# Optics

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Journal Club

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- Focus
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- Diffraction optical elements
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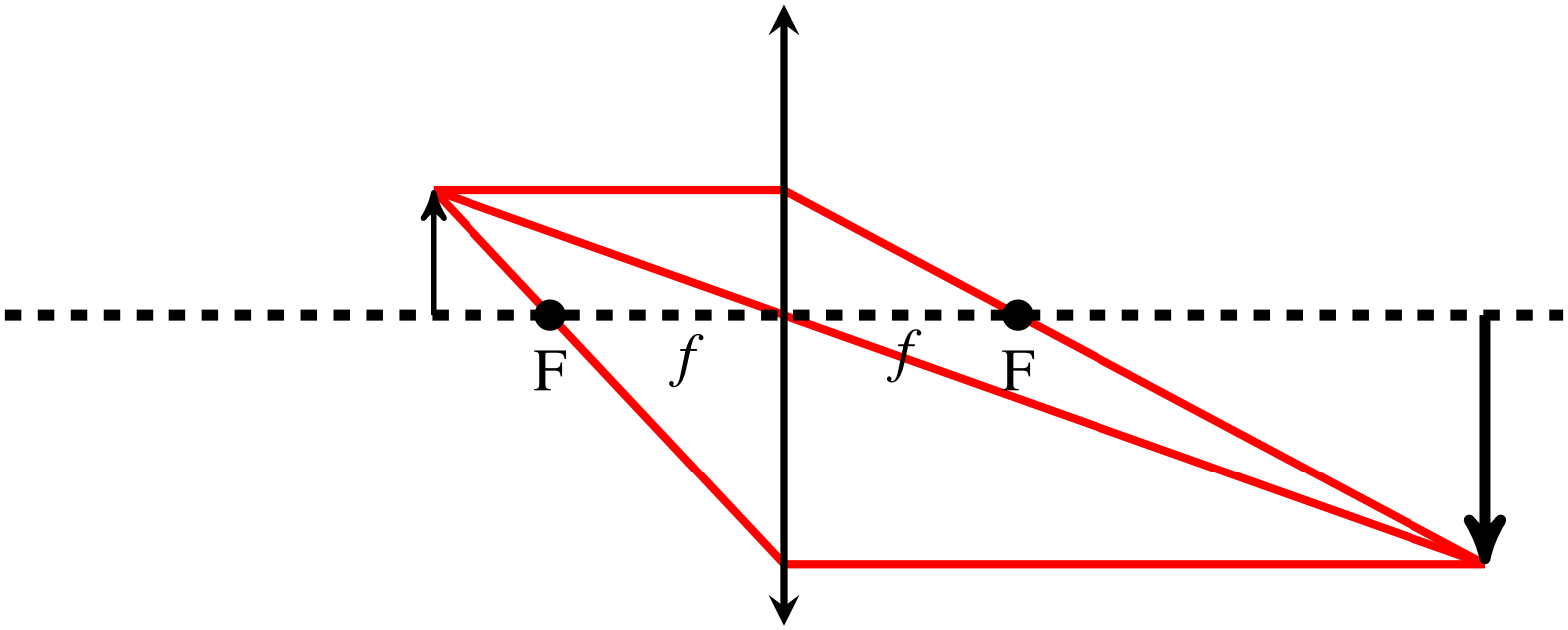
# Ideal Lens



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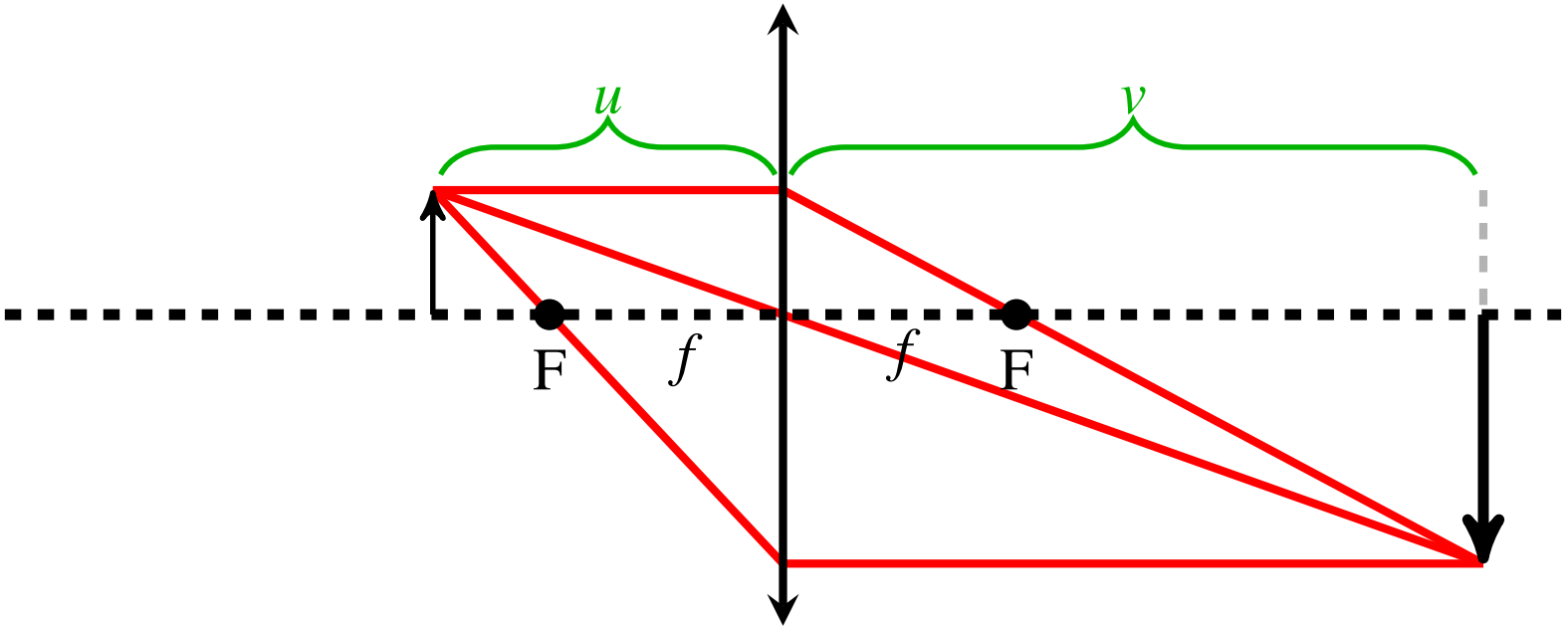


$$\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$$

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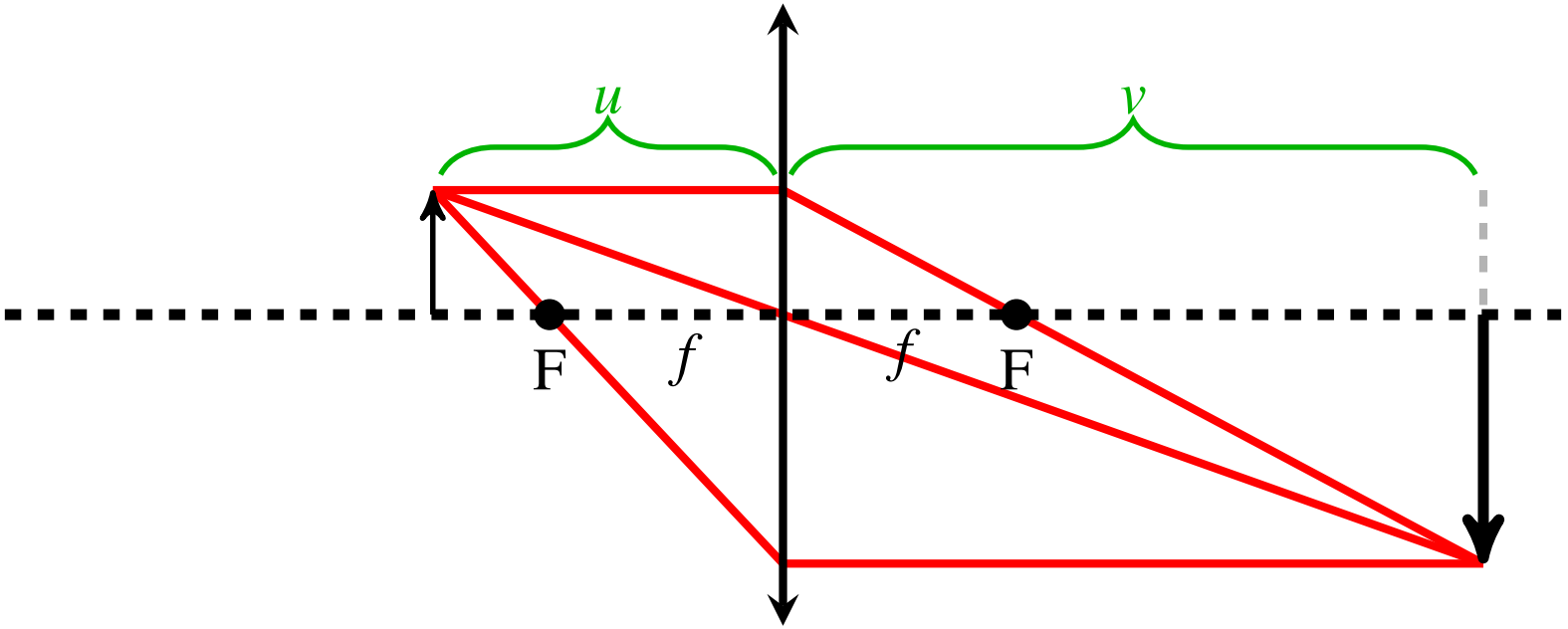


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$$M=\frac{v}{u}$$

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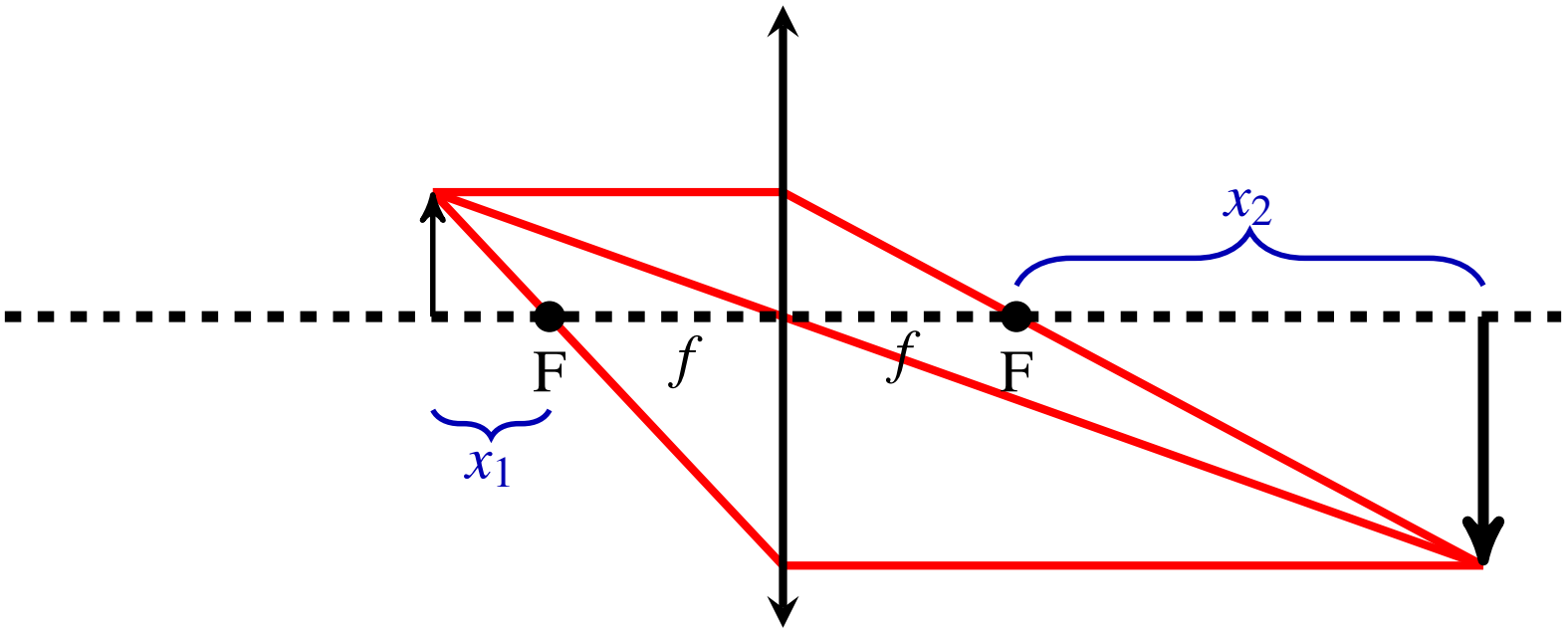


$$x_1 x_2 = f^2$$

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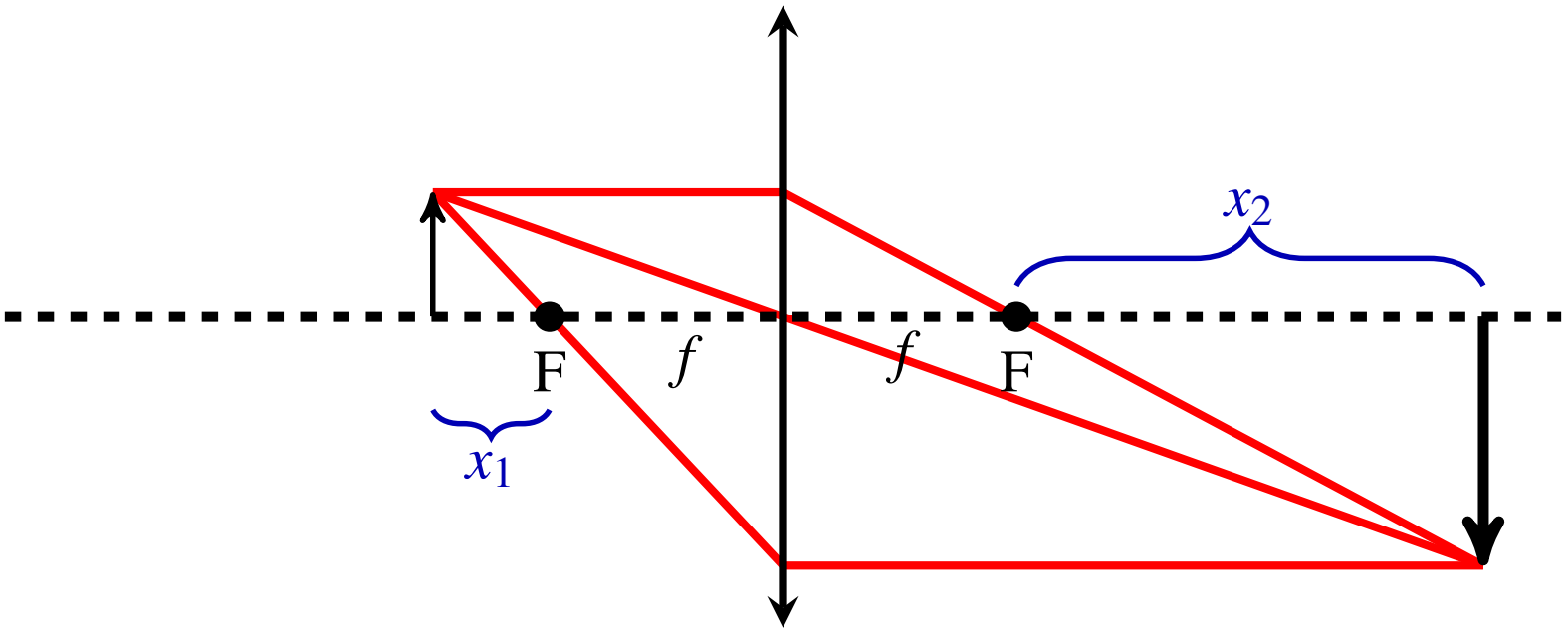


$$x_1 x_2 = f^2$$

$$M = \frac{f}{x_1} = \frac{x_2}{f} = \sqrt{\frac{x_2}{x_1}}$$

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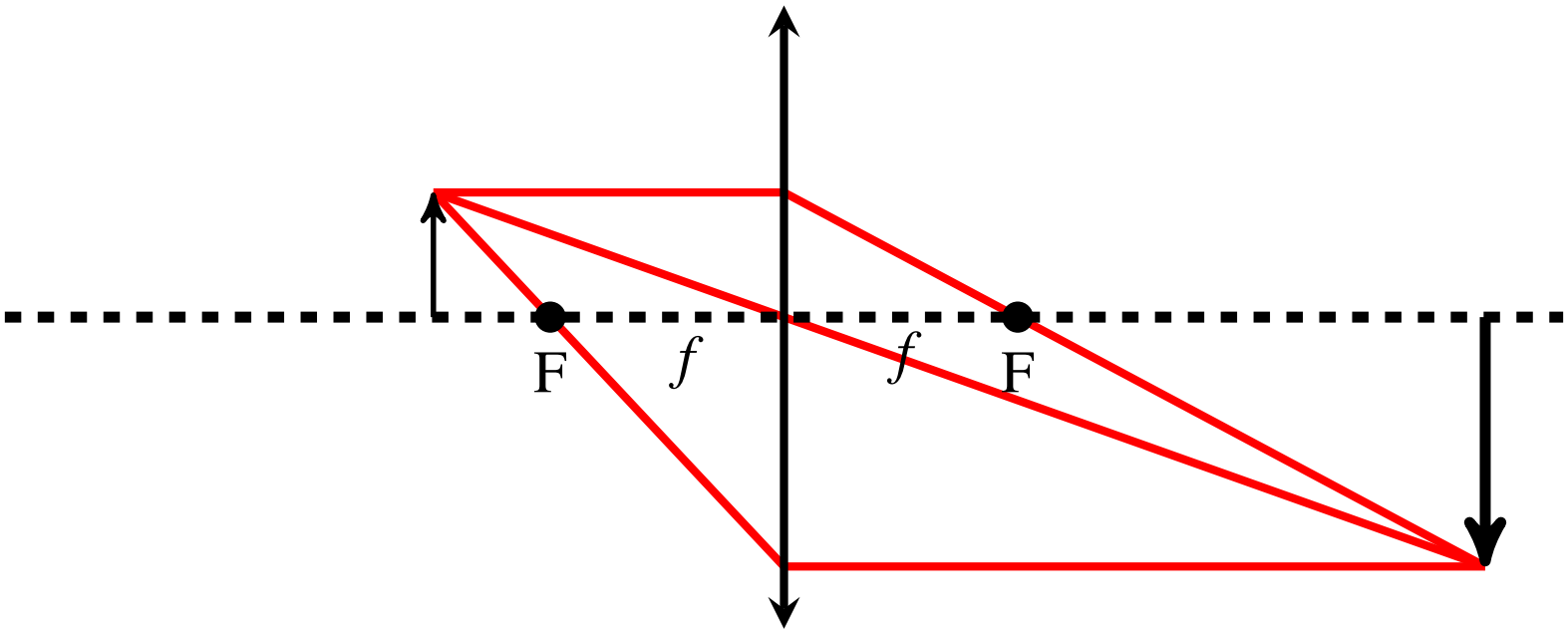


Conjugate plane: Perfect image under ray optics

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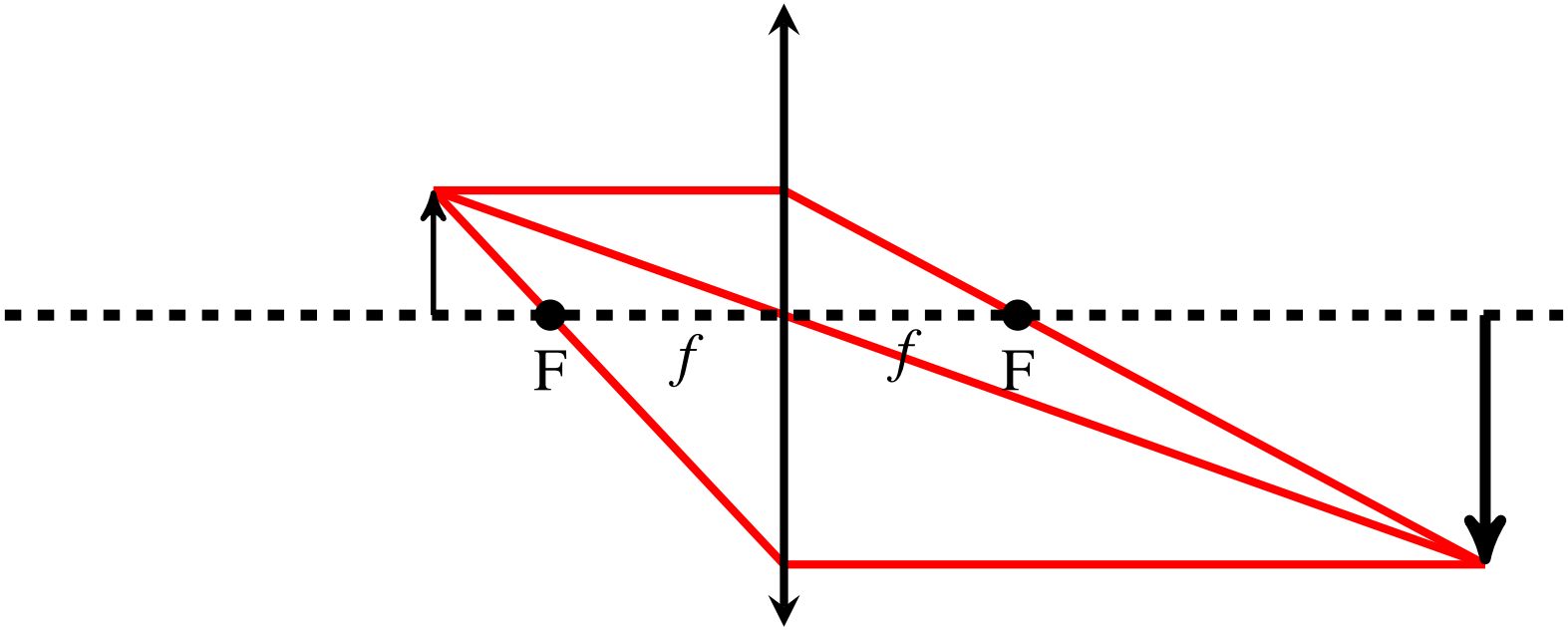


Conjugate plane: Perfect image under ray optics

Principal planes: Conjugate plane where $M = 1$

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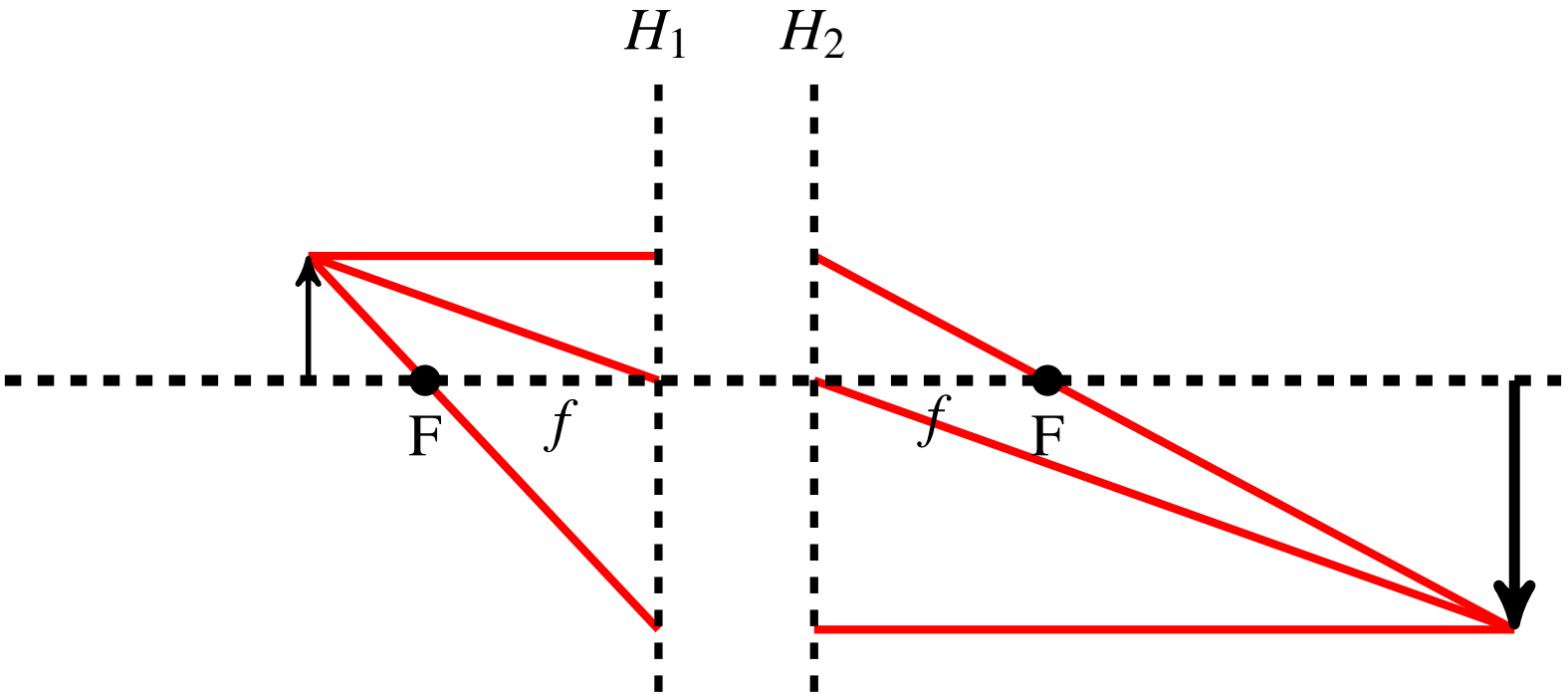
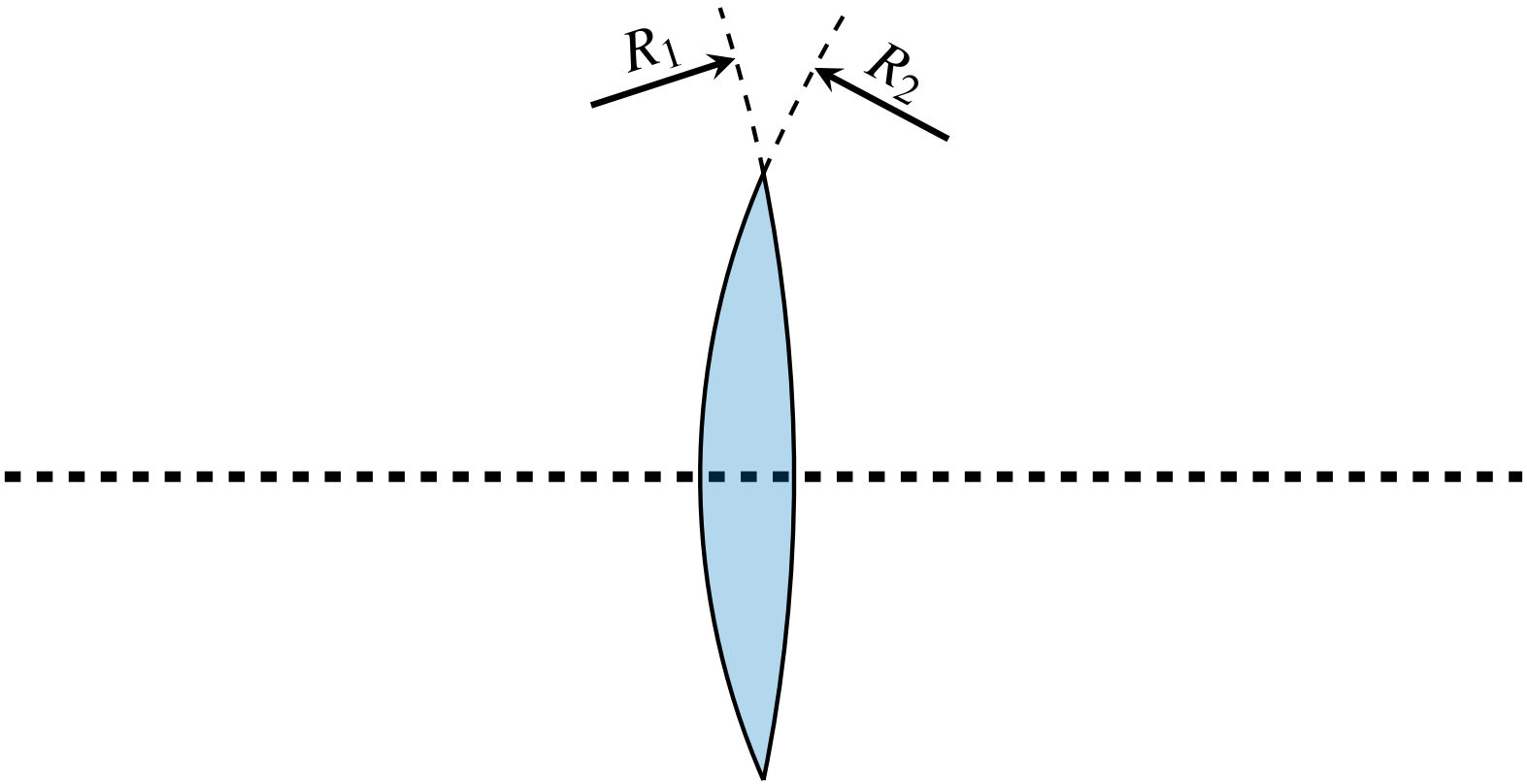


# Spherical lens



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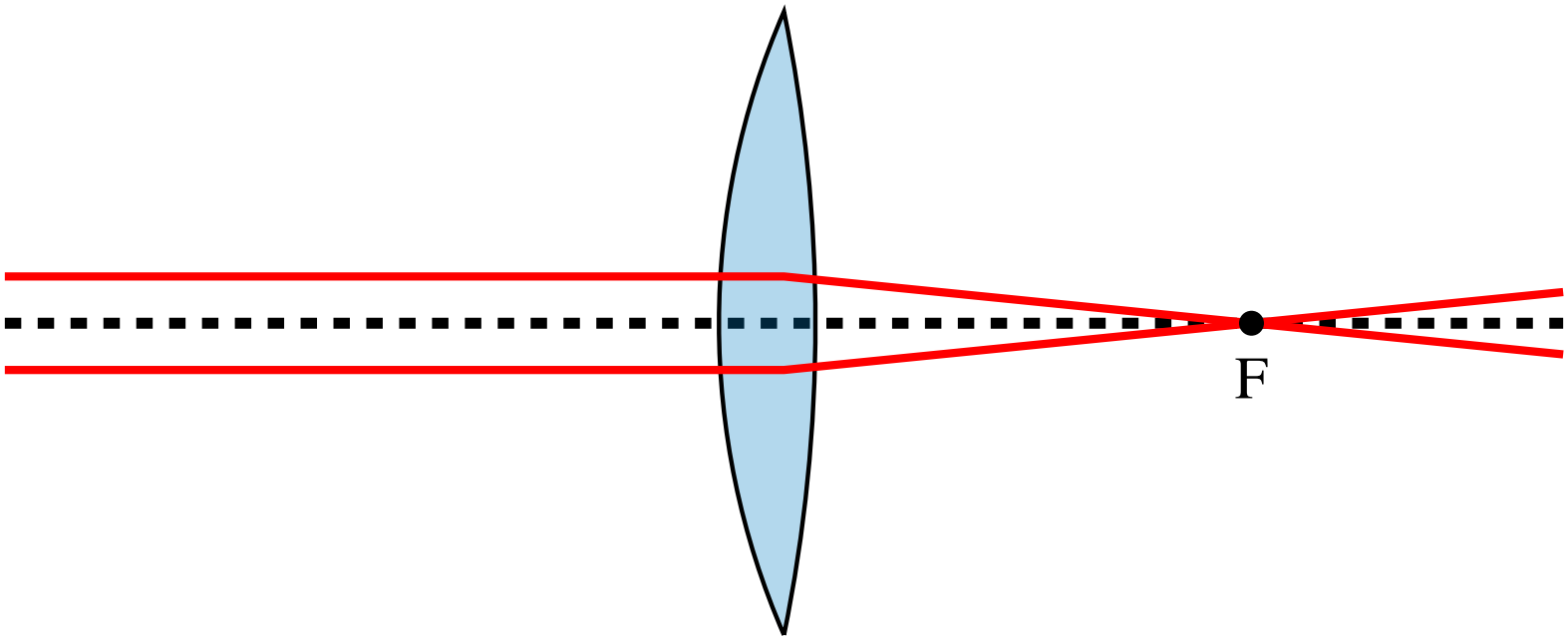

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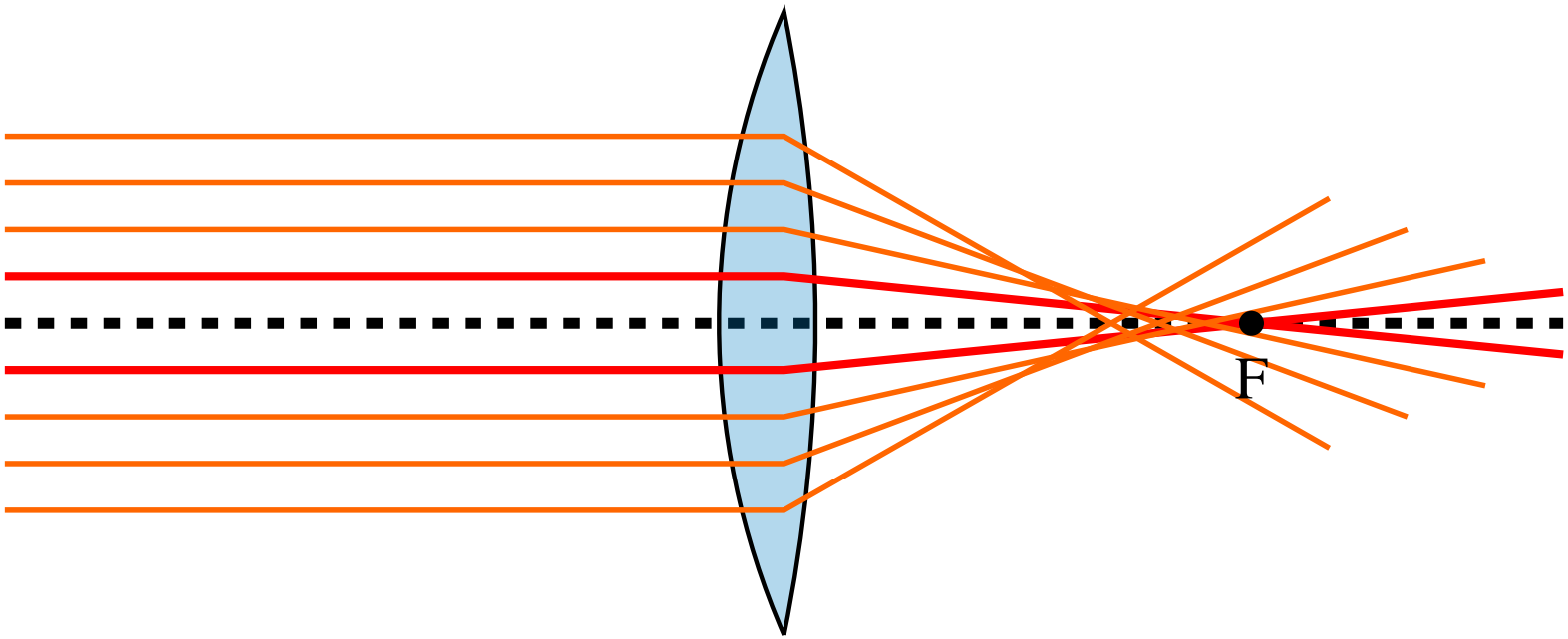

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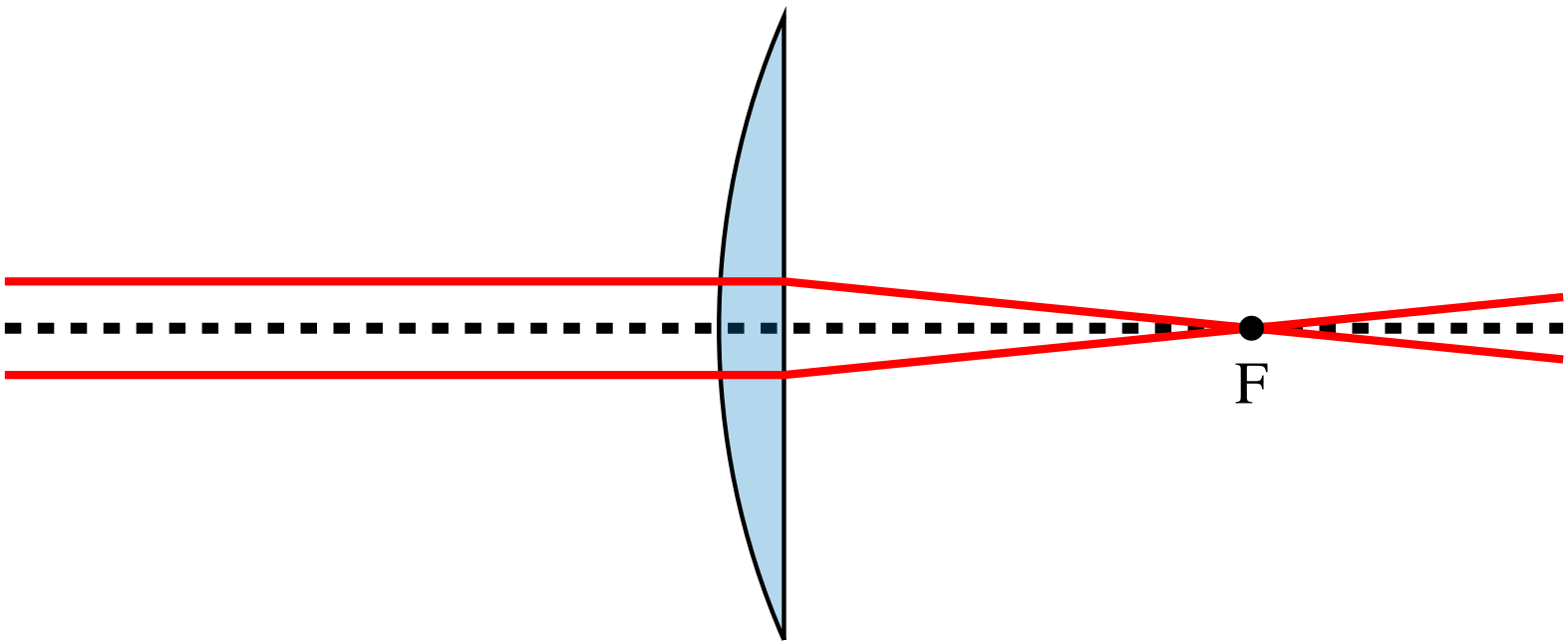

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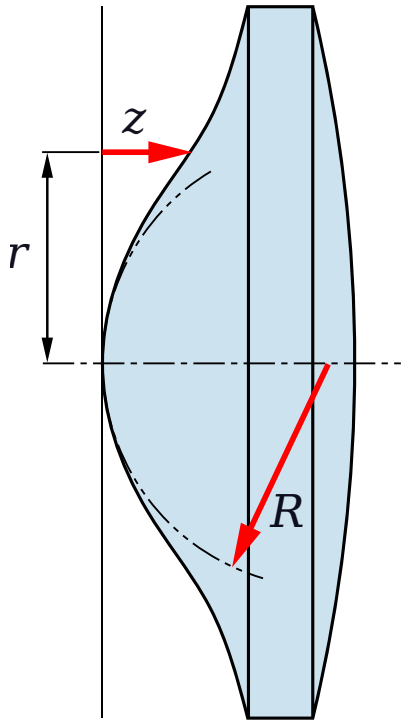

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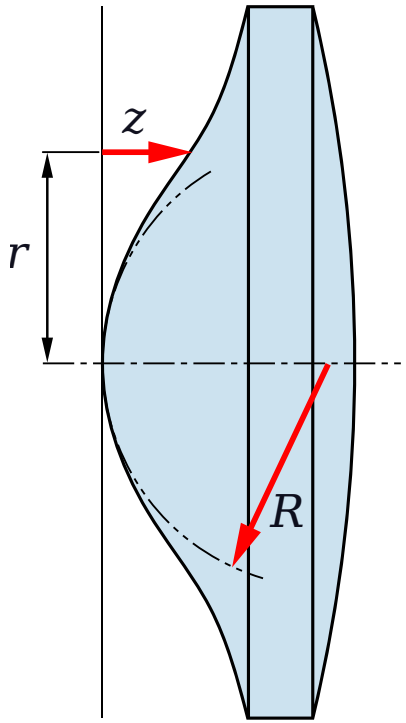


## Use cases

- Collimation
- Fiber coupling

# Other lens types

## Reflective

- No chromatic shift
- Can be aspherical
- More difficult beam path layout

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## Reflective

- No chromatic shift
- Can be aspherical
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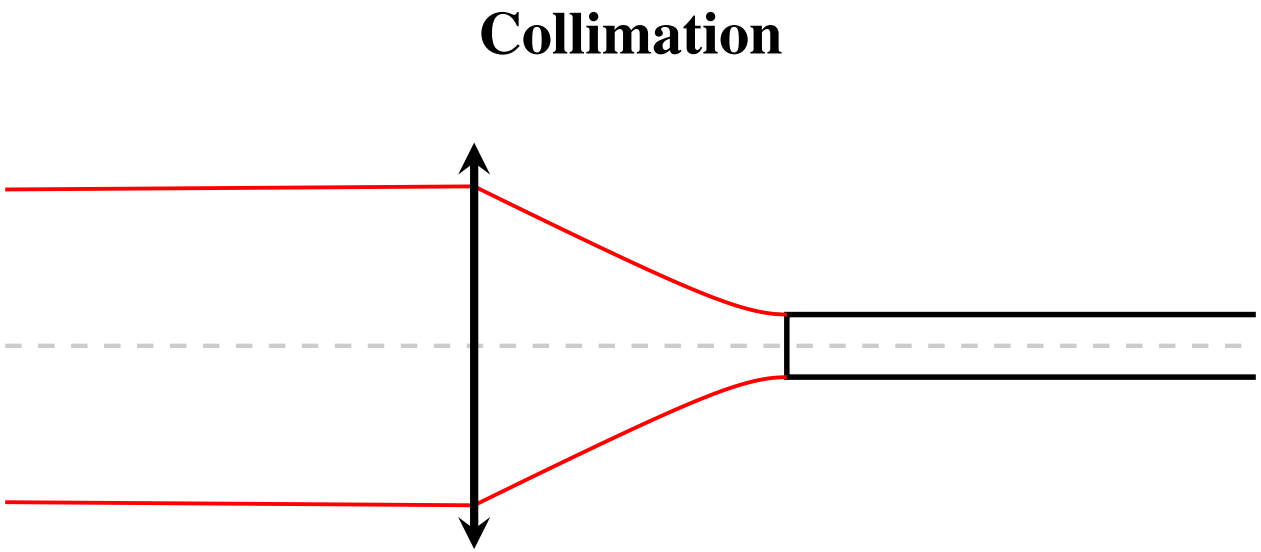
## Lens set

- Could fix chromatic shift
- Could fix monochromatic aberration
- Better surface quality
- May not be UV compatible

# Fiber coupling



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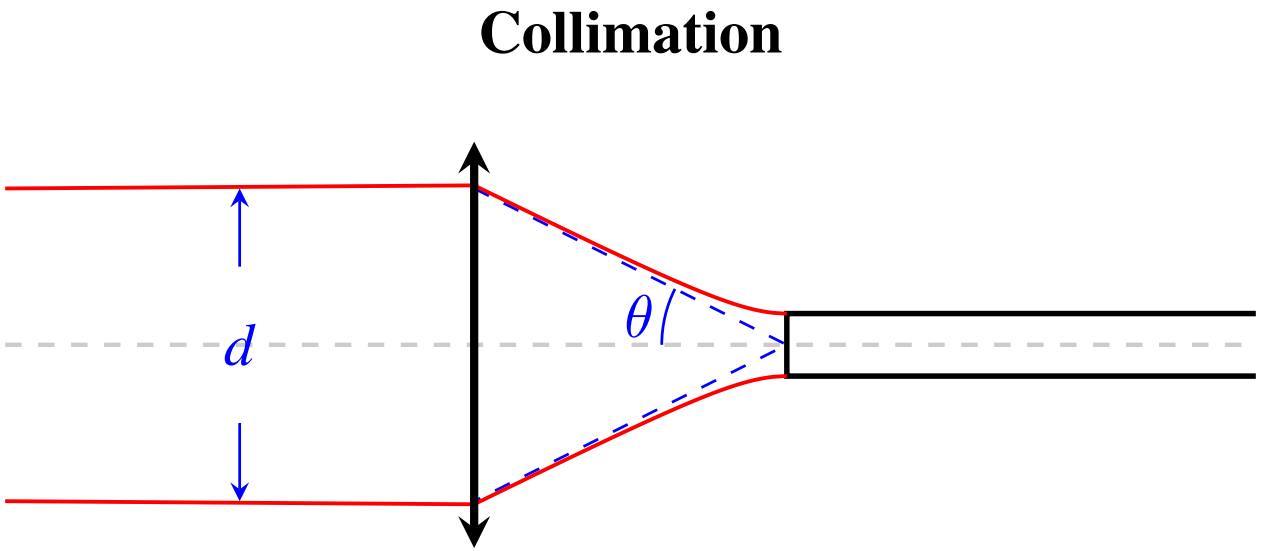

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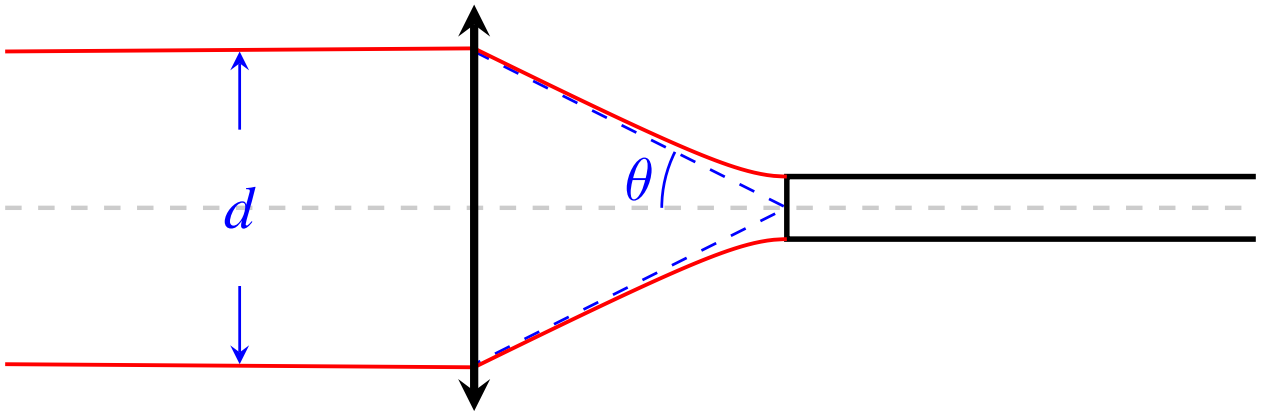


$$d \approx 2f \tan\theta$$

# Alignment

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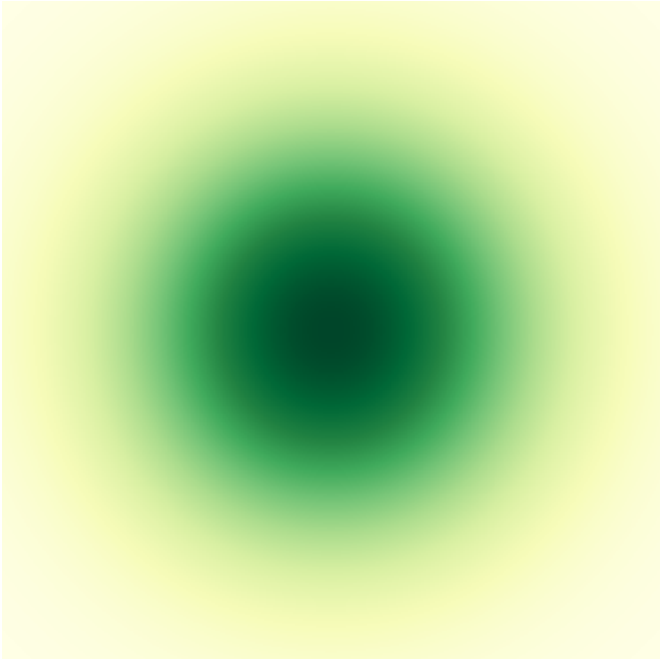

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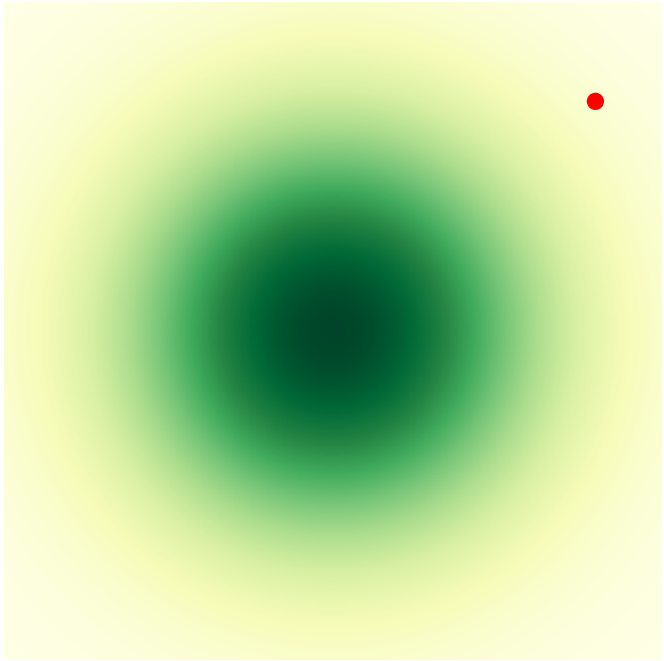

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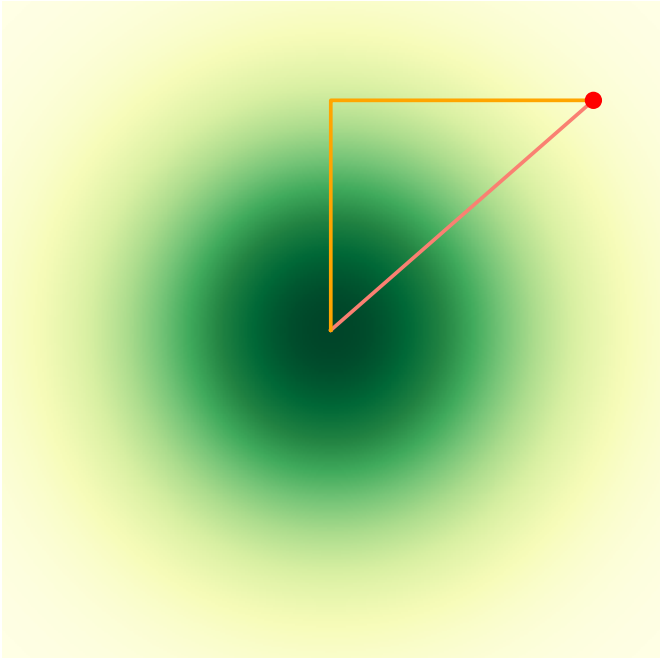

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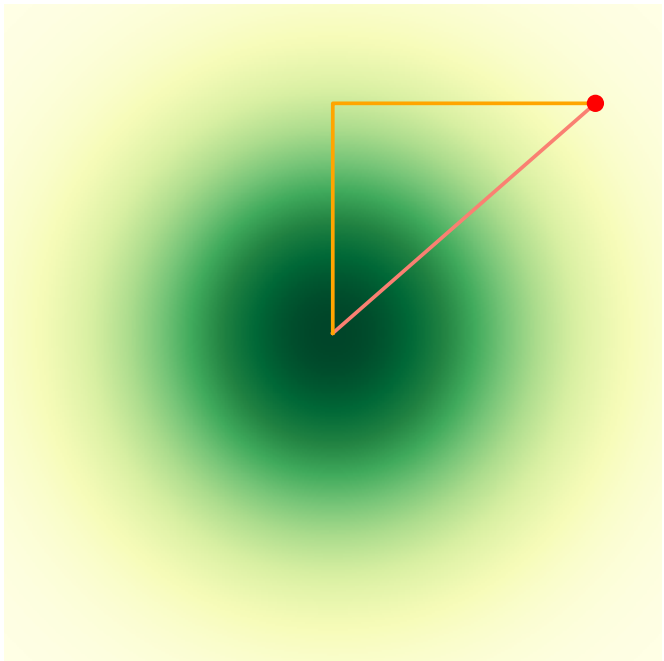

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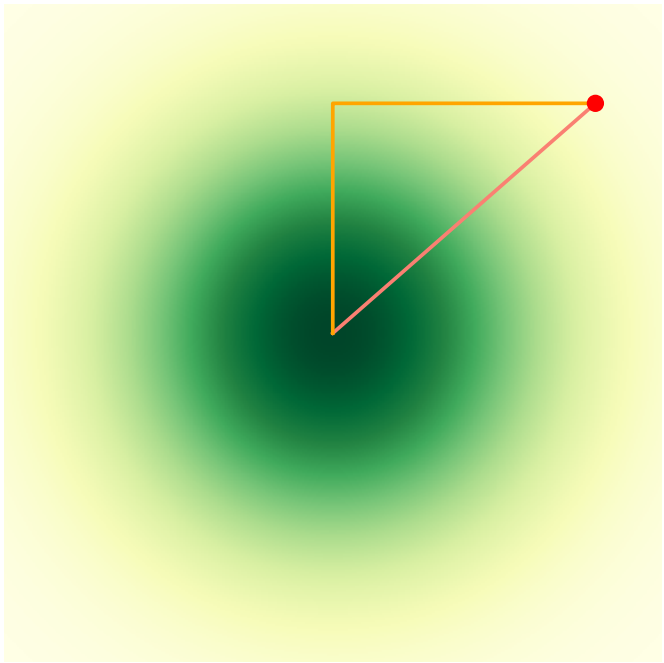

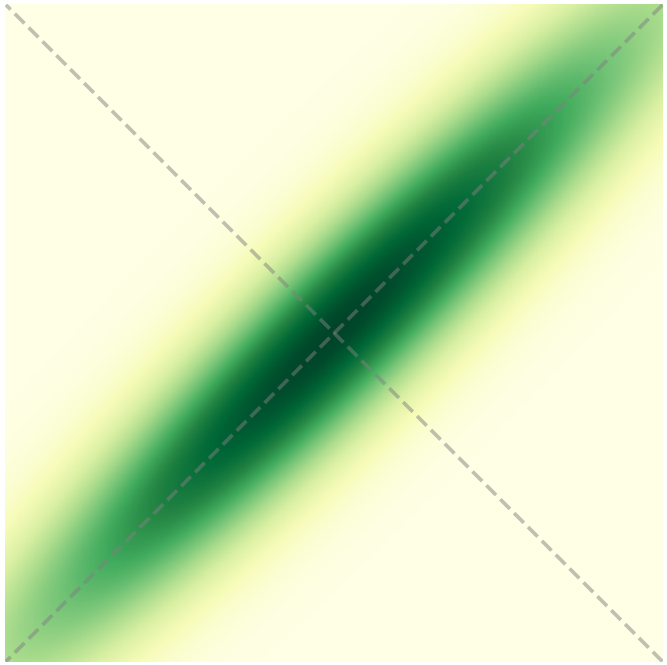

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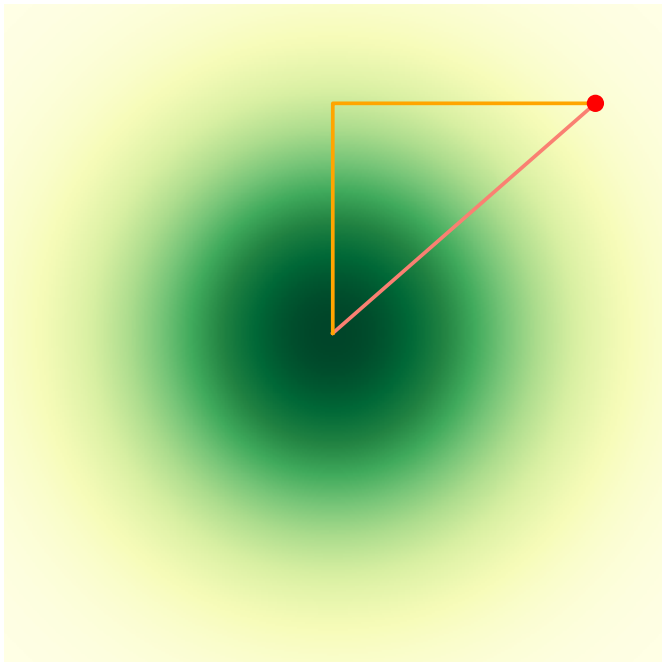

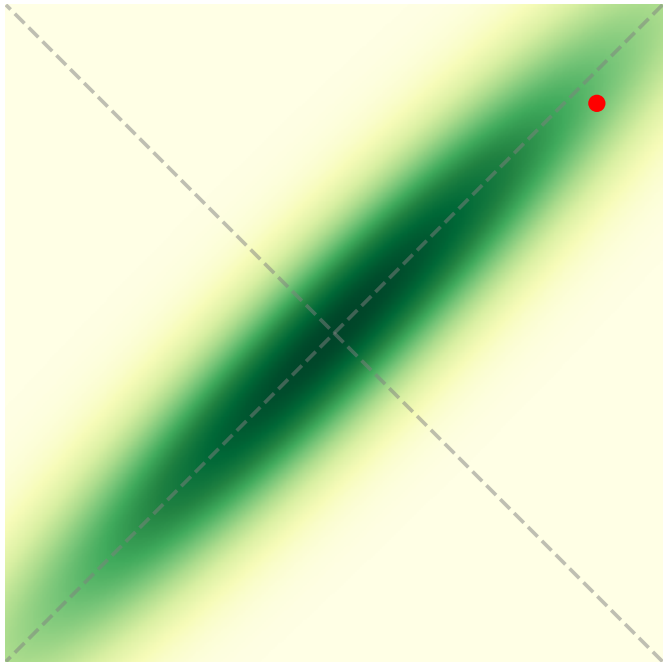

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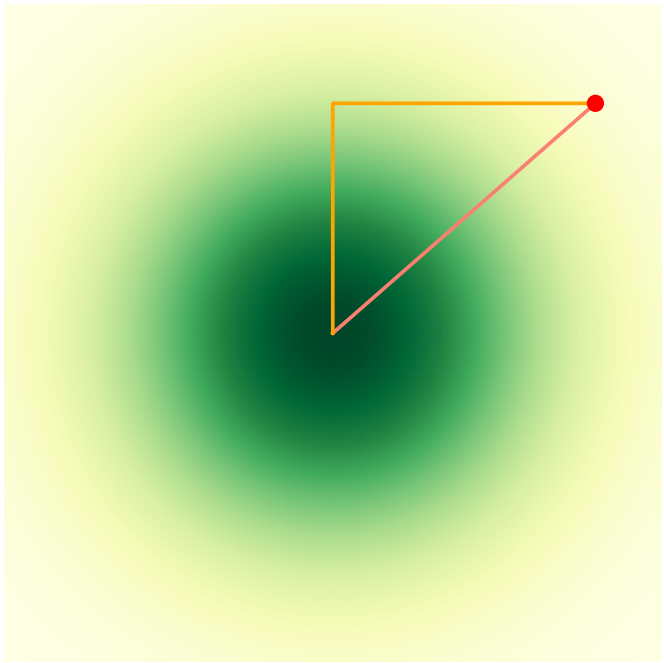

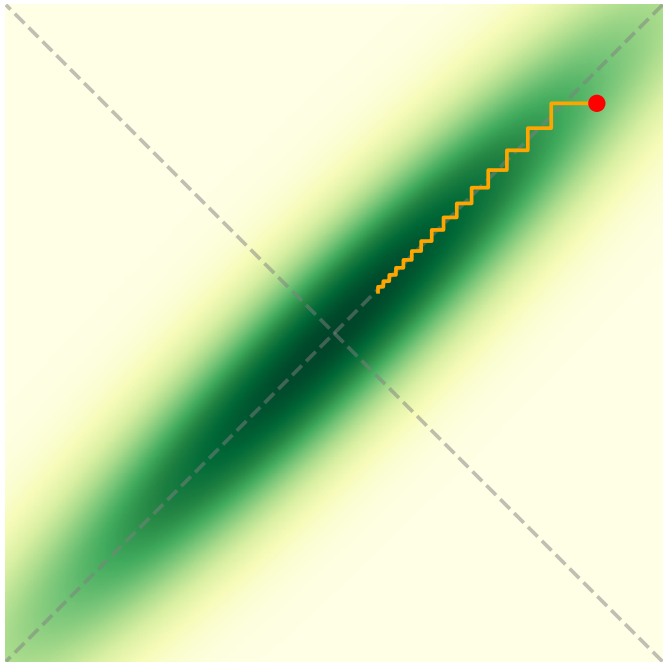

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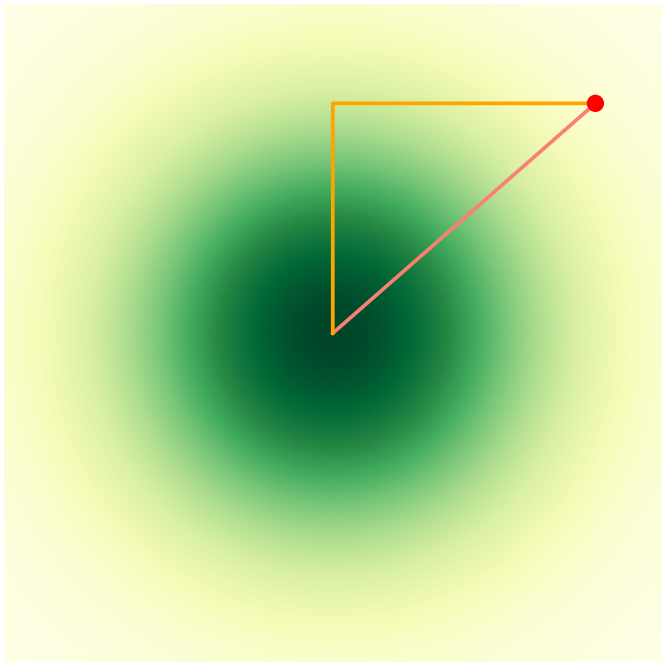

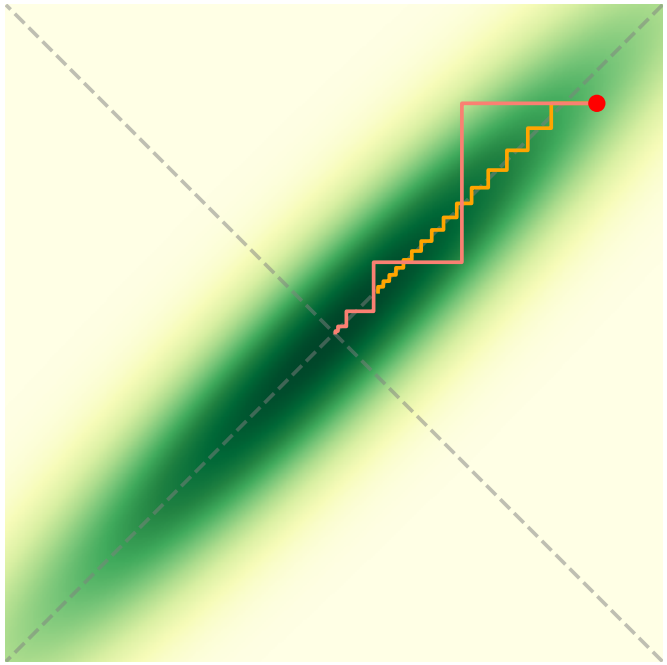

# Polarization

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# Polarization: Waveplates

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Other WP type: Achromatic, "Magic"

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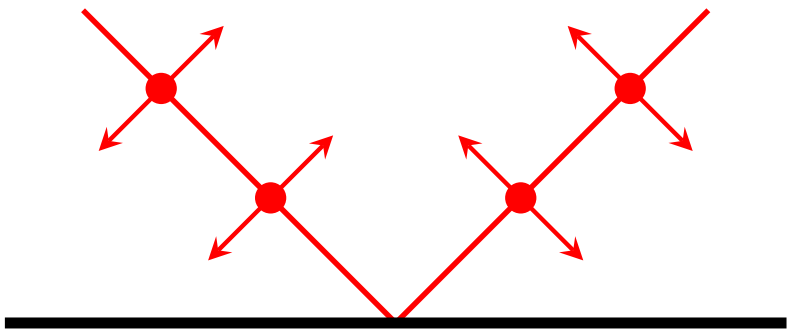

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## Simple surface

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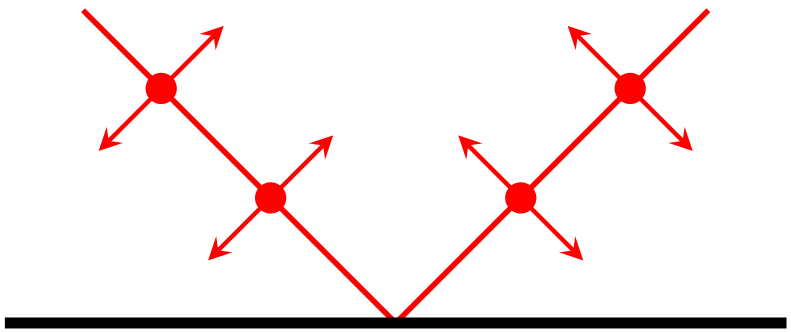

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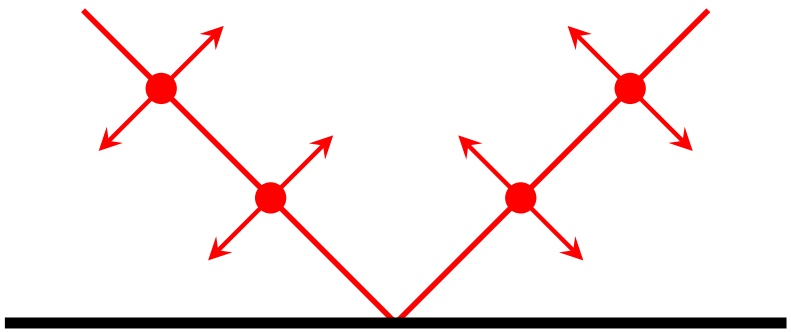

## Coating

- "Arbitrary" phase shift
- Change relative amplitude
- (dielectric mirror, dichroics)

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● *s*-polarization

# Electro-optic modulator (EOM)

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- Phase modulation/sideband
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$$\begin{aligned}
\phi =& \phi_0 + \beta \sin(\omega t) \\
\tilde{A} =& A_0 \exp(\mathrm{i}\phi) \\
=& \tilde{A_0} \exp(\mathrm{i}\beta \sin(\omega t)) \\
=& \tilde{A_0} \sum_{n=-\infty}^{\infty} J_n(\beta) \exp(\mathrm{i}n\omega t)
\end{aligned}$$

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## AC EOM: phase/polarization modulation

- Polarization modulation
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- Asymmetric sideband: sawtooth drive

$$\phi = mod(\phi_0 + \omega t, 2\pi)$$

# Acousto-optic modulator (AOM)