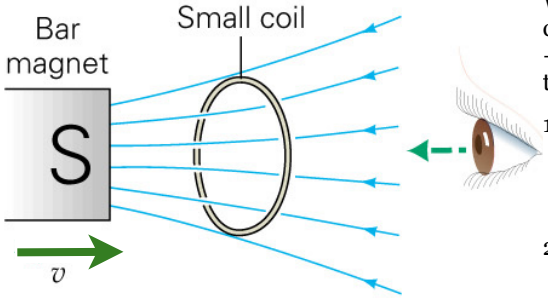
Exam IV: Chapters 20—24



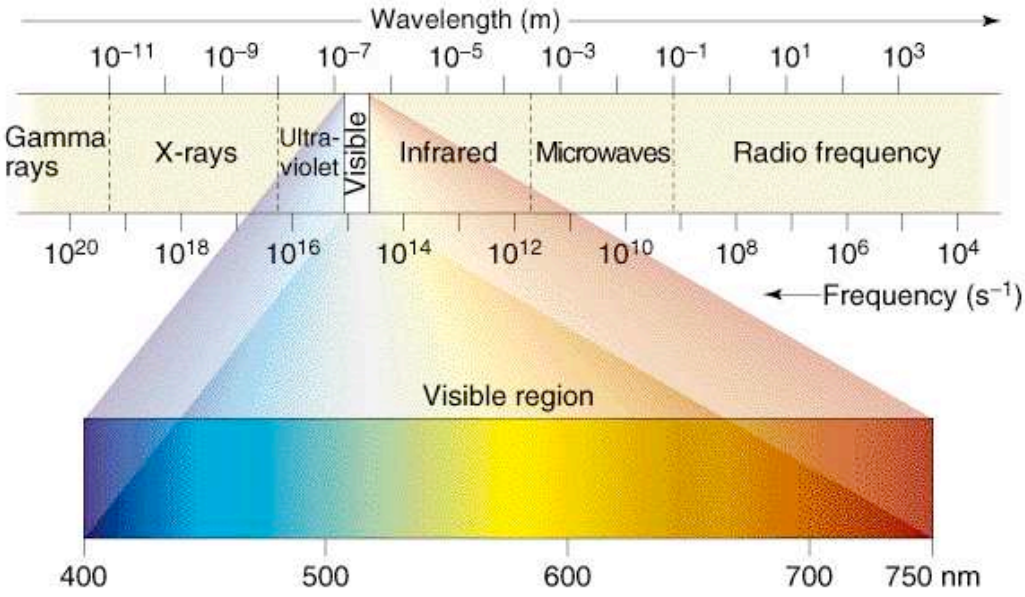
We want to use the magnet shown on the left to induce a current in the closed loop of wire. As shown in the picture, your eye is at some position +x, and you are looking at the loop in the yz-plane. The magnet is pushed toward you, in the +x direction.

1. The direction of the current in the loop is
   A) clockwise.
   B) counterclockwise.
   C) neither; no current is induced.

2. If we keep the magnet stationary, and spin the loop clockwise (loop is initially in the yz-plane, spin with respect to y-axis),
   A) the magnetic flux through the loop decreases until the loop is flat (in the xy-plane of the paper).
   B) the magnetic flux increases until the loop is flat.
   C) the magnetic flux does not change. It is zero no matter how you spin the loop of wire.
   D) the magnetic flux remains constant (and non–zero)because the magnetic field remains constant.
   E) the flux changes, but there is no way to tell if it is increasing or decreasing unless we have the area of the loop and the number of coils that make up the loop.

3. True or **false**: Gamma rays have about double the frequency of microwave radiation.

4. True or **false**: Radio waves with a wavelength of 1m travel 10 times faster through space than x–rays with a wavelength of 10^{-10}m.



5. What is the frequency of red light which has a wavelength of 750nm (7.5×10^{-7}m)?
   A) $f = 7.5\times10^{-14}$Hz.
   B) $f = 2.5\times10^{14}$Hz.
   C) $f = 4\times10^{14}$Hz.
   D) $f = 5\times10^{14}$Hz.
   E) $f = 7.5\times10^{14}$Hz.

6. **True** or false: Ultraviolet radiation with frequency 10^{16}Hz is literally 1000 times more energetic than infrared radiation with a frequency of 10^{13}Hz.

7. Compute the energy of visible light having a wavelength $\lambda = 7\times10^{-7}$m. Planck's constant $h = 6.63\times10^{-34}$J·s.
   A) 4.6×10^{-40}J. **B) 2.8×10^{-19}J.** C) 46.4J. D) 3.6×10^{18}J. E) 7.5×10^{43}J.

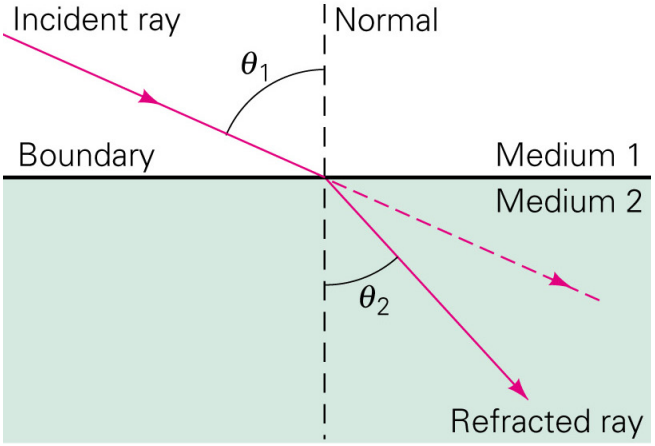
8. The law of reflection states that
   A) incoming light is reflected back along its original path.
   B) the angle of incidence is equal to the angle of reflection.
   C) the angles of incidence and reflection always add up to 90°.
   D) for curved mirrors, the angle of reflection is twice the angle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

9. Diffuse reflection occurs when
   A) randomly oriented rays of light are passed through a narrow aperture. The result is a narrow beam of polarized light.
   B) randomly oriented rays of incoming light reflect off a smooth surface. The reflected rays are all normal to the surface.
   C) randomly oriented rays of incoming light reflect off a rough surface. The reflected rays are all normal to the surface.
   D) parallel rays of light are reflected from a rough or uneven surface. The reflected rays are not parallel.
   E) parallel rays of incoming light are reflected from a smooth surface. The reflected rays are parallel.

10. 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) a beam of light will always follow the fastest path from one point to another.
    D) a beam of light will always travel along the shortest path from one point to another.
    E) it always takes less time for light to travel a path than anything else.

11. When light passes from one medium to another,
    A) it changes speed. The wave will change direction, bending toward the slower medium.
    B) it continues to travel at $3x10^8$ m/s regardless of the type of medium or the angle of incidence.
    C) it always slows down, and it always refracts by the same amount regardless of the angle of incidence.
    D) it always speeds up, and it never refracts unless the angle of incidence is less than the critical angle.
    E) it bends only when it strikes the boundary between the media at a 90° angle to the surface.

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. Answer questions 12 through 14 using this ray diagram.



12. At what angle of incidence will the incident ray experience no refraction as it crosses the boundary into Medium 2?
    A) When $\theta_1 = 90°$, $\theta_2 = 0°$.
    B) When $\theta_1 = 45°$, $\theta_2 = 45°$. This is zero refraction.
    C) When θ_1 = zero, θ_2 also = 0°.
    D) There is no possible incident angle for zero refraction, since the two media are not the same.

13. True or **false**: The index of refraction n_1 must be greater than the index of refraction n_2.

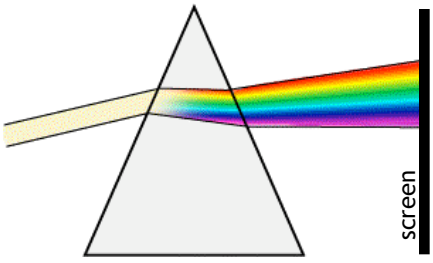
14. True or **false**: There exists a critical angle of incidence θ_c beyond which any incident light will be totally internally reflected back into Medium 1.

15. The index of refraction for water is n = 1.33. What is the speed of light through this medium?
    A) $v = 1.6x10^8$m/s. B) $v = 1.9x10^8$m/s. **C) $v = 2.3x10^8$m/s.** D) $v = 3x10^8$m/s.

16. Light traveling through air strikes the plastic surface of a transparent tabletop at an angle of 20° with respect to the normal. The index of refraction for lucite is n = 1.495. Find the angle of refraction.
    A) θ=13.2° B) θ=25.5° C) θ=41.0° D) θ=73.9° E) θ=90°

17. What is the critical angle for total internal reflection for lucite (n=1.495) and air (n=1)?
    A) θ = 0° **B) θ = 42°** C) θ = 44° D) θ = 46° E) θ = 90°

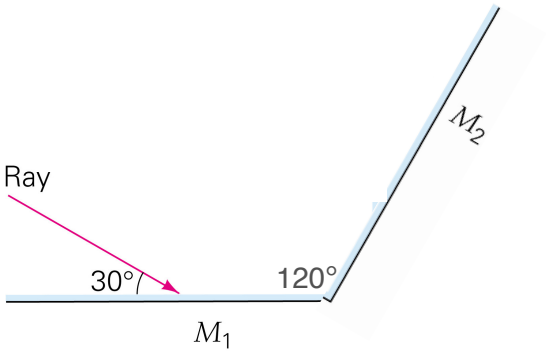
18. You are driving I-40 across New Mexico. It's gorgeous! Suddenly your sister wakes up and yells, "Watch out! The road is wet! Don't skid!" What do you do?
    A) Remind her of that time when you were little and she thought that if you ate Pop Rocks while drinking a Coke your head would explode. Then 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.



White light shines through a prism and strikes a screen as shown on the left.

19. In what order do the colors appear on the screen?
    A) ROY G BIV, reading from top to bottom.
    B) ROY G BIV, reading from bottom to top.
    C) BRIG V OY, reading from bottom to top.
    D) GIB V YOR, reading from top to bottom.
    E) The colors might appear in any order at all. It depends on the index of refraction of the glass used to make the prism.

20. 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°. Enter the numeric answer for the reflection angle. **60°**



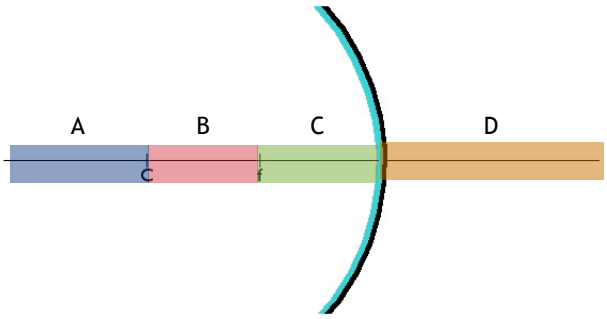
21. True or **false**: To increase the field of view of a plane mirror, just hold it farther away from you. Double the distance, double the field of view.

22. You are at the Target store buying some great new stuff to redecorate your room! Plus, you can always use some sock monkey pajamas, 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.

23. 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.

24. A person stands 2 m in front of a plane mirror and flexes his imaginary biceps. His image
    A) is virtual, located 2 m in front of the mirror.
    B) is virtual, located exactly at the surface of the mirror.
    C) is virtual, located 2 m behind the mirror.
    D) is real, located 2 m in front of the mirror.
    E) is real, located 2 m behind the mirror.

25. 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) inverted and minified. The image will appear smaller than the object, and the farther away he stands, the smaller the image.
    B) inverted and magnified. The image height depends on how far from the mirror he stands, but it will be greater than 20 cm..
    C) upright and magnified. The image height depends on how far from the mirror he stands, but it will be greater than 20 cm.
    D) upright and unmagnified. Unless the mirror is curved, it cannot form any image that is bigger (or smaller) than the actual object.
    E) upright and minified. The image will appear smaller than the object, and the farther away he stands, the smaller the image.



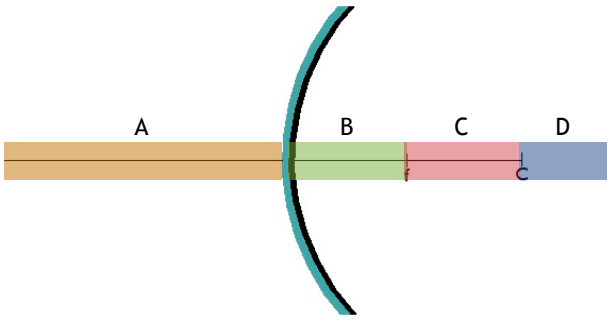
A concave mirror is placed as shown on the left. The light source is to the left of the mirror, and you are going to place a real object. Answer questions 26 and 27 using the letters on the picture for your responses A through D. *If you think that the correct response is* **T** *or* **F**, *use the* **TRUE** *or* **FALSE** *keys on your responder.*

26. In order to form an image that is inverted, where should you position an object?
    E) Either region A or B will create an inverted reflection.
    F) Nowhere! A concave mirror cannot invert an image.
    T) Anywhere! A concave mirror can only form real images.

27. In order to form an image that is magnified, where should you position an object?
    F) Nowhere! A concave mirror cannot magnify.
    T) Anywhere! A concave mirror only forms magnified images.

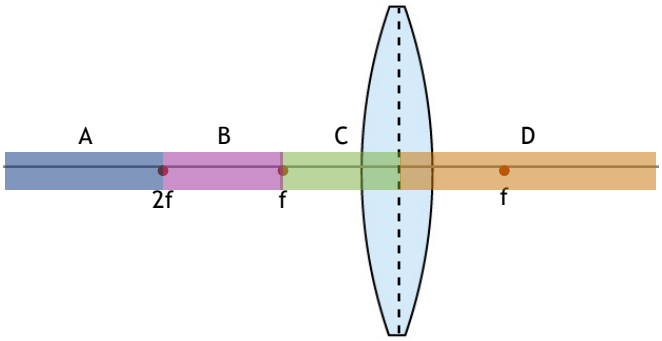
E) Either region B or C will create a magnified image.

A convex mirror is placed as shown on the right. The light source is to the left of the mirror, and you are going to place a real object. Answer questions 28 and 29 using the letters on the picture for your responses A through D. *If you think that the correct response is* **T** *or* **F**, *use the* **TRUE** *or* **FALSE** *keys on your responder.*



28. In order to form an image that is inverted, where should you position an object?
    E) Any region A, B, C, or D will create an inverted reflection.
    F) Anywhere! A convex mirror can only form real images.
    T) Nowhere! A convex mirror cannot invert an image.

29. In order to form an image that is magnified, where should you position an object?
    E) Either region C or D will create a magnified image.
    F) Anywhere! A convex mirror can only magnify images.
    T) Nowhere! A convex mirror cannot magnify an image.



A convex lens is placed as shown on the left. The light source is to the left of the lens, and you are going to place a real object. Answer questions 30 and 31 using the letters on the picture for your responses A through D. *If you think that the correct response is* **T** *or* **F**, *use the* **TRUE** *or* **FALSE** *keys on your responder.*

30. In order to form a real image, where should you place an object?
    E) Either region A or B will create a real image.
    F) Either region B or C will create a real image.
    T) Nowhere! A convex lens cannot form a real image.

31. In order to form an image that is magnified, where should you position an object?
    F) Anywhere! A convex lens can only magnify images.
    T) Nowhere! A convex lens cannot magnify an image.

E) Either region B or C will create a magnified image.

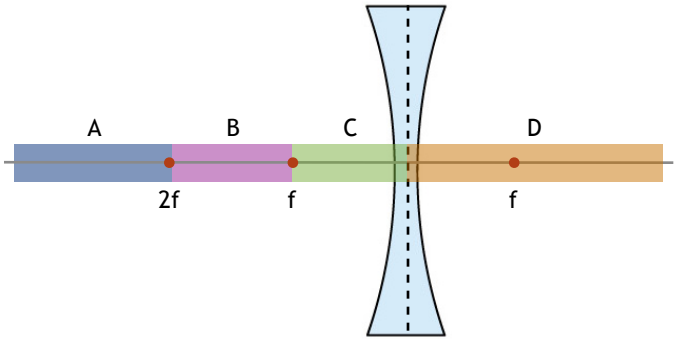
32. **True** or false: An object placed precisely at d_o = 2f will form an image that has a magnification M = –1.

33. True or **false**: An object placed precisely at d_o = f will form an image that has a magnification M = +1.

34. The converging lens above has a focal length **f = 15cm**. Locate the image (d_i) formed when an object (**h_o = 2cm**) is placed at a distance **d_o = 10cm**. Answer with two sig figs, and include sign where appropriate. **d_i = –30 cm**

35. The image formed in question 34 is
    A) real, inverted, magnified.
    B) real, inverted, minified.
    C) real, upright, unmagnified.
    D) virtual, upright, magnified.
    E) virtual, upright, minified.

A concave lens is placed as shown on the left. The light source is to the left of the lens, and you are going to place a real object. Answer questions 36 and 37 using the letters on the picture for your responses A through D. *If you think that the correct response is* **T** *or* **F**, *use the* **TRUE** *or* **FALSE** *keys on your responder.*



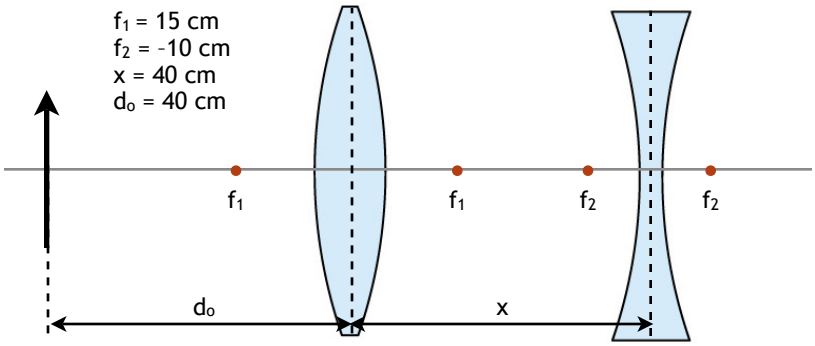
36. In order to form a virtual image, where should you position an object?
    E) Either region A or B will create a virtual image.
    F) Nowhere! A concave lens cannot form virtual images.
    T) Anywhere! A concave lens can only create virtual images.

37. In order to form an image that is magnified, where should you position an object?
    E) Either region B or C will create a magnified image.
    F) Anywhere! A concave lens can only magnify images.
    T) Nowhere! A concave lens cannot magnify an image.

38. True or **false**: An object placed precisely at d_o = 2f will form an image that has a magnification M = –1.

39. A diverging lens has a focal length **f = –15cm**. When an object is placed at **d_o = 10cm**, where does the image form? Answer with two sig figs, and include sign. **d_i = –6 cm**

40. What is the magnification of the image formed in question 39? Answer with two sig figs, and include sign. **M = +0.6**



The compound lens system shown on the left consists of a **converging lens** with focal length $\mathbf{f_1}$ = **15 cm**, and a **diverging lens** with a focal length $\mathbf{f_2}$ = **−10 cm**. The lenses are separated by a distance **x = 40 cm**, and a real object is positioned to the left of the convex lens, at a distance $\mathbf{d_o}$ = **40 cm**.

The convex lens will form the first image, which will be located **24cm to the right** of the first lens. This image becomes the object for the diverging lens, which forms the final image.

41. Locate the position of the final image.
   A) d_f = −6cm, placing it 6 cm to the left of the concave lens.
   B) d_f = +6cm, placing it 6 cm to the right of the concave lens.
   C) d_f = +7cm, placing it 7 cm to the right of the concave lens.
   D) d_f = −7cm, placing it 7 cm to the left of the concave lens.
   E) There is no final image formed, because the first image is to the right of the second lens. You cannot form an image of a virtual object!

42. Describe the final image of the arrow.
   A) The final image arrow is upside down and smaller than the original object.
   B) The final image arrow is right-side up, and smaller than the original object.
   C) The final image arrow is upside down and larger than the original arrow.
   D) The final image arrow is right-side up and larger than the original arrow.
   E) The final image arrow is exactly the same size as the object, and points in the same direction as well.

43. 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.