BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE PILANI, PILANI (RAJ)

Semester I 2023-2024

Electricity Magnetism and Optics Lab (PHY F214)

Comprehensive Examination

Date: 2nd December 2023 Max. Marks: 2x30 = **60** Max. duration: **90 min**

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Write your final answer in the box provided on the last page. Overwriting is strongly discouraged. Given $\varepsilon_0 = 8.85\times10^{-12}$ F/m and $\mu_0 = 4\pi \times 10^{-7}$ H/m]

Q1. In the Michelson Interferometer set-up, two mirrors M_1 and M_2 are initially placed at distances 8.31 cm and 8.56 cm, respectively, from the beam splitter. The mirror M_1 is then moved to a distance 8.305 cm from the beam splitter. If He-Ne laser (λ = 640 nm) is used to perform this experiment, how many fringes would collapse?

Q2. From the given data in Q1. at which angle the fringe of order m = 6000 will form?

Q3. What is the main experimental criteria to obtain perfectly circular fringes in the Michelson Interferometer set-up?

Q4. In the ultrasonic diffraction experiment, what is the angular separation (in degree) of the 2nd order maxima from the central maxima if the speed of the ultrasound wave is 2200 m/s, the frequency of the oscillator is 3 MHz, and the wavelength of the monochromatic light used is 589 nm?

Q5. In the Ultrasonic Diffraction experiment, the grating element is found to be 0.235 mm. If the wavelength of the Mercury light used is 5777 A° and the frequency of the oscillator is set to 5.0 MHz, what is the angle of diffraction for the first-order maxima?

Q6. In Fresnel's bi-prism experiment, if the separation between the slit and bi-prism is slowly increased, keeping the separation between slit and screen constant, how the fringe width of a monochromatic light will change on the screen?

Q7. In Fresnel's bi-prism experiment, the separation between the slits at the first position of the lens is found to be 0.25 cm, and the fringe width is found to be 0.025 cm when the eye-piece is 50 cm from the slit. If you are using the sodium lamp having a wavelength of 589 nm, determine the separation between the slits at the second position of the lens?

Q8. In the Fresnel bi-prism experiment, the separation between two virtual sources is 3 mm, and the distance between the slit and the eyepiece is 1.3 m. If the distance between two fringes is observed to be 0.2 mm, find the wavelength of the light used in the experiment.

Q9. An unpolarized light traveling from a medium of refractive index 1.45 is incident on a dielectric medium of refractive index 1.9. At what angle will the reflected light be completely polarized?

Q10. An unpolarized light is incident on a glass slab and reflected ray is found to be totally polarized. If the angle of refraction is 30°, Find the refractive index of the glass.

Q11. Two Polarizers P_1 and P_2 are placed with their axis perpendicular to each other. Unpolarized light of intensity I_0 is incident on P_1. A third polarizer P_3 is now kept in between P_1 and P_2 such that its axis makes an angle of 45° with that of P_1. What is the intensity of the transmitted light after passing through P_2?

Q12. The beam diameters of a laser beam are found to be 6 mm and 12 mm, when the detector is placed at distances of 30 cm and 32 cm, respectively from the laser. Determine the angle of divergence of the laser beam in degree.

Q13. An optical fiber has a core layer of refractive index n_1 = 1.425. If the acceptance angle for light entering the fiber from air is found to be 8.5° what is the refractive index of the cladding layer of this fiber?

Q14. For an optical fiber, the refractive index of the core layer is 1.482 and that of the cladding layer is 1.44. What is the critical angle for the core-cladding interface?

Q15. Consider an optical fiber with refractive index of the core and cladding layers are 1.480 and 1.474, respectively. What is the acceptance angle of this fiber?

Q16. Which of the following statements is incorrect about the Gaussian nature of laser beam?

A. Spot size of the beam is 'the radial distance from the center point of maximum irradiance to the $1/e^2$ point'.

B. Beam diameter is 'the distance across the center for which the irradiance is equal to $1/e^2$ of maximum irradiance'.

C. Spot size of the beam increases with the distance of the detector from the laser.

D. The Intensity profile of the laser beam follows e^{-ax} distribution with x distance from the center (a is a positive constant).

E. None of the above.

Q17. If the capacitance of a parallel plate capacitor connected against a DC power source of 10V is found to be 3μF find out the amount of energy (in joule) stored within the capacitor.

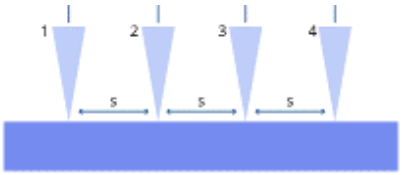
Q18. A dielectric material is filled between two parallel plates of a capacitor of plate area 100 mm^2 and plate separation 2 mm. If the capacitance is found to be 10 nF, find the dielectric constant of the material.

Q19. When a dielectric is material of volume V is placed under an external electric field **E**, electrical polarization **P** is occurred due to the formation of induced dipole moment **m** within the material. How do you quantify the polarization P?

Q20. If an electron ($1.6\ x10^{-19}\ C$) rotating in a circular path with an angular velocity of 10^6 rev/sec produces a magnetic moment of 8×10^{-30} A-m^2, what is the radius of the circle.

Q21. A wire carrying a steady current I is bent into a circular loop which produces a magnetic induction B at the center of loop. If the same wire (fixed length) is now coiled into three equal concentric loops, find the magnetic induction at the center of this coil.

Q22. In your magnetoresistance measurement experiment, find the numbers of connecting ports number for voltage measurement in the following four probe set-up.



Q23. A capacitor is fully charged up to a potential of 1 V. If it starts to discharge through the same RC loop now, what will be the voltage across the capacitor after a time $t = \tau$ (time constant of the loop)?

Q24. If 10 μF and 20 μF capacitors are charging separately using two DC batteries of voltage 12 V and 6 V, respectively, what will be potential drop across them, after a sufficiently long time?

Q25. For an RC circuit with DC battery of 20 V, where R= 100 Ω and C = 5 μF, find out the initial value of charging and discharging currents.

Q26. Two parallel circular loops, each of diameter 10 cm are placed at a distance of 1cm apart. If each loop carries a current of 1A (in same direction), find the magnetic field at the center of either loop.

Q27. In the M-B curve experiment, the magnetization $M = k\ tan\theta$ is observed, where constant k is given as 8×10^6. If the magnetometer needle deflects to an angle of 75°, what is the magnetic dipole moment of the rod? Given: l = 0.3m, $A = 2\times10^{-5}$ m^2, BE =3.5×10^{-5} T, and n = 1600 turns/m.

Q28. The core material of an electromagnet should have (a) ---------- retentivity and (b)_____ coercivity. (Write in terms of high and low only).

Q29. What is the force per unit length F between two infinite straight wires carrying parallel currents of 5 A separated by a distance of 20 cm?

Q30. In your dielectric constant measurement following data is given: C_{SC} = 50 pf, V_{DC} = 0.35 V, V_{SC} =1.25 V. If the diameter of plates is 0.8 cm and the thickness of the dielectric slab is 0.3 mm, find out the value of dielectric constant of a material.

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Comprehensive Examination Answer Sheet

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Name: ID:

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Q1		Q16	
Q2		Q17	
Q3		Q18	
Q4		Q19	
Q5		Q20	
Q6		Q21	
Q7		Q22	
Q8		Q23	
Q9		Q24	
Q10		Q25	
Q11		Q26	
Q12		Q27	
Q13		Q28	
Q14		Q29	
Q15		Q30	

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