DEPARTEMENT DU PREMIER CYCLE

SCAN FIRST

SCHOOLYEAR 2013/2014

PHYSICS

Exam #1 – 1st semester

Friday, November 22, 2013

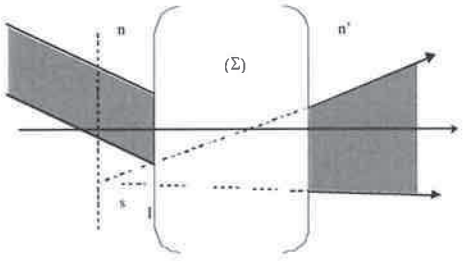
Duration: 2 h

No documents allowed. The use of not-programmable calculator is allowed.
The marks will account for the justifications, the writing and the general clarity and cleanness of your papers.
Indicative grading scale.

Lecture questions (4 points)

1) Give the definition of the paraxial conditions, which are used to obtain the approximated stigmatism in centered optical systems.

2) Let us consider the optical system represented in the picture opposite. Is it focal or afocal, convergent or divergent? Justify briefly your answer.

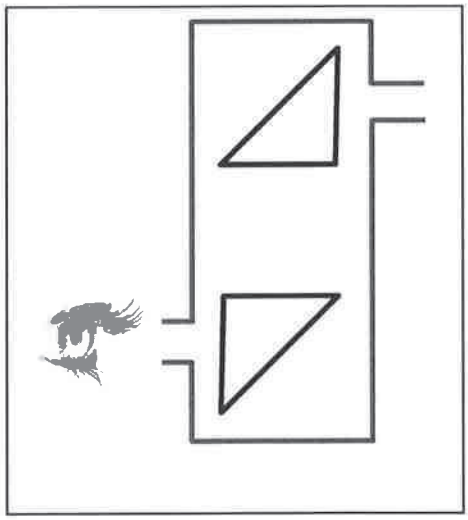


3) Give the base units of the international system of units (names, symbols).

4) What is the difference between error and uncertainty?

1- Periscope (3 points)

A periscope is composed of two prisms of same optical index n, placed in a tube filled with air, see in the figure opposite.



1) Describe how the periscope works. Draw the path of light from an object at infinity to the observer's eye.

2) Which is the condition on the prism optical index?

3) By accident, water enters the periscope and totally covers the prism below. How is the use of the periscope affected by water?

2- Galileo telescope (6 points)

Opera glasses are composed of two identical Galileo telescopes, of parallel optical axes. The focus is done by adjusting the distance between the oculars and the objective lenses. In the following, a single Galileo telescope will be studied in the paraxial approximation.

The Galileo telescope is composed of two thin lenses. (L_1) is a convergent lens of focal length f'_1 and (L_2) is a divergent thin lens of focal length f'_2. The compound lens is afocal and has an angular magnification of 2.5. The distance between (L_1) and (L_2) is 75 mm.

1) What is the condition to obtain an afocal compound lens? How would you experimentally check that the Galileo telescope is an afocal system?
2) Prove that the angular magnification M is equal to $\frac{-f'_1}{f'_2}$
3) Deduce the values of the focal lengths f'_1 and f'_2.
4) Illustrate with a ray-diagram the principles of the Galileo telescope by representing the image of a real object AB, located at a finite distance. Is the image upright or reversed?
5) An observer having a normal vision is placed at 15 mm from (L_2) and sees without any accommodation an object placed at 2.5 m away from (L_1). Calculate the distance from which the ocular should be translated.

3- Planck units (7 points)

Several quantities, called Planck quantities, can be obtained by combining the constants G (gravitational constant), c (speed of light) and $\hbar = \frac{h}{2\pi}$ (reduced Planck constant).

$G = 6.674.10^{-11}$ $m^3.kg^{-1}.s^{-2}$
$c = 299{,}792$ $m.s^{-1}$
$\hbar = 1.054571628.10^{-34}$ J.s
$k_B = 1.3806503.10^{-23}$ $m^2.kg.s^{-2}.K^{-1}$

1) Among the 3 following quantities, $\sqrt{\frac{\hbar G}{c^5}}$; $\sqrt{\frac{\hbar G}{c^3}}$; $\sqrt{\frac{\hbar c}{G}}$, determine which one is homogeneous to
   - A length (called Planck length, symbol ℓ_P);
   - A mass (called Planck mass, symbol m_P);
   - A time (called Planck time, symbol τ_P).
2) Propose an expression for the Planck temperature T_P by combining c, k_B and m_P.
3) Give the value of G in the CGS system of units (units cm, g and s).
4) What would be the units of l_P, m_P and τ_P in the CGS system of units?
5) The value of the speed of light c in SI units is not subjected to measurement error. The relative uncertainty for $\hbar$ and G are $4.4.10^{-8}$ and $1.2.10^{-4}$, respectively (in SI units). Calculate the maximum uncertainty on m_P in SI units. The result will be presented under the form $m_P = (\ldots \pm \ldots)$ unit.