**Reflection:**
0 phase change from high to low index of refraction *n*
π phase change from low to high index of refraction.
Speed of light in a medium of index of refraction *n*

$$v = \frac{c}{n}$$

Interference in thin films:

| | $\pi$ | $0,2\pi$ |
|---|---|---|
| *Destructive* | $2t = m\lambda$ | $2t = (m - \frac{1}{2})\lambda$ |
| *Constructive* | $2t = (m - \frac{1}{2})\lambda$ | $2t = m\lambda$ |

Double Slit

| | |
|---|---|
| $d \sin\theta = m\lambda$ | *constructive* |
| $d \sin\theta = (m - \frac{1}{2})\lambda$ | *destructive* |

Diffraction minima

$$W \sin\theta = m\lambda$$

Diffraction grating

$d \sin\theta = m\lambda$ constructive
$d = 1/N$

Resolution through spherical aperature

$$\theta_{\min} = 1.22\frac{\lambda}{D}$$

Speed of light $c = 3.0\text{x}10^8$ m/s

Relativity

$$\Delta t = \frac{\Delta t_o}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$L = L_o\sqrt{1 - \frac{v^2}{c^2}}$$

$$E = \frac{mc^2}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$E = K + mc^2$$

$$p = \frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Spacetime Interval and GR

$v_{13} = \frac{v_{23} + v_{12}}{1 + \frac{v_{23}v_{12}}{c^2}}$ Relativistic addition of velocities

$\Delta s^2 = -(c\Delta t)^2 + \Delta x^2$ Flat spacetime (invariant)

1. Matter/Energy curves spacetime
2. Objects move through extreme of spacetime (max or min) called a geodesic

$R_s = \frac{2GM}{c^2}$ Schwarzschild Radius

**Constituents of the Universe**

Matter (Atoms)
Dark Matter
Electromagnetic Radiation
Dark Energy (Vacuum energy, Cosmological constant)

**Geometries of the Universe:**
Spherical, Positive curvature
Flat, Zero curvature
Hyperbolic, Negative curvature