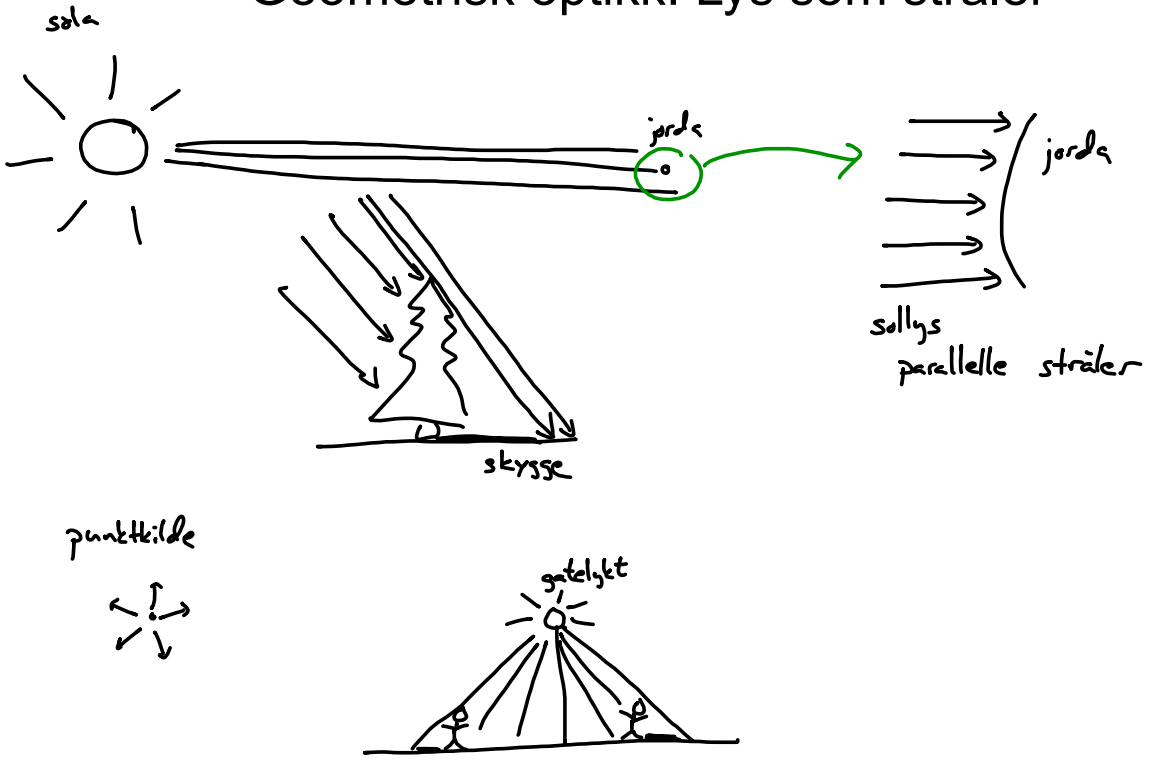

Hva er et speilbilde?

Geometrisk optikk: Lys som stråler

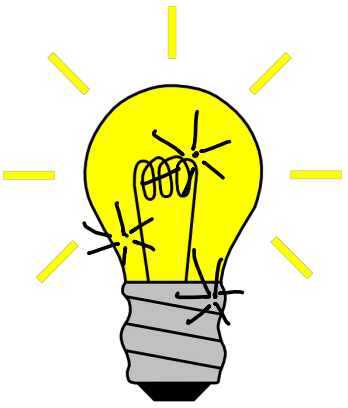
Bilde: Ishikawa Ken/Flickr/Shadow/CC license

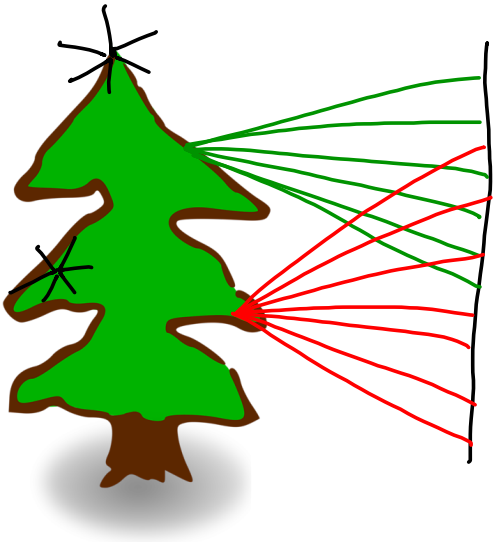
- Lys beveger seg rett linje gjennom et homogent medium

Geometrisk optikk: Lys som stråler

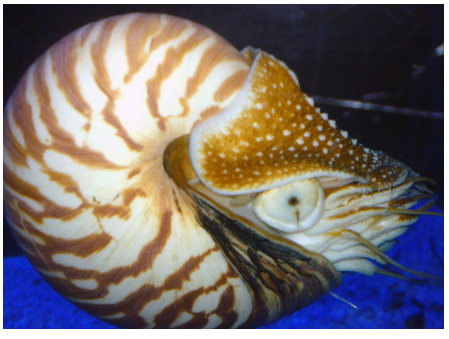


Objekt: Samling av punktkilder





Øyet til Nautilus Pompilius - et biologisk *Camera Obscura*



https://commons.wikimedia.org/wiki/File:Nautilus_Pompilius.jpg

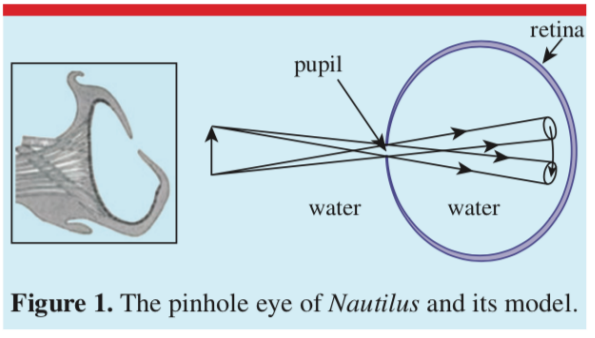
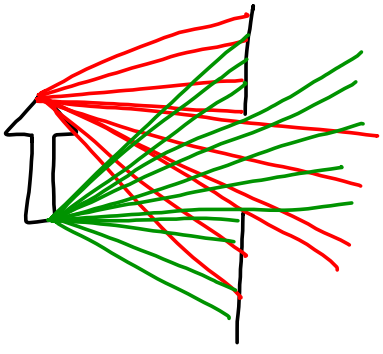


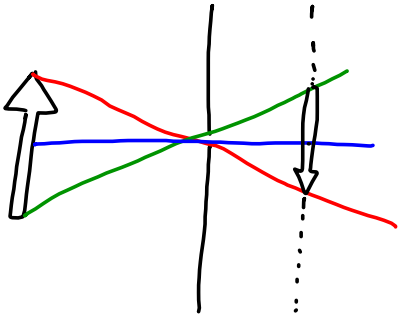
Figure 1. The pinhole eye of *Nautilus* and its model.

Kaltakci and Eryilmaz, Physics Education 46 (2011)

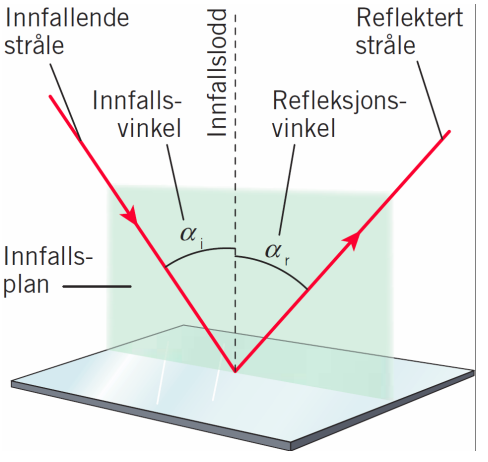
https://youtu.be/gvzpu0Q9RTU

Camera Obscura - Hullkamera (pinhole)

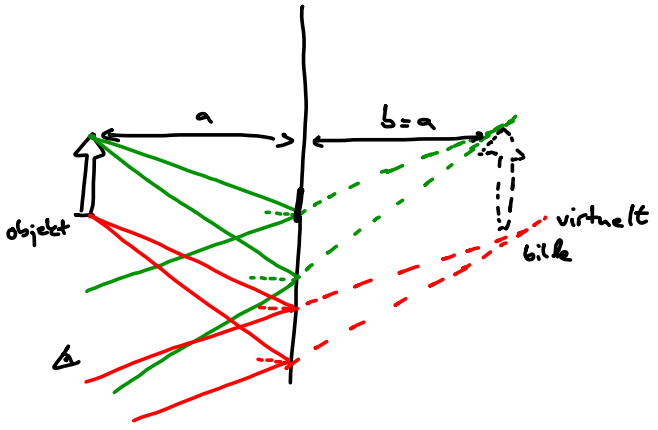




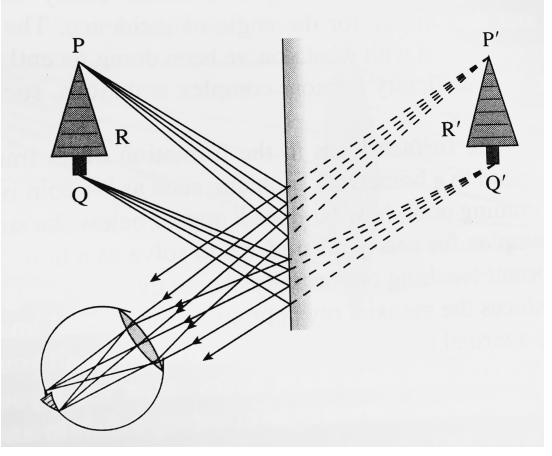
Refleksjon


Innfallende stråle
Innfalls-vinkel
Innfallslodd
Refleksjons-vinkel
Reflektert stråle
α_i
α_r
Innfalls-plan

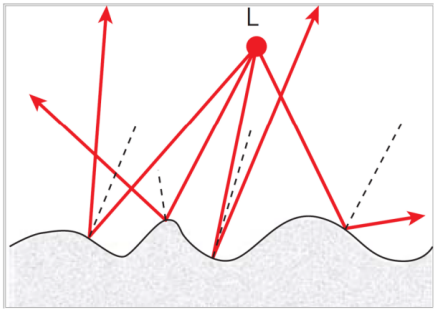
Plant speil



Speilbilde



Diffus refleksjon



«perfekt»

diffus

Kamskjellets speiløyne

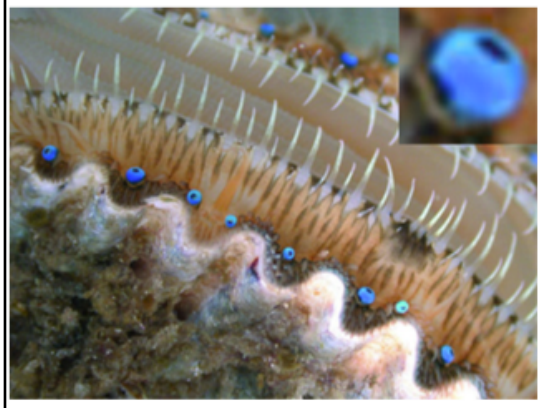


Figure 1. Close-up view of the brilliantly iridescent blue eyes of a scallop. (Picture by Dr W Capman, Minneapolis, Minnesota.)

Colicchia *et al.*, Physics Education 44 (2009)

Flickr/Christian Gloor/Blue Eyes/CC license

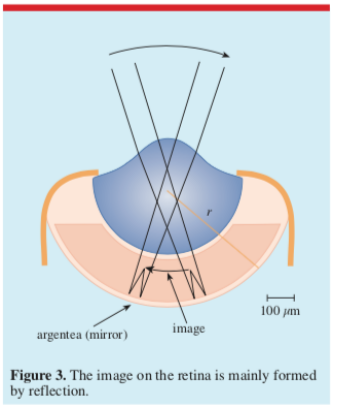
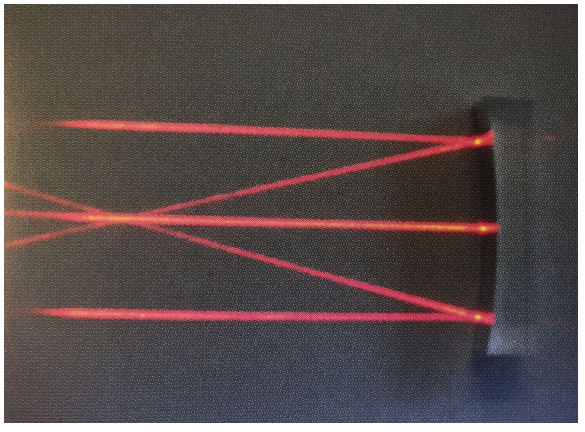
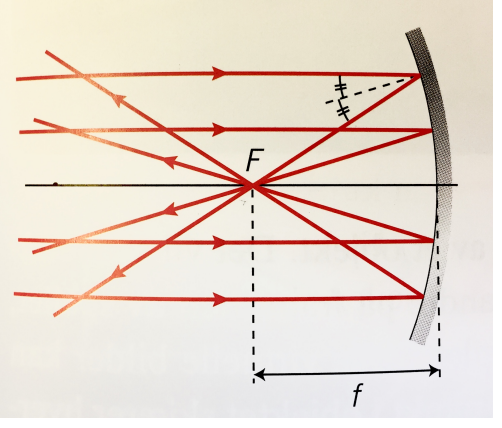


Figure 3. The image on the retina is mainly formed by reflection.

Colicchia *et al.*, Physics Education 44 (2009)

Konkavt speil



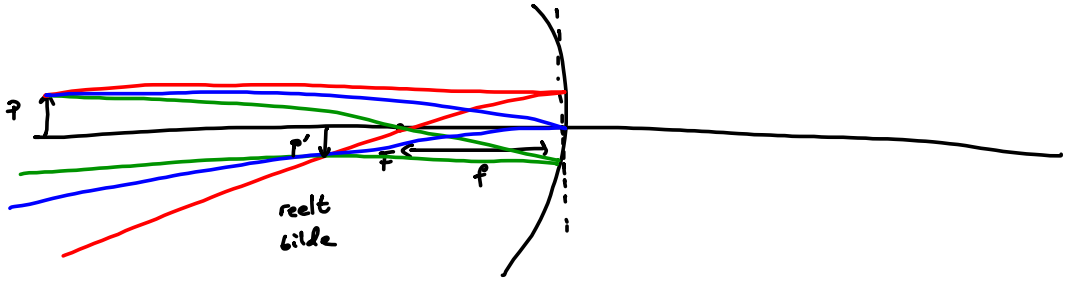


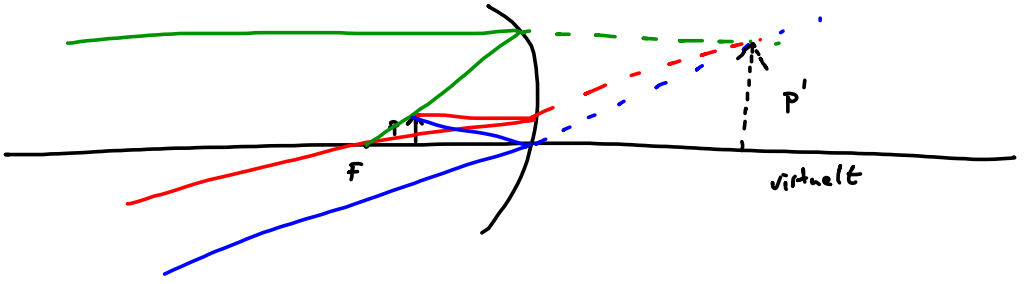
F: Brennpunkt

f: brennvidde

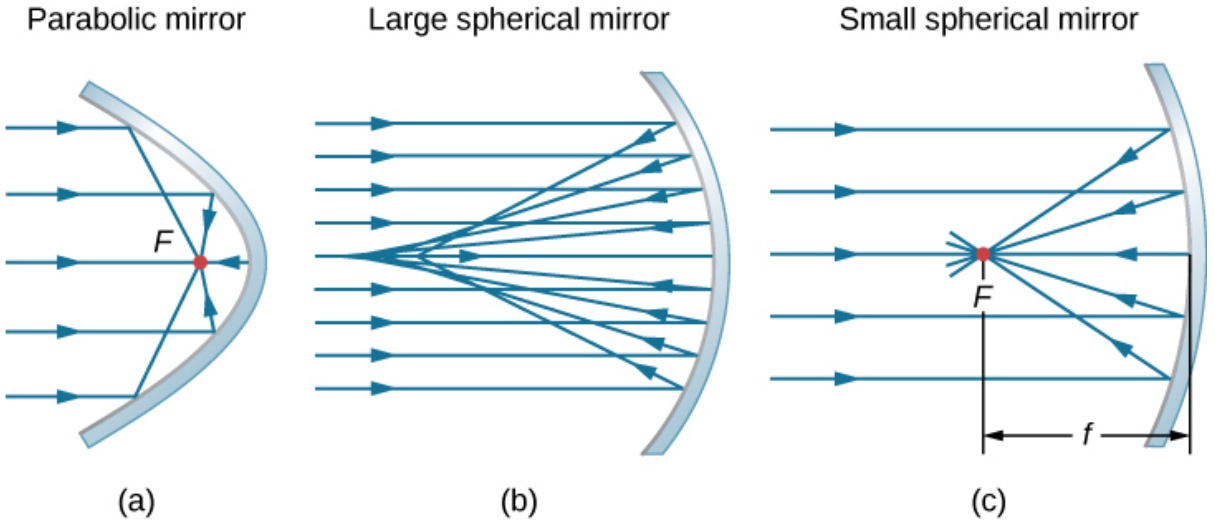
Konstruksjon av bilde

1. Parallell med aksen inn, gjennom brennpunktet ut
2. Gjennom brennpunktet inn, parallell med aksen ut
3. Refleksjon med samme vinkel i midtpunktet





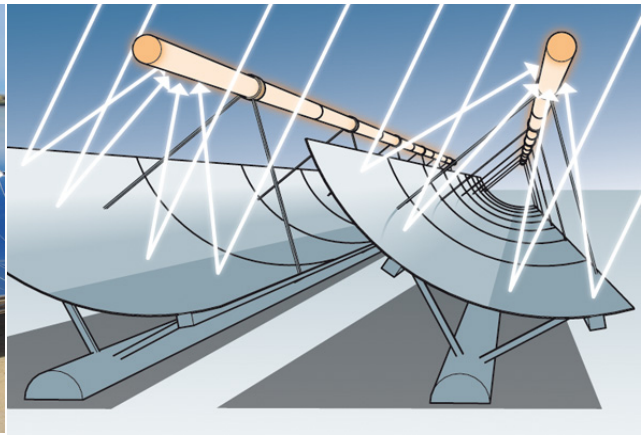
Parabolspeil og sfæriske speil



https://phys.libretexts.org/TextMaps/University_Physics_TextMaps/Map%3A_University_Physics_(OpenStax)/Map%3A_University_Physics_III_-_Optics_and_Modern_Physics_(OpenStax)/2%3A_Geometric_Optics_and_Image_Formation/2.2%3A_Spherical_Mirrors

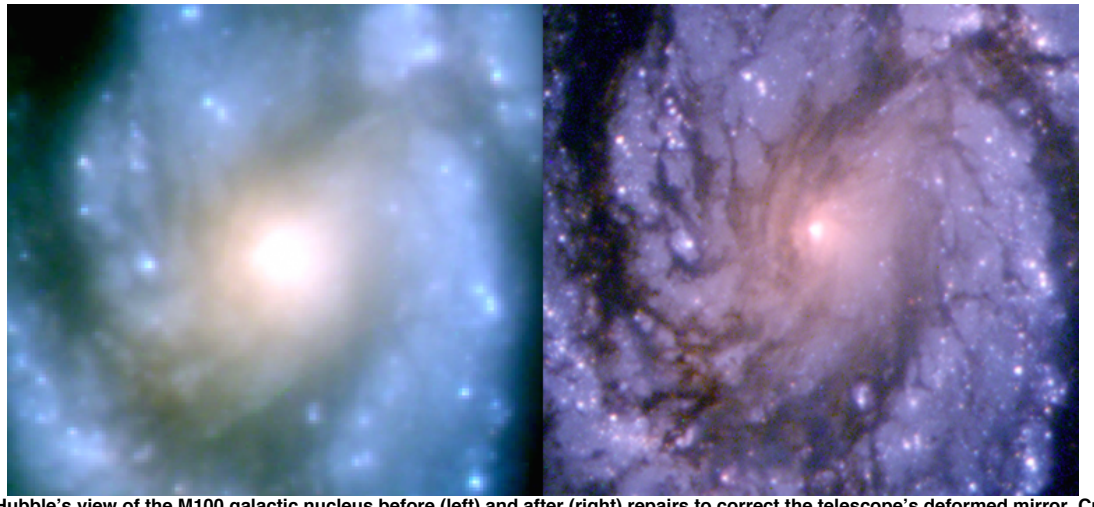
Parabolspeil som solfanger

https://www.renewableenergyworld.com/articles/2015/06/solar-thermal-desalination-now-underway-in-water-hungry-cali-fornia.html



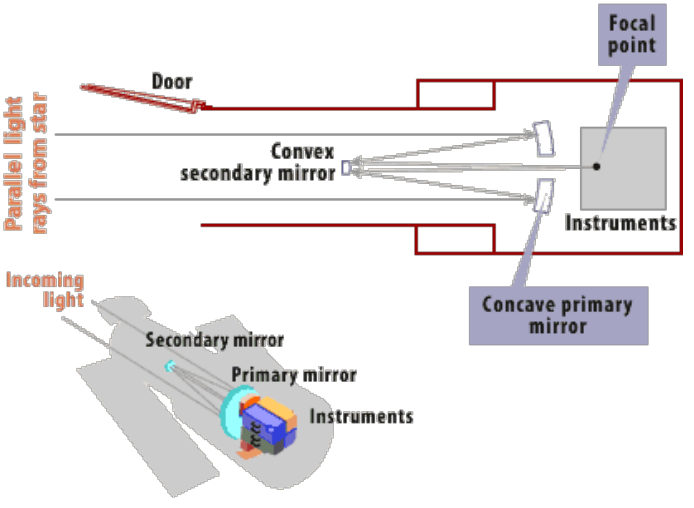
http://streammisr.com/l3.php?id=164

Hubble-teleskopet



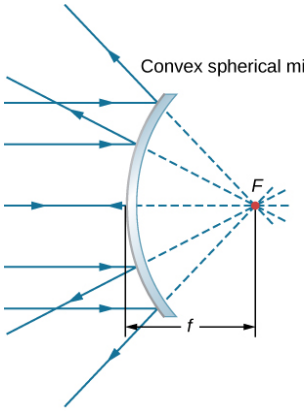
Hubble's view of the M100 galactic nucleus before (left) and after (right) repairs to correct the telescope's deformed mirror. Credit: NASA/ STScI/JPL

https://spaceflightnow.com/2015/04/23/fixing-hubbles-blurry-vision/



https://amazing-space.stsci.edu/resources/explorations/groundup/lesson/basics/g28a/

Konvekst speil



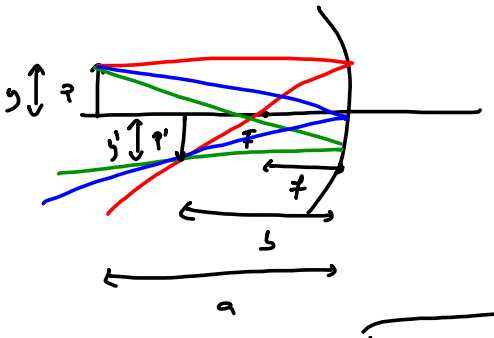
(a)

(b)

https://phys.libretexts.org/TextMaps/University_Physics_TextMaps/Map%3A_University_Physics_(OpenStax)/Map%3A_University_Physics_III_-_Optics_and_Modern_Physics_(OpenStax)/2%3A_Geometric_Optics_and_Image_Formation/2.2%3A_Spherical_Mirrors

Bilde i konvekst speil

Speilformelen og forstørring



speilformelen:

$$\frac{1}{a} + \frac{1}{b} = \frac{1}{f}$$

objekt-avstand, bilde-avstand, brennvidde

Lengdeforstørring

$$m = \frac{y'}{y} = \frac{|b|}{|a|}$$

$f > 0$, konkav
$f < 0$, konveks
$b > 0$, reelt bilde
$b < 0$, virtuelt

Eksempel: $a = 12\,\text{mm}$

$f = 4{,}0\,\text{mm}$, konkav

$b = ?$

$$\frac{1}{a} + \frac{1}{b} = \frac{1}{f}$$

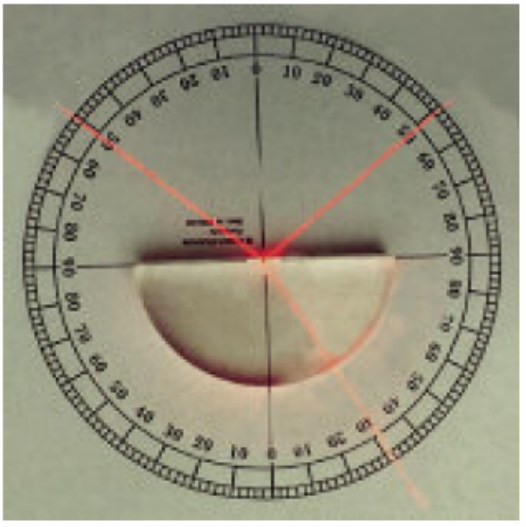
$$\frac{1}{b} = \frac{1}{f} - \frac{1}{a} = \frac{a}{af} - \frac{f}{af} = \frac{a-f}{af}$$

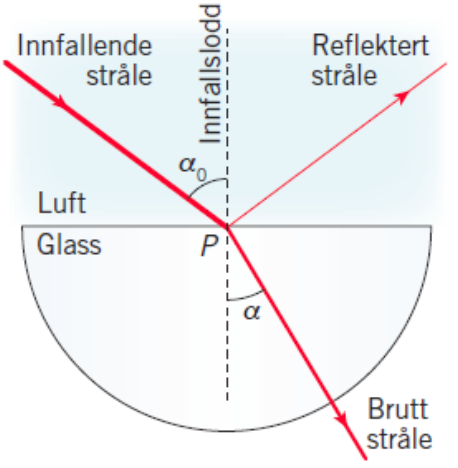
$$b = \frac{af}{a-f} = \frac{(12 \cdot 4)\,\text{mm}^2}{12-4\,\text{mm}} = 6\,\text{mm}$$


Hva er et speilbilde?

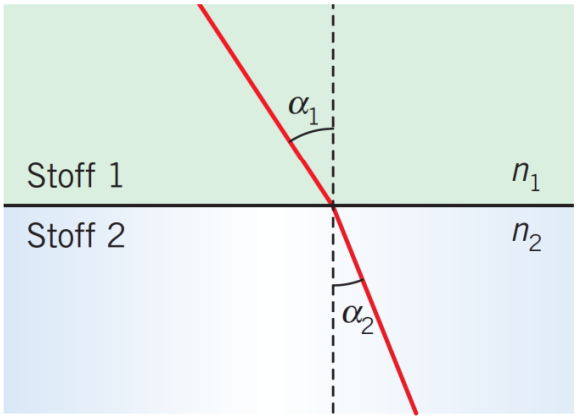
Bilde: Ano Lobb/Summer time Boy Underwater/Flickr/CC license

Brytning




Innfallende stråle
Innfallslodd
Reflektert stråle
α_0
Luft
Glass
P
α
Brutt stråle

Snells brytningslov



$$\frac{\sin\alpha_1}{\sin\alpha_2} = \frac{c_1}{c_2}$$ ← lysfart i stoffet

brytningsindeks $n = \frac{c_0}{c}$ ← lysfart i vakuum

$$c = \frac{c_0}{n}$$

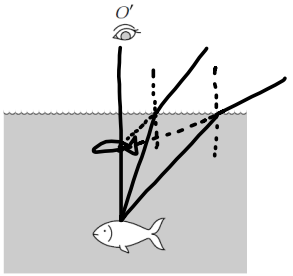
$$\frac{\sin\alpha_1}{\sin\alpha_2} = \frac{\cancel{c_0}}{n_1} \cdot \frac{n_2}{\cancel{c_0}} = \frac{n_2}{n_1}$$

$$n_1 \sin\alpha_1 = n_2 \sin\alpha_2$$

Brytningsindeks for noen stoffer

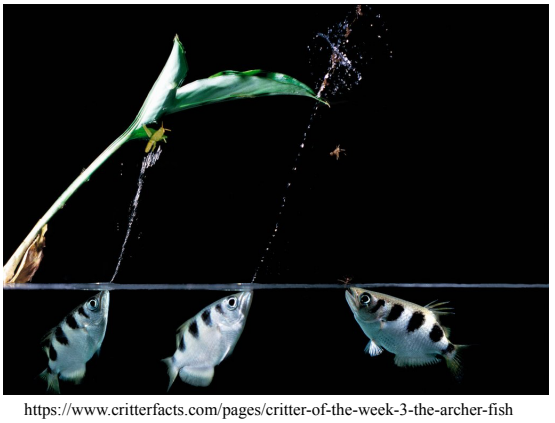
Luft	1,0003
Vann	1,33
Is	1,31
Pleksiglass	1,48
Kronglass	1,51
Kvartskrystall	1,54
Plast (polystyren)	1,59
Flintglass	1,61
Diamant	2,42

A fish swims below the surface of the water. Suppose an observer is looking at the fish from point O'—straight above the fish. The observer sees the fish at

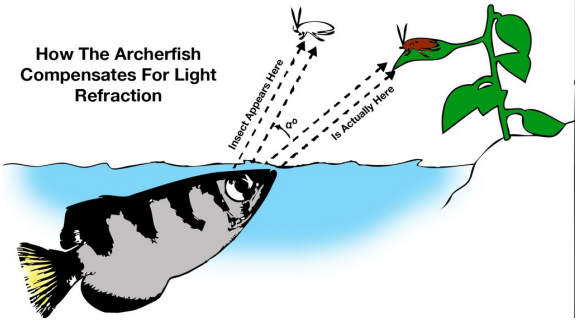


1. a greater depth than it really is.
2. the same depth.
3. a smaller depth than it really is.

Skytterfisken må ta hensyn til lysbrytning

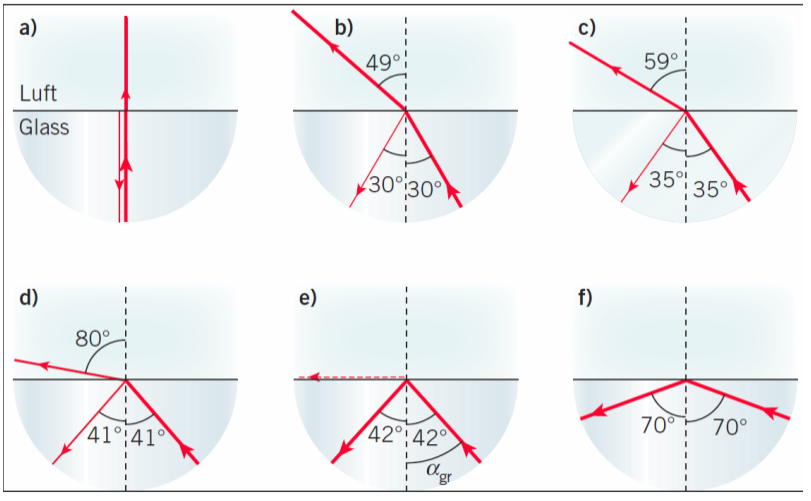


https://www.critterfacts.com/pages/critter-of-the-week-3-the-archer-fish



https://www.critterfacts.com/pages/critter-of-the-week-3-the-archer-fish

Totalrefleksjon



$n_1 \sin\alpha_1 = n_2 \sin\alpha_2$

$\alpha_2 = 90^\circ \Rightarrow \sin\alpha_2 = \sin 90^\circ = 1$

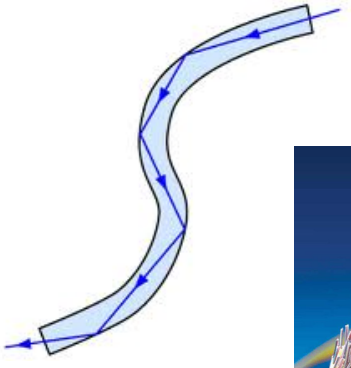
$\alpha_1 = \alpha_g$ grensevinkel

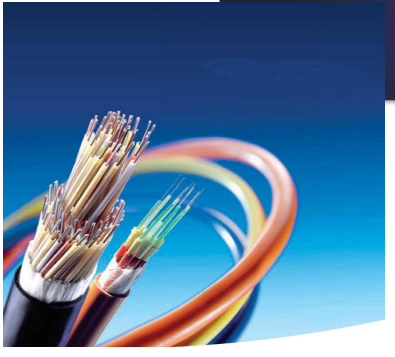
totalreflekssjon når $\alpha_1 > \alpha_g$

$n_1 \sin\alpha_g = n_2$

$\alpha_g = \sin^{-1}\left(\frac{n_2}{n_1}\right)$

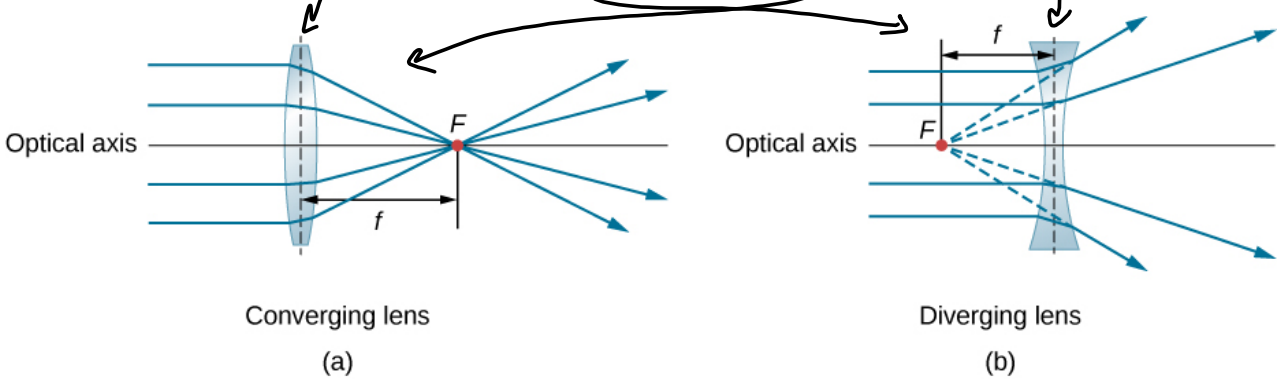
Optisk fiber





En optisk fiber leder lyset fra ene enden til andre, selv om den ikke er rett. Lyset totalreflekteres mange ganger på veien.

Konvekse og konkave linser
Spredelinser og samlelinser



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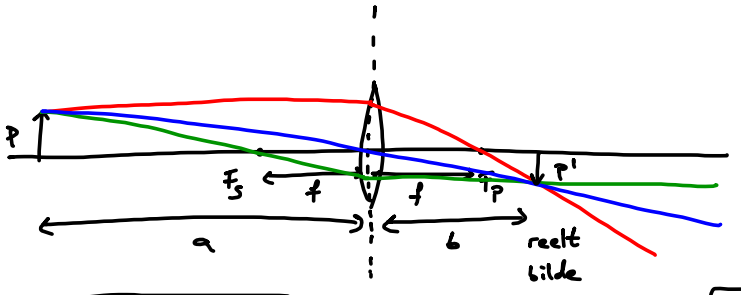
Bilde i konveks linse

samlelinse



Linseformelen

$$\frac{1}{a} + \frac{1}{b} = \frac{1}{f}$$

$f > 0$ samlelinse

$f < 0$ spredelinse

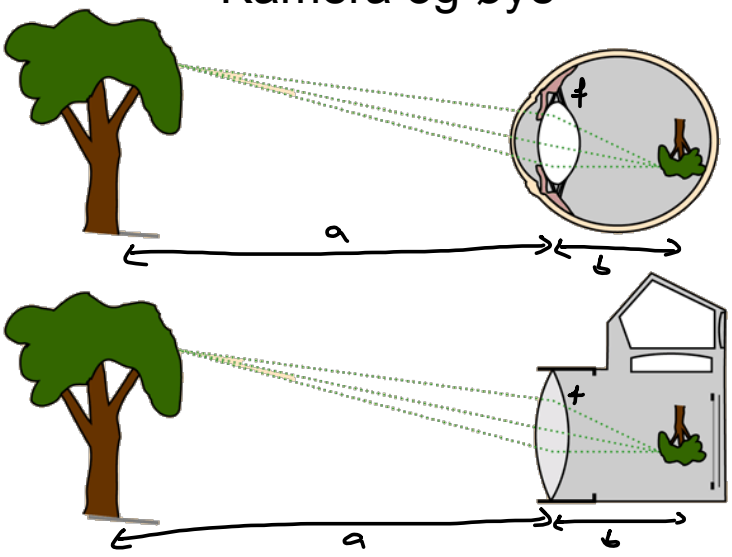
$b > 0$ reelt bilde

$b < 0$ virtuelt bilde

Lengdeforstørring

$$m = \frac{|b|}{|a|}$$

Kamera og øye



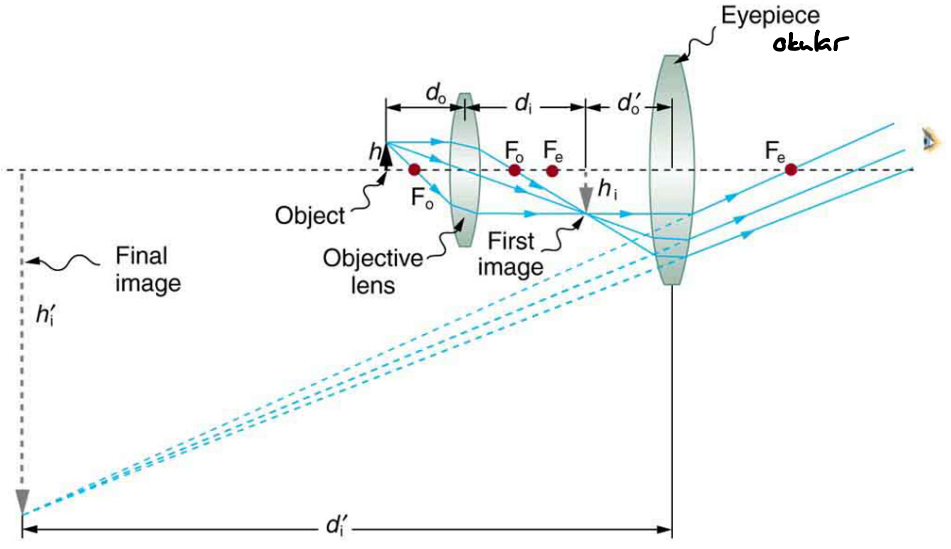
http://hyperphysics.phy-astr.gsu.edu/hbase/vision/rfreye.html#c2

$\frac{1}{a} + \frac{1}{b} = \frac{1}{f}$

b konstant

f forandrer seg

Mikroskopet



https://courses.lumenlearning.com/physics/chapter/26-4-microscopes/

$a_{ob} = 6{,}20\,mm$

$f_{ob} = 6{,}00\,mm$

$f_{ok} = 50{,}0\,mm$

$L_{ob-ok} = 23{,}0\,cm$

$m = ?$

$m = m_{ob} \cdot m_{ok}$

objektiv: $\frac{1}{a} + \frac{1}{b} = \frac{1}{f}$

$\frac{1}{b} = \frac{1}{f} - \frac{1}{a} = \frac{a}{af} - \frac{f}{af}$

$b = \frac{af}{a-f} = \frac{(6{,}20 \cdot 6{,}00)\,mm^2}{0{,}20\,mm} = 186\,mm$ reelt bilde

$m_{ob} = \frac{|b|}{|a|} = 30{,}0$

okular: $a_{ok} = 230\,mm - 186\,mm = 44{,}0\,mm$

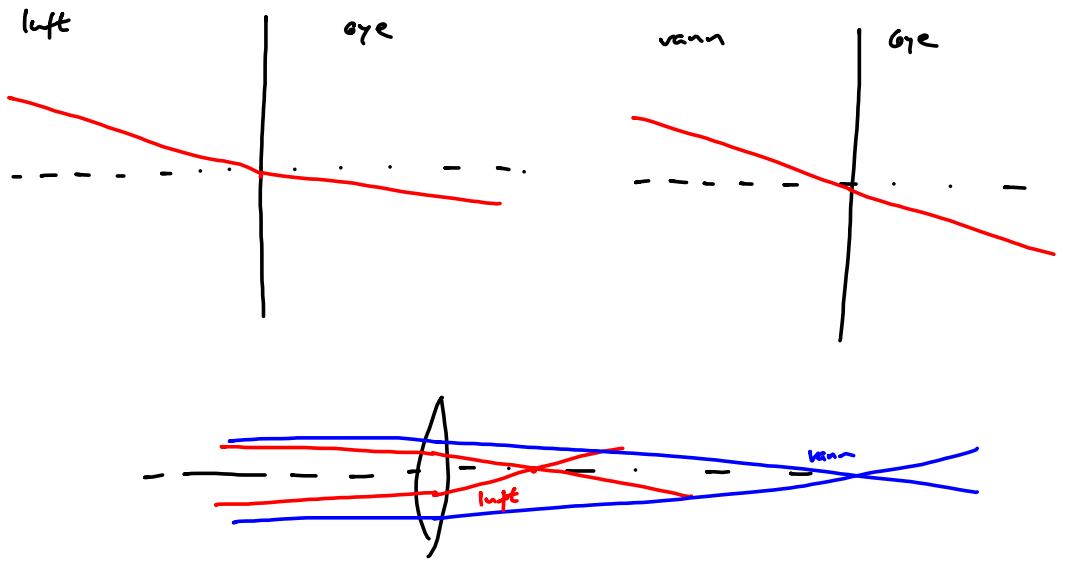
$b = \frac{af}{a-f} = \frac{(44{,}0 \cdot 50{,}0)\,mm^2}{-6{,}0\,mm} = -367\,mm$ virtuelt

$m_{ok} = \frac{367\,mm}{44{,}0\,mm} = 8{,}33$

$m = m_{ob} \cdot m_{ok} = 250$

Linse i vann

Oppgitt brennvidde gjelder for linse i luft!



Bilde: Ano Lobb/Summer time Boy Underwater/Flickr/CC license