Mr. Wright's Math Extravaganza

Physical Sciences

(Chemistry, Physics, Physical Science)

Electromagnetic Radiation

Units 10 Waves and Sound, 11 Electromagnetic Rays, 12 Dual Nature of Light

Average Level for All Three Units

Level 2.0: 70% on test, Level 3.0: 80% on test, Level 4.0: level 3.0 and success on particle-wave lab

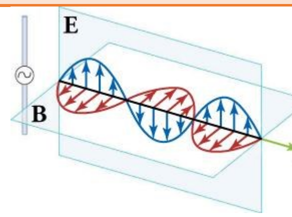
Score	I Can Statements
4.0	**12 Dual Nature of Light** ☐ I can decide whether the effects of different frequencies of electromagnetic radiation are best explained by the particle model or the wave model.
3.5	In addition to score 3.0 performance, partial success at score 4.0 content.
3.0	**11 Electromagnetic Rays** ☐ I can explain the effects of different frequencies of electromagnetic radiation on matter when absorbed. **12 Dual Nature of Light** ☐ I can explain differences between the particle model and the wave model for electromagnetic radiation.
2.5	No major errors or omissions regarding score 2.0 content, and partial success at score 3.0 content.
2.0	**10 Waves and Sound** ☐ I can explain that energy can be transferred from one point to another through a wave or a particle. ☐ I can define characteristics and properties of waves and wave interactions. ☐ I can explain how wave interactions would affect the amplitude of the wave. ☐ I can explain the relationship between the energy carried by a wave, its frequency, its wavelength, and its amplitude. ☐ I can explain the Doppler effect. **11 Electromagnetic Rays** ☐ I can describe the types of waves that compose the electromagnetic spectrum in order from low frequency to high frequency. ☐ I can explain the difference between electromagnetic waves traveling in a vacuum versus those traveling through various media. ☐ I can list characteristics of electromagnetic waves. ☐ I can explain why electromagnetic waves above visible light are considered dangerous to humans after too much exposure. ☐ I can explain how scientists use the emission and absorption spectra to identify the composition of substances. ☐ I can explain the behaviors of waves at a boundary. **12 Dual Nature of Light** ☐ I can relate photons to electromagnetic radiation in terms of waves and particles. ☐ I can explain how photons simultaneously act like particles and waves.

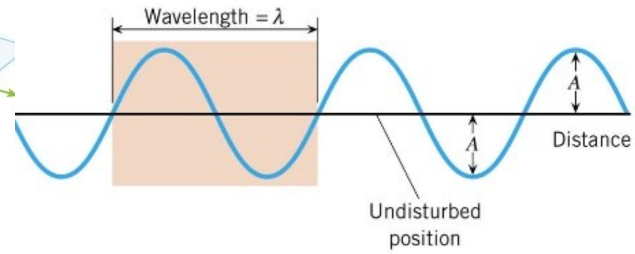
	☐ I can describe the behavior of waves passing through a slit(s). I can identify nodes and antinodes on a resonating wave.
1.5	Partial success at score 2.0 content, and major errors or omissions regarding score 3.0 content.
1.0	With help, partial success at score 2.0 content and score 3.0 content.
0.5	With help, partial success at score 2.0 content but not at score 3.0 content.
0.0	Even with help, no success.

Physics 11-01 Electromagnetic Spectrum and Behavior Name: ______________

How to create electromagnetic (EM) waves

- Move a ______________(current)
- This creates an ______________field
- Also creates a ______________field
- These are ______________ to each other





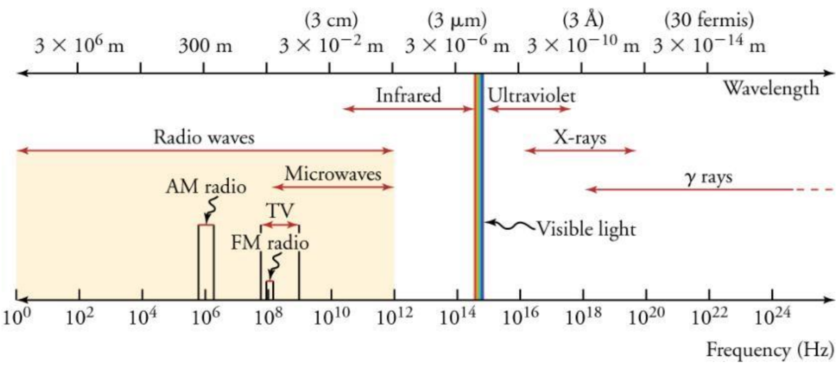
(*a*) At a particular time

EM Waves

- Wavelength – ______________of one cycle
- Frequency – ______________of cycles per second
- Amplitude – ______________of a crest above the undisturbed position
- $v = f\lambda$

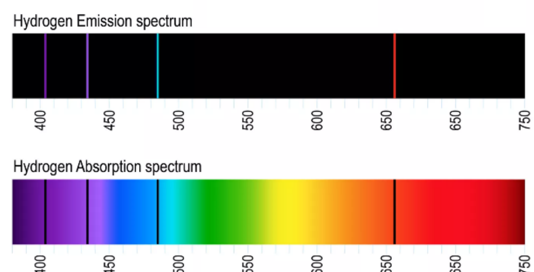
Types of EM radiation

- Based on the ______________



Bohr model of the atom

- Electrons orbit the ______________
- When an electron ______________energy it gets excited, it ______________out to a higher orbital
    - Electrons gain energy when they are ______________by a ______________
    - Photons are ______________of light
    - Too much ______________and electron completely removed from atom, ionizes, allows ______________reactions
- When the excited electron ______________back down to its orbital, it ______________energy as a ______________
- The energy released is based on the __________between the __________
- The frequency (and wavelength) of the released photon is based on the ______________released
- So only a few certain ______________are emitted



Emission spectrum

- Shows the wavelengths (or frequencies) of the ______________light

Absorption spectrum

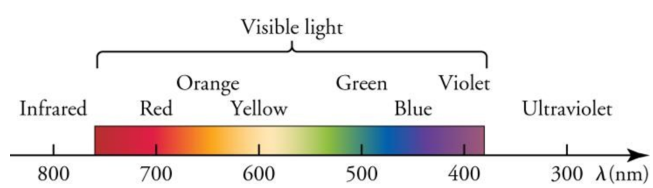
- Shows the wavelengths (or frequencies) of the ______________light

De Broglie model

- The Bohr model only works for ______________
- Electrons behave like waves with a set ______________
- Each electron orbits the nucleus in ______________waves
- This allows for orbitals in more ______________atoms

Visible Light

- Between ______________ Hz and ______________ Hz
- 750 nm (end of red); 380 nm (end of violet)



Speed of light in a vacuum (space)

- $c = 3.00 \times 10^8\ m/s$
- $c = f\lambda$
- When light travels through a material it ______________down due to the ______________and ______________of the photons

Physics 11-01 Electromagnetic Spectrum and Behavior **Name: ______________**

Measurements of light

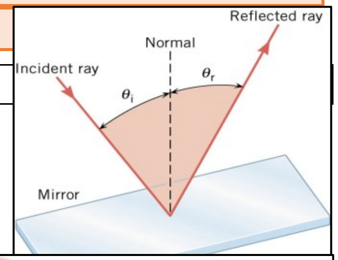
- Luminous flux
  - _____________at which light is radiated from a source
  - Unit: _____________(lm)
- Illuminance
  - Lumens per _____________
  - $illuminance = \frac{P}{4\pi r^2}$
  - Unit: _____________(lx)

Practice Work

1. Explain how atoms (a) absorb light and (b) produce light. (RW)
2. Can a single microwave photon cause cell damage? (HSP 21.7)
3. Shortly after the introduction of photography, it was found that photographic emulsions were more sensitive to blue and violet light than they were to red light. Explain why this was the case. (HSP 21.12)
4. Give an example of energy carried by an electromagnetic wave. (OpenStax 24.8)
5. Why does the emission spectrum of an isolated gas differ from the emission spectrum created by a white light? (HSP 22.5)
6. Why do Bohr's calculations for electron energies not work for all atoms? (HSP 22.21)
7. (a) Two microwave frequencies are authorized for use in microwave ovens: 900 and 2560 MHz. Calculate the wavelength of each. (b) Which frequency would produce smaller hot spots in foods due to interference effects? (OpenStax 24.6) **33.3 cm**, **11.7 cm**
8. A radio station utilizes frequencies between commercial AM and FM. What is the frequency of a 11.12-m-wavelength channel? (OpenStax 24.8) **26.96 MHz**
9. Combing your hair leads to excess electrons on the comb. How fast would you have to move the comb up and down to produce red light? (OpenStax 24.10) $\mathbf{4.0 \times 10^{14}}$ **Hz**
10. Some radar systems detect the size and shape of objects such as aircraft and geological terrain. Approximately what is the smallest observable detail utilizing 500-MHz radar? (OpenStax 24.14) **0.600 m**
11. Determine the amount of time it takes for X-rays of frequency 3×10^{18} Hz to travel (a) 1 mm and (b) 1 cm. (OpenStax 24.15) $\mathbf{3 \times 10^{-12}}$ **s,** $\mathbf{3 \times 10^{-11}}$ **s**
12. If you wish to detect details of the size of atoms (about 1×10^{-10} m) with electromagnetic radiation, it must have a wavelength of about this size. (a) What is its frequency? (b) What type of electromagnetic radiation might this be? (OpenStax 24.16) $\mathbf{3 \times 10^{18}}$ **Hz, X-rays**
13. If the Sun suddenly turned off, we would not know it until its light stopped coming. How long would that be, given that the Sun is 1.50×10^{11} m away? (OpenStax 24.17) **500 s**
14. Conversations with astronauts on lunar walks had an echo that was used to estimate the distance to the Moon. The sound spoken by the person on Earth was transformed into a radio signal sent to the Moon and transformed back into sound on a speaker inside the astronaut's space suit. This sound was picked up by the microphone in the spacesuit (intended for the astronaut's voice) and sent back to Earth as a radio echo of sorts. If the round-trip time was 2.60 s, what was the approximate distance to the Moon, neglecting any delays in the electronics? (OpenStax 24.25) $\mathbf{3.90 \times 10^{8}}$ **m**
15. Lunar astronauts placed a reflector on the Moon's surface, off which a laser beam is periodically reflected. The distance to the Moon is calculated from the round-trip time. (a) To what accuracy in meters can the distance to the Moon be determined, if this time can be measured to 0.100 ns? (b) What percent accuracy is this, given the average distance to the Moon is 3.84×10^{8} m? (OpenStax 24.26) $\mathbf{1.50}$ **cm,** $\mathbf{3.91 \times 10^{-9}}$ **%**
16. (a) Neil Armstrong was the first person to walk on the moon. The distance between the earth and the moon is 3.85×10^{8} m. Find the time it took for his voice to reach earth via radio waves. (b) Someday a person will walk on Mars, which is 5.6×10^{10} m from earth at the point of closest approach. Determine the minimum time that will be required for that person's voice to reach earth. (Cutnell 24.2) **1.28 s, 190 s**

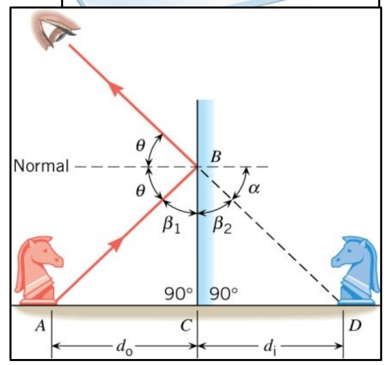
Physics 11-02 Reflection — *Name: ______________*

Reflection

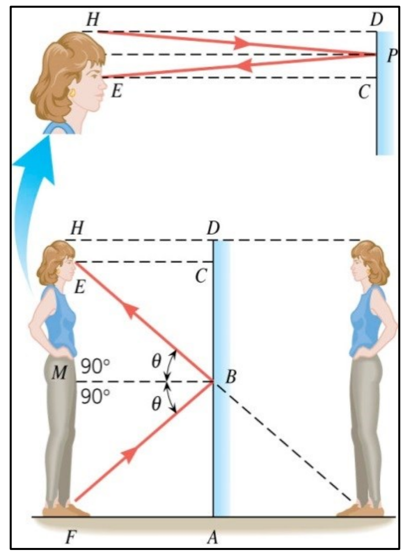


Law of Reflection: $\theta_r = \theta_i$

- ____________ Reflection
  - ____________ light rays are reflected ____________
- ____________ Reflection
  - ____________ light rays are ____________ by irregularities in the surface.
- Plane Mirror
  - Image is ____________
  - Image is ____________ size
  - Image is __________ as far _________ the mirror as you are in _________ of it
- Since light rays appear to come from ____________ mirror, the image is called a ____________ image.
- If light rays ____________ to come from a ____________ location, the image is called a ____________ image.
- Real images can be ____________ on a screen, virtual images ____________.
- ____________ mirrors only produce ___________ images.

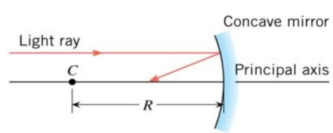


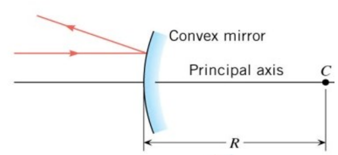
How long must a plane mirror be to see your whole reflection?

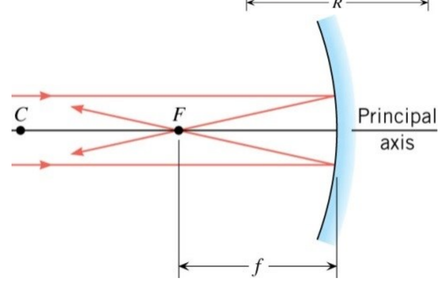


Spherical Mirrors

- Concave: bends ____________
- Convex: bends ____________
- ____________are always ________________ to the surface and pass through the ____________ of curvature, C.
  - Law of Reflection says that the ____________ to the ____________ is the same for the ____________ and ____________ rays
- Principal axis: imaginary line through _______ and the __________ of the mirror.
- Focal point (F): ____________ rays strike the mirror and ____________ at the focal point.
- Focal length (f): distance between ____________ and ____________
- Concave mirrors: $f = \frac{1}{2}R$
- Convex mirrors: $f = -\frac{1}{2}R$



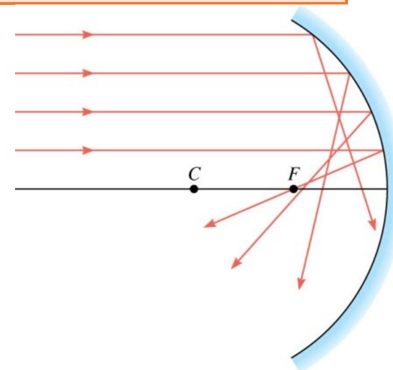




Physics 11-02 Reflection **Name: _______________**

Spherical aberration

- Rays _______ from the principle axis actually cross between _____ and the _________.
- Fix this by using a ____________ mirror.

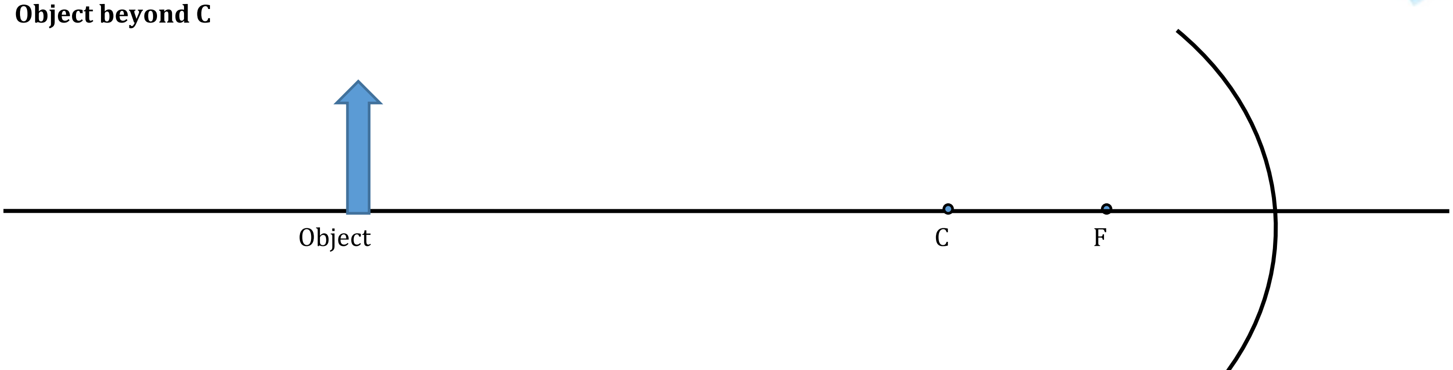


Ray Diagrams

Concave Mirror

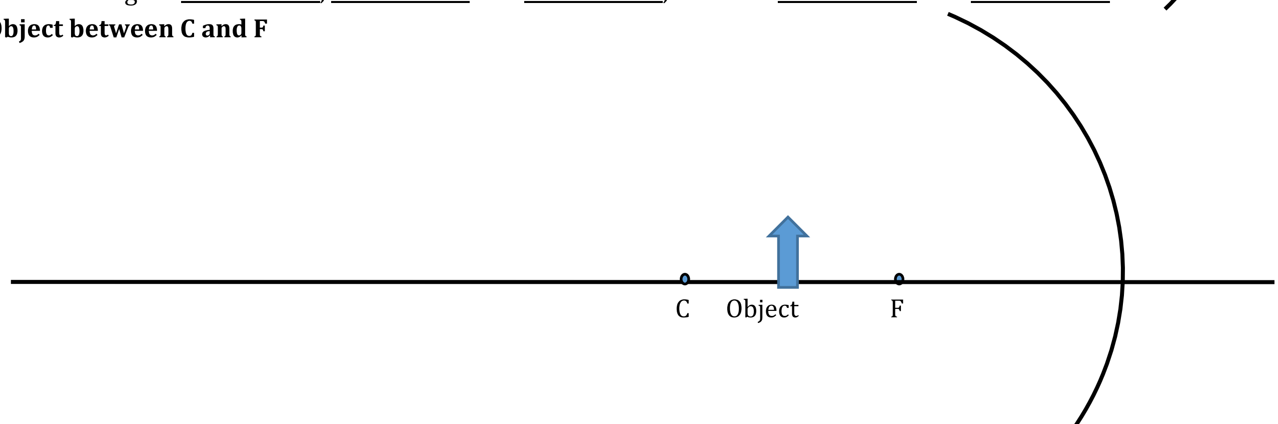
- Ray 1 – ____________ to principal axis, strikes mirror and reflects through _________
- Ray 2 – Through _________, strikes mirror and reflects ____________ to principal axis
- Ray 3 – Through _________, strikes mirror and reflects back through ____________

Object beyond C



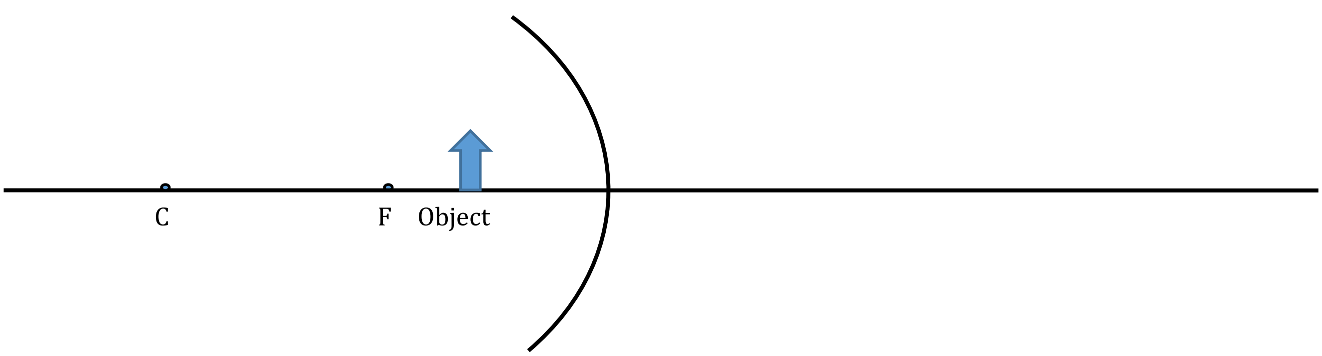
- Image is ____________, ____________ and ____________, between ____________ and ____________

Object between C and F



- Image ____________, ____________, and ____________, beyond ____________

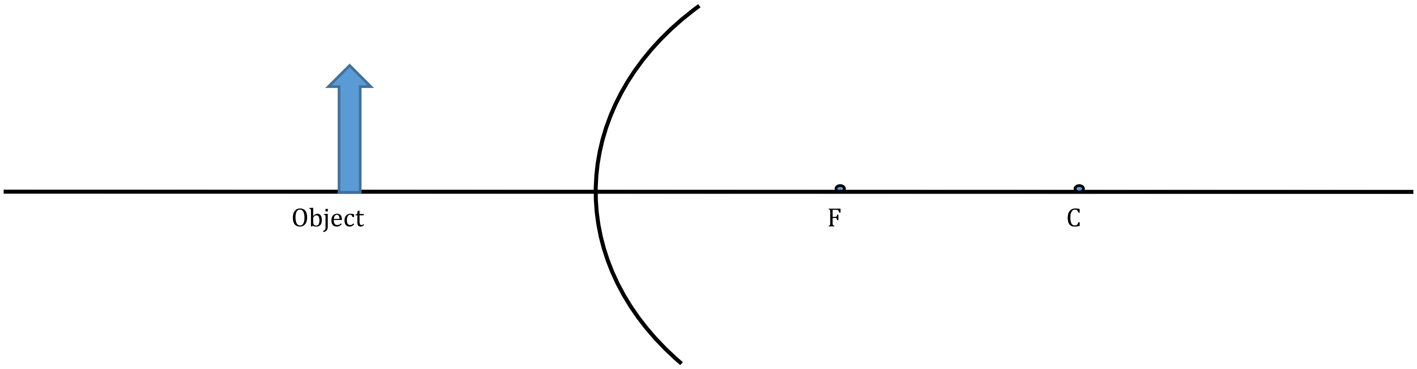
Object between F and mirror



- Image ____________, ____________, ____________, ____________ mirror

Physics 11-02 Reflection *Name:* ______________

Convex Mirrors



- Image ___________, ___________, ___________, ___________ mirror between F and ___________

Mirror Equation

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

- Where f = focal length (negative if ___________), d_0 = object distance, d_i = image distance (negative if ___________)

Magnification Equation

$$m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

- Where m = magnification, h_o = object height, h_i = image height (negative if ___________), d_o = object distance, d_i = image distance (negative if ___________)

A 0.5-m high toddler is playing 10 m in front of a concave mirror with radius of curvature of 7 m.
What is the location of his image?

What is the height of his image?

A 0.5-m high toddler is playing 10 m in front of a convex mirror with radius of curvature of 7 m.
What is the location of his image?

What is the height of his image?

Physics 11-02 Reflection *Name:* _______________

Practice Work

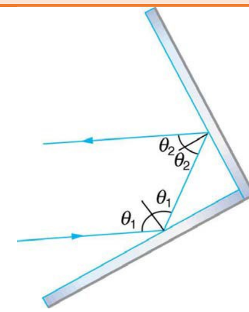


Figure 1

1. Using the law of reflection, explain how powder takes the shine off of a person's nose. What is the name of the optical effect?
2. Show that when light reflects from two mirrors that meet each other at a right angle, the outgoing ray is parallel to the incoming ray, as illustrated in figure 1. (OpenStax 25.2) **See below**
3. Light shows staged with lasers use moving mirrors to swing beams and create colorful effects. Show that a light ray reflected from a mirror changes direction by 2θ when the mirror is rotated by an angle θ. (OpenStax 25.3) **See below**
4. What are the differences between real and virtual images? How can you tell (by looking) whether an image formed by a single lens or mirror is real or virtual?
5. Can you see a virtual image? Can you photograph one? Can one be projected onto a screen with additional lenses or mirrors? Explain your responses.
6. Is it necessary to project a real image onto a screen for it to exist?
7. Under what circumstances will an image be located at the focal point of a lens or mirror?
8. What is meant by a negative magnification? What is meant by a magnification that is less than 1 in magnitude?
9. Suppose a man stands in front of a mirror. His eyes are 1.65 m above the floor, and the top of his head is 0.13 m higher. (a) Find the height above the floor of the top and bottom of the smallest mirror in which he can see both the top of his head and his feet. (b) How is this distance related to the man's height? (OpenStax 25.1) **bottom 0.825 m, top 1.715 m; not related**
10. Some telephoto cameras use a mirror rather than a lens. What radius of curvature mirror is needed to replace a 800 mm focal length telephoto lens? (OpenStax 25.54) **+1.60 m**
11. Calculate the focal length of the mirror formed by the shiny back of a spoon that has a 3.00 cm radius of curvature. (OpenStax 25.55) $\mathbf{-1.50 \times 10^{-2}\ m}$
12. Electric room heaters use a concave mirror to reflect infrared (IR) radiation from hot coils. Note that IR follows the same law of reflection as visible light. Given that the mirror has a radius of curvature of 50.0 cm and produces an image of the coils 3.00 m away from the mirror, what is the magnification of the heater element. Note that its large magnitude helps spread out the reflected energy. (OpenStax 25.56) **-11.0**
13. What is the focal length of a makeup mirror that produces a magnification of 1.50 when a person's face is 12.0 cm away? (OpenStax 25.57) **0.360 m**
14. A shopper standing 3.00 m from a convex security mirror sees his image with a magnification of 0.250. (a) Where is his image? (b) What is the focal length of the mirror? (c) What is its radius of curvature? (OpenStax 25.58) **-0.750 m, -1.00 m, 2.00 m**
15. An object 1.50 cm high is held 3.00 cm from a person's cornea, and its reflected image is measured to be 0.167 cm high. (a) What is the magnification? (b) Where is the image? (c) Find the radius of curvature of the convex mirror formed by the cornea. (Note that this technique is used by optometrists to measure the curvature of the cornea for contact lens fitting. The instrument used is called a keratometer, or curve measurer.) (OpenStax 25.59) **+0.111, -0.334 cm, -0.752 cm**

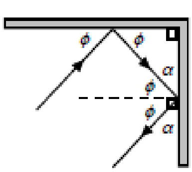


Figure 2 Answer to #2

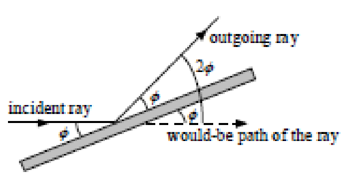
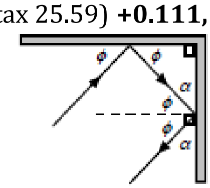
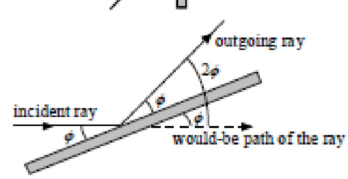


Figure 3 Answer to #3





Physics 11-03 Refraction **Name:** ______________

Refraction

Table 25.1 Index of Refraction in Various Media

Medium	*n*
Gases at 0ºC , 1 atm	
Air	1.000293
Carbon dioxide	1.00045
Hydrogen	1.000139
Oxygen	1.000271
Liquids at 20ºC	
Benzene	1.501
Carbon disulfide	1.628
Carbon tetrachloride	1.461
Ethanol	1.361
Glycerine	1.473
Water, fresh	1.333
Solids at 20ºC	
Diamond	2.419
Fluorite	1.434
Glass, crown	1.52
Glass, flint	1.66
Ice at 20ºC	1.309
Polystyrene	1.49
Plexiglas	1.51
Quartz, crystalline	1.544
Quartz, fused	1.458
Sodium chloride	1.544
Zircon	1.923

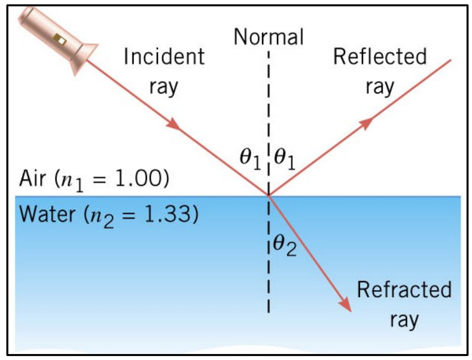
- Speed of light in a vacuum: $c = 3.00 \times 10^8 \frac{m}{s}$
- Light travels __________ through materials due to light _________, absorbed by, emitted by, and scattered by _________.

Index of Refraction

- _____________to indicate relative _____________ of light in a _____________

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

- When light hits the surface of a material part of it is _____________
- The other part goes into the _____________
- The transmitted part is _________ (_____________)



Snell's Law (The Law of Refraction)

$$\boldsymbol{n_1 \sin\theta_1 = n_2 \sin\theta_2}$$

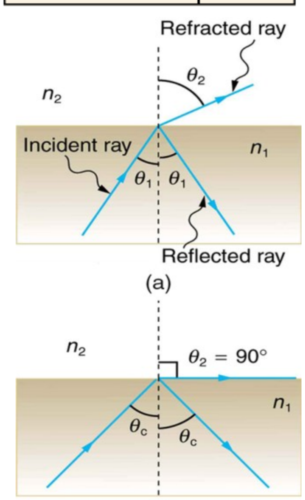
Where $\boldsymbol{n_1}$ = index of refraction of incident, $\boldsymbol{n_2}$ = index of refraction of second, $\boldsymbol{\theta_1}$ = angle of incidence (to normal), $\boldsymbol{\theta_2}$ = angle of refraction (to normal)

You shine a laser into a piece of clear material. The angle of incidence is 35°. You measure the angle of refraction as 26°. What is the material?

What is the speed of light in the material?

Total Internal Reflection

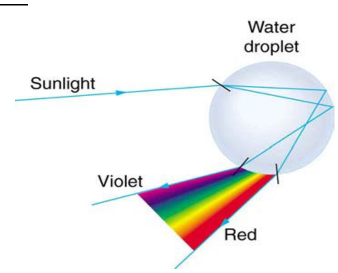
- When light hits an ____________ between two types of ____________ with different indices of ____________
  - Some is ____________, Some is ____________
- Critical angle
  - Angle of ____________ where ____________ angle is ____________
  - Angles of incidence ____________ than this cause the ____________ angle to be ____________ the material. This can't happen, so ____________ refraction occurs.
    - $\theta_c = \sin^{-1}\frac{n_2}{n_1}$ where $n_1 > n_2$



What is the critical angle from cubic zirconia (n=2.16) to air? Will an angle of 25° produce total internal reflection?

Dispersion

- Each ______________ of light has a different ____________ of refraction
  - Red — ____________ Violet — ____________
  - When light is refracted, the violet bends more than red, which ____________ the colors
- Rainbows
  - ______________ by ____________ with internal ____________
  - Rainbows are always the ____________ direction from the sun



Physics 11-03 Refraction	***Name:*** ______________

Table 25.2 Index of Refraction n in Selected Media at Various Wavelengths

Medium	Red (660 nm)	Orange (610 nm)	Yellow (580 nm)	Green (550 nm)	Blue (470 nm)	Violet (410 nm)
Water	1.331	1.332	1.333	1.335	1.338	1.342
Diamond	2.410	2.415	2.417	2.426	2.444	2.458
Glass, crown	1.512	1.514	1.518	1.519	1.524	1.530
Glass, flint	1.662	1.665	1.667	1.674	1.684	1.698
Polystyrene	1.488	1.490	1.492	1.493	1.499	1.506
Quartz, fused	1.455	1.456	1.458	1.459	1.462	1.468

Practice Work

1. Diffusion by reflection from a rough surface is described in this chapter. Light can also be diffused by refraction. Describe how this occurs in a specific situation, such as light interacting with crushed ice.
2. Will light change direction toward or away from the perpendicular when it goes from air to water? Water to glass? Glass to air?
3. Explain why an object in water always appears to be at a depth shallower than it actually is? Why do people sometimes sustain neck and spinal injuries when diving into unfamiliar ponds or waters?
4. A high-quality diamond may be quite clear and colorless, transmitting all visible wavelengths with little absorption. Explain how it can sparkle with flashes of brilliant color when illuminated by white light.
5. The most common type of mirage is an illusion that light from faraway objects is reflected by a pool of water that is not really there. Mirages are generally observed in deserts, when there is a hot layer of air near the ground. Given that the refractive index of air is lower for air at higher temperatures, explain how mirages can be formed.
6. What is the speed of light in water? In glycerine? (OpenStax 25.5) $\mathbf{2.25 \times 10^8\ m/s, 2.04 \times 10^8\ m/s}$
7. Calculate the index of refraction for a medium in which the speed of light is 2.012×10^8 m/s, and identify the most likely substance based on Table 25.1. (OpenStax 25.7) **1.490, polystyrene**
8. In what substance in Table 25.1 is the speed of light 2.290×10^8 m/s? (OpenStax 25.8) **ice**
9. Components of some computers communicate with each other through optical fibers having an index of refraction n = 1.55. What time in nanoseconds is required for a signal to travel 0.200 m through such a fiber? (OpenStax 25.11) **1.03 ns**
10. What is the angle of refraction when light in air strikes the surface of plexiglass at 30°? (RW) **19.6°**
11. What is the angle of refraction when light in water strikes the surface of fluorite at 25°? (RW) **23.1°**
12. Suppose you have an unknown clear substance immersed in water, and you wish to identify it by finding its index of refraction. You arrange to have a beam of light enter it at an angle of 45.0°, and you observe the angle of refraction to be 40.3°. What is the index of refraction of the substance and its likely identity? (OpenStax 25.13) **1.46, fused quartz**
13. (a) Verify that the critical angle for light going from diamond to air is 24.4°. (b) What is the critical angle for light going from zircon to air? (OpenStax 25.21) $\mathbf{24.4°, 31.3°}$
14. You can determine the index of refraction of a substance by determining its critical angle. (a) What is the index of refraction of a substance that has a critical angle of 68.4° when submerged in water? What is the substance, based on Table 25.1? (b) What would the critical angle be for this substance in air? (OpenStax 25.25) **Fluorite,** $\mathbf{44.2°}$
15. A ray of light, emitted beneath the surface of an unknown liquid with air above it, undergoes total internal reflection as shown in Figure 1. What is the index of refraction for the liquid and its likely identification? (OpenStax 25.26) **1.50, Benzene**

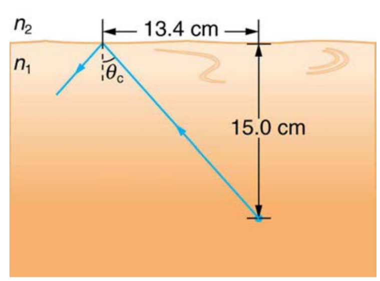
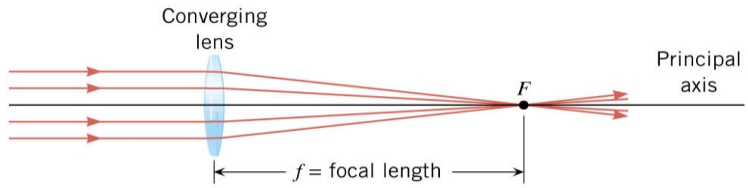


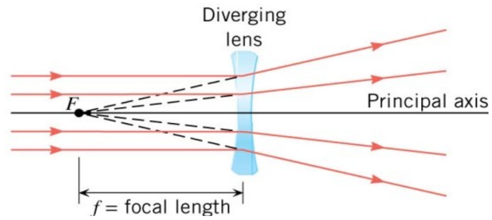
Figure 1

16. (a) What is the ratio of the speed of red light to violet light in diamond, based on Table 25.2? (b) What is this ratio in polystyrene? (c) Which is more dispersive? (OpenStax 25.28) **1.020, 1.012, diamond**
17. A beam of white light goes from air into water at an incident angle of 75.0°. At what angles are the red (660 nm) and violet (410 nm) parts of the light refracted? (OpenStax 25.29) $\mathbf{46.5°,\ 46.0°}$

Lenses

- Lens - Made from ______________ material, usually with a ___________ edge.
- Converging Lens – ___________ middle, ___________ edge (___________)
- Diverging Lens – ___________ middle, ___________ edge (___________)
- Power of lens
  - $P = \frac{1}{f}$
  - Unit: ___________ (D)



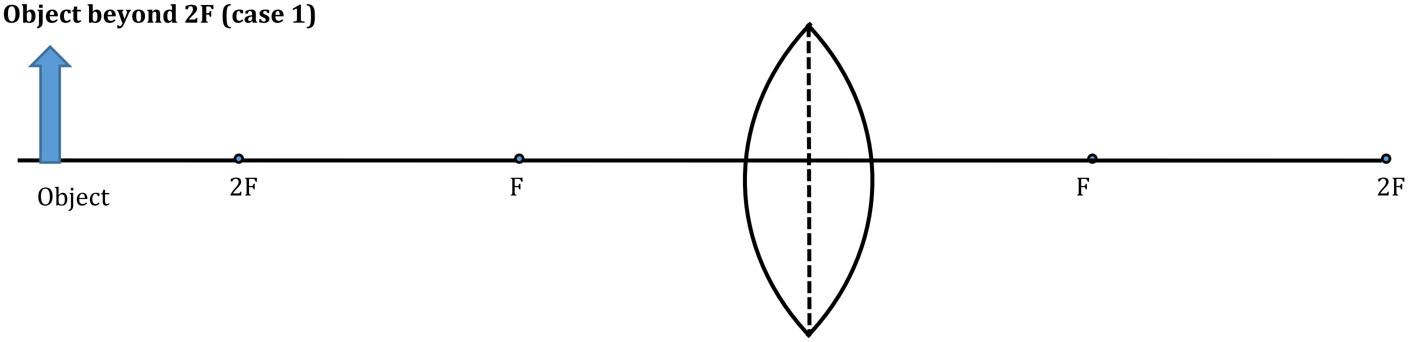


Ray Diagrams

Converging Lenses

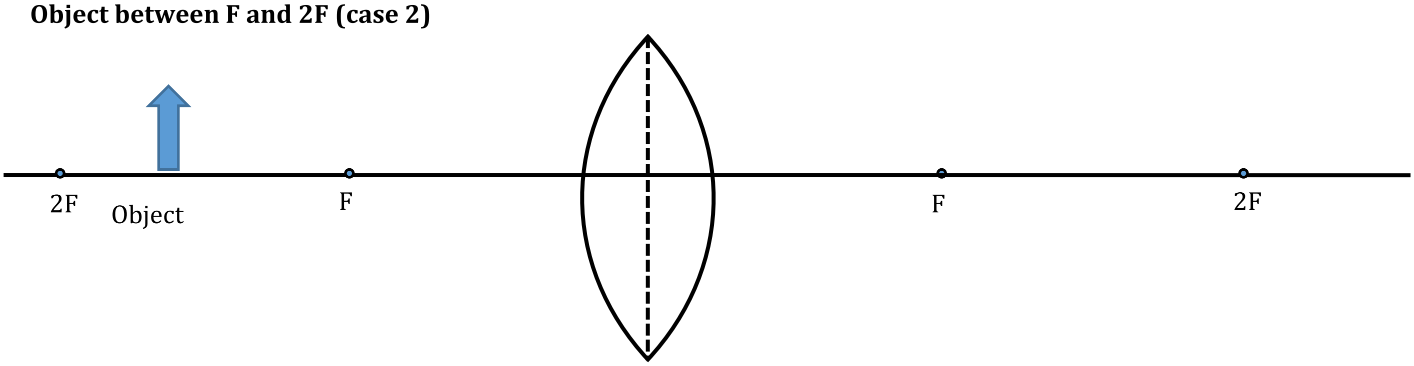
- Ray 1 – ___________ to principal ___________, bends through ___________
- Ray 2 – Through ___________, bends ___________ to principal axis
- Ray 3 – Goes through ___________ of lens, does ___________ bend

Object beyond 2F (case 1)



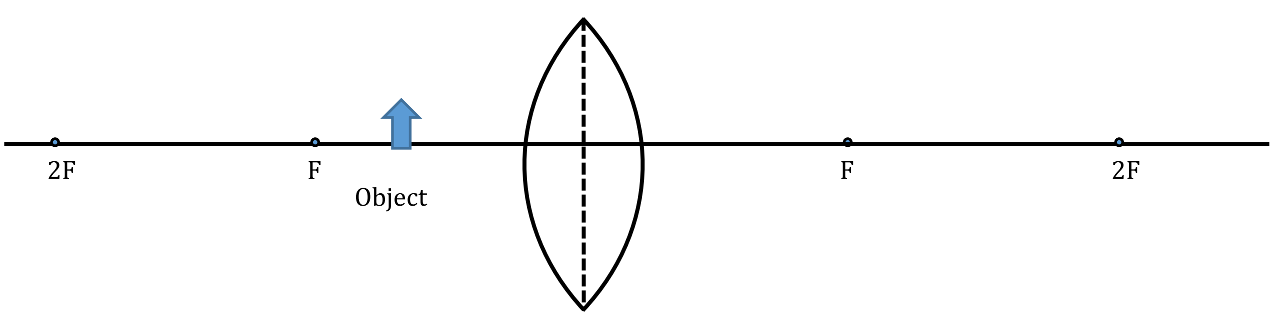
- Image ___________, ___________, ___________, between ___________ and ___________

Object between F and 2F (case 2)



- Image ___________, ___________, ___________, beyond ___________

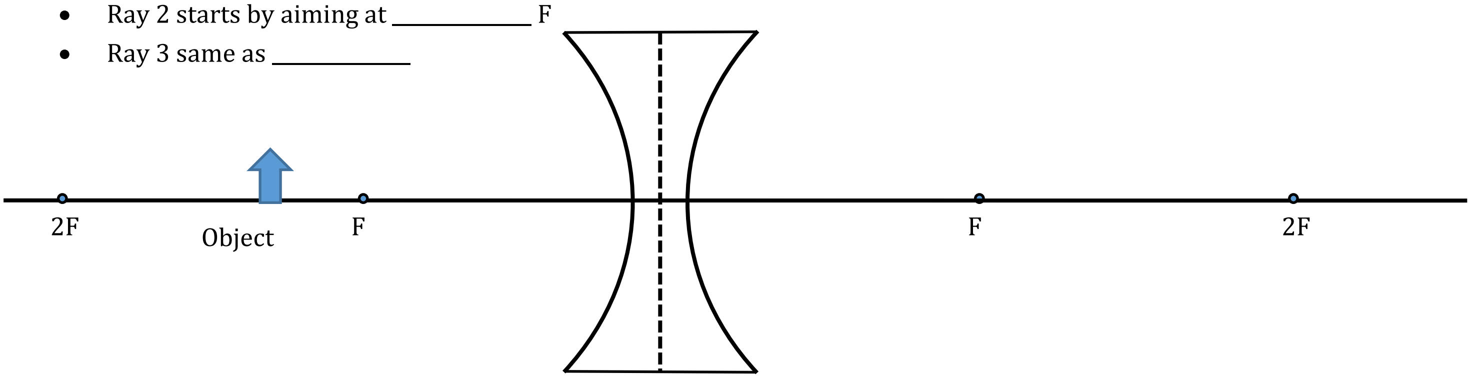
Object between F and lens (case 3)



- Image ___________, ___________, between ___________ and ___________ on side with ___________

Diverging Lens

- Ray 1 now bends ___________ from axis so that it looks like it came ___________ F
- Ray 2 starts by aiming at ___________ F
- Ray 3 same as ___________



- Image ___________, ___________, ___________, between ___________ and ___________

Thin-lens and Magnification Equations

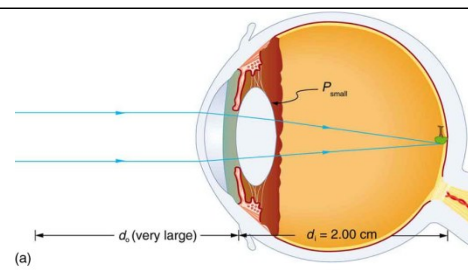
$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \qquad m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

- Where f = focal length, d_o = object distance, and d_i = image distance
- Converging Lens
  - f ___________
  - d_o ___________ if real (left side)
  - d_i ___________ if real (right side)
- Diverging Lens
  - f ___________
  - d_o ___________ if real (left side)
  - d_i ___________ if virtual (left side)

A child is playing with a pair of glasses with diverging lenses. The focal length is 20 cm from the lens and his eye is 5 cm from the lens. A parent looks at the child's eye in the lens. If the eye is the object, where is the image located?

If his eye is really 3 cm across, how big does it appear?

Physics of the Eye

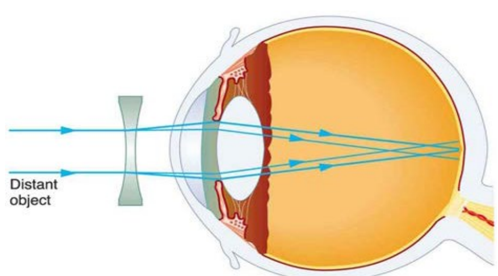


- Cornea/Lens act as ___________ thin ___________
- To see something in focus the ___________ must be on the ___________ at ___________ of eye
- Lens can change _________ to focus objects from different object _________

Vision Correction

Near-sightedness

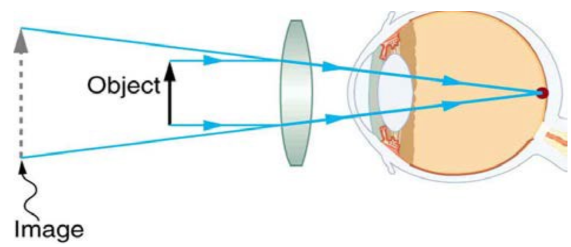
- ___________
- Image in ___________ of retina
- Correct with ___________ lens



Myopia

Far-sightedness

- ___________
- Image ___________ retina
- Correct with _______________ lens



Hyperopia

What power of spectacle lens is needed to correct the vision of a nearsighted person whose far point is 20.0 cm? Assume the spectacle (corrective) lens is held 1.50 cm away from the eye by eyeglass frames.

Color Vision and Color

Photoreceptors in Eye

- Rods
  - ____________ sensitive (see in ____________)
  - No ____________ info
  - _______________ vision
- Cones
  - Centered in ____________ of retina
  - Work in ____________ in ____________ light
  - Give ____________ info
  - Essentially ____________ types each picking up one ____________ color

Color

- Non-light producing objects
  - The ____________ we see is the color that ____________ off the object
  - The object ____________ all the other ____________
- Light-producing
  - The color we ____________ is the color ____________

Practice Work

1. When you focus a camera, you adjust the distance of the lens from the film. If the camera lens acts like a thin lens, why can it not be a fixed distance from the film for both near and distant objects?
2. A thin lens has two focal points, one on either side, at equal distances from its center, and should behave the same for light entering from either side. Look through your eyeglasses (or those of a friend) backward and forward and comment on whether they are thin lenses.
3. Will the focal length of a lens change when it is submerged in water? Explain.
4. If the cornea is to be reshaped (this can be done surgically or with contact lenses) to correct myopia, should its curvature be made greater or smaller? Explain. Also explain how hyperopia can be corrected.
5. A pure red object on a black background seems to disappear when illuminated with pure green light. Explain why.

6. Your camera's zoom lens has an adjustable focal length ranging from 80.0 to 200 mm. What is its range of powers? (OpenStax 25.37) **12.5 D, 5.00 D**
7. What is the focal length of 1.75 D reading glasses found on the rack in a pharmacy? (OpenStax 25.38) **57.1 cm**
8. How far from the lens must the film in a camera be, if the lens has a 35.0 mm focal length and is being used to photograph a flower 75.0 cm away? Solve using both a ray diagram and the thin lens equation. (OpenStax 25.40) **36.7 mm**
9. A camera lens used for taking close-up photographs has a focal length of 22.0 mm. The farthest it can be placed from the film is 33.0 mm. (a) What is the closest object that can be photographed? (b) What is the magnification of this closest object? (OpenStax 25.45) **6.60 cm, -0.5**
10. Suppose your 50.0 mm focal length camera lens is 51.0 mm away from the film in the camera. (a) How far away is an object that is in focus? (b) What is the height of the object if its image is 2.00 cm high? (OpenStax 25.46) **2.55 m, 1.00 m**
11. (a) What is the focal length of a magnifying glass that produces a magnification of 3.00 when held 5.00 cm from an object, such as a rare coin? (b) Calculate the power of the magnifier in diopters. (c) Discuss how this power compares to those for store-bought reading glasses (typically 1.0 to 4.0 D). Is the magnifier's power greater, and should it be? (OpenStax 25.47) **7.50 cm, 13.3 D, lots stronger**
12. (a) Where is the image that will be produced by a lens of power −4.00 D (such as might be used to correct myopia) if an object is held 25.0 cm away? Solve by using both a ray diagram and the thin lens equation. (b) What is the magnification? (OpenStax 25.48) **-12.5 cm, +0.500**
13. What is the power of the eye when viewing an object 50.0 cm away? (OpenStax 26.1) **52.0 D**
14. The print in many books averages 3.50 mm in height. How high is the image of the print on the retina when the book is held 30.0 cm from the eye? (OpenStax 26.3a) **−0.233 mm**
15. Suppose a certain person's visual acuity is such that he can see objects clearly that form an image 4.00 μm high on his retina. What is the maximum distance at which he can read the 75.0 cm high letters on the side of an airplane? (OpenStax 26.4) **3.75 km**
16. What is the far point of a person whose eyes have a relaxed power of 50.5 D? (OpenStax 26.6) **2.00 m**
17. What is the near point of a person whose eyes have an accommodated power of 53.5 D? (OpenStax 26.7) **28.6 cm**
18. A very myopic man has a far point of 20.0 cm. What power contact lens (when on the eye) will correct his distant vision? (OpenStax 26.16) **−5.00 D**
19. Repeat the previous problem for eyeglasses held 1.50 cm from the eyes. (OpenStax 26.17) **-5.41 D**

Physics Unit 11: Electromagnetic Rays Review

1. Know about electromagnetic waves, emission spectra, absorption spectra, refraction, reflection, myopia, hyperopia.
2. Know the spectrum of light including the complete spectrum and visible light.
3. Which types of electromagnetic waves are dangerous and why?
4. Know how an atom absorbs or emits light.
5. Know about the eye, vision correction, and color vision.
6. Know how to make ray diagrams for mirrors and lenses.
7. What type of images to the various mirrors and lenses make? (real or virtual) (upright or inverted) (enlarged or reduced)
8. Why does refraction happen?
9. WAUS has a frequency of 90.7 MHz. What is its wavelength?
10. If the index of refraction is 12.5, what is the speed of light in the material?
11. A beam of light in a material of index of refraction of 1.5 hits a boundary with air ($n = 1.00$). If the angle of incidence is 25°, what is the angle of refraction?
12. A light ray is traveling in a fluorite ($n = 1.434$). If the ray approaches the fluorite-air interface, what is the minimum angle of incidence that will result in all of the light being reflected back into the diamond? The index of refraction for air is 1.000.
13. A beetle is 3.0 cm in front of a convex lens with focal length of 5.0 cm. Where is the image?
14. A 2 cm object is placed 15 cm from a lens. The resulting image height has a magnitude of 0.5 cm and the image is inverted. What is the focal length of the lens?
15. The focal length of a spherical convex mirror is −4.0 cm. What is its radius of curvature?
16. What is the image distance if an object is placed 10 cm in front of a concave mirror with radius of curvature of 12 cm?
17. A pebble is 15.0 cm from a convex mirror. If the magnification is -2.5, where is the image?

Physics Unit 11: Electromagnetic Rays Review

Answers

3. UV, x-rays, gamma rays cause cell damage. When absorbed by an electron, one of these photons can completely remove the electron from the atom. This leaves the atom ionized and subject to chemical reactions.

4. Absorption: An electron absorbs a photon and its energy. This causes it to jump to a higher energy orbital.
Emission: An electron falls from a higher energy orbital to a lower orbital. The excess energy is released as a photon.
Because the orbitals are specific levels, the absorption and emission spectra have distinct lines.

7. Mirrors
Concave: $d_o > R$ image real, inverted, reduced, between C and F
$f < d_o < R$ image real, inverted, enlarged, beyond C
$d_o < f$ image virtual, upright, enlarged, behind mirror
Convex: image virtual, upright, reduced, behind mirror

Lenses
Converging: $d_o > 2f$ image real, inverted, reduced, between 2F and F
$f < d_o < 2f$ image real, inverted, enlarged, beyond 2F
$d_o < f$ image virtual, upright, enlarged, behind lens
Diverging: image virtual, upright, reduced, behind lens

8. **Speed of light changes**

9. $f = 90.7 \times 10^6\ Hz, c = 3.00 \times 10^8 \frac{m}{s}$
$c = f\lambda$
$3.00 \times 10^8 \frac{m}{s} = (90.7 \times 10^6 Hz)\lambda$
$\boldsymbol{\lambda = 3.31\ m}$

10. $n = 12.5$
$n = \frac{c}{v}$
$12.5 = \frac{3.00\times10^8 \frac{m}{s}}{v}$
$\boldsymbol{v = 2.4 \times 10^7 \frac{m}{s}}$

11. $n_1 = 1.5, \theta_1 = 25°, n_2 = 1.0, \theta_2 = ?$
$n_1 \sin\theta_1 = n_2 \sin\theta_2$
$1.5 \sin 25° = 1.0 \sin\theta$
$0.6339 = \sin\theta$
$\theta = \sin^{-1} 0.6339 = \boldsymbol{39.3}°$

12. $n_1 = 1.434, n_2 = 1.000\ , \theta_c = ?$
$\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$
$\theta_c = \sin^{-1}\left(\frac{1.000}{1.434}\right)$
$\boldsymbol{\theta_c = 44.2°}$

13. $d_o = 3.0\ cm, f = 5.0\ cm, d_i = ?$
$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$
$\frac{1}{5.0\ cm} = \frac{1}{3.0\ cm} + \frac{1}{d_i}$
$\frac{1}{5.0\ cm} - \frac{1}{3.0\ cm} = \frac{1}{d_i}$
$-\frac{2}{15\ cm} = \frac{1}{d_i}$
$d_i = \boldsymbol{-7.5\ cm}$

14. $h_0 = 2\ cm, d_o = 15\ cm, h_i = -0.5\ cm, f = ?$
$\frac{h_i}{h_o} = -\frac{d_i}{d_o}$
$\frac{-0.5}{2} = \frac{-d_i}{15}$
$-2d_i = -7.5$
$d_i = 3.75\ cm$
$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$
$\frac{1}{f} = \frac{1}{15} + \frac{1}{3.75}$
$\boldsymbol{f = 3\ cm}$

15. $f = -4.0\ cm, R = ?$
$f = -\frac{1}{2}R$
$-4.0\ cm = -\frac{1}{2}R$
$\boldsymbol{R = 8.0\ cm}$

16. $R = 12\ cm, f = 6\ cm, d_o = 10\ cm$
$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$
$\frac{1}{6} = \frac{1}{10} + \frac{1}{d_i}$
$\frac{1}{6} - \frac{1}{10} = \frac{1}{d_i}$
$\boldsymbol{d_i = 15\ cm}$

17. $d_o = 15.0\ cm, m = -2.5, d_i = ?$
$m = -\frac{d_o}{d_i}$
$-2.5 = -\frac{15.0\ cm}{d_i}$
$2.5d_i = 15.0\ cm$
$\boldsymbol{d_i = 6.0\ cm}$