Exercise 1

Light of wavelength $\lambda$ propagates through some medium with refractive index $n_0$ and meets an interface to another medium of thickness $d$ and refractive index $n_1$. Use the law of reflection and refraction to deduce a relation between wavelength and refractive indices for constructive interference.

Exercise 2

Derive the dispersion relation for a 1D photonic crystal using Bloch’s theorem. Why can the 1D photonic crystal be called an optical insulator?

Exercise 3

Three-dimensionally ordered macroporous (3DOM) materials with a periodicity similar to visible wavelengths can be used as photonic crystals. Starting from polystyrene (PS) spheres, what are possible fabrication steps to achieve 3DOM photonic crystals? What challenges need to be overcome for an interconnected structure?
Exercise 4

A direct opal made of closely packed silica spheres \((r = 260 \text{ nm}, \text{ filling fraction } \phi = 0.74)\) has a refractive index of \(n_1 = 1.86\) in vacuum. Which are the maximum wavelengths reflected by the \((111)\) crystal planes, after filling with organic solvents A and B of different refractive indices \(n_A = 1.24\) and \(n_B = 1.26\), respectively? Compared to an inverse opal of same material, which photonic crystal has the better wavelength resolution?