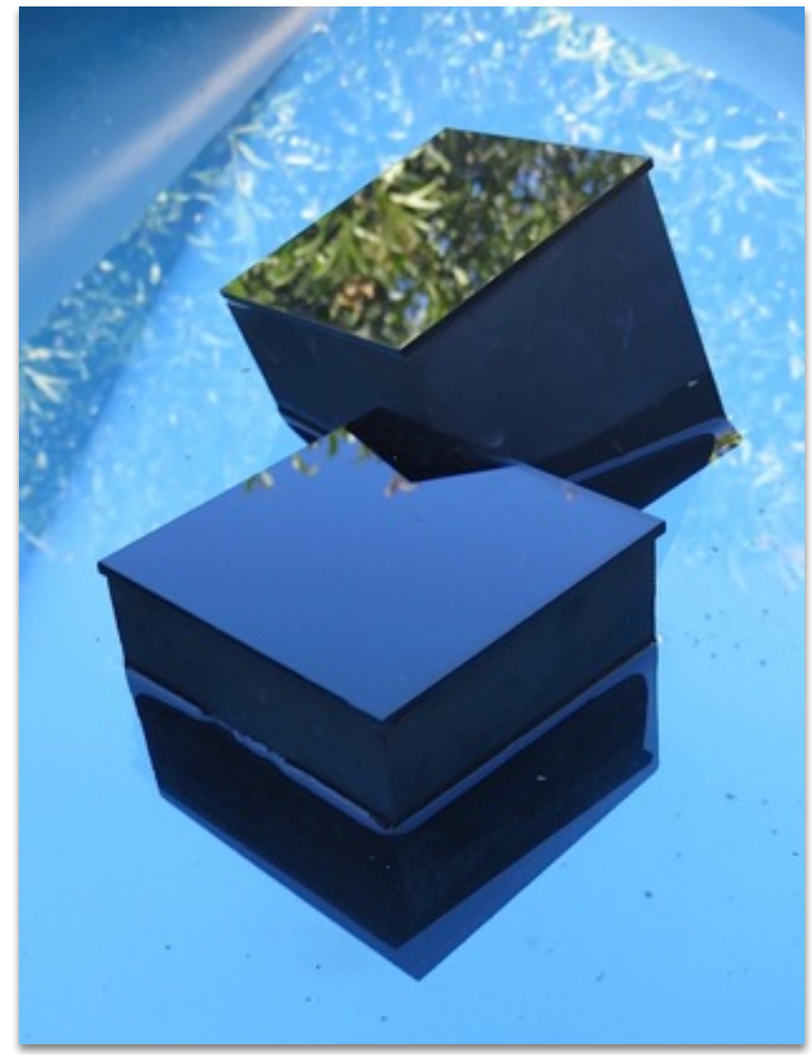
Des lois de la nature géométriques

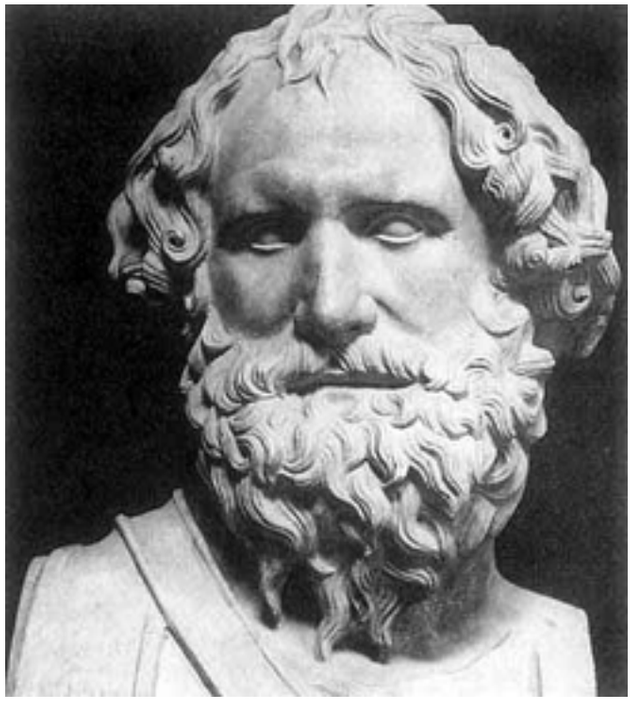
Pierre Coullet
Université de Nice-Sophia Antipolis

Des miroirs concaves …

Au corps flottants



Deux immenses savants



Archimède (287 BC, 212 BC)

Ibn Al Haytham (964, 1040)

Archimède (287 BC, 212 BC)

Ibn Al Haytham (964, 1040)

Le grand « récit » de notre histoire

Big-Bang:13.8 Milliards d’années

Système solaire: 4.55 Milliards d’années

La vie sur terre: Milliards d’années

Le genre « Homo »: 2.5 Millions d’années

La découverte du feu: 800 000 ans

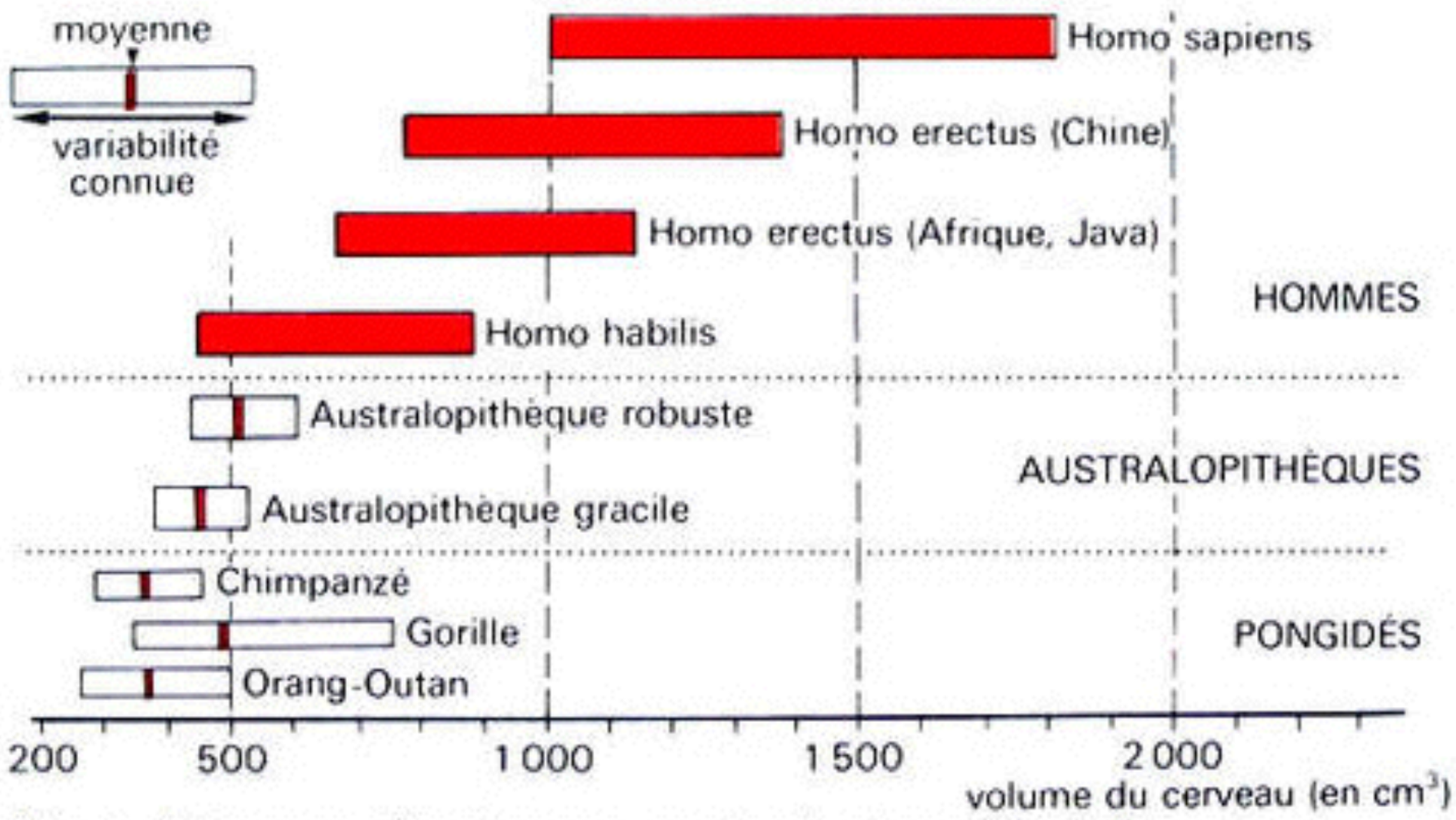
L’art préhistorique: 40 000 ans

L’écriture et la comptabilité: 3000 ans

Les mathématiques abstraites: 600 BC

La physique: 200 BC

Taille du cerveau
Un inconvénient ou un avantage ?

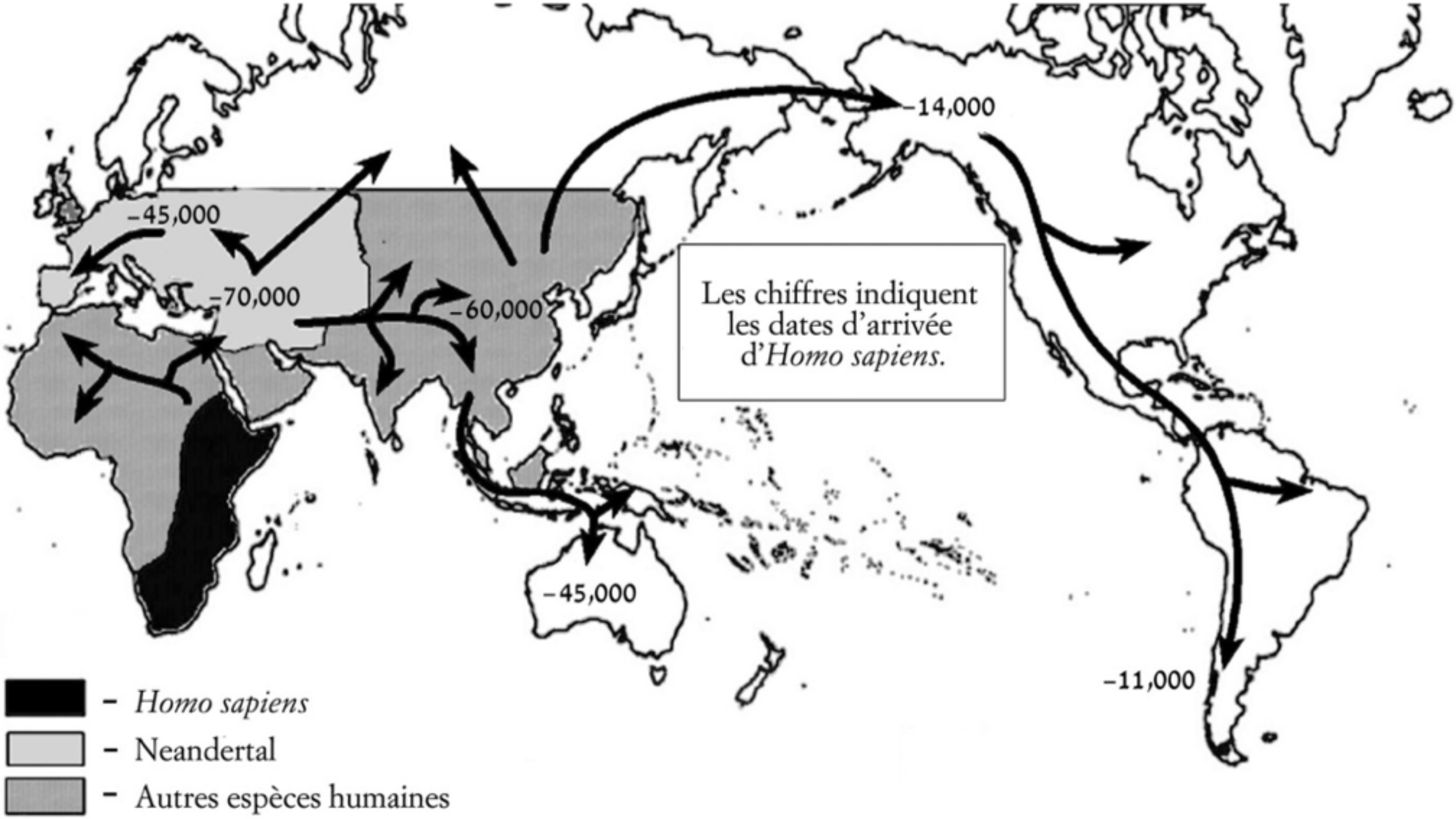


D'après A. Langaney *"Les hommes, passé, présent, conditionnel"*.

L'énergie considérable dépensée par le cerveau
Nécessité d'accouchements prématurés

Nécessité d'une longue education du petit animal « homo »

La fabrique à « Sapiens »: Le grand rift



Noah Yuval Harari « Sapiens: Une histoire brève de l'humanité »

L’évolution des sapiens depuis 100000 ans

La révolution « cognitive », -70000 ans
La révolution agricole, -10000 ans
La révolution industrielle, -500 ans

L'homme-lion du
Hohlenstein-Stadel
-40 000

Comment sait on tout cela ?

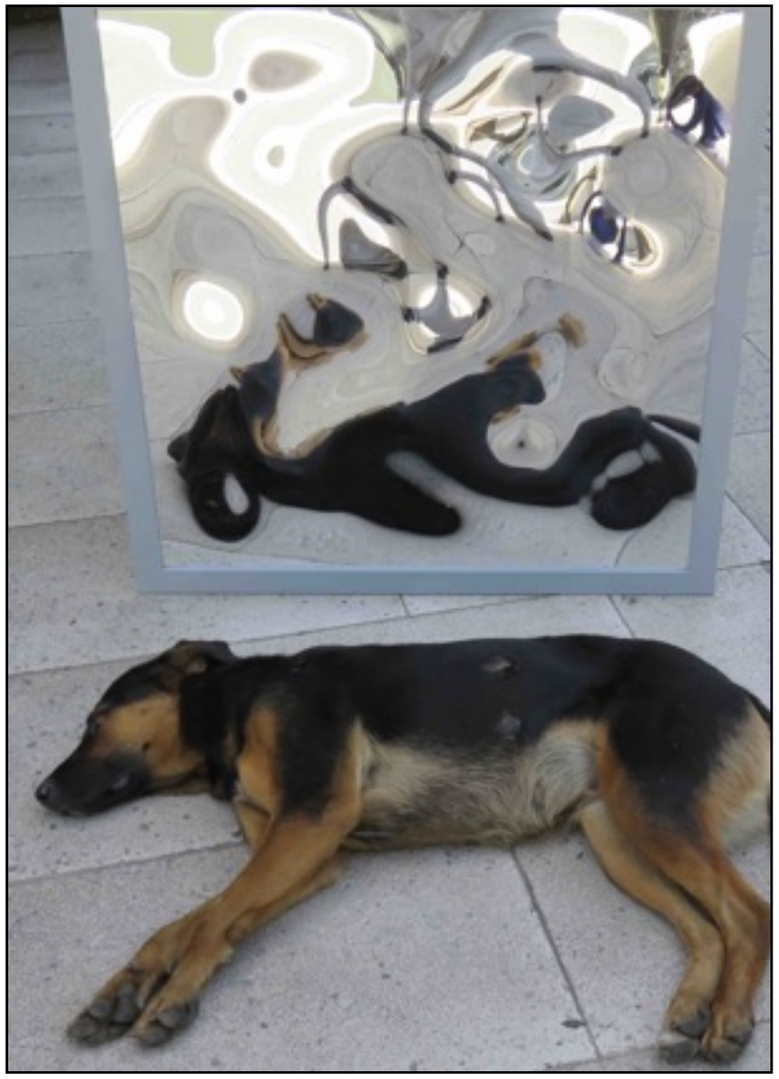
Méthodes de datations
Analyse du génome

Stanve Paabo: Neandertal
A la recherche des Génomes Perdus

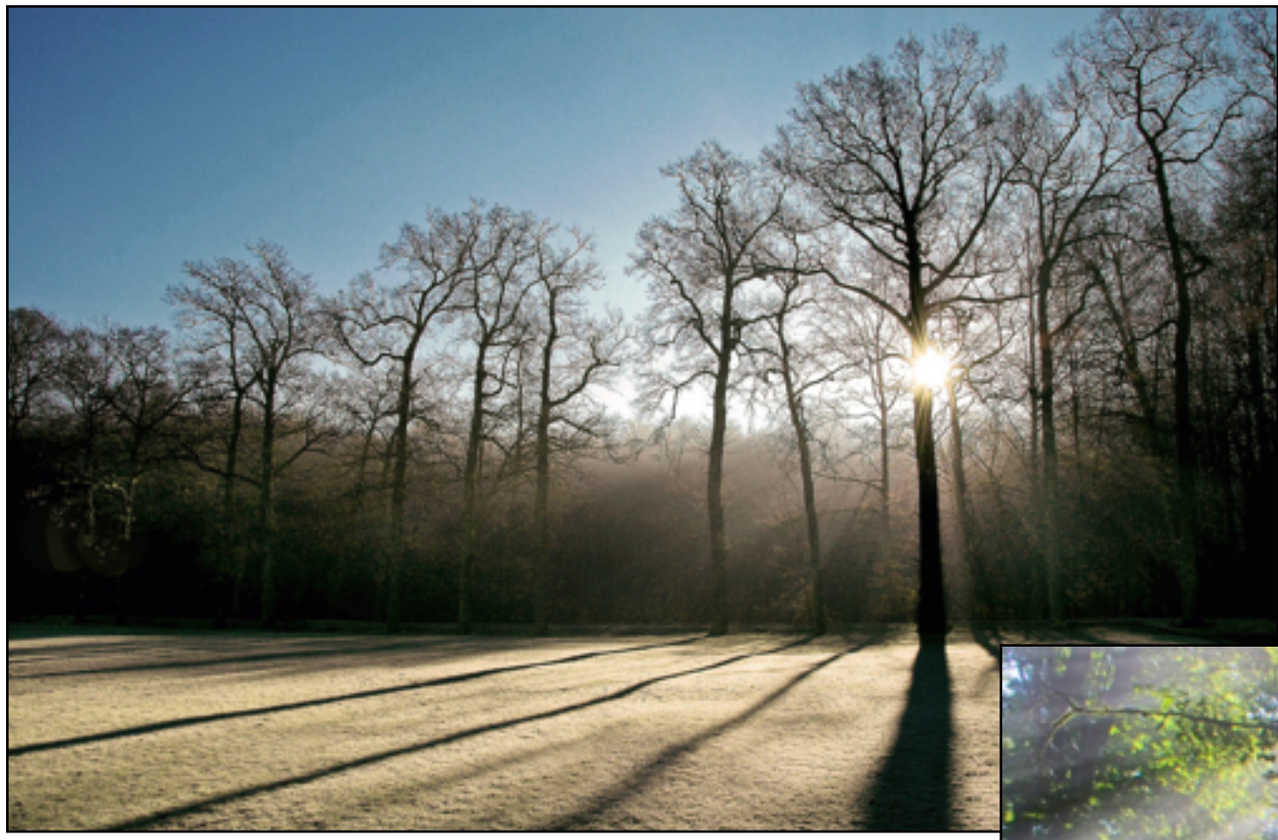
Des progrès considérables à venir

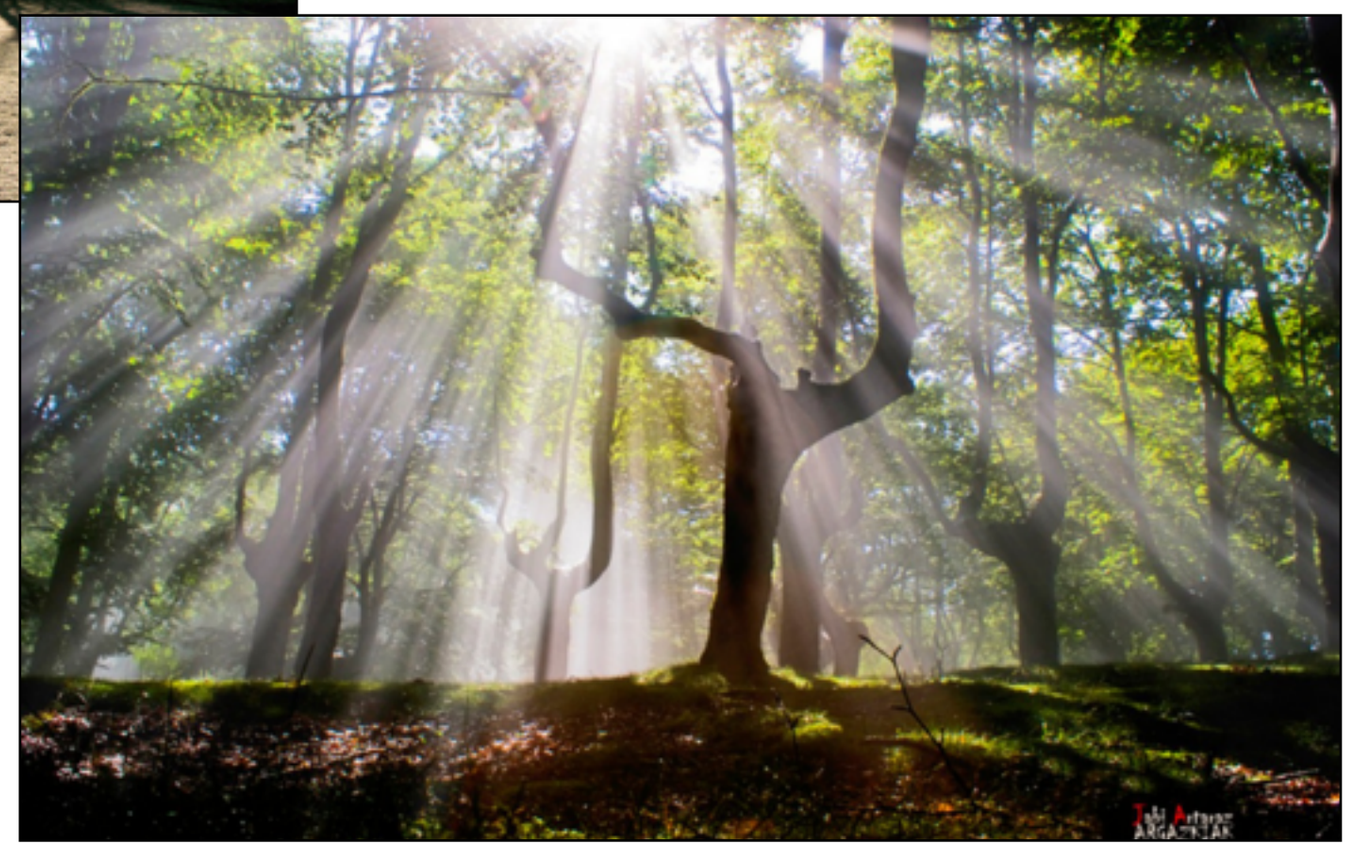
Des miroirs ardents ..

aux miroirs déformants

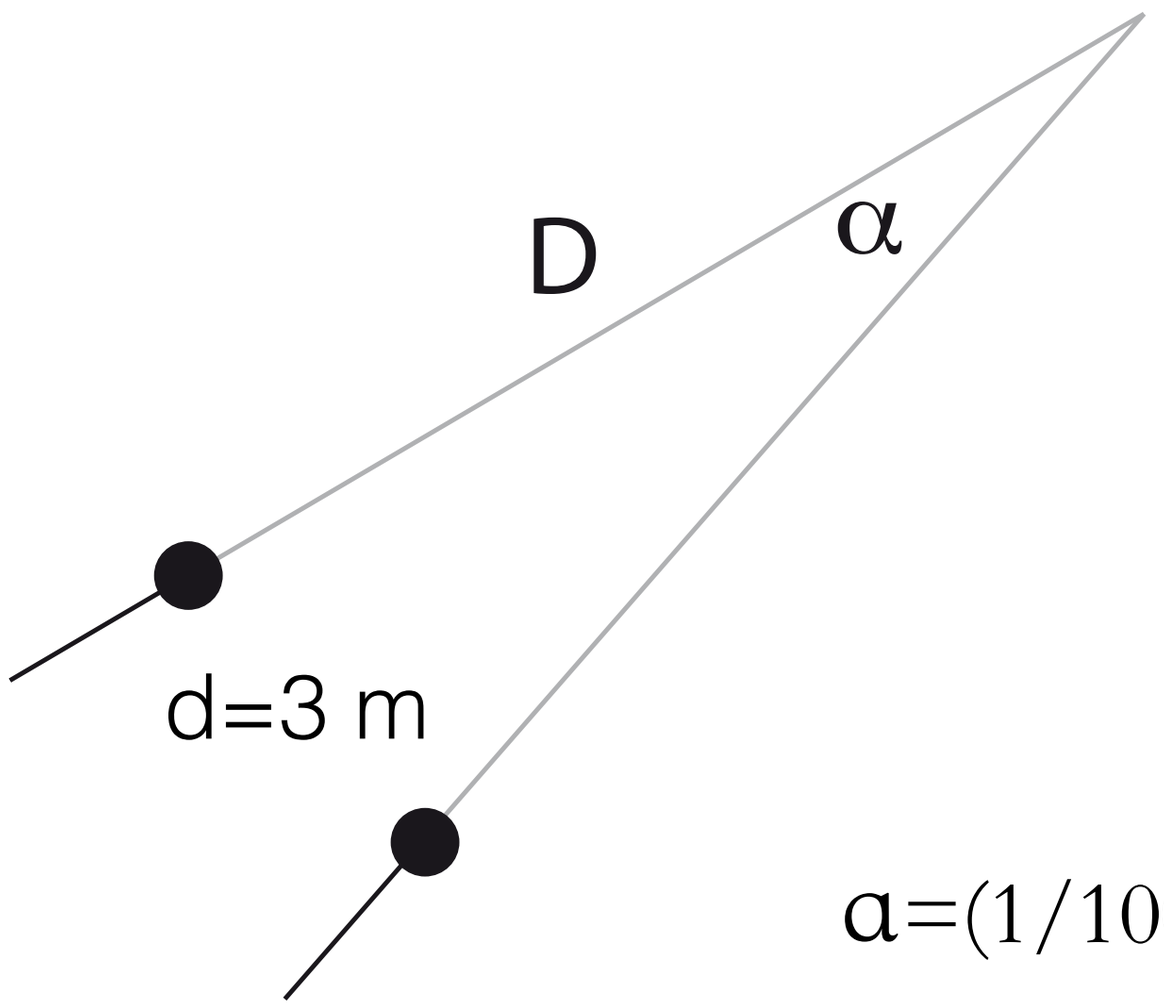


La lumière en ligne droite





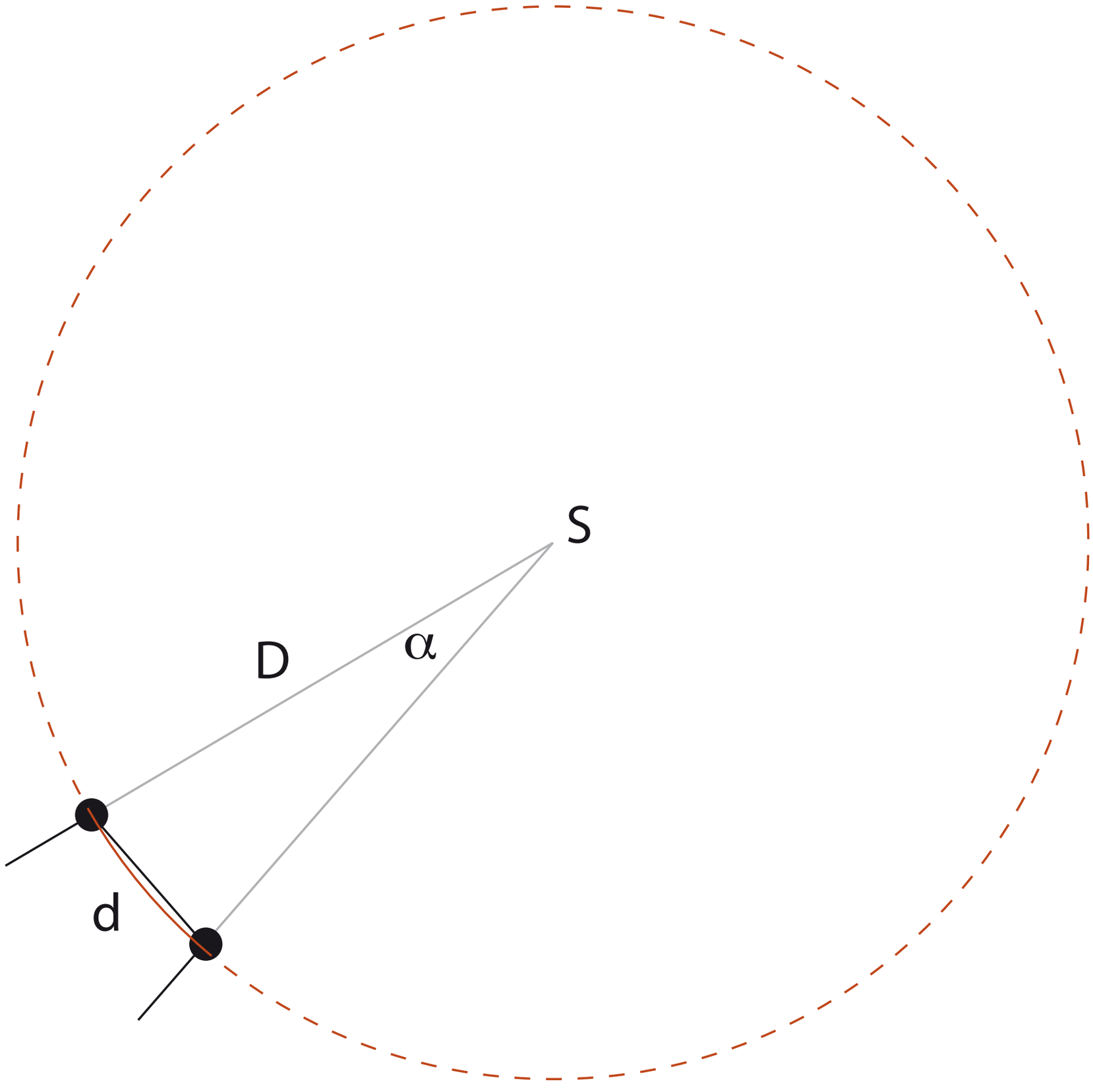
Distance Terre-Soleil
D=150 000 000 000 m



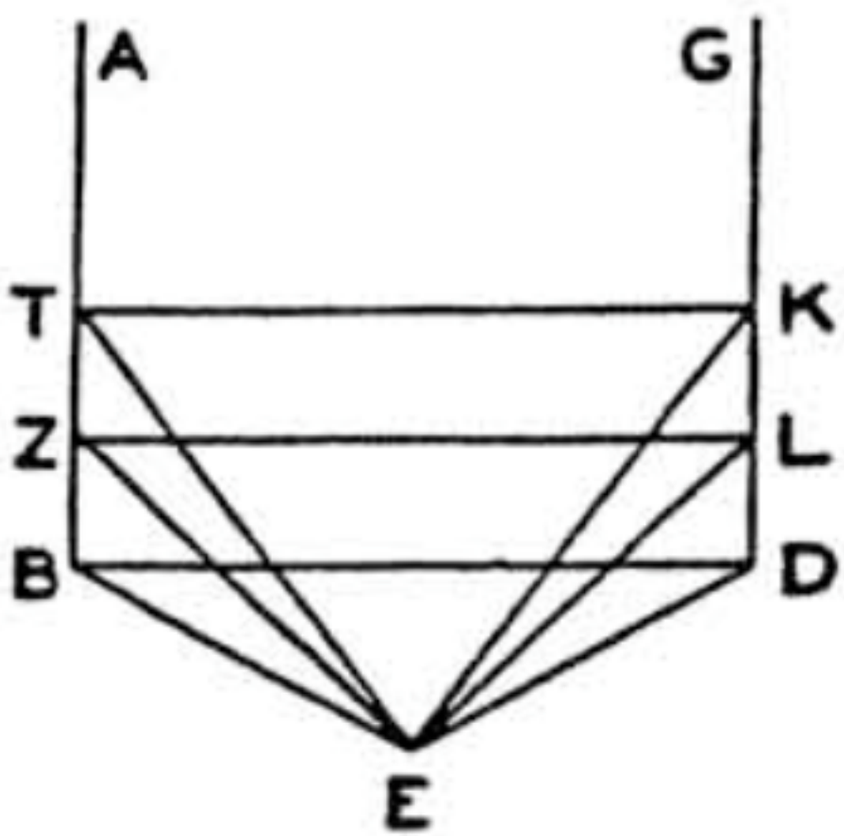
$$\alpha = (1/1000\ 000\ 000)^{\circ}$$

Mais le pouvoir de résolution de l'oeil humain est de (2/100)° !

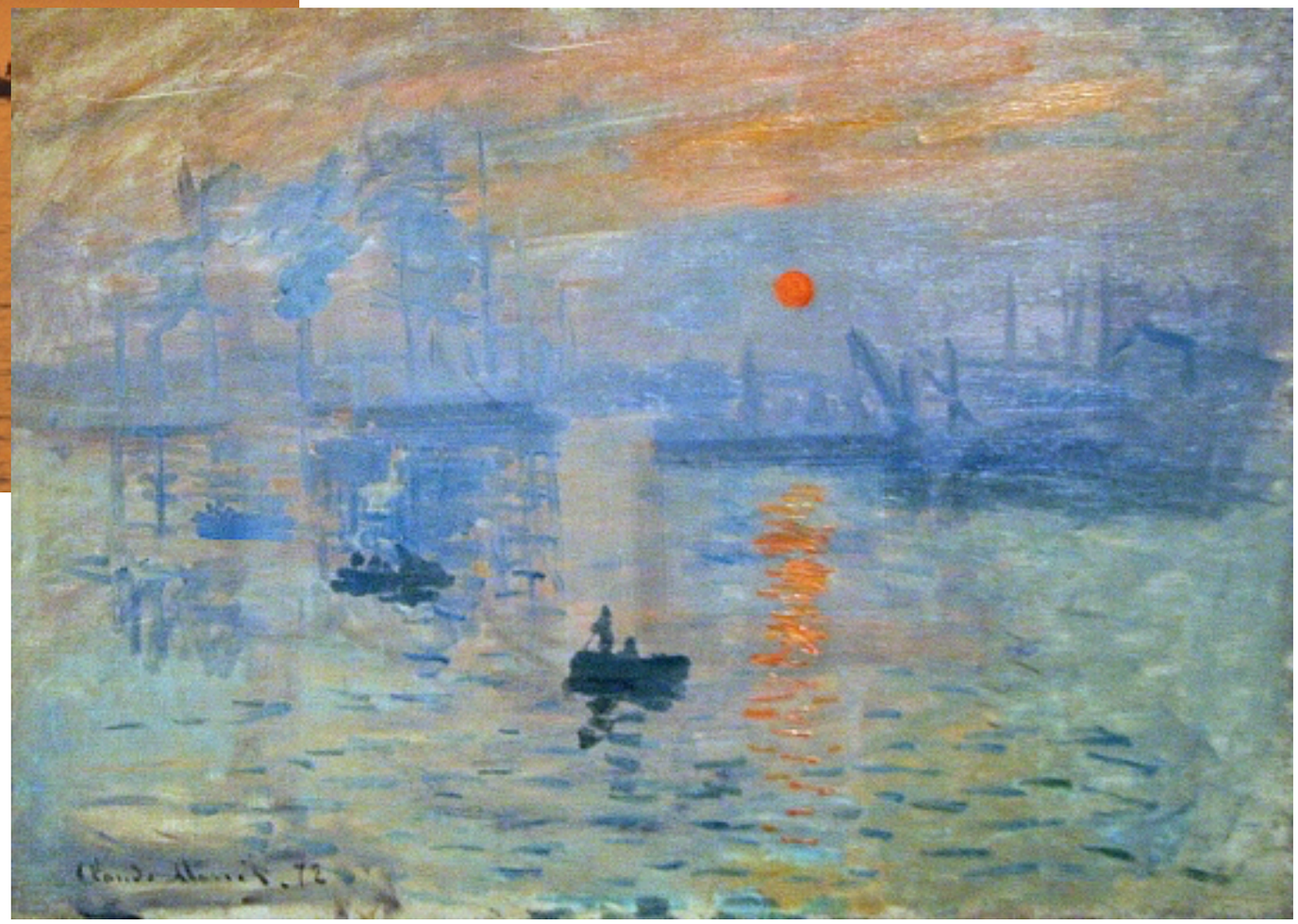
Comment mesure-t-on cet angle ?



La perspective selon Euclide (-300 BC)



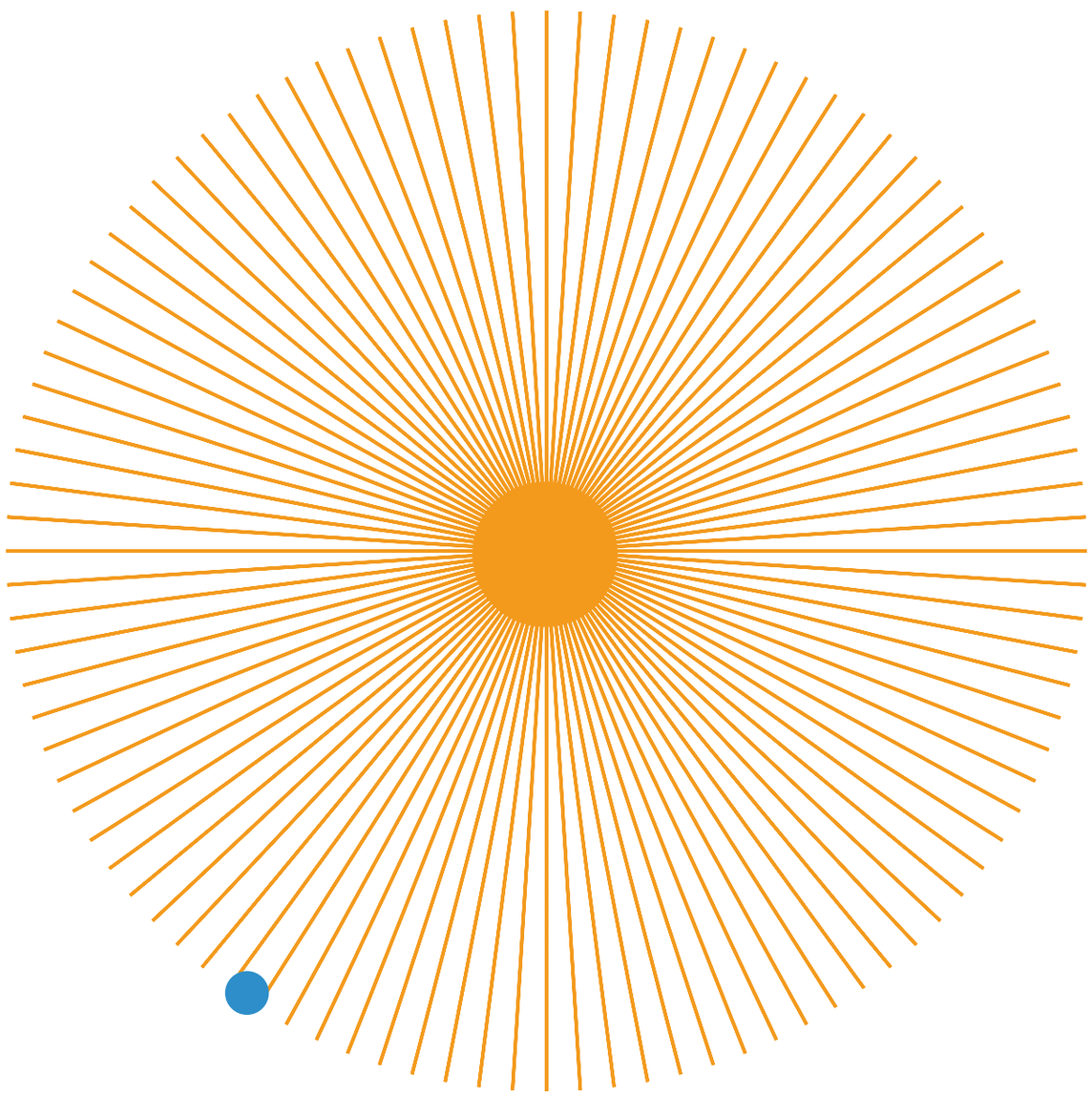
Peut on observer des droites (presque) parallèle dans la nature ?

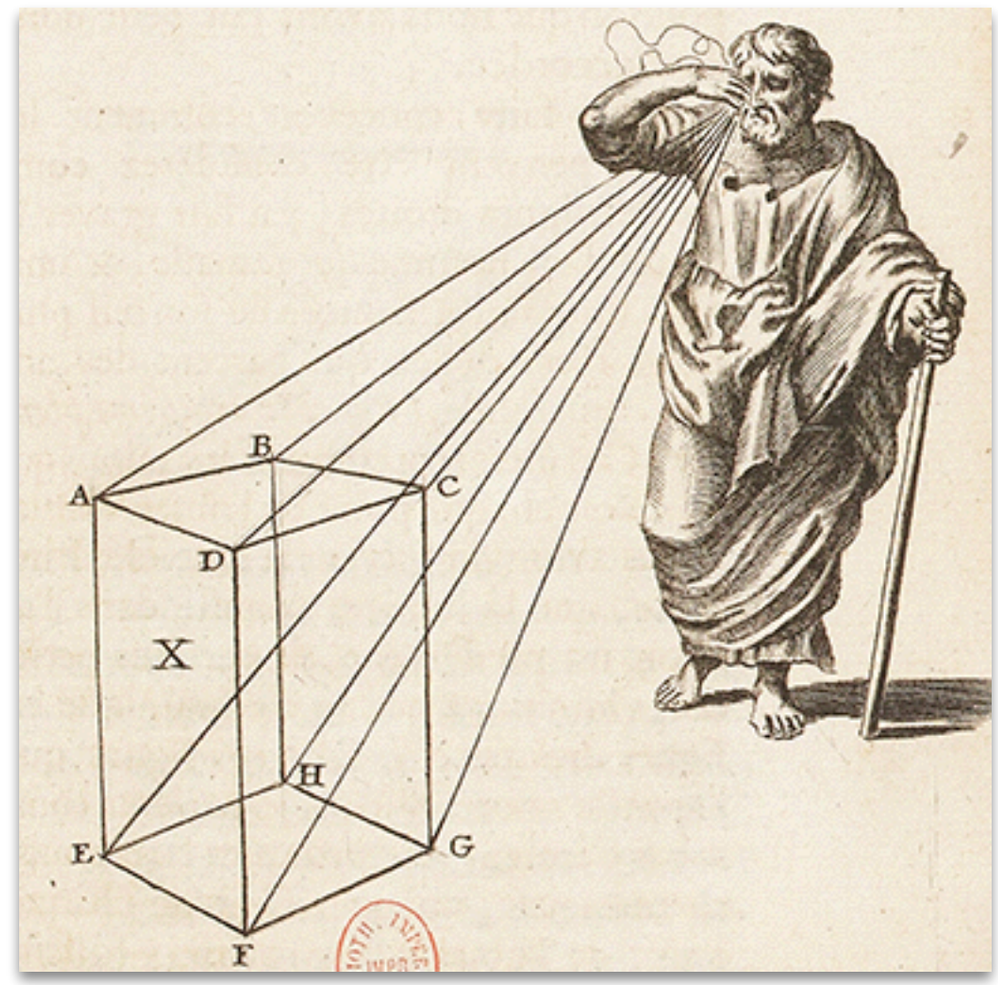


Impression de soleil levant, Claude Monet, Paris, 1872

Les rayons solaires et les rayons visuels
Une très grande confusion jusqu'au 10e siècle

Le soleil: une source primaire



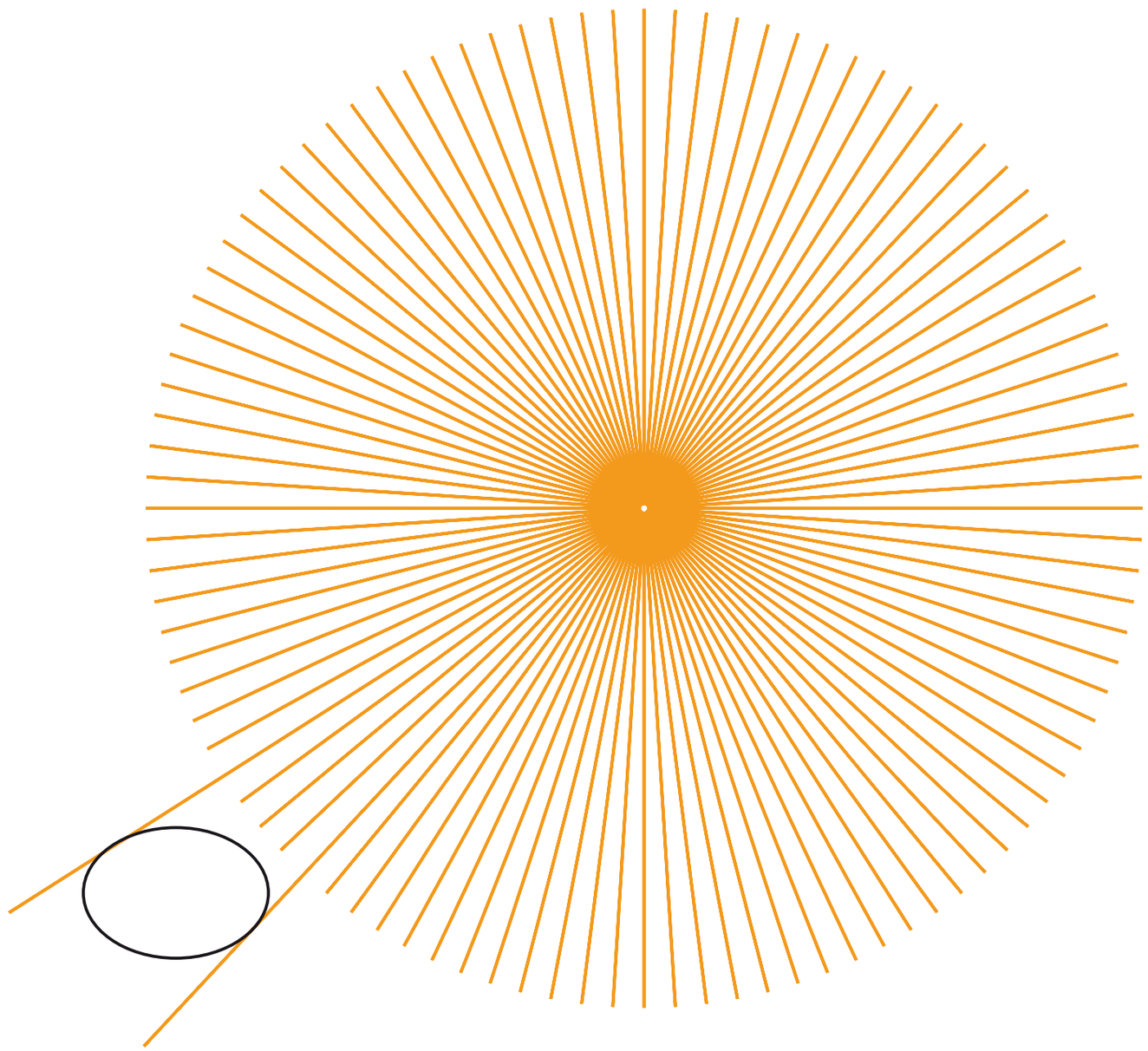


L'oeil émet des rayons visuels !

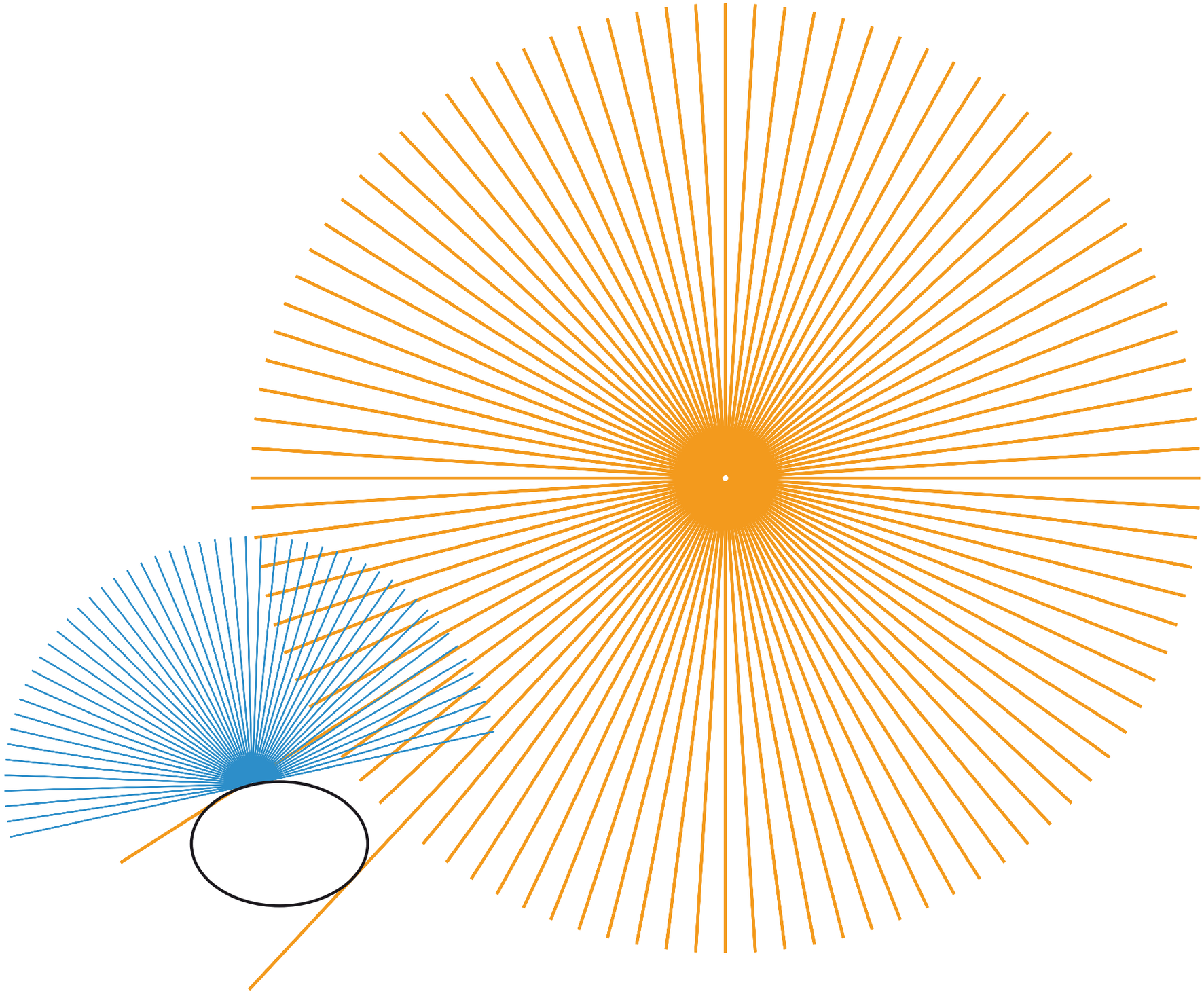
Paradoxe:
Pourquoi voit on un objet qui n'est pas éclairé directement par le soleil ?

La réponse d’Ibn Al Haytham (1000)

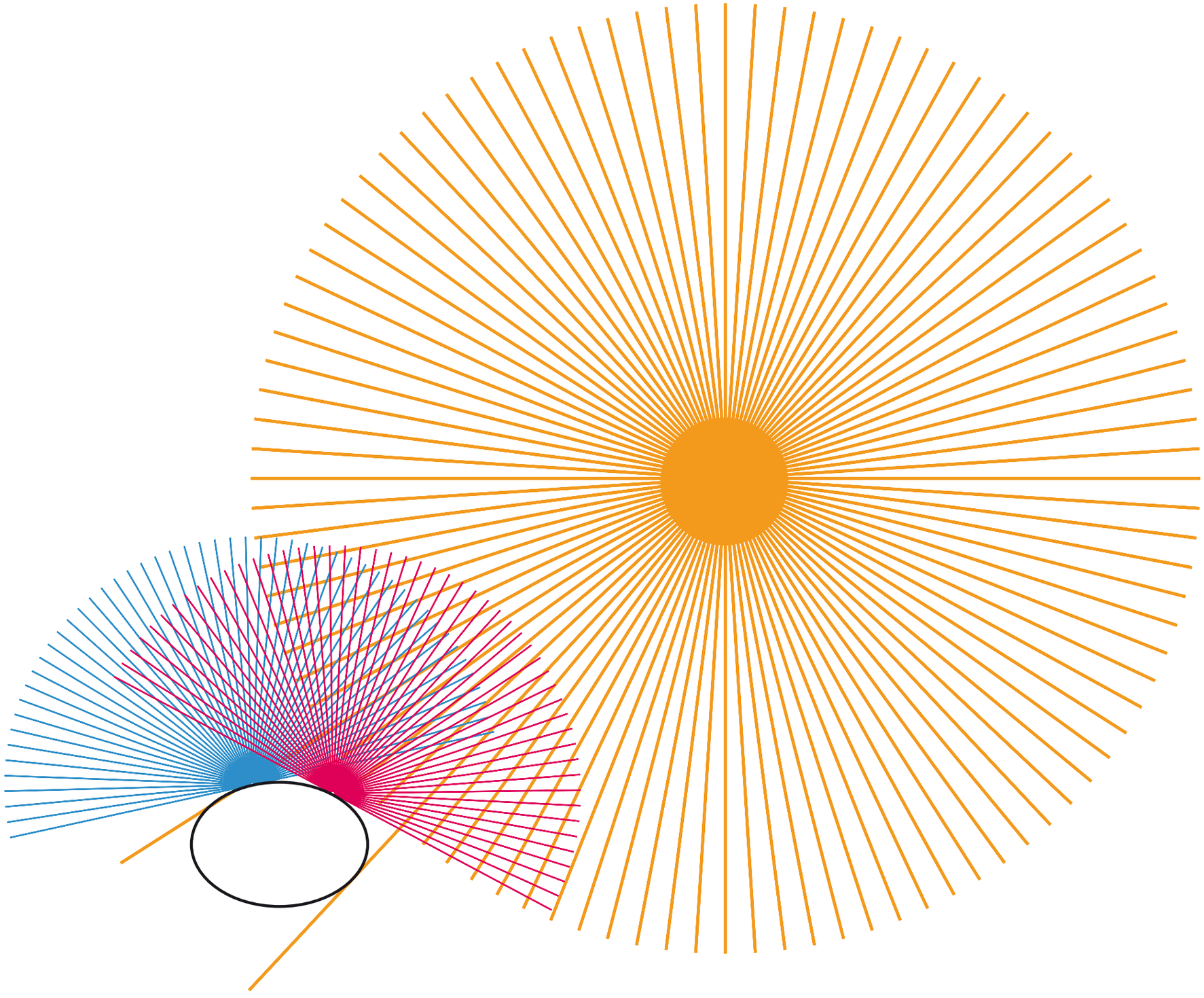
Chaque point d’un objet éclairé se comporte comme d’innombrable petit miroirs qui renvoient la lumière dans toutes les directions. Ce sont des « sources secondaires » de lumière



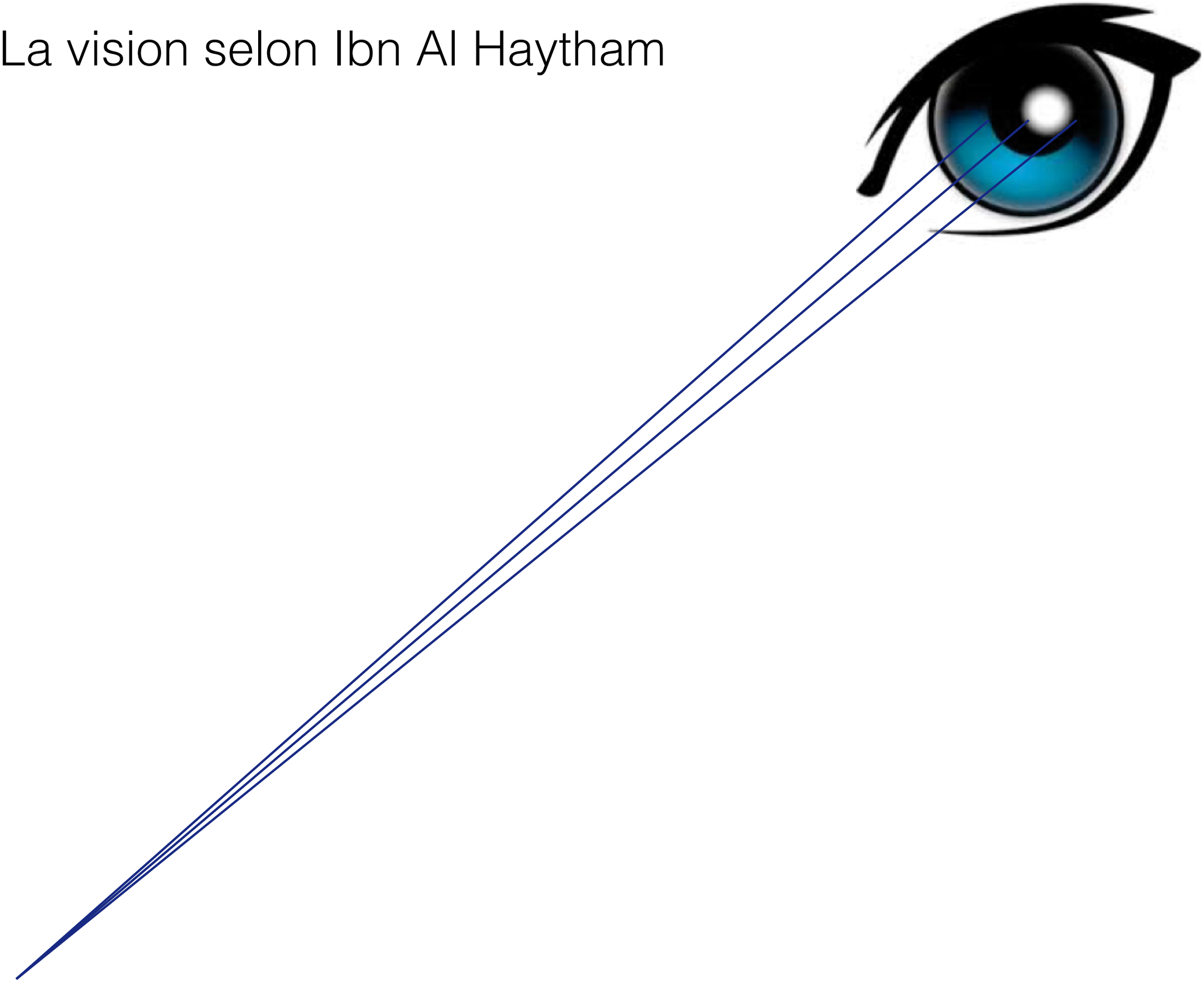
Un point bleu



Un point bleu et un point rouge

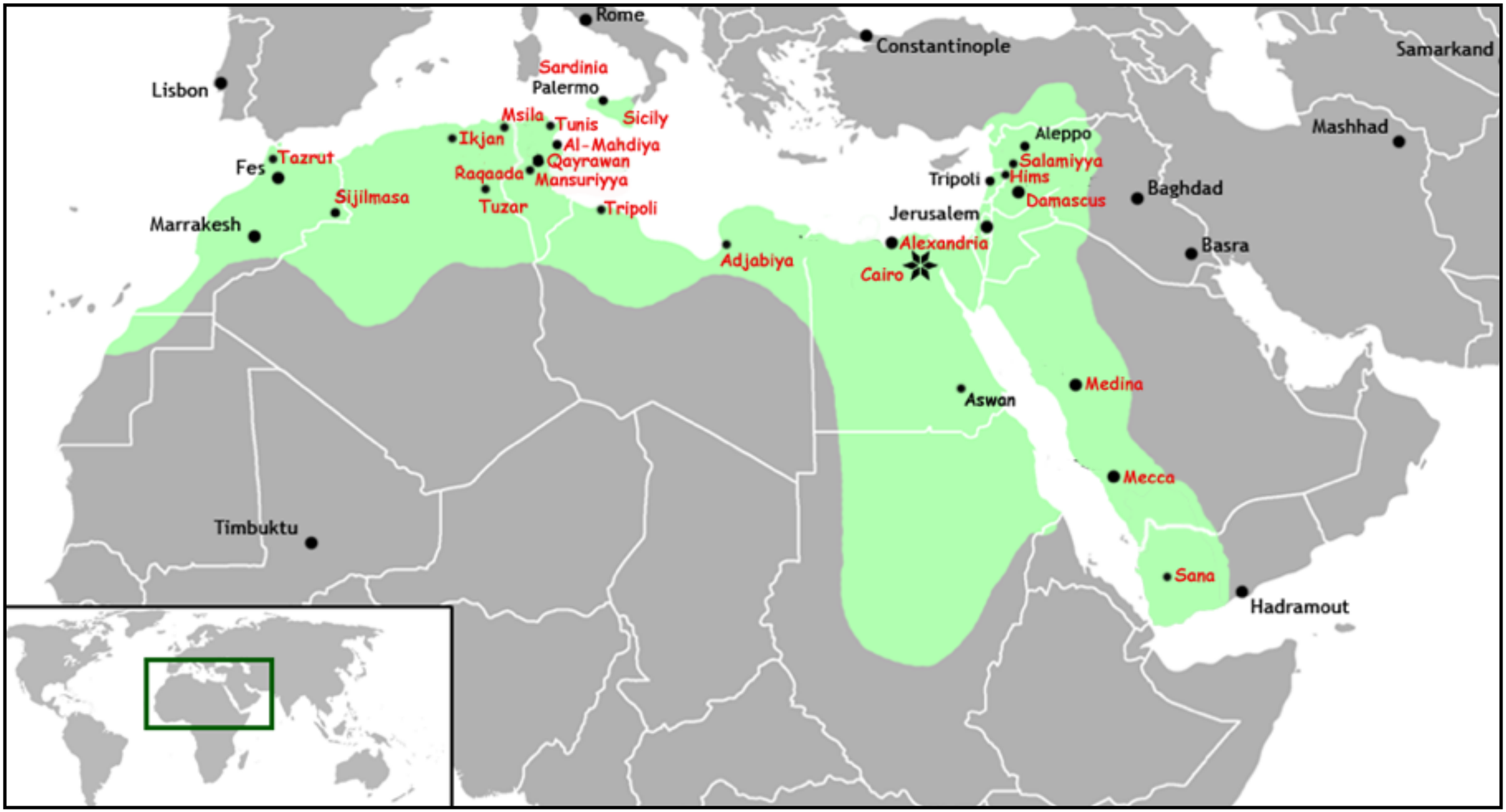


La vision selon Ibn Al Haytham



Ibn Al Haytham
ou
Alhazen (965-1040)

Fatimid califat au onzième siècle



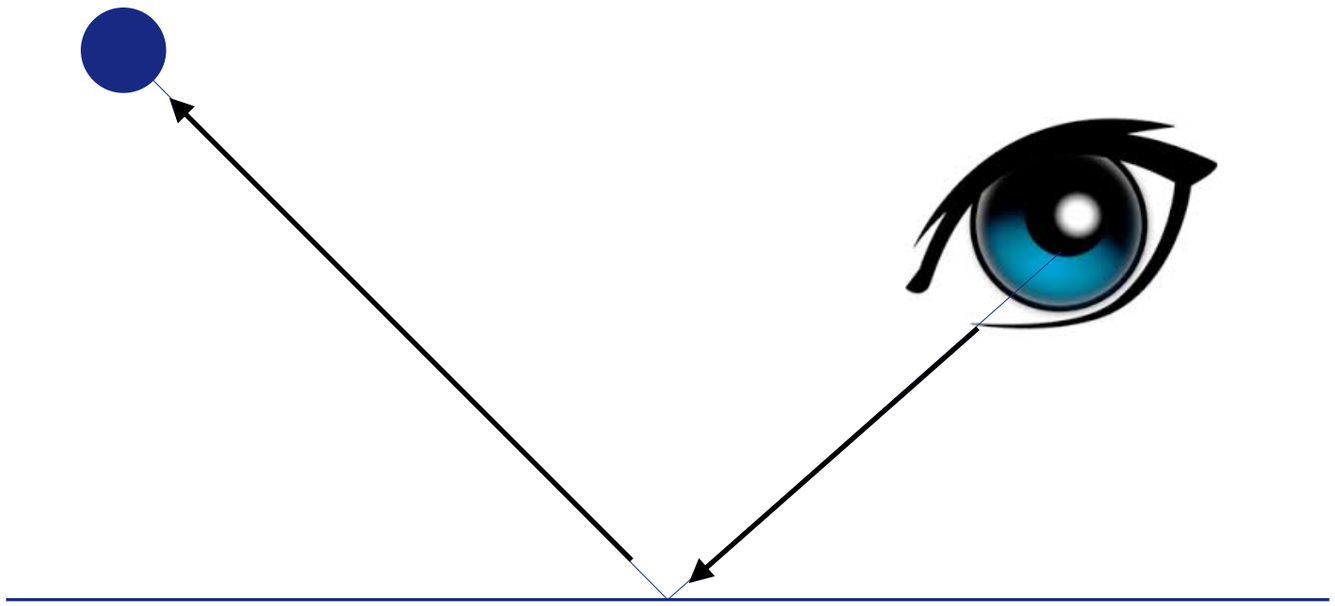
Régulation des crues du nil et le calife Hakim

Une chambre noire naturelle (Aristote)

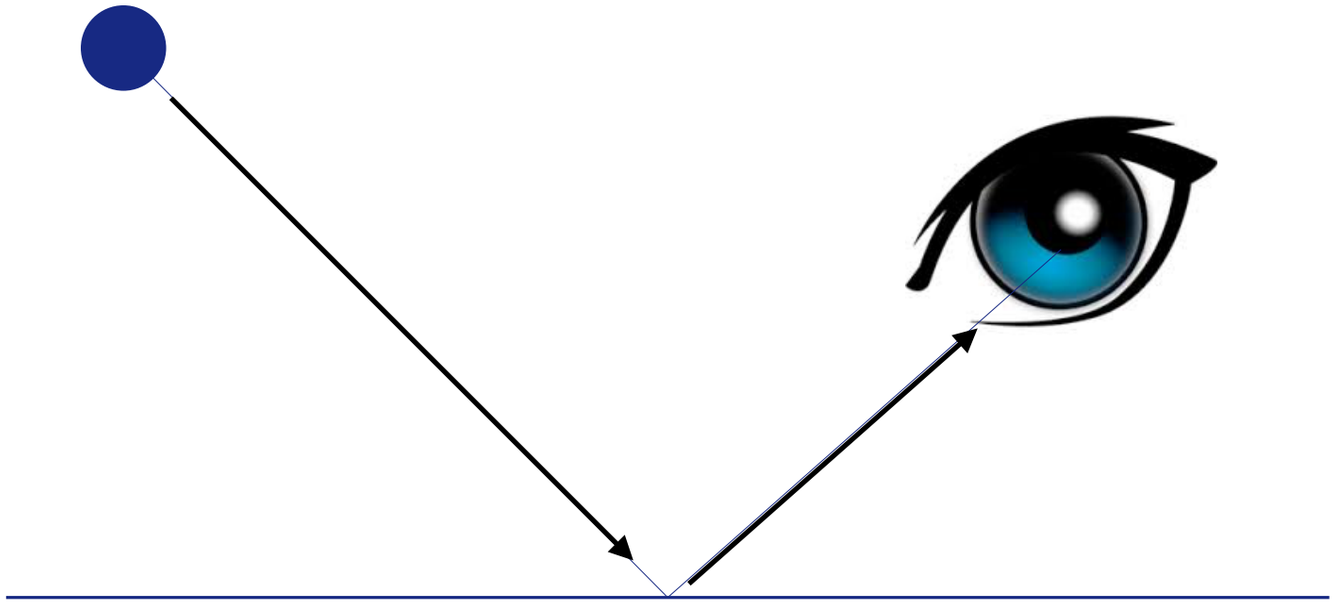
Une chambre noire naturelle (Aristote)

Le miroir

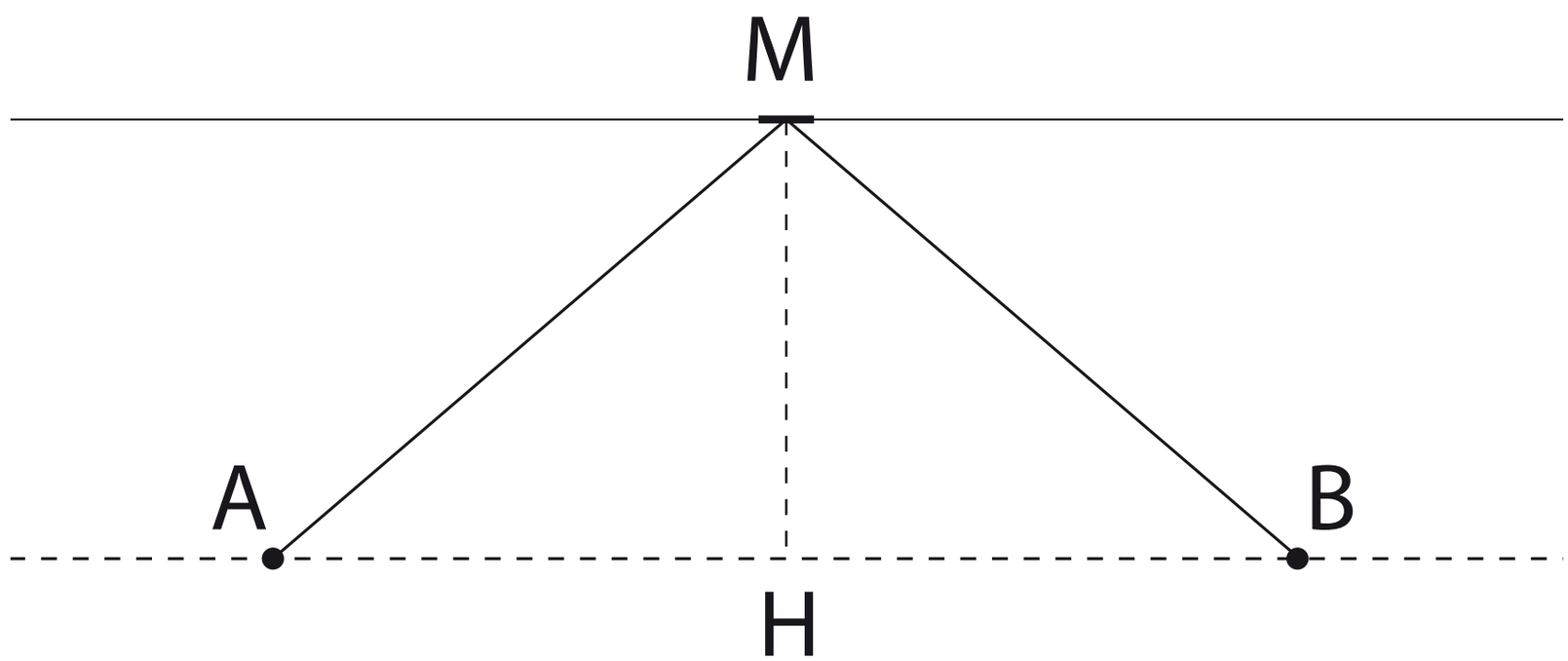
Avant Alhazen



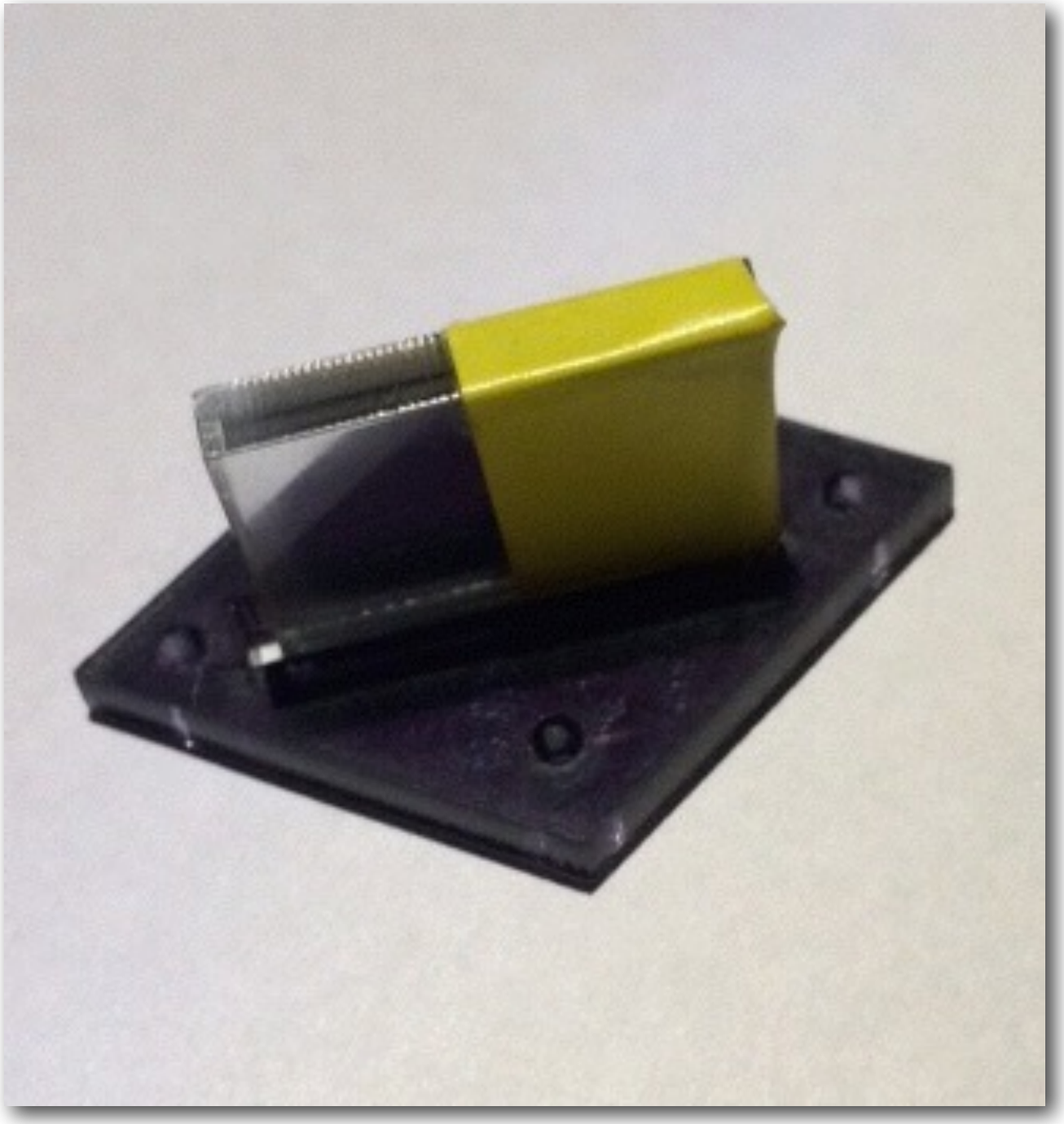
Après Alhazen



Une verification visuelle de la loi de réflexion

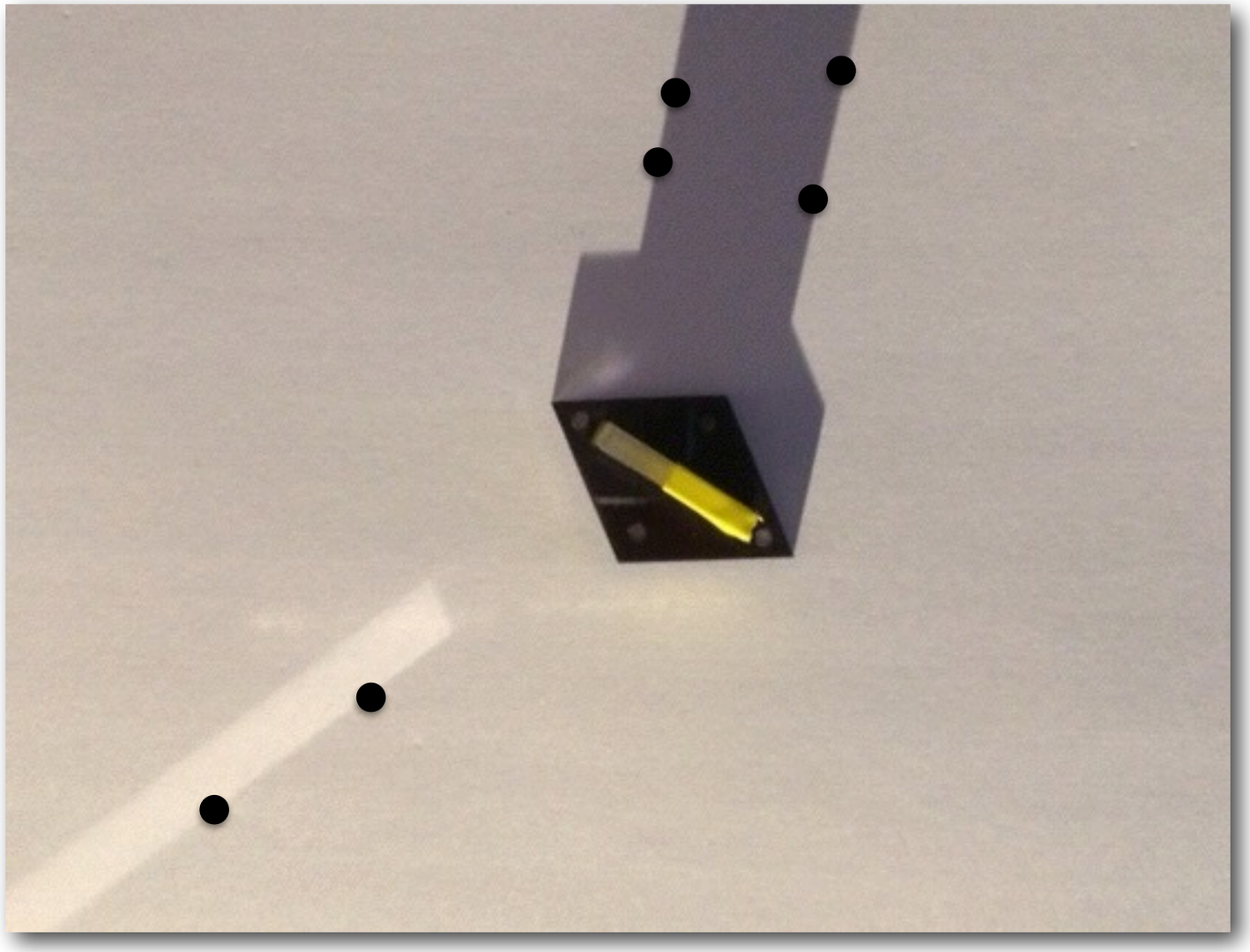


Un petit miroir



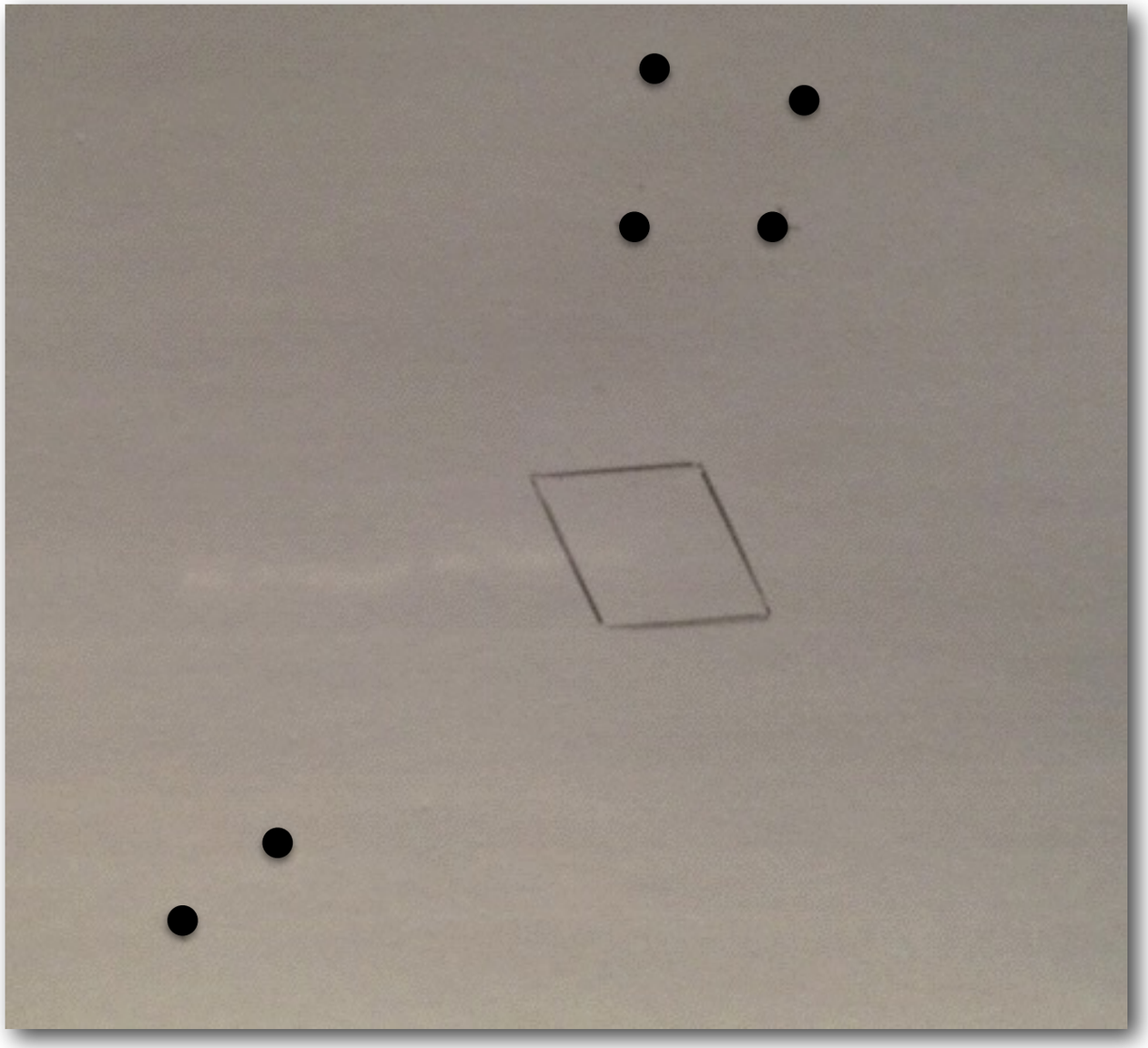
caché à moitié

On note deux points sur le bord central du faisceau réfléchi

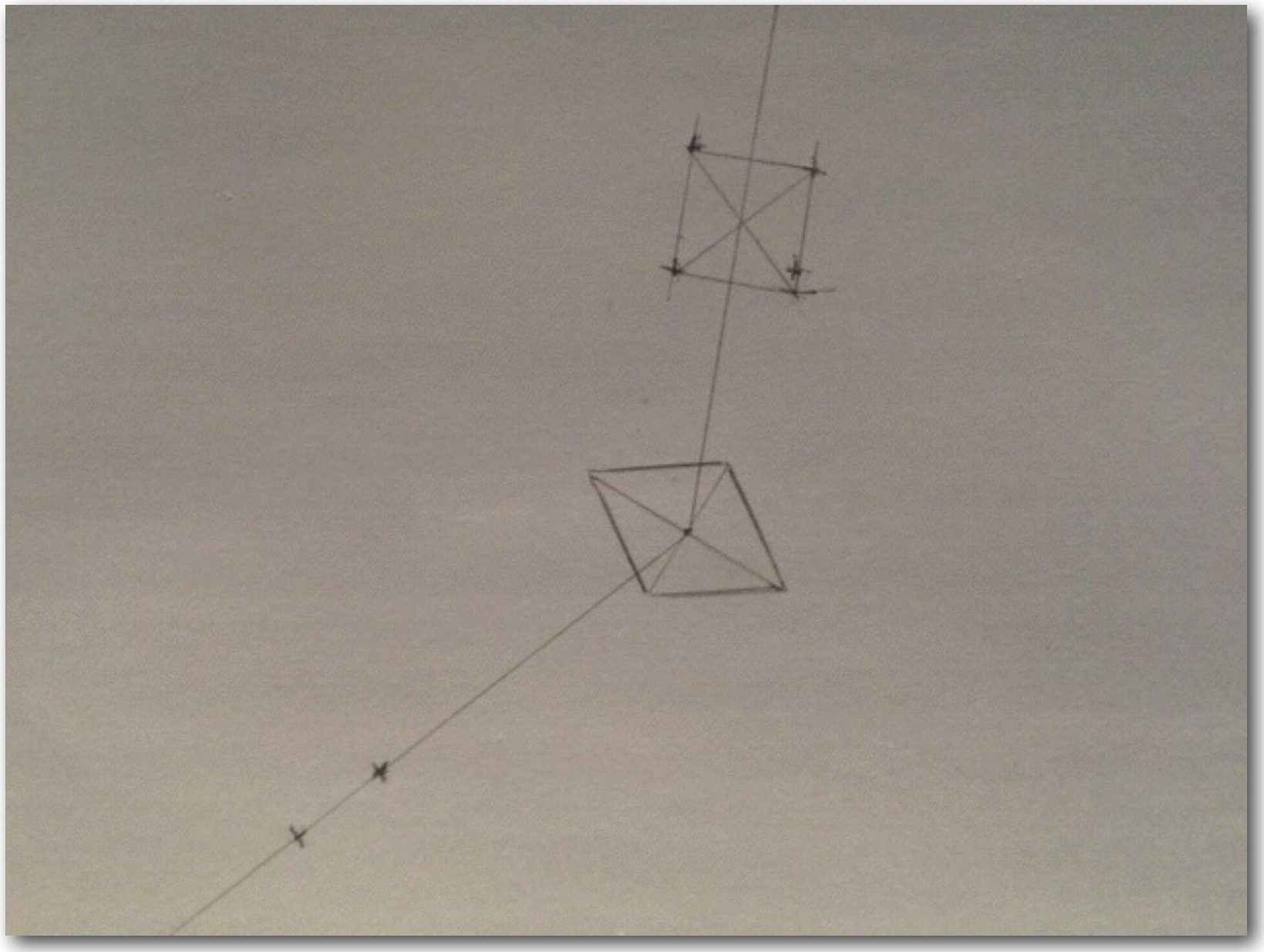


deux points sur chaque extrémité de l’ombre
et l’on dessine le contour du support « losange »

On enlève le miroir

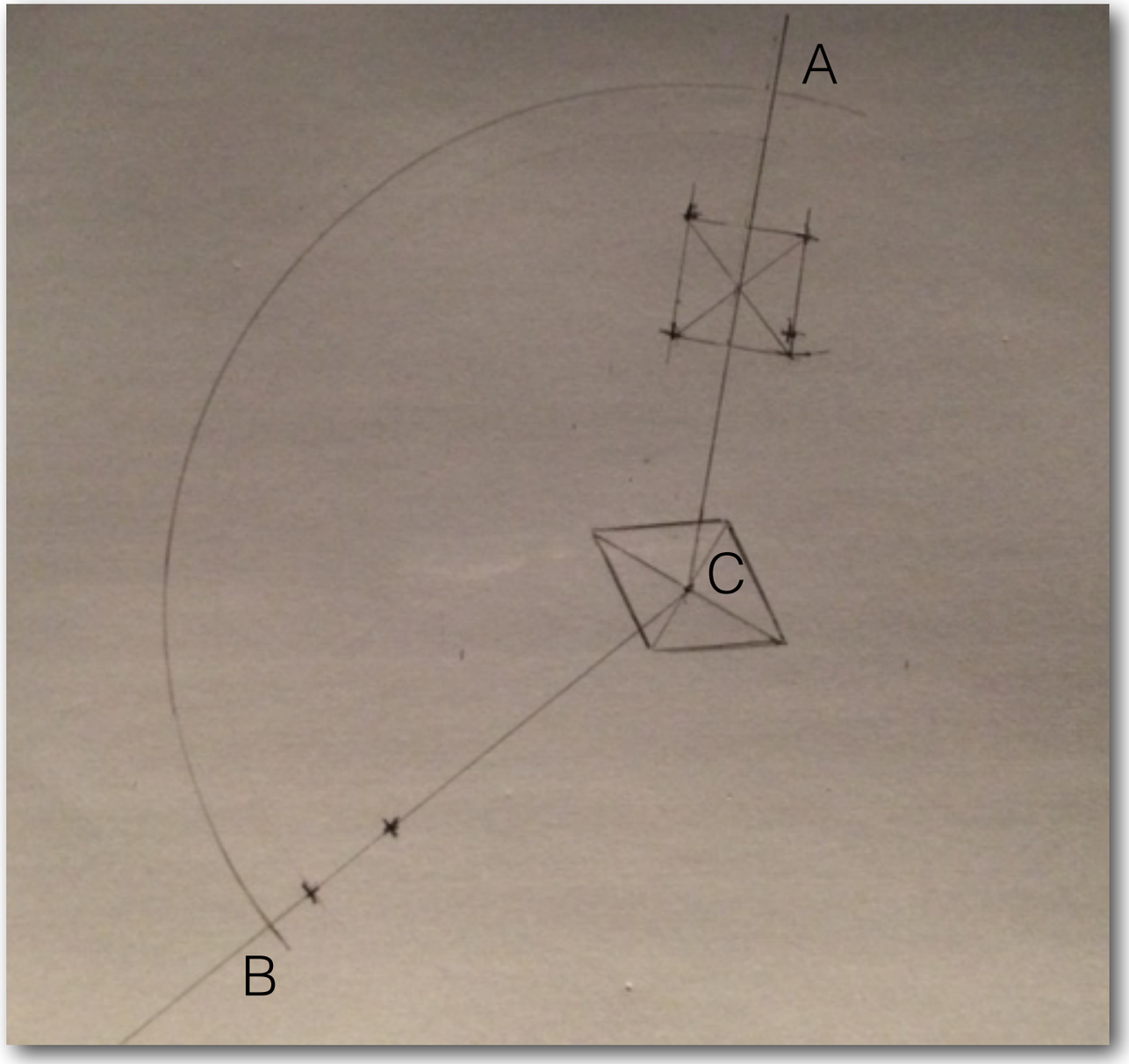


On trace les diagonales du losange
La grande diagonale est la direction du miroir



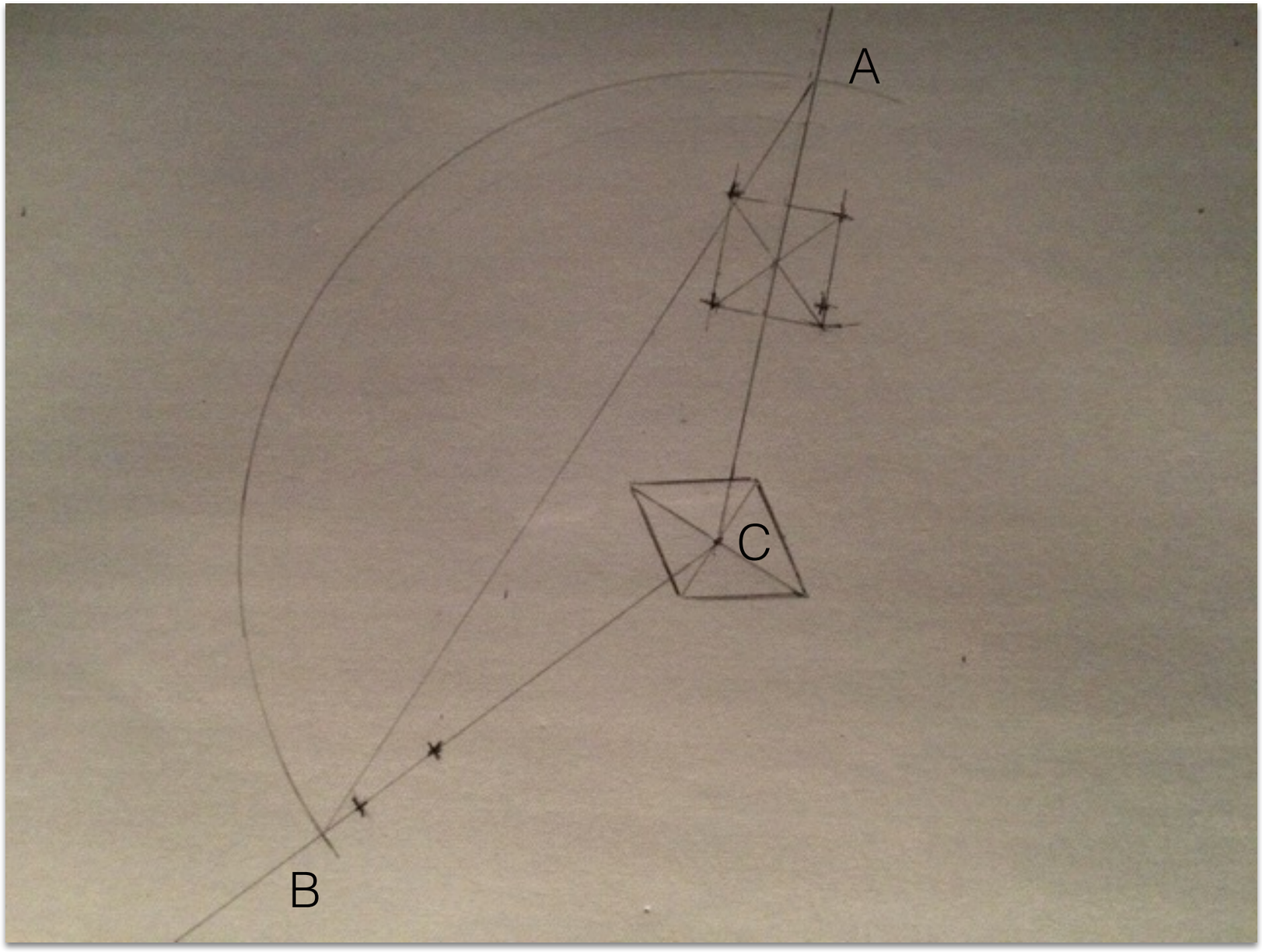
On construit un losange pour tracer le centre de l’ombre

On trace un grand cercle centré sur le centre du miroir

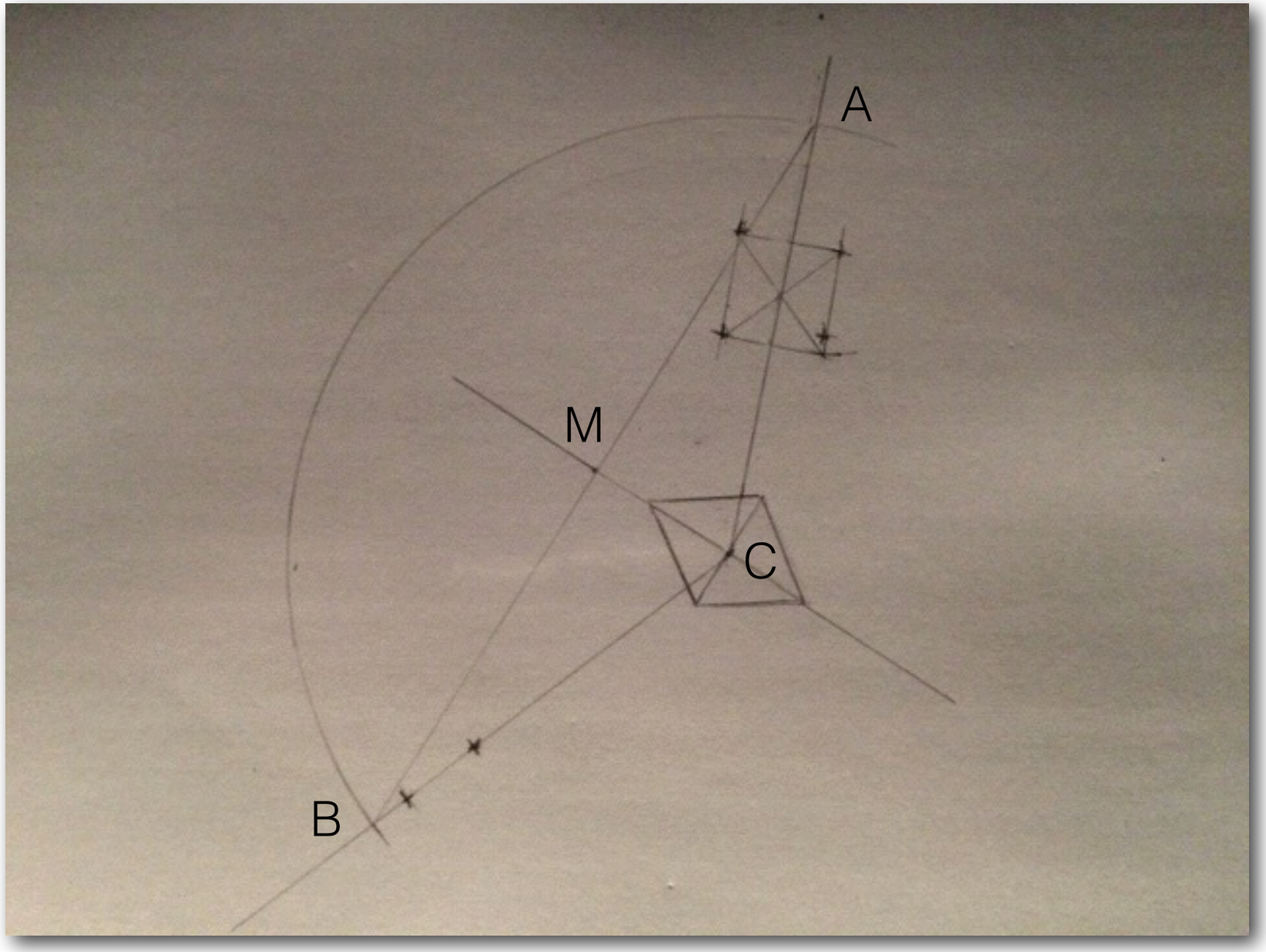


CA=CB

On joint A et B

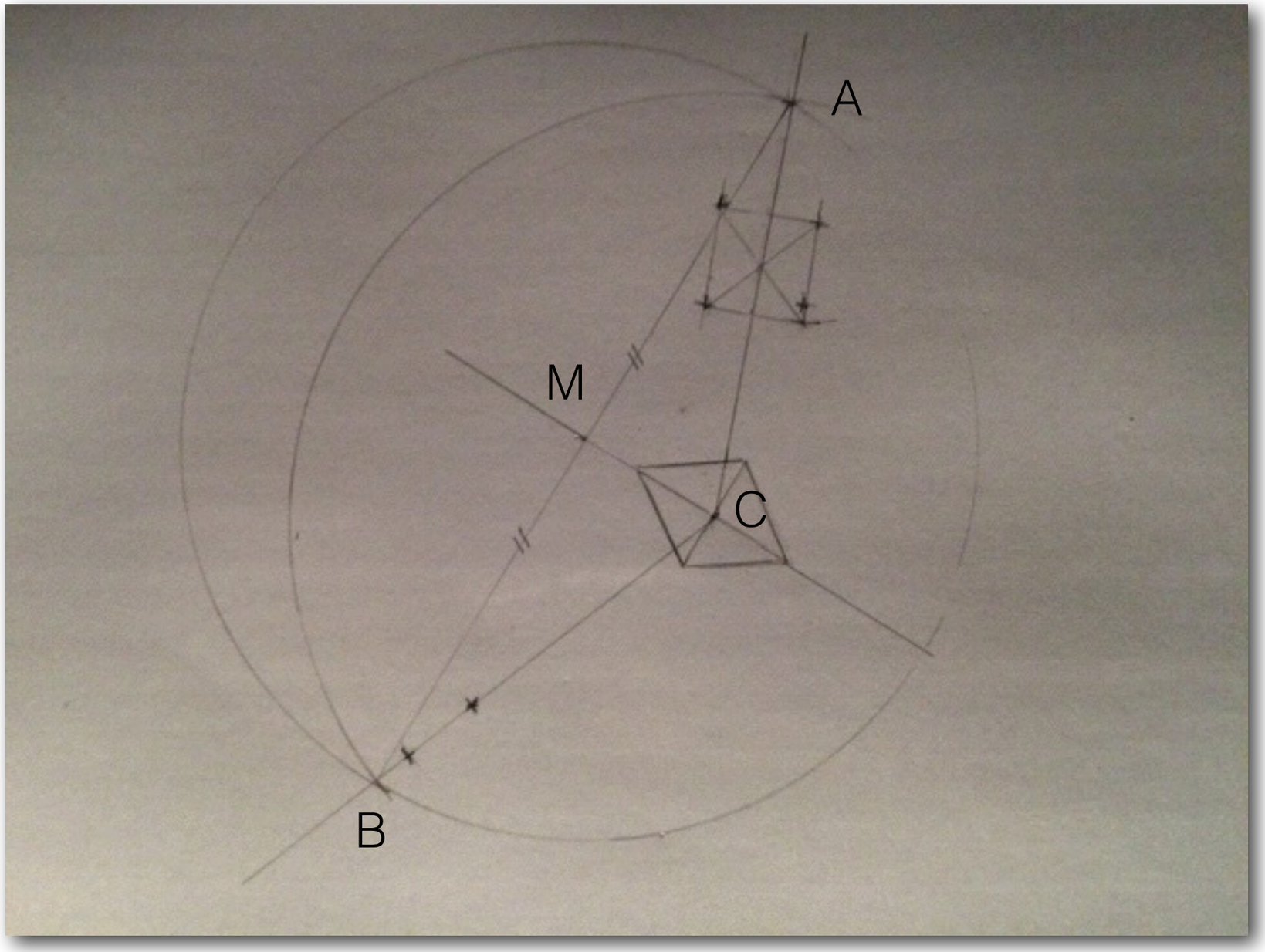


On prolonge la direction du miroir



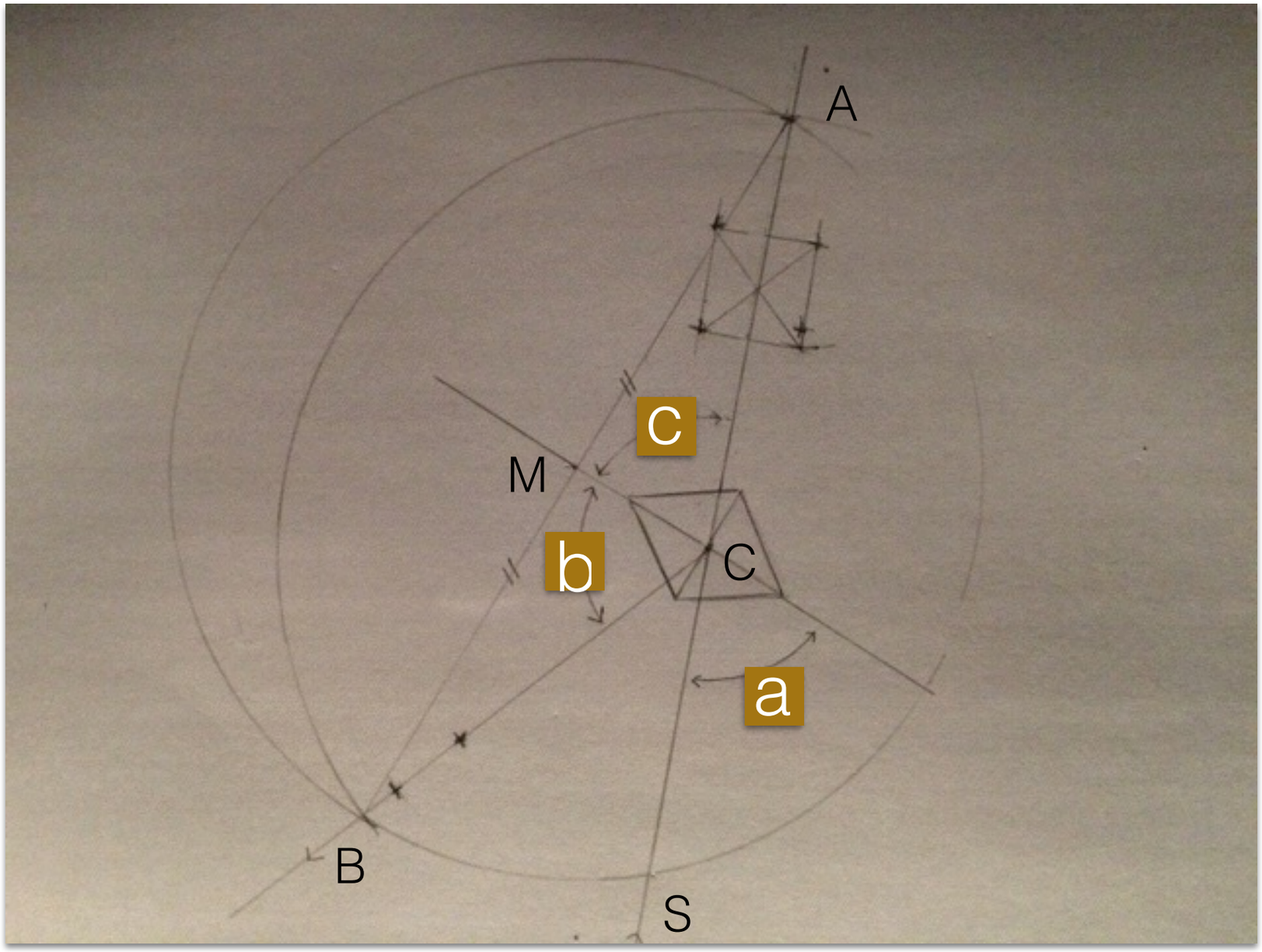
La droite qui porte le miroir coupe AB en M

On trace le cercle de centre M de rayon MA



Il coupe AB en B, ce qui montre que MA=MB

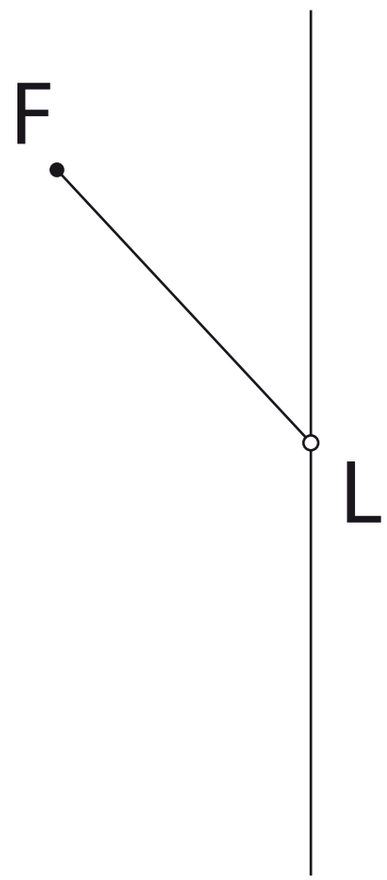
On prolonge la direction de l'ombre AC en CS.
SC est le rayon incident. Les angles a et c sont égaux



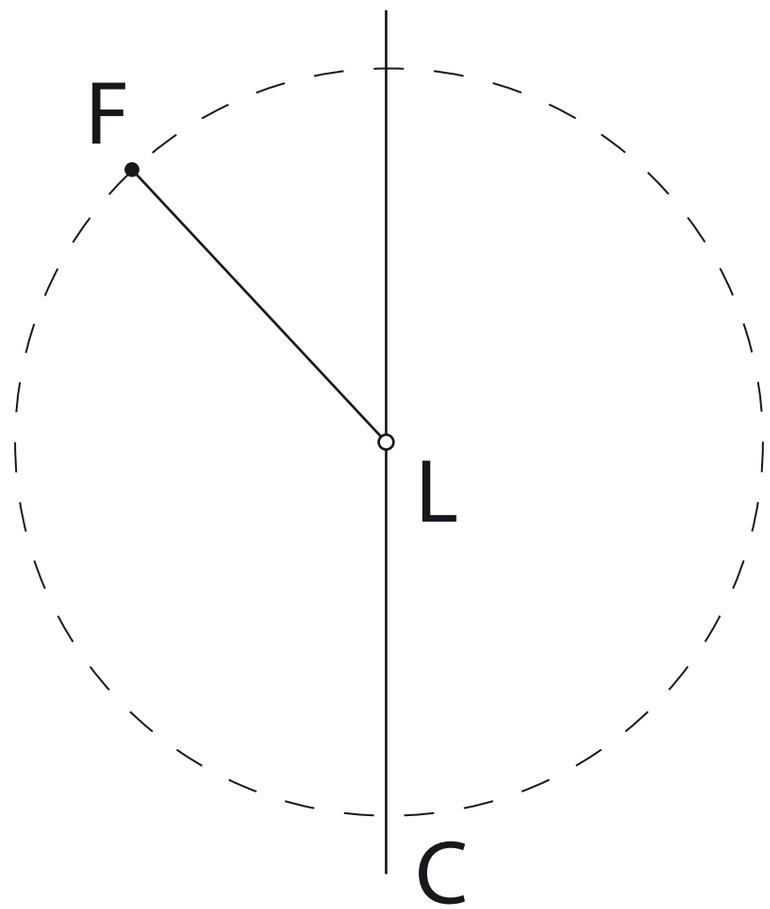
Puisque le triangle ABC est isocèle, MC est sa médiatrice en C,
donc également sa bissectrice, d'ou b=c

On en déduit que le rayon incident et le rayon réfléchi
forment des angles égaux avec le miroir (a=b)

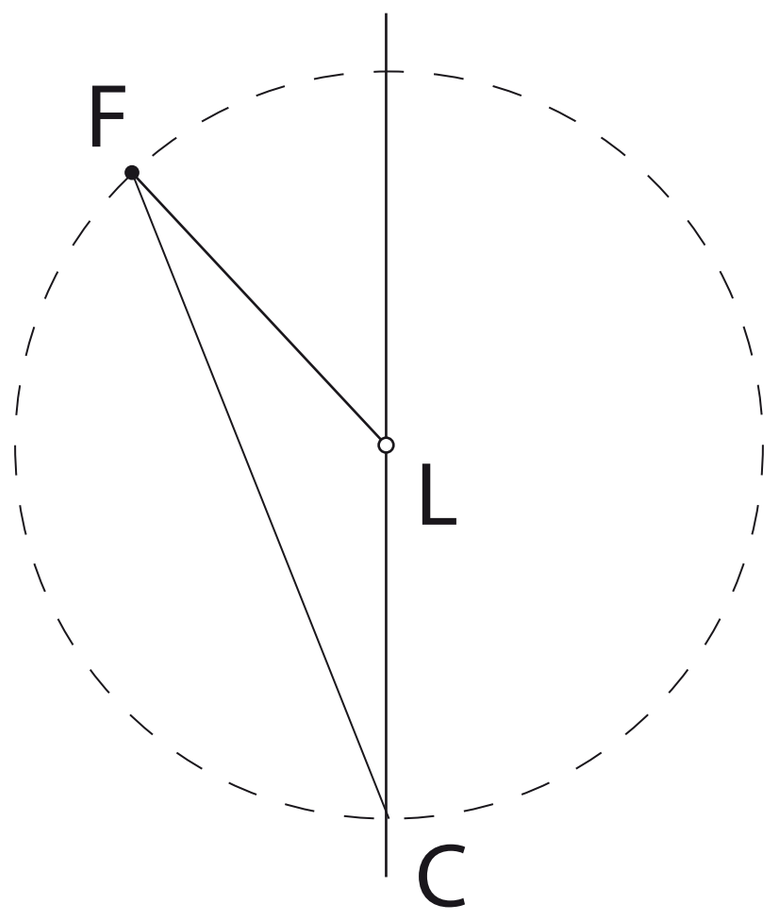
Prediction



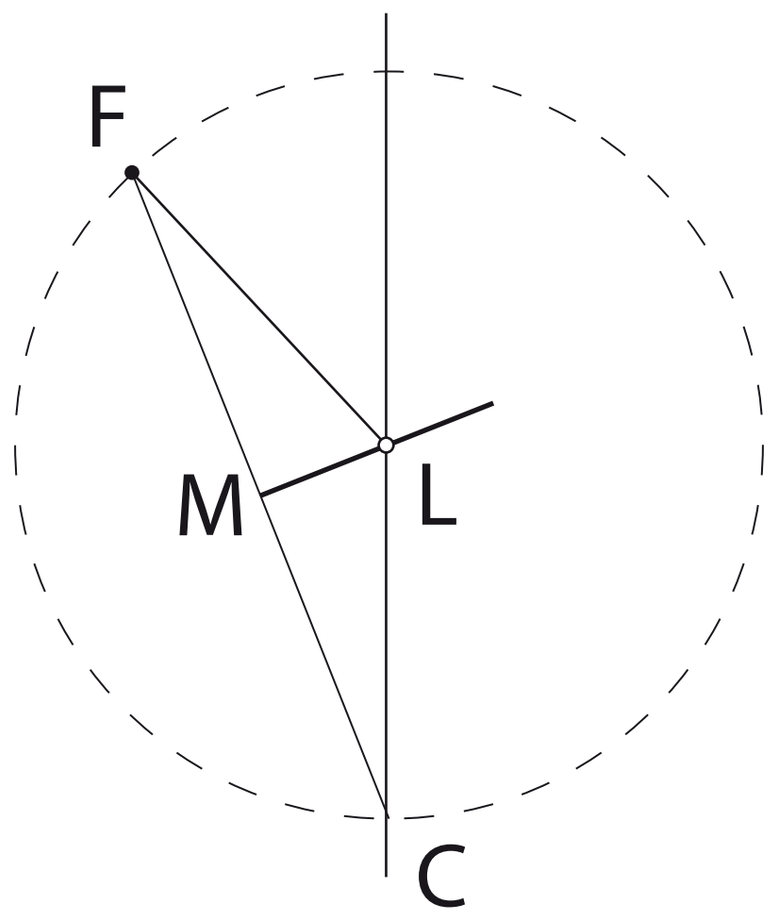
Prediction

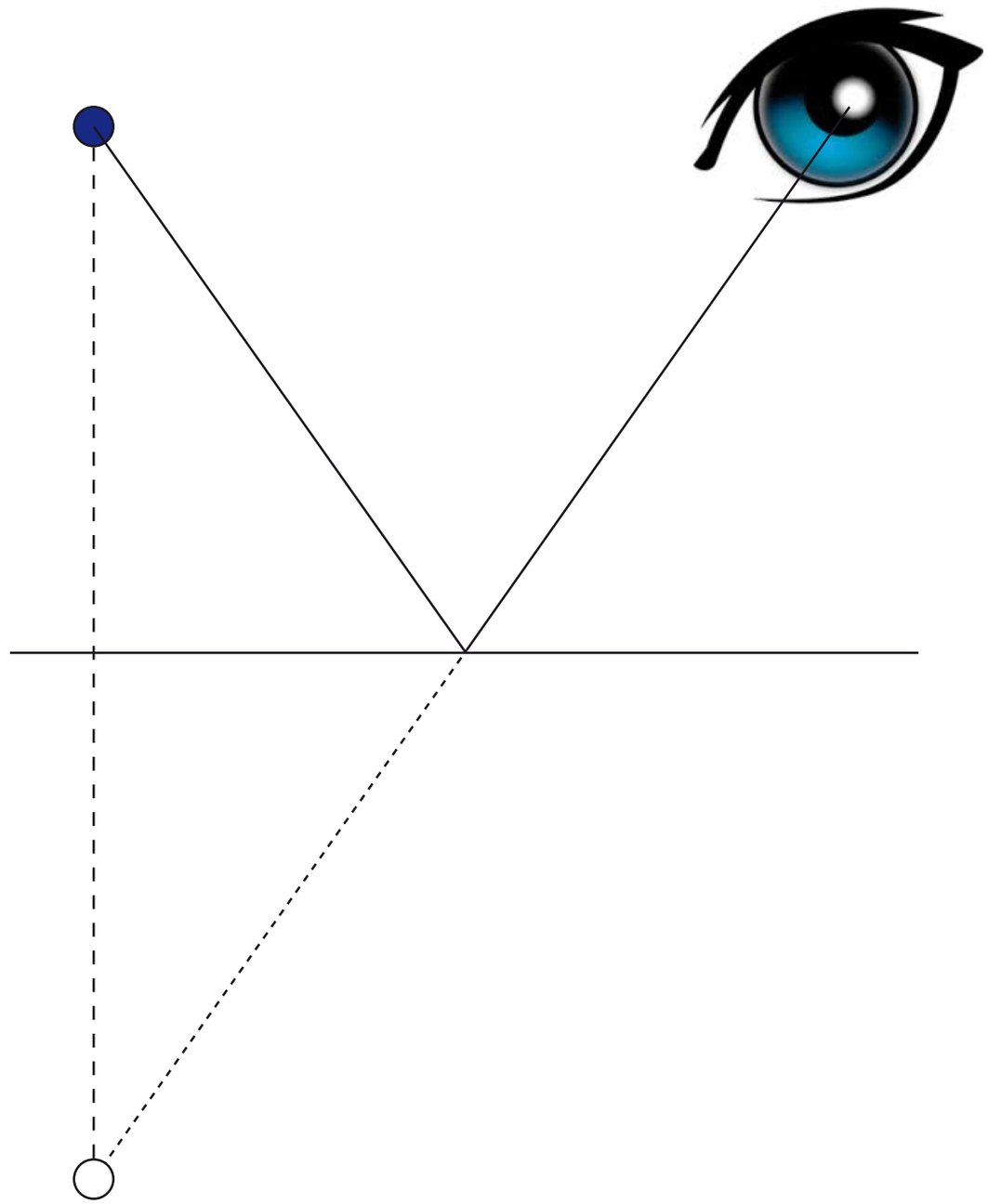


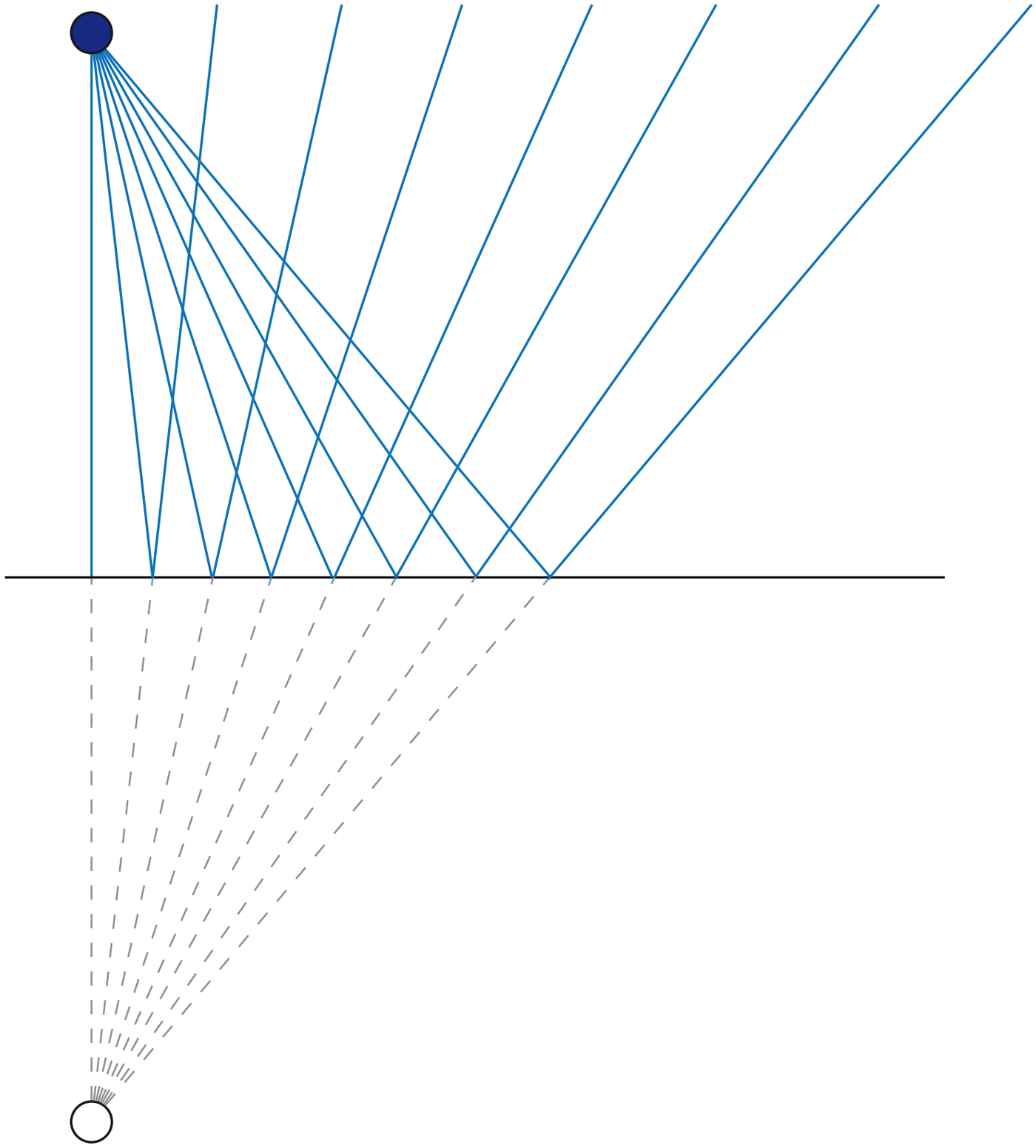
Prediction



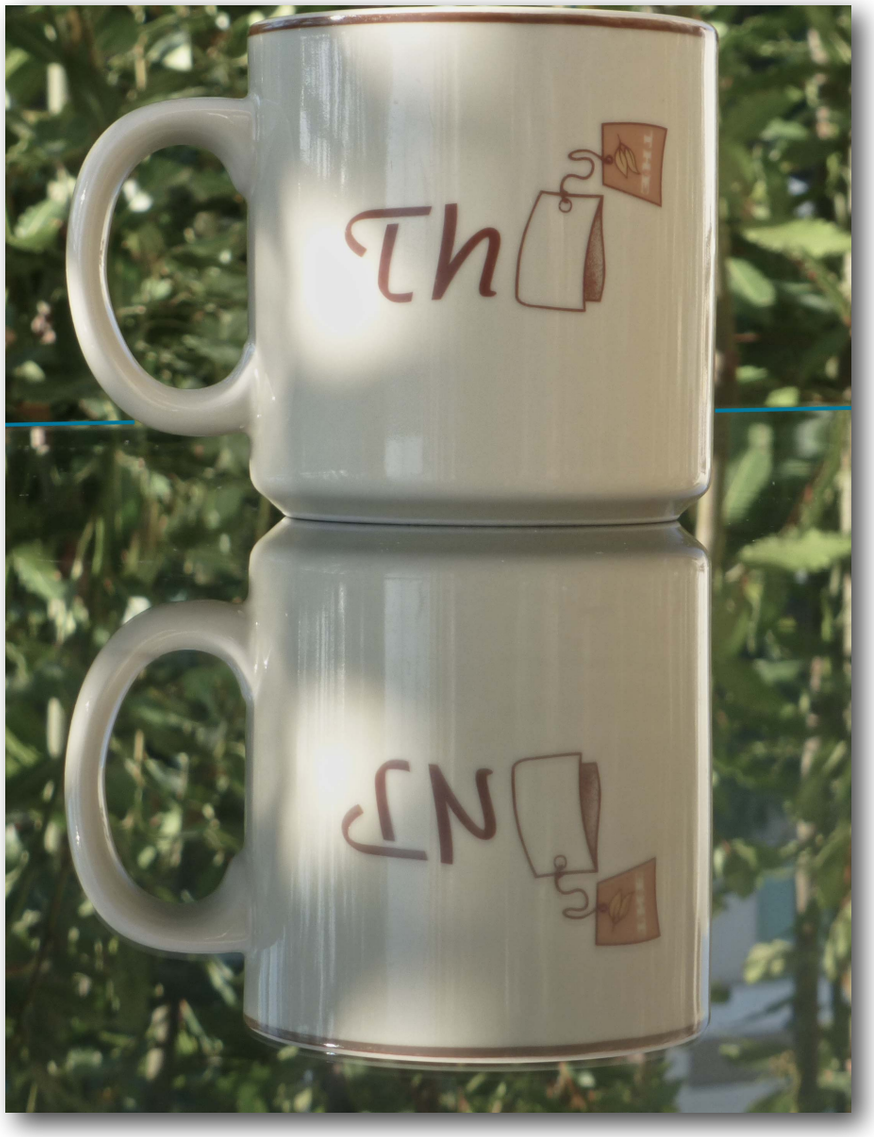
Prediction

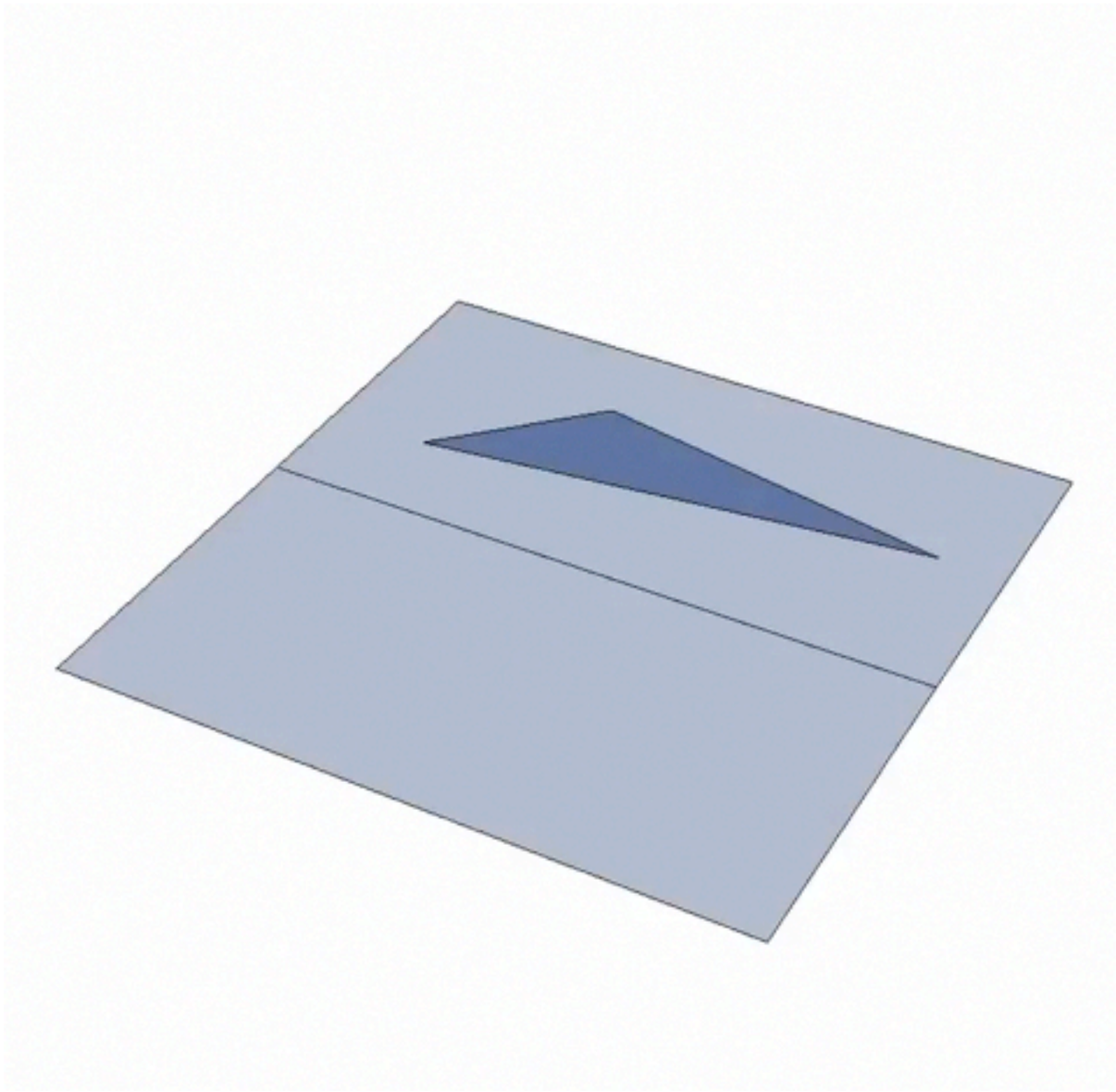






Reflexion of Light and Mirror Symmetry



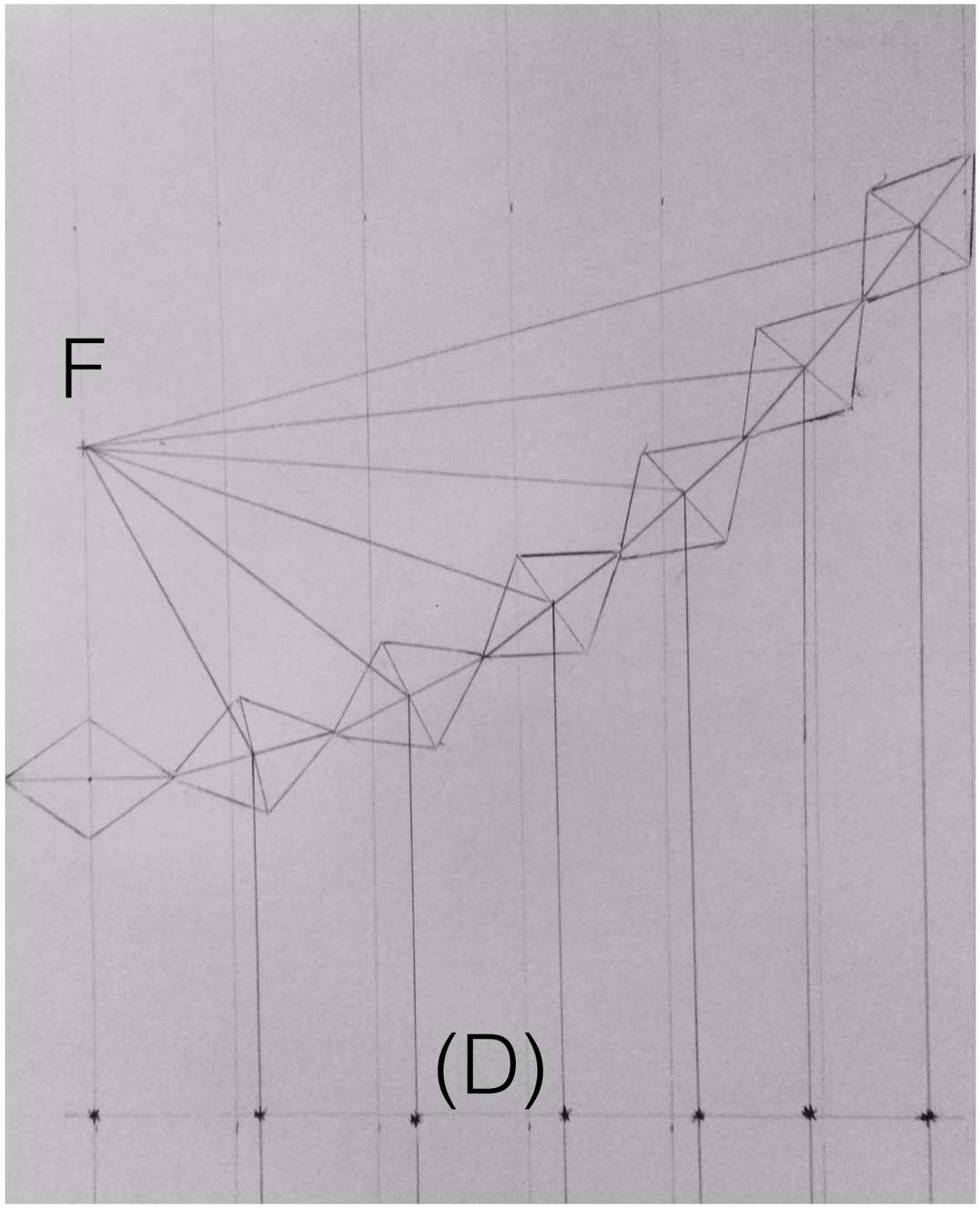


The first law of nature

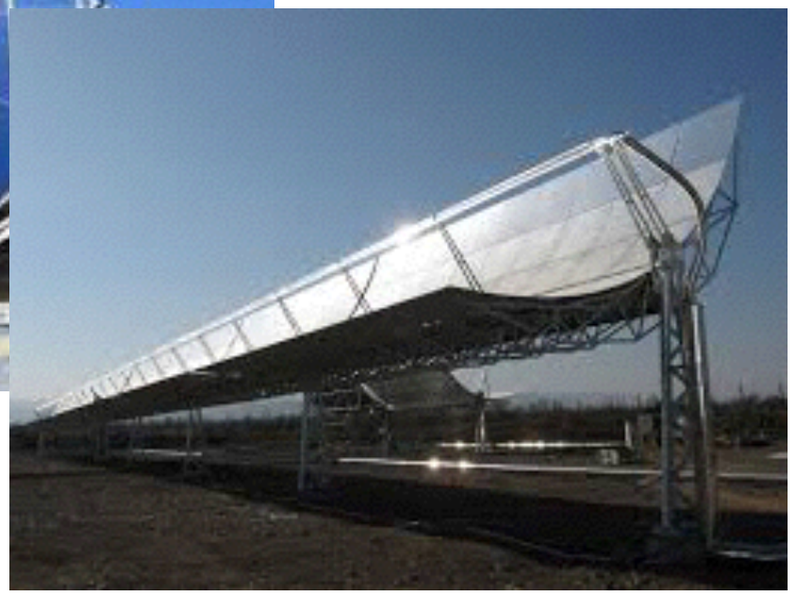
Hola ¡

¿Qué tal ¡

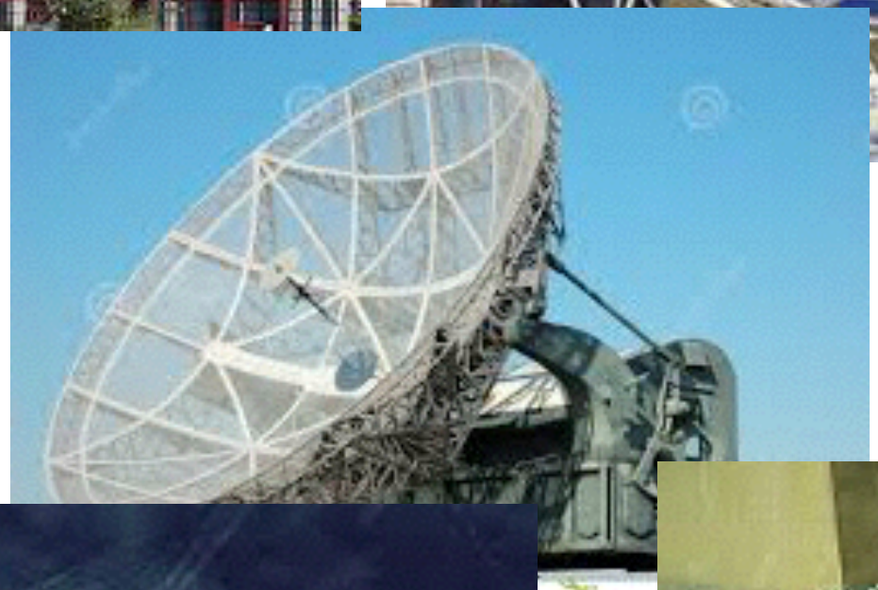
Le miroir ardent
Diocles (-180)

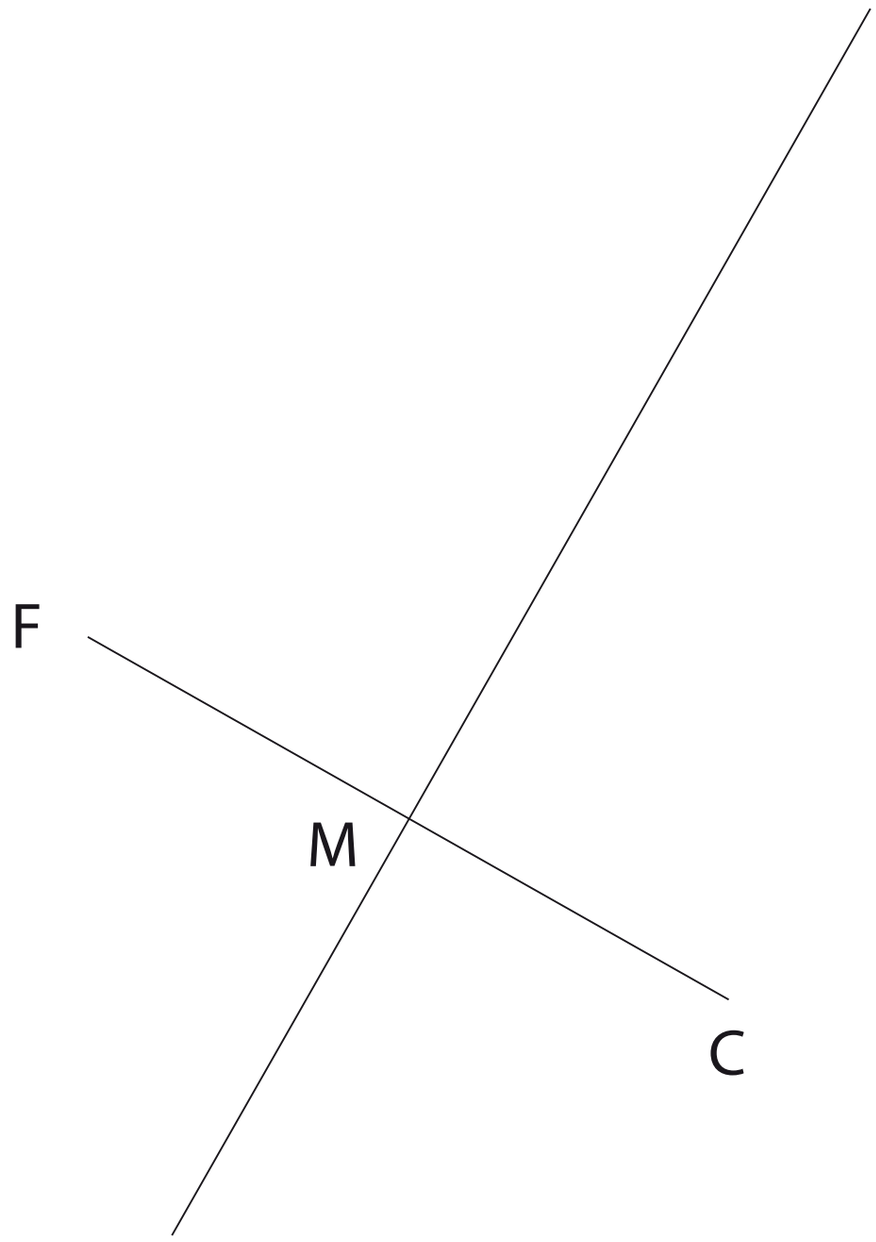


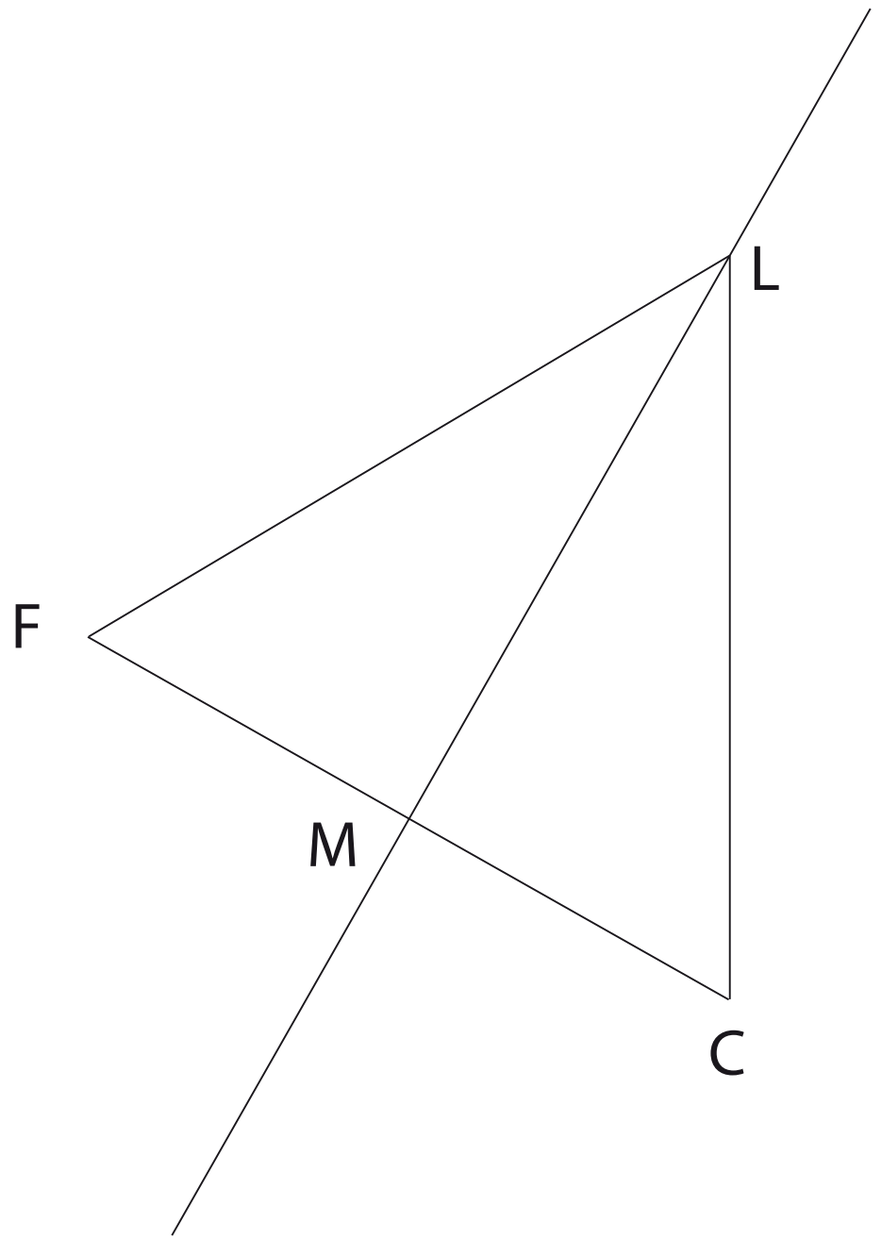
La courbe dont tous les points sont à égale distance d'un point F
et d'une droite (D) est une parabole

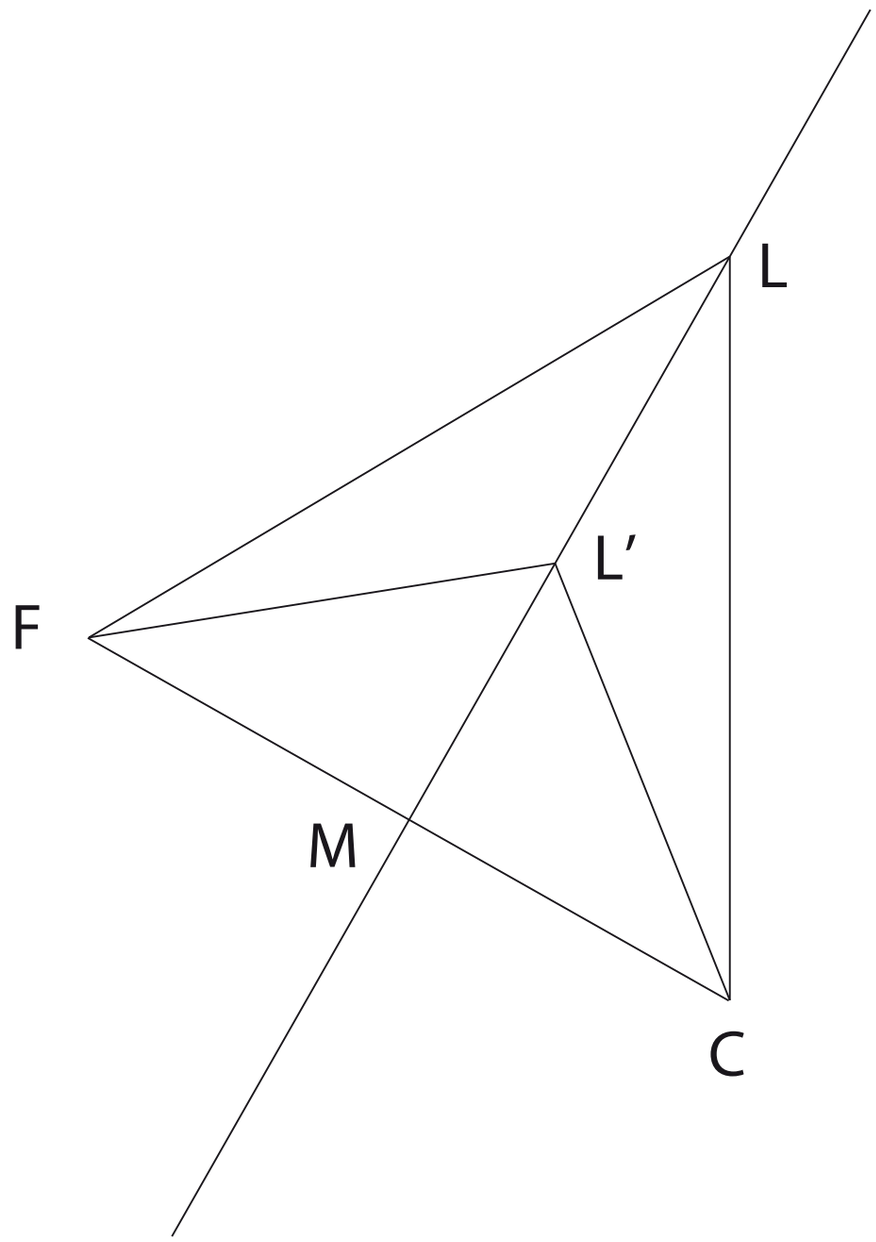


Lenson



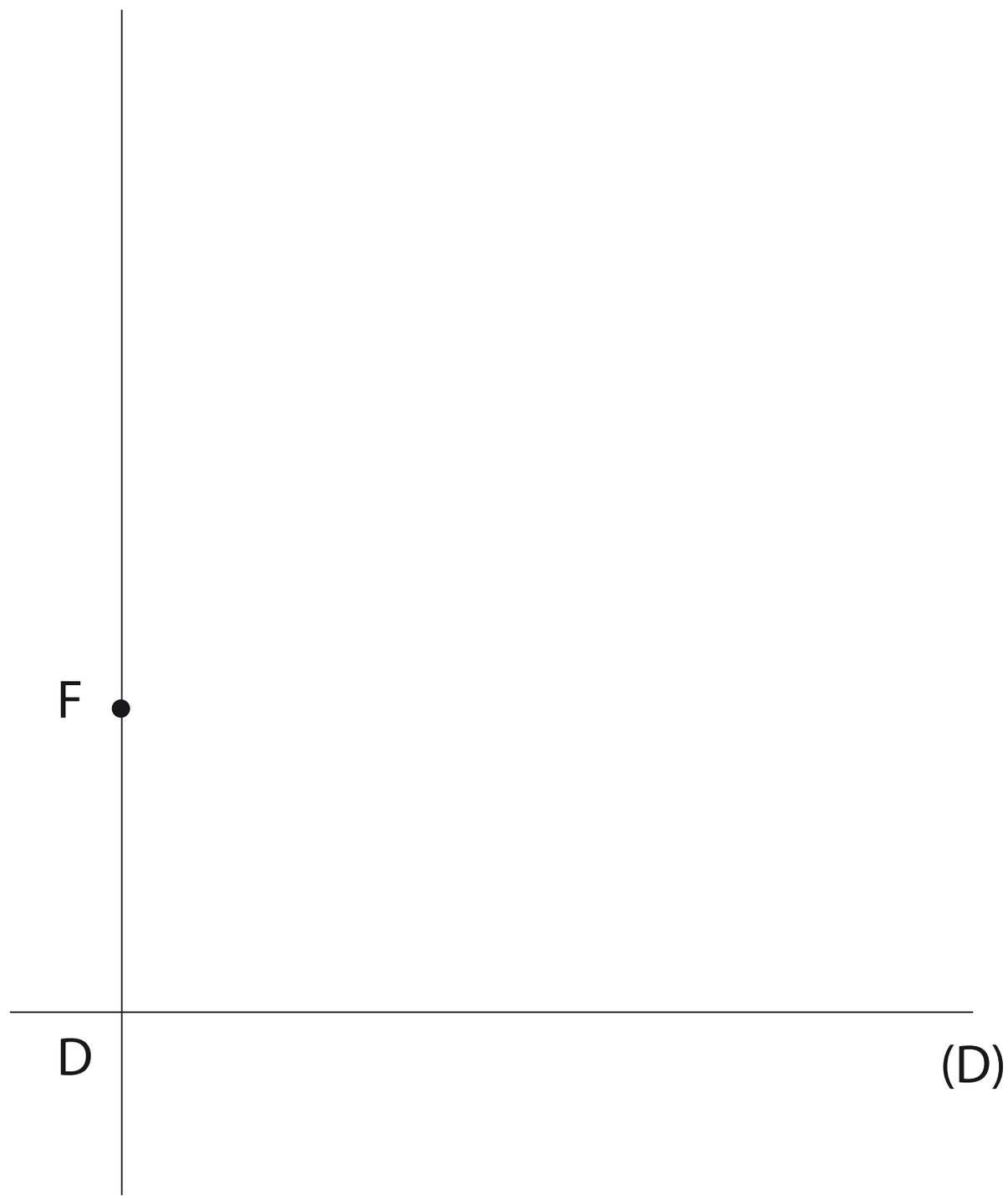

F
M
C


L
F
M
C


L
L′
F
M
C

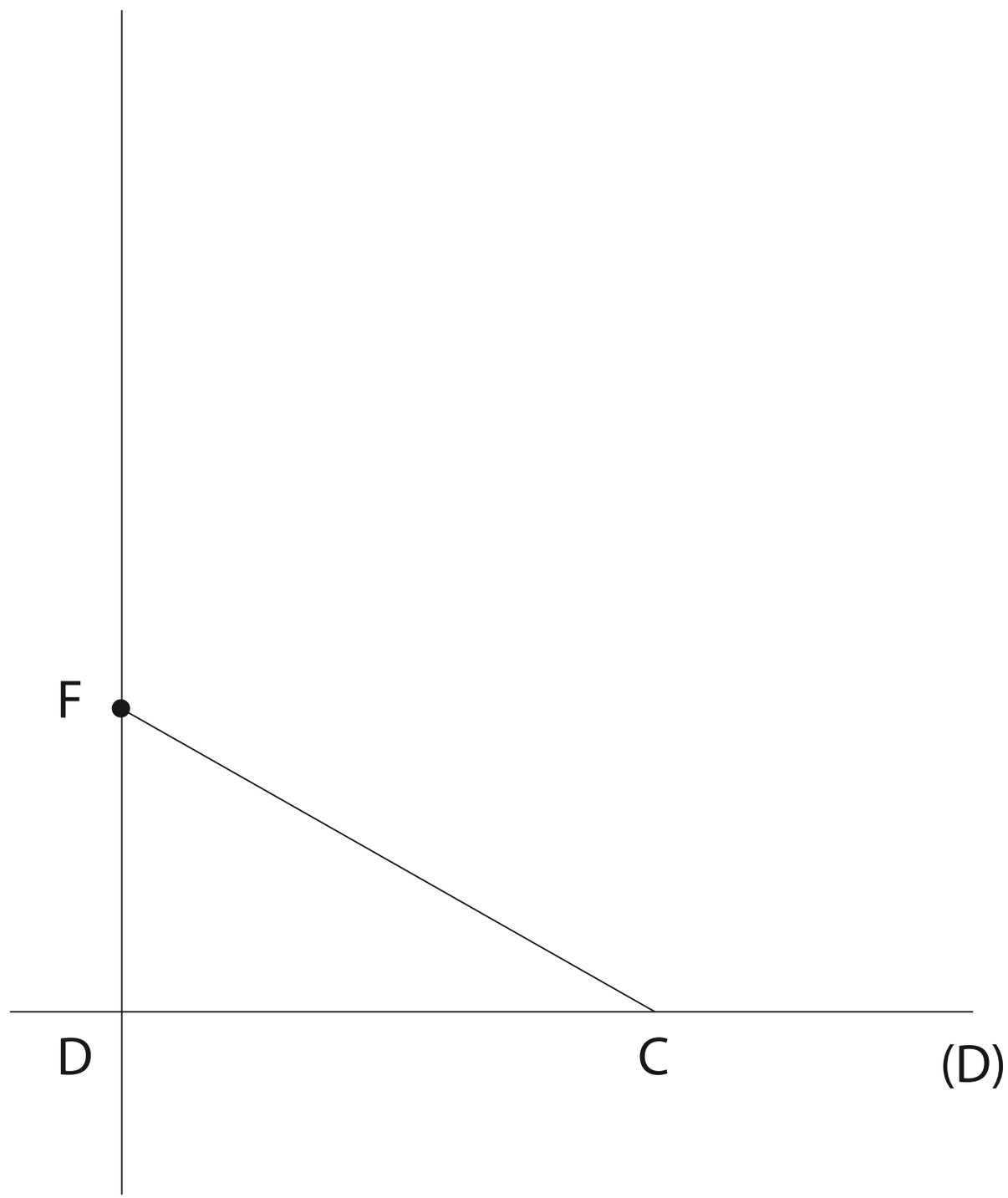
On se donne un point F, une droite (D)

On trace la droite FD perpendiculaire à (D) en D

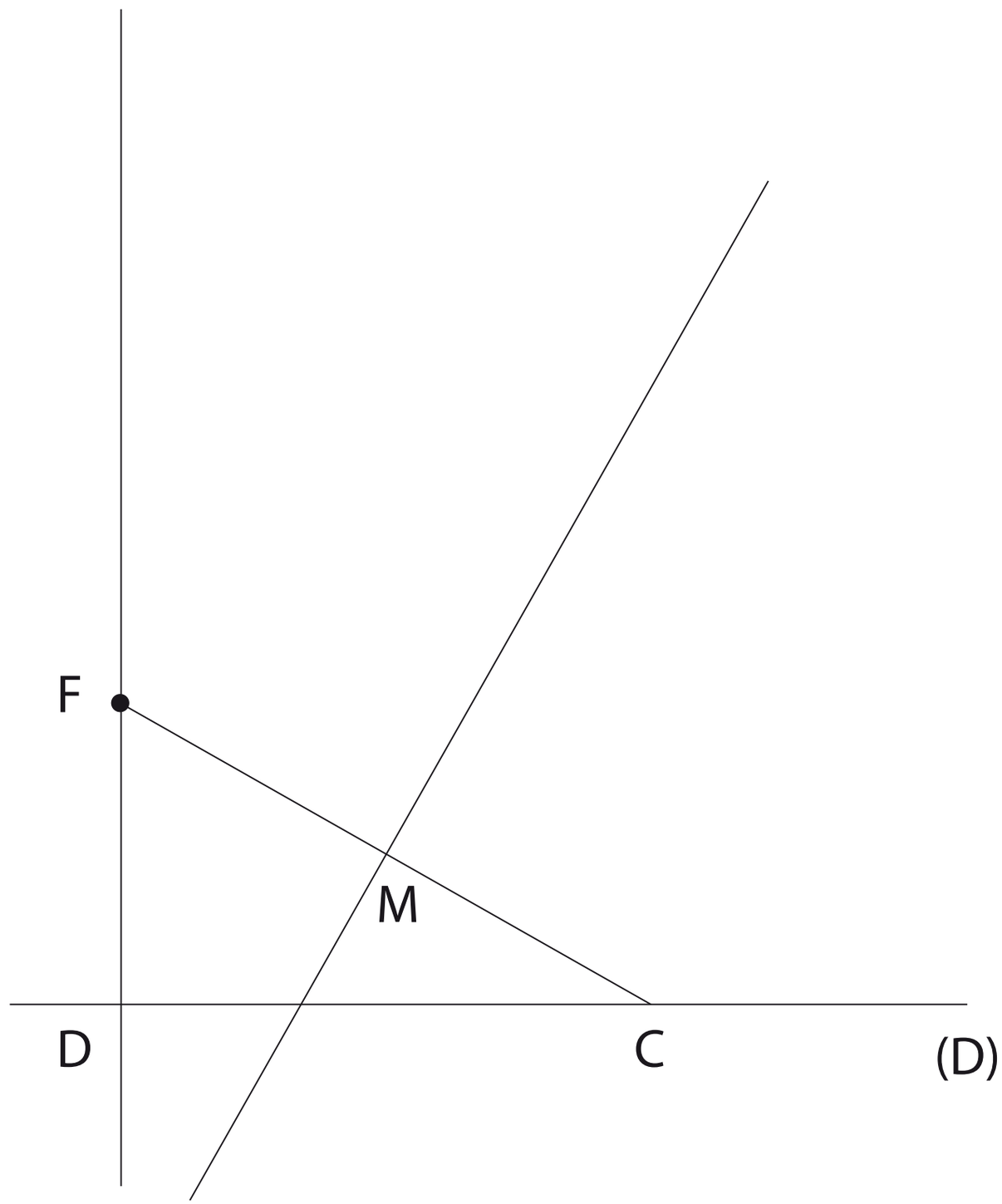


Elle représente la direction de la source lumineuse « lointaine »

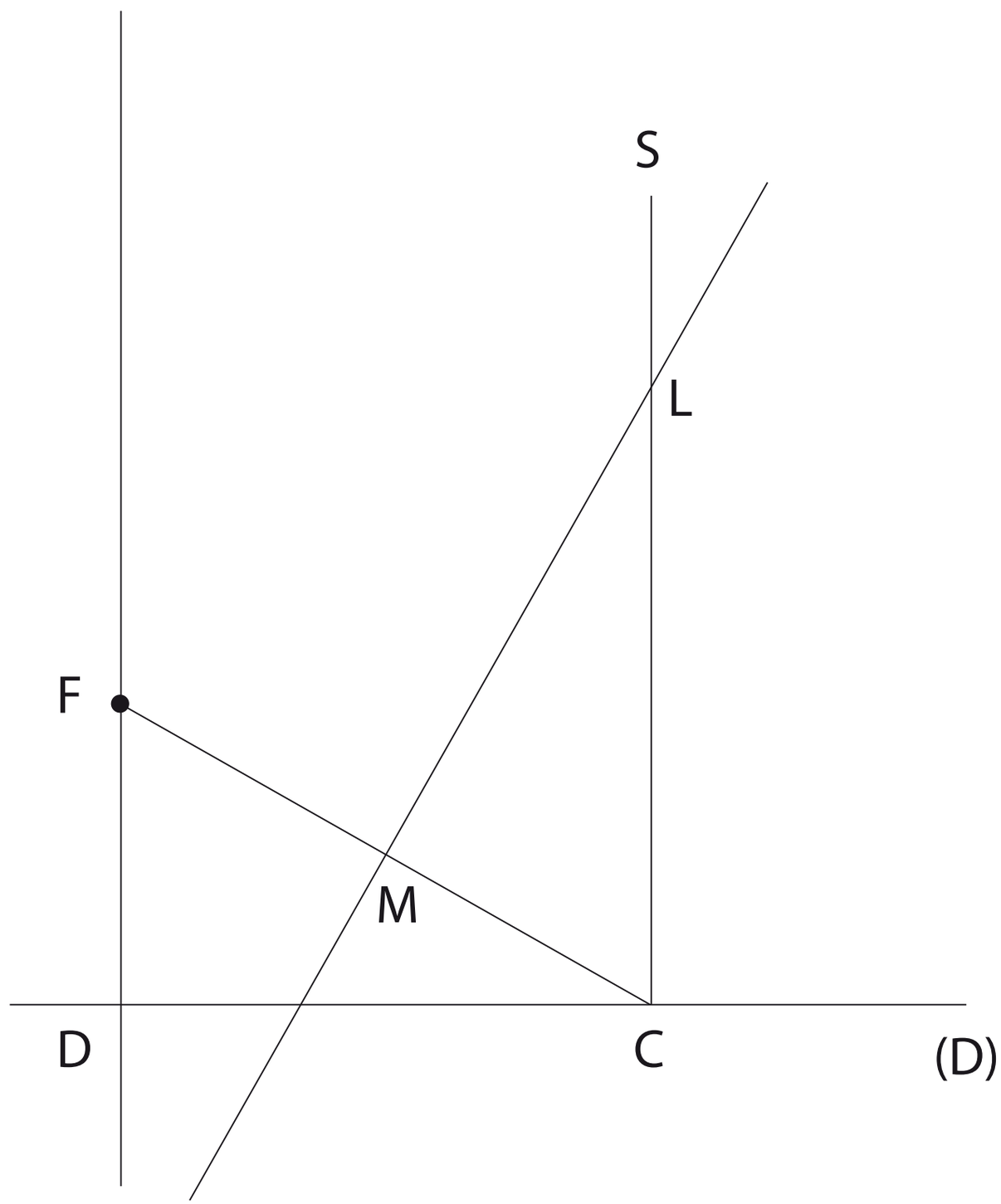
On joint F à un point quelconque C de (D)



On trace la médiatrice de FC

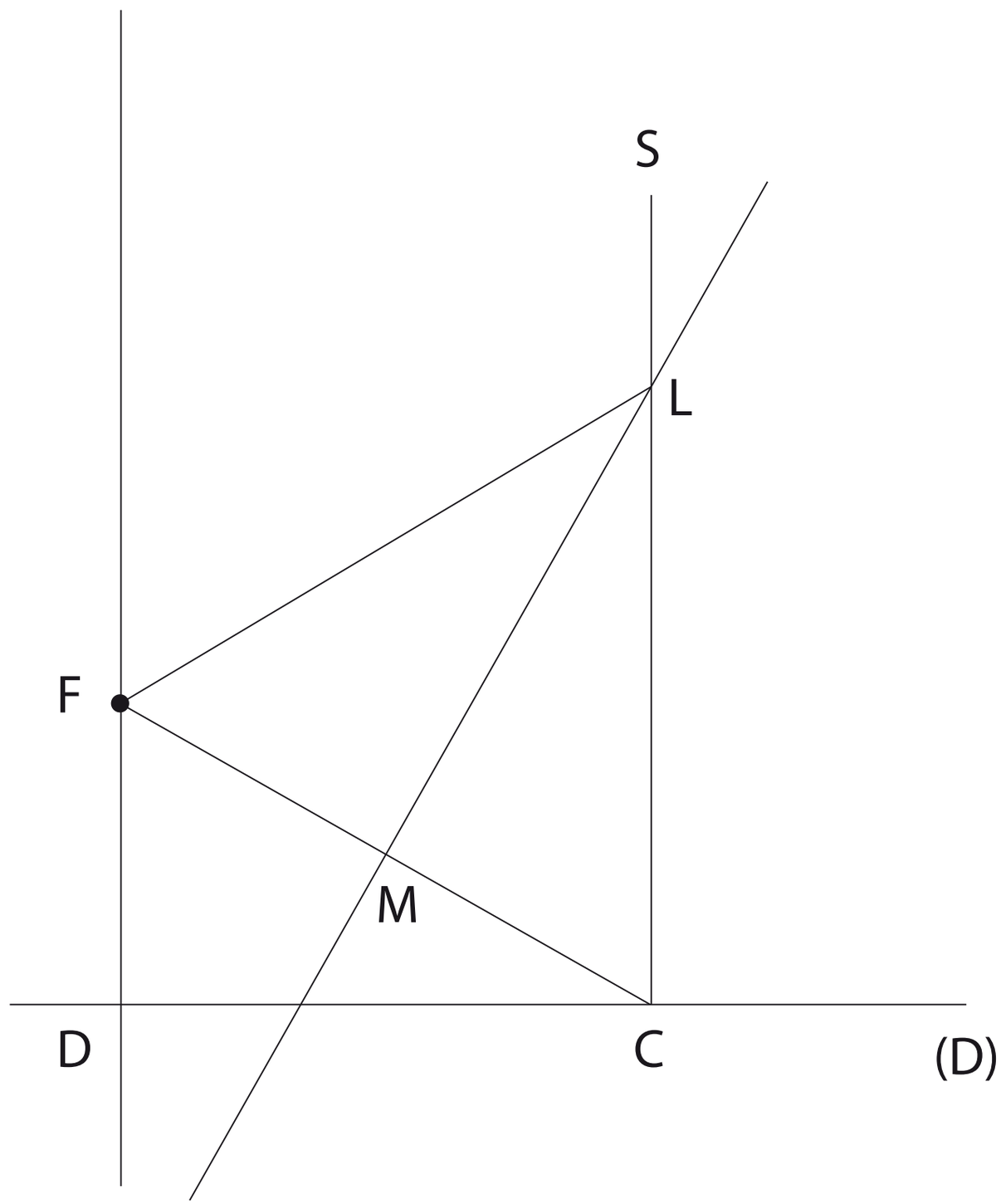


On trace la direction de la source CS passant par C



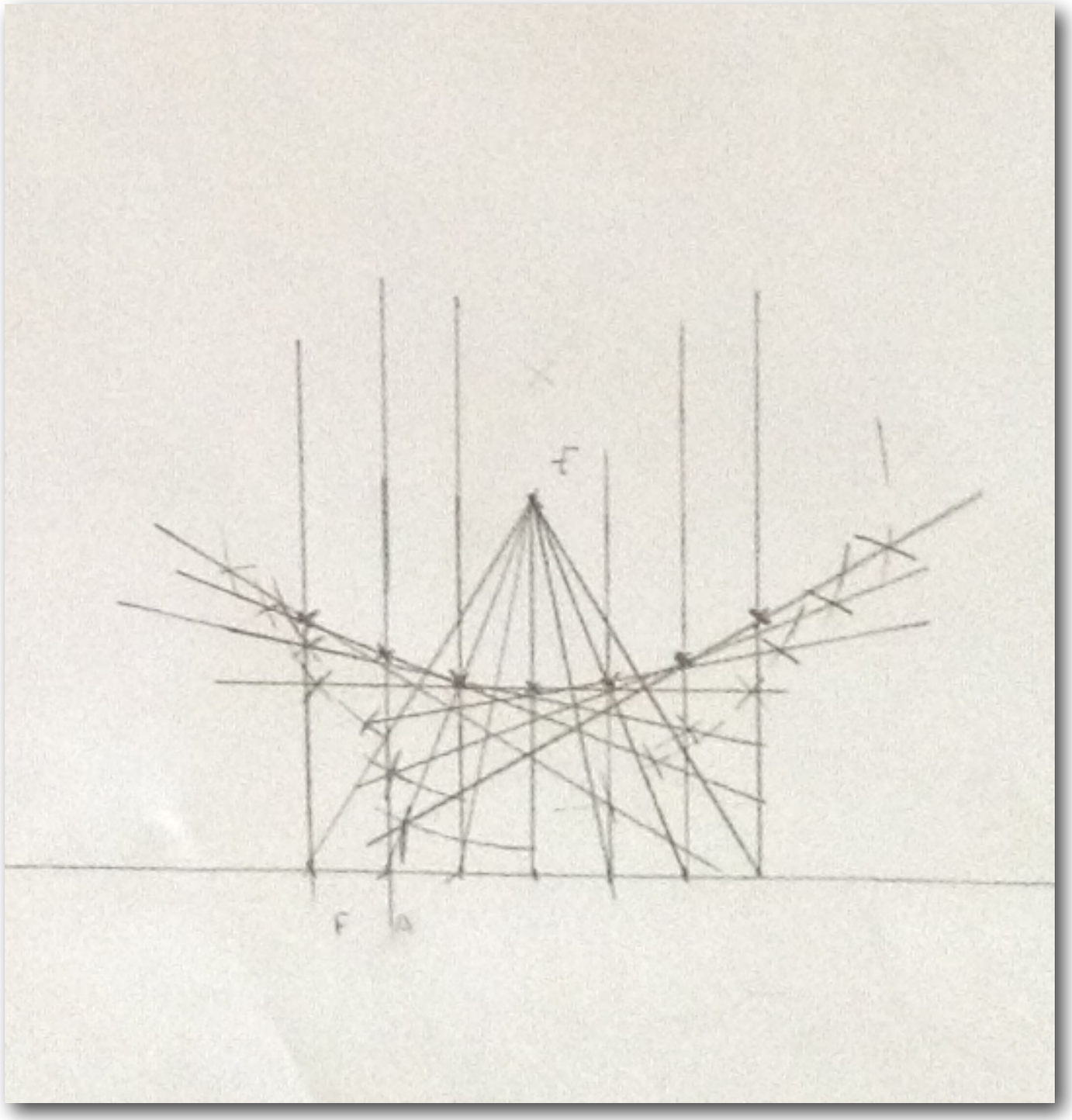
Elle coupe la médiatrice en L

On joint F et L



L appartient à la parabole car LF=LC

Construction d’une élève au« Compas et à la Règle »



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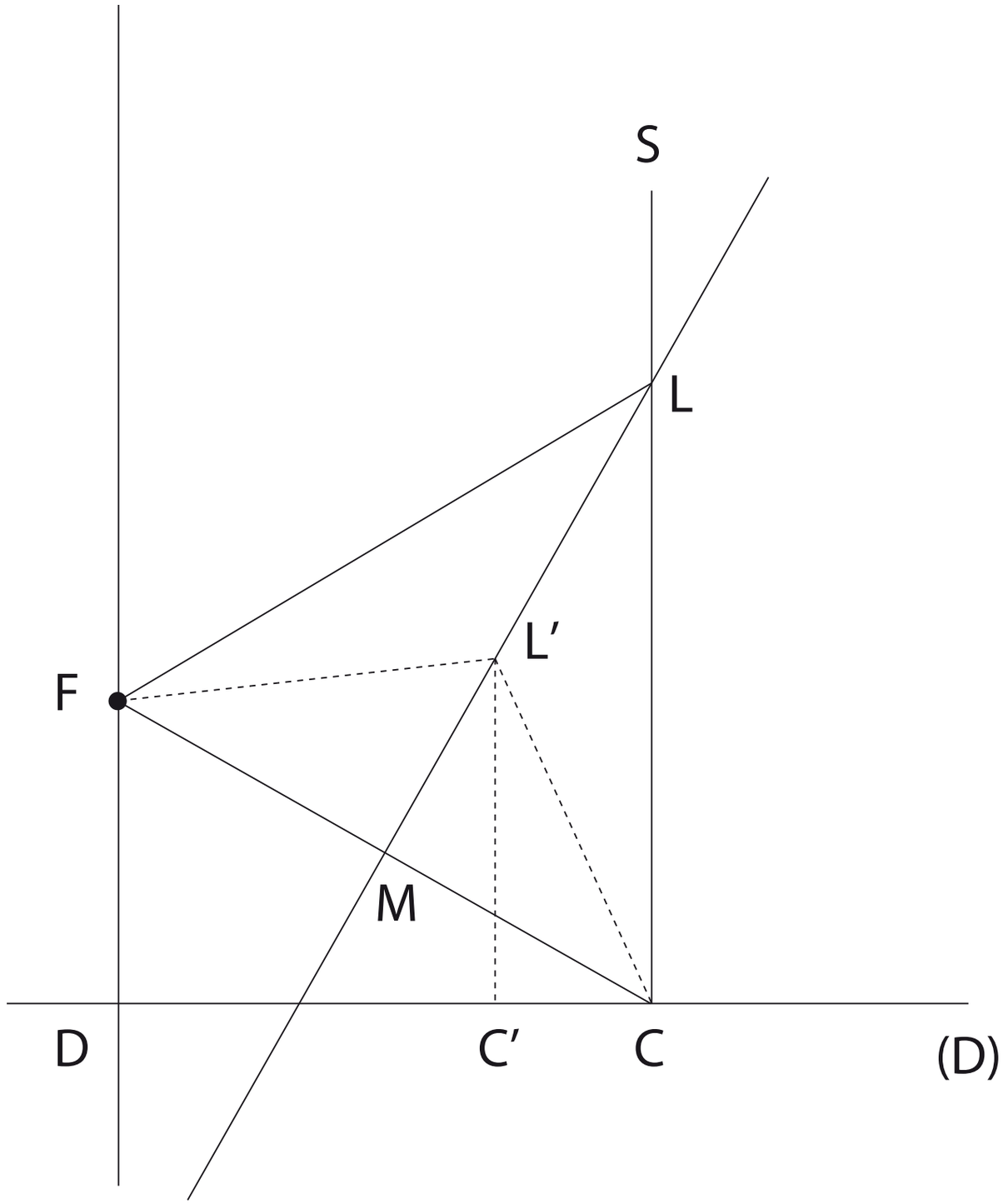
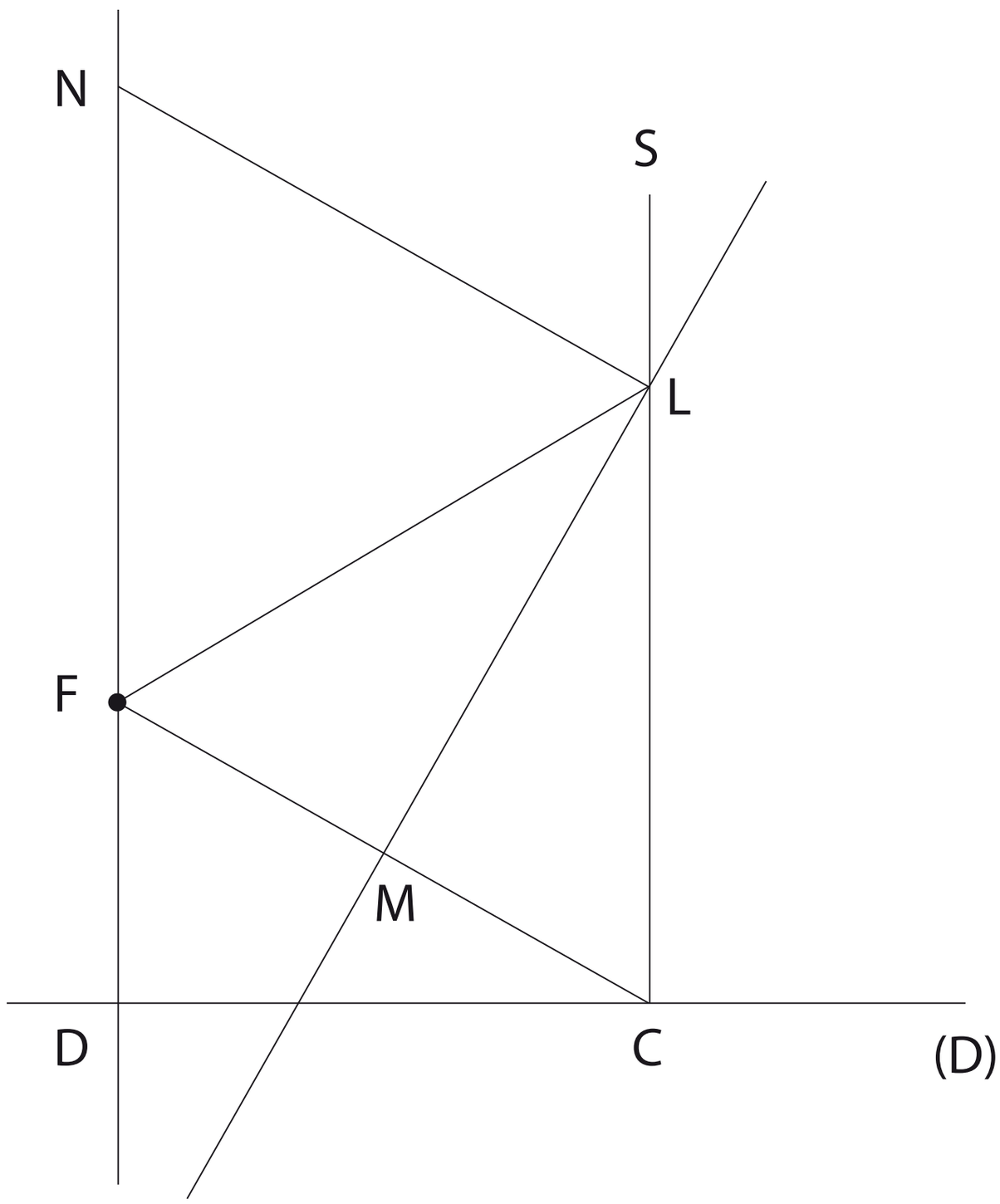
ML est tangente à la parabole



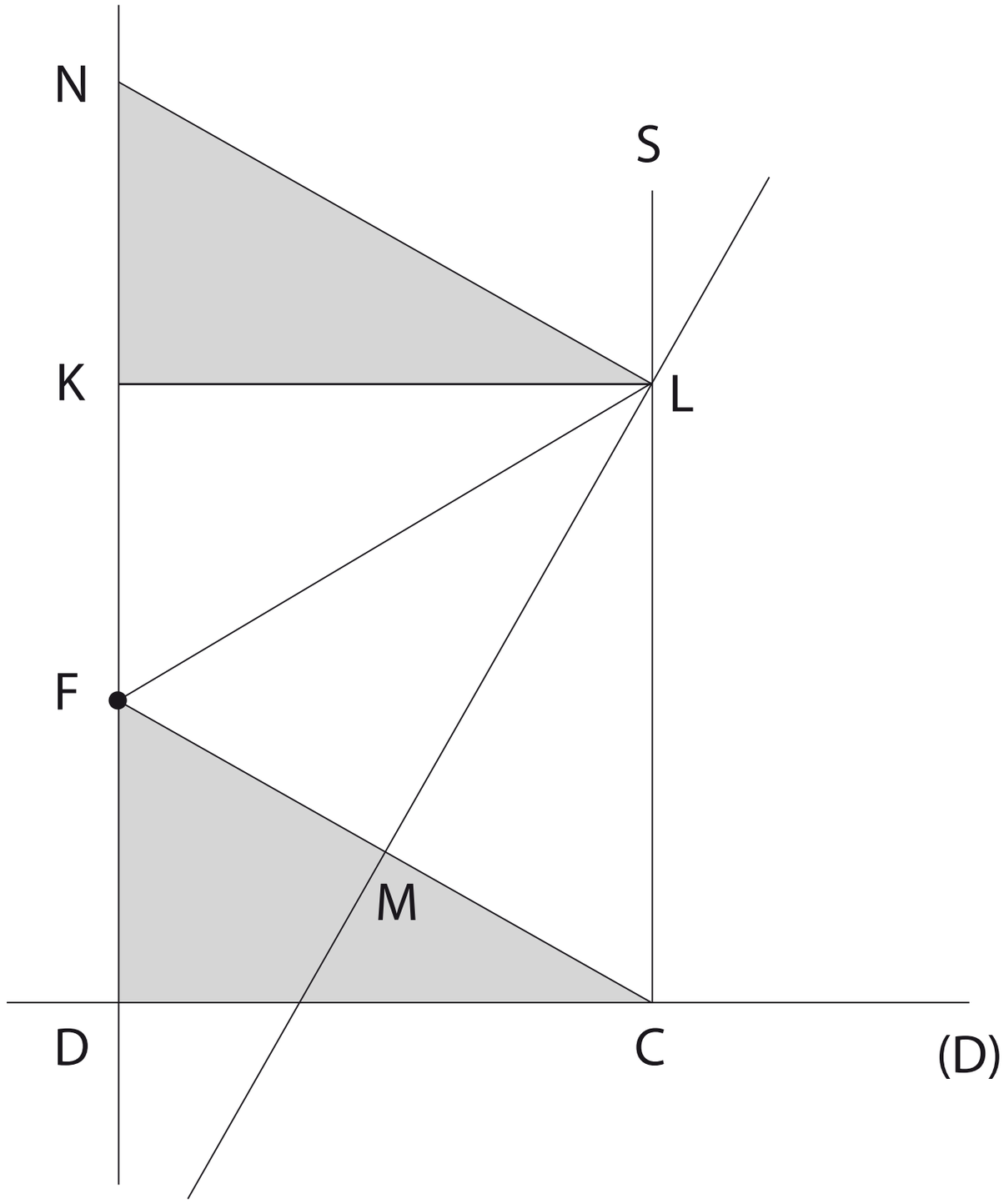
FL'=L'C>L'C'

FC est perpendiculaire à ML, tangente à la parabole



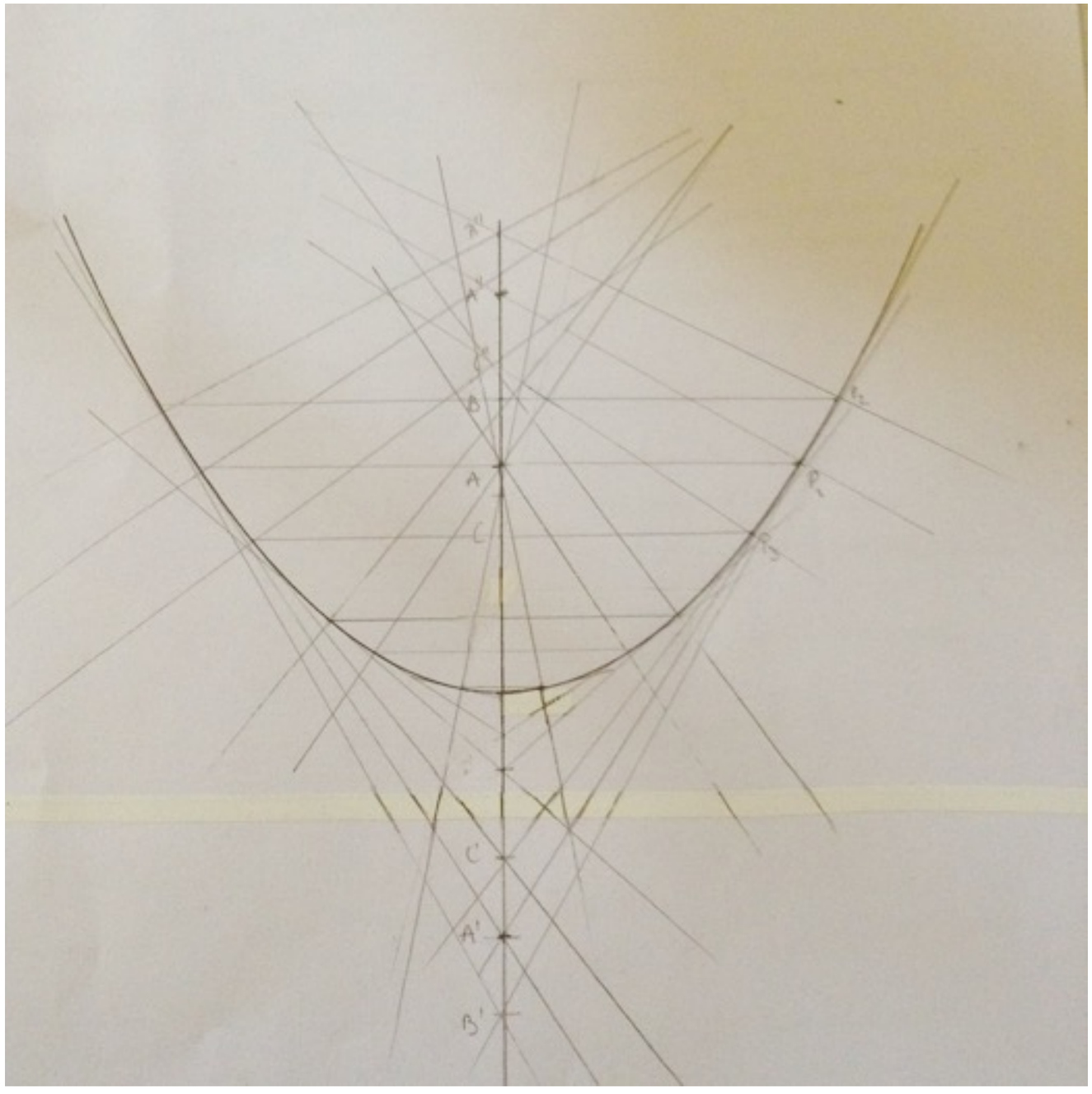
LN, parallèle à CN est la normale à la parabole en L

Les triangles rectangles grisés sont égaux



KN=DF, distance entre le foyer et la directrice

Les normales dessinées par les élèves



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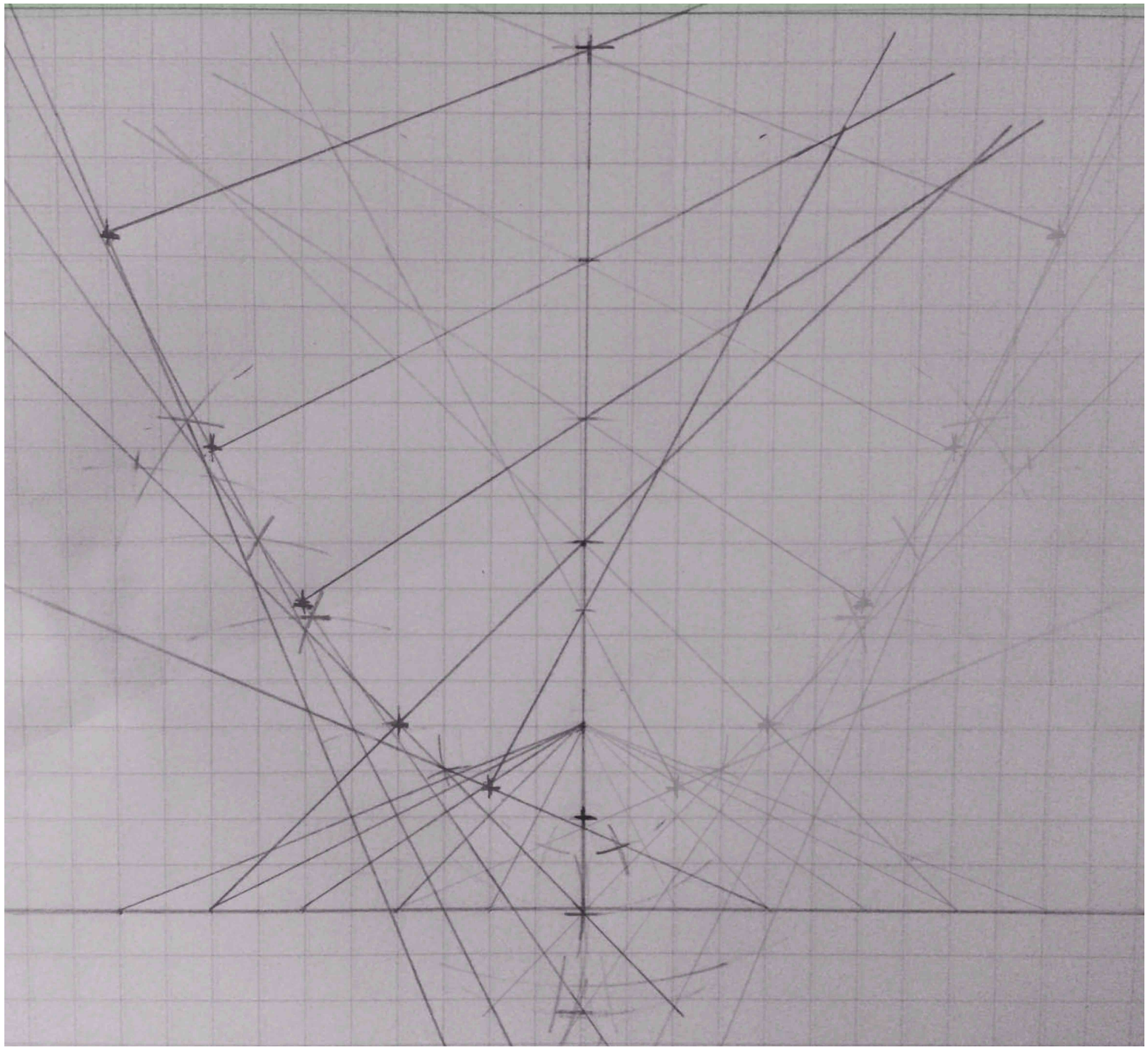
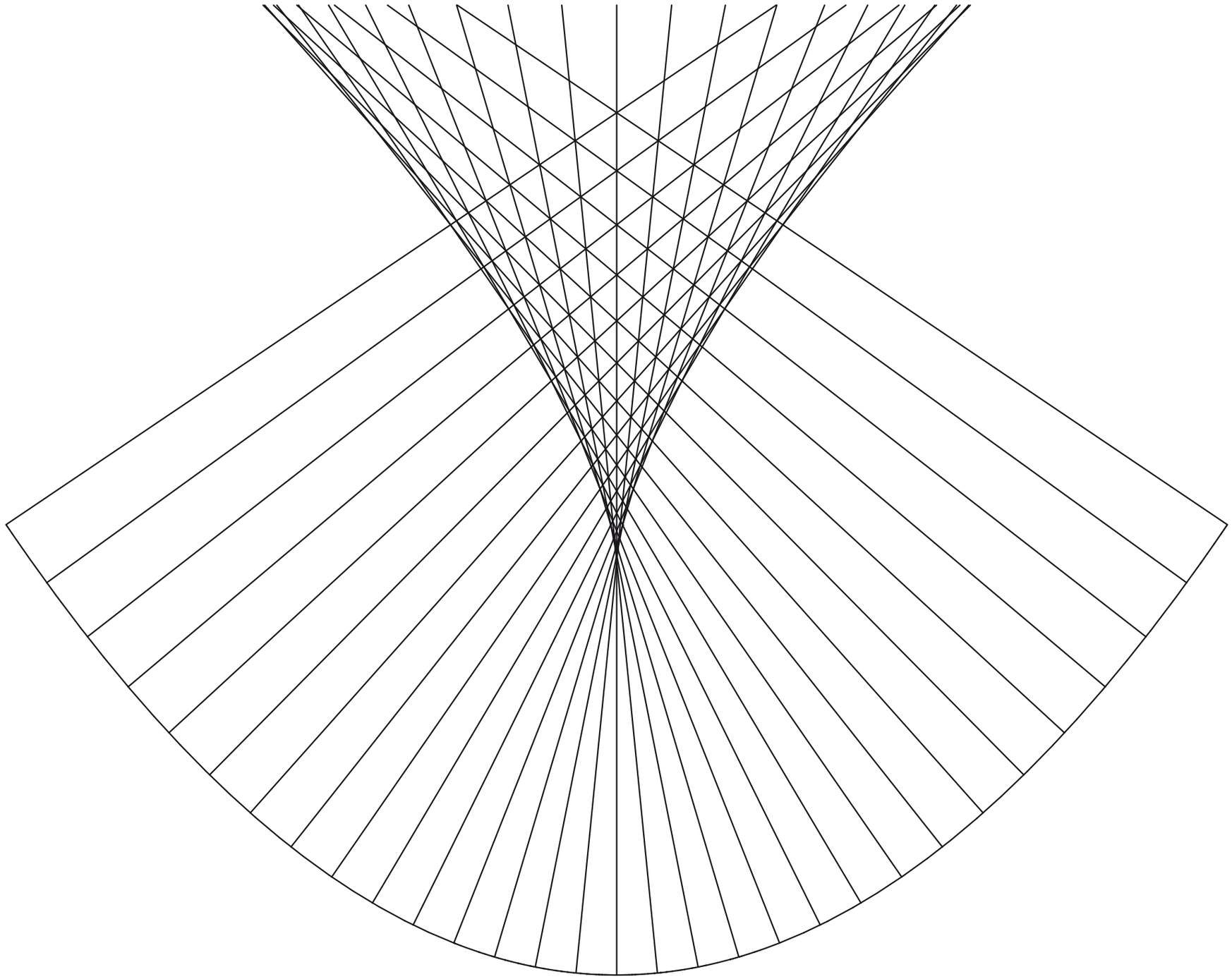
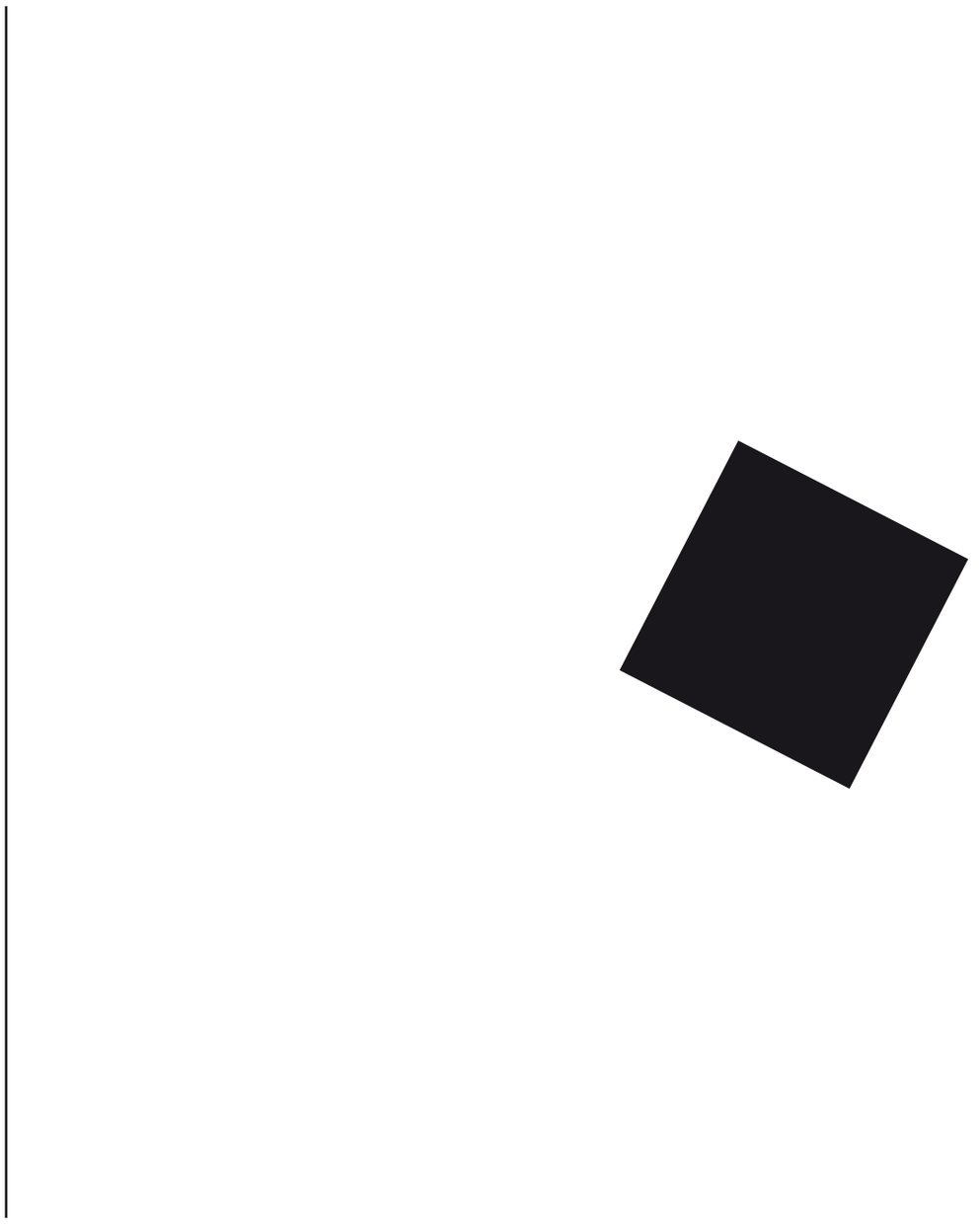
Ma construction

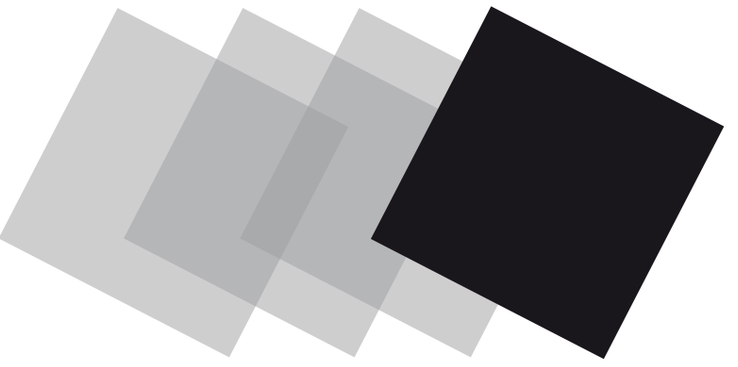


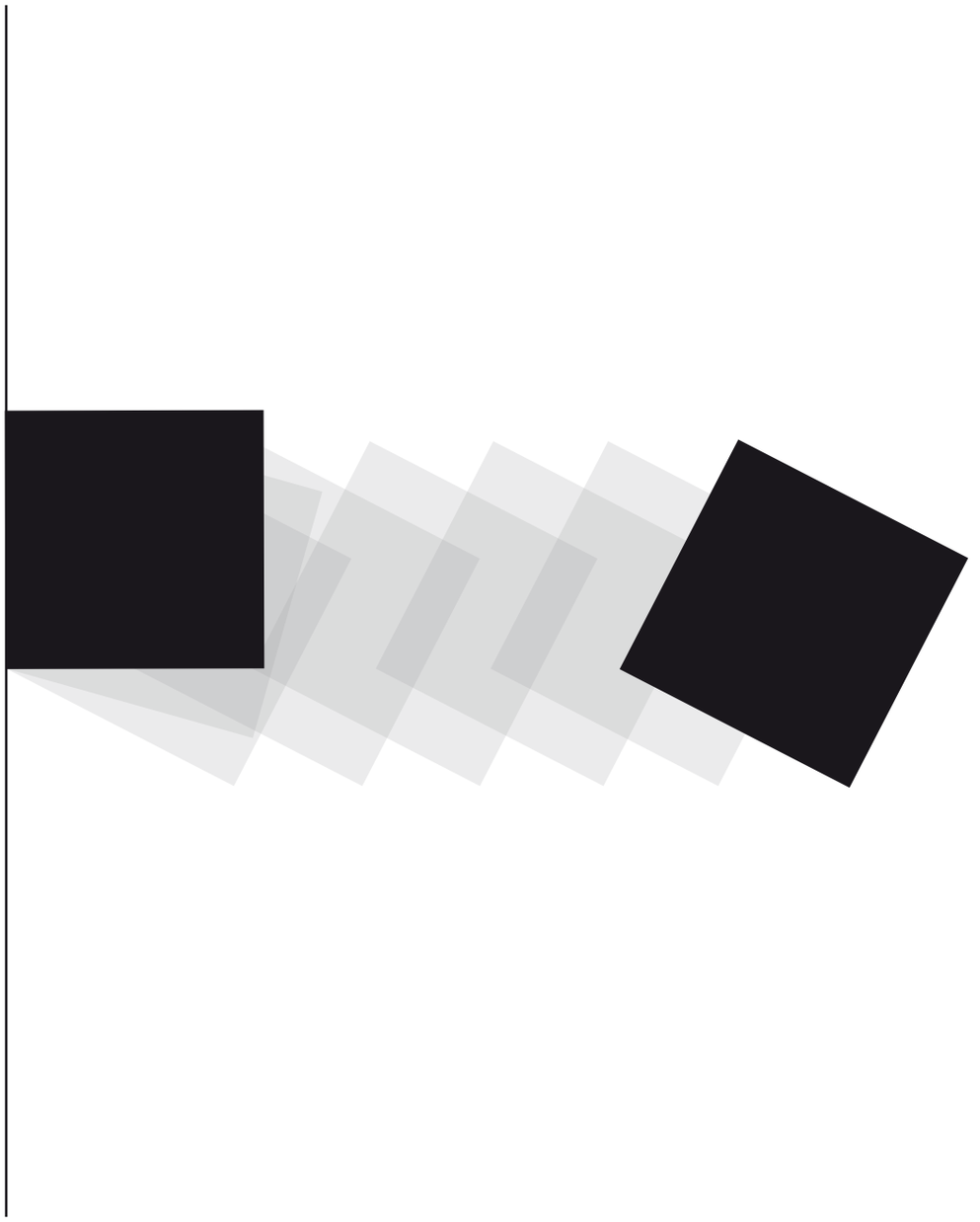


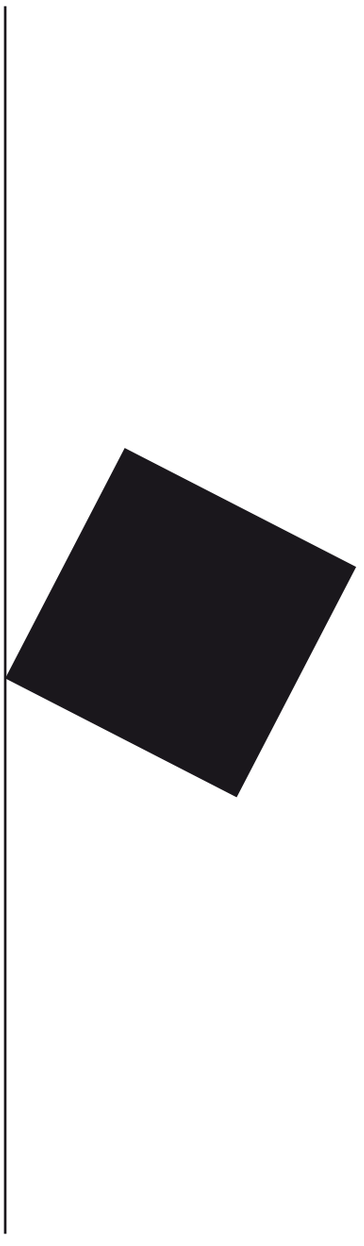
De l’équilibre à la stabilité des corps flottants

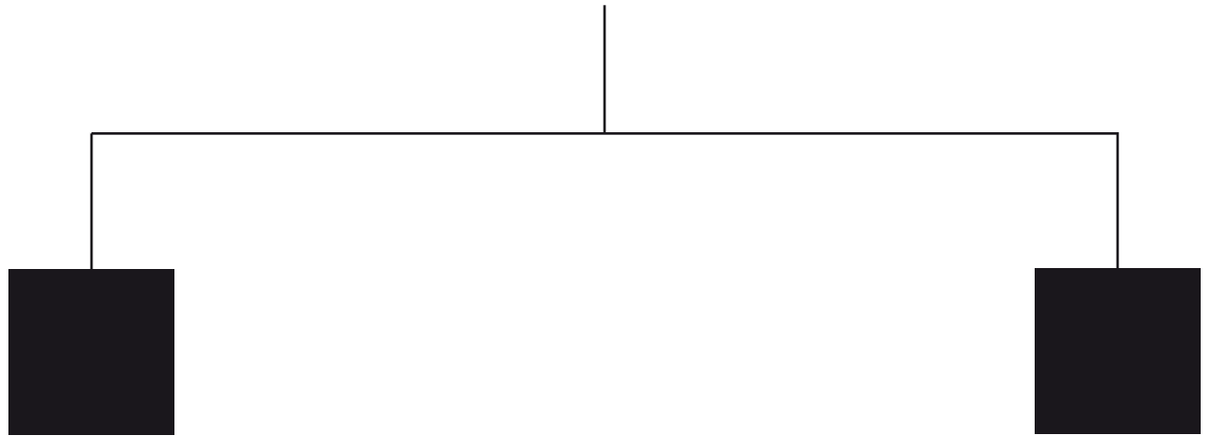
Archimèdes

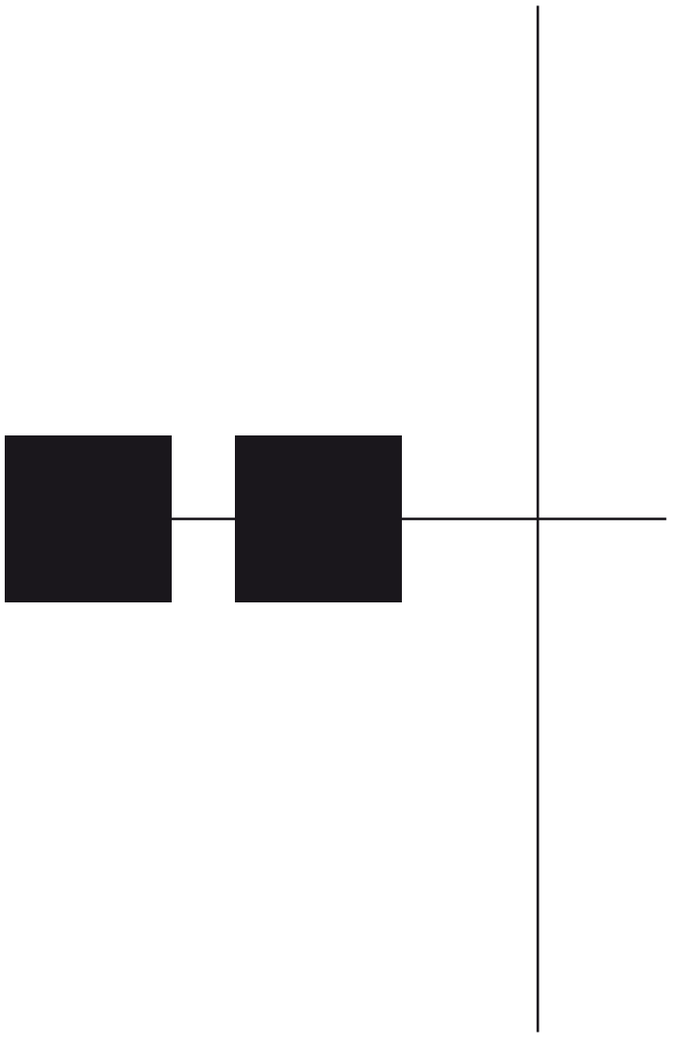


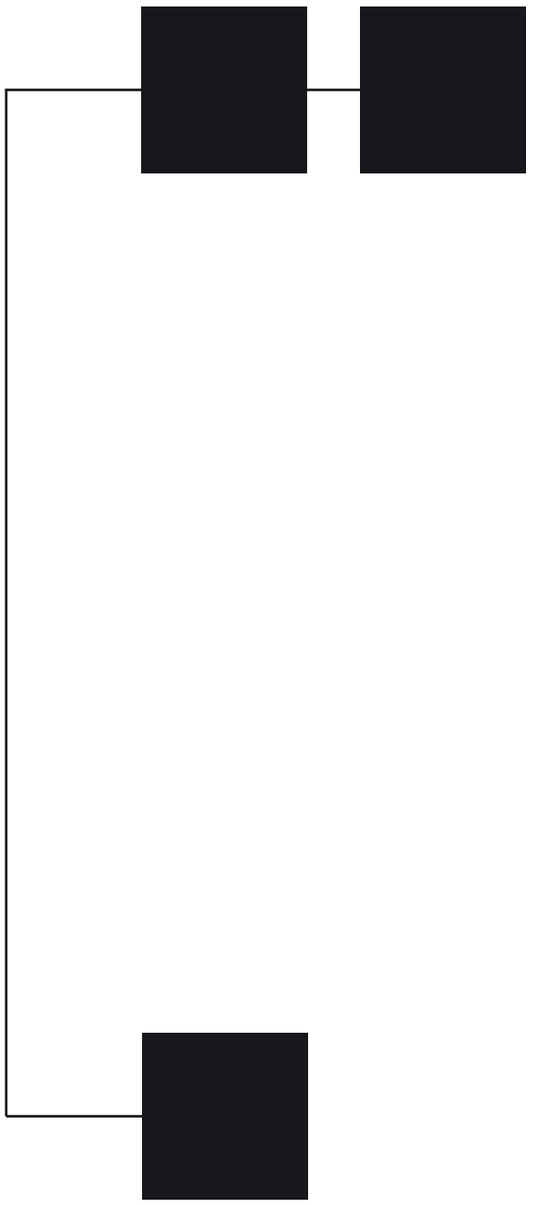


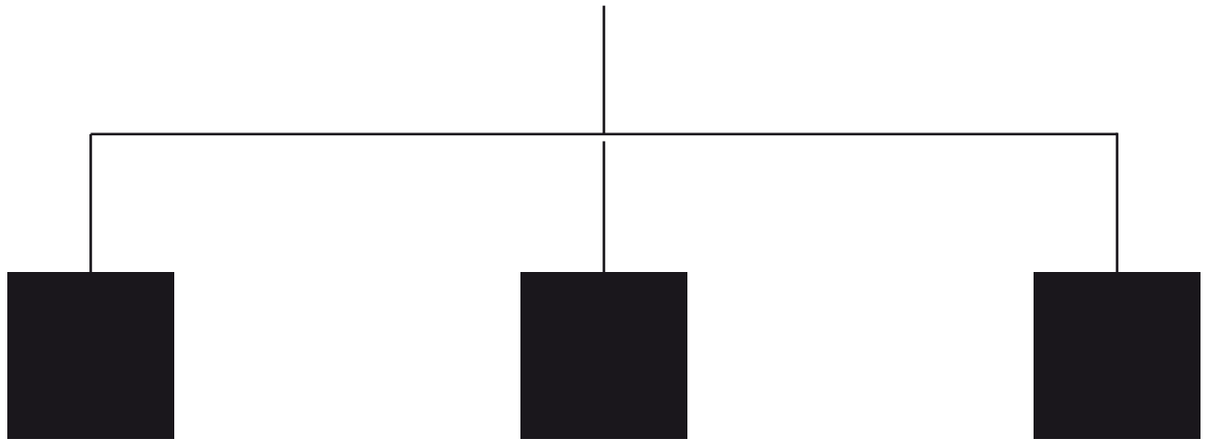


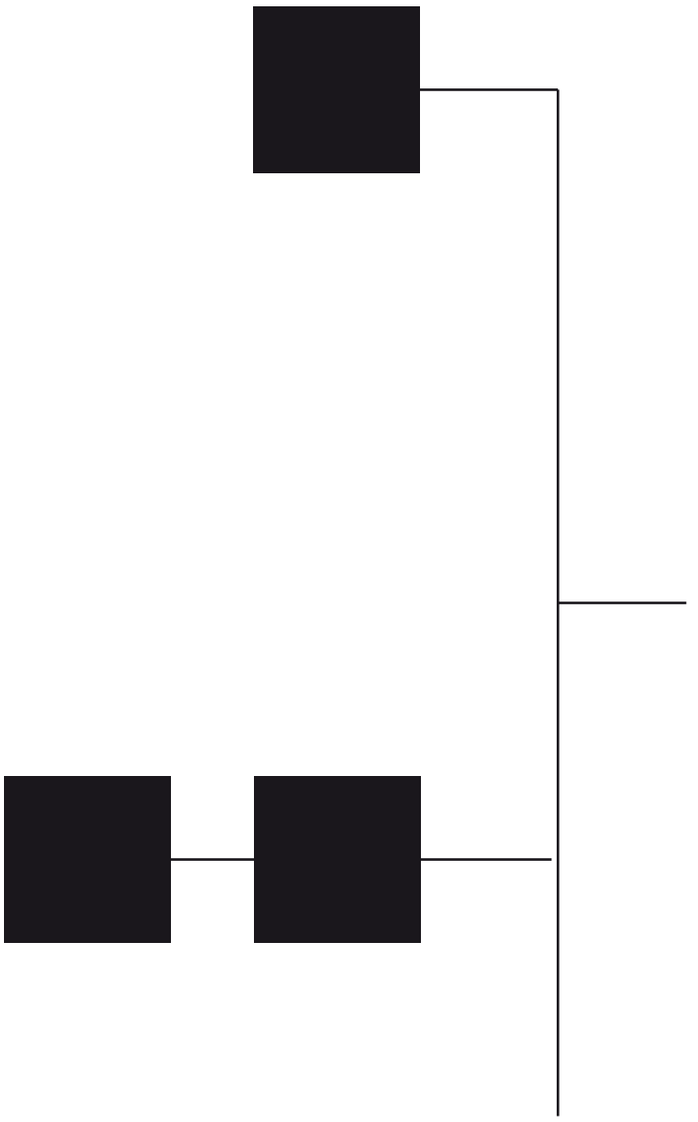


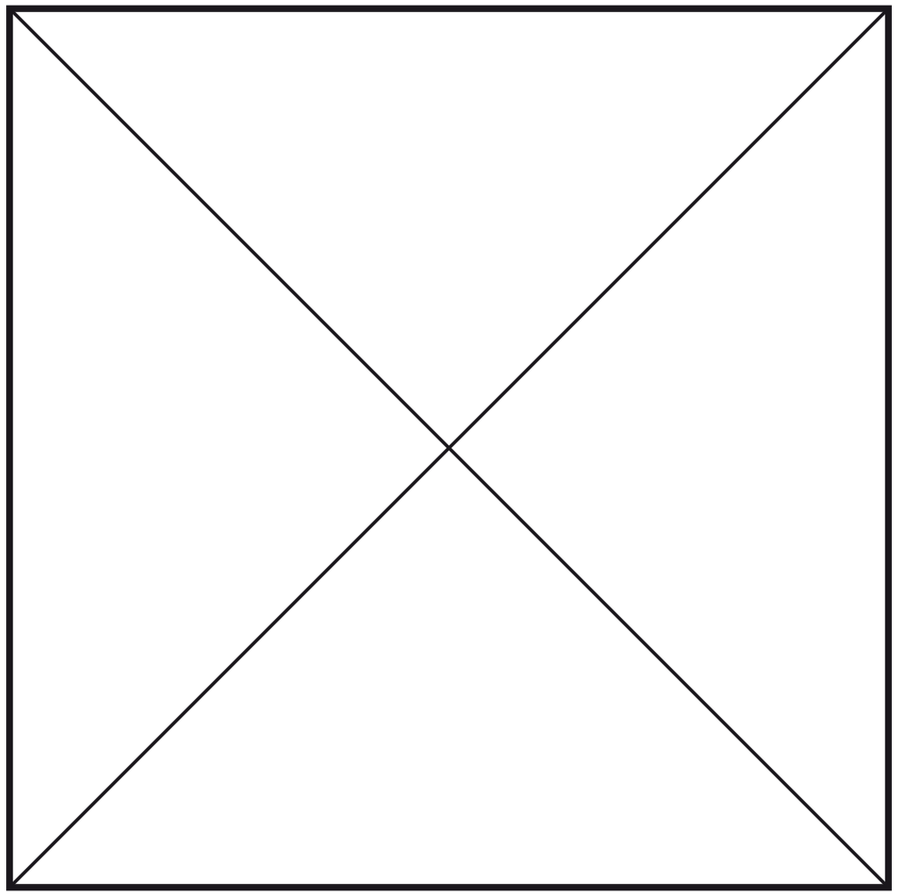


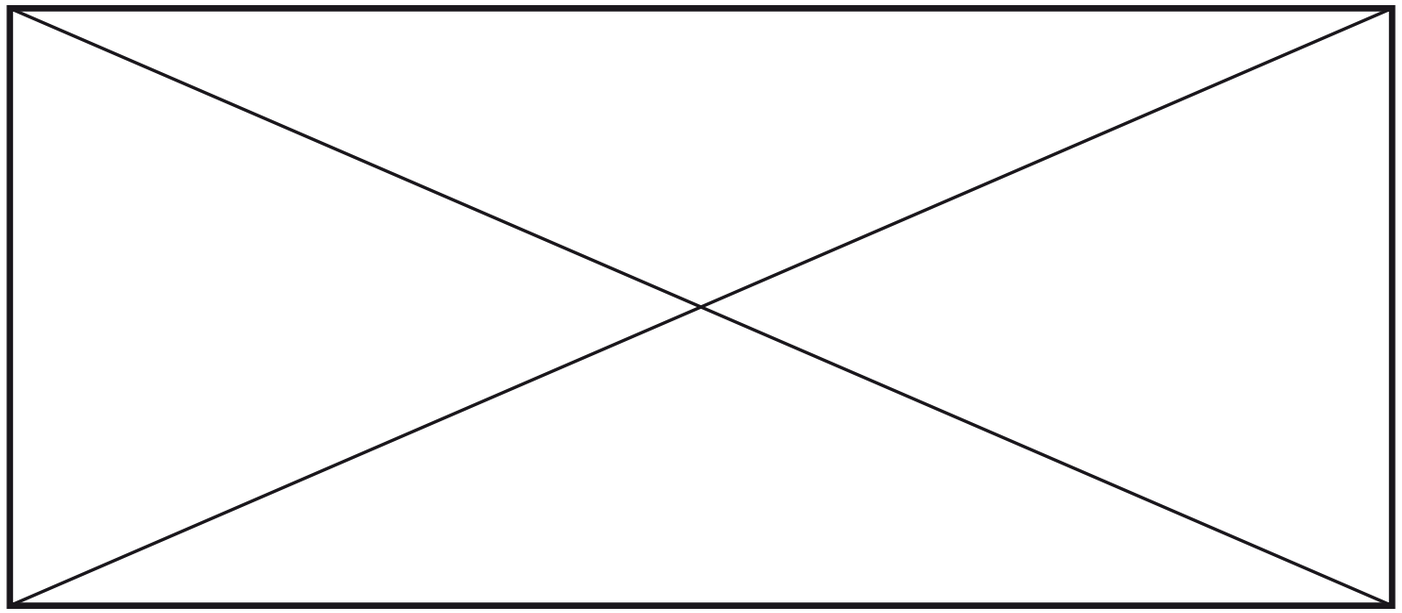


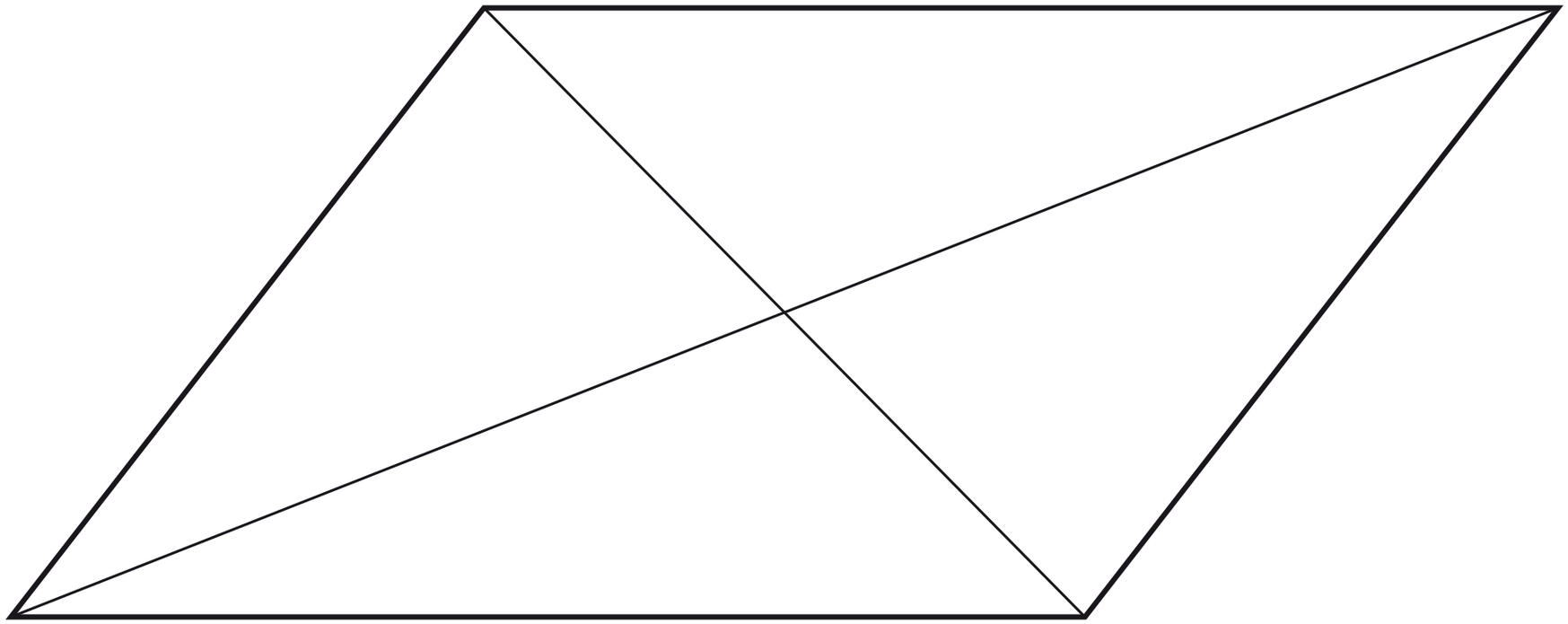












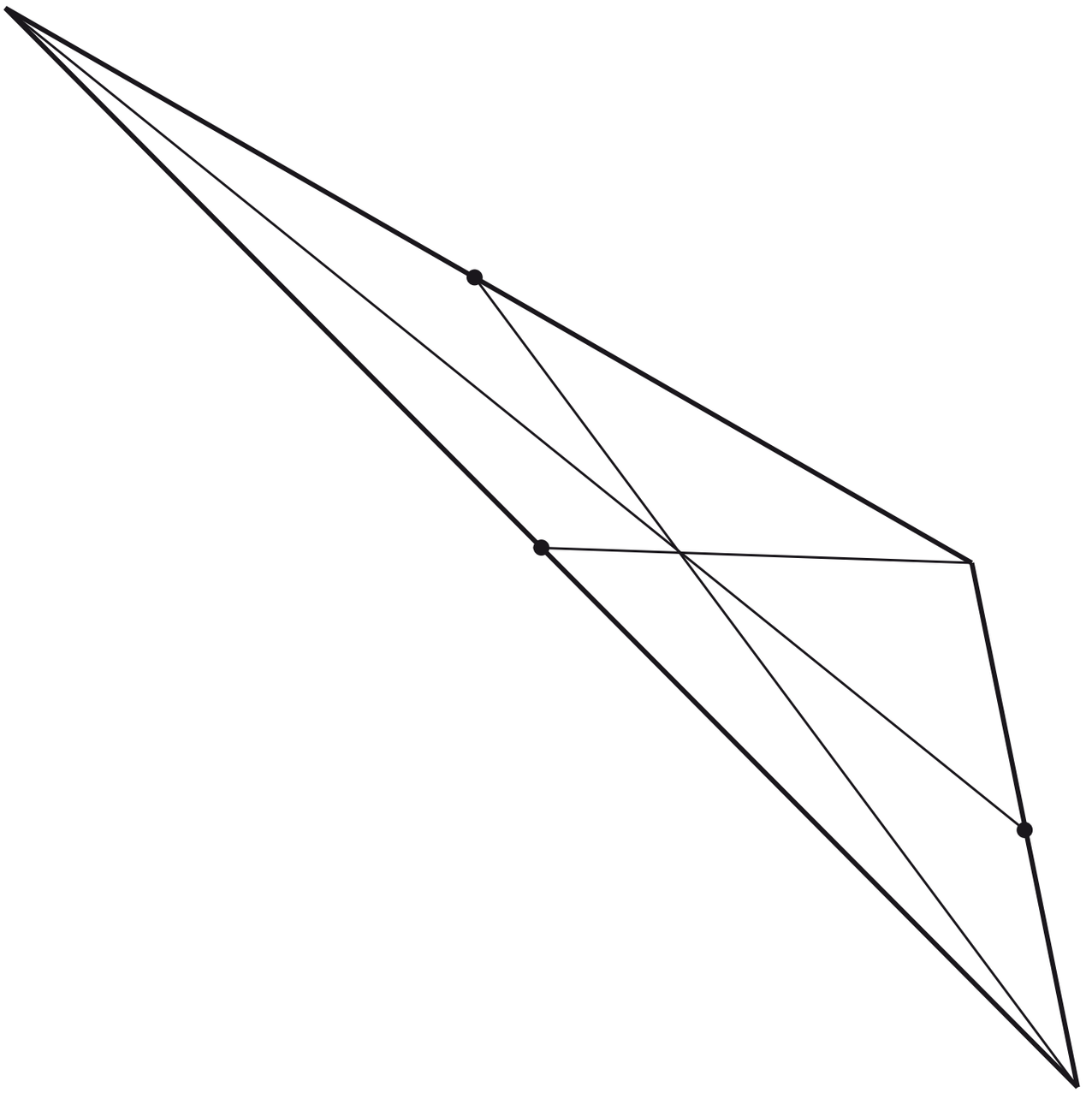
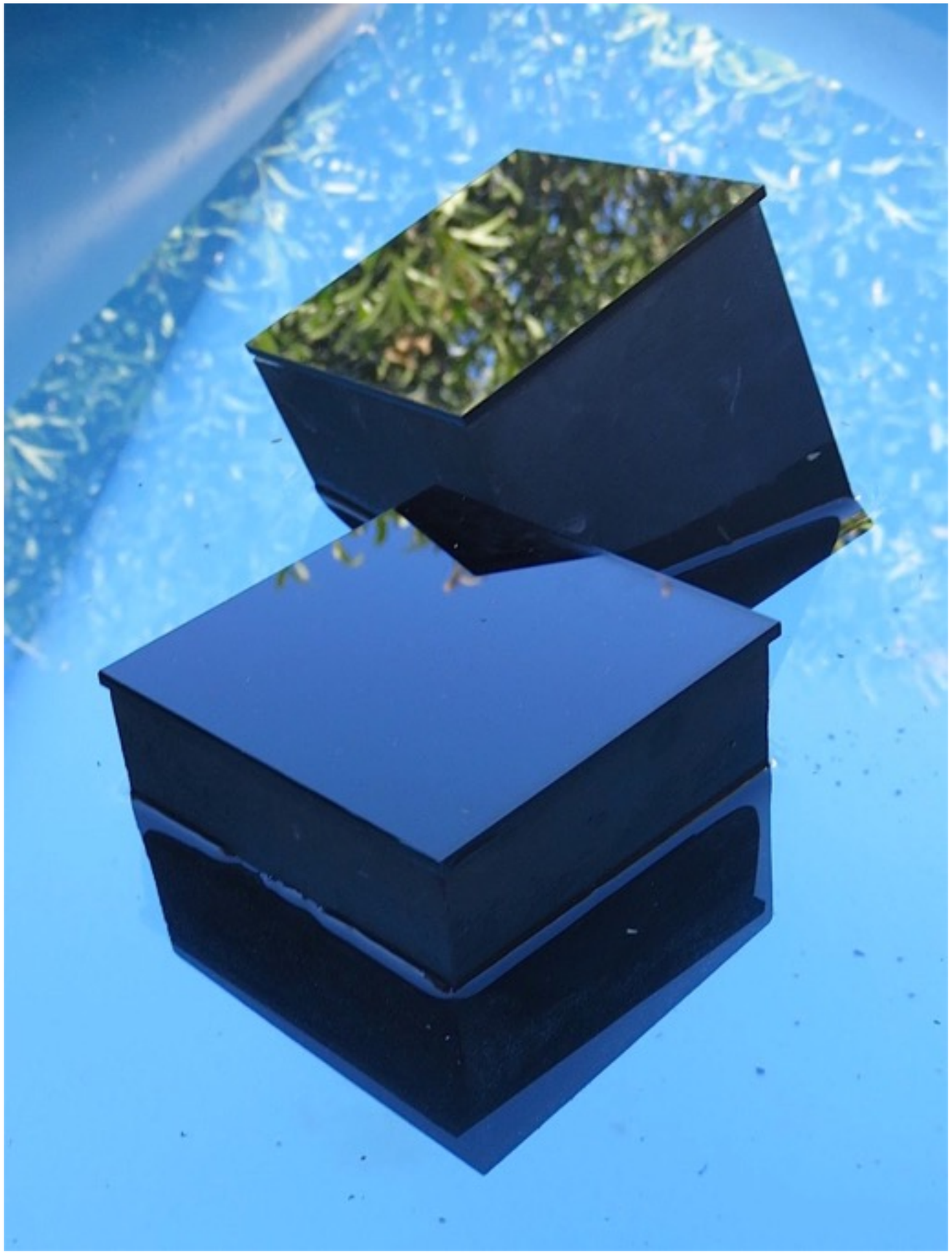
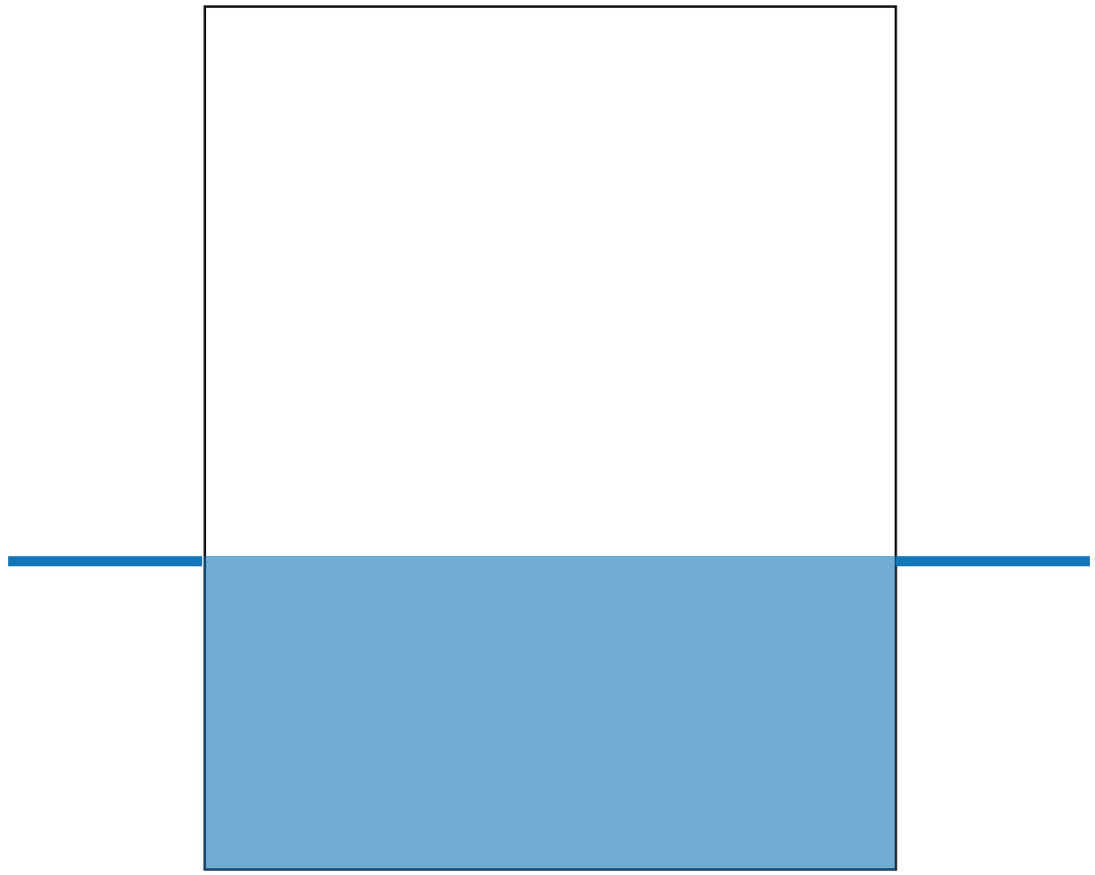


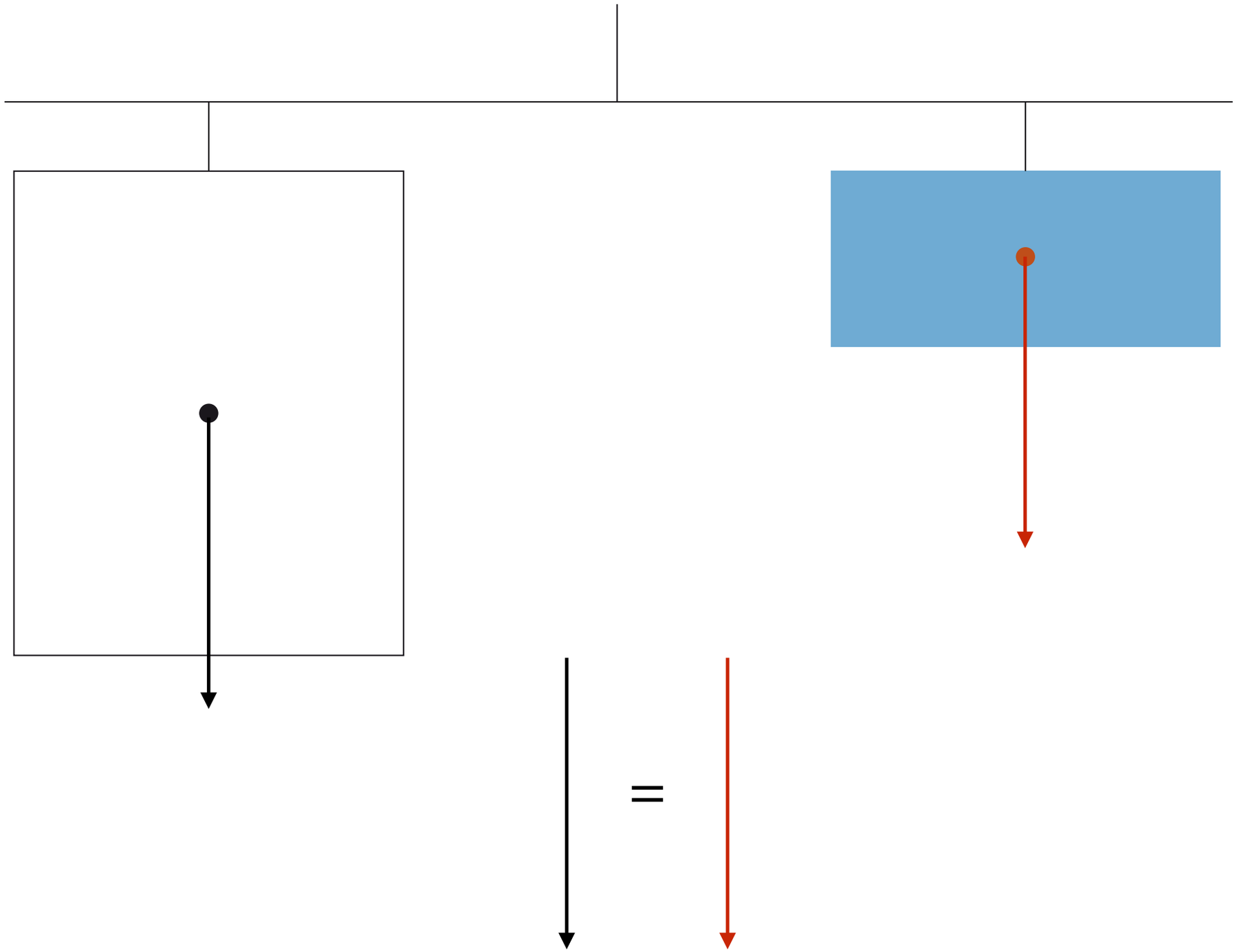
Illustration de la catastrophe du « Vasa »
10 Août1628



Un parallélépipède flottant en position d ‘équilibre verticale

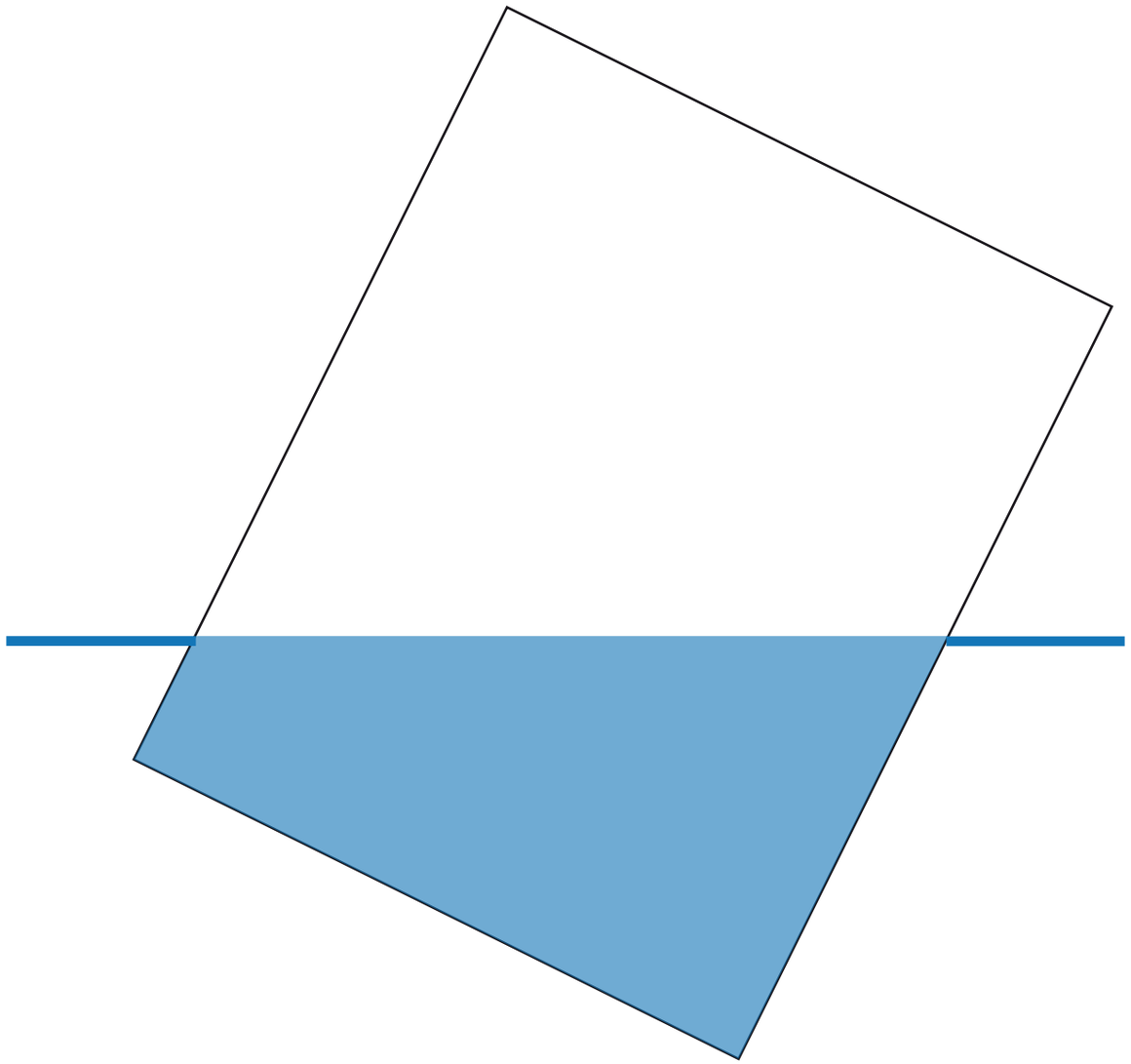


La loi d’Archimède

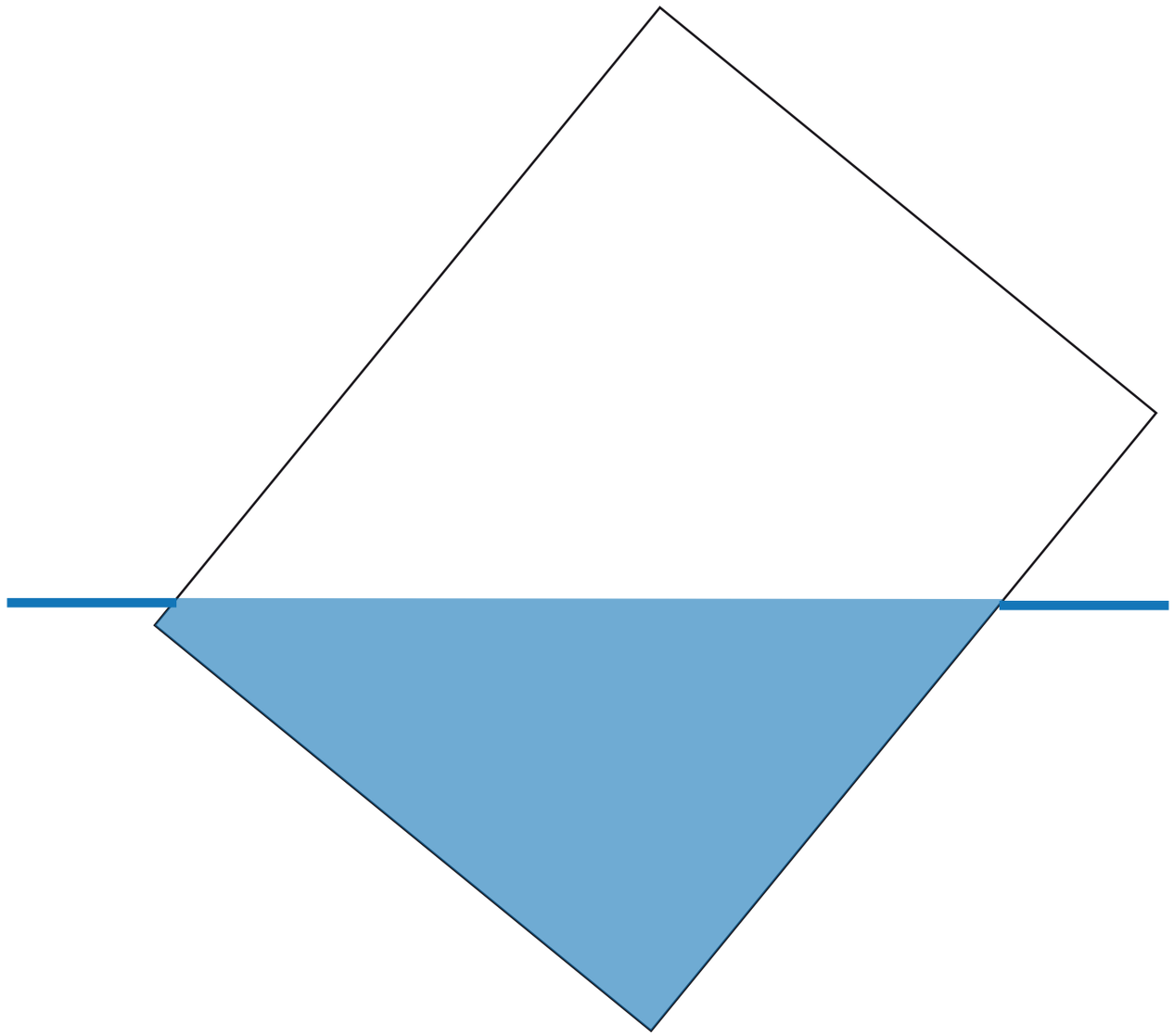


La poussée est égale au poids du volume de fluide déplacé

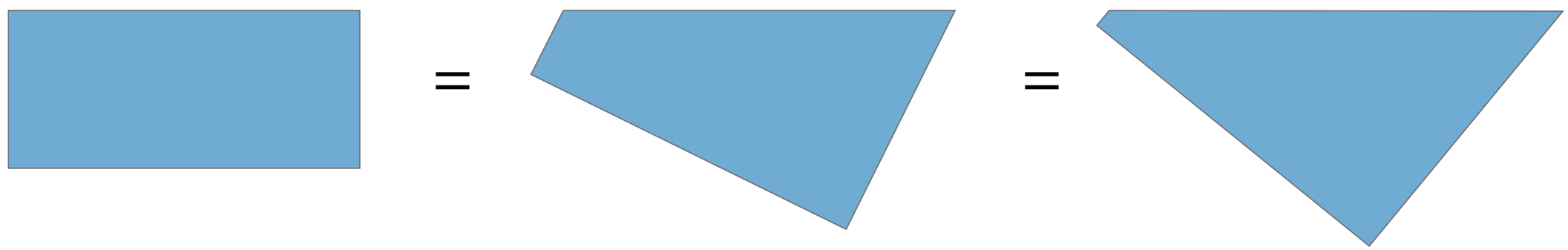
Le corps flottant gîte



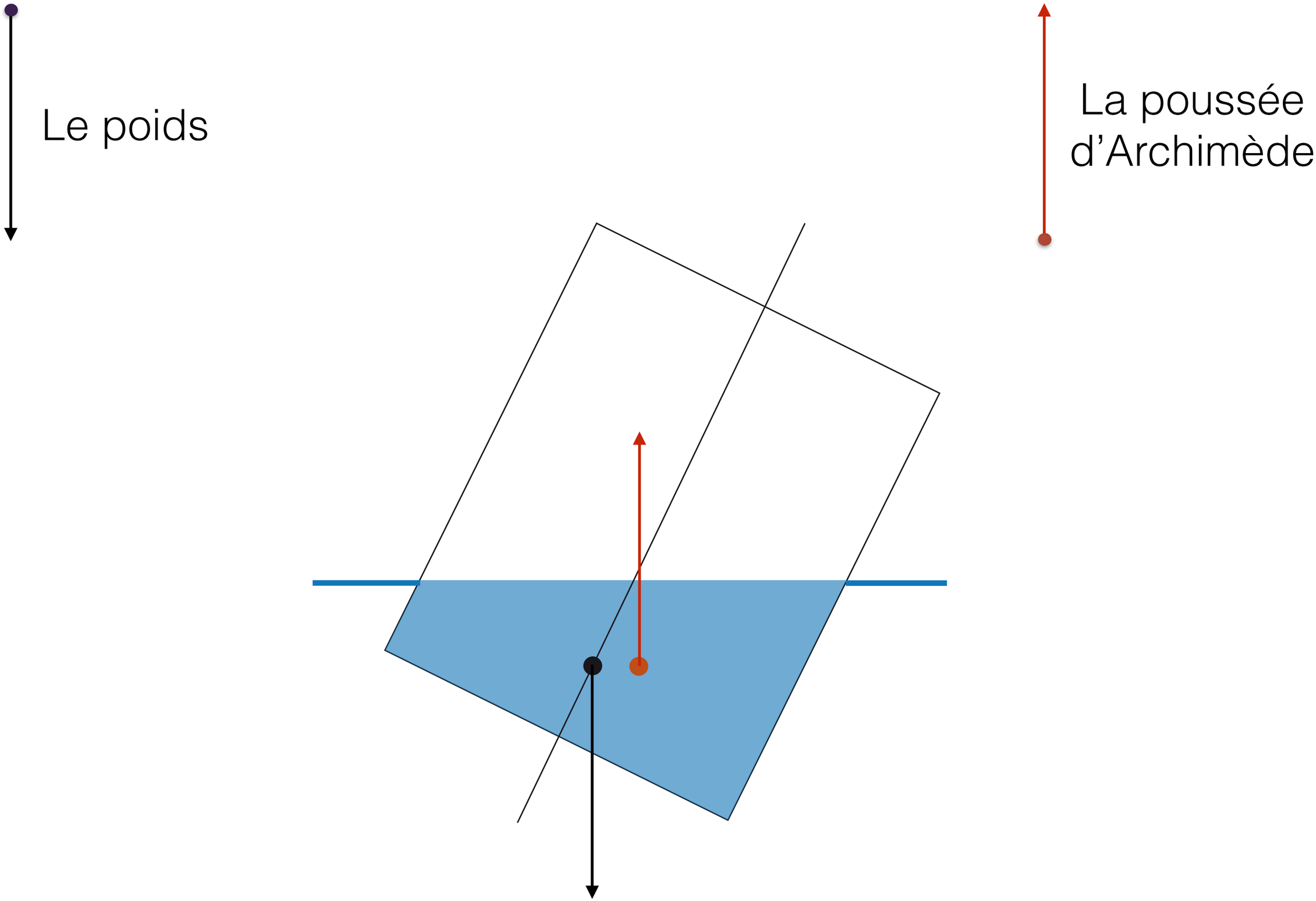
Le corps flottant gîte plus fortement



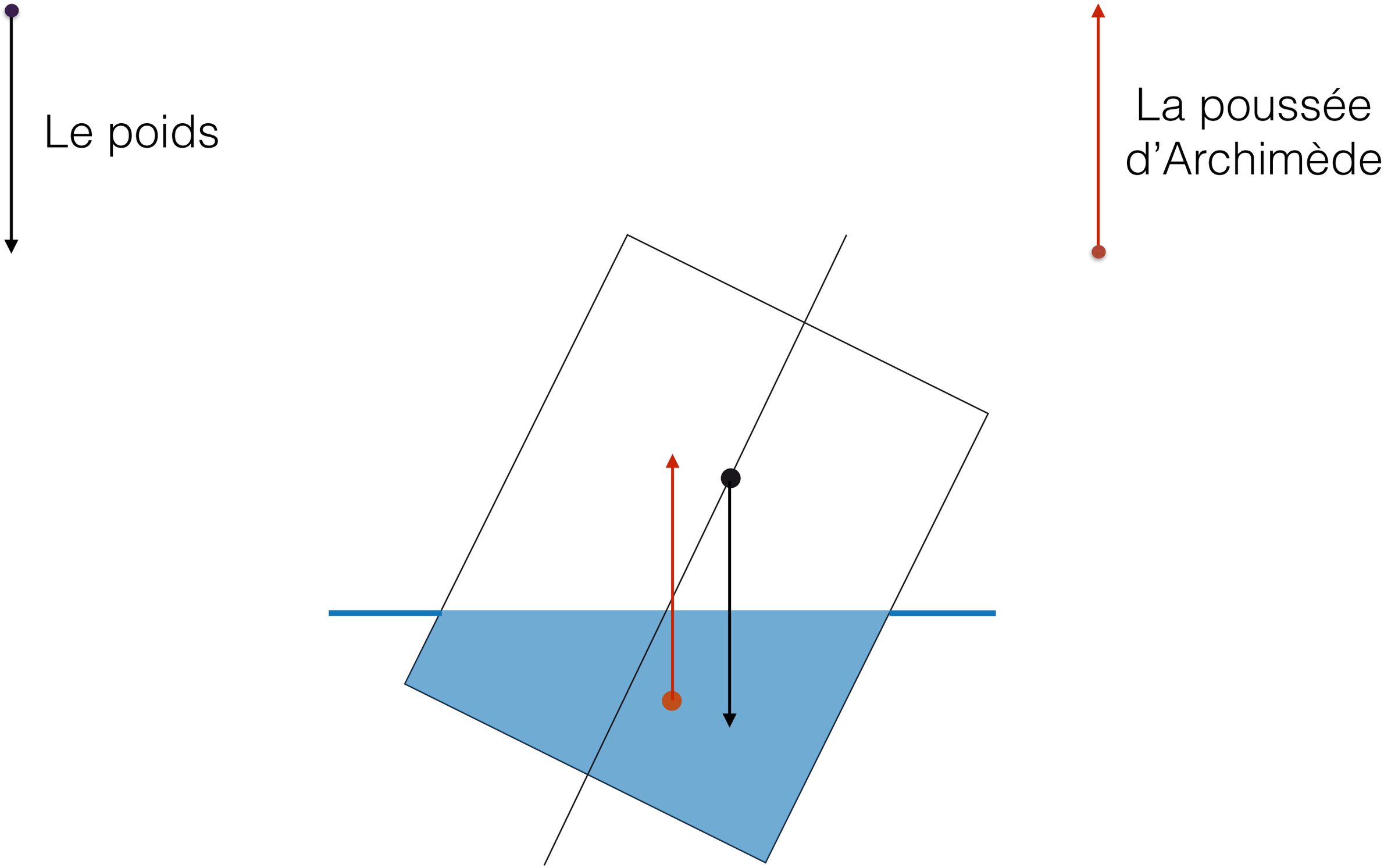
Le volume de fluide déplacé
ne change pas lors de la gîte du corps



Pourquoi ?



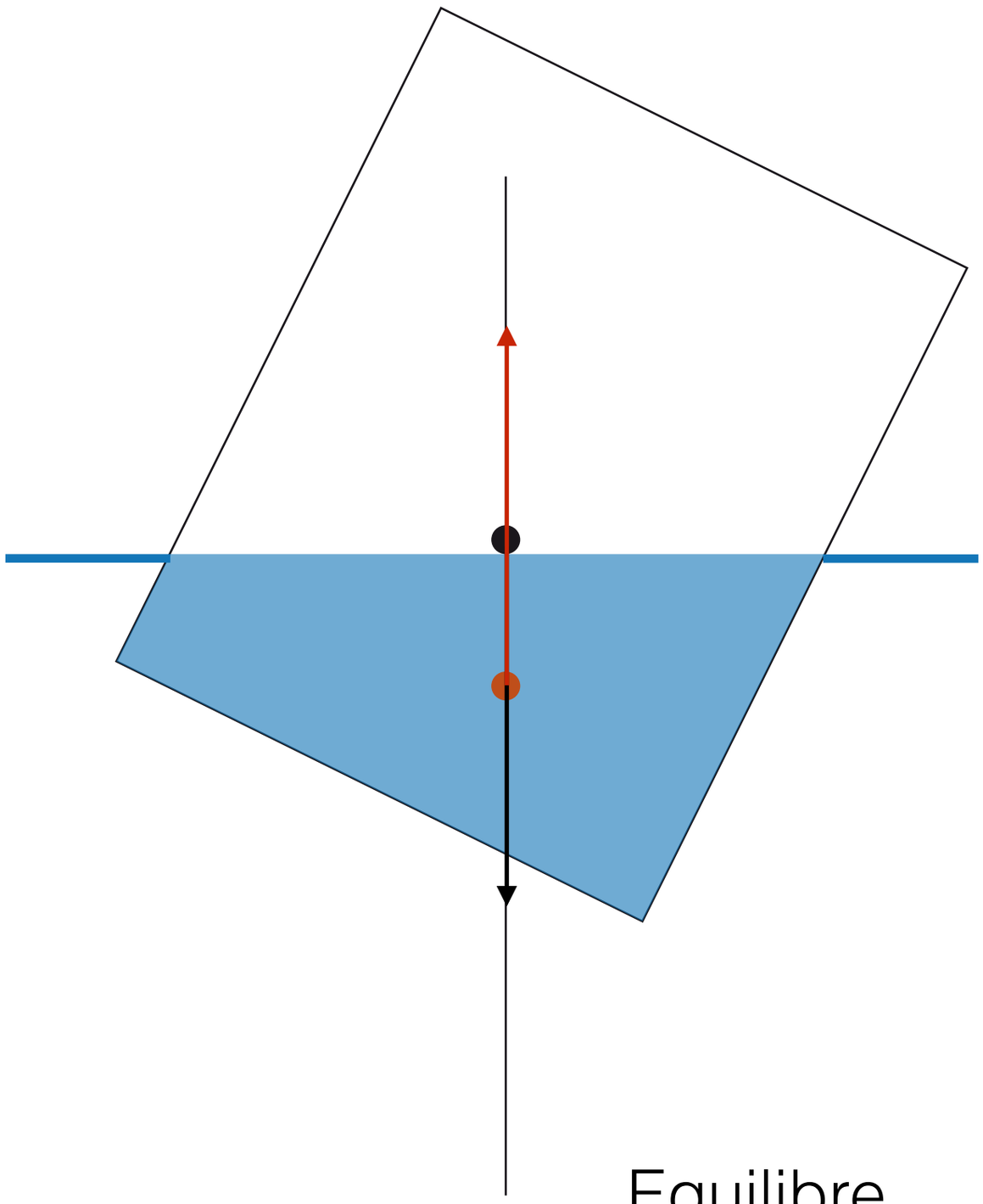
Centre de gravité du corps bas. Le corps se redresse.



Centre de gravité du corps haut. Le corps bascule.

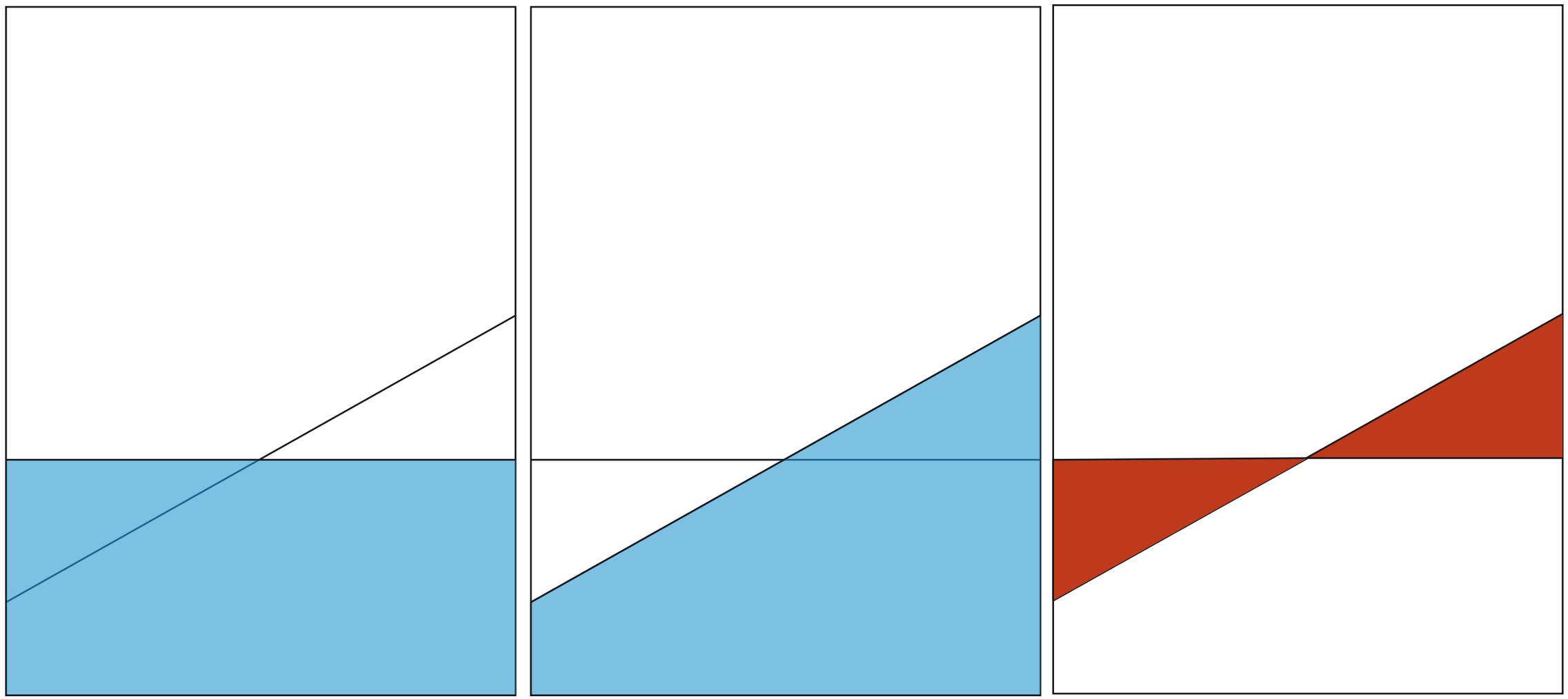
Le poids

La poussée d'Archimède



Equilibre

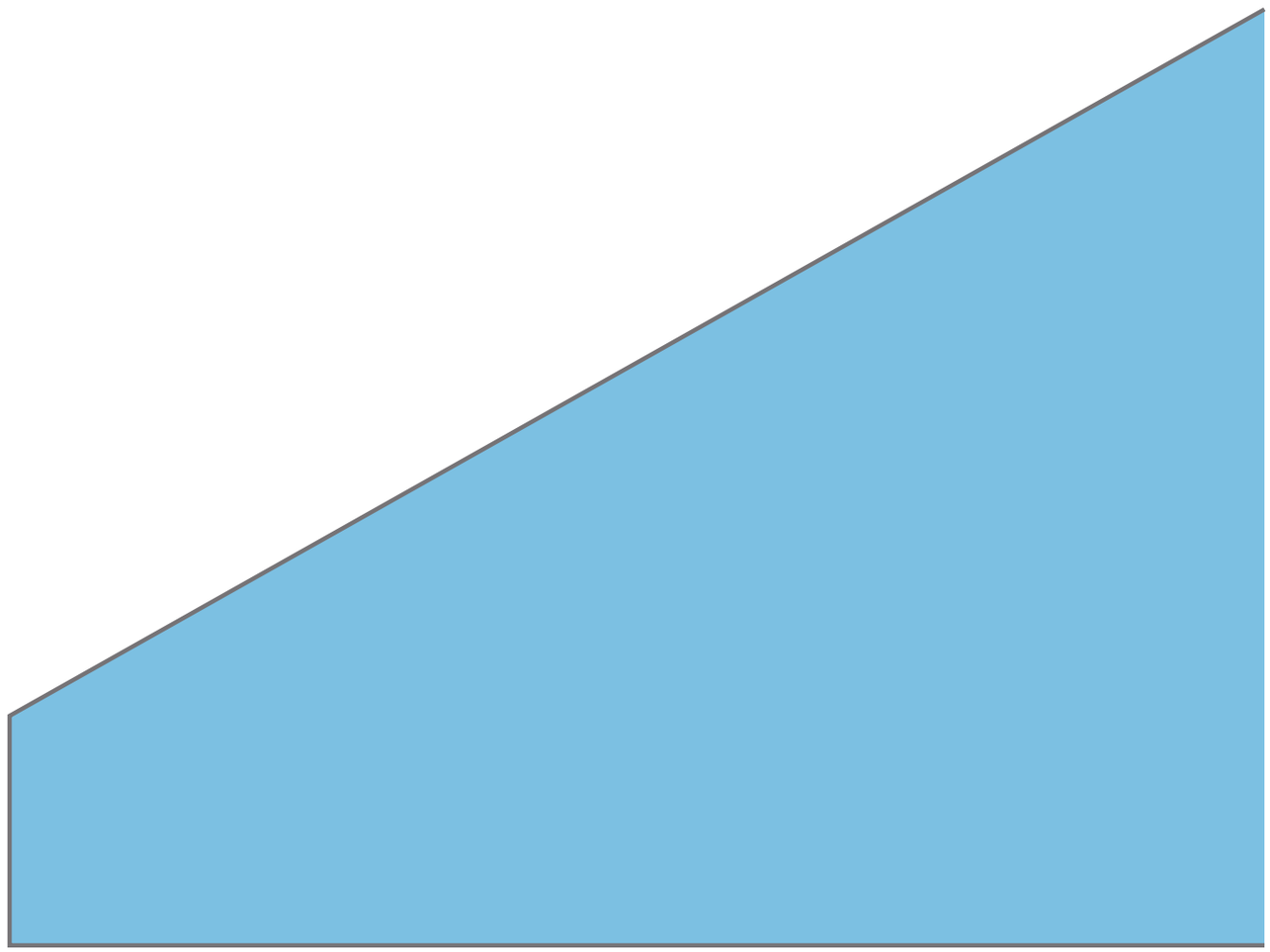
La géométrie du gîte



Les surfaces bleues sont égales
car celles des triangles rouges le sont également.

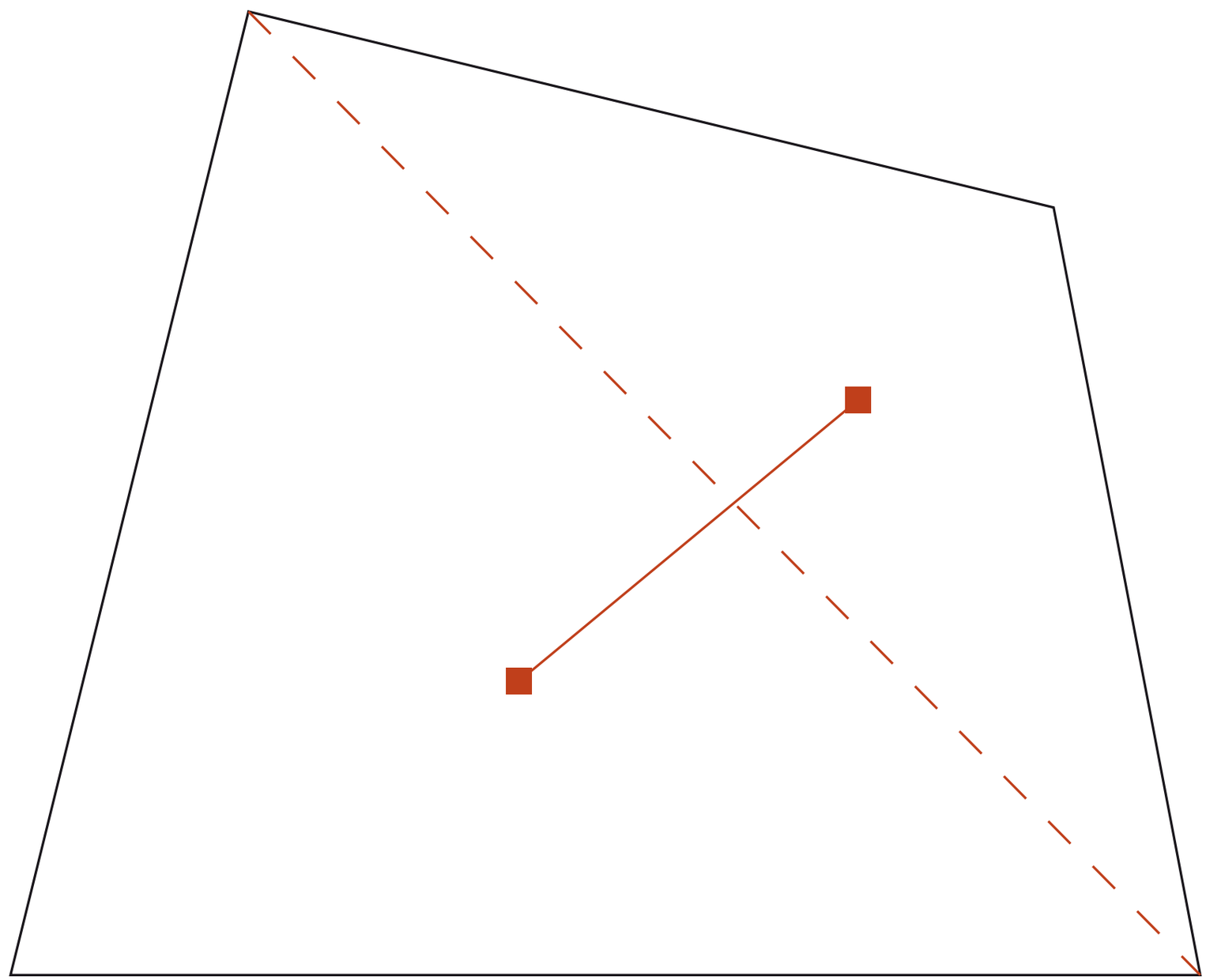
Il en va de même pour les surfaces immergées

Le problème de la stabilité verticale du corps



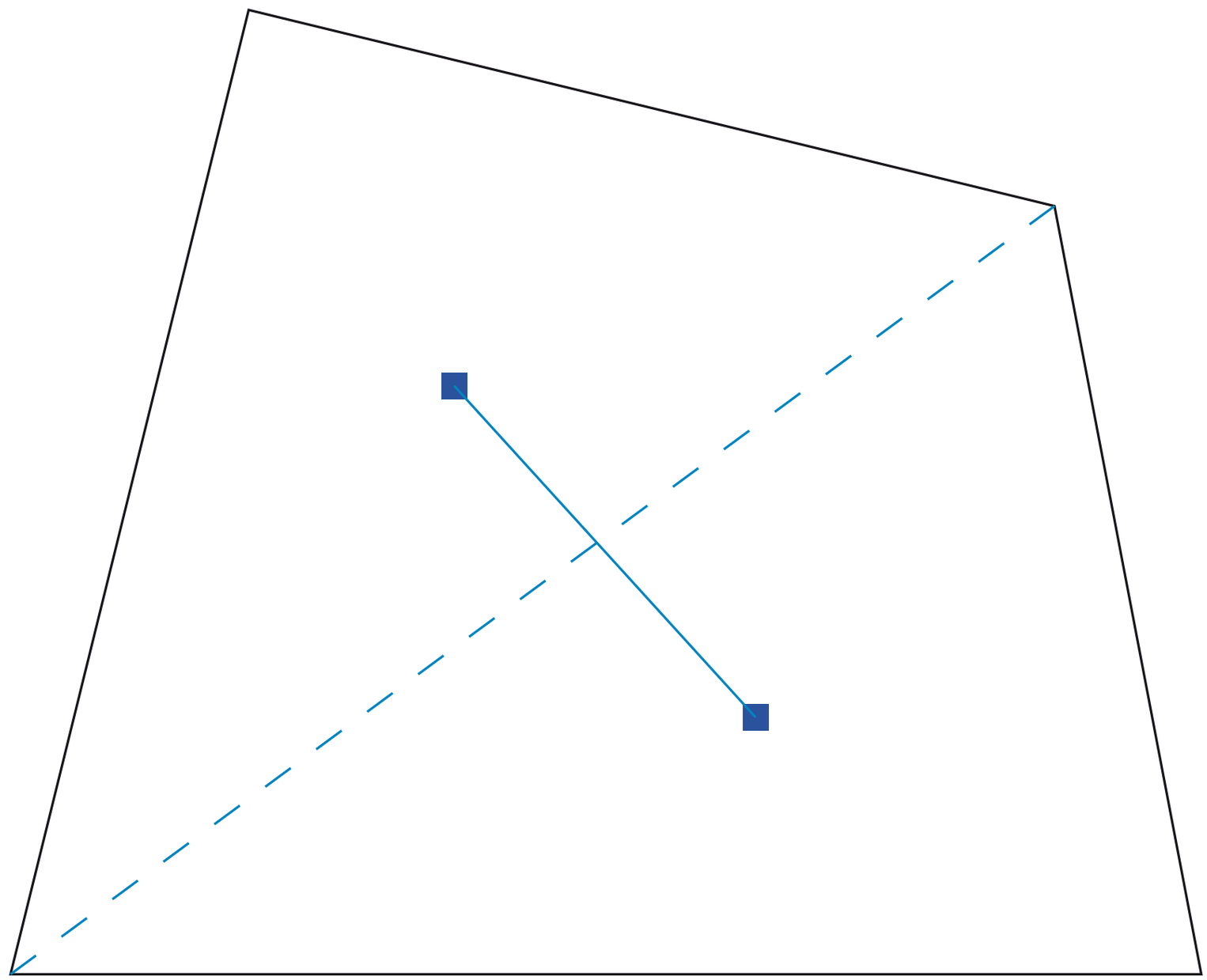
se ramène à la recherche du centre de poussée,
centre de gravité du quadrilatère immergé

La diagonale en pointillées rouge divise le quadrilatère en deux triangles

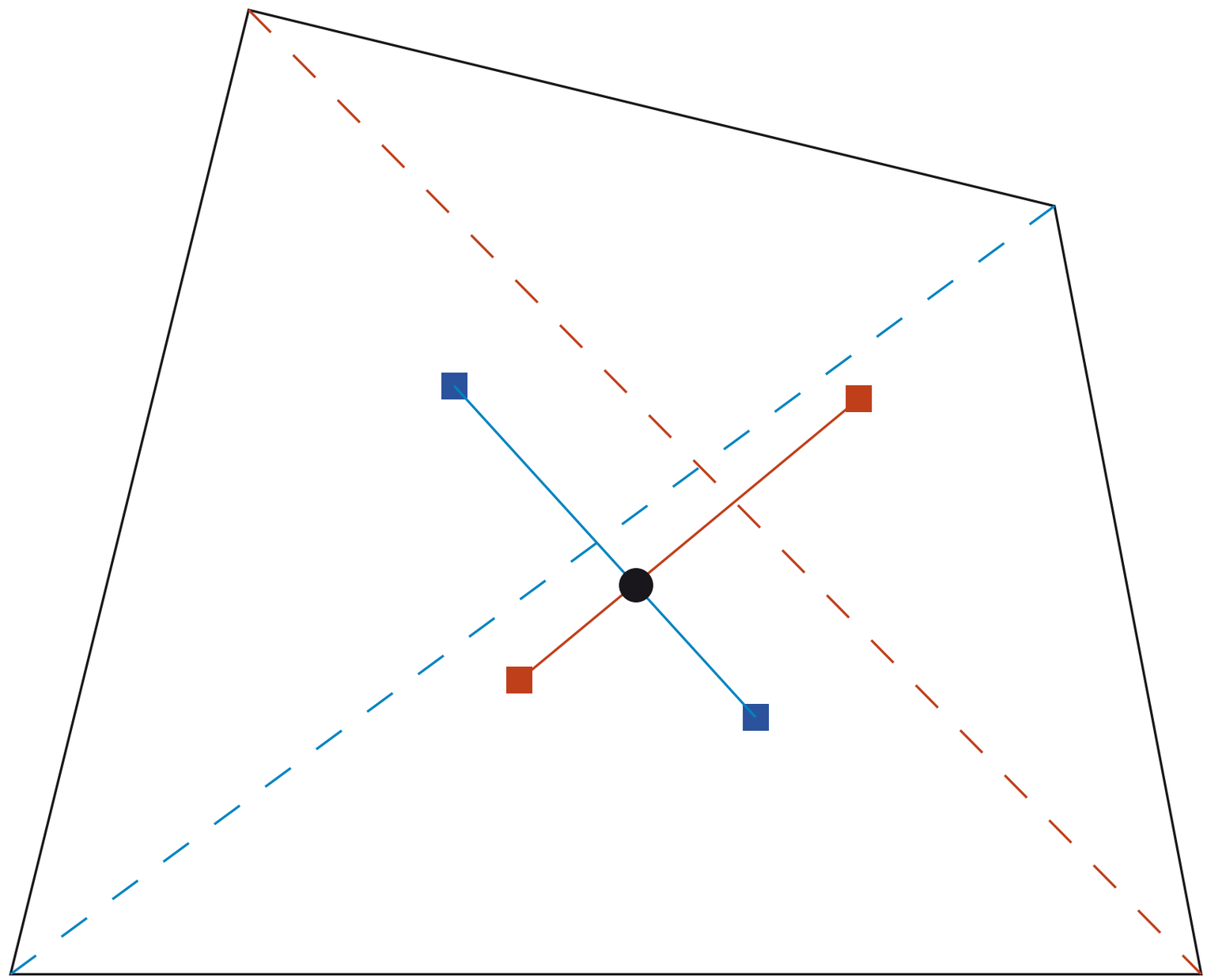


Le centre de gravité se situe sur la ligne rouge, qui joint les centres de gravité des deux triangles

La diagonale en pointillées bleue divise le quadrilatère en deux triangles

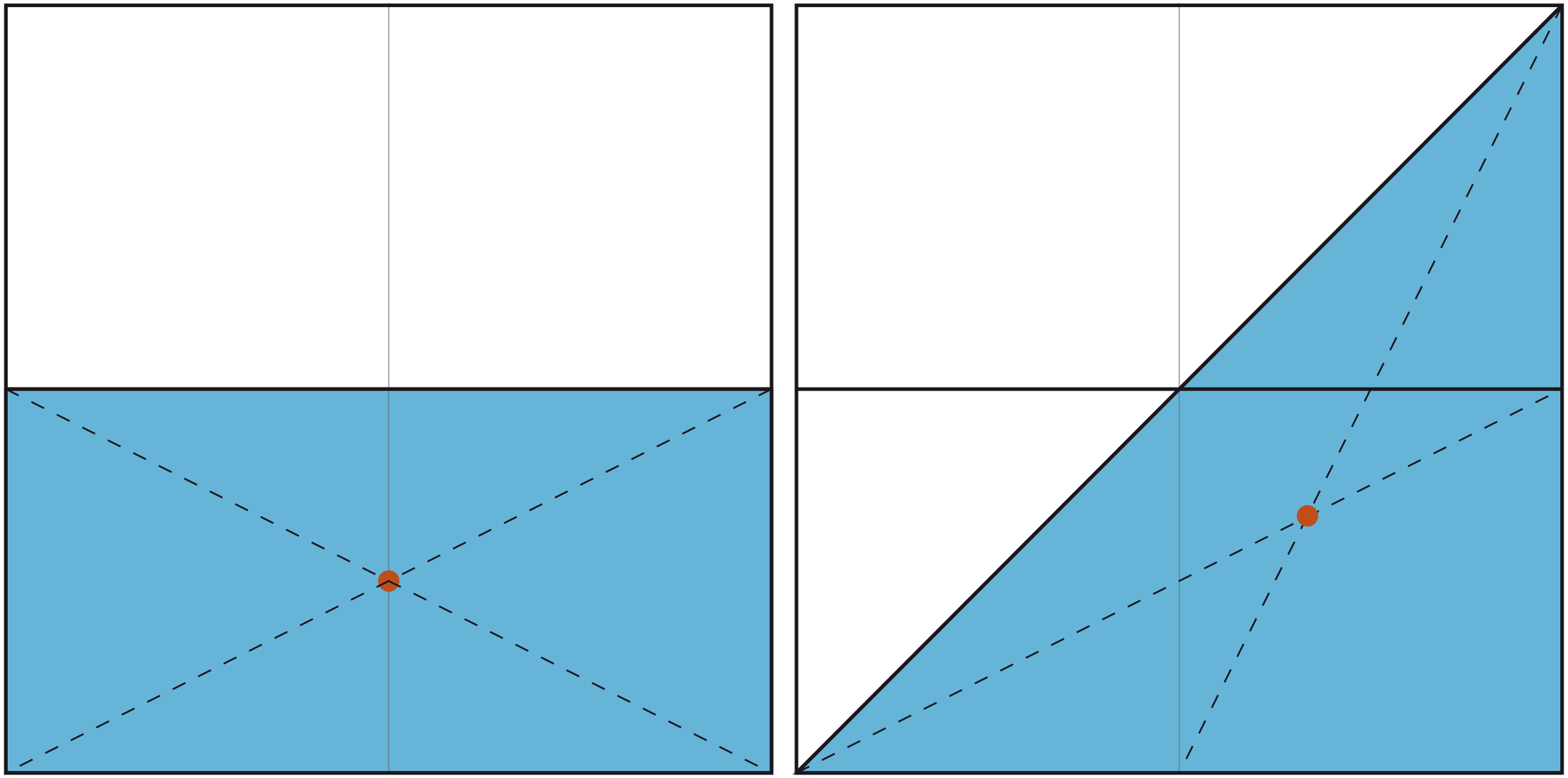
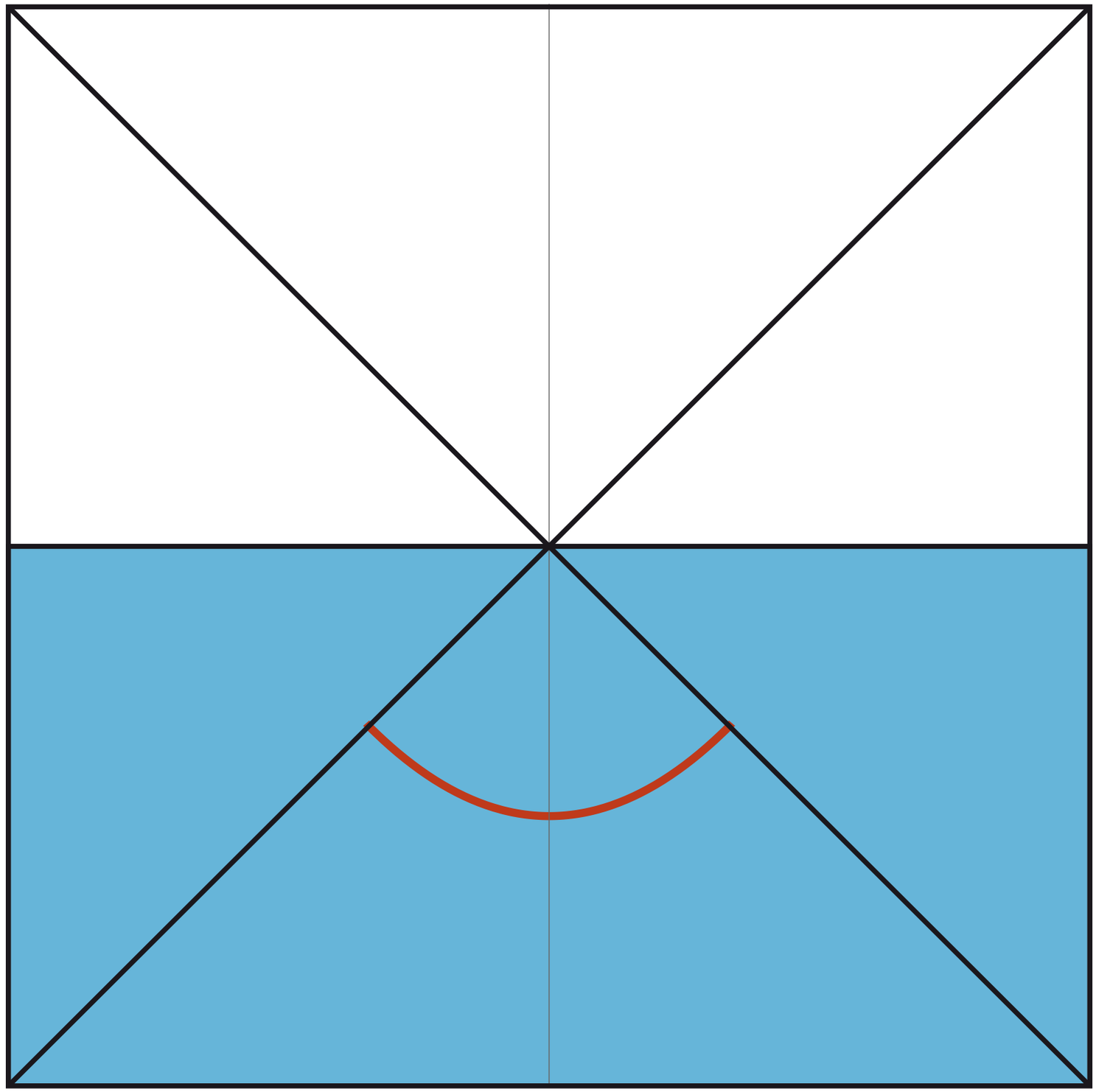
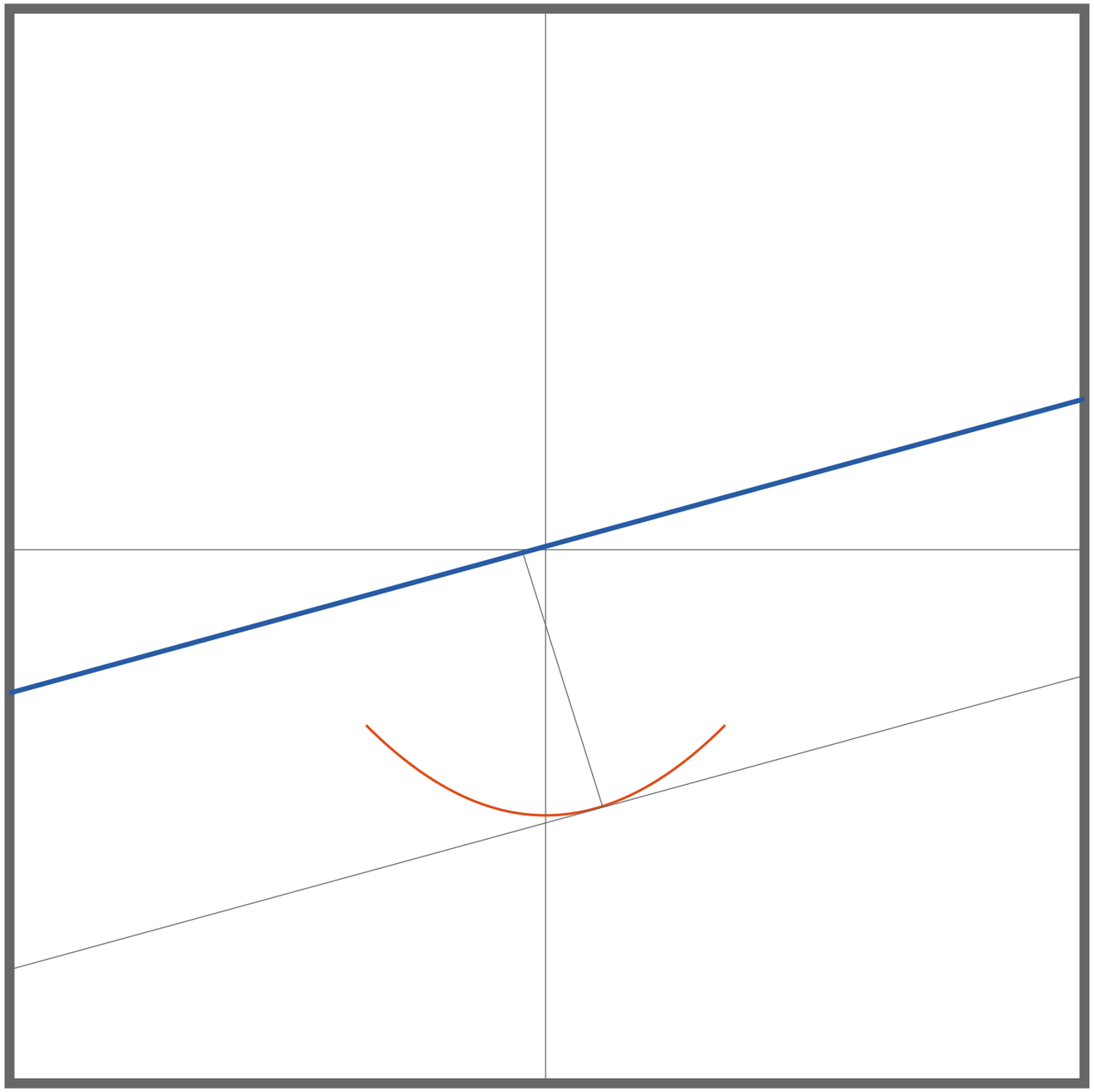
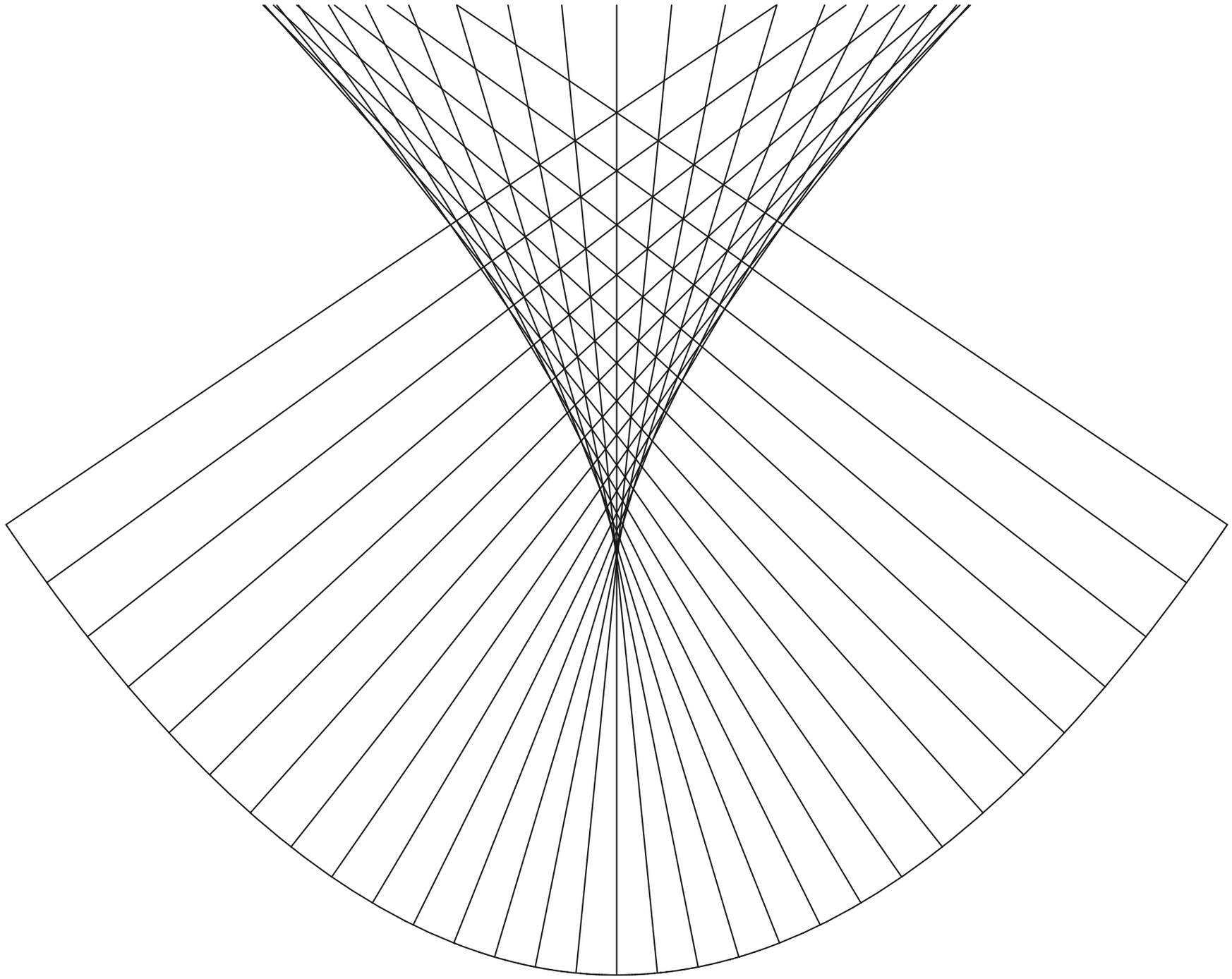
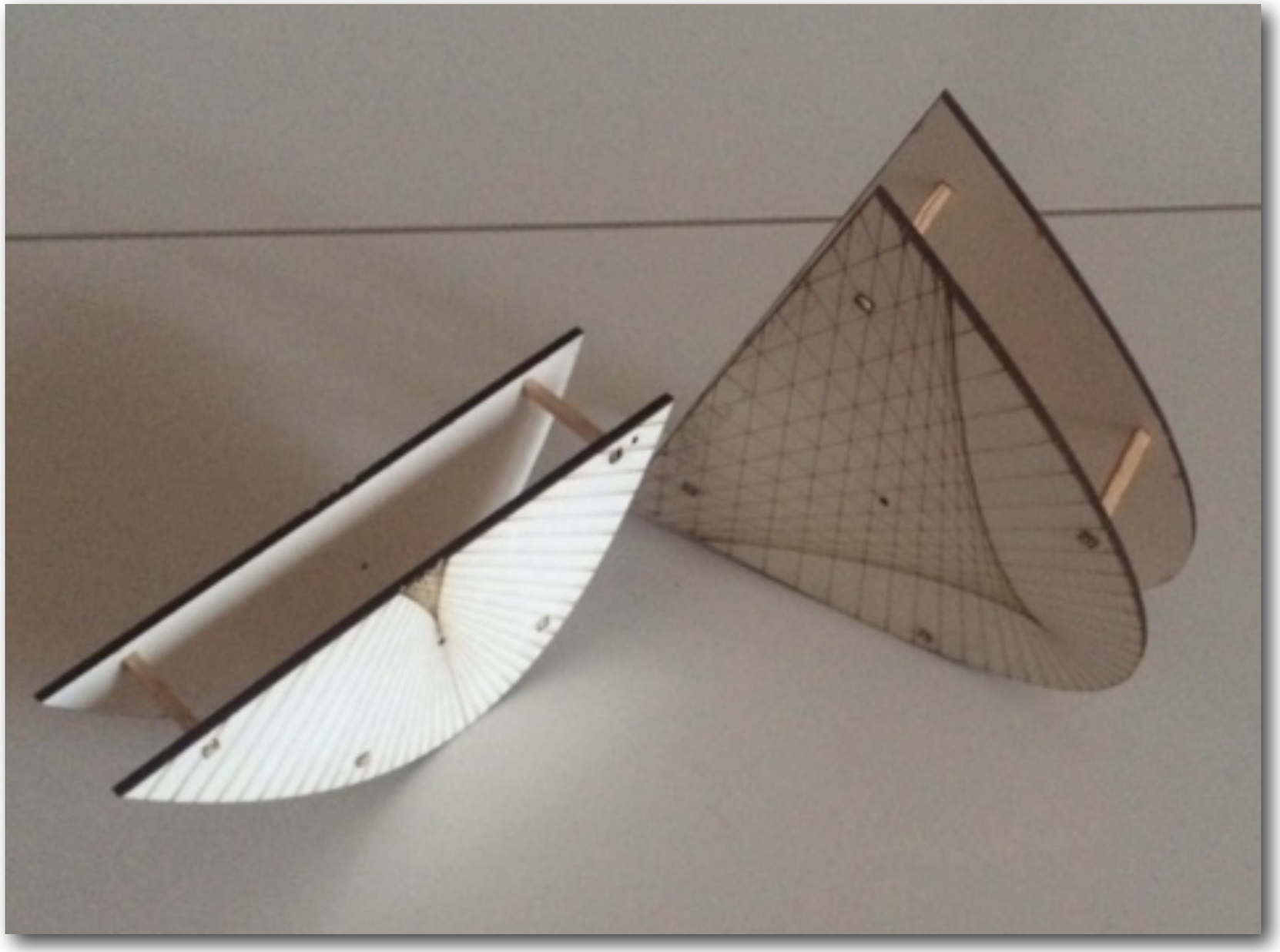
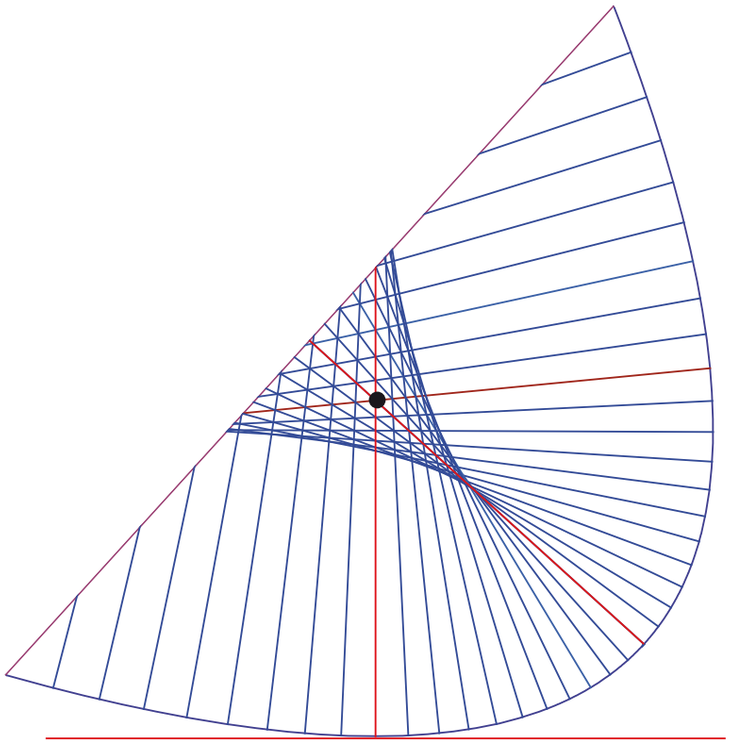
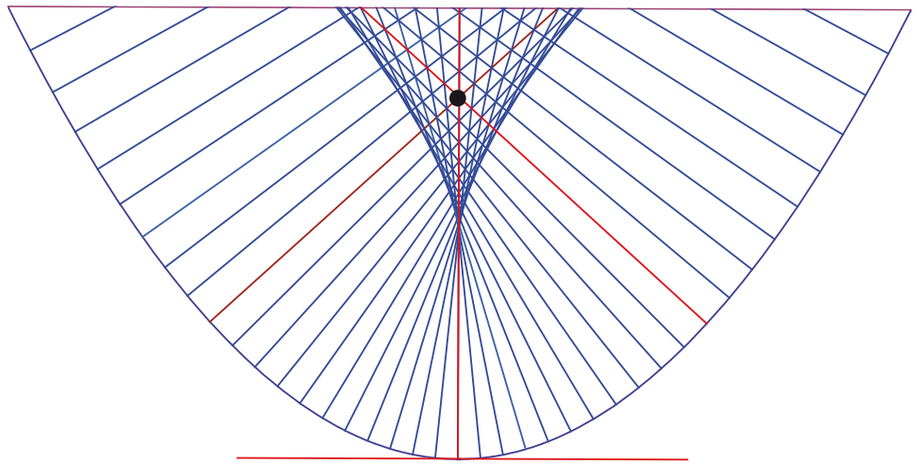
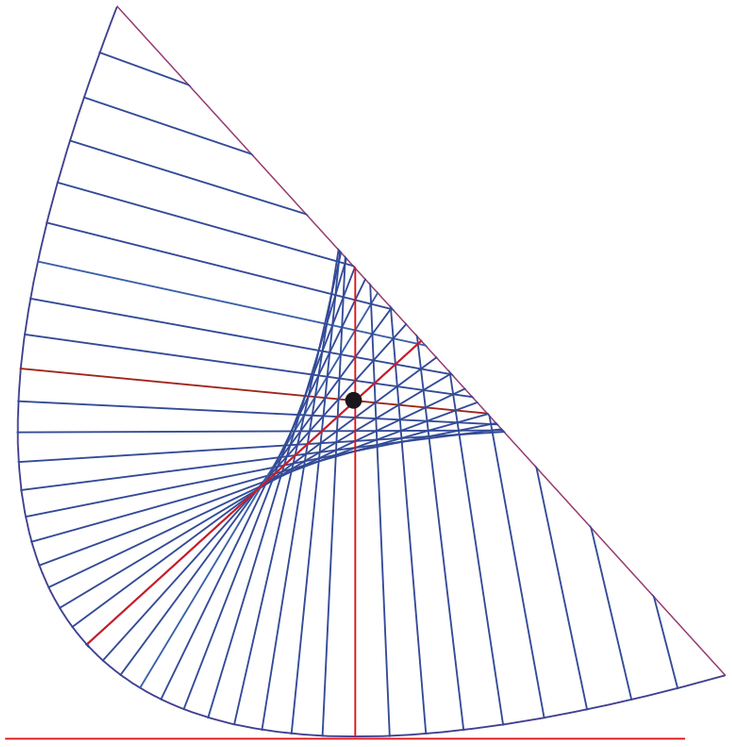
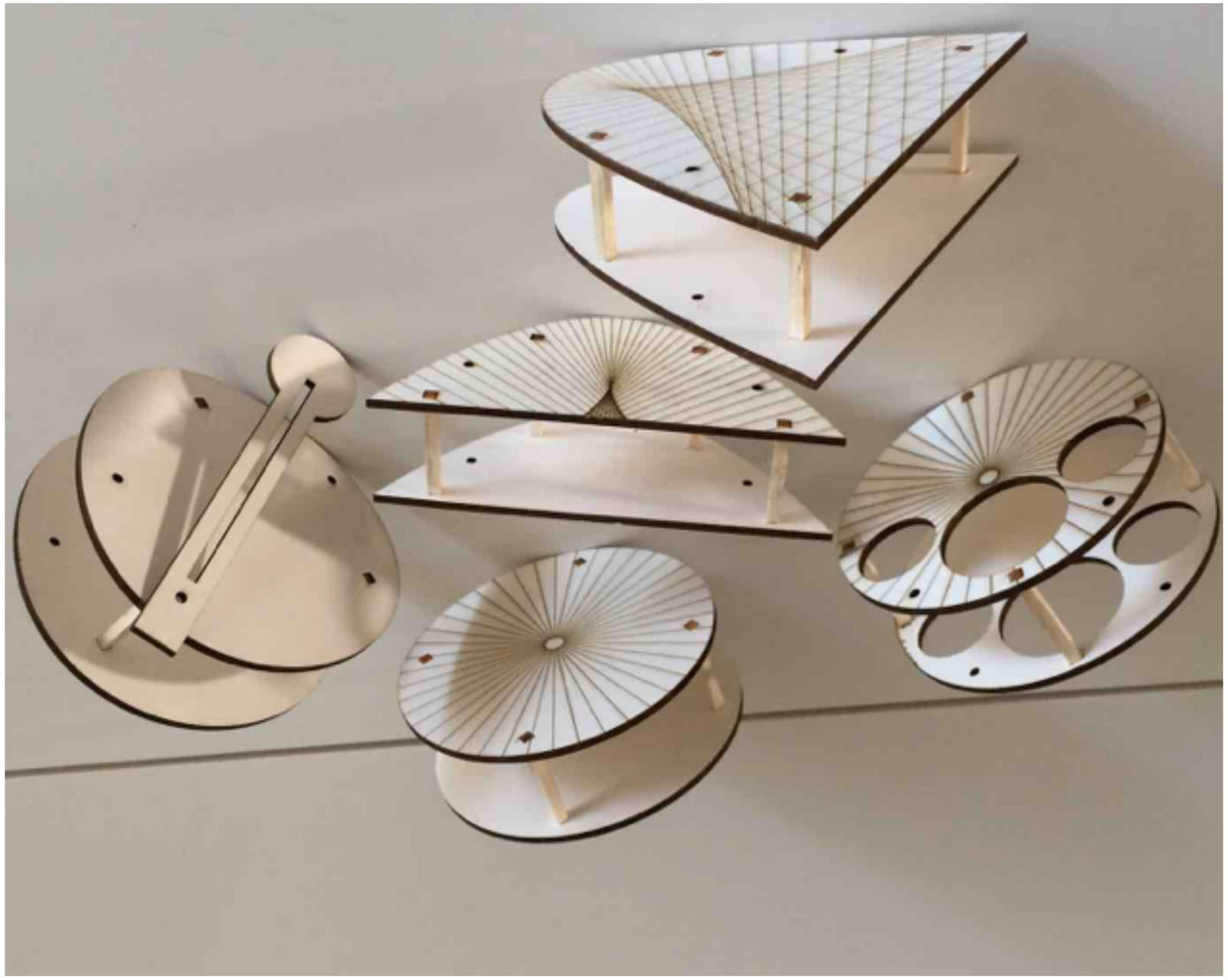
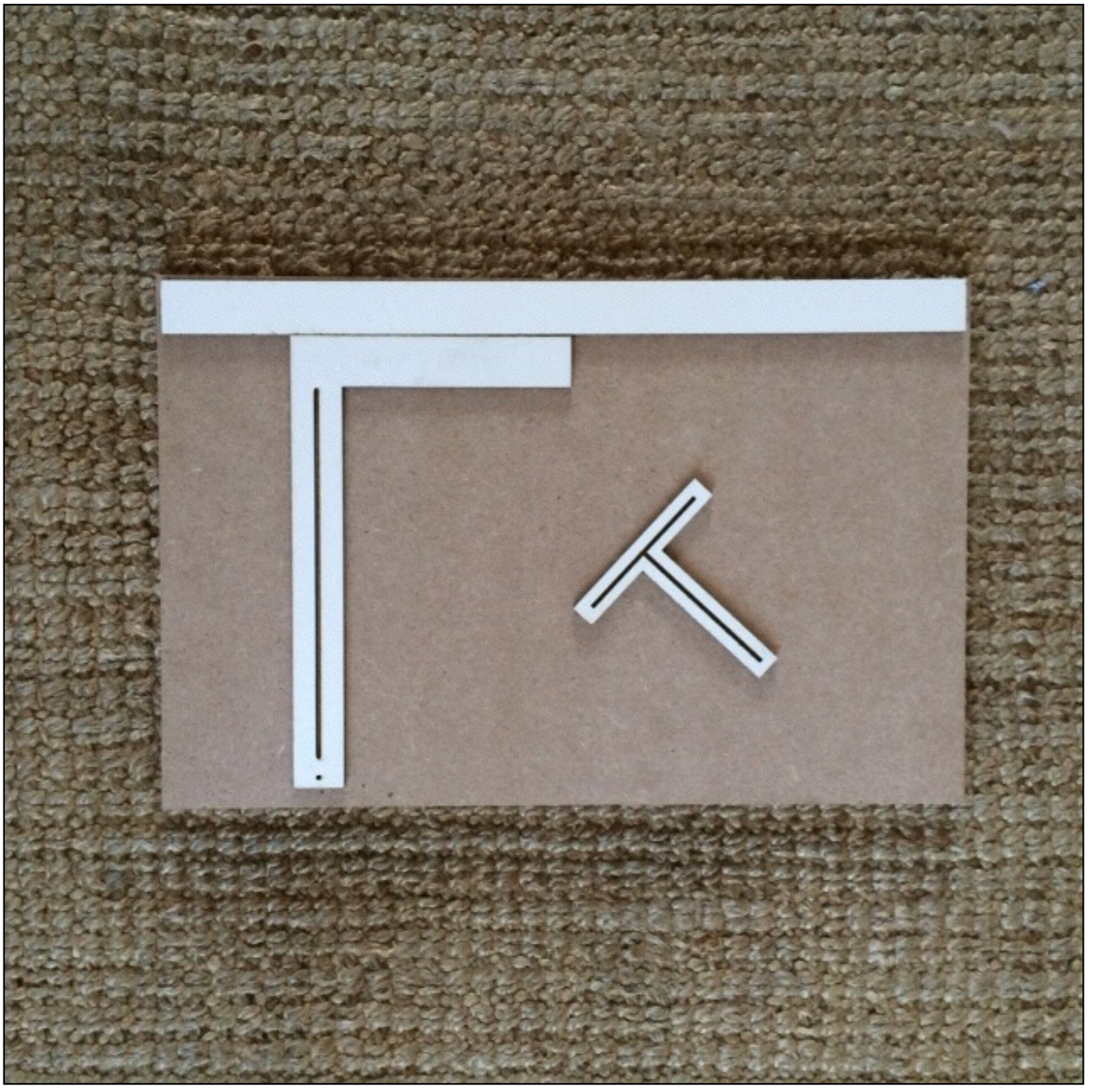


Le centre de gravité se situe sur la ligne bleu, qui joint les centres de gravité des deux triangles



Le centre de gravité du quadrilatère est l’intersection
de la ligne bleu et de la ligne rouge

Lorsque le corps gîte, son centre de poussée se déplace.



Lorsque le corps gîte, son centre de poussée décrit une parabole.