This exam is formed of three obligatory exercises in two pages.
The use of non programmable calculators is allowed.

First exercise (7 points)   **Converging lens**

Consider a converging lens (L) of focal length f and a luminous object (AB) of size AB. (AB) is placed at a distance P from (L) and perpendicularly to the optical axis of (L) at A. (A'B') is the image of (AB) given by (L). It is situated at a distance P' from (L) and of size A'B'.
The table below gives, for different values of P, the corresponding values of P' and of A'B'.

P (cm)	30	20	15	12	11
P' (cm)	15	20	30	60	110
A'B' (cm)	2.5	5	10	25	50

I – Variation of some characteristics of (A'B') with P
    1) Referring to the table:
        a) show that:
            i) f = 10 cm ;
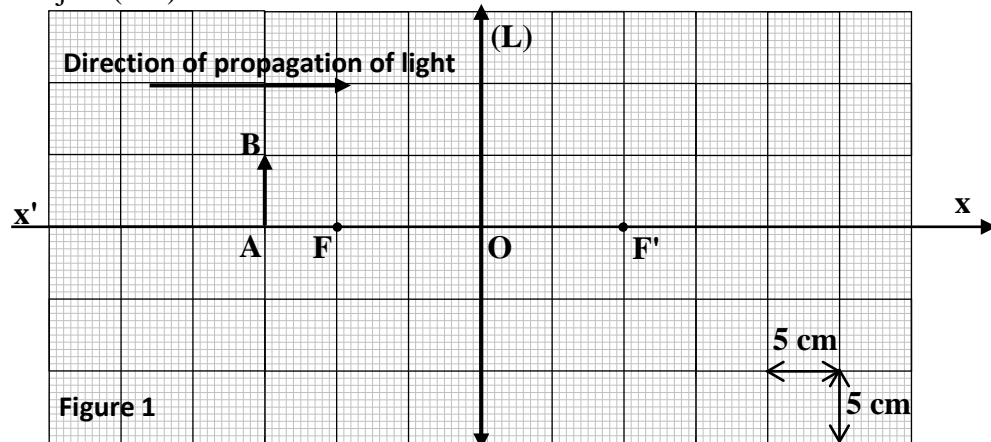   **ii)** AB = 5 cm ;
            iii) (A'B') is real;
        b) specify how A'B' varies as the object (AB) gets closer to the object focus.
    2) Give, for the different positions of the object listed in the table, the direction of (A'B') with respect to (AB). Justify.

II – Geometrical construction of (A'B')
Figure (1) shows (L), its optical axis (x'x), its optical center O, the object focus F, the image focus F' and the object (AB).

Figure 1

    1) Redraw, on the graph paper, figure 1 using the same scale.
    2) Trace, on this drawing, the path of a luminous ray:
        a) issued from B and parallel to the optical axis of (L);
   **b)** issued from B and passing through F.
    3) Construct then (A'B').
    4) Determine the values of P' and that of A'B'.
    5) Are the obtained values compatible with those given in the table?

Second exercise (7 points)   **Heating plate**

A heating plate carries two inscriptions. The first is 220 V and the second is expressed in watt but its numerical value is erased. The characteristic current-voltage curve of this heating plate is shown in figure 2.
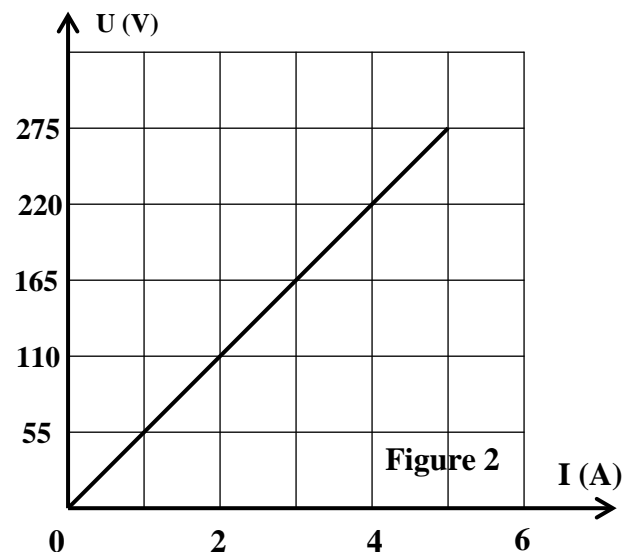
1) Give the physical significance of:
   a) the inscription 220 V ;
   b) the erased inscription.
2)
   a) This plate acts as a resistor. Justify.
   b) Determine the value of the resistance R of this resistor.
3)
   a) Referring to figure 2, give the value of the current carried by the heating plate during normal functioning.
   b) Deduce the power consumed by the heating plate during normal functioning.
   c) Give then the numerical value corresponding to the erased inscription.
4) The heating plate is used for four hours per day. Determine:
   a) the energy (in kWh) consumed by the plate during 1 month (30 days) ;
   b) the corresponding monthly cost, knowing that the average price of the kWh is 100 L.L.

Figure 2

Third exercise (6 points)   **Solid on an inclined plane**

A solid (S), having the shape of a cube of side a = 10 cm, is placed on a very smooth inclined plane (negligible friction) as shown in figure 3.
The density of (S) is $\rho = 2000 \text{ kg/m}^3$.
Given: g = 10 N/kg.
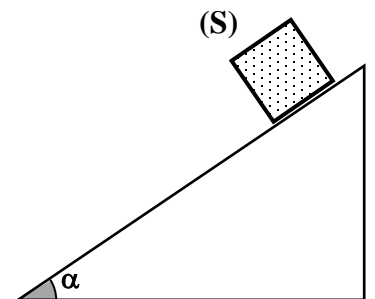
1) Calculate the volume V of (S).
2) Show that the mass of (S) is M = 2 kg.
3) Calculate the value W of $\vec{W}$.
4) Give the line of action and the direction of $\vec{W}$.
5) Redraw figure 3 and represent on it $\vec{W}$ using the scale 1 cm → 5 N.
6) (S) is submitted to its weight $\vec{W}$ and another force. Give the name of this force and specify, for each of them, whether it is a contact force or a force acting from a distance.
7) (S) is not at rest. Justify.

Figure 3

First exercise (7 points)

Part	Solution	Note
I.1.a.i	$P = P' \Rightarrow P = 2f \Rightarrow f = \dfrac{P}{2} = \dfrac{20}{2} = 10$ cm.	**1**
I.1.a.ii	P = P' then AB = A'B' therefore AB = 5 cm.	**0.5**
I.1.a.iii	A'B' is real because in all the cases listed in the table we have P > f.	**0.5**
I.1.b	As the object gets closer to the object focus , A'B' increases.	**0.5**
I.2	(A'B') inverted with respect to the object (AB) (0.5) because the image is real (0.5)	**1**
II.1	Redraw	**0.5**
II.2.a	Trace of the 1st ray	**0.5**
II.2.b	Trace of the 2nd ray	**0.5**
II.3	Construction	**0.5**
II.4	P' = 6×5 = 30 cm (0.5) A'B' = 2×5 = 10 cm (0.5)	**1**
II.5	Yes	**0.5**

Second exercise (7 points)

Part	Solution	Note
1) – a)	220 V represents the rated voltage (voltage to function normally)	**0.5**
1) – b)	the erased inscription represents the rated power	**0.5**
2) – a)	because the characteristic current-voltage curve is a straight line passing through the origin	**0.5**
2) – b)	For U = 220 V $\Rightarrow$ I = 4 A (0.5) U = RI (0.5) $\Rightarrow$ R = 55 Ω (0.5) Or R = slope of the line $R = \dfrac{\Delta U}{\Delta I} = \dfrac{220}{4} = 55 \ \Omega$	**1.5**
3) – a)	From the graph, for U = 220V we find I = 2A.	**0.5**
3) – b)	P = U.I (0.5) = 220×4 = 880 W (0.5)	**1**
3) – c)	the erased value is 880 (0.5)	**0.5**
4) – a)	W = P.t (0.5) = 0.880×4×30 = 105.6 kWh (1)	**1.5**
4) – b)	Monthly cost : 105.6×100 = 105602 L.L (0.5)	**0.5**

Third exercise (6 points)

Part	Solution	Note
1	(S) is of the form of a cube : $V = a^3 = 1000 \text{ cm}^3$ (0.5)	**0.5**
2	$\rho = \dfrac{M}{V}$ (0.5) $\Rightarrow M = \rho \times V = 2000 \times 10^{-3} = 2 \text{ kg}$ (0.5)	**1**
3	Weight of the solid : $W = Mg$ (0.25) $W = 2 \times 10 = 20 \text{ N}$ (0.25)	**0.5**
4	Line of action : vertical (0.5) Direction : downward (0.5)	**1**

5	Redrawing + representation of $\vec{W}$ (0.5)
	              1cm$\Longrightarrow$5N
	            x $\Longleftarrow$ 20N
	
	 $x = \dfrac{20}{5} = 4 \text{ cm}$ (0.5)
		1

6	Normal reaction of the inclined plane $\vec{N}$ $\vec{W}$: force acting from a distance (0.5) $\vec{N}$: contact force (0.5)	**1.5**
7	(S) is not at rest, because the two forces are not in opposite directions (0.5)	**0.5**