

Chapter 26
Exercises

3. The fundamental source of electromagnetic radiation is oscillating electric charges, which emit oscillating electric and magnetic fields.
4. The wavelengths of radio waves are longer than those of light waves, which are longer than the wavelengths of X- rays.
5. The shorter wavelength corresponds to a higher frequency, so the short-wavelength ultraviolet light from the argon laser has higher frequency than the long-wavelength infrared light.
9. We can see the stars.
19. Radio waves most certainly travel at the speed of every other electromagnetic wave – the speed of light.
21. The fact that the different parts of the electromagnetic spectrum emitted in the explosion are received simultaneously is evidence for the frequency independence of the speed of light. If wave speed depended on frequency, different frequencies would be received at different times.
29. Clouds are transparent to ultraviolet light, which is why clouds offer no protection from sunburn. Glass, however, is opaque to ultraviolet light, and will therefore shield you from sunburn.
43. Energy is spread out and diluted, but not "lost." We distinguish between something being diluted and something being annihilated. In accord with the inverse-square law, light intensity gets weaker with distance, but the total amount of light over a spherical surface is the same at all distances from the source.
44. Light from the flash spreads via the inverse-square law to the ground below, and what little returns to the airplane spreads further. The passenger will find that the flash makes no difference at all. Taking pictures at great distances, whether from an airplane or the football stands, with the flash intentionally turned on is rather foolish.
48. You're seeing the galaxies as they "were" when light left them, long long ago.

Problems

4. Earth-moon distance is 3.8×10^8 m, so the round-trip distance is 7.6×10^8 m. As in the previous problem, $t = \frac{d}{v} = \frac{7.6 \times 10^8 \text{ m}}{3 \times 10^8 \text{ m/s}} = 2.5 \text{ s}$.
(In 1969, when TV showed astronauts first landing on the moon, people in their living rooms could listen in on conversations between the astronauts and "Earthlings" and directly perceive the time delay. In 1675 Roemer saw the effect of light's finite speed

"with his own eyes." Nearly 300 years later, millions of people heard the effect of the finite speed of electromagnetic waves "with their own ears.")

5. As in the previous problem, $t = 1.4 \times 10^8$ s, from

$$t = \frac{d}{v} = \frac{4.2 \times 10^{16} \text{ m}}{3 \times 10^8 \text{ m/s}} = 1.4 \times 10^8 \text{ s.}$$

Converting to years by dimensional analysis,
(1.4×10^8 s) x

$$\frac{1\text{h}}{3600\text{s}} \times \frac{1\text{day}}{24\text{h}} \times \frac{1\text{yr}}{365\text{day}} = 4.4 \text{ yr.}$$

6. Wavelength $589 \text{ nm} = 589 \times 10^{-9} \text{ m} = 5.89 \times 10^{-7} \text{ m}$. From $c = f\lambda$, $f = c/\lambda = (3 \times 10^8 \text{ m/s}) / (5.89 \times 10^{-7} \text{ m}) = 5.09 \times 10^{14} \text{ Hz}$.

7. From $c = f\lambda$, $\lambda = c/f = 5 \times 10^{-7} \text{ m}$, or 500 nanometers. This is 5000 times larger than the size of an atom, which is 0.1 nanometer. (The nanometer is a common unit of length in atomic and optical physics.)