Control Flow Part I

CS 18000

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Problem

- *Write a program that tells a patient if their total cholesterol measure is too high or not.*
  - *The measure is an integer and is too high if it exceeds 239.*
- *Your program should read in the measure and output an appropriate evaluation.*

Choices

- Clearly, in order to solve this problem, we need to be able to choose which of the alternative messages to print.
- All programming languages provide this ability to choose: selection statements.
- Java provides **if-else**, and **switch** selection statements.
- This week we will study **if-else** statements

Flow of control

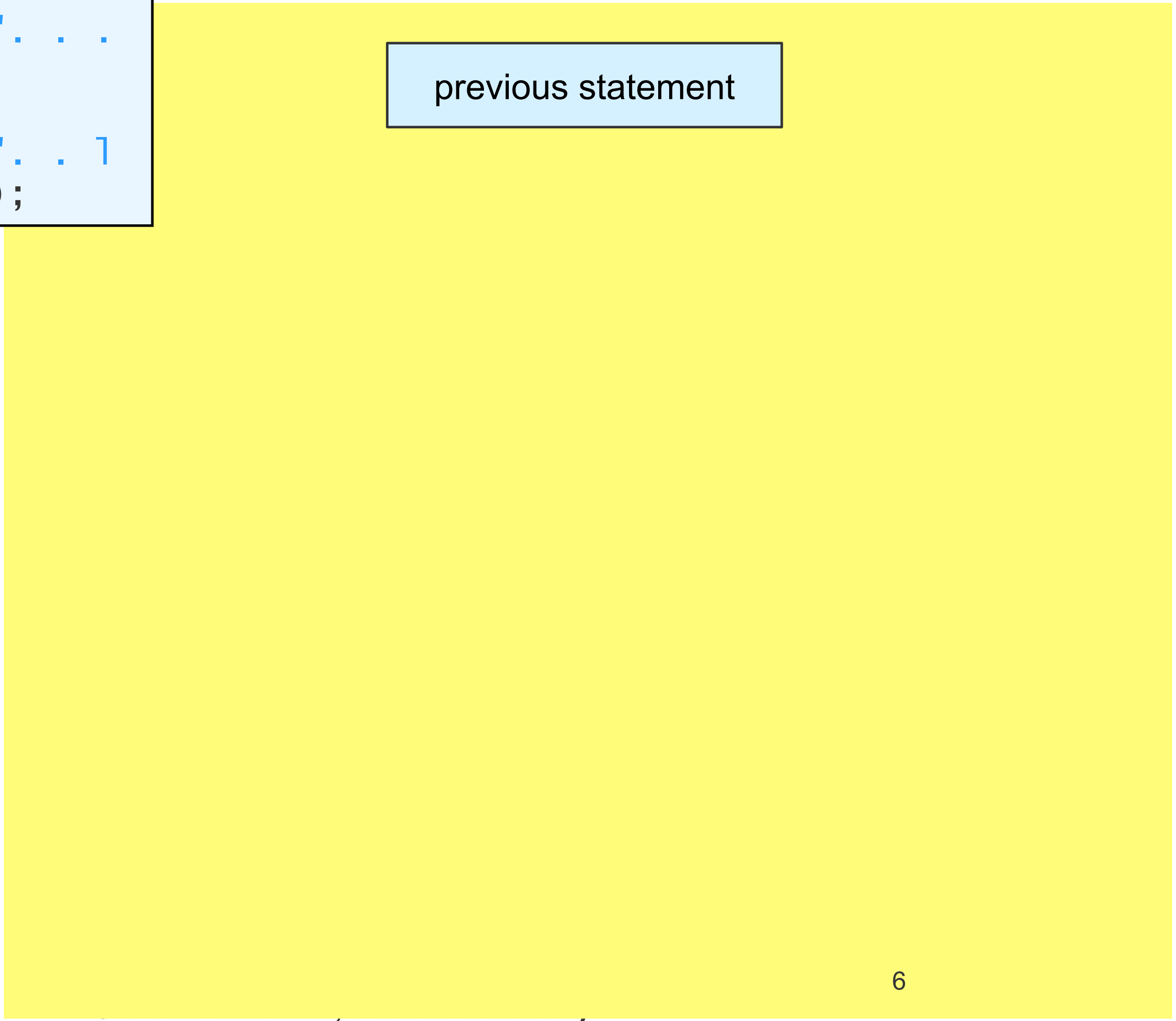
- Once a statement is executed, the next statement of the program is executed.
- Calling a method transfers the control to the statements in the method.
  - Once the method returns, control returns to statement that made the call.
- Changing this flow of control is achieved using **if-else** and **do-while** etc. statements.
- These are called control flow statements.

Solution

```
public class CholesterolCheck {
   public static void main(String[] args){

      int chLevel;

      chLevel = Integer.parseInt(JOptionPane.showInputDialog(
                   null, "Enter your cholesterol measure"));


      if(chLevel > 239)
         System.out.print("Your cholesterol level is too high.");
      else
         System.out.print("Your cholesterol level is not too
         high.");


   }
}
```

if-else Control Flow

```
if (chLevel > 239)
         System.out.print(". . .
         is too high.");
else
         System.out.print(". . l
         is not too high.");
```



if-else Control Flow

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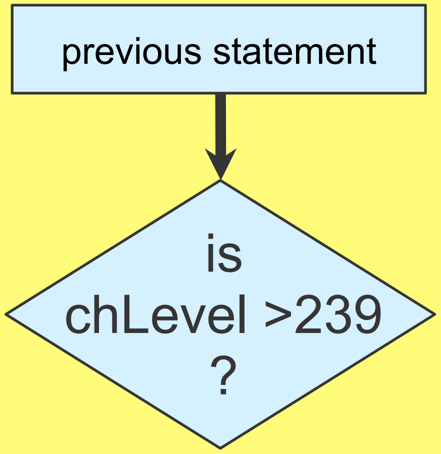

if-else Control Flow

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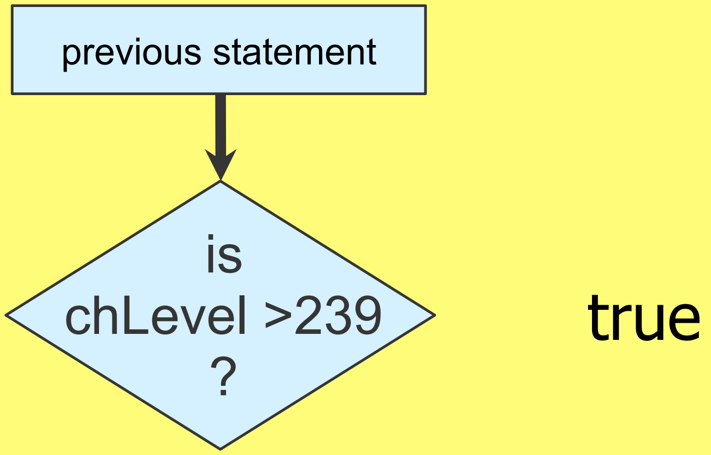

if-else Control Flow

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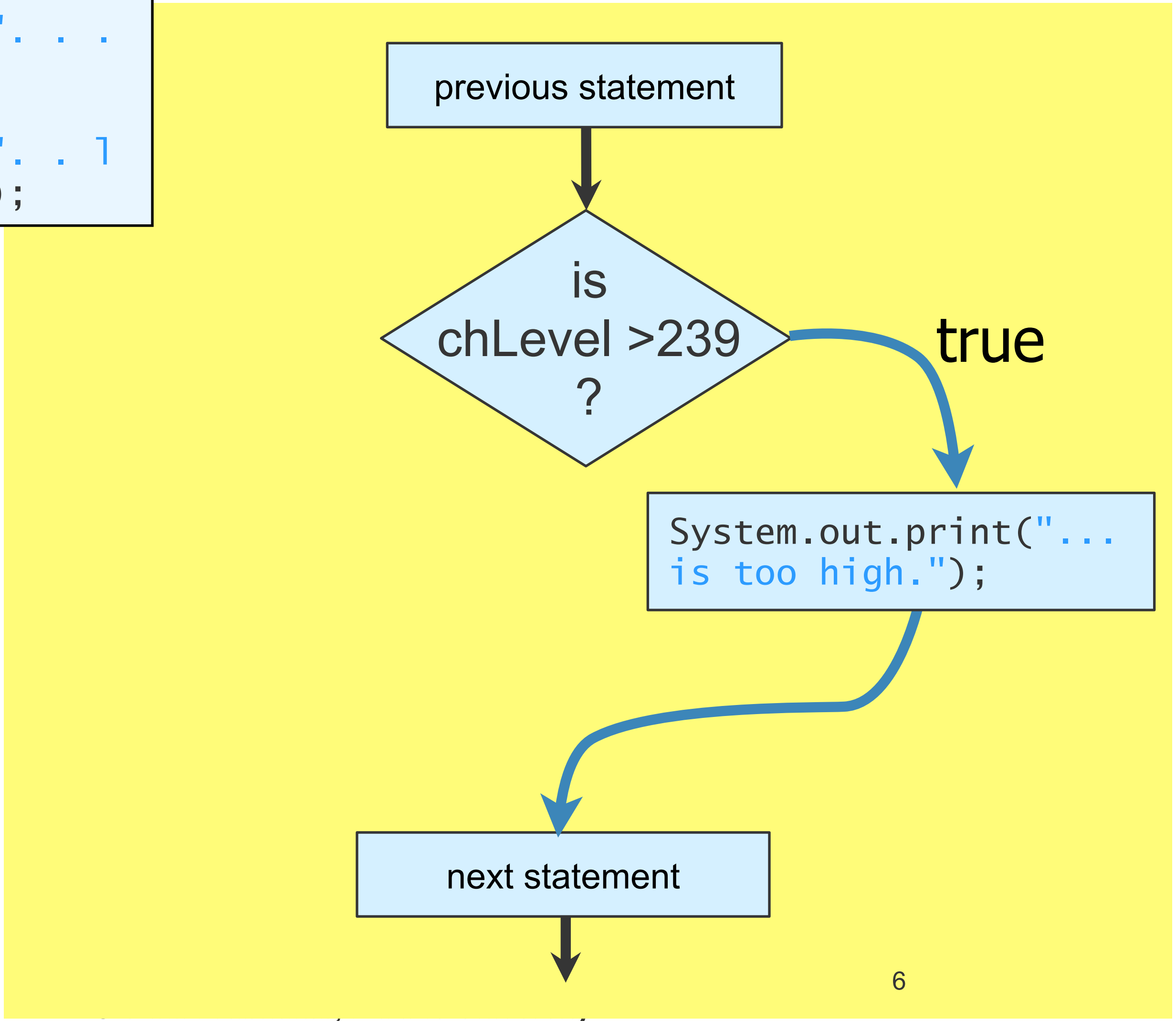

if-else Control Flow

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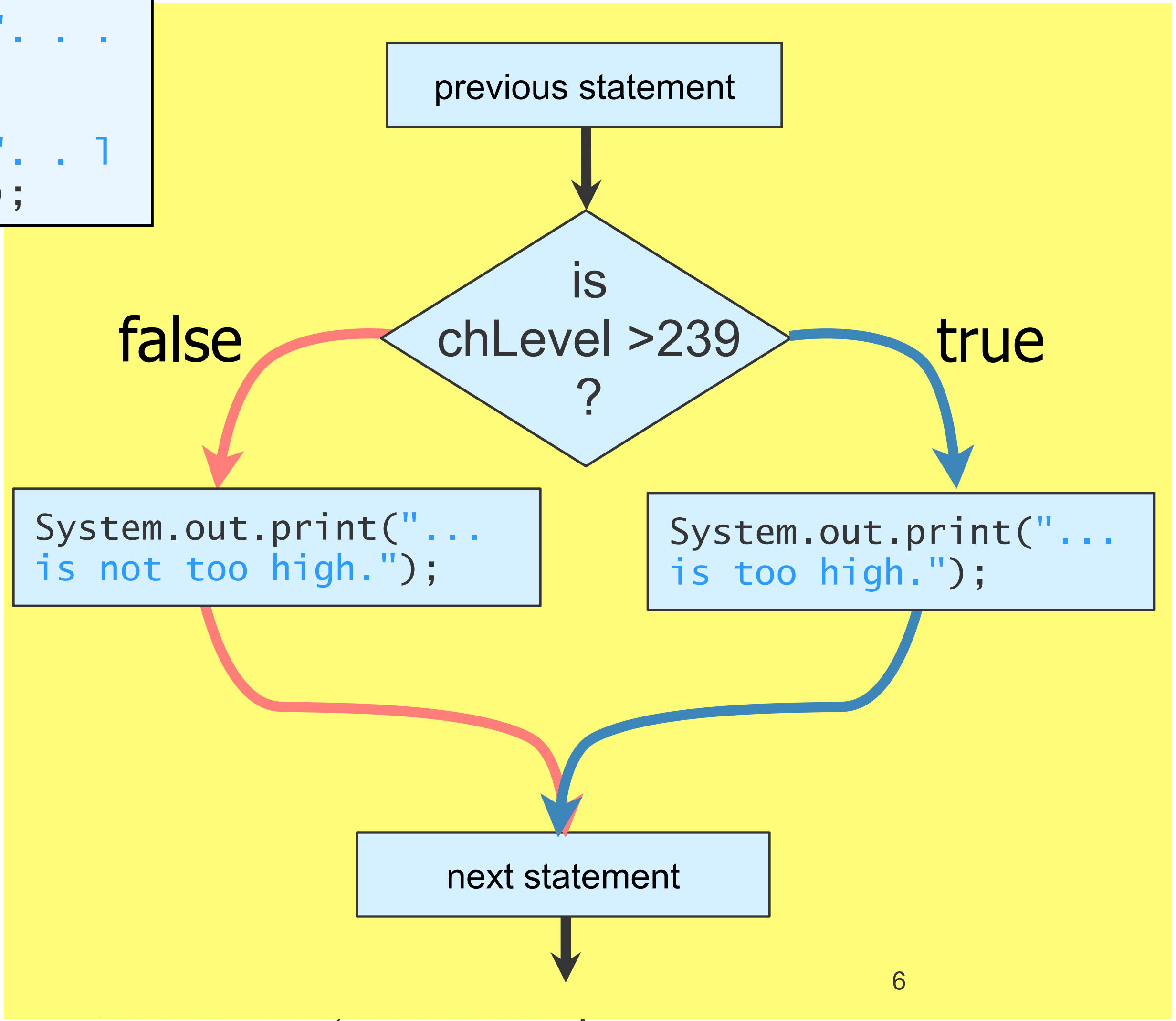
previous statement
is chLevel >239 ?
false
true
System.out.print("... is not too high.");
System.out.print("... is too high.");
next statement

if-else Control Flow

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if (chLevel > 239)
        System.out.print(". . .
        is too high.");
else
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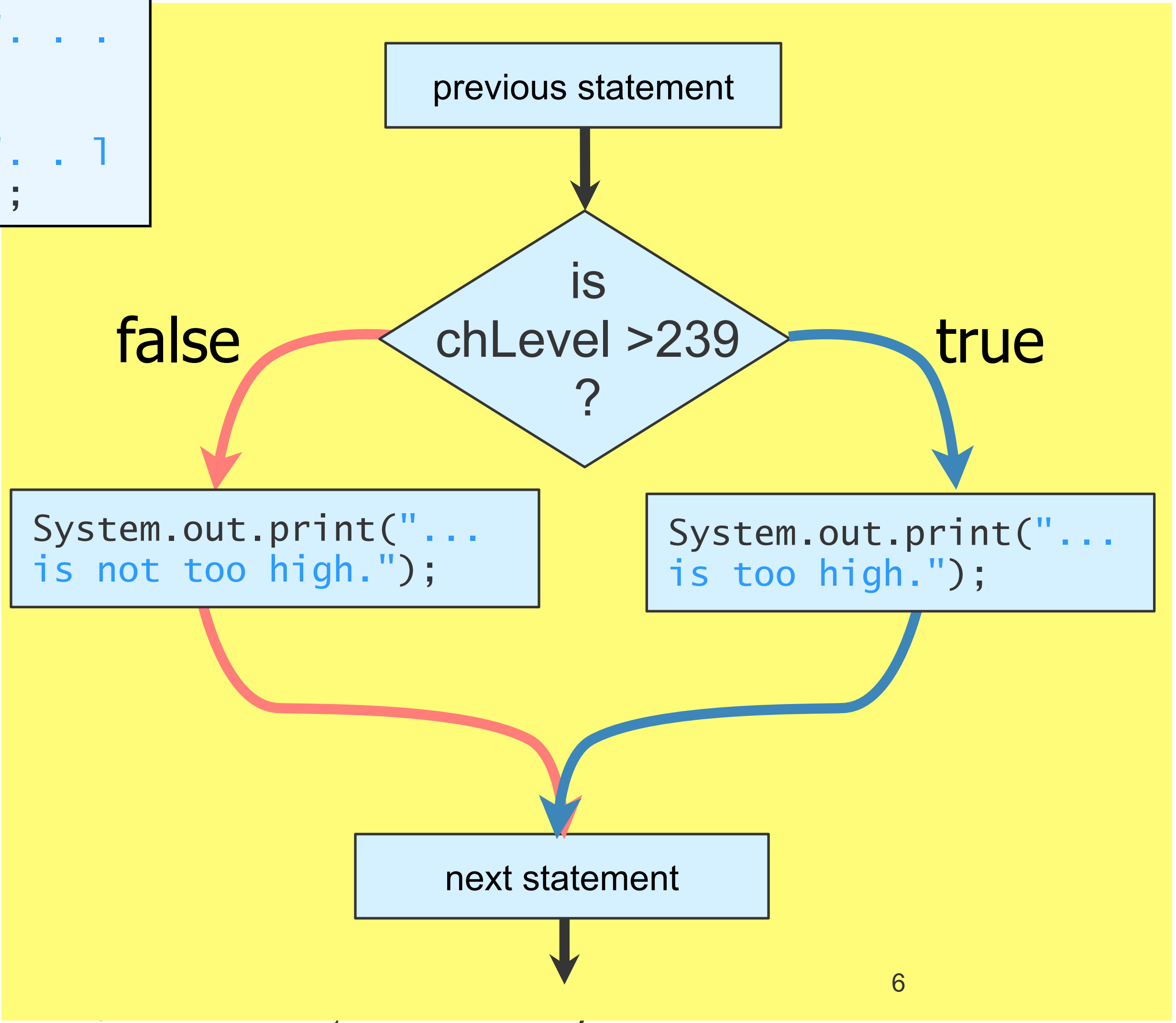
previous statement
is chLevel >239 ?
false
true
System.out.print("... is not too high.");
System.out.print("... is too high.");
next statement

Depending upon the value of chLevel, one or the other branch is executed, not both.

if-else syntax

```
if ( <boolean expression> )
         if-statement;
else
         else-statement;
```

- The boolean expression is a special type of expression which can have one of two values: **true** or **false** values
- If the expression evaluates to **true**, the if-statement is executed; otherwise
- the else-statement is executed.

Multiple conditional statements

```
if ( <boolean expression> )
{
     if-statement1;
     if-statement2;
     ...
}
else
{
     else-statement1;
     else-statement2;
     else-statement3;
     ...
}
```

- We can have multiple statements for the if and/or else branches.
- Braces are used to combine multiple statements into a single block.

Multiple conditional statements

Then block

```
if ( <boolean expression> )
{
        if-statement1;
        if-statement2;
        ...
}
else
{
        else-statement1;
        else-statement2;
        else-statement3;
        ...
}
```

- We can have multiple statements for the if and/or else branches.
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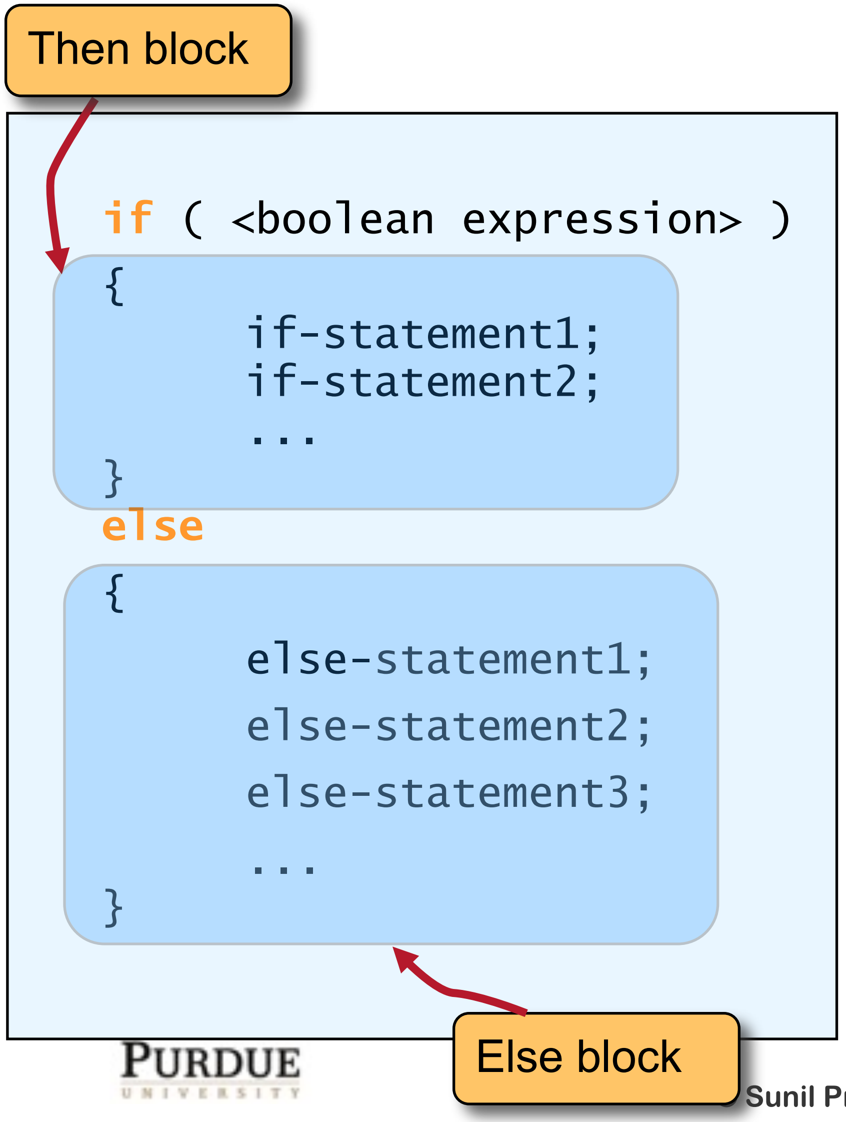
Multiple conditional statements

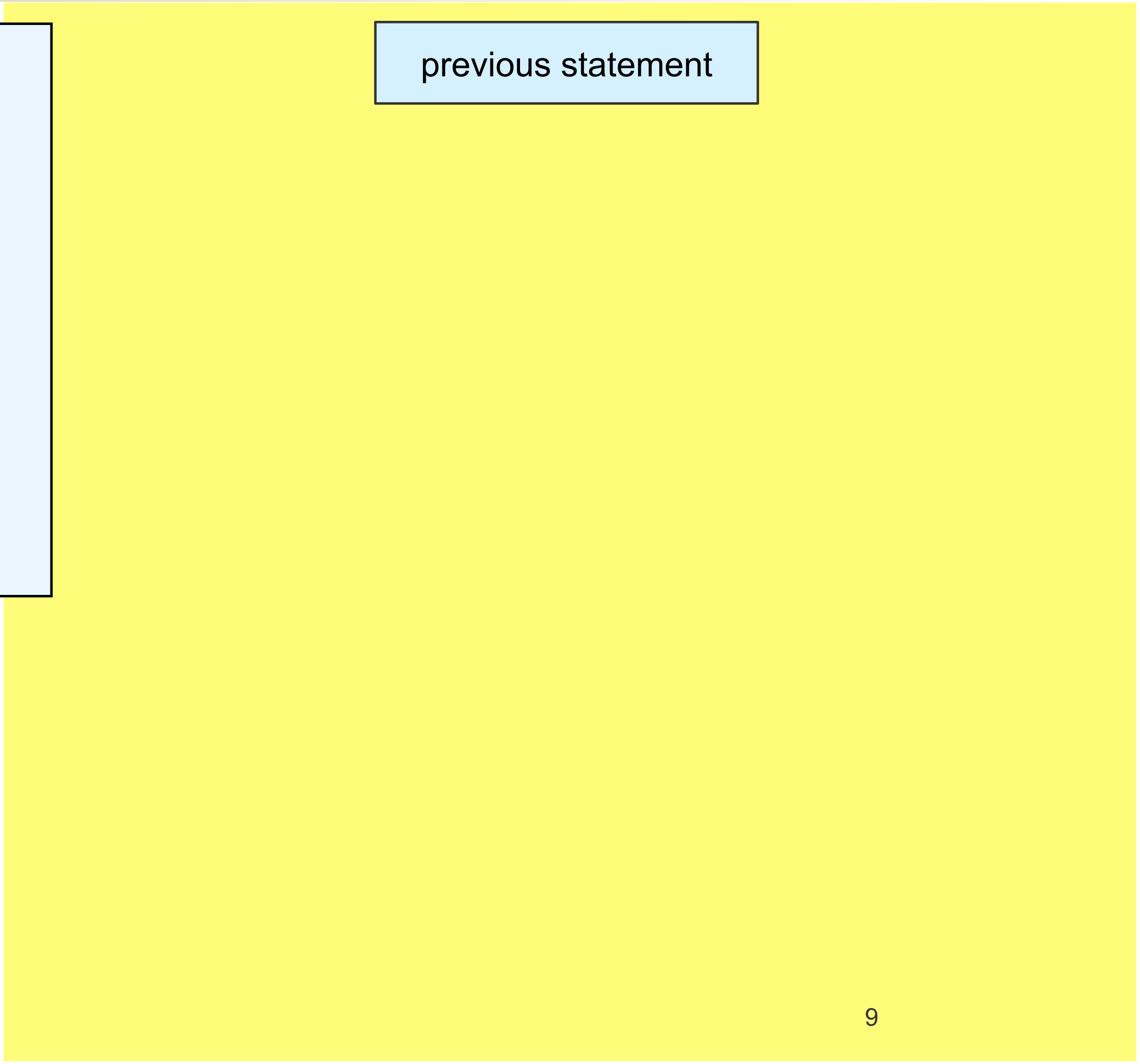


```
if ( <boolean expression> )
{
        if-statement1;
        if-statement2;
        ...
}
else
{
        else-statement1;
        else-statement2;
        else-statement3;
        ...
}
```

- We can have multiple statements for the if and/or else branches.
- Braces are used to combine multiple statements into a single block.

if-else Blocks Control Flow

```
if (<boolean expression>)
{
    if-statement1;
    if-statement2;
        …
}
else
{
    else-statement1;
    else-statement2;
    else-statement3;
        …
}
```



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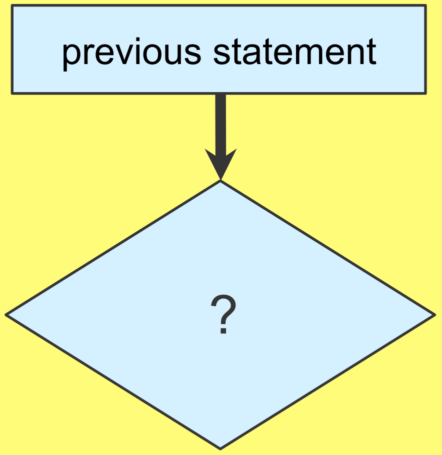

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        …
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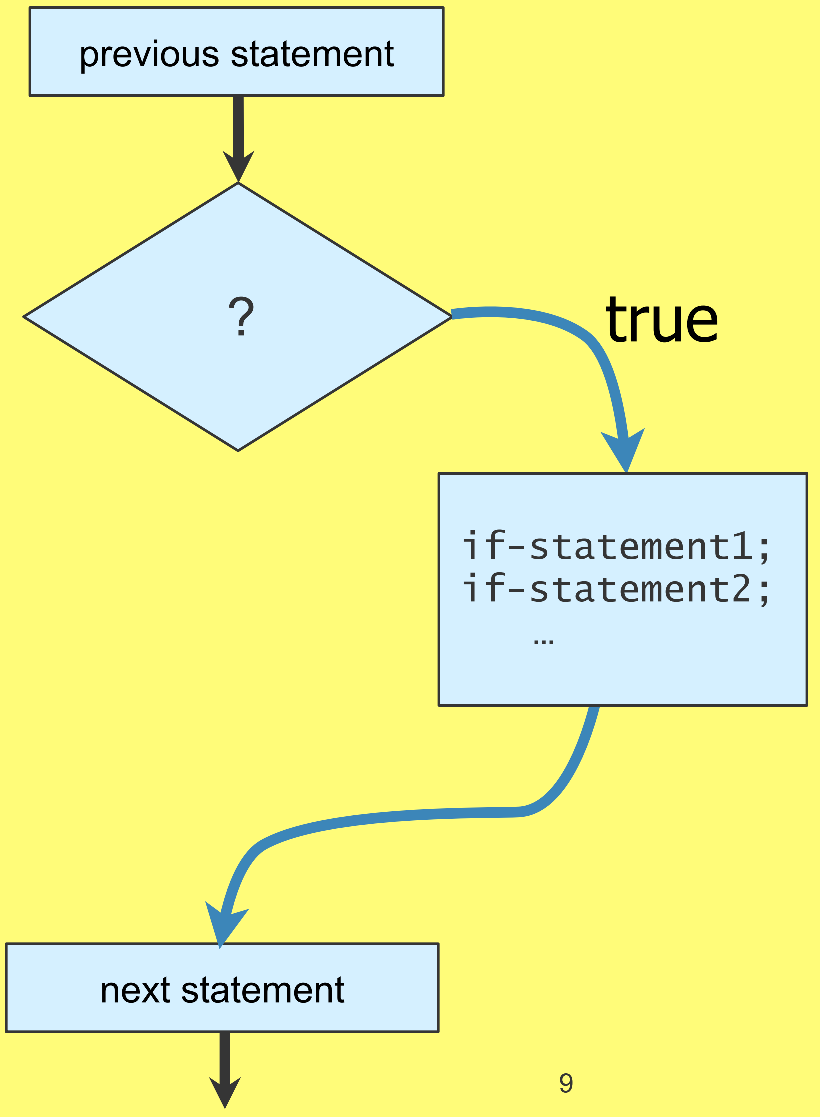

if-else Blocks Control Flow

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if (<boolean expression>)
{
    if-statement1;
    if-statement2;
        …
}
else
{
    else-statement1;
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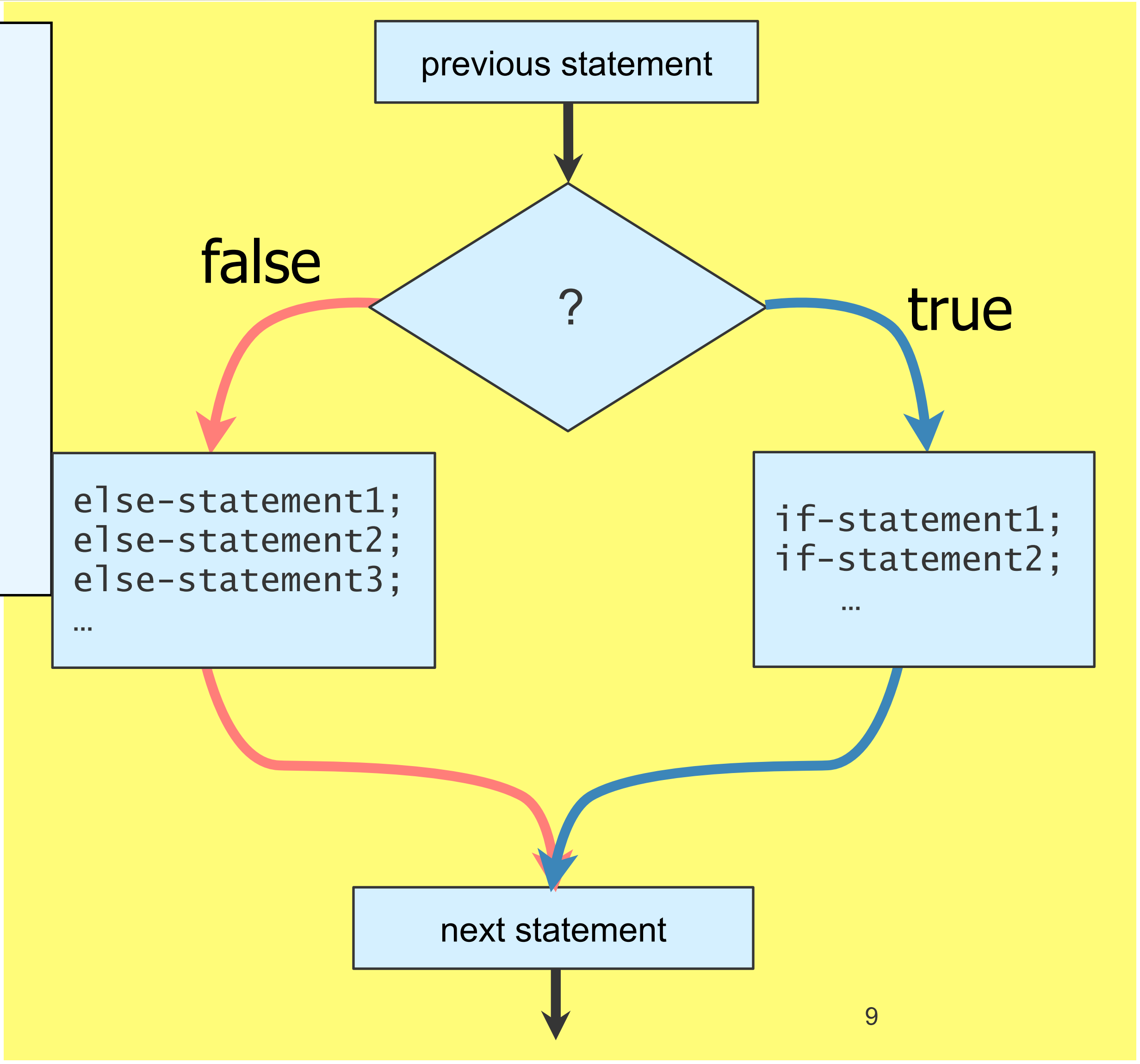
    else-statement3;
        …
}
```



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Solution

```
public class CholesterolCheck {
    public static void main(String[] args){
        int chLevel;
        chLevel = Integer.parseInt(JOptionPane.showInputDialog(
                        null, "Enter your cholesterol measure"));

        if(chLevel > 239) {

            System.out.println("Your cholesterol level is too high.");
            System.out.println ("You should probably see a doctor.");

        } else {

            System.out.println("Your cholesterol level is not too high.");
            System.out.println("Don't forget to exercise.");

        }

    }
}
```

Boolean Expressions

- boolean is a primitive data type.
- A boolean value can only be either **true** or **false**
- A simple boolean expression compares two values using a relational operator, e.g.,
  - chLevel > 239
  - height < weight
  - gpa == 3.0
- The operands can be either variables or literal values.

Relational Operators

- The following operators can be used to compare numeric data types:

Relational Operator	Meaning
>	Greater than
<	Less than
==	Equal to
>=	Greater than or equal to
<=	Less than or equal to
!=	Not equal to

Do not confuse with assignment (=).

Complex boolean expressions

- Boolean expressions can be combined using boolean operators to form more complex expressions.
  - Analogous to normal conditional statements.
- For example,
  - given three **int** variables i,j, and k:

```
(i > j) && (k == 5)
```

  - evaluates to **true** only if the value stored in i is greater than the value stored in j AND the value stored in k is equal to 5; **false** otherwise.

Boolean Operators

- Boolean operators take boolean expressions as operands.

Boolean Operator	Meaning
&&	AND
||	OR
!	Not (negation). Takes only one operand
^	Exclusive-OR

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Boolean Operator	Meaning
&&	AND
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^	Exclusive-OR

These are two "pipe" characters

Boolean Operators (contd)

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- bool1 && bool2
  - is **true** if both bool1 and bool2 are **true**;
  - otherwise it is **false**
    - (x > 2) && (x<10) is **true** for x=3; **false** for x=11;

Boolean Operators (contd)

- bool1 && bool2
  - is **true** if both bool1 and bool2 are **true**;
  - otherwise it is **false**
    - (x > 2) && (x<10) is **true** for x=3; **false** for x=11;

- bool1 || bool2
  - is **true** if either bool1 or bool2 (or both) are **true**;
  - otherwise it is **false**
    - (x>2) || (x<10) is always true.

Boolean Operators (contd)

Boolean Operators (contd)

- !bool1
  - is **true** if bool1 is **false**,
  - and **false** if bool1 is **true**
    - !(x>2) is **true** for x=1; and **false** for x=3;

Boolean Operators (contd)

- !bool1
  - is **true** if bool1 is **false**,
  - and **false** if bool1 is **true**
    - !(x>2) is **true** for x=1; and **false** for x=3;

- bool1 ^ bool2
  - is **true** if bool1 and bool2 are **different**;
  - otherwise it is **false**
    - (x>2) ^ (x<10) is false for x=3; and true for x = 11;

Definition of Boolean Operators

- Truth table for boolean operators

p	q	p && q	p || q	!p	p^q
false	false	false	false	true	false
false	true	false	true	true	true
true	false	false	true	false	true
true	true	true	true	false	false

- Sometimes true and false are represented by 1 and 0 (NOT in Java).
- In C and C++, 0 is **false**, everything else is **true**.

Examples of boolean expressions.

```
int i, j;
byte b, c;
float f, g;
double d, e;
```

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```
int i, j;
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```
i < j
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```
f >= i
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d > 9.3
```

Examples of boolean expressions.

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int i, j;
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```
i < j
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f >= i
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```
d > 9.3
```

```
2 == c
```

Examples of boolean expressions.

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`i < j`

`f >= i`

`d > 9.3`

`2 == c`

`j != i`

Examples of boolean expressions.

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i < j
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2 == c
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```
j != i
```

```
g <= (b*c + d)
```

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g <= (b*c + d)
```

```
(i > j)  &&  (f >= i)
```

Examples of boolean expressions.

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int i, j;
byte b, c;
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i < j
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```
g <= (b*c + d)
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```
(i > j)  &&  (f >= i)
```

```
(d > 9.3) || (2 != d)
```

Examples of boolean expressions.

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(i > j)  &&  (f >= i)
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```
!(c <= j) ^ (j != i)
```

Examples of boolean expressions.

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int i, j;
byte b, c;
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i < j
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d > 9.3
```

```
2 == c
```

```
j != i
```

```
g <= (b*c + d)
```

```
(i > j)  &&  (f >= i)
```

```
(d > 9.3) || (2 != d)
```

```
!(c <= j) ^ (j != i)
```

```
((i > j)  &&  (f >= i)) || ((d > 9.3) || (2 != d)) ^ (!(c <= j) ^ (j != i))
```

Problem

- *Write a program that tells a patient how to interpret their total cholesterol measure. The measure is an integer. A cholesterol measure*
    - *Less than 200 is "Desirable"*
    - *200-239 is "Mildly High"*
    - *240 and above is "High"*
- *Your program should read in the measure and output an appropriate evaluation.*

The Nested-if Statement

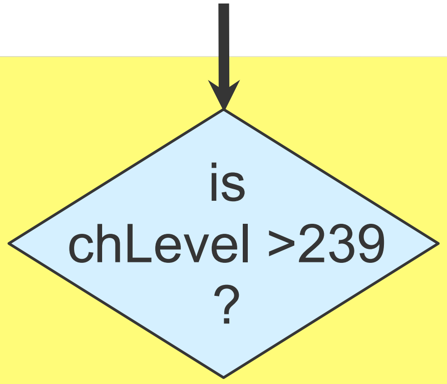
- The `then` and `else` block of an if statement can contain any valid statements, including other if statements. An if statement containing another if statement is called a nested-if statement.

```
if (chLevel > 239)
   System.out.print(". . . is too high.");
else
   if (chLevel > 199)
      System.out.print(". . is mildly high.");
   else
      System.out.print(". . is normal.");
```

Sample control flow

```
if (chLevel > 239)
   . . .("too high.");
else
   if (chLevel > 199)
      . . .("mildly high.");
   else
      . . .("normal.");
```

Sample control flow



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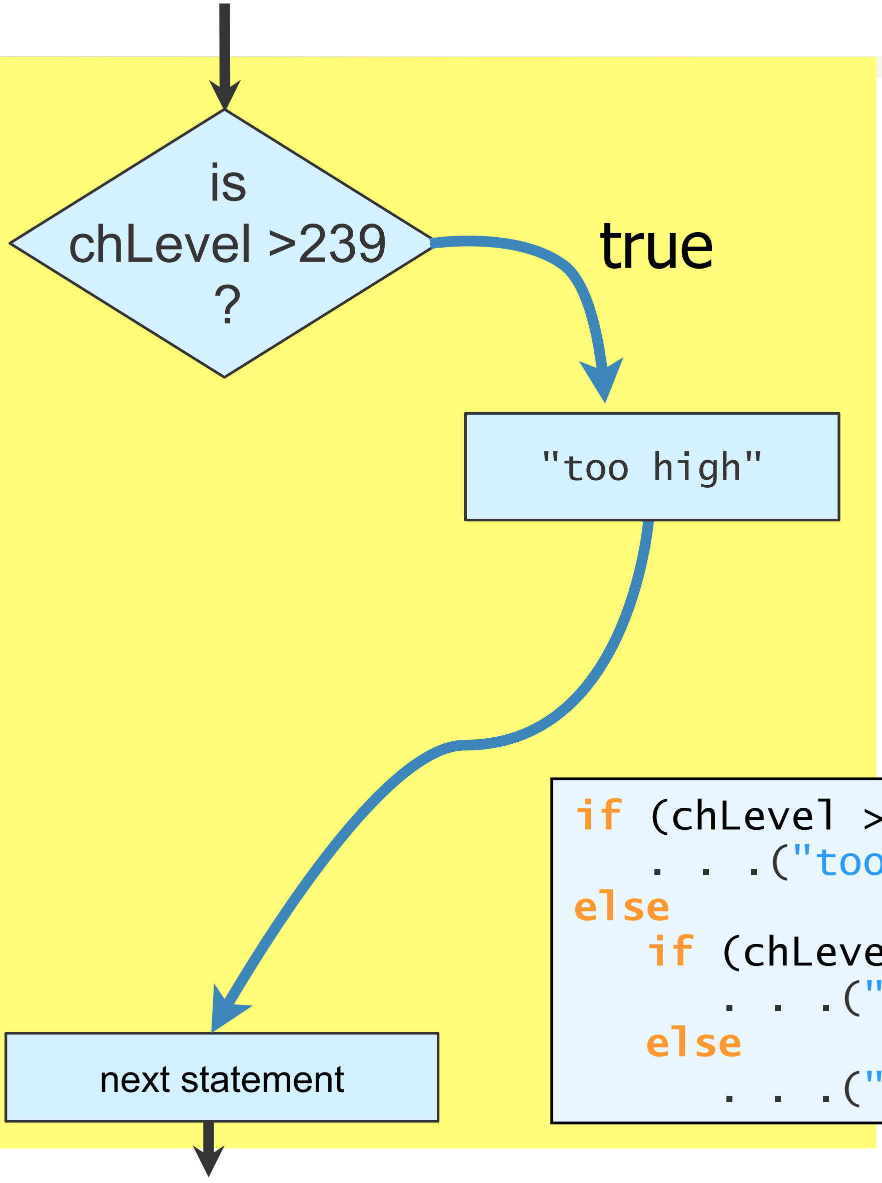

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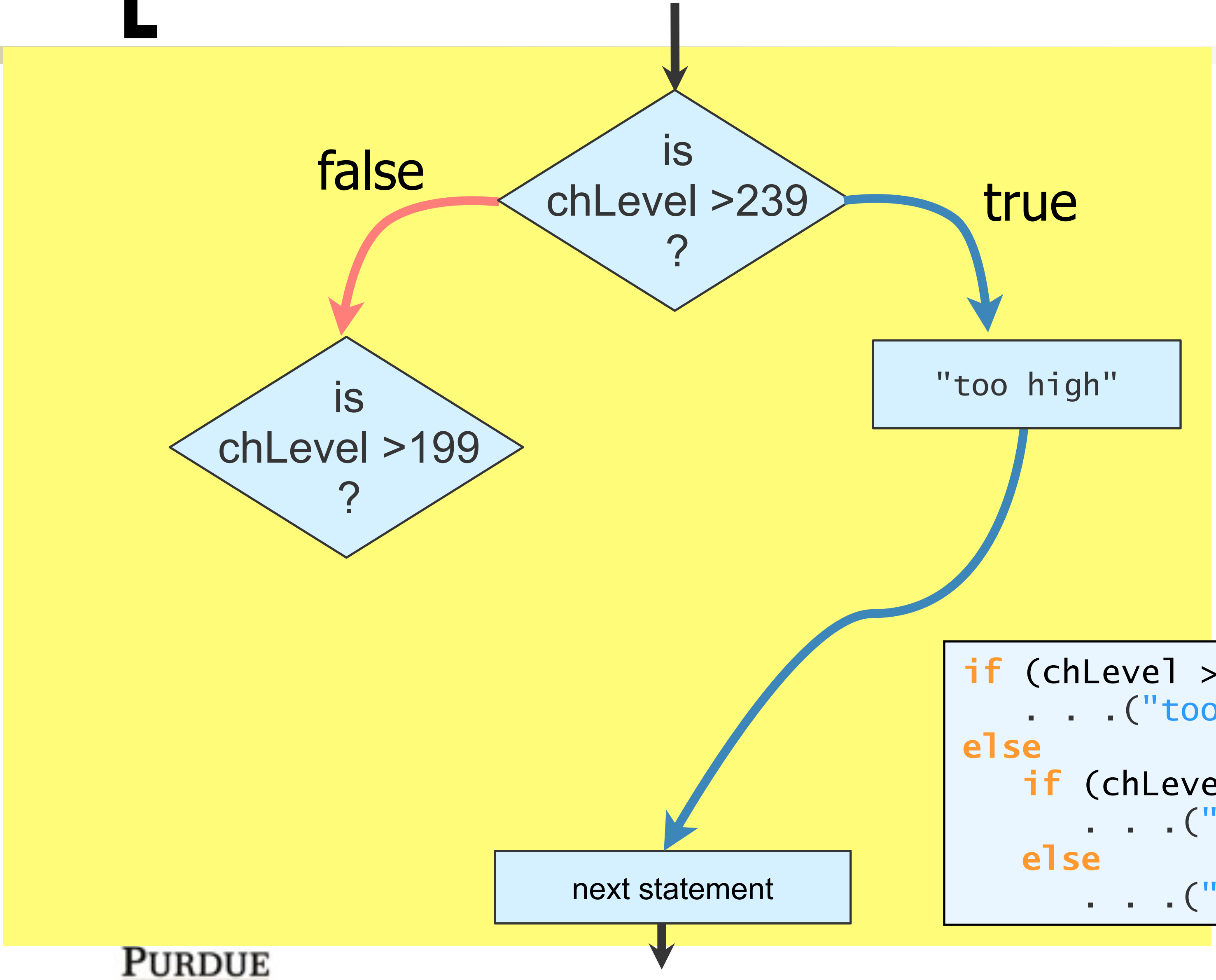

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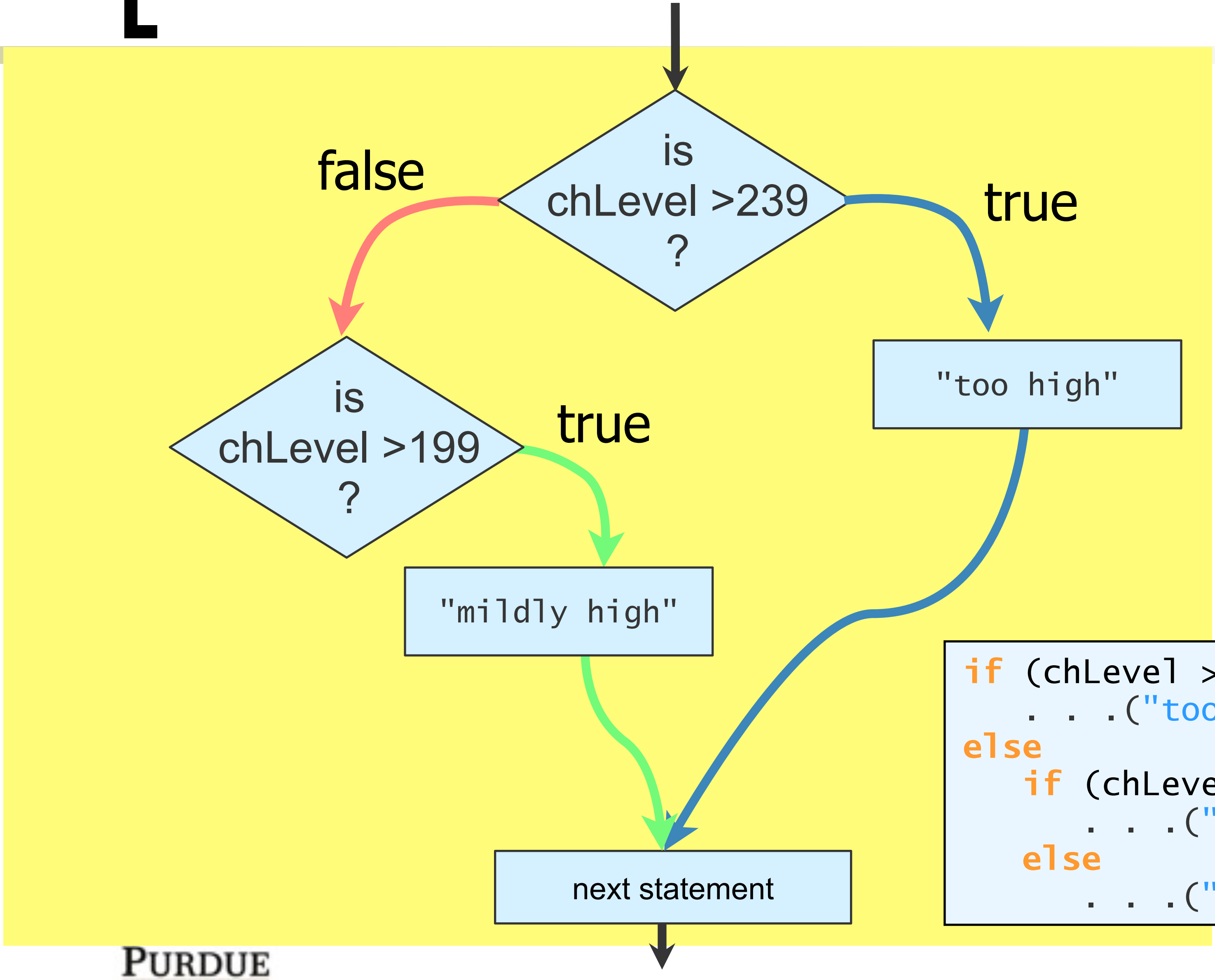

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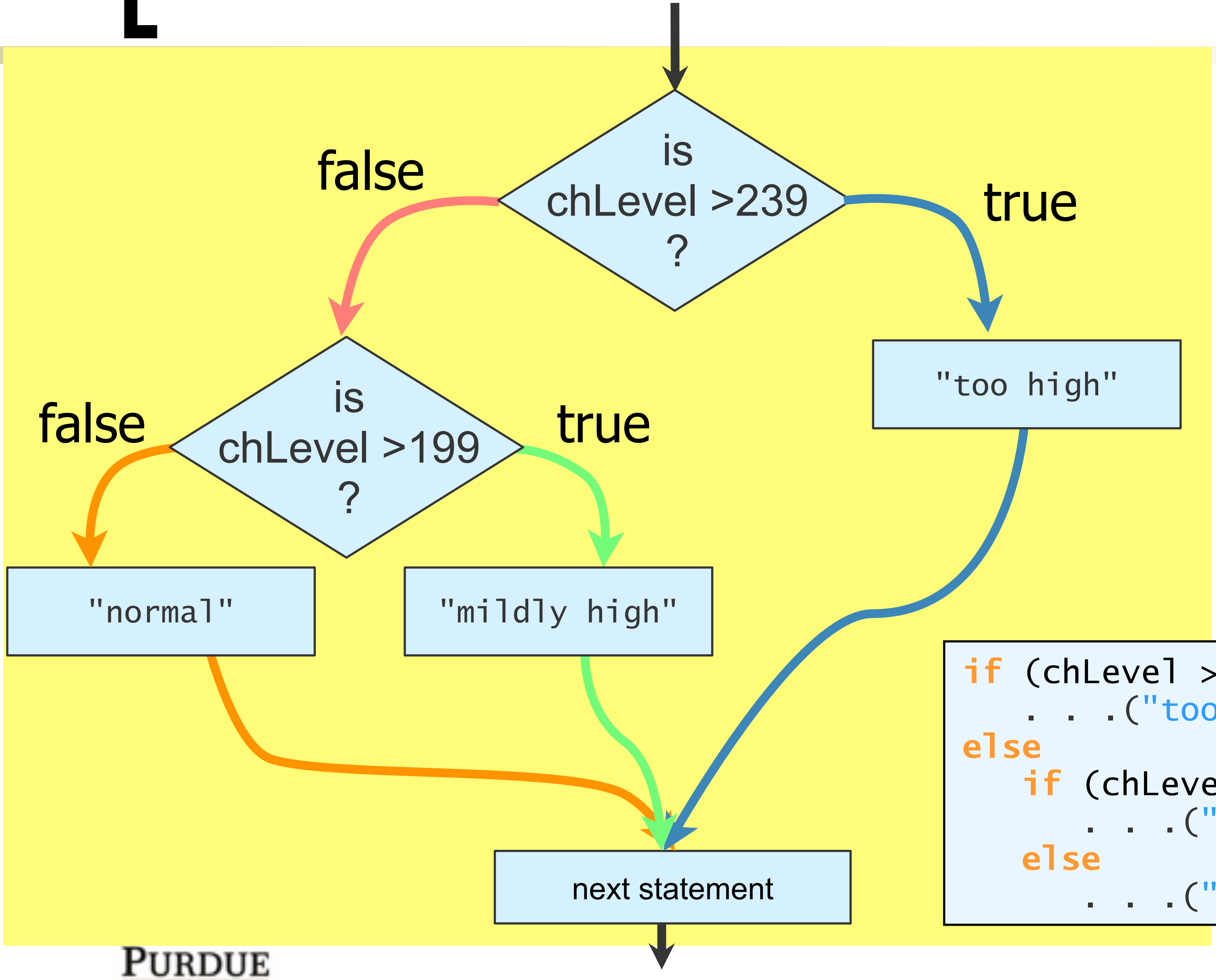

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if (chLevel > 239)
    . . .("too high.");
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    if (chLevel > 199)
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    else
        . . .("normal.");
```
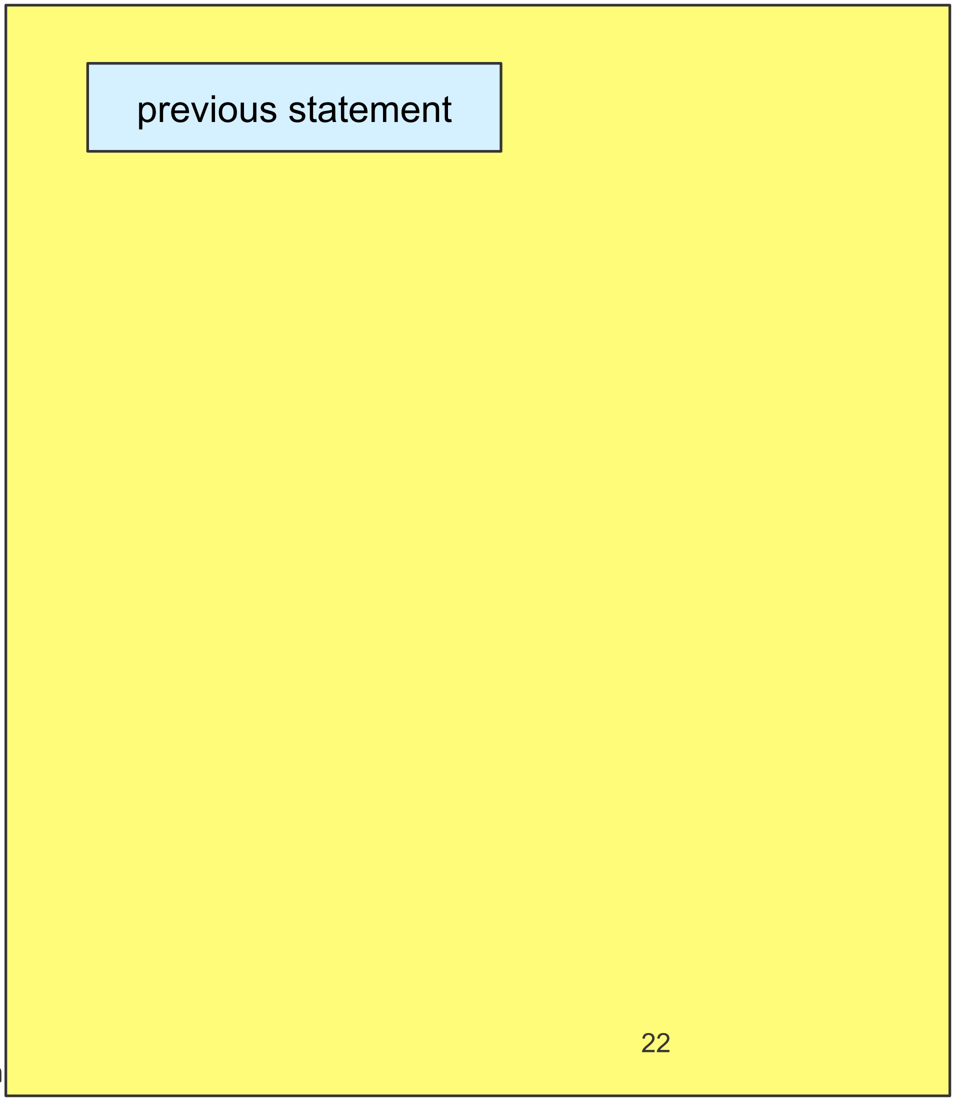

else is Not Required

```
if (chLevel < 1){
    System.out.print("There is an
    error in your input");
}
...
```



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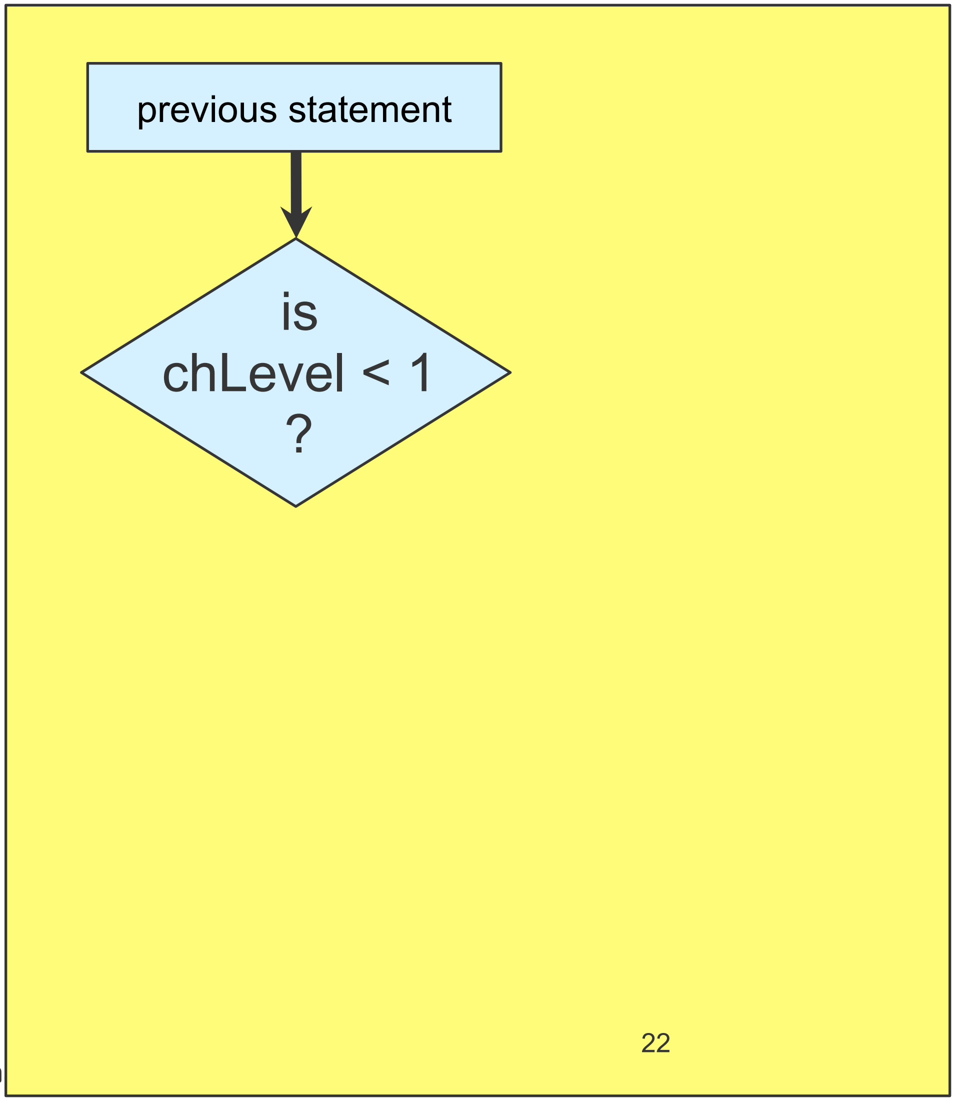

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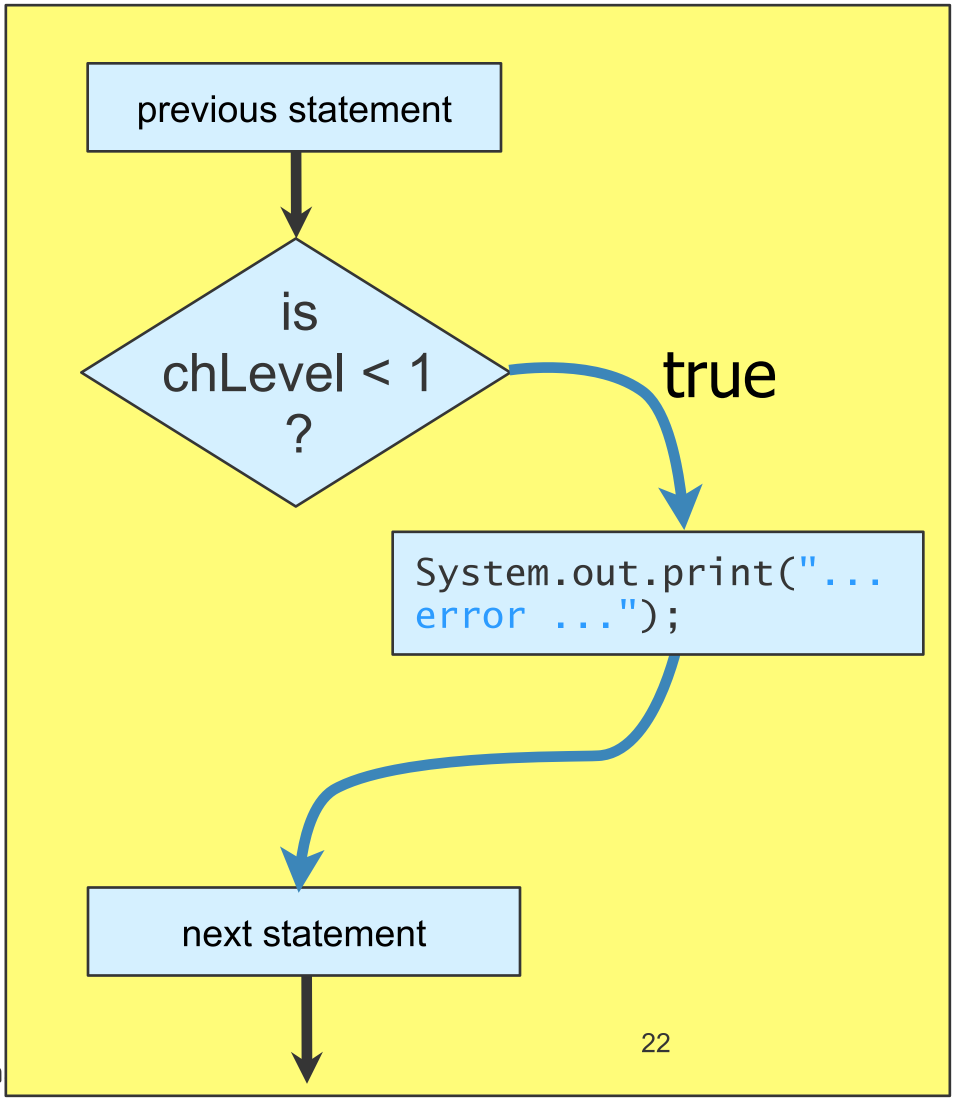

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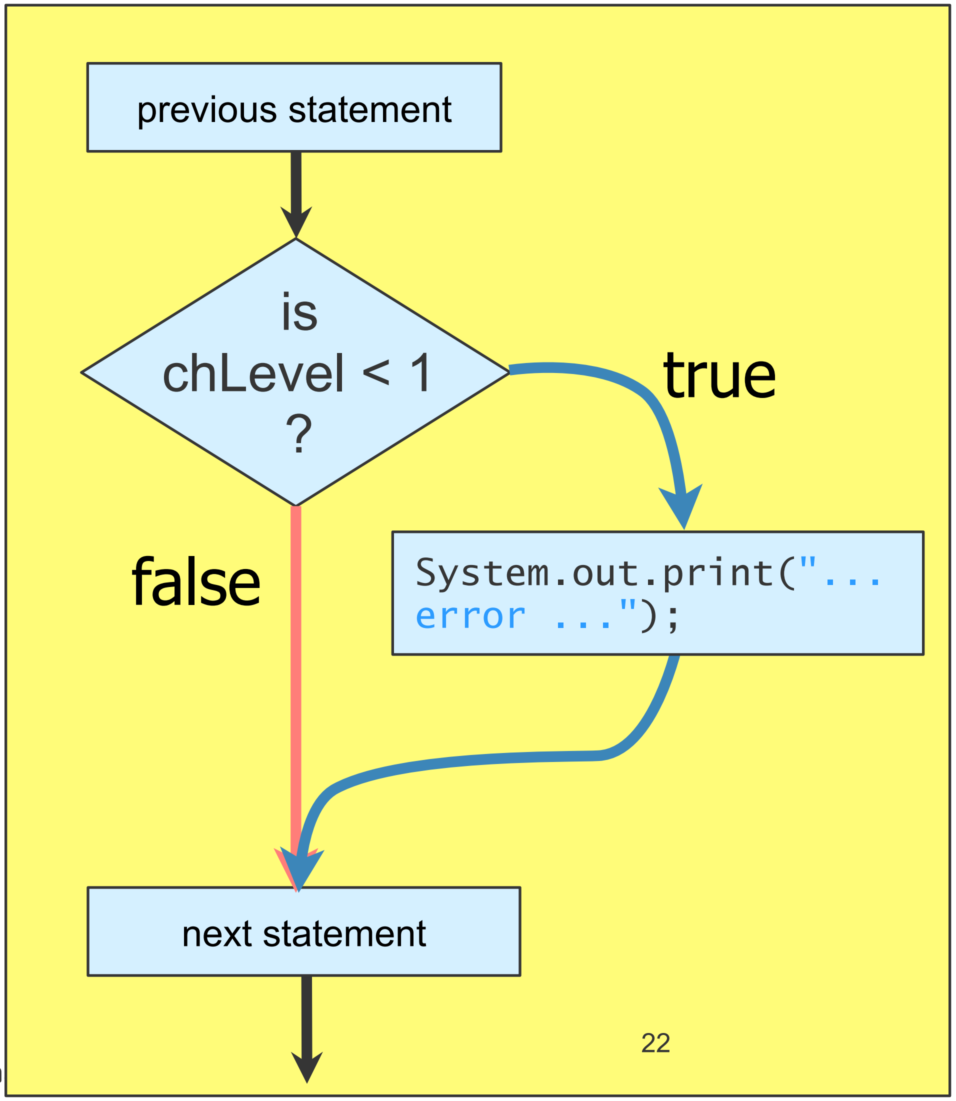

Caution: Dangling else

```
if (chLevel > 199)
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   if (chLevel > 239)
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Each else paired with nearest unmatched if -- use braces to change this as needed.

Caution: Dangling else

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if (chLevel > 199)
   if (chLevel > 239)
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Same as

```
if (chLevel > 199){
   if (chLevel > 239)
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Boolean Variables

- Boolean values can be stored in **boolean** variables -- a primitive datatype.
- Can be used in boolean expressions.

Boolean Variables

- Boolean values can be stored in **boolean** variables -- a primitive datatype.
- Can be used in boolean expressions.

```
boolean hasWon,isFinalLevel;

isFinalLevel = false;
…
isFinalLevel = (gameLevel == 10);
hasWon = (numberOfZombies == 0);

if (hasWon)
   if (isFinalLevel)
      System.out.println("WOW -- you beat the game!");
   else
      startNextLevel();
else
   restartSameLevel();
```

Boolean Methods

- A method that returns a boolean value is a Boolean method.
- A call to this method can be used as a boolean value.

Boolean Methods

- A method that returns a boolean value is a Boolean method.
- A call to this method can be used as a boolean value.

```
public boolean isGameOver(){
  if((numberOfHumans < 1) || (numberOfZombies<1))
      return true;
   else
      return false;
}
```

Boolean Methods

- A method that returns a boolean value is a Boolean method.
- A call to this method can be used as a boolean value.

```
public boolean isGameOver(){
  if((numberOfHumans < 1) || (numberOfZombies<1))
      return true;
   else
      return false;
}
```

```
if( isGameOver() )
   if(numberOfZombies < 1)
      System.out.println("You WON!!");
   else
      System.out.println("Sorry, you lost!!");
else
   System.out.println("Battle on…");
```

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Operator Precedence Rules

Group	Operator	Order
Subexpresion	( )	**Innermost first**
Unary operators	- , !	**Right to Left**
Unary operators	*, /, %	Left to Right
Additive	+ , -	Left to Right
Relational	<, <=, >, <,	Left to Right
Equality	!=, ==	Left to Right
Boolean AND	&&	Left to Right
Boolean OR	||	Left to Right
Assignment	=	**Right to Left**

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Announcements

- Midterm exam 1:
  - September 26, 8:00 – 9:00pm
  - Two rooms EE129 & FRNY G140
  - You will be assigned a room
  - Coverage: upto Week 5.
  - Closed book/notes. Can bring one sheet.
  - Sample exams are on website.

Problem

- *Write a program that classifies triangles*
  - *by their sides*
  - *by their angles*
- *Write a program that classifies quadrilaterals by their sides and one angle*
  - *consider only parallelograms, rectangles, squares and rhombi.*

TriangleClassifier

```
class TriangleClassifier {
  public static void main(String args[]) {
   int side1, side2, side3;
   String type;
     . . . // read in all three side lengths
   if (side1 == side2)
     if (side1 == side3)
       type = "Equilateral";
     else
       type = "Isosceles";
   else
     type = "Scalene";
   System.out.println("This is a " + type + "
   triangle.");
  }
}
```

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TriangleClassifier

```
class TriangleClassifier {
  public static void main(String args[]) {
   int side1, side2, side3;
   String type;
     . . . // read in all three side lengths

   if (side1 == side2)
      if (side1 == side3)
         type = "Equilateral";
      else
         type = "Isosceles";
   else
      type = "Scalene";
   System.out.println("This is a " + type + "
   triangle.");
  }
}
```

Not quite!!

TriangleClassifier

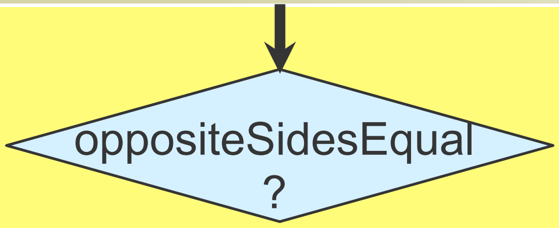
```
class TriangleClassifier {
  public static void main(String args[]) {
    int side1, side2, side3;
    String type;
     . . . // read in all three side lengths
    if (side1 == side2)
       if (side1 == side3)
          type = "Equilateral";
       else
          type = "Isosceles";

     else
        if ((side2 == side3)||(side1 == side3))
          type = "Isosceles";
       else
           type = "Scalene";
     System.out.println("This is a " + type + " triangle.");
  }
}
```

TriangleClassifier2

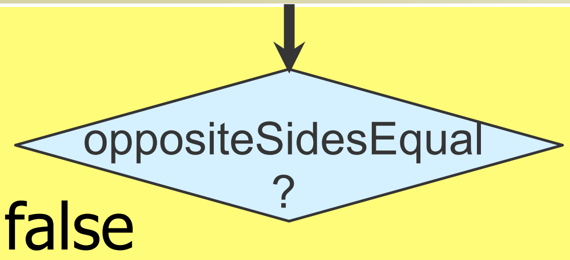
```
class TriangleClassifier2 {
  public static void main(String args[]) {
     double angle1, angle2, angle3, maxAngle;
     String type;
      . . . // read in all three angles
     maxAngle = Math.max(angle1, Math.max(angle2, angle3));
     if (Math.abs(maxAngle - 90.0) < 0.0000001)
        type = " right-angled";
     else
        if (maxAngle > 90)
           type = "n obtuse";

    else
        type = "n acute";
     System.out.println("This is a" + type + " triangle.");
  }
}
```

Quadrilateral Logic

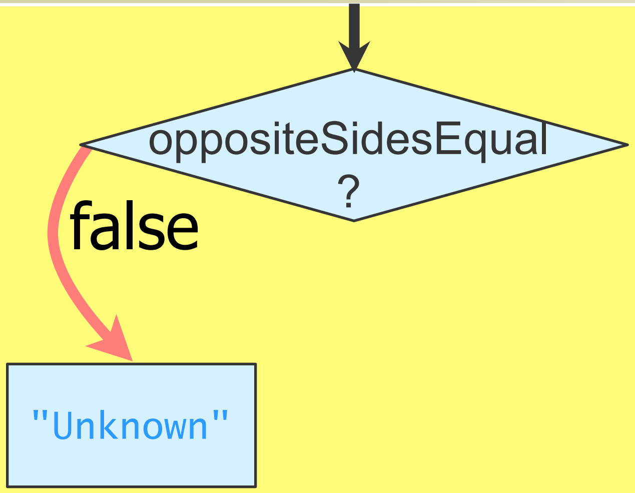
Quadrilateral Logic



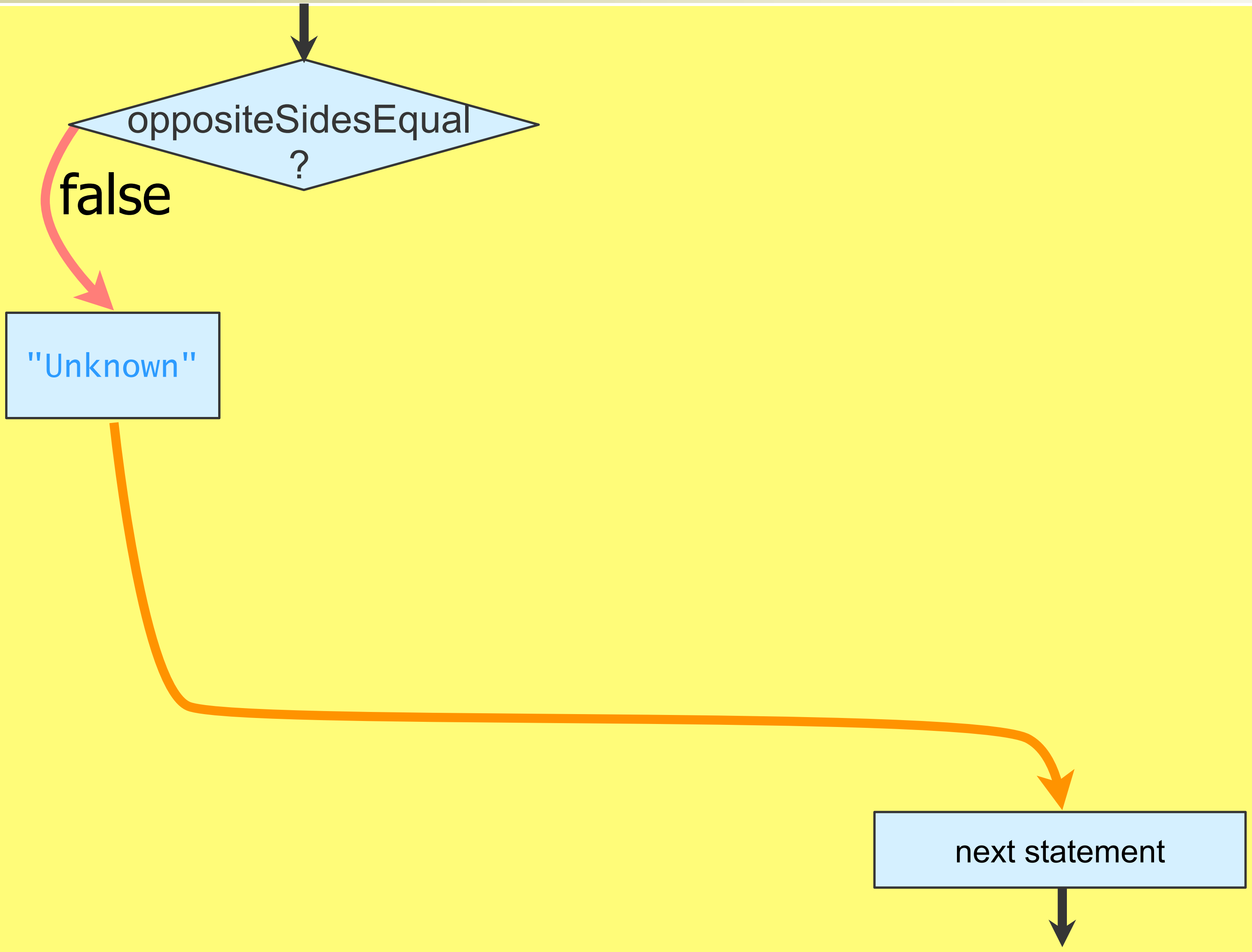
Quadrilateral Logic



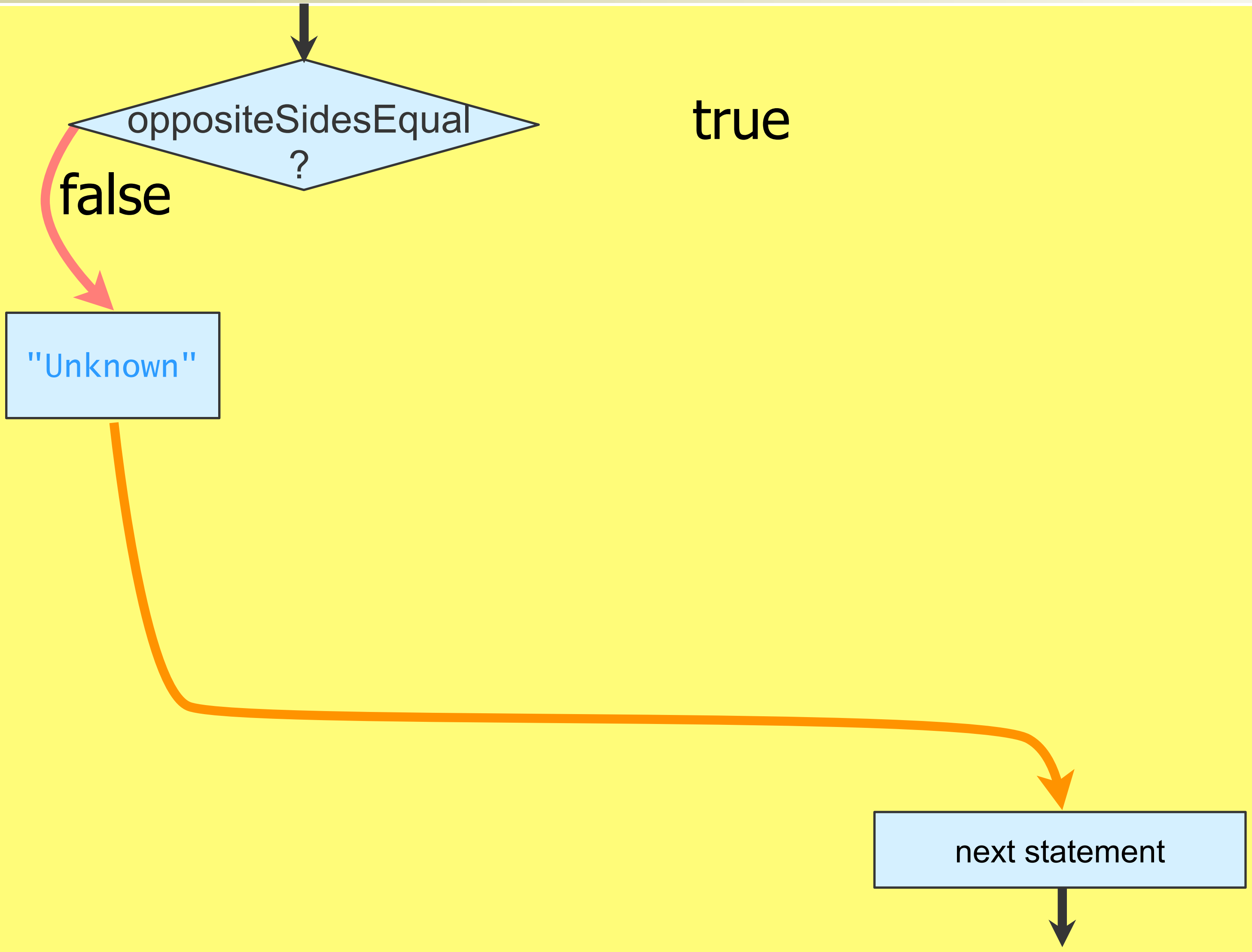
Quadrilateral Logic



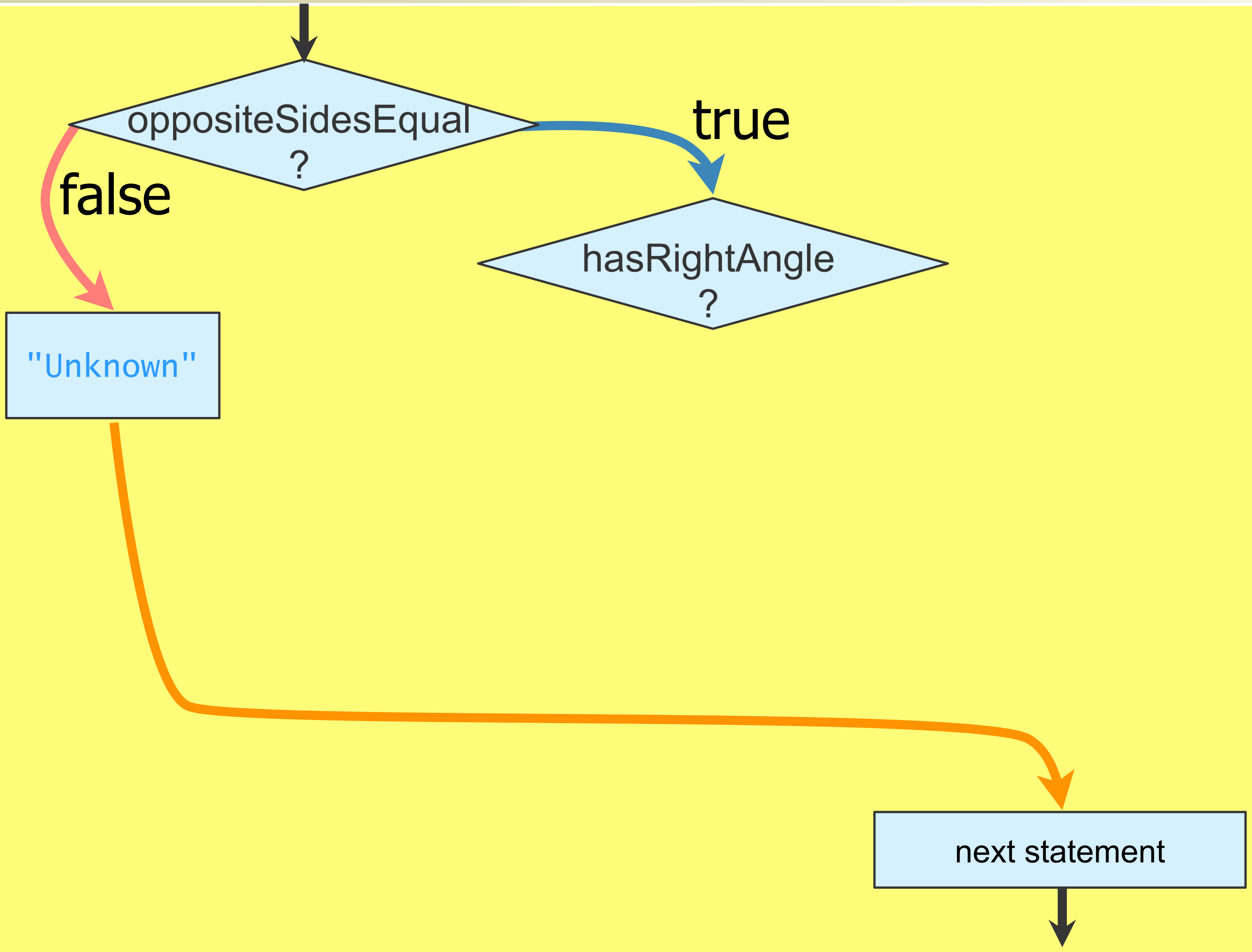
Quadrilateral Logic



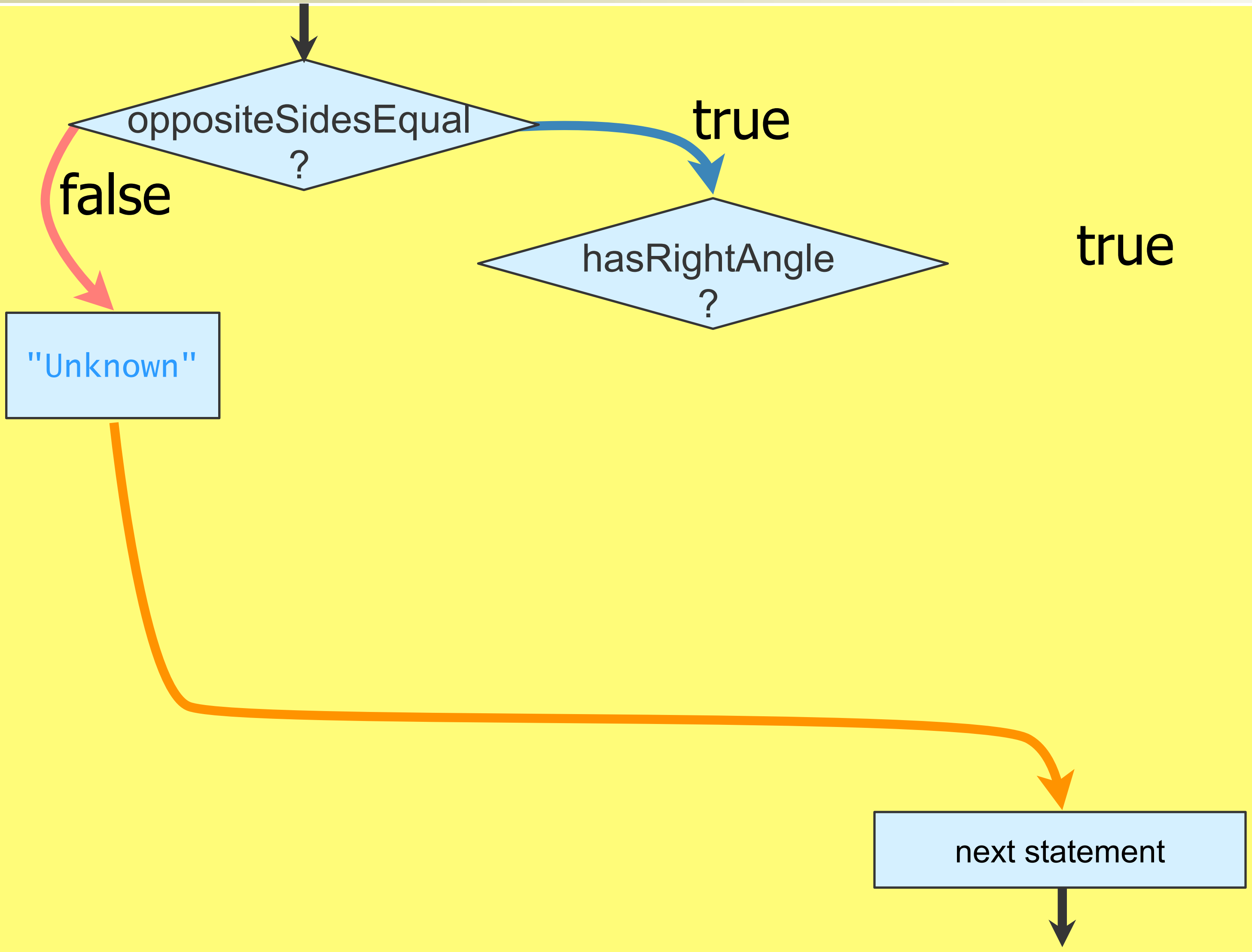
Quadrilateral Logic



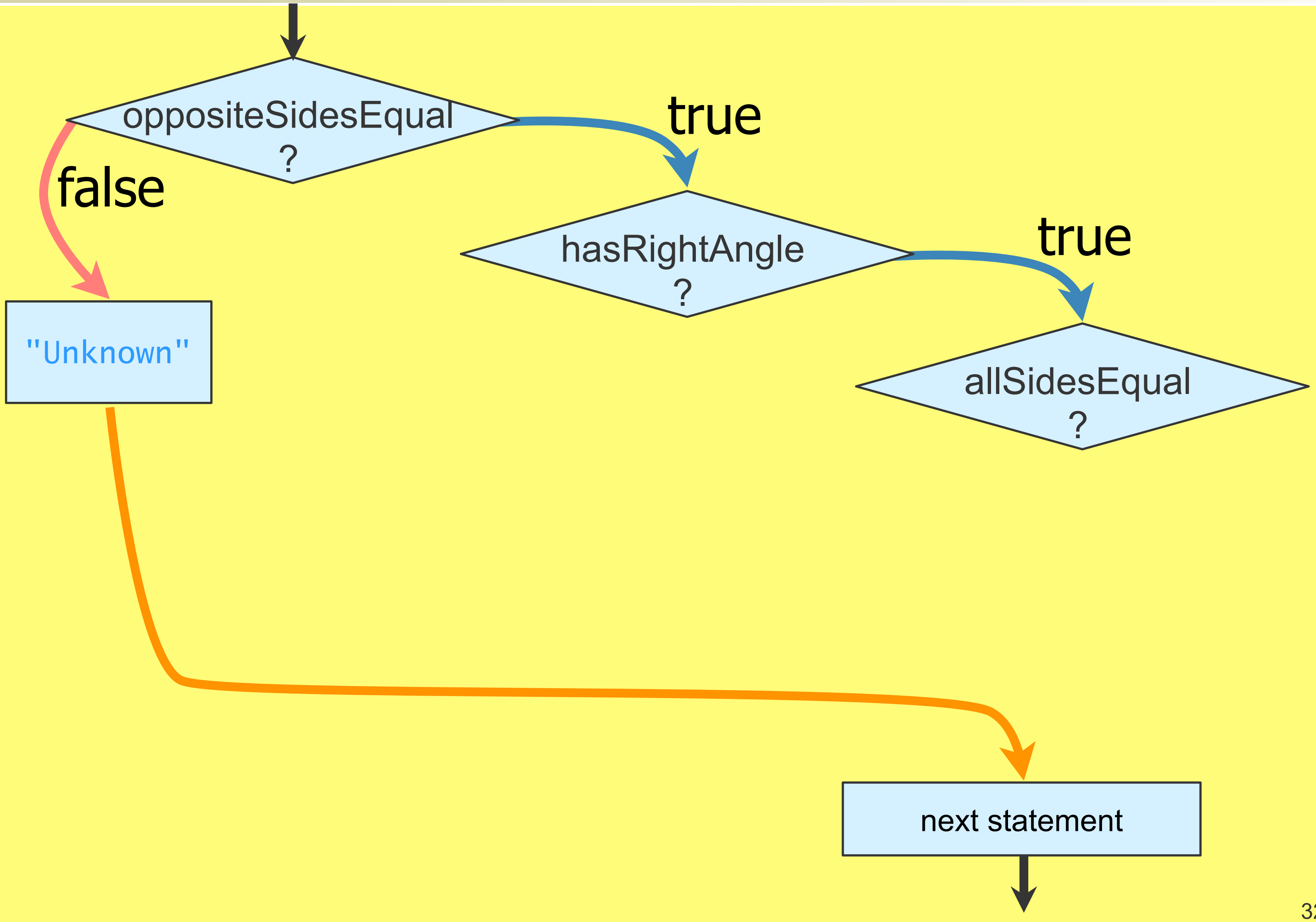
Quadrilateral Logic



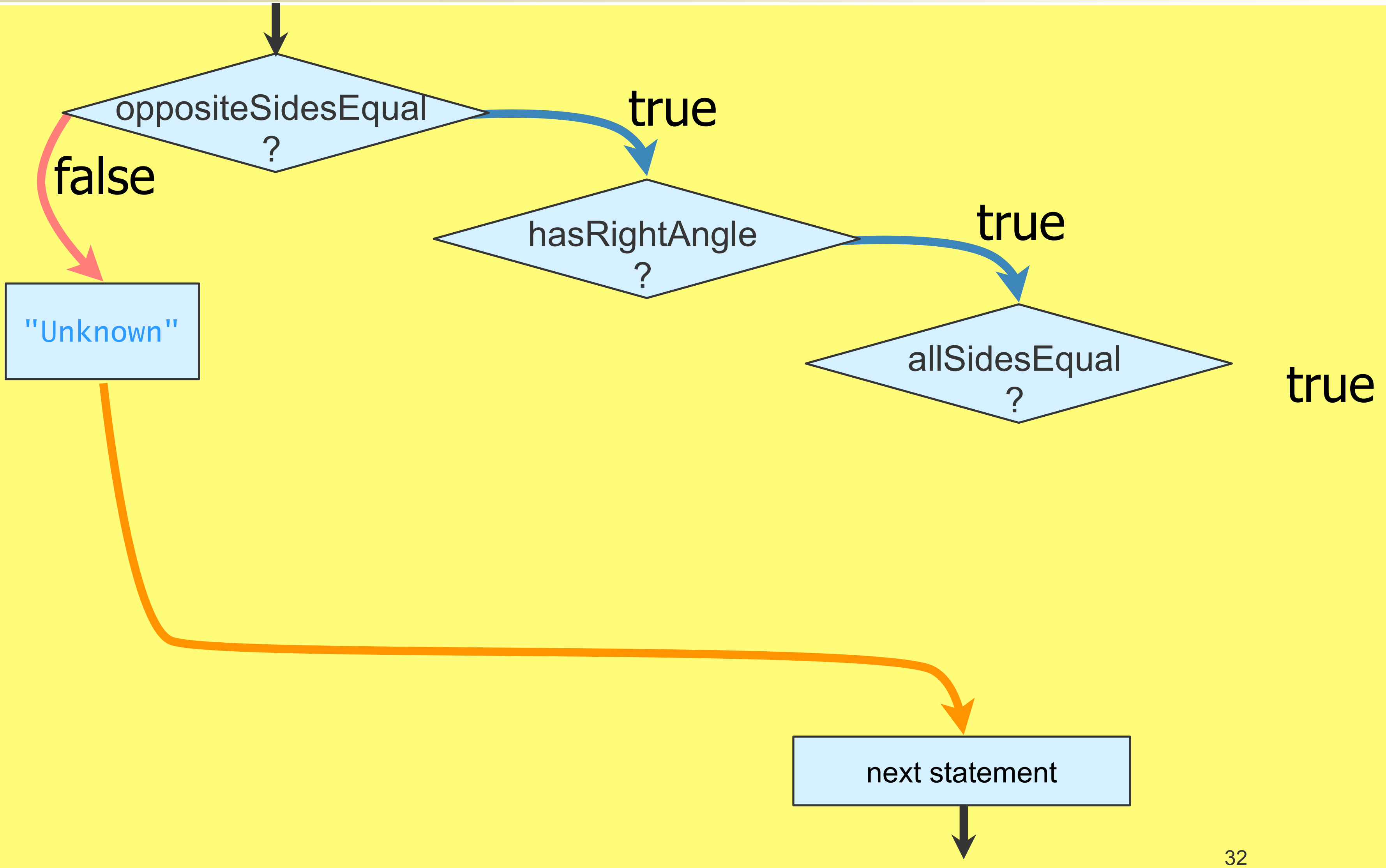
Quadrilateral Logic



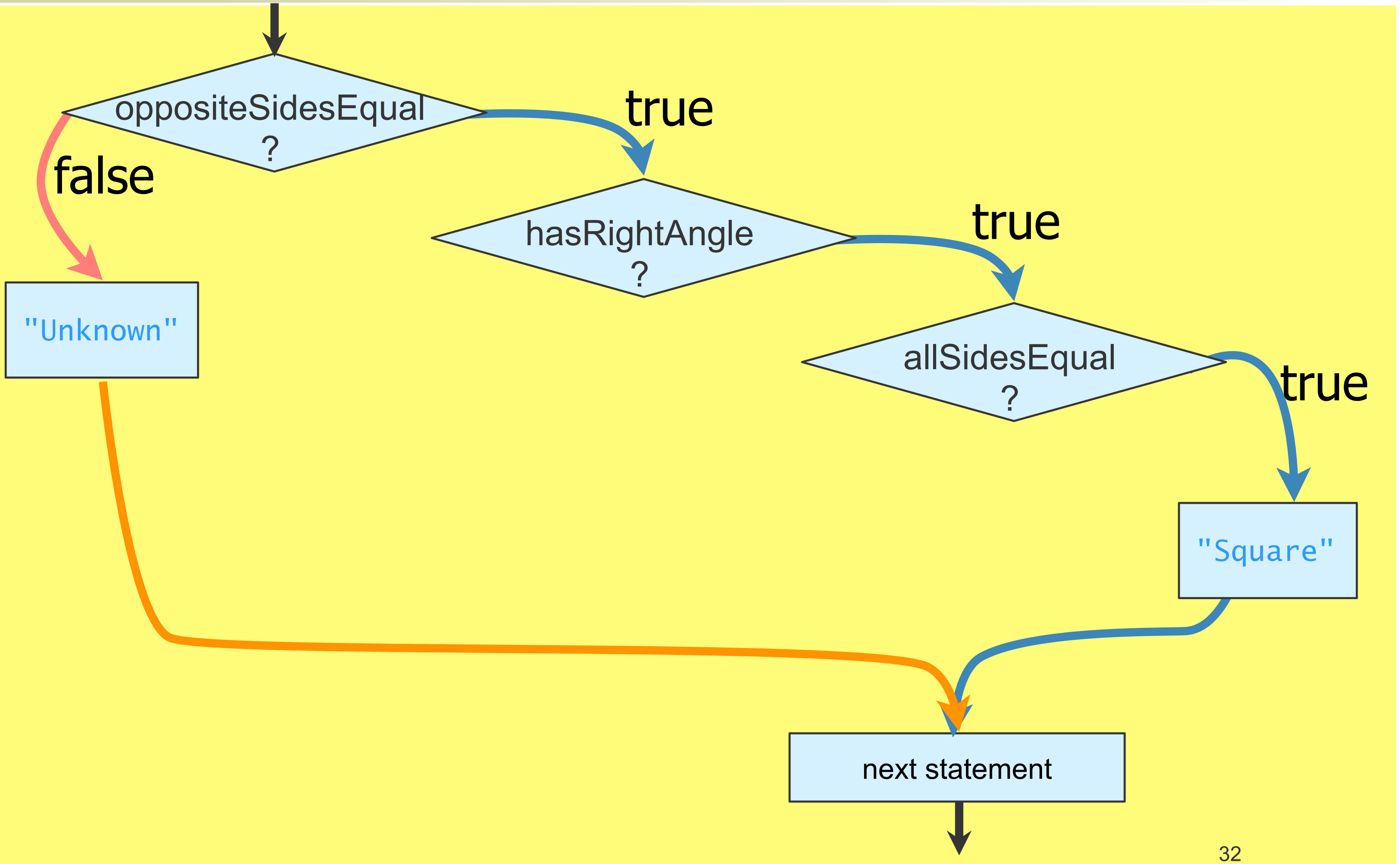
Quadrilateral Logic



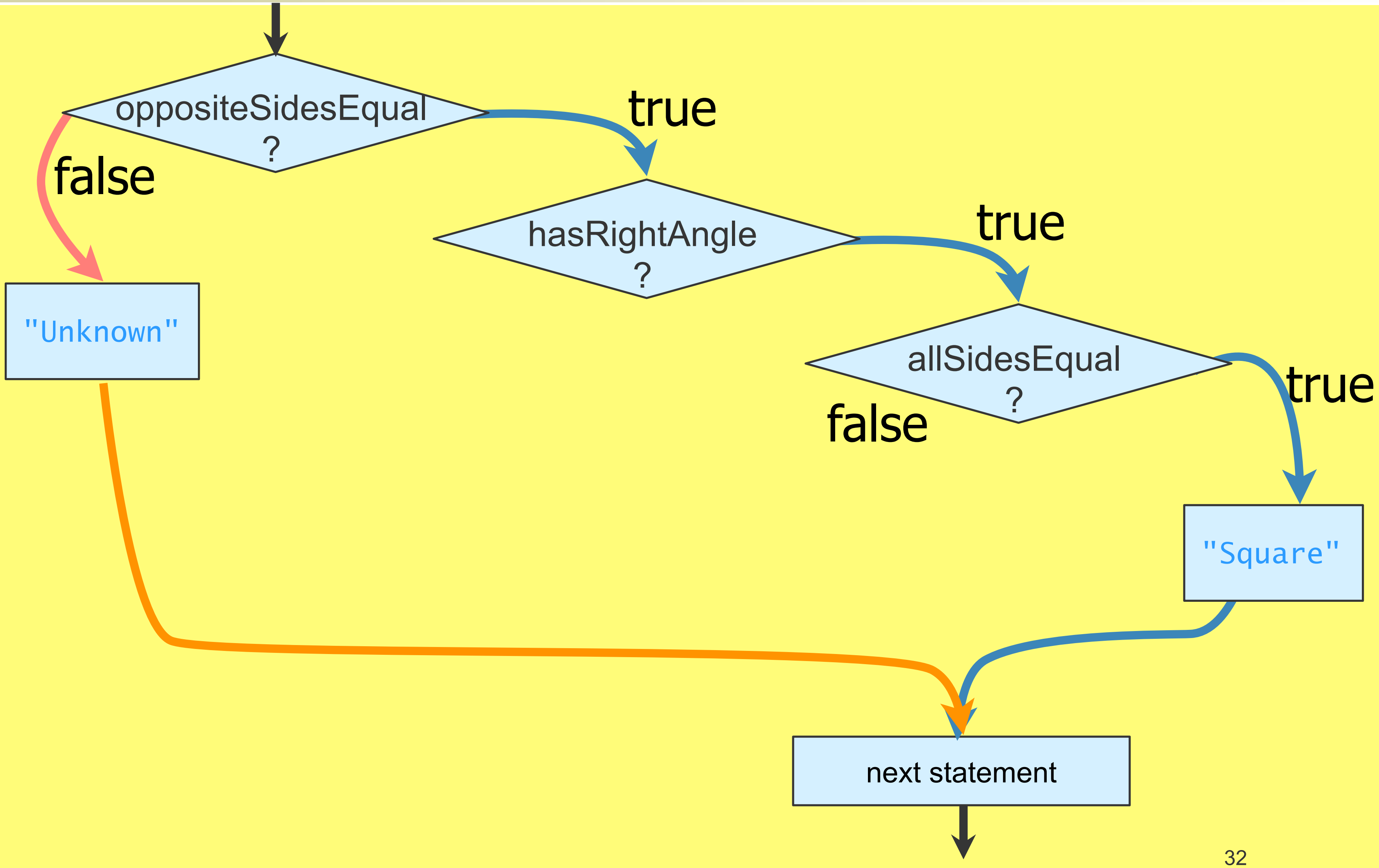
Quadrilateral Logic



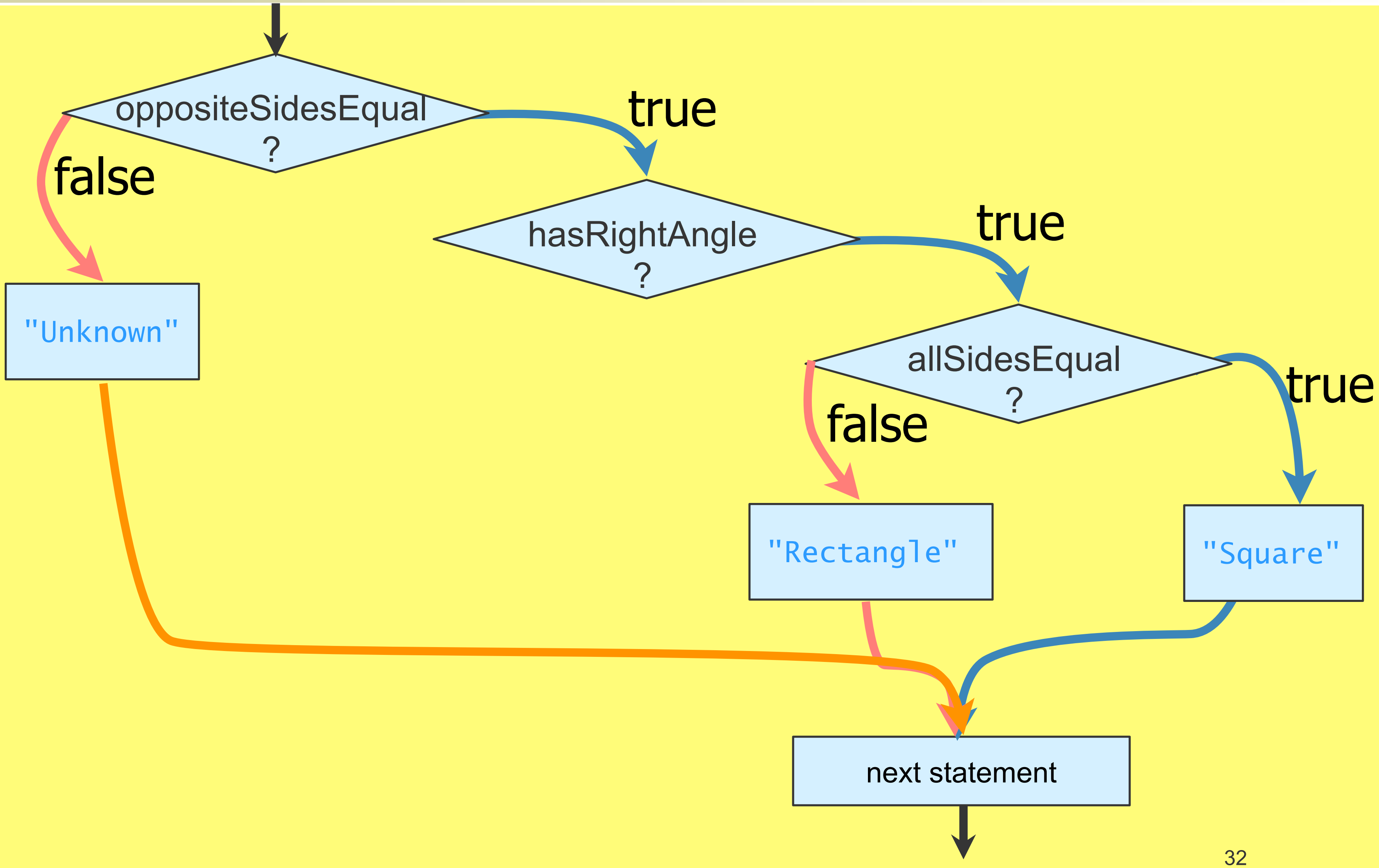
Quadrilateral Logic



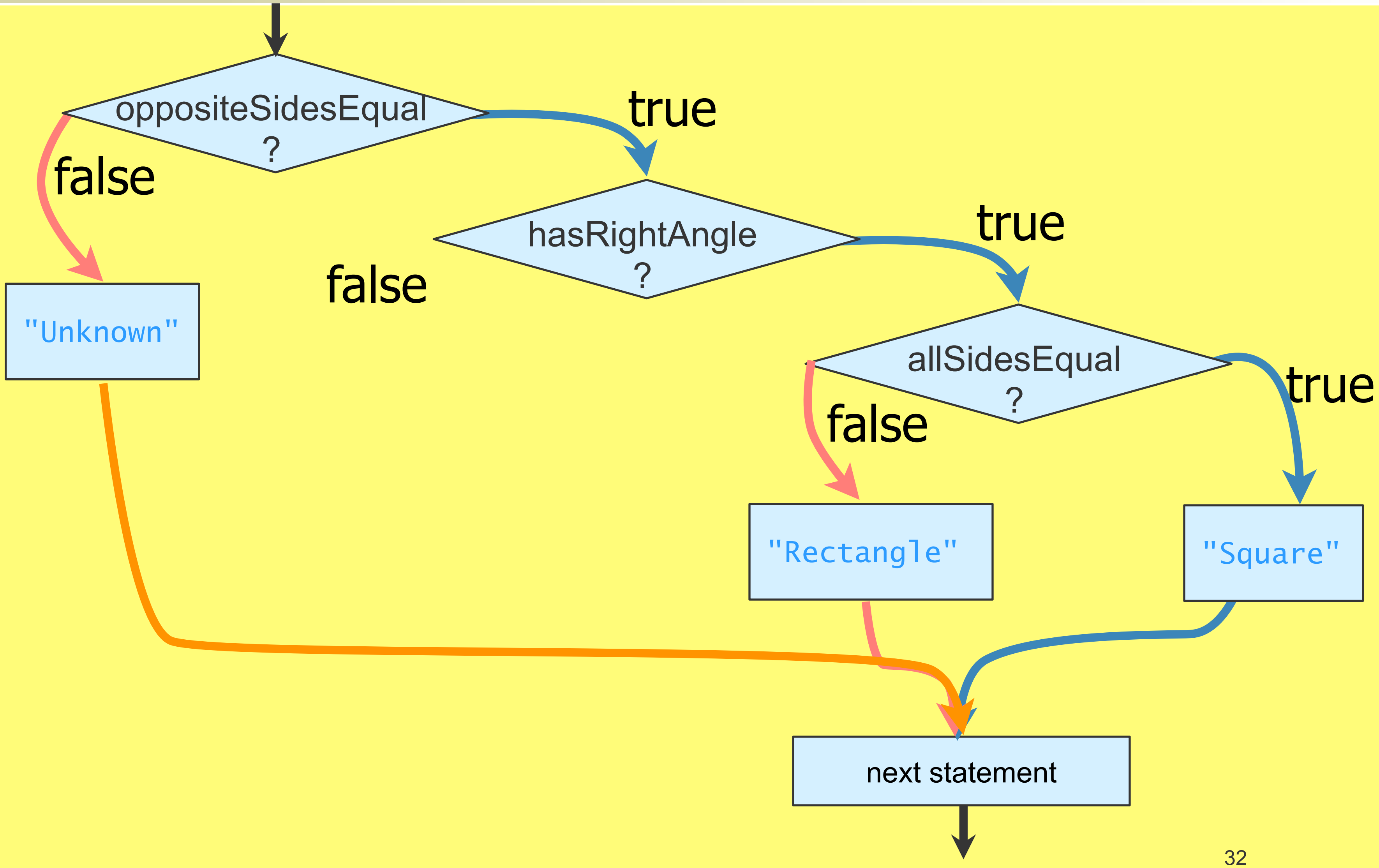
Quadrilateral Logic



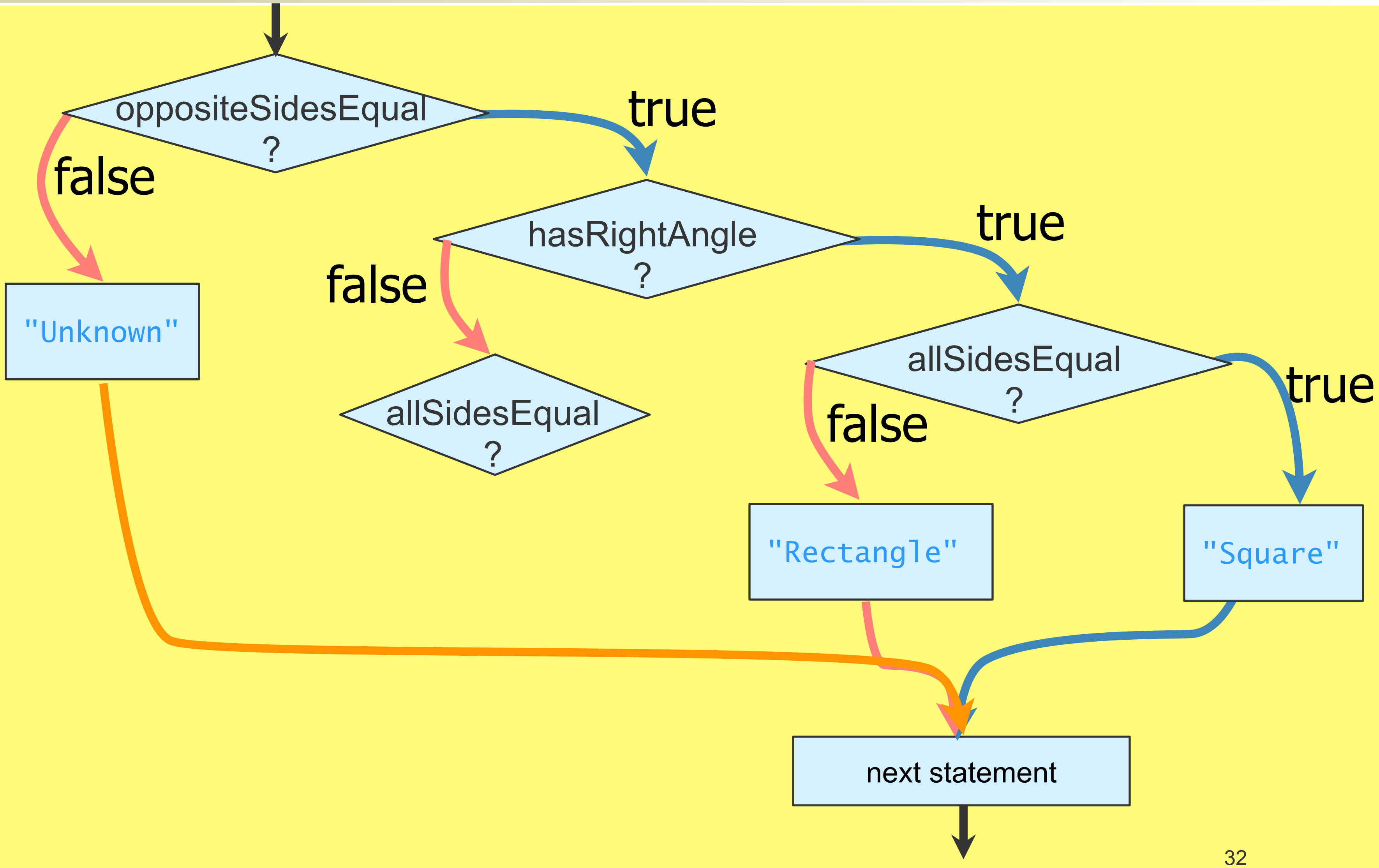
Quadrilateral Logic



Quadrilateral Logic



Quadrilateral Logic



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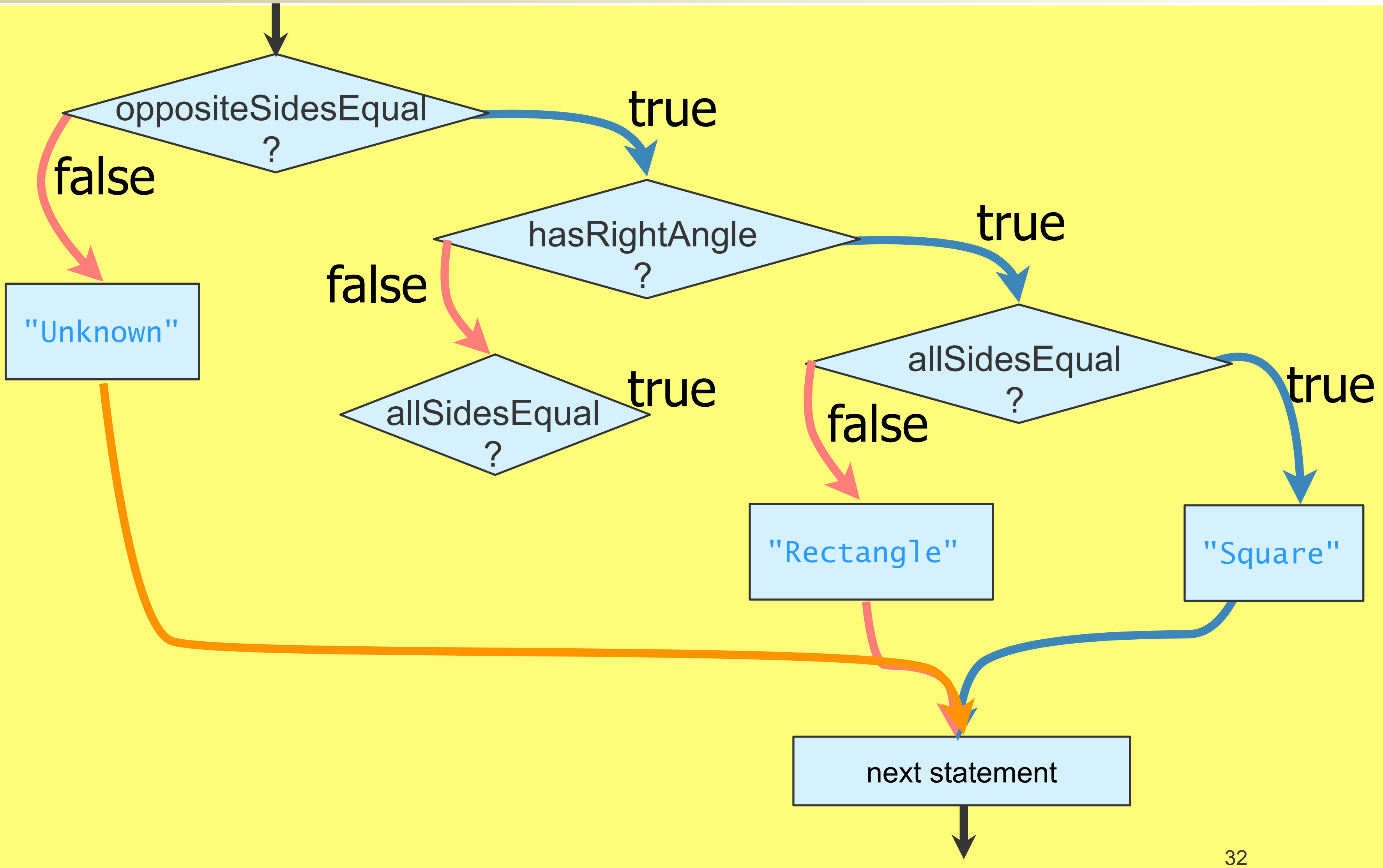

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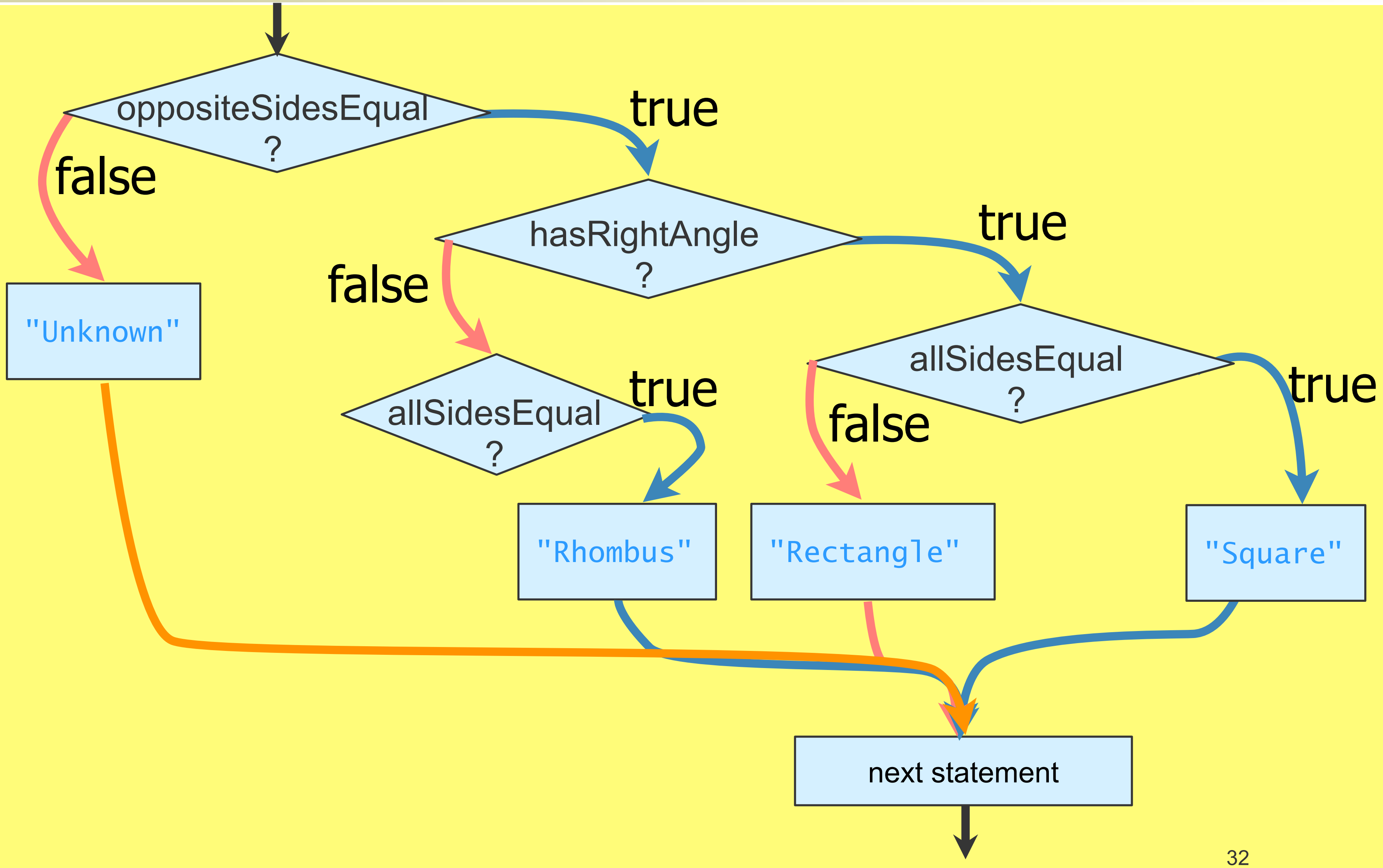
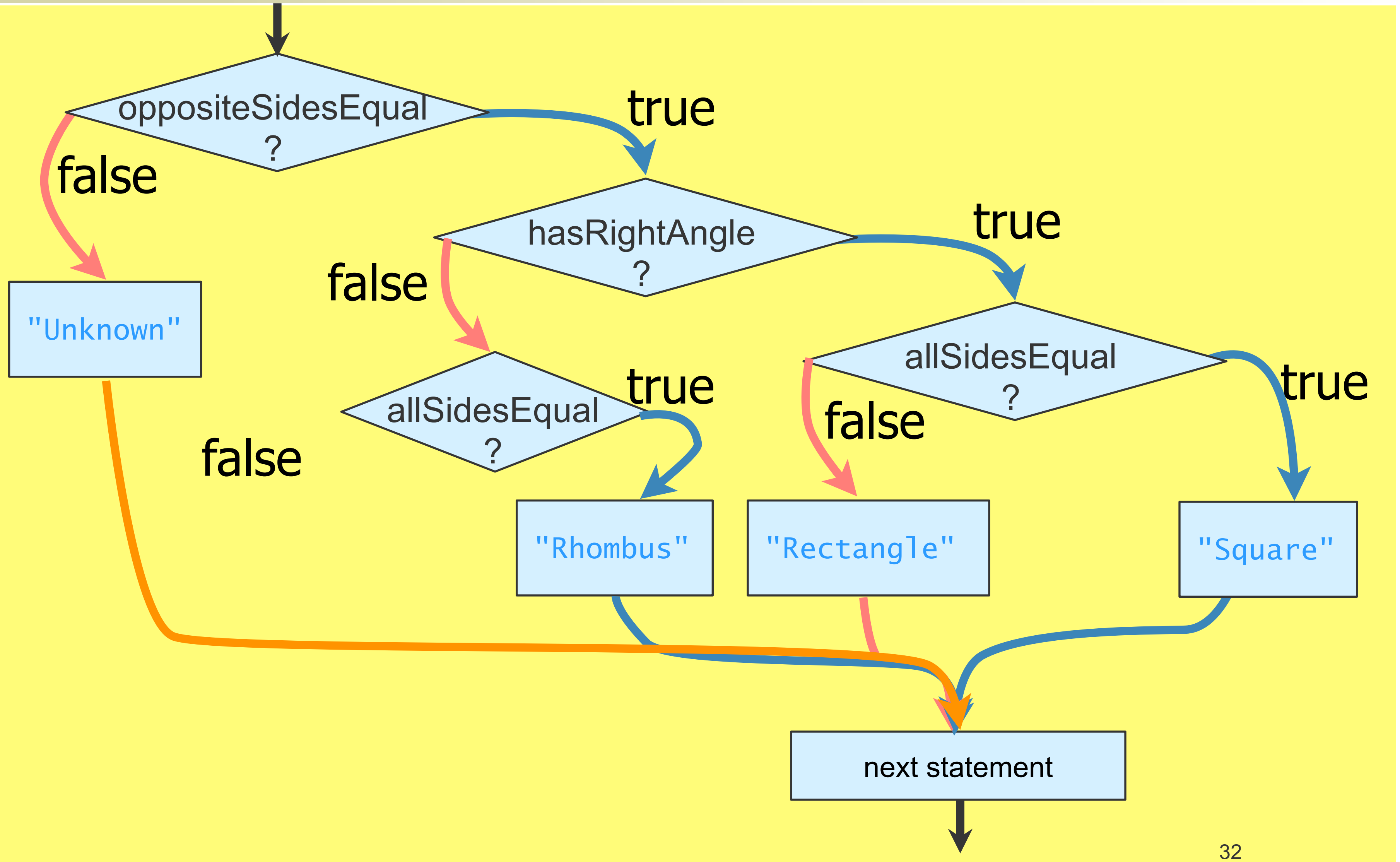
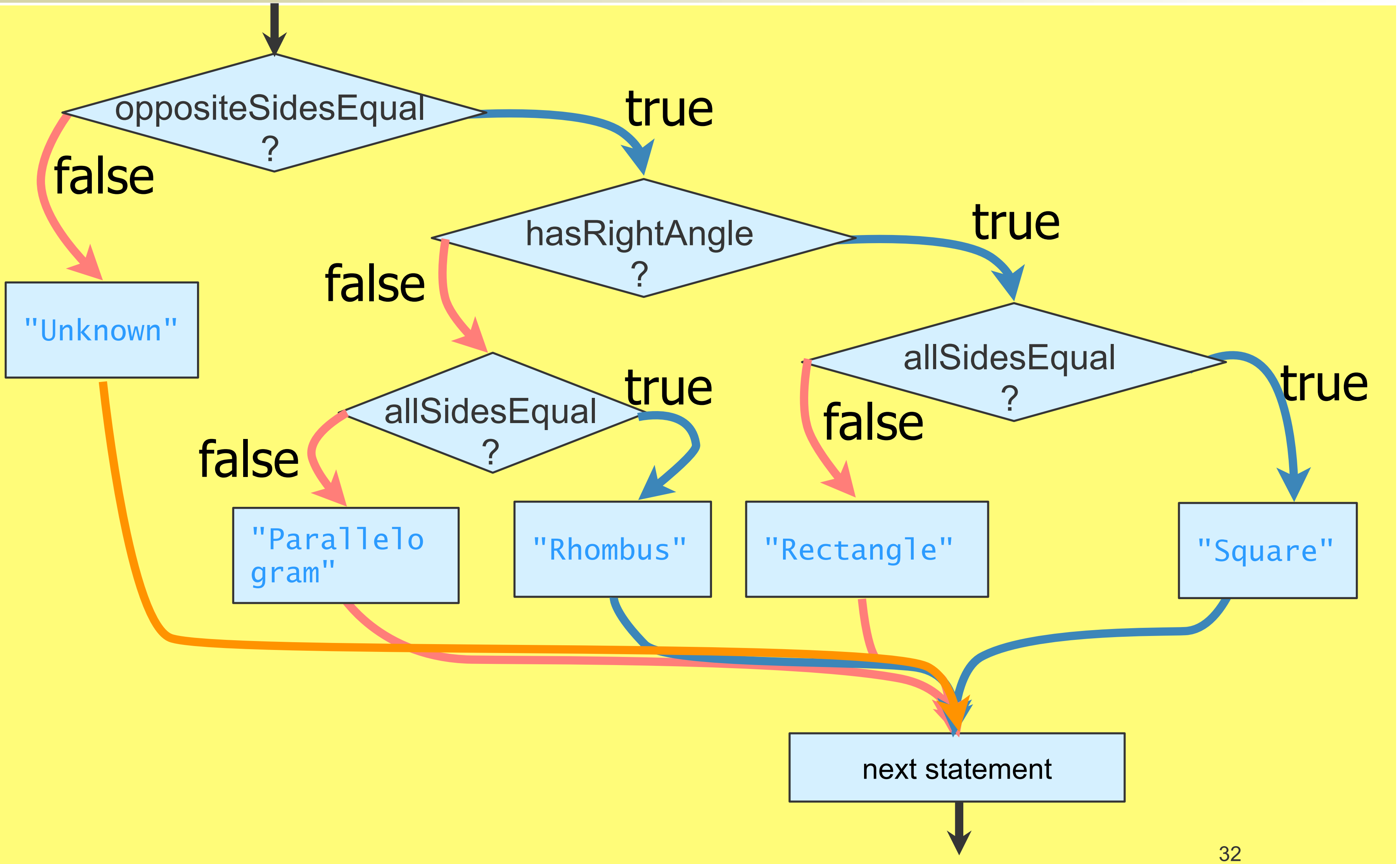


Quadrilateral Logic



Quadrilateral Logic



```
public class QuadClassifier {
 public static void main(String args[]){
   int side1, side2, side3, side4;
   int anyAngle;
    . . . // read in all four side lengths and any one angle
   if ((side1==side3) && (side2==side4))
      if(anyAngle == 90)
         if(side1 == side2)
            type = "Square";
         else
            type = "Rectangle";
      else
         if(side1 == side2)
            type = "Rhombus";
         else
            type = "Parallelogram";
   else
      type = " type that is unfamiliar to this program";

   System.out.println("The quadilateral is a " + type);
```

QuadClassifier

```
public class QuadClassifier {
 public static void main(String args[]){
   int side1, side2, side3, side4;
   int anyAngle;
    . . . // read in all four side lengths and any one angle
   if ((side1==side3) && (side2==side4))
      if(anyAngle == 90)
         if(side1 == side2)
            type = "Square";
         else
            type = "Rectangle";
      else
         if(side1 == side2)
            type = "Rhombus";
         else
            type = "Parallelogram";
   else
      type = " type that is unfamiliar to this program";

   System.out.println("The quadilateral is a " + type);
```

QuadClassifier

```
public class QuadClassifier2 {
   . . .
   boolean oppositeSidesEqual, allSidesEqual, hasRightAngle;
    . . .
   oppositeSidesEqual = (side1==side3) && (side2==side4);
   allSidesEqual = oppositeSidesEqual && (side1 == side2);
   hasRightAngle = anyAngle==90;
   if (oppositeSidesEqual){
      if(hasRightAngle){
         if(allSidesEqual){
            type = "Square";
         } else {
            type = "Rectangle";
      } else {
         if(allSidesEqual) {
            type = "Rhombus";
         } else {
            type = "Parallelogram";
   } else {
      type = " type that is unfamiliar to this program";
   }

   System.out.println("The quadilateral is a " + type);
```

QuadClassifier2

```
public class QuadClassifier2 {
   . . .
   boolean oppositeSidesEqual, allSidesEqual, hasRightAngle;
    . . .
   oppositeSidesEqual = (side1==side3) && (side2==side4);
   allSidesEqual = oppositeSidesEqual && (side1 == side2);
   hasRightAngle = anyAngle==90;
   if (oppositeSidesEqual){
      if(hasRightAngle){
         if(allSidesEqual){
            type = "Square";
         } else {
            type = "Rectangle";
      } else {
         if(allSidesEqual) {
            type = "Rhombus";
         } else {
            type = "Parallelogram";
   } else {
      type = " type that is unfamiliar to this program";
   }

   System.out.println("The quadilateral is a " + type);
```

Easier to understand.

QuadClassifier2

Alternative styles

All are equivalent -- the compiler doesn't care.

Alternative styles

```
if ( <boolean expression> ) {
    …
}
else {
    …
}
```

All are equivalent -- the compiler doesn't care.

Alternative styles

```
if ( <boolean expression> ) {
    …
}
else {
    …
}
```

```
if ( <boolean expression> )
{
    …
}
else
{
    …
}
```

All are equivalent -- the compiler doesn't care.

Alternative styles

```
if ( <boolean expression> ) {
    …
}
else {
    …
}
```

```
if ( <boolean expression> ){
    …
} else {
    …
}
```

```
if ( <boolean expression> )
{
    …
}
else
{
    …
}
```

All are equivalent -- the compiler doesn't care.

Problem

- *Write a game program that requires the user to guess a random integer.*
- *After each input from the user*
    - *Let the user know if the guess was correct*
    - *Otherwise, inform the user that the guess was either too high or too low.*
- *The game ends only when the user correctly guesses the value.*

Repetition

- To solve this problem, we need the ability to repeat a set of operations (get input, compare with secret and respond) an unknown number of times
- The number is determined by how many guesses the user takes to get it right.
- This week we will learn how to repeatedly execute portions of code using **while**, and **do**-**while** loops.

Guess

```
public class Guess {
   public static void main(String[] args){
      int secret, guess;
      boolean done;
      Random random = new Random();
      secret = random.nextInt();
      done = false;
      while(!done){
         guess = Integer.parseInt(JOptionPane.showInputDialog(
                     null, "Enter your guess."));
         if(guess == secret){
            done = true;
            System.out.println("You guessed correctly!");
         } else if (guess < secret)
            System.out.println("Your guess was too low");
         else
            System.out.println("Your guess was too high");
      }
   }
}
```

Guess

Sentinel

```
public class Guess {
   public static void main(String[] args){
      int secret, guess;
      boolean done;
      Random random = new Random();
      secret = random.nextInt();
      done = false;
      while(!done){
         guess = Integer.parseInt(JOptionPane.showInputDialog(
                    null, "Enter your guess."));
         if(guess == secret){
            done = true;
            System.out.println("You guessed correctly!");
         } else if (guess < secret)
            System.out.println("Your guess was too low");
         else
            System.out.println("Your guess was too high");
      }
   }
}
```

Guess

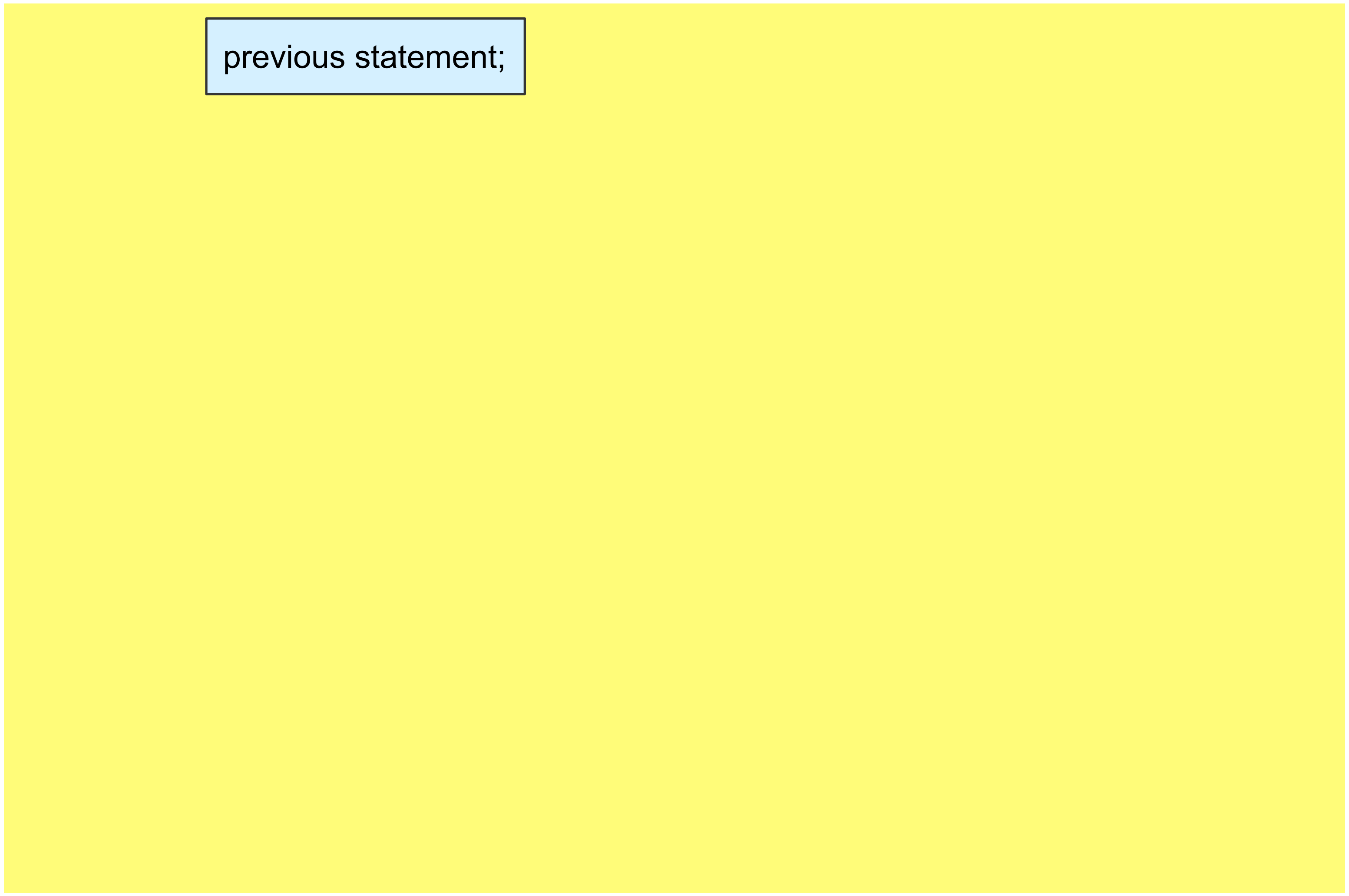
```
public class Guess {
   public static void main(String[] args){
      int secret, guess;
      boolean done;
      Random random = new Random();
      secret = random.nextInt();
      done = false;
      while(!done){
         guess = Integer.parseInt(JOptionPane.showInputDialog(
                     null, "Enter your guess."));
         if(guess == secret){
            done = true;
            System.out.println("You guessed correctly!");
         } else if (guess < secret)
            System.out.println("Your guess was too low");
         else
            System.out.println("Your guess was too high");
      }
   }
}
```

Sentinel

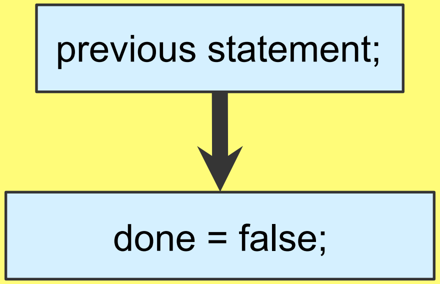
while loop

Control Flow of **while**

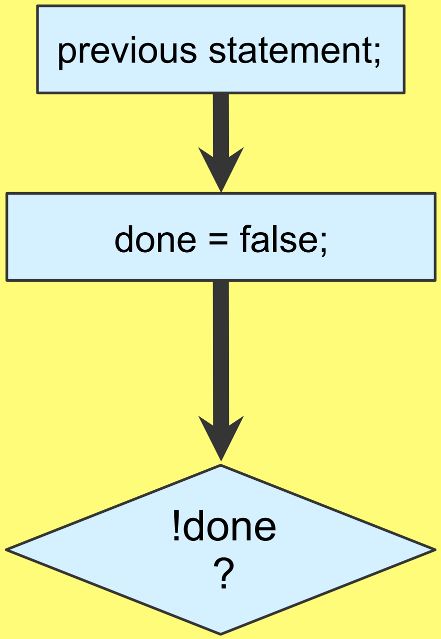
Control Flow of **while**



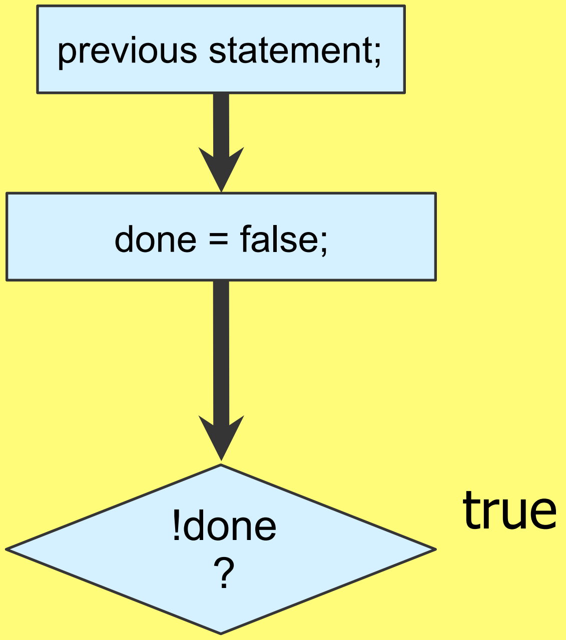
Control Flow of **while**



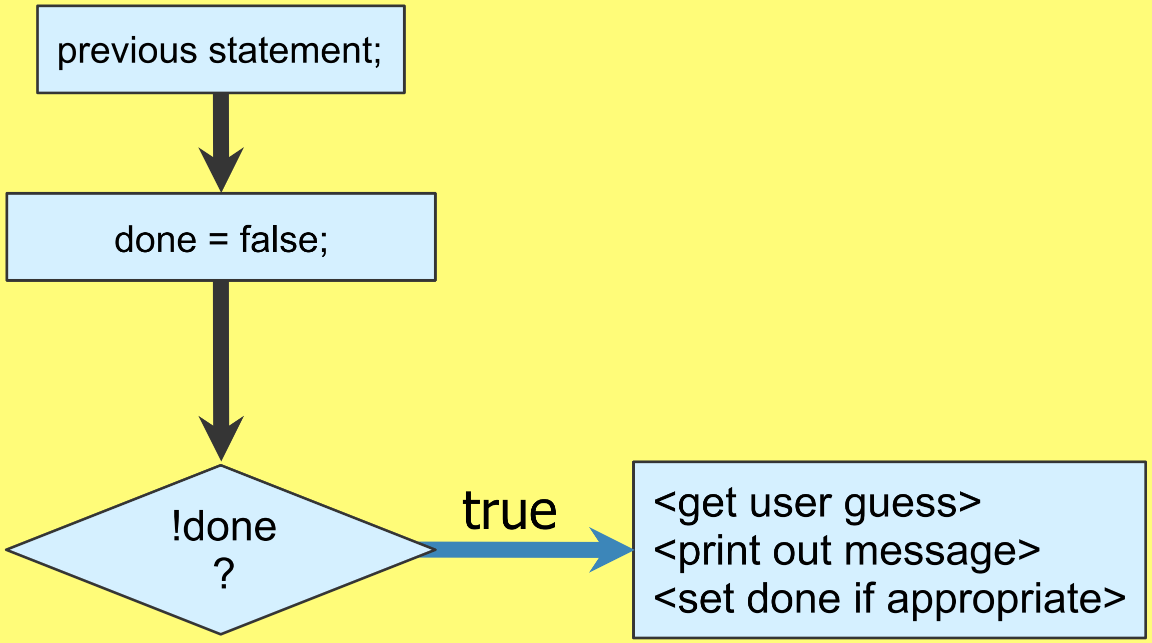
Control Flow of **while**



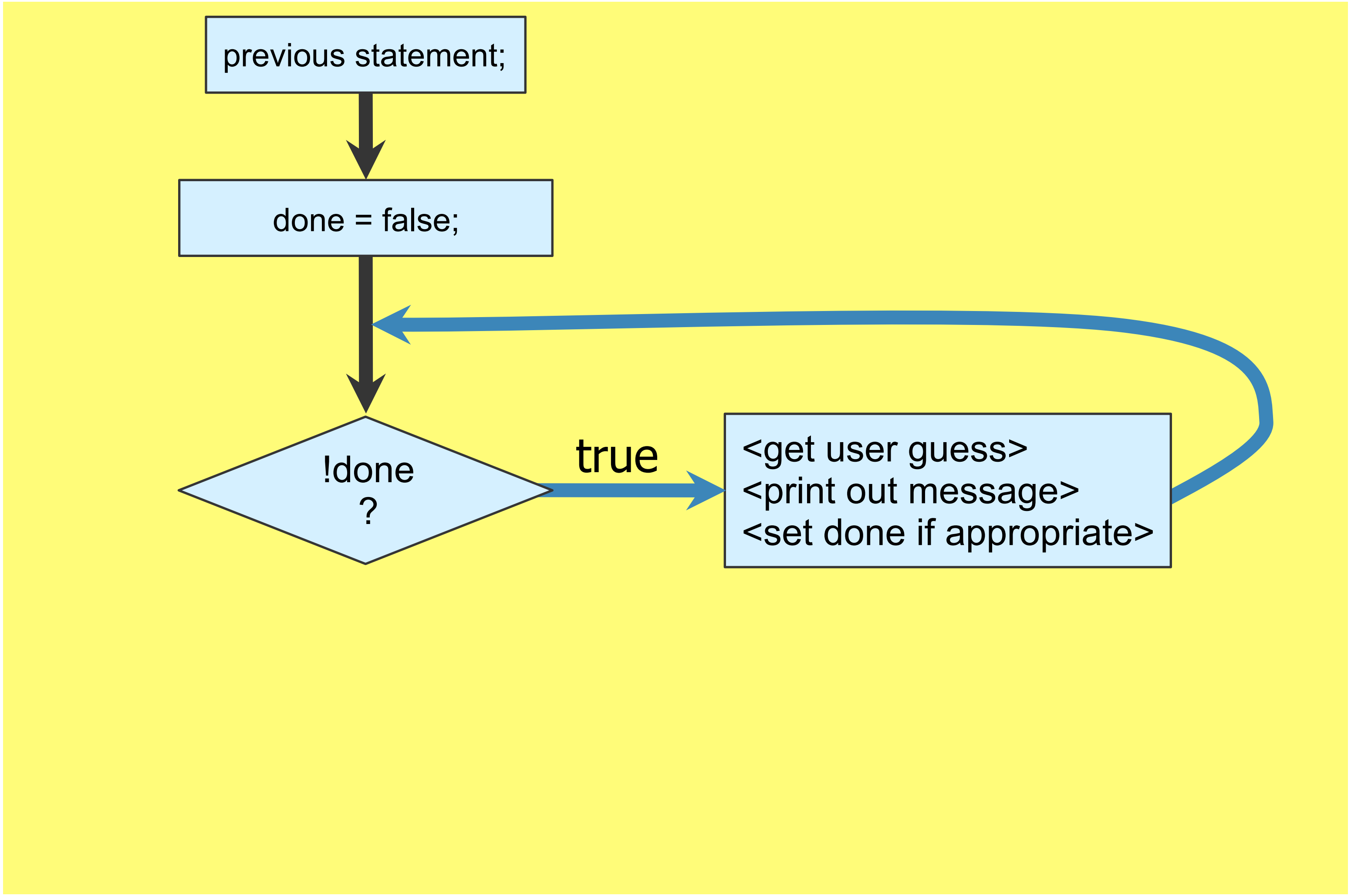
Control Flow of **while**



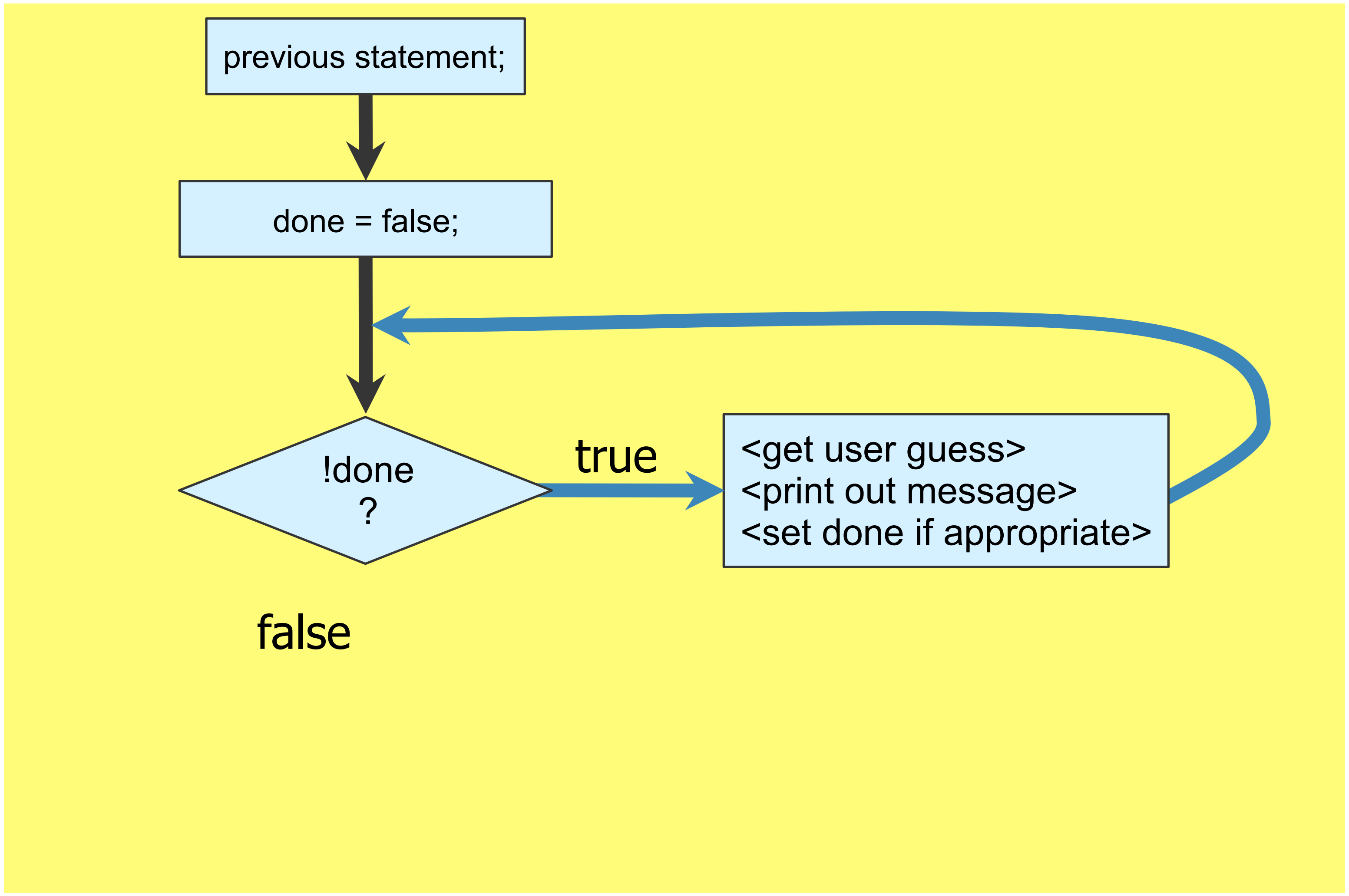
Control Flow of **while**



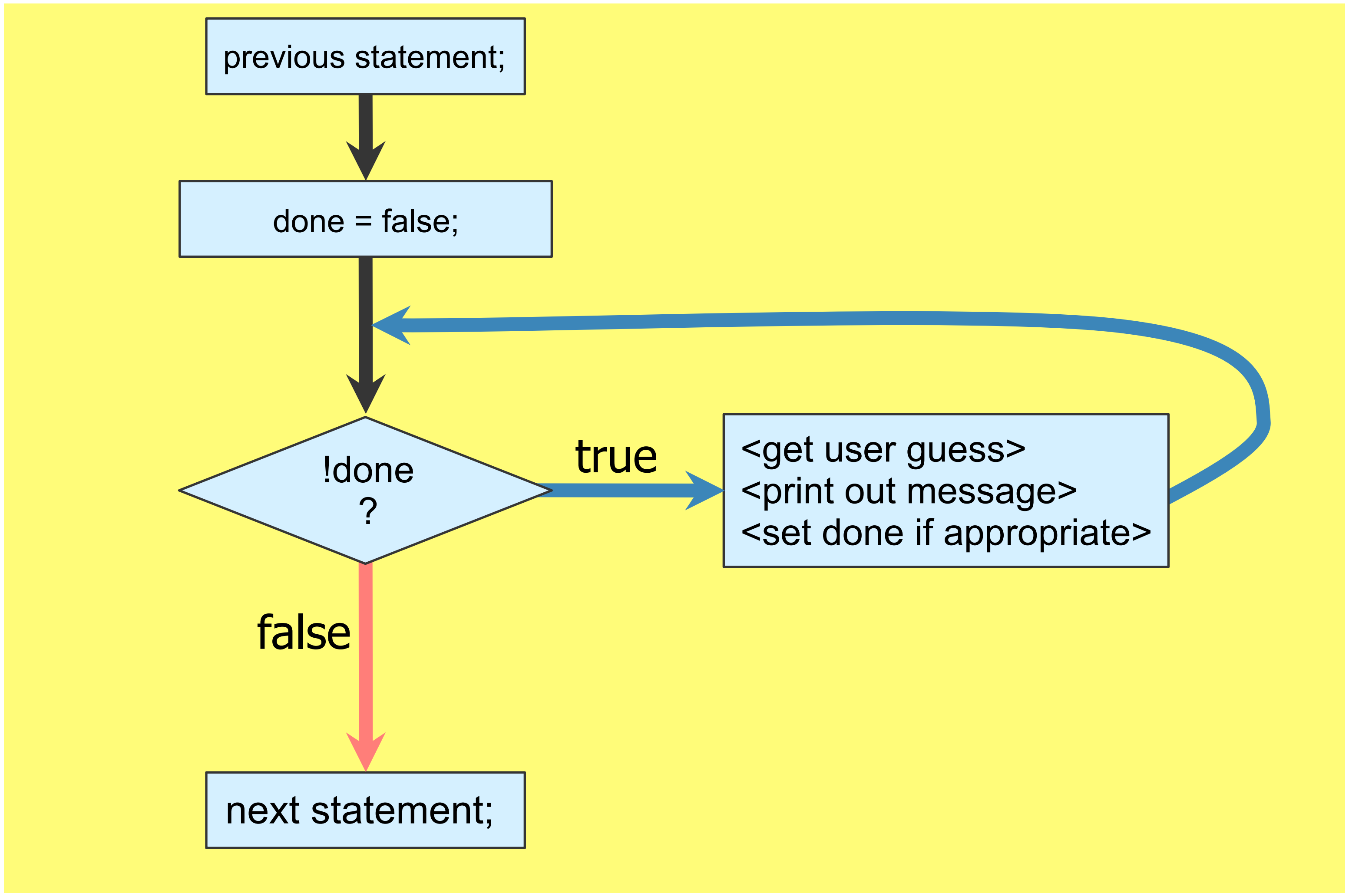
Control Flow of **while**



Control Flow of **while**



Control Flow of **while**



Syntax for the **while** Statement

```
while ( <boolean expression> )

        <statement>
```

```
while ( <boolean expression> ) {
        <statements>
}
```

Syntax for the **while** Statement

```
while ( <boolean expression> )

        <statement>
```

```
while ( <boolean expression> ) {
        <statements>
}
```

```
while ( !done )
{
    guess = Integer.parseInt(…);
    if (guess == secret)
      ...
}
```

Syntax for the **while** Statement

```
while ( <boolean expression> )

        <statement>
```

```
while ( <boolean expression> ) {
        <statements>
}
```

boolean expression

```
while ( !done )
{
    guess = Integer.parseInt(…);
    if (guess == secret)
      ...
}
```

Syntax for the while Statement

```
while ( <boolean expression> )

        <statement>
```

```
while ( <boolean expression> ) {
        <statements>
}
```

boolean expression

```
while ( !done )
{
    guess = Integer.parseInt(…);
    if (guess == secret)
      ...
}
```

loop body is repeatedly executed as long as boolean expression is **true**

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Example: input check

```
char    credit;

credit = JOptionPane.showInputDialog(null, "Enter credit").charAt(0);

while (grade < 1 || grade > 5)
  credit = JOptionPane.showInputDialog(null,"Enter credit").charAt(0);
```

- Only accepts credits 1 through 5
- Note: need for initial input before loop
  - better option **do-while** loop

The do-while Statement

```
char     credit;
do {

  credit = JOptionPane.showInputDialog(null,"Enter credit").charAt(0);

} while ( credit < 1 || credit > 5 )
```

- Loop body executed before test (at least once).
- No need for initial input before loop

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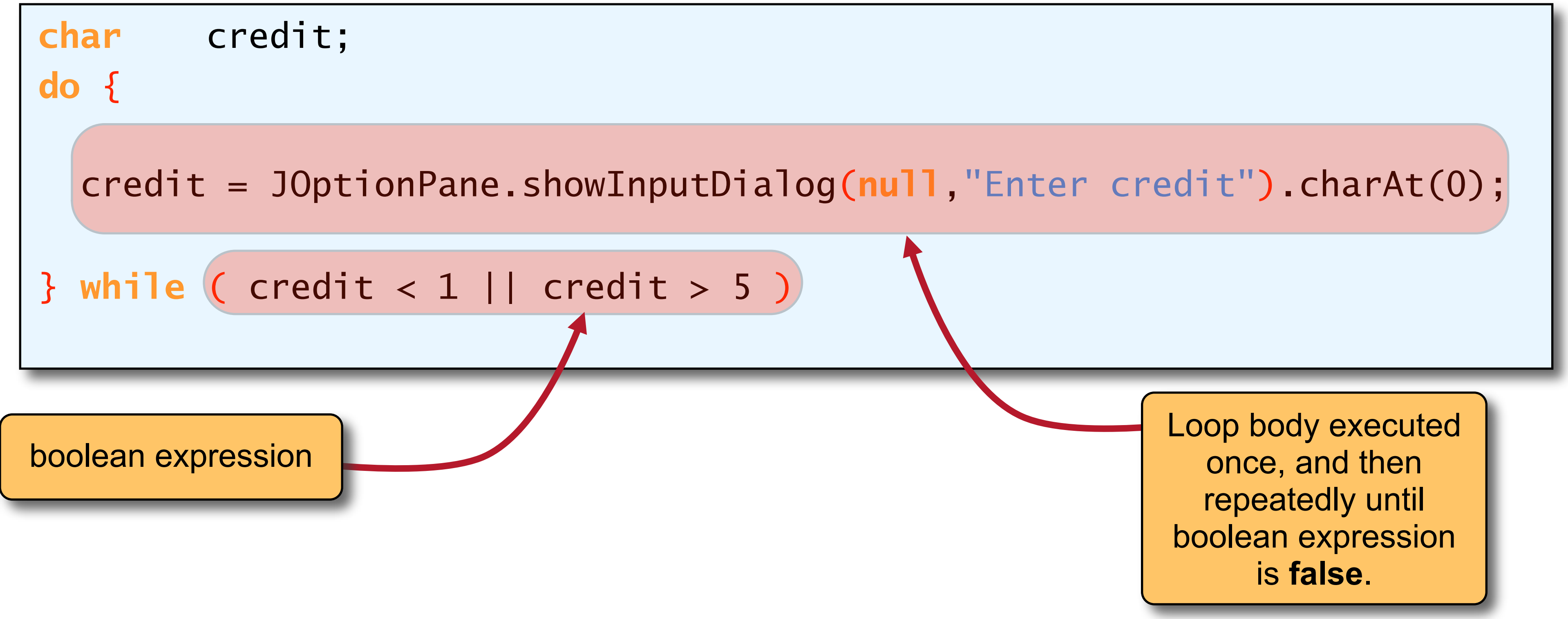
The do-while Statement

```
char     credit;
do {

  credit = JOptionPane.showInputDialog(null,"Enter credit").charAt(0);

} while ( credit < 1 || credit > 5 )
```

boolean expression

- Loop body executed before test (at least once).
- No need for initial input before loop

The do-while Statement



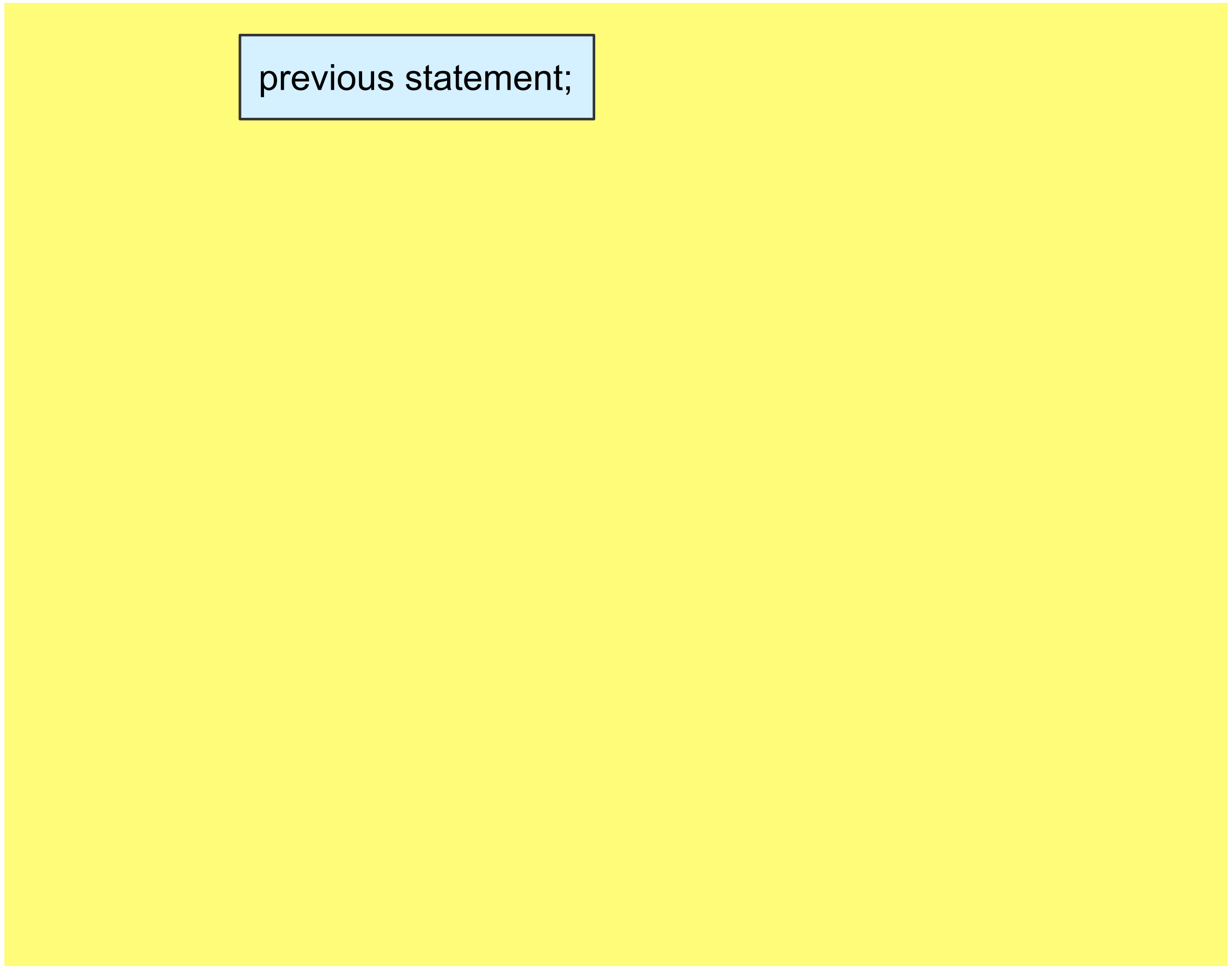
```
char     credit;
do {
  credit = JOptionPane.showInputDialog(null,"Enter credit").charAt(0);
} while ( credit < 1 || credit > 5 )
```

boolean expression
Loop body executed once, and then repeatedly until boolean expression is **false**.

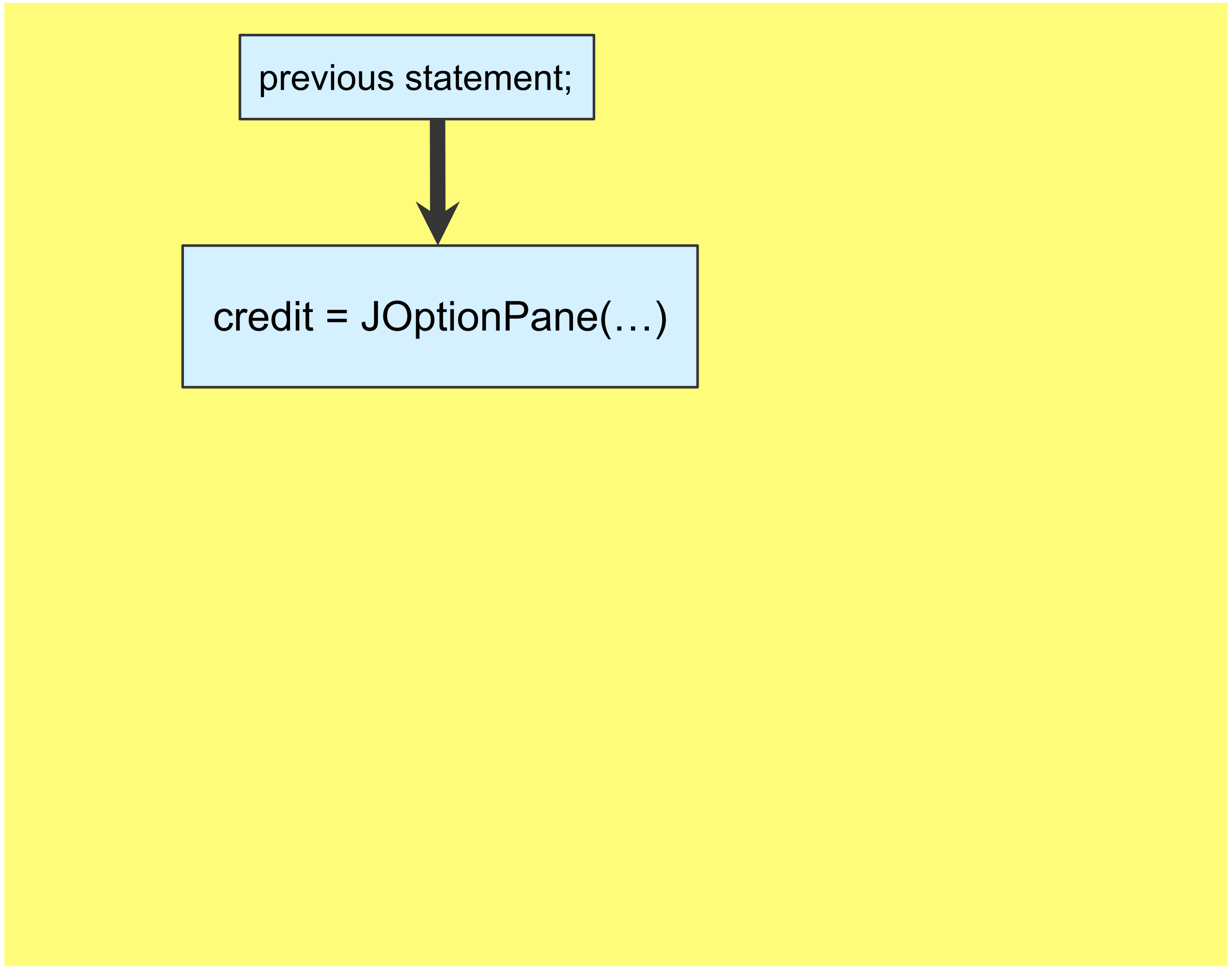
- Loop body executed before test (at least once).
- No need for initial input before loop

Control Flow of **do while**

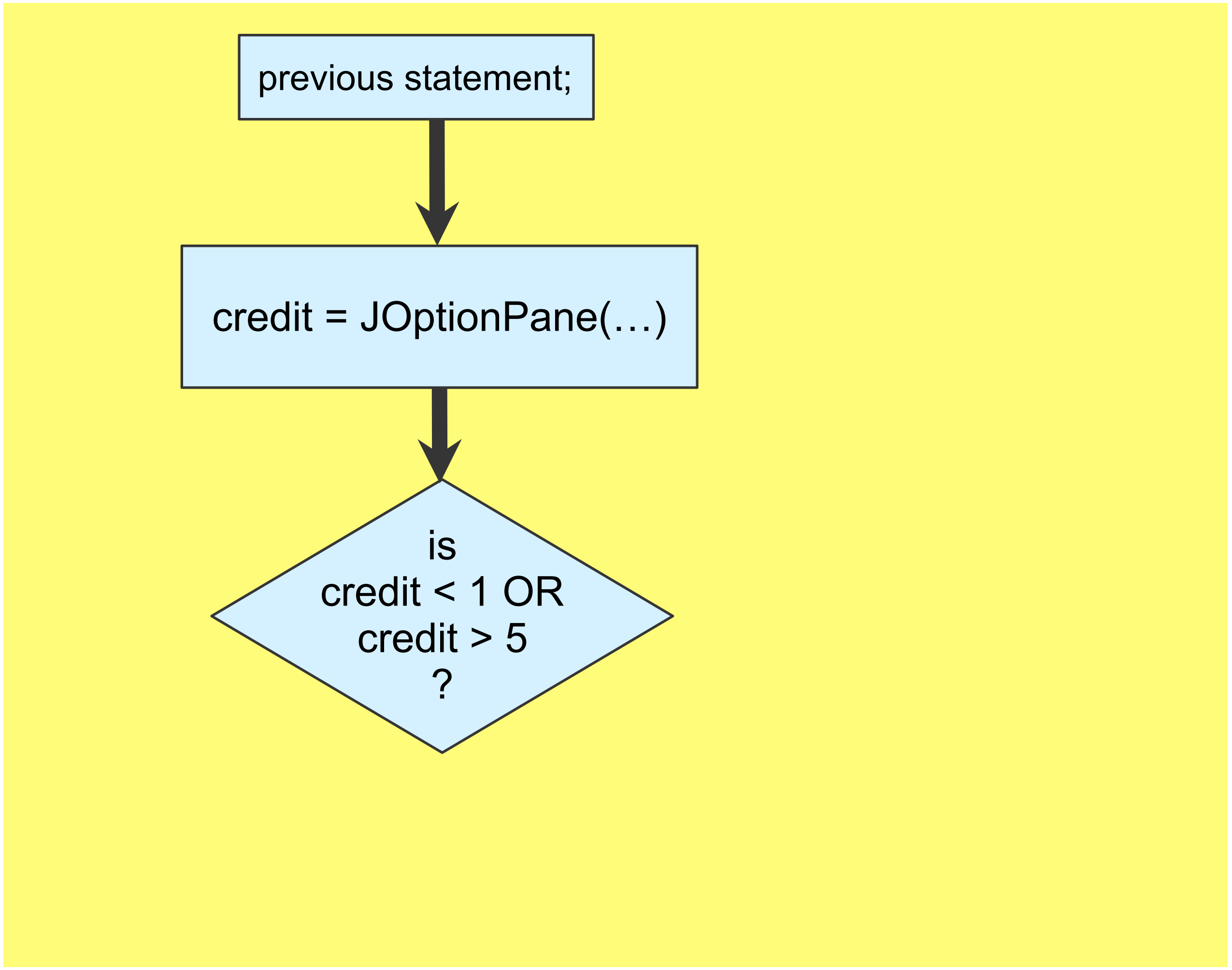
Control Flow of **do while**



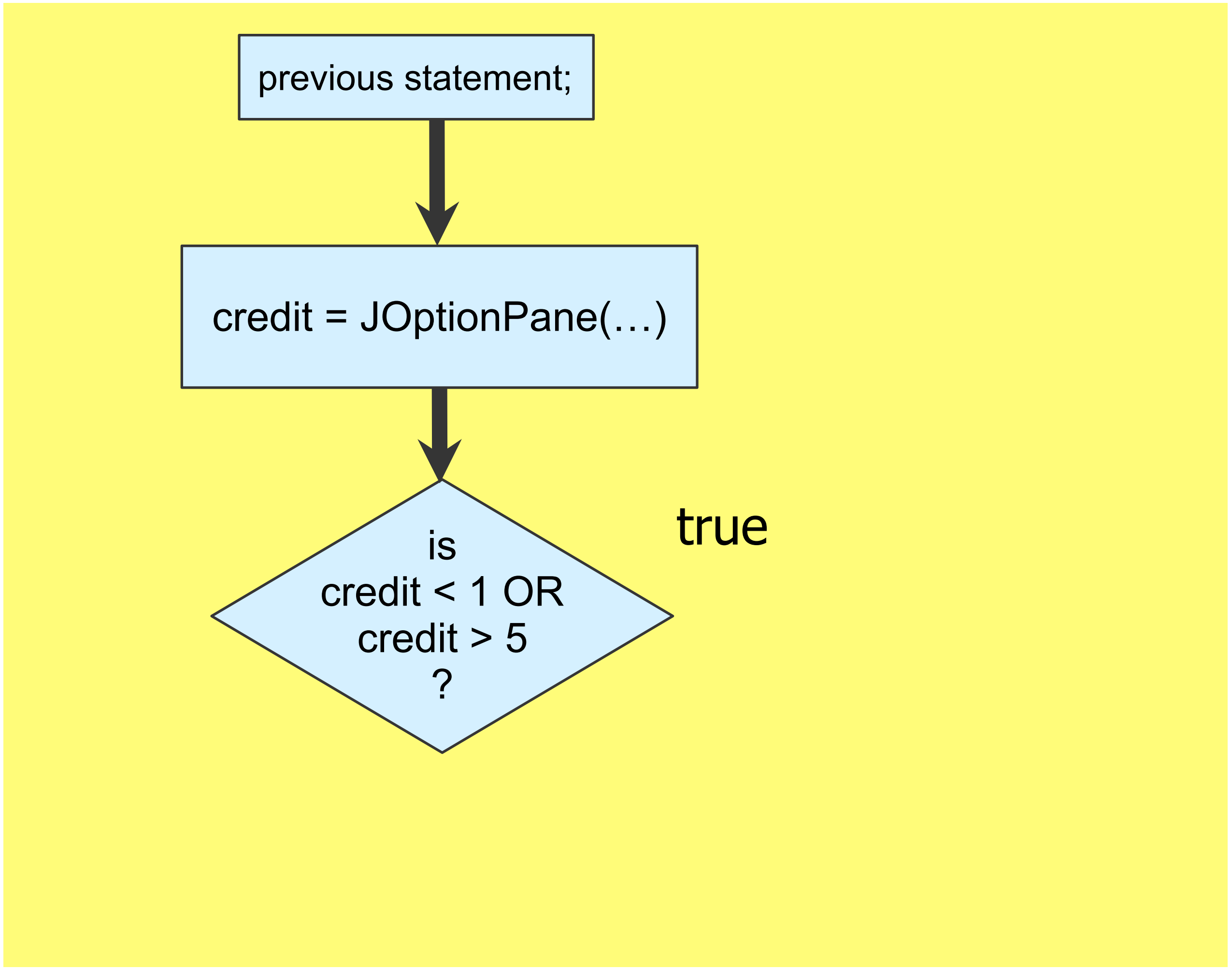
Control Flow of **do while**



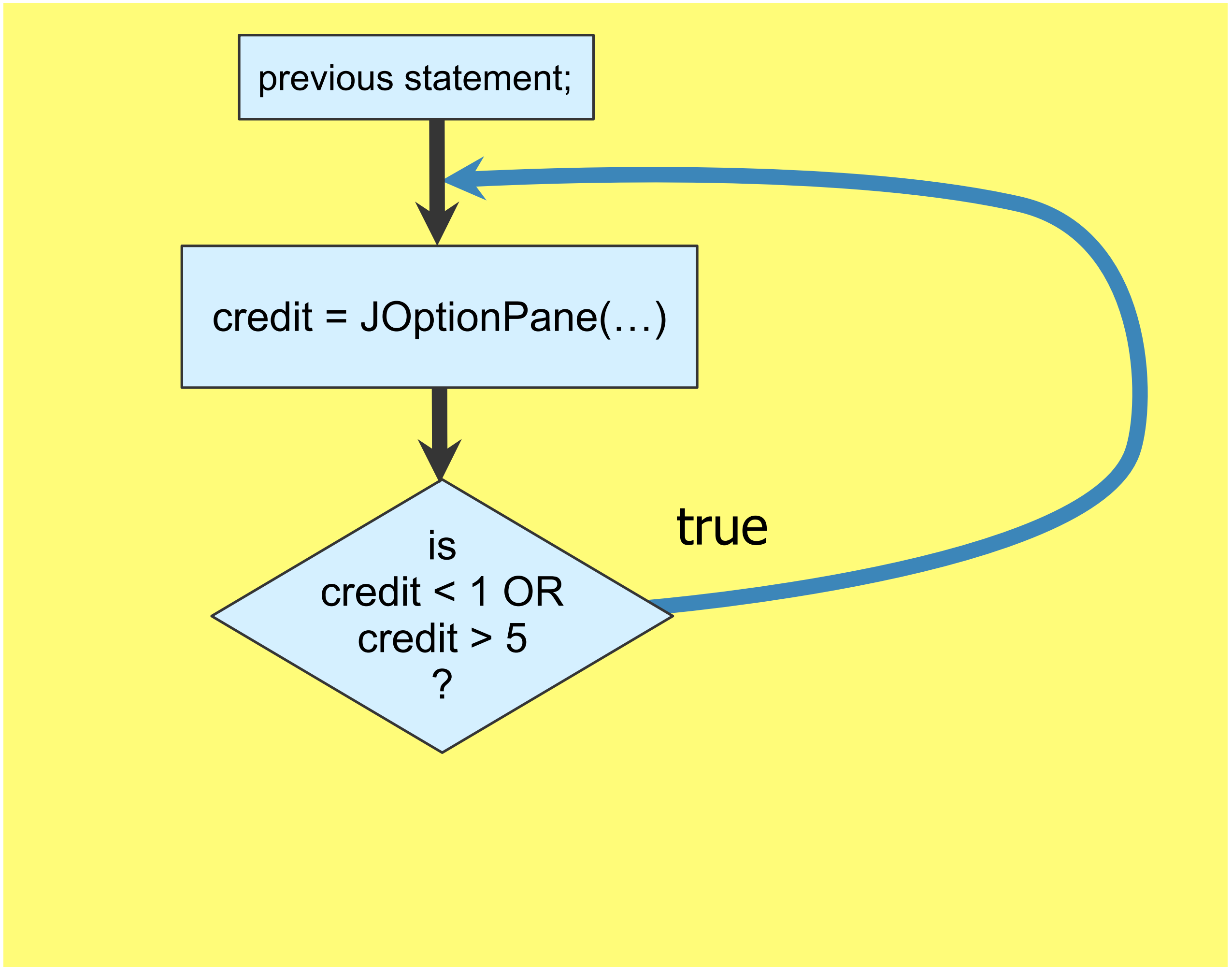
Control Flow of **do while**



Control Flow of **do while**



Control Flow of **do while**



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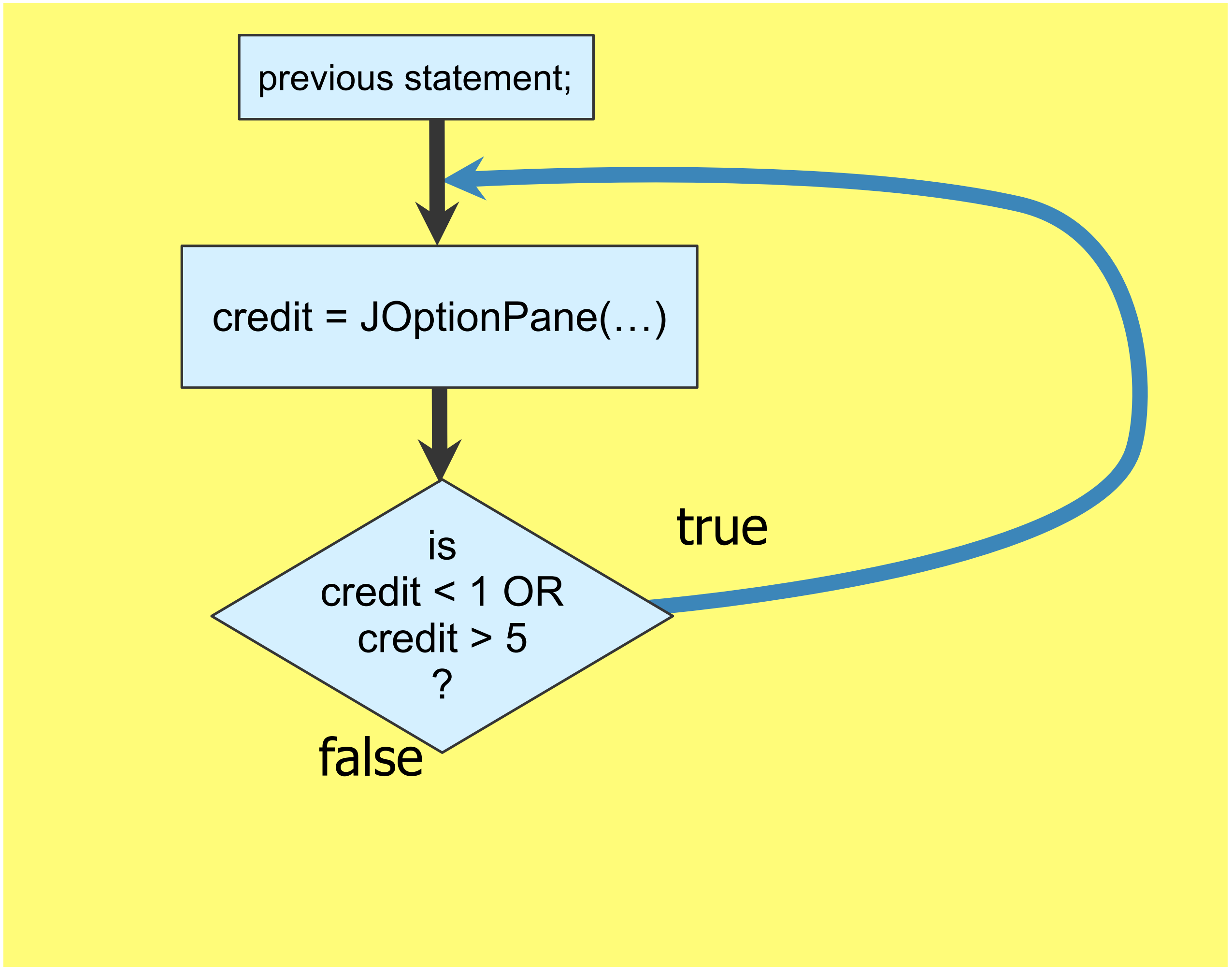
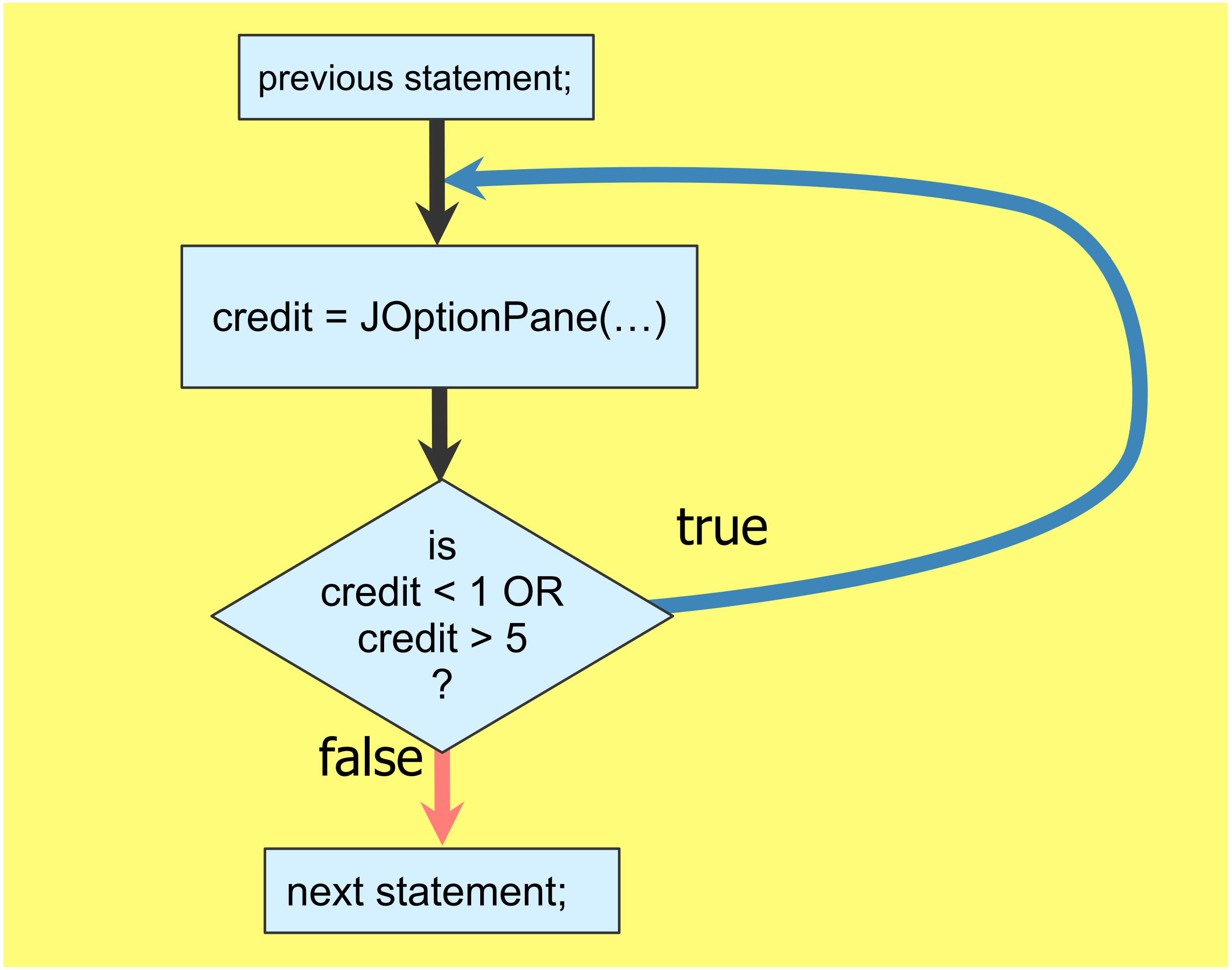
Control Flow of do while



Control Flow of **do while**



Common Errors

- Infinite loop
  - if the loop condition never becomes false the loop body will be executed endlessly
  - unless this is desired, ensure that the loop condition will change to false at some point

```
while(!done){
   guess = . . . ;
   if(guess == secret){
      done = true;
      System.out.println("You guessed
      correctly!");
   } else if . . .

}
```

Caution: Reals and Equality

1

```
float count = 0.0f;

while ( count != 1.0f ) {
    count = count + 0.3333333f;
}                //seven 3s
```

2

```
float count = 0.0f;

while ( count != 1.0f ) {
    count = count + 0.33333333f;
}                //eight 3s
```

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Caution: Reals and Equality

1

```
float count = 0.0f;

while ( count != 1.0f ) {
    count = count + 0.3333333f;
}                  //seven 3s
```

2

```
float count = 0.0f;

while ( count != 1.0f ) {
    count = count + 0.33333333f;
}                  //eight 3s
```

Using Real Numbers
Loop 2 terminates, but Loop 1 does not because only an approximation of a real number can be stored in a computer's memory.

Loop Pitfall – 2a

1

```
int result = 0; double cnt = 1.0;
while (cnt <= 10.0){
    cnt += 1.0;
    result++;
}
System.out.println ( result);
```

2

```
int result = 0; double cnt = 0.111111111;
while ( cnt <= 1.11111111){
    cnt += 0.111111111;
    result++;
}
System.out.println ( result);
```

Loop Pitfall – 2a

1

```
int result = 0; double cnt = 1.0;
while (cnt <= 10.0){
    cnt += 1.0;
    result++;
}
System.out.println ( result);
```

→ 10

2

```
int result = 0; double cnt = 0.111111111;
while ( cnt <= 1.11111111){
    cnt += 0.111111111;
    result++;
}
System.out.println ( result);
```

→ 9

Using Real Numbers

Loop 1 prints out 10, as expected, but Loop 2 prints out 9. The value 0.111111111 cannot be stored precisely in computer memory.