Study Guide: Properties of Light

1. Define these properties of light and be able to recognize them in a diagram of a waveform:
    a. Wavelength
    b. Speed
    c. Amplitude
    d. Phase
    e. Polarization
    f. Frequency
    g. Period
    h. Energy
    i. Coherence

2. Describe the dual nature of light—both as a continuous wave and as a discrete particle—and give examples where light exhibits each nature.

3. Describe the electromagnetic spectrum and sketch a diagram of its main optical regions.

4. Describe the properties of electromagnetic waves.

5. Define the terms reflection, refraction, and index of refraction.

6. State the law of reflection and Snell's law of refraction.

7. Describe diffraction and interference.

8. Give a basic explanation of atoms and molecules and their ability to absorb, store, and emit quanta of electromagnetic energy.

9. Describe how spectra of light sources are formed.

10. Describe line spectra, band spectra, and continuous blackbody radiation.

11. Describe how light is scattered, absorbed, and transmitted when passing through optical materials.

12. Describe safety procedures to be followed when working in laser/optics laboratories.

13. Ordinary helium-neon laser light has a wavelength of 632.8 nanometers.
    a. What is its speed in air in m/s?
    b. What is its frequency in Hertz?
    c. What is its energy in joules?

14. A Nd-YAG laser has a wavelength of 1064 nm. What is its equivalent wavelength in:
    a. Angstroms
    b. Micrometers
    c. Meters

15. A normal body temperature for a healthy person is 98.6ºF. This is equivalent to 37ºC or 310 K.
    a. Based on Wien's displacement law, what is the maximum wavelength in NANOmeters emitted by a normal body at this temperature?
    b. What type of detector is needed to "see" this radiation?

16. From a diagram of the electromagnetic spectrum:
    a. Determine the wavelength spread (in nanometers) and frequency spread (in Hz) for visible light.
    b. Identify the type of EM radiation that has wavelengths around 10–12 meters and frequencies around 1021 Hz.
    c. Identify the type of EM radiation with a wavelength around 1 meter and frequency near 108 Hz.

17. A beam of light in air is incident on an air-diamond interface along a normal to the interface.
    a. As the light enters the diamond, does the beam bend toward the normal, bend away from the normal, or remain along the normal?
    b. Does the light speed up or slow down in the diamond crystal?
    c. If diamond has an index of refraction of 2.42, what is the speed of light in diamond?

18. A beam of HeNe laser light at 632.8 nm is incident on a smooth, flat germanium crystal at an angle of 60º with the normal. The index of refraction of germanium at this wavelength is near 4.1.
    a. What angle does the reflected beam make with the normal?
    b. What angle does the refracted beam make with the normal?
    c. What is the speed of light in germanium?
    d. Draw a sketch showing the incident ray, reflected ray, refracted ray, normal, and air/germanium interface. You will be responsible for converting your sketch into an electronic format to submit with your other assignment answers.

19. One thousand photons in a beam are incident on a semi-transparent glass slide at an angle of 10º. One hundred photons are reflected back and lost at the front air-glass interface as well as at the rear glass-air interface. Fifty photons are scattered out of the beam by impurities in the glass while the beam is passing through, and 150 are absorbed by the glass material.
    a. How many photons are in the transmitted beam?
    b. Compared with the number of photons in the incident beam, what is the percent transmission of this beam through the slide?

20. A hydrogen atom in excited energy state E3 = -2.4×10^{-19} joules drops down to the ground state at energy level E1 = -21.76×10^{-19} joules, giving off a photon.
    a. What is the energy of the emitted photon in joules?
    b. What is its wavelength in meters?
    c. Based on the EM spectrum, what type of electromagnetic radiation is this?
