Indian Association for the Cultivation of Science
(Deemed to be University under the *de novo* category)

Integrated Bachelor's and Master's Program

End Semester Examination (Semester II - 2020)

Subject: Electricity, Magnetism and Optics ***Subject Code(s): PHS 1201***
Full marks: 50 ***Time allotted: 3 hr***

Attempt any *five* questions

1. Consider two positive and two negative charges of equal magnitudes placed at the four corners of a square such that two positives are diagonally opposite to each other and same for the two negative charges. Taking the origin at the intersection of the two diagonals and the length of each side of the square being a,

   (a) Find the monopole potential at a point given by the vector $\vec{r}$ from the origin, where $|\vec{r}| \gg a$.

   (b) Find the dipole moment about the chosen origin.

   (c) Does the dipole moment depend on the choice of origin? Justify your answer.

   (10 marks)

2. Describe the Fermat's principle in the context of geometrical optics and hence derive the laws of reflection and refraction from planar surfaces. **(10 marks)**

3. Describe the basic setup of the Young's double slit experiment. Hence derive the fringe width and the shape of the interference fringes. **(10 marks)**

4. Solve the following two problems:

   (a) Fringes are produced with monochromatic light of wavelength 689 nm. A thin film of glass of refractive index 1.52 is placed normally in the path of one of the interfering rays. The central bright fringe is found to move to a position occupied by the fifth bright fringe from the centre. Calculate the thickness of the glass film. **(5 marks)**

   (b) In a Newton's ring experiment, the rings are formed using a source of light which has two wavelengths λ_1 and λ_2. If mth order dark ring due to λ_1 coincides with the $(m+1)$th order dark ring due to λ_2, prove that the radius of mth dark ring of λ_1 is equal to $\sqrt{\lambda_1\lambda_2 R/(\lambda_1 - \lambda_2)}$. Here R is the radius of curvature of the lower surface. **(5 marks)**

5. Describe the structure of a diffraction grating. If a monochromatic source of light of intensity I_0 falls on the diffracting grating, what will be the intensity at a point after the light has passed through the grating. Hence derive the condition of getting a principal maxima. **(10 marks)**

6. Solve the following two problems:

   (a) Suppose you have placed two polarizers at 90^o between their pass axis. Another polarizer is placed between them, which is rotated at a constant angular velocity ω about their common central axis. If un-polarized light of intensity I_0 is incident on the first polarizer, then show that the intensity of transmitted light is $(I_0/16)(1 - \cos 4\omega t)$. **(5 marks)**

   (b) Calculate the ratio of spontaneous emission rate to the stimulated emission rate at $T = 10^3$ K for visible light of frequency 5×10^{14} Hz and microwave of frequency 10^9 Hz. Thus comment on the result. **(5 marks)**