Physics 122 – Class #4 – Outline

- Announcements/Reading Assignment
- Lab 1 – Refraction/Dispersion/Polarization
- Ray model of light why you see
- Lenses / Real and Virtual images
- Examples

Announcements

- You have to pay for the clicker "Reg Code" (unless new clicker)
- Did you get my e-mail?
- You may try iGo clicker if you do not have a clicker. Clickers work better …
    - Registration may not work.
- Homework WR-01 due in class next Tuesday. Homework OL-02 due Saturday.

Reading Assignment (next class)

Chapter 20 sections 20.1—20.5

Try to understand why

$$D(x,t) = A\sin(kx - \omega t + \varphi_0)$$

Describes a wave traveling to the right.

What is phase? (needed for interference)

$$k = \frac{2\pi}{\lambda} \qquad \omega = \frac{2\pi}{\text{period}}$$

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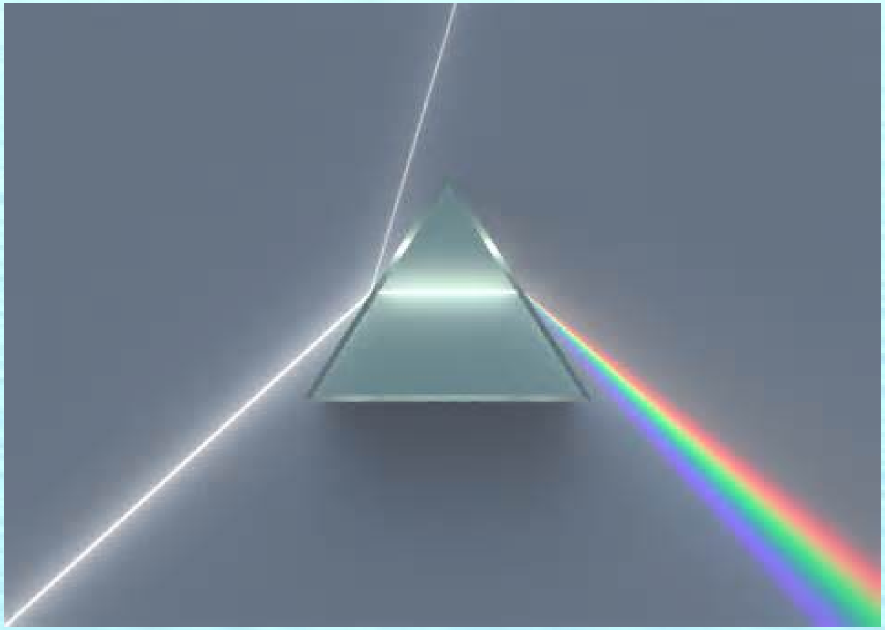
Lab 1
Refraction, dispersion, polarization.



Refraction – light is bent on entering a prism. (Snell's law)
Dispersion – different colors bend by slightly different amounts

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Ray Tracing – Why can you see?

Objects emit, reflect or scatter rays in all directions (usually).

Some ray from the object has to enter your eye for you to see it.

Your eye is like a camera. Images occur because light rays strike your retina at different positions.

Specular and Diffuse Reflection

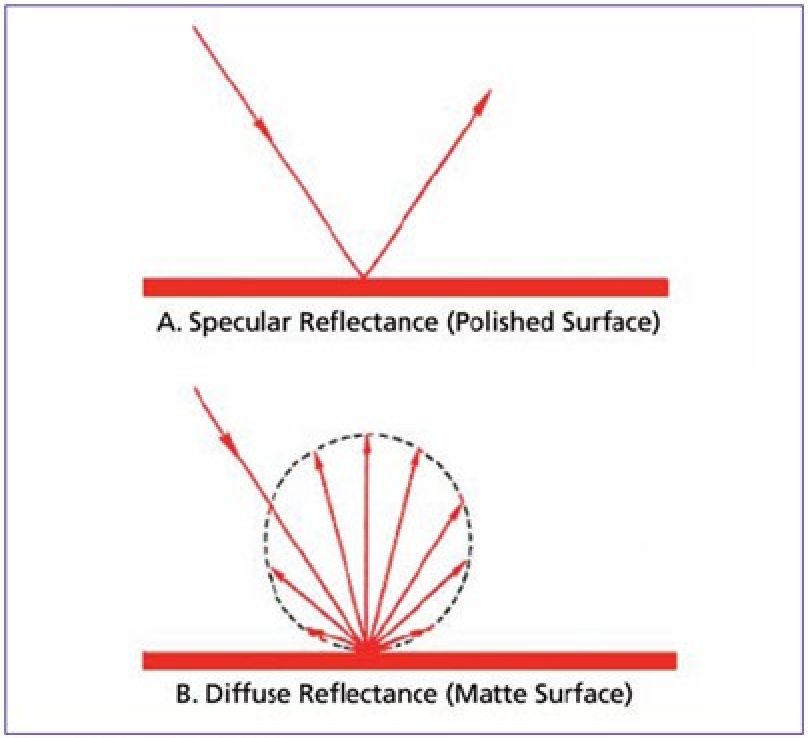


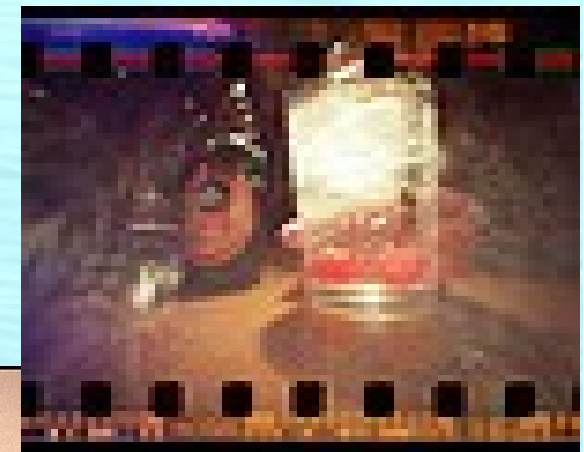
Figure 1. Types of reflection.

Specular – Angle of incidence = angle of reflection

Diffuse – Rays scatter in all directions with a preference for right angles to surface.

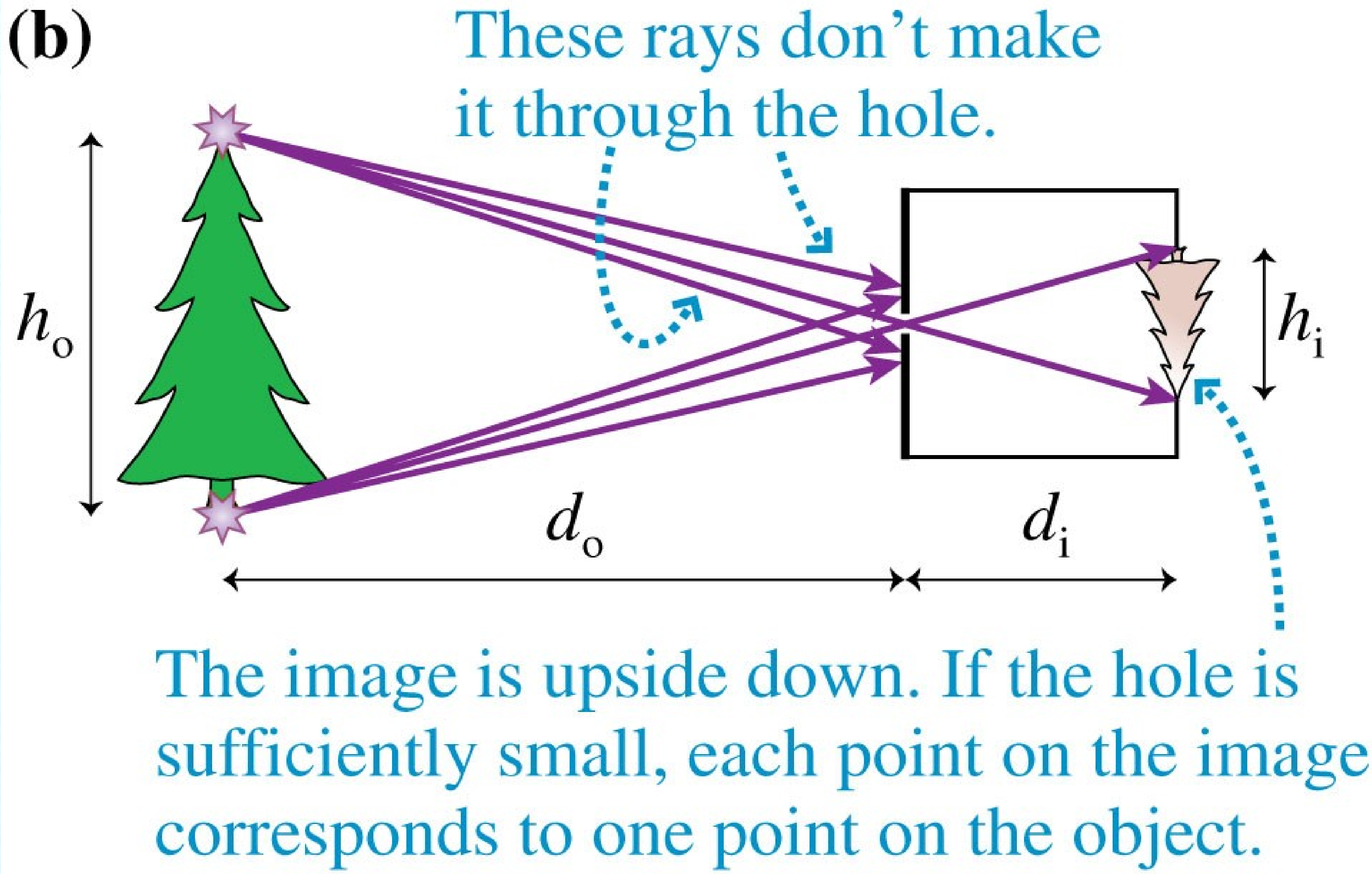
Pinhole camera

No lens needed!



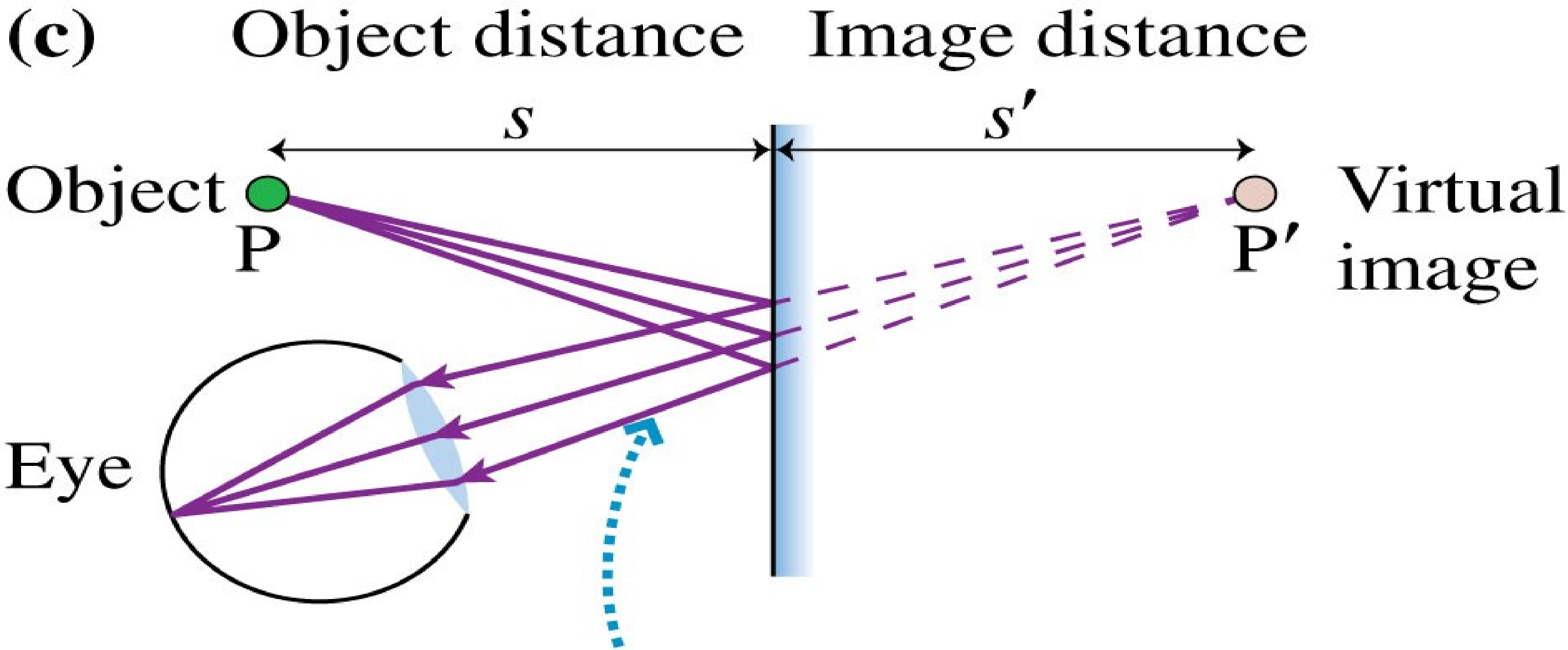
How Pinhole camera works

How Pinhole camera (and your eye) works



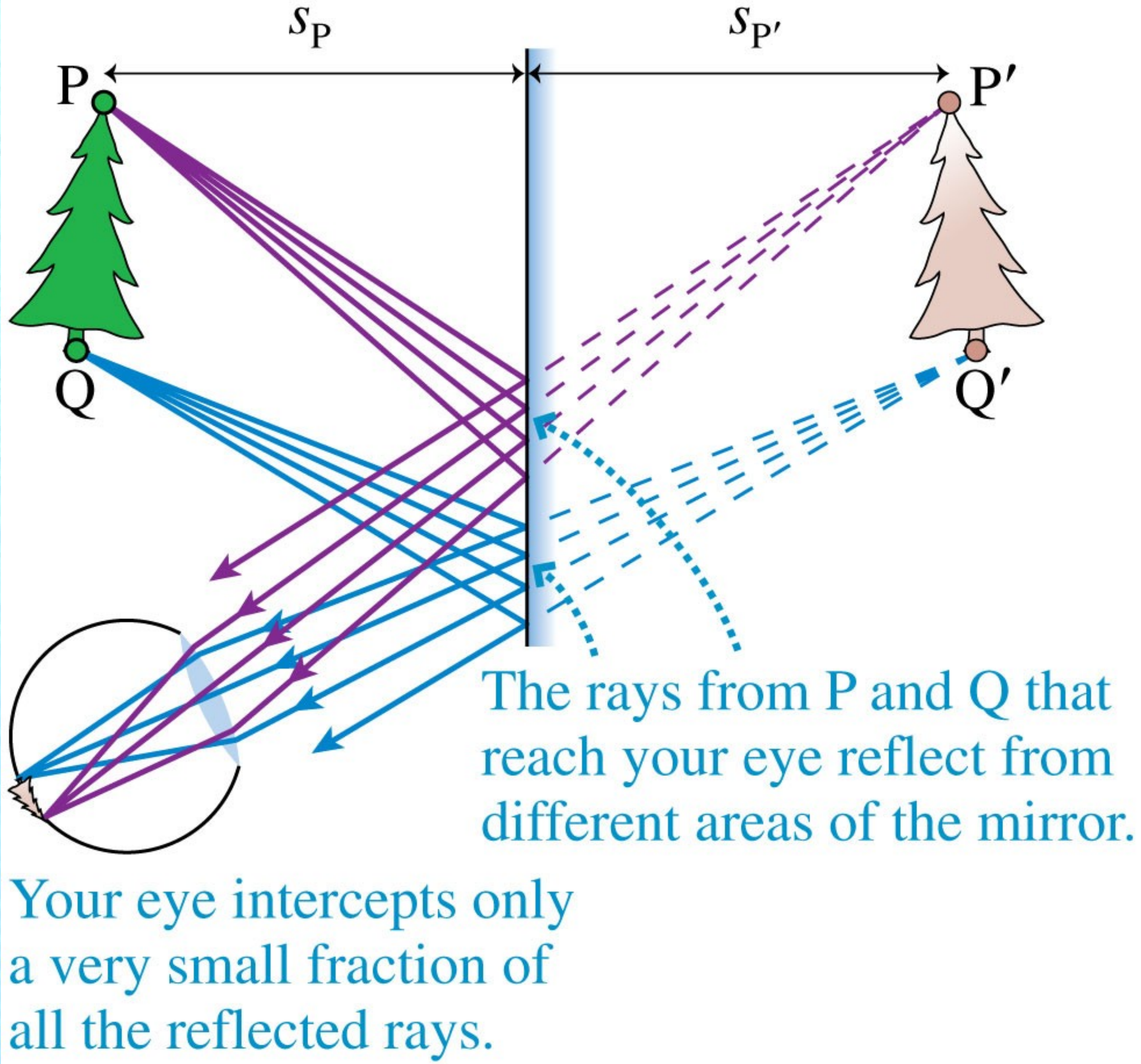
Ray tracing: Why can you see yourself in a mirror?

How a Mirror works



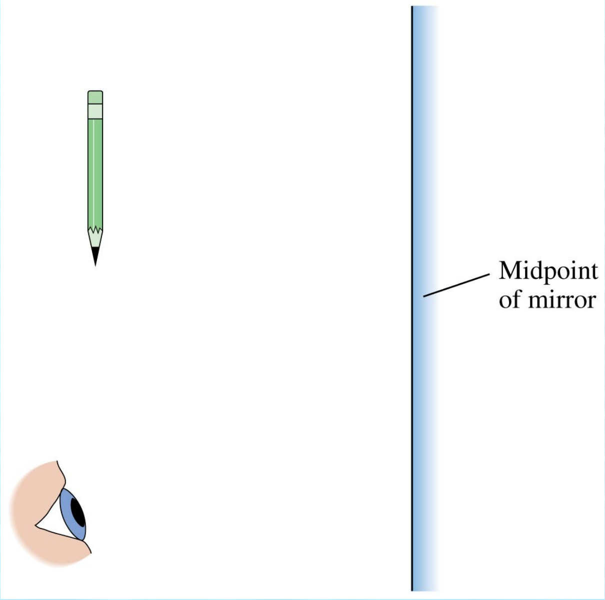
The reflected rays *all* diverge from P′, which appears to be the source of the reflected rays. Your eye collects the bundle of diverging rays and “sees” the light coming from P′.

How a Mirror works



Clicker Question

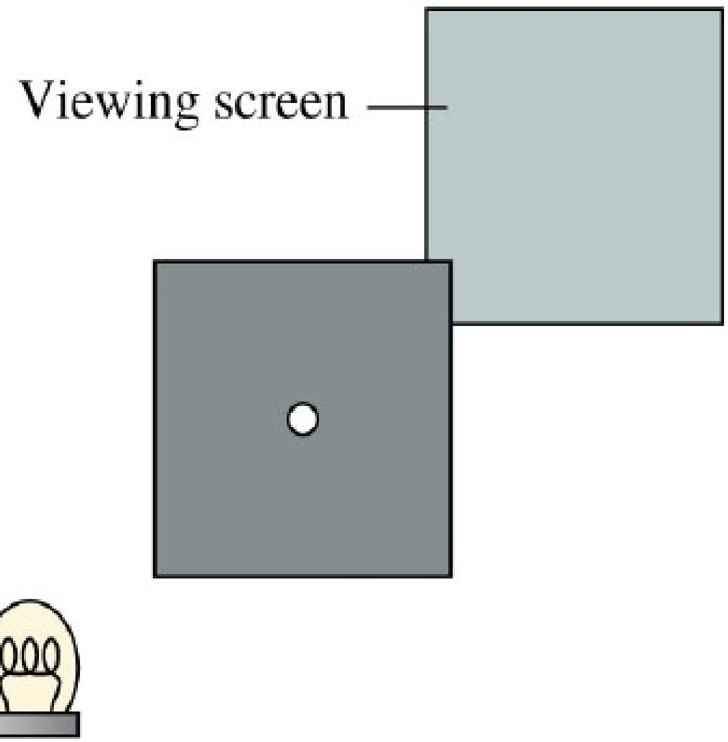
You are looking at the image of a pencil in a mirror. What do you see in the mirror if the top half of the mirror is covered with a piece of dark paper?

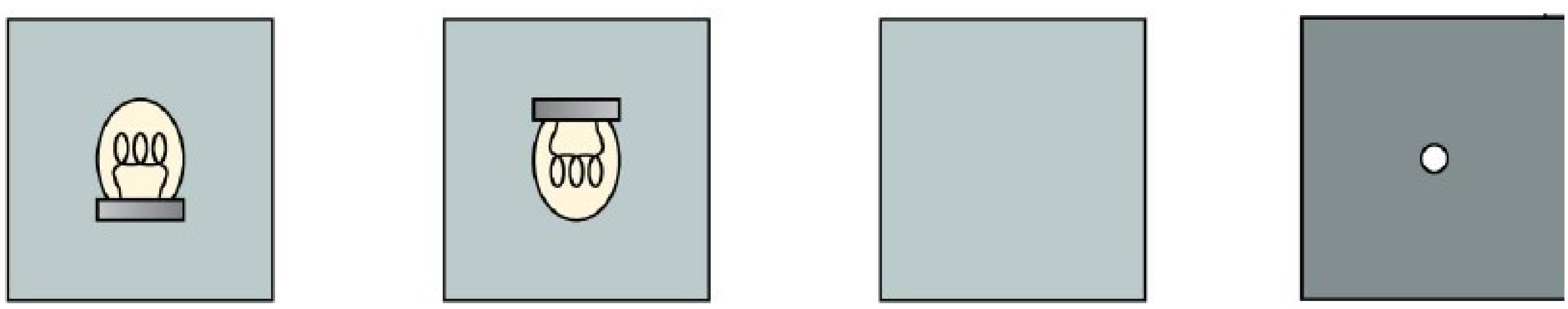


A. The full image of the pencil.
B. The top half only of the pencil.
C. The bottom half only of the pencil.
D. No pencil, only the paper.

Clicker Question

The dark screen has a small hole, ≈2 mm in diameter. The lightbulb is the only source of light. What do you see on the viewing screen?





A. B. C. D.

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Convex lenses cause light rays to converge.

Concave lenses cause light rays to diverge.

If lens is thicker in the Middle than edges, It will converge

If thicker on edges Than middle, it Will diverge.

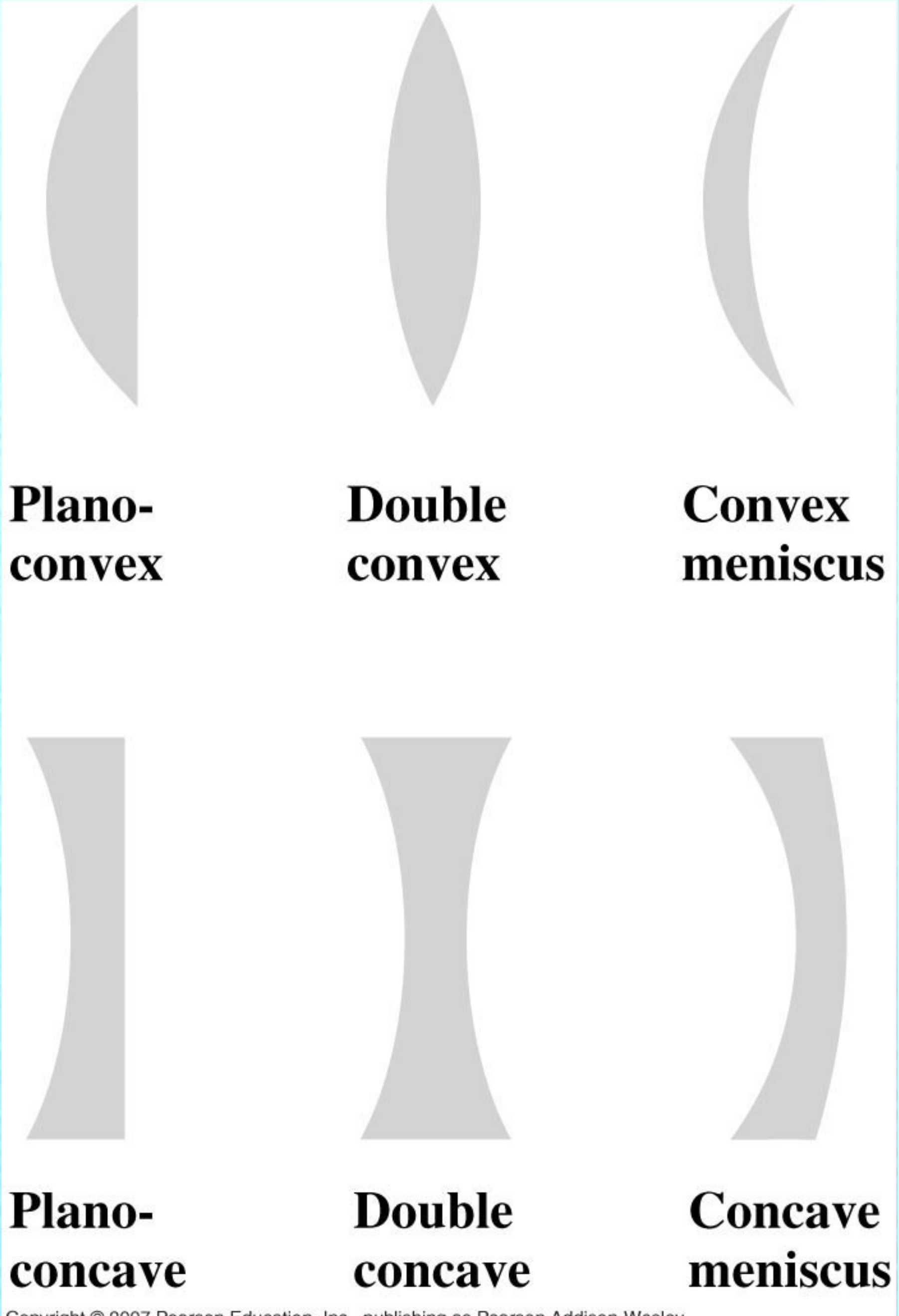


Image position and magnification

$$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$$

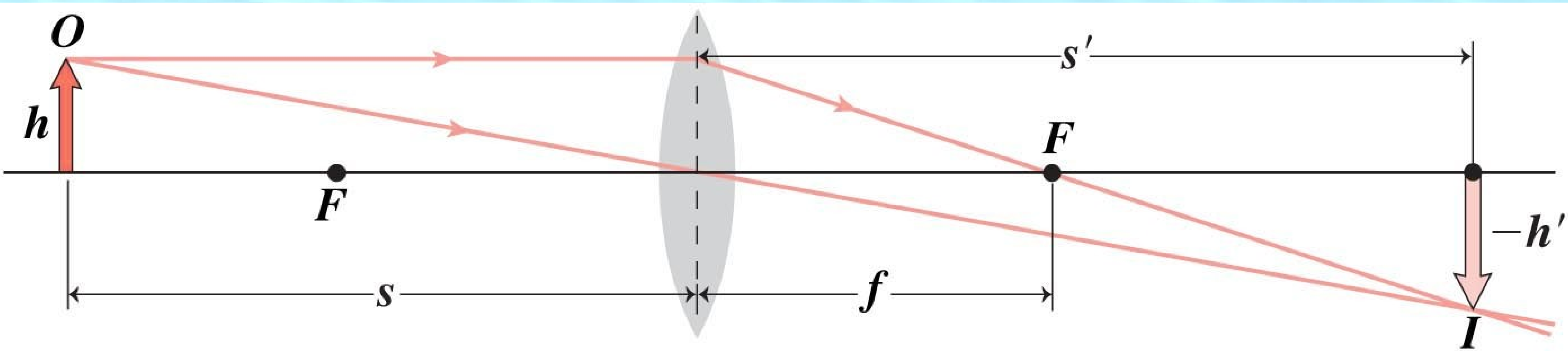
$$m = \frac{-s'}{s}$$

s = distance to object

s' = distance to image

f = focal length

m = magnification



Real and virtual images.

Rays meet at a real image. Focus a flame and it will burn.

Real images are on opposite side of lens (and same side of mirror) from object.

Virtual images are on same side of lens (and opposite side of mirror) from object.

Real images are inverted, virtual are erect.

Concave mirror can form a real image that appears out in front of the mirror.

Convex mirror only forms virtual images That are behind mirror and always smaller than the object.

Ray Tracing with Lenses: The principal rays

P-ray: Ray parallel to symmetry axis goes thru focal point F.

F-ray: Ray thru F comes out parallel to symmetry axis

M-ray: Ray through middle of lens passes straight thru unchanged.

Ray Tracing:

Lenses:

Case I: f= 10 cm, s=15 cm.

Case II: f= 10 cm, s=5 cm.

Case III: f=-10 cm, s=15 cm.

Mirrors:

Case I: f= 10 cm, s=12 cm.

Case II: f=-10 cm, s=5 cm.

Case III: f= -10 cm, s=20 cm.

Ray Tracing with Mirrors:
The principal rays

P-ray: Ray parallel to symmetry axis goes thru focal point F.
F-ray: Ray thru F comes out parallel to symmetry axis
M-ray: Ray hits middle of mirror and reflects off at angle of incidence (as if mirror were flat)

Question

Given an object placed 15 cm from a biconvex lens with focal length 10 cm, find the distance of the image from the lens (and the magnification M).

Lenses:

Case I: f= 10 cm, s=15 cm.

Lenses:

Case II: f= 10 cm, s=5 cm.

pHeT

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Clicker Question

Given an object placed 20 cm from a lens with focal length 10 cm, find the distance of the image from the lens (and the magnification M).

(A) 5 cm, M= -1/4
(B) 10 cm, M= -1/2
(C) 20 cm, M= -1
(D) 30 cm, M= -3/2

Lenses:

Case III: f= -10 cm, s=15 cm.

pHeT

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Clicker Question

Given an object placed 20 cm from a biconcave lens with focal length magnitude 10 cm, find the magnification of the image

(A) M= 20/3
(B) M= 1/2
(C) M= 1/3
(D) M= 3
(E) M=-1/2

Mirror:

Case I: f= 10 cm, s=12 cm.

Mirror:

Case II: f= -10 cm, s=5 cm.

Mirror:

Case III: f= -10 cm, s=20 cm.

Which of the following changes its focal length when it is immersed in water?

A. a concave mirror
B. a convex mirror
C. a convex lens
D. all of the above
E. none of the above

Ch. 23: Geometrical Optics

$$\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}$$

Relation between object and image distance for single lenses and mirrors.

$$m=-\frac{s'}{s}$$

Magnification for single lens or mirror.

$$\frac{1}{f}=(n-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

Lensmaker's formula

Real and virtual images – PHET

Ray Tracing with Lenses: The principal rays

P-ray: Ray parallel to symmetry axis goes thru focal point F.
F-ray: Ray thru F comes out parallel to symmetry axis
M-ray: Ray through middle of lens passes straight thru unchanged.

Ray Tracing:

Lenses:

Case I: $f = 10$ cm, $s = 15$ cm.

Case II: $f = 10$ cm, $s = 5$ cm.

Case III: $f = -10$ cm, $s = 15$ cm.

Mirrors:

Case I: $f = 10$ cm, $s = 12$ cm.

Case II: $f = -10$ cm, $s = 5$ cm.

Case III: $f = -10$ cm, $s = 20$ cm.

Question

Given an object placed 15 cm from a biconvex lens with focal length 10 cm, find the distance of the image from the lens (and the magnification M).

Lenses:

Case I: $f = 10$ cm, $s = 15$ cm.

Lenses:

Case II: f= 10 cm, s=5 cm.

Clicker Question

Given an object placed 20 cm from a lens with focal length 10 cm, find the distance of the image from the lens (and the magnification M).

(A) 5 cm, M= -1/4
(B) 10 cm, M= -1/2
(C) 20 cm, M= -1
(D) 30 cm, M= -3/2

Lenses:

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Given an object placed 20 cm from a biconcave lens with focal length magnitude 10 cm, find the magnification of the image

(A) M= 20/3
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(C) M= 1/3
(D) M= 3
(E) M=-1/2

Mirror:

Case I: f= 10 cm, s=12 cm.

Mirror:

Case II: $f = -10$ cm, $s = 5$ cm.

Mirror:

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Which of the following changes its focal length when it is immersed in water?

A. a concave mirror

B. a convex mirror

C. a convex lens

D. all of the above

E. none of the above

Ch. 23: Ray Optics Formulae

$v = f\lambda$ General property of waves

$v_n = \frac{c}{n}$ True for light in media

$\theta_1' = \theta_1$ Law of reflection (specular)

$n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$ Snell's law (refraction)

$\sin(\theta_c) = n_2/n_1$ Total internal reflection

$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$ Thin lens formula

Ch. 23: Geometrical Optics

$$\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}$$

Relation between object and image distance for single lenses and mirrors.

$$m=-\frac{s'}{s}$$

Magnification for single lens or mirror.

$$\frac{1}{f}=(n-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

Lensmaker's formula

Next Time

Properties of Waves