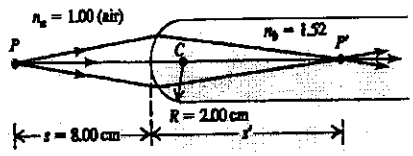
University of Technology
Department of Laser & Optoelectronic Engineering
Final Examination 2011-2012

Subject: University Physics — *Class: 1st year*
Division: Laser & Optoelectronic — *Time: 3 hours*
Examiner: Dr. Mohammed Abdul-Redha — *Date: 23/ 5/2012*

Answer five questions only

Q (1): a) A cylindrical glass rod in air (Fig. 1) has index of refraction 1.52. One end is ground to a spherical surface with radius $R = 2$ cm. Find the image distance and magnification of a small object on the axis of the rod, 8.00 cm to the left of the vertex. **5**



b) Answer the followings: **5**
1) Write down the equation of total internal reflection.
2) Write down only the three types of polarization.
3) State Richardson's law of thermionic emission.

Q (2): a) The distance between two slits 0.45 mm are placed 75.0 cm from a screen. What is the distance between the second and fourth dark fringes of the interference pattern on the screen when the slits are illuminated with coherent light with a wavelength of 500 nm? **5**

b) What is the polarizing angle for light incident on glass with refractive index (1.5)? **5**

Q (3): In Newton's ring experiment, a Plano-convex lens with refractive index (1.5) with focal length (50) cm is used. Interference fringe are observed by using light with wavelength 500 nm. Find the radius of the first dark and fourth bright circular fringes? **10**

Q (4): a) Diffraction fringe pattern is observed for single slit of width 50 nm when using light of wavelength (500 nm). What is the intensity percentage on the screen at a position making angle (45^o deg) with the slit. **5**

b) Answer the followings: **5**
1) The conditions of constructive interference.
2) Define Fraunhofer diffraction.
3) The reason of using two parallel high reflection mirrors in laser design.

Q (5): a) In a photoelectric-effect experiment, the kinetic energy of the ejected photoelectrons is (50 eV) for a metal with work function (30 eV). Find the wavelength of the ejected photon. **5**

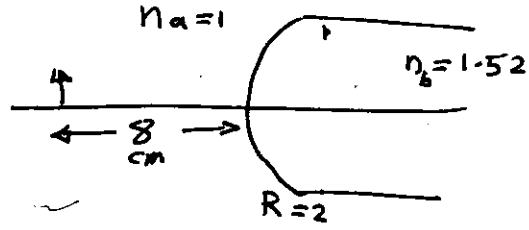
b) What is the wavelength of the emitted light when electron at the third orbit moves down to the first orbit of the atom by spontaneous emission? **5**

Q (6): A spherical mirror has magnification (-5) for an object at 30 cm. Find the type, radius and the focal length of the mirror. **10**

Note (h=6.6x10^{-34} J.sec, m_e=9.1x10^{-31} kg, c=3x10^8 m/sec, e=16x10^{-20} col)

حلول المنزل (1) من الأسئلة

Q1) a)



$$\frac{n_a}{s} + \frac{n_b}{s'} = \frac{n_b - n_a}{R}$$

$$\frac{1}{8} + \frac{1.52}{s'} = \frac{1.52-1}{2} = \frac{0.52}{2}$$

$$\frac{1.52}{s'} = \frac{0.52}{2} - \frac{1}{8} = \frac{2.08-1}{8} = \frac{1.08}{8}$$

$$\therefore s' = \frac{1.52 \times 8}{1.08} = 11.26 \text{ cm}$$

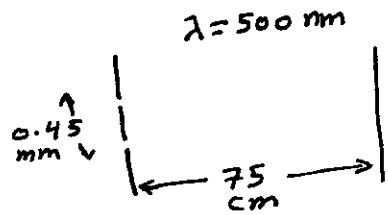
$$m = -\frac{s'}{s} = -\frac{11.26}{8} = -1.4$$

b) 1) $\sin\theta = \frac{1}{n}$

2) Linear, circular and elliptical polarization

3) $I = AT^2 e^{-\frac{W}{KT}}$

Q2) a)



$$y_m = \frac{m\lambda D}{d}$$

$$y_2 = \frac{2 \times 500 \times 10^{-9} \times 75 \times 10^{-2}}{0.45 \times 10^{-3}} = 3.33 \text{ mm}$$

$$\therefore y_4 = \frac{4 \times 500 \times 10^{-9} \times 75 \times 10^{-2}}{0.45 \times 10^{-3}} = 6.66 \text{ mm}$$

$$\therefore y_4 - y_2 = 6.66 - 3.33 = 3.33 \text{ mm}$$

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b) $\tan\theta = n$

$= 1.5$

$\therefore \theta = \tan^{-1}(1.5) = 56.31^\circ$

Q3): For dark fringe $r_m^2 = mR\lambda$

For Bright fringe $r_m^2 = (m+\frac{1}{2})R\lambda$

since: $\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$$\frac{1}{50} = (1.5-1)\left(\frac{1}{R} - \frac{1}{\infty}\right) = \frac{0.5}{R} \Rightarrow R = 25 \text{ cm}$$

$\therefore$ first dark: $r_1^2 = 1 \times 25 \times 10^{-2} \times 500 \times 10^{-9} = 12.5 \times 10^{-8} \Rightarrow r_1 = 3.5 \times 10^{-4} \text{ m} = 0.35 \text{ mm}$

Fourth Bright: $r_4^2 = (4+\frac{1}{2}) \times 25 \times 10^{-2} \times 500 \times 10^{-9} = 56.25 \times 10^{-8} \Rightarrow r_1 = 7.5 \times 10^{-4} \text{ m} = 0.75 \text{ mm}$

Q4) a

$I = I_0 \left(\frac{\sin(\frac{\beta}{2})}{\frac{\beta}{2}}\right)^2$, $\beta = \frac{2\pi}{\lambda} a \sin\theta$

$\therefore \beta = \frac{2\pi}{500} \times 50 \sin(12^\circ) = \frac{2\pi}{10} \times 0.2079 = 0.1306$

$\therefore \frac{\beta}{2} = 0.0653$

$\therefore \frac{I}{I_0} = \left[\frac{\sin 0.0653}{0.0653}\right]^2 \left[\frac{0.0342}{0.0169}\right]^3 = \left[\frac{0.0652}{0.0653}\right]^2$

$= 0.994 = 99.4\%$

$\beta = \frac{2\pi a}{\lambda} \sin\theta = \frac{2\pi \times 50}{500} \sin 45^\circ = 0.444$

$\therefore \frac{\beta}{2} = 0.222$

Then: $I = I_0 \left[\frac{\sin\frac{\beta}{2}}{\frac{\beta}{2}}\right]^2 = I_0 \left[\frac{\sin 0.222}{0.222}\right]^2 = I_0 \left[\frac{0.22}{0.222}\right]^2 = 0.982\, I_0$

$\therefore \frac{I}{I_0} = 0.982 = 98.2\%$

b) 1) The path difference Δ must equal to $(m+1)\lambda$

2) It is far-field diffraction with parallel rays.

3) to amplify the stimulated light within the gain medium.

Q5) a) $hf = T + W$

$hf = 50 + 30 = 80\ ev = 80 \times 16 \times 10^{-20}\ J$

$\therefore f = \frac{80 \times 16 \times 10^{-20}}{6.6 \times 10^{-34}} = 194 \times 10^{14}\ Hz$

$\therefore \lambda = \frac{c}{f} = \frac{3 \times 10^8}{194 \times 10^{14}} = 0.0154 \times 10^{-6} = 15.4 \times 10^{-9}\ m = 15.4\ nm$

b) $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = 1.097 \times 10^7 \left(\frac{1}{1^2} - \frac{1}{3^2}\right) = 0.975 \times 10^7\ m^{-1}$

$\therefore \lambda = 1.025 \times 10^{-7}\ m = 0.1025 \times 10^{-6}\ m = 0.1025\ \mu m$

Q6) $m = -\frac{s'}{s} \Rightarrow s = 30\ cm \Rightarrow -5 = -\frac{s'}{30} \Rightarrow s' = 150\ cm$

and $\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \Rightarrow \frac{1}{30} + \frac{1}{150} = \frac{1}{f} = \frac{6}{150} \Rightarrow f = 25\ cm$

Then $R = -\frac{f}{2} = -\frac{25}{2} = -12.5\ cm$

The type: concave