

Euclid's Elements

Book VI

One can state, without exaggeration, that the observation of and the search for similarities and differences are the basis of all human knowledge.

Alfred Nobel



Table of Contents, Chapter 6

1	If the height of two triangles are equal, then the ratio of the areas is equal to the ratio of the bases	7	If two triangles have one angle equal to one angle, and the sides about other angles are proportional, and the remaining angles either both less or both not less than a right angle, then triangles will be equiangular	14	In equal and equiangular parallelograms, the sides about the equal angles are reciprocally proportional; and vice versa
2	If a line cuts a triangle, parallel to its base, it will cut the sides of the triangle proportionally			15	In equal triangles which have one angle equal to one angle the sides about the equal angles are reciprocally proportional; and vice versa
3	If an angle of a triangle is bisected and the straight line cutting the angle also cuts the base, the segments of the base will have the same ratio as the remaining sides of the triangle	8	If in a right-angled triangle a perpendicular be drawn from the right angle to the base, the triangles adjoining the perpendicular are similar both to the whole and to one another	16	If four straight lines are proportional, the rectangle contained by the extremes is equal to the rectangle contained by the means, and vice versa
4	If two triangles have equal angles, then the sides opposite the equal angles are proportional, as well, the sides of the triangles on either side of the equal angles are also proportional	9	From a given straight line to cut off a given fraction	17	If three straight lines are proportional, the rectangle contained by the extremes is equal to the square on the mean; and vice versa
5	If two triangles have proportional sides, the triangles will be equiangular	10	To cut a given uncut straight line similarly to a given cut straight line	18	On a given straight line to describe a rectilineal figure similar and similarly situated to a given rectilineal figure
6	If two triangles have one angle equal to one angle and the sides about the equal angles are proportional, then the triangles will be equiangular	11	To two given straight lines to find a third proportional	19	Similar triangles are to one another in the duplicate ratio of the corresponding sides
		12	To three given straight lines to find a fourth proportional		
		13	To two given straight lines to find a mean proportional		



Table of Contents, Chapter 3

20	Similar polygons are divided into the same number of similar triangles, which have the same ratio as the wholes, and the polygons have duplicate ratios to their corresponding sides	26	If from a parallelogram a similar parallelogram with a common angle is subtracted, it is about the same diameter as the original	30	To cut a finite straight line in extreme ratio
21	Figures which are are similar to the same rectilineal figure are also similar to one another	27	Of all the parallelograms applied to the same straight line and deficient by parallelogrammic figures similar to a parallelogram drawn on half the said line, the largest will be one that is drawn on half of the straight line and is similar to the defect	31	In right-angled triangles the figure on the side subtending the right angle is equal to the similar and similarly described figures on the sides containing the right angle
22	If four straight lines are proportional, similar rectilineal figures will also be proportional; and vice versa	28	To a given straight line, apply a parallelogram equal to a given rectilineal figure and deficient by a parallelogrammic figure similar to a given one		
23	Equiangular parallelograms have to one another the ratio compounded of the ratios of their sides	29	To a given straight line, apply a parallelogram equal to a given rectilineal figure and exceeding by a parallelogrammic figure similar to a given one		
24	In any parallelogram the parallelograms about the diameter are similar both to the whole and to one another				
25	To construct one and the same figure similar to a given rectilineal figure and equal to another given rectilineal figure				



Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilineal figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilineal figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



Proposition 28 of Book VI

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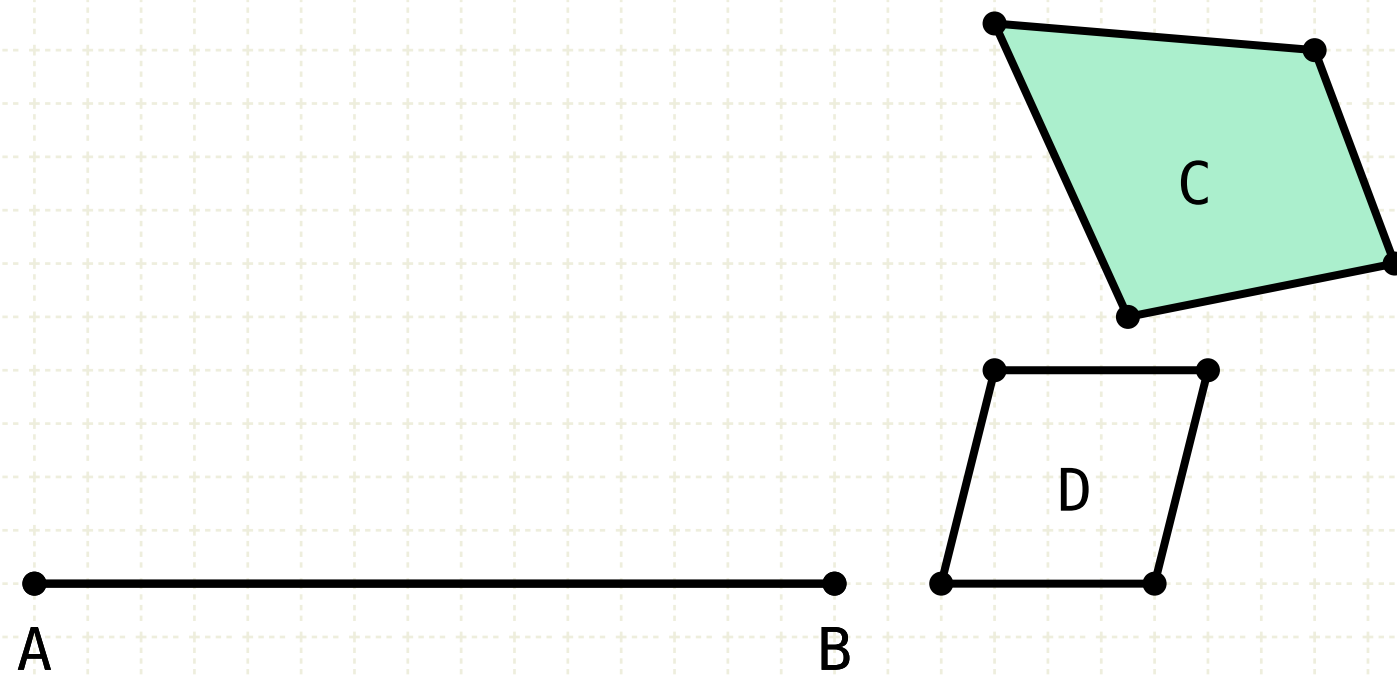
In other words

Given a straight line AB and



Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



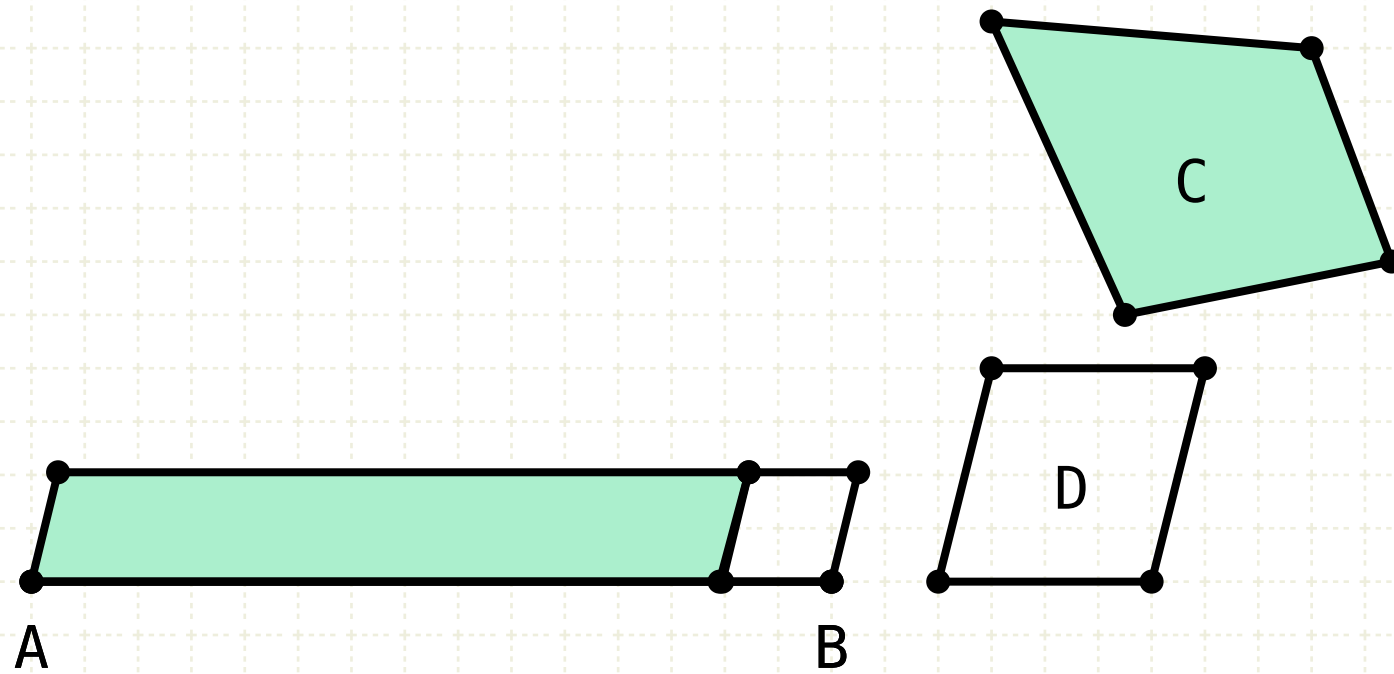
In other words

Given a straight line AB and

Let C be a rectilinear figure and D be a parallelogram

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To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



In other words

Given a straight line AB and

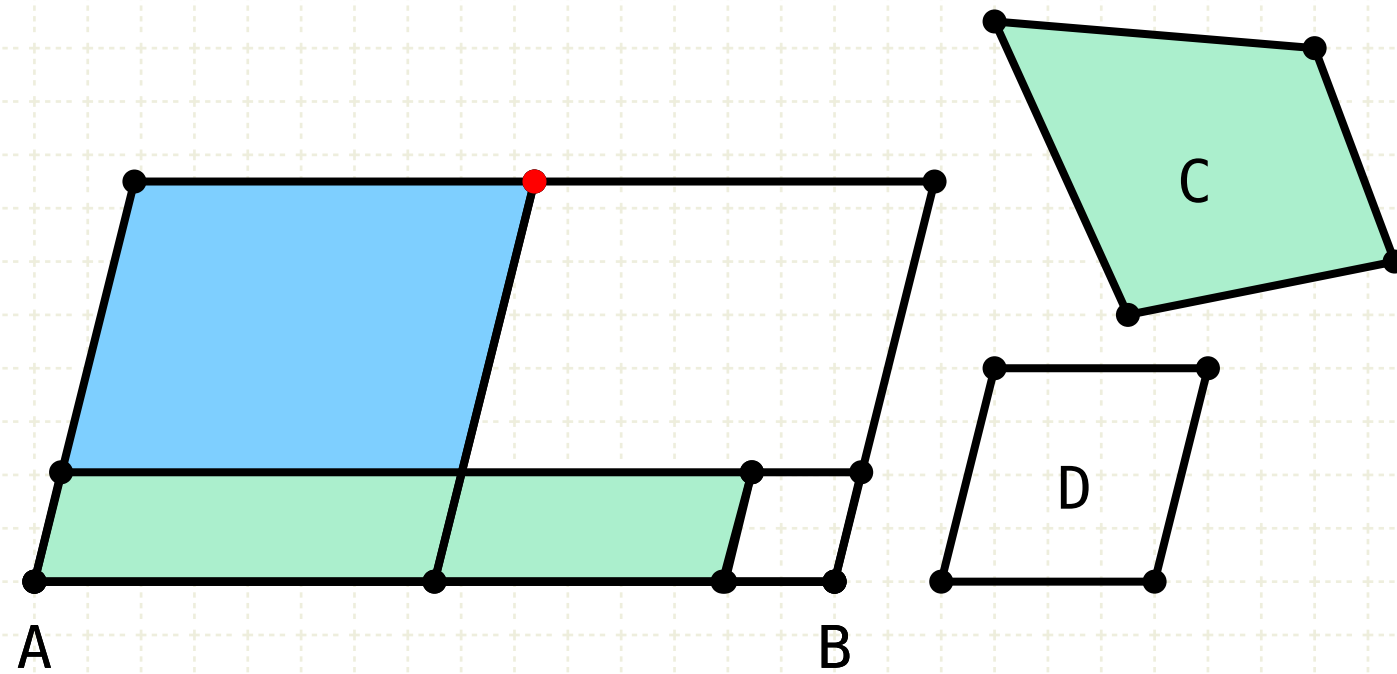
Let C be a rectilinear figure and D be a parallelogram

We want to draw a parallelogram on AB such that ...

- * If a parallelogram similar to parallelogram D is removed, then...
- * the remainder is equal in area to C

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To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



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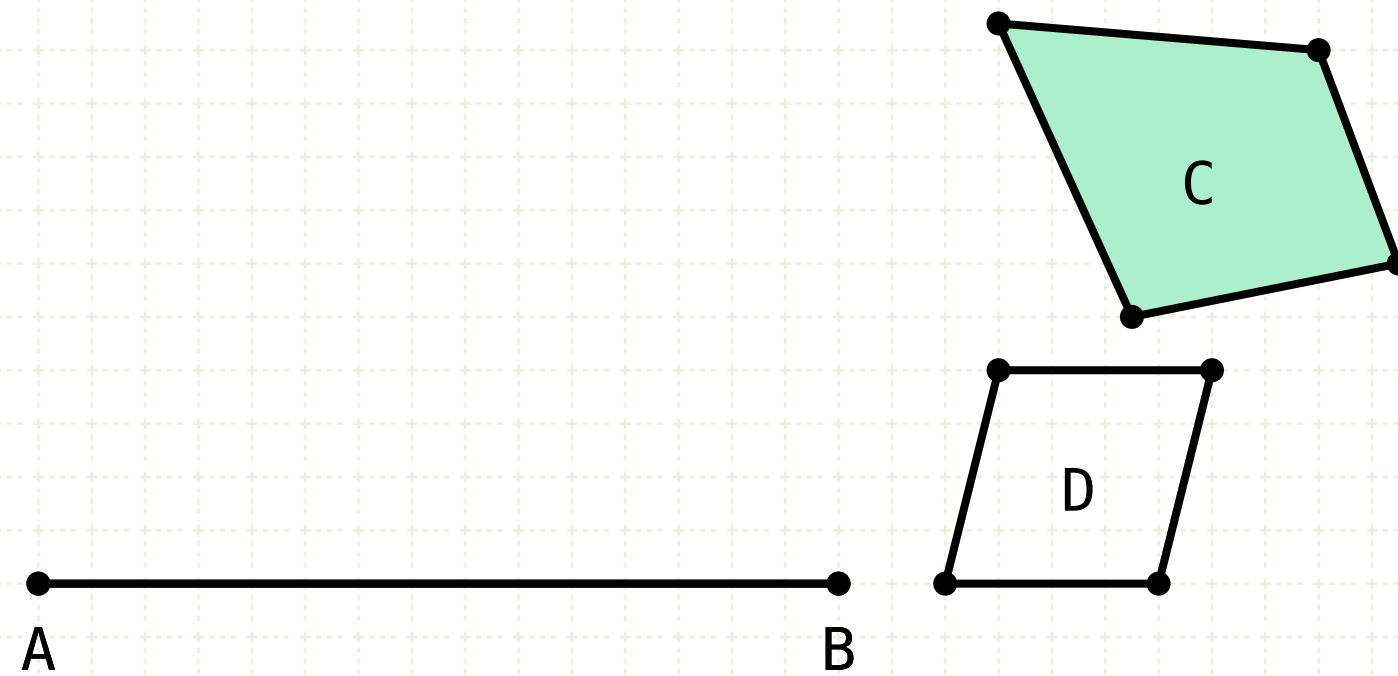
- * If a parallelogram similar to parallelogram D is removed, then...
- * the remainder is equal in area to C

Note that:

- * the area of C cannot be greater than the area of half the parallelogram on the line AB

Proposition 28 of Book VI

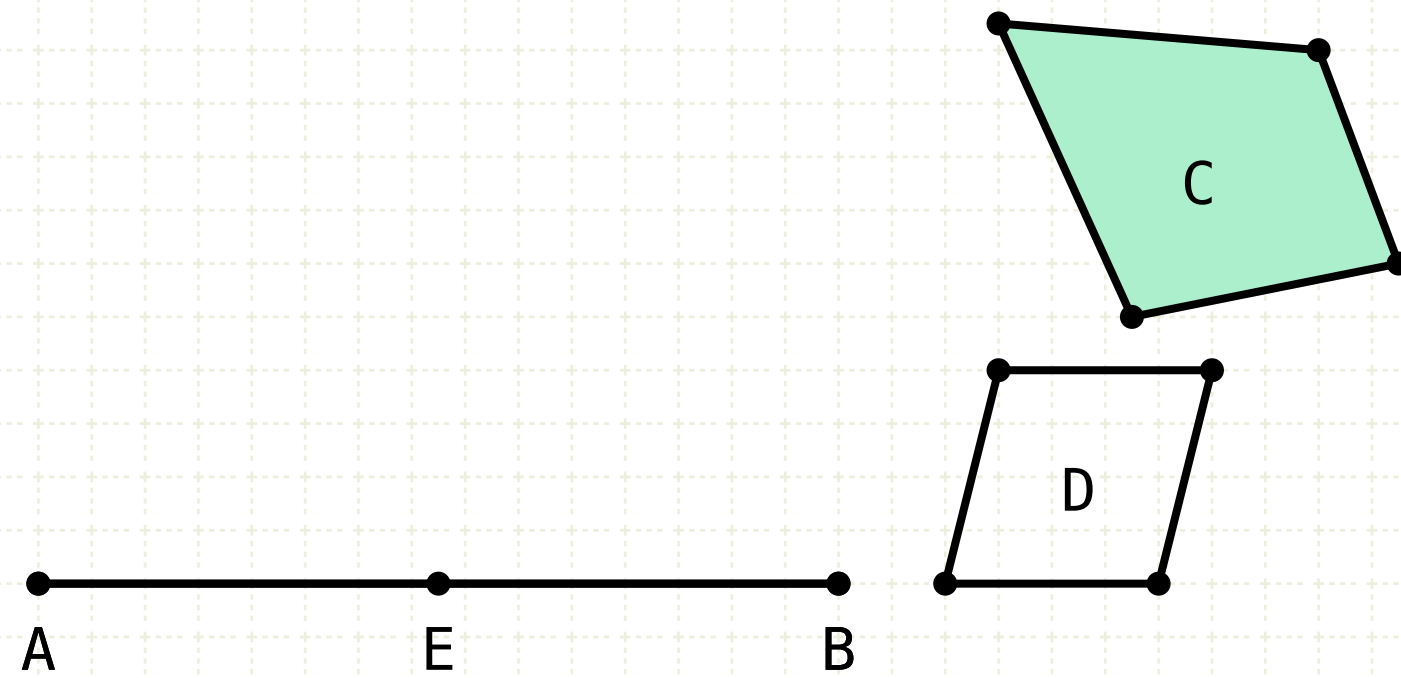
To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



Construction

Proposition 28 of Book VI

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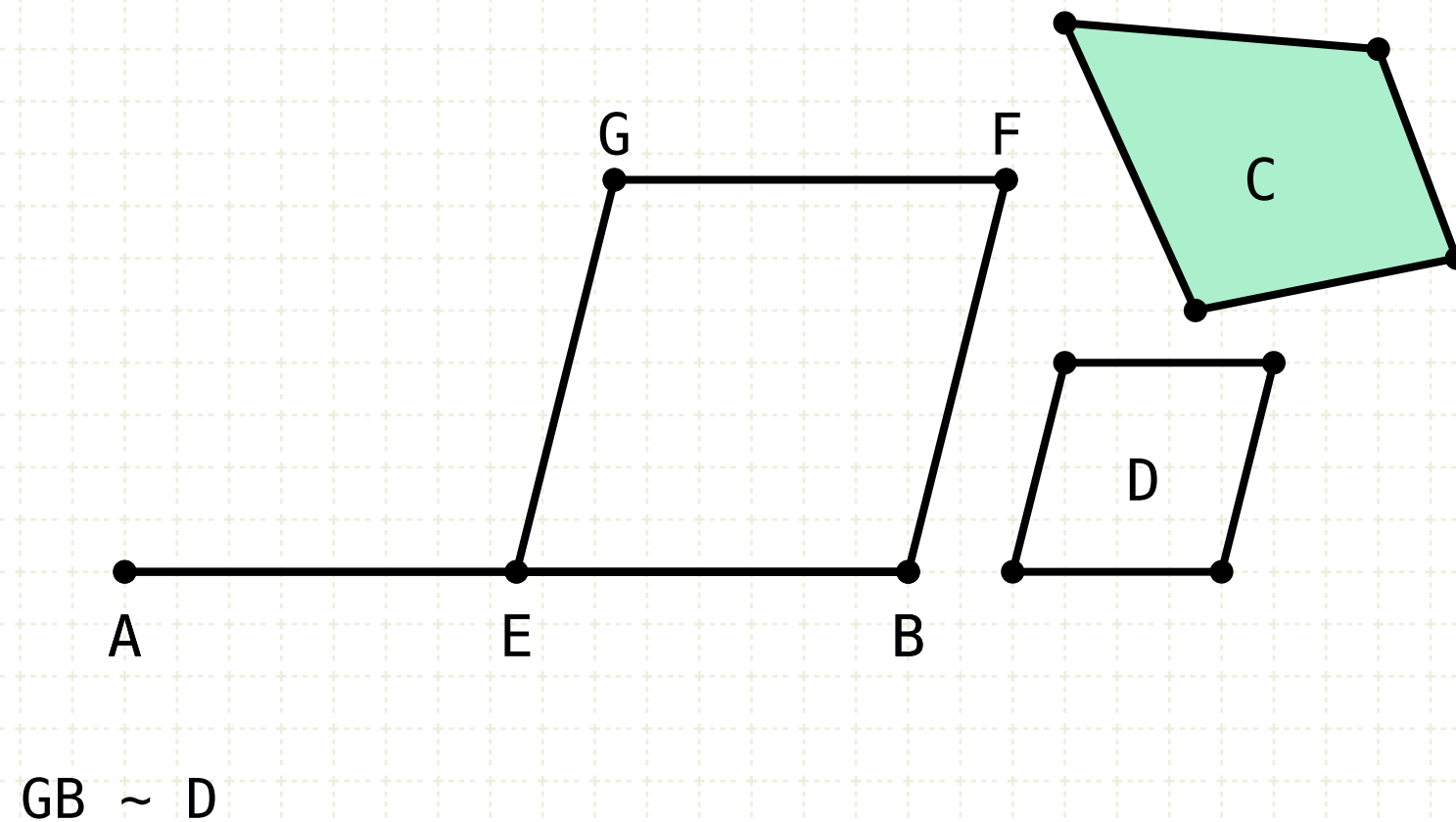


Construction

Bisect the line AB at point E

Proposition 28 of Book VI

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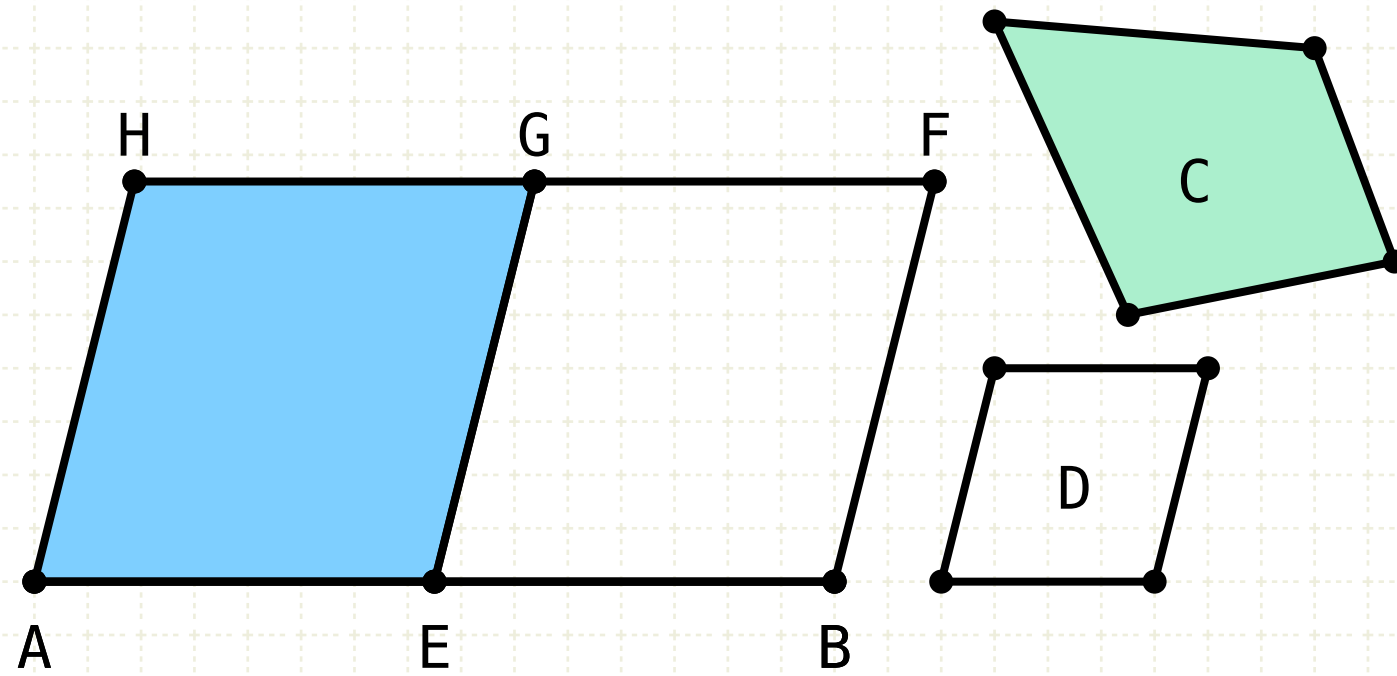
Construction

Bisect the line AB at point E

Create a parallelogram similar to D on line EB (VI·18)

Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



$GB \sim D$

Construction

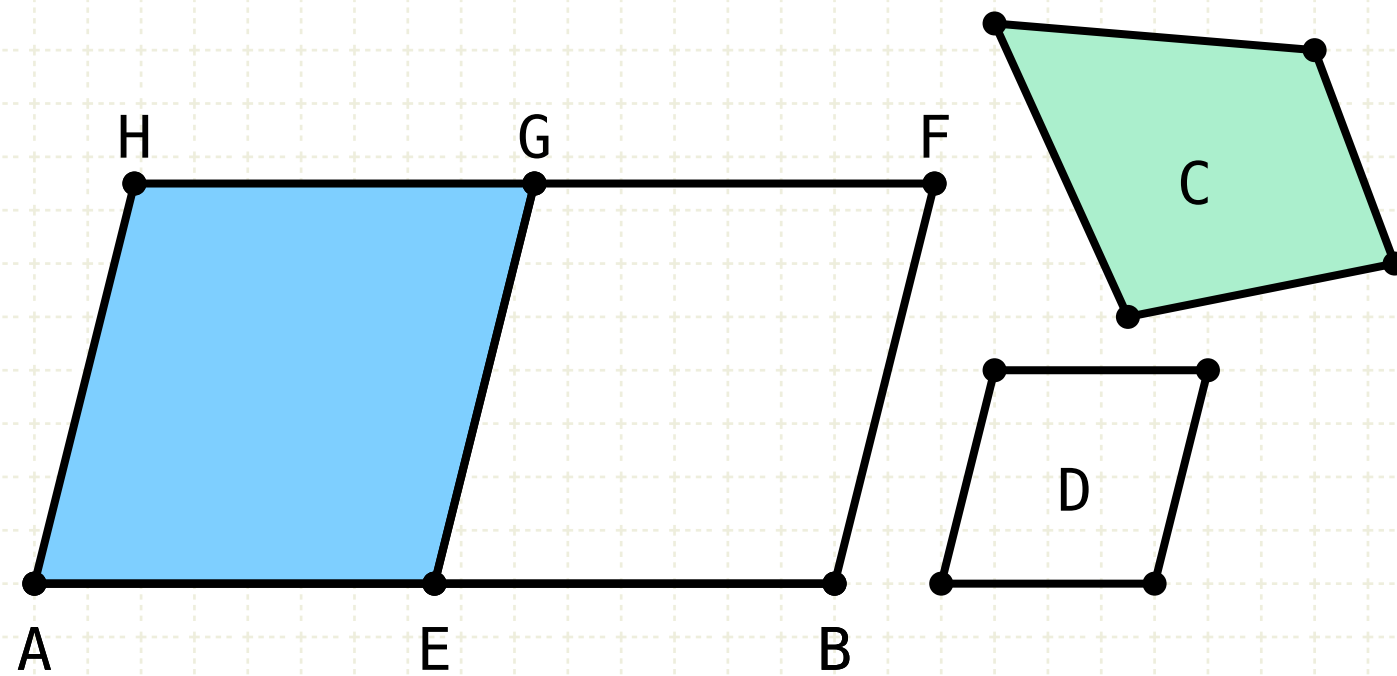
Bisect the line AB at point E

Create a parallelogram similar to D on line EB (VI·18)

Let the parallelogram AG be completed

Proposition 28 of Book VI

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$GB \sim D$
If $HE > C$

Construction

Bisect the line AB at point E

Create a parallelogram similar to D on line EB (VI·18)

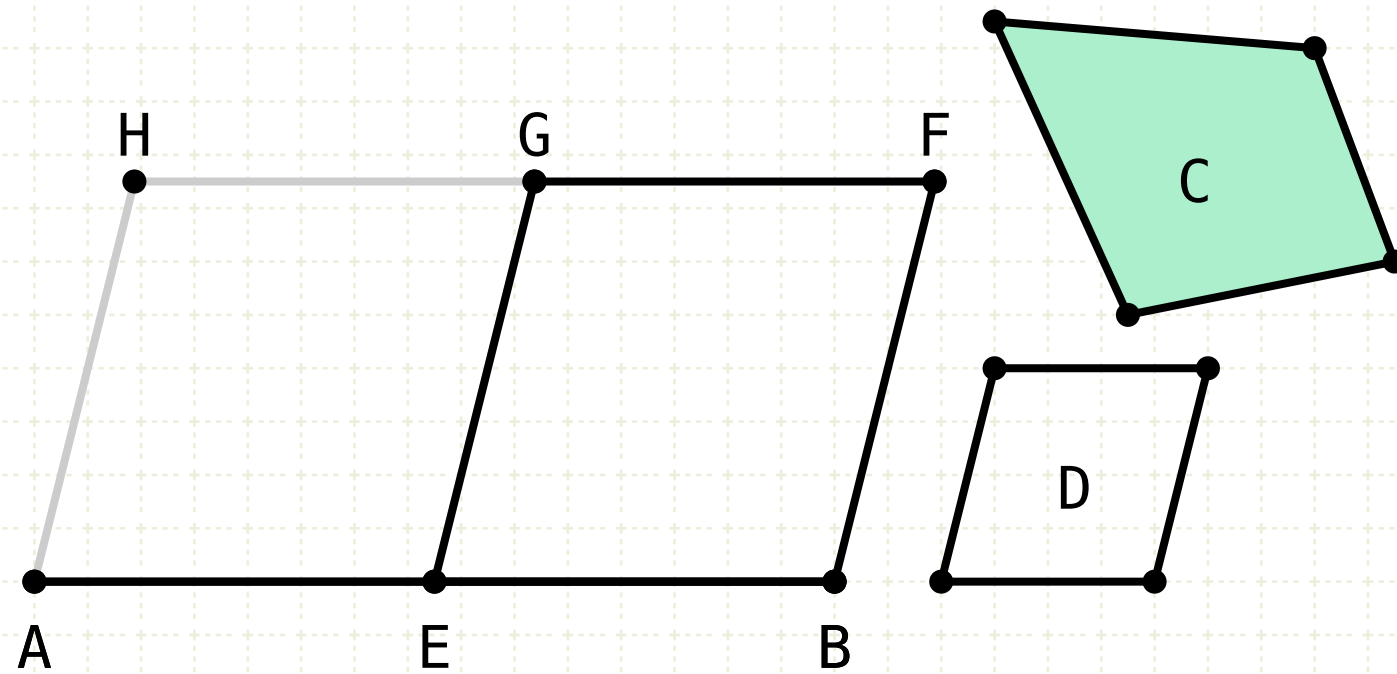
Let the parallelogram AG be completed

If AG is equal in size to C , then we are finished, otherwise ...

HE is greater than C

Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



$GB \sim D$

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$HE = GB$

$GB > C$

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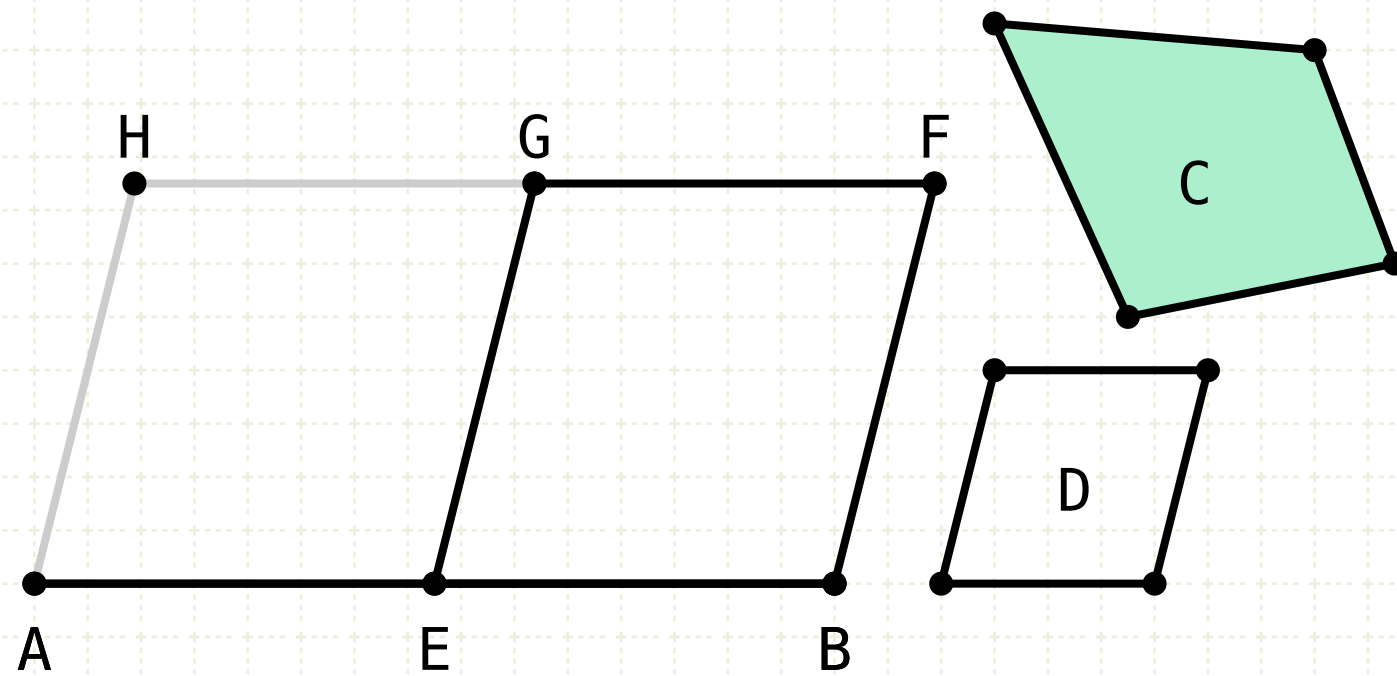
If AG is equal in size to C, then we are finished, otherwise ...

HE is greater than C

HE is equal to GB, therefore GB is also greater than C

Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



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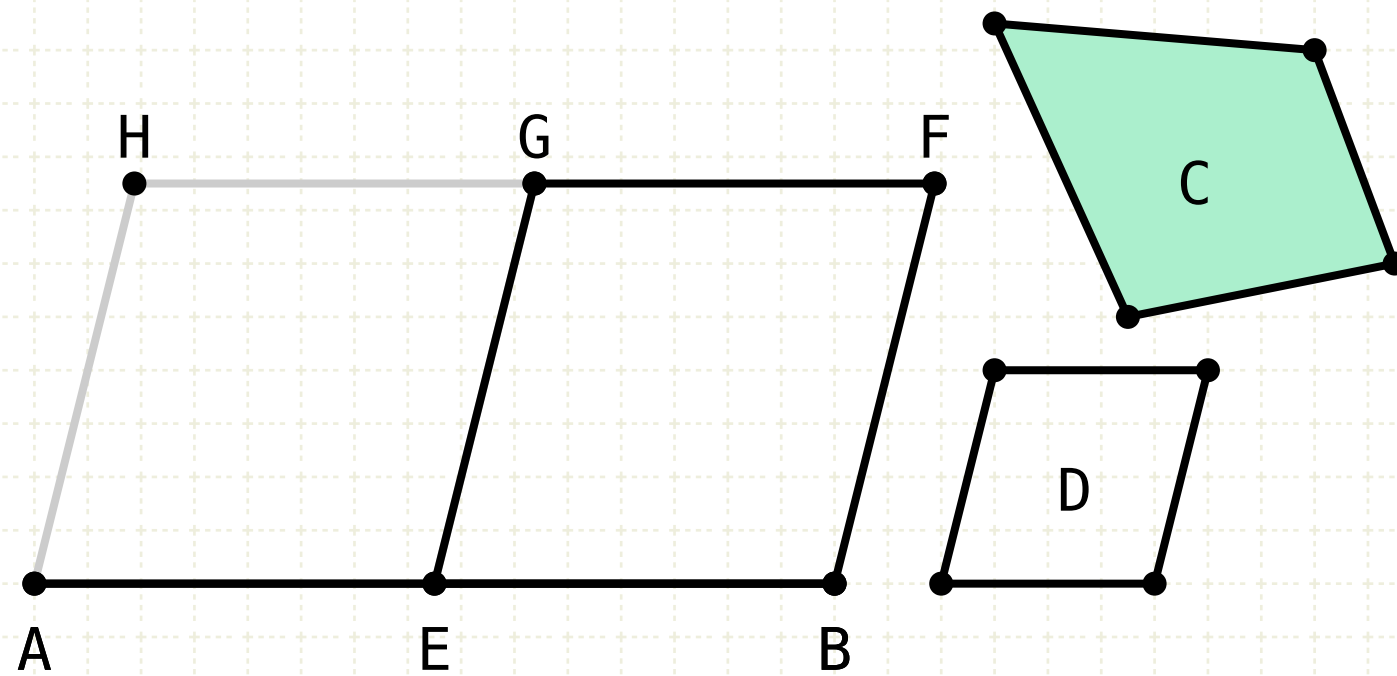
HE is greater than C

HE is equal to GB, therefore GB is also greater than C

Let KLMN be constructed such that it is equal to the the area of GB minus the area of C, and is similar to D (VI·25)

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To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



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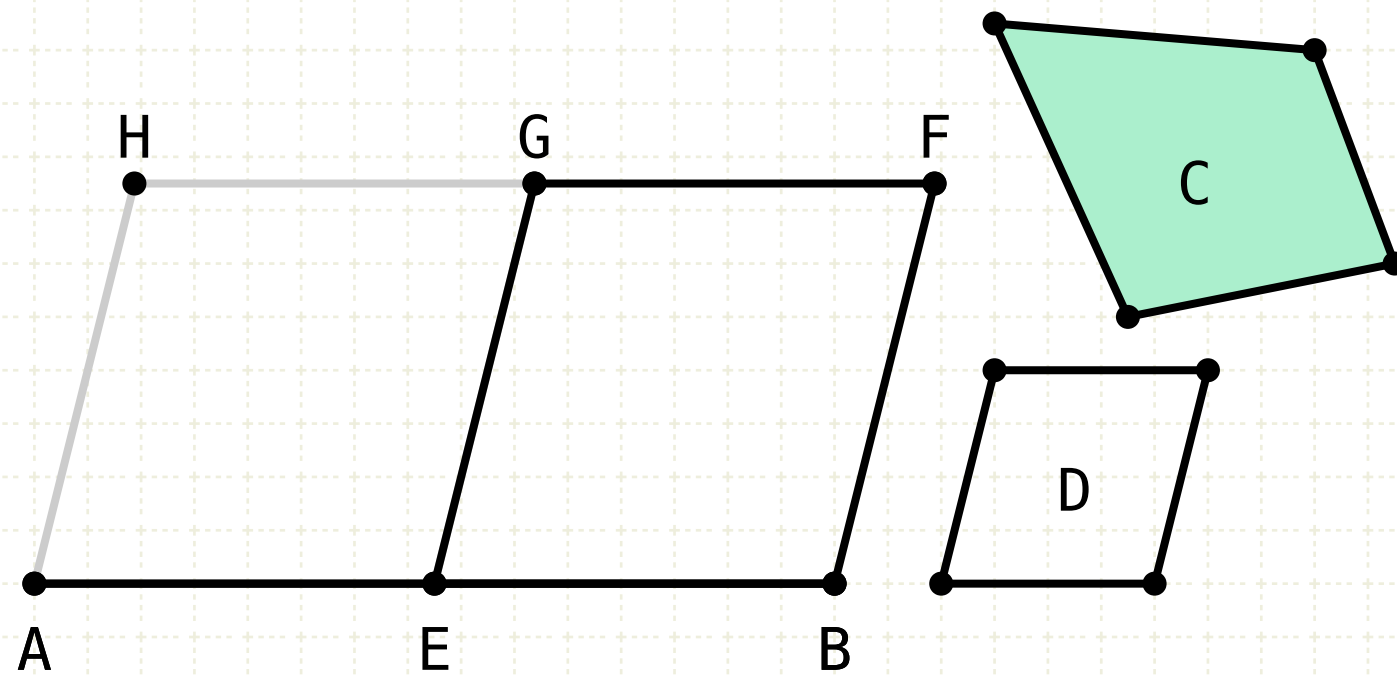
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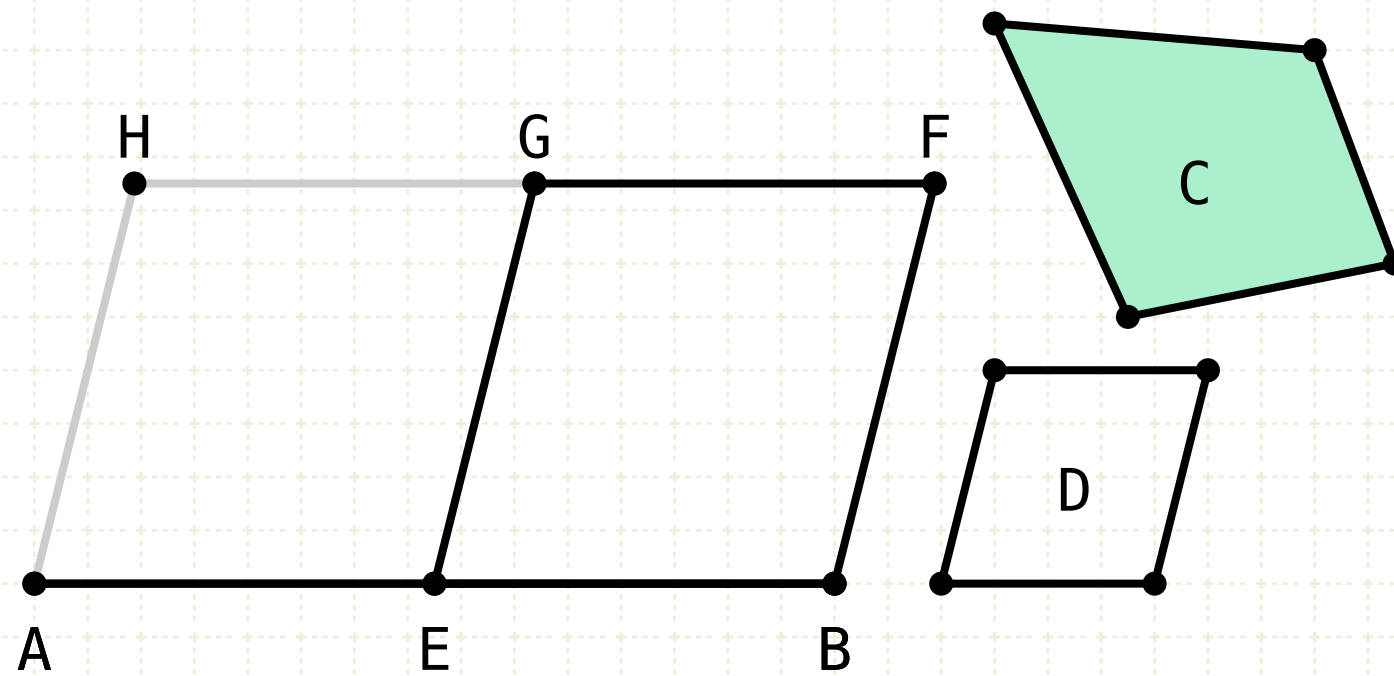


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Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



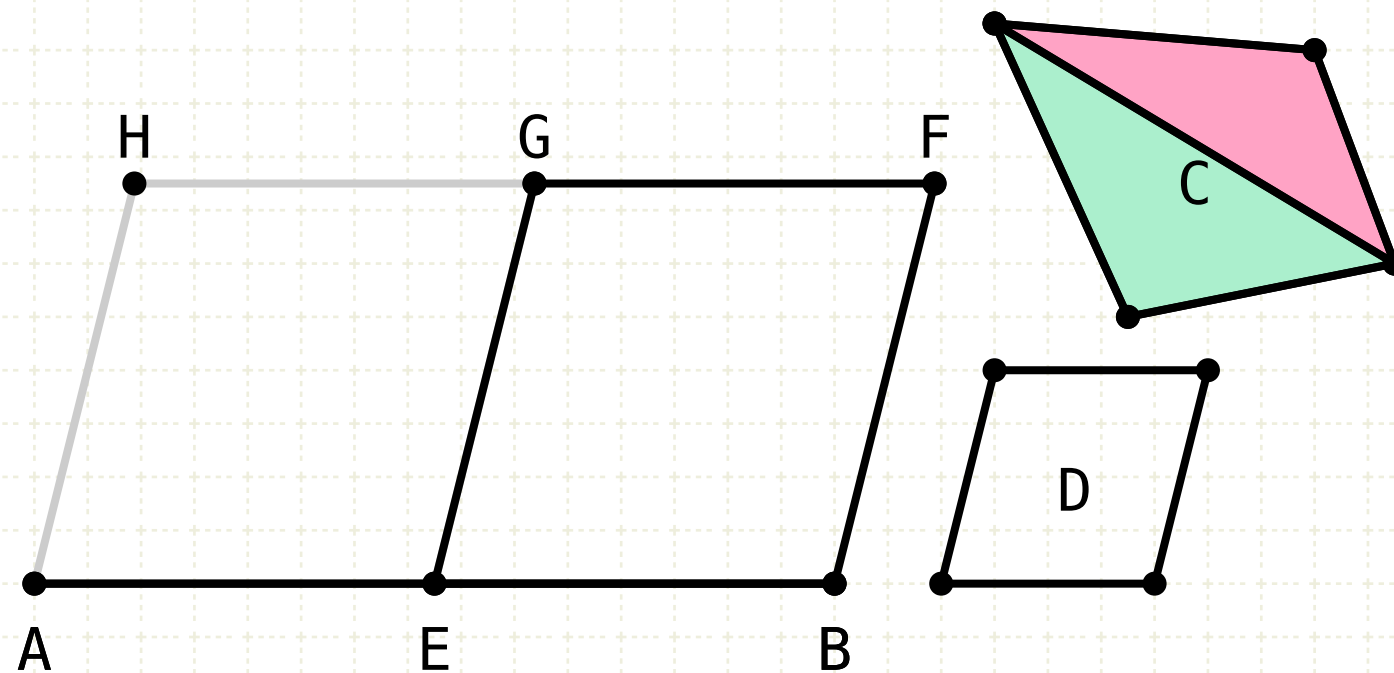
Let KLMN be constructed...

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Copy the rectilinear figure C to a parallelogram on line EB, with an inner angle of GEB

Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



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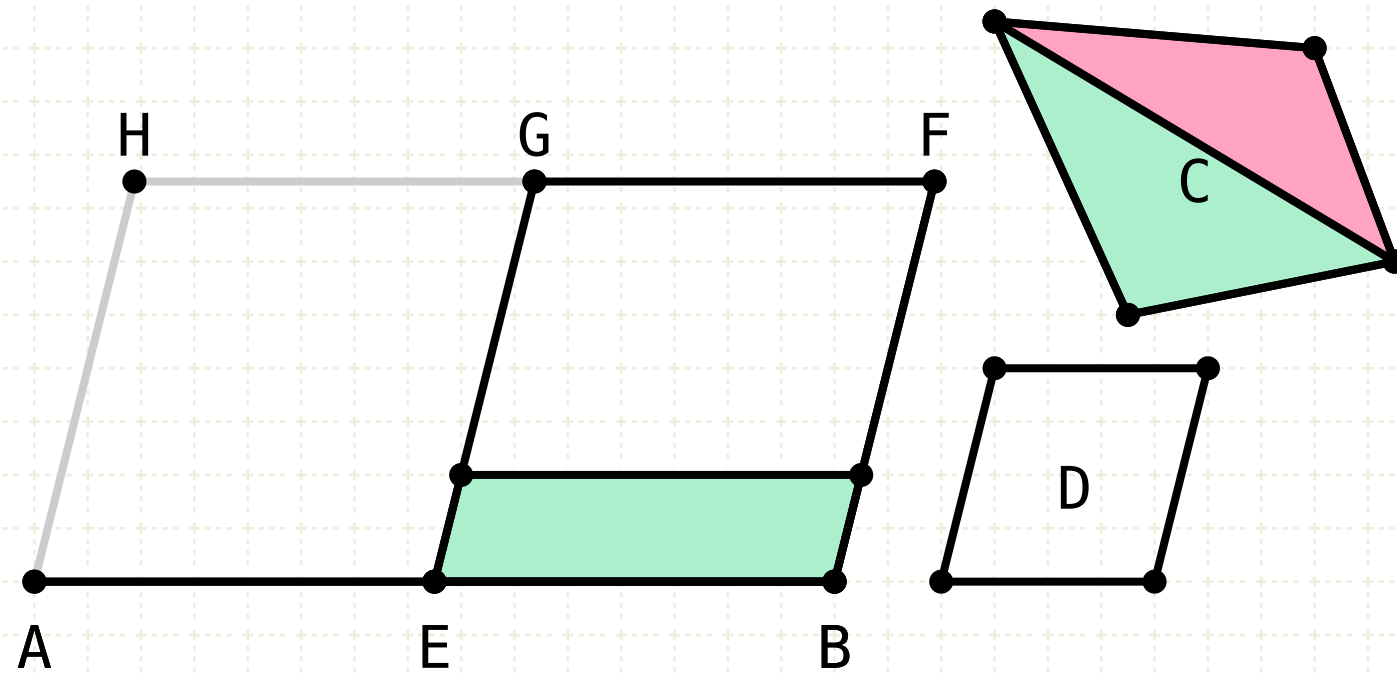
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Copy the rectilinear figure C to a parallelogram on line EB , with an inner angle of GEB

* Split C into two triangles $C1$ and $C2$

Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



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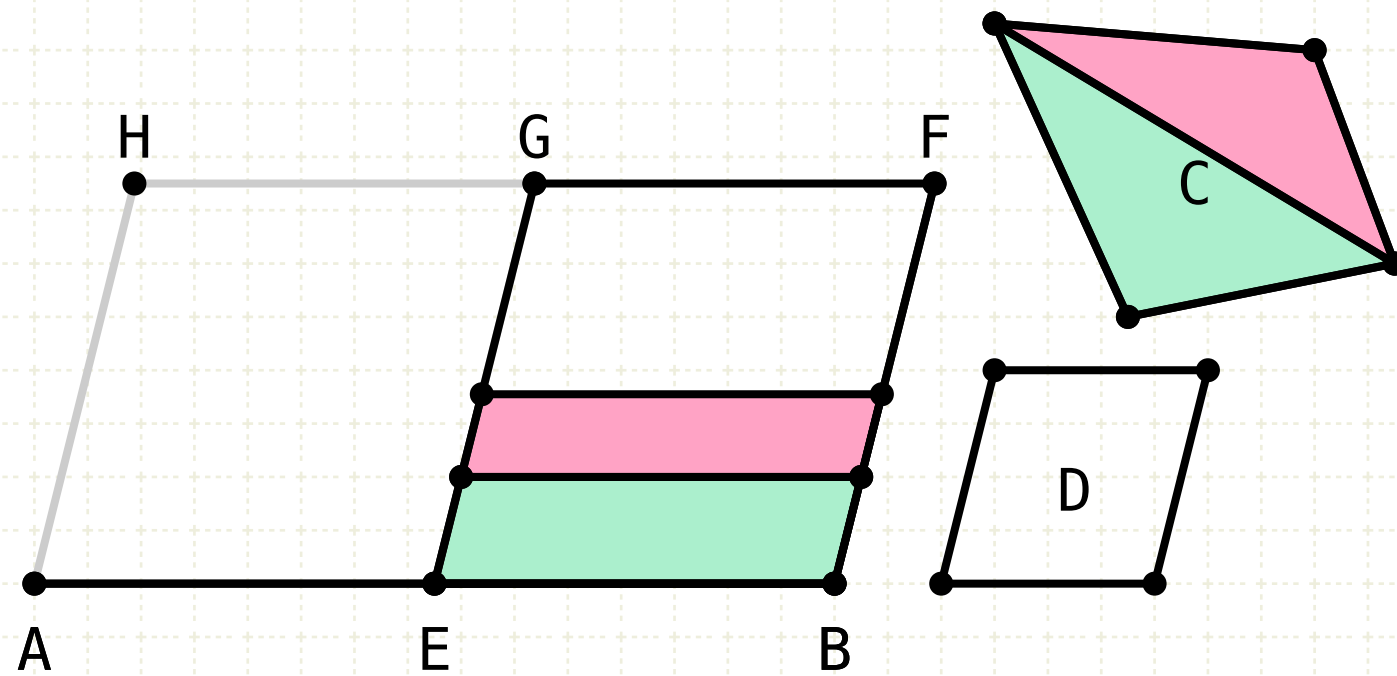
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Copy the rectilinear figure C to a parallelogram on line EB, with an inner angle of GEB

- * Split C into two triangles C1 and C2
- * Construct a parallelogram on the base EB such that it is equal in area to the triangle C1 (I.44)

Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



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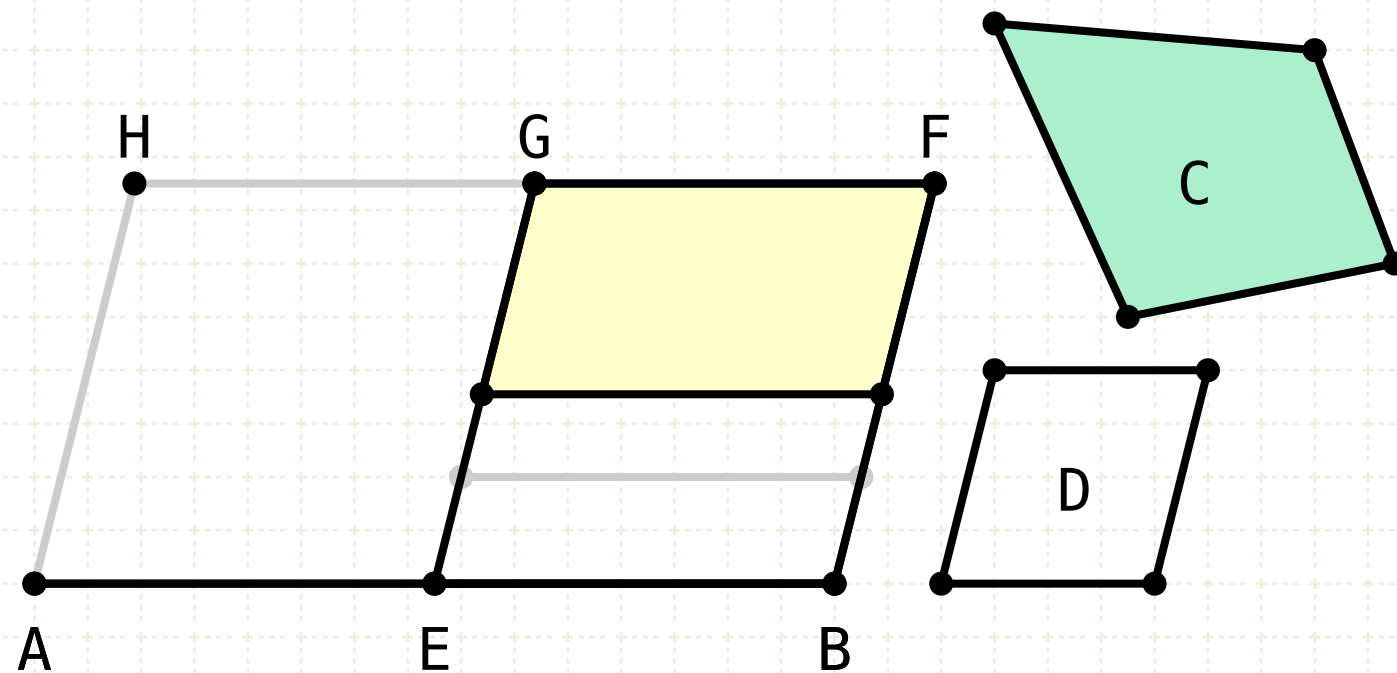
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Copy the rectilinear figure C to a parallelogram on line EB, with an inner angle of GEB

- * Split C into two triangles C1 and C2
- * Construct a parallelogram on the base EB such that it is equal in area to the triangle C1 (I·44)
- * Construct a parallelogram on the top of the previous parallelogram such that it is equal in area to the triangle C2 (I·44)

Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



Let KLMN be constructed...

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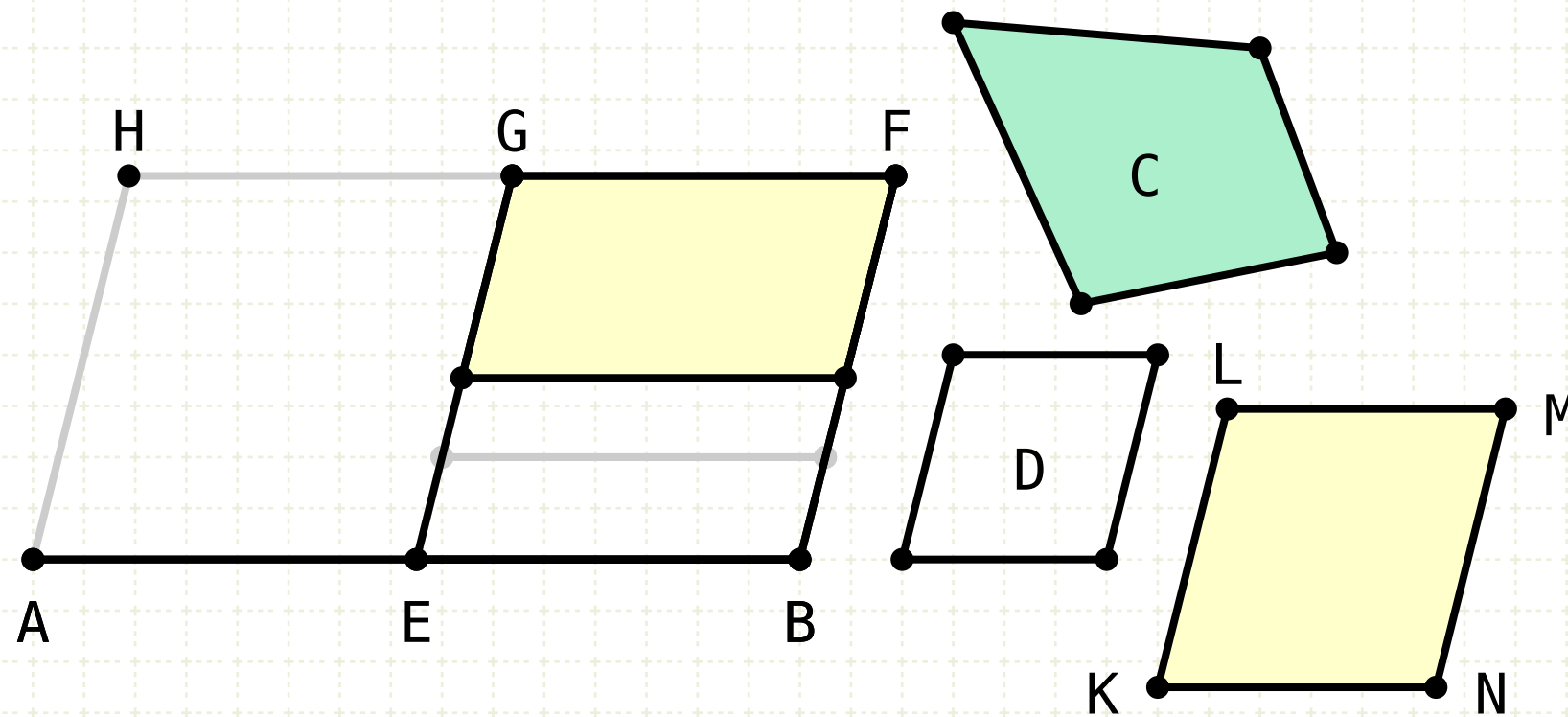
Copy the rectilinear figure C to a parallelogram on line EB, with an inner angle of GEB

- * Split C into two triangles C1 and C2
- * Construct a parallelogram on the base EB such that it is equal in area to the triangle C1 (I·44)
- * Construct a parallelogram on the top of the previous parallelogram such that it is equal in area to the triangle C2 (I·44)

What is left over in the parallelogram EF is now equal to the area of EF minus the area of C

Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



Let KLMN be constructed...

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Copy the rectilinear figure C to a parallelogram on line EB, with an inner angle of GEB

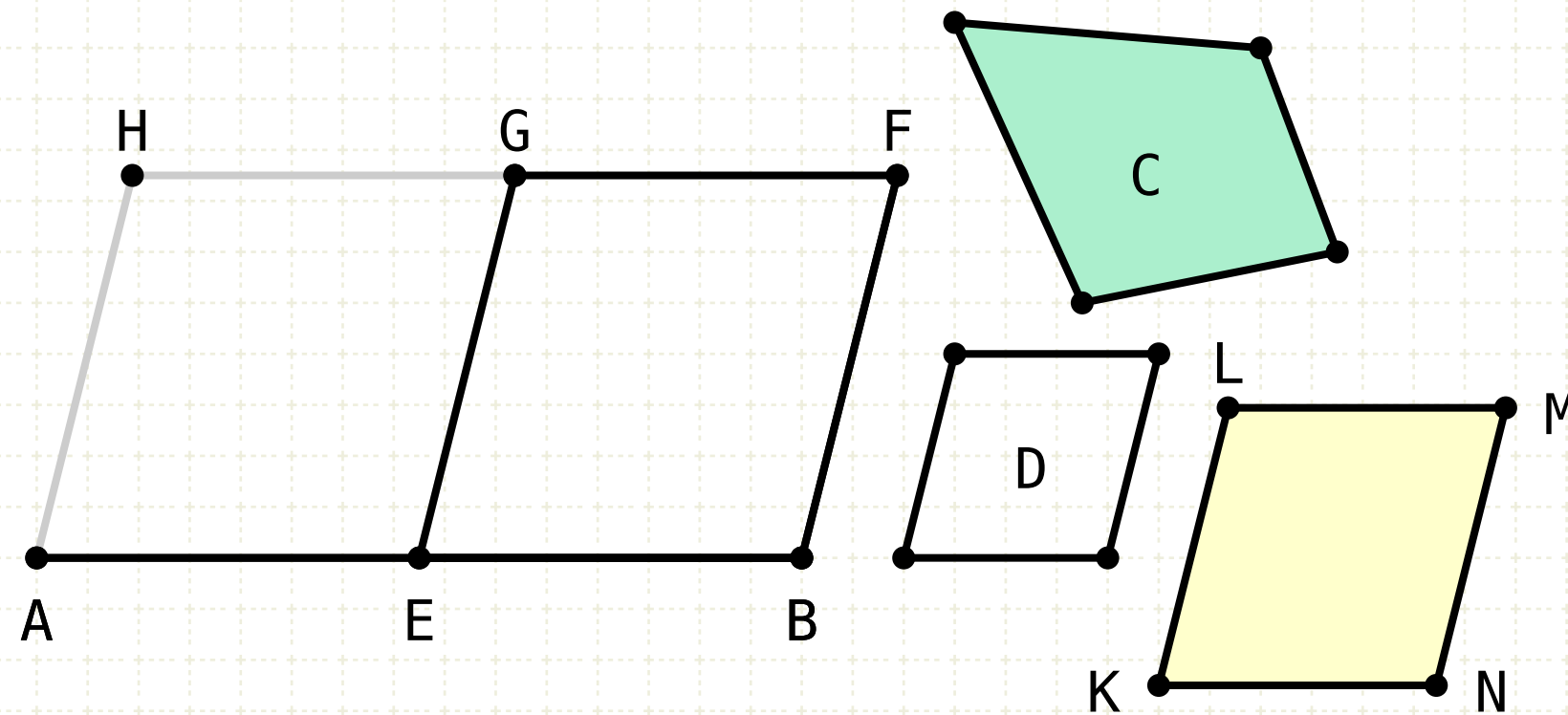
- * Split C into two triangles C1 and C2
- * Construct a parallelogram on the base EB such that it is equal in area to the triangle C1 (I·44)
- * Construct a parallelogram on the top of the previous parallelogram such that it is equal in area to the triangle C2 (I·44)

What is left over in the parallelogram EF is now equal to the area of EF minus the area of C

Now, copy this new polygon to KLMN, which is similar to the polygon D (VI·25)

Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



$$HE = GB$$

$$GB \sim D$$

$$\text{If } HE > C$$

$$GB > C$$

$$KM + C = GB$$

Construction

Bisect the line AB at point E

Create a parallelogram similar to D on line EB (VI·18)

Let the parallelogram AG be completed

If AG is equal in size to C, then we are finished, otherwise ...

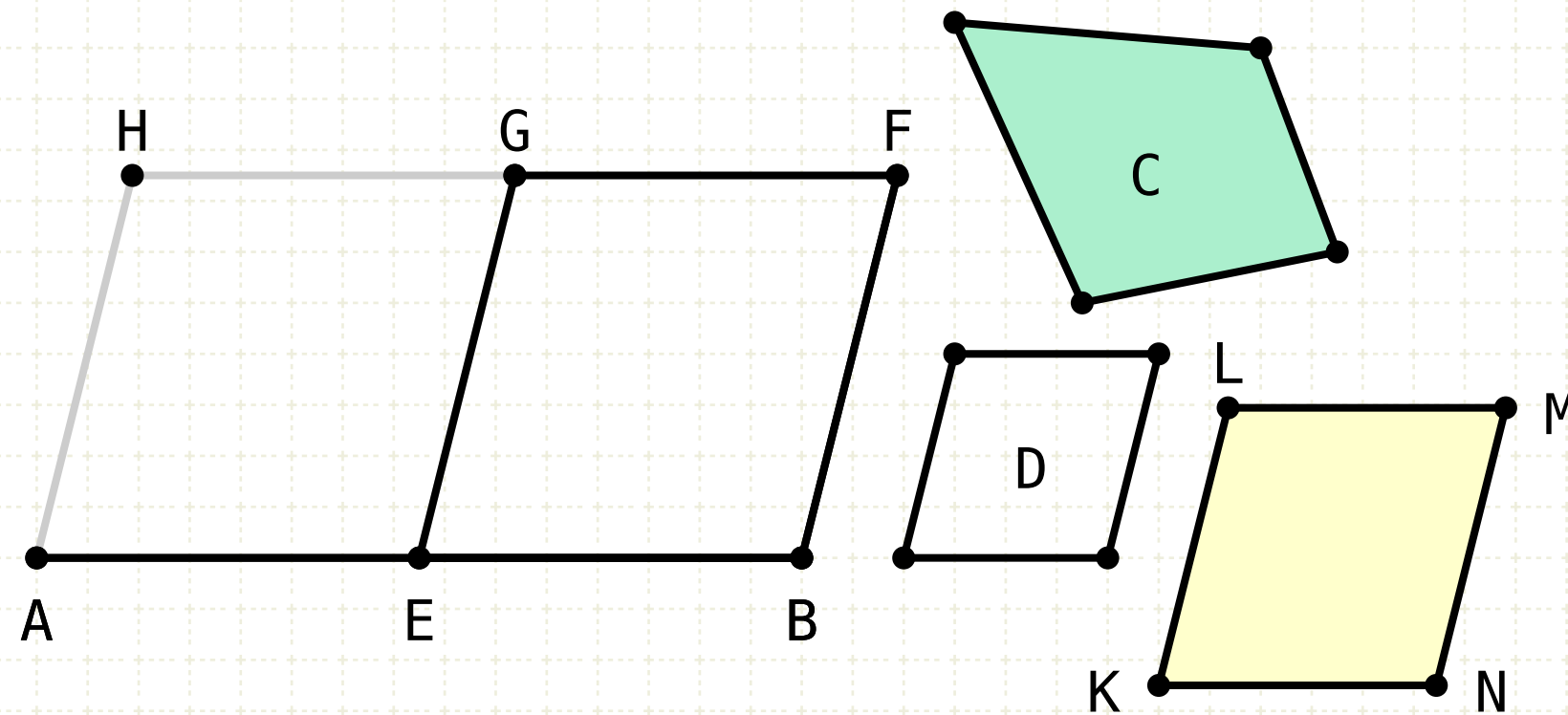
HE is greater than C

HE is equal to GB, therefore GB is also greater than C

Let KLMN be constructed such that it is equal to the the area of GB minus the area of C, and is similar to D (VI·25)

Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



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$$KM + C = GB$$

$$KM \sim D$$

$$D \sim GB$$

$$\therefore KM \sim GB$$

Construction

Bisect the line AB at point E

Create a parallelogram similar to D on line EB (VI·18)

Let the parallelogram AG be completed

If AG is equal in size to C, then we are finished, otherwise ...

HE is greater than C

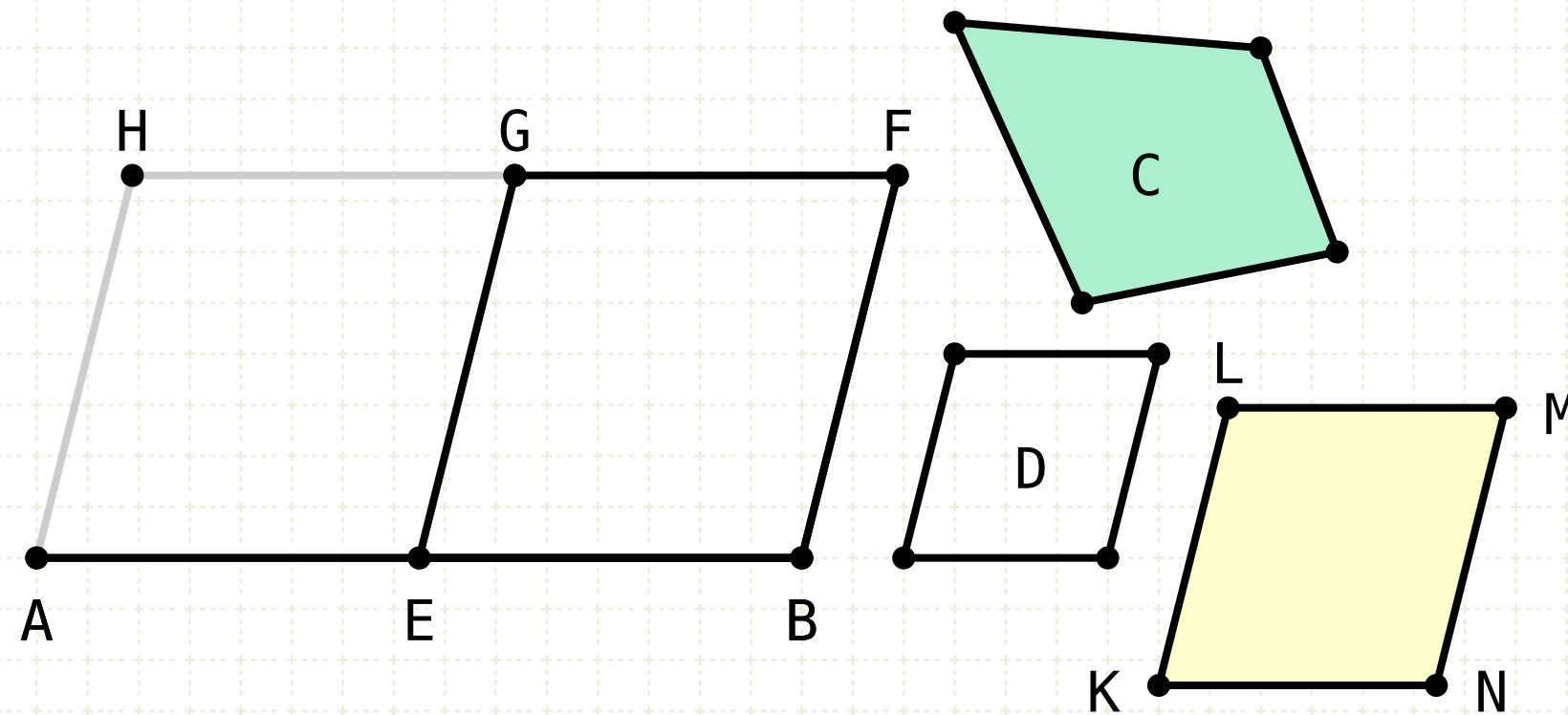
HE is equal to GB, therefore GB is also greater than C

Let KLMN be constructed such that it is equal to the the area of GB minus the area of C, and is similar to D (VI·25)

KLMN is similar to D, which is also similar to GB, therefore KLMN is similar to GB (VI·21)

Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



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$$D \sim GB$$

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Construction

Bisect the line AB at point E

Create a parallelogram similar to D on line EB (VI·18)

Let the parallelogram AG be completed

If AG is equal in size to C, then we are finished, otherwise ...

HE is greater than C

HE is equal to GB, therefore GB is also greater than C

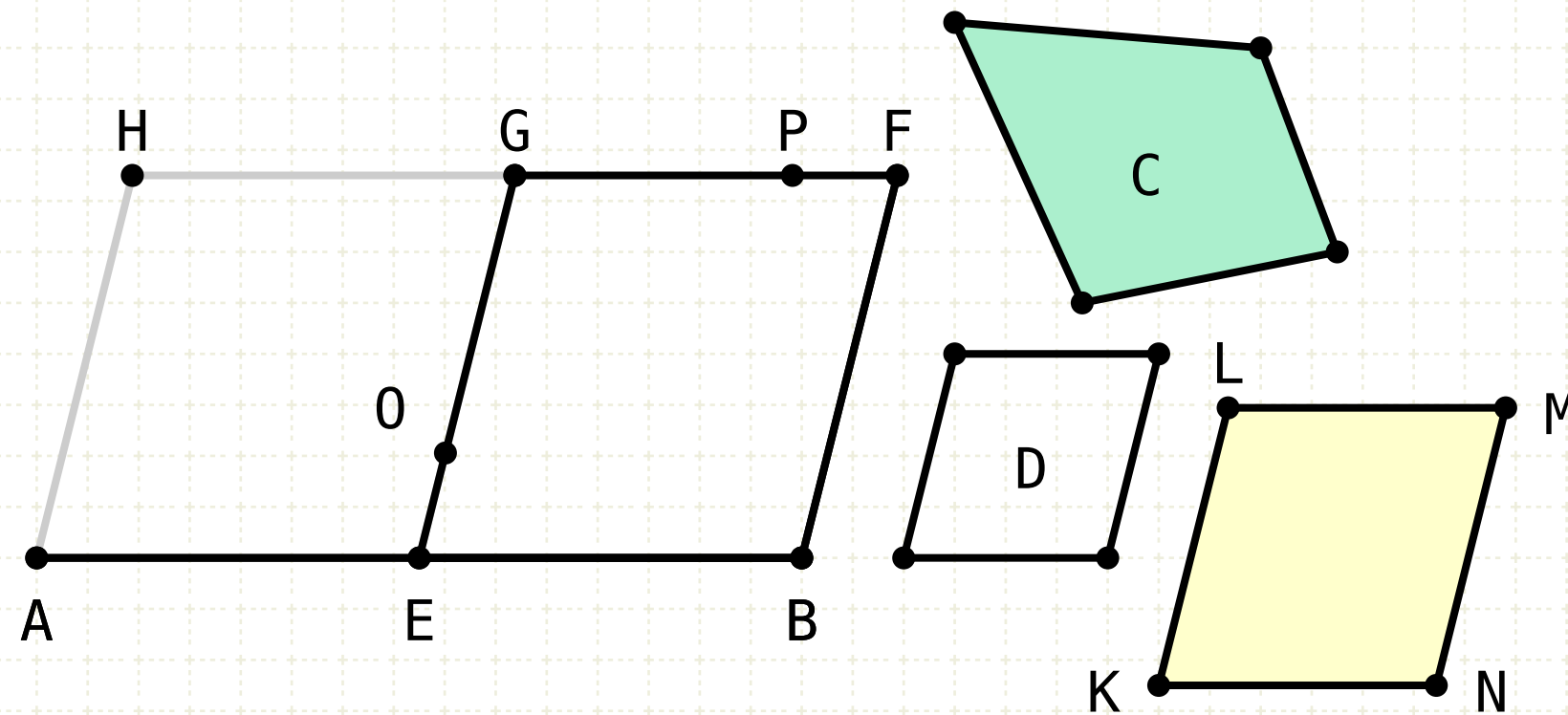
Let KLMN be constructed such that it is equal to the the area of GB minus the area of C, and is similar to D (VI·25)

KLMN is similar to D, which is also similar to GB, therefore KLMN is similar to GB (VI·21)

Since KM is smaller than GB, and since they are similar, LM is less than GF and LK is less than GE

Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



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$$KM \sim D$$

$$D \sim GB$$

$$\therefore KM \sim GB$$

Construction

Bisect the line AB at point E

Create a parallelogram similar to D on line EB (VI·18)

Let the parallelogram AG be completed

If AG is equal in size to C, then we are finished, otherwise ...

HE is greater than C

HE is equal to GB, therefore GB is also greater than C

Let KLMN be constructed such that it is equal to the the area of GB minus the area of C, and is similar to D (VI·25)

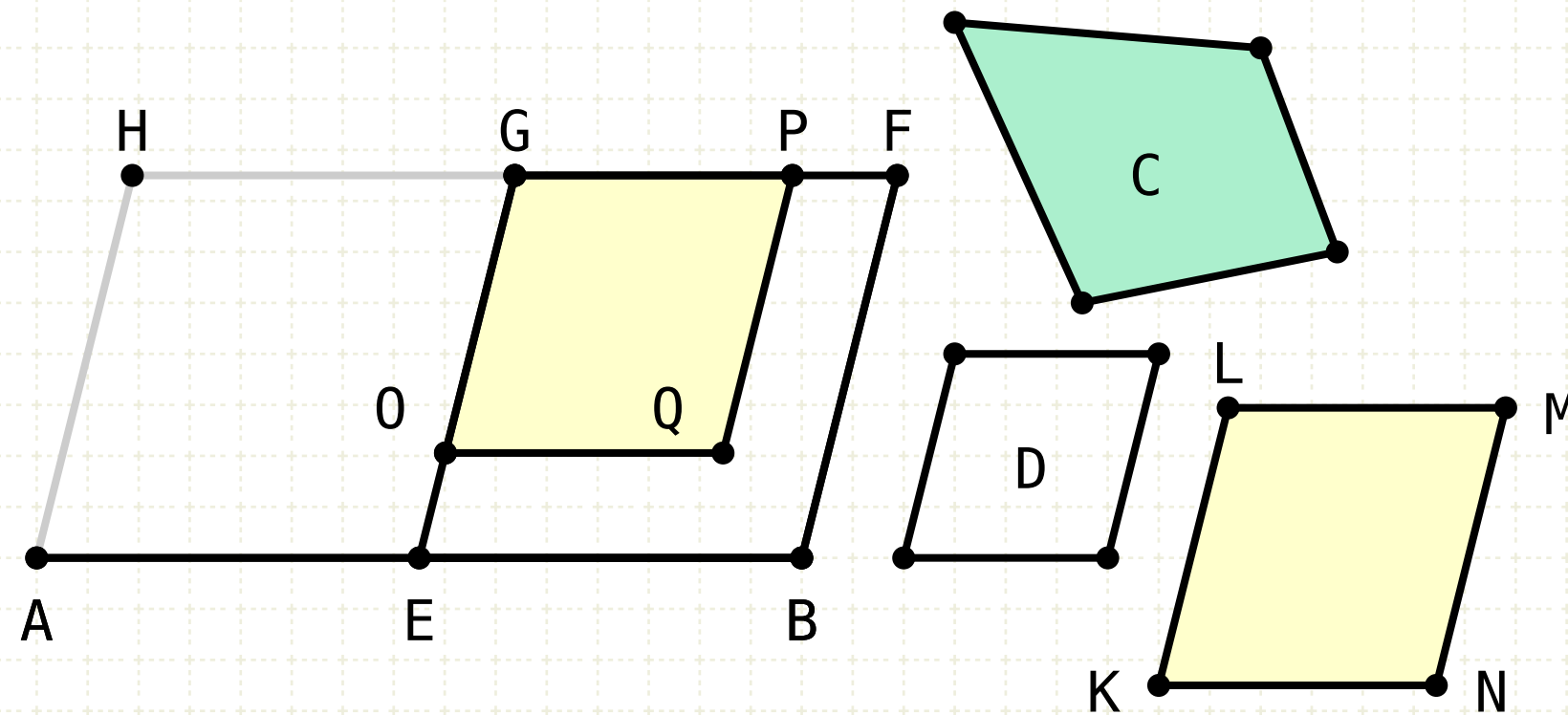
KLMN is similar to D, which is also similar to GB, therefore KLMN is similar to GB (VI·21)

Since KM is smaller than GB, and since they are similar, LM is less than GF and LK is less than GE

Copy line KL to GE, and LM to GF

Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



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$$KM + C = GB$$

$$KM \sim D$$

$$D \sim GB$$

$$\therefore KM \sim GB$$

$$GQ = KM$$

Construction

Bisect the line AB at point E

Create a parallelogram similar to D on line EB (VI-18)

Let the parallelogram AG be completed

If AG is equal in size to C, then we are finished, otherwise ...

HE is greater than C

HE is equal to GB, therefore GB is also greater than C

Let KLMN be constructed such that it is equal to the the area of GB minus the area of C, and is similar to D (VI-25)

KLMN is similar to D, which is also similar to GB, therefore KLMN is similar to GB (VI-21)

Since KM is smaller than GB, and since they are similar, LM is less than GF and LK is less than GE

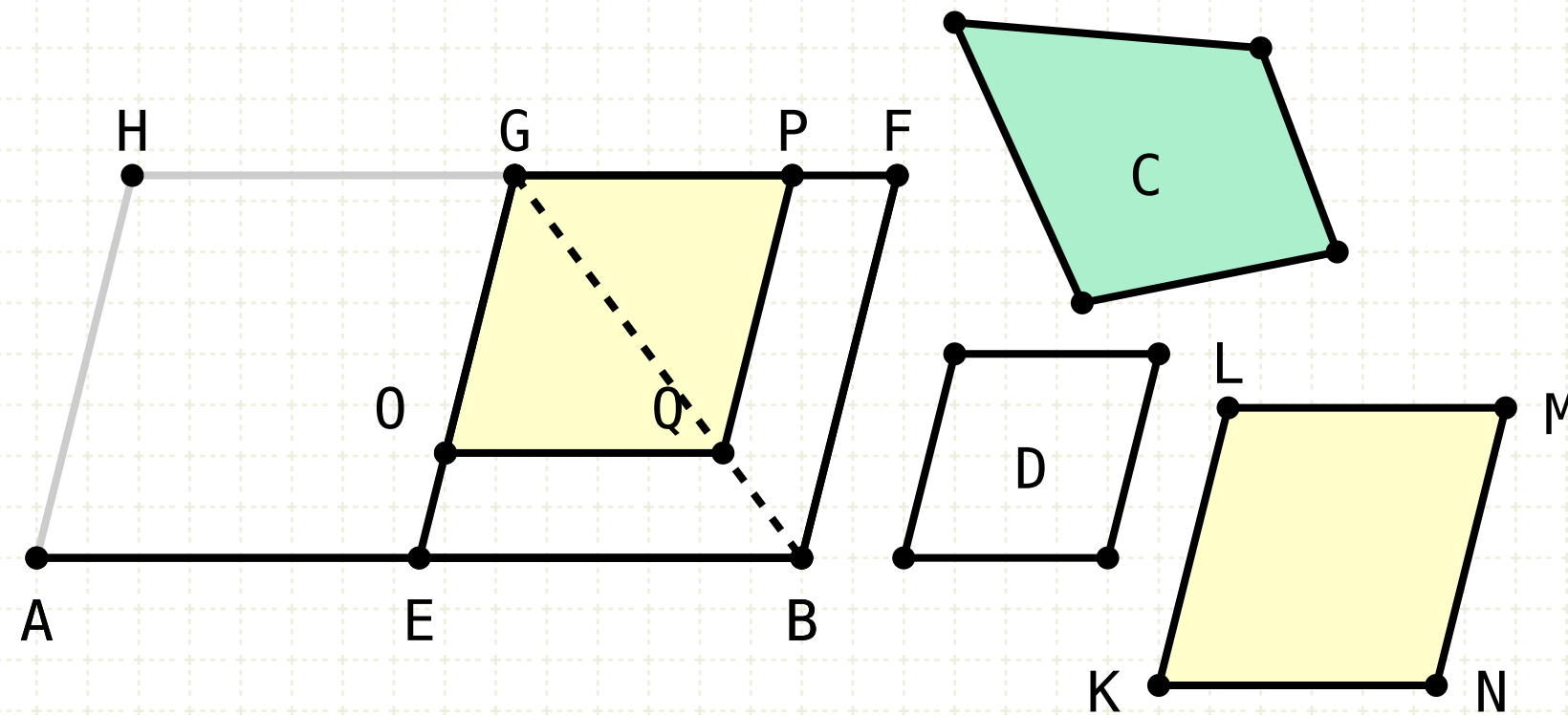
Copy line KL to GE, and LM to GF

Complete the parallelogram OGPQ



Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



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$$KM + C = GB$$

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$$D \sim GB$$

$$\therefore KM \sim GB$$

$$GQ = KM$$

$$GQ \sim KM \sim D \sim GB$$

Construction

Bisect the line AB at point E

Create a parallelogram similar to D on line EB (VI·18)

Let the parallelogram AG be completed

If AG is equal in size to C, then we are finished, otherwise ...

HE is greater than C

HE is equal to GB, therefore GB is also greater than C

Let KLMN be constructed such that it is equal to the the area of GB minus the area of C, and is similar to D (VI·25)

KLMN is similar to D, which is also similar to GB, therefore KLMN is similar to GB (VI·21)

Since KM is smaller than GB, and since they are similar, LM is less than GF and LK is less than GE

Copy line KL to GE, and LM to GF

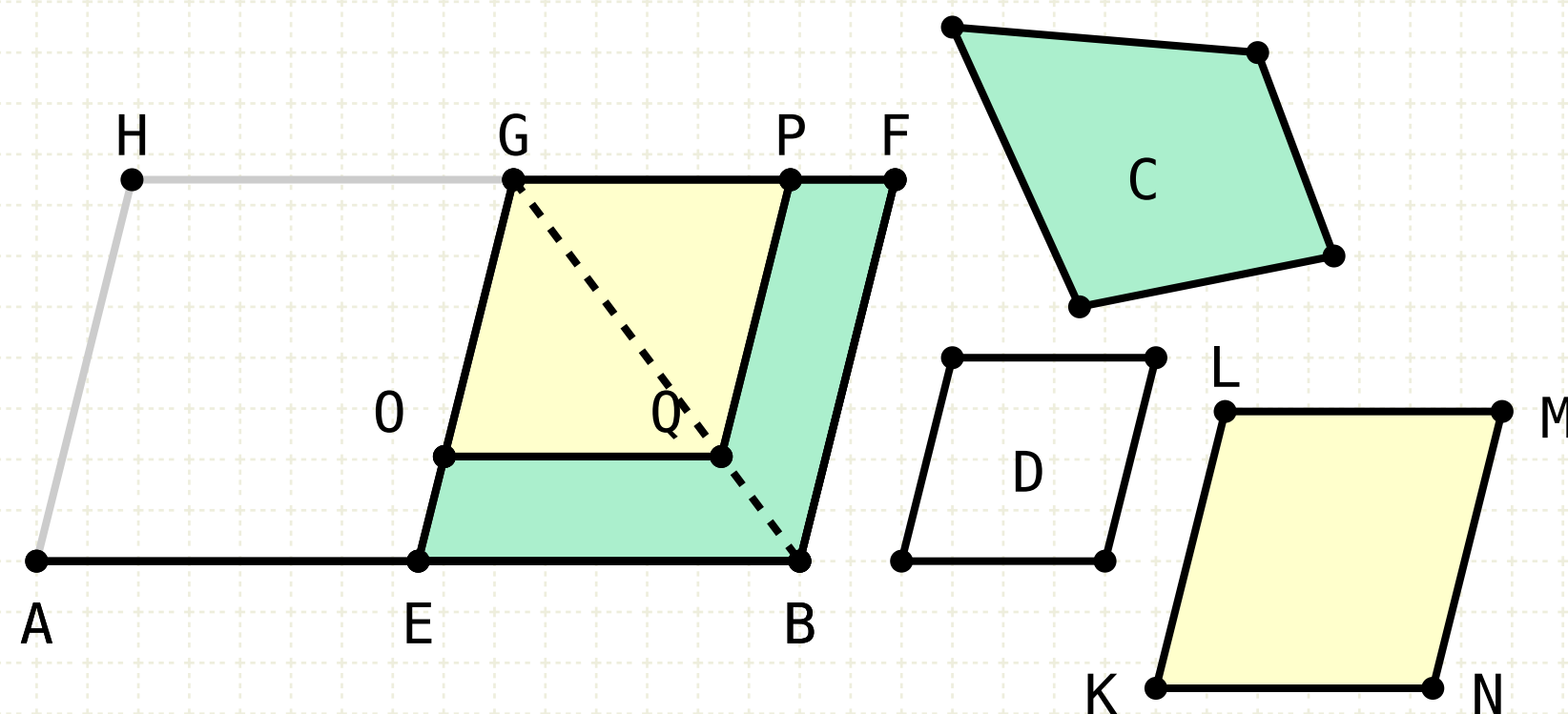
Complete the parallelogram OGPQ

Since GB is similar to KM, so is GQ similar to GB (VI·21), thus the points Q and B lie on the same diagonal (VI·26)



Proposition 28 of Book VI

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$$GQ \sim KM \sim D \sim GB$$

$$OEBFPQ = C$$

Construction

Bisect the line AB at point E

Create a parallelogram similar to D on line EB (VI-18)

Let the parallelogram AG be completed

If AG is equal in size to C, then we are finished, otherwise ...

HE is greater than C

HE is equal to GB, therefore GB is also greater than C

Let KLMN be constructed such that it is equal to the the area of GB minus the area of C, and is similar to D (VI-25)

KLMN is similar to D, which is also similar to GB, therefore KLMN is similar to GB (VI-21)

Since KM is smaller than GB, and since they are similar, LM is less than GF and LK is less than GE

Copy line KL to GE, and LM to GF

Complete the parallelogram OGPQ

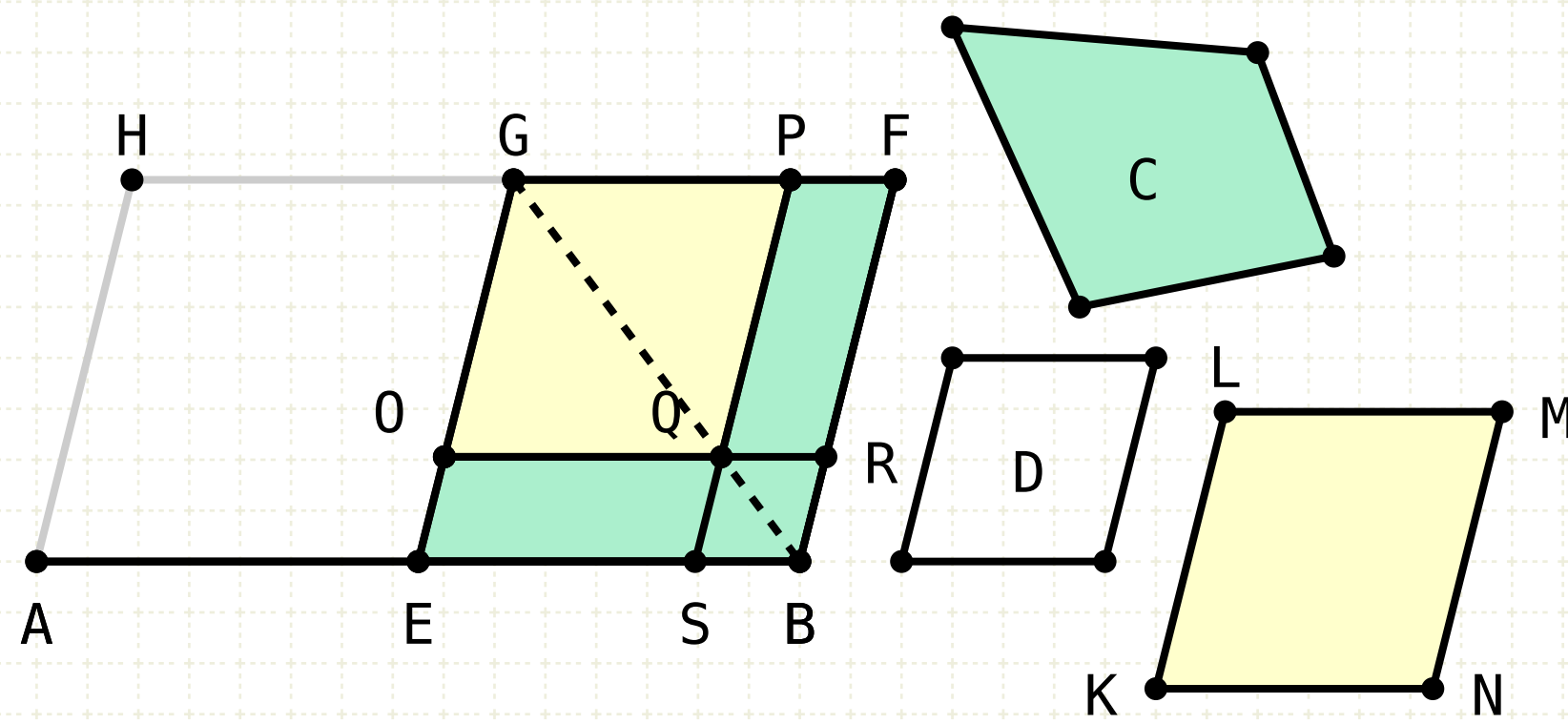
Since GB is similar to KM, so is GQ similar to GB (VI-21), thus the points Q and B lie on the same diagonal (VI-26)

GB is equal to sum of KM and C, and since GQ is equal to KM, the remaining gnomon (OEBFPQ) is equal in area to C



Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



Construction (cont.)

extend OQ to R, and PQ to S

$HE = GB$

$GB \sim D$

If $HE > C$

$GB > C$

$KM + C = GB$

$KM \sim D$

$D \sim GB$

$\therefore KM \sim GB$

$GQ = KM$

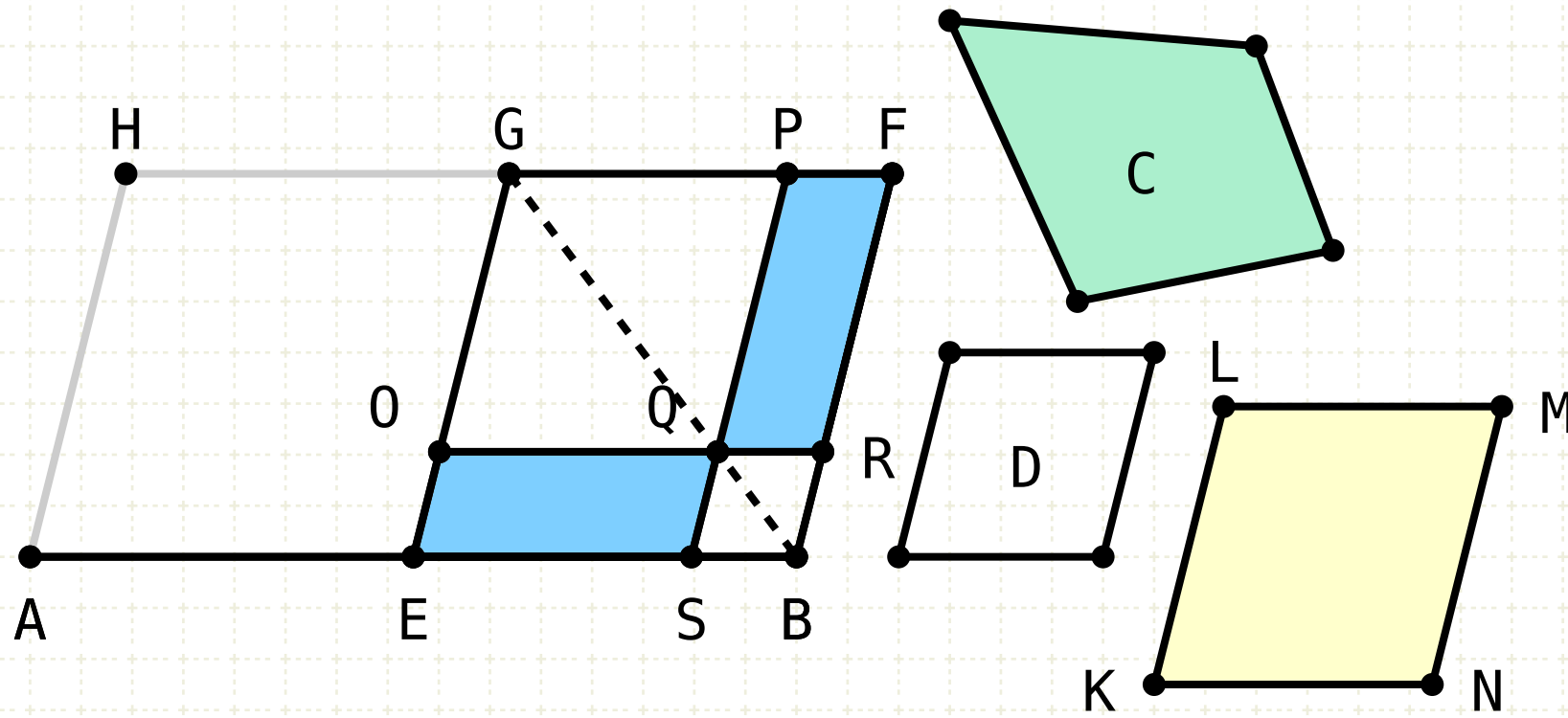
$GQ \sim KM \sim D \sim GB$

$OEBFQP = C$



Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilineal figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilineal figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



Construction (cont.)

extend OQ to R, and PQ to S

The parallelograms PR and OS are equal

HE = GB

$$GB \sim D$$

If $HE > C$

$$GB > C$$

$$KM + C = GB$$

$$KM \sim D$$

D ~ GB

∴ KM ~ GB

GQ = KM

GQ ~ KM ~ D ~ GB

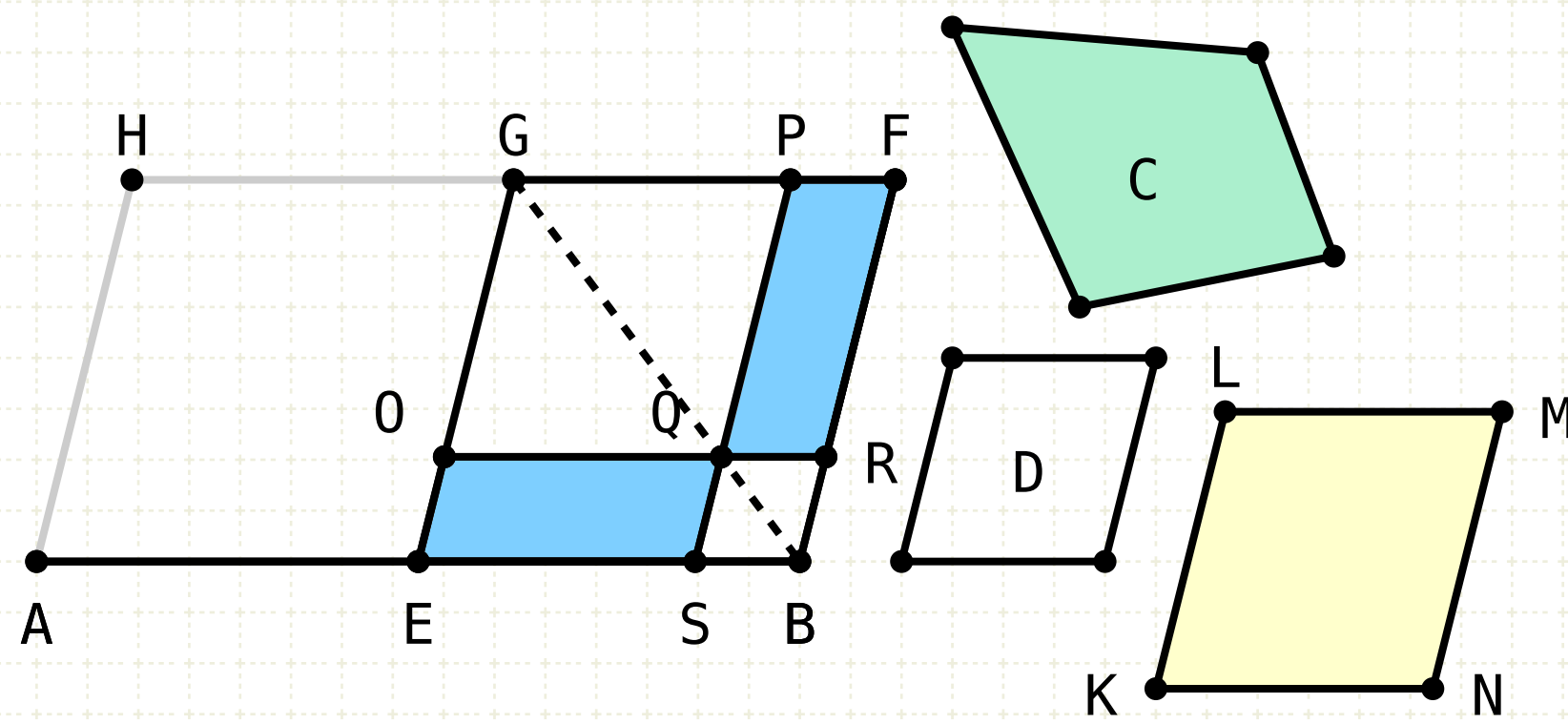
$$OEBFQP = C$$

$$PR = OS$$



Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



Construction (cont.)

extend OQ to R, and PQ to S

The parallelograms PR and OS are equal

If QB is added to PR and OS, then OB and PB are equal

$$HE = GB$$

$$GB \sim D$$

$$\text{If } HE > C$$

$$GB > C$$

$$KM + C = GB$$

$$KM \sim D$$

$$D \sim GB$$

$$\therefore KM \sim GB$$

$$GQ = KM$$

$$GQ \sim KM \sim D \sim GB$$

$$OE B F Q P = C$$

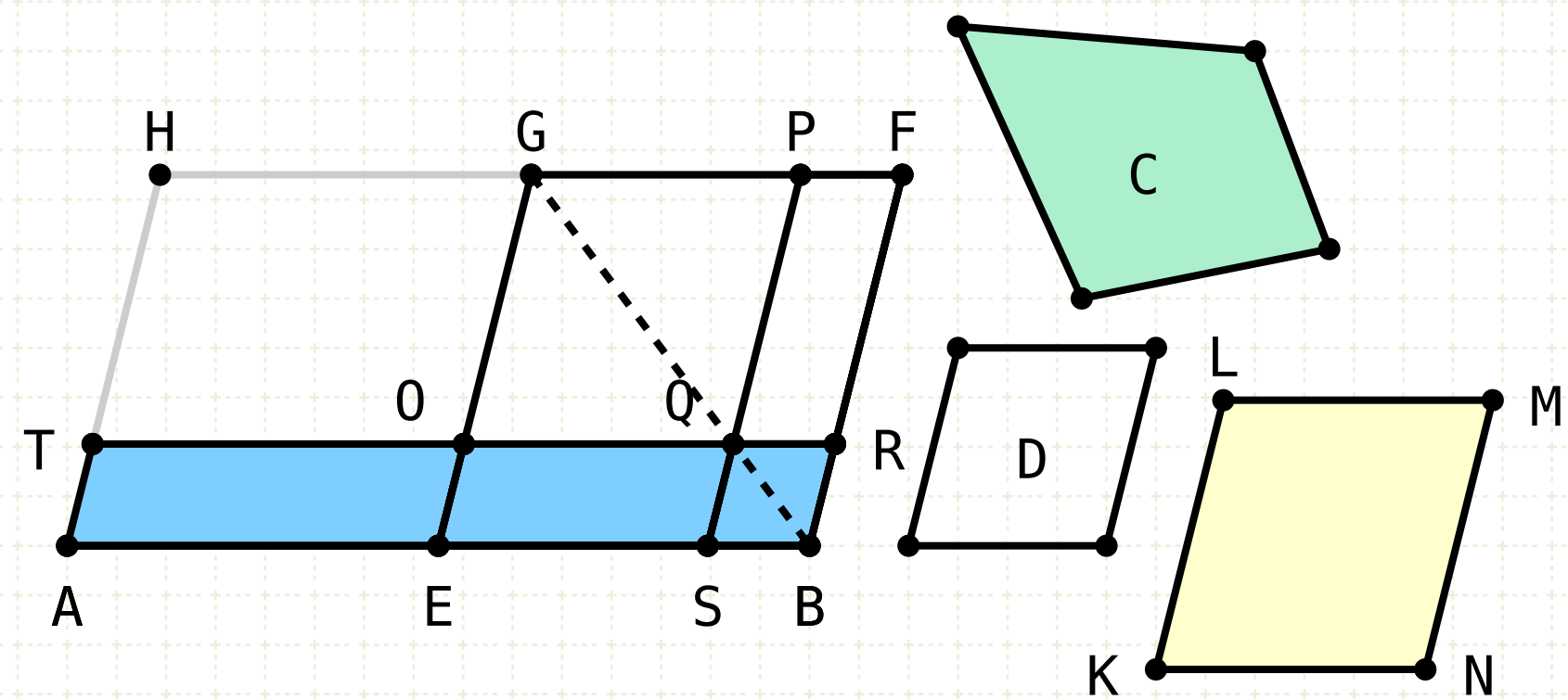
$$PR = OS$$

$$PB = OB$$



Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



Construction (cont.)

extend OQ to R, and PQ to S

The parallelograms PR and OS are equal

If QB is added to PR and OS, then OB and PB are equal

OB is equal to TE, since AE and EB are equal (I-36)

$HE = GB$

$GB \sim D$

If $HE > C$

$GB > C$

$KM + C = GB$

$KM \sim D$

$D \sim GB$

$\therefore KM \sim GB$

$GQ = KM$

$GQ \sim KM \sim D \sim GB$

$OEBFQP = C$

$PR = OS$

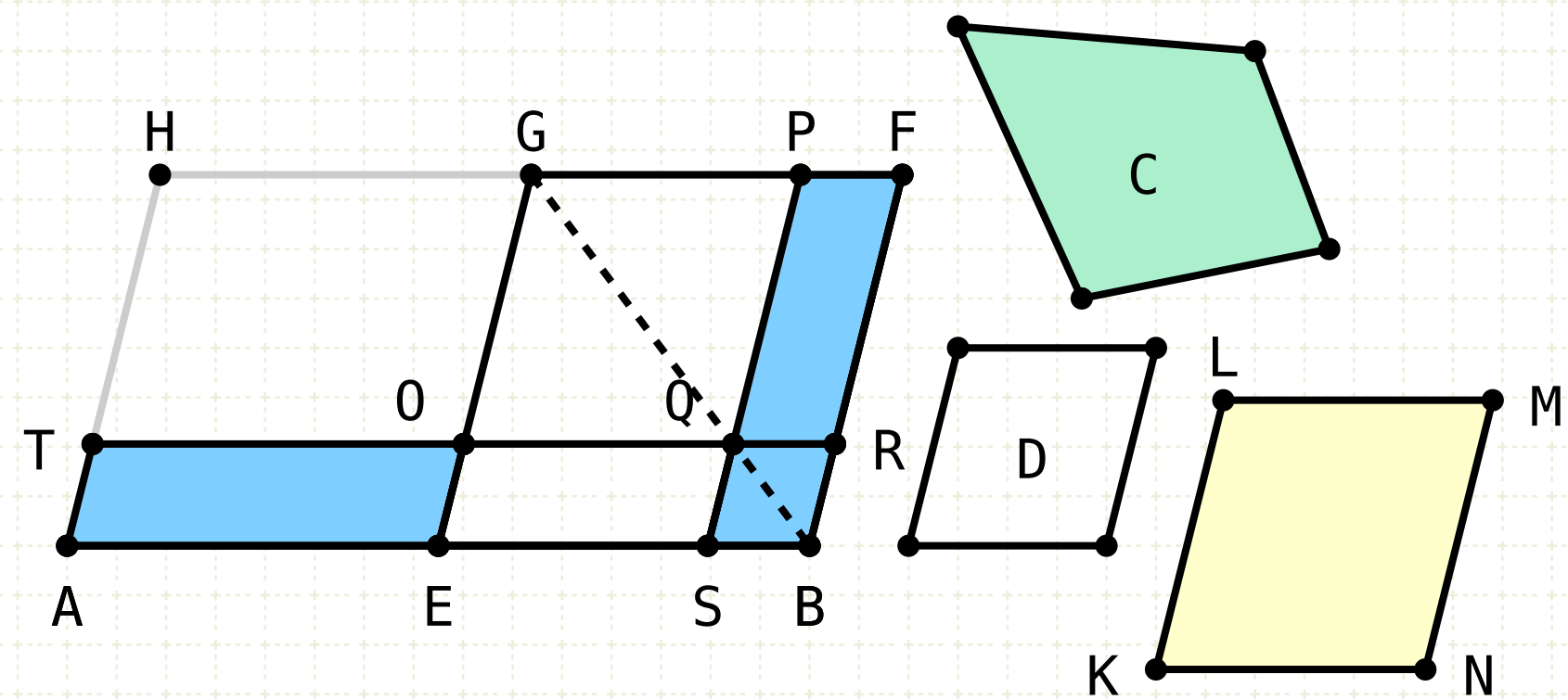
$PB = OB$

$TE = OB$



Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



Construction (cont.)

extend OQ to R, and PQ to S

The parallelograms PR and OS are equal

If QB is added to PR and OS, then OB and PB are equal

OB is equal to TE, since AE and EB are equal (I-36)

PB equals OB, TE is equal to PB

$HE = GB$

$GB \sim D$

If $HE > C$

$GB > C$

$KM + C = GB$

$KM \sim D$

$D \sim GB$

$\therefore KM \sim GB$

$GQ = KM$

$GQ \sim KM \sim D \sim GB$

$OEBFQP = C$

$PR = OS$

$PB = OB$

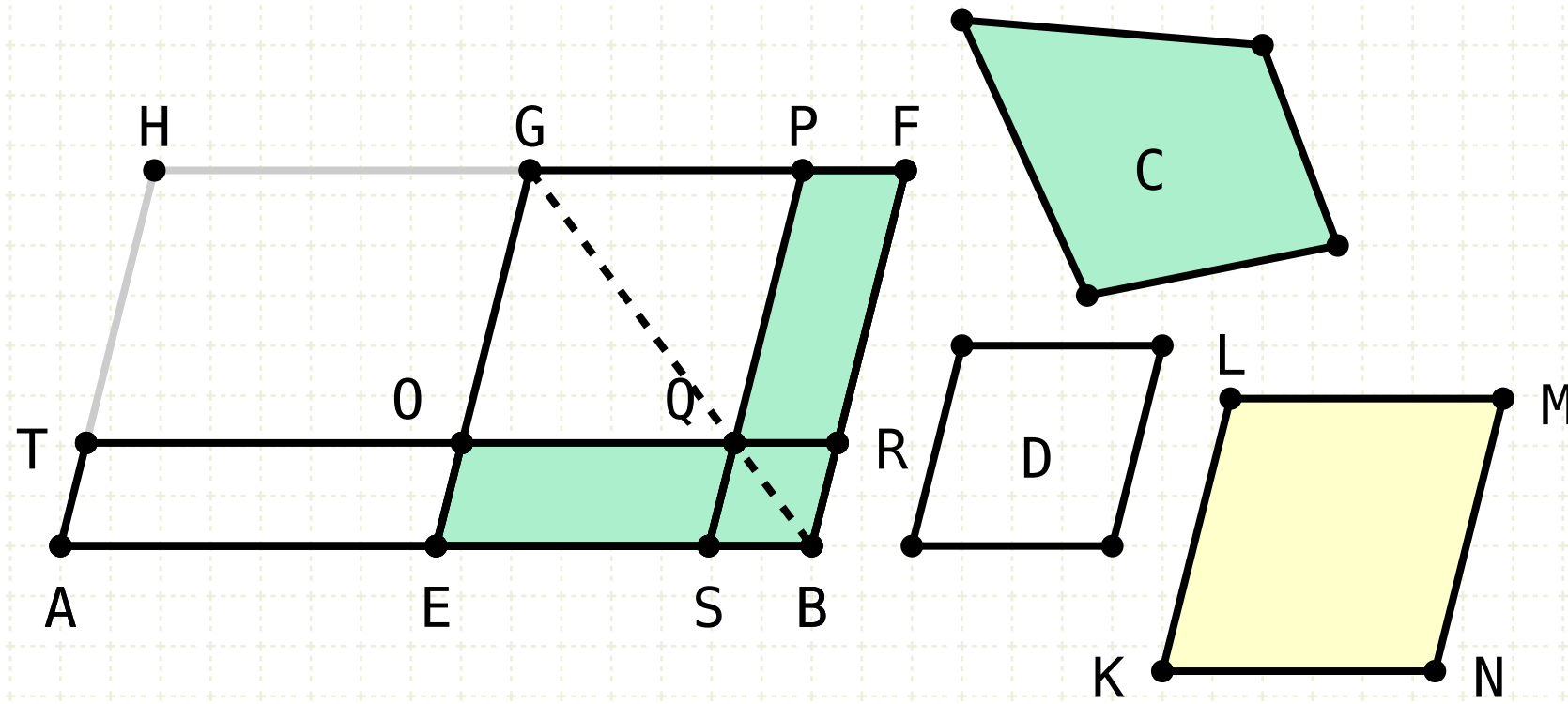
$TE = OB$

$TE = PB$



Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilineal figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilineal figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



Construction (cont.)

extend OQ to R, and PQ to S

The parallelograms PR and OS are equal

If QB is added to PR and OS, then OB and PB are equal

OB is equal to TE, since AE and EB are equal (I-36)

PB equals OB, TE is equal to PB

But PB, or TE, added together with OS is the gnomon that is equal to the area of C

HE = GB

$$GB \sim D$$

If $HE > C$

$$GB > C$$

$$KM + C = GB$$

$$KM \sim D$$

D ~ GB

∴ KM ~ GB

GO = KM

GQ ~ KM ~ D ~ GB

$$0EBFQP = C$$

$$PR = OS$$

$$PB = OB$$

$$TE = 0B$$

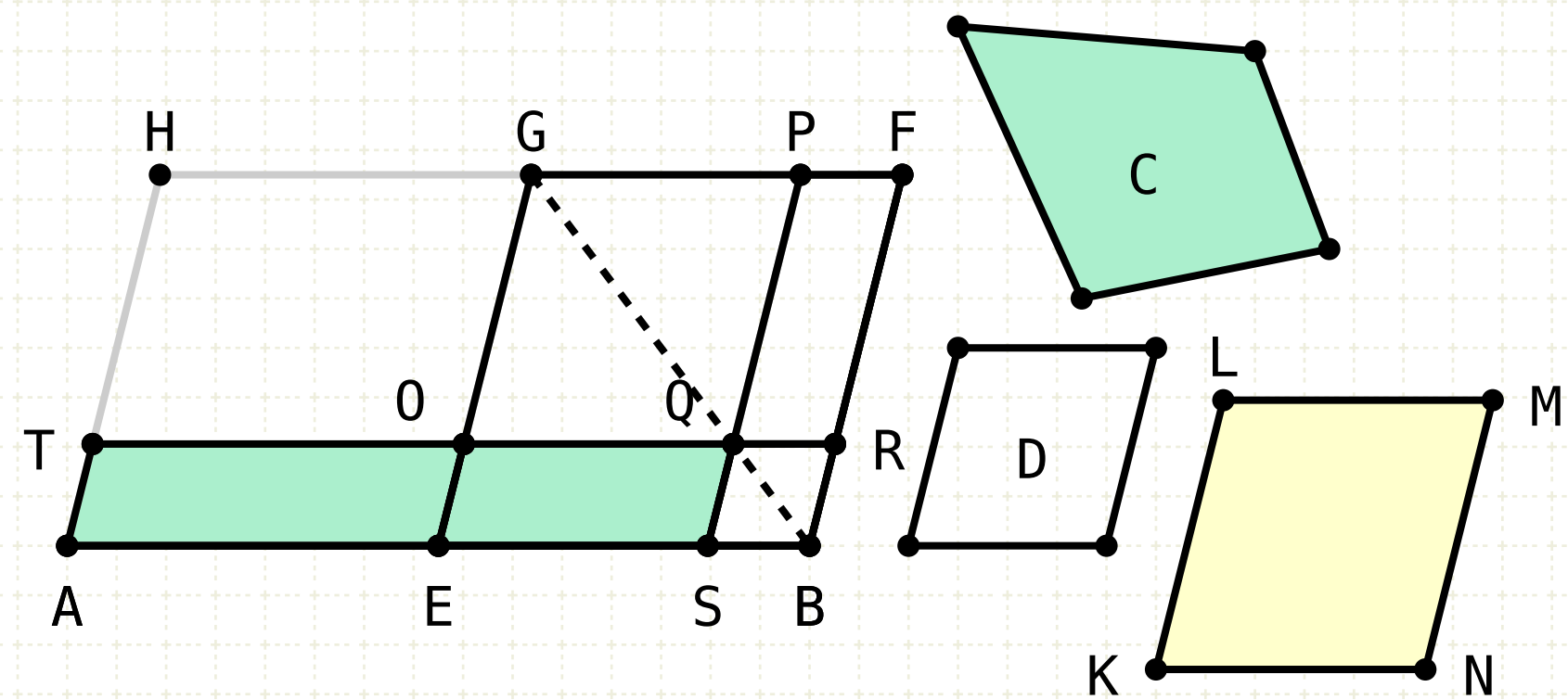
$$TE = PB$$

$$OS + PB = C$$



Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



Construction (cont.)

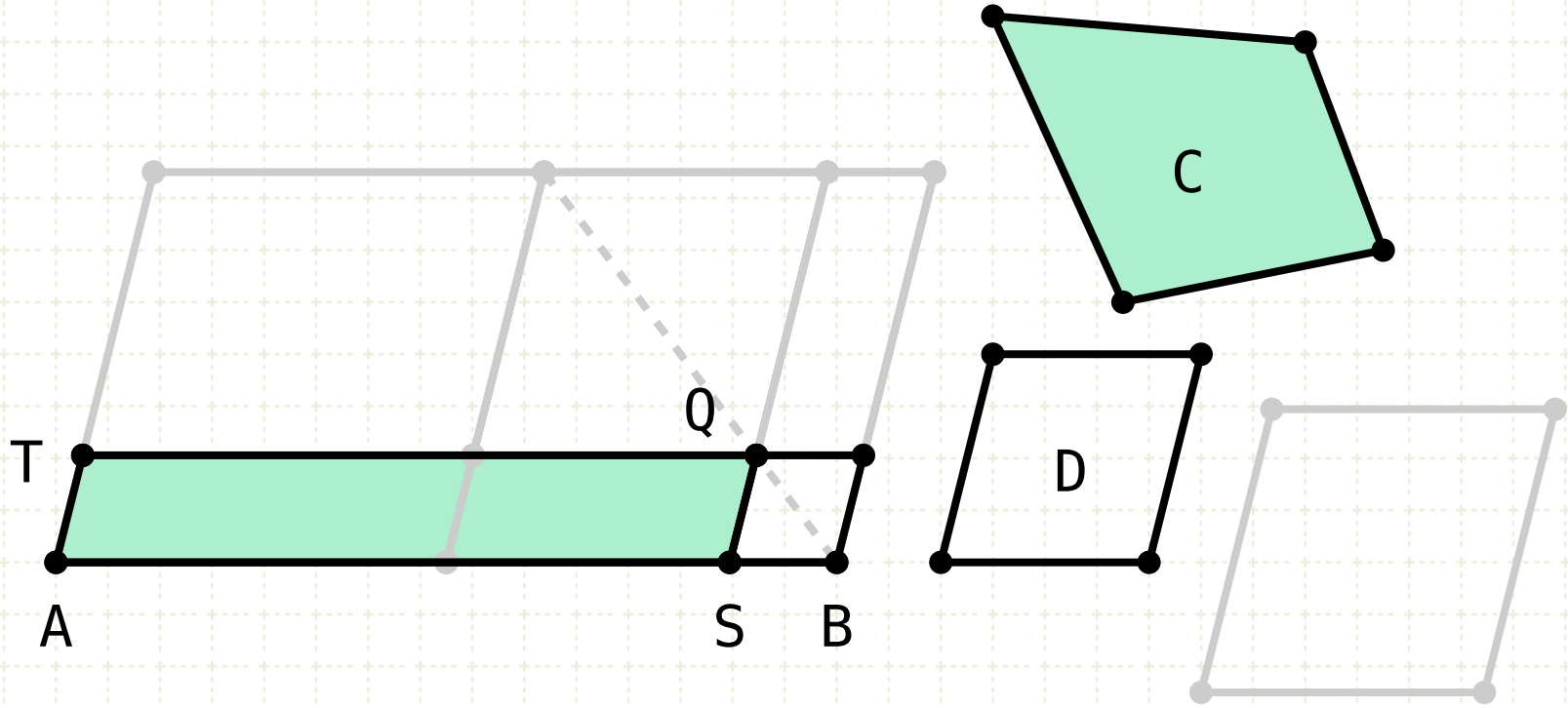
extend OQ to R, and PQ to S
 The parallelograms PR and OS are equal
 If QB is added to PR and OS, then OB and PB are equal
 OB is equal to TE, since AE and EB are equal (I-36)
 PB equals OB, TE is equal to PB
 But PB, or TE, added together with OS is the gnomon that is equal to the area of C

HE = GB
 GB ~ D
 If HE > C
 GB > C
 KM + C = GB
 KM ~ D
 D ~ GB
 ∴ KM ~ GB
 GQ = KM
 GQ ~ KM ~ D ~ GB
 OE B F Q P = C
 PR = OS
 PB = OB
 TE = OB
 TE = PB
 OS + PB = C
 OS + TE = C



Proposition 28 of Book VI

To a given straight line to apply a parallelogram equal to a given rectilinear figure and deficient by a parallelogrammic figure similar to a given one: thus the given rectilinear figure must not be greater than the parallelogram described on the half of the straight line and similar to the defect



Construction (cont.)

extend OQ to R, and PQ to S
 The parallelograms PR and OS are equal
 If QB is added to PR and OS, then OB and PB are equal
 OB is equal to TE, since AE and EB are equal (I-36)
 PB equals OB, TE is equal to PB
 But PB, or TE, added together with OS is the gnomon that is equal to the area of C

Thus TS is a parallelogram, drawn on AB, minus the parallelogram QB (which is similar to D), whose area equals the polygon C

HE = GB

GB ~ D

If HE > C

GB > C

KM + C = GB

KM ~ D

D ~ GB

∴ KM ~ GB

GQ = KM

GQ ~ KM ~ D ~ GB

OEBCFP = C

PR = OS

PB = OB

TE = OB

TE = PB

OS + PB = C

OS + TE = C

TS = C



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