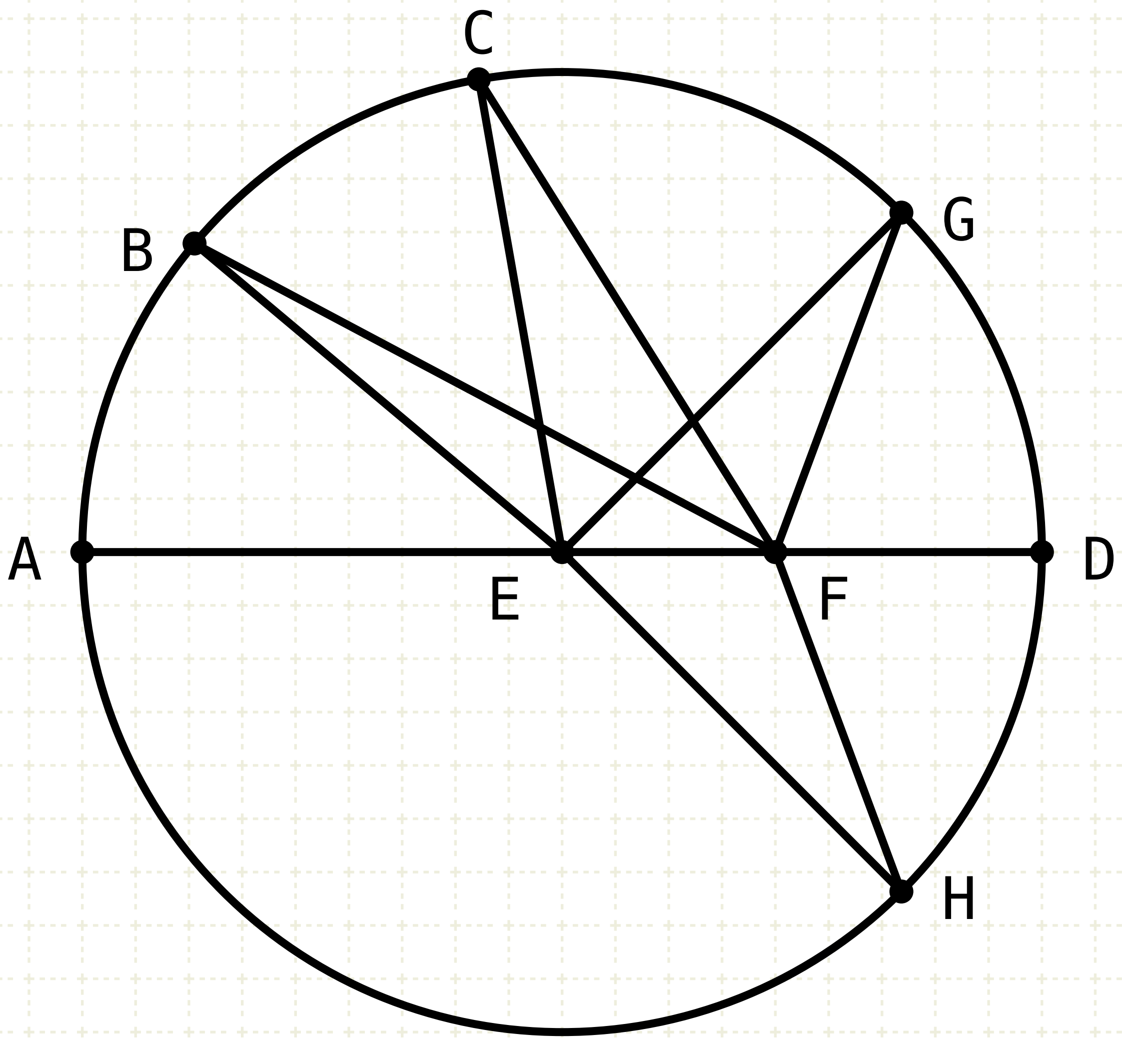
# Euclid's Elements

# Book III




*A circle is a round straight line with a hole in the middle.*

**Mark Twain**

quoting a schoolchild in "-English as She Is Taught-"

*If people stand in a circle long enough, they'll eventually begin to dance.*

**George Carlin, Napalm and Silly Putty (2001)**

# Table of Contents, Chapter 3


1 To find the centre of a circle

2 A chord of a circle always lies inside the circle

3 A line through the centre of a circle bisects a chord, and vice versa

4 A line not through the centre of a circle does not bisect a chord

5 If two circles cut one another, they will not have the same center

6 If two circles touch one another, they will not have the same center

7 Consider two lines from a point inside a circle to the edge, the longer one will be the one closest to the longest part of the diameter passing through the original point

8 Consider two lines from a point outside a circle to the edge, the line closest to the centre will be longer on the concave side and shorter on the convex side

9 If three lines, starting at a point 'A' and touching the circle, are all equal, then 'A' is the centre of the circle

10 A circle does not cut a circle at more points than two

11 Point of contact between two internal circles, and their centres, are collinear

12 Point of contact between two external circles, and their centres, are collinear

13 A circle does not touch a circle at more points than one, whether it touch it internally or externally.

14 In a circle equal straight lines are equally distant from the centre, and those which are equally distant from the centre are equal to one another.

15 The longest line in a circle is its diameter, shorter the farther away from the diameter

16 A line on the circle, perpendicular to the diameter, lies outside the circle

17 From a given point to draw a straight line touching a given circle

18 If line touches a circle, then it is perpendicular to the diameter that touches that point

19 If line touches a circle, then the centre of the circle lies on a line perpendicular to the original

20 The angle at the centre of a circle is twice that from an angle from the circumference

21 In a circle the angles in the same segment are equal to one another

22 The opposite angles of quadrilaterals in circles are equal to two right angles

23 On the same straight line there cannot be constructed two similar and unequal segments of circles on the same side

24 Similar segments of circles on equal straight lines are equal to one another

# Table of Contents, Chapter 3


25 Given a segment of a circle, to describe the complete circle of which it is a segment.

26 In equal circles equal angles stand on equal circumferences

27 In equal circles angles standing on equal circumferences are equal to one another

28 In equal circles equal straight lines cut off equal circumferences

29 In equal circles equal circumferences are subtended by equal straight lines

30 To bisect a given circumference

31 In a circle the angle in the semicircle is right …

32 The angle between a tangent and a straight line cutting a circle is equal to the angle in the alternate segment

33 Construct a circle segment on a given line, such that the angle within the segment is equal to a given angle

34 Construct a circle segment on a given circle, such that the angle within the segment is equal to a given angle

**35 If two circle chords intersect, the segments on one multiplied together equals the segments of the other multiplied together**

36 Secant-tangent law

37 Converse of the secant-tangent law

# Proposition 35 of Book III

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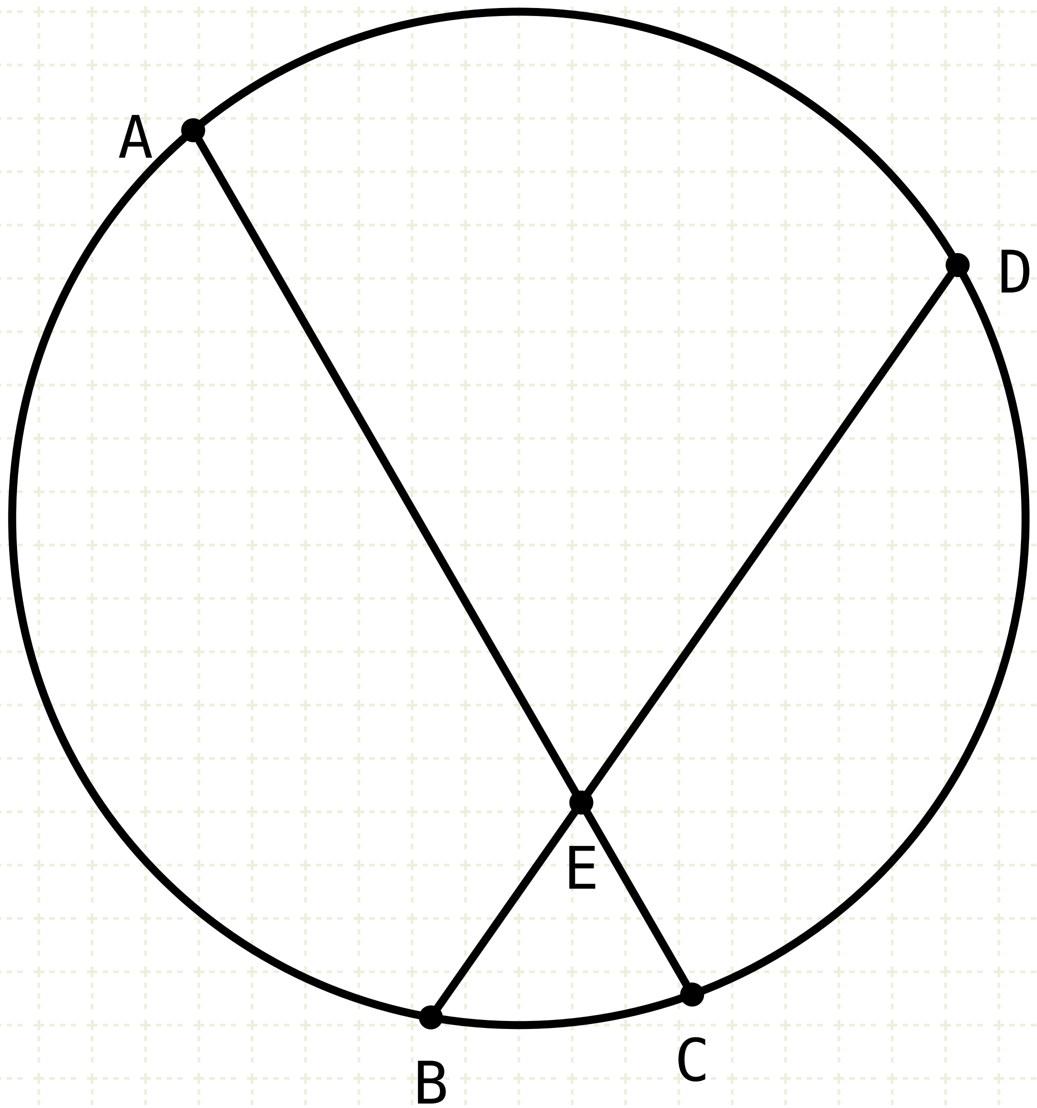


$AE \cdot EC = BE \cdot ED$

## In other words

If lines AC and BD cross each other in a circle at point E, then the product of AE,EC is equal to the product BE,ED

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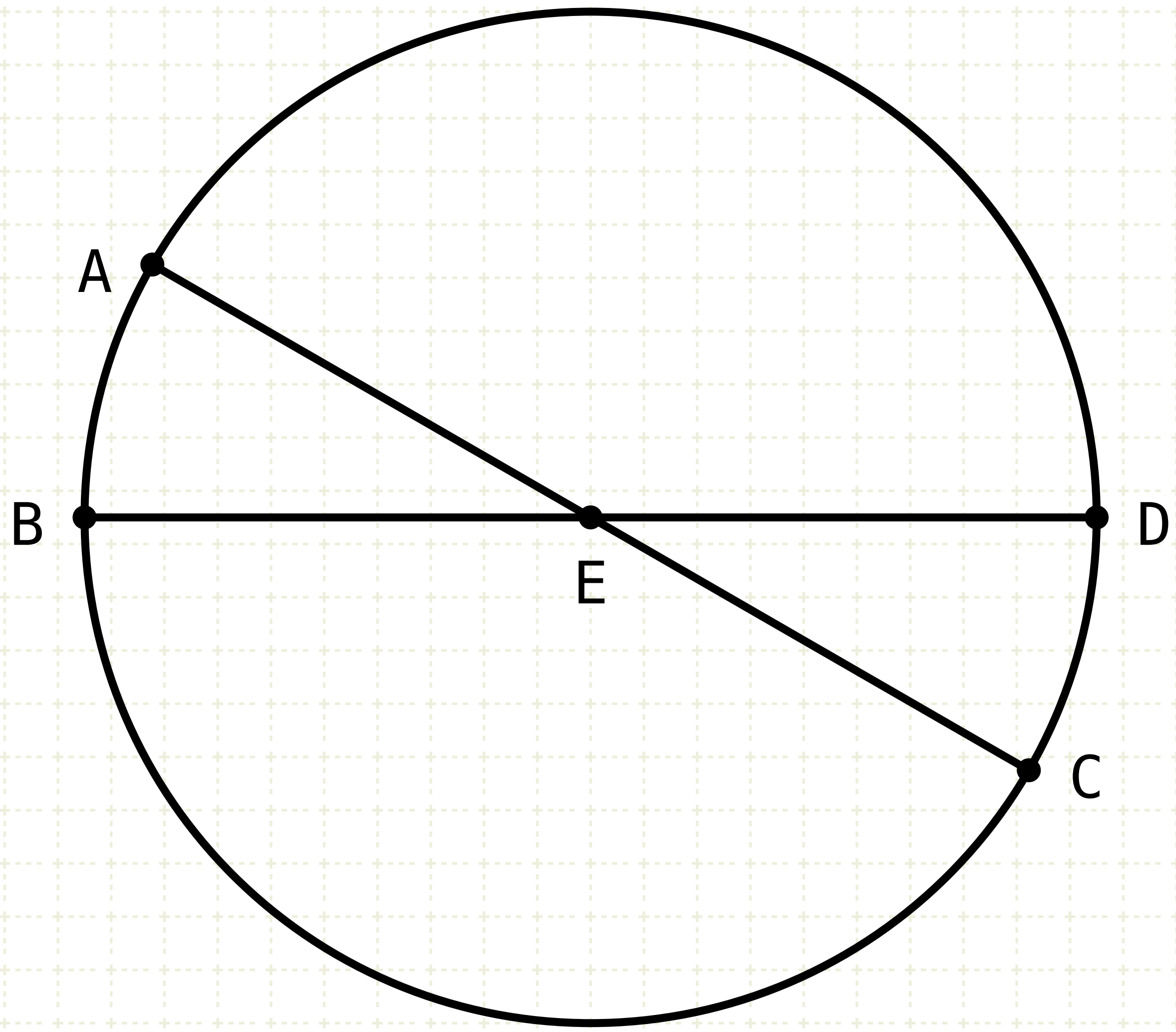


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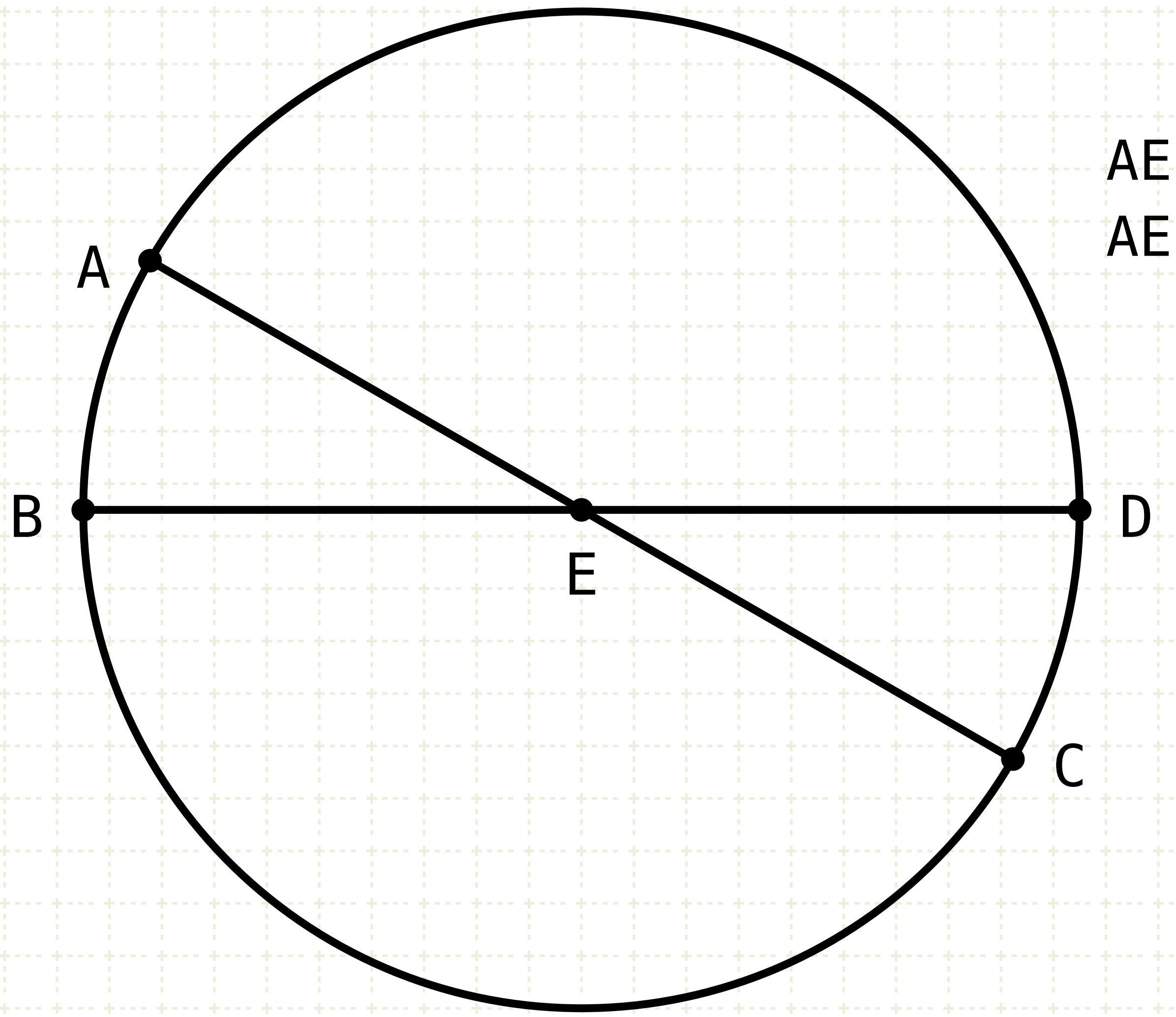


$AE = BE = ED = EC$

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If lines AC and BD cross each other in a circle at point E, then the product of AE,EC is equal to the product BE,ED

## Proof 1

If E is the centre of the circle, then AE,BE,DE,CE are all equal (radii of the same circle), so it is obvious that AE,CE equals BE, ED

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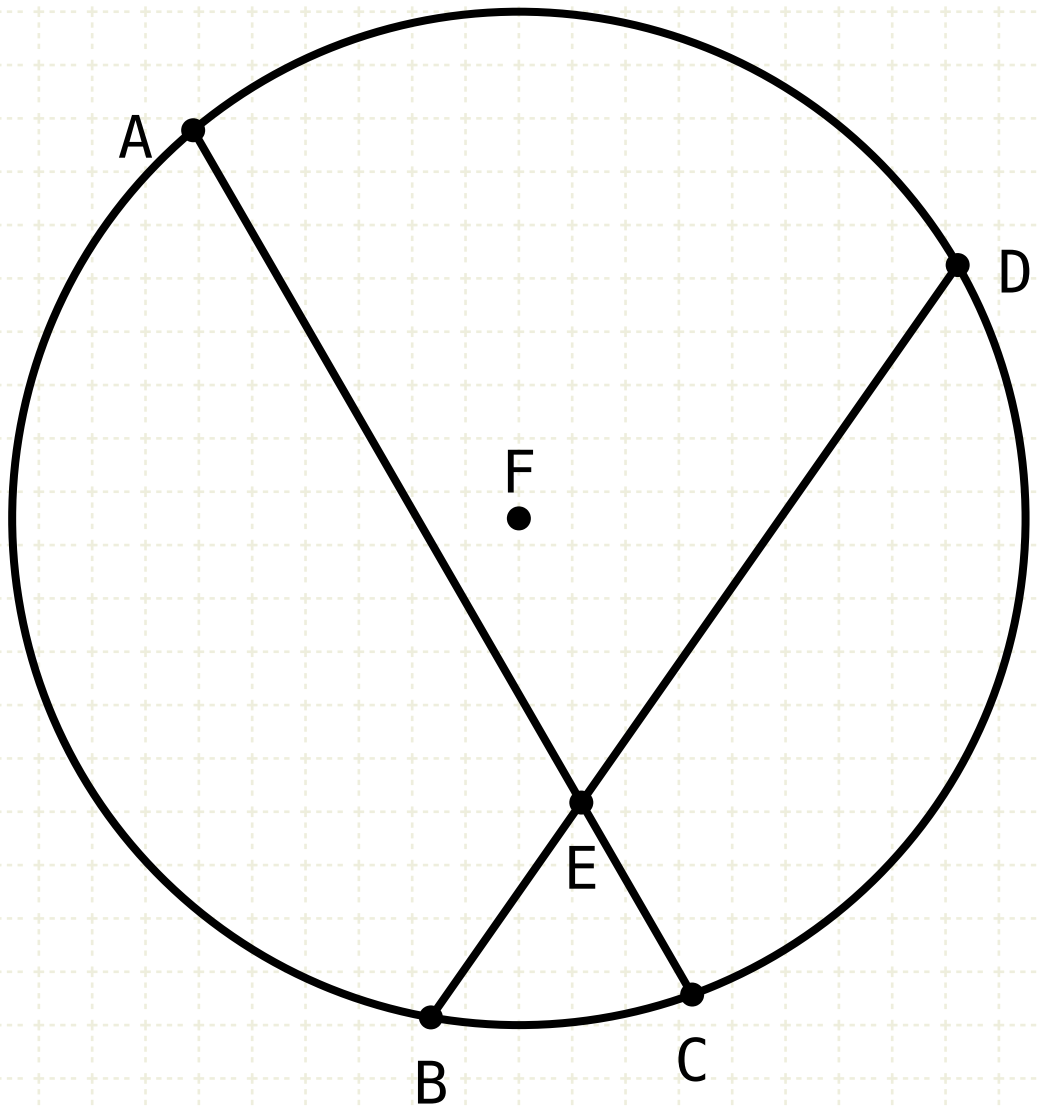


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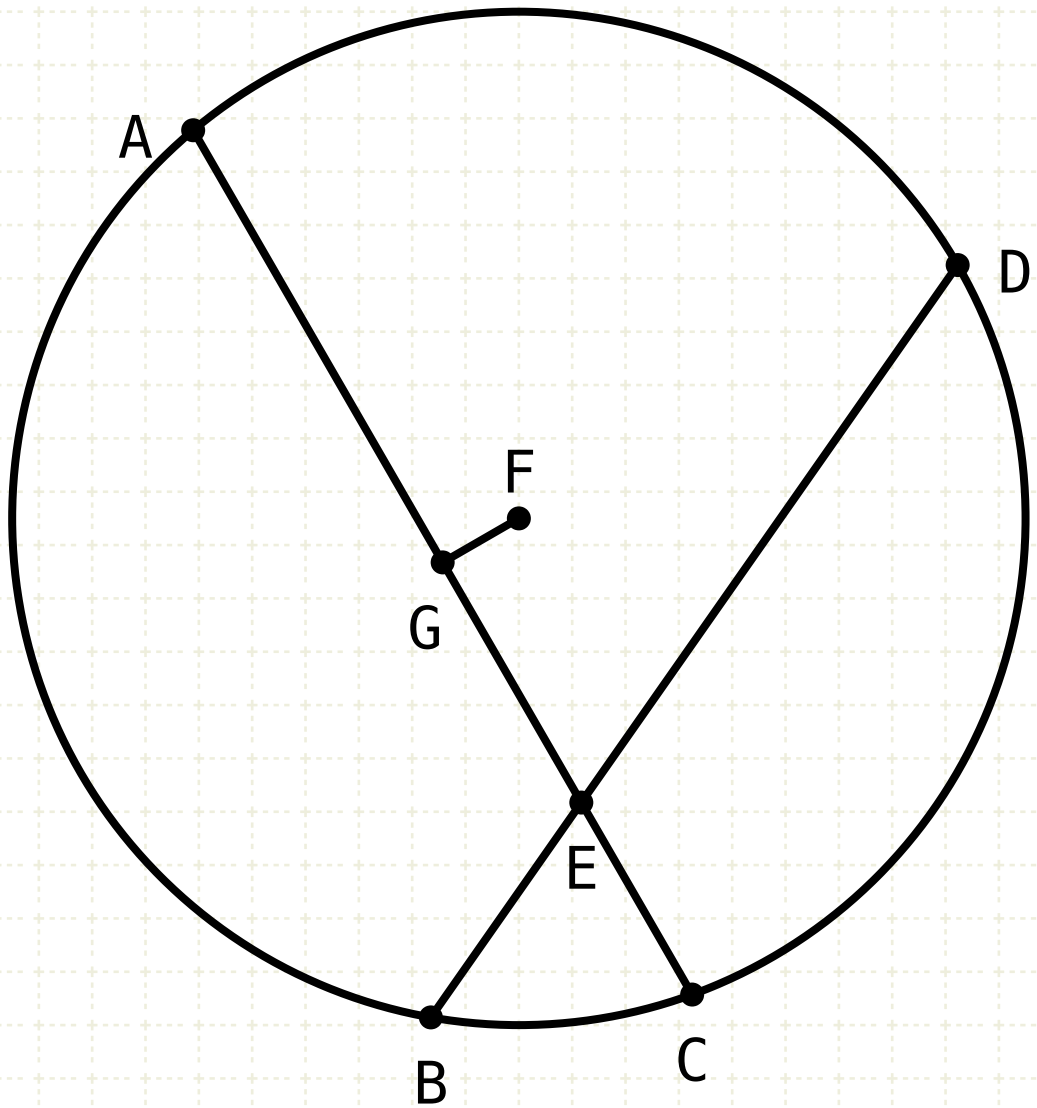


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From F, draw FG perpendicular to AC

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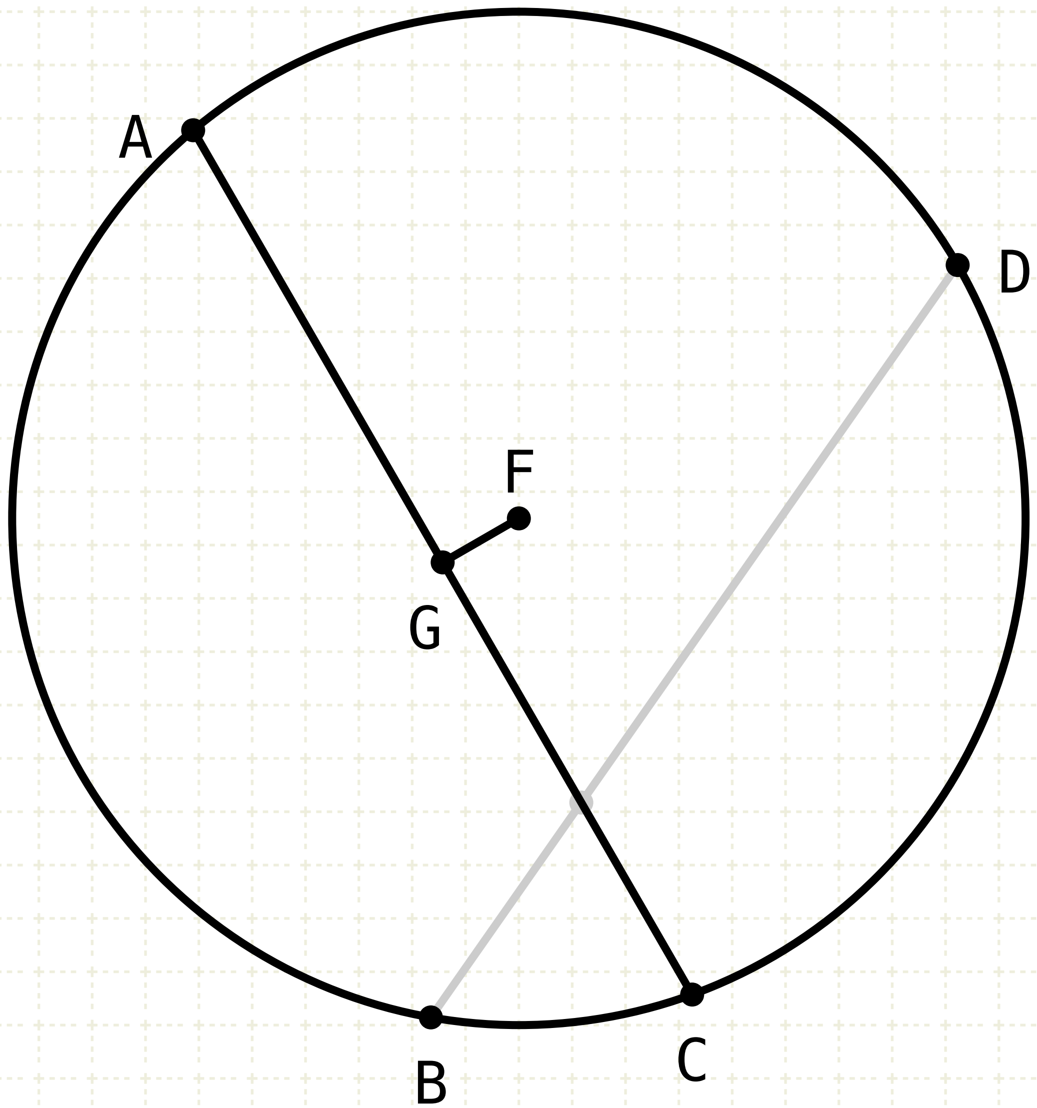


AG = GC

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From F, draw FG perpendicular to AC

Since FG passes through the centre of the circle, and is at right angles to AC, it also bisects AC (III·3)

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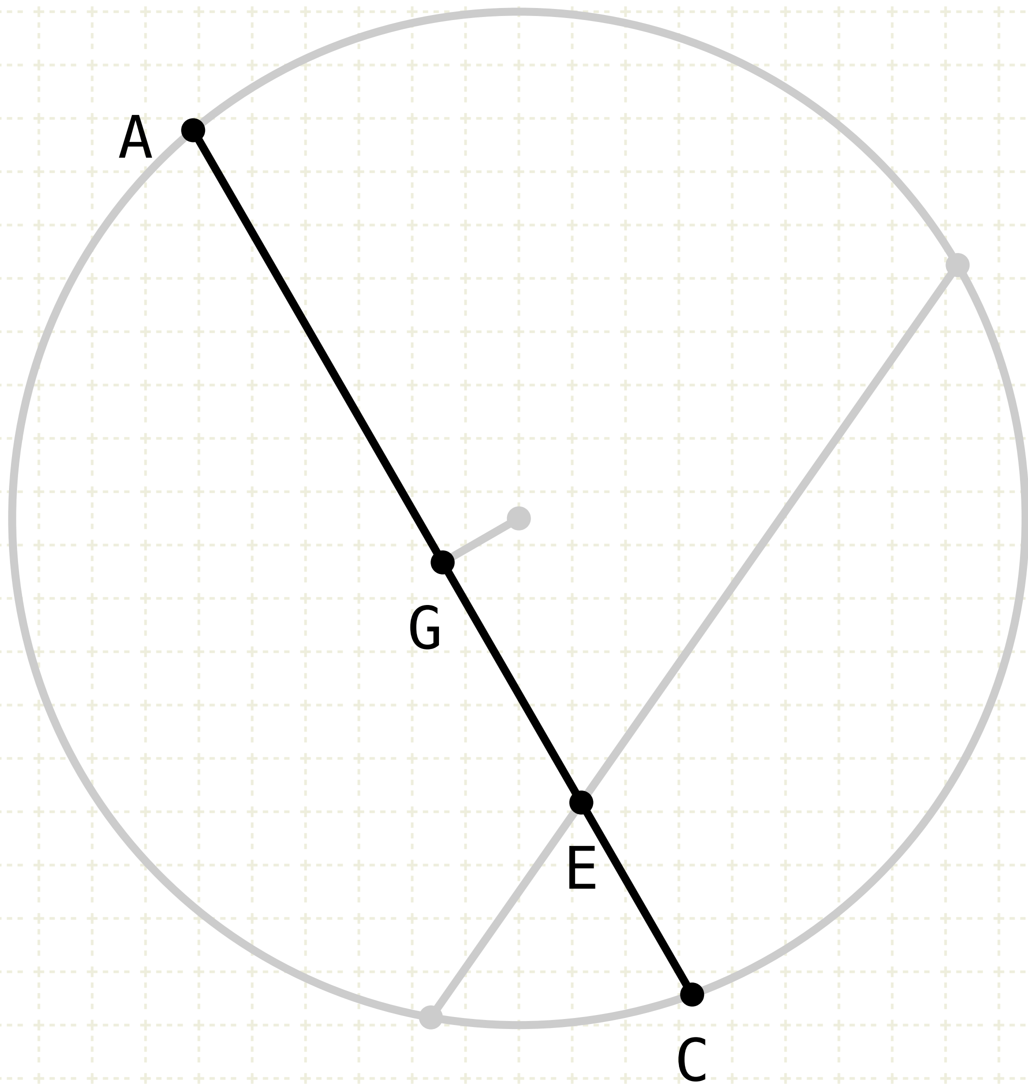


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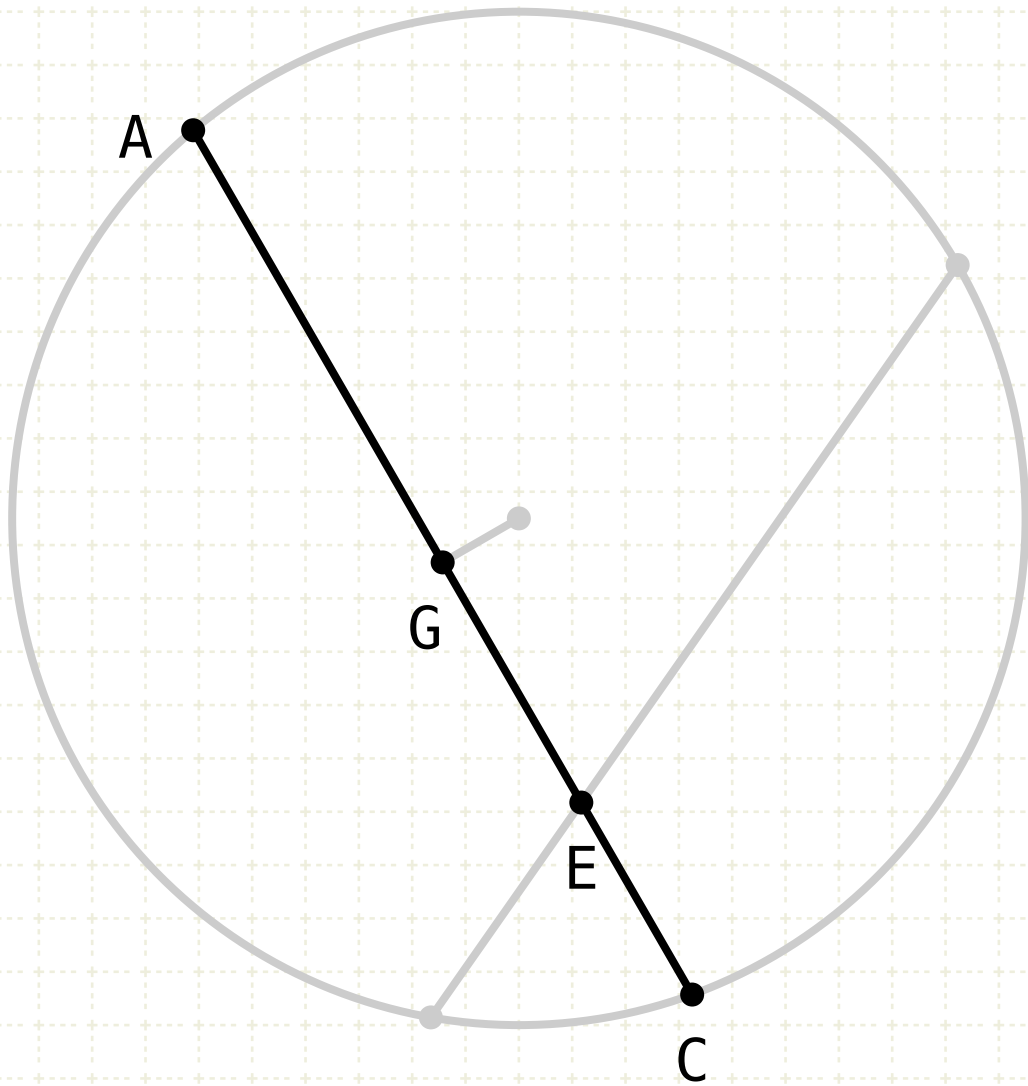


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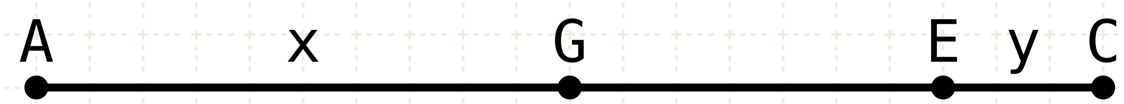

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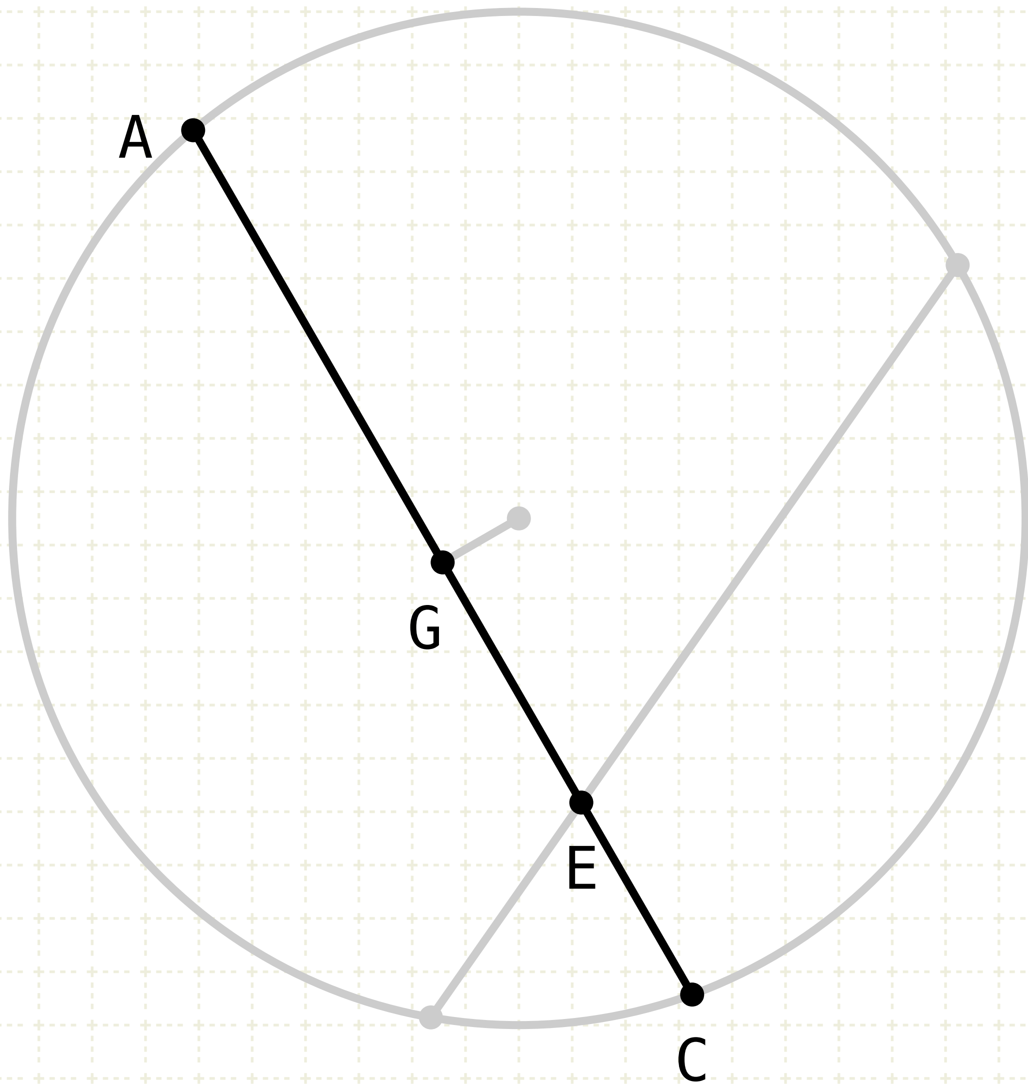


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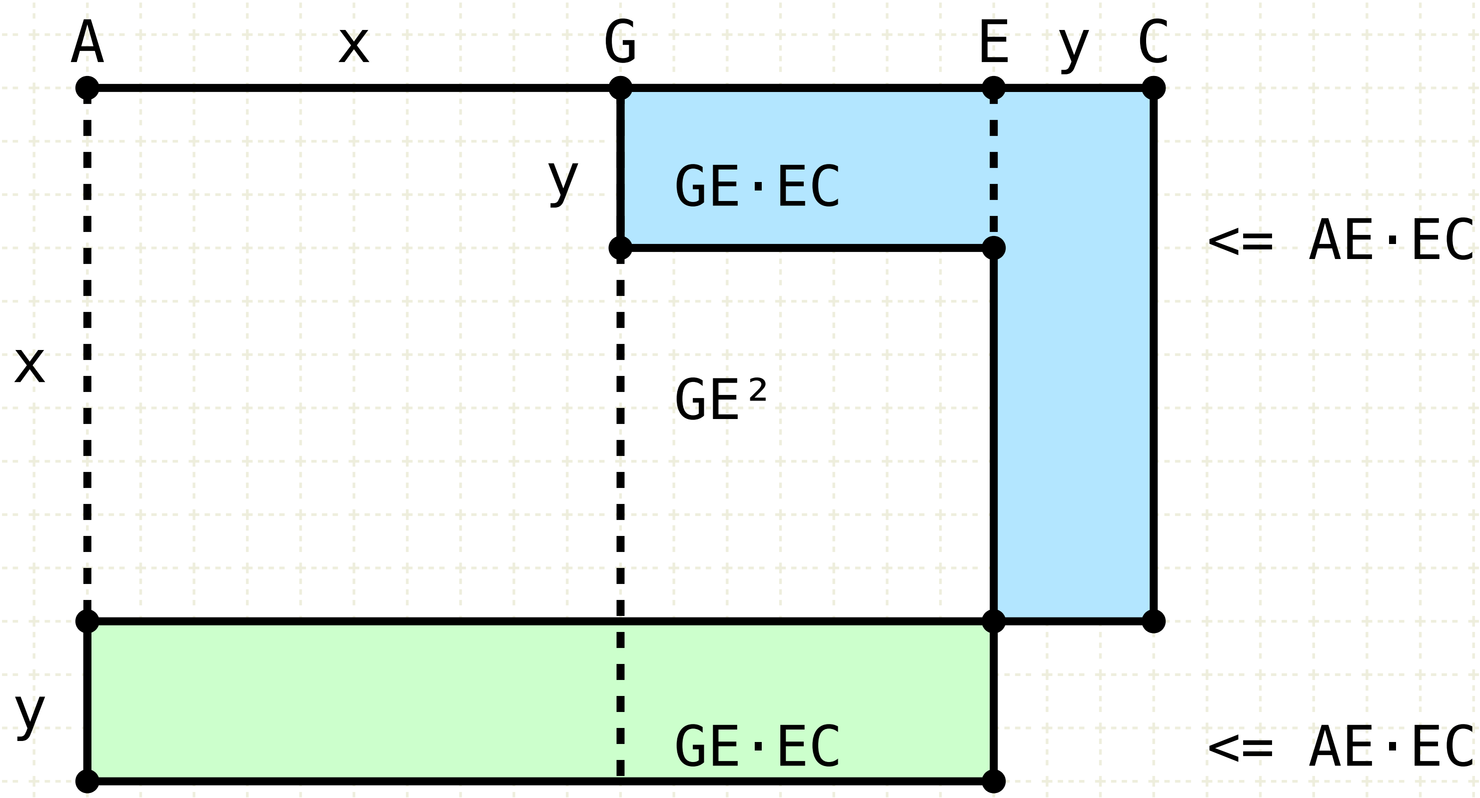

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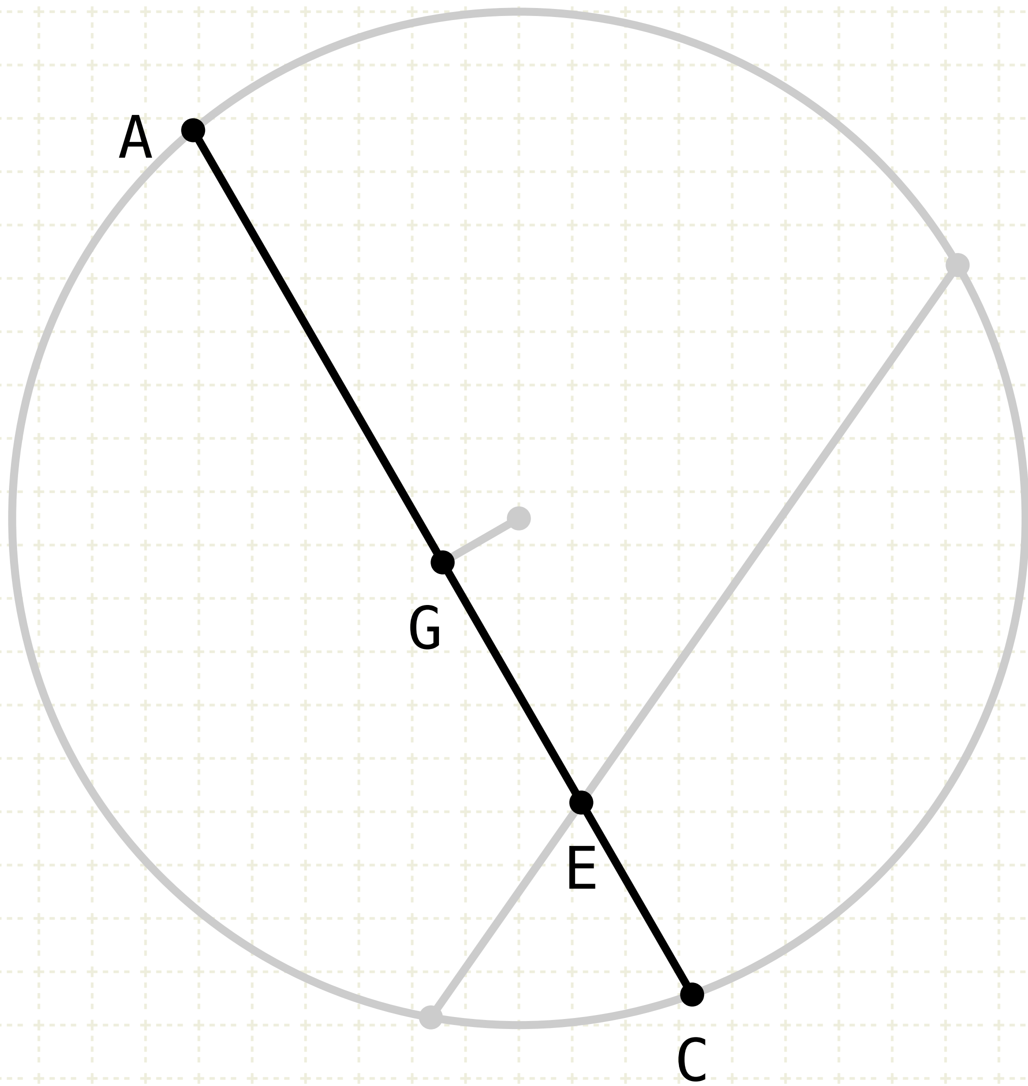


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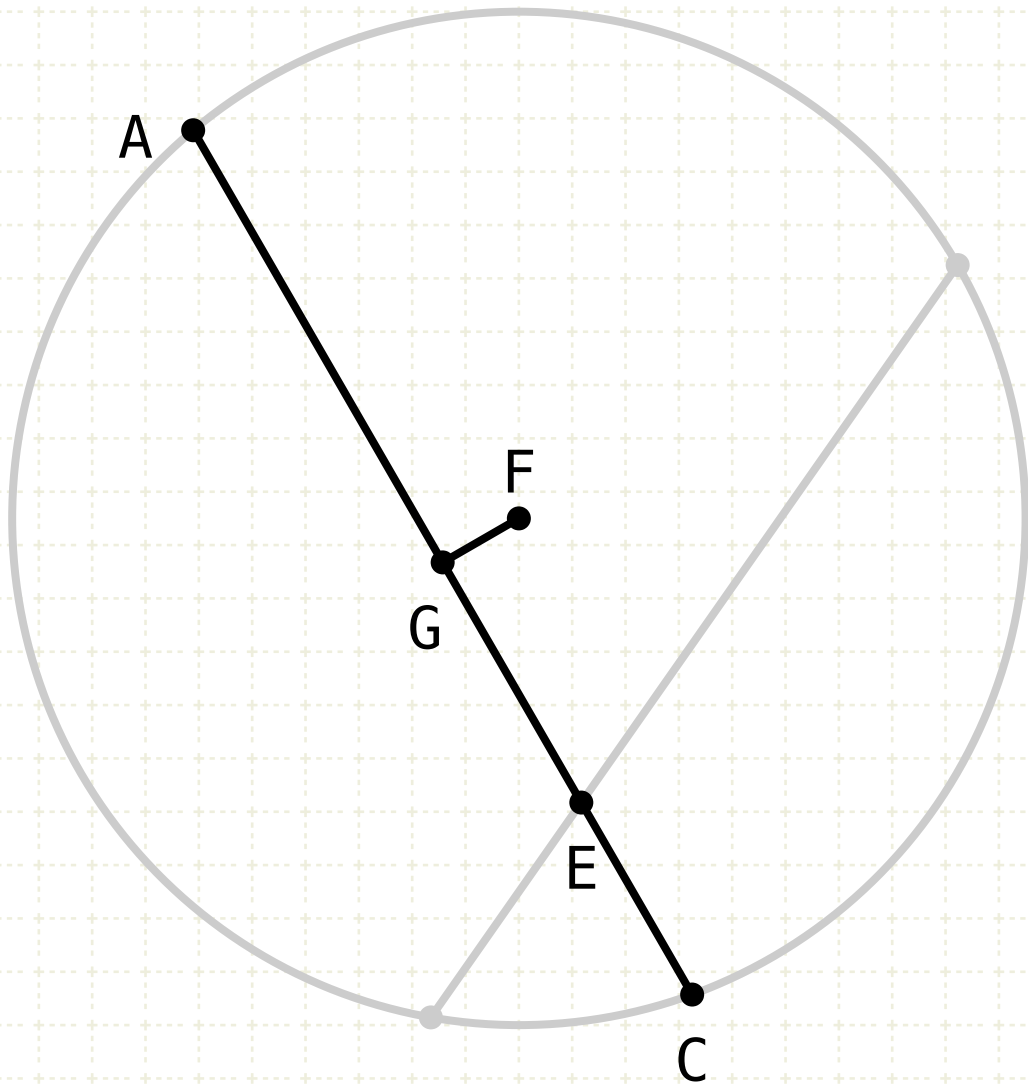


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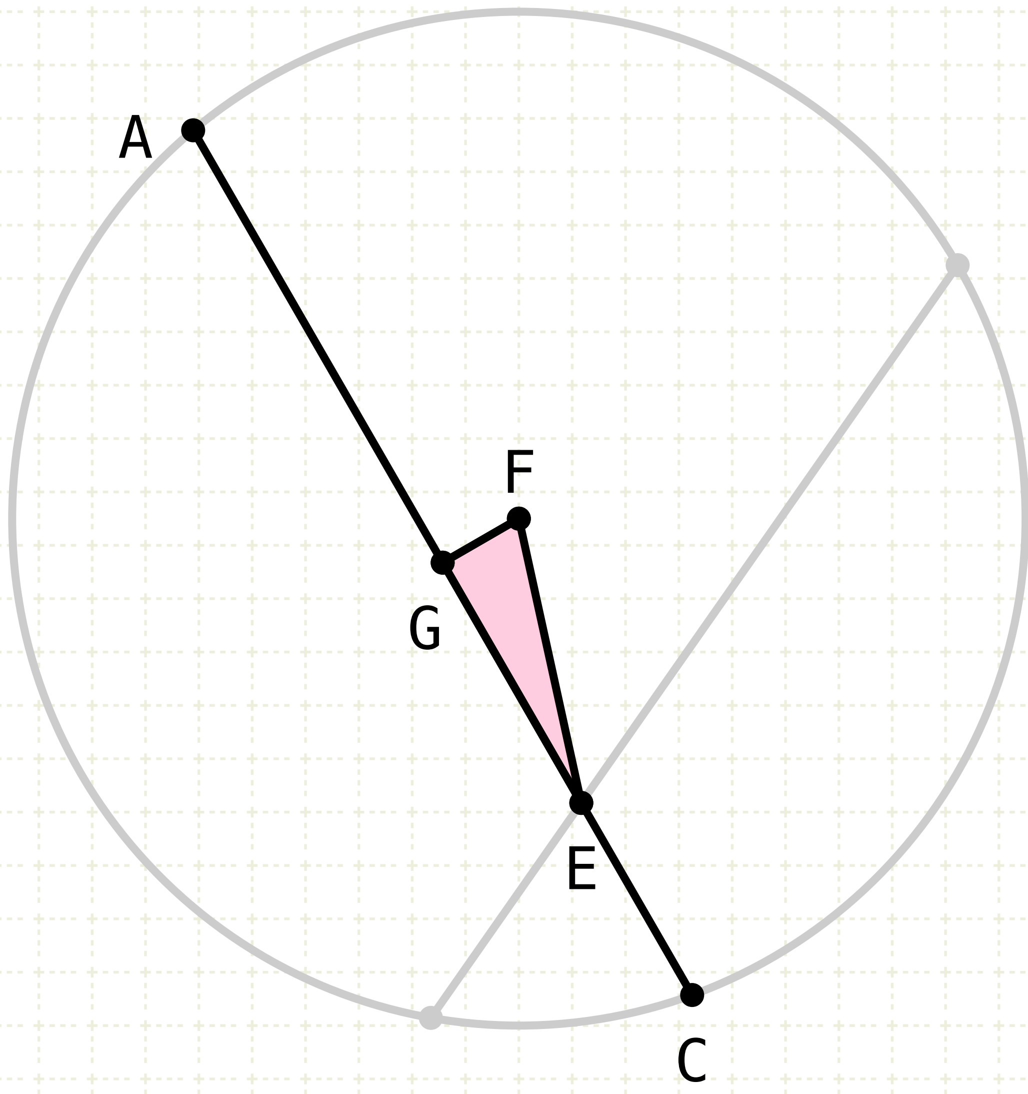


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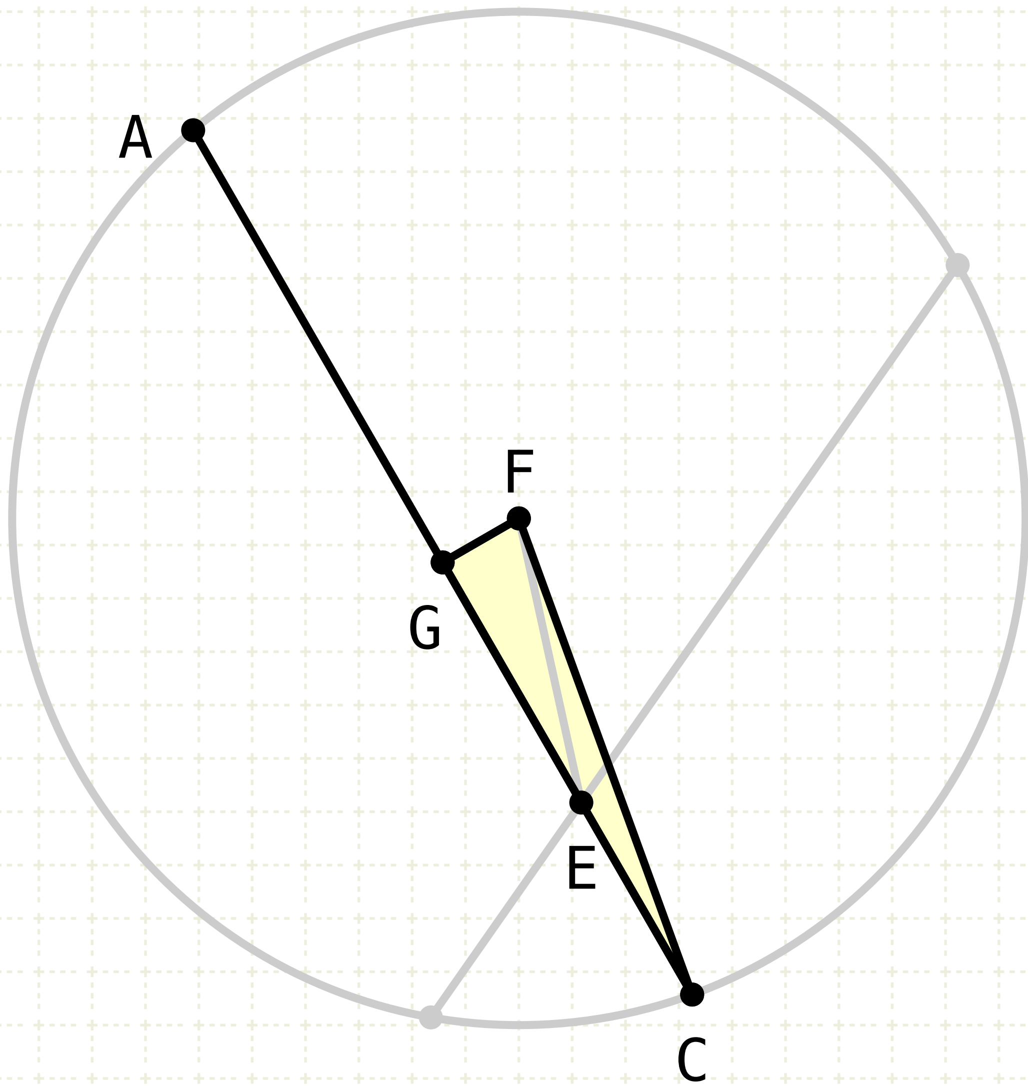


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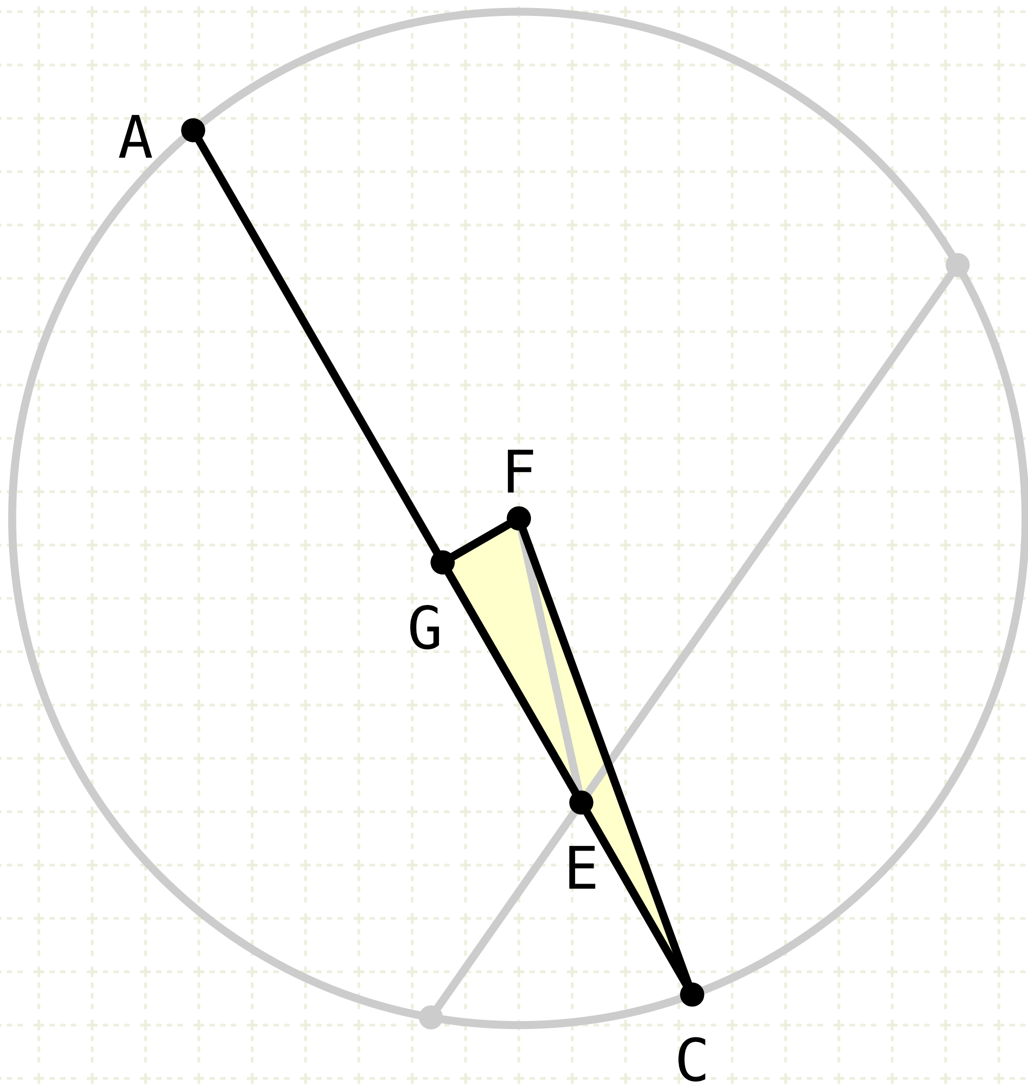


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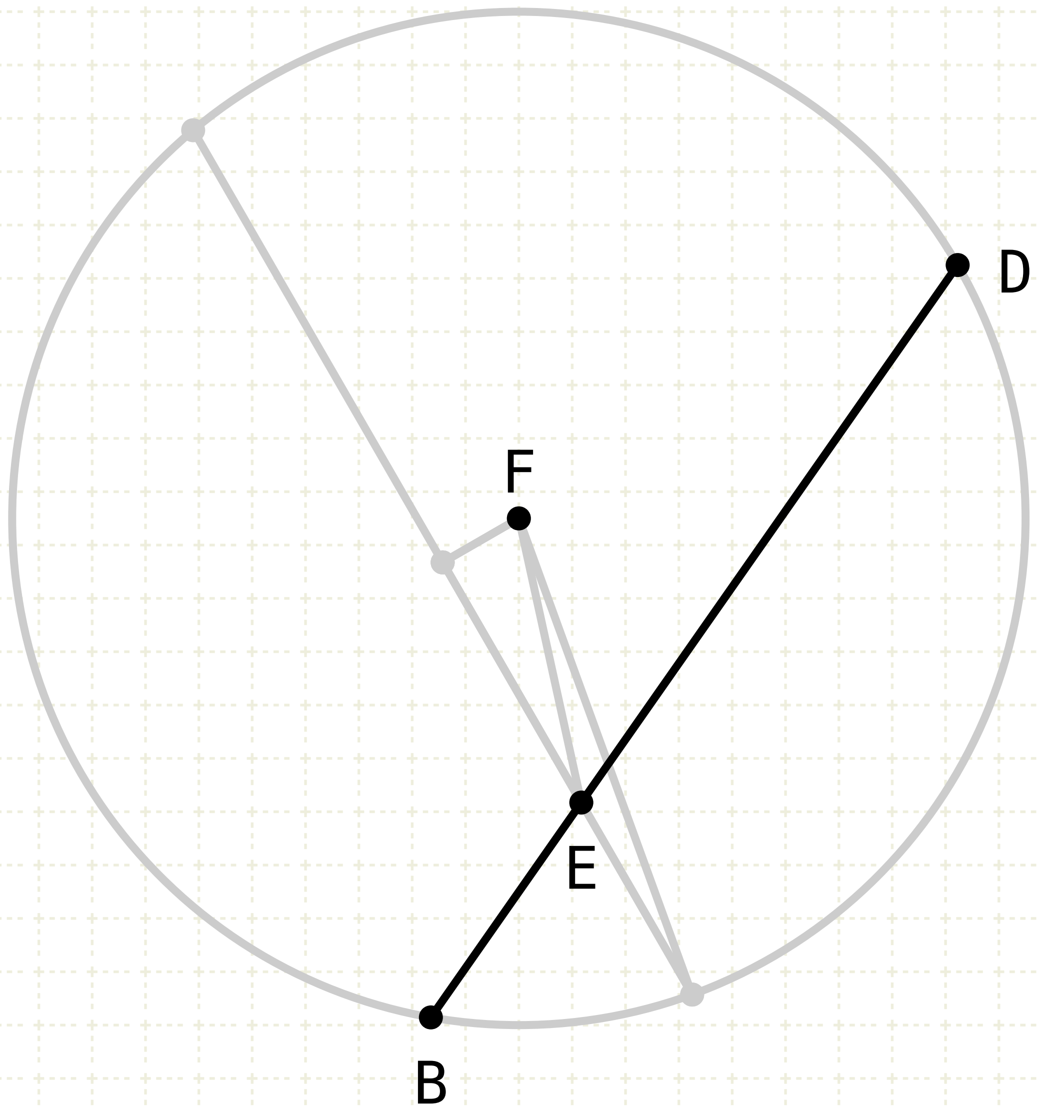


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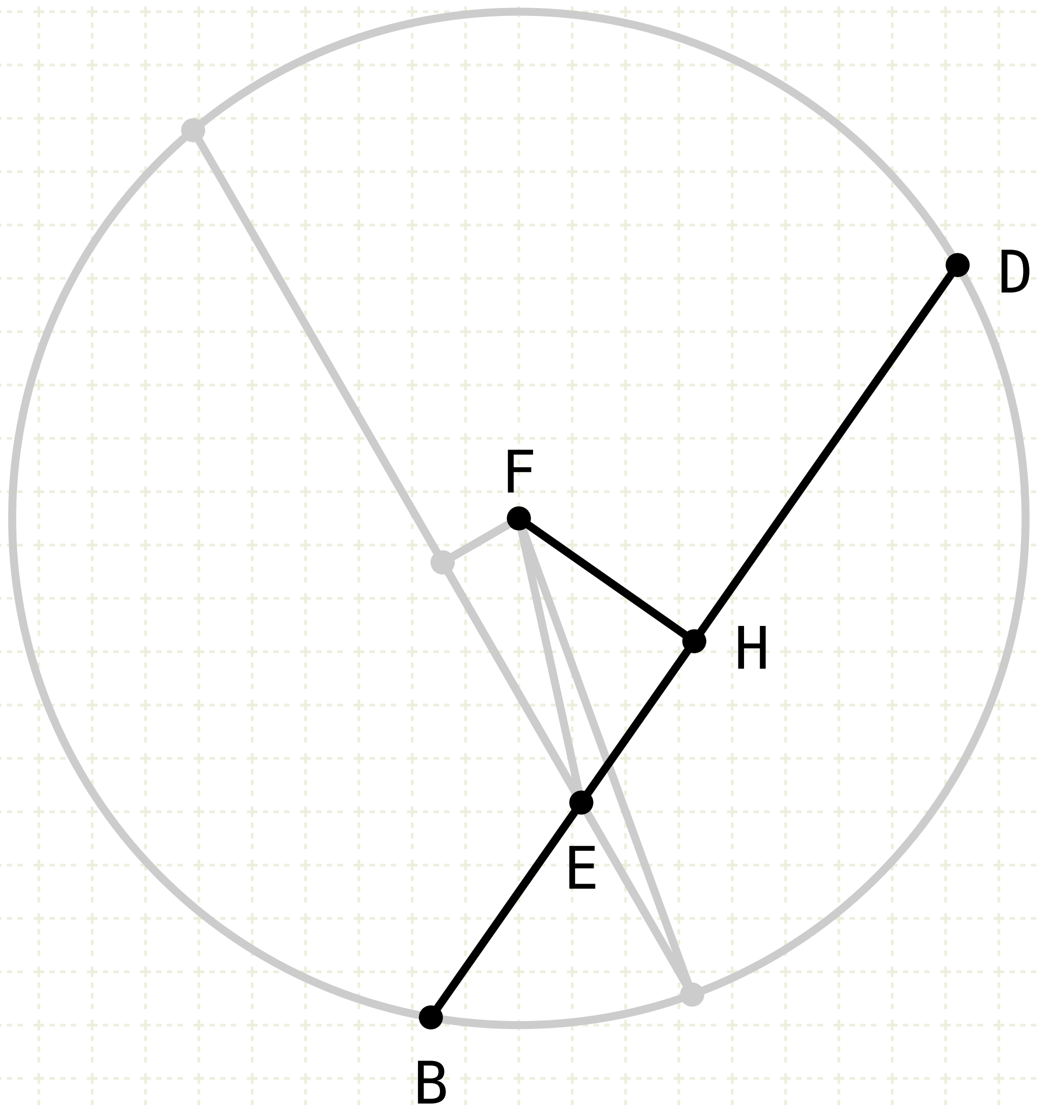


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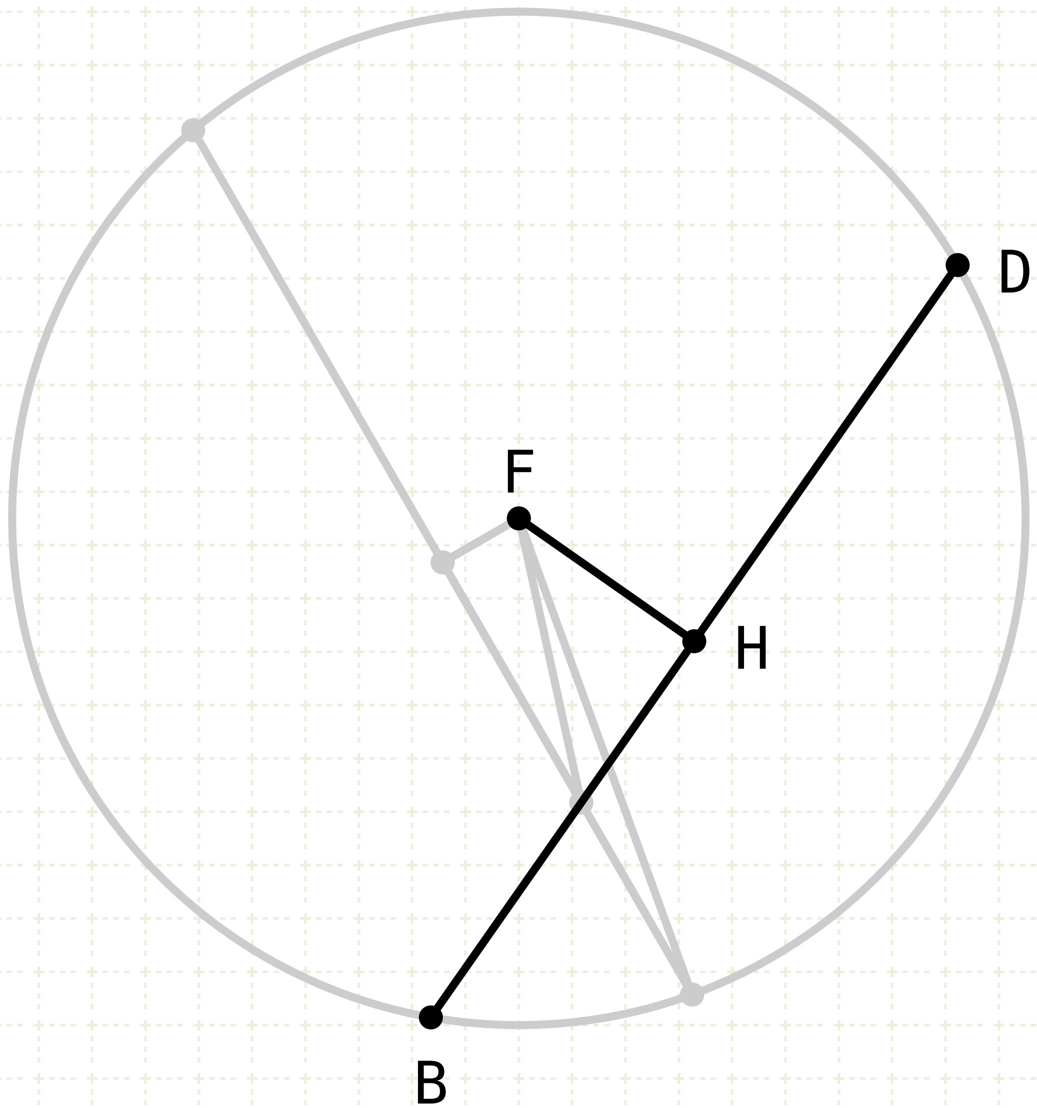


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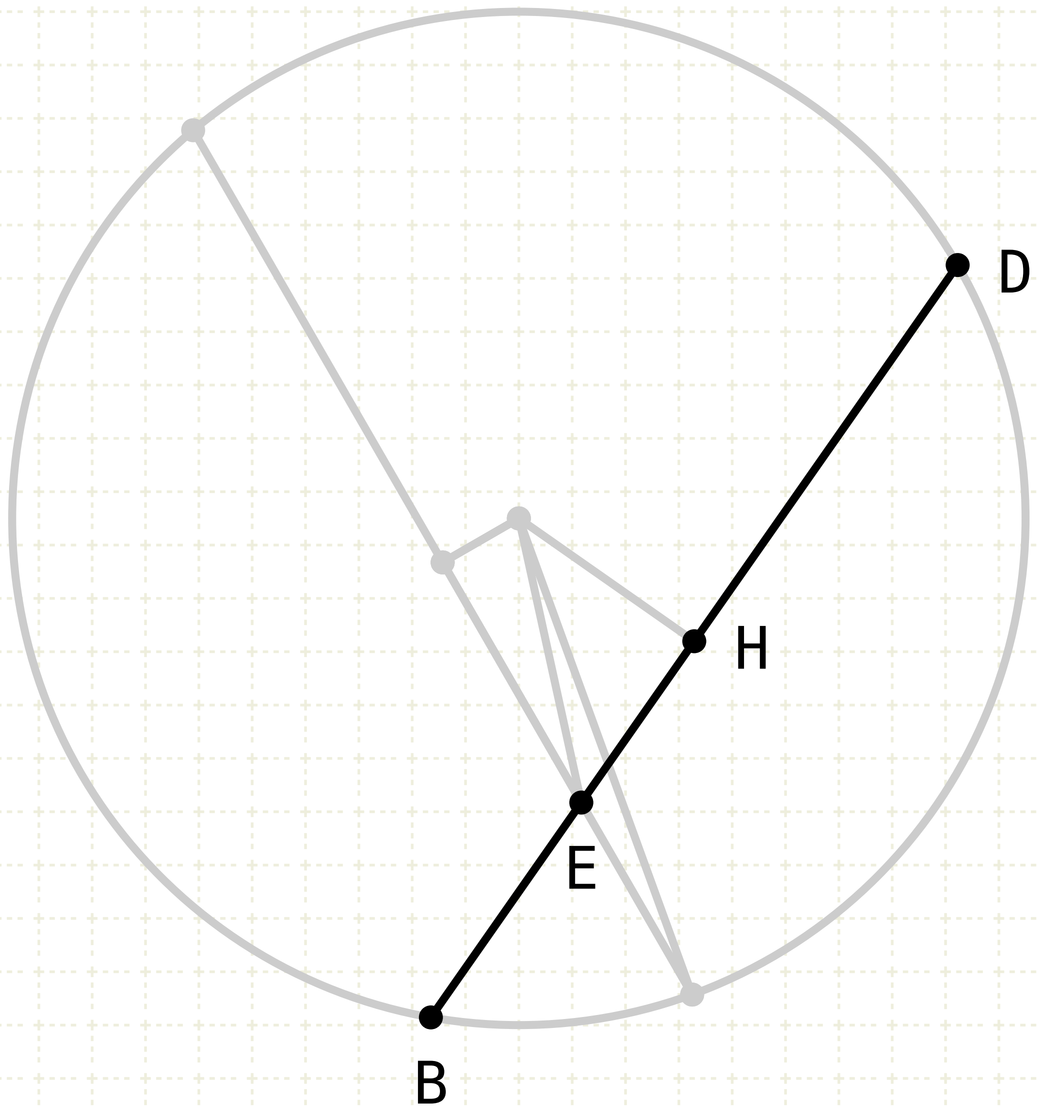


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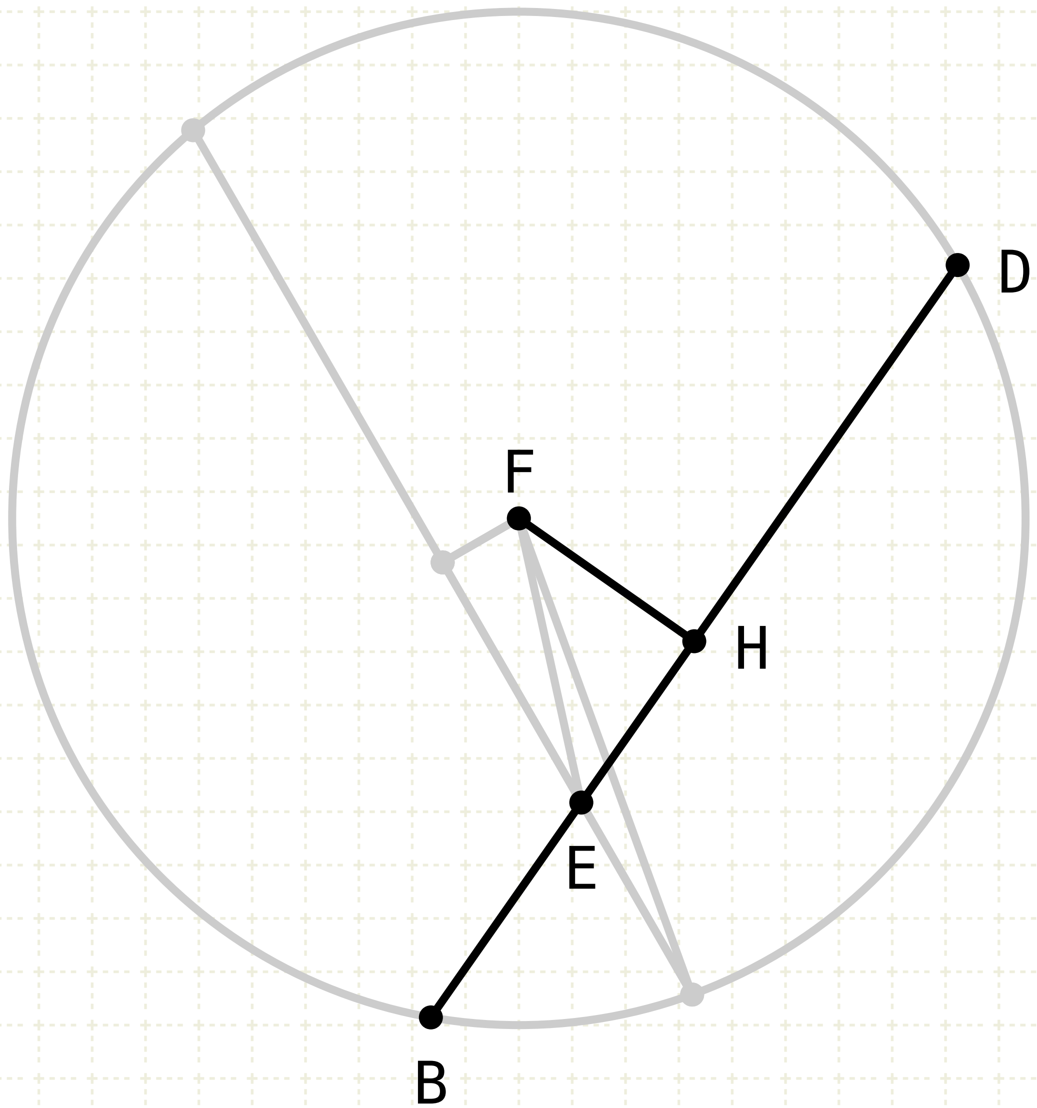


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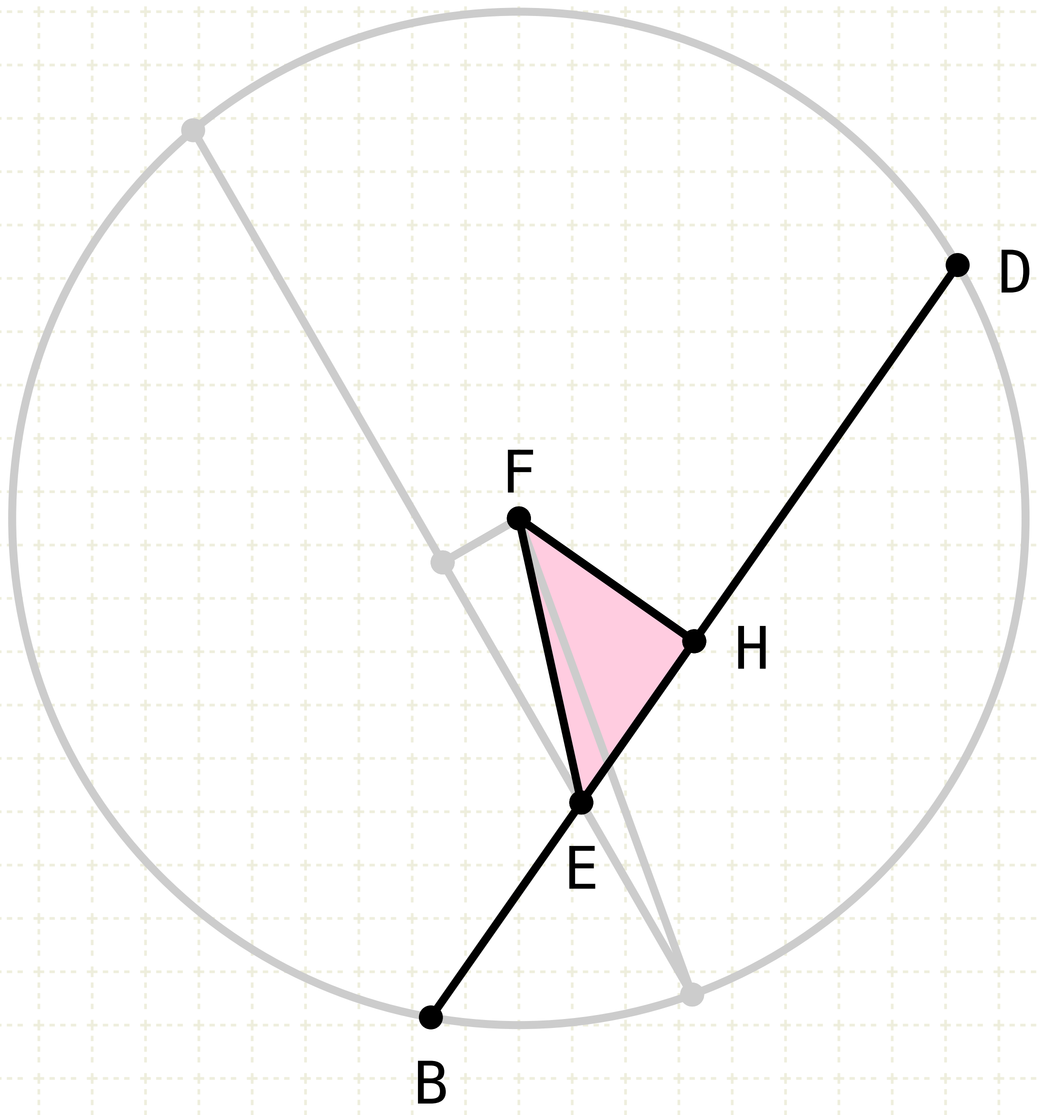


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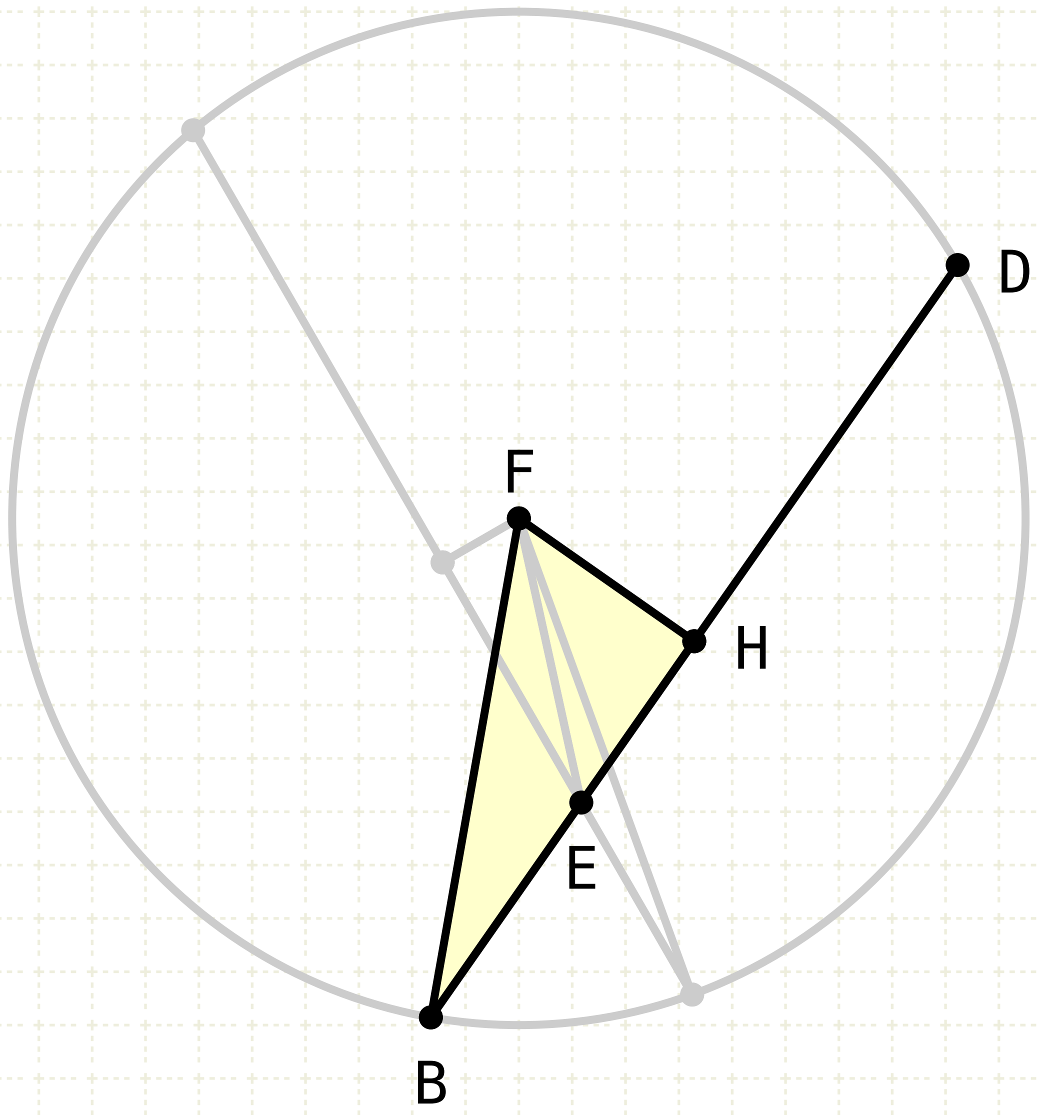


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When a line (AC) is broken into equal parts (AG,GC) and unequal parts (AE,EC), then the product AE,EC plus the square of GE is equal to the square of GC (II·5)

Add the square of FG (the radius) to both sides of the equality

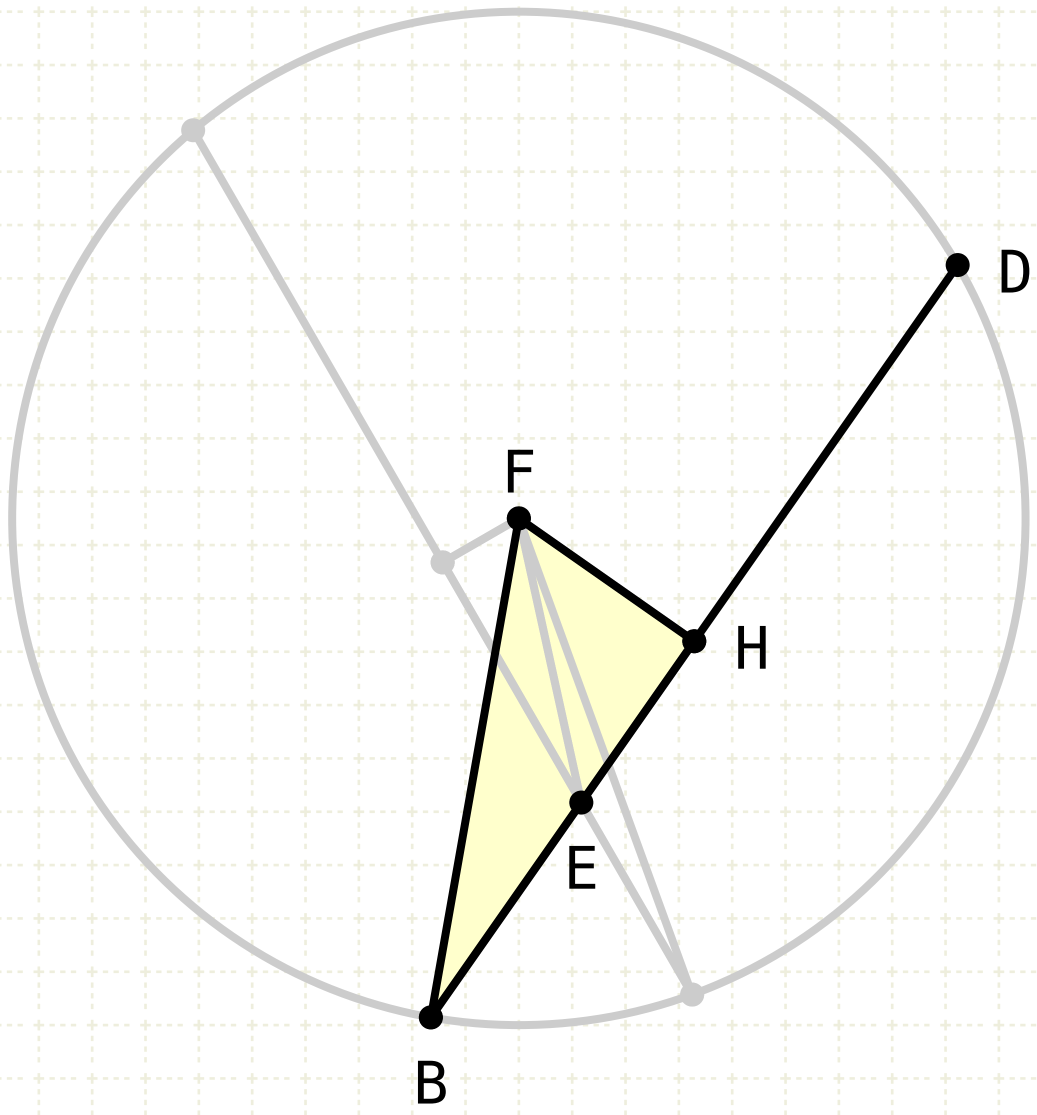
By pythagoras' theorem (I·47), the sum of the squares GE, GF is equal to the square of FE

Similarly, the sum of the squares GC, GF is equal to the square of FC

Follow the same steps for line BD

# Proposition 35 of Book III

If in a circle two straight lines cut one another, the rectangle contained by the segments of the one is equal to the rectangle contained by the segments of the other.




$AG = GC$

$AE \cdot EC + GE^2 = GC^2$

$AE \cdot EC + GE^2 + FG^2 = GC^2 + FG^2$

$GE^2 + FG^2 = FE^2$

$GC^2 + FG^2 = FC^2 = r^2$

$AE \cdot EC + FE^2 = r^2$

$BH = DH$

$DE \cdot EB + HE^2 = HB^2$

$DE \cdot EB + HE^2 + HF^2 = HB^2 + HF^2$

$HE^2 + HF^2 = FE^2$

$HB^2 + HF^2 = FB^2 = r^2$

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## Proof 2

F is the centre of the circle, not E

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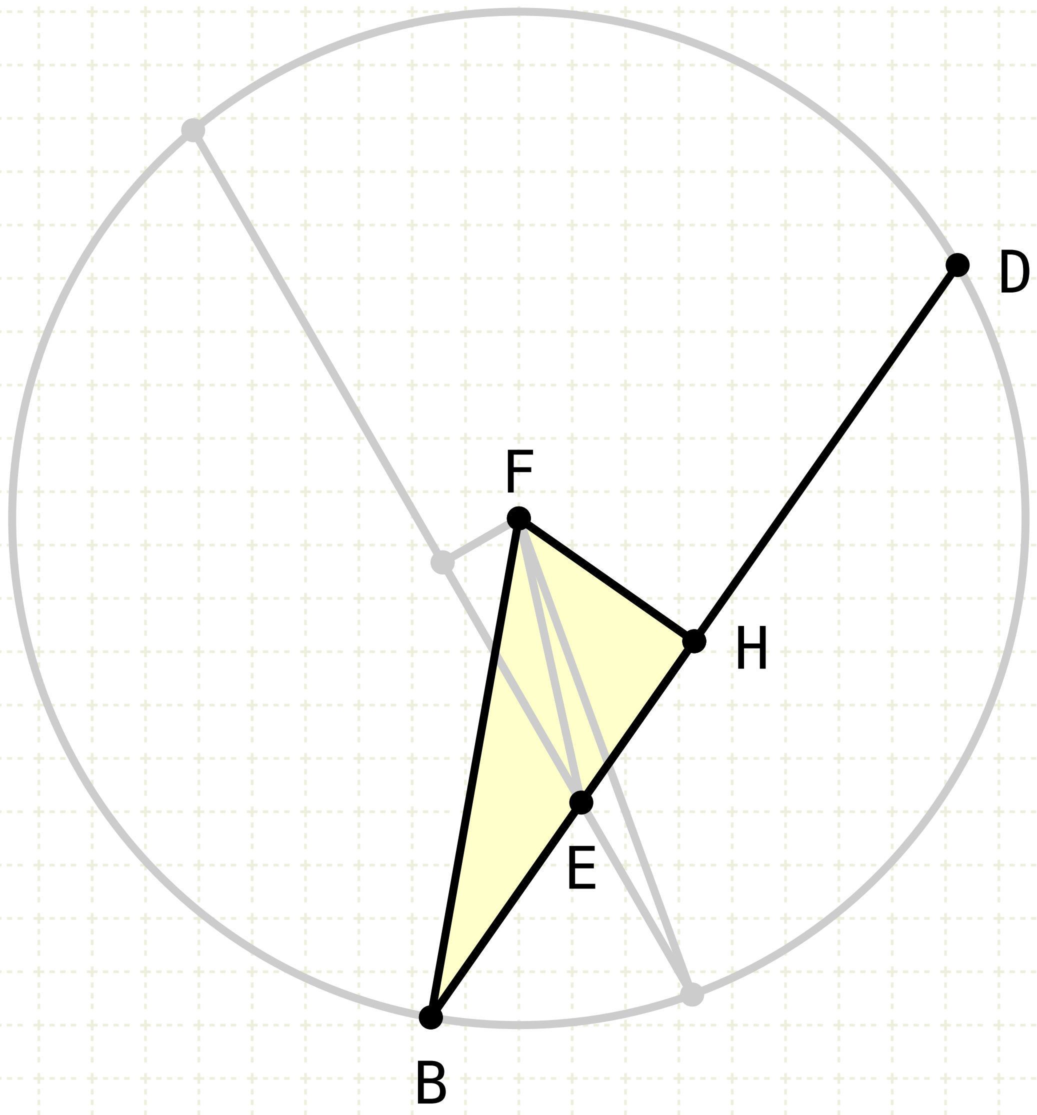


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$AE \cdot EC = DE \cdot EB$

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Follow the same steps for line BD

Since FB and FC are both equal to the circle's radius, it can be easily seen that the rectangle formed by AE,EC is equal to the rectangle formed by DE,EB

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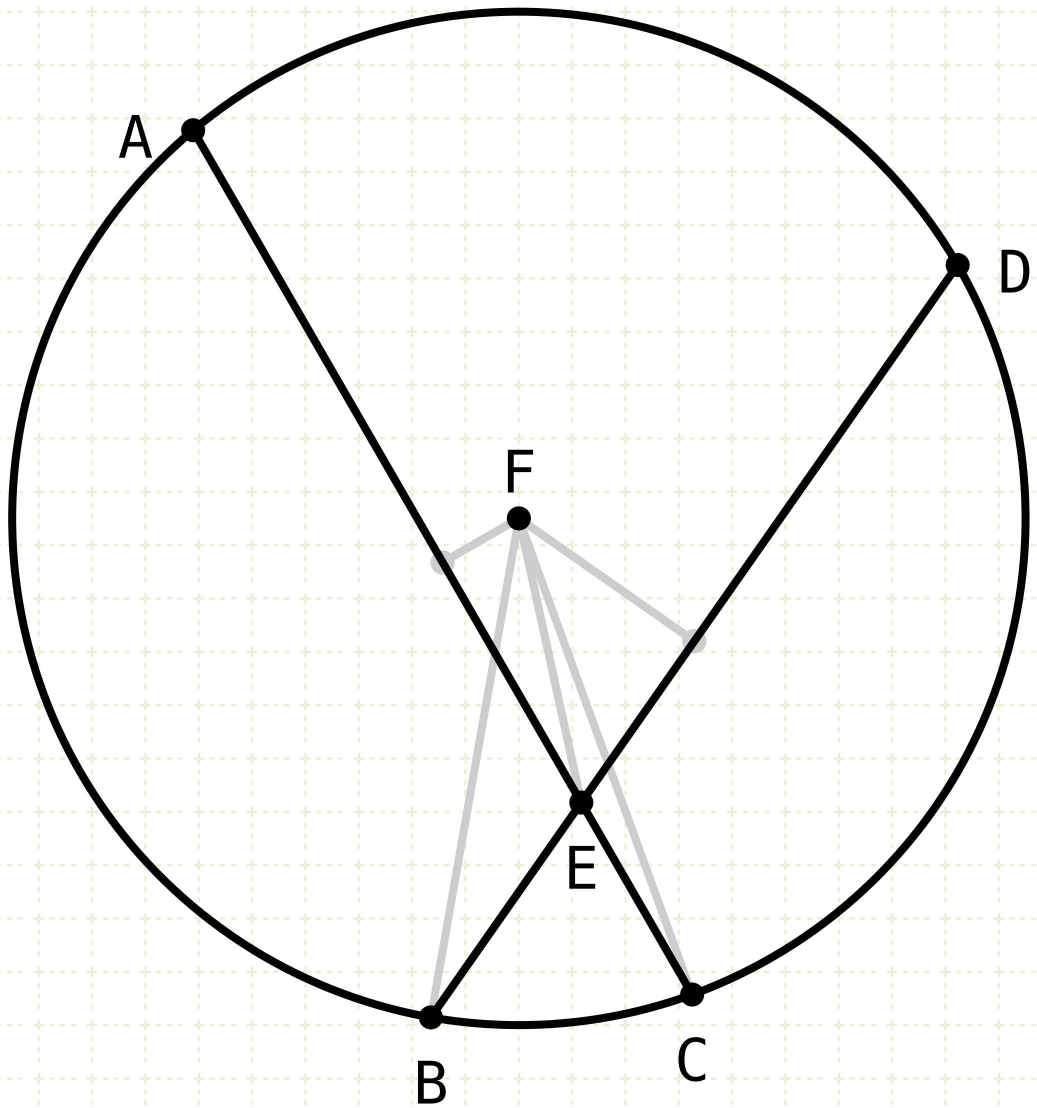


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# Proposition 35 of Book III

If in a circle two straight lines cut one another, the rectangle contained by the segments of the one is equal to the rectangle contained by the segments of the other.

## Compare to II-14 - squaring a rectangle

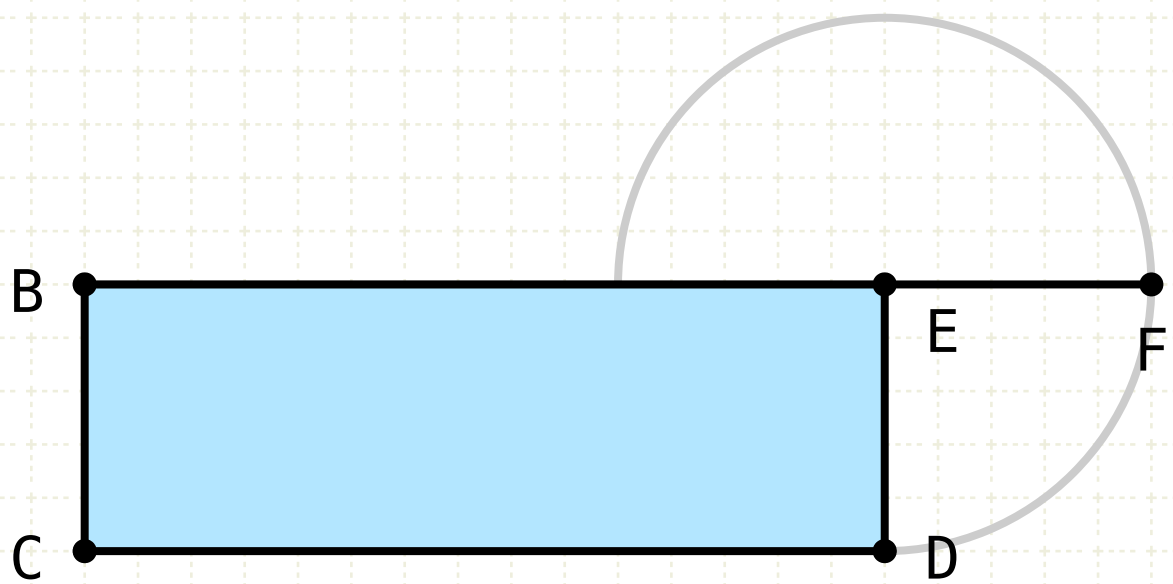
# Proposition 35 of Book III

If in a circle two straight lines cut one another, the rectangle contained by the segments of the one is equal to the rectangle contained by the segments of the other.

EF = ED

## Compare to II-14 - squaring a rectangle

Extend BE to F, where EF equals ED



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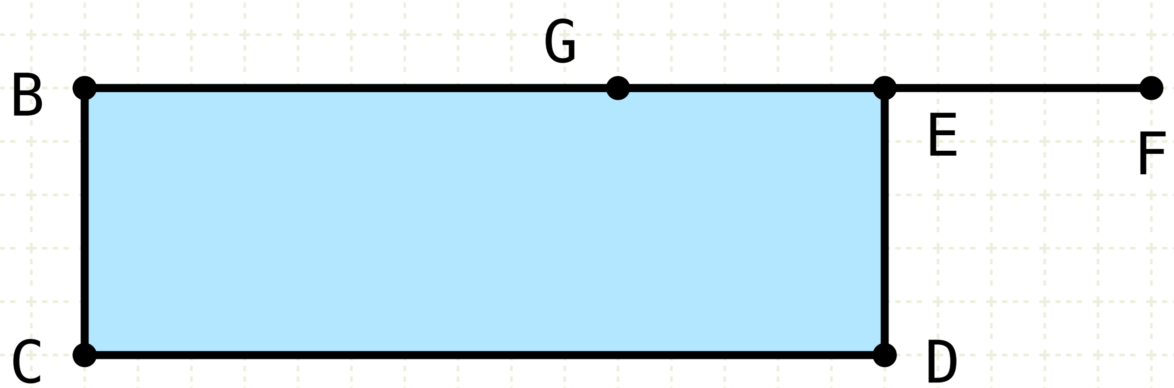
## Compare to II-14 - squaring a rectangle

Extend BE to F, where EF equals ED

Bisect BF (and label it point G)



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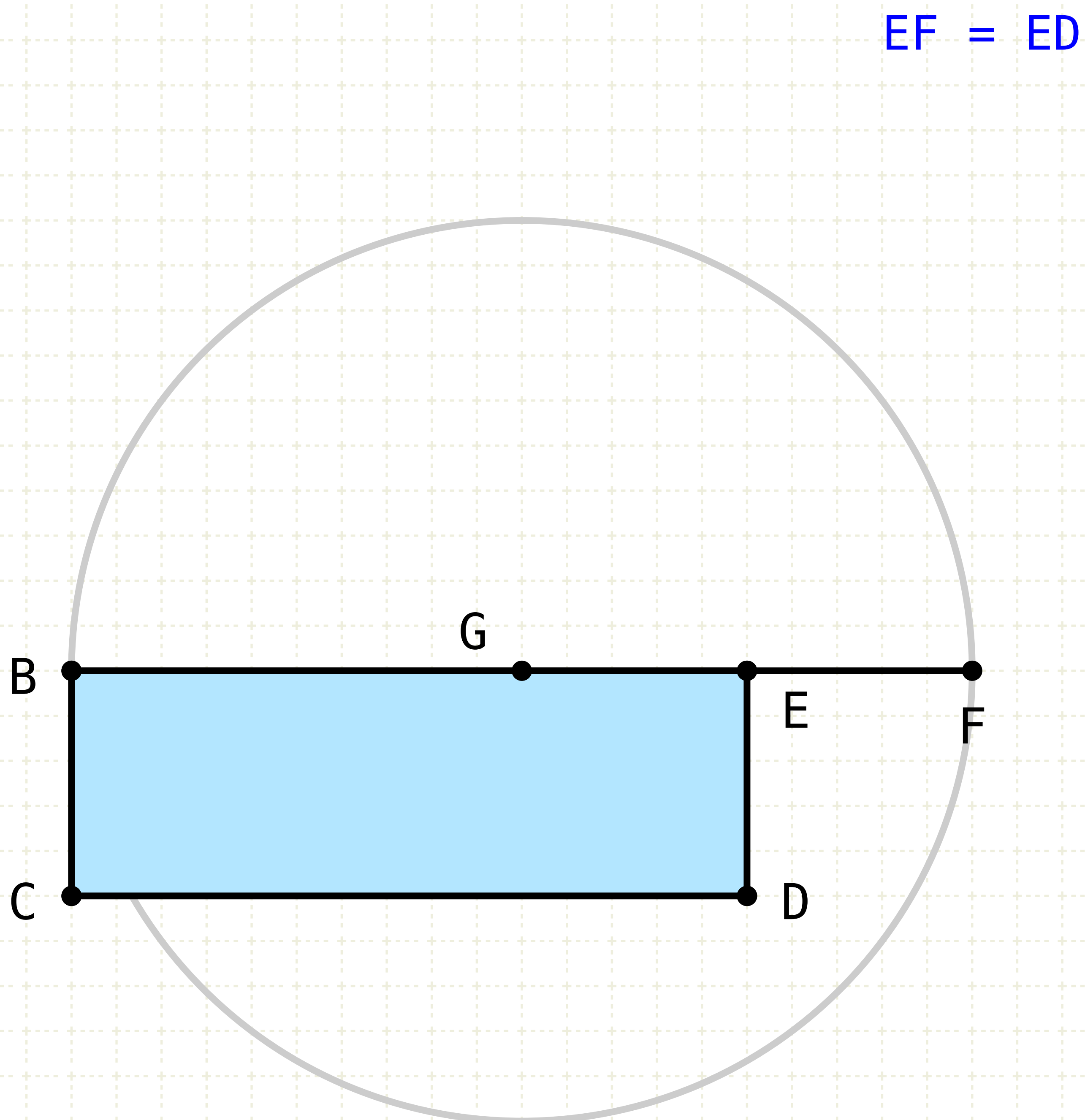


## Compare to II-14 - squaring a rectangle

Extend BE to F, where EF equals ED

Bisect BF (and label it point G)

Draw a circle with G as the center and GF as the radius

# Proposition 35 of Book III

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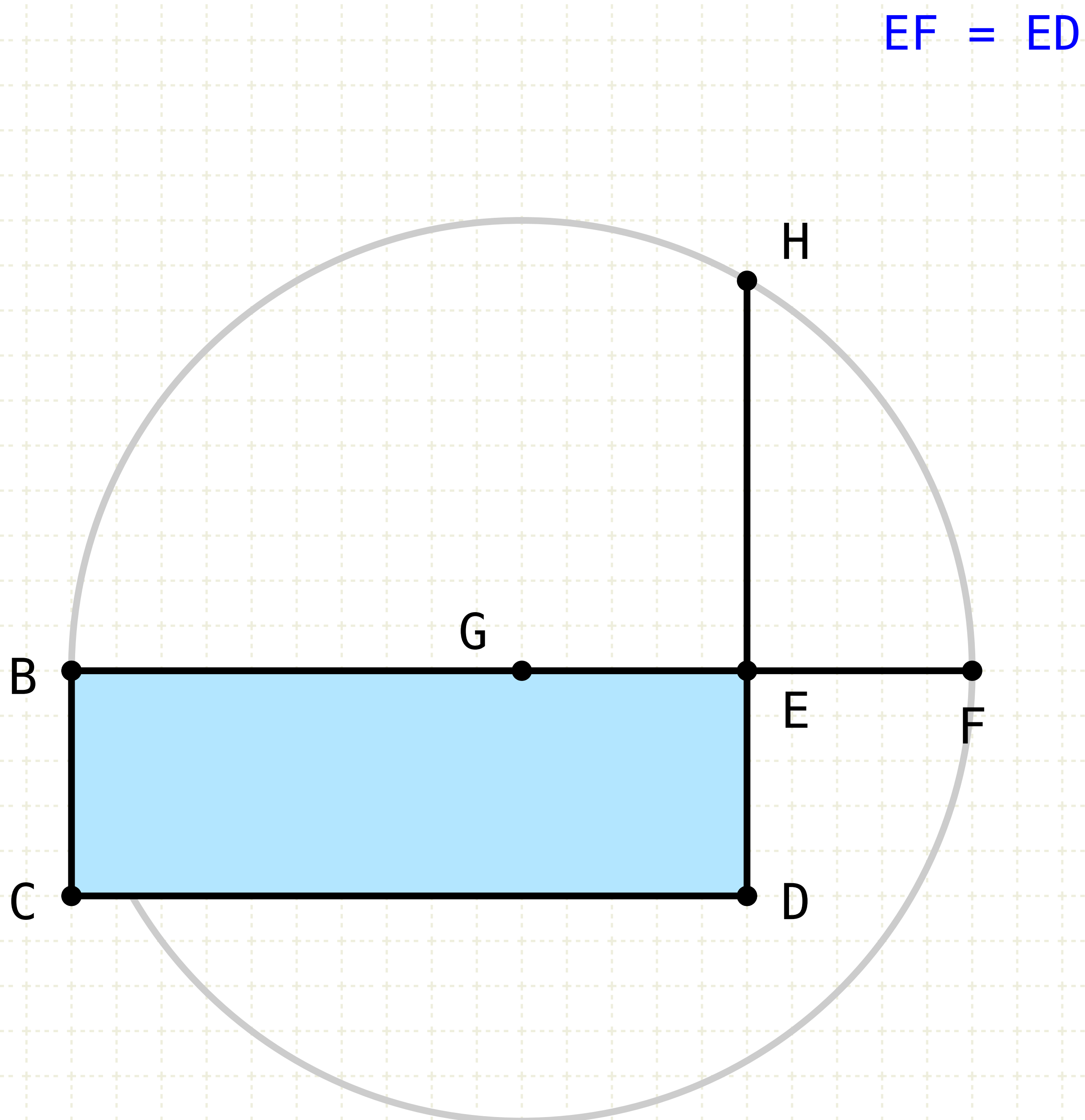


## Compare to II-14 - squaring a rectangle

Extend BE to F, where EF equals ED

Bisect BF (and label it point G)

Draw a circle with G as the center and GF as the radius

Extend DE to intersect with the circle at point H

# Proposition 35 of Book III

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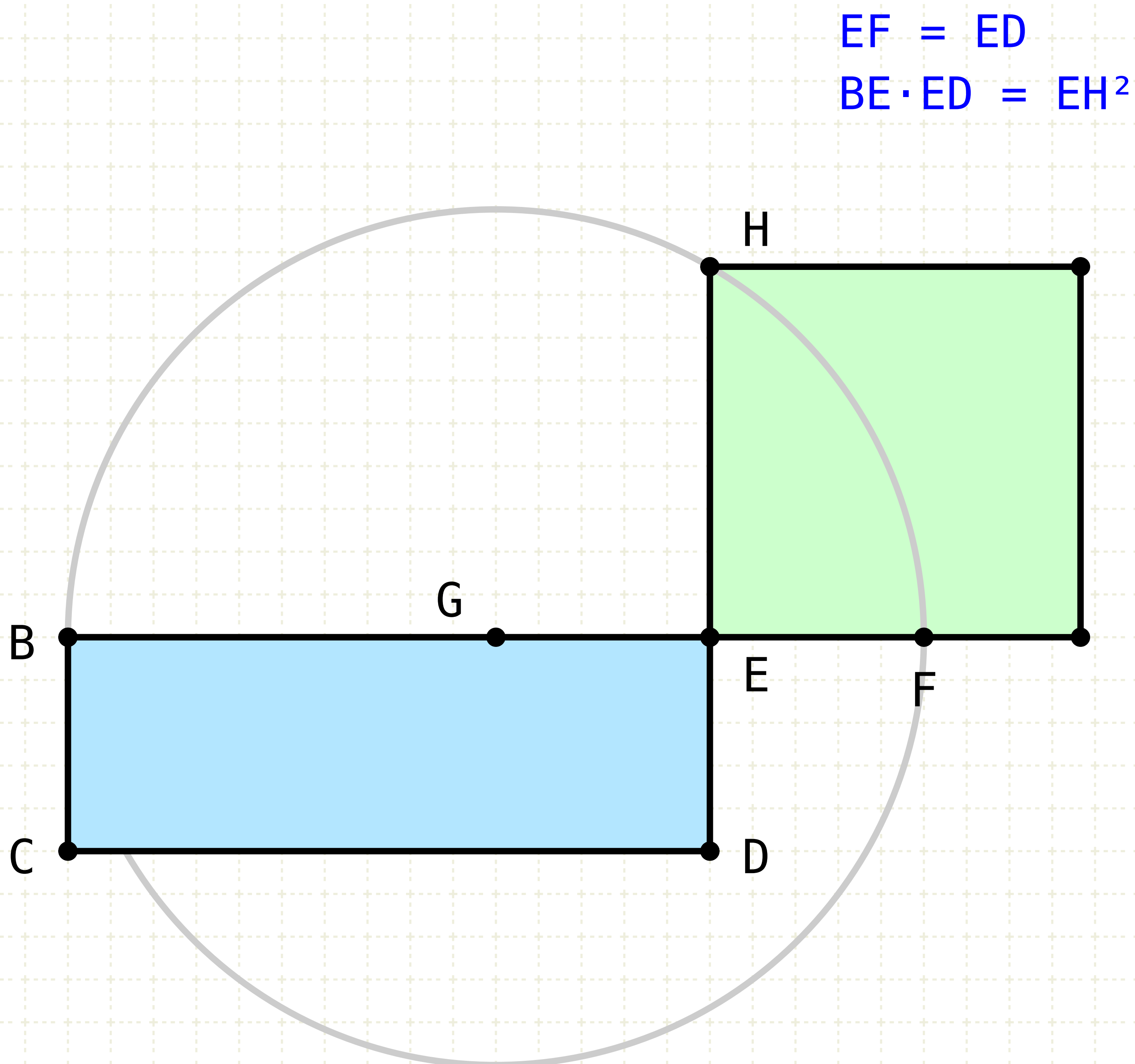


## Compare to II-14 - squaring a rectangle

Extend BE to F, where EF equals ED

Bisect BF (and label it point G)

Draw a circle with G as the center and GF as the radius

Extend DE to intersect with the circle at point H

According to II·14, the square on HE is equal in area of the rectangle

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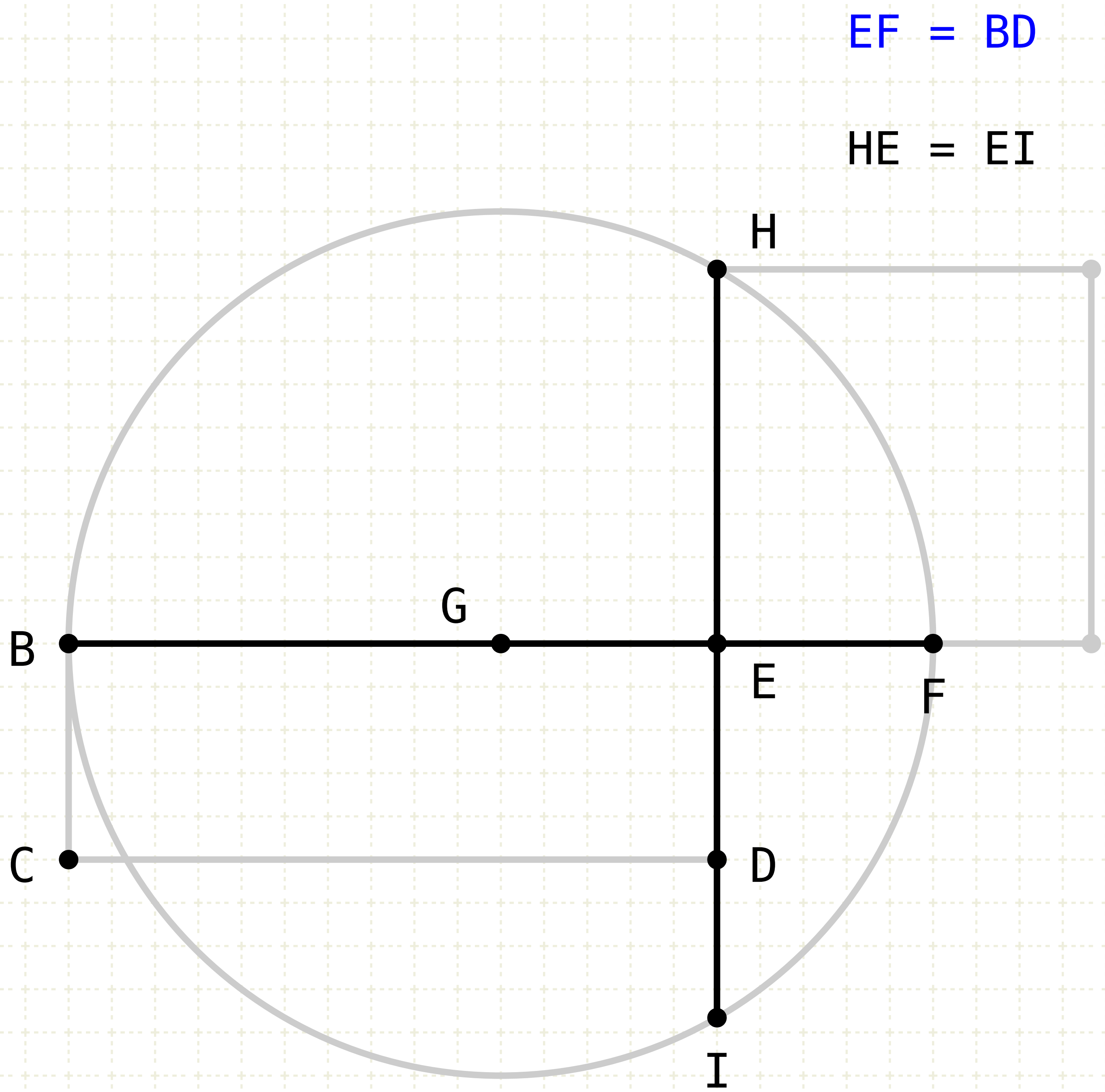


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Extend BE to F, where EF equals ED

Bisect BF (and label it point G)

Draw a circle with G as the center and GF as the radius

Extend DE to intersect with the circle at point H

According to II·14, the square on HE is equal in area of the rectangle

Since BF is perpendicular to HE (BCDE is a rectangle), and BF passes through the centre of the circle, HE is equal to EI (III·3)

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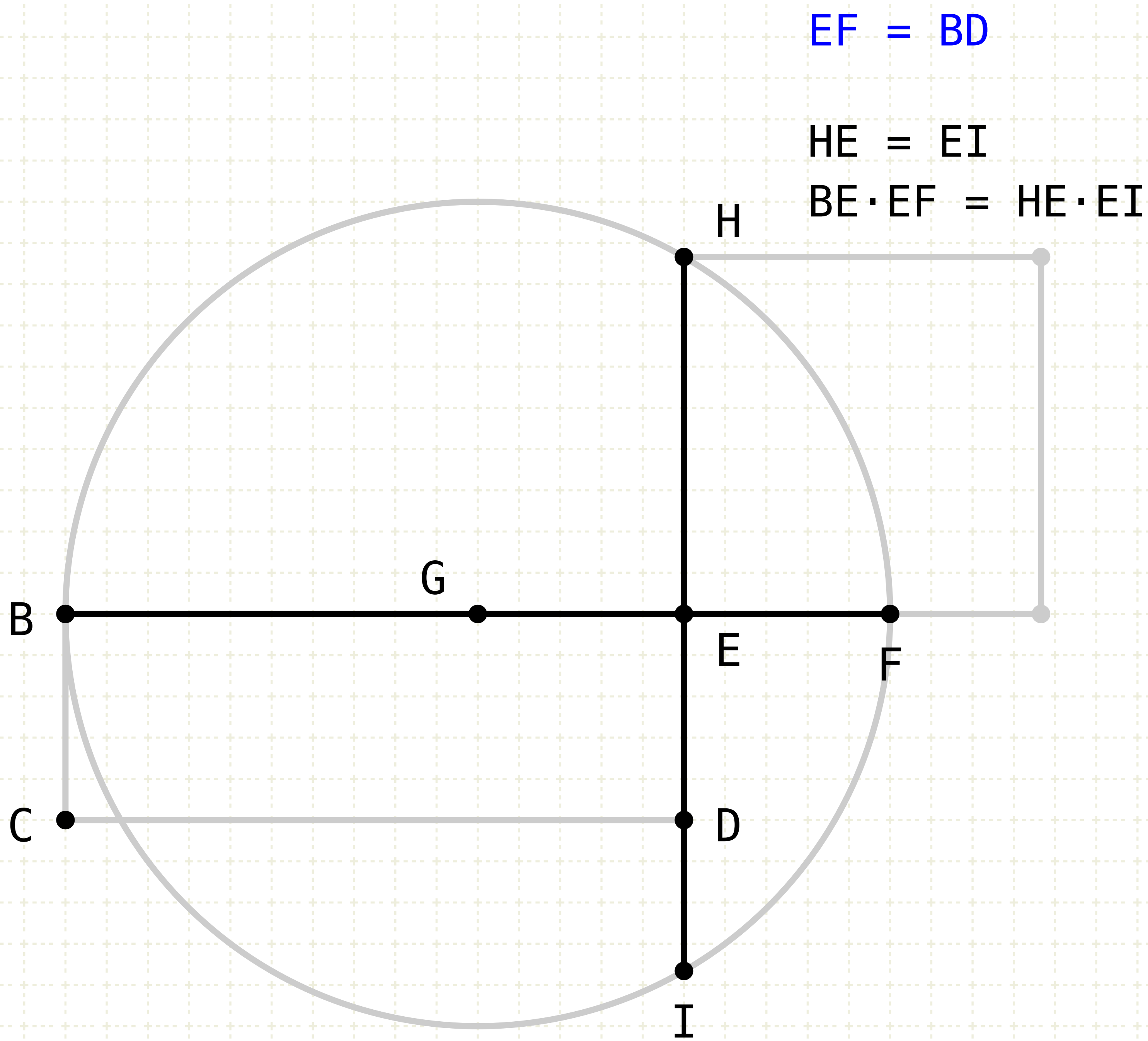



## Compare to II-14 - squaring a rectangle

Extend BE to F, where EF equals ED

Bisect BF (and label it point G)

Draw a circle with G as the center and GF as the radius

Extend DE to intersect with the circle at point H

According to II·14, the square on HE is equal in area of the rectangle

Since BF is perpendicular to HE (BCDE is a rectangle), and BF passes through the centre of the circle, HE is equal to EI (III·3)

And, according to this proposition, BE,EF is equal to HE,EI

# Proposition 35 of Book III

If in a circle two straight lines cut one another, the rectangle contained by the segments of the one is equal to the rectangle contained by the segments of the other.

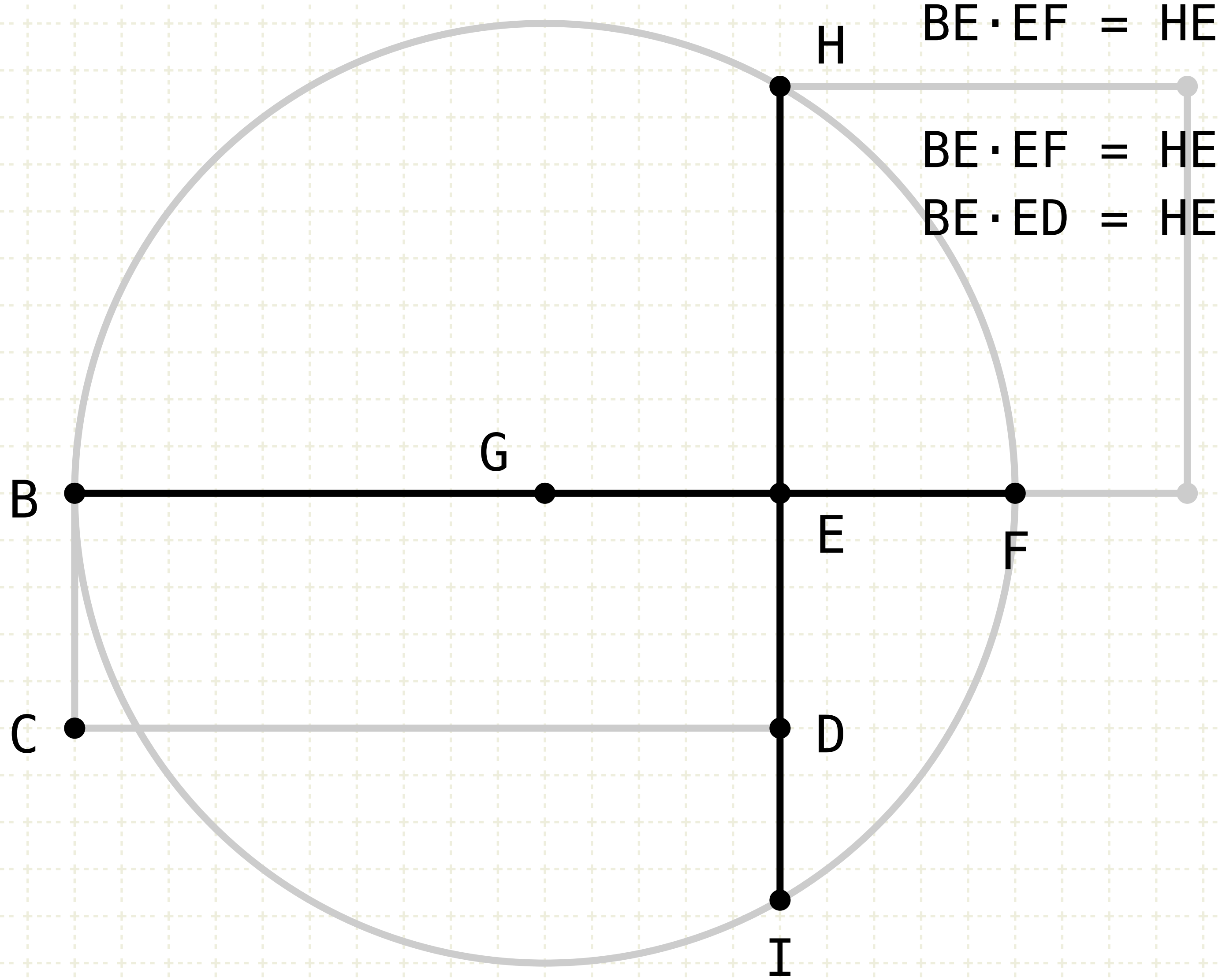
$EF = BD$

$HE = EI$

$BE \cdot EF = HE \cdot EI$

$BE \cdot EF = HE^2$

$BE \cdot ED = HE^2$




## Compare to II-14 - squaring a rectangle

Extend BE to F, where EF equals ED

Bisect BF (and label it point G)

Draw a circle with G as the center and GF as the radius

Extend DE to intersect with the circle at point H

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With the appropriate substitutions, we get the same result as II·14

## Youtube Videos

https://www.youtube.com/c/SandyBultena