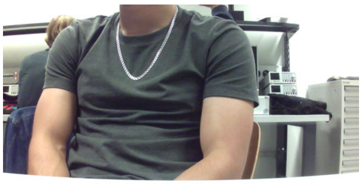
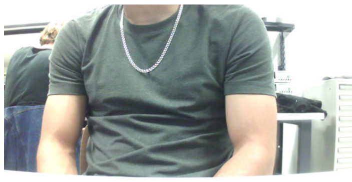
GROUP: A2-4 NAME: MORAND + RAMIREZ

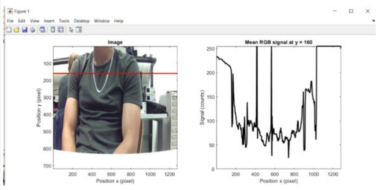
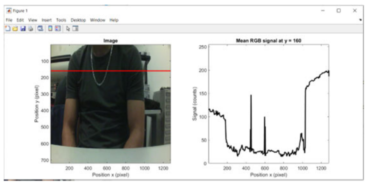
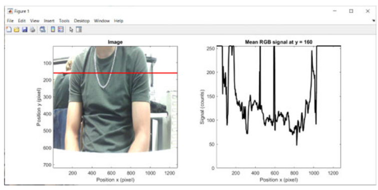
TP 01: Imaging

1. Saturation and intensity adjustment of the camera

Take an image of the same scene at different exposure levels: one with default
Make line plots at areas were automatic exposure gave saturation and compare the plots

Picture 1 - default exposure	Picture 2 - no saturated pixel	Picture 3 - few saturated pixel
		

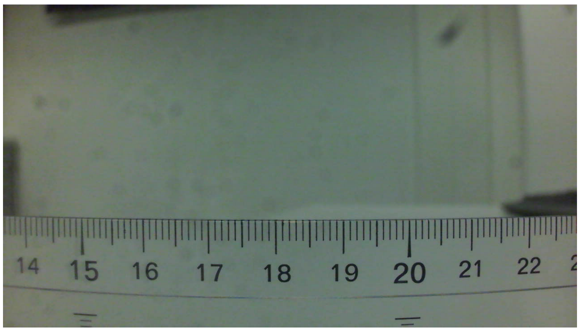
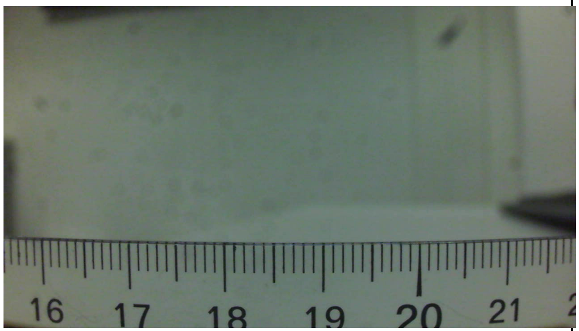
for the three exposure conditions.

Line plot 1 - automatic exposure	Line plot 2 - no saturated pixel	Line plot 3 - few saturated pixel
		

Comments:
We notice that the auto exposure is quite smart and will allow some saturation without letting too much information be lost to have a better contrast for the darker part of the image. As we can see in the non saturated image, there are no saturated region but image is quite dark because the brigthest region is the necklace and the rest has to scale accordingly. While in the third image we can see a lot of saturation in the background while having a better contrast in the darker region of the tshirt.

2 Procedure to measure the focal lengths

Show your two images with different magnifications.

Image with magnification one A	Image with magnification two B
	

m_A= 3.888[mm]/93[mm]=0.0418 **m_B= 3.888[mm]/63.5[mm]=0.0612**

Determine the focal length and show the numbers used for the calculation. (d_{IA}=0.5 mm for one turn of the objective)

$$f = \frac{\Delta d_I}{(m_B - m_A)} = \frac{0.125\ [mm]}{(0.0612-0.0418)} = 6.4432\ [mm]$$

Make an error estimation (see "Uncertainties and Error Propagation.pdf") assuming no error is made on d_{IA} and d_{IB}.

Give the steps to obtain the formula for Δf :

assuming we turned the objective by exactly a quarter of a turn, the only factor of error left is the measured lenght of the image. we assume the worse error is +- 1 [mm]

$$\Delta m_b = \frac{h_i}{h_{ob}^2}\Delta h_{ob} = \frac{3.888[mm]}{63.5^2[mm^2]} * (\pm 1[mm]) = \pm 0.96423$$

$$\Delta m_a = \frac{h_i}{h_{oa}^2}\Delta h_{oa} = \frac{3.888[mm]}{93^2[mm^2]} * (\pm 1[mm]) = \pm 0.449532$$

$$f = \frac{d_{ib} - d_{ia}}{x_1 - x_2}$$

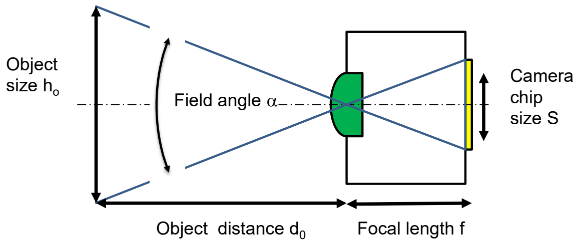
$$df = \frac{0 - (d_{ib} - d_{ia})}{(x_1 - x_2)^2} dm_b + \frac{0 + (d_{ib} - d_{ia})}{(x_1 - x_2)^2} dm_a$$

$$\Delta f = |\frac{\partial f}{\partial m_b}| * \Delta m_b + |\frac{\partial f}{\partial m_a}| * \Delta m_a = \frac{d_{ib} - d_{ia}}{(m_b - m_a)^2}(\Delta m_b + \Delta m_a)$$

$$\boxed{\Delta f = \frac{0.125[mm]}{(0.0612 - 0.0418)^2}(0.96423 + 0.449532) = \pm 0.469551[mm]}$$

$$\boxed{f \pm \Delta f = (6.4432[mm] \pm 0.469551[mm])}$$

3 Measurement of the field of view (angle of view)



Measure h_o and d_o. Calculate the angle of view (field of view) and make an error estimation.

$$\alpha = 2\arctan\frac{S}{2f} = 2\arctan\frac{h_o}{2d_o} \approx \frac{h_o}{d_o} =>$$

Give the steps to obtain the formula for $\Delta\alpha$:

we measured :

$$d_o = 68[mm]$$

$$h_o = 64[mm]$$

$$\Delta h_o = \pm 2[mm]$$

$$\Delta d_o = \pm 2[mm]$$

we can deduce

$$s = h_0 \pm dh_0$$

$$2f = 2d_o \pm d(d_0)$$

$$\alpha = 2 * arctan(\frac{S}{2f}) = 2 * arctan(\frac{h_0}{2d_0}) \approx \frac{h_0}{d_0} = 1.0625[rad]$$

$$d\alpha = 2\frac{2d_o}{{h_o}^2 + 4{d_o}^2}dh_o - 2\frac{2h_o}{{h_o}^2 + 4{d_o}^2}dd_o$$

$$\Delta\alpha = |\frac{\partial\alpha}{\partial h_0}|dh_o + |\frac{\partial\alpha}{\partial d_0}|dd_o = \frac{4}{{h_o}^2 + 4{d_o}^2}(d_o * d(h_o) + h_o * d(d_o))$$

$$\Delta\alpha = \frac{1}{{d_o}^2}(d_o\Delta h_o + h_o\Delta d_o)$$

thus :

$$\boxed{\Delta\alpha = \frac{1}{(68[mm])^2}(68[mm] * 2[mm] + 64[mm] * 2[mm]) = \pm 0.05709[rad]}$$

$$\boxed{\alpha \pm \Delta\alpha = 1.0625[rad] \pm 0.05709[rad]}$$

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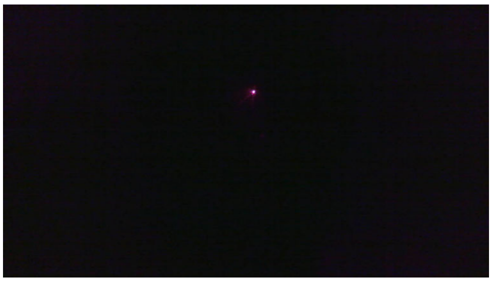
4 Measurement of the F# number.

A picture of the smallest spot size.

Smallest spot size –



Fill the table below with your measurements of luminous disc size versa relative focusing position (min 5 measurements).

No.	relative position	Spot size in pixel (from image)	Spot size in micron	Angle u	NA	F#
1	0	10	30			
2	**0.125[mm]**	12	36	**8.19°**	0.1425	3.508
3	**0.25[mm]**	34	102	**11.53°**	0.1998	2.501
4	**0.375[mm]**	38	114	**8.64°**	0.1503	3.327
5	0.5[mm]	40	120	6.84°	0.1191	4.196
6						

Calculate the averaged values

u = 8.8 °

NA = 0.152925

F# = 3.383

Comments:
On remarque qu'en changeant le focus, le point diminue, atteint un minimum puis grandis a nouveau. Et bien que cette variation de taille n'est pas négligeable et dont la mesure du nombre de pixel est bruité elle permet tout de fois d'approximer le F number en faisant une moyenne sur suffisamment d'échantillon.

5 Example from real world

Find an example on the internet of **one photographic lens** with small F# number. Try to find something that not all your classmates have. You might look at websites of well-known lens producers such as Nikon, Canon, Leica, Zeiss, Rodenstock, Fuji, etc. You can also include c-mount lenses (used for automated machine vision) in your search. Add a photo **of** the objective!

Photo of your objective

Leica Noctilux-M 1:0.95/50mm ASPH.

Ref: https://www.arducam.com/product/arducam-2-8-12mm-varifocal-c-mount-lens-for-raspberry-pi-hq-camera-with-c-cs-adapter/
(the F number vary between 1 and 1.6 depending on the settings)

(Optional) Personal feedback:

Was the amount of work adequate?
Yes. It took a bit longer than 4 hours in total

What is difficult to understand?
No except for the F number

What did you like about it?
Is very practical

How can we do better?
Find a way to ensure the measure data vary less. Expose the common factor of variation between students.