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

<table>
<thead>
<tr>
<th>Element</th>
<th>Resistor</th>
<th>Inductor</th>
<th>Capacitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy stored</td>
<td>( U = 0 )</td>
<td>( U_B = \frac{1}{2} Li^2 )</td>
<td>( U_E = \frac{1}{2} \frac{q^2}{C} )</td>
</tr>
<tr>
<td>Voltage change</td>
<td>( V = iR )</td>
<td>( V = -L \frac{di}{dt} )</td>
<td>( V = \frac{q}{C} )</td>
</tr>
<tr>
<td>Power lost</td>
<td>( P = i^2 R )</td>
<td>( P = 0 )</td>
<td>( P = 0 )</td>
</tr>
</tbody>
</table>
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
  \[ q = Qe^{-\frac{Rt}{2L}} \cos(\omega' t) \]

- Angular frequency
  \[ \omega' = \sqrt{\omega^2 - \left(\frac{R}{2L}\right)^2} \]

- Natural frequency
  \[ \omega = \sqrt{\frac{1}{LC}} \]
AC circuits

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

\[ I_L = \frac{V_L}{X_L} \]

\[ X_L = \omega_d L \]

\( \omega_d \) is the driving frequency

\[ E = E_m \sin \omega_d t \]
AC circuits

- Current (same everywhere)
  - \( i = I \sin(\omega_d t - \phi) \)

- Solution
  - \( I = \frac{E_m}{Z} \)
  - \( \tan \phi = \frac{X_L - X_C}{R} \)
  - \( \frac{X_L}{X_C} = \frac{(\omega_d)^2}{\omega^2} \)

- \( Z \) is the impedance
  - \( Z = \sqrt{R^2 + (X_L - X_C)^2} \)

- \( I \) is maximum on resonance where
  - \( X_L = X_C \)
  - \( Z = R \)
  - \( \omega_d = \omega \)
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

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

Pressure
\[ p_r = \frac{I}{c} \]

absorption 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**
  \[ n = \frac{\text{speed in vacuum}}{\text{speed in medium}} = \frac{c}{v} \]
  \[ \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1} \]

- **Critical angle (no refracted wave)**
  \[ \theta_c = \sin^{-1} \frac{n_2}{n_1} \]

Frequency does not change with \( n \)

\( f = \frac{\lambda}{v} \)
Mirrors

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

\[ \frac{1}{p} + \frac{1}{i} = \frac{1}{f} \]

- \( r \) = 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:
  \[
  \frac{1}{p} + \frac{1}{i} = \frac{1}{f}
  \]
  \[
  m = -\frac{i}{p}
  \]
- Lens maker’s equation:
  \[
  \frac{1}{f} = (n-1) \left( \frac{1}{r_1} - \frac{1}{r_2} \right)
  \]
## Mirrors

<table>
<thead>
<tr>
<th>Mirror Type</th>
<th>Object Location</th>
<th>Image Location</th>
<th>Image Size</th>
<th>Image Type</th>
<th>Image Orientation</th>
<th>Sign of $f$</th>
<th>Sign of $i$</th>
<th>Sign of $m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plane</td>
<td>Anywhere</td>
<td>$i = -p$</td>
<td>Equal</td>
<td>Virtual</td>
<td>Same</td>
<td>$\infty$</td>
<td>-</td>
<td>$+1$</td>
</tr>
<tr>
<td>Concave</td>
<td>$p &lt; f$</td>
<td>Anywhere</td>
<td>Bigger</td>
<td>Virtual</td>
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<td>-</td>
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**Thin lenses**

Converging lens = concave mirror

Diverging lens = convex mirror

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