1/9/15 Ken Intriligator's Phys 4D Lecture outline

$\star$ Reading: Volume 1, chapters 26 and 27, of Feynman Lectures (see link on class website).

• Last time: Spherical mirror of radius R, with object at distance d_0 from the mirror. Found the location of the image at d_i, from the condition that all rays have the same length:

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{2}{R} \equiv \frac{1}{f}, \qquad m \equiv \frac{h_i}{h_o} = -\frac{d_i}{d_0}.$$

(Used $R - x \approx y^2/2x$ for triangle with $y \ll x$). For concave mirror, $R > 0$; above also applies for convex mirror, with $R < 0$.

• Draw light rays for mirror. Show from the geometry that the magnification is

$$m \equiv \frac{h_i}{h_o} = -\frac{d_i}{d_0}.$$

Flat mirror is limit $f \to \infty$, get $d_i = -d_0$ and $m = 1$.

Concave ($f > 0$) vs convex ($f < 0$) mirrors: in concave case, taking $d_o > 0$, can get either upside-down real image ($d_i > 0$), or rightside-up virtual image ($d_i < 0$) depending on if $d_0 > f$ or $d_0 < f$, respectively: $m = -R/(2d_0 - R)$.

In convex case, get $d_i < 0$ and $|d_i| < d_0$, always get $0 < m < 1$, rightside up, smaller, virtual image.

• Shaving mirror example.

• Index of refraction, $v_{eff} = c/n$, from light bouncing around. Air: $n \approx 1.00029$, water: $n \approx 1.33$, diamond $n \approx 2.42$, some modern condensed matter setups: $n \approx \infty$. Aside: at UCSD in the 1990s, Smith and Schultz fabricated meta-materials with effectively negative n.

• Lights guiding principle (Fermat): it always takes the path of (locally) least time. Explain mirages from this.

• This principle leads to Snell's law of refraction: $n_1 \sin\theta_1 = n_2 \sin\theta_2$. Lifeguard analogy example: path of minimum time determined by $v_{sand}^{-1} \sin\theta_1 = v_{water}^{-1} \sin\theta_2$.