Answers to selected problems from Essential Physics, Chapter 22

1. A common way to implement a collision avoidance/mitigation system is to use the Doppler effect for EM waves. If a system mounted on the front of the car emitted pulses consisting of waves of a particular frequency, the time taken to receive the reflected waves back tells the system the distance away that an object ahead of the car is (this requires knowing the speed of light, which we know very accurately). In addition, the frequency of the reflected waves, by the Doppler effect, tells the system the velocity of an object ahead relative to the car. A significant velocity of that object toward the car would indicate an impending collision.

3. There will be no frequency difference.

5. The sky will look darker in case 1. Let's say you are initially looking north, and the Sun is setting in the south, behind you. Light coming from the sky directly above you is polarized along an east-west line. This is exactly what your sunglasses would block if you then, when first facing north, look straight up. In case 2, let's say you were initially facing east, with the Sun setting in the South. Looking up, your sunglasses would block anything polarized along a north-south line. The light coming from above you, however, is polarized along an east-west line, so it gets through your sunglasses in case 2.

7. Graph 2. No matter what the direction of the polarizer's transmission axis is, when unpolarized light passes through the polarizer 50% of the intensity is blocked.

9. It can't be done with only one of these polarizers. With two polarizers, it can be done by passing the light through A and then C, or through C and then A. With three polarizers, polarizer B needs to be either first or last. This gives four possible arrangements: B→ A→ C, B → C → A, A→ C→ B, or C→ A→ B.

11. (a) The sequence could be A→ B→ C or C→B→A. (b) 67.5 W/m^2

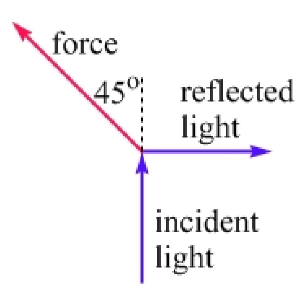
13. It's hard to tell on a logarithmic scale, but the FM band is substantially wider. The AM band is a little wider than 1 MHz. The FM band, in contrast, covers about 20 MHz.

15. (a) VHF = very high frequency (b) 30 MHz – 300 MHz (c) FM radio broadcasts are part of the VHF band, as are some television broadcasts. Communications with airplanes and ships falls under the VHF band, also. Wireless microphones also operate in the VHF band.

17. (a) 4.75×10^{14} Hz (b) 1.58×10^{6}

19. 15000 V/m. This is a rather large electric field, much larger than you would find in a typical electromagnetic wave.

21. (a) 45° to the incident light (b)



23. (a) 5.7×10^7 m/s

25. (a) Moving away (b) 1.4×10^7 m/s

27. (a) The man’s velocity with respect to the ground was 110 km/h south. He still deserves a speeding ticket, but the verdict should be based on being 10 km/h over the speed limit, as opposed to 60 km/h.

29. (a) 30° (b) 450 W/m^2 (c) at 40° to the vertical (d) 30° (e) 340 W/m^2

31. (a) 360 W/m^2 (b) at 90° to the vertical (c) 60° (d) 90 W/m^2
(e) at 30° to the vertical (f) 30° (g) 67.5 W/m^2

33. 150 km

35. (a) 2.2×10^7 times larger (b) 1×10^8 W/m^2 (c) 1.9×10^5 V/m

39. 4×10^{26} W

41. (a) About 3 km (b) Every 3 s corresponds to 1 km (c) Yes

43. (a) 8700 W/m^2 (b) 2500 W/m^2 (c) 560 W/m^2 (d) 48 W/m^2

45. The intensity is about 570 W/m^2. This is less than the intensity of sunlight, but within a factor of 2, and hence still very bright. In addition, while the energy in a beam of sunlight is spread out over all wavelengths of the visible spectrum, the energy in the laser beam is all at one wavelength, which increases the danger. Thus, it is not a good idea to look into the laser beam, and you should ask your professor to be more careful.

47. (a) 3.00 MHz (b) 2.97 MHz (c) 3.04 MHz.

49. 4 cm away from the filament

51. (a) 1170 Hz (b) 1949 Hz (c) 2924 Hz

53. (a) Toward the officer. (b) 2.268×10^{10} Hz

55. (a) 90 W/m^2 (b) 45°

57. We can’t tell. With the correct angle between the transmission axes of the two polarizers, we can get 35% of the intensity if we start with unpolarized light. With polarized light, there are many combinations of angles that will produce a final intensity that is 35% of the initial intensity. So, we can’t say whether the incident light is polarized or unpolarized.