed in medium}} = \frac{c}{v}$$

$$\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$$

Frequency does not change with n

$$f = \lambda / v$$

- Critical angle (no refracted wave)

$$\theta_C = \sin^{-1}\frac{n_2}{n_1}$$

# Mirrors

- Plane – flat mirror
- Concave – caved in towards object
- Convex – flexed out away from object

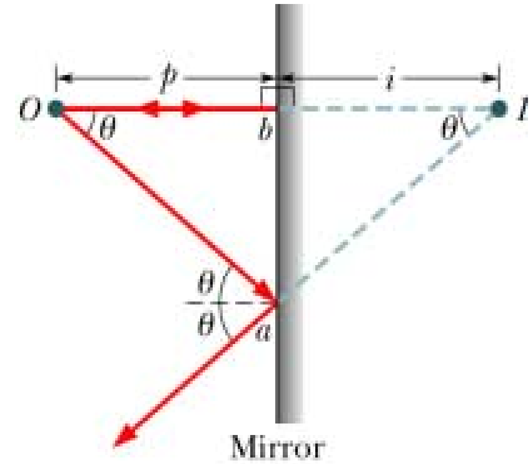
$$\frac{1}{p}+\frac{1}{i}=\frac{1}{f}$$

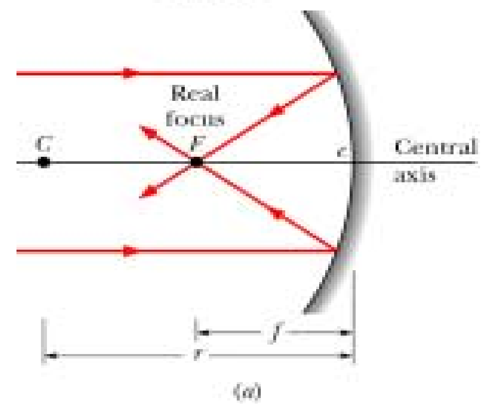
$$f=\tfrac{1}{2}r$$

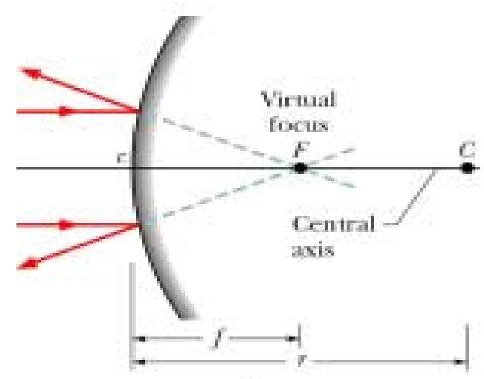
  - r = radius of curvature
  - f = focal length, f>0 concave, f<0 convex
  - p = position of object
  - i = position of image
- real images on side where object is
- virtual images on opposite side
- lateral magnification:

$$|m|=\frac{h'}{h}$$

$$m=-\frac{i}{p}$$



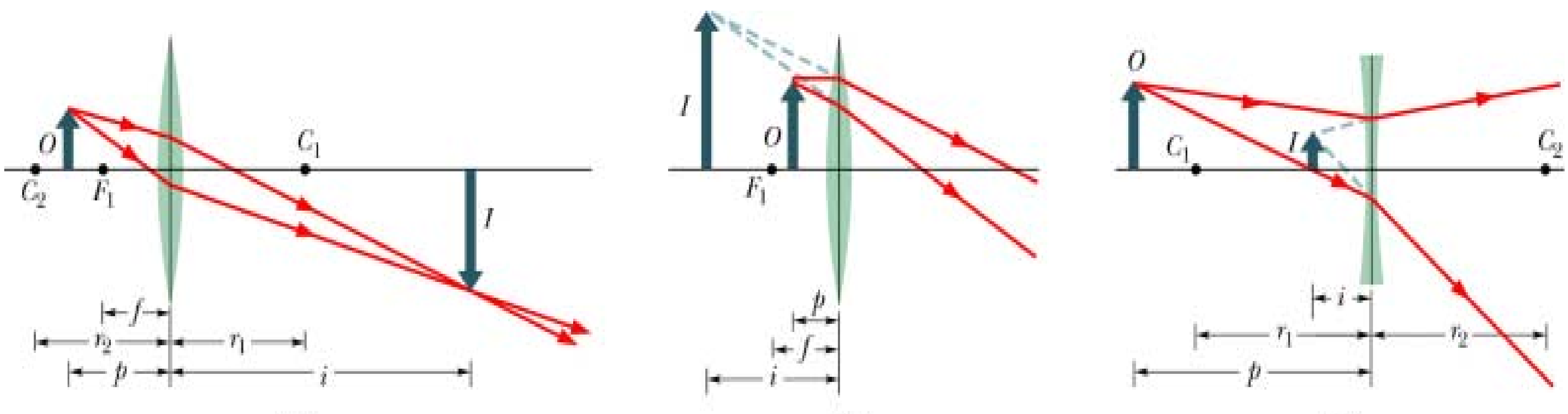



# Thin lenses

- Real images: opposite side - virtual images: same side
- Diverging lens (f<0): smaller, same orientation, virtual images
- Converging lens (f>0): both real and virtual images
- Image position and magnification: $\frac{1}{p}+\frac{1}{i}=\frac{1}{f}$ $\quad m=-\frac{i}{p}$
- Lens maker's equation:

$$\frac{1}{f}=(n-1)\left(\frac{1}{r_1}-\frac{1}{r_2}\right)$$



# Mirrors

| Mirror Type | Object Location | Image Location | Image Size | Image Type | Image Orient-ation | Sign of *f* | Sign of *i* | Sign of *m* |
|---|---|---|---|---|---|---|---|---|
| Plane | Anywhere | i = - p | Equal | Virtual | Same | ∞ | - | +1 |
| Concave | p < f | Anywhere | Bigger | Virtual | Same | + | - | + |
| Concave | f < p < 2f | i > 2f | Bigger | Real | Invert | + | + | - |
| Concave | p = 2f | i = 2f | Equal | Real | Invert | + | + | - |
| Concave | p > 2f | 2f > i > f | Smaller | Real | Invert | + | + | - |
| Convex | Anywhere | \|i\| < \|f\| | Smaller | Virtual | Same | - | - | + |

# Thin lenses

## Converging lens = concave mirror

## Diverging lens = convex mirror

| Thin Lens Type | Object Location | Image Location | Image Size | Image Type | Image Orient-ation | Sign of $f$ | Sign of $i$ | Sign of $m$ |
|---|---|---|---|---|---|---|---|---|
| Converging | $p < f$ | Anywhere | Bigger | Virtual | Same | + | - | + |
| Converging | $f < p < 2f$ | $i > 2f$ | Bigger | Real | Invert | + | + | - |
| Converging | $p = 2f$ | $i = 2f$ | Equal | Real | Invert | + | + | - |
| Converging | $p > 2f$ | $2f > i > f$ | Smaller | Real | Invert | + | + | - |
| Diverging | Anywhere | $\|i\| < \|f\|$ | Smaller | Virtual | Same | - | - | + |