
NEW JERSEY CENTER
FOR TEACHING & LEARNING
Progressive Mathematics Initiative®
This material is made freely available at www.njctl.org and is intended for the non-commercial use of students and teachers. It may not be used for any commercial purpose without the written permission of NJCTL.
We, at the New Jersey Education Association, are proud founders and supporters of NJCTL, an independent non-profit organization with the mission of empowering teachers to lead school improvement for the benefit of all students.
njea

NEW JERSEY CENTER
FOR TEACHING & LEARNING

Geometry

Parallel Lines

2015-10-21

www.njctl.org

Table of Contents

Click on the topic to go to that section

Constructions Videos Table of Contents

Click on the topic to go to that video

Throughout this unit, the Standards for Mathematical Practice are used.

MP1: Making sense of problems & persevere in solving them.
MP2: Reason abstractly & quantitatively.
MP3: Construct viable arguments and critique the reasoning of others.
MP4: Model with mathematics.
MP5: Use appropriate tools strategically.
MP6: Attend to precision.
MP7: Look for & make use of structure.
MP8: Look for & express regularity in repeated reasoning.

Additional questions are included on the slides using the "Math Practice" Pull-tabs (e.g. a blank one is shown to the right on this slide) with a reference to the standards used.

If questions already exist on a slide, then the specific MPs that the questions address are listed in the Pull-tab.

Throughout this unit, the St
are used.

MP1: Making sense of
MP2: Reason abstract
MP3: Construct viable
others.
MP4: Model with math
MP5: Use appropriate
MP6: Attend to precisi
MP7: Look for & make
MP8: Look for & expre

Math Practice

Additional questions a
Practice" Pull-tabs (e.g.
this slide) with a reference

If questions already exist on a slide, then the specific MPs that the questions address are listed in the Pull-tab.

Lines: Intersecting, Parallel & Skew

Return to Table
of Contents

Euclid's Fifth Postulate

Euclid's Fifth Postulate is perhaps his most famous.

It's bothered mathematicians for thousands of years.

Fifth Postulate: That, if a straight line falling on two straight lines make the interior angles on the same side less than two right angles, the two straight lines, if produced indefinitely, meet on that side on which are the angles less than the two right angles.

Euclid's Fifth Postulate

This seemed so natural that the Greek geometers thought they should be able to prove it, and wouldn't need it to be a postulate.

They resisted using it for years.

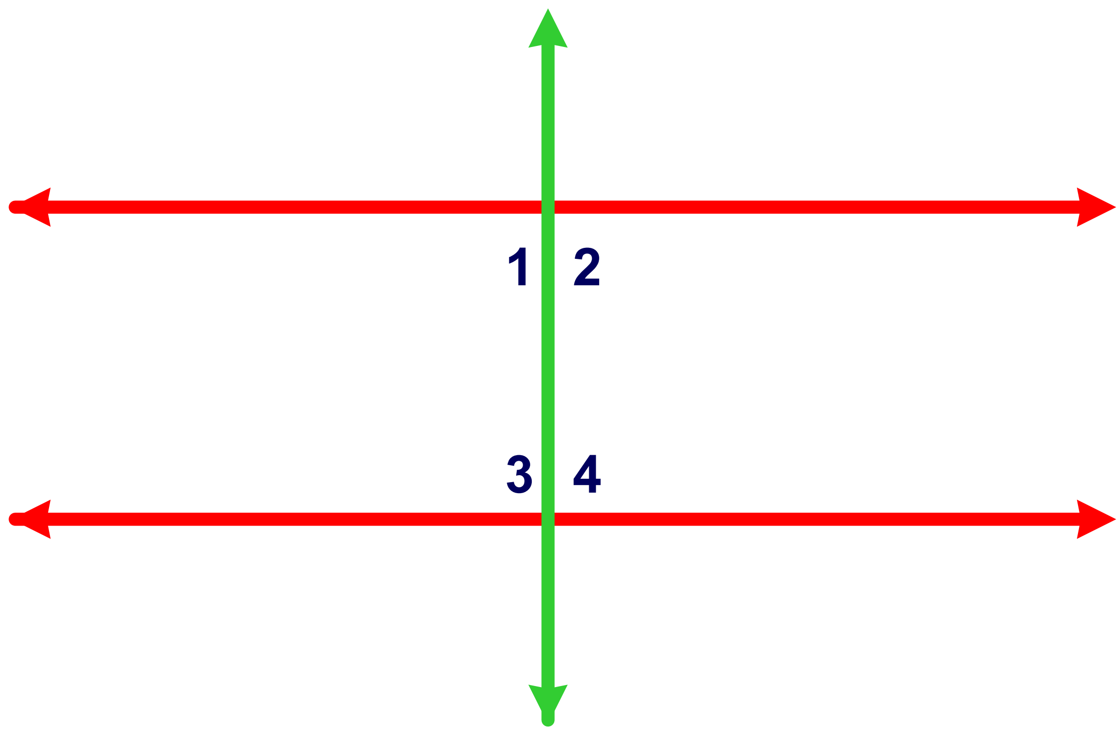
However, they found that they needed it.

And they couldn't prove it.

They just had to postulate it.

Euclid's Fifth Postulate

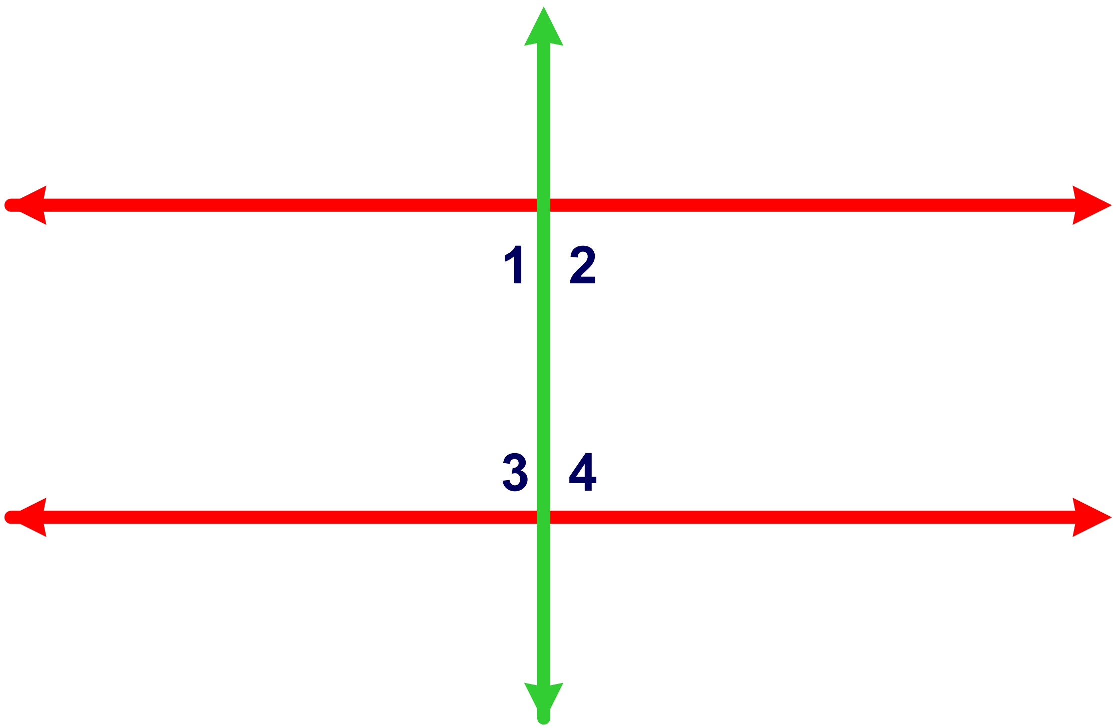
It says that there are two possible cases if one line crosses two others.



Euclid's Fifth Postulate

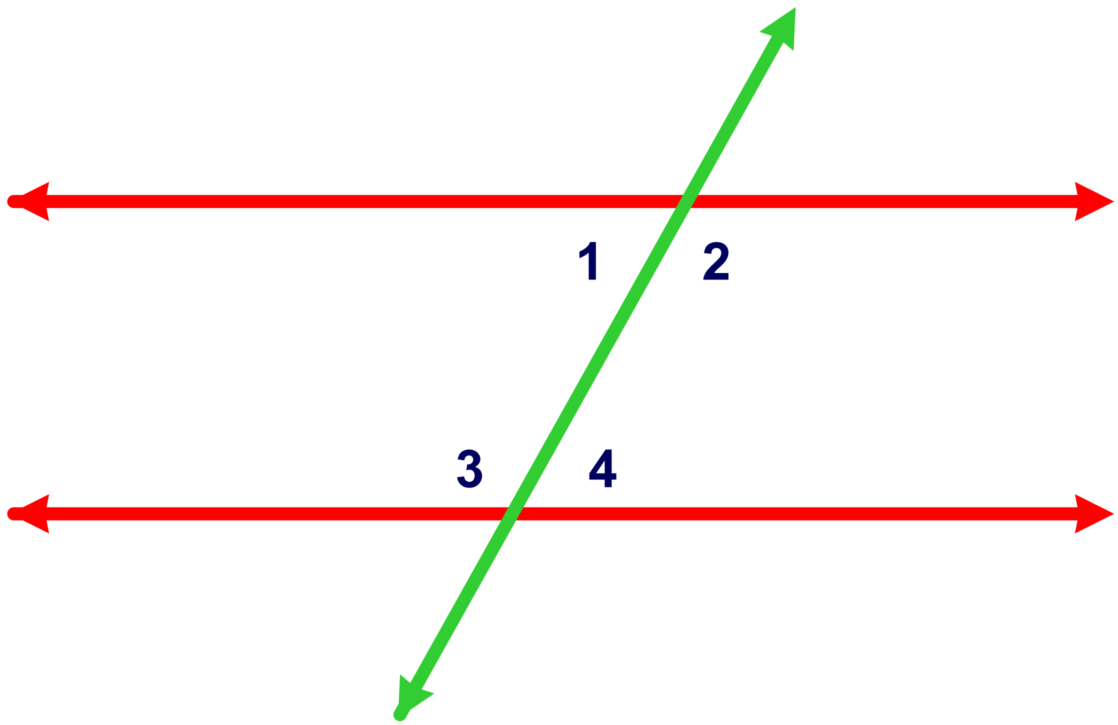
The pairs of angles on both sides, (either ∠1 & ∠3 or ∠2 & ∠4) each add up to 180º, two right angles, and the two red lines never meet.

Like this....



Euclid's Fifth Postulate

Or like this.

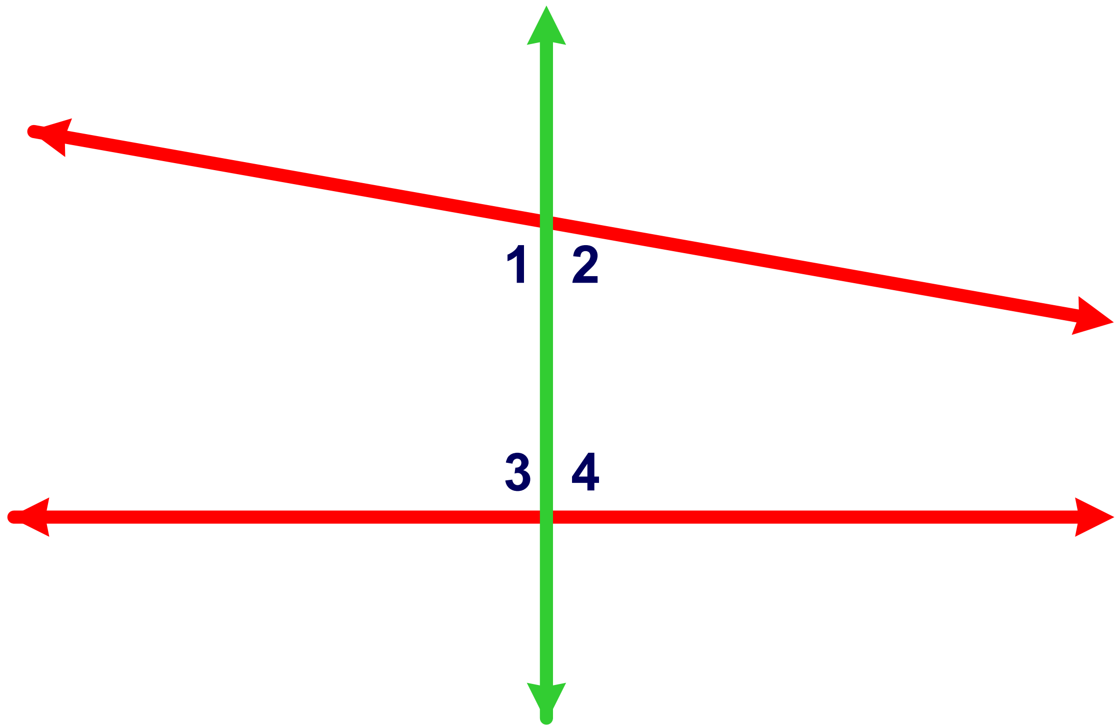


Or, ...

Euclid's Fifth Postulate

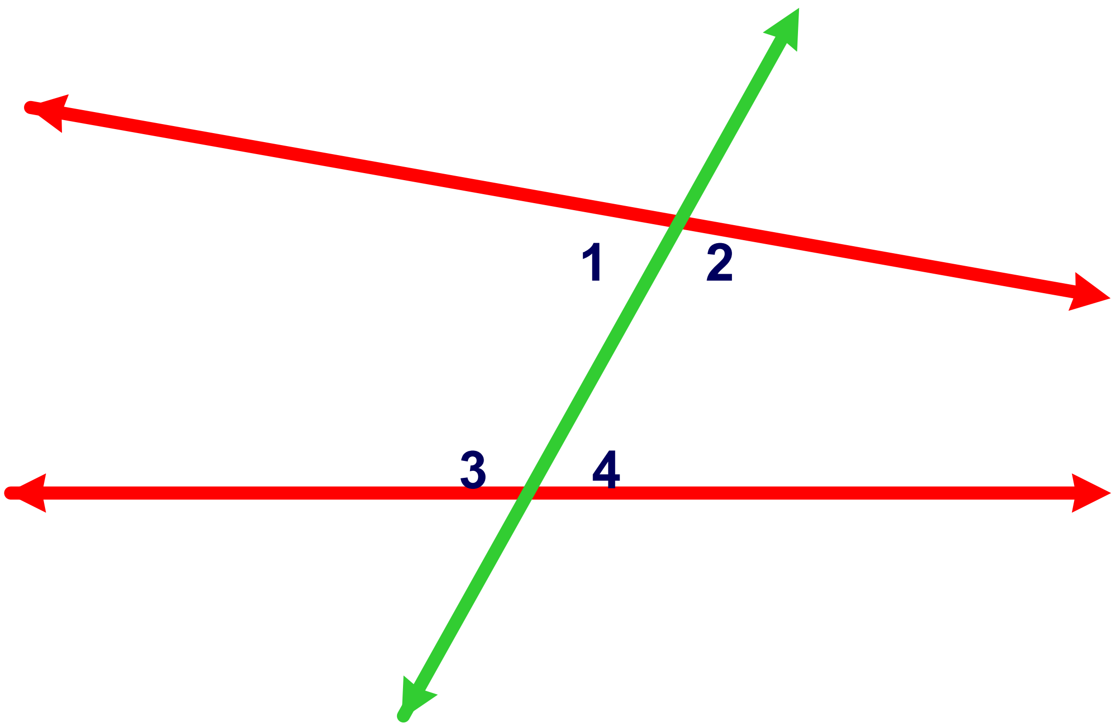
They add up to less than 180º on one side (angles ∠2 & ∠4), and more than 180º on the other (angles ∠1 & ∠3), in which case the lines meet on the side with the smaller angles.

Like this...



Euclid's Fifth Postulate

Or like this.



Euclid's Fifth Postulate

They couldn't prove this from the other axioms and postulates. But, without it there were a lot of important pieces of geometry they couldn't prove.

So they gave in and made it the final postulate of Euclidean Geometry. For the next thousands of years, mathematicians felt the same way. They kept trying to show why this postulate was not needed.

No one succeeded.

Euclid's Fifth Postulate

In 1866, Bernhard Riemann took the other perspective.

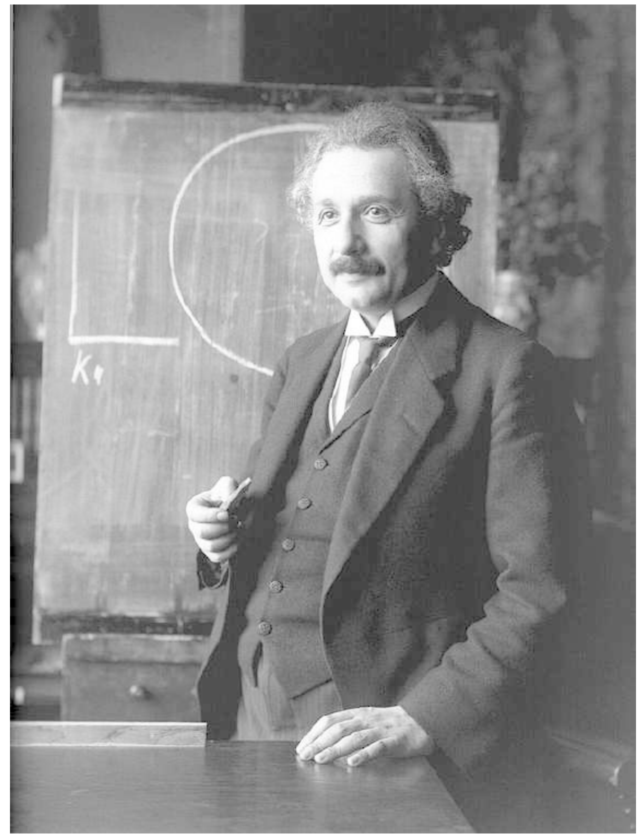
For his doctoral dissertation he designed a geometry in which Euclid's Fifth Postulate was not true, rather than assuming it was.

This led to non-Euclidean geometry. Where parallel lines always meet, rather than never meet.

Euclid's Fifth Postulate

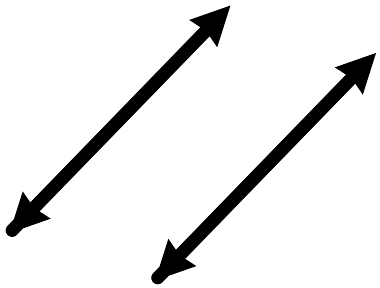
But half a century later, non-Euclidean geometry, based on rejecting the fifth postulate, became the mathematical basis of Einstein's General Relativity.

It creates the idea of curved spacetime. This is now the accepted theory for the shape of our universe.



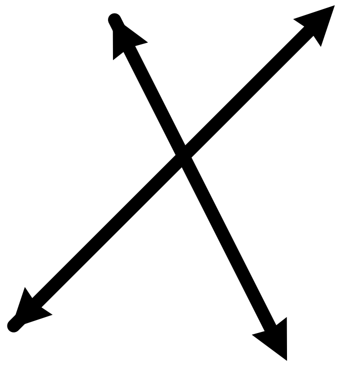
Euclid's Fifth Postulate

Lines that are in the same plane and never meet are called **parallel**.



Lines that intersect are called **non-parallel** or **intersecting**.

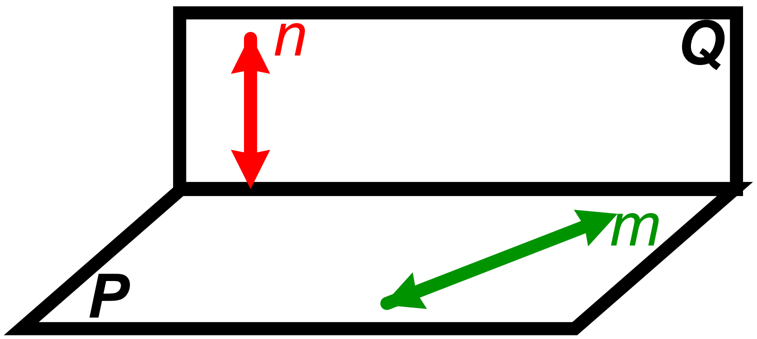
All lines that intersect are in a common plane.



Euclid's Fifth Postulate

Lines that are in different planes and never meet are called **skew**.

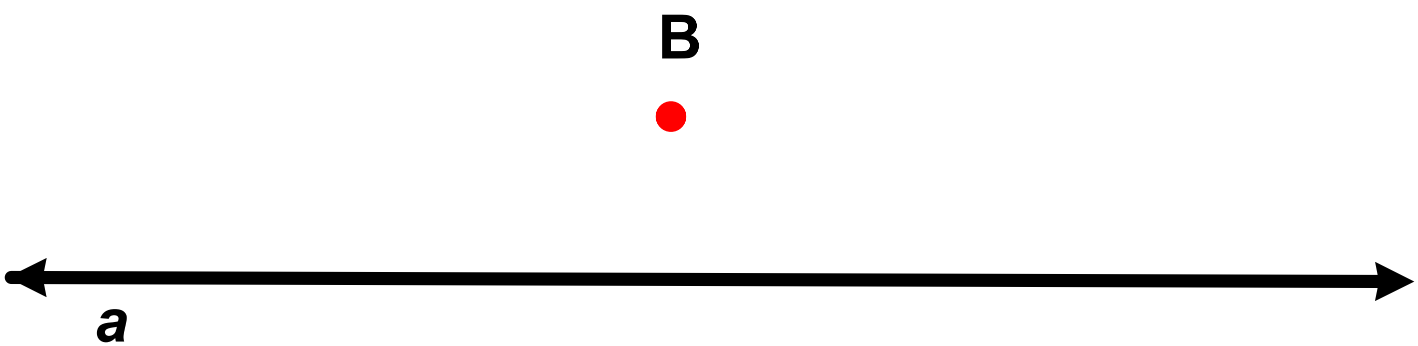
Lines *m* & *n* in the figure are skew.



The Parallel Postulate

One way of restating Euclid's Fifth Postulate is to say that parallel lines never meet.

An extension of it is the Parallel Postulate: given a line and a point, not on the line, there is one, and only one, line that can be drawn through the point which is parallel to the line.



Can you estimate where

the parallel line would be?

The Parallel Postulate

One way of restating Eucli... parallel lines never meet.

An extension of it is the l... point, not on the line, there is o... awn through the point which i...

Math Practice

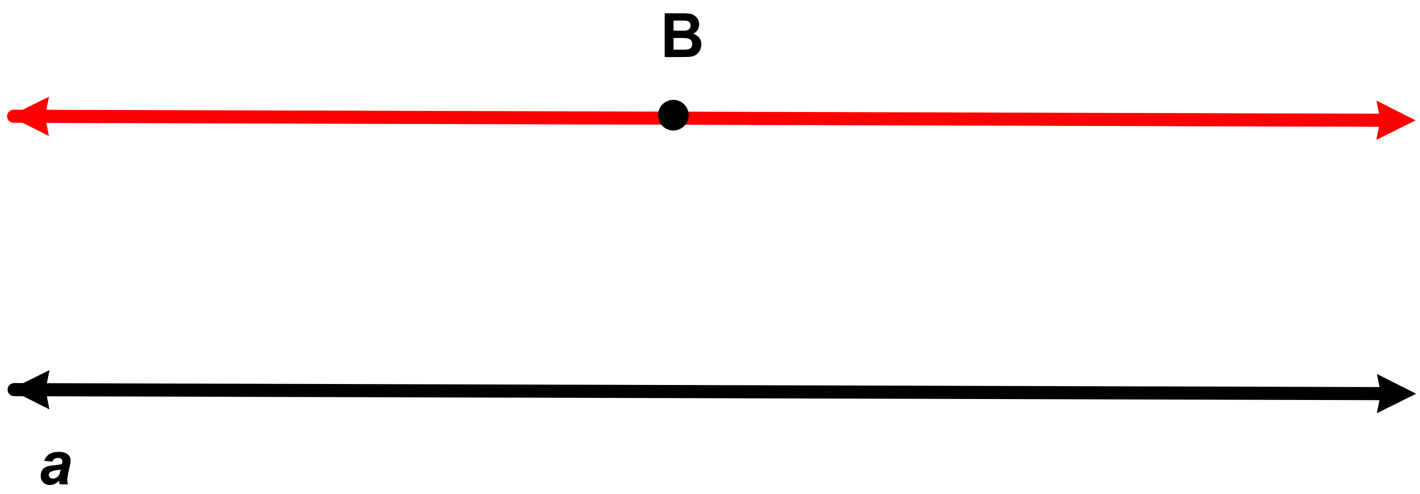
Question on this slide addresses MP2

Can you estimate where

the parallel line would be?

The Parallel Postulate

Can you imagine any other line which could be drawn through Point B and still be parallel to line *a*?



The Parallel Postulate

Can you imagine any o... ...ugh Point B and still be parallel t...

Math Practice

Question on this slide addresses MP2

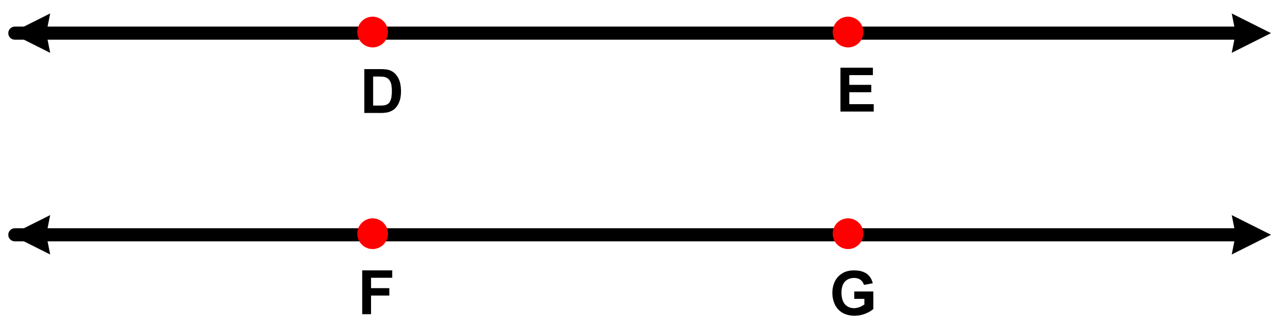
Parallel, Intersecting and Skew

Parallel lines are two lines in a plane that never meet.

We would say that lines DE and FG are parallel.

Or, symbolically:

$$\overleftrightarrow{DE} \parallel \overleftrightarrow{FG}$$



Parallel, Intersecting and Skew

Parallel line

We would s

Or, symboli

Math Practice

Remind students throughout this lesson about the proper notation and letter order (if required) for naming segments, rays & lines

Also emphasize the notation for parallel lines.

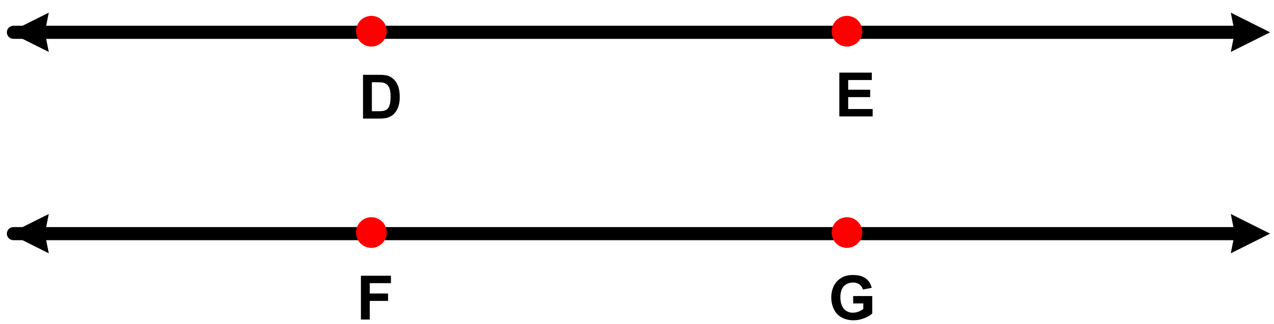
Indicating Lines are Parallel

Lines cannot be assumed to be parallel unless it is indicated that they are. Just looking like they are parallel is not sufficient.

There are two ways of indicating that lines are parallel.

The first way is as shown on the prior slide:

$$\overleftrightarrow{DE} \parallel \overleftrightarrow{FG}$$

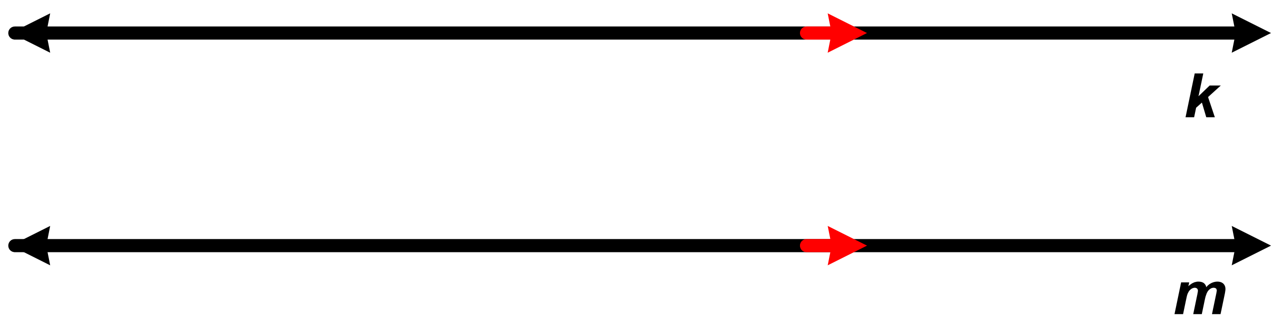


Indicating Lines are Parallel

The other way to indicate lines are parallel is to label them with arrows, as shown below.

The lines which share the arrow (shown in red to make it more visible here) are parallel.

If two different pairs of lines are parallel, the ones with the matching number of arrows are parallel, as shown on the next slide.



Indicating Lines are Parallel

The other way to indicate lines are parallel is to label them with arrows, as shown below.

The lines wh ... more visible here)

If two diffe ... matching number of a

Math Practice

Remind students throughout this lesson about the proper notation and letter order (if required) for naming segments, rays & lines

Also emphasize the notation for parallel lines.

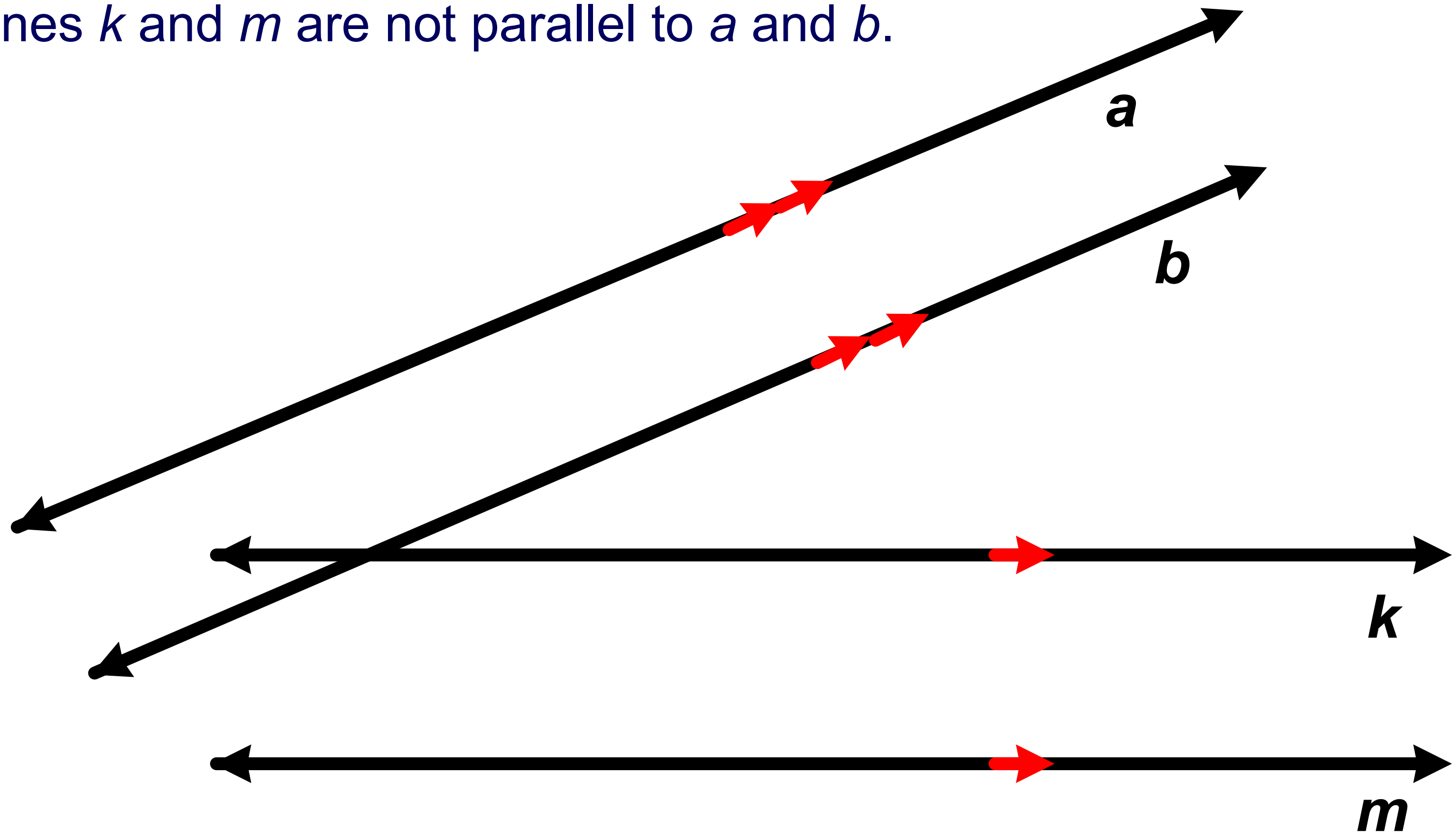
n

Indicating Lines are Parallel

This indicates that lines *k* and *m* are parallel to each other.

And, lines *a* and *b* are parallel to each other.

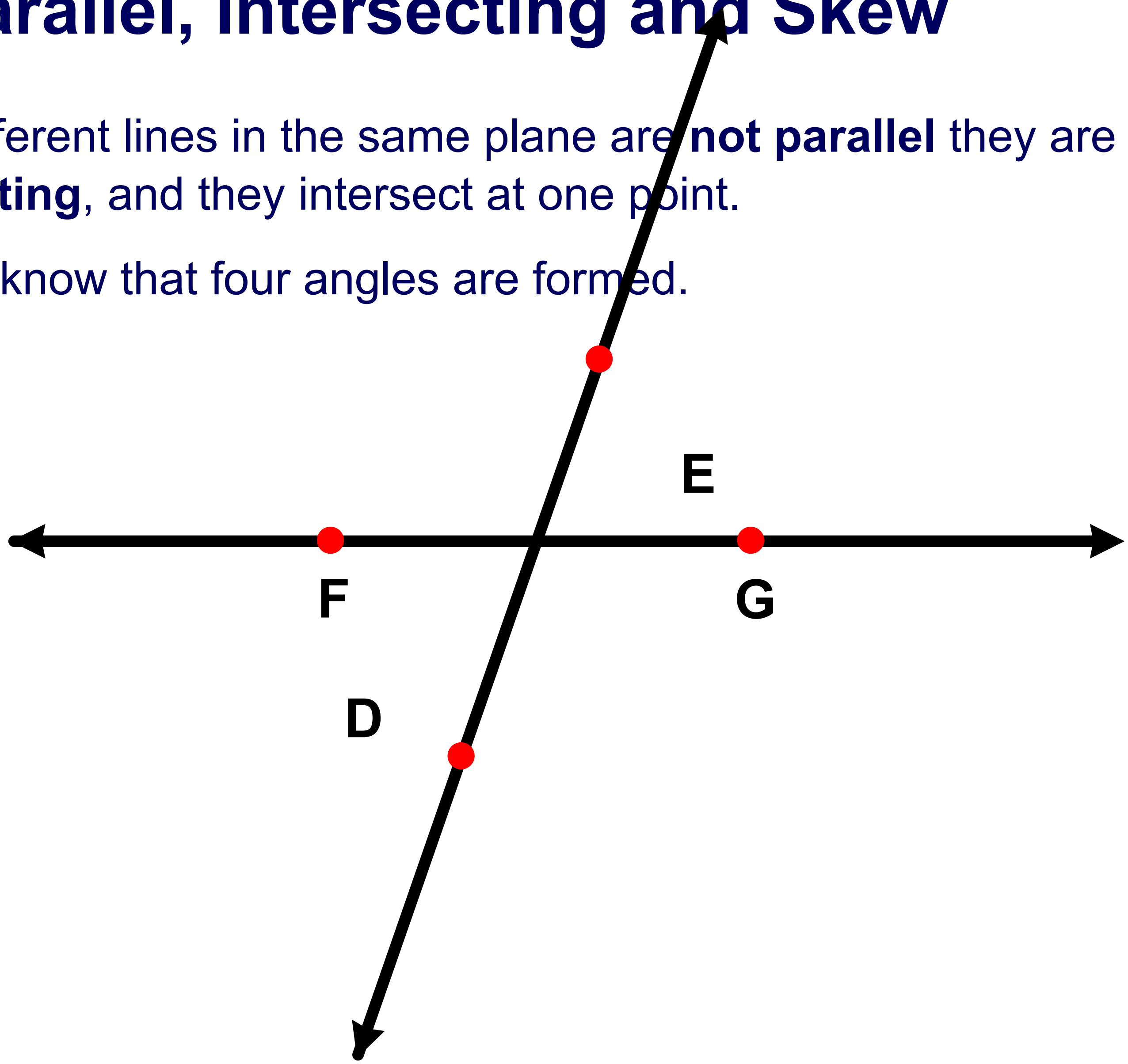
But lines *k* and *m* are not parallel to *a* and *b*.



Parallel, Intersecting and Skew

If two different lines in the same plane are **not parallel** they are **intersecting**, and they intersect at one point.

We also know that four angles are formed.

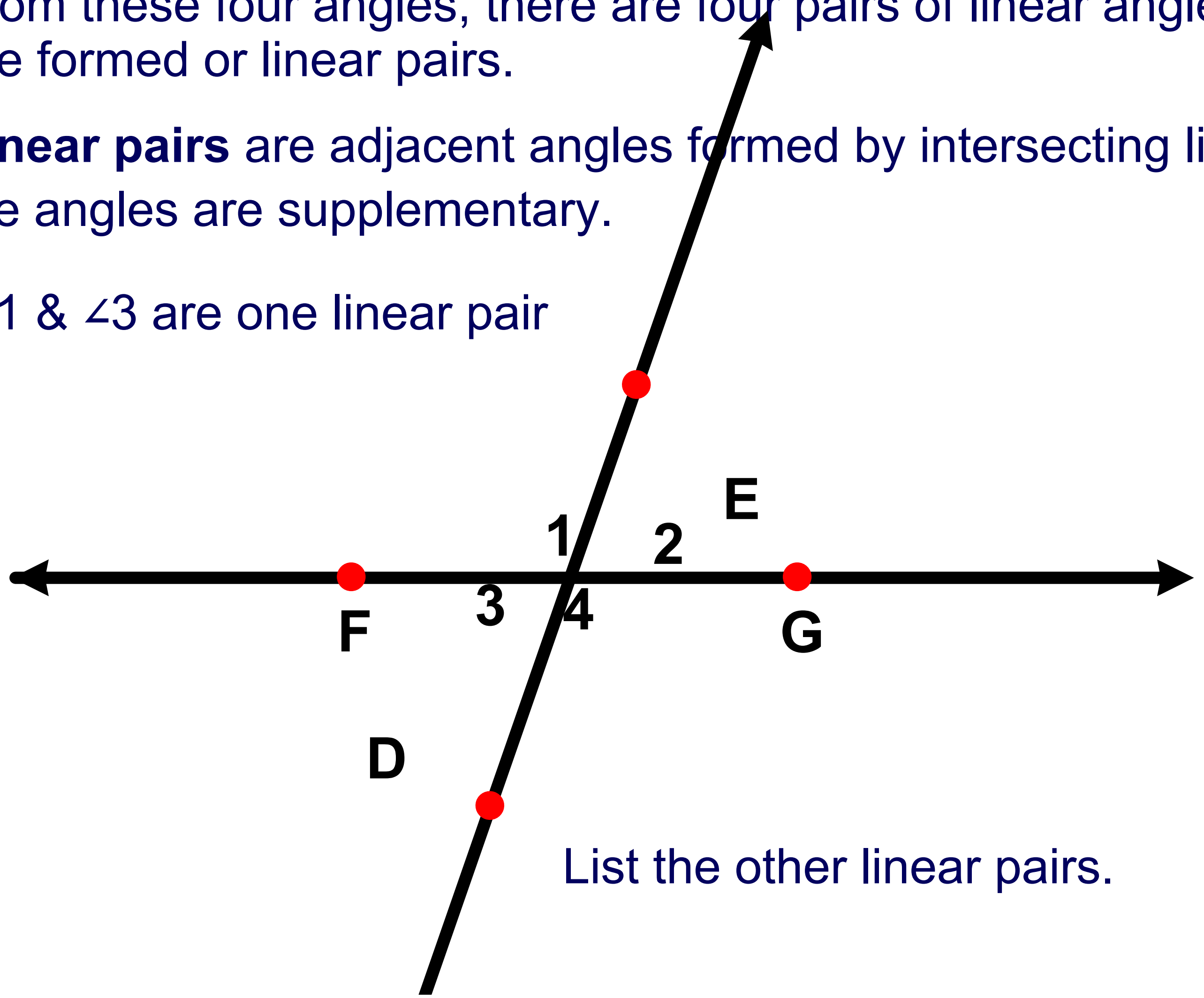


Parallel, Intersecting and Skew

From these four angles, there are four pairs of linear angles that are formed or linear pairs.

Linear pairs are adjacent angles formed by intersecting lines; the angles are supplementary.

∠1 & ∠3 are one linear pair



List the other linear pairs.

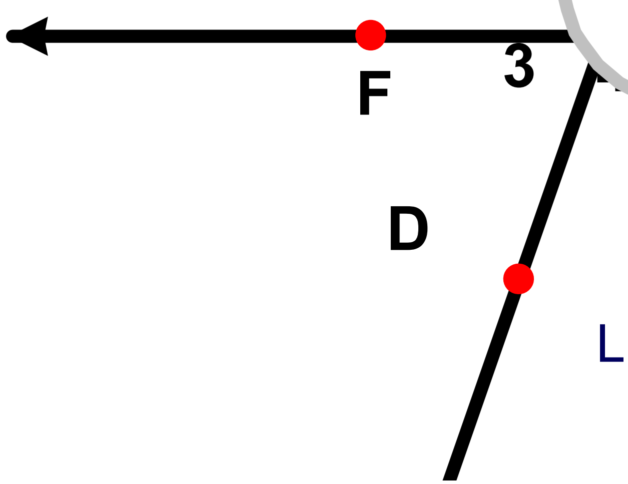
Parallel, Intersecting and Skew

From these four angles, the
are formed or linear pairs.

Linear pairs are adjacent
the angles are supplement

∠1 & ∠3 are one linear pai

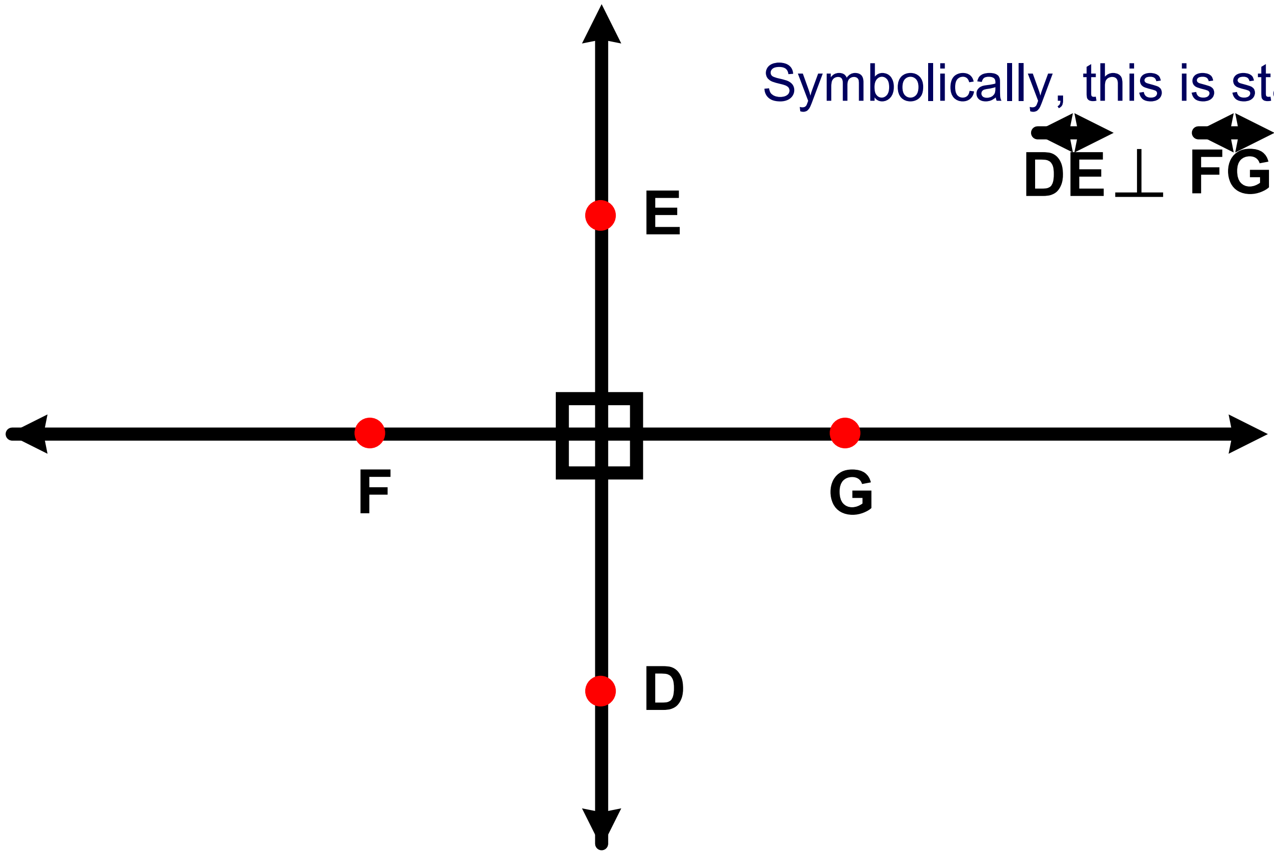
Answer



List the other linear pairs.

Perpendicular Lines

If the adjacent angles formed by intersecting lines are congruent, the lines are **perpendicular**.



Symbolically, this is stated as

$\overleftrightarrow{DE} \perp \overleftrightarrow{FG}$

Perpendicular Lines

If the adjacent angles formed by intersecting lines are congruent

stated as

G

Math Practice

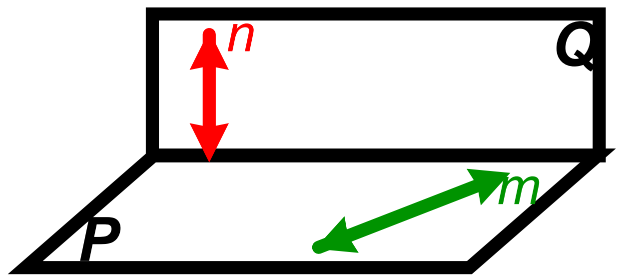
Remind students throughout this lesson about the proper notation and letter order (if required) for naming segments, rays & lines

Also emphasize the notation for perpendicular lines.

Skew Lines

If two lines intersect, then they define a plane, so are co-planar.

Two lines that do not intersect can either be parallel if they are in the same plane or **skew** if they are in different planes.



Lines *m* & *n* in the figure are skew.

Skew Lines

If two lines interse ar.

Two lines that
intersect ca
parallel if they
same plane o
they are in dif
planes.

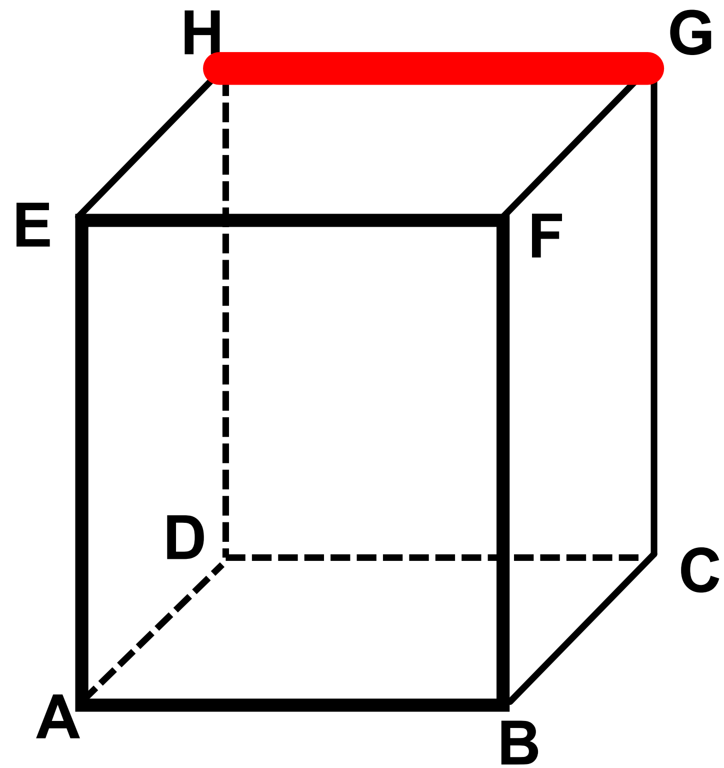
Math Practice

Additional Examples of skew lines that can also be used:

Line between the ceiling and the front wall & the line between the floor and the side wall are skew.
(MP2 & MP4)

Skew Lines

Using the following diagram, name a line which is skew with Line HG: a line that does not lie in a common plane.



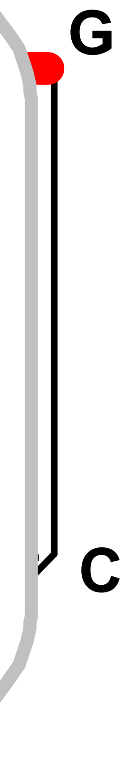
Skew Lines

Using the following
diagram, name a li
which is skew wi
Line HG: a line tha
does not lie in a
common plane.

Answer

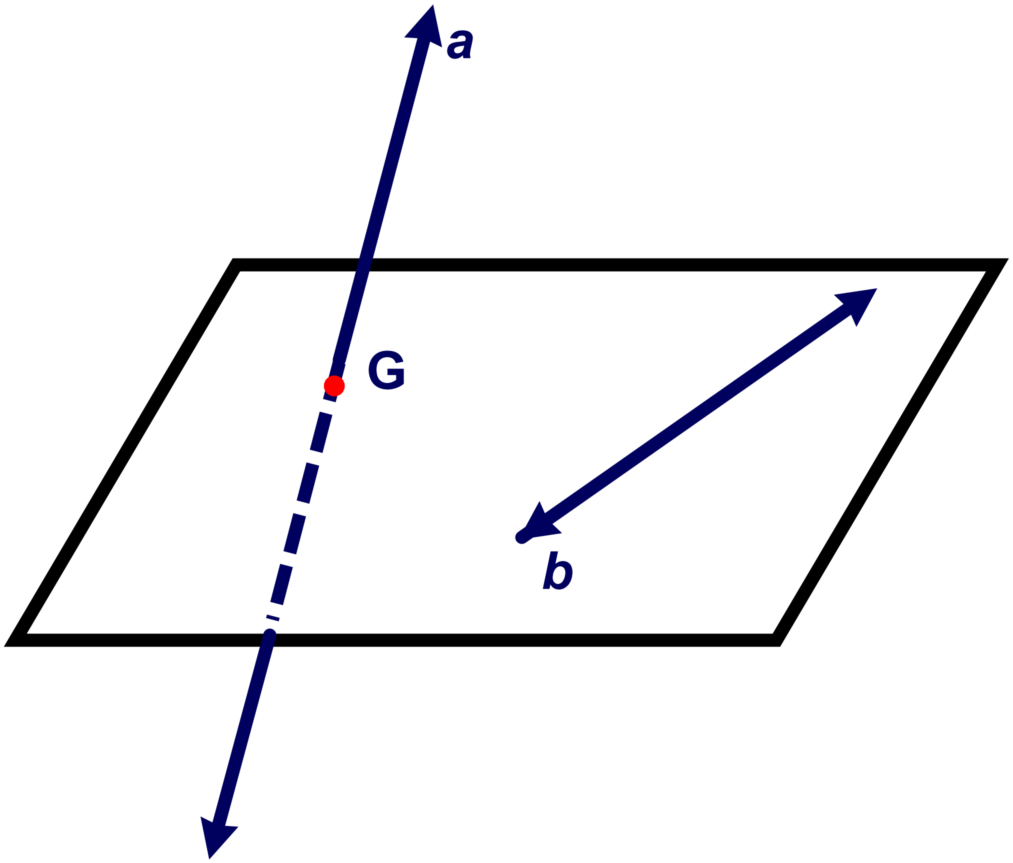
Line BC, Line AD, Line AE, Line BF

This example addresses MP2



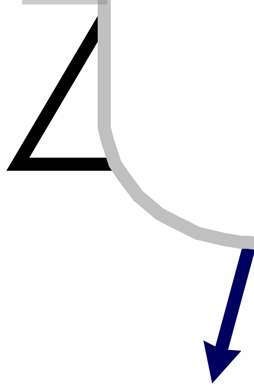
1 Are lines *a* and *b* skew?

- Yes
- No



1 Are lines *a* and *b* skew?

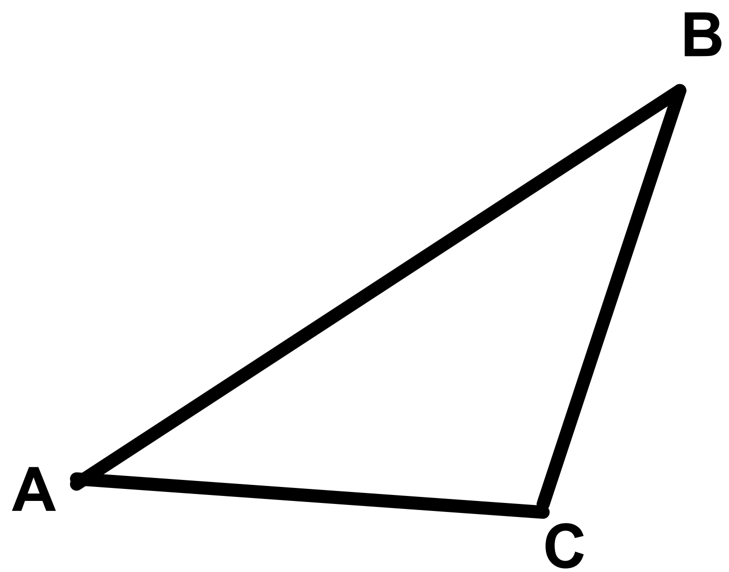
- Yes
- No



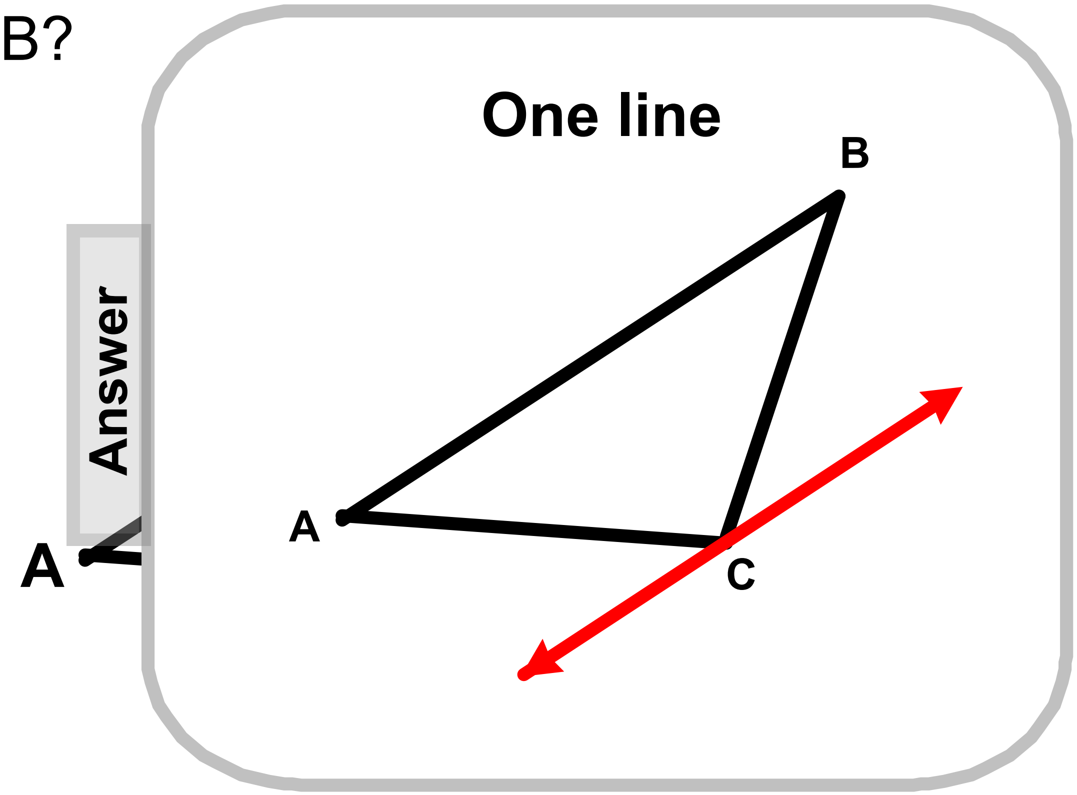
Answer

Yes, lines *a* and *b* are skew. Lines *a* and *b* are noncoplanar and do not intersect.

2 How many lines can be drawn through C and parallel to Line AB?

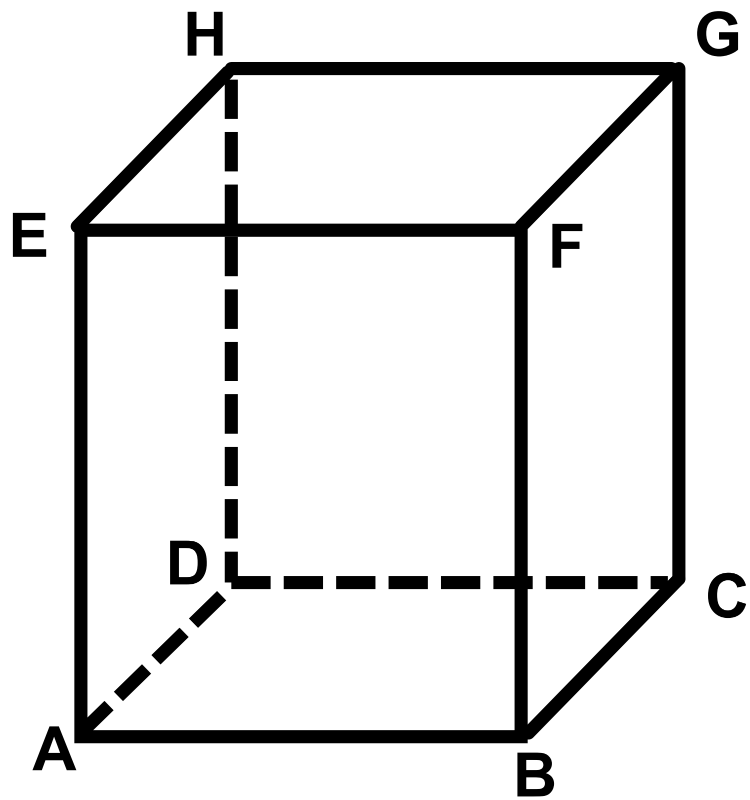


2 How many lines can be drawn through C and parallel to Line AB?



3 Name all lines parallel to $\overleftrightarrow{EF}$.

- ☐ A $\overleftrightarrow{AB}$
- ☐ B $\overleftrightarrow{BC}$
- ☐ C $\overleftrightarrow{DC}$
- ☐ D $\overleftrightarrow{HD}$
- ☐ E $\overleftrightarrow{HG}$



3 Name all lines parallel to $\overleftrightarrow{EF}$

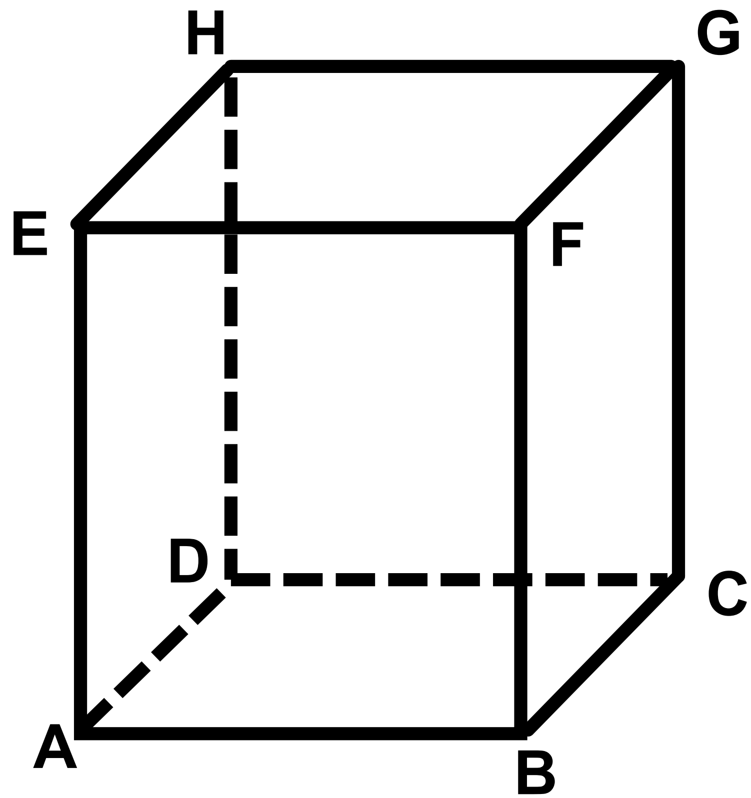
- ☐ A $\overleftrightarrow{AB}$
- ☐ B $\overleftrightarrow{BC}$
- ☐ C $\overleftrightarrow{DC}$
- ☐ D $\overleftrightarrow{HD}$
- ☐ E $\overleftrightarrow{HG}$

Answer

A, C & E

4 Name lines skew to $\overleftrightarrow{EF}$.

- A $\overleftrightarrow{BC}$
- B $\overleftrightarrow{DC}$
- C $\overleftrightarrow{HD}$
- D $\overleftrightarrow{AB}$
- E $\overleftrightarrow{GC}$



4 Name lines skew to $\overleftrightarrow{EF}$.

- ☐ A $\overleftrightarrow{BC}$
- ☐ B $\overleftrightarrow{DC}$
- ☐ C $\overleftrightarrow{HD}$
- ☐ D $\overleftrightarrow{AB}$
- ☐ E $\overleftrightarrow{GC}$

Answer

A, C, & E

5 Two intersecting lines are always coplanar.

- True
- False

5 Two intersecting lines are always coplanar.

- True
- False

Answer

True

6 Two skew lines are coplanar.

- True
- False

6 Two skew lines are coplanar.

- True
- False

Answer

False

7 Complete this statement with the best appropriate word:

Two skew lines are ___________ parallel.

- A always
- B never
- C sometimes

7 Complete this statement with the best appropriate word:

Two skew lines are _

A always

B never

C sometimes

Answer

B

Lines & Transversals

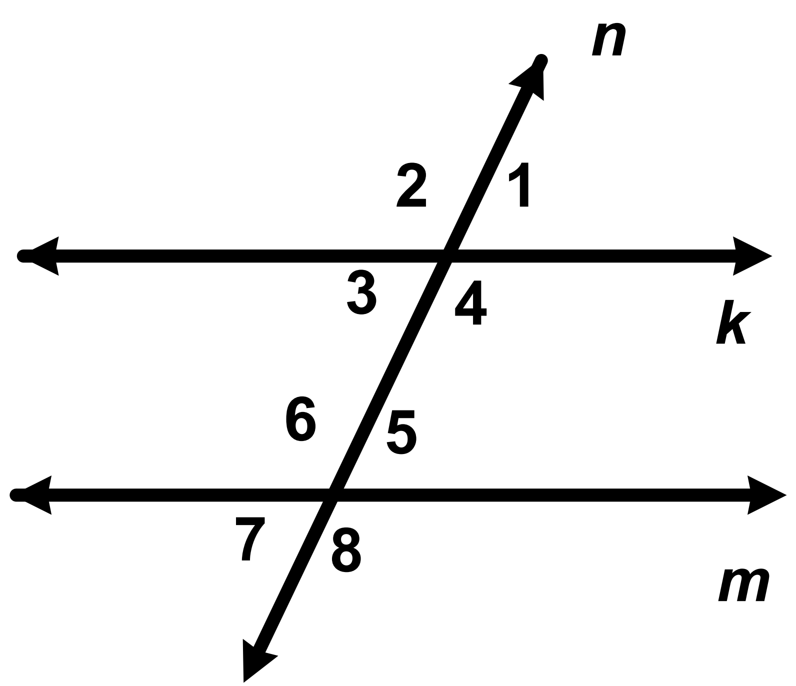
Return to Table
of Contents

Transversals

A **Transversal** is a line that intersects two or more coplanar lines.

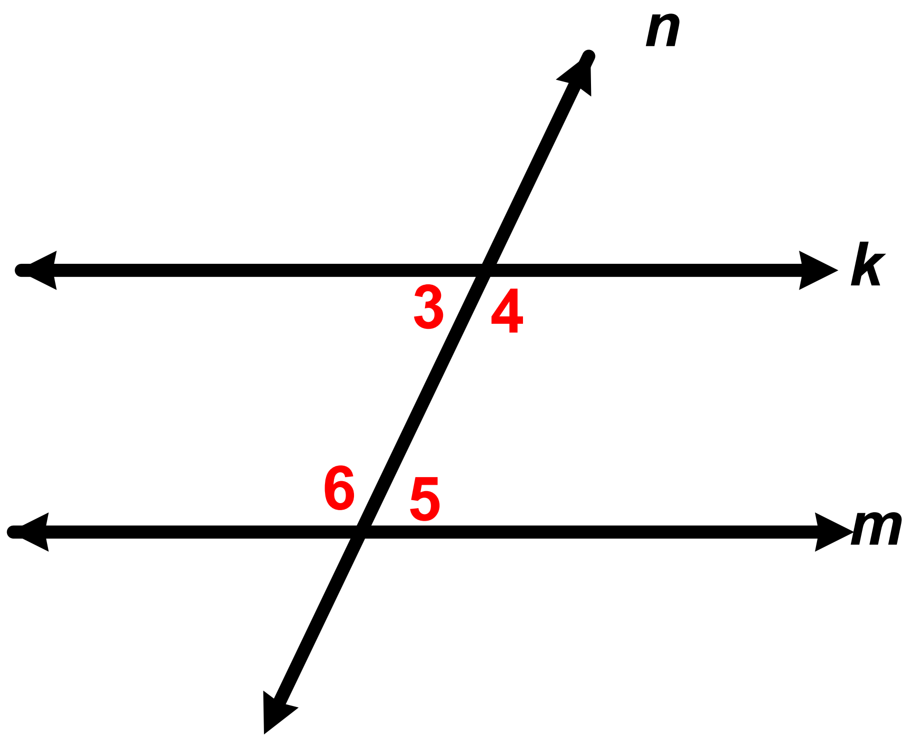
(This is the name of the line that Euclid used to intersect two lines in his fifth postulate.)

In the image, transversal, Line *n*, is shown intersecting Line *k* and Line *m*.



Line *k* and Line *m* may or may not be parallel.

Angles Formed by a Transversal

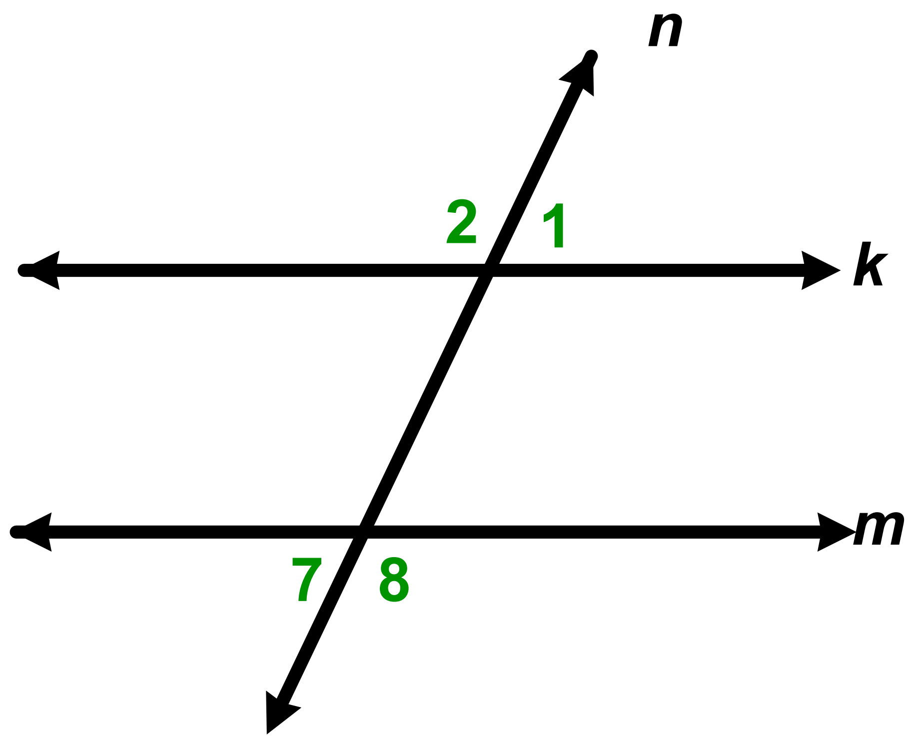


When a transversal intersects two lines, eight angles are formed. These angles are given special names.

Interior Angles are the 4 angles that lie between the two lines.

Angles Formed by a Transversal

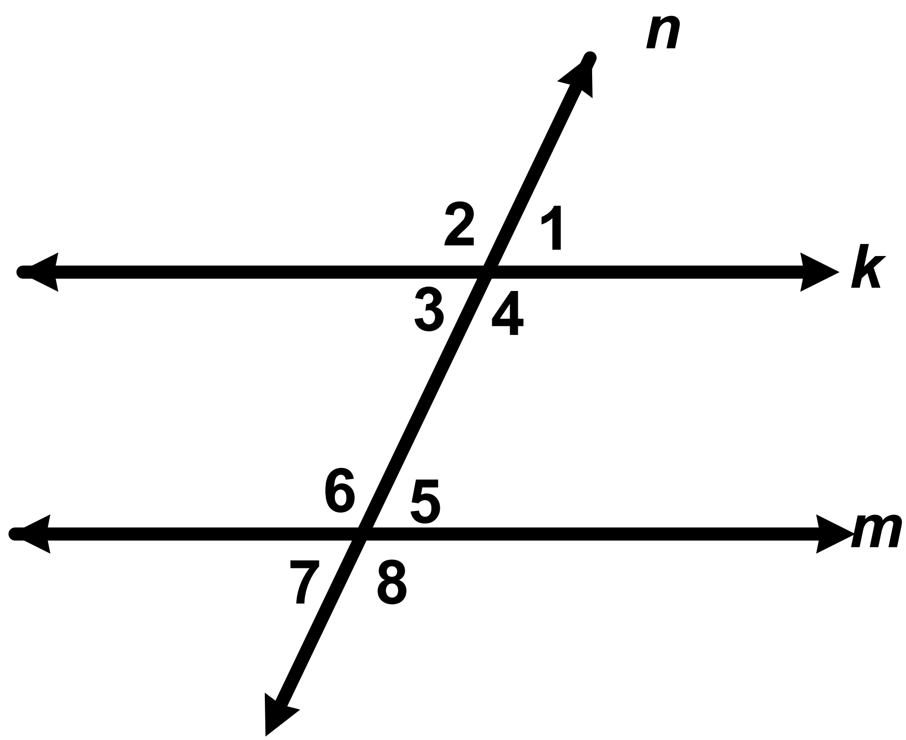
When a transversal intersects two lines, eight angles are formed. These angles are given special names.



Exterior Angles are the 4 angles that lie outside the two lines.

8 Name all of the interior angles.

- ☐ ∠1
- ☐ ∠2
- ☐ ∠3
- ☐ ∠4
- ☐ ∠5
- ☐ ∠6
- ☐ ∠7
- ☐ ∠8



8 Name all of the interior angles.

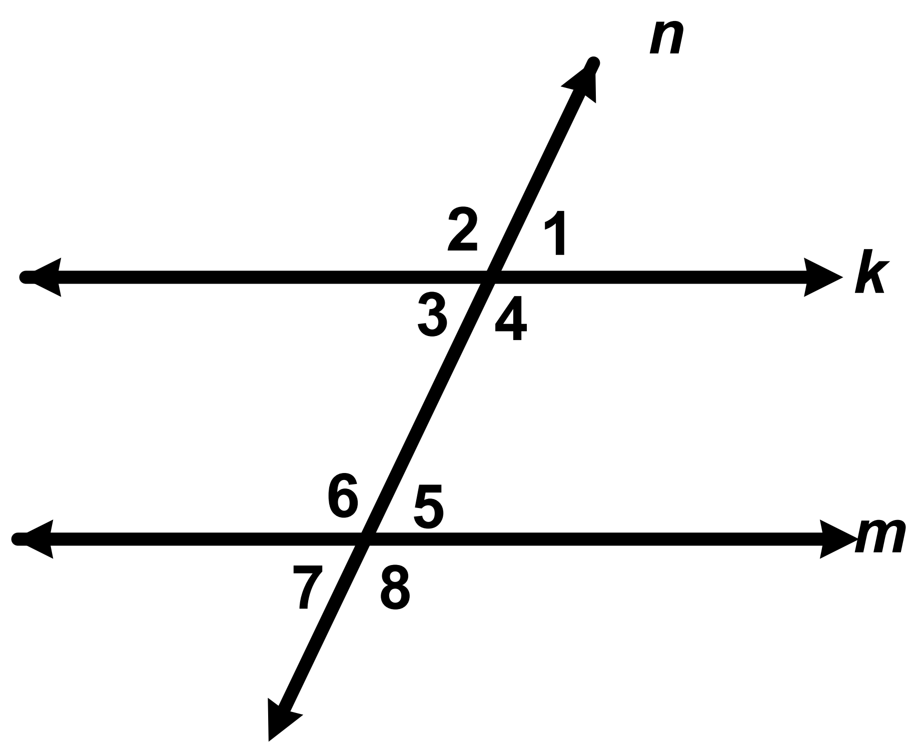
- ☐ ∠1
- ☐ ∠2
- ☐ ∠3
- ☐ ∠4
- ☐ ∠5
- ☐ ∠6
- ☐ ∠7
- ☐ ∠8

Answer

C, D, E, F

9 Name all of the exterior angles.

- ☐ ∠1
- ☐ ∠5
- ☐ ∠2
- ☐ ∠6
- ☐ ∠3
- ☐ ∠7
- ☐ ∠4
- ☐ ∠8



9 Name all of the exterior angles

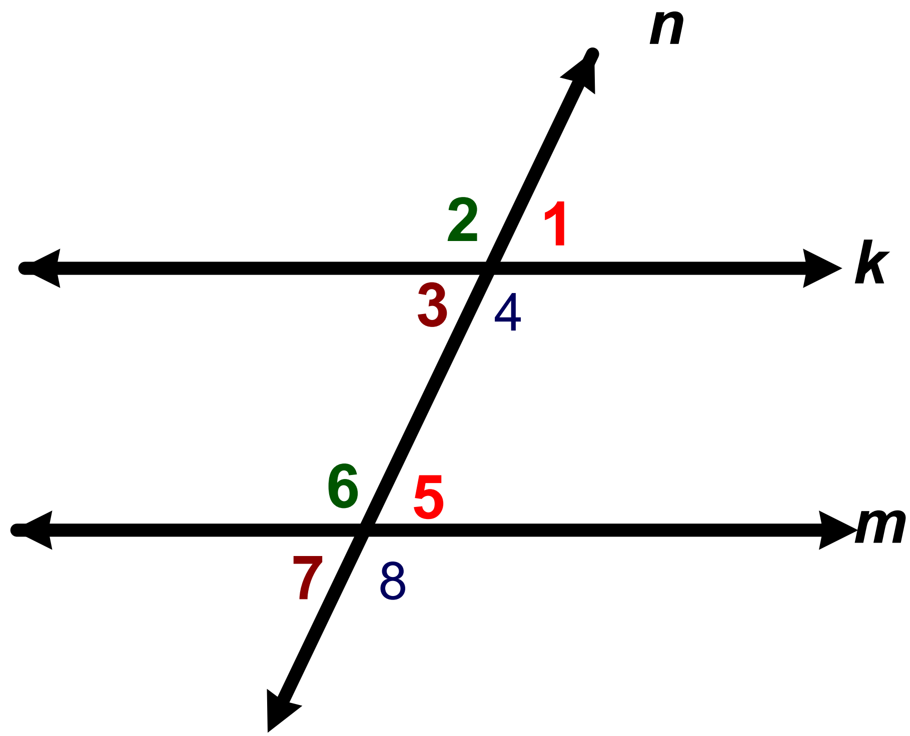
- ☐ ∠1
- ☐ ∠5
- ☐ ∠2
- ☐ ∠6
- ☐ ∠3
- ☐ ∠7
- ☐ ∠4
- ☐ ∠8

Answer

A, B, G, H

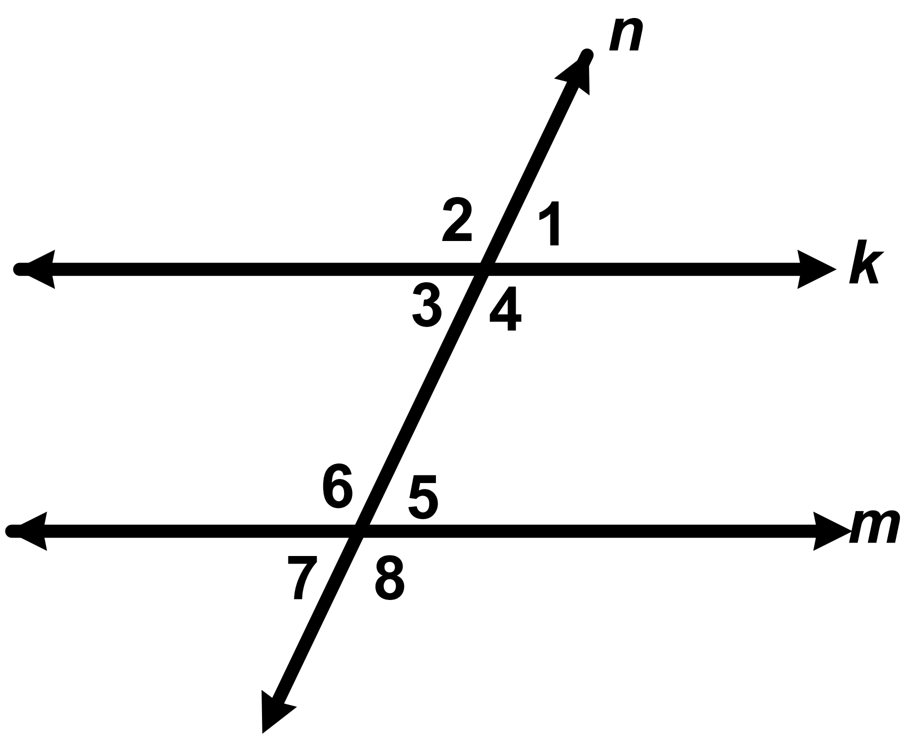
Corresponding Angles

Corresponding Angles are pairs of angles that lie in the same position relative to the transversal, as shown above.

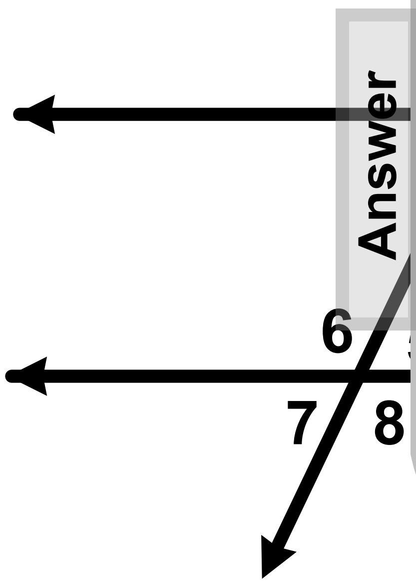


There are four pairs of corresponding angles formed when a transversal intersects two lines.

10 Which angle corresponds with ∠1?

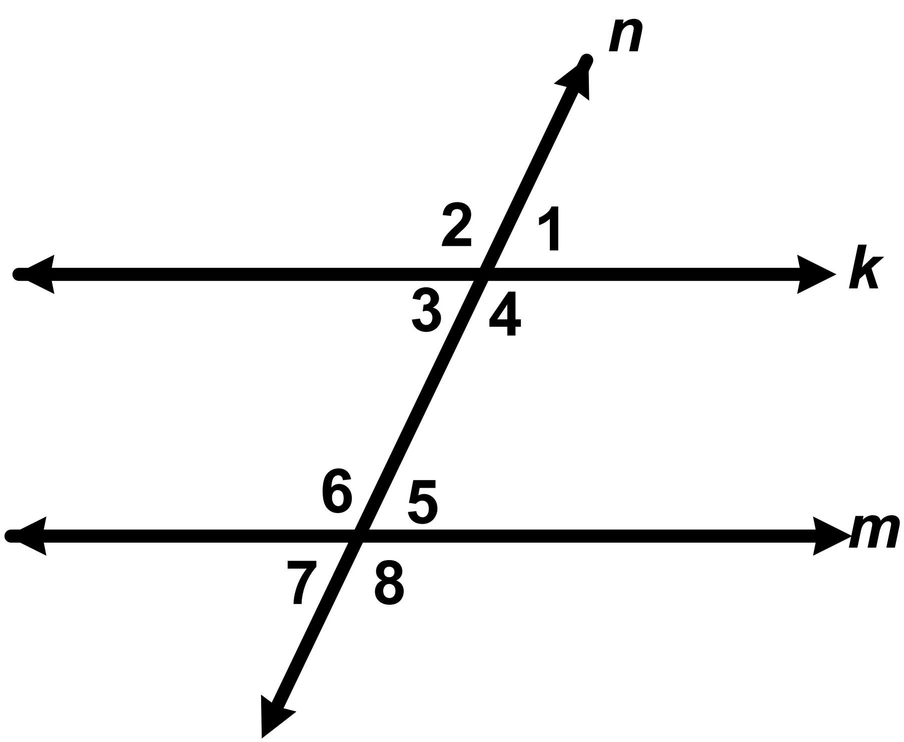


10 Which angle corresponds with ∠1?

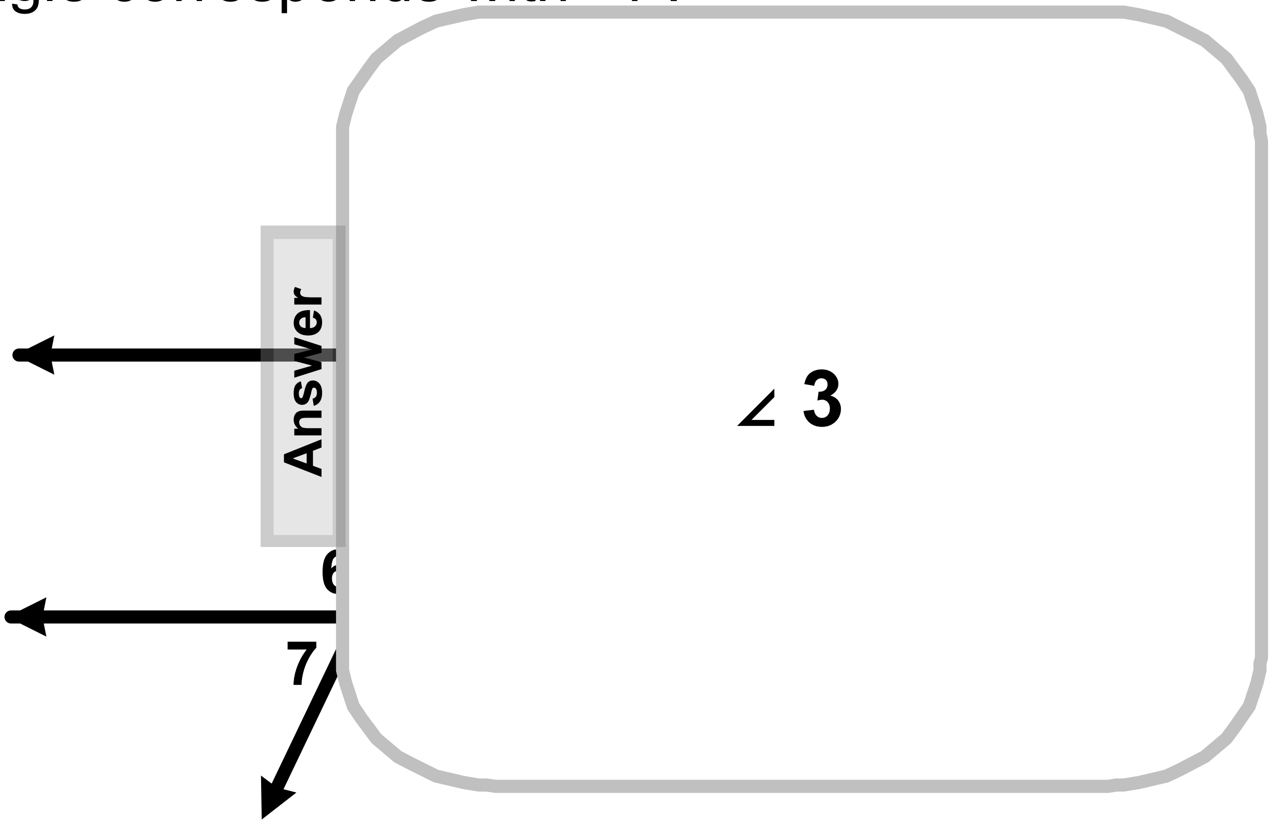


∠ **5**

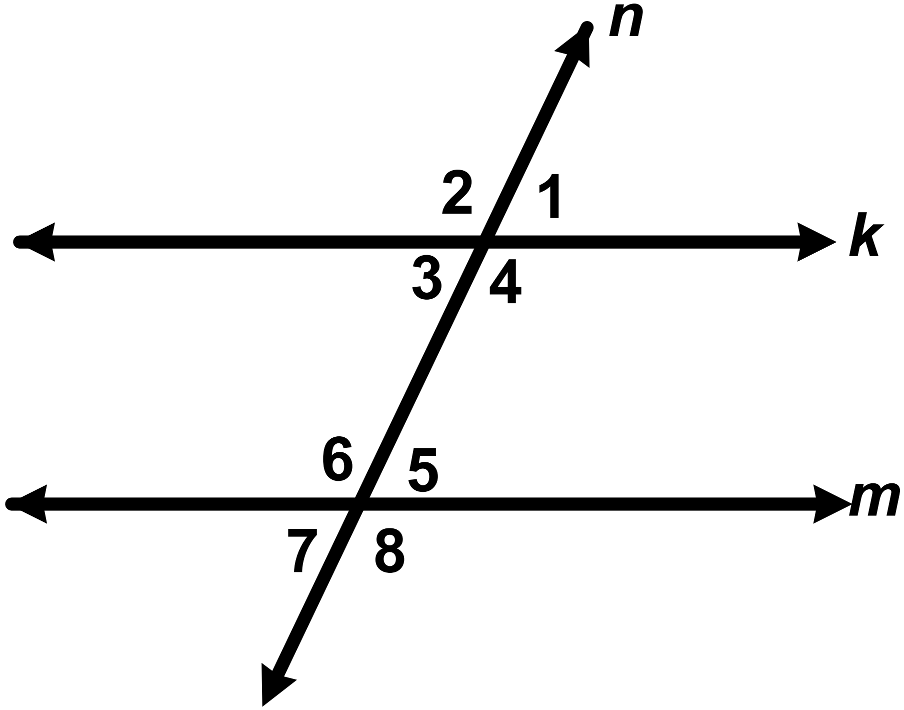
11 Which angle corresponds with ∠7?



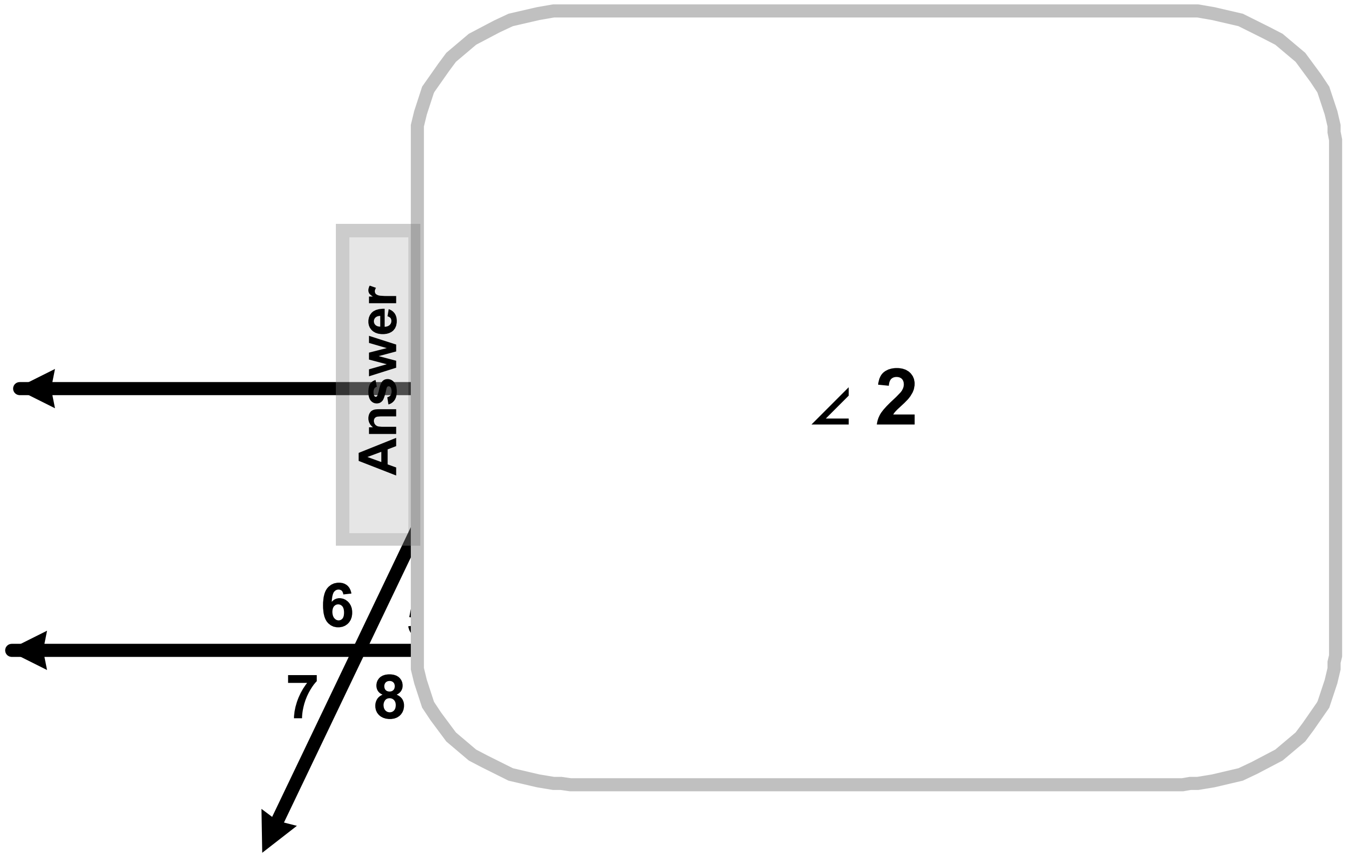
11 Which angle corresponds with ∠7?



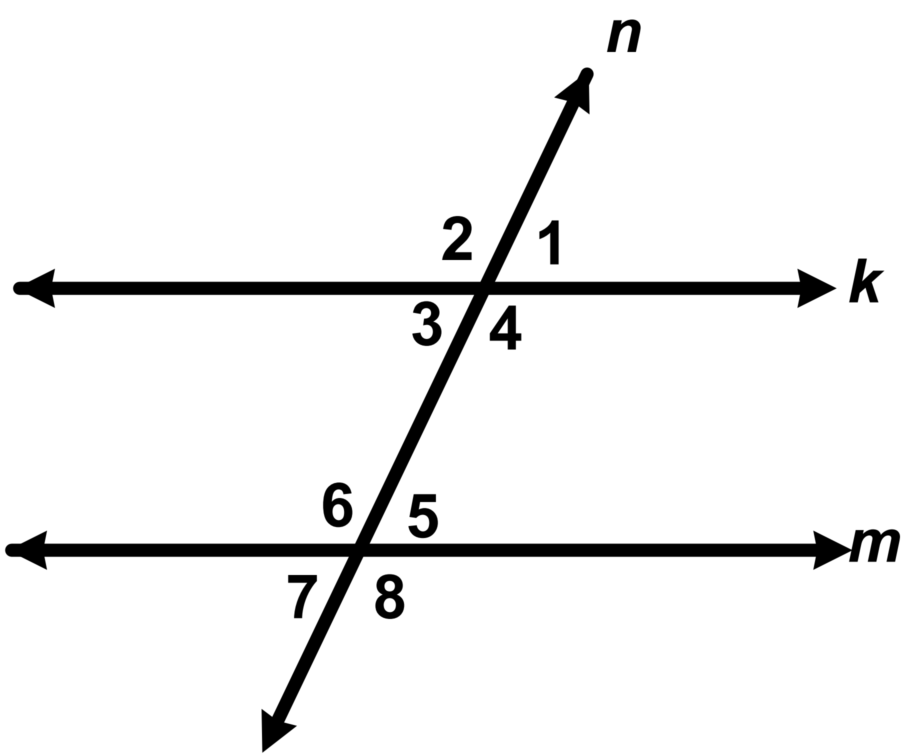
12 Which angle corresponds with ∠6?



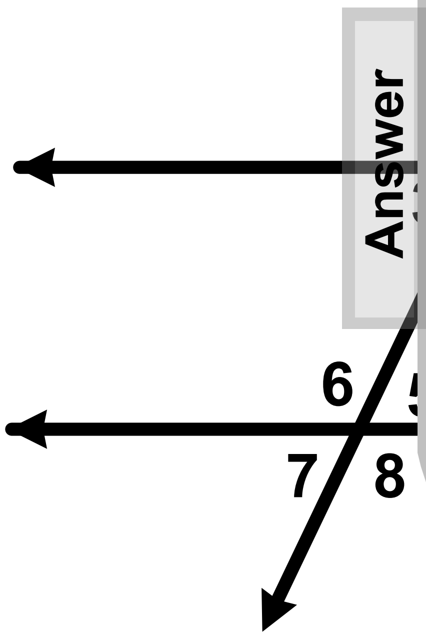
12 Which angle corresponds with ∠6?



13 Which angle corresponds with ∠4?



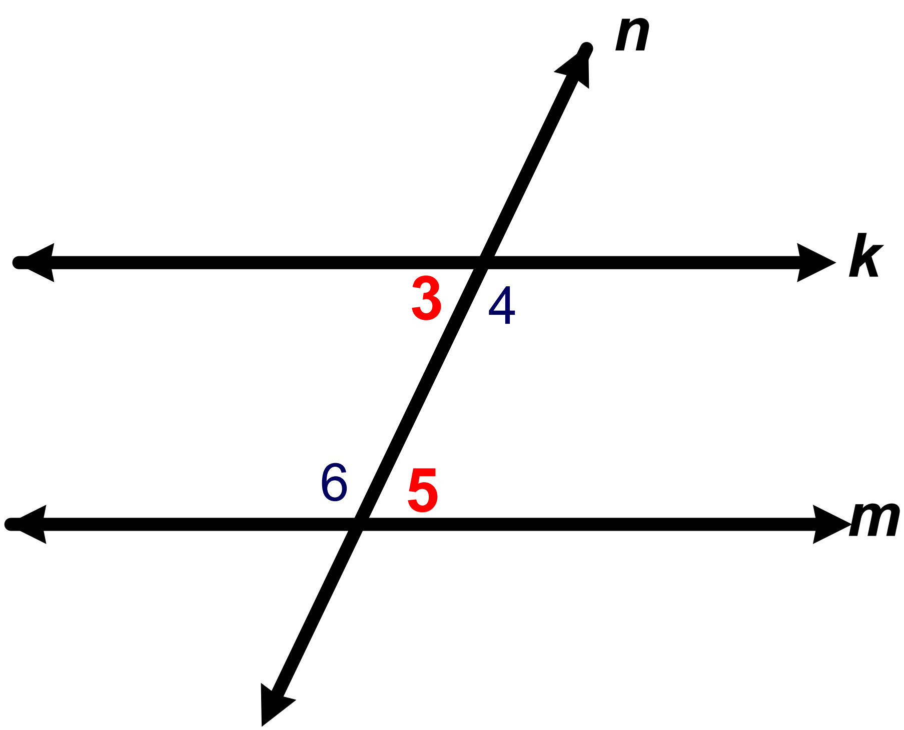
13 Which angle corresponds with ∠4?



∠ 8

Alternate Interior Angles

Alternate Interior Angles are interior angles that lie on opposite sides of the transversal.



There are two pairs formed by the transversal; they are shown above in red and blue.

Alternate Interior Angles

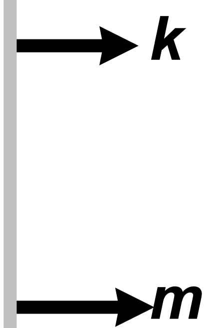
Alternate Interio
Angles are inter
angles that lie o
opposite sides o
the transversal.

Math Practice

MP6
Emphasize breaking apart the words in each vocabulary term to understand the meaning.

Alternate means "opposite"
Interior means "inside"

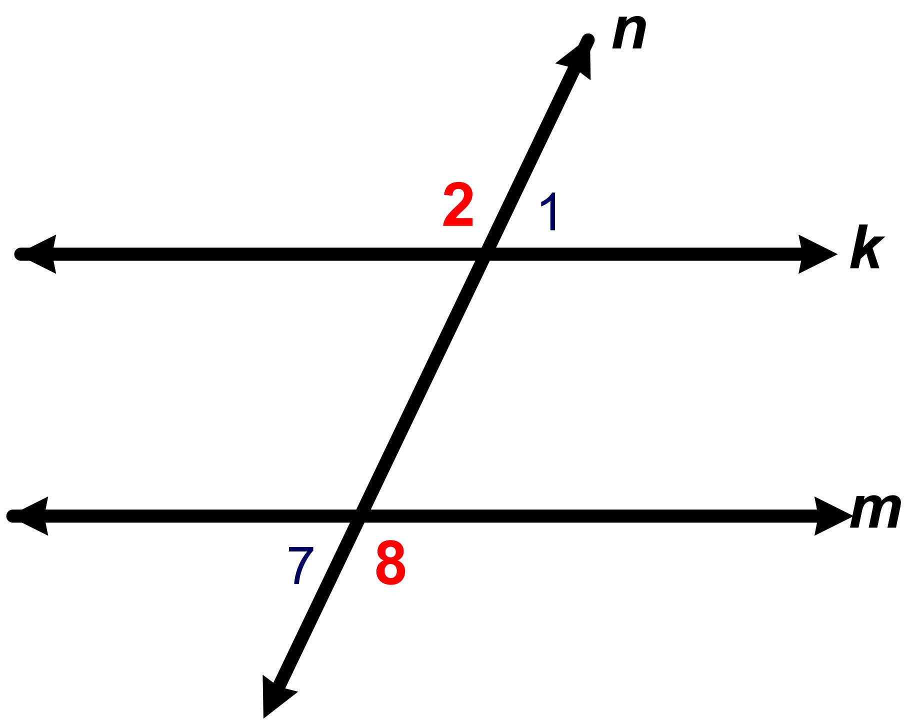
So Alternate Interior Angles are on opposite sides of the transversal and inside of the other 2 lines.



There are two pairs formed by the transversal; they are shown above in red and blue.

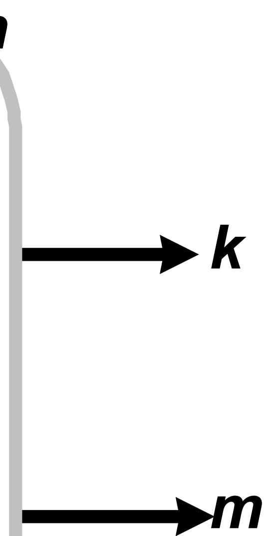
Alternate Exterior Angles

Alternate Exterior Angles are exterior angles that lie on opposite sides of the transversal.



There are two pairs formed by the transversal; they are shown above in red and blue.

Alternate Exterior Angles



Alternate Exteric
Angles are exter
angles that lie or
opposite sides o
transversal.

Math Practice

MP6
Emphasize breaking apart the words in each vocabulary term to understand the meaning.

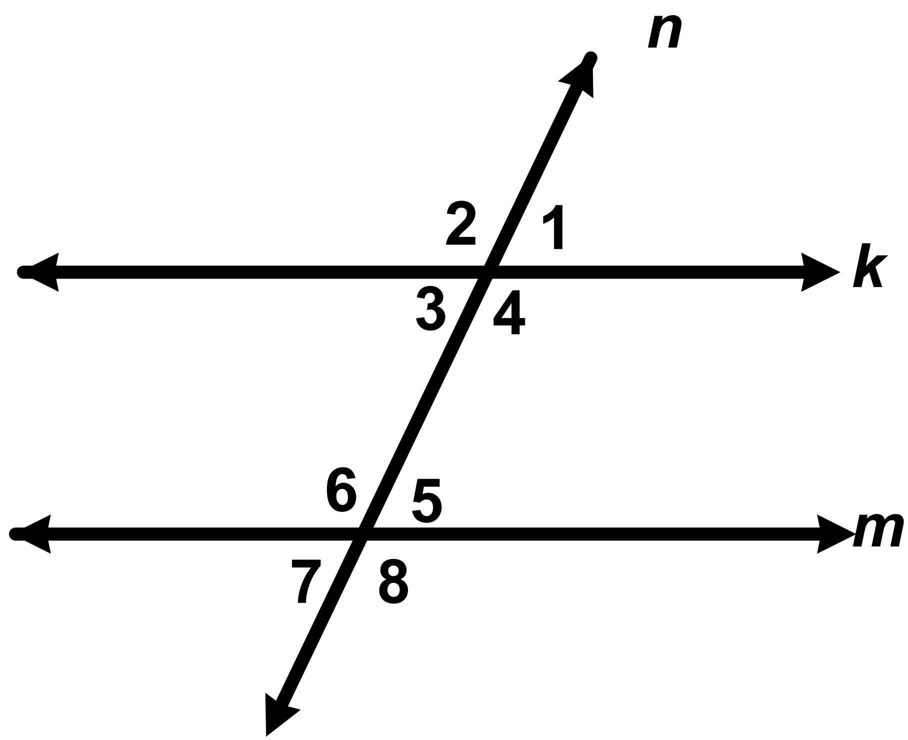
Alternate means "opposite"
Exterior means "outside"

So Alternate Exterior Angles are on opposite sides of the transversal and outside of the other 2 lines.

There are two pairs formed by the transversal; they are shown above in red and blue.

14 Which is the alternate interior angle that is paired with $\angle 3$?

- A $\angle 1$
- B $\angle 2$
- C $\angle 3$
- D $\angle 4$
- E $\angle 5$
- F $\angle 6$
- G $\angle 7$
- H $\angle 8$



14 Which is the alternate interior angle that is paired with ∠3?

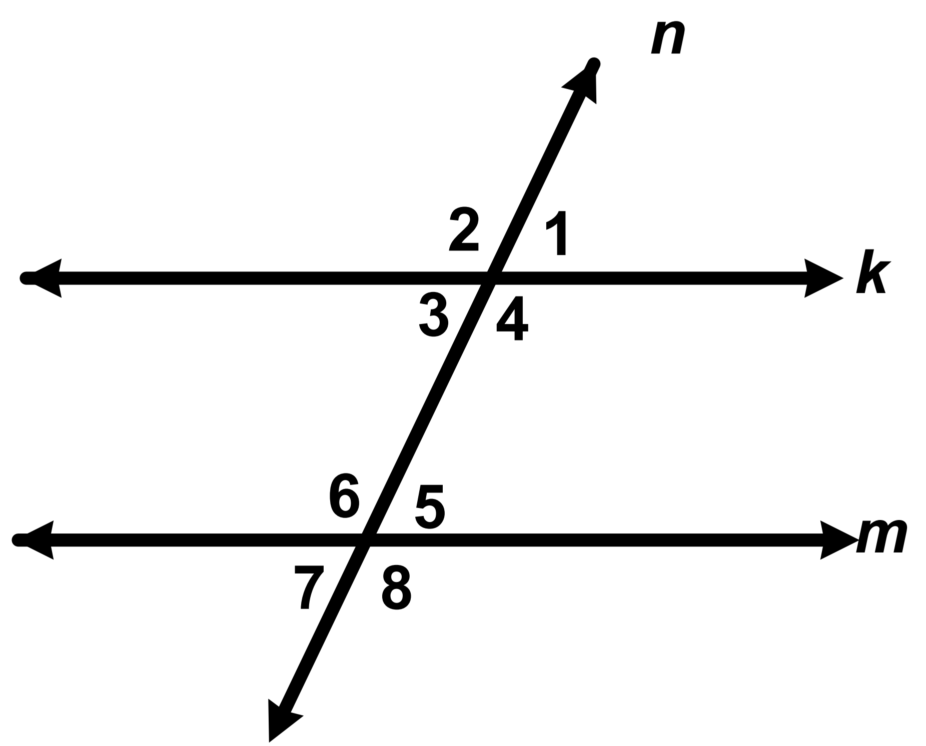
- A ∠1
- B ∠2
- C ∠3
- D ∠4
- E ∠5
- F ∠6
- G ∠7
- H ∠8

Answer

E

15 Which is the alternate exterior angle that is paired with ∠7?

- A ∠1
- B ∠2
- C ∠3
- D ∠4
- E ∠5
- F ∠6
- G ∠7
- H ∠8



15 Which is the alternate exterior angle that is paired with ∠7?

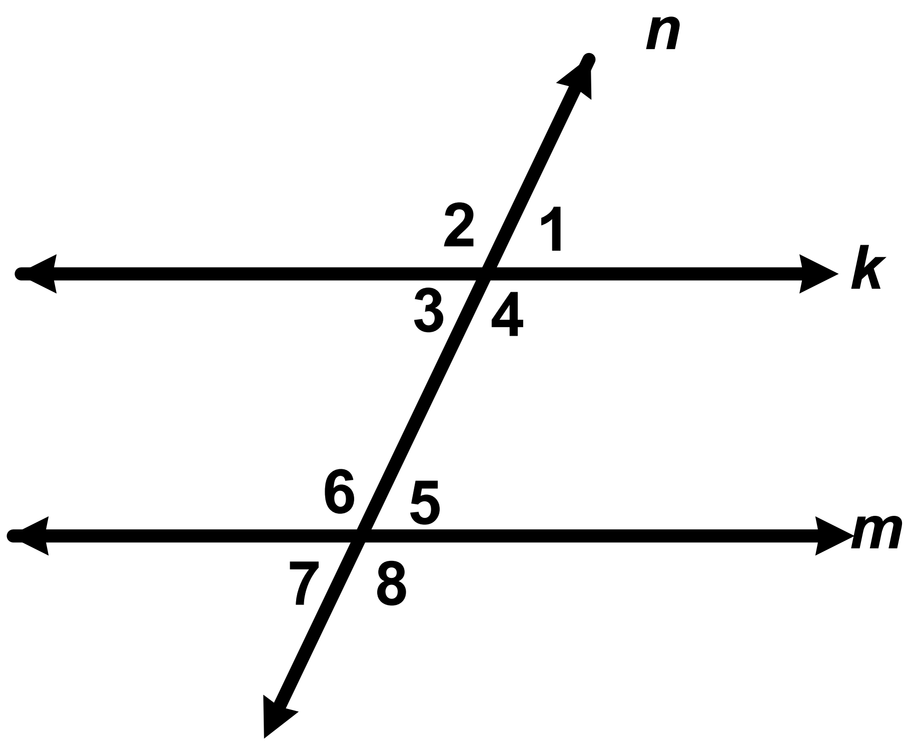
- A ∠1
- B ∠2
- C ∠3
- D ∠4
- E ∠5
- F ∠6
- G ∠7
- H ∠8

Answer

A

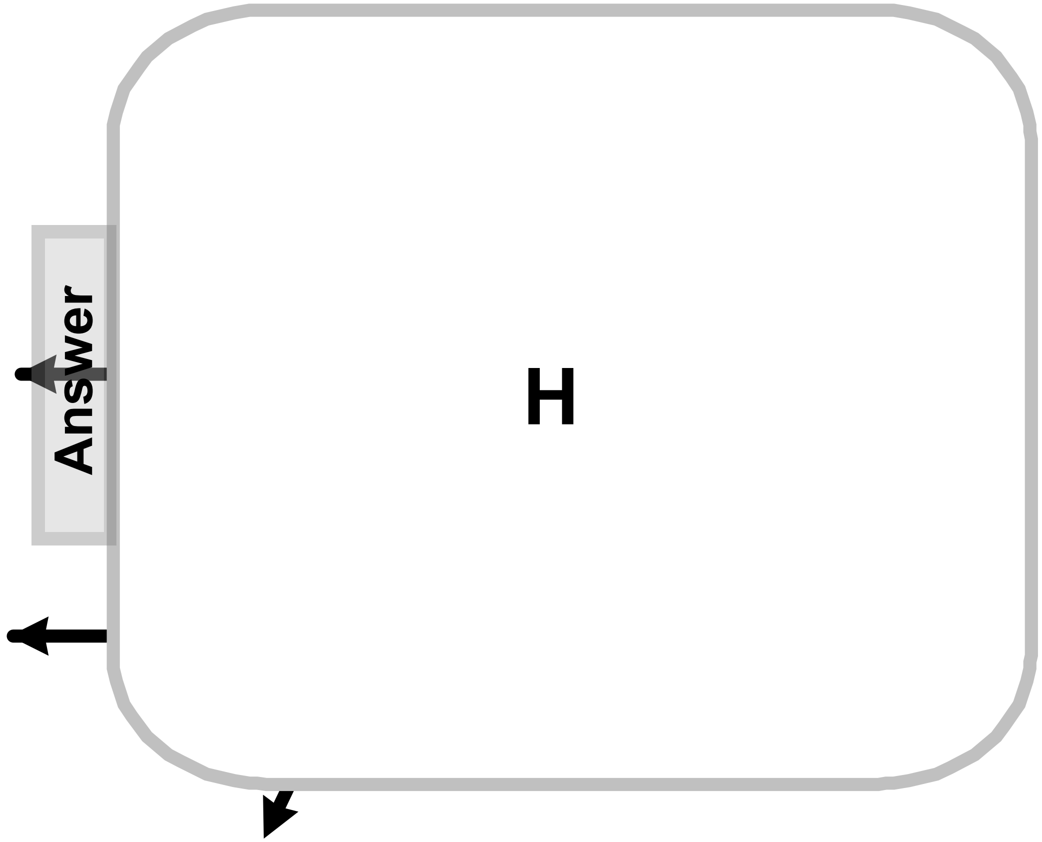
16 Which is the alternate exterior angle that is paired with ∠2?

- A ∠1
- B ∠2
- C ∠3
- D ∠4
- E ∠5
- F ∠6
- G ∠7
- H ∠8



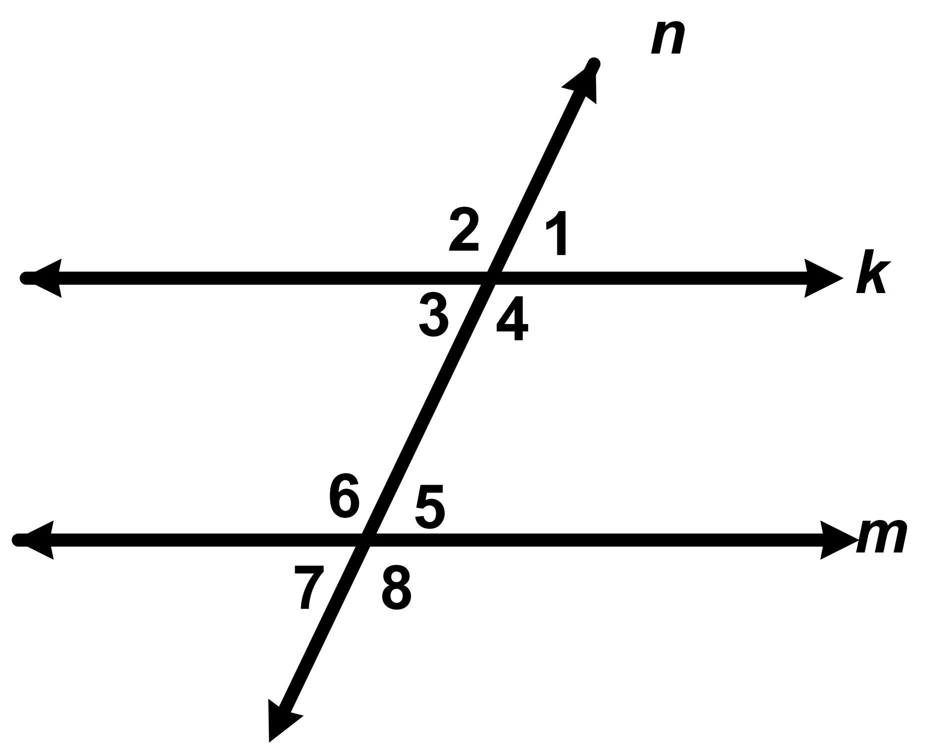
16 Which is the alternate exterior angle that is paired with ∠2?

- A ∠1
- B ∠2
- C ∠3
- D ∠4
- E ∠5
- F ∠6
- G ∠7
- H ∠8



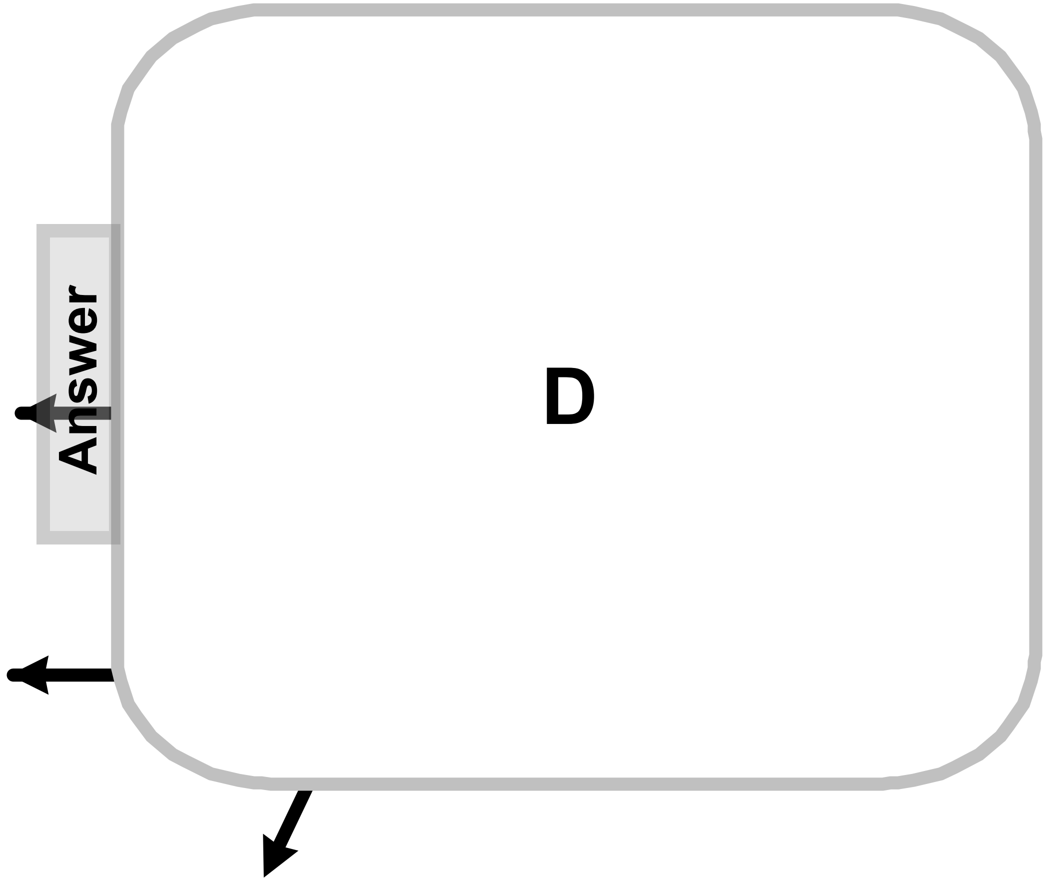
17 Which is the alternate interior angle that is paired with ∠6?

- A ∠1
- B ∠2
- C ∠3
- D ∠4
- E ∠5
- F ∠6
- G ∠7
- H ∠8



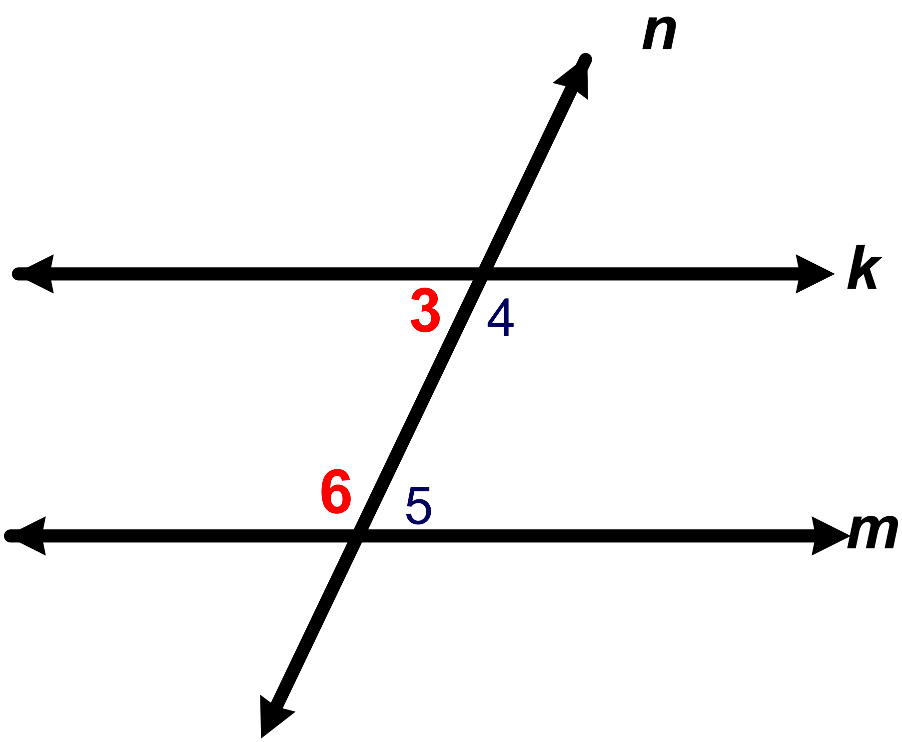
17 Which is the alternate interior angle that is paired with ∠6?

- A ∠1
- B ∠2
- C ∠3
- D ∠4
- E ∠5
- F ∠6
- G ∠7
- H ∠8



Same Side Interior Angles

Same Side Interior Angles are interior angles that lie on the same side of the transversal.



There are two pairs formed by the transversal; they are shown above in red and blue.

Same Side Interior Angles

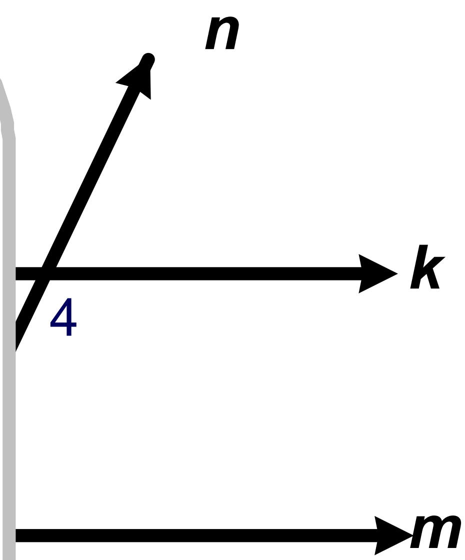
Sar
Ang
ang
sam
trar

Math Practice

MP6

Emphasize breaking apart the words in each vocabulary term to understand the meaning.

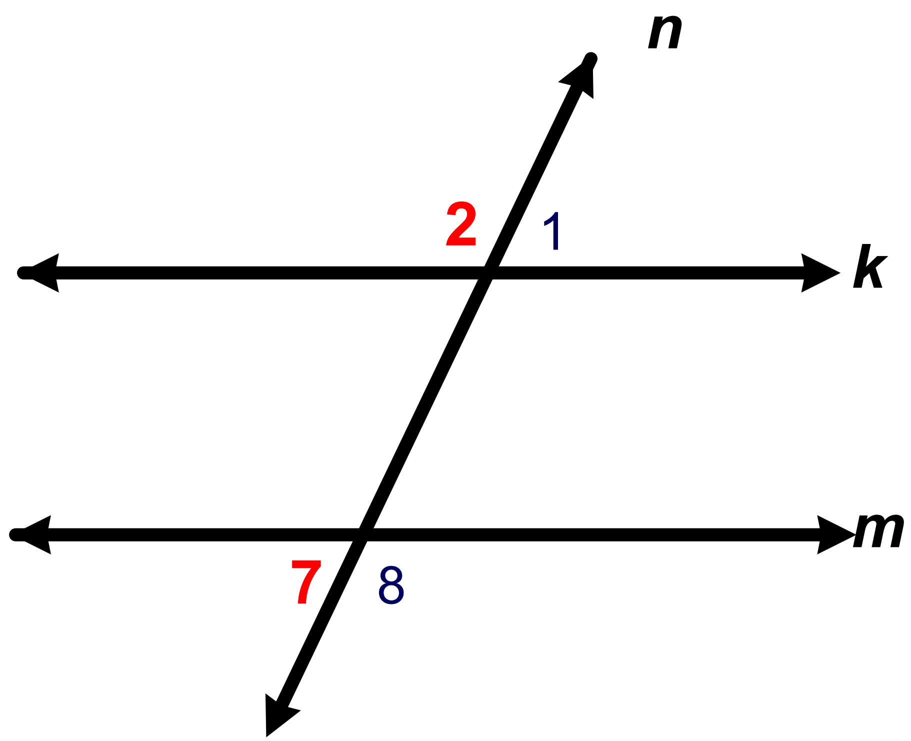
Same side means "on the same side", Interior means "inside" So Same Side Interior Angles are on same side of the transversal and inside of the other 2 lines. Note: a.k.a. Consecutive Interior Angles



The... ersal; they are shown above in red and blue.

Same Side Exterior Angles

Same Side Exterior Angles are exterior angles that lie on the same side of the transversal.



There are two pairs formed by the transversal; they are shown above in red and blue.

Same Side Exterior Angles

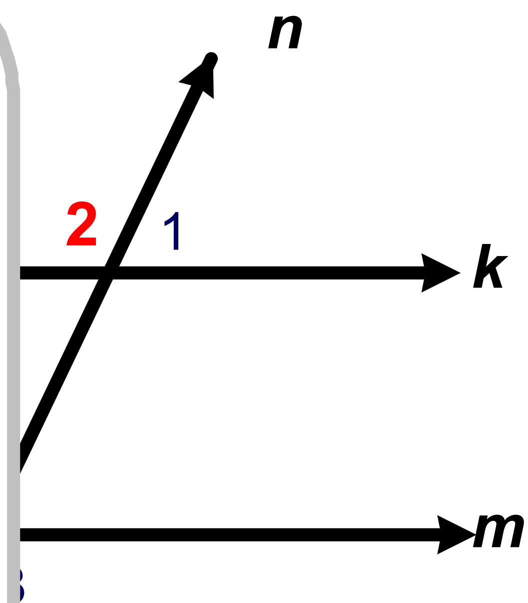
Sar
Ext
are
ang
the
the

Math Practice

MP6

Emphasize breaking apart the words in each vocabulary term to understand the meaning.

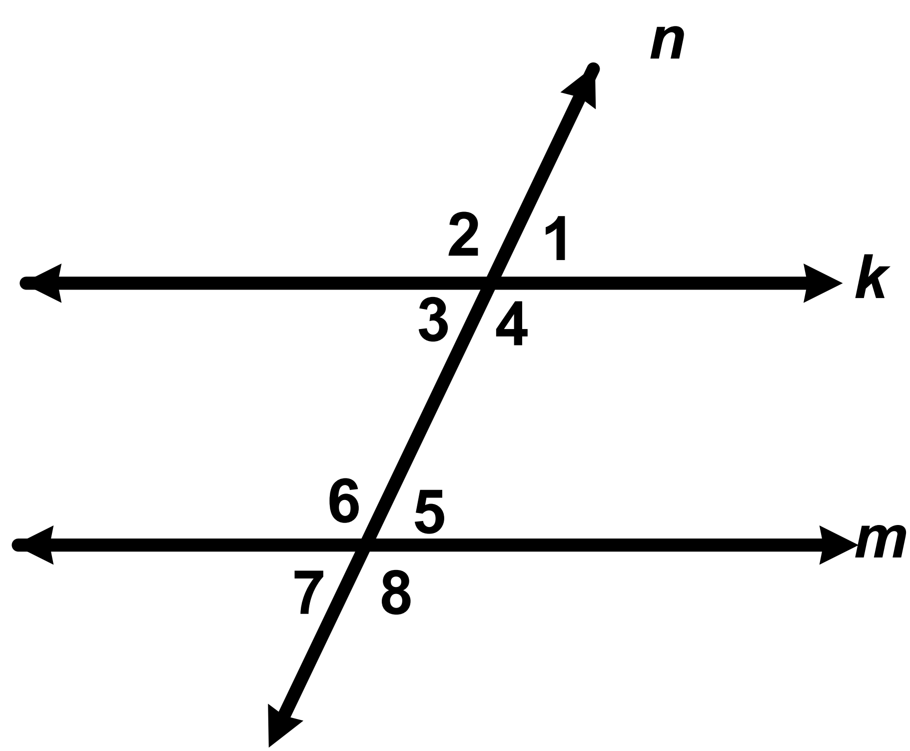
Same side means "on the same side", Interior means "inside" So Same Side Interior Angles are on same side of the transversal and inside of the other 2 lines. <u>Note</u>: a.k.a. Consecutive Interior Angles



There are two pairs formed by the transversal; they are shown above in red and blue.

18 Which is the same side interior angle that is paired with ∠6?

- A ∠1
- B ∠2
- C ∠3
- D ∠4
- E ∠6
- F ∠7
- G ∠8



18 Which is the same side interior angle that is paired with ∠6?

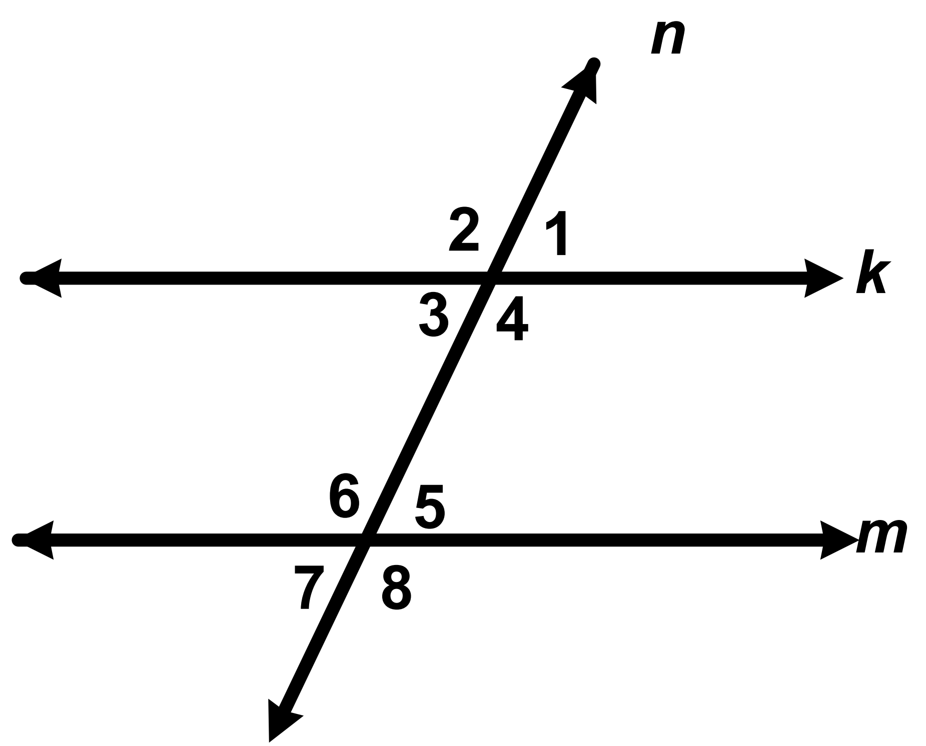
- A ∠1
- B ∠2
- C ∠3
- D ∠4
- E ∠6
- F ∠7
- G ∠8

Answer

C

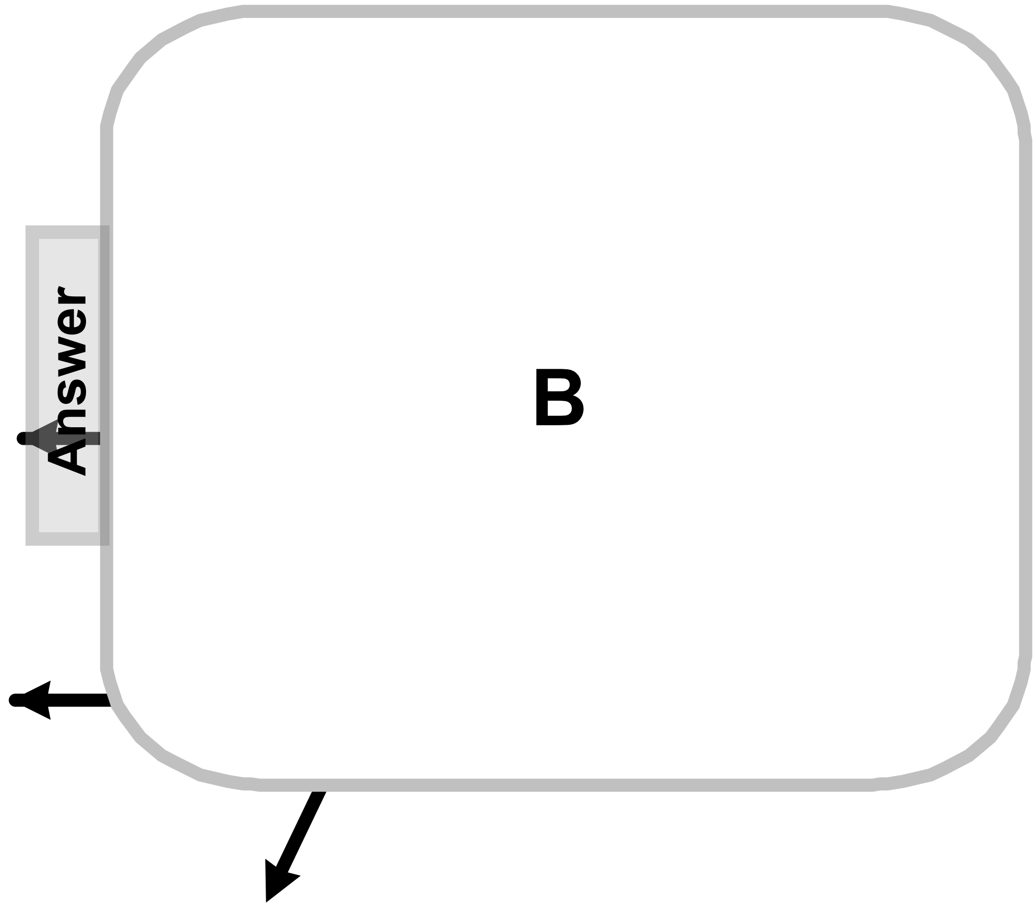
19 Which is the same side exterior angle that is paired with ∠7?

- A ∠1
- B ∠2
- C ∠3
- D ∠4
- E ∠6
- F ∠7
- G ∠8



19 Which is the same side exterior angle that is paired with ∠7?

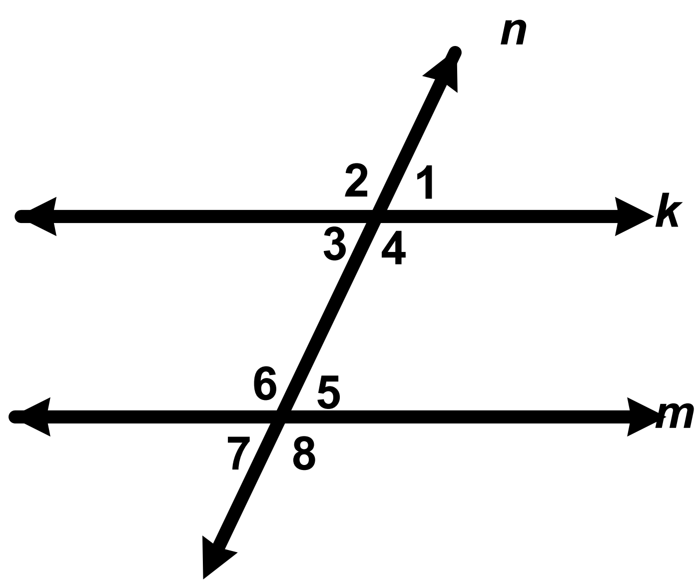
- A ∠1
- B ∠2
- C ∠3
- D ∠4
- E ∠6
- F ∠7
- G ∠8



Classifying Angles

Slide each word into the appropriate square to classify each pair of angles.

a. ∠1 and ∠2	
b. ∠1 and ∠3	
c. ∠1 and ∠5	
d. ∠3 and ∠6	
e. ∠3 and ∠5	
f. ∠3 and ∠8	



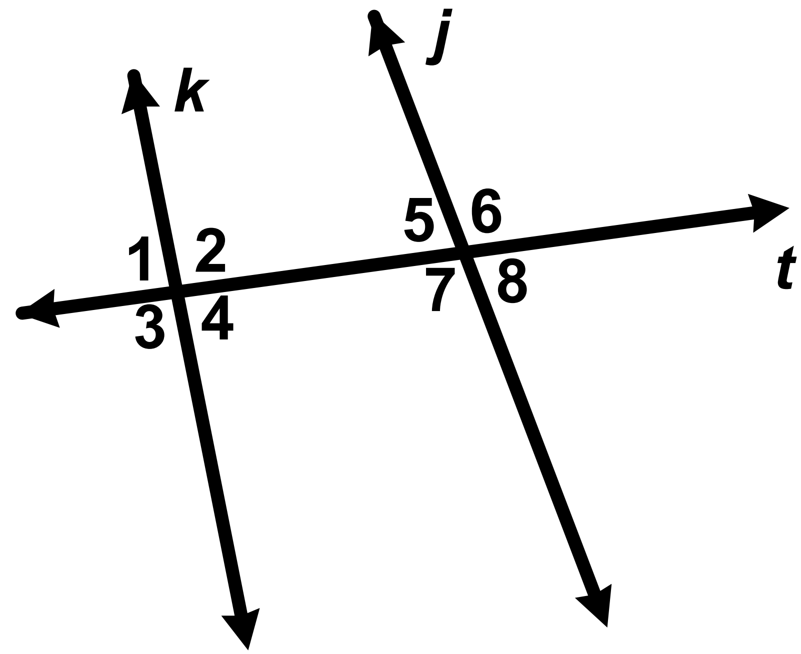
Answer

Linear Pair **Vertical** **Same-Side Exterior** **Alternate Interior**

Corresponding **Same Side Interior** **Alternate Exterior**

20 ∠3 and ∠6 are...

- A Corresponding Angles
- B Alternate Exterior Angles
- C Same-Side Exterior Angles
- D Vertical Angles
- E None of these



20 ∠3 and ∠6 are...

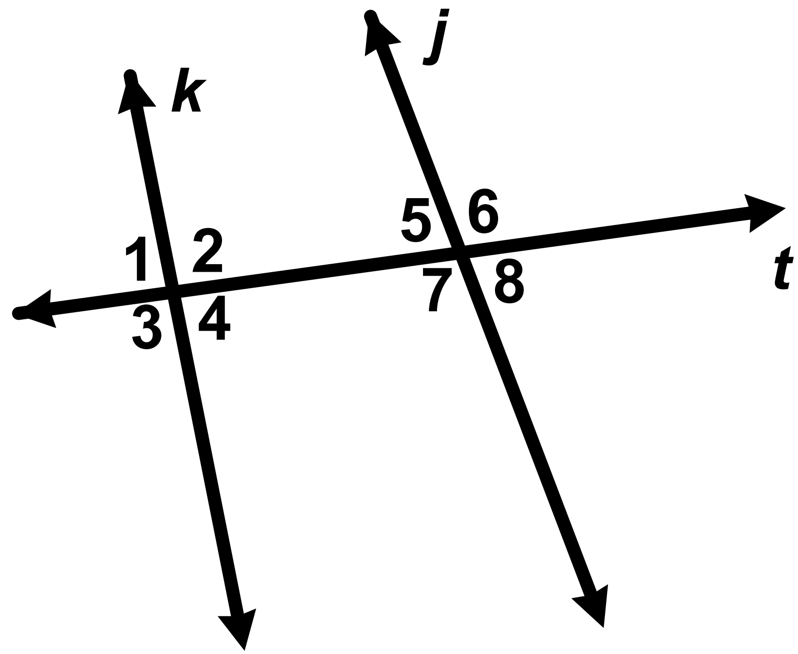
- A Corresponding Angles
- B Alternate Exterior Angl
- C Same-Side Exterior Ar
- D Vertical Angles
- E None of these

Answer

B

21 ∠1 and ∠6 are ____.

- A Corresponding Angles
- B Alternate Exterior Angles
- C Same-Side Exterior Angles
- D Vertical Angles
- E None of these



21 ∠1 and ∠6 are ____.

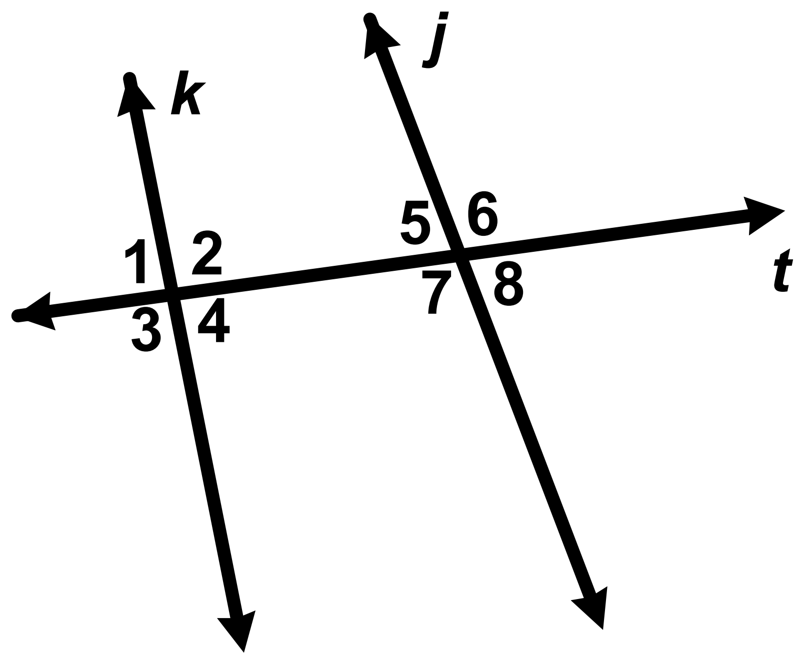
- A Corresponding Angles
- B Alternate Exterior Angl
- C Same-Side Exterior Ar
- D Vertical Angles
- E None of these

Answer

C

22 ∠2 and ∠7 are ____.

- A Corresponding Angles
- B Alternate Interior Angles
- C Same-Side Interior Angles
- D Vertical Angles
- E None of these



22 ∠2 and ∠7 are ____.

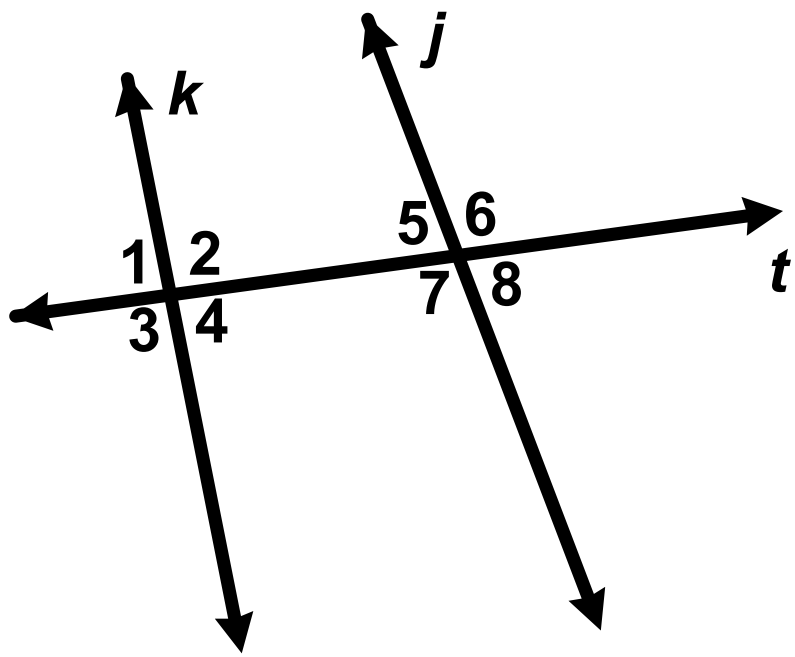
- A Corresponding Angles
- B Alternate Interior Ang
- C Same-Side Interior Ar
- D Vertical Angles
- E None of these

Answer

B

23 ∠4 and ∠8 are ____.

- A Corresponding Angles
- B Alternate Exterior Angles
- C Same-Side Exterior Angles
- D Vertical Angles
- E None of these



23 ∠4 and ∠8 are ____.

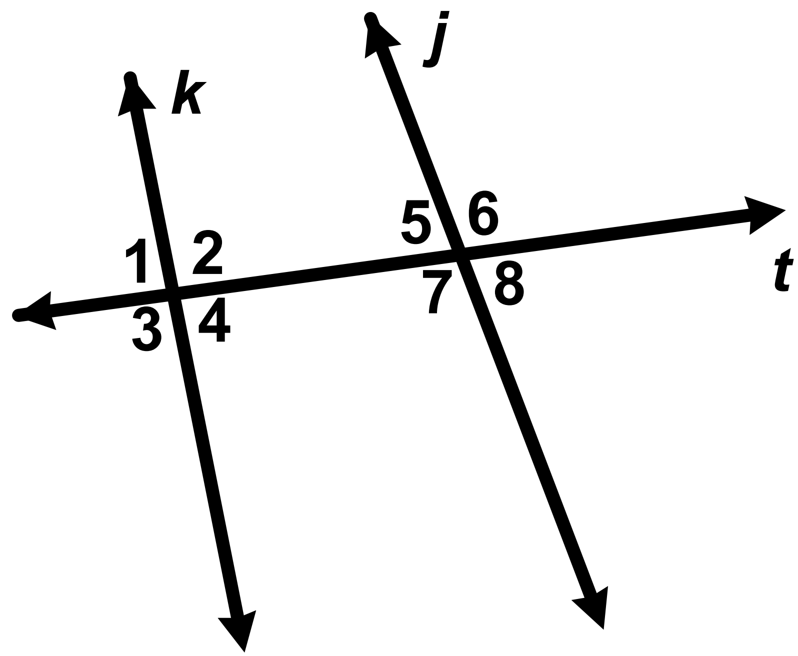
- A Corresponding Angles
- B Alternate Exterior Ang
- C Same-Side Exterior A
- D Vertical Angles
- E None of these

Answer

A

24 ∠1 and ∠7 are ____.

- A Corresponding Angles
- B Alternate Exterior Angles
- C Same-Side Exterior Angles
- D Vertical Angles
- E None of these



24 ∠1 and ∠7 are ____.

- A Corresponding Angl
- B Alternate Exterior
- C Same-Side Exter
- D Vertical Angles
- E None of these

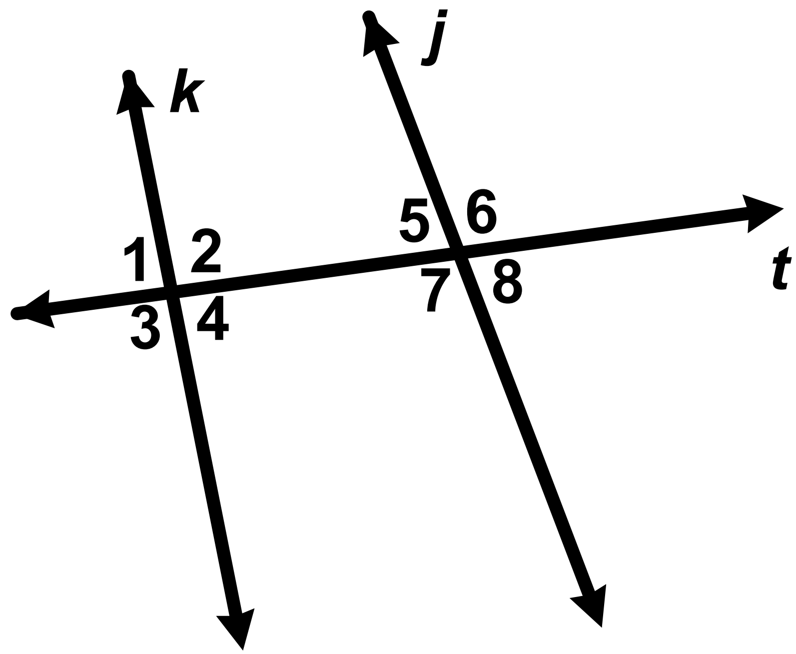
Answer

E
These angles have no relationship w/ one another

t

25 ∠5 and ∠8 are ____.

- A Corresponding Angles
- B Alternate Exterior Angles
- C Same-Side Exterior Angles
- D Vertical Angles
- E None of these



25 ∠5 and ∠8 are ____.

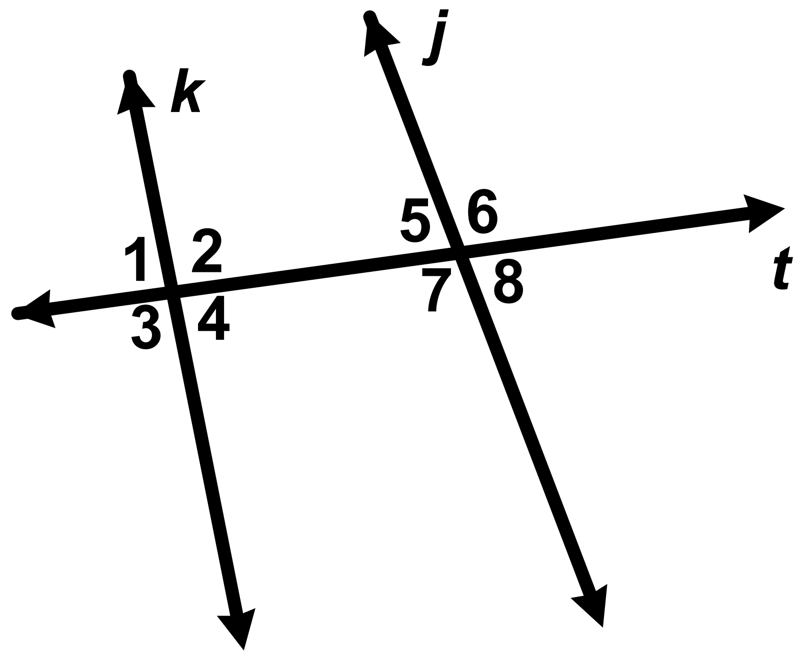
- A Corresponding Angles
- B Alternate Exterior An
- C Same-Side Exterior A
- D Vertical Angles
- E None of these

Answer

D

26 ∠2 and ∠5 are _____.

- A Corresponding Angles
- B Alternate Interior Angles
- C Same-Side Interior Angles
- D Vertical Angles
- E None of these



26 ∠2 and ∠5 are ____.

- A Corresponding Angles
- B Alternate Interior Ang
- C Same-Side Interior A
- D Vertical Angles
- E None of these

Answer

C

Parallel Lines & Proofs

Lab: Starting a Business - Worksheet

Lab: Starting a Business - Teacher Slides

Return to Table of Contents

Paral

Lab: S

Lab: Sta

Math Practice

This lab addresses MP1, MP3, MP4, MP6 & MP7

Return to Table of Contents

Properties of Congruence and Equality

In addition to the postulates and theorems used so far, there are three essential properties of congruence upon which we will rely as we proceed.

There are also four properties of equality, three of which are closely related to matching properties of congruence.

Properties of Congruence and Equality

They all represent the sort of common sense that Euclid would have described as a Common Understanding, and which we would now call an Axiom.

The congruence properties are true for all congruent things: line segments, angles and figures.

The equality properties are true for all measures of things including lengths of lines and measures of angles.

Reflexive Property of Congruence

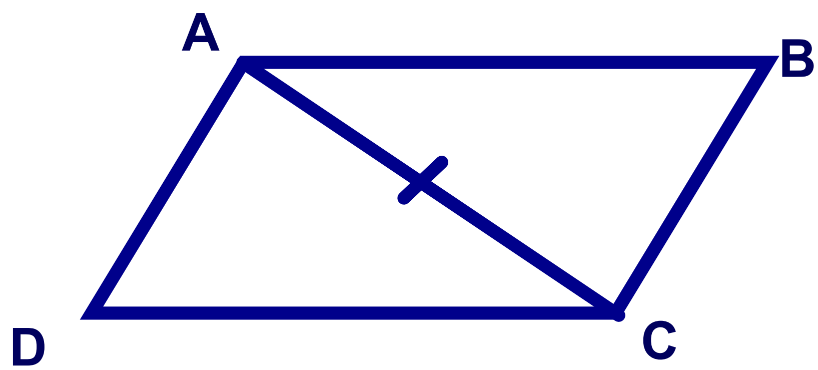
A thing is always congruent to itself.

While this is obvious, it will be used in proving theorems as a reason.

For instance, when a line segment serves as a side in two different triangles, you can state that the sides of those triangles are congruent with the reason:

Reflexive Property of Congruence

In the diagram, $\overline{AC} \cong \overline{AC}$

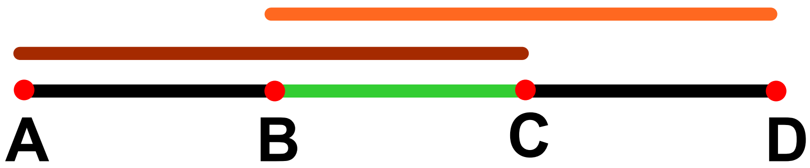


Reflexive Property of Equality

The measures of angles or lengths of sides can be taken to be equal to themselves, even if they are parts of different figures,

with the reason:

Reflexive Property of Equality



The Line Segment Addition Postulate tell us that

AC = AB + **BC** and BD = CD + **BC**

The Reflexive Property of Equality indicates that the length BC is equal to itself in both equations

Symmetric Property of Congruence

If one thing is congruent to another, the second thing is also congruent to the first.

Again, this is obvious but allows you to reverse the order of the statements about congruent properties with the reason:

Symmetric Property of Congruence

For example:

∠ABC is congruent to ∠DEF that ∠DEF is congruent to ∠ABC,

Symmetric Property of Equality

If one thing is equal to another, the second thing is also equal to the first.

Again, this is obvious but allows you to reverse the order of the statements about equal properties with the reason:

Symmetric Property of Equality

For example:

If m∠ABC = m∠DEF, then m∠DEF = m∠ABC,

Transitive Property of Congruence

If two things are congruent to a third thing, then they are also congruent to each other.

So, if ΔABC is congruent to ΔDEF and ΔLMN is also congruent to ΔDEF, then we can say that ΔABC is congruent to ΔLMN due to the

With the reason:

Transitive Property of Congruence

Transitive Property of Equality

If two things are equal to a third thing, then they are also equal to each other.

If m∠A = m∠B and m∠C = m∠B, then m∠A = m∠C

This is identical to the transitive property of congruence except it deals with the measure of things rather than the things.

Transitive Property of Equality

Substitution Property of Equality

If one thing is equal to another, then one can be substituted for another.

This is a common step in a proof where one thing is proven equal to another and replaces that other in an expression using the reason:

Substitution Property of Equality

For instance if $x + y = 12$, and $x = 2y$

We can substitute 2y for x to get

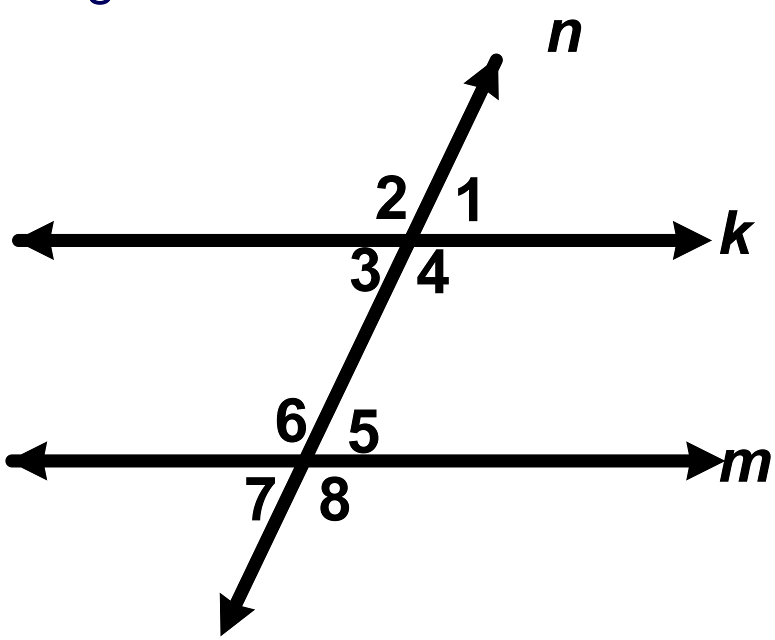
$$2y + y = 12$$

and use the division property to get $y = 4$

Corresponding Angles Theorem

If parallel lines are cut by a transversal, then the corresponding angles are congruent.

According to the Corresponding Angles which of the above angles are congruent?



Corresponding Angles Theorem

If parallel lines are ... onding angles

According to the Corresponding ... which of the abo... angles are cong...

Answer

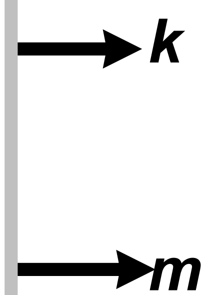
According to Corresponding Angles Postulate the following angles are congruent:

∠1 ≅ ∠5

∠2 ≅ ∠6

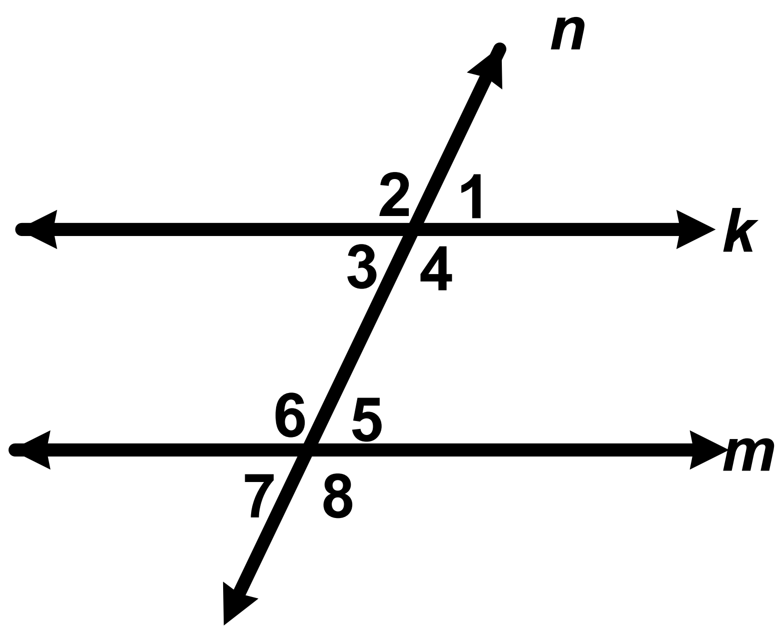
∠3 ≅ ∠7

∠4 ≅ ∠8



Corresponding Angles Proof

To keep the argument clear, let's just prove one pair of those angles equal here. You can follow the same approach to prove the other three pairs of angles equal.



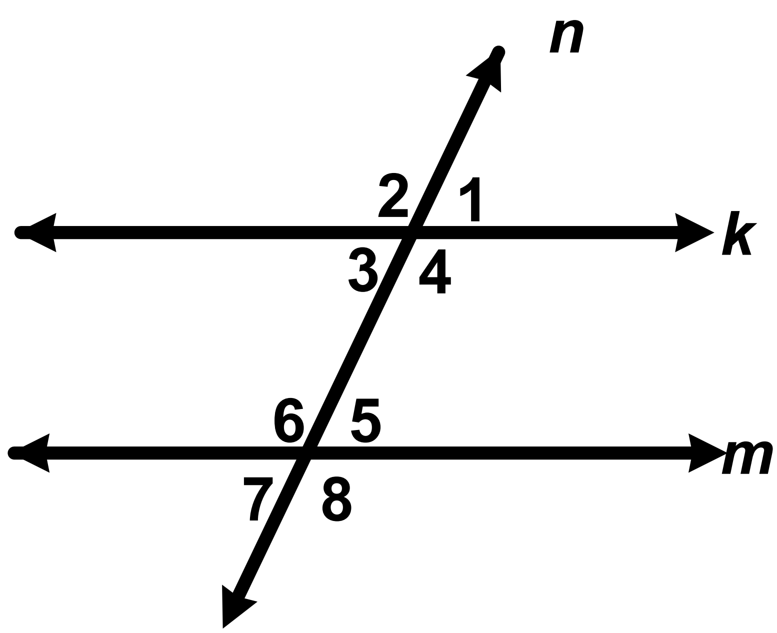
We could pick any pair of corresponding angles: ∠2 & ∠6; ∠3 & ∠7; ∠1 & ∠5; or ∠4 & ∠8.

Together, let's prove that ∠2 & ∠6 are congruent.

Corresponding Angles Proof

Given: Line *m* and Line *k* are parallel and intersected by line *n*

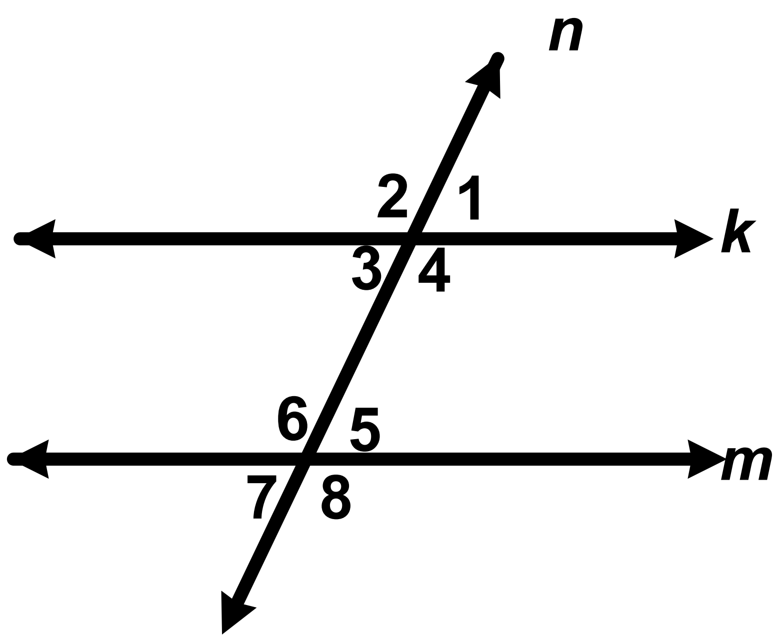
Prove: m∠2 = m∠6



Corresponding Angles Proof

Given: Line *m* and Line *k* are parallel and intersected by line *n*

Prove: m∠2 = m∠6



Statement 1

Line *m* and Line *k* are parallel and intersected by line *n*

Corresponding Angles Proof

Given: Line *m* and L
parallel and intersec
line *n*

Prove: m∠2 = m∠6

Math Practice

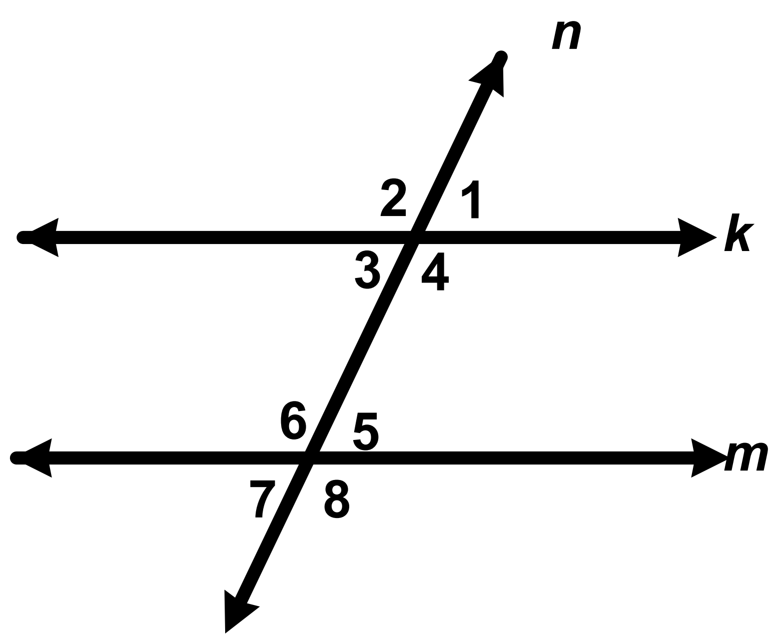
MP7
Emphasize that the 1st step to any proof is stating the "Givens". Then, one uses the properties of the 1st statement to ask questions and continue to solve the proof.

<u>Statement 1</u>
Line *m* and Line *k* are parallel and intersected by line *n*

Corresponding Angles Proof

Given: Line *m* and Line *k* are parallel and intersected by line *n*

Prove: m∠2 = m∠6



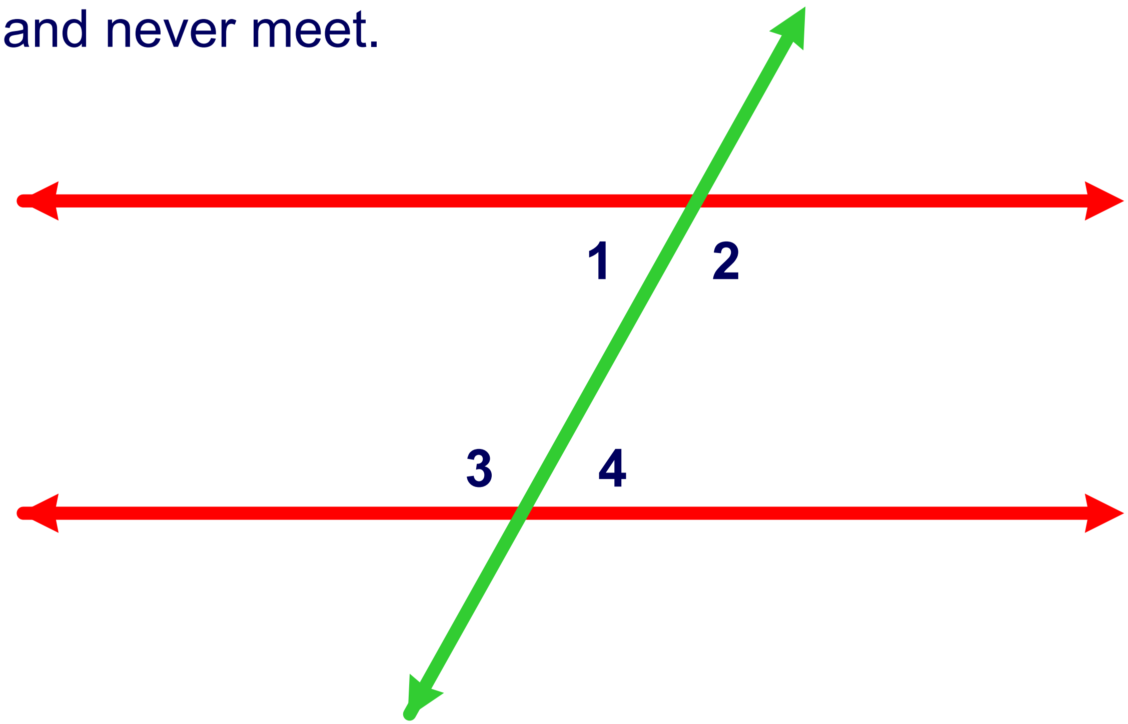
Remember Euclid's Fifth Postulate. The one that no one likes but which they need. This is where it's needed.

Euclid's Fifth Postulate

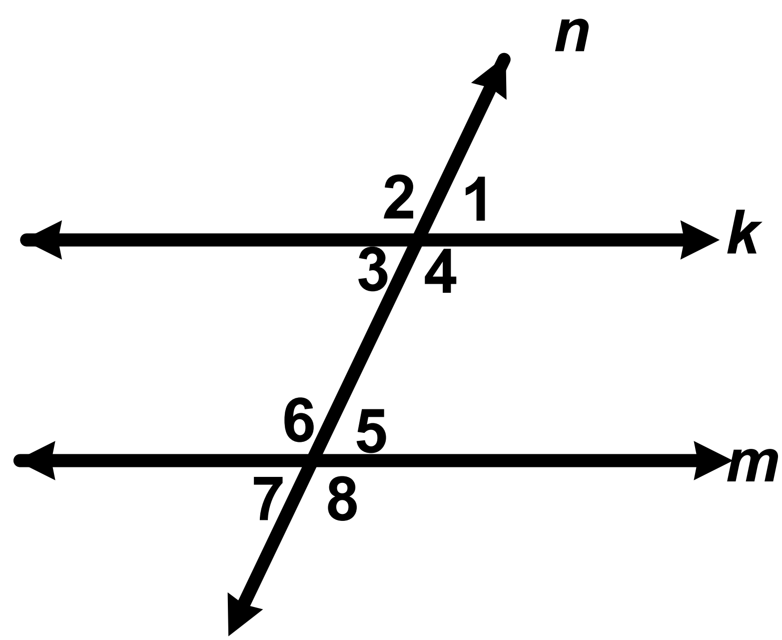
Euclid's Fifth Postulate

Recall that we learned early in this unit that this means that...

If the pairs of interior angles on both sides of the transversal, (both ∠1 & ∠3 or ∠2 & ∠4) each add up to 180º, the two red lines are parallel...and never meet.



27 So, in this case, which angles must add up to 180º based on Euclid's Fifth Postulate?



- ☐ ∠1 & ∠4
- ☐ ∠6 & ∠8
- ☐ ∠4 & ∠5
- ☐ ∠3 & ∠6
- ☐ All of the above

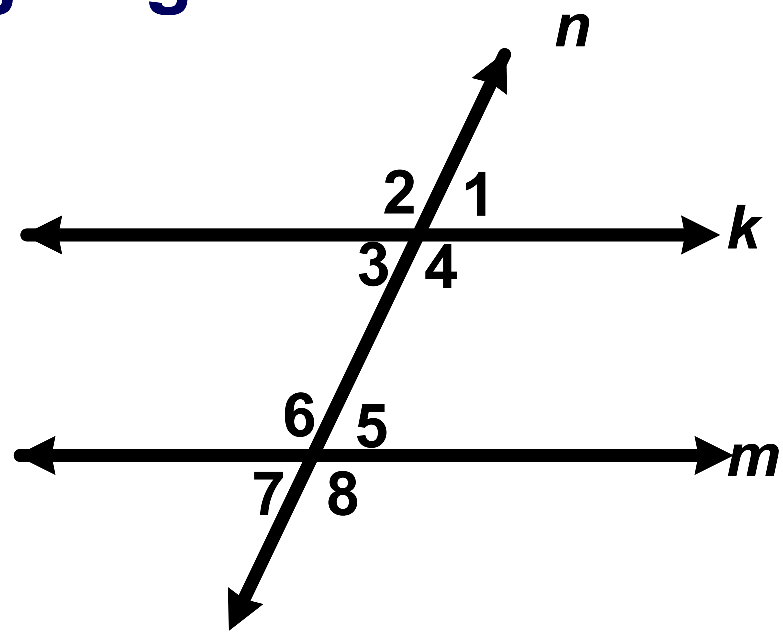
27 So, in this case, which angles must add up to 180º based on Euclid's Fifth P

- ∠1 & ∠4
- ∠6 & ∠8
- ∠4 & ∠5
- ∠3 & ∠6
- All of the above

Answer

C & D

Corresponding Angles Proof



Given: Line *m* and Line *k* are parallel and intersected by line *n*

Prove: m∠2 = m∠6

= 180

When angles sum to 180º, what type of angles are they?

Corresponding Angles Proof

n

Given: Line *m* and Lin
parallel and intersecte
line *n*

k

Prove: m∠2 = m∠6

m

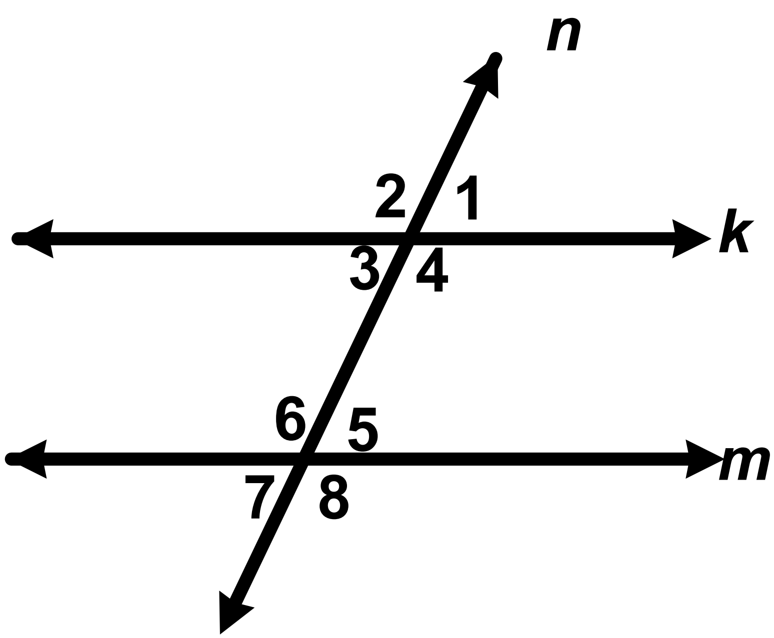
Math Practice

Questions on this slide address MP2 & MP3.

= 180

When angles sum to 180º, what type of angles are they?

Corresponding Angles Proof



Given: Line *m* and Line *k* are parallel and intersected by line *n*

Prove: m∠2 = m∠6

Which other angle is supplementary to ∠3, because together they form a straight angle? How about to angle ∠6?

Corresponding Angles Proof

Given: Line *m* and Line
parallel and intersected
line *n*

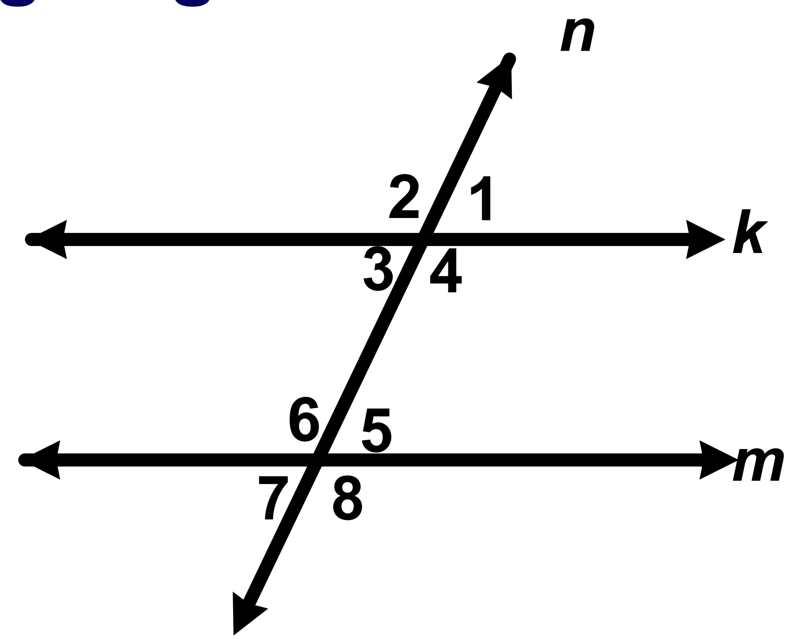
Prove: m∠2 = m∠6

Math Practice

Questions on this slide address MP2 & MP3.

Which other angle is supplementary to ∠3, because together they form a straight angle? How about to angle ∠6?

Corresponding Angles Proof



Given: Line *m* and Line *k* are parallel and intersected by line *n*

Prove: m∠2 = m∠6

What do we know about angles who have the same supplements?

Corresponding Angles Proof

Given: Line *m* and Li
parallel and intersect
line *n*

Prove: m∠2 = m∠6

Math Practice

Questions on this slide address MP2 & MP4.

k

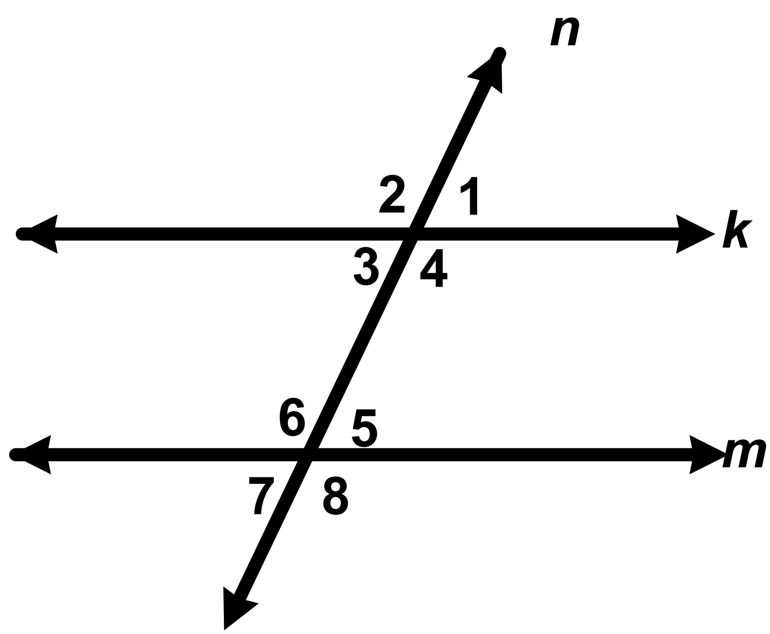
m

What do we know about angles who have the same supplements?

Corresponding Angles Proof

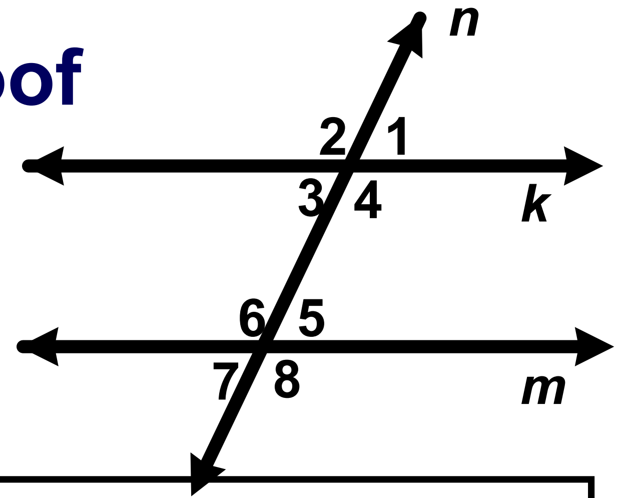
Given: Line *m* and Line *k* are parallel and intersected by line *n*

Prove: m∠2 = m∠6



Reason 5
Two angles supplementary to the same angle are equal

Corresponding Angles Proof



Given: Line *m* and Line *k* are parallel and intersected by Line *n*

Prove: m∠2 = m∠6

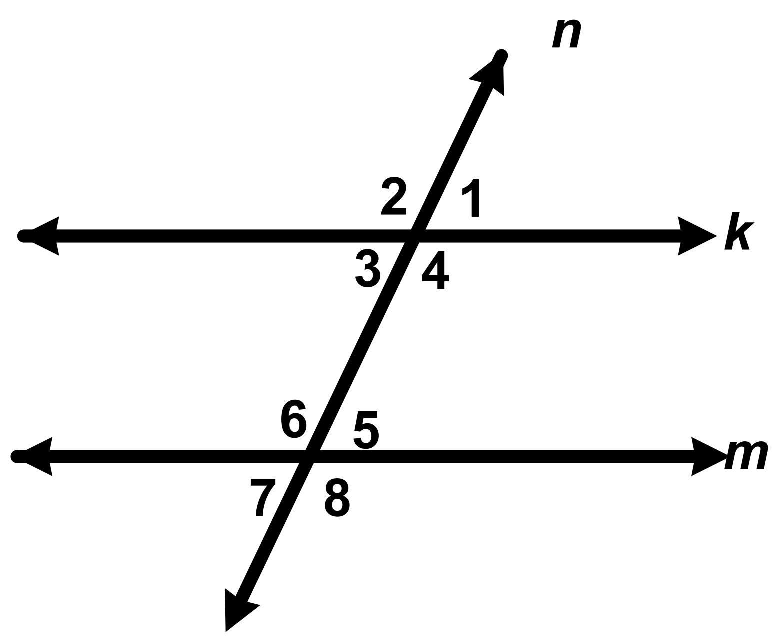
	Statement	Reason
1	Line *m* and Line *k* are parallel and intersected by Line *n*	Given
2		
3	∠4 & ∠5 are supplementary ∠3 & ∠6 are supplementary	Definition of supplementary angles
4	∠3 & ∠2 are supplementary	Angles that form a linear pair are supplementary
5	m∠2 = m∠6	Two angles supplementary to the same angle are equal

Properties of Parallel Lines

This is an important result, which was only made possible by Euclid's Fifth Postulate.

It leads to some other pretty important results. It allows us to prove some pairs of angles congruent and some other pairs of angles supplementary.

And, it works in reverse, if any of these conditions are met we can prove that lines are parallel.



Converses of Parallel Line Proofs

We proved that if two lines are parallel, their corresponding angles are equal.

The converse must also be true:

If two lines are cut by a transversal and the corresponding angles are congruent, then the lines are parallel.

Converses of Parallel Line Proofs

We proved t ... nding

If two lines a ... onding angles are co

Teacher Notes

You might need to explain the difference between an original if-then statement and its converse, which is formed by switching the hypothesis & conclusion.

Ex:

<u>Original:</u> If it is 3pm in New Jersey, then it is 1pm in Colorado.

<u>Converse:</u> If it is 1pm in Colorado, then it is 3pm in New Jersey.

Converses of Parallel Line Proofs

The same reason: Corresponding Angles of Parallel Lines are Equal is used in each case.

To prove the relationship between certain angles if we know the lines are parallel

OR

To prove that the lines are parallel if we know the relationship between those angles.

Converses of Parallel Line Proofs

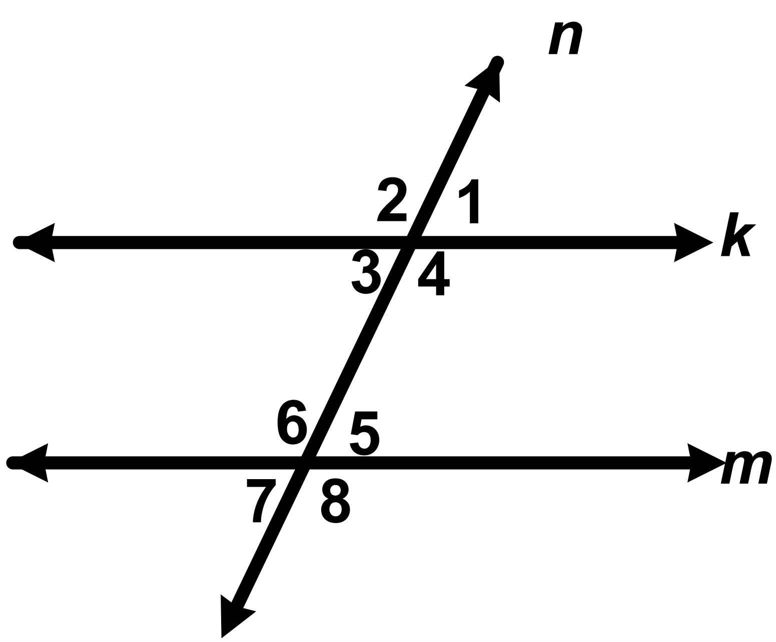
This pattern will be true of each theorem we prove about the angles formed by the transversal intersecting the parallel lines.

They prove the relationship between angles of lines known to be parallel, or they prove that the lines are parallel.

Alternate Interior Angles Theorem

If parallel lines are cut by a transversal, then the alternate interior angles are congruent.

According to the Alternate Interior Angles Theorem which of these angles are congruent?



Alternate Interior Angles Theorem

If parallel lines are cut by a transversal, then the alternate interior angles are congruent.

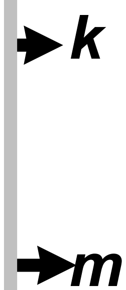
According to the Alternate Interior A Theorem which a angles are congru

Answer

According to Alternate Interior Angles Theorem the following angles are congruent:

$\angle 3 \cong \angle 5$

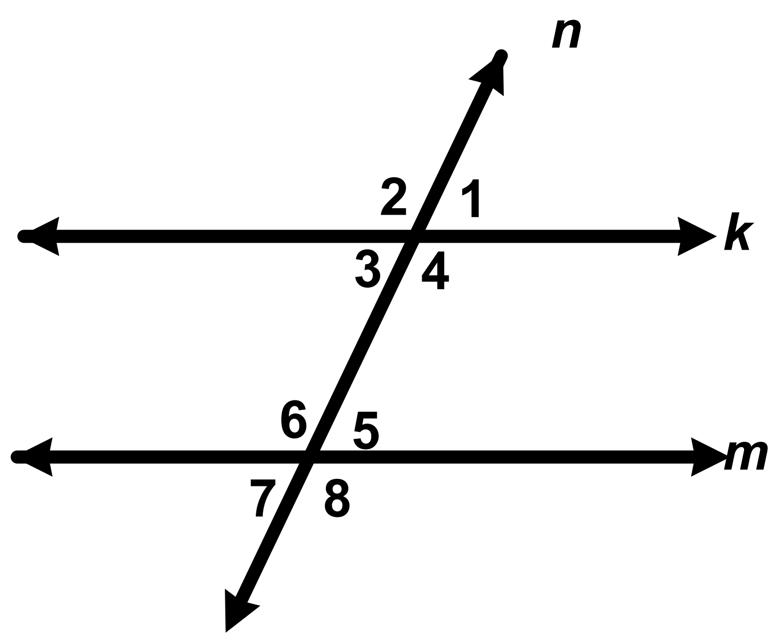
$\angle 4 \cong \angle 6$



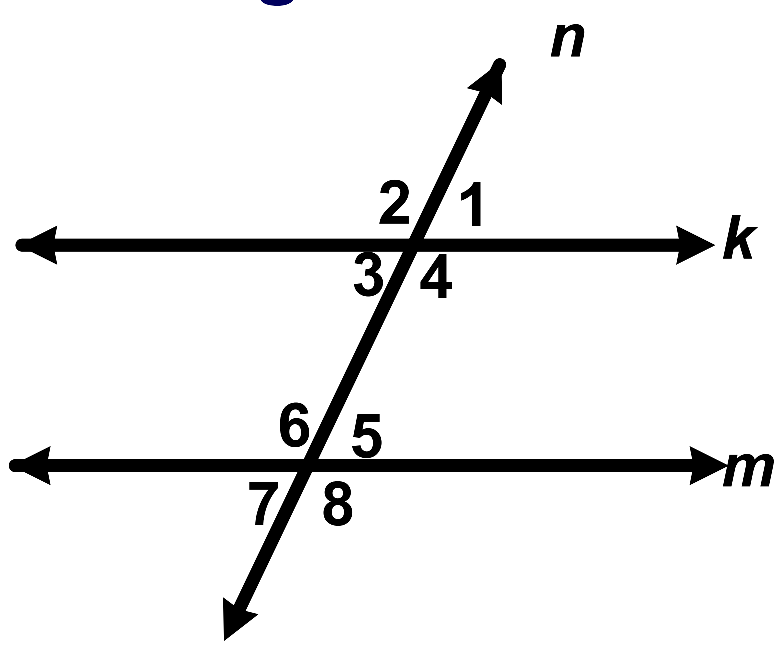
Alternate Interior Angles Proof

Given: Line *m* and Line *k* are parallel and intersected by line *n*

Prove: $\angle 3 \cong \angle 5$ and $\angle 4 \cong \angle 6$



Alternate Interior Angles Proof



Given: Line *m* and Line *k* are parallel and intersected by line *n*

Prove: $\angle 3 \cong \angle 5$ and $\angle 4 \cong \angle 6$

Statement 1

Line *m* and Line *k* are parallel and intersected by line *n*

According to the Corresponding Angles Theorem which of the above angles are congruent?

Alternate Interior Angles Proof

Given: Line *m* and Line
parallel and intersected
line *n*

Prove: ∠3 ≅ ∠5 and ∠4

Math Practice

Question on this slide addresses MP3 & MP6.

n

Statement 1

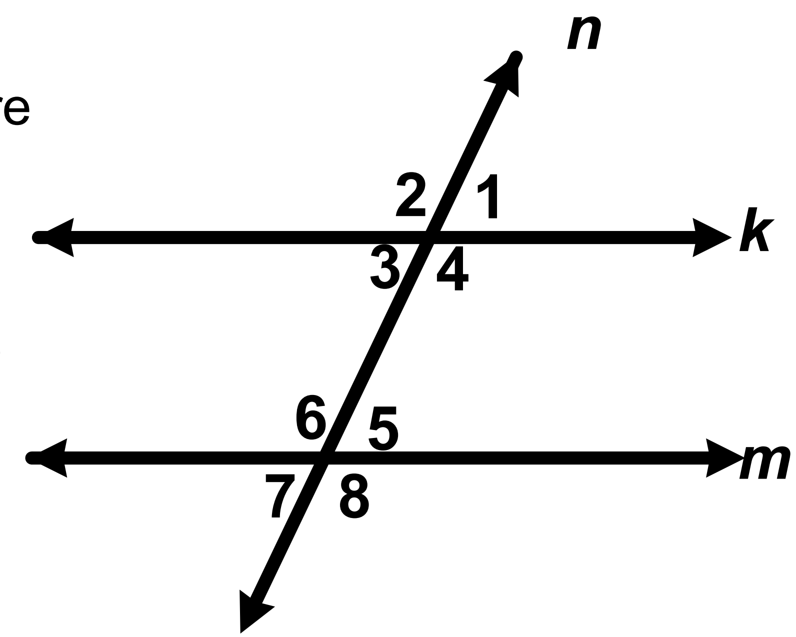
Line *m* and Line *k* are p
and intersected by line *n*

According to the Corresponding Angles Theorem which of the above angles are congruent?

Alternate Interior Angles Proof

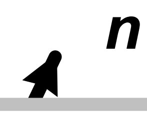
Given: Line *m* and Line *k* are parallel and intersected by line *n*

Prove: ∠3 ≅ ∠5 and ∠4 ≅ ∠6



Which other angle is congruent to ∠1? Which other angle is congruent to ∠2? Why are these angles congruent?

Alternate Interior Angles Proof



Given: Line *m* and Line *k* are parallel and intersected by line *n*

Prove: ∠3 ≅ ∠5 and ∠

Math Practice

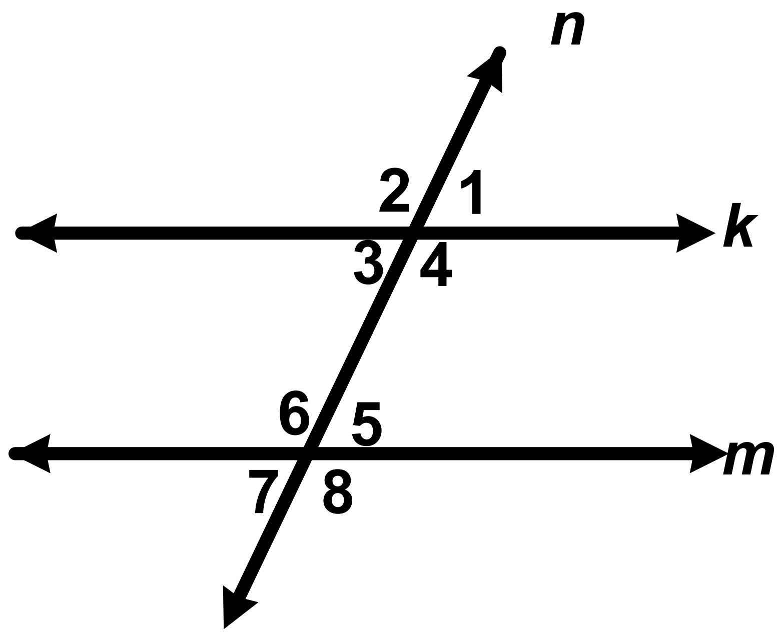
Questions on this slide address MP3, MP6 & MP7.

Which other angle is congruent to ∠1? Which other angle is congruent to ∠2? Why are these angles congruent?

Alternate Interior Angles Proof

Given: Line *m* and Line *k* are parallel and intersected by line *n*

Prove: ∠3 ≅ ∠5 and ∠4 ≅ ∠6



What do we know about angles that are congruent to the same angle? Explain your answer.

Alternate Interior Angles Proof

n

Given: Line *m* and Lin
parallel and intersecte
line *n*

k

Prove: ∠3 ≅ ∠5 and ∠

Math Practice

Questions on this slide address MP2, MP3 & MP6.

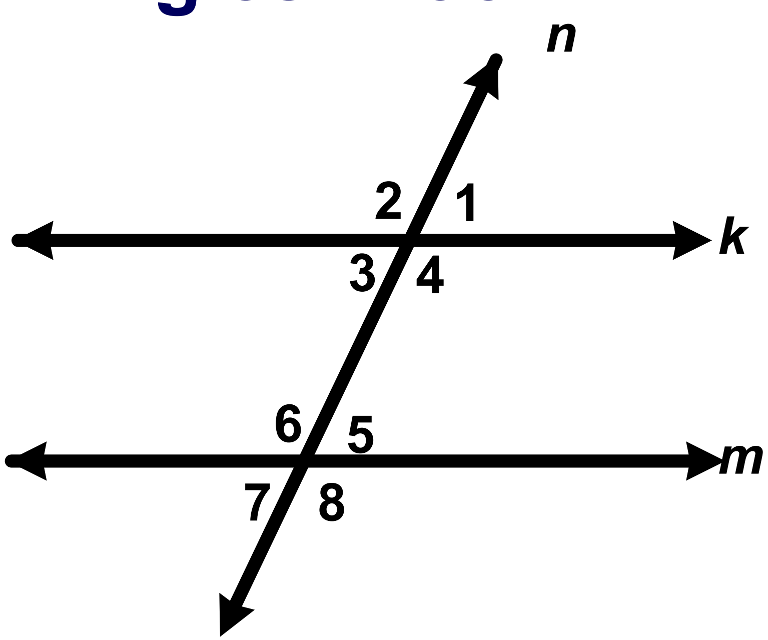
m

What do we know about angles that are congruent to the same angle? Explain your answer.

Alternate Interior Angles Proof

Given: Line *m* and Line *k* are parallel and intersected by line *n*

Prove: $\angle 3 \cong \angle 5$ and $\angle 4 \cong \angle 6$



Statement 4

$\angle 3 \cong \angle 5$

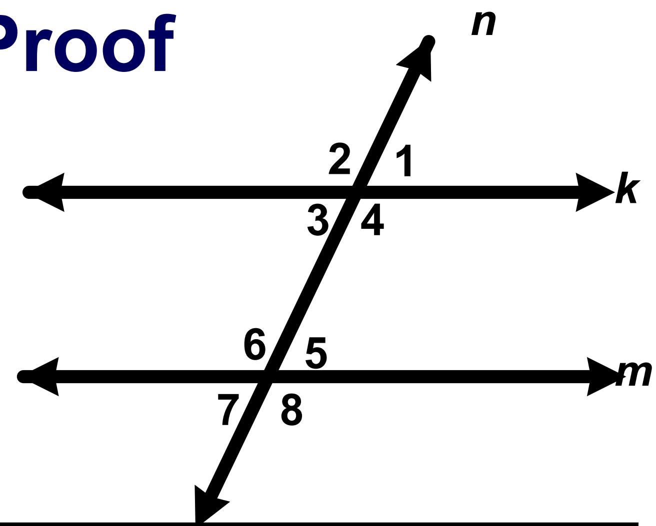
$\angle 4 \cong \angle 6$

Reason 4

Transitive property of congruence

But those are the pairs of alternate interior angles which we set out to prove are congruent. So, our proof is complete: Alternate Interior Angles of Parallel Lines are Congruent

Alternate Interior Angles Proof



Given: Line *m* and Line *k* are parallel and intersected by Line *n*

Prove: ∠3 ≅ ∠5
∠4 ≅ ∠6

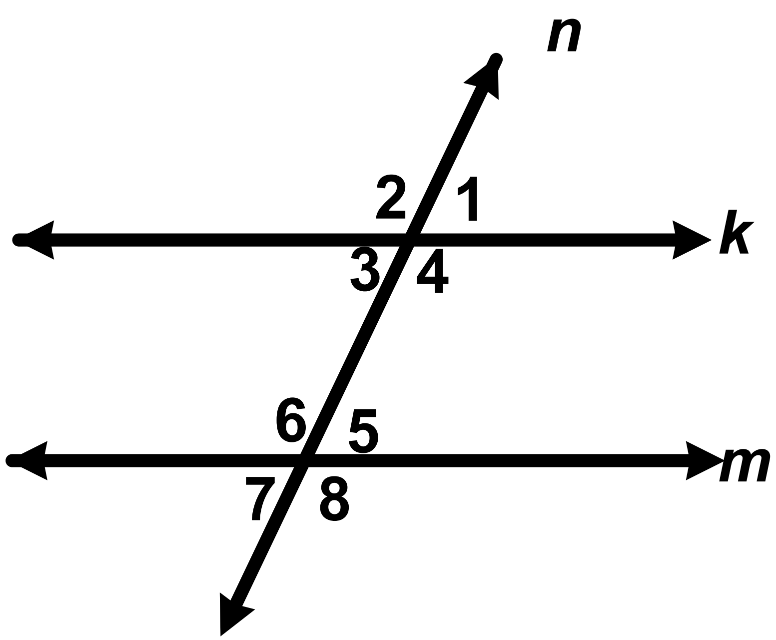
	Statement	**Reason**
1	Line *m* and Line *k* are parallel and intersected by Line *n*	Given
2	∠1 ≅ ∠5 and ∠2 ≅ ∠6	If two parallel lines are cut by a transversal, then the corresponding angles are ≅
3	∠1 ≅ ∠3 and ∠2 ≅ ∠4	Vertical Angles are ≅
4	∠3 ≅ ∠5 and ∠4 ≅ ∠6	Transitive Property of Congruence

Converse of Alternate Interior Angles Theorem

If two lines are cut by a transversal and the alternate interior angles are congruent, then the lines are parallel.

Alternate Exterior Angles Theorem

If two parallel lines are cut by a transversal, then the alternate exterior angles are congruent.



According to the Alternate Exterior Angles Theorem which angles are congruent?

Alternate Exterior Angles Theorem

If two parallel
lines are cut b
transversal, th
the alternate
exterior angle
are congruent

Answer

According to Alternate Exterior Angles Theorem the following angles are congruent:

∠1 ≅ ∠7

∠2 ≅ ∠8

According to the Alternate Exterior Angles Theorem which angles are congruent?

Alternate Exterior Angles Theorem

Since the proof for the Alternate Exterior Angles Theorem is very similar to the Alternate Interior Angles Theorem, you will be completing this proof as a part of your Homework for this lesson.

Converse of Alternate Exterior Angles Theorem

If two lines are cut by a transversal and the alternate exterior angles are congruent, then the lines are parallel.

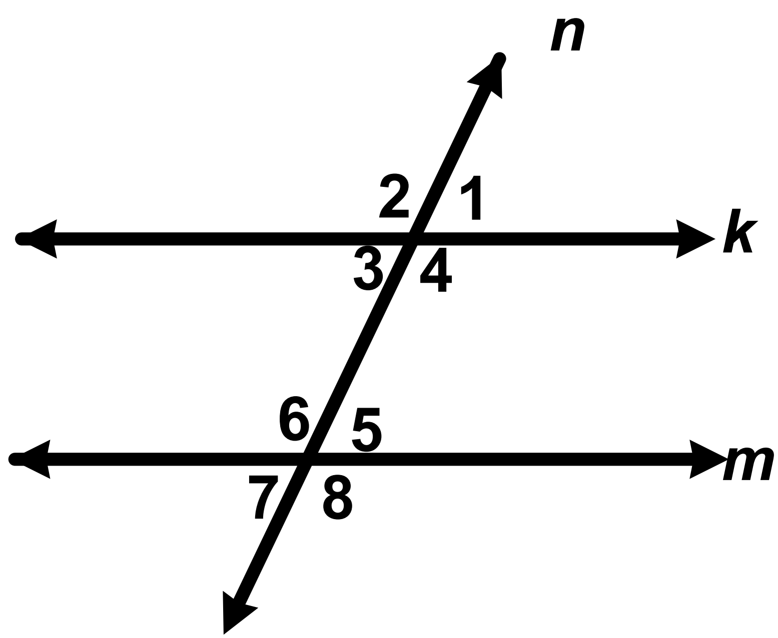
Same-Side Interior Angles Theorem

According to Same-Side Interior Angles Theorem:

$m<3+m<6=180^0$

$m<4+m<5=180^0$

If two parallel lines are cut by a transversal, then the same-side interior angles are supplementary.



According to the Same-Side Interior Angles Theorem which pairs of angles are supplementary?

Same-Side In

If two parallel lines are cut
interior angles are supplem

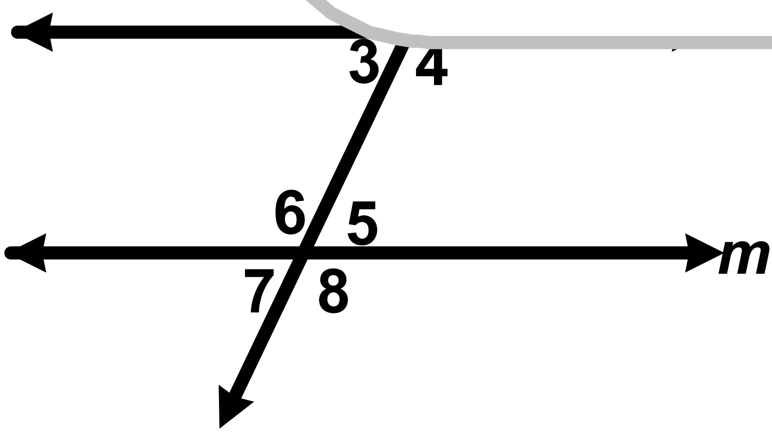
Answer

According to Same-Side Interior
Angles Theorem:

$m<3+m<6=180^{0}$

$m<4+m<5=180^{0}$

Answer

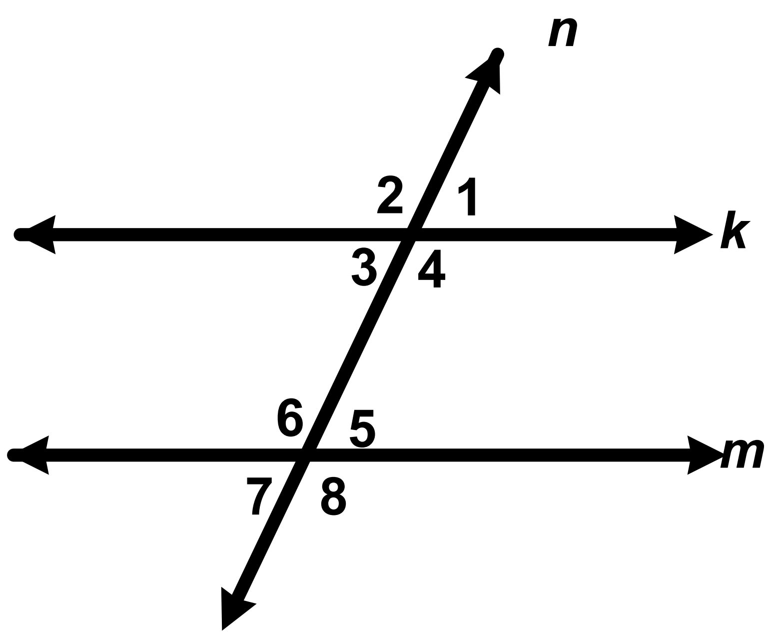


According to the Same-Side Interior Angles Theorem which pairs of angles are supplementary?

Same-Side Interior Angles Proof

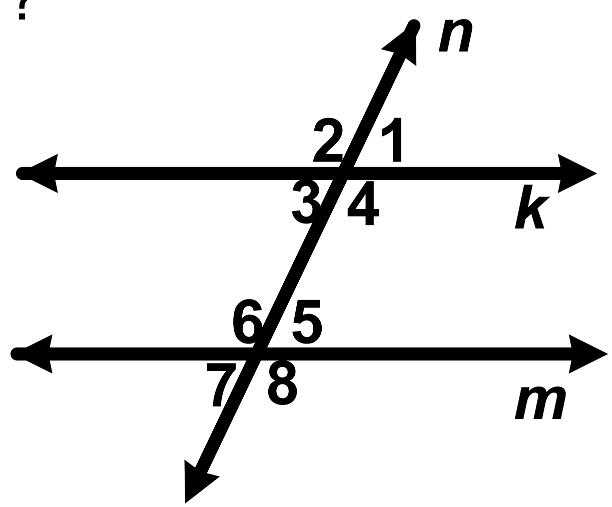
Given: Lines *m* and *k* are parallel and intersected by line *n*

Prove: ∠3 & ∠6 are supplementary and ∠4 & ∠5 are supplementary



28 Which reason applies to step 1?

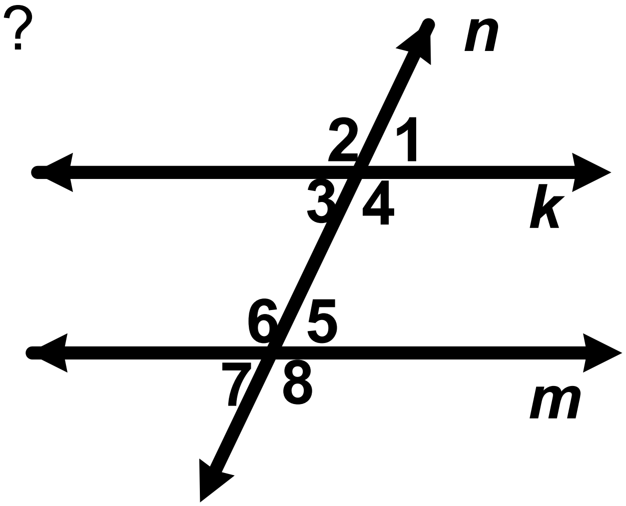
- A Definition of supplementary
- B Euclid's Fifth Postulate
- C Given
- D Alternate Interior ∠s are ≅
- E Corresponding ∠s are ≅



Answer

	Statement	Reason
1	Lines *m* and *k* are parallel and intersected by line *n*	?
2	m∠3 + m∠6 = 180º m∠4 + m∠5 = 180º	?
3	?	Definition of supplementary ∠s

29 Which reason applies to step 2?



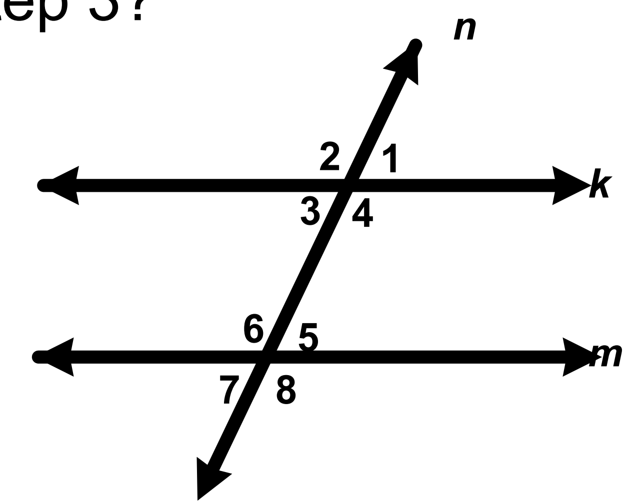
- A Definition of supplementary
- B Euclid's Fifth Postulate
- C Given
- D Alternate Interior ∠s are ≅
- E Corresponding ∠s are ≅

Answer

	Statement	Reason
1	Lines *m* and *k* are parallel and intersected by line *n*	?
2	m∠3 + m∠6 = 180º m∠4 + m∠5 = 180º	?
3	?	Definition of supplementary ∠s

30 Which statement should be in step 3?

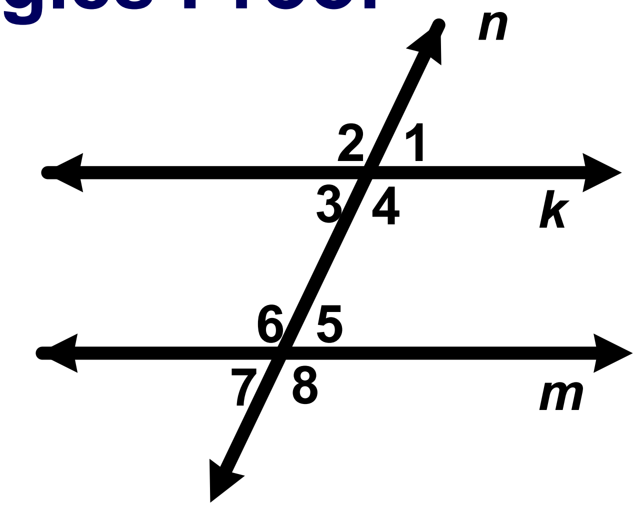
- ☐ A ∠3 and ∠6 are supplementary
- ☐ B ∠6 and ∠5 are supplementary
- ☐ C ∠2 and ∠6 are supplementary
- ☐ D ∠4 and ∠5 are supplementary
- ☐ E ∠3 and ∠5 are supplementary



Answer

	Statement	Reason
1	Line *m* and Line *k* are parallel and intersected by Line *n*	?
2	The sums of m∠3 and m∠6 and of m∠4 and m∠5 are 180º.	?
3	?	Definition of supplementary angles

Same Side Interior Angles Proof



Given: Line *m* and Line *k* are parallel and intersected by Line *n*

Prove: ∠3 & ∠6 are supplementary and ∠4 & ∠5 are supplementary

	Statement	Reason
1	Lines *m* and *k* are parallel and intersected by line *n*	Given
2	m∠3 + m∠6 = 180º m∠4 + m∠5 = 180º	Euclid's Fifth Postulate
3	∠3 and ∠6 are supplementary ∠4 and ∠5 are supplementary	Definition of supplementary ∠s

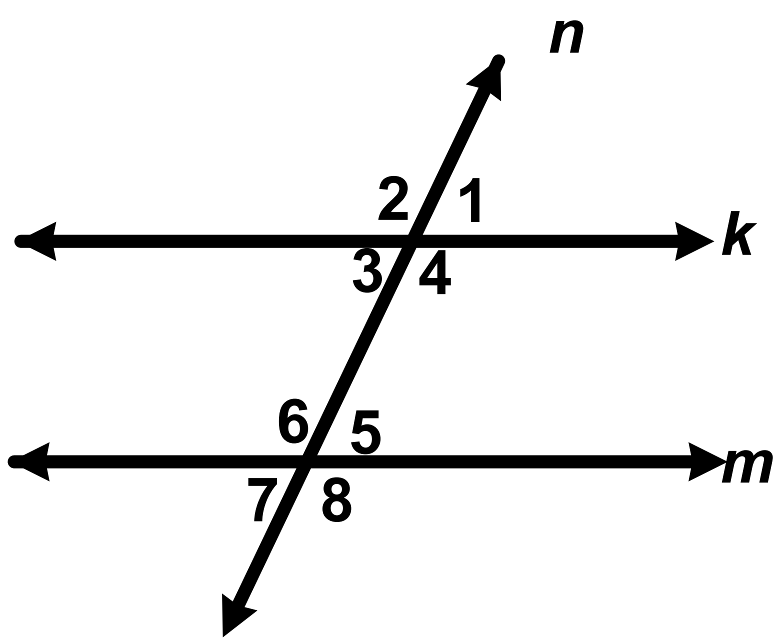
Converse of Same-Side Interior Angles Theorem

If two lines are cut by a transversal and the same-side interior angles are supplementary, then the lines are parallel.

Same-Side Exterior Angles Theorem

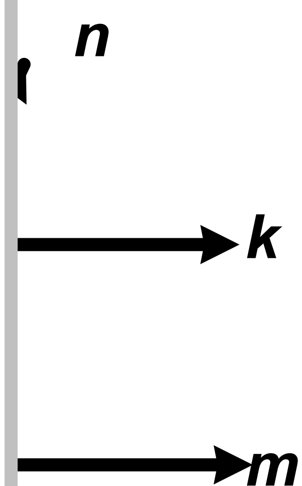
If two parallel lines are cut by a transversal, then the same-side exterior angles are supplementary.

According to the Same-Side Exterior Angles Theorem which angles are supplementary?



Same-Side Exterior Angles Theorem

If two parallel lines are cut by a transversal, then the same-side exterior angles



According t
Side Exterio
Theorem whi
supplementa

Answer

According to Same-Side Exterior Angles Theorem the following angles are supplementary:

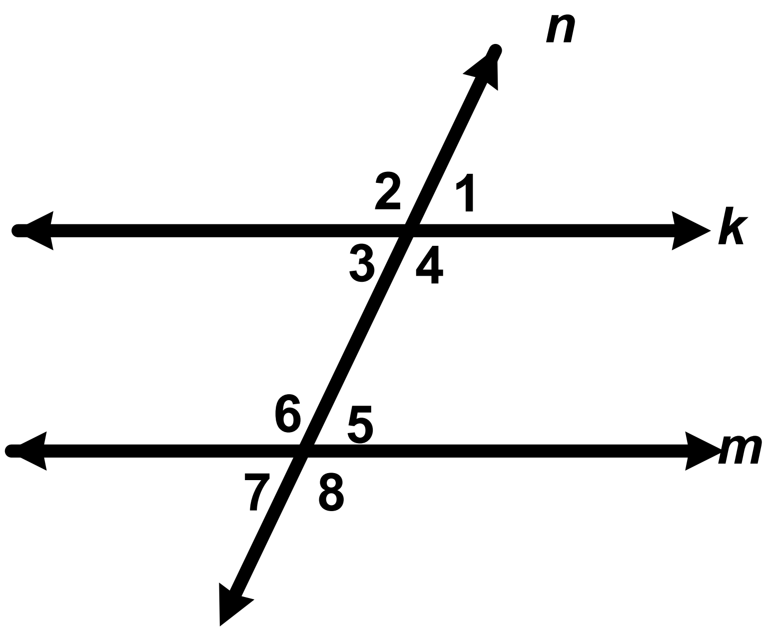
$m\angle 2 + m\angle 7 = 180^\circ$

$m\angle 1 + m\angle 8 = 180^\circ$

Same Side Exterior Angles Proof

Given: Lines *m* and *k* are parallel and intersected by Line *n*

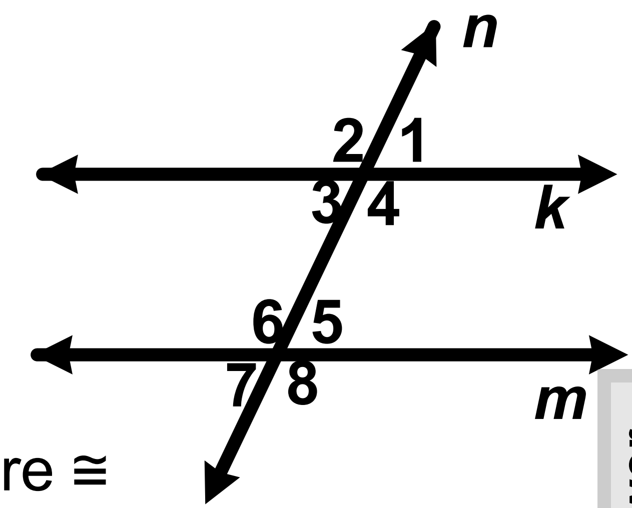
Prove: ∠2 & ∠7 are supplementary



In proving that ∠2 & ∠7 are supplementary we are thereby proving that ∠1 & ∠8 are supplementary as the same arguments apply to both pairs of angles.

31 Which reason applies to step 1?

- A Definition of supplementary ∠s
- B Substitution property of equality
- C Given
- D ∠s that form a linear pair are supplementary
- E ∠s supplementary to the same ∠ are ≅

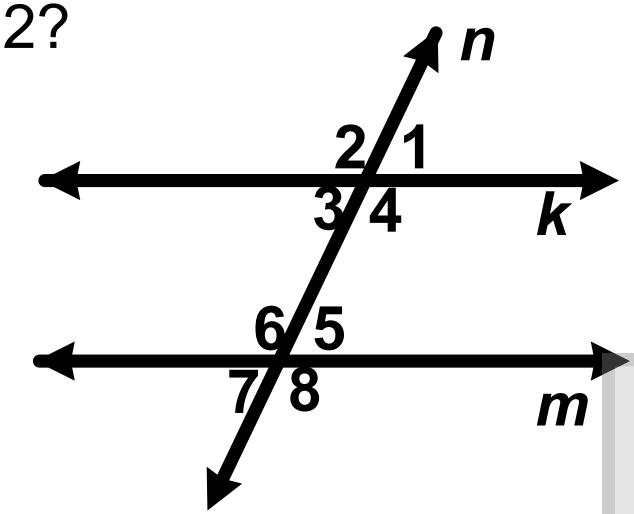


Answer

	Statement	Reason
1	Line *m* and Line *k* are parallel and intersected by Line *n*	?
2	?	Same-side interior angles are supplementary
3	?	Angles that form a linear pair are supplementary
4	∠2 ≅ ∠6 and ∠3 ≅ ∠7	?
5	∠2 & ∠7 are supplementary	?

32 Which statement is made in step 2?

- A ∠2 & ∠1 are supplementary
- B ∠7 & ∠8 are supplementary
- C ∠3 & ∠6 are supplementary
- D ∠4 & ∠5 are supplementary
- E ∠5 & ∠8 are supplementary

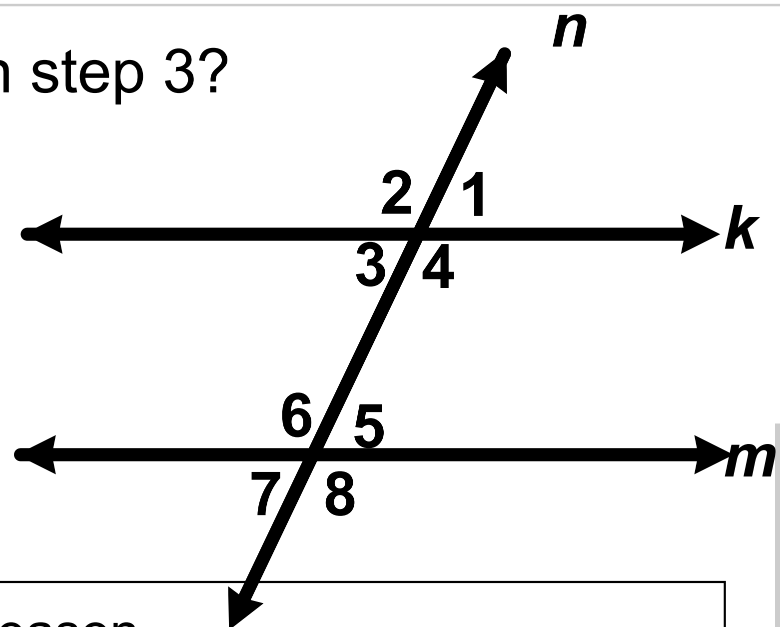


Answer

	Statement	Reason
1	Line *m* and Line *k* are parallel and intersected by Line *n*	?
2	?	Same-side interior angles are supplementary
3	?	Angles that form a linear pair are supplementary
4	∠2 ≅ ∠6 and ∠3 ≅ ∠7	?
5	∠2 & ∠7 are supplementary	?

33 Which statement is made in step 3?

- A ∠2 & ∠3 are supplementary
- B ∠1 & ∠3 are supplementary
- C ∠6 & ∠8 are supplementary
- D ∠6 & ∠7 are supplementary
- E ∠7 & ∠1 are supplementary

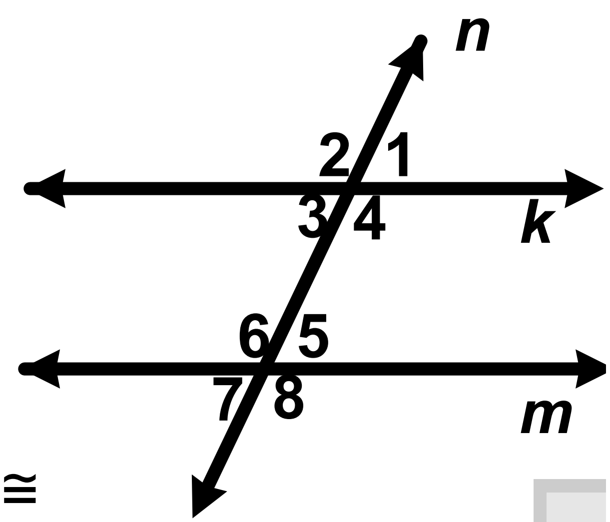


	Statement	Reason
1	Line *m* and Line *k* are parallel and intersected by Line *n*	?
2	?	Same-side interior angles are supplementary
3	?	Angles that form a linear pair are supplementary
4	∠2 ≅ ∠6 and ∠3 ≅ ∠7	?
5	∠2 & ∠7 are supplementary	?

Answer

34 Which reason applies to step 4?

- A Definition of supplementary ∠s
- B Substitution property of equality
- C Given
- D ∠s that form a linear pair are supplementary
- E ∠s supplementary to the same ∠ are ≅



	Statement	Reason
1	Line *m* and Line *k* are parallel and intersected by Line *n*	?
2	?	Same-side interior angles are supplementary
3	?	Angles that form a linear pair are supplementary
4	∠2 ≅ ∠6 and ∠3 ≅ ∠7	?
5	∠2 & ∠7 are supplementary	?

Answer

35 Which reason applies to step 5?

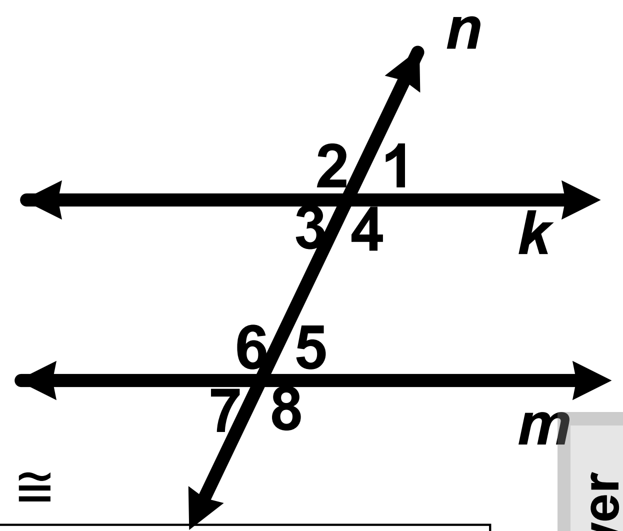
A Definition of supplementary ∠s

B Substitution property of equality

C Given

D Angles that form a linear pair are supplementary

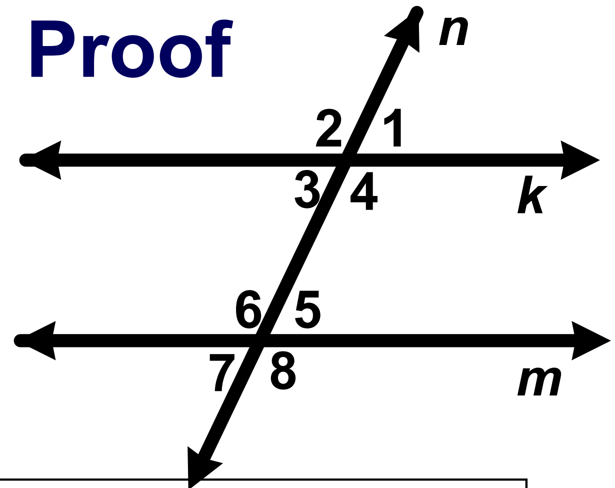
E ∠s supplementary to the same ∠ are ≅



	Statement	Reason
1	Lines *m* and *k* are parallel and intersected by line *n*	?
2	?	Same-side interior angles are supplementary
3	?	Angles that form a linear pair are supplementary
4	∠2 ≅ ∠6 and ∠3 ≅ ∠7	?
5	∠2 & ∠7 are supplementary	?

Answer

Same Side Exterior Angles Proof



Given: Line *m* and Line *k* are parallel and intersected by Line *n*

Prove: ∠2 & ∠7 are supplementary (and thereby that ∠1 & ∠8 are as well)

	Statement	Reason
1	Lines *m* and *k* are parallel and intersected by line *n*	Given
2	∠3 & ∠6 are supplementary	Same-side interior angles are supplementary
3	∠2 & ∠3 are supplementary ∠6 & ∠7 are supplementary	Angles that form a linear pair are supplementary
5	∠2 ≅ ∠6 and ∠3 ≅ ∠7	Angles supplementary to the same angle are congruent
6	∠2 & ∠7 are supplementary	Substitution Property of Equality

Converse of Same Side Exterior Angles Theorem

If two lines are cut by a transversal and the same side exterior angles are supplementary, then the lines are parallel.

Properties of Parallel Lines

Return to Table of Contents

Properties of Parallel Lines

There are several theorems and postulates related to parallel lines. At this time, please go to the lab titled, "Properties of Parallel Lines".

Click here to go to the lab titled, "Properties of Parallel Lines"

Properties of Parallel Lines

There are severa nes. At this time, please s".

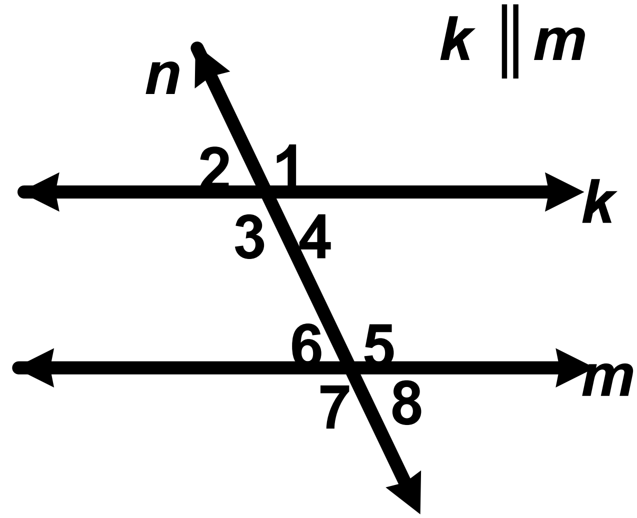
Math Practice

This lab addresses MP1, MP3, MP4, MP5, MP6, MP7 & MP8

Properties of Parallel Lines

Example: If m∠4 = 54º,
find the m∠8.

Explain your answer.



Properties of Parallel Lines

$k \parallel m$

Example: If m∠4

find the m∠8.

Explain your ans

k

m

Answer

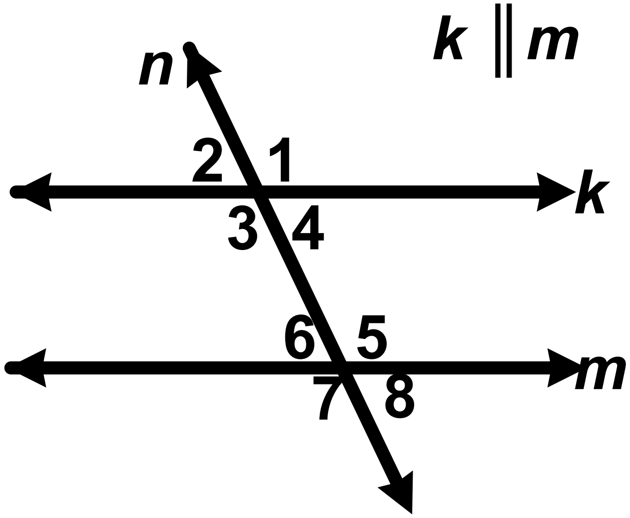
According to Corresponding Angles Postulate

∠4 ≅ ∠8, therefore

m∠8 = 54º.

This example addresses MP1, MP2 & MP3

Properties of Parallel Lines



Example: If m∠3 = 125º, find the m∠5.

Explain your answer.

Properties of Parallel Lines

k ∥ m

Example: If m∠3 =

find the m∠5.

Explain your answ

k

m

Answer

According to the Alternate Interior Angles Theorem,

∠3≅ ∠5.

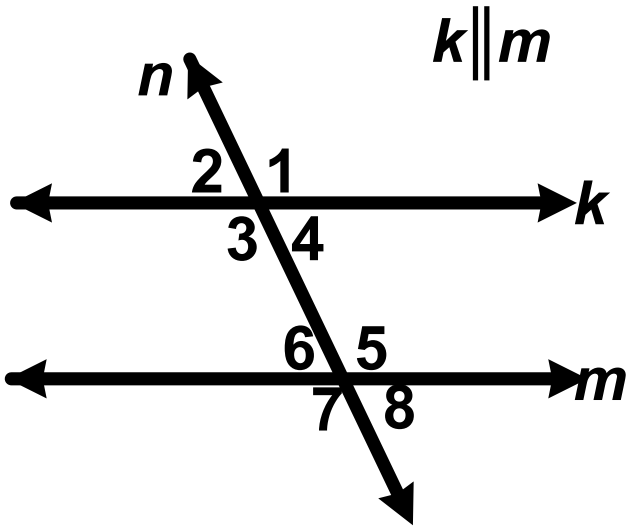
Therefore, m∠5 = 125º.

This example addresses MP1, MP2 & MP3

Properties of Parallel Lines

Example: If m∠2 = 78º,
find the m∠8.

Explain your answer.



Properties of Parallel Lines

Example: If m∠2 =

find the m∠8.

Explain your answ

Answer

According to the Alternate Exterior Angles Theorem,

∠2 ≅ ∠8.

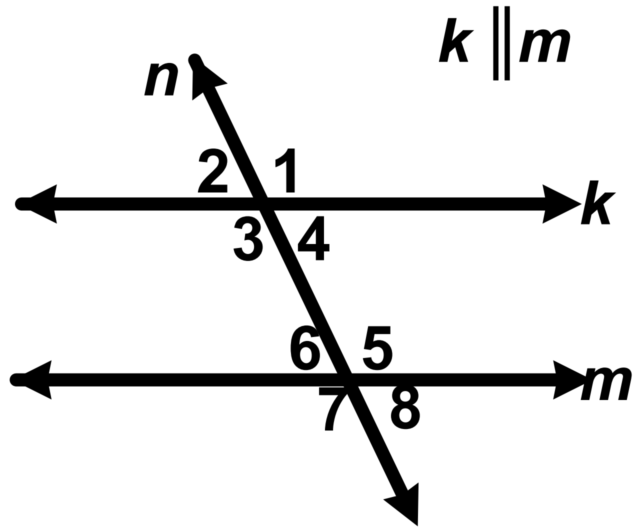
Therefore, m∠8 = 78º

This example addresses MP1, MP2 & MP3

Properties of Parallel Lines

Example: If m∠3 = 163º, find m∠6.

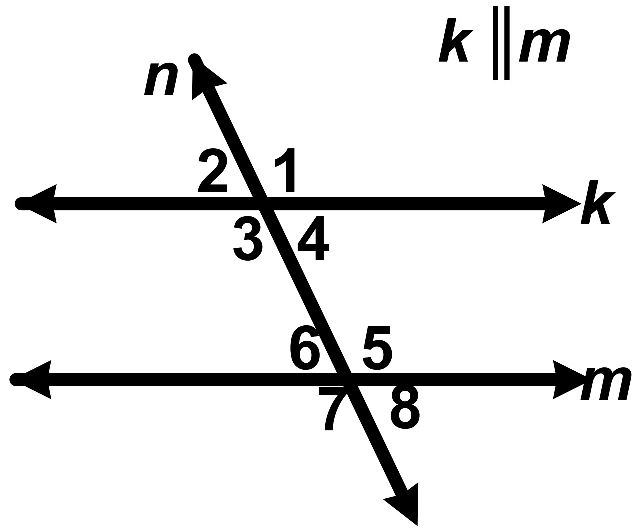
Explain your answer.



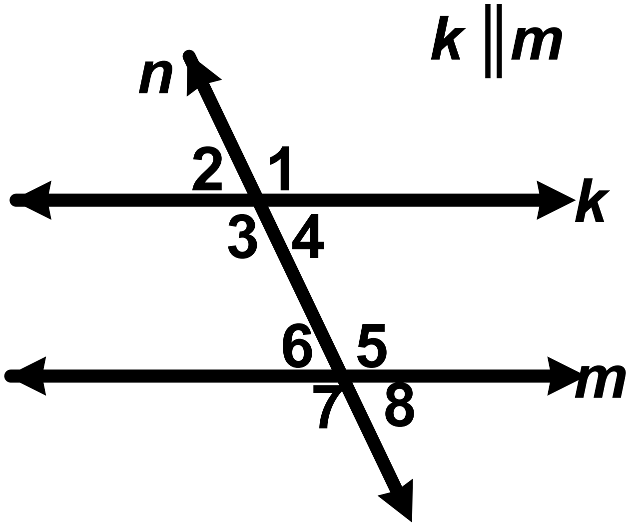
Properties of Parallel Lines

Example: If m∠3 = 163º, find m∠6.

Explain your answer.

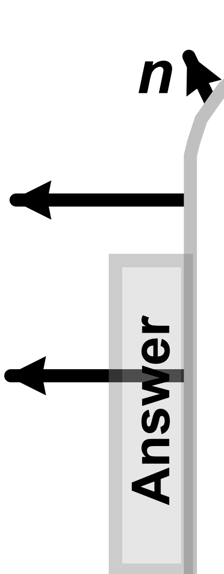


Properties of Parallel Lines



Name all of the angles congruent to ∠1.

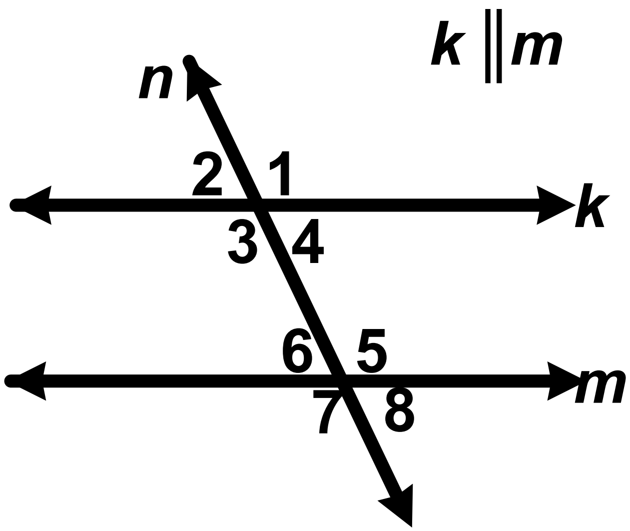
Properties of Parallel Lines



$\angle 1 \cong \angle 3 \cong \angle 5 \cong \angle 7$

Name a

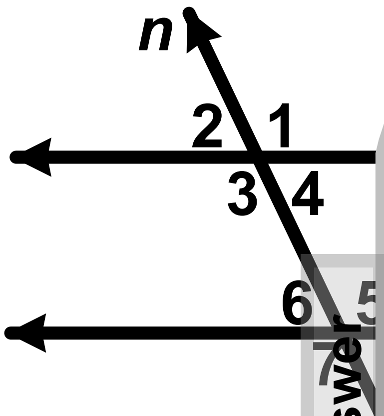
Properties of Parallel Lines



Name all of the angles supplementary to ∠1.

Properties of Parallel Lines

$k \parallel m$



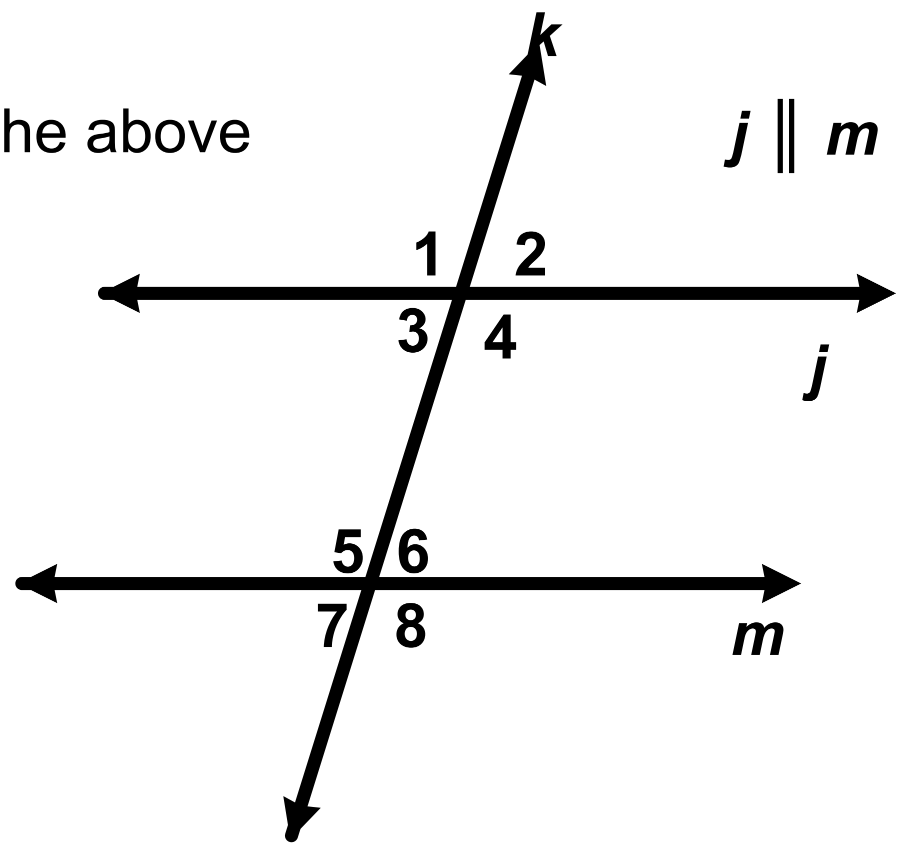
Answer

$\angle 1$ is supplementary to angles:
$\angle 2$, $\angle 4$, $\angle 6$, and $\angle 8$.

Name all of the

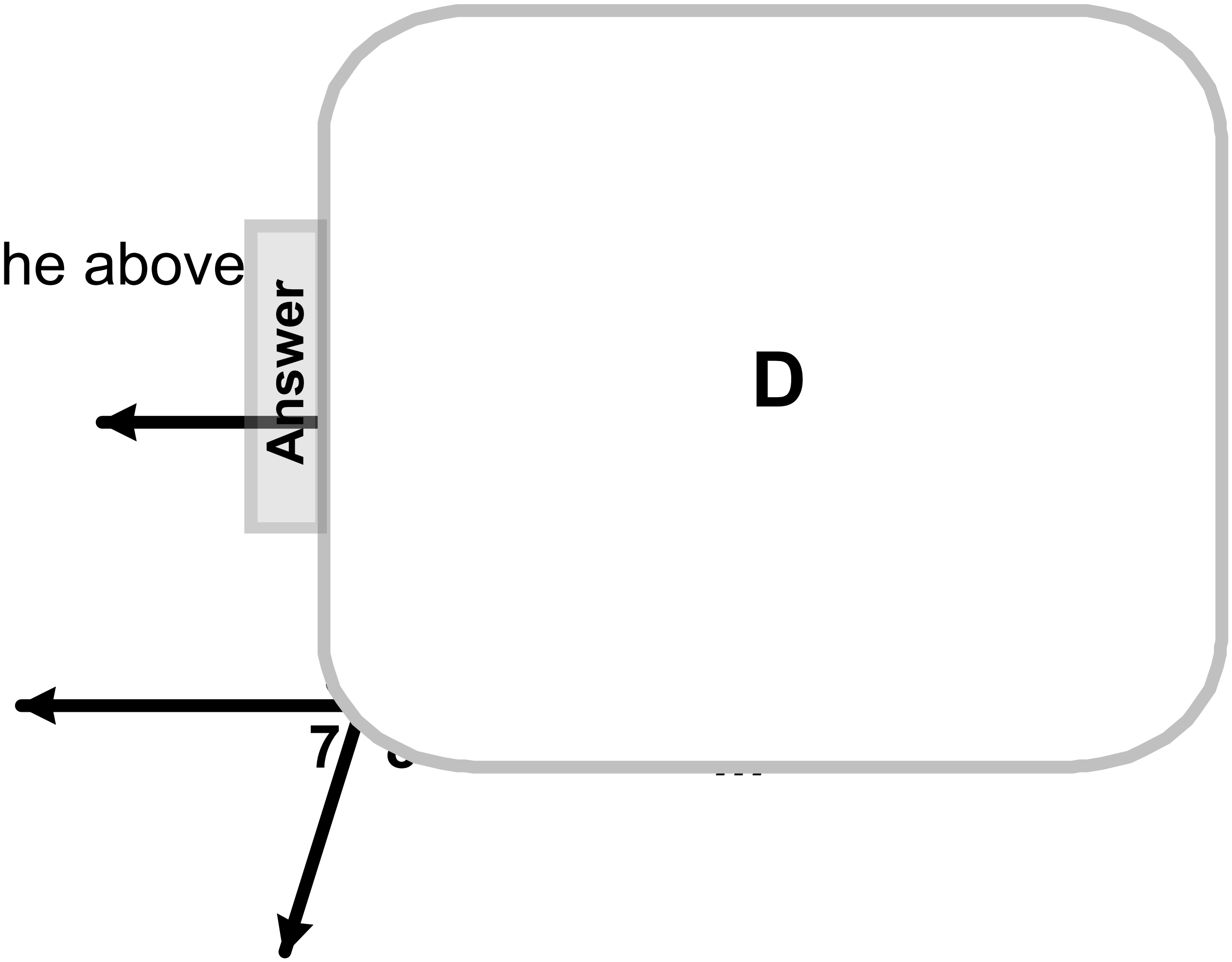
36 Find all of the angles congruent to ∠5.

- A ∠1
- B ∠4
- C ∠8
- D all of the above

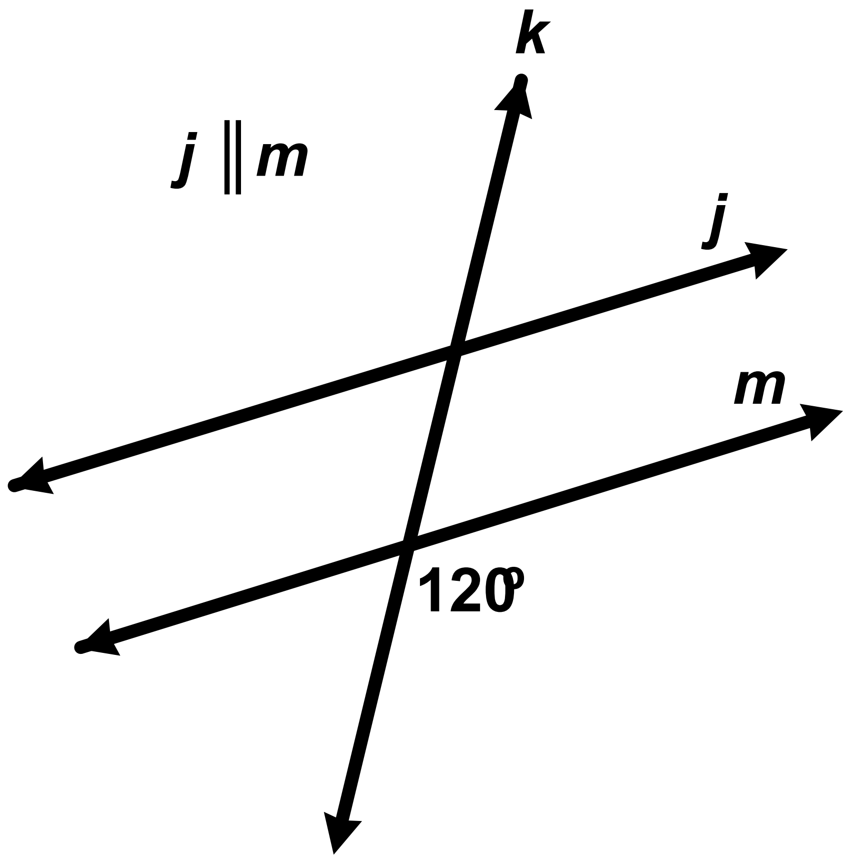


36 Find all of the angles congruent to ∠5.

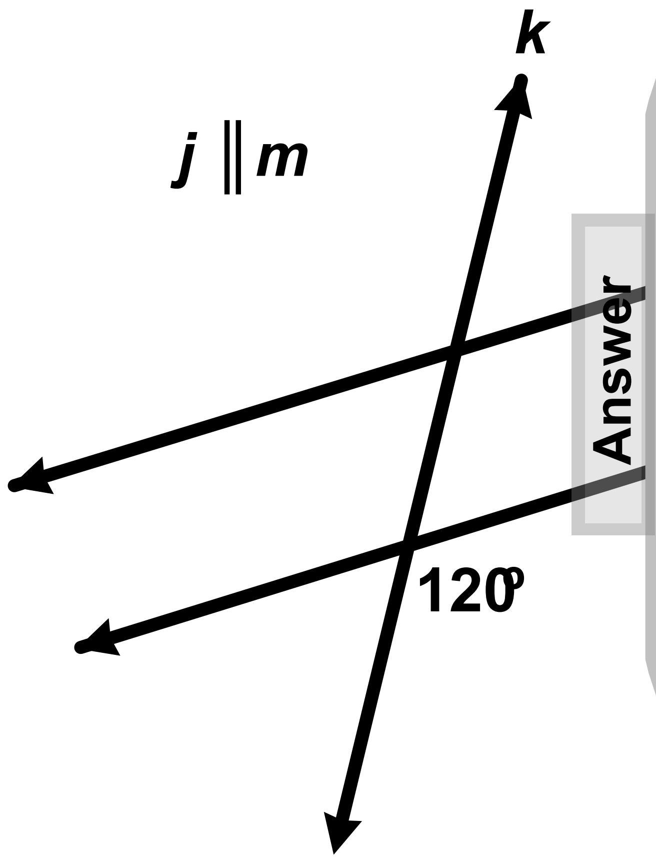
- A ∠1
- B ∠4
- C ∠8
- D all of the above



37 Find the value of x.

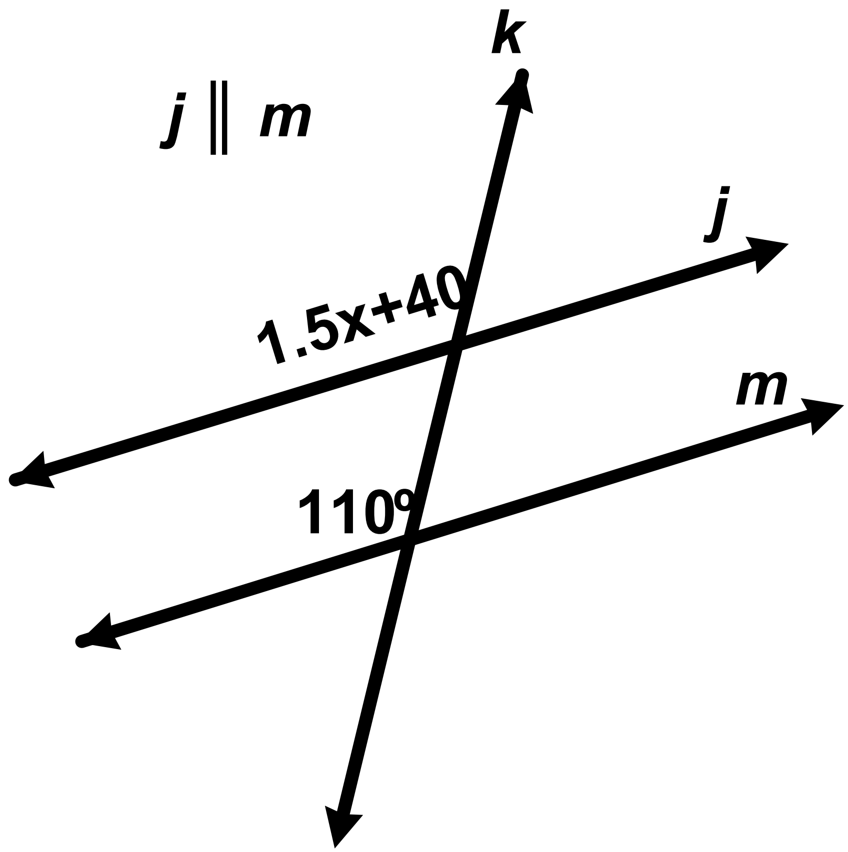


37 Find the value of x.

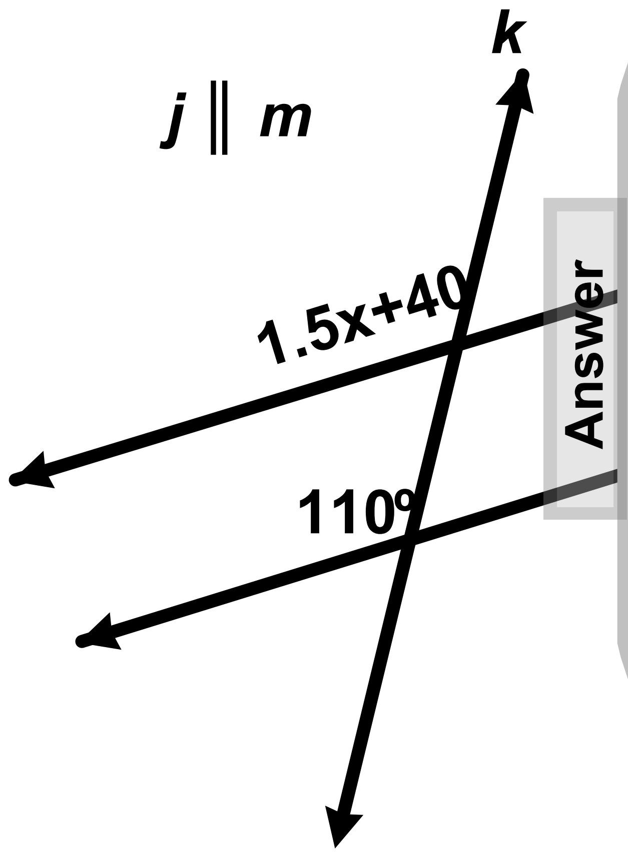


x = 18

38 Find the value of x.

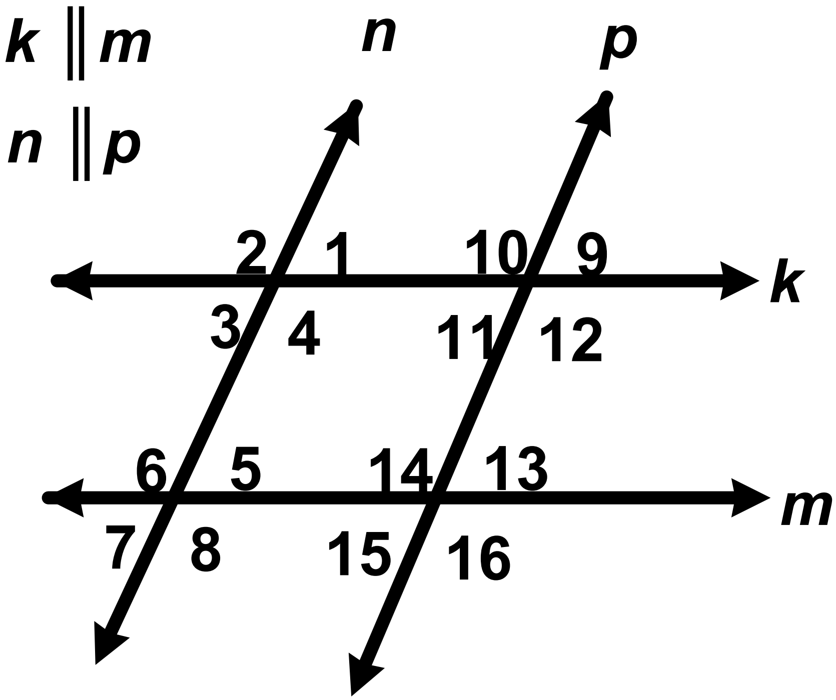


38 Find the value of x.

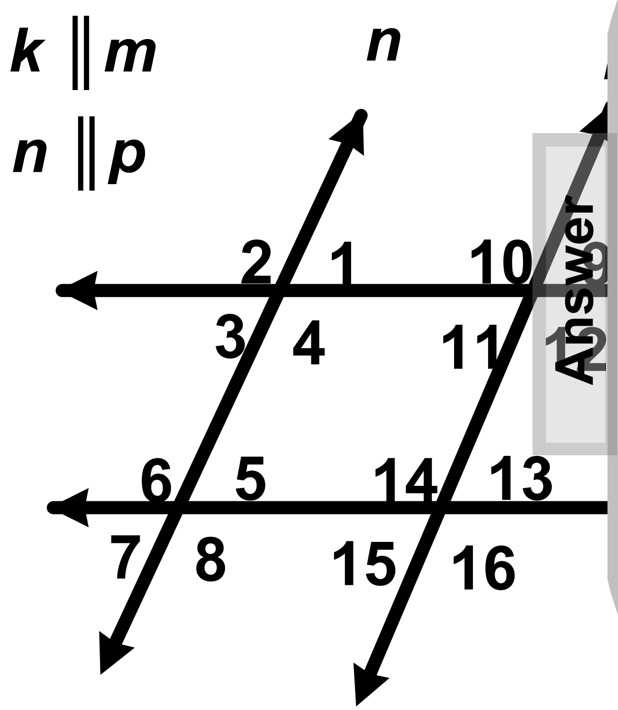


x = 20

39 If the m∠4 = 116º then m∠9 = ______º?



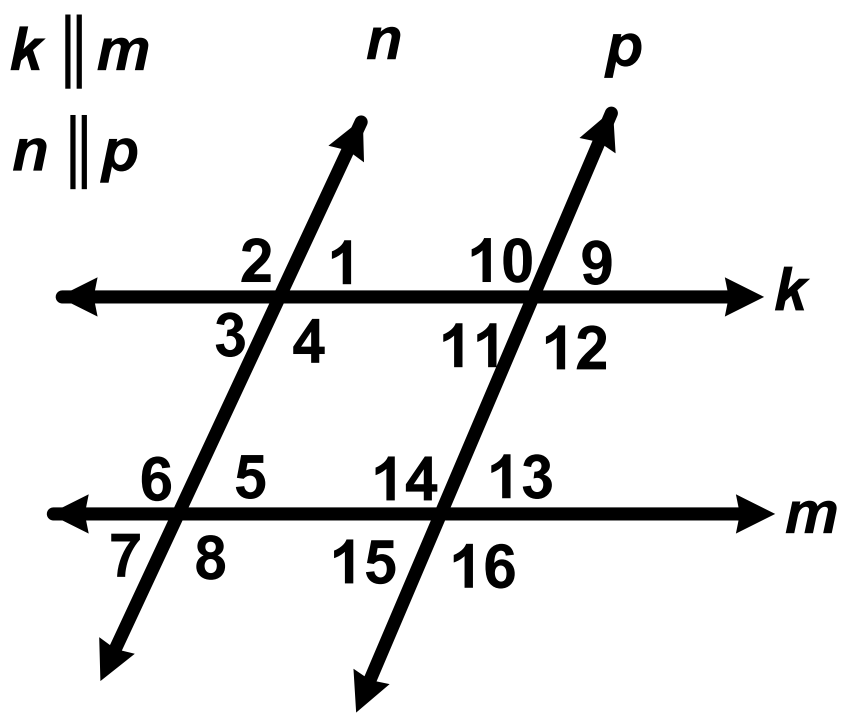
39 If the m∠4 = 116º then m∠9 = ______º?



64

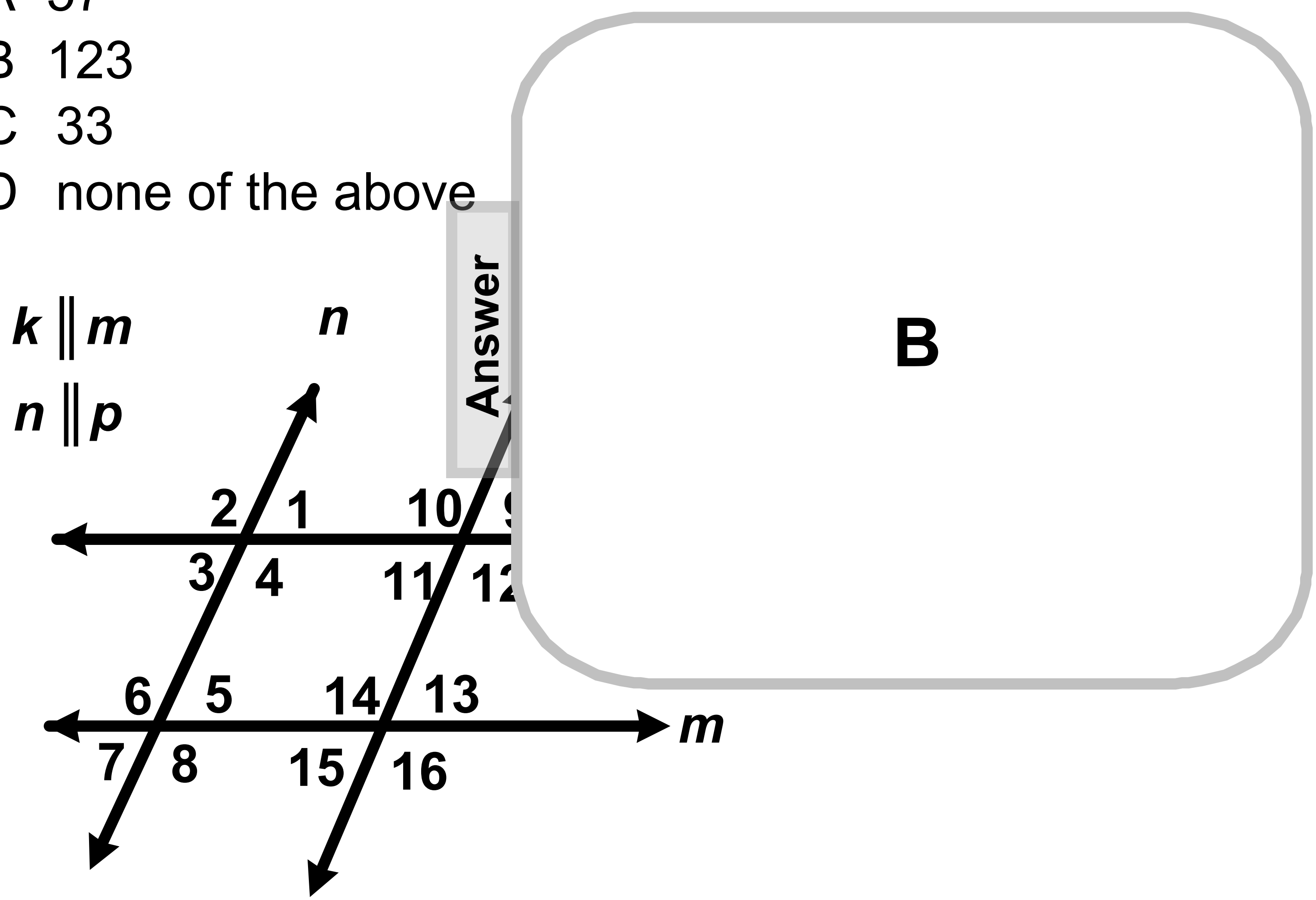
40 If the m∠15 = 57º, then the m∠2 = _____º.

- A 57
- B 123
- C 33
- D none of the above



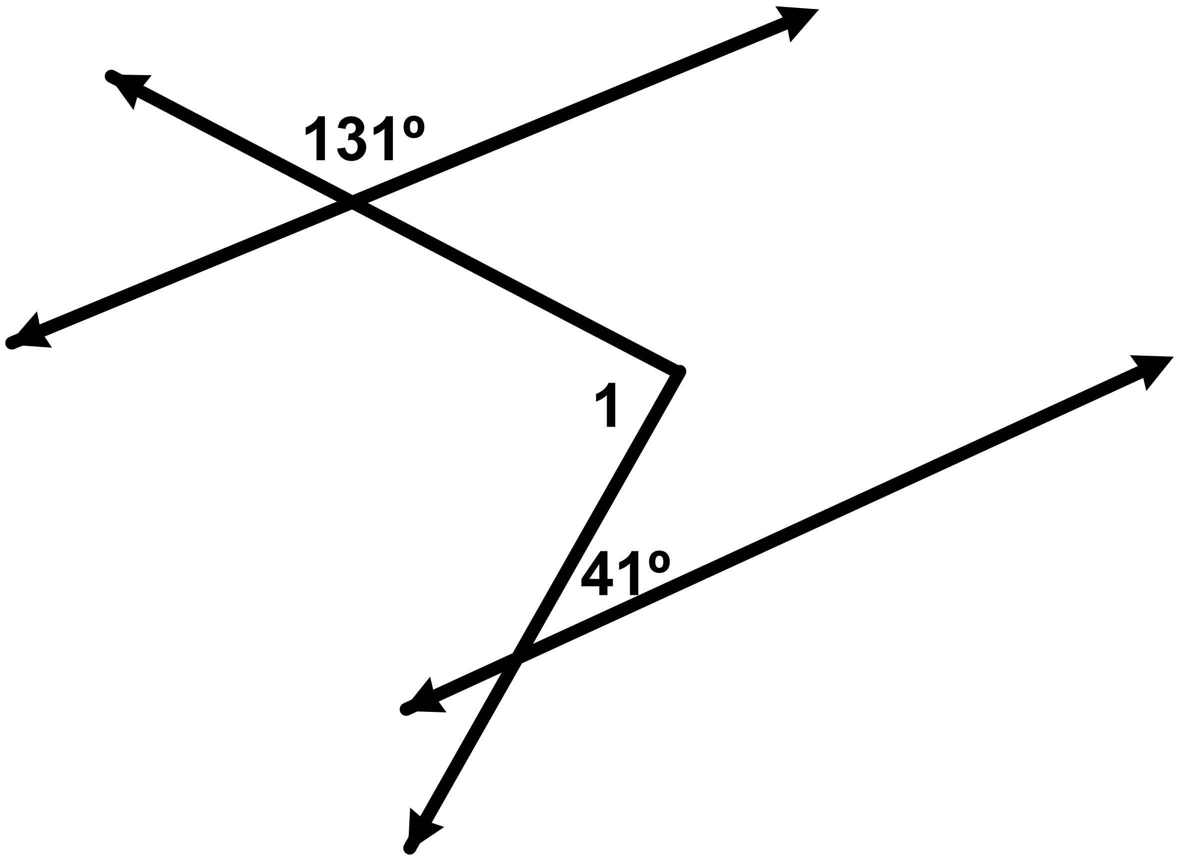
40 If the m∠15 = 57º, then the m∠2 = ______º.

- A 57
- B 123
- C 33
- D none of the above



Extending Lines to Make Transversals

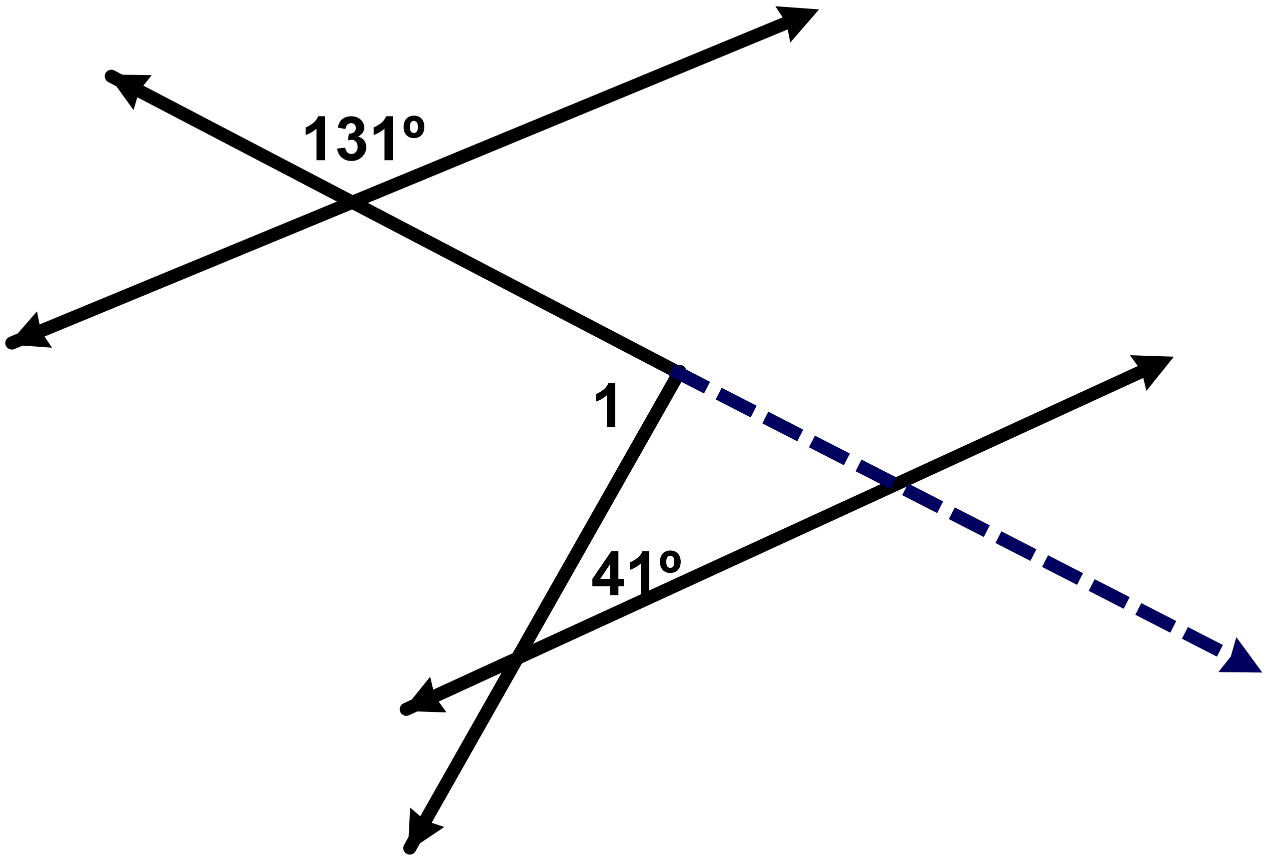
Find m∠1.



With the given diagram, no transversal exists but we can extend one of the lines to make a transversal.

Extending Lines to Make Transversals

Find m∠1.

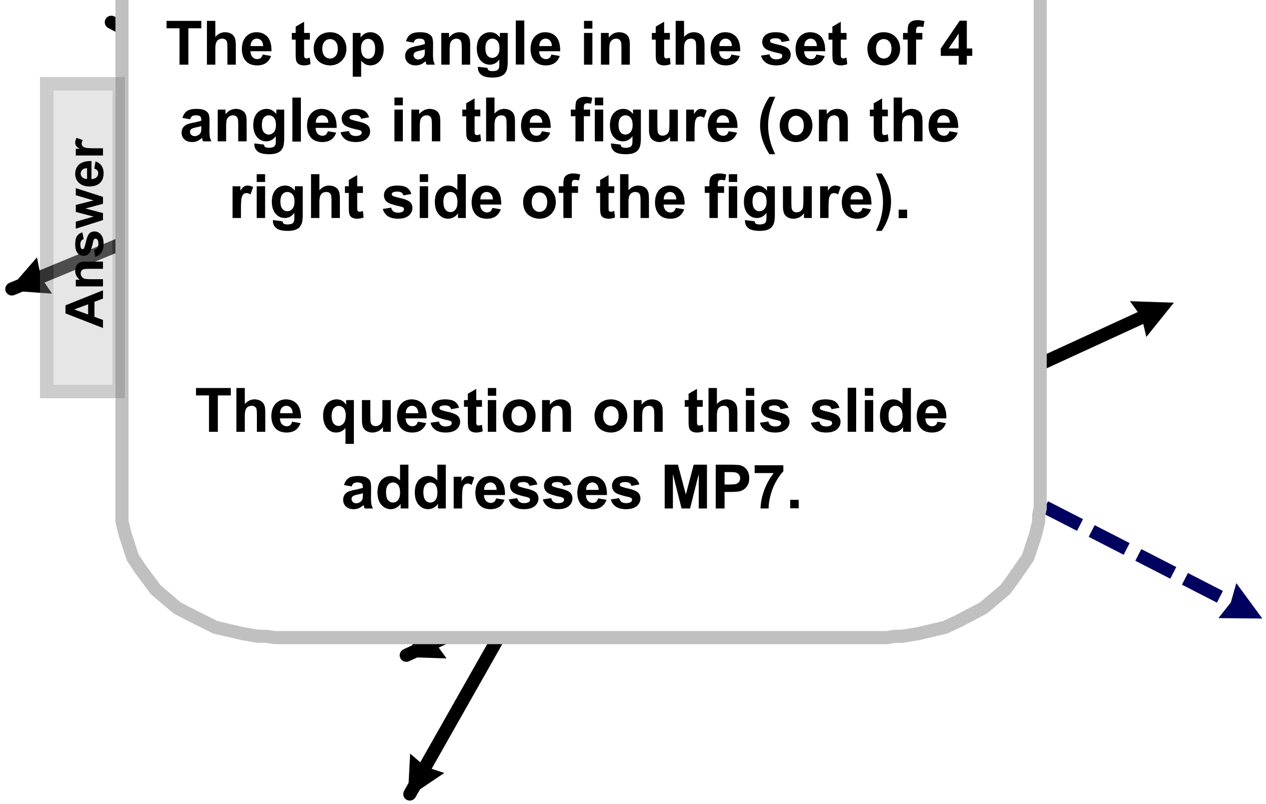


Then fill in the angle which is corresponding to the 131º angle.

Which angle corresponds to the 131º?

Extending Lines to Make Transversals

Find m∠1.



Answer

The top angle in the set of 4 angles in the figure (on the right side of the figure).

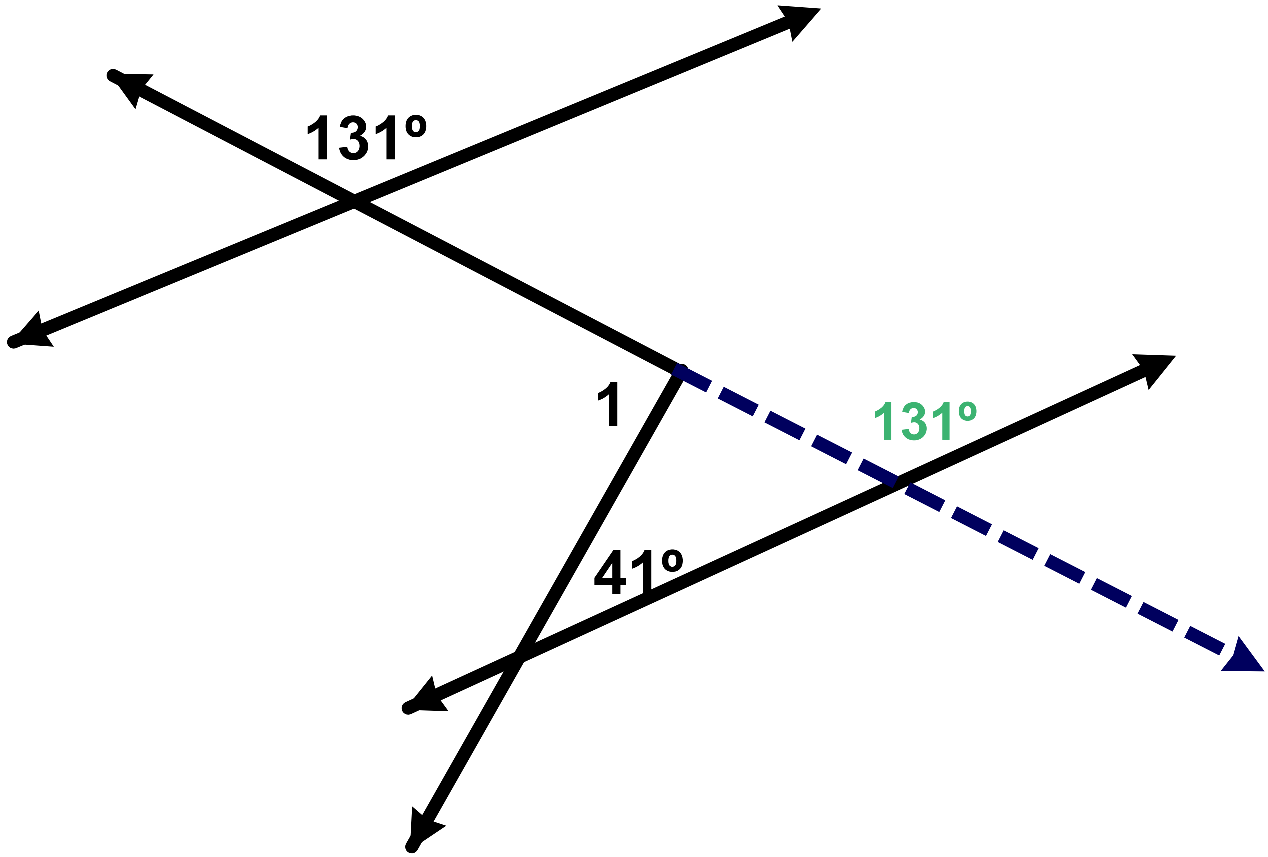
The question on this slide addresses MP7.

Then fill in the angle which is corresponding to the 131º angle.

Which angle corresponds to the 131º?

Extending Lines to Make Transversals

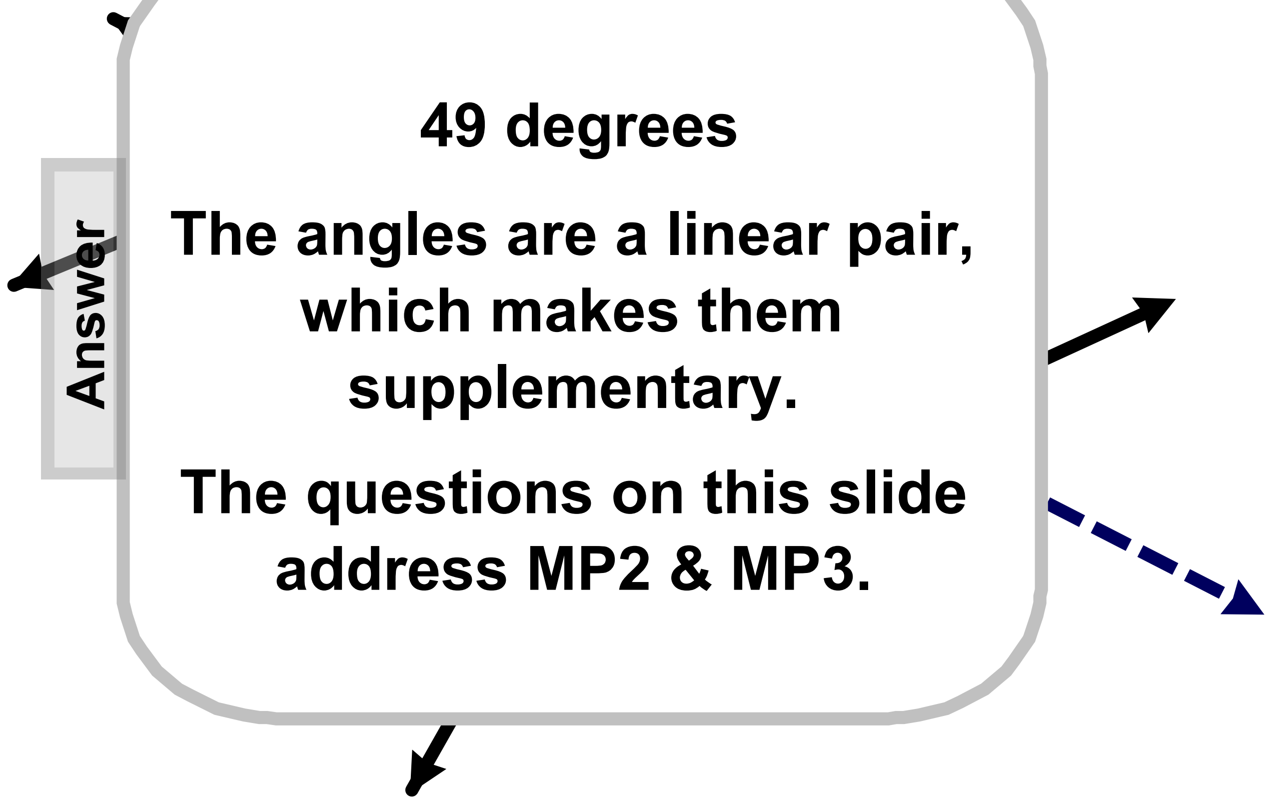
Find m∠1.



Then find the measurement of the angle adjacent to 131° that is inside of the triangle. What is the measurement of this angle? Explain your answer.

Extending Lines to Make Transversals

Find m∠1.



Answer

49 degrees

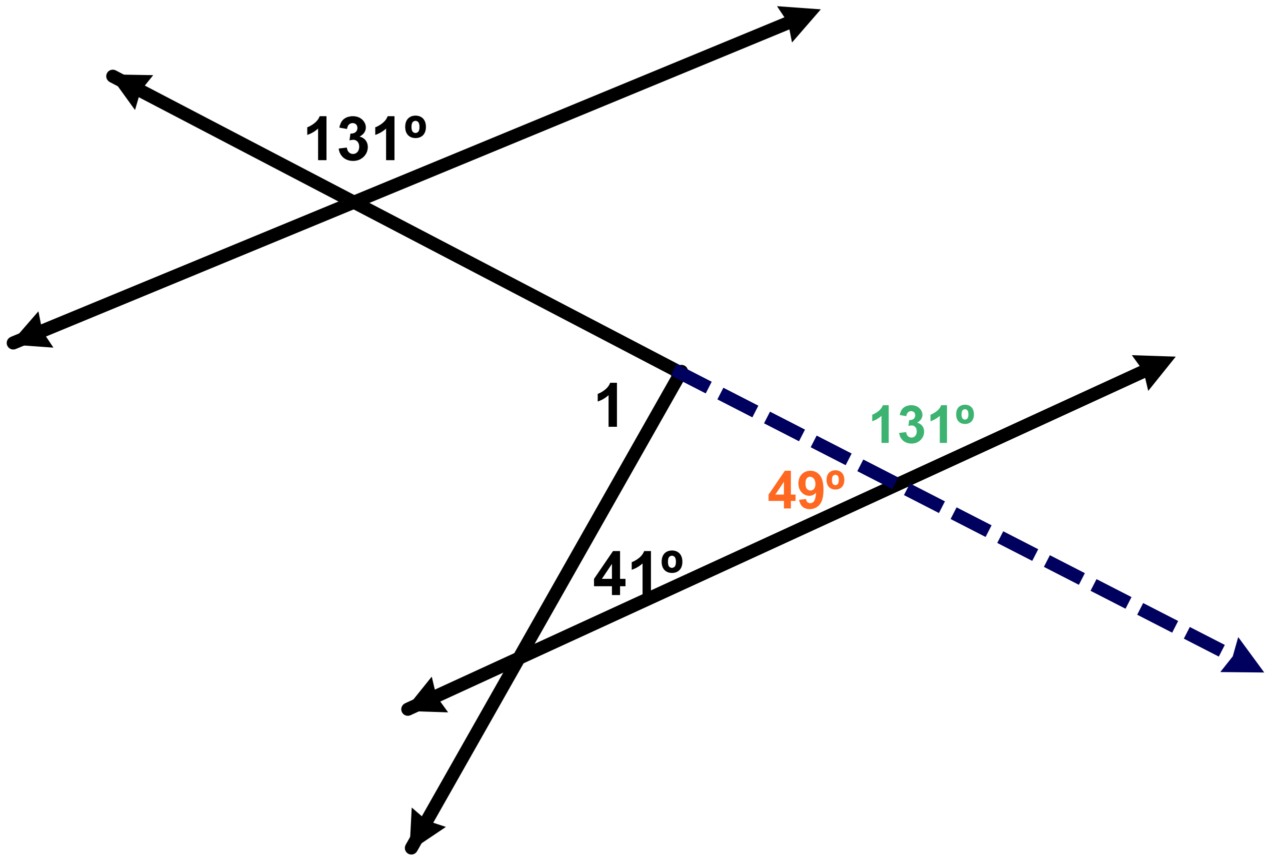
The angles are a linear pair, which makes them supplementary.

The questions on this slide address MP2 & MP3.

Then find the measurement of the angle adjacent to 131º that is inside of the triangle. What is the measurement of this angle? Explain your answer.

Extending Lines to Make Transversals

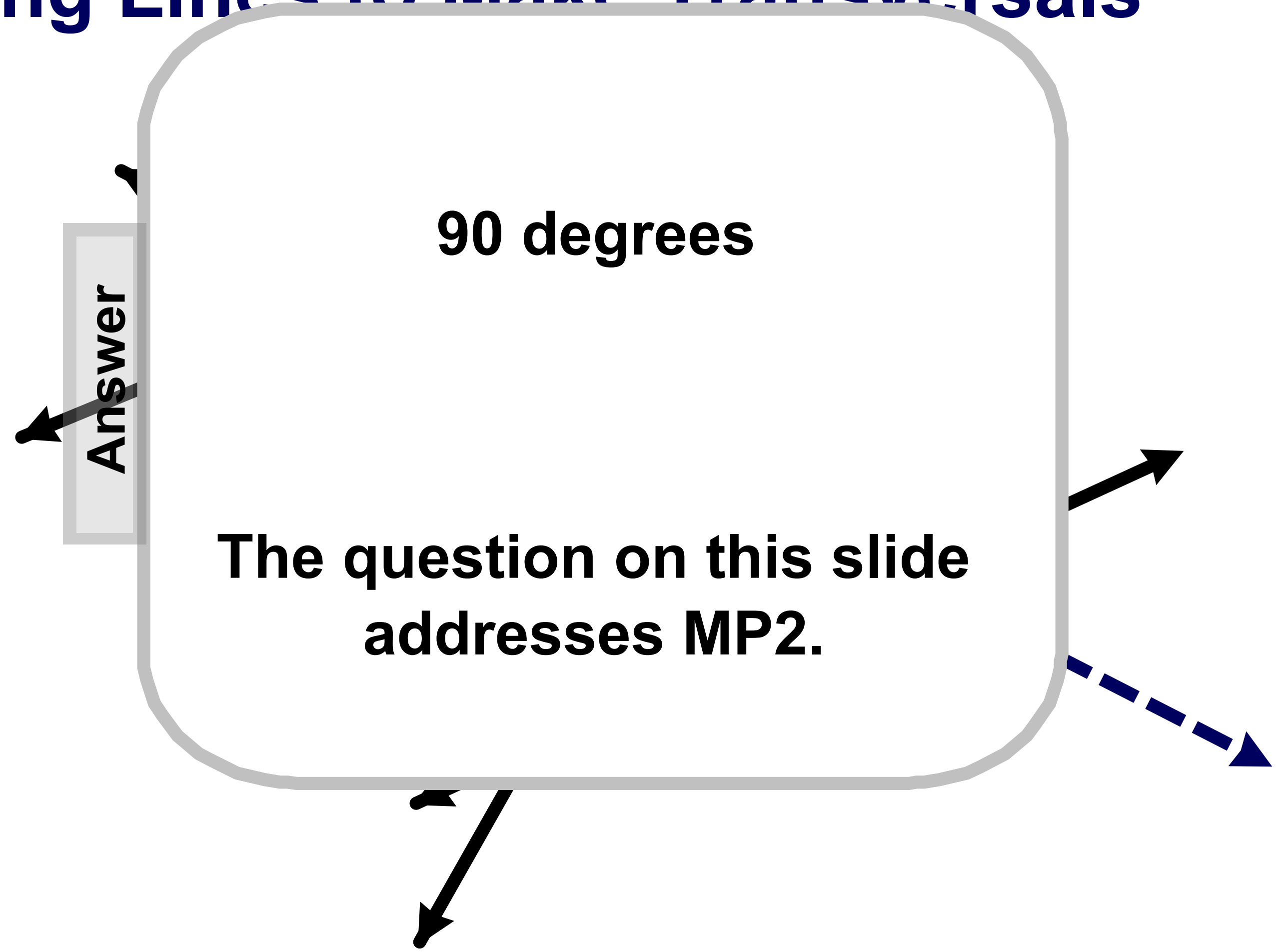
Find m∠1.



As you may recall, the third angle in the triangle must make the sum of the angles equal to 180º. What is the measurement of the 3rd angle in the triangle?

Extending Lines to Make Transversals

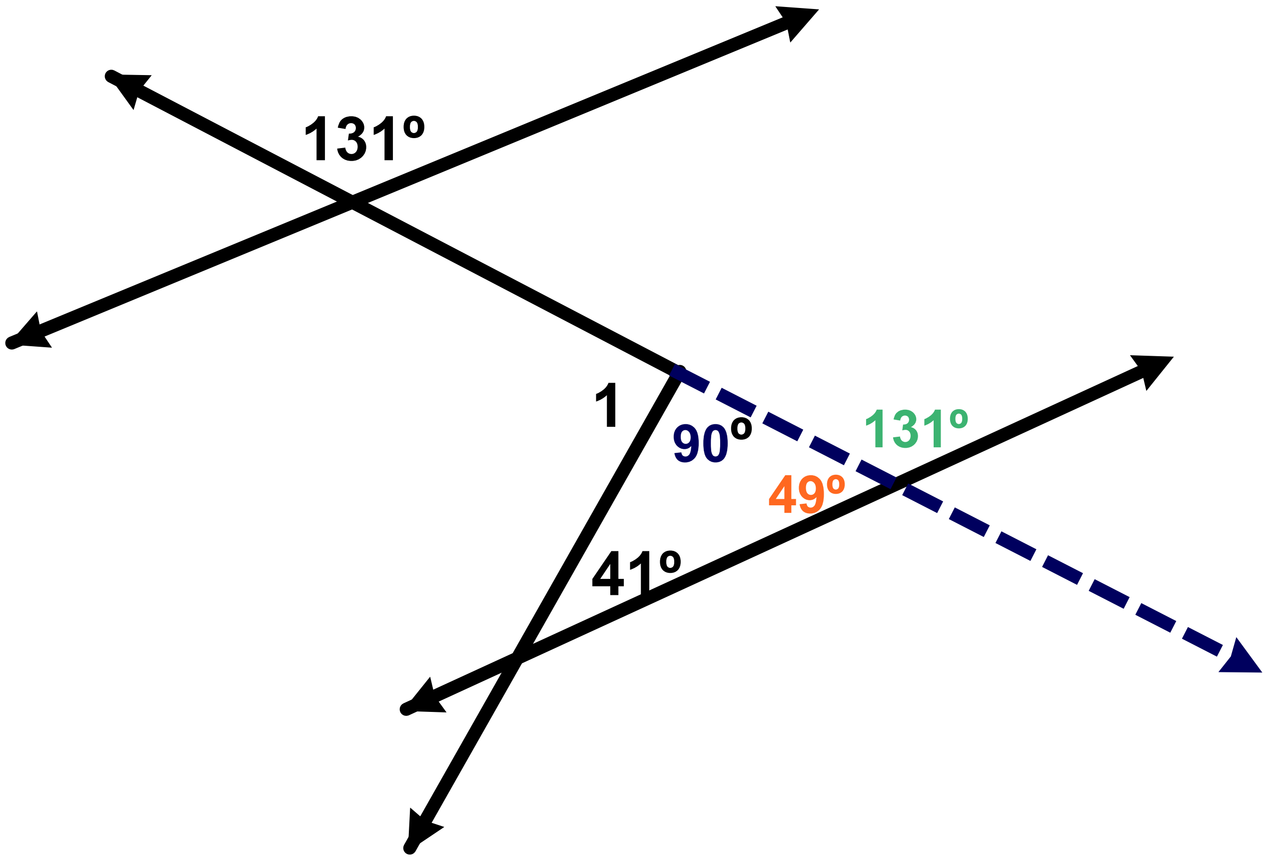
Find m∠1.



As you may recall, the third angle in the triangle must make the sum of the angles equal to 180º. What is the measurement of the 3rd angle in the triangle?

Extending Lines to Make Transversals

Find m∠1.

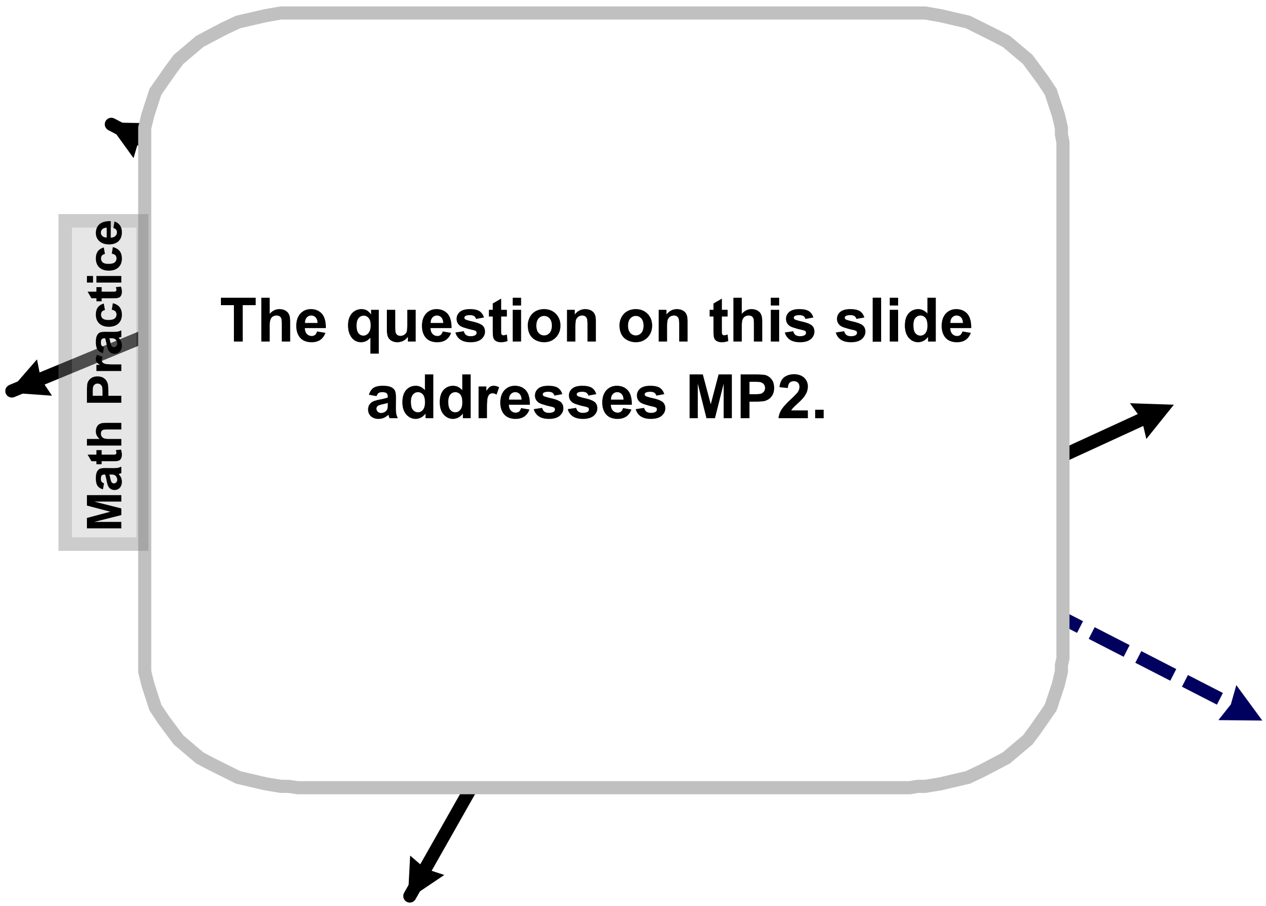


And, finally that angle 1 is supplementary to that 90º angle.

What is m∠1?

Extending Lines to Make Transversals

Find m∠1.

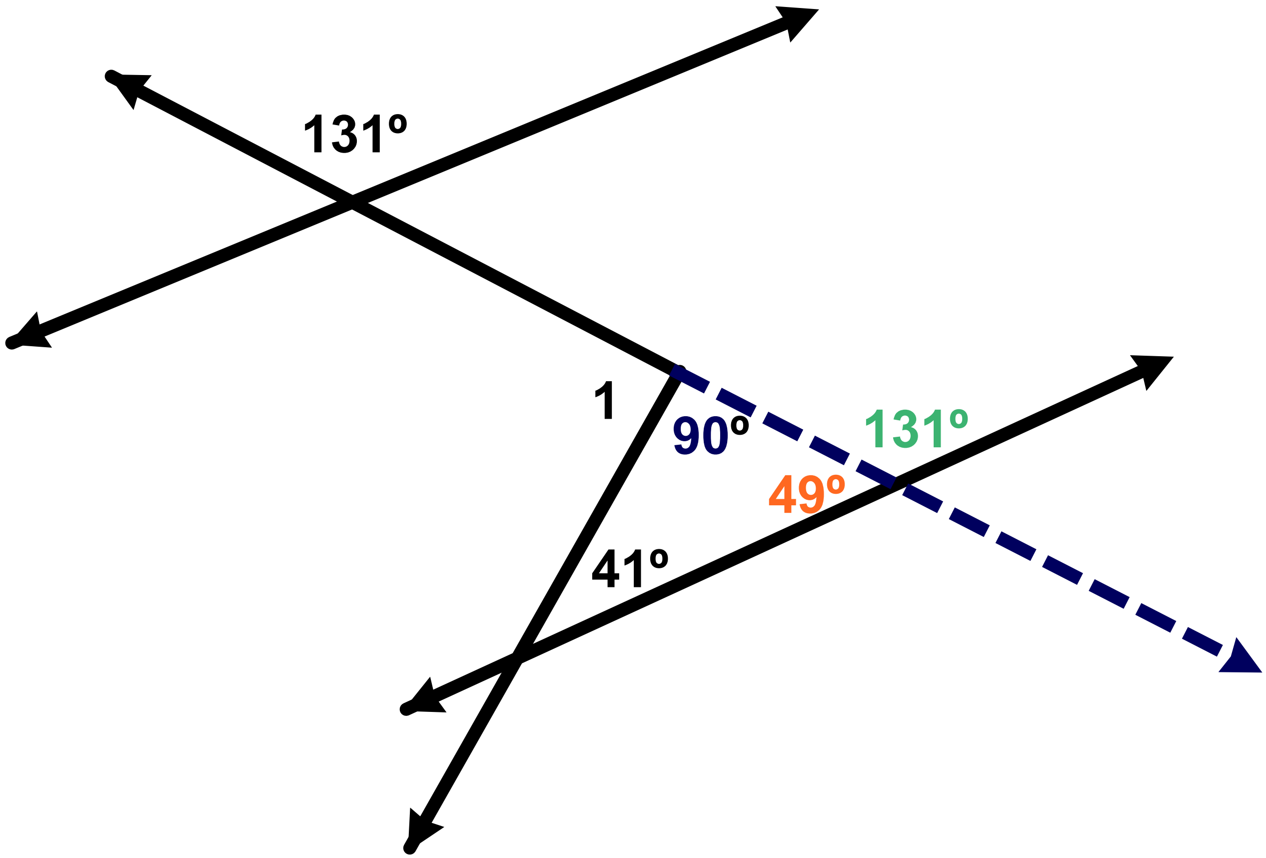


And, finally that angle 1 is supplementary to that 90º angle.

What is m∠1?

Extending Lines to Make Transversals

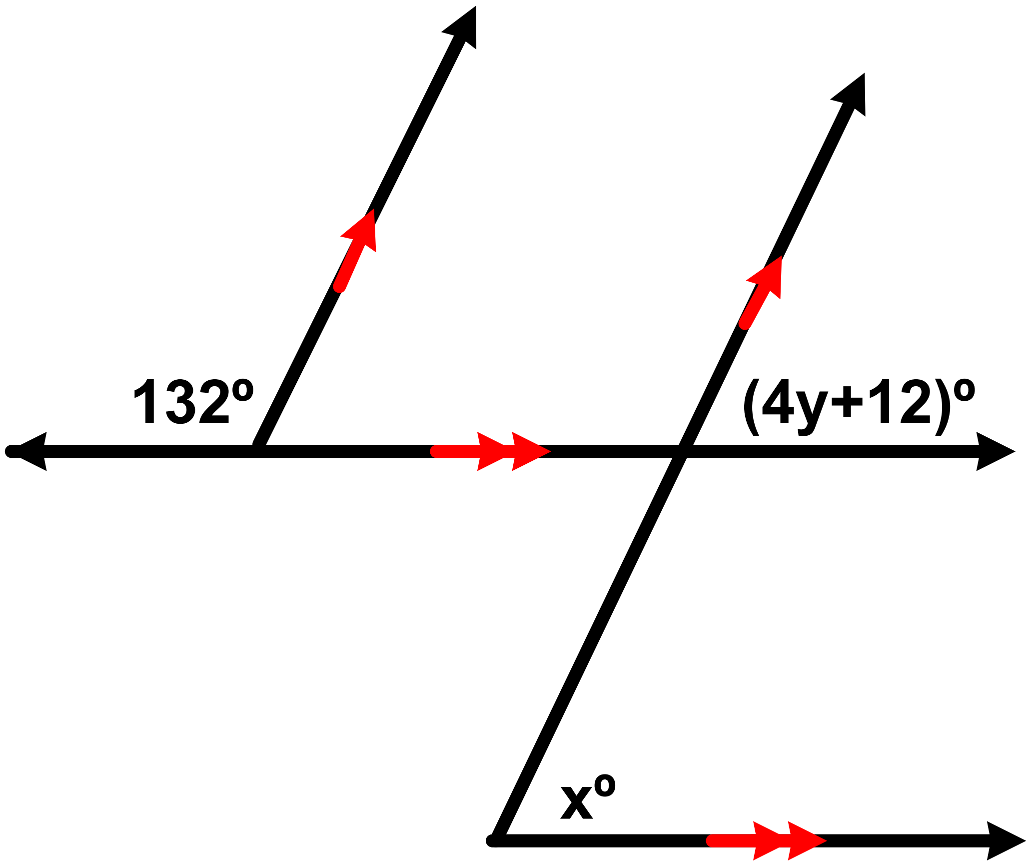
Find m∠1.



m∠1 = 90º

Double Transversals

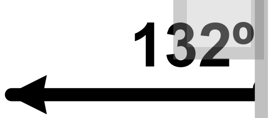
Find the values of *x* and *y*.



Double Transversals

Find the valu

Answer



y = 9
x = 48

Additional Q's that address MP's:

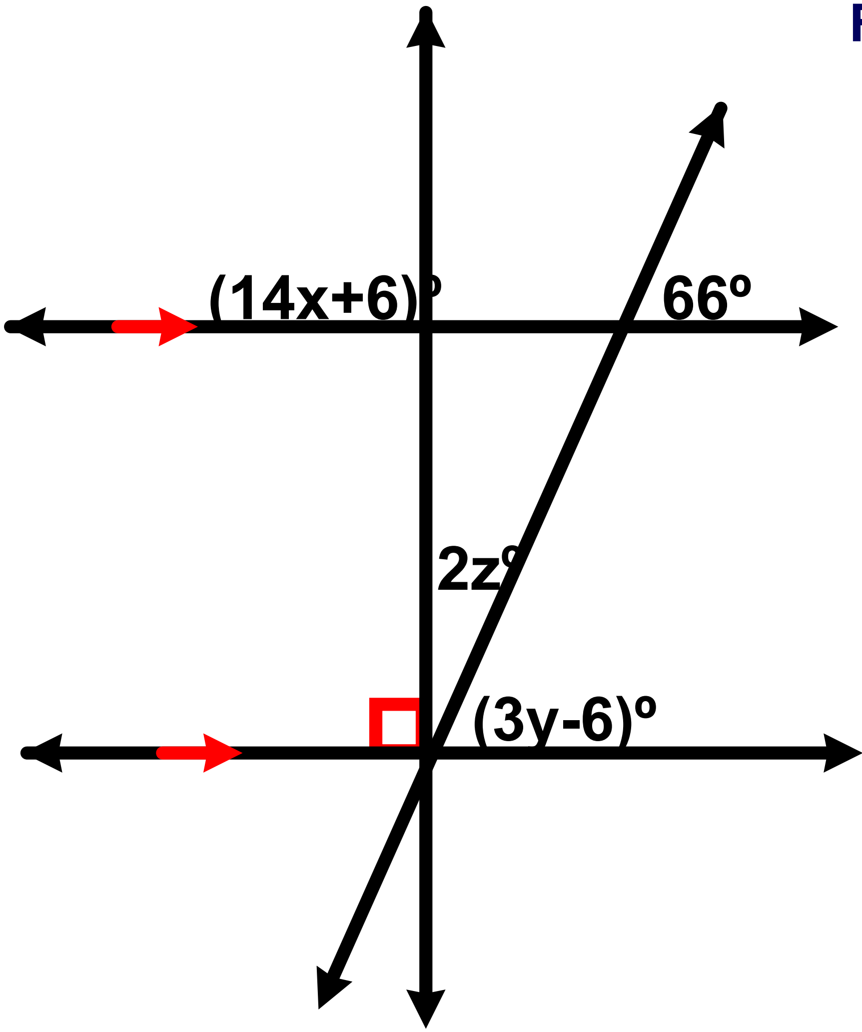
What information are you given? (MP1)

What do you need to find? (MP1)

Create an equation to represent the problem. (MP2)

How are the angles w/ the expressions related the 132 angle? (MP7)

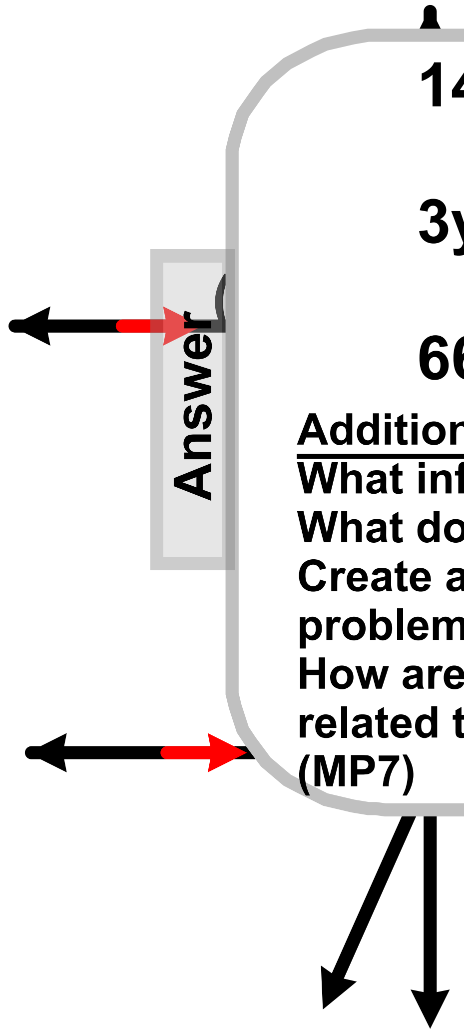
Transversals and Perpendicular Lines



Find the values of *x*, *y*, and *z*.

Transversals and Perpendicular Lines

Find the values of *x*, *y*, and *z*.



Answer

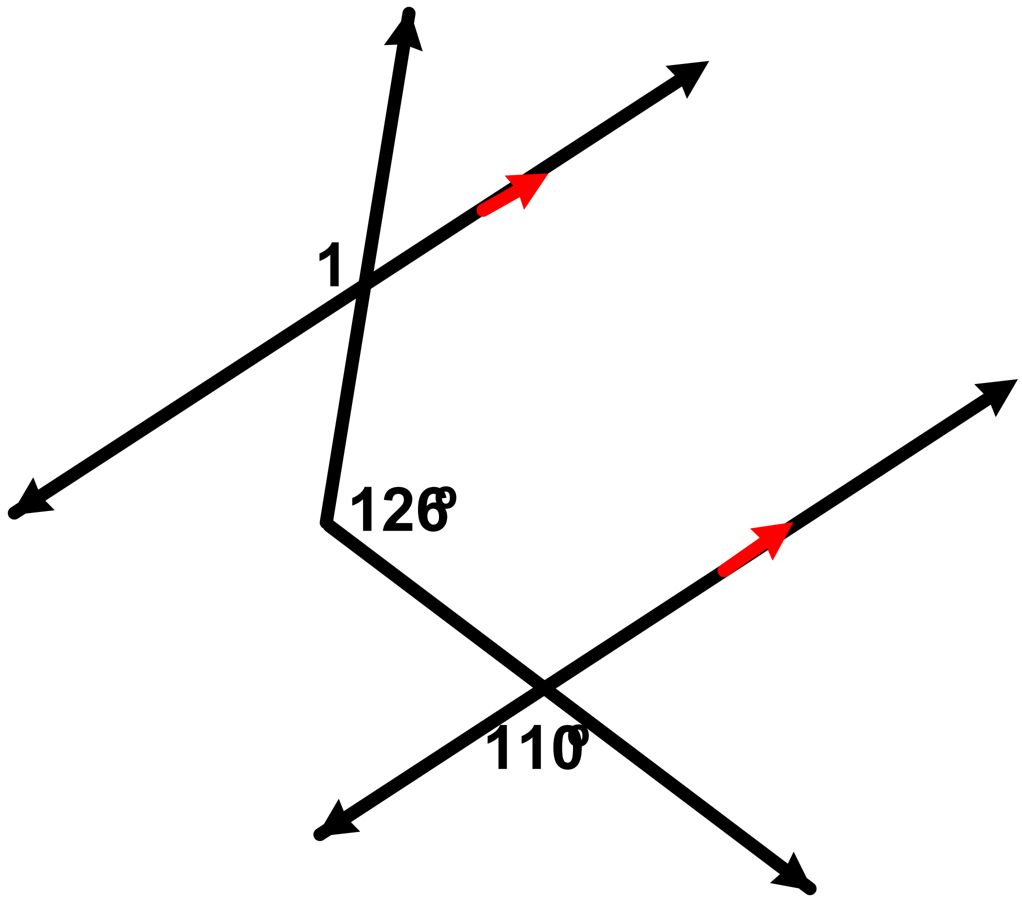
14x + 6 = 90 so x = 6

3y - 6 = 66 so y = 24

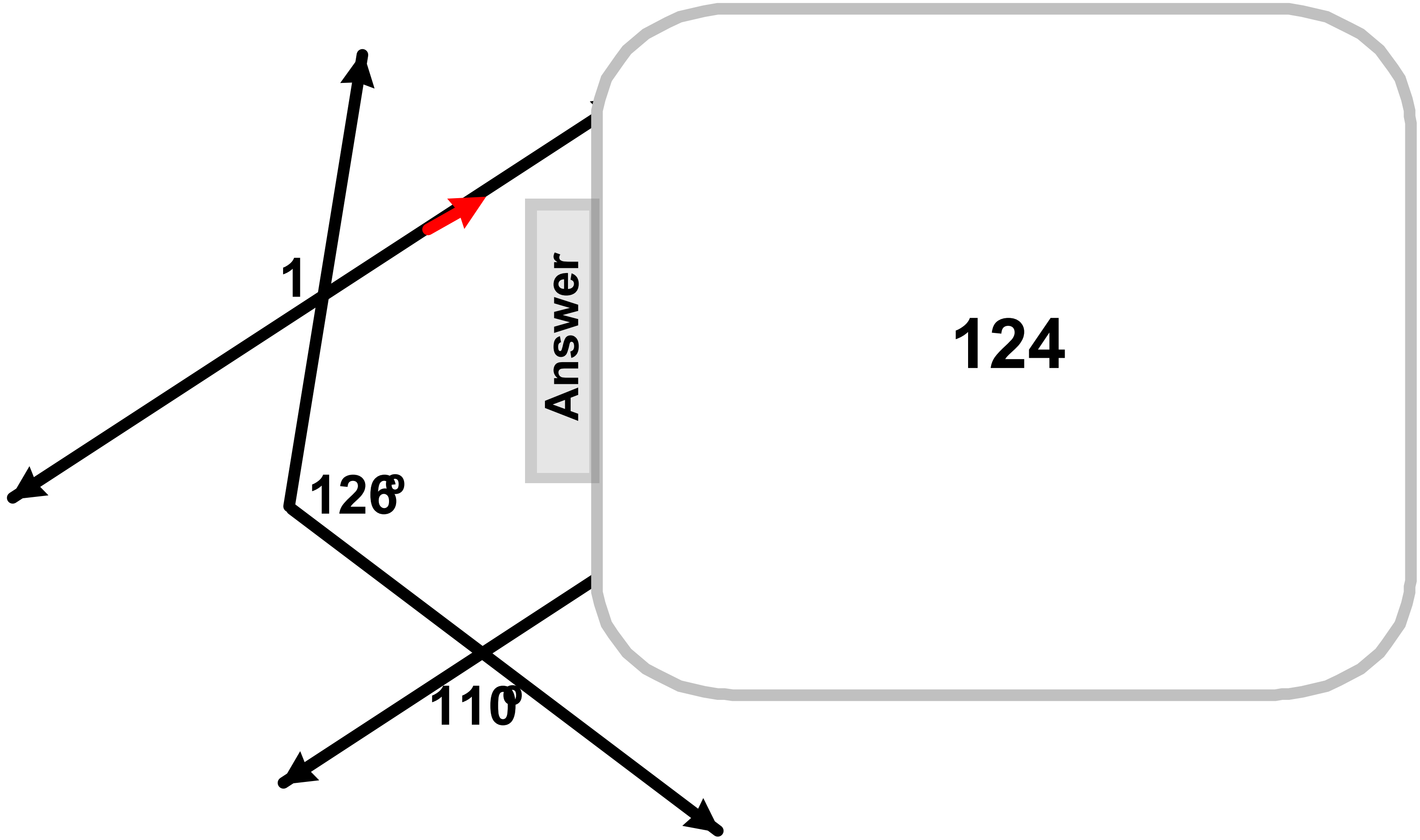
66 + 2z = 90 so z = 12

<u>Additional Q's that address MP's:</u>
What information are you given? (MP1)
What do you need to find? (MP1)
Create an equation to represent the problem. (MP2)
How are the angles w/ the expressions related the 66 angle or 90 ? (MP7)

41 Find the m∠1.

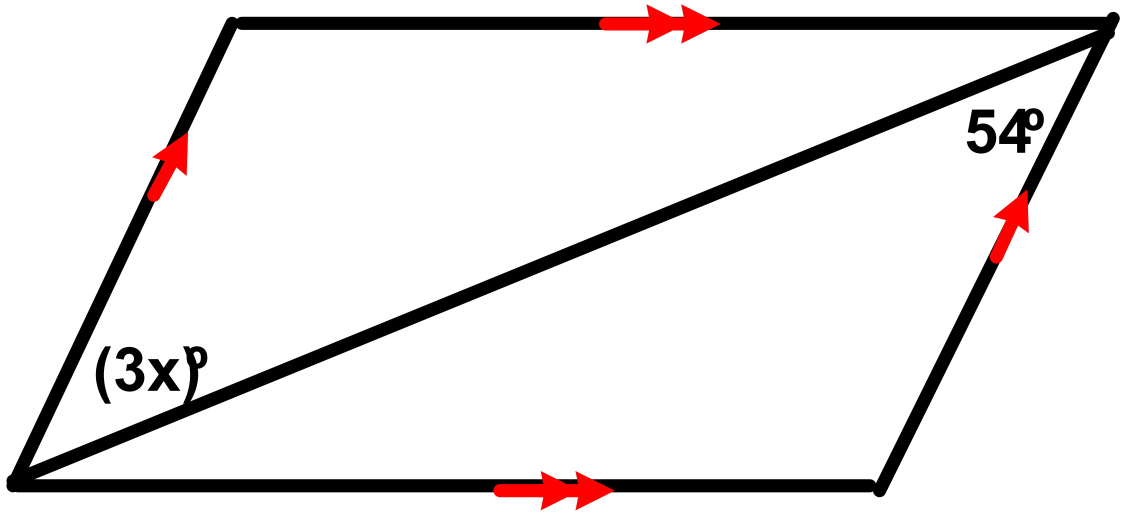


41 Find the m∠1.



42 Find the value of x.

- A 12
- B 54
- C 42
- D 18

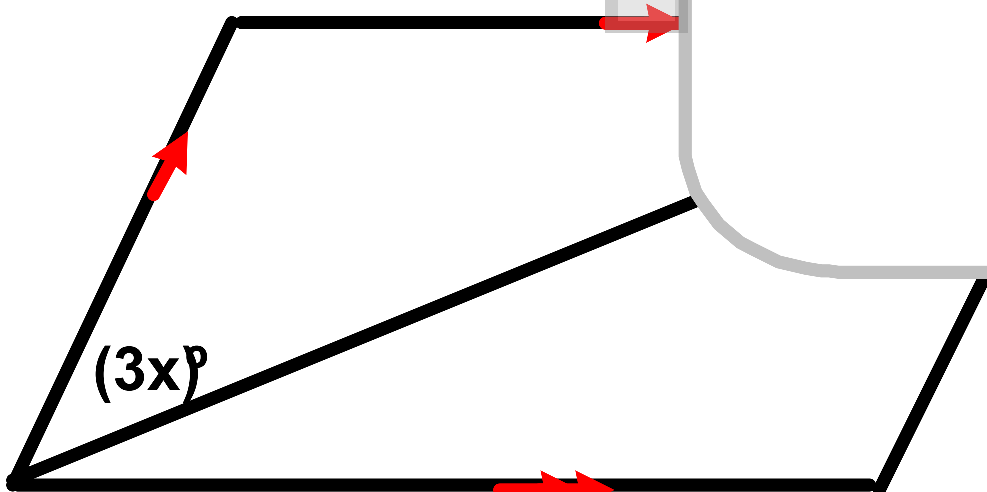


42 Find the value of x.

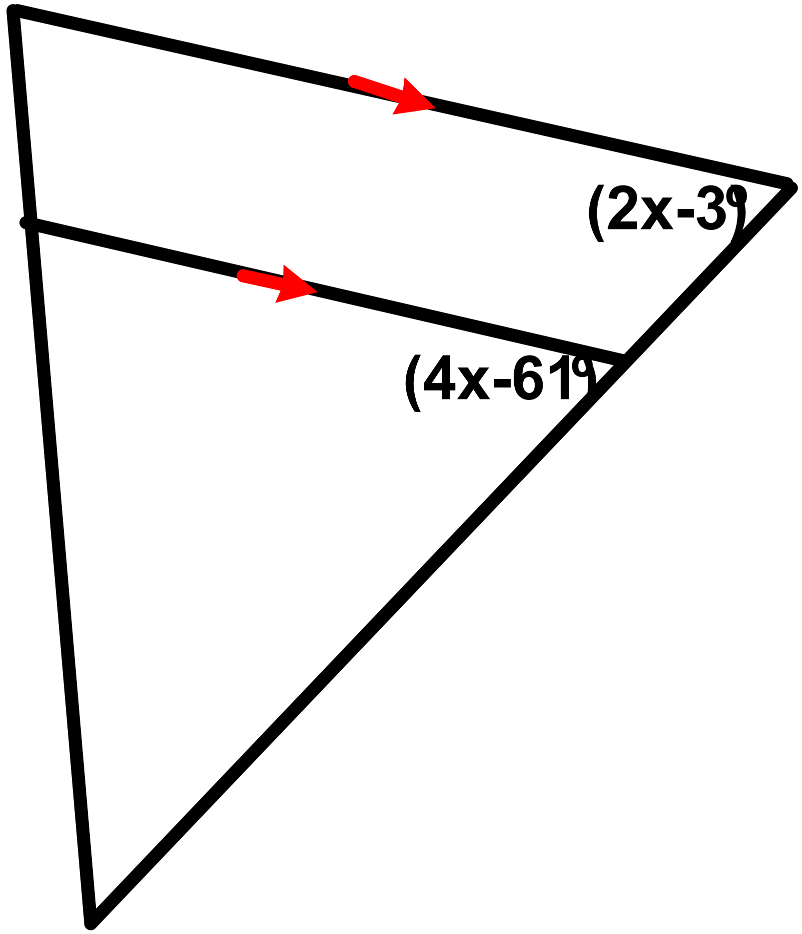
- A 12
- B 54
- C 42
- D 18

Answer

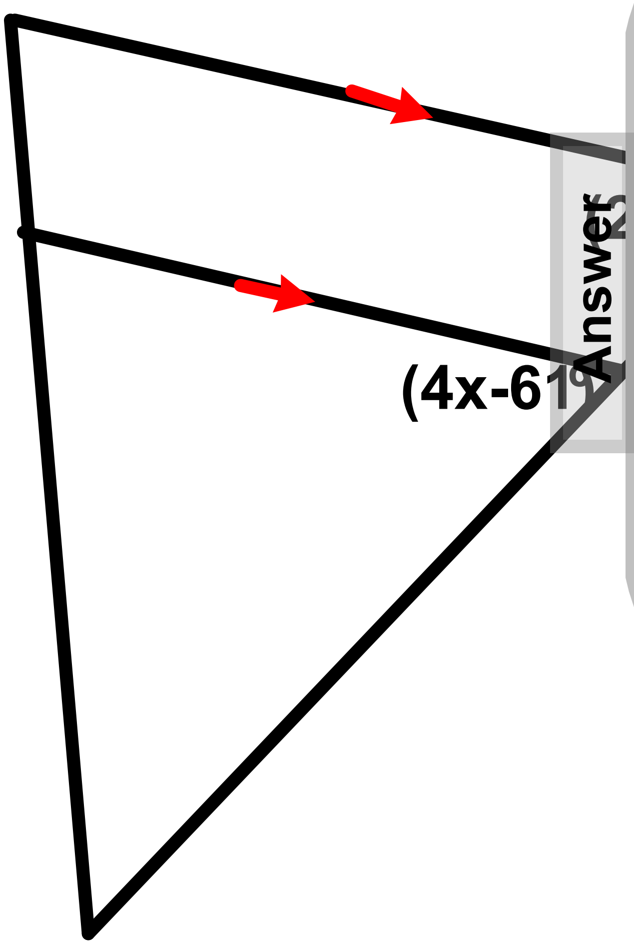
D



43 Find the value of x.

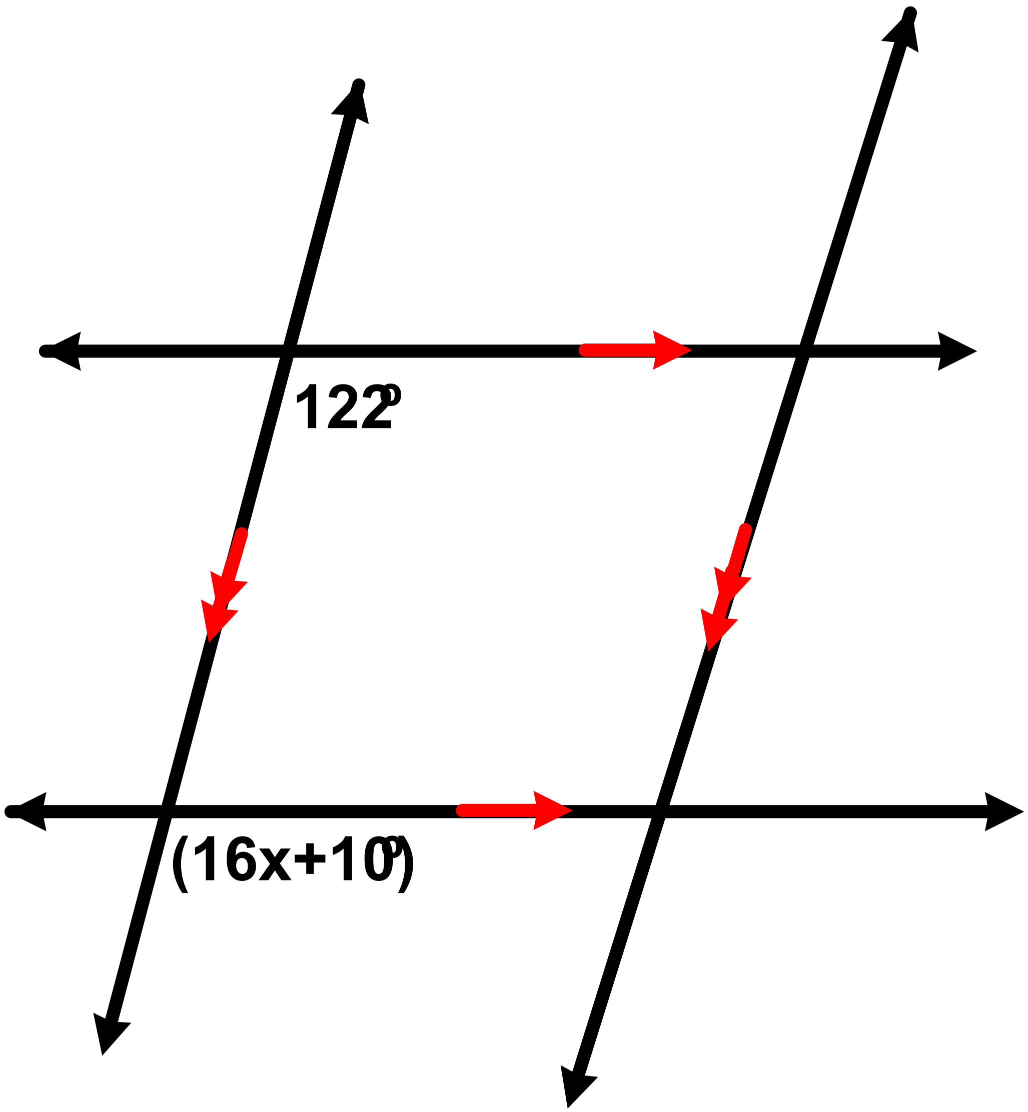


43 Find the value of x.

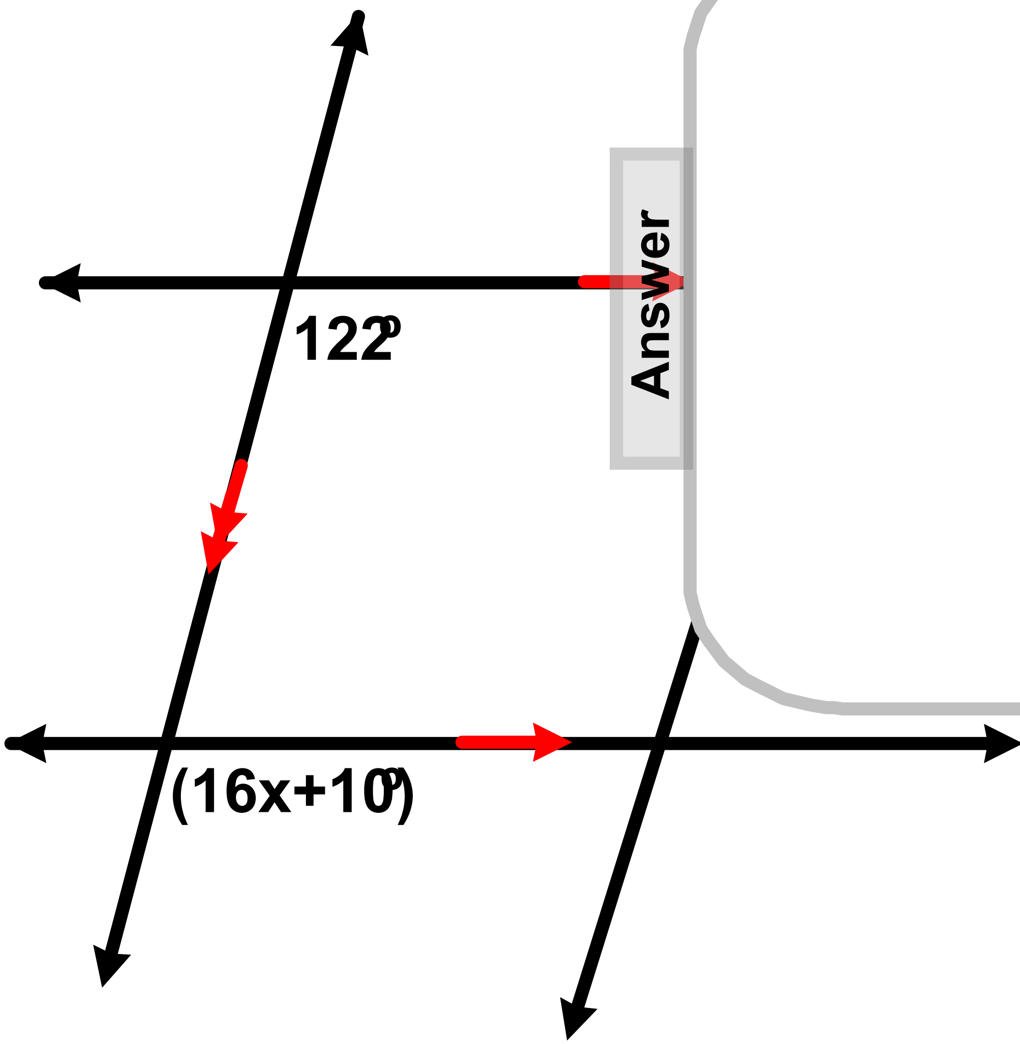


29

44 Find the value of x.



44 Find the value of x.

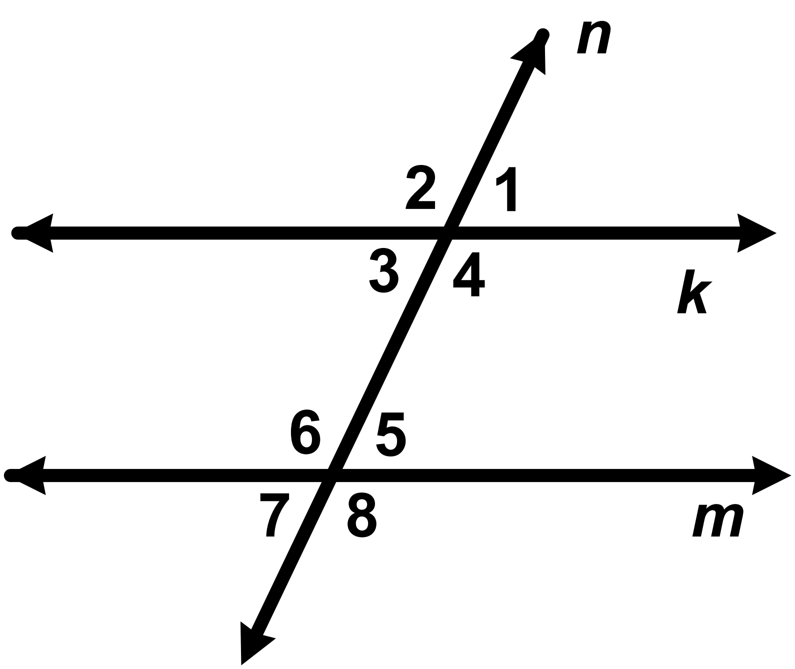


3

Proving Lines are Parallel

If m∠3 = 56º, find the m∠7 that makes lines *k* and *m* parallel.

Explain your answer.

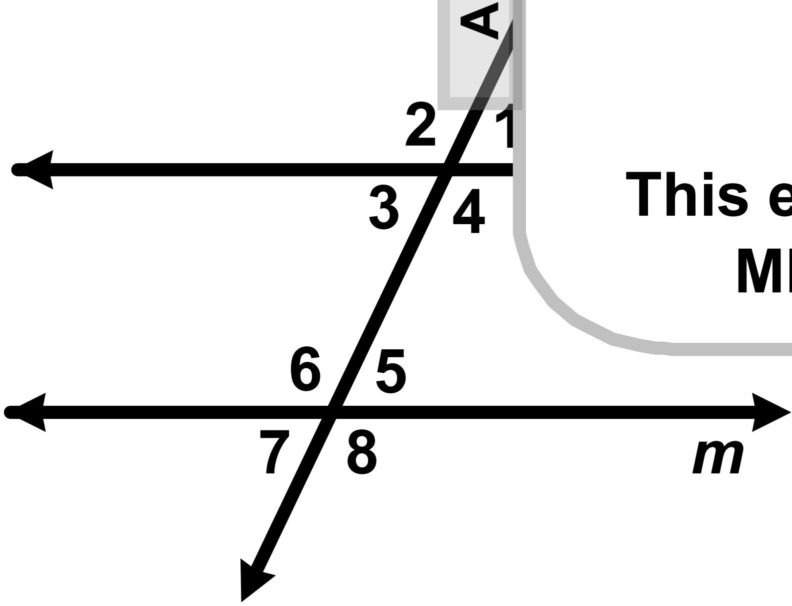


Proving Lines are Parallel

If m∠3 = 56º, find the
makes lines *k* and *m*

Explain your answer

Answer



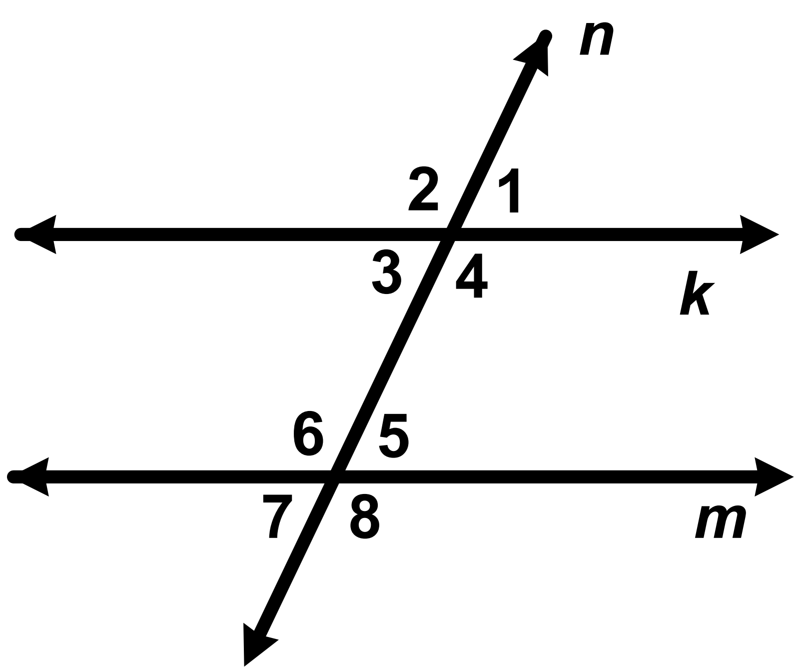
According to the Converse of the Corresponding Angles Theorem, if m∠3= m∠7, then k║m. Therefore, if m∠3 = 56º, then m∠7 = 56º.

This example addresses MP1, MP2 & MP3

Proving Lines are Parallel

If m∠4 = 110º, find the m∠6 that makes lines *k* and *m* parallel.

Explain your answer.



Proving Lines are Parallel

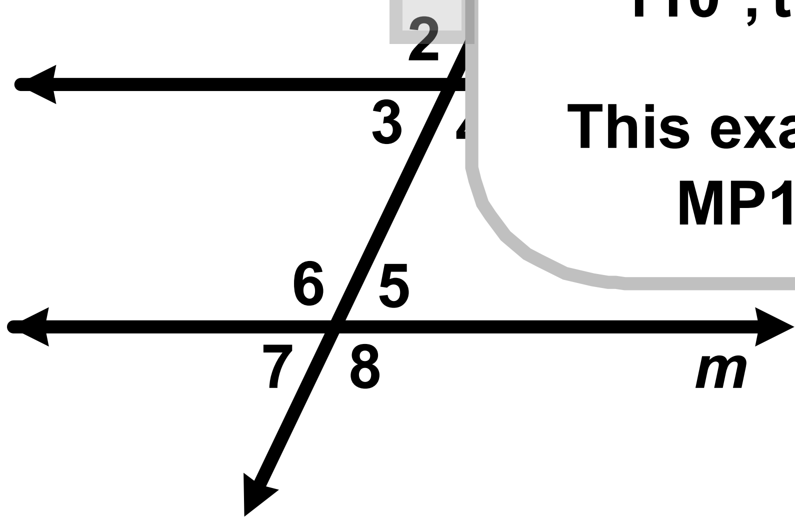
If m∠4 = 110º, find th
makes lines *k* and *r*

Explain your answe

Answer

According to the Converse of the Alternate Interior Angles Theorem, if m∠4= m∠6, then k║m. Therefore, if m∠4 = 110º, then m∠6 = 110º.

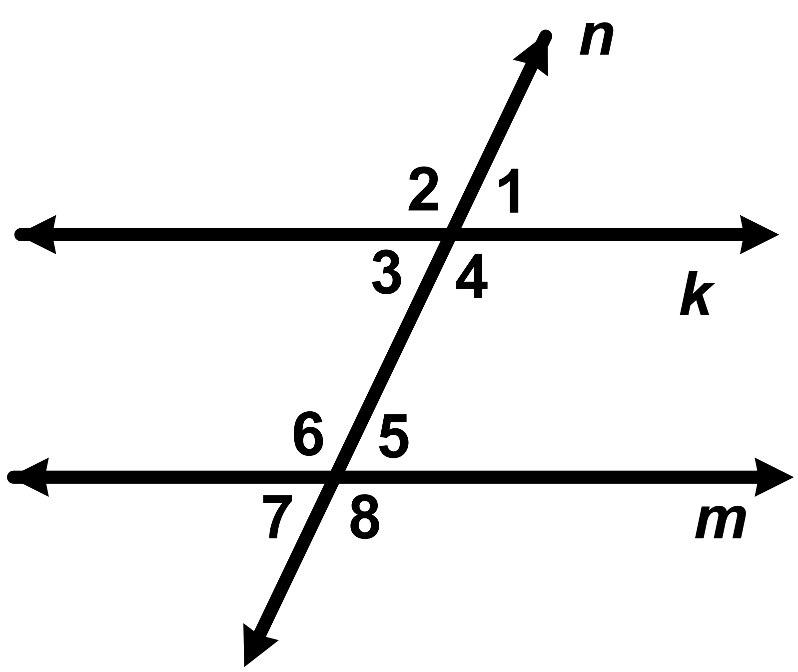
This example addresses MP1, MP2 & MP3



Proving Lines are Parallel

If m∠1 = 48º, find the m∠7 that makes lines *k* and *m* parallel.

Explain your answer.

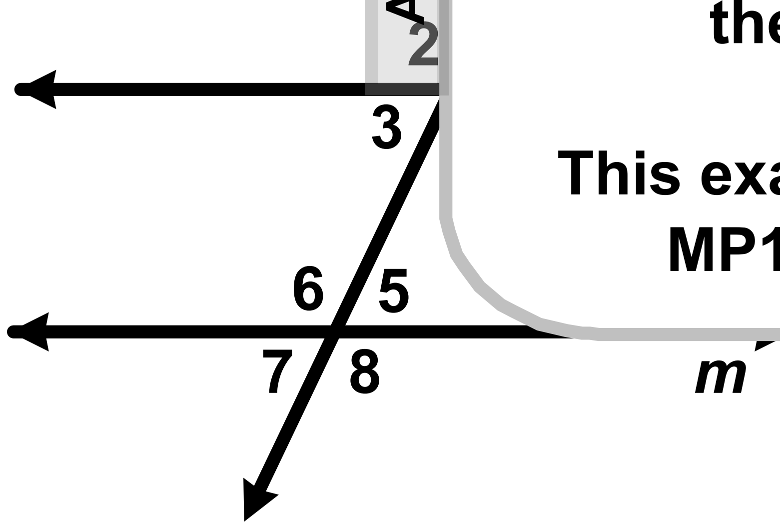


Proving Lines are Parallel

If m∠1 = 48º, find the r
makes lines *k* and *m*

Explain your answer.

Answer



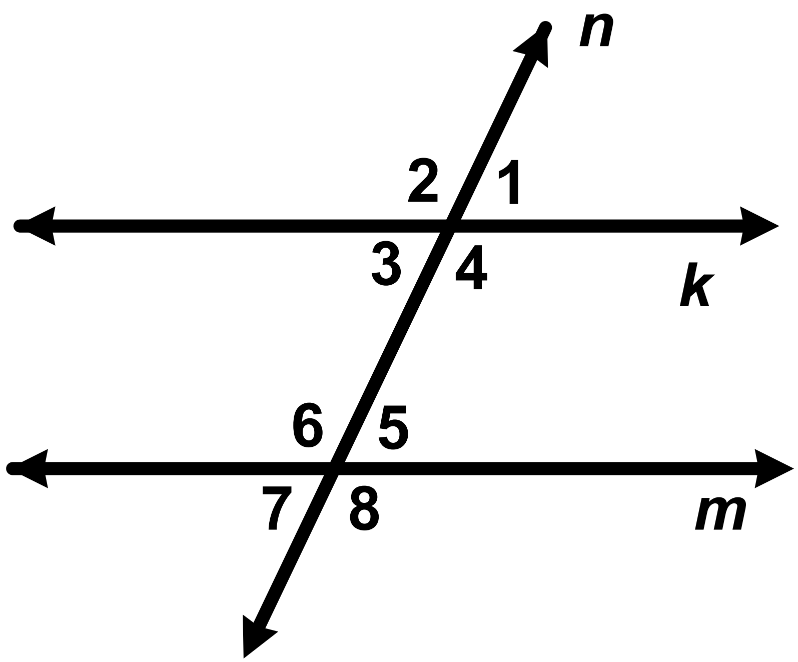
According to the Converse of the Alternate Exterior Angles Theorem, if m∠1 = m∠7, then k‖m. If m∠1= 48º, then m∠7= 48º

This example addresses MP1, MP2 & MP3

Proving Lines are Parallel

If m∠5 = 54°, find the m∠4 that makes lines *k* and *m* parallel.

Explain your answer.



Proving Lines are Parallel

If m∠5 = 54º, find the

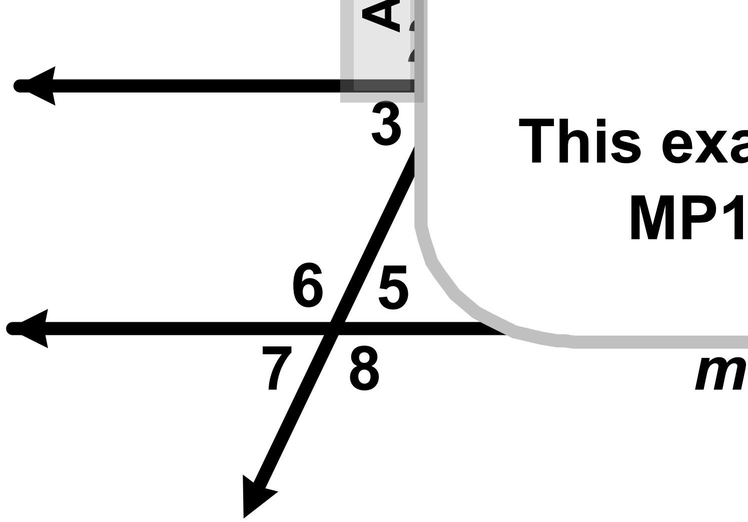
makes lines *k* and *m*

Explain your answer

Answer

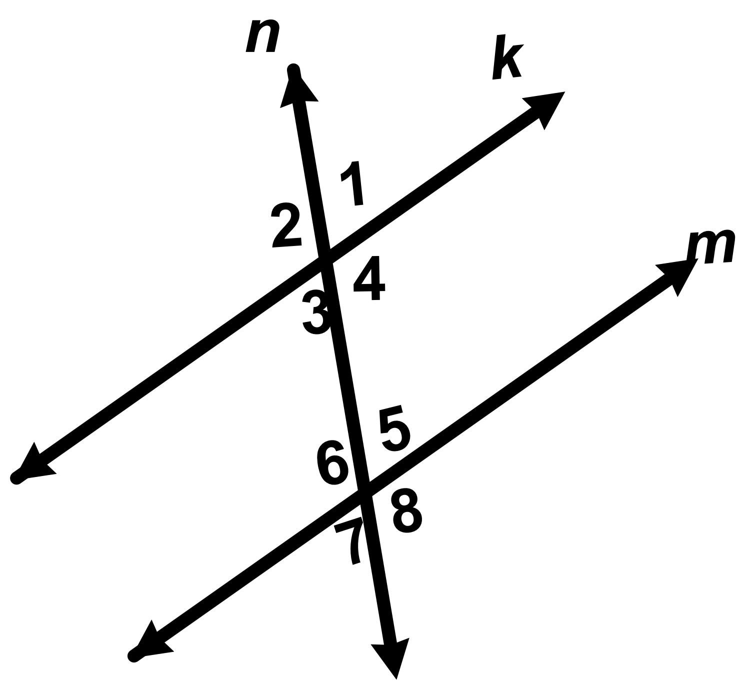
According to the Converse of the Same-Side Angles Theorem, if m∠5 + m∠4 = 180º, then k║m. Therefore, if m∠5 = 54º, then m∠4 = 126º.

This example addresses MP1, MP2 & MP3



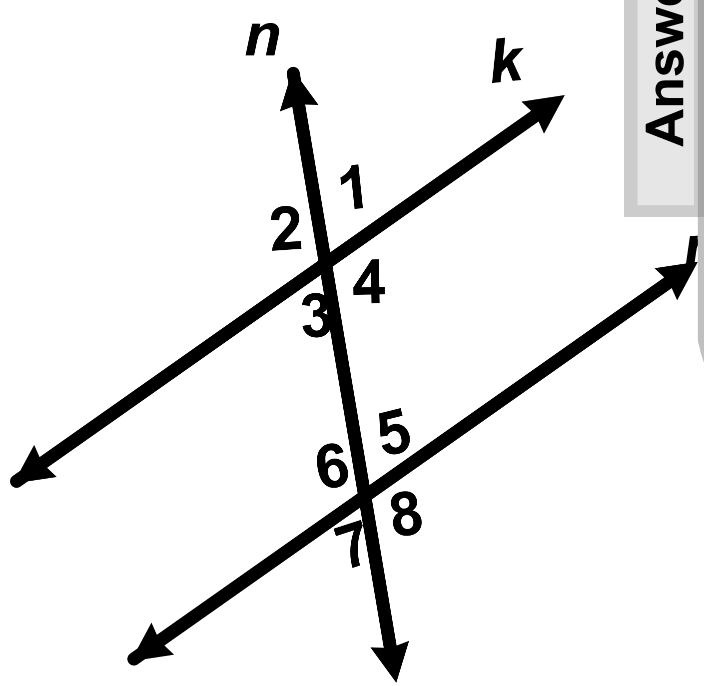
45 Which statement would show lines *k* and *m* parallel?

- A $m\angle 2 = m\angle 4$
- B
- C $m\angle 3 = m\angle 5$
- D



45 Which statement would show lines *k* and *m* parallel?

- A m∠2 = m∠4
- B
- C m∠3 = m∠5
- D

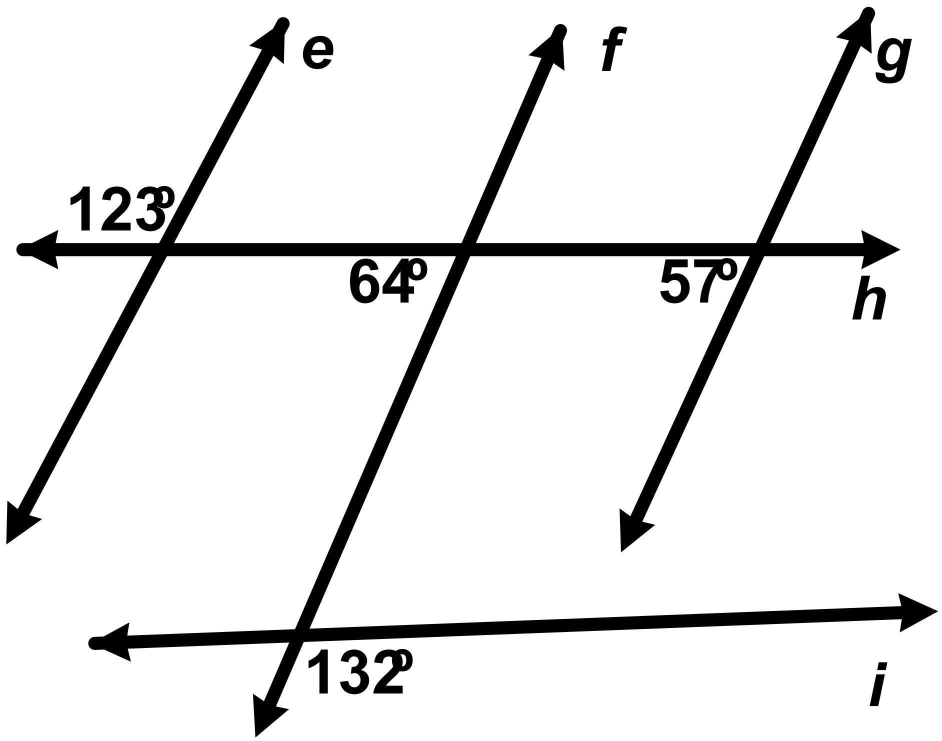


Answer

C

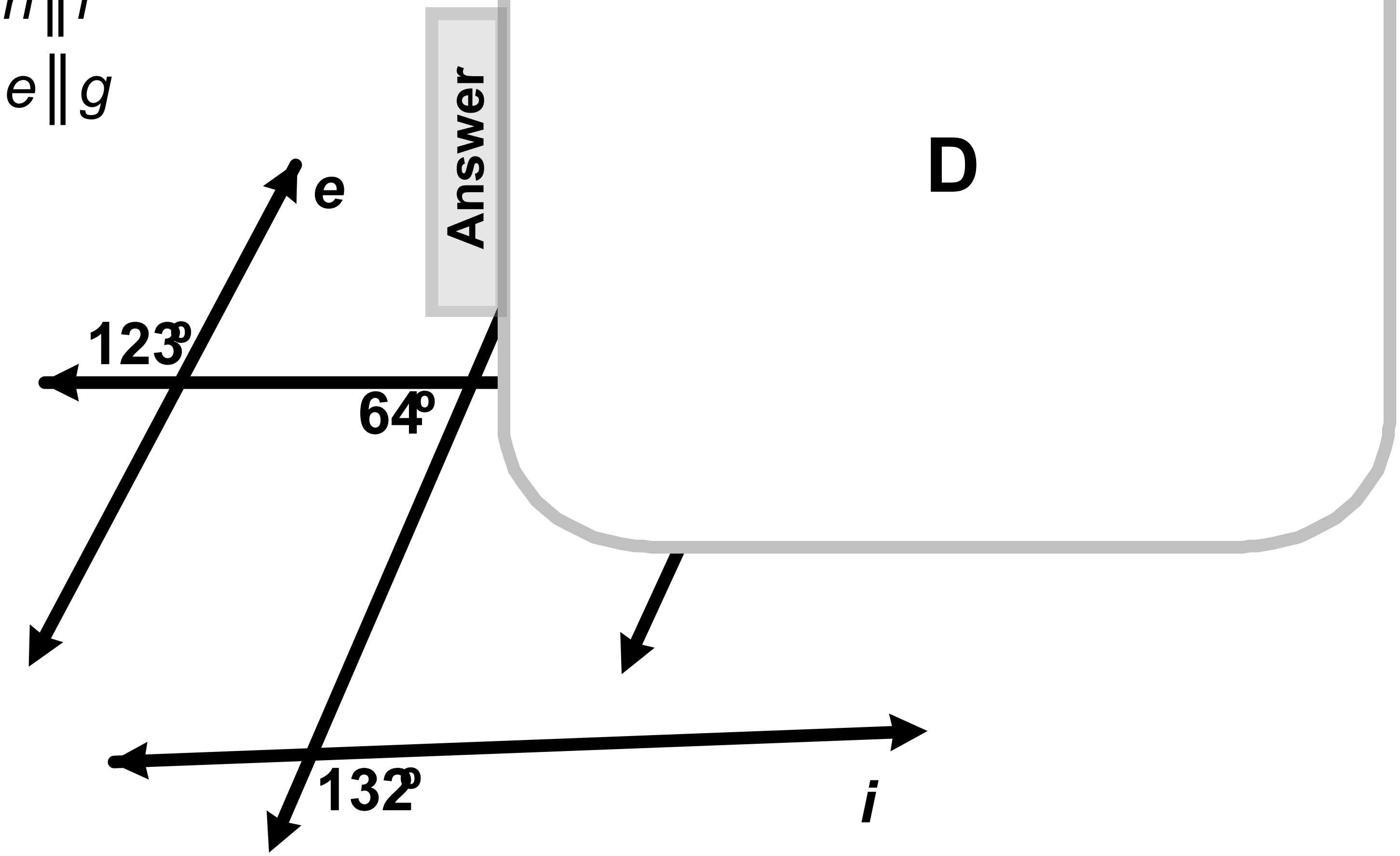
46 In this diagram, which of the following is true?

- A $e \parallel f$
- B $f \parallel g$
- C $h \parallel i$
- D $e \parallel g$



46 In this diagram, which of the following is true?

- A $e \parallel f$
- B $f \parallel g$
- C $h \parallel i$
- D $e \parallel g$



47 If lines *a* and *b* are cut by a transversal which of the following would NOT prove that they are parallel?

- A Corresponding angles are congruent.
- B Alternatne interior angles are congruent.
- C Same-side interior angles are complementary.
- D Same-side interior angles are supplementary.
- E All of the above.

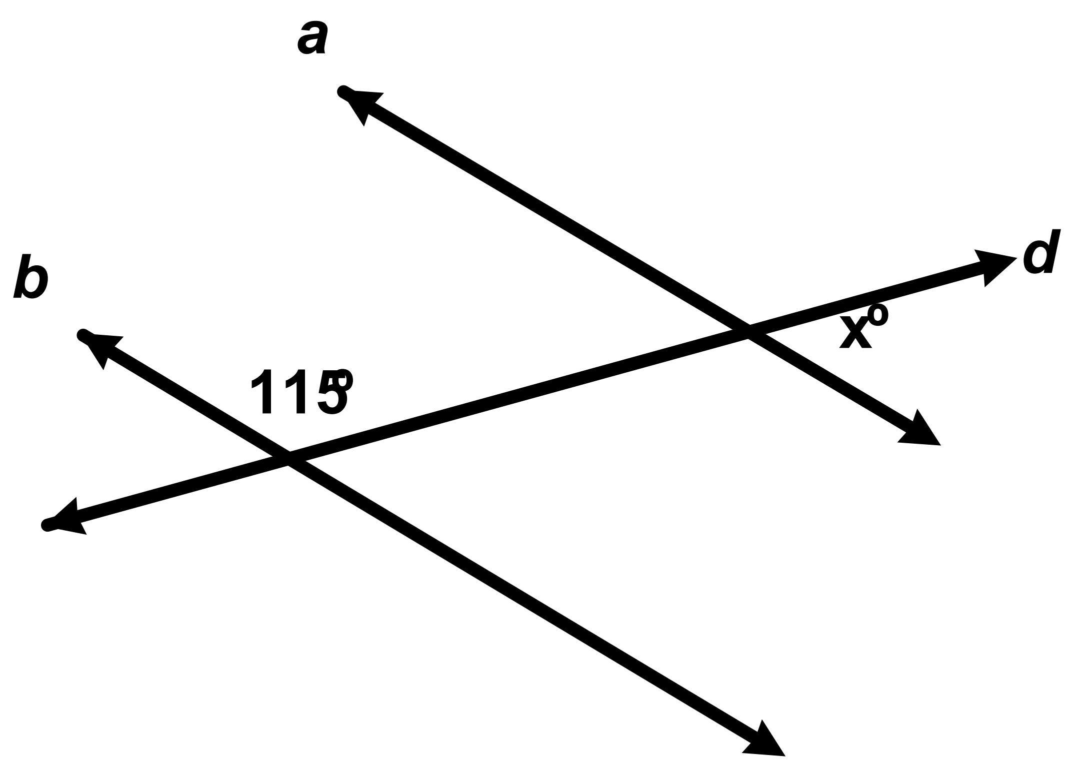
47 If lines *a* and *b* are cut by a transversal which of the following would NOT prove that they are parallel?

- A Corresponding an
- B Alternatne interior
- C Same-side interior
- D Same-side interi
- E All of the above.

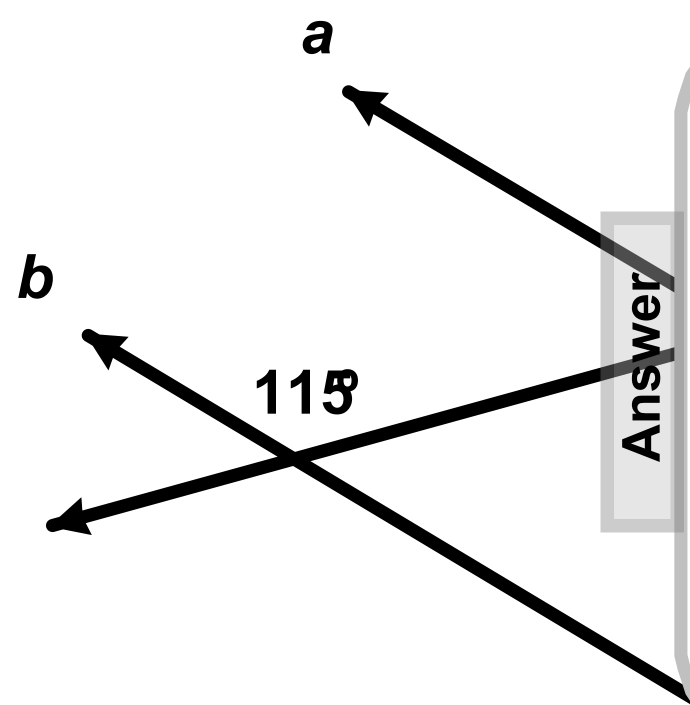
Answer

C

48 Find the value of x for which $a \parallel b$.

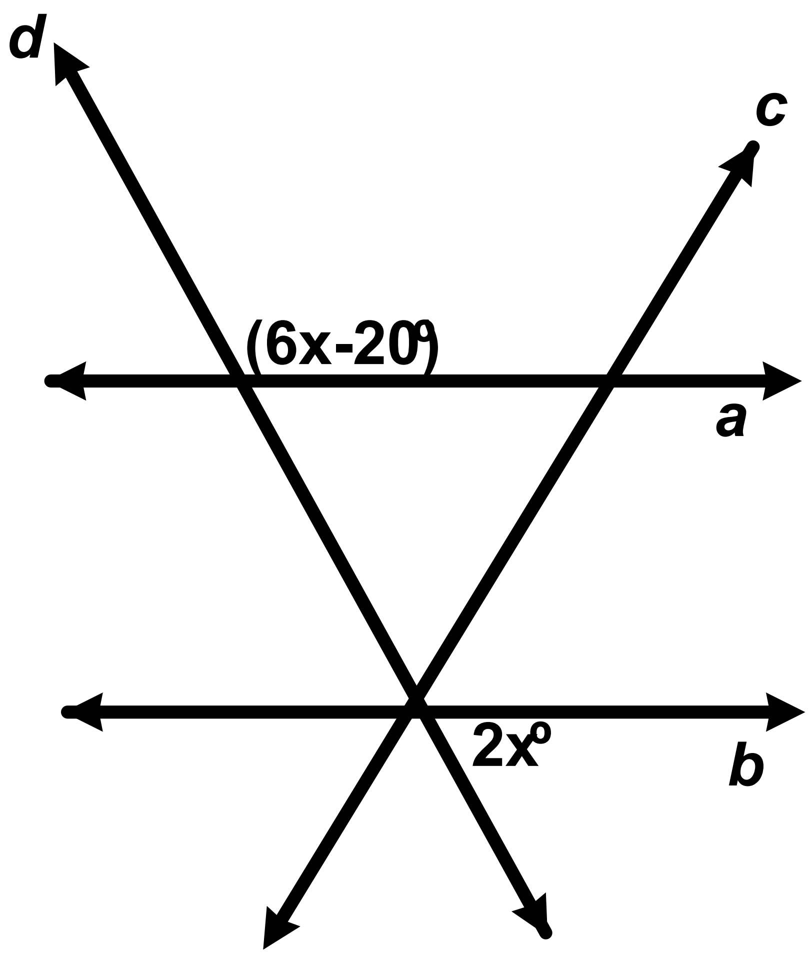


48 Find the value of x for which $a \parallel b$.

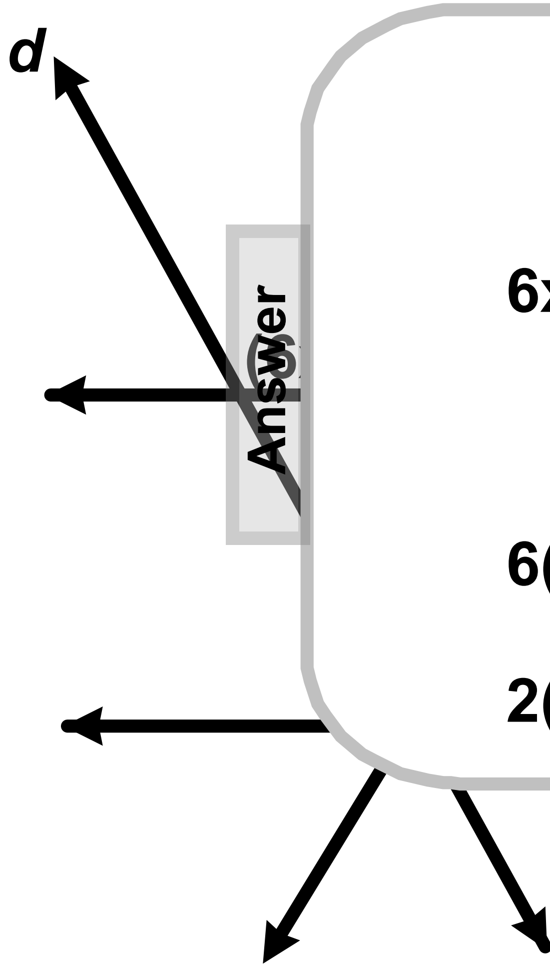


65

49 Find the value of x which makes $a \parallel b$.



49 Find the value of x which makes $a \parallel b$.



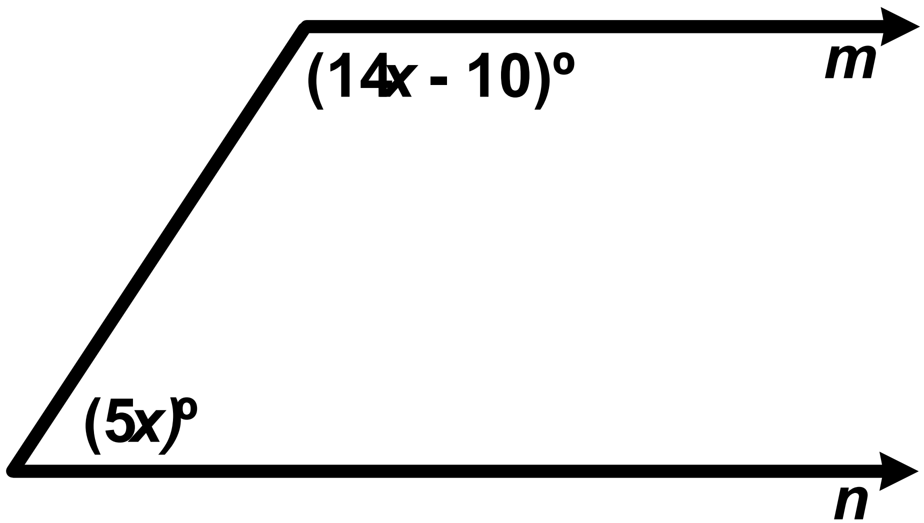
x=25

$$6x - 20 + 2x = 180$$
$$8x = 200$$
$$x = 25$$

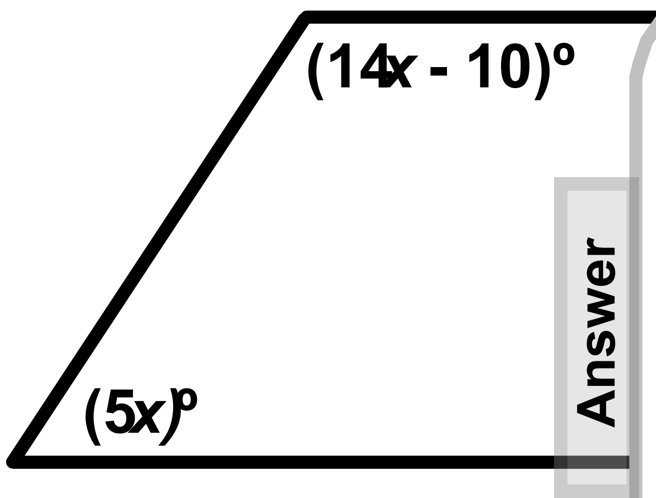
$$6(25) - 20 = 130$$

$$2(25) = 50$$

50 Find the value of x for which $m \parallel n$.



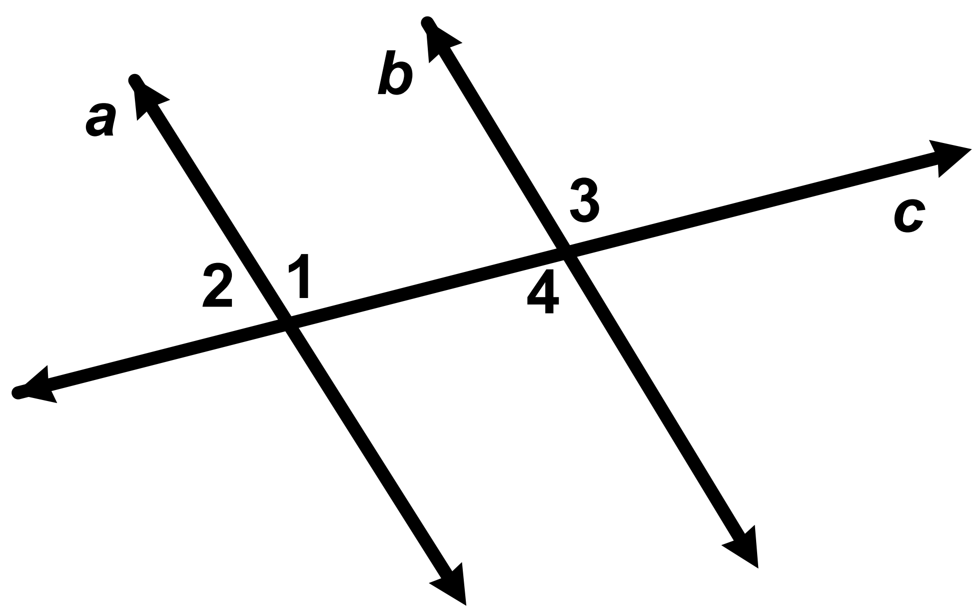
50 Find the value of x for which $m \parallel n$.



10

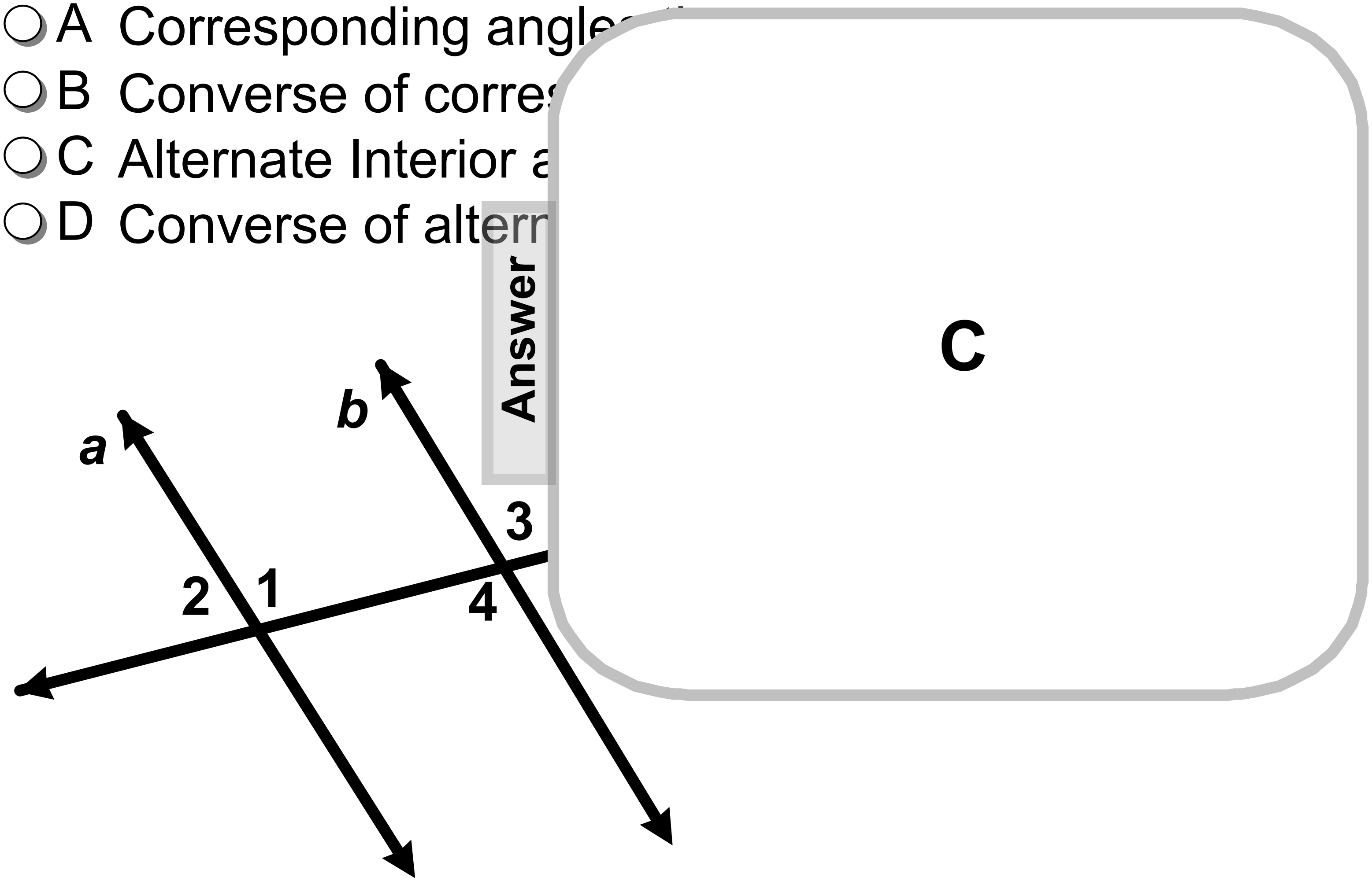
51 If $a \parallel b$, how can we prove $m\angle 1 = m\angle 4$?

- A Corresponding angles theorem
- B Converse of corresponding angles theorem
- C Alternate Interior angles theorem
- D Converse of alternate interior angles theorem



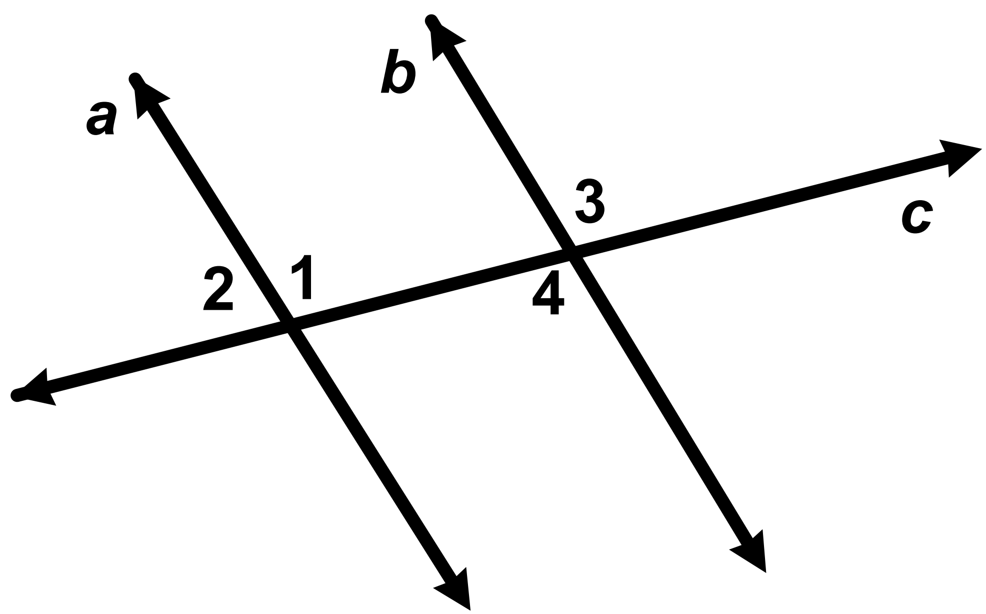
51 If $a \parallel b$, how can we prove m∠1 = m∠4?

- A Corresponding angle...
- B Converse of corres...
- C Alternate Interior a...
- D Converse of altern...



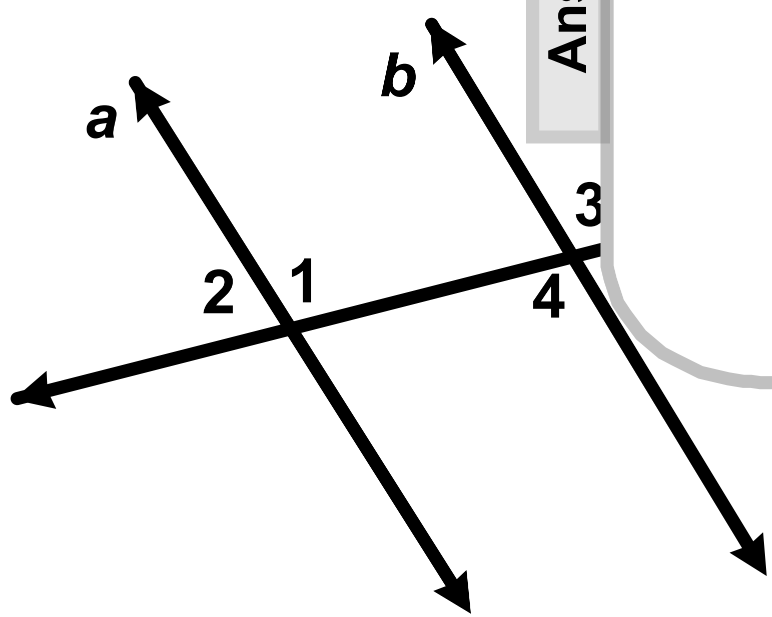
52 If $m\angle 1 = m\angle 3$, how can we prove $a \parallel b$?

- A Corresponding angles theorem
- B Converse of corresponding angles theorem
- C Alternate Interior angles theorem
- D Converse of alternate interior angles theorem



52 If m∠1 = m∠3, how can we prove $a \parallel b$?

- A Corresponding angles theorem
- B Converse of corres
- C Alternate Interior a
- D Converse of altern

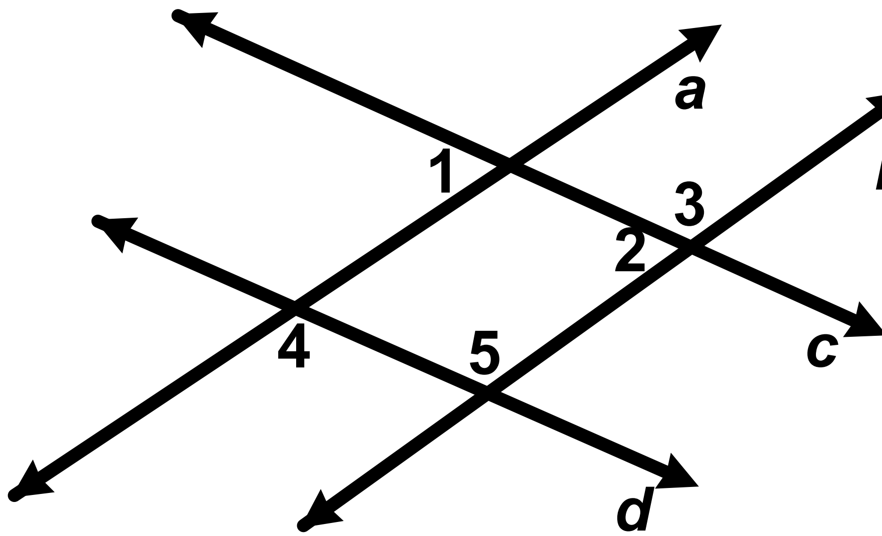


Answer

B

53 Given m∠1 = m∠2, m∠3 = m∠4, what can we prove? (choose all that apply)

- ☐ A $a \parallel b$
- ☐ B $c \parallel d$
- ☐ C line *a* is perpendicular to line *c*
- ☐ D line *b* is perpendicular to line *d*

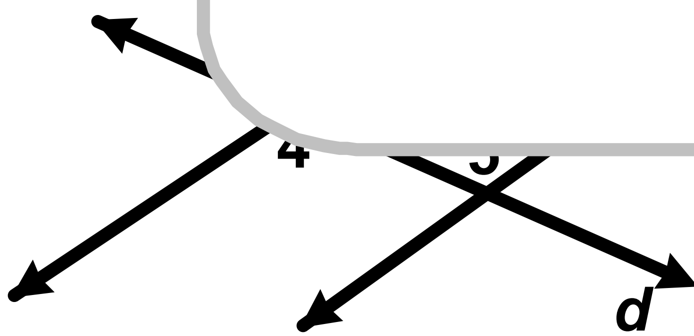


53 Given m∠1 = m∠2, m∠3 = m∠4, what can we prove? (choose all that apply)

- ☐ A $a \parallel b$
- ☐ B $c \parallel d$
- ☐ C line *a* is perpendic
- ☐ D line *b* is perpendic

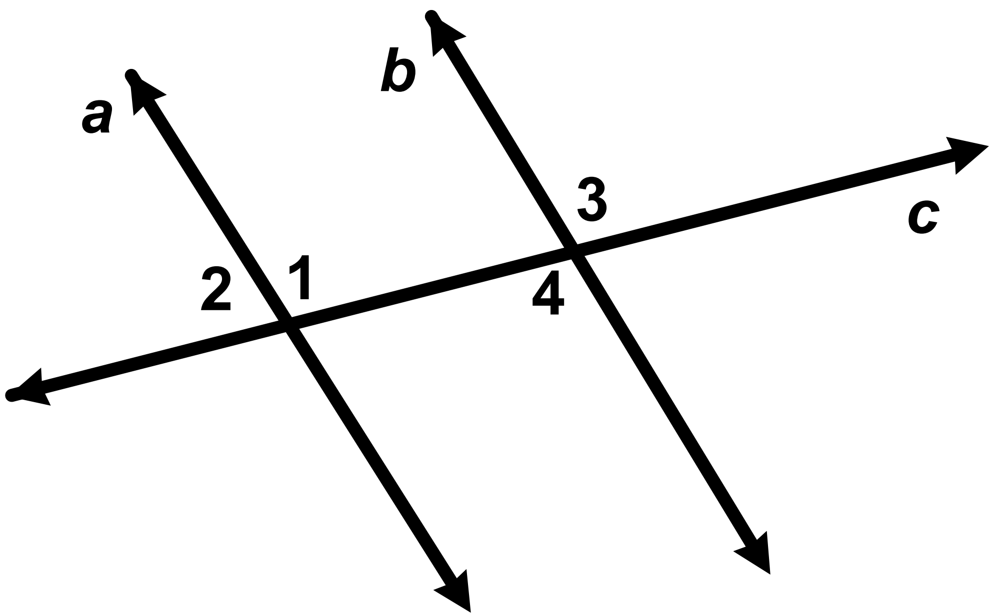
Answer

A & B



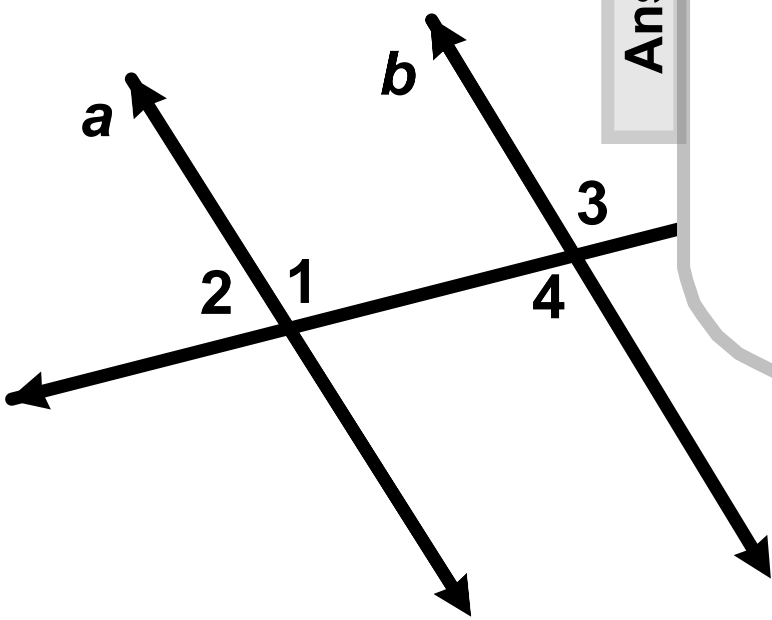
54 Given $a \parallel b$, what can we prove?

- A $m\angle 1 = m\angle 2$
- B $m\angle 1 = m\angle 4$
- C $m\angle 2 = m\angle 3$
- D $m\angle 1 + m\angle 3 = 180^{\circ}$



54 Given $a \parallel b$, what can we prove?

- A $m\angle 1 = m\angle 2$
- B $m\angle 1 = m\angle 4$
- C $m\angle 2 = m\angle 3$
- D $m\angle 1 + m\angle 3 = 180°$



Answer

B

Constructing Parallel Lines

Return to Table of Contents

Constru

Math Practice

This entire lesson w/ constructions addresses MP5

le
of Contents

Parallel Line Construction

Constructing geometric figures means you are constructing lines, angles, and figures with basic tools accurately.

We use a compass, and straightedge for constructions, but we also use some paper folding techniques.

Click here to see an animated construction of a parallel line through a point.

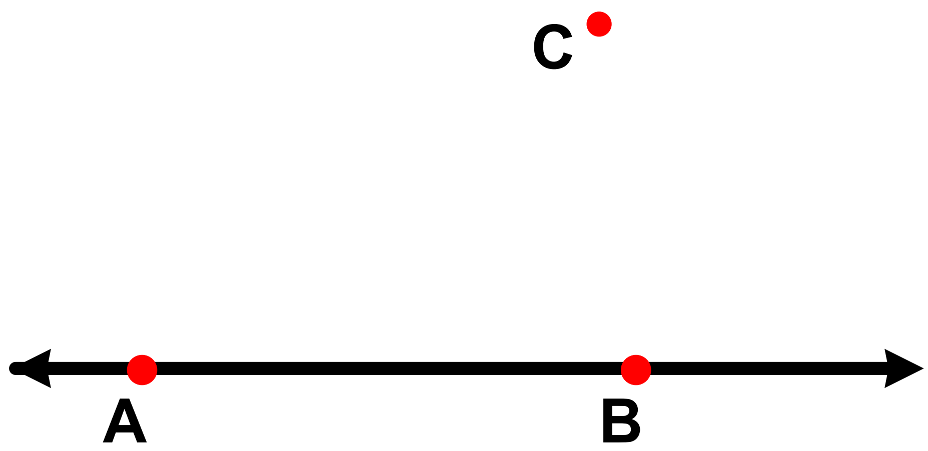
Construction by: MathIsFun

Parallel Line Construction

Given: Line AB and point C, not on the line, draw a second line that is parallel to AB and goes through point C.

There are three different methods to achieve this.

Method 1: Corresponding Angles



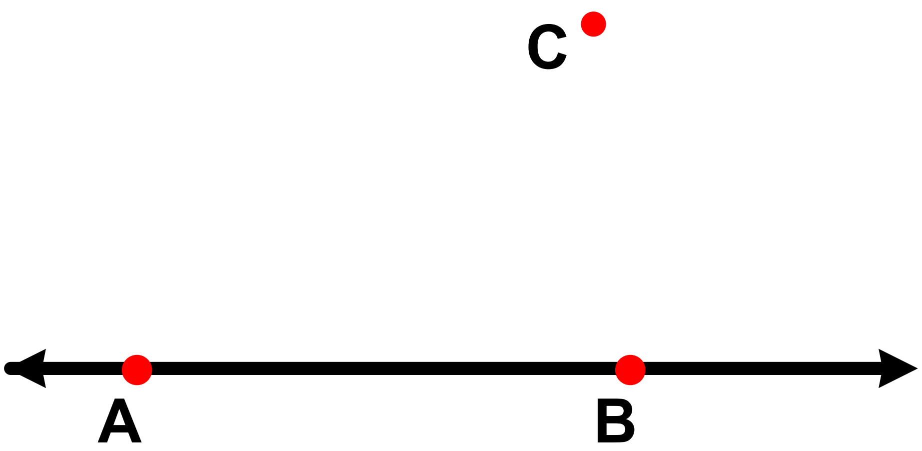
Parallel Line Construction: Method 1

The theory of this construction is that the corresponding angles formed by a transversal and parallel lines are equal.

To use this theory, we will draw a transversal through C that creates an acute angle with line AB.

Then we will create a congruent angle at C, on the same side of the transversal as the acute angle formed with line AB.

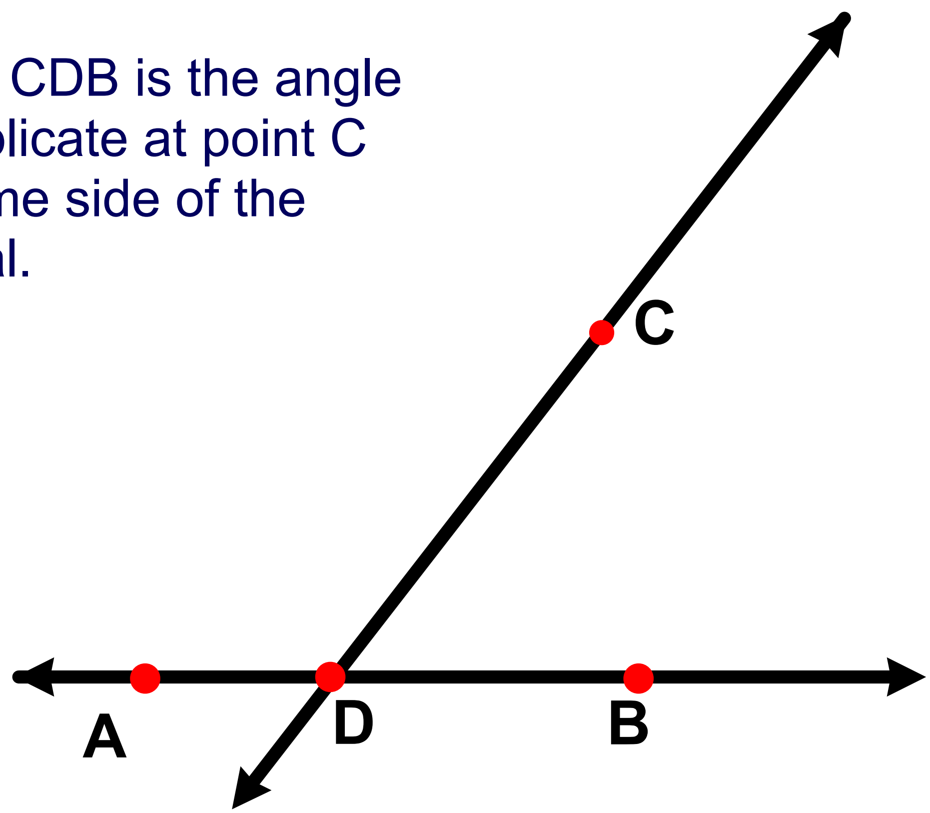
Since these are congruent corresponding angles, the lines are parallel.



Parallel Line Construction: Method 1

Step 1: Draw a transversal to AB through point C that intersects AB at point D. An acute angle with point D as a vertex is formed (the measure of the angle is not important).

The angle CDB is the angle we will replicate at point C on the same side of the transversal.

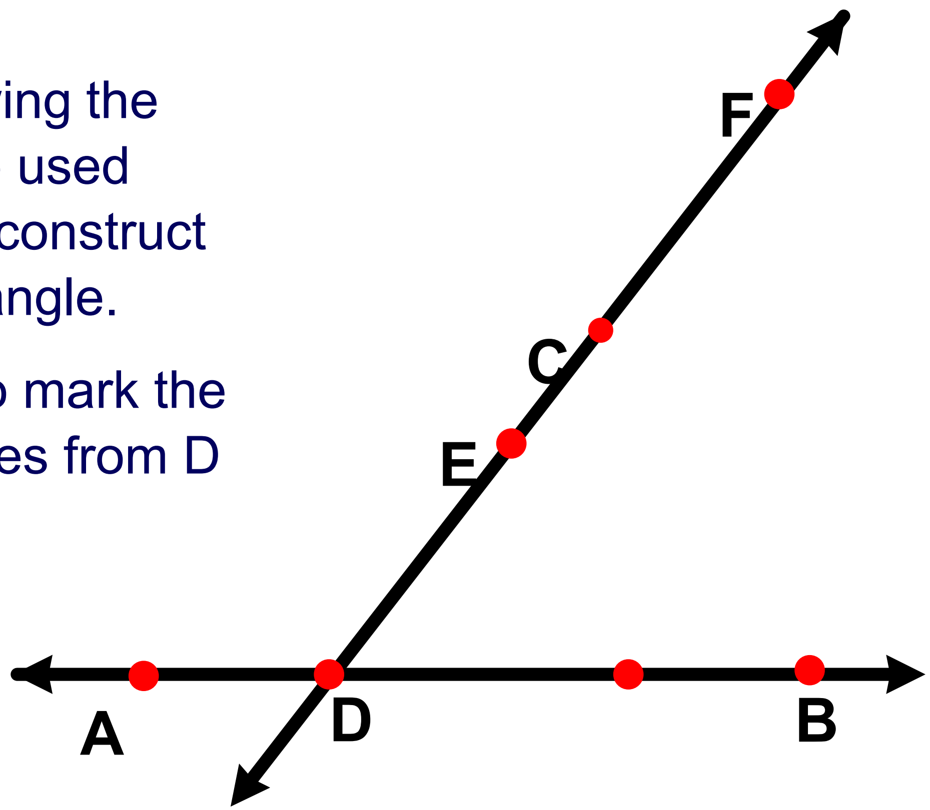


Parallel Line Construction: Method 1

Step 2: Center the compass at point D and draw an arc that intersects both lines. Using the same radius of the compass, center it at point C and draw another arc. Label the point of intersection on the second arc F.

We are following the procedure we used previously to construct a congruent angle.

This step is to mark the same distances from D and from C.

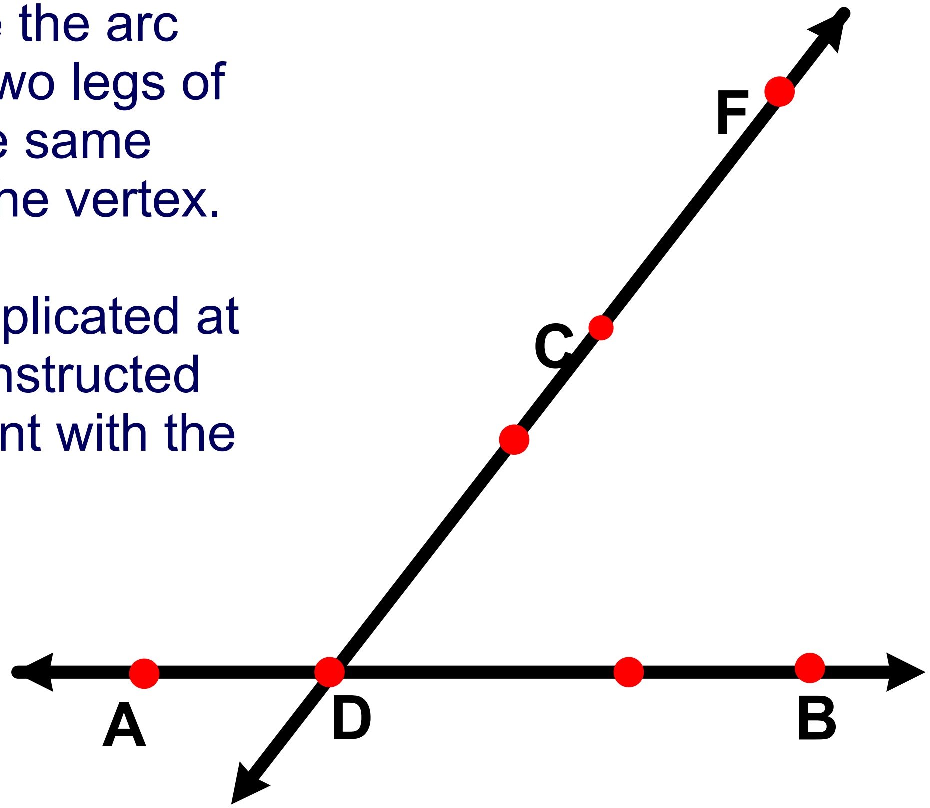


Parallel Line Construction: Method 1

Step 3: Set the compass radius to the distance between the two intersection points of the first arc.

This replicates the distance between where the arc intersects the two legs of the angle at the same distance from the vertex.

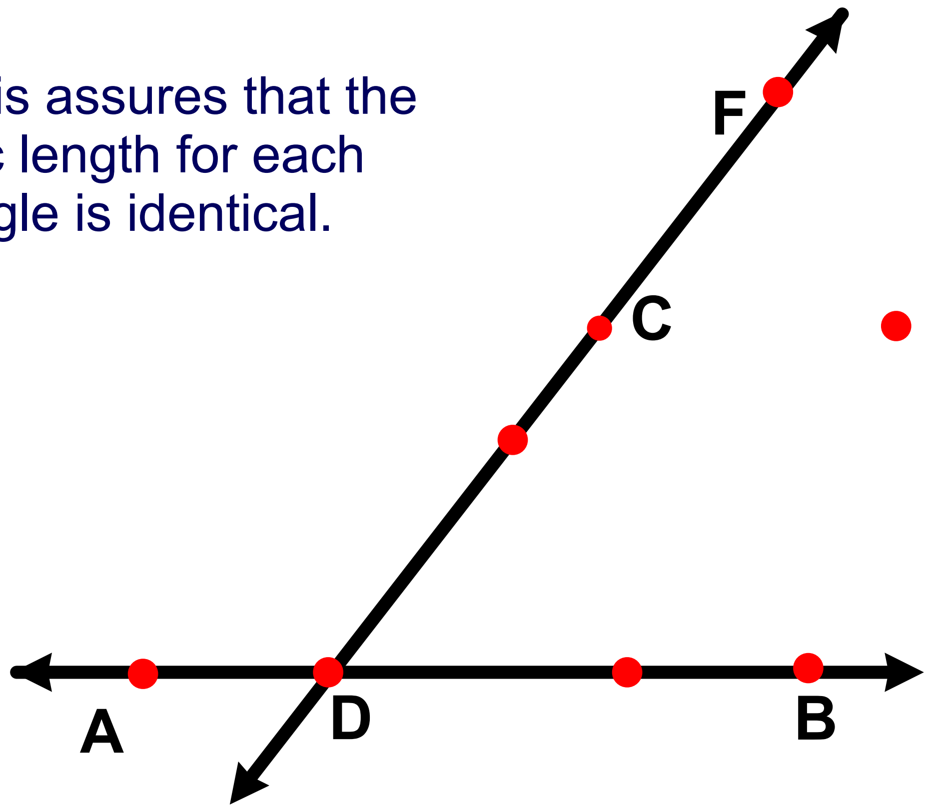
When that is replicated at C the angle constructed will be congruent with the original angle.



Parallel Line Construction: Method 1

Step 4: Center the compass at the point F where the second arc intersects line DC and draw a third arc.

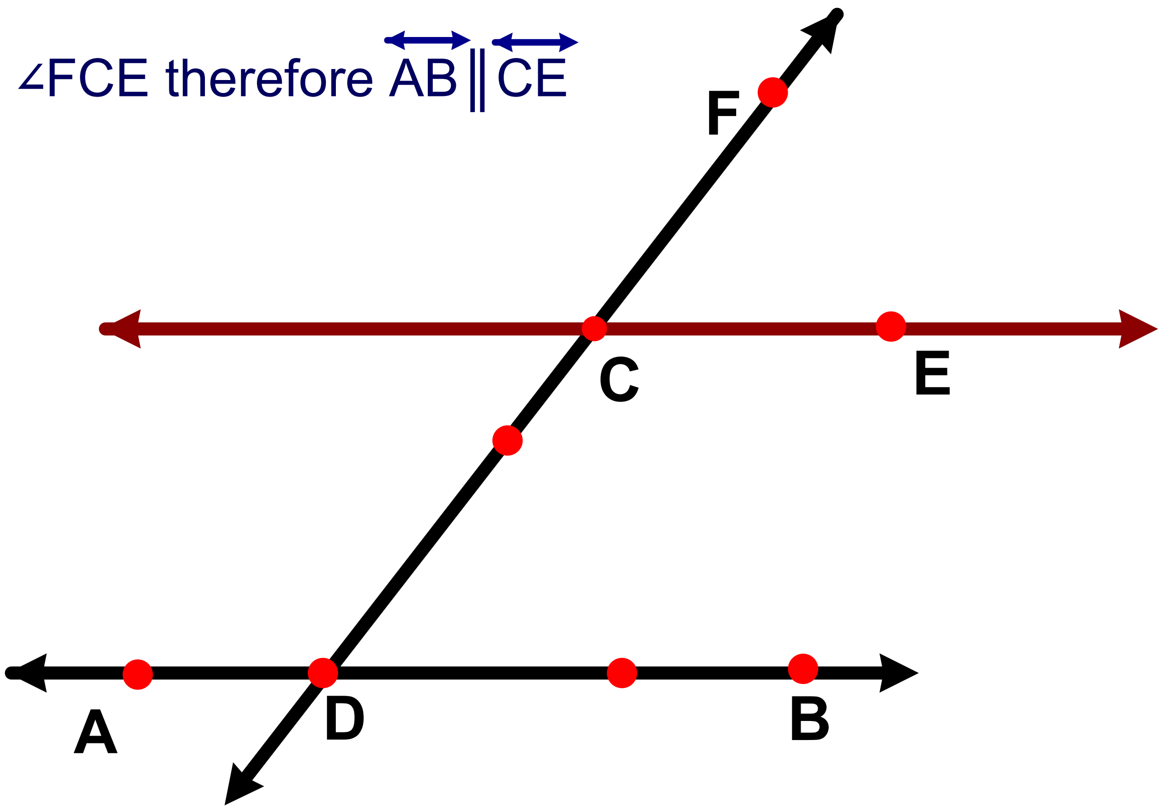
This assures that the arc length for each angle is identical.



Parallel Line Construction: Method 1

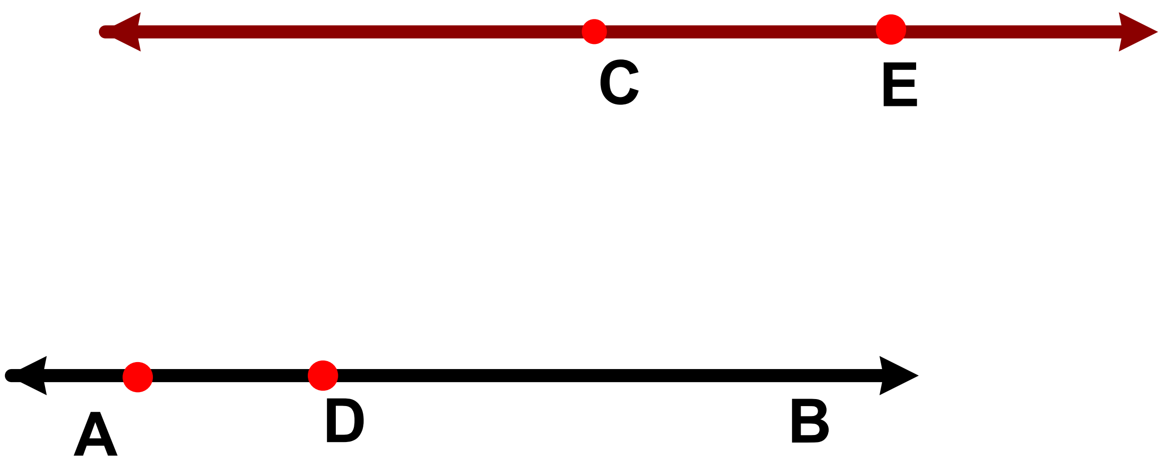
Step 5: Mark the arc intersection point E and use a straight edge to join C and E.

∠CDB ≅ ∠FCE therefore $\overleftrightarrow{AB} \parallel \overleftrightarrow{CE}$



Parallel Line Construction: Method 1

Here are my parallel lines without the construction lines.



Video Demonstrating Constructing Parallel Lines with Corresponding Angles using Dynamic Geometric Software

Click here to see video

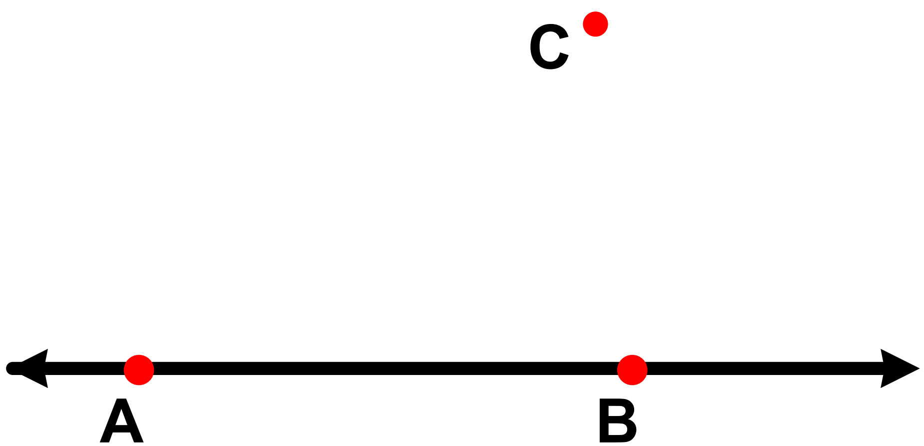
Parallel Line Construction: Method 2

The theory of this construction is that the alternate interior angles formed by a transversal and parallel lines are equal.

To use this theory, we will draw a transversal through C that creates an acute angle with line AB.

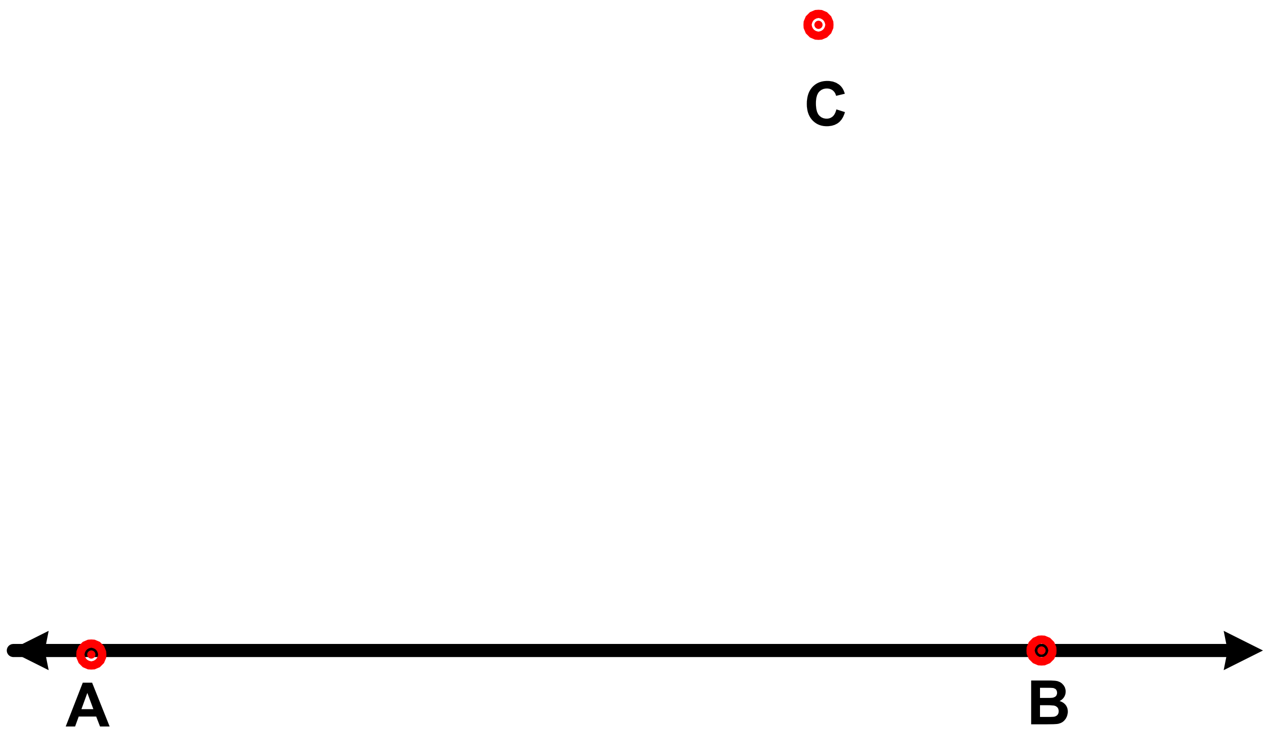
Then we will create a congruent angle at C, on the opposite side of the transversal as the acute angle formed with line AB.

Since these are congruent alternate interior angles the lines are parallel.



Method 2: Alternate Interior Angles

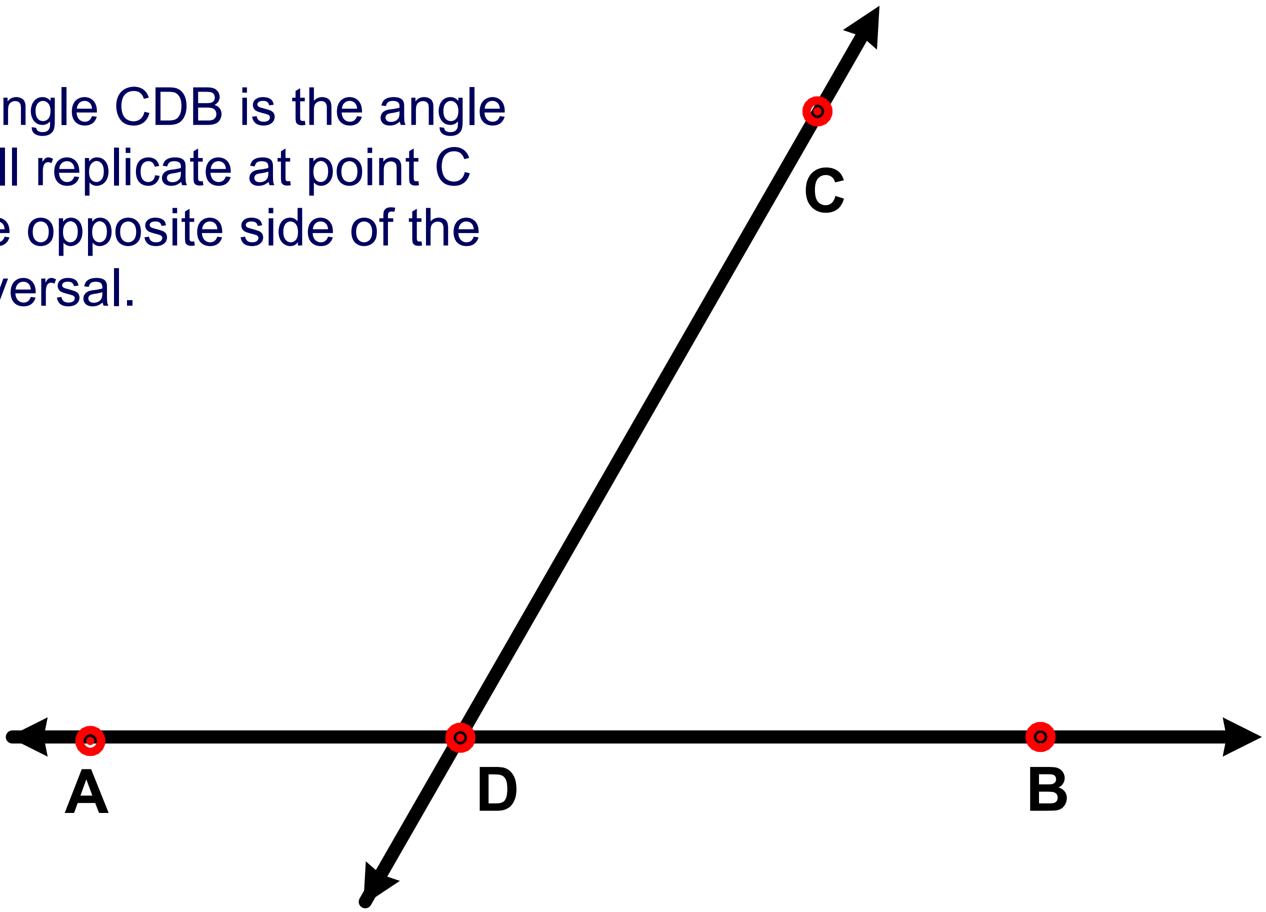
Given $\overleftrightarrow{AB}$ and point C, not on the line, draw a second line that is parallel to $\overleftrightarrow{AB}$ and goes through point C.



Method 2: Alternate Interior Angles

Step 1: Draw a transversal to line AB through point C that intersects line AB at point D. An acute angle with point D as a vertex is formed.

The angle CDB is the angle we will replicate at point C on the opposite side of the transversal.

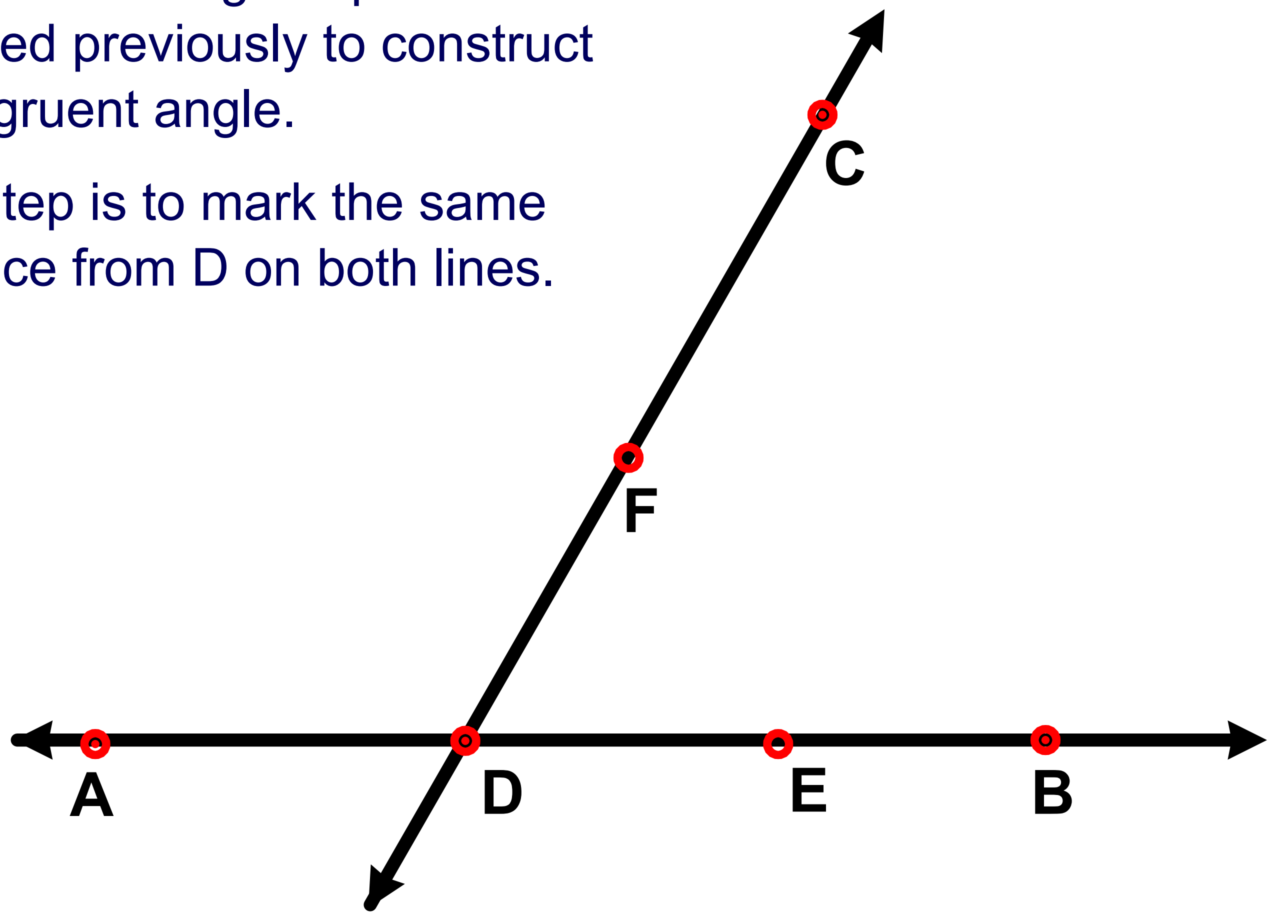


Method 2: Alternate Interior Angles

Step 2: Center the compass at point D and draw an arc that intersects both lines, at points E and at F.

We are following the procedure we used previously to construct a congruent angle.

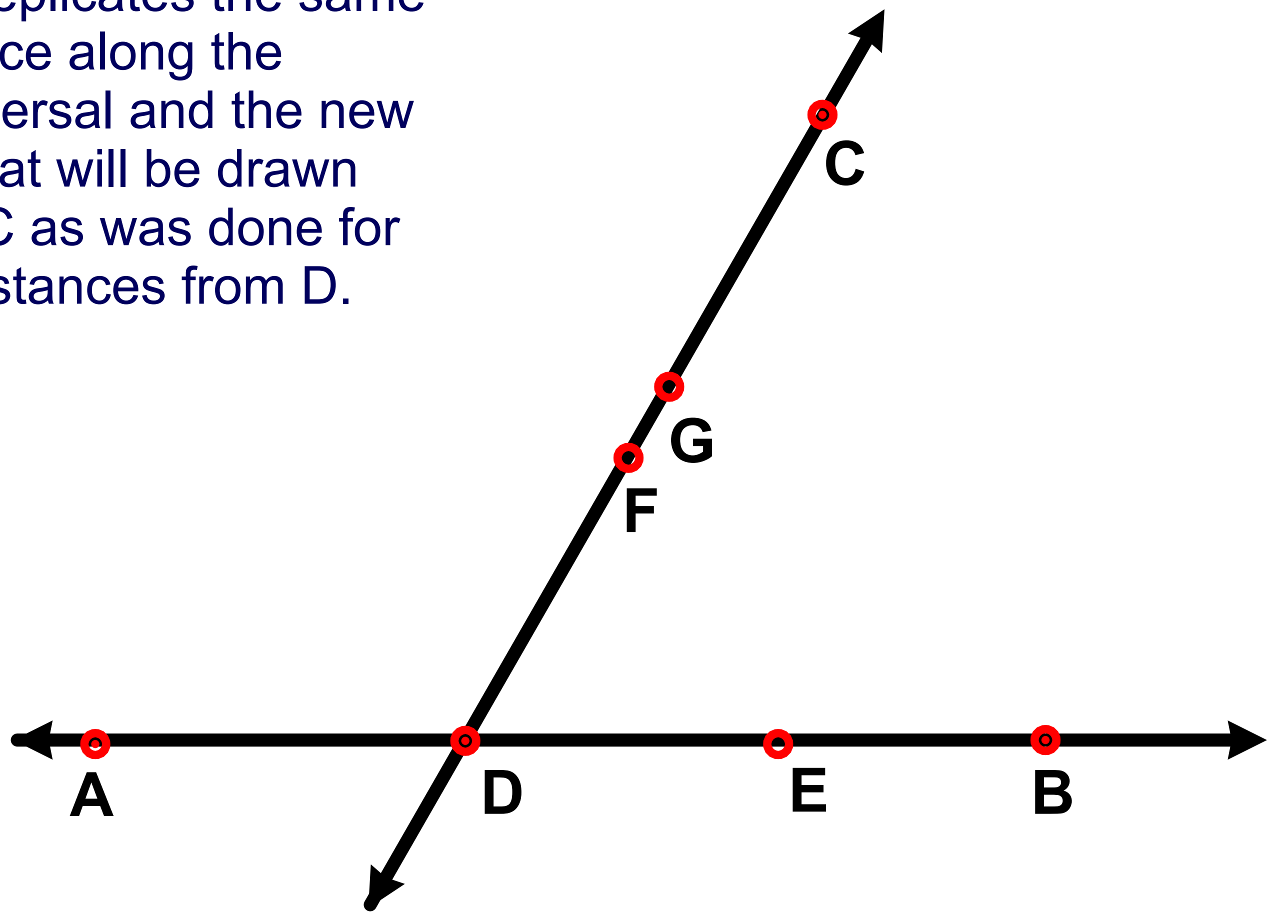
This step is to mark the same distance from D on both lines.



Method 2: Alternate Interior Angles

Step 3: Using the same radius, center the compass at point C and draw an arc that passes through line DC at point G.

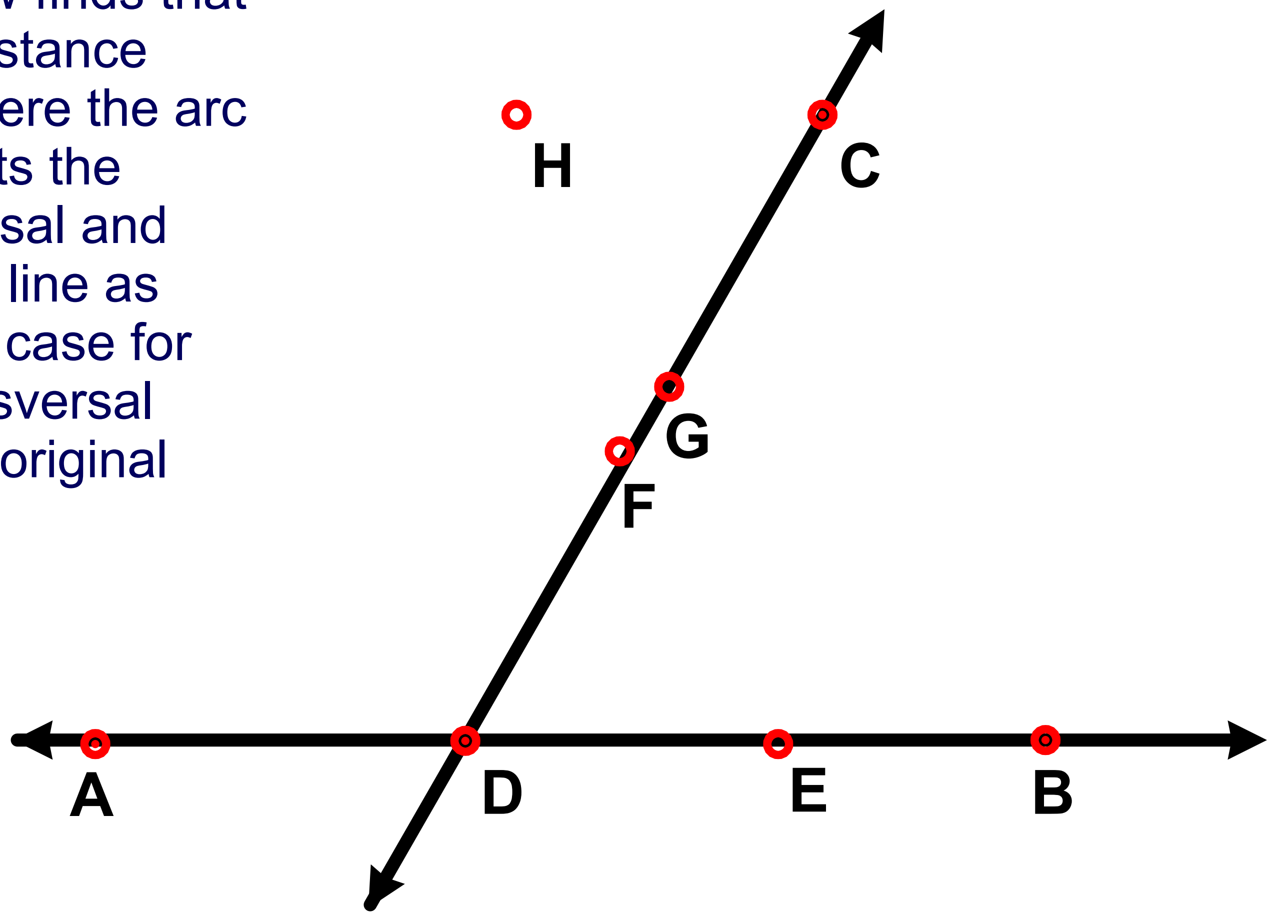
This replicates the same distance along the transversal and the new line that will be drawn from C as was done for the distances from D.



Method 2: Alternate Interior Angles

Step 4: Again, with the same radius, center the compass at point G and draw a third arc which intersects the earlier one, at H.

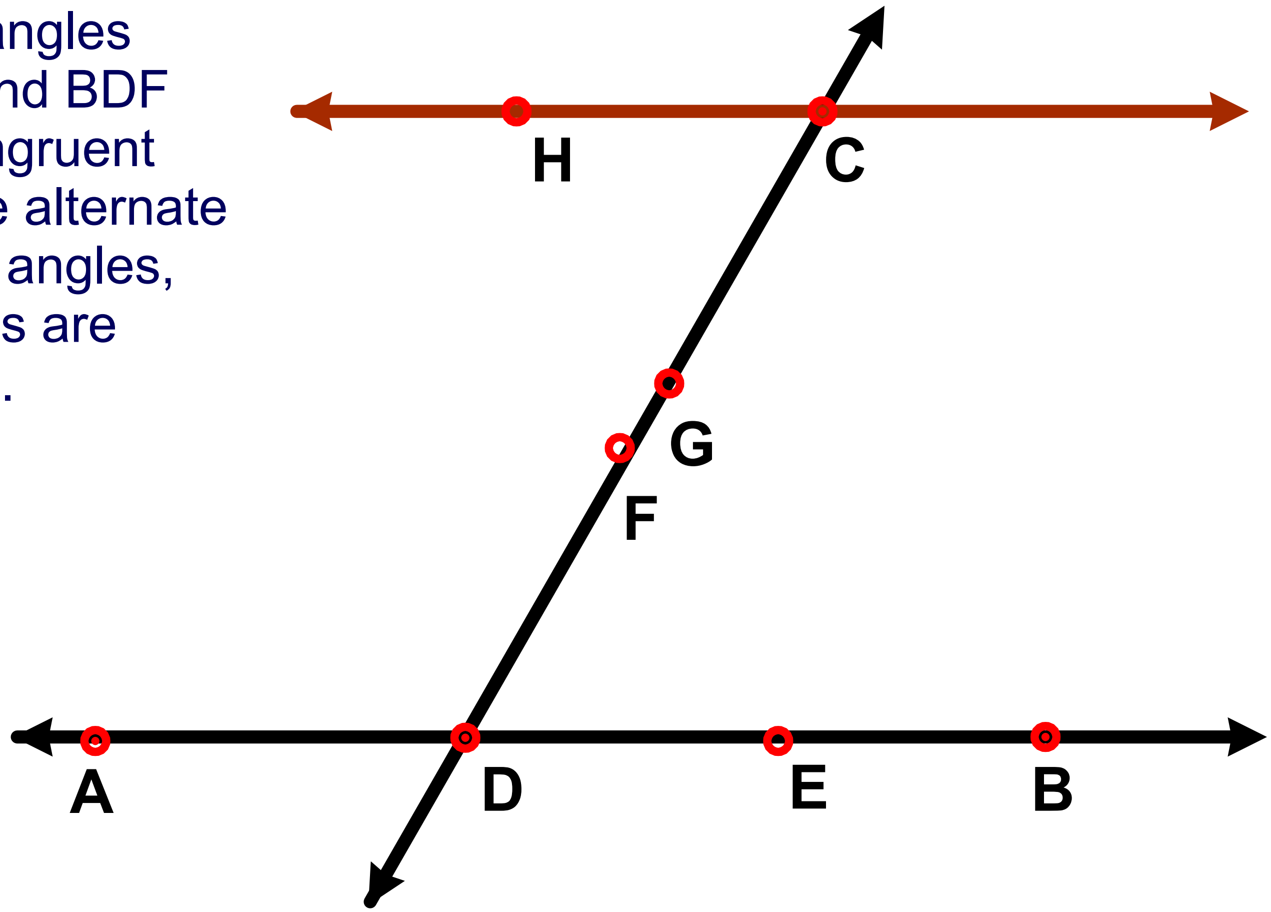
This now finds that same distance from where the arc intersects the transversal and the new line as was the case for the transversal and the original line.



Method 2: Alternate Interior Angles

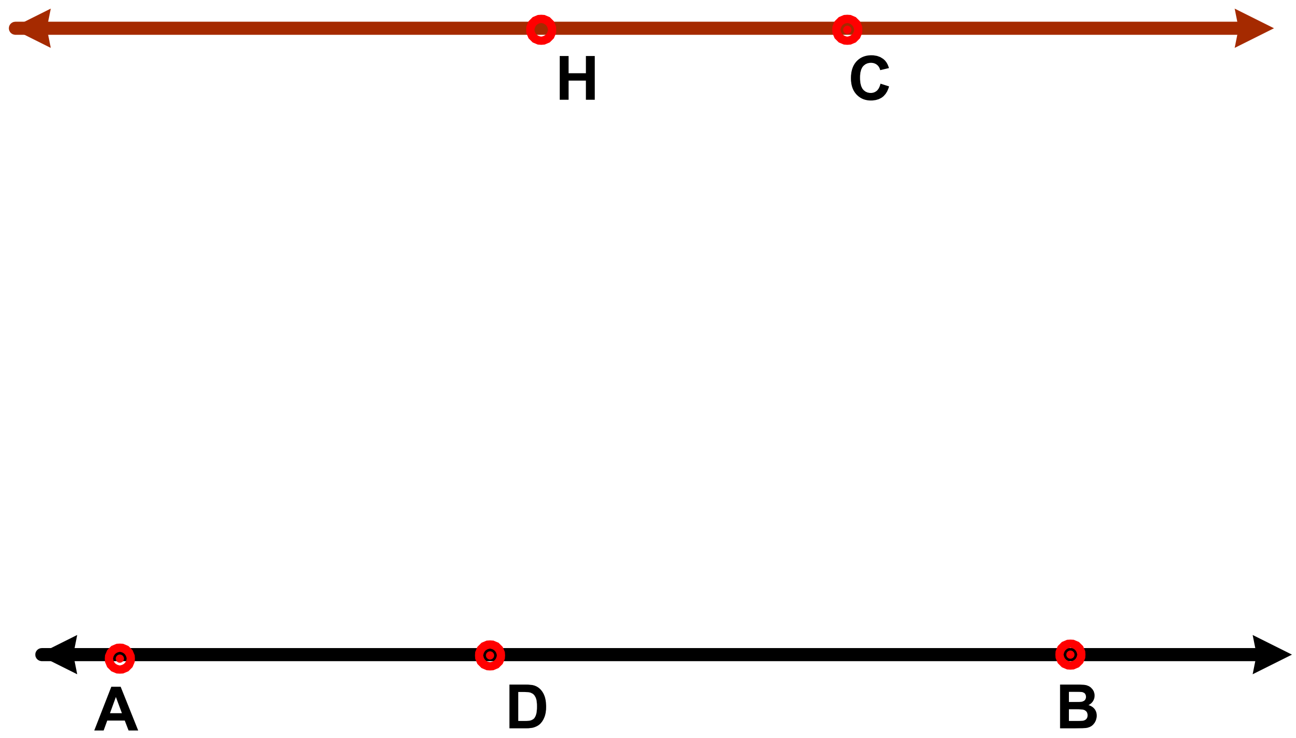
Step 5: Draw line CH, which will be parallel to line AB since their alternate interior angles are congruent.

Since angles HCG and BDF are congruent and are alternate interior angles, the lines are parallel.



Method 2: Alternate Interior Angles

Here are the lines without the construction steps shown.

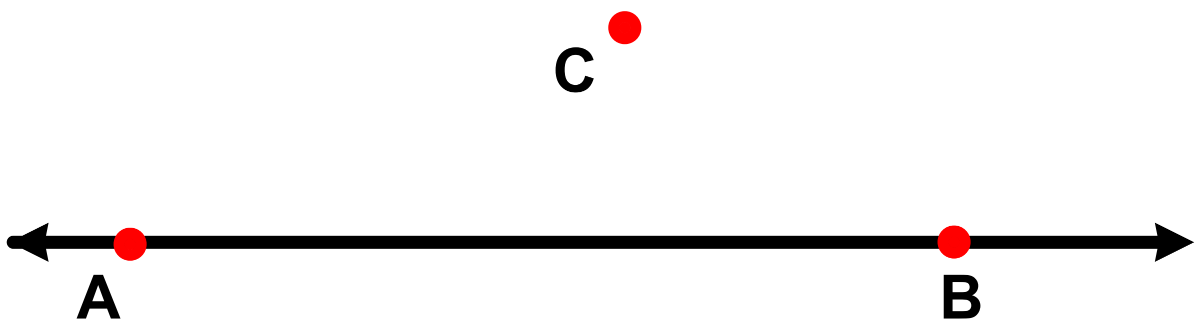


Video Demonstrating Constructing Parallel Lines with Alternate Interior Angles using Dynamic Geometric Software

Click here to see video

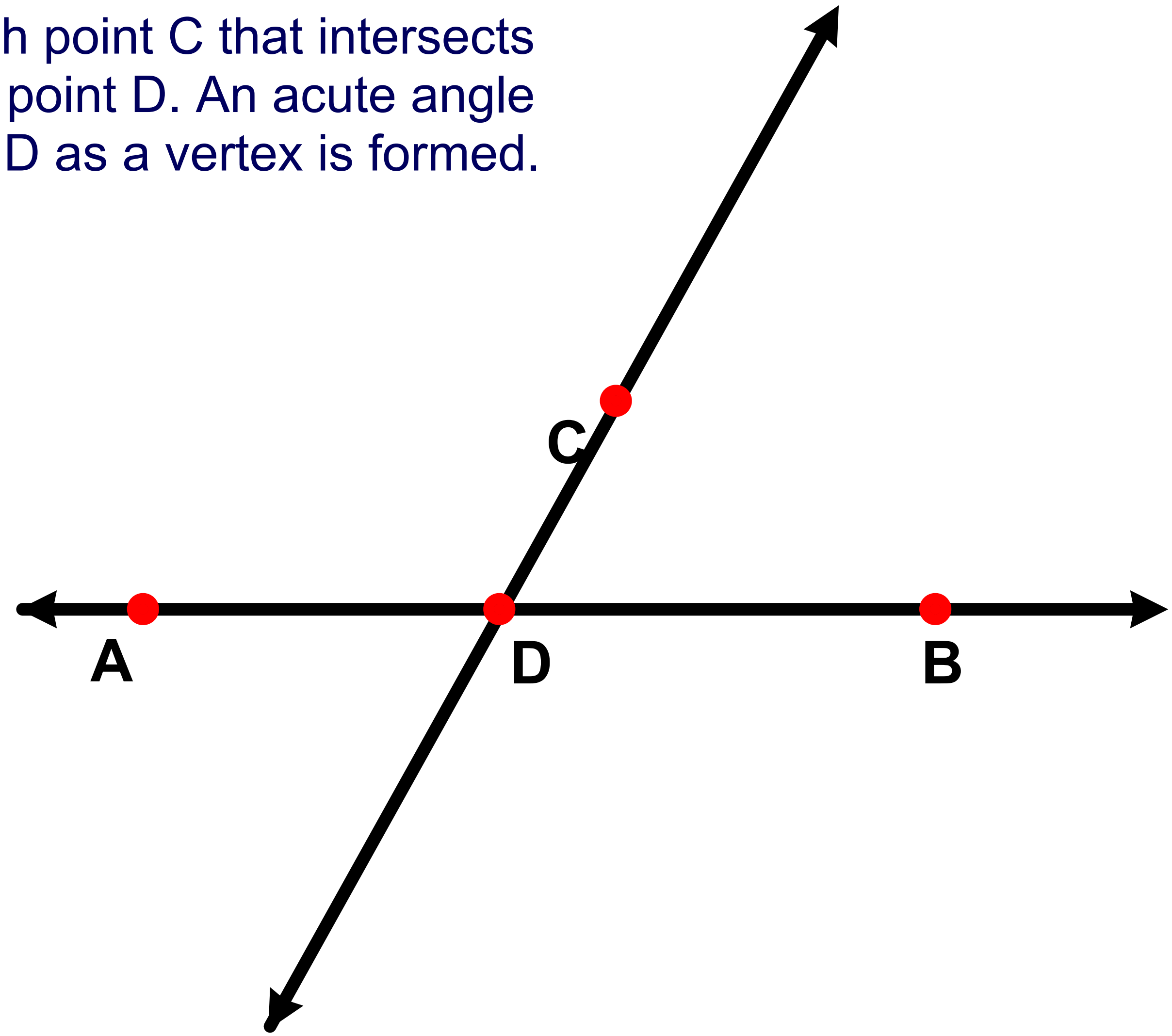
Method 3: Alternate Exterior Angles

Given line AB and point C, not on the line, draw a second line that is parallel to line AB and goes through point C.



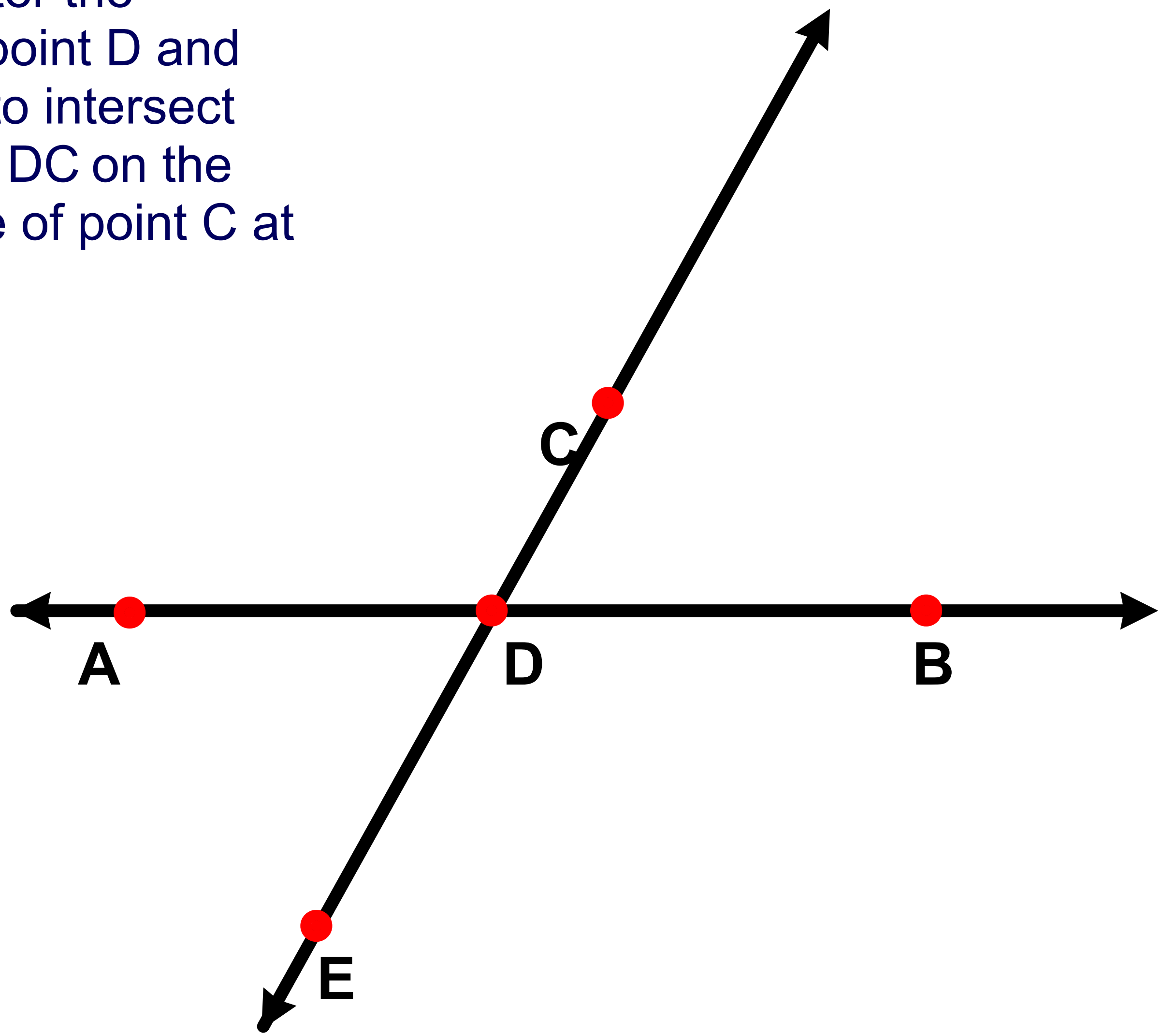
Method 3: Alternate Exterior Angles

Step 1: Draw a transversal to line AB through point C that intersects line AB at point D. An acute angle with point D as a vertex is formed.



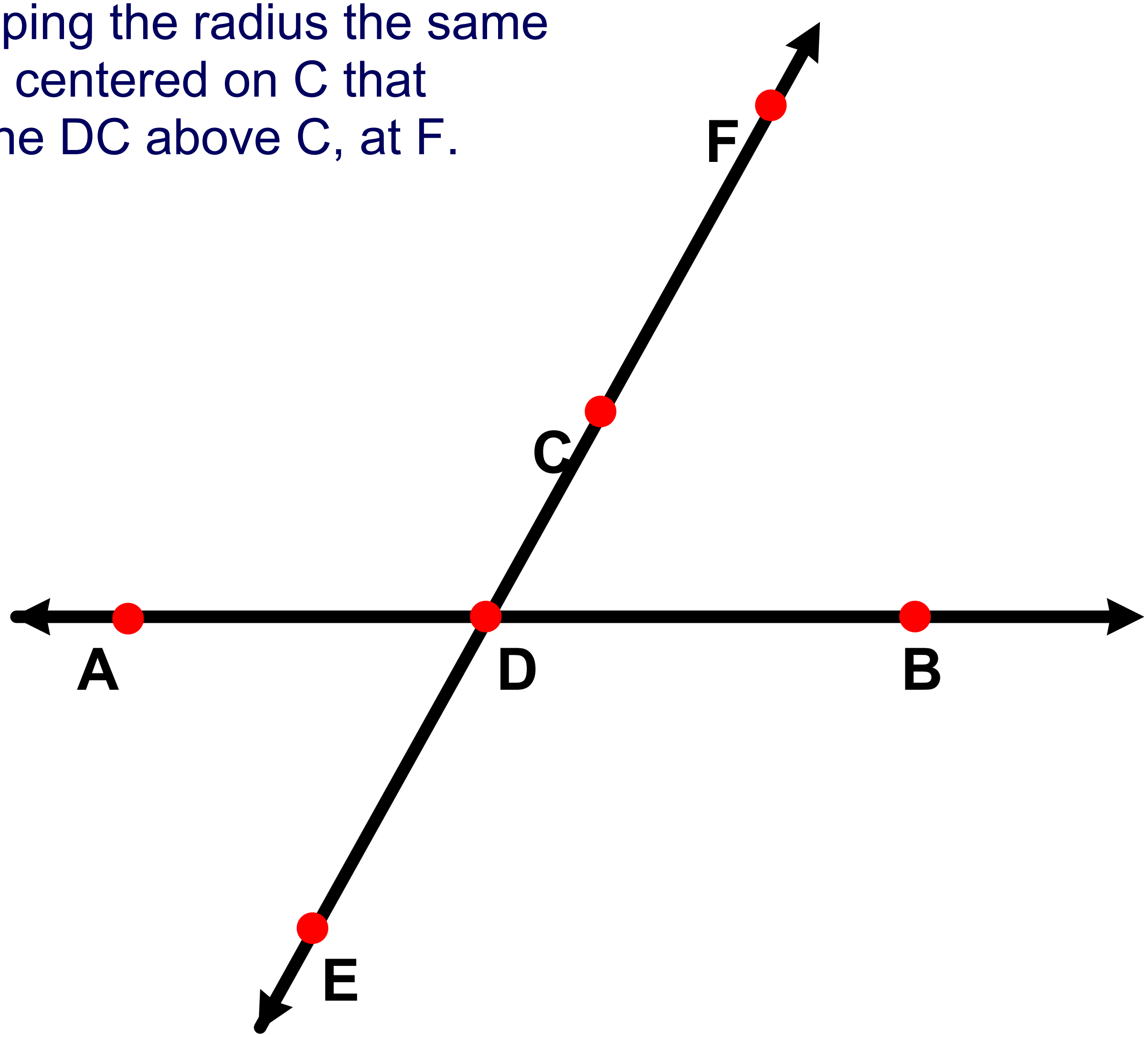
Method 3: Alternate Exterior Angles

Step 2: Center the compass at point D and draw an arc to intersect lines AB and DC on the opposite side of point C at A and E.



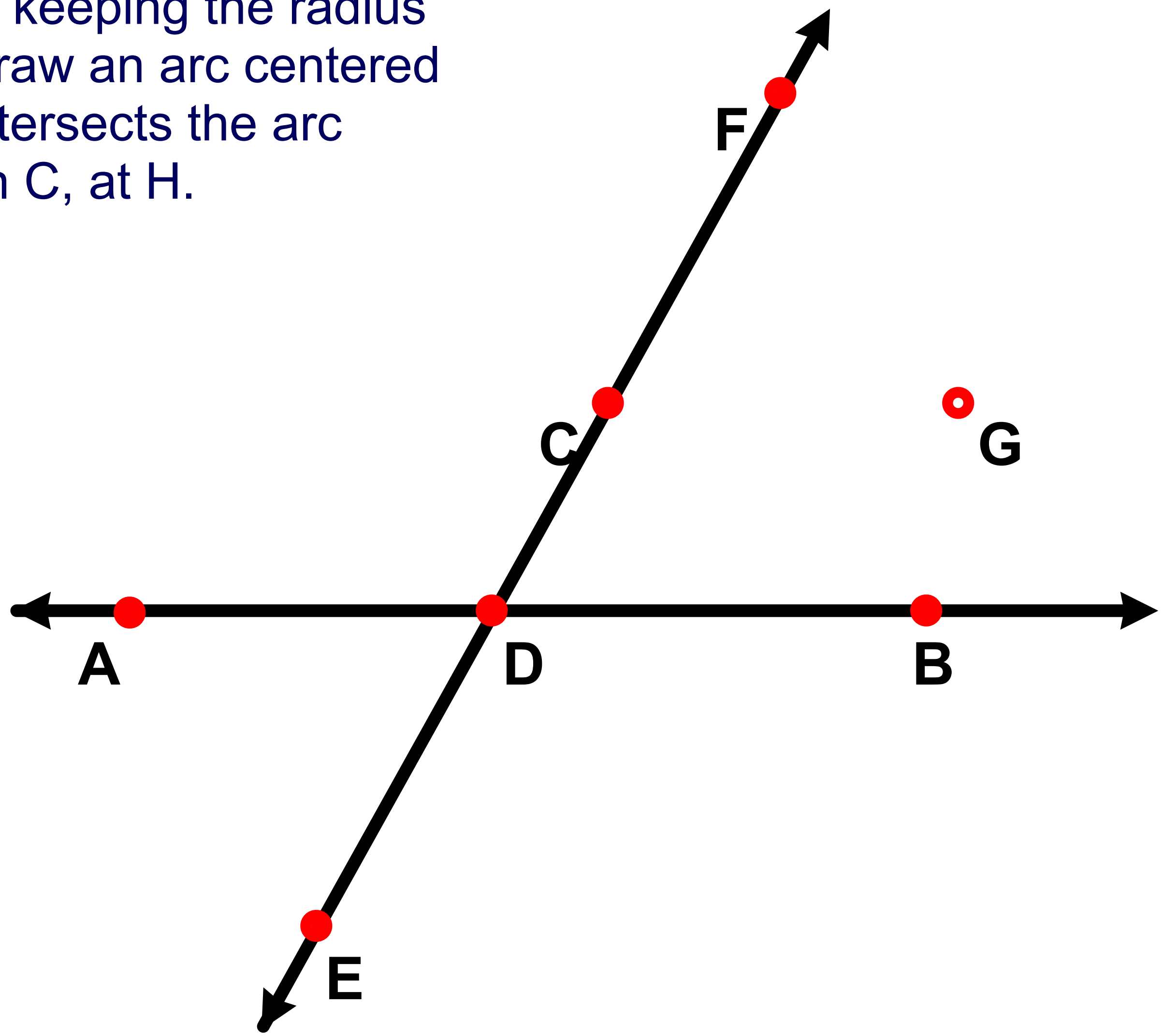
Method 3: Alternate Exterior Angles

Step 3: Keeping the radius the same draw an arc centered on C that intersects line DC above C, at F.



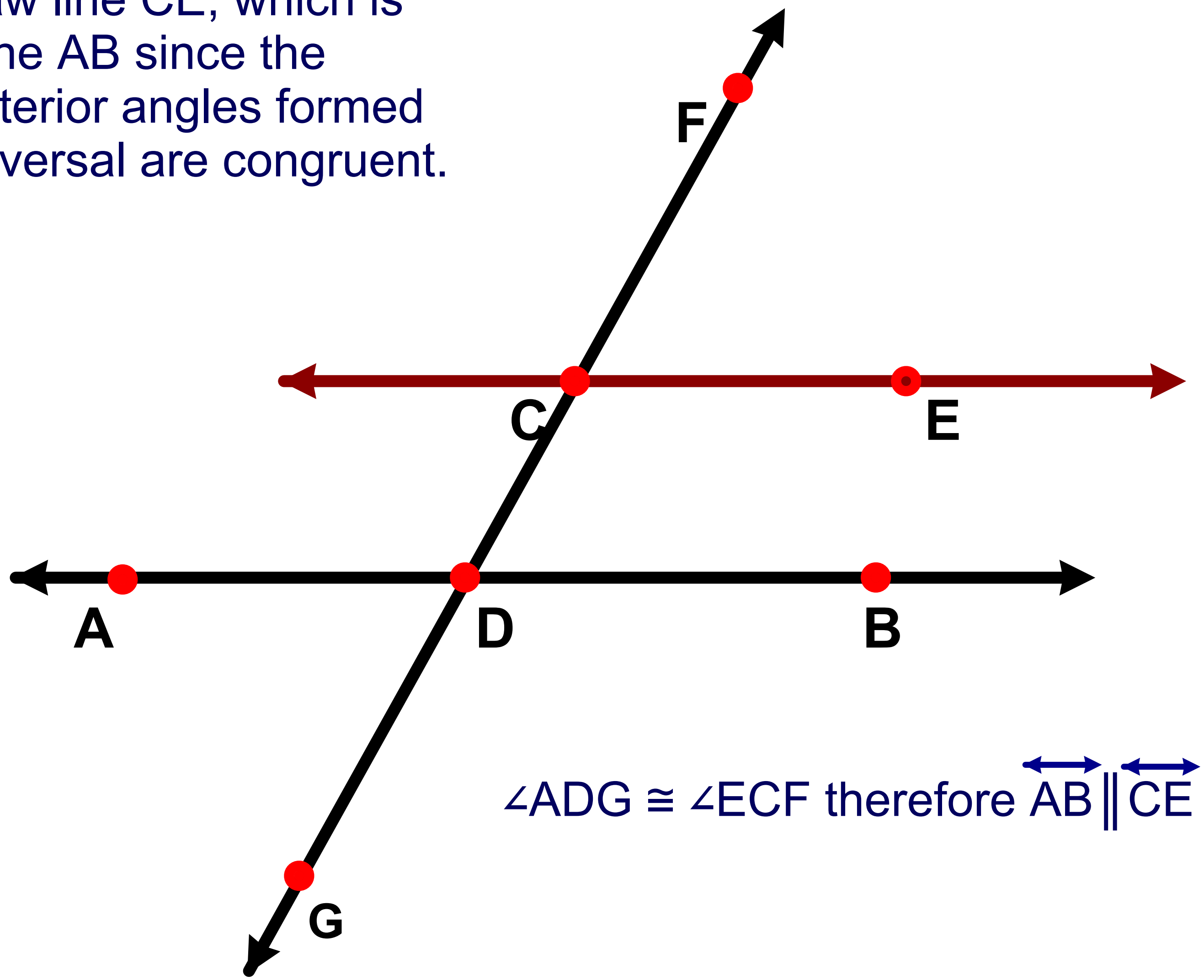
Method 3: Alternate Exterior Angles

Step 4: Still keeping the radius the same draw an arc centered on F that intersects the arc centered on C, at H.



Method 3: Alternate Exterior Angles

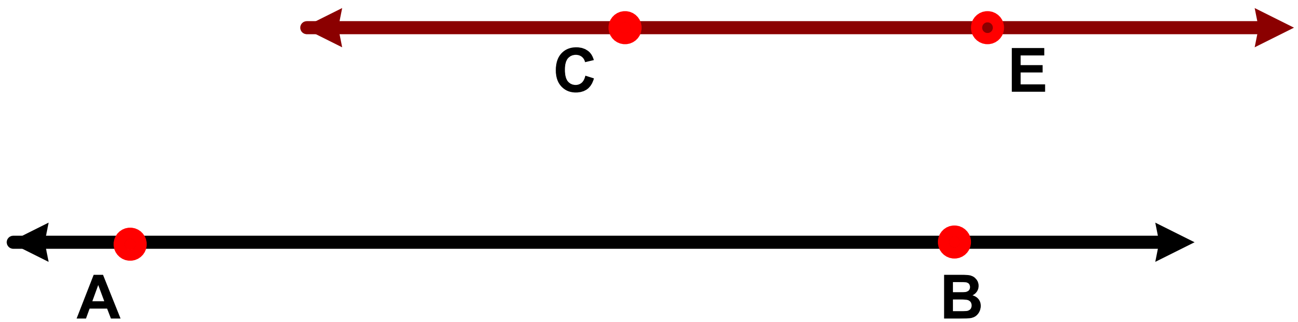
Step 5: Draw line CE, which is parallel to line AB since the alternate exterior angles formed by the transversal are congruent.



$\angle ADG \cong \angle ECF$ therefore $\overleftrightarrow{AB} \parallel \overleftrightarrow{CE}$

Method 3: Alternate Exterior Angles

Here are the lines without the construction lines.

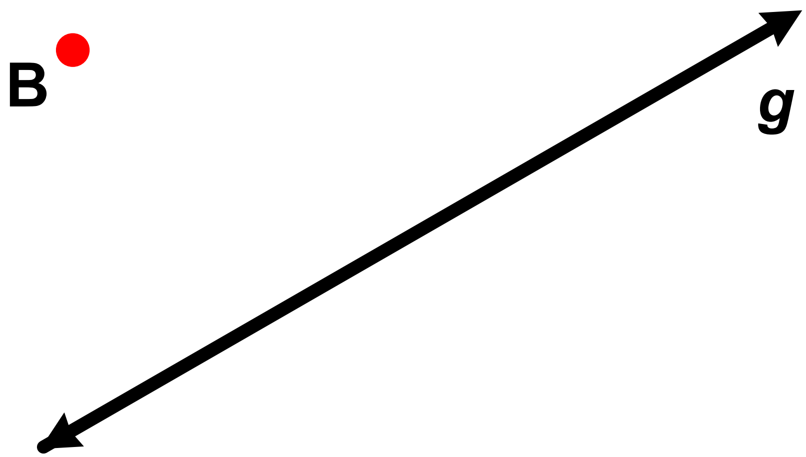


Video Demonstrating Constructing Parallel Lines with Alternate Exterior Angles using Dynamic Geometric Software

Click here to see video

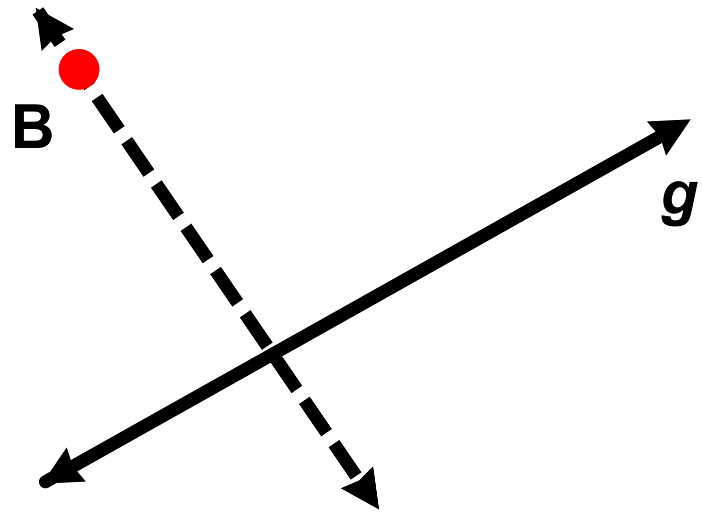
Parallel Line Construction Using Patty Paper

Step 1: Draw a line on your patty paper. Label the line *g*. Draw a point not on line *g* and label the point B.



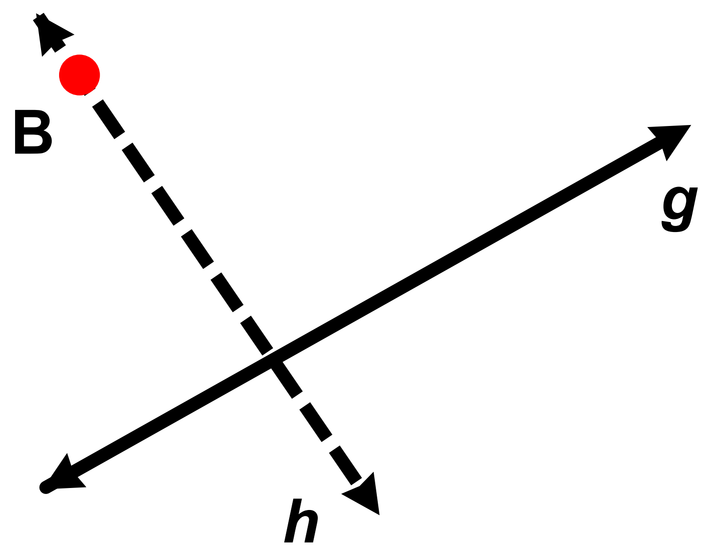
Parallel Line Construction Using Patty Paper

Step 2: Fold your patty paper so that the two parts of line *g* lie exactly on top of each other and point B is in the crease.



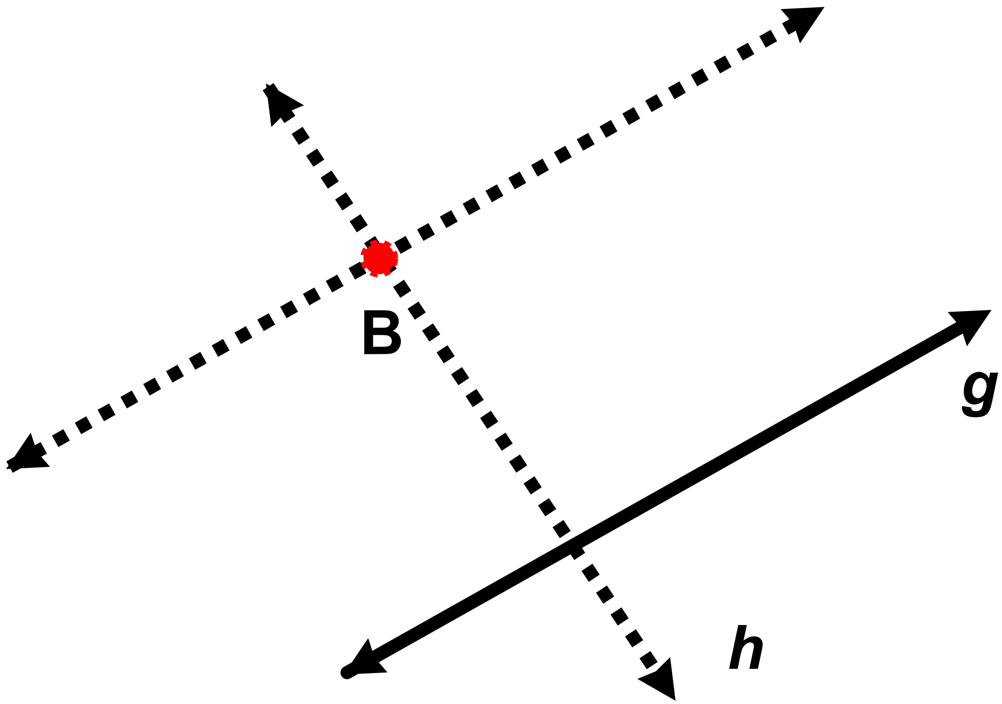
Parallel Line Construction Using Patty Paper

Step 3: Open the patty paper and draw a line on the crease. Label this line *h*.



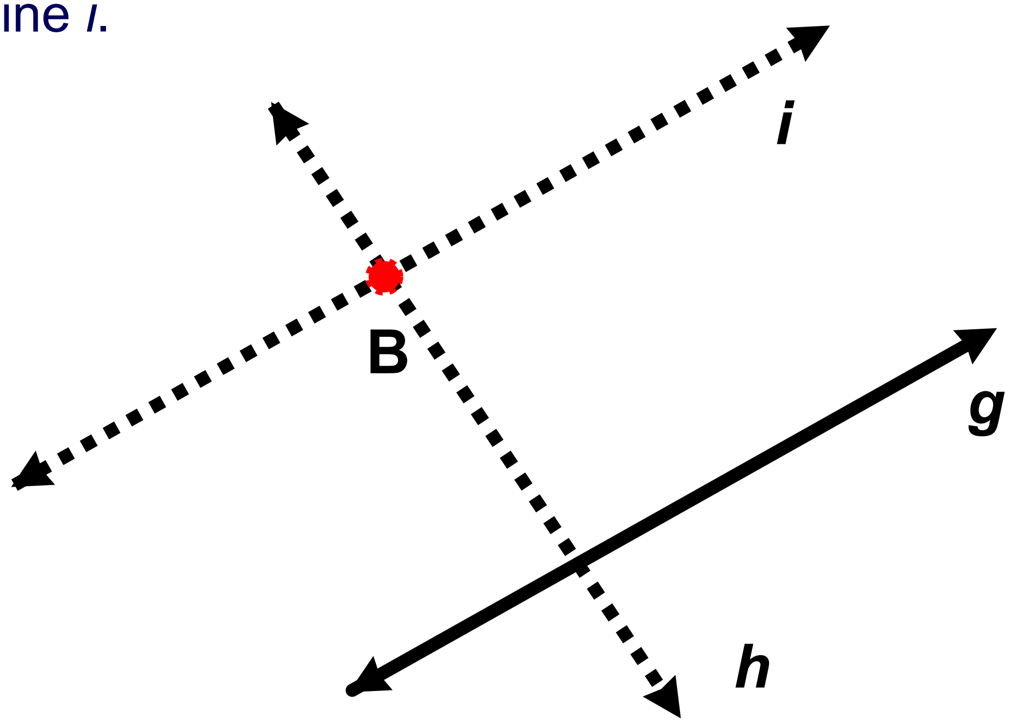
Parallel Line Construction Using Patty Paper

Step 4: Through point B, make another fold that is perpendicular to line *h*.



Parallel Line Construction Using Patty Paper

Step 5: Open the patty paper and draw a line on the crease. Label this line *i*.



Because lines *i* and *g* are perpendicular to line *h* they are parallel to each other. Therefore line *i* ‖ line *g*.

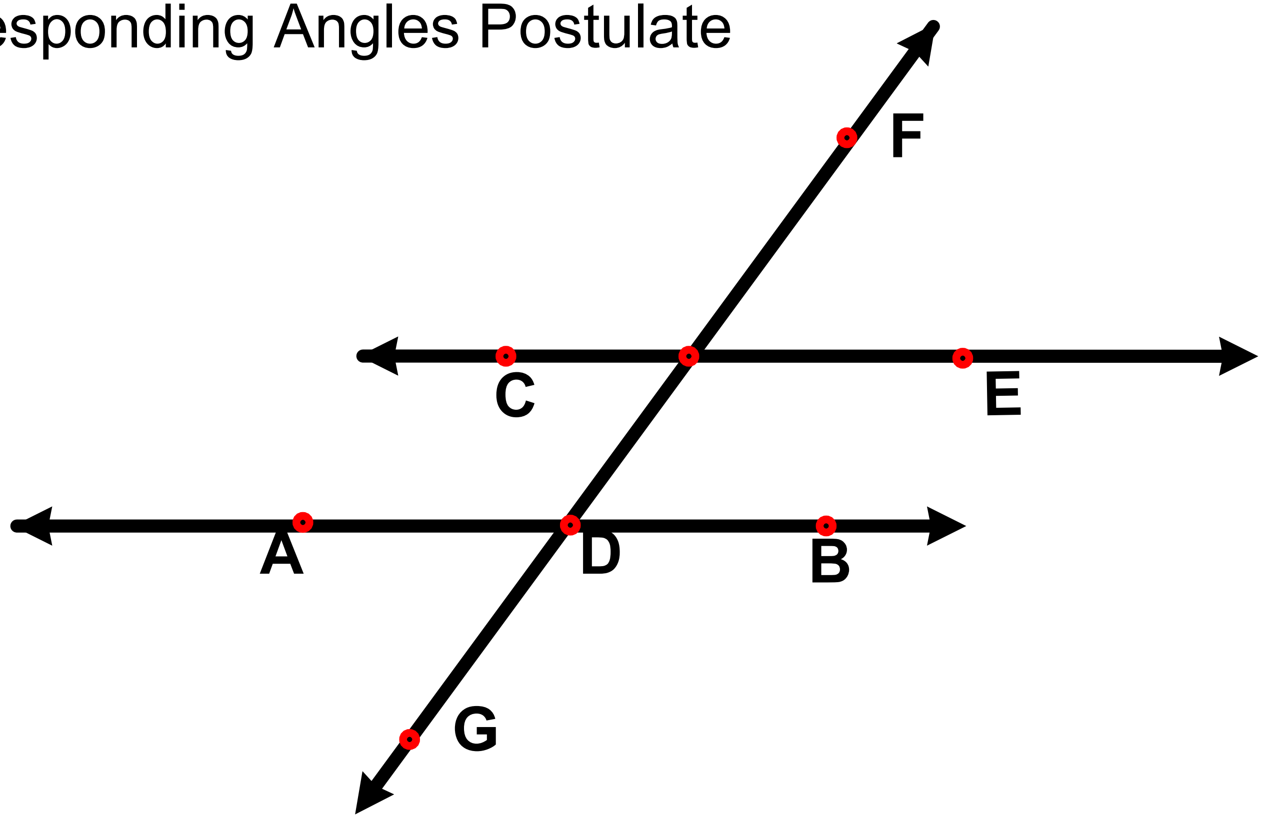
Video Demonstrating Constructing a Parallel Line using Menu Options of Dynamic Geometric Software

Click here to see video 1

Click here to see video 2

55 The lines in the diagram below are parallel because of the:

- A Alternate Interior Angles Theorem
- B Alternate Exterior Angles Theorem
- C Same-Side Angles Theorem
- D Corresponding Angles Postulate

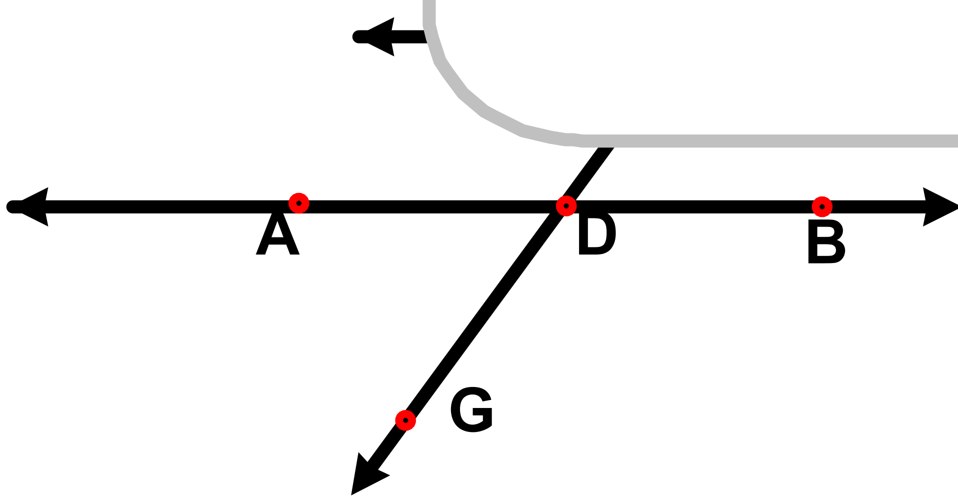


55 The lines in the diagram below are parallel because of the:

- A Alternate Interior Angl
- B Alternate Exterior Ang
- C Same-Side Angles Th
- D Corresponding Angle

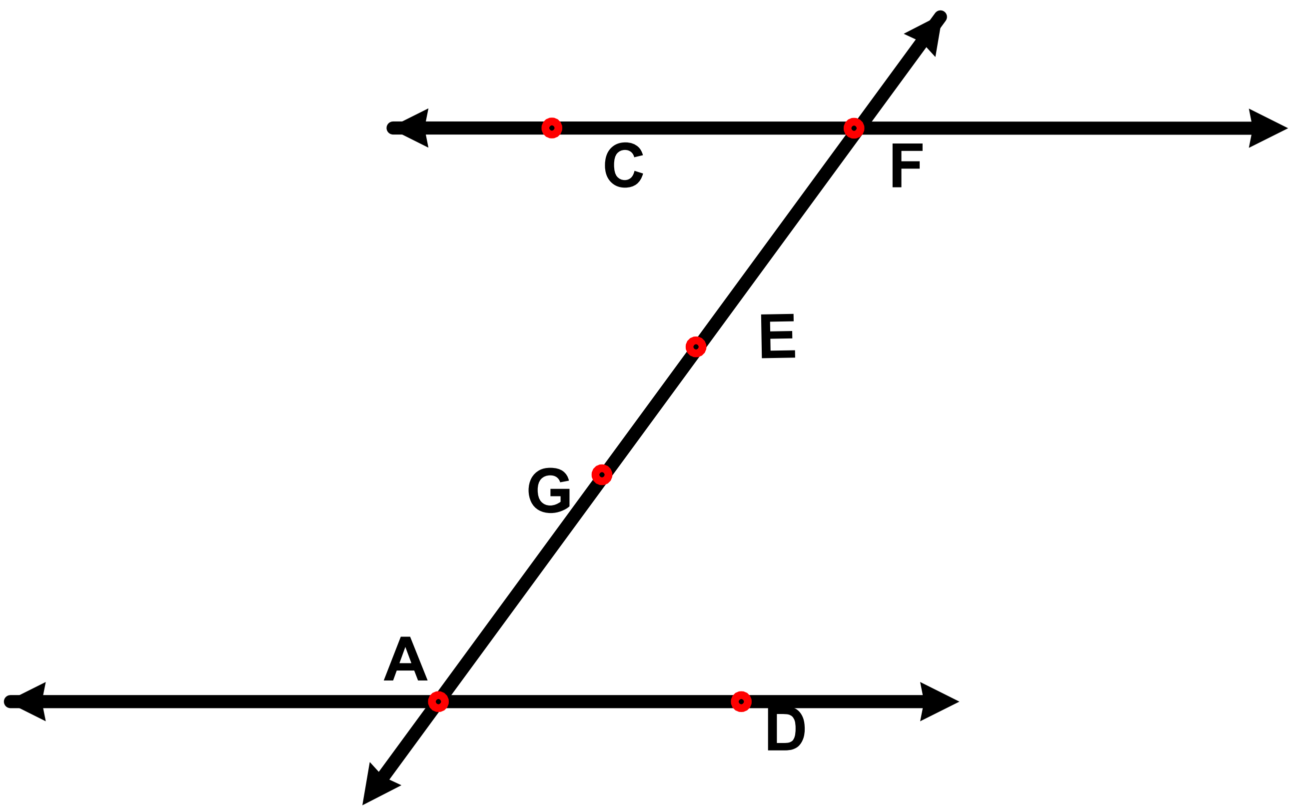
Answer

B



56 The lines below are shown parallel by the:

- A Alternate Interior Angles Theorem
- B Alternate Exterior Angles Theorem
- C Same-Side Angles Theorem
- D Corresponding Angles Postulate



56 The lines below are shown parallel by the:

A Alternate Interior Angles Th

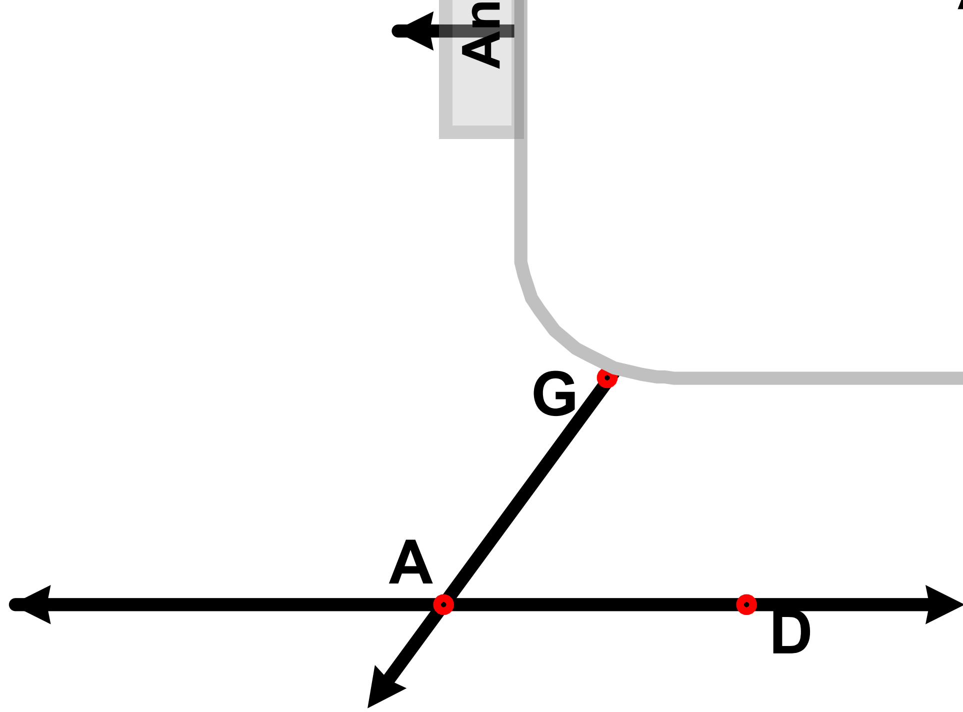
B Alternate Exterior Angles

C Same-Side Angles Theo

D Corresponding Angles P

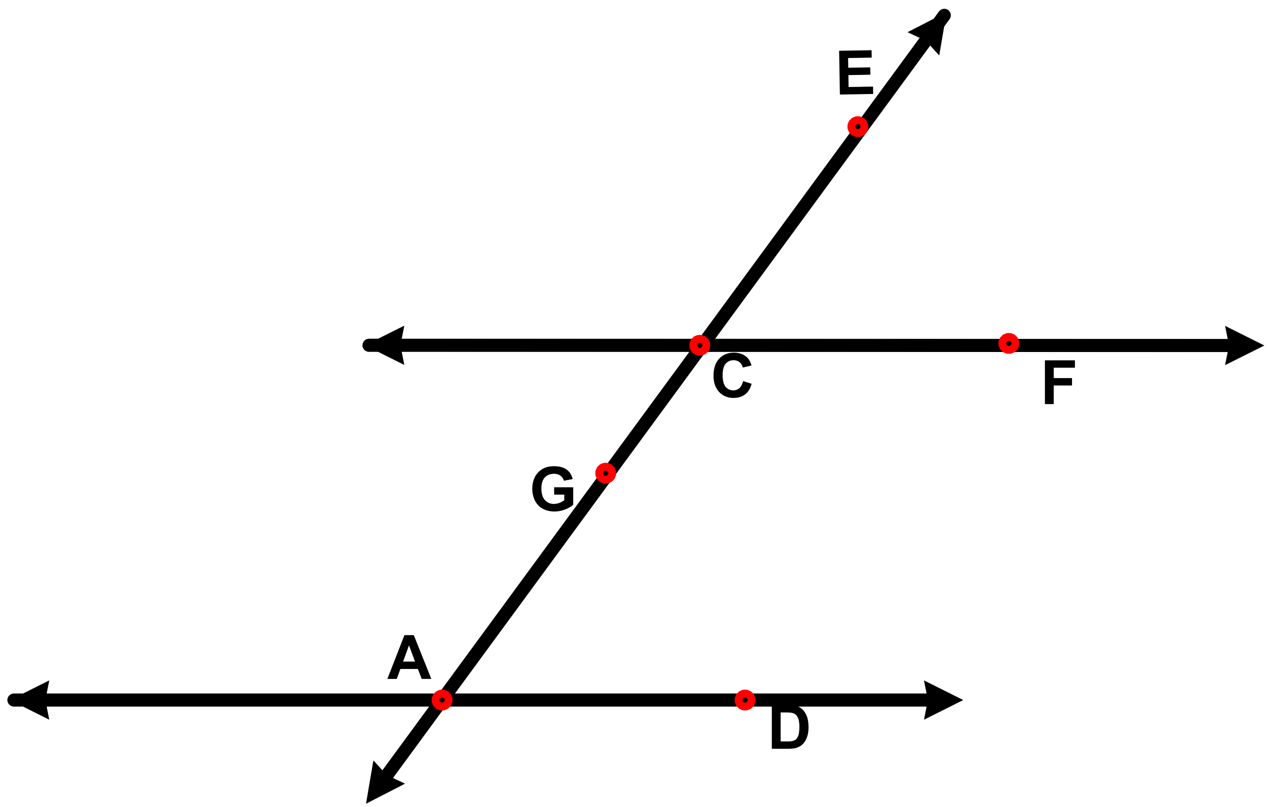
Answer

A



57 The below lines are shown parallel by the:

- A Alternate Interior Angles Theorem
- B Alternate Exterior Angles Theorem
- C Same-Side Angles Theorem
- D Corresponding Angles Postultate

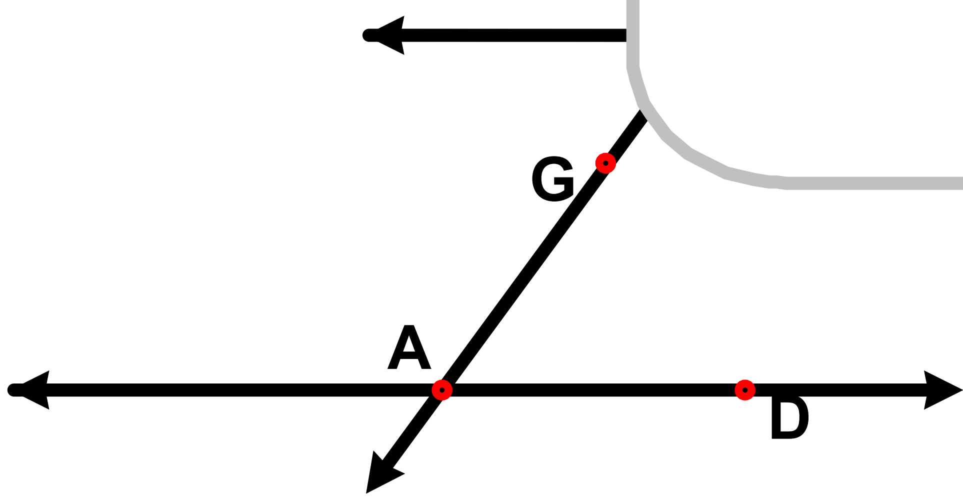


57 The below lines are shown parallel by the:

- A Alternate Interior Angles Theorem
- B Alternate Exterior Angl
- C Same-Side Angles Th
- D Corresponding Angle

Answer

D



PARCC Sample Test Questions

The remaining slides in this presentation contain questions from the PARCC Sample Test. After finishing unit 3, you should be able to answer these questions.

Good Luck!

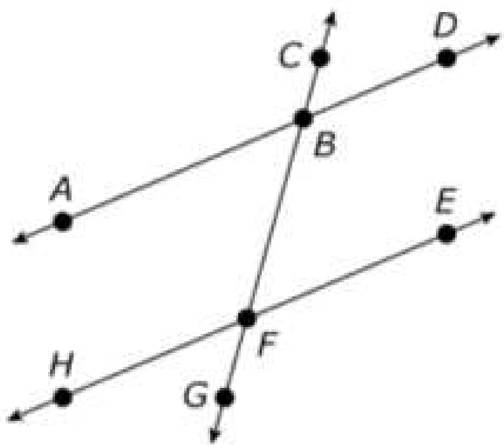
Return to Table of Contents

PARCC Sample Test Questions

Question 23/25 part A

Topic: Parallel Lines & Proofs

In the figure shown, $\overleftrightarrow{CF}$ intersects $\overleftrightarrow{AD}$ and $\overleftrightarrow{EH}$ at points B and F, respectively.

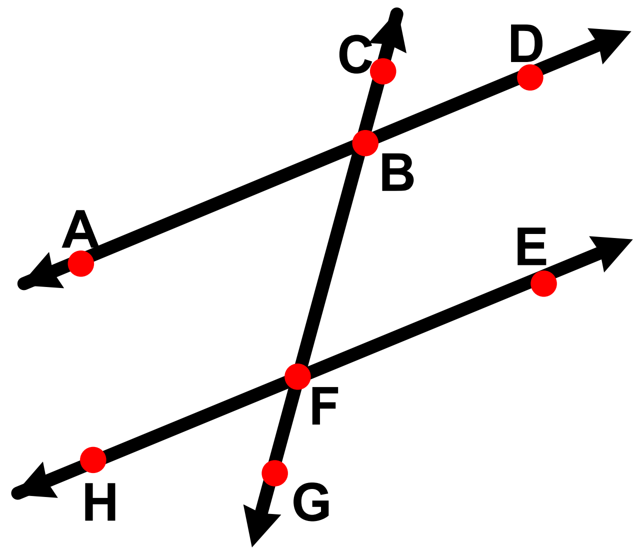


Part A

- Given: $\angle CBD \cong \angle BFE$
- Prove: $\angle ABF \cong \angle BFE$

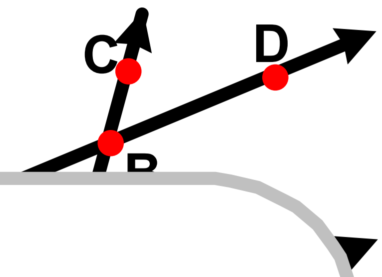
Circle the reason that supports each line of the proof.

PARCC Released Question (EOY)



58 ∠CBD ≅ ∠BFE

- A Given
- B Definition of congruent angles
- C Vertical angles are congruent
- D Reflexive property of congruence
- E Symmetric property of congruence
- F Transitive property of congruence

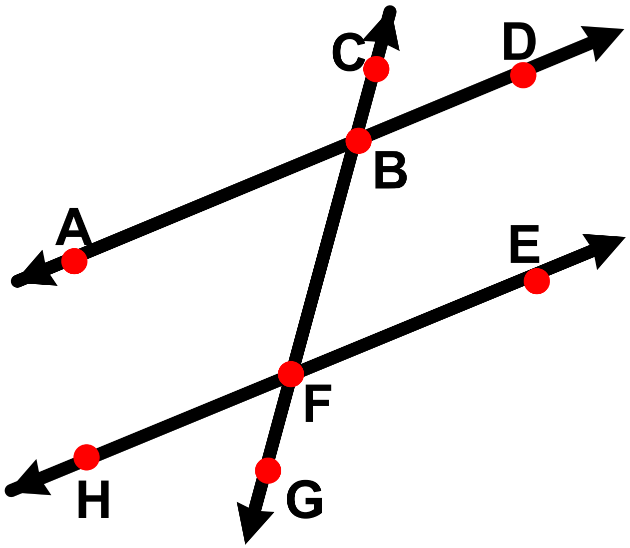


58 ∠CBD ≅ ∠BFE

- A Given
- B Definition of cong
- C Vertical angles a
- D Reflexive property
- E Symmetric property of congruence
- F Transitive property of congruence

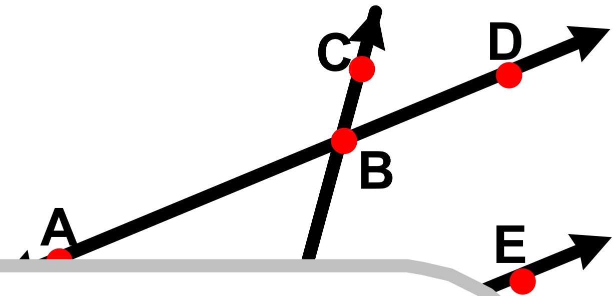
Answer

A



59 ∠CBD ≅ ∠ABF

- A Given
- B Definition of congruent angles
- C Vertical angles are congruent
- D Reflexive property of congruence
- E Symmetric property of congruence
- F Transitive property of congruence

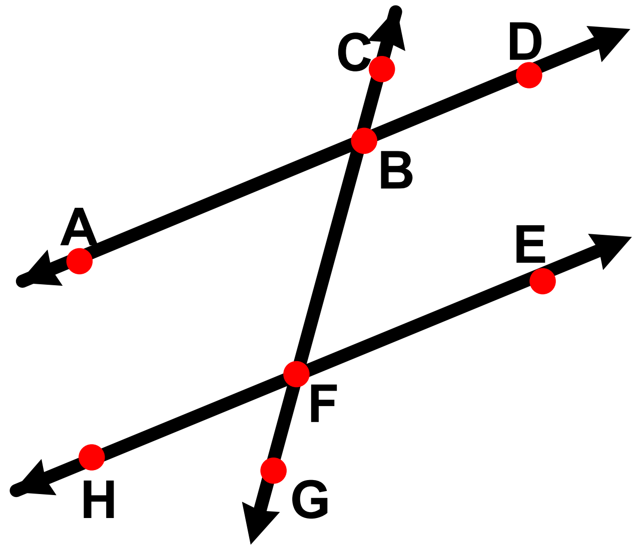


59 ∠CBD ≅ ∠ABF

- A Given
- B Definition of con
- C Vertical angles a
- D Reflexive proper
- E Symmetric property
- F Transitive property of congruence

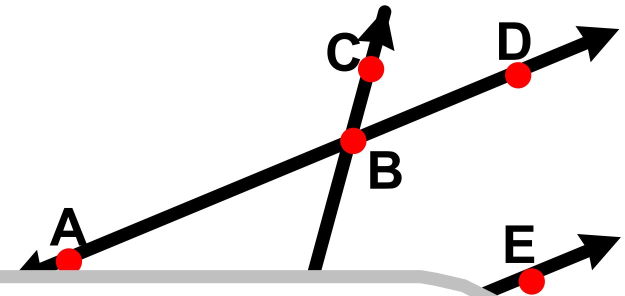
Answer

C



60 ∠ABF ≅ ∠BFE

- A Given
- B Definition of congruent angles
- C Vertical angles are congruent
- D Reflexive property of congruence
- E Symmetric property of congruence
- F Transitive property of congruence



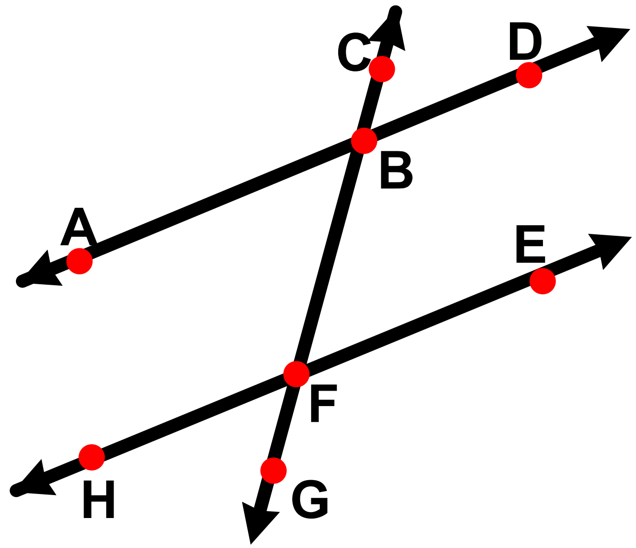
60 ∠ABF ≅ ∠BFE

- A Given
- B Definition of con
- C Vertical angles a
- D Reflexive proper
- E Symmetric prope
- F Transitive property of congruence

Answer

F

In the figure shown, Line CF intersects lines AD and EH at points B and F, respectively.



Given: ∠CBD ≅ ∠BFE
Prove: ∠ABF ≅ ∠BFE

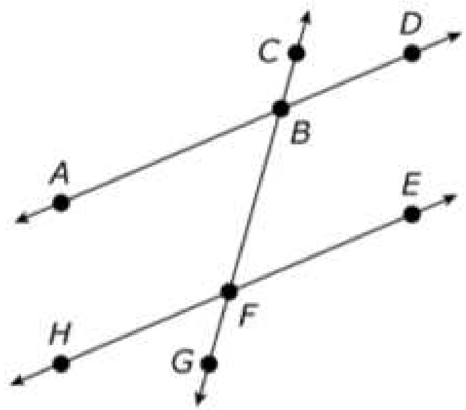
Completed proof shown below.

	Statement	**Reason**
1	∠CBD ≅ ∠BFE	Given
2	∠CBD ≅ ∠ABF	Vertical Angles are congruent
3	∠ABF ≅ ∠BFE	Transitive property of congruence

PARCC Sample Test Questions

Question 23/25 part B **Topic: Parallel Lines & Proofs**

In the figure shown, $\overleftrightarrow{CF}$ intersects $\overleftrightarrow{AD}$ and $\overleftrightarrow{EH}$ at points B and F, respectively.

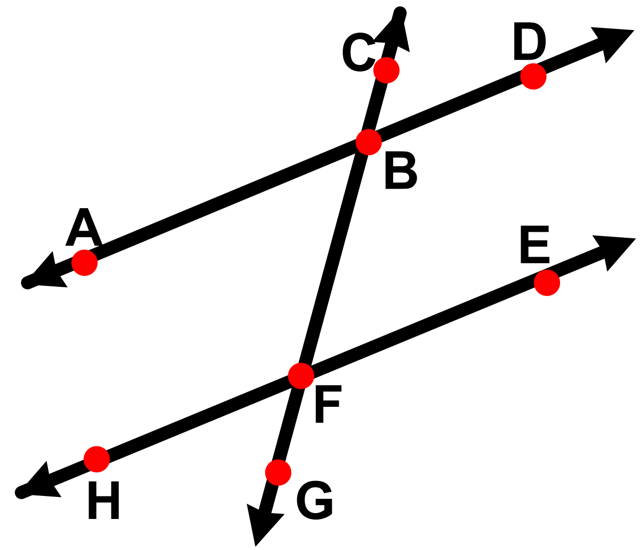


Part B

- Given: $m\angle CBD = m\angle BFE$
- Prove: $m\angle BFE + m\angle DBF = 180^\circ$

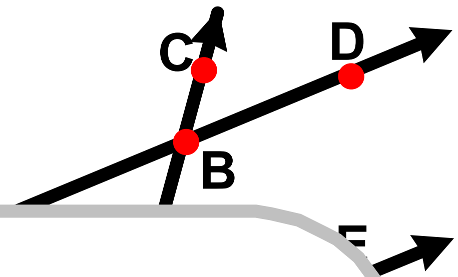
Circle the reason that supports each line of the proof.

PARCC Released Question (EOY)



61 m∠CBD = m∠BFE

- A Given
- B Angles that form a linear pair are supplementary
- C Angles that are adjacent are supplementary
- D Reflexive property of equality
- E Substitution property of equality
- F Transitive property of equality

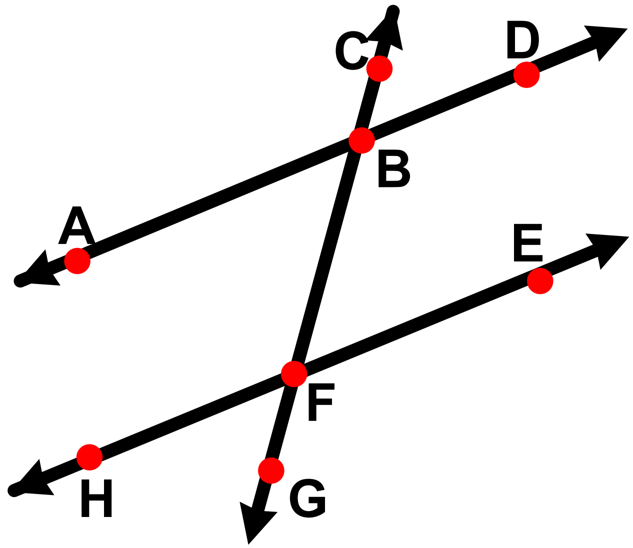


61 m∠CBD = m∠BFE

- A Given
- B Angles that form a
- C Angles that are ad
- D Reflexive property o
- E Substitution property of equality
- F Transitive property of equality

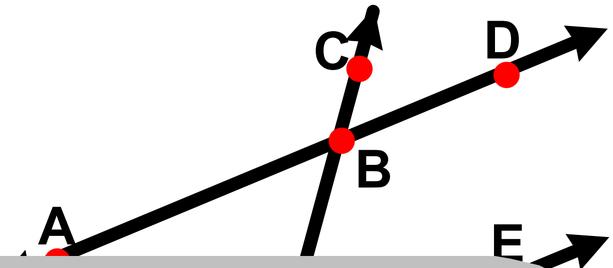
Answer

A



62 m∠CBD + m∠DBF = 180º

- A Given
- B Angles that form a linear pair are supplementary
- C Angles that are adjacent are supplementary
- D Reflexive property of equality
- E Substitution property of equality
- F Transitive property of equality



62 m∠CBD + m∠DBF =

A Given

B Angles that form a l

C Angles that are adj

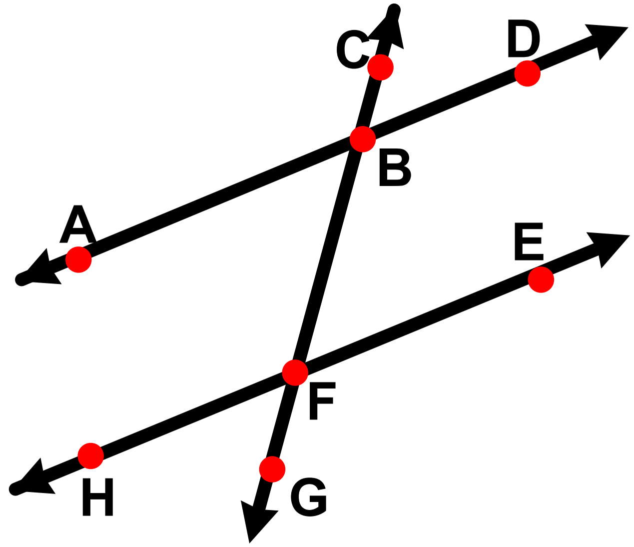
D Reflexive property

E Substitution property o

F Transitive property of equality

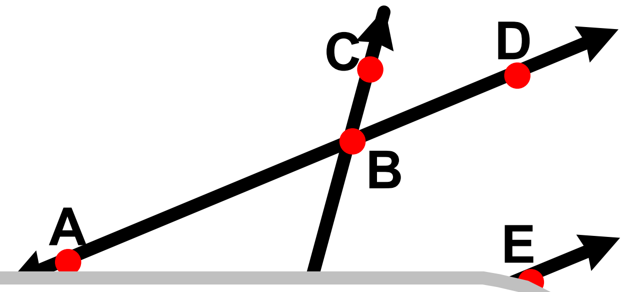
Answer

B



63 m∠BFE + m∠DBF = 180º

- A Given
- B Angles that form a linear pair are supplementary
- C Angles that are adjacent are supplementary
- D Reflexive property of equality
- E Substitution property of equality
- F Transitive property of equality



63 m∠BFE + m∠DBF =

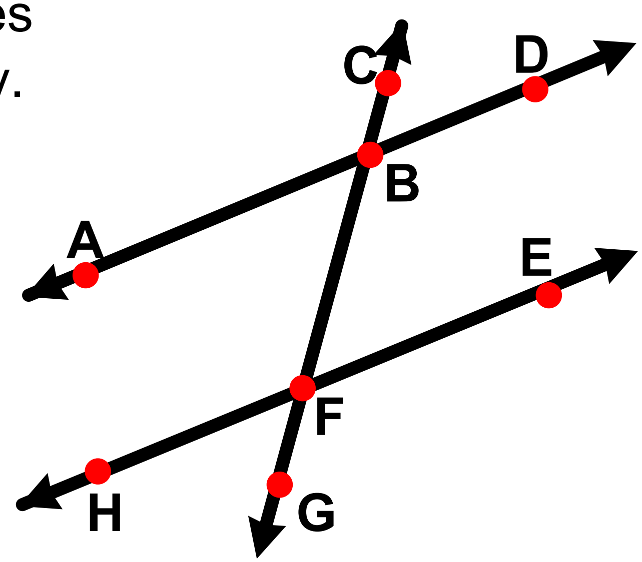
- A Given
- B Angles that form a lin
- C Angles that are adja
- D Reflexive property of
- E Substitution property
- F Transitive property of equality

Answer

E

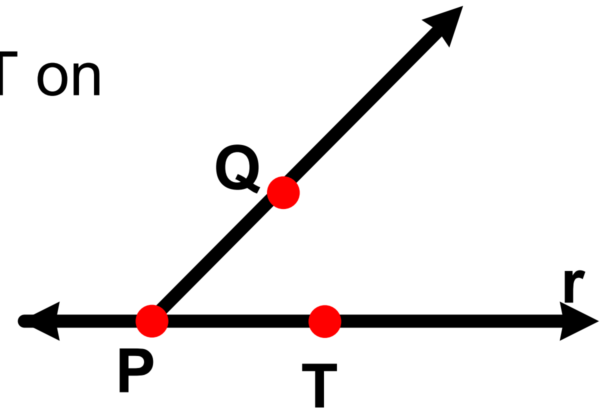
In the figure shown Line CF intersects lines AD and EH at points B and F, respectively.

Given: m∠CBD = m∠BFE
Prove: m∠BFE + m∠DBF = 180º



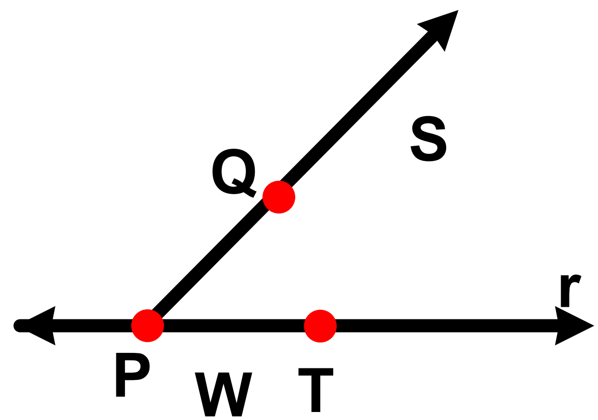
	Statement	Reason
1	m∠CBD = m∠BFE	Given
2	m∠CBD + m∠DBF = 180º	Angles that form a linear pair are supplementary
3	m∠BFE + m∠DBF = 180º	Substitution Property of Equality

The figure shows line r, points P and T on line r, and point Q not on line r. Also shown is ray PQ.



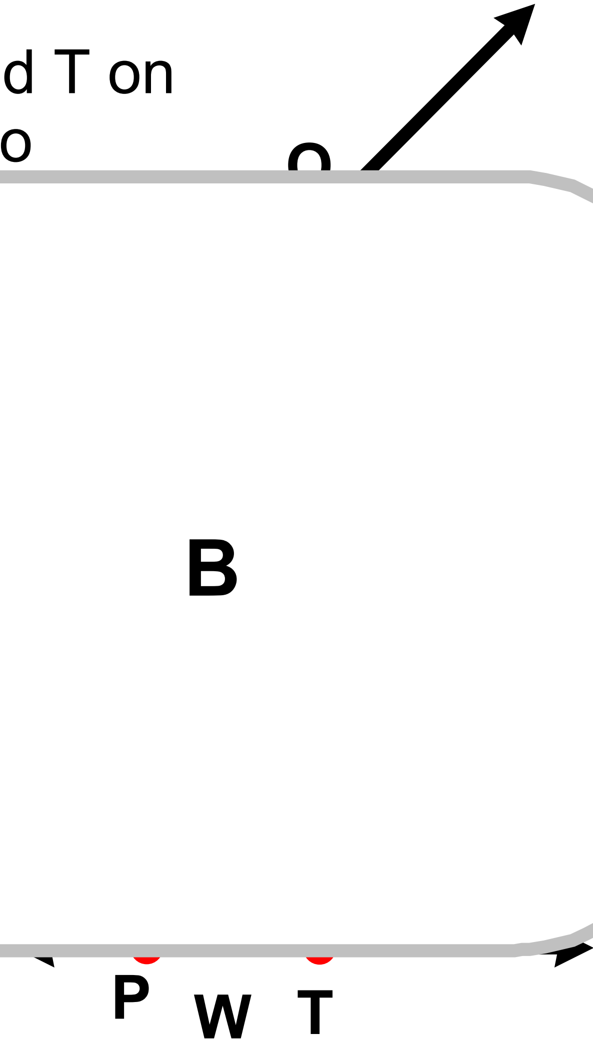
64 **PART A** Consider the partial Construction of a line parallel to r through point Q. what would be the final step in the construction?

- A Draw a line through P and S
- B Draw a line through Q and S
- C Draw a line through T and S
- D Draw a line through W and S



PARCC Released Question (EOY)

The figure shows line r, points P and T on line r, and point Q not on line r. Also shown is ray PQ.



64 **PART A** Consider the
parallel to r through p
step in the constructio

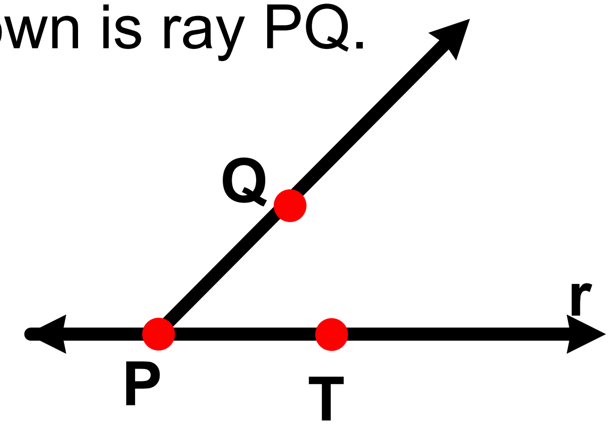
- A Draw a line through P
- B Draw a line through Q
- C Draw a line through T
- D Draw a line through W and S

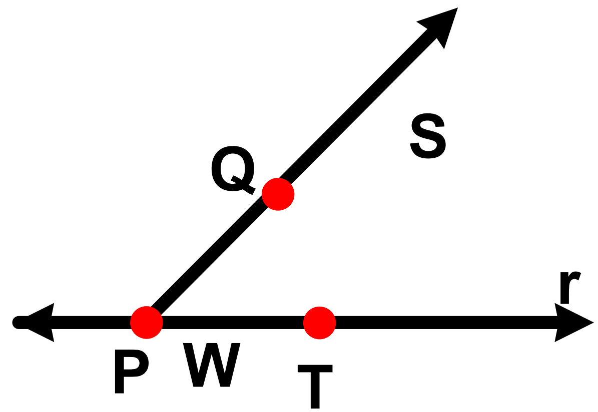
Answer

B

PARCC Released Question (EOY)

The figure shows line r, points P and T on line r, and point Q not on line r. Also shown is ray PQ.



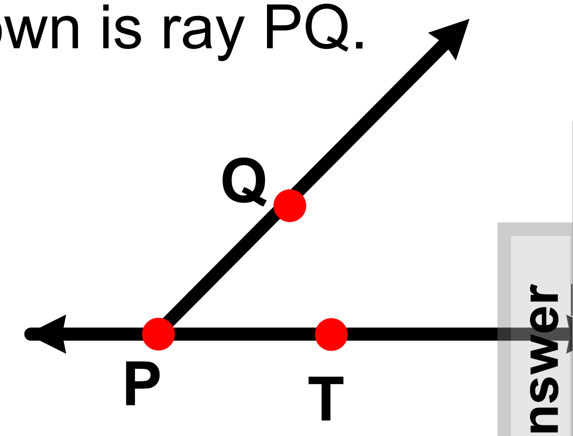


65 **PART B** Once the construction is complete, which of the reasons listed contribute to proving the validity of the construction?

- A When two lines are cut by a transversal and the corresponding angles are congruent, the lines are parallel.
- B When two lines are cut by a transversal and the vertical angles are congruent, the lines are parallel.
- C Definition of segment bisector.
- D Definition of an angle bisector.

PARCC Released Question (EOY)

The figure shows line r, points P and T on line r, and point Q not on line r. Also shown is ray PQ.



65 **PART B** Once the constru
listed contribute to proving

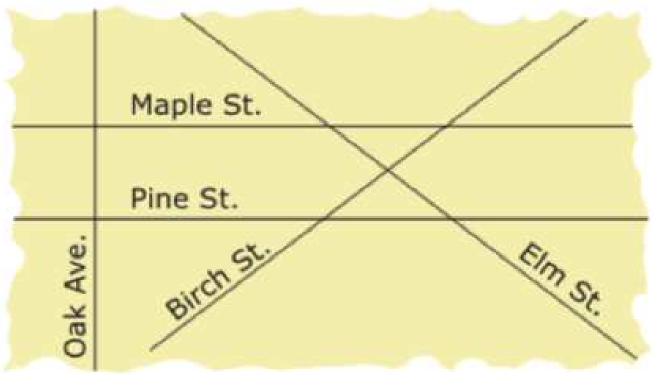
- A When two lines are cut b
  angles are congruent, the
- B When two lines are cut by a
  angles are congruent, the lines are parallel.
- C Definition of segment bisector.
- D Definition of an angle bisector.

PARCC Released Question (EOY)

Question 1/7

Topic: Lines: Intersecting, Parallel & Skew

66



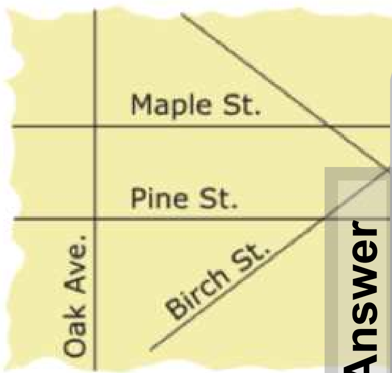
Which statements must be true based only on the given information? Select **all** that apply.

- ☐ Birch Street and Elm Street intersect at right angles.
- ☐ Maple Street and Pine Street are parallel.
- ☐ If more of the map is shown, Elm Street and Oak Avenue will not intersect.
- ☐ Pine Street intersects both Birch Street and Elm Street.
- ☐ Oak Avenue and Maple Street are perpendicular.

PARCC Released Question (PBA)

Question 1/7 **Topic: Lines: Intersecting, Parallel & Skew**

66



Answer

B, D & E

Which statements must be true b
information? Select **all** that apply

- [ ] Birch Street and Elm Street i
- [ ] Maple Street and Pine Street a
- [ ] If more of the map is shown, Elm Street and Oak Avenue will not intersect.
- [ ] Pine Street intersects both Birch Street and Elm Street.
- [ ] Oak Avenue and Maple Street are perpendicular.

PARCC Released Question (PBA)