Arvind Borde / PHY 12, Week 8: Light as a Ray

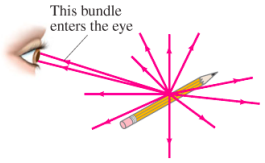
(1) Is light a particle or a wave? _____

(2) If a particle, how do you expect it to travel (if no obstacles are in its way)?

_____

1

In this model, this is how we see:



When light Light hits a surface,

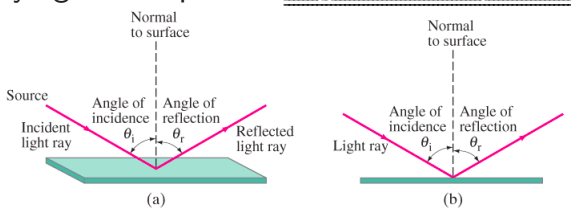
some of it bounces off (reflects),

some of it is absorbed (thermally), and

some of it may pass through.

2

The light that reflects, does so at precise angles. Studying how is part of _____



Reflection off a mirror

A smooth, shiny surface might reflect over 95% of the light that "is incident on it."

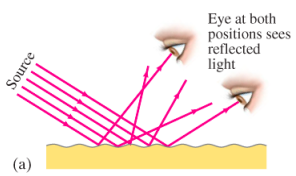
3

Law of Reflection

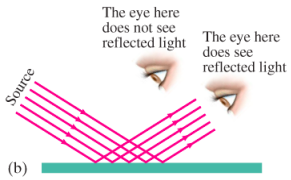
When a light ray reflects off a surface, the incident ray, the reflected ray and the normal lie in the same plane, and

(The angle of reflection equals the angle of incidence.)

4



Diffuse reflection



Specular reflection

This illustrates the difference between seeing yourself in a mirror and *not* seeing yourself in a sheet of paper.

5

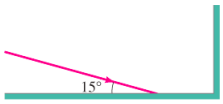
(3) Based on this, is the surface of the moon likely to be rough or shiny?

_____

6

ADDITIONAL NOTES

(4) Following the ray of light shown below, trace its subsequent path and label all the angles of incidence and reflection in order:

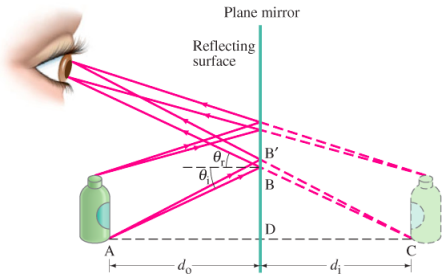


(5) What are the values of these angles?

_____, _____, _____.

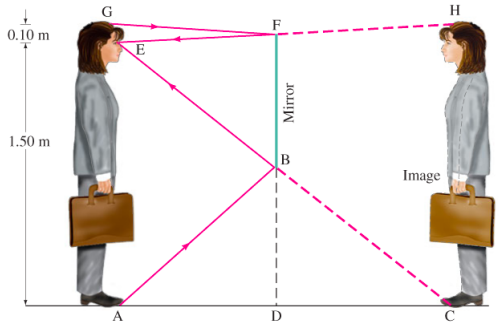
7

Image Formation in Mirrors



8

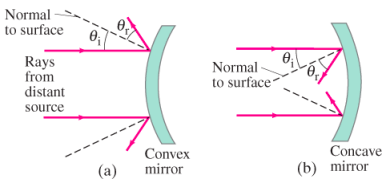
How Large a Mirror?



$$\text{BD} = \frac{1}{2}\text{EA} \quad \text{so} \quad \text{FB} = \frac{1}{2}\text{GA}$$

9

Reflection off Spherical Mirrors

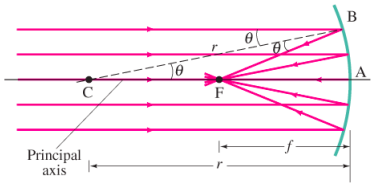


(6) One of these magnifies, one reduces. Which does which?

_____

10

Focal Point and Focal Length

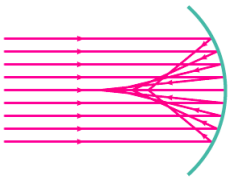


r is the radius of curvature of the sphere.

The convergence of parallel rays to a point is not perfect: only works if $r \gg$ mirror size.

11

Otherwise:



You get _____

Ignoring aberration, _____.

12

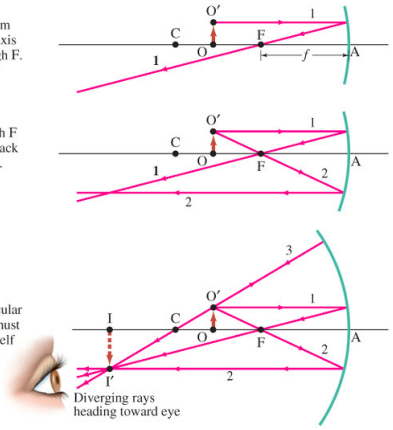
ADDITIONAL NOTES

Ray Diagrams

(a) Ray 1 goes out from O′ parallel to the axis and reflects through F.

(b) Ray 2 goes through F and then reflects back parallel to the axis.

(c) Ray 3 is perpendicular to mirror, and so must reflect back on itself and go through C (center of curvature).



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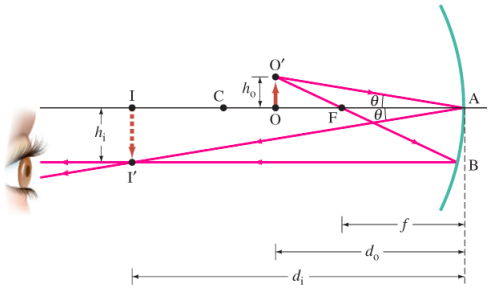
Mirror Equations



14

Sign Conventions

- _____
- _____

15

(7) A 1.5 cm-high object is placed 20.0 cm from a concave mirror with radius of curvature 30.0 cm. Determine the position of the image.

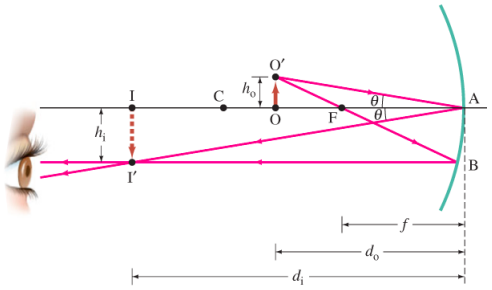
_____

16

(8) In the previous, determine the image size.

17

The previous problem was an example of the scenario $r > d_o > f$:



18 We found $d_i > r$, $m < -1$.

ADDITIONAL NOTES

(9) What's the significance of $m < 0$?

(10) What's the significance of $m < -1$?

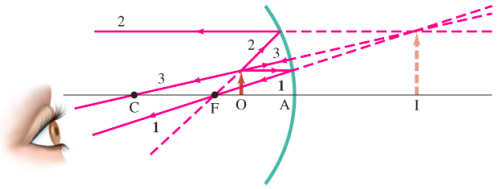
(11) In this example, d_0 was 20.0 cm, and d_i came out to be 60.0 cm. What would d_i have been if d_0 was 60.0 cm.?

19

If you reverse the light rays, you get an alternative scenario where the image is the object, and the object the image.

20

Another scenario:



Here, $d_0 < f$.

(12) Does that not shock you?

21

OK, how often have I asked you rapscallions to

(13) Ponder?

(14) Contemplate?

(15) Gaze (soulfully)?

22

So contemplate/ponder (or, at least, gaze at)

$$\frac{1}{d_0} + \frac{1}{d_i} = \frac{1}{f}$$

Contemplate, as if your life (= grade) depended on it.

⋱

⋱

⋱

23

Done?

(16) Remind you of any old friends?

24

ADDITIONAL NOTES

(**17**) R is the effective resistance of resistors in series? In parallel? _____

(**18**) What did we say about the effective resistance of resistors in parallel? _____

(**19**) If f plays the role of R, and d_i and d_o the roles of R_1 and R_2, how come we just saw a scenario with $d_0 < f$? _____

_____

25

(**20**) A 1.0 cm-high object is placed 10.0 cm from a concave mirror whose radius is 30.0 cm. What's the position of the image, the magnification, and image size? Is the image inverted or upright?

_____

26 _____

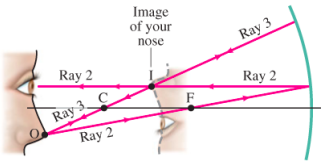
Magnification:

Size:

27

(**21**) Moving on, you like the way your nose looks?

_____



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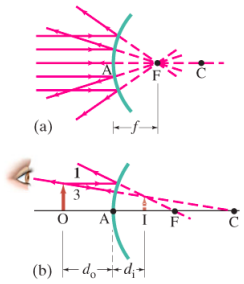
Convex mirrors



f, d_o, d_i have their usual meanings.

29

(**22**) A convex external rearview car mirror has radius of curvature of 16.0 m. What's the location of the image and magnification for an object 10.0 m from the mirror?

_____

30 _____

ADDITIONAL NOTES

Magnification:

Note: Rearview mirrors compress a wide field of view into a small image, making objects look smaller than they are. Our brains have been trained into thinking smaller objects are further away. But because $m < 1$, objects in a rearview mirror are

31

Light in a Medium

Light travels at slower speeds inside material bodies than it does in vacuum.

The index of refraction of a material is the ratio of the speed of light in vacuum, c, to the speed in that material, v:

Examples: $n_{\text{air}} = 1.0003$, $n_{\text{water}} = 1.33$

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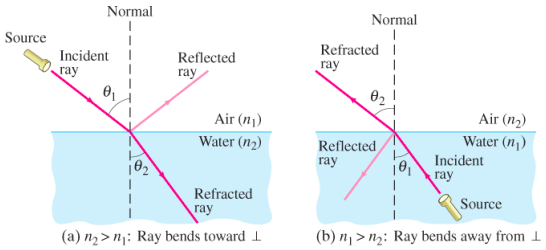
Refraction: Snell's Law



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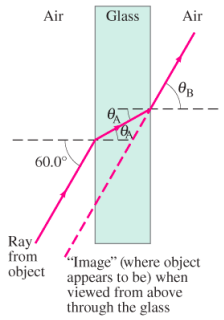


(23) Light traveling in air strikes a flat piece of uniformly thick glass at an incident angle of $60°$. If the index of refraction of the glass is 1.50, (a) what is the angle of refraction θ_A in the glass; (b) what is the angle θ_B at which the ray emerges from the glass?

34

We have _____

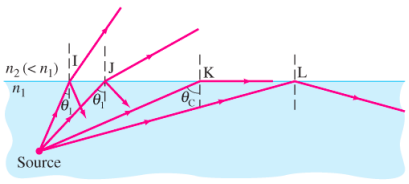
So, _____

Next, _____

So _____

35

Total Internal Reflection



So,

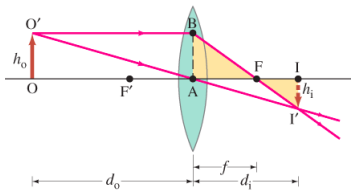
36

ADDITIONAL NOTES

(24) What is θ_C for water $\rightarrow$ air?

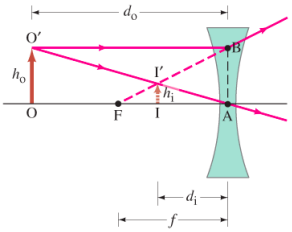
37

Thin Lenses: Converging



38 f, d_o, d_i have their usual meanings.

Thin Lenses: Diverging



39 f, d_o, d_i have their usual meanings.

Sign conventions for lenses

1)

2)

40

3)

4)

41

Magnification by Lenses

42

ADDITIONAL NOTES

ADDITIONAL NOTES