Exam IV: Chapters 22—24

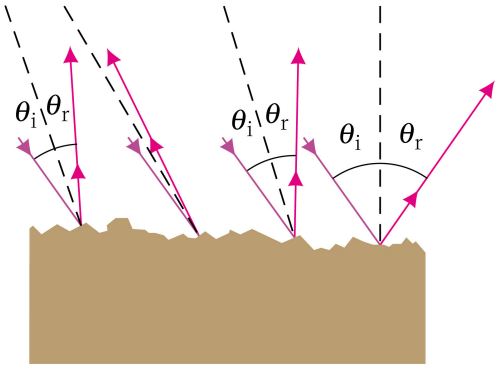
1. Compare the speed of radio waves to the speed of x-rays traveling through the vacuum of space.
   A) Radio waves travel faster because they have a longer wavelength.
   B) Radio waves travel more slowly because they have a lower frequency.
   C) X–rays travel more slowly because they have a shorter wavelength.
   D) X–rays travel faster because they have a higher frequency.
   E) The speed is the same for both, $c = 3x10^8 m/s$.

2. What is the frequency of yellow light which has a wavelength of 600nm ($6x10^{-7}$m)?
   A) $f = 2x10^{-15}$Hz. B) $f = 180$Hz **C) $f = 5x10^{14}$Hz.** D) $f = 1.8x10^{16}$Hz.

3. Compare the energy of infrared radiation to ultraviolet.
   A) Infrared radiation has a lower frequency and therefore less energy.
   B) Infrared radiation has a longer wavelength, and therefore more energy.
   C) The energy of both depends on speed (you know, $E = mc^2$), so they have the same energy.

4. Compute the energy of microwaves having a frequency $f = 5x10^{10}$Hz. Planck's constant $h = 6.63x10^{-34}$J·s.
   A) $E = 1.3x10^{-44}$J. B) $E = 4.0x10^{-36}$J. **C) $E = 3.3x10^{-23}$J.** D) $E = 7.5x10^{43}$J.

5. The law of reflection states that
   A) incoming light is reflected back along its original path.
   B) the angle of incidence is equal to the angle of reflection.
   C) the angles of incidence and reflection always add up to 90°.
   D) for curved mirrors, the angle of reflection is twice the angle of incidence.
   E) angle of incidence only equals angle of reflection for flat, perfectly smooth, plane mirrors.



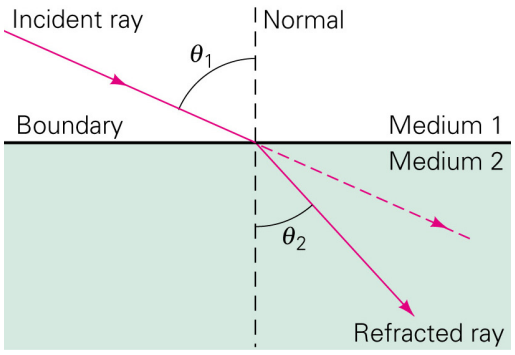
6. The parallel rays shown strike the surface and reflect as shown.
   A) Specular reflection. **D) Diffuse reflection.**
   B) Spectacular reflection. E) Refuse reflection.
   C) Suffuse reflection.

7. Specular reflection occurs when
   A) parallel rays of incoming light are reflected from a smooth surface. The reflected rays are also parallel.
   B) parallel rays of light are reflected from a rough or uneven surface. The reflected rays are not parallel.
   C) randomly oriented rays of incoming light reflect off a smooth surface. The reflected rays are all normal to the surface.
   D) randomly oriented rays of incoming light reflect off a rough surface. The reflected rays are all normal to the surface.
   E) randomly oriented rays of light are passed through a parallel ray lens, to create a narrow beam of light. This narrow beam strikes a smooth surface and is reflected normal to the surface.

8. The principle of least time states that
   A) the shortest distance between two points is a straight line.
   B) the shortest path between two points is always the fastest path.
   C) it always takes less time for light to travel a path than anything else.
   D) a beam of light will always travel along the shortest path from one point to another.
   E) a beam of light will always follow the fastest path from one point to another.

9. When light passes from one medium to another,
   A) it continues to travel at $3x10^8$ m/s regardless of the type of medium.
   B) it always slows down, and it always refracts regardless of the angle of incidence.
   C) it always speeds up, and it never refracts regardless of the angle of incidence.
   D) it bends only when it strikes the boundary between the media at a 90° angle to the surface.
   E) it may slow down or speed up, depending on the medium. The amount of refraction depends on the angle at which the light strikes the boundary.

10. A beam of light is shown on the right striking a boundary between two media. Neither medium is vacuum or air, and Medium 1 is not the same as Medium 2.
    A) The speed does not change and the light should not bend. The real refracted ray should match the undeflected dotted ray.
    B) The incident ray speeds up when it strikes Medium 2.
    C) The beam slows down, because it bends toward the normal. Medium 2 is slower than Medium 1.
    D) The picture cannot tell you which medium is faster. Unless you have the indices of refraction to compare, you have no way to know. Whether a refracted ray bends one way or another does not depend on the medium, it depends on the wavelength. Red light bends toward the normal, blue light bends away.



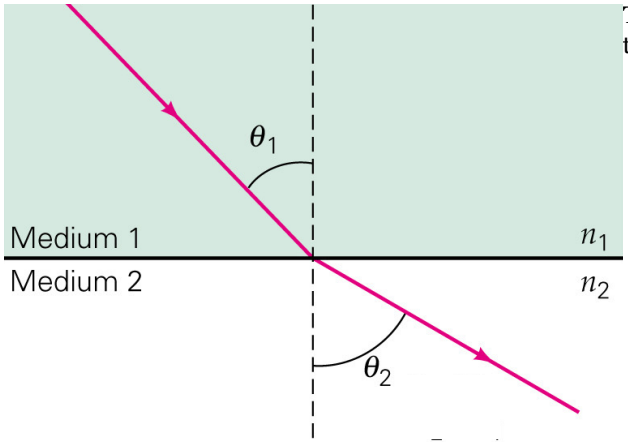
11. In the above diagram, what happens as the angle of incidence is decreased from θ_1=60° to θ_1=0°?
A) The angle of refraction decreases. When θ_1 reaches zero, θ_2 also reaches 0°.
B) The angle of refraction increases. When θ_1 reaches zero, θ_2 reaches 90°.
C) The angle of refraction θ_2 remains constant, because Medium 2 does not change.
D) There is no angle of refraction. When θ_1=0°, the beam of light is skimming the surface between the media.

12. The index of refraction for a piece of glass is 1.6. What is the speed of light through this medium?
A) $v = 1.6x10^8$m/s. **B) $v = 1.9x10^8$m/s.** C) $v = 3x10^8$m/s. D) $v = 4.8x10^8$m/s.

13. The refraction index for water is 1.3. Compare the speed of light through water to the speed through the above glass.
A) The higher the index of refraction, the faster the speed of light through the medium.
B) The higher the index of refraction, the slower the speed of light through the medium.
C) The speed is the same through either medium. It's the frequency of the light that changes: the greater the index, the greater the increase in frequency.
D) The speed remains constant. Both frequency and wavelength decrease as index of refraction increases.

14. A beam of light traveling through air will be bent more when it strikes which medium? Assume equal angles of incidence.
A) The glass will bend the light more. Higher index means more bending.
B) The water will bend the light more. Lower index of refraction means more bending.
C) The light will be bent by the same amount regardless of the index of the refracting medium.
D) The light will not be bent by either medium, because an index of refraction greater than 1 means that the medium is unable to transmit light.

15. Light traveling through air strikes the plastic surface of a transparent tabletop at an angle of 40° with respect to the normal. The index of refraction for lucite is 1.495. Find the angle of refraction.
A) θ=0° B) θ=16.1° **C) θ=25.5°** D) θ=41.0° E) θ=73.9°



The beam of light shown on the left strikes the boundary between the media at an angle θ_1. Neither medium is vacuum or air.

16. For total internal reflection to be observed,
A) Medium 1 must be a slower medium than Medium 2.
B) Medium 1 must be a faster medium than Medium 2.
C) Medium 1 might be faster or slower than Medium 2. For total internal reflection to occur, the angle of incidence θ_1 must be exactly 42°. Any angle bigger or smaller, and the beam passes through.
D) Any angle θ_1 greater than 45° with respect to the normal will result in total internal reflection. The indices of refraction of the media do not matter.
E) The direction of the light must be reversed. You will only see total internal reflection when the beam strikes the boundary from below, never from above.

17. What is the critical angle for total internal reflection for fused quartz with an index of refraction n=1.44 and air (n=1)?
A) θ = 0° B) θ = 42° **C) θ = 44°** D) θ = 46° E) θ = 90°

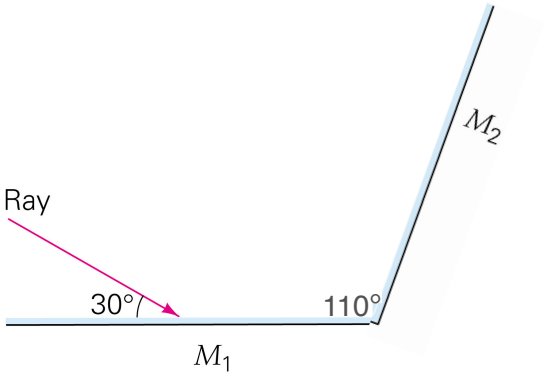
18. You are driving I-40 across New Mexico. It's gorgeous! Suddenly your sister wakes up and yells, "Watch out! The road is wet! Don't skid!" What do you do?
A) Remind her of that time when you were little and she thought that if you ate Pop Rocks while drinking a Coke your head would explode. Then make fun of her hair from sleeping in the car.
B) Slow down and pull over. The road really is wet, and since you're in New Mexico on a sunny day, it's probably a trap. When you spin out on the wet road the aliens come and abduct you.
C) The road probably is wet, but there are no aliens. The water condenses on the highway because it is warmer than the surrounding desert. Just drive carefully, but you don't need to panic.
D) Nothing. Well, keep right on singing really loud along with the radio, but you don't need to worry about the road. It's a mirage caused by the refraction of light through the air.
E) Keep singing, but know that the mirage is not a result of refraction at all. It is a dispersion effect, as red light and blue light are reflected differently off the surface of the highway.

19. White light shines through a prism.
A) White light emerges, unbent.
B) The prism scatters the blue light, and only red light emerges.
C) The prism scatters the red light, and only blue light emerges.
D) Red light, having the longest wavelength, gets bent the most.
E) Blue light, having the shortest wavelength, gets bent the most.

You are vacationing in Hawaii, and after a late afternoon shower, you see a rainbow.

1. No, wait! It's a *double* rainbow! Who doesn't love a rainbow?
   A) The primary rainbow reads "ROYGBIV" from top to bottom. So does the secondary rainbow, just fainter.
   B) The primary rainbow reads "ROYGBIV" from bottom to top. So does the secondary rainbow, just fainter.
   C) The primary rainbow reads "ROYGBIV" from bottom to top. But the secondary rainbow reads "ROYGBIV" from top to bottom.
   D) The primary rainbow reads "ROYGBIV" from top to bottom. But the secondary rainbow reads "ROYGBIV" from bottom to top.
   E) The primary rainbow has a pot of gold guarded by a genial (slightly drunk) leprechaun. The secondary rainbow has a pot of haggis guarded by a surly (slightly drunk) Scotsman. Who knows how either one of them got to Hawaii.

2. Incoming light strikes the mirror M_1 as shown on the right. At what angle with respect to the normal to mirror M_2 will the reflected ray finally emerge? Notice that M_2 is not perpendicular to M_1! Remember also that the angles of any triangle must add up to 180°.
   A) 0° B) 30° C) 40° **D) 50°** E) 90°



3. You are at the Target store buying some great new stuff to redecorate your room! Plus, you can always use some socks, ziploc bags, candy, wine glasses, cereal, and a few DVDs. It's the holidays! Shop on! If you are precisely 6 feet tall, how long should the mirror you plan to buy be if you want to use it as a full-length mirror?
   A) Any size will work. The farther away you get, the more of yourself you will see.
   B) The mirror must be at least 6 feet long, or you will never see your complete image.
   C) The mirror must be exactly 3 ft tall, if you stand exactly 6 feet away from it. If you move any closer to the mirror, it needs to be bigger for you to see your complete image.
   D) The ratio of mirror height to object distance must be exactly ½. This means that if you have a mirror 1ft tall, you must stand 2ft away from it to see your entire image. Your height does not matter.
   E) The mirror must be at least half your height, and your distance from the mirror is not material.

4. When you use a second mirror to look at the back of your head, you are seeing
   A) the real image of a real object.
   B) the real image of a virtual object.
   C) the virtual image of a real object.
   D) the virtual image of a virtual object.

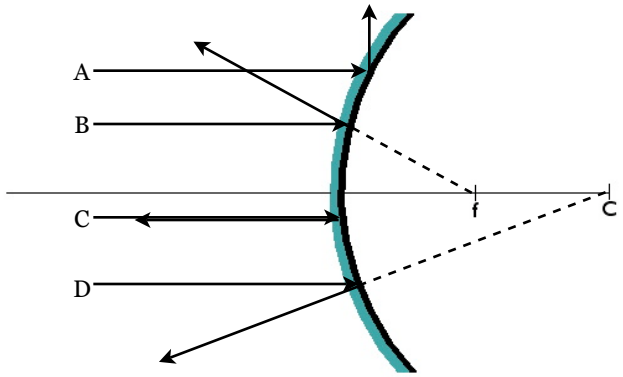
5. A person stands 2 m in front of a plane mirror and flexes his imaginary biceps. His reflection appears
   A) 2 m behind the mirror.
   B) 2 m in front of the mirror.
   C) 1 m behind the mirror.
   D) 1 m in front of the mirror.

6. Now he is holding a hairbrush and singing into it like it's a microphone (maybe we should leave before he starts combing over his bald spot). The brush is 20 cm tall. The image of the brush is
   A) 2 cm tall. B) 10 cm tall. **C) 20 cm tall.** D) 40 cm tall.

7. His image in the mirror
   A) is a little sad, but it's our own fault for snooping where we should have minded our own business.
   B) is not inverted, since a plane mirror cannot create an image.
   C) is inverted along the horizontal (x) left–right axis.
   D) is inverted along the vertical (y) up–down axis.
   E) is inverted along the horizontal (z) front–back axis.

8. Which of the following does ***not*** describe or characterize a **concave** mirror?
   A) A concave mirror is curved inward.
   B) Parallel light striking a concave mirror reflects to converge at a real focal point.
   C) A concave mirror can form images that are either magnified or minified.
   D) A concave mirror can form images that are either upright or inverted.
   E) Concave mirrors are also called diverging mirrors.

9. Which of the following does ***not*** describe or characterize a **convex** mirror?
   A) A convex mirror is curved outward.
   B) Parallel light striking a convex mirror reflects to converge at a real focal point.
   C) Convex mirrors are also called diverging mirrors.
   D) A convex mirror can only form images that are smaller than the object.
   E) A convex mirror can only form images that are upright.



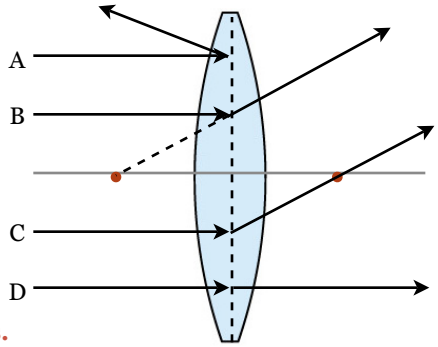
10. An incoming ray of light reflected off the convex mirror shown on the right will follow which path? **B**
E) None of these!

11. An object is placed in front of the convex mirror at at a distance $d_o = 3f$, where f is the focal length of the mirror. Describe the image formed.
A) Real, inverted, magnified.
B) Real, inverted, minified.
C) Virtual, upright, magnified.
D) Virtual, upright, minified.
E) No image formed.

12. Using a converging mirror, where would you place an object to form an image that was inverted and magnified?
A) $d_o < f$ **B) $f < d_o < 2f$** C) $d_o > 2f$
D) None of these. A converging mirror cannot form this sort of an image at any distance!

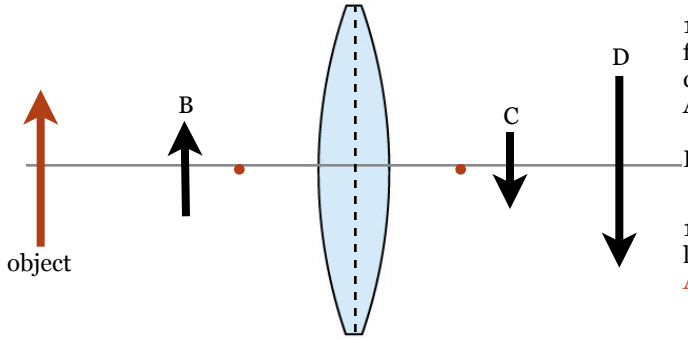
13. Explain the difference between a real image and a virtual image.
A) Either type of image may appear magnified or minified. A real image will always be inverted with respect to the object. A virtual image will always appear upright.
B) Either type of image can appear inverted or upright. The only way to tell the difference is to check the magnification: real images are the same size as the original object, virtual images are larger or smaller.
C) A real image is always right side up, never inverted; this is why it cannot be distinguished from the original real object. A virtual image is always inverted, so it can easily be distinguished from the original object.
D) A real image is an image that can be displayed on a screen. Whether it is upright or inverted is not material. A virtual image is virtual because you can't see it; you can trace a ray diagram on paper to show where an image ought to form, but if you really looked for that image using an actual screen, you would not be able to locate it.
E) There is no physical difference between real and virtual images; either may appear upright or inverted, either may appear magnified or minified. The convention is to call an image formed by a converging lens or mirror a real image, and an image formed by a diverging lens or mirror a virtual image.

14. Which of the light rays is correctly drawn for the converging lens shown on the right? **C**
E) None of these!



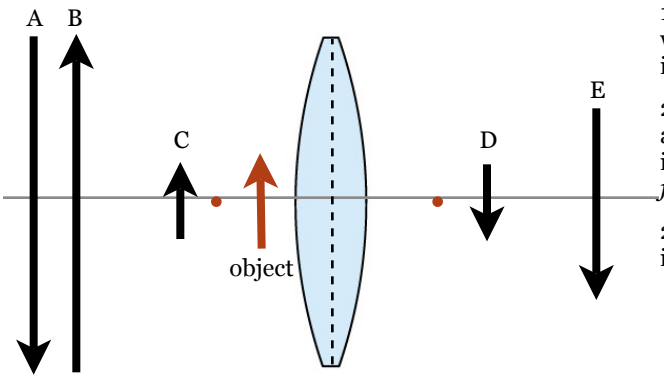
15. Which of the following does ***not*** describe or characterize a **convex lens**?
A) Parallel light striking a convex lens converges at a real focal point.
B) A convex lens can form images that are either magnified or minified.
C) A convex lens can form images that are either upright or inverted.
D) Convex lenses are also called diverging lenses.
E) A convex lens is curved outward.

16. When a converging lens is used as a magnifying glass, the object is
A) is placed at a distance less than the focal length in front of the lens.
B) placed at a distance greater than the focal length in front of the lens.
C) placed at a distance exactly equal to the focal length of the lens.
D) distance does not matter, as long as the image distance is greater than the focal length.



17. Which of the images shown on the right will be formed when the object is placed as shown in front of the converging lens? **C**
A) No image will form at all because the object is not at the focal point.
E) An image will form, but it will be a magnified virtual image located to the left of the object.

18. An object is placed at the focal point of a converging lens, $d_o = f$. What kind of image will be formed?
A) None; the rays of light will all be parallel on both sides of the lens. No real or virtual image forms.
B) A real image. Real rays of light will intersect on the side of the lens opposite the object.
C) The real image is formed when real rays intersect on the same side of the lens as the object.
D) Virtual. Real rays diverge. Virtual rays intersect on the opposite side of the lens as the object.
E) A virtual image forms, but the virtual rays intersect on the same side of the lens as the object.

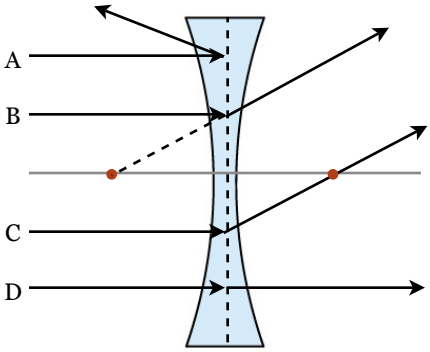


19. Which of the images shown on the left will be formed when the object is placed as shown in front of the converging lens? **B**

20. Calculate the **focal length** of a converging lens when an object is placed **15cm** in front of the lens, and the image is found **25 cm** from the lens, on the *same side as the object*. Answer with two sig figs. **f = 37.5cm**

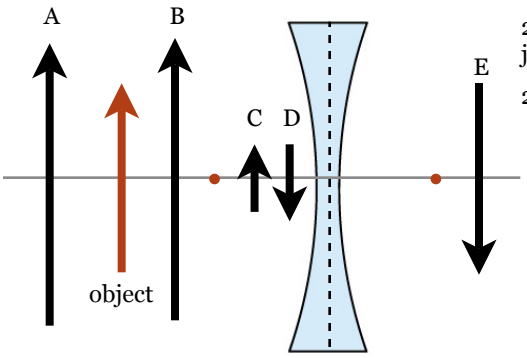
21. Which of the following does ***not*** describe or characterize a **concave lens**?
A) Parallel light striking a concave lens diverges away from the focal point.
B) A concave lens can only form images that are smaller than the object.
C) Concave lenses are also called diverging lenses.
D) A concave lens can only form images that are upright.
E) A concave lens is curved outward.

22. Which of the light rays is correctly drawn for the diverging lens shown on the right? **B**
E) None of these!



23. A diverging lens has a focal length **f = 20cm**. When an object is placed at $\mathbf{d_o}$ = **10cm**, where does the image form? Answer with two sig figs, and include sign. **$d_i = -20$cm**

24. An object is placed at the focal point of a diverging lens, $d_o = f$. What kind of image will be formed?
A) None; the rays of light will all be parallel on both sides of the lens. No real or virtual image forms.
B) A real image. Real rays of light will intersect on the side of the lens opposite the object.
C) The real image is formed when real rays intersect on the same side of the lens as the object.
D) Virtual. Real rays diverge. Virtual rays intersect on the opposite side of the lens as the object.
E) A virtual image forms, but the virtual rays intersect on the same side of the lens as the object.



25. Which of the images shown on the left will be formed when the object is placed as shown in front of the diverging lens? **C**

26. Spherical aberration
A) is the tendency of lenses to make objects appear to be out of focus.
B) is the result of using colored glass to make a lens.
C) results because different colors of light have different speeds through the lens, so they will be bent by the lens slightly differently. Blue light will have a slightly shorter focus than red light.
D) occurs when light passing through the edges of a lens is focused differently than light passing through the center of the lens.

27. Chromatic aberration
A) is the tendency of lenses to make objects appear to be out of focus.
B) is the result of using colored glass to make a lens.
C) occurs when light passing through the edges of a lens is focused differently than light passing through the center of the lens.
D) results because different colors of light have different speeds through the lens, so they will be bent by the lens slightly differently. Blue light will have a slightly shorter focus than red light.

28. Young's double–slit experiment
A) demonstrates convincingly that light is a particle. The pattern created on a screen shows two bright fringes that line up exactly with the position of each slit. There is a dark fringe on center, which you would expect since no particle passing through a slit could actually hit the center of the screen.
B) demonstrates conclusively that light is a wave. The alternating pattern of bright and dark fringes on the screen show how two light waves interfere. The central bright maximum proves that the light can't be a particle.
C) proves that light is a particle. When a bright light shines on a metal foil, the photons crash into the surface and knock electrons right off. Young observed that a wave could not do this, but he could not explain why. Einstein actually explained it, and won a Nobel Prize for his mathematical proof of Young's hypothesis.
D) showed that light has a dual wave–particle nature. Newton first suggested this, but got distracted by trying to turn lead into gold before he could prove it. Young's experiment laid the groundwork for Maxwell, whose equations finally proved that electricity is a wave and magnetism is a particle.