# LF EXAM TFY4195 H2020 (5. DEC, 2020)

**MC 8**

$$E = h\nu = \frac{hc}{\lambda} = \frac{6.62\cdot 10^{-34}\cdot 3\cdot 10^{8}}{10^{-10}}$$

UNITS

$$[J] = \frac{\frac{kg\cdot m}{s}\cdot\frac{m}{s}}{m}$$

CHANGE TO eV

$E = q\cdot U$

CHARGE J ↑ electron volt

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

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

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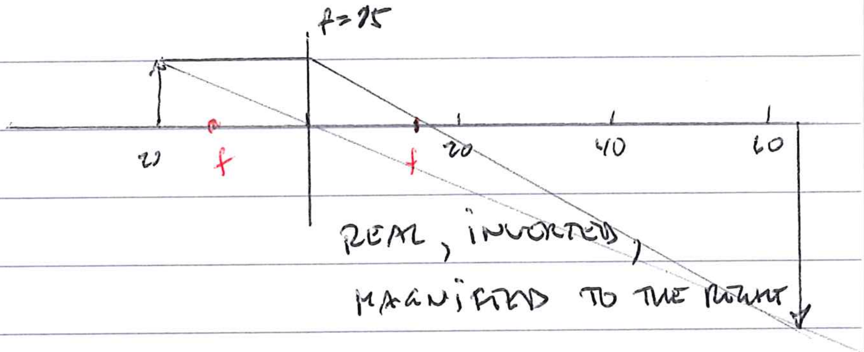
**MC7** $s_o = 20$ cm

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

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




REAL, INVERTED, MAGNIFIED TO THE RIGHT

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**MC10**

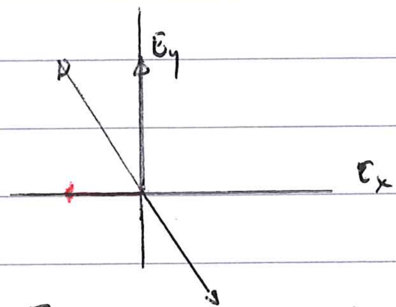
$E_x = 4.6\cos(kz-\omega t)$

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

$\frac{\pi}{2}$ 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

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

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

$\frac{\pi}{2}$ PHASE-SHIFT DIFFERENCE, SAME AMPLITUDE $\Rightarrow$ CIRCULAR

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

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

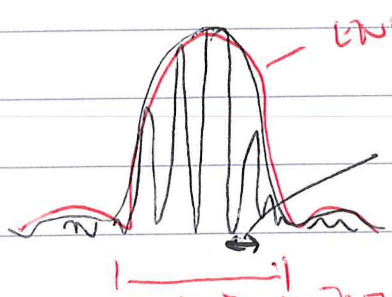
$\sin\alpha = \cos(\alpha-\frac{\pi}{2})$

LINEAR 45°

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

$\Rightarrow$ ELLIPTICALLY POLARIZED

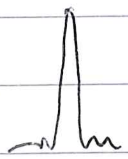
MCL WE CAN SOLVE THIS BY EXCLUSION PRINCIPLE




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

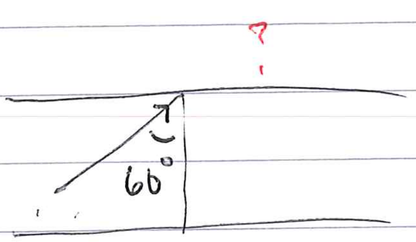
4) } MUST HAVE THE SAME/SIMILAR 'b'

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




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

$1.499 > 1$

TOTAL INTERNAL REFLECTION

ALL LIGHT IS REFLECTED

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## 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 $= \dfrac{m}{a \cos\theta}$

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

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

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

$$\begin{pmatrix} 2 & -14 \\ 1/2 & -3 \end{pmatrix} \begin{pmatrix} 1 & s_0 \\ 0 & 1 \end{pmatrix} =$$

$f_1 \to$ IMAGE  OBJECT $\to f_1$

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

$= 0$ GIVES IMAGING CONDITION

$s_0 = 7$ cm

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

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MC 14  WE REALIZE 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

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

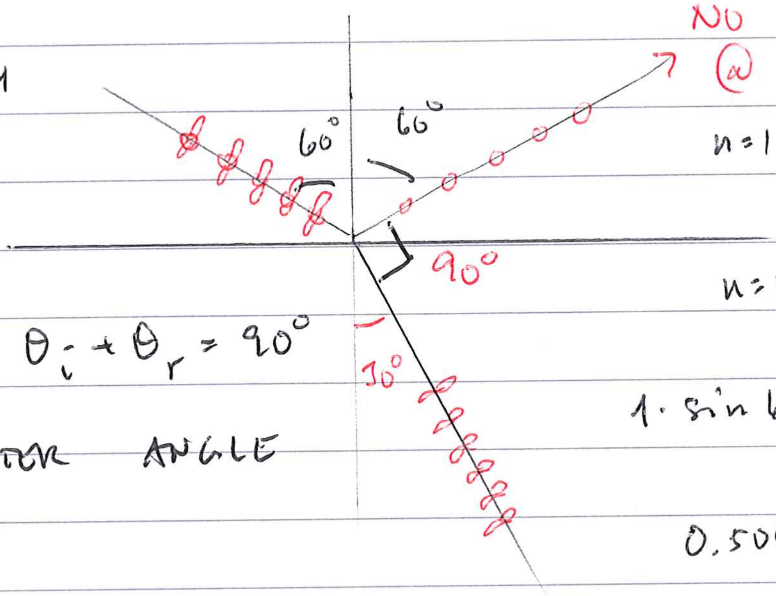
SIGN CONVENTION FOR TWO CONVEX SURFACES

$R_2 = 10$ 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




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

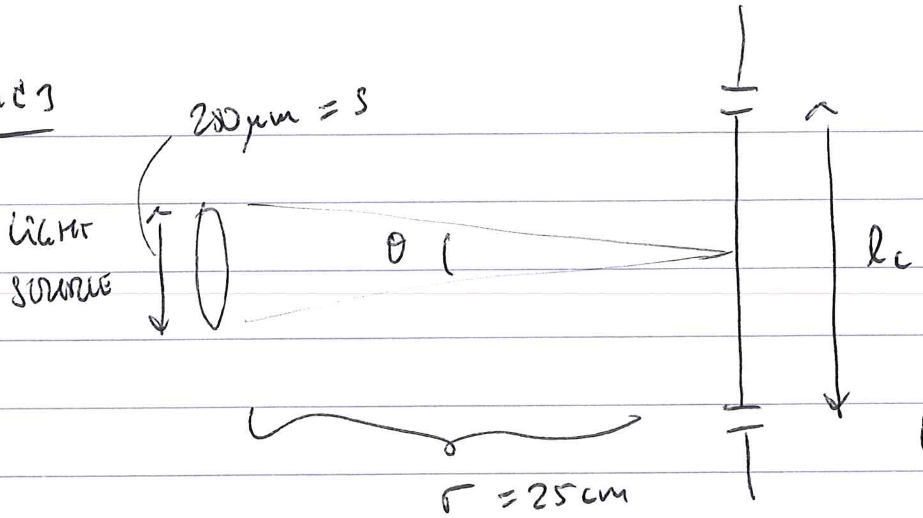
**MC2**  THE COHERENCE LENGTH CAN BE WRITTEN

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

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

ANGULAR MAGNIFICATION

## MC 3




FOR SPATIAL COHERENCE

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

CIRCULAR APERTURE

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

$$\Rightarrow l_c = \frac{550\cdot 10^{-9}\cdot 0.25 \cdot 1.22}{250\cdot 10^{-6}} \sim 6.7\cdot 10^{-4}\ \text{m} \sim 0.67\ \text{mm}$$

670 μm

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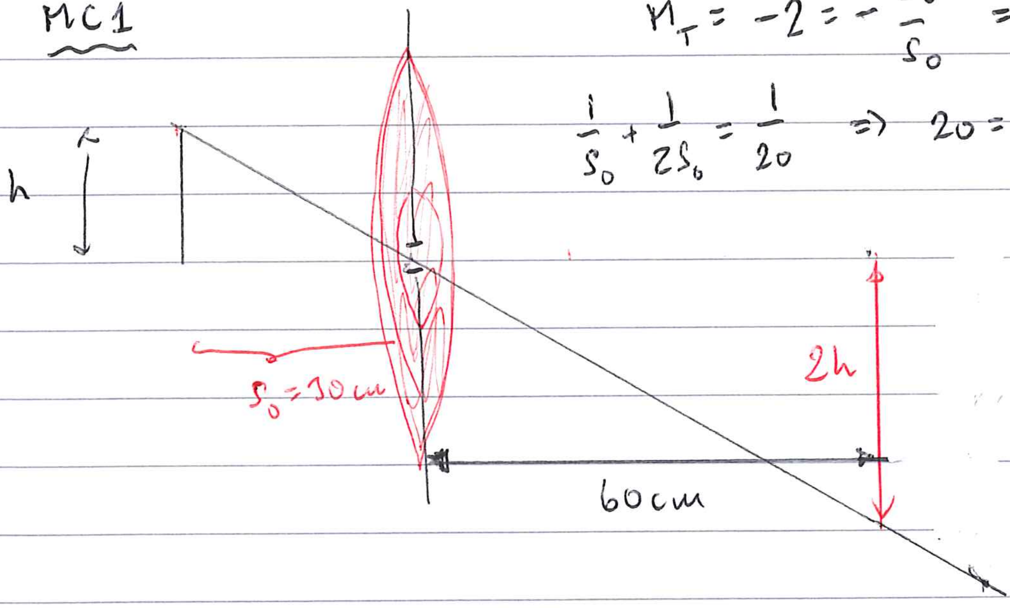
## MC 1

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

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

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