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INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

Scan First
Year 2020-2021

Physics - S1 – Exam #2

October 16, 2020 **Duration: 1 h 30**

No document allowed. No mobile phone. ***Any type of calculator allowed****. The proposed grading scale is indicative.*

The marks will account not only for the results, but also for the justifications, and the way you analyze the results. Moreover, any result must be given ***in its literal form involving only the data given in the text****. It is also reminded that the general clarity and cleanness of your paper may also be taken into account.*

I – Energy of photons (≈ 7.5 points)

Light is composed of photons. The following equation gives the expression and the value of the photon energy E of red light as a function of its wavelength λ:

$$E = \frac{hc}{\lambda} = (1{,}90 \pm 0{,}05)\ \text{eV}$$

where h is the Planck constant ($h \approx 6.626\times10^{-34}$ USI, that is in the international system of unit) and c is the speed of light in vacuum ($c \approx 3.00\times10^{8}$ USI). The electronvolt (symbol eV) is a unit of energy defined as $2{,}247 \times 10^{25}\,\text{eV} \approx 1\ \text{kW.h}$.

1) Determine the dimension of the Planck constant h and deduce its unit in the international system of units. Can h be expressed in J.s? in W.h^{-1}?

2) Give the value of h in the imperial system of units, using inch ($1\ in = 25.40\ mm$) and pound ($1\ lb = 453.60\ g$) as units of lengths and masses, respectively.

In the following question, we will use the international system of units. We will also consider that the Planck constant, the speed of light in vacuum and the conversion coefficient eV/J are known without any uncertainty.

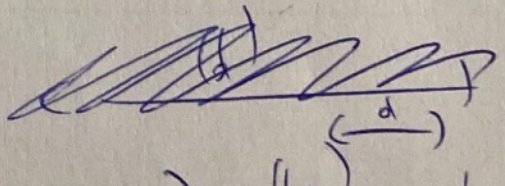
3) Determine the wavelength of red photons in µm and its corresponding uncertainty. The result will be written as $\lambda = (\ldots \pm \cdots)\ unit$.

II – Optical instrument (≈ 12.5 points)

An optical instrument, composed of two thin lenses L_1 and L_2, is used to form an image $\overline{A'B'}$ from a real object $\overline{AB}$. We want to observe the image on a screen. D is the distance between O_1 and the screen. d is the distance between O_2 and the screen (see Figure 1).

In the whole exercise, L_1 is a converging lens of focal length $f'_1 = 4$ cm and L_2 is a diverging lens of focal length $f'_2 = -6$ cm.

We note : $\overline{AB} \xrightarrow{L_1} \overline{A_1B_1} \xrightarrow{L_2} \overline{A'B'}$



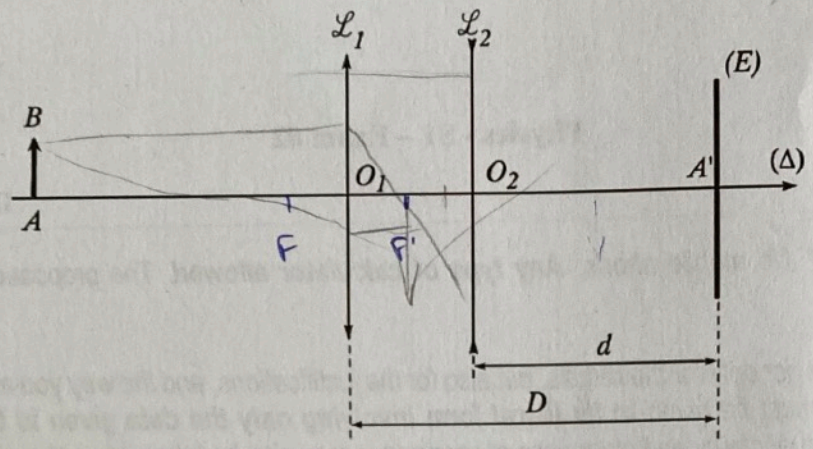


Figure 1 : scheme of the set-up and notations used.

Preliminary question:

1) Using the method of your choice, indicate where the intermediate image $\overline{A_1B_1}$ has to be placed.

The following sections (Parts I and II) are independent from each other.

Part I : Object at a finite distance

2) Consider the object $\overline{AB}$ is placed at a finite distance in front of L_1. By using a scheme, indicate qualitatively where the object $\overline{AB}$ has to be placed in order to obtain a sharp image $\overline{A'B'}$ on the screen.
3) With the equipment used during the labs, indicate the different sources of uncertainty involved in the measurement of the image position.

By taking $D = 12$ cm and $d = 6$ cm, a sharp image $\overline{A'B'}$ of size $\overline{A'B'} = 5$ cm is formed on the screen.

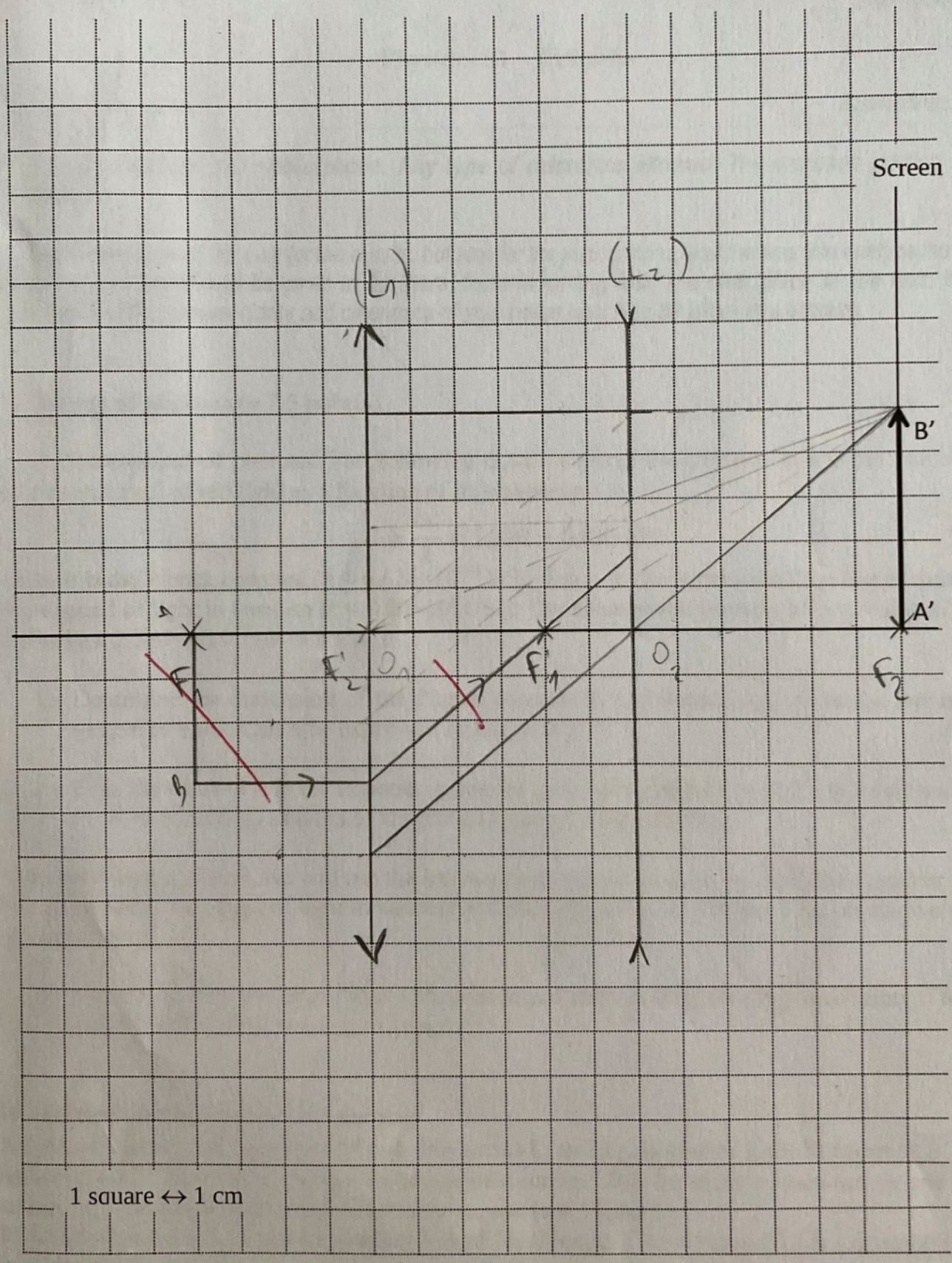
4) Fill in with care the ray-diagram given page 3 and find the position of the real object $\overline{AB}$.
5) Find the position of $\overline{AB}$ by calculation (give the literal expression and the numerical values of $\overline{O_2A_1}$ and $\overline{O_1A}$).

Part II : Object at infinity

The object $\overline{AB}$ is now located at infinity. We try to measure the distance d, denoted d_∞, for which the image $\overline{A'B'}$ is sharp.

6) Give the condition on F'_1.
7) Using Descartes' conjugate equation, show that d_∞ is a solution of the following equation:
$$d_\infty^2 + (f_1' - D)d_\infty - f_2'(f_1' - D) = 0$$
8) Give the literal expression of d_∞ and its value for $D = 5$ cm.

LAST NAME, first name, group:



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