BIRLA INSTITUTE OF TECHNOLGY AND SCIENCE, PILANI (RAJASTHAN)
First Semester 2017-2018

Comprehensive Examination (Closed Book/ Open Book)

PHY F213	**OPTICS**	**Weightage: 40%**
Date: 01/12/17	**Duration: 3 hrs.**	**Full Marks: 120**

PART A (Closed Book) (75 Marks)

I. Each question carries three marks. Answer any ten questions in the first two or three pages of the *answer sheets*. (30 Marks)

1. For a x-polarized wave travelling through a negative index material along z- direction, sketch the directions of electric field, magnetic field, propagation direction and poynting vector.
2. What is second harmonic generation? Explain the physical origin behind this.
3. What is electro-optic effect. Explain briefly any two electro-optic effects.
4. Consider a 2 MW laser beam of 633nm with a beam diameter of 12mm is incident on a lens of focal length 5cm. Estimate the intensity of radiation on the focal plane of the lens.
5. Determine the coherence length and spectral purity of a 546 nm green line of mercury vapor lamp with an emission line width of 6×10^8 Hz.
6. The refractive index variation of a medium is described by $n(x) = A + Bx$, where A and B are constants. Using the ray equation, obtain the expression for ray path $x(z)$.
7. What is Rayleigh scattering?
8. Write the Maxwell's equations for a conducting medium.
9. Consider a linearly polarized wave (making an angle of 45° with the x-axis) incident normally on a Half Wave plate with its fast axis along the y direction. Using Jones Matrix method, obtain the state of polarization of the output.
10. Consider two crossed polaroids placed in the path of the unpolarized beam of intensity I_0. If we place a third polaroid in between the two polaroids such that its pass axis makes an angle of 30° with respect to the pass axis of the first polaroid, calculate the intensity of transmitted beam by this set up.
11. The refractive index for borosilicate glass measured at two wavelengths are found to be n(656.3nm) = 1.50883 and n(486.1nm) = 1.51690. Calculate the Cauchy's constants for the borosilicate glass.
12. Estimate the numerical aperture and the acceptance angle of a step index optical fiber with $n_1 = 1.46$ and $\Delta = 0.01$.

II. Answer all five questions [45 Marks].

Q1. Is a two level laser possible? Justify your answer through proper derivations and explain**.** **[12]**

Q2. Consider two thin lenses of same material placed some distance apart. If focal length of one lens is 28cm, calculate (i) the focal length of the other lens and (ii) the separation between the two lenses to obtain achromatic doublet with focal length of 40cm. **[7]**

Q3. Two strings of linear mass densities μ_1 and μ_2 are joined together and the composite string is stretched with a certain tension. A transverse wave travelling in the first string is incident on the junction separating

the second string. (i) Calculate the fraction of the incident amplitude reflected and transmitted at the junction.(ii) Using the results derived in the part (i) compute the values of fraction of incident amplitude reflected and transmitted for $\mu_1 = 5\mu_2$ and $\mu_1 = 0.2\mu_2$. **[8+2+2]**

Q4. (a) A corn syrup is an excellent example of an isotropic optically active medium. Linearly polarized white light is incident on a sample of length 10cm, and as the analyzer is rotated a complete spectrum of colours can be observed. Estimate the difference in refractive index $n_L - n_R$, given that the mean value is 1.5.

(b) The indices of refraction for the fast and slow axes of quartz are 1.5462 1nd 1.5553 respectively at 546nm. Estimate the minimum thickness should a piece of quartz to act as as a quarter wave plate for a wavelength of 546nm.

(c) Light is incident on a water surface at such an angle that the reflected light is completely lineary polarized. The light refracted into the water is intercepted by the top flat surface of a block of glass. The light reflected from the glass is completely linearly polarized. What is the angle between the glass and water surfaces. (Refractive indices of water and glass are 1.33 and 1.5 respectively.) **[5+4+5]**

PART B (Open Book) (45 Marks)

Each question carries 15 marks. Answer any 3 questions.

1. **(a)** A thick lens has unit planes U_1 and U_2 at 0.4 cm and -0.5 cm respectively. It is found that the sunlight is focused to a spot at 29.5 cm to the right of the second refracting surface of this lens. Determine the location and magnification of the image of an object of 2 cm height placed 49.6cm in front of the lens.

   (b) Consider two diffraction gratings one with 20 lines spaced 1 cm apart and the other with 100,000 lines spaced 1 micron apart. Compare the two gratings in terms of i) maximum resolving powers ii) number of observable orders and iii) intensities of principal maxima for an incident wavelength of 600 nm.

2. A s-polarized electromagnetic wave of $\lambda = 630$nm is incident from air onto a dielectric interface at x=0 at an angle of 15°. The magnitude of electric field is 8V/m. The dielectric constant of the medium is 2.4. Write down the complete expressions for the electric and magnetic fields associated with the incident, reflected and transmitted waves (**Represent a proper labelled diagram with all the vectors and axes**).

3. An EM wave of 600nm is incident normally at an air to metal interface. Estimate the reflection co-efficient R. Assume $\mu_1 = \mu_2 = \mu_0$, $\varepsilon_1 = \varepsilon_0$, $\sigma = 65 \times 10^6\ \Omega^{-1}\ m^{-1}$.

4. A plane polarized EM wave of 589 nm is incident on (**i**) quartz , **(ii)** Calcite crystals. If the EM wave makes an angle of 50° with respect to optic axis of the crystal. In each case compute the appropriate parameters and sketch the diagram for both ordinary and extraordinary waves indicating **k, S, D, E, H** vectors and the appropriate angles between them with respect to optic axis of crystal.

All the best