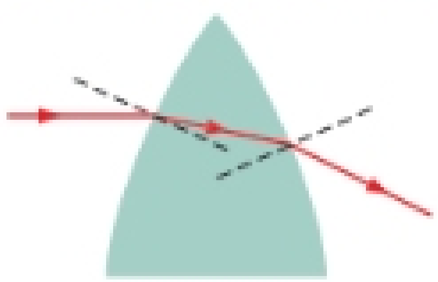
Ch 33

- An electromagnetic wave consists of oscillating electric and magnetic fields.
- Electromagnetic waves
  - The electric and magnetic fields and are always perpendicular to the direction in which the wave is traveling. Thus, the wave is a transverse wave, as discussed in Chapter 16.
  - The electric field is always perpendicular to the magnetic field.
  - The cross product ExB always gives the direction in which the wave travels.
  - The fields always vary sinusoidally, just like the transverse waves discussed in Chapter 16. Moreover, the fields vary with the same frequency and in phase (in step) with each other
- All electromagnetic waves, including visible light, have the same speed c in vacuum
- When a light ray encounters a boundary between two transparent media, a reflected ray and a refracted ray generally appear. Both rays remain in the plane of incidence. The angle of reflection is equal to the angle of incidence, and the angle of refraction is related to the angle of incidence by Snell's law
- Snell's Law
  - If n_2 is equal to n_1, then θ_2 is equal to θ_1 and refraction does not bend the light beam, which continues in the undeflected direction
  - If n_2 is greater than n_1, then θ_2 is less than θ_1. In this case, refraction bends the light beam away from the undeflected direction and toward the normal,
  - If n_2 is less than n_1, then θ_2 is greater than θ_1. In this case, refraction bends the light beam away from the undeflected direction and away from the normal
- A wave encountering a boundary across which the index of refraction decreases will experience total internal reflection if the angle of incidence exceeds a critical angle θ_C
- A reflected wave will be fully polarized, with its vectors perpendicular to the plane of incidence, if it strikes a boundary at the Brewster angle θ_B

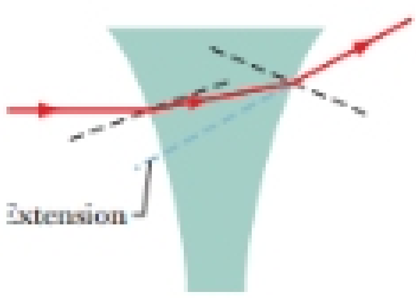
Ch. 34

- An image is a reproduction of an object via light. If the image can form on a surface, it is a real image and can exist even if no observer is present. If the image requires the visual system of an observer, it is a virtual image
- A spherical mirror is in the shape of a small section of a spherical surface and can be concave (the radius of curvature r is a positive quantity), convex (r is a negative quantity), or plane (flat, r is infinite).
- If parallel rays are sent into a (spherical) concave mirror parallel to the central axis, the reflected rays pass through a common point (a real focus F) at a distance f (a positive quantity) from the mirror. If they are sent toward a (spherical) convex mirror, backward extensions of the reflected rays pass through a common point (a virtual focus F) at a distance f (a negative quantity) from the mirror
- A concave mirror can form a real image (if the object is outside the focal point) or a virtual image (if the object is inside the focal point).
- A convex mirror can form only a virtual image
- Real images form on the side of a refracting surface that is opposite the object, and virtual images form on the same side as the object

- If parallel rays are sent through a converging lens parallel to the central axis, the refracted rays pass through a common point (a real focus F) at a focal distance f (a positive quantity) from the lens. If they are sent through a diverging lens, backward extensions of the refracted rays pass through a common point (a virtual focus F) at a focal distance f (a negative quantity) from the lens.
- A diverging lens can form only a virtual image
- A converging lens can form a real image (if the object is outside the focal point) or a virtual image (if the object is inside the focal point).
- A lens can produce an image of an object only because the lens can bend light rays, but it can bend light rays only if its index of refraction differs from that of the surrounding medium.



(b)



(d)

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- 1. A ray that is initially parallel to the central axis of the lens will pass through focal point F2 (ray 1 in Fig. 34-16a).
- 2. A ray that initially passes through focal point F1 will emerge from the lens parallel to the central axis (ray 2 in Fig. 34-16a).
- 3. A ray that is initially directed toward the center of the lens will emerge from the lens with no change in its direction (ray 3 in Fig. 34-16a) because the ray encounters the two sides of the lens where they are almost parallel.

Ch. 35

- The three-dimensional transmission of waves, including light, may often be predicted by Huygens' principle, which states that all points on a wavefront serve as point sources of spherical secondary wavelets. After a time t, the new position of the wavefront will be that of a surface tangent to these secondary wavelets.
- The phase difference between two light waves can change if the waves travel through different materials having different indexes of refraction.
- The phase difference between two waves can change if the waves travel paths of different lengths.

- If two light waves that meet at a point are to interfere perceptibly, the phase difference between them must remain constant with time; that is, the waves must be coherent. When two coherent waves meet, the resulting intensity may be found by using phasors
- Whatever the number of waves is, our general procedure is this: 1. Construct a series of phasors representing the waves to be combined.
    - Draw them end to end, maintaining the proper phase relations between adjacent phasors.
    - Construct the vector sum of this array. The length of this vector sum gives the amplitude of the resultant phasor. The angle between the vector sum and the first phasor is the phase of the resultant with respect to this first phasor. The projection of this vector-sum phasor on the vertical axis gives the time variation of the resultant wave.
- The phase difference between two waves can change if one or both are reflected.
- When light reflects:

Reflection	Reflection phase shift
Off lower index	0
Off higher index	0.5 wavelength