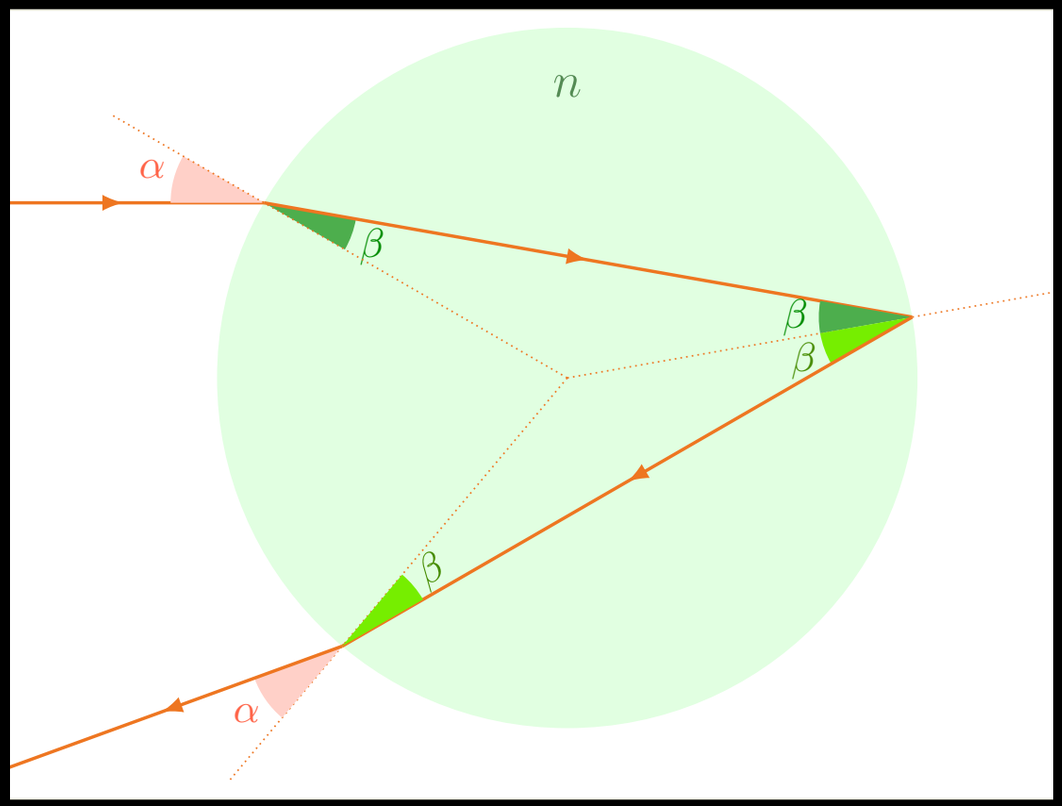
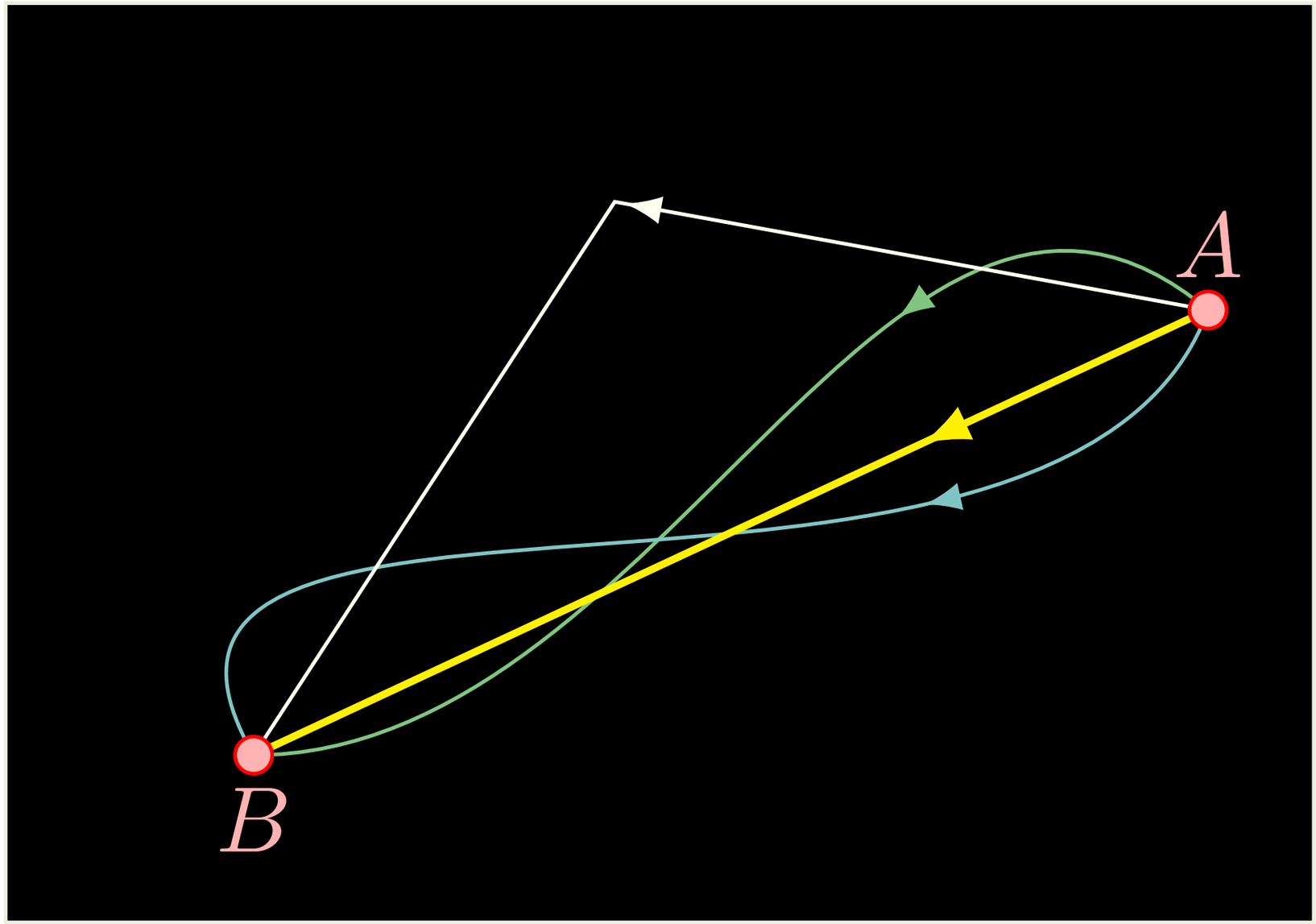


Física IV

20 outubro 2020

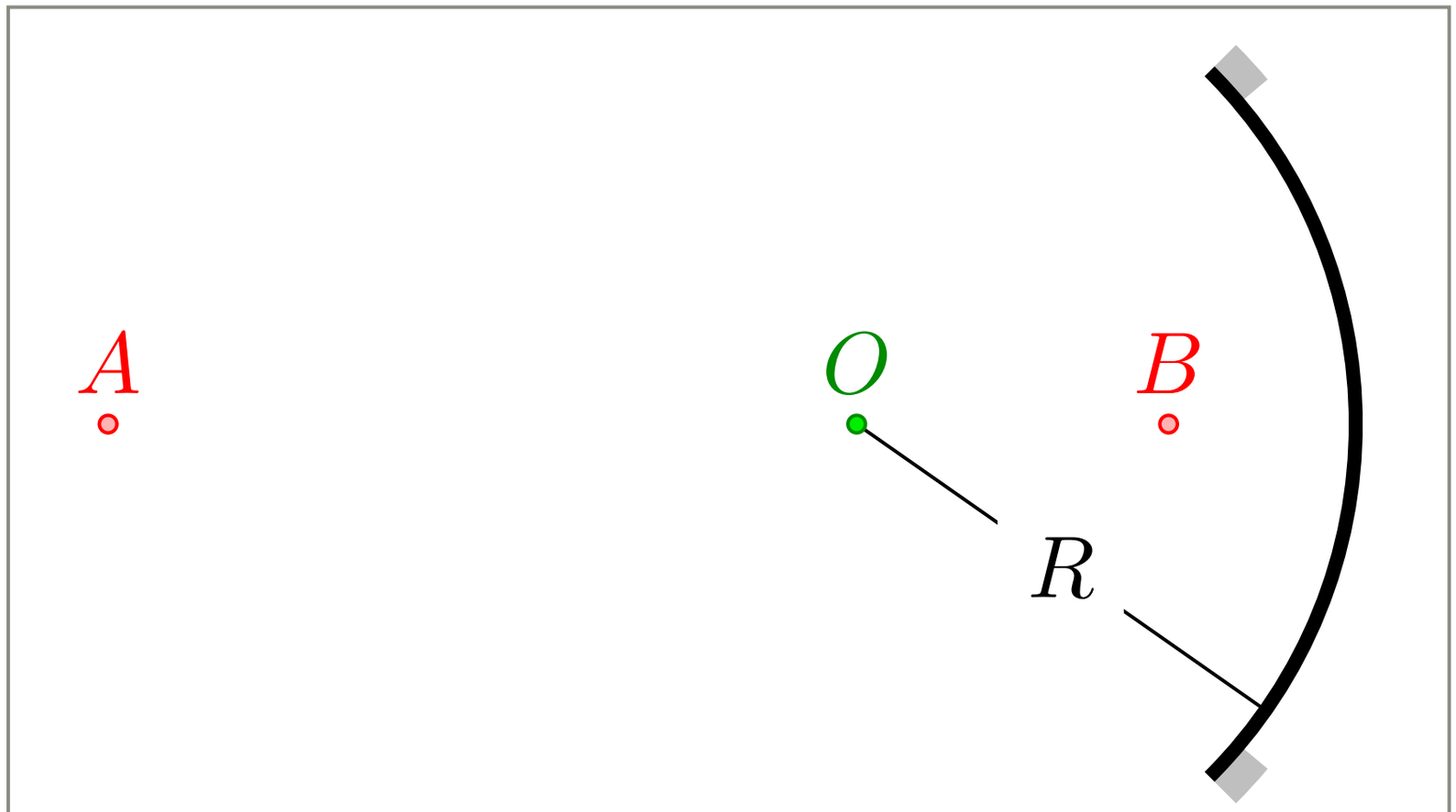
Ótica geométrica

Princípio de Fermat

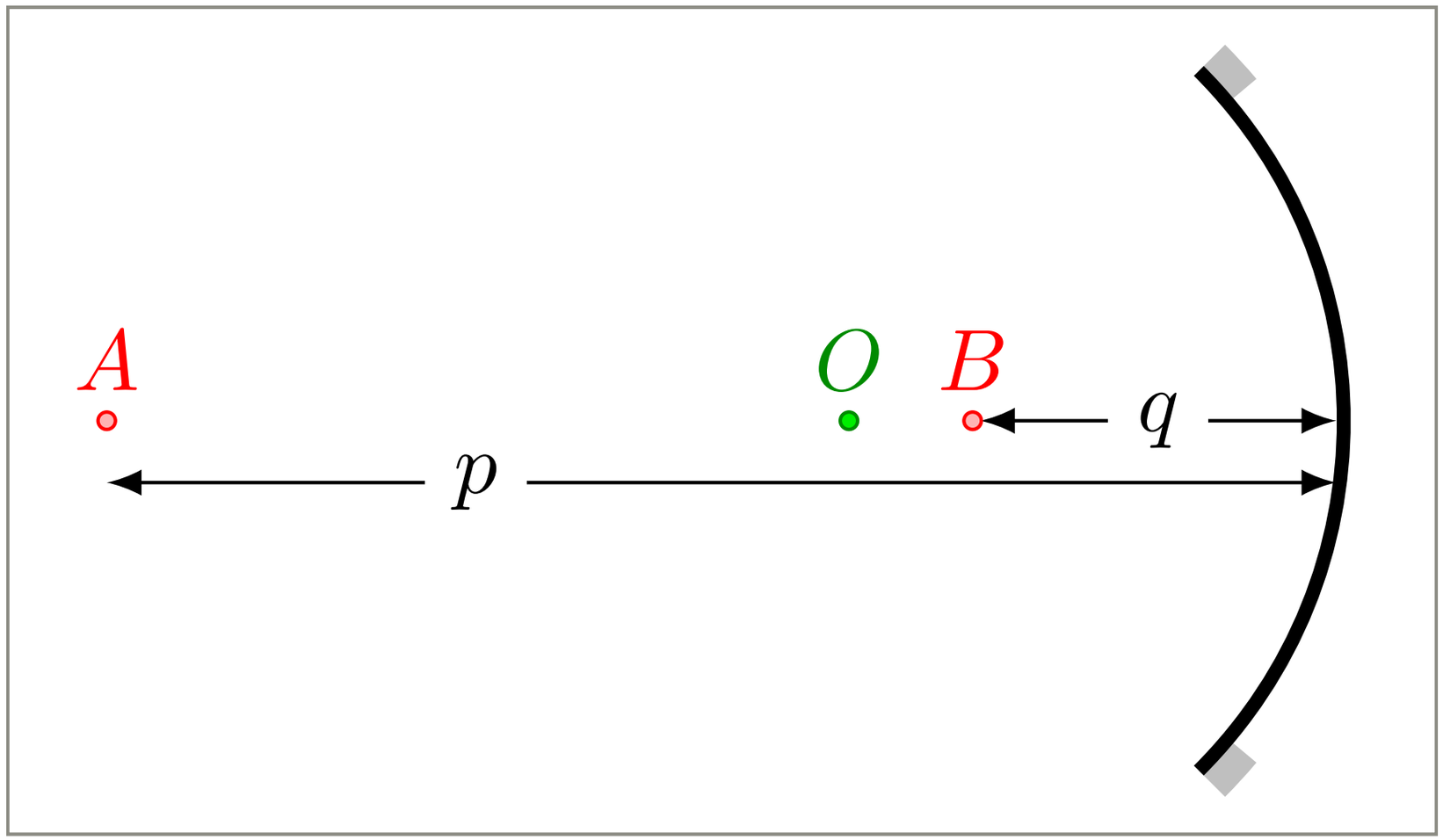


Minimiza o tempo

Princípio de Fermat
Espelho esférico

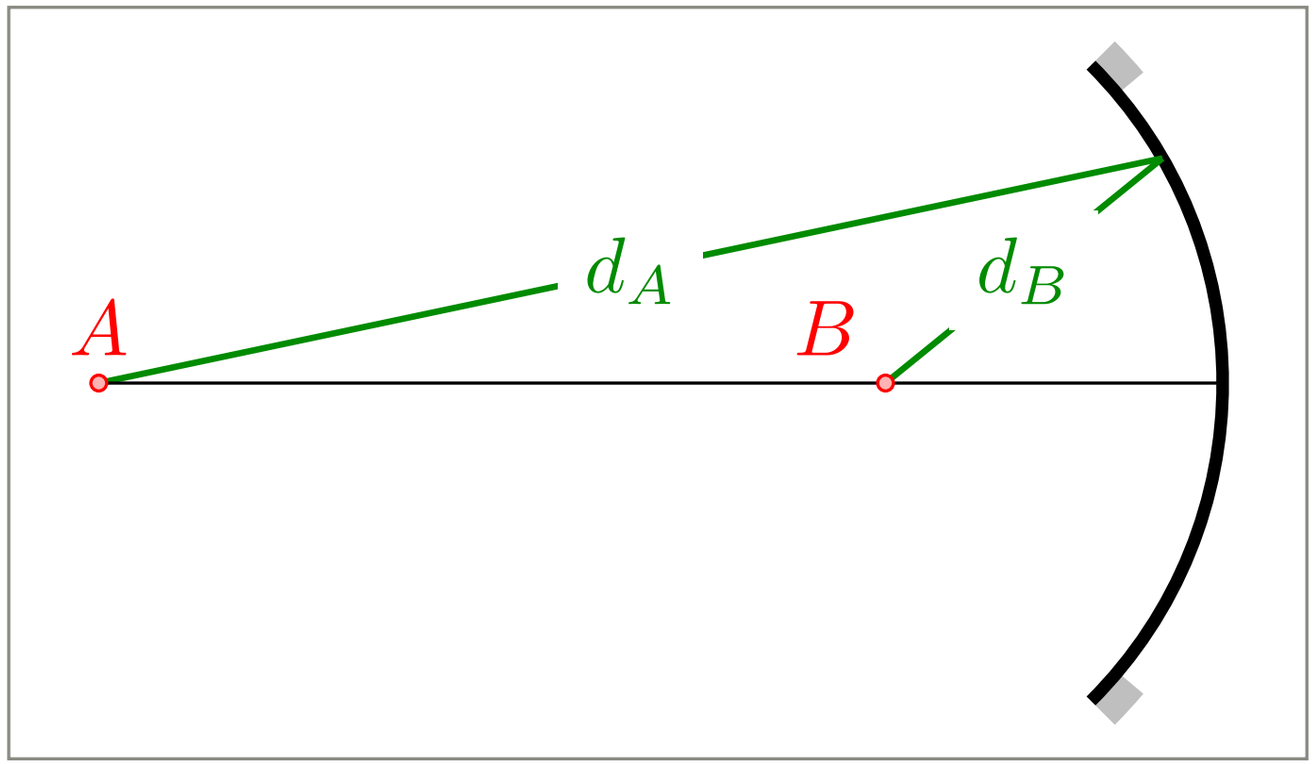


Princípio de Fermat
Espelho esférico



Princípio de Fermat
Espelho esférico

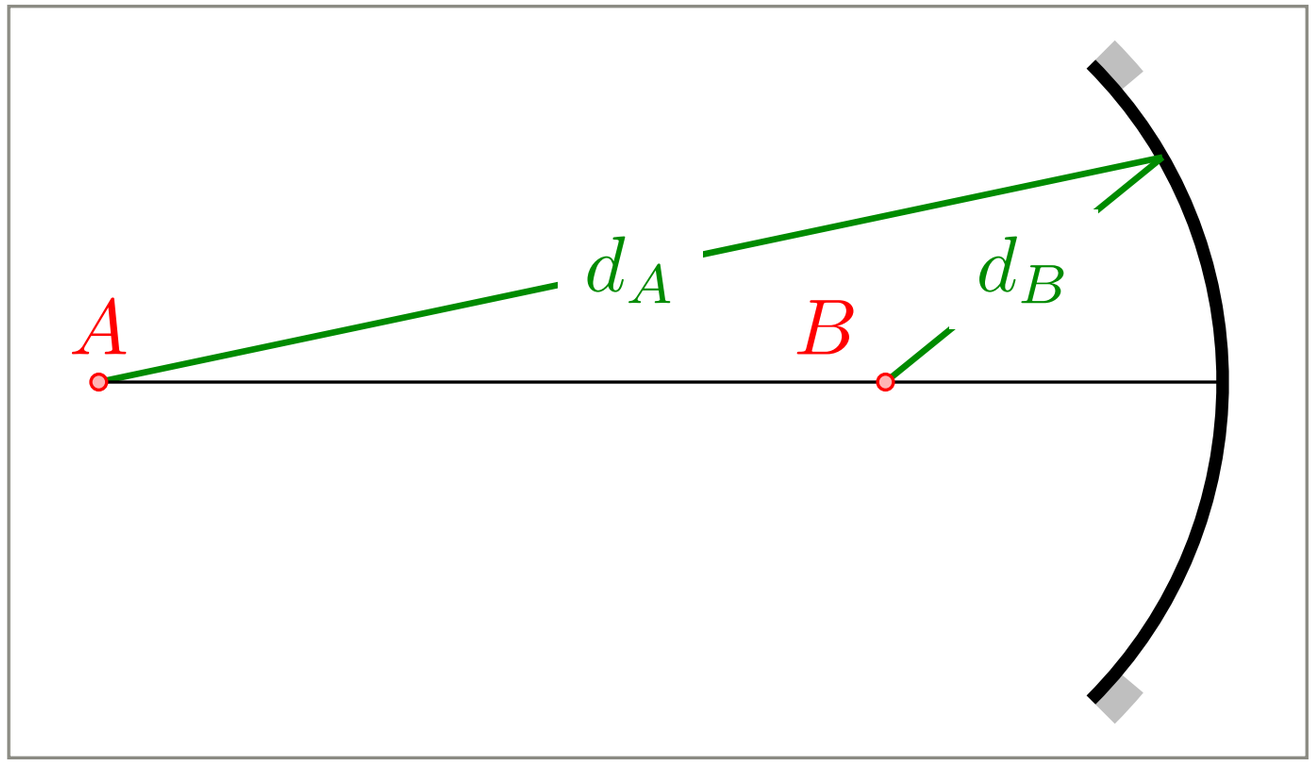
$$\Delta t = \Delta t_A + \Delta t_B$$



Princípio de Fermat
Espelho esférico

$$\Delta t = \Delta t_A + \Delta t_B$$

$$\Delta t = \frac{d_A + d_B}{c}$$

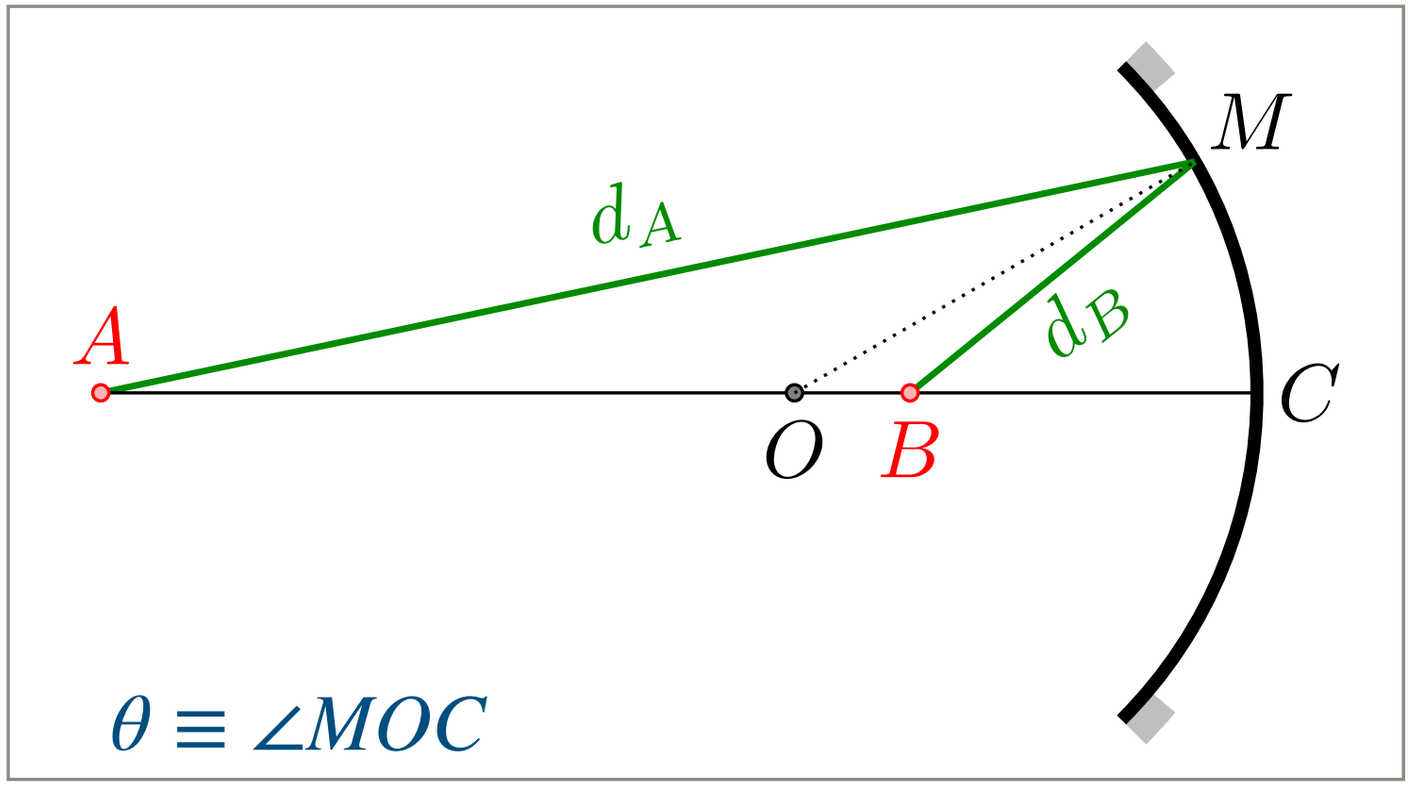


Princípio de Fermat
Espelho esférico

$$\Delta t = \Delta t_A + \Delta t_B$$

$$\Delta t = \frac{d_A + d_B}{c}$$

$$\Rightarrow \frac{\mathrm{d}d_A}{\mathrm{d}\theta} + \frac{\mathrm{d}d_B}{\mathrm{d}\theta} = 0$$

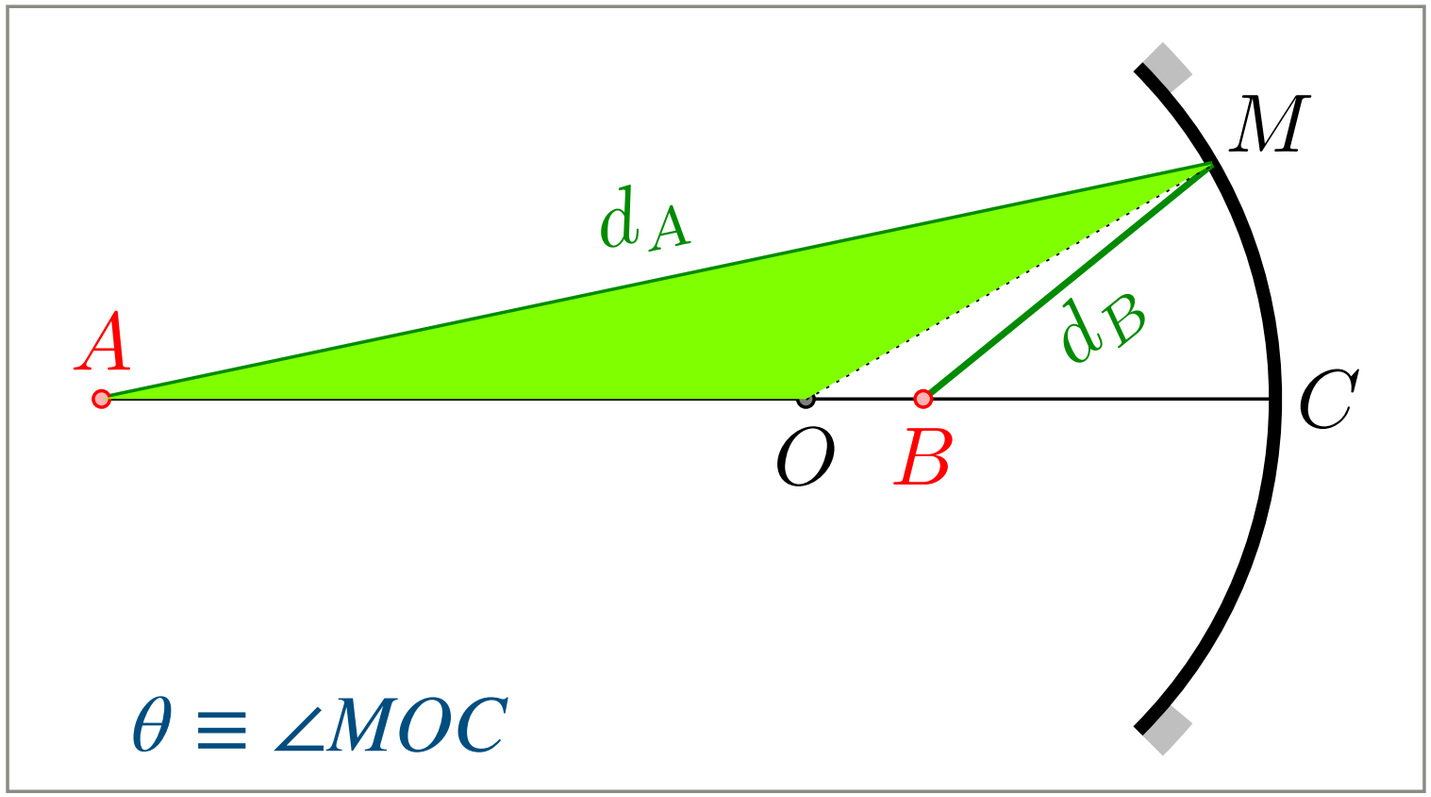


Princípio de Fermat
Espelho esférico

$$\Delta t = \Delta t_A + \Delta t_B$$

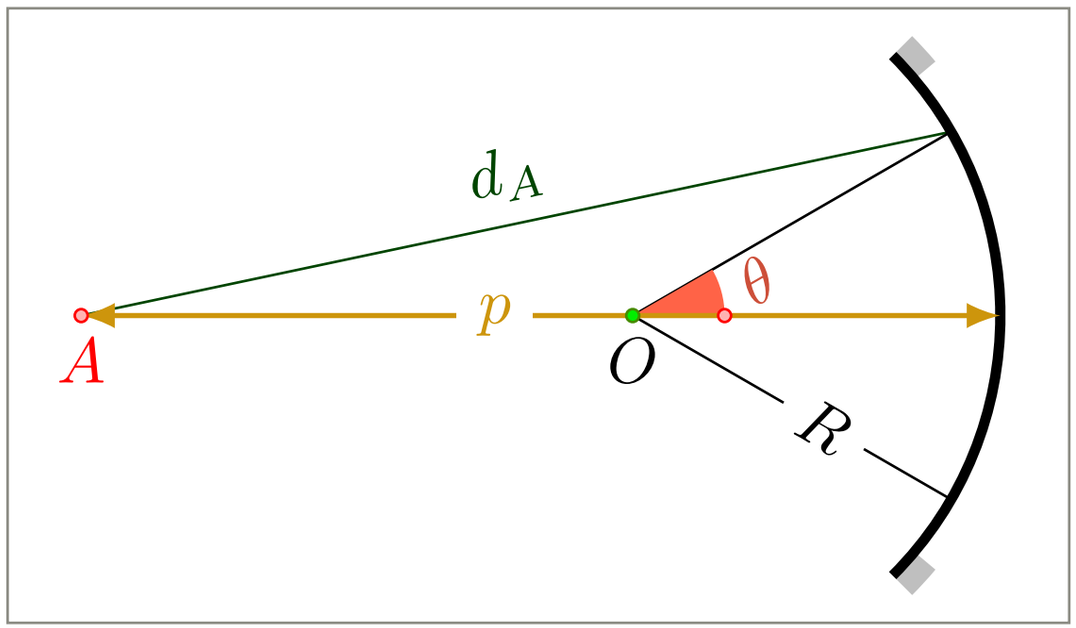
$$\Delta t = \frac{d_A + d_B}{c}$$

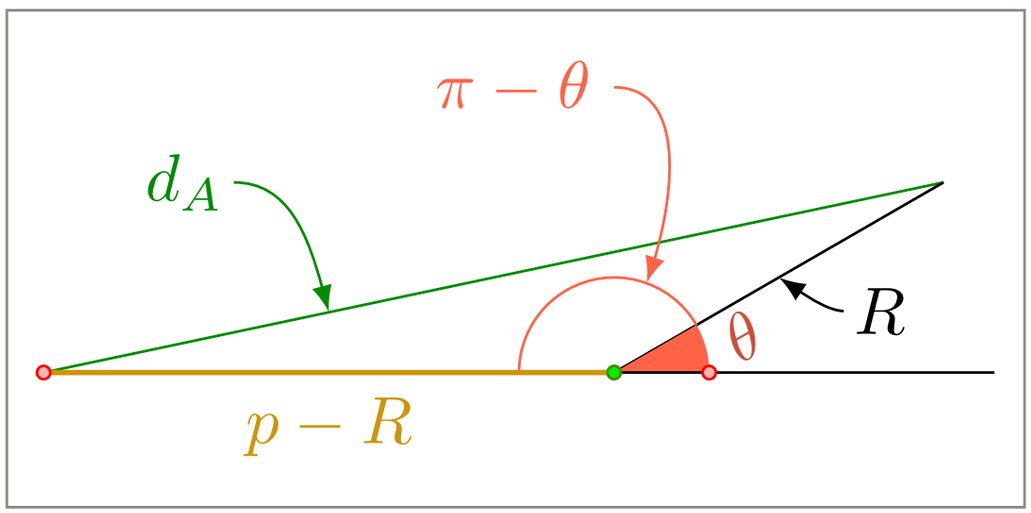
$$\Rightarrow \frac{\mathrm{d}d_A}{\mathrm{d}\theta} + \frac{\mathrm{d}d_B}{\mathrm{d}\theta} = 0$$



Princípio de Fermat
Espelho esférico

$$d_A^2 = R^2 + (p - R)^2 + 2R(p - R)\cos\theta$$

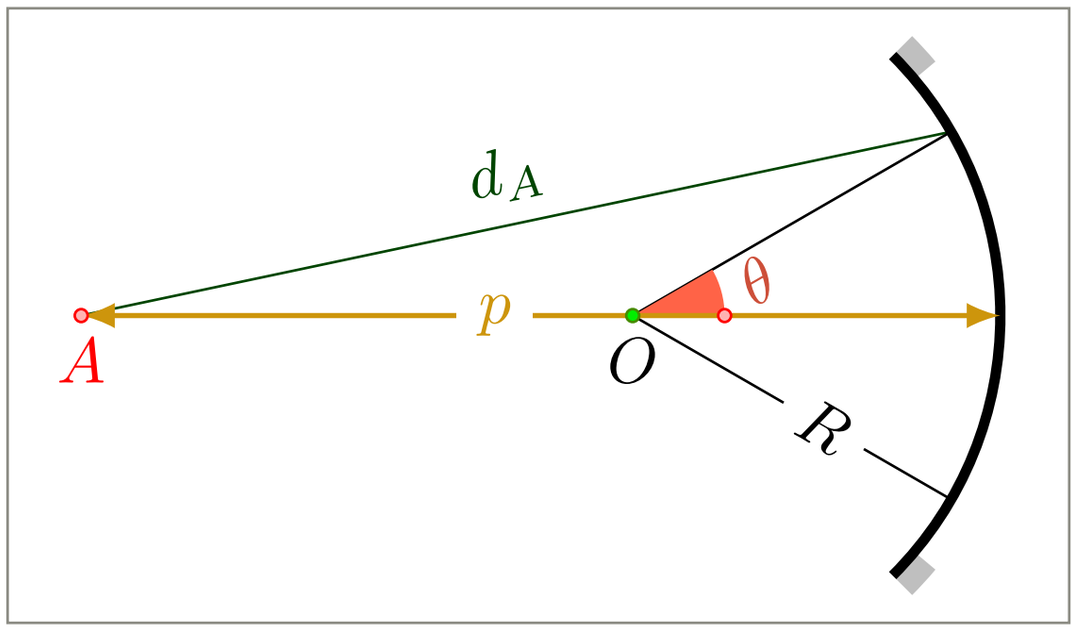




Princípio de Fermat
Espelho esférico

$$d_A^2 = R^2 + (p-R)^2 + 2R(p-R)\cos\theta$$

$$2d_A\frac{d_A}{d\theta} = -2R(p-R)\sin\theta$$

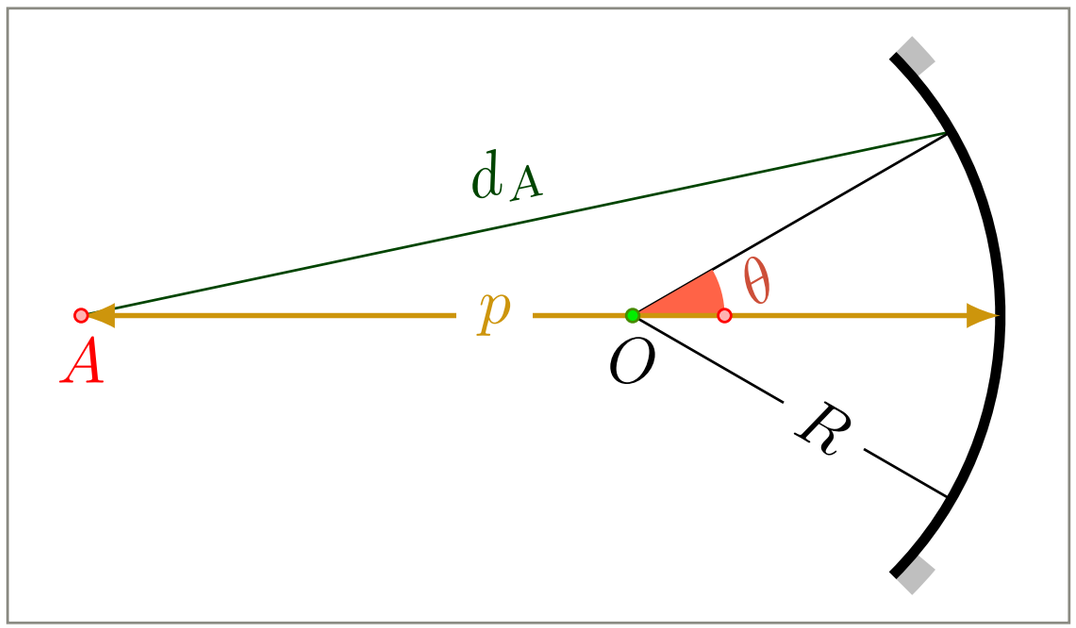


Princípio de Fermat
Espelho esférico

$$d_A^2 = R^2 + (p-R)^2 + 2R(p-R)\cos\theta$$

$$2d_A\frac{d_A}{d\theta} = -2R(p-R)\sin\theta$$

$$\frac{d_A}{d\theta} = -\frac{R(p-R)}{d_A}\sin\theta$$

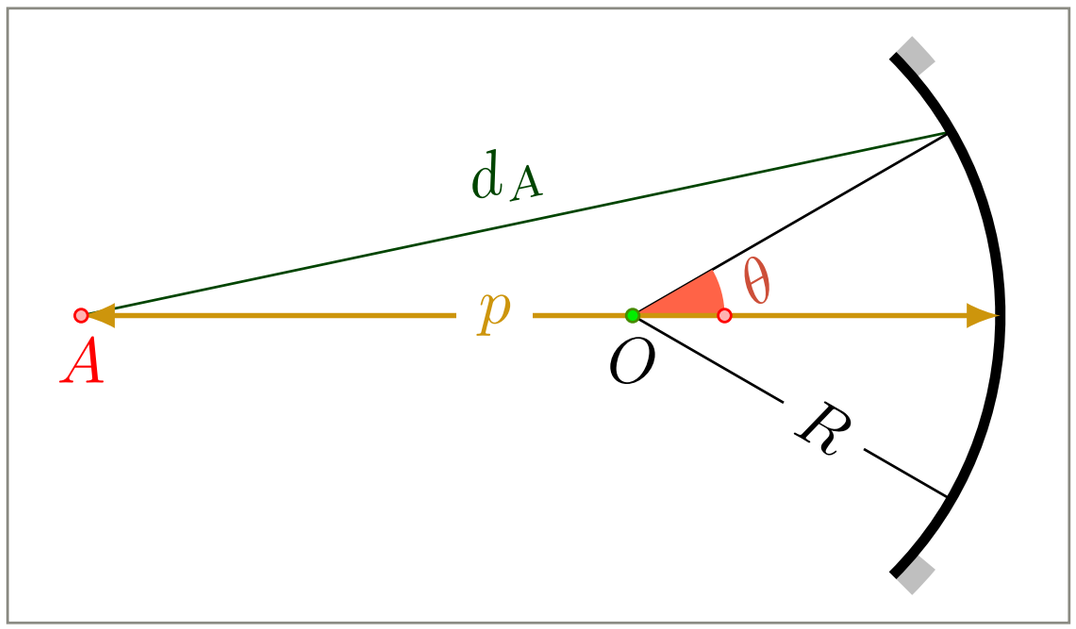


Princípio de Fermat
Espelho esférico

$$d_A^2 = R^2 + (p-R)^2 + 2R(p-R)\cos\theta$$

$$2d_A\frac{\mathrm{d}d_A}{\mathrm{d}\theta} = -2R(p-R)\sin\theta$$

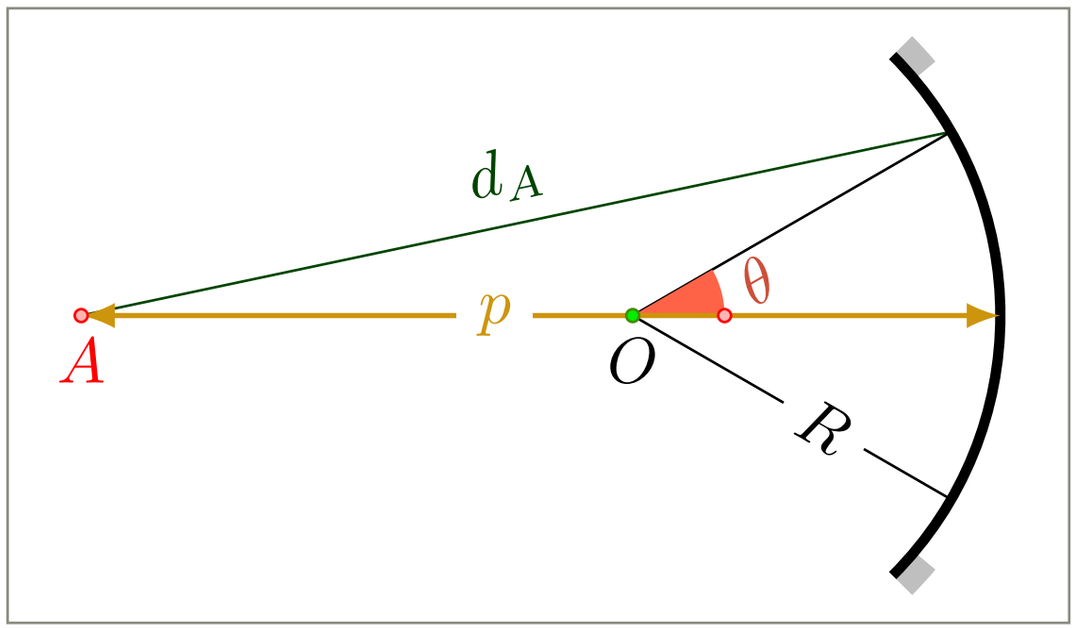
$$\frac{\mathrm{d}d_A}{\mathrm{d}\theta} = -\frac{R(p-R)}{d_A}\sin\theta$$



$$\left(\theta \ll 1 \Rightarrow d_A \approx p\right)$$

Princípio de Fermat
Espelho esférico

$$d_A^2 = R^2 + (p-R)^2 + 2R(p-R)\cos\theta$$



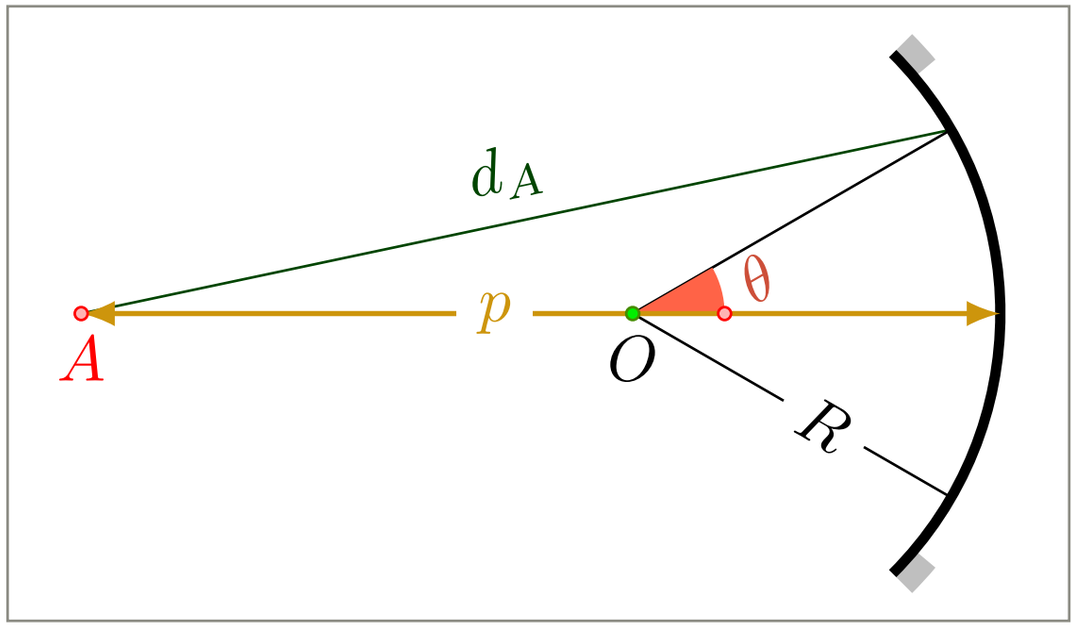
$$2d_A\frac{\mathrm{d}d_A}{\mathrm{d}\theta} = -2R(p-R)\sin\theta$$

$$\frac{\mathrm{d}d_A}{\mathrm{d}\theta} = -\frac{R(p-R)}{d_A}\sin\theta \qquad \left(\theta \ll 1 \Rightarrow d_A \approx p\right)$$

$$\frac{\mathrm{d}d_A}{\mathrm{d}\theta} = -\frac{R(p-R)}{p}\sin\theta$$

Princípio de Fermat
Espelho esférico

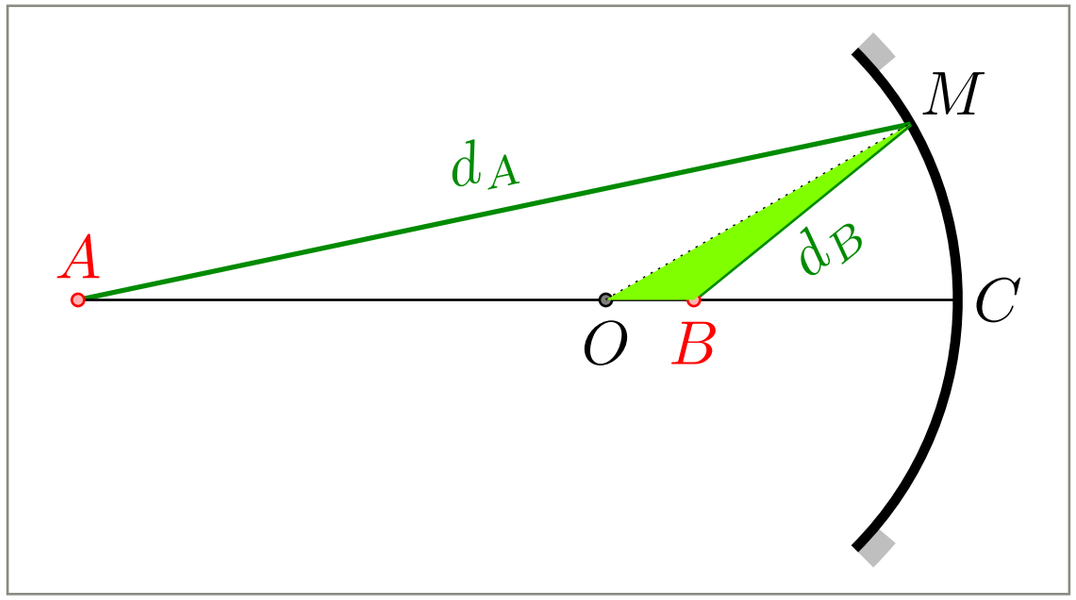
$$\frac{\mathrm{d}d_A}{\mathrm{d}\theta} = -\frac{R(p-R)}{p}\sin\theta$$



Princípio de Fermat
Espelho esférico

$$\frac{\mathrm{d}d_A}{\mathrm{d}\theta} = -\frac{R(p-R)}{p}\sin\theta$$

$$\frac{\mathrm{d}d_B}{\mathrm{d}\theta} = -\frac{R(q-R)}{q}\sin\theta$$



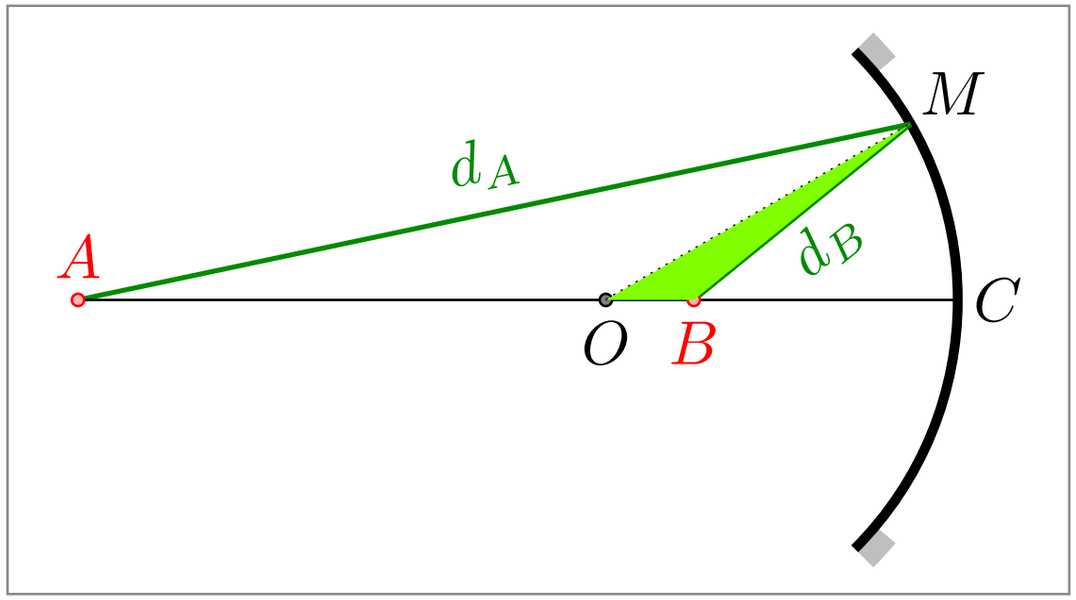
Princípio de Fermat
Espelho esférico

$$\frac{\mathrm{d}d_A}{\mathrm{d}\theta} = -\frac{R(p-R)}{p}\sin\theta$$

$$\frac{\mathrm{d}d_B}{\mathrm{d}\theta} = -\frac{R(q-R)}{q}\sin\theta$$

$$\Rightarrow \frac{p-R}{p} + \frac{q-R}{q} = 0$$

$$2 - \frac{R}{p} - \frac{R}{q} = 0$$



$$\frac{1}{p} + \frac{1}{q} = \frac{2}{R}$$

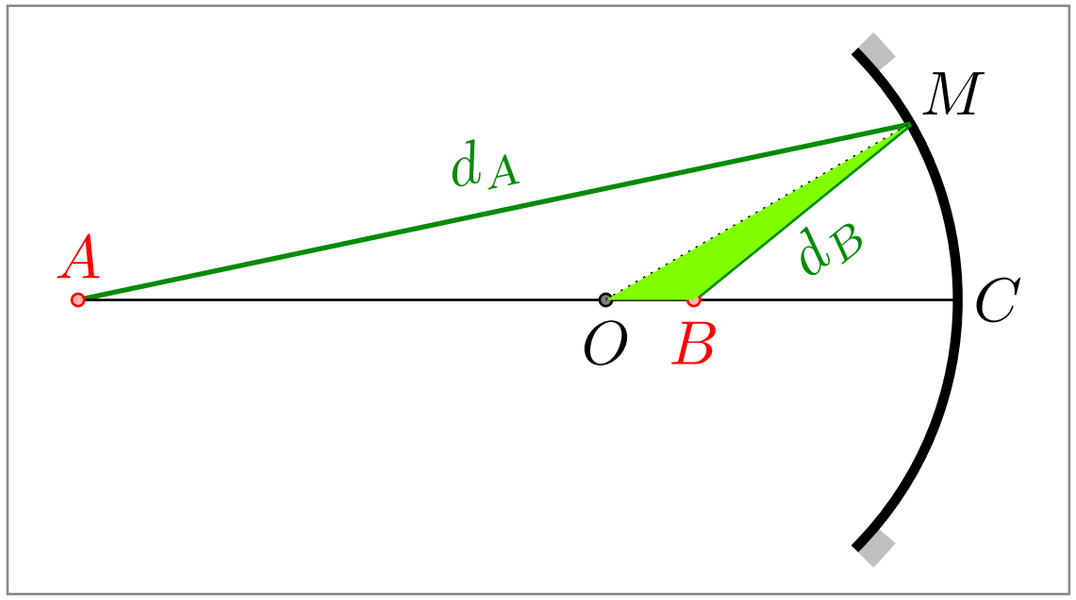
Princípio de Fermat
Espelho esférico

$$\frac{\mathrm{d}d_A}{\mathrm{d}\theta} = -\frac{R(p-R)}{p}\sin\theta$$

$$\frac{\mathrm{d}d_B}{\mathrm{d}\theta} = -\frac{R(q-R)}{q}\sin\theta$$

$$\Rightarrow \frac{p-R}{p} + \frac{q-R}{q} = 0$$

$$2 - \frac{R}{p} - \frac{R}{q} = 0$$

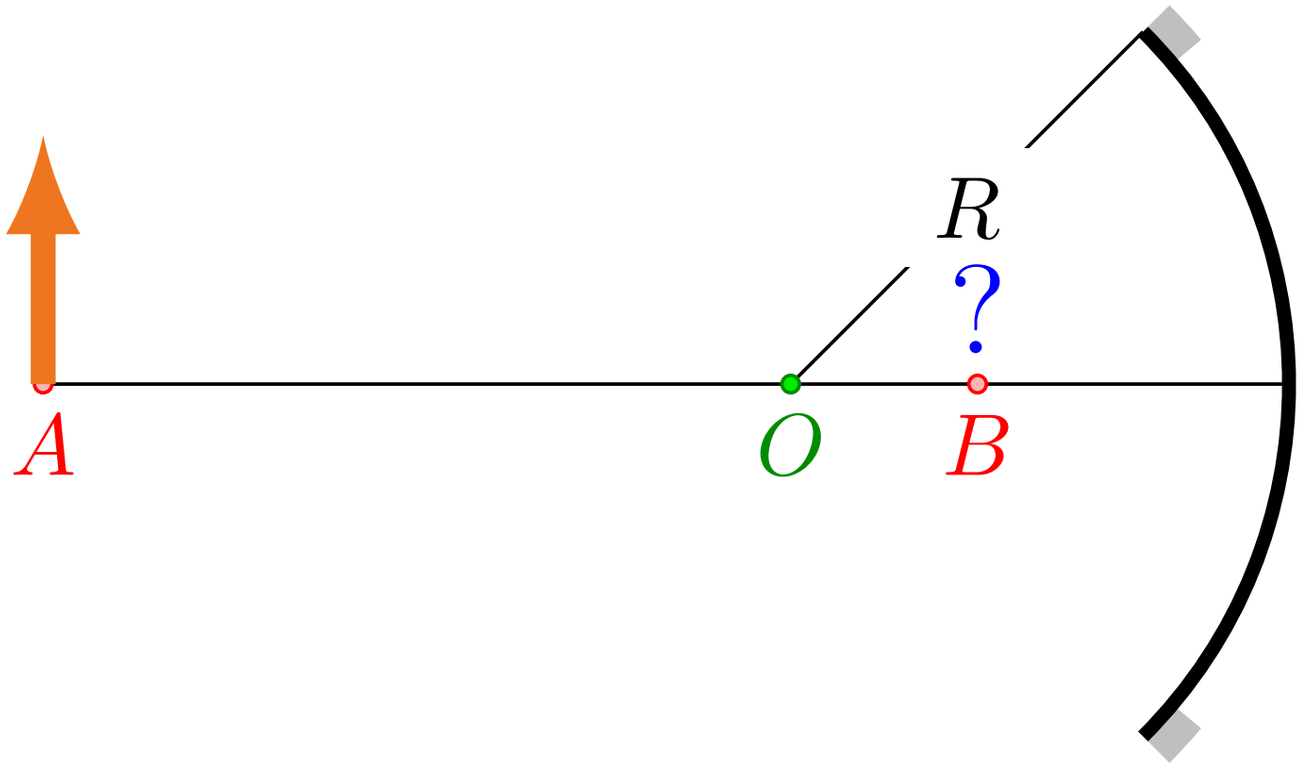


$$\frac{1}{p} + \frac{1}{q} = \frac{2}{R}$$

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

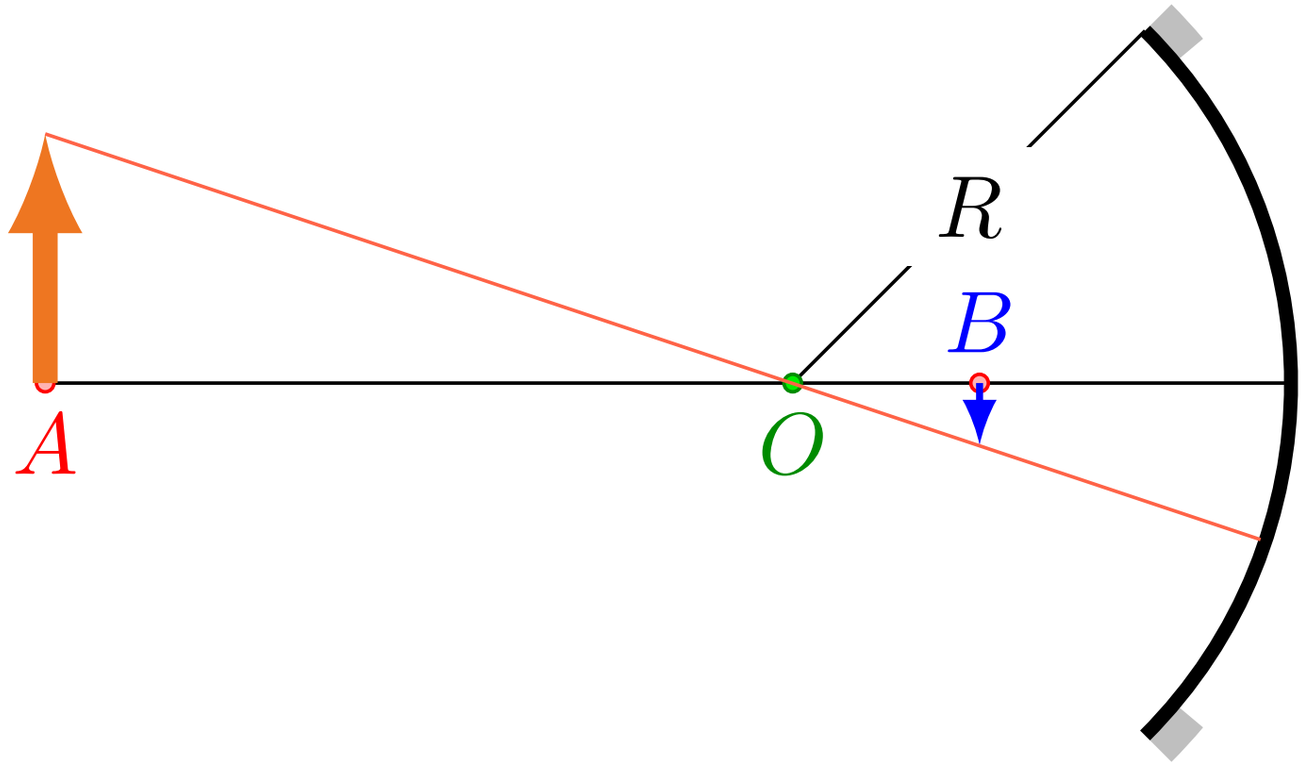
$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

Pratique o que aprendeu



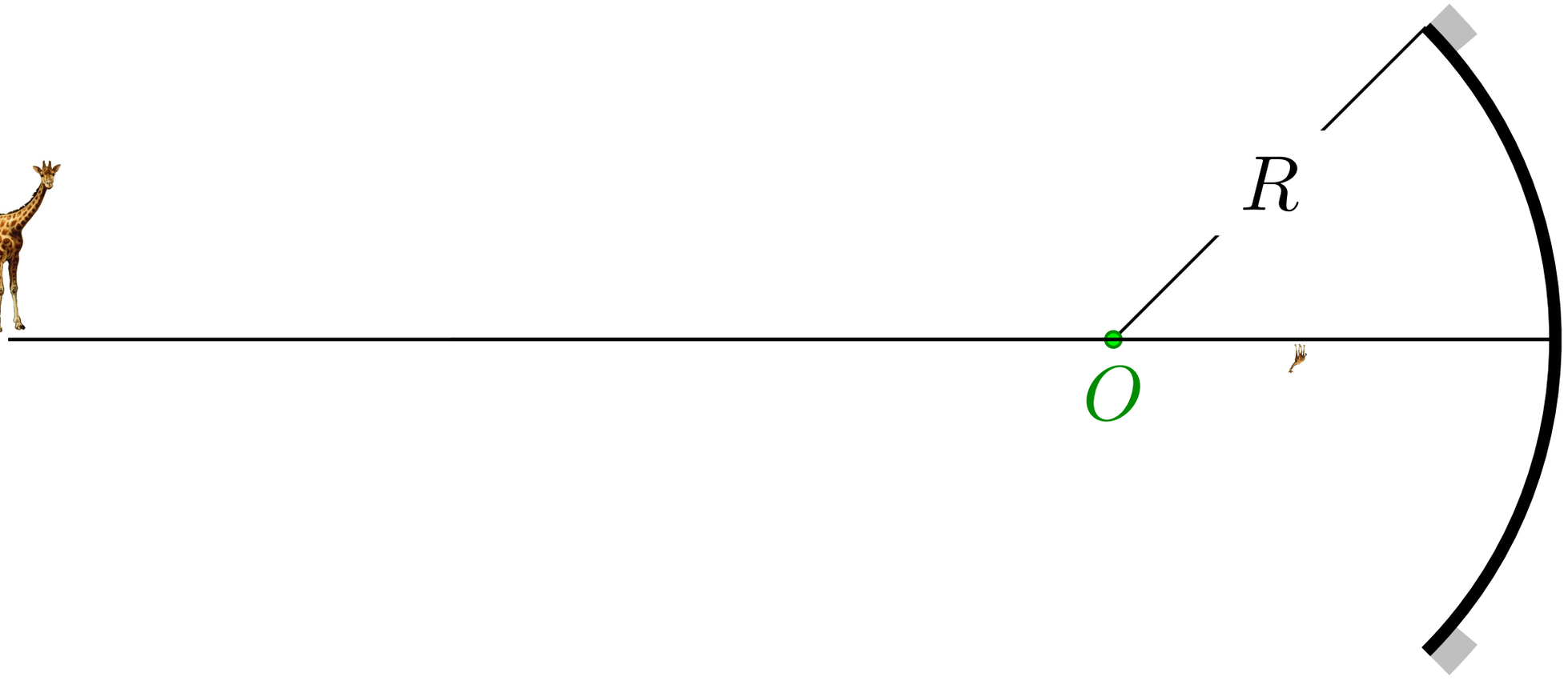
$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

Pratique o que aprendeu



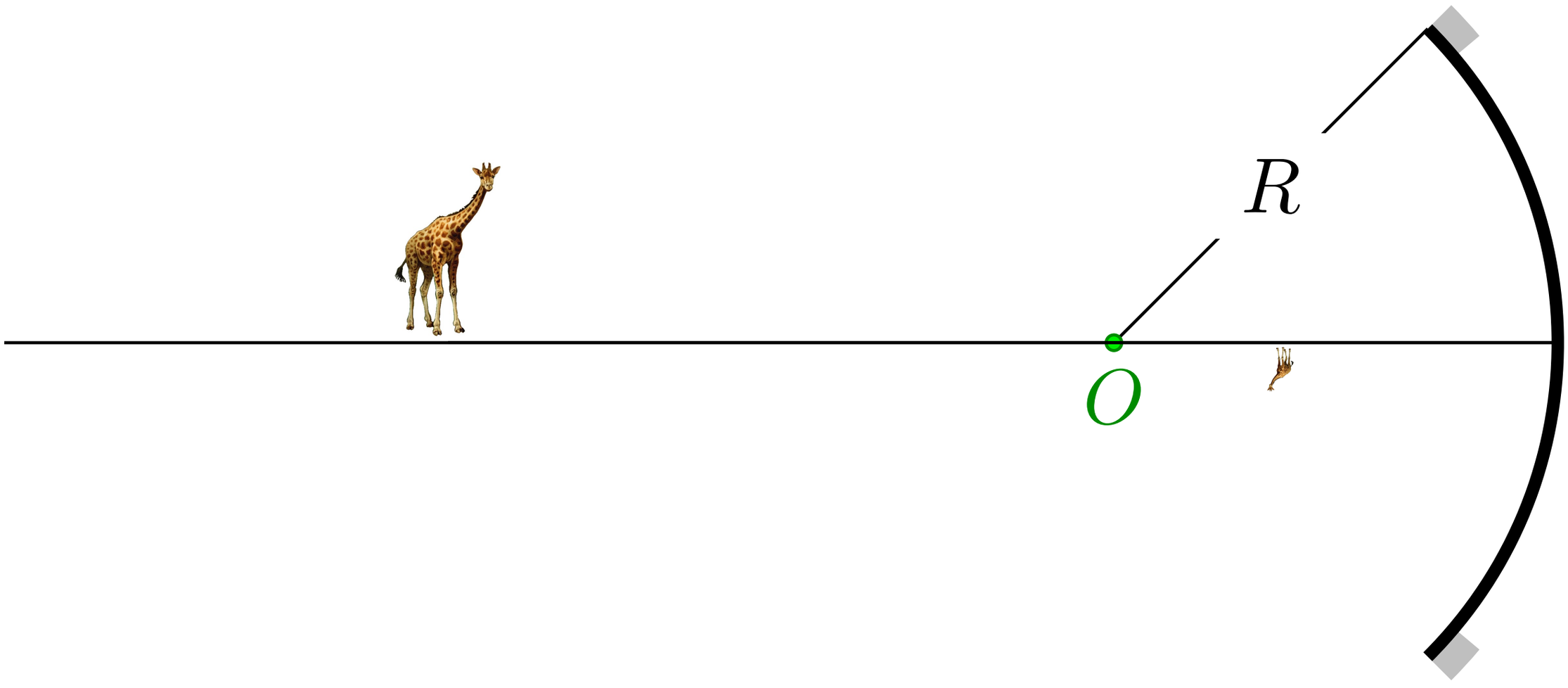
$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

Pratique o que aprendeu



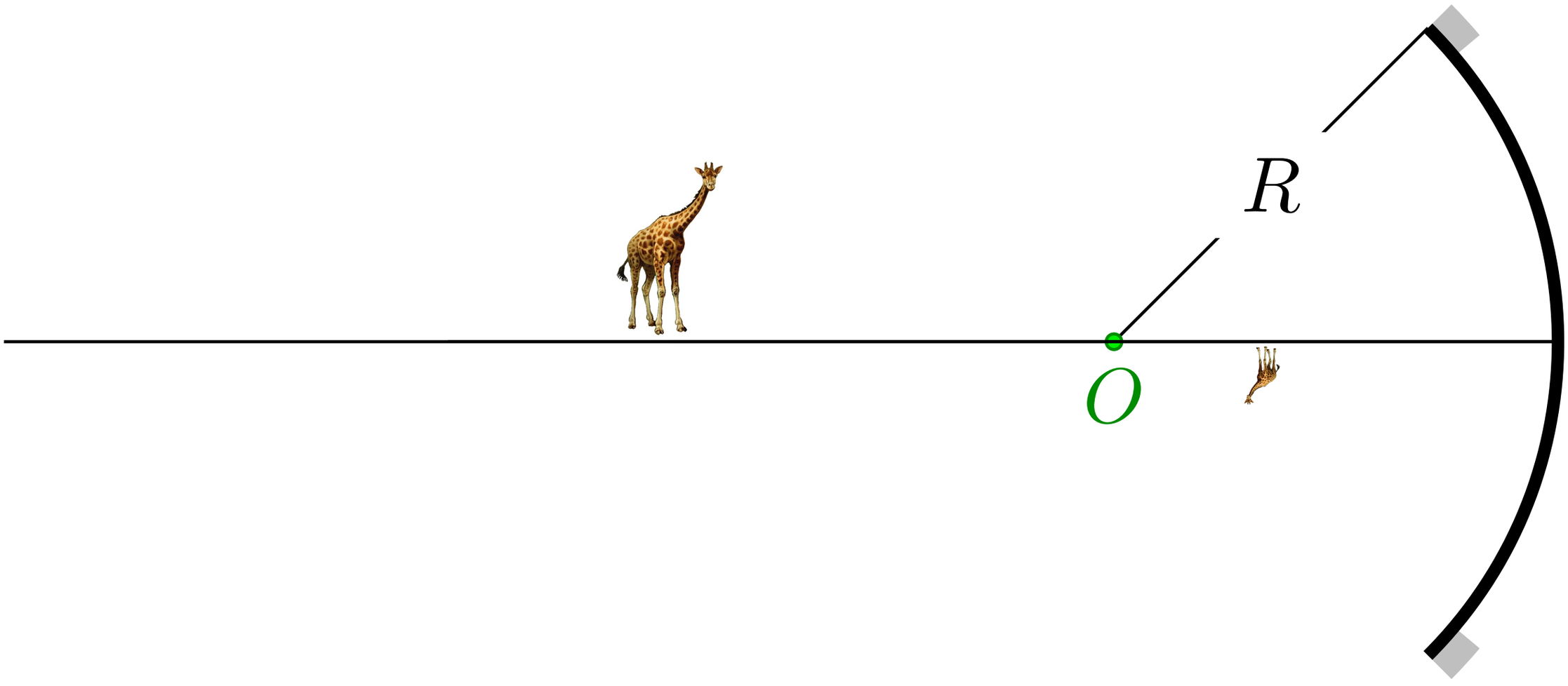
$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

Pratique o que aprendeu



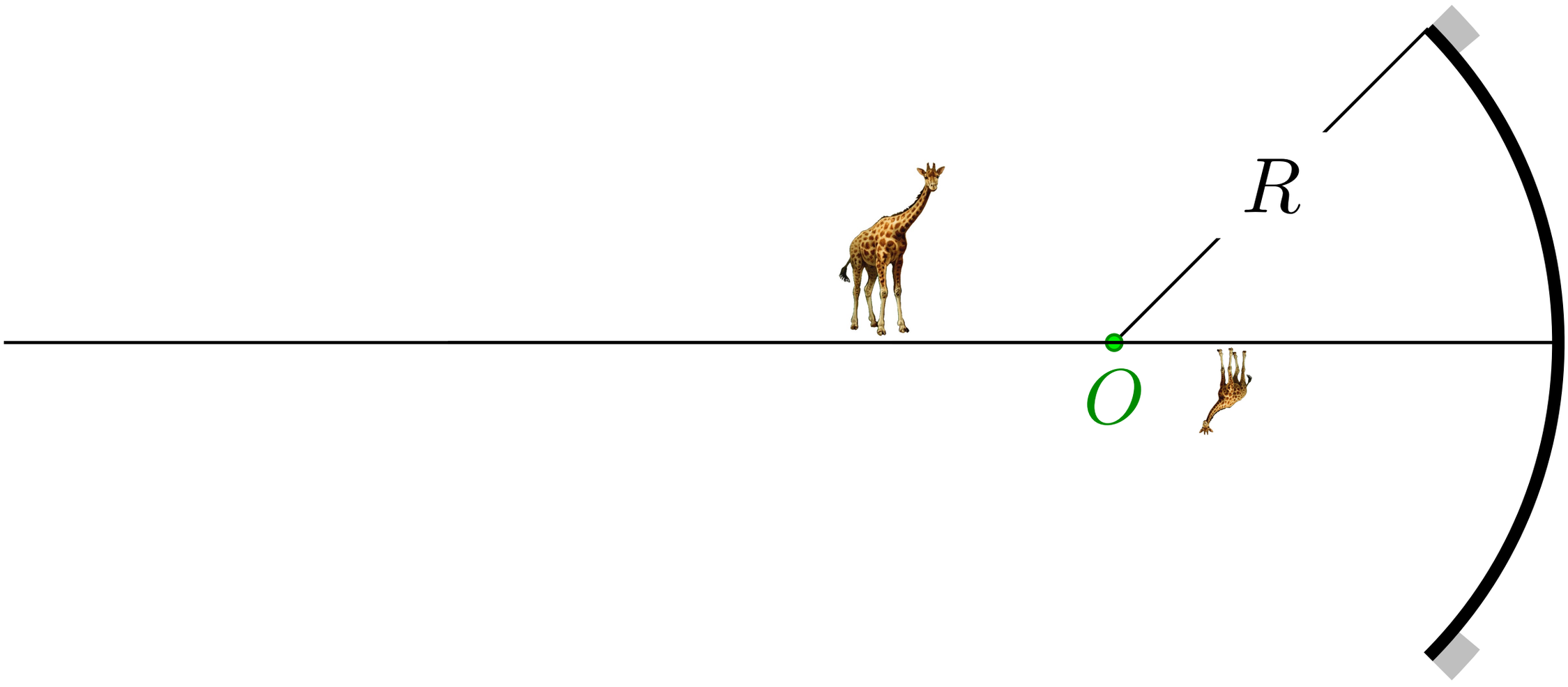
$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

Pratique o que aprendeu



$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

Pratique o que aprendeu

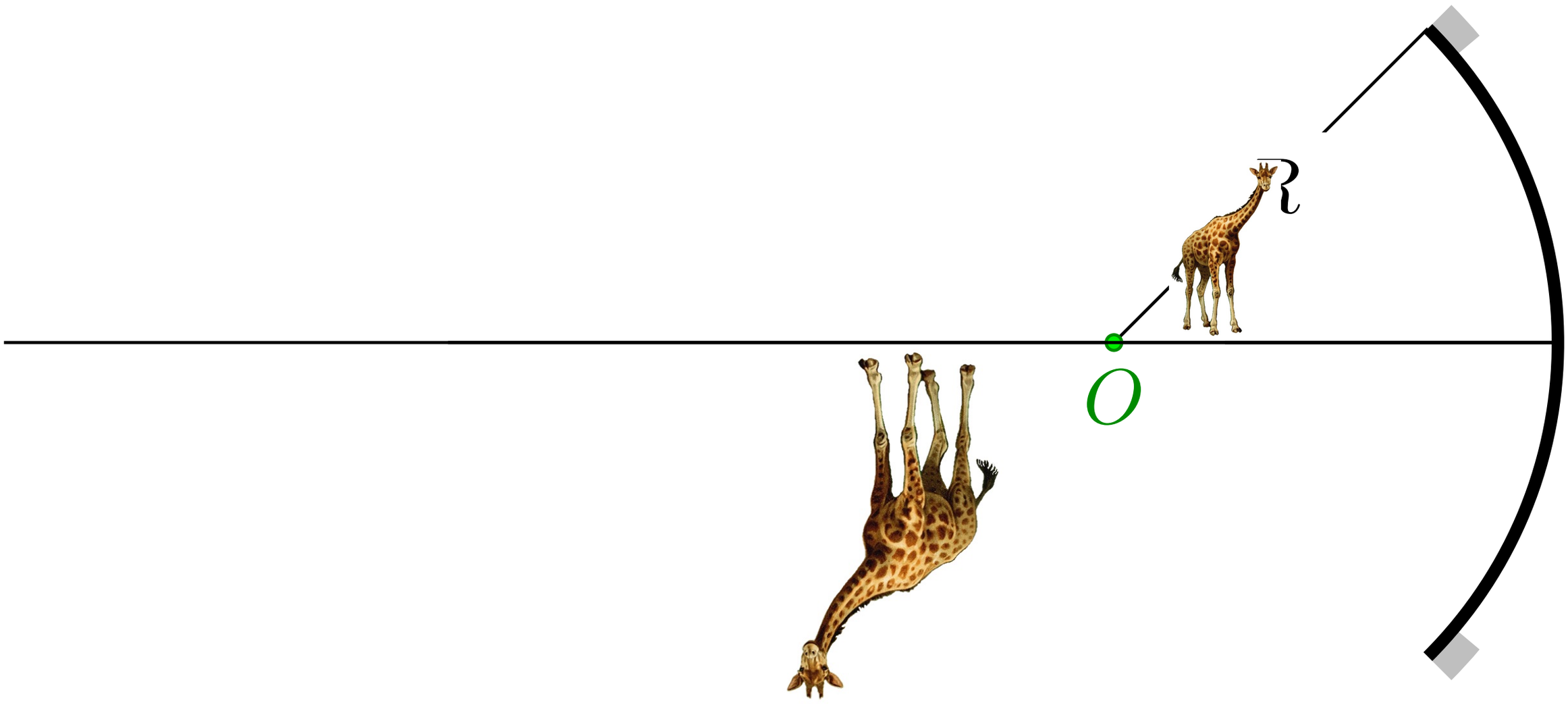


$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

Pratique o que aprendeu

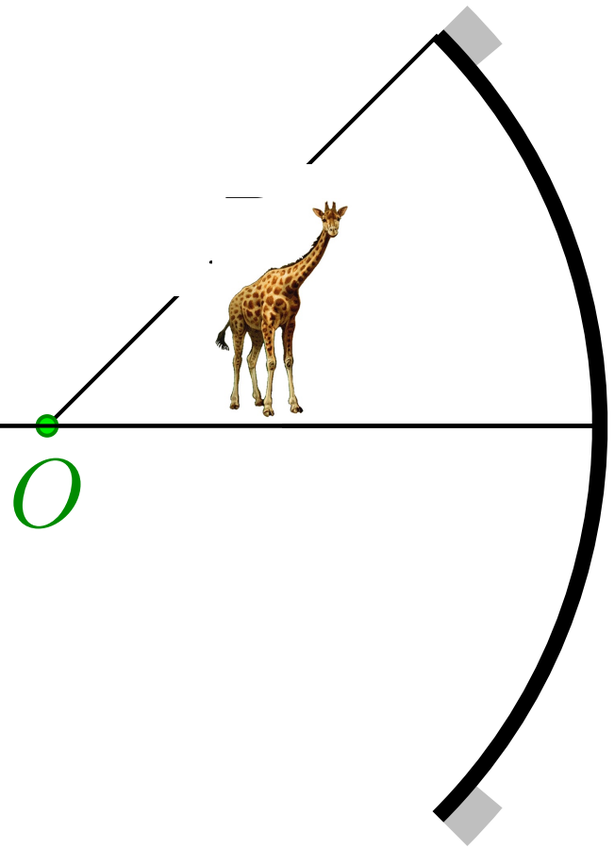
$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

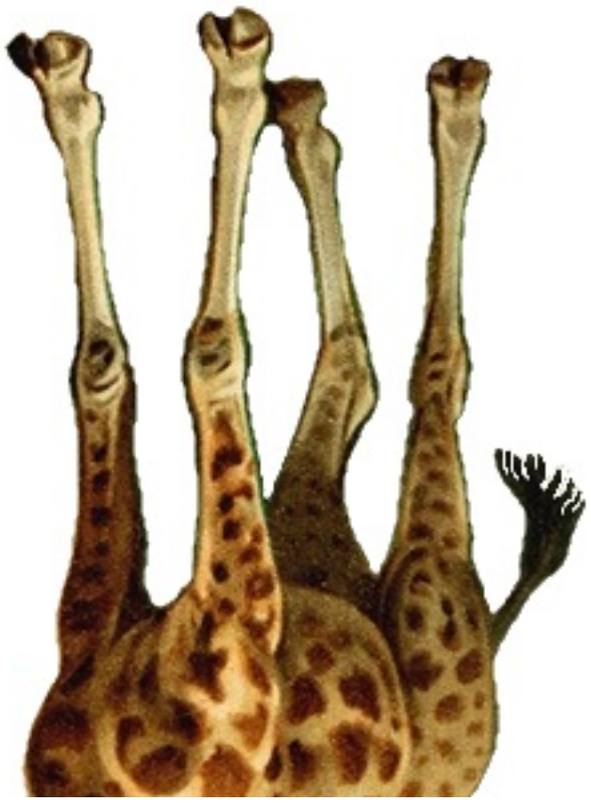
Pratique o que aprendeu



$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

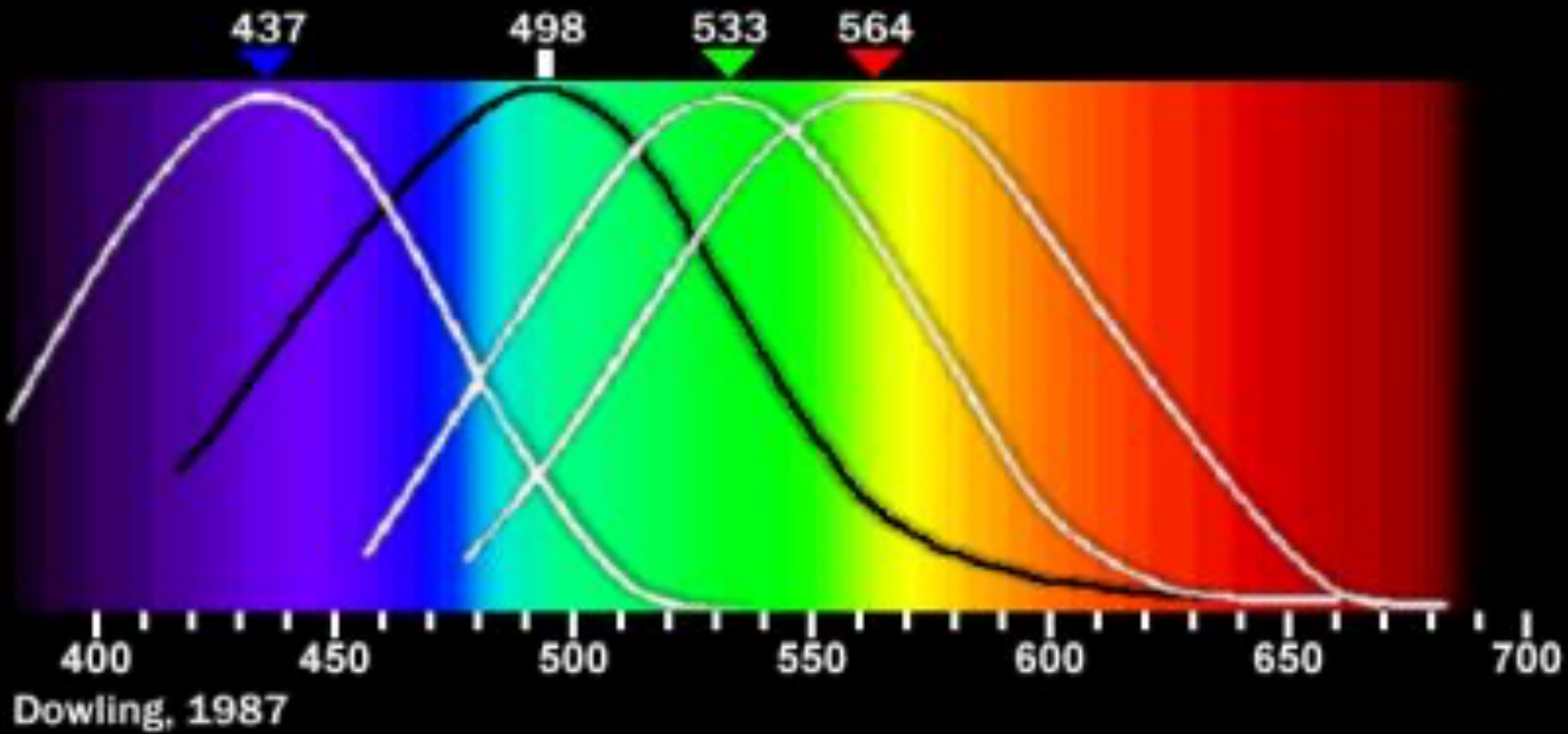
Pratique o que aprendeu





Luz e cor

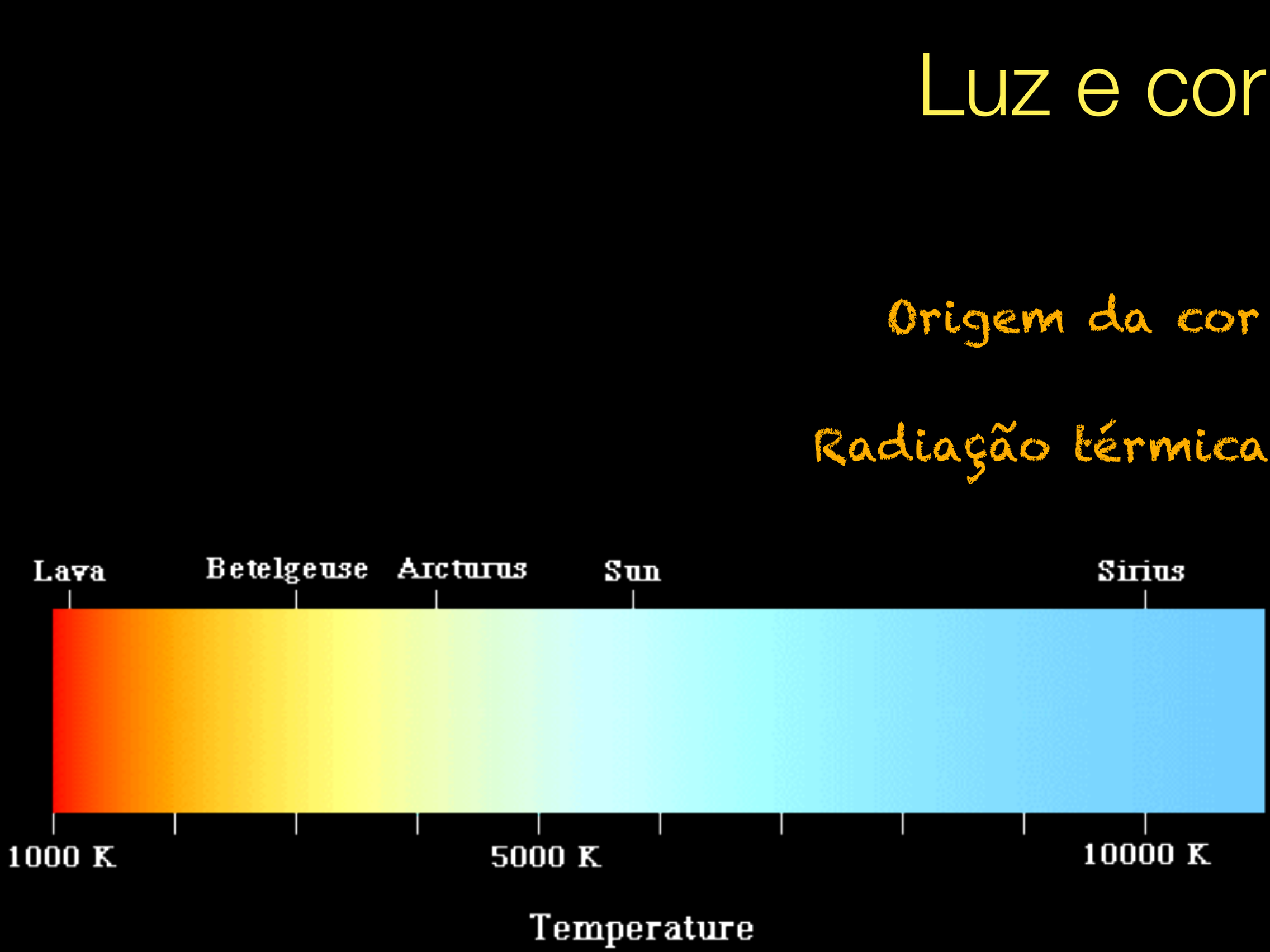
Visão



Luz e cor

Origem da cor

Radiação térmica



Luz e cor

Origem da cor

Radiação de reações químicas

Luz e cor

Origem da cor

Reflexão