LF EXAM TFY4195 H2020 (5. DEC, 2020)

MC 8

$$E = h\nu = \frac{hc}{\lambda} = \frac{6.62\cdot10^{-34}\cdot 3\cdot10^{8}}{10^{-10}} \qquad [J] = \frac{\frac{kg\cdot m}{s}\cdot\frac{m}{s}}{m}$$

UNITS

CHANGE TO eV $\quad E = q\cdot U$

CHANGE $\quad$ J $\quad$ 1 electron volt

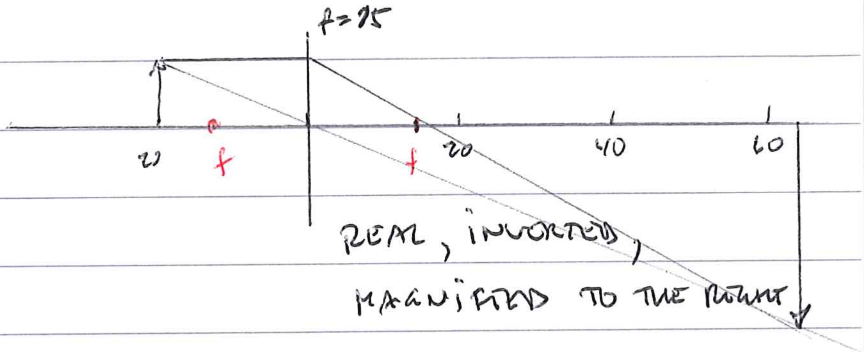
$$\Rightarrow E(eV) = \frac{6.62\cdot10^{-34}\cdot 3\cdot10^{8}}{10^{-10}\cdot 1.6\cdot10^{-19}}$$

$$= 12400\ eV = \underline{12.4\ keV}$$

MC7 $\quad s_0 = 20\ cm$

$$\frac{1}{20} + \frac{1}{s_i} = \frac{1}{15} \Rightarrow \frac{1}{s_i} = \frac{1}{15} - \frac{1}{20} = \frac{1}{60} \Rightarrow s_i = 60$$

$$M_T = -\frac{s_i}{s_0} = -3$$



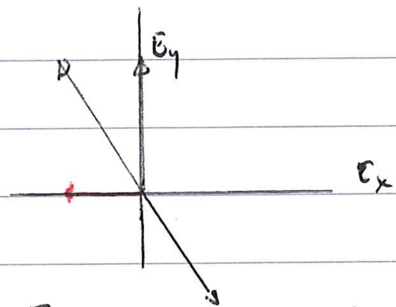
REAL, INVERTED, MAGNIFIED TO THE RIGHT

MC10 $\quad E_x = 4.6\cos(kz-\omega t)$

$E_y = 4.6\sin(kz-\omega t)$ $\quad \frac{\pi}{2}$ PHASE-SHIFT, SAME AMPLITUDE $\Rightarrow$ CIRCULAR

$E_x = 2.3\cdot\cos(kz-\omega t+\pi)$

$E_y = 4.6\cos(kz-\omega t)$



LINEAR

$E_x = 2.3\cos(kz-\omega t+\frac{\pi}{4})$

$E_y = 2.3\cos(kz-\omega t-\frac{\pi}{4})$ $\quad \frac{\pi}{2}$ PHASE-SHIFT DIFFERENCE, SAME AMPLITUDE $\Rightarrow$ CIRCULAR

$E_x = 4.6\cos(kz-\omega t-\frac{\pi}{2})$

$E_y = 4.6\sin(kz-\omega t)$

$\sin\alpha = \cos(\alpha-\frac{\pi}{2})$

$\Downarrow$

LINEAR 45°

THE REMAINING 2 HAVE DIFFERENT AMPLITUDES, PHASE-DIFFERENCES $\neq 0\ \&\ \pi$

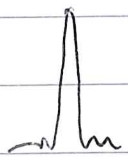
$\Rightarrow$ ELLIPTICALLY POLARIZED

MCL WE CAN SOLVE THIS BY EXCLUSION PRINCIPLE

THESE SEPARATIONS ARE GIVEN BY THE (NUMBER &) SEPARATION OF SLITS.

THIS WIDTH IS GIVEN BY SLIT WIDTH "b"

3) CENTER



THIS HAS THE MOST NARROW DIFFRACTION PATTERN => WIDEST SLIT (SINGLE SLIT 0.1 mm WIDE)

TYPICAL MULTI-SLIT, 6 SLITS 0.025 WIDE SEPARATED 0.1 ONLY ALTERNATIVE

4) MUST HAVE THE SAME/SIMILAR 'b'

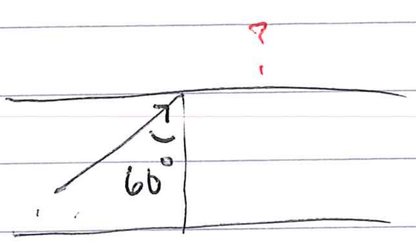
5) TYPICAL SINGLE SLIT 0.025 mm

1) BOTH HAS BROADER ENVELOPE => 0.01 mm WIDE

2)

1) HAS LARGER WIDTH BETWEEN PEAKS => SMALLEST SLIT SEPARATION 0.03

MC 5 INTERNAL REFLECTION



$1.75 \cdot \sin 60^\circ = 1 \cdot \sin \alpha$

$\underbrace{1.75 \cdot \sin 60^\circ}_{1.499 > 1}$

TOTAL INTERNAL REFLECTION

ALL LIGHT IS REFLECTED

MC 11 THE GRATING EQUATION $a \cdot \sin\theta = m \cdot \lambda$ ↓ ORDER

LET $\lambda = 550$ nm

GRATING G1 $a_1 = 2.5 \cdot 10^{-6}$

$\Rightarrow \sin\theta_1 = \dfrac{2 \cdot 550 \text{ nm}}{2.5 \cdot 10^{-6}} \Rightarrow \theta_1 = 26.10^\circ$

GRATING G2 $a_2 = 2 \cdot a_1 = 5 \cdot 10^{-6}$ ... $\theta_2 = 12.71^\circ$

STATEMENT A)

ANGULAR DISPERSION $= \dfrac{m}{a \cos\theta}$

$\theta_1 \rightarrow 8.91 \cdot 10^{-4} \ \dfrac{\text{rad}}{\text{nm}}$

$\theta_2 \rightarrow 4.10 \cdot 10^{-4} \ \dfrac{\text{rad}}{\text{nm}}$

SO DISPERSION IS SMALLER FOR G2

STATEMENT B)

RESOLVING POWER $R = \dfrac{\lambda}{(\Delta\lambda)_{min}} = m \cdot N$

SINCE GRATING 2 HAS HALF THE NUMBER

$\Rightarrow R_{G1} > R_{G2}$ G1

MC 13

$$\underbrace{\begin{pmatrix} 2 & -14 \\ 1/2 & -3 \end{pmatrix}}_{f_1 \to \text{IMAGE}} \underbrace{\begin{pmatrix} 1 & s_0 \\ 0 & 1 \end{pmatrix}}_{\text{OBJECT} \to f_1} =$$

$$= \begin{pmatrix} 2 & 2s_0 - 14 \\ 1/2 & s_0/2 - 3 \end{pmatrix}$$

$= 0$ GIVES IMAGING CONDITION

$s_0 = 7\ \text{cm}$

M_T $\quad M_T = 2$ REAL, MAGNIFIED, ERECT IMAGE

MC 14 WE RECALL THE GUIDED WAVE IS ASSUMED TO BE PROPORTIONAL TO $e^{i(\beta z - \omega t)}$

WITH $\beta = \frac{2\pi}{\lambda} \cdot N$; THE k-VECTOR FOR THE GUIDED MODE

$\uparrow$ EFFECTIVE INDEX

ALSO $N_{TM} < N_{TE}$ FOR ISOTROPIC SYSTEMS

AS $v_{ph} = \frac{c}{n} \Rightarrow v_{TM} > v_{TE}$

ALSO $v_{ph} \simeq \frac{3 \cdot 10^8}{N} \sim 2 \cdot 10^8\ \frac{m}{s}$

$N \sim 1.485$ FROM FIGURE

MC9 $n = 1.5$ LENSMAKER FORMULA

$R_1 = 15\ cm$

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

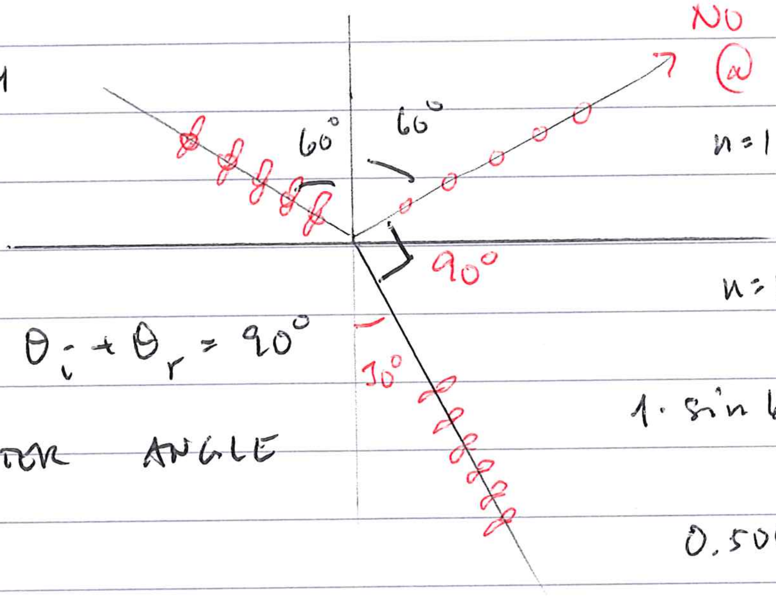
$+$ SIGN CONVENTION FOR TWO CONVEX SURFACES

$R_2 = 10\ cm$

$$\frac{1}{f} = 0.5\left(\frac{1}{15} + \frac{1}{10}\right) = \frac{1}{12} \Rightarrow f = 12\ cm$$

MC4

NO REFLECTED TM LIGHT @ BREWSTER ANGLE



$n = 1$

$n = 1.73$

SINCE $\theta_i + \theta_r = 90°$

BREWSTER ANGLE

$$1 \cdot \sin 60° = 1.73 \cdot \sin \alpha$$

$$0.5006 = \sin \alpha \Rightarrow \alpha = 30.0°$$

TRANSMITTED LIGHT IS MOSTLY POLARIZED IN THE PLANE OF INCIDENCE

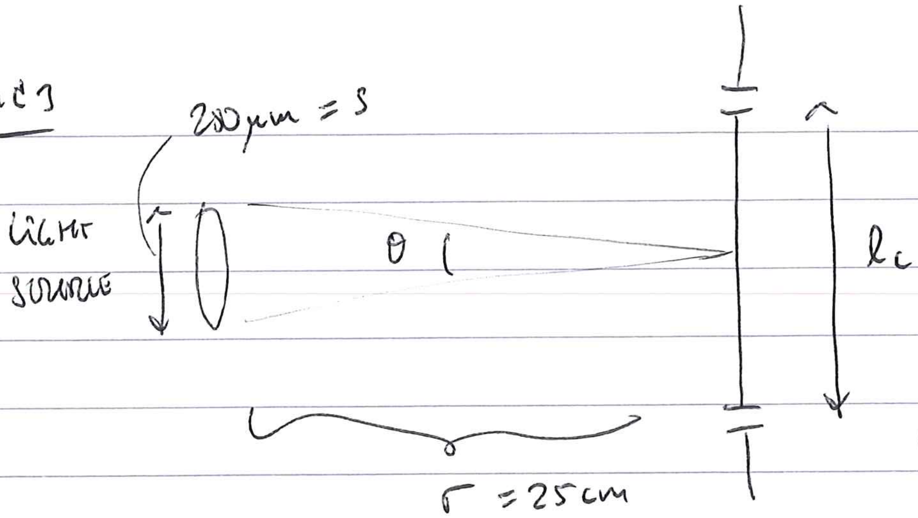
MC2 THE COHERENCE LENGTH CAN BE WRITTEN

$$l_c = \frac{\lambda^2}{\Delta\lambda} = \frac{550^2}{10} = 30.25 \cdot 10^3\ nm \sim 30\ \mu m$$

MC12 $M_{sys} = \begin{pmatrix} -1/4 & 25 \\ 0 & -4 \end{pmatrix}$ $M_{21} = 0$ TELESCOPE SYSTEM

ANGULAR MAGNIFICATION

MC3



FOR SPATIAL COHERENCE

$$l_c = \frac{\lambda}{\theta}\cdot 1.22$$

CIRCULAR APERTURE

$$\theta \simeq \frac{s}{r}$$

$$\Rightarrow l_c = \frac{550\cdot10^{-9}\cdot 0.25 \cdot 1.22}{250\cdot10^{-6}} \sim 6.7\cdot10^{-4}\ \text{m} \sim 0.67\ \text{mm}$$

670 μm

MC1

$$M_T = -2 = -\frac{s_i}{s_o} \Rightarrow s_i = 2s_o$$

$$\frac{1}{s_o} + \frac{1}{2s_o} = \frac{1}{20} \Rightarrow 20 = \frac{2s_o}{3} \Rightarrow s_o = 30\ \text{cm}$$