ROU-S1 E2

Experimental Set
No. 155

Cover Sheet for Solutions

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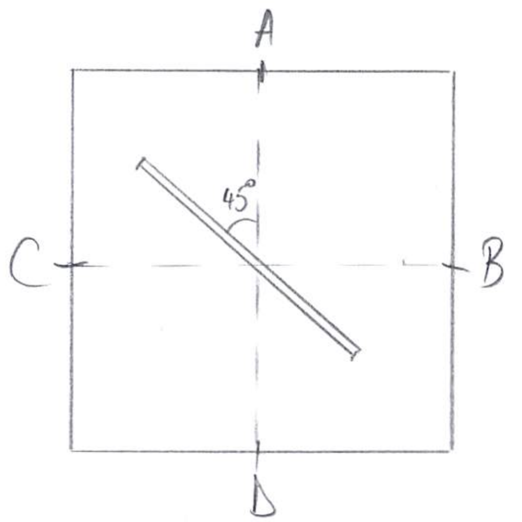
E2.1.

At the center there is a ~~pa~~ semi-transparent mirror, oriented like this



This can be concluded because when laser enters A, it mostly exits B and D, when it enters B, it exits A and C and so on

E2.2

C - diffraction grating → when ~~lg~~ laser exits C, 3 ~~diffraction~~ interference like spots form
→ when laser enters C, 2 internal ~~s~~ light spots can be seen inside the optical box on A and D sides.
→ it cannot be a slit or a pin hole because those would produce diffraction, which is not seen

A - convex lens

→ if we watch the laser spot dimension when laser exits port A, initially, its dimension decreases until it reaches a minimum, and then it starts growing (this happens due to a converging lens)

B - concave lens

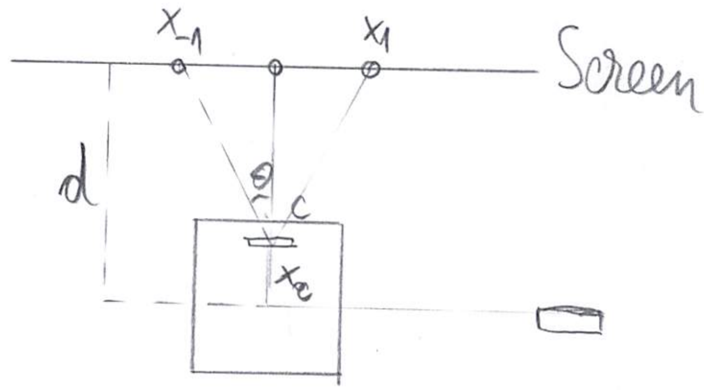
→ when laser enters B port, ~~the~~ spots ~~one~~ exiting the ~~bla~~ optical box grow with the distance from the box

Δ - polarizer

→ when laser light enters Δ, the intensity of all exiting spots changes ~~a~~ when the laser source is rotated, which means Δ port has a prefered axis, the polarizer axis

E2.3

For the diffraction grating properties:



d(cm)	x_1(cm)	x_{-1}(cm)
5	0,65	-0,65
10	2,30	-2,40
15	4,00	-4,10
20	5,60	-5,70
25	7,45	-7,40
30	9,20	-9,20
35	11,00	-10,90
40	12,35	-12,50
45	14,15	-14,05
~~50~~		

$\Delta d = 0{,}05\,cm$ (~~0,1~~)

$\Delta x = 0{,}05\,cm$ (~~0,1~~)

~~$\sin\theta =$~~

$a \sin\theta_i = i\lambda$

$\sin\theta_{1,-1} = \frac{\lambda}{a}$

~~$x_1 = x_c + (d - x_c)$~~

$x_1 = (d - x_c)\,tg\,\theta$

$x_{-1} =$ ~~$d($~~ $-(d - x_c)\,tg\,\theta$

$$x_1 - x_{-1} = 2(d - x_c)\,tg\theta$$

d (cm)	$x_1 - x_{-1}$ (cm)
5	1,30
10	4,70
15	8,10
20	11,30
25	14,~~95~~85
30	18,40
35	21,90
40	24,85
45	28,20

$$x_1 - x_{-1} = -2{,}0511 + 0{,}6758\,d$$

$$2\,tg\theta = 0{,}6758$$

$$\theta = 18{,}671^\circ$$

$$a = \frac{\lambda}{\sin\theta}$$

$$a = 2{,}03\ \mu m$$

$$\sout{\Delta a =}\ \frac{\Delta a}{a} = \sqrt{\left(\frac{\Delta\lambda}{\lambda}\right)^2 + \left(\frac{\Delta \sin\theta}{\sin\theta}\right)^2}$$

$$\Delta(\sin\theta) = \cos\theta\,\Delta\theta$$

~~$a = 2{,}03 \pm 0{,}02\,\mu$~~

$$tg\theta = \frac{x_{1,-1}}{2d} \Rightarrow \frac{\Delta(tg\theta)}{tg\theta} = \sqrt{\left(\frac{\Delta x_{1,-1}}{\langle x_{1,-1}\rangle}\right)^2 + \left(\frac{\Delta d}{\langle d\rangle}\right)^2}$$

$$\langle x\rangle = 15\,cm$$

$$\langle d\rangle = 25\,cm$$

$$\Delta\left(\frac{\Delta\theta}{\cos^2\theta\,tg\theta}\right) \Rightarrow \Delta\theta = 1{,}179\cdot10^{-3}\,rad \Rightarrow \Delta a = 0{,}02\,\mu m$$

$a = 2{,}03 \pm 0{,}02\ \mu m$

$-2x_c \cdot tg\theta = -2{,}051$

$x_c = 3{,}03\ cm$

On a similar reasoning, $\Delta x_c \cong 0{,}03\ cm$

$x_c = 3{,}03 \pm 0{,}03\ cm$

Also, ~~the~~ to find the direction of the stripes with the vertical we just measure angle φ between diffraction maxima line and horizontal:

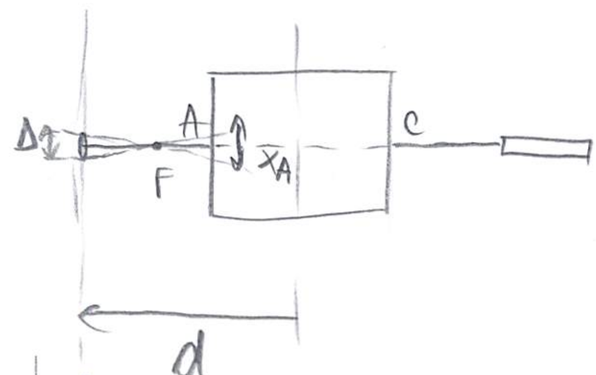
$tg\varphi = 0{,}0429 \Rightarrow \varphi = 2{,}45° \cong 2{,}5°$

$\Delta\varphi \cong 0{,}2°$ (hard to measure small angles precisely

In order to measure focal distance of lenses, we measure spot diameter variation with distance

$\Delta d_0 = 4\,mm$, $\Delta D_0 = 0{,}2\,mm$

For convex lens:



d(cm)	D(mm)
10	0,50
20	6,20
30	12,00
40	17,50
50	~~24,00~~ 22,50
60	~~30,00~~ 29,00
70	~~36,00~~ 35,00
80	~~42,00~~ 40,00
90	45,00

$$D = \frac{d_0}{f}\cdot(d - f - x_A)$$

$$D = -4{,}997\cdot 10^{-3} + 0{,}0562\cdot d_{(m)}$$

$$\frac{d_0}{f} = 0{,}0562$$

$$f = 7{,}12\,cm$$

$$0{,}0562(f + x_A) = -0{,}4997\ (cm)$$

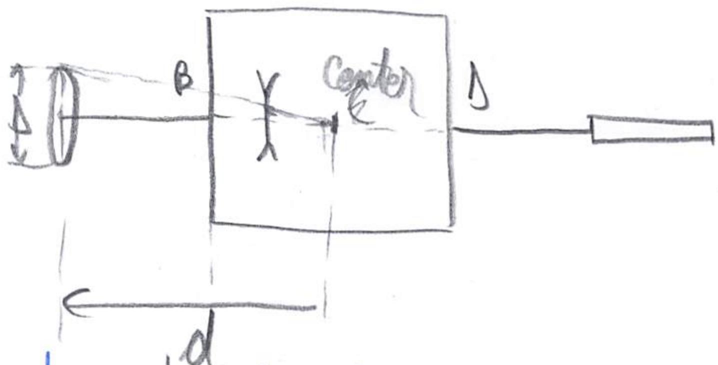
$$f + x_A = 8{,}89\,cm \Rightarrow x_A = 1{,}77\,cm$$

$\frac{\Delta f}{f} \simeq \frac{\Delta D_0}{D_0} \Rightarrow \Delta f = 0{,}4\,cm$

$f = (7{,}1 \pm 0{,}4)\,cm$

~~x_A~~ $\Delta x_A = \Delta f \Rightarrow x_A = (1{,}8 \pm 0{,}4)\,cm$

For concave lens:



d(cm)	D(mm)
10	7,00
20	12,00
30	16,00
40	~~21,00~~ 20,00
50	~~25,00~~ 24,00
60	~~30,00~~ 28,00
70	~~35,00~~ 32,00
80	~~40,00~~ 36,00
90	~~44,00~~ 40,00

~~$d =$~~

$D = \frac{D_0}{|f|}(d - x_B + |f|)$

$D = 3{,}556 + \sim\sim 0{,}4067 \sim\sim 0{,}04067\, d_{(m)}$ (10^{-3})

$|f| = 9{,}84\,cm$

$f = -9{,}84\,cm$

$0{,}04067(|f| - x_B) = 0{,}3556$

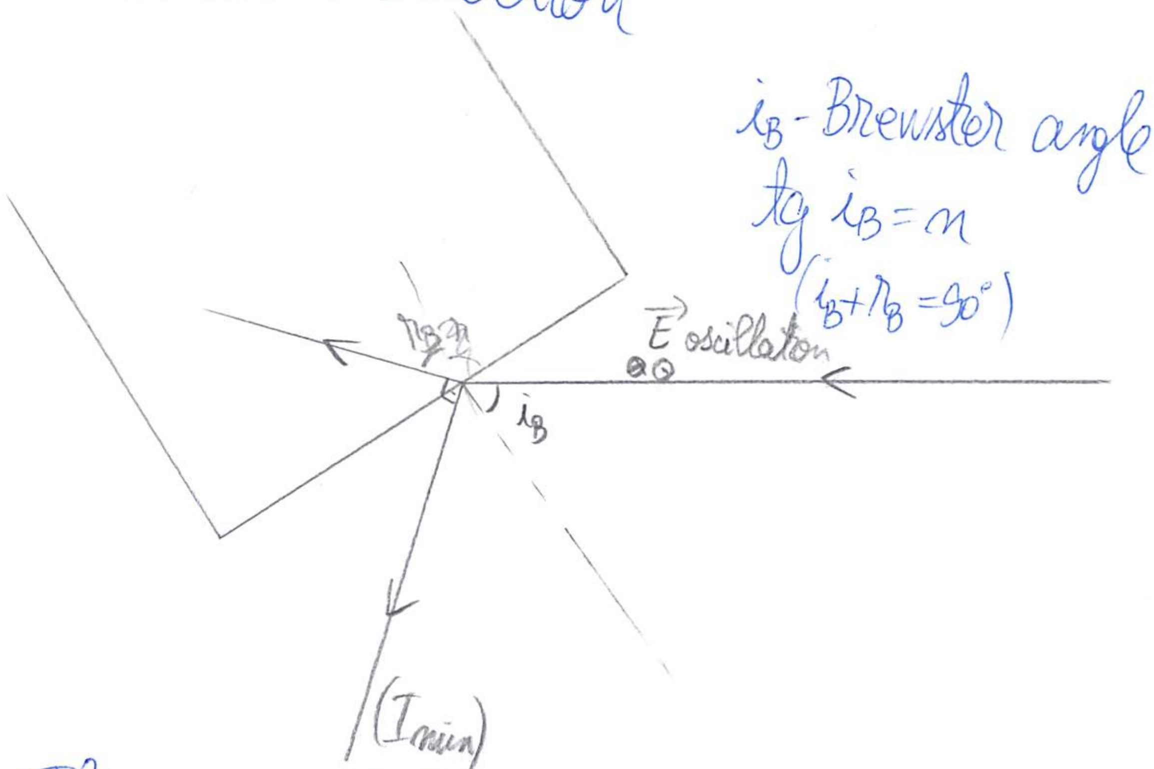
~~x~~ $x_B = 4\sim\sim 0 \sim\sim 1{,}10\,cm$

$\Delta f = 0{,}5\,cm \Rightarrow f = \sim\sim 9{,}84 \sim\sim 9{,}8 \pm 0{,}5\,cm$

$\Delta x_B = \Delta f \Rightarrow$ ~~$x_B = 9,8$~~ $x_B = 1,1 \pm 0,5$ cm

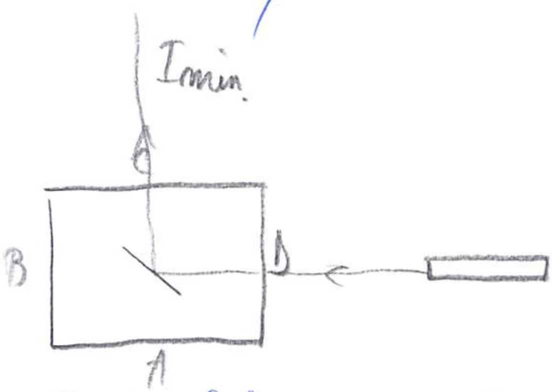
For the polarizer:

We use the glass block and position it at $\Theta = \text{arctg}(n) = 56,3°$ from the incident laser beam direction



Then, we rotate the laser until we reach a minimum intensity for the reflected beam. This happens when the polarization direction of the laser is vertical. We mark this angle on the laser.

Then, we ~~t~~ use the optical box and see where the exiting laser light has the lowest intensity:



The angle difference ~~f~~ between the 2 laser positions is $\Delta\Theta \simeq 115°$ => We can conclude that $\alpha = 25°$ is the angle between the polarizer transmission lines and the vertical through the box