5. Refraction (Snell's law) is commonly understood within the context of classical electrodynamics in terns of "waves".

Should one adopt a description of electrodynamics in terms of "particles", could such refraction still be described in terms of "photons". Explain your reasoning.

6.

a. Compute the De Broglie wavelength (λ_{DB}) associated with a molecule of air ($\sim N_2$) in your room (STP).

Compute the average distance (d) between molecules (STP) and compare d and λ_{DB}.

b. Is this any different from the case discusse din class foe a conduction band electron (STP). Briefly explain.

- The STP conditions are: $T = 273{,}16\ K$ $\quad P = 1\ atm$
- The molecule of air can be considered as N_2, so:

  ↳ $m_{N_2} = 2 \cdot 14{,}007u = 28{,}0152u \cdot \frac{1{,}66 \cdot 10^{-27} kg}{1u} = 4{,}65 \cdot 10^{-26}\ kg$

- The internal energy of an ideal gas: $K_{gas} = \frac{3}{2} K_B T$
- Now, the kinetic energy: $K_e = \frac{1}{2} m v^2$

  ↳ $K_{gas} = K_e \Rightarrow \frac{3}{2} K_B T = \frac{1}{2} m_{N_2} v^2 \Rightarrow v = \sqrt{\frac{3 K_B T}{m_{N_2}}}$

- De Broglie: $\lambda = \frac{h}{p} = \frac{h}{m_{N_2} \cdot v} = \frac{h}{\sqrt{3 m_{N_2} K_B T}} = \frac{6{,}64 \cdot 10^{-34}}{\sqrt{3 \cdot 4{,}65 \cdot 10^{-26} \cdot 1{,}38 \cdot 10^{-23} \cdot 273{,}16}}$

$$\boxed{\lambda = 0{,}029\,nm}$$

7.

In a single-photon double-slit experiment the (single-photon "sp") source has been generated via a time-correlated photon parametric down-conversion process whereby a photon (pump) of energy $\hbar\omega_p$ is converted into a "pair" of photon each having energy $\hbar\omega_{sp}$.

a. If $\lambda_p = 355\ nm$ is the pump photon wavelength, compute the photon wavelength λ_{sp} of the down-converted single-photon impinging onto the double slit.

b. In a real experiment we need to place a "lens" between the image plane of the two slits and the farfield screen where the interference pattern is generated. Draw a scheme of the double slit interferometer showing all its components.

c. Derive an expression for the distance between the fringes in terms of the wavelength λ_{sp}, the lens focal length f and the distance d between the two slits.

d. Assuming that the center-to-center distance between the two slits is $d \simeq 500\ \mu m$, the focal length $f \simeq 500\ mm$, "estimate" the fringes distance. Compare your result with the observed fringe spacing that you may infer from the data collected (photon by photon) in the attached video.