

Homework 2 (Due Wednesday 2 February 2005)

1. At a boundary between two refractive media with relative refractive index n , let the incident intensity (meaning power per unit area) normal to the boundary be I . Then the reflected intensity is $R = ((n^2 - 1)/(n^2 + 1))^2 I$, and the transmitted intensity is $T = (2n/(n^2 + 1))^2 I$. What is the probability of reflection of a photon striking the boundary? What is the probability of transmission?
2. What is the total probability of transmission plus reflection in Problem 1?
3. What are all the probabilities in 1 and 2 if the photon is coming the other way?
4. For light with wavelength λ , what is the momentum of each photon? How does this relate to the energy $E = h\nu$? Does this agree with Einstein's special relativity formula $E = \sqrt{(pc)^2 + (mc^2)^2}$? What does it say about the rest mass of a photon? Check the Einstein formula for a particle with nonzero rest mass moving slowly ("nonrelativistically") by expanding it through first order in the small quantity $(p/mc)^2$.
5. Imagine a beam of light of two different frequencies. Now the recipe for probability density $\mathcal{E}(x,t)/h\nu$ becomes ambiguous. Should there be a similar problem for nonrelativistic particles, whose kinetic energy is negligible compared to their rest energy?