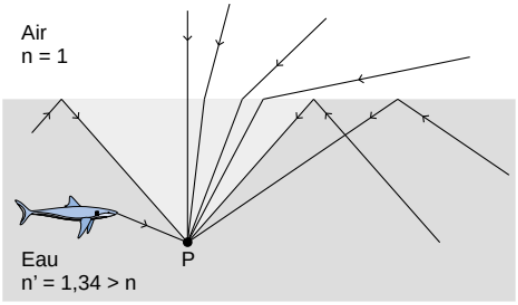
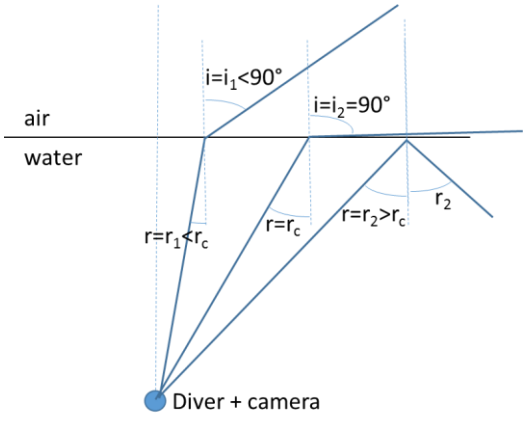
INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

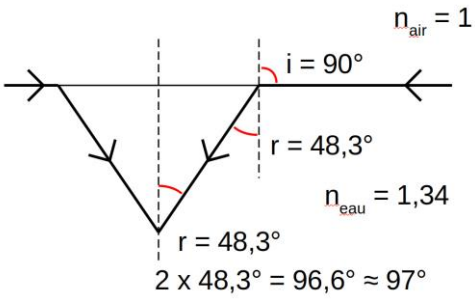
Scan First
Year 2020-2021

Physics - S1 – Exam #1

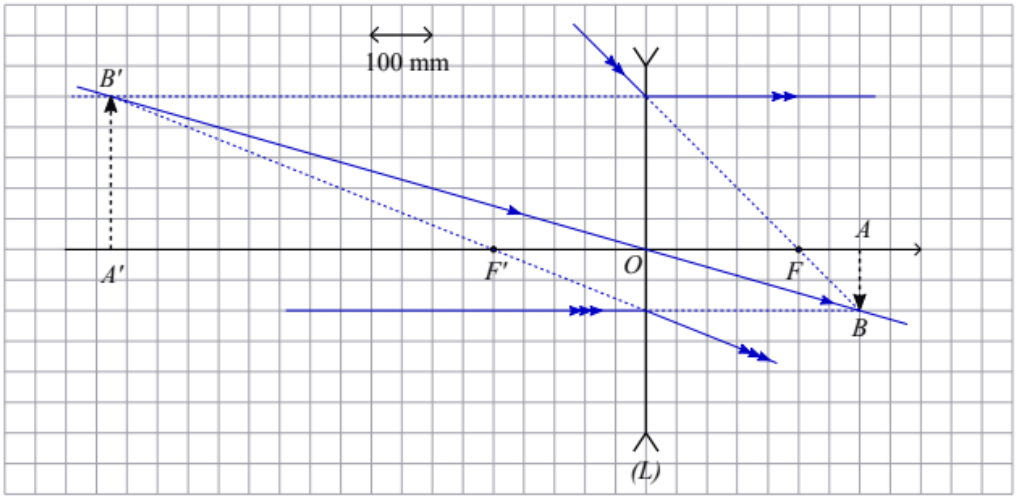
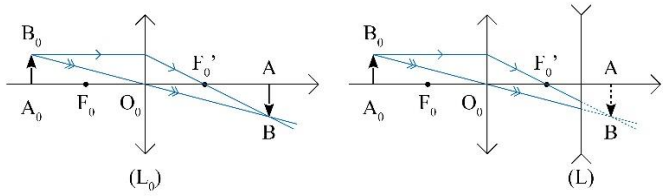
October 16, 2020 **Duration: 1 h**

Solutions and grading scale

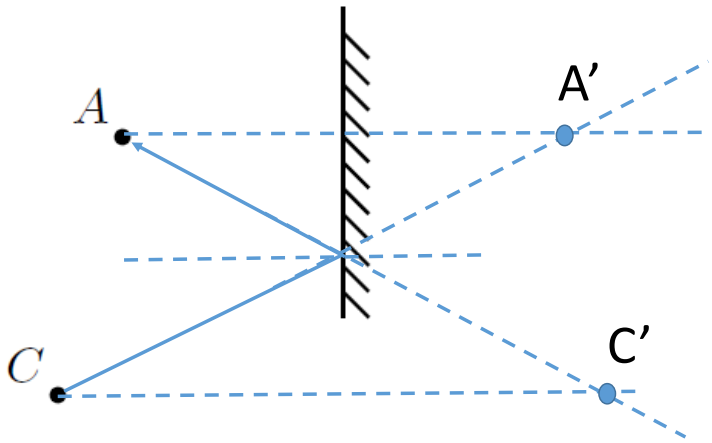
Snell's window (7 points + bonus 0.5)	
1) Assumption : diver (or his camera) = point object ***Preliminary comment**: in the following, it is also possible to consider the rays emitted by the diver (principle of ray reversibility). The conclusions will be exactly the same.* - All the rays coming from the outside (= from the sun) can penetrate into water, because the optical index of water is larger than the optical index of the air. For an angle of incidence i ranging between 0 and 90°, the angle of refraction will range between 0 and a maximum r_c. If one calls r the angle between the ray coming onto the diver and the normal to the water-air interface, two cases have to be distinguished: 1/ if r is smaller than r_c, we can find an angle i such that one ray comes from the outside, is refracted. The diver sees the outside. 2/ if r is larger than r_c, no angle i can be found. The rays coming onto the diver come either directly from underwater or are reflected at the water-air interface. The envelope of the rays coming from the outside form a cone of light. As a consequence, the diver sees a bright disk at the water-air interface. Outside this cone, the rays come from underwater. The cone is therefore surrounded by either a completely dark region, or a region where underwater objects are reflected (brightness far lower than in the cone anyway).  	3 sources of ray coming onto the diver : Refraction: **1** At critical angle: **1** Above critical angle : **1** Quality of the scheme: **1** Quality of reasoning + writing: **1** **+0.5** bonus for reflection of underwater rays
2) Value of the critical angle: $r_c = \sin^{-1}(1/n) = \sin^{-1}(1/1{,}34) = 48{,}3°$ (0,84 rad) Cone angle is $2r_c \approx 97°$	**1** (explanations + scheme)

	**0,5** (expression + value r_c) **0,5** (cone angle)

Ray-tracing and calculations (7 points + bonus 0.5 pt)

1) 	**3** (0.5 ray/O + 1 ray/F + 1 ray/F' + 0.5 A'B') malus -0.25 per line if not accurate malus -0.25 if A'B' in solid line
2) A'B' = **virtual image** because it is before (L), **reversed**, **magnified**.	**3*0.25** **0.25** (justification)
3) Descartes' conjugate equation gives : $\overline{OA'} = \left(\frac{1}{f'} + \frac{1}{\overline{OA}}\right)^{-1} = \frac{f'\overline{OA}}{f'+\overline{OA}}$= - 875 mm , in agreement with the ray-diagram	Expression: **0.5** Value **0.5**
Magnification $\gamma = \frac{\overline{OA'}}{\overline{OA}}$= -2,5 , in agreement with the ray-diagram	Expression: **0.5** Value **0.5**
BONUS : if $\overline{OA'}$ is measured on the ray-diagram with its uncertainty, and if the comparison theory/experiment is quantified (relative different in %, for instance)	**+ 0.5**
4) An additional converging lens (L_0) placed before (L) can be used to create a real image AB from a real object A_0B_0. AB is a virtual object for (L) if (L) is placed between (L_0) and AB. Example of scheme (ray tracing non required). The following scheme can be enough:  a) On utilise une première lentille convergente pour obtenir une image réelle d'un objet réel b) On place la lentille divergente avant l'image donnée par la première lentille	**0.5** **0.5**

III – Mirror in the film studio (6 points)

1) The image of the actress is at point A’  	**2**
2) The image of the camera is at point C’. The actress can see the camera as there is at least one ray coming from C to A which undergoes reflection onto the mirror.	**2**
3) The camera does not see its own image because no ray emitted from C can reach C’ after reflection onto the mirror.	**2**