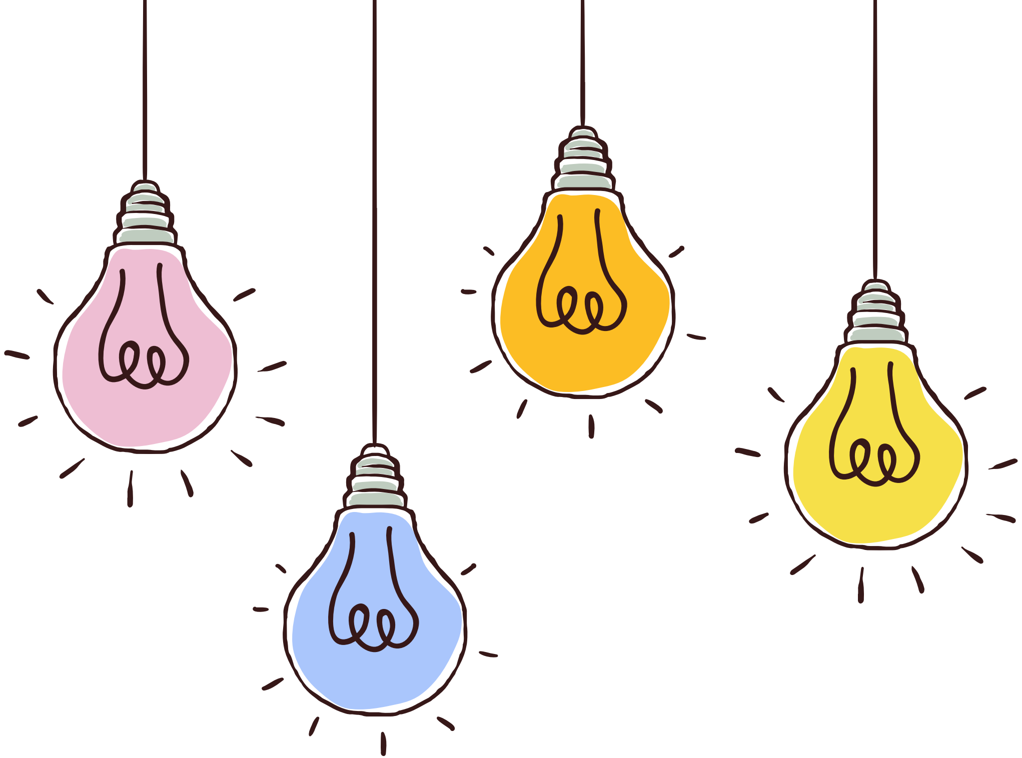

Light & Vision

Pouya Taghipour

Dr. Malikeh Nabaei

Spring 2024

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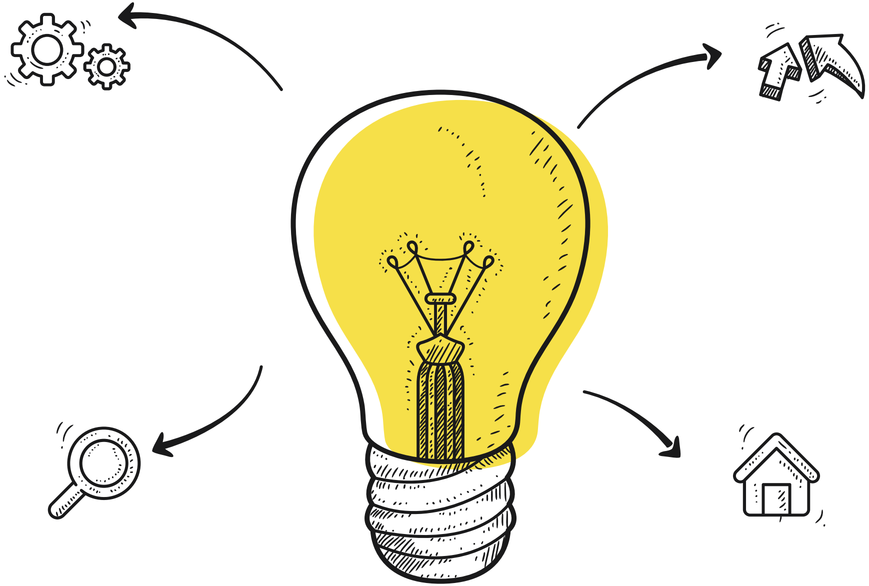
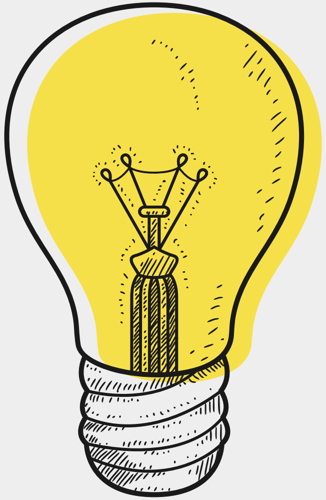


01

Overview



Final Exam

Electrical Properties of Body

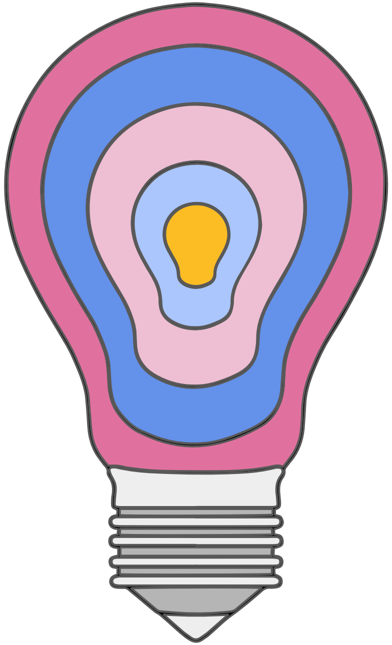
Electrical Properties of Body

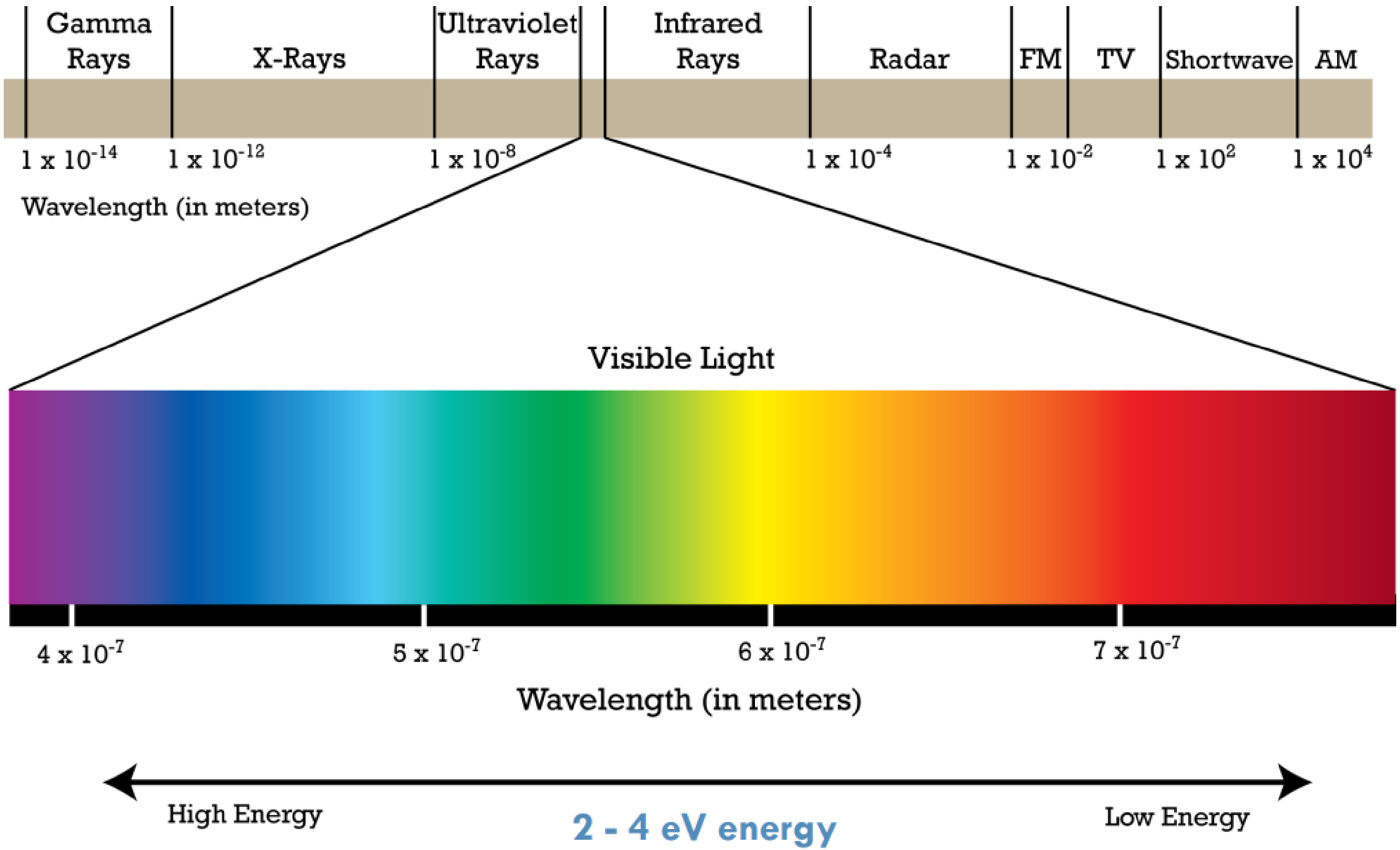
Sound, Hearing, Speech

Light & Vision

Introduction

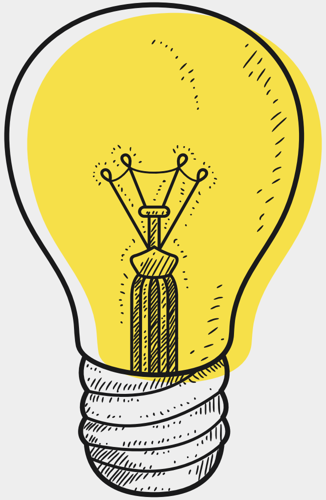
Our eyes image a source onto light-sensitive retinas. Cells in the retina convert the imaged light into electrical signals. This information is carried to the brain by neurons via the optic nerve. The visual cortex in the brain processes this information, and we somehow perceive a visual image. Each of these four steps in the vision process is important and contains interesting physics. The physics of the first step is the optics of imaging the source onto the retina and the second is the quantum physics of the absorption of light by the retina. The physics of the conduction of electrical signals in nerves is step three and we will discuss this in. Physical processes and processing are also important in the fourth step, within the. In this chapter, we will focus on the physics of imaging and briefly consider the absorption of light by retinal cells. Feedback and control are also important in vision. For example, the body controls the focal length of the eye lens (accommodation) to enable the imaging of both near and far objects and changes the diameter of the pupil to adjust the amount of light entering the eye

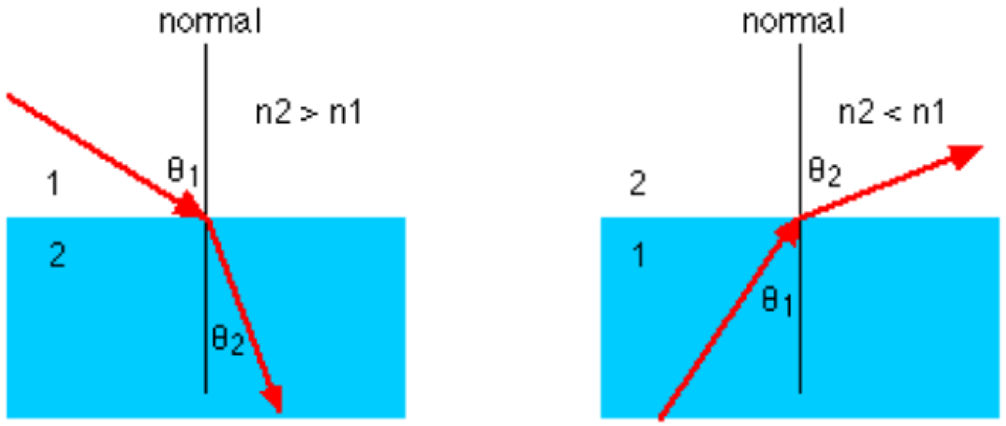



Gamma Rays
X-Rays
Ultraviolet Rays
Infrared Rays
Radar
FM
TV
Shortwave
AM
1 x 10-14
1 x 10-12
1 x 10-8
1 x 10-4
1 x 10-2
1 x 102
1 x 104
Wavelength (in meters)
Visible Light
4 x 10-7
5 x 10-7
6 x 10-7
7 x 10-7
Wavelength (in meters)
High Energy
Low Energy
2 - 4 eV energy

02

Generals

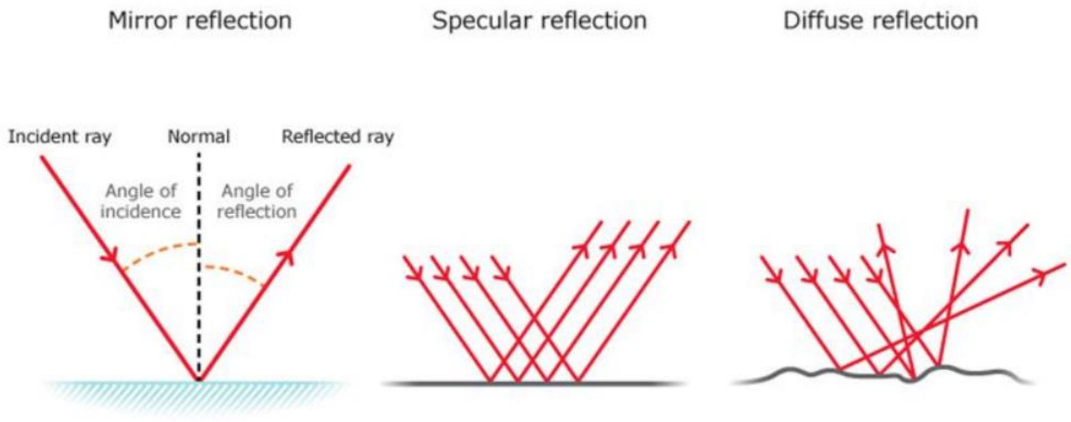




Snell's law : $n_1 \sin\theta_1 = n_2 \sin\theta_2$ or, equivalently, $\sin\theta_1 / \sin\theta_2 = v_1 / v_2$

index of refraction : $n = c / v$ **c: light speed in vacuum**

v: light speed in medium

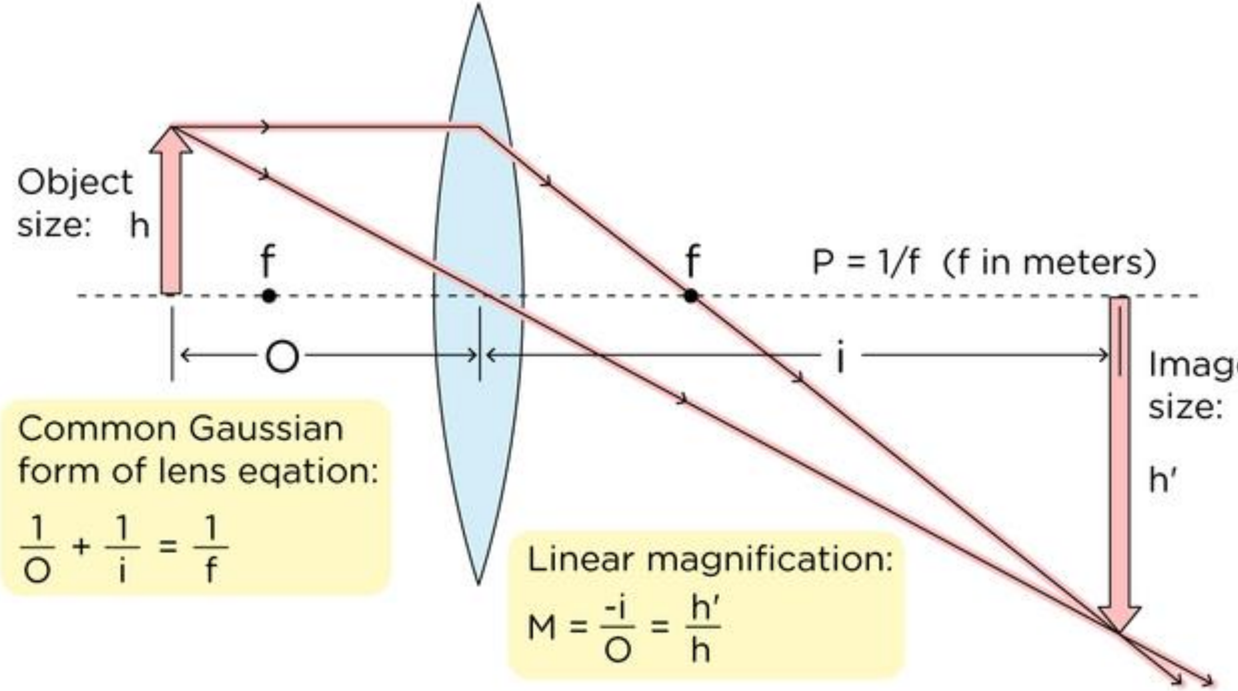

Mirror reflection
Specular reflection
Diffuse reflection
Incident ray
Normal
Reflected ray
Angle of incidence
Angle of reflection

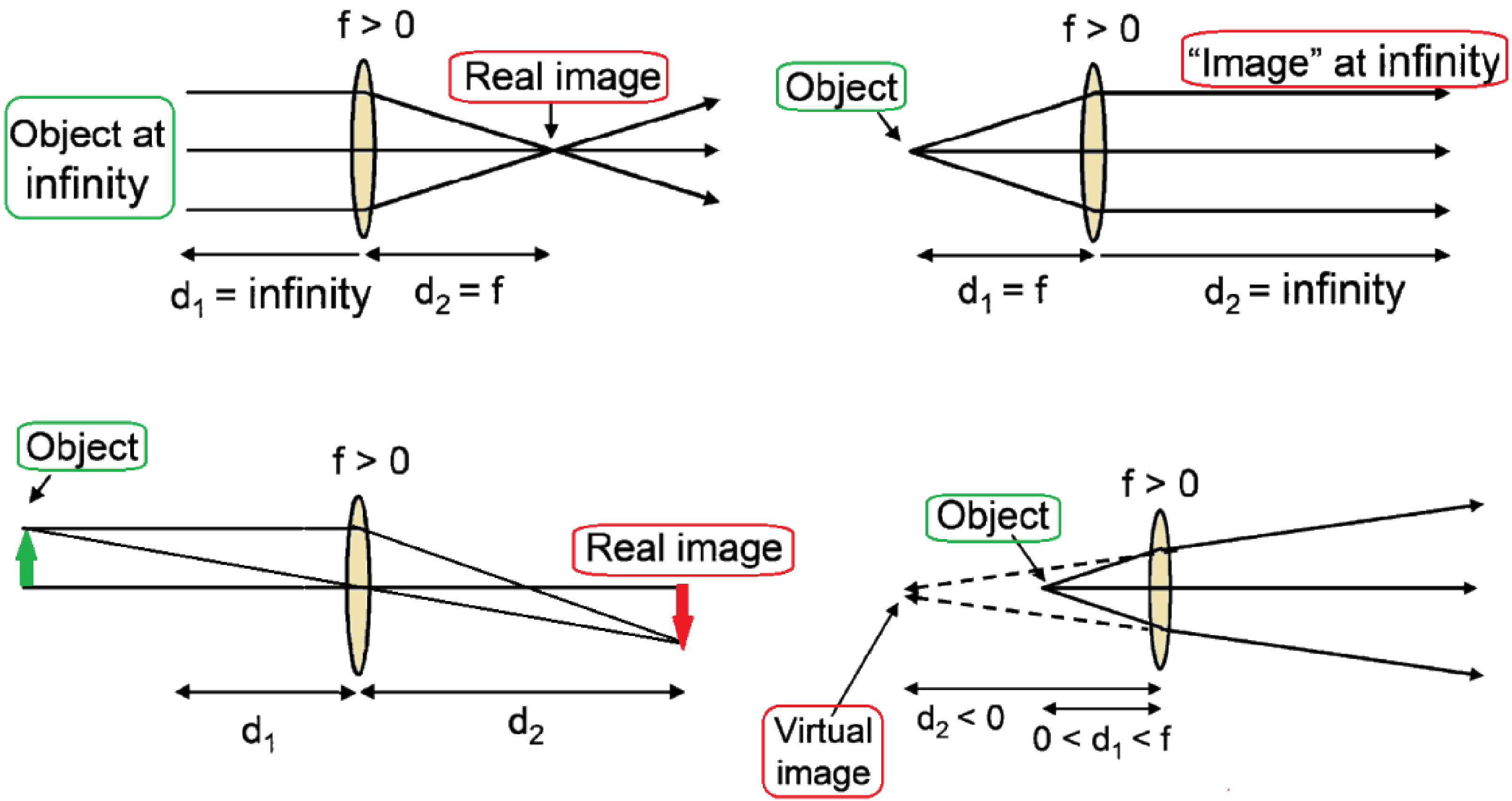
Eyesight

Eyes that focus an image of the outside world on the retina.

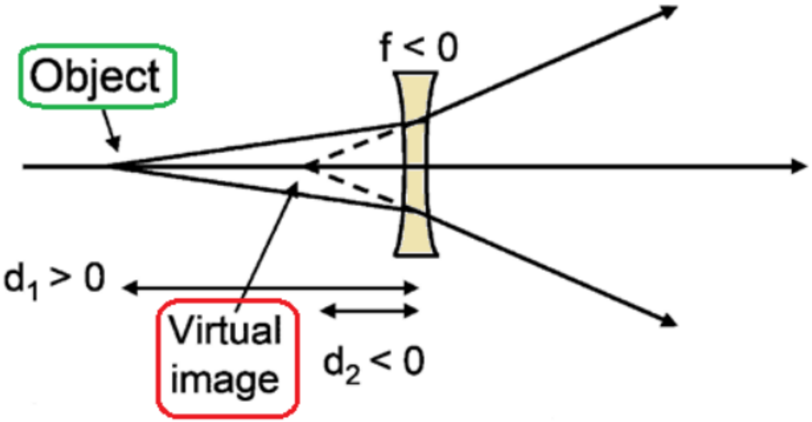
Nerves that send information to the brain.

The visual cortex of the brain that analyzes information.

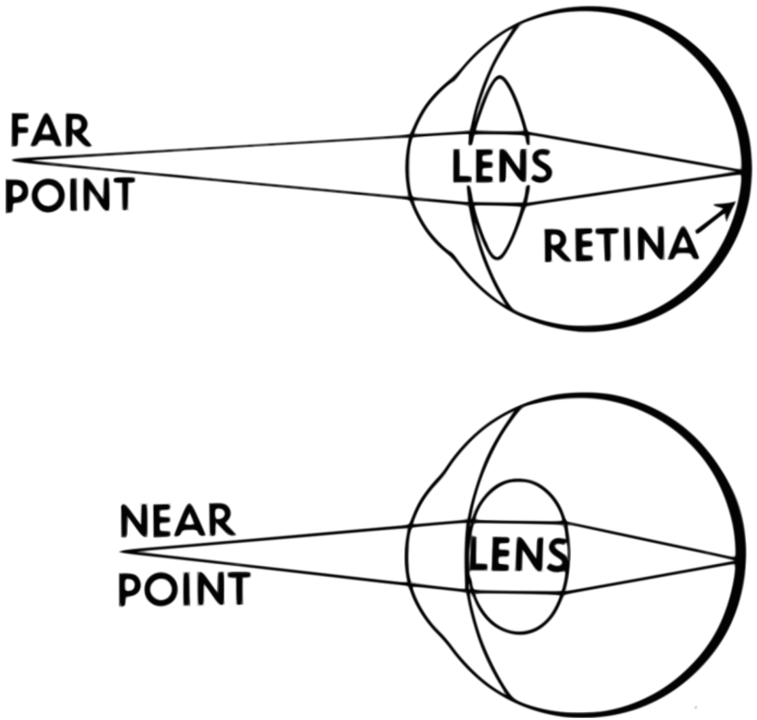

Object
size: h
f
f
P = 1/f (f in meters)
O
i
Image
size:
h′
Common Gaussian
form of lens eqation:
$\frac{1}{O} + \frac{1}{i} = \frac{1}{f}$
Linear magnification:
$M = \frac{-i}{O} = \frac{h'}{h}$

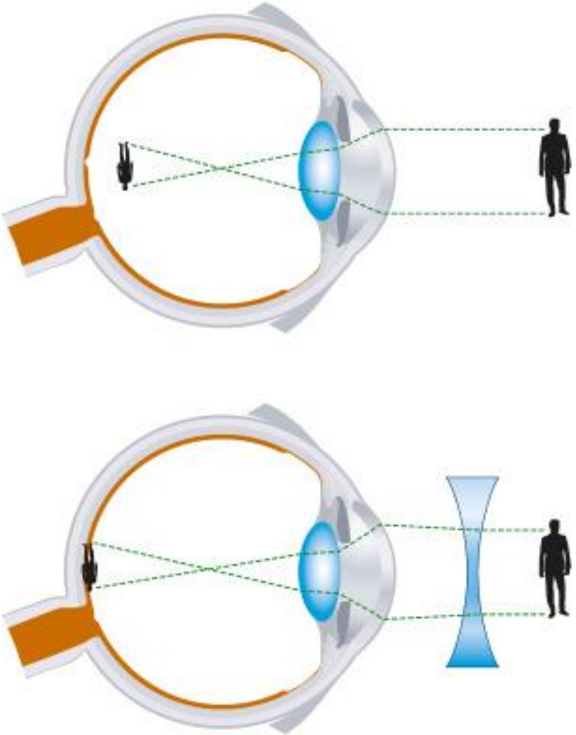


f > 0
Real image
Object at infinity
d1 = infinity
d2 = f
f > 0
"Image" at infinity
Object
d1 = f
d2 = infinity
Object
f > 0
Real image
d1
d2
f > 0
Object
Virtual image
d2 < 0
0 < d1 < f

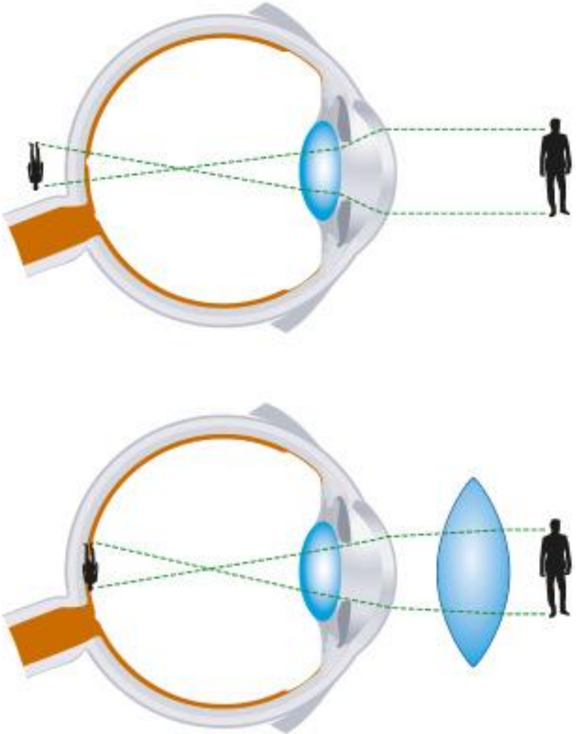


$$\frac{1}{d_1} + \frac{1}{d_2} = \frac{1}{f}.$$

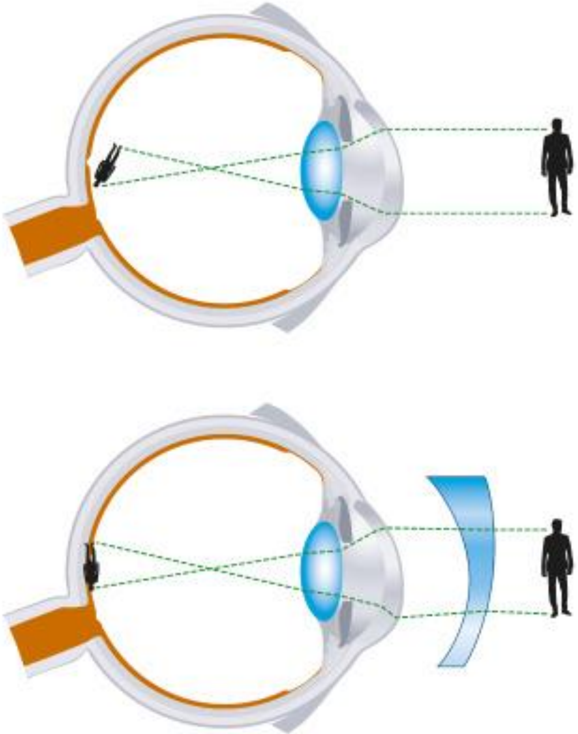

FAR
POINT
LENS
RETINA
NEAR
POINT
LENS



Myopia



Hyperopia



Astigmatism

03

Examples

Example 8-1

A person can focus his eye between 57 and 59 diopters. This person can clearly see a periodic star with a relaxed lens.

A. What is the distance from the retina to the lens (eyeball length) of this person?

B. Where is this person's closest point?

C. What kind of glasses should this person use to bring his near point to the normal state (25 cm)?

Example 8-1

Answer:

A)

$$\frac{1}{d_1}+\frac{1}{d_2}=\frac{1}{f} \longrightarrow \frac{1}{\infty}+\frac{1}{d_2}=+57$$

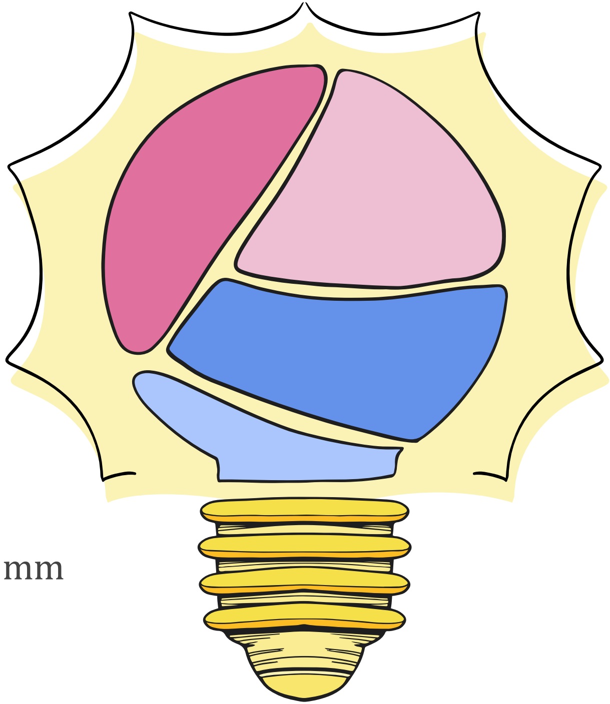
$$d_2=\frac{1}{57}=0.0175 \longrightarrow \text{eyeball length: } 17.5\ \text{mm}$$

B)

$$\frac{1}{d_1}+\frac{1}{d_2}=\frac{1}{f} \xrightarrow{\frac{1}{d_2}=57} \frac{1}{d_1}+57=59 \rightarrow d_1=50\ cm$$

C)

$$\frac{1}{0.25}+57=\frac{1}{f} \rightarrow \frac{1}{f}=61 \rightarrow This\ personneeds\ a\ pair\ of\ glasses\ with\ a\ positive\ power\ of\ 2\ and\ a\ \color{red}{convex\ shape}$$



Example 8-2

If a ray with an angle of 20 degrees (relative to the perpendicular line) hits the surface of the cornea, will the ray entering the cornea have a smaller angle than the perpendicular line or a larger one? Assume that the surface of the cornea is flat.

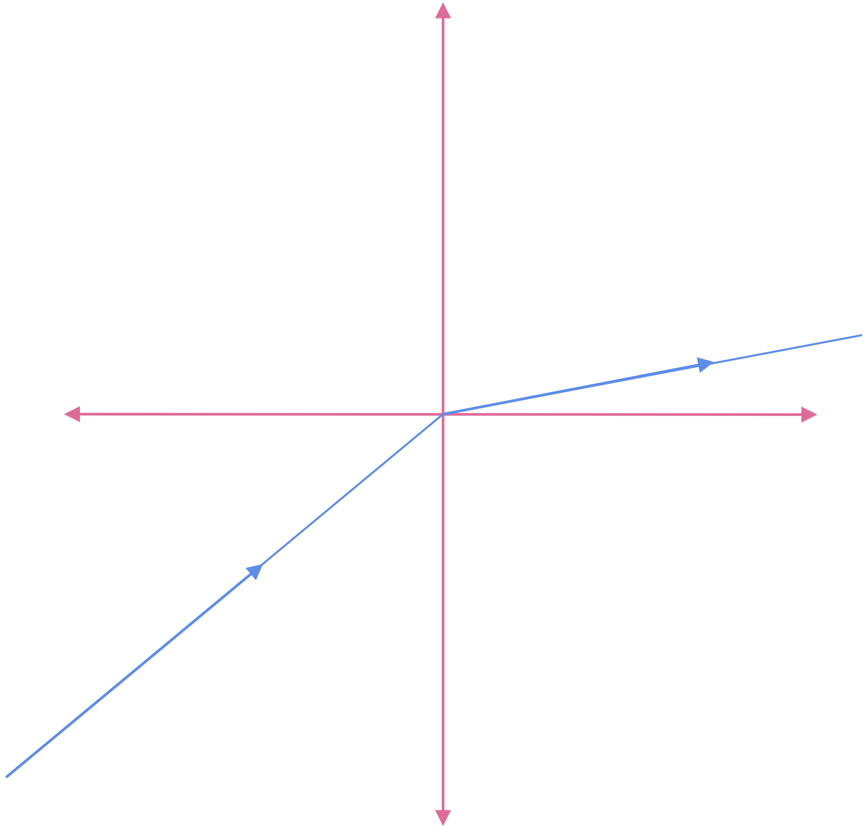
Example 8-2

Answer:

$n_{air} = 1\,, n_{Cornea} = 1.37$

$snell's\ law\ n_1 sin\theta_1 = n_2 sin\theta_2 \ \rightarrow \dfrac{n_1}{n_2} = \dfrac{sin\theta_2}{sin\theta_1}$

$n_{cornea} > n_{air} \rightarrow \ \theta_{cornea} < \ \theta_{air}$



Example 8-3

A person with Hyperopia uses D2 glasses to read 25 cm. What is his near vision without glasses?

Example 8-3

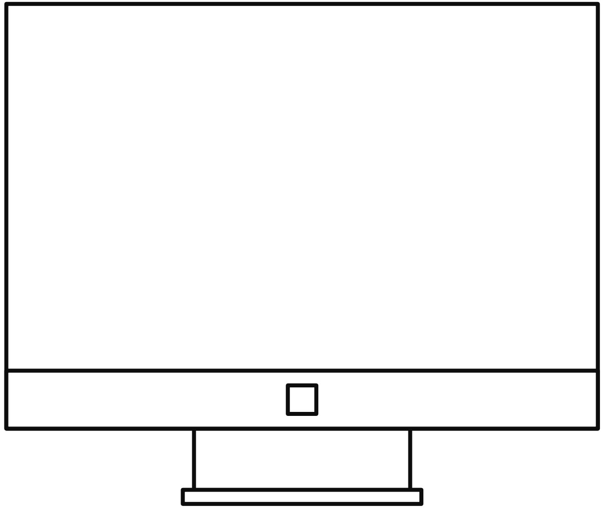
Answer:

$$\left.\begin{array}{r}\dfrac{1}{x}+\dfrac{1}{d_2}=\dfrac{1}{f}\\[2ex]\dfrac{1}{0.25}+\dfrac{1}{d_2}=\dfrac{1}{f'}=\dfrac{1}{f}+2D\end{array}\right\}\dfrac{1}{0.25}+\dfrac{1}{d_2}=\left(\dfrac{1}{x}+\dfrac{1}{d_2}\right)+2$$

$$\rightarrow \frac{1}{x}=2 \;\rightarrow x=0.5\ m\ or\ 50\ cm$$

04

Assignment

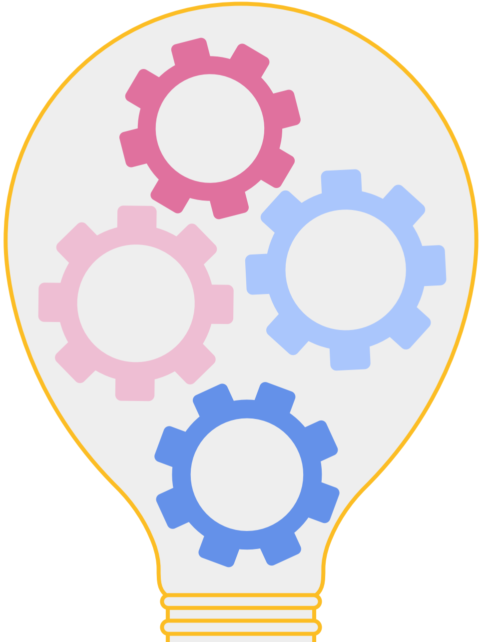


HWh07

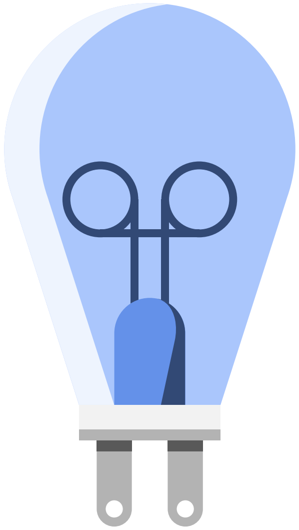
HWc07

HWc07

As you know, there are two groups of light-sensitive cells in the retina. Check these two groups in terms of different characteristics.



Resources



Dr. Malikeh Nabaei:

- Slides
- Classes

Faezeh Jahani:

- Slides

biological and medical physics, biomedical engineering

- The reference book

Thanks!

Does anyone have any questions?

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@PouyaTghpr
Pouya Taghipour

Some Icons are taken from “Vector Icons and Stickers” and all the pictures are taken from the web

Have a good afternoon