1. Relationship between energy and momentum for light.

2. Radiative pressure. Reflective case and the absorptive case.

3. Polarization of EM waves.
   - Parallel metal strips. Define the transmission axis.
   - The ratio between the transmitted intensity and the initial intensity.
   - The metal strip analyzer and the un-polarized light

4. The magnetic force due to an em waves exerts on q which is initially at rest.

5. Why the sky is blue and the light is polarized?
   - The setup.
   - Comparison of the intensities of the rescattered light at two wavelength.

Announcement:

1. The updated course summary of unit 4 has been posted with the date 4/21/13.
   - Since the posted LM covered Malus law, Malus law has been added in the summary.
   - The homework set: Ch24.h5 has been deleted from unit 4 in our updated lesson plan. The course-material on lens has also been removed from the summary.

2. My plan is to cover Sec 24.7 and 24.8 this Friday. Sec 25.1 on Monday. The content of the materials are straightforward please read ahead and do your homework problem.

3. I plan to post review unit4 problems before noon, next Monday
1. Relativistic kinematics: Relationship between energy, mass, and velocity for light.

For a particle with mass \( m \),

\[
E = mc^2, \quad \beta = \frac{v}{c}, \quad \gamma = \frac{1}{\sqrt{1 - \beta^2}}.
\]

**Momentum** \( mv \gamma \)

\[
\frac{E}{m} = \frac{\gamma c^2}{c}
\]

Photon - light particle has negligible mass, \( m = 0 \)

\[
\frac{U}{P} = \frac{\gamma^2 c^2}{c} = c, \quad \gamma = \frac{U}{c^2}.
\]

2. Radiative pressure. Pressure = \( \frac{F}{A} \)

\[
F = \frac{\Delta P}{\Delta t}
\]

Impact on the medium:

**Reflective case:** \( \Delta P = 2P = 2 \frac{U}{c} \)

**Absorptive case:** \( \Delta P = P = \frac{U}{c} \)

Pressure = \( \frac{\Delta P}{\Delta t} = \begin{cases} \text{refl.} \quad \frac{2U/c}{A \Delta t} = \frac{2U}{A \Delta t} = 2U \\ \text{abs.} \quad U \end{cases} \)
Polarization: Direction along oscillation of $\mathbf{E}$

- Parallel metal strips

\[
\begin{align*}
\mathbf{E}_\text{II} & \quad \text{Incident polarization is along} \\
\mathbf{E}_\text{I} & \quad \text{the arrow. Decompose it into} \\
\mathbf{E}_\text{I}' & \quad \text{l and II components.}
\end{align*}
\]

II component: Large induced current within the strip. Large energy lost. Transmission Choppier

I component: Negligible induced current. Negligible energy lost. Allow transmission

I direction here defines transmission axis.

- Intensity ratio:

\[
\frac{I_{\text{out}}}{I_{\text{in}}} = \left( \frac{E_\text{I}}{E_\text{II}} \right)^2 = \cos^2 \theta
\]

where $\theta$ is the angle between incident polarization + transmission axis.
Metal strip analyzer:

- Rotating the sheet can check polarization of the incident light.
- Unpolarized incident light, if no variation in intensity.
- Unpolarized light may be represented by:
  
  Two equal weight mutually perpendicular polarized lights.

- Two mutually perpendicular analyzers can fully block out an unpolarized light.

4. Rotation from a charged particle initially at rest:

\[ \vec{\vec{F}} = \langle \vec{q} \times \overrightarrow{E} \rangle = \langle \vec{q} \times \overrightarrow{B} \rangle \]

\[ F = q \vec{v} \times \overrightarrow{B} \]

\[ F > 0 \quad \rightarrow \quad \text{motion in the direction of the vector} \]

\[ \langle \vec{F} \rangle = \langle \vec{q} \times \overrightarrow{B} \rangle = \langle \overrightarrow{\vec{v}} \times \overrightarrow{B} \rangle = \langle \overrightarrow{E} \times \overrightarrow{B} \rangle \]

Dir of magnetic force on q initially at rest

\[ q > 0 \quad \| \quad q < 0 \]

\[ 1) \quad \text{Left} \quad | \quad \text{Left} \quad \| \quad \vec{F} = q \vec{v} \times \overrightarrow{B} \]

\[ 2) \quad \text{Right} \quad | \quad \text{Left} \quad \| \quad \langle \overrightarrow{\vec{v}} \rangle = \langle q \overrightarrow{E} \rangle \]

4) Right \quad \checkmark \quad \text{Notice:} \quad \langle \vec{F} \rangle = q^2 \langle E \times B \rangle !
5. The polarized sky light.

![Diagram of light path through air molecules]

**Unpolarized**

**Slight**: Unpolarized light.

Recoil light viewed by ground observer is polarized along $z$.

**Intensity of scattered light**:

- $I = cU = c(u + u_B)$
- $c \cdot 2uE = cE^2$, $E \approx \Delta E \approx \Delta \nu$.
- Compare intensity of scattered light with frequency $w_0$ and $w_0'$:

\[
\frac{I_f}{I_0} = \frac{E_f^2}{E_0^2} \left( \frac{\Delta \nu_1}{\Delta \nu_2} \right)^2 \left( \frac{2
\Delta \nu_2}{\Delta \nu_1} \right)^2 \left( \frac{\nu_1}{\nu_2} \right)^4 = \left( \frac{\lambda_2}{\lambda_1} \right)^4
\]

\[
\frac{I_{\text{blue}}}{I_{\text{red}}} = \left( \frac{\lambda_5}{\lambda_1} \right)^4,
\end{align*}

where

\[
\lambda_5 = 780 \text{nm}, \quad \frac{\lambda_5}{\lambda_6} = 400 \text{nm} = 1.75, \quad \frac{I_{\text{blue}}}{I_{\text{red}}} = \left( 1.75 \right)^4 
\]