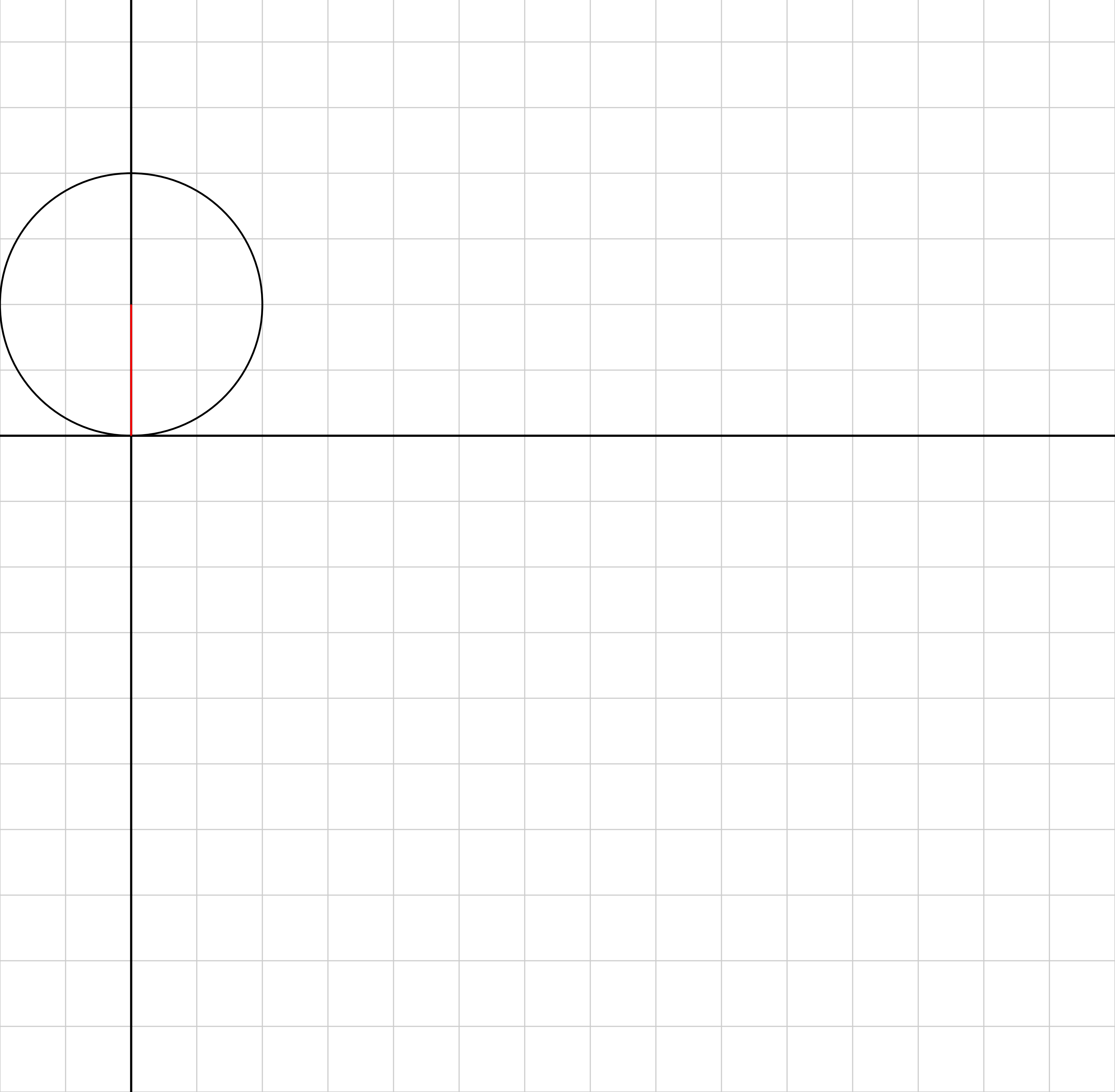
Project: Cycloid

Calvert Ma
96757018
Math 308

Cycloid



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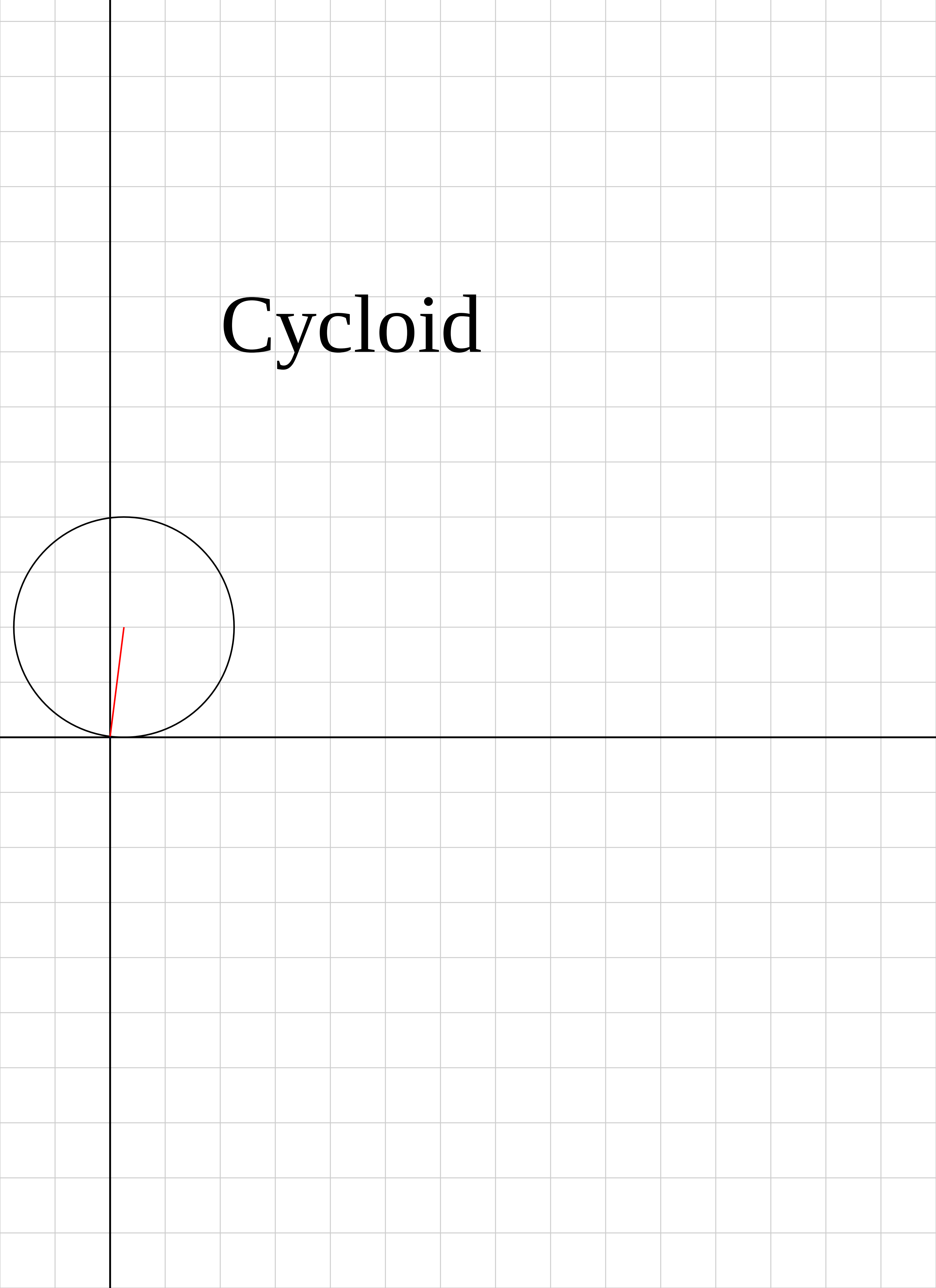

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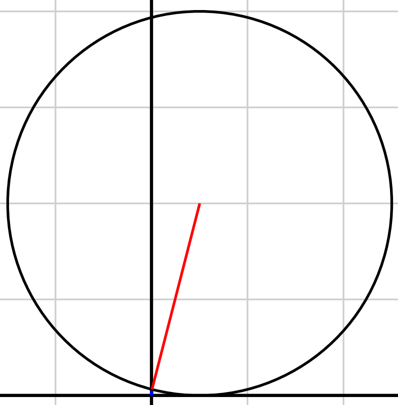

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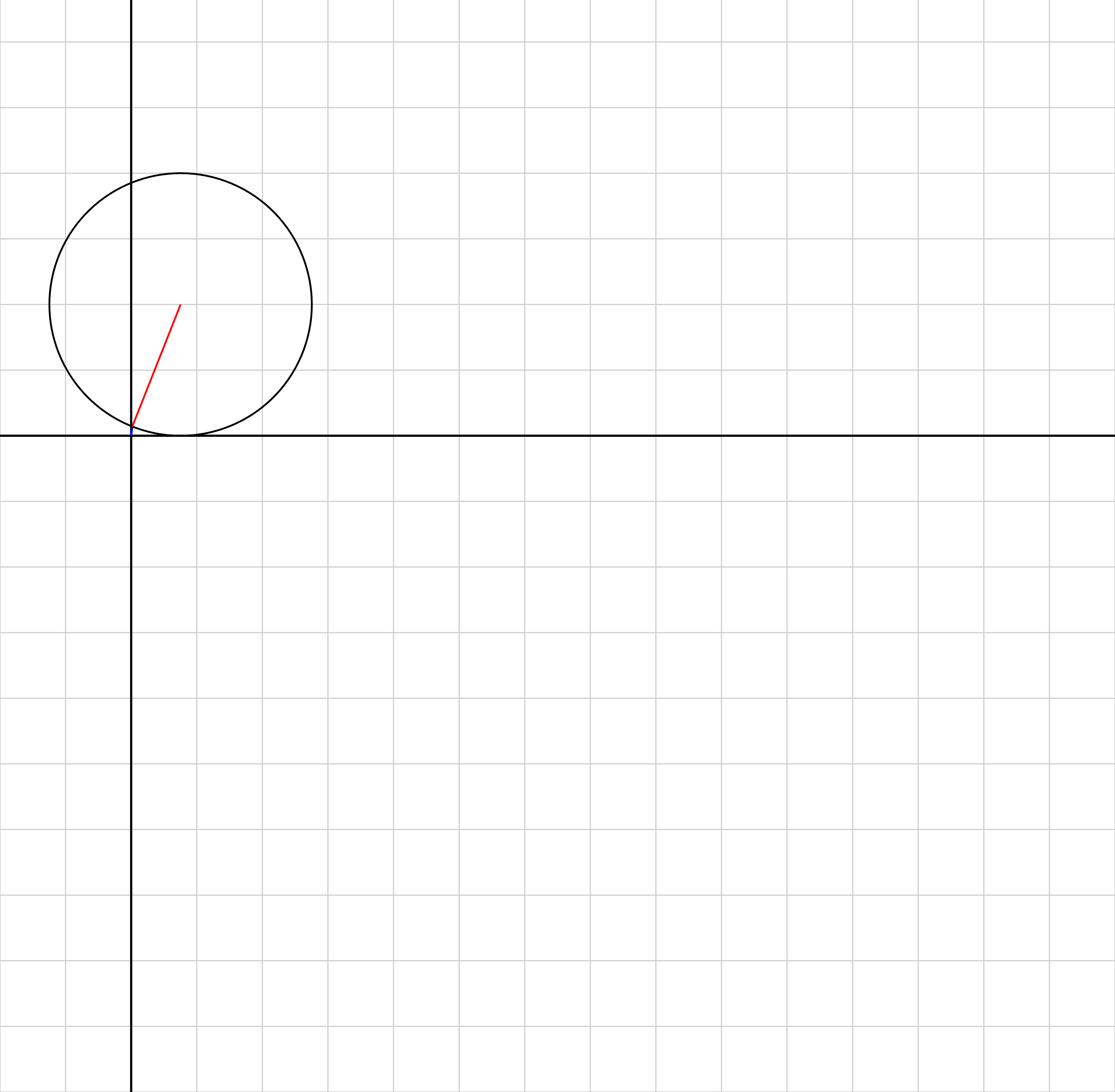

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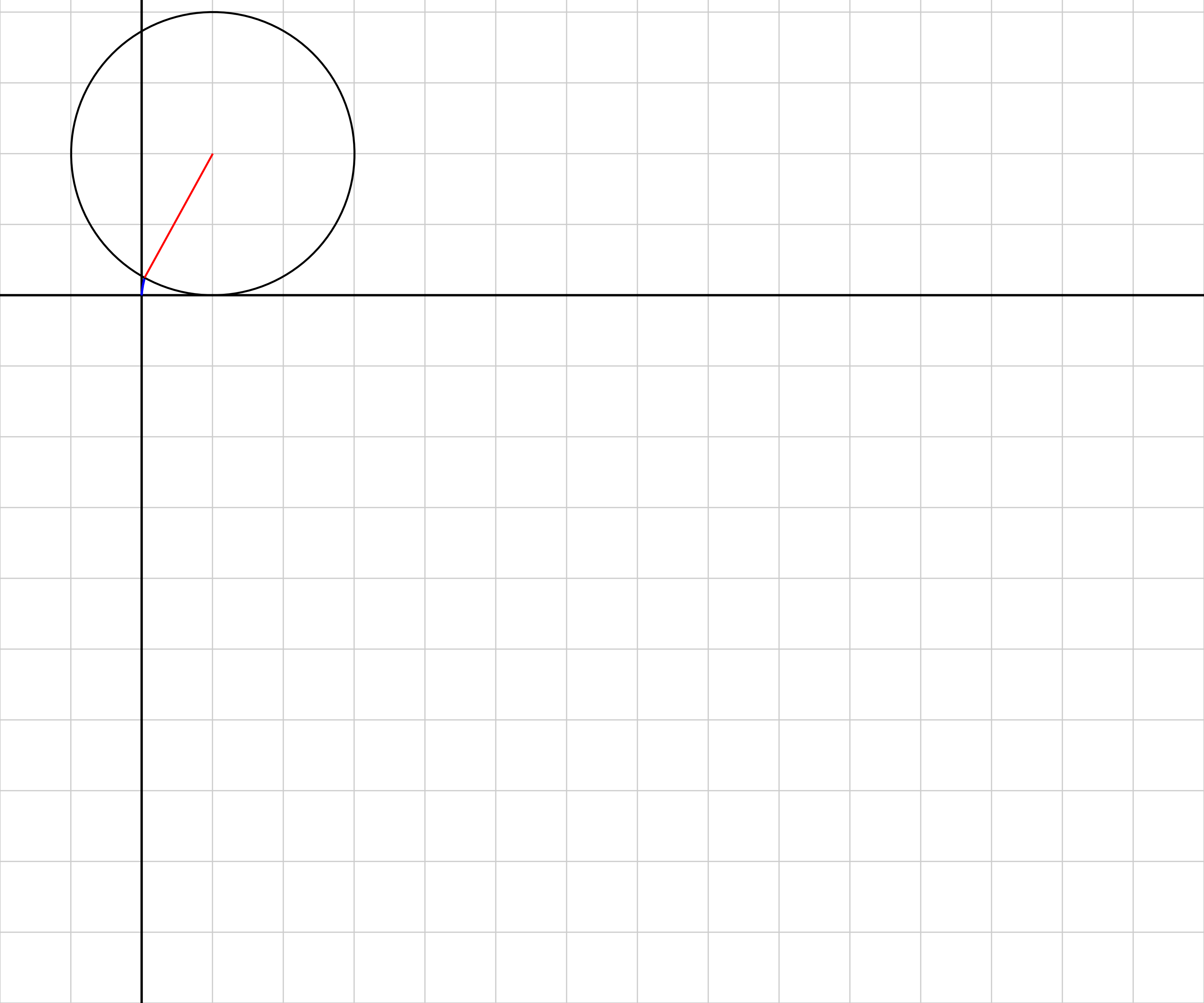

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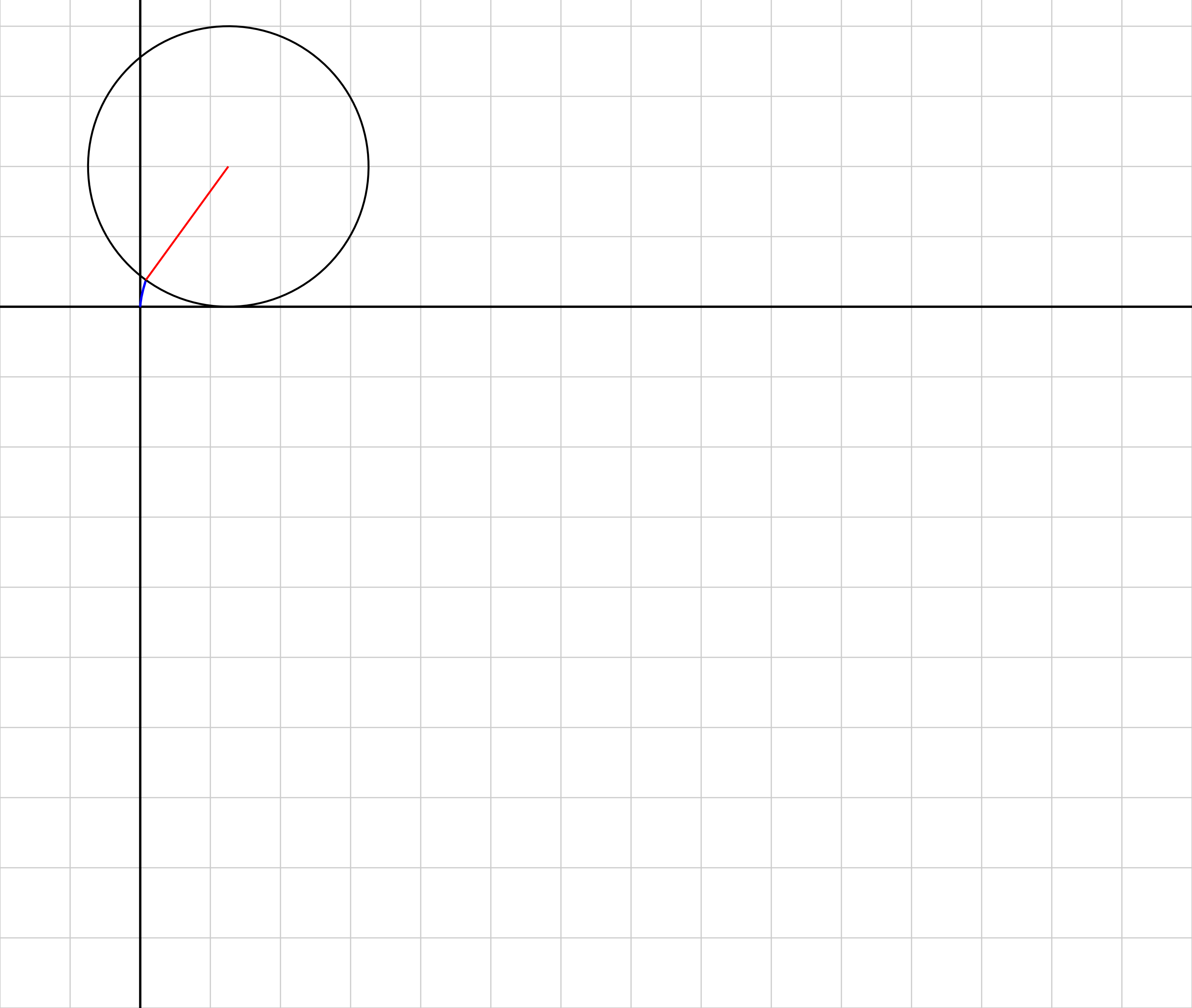

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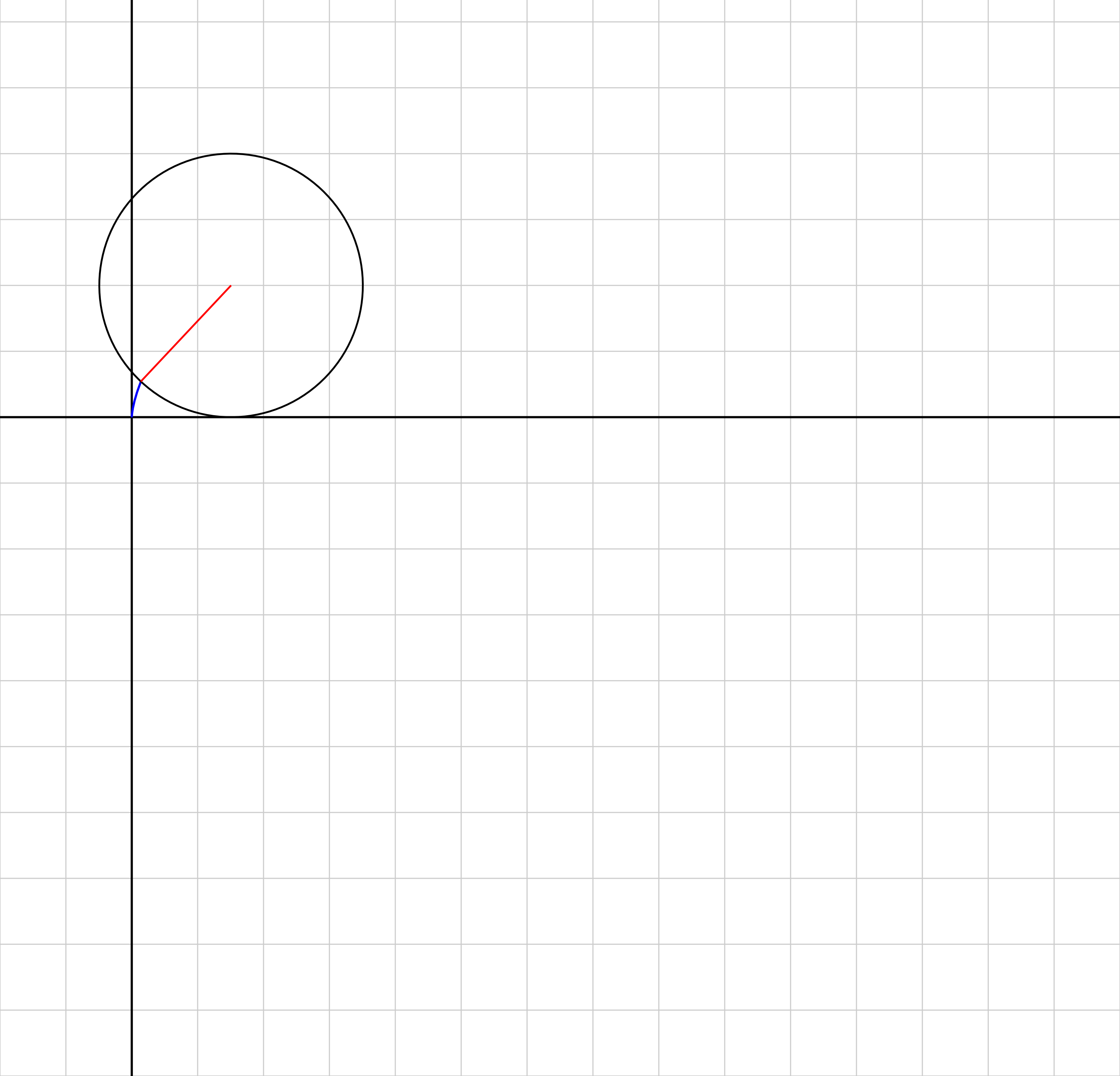

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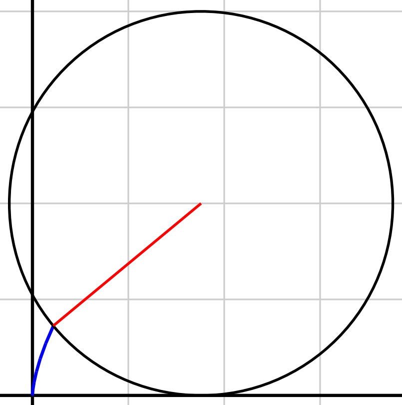

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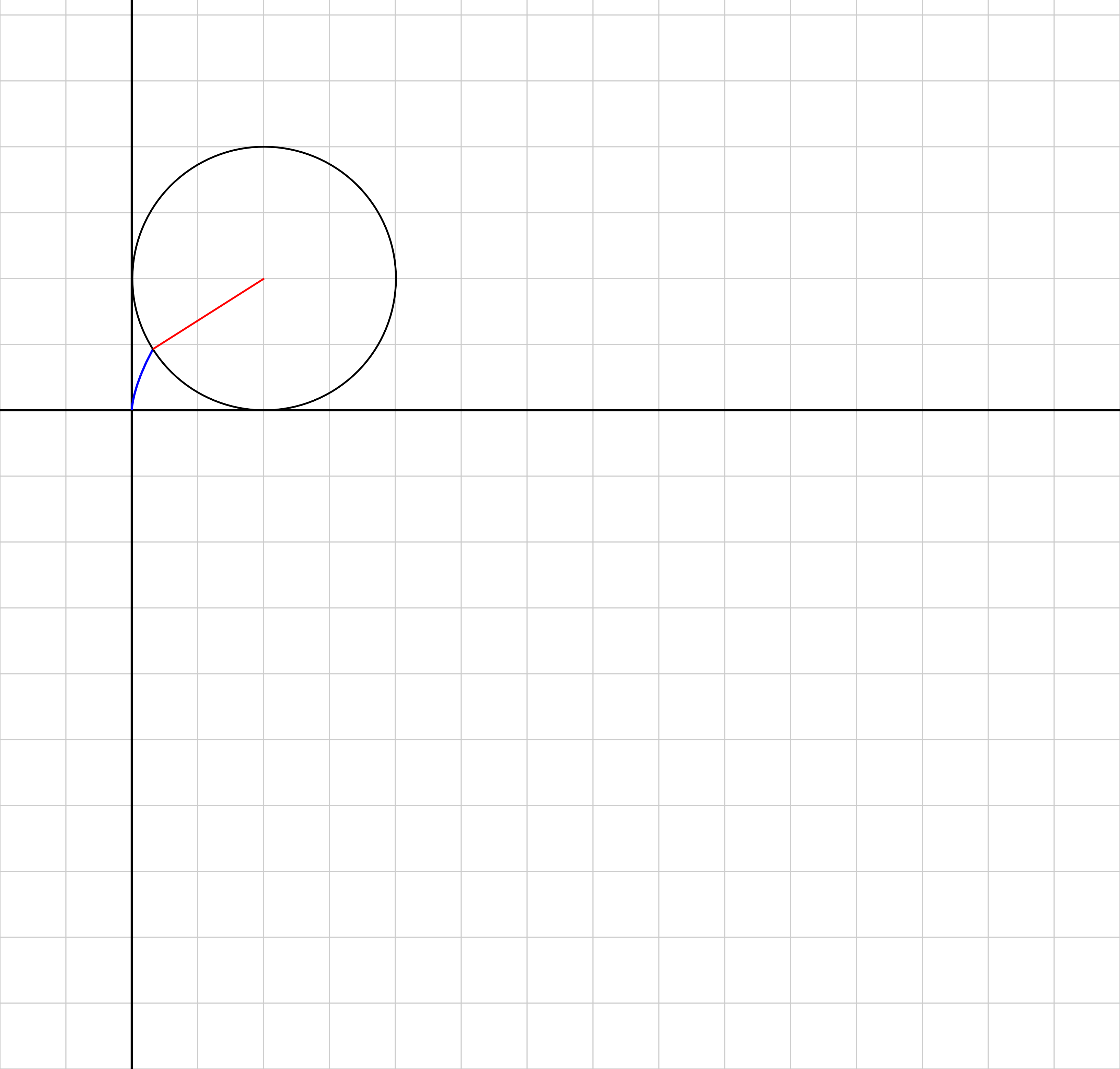

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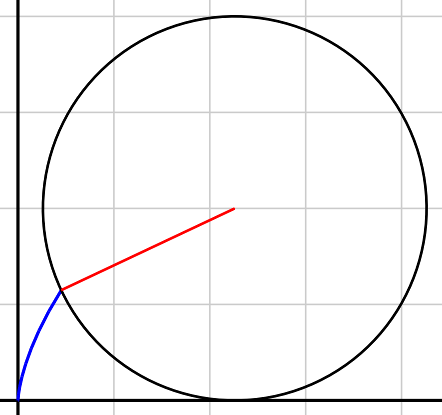

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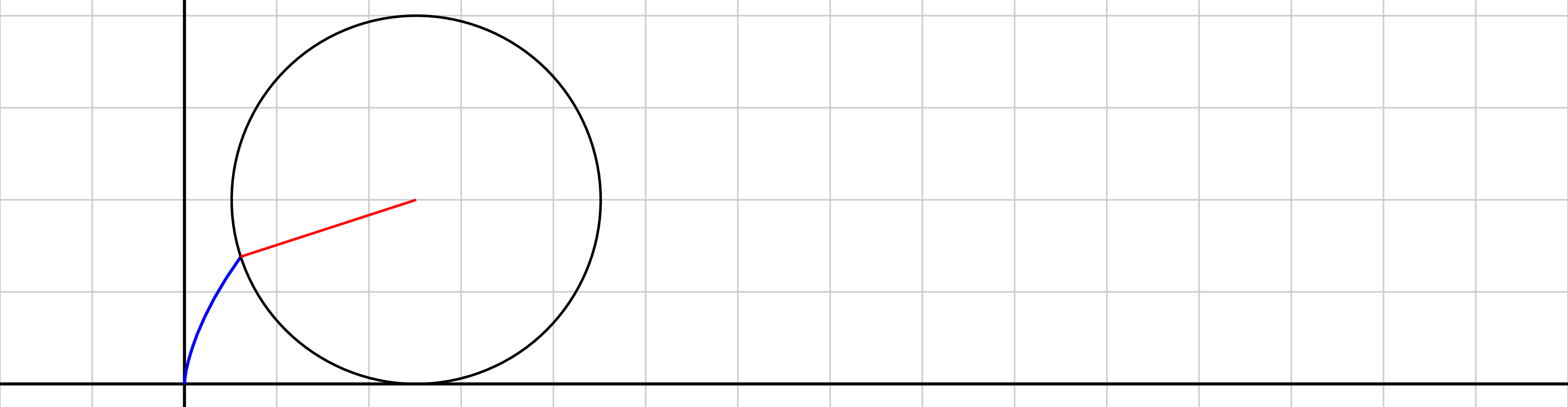

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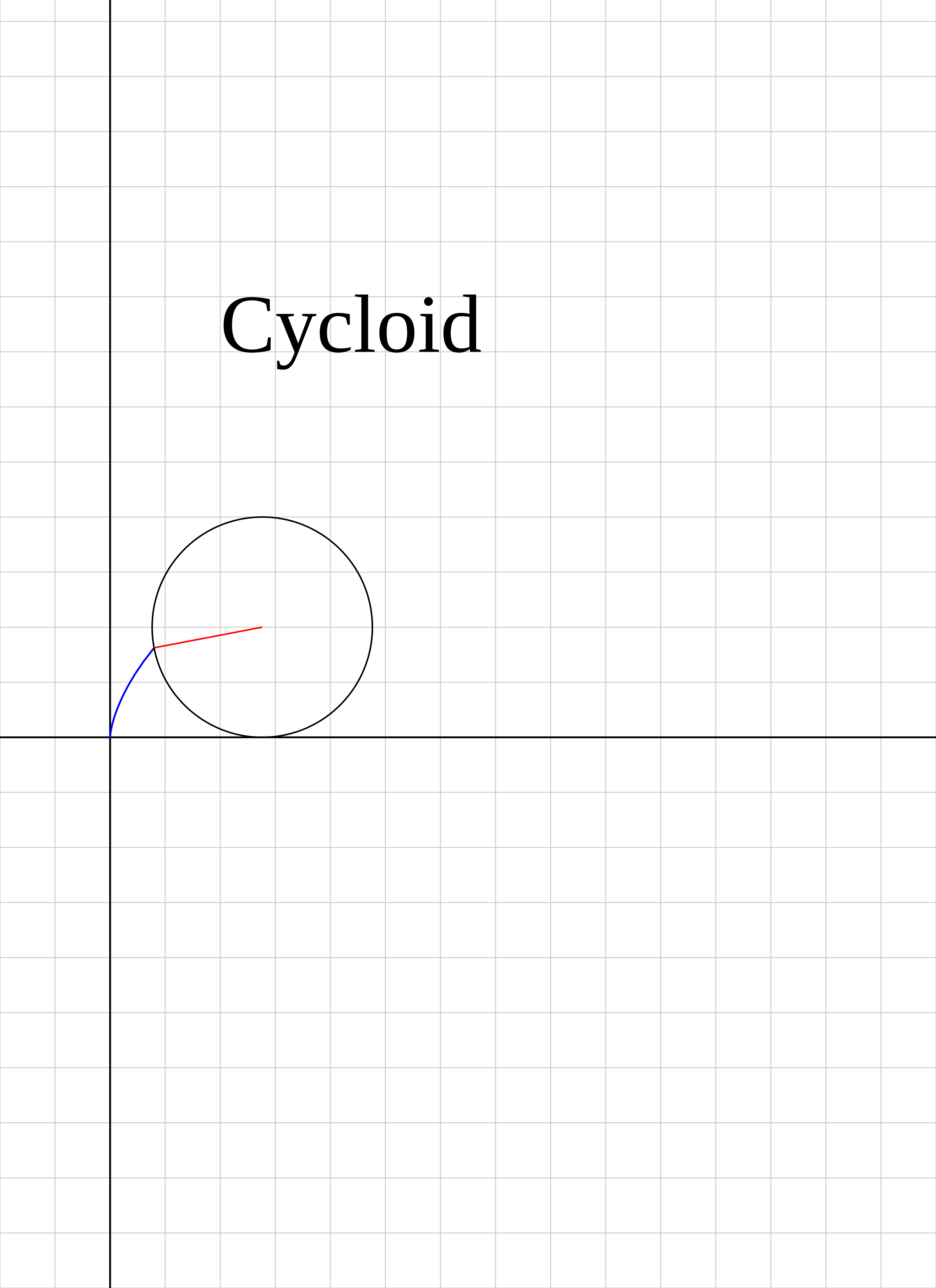

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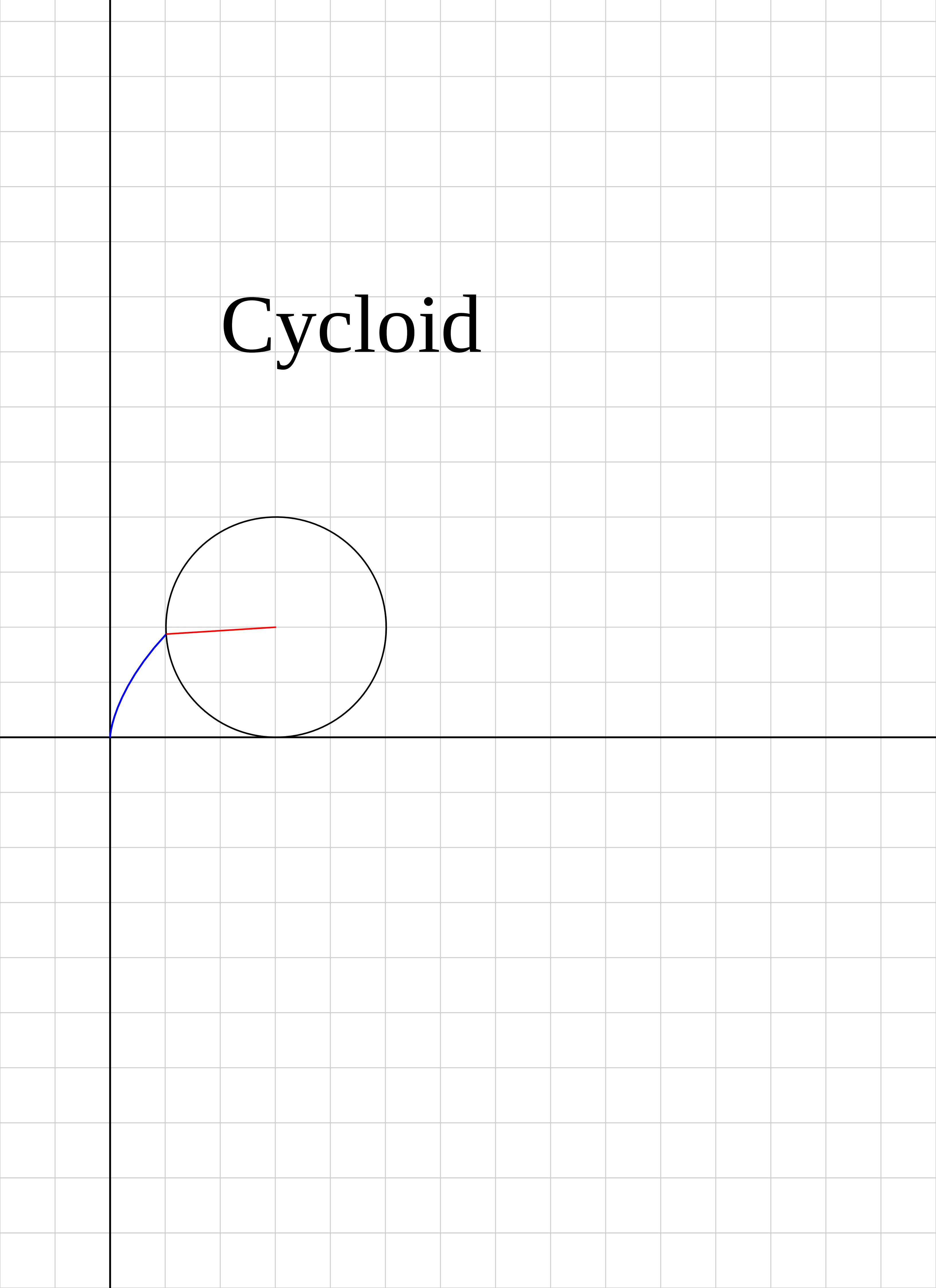

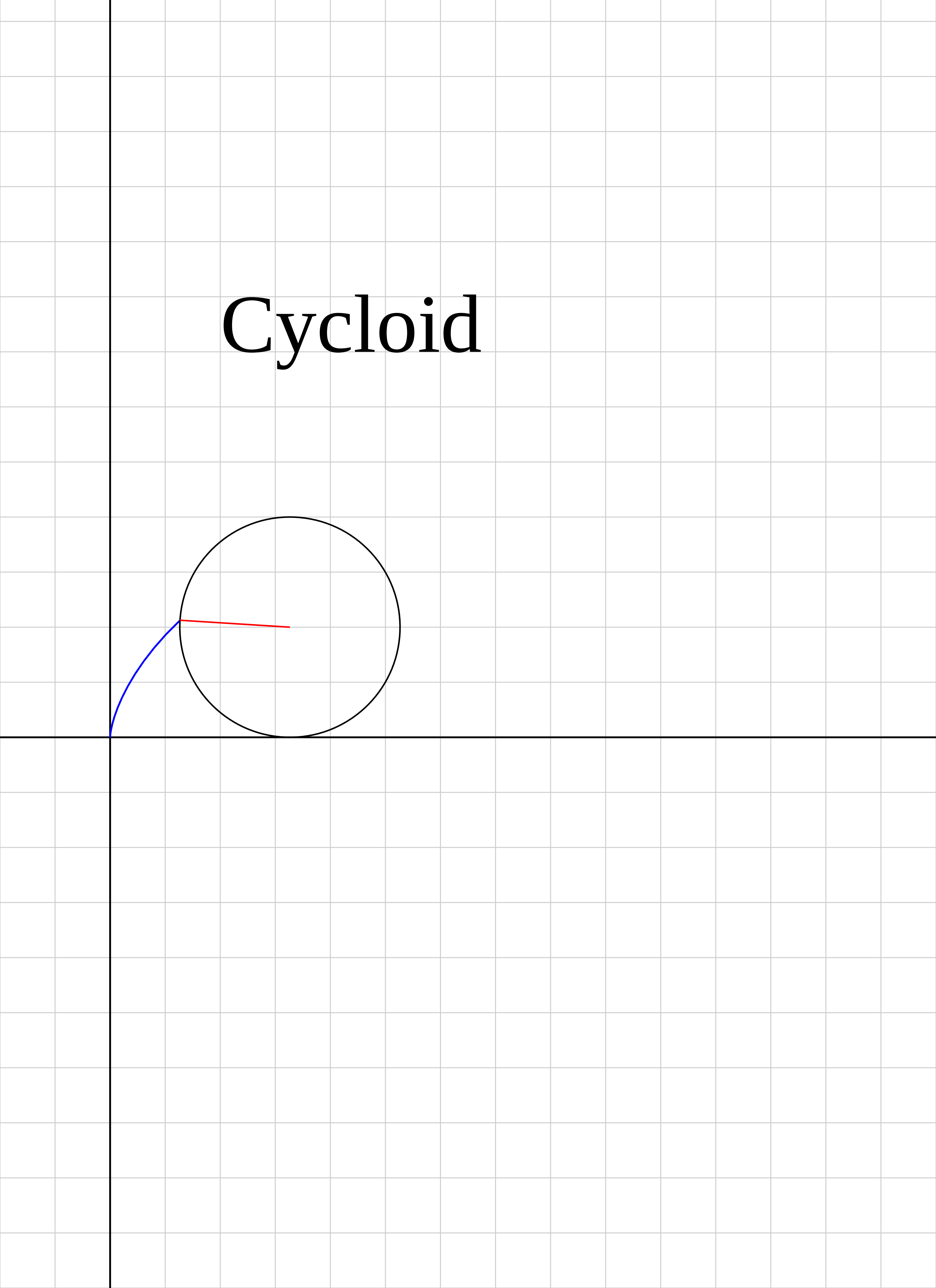
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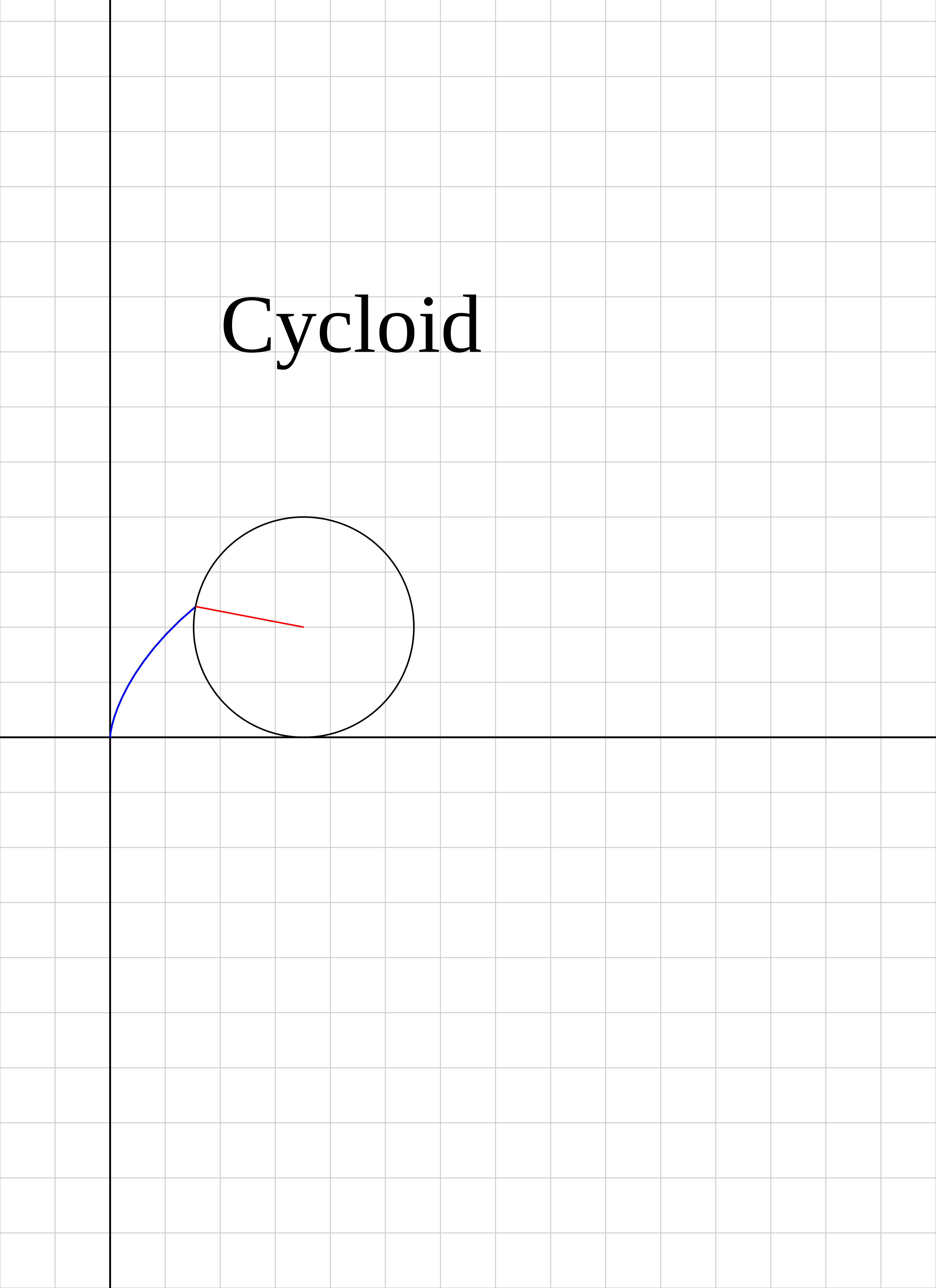

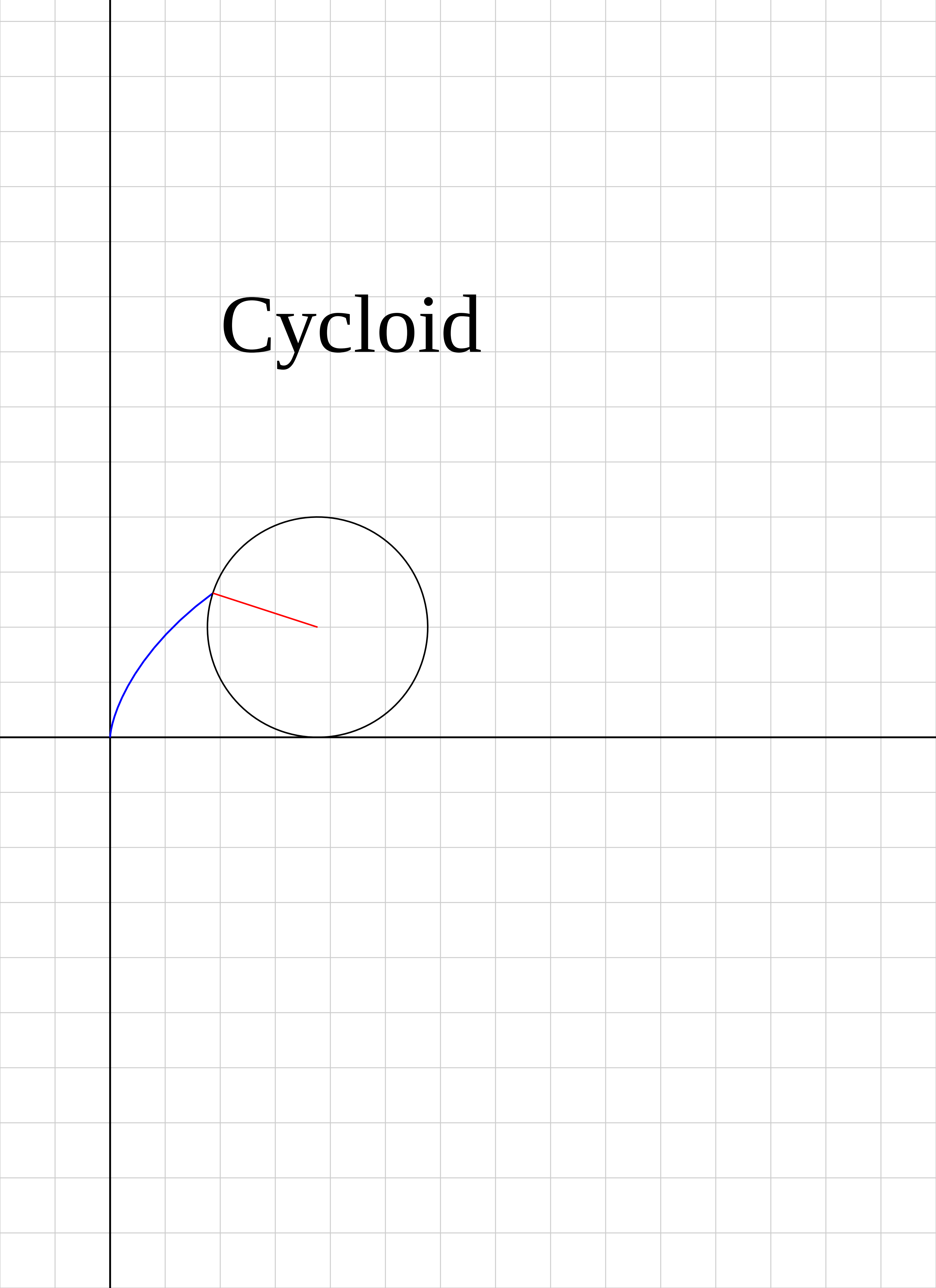
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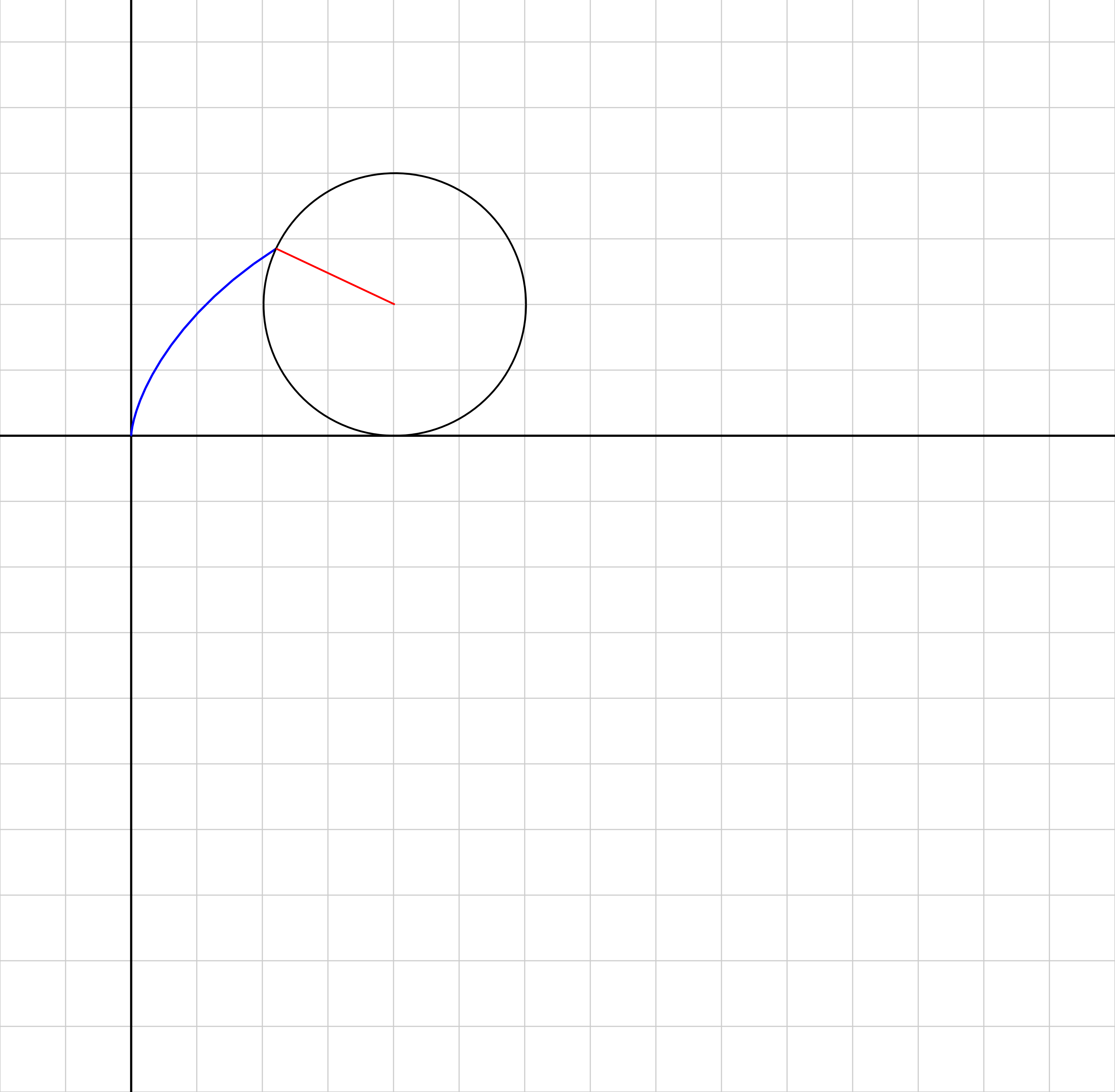

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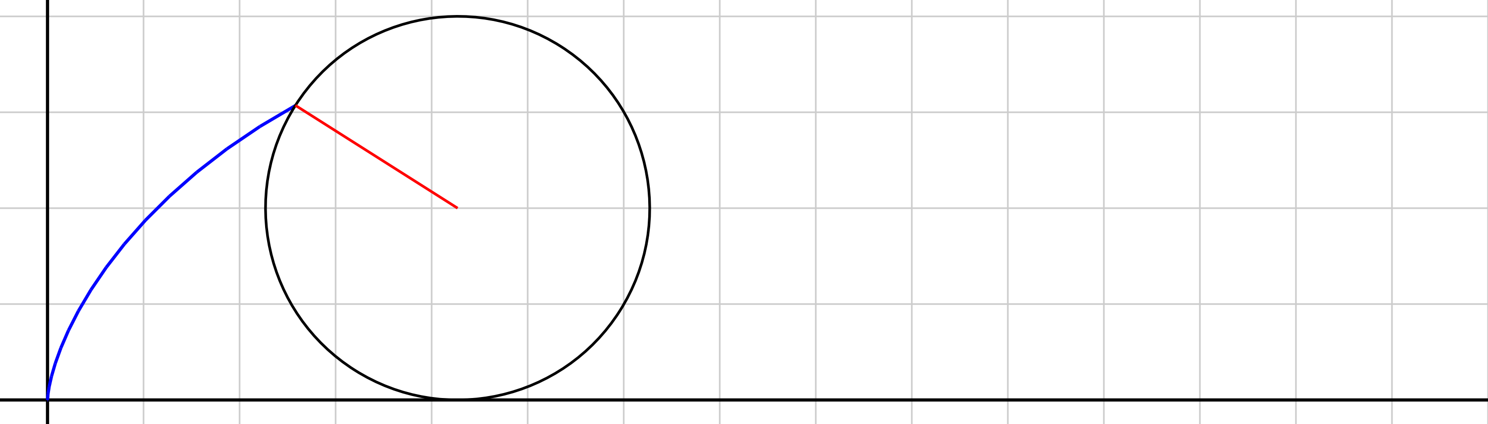

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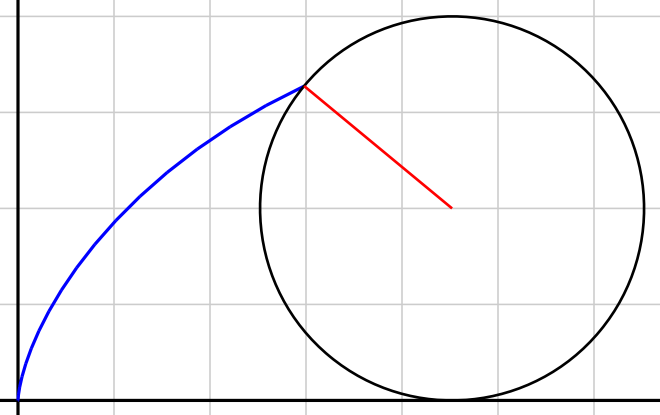

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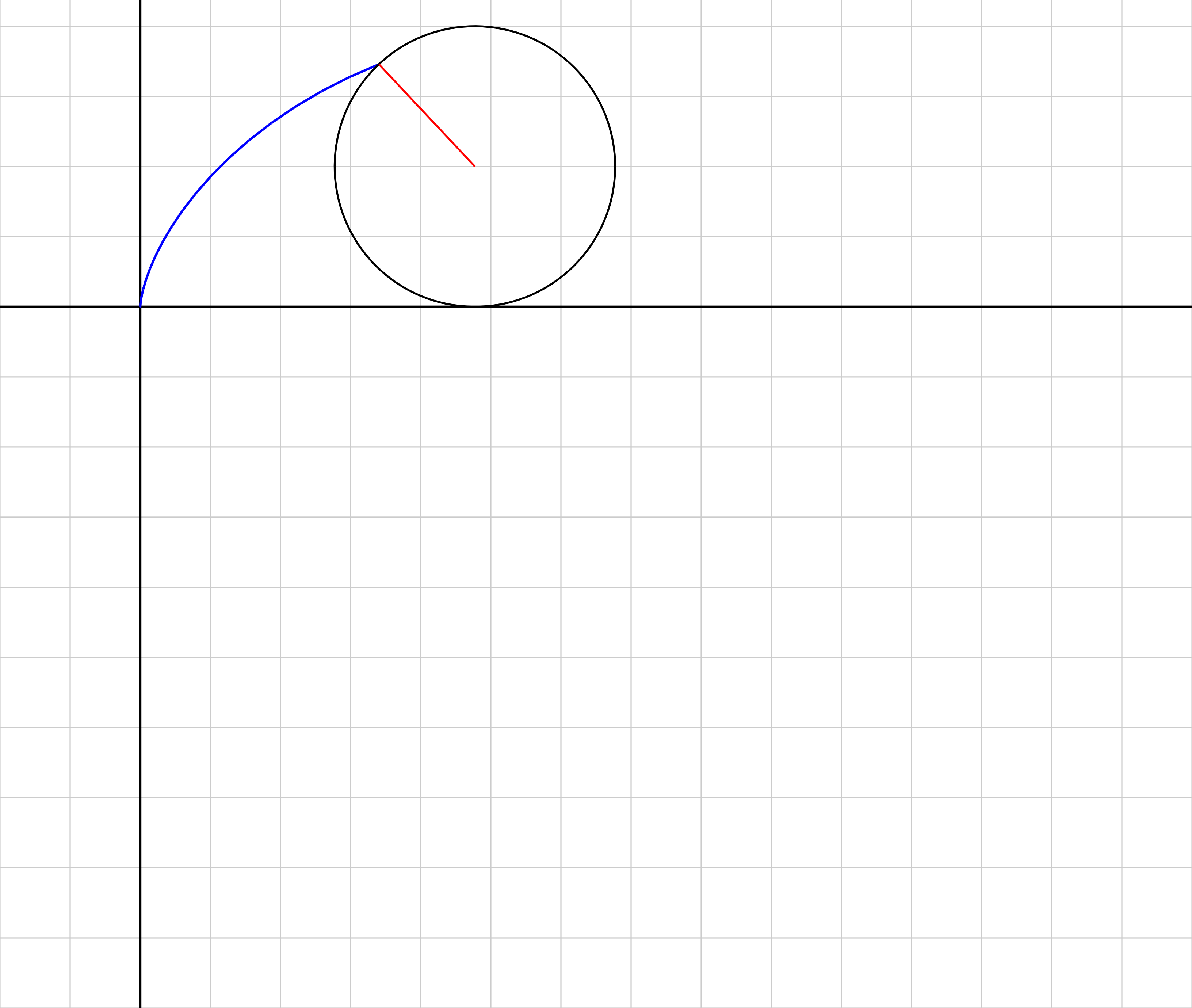

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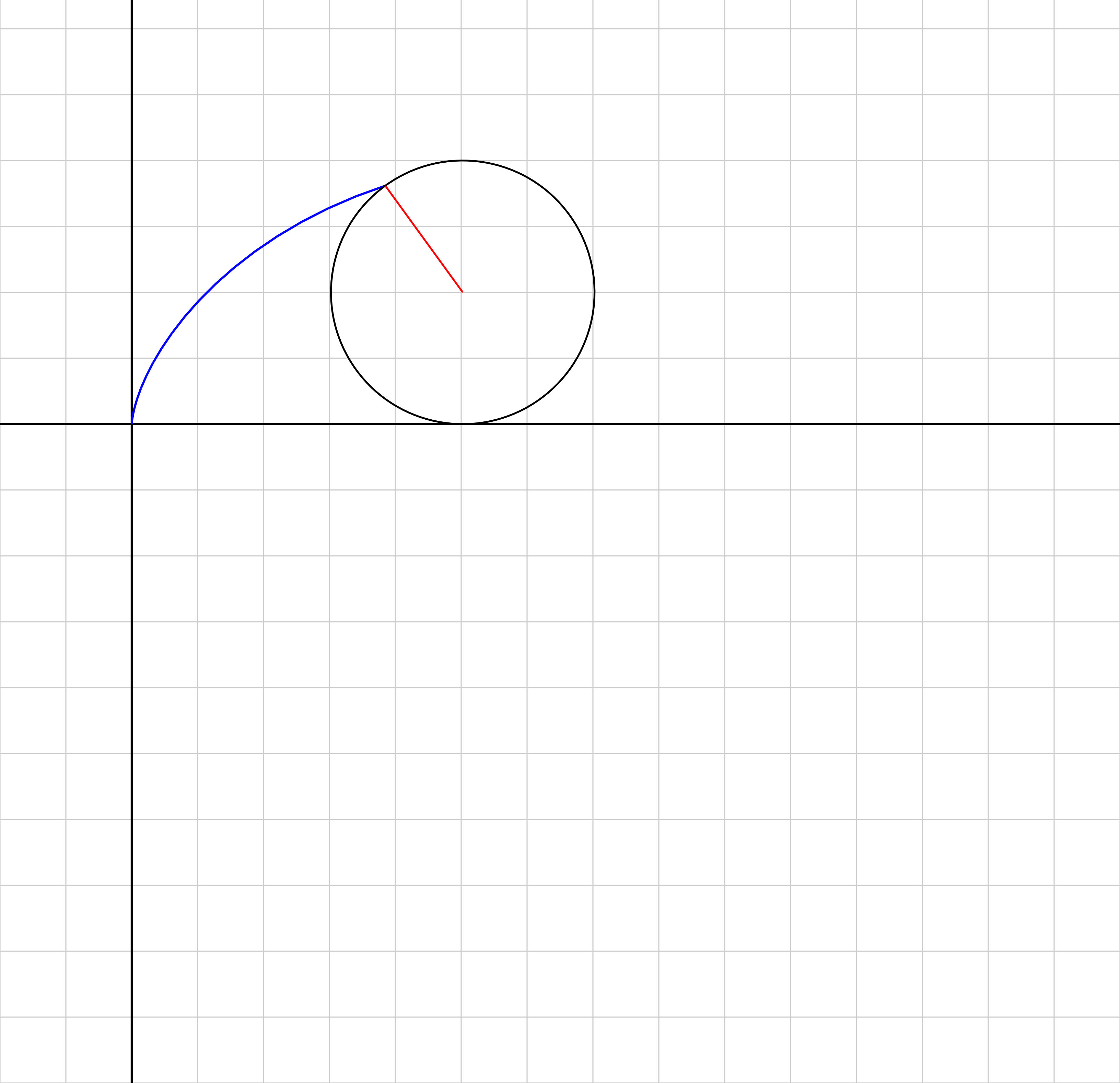

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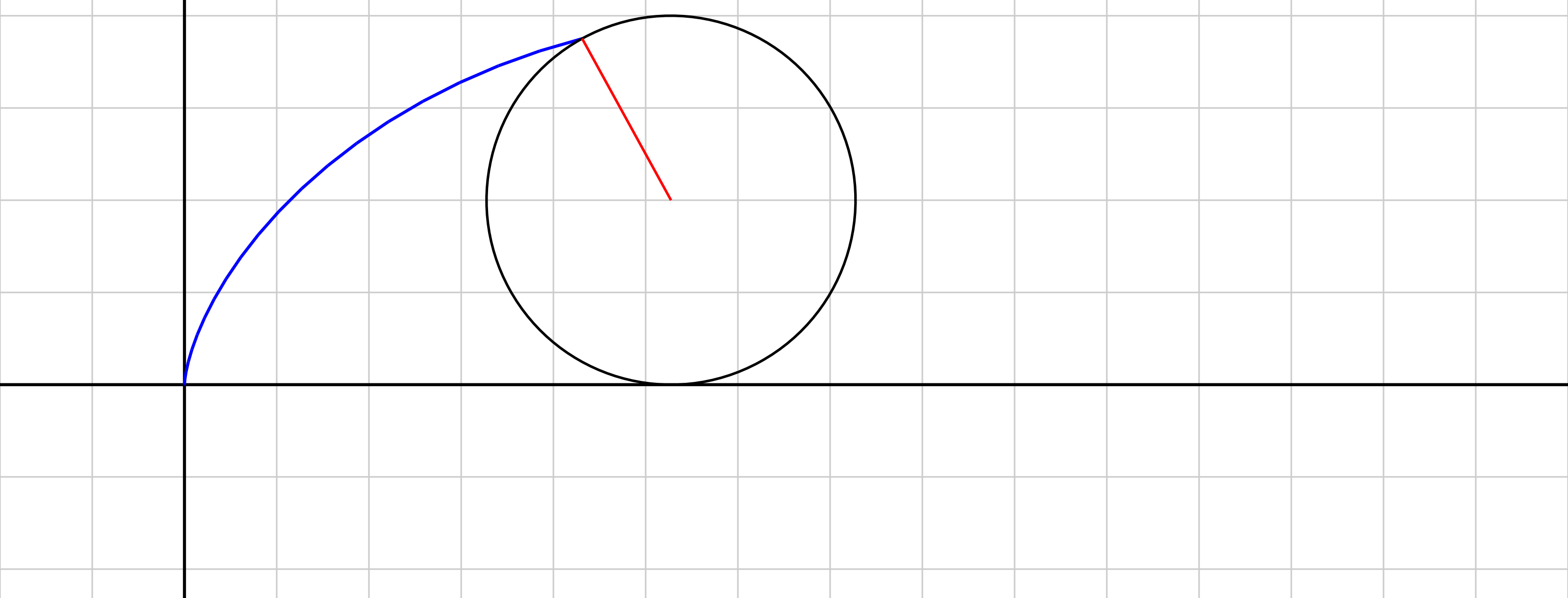

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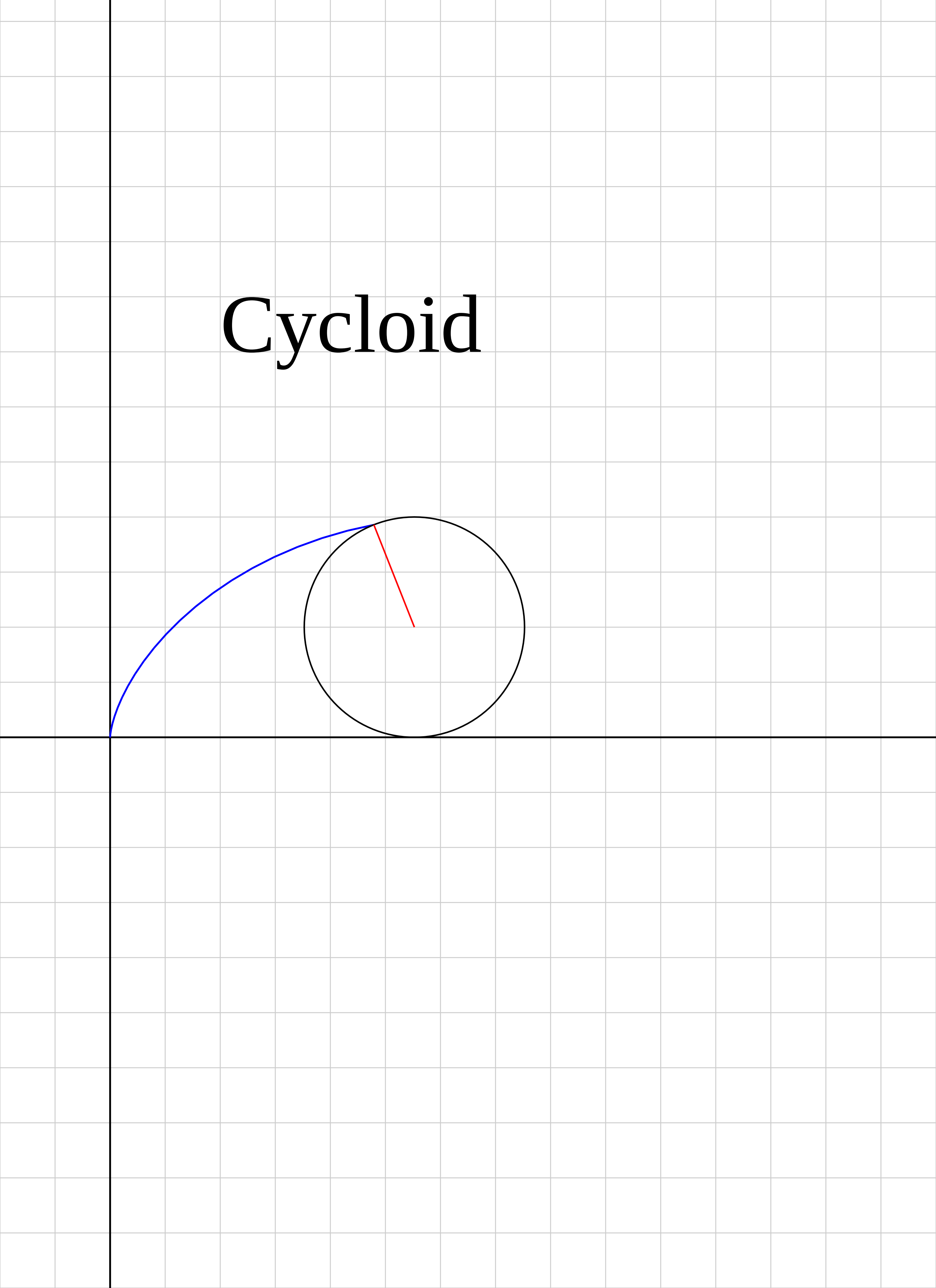

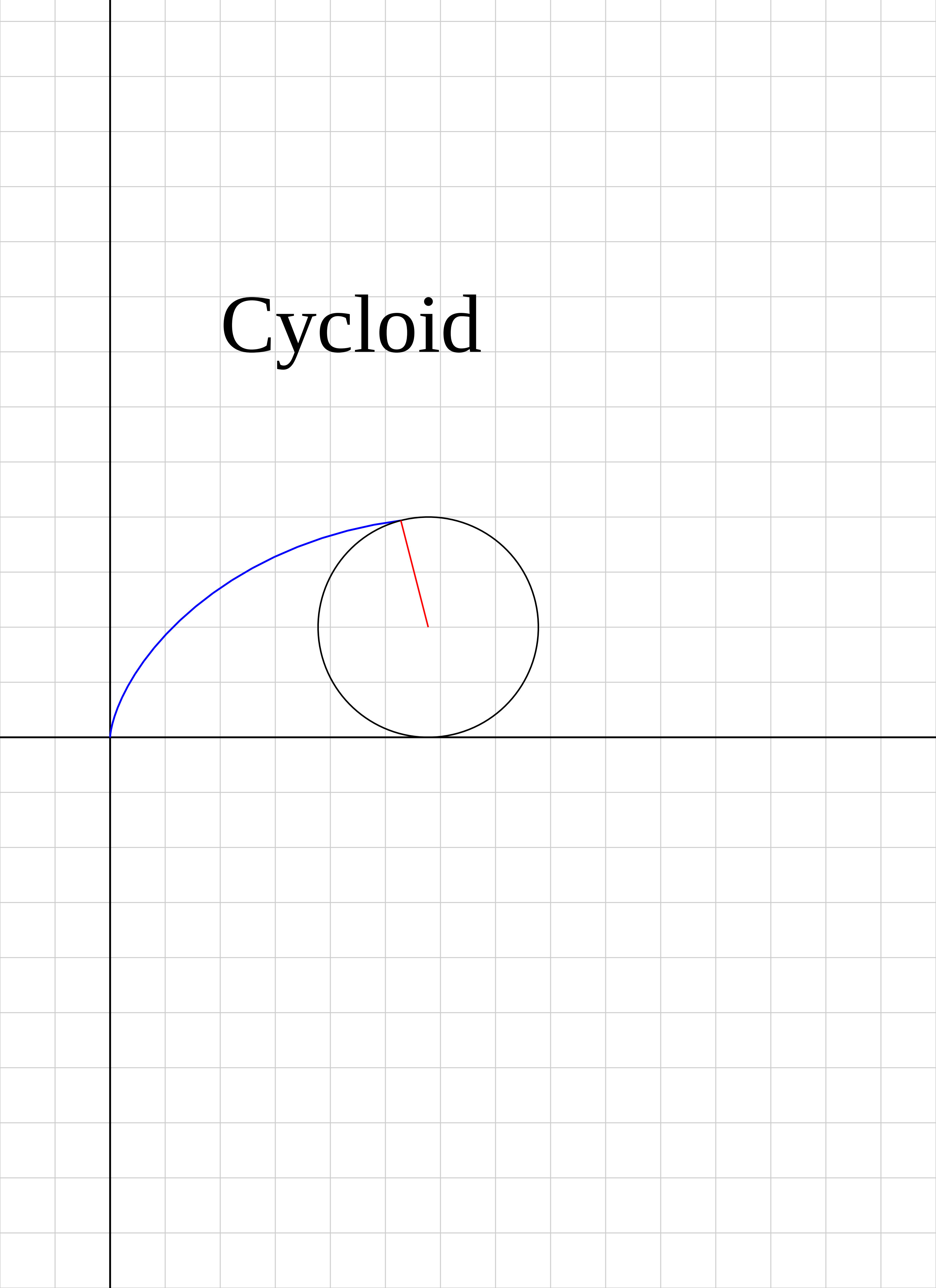
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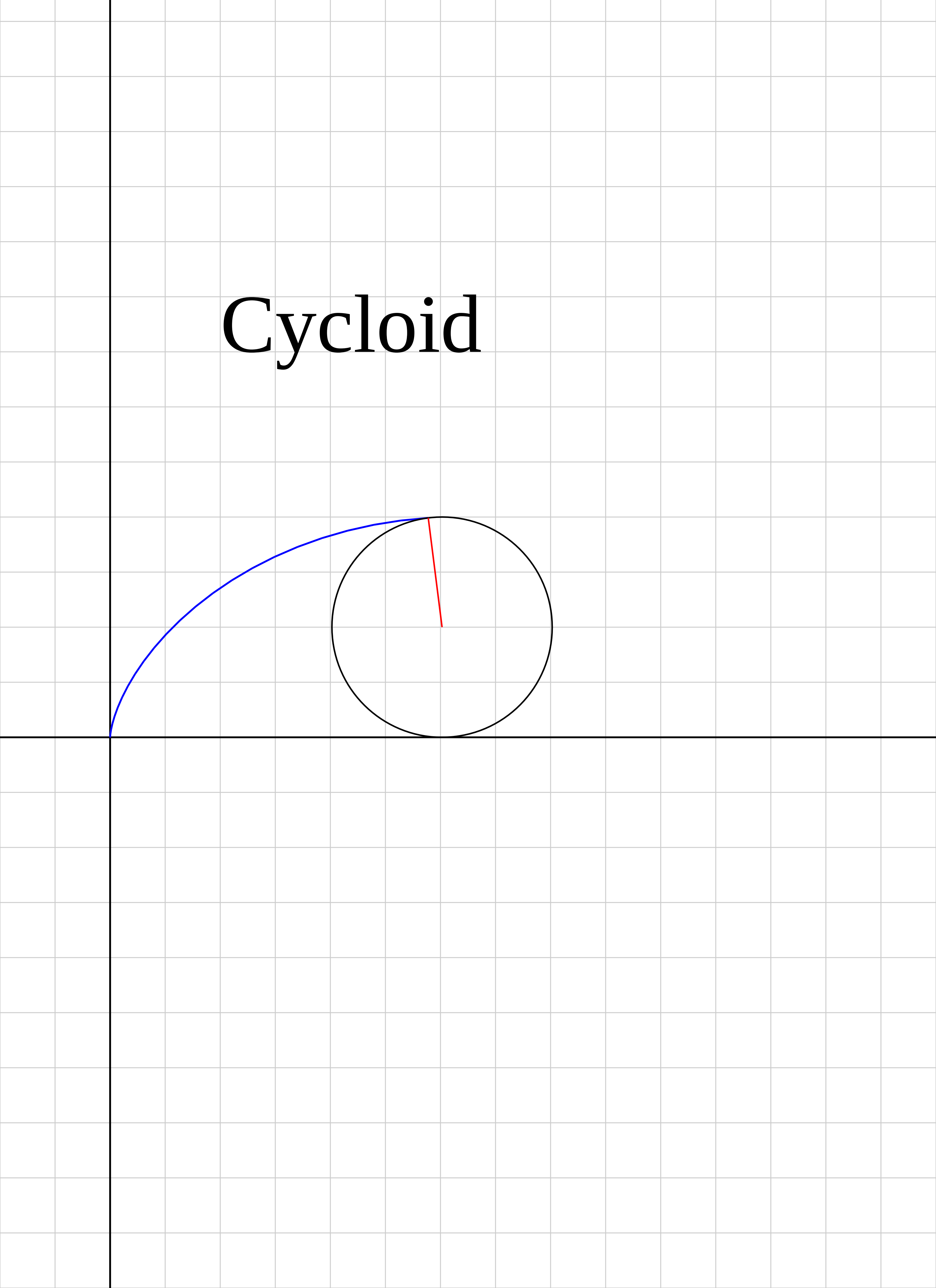
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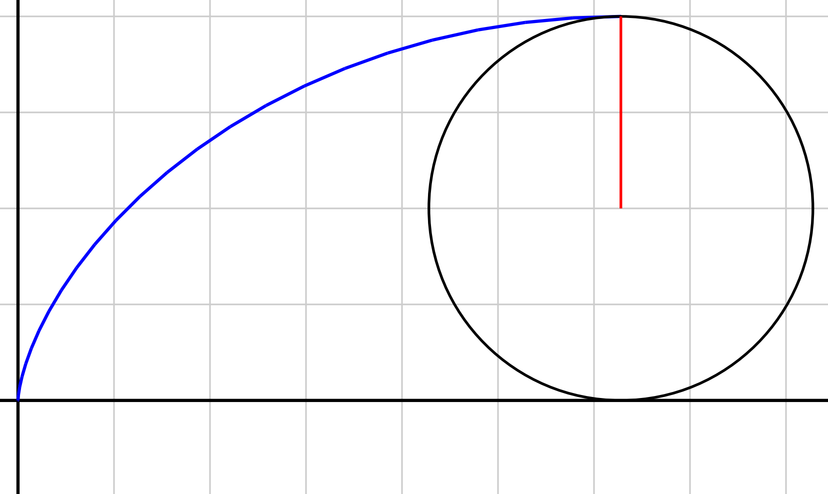

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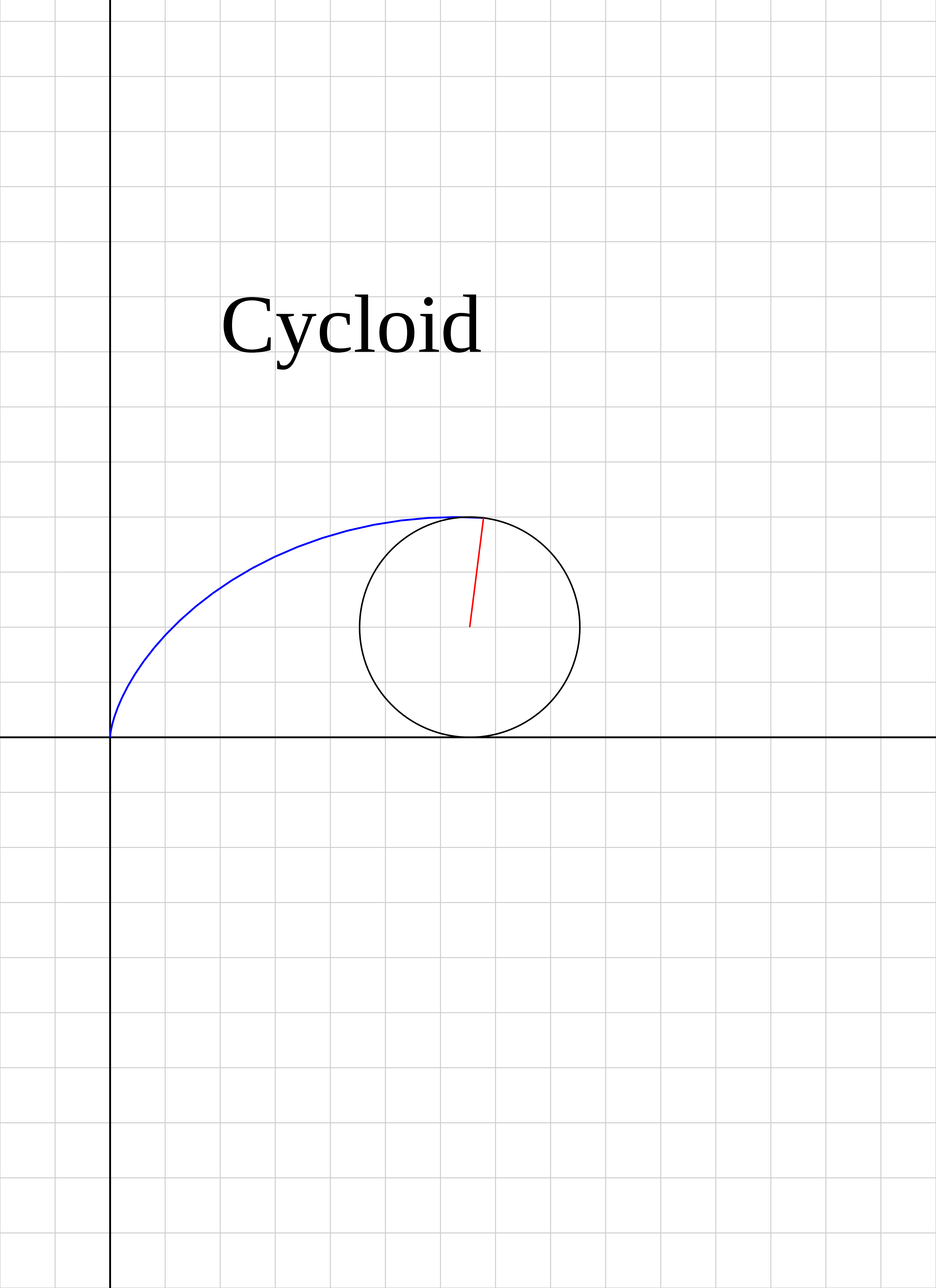

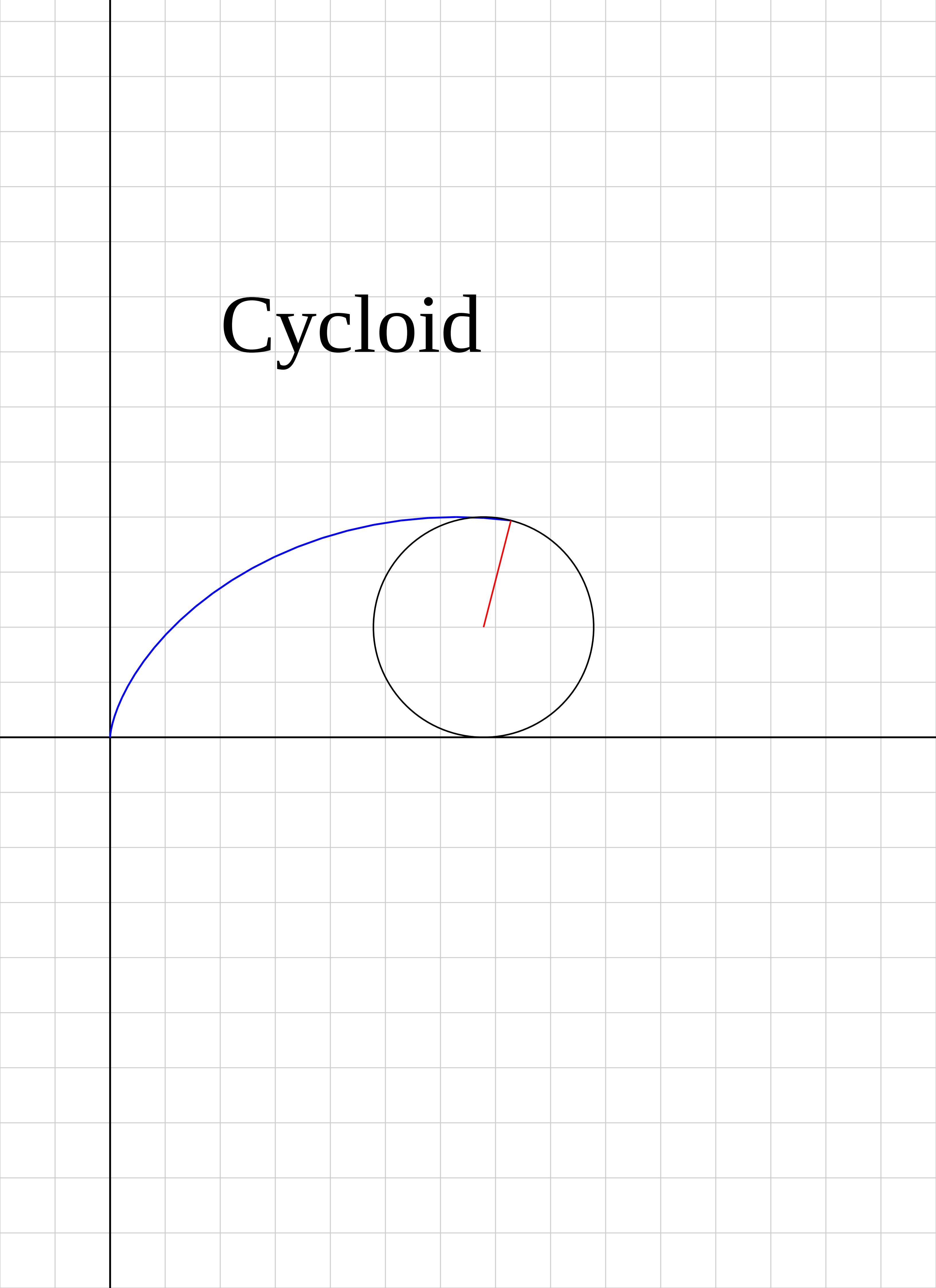
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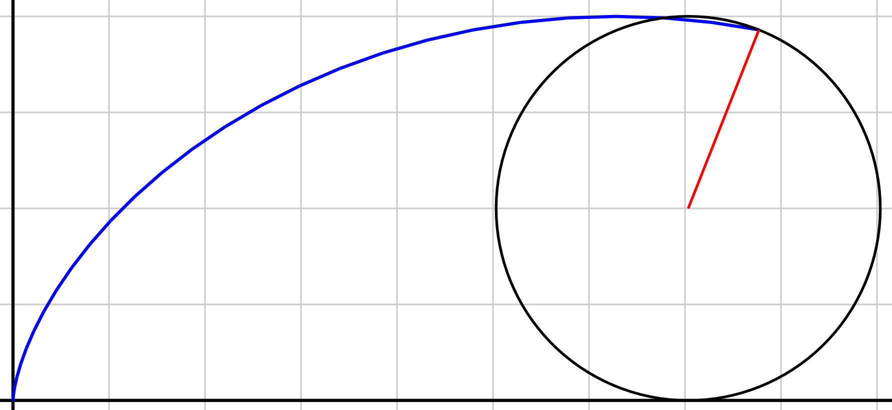

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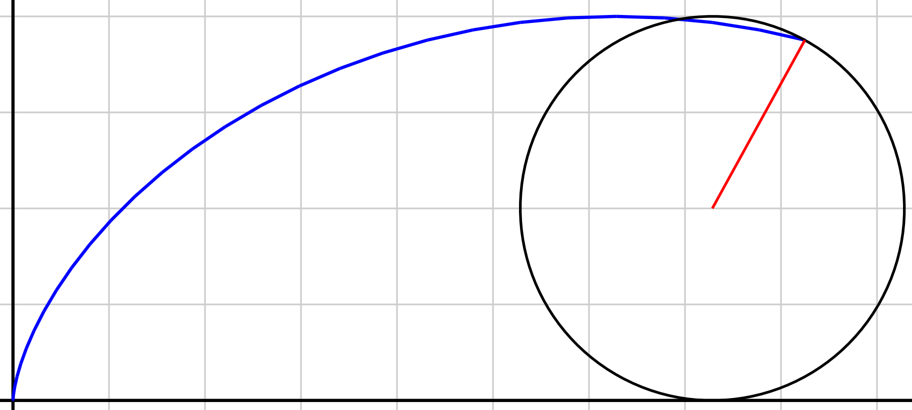

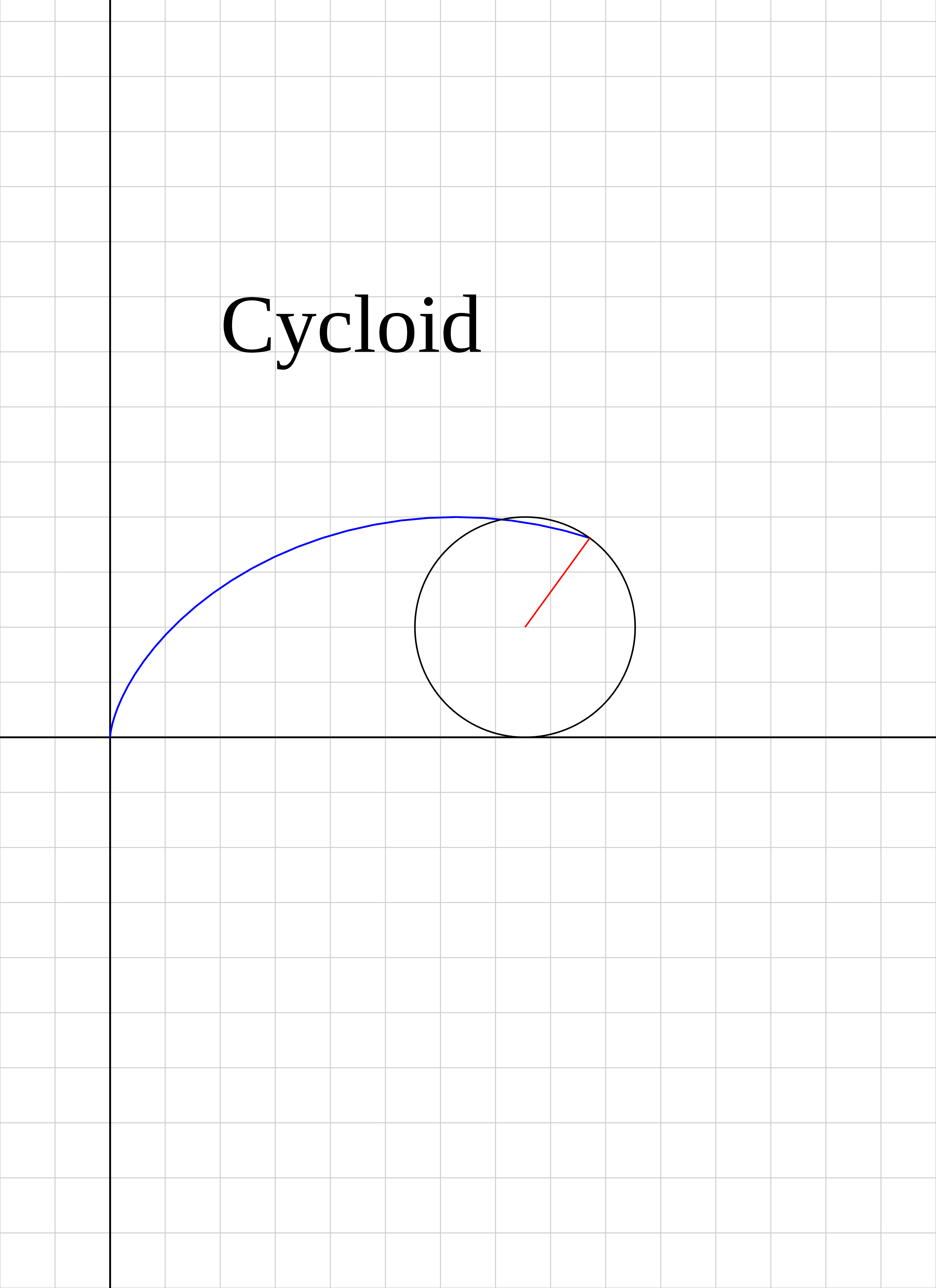
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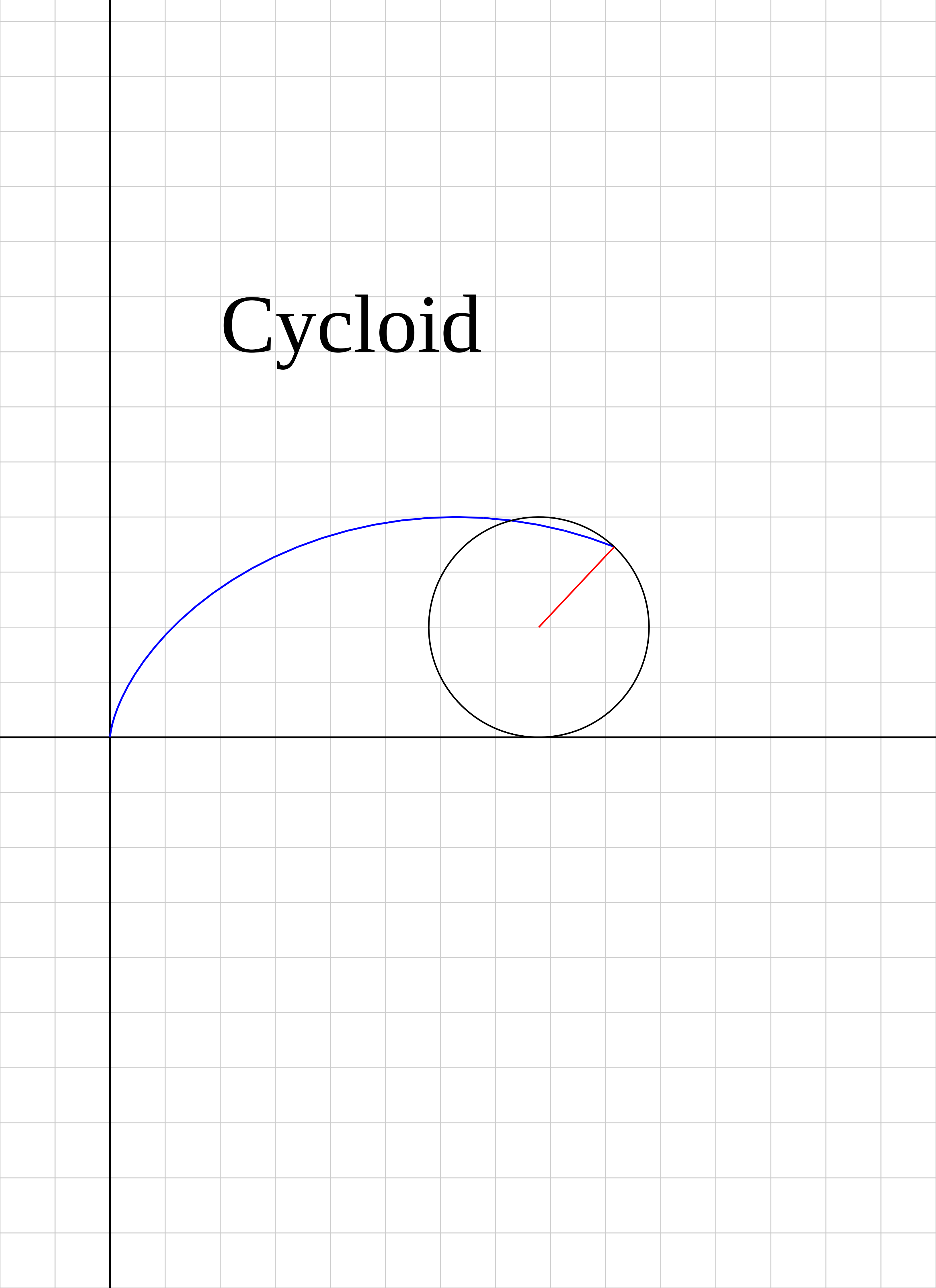
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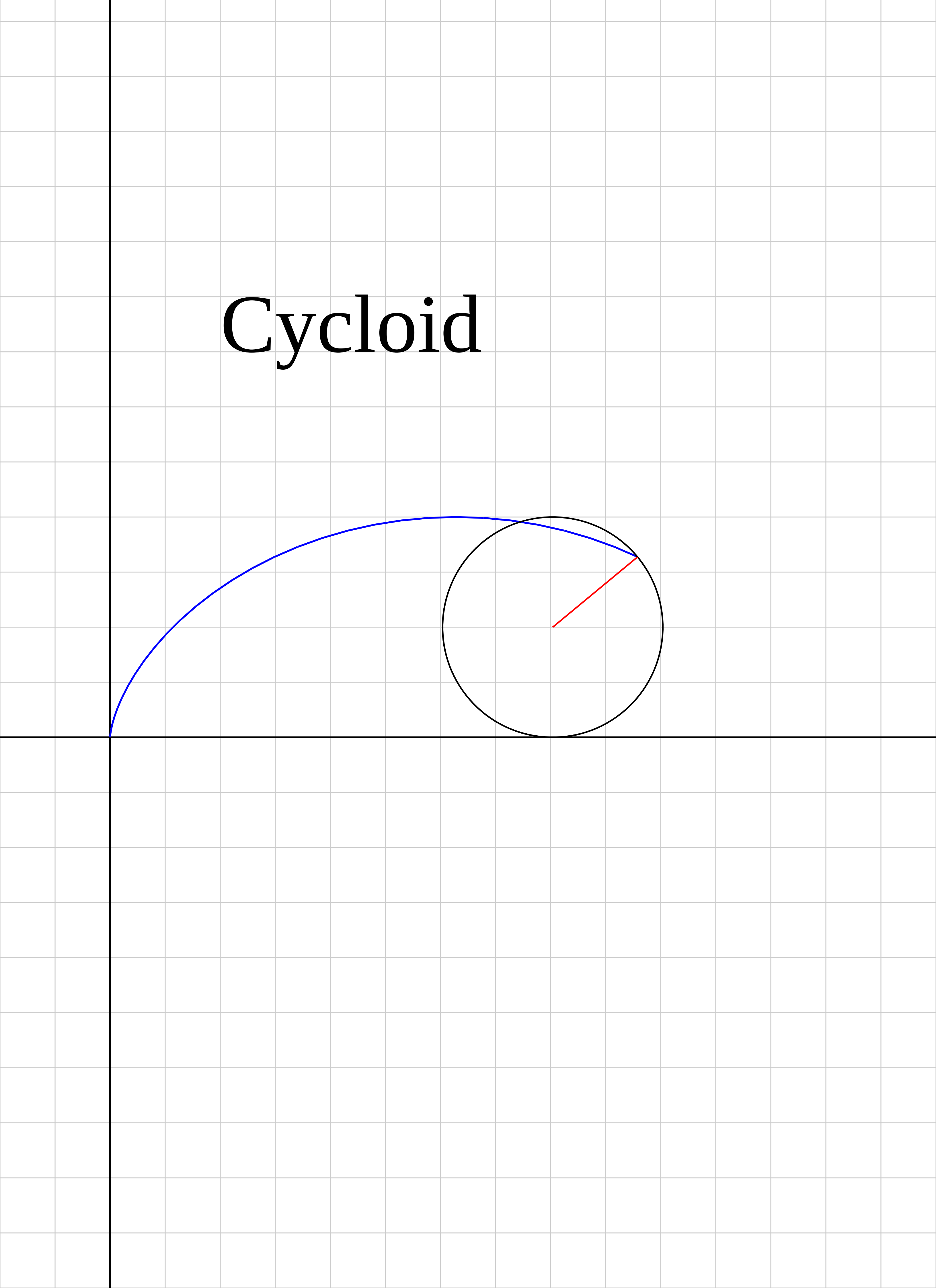
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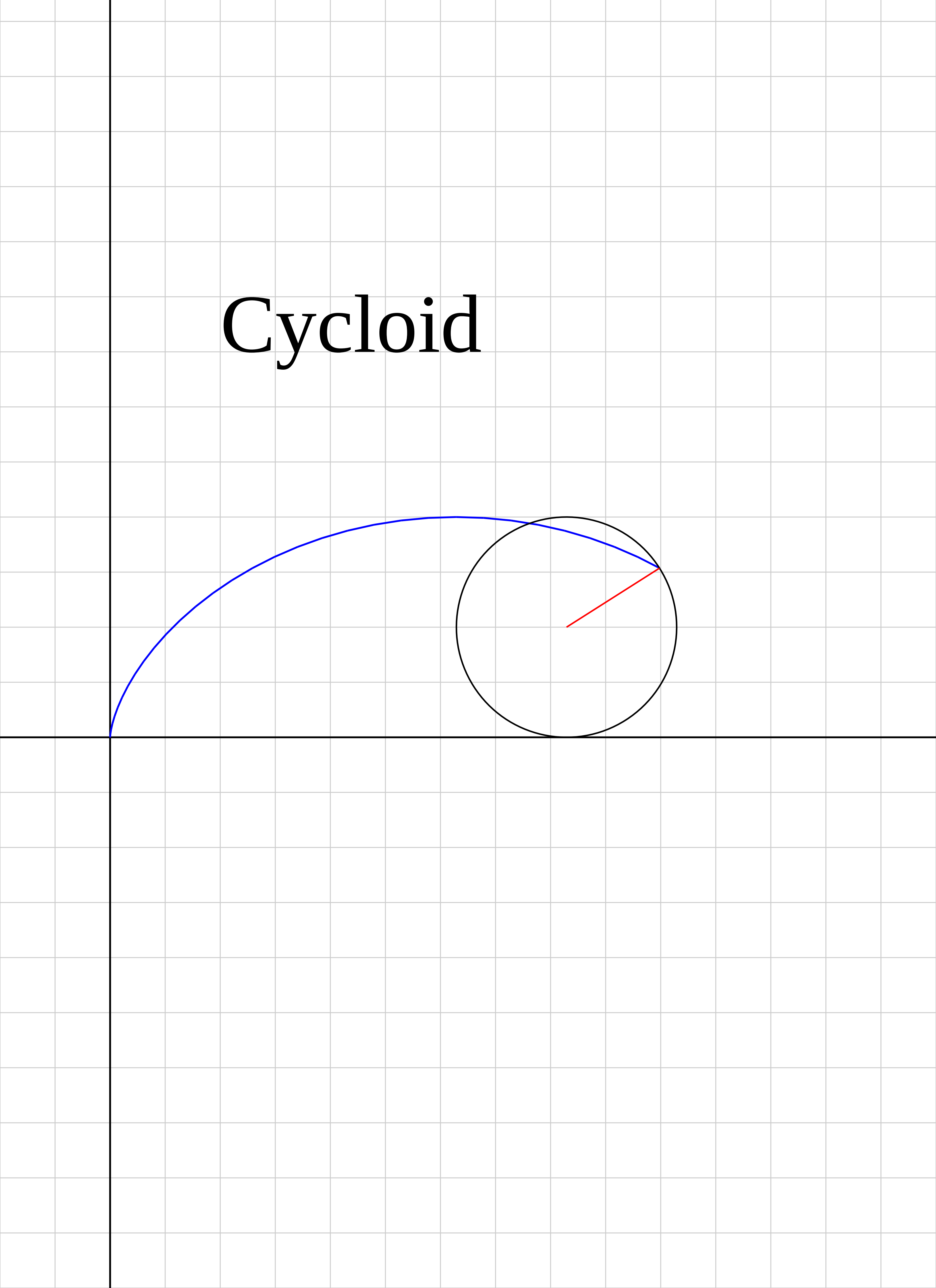
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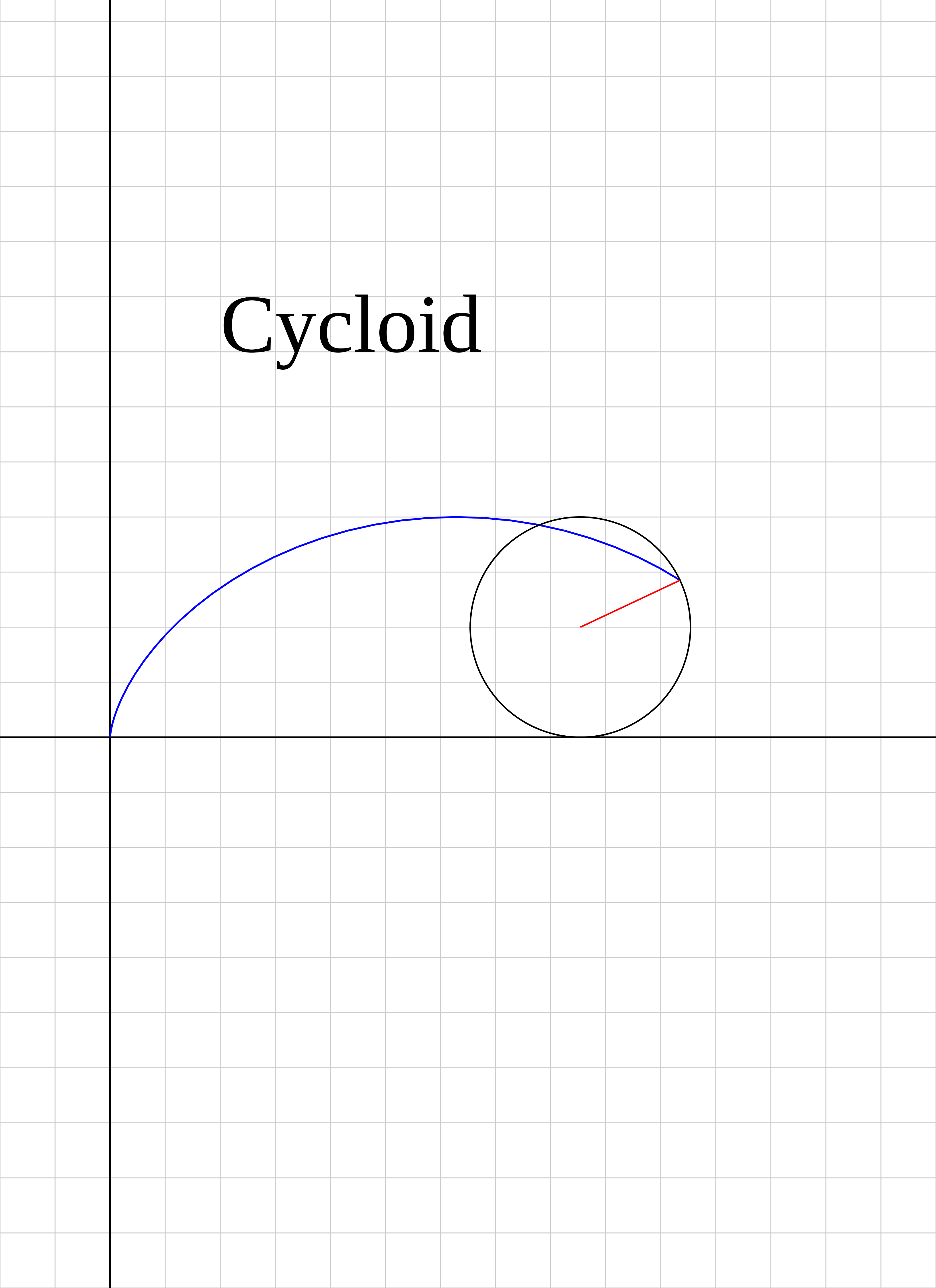
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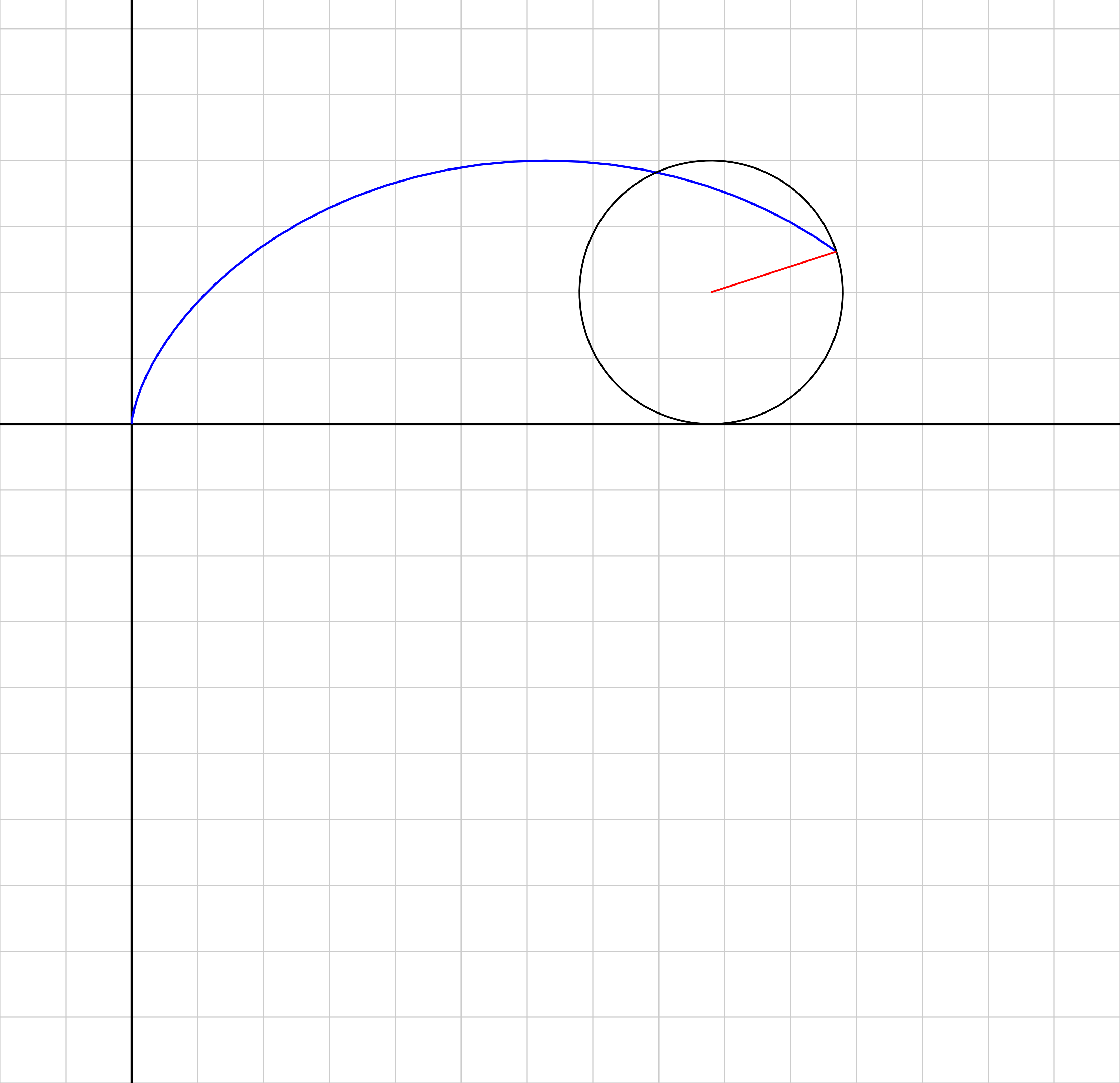

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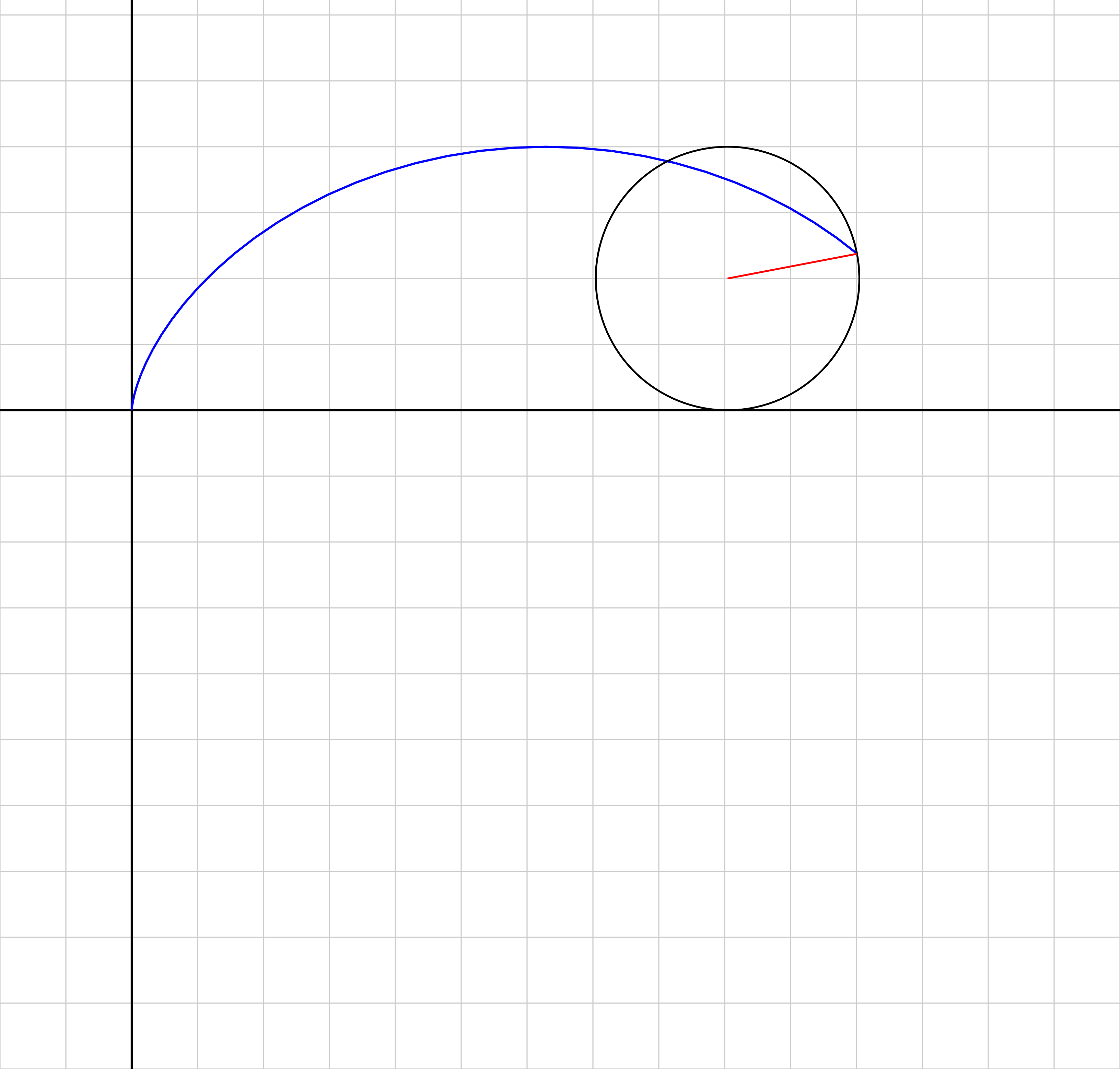

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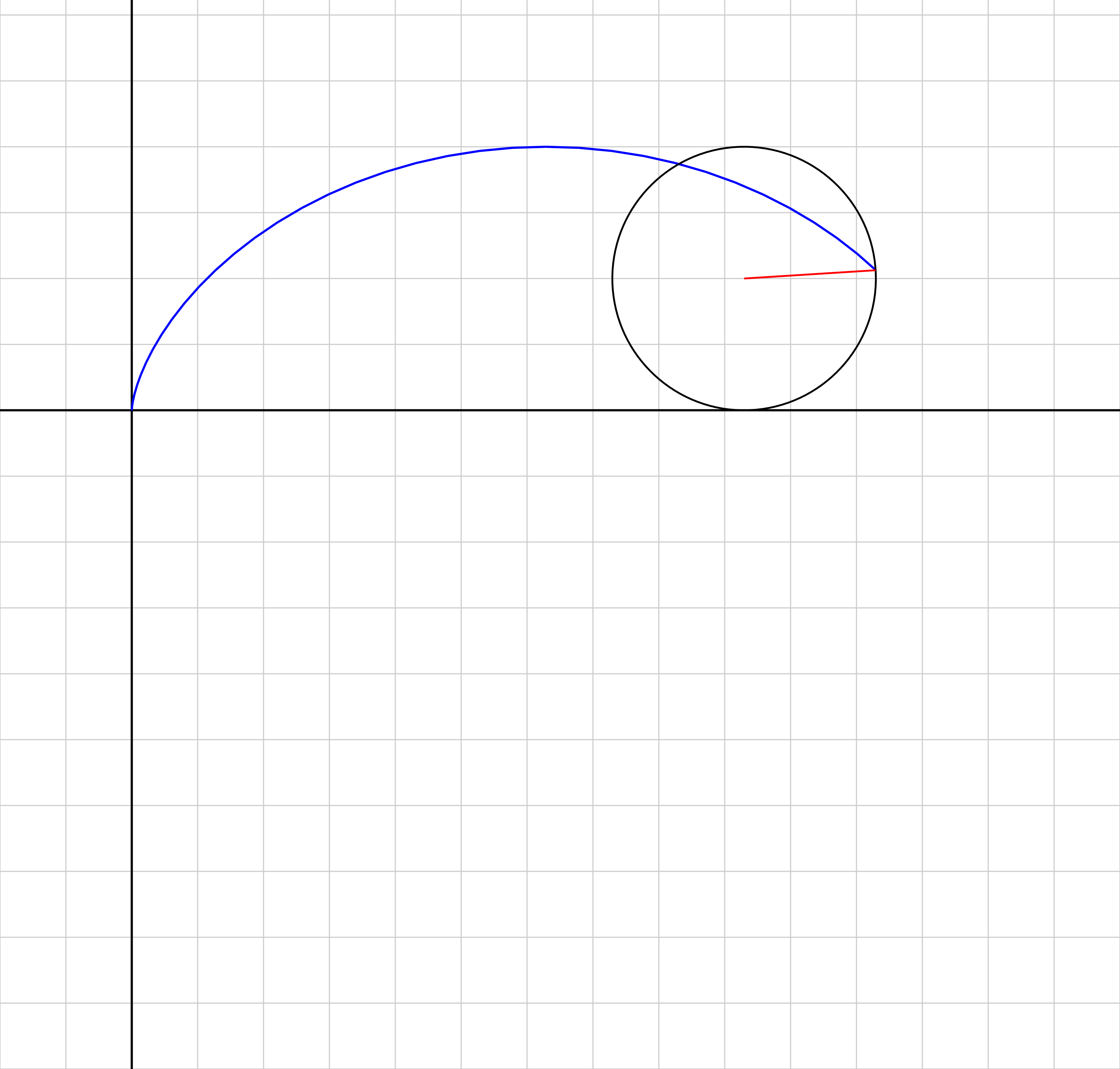

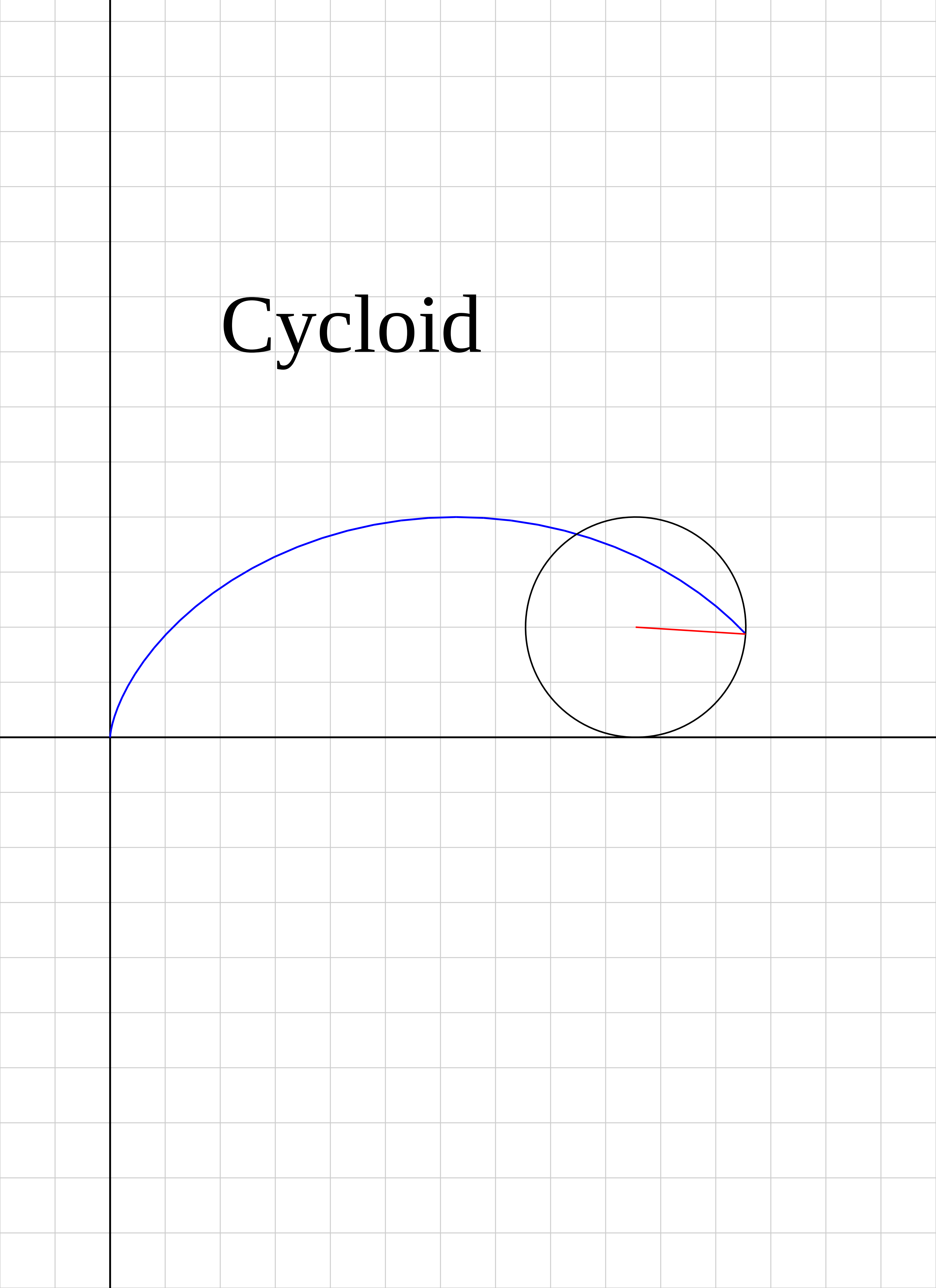
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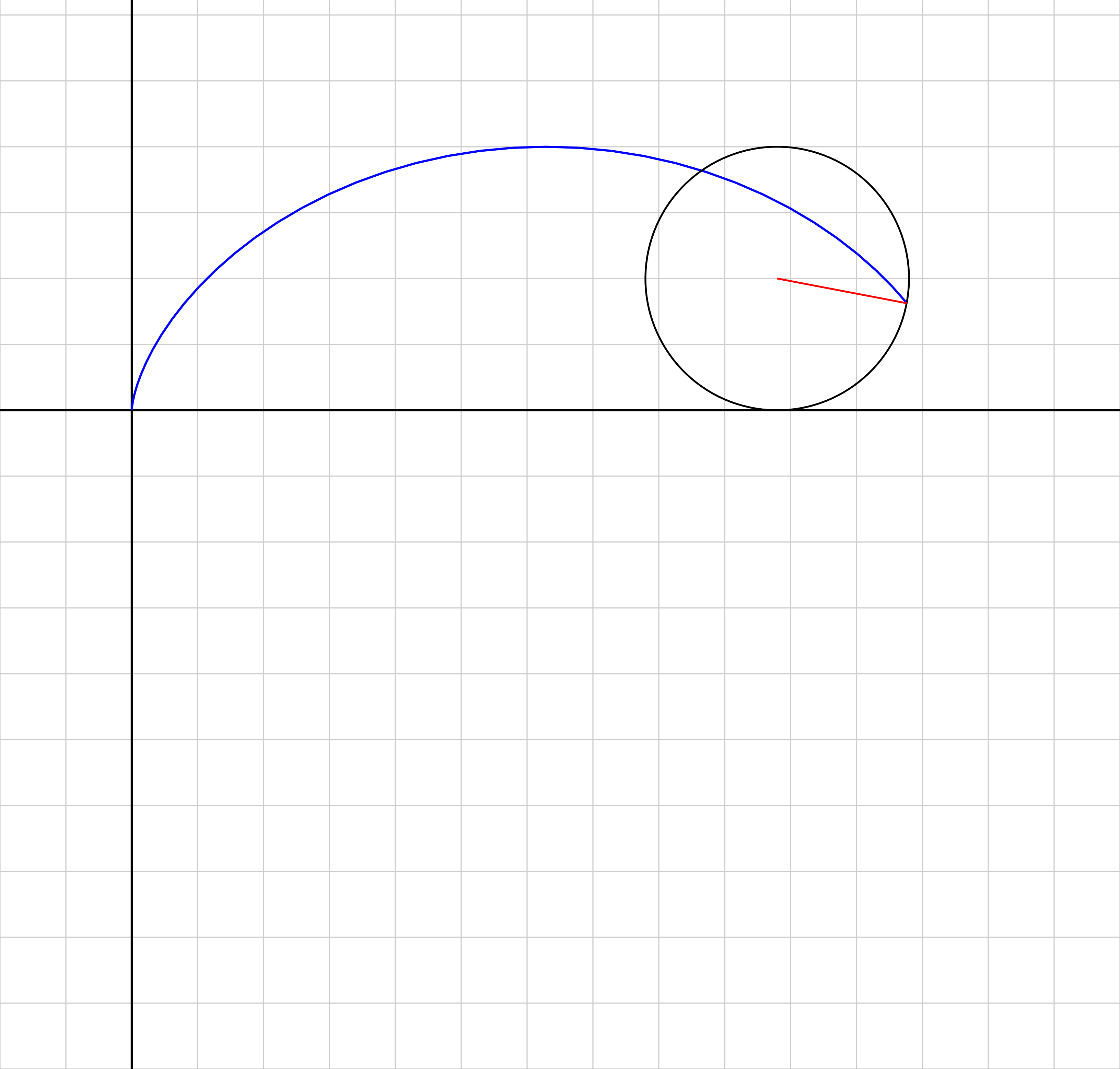

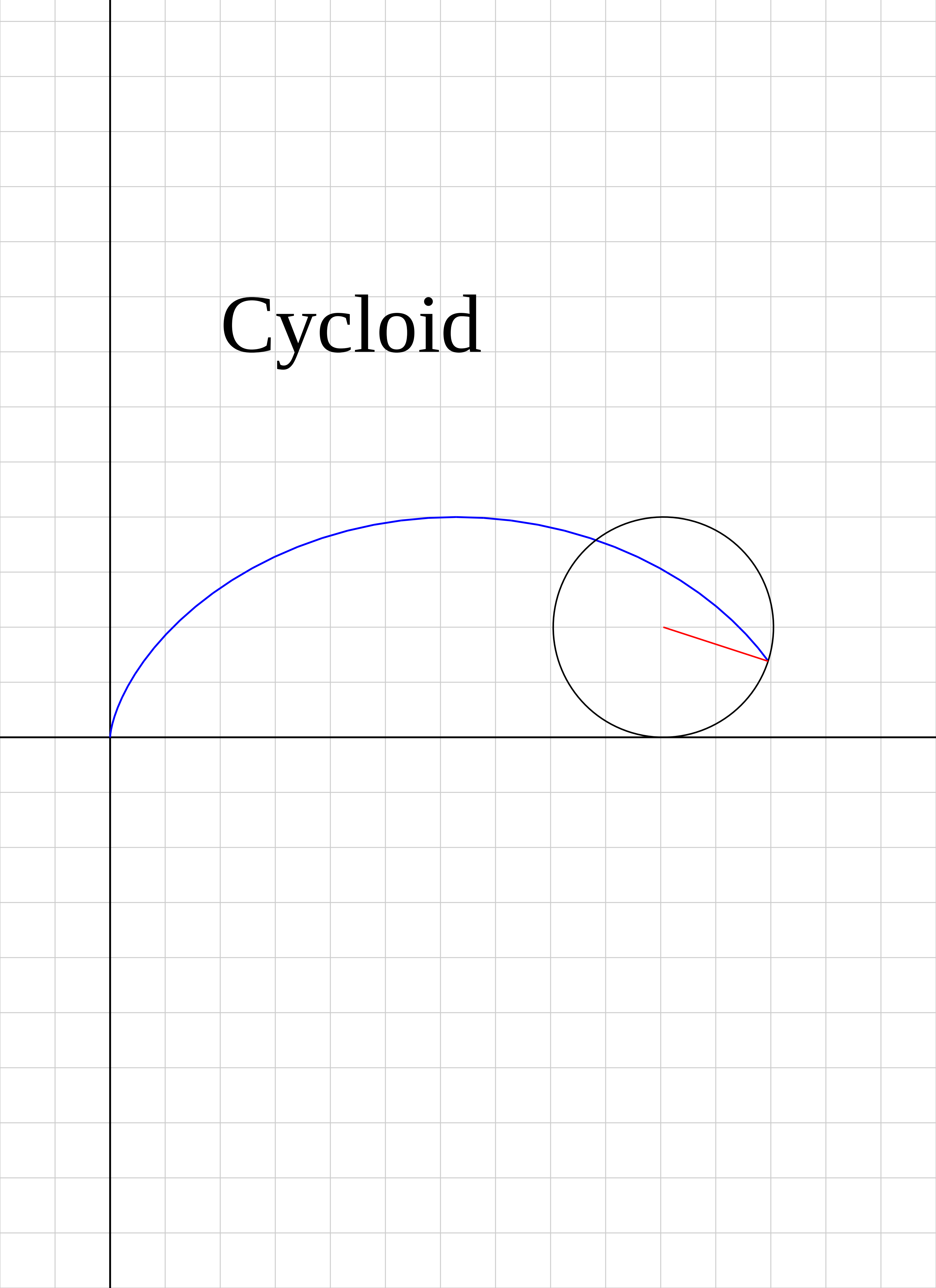
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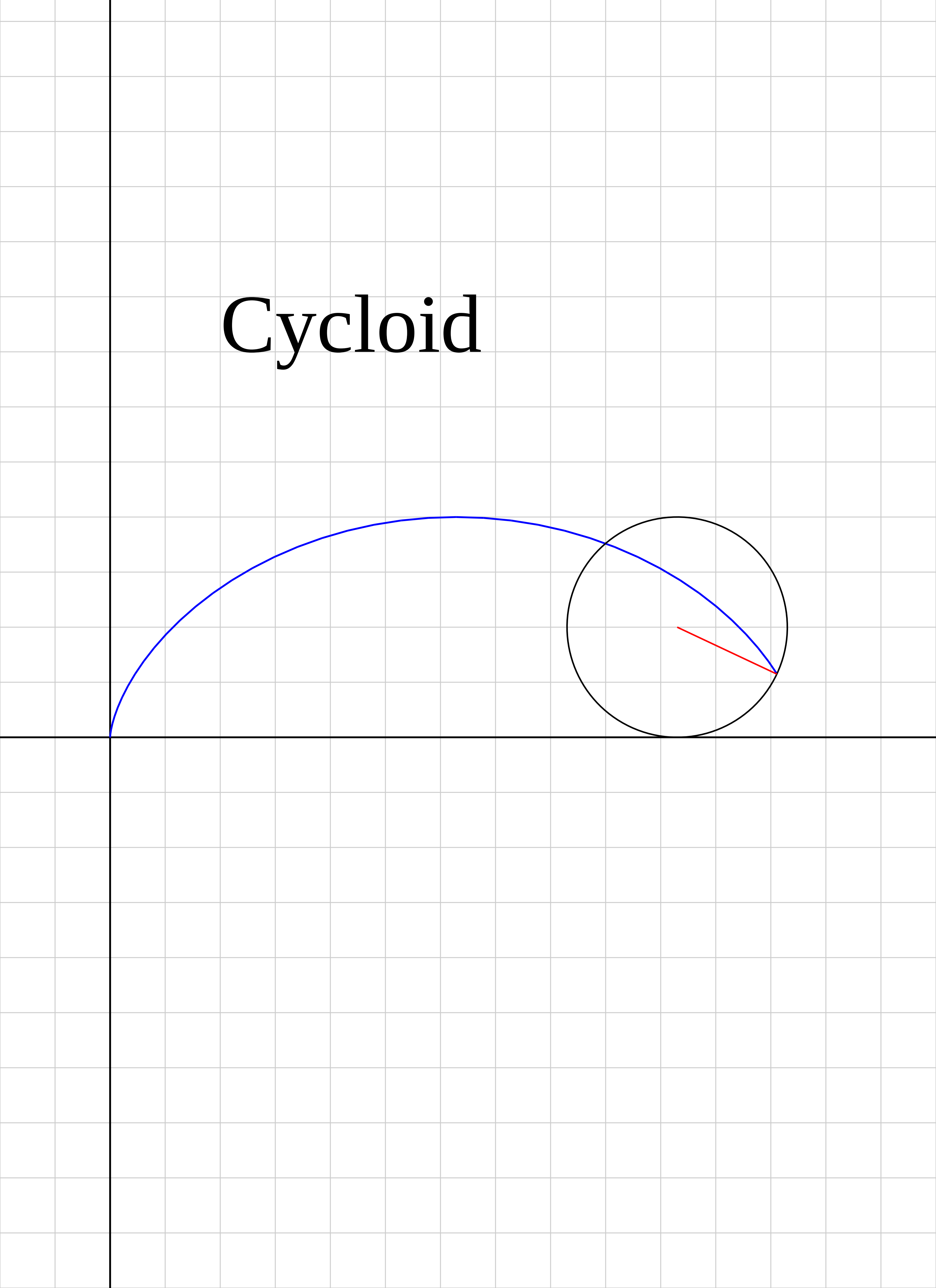

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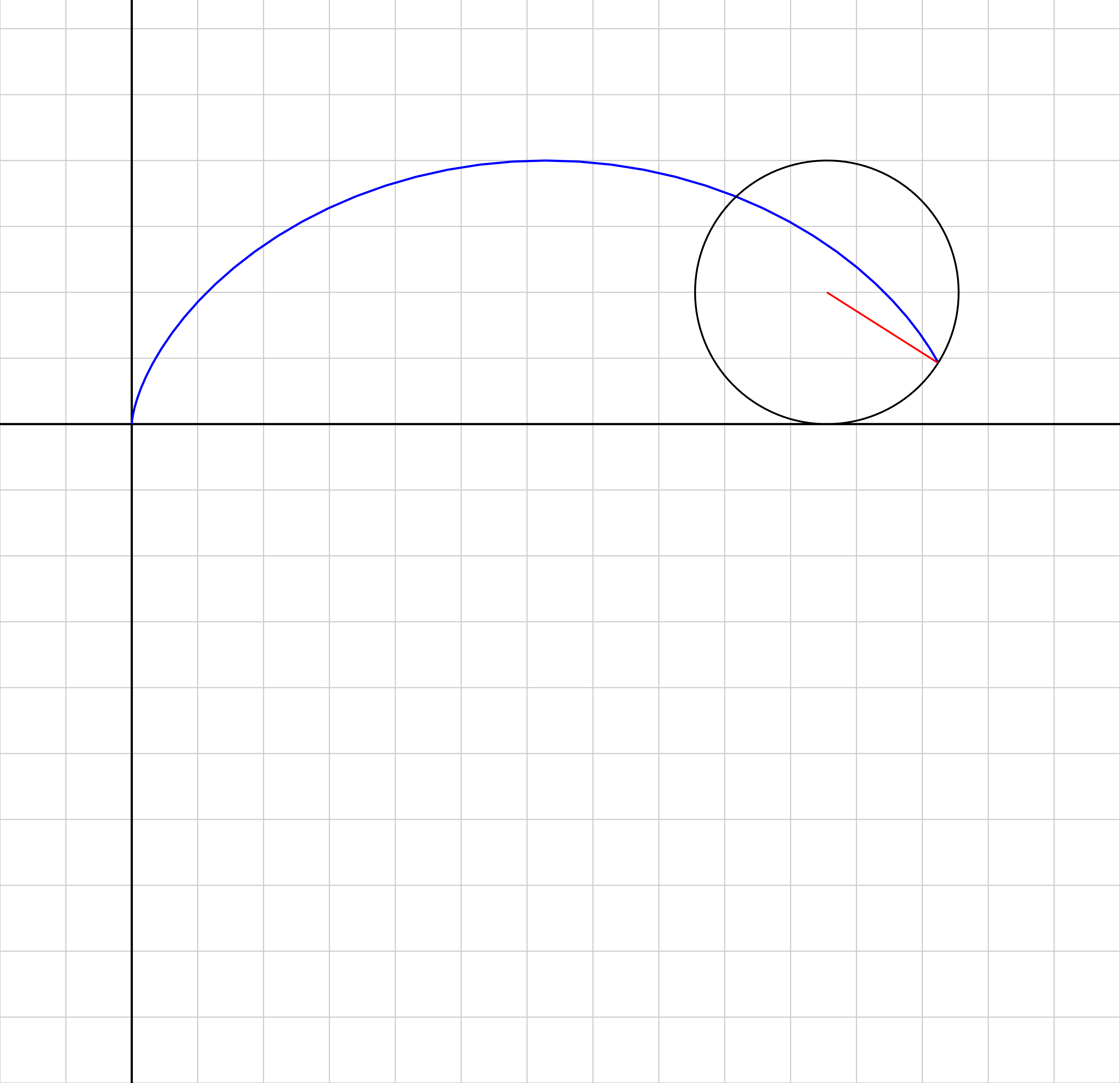

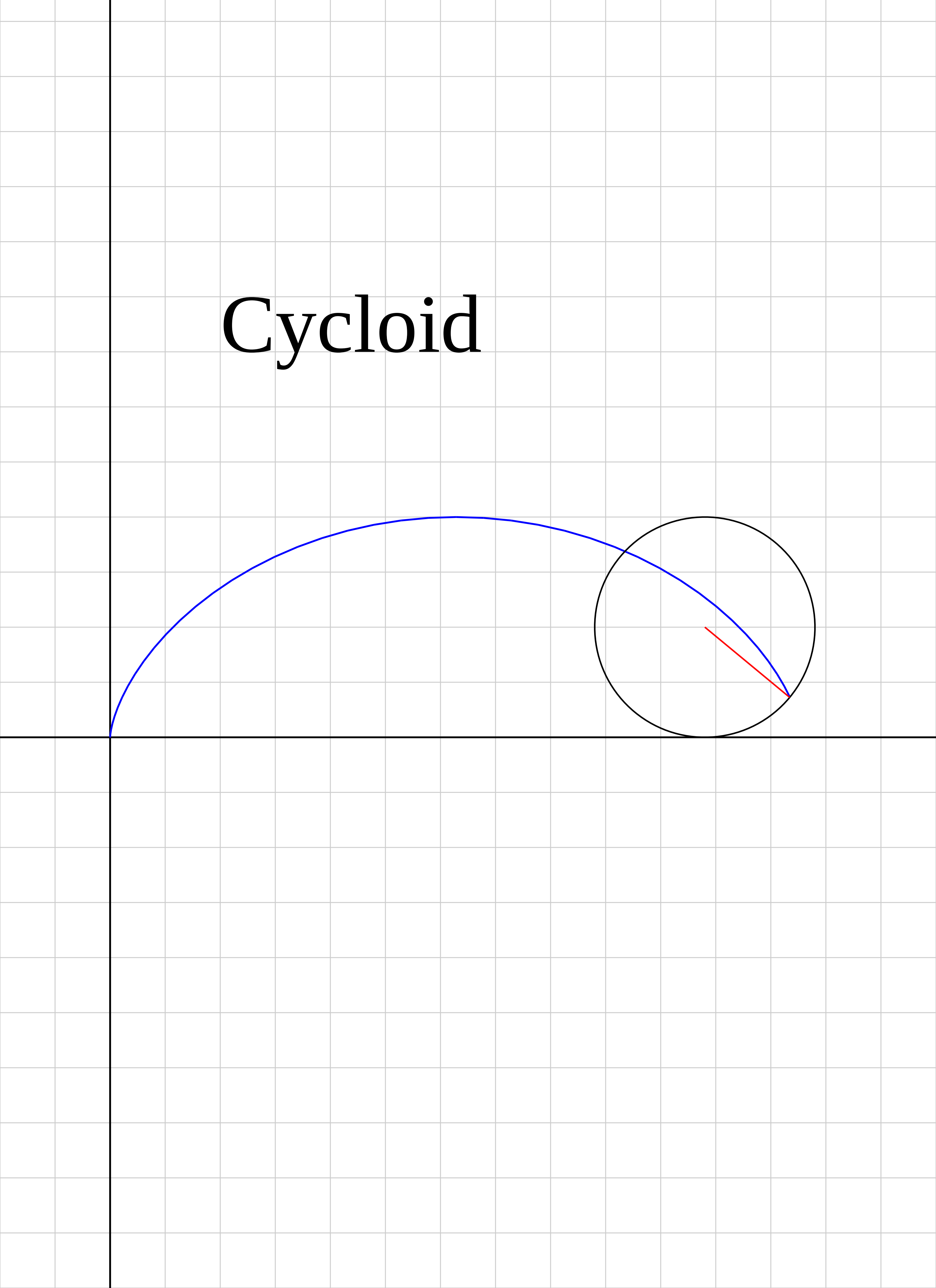
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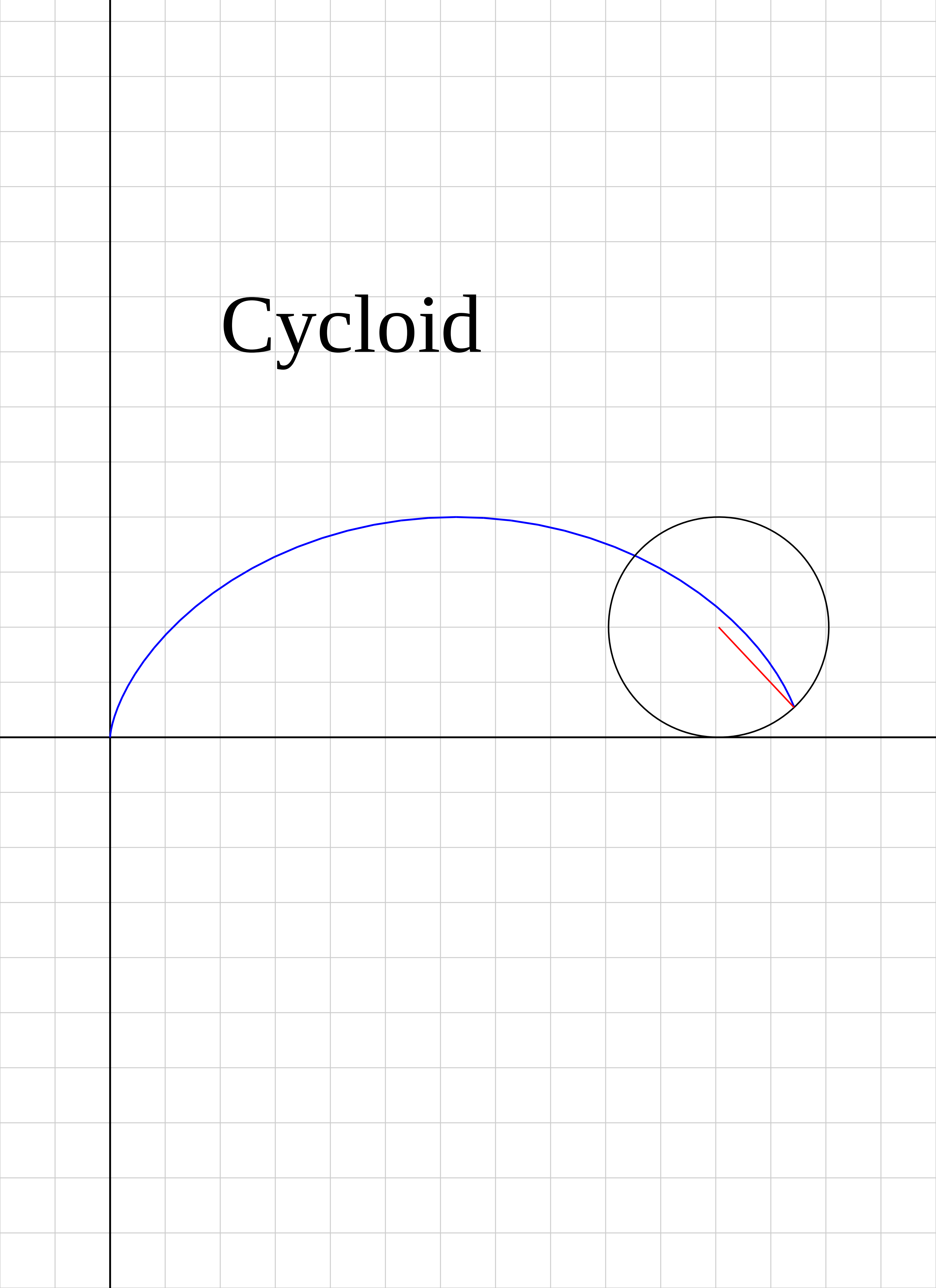
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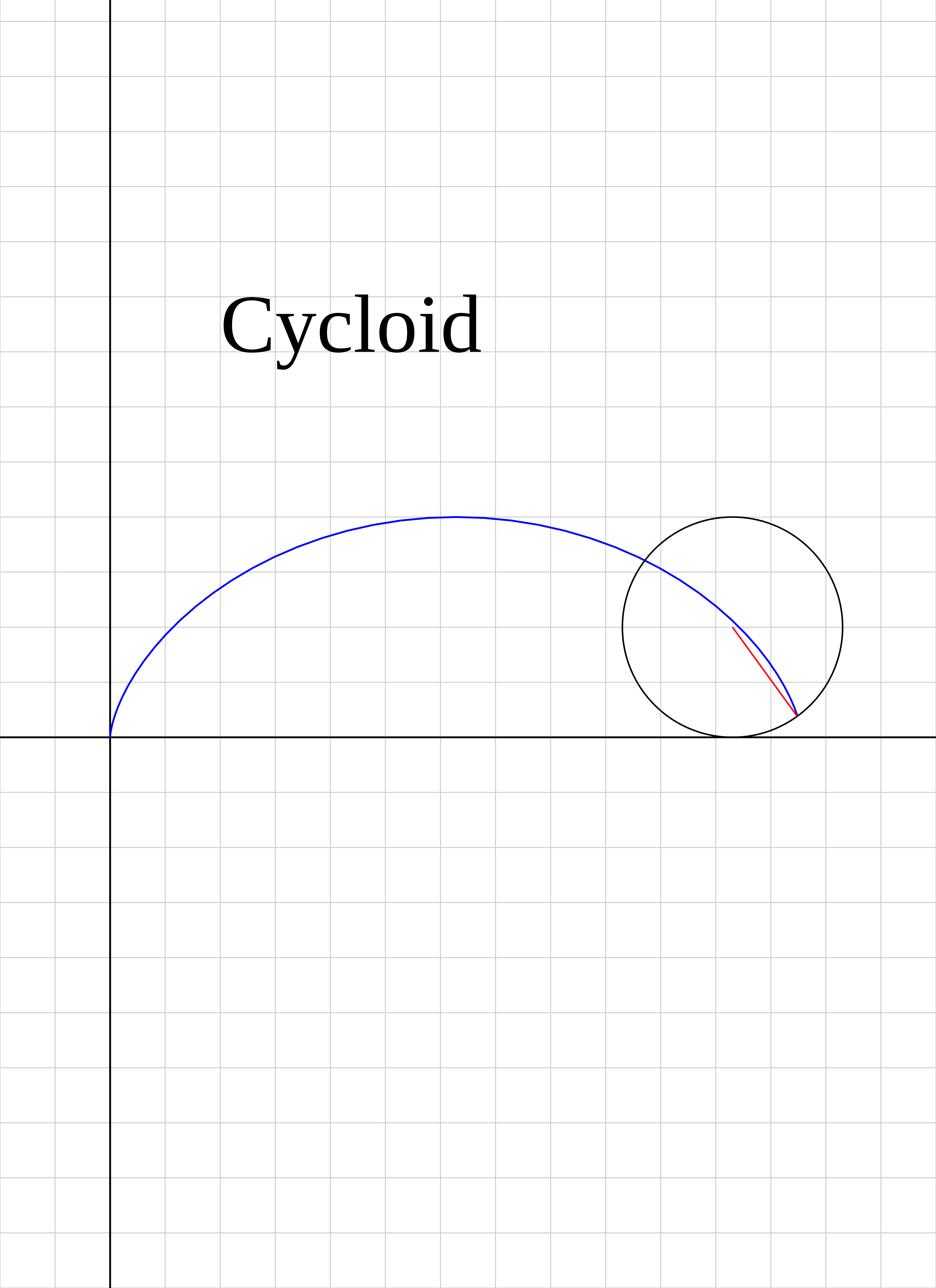

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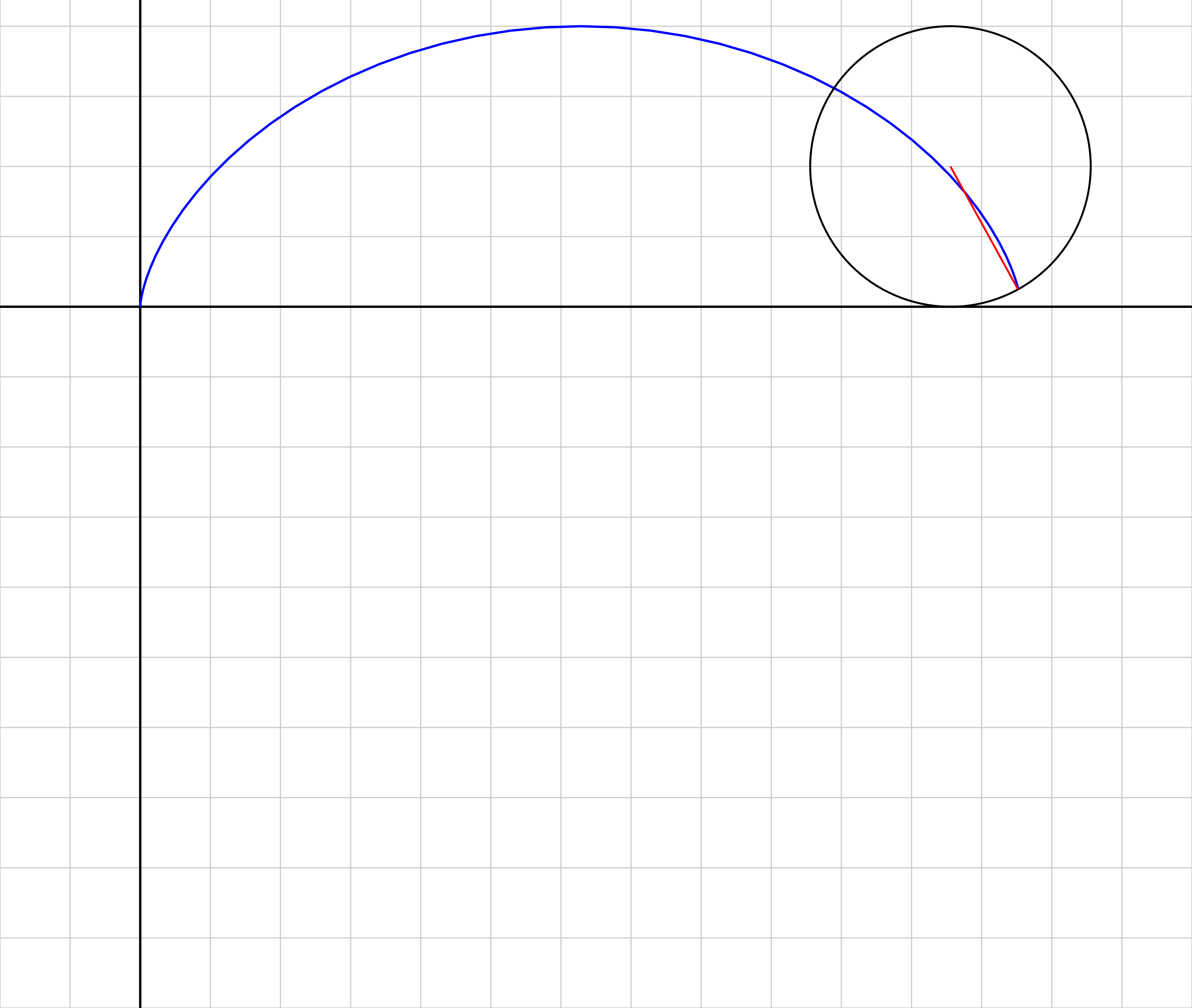

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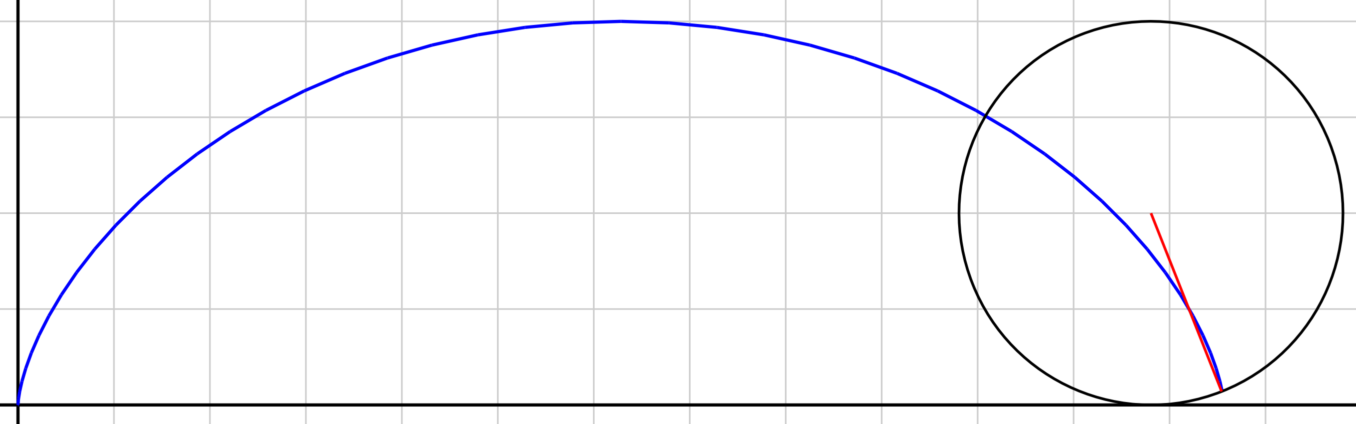

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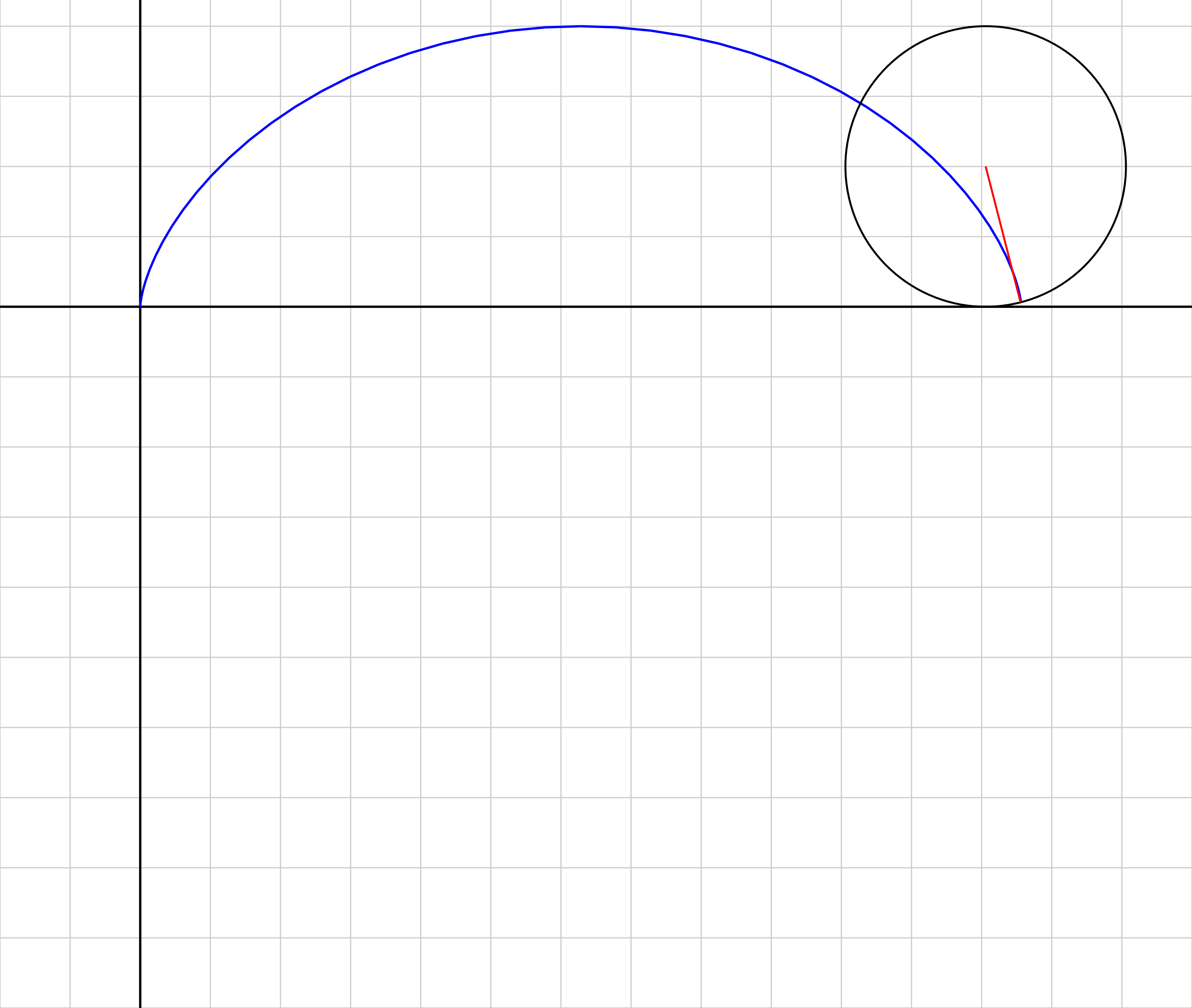

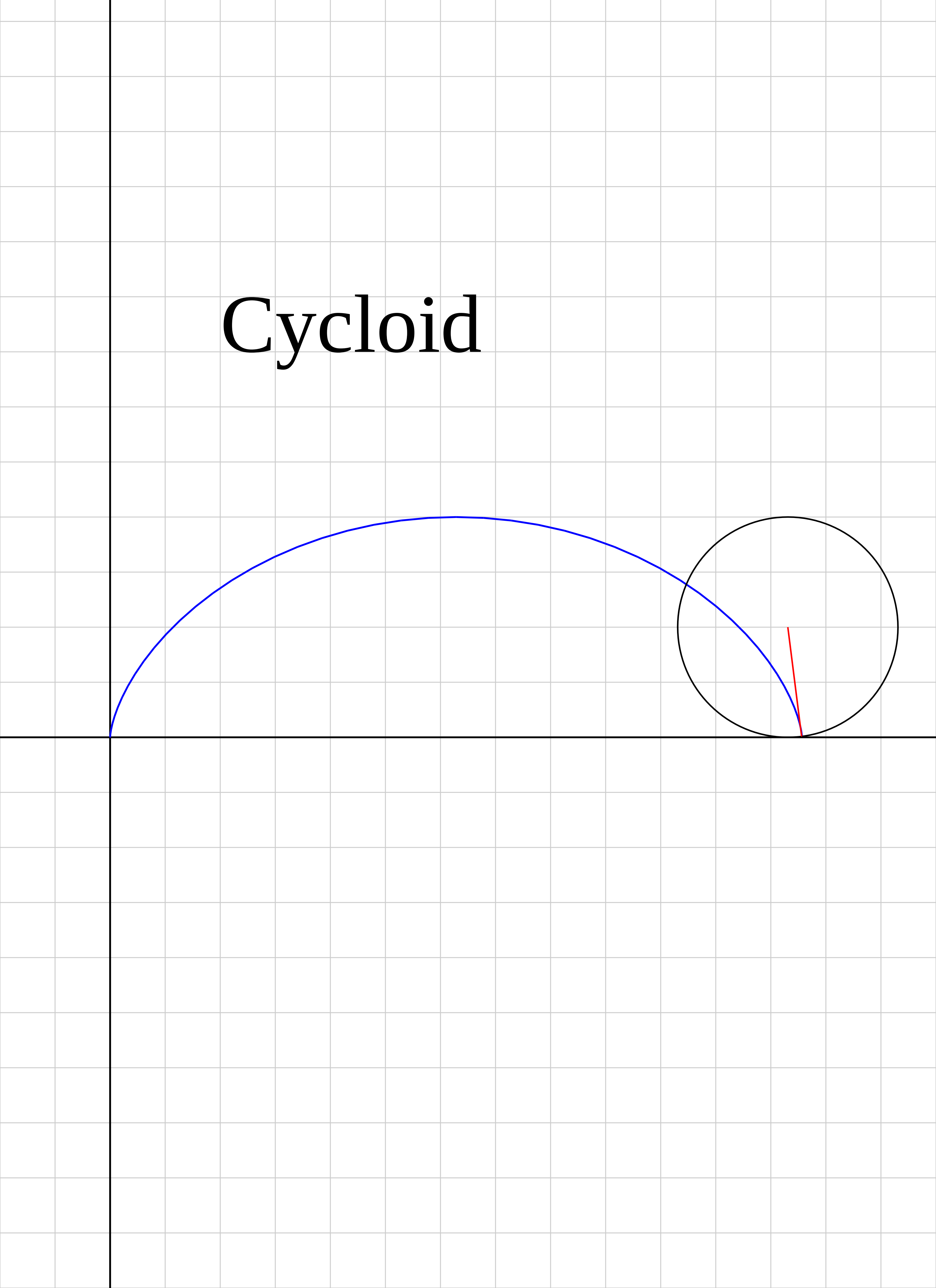

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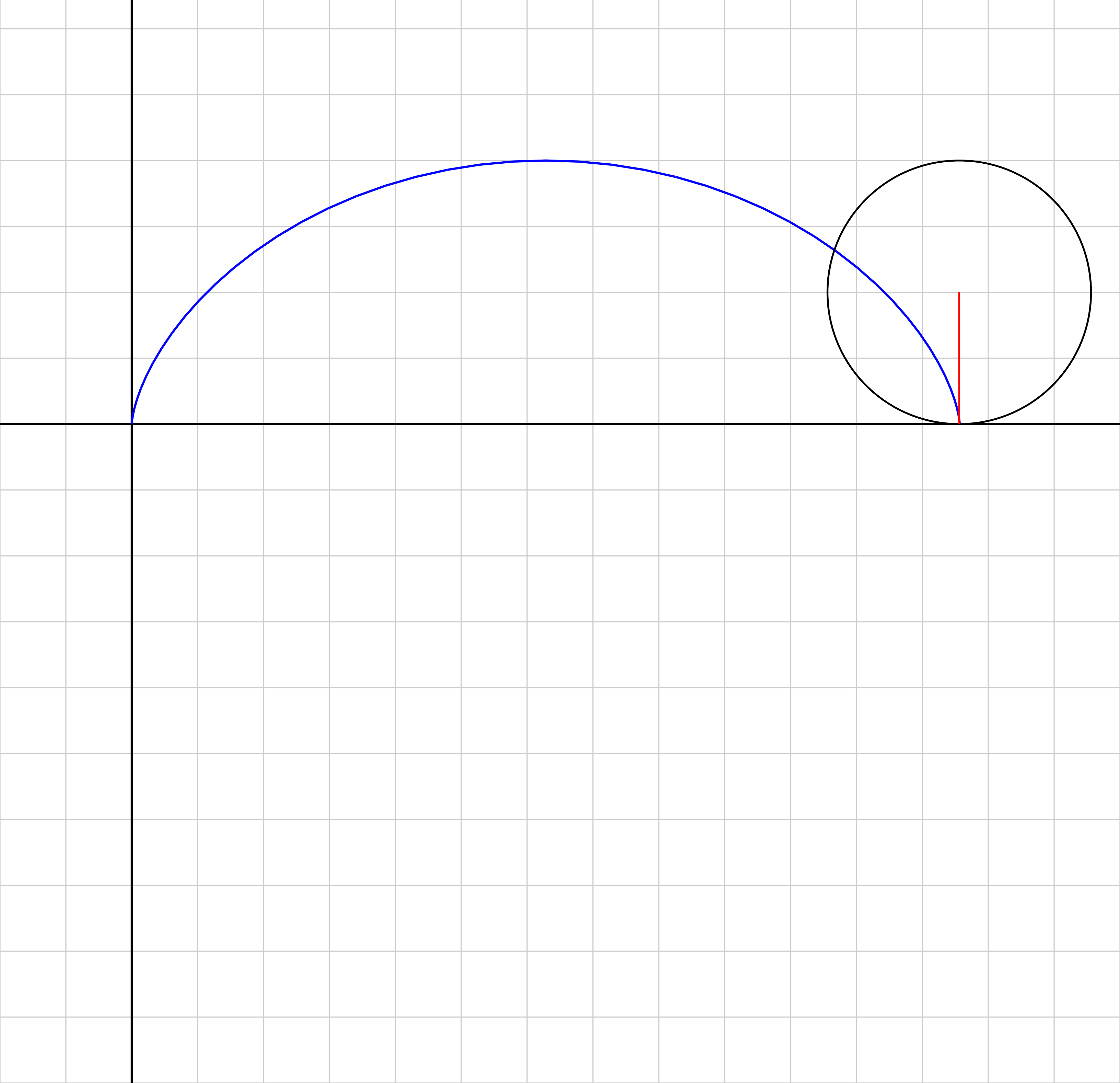
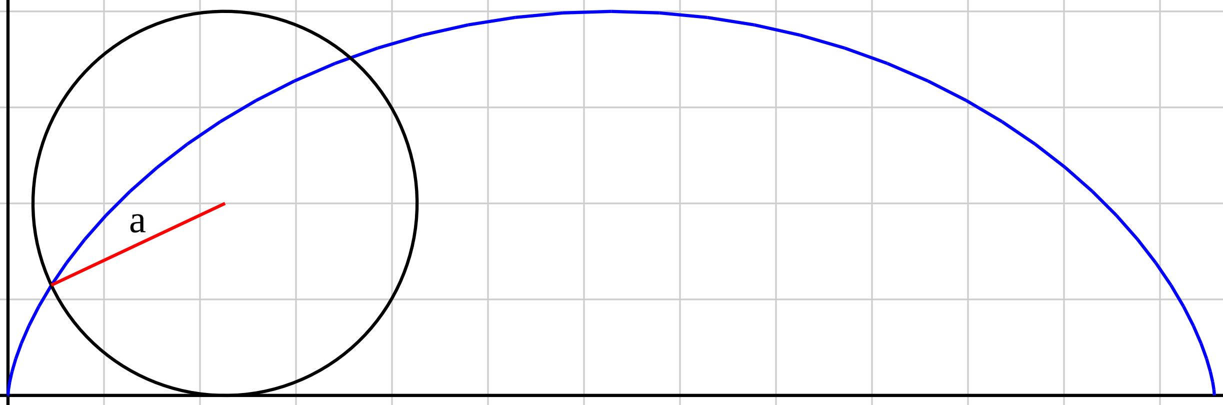
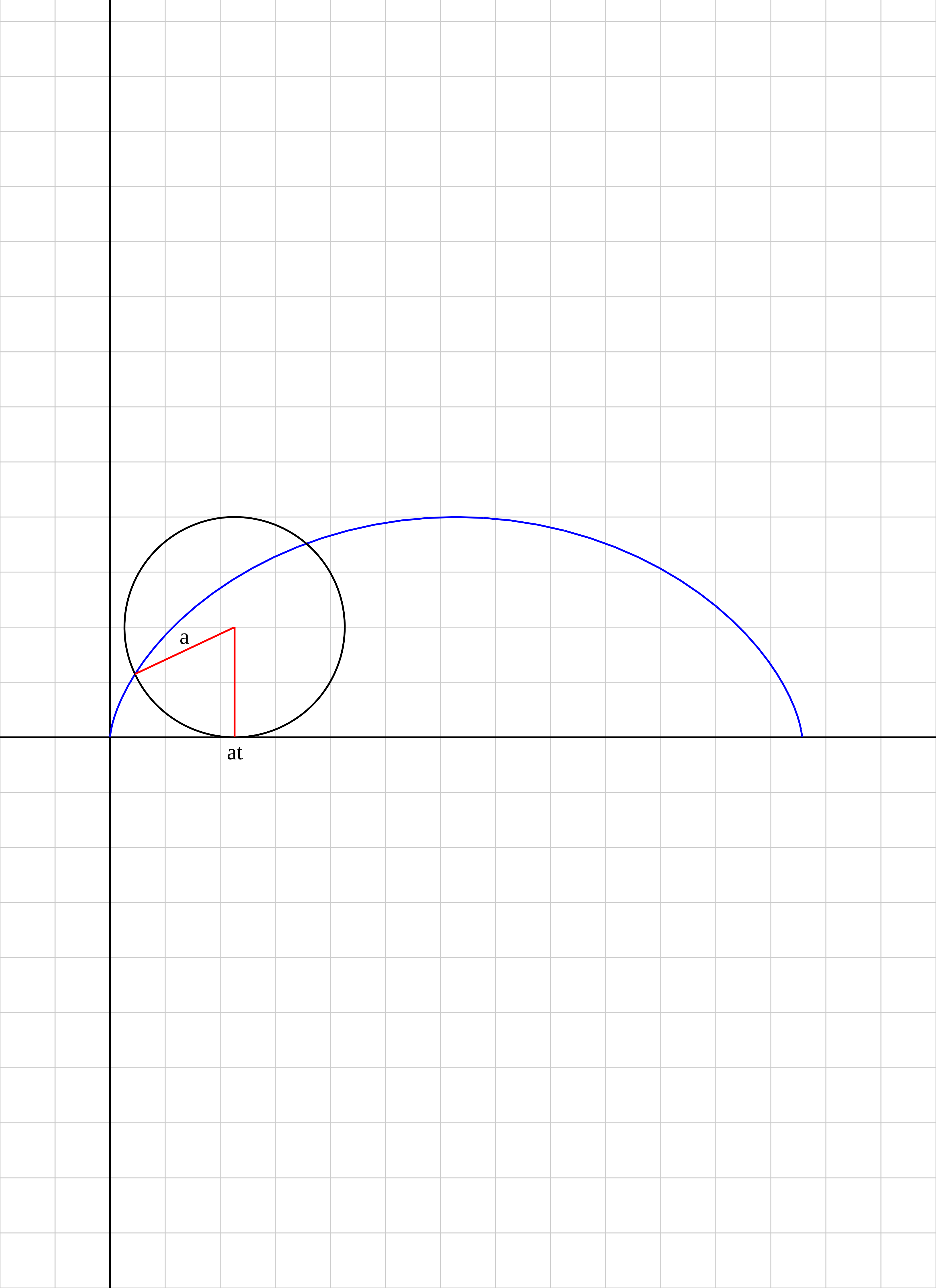
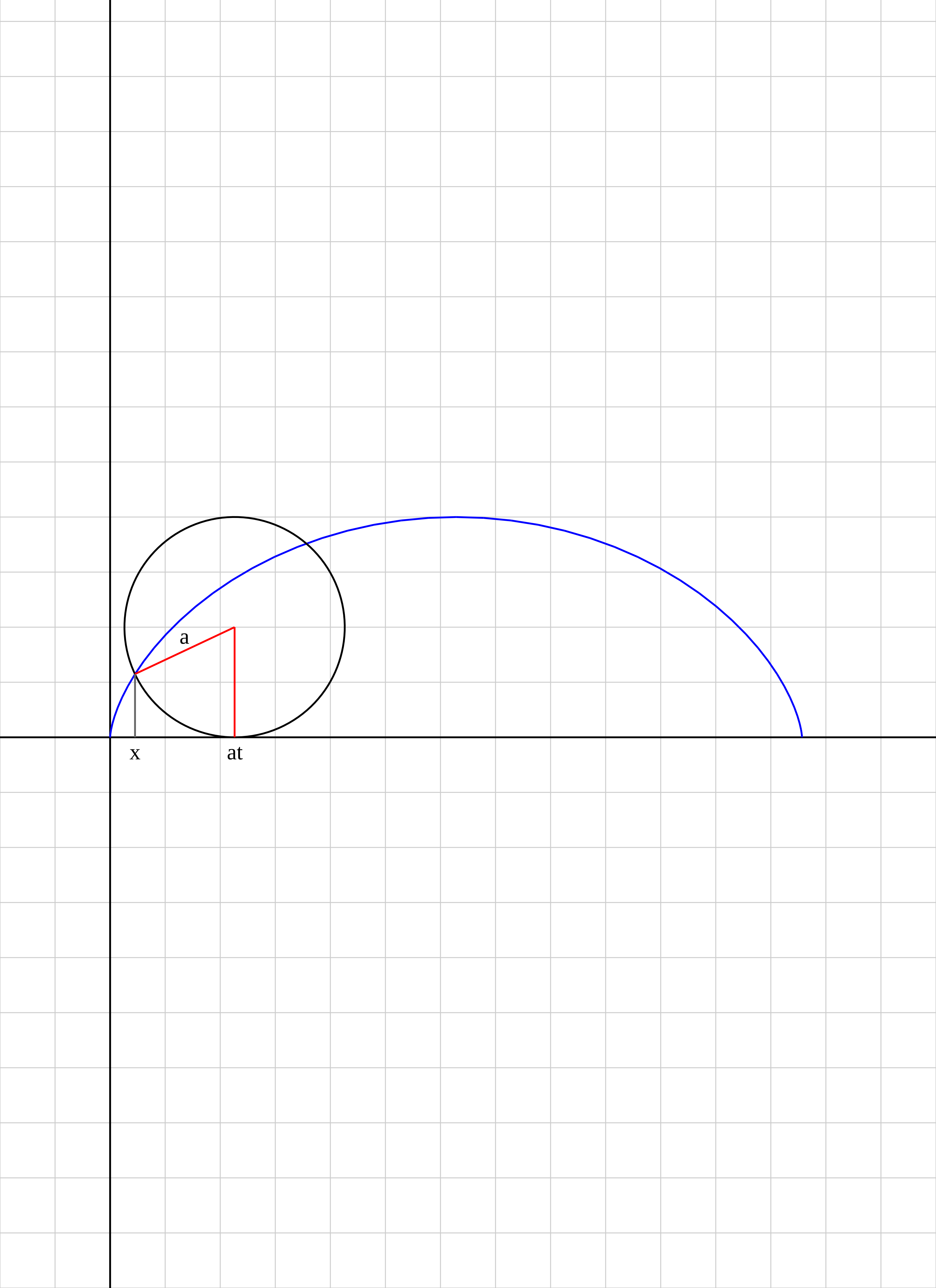


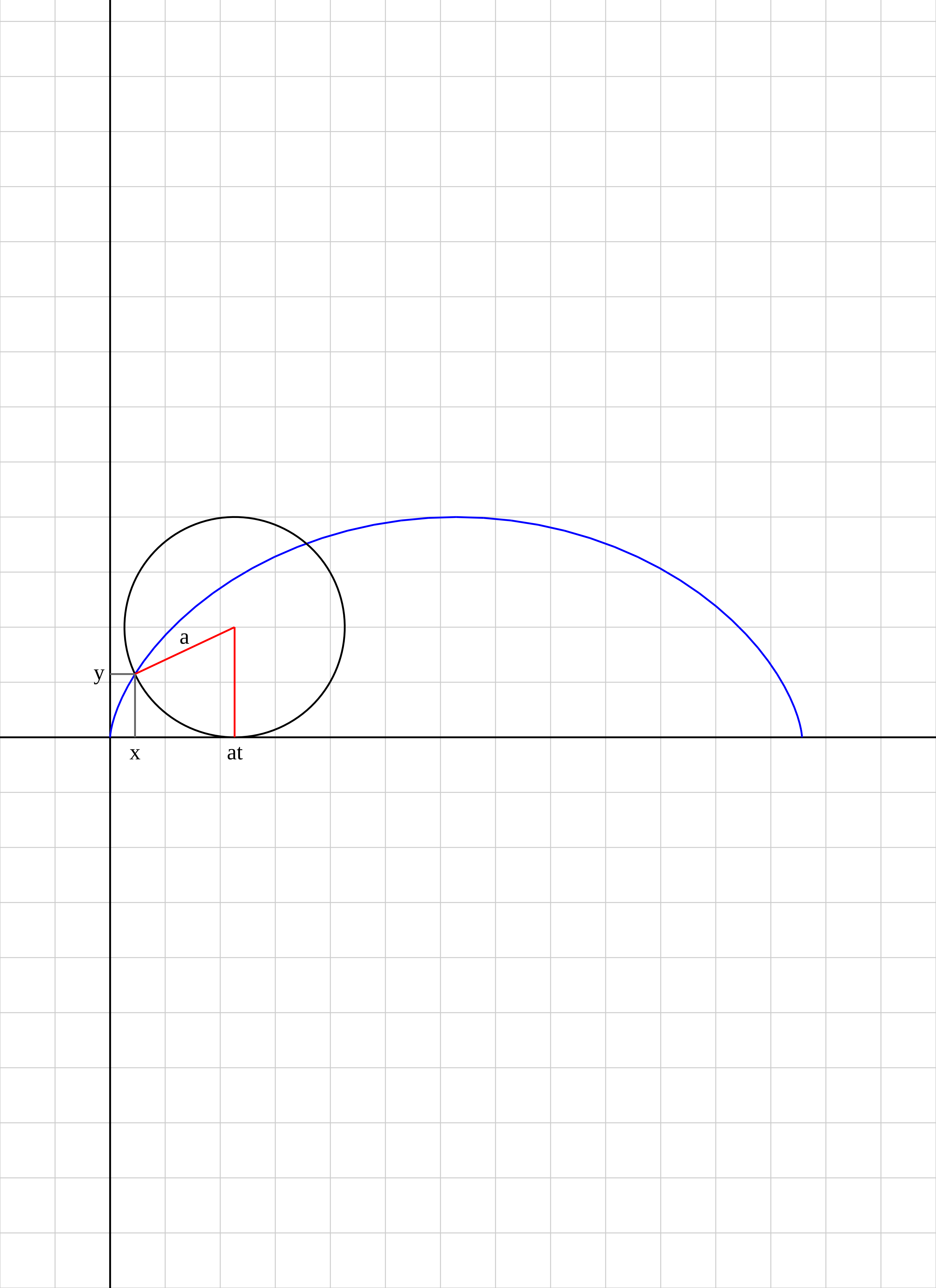
Prove of Cycloid



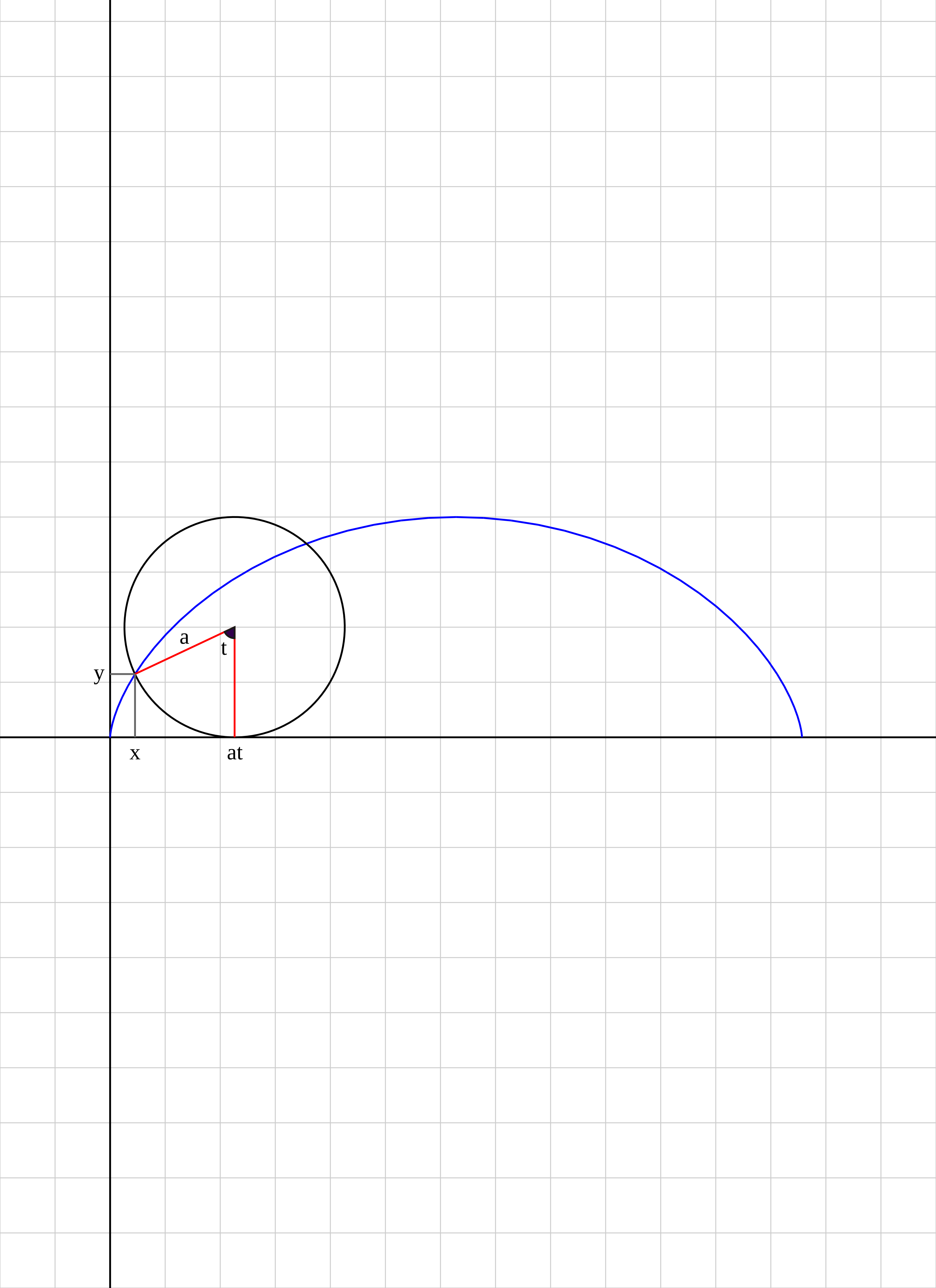


a
at

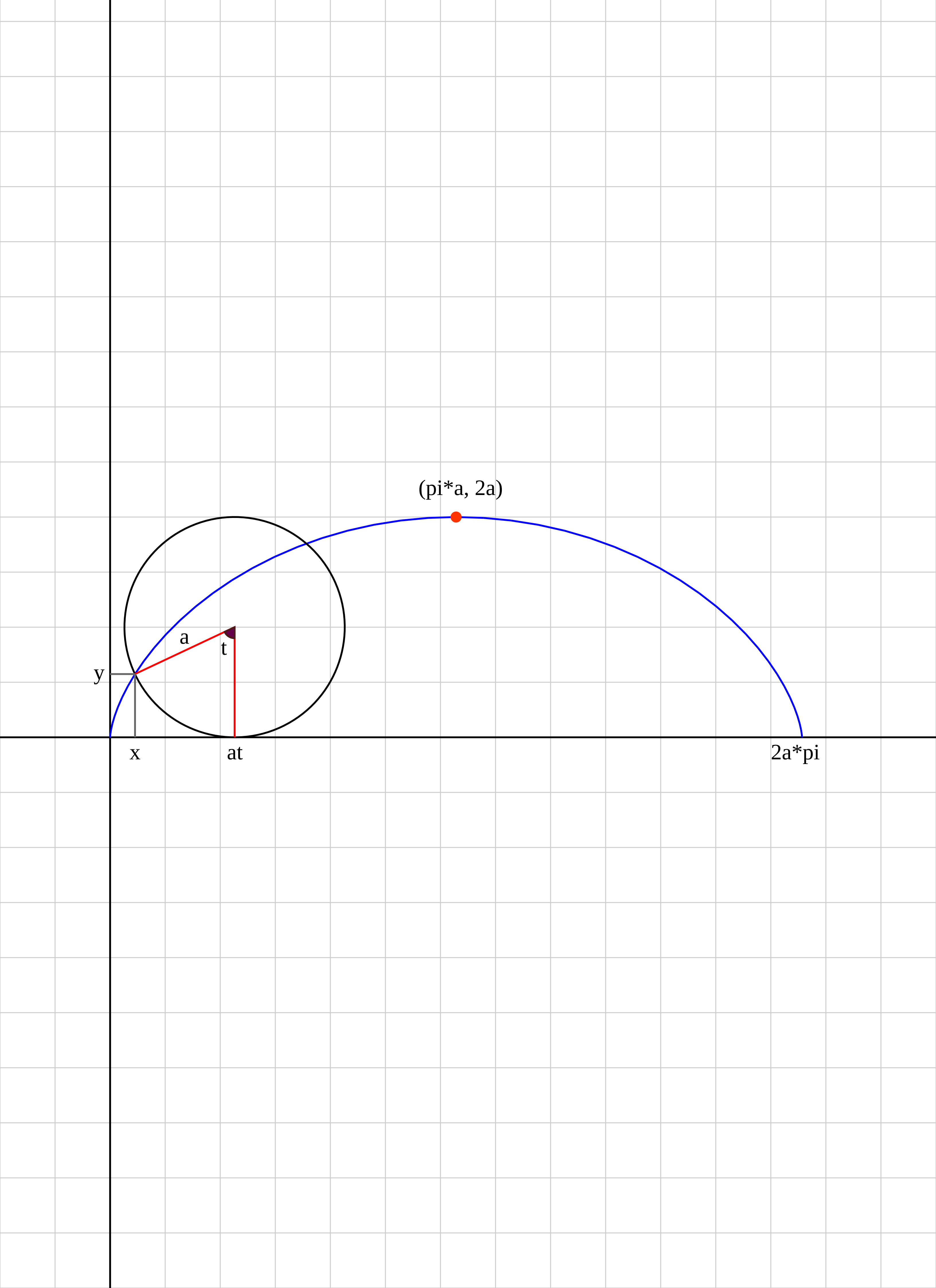

a
x
at



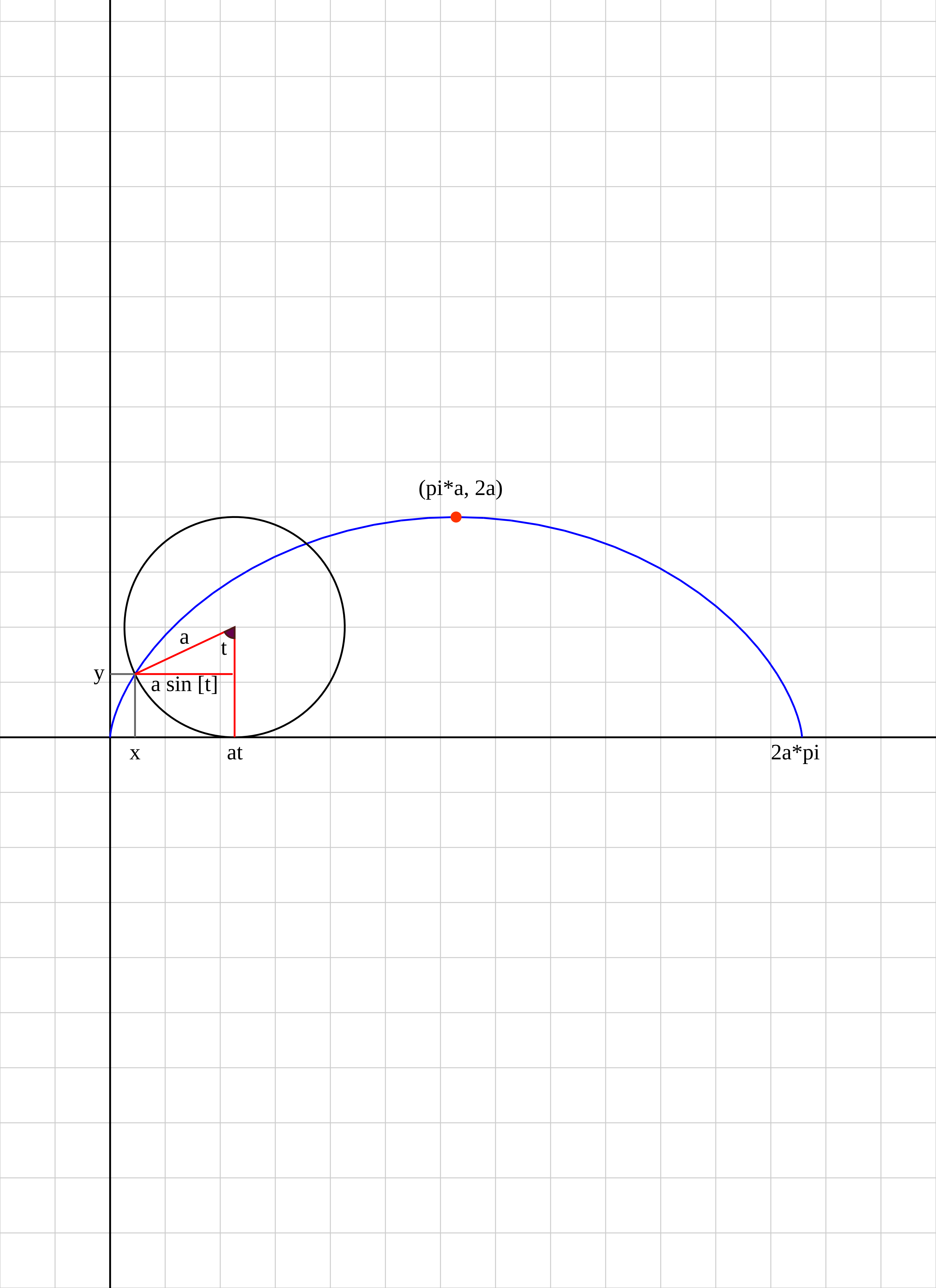
a
y
x
at

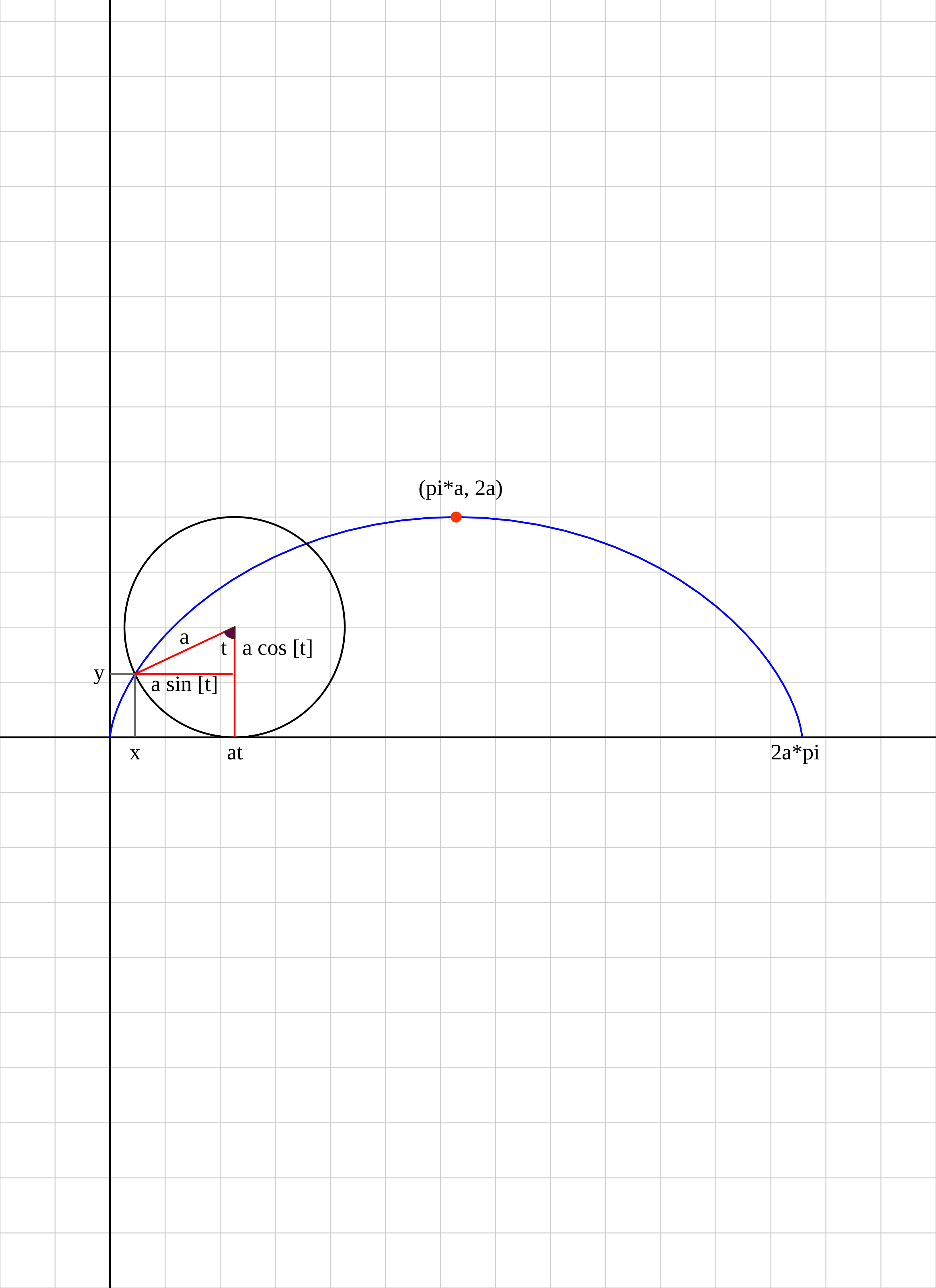


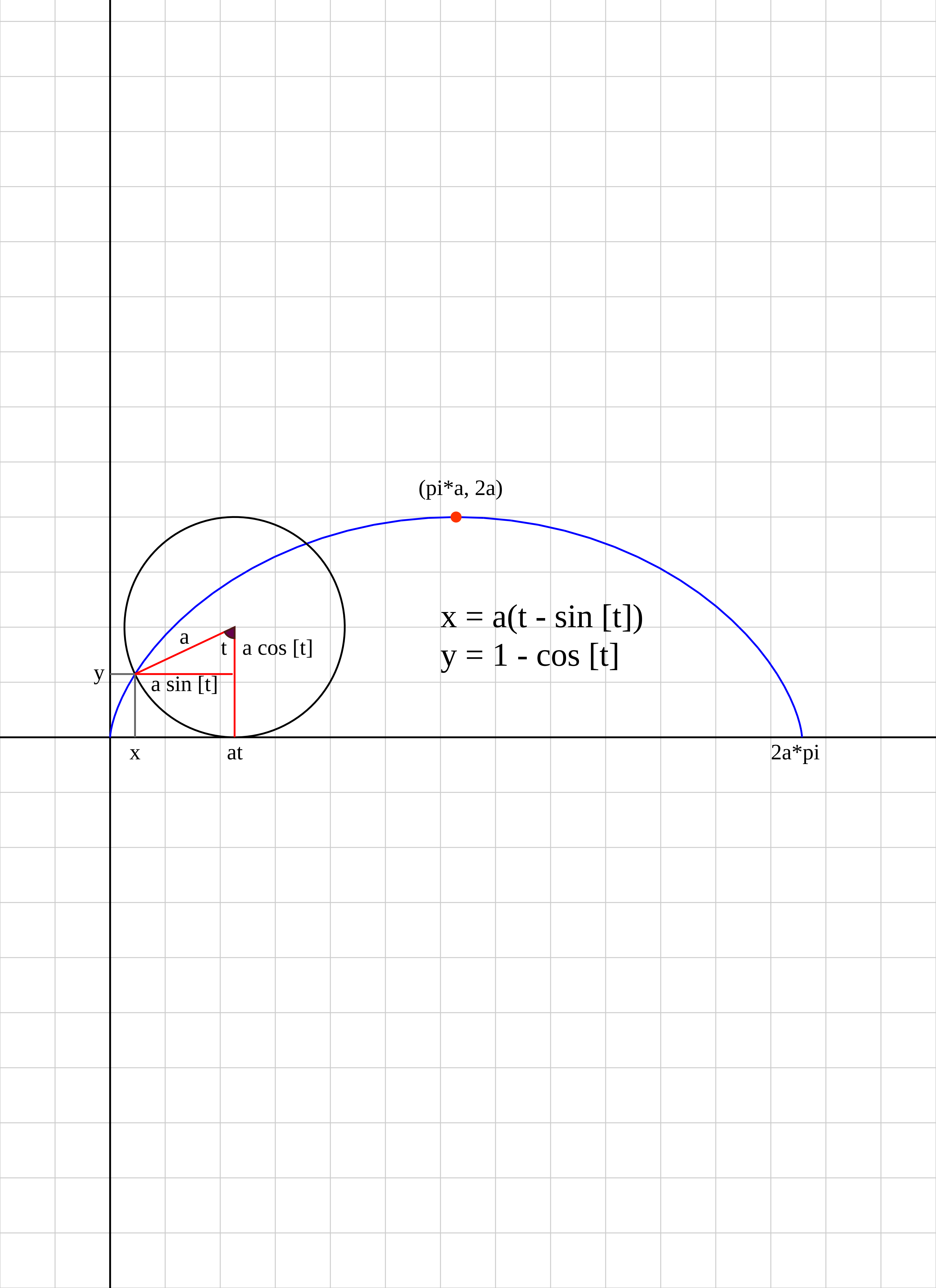
a
t
y
x
at

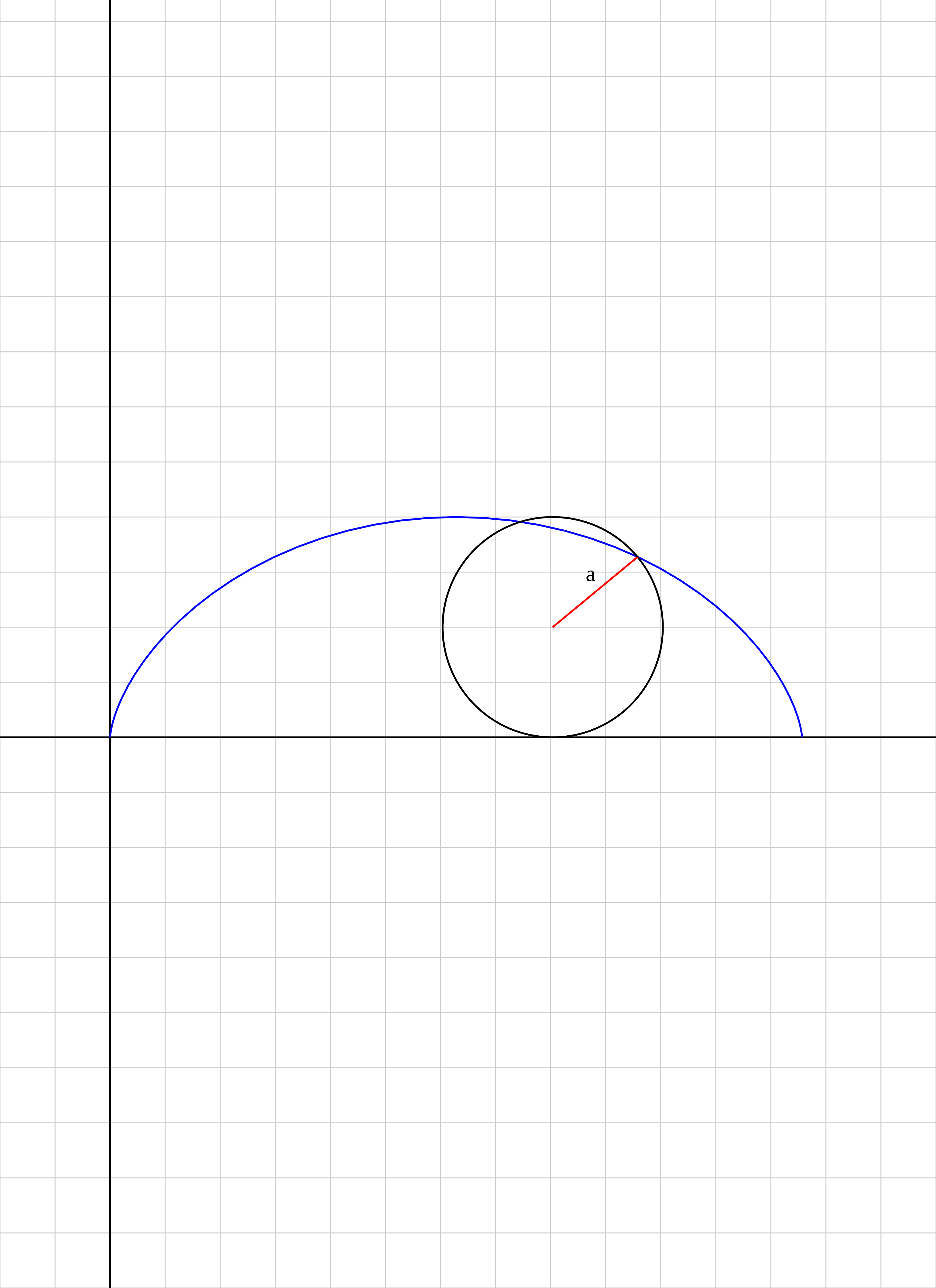


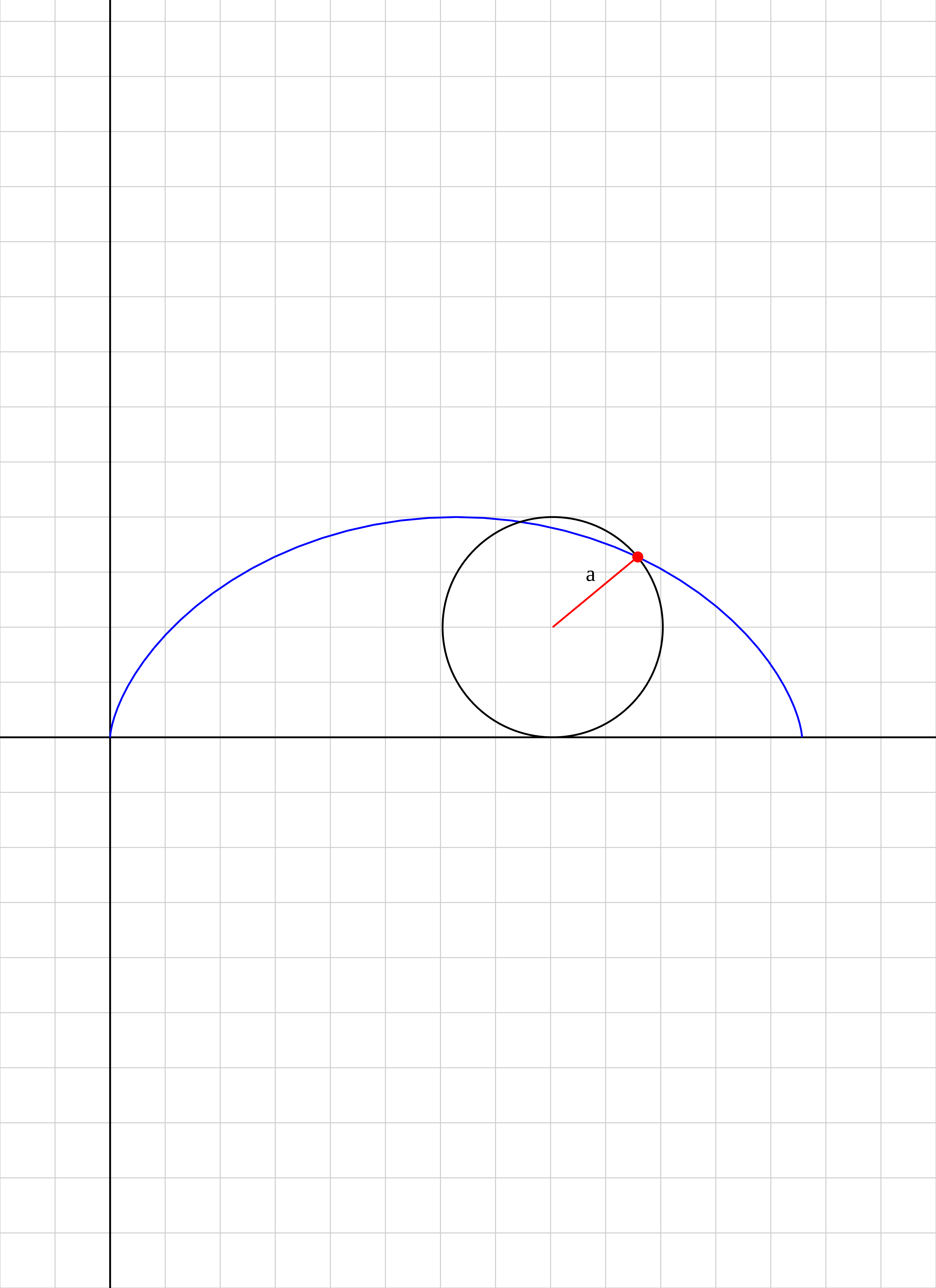
(pi*a, 2a)
a
t
y
x
at
2a*pi

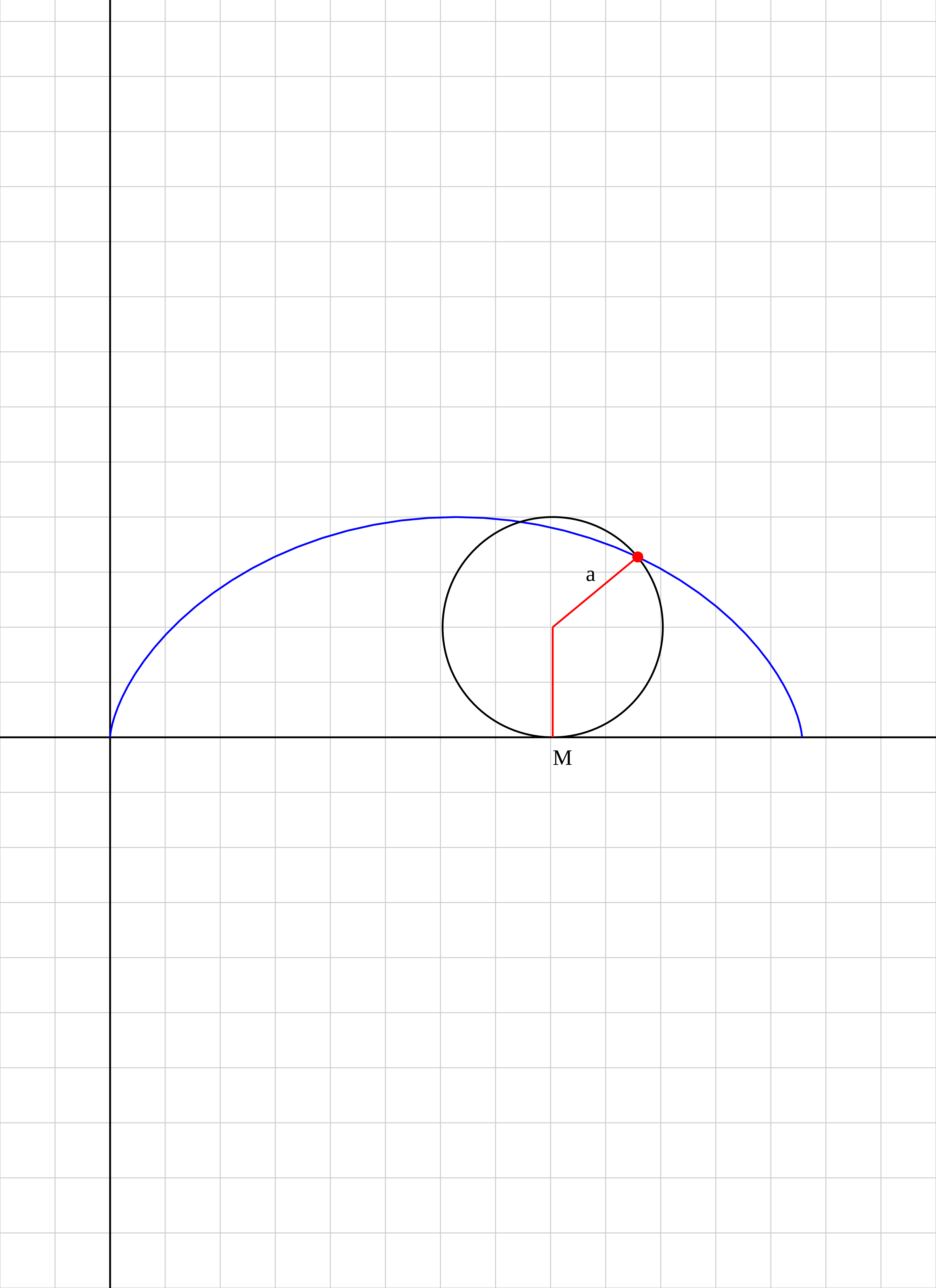

(pi*a, 2a)
a
t
y
a sin [t]
x
at
2a*pi

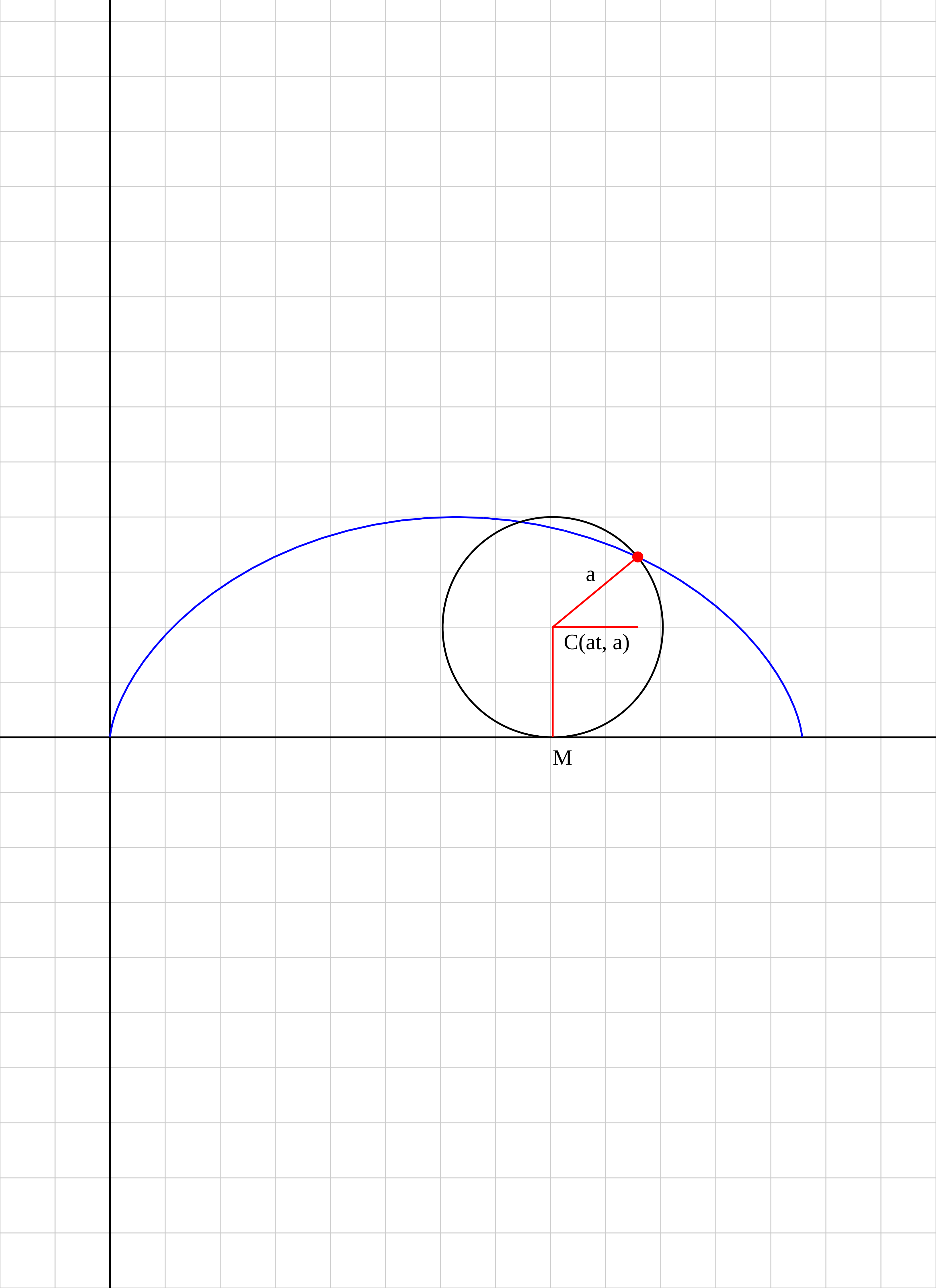

(pi*a, 2a)
a
t
a cos [t]
y
a sin [t]
x
at
2a*pi

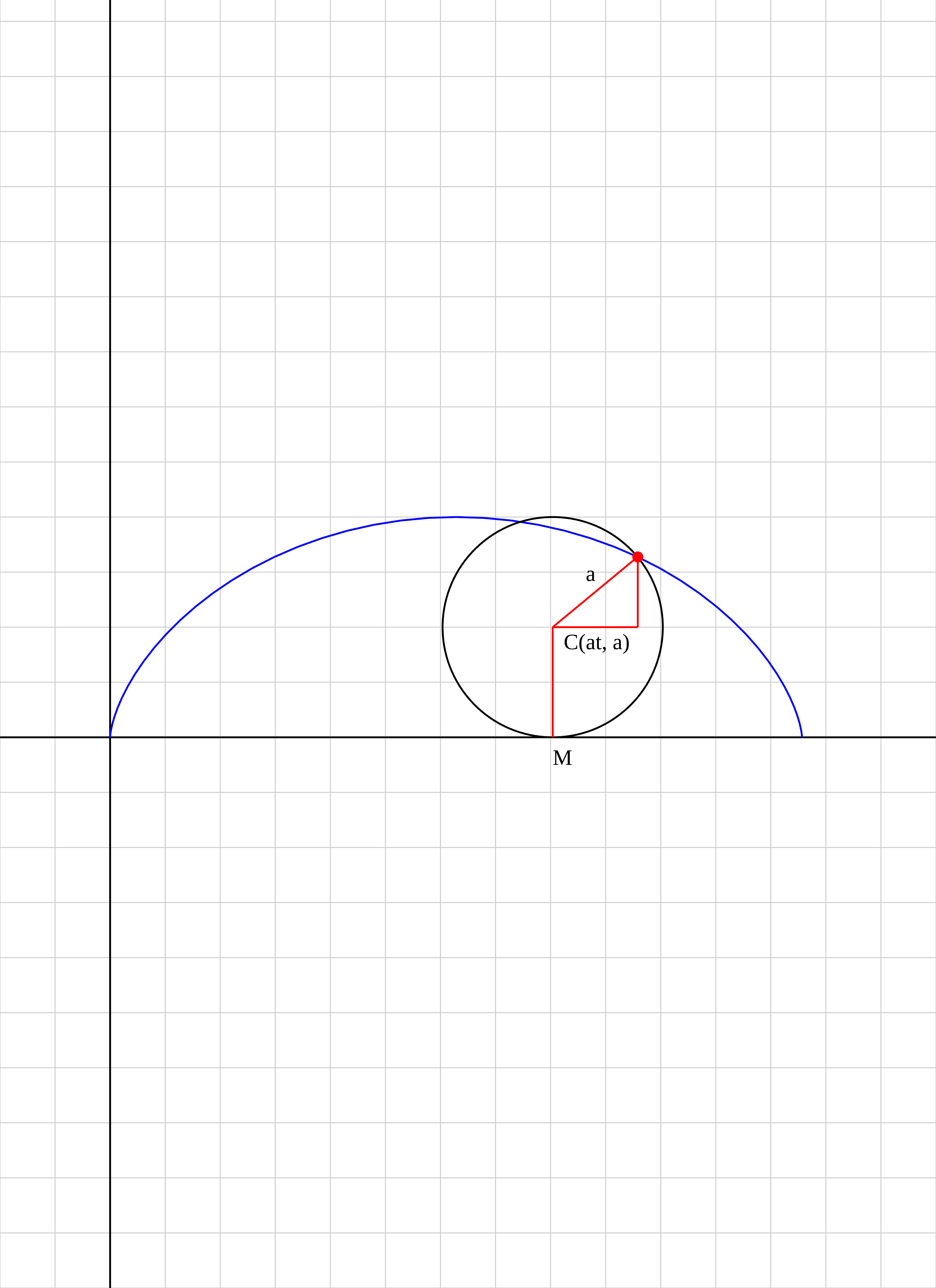

(pi*a, 2a)
x = a(t - sin [t])
y = 1 - cos [t]
a
t
a cos [t]
y
a sin [t]
x
at
2a*pi

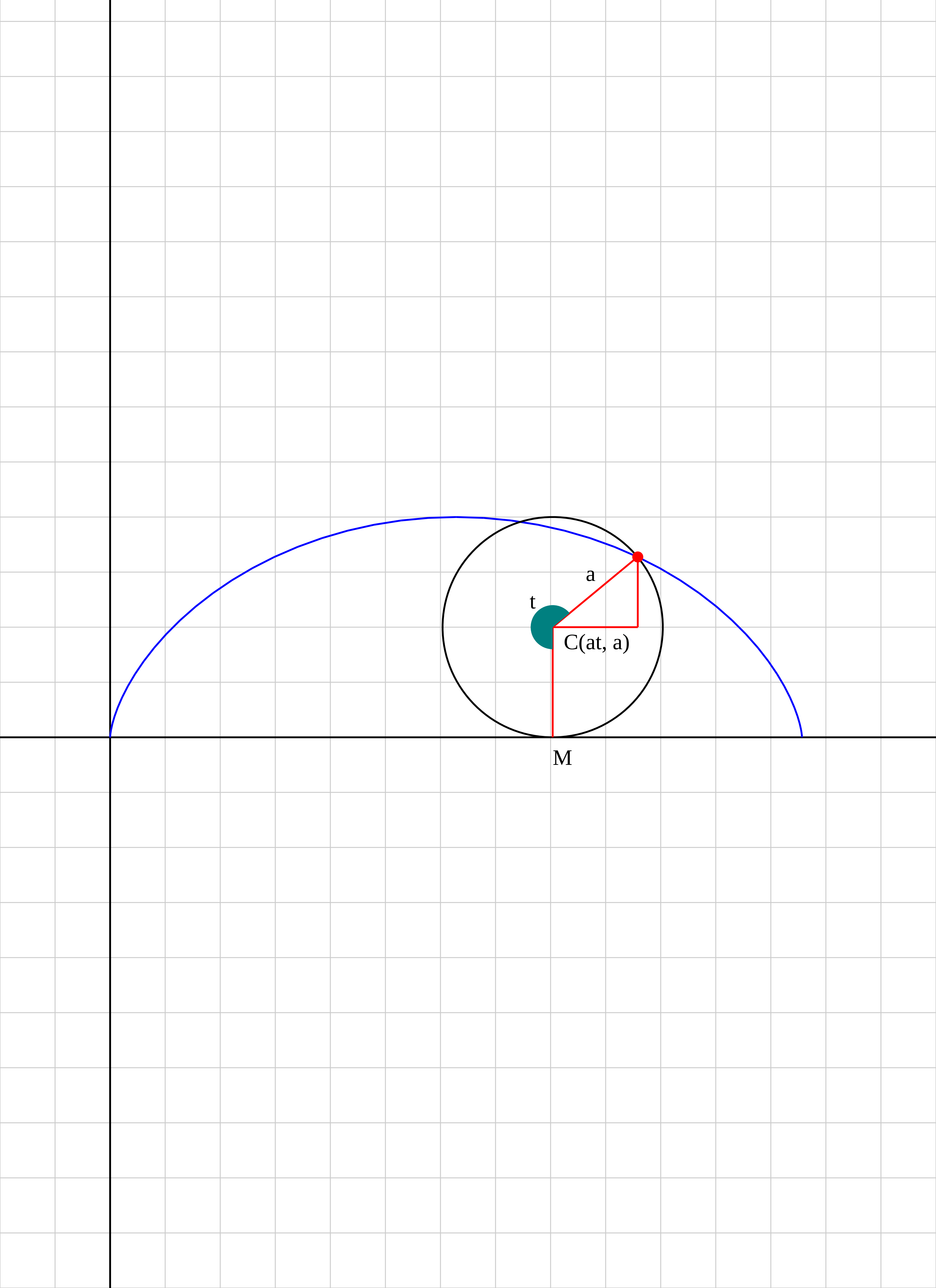

a

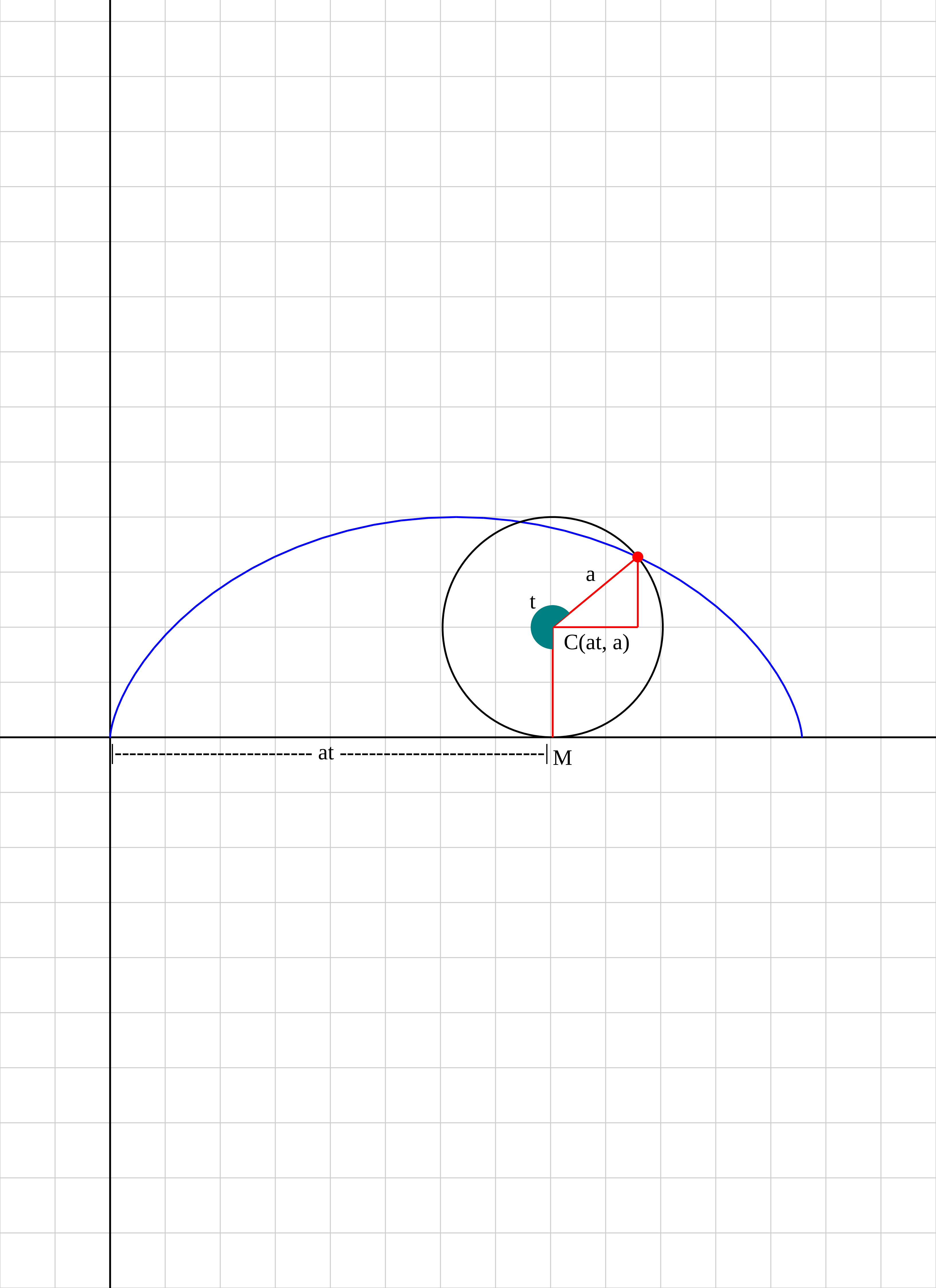

a


a
M

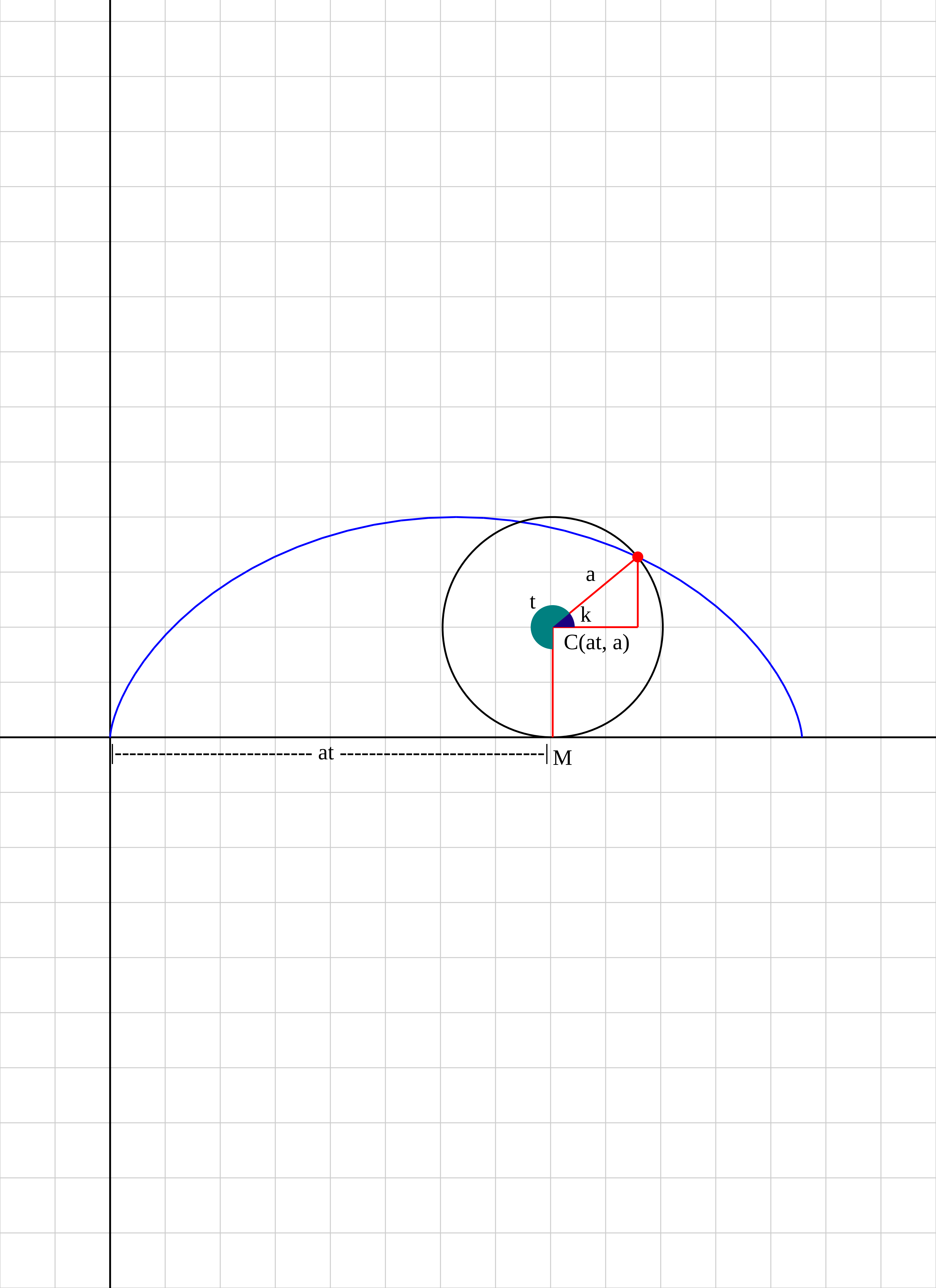

a
C(at, a)
M

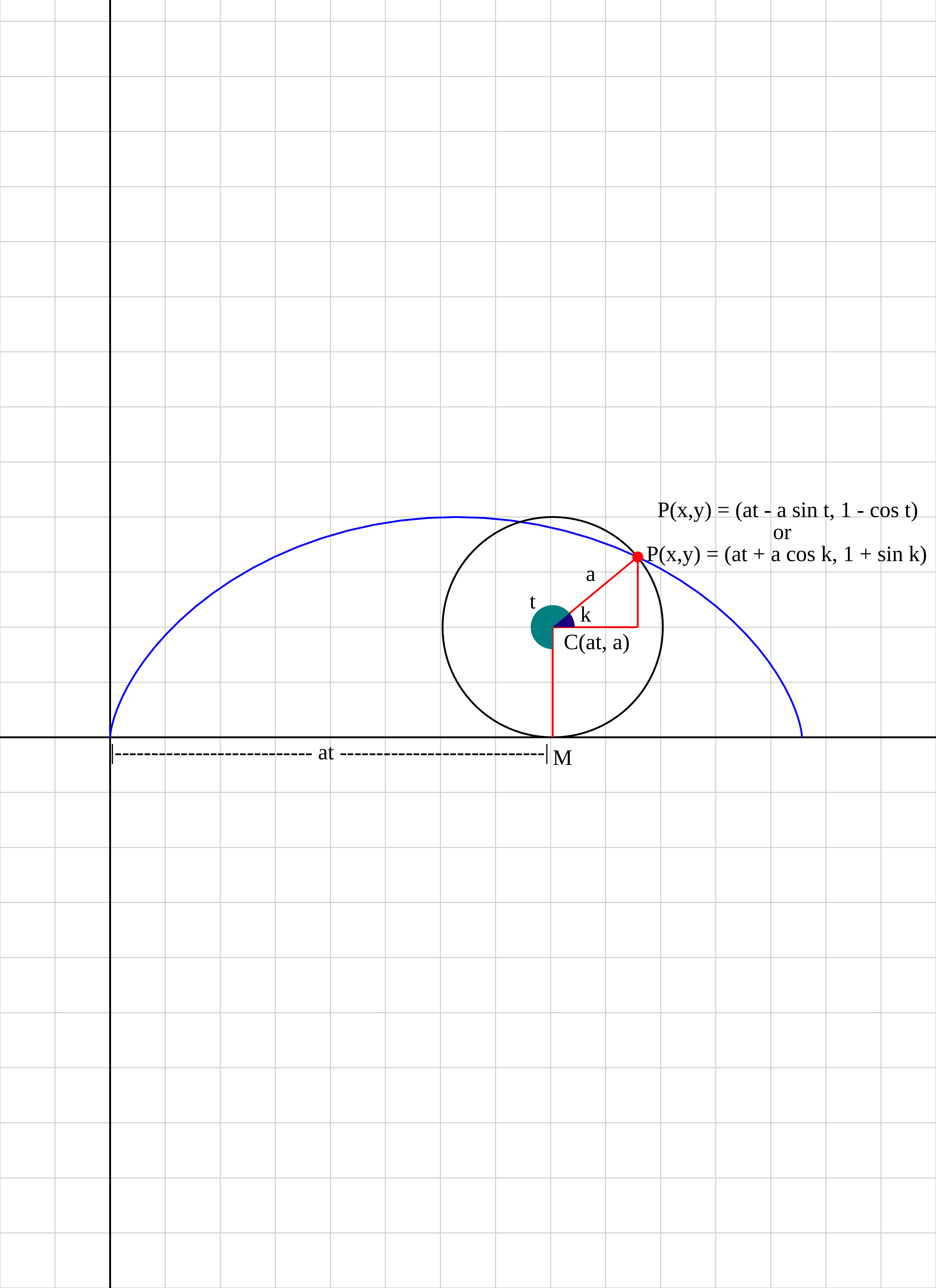

a
C(at, a)
M


a
t
C(at, a)
M



a
t
C(at, a)
at
M

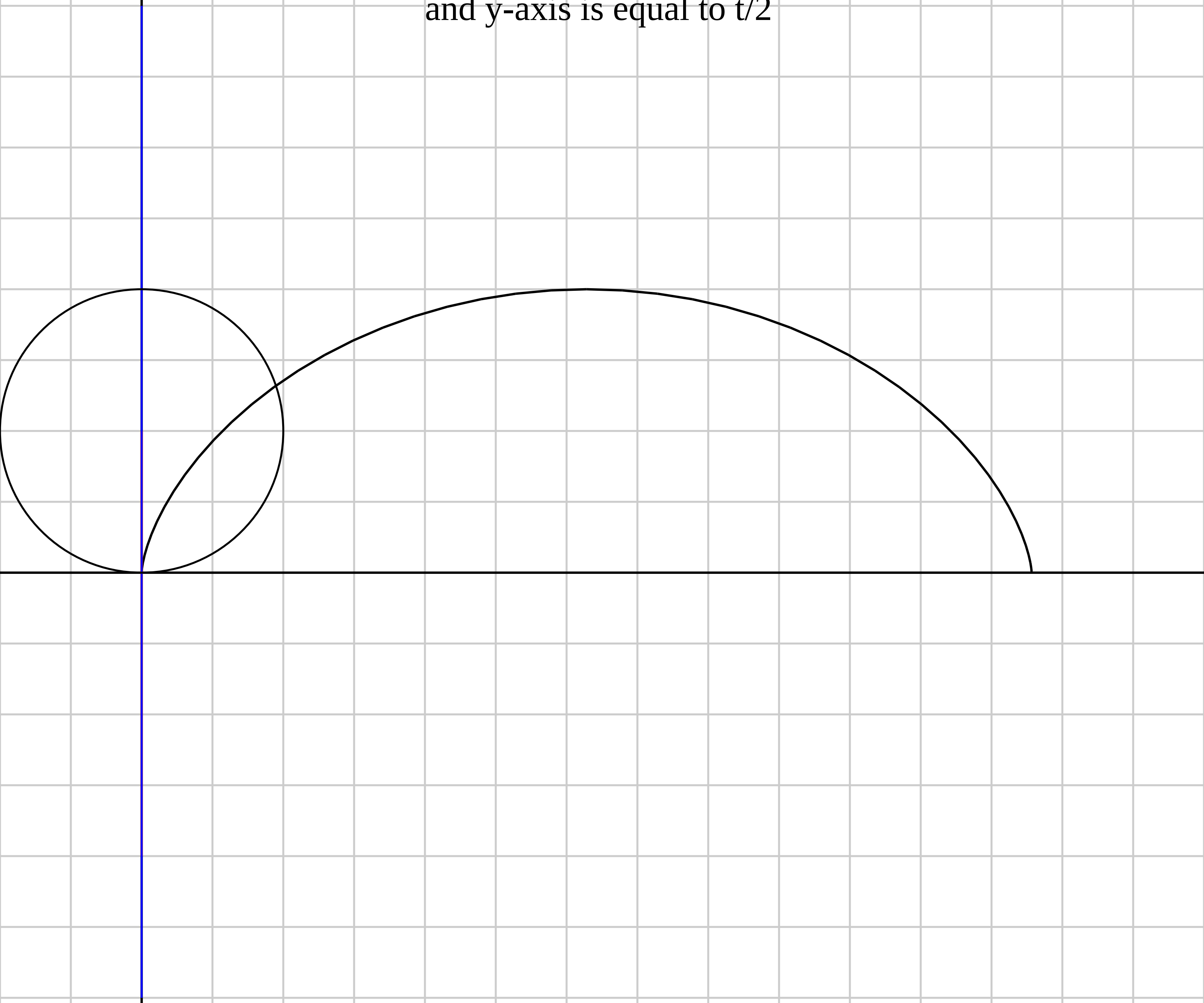

a
t
k
C(at, a)
at
M



P(x,y) = (at - a sin t, 1 - cos t)
or
P(x,y) = (at + a cos k, 1 + sin k)
a
t
k
C(at, a)
|--------------------------- at ---------------------------|
M

Property of Cycloid

The angle by the tangent line of cycloid
and y-axis is equal to t/2



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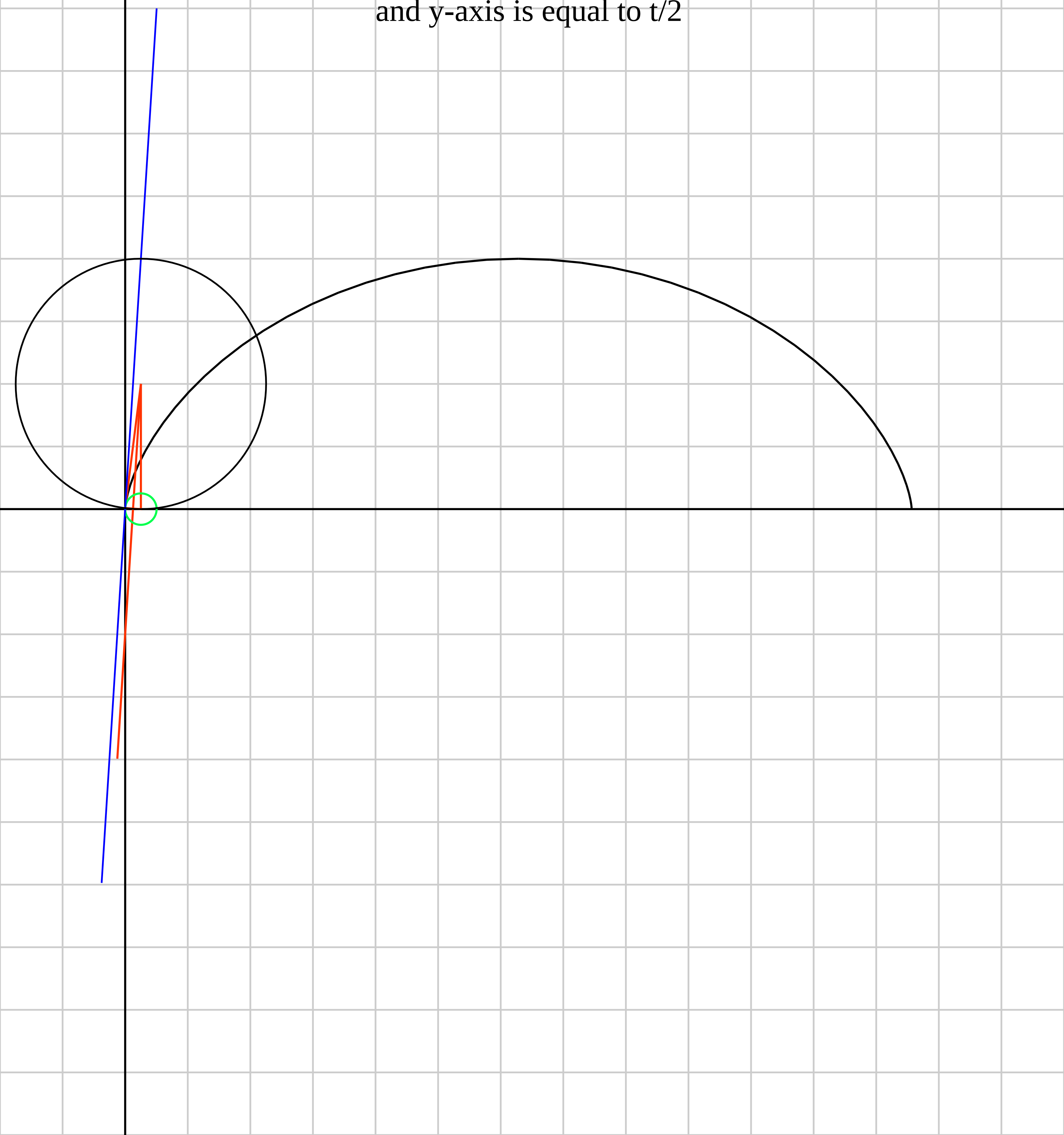

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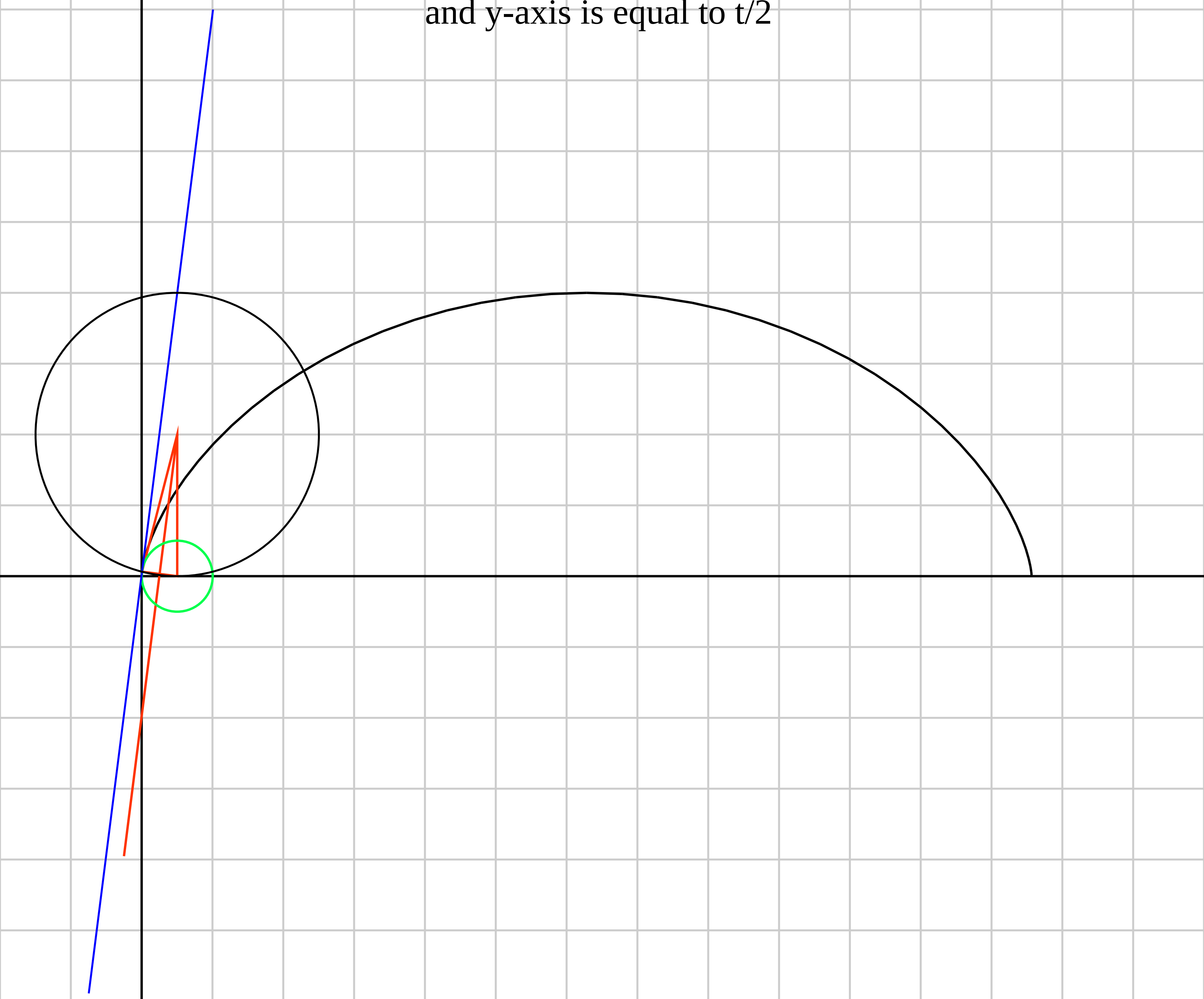

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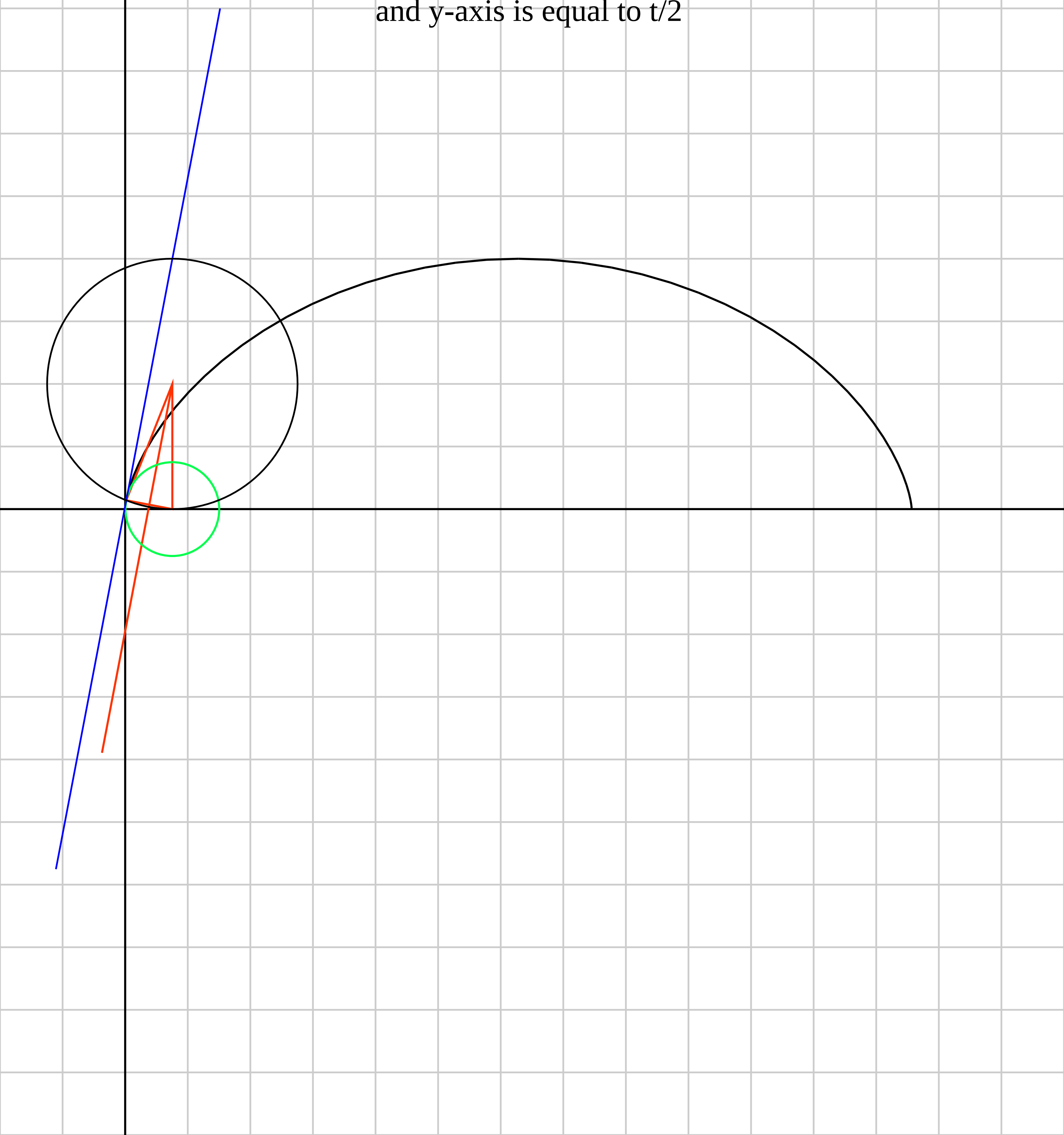

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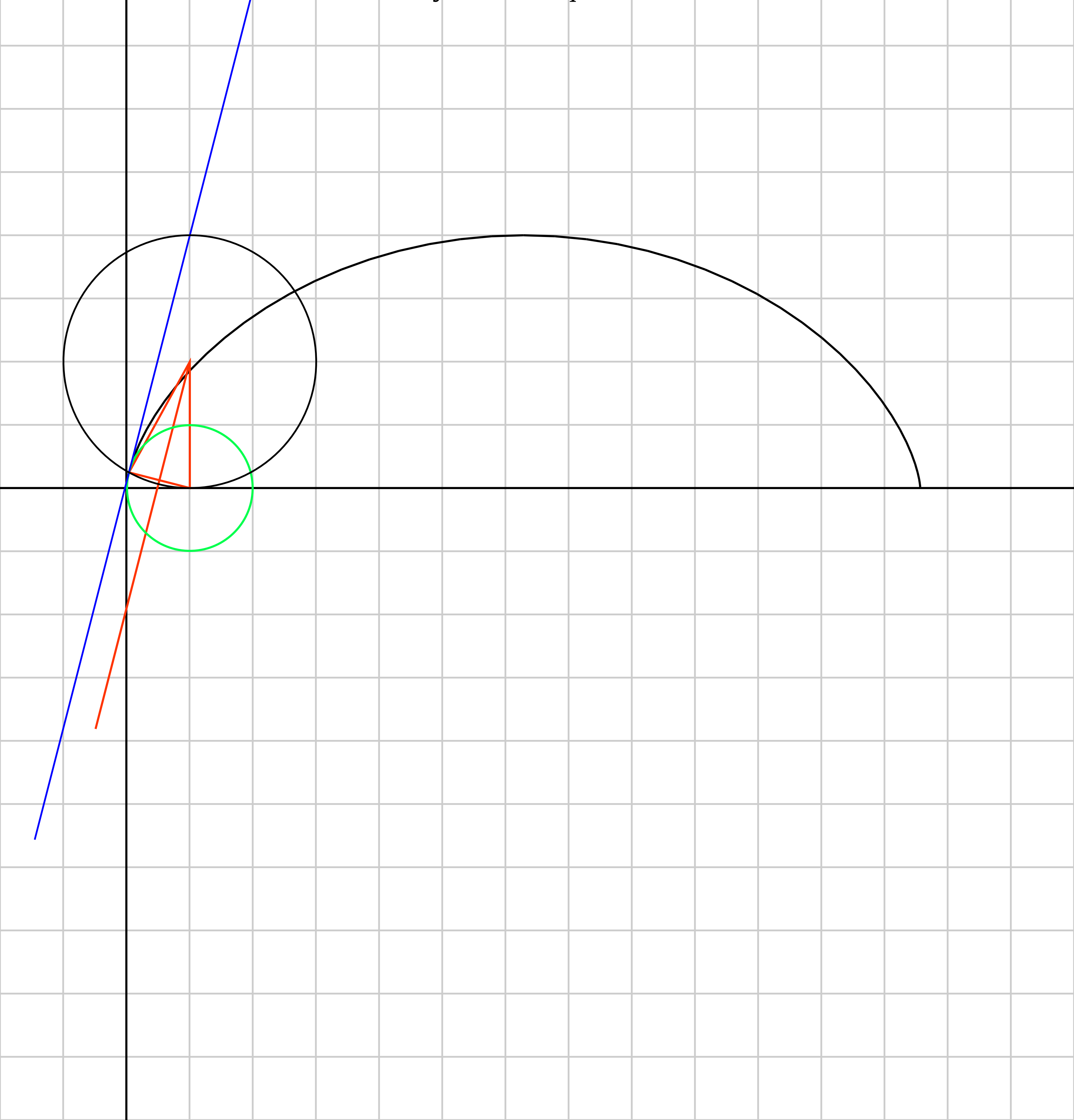

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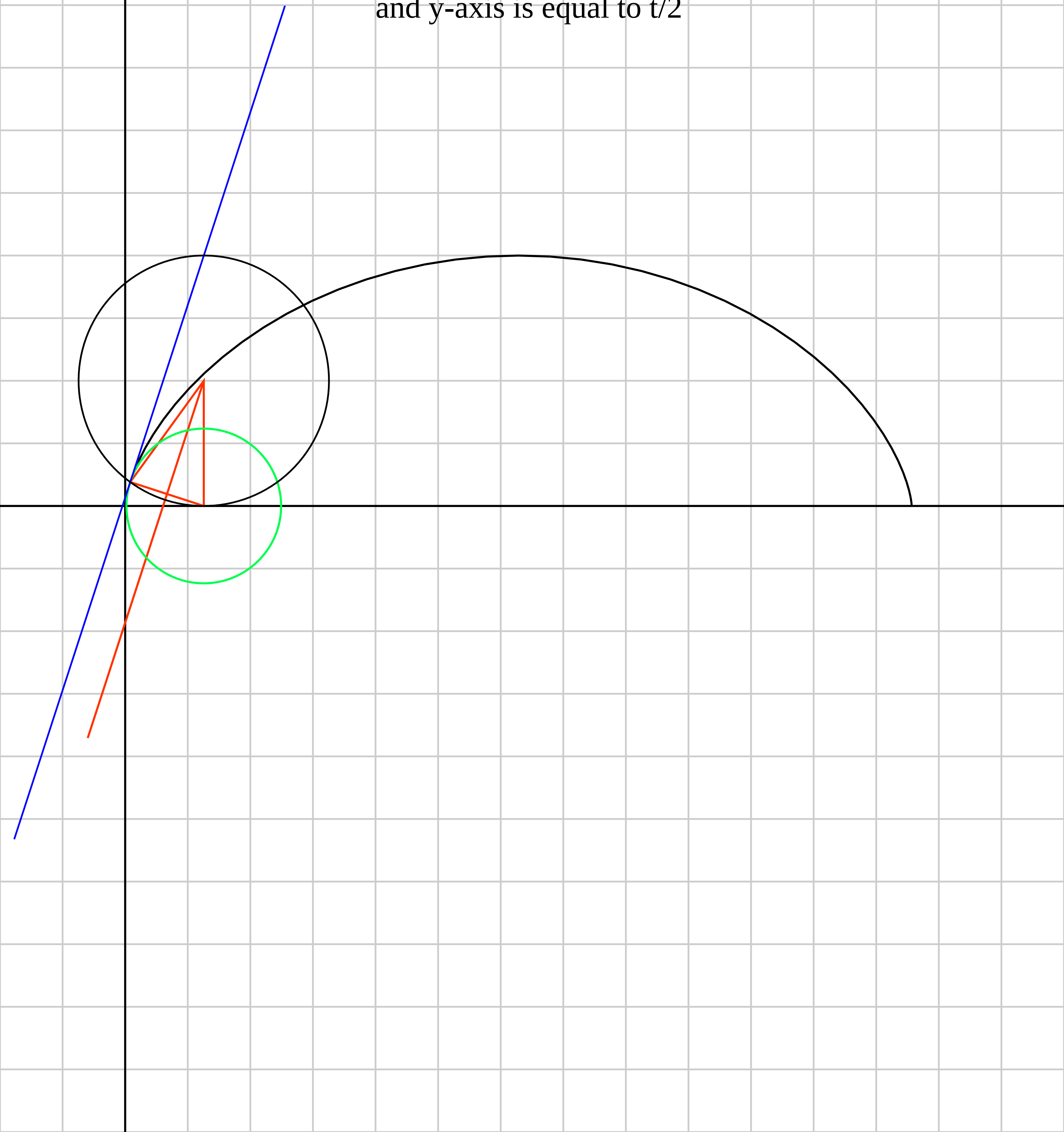

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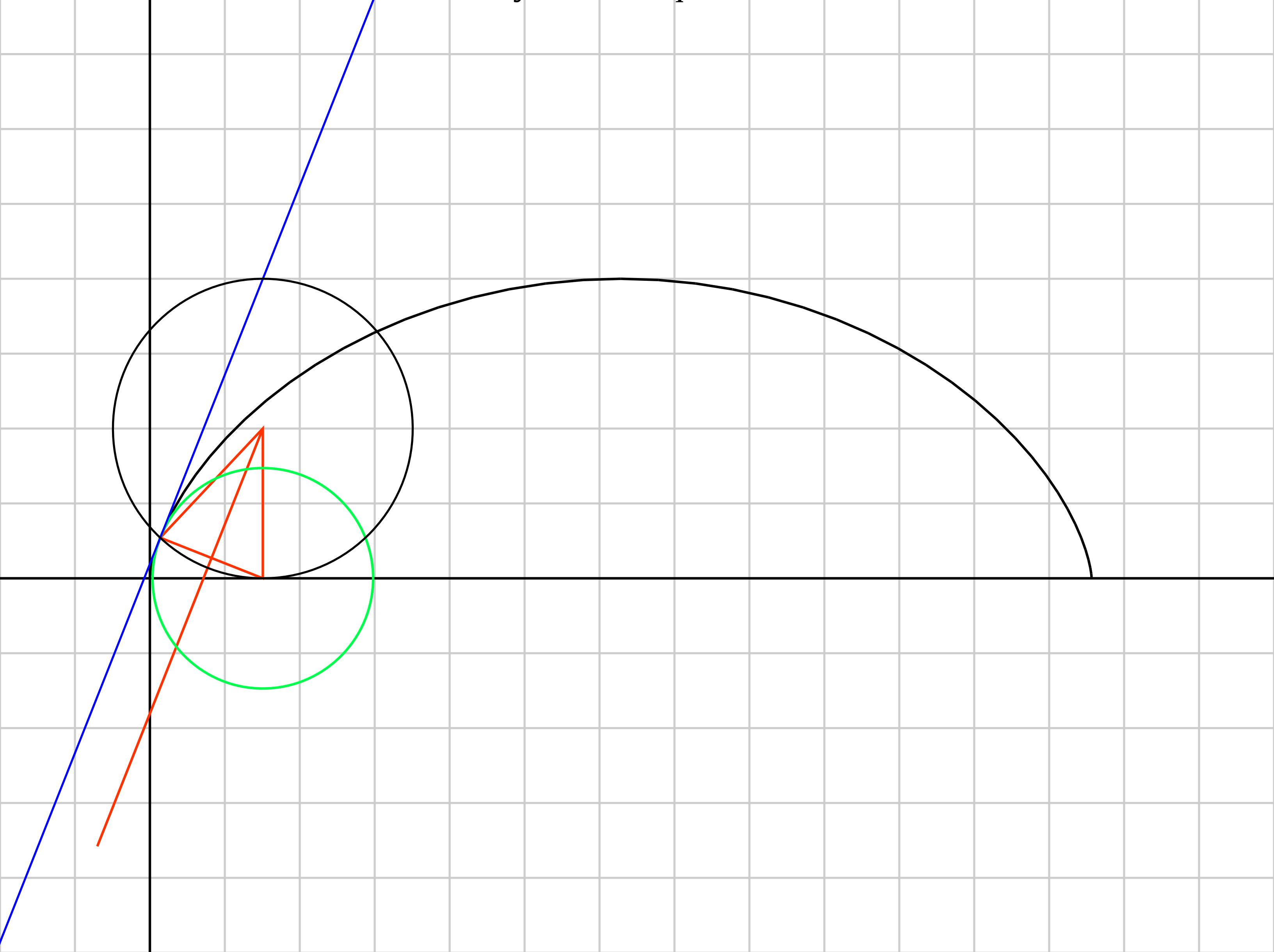

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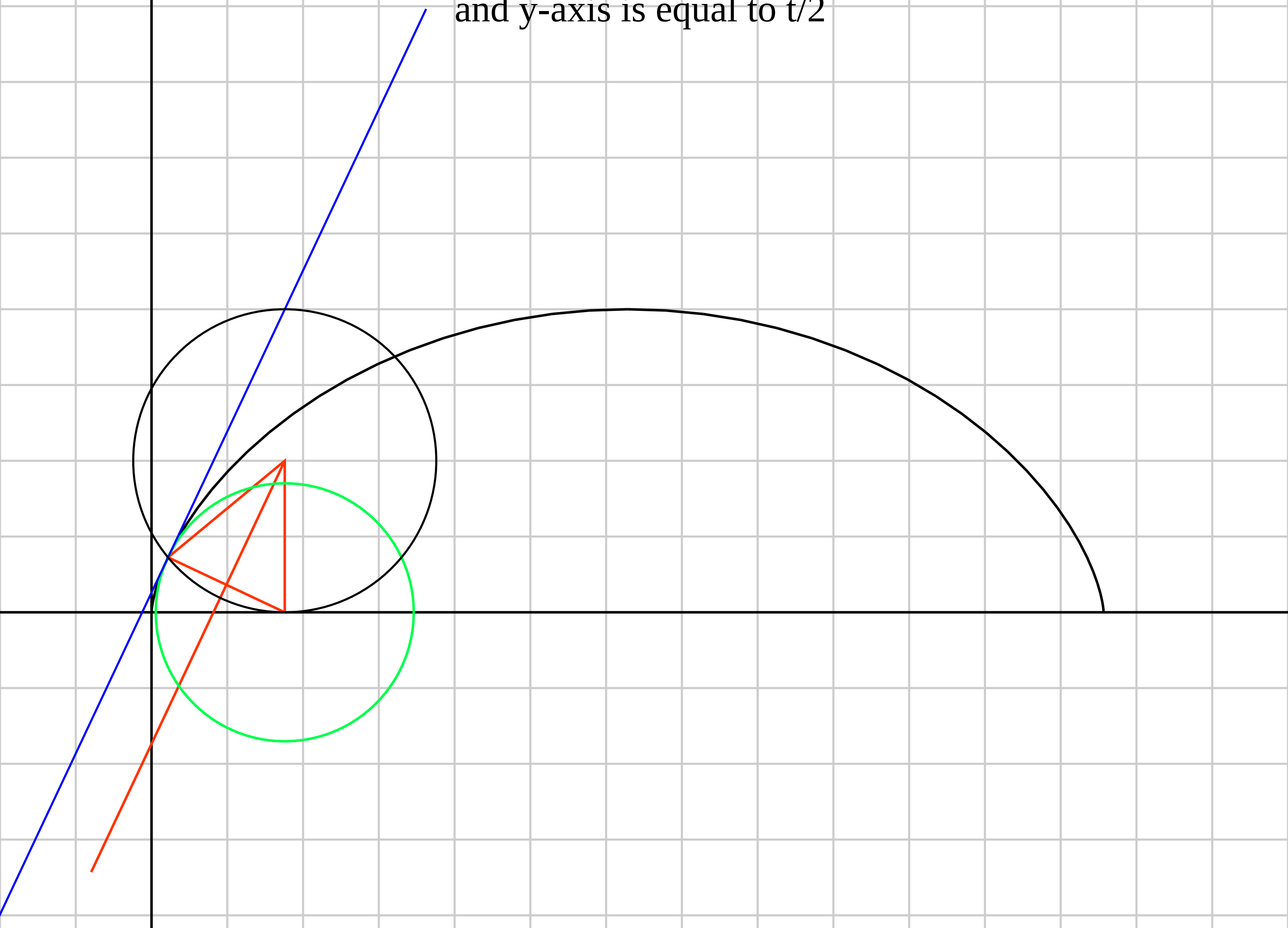

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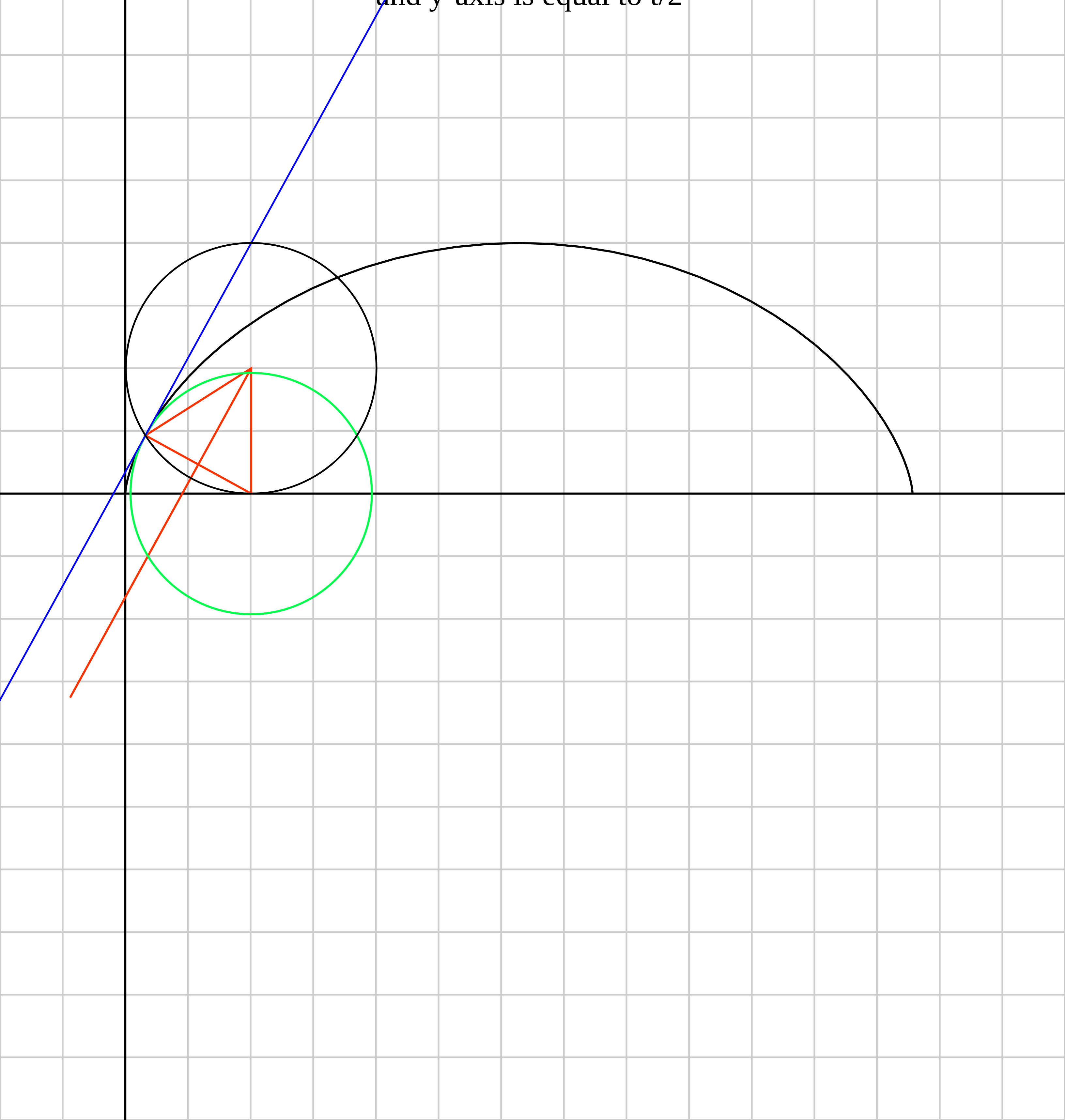

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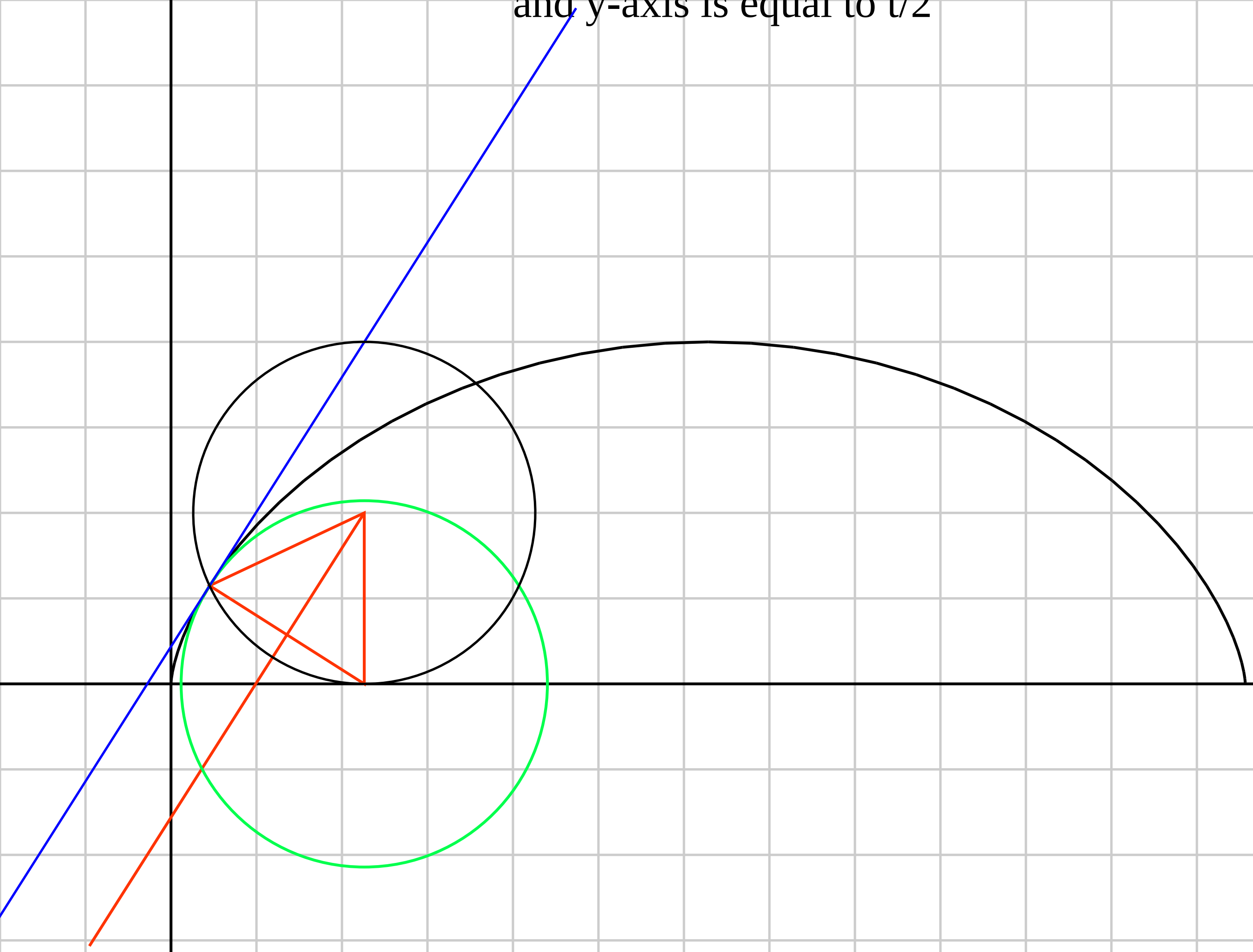

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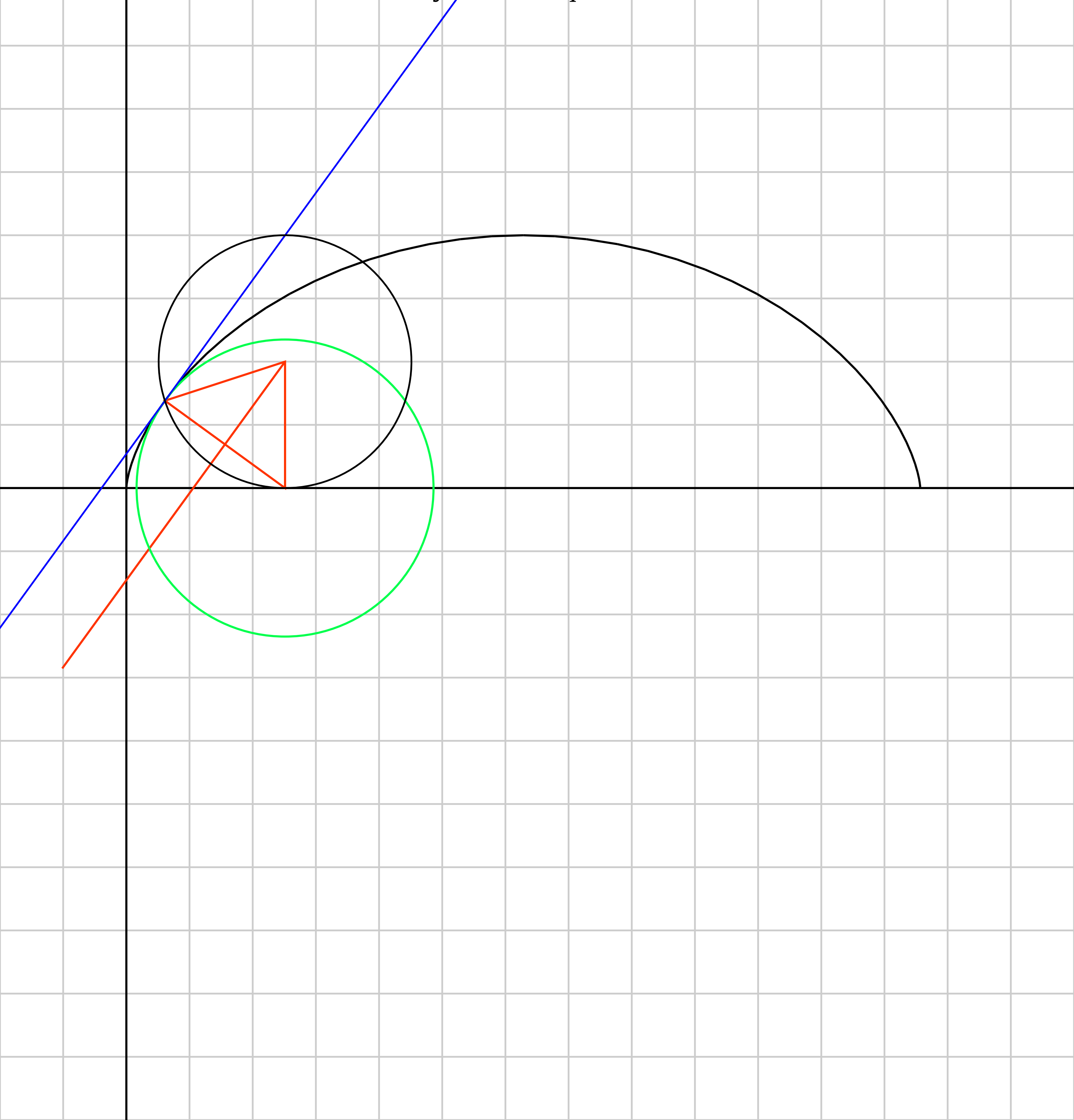

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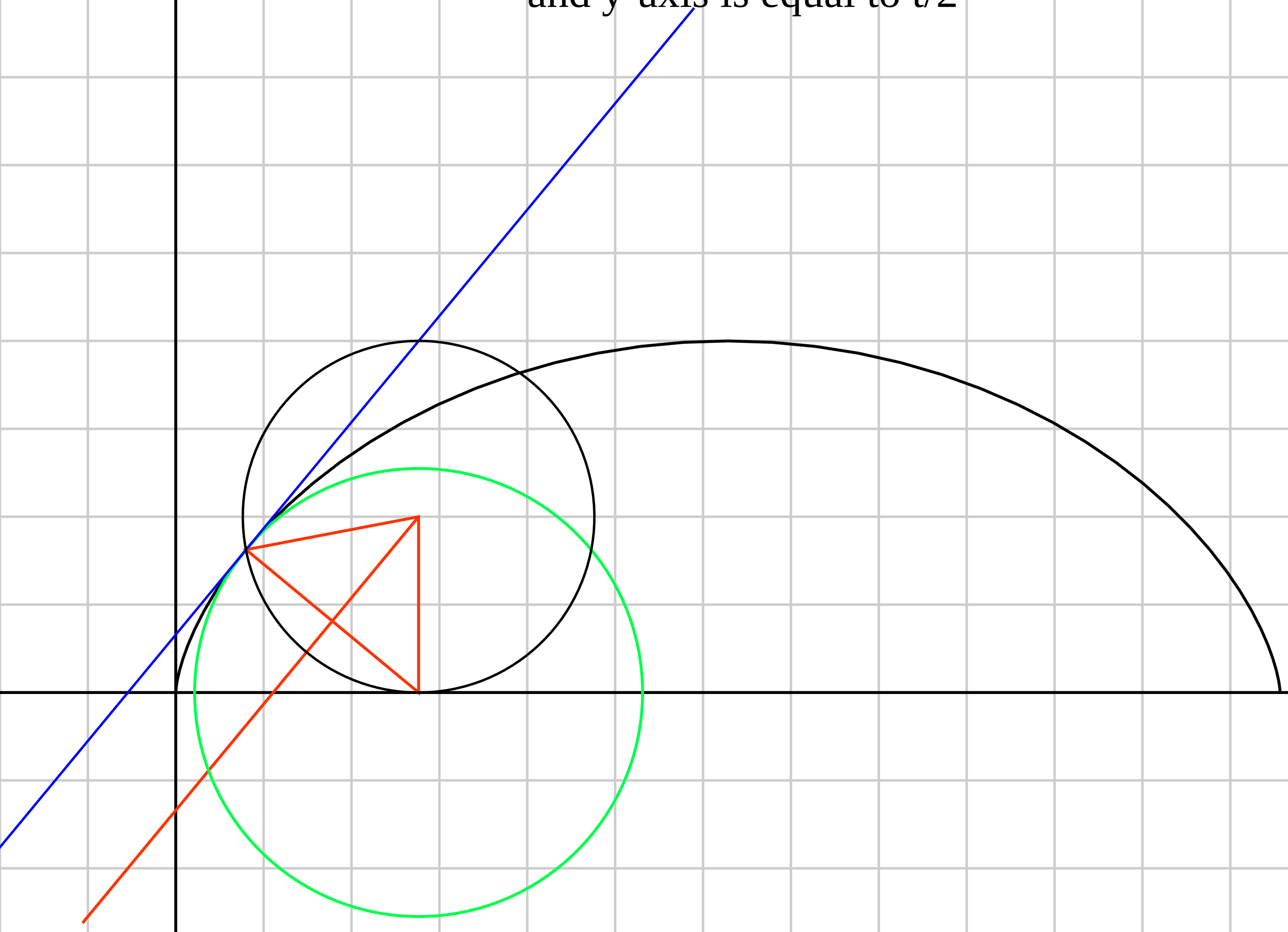

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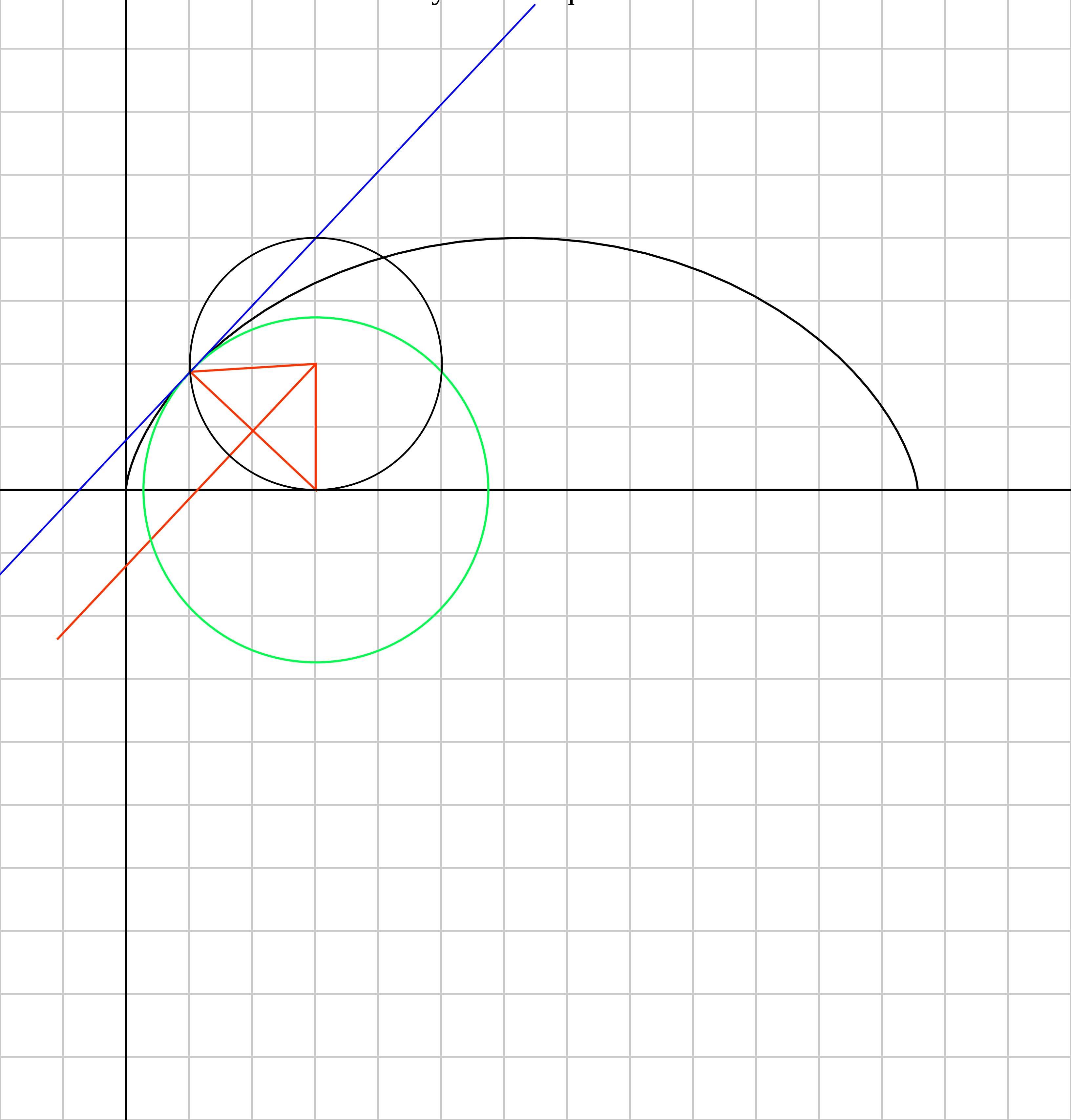

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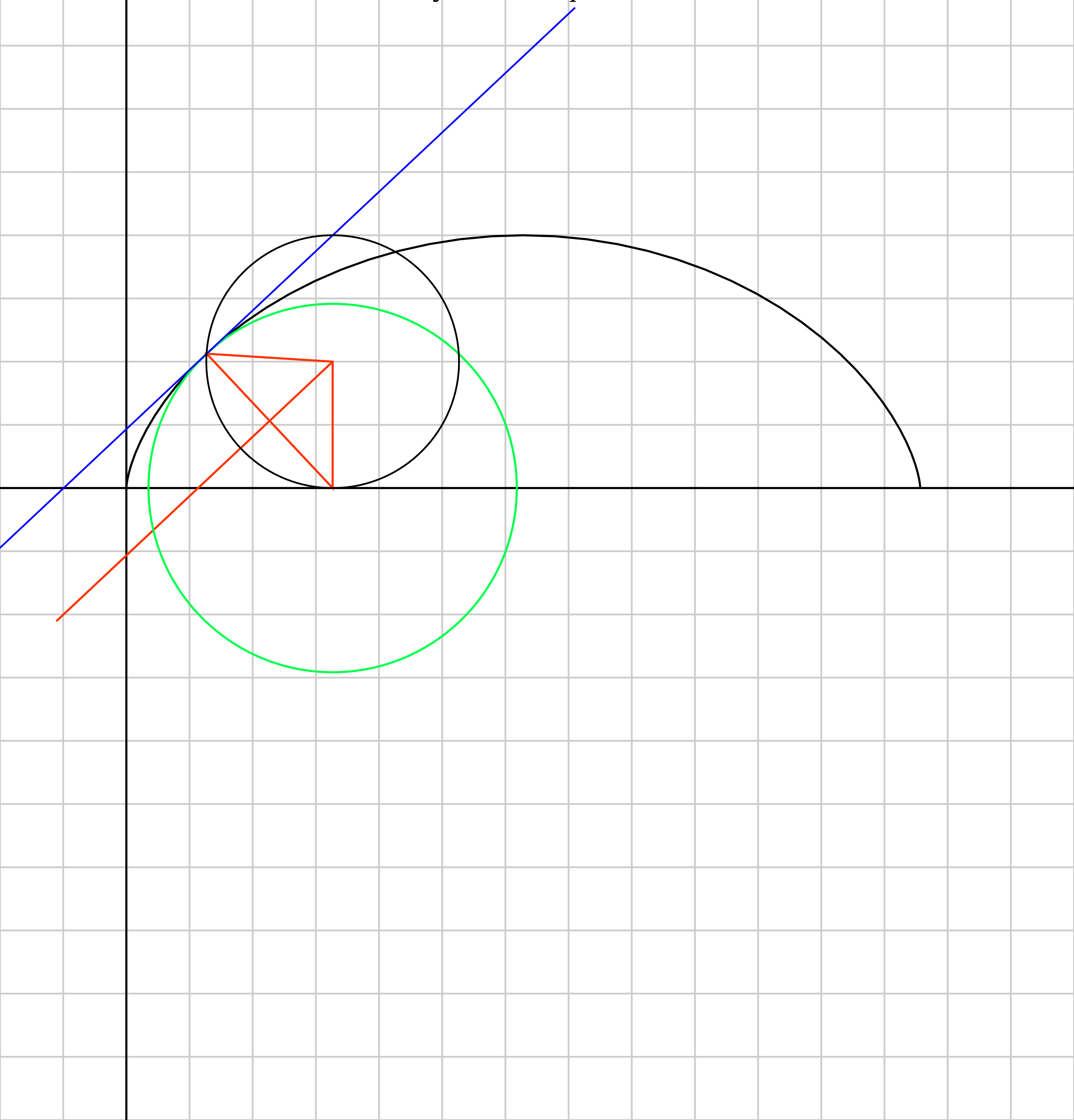

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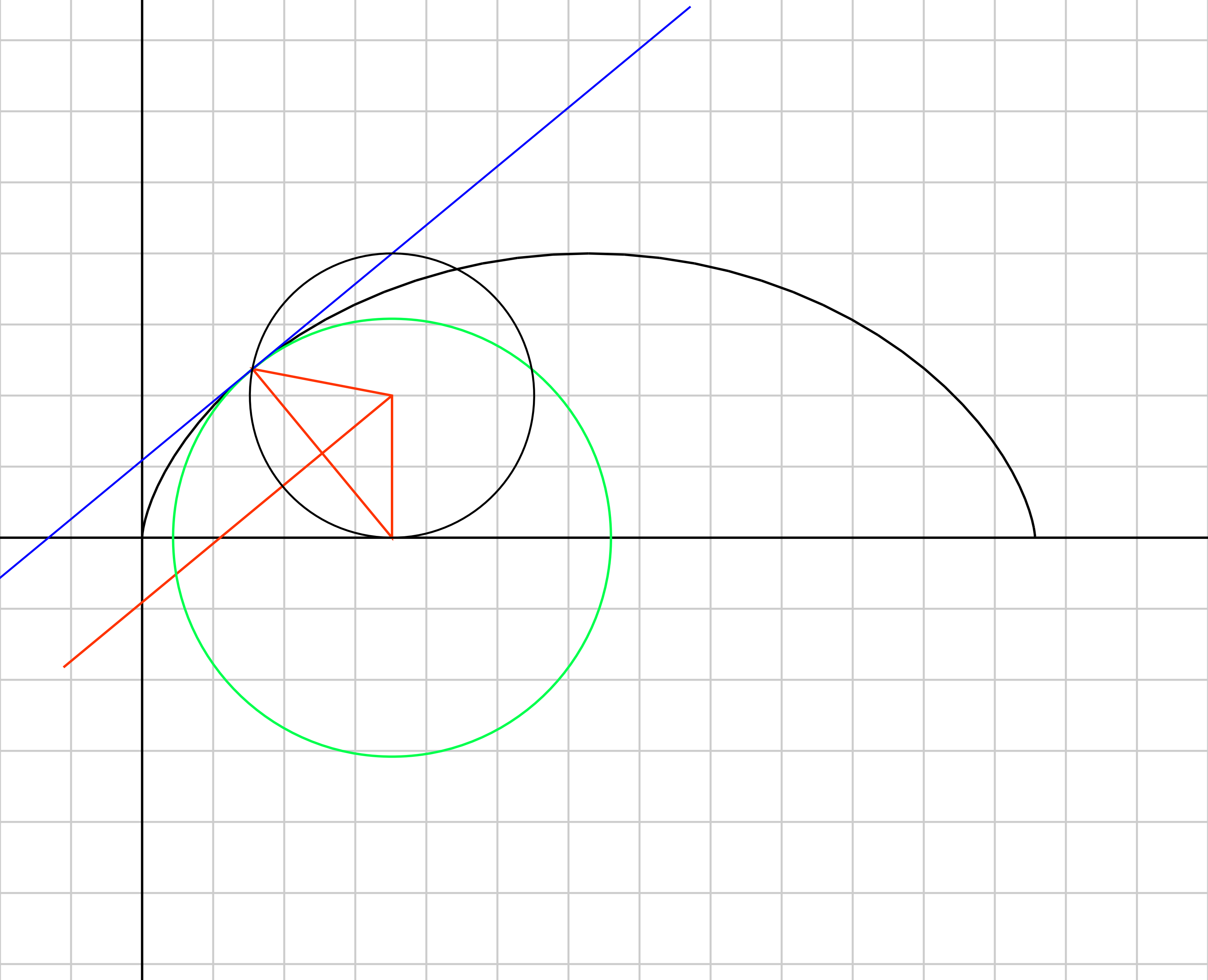

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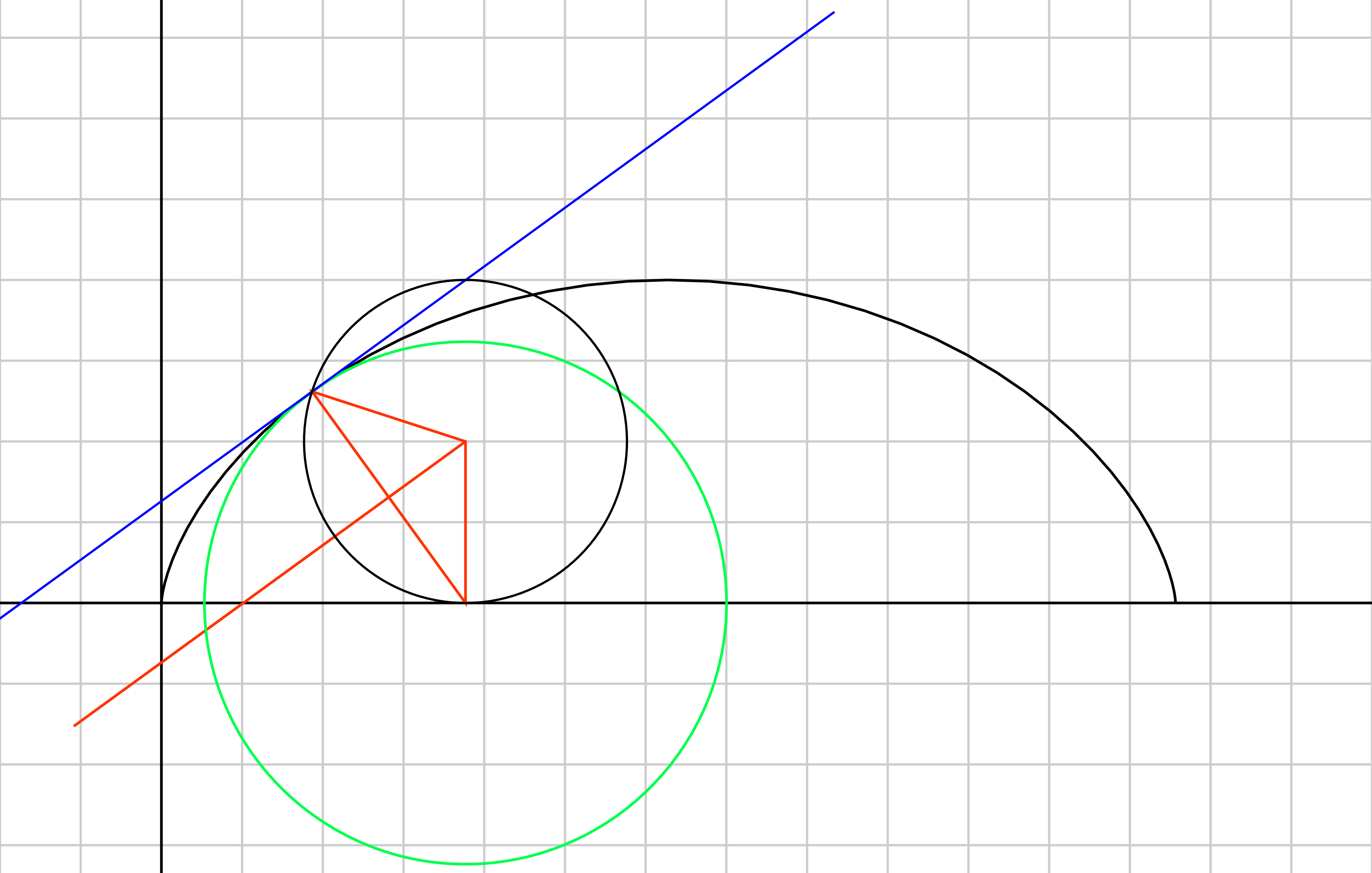

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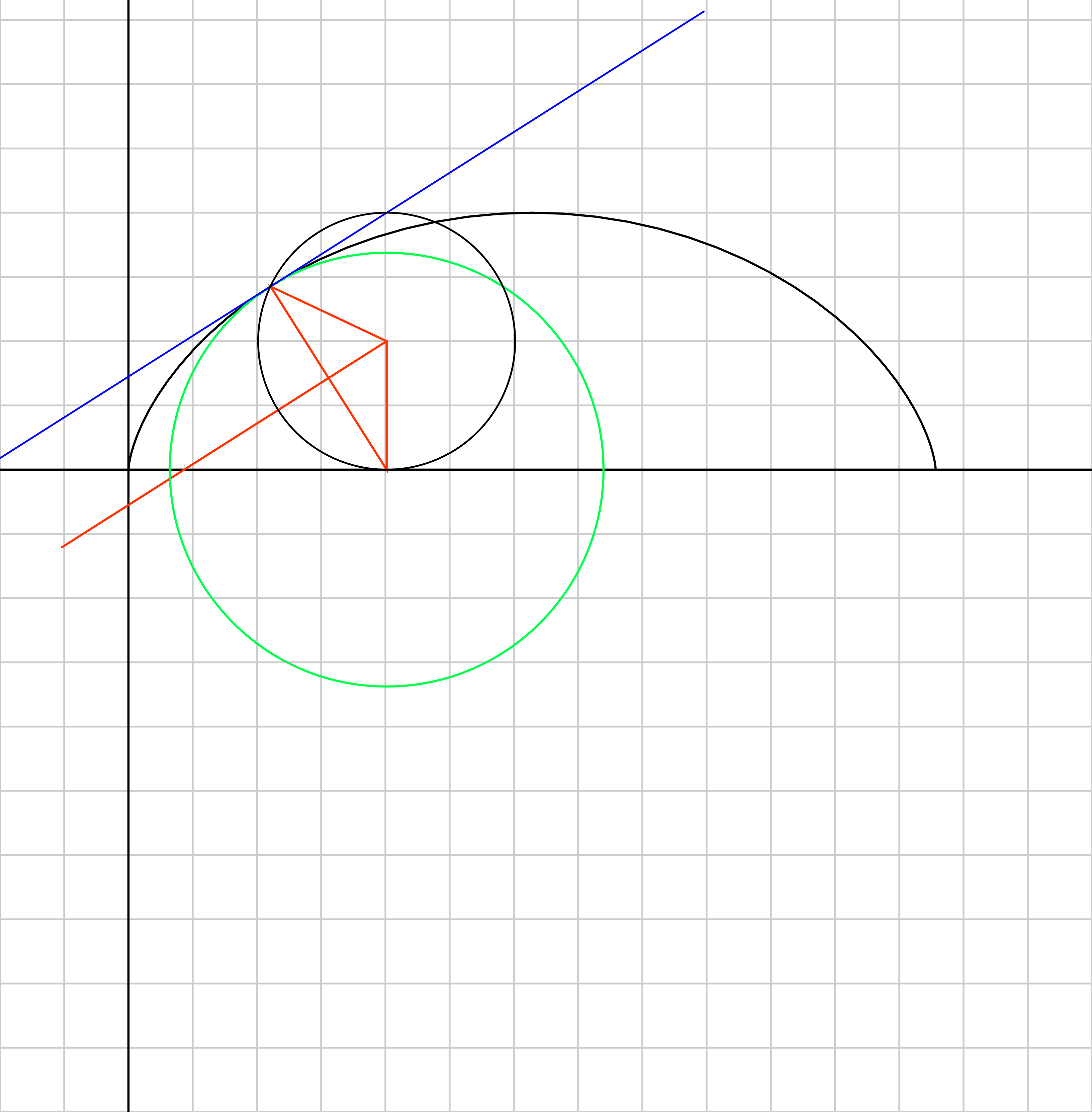

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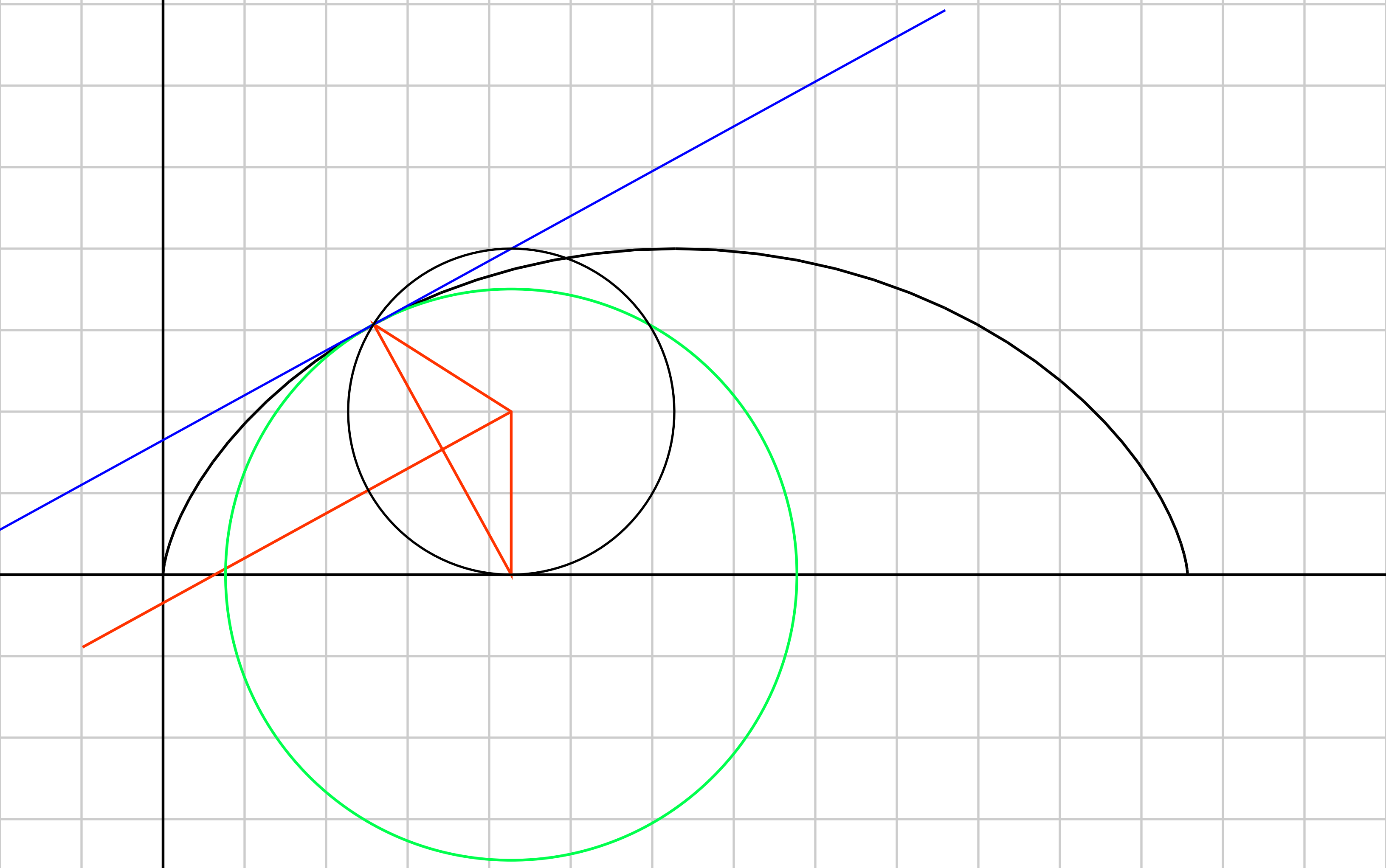

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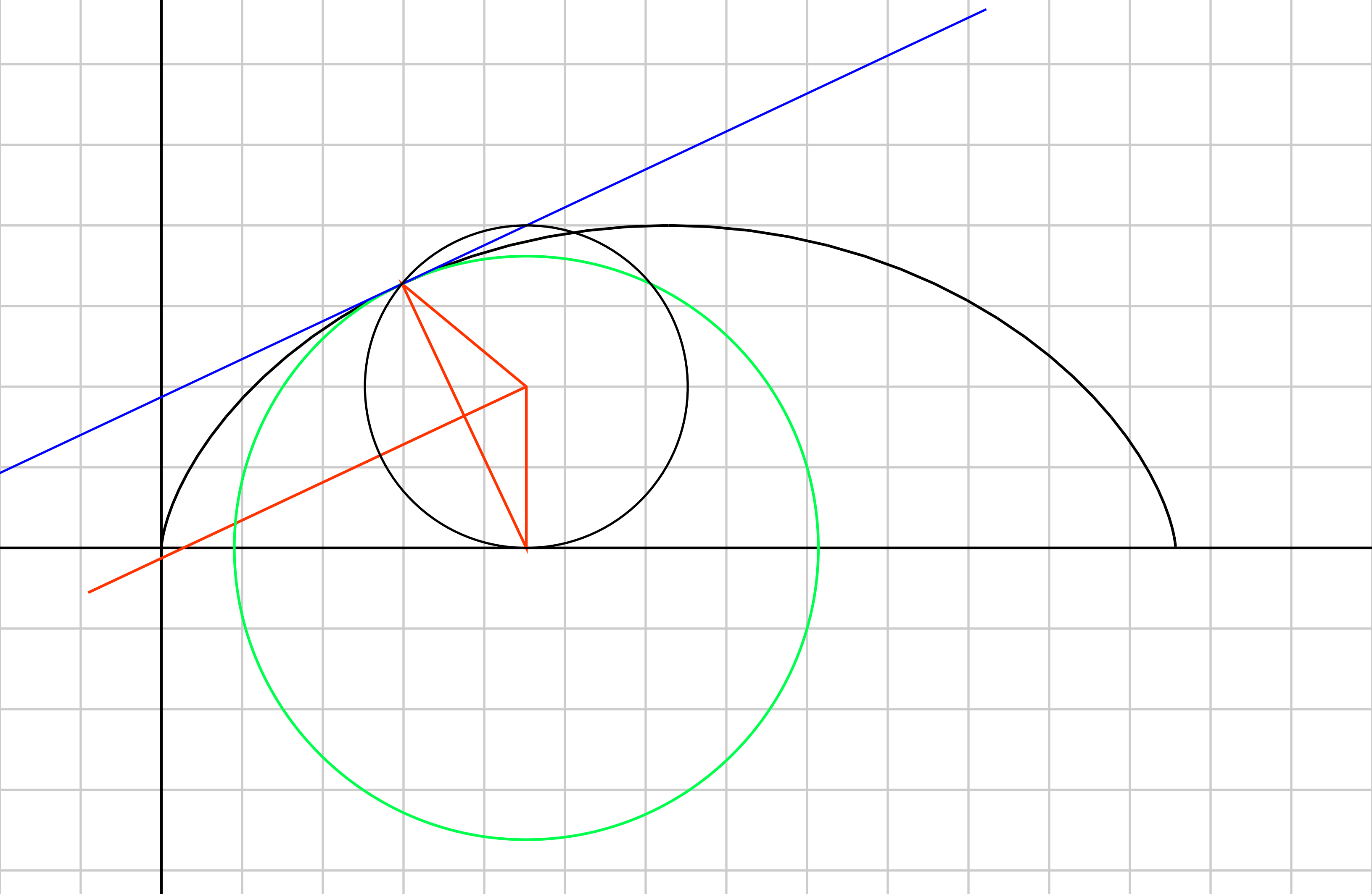

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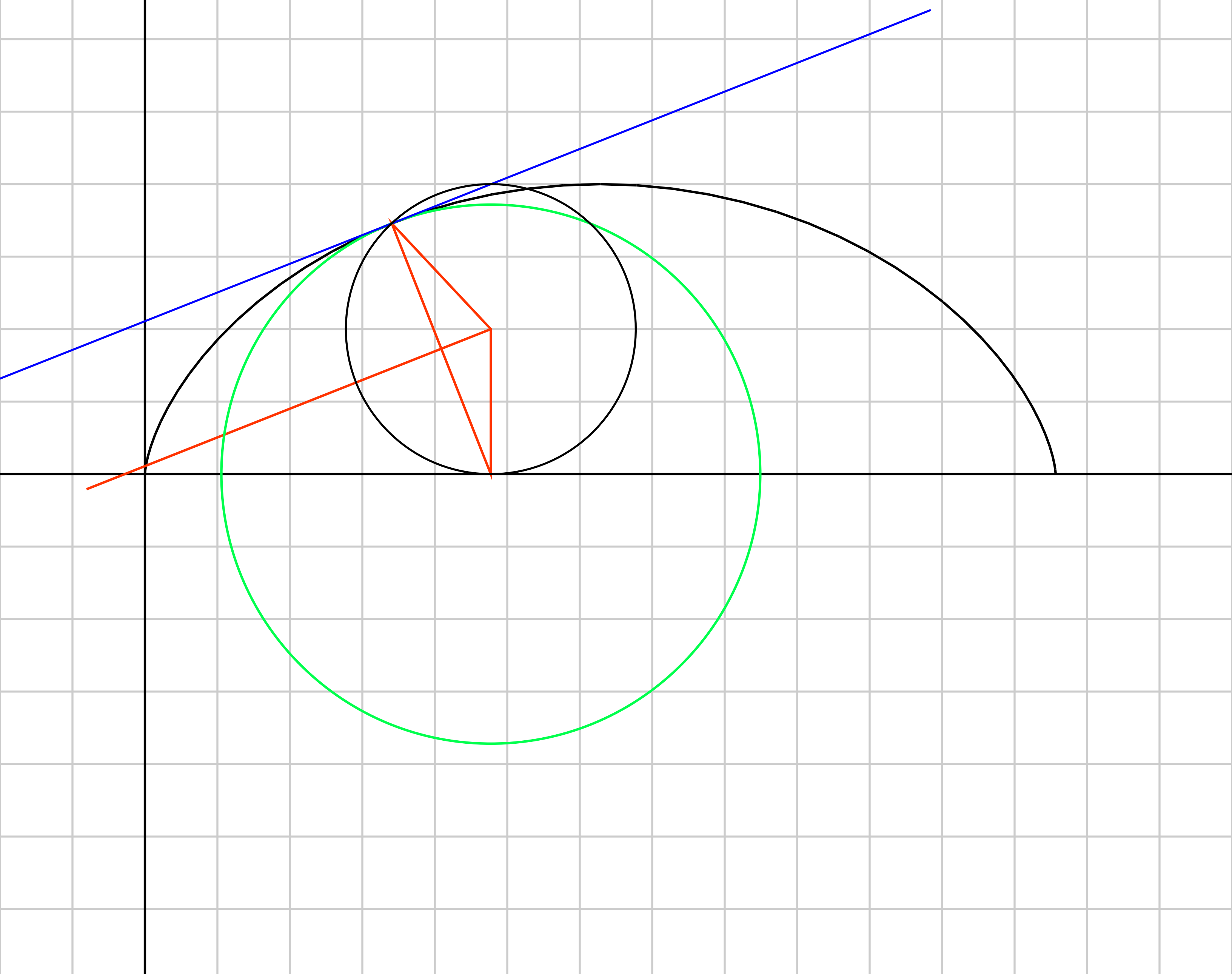

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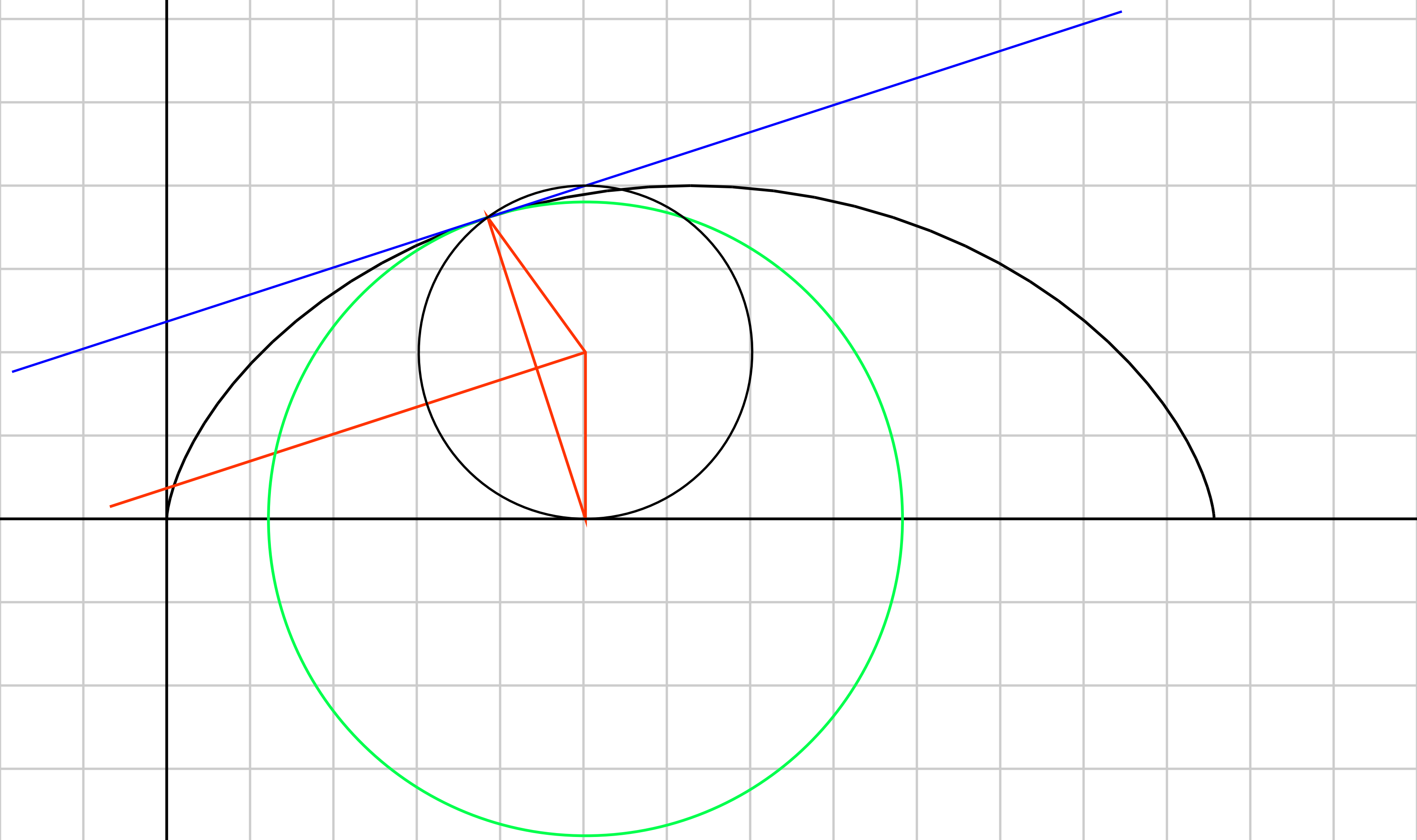

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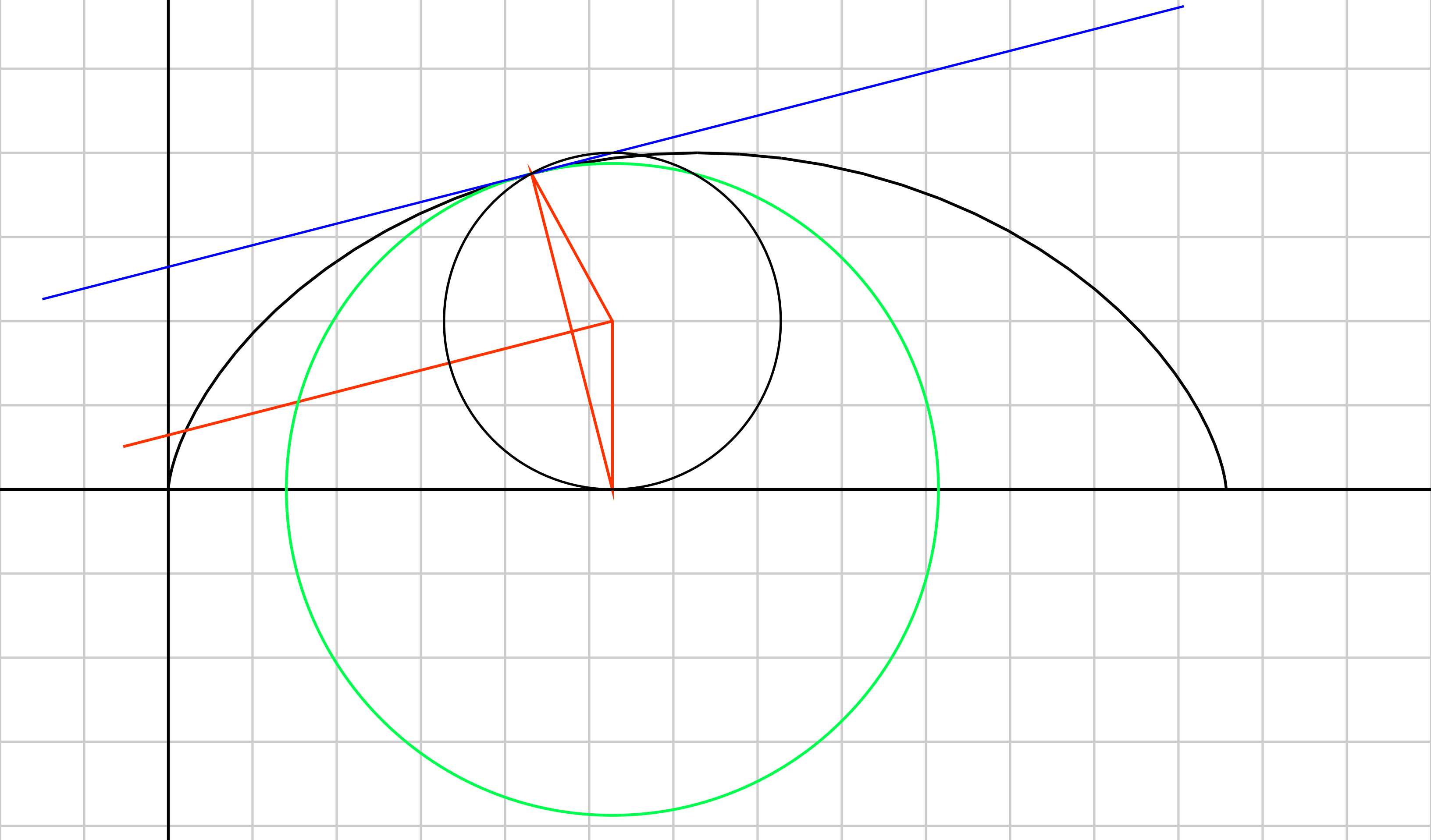

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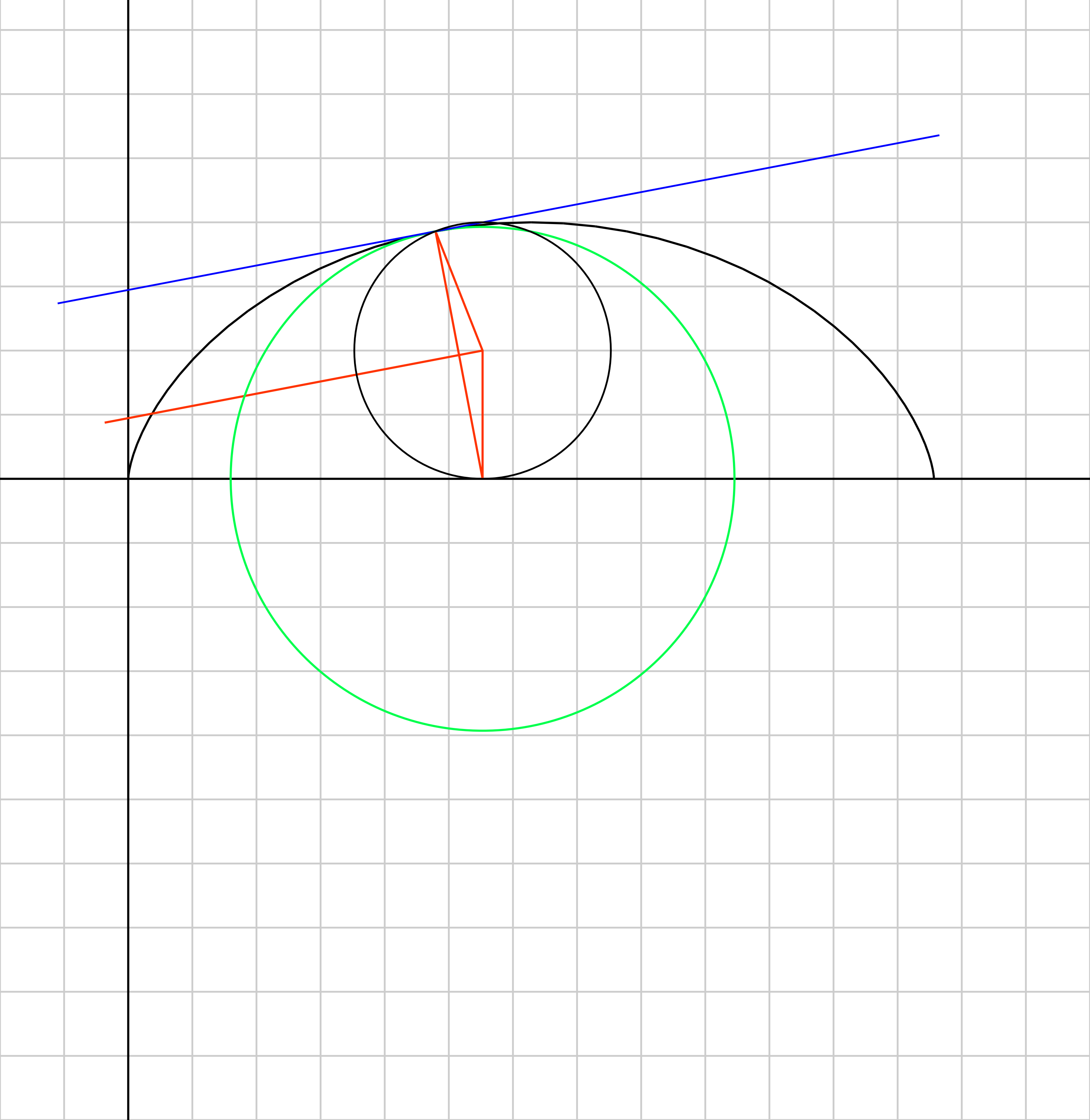

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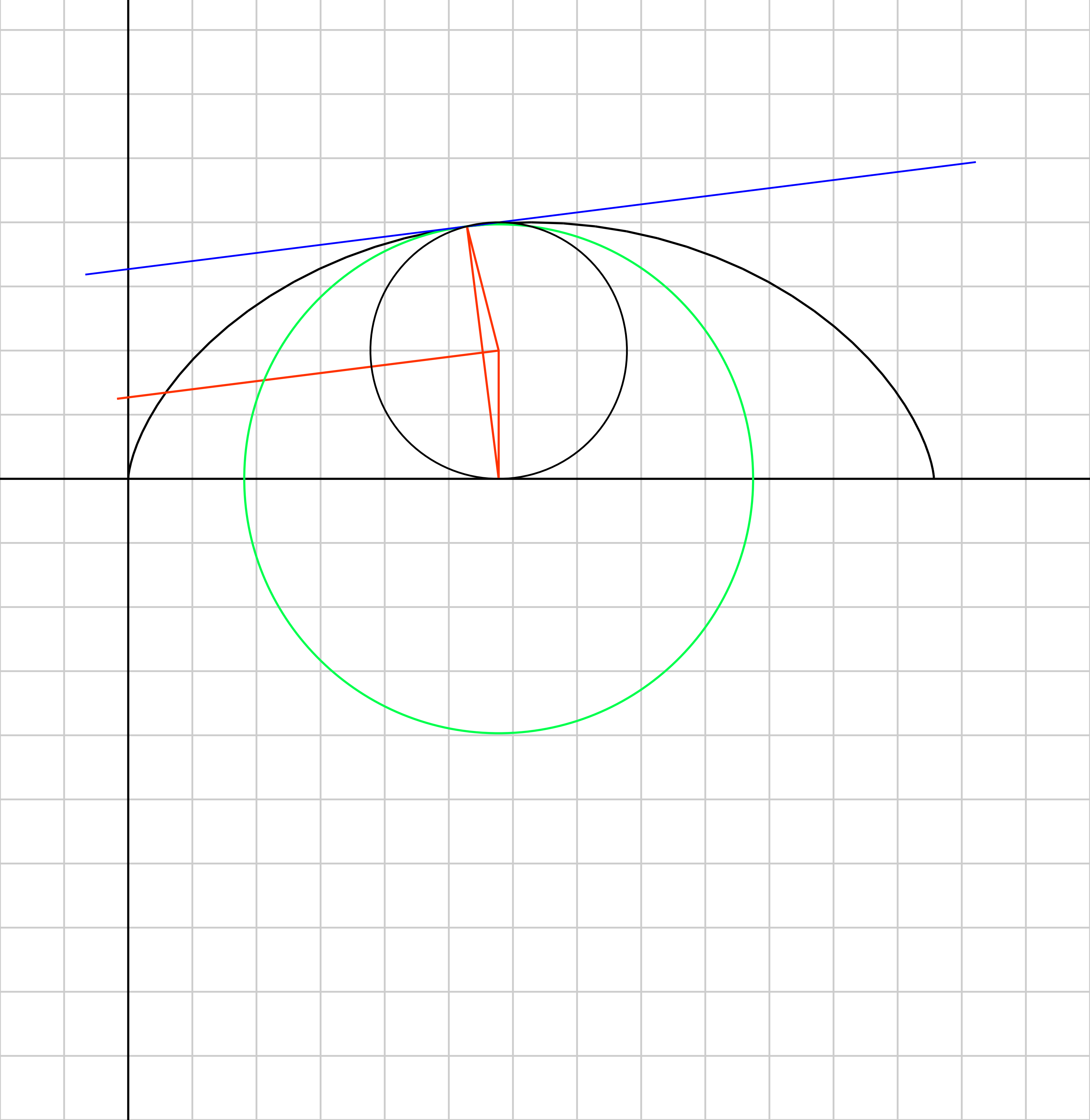

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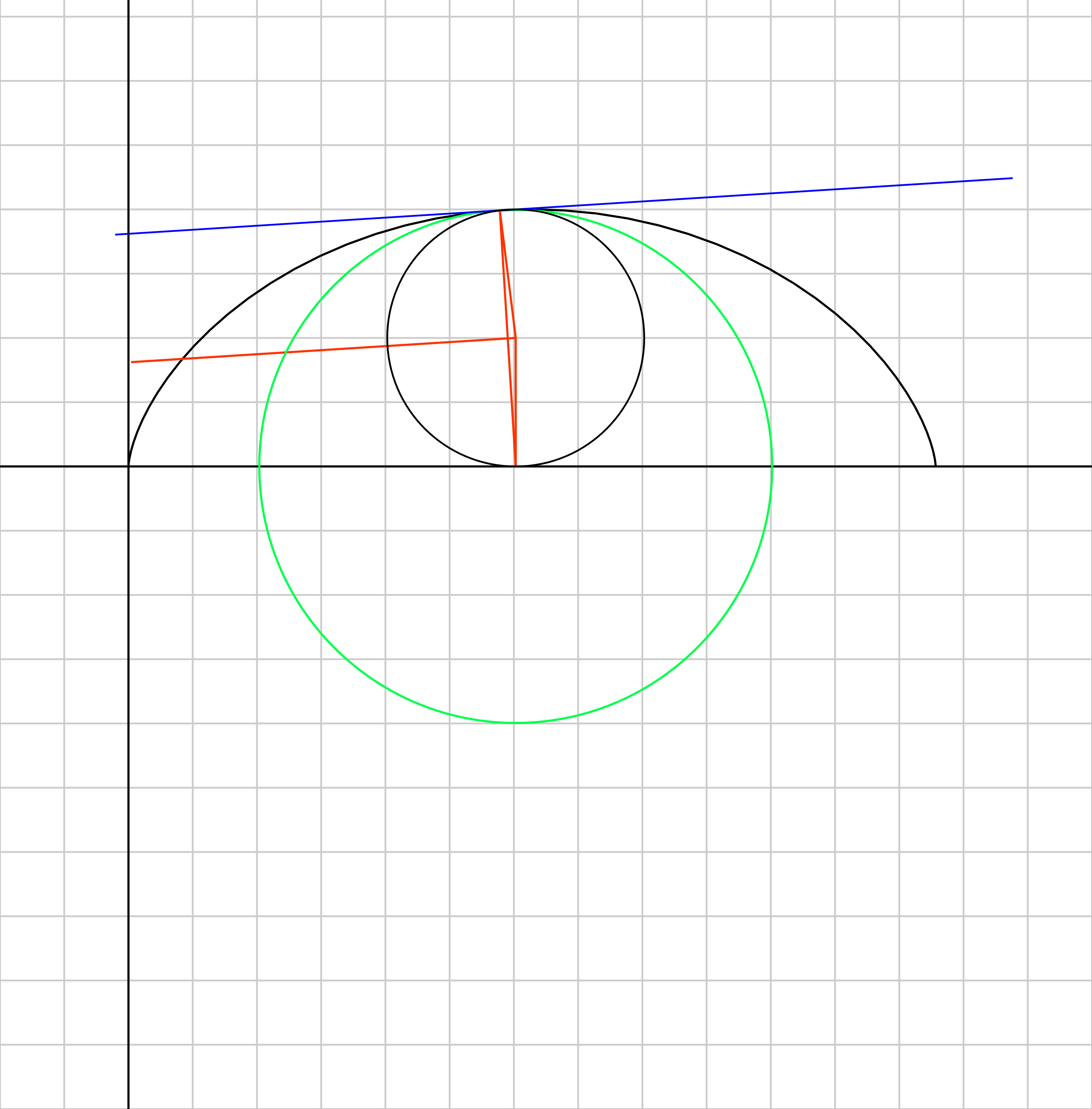

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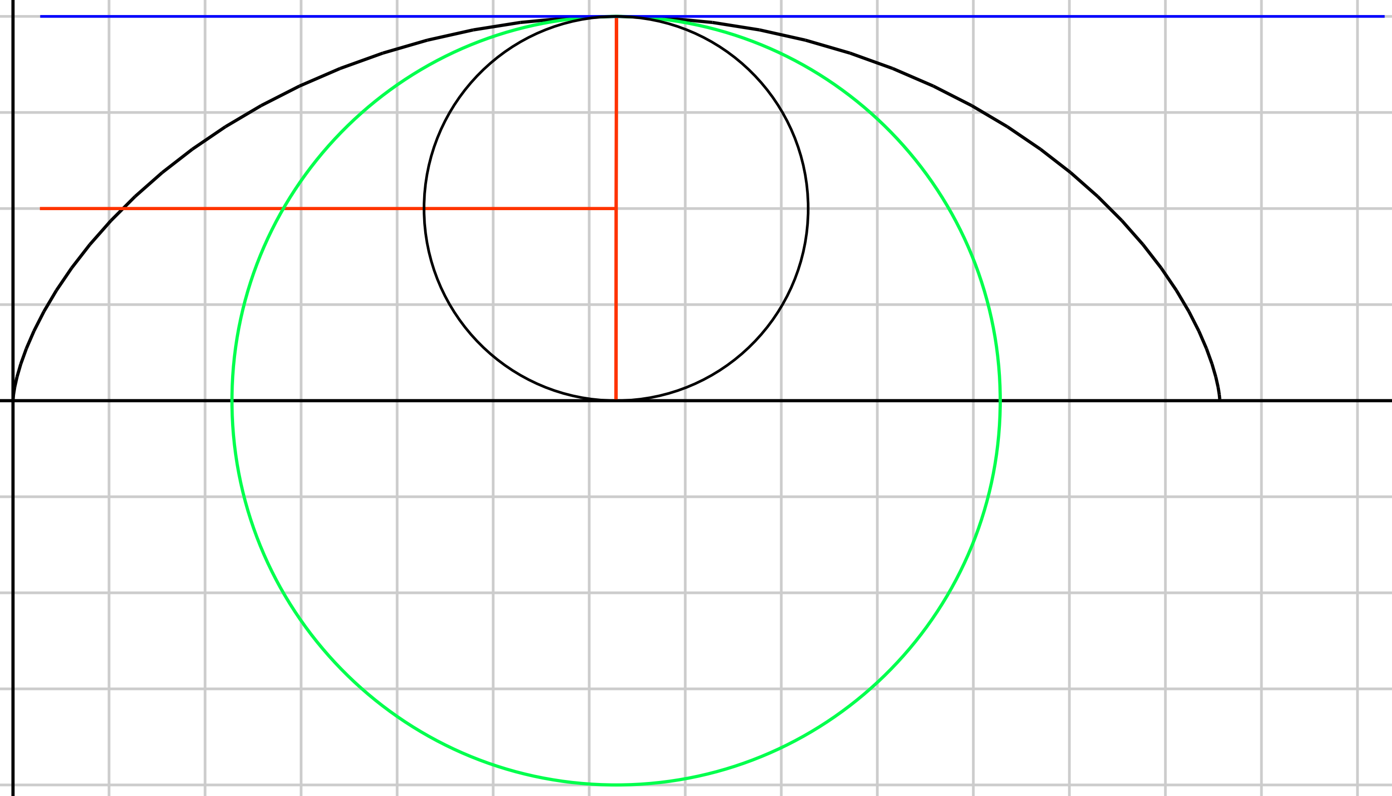

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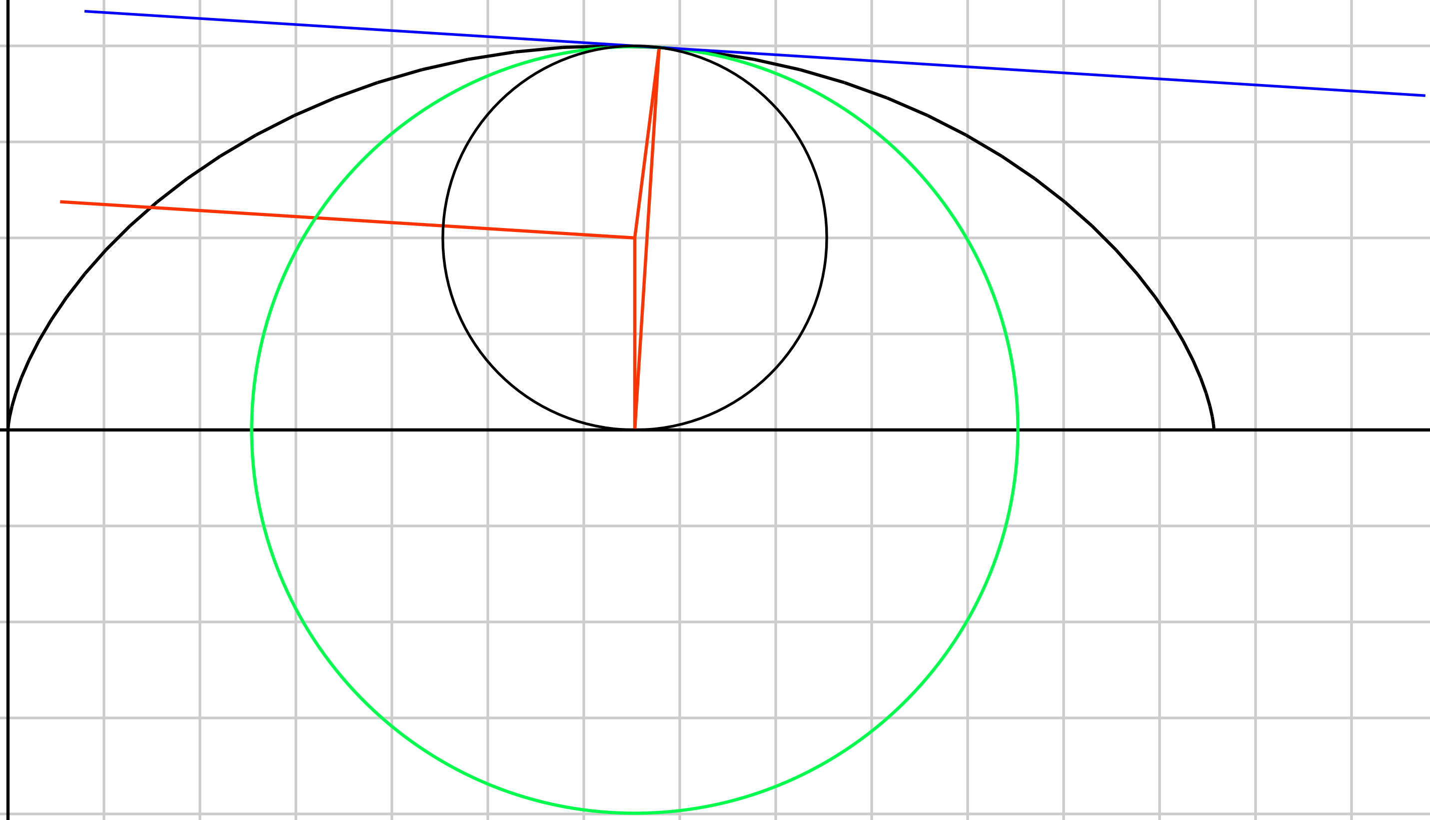

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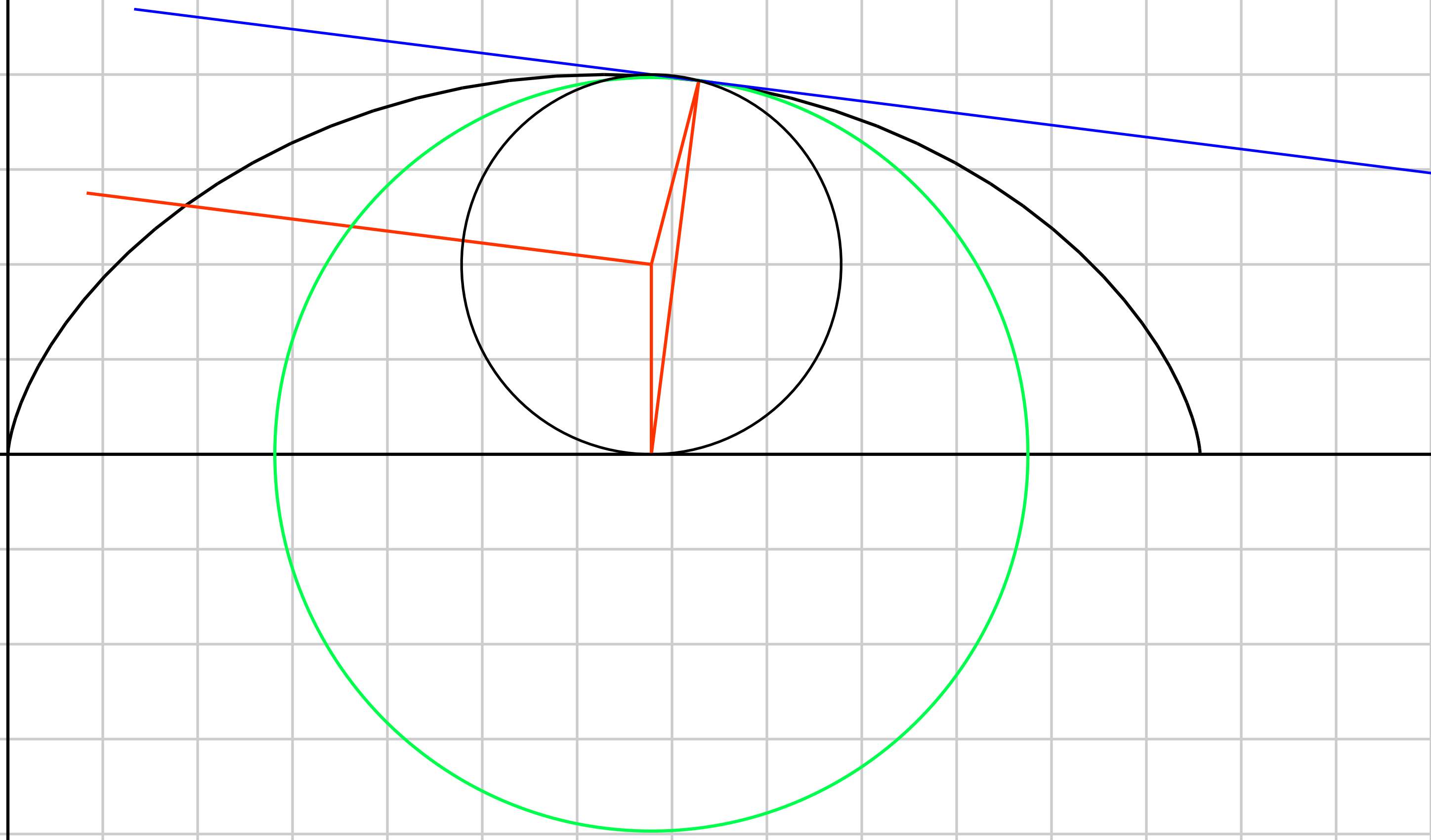

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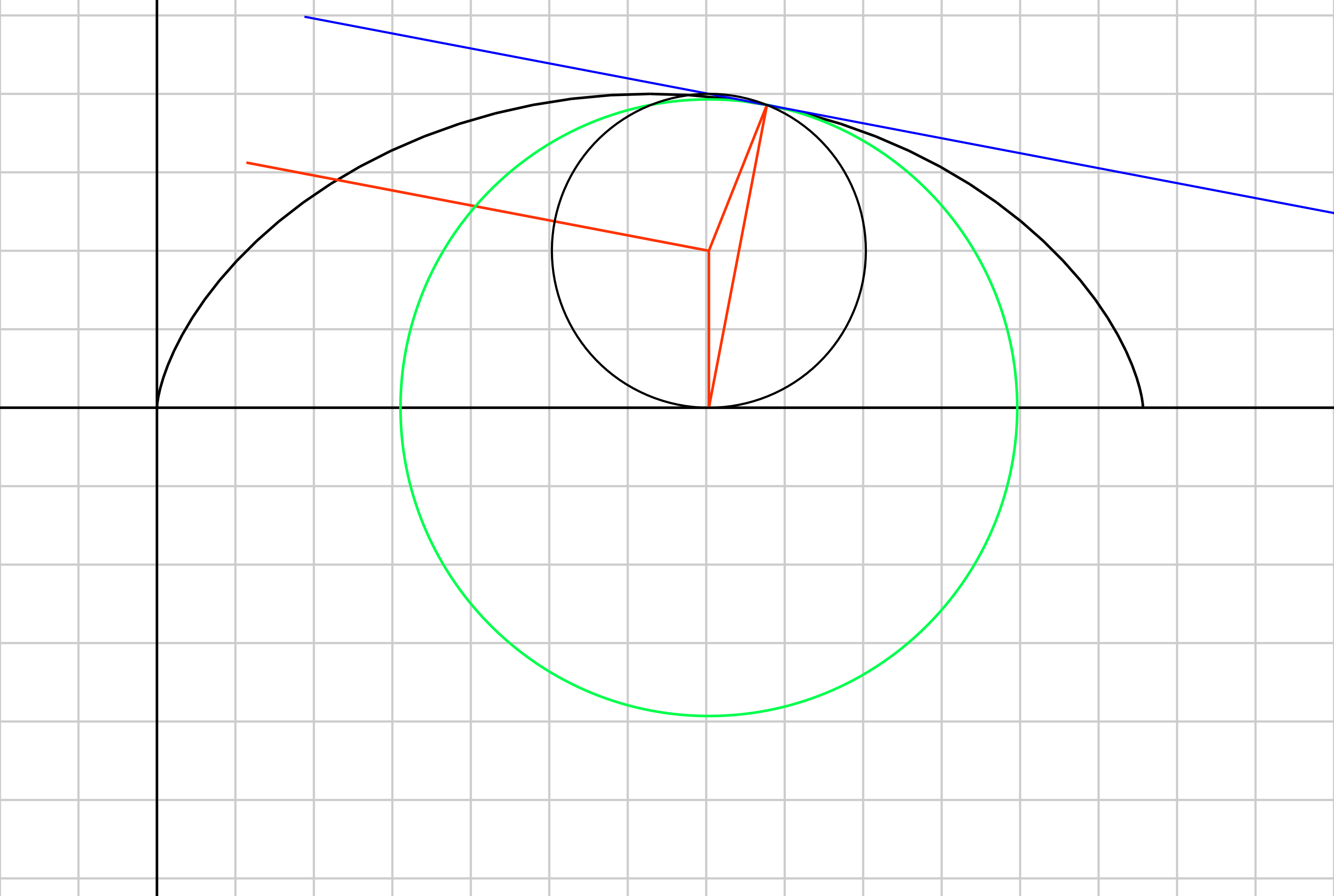

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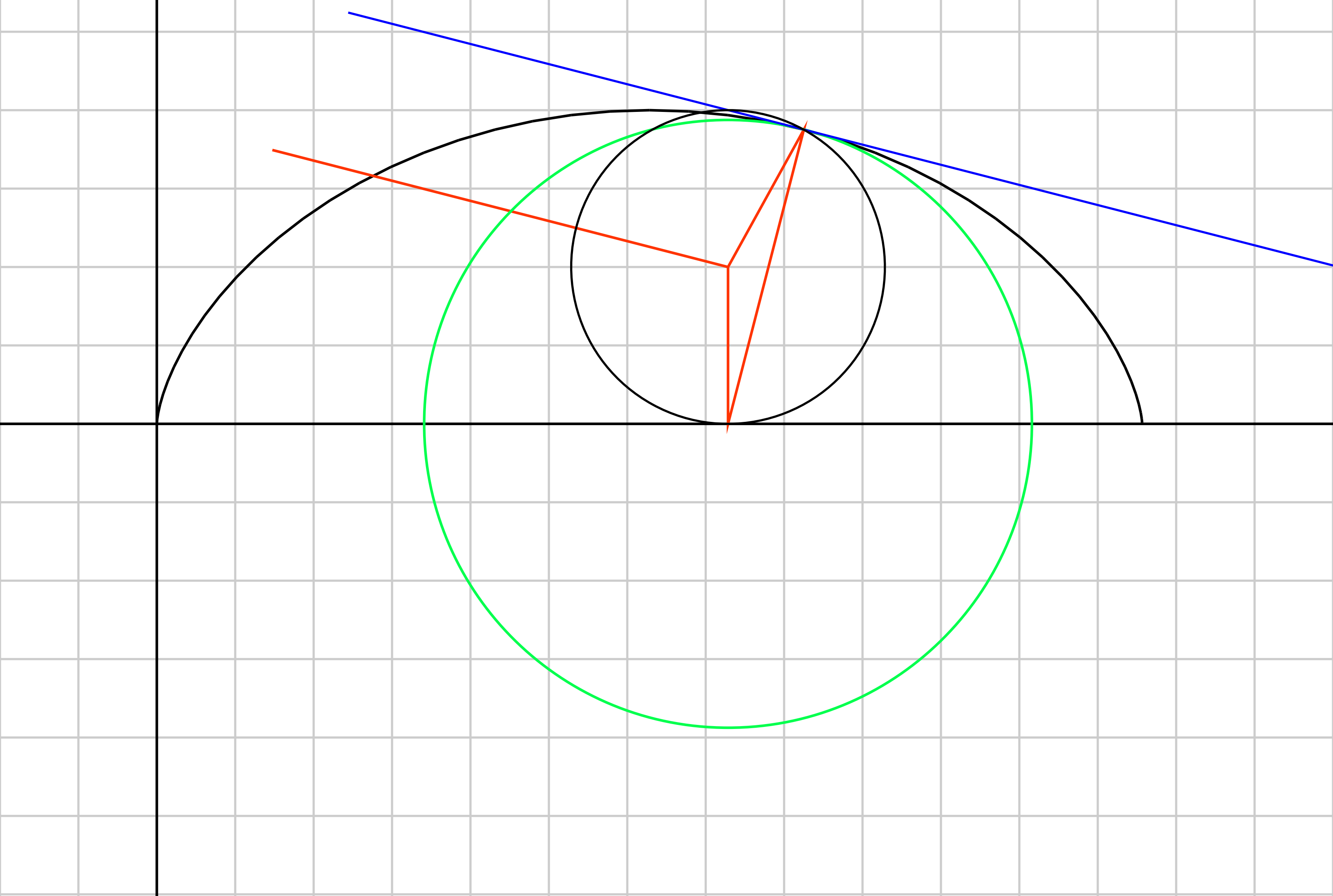

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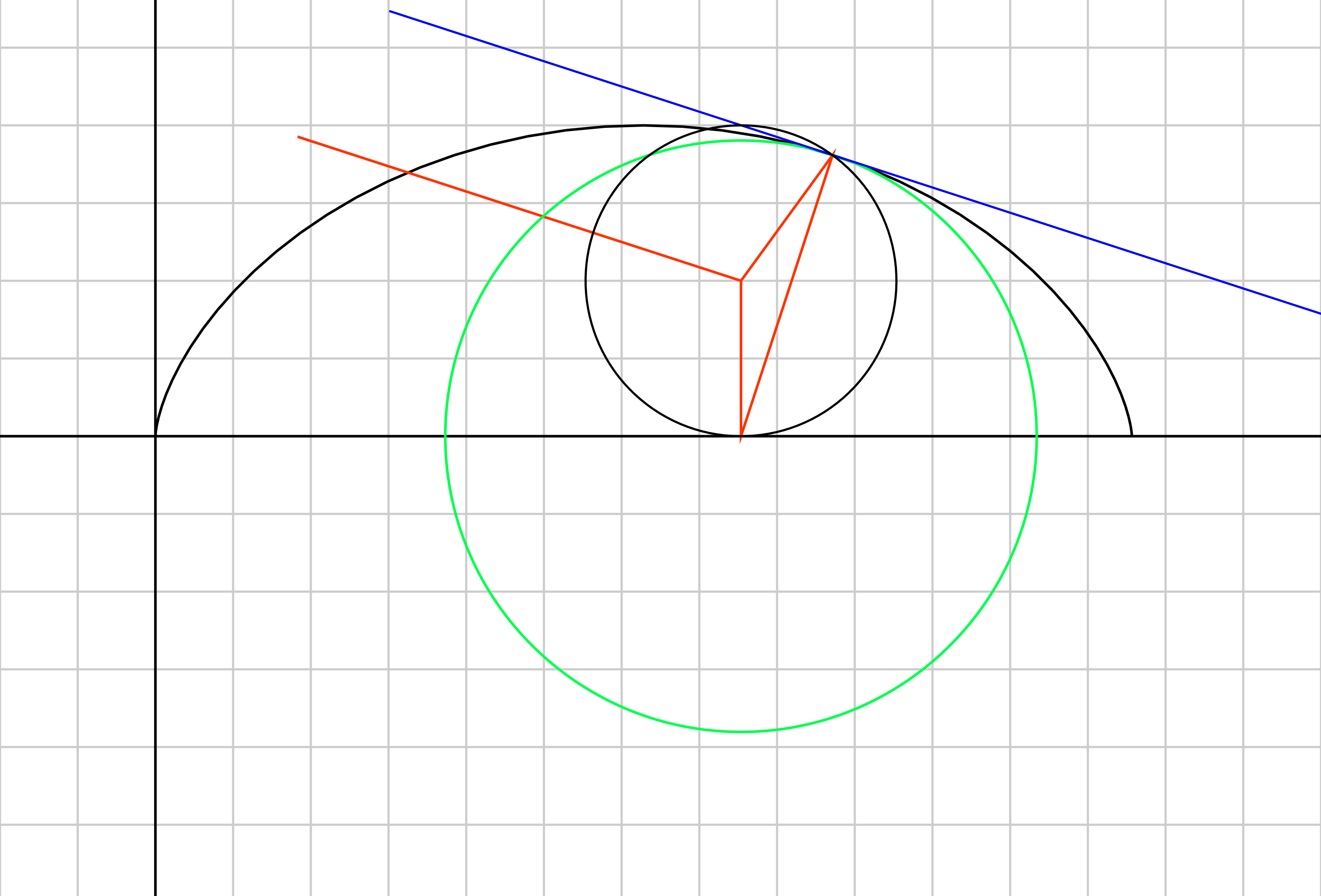

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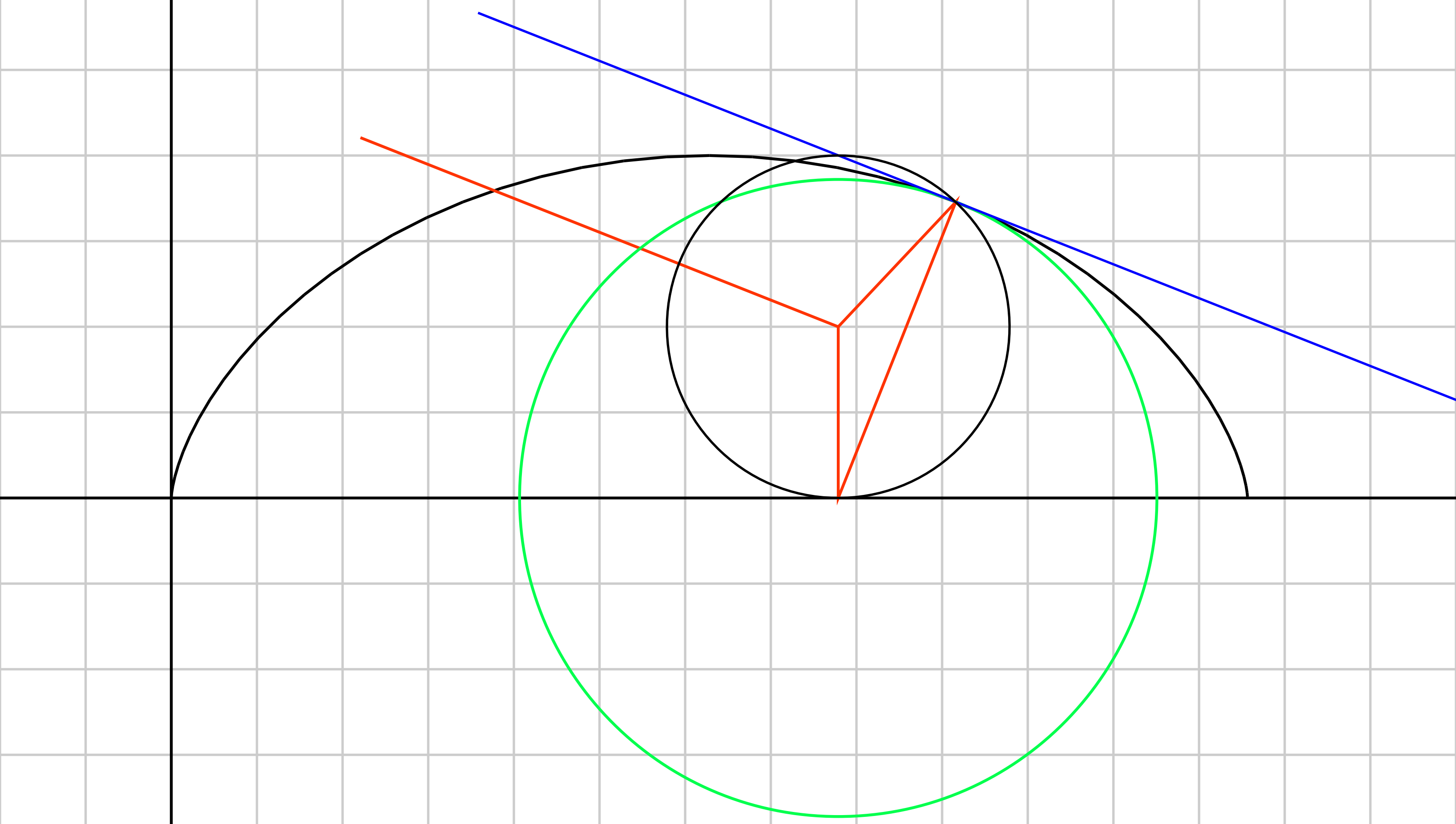

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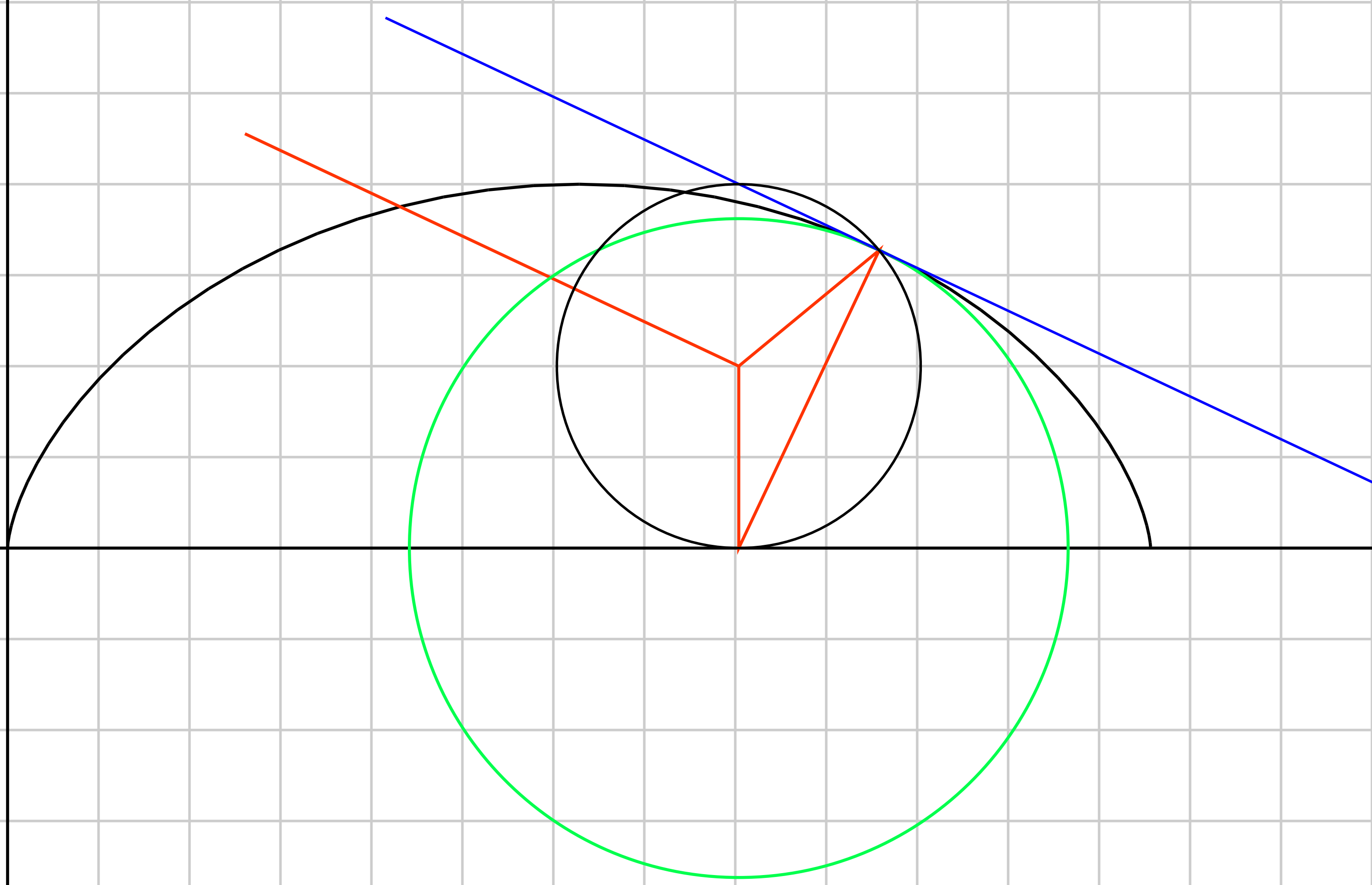

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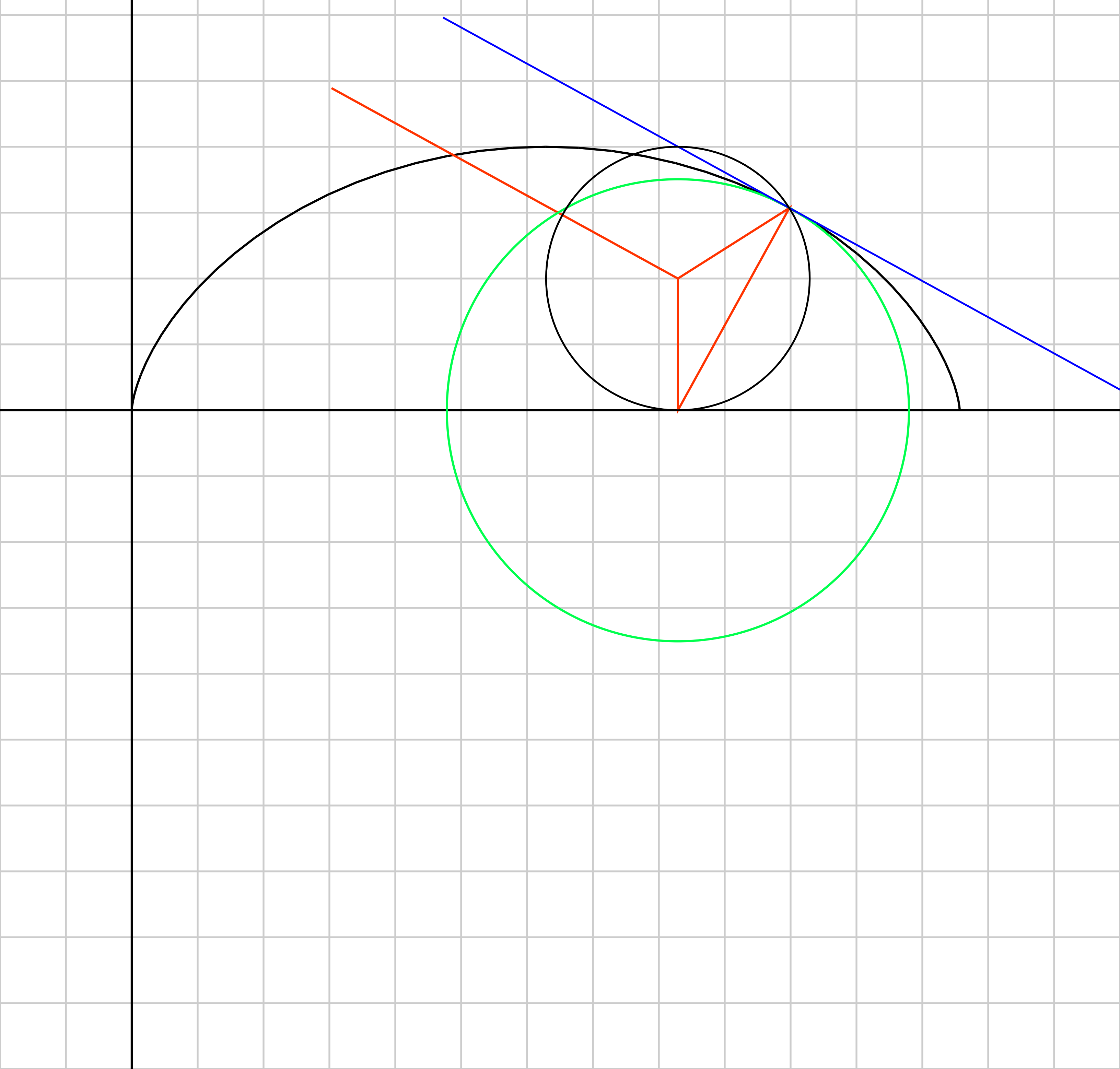

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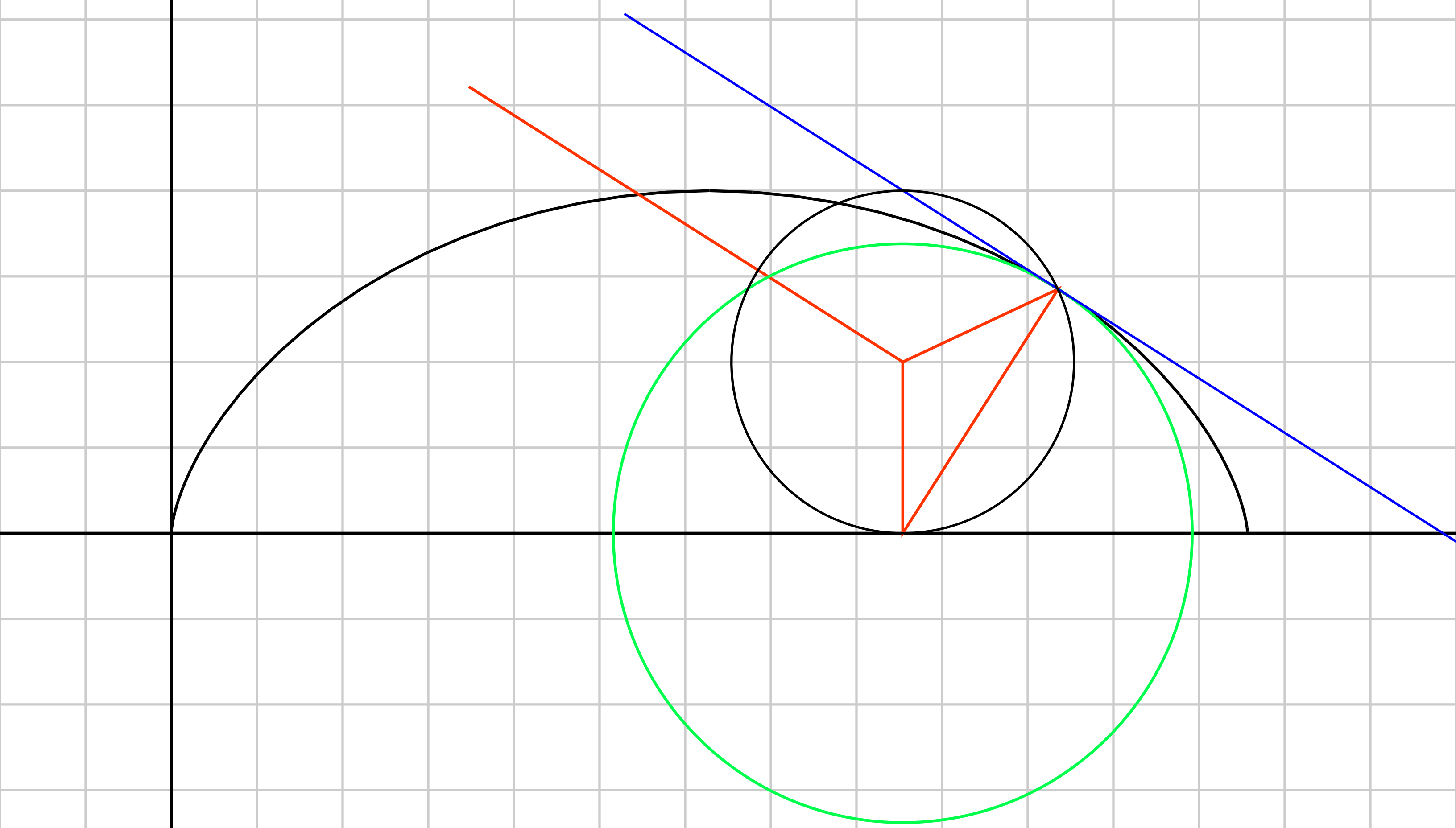

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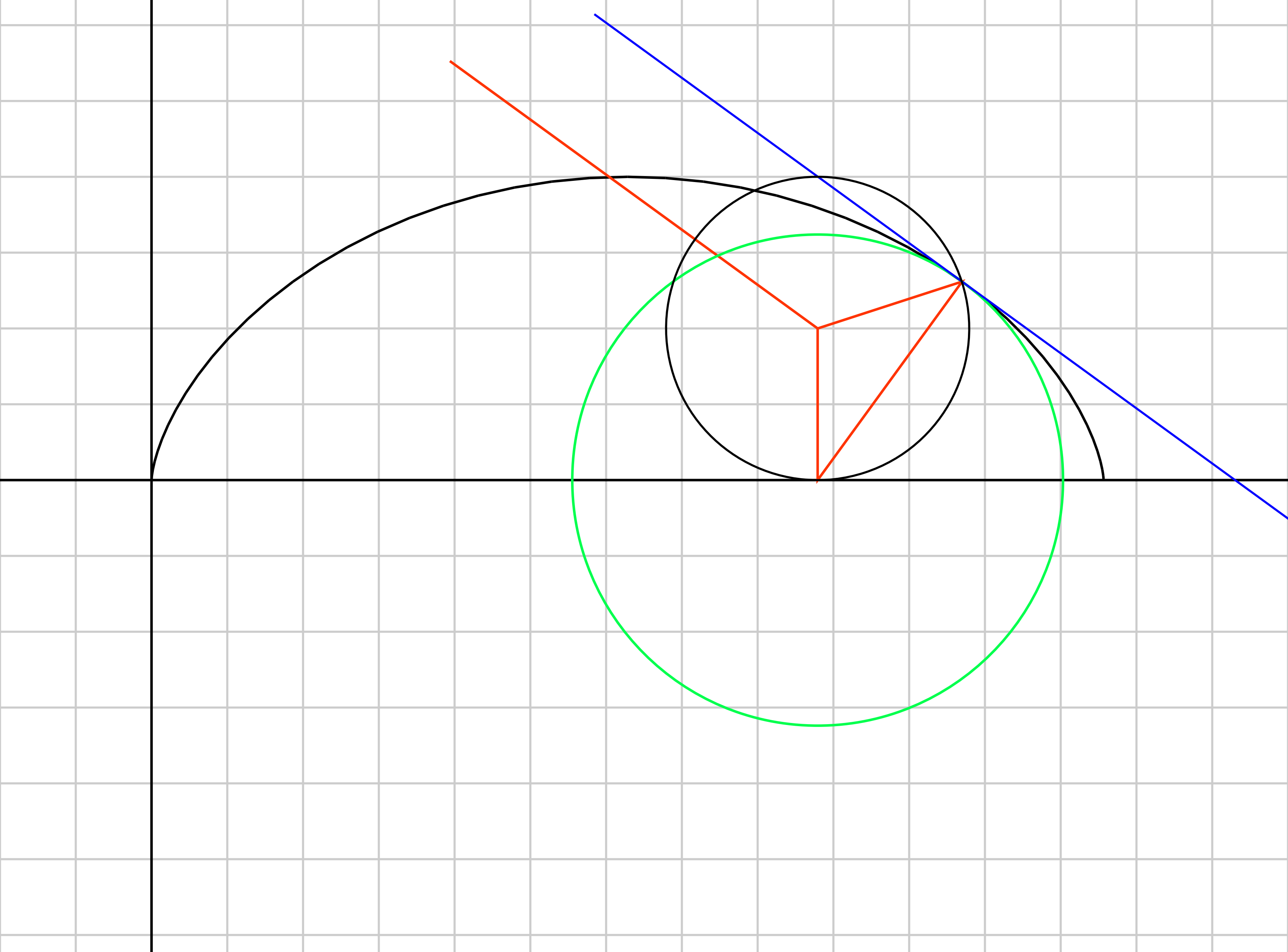

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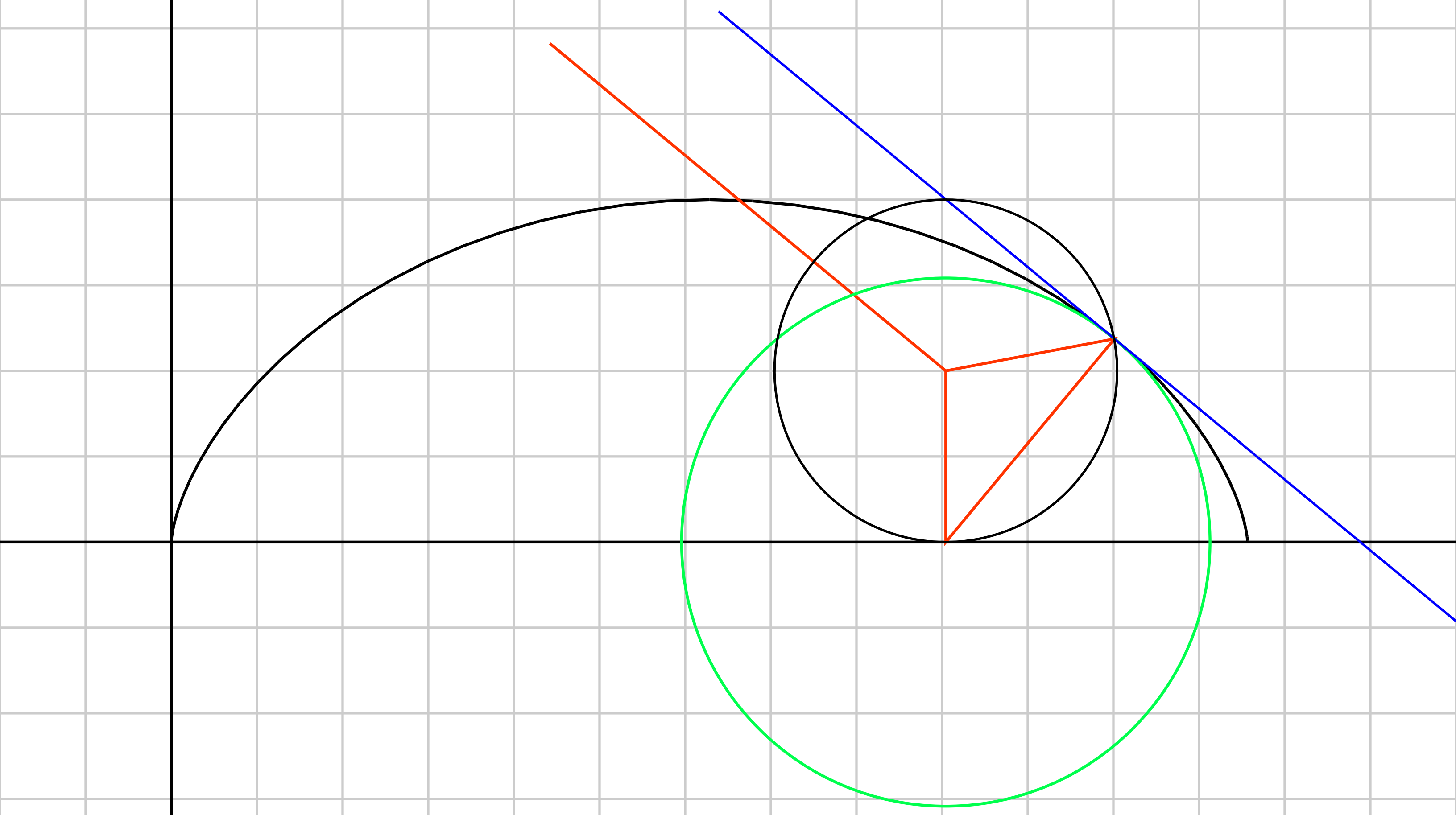

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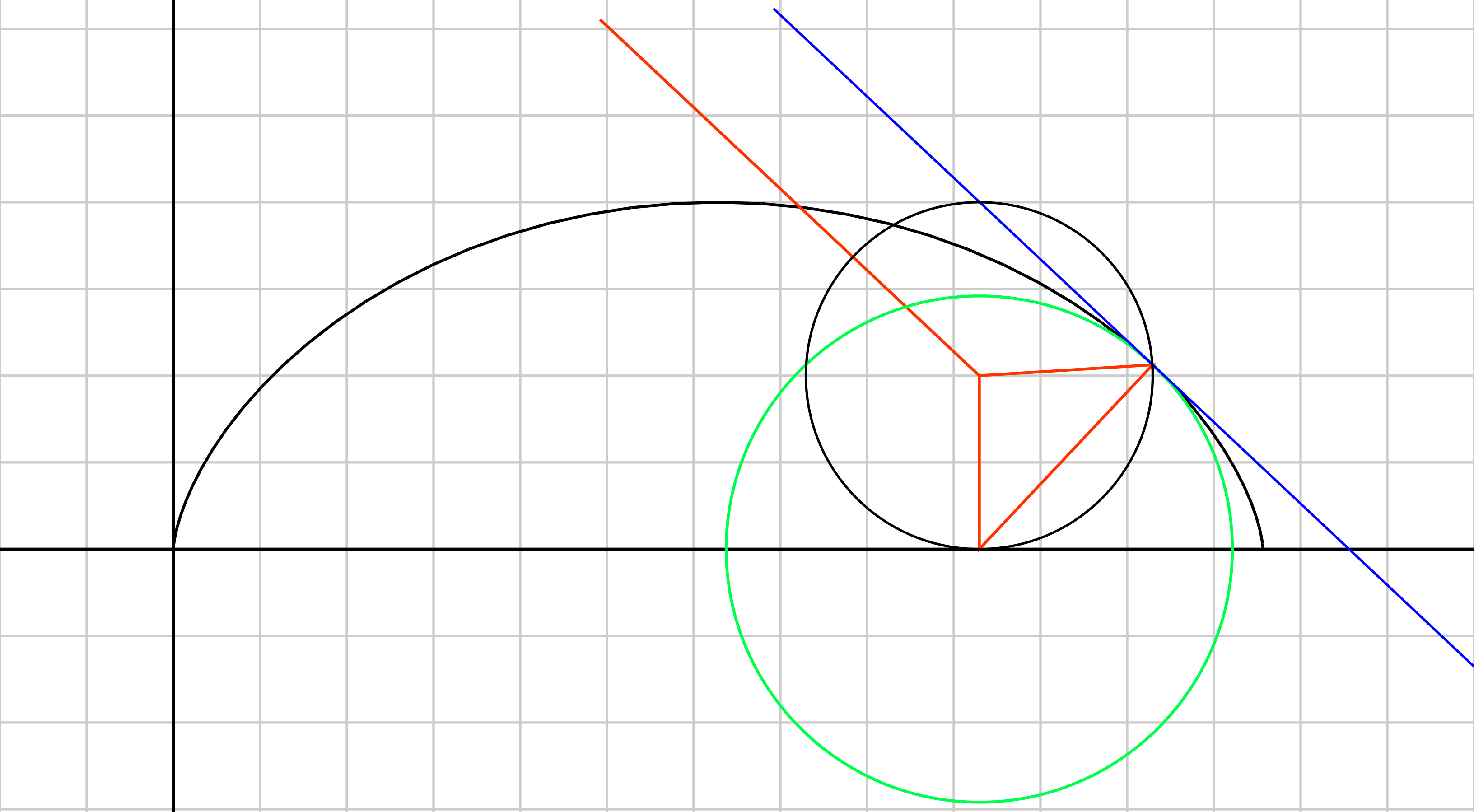

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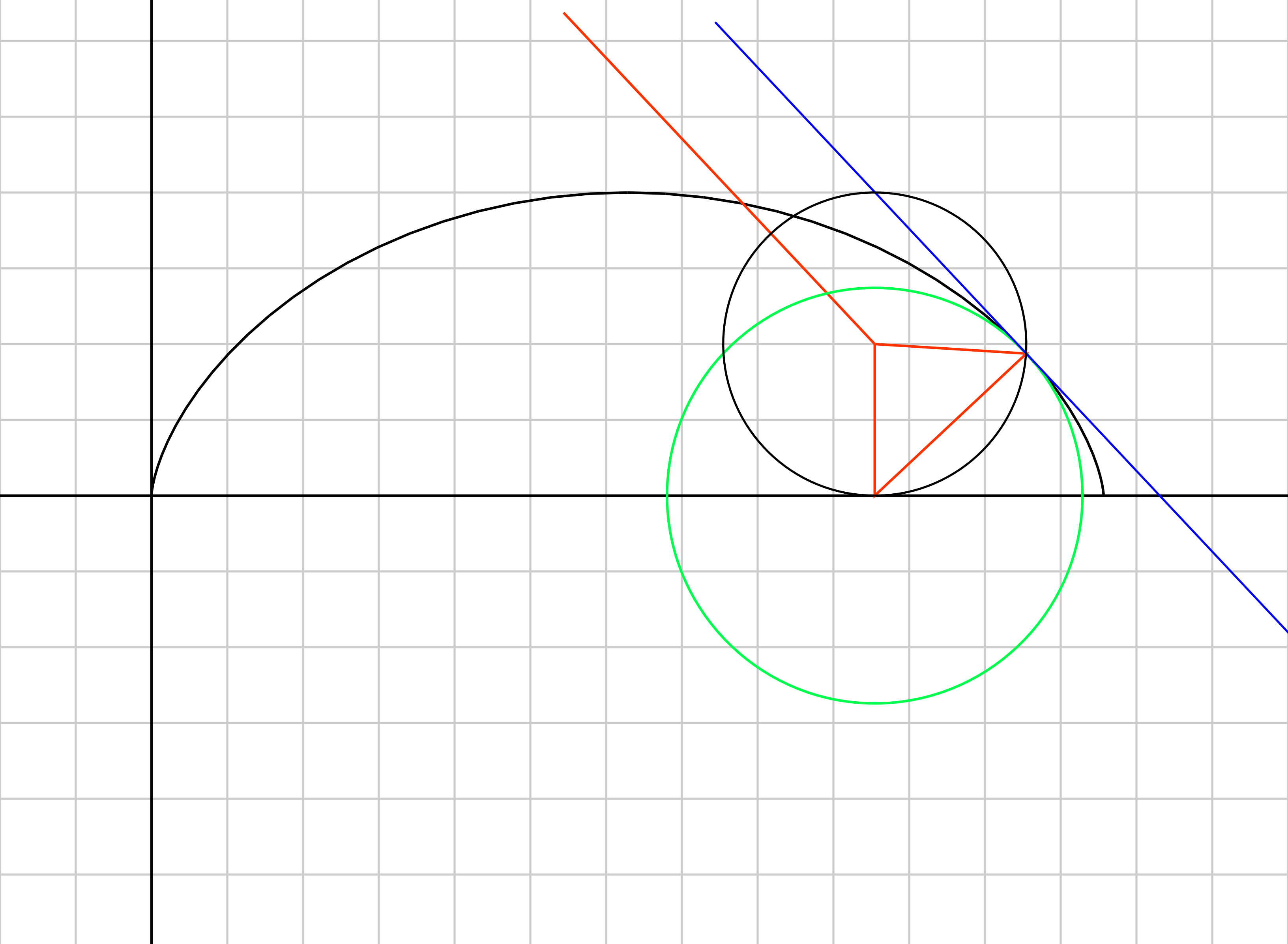

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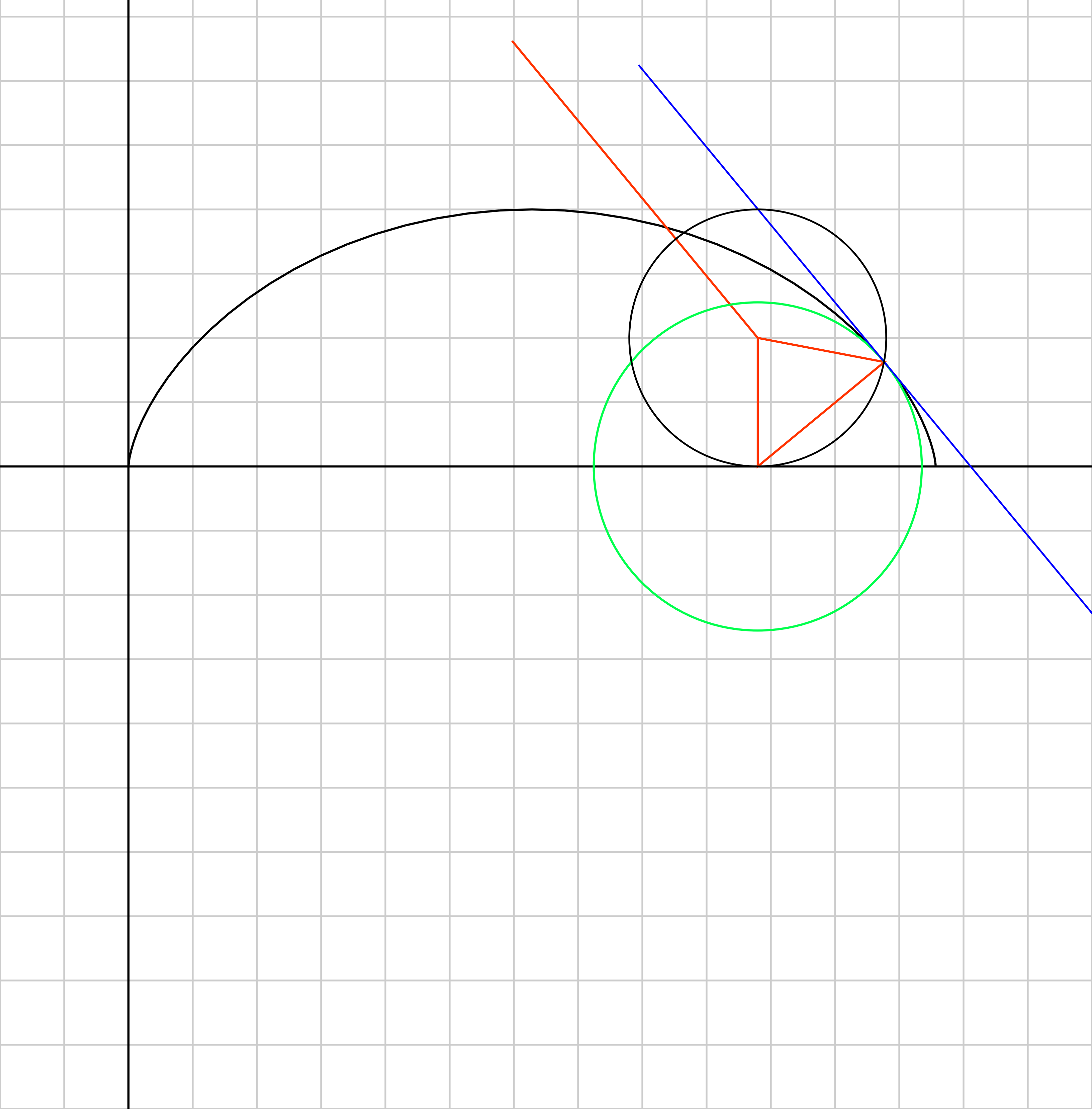

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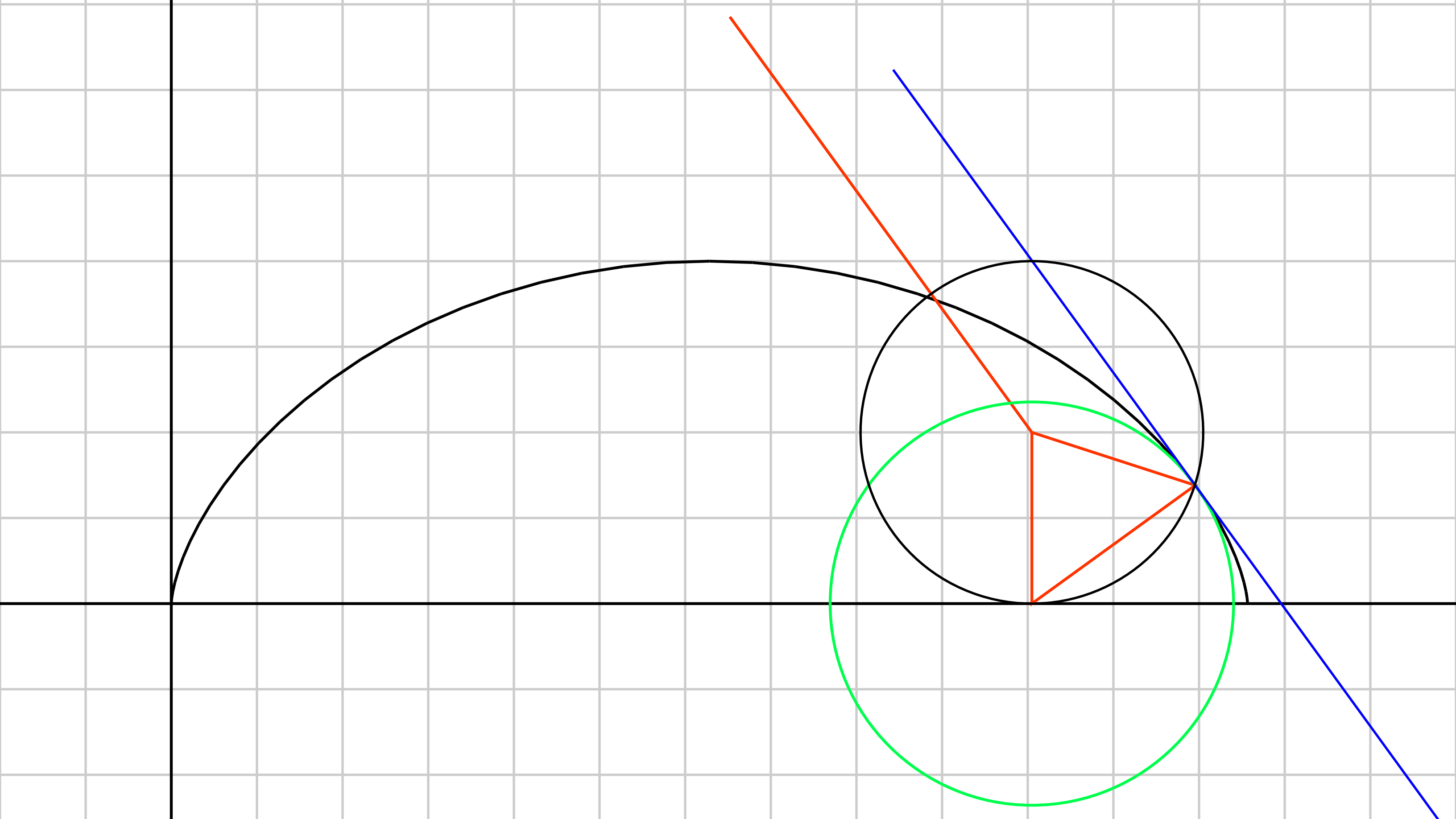

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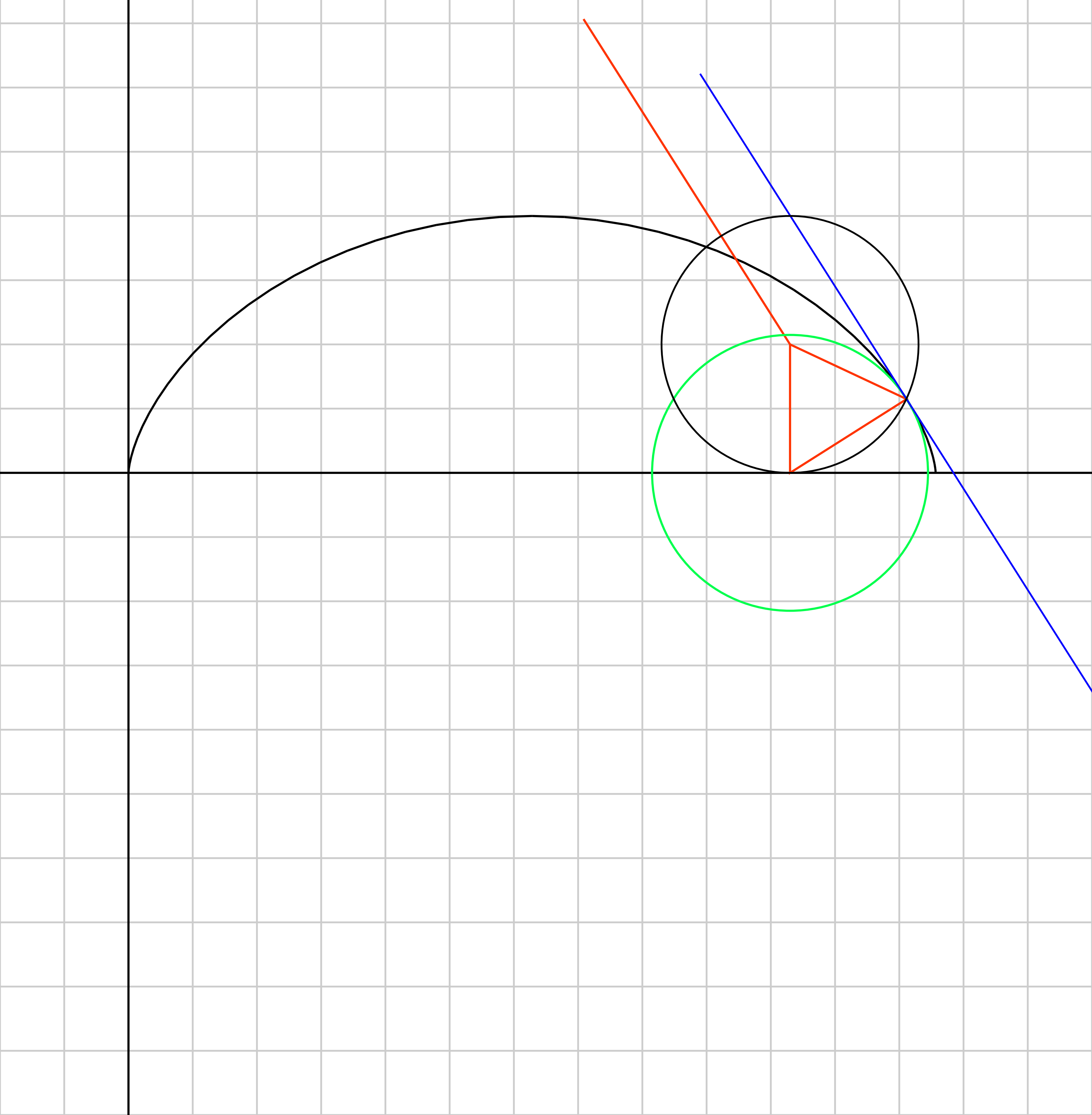

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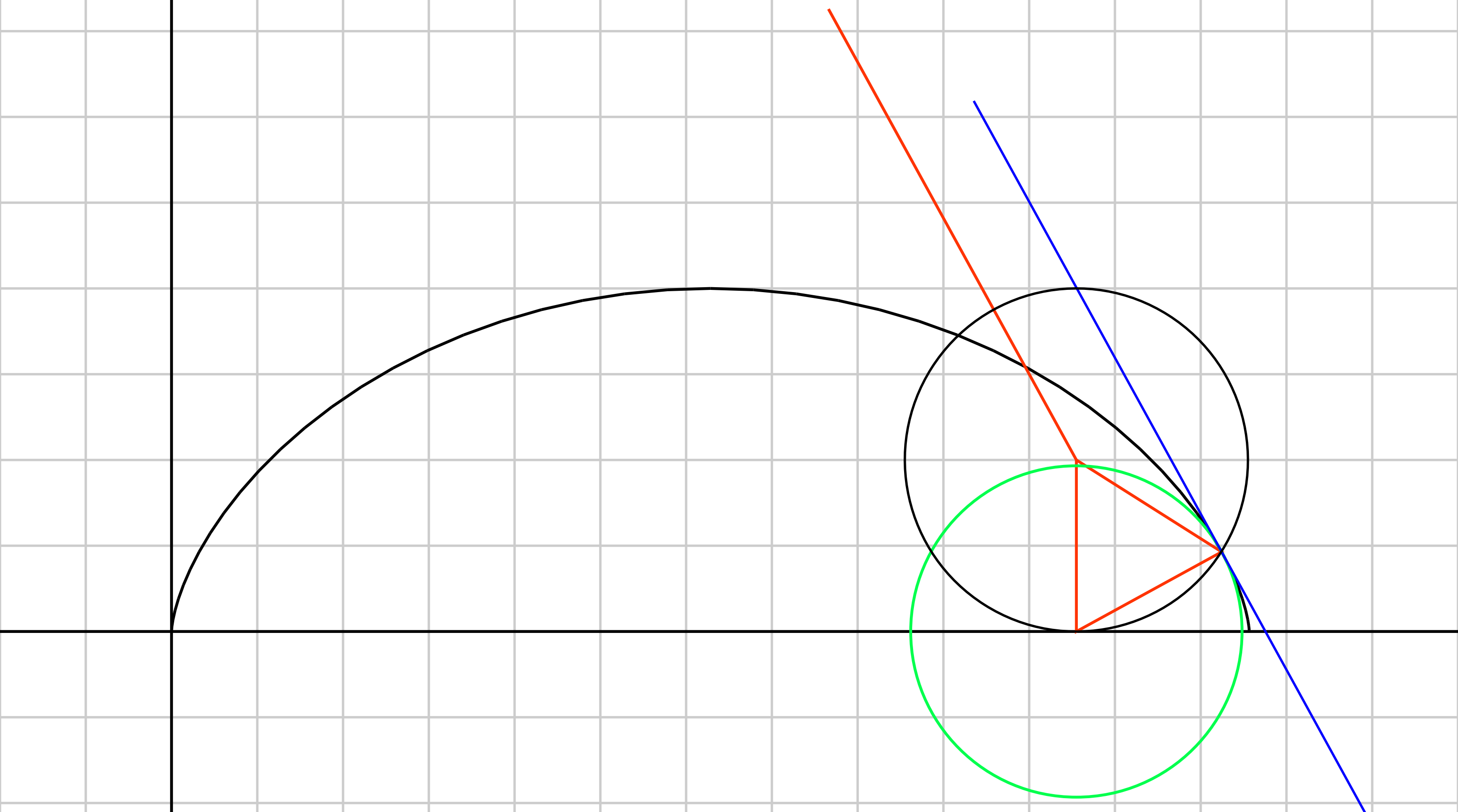

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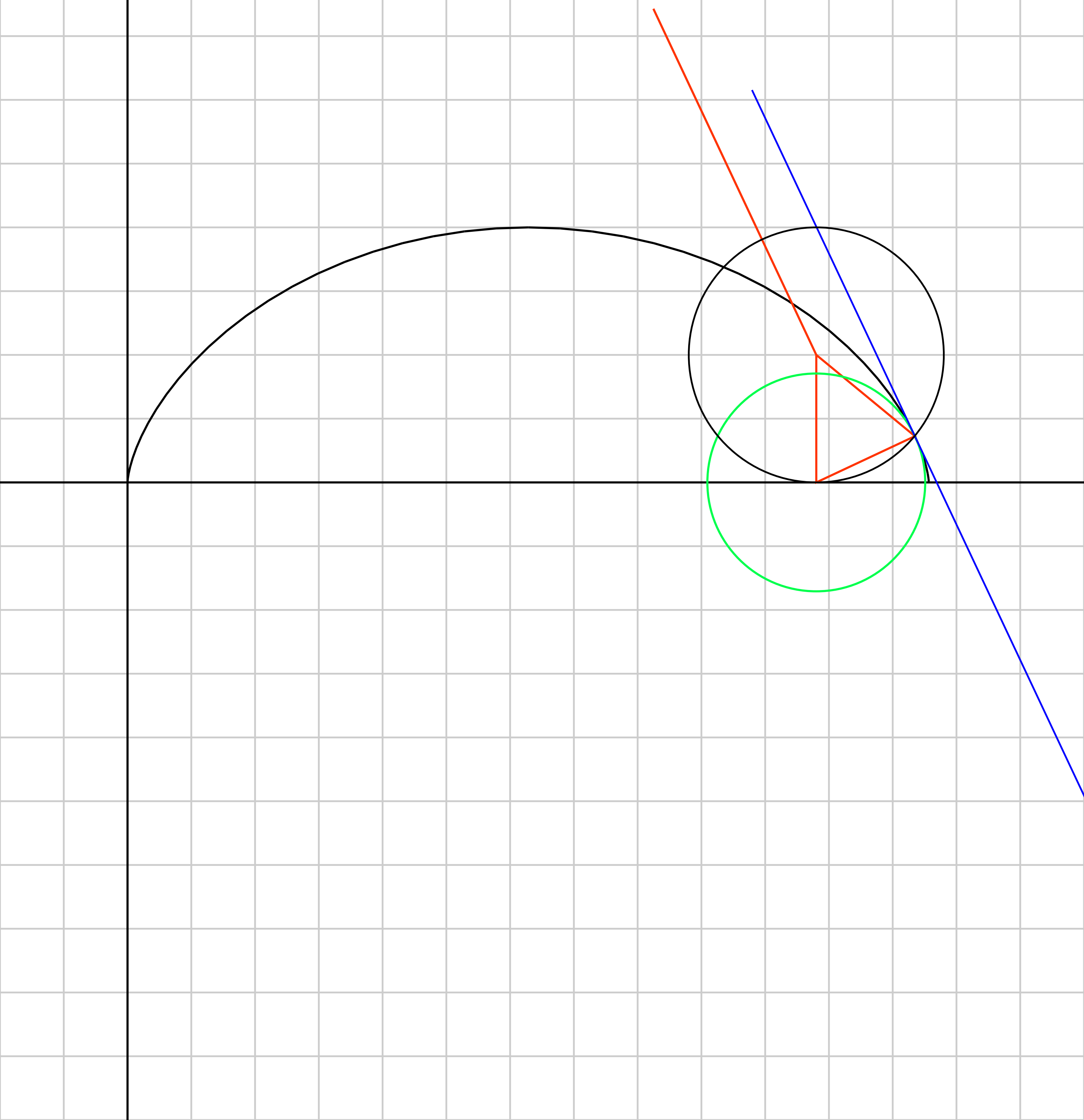

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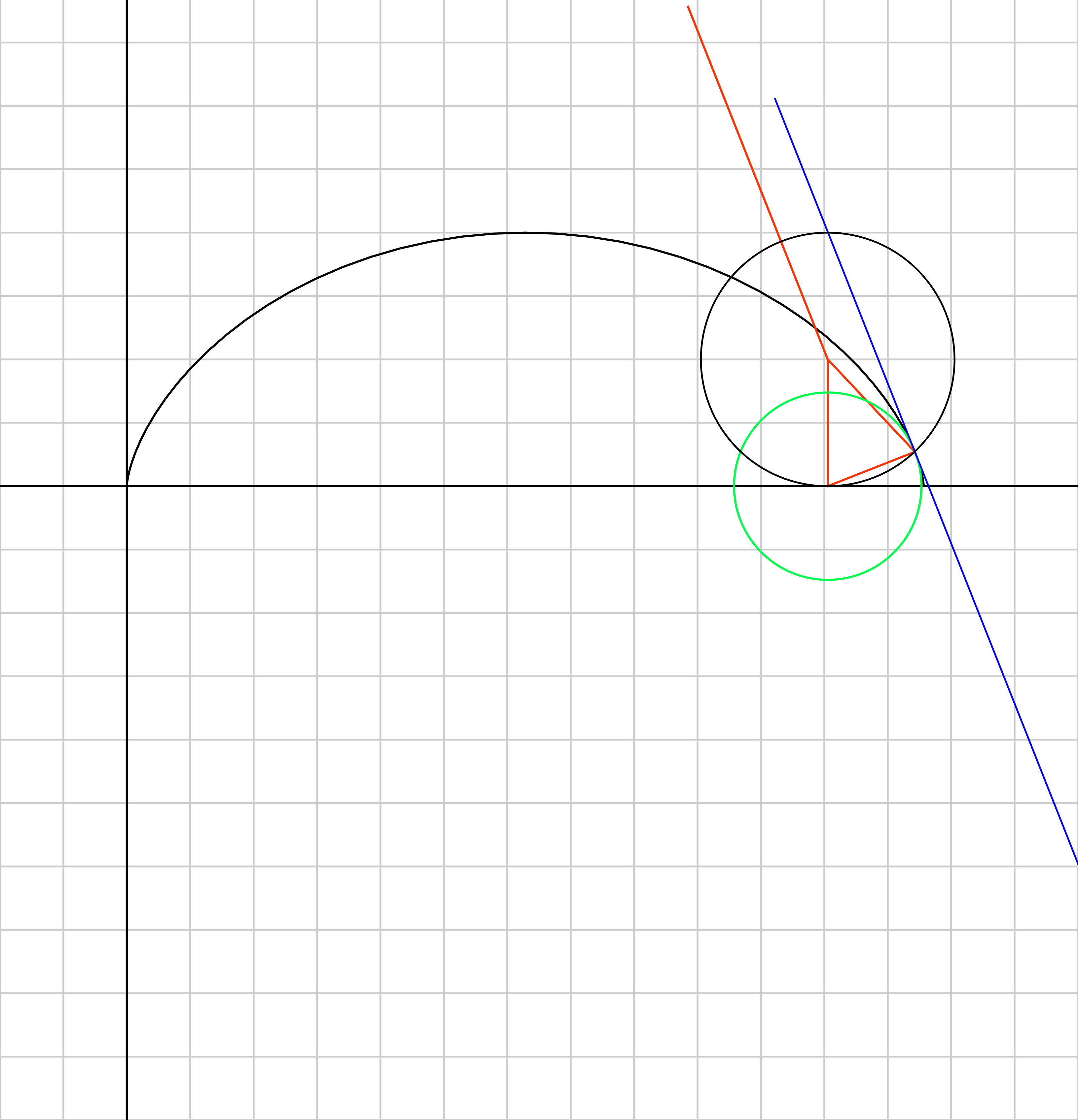

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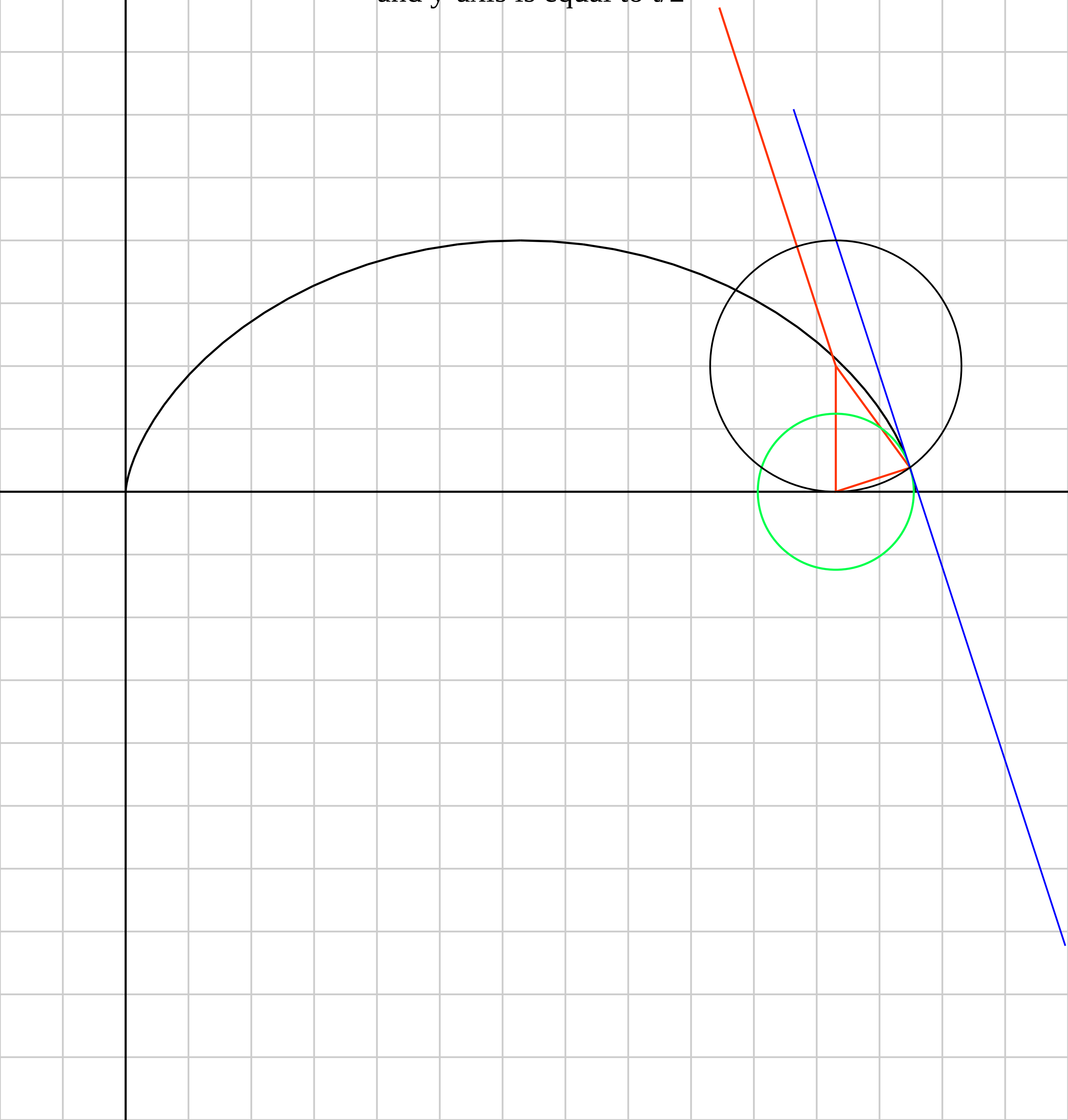

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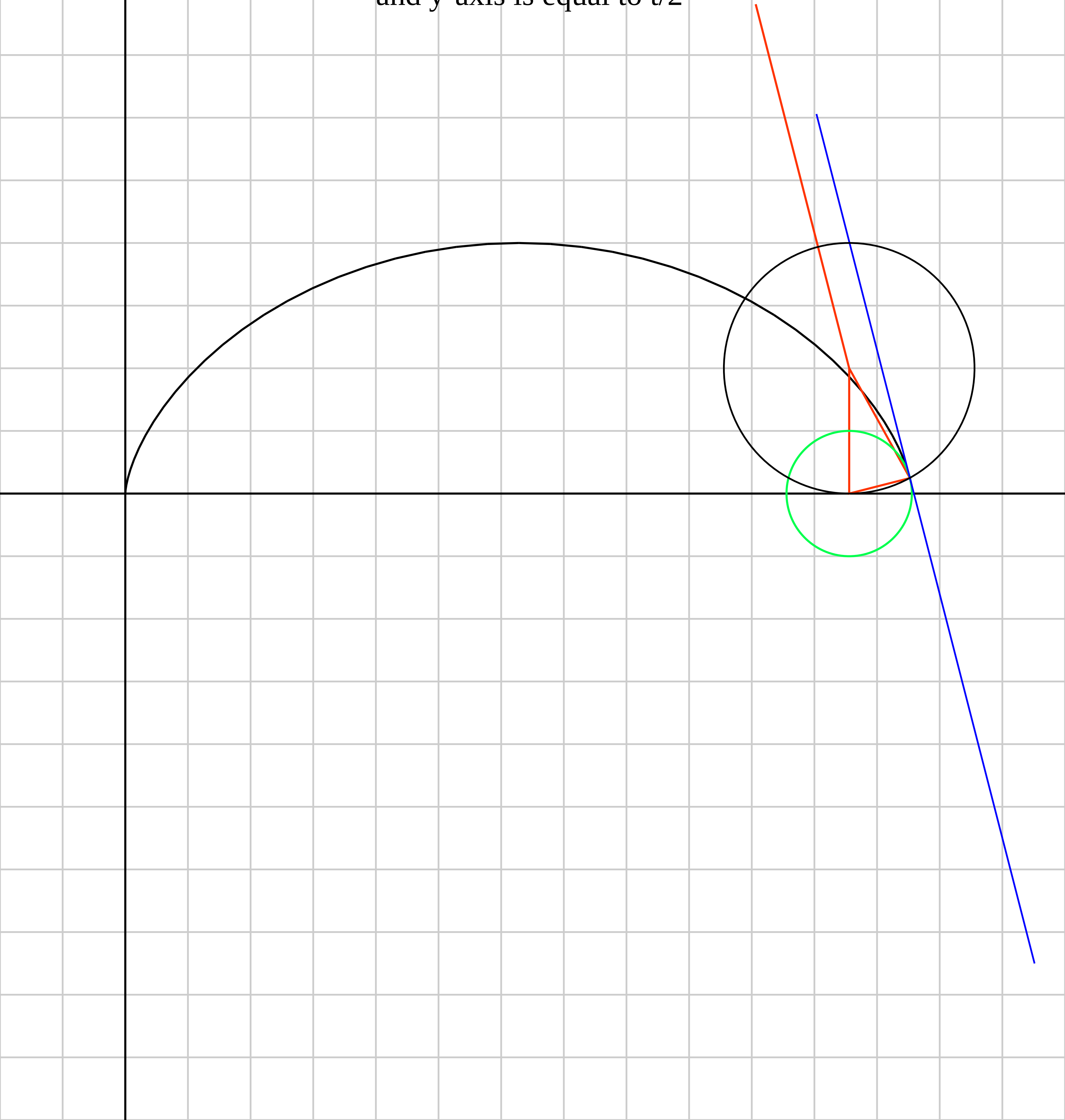

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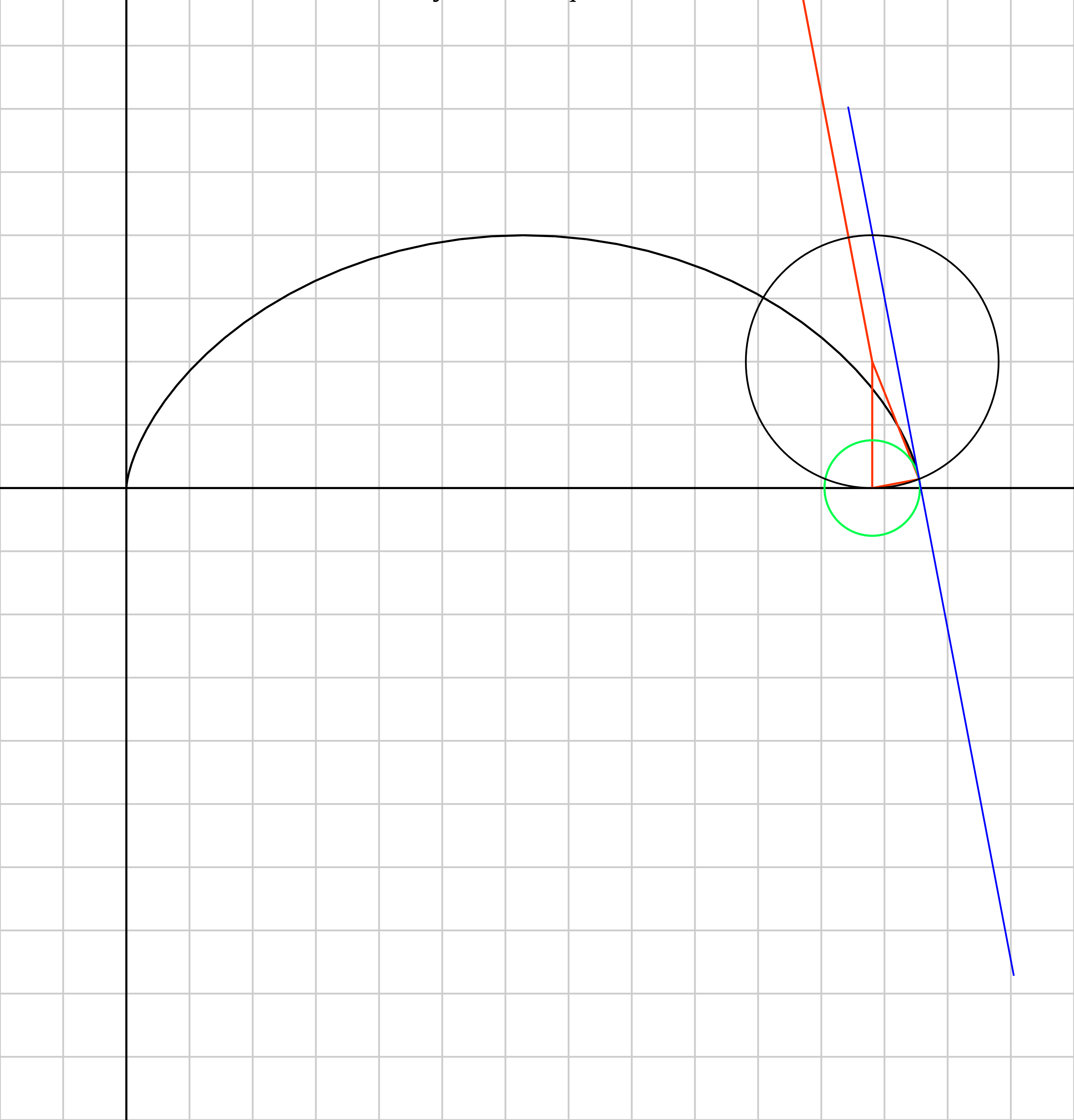

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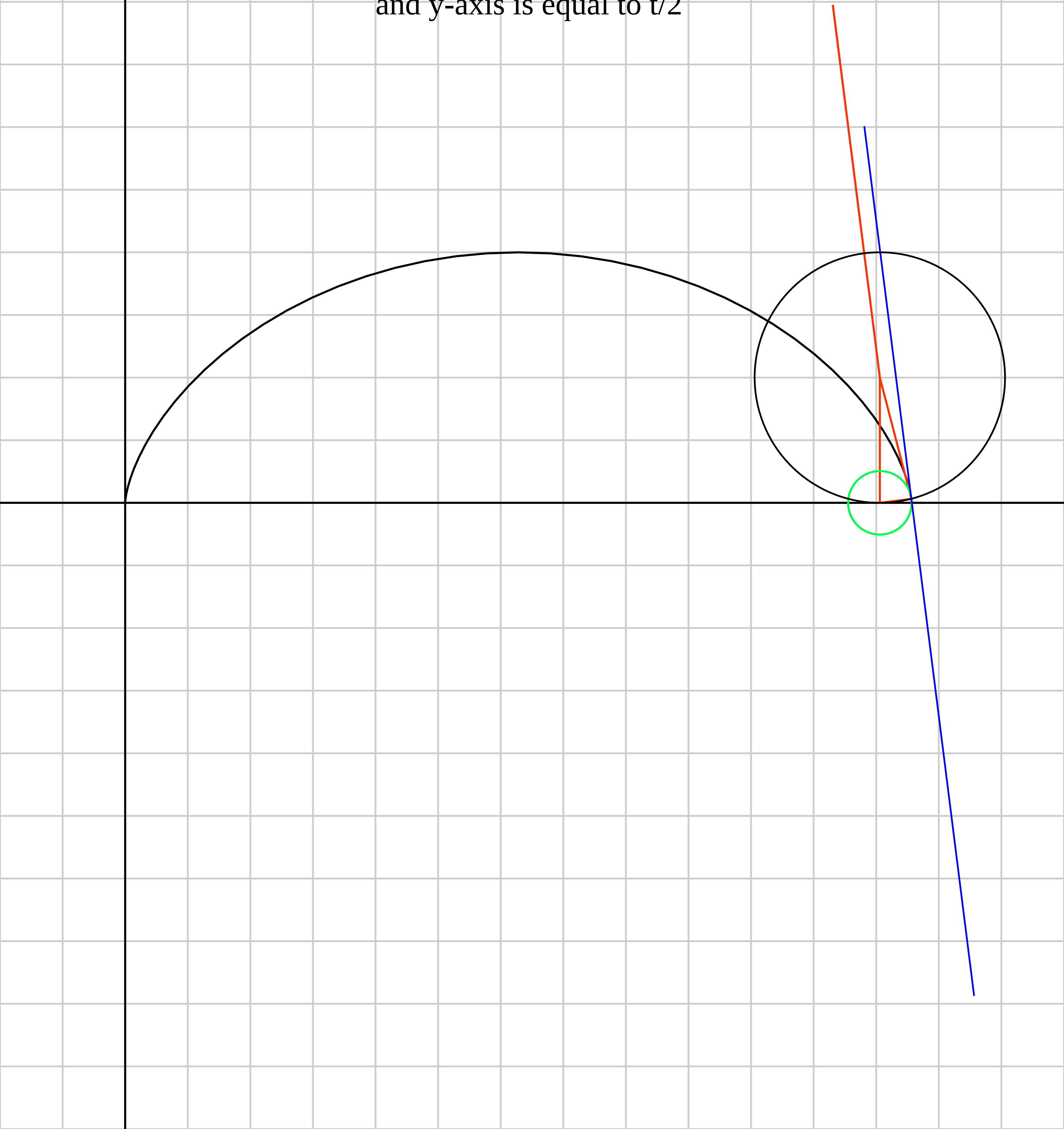

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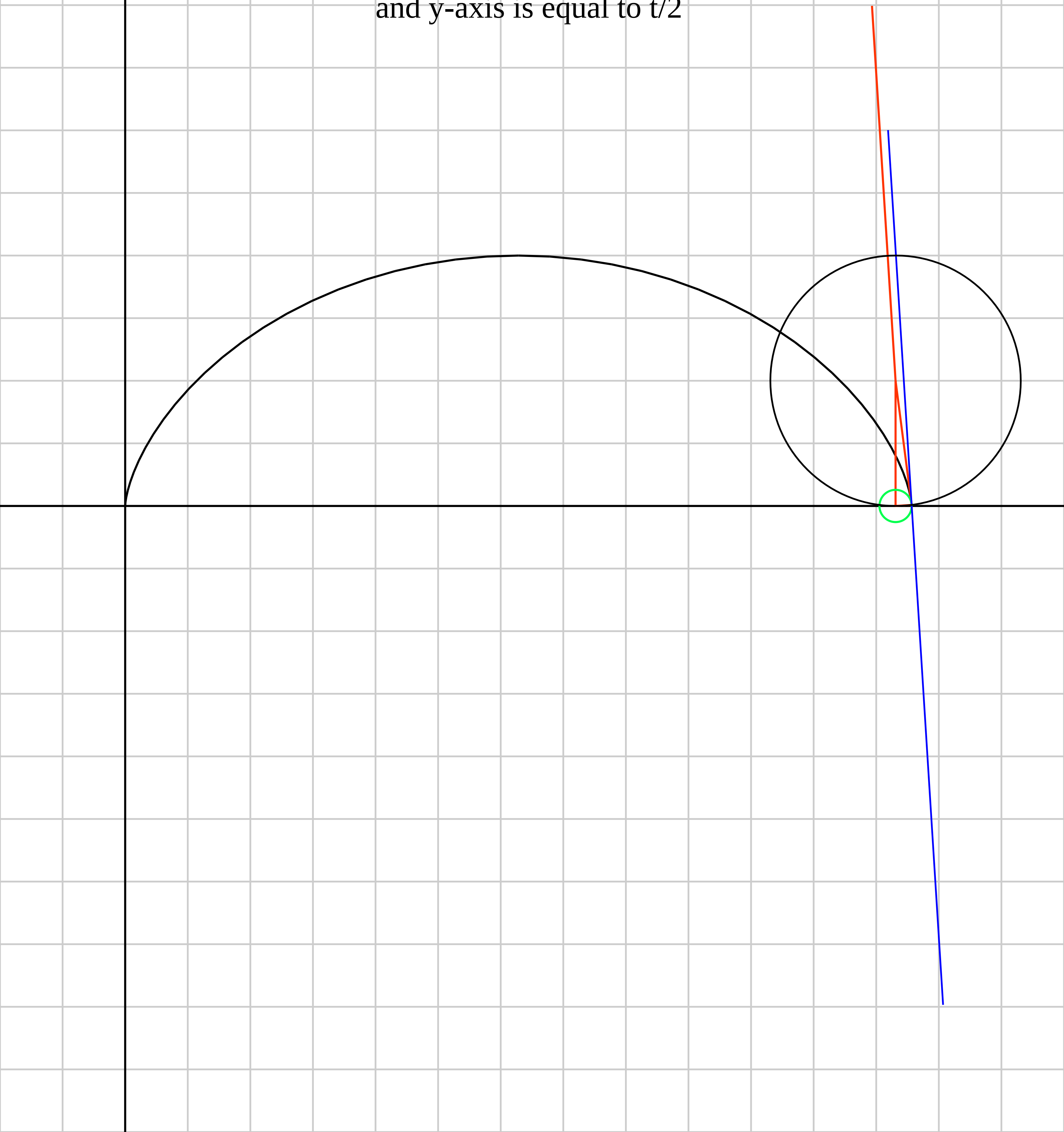

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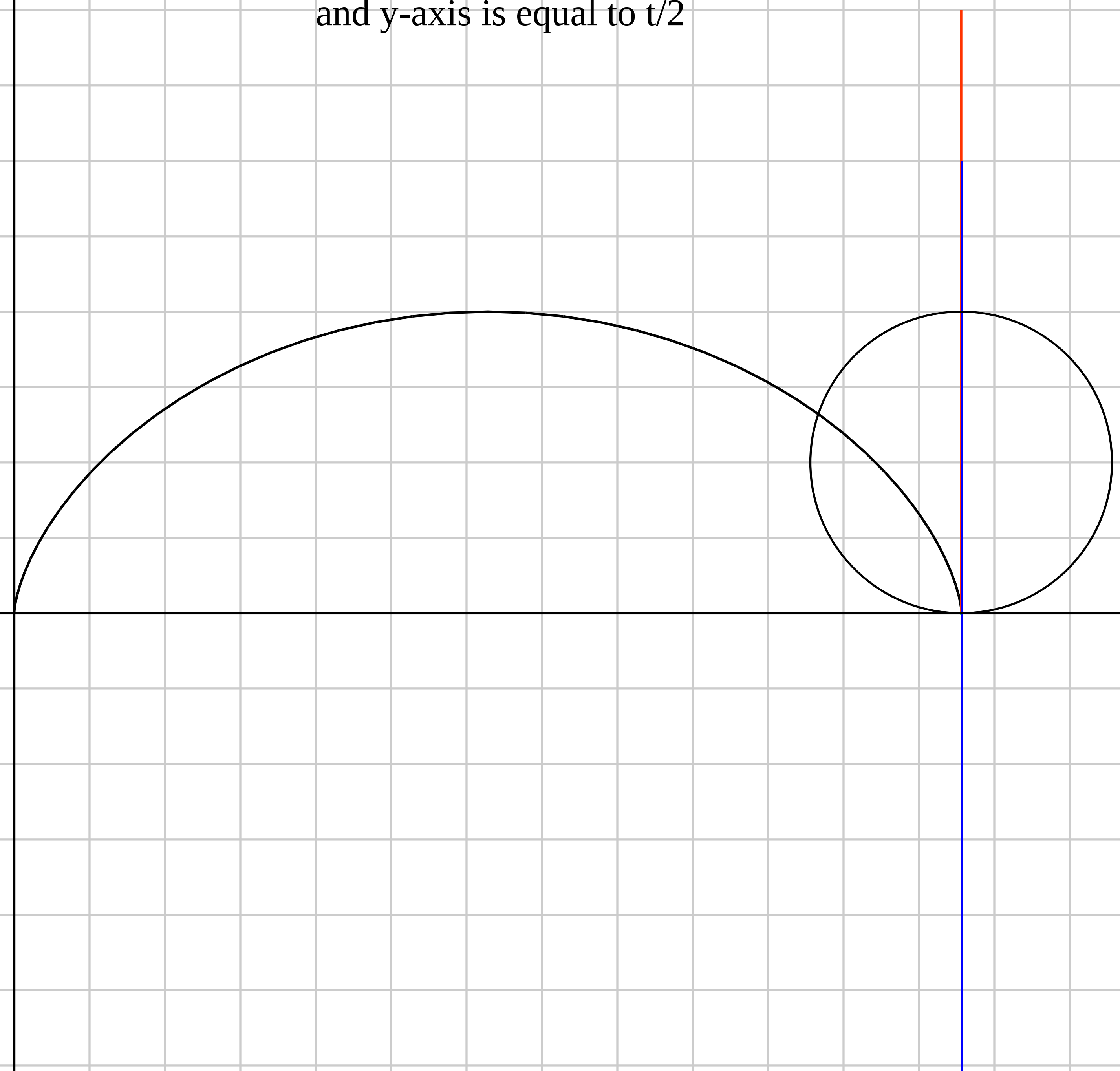
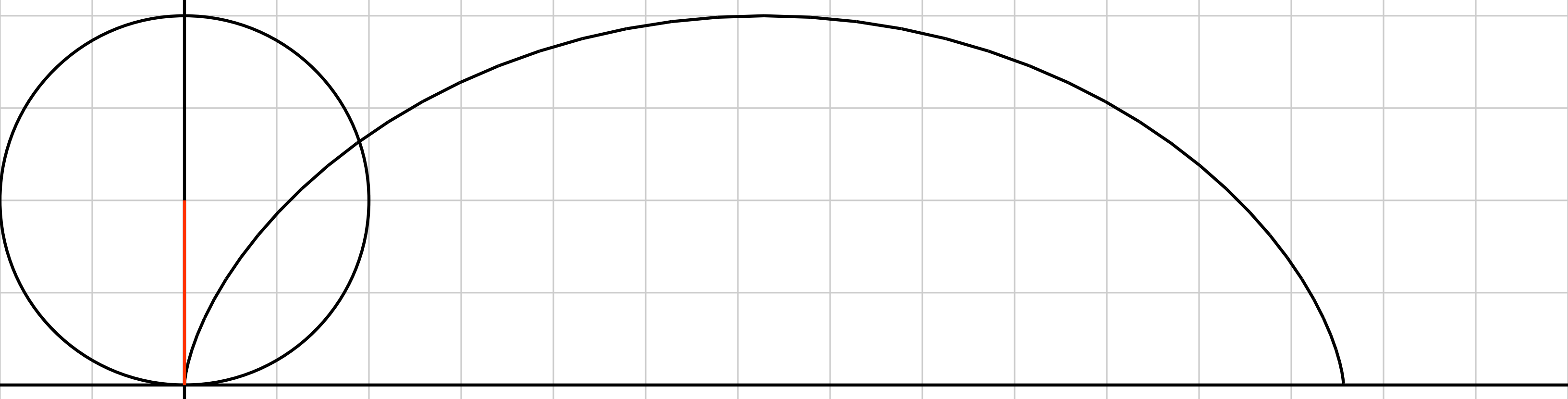


Prove that tangent line of cycloid is equal to t/2



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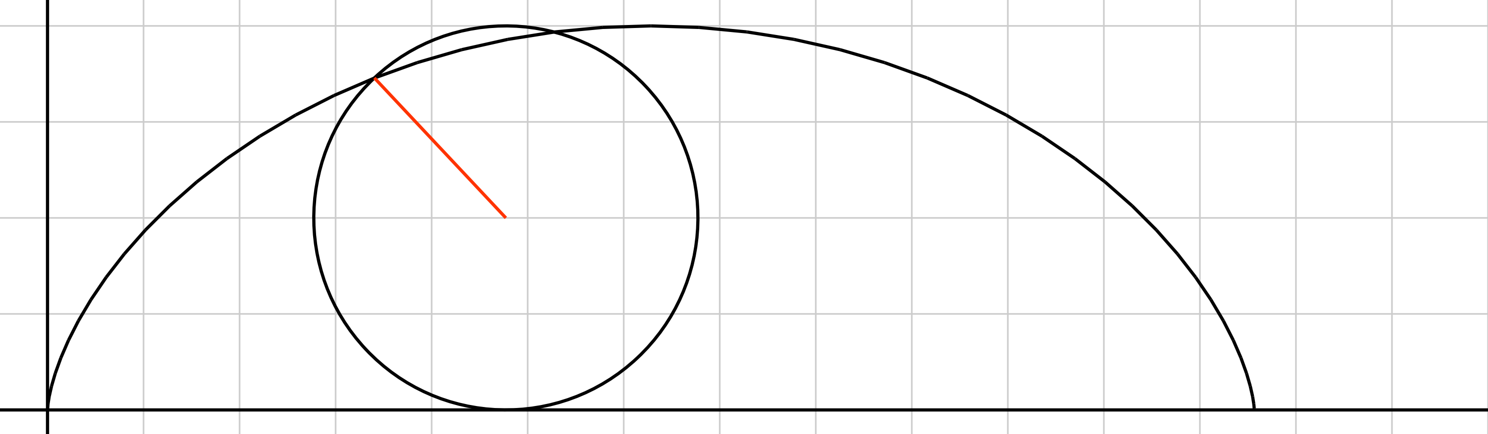

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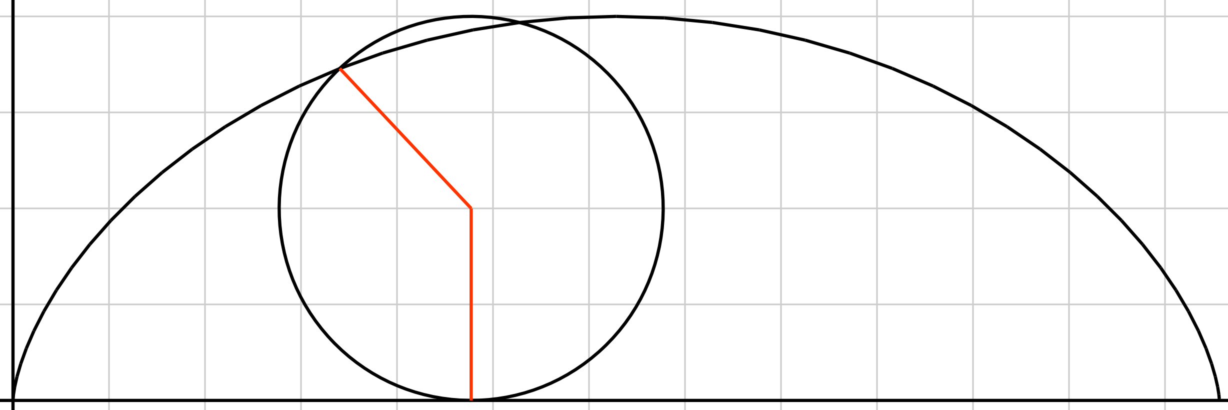

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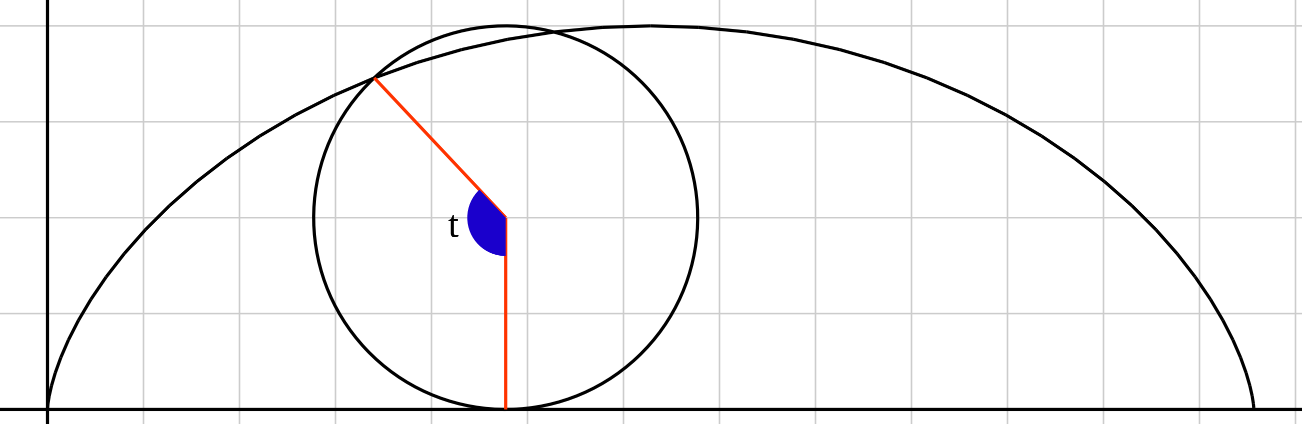

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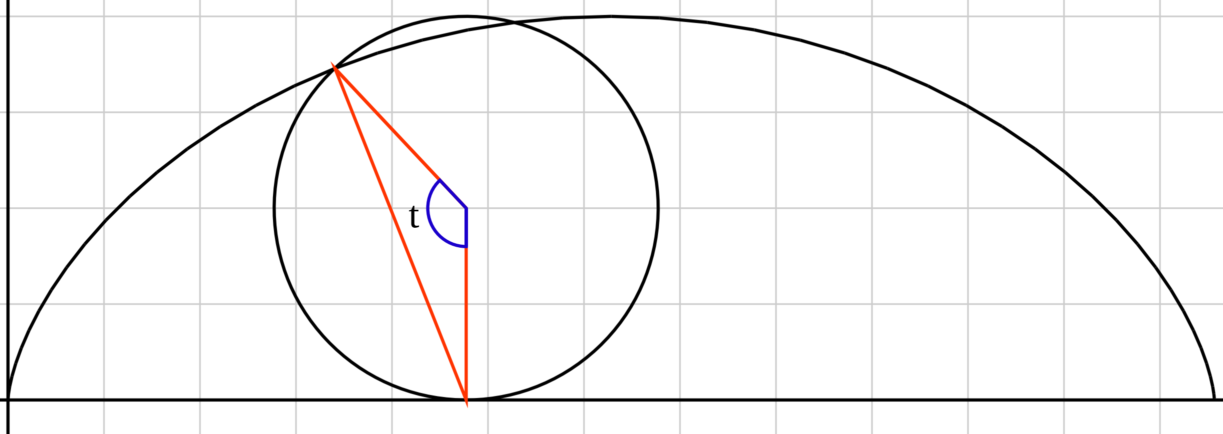

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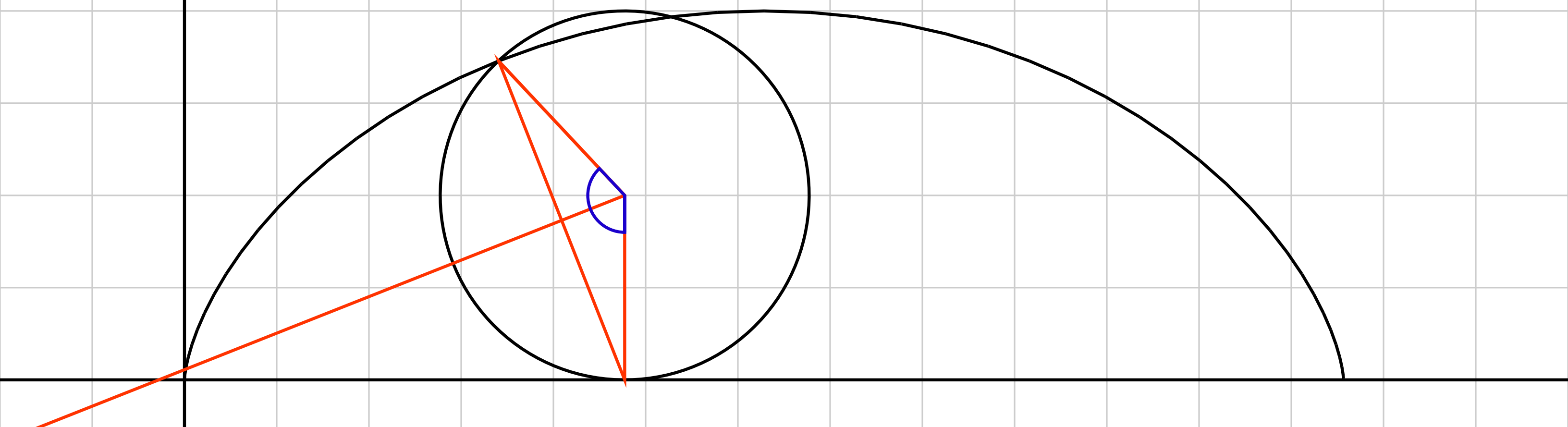

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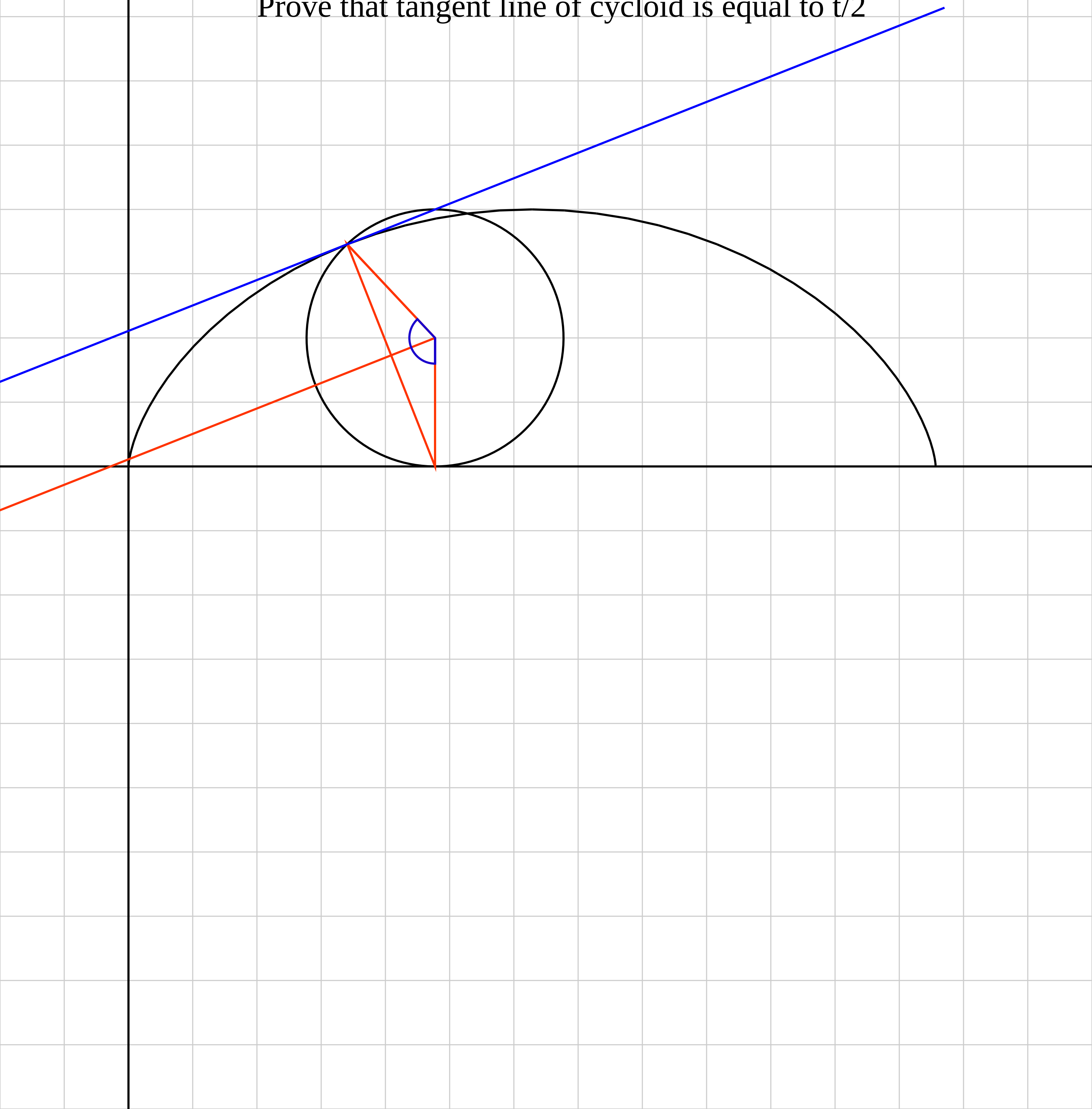

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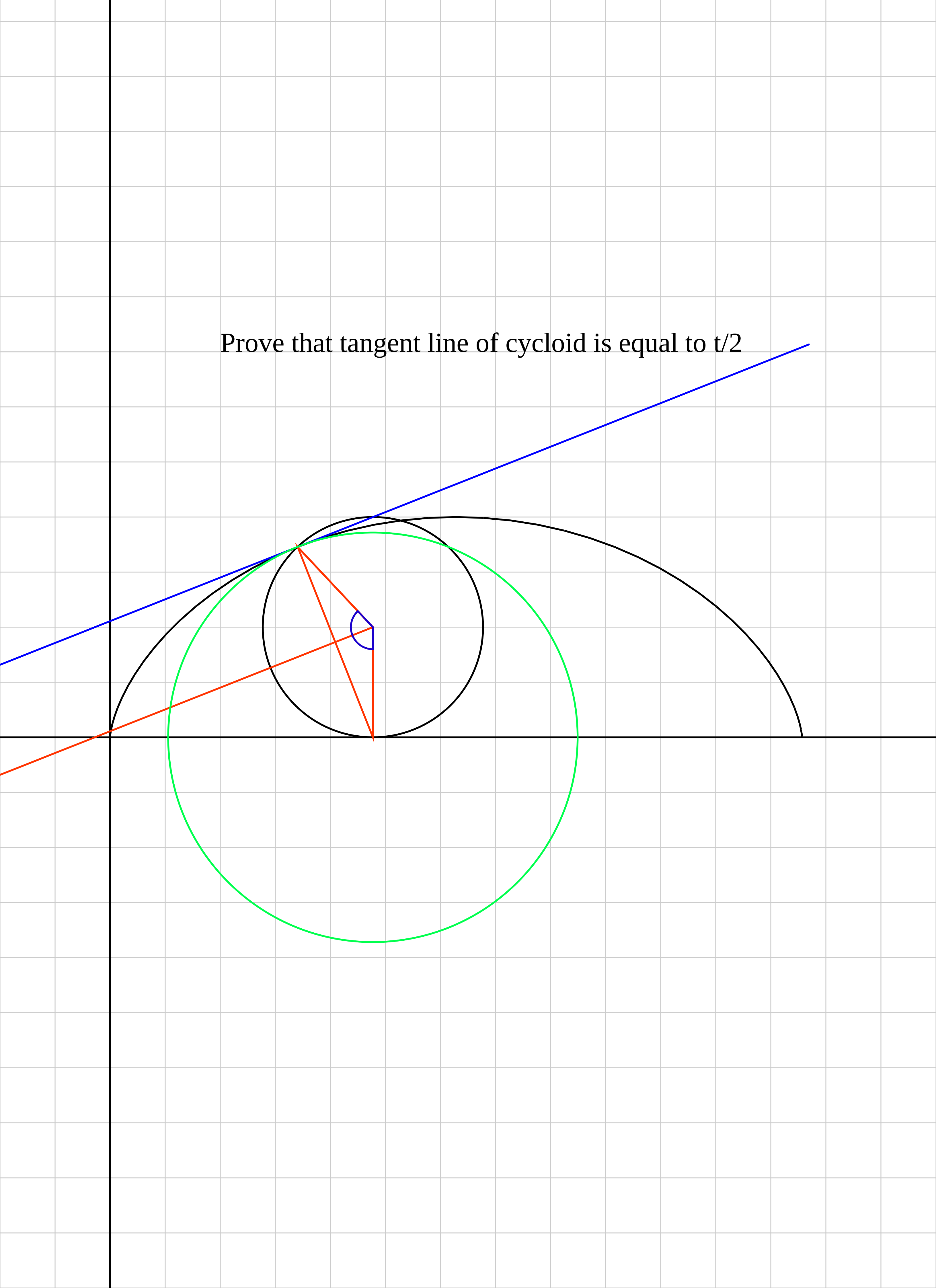

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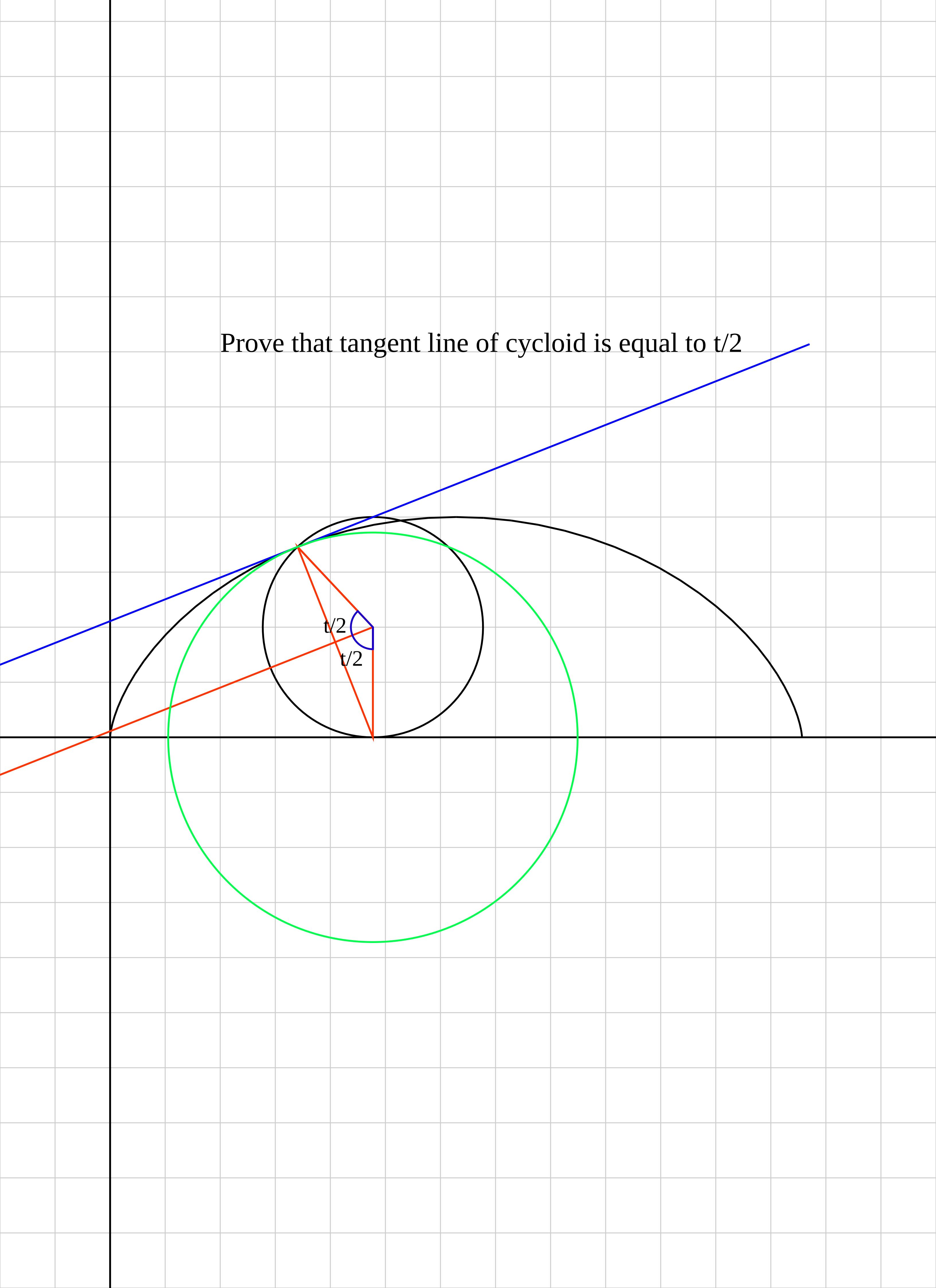

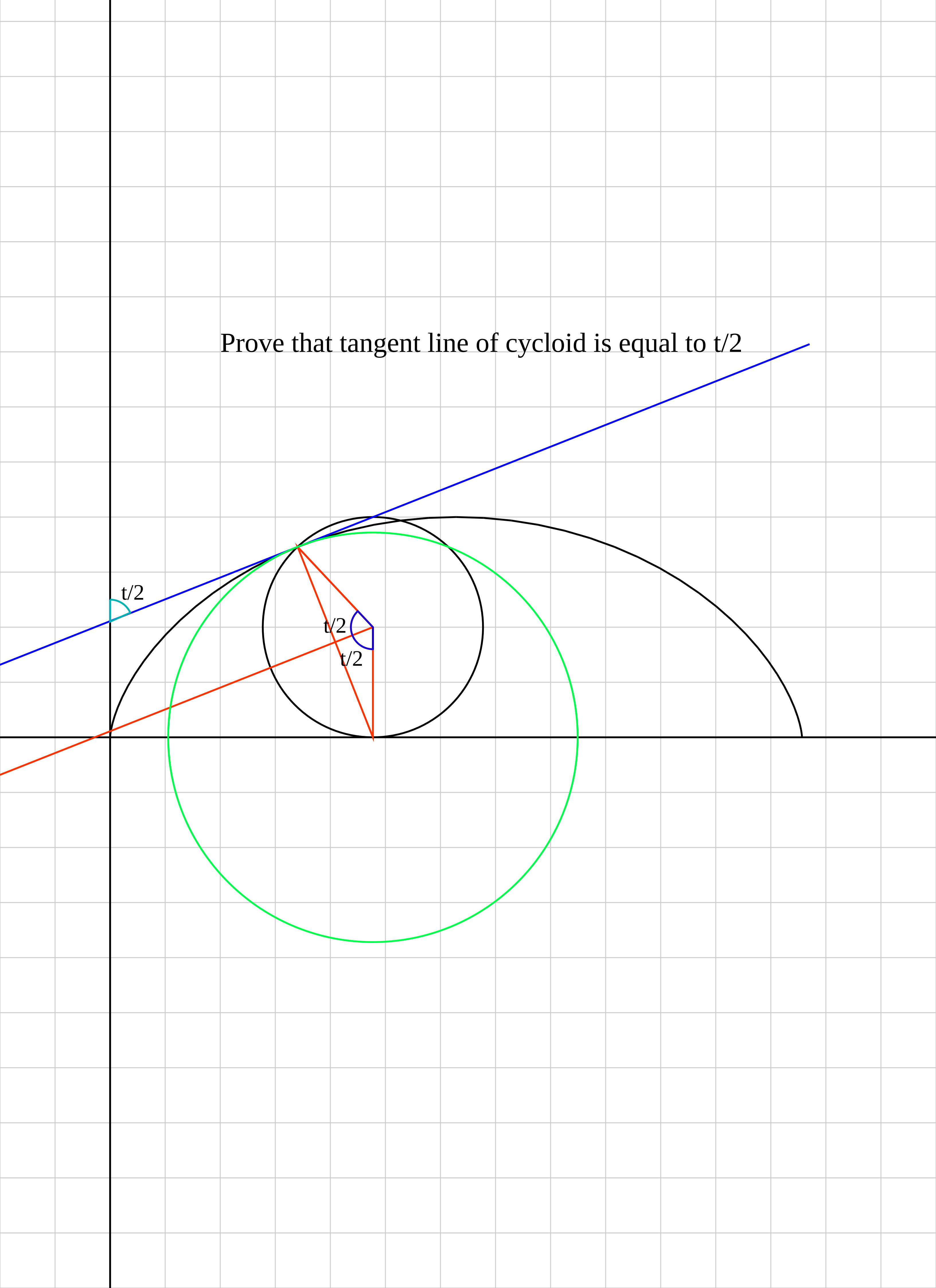
Prove that tangent line of cycloid is equal to t/2
t/2
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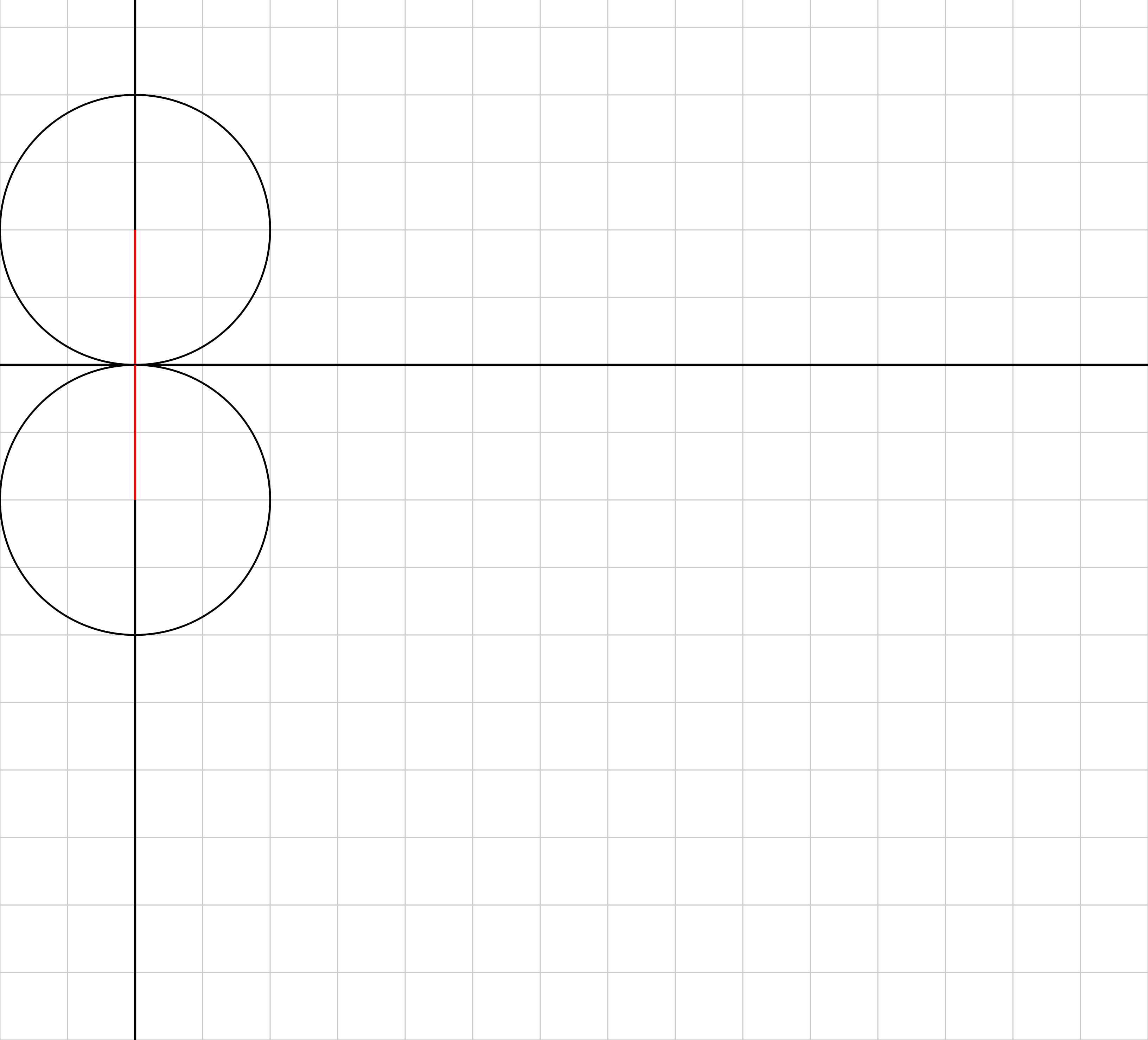
Cycloid:
Evolute Curve



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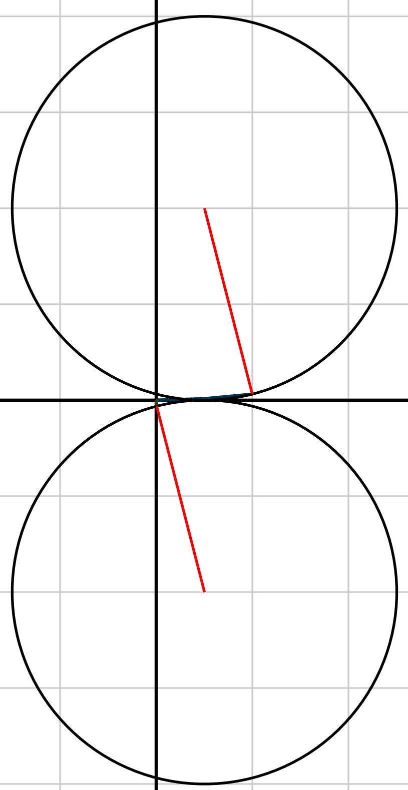

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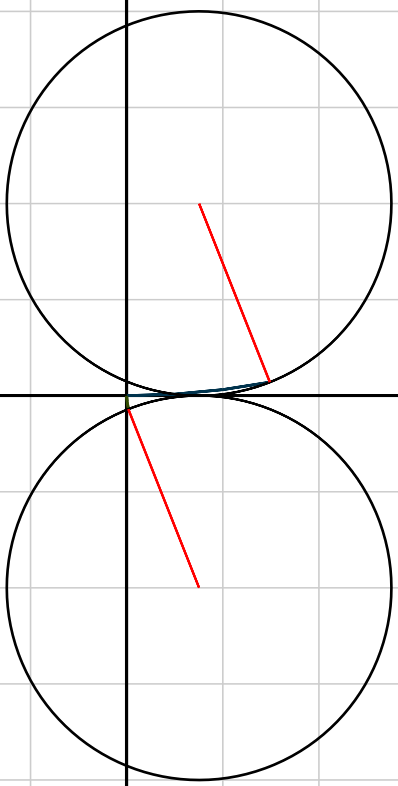

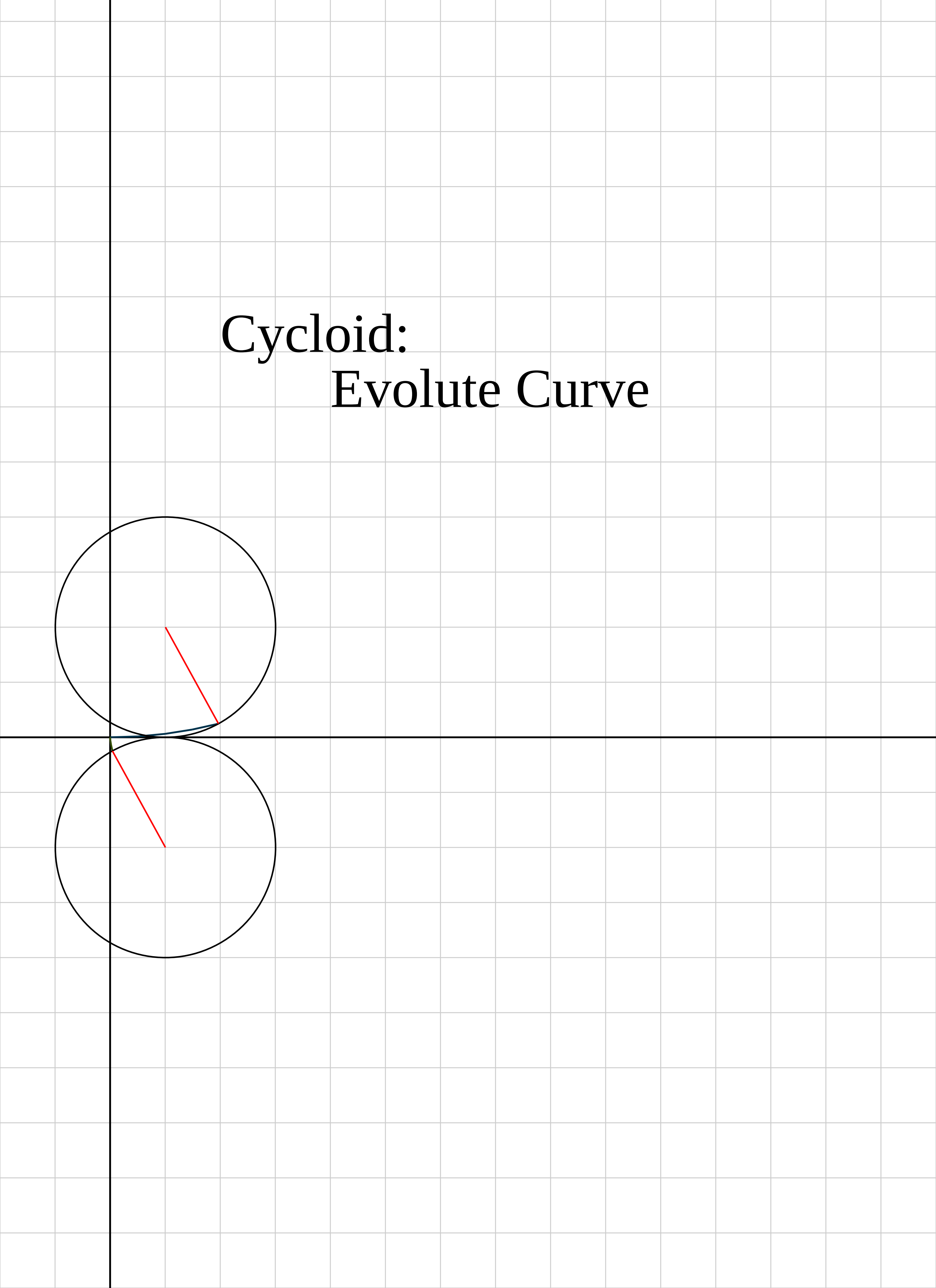
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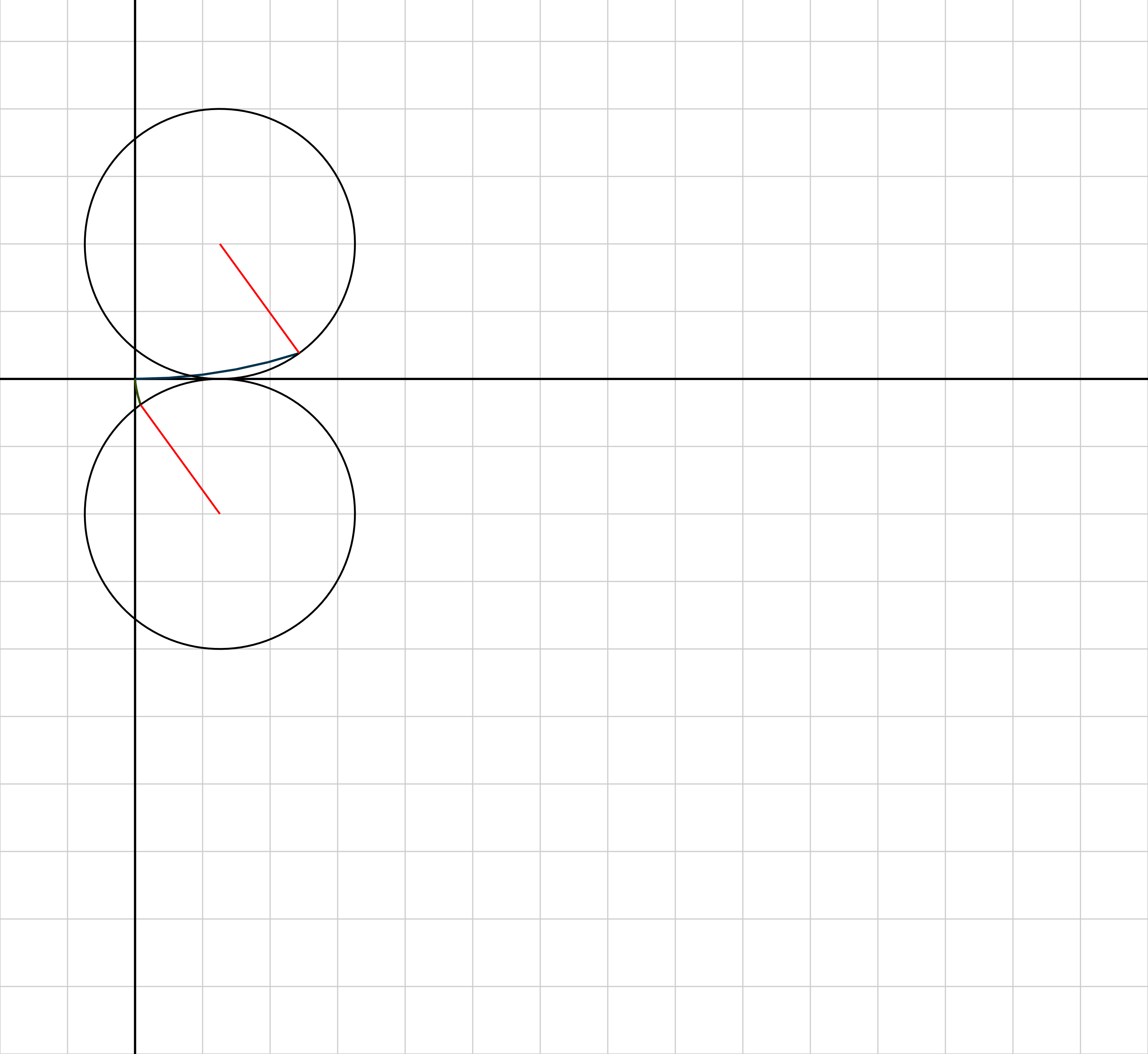

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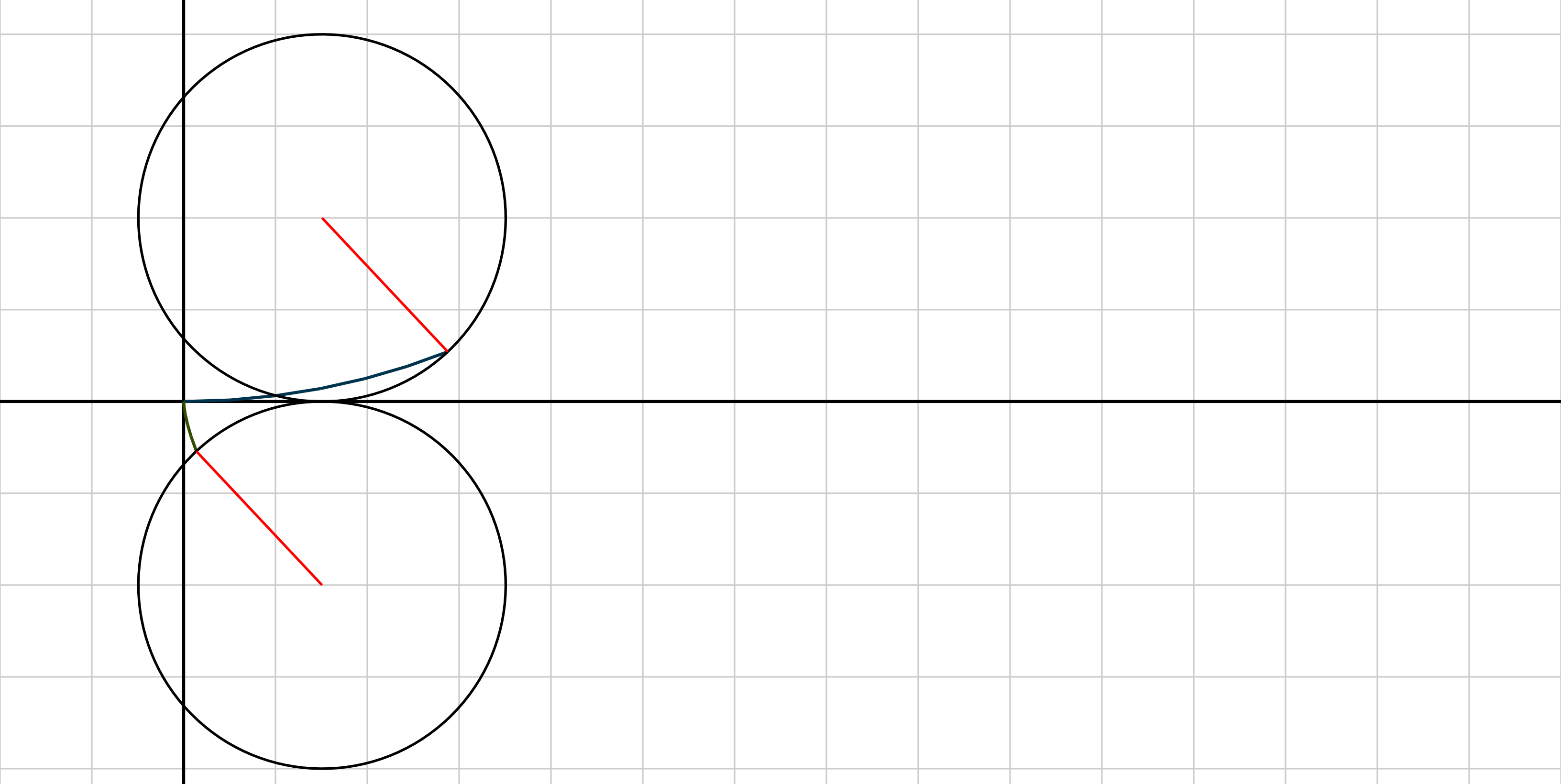

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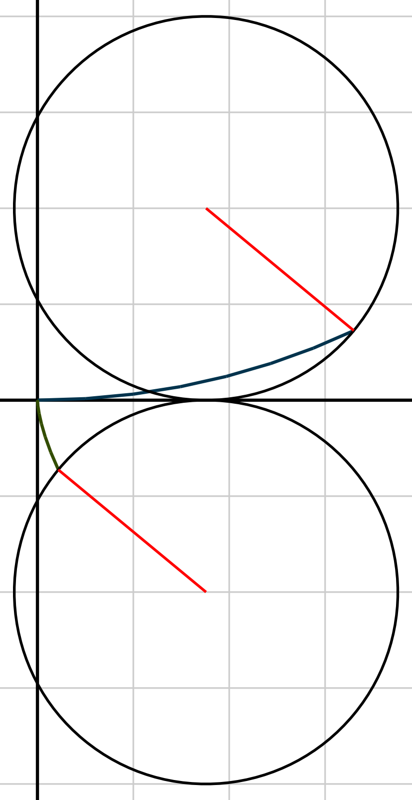

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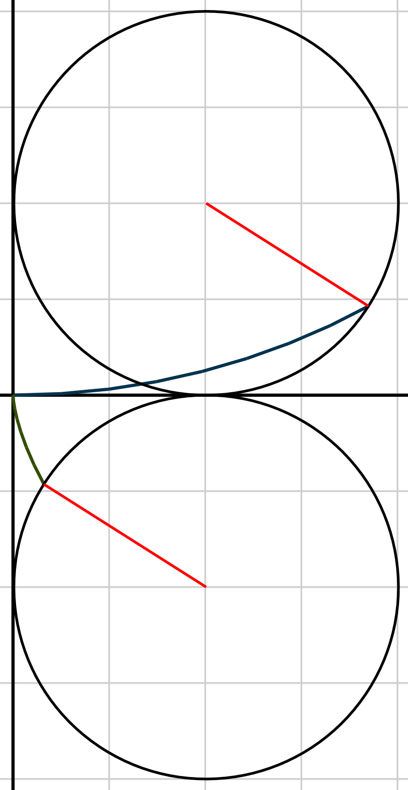

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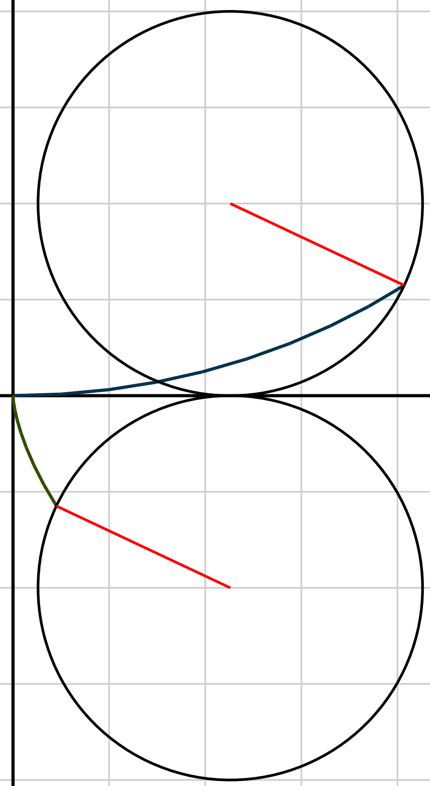

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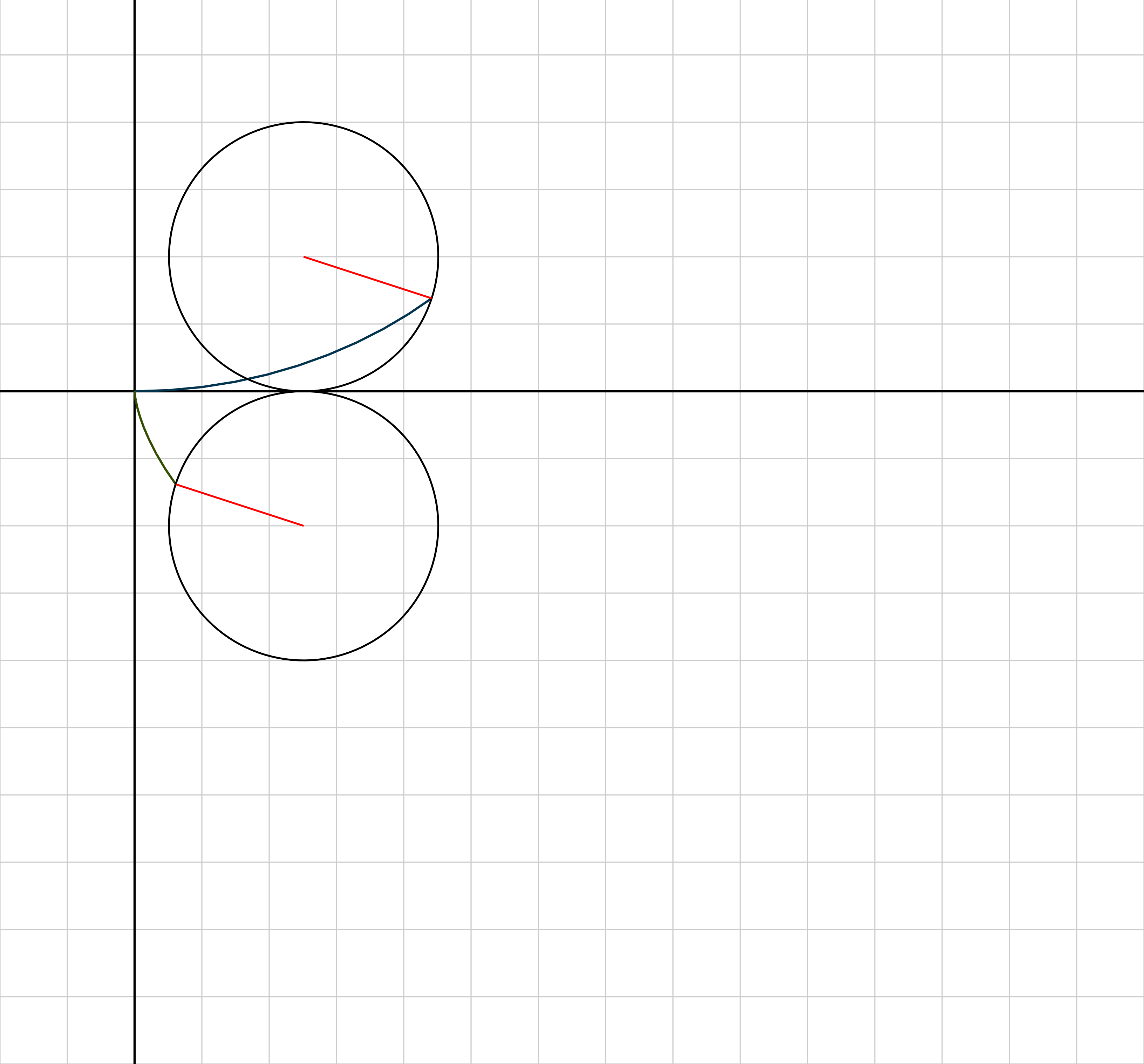

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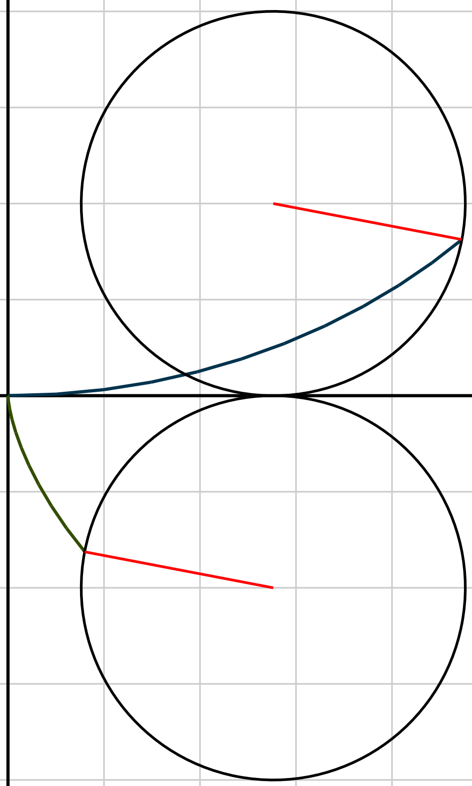

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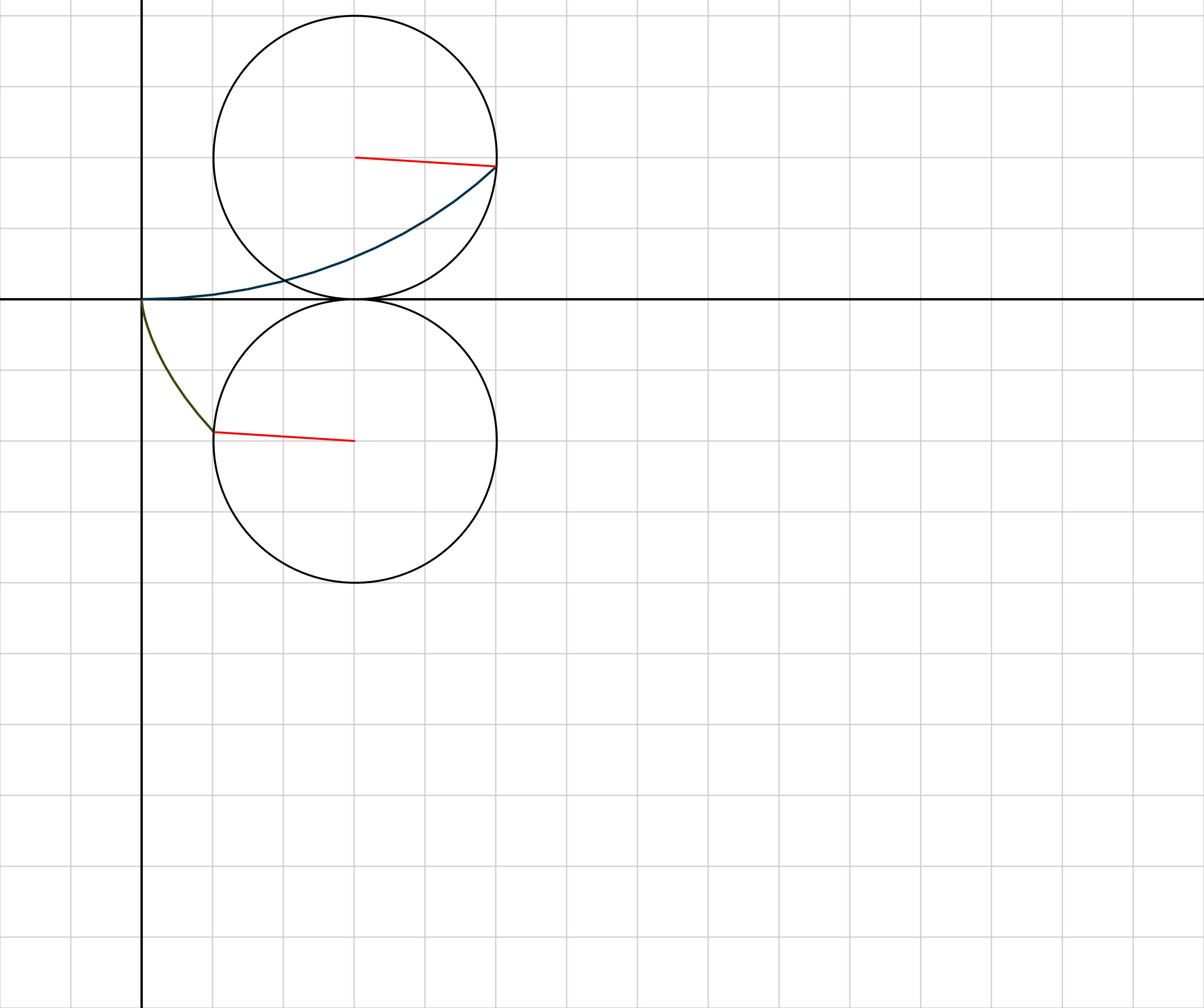

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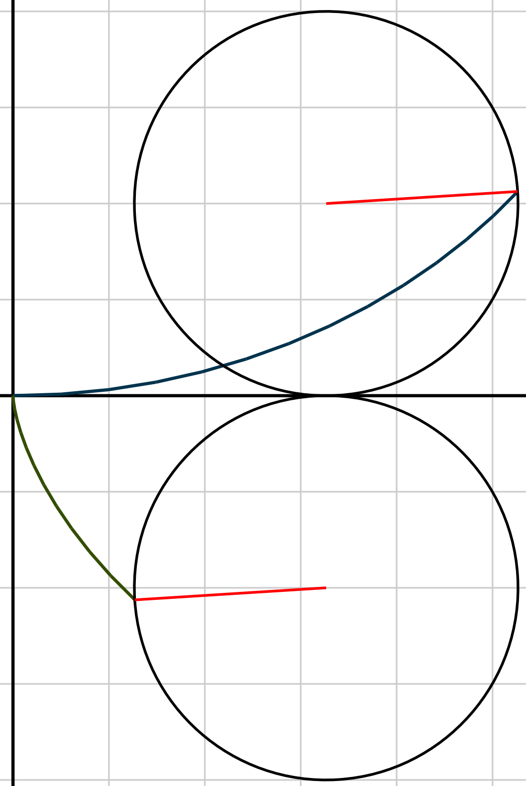

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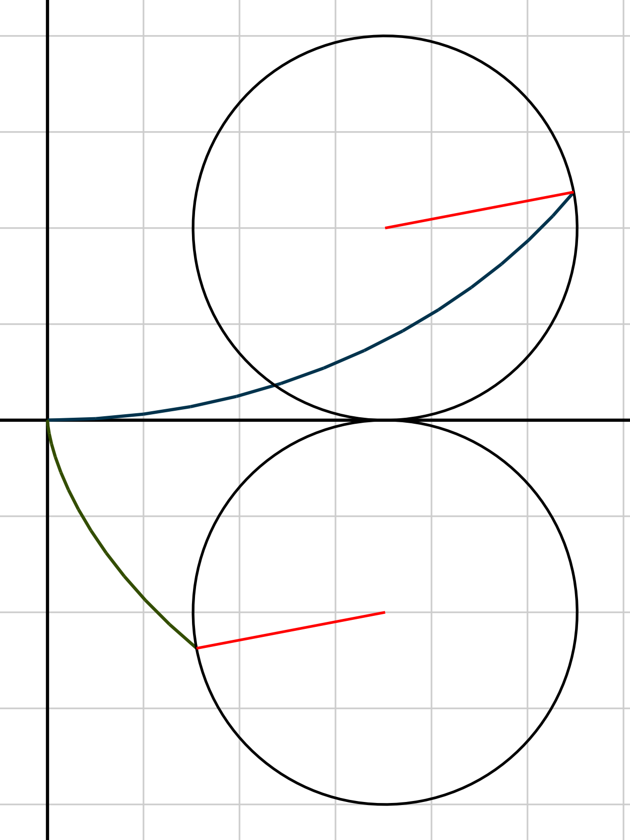

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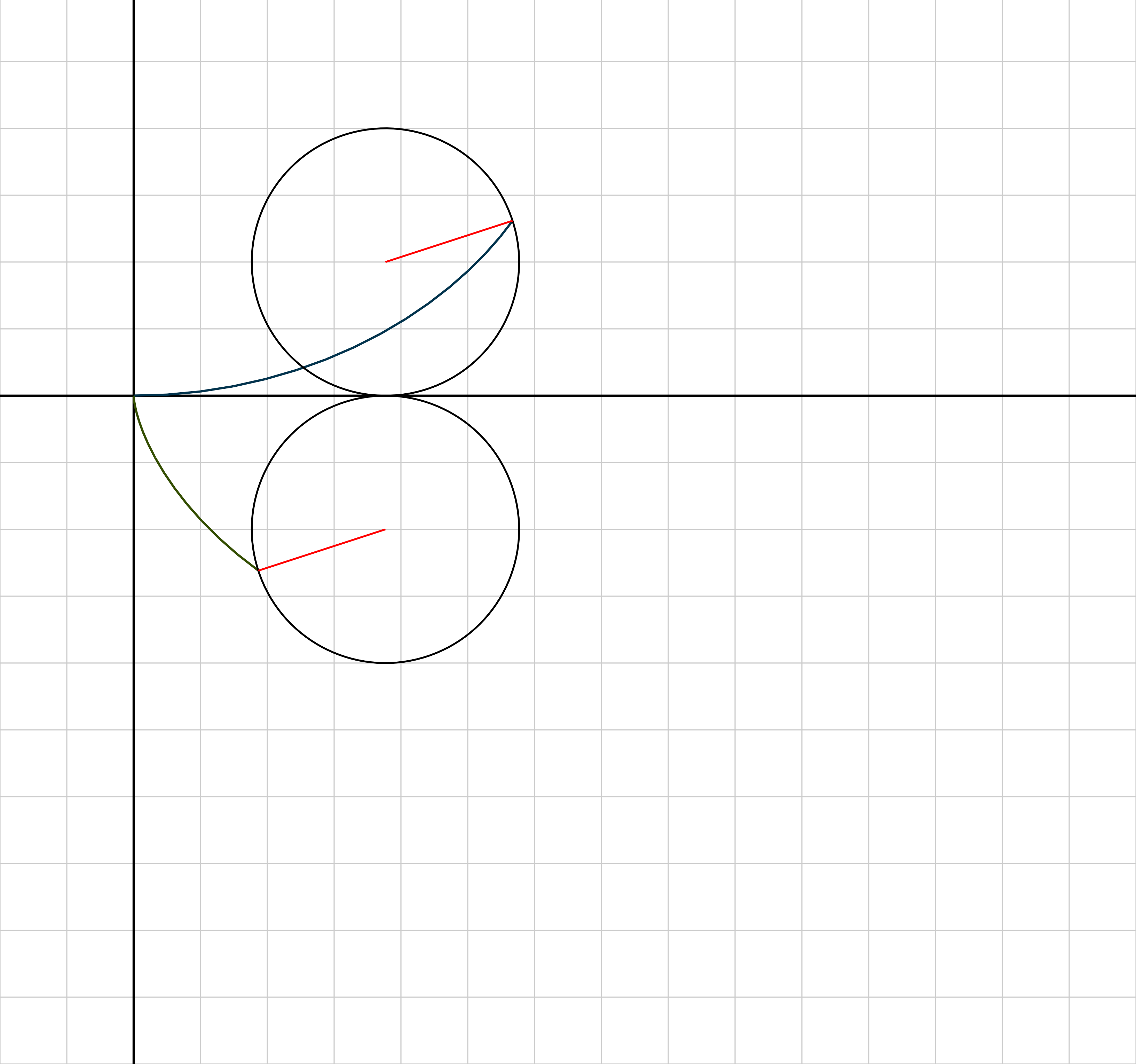

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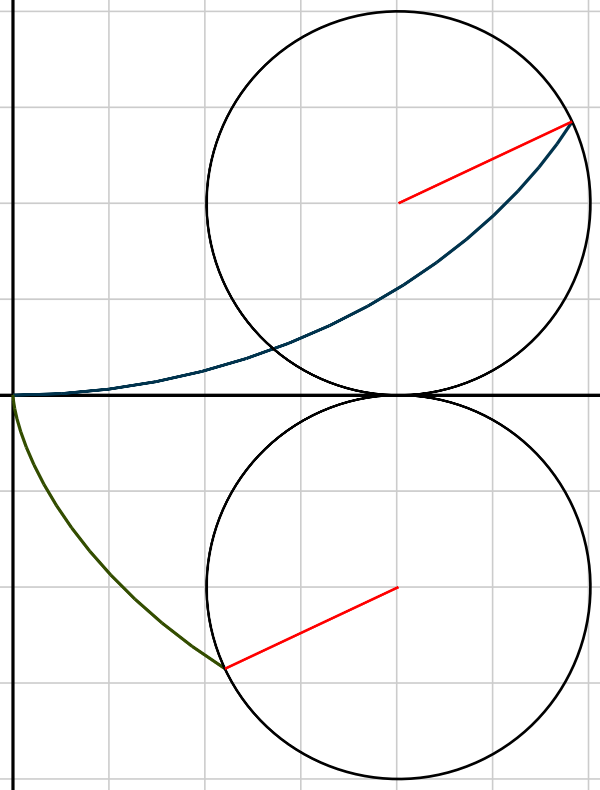

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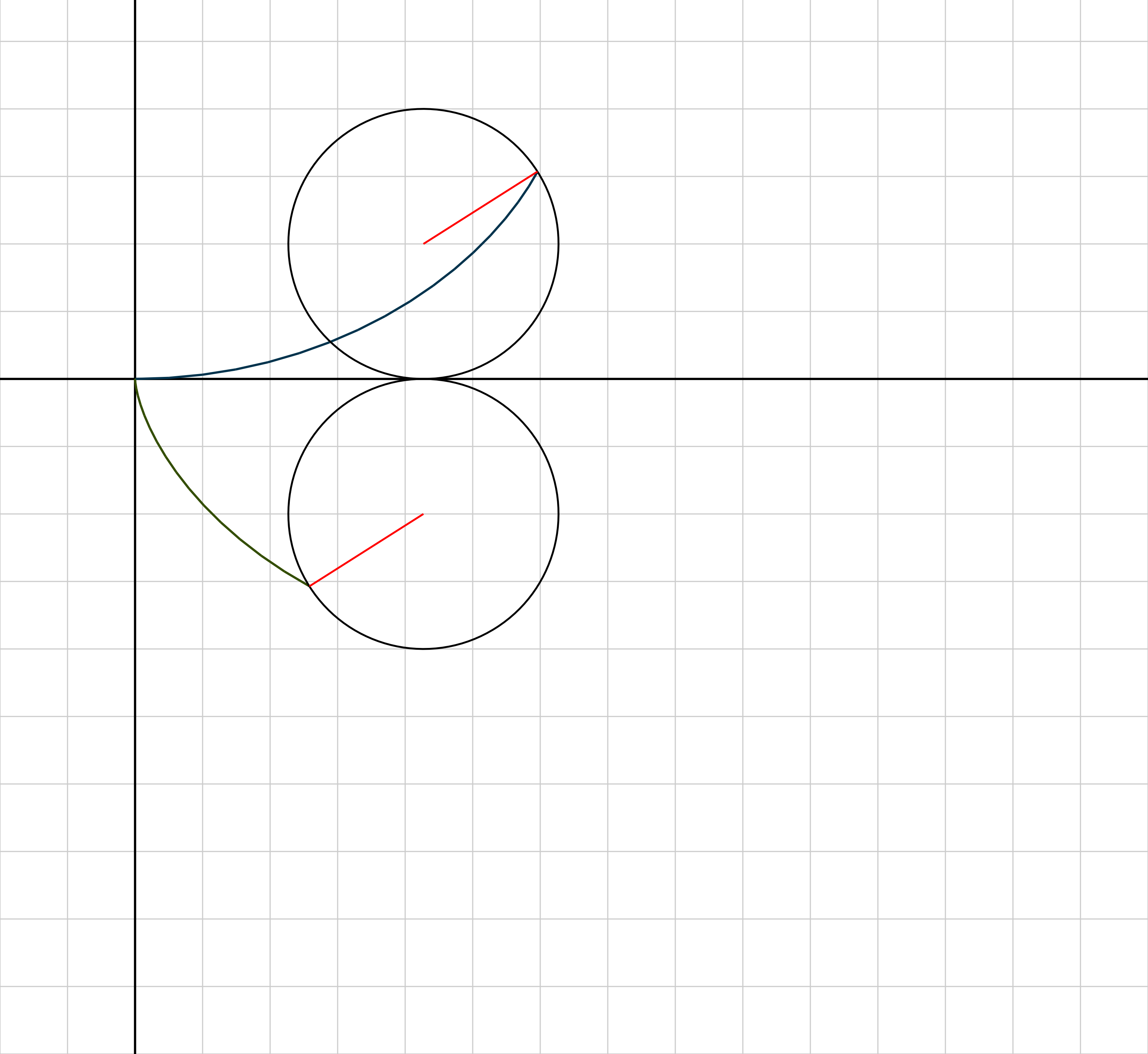

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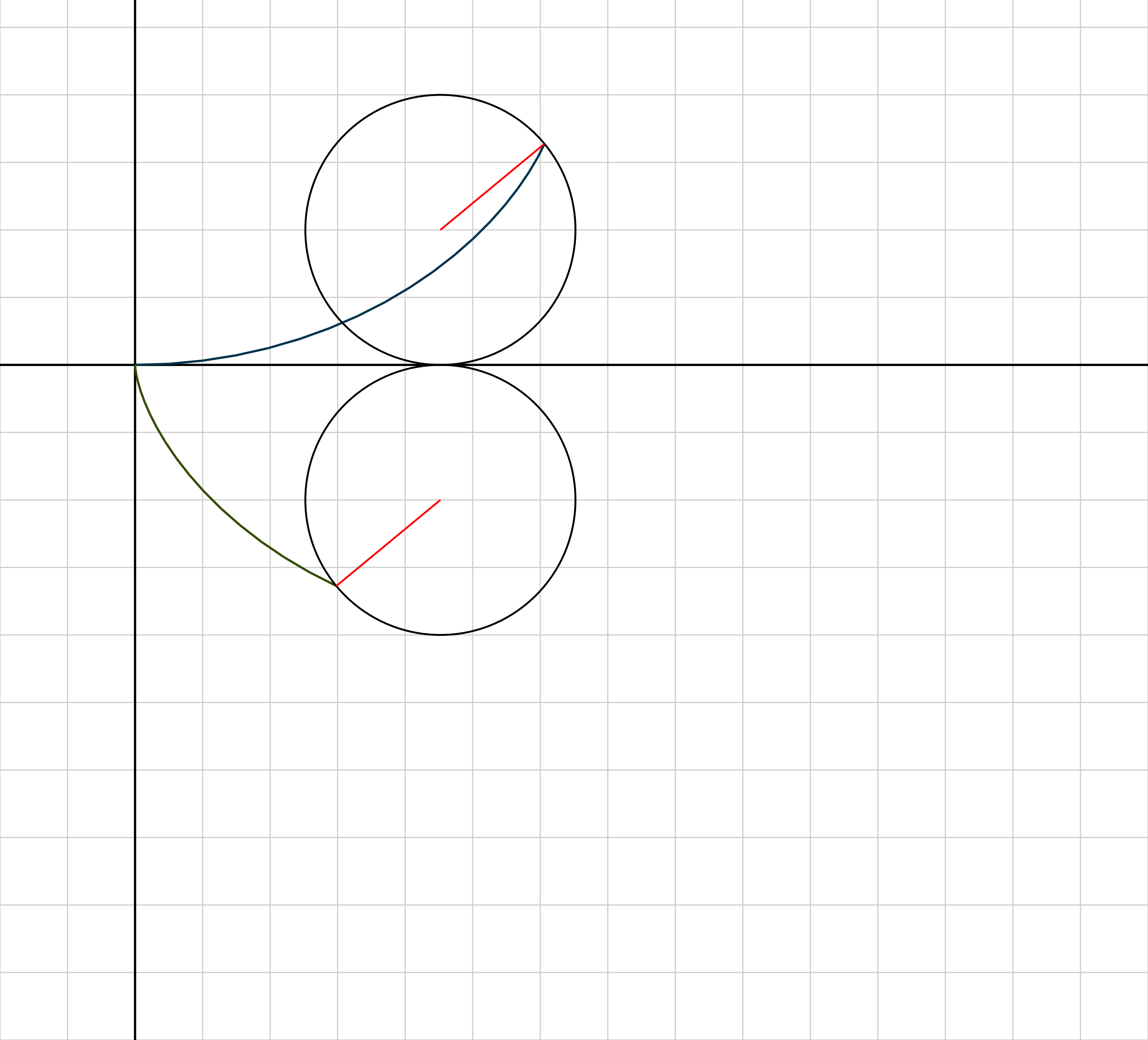

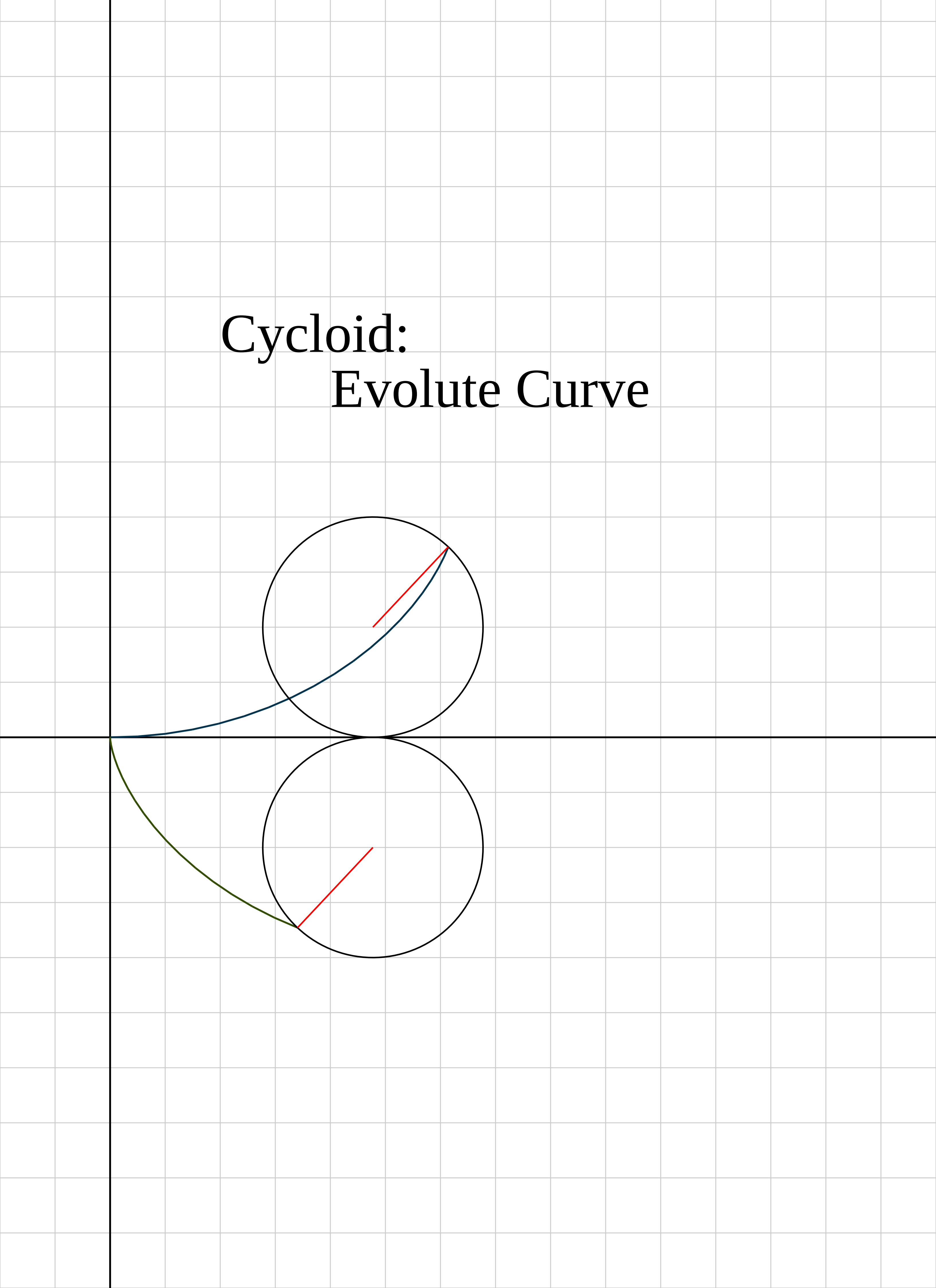
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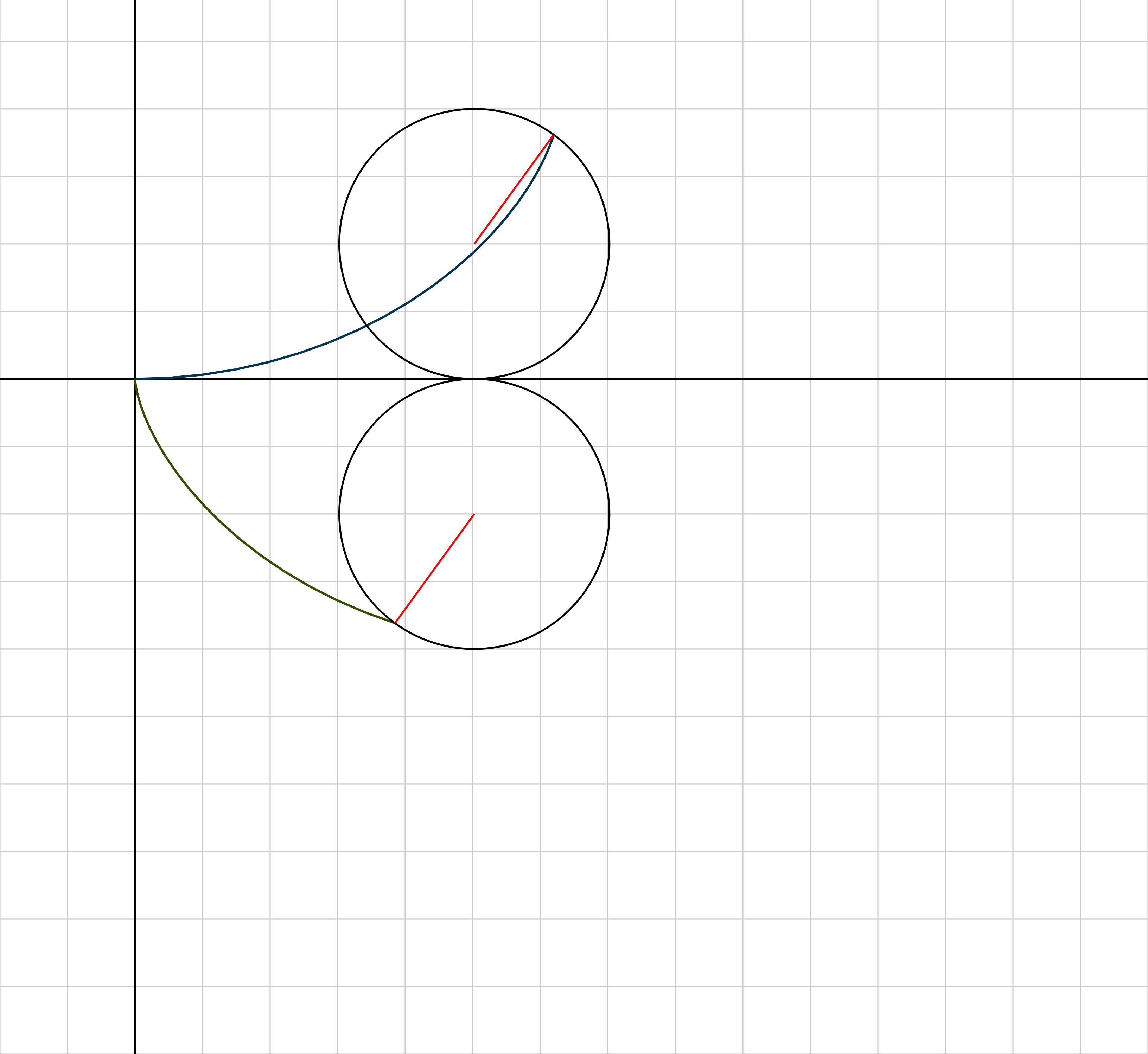

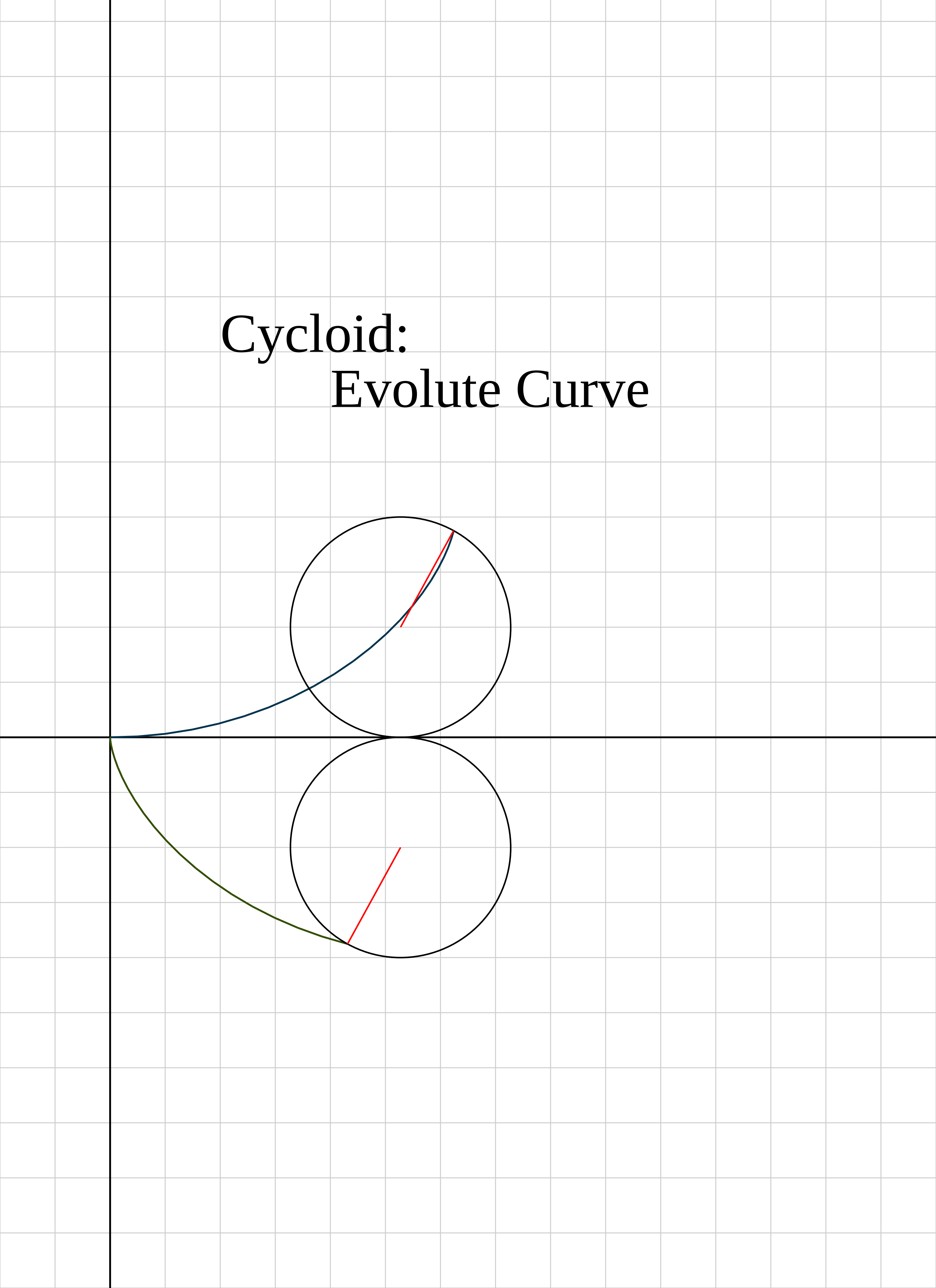
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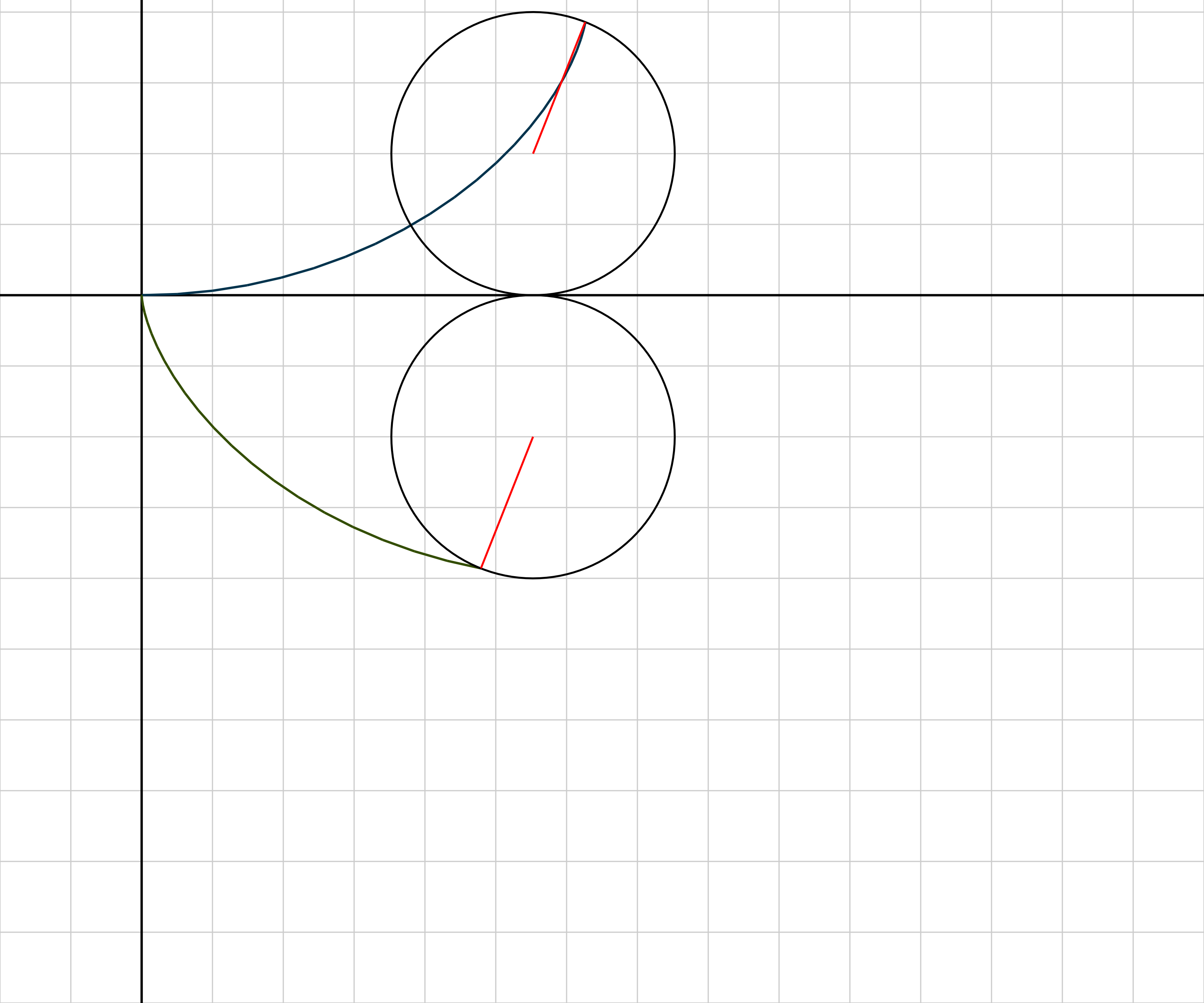

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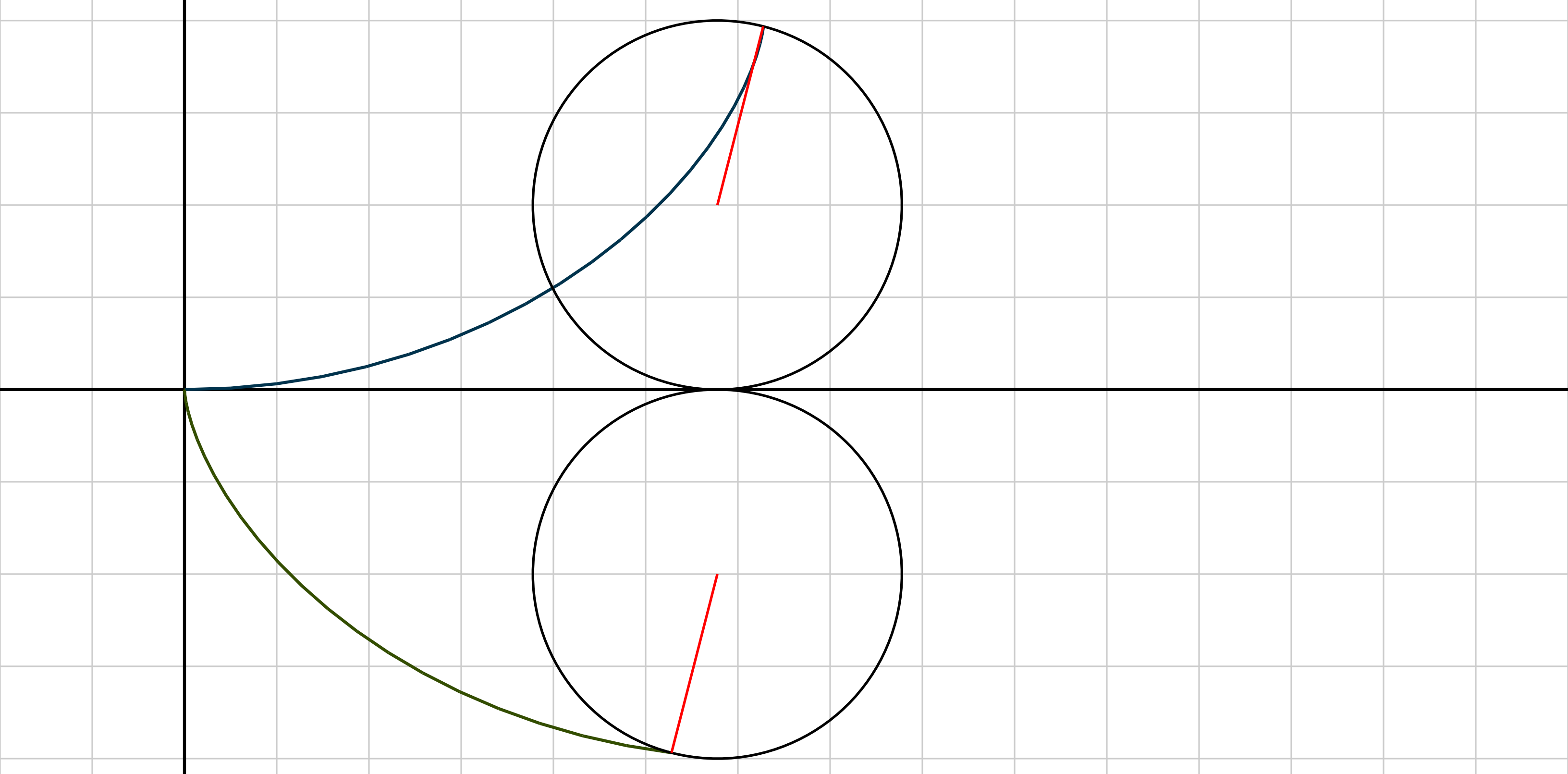

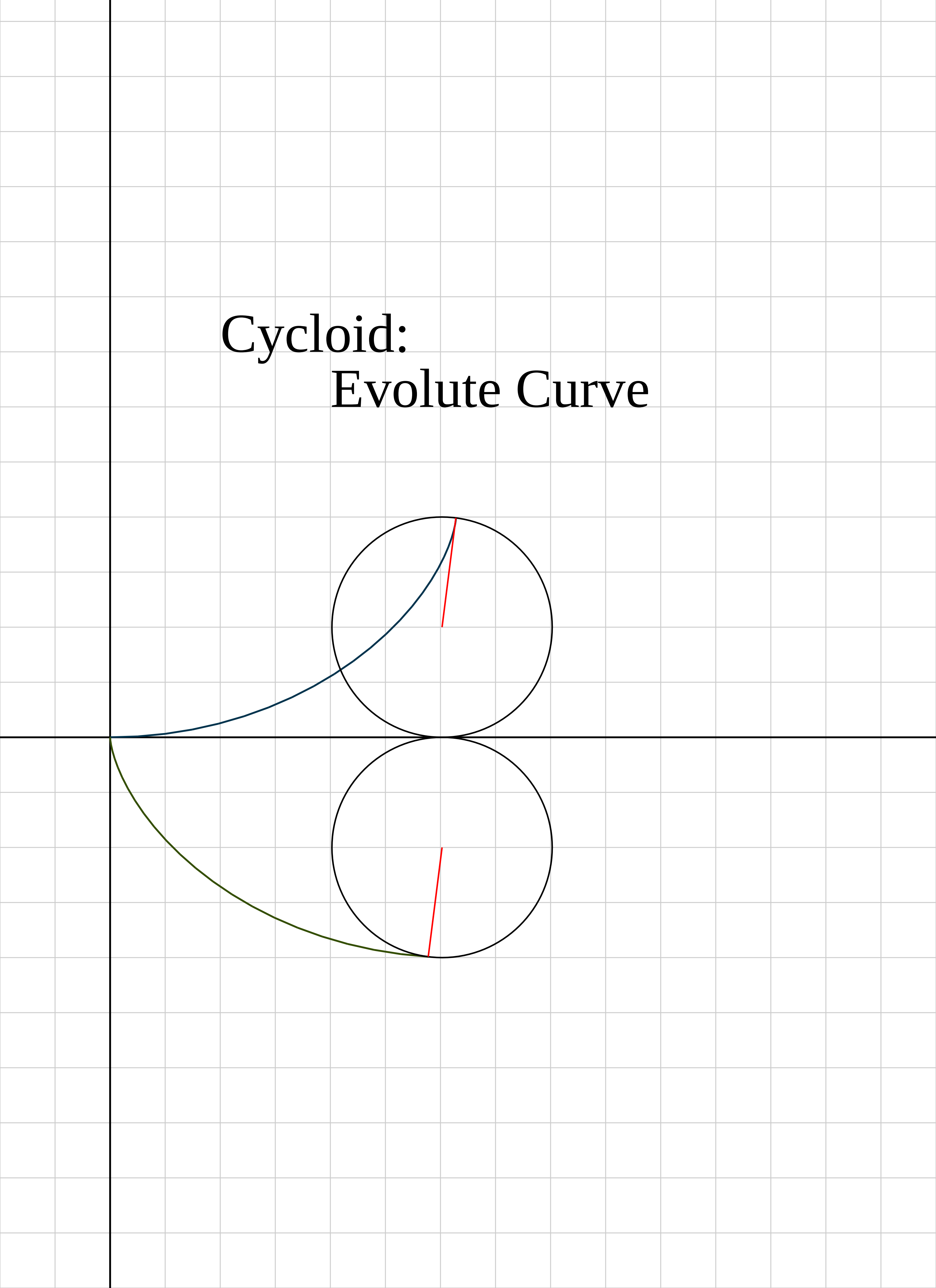
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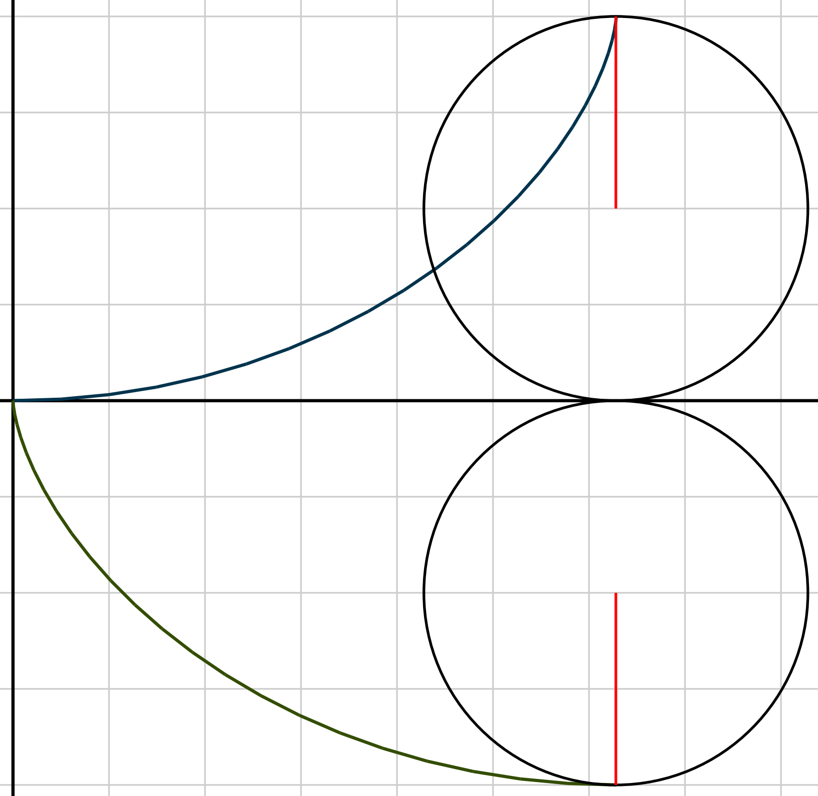

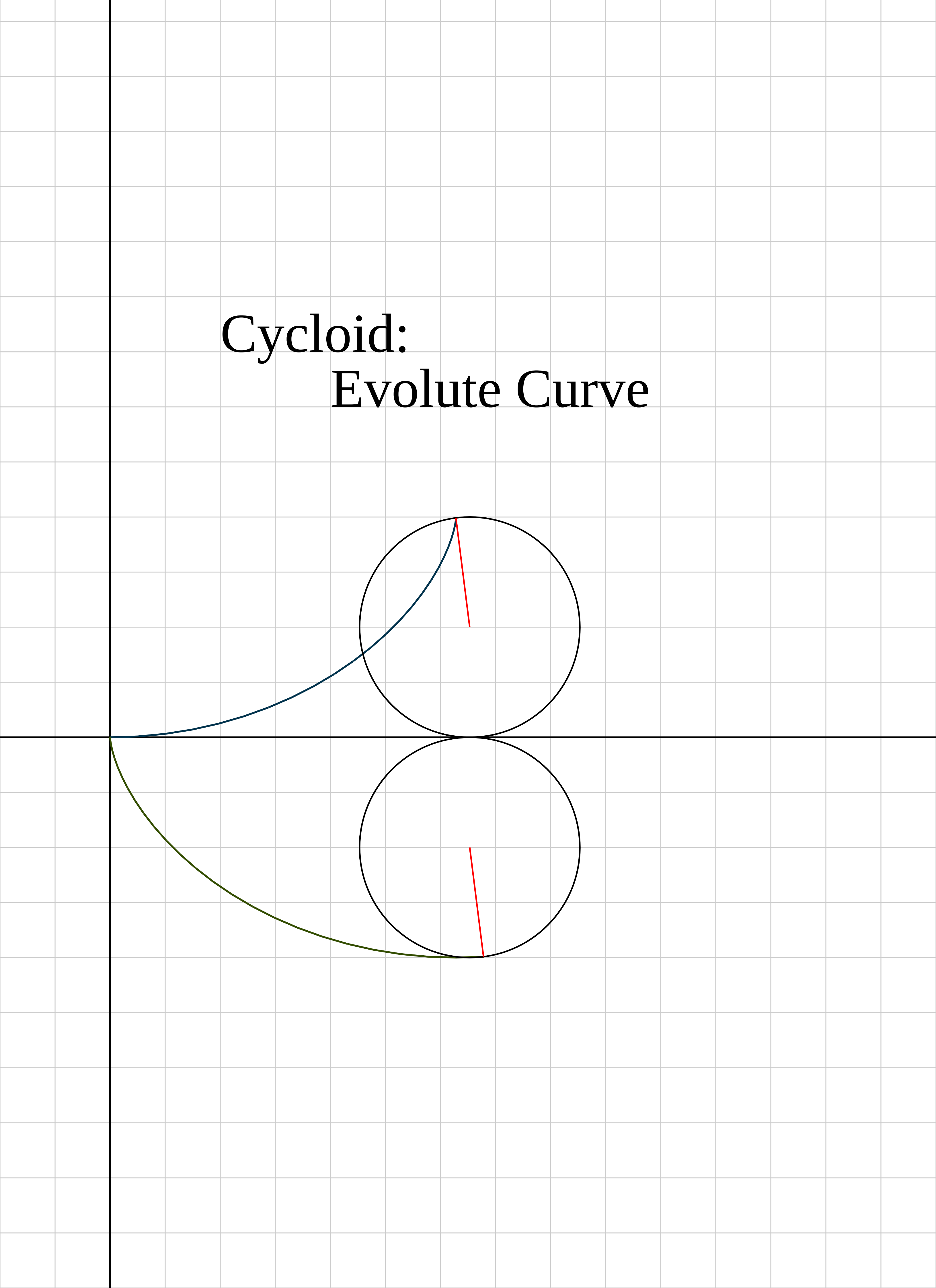
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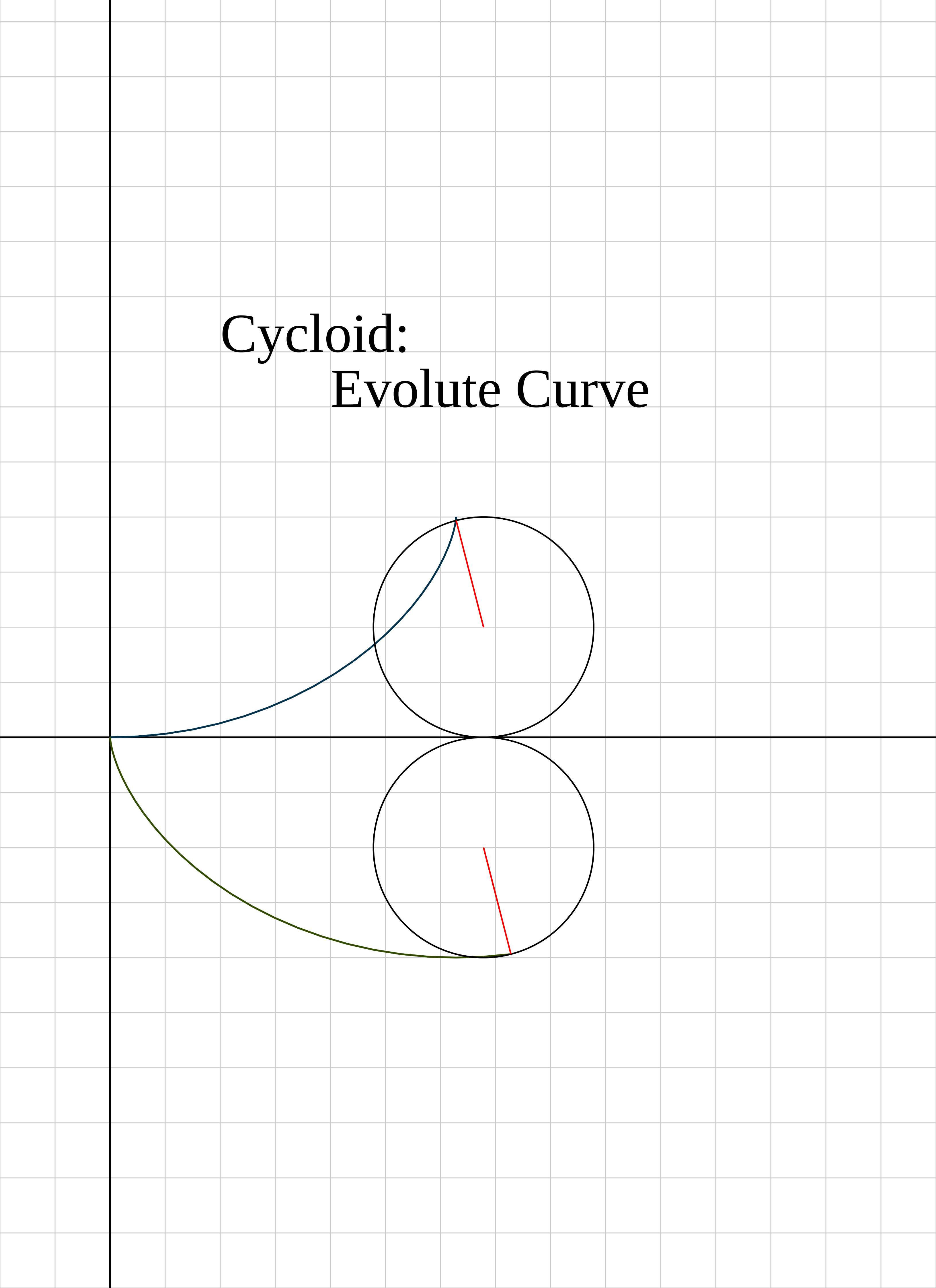
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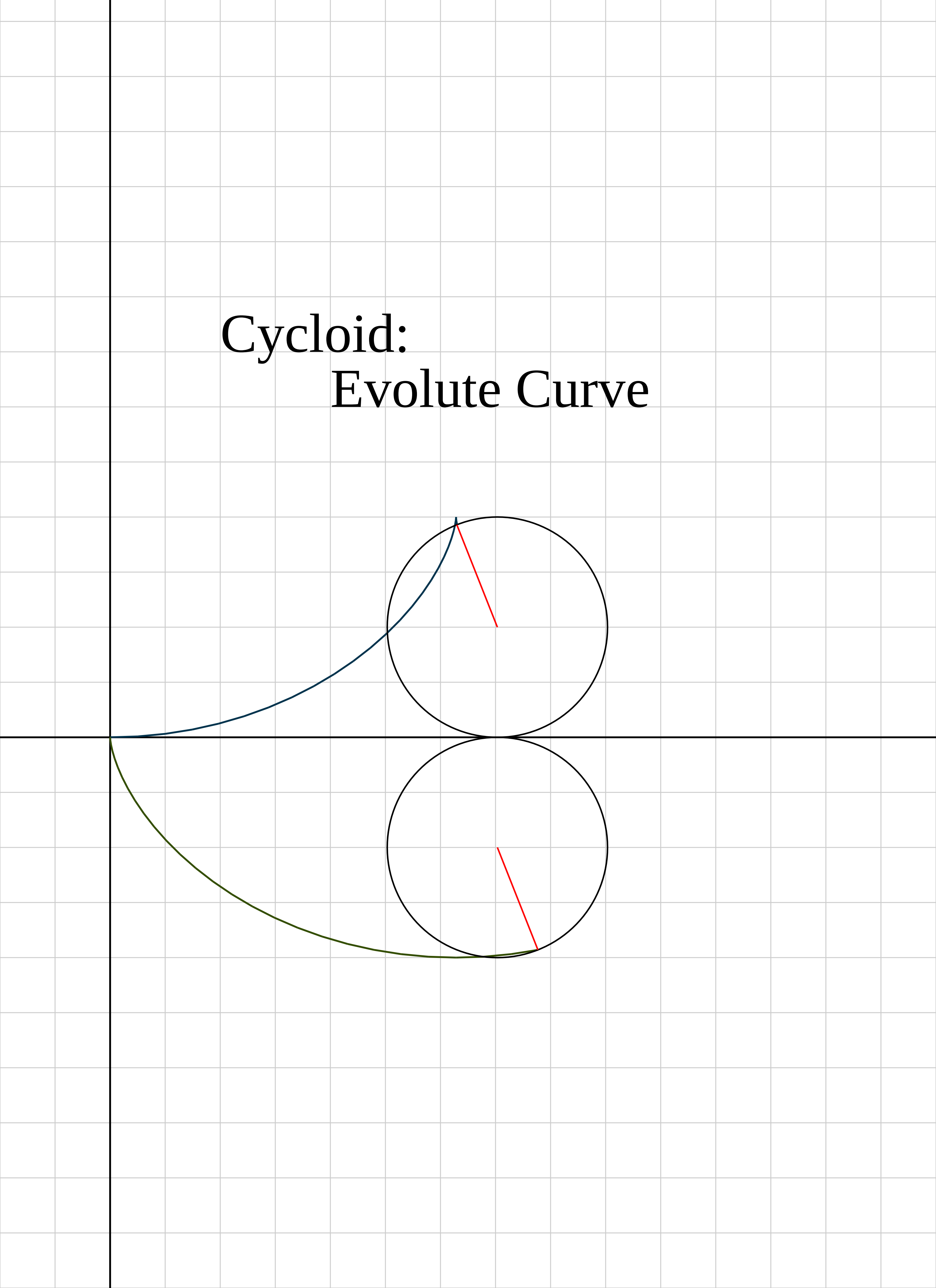
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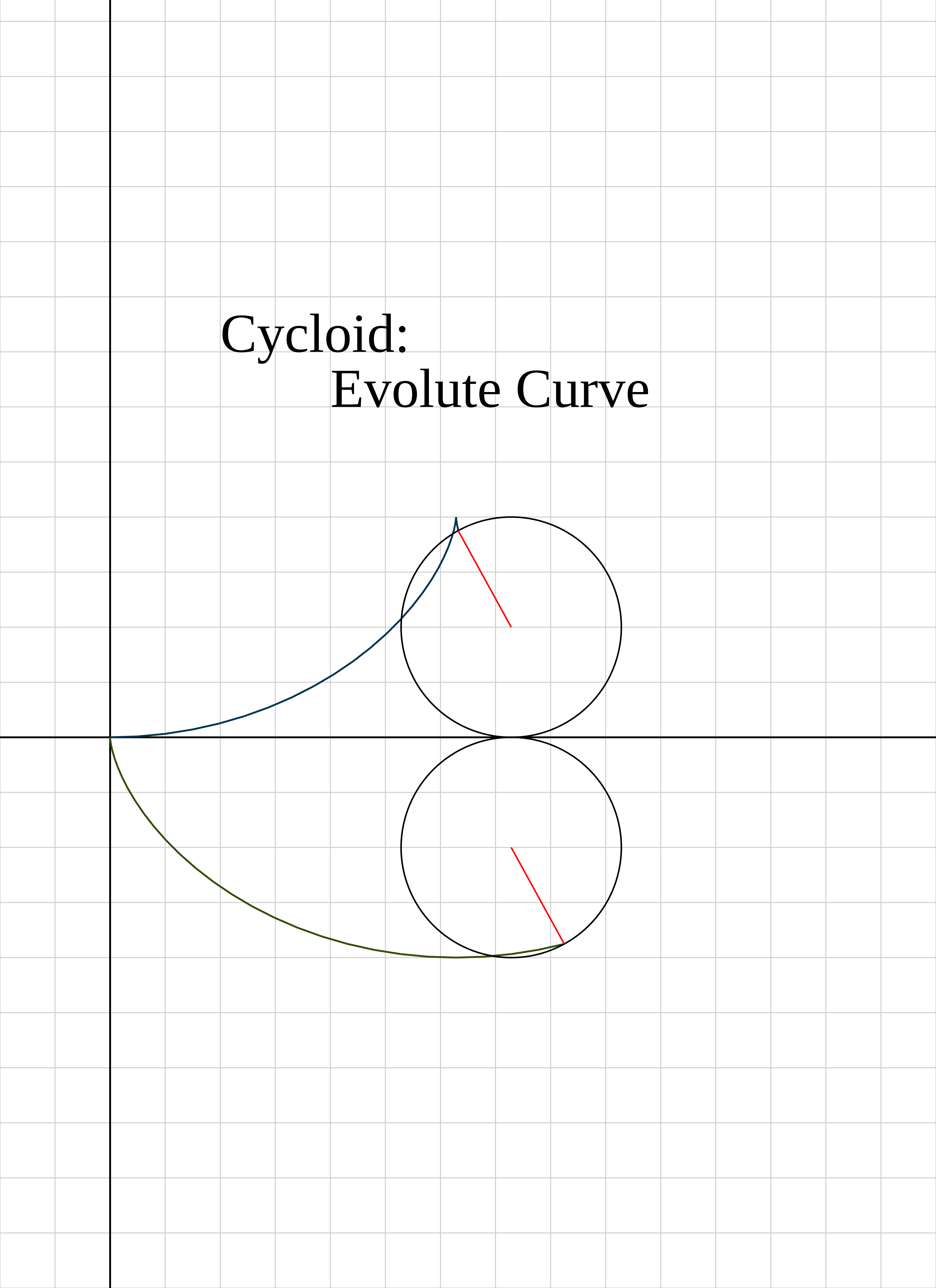
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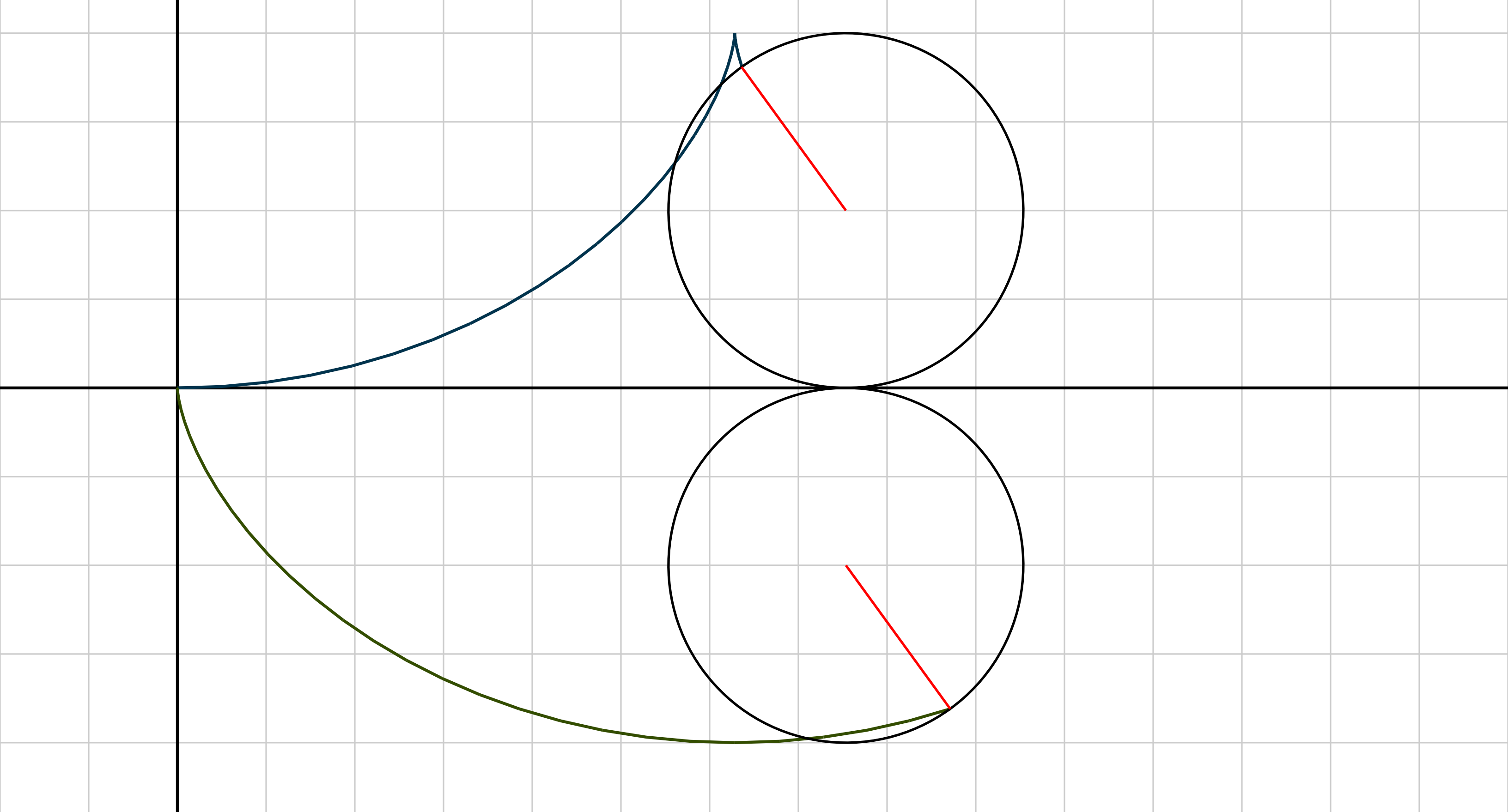

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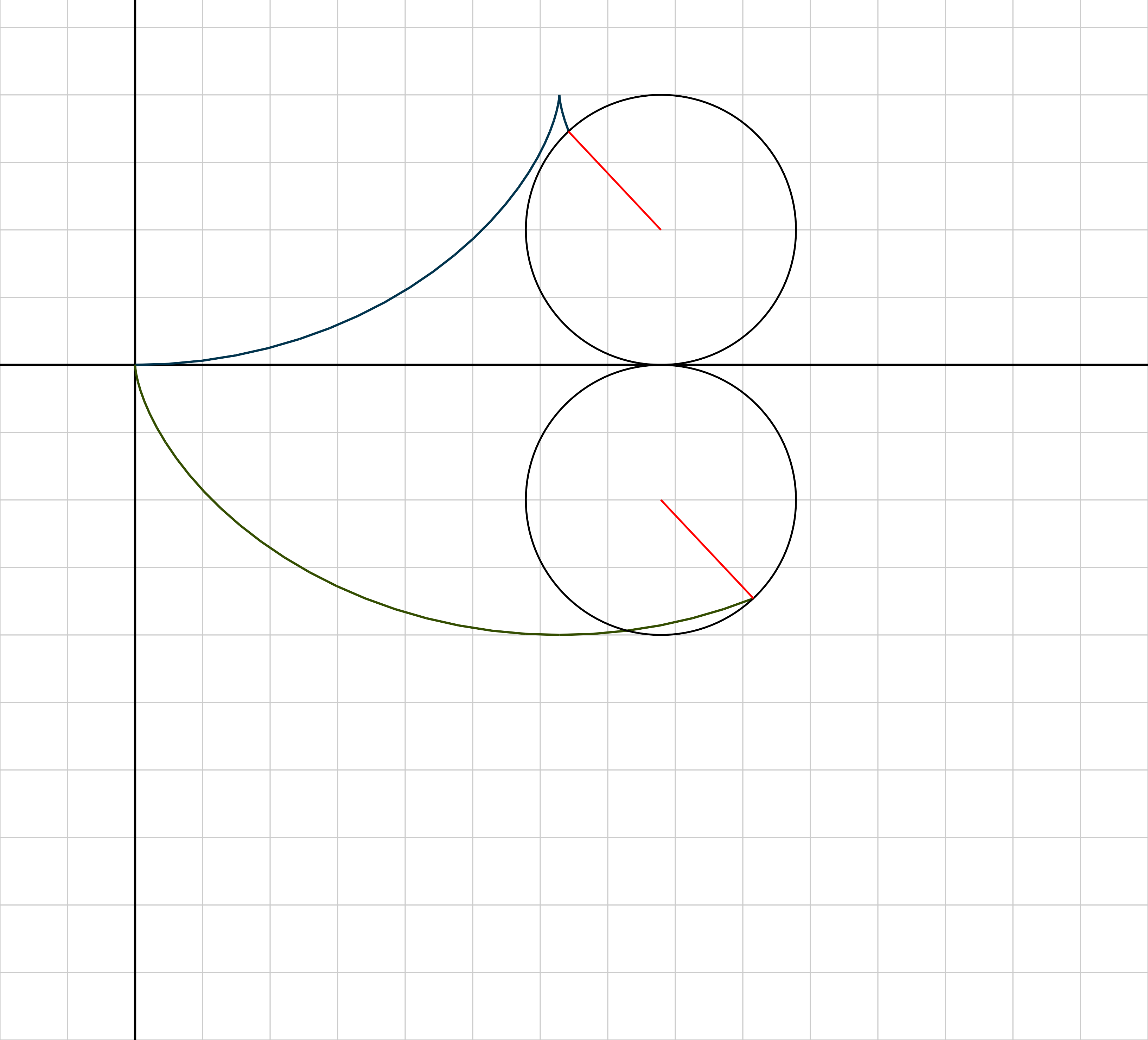

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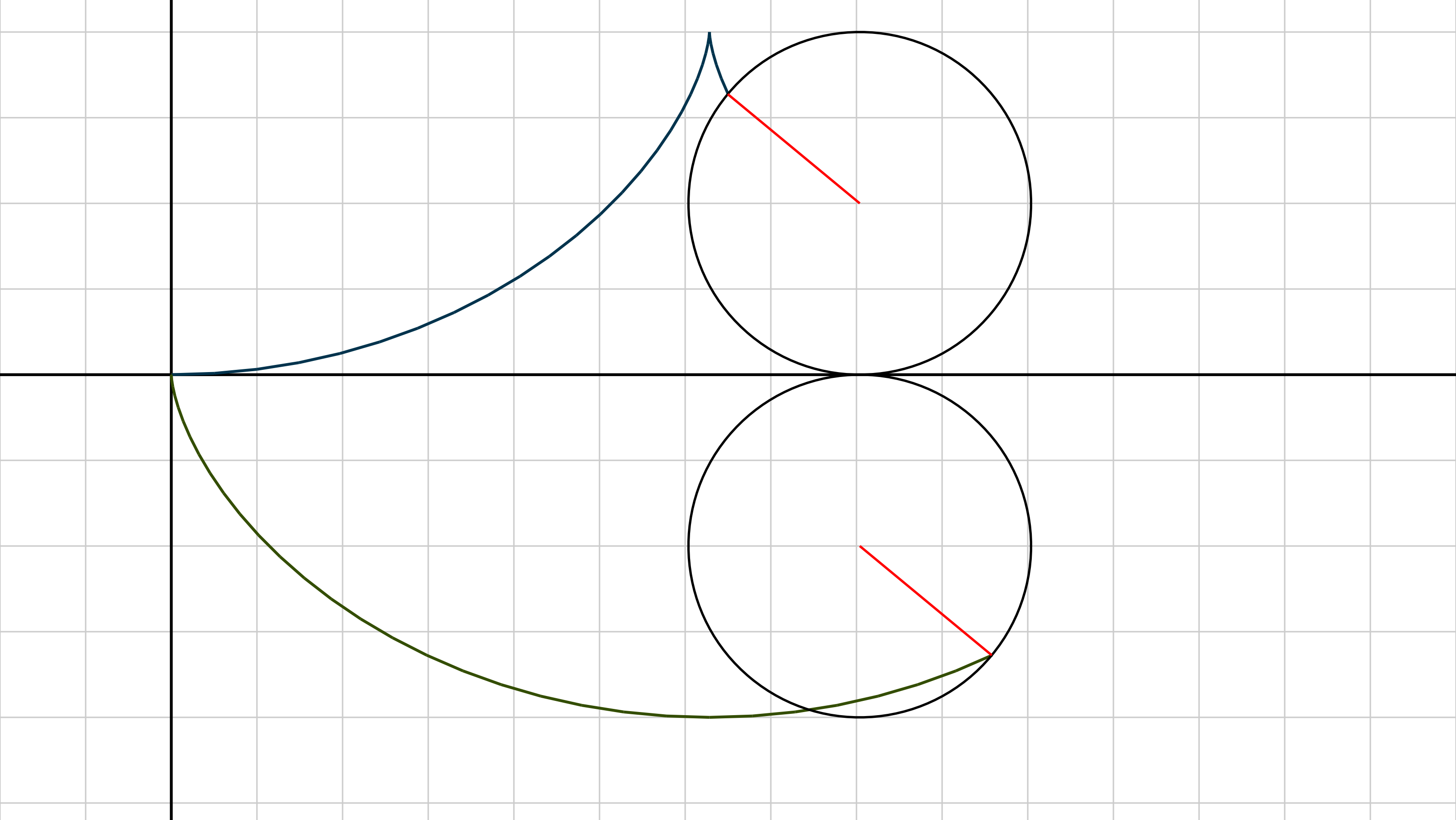

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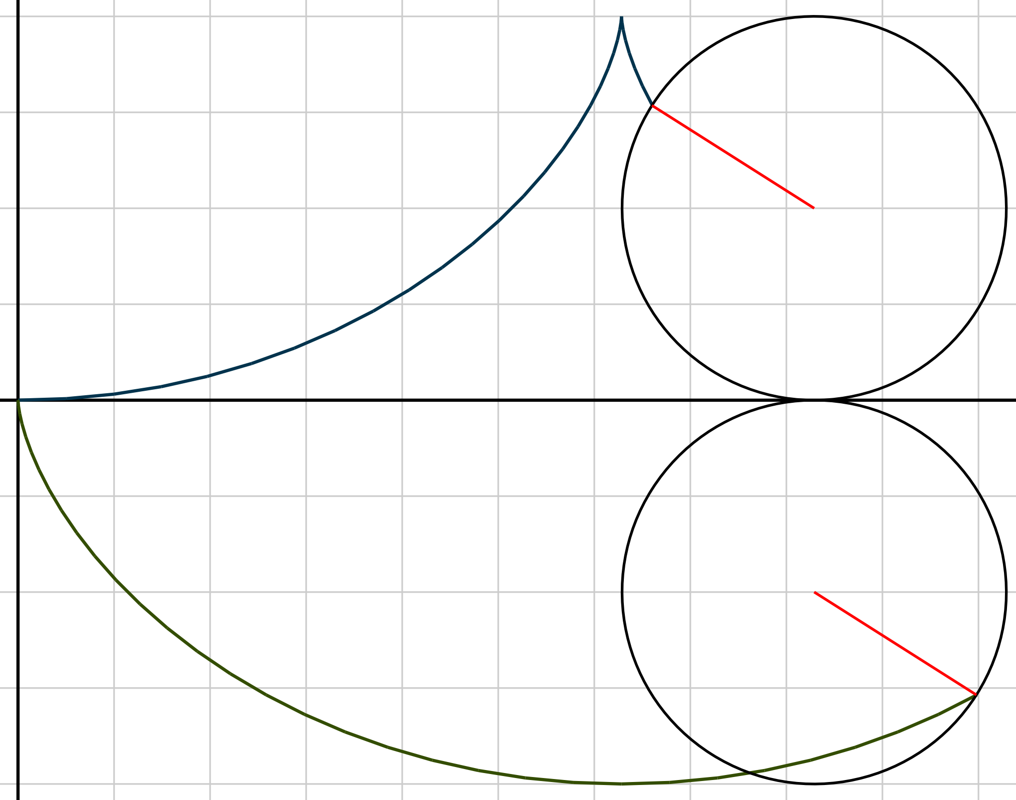

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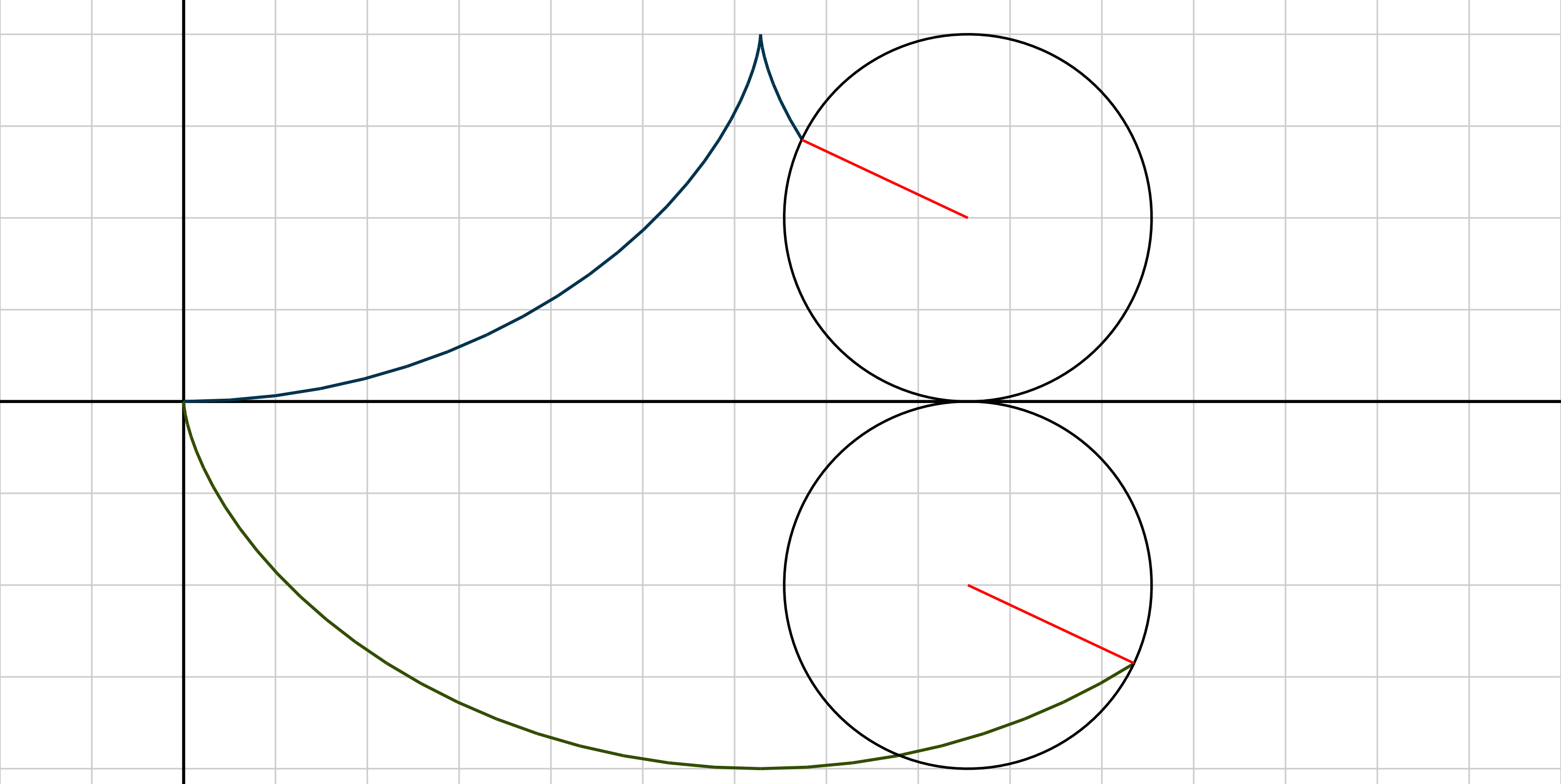

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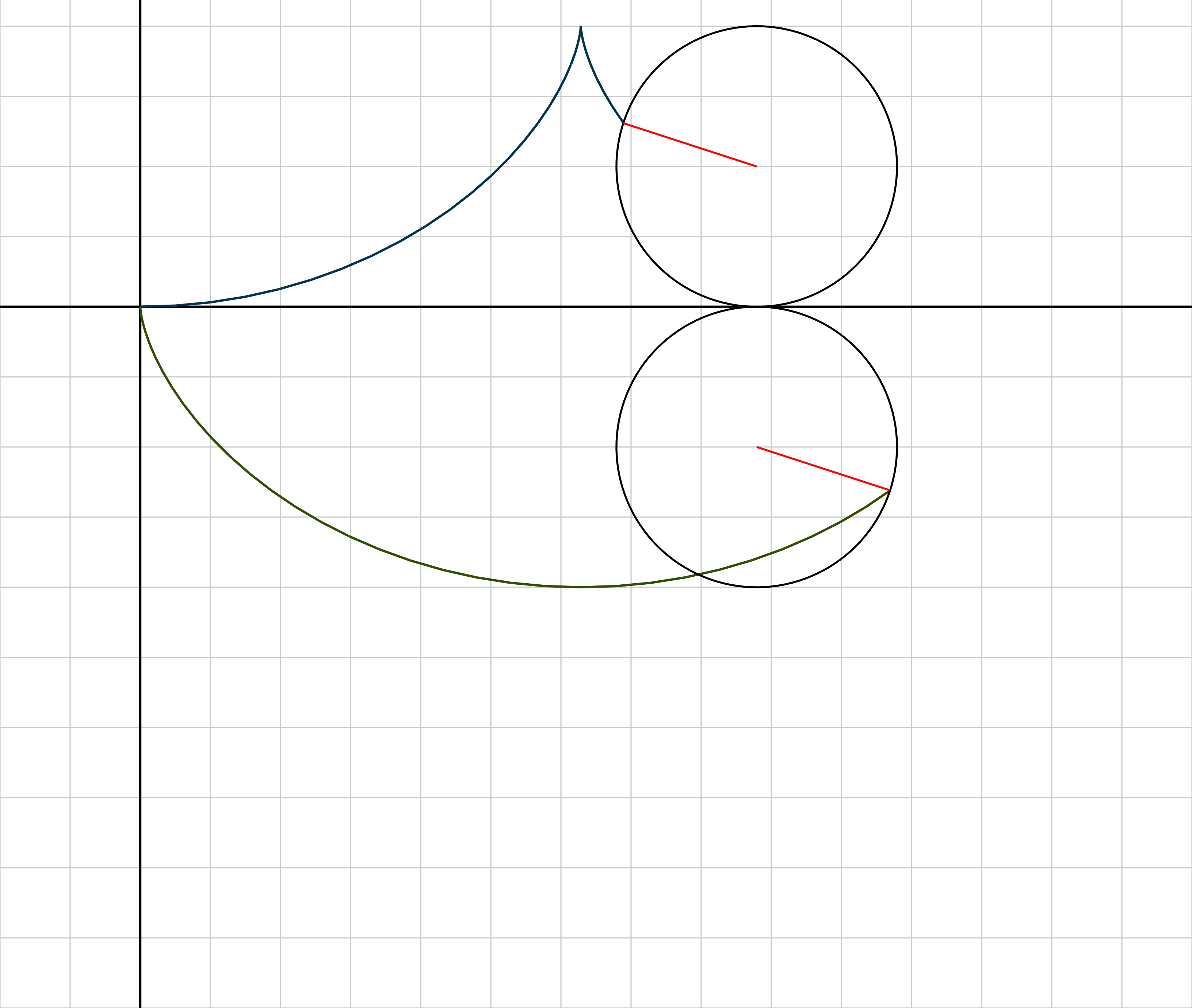

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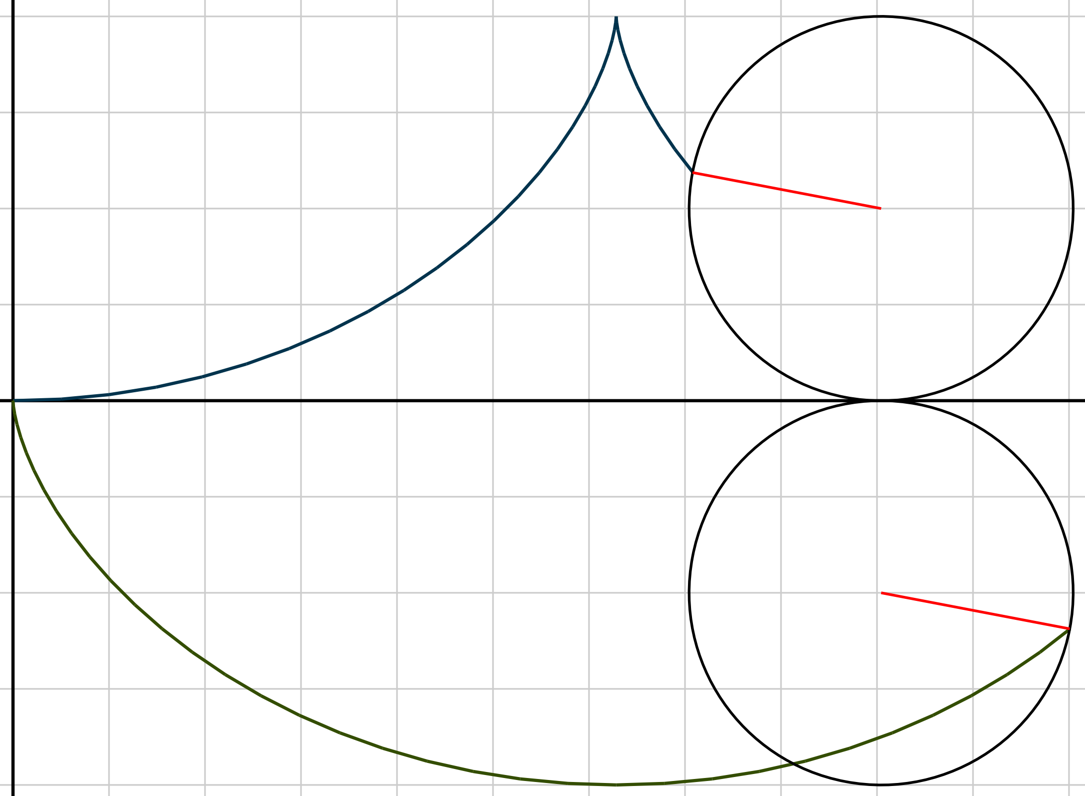

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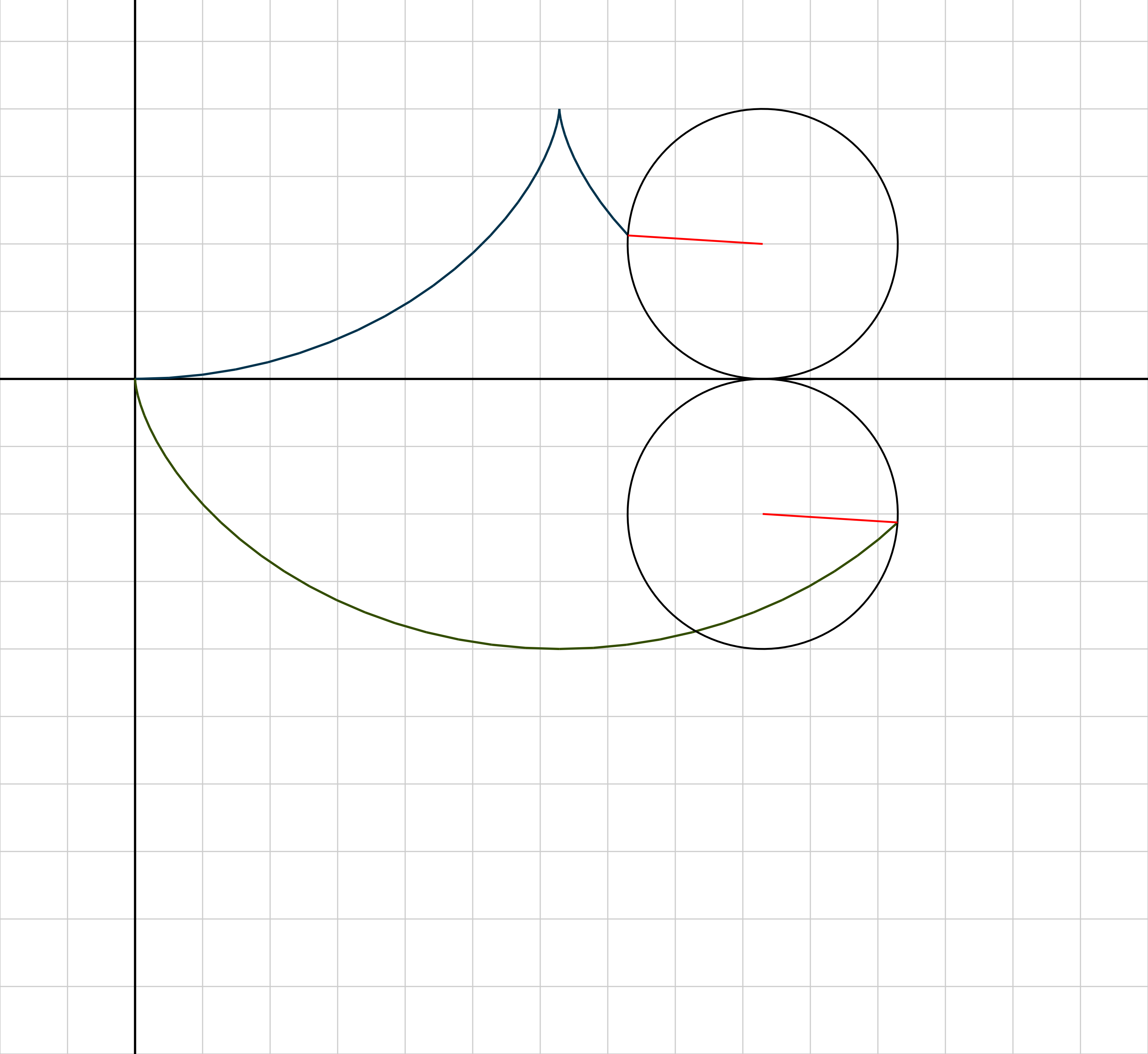

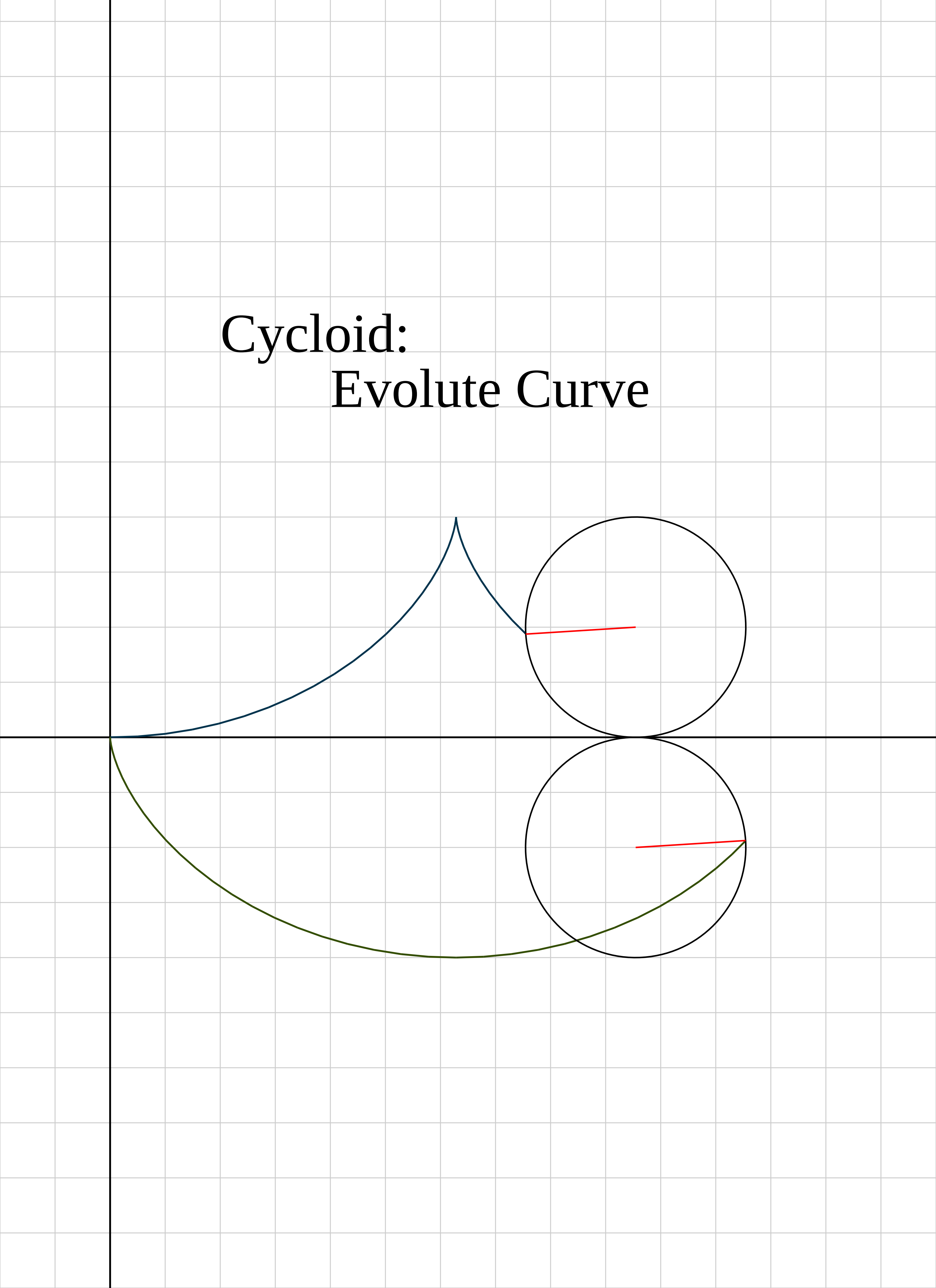
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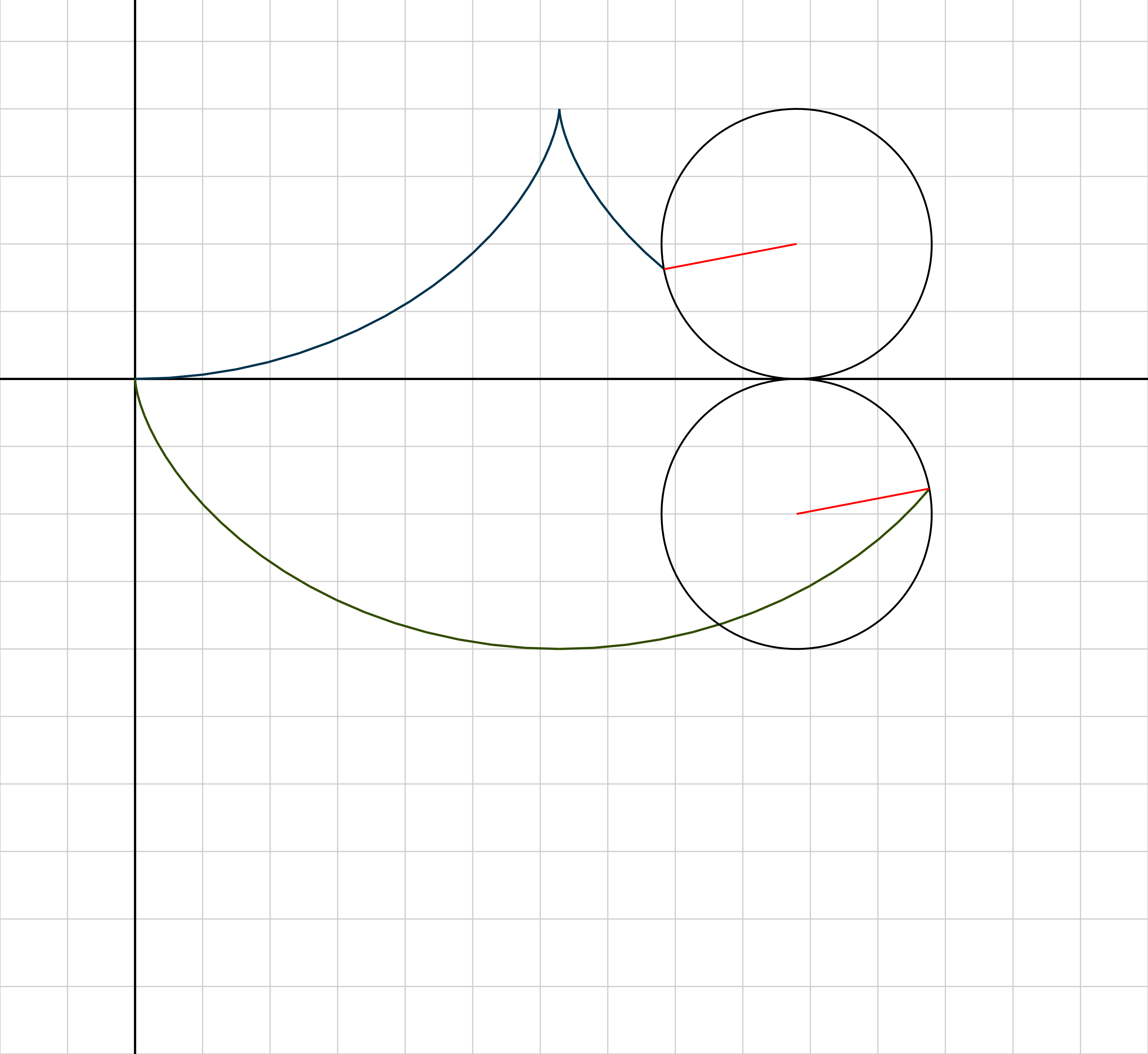

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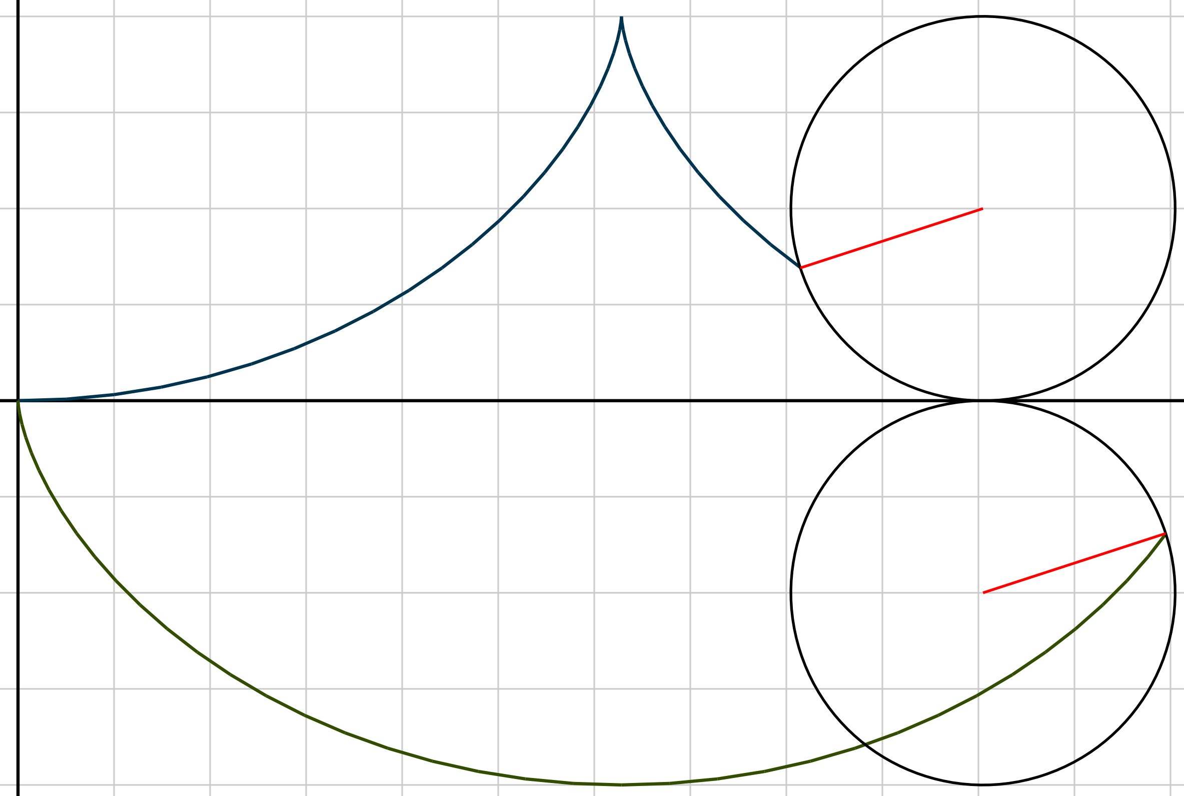

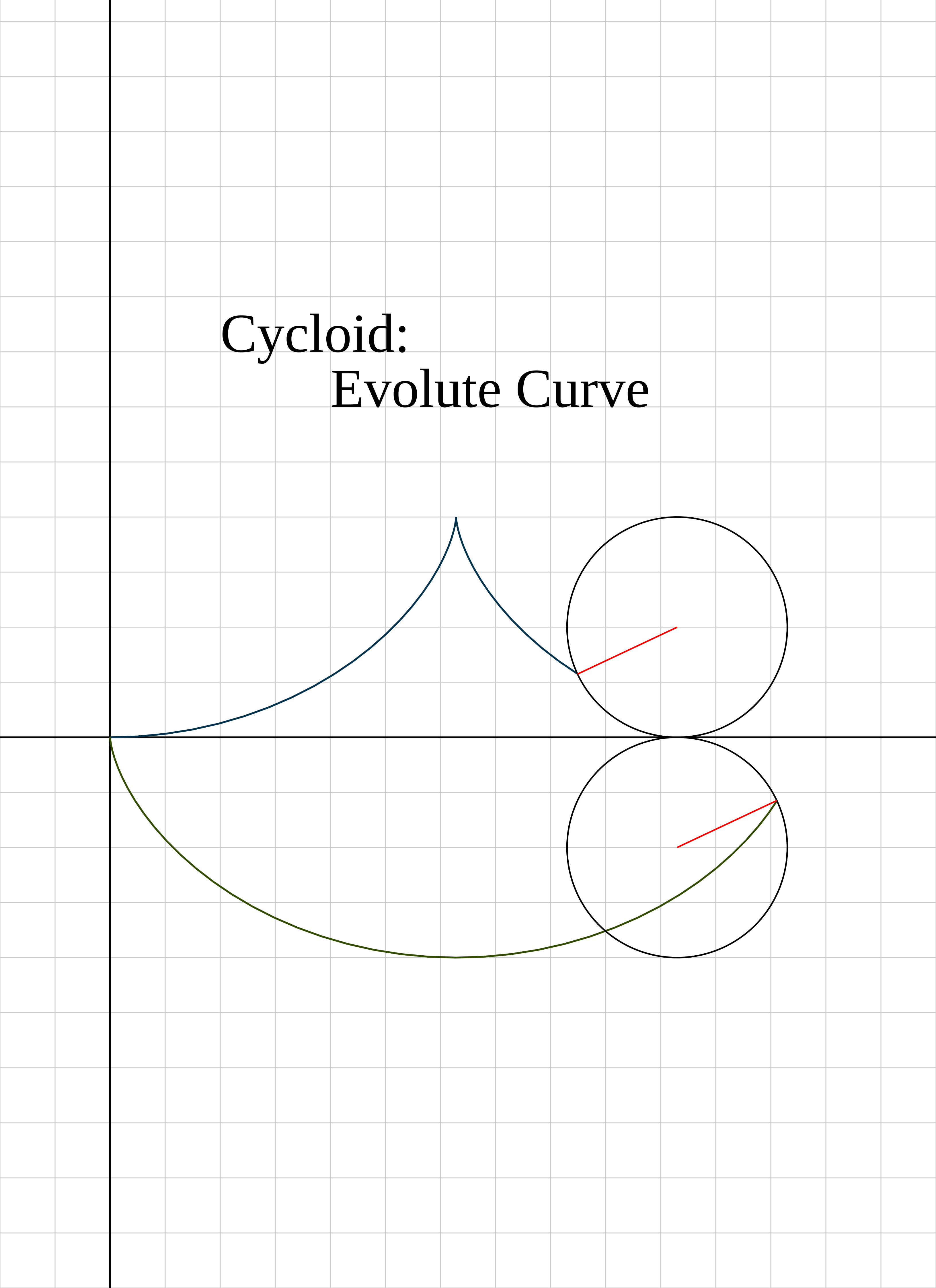
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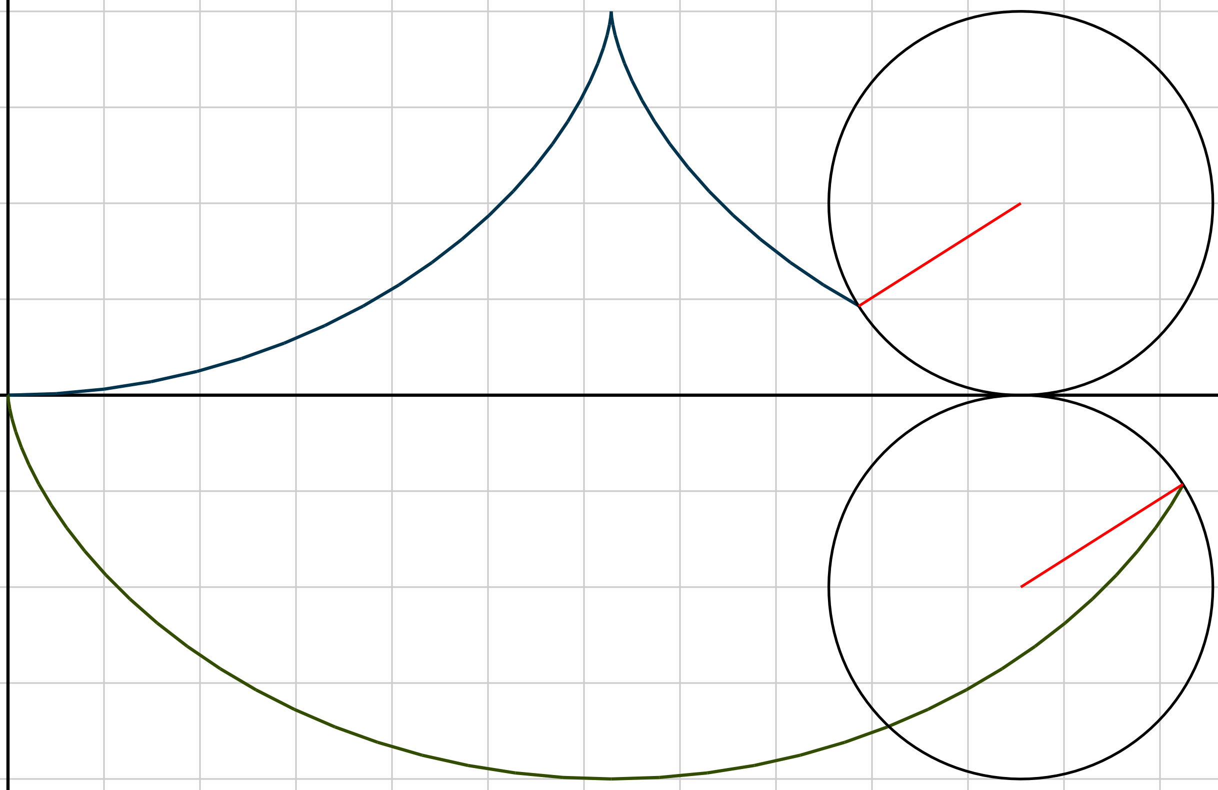

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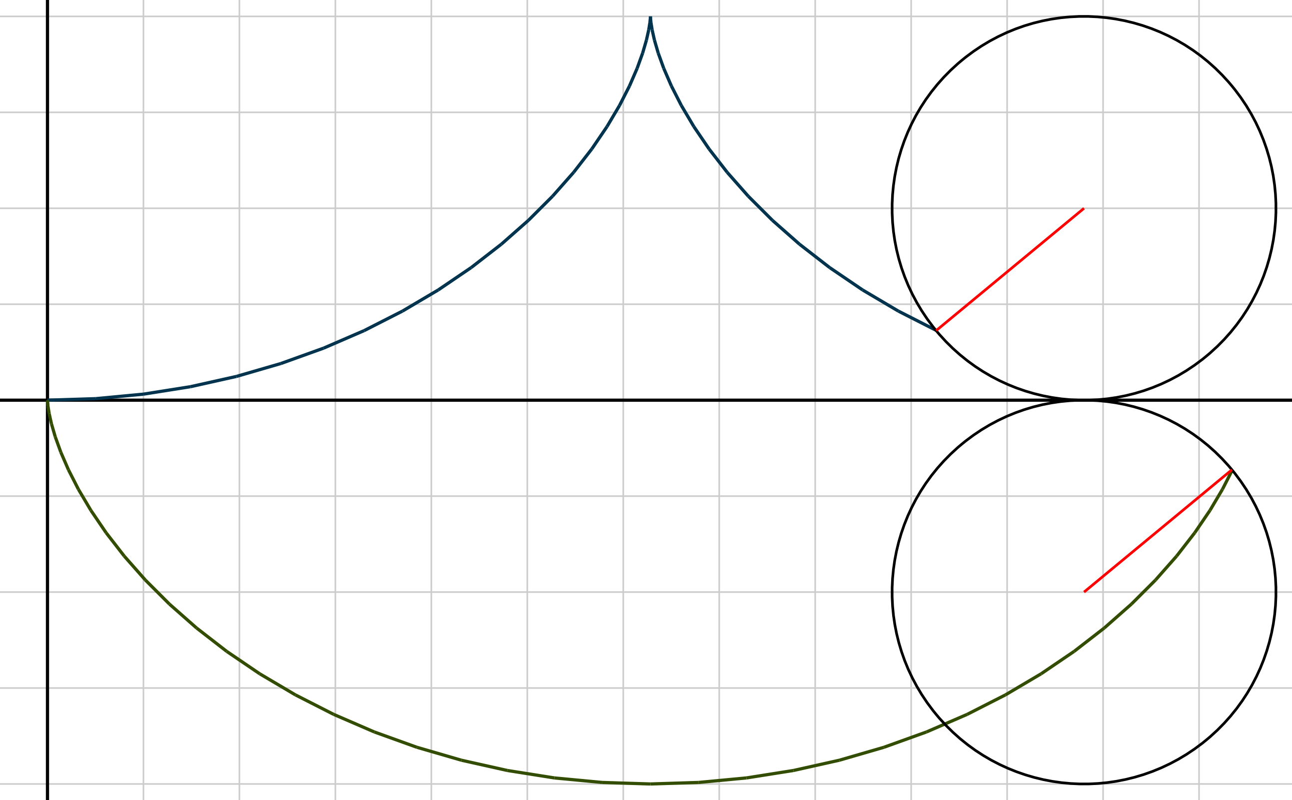

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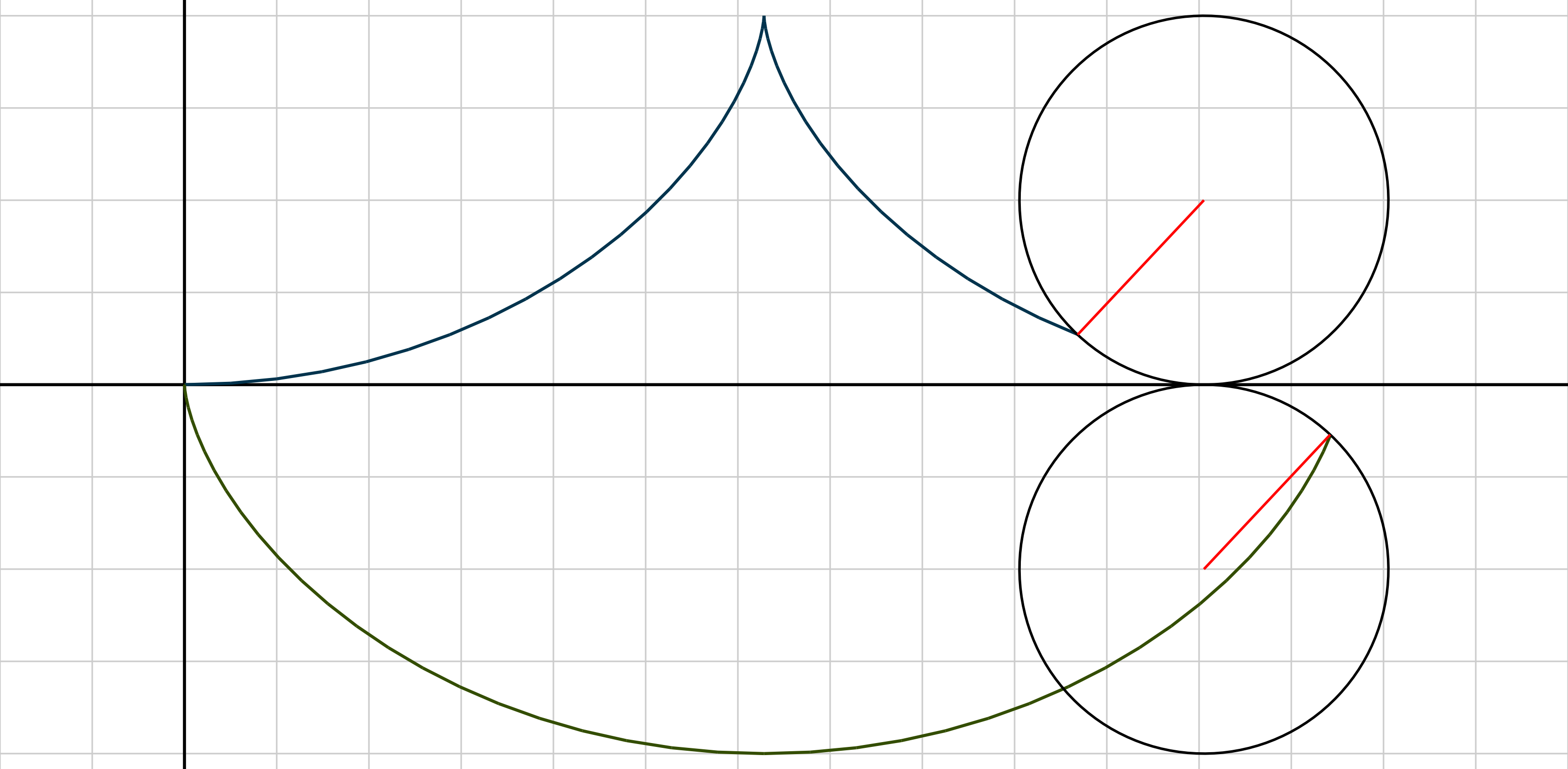

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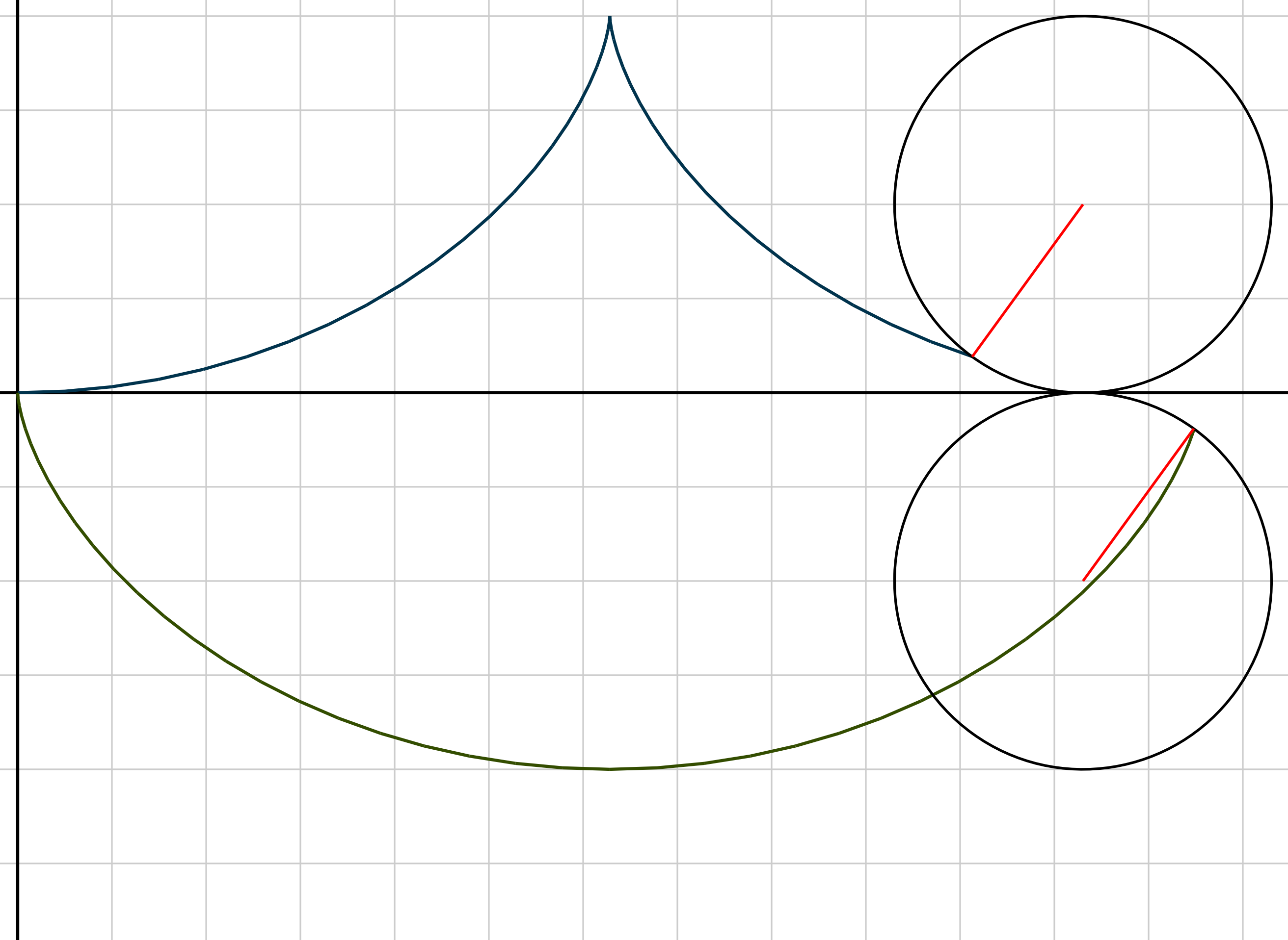

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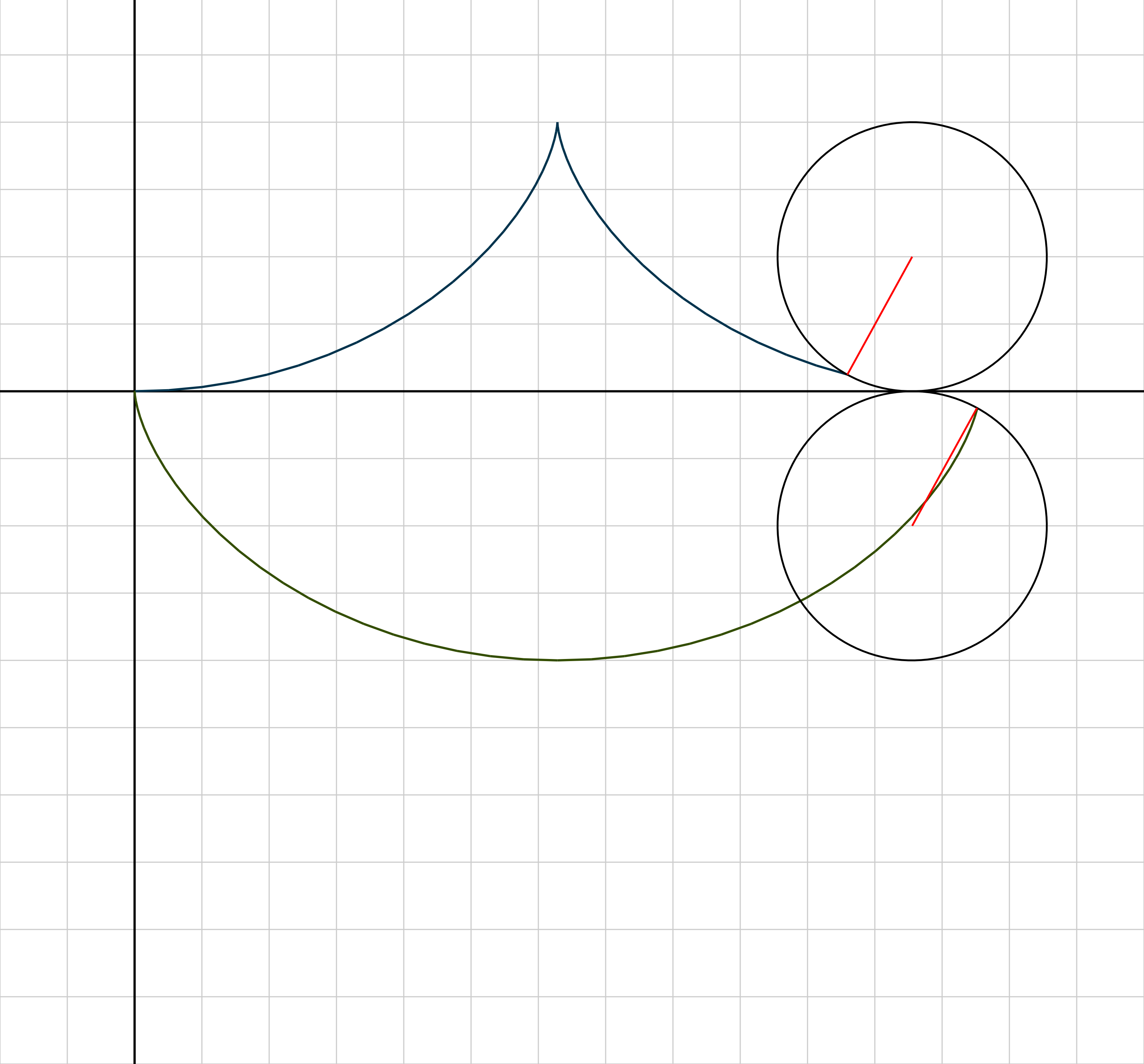

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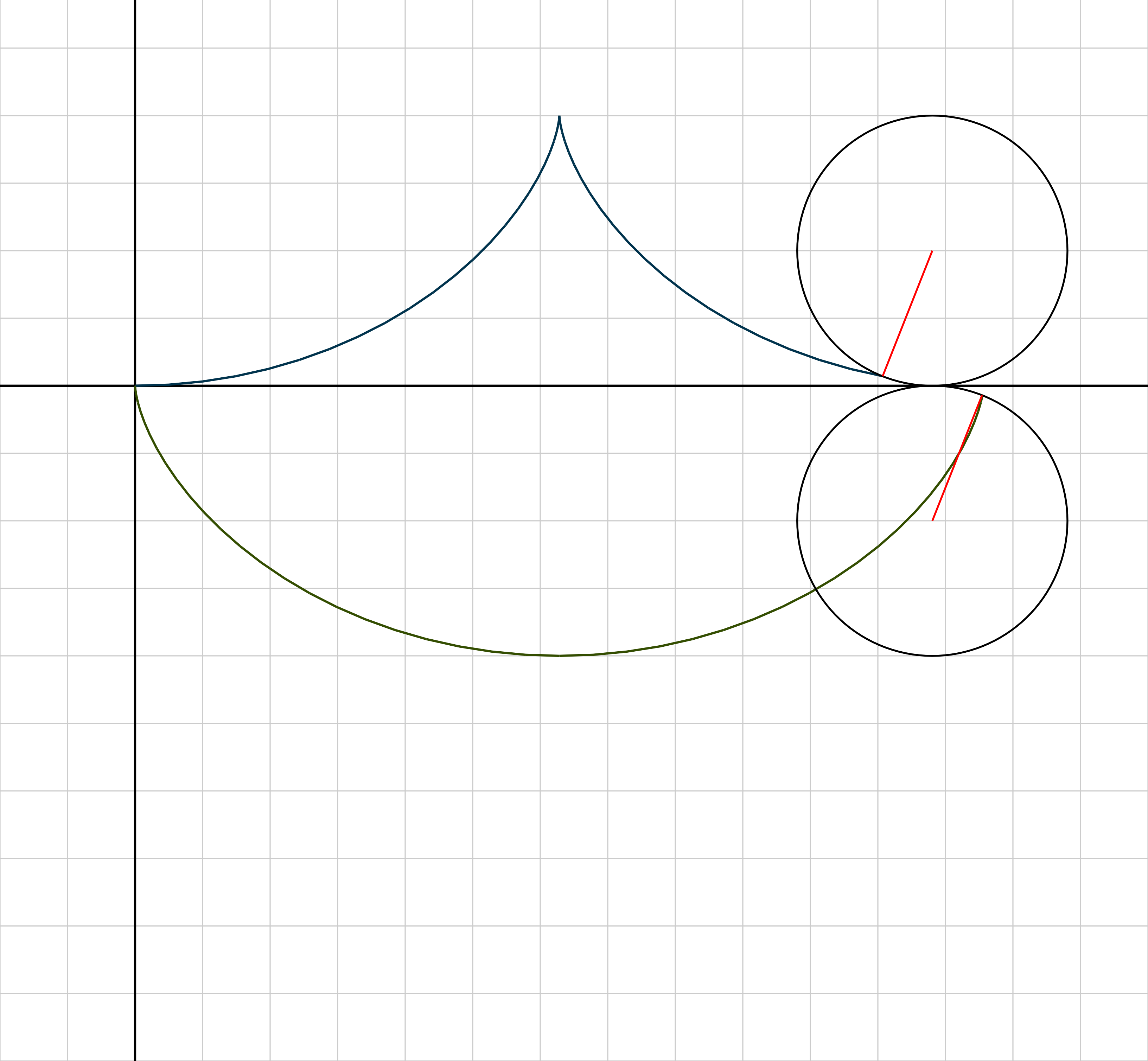

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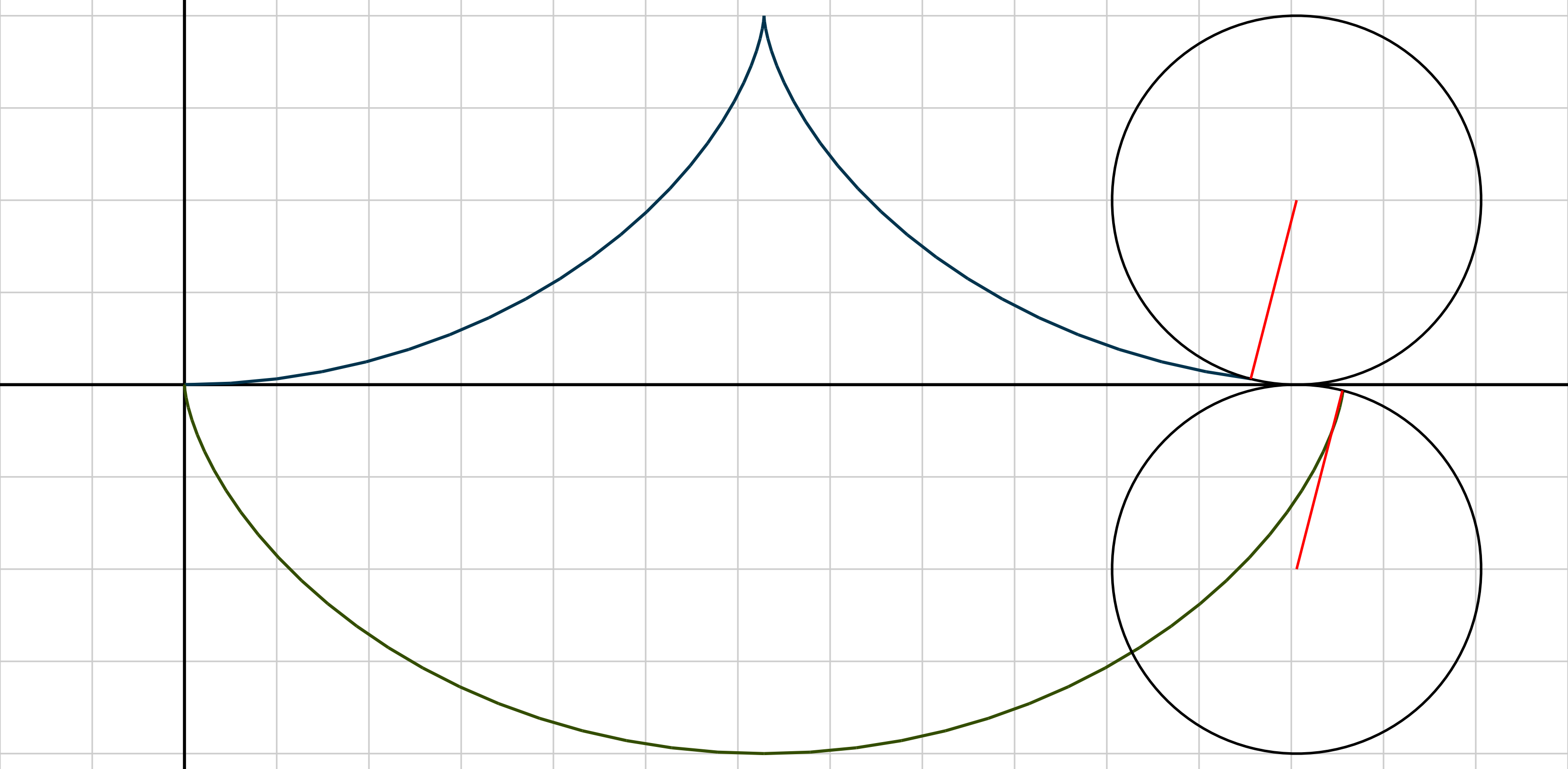

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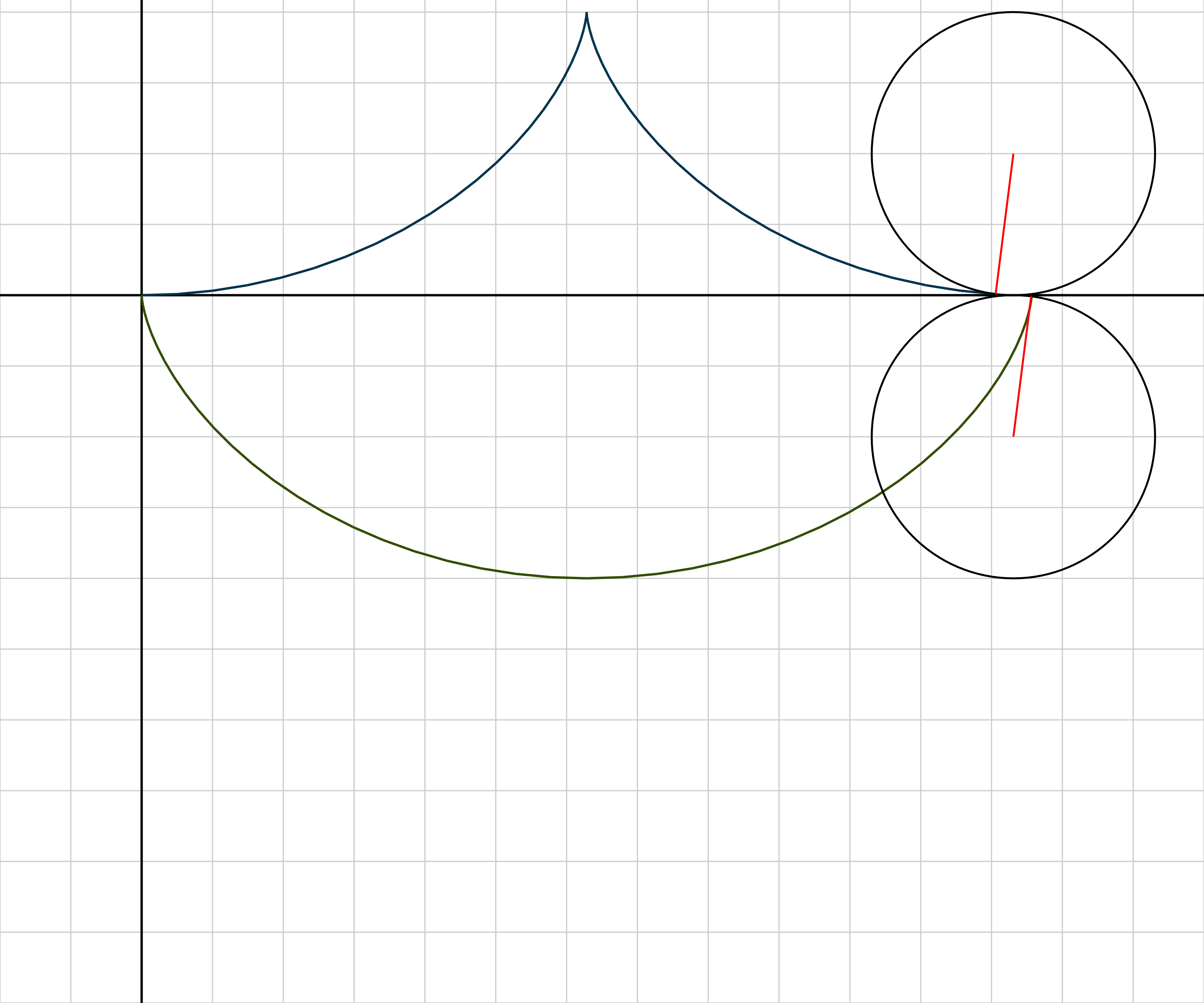

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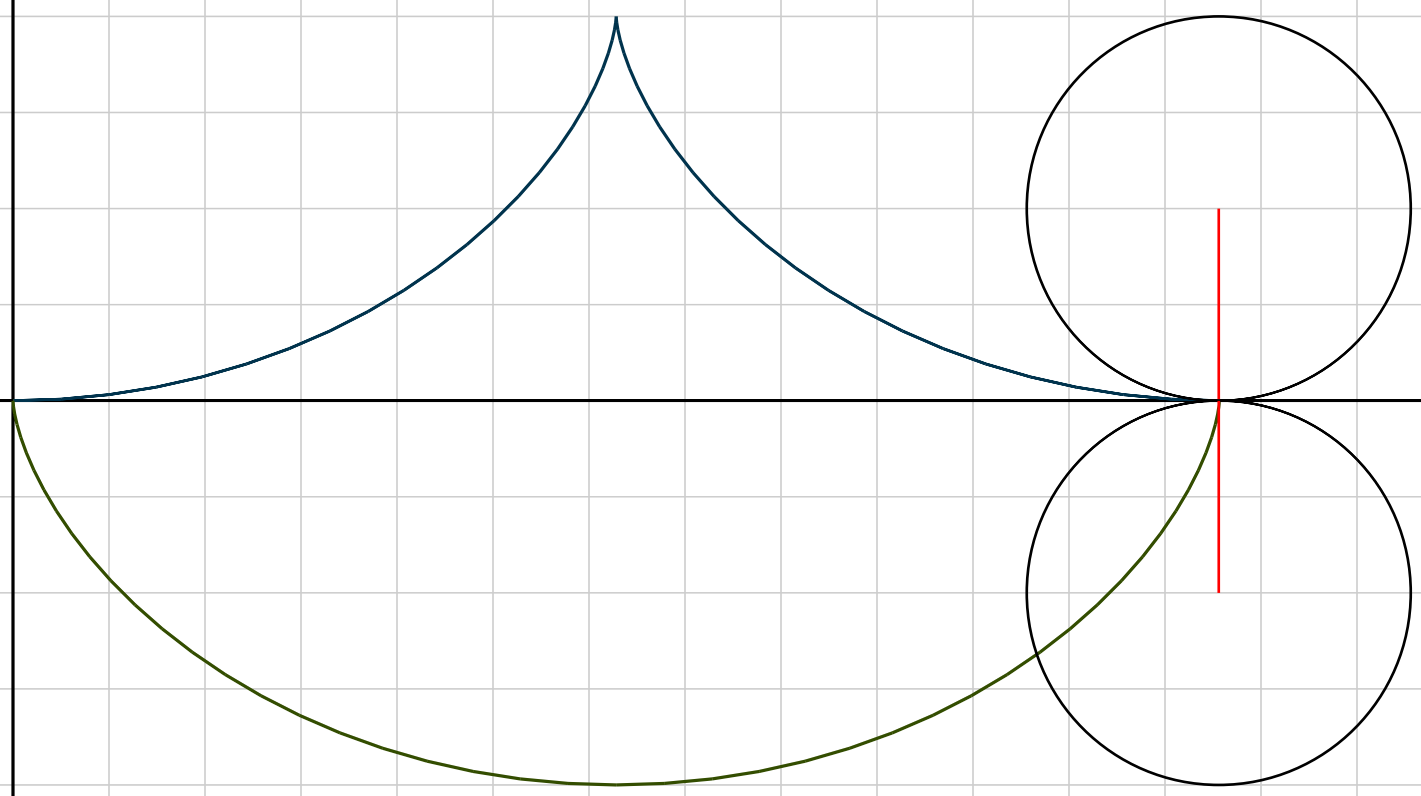

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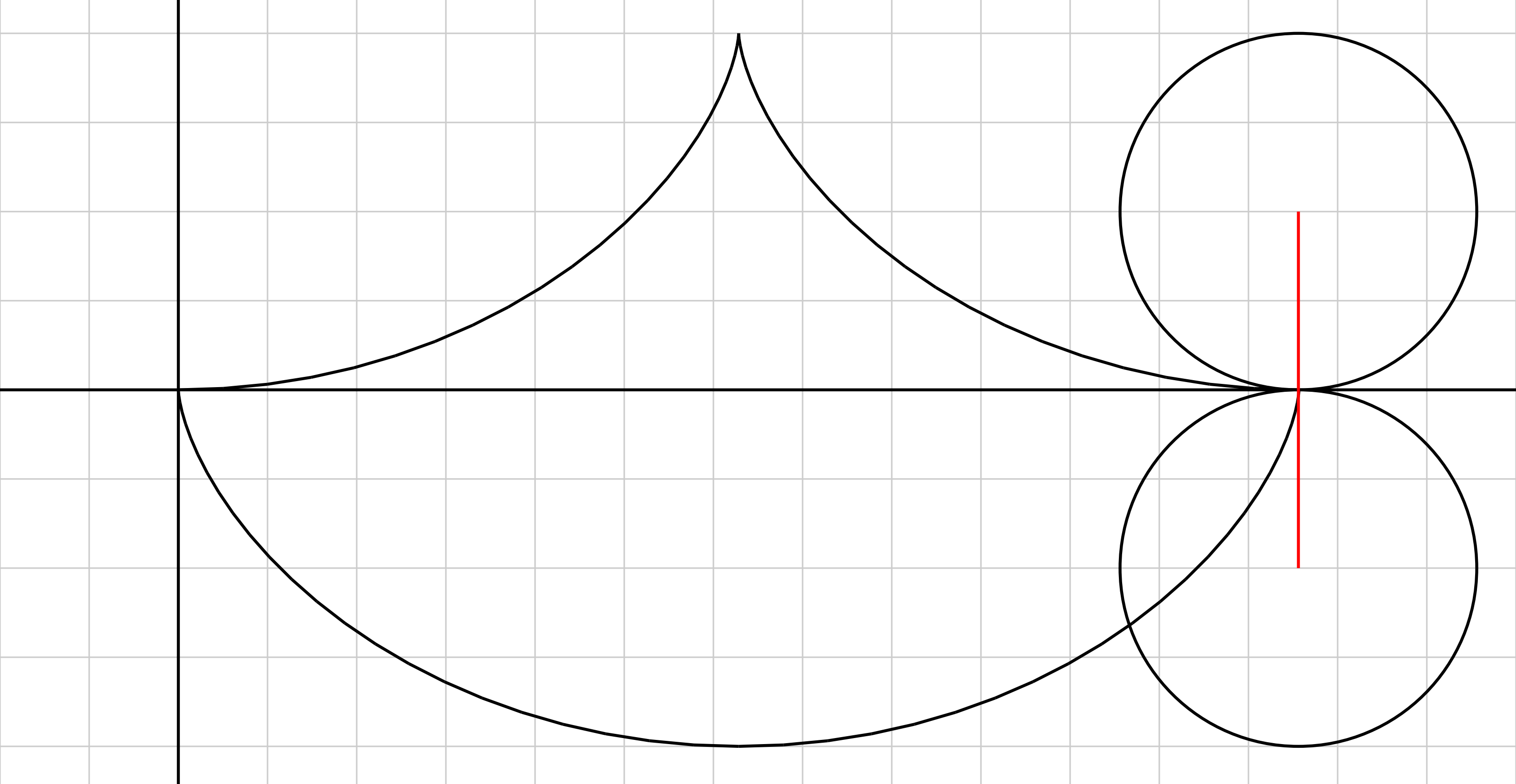
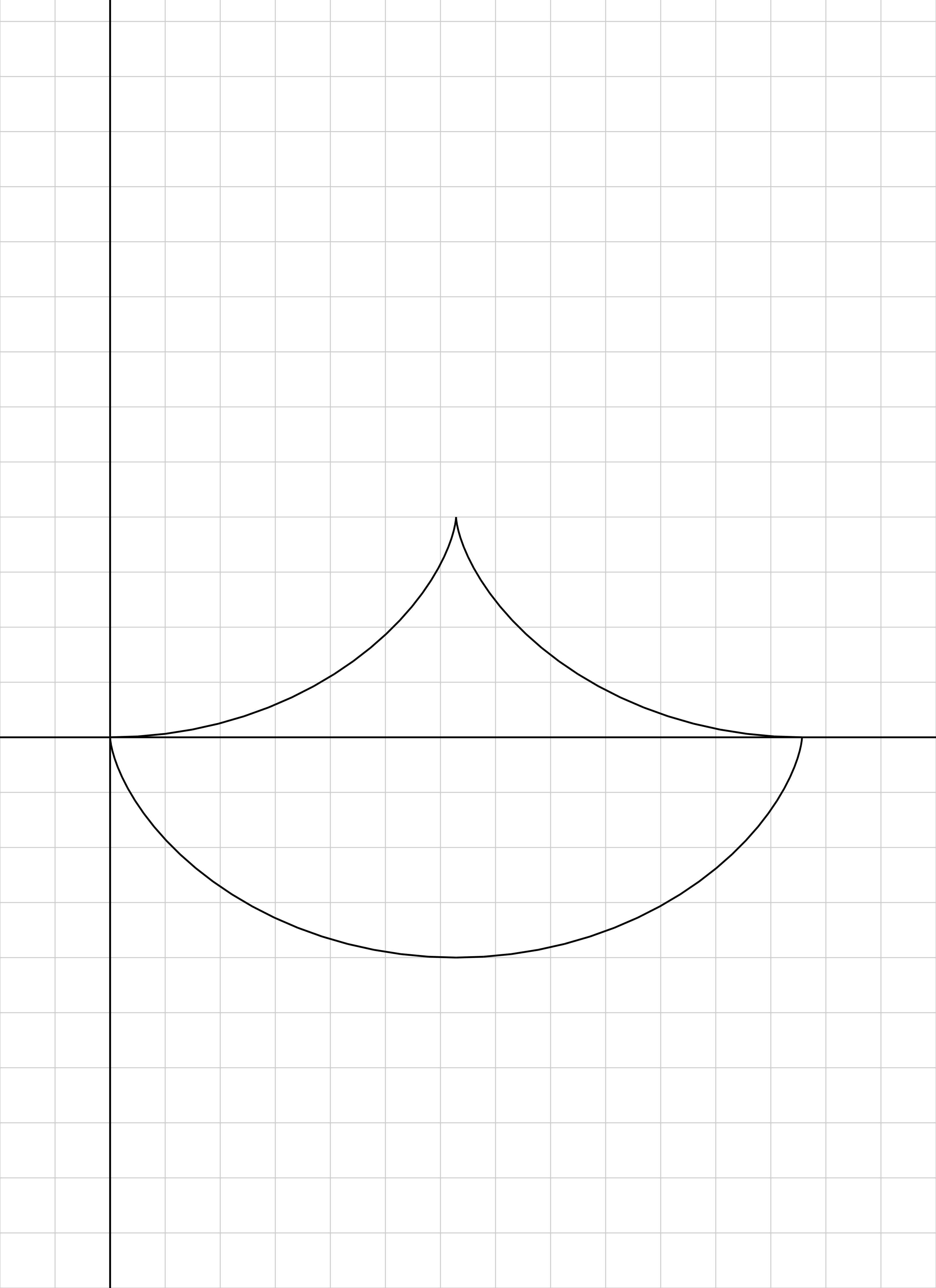
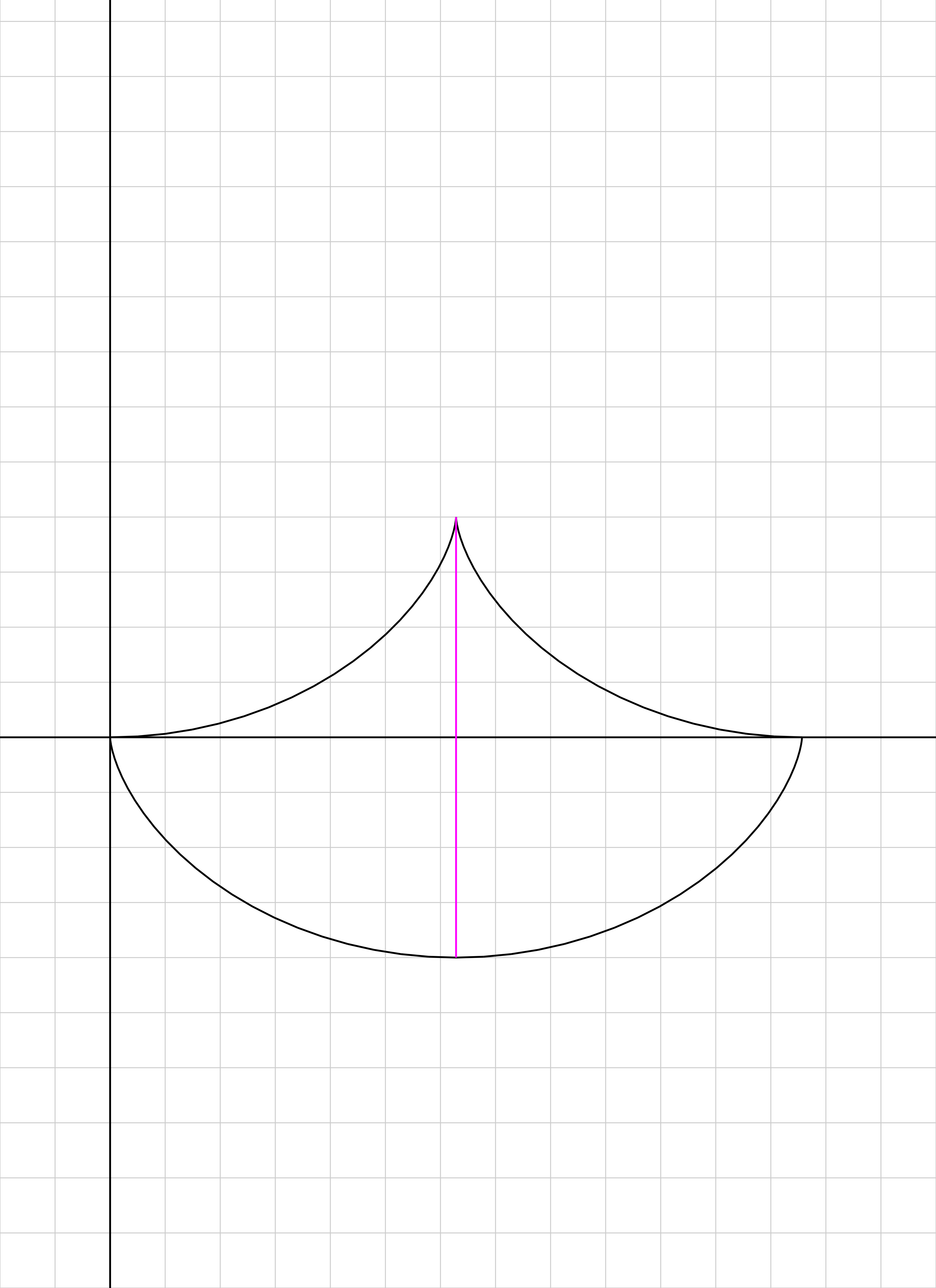
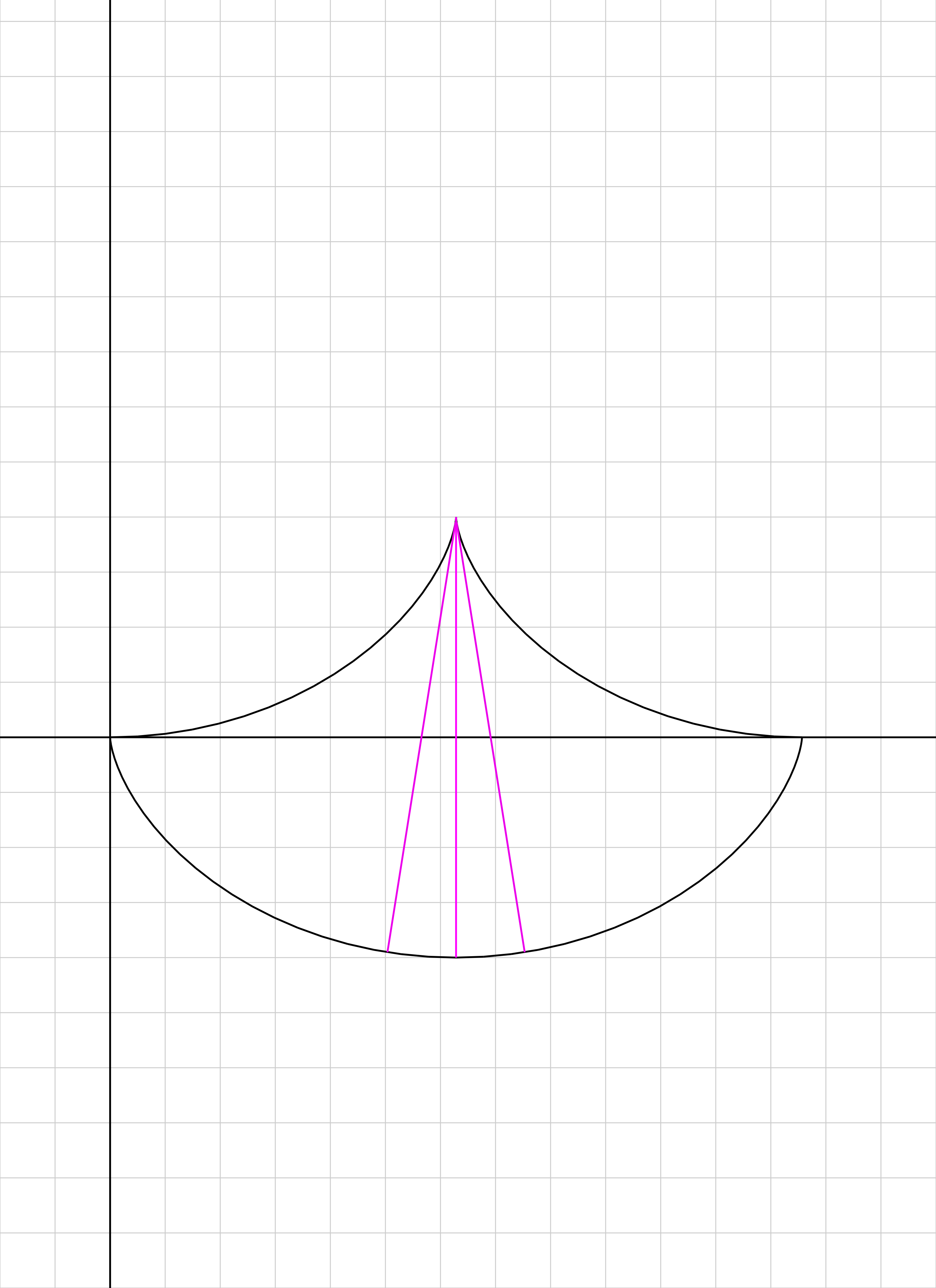
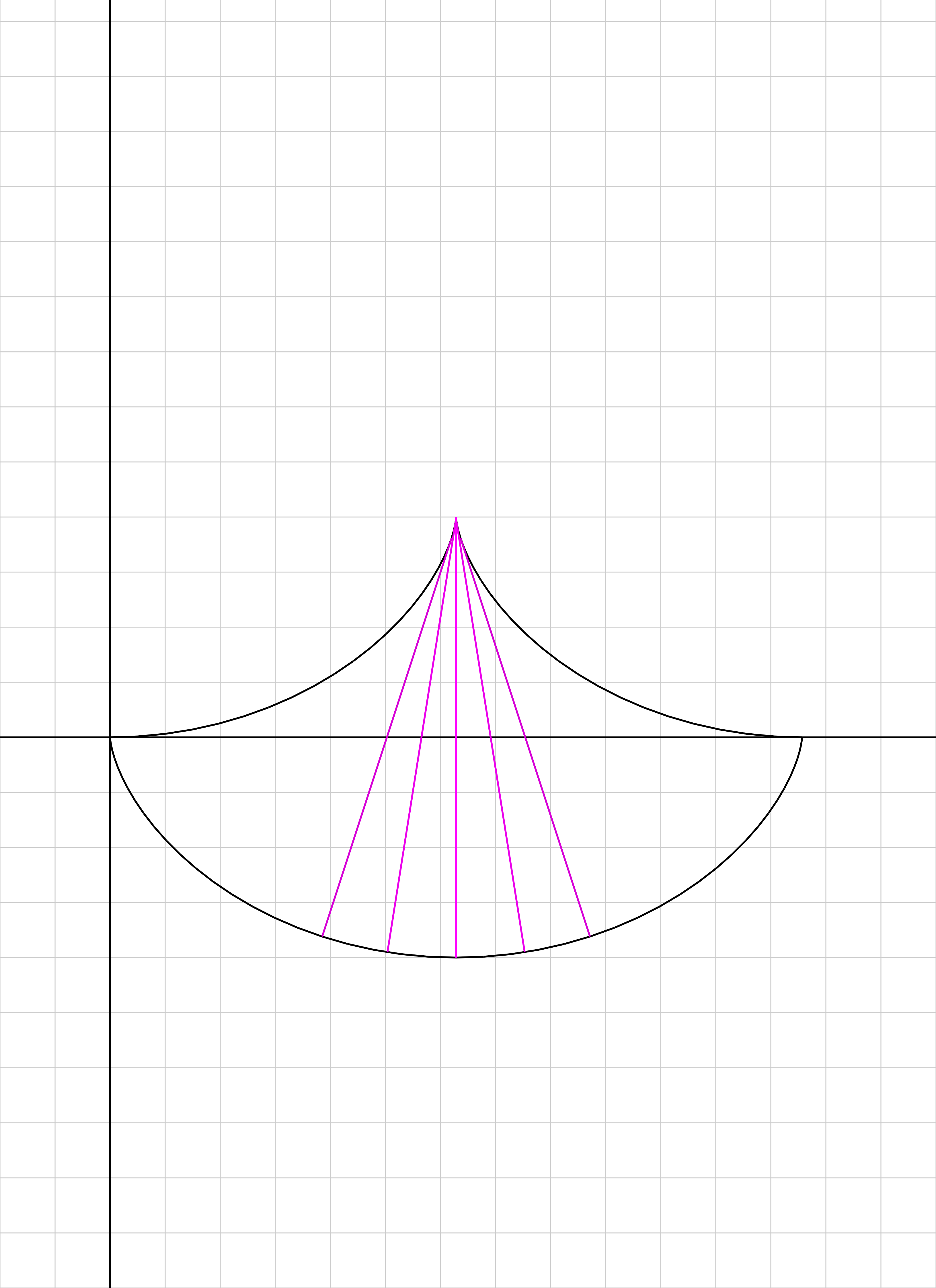
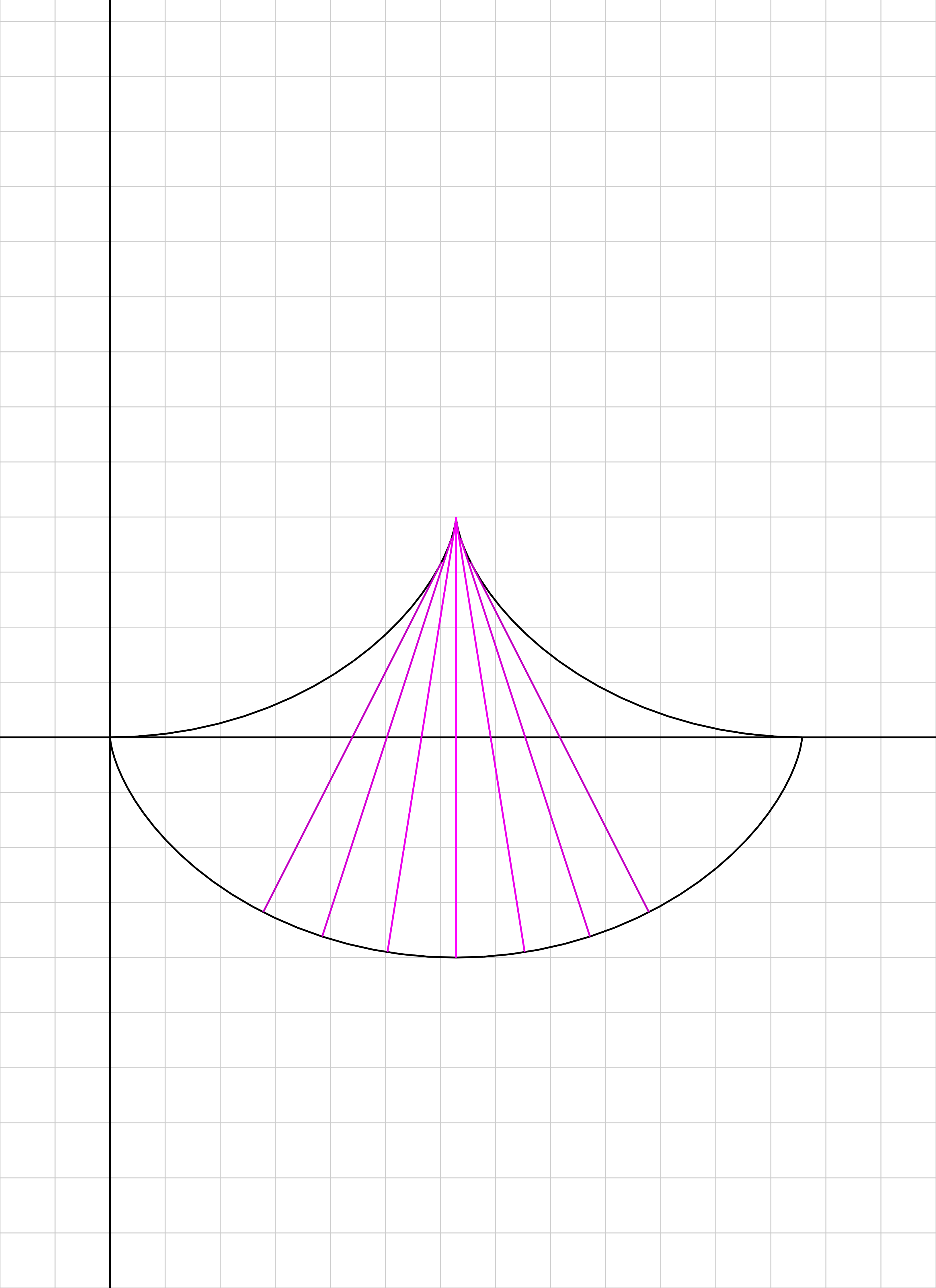


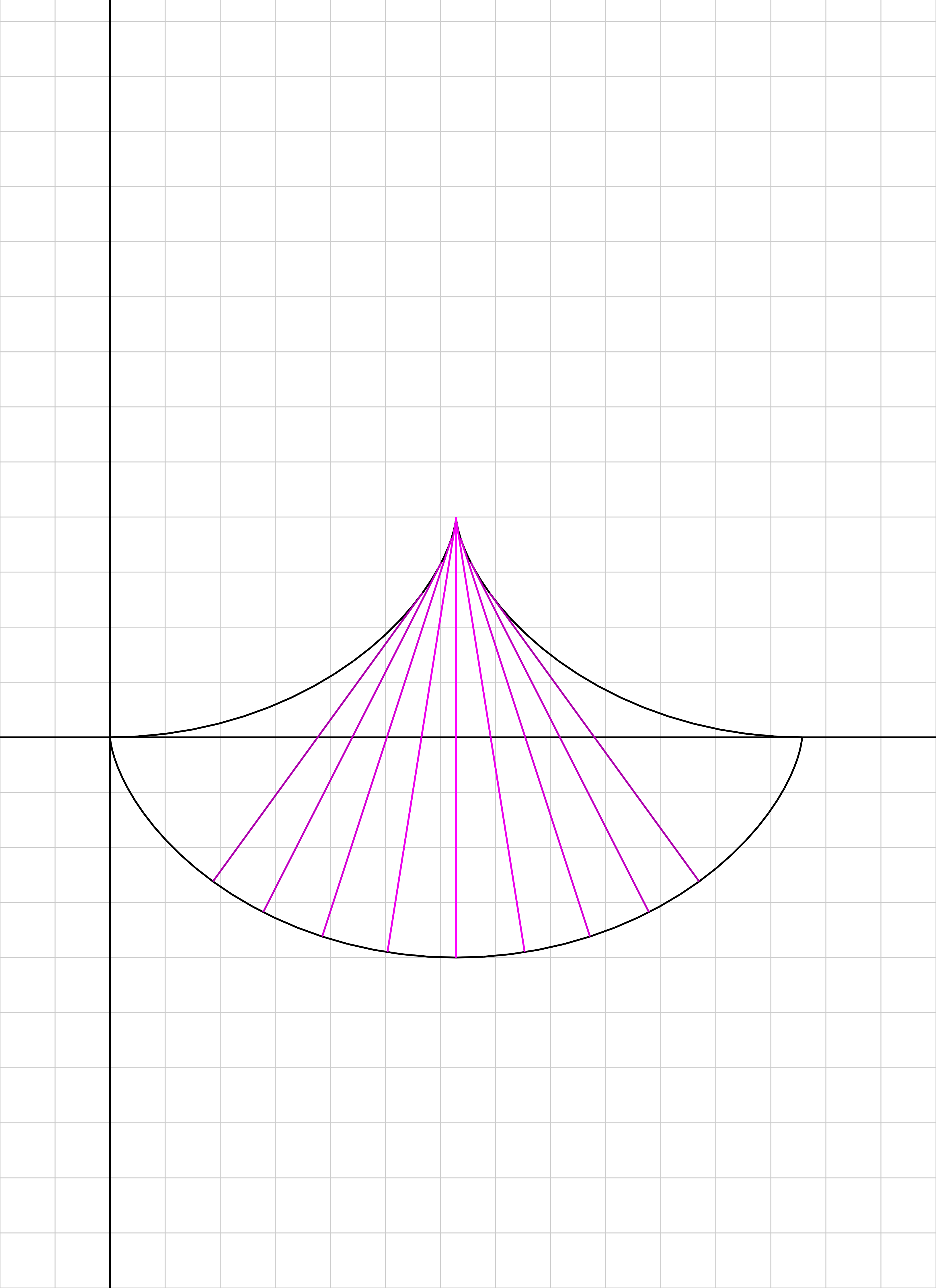


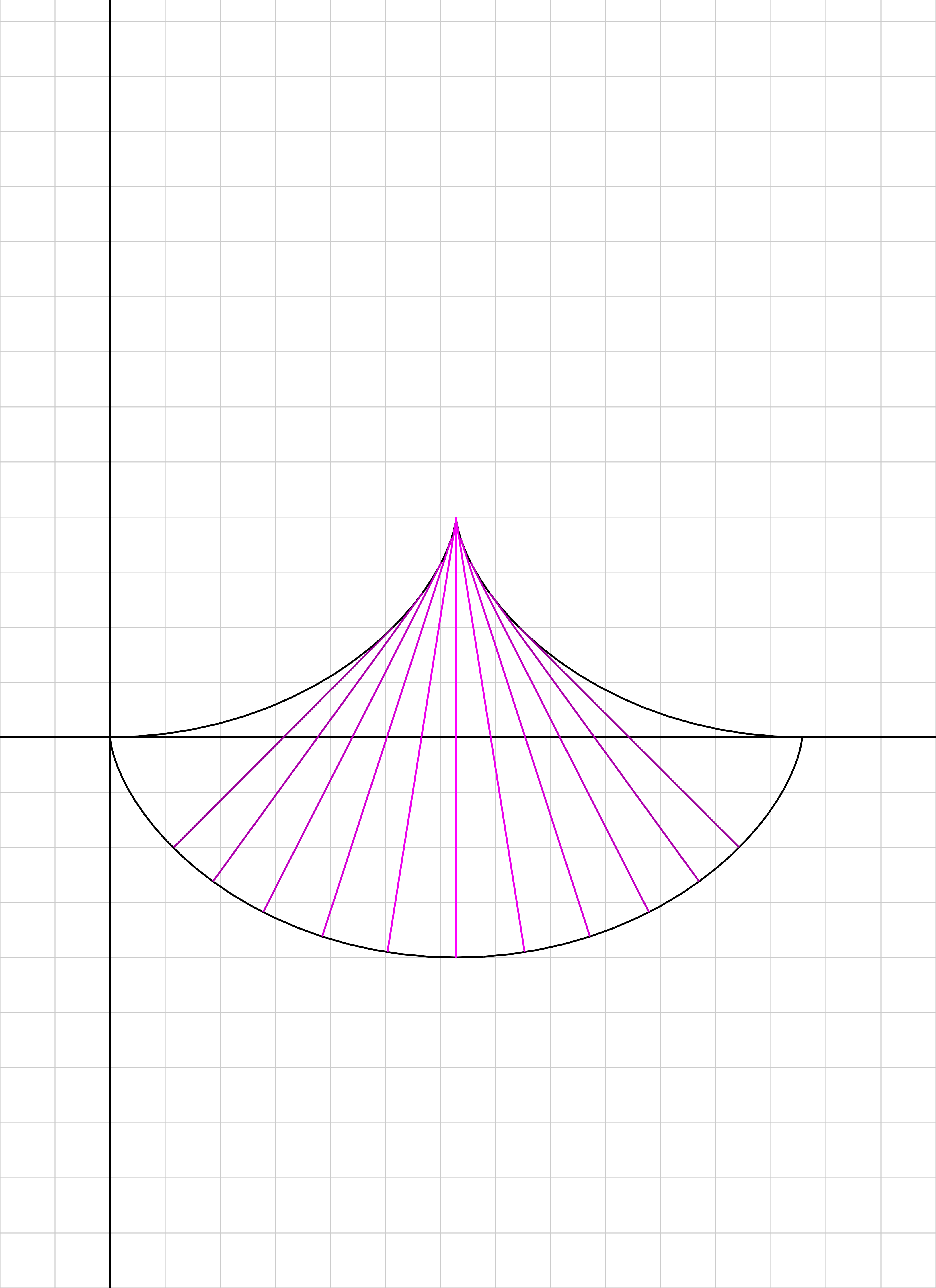


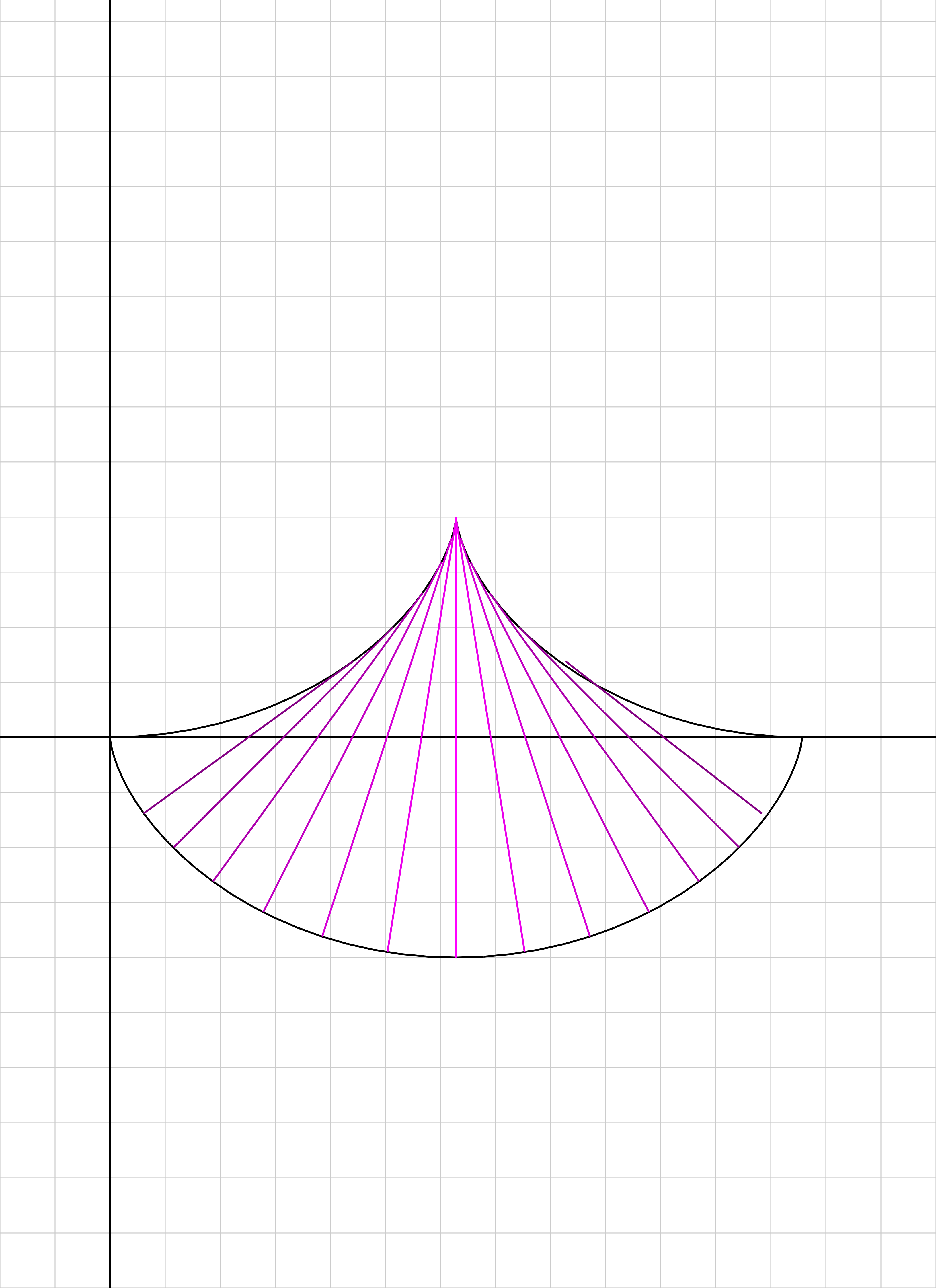


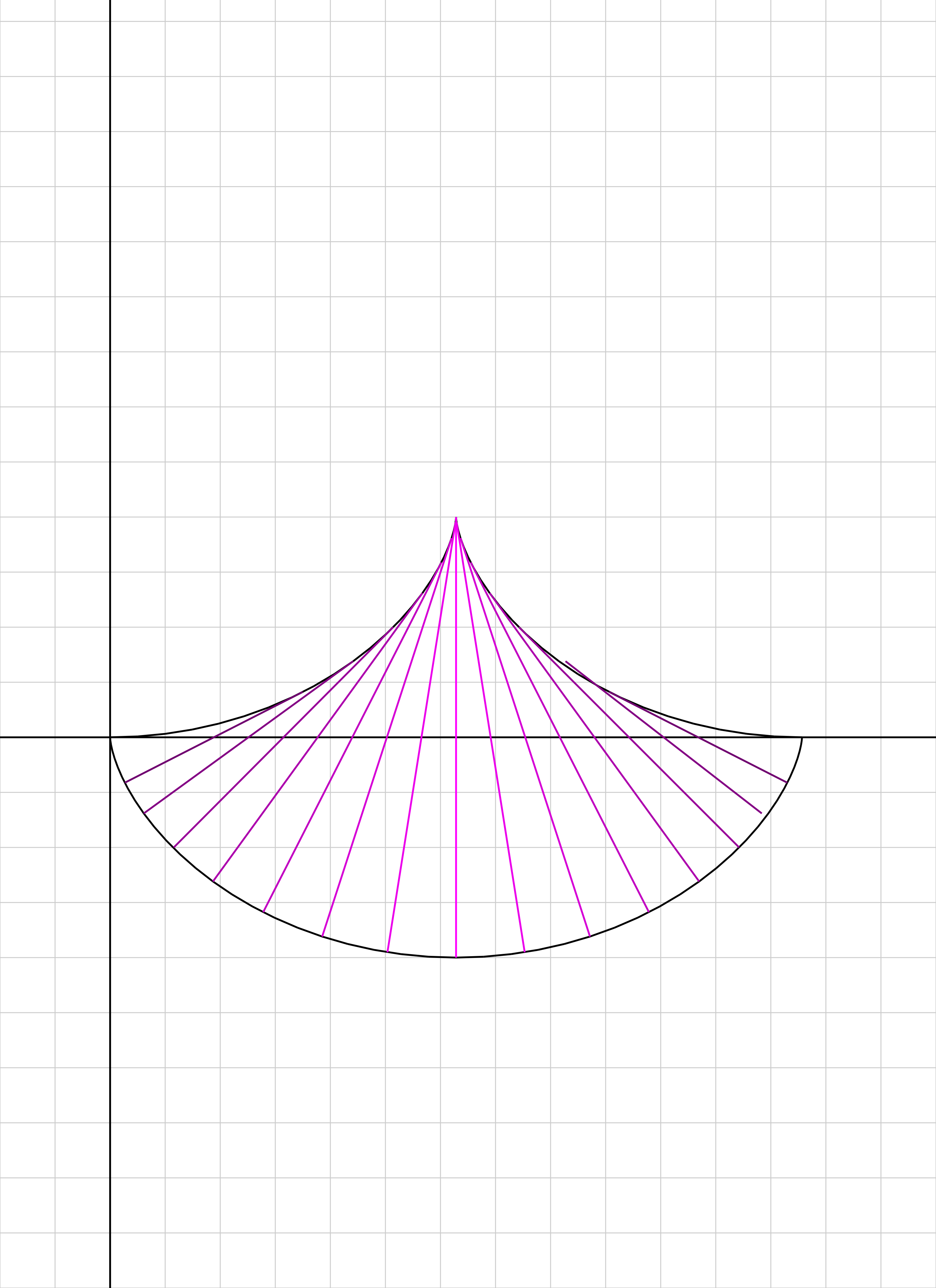


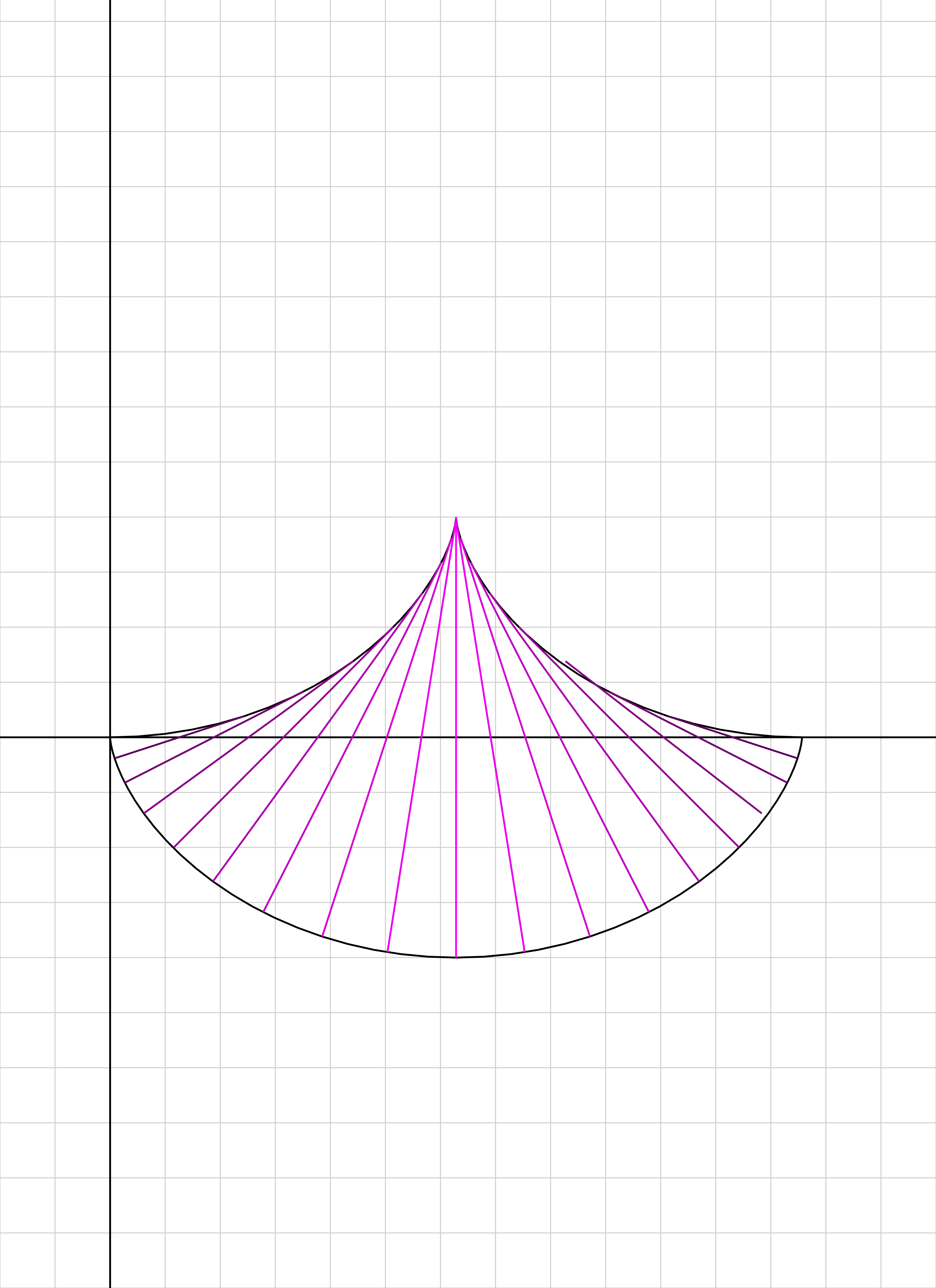


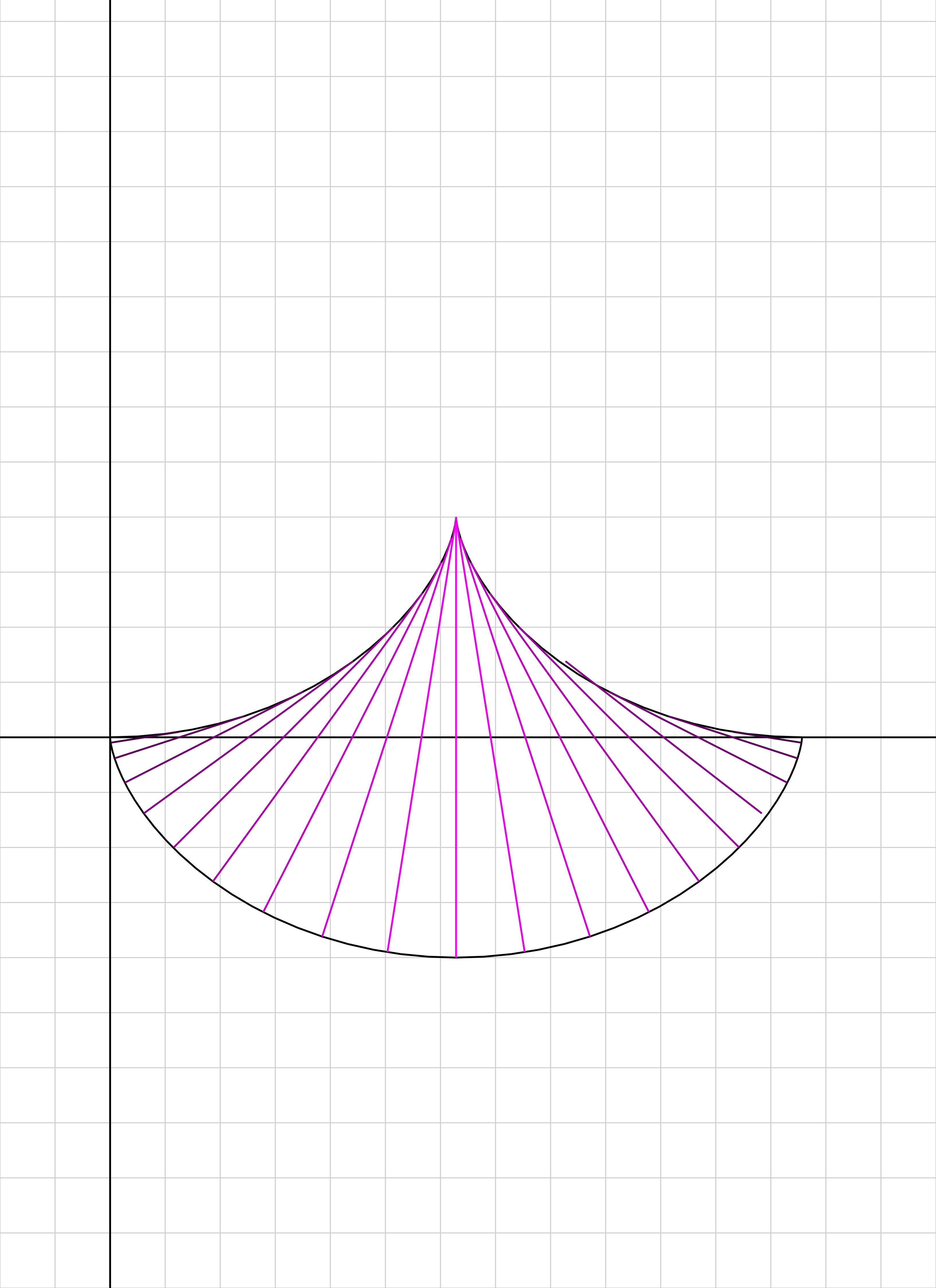


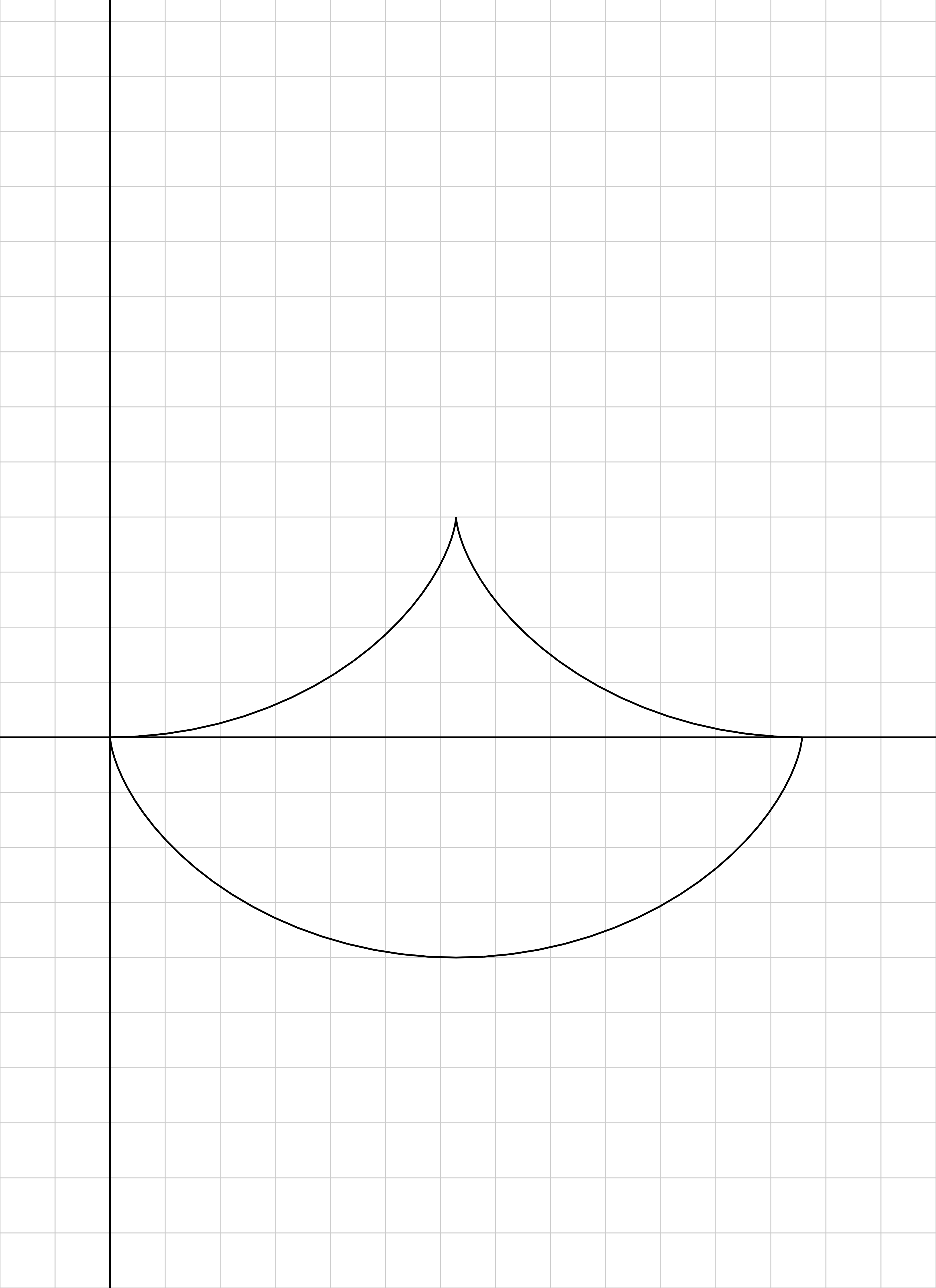


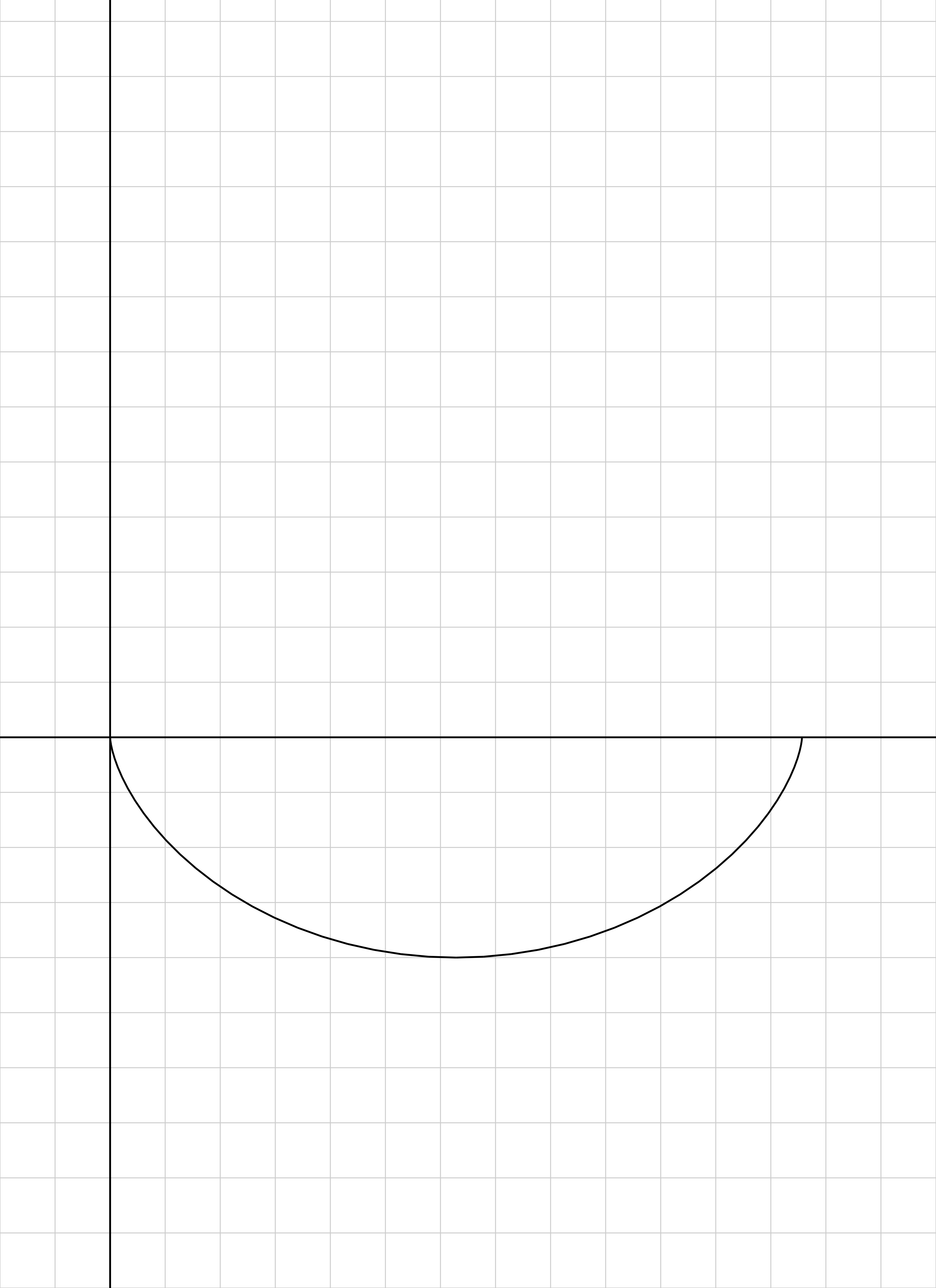


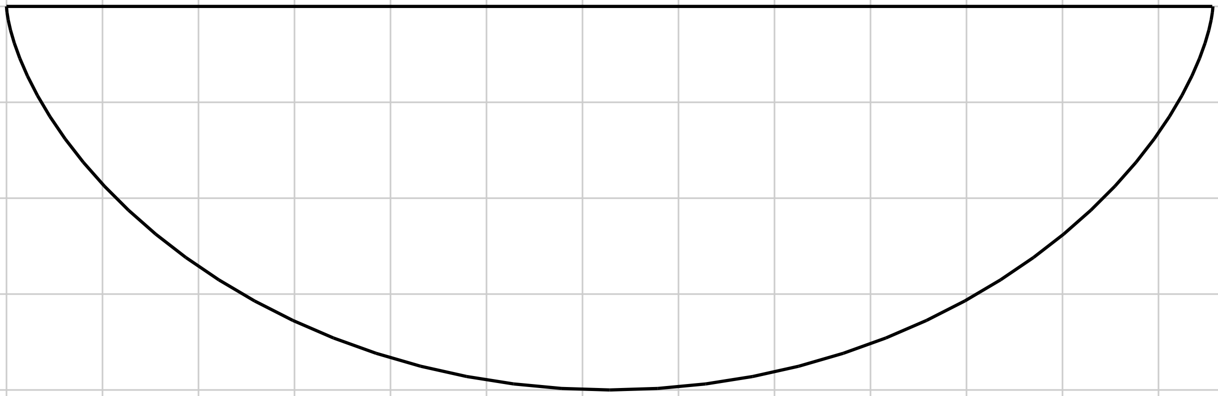


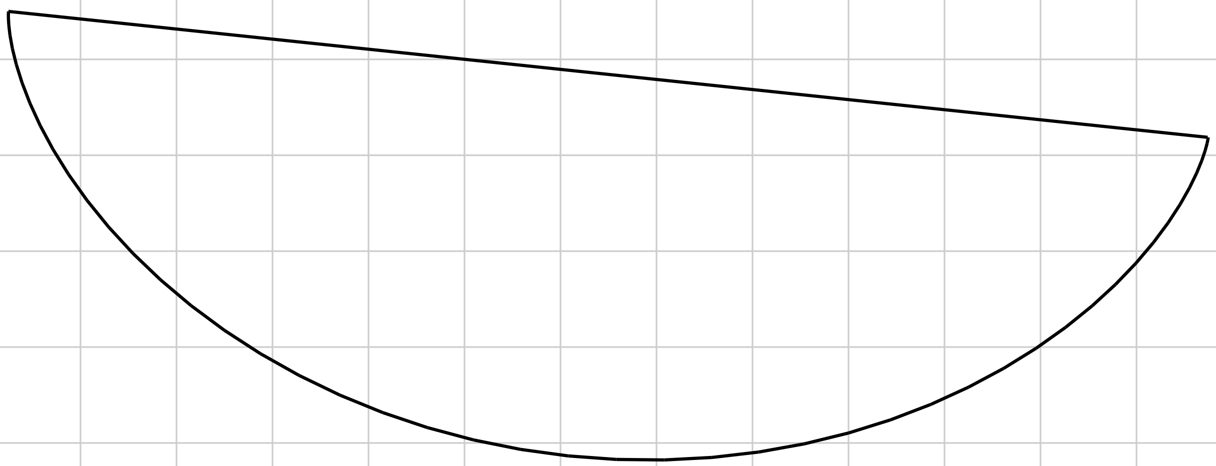


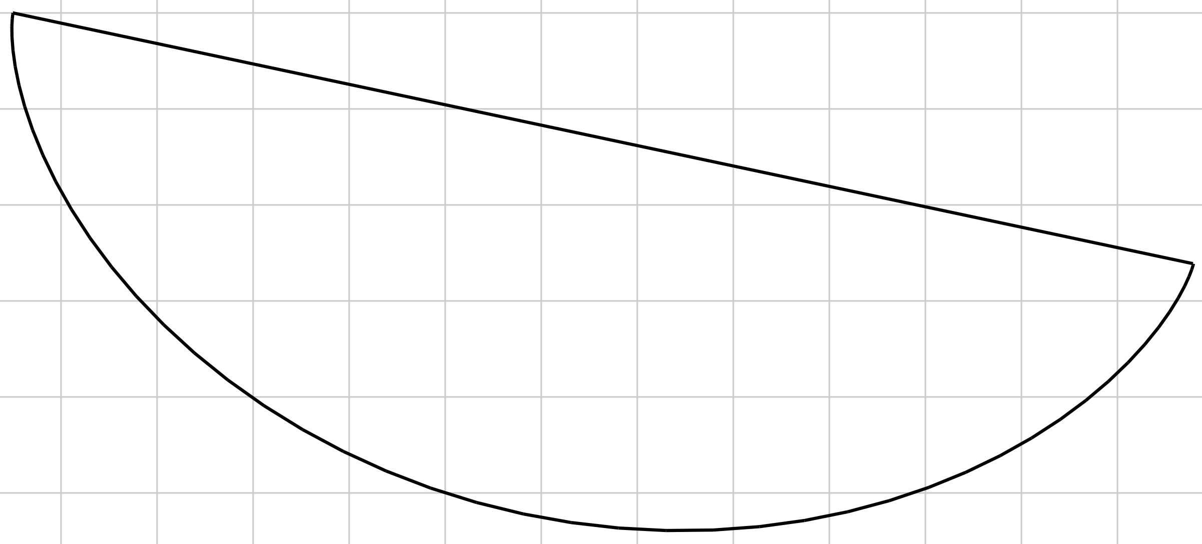


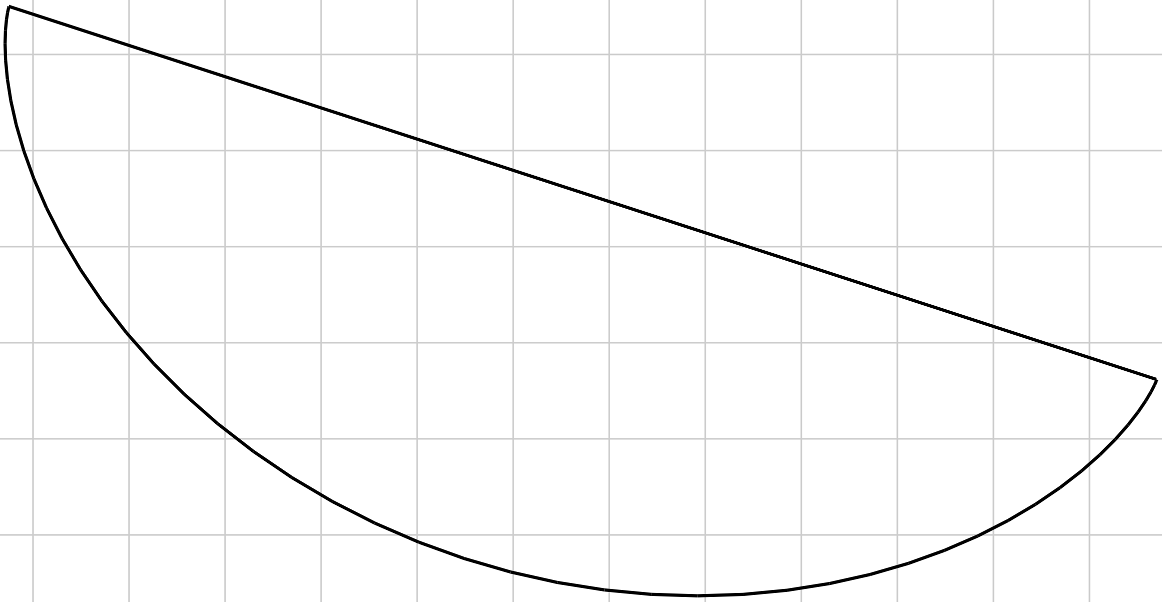


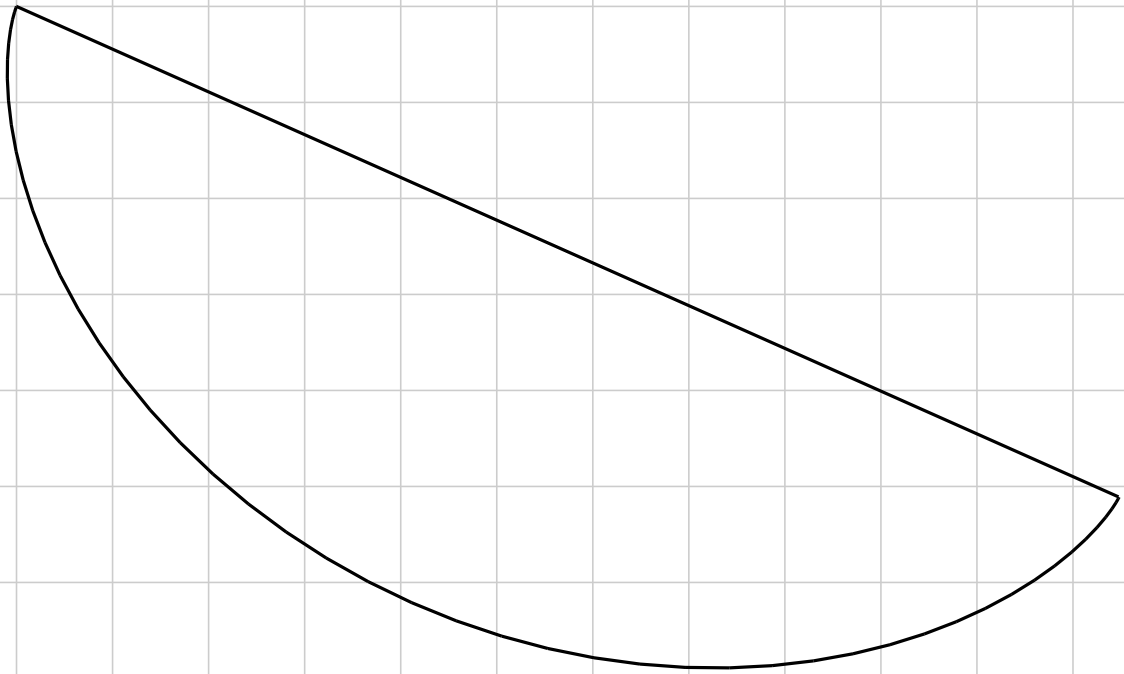


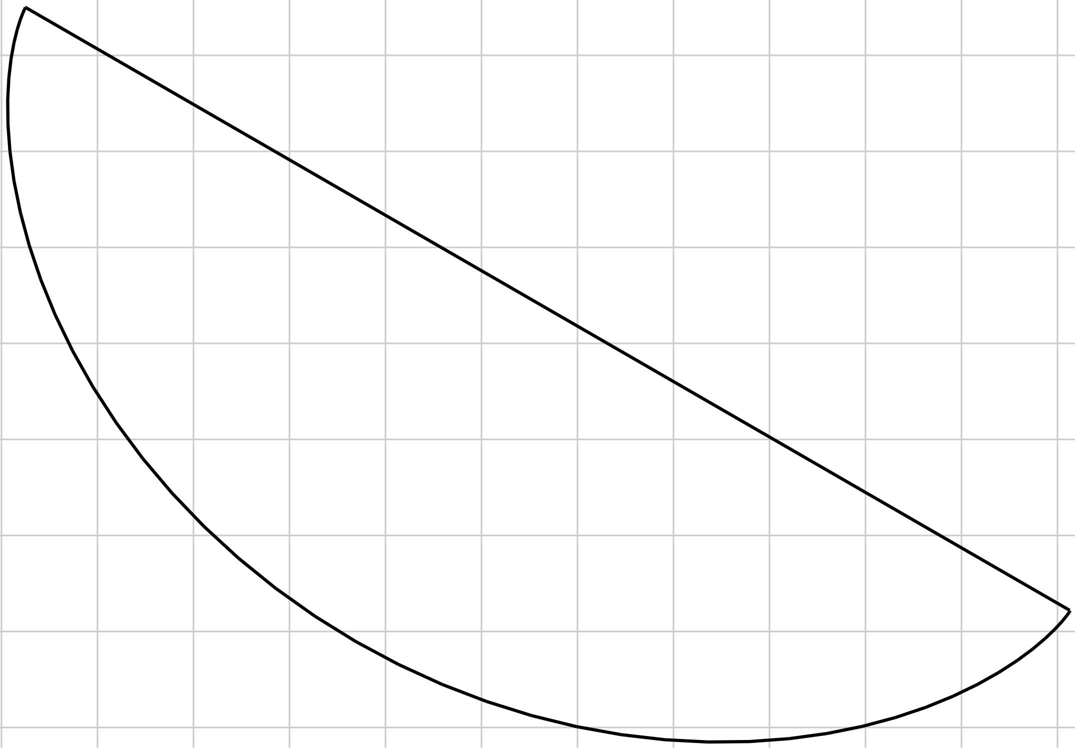


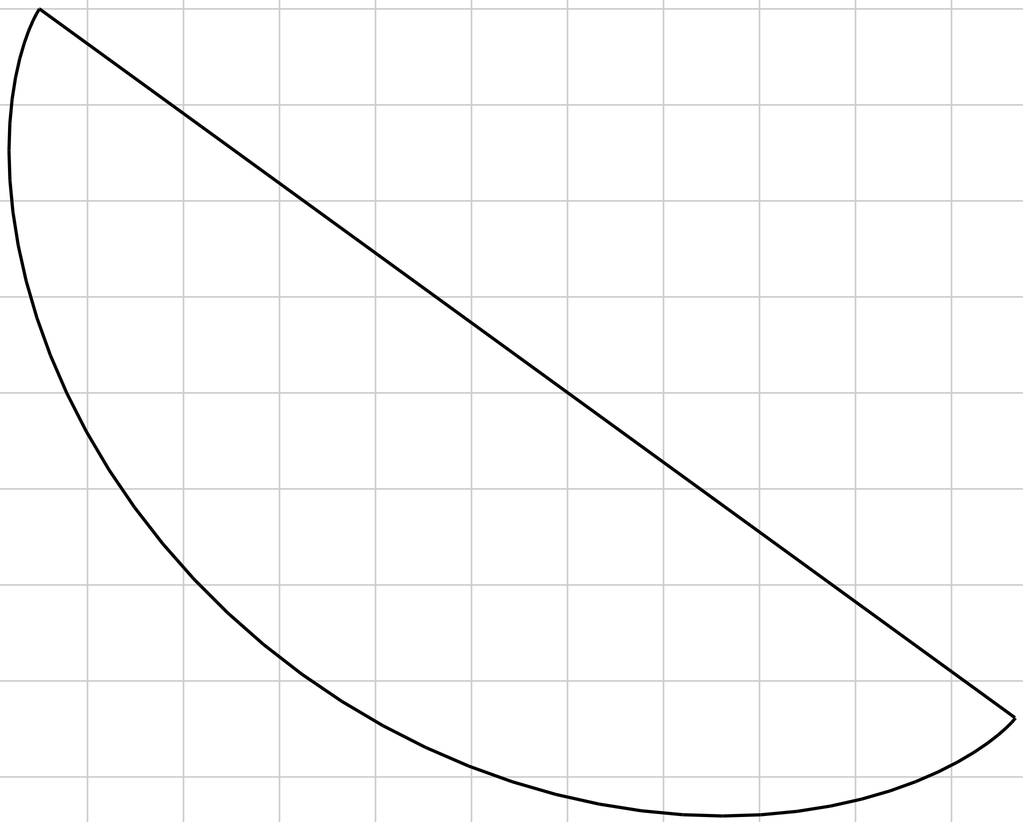


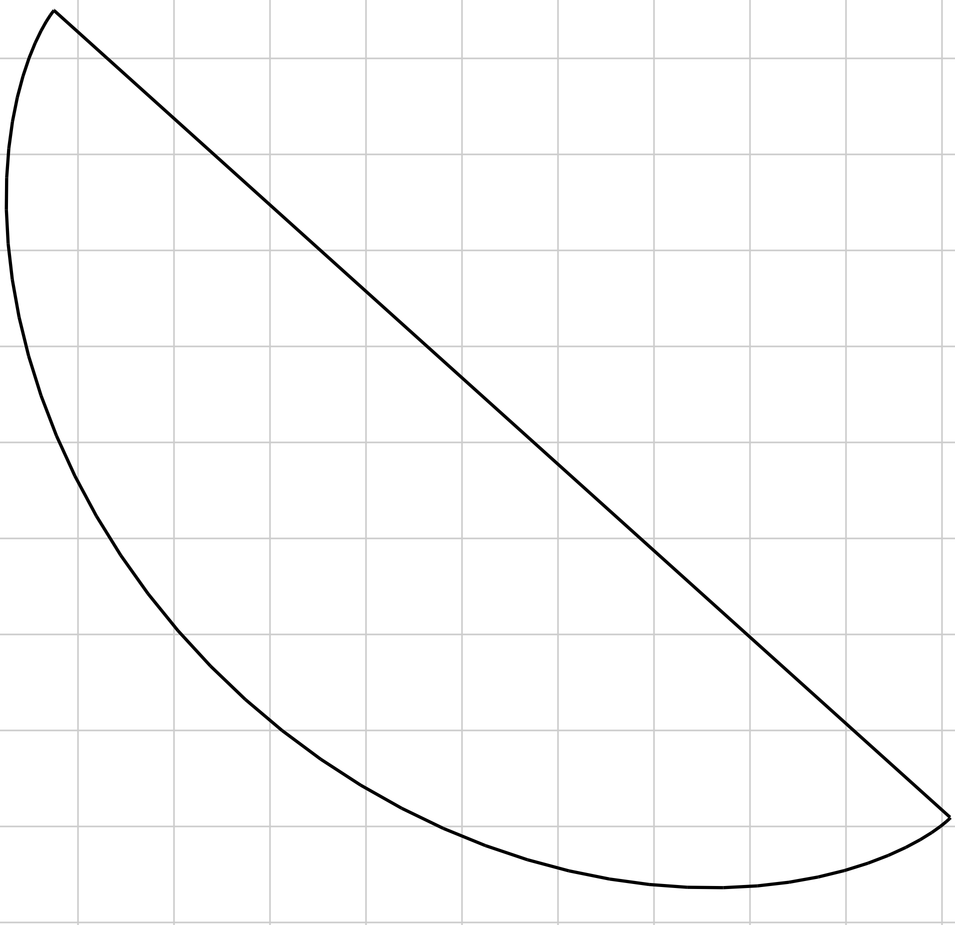


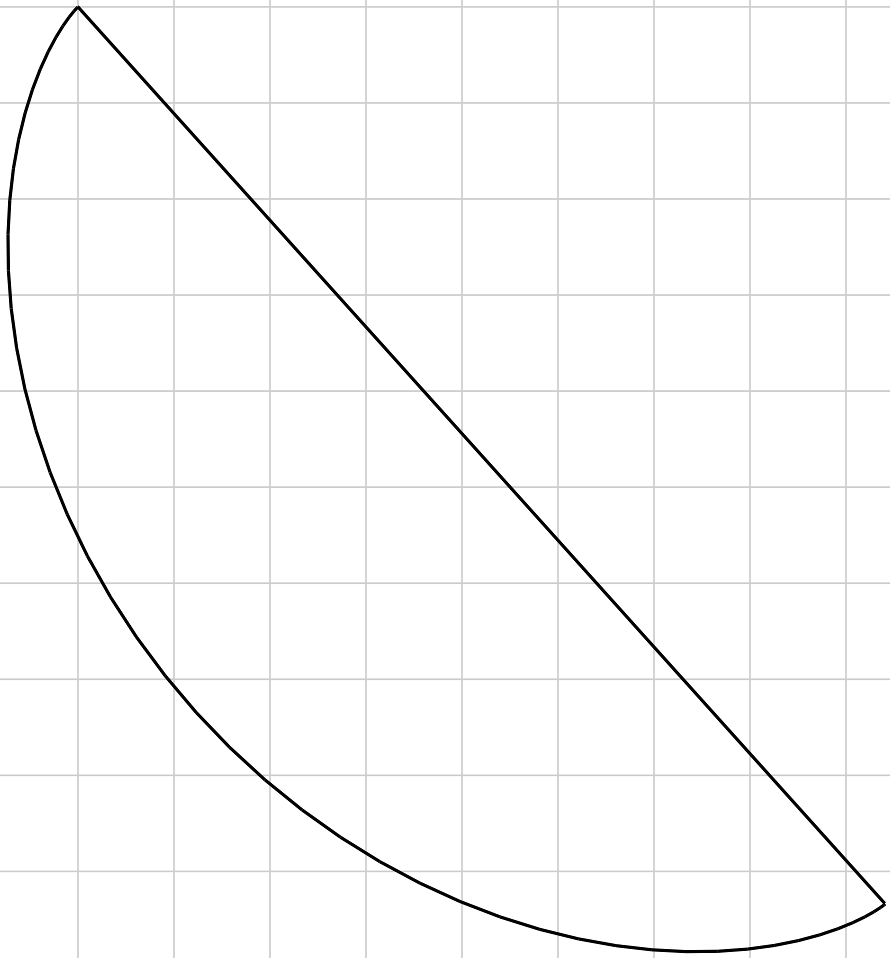


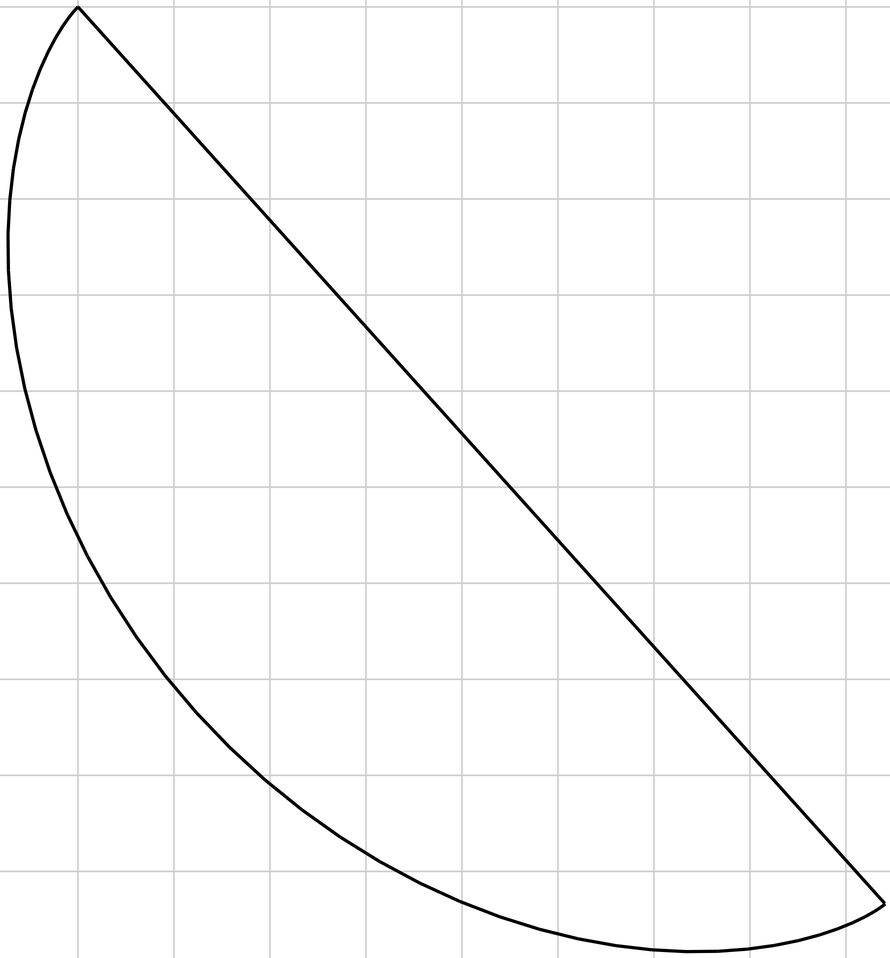


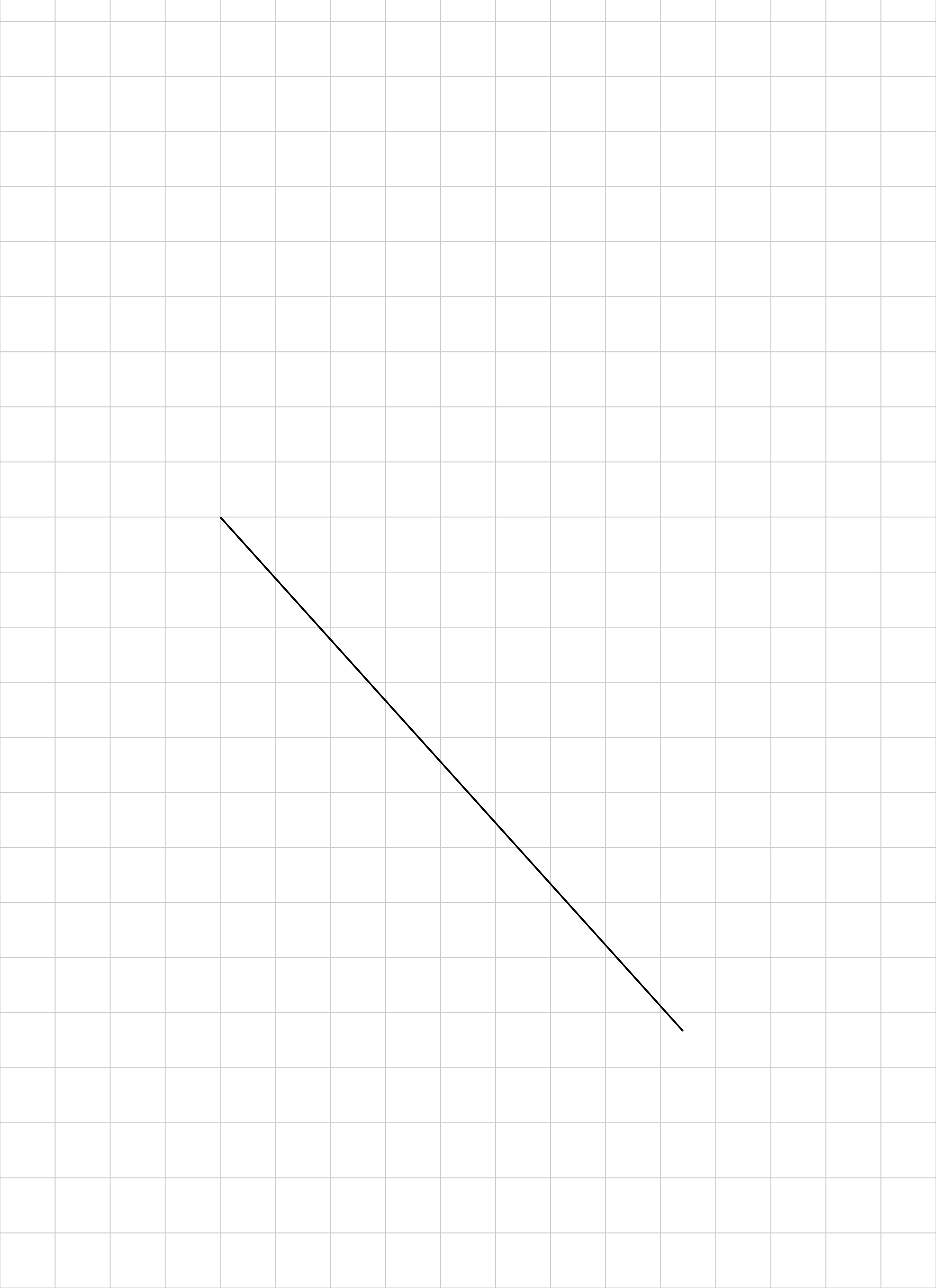


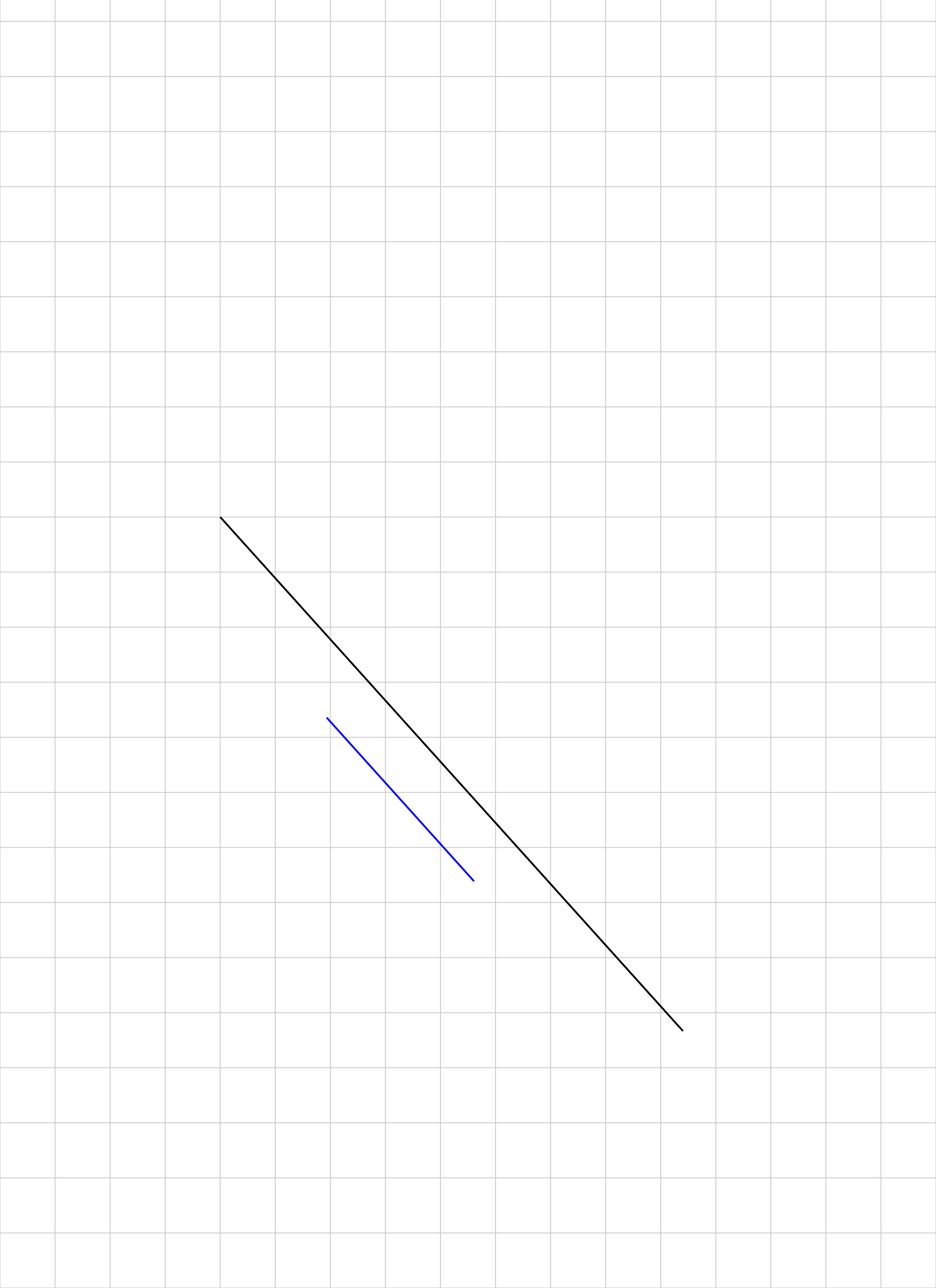


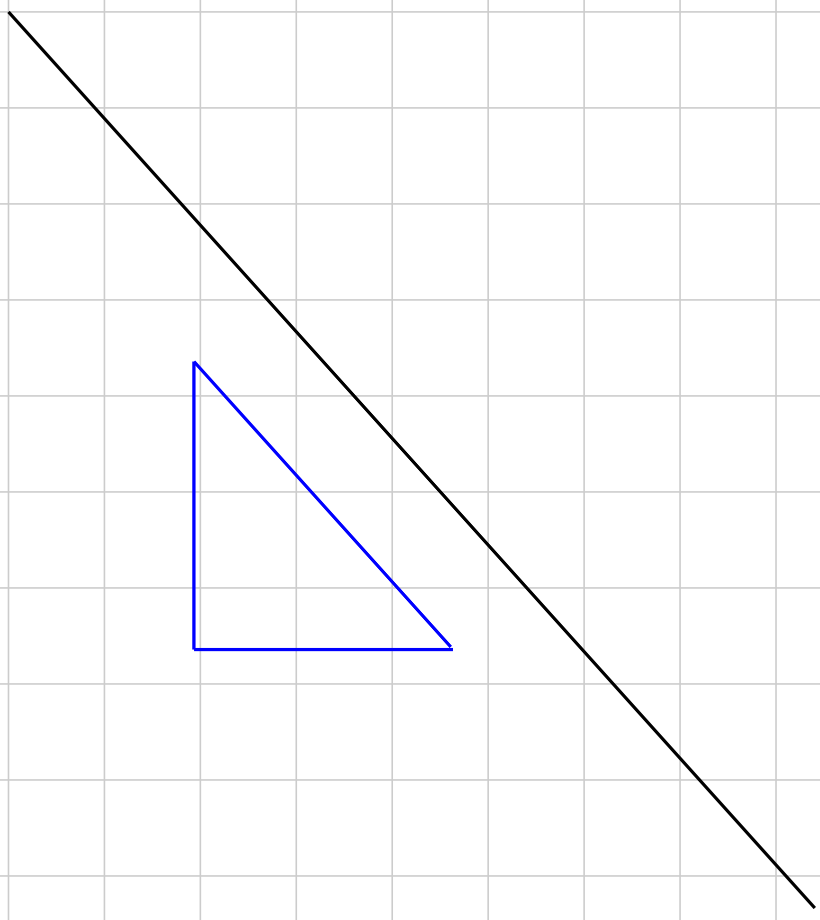


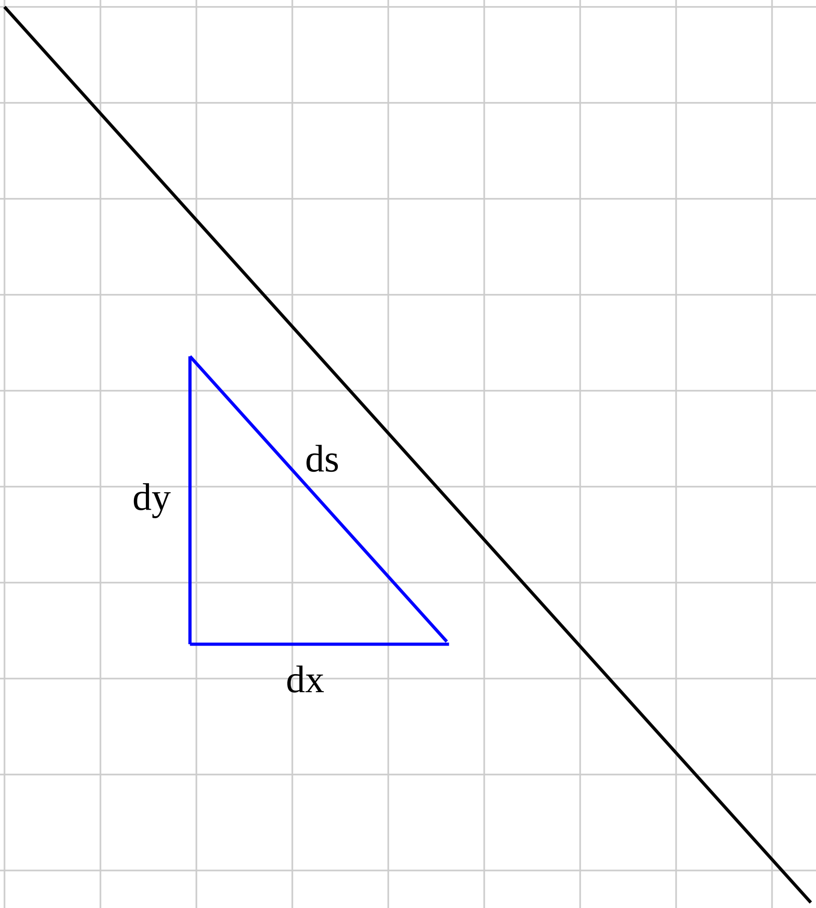


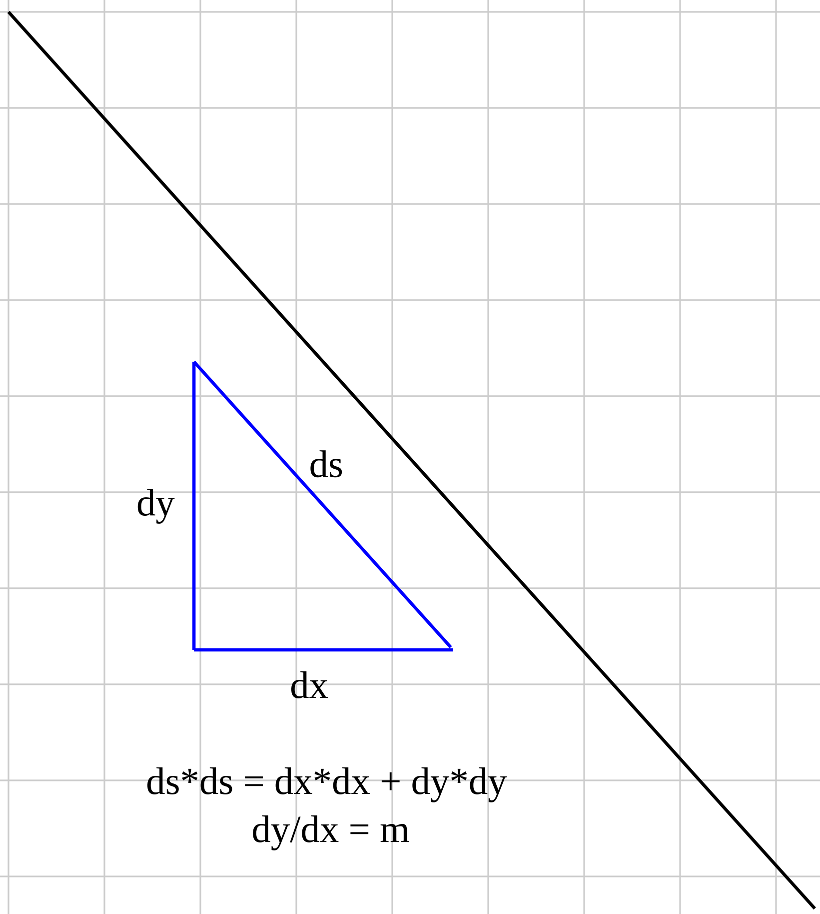






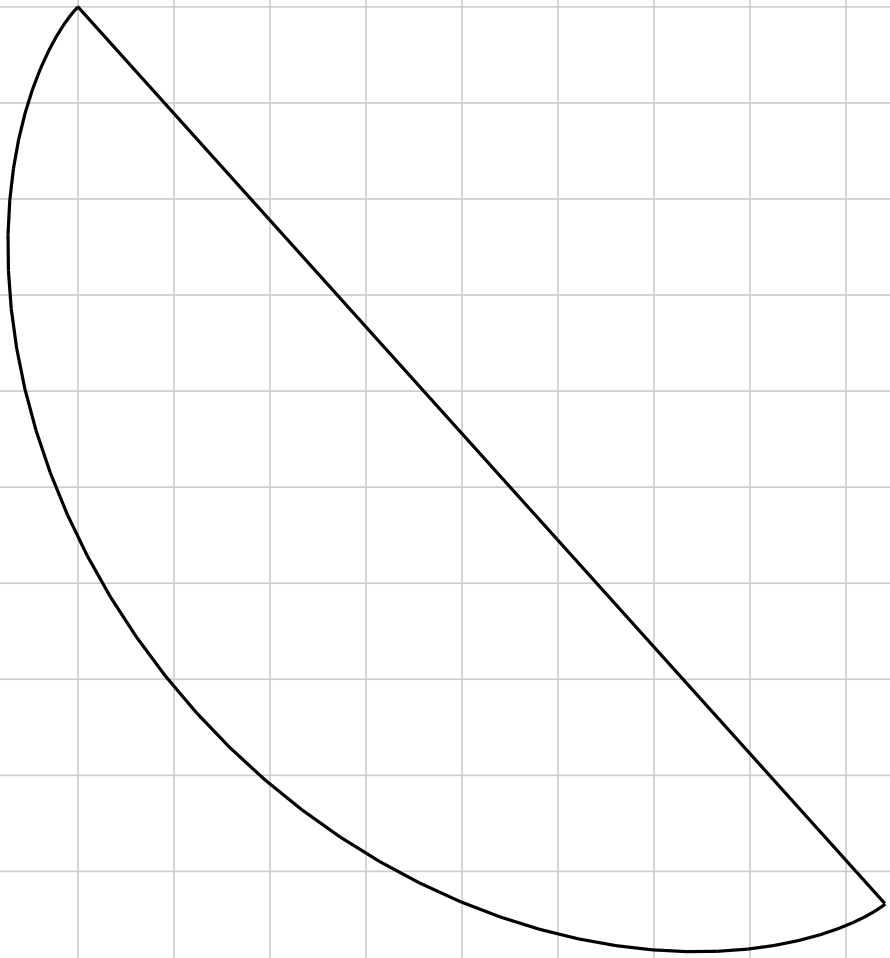


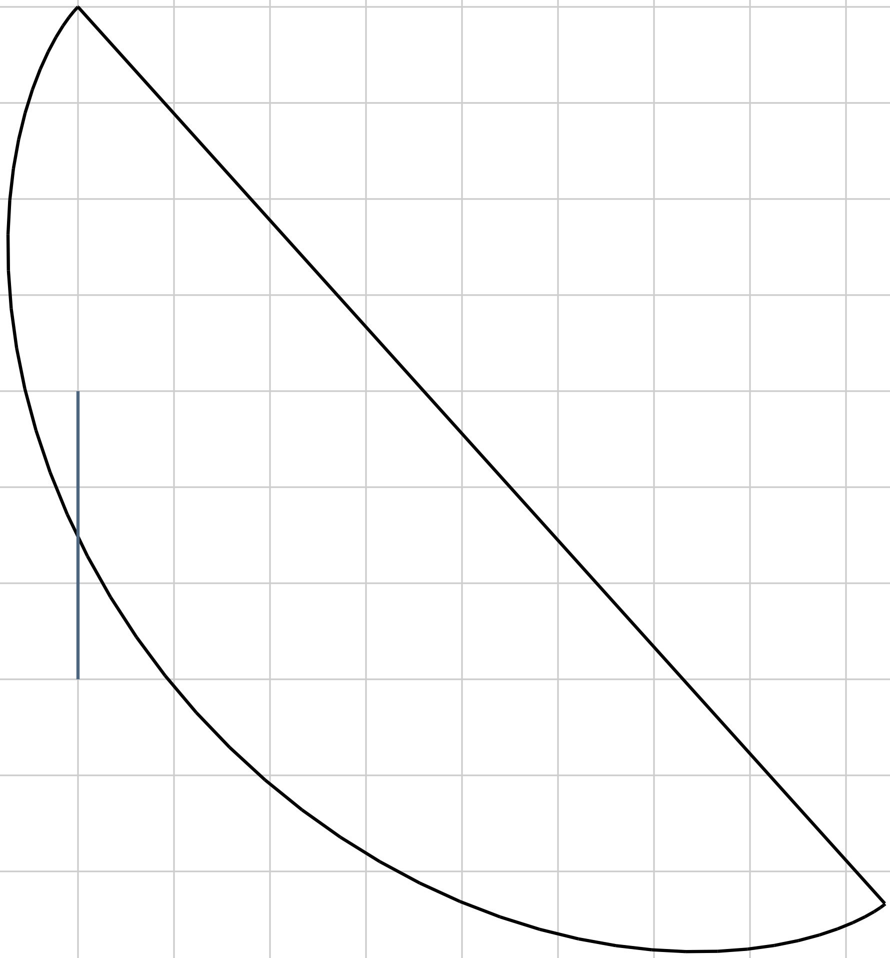

ds
dy
dx

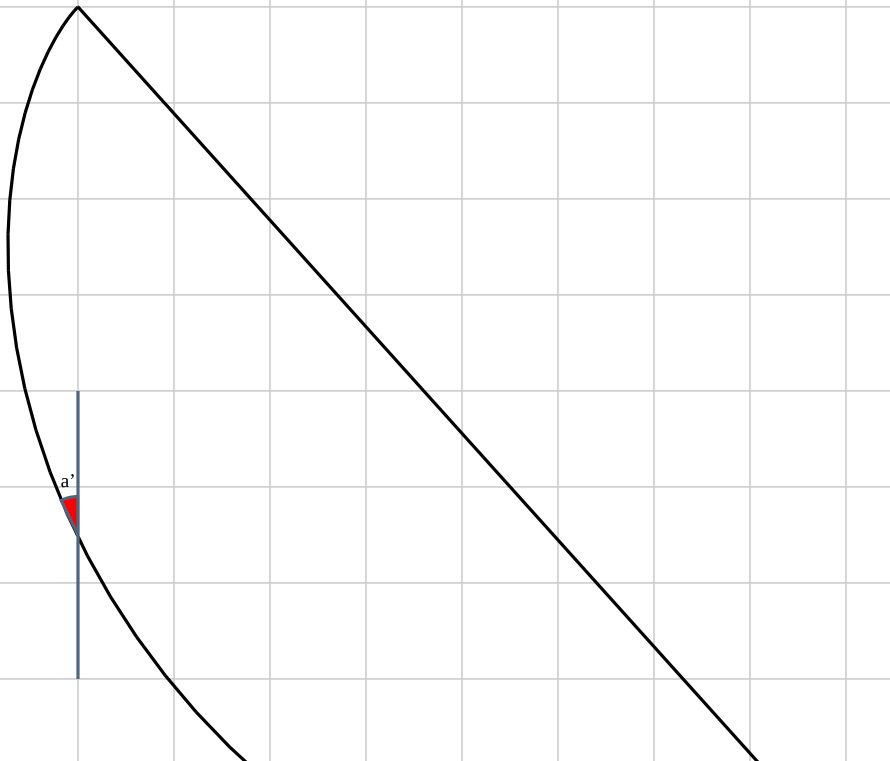


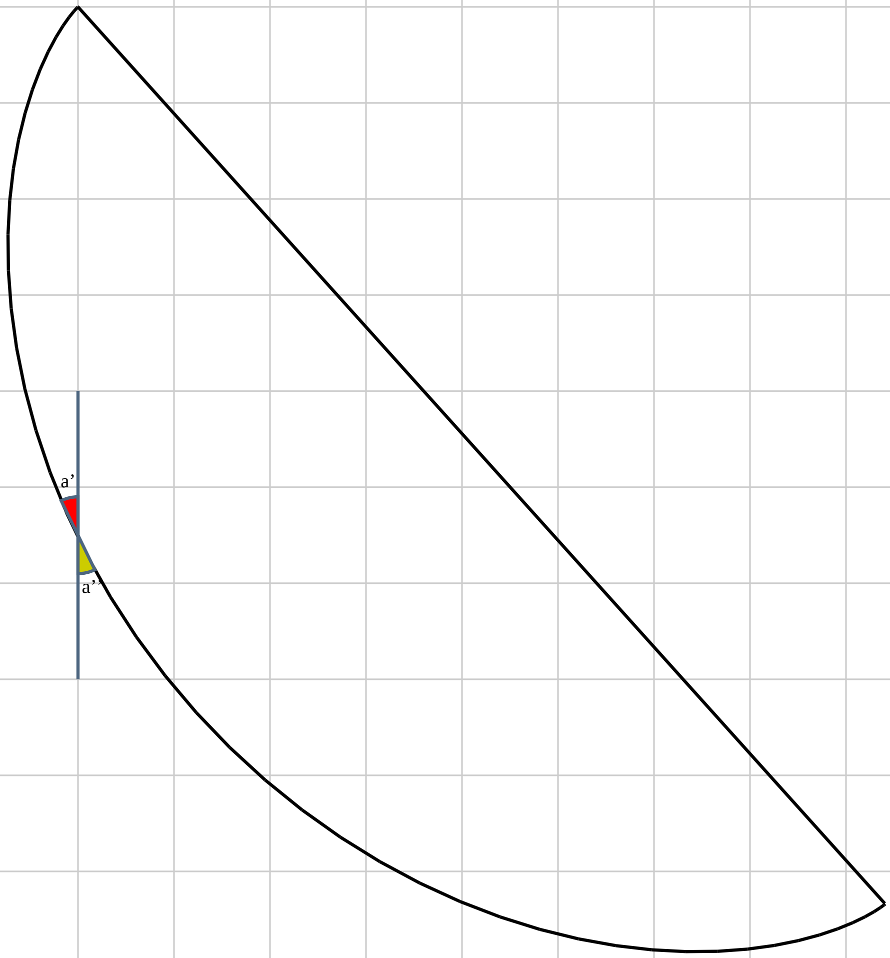
$$ds*ds = dx*dx + dy*dy$$
$$dy/dx = m$$

Cycloid as Brachistochrone






a'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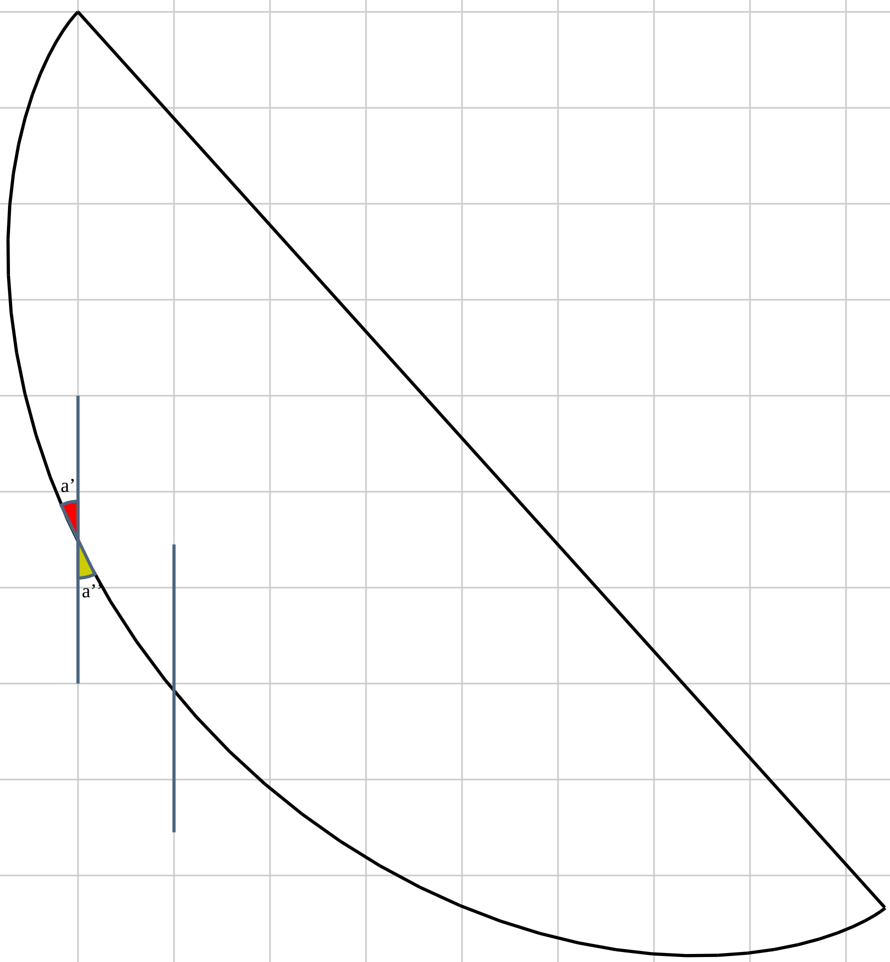
a’’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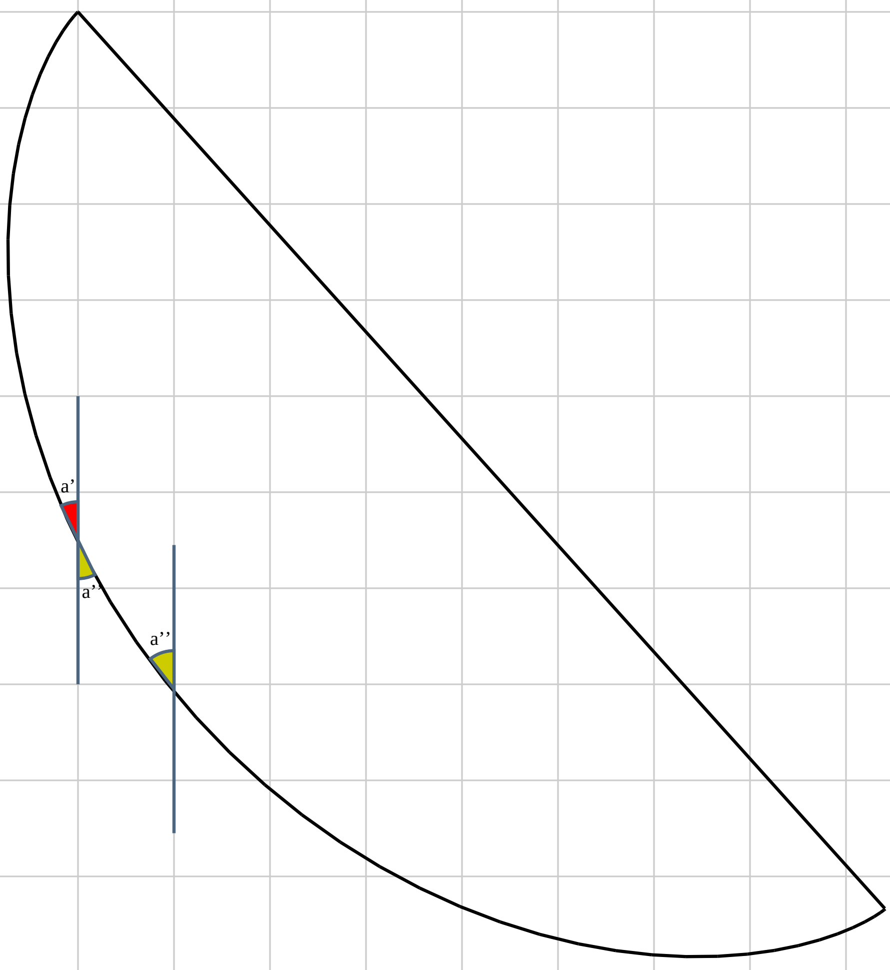
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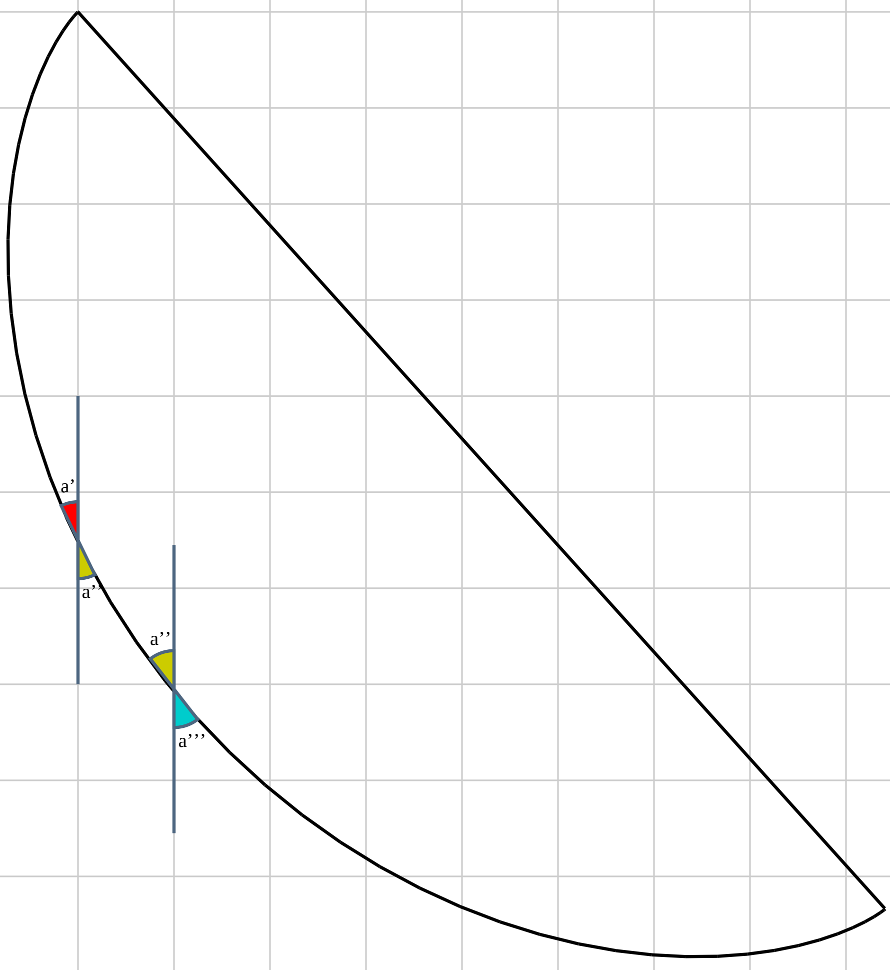
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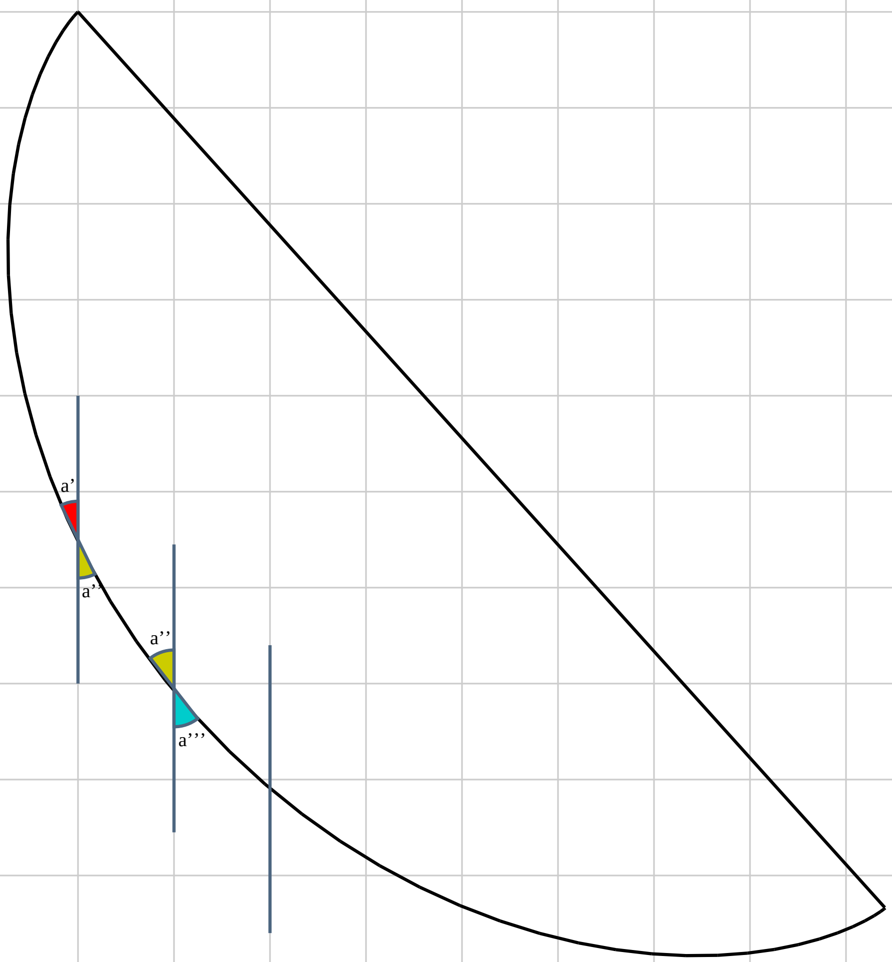
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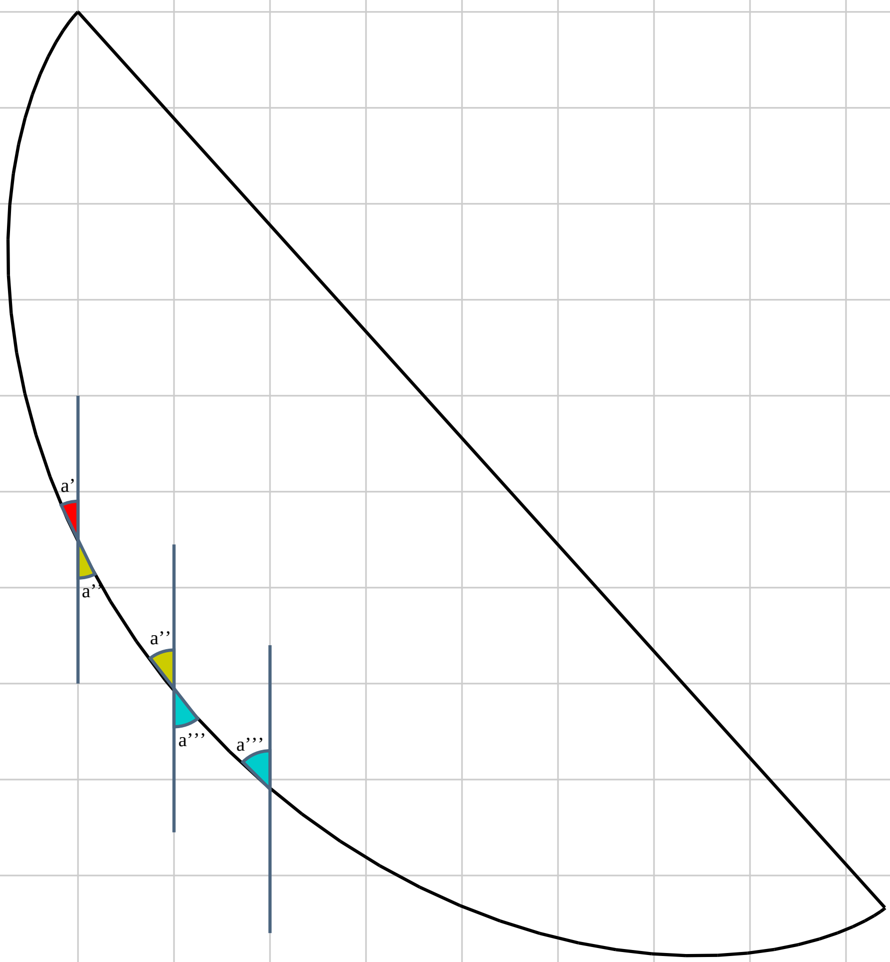
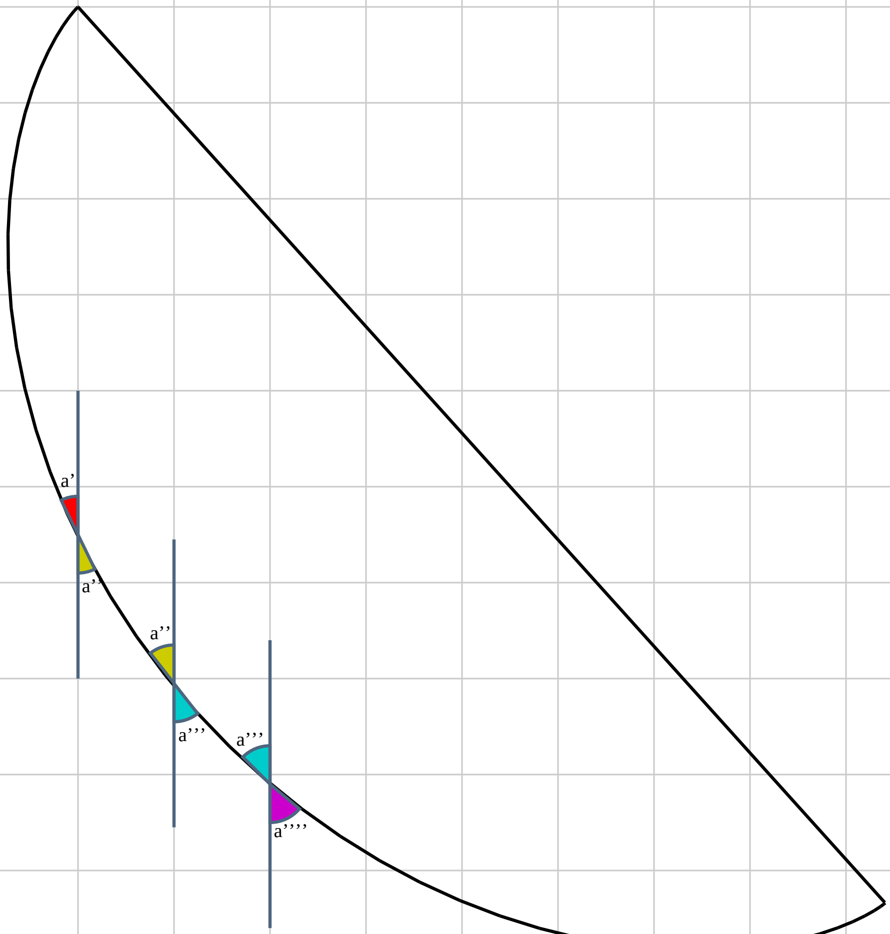

a'
a''
a''
a'''
a'''



a’
a’’
a’’
a’’’
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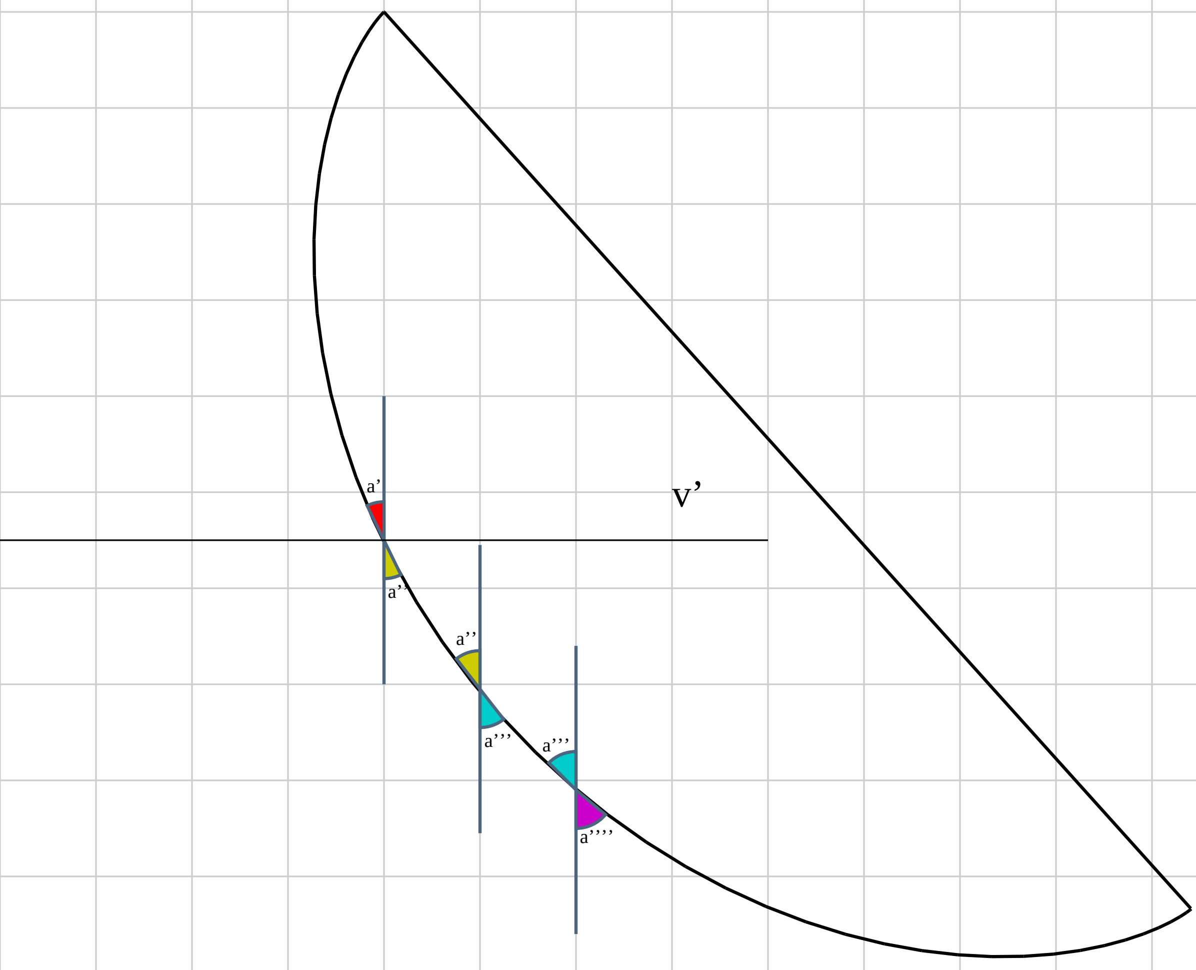
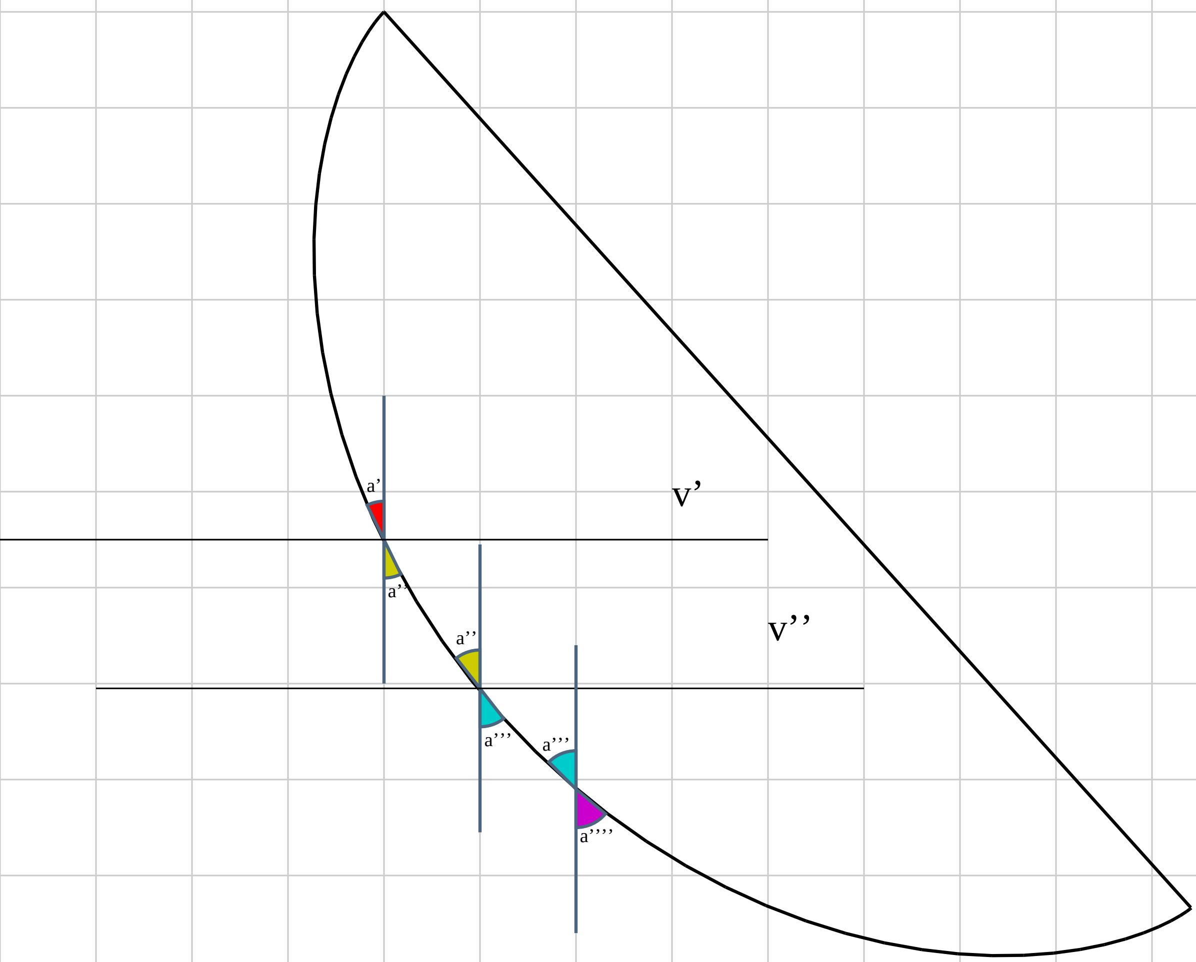
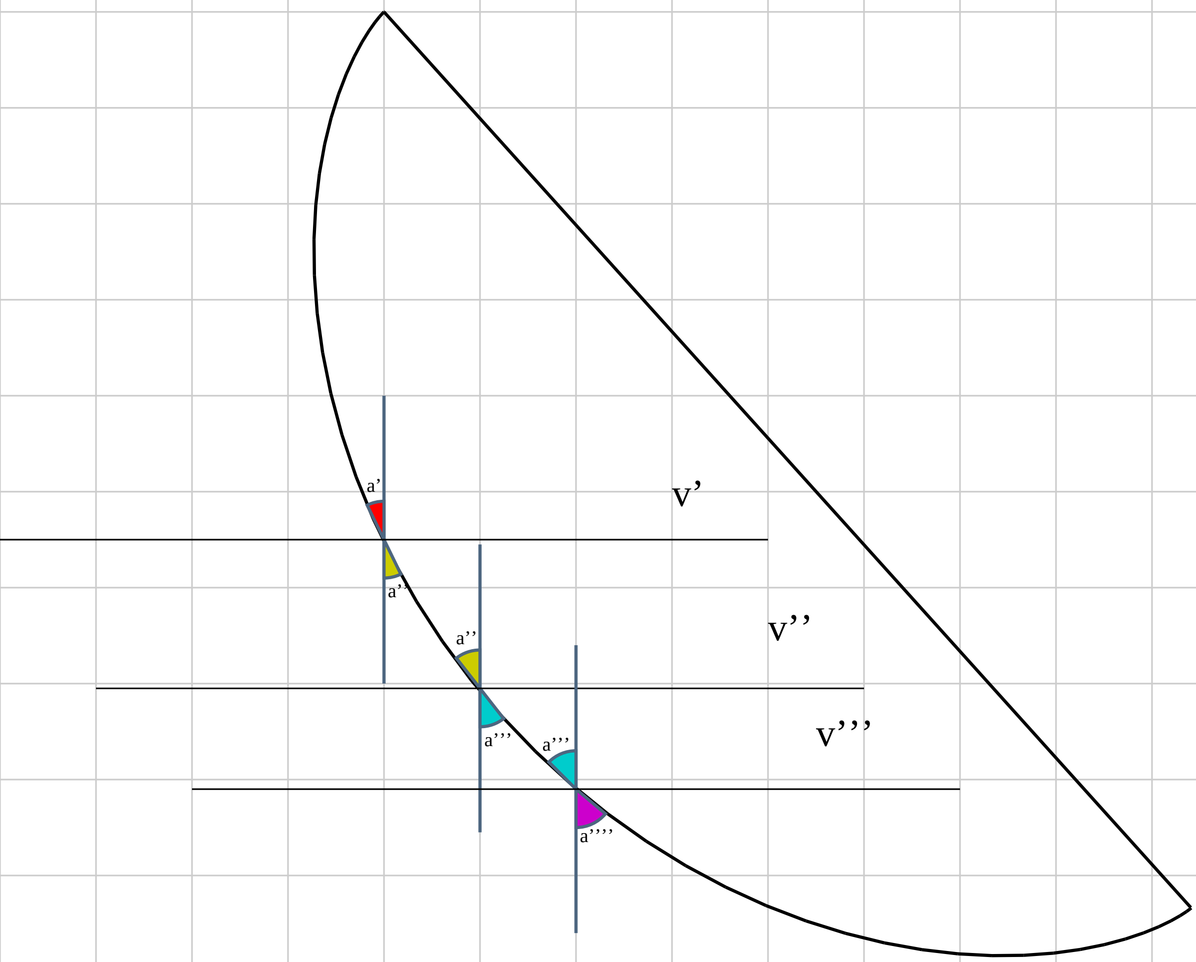

v’
a’
a’’
a’’
a’’’
a’’’
a’’’’



a'
v'
a''
a''
v''
a'''
a'''
a''''



a'
a''
v'
a''
v''
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v'''
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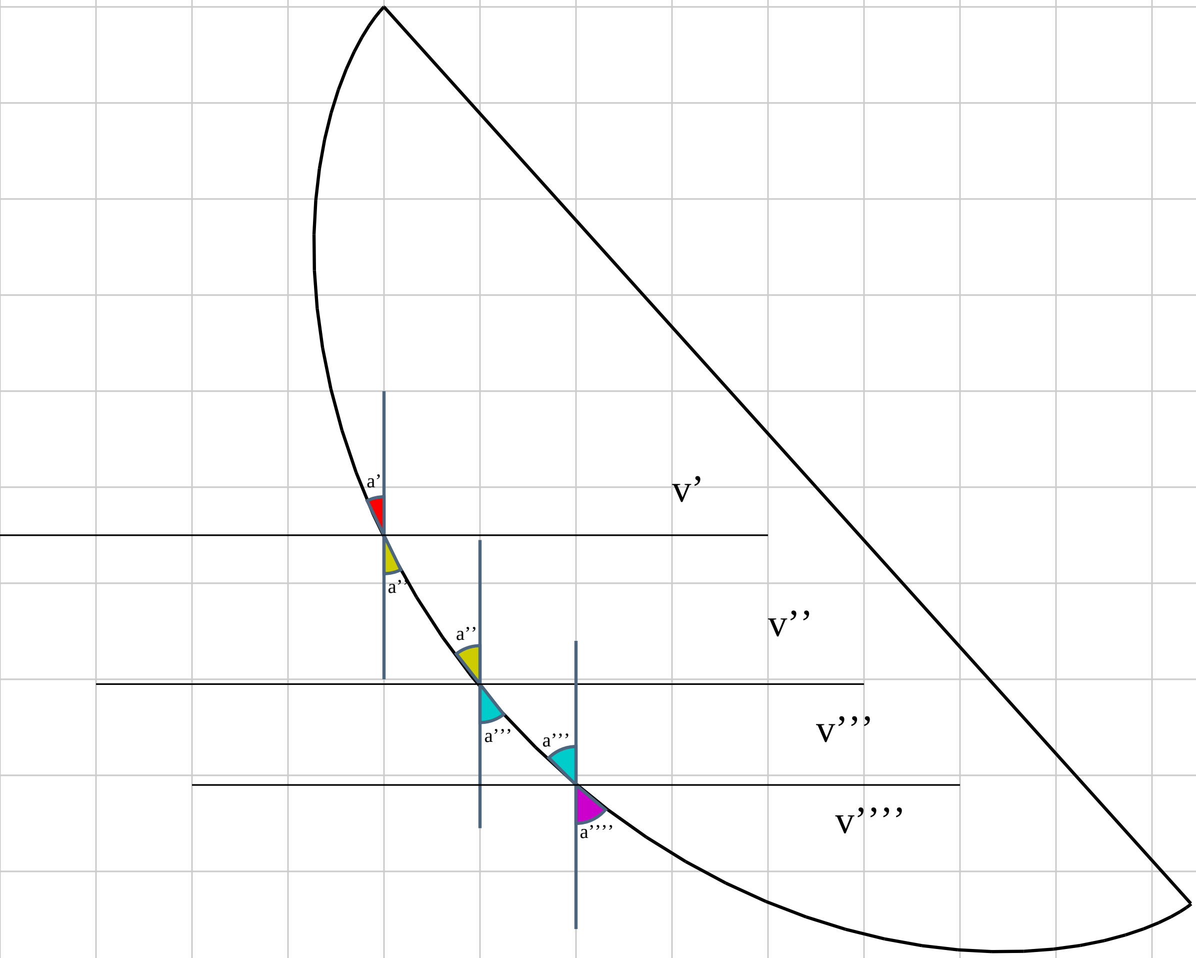

a'
v'
a''
v''
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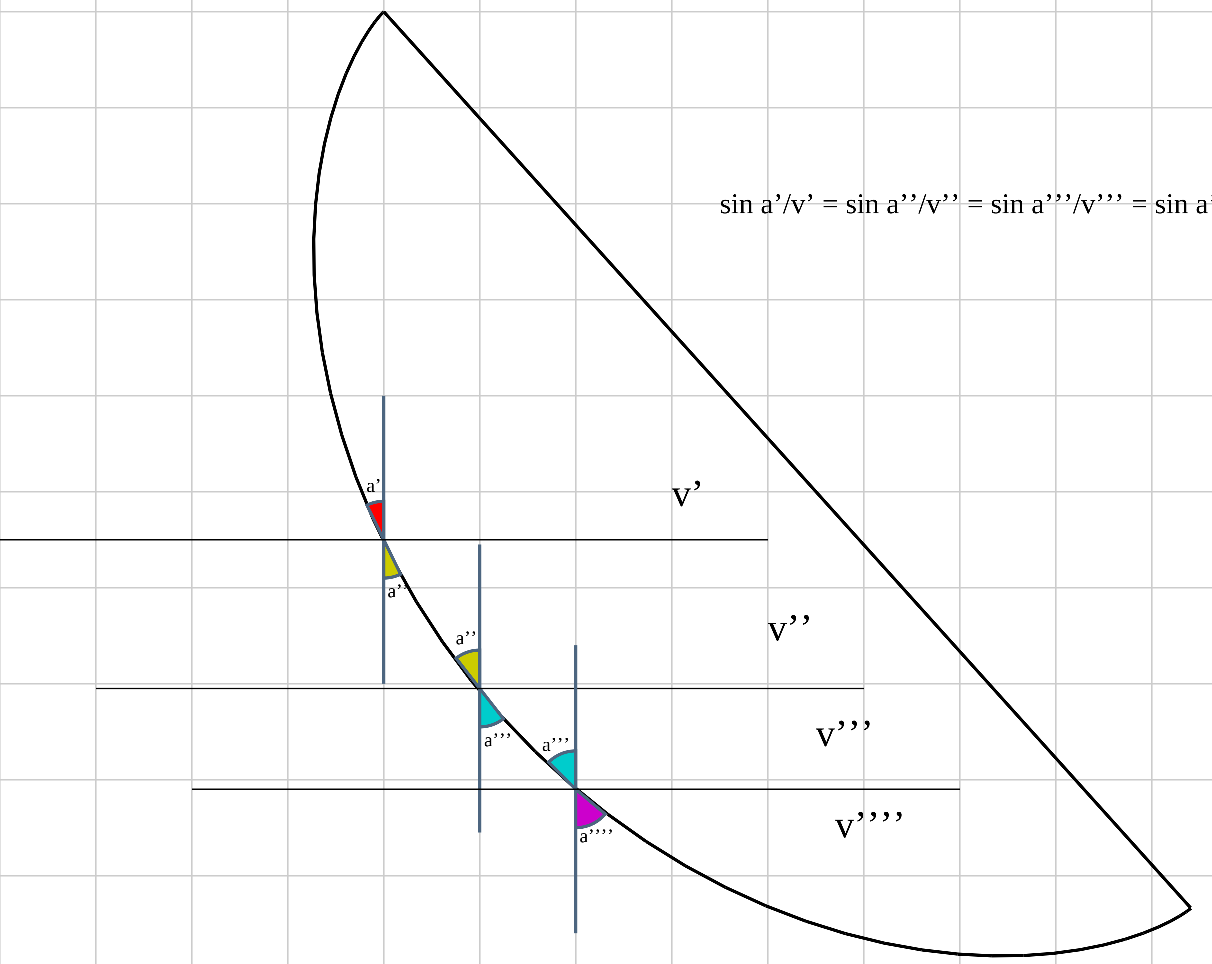
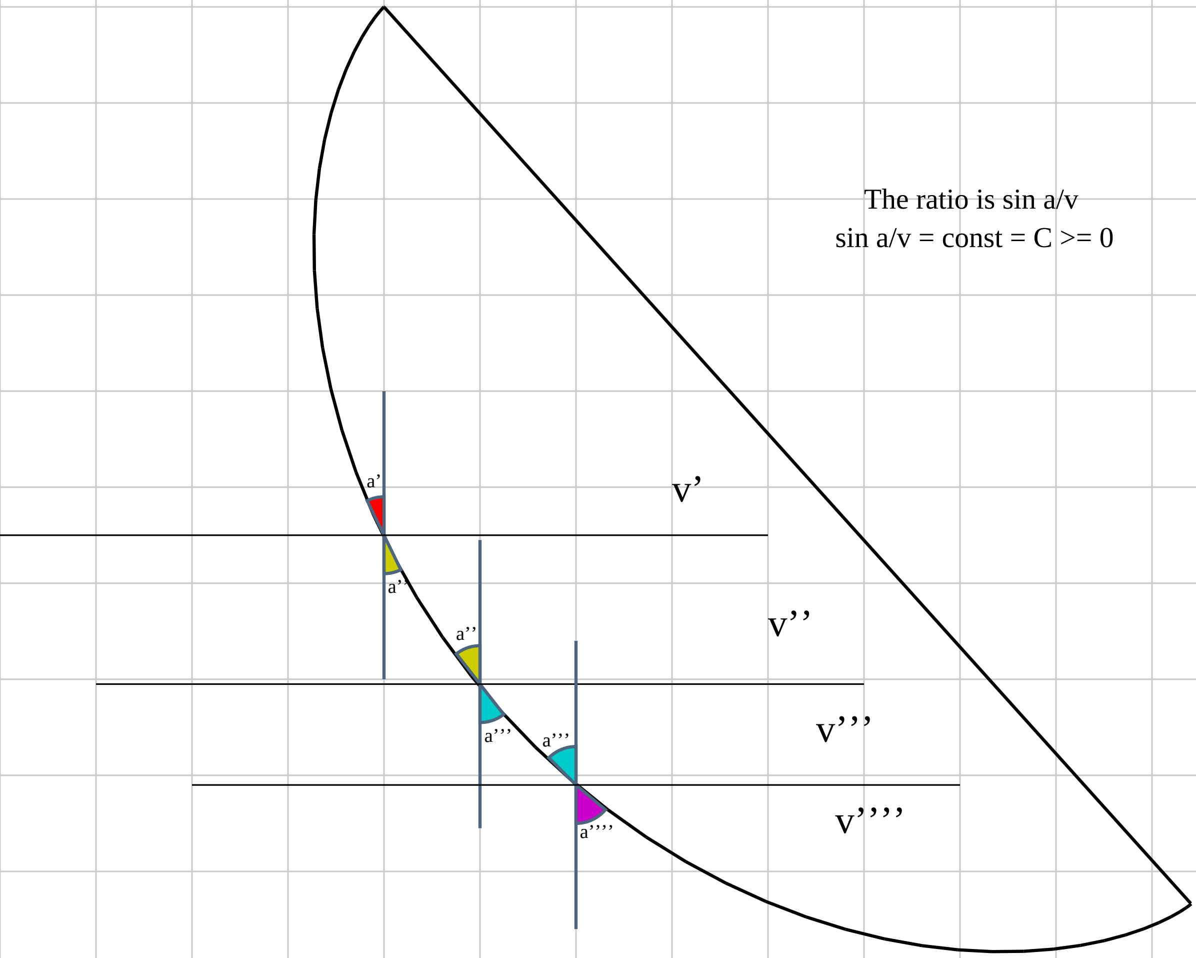
v'''
a''''
v''''

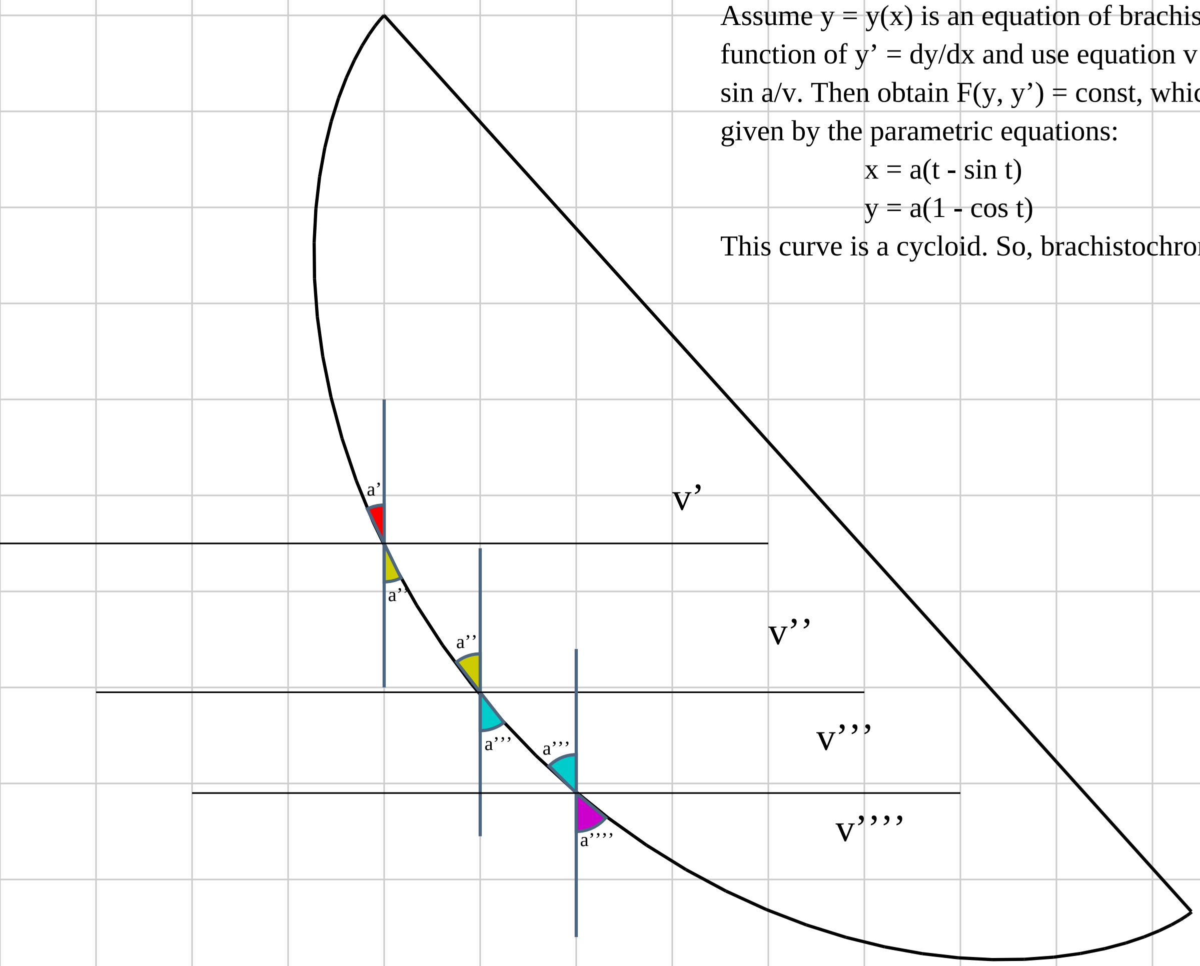
$$\sin a'/v' = \sin a''/v'' = \sin a'''/v''' = \sin a''''/v'''' = \ldots$$





The ratio is sin a/v

sin a/v = const = C >= 0



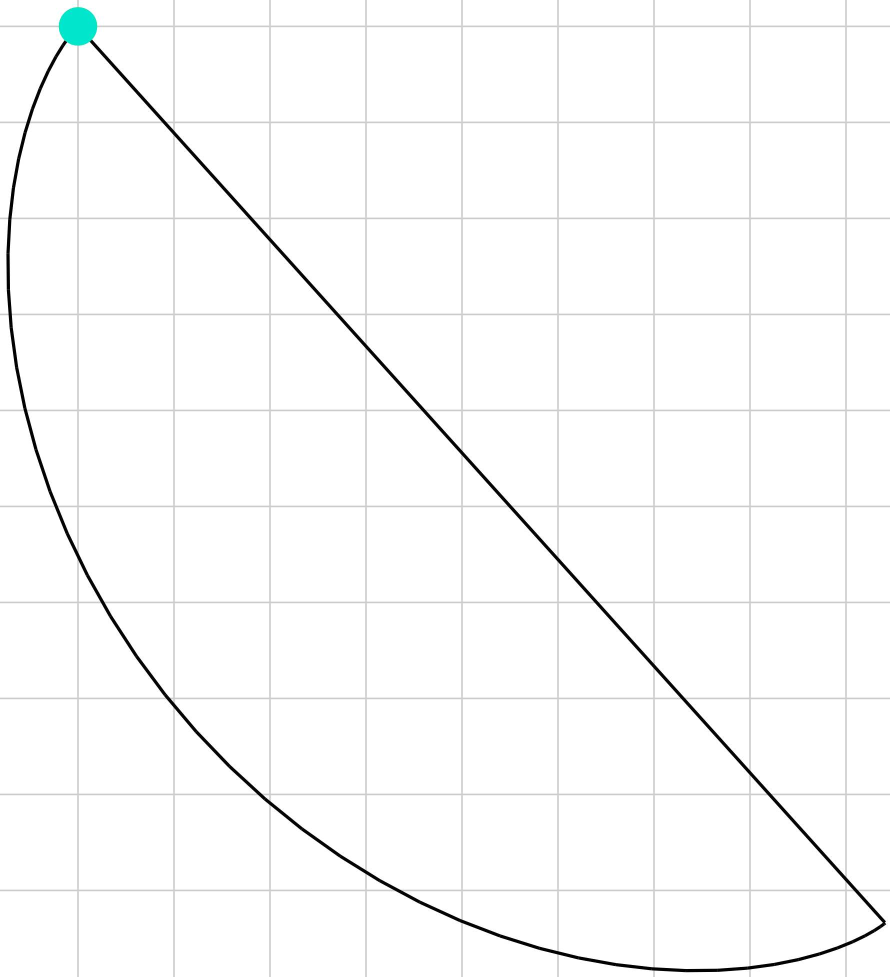
Assume y = y(x) is an equation of brachistochrone. Express sin a as a function of y' = dy/dx and use equation v = sqrt(2gy) to represent sin a/v. Then obtain F(y, y') = const, which satisfied by curve y = y(x) given by the parametric equations:

$$x = a(t - \sin t)$$

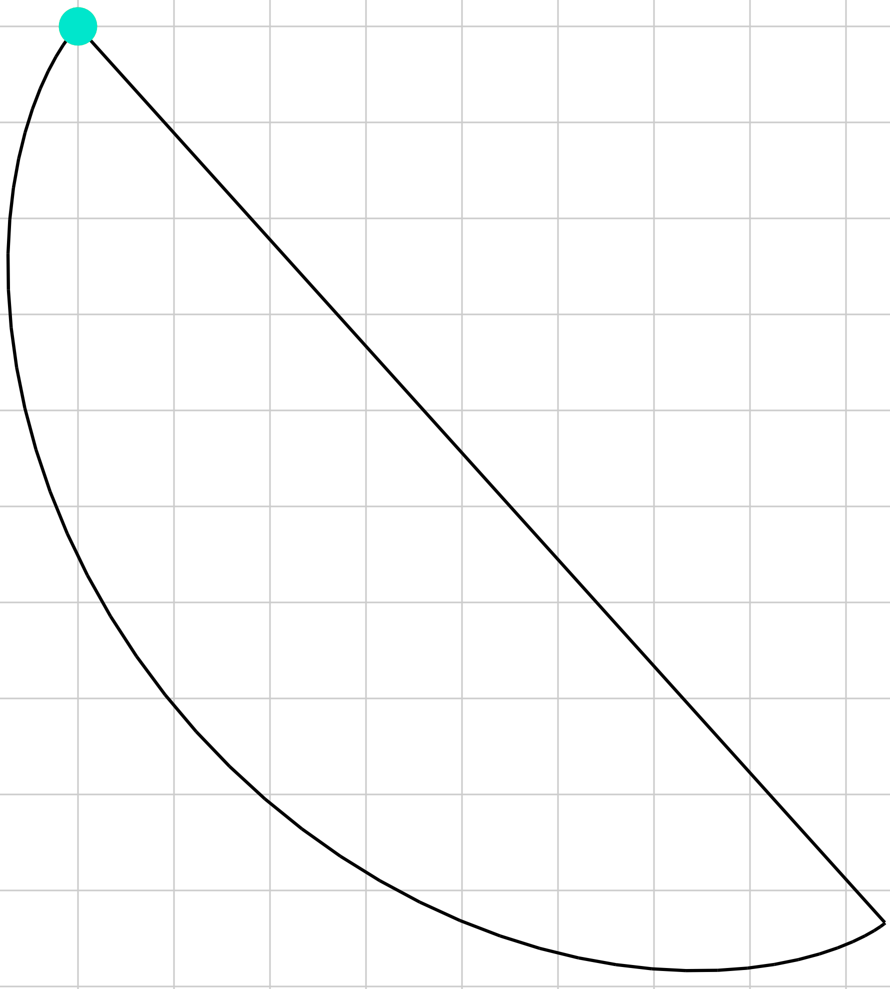
$$y = a(1 - \cos t)$$

This curve is a cycloid. So, brachistochrone is a cycloid.

Proving cycloid as the minimum time path between two points.
By using cycloid as brachistochrone, this can be proven!



Example: For cycloid, solving parametric equation for value of radius, a, and the rotate angle, t, through the horizontal and vertical of 100 feet.
x = 100 = (at - a sin t)
x = 100 = (a - a cos t)
Which gives a = 57.2925, t = 138.2



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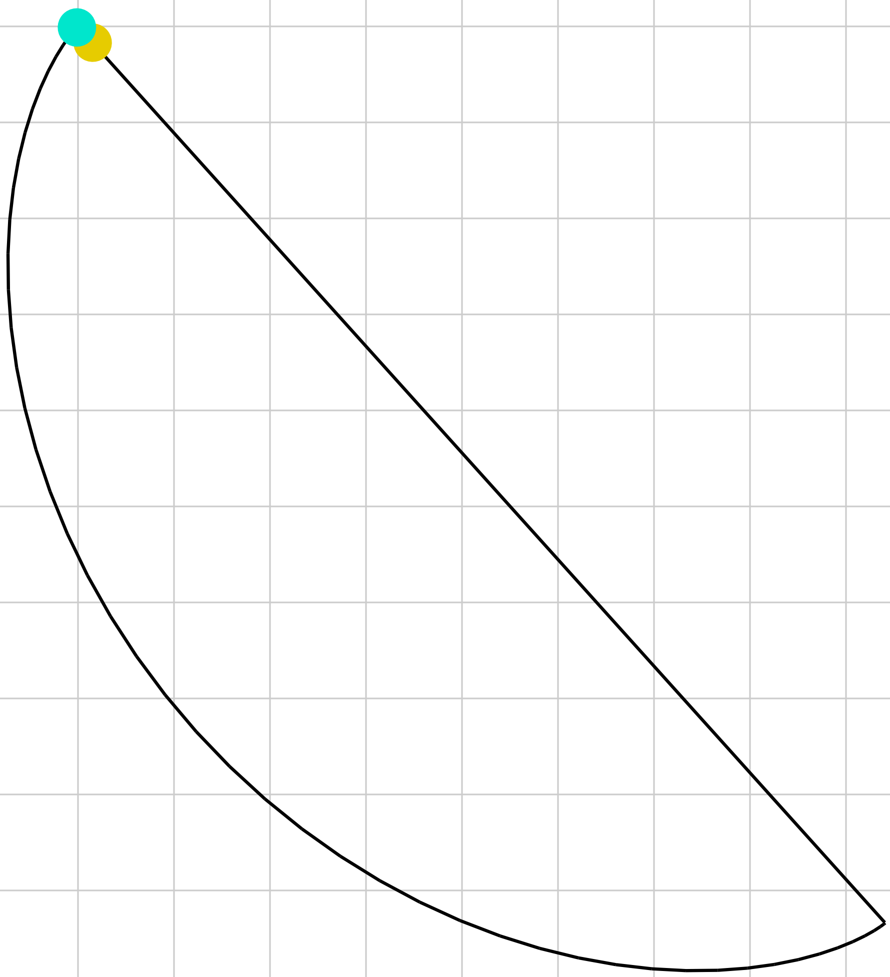

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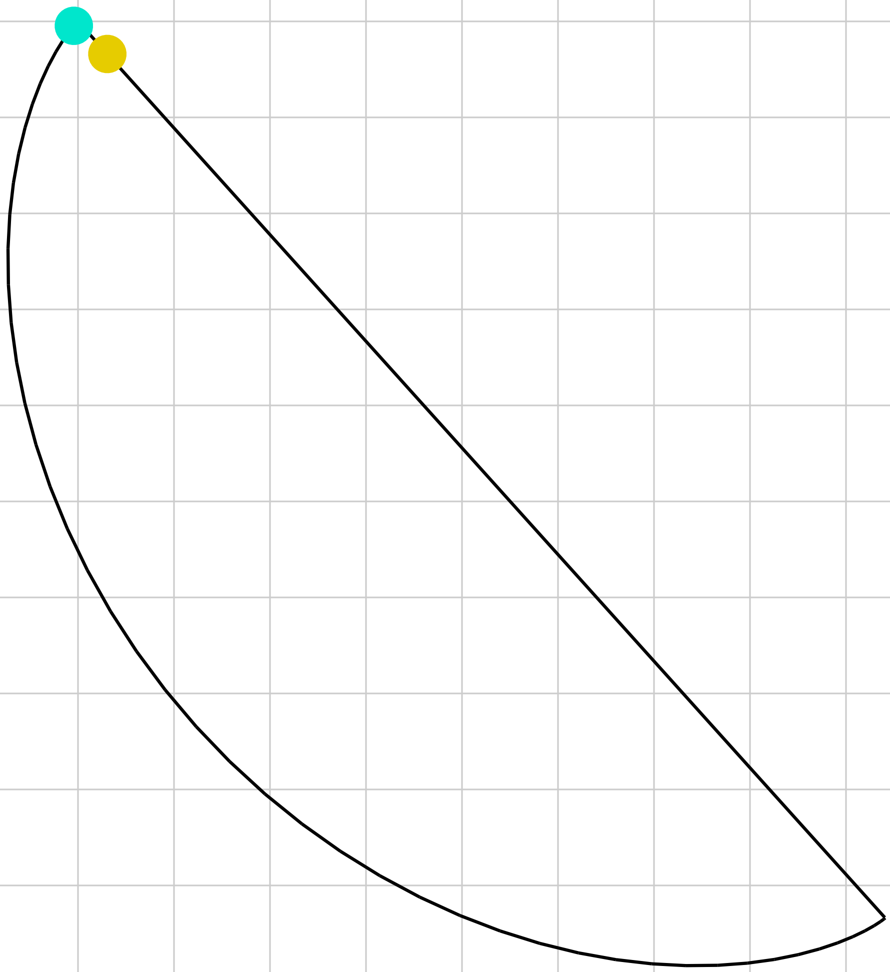

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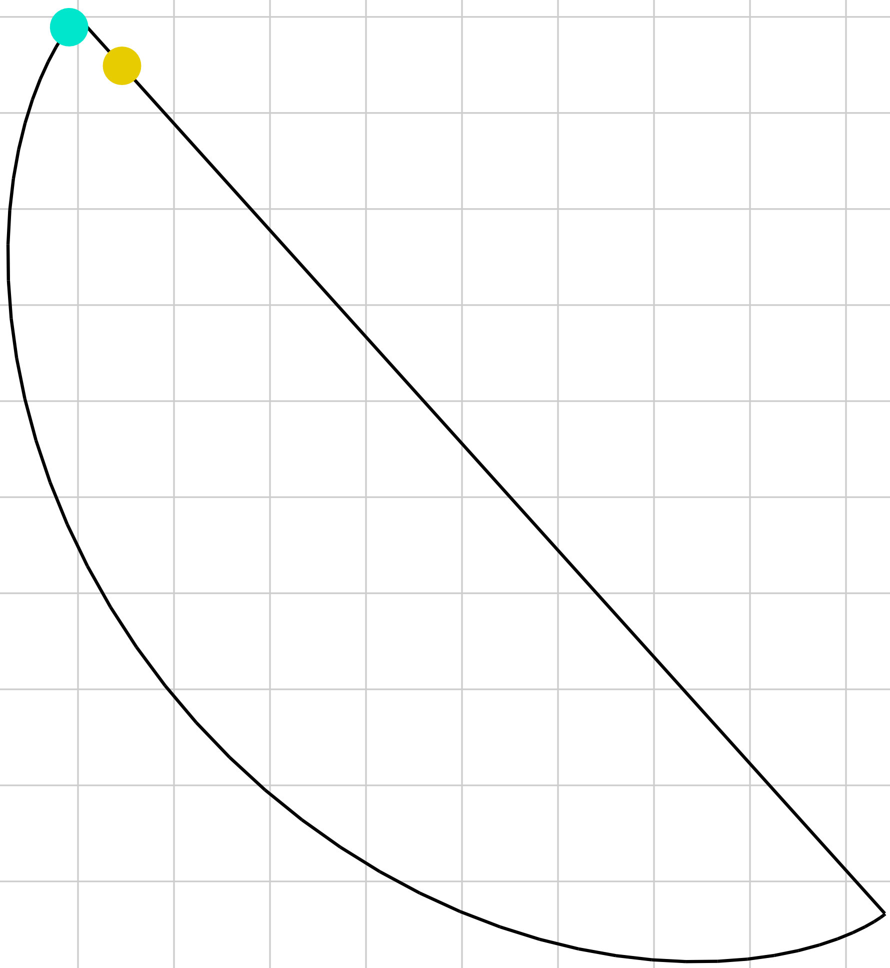

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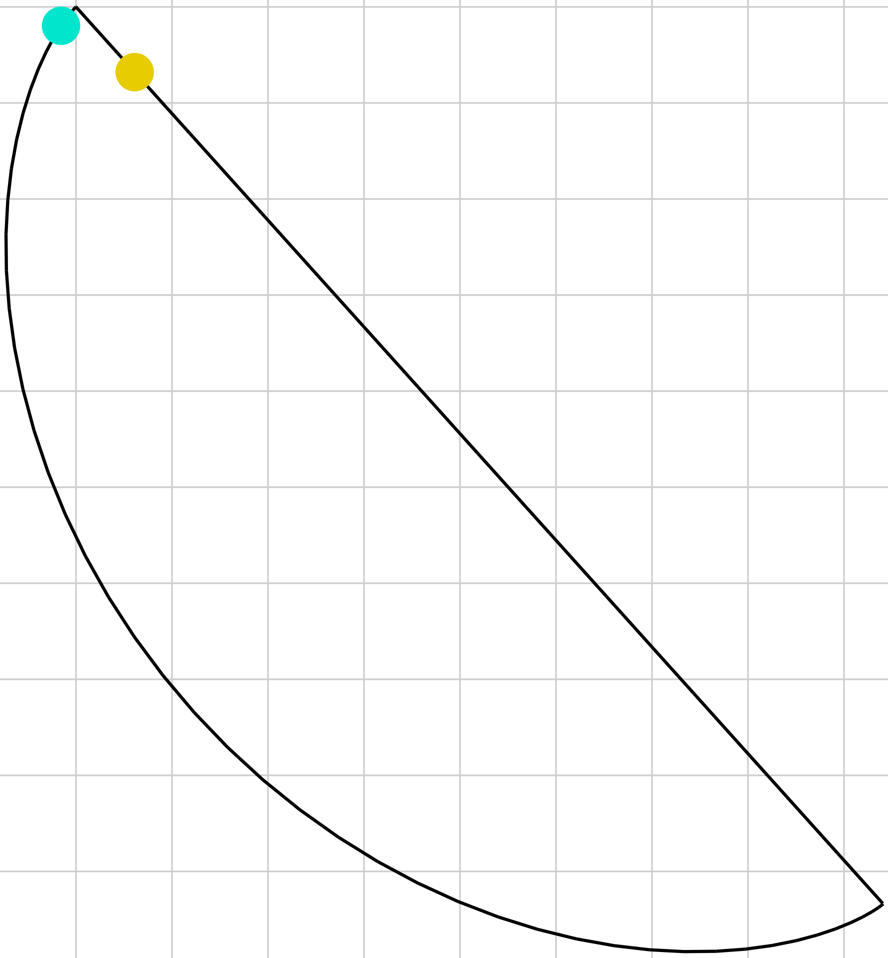

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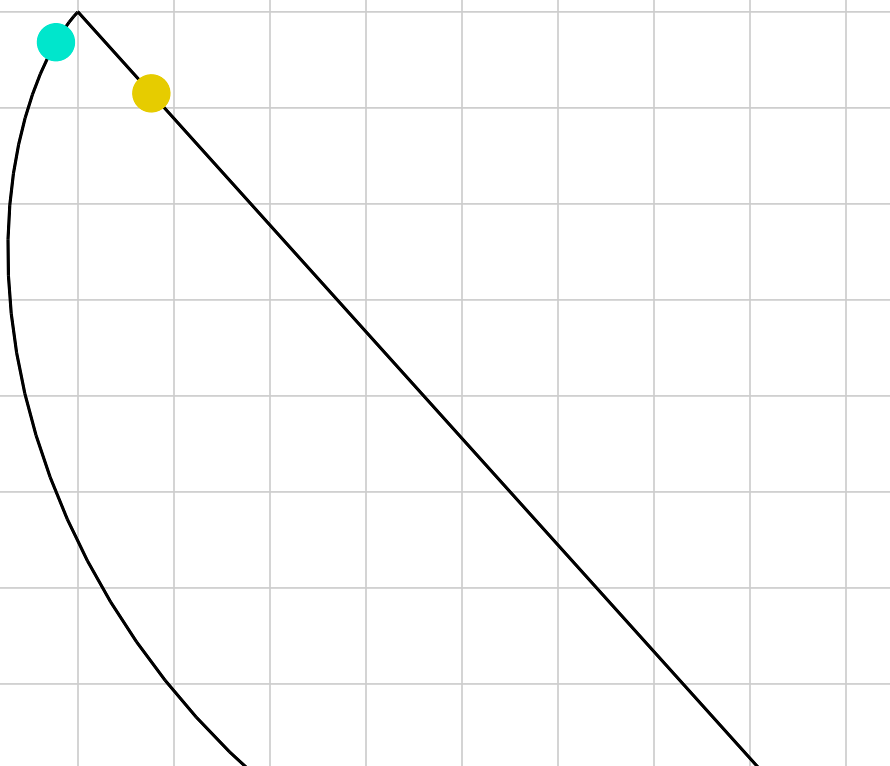

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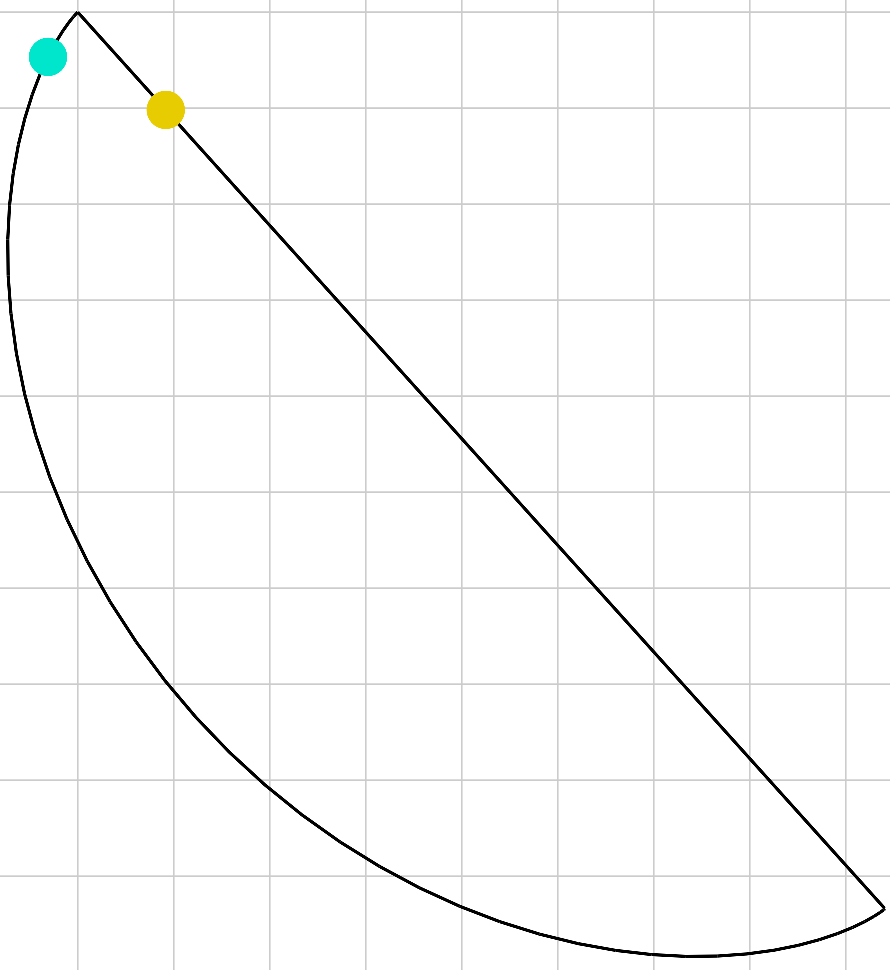

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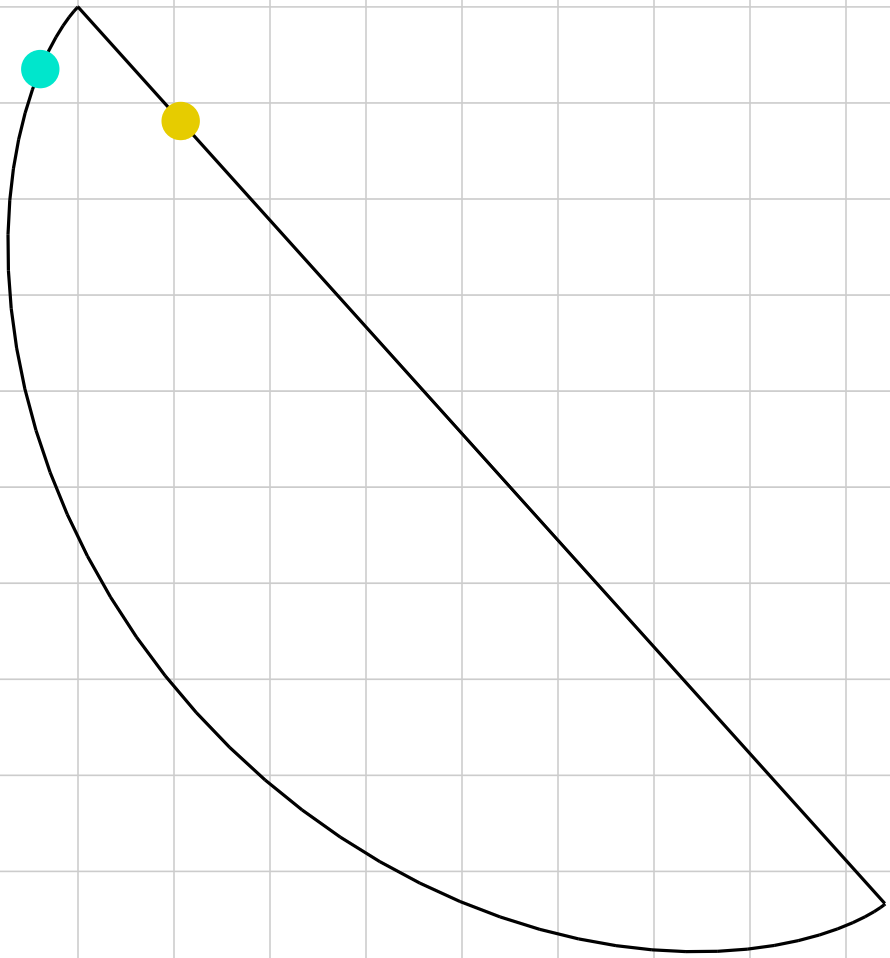

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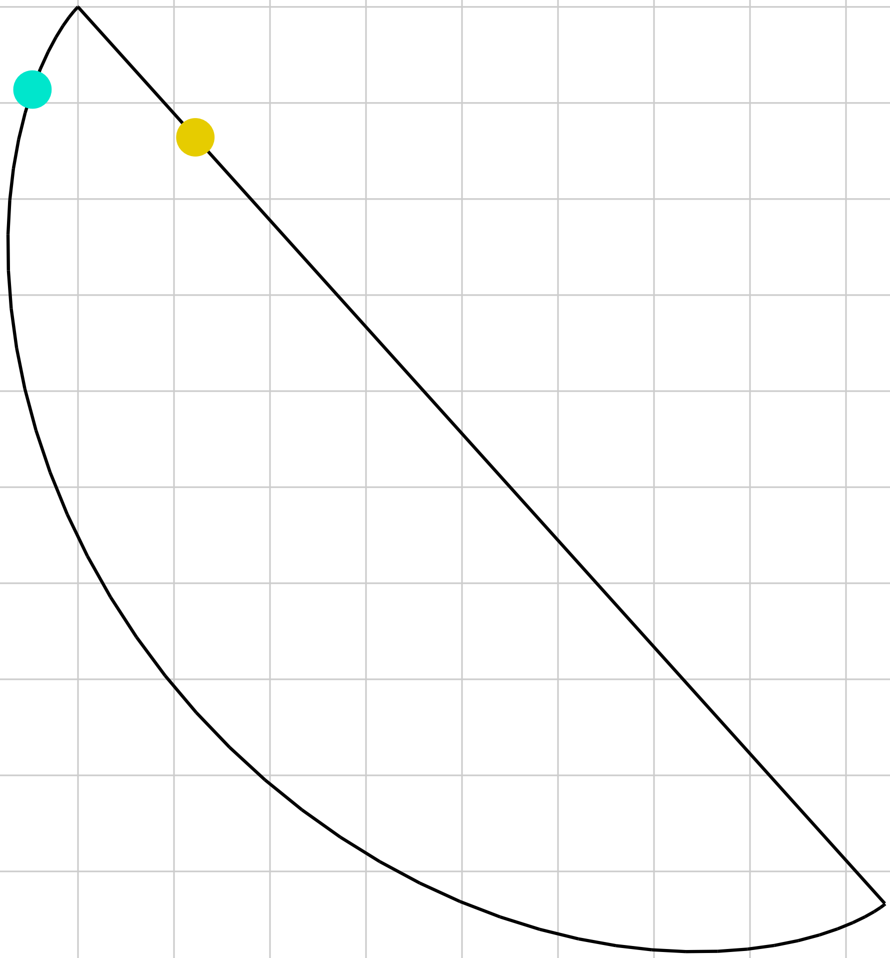

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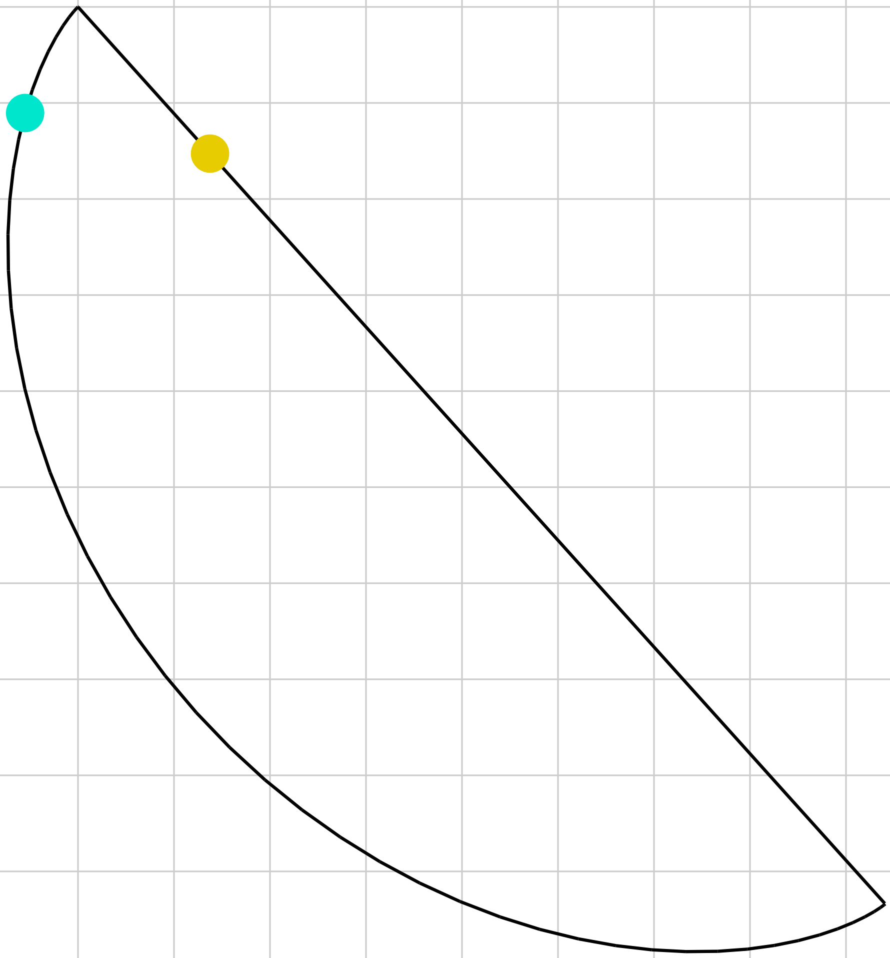

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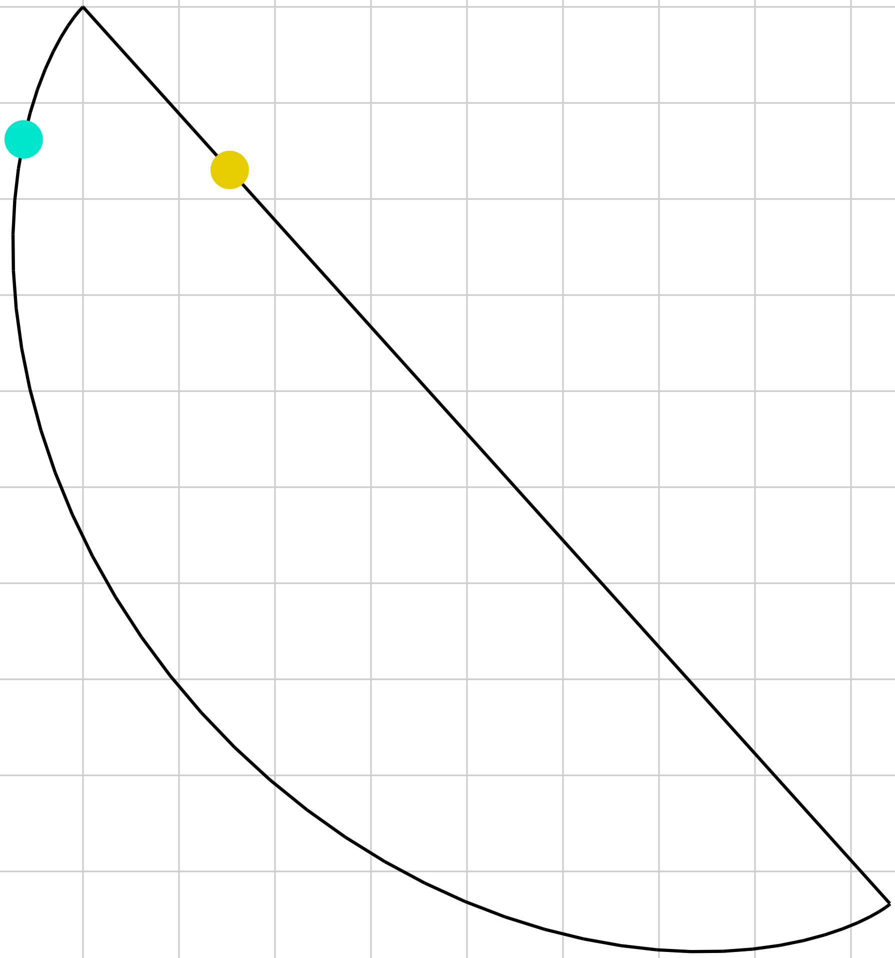
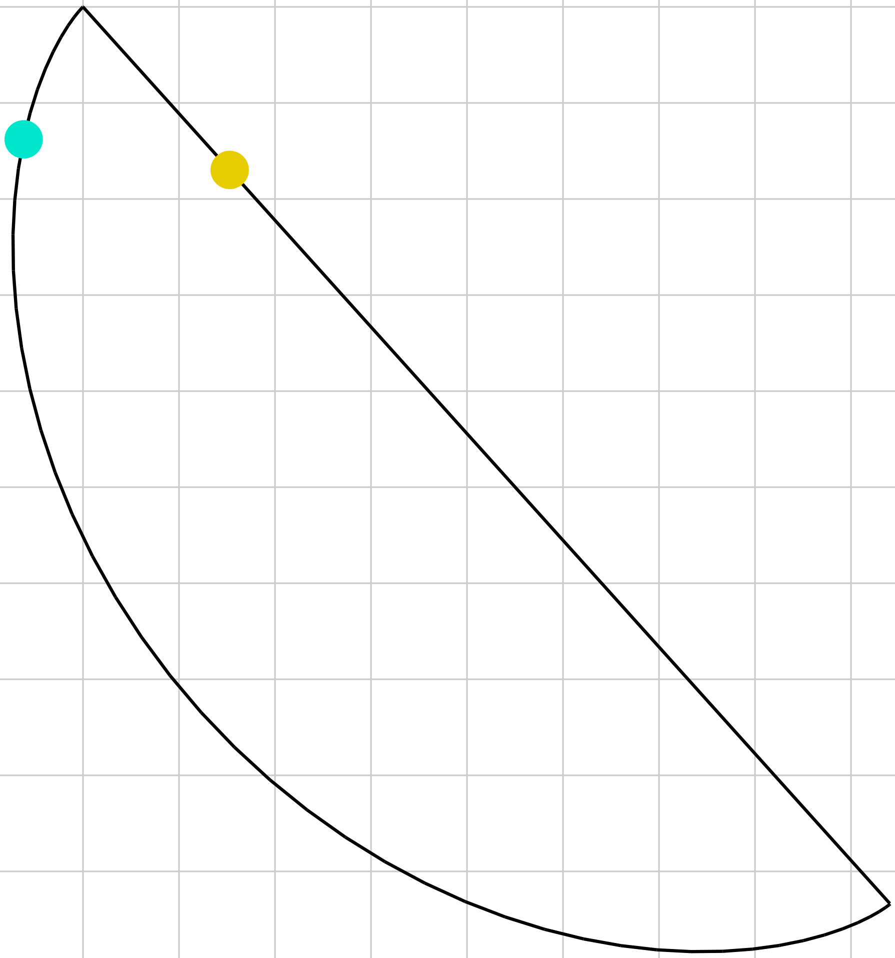


As for flat slide, slope = dy/dx = m for y = mx.
Substitute m for y’ and mx for y in the time equation when m = 1
since the slope is 45



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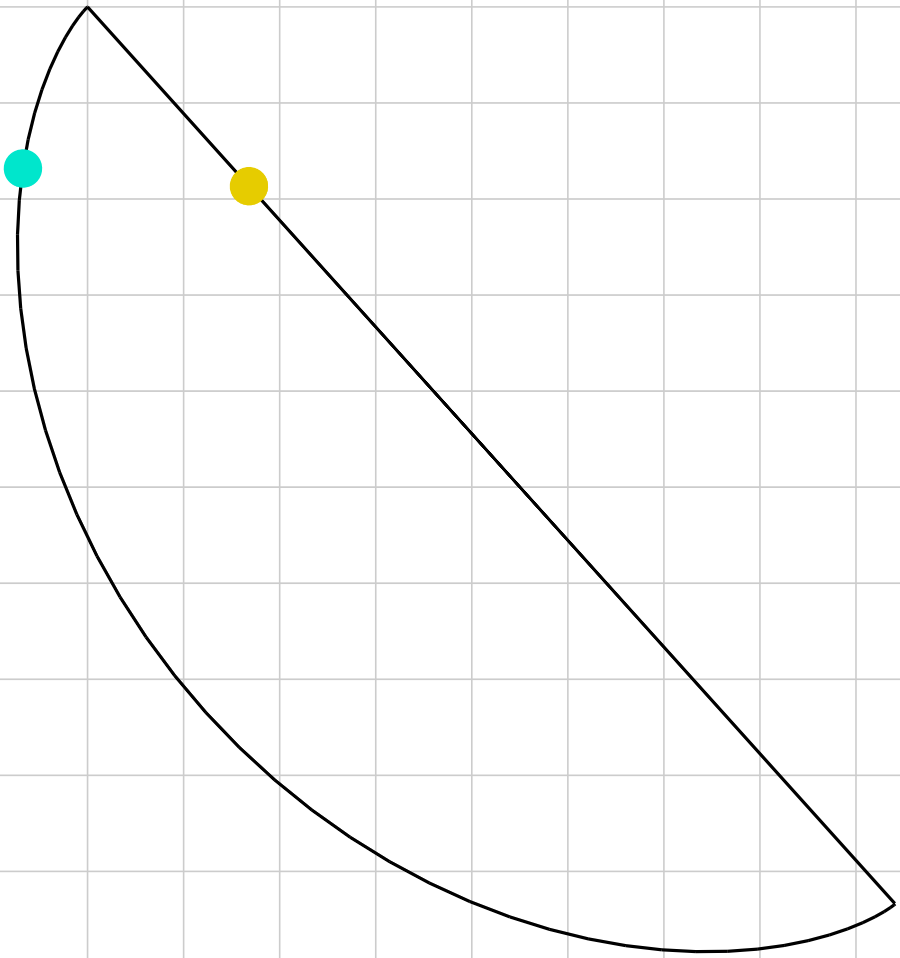

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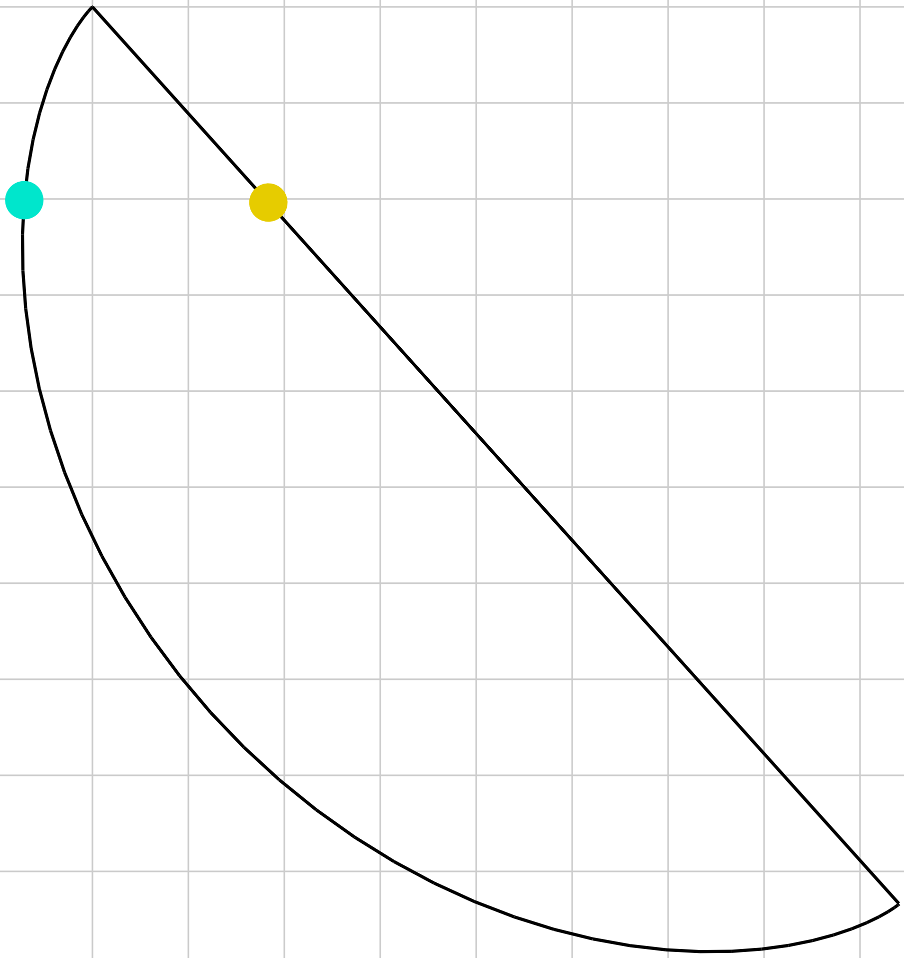

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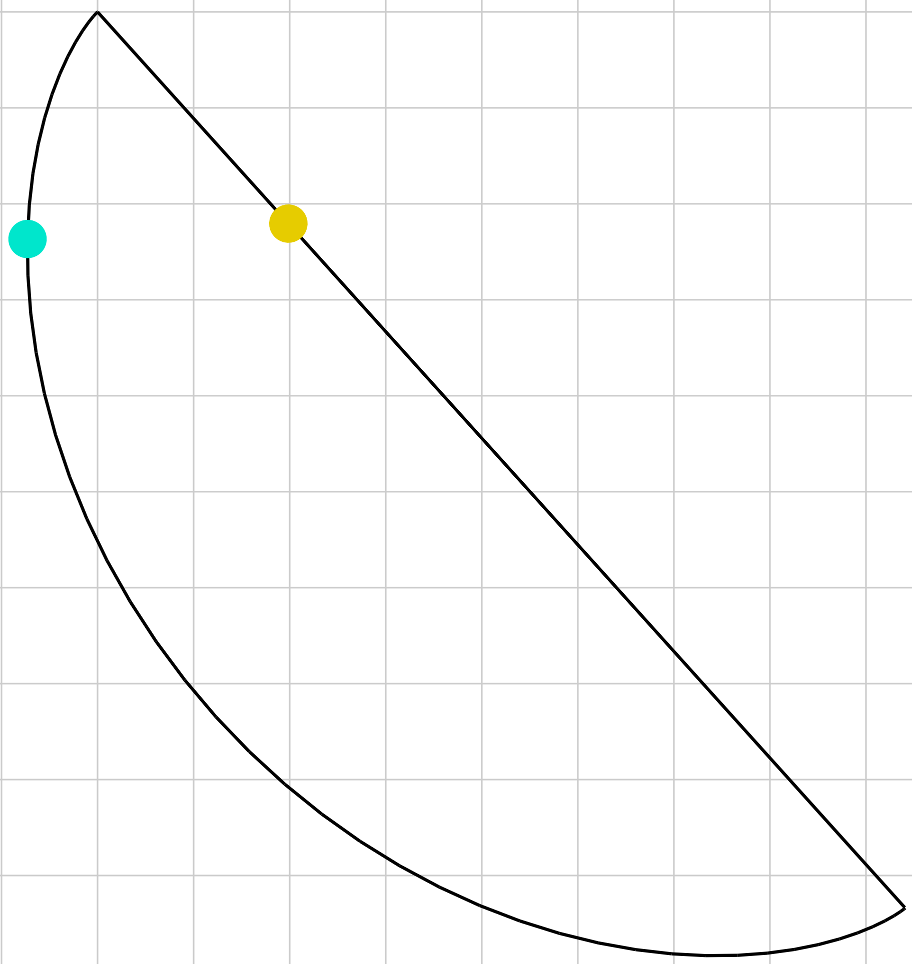

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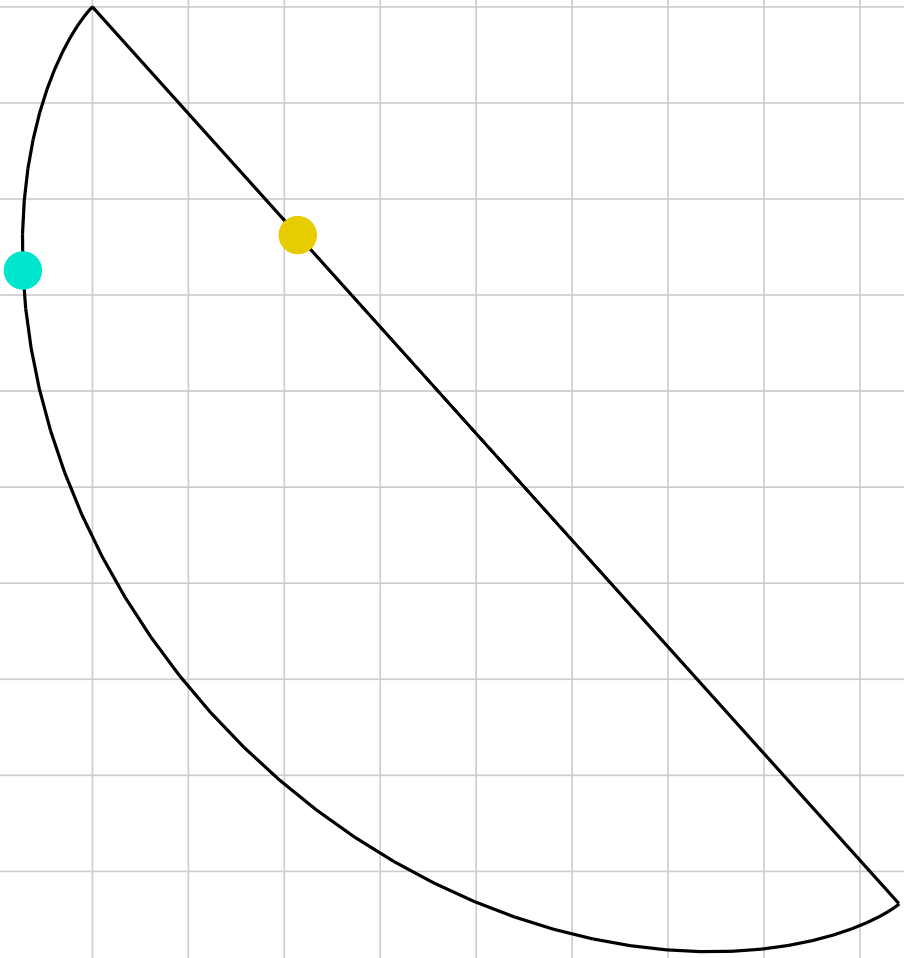

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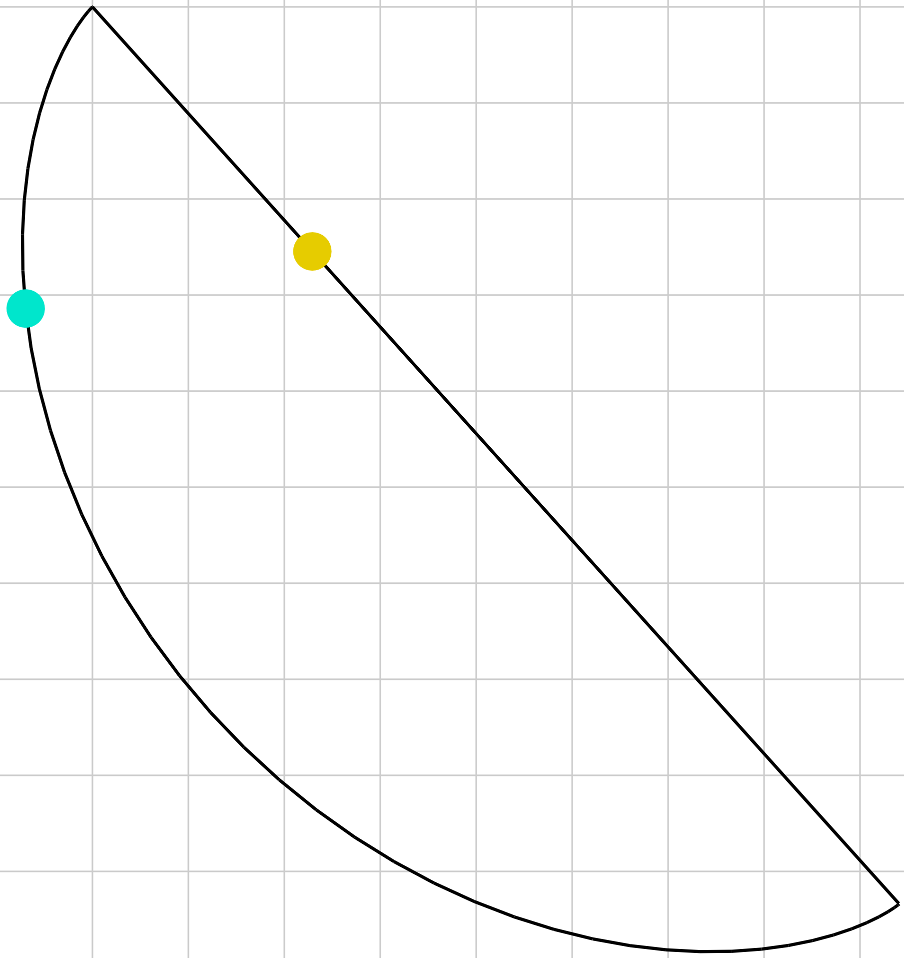

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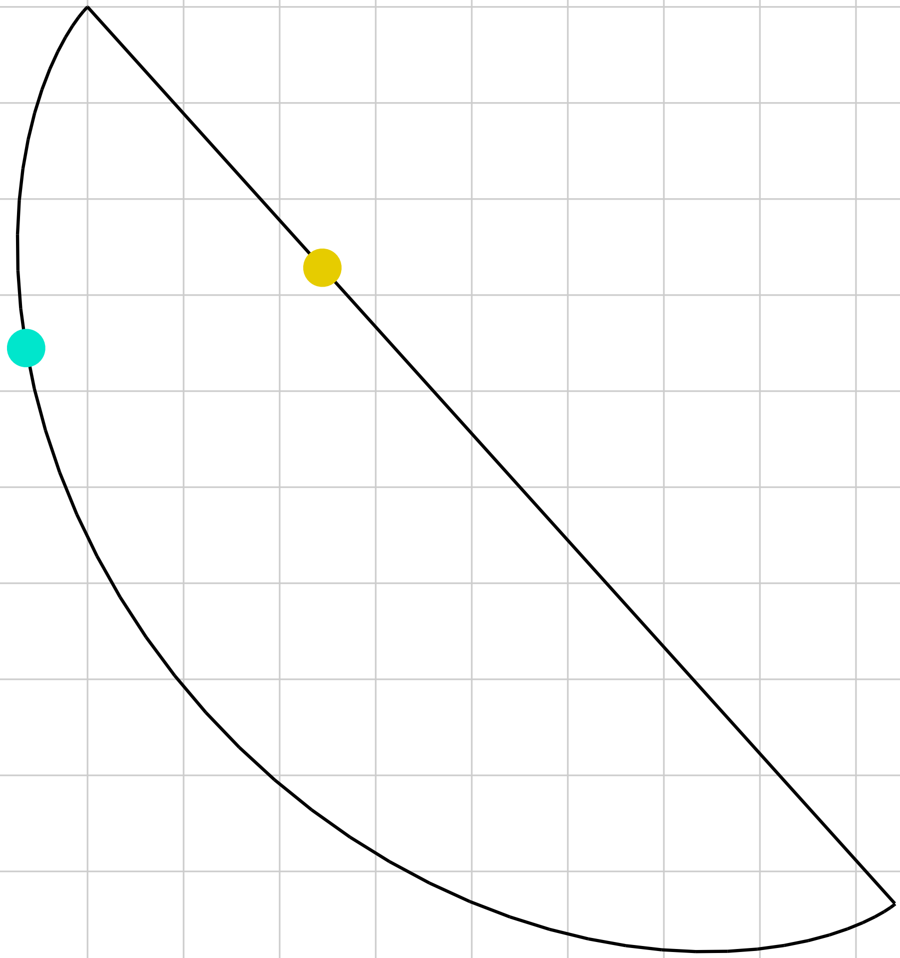

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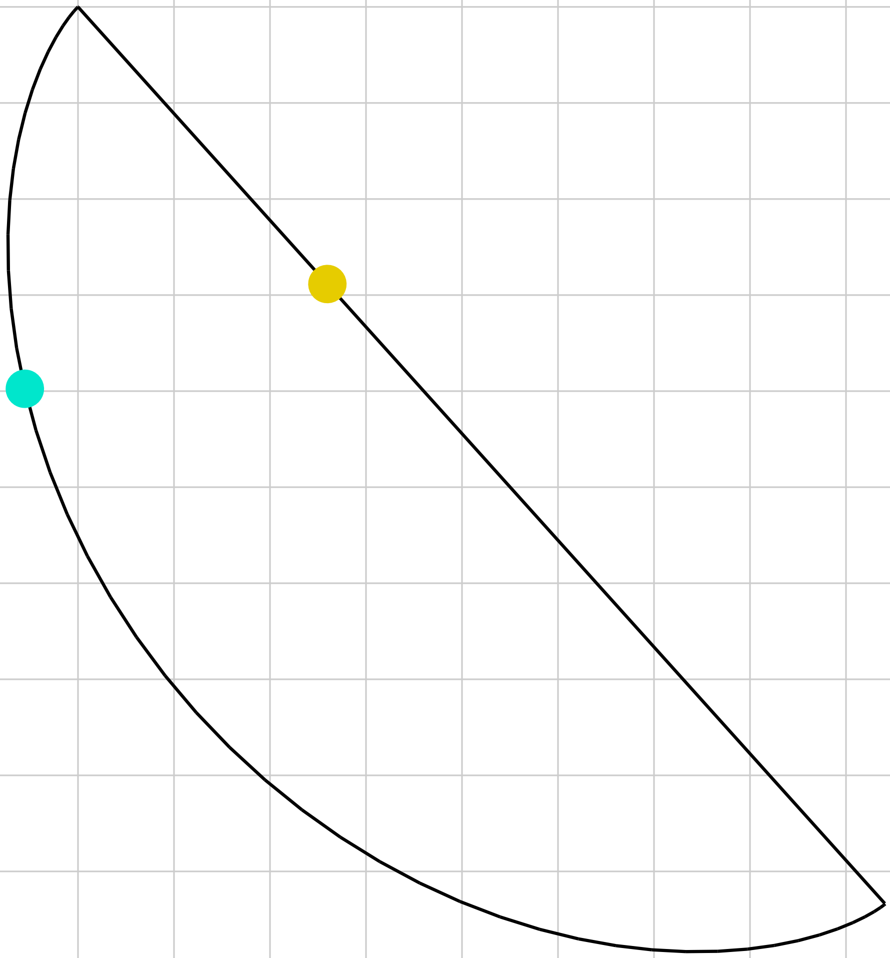

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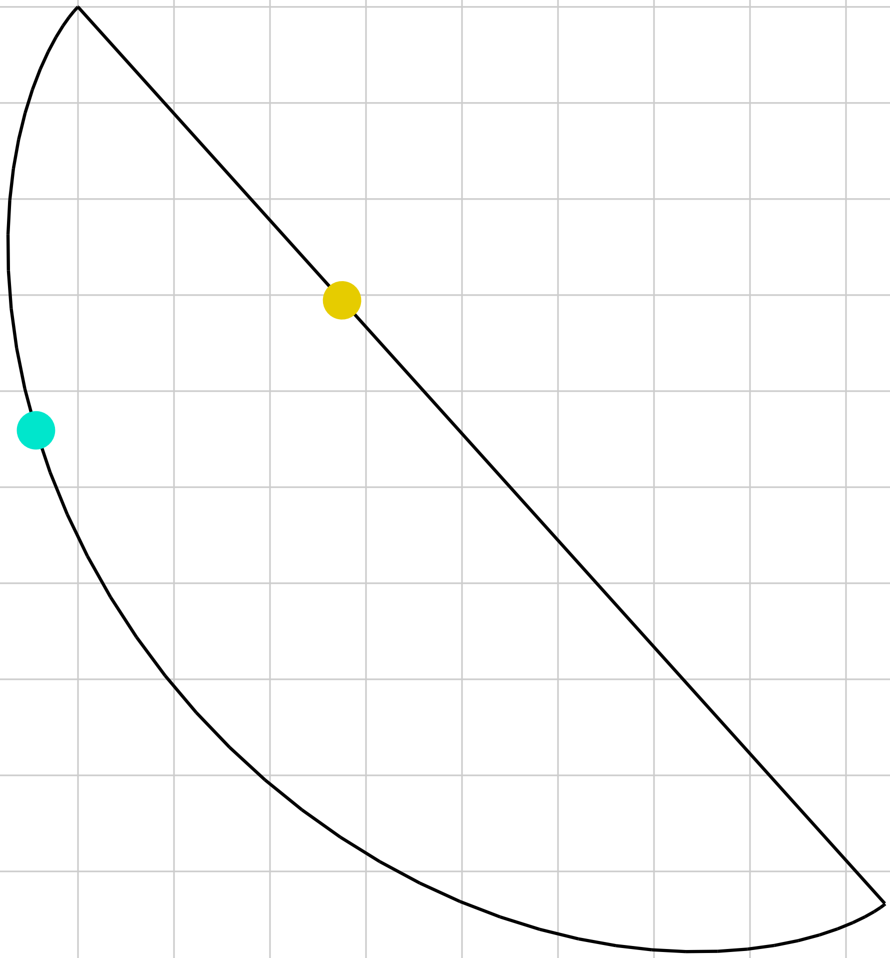

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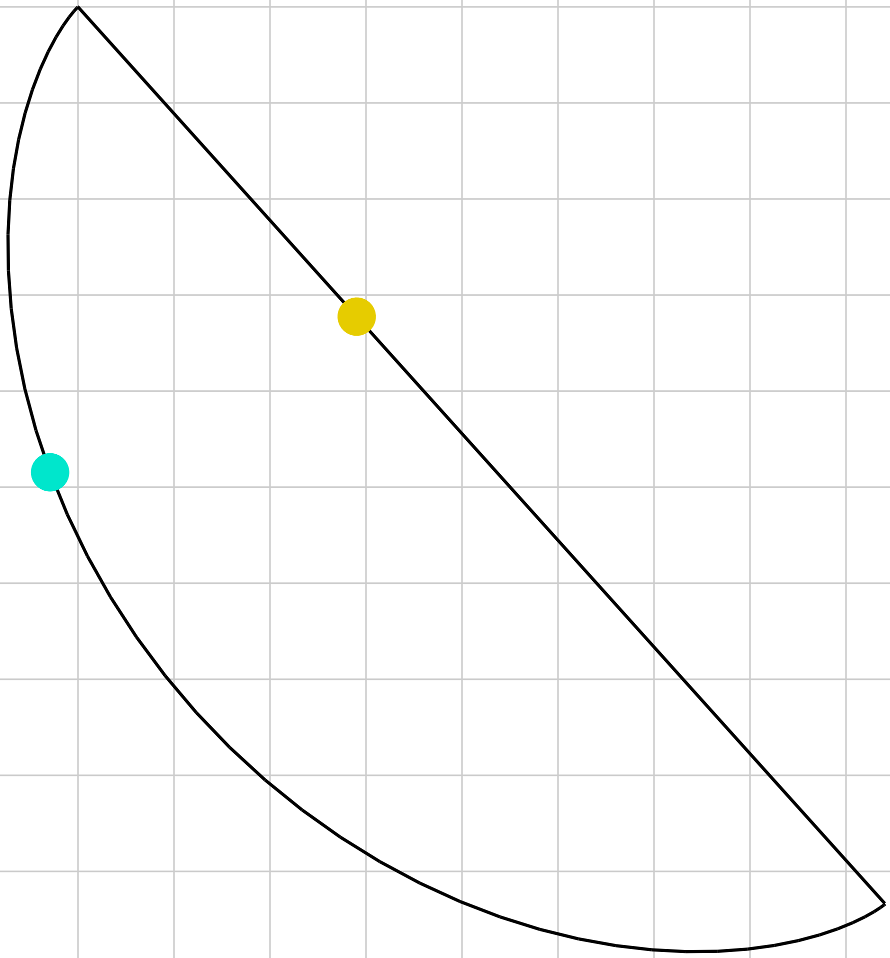

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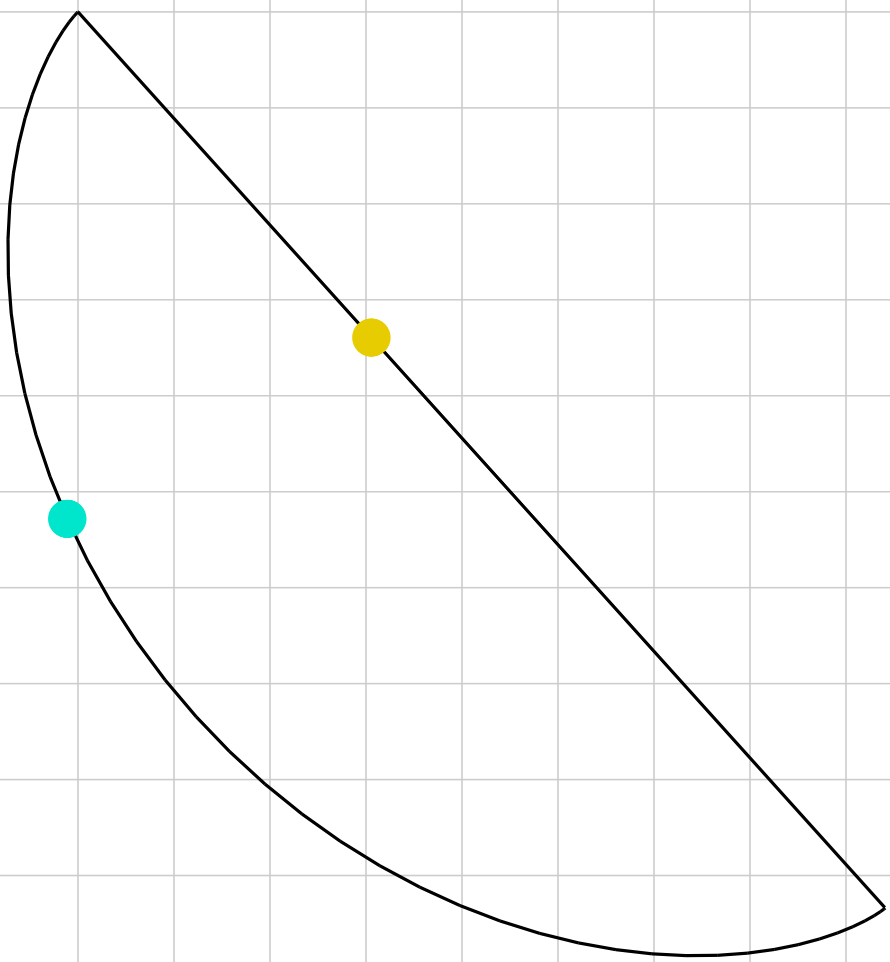

Using Euler-LaGrange Equation, for cycloid as brachistochrone, the time equation is t = integrate (ds/v) = integrate([(dx*dx + dy*dy)/(2gy)]^2)
= 1/(2g)^(1/2)*integrate[(1 + x'^2)/y]^(1/2)]dy
Applying Euler-LaGrange Equation, dF/dx - (d/dy)*(dF/dx') = 0
=> (d/dy)*(dF/dx') = 0.
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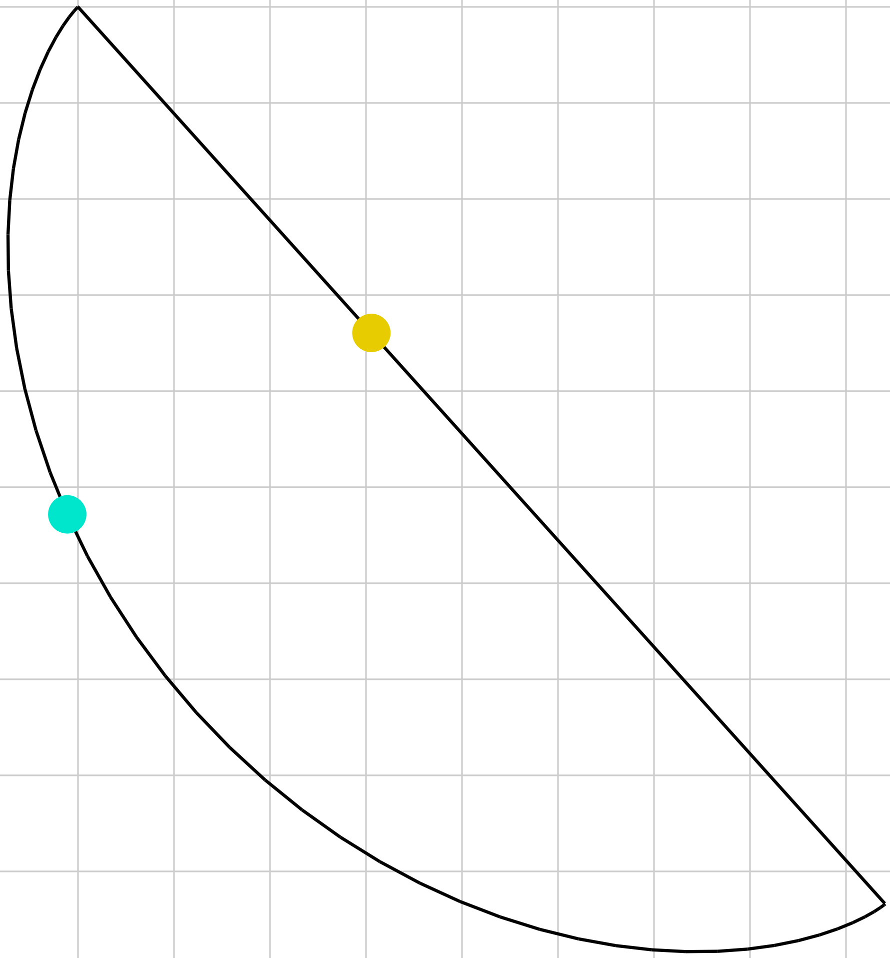

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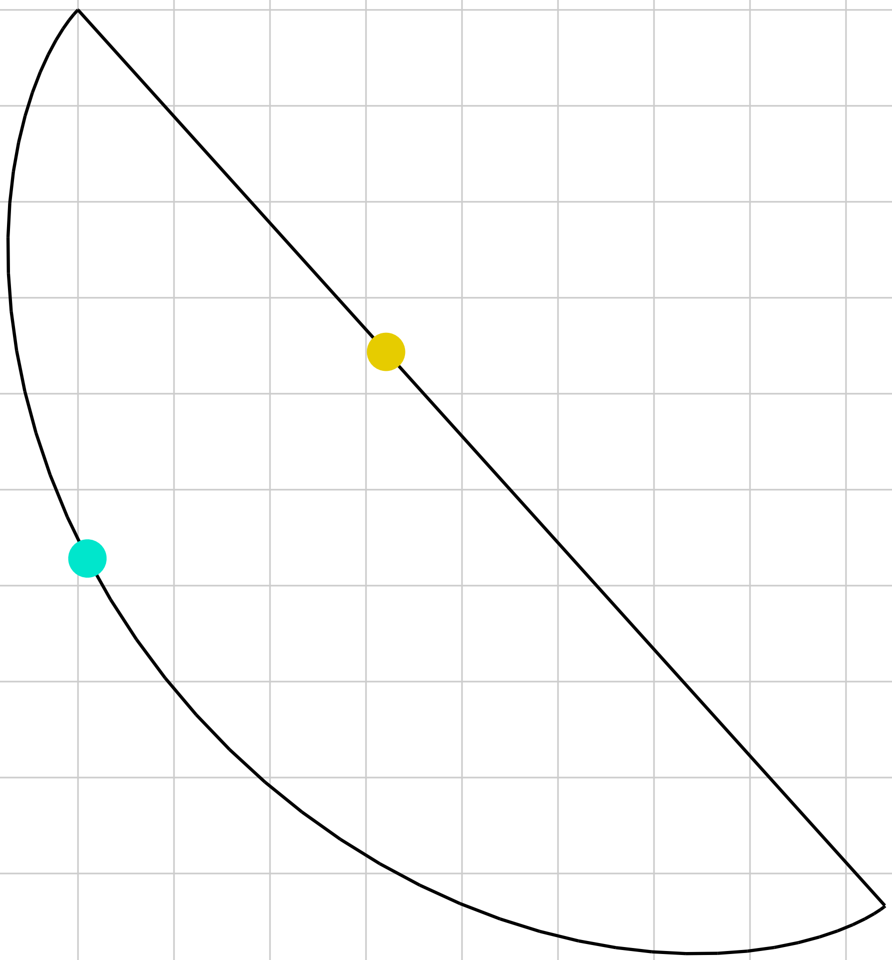

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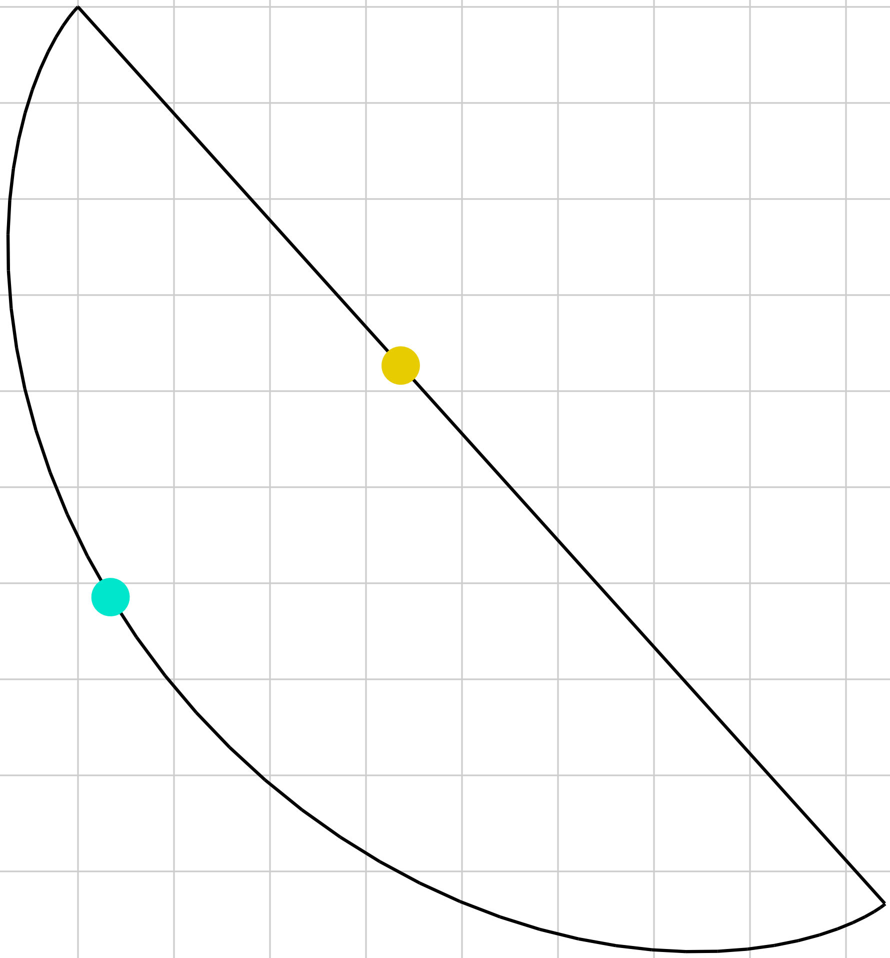

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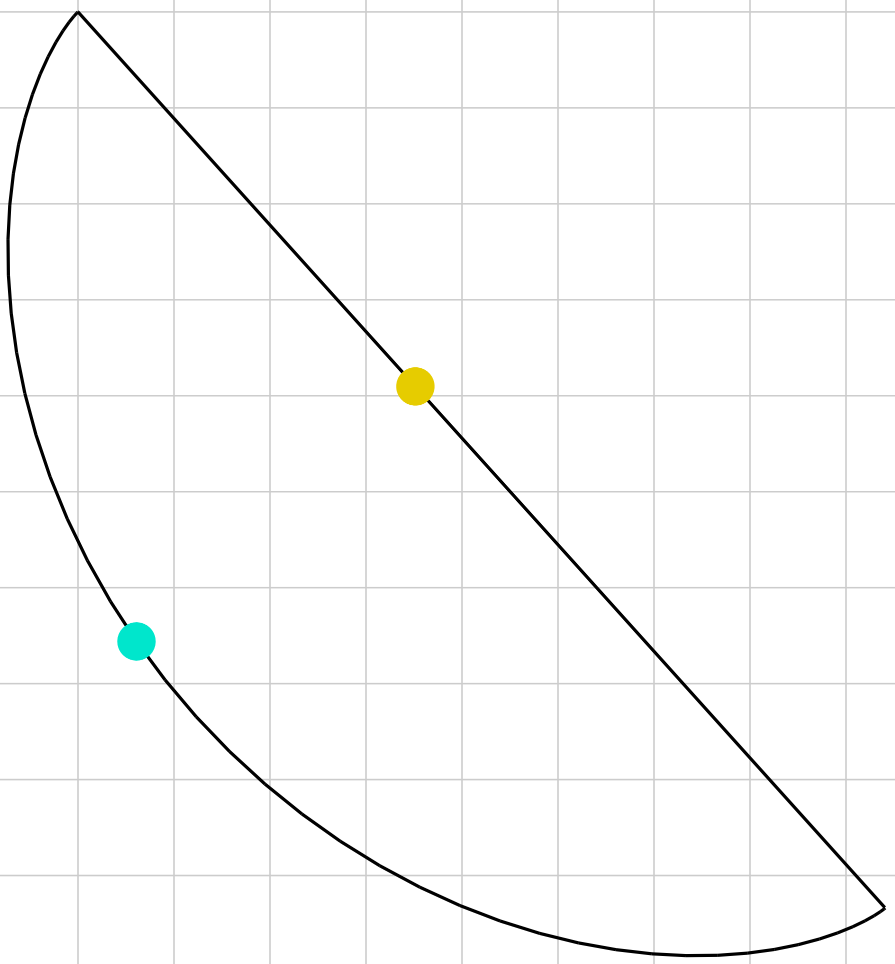

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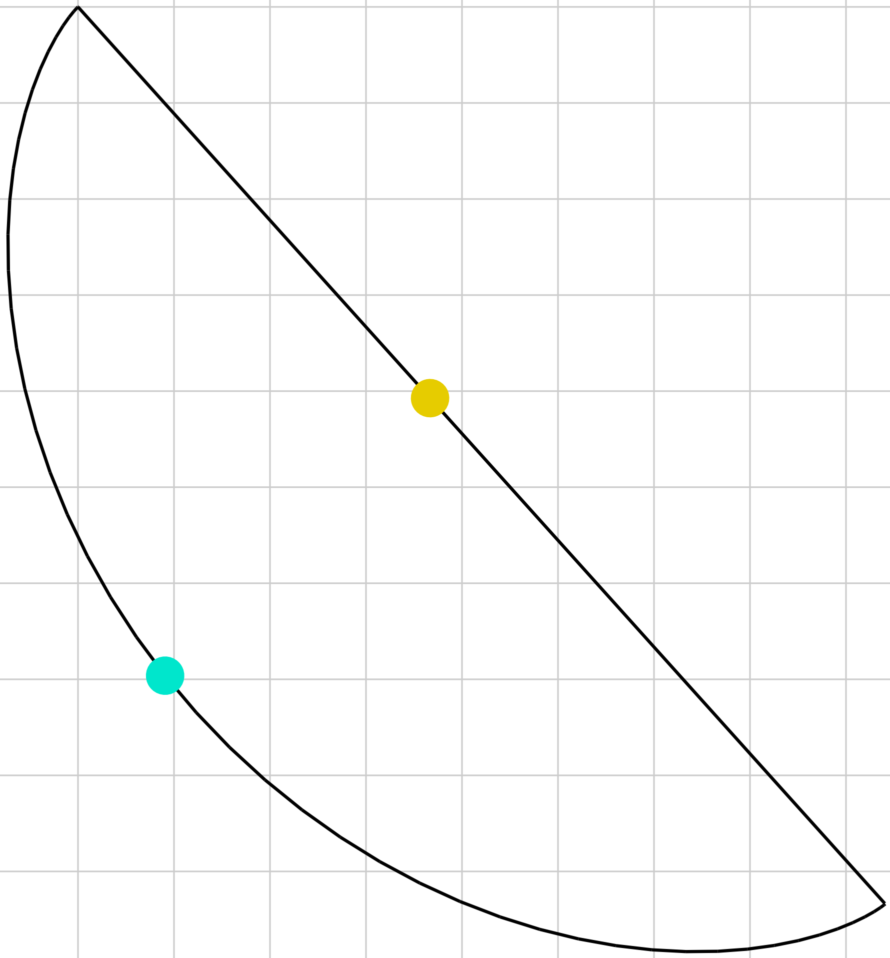

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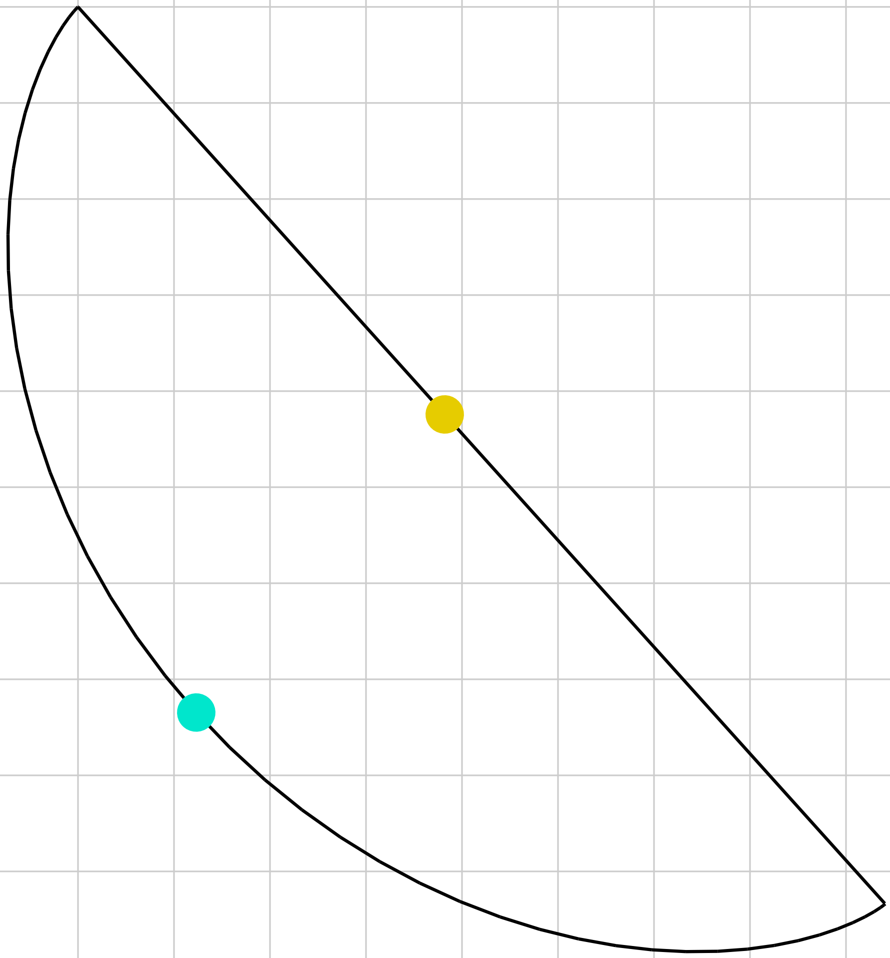

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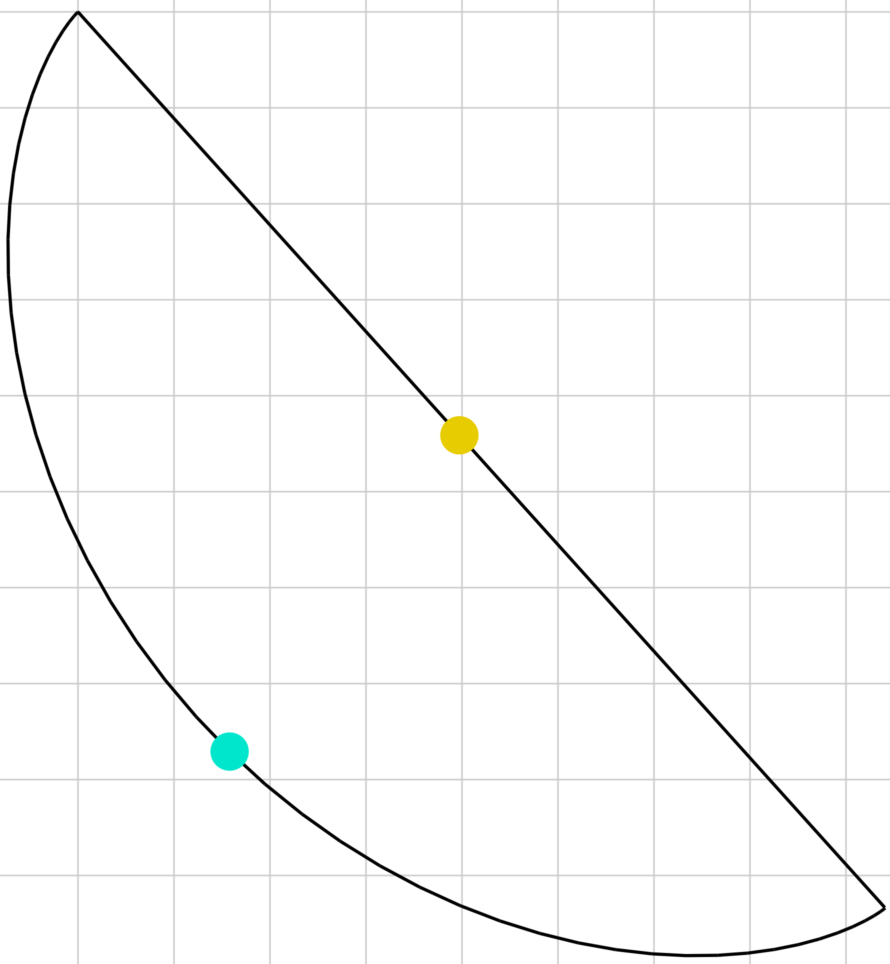

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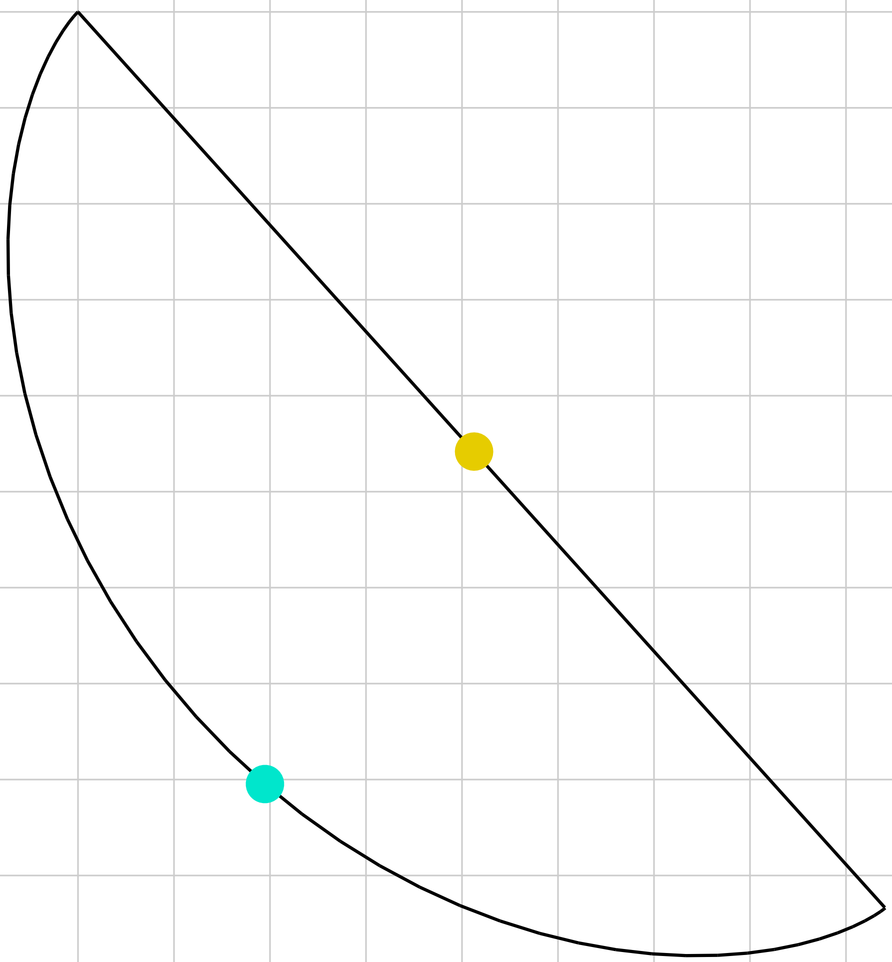

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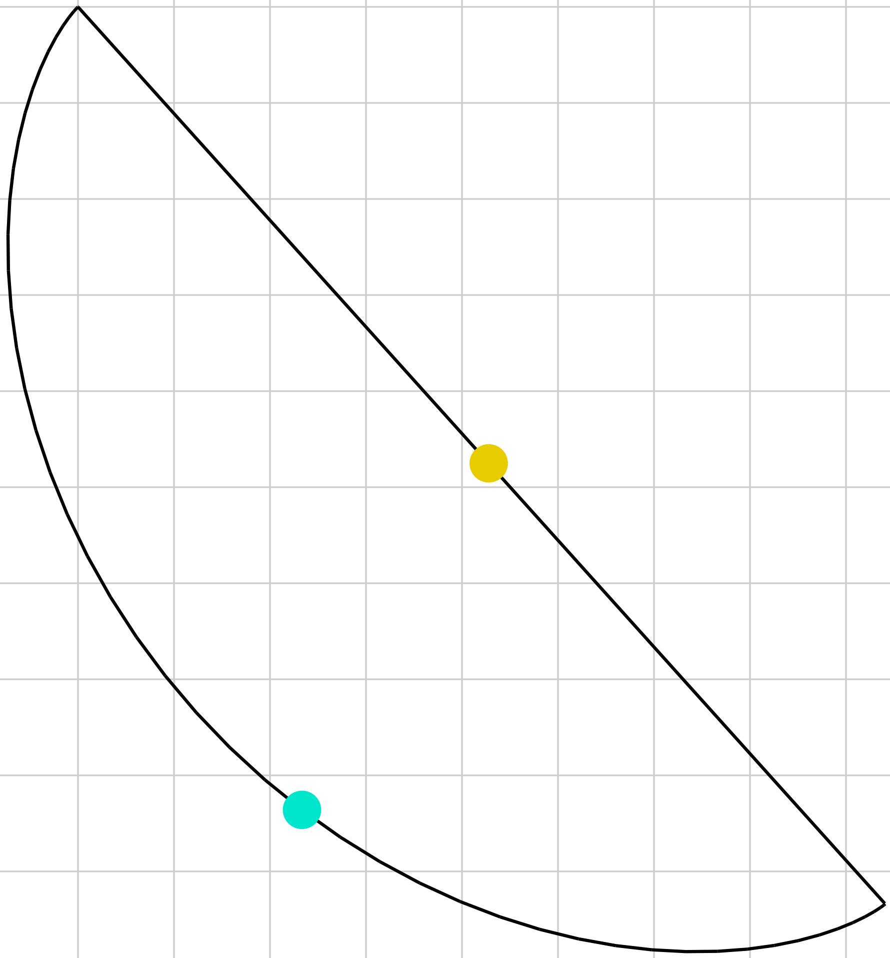

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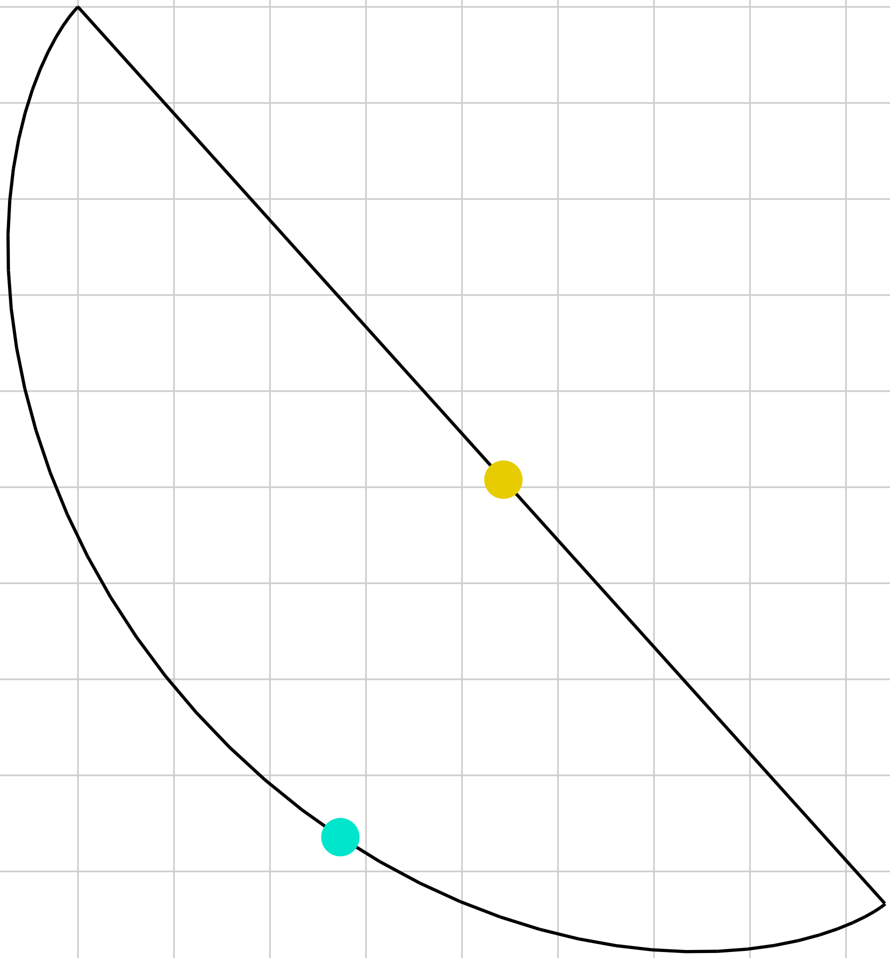

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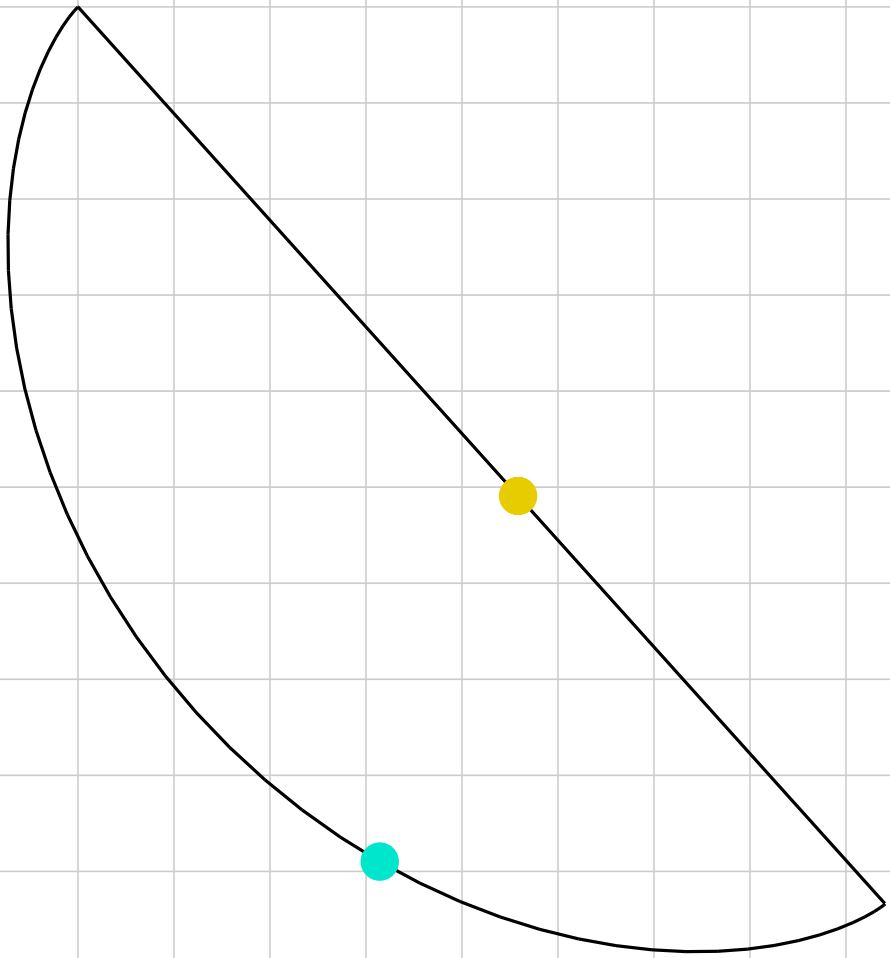

The physics for sliding board deals with the exchange of potential energy for kinetic energy at any distance y

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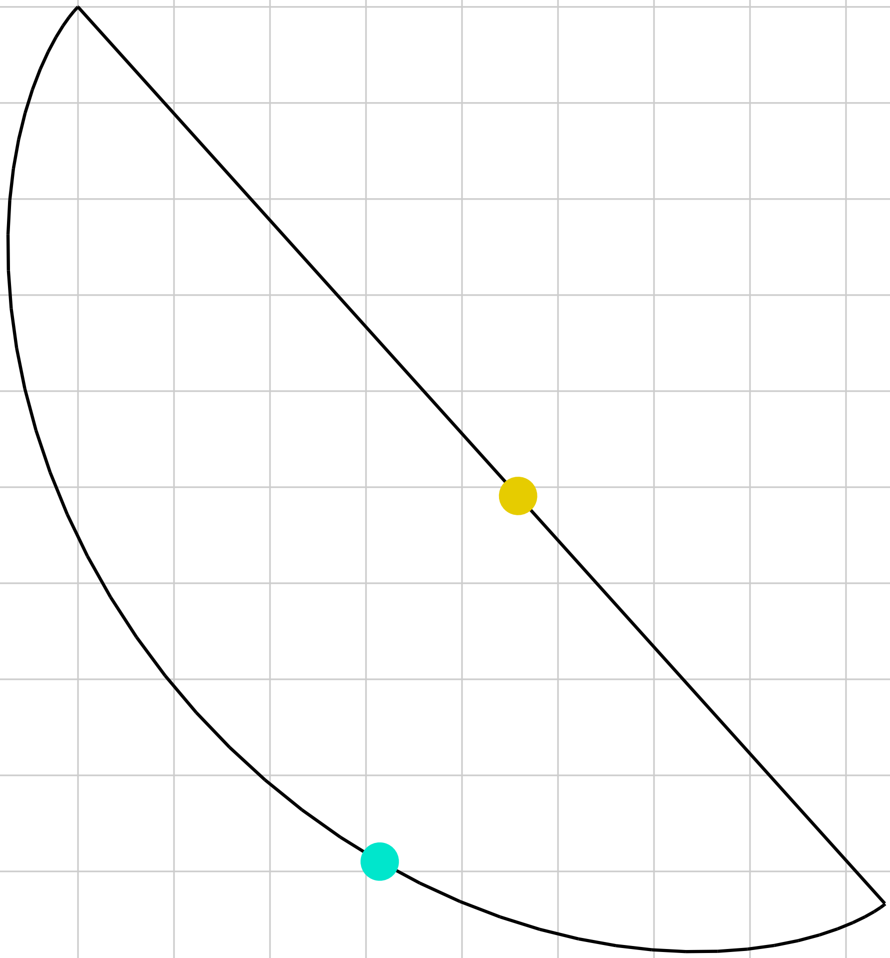

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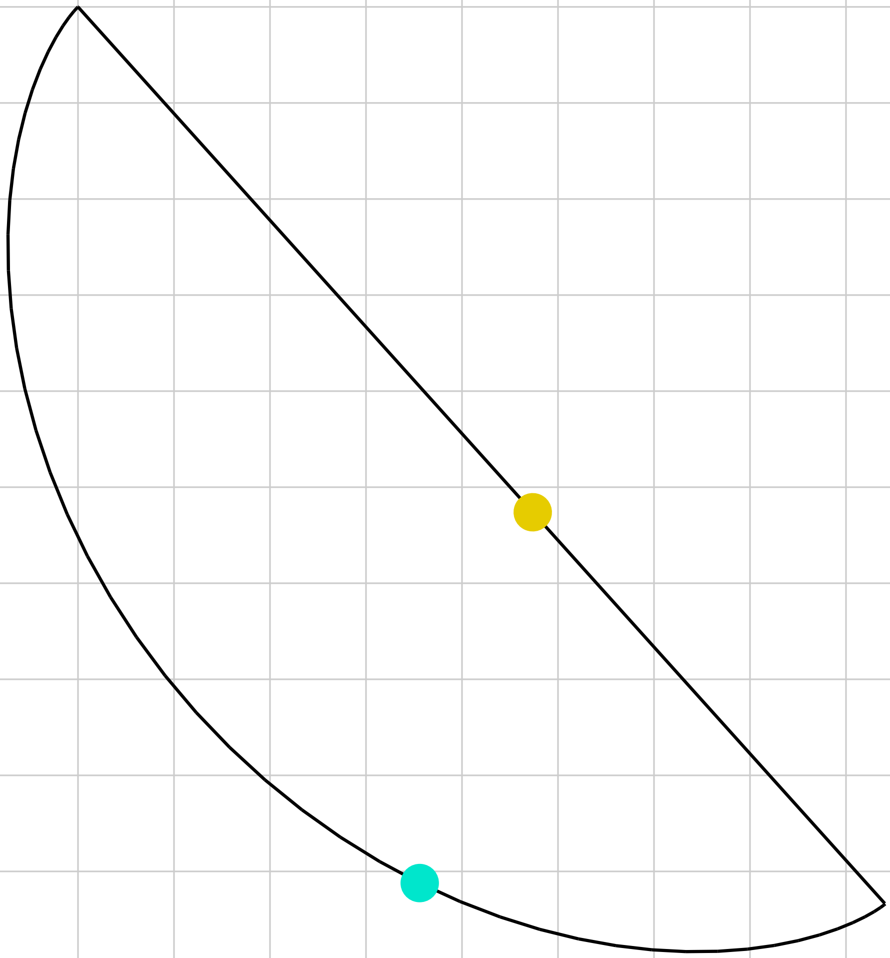

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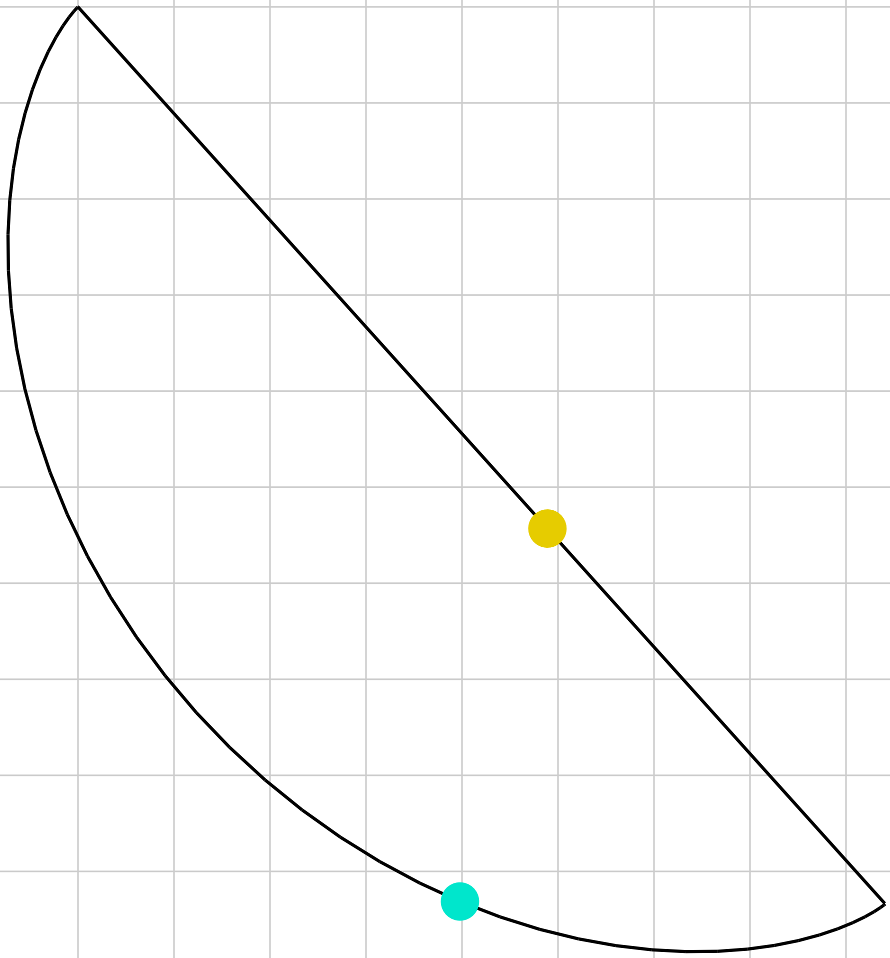

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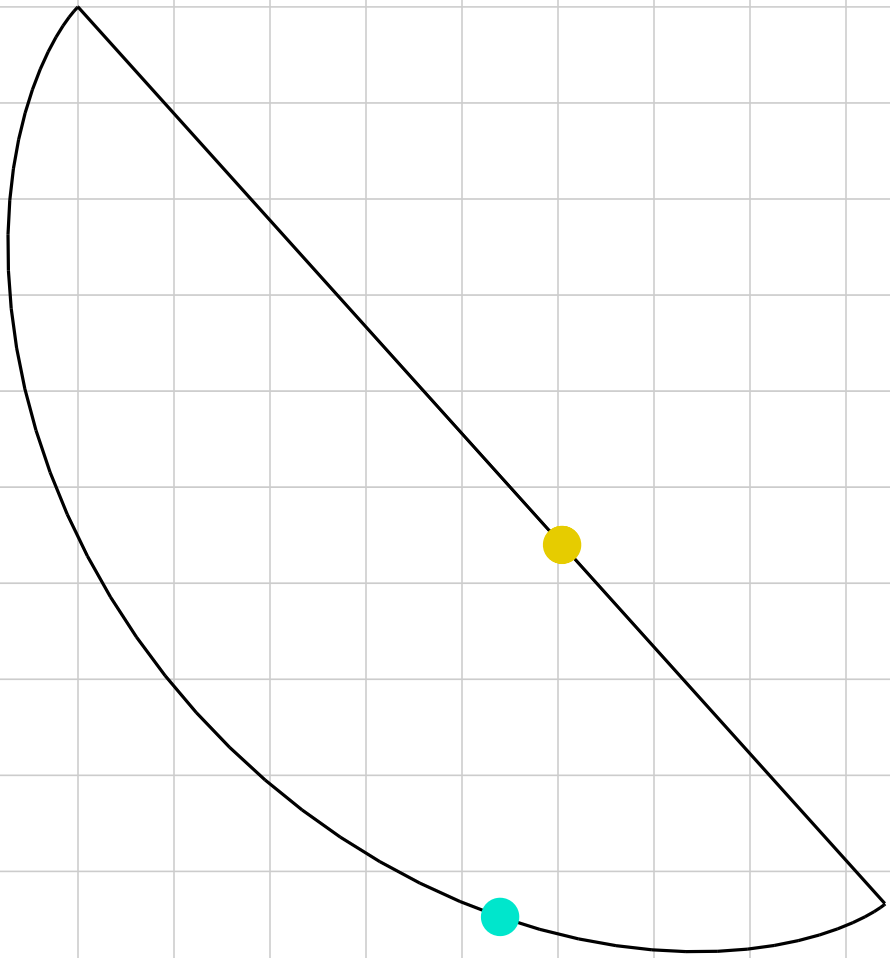

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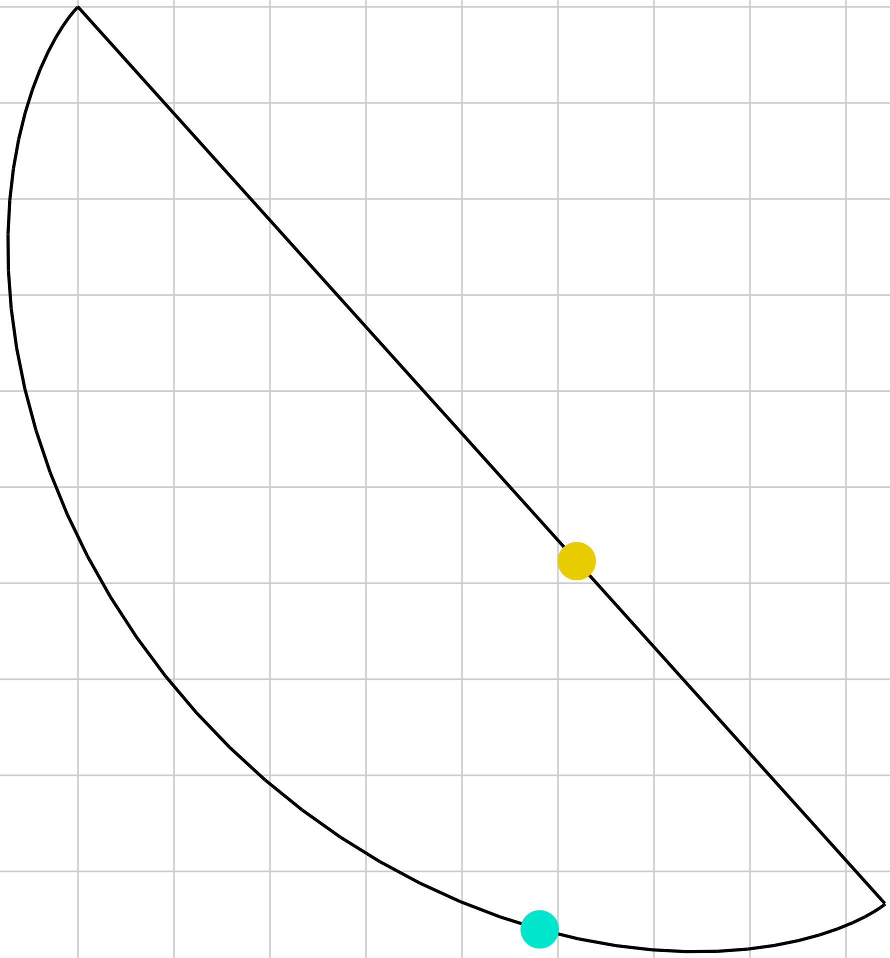

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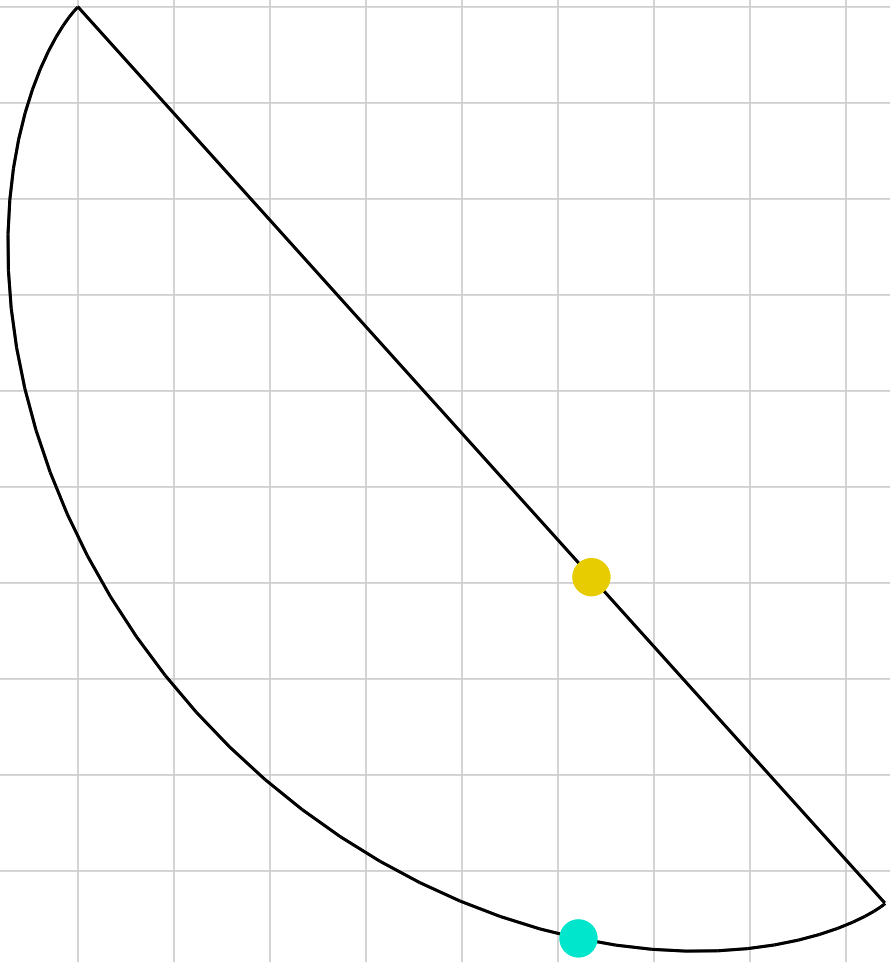

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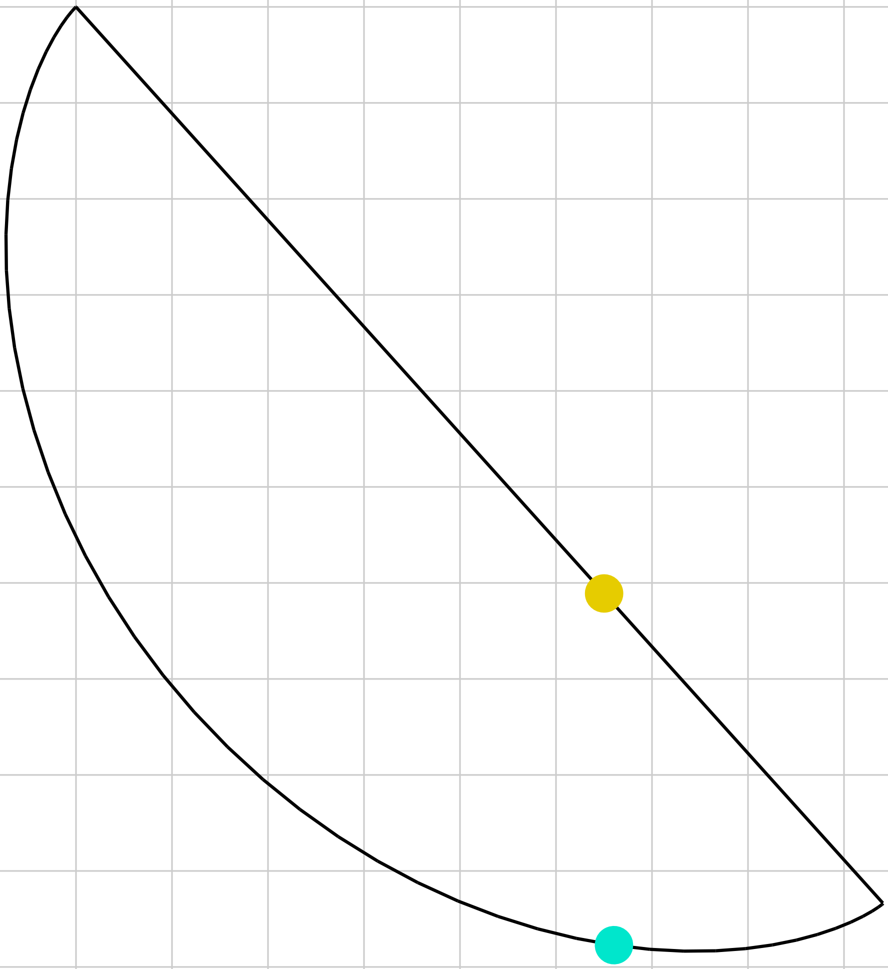

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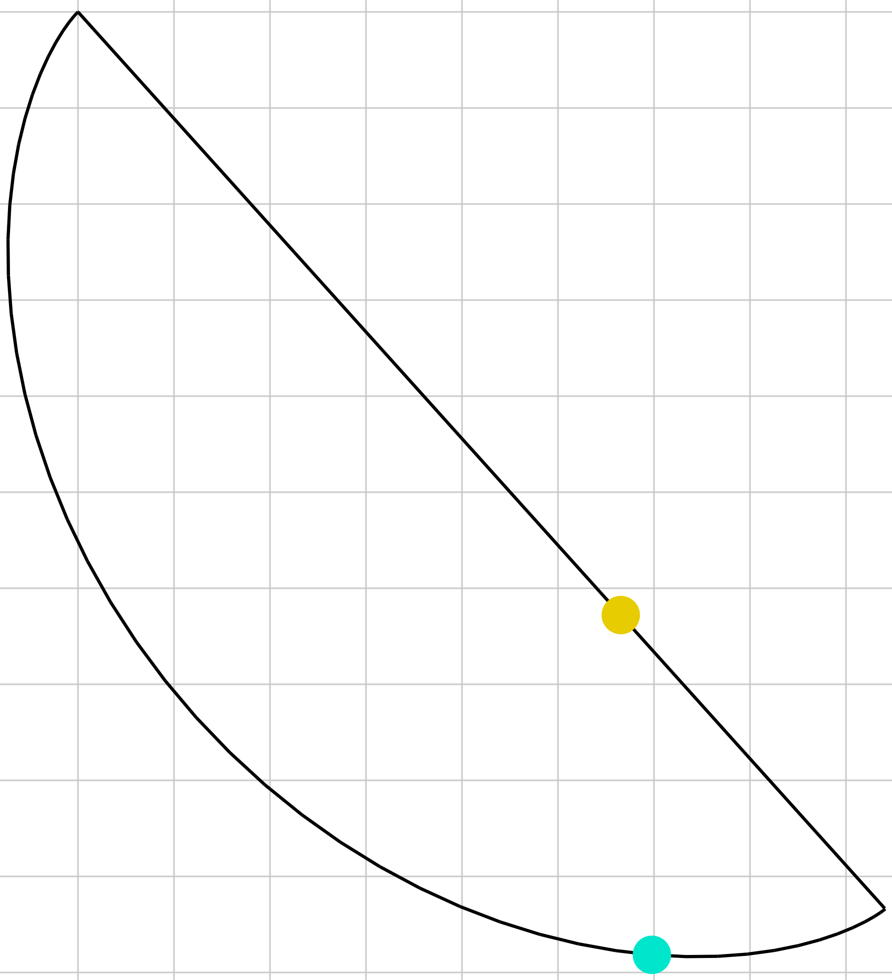

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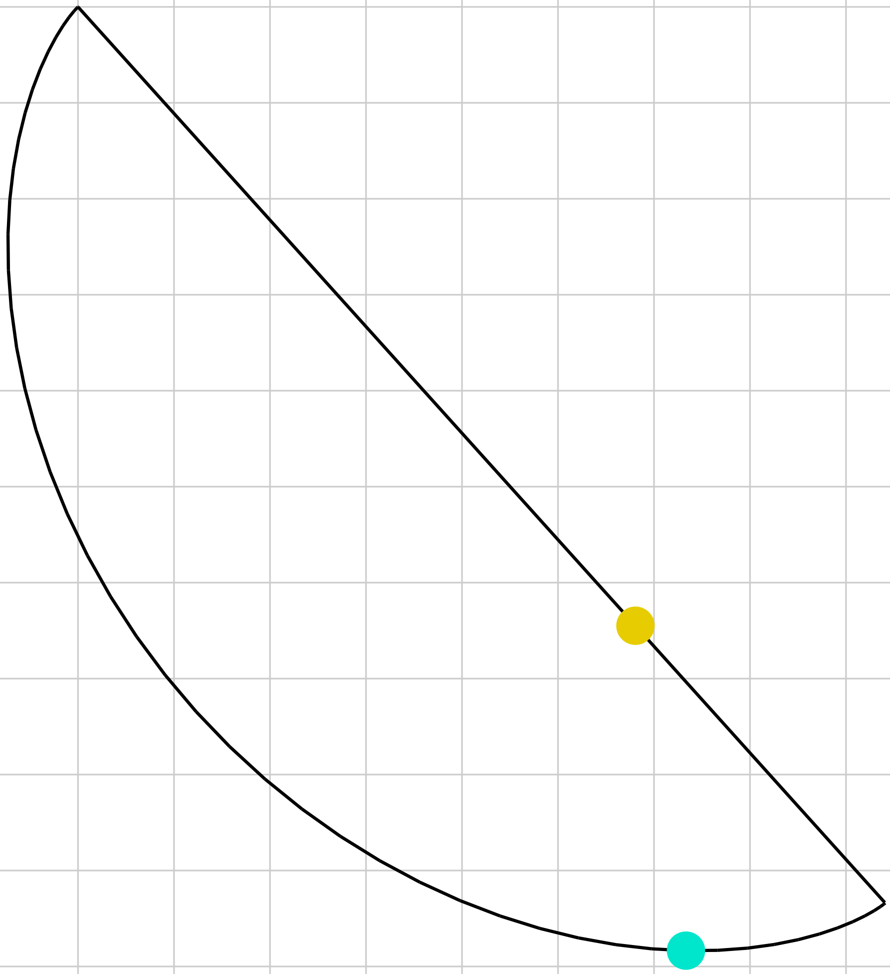

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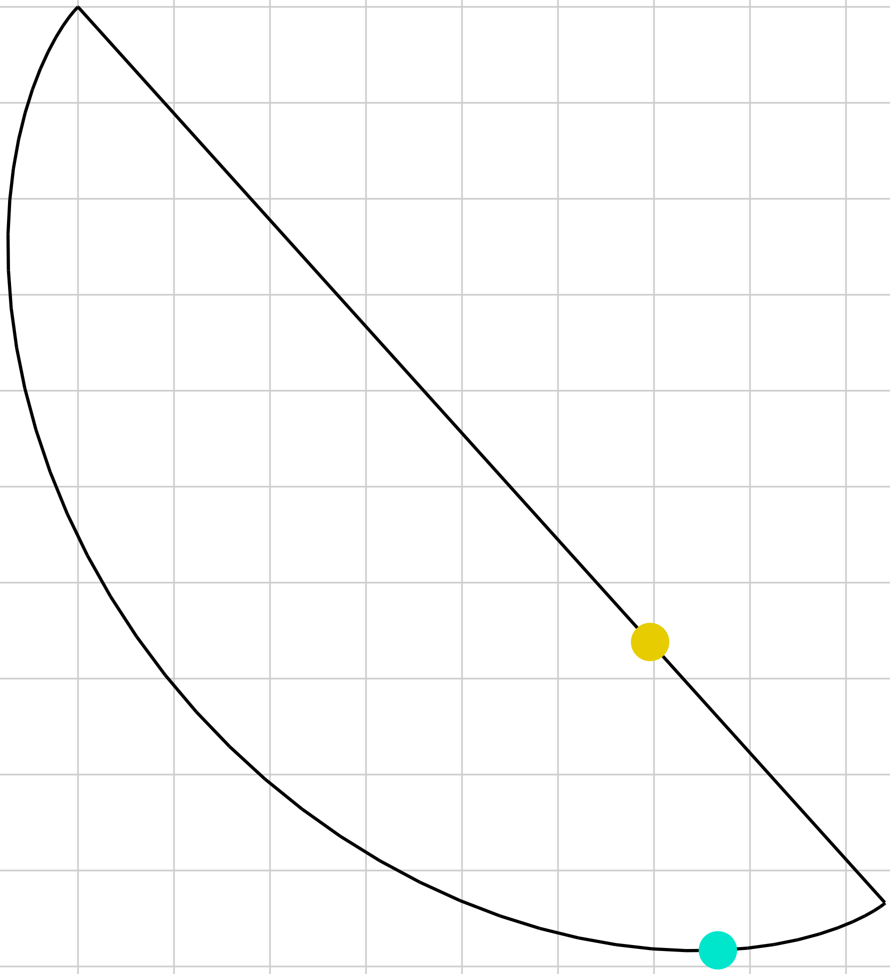

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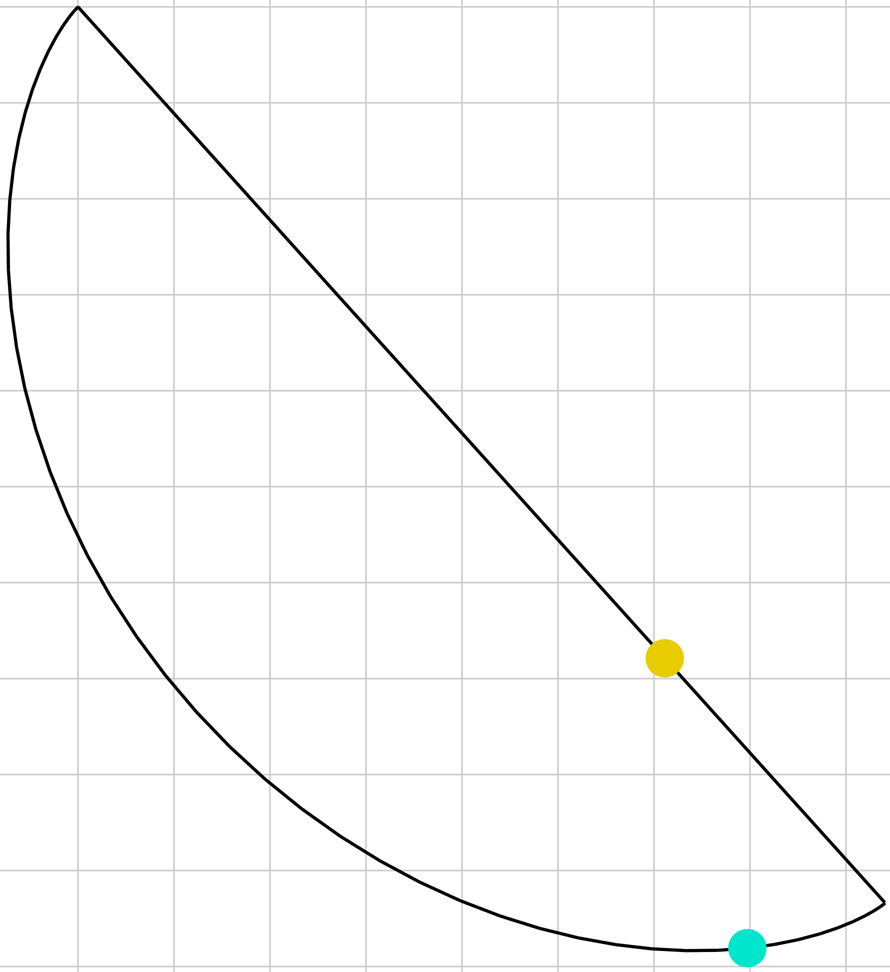

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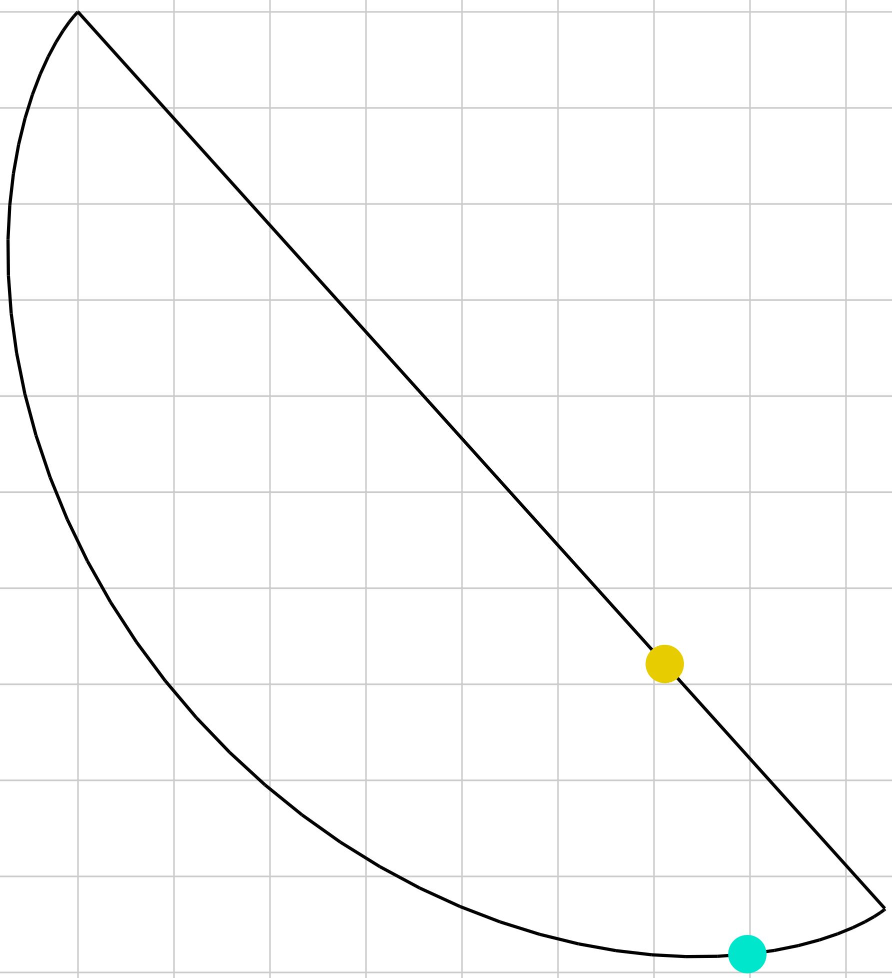

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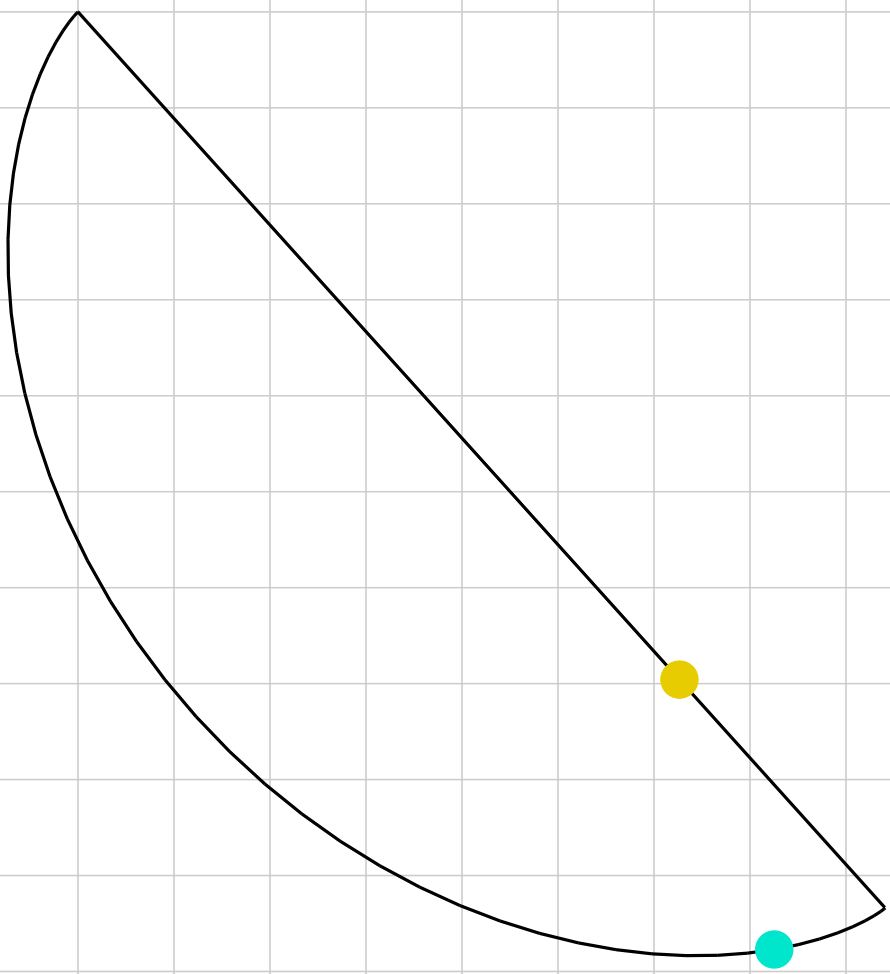

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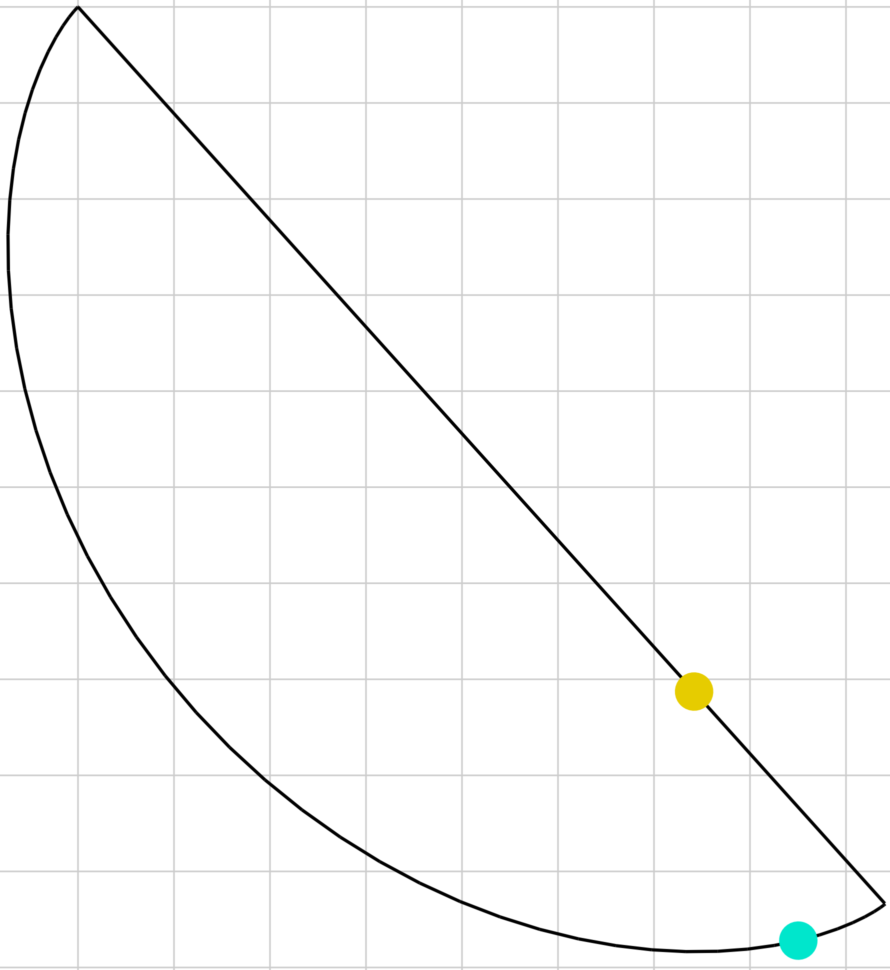

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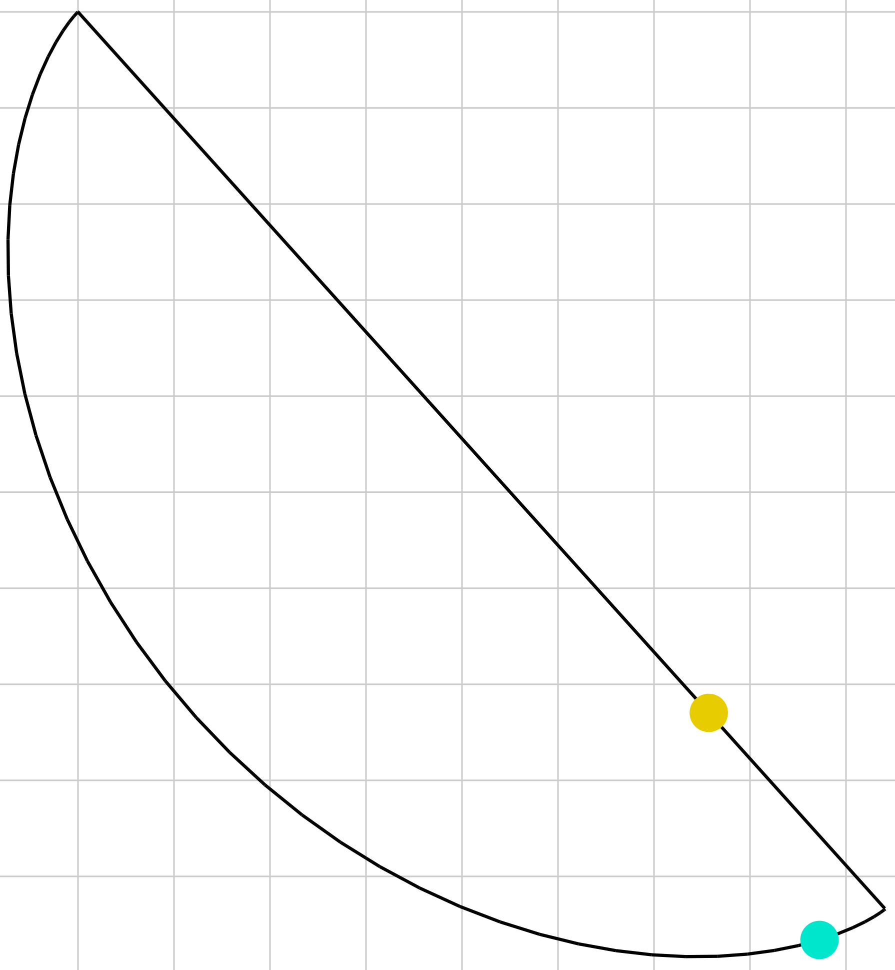

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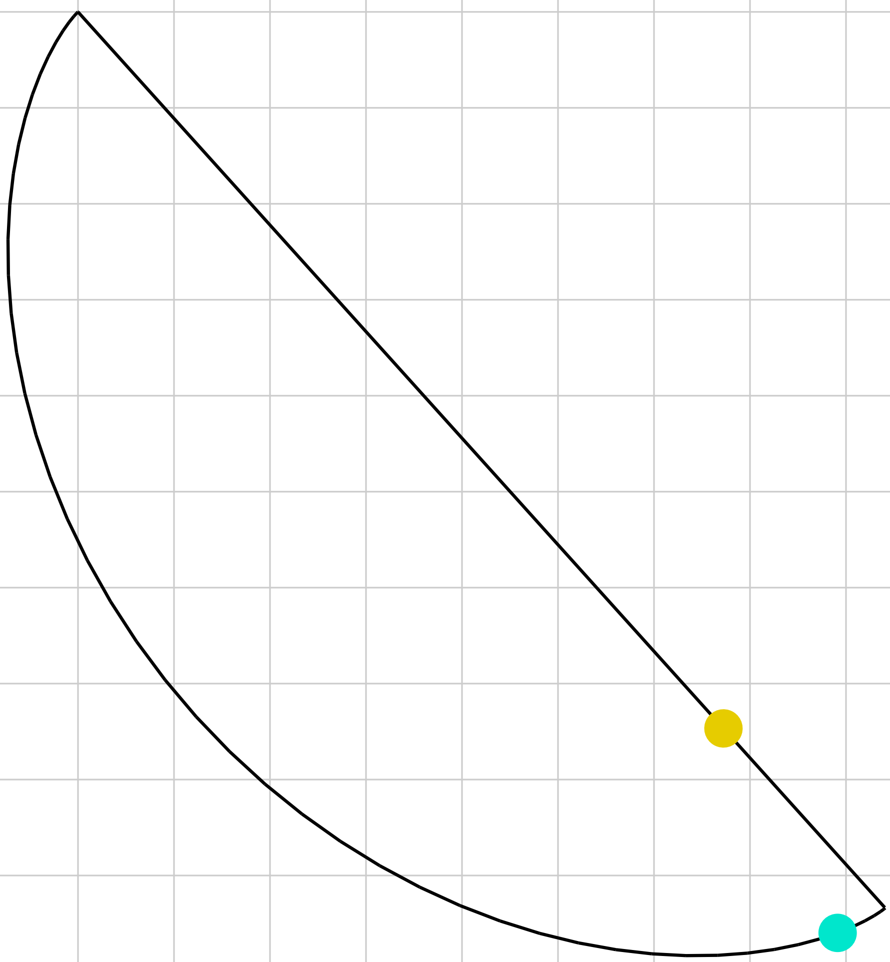

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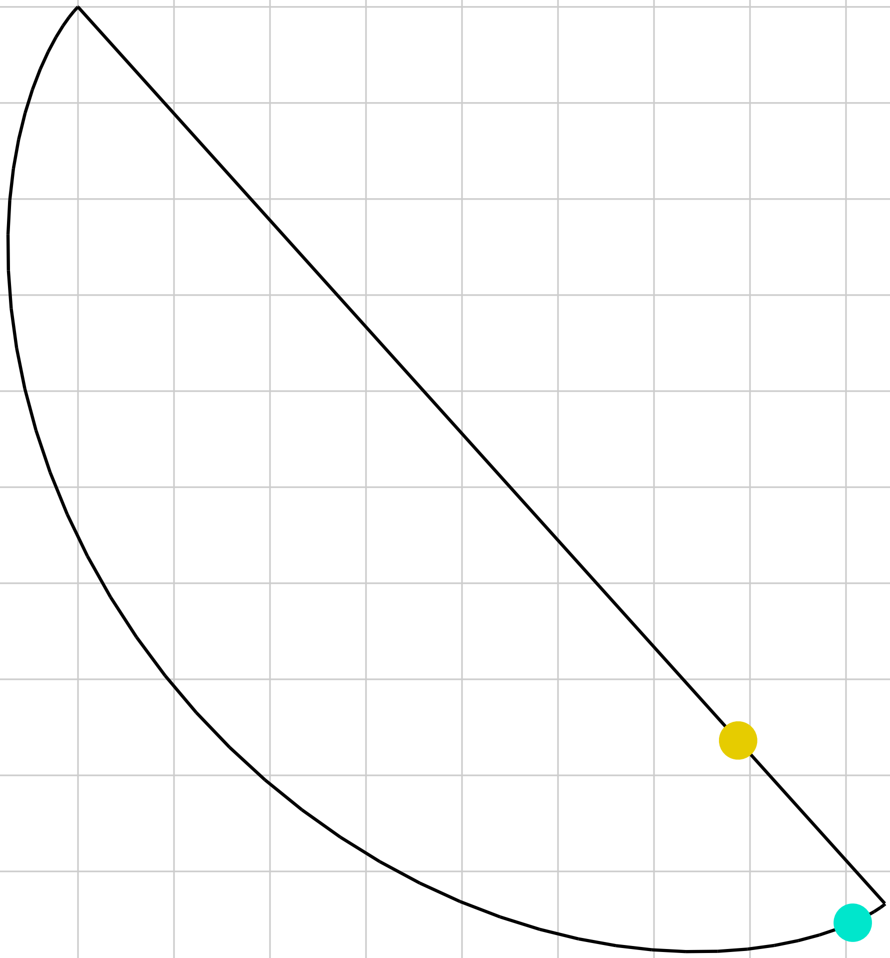

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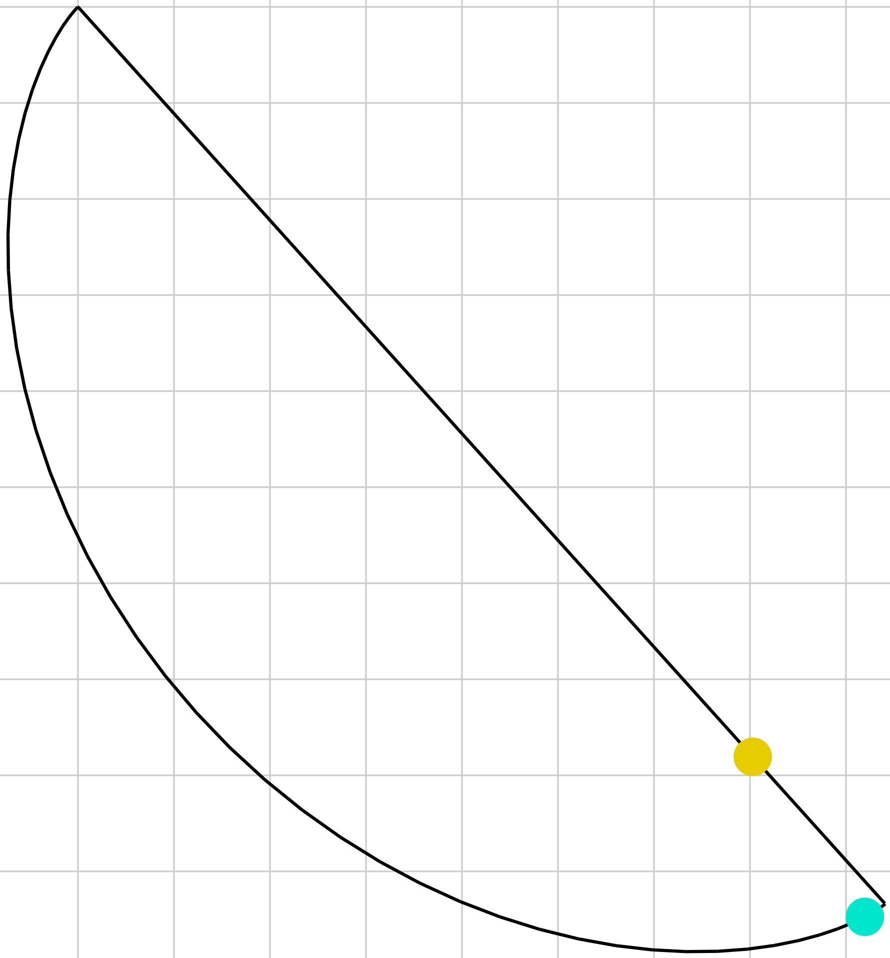

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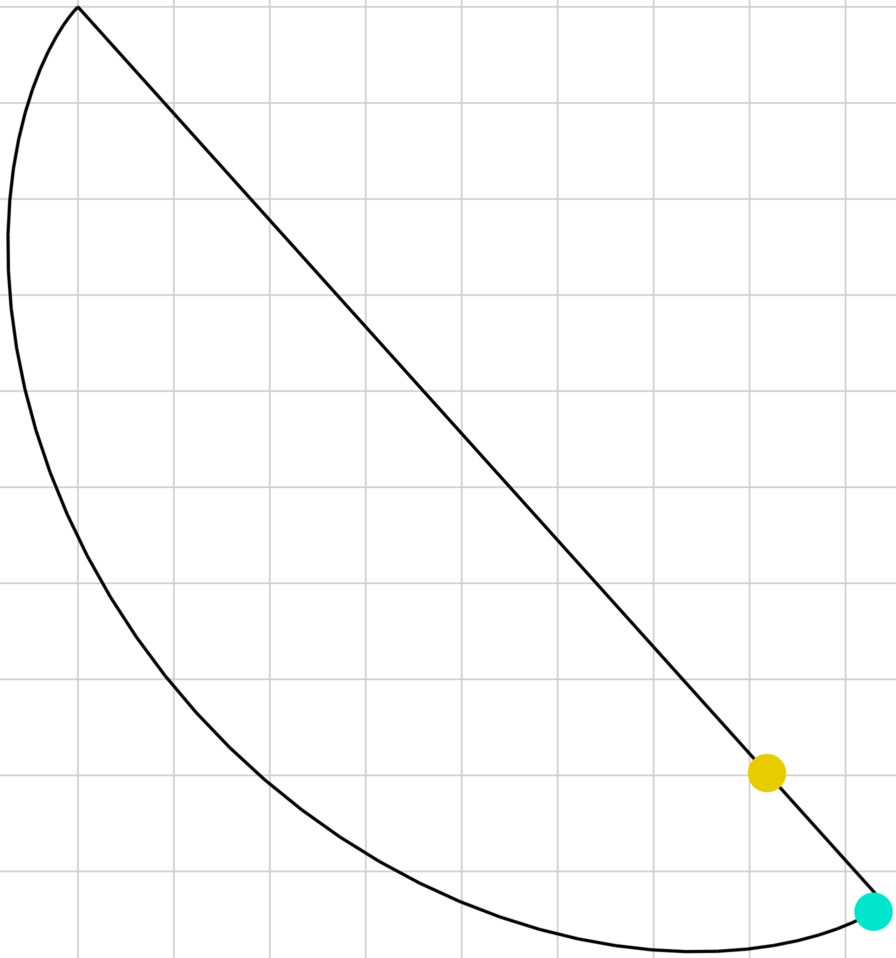

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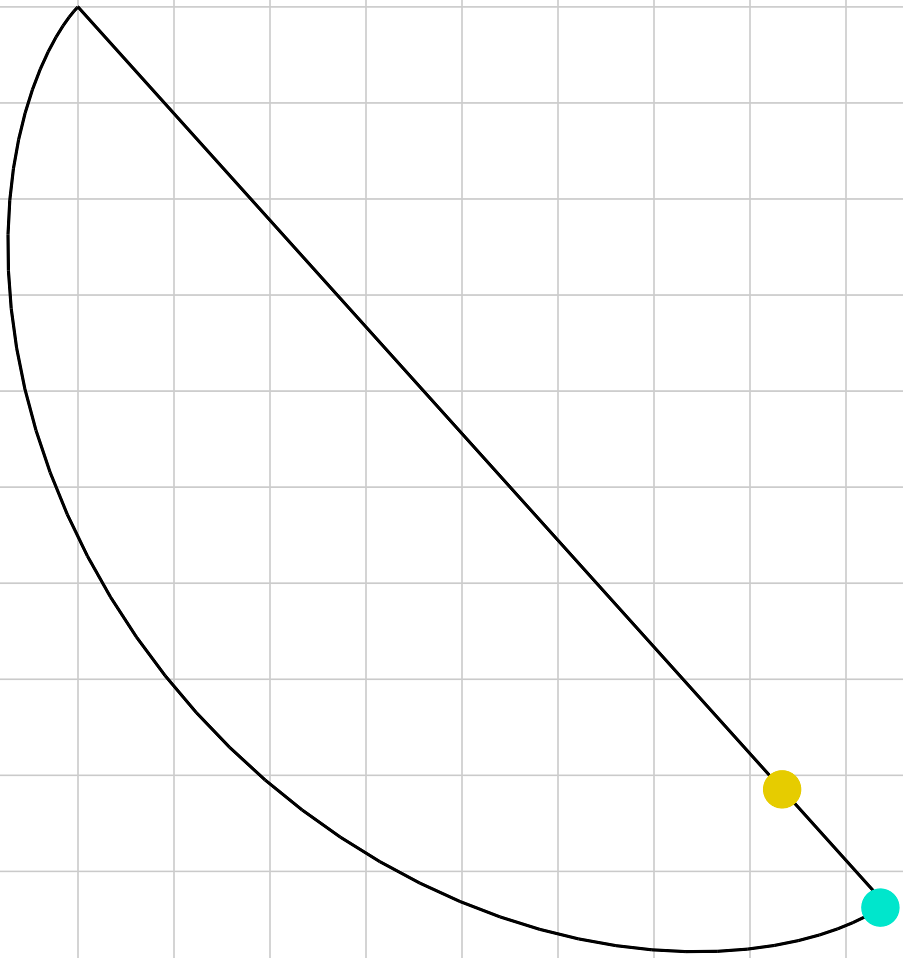

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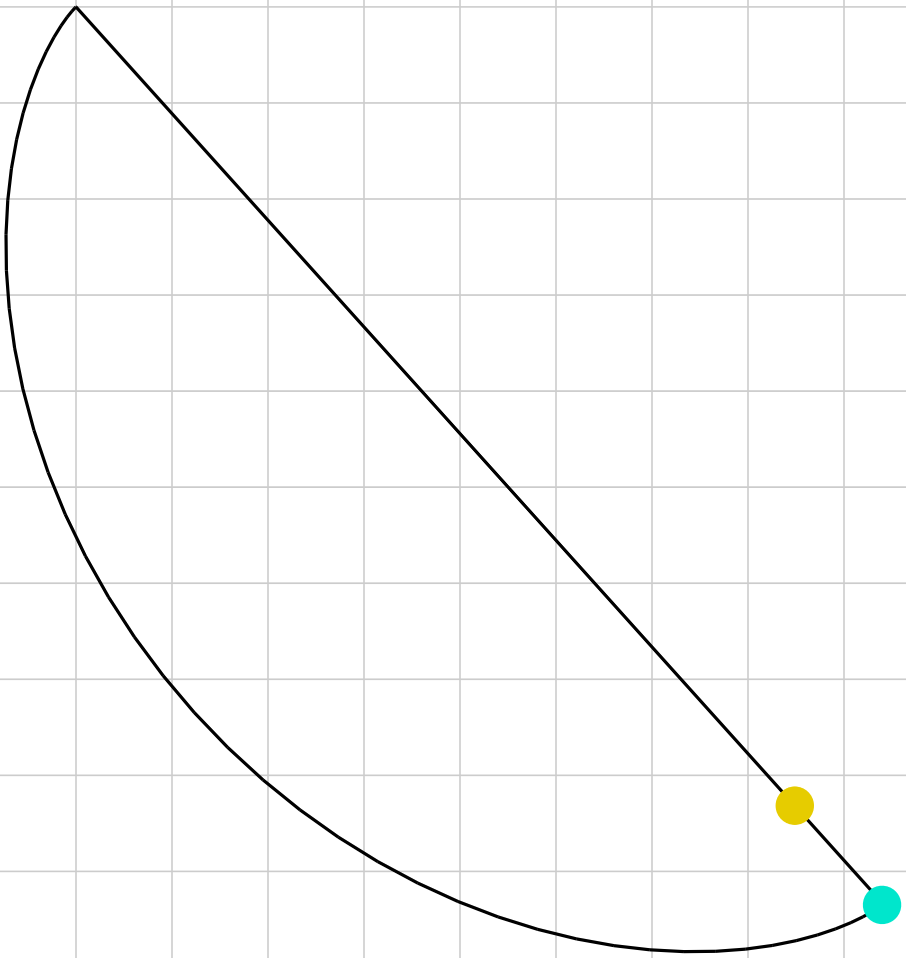

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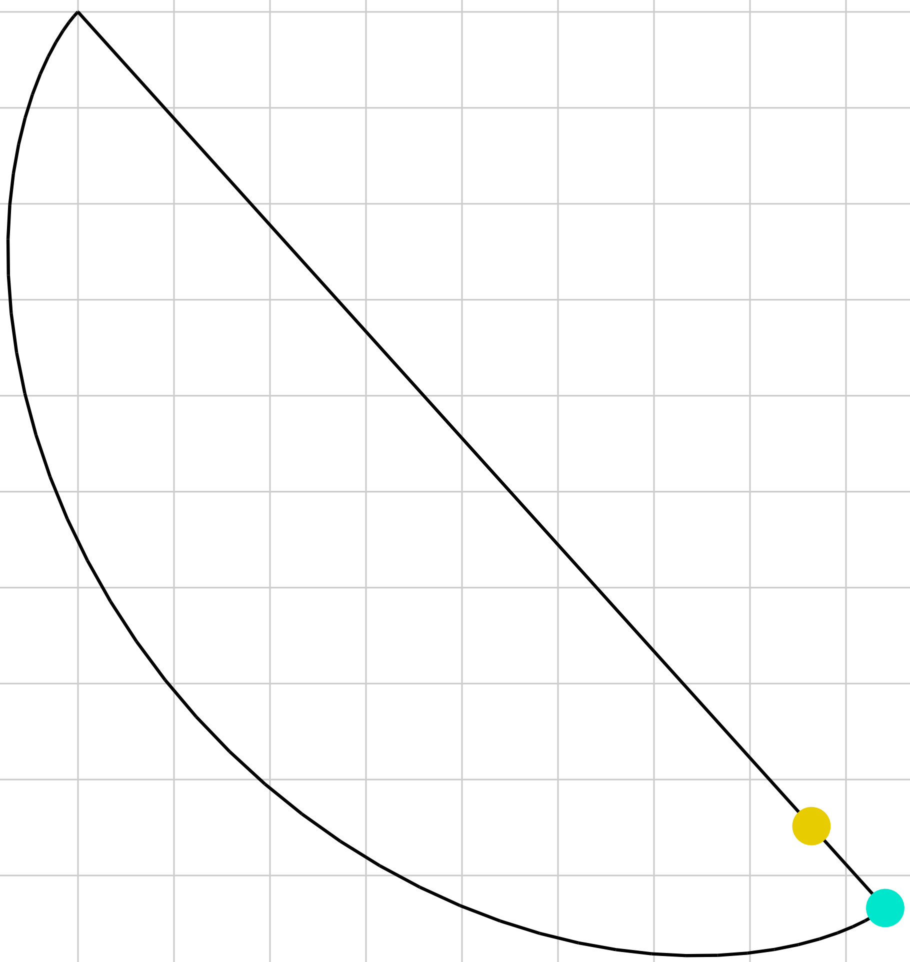

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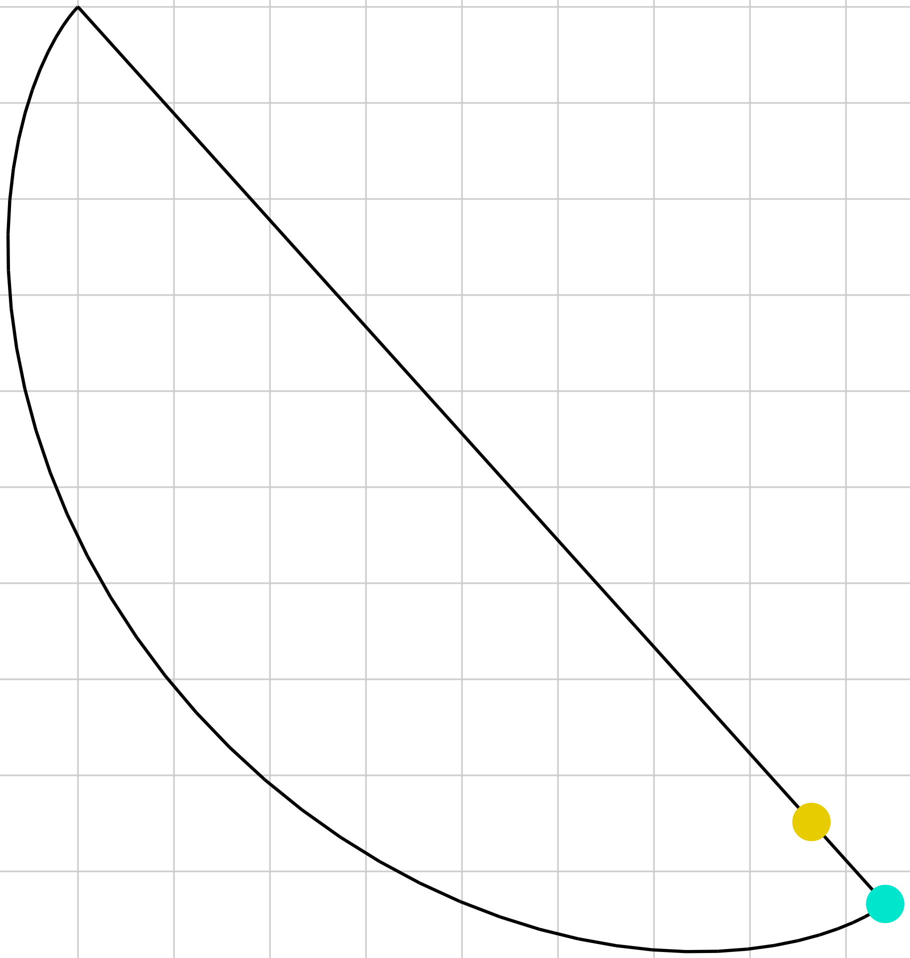
Thus, from all the proofs, cycloid as brachistochrone is the minimum time path between 2 points



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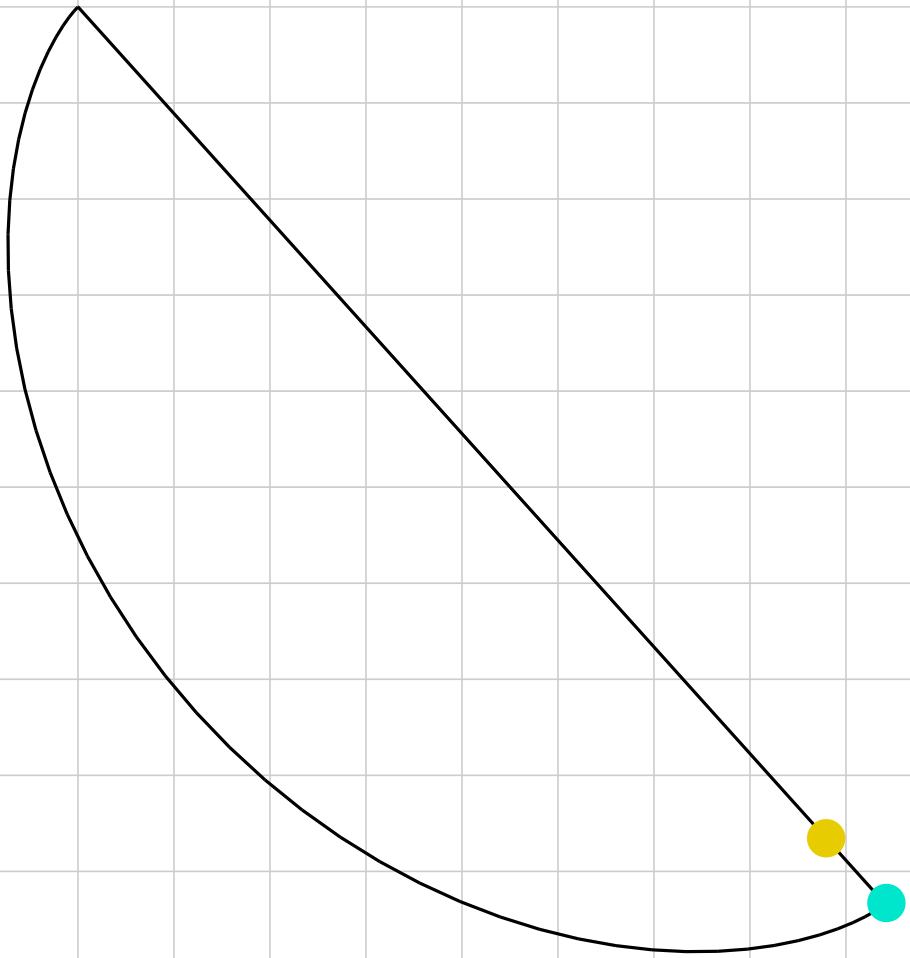

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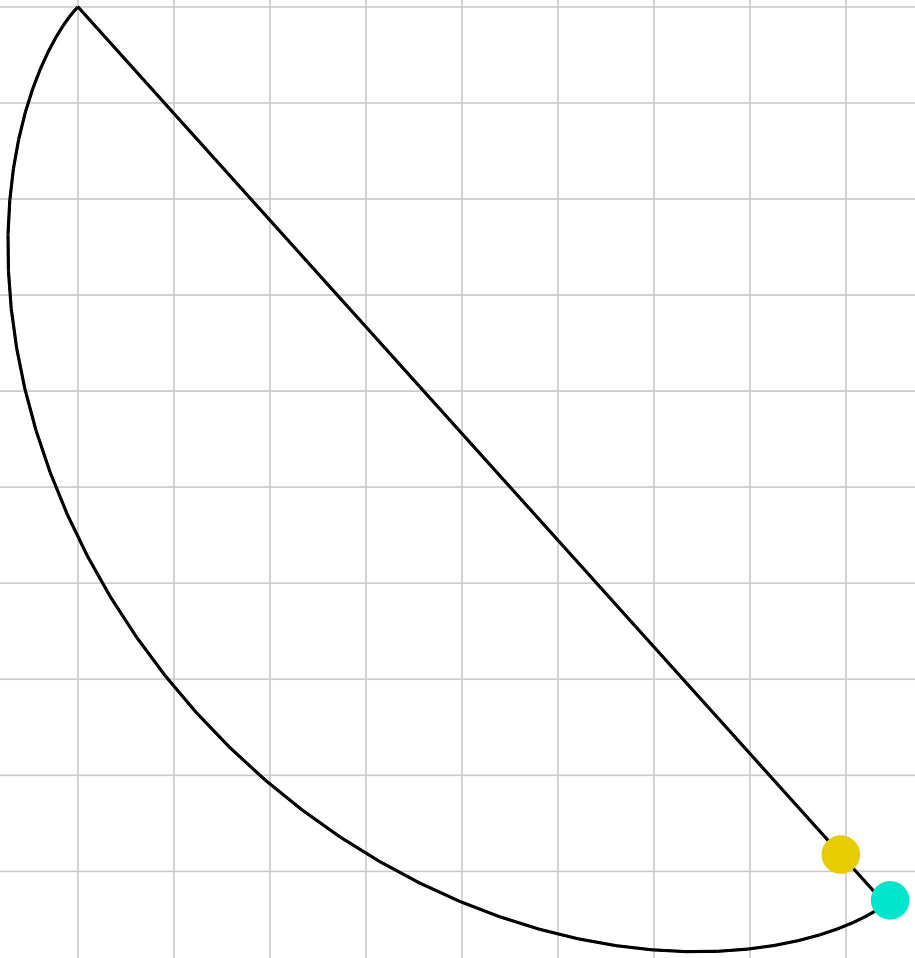

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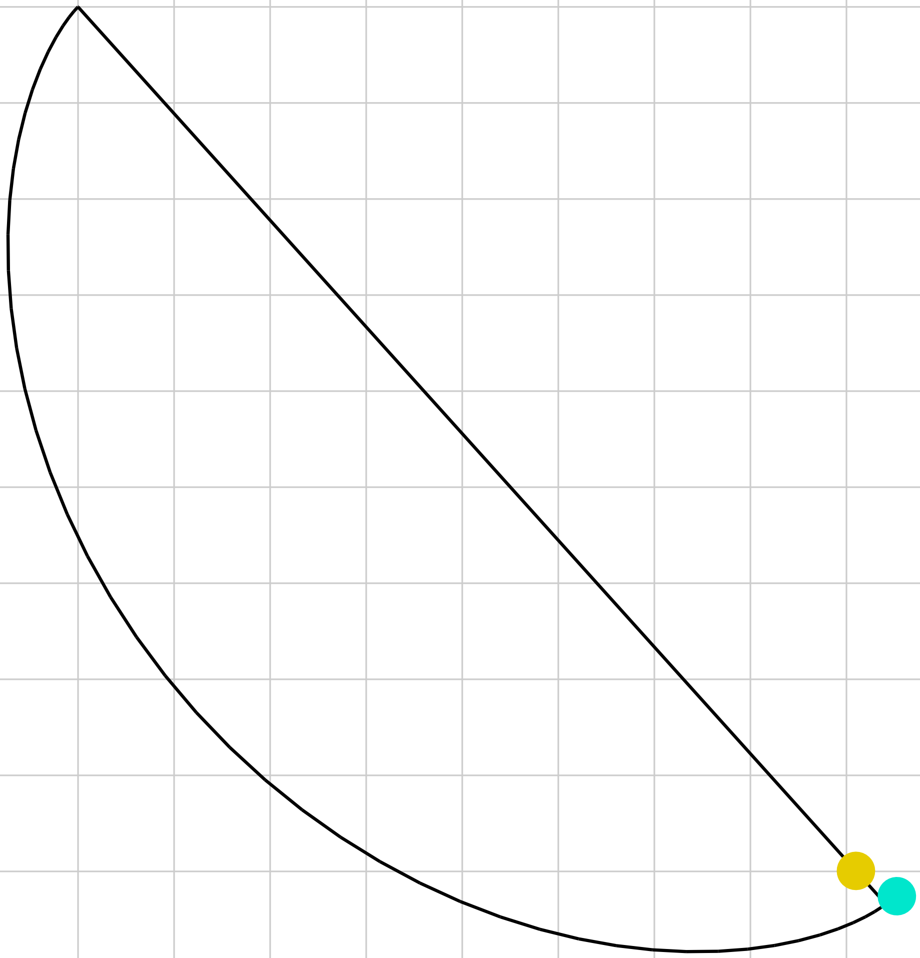

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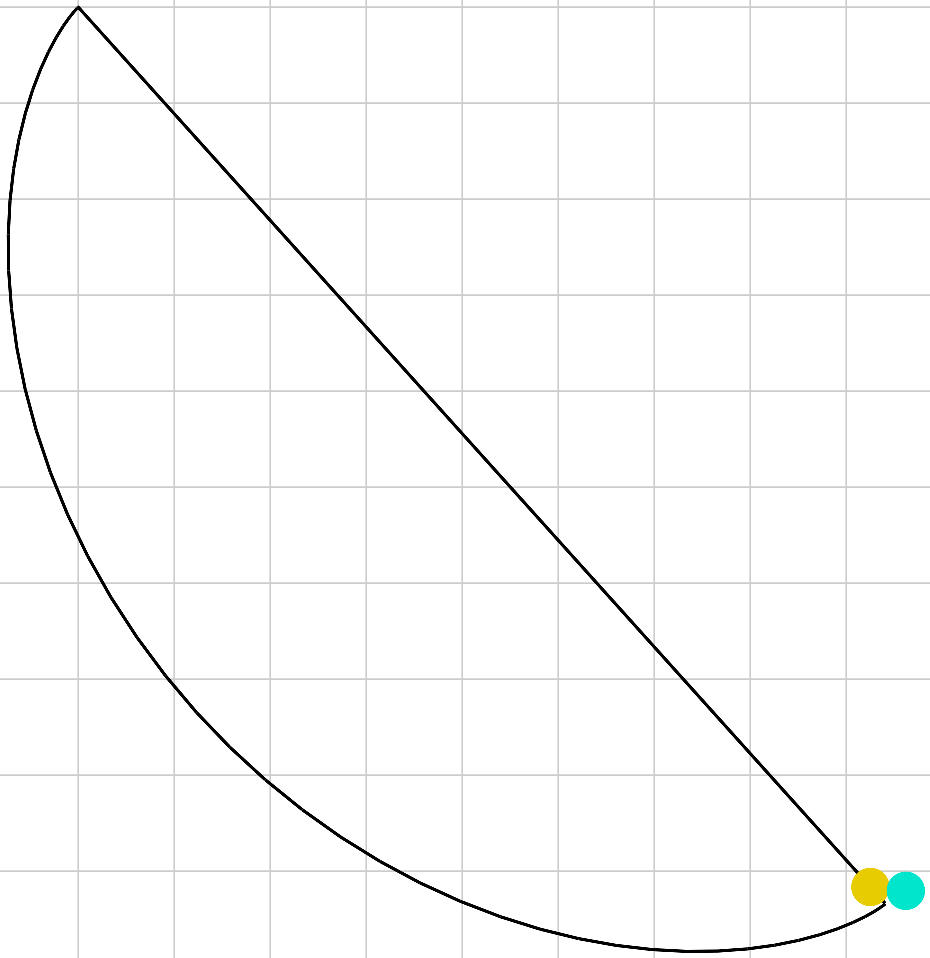

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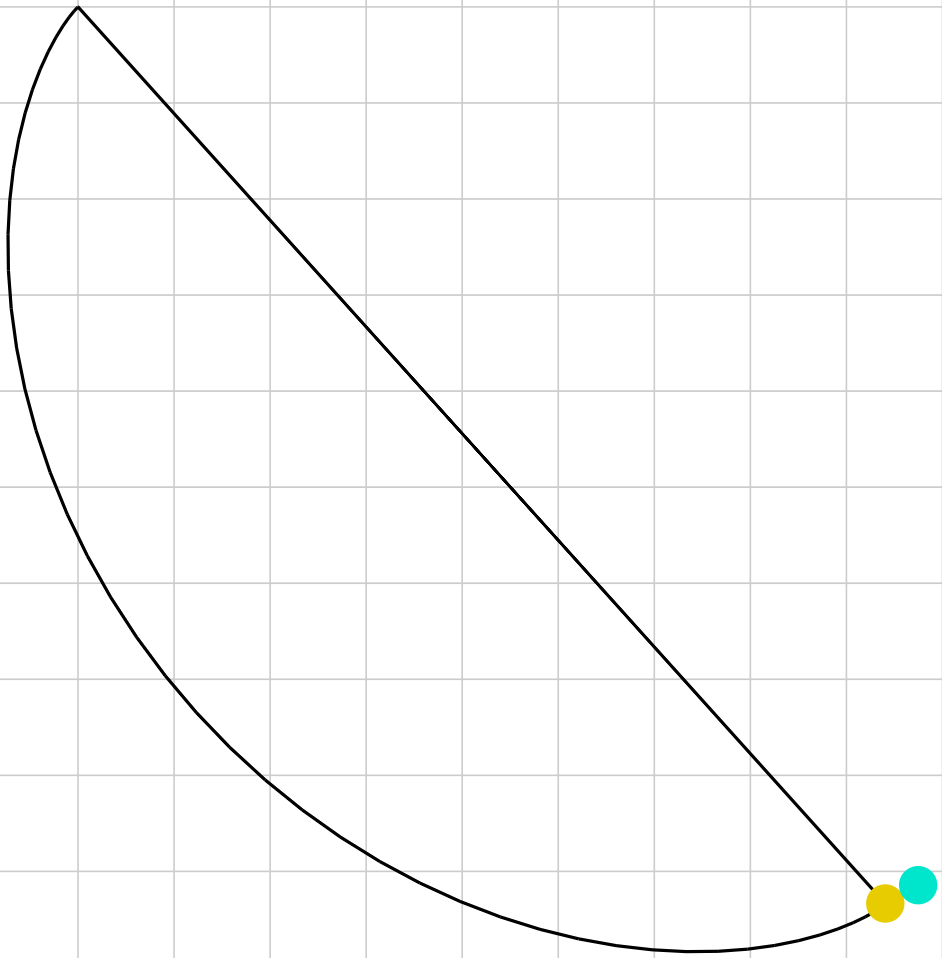
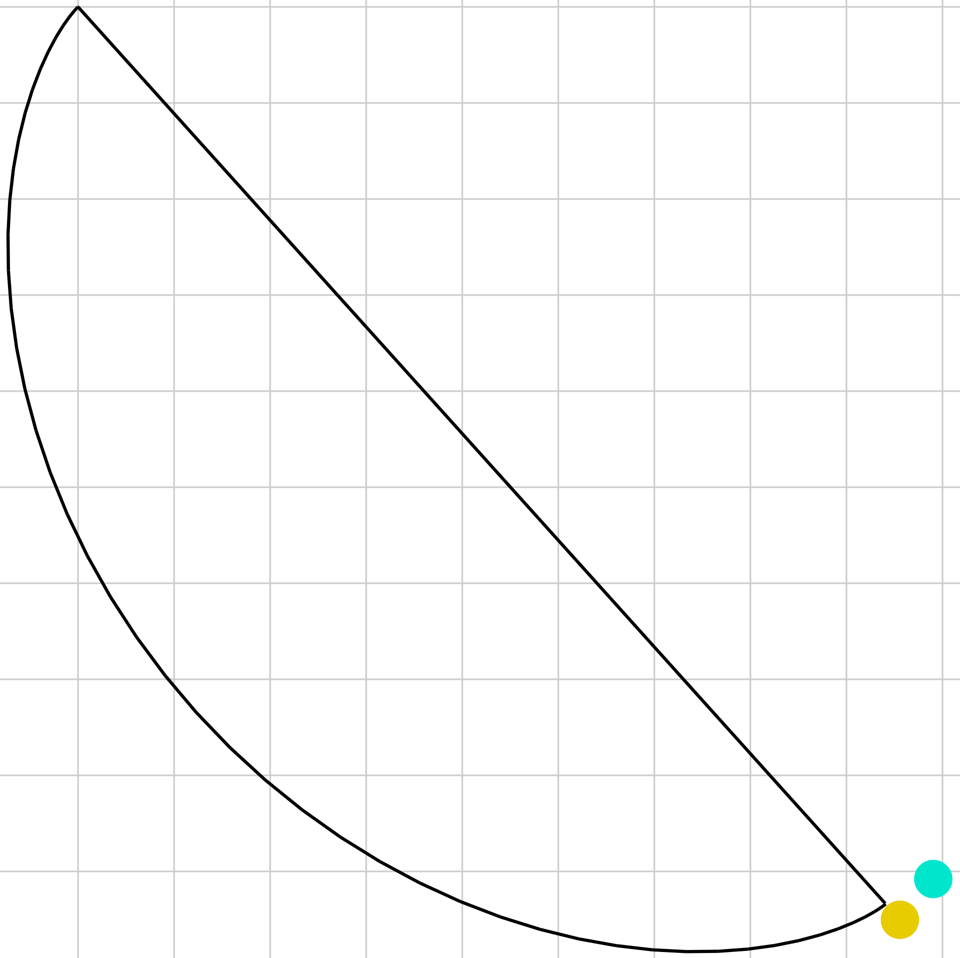


From the calculation, the cycloid has a shorter time path.

cycloid as brachistochrone, t = 3.23

flat slide, t = 3.54

Thus, from all the proofs, cycloid as brachistochrone is the minimum time path between 2 points



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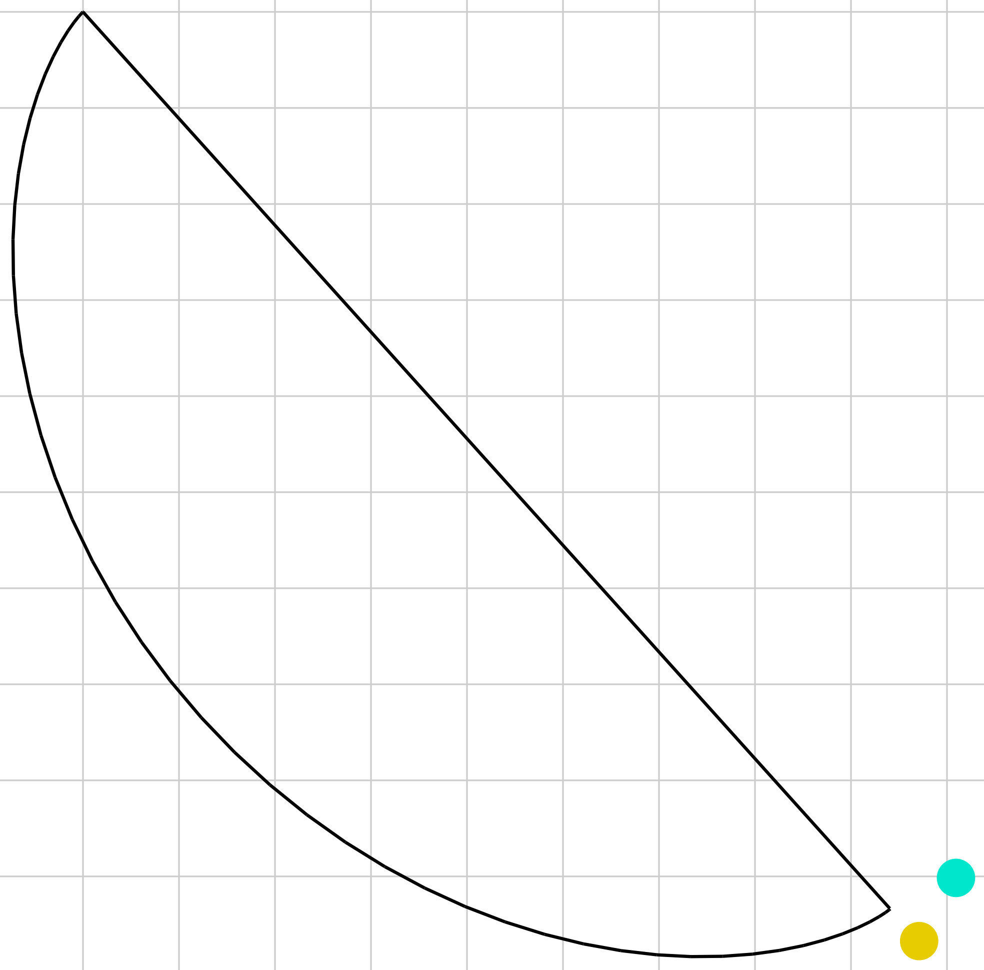

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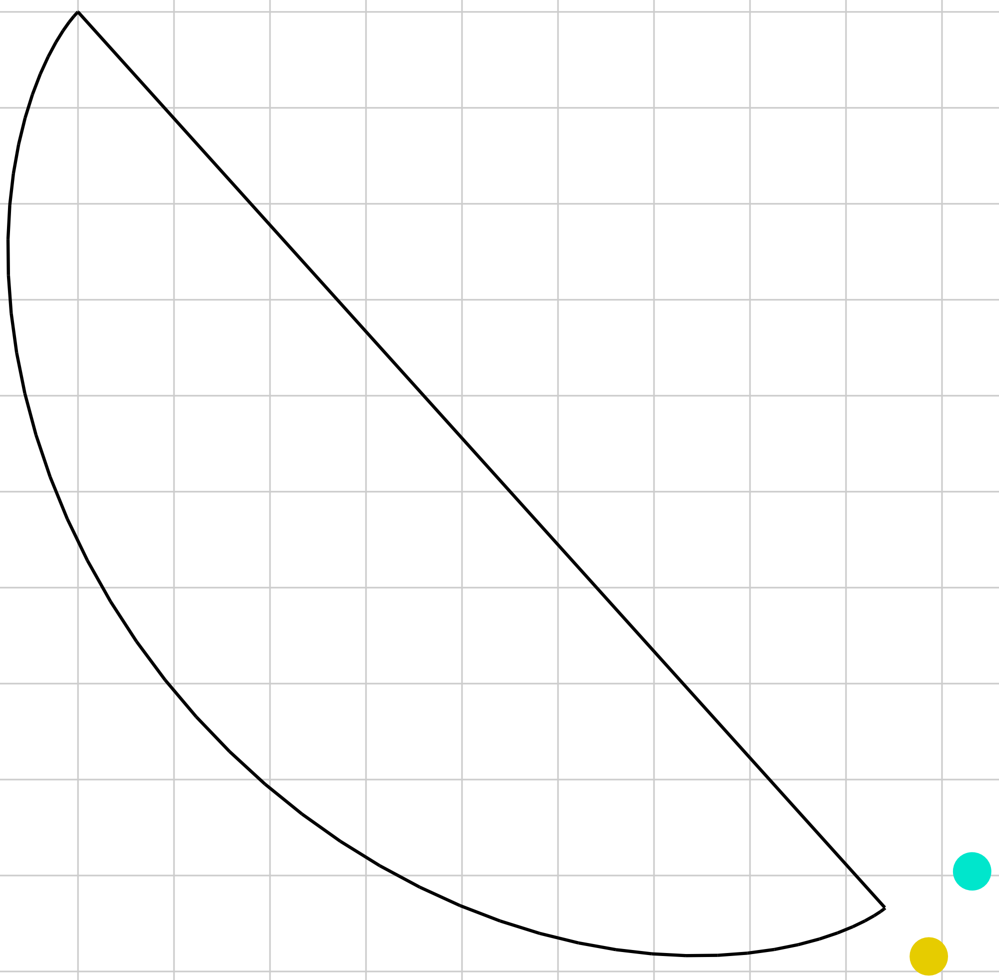

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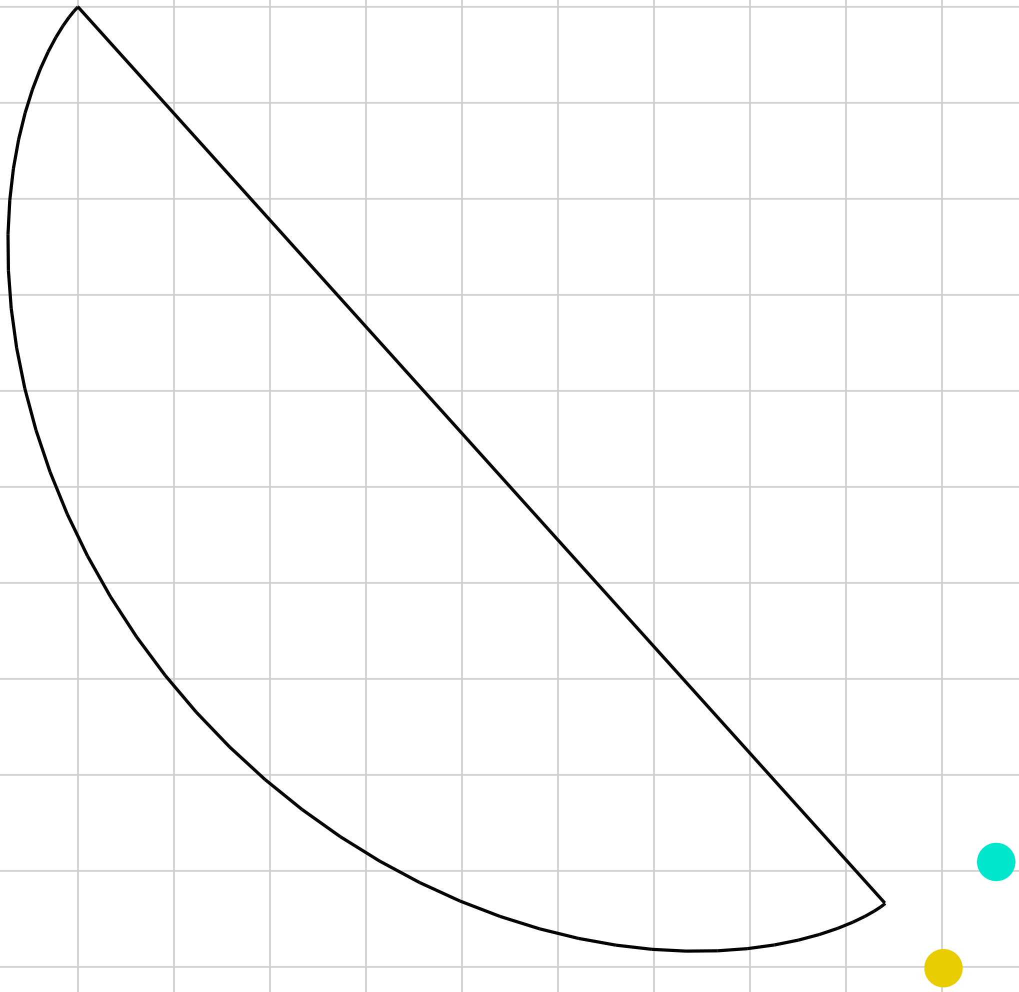

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