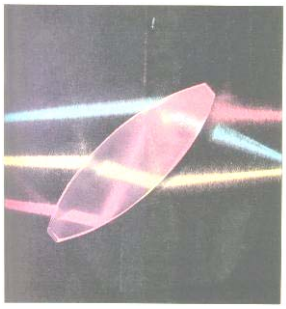
Physics Traditional 1314 Williams

Lenses & Refractive Optics

Chapter 14

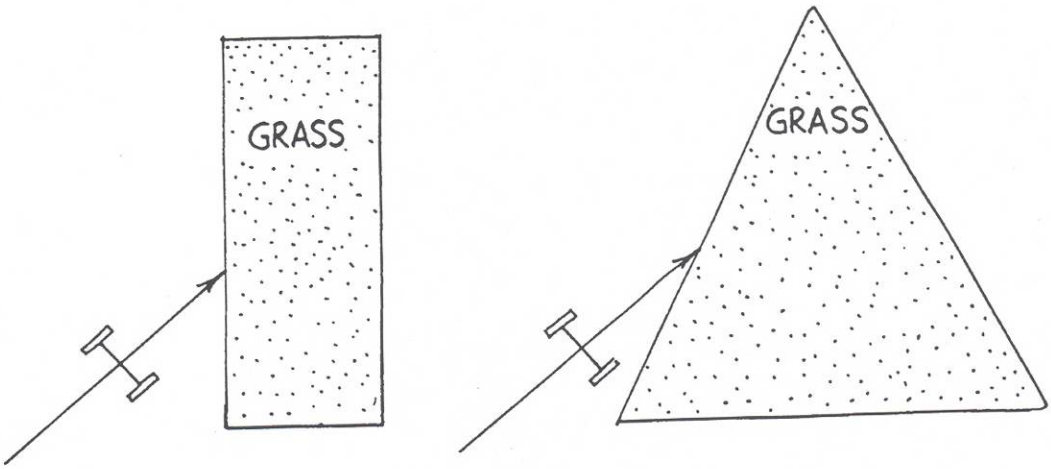


Name Period Date

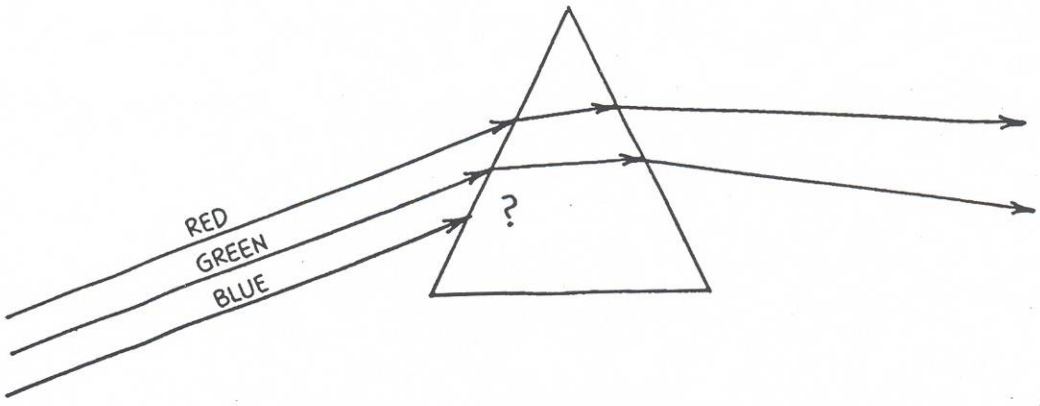
Concept-Development Practice Page **29–3**

Refraction

1. A pair of toy cart wheels that can spin independently are rolled obliquely from a smooth surface onto two plots of grass — a rectangular plot as shown at the left, and a triangular plot as shown at the right. The ground is on a slight incline so that after slowing down in the grass, the wheels speed up again when emerging on the smooth surface. Finish each sketch and show some positions of the wheels inside the plots and on the other side. Clearly indicate their paths and directions of travel.



2. Red, green, and blue rays of light are incident upon a glass prism as shown. The average speed of red light in the glass is less than in air, so the red ray is refracted. When it emerges into the air it regains its original speed and travels in the direction shown. Green light takes longer to get through the glass. Because of its slower speed it is refracted as shown. Blue light travels even slower in glass. Complete the diagram by estimating the path of the blue ray.



Refraction Practice **($n_1 \sin\theta_1 = n_2 \sin\theta_2$)**

The angles light moves across two different materials can be found using Snell's law.
Remember to first make sure the incident angle is less than the critical angle!

For each problem, draw a picture & label the angles!

1. What is the angle of refraction θ_2 if light coming from air enters water at 30^o?

2. What is the incident angle of light coming from air when the refracted angle is 40^o in water?

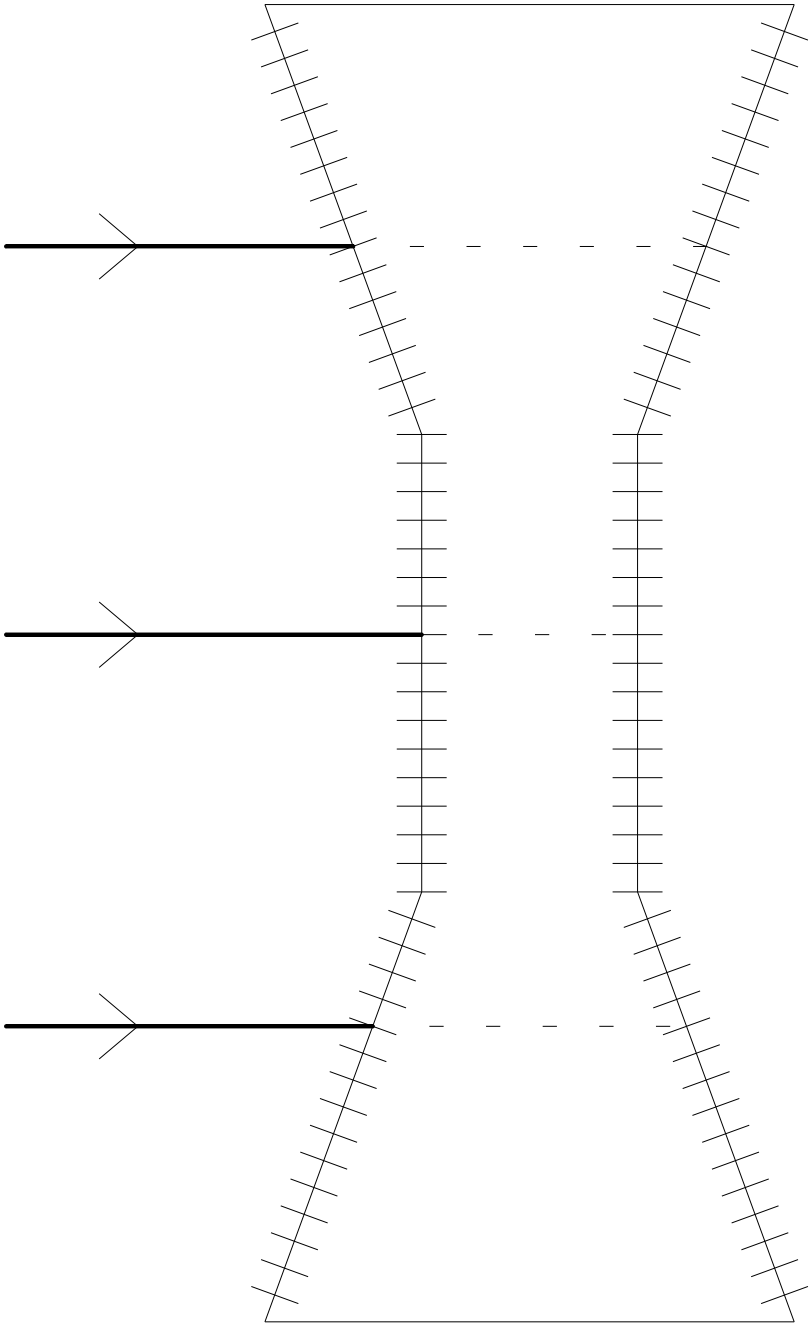
3. Light coming from water has an incident angle of $44^{o.}$ The light is bent by an unknown material by 24^o away from the normal. What is the refractive index of the unknown? Is light faster in this material than in diamond?

4. What is the angle of refraction θ_2 if light coming from air enters water at 60^o?

Simplified Lens Model: Look at the three incident horizontal light rays for the lens below. The light rays are going from air (fast) to glass (slow). Several normal lines are pre-drawn for you as well so you can bend your light ray toward or away from the normal as appropriate. Draw the light rays as they exit the lens too and extend them forward or backward to find where they intersect.

1. Do the light rays REALLY converge to a single point? Do they seem to originate from a single point behind the lens?
2. What name do you think we would give to a point where all horizontal light rays meet or seem to meet?

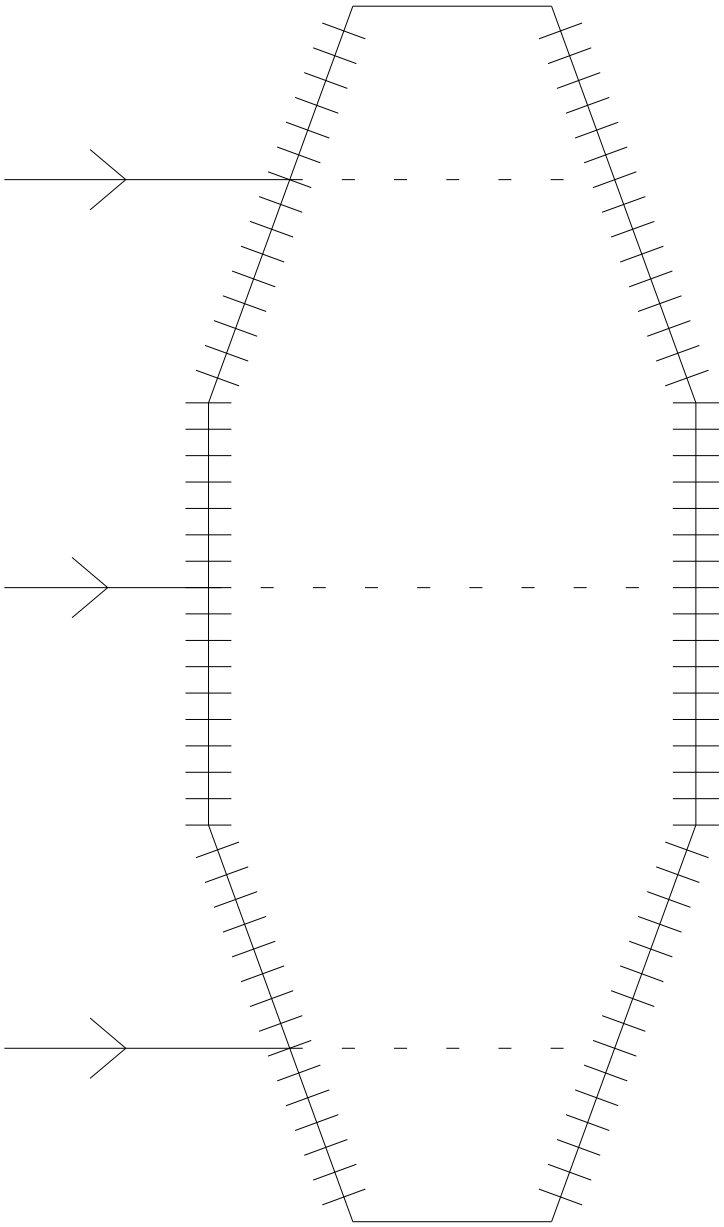
Simplified model of a Concave Lens



Look at the three incident horizontal light rays for the lens below. The light rays are going from air (fast) to glass (slow). Several normal lines are pre-drawn for you as well so you can bend your light ray toward or away from the normal as appropriate. Draw the light rays as they exit the lens too and extend them forward or backward to find where they intersect.

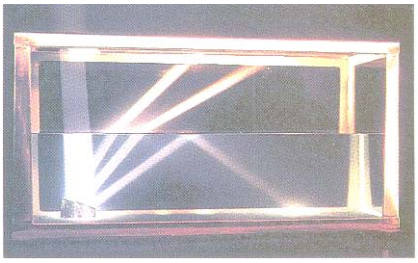
1. Do the light rays REALLY converge to a single point? Do they seem to originate from a single point behind the lens?
2. What name do you think we would give to a point where all horizontal light rays meet or seem to meet?

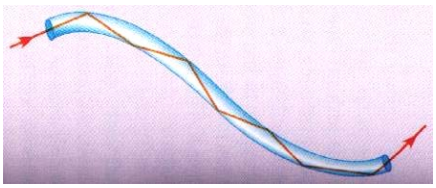
Simplified model of a Convex Lens



Practice Finding Critical Angle - Total Internal Reflection

Find the Critical Angle (θ_c) for Water (n=1.33) to Air:





Find the Critical Angle (θ_c) for Cubic Zirconium (1.92) to Air:

Find the Critical Angle (θ_c) for Diamond (2.42) to Air:

PhyzJob: Ray Tracing part 3
Images in a Converging Lens

INSTRUCTIONS: Determine the location and size of the image by means of a ray diagram. Use *any* two principal rays to locate the image. Draw the image and indicate whether it is erect or inverted, enlarged or reduced, real or virtual (consult the phyzguide for clarification).

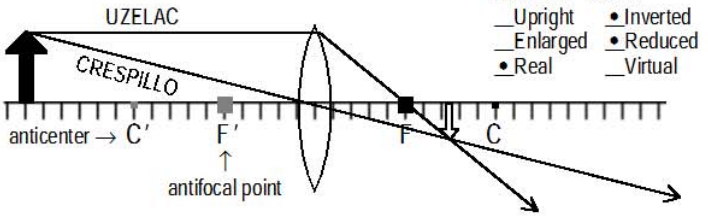
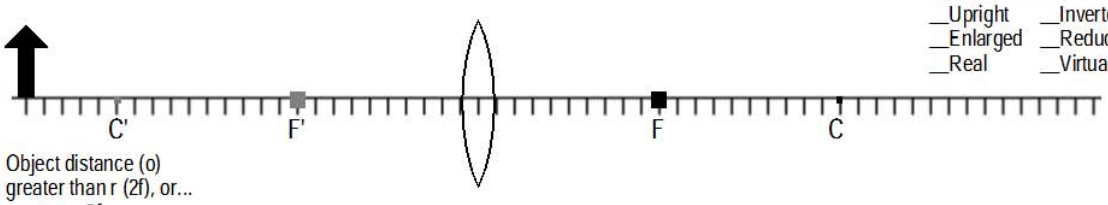


IMAGE IS...
__Upright • Inverted
__Enlarged • Reduced
• Real __Virtual

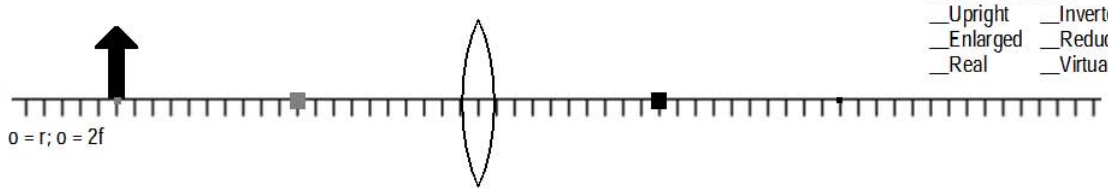
1



Object distance (o) greater than r (2f), or...
o > r; o > 2f

IMAGE IS...
__Upright __Inverted
__Enlarged __Reduced
__Real __Virtual

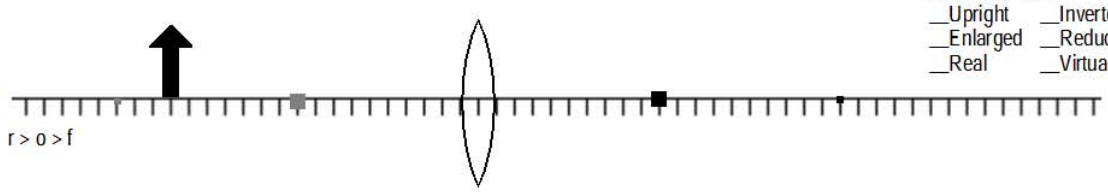
2



o = r; o = 2f

IMAGE IS...
__Upright __Inverted
__Enlarged __Reduced
__Real __Virtual

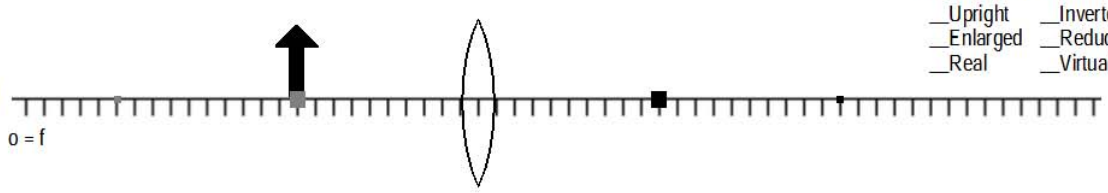
3



r > o > f

IMAGE IS...
__Upright __Inverted
__Enlarged __Reduced
__Real __Virtual

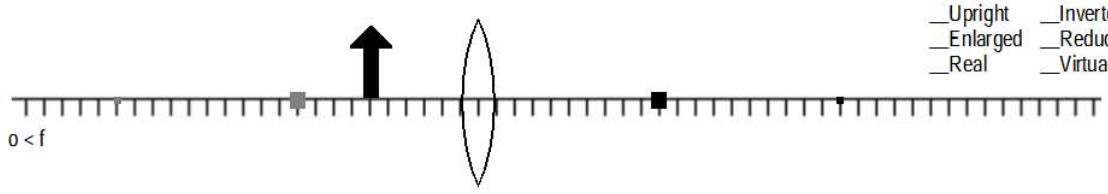
4



o = f

IMAGE IS...
__Upright __Inverted
__Enlarged __Reduced
__Real __Virtual

5



o < f

IMAGE IS...
__Upright __Inverted
__Enlarged __Reduced
__Real __Virtual

db

PhyzJob: Ray Tracing part 4
Images in a Diverging Lens

INSTRUCTIONS: Determine the location and size of the image by means of a ray diagram. Use *any* two principal rays to locate the image. Draw the image and indicate whether it is erect or inverted, enlarged or reduced, real or virtual (consult the phyzguide for clarification).

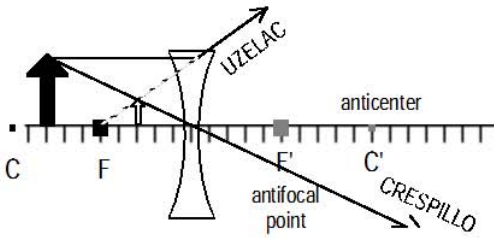
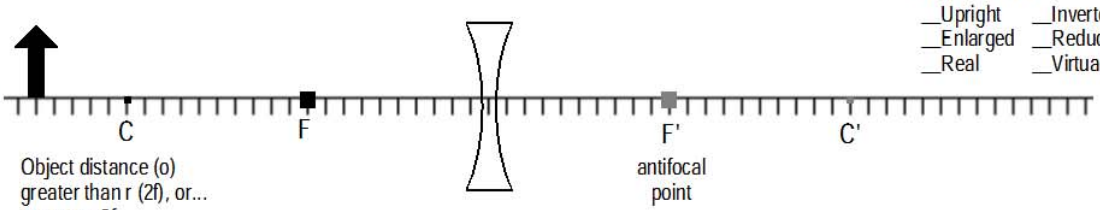


IMAGE IS...
• Upright __Inverted
__Enlarged • Reduced
__Real • Virtual

1

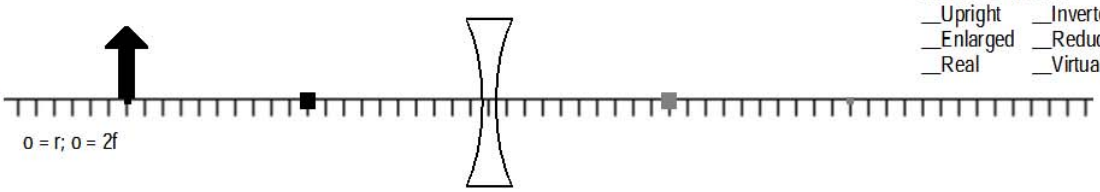


Object distance (o) greater than r (2f), or... o > r; o > 2f

antifocal point

IMAGE IS...
__Upright __Inverted
__Enlarged __Reduced
__Real __Virtual

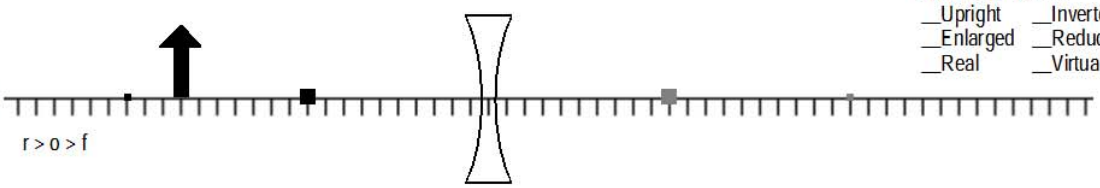
2



o = r; o = 2f

IMAGE IS...
__Upright __Inverted
__Enlarged __Reduced
__Real __Virtual

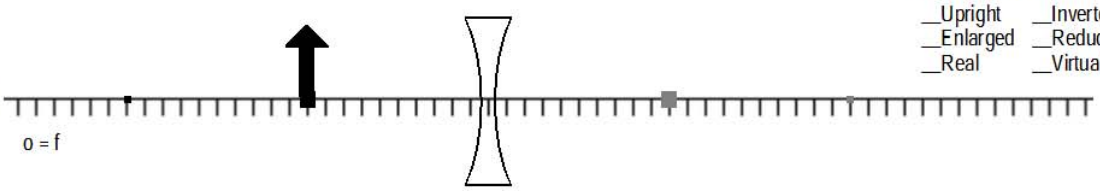
3



r > o > f

IMAGE IS...
__Upright __Inverted
__Enlarged __Reduced
__Real __Virtual

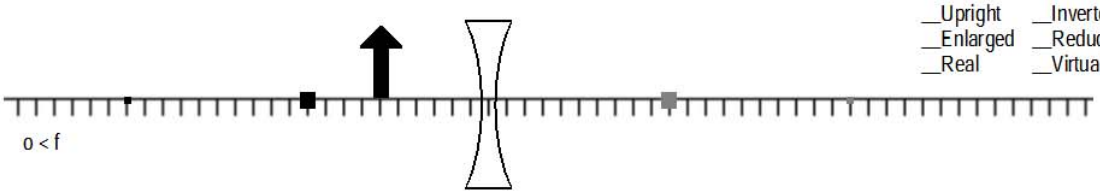
4



o = f

IMAGE IS...
__Upright __Inverted
__Enlarged __Reduced
__Real __Virtual

5



o < f

IMAGE IS...
__Upright __Inverted
__Enlarged __Reduced
__Real __Virtual

db

Unit 13 Traditional – Vocabulary and Equations – Refraction & Lenses

Vocabulary:
previous vocabulary
medium, interface
index of refraction, optically dense medium
total internal reflection, critical angle
dispersion
speed of light in a vacuum
normal, light ray, wave front, Snell's law
angle of incidence, angle of refraction
convex, converging
concave, diverging
myopia, near-sighted, hyperopia, far-sighted
20/20 vision
real image, virtual image, enlarged image
reduced image, upright image, inverted image
principal axis, focal point, center
* thin lens equation, * magnification equation

Symbols:
c, v, n

Equations & constants:
You use a 3 x 5 index card on this test:
$n = c/v$ $n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$ $\sin(\theta_c) = n_2/n_1$
$V_{light} = c = 3 \times 10^8$ m/s $f = 1/T$, $v = f\lambda$ $d = v\,t$
Lens/mirror: $1/d_o + 1/d_i = 1/f$
Magnification: $M = -d_i / d_o$ $M = h_i / h_o$

Unit Objectives - Williams
1. I understand all the vocabulary & math of this unit and all demos, videos, equations, and class assignments.
2. I remember objectives & vocabulary from previous units.
3. I know the image properties both lens types produce depending on object position
4. I know why light speed slows down and how this causes refraction and dispersion
5. I can distinguish between refraction, reflection and diffraction
6. I understand various vision problems and how lenses correct these, and other lens applications
7. I reviewed the candle lab and understand what's covered in it, even if I was absent for it
8. I can compute light speed using tabulated index of refraction information
9. I can model why light bends using wavefronts and I know the two things necessary to make light rays bend
10. Relative to the normal I know which way light bends when going to or from a faster/slower medium
11. I know how water distorts an object's depth and why divers have a reduce field of view looking up
12. I can use Snell's law to predict how much light bends, why there is a critical angle and how to find it
13. I know 3 ways lens ray tracing differs from mirrors: focal point not predicted by geometry alone, different center ray, opposite behavior (including why behavior is opposite)
14. I know why blurred images form in the eye or elsewhere
15. I understand refraction related phenomena like mirages, prisms, rainbows, fiber optics, TIR, etc.
16. I know lens ray tracing including 3 principal rays, special principal axis points and 3 image properties
17. I know how to use the lens and magnification equations ($d_o>0$, $d_i>$ where light rays REALLY converge, $f>0$ for converging lenses)

DuPage ROE Objectives
801. I can distinguish between transverse or longitudinal waves.
802. I can identify waves as either mechanical or electromagnetic.
803. I can identify: wavelength, amplitude, crest, trough, and period, given a visual representation.
804. I can solve problems using the relationships between velocity, wavelength, frequency, and period.
805. I can recognize that the speed of a wave is dependent upon the material/medium through which the wave travels.
806. I can recognize that waves transfer energy and not matter.
807. I can analyze wave superposition in terms of the effects of constructive and destructive interference.
808. I can identify and describe refraction.

Physics Calendar - Refraction & Lenses: 2013-14(Williams) - Chapters 14 (13 days)

Bold and underlined means put in journal notes (for any problems: Show your work!)

1	**Fr:05/02/14**	GOALS: Speed of light is NOT constant! Why light bends. • Slowing/bending of light, n = c/v & Snell (13-01 notes)	• **(13-02)** p. 493: PA1-3, SR 1-3
2	**Mo:05/05/14** *AP Exams - end 5/16*	GOALS: Diverging/converging lenses & ray tracing • Snell's law model of both lenses, ray tracing - know which side observer is looking at! Center ray is way different!	• H13-01
3	**Tu:05/06/14**	GOALS: Using thin lens equation • Same as mirror equation with different rules • Projecting an image (real image with lens demo)	• **(13-05)** p. 501: 1-4; p. 505: 1-3
4L	**We:05/07/14**	GOALS: Review day • Group activity, time for HWQ's	• H13-02
5	**Th:05/08/14**	GOALS: Ye old lens lab • Go over HW, do lab	• H13-03
6	**Fr:05/09/14**	GOALS: Total internal reflection • TIR w/demo, critical angle, problem solving and examples	• **(13-08)** p. 505: 1-3
7	**Mo:05/12/14**	GOALS: Refraction phenomena • **(13-09)** Notes: Spearing fish (aim low), prisms (dispersion), rainbows & mirages	• **(13-11)** p. 514+: 1,2,4,11,12
8	**Tu:05/13/14**	• Review day - opportunity for questions, group review activity with answers by class end	• **(13-12)** p. 514+: 14,24-26
9	**We:05/14/14**	• Refraction & Lenses Test	• Relax
10	**Th:05/15/14**	Goals: Make & use a sextant; Go over Six Flags packet/skills • Mostly semester 1 skills	• Convince weatherman for nice weather!
11	**Fr:05/16/14**	• Six Flags & alternate assignment for those not going	•
12	**Mo:05/19/14**	• Final review: Mostly Q3	• Possible review sheet
13	**Tu:05/20/14**	• Final review: Mostly Q3	• Possible review sheet
14	**We:05/21/14**	• Final review	• Possible review sheet
15	**Th:05/22/14**	• Final review	• Possible review sheet
Senior Finals	**Fr:05/23/14**	Juniors Final Exam Part 1, periods 9,10 Senior Final Exam, periods 9,10 Final Exam Review Day	• Study for Final
Senior Finals	**Tu:05/27/14**	Juniors Final Exam Part 1, periods 3-8 Senior Final Exam, periods 3-8 2nd period: Final Exam Review Day	• Study for Final
Senior Finals	**We:05/28/14**	Juniors Final Exam Part 1, periods 1,2 Senior Final Exam, periods 1,2 4/5: Final Exam Review Day - juniors	• Study for Final
Grad	**Th:05/29/14**	GOALS: • Final Exam Review Day	• Study for Final
	Fr:05/30/14	GOALS: • Final Exam Review Day	• Study for Final
	Mo:06/02/14	**Final Exam, part 2**	• No Homework
	Tu:06/03/14	• Retro-lab, day 1	• No Homework
Finals	**We:06/04/14**	• Retro-lab, day 2	• No Homework
Finals	**Th:06/05/14**	• Retro-lab, day 3	• No Homework
Finals	**Fr:06/06/14**	• Retro-lab, day 4	• No Homework