UNIVERSITÀ DEGLI STUDI DI BRESCIA

**Nanophotonics Test**
**June 7, 2018**

**Student ID:**
**First Name:**
**Last Name:**

**Instructions:** You have 2 hours to complete the test. If you need extra blank sheets to complete the test please ask. Please write everything with blue or black ink pen. You can use your calculator. Use of cell phone, course notes or personal computer will invalidate the results of the test. If you don't have a calculator, you can leave the formulas in expression forms and still get full score for the exercises.

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**Questions:**

1. A TE polarized wave illuminates the interface between air ($n_a$=1) and water ($n_w$=1.33) at $\theta_i$= 60°. Calculate the angles of reflection and transmission, reflectance (R) and transmittance (T) values. What happens to the angles and values of R and T if the light impinges from the water side at the same angle?

2. Describe the concept of scattering and the parameters that govern this phenomenon.

3. A diffraction grating produces a deviation of $\theta$=33° in the second diffracted order with light incident at normal incidence and wavelength $\lambda$=600 nm. What is the total number of slits in the structure if the grating is 3cm wide?

4. Design a 1D photonic crystal whose normal-incidence gap is maximized assuming the materials composing the multilayer are glass ($n_1$=1.5) and silicon ($n_2$=3). Assume the periodicity a = 300nm. What is the central wavelength of the band-gap? Assuming the original multilayer is composed of N=5 periods, how can you modify the structure to obtain a defect state at the center of the band gap? (You can draw the original and modified stack for illustrative purposes).

5. Calculate the phase velocity of a surface plasmon propagating on a flat silver-air interface at $\lambda$=532nm and compare it to the phase velocity of light in air. Is the surface plasmon slower or faster than light in air? Assume the dielectric constant of silver at $\lambda$=532nm is $\varepsilon_{Ag}$=-9.3+i0.87 whereas the permittivity of air is $\varepsilon_{Air}$=1.

6. Consider a metal-dielectric, planar multilayer in the electrostatic approximation with metal fill factor *f* = 0.1. Assume for metal a complex, frequency-dependent dielectric constant that can be modeled with a single Drude oscillator with $\omega_p$=2π 2.18x10$^{15}$ s$^{-1}$ and damping coefficient $\gamma$ = 2π 4.35x10$^{12}$ s$^{-1}$ and for the dielectric a dispersion-free relative permittivity of 2.25. Is the structure *hyperbolic* for a TM polarized wave at $\lambda$=500nm? What changes when the metal fill-factor is increased to *f* = 0.8?

7. Describe a thin film deposition process of your choice.