Exam 1 – Physics
October 19, 2018, 16 h. Duration : 1 hour

No document allowed. No mobile phone. The use of non-programmable calculator is allowed. The proposed grading scale is only indicative. The marks will account not only for the results, but also for the justifications, and the way you analyze the results. It is also reminded that the general clarity and cleanness of your paper may also be taken into account. It is not necessary to use a protractor : the exact values of the angles drawn are not required.

Exercise 1 : Head-up Display $[\approx 8$ pts.$]$

A head-up display device is an optical system that projects visual information on a vehicle's windshield. Initially used in aviation, some cars are now equipped with such systems, so that drivers can keep their eyes on the road while checking the dashboard or a GPS (see figure 1).

The light source studied here is a diode light source displaying for instance the value of the vehicle speed. It will play the role of an object and will be noted AB. The operating principle of this device can be decomposed in two steps :

- first, a thin converging lens of focal length f' creates an image A_1B_1 from an object AB ;
- this image is then reflected by the windshield, which will be modeled here as a plane mirror, making an angle of 45° with respect to the horizontal axis. The driver sees the final image $A'B'$ formed by the mirror.

Study of the converging lens

1. On figure 1, draw the paths of **three rays** in order to construct image A_1B_1 of objet AB by the lens L.
2. Is the image A_1B_1 real or virtual ? Is it upright or reversed ?
3. Find again, this time by calculation, the position, size, nature (real or virtual) and orientation of the image, for a lens of focal length $f' = 20$ cm and an object AB of 1 cm height, located 15 cm before the lens.

Study of the reflection on the windshield

This image A_1B_1 is then reflected by the windshield, which will be modeled here as an infinite plane mirror.

4. Determine graphically the position of image $A'B'$ by the plane mirror, by completing figure 1.
5. Is it a real or virtual image ?

Exercise inspired from French "Baccalauréat" 2010.

Exercise 2 : Where is the object ? $[\approx 3,5$ pts.$]$

Complete figure 2 in order to find the position of object AB whose image through the diverging lens L will be $A'B'$.

Exercise 3 : About diamond cutting $\left[\approx 8,5\,\textbf{pts.}\right]$

Pop-singer Rihanna recorded in 2012 a song entitled “Diamonds”. The song begins with “Shine bright like a diamond”. Is this scientifically correct ? Of course not ! A diamond does not shine but reflects light. In order to do so, diamonds are “ideally” cut as shown in the side view on the left of figure 3. In the side view on the right of figure 3 you have the case of a diamond which is considered to be of lower quality.

Relying on the schemes that you will complete by tracing the path of the light rays in the two diamonds (figure 3), explain the difference in quality between the two cuts proposed. The representation of the exact angles of the rays is not required. However the rays evolution should be correct and every drawing should be justified.

Refraction indexes :

$$n_{\text{diamond}} = 2.42 \qquad \text{and} \qquad n_{\text{air}} = 1.00.$$

Remark : this is an “open” exercise for which essentially the modeling and reasoning quality will be evaluated. In this context, you should keep in mind that the ray paths in the diamond only constitute simple elements on which you can build your arguments.

Skills evaluated in this last exercise
Problem self-appropriation and rephrasing : Translate the text into physical terms Make a clear and well-set scheme Identify on the scheme the relevant physical variables and define them with a unique symbol
Build a methodology to solve the problem (analyze) : Determine and state the physical laws that will be used
Use the methodology : Be able to perform analytical calculations and/or use optical schemes efficiently Carry on a process until the end and answer explicitly to the question asked
Have a critical look on the results (validate) : Make sure the question was correctly answered
Communicate : Be able to write the solution stating clearly the different reasoning that yielded the results obtained : identify clearly the different steps, present them in a logical order. Use correctly the logical connectors Use of a well adapted scientific vocabulary Write in correct and understandable English

NAME and GROUP: .....

To be handed back with your work

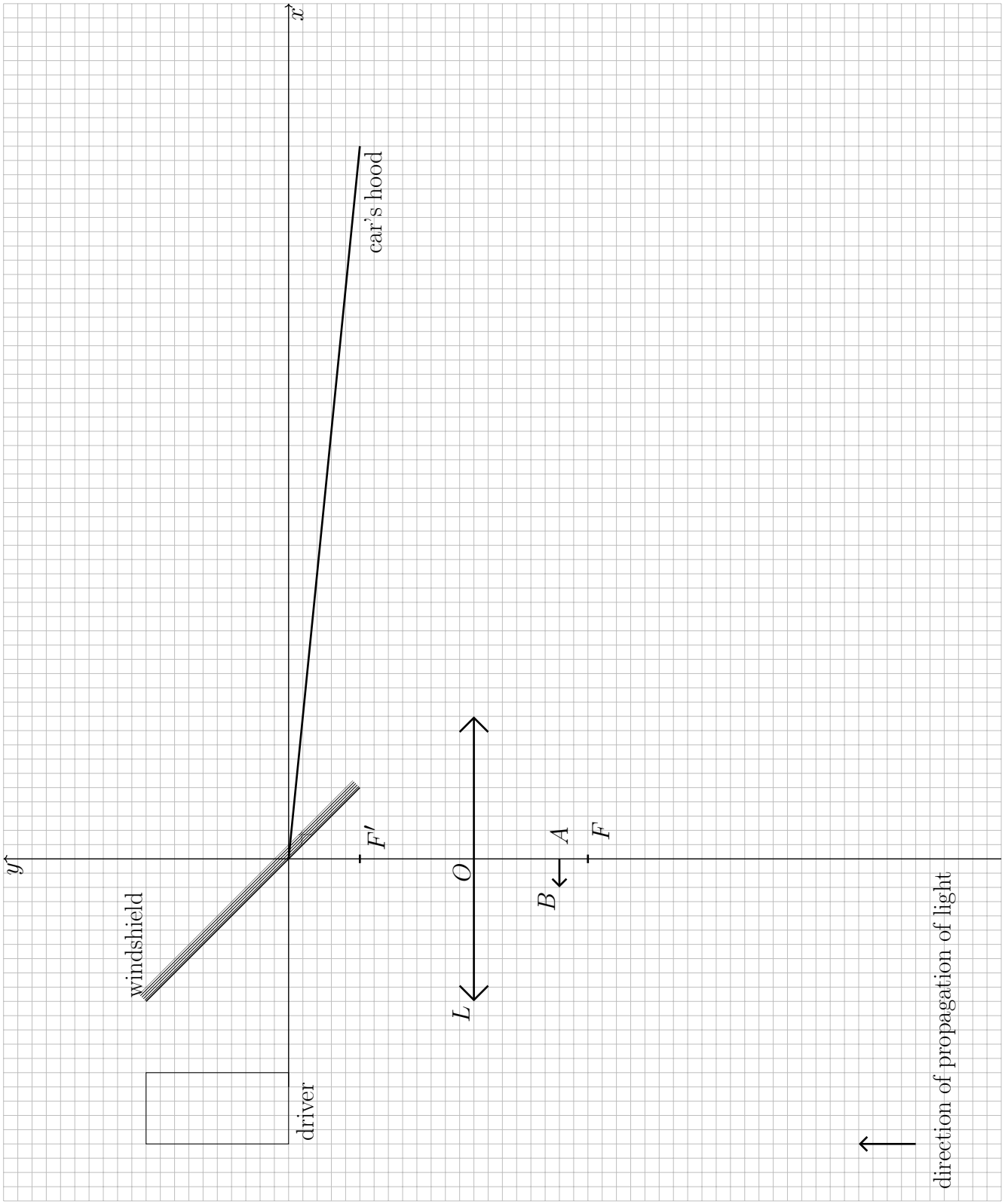

FIGURE 1 – Head-up display device

NAME and GROUP: .....

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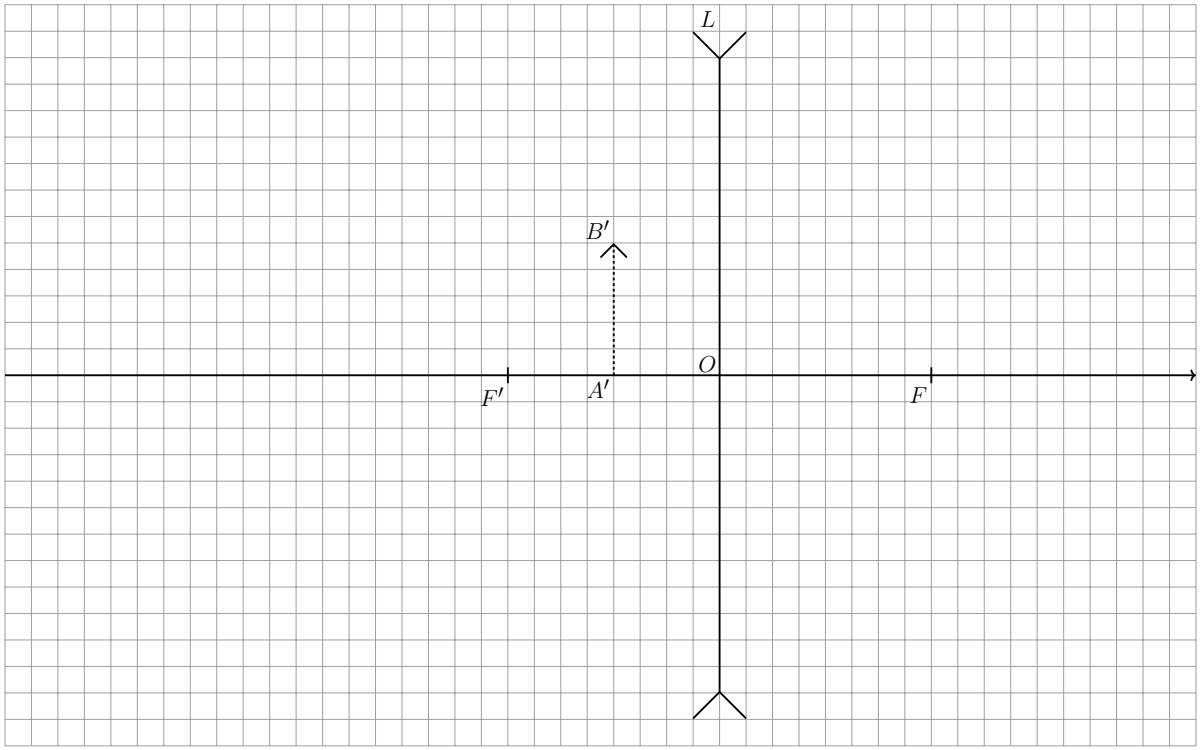

FIGURE 2 – Find the object position

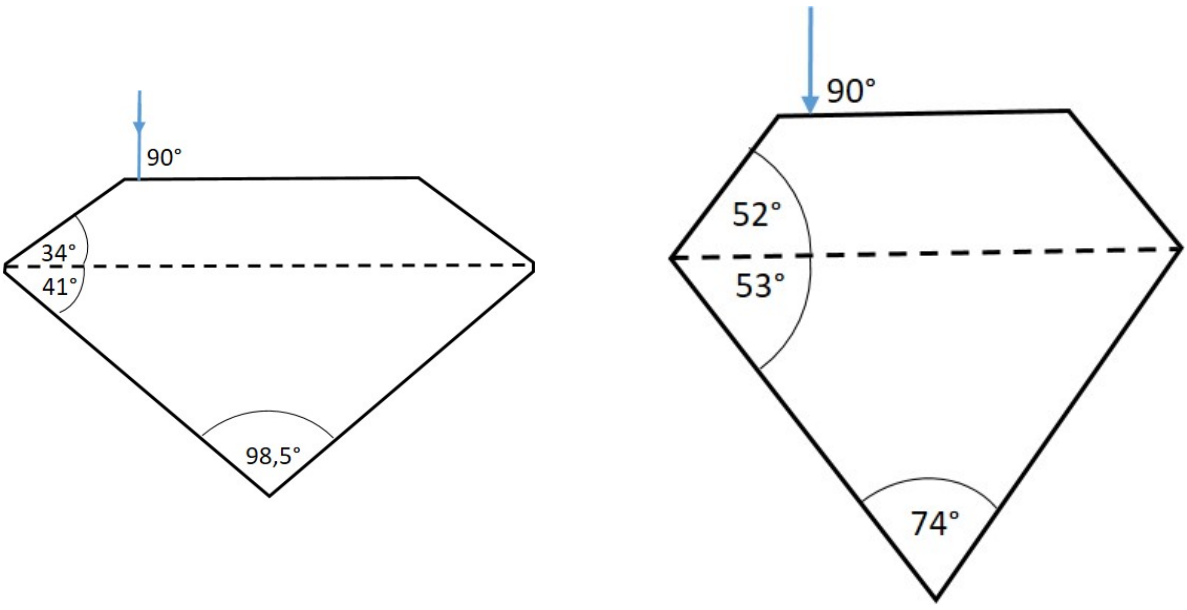

FIGURE 3 – Diamonds of good quality (left) and poor quality (right).