Electromagnetic Waves Chapter Questions

1. Sir Isaac Newton was one of the first physicists to study light. What properties of light did he explain by using the particle model?

2. Who was the first person who was credited with the wave theory of light?

3. The particle theory of light was brought back by what two physicists in the 20th century? What phenomena were they explaining with the particle theory?

4. What is the name of the theory that integrated quantum physics with electromagnetism?

5. Light is incident upon a mirror and it reflects. The initial angle is called the angle of incidence, and its final angle is the angle of return/reflection. What is true about those two angles?

6. What is refraction? Why does light refract when it passes through different media, like air to water?

7. There are three qualities of light; wavelength, speed and frequency. Which one of those stays constant as light passes from air to water?

8. During refraction, the angle of incidence and the angle of refraction are measured with respect to what?

9. What is Fermat's Principle of Least time?

10. What is dispersion? What object is used to separate white light into its constituent colors?

11. What is diffraction? Give an example of diffraction using water waves.

12. When a wave passes through two openings, and then creates a unique wave pattern on the other side of the openings, what phenomena are being exhibited?

13. Summarize Young's Double Slit Experiment for light. If light acted only as a particle, what would he have observed?

14. What causes the maxima and minima in the Double Slit Experiment?

15. If, instead of having two slits, a material is etched with thousands of thin lines, each acting as a slit for light to pass through. What is this material called?

16. For single slit interference, what happens to the sharpness of the images on the detection screen if the width of the slit is decreased?

17. What phenomena contribute to seeing many colors in a soap bubble or a thin film of oil

on asphalt?

18. What four equations were included in Maxwell's Equations?

19. What is the geometric relationship of the magnetic field, the electric field, and the direction of movement of a Electromagnetic wave?

20. How did Maxwell conclude that light waves were Electromagnetic waves?

21. From smallest to largest wavelength, order the various types of Electromagnetic radiation.

22. What is the purpose of polarized sunglasses?

Chapter Problems

Reflection, Refraction and Dispersion of Light
Class Work

1. Light is incident upon a mirror at an angle of 50^0 to a line normal to the surface. What angle does the reflected light make with respect to the normal?

2. Light has a wavelength of 450 nm in vacuum. It enters a glass prism with an index of refraction 1.6. What is the wavelength in glass? What is the speed of light in glass? What is the frequency in glass?

3. Light has a frequency of 5.50×10^{14} Hz in vacuum. It enters a liquid with an index of refraction 1.33. What is the frequency in the liquid? What is the speed of light in the liquid? What is the wavelength in the liquid?

4. Light travels from air (n=1.0) to water (n=1.3). Its angle of incidence is 45^0. What is its angle of refraction?

5. Light travels from water (n=1.3) to air (n=1.0). Its angle of incidence is 36^0. What is its angle of refraction?

Homework

6. Light is incident upon a mirror at an angle of 38^0 to a line normal to the surface. What angle does the reflected light make with respect to the normal?

7. Light has a wavelength of 650 nm in vacuum. It enters a glass prism with an index of refraction 1.8. What is the wavelength in glass? What is the speed of light in glass? What is the frequency in glass?

8. Light has a frequency of 4.80×10^{14} Hz in vacuum. It enters a liquid with an index of refraction 1.36. What is the frequency in the liquid? What is the speed of light in the liquid? What is the wavelength in the liquid?

9. Light travels from air (n=1.0) to glass (n=1.5). Its angle of incidence is 55^0. What is its angle of refraction?

10. Light travels from diamond (n=2.4) to air (n=1.0). Its angle of incidence is 15^0. What is its angle of refraction?

Diffraction and Interference of Light
Class Work

11. In a double-slit experiment, the two slits are 2.5 mm apart. Light of wavelength 520 nm is incident on the slits. What is the distance to the first maximum on a screen 4.0 m away?

12. In a double-slit experiment, the two slits are 1.8 mm apart. Light of wavelength 480 nm is incident on the slits. What is the distance to the third maximum on a screen 2.0 m away?

13. In a double-slit experiment, the distance between the central and second order maximum is 1.2 mm. Light of wavelength 620 nm is incident on the slits. What is the distance between the two slits if the screens are 3.0 m apart?

14. The distance between etchings on a Diffraction Grating is 1.8 μm and the distance between the grating and the observation screen is 0.85 m. What is the distance from the midpoint of the screen to the 2^{nd} order maxima for light with a wavelength of 510 nm?

15. A diffraction grating is etched with 6667 lines/cm. The distance between the grating and the observation screen is 0.75 m. What is the distance from the midpoint of the screen to the 1^{st} order maximum for light with a wavelength of 450 nm?

16. Light with a wavelength of 590 nm is incident on a screen with a single slit 0.80 mm wide. What is the distance between the central maximum and the first dark fringe on a screen 2.1 m away from the first screen?

17. Light illuminates a single-slit apparatus with a slit opening of 0.75 mm producing an interference pattern with the central maximum width of 0.40 mm on the second screen 2.8 m away. What is the wavelength of the incident light?

18. Light with a wavelength of 550.0 nm is normally incident on a soap bubble with an index of refraction 1.33. What is the minimum thickness of the bubble in order to produce maximum reflection of the normally incident rays?

19. Light with a wavelength of 580.0 nm illuminates a soap film with an index of refraction of 1.33. What is the minimum thickness of the film in order to produce no reflection for the normally incident rays?

20. A glass lens n = 1.80 is coated with a film n = 1.32. What should be the minimum thickness of the film in order to produce maximum reflection for the normally incident light of wavelength 540.0 nm?

21. A glass lens n = 1.65 is coated with a film n = 1.30. What should be the minimum thickness of the film in order to produce minimum reflection for the normally incident light of wavelength 600.0 nm?

Homework

22. In a double-slit experiment, the distance between the central and fifth order maxima is 2.2 mm. Light of wavelength 700.0 nm is incident on the slits. What is the distance between the two slits if the screens are 4.5 m apart?

23. Light striking a double-slit apparatus with a slit spacing of 1.6 mm forms an interference pattern where the distance between two consecutive maxima is 0.80 mm on a screen 2.7 m behind the first screen. What is the wavelength of the incident light?

24. Light striking a double-slit apparatus with a slit spacing of 2.3 mm forms an interference pattern where the distance between two consecutive maxima is 0.90 mm on a screen 3.4 m behind the first screen. What is the wavelength of the incident light?

25. The distance between etchings on a Diffraction Grating is 2.0 μm and the distance between the grating and the observation screen is 0.88 m. What is the distance from the midpoint of the screen to the 1st order maxima for light with a wavelength of 480 nm?

26. A diffraction grating is etched with 7100 lines/cm. The distance between the grating and the observation screen is 0.65 m. What is the distance from the midpoint of the screen to the 2nd order maxima for light with a wavelength of 470 nm?

27. Light illuminates a single-slit apparatus with slit opening of 0.65 mm producing an interference pattern with the central maximum width of 0.50 mm on the second screen 3.1 m away. What is the wavelength of the incident light?

28. Light with a wavelength of 485 nm is incident on a screen with a single slit 0.500 mm wide. What is the distance between the central maximum and the second dark fringe on a screen 1.70 m away from the first screen?

29. Light has a wavelength of 460.0 nm is incident on a soap bubble with an index of refraction 1.33. What is the minimum thickness of the bubble in order to produce maximum reflection of the normally incident rays?

30. Light with a wavelength of 620.0 nm illuminates a soap film with an index of refraction of 1.33. What is the minimum thickness of the film in order to produce no reflection for the normally incident rays?

31. A glass lens n = 1.60 is coated with a film n = 1.25. What should be the minimum thickness of the film in order to produce maximum reflection for the normally incident light of wavelength 560.0 nm?

32. A glass lens n = 1.75 is coated with a film n = 1.28. What should be the minimum thickness of the film in order to produce minimum reflection for the normally incident light of wavelength 520 nm?

Properties of Electromagnetic Waves
Class Work

33. Light with a wavelength of 400.0 nm travels in vacuum. What is the frequency?

34. Light with a frequency of 6.0×10^{14} Hz travels in vacuum. What is the wavelength?

35. The speed of light in water is 2.26×10^{8} m/s. If the frequency of the light in water is 7.50×10^{14} Hz, what is its wavelength?

36. If the wavelength of light in diamond is 686 nm, and its frequency is 1.81×10^{14} Hz, what is its speed?

Homework

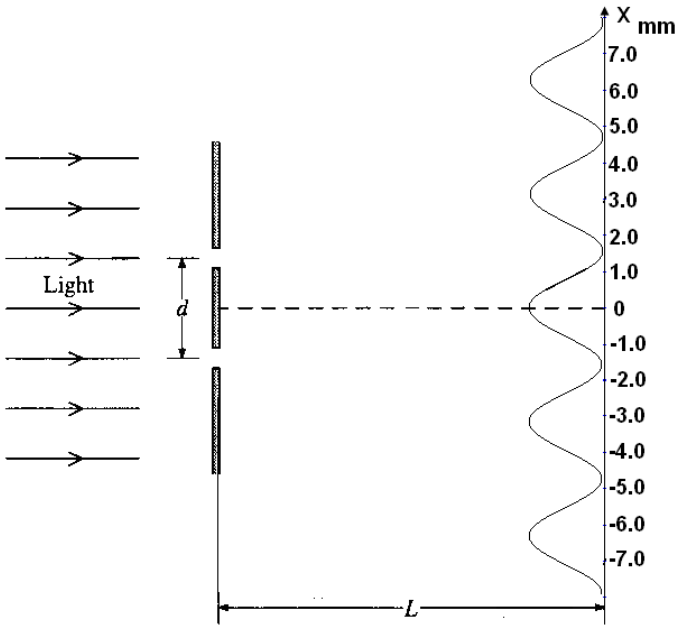
37. Light with a wavelength of 600.0 nm travels in vacuum. What is the frequency?

38. Light with a frequency of 4.0×10^{14} Hz travels in vacuum. What is the wavelength?

39. The speed of light in diamond is 1.24×10^{8} m/s. If the frequency of the light in diamond is 9.55×10^{14} Hz, what is its wavelength?

40. If the wavelength of light in water is 525 nm, and its frequency is 4.30×10^{-14} Hz, what is its speed?

General Problems



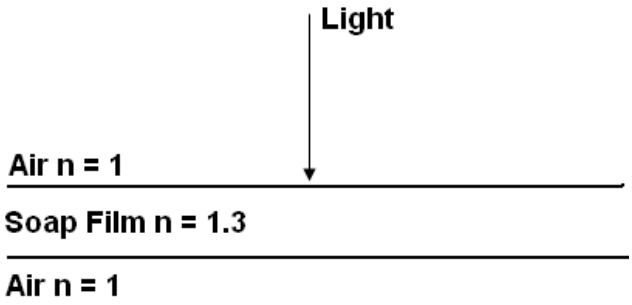
This picture is applicable to General Problems 1 and 2.

1. Monochromatic light strikes a double-slit apparatus as shown above. The separation between the slits is 0.400 mm. As result of diffraction an interference pattern is produced on the second screen 4.00 m away.
    a. What property of light does this experiment demonstrate?
    b. Find the wavelength of the incident light based on the interference pattern.

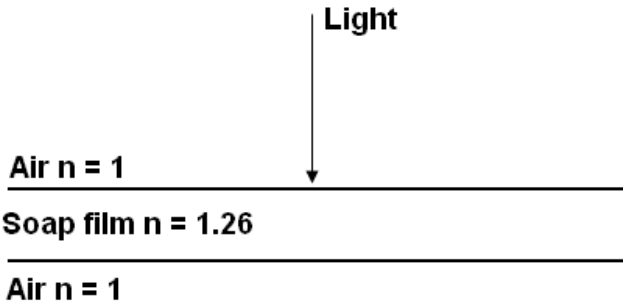
   The double-slit apparatus is submerged into water (n = 1.33)
    c. What is the frequency of the light in water?
    d. What is the wavelength of the light in water?
    e. What happens to the distance between two adjacent fringes in water?

2. Monochromatic light strikes a double-slit apparatus as shown above. The separation between the slits is 0.600 mm. As result of diffraction an interference pattern is produced on the second screen 5.00 m away.
    a. What property of light does this experiment demonstrate?
    b. Find the wavelength of the incident light based on the interference pattern.

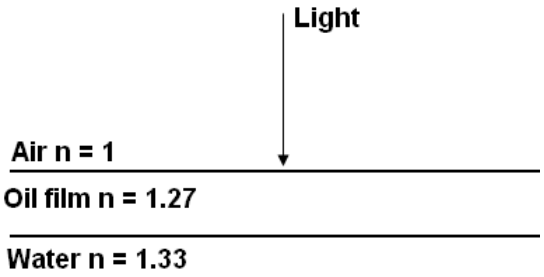
   The double-slit apparatus is submerged into water (n = 1.33)
    c. What is the frequency of the light in water?
    d. What is the wavelength of the light in water?
    e. What happens to the distance between two adjacent fringes in water?



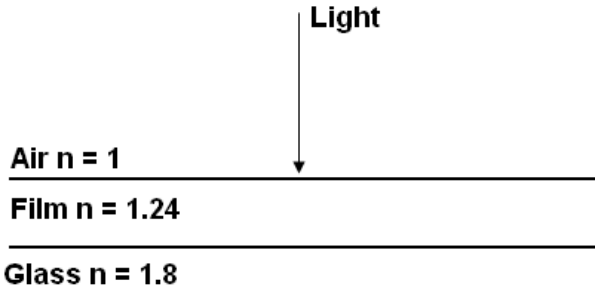
3. A soap film is illuminated with monochromatic light wavelength of 600.0 nm as shown above.
    a. What is the frequency of the incident light in vacuum?
    b. What is the frequency of light in the film?
    c. What is the speed of light in the film?
    d. What is the wavelength of light in the film?
    e. Calculate the minimum thickness of the film required to produce no reflected light.
    f. Calculate the minimum thickness of the film required to produce maximum intensity of the reflected light.



4. A soap film is illuminated with monochromatic light wavelength of 580.0 nm as shown above.
    a. What is the frequency of the incident light in vacuum?
    b. What is the frequency of light in the film?
    c. What is the speed of light in the film?
    d. What is the wavelength of light in the film?
    e. Calculate the minimum thickness of the film required to produce no reflected light.
    f. Calculate the minimum thickness of the film required to produce maximum intensity of the reflected light.



5. An oil film on the surface of water is illuminated with monochromatic light of wavelength 560.0 nm as shown above.
    a. What is the frequency of the incident light in vacuum?
    b. What is the frequency of light in the oil film?
    c. What is the speed of light in the oil film?
    d. What is the wavelength of light in the oil film?
    e. Calculate the minimum thickness of the film required to produce no reflected light.
    f. Calculate the minimum thickness of the film required to produce maximum intensity of the reflected light.



6. The glass surface is coated with a thin film and illuminated with monochromatic light of wavelength 555 nm.
    a. What is the frequency of the incident light in vacuum?
    b. What is the frequency of light in the film?
    c. What is the speed of light in the film?
    d. What is the wavelength of light in the film?
    e. Calculate the minimum thickness of the film required to produce no reflected light.
    f. Calculate the minimum thickness of the film required to produce maximum intensity of the reflected light.

Chapter Questions

1. Reflection, Refraction and Dispersion.
2. Christiaan Huygens.
3. Max Planck (Blackbody radiation) and Albert Einstein (Photoelectric effect).
4. Quantum Electrodynamics.
5. They are equal.
6. When light passes from one media to another, it bends. The speed of light changes in different media.
7. Frequency.
8. A line that is normal (perpendicular) to the surface between the two media.
9. Light follows a path through different media that takes the least time.
10. The separation of the various colors that make up white light by a double refracting surface. A prism.
11. The bending of a wave when it meets an obstacle. Also, when a wave encounters a small opening, it generates a new wave on the other side.
12. Diffraction and Interference.
13. Monochromatic light is incident upon two slits of width comparable to the light's wavelength. An interference pattern is observed. If light acted only as a particle, there would be a maximum detected opposite each slit opening.
14. The superposition of the peak values of the wave from each slit (constructive interference); the superposition of a peak and a valley of the two waves (destructive interference).
15. Diffraction Grating.
16. The image spreads out, and gets less sharp and more smeared out.
17. Reflection, Refraction and Interference.
18. Gauss's Law for Electricity, Gauss's Law for Magnetism, Faraday's Law and Ampere's Law.
19. They are all mutually perpendicular.
20. The solutions to his equations showed that Electromagnetic waves moved at the same speed as light.
21. Gamma rays, X-rays, Ultraviolet rays, Visible light, Infrared radiation, microwaves, radio waves.
22. To reduce the intensity of the light by absorbing much of the Electric Field vector and minimizing glare.

Chapter Problems

1. 50^0
2. 280 nm, 1.9×10^8 m/s, 6.7×10^{14} Hz
3. 5.50×10^{14}Hz, 2.26×10^8m/s, 410nm
4. 33^0
5. 50^0
6. 38^0
7. 360 nm, 1.7×10^8 m/s, 4.6×10^{14} Hz
8. 4.80×10^{14}Hz, 2.21×10^8m/s, 460nm
9. 33^0
10. 38^0
11. 8.3×10^{-4} m
12. 1.6×10^{-3} m
13. 3.1×10^{-3} m
14. 4.8×10^{-1} m
15. 2.3×10^{-1} m
16. 1.5×10^{-3} m
17. 54 nm
18. 1.03×10^{-7} m
19. 2.18×10^{-7} m
20. 2.05×10^{-7} m
21. 1.15×10^{-7} m
22. 7.2×10^{-3} m
23. 4.7×10^{-7} m
24. 6.09×10^{-7} m
25. 2.1×10^{-1} m
26. 4.3×10^{-1} m

27. 52 nm
28. 3.3×10^{-3} m
29. 8.65×10^{-8} m
30. 2.33×10^{-7} m
31. 2.24×10^{-7} m
32. 1.02×10^{-7} m
33. 7.50×10^{14} Hz
34. 500 nm
35. 301 nm
36. 1.24×10^{8} m/s
37. 5.00×10^{14} Hz
38. 750 nm
39. 130 nm
40. 2.26×10^{8} m/s

General Problems

1. a) wave nature
   b) 300 nm
   c) 1.00×10^{15} Hz
   d) 2.26×10^{-7} m
   e) decreases

2. a) wave nature
   b) 360 nm
   c) 8.33×10^{14} Hz
   d) 2.71×10^{-7} m
   e) decreases

3. a) 5.00×10^{14} Hz
   b) 5.00×10^{14} Hz
   c) 2.31×10^{8} m/s
   d) 462 nm
   e) 2.31×10^{-7} m
   f) 1.16×10^{-7} m

4. a) 5.17×10^{14} Hz
   b) 5.17×10^{14} Hz
   c) 2.38×10^{8} m/s
   d) 461 nm
   e) 2.30×10^{-7} m
   f) 1.15×10^{-7} m

5. a) 5.36×10^{14} Hz
   b) 5.36×10^{14} Hz
   c) 2.36×10^{8} m/s
   d) 441 nm
   e) 1.10×10^{-7} m
   f) 2.20×10^{-7} m

6. a) 5.41×10^{14} Hz
   b) 5.41×10^{14} Hz
   c) 2.42×10^{8} m/s
   d) 447 nm
   e) 1.12×10^{-7} m
   f) 2.24×10^{-7} m