1 Practice problems: Photons of Visible Light

(a) **(Q4B.1 from textbook)** Red light emitted by a standard helium-neon laser has a wavelength of about 633 nm. What is the energy of one photon of such red light?

(b) **(Q4B.2 from textbook)** Yellow light has a wavelength of about 590 nm. What is the energy of one photon of such light?

(c) **(Q4B.4 from textbook)** A typical laboratory helium-neon laser produces about 1 mW (0.001 J/s) of light at a wavelength of 633 nm. How many photons per second does this laser produce?

(d) **(Q4B.5 from textbook)** A certain argon laser produces about 5 mW of light at a wavelength of 514 nm. How many photons per second does this laser produce?

(e) **(Q4B.10 from textbook)** Suppose red and green light-emitting diodes (LEDs) radiate the same amount of power in the form of light at wavelengths of 650 nm and 560 nm, respectively. Which emits more photons per second? By what factor?

2 Practice problem: Radio Station

(Q4B.13 from textbook) About how many photons per second are broadcast by a FM radio station whose transmitter power is 10,000 W and whose frequency is 89.9 MHz?

3 Human Vision

(Q4M.5 from textbook) Suppose you are standing in the dark and facing a 20 W LED bulb 100 m away. If the diameter of your pupils is about 8 mm under these conditions, about how many photons of *visible* light enter your eye every second?

4 Practice problems: deBroglie basics

(a) **(Q5B.1 from textbook)** Compute the de Broglie wavelength of an electron beam whose electrons each have a kinetic energy of 25 eV.

(b) **(Q5B.6 from textbook)** What would be the kinetic energy of electrons in a beam having a de Broglie wavelength of 420 nm (the wavelength of violet light)?

(c) **(Q5B.7 from textbook)** "Thermal" neutrons are neutrons whose kinetic energy is roughly equal to the average kinetic energy that any object has at room temperature due to thermal effects (≈ 0.04 eV). What would be the de Broglie wavelength of a beam of such neutrons? (For a neutron, $mc^2 = 939$ MeV)

(d) **(Q5B.8 from textbook)** Compare the wavelength of a 1.0 MeV gamma-ray photon with that of a neutron having the same kinetic energy. (For a neutron, $mc^2 = 939$ MeV)

(e) **(Q5B.9 from textbook)** A baseball has a mass of 0.15 kg, and a major-league pitcher can throw a ball with a speed of 40 m/s (90 mi/h).

(a) What is the approximate de Broglie wavelength of a beam of baseballs pitched at such a speed?

(b) Why do we not have to worry much about the wave aspects of a beam of baseballs?

(f) **(Q5B.10 from textbook)** The electron in a hydrogen atom “bits” its proton with a speed of $(1/137)c$. Assume that the orbit is circular and that the magnitude of the electron’s momentum is thus constant and well-defined. What is the electron’s de Broglie wavelength? How does this compare to the atom’s radius (which is about 0.053 nm)?

5 Practice problems: Observing double-slit interference with soot

(Q5M.8 from textbook) Consider particles of fine soot 100 nm in diameter, each consisting of roughly 10^9 carbon atoms (the mass of a carbon atom is about 12.01 u, where $1\ u = 1.67 \times 10^{-27}$ kg). Imagine a beam of such particles moving at 1 mm/s.

(a) What would the beam’s de Broglie wavelength be?

(b) Imagine that we manage to send the beam through two slits 150 nm wide and 300 nm apart. To separate “bright spots” of the soot-particle interference pattern by more than 1 μm, about how far from the slits would we have to place the screen for displaying the pattern?

(c) What would be the minimum time required to perform the experiment?