INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

Scan First
Year 2020-2021

Physics - S1 – Exam #2

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

I – Energy of photons	**7.5 points**
1) $[h]=\left[\frac{E\lambda}{c}\right]=\frac{[E]L}{LT^{-1}}=\frac{ML^2T^{-2}L}{LT^{-1}}=ML^2T^{-1}$ $USI: kg.m^2.s^{-1}$ Joule is the unit of energy with $[energy]=ML^2T^{-2}$ h can be expressed in J.s Watt is the unit of power $[power]=\frac{[energy]}{time}=ML^2T^{-3}$ $\left[\frac{power}{time}\right]=ML^2T^{-4}\neq[h]$ So h cannot be expressed in $W.h^{-1}$	**1** **0,5** **0.25** for [energy] **0.25** conclusion **0.25** for [power] **0.25** conclusion
2) $1m=\frac{1}{0.02540}in$ and $1\,kg=\frac{1}{0.4536}lb$ $h=6.626*10^{-34}\,kg.m^2.s^{-1}$ $=6.626\,10^{-34}*\frac{1}{0.4536}lb*\left(\frac{1}{0.02540}in\right)^2*s^{-1}$ $=2.264*10^{-30}lb.in^2.s^{-1}$	**1** **0.25**
3) $1eV\approx\frac{1}{2{,}247\times10^{25}}kWh=\frac{3600\times10^3}{2{,}247\times10^{25}}J\approx1{,}602\times10^{-19}J$ $E=(3{,}04\pm0{,}08)\times10^{-19}J$ $\lambda=\frac{hc}{E}\approx0{,}654\ \mu m$ $\lambda_{min}=\frac{hc}{E+\Delta E}\approx0{,}637\ \mu m$ (arrondi par défaut) $\lambda_{max}=\frac{hc}{E-\Delta E}\approx0{,}672\ \mu m$ (arrondi par excès) $\Delta\lambda=\frac{\lambda_{max}-\lambda_{min}}{2}\approx0{,}018\ \mu m\ ou\ 0{,}02\mu m$ **4)** $\lambda=(0{,}654\pm0{,}018)\mu m\ \ ou\ \ (0{,}65\pm0{,}02)\mu m$	**1** **0,5** value **0,25** value **0,25** litteral expression + **0,25** value **0,25** litteral expression + **0,25** value **0,25** litteral expression + **0,25** value **0,5** correct result (2 significant digits on the uncertainty, correct number of decimal places, unit OTHERWISE **0**)

Exercice 2 : Optical instrument	12,5 points + 2 points BONUS
1) The intermediate image $\overline{A_1B_1}$ must be located between O_2 and F_2 so that the image $\overline{A'B'}$ is real. Schemes required, or demo using conjugate equation: - Case where $\overline{A_1B_1}$ is before O_2 : virtual image $\overline{A'B'}$ - Case where $\overline{A_1B_1}$ is after F_2 : virtual image $\overline{A'B'}$ - Case where $\overline{A_1B_1}$ is between O_2 and F_2 : real image $\overline{A'B'}$ Compter les points si la démonstration est faite à partir de la relation de conjugaison	**0,5** **0,5** **0,5** **0,5**
2) Il faut que $\overline{AB}$ soit avant le foyer objet F_1, pour avoir une image $\overline{A_1B_1}$ réelle pour la lentille L_1. + schéma	**0,5** **0,5**
3) Sources of uncertainty : Ruler (random) + interval of sharpness (random) + position of the screen with respect to its support (systematic)	**0.25** ruler **0,5** interval of sharpness **0,5** position wrt support **BONUS : +1** for the nature of each source of uncertainty (random/systematic)
4) Ray-diagram	**2 (1** per correct ray**)** **BONUS** : +**0,5** if a 3rd ray is traced
5) with $D = 12\ cm$ and $d = 6\ cm$, we have : $$\frac{1}{\overline{O_2A'}} - \frac{1}{\overline{O_2A_1}} = \frac{1}{f'_2}$$ $$\overline{O_2A_1} = \frac{f'_2\overline{O_2A'}}{f'_2 - \overline{O_2A'}} = \frac{f'_2 d}{f'_2 - d}$$ $$\overline{O_2A_1} = 3\ cm$$ Therefore $\overline{O_1A_1} = \overline{O_1O_2} + \overline{O_2A_1} = D - d + \overline{O_2A_1} = 9\ cm$ $$\frac{1}{\overline{O_1A_1}} - \frac{1}{\overline{O_1A}} = \frac{1}{f'_1}$$ Which gives $$\overline{O_1A} = \frac{f'_1\overline{O_1A_1}}{f'_1 - \overline{O_1A_1}} = -7{,}2\ cm$$ The result is in agreement with the ray-diagram	**0,25** **0,25** **0,25** **0,25 (**expression)**+ 0,25** (value) **0,25**
6) If A is at infinity, then $A_1 = F'_1$. F'_1 should be placed between O_2 and F_2 from question 1)	**0,5** **0,25**
7) Descartes' conjugate equation for L_2: $$\frac{1}{\overline{O_2A'}} - \frac{1}{\overline{O_2F'_1}} = \frac{1}{f'_2}$$ with $\overline{O_2A'} = d_\infty$ and $\overline{O_2F'_1} = \overline{O_2O_1} + \overline{O_1F'_1} = (d_\infty - D) + f'_1$ $$\frac{1}{d_\infty} - \frac{1}{d_\infty - D + f'_1} = \frac{1}{f'_2}$$	**0,25** **0,25** **0,5**

$d_\infty^2 + (f_1' - D)d_\infty - f_2'(f_1' - D) = 0$	**1**
8) The discriminant is : $\Delta = (f'_1 - D)^2 + 4f'_2(f'_1 - D) = (D - f'_1)(D - f'_1 - 4f'_2)$ *Note : it is possible to show that $\Delta > 0$: from question 1) the points O_2, A_1 et A' must be in this order on the optical axis. As A_1=F'_1 in the present cas, we have $\overline{O_1A_1} = f'_1 \leq D$, which means $D - f'_1 \geq 0$. As $f'_2 < 0$, we get $\Delta > 0$.* d_∞ is the positive solution (the only one acceptable as d_∞ is a length): $d_\infty = \frac{1}{2}\left(D - f'_1 + \sqrt{(D - f'_1)(D - f'_1 - 4f'_2)}\right)$ NA : $d_\infty = 3\ cm$ Note : the other solution would give $d_\infty = -2\ cm$, which cannot be accepted.	**0,5** **BONUS : +0,5** **0,5** comment on the fact that there is only one acceptable solution **0,5** **0,5**