Indian Institute of Technology Patna

Physics Department

PH 201: Tutorial (Lasers)

1. Find phase and group velocities of an electron whose de-Broglie's wavelength is 14 nm.
2. A silicon photo diode has quantum efficiency of 65% with photon energy 1.5×10^{-19} J. Its bandgap energy is 0.67 eV. Calculate
   (a) long wavelength cut off (λ_c),
   (b) responsivity (R), and
   (c) incident power required to obtain a photo current 2.5 μA?
3. Find how many photons are required per second to produce laser beam of 3 mW power, when wavelength of laser is 694.3 nm.
4. Calculate the frequency in Hertz and wavenumbers (cm^{-1}) and the energy in electronvolts of a photon of wavelength λ = 1 μm in vacuum.
5. Calculate the wavenumbers corresponding to an energy spacing of kT, where k is the Boltzmann constant and T is the absolute temperature. Assume T = 300 K.
6. The brightness of probably the brightest lamp so far available (PEK Labs type 107/109™, excited by 100 W of electrical power) is about 95 W/cm² sr in its most intense green line (λ = 546 nm). Compare this brightness with that of a 1 W Argon laser (λ = 514.5 nm), which can be assumed to be diffraction limited.
7. An interference filter with a pass band of 10 nm centered at 500 nm is used to obtain approximately monochromatic light from a white source. Calculate the coherence time of the filtered light and its coherence length.
8. When 3×10^{11} photons each with wavelength of 0.85 μm are incident on a photo diode, on average 1.2×10^{11} electrons are generated. Determine quantum efficiency and responsivity.

9. Determine the ABCD matrix for a beam translated a distance d_1, focused through a thin lens of focal length f_1, and then translated a distance d_2.
10. Determine the saturation energy of Nd:YAG laser operating at wavelength 1.06 μm. Given that cross-section $\sigma^H = 1.14 \times 10^{-22}$ m^2.
11. At the surface of the earth, the intensity of the sun is approximately 1 kW m^{-2}. Calculate the intensity at the retina that results when looking directly at the sun. Assume that: (i) the pupil of a bright-adapted eye is 2 mm in diameter; (ii) the focal length of the eye is 22.5 mm; (iii) the Sun subtends an angle of 0.5°. Compare this intensity with that resulting when looking into a 1 mW He-Ne laser (λ = 632.8 nm) with a 2 mm diameter.
12. Light travelling in air strikes a glass plate at a glancing angle 33°. While striking the glass plate, part of the beam is reflected and part is refracted. If the refracted and reflected beams make an angle 90°, with each other, then
    (a) what is the refractive index of the glass and
    (b) what is the critical angle for that glass?
13. The numerical aperture of an optical fiber is 0.5 and core refractive index 1.54.
    (a) Find refractive index of cladding.
    (b) Calculate the change in core cladding refractive index per unit refractive index of core and
    (c) Critical angle.
14. Relative refractive index of a fiber is 5.5% when core refractive index is 1.48. Find numerical aperture, cladding refractive index, acceptance angle, and velocity of light in core and cladding.
