[Answer in Finnish, Swedish or English]

1. Explain (very) **briefly**:

   A) Poynting vector
   B) Free spectral range
   C) Optical activity
   D) Frustrated total internal reflection

2. a) Suppose you need circularly polarized light in an experiment. You have a light source that emits all polarization components. Design an optical setup and specify the components.

   b) Linearly polarized light goes through a "black box" that rotates the polarization plane by an angle of α. The operation of the "black box" is based on a) optical activity, b) Faraday effect. After the "black box" the light is reflected back with a mirror and directed to go through the box once more. After that, the polarization state of the light is analyzed. What is the result in case a) and b)?

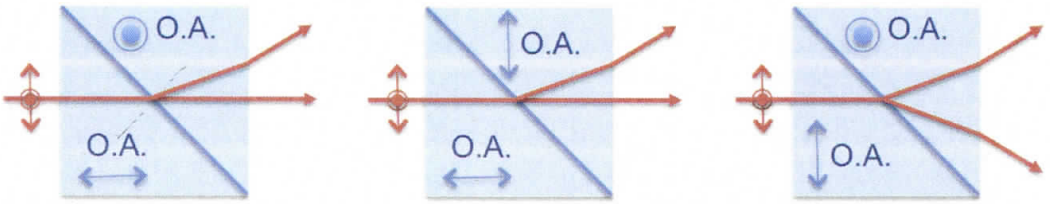
   c) The dipole moment of an electric dipole emitter oscillates in the z-direction. What is the irradiance (intensity) of the radiation emitted in the z-direction compared to x-direction when measured in the far field?

   d) Late-afternoon sunlight is reflected from a nearly horizontal surface such as the rear window of a car. How will polarizing sunglasses help to reduce glare more than simply attenuating sunglasses? Which plane of polarization should be transmitted by the polarizing lenses?

3. An unpolarized light beam enters at normal incidence a slab of positive uniaxial crystal ($n_e > n_o$).

   a) Explain the propagation of the light beam through the crystal, when the optic axis of the crystal is
      i. along the beam direction
      ii. perpendicular to the beam direction

   b) Indicate on the figures below the polarizations of the transmitted beams in the following cases ($n_e > n_o$).



Rochon prism Sernamont prism Wollaston prism

4. A Michelson interferometer is illuminated with monochromatic light. When one of the mirrors of the interferometer is moved by 25 μm, in total 92 minima and 92 maxima of interference are detected during the movement. Calculate the wavelength of the light.

5. A glass surface should be coated with a dielectric film to reduce reflection at λ_{air} = 550 nm. The index of refraction of the glass is $n_G = 1.46$. The surrounding medium is air ($n = 1$).

   a) What is the reflectance of the glass surface without any coating at normal incidence?

   b) Consider coating the surface with a single dielectric layer. How should the parameters of the film be chosen?

   c) Consider next coating the glass with two layers. How would you design your structure?

Assume that you have the following materials available for this task:

MgF_2 ($n = 1.38$), SiO_2 ($n = 1.46$), Al_2O_3 ($n = 1.60$), ThO_2 ($n = 1.80$), Nd_2O_3 ($n = 2.00$), TiO_2 ($n = 2.40$)

Help is available!

The transfer matrix for a single layer is

$$M = \begin{bmatrix} \cos k_1 d & -\frac{i}{n_1}\sin k_1 d \\ -in_1 \sin k_1 d & \cos k_1 d \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix},$$ where d is the layer thickness and n_1 its index.

The reflection coefficient can be calculated from

$$r = \frac{A + Bn_G - C - Dn_G}{A + Bn_G + C + Dn_G},$$ where n_G is the index of the substrate (glass).