CHAPTER 3

DECISIONS

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Chapter Goals

- To implement decisions using the `if` statement
- To compare integers, floating-point numbers, and Strings
- To write statements using the Boolean data type
- To develop strategies for testing your programs
- To for validate user input

In this chapter, you will learn how to program simple and complex decisions. You will apply what you learn to the task of checking user input.

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Contents

- The `if` Statement
- Comparing Numbers and Strings
- Multiple Alternatives
- Nested Branches
- Problem Solving: Flowcharts
- Problem Solving: Test Cases
- Boolean Variables and Operators
- Application: Input Validation

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3.1 The `if` Statement

- A computer program often needs to make **decisions** based on input, or circumstances
- For example, buildings often 'skip' the 13th floor, and elevators should too
  - The 14th floor is really the 13th floor
  - So every floor above 12 is really 'floor - 1'
    - If floor > 12, Actual floor = floor - 1

- The two keywords of the if statement are:
  - `if`
  - `else`

The `if` statement allows a program to carry out different actions depending on the nature of the data to be processed.

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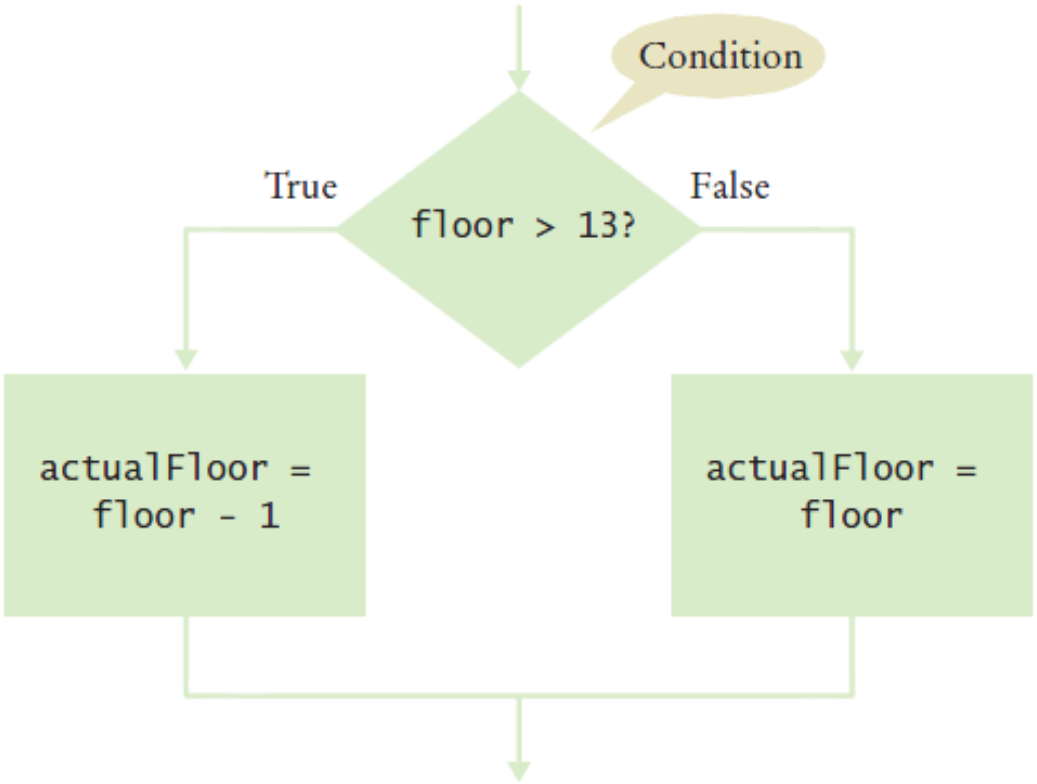
Flowchart of the `if` statement

- One of the two branches is executed once
  - True (`if`) branch or False (`else`) branch




```
int actualFloor;

if (floor > 13)
{
   actualFloor = floor - 1;
}
else
{
   actualFloor = floor;
}
```

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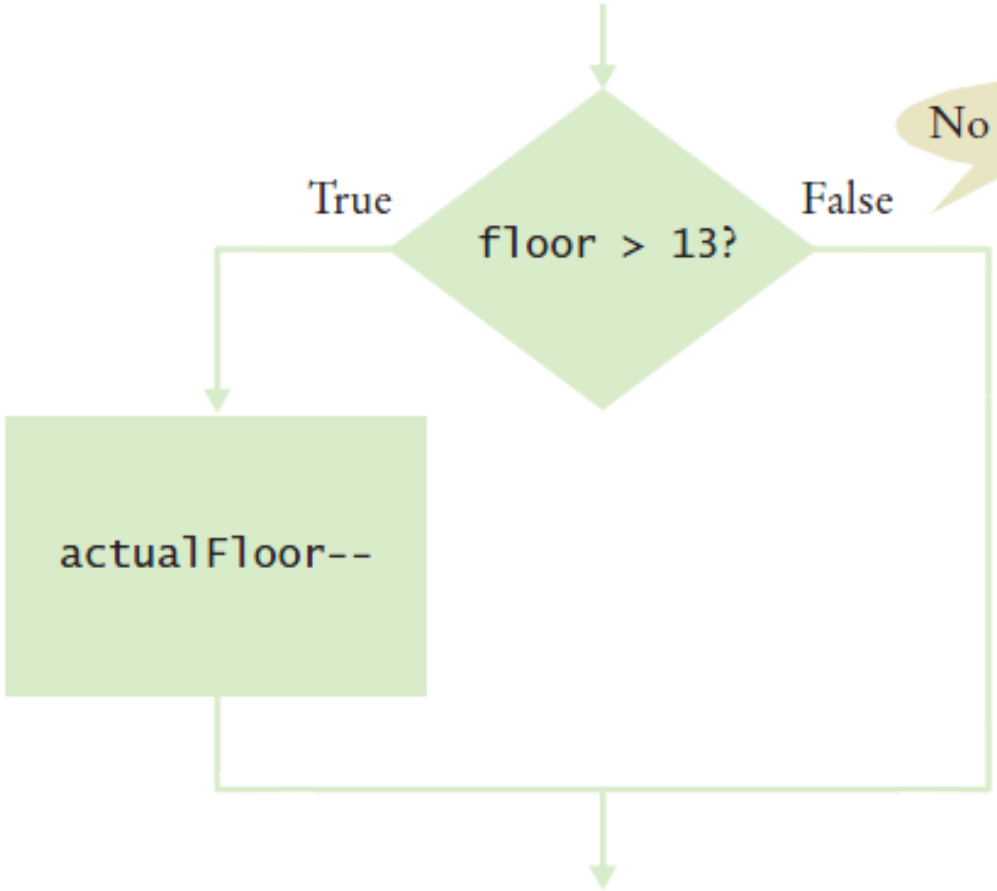
Flowchart with only true branch

- An `if` statement may NOT need a 'False' (`else`) branch




```
int actualFloor = floor;

if (floor > 13)
{
   actualFloor--;
} // No else needed
```

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Syntax 3.1: The `if` statement

A condition that is true or false. Often uses relational operators: == != < <= > >= (See page 89.)

Braces are not required if the branch contains a single statement, but it's good to always use them. See page 86.

```
if (floor > 13)
{
   actualFloor = floor - 1;
}
else
{
   actualFloor = floor;
}
```

Don't put a semicolon here! See page 86.

If the condition is true, the statement(s) in this branch are executed in sequence; if the condition is false, they are skipped.

Omit the `else` branch if there is nothing to do.

If the condition is false, the statement(s) in this branch are executed in sequence; if the condition is true, they are skipped.

Lining up braces is a good idea. See page 86.

if (condition)
{
statement
}

if (condition) {statement1}
else {statement2}

If a semicolon after the if condition:
The statement enclosed in braces is no longer a part of the if statement.
It is always executed.
The actualFloor value will be decremented

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ElevatorSimulation.java

```
1  import java.util.Scanner;
2
3  /**
4     This program simulates an elevator panel that skips the 13th floor.
5  */
6  public class ElevatorSimulation
7  {
8     public static void main(String[] args)
9     {
10       Scanner in = new Scanner(System.in);
11       System.out.print("Floor: ");
12       int floor = in.nextInt();
13
14       // Adjust floor if necessary
15
16       int actualFloor;
17       if (floor > 13)
18       {
19          actualFloor = floor - 1;
20       }
21       else
22       {
23          actualFloor = floor;
24       }
25
26       System.out.println("The elevator will travel to the actual floor "
27          + actualFloor);
28    }
29 }
```

Program Run

```
Floor: 20
The elevator will travel to the actual floor 19
```

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Tips On Using Braces

- Line up all pairs of braces vertically
  - Lined up

```
if (floor > 13)
{
   floor--;
}
```

Not aligned (saves lines)

```
if (floor > 13) {
   floor--;
}
```

- Always use braces
  - Although single statement clauses do not require them

```
if (floor > 13)
{
   floor--;
}
```

```
if (floor > 13)
   floor--;
```

Most programmer's editors have a tool to align matching braces.

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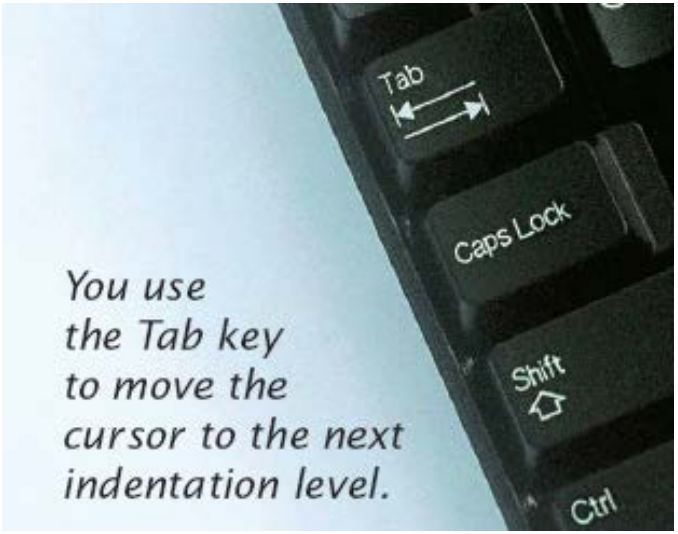
Tips on indenting blocks

- Use Tab to indent a consistent number of spaces

```
public class ElevatorSimulation
{
|   public static void main(String[] args)
|   {
|   |   int floor;
|   |   . . .
|   |   if (floor > 13)
|   |   {
|   |   |   floor--;
|   |   }
|   |   . . .
|   }
|   |   |   |
0   1   2   3    Indentation level
```



This is referred to as '**block-structured**' code. Indenting consistently makes code much easier for humans to follow.

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Common Error 3.1

A semicolon after an `if` statement

- It is easy to forget, and add a semicolon after an `if` statement.
  - The true path is now the space just before the semicolon

```
if (floor > 13) ;
{
   floor--;
}
```

  - The 'body' (between the curly braces) will always be executed in this case

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The Conditional Operator

- A ‘shortcut’ you may find in existing code
  - It is not used in this book

condition ? value1 : value2

Condition — True branch — False branch

```
actualFloor = floor > 13 ? floor - 1 : floor;
```

Equivalent to
if(floor > 13) {actualFloor = floor -1} else {actualFloor = floor}

  - Includes all parts of an if-else clause, but uses:
    - ? To begin the true branch
    - : To end the true branch and start the false branch

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3.2 Comparing Numbers and Strings

- Every `if` statement has a condition
  - Usually compares two values with an operator

```
if (floor > 13)
   ..
if (floor >= 13)
   ..
if (floor < 13)
   ..
if (floor <= 13)
   ..
if (floor == 13)
   ..
```

Beware!

Table 1 Relational Operators

Java	Math Notation	Description
>	>	Greater than
>=	≥	Greater than or equal
<	<	Less than
<=	≤	Less than or equal
==	=	Equal
!=	≠	Not equal

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Syntax 3.2: Comparisons

These quantities are compared.

```
floor > 13
```

One of: == != < <= > >= (See page 89.)

Check that you have the right direction:
> (greater) or < (less)

Check the boundary condition:
> (greater) or >= (greater or equal)?

```
floor == 13
```

Checks for equality.

Use ==, not =.

= assignment
== relational operator

```
String input;
if (input.equals("Y"))
```

Use `equals` to compare strings. (See page 92.)

```
double x; double y; final double EPSILON = 1E-14;
if (Math.abs(x - y) < EPSILON)
```

Checks that these floating-point numbers are very close.
See page 91.

Ex.
floor = 13; //assign 13 to floor

if(floor == 13) // test whether floor equals 13

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Operator Precedence

- The **comparison** operators have **lower precedence** than **arithmetic operators**
  - Calculations are done before the comparison
  - Normally your calculations are on the 'right side' of the **comparison** or **assignment** operator

Calculations

```
actualFloor = floor + 1;
```

```
if (floor > height + 1)
```

Ex.
floor – 1 < 13
Equivalent to
(floor -1) < 13

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Relational Operator Use (1)

Table 2 Relational Operator Examples

Expression	Value	Commment
`3 <= 4`	`true`	3 is less than 4; <= tests for "less than or equal".
`3 =< 4`	**Error**	The "less than or equal" operator is <=, not =<. The "less than" symbol comes first.
`3 > 4`	`false`	> is the opposite of <=.
`4 < 4`	`false`	The left-hand side must be strictly smaller than the right-hand side.
`4 <= 4`	`true`	Both sides are equal; <= tests for "less than or equal".
`3 == 5 - 2`	`true`	== tests for equality.
`3 != 5 - 1`	`true`	!= tests for inequality. It is true that 3 is not 5 – 1.

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Relational Operator Use (2)

Table 2 Relational Operator Examples

`3 = 6 / 2`	**Error**	Use == to test for equality.
`1.0 / 3.0 == 0.333333333`	`false`	Although the values are very close to one another, they are not exactly equal. See Common Error 3.2 on page 87.
`"10" > 5`	**Error**	You cannot compare a string to a number.
`"Tomato".substring(0, 3).equals("Tom")`	`true`	Always use the `equals` method to check whether two strings have the same contents.
`"Tomato".substring(0, 3) == ("Tom")`	`false`	Never use == to compare strings; it only checks whether the strings are stored in the same location. See Common Error 3.3 on page 88.

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Common Error 3.2

- Comparison of Floating-Point Numbers
  - Floating-point numbers have limited precision
  - Round-off errors can lead to unexpected results

```
double r = Math.sqrt(2.0);
if (r * r == 2.0)
{
   System.out.println("Math.sqrt(2.0) squared is 2.0");
}
else
{
   System.out.println("Math.sqrt(2.0) squared is not 2.0
    but " + r * r);
}
```

roundoff errors

```
Output:
Math.sqrt(2.0) squared is not 2.0 but 2.0000000000000044
```

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The use of EPSILON

- Use a very small value to compare the difference if floating-point values are '*close enough*'
  - The magnitude of their difference should be less than some threshold
  - Mathematically, we would write that x and y are close enough if: $|x - y| < \varepsilon$

```
final double EPSILON = 1E-14;
double r = Math.sqrt(2.0);
if (Math.abs(r * r - 2.0) < EPSILON)
{
   System.out.println("Math.sqrt(2.0) squared is approx.
    2.0");
}
```

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Comparing Strings

- Strings are a bit 'special' in Java
- Do not use the `==` operator with Strings
  - The following compares the locations of two strings, and not their contents

```
if (string1 == string2) ...
```

- Instead use the String's `equals` method:

```
if (string1.equals(string2)) ...
```

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Common Error 3.3

- Using == to compare Strings
  - == compares the locations of the Strings
- Java creates a new String every time **a new word inside double-quotes** is used
  - If there is one that matches it exactly, Java re-uses it

```
String nickname = "Rob";
. . .
if (nickname == "Rob") // Test is true
```

```
String name = "Robert";
String nickname = name.substring(0, 3);
. . .
if (nickname == "Rob") // Test is false
```

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Lexicographical Order

- To compare Strings in '**dictionary**' order
  - When compared using `compareTo`, string1 comes:
    - Before `string2` if `string1.compareTo(string2) < 0`
    - After `string2` if `string1.compareTo(string2) > 0`
    - Equal to `string2` if `string1.compareTo(string2) == 0`
  - Notes
    - All UPPERCASE letters come before lowercase
    - 'space' comes before all other printable characters
    - Digits (0-9) come before all letters
    - See Appendix A for the Basic Latin Unicode (ASCII) table

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Comparing Objects

- `==` tests for identity, `equals` for identical content
- ```
  Rectangle box1 = new Rectangle(5, 10, 20, 30);
  Rectangle box2 = box1;
  Rectangle box3 = new Rectangle(5, 10, 20, 30);
  ```
- `box1 != box3`, but `box1.equals(box3)`
- `box1 == box2`
- Caveat: `equals` must be defined for the class

Rectangle(int x, int y, int width, int height)

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  ```

Object Comparison

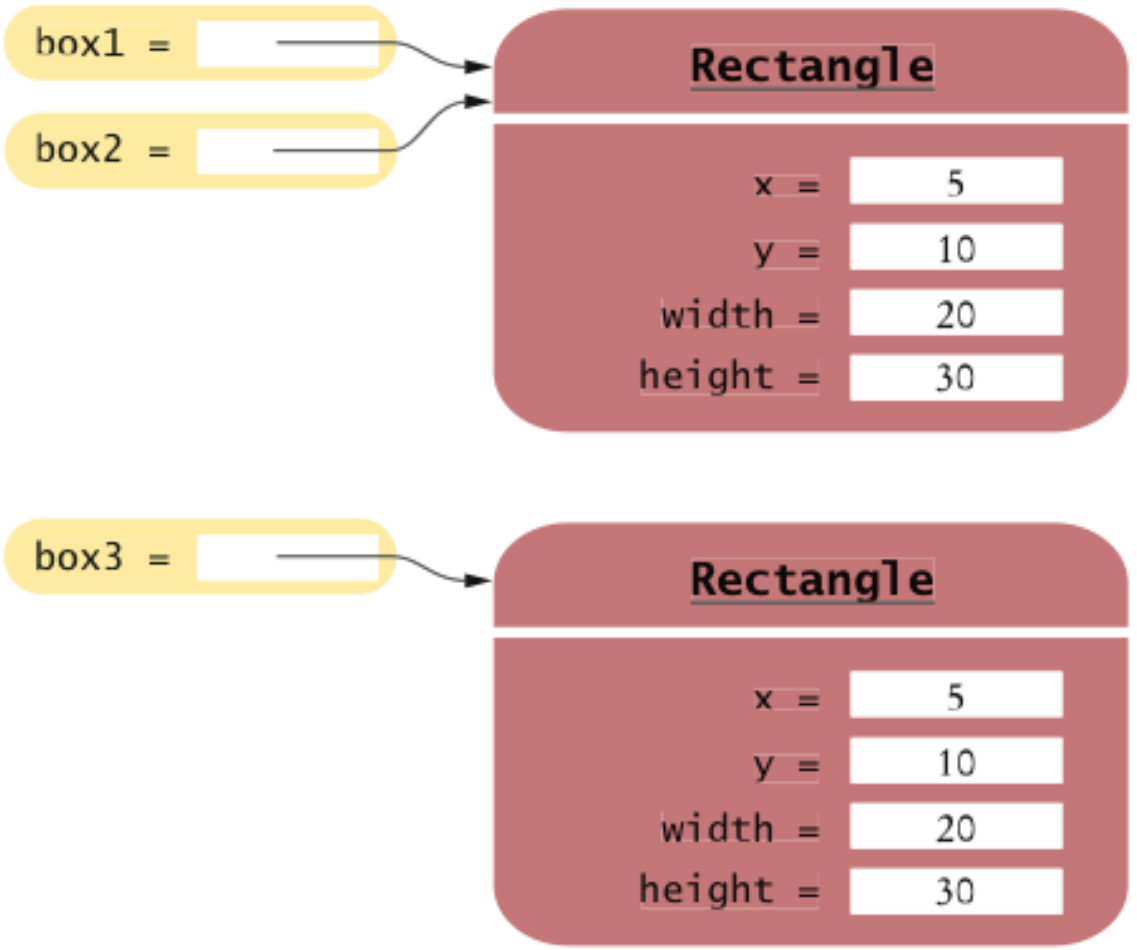

Figure 4
Comparing Object References

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Testing for `null`

- `null` reference refers to no object:

```
String middleInitial = null; // Not set
if ( ... )
   middleInitial = middleName.substring(0, 1);
```

- Can be used in tests:

```
if (middleInitial == null)
   System.out.println(firstName + " " + lastName);
else
   System.out.println(firstName + " " + middleInitial +
      ". " + lastName);
```

- Use `==`, not `equals`, to test for `null`
- `null` is not the same as the empty string `""`

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Implementing an `if` Statement

1) Decide on a branching condition

original price < 128?

2) Write pseudocode for the true branch

discounted price = 0.92 x original price

3) Write pseudocode for the false branch

discounted price = 0.84 x original price

4) Double-check relational operators
   - Test values below, at, and above the comparison (127, 128, 129)

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Implementing an `if` Statement (cont.)

5) Remove duplication

discounted price = ____ x original price

6) Test both branches

discounted price = 0.92 x 100 = 92

discounted price = 0.84 x 200 = 168

7) Write the code in Java

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Implemented Example

- The university bookstore has a Kilobyte Day sale every October 24, giving an 8 percent discount on all computer accessory purchases if the price is less than $128, and a 16 percent discount if the price is at least $128.

```
if (originalPrice < 128)
{
   discountRate = 0.92;
}
else
{
   discountRate = 0.84;
}
discountedPrice = discountRate * originalPrice;
```

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3.3 Multiple Alternatives

- What if you have more than two branches?
- Count the branches for the following earthquake effect example:
  - 8 (or greater)
  - 7 to 7.99
  - 6 to 6.99
  - 4.5 to 5.99
  - Less than 4.5

When using multiple `if` statements, test general conditions after more specific conditions.

Table 3 Richter Scale

Value	Effect
8	Most structures fall
7	Many buildings destroyed
6	Many buildings considerably damaged, some collapse
4.5	Damage to poorly constructed buildings

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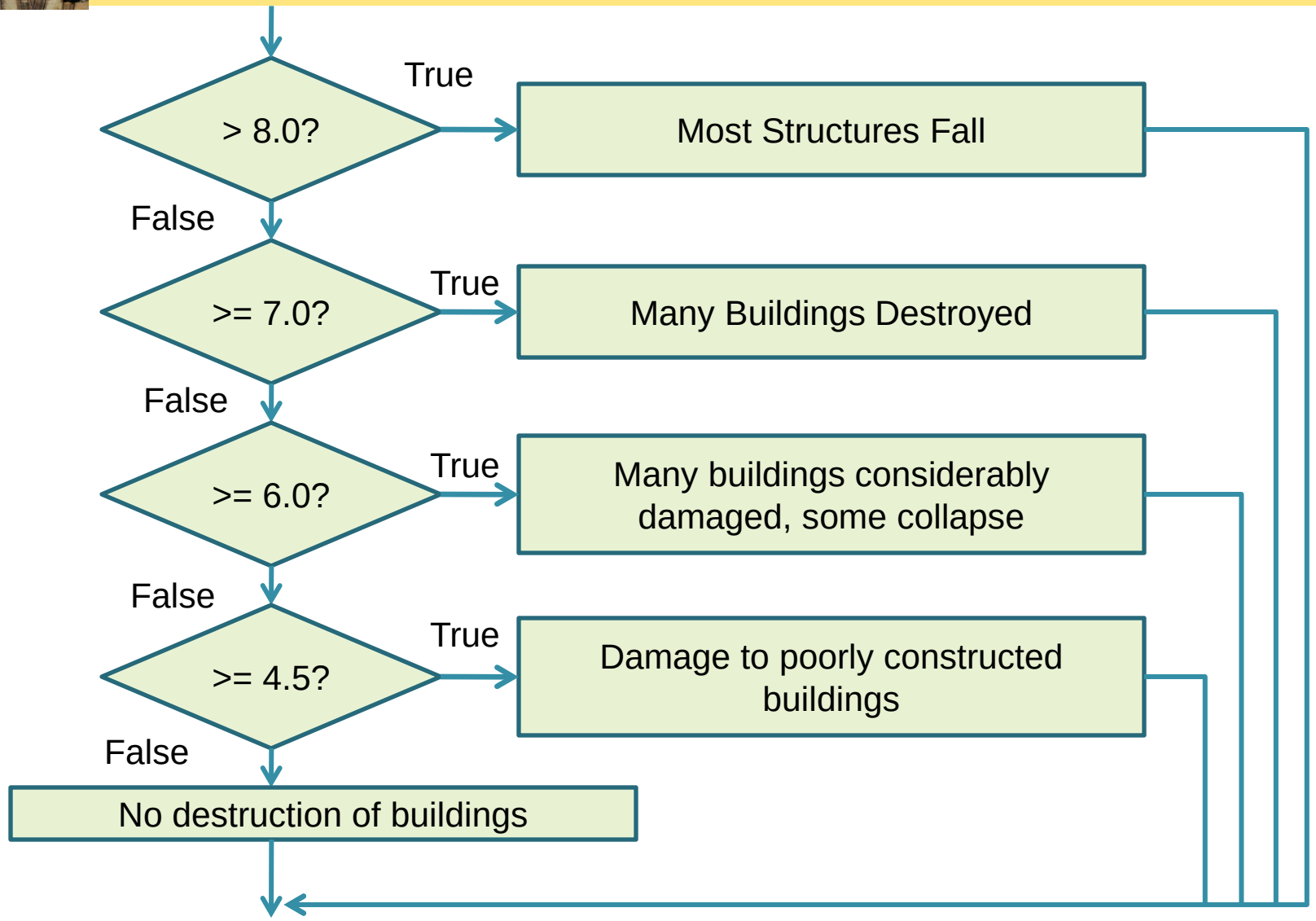
Flowchart of Multiway branching



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if, else if multiway branching

```
if (richter >= 8.0)   // Handle the 'special case' first
{
  System.out.println("Most structures fall");
}
else if (richter >= 7.0)
{
  System.out.println("Many buildings destroyed");
}
else if (richter >= 6.0)
{
  System.out.println("Many buildings damaged, some collapse");
}
else if (richter >= 4.5)
{
  System.out.println("Damage to poorly constructed buildings");
}
else    // so that the 'general case' can be handled last
{
  System.out.println("No destruction of buildings");
}
```

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What is wrong with this code?

```
if (richter >= 8.0)
{
   System.out.println("Most structures fall");
}
if (richter >= 7.0)
{
   System.out.println("Many buildings destroyed");
}
if (richter >= 6.0)
{
   System.out.println("Many buildings damaged, some collapse");
}
if (richter >= 4.5)
{
   System.out.println("Damage to poorly constructed buildings");
}
```

If the earthquake scale is 8.0, all statements will be executed.

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Another way to multiway branch

- The **`switch`** statement chooses a `case` based on an integer value.
- `break` ends each `case`
- `default` catches all other values

```
int digit = . . .;
switch (digit)
{
   case 1: digitName = "one";   break;
   case 2: digitName = "two";   break;
   case 3: digitName = "three"; break;
   case 4: digitName = "four";  break;
   case 5: digitName = "five";  break;
   case 6: digitName = "six";   break;
   case 7: digitName = "seven"; break;
   case 8: digitName = "eight"; break;
   case 9: digitName = "nine";  break;
   default: digitName = "";     break;
}
```

If the `break` is missing, the case *falls through* to the next case's statements.

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3.4 Nested Branches

- You can *nest* an if inside either branch of an if statement.
- Simple example: Ordering drinks
  - Ask the customer for their drink order
  - `if` customer orders wine
    - Ask customer for ID
    - `if` customer's age is 21 or over
      - Serve wine
    - Else
      - Politely explain the law to the customer
  - Else
    - Serve customers a non-alcoholic drink

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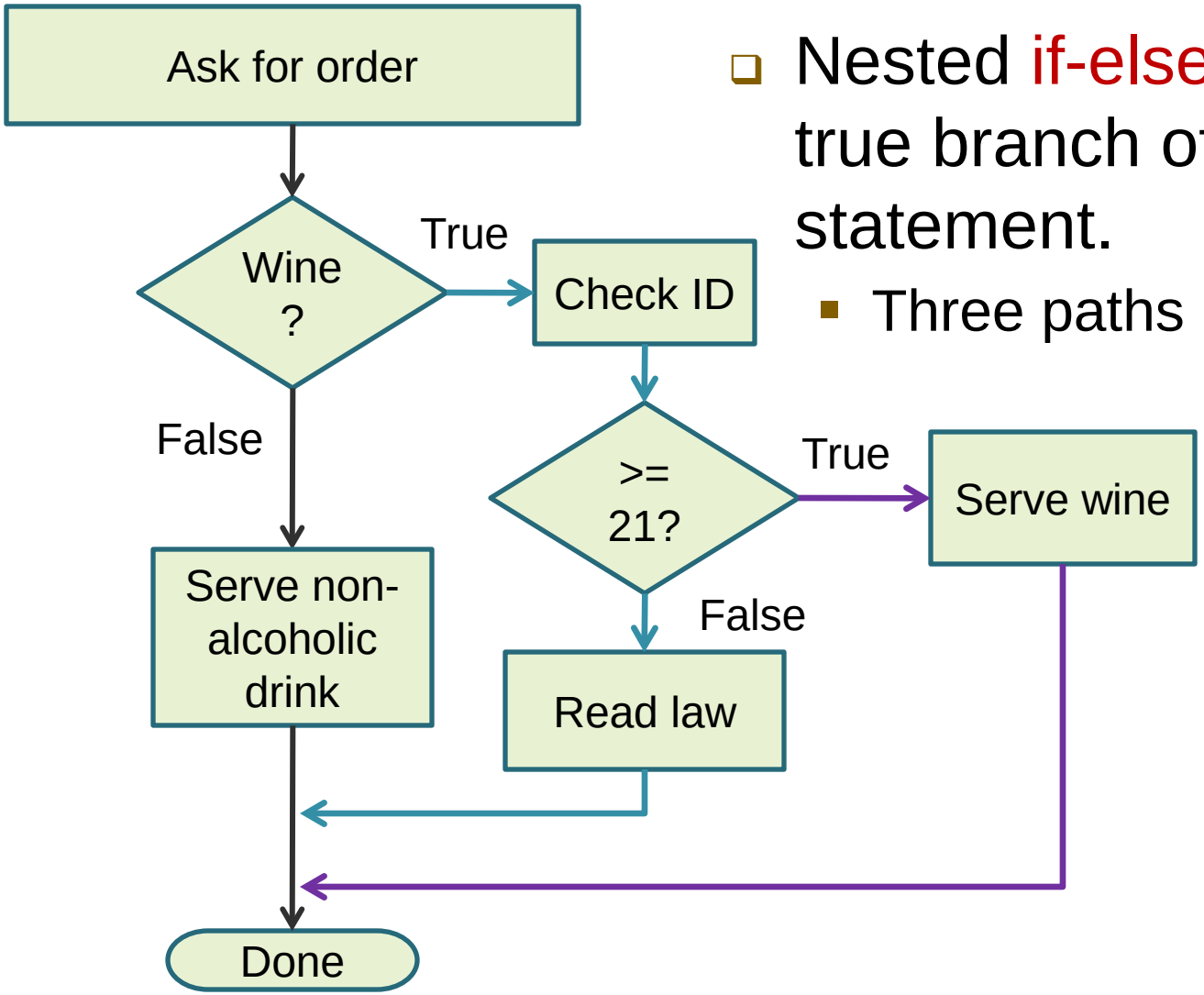
Flowchart of a Nested if



- Nested if-else inside true branch of an if statement.
  - Three paths

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Tax Example: Nested `if`s

- Four outcomes (branches)
  - Single
    - <= 32000
    - > 32000
  - Married
    - <= 64000
    - > 64000

Table 4 Federal Tax Rate Schedule		
If your status is Single and if the taxable income is	the tax is	of the amount over
at most $32,000	10%	$0
over $32,000	$3,200 + 25%	$32,000
If your status is Married and if the taxable income is	the tax is	of the amount over
at most $64,000	10%	$0
over $64,000	$6,400 + 25%	$64,000

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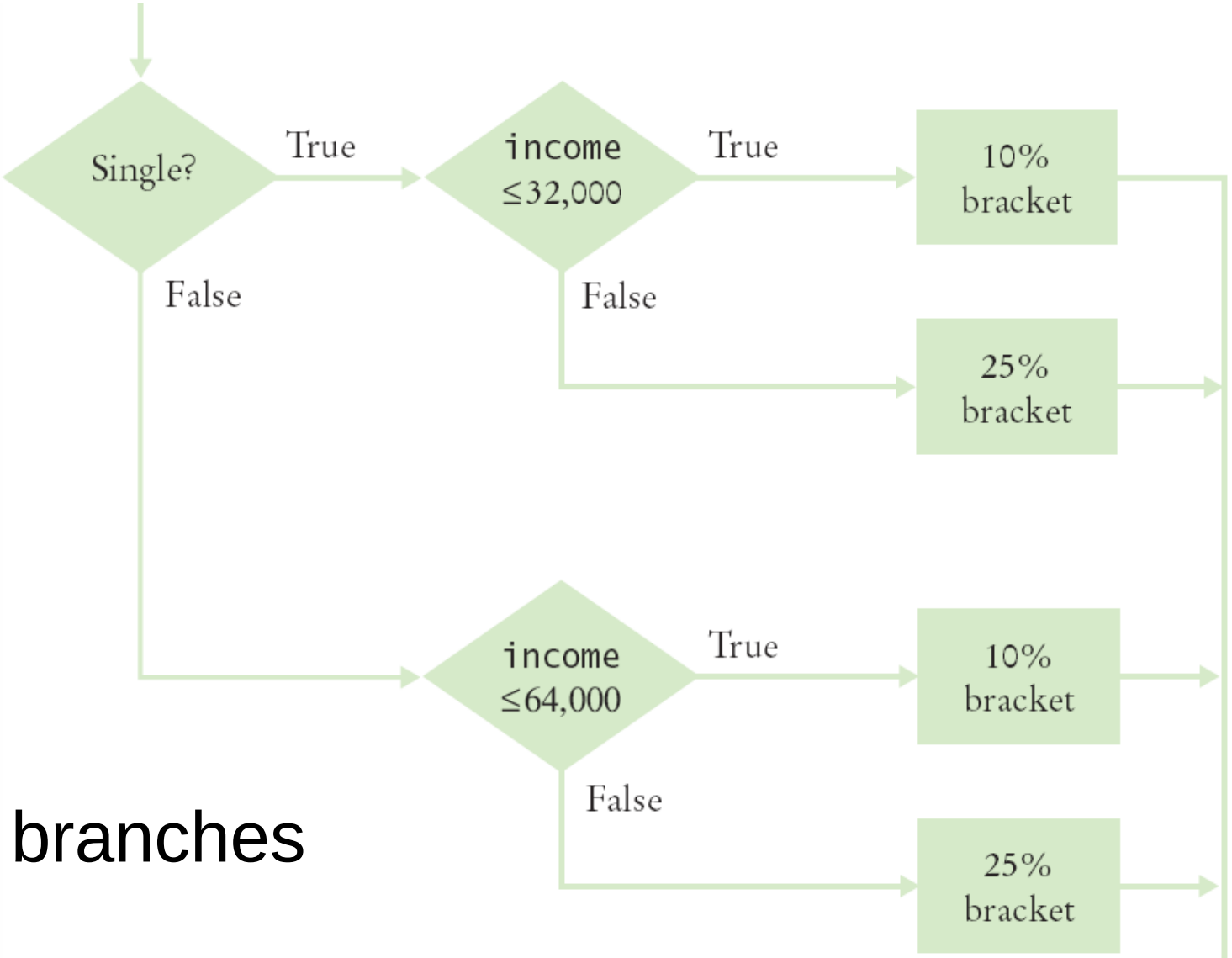
Flowchart for Tax Example



- Four branches

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TaxCalculator.java (1)

```
1  import java.util.Scanner;
2
3  /**
4     This program computes income taxes, using a simplified tax schedule.
5  */
6  public class TaxCalculator
7  {
8     public static void main(String[] args)
9     {
10       final double RATE1 = 0.10;
11       final double RATE2 = 0.25;
12       final double RATE1_SINGLE_LIMIT = 32000;
13       final double RATE1_MARRIED_LIMIT = 64000;
14
15       double tax1 = 0;
16       double tax2 = 0;
17
18       // Read income and marital status
19
20       Scanner in = new Scanner(System.in);
21       System.out.print("Please enter your income: ");
22       double income = in.nextDouble();
23
24       System.out.print("Please enter s for single, m for married: ");
25       String maritalStatus = in.next();
26
```

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TaxCalculator.java (2)

- The 'True' branch (Married)
  - Two branches within this branch

```
27      // Compute taxes due
28
29      if (maritalStatus.equals("s"))
30      {
31         if (income <= RATE1_SINGLE_LIMIT)
32         {
33            tax1 = RATE1 * income;
34         }
35         else
36         {
37            tax1 = RATE1 * RATE1_SINGLE_LIMIT;
38            tax2 = RATE2 * (income - RATE1_SINGLE_LIMIT);
39         }
40      }
```

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TaxCalculator.java (3)

- The 'False' branch (not Married)

```
41          else
42          {
43             if (income <= RATE1_MARRIED_LIMIT)
44             {
45                tax1 = RATE1 * income;
46             }
47             else
48             {
49                tax1 = RATE1 * RATE1_MARRIED_LIMIT;
50                tax2 = RATE2 * (income - RATE1_MARRIED_LIMIT);
51             }
52          }
53
54          double totalTax = tax1 + tax2;
55
56          System.out.println("The tax is $" + totalTax);
57       }
58    }
```

Program Run

```
Please enter your income: 80000
Please enter s for single, m for married: m
The tax is $10400
```

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Hand-Tracing

- Hand-tracing helps you understand whether a program works correctly
- Create a table of key variables
  - Use pencil and paper to track their values
- Works with pseudocode or code
  - Track location with a marker such as a paper clip
- Use example input values that:
  - You know what the correct outcome should be
  - Will test each branch of your code

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Hand-Tracing Tax Example (1)

tax1	tax2	income	marital status
0	0		

- Setup
  - Table of variables
  - Initial values

```
 8  public static void main(String[] args)
 9  {
10     final double RATE1 = 0.10;
11     final double RATE2 = 0.25;
12     final double RATE1_SINGLE_LIMIT = 32000;
13     final double RATE1_MARRIED_LIMIT = 64000;
14
15     double tax1 = 0;
16     double tax2 = 0;
17
```

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Hand-Tracing Tax Example (2)

tax1	tax2	income	marital status
0	0	80000	m

- Input variables
  - From user
  - Update table

```
20    Scanner in = new Scanner(System.in);
21    System.out.print("Please enter your income: ");
22    double income = in.nextDouble();
23
24    System.out.print("Please enter s for single, m for married: ");
25    String maritalStatus = in.next();
```

- Because marital status is not "s" we skip to the `else` on line 41

```
29    if (maritalStatus.equals("s"))
30    {

41     else
42    {
```

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Hand-Tracing Tax Example (3)

- Because income is not <= 64000, we move to the `else` clause on line 47
  - Update variables on lines 49 and 50
  - Use constants

tax1	tax2	income	marital status
~~0~~	~~0~~	80000	m
6400	4000		

```
43       if (income <= RATE1_MARRIED_LIMIT)
44       {
45          tax1 = RATE1 * income;
46       }
47       else
48       {
49          tax1 = RATE1 * RATE1_MARRIED_LIMIT;
50          tax2 = RATE2 * (income - RATE1_MARRIED_LIMIT);
51       }
```

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Hand-Tracing Tax Example (4)

tax1	tax2	income	marital status	total tax
~~0~~	~~0~~	80000	m	
6400	4000			10400

- Output
  - Calculate
  - As expected?

```
54     double totalTax = tax1 + tax2;
55
56     System.out.println("The tax is $" + totalTax);
57  }
```

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Common Error 3.4

The Dangling `else` Problem

- When an `if` statement is nested inside another `if` statement, the following can occur:

```
double shippingCharge = 5.00; // $5 inside continental U.S.
if (country.equals("USA"))
  if (state.equals("HI"))
    shippingCharge = 10.00;   // Hawaii is more expensive
else // Pitfall!
  shippingCharge = 20.00;     // As are foreign shipment
```

- The indentation level suggests that the `else` is related to the `if` country (“USA”)
- **Else clauses always associate to the closest `if`**

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Enumerated Types

- Java provides an easy way to name a finite list of values that a variable can hold
  - It is like declaring a new type, with a list of possible values

```
public enum FilingStatus {
 SINGLE, MARRIED,MARRIED_FILING_SEPARATELY }
```

  - You can have any number of values, but you must include them all in the enum declaration
  - You can declare variables of the enumeration type:

```
FilingStatus status = FilingStatus.SINGLE;
```

  - And you can use the comparison operator with them:

```
if (status == FilingStatus.SINGLE) . . .
```

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3.5 Problem Solving: Flowcharts

- You have seen a few basic flowcharts
- A flowchart shows the structure of decisions and tasks to solve a problem
- Basic flowchart elements:

- Connect them with arrows
  - But never point an arrow inside another branch!

Each branch of a decision can contain tasks and further decisions.

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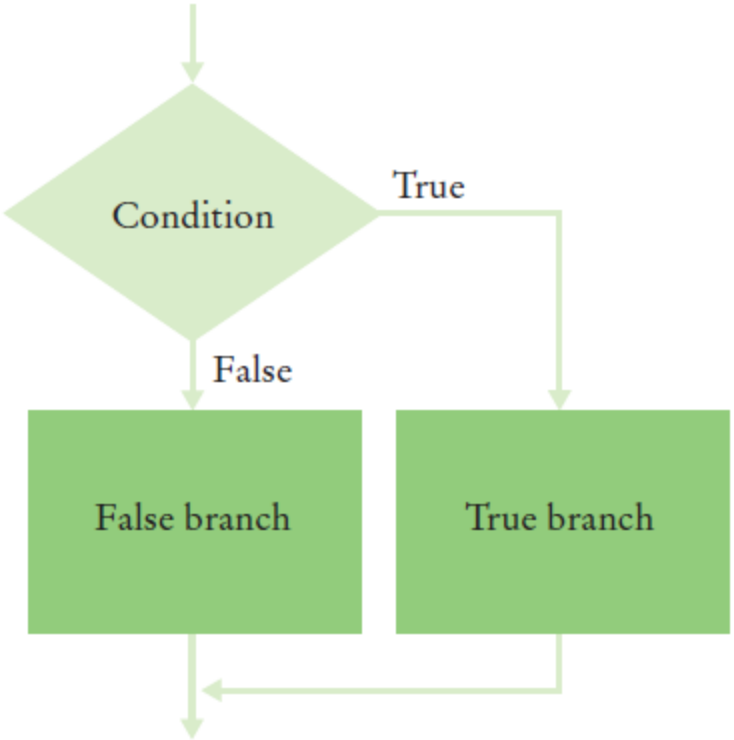
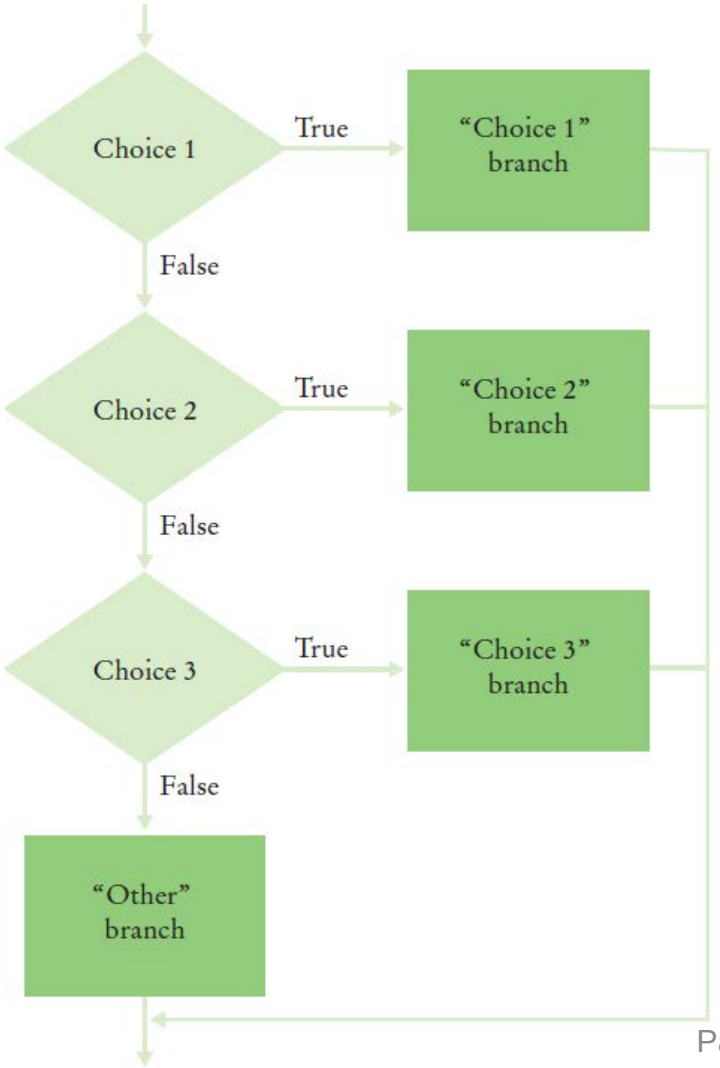
Conditional Flowcharts

- Two Outcomes



- Multiple Outcomes



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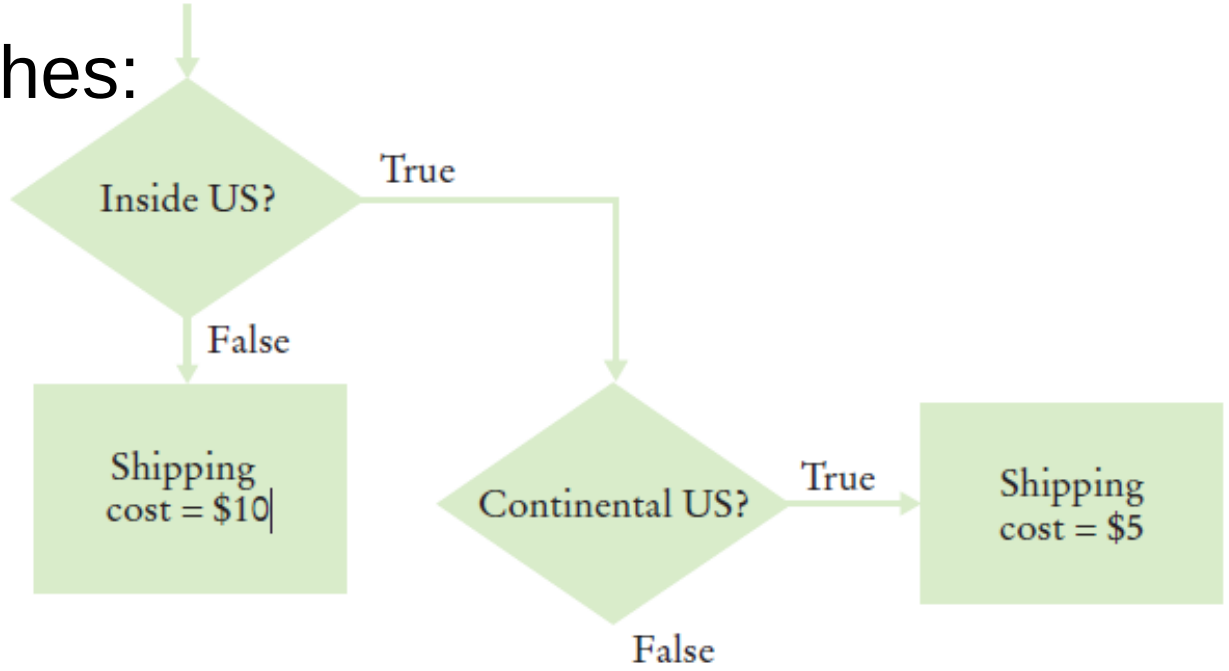
Shipping Cost Flowchart

Shipping costs are $5 inside the United States, except that to Hawaii and Alaska they are $10. International shipping costs are also $10.

- Three Branches:



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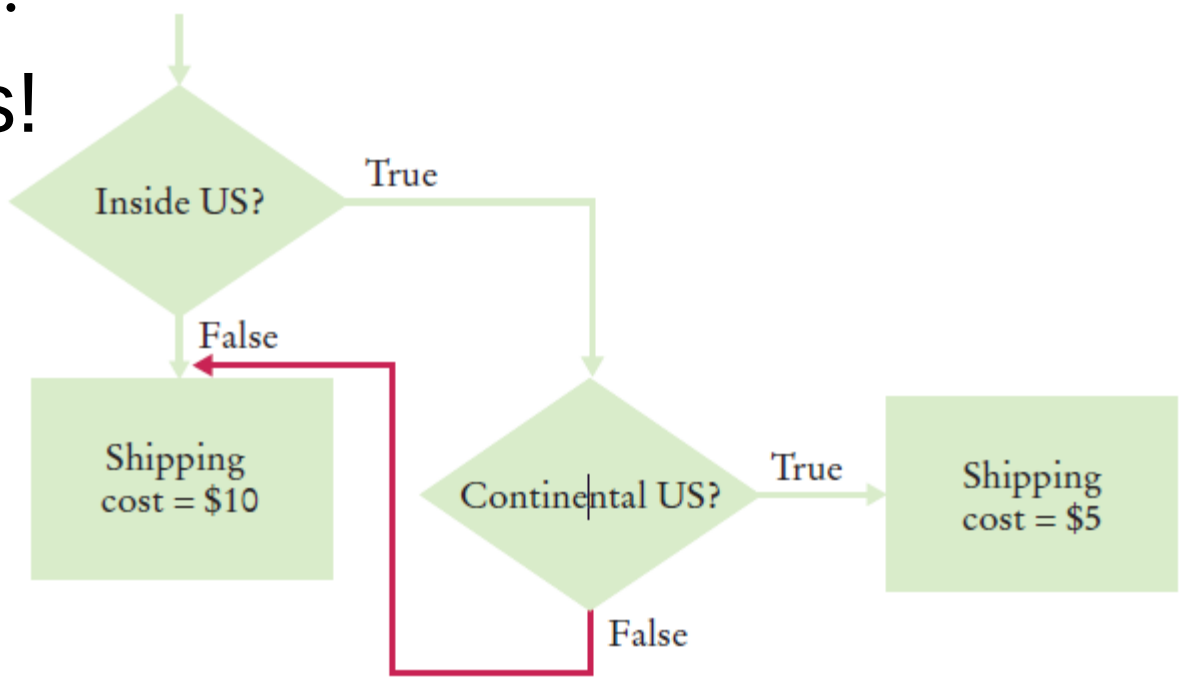
Don’t connect branches!

Shipping costs are $5 inside the United States, except that to Hawaii and Alaska they are $10. International shipping costs are also $10.

- Don’t do this!



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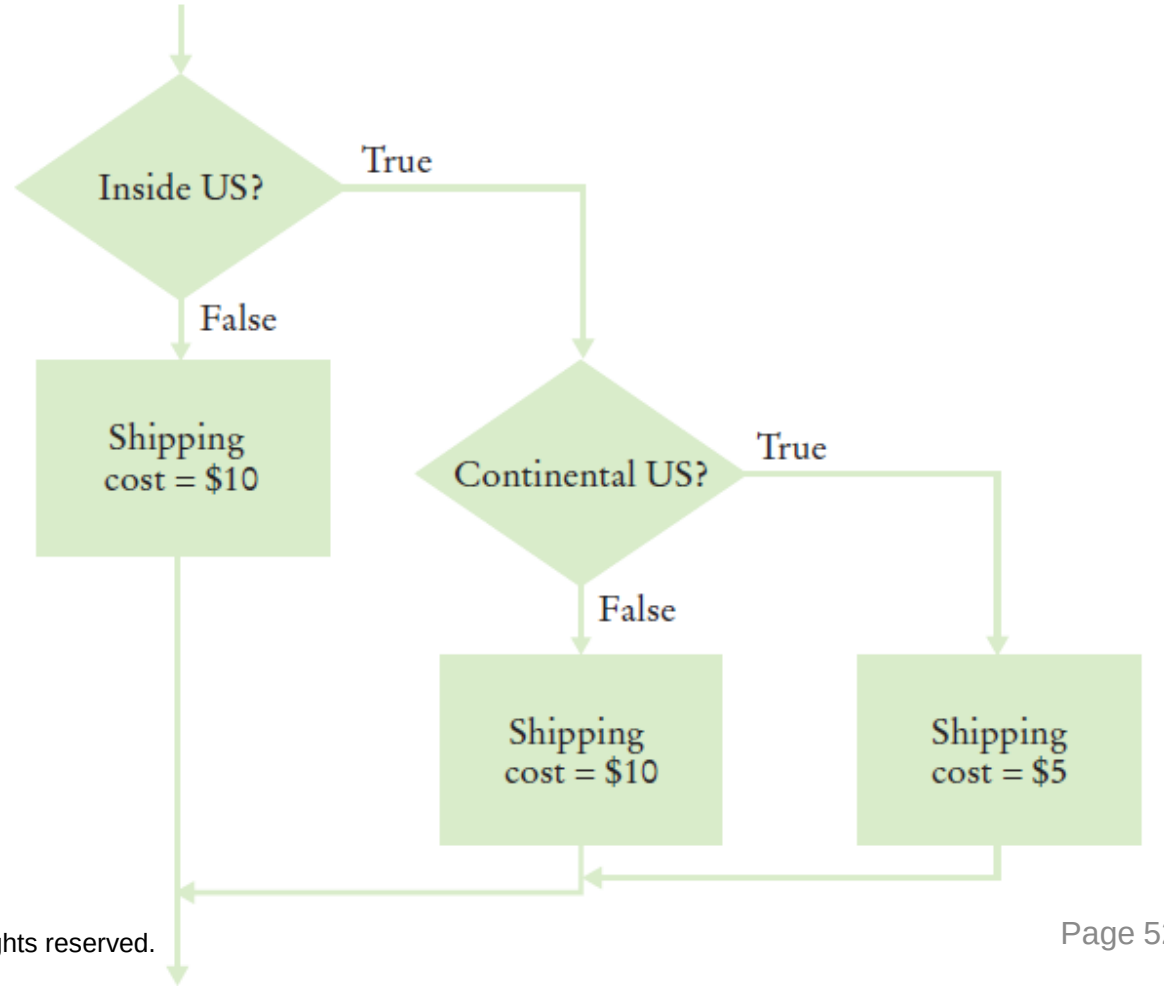
Shipping Cost Flowchart

Shipping costs are $5 inside the United States, except that to Hawaii and Alaska they are $10. International shipping costs are also $10.

- Completed:



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3.6 Problem Solving: Test Cases

- Aim for complete *coverage* of all decision points:
  - There are two possibilities for the marital status and two tax brackets for each status, yielding four test cases
  - Test a handful of ***boundary*** conditions, such as an income that is at the boundary between two tax brackets, and a zero income
  - If you are responsible for error checking (which is discussed in Section 3.8), also test an invalid input, such as a negative income

Each branch of your code should be covered with a test case

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Choosing Test Cases

- Choose input values that:
  - Test boundary cases and 0 values
  - Test each branch

A ***boundary case*** is a value that is tested in the code.

Test Case	Expected Output	Comment
30,000 s	3,000	10% bracket
72,000 s	13,200	3,200 + 25% of 40,000
50,000 m	5,000	10% bracket
104,000 m	16,400	6,400 + 25% of 40,000
32,000 m	3,200	boundary case
0	0	boundary case

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Code Coverage

- **Black-box testing:** Test functionality without consideration of internal structure of implementation
- **White-box testing:** Take internal structure into account when designing tests
- **Test coverage:** Measure of how many parts of a program have been tested
- Make sure that each part of your program is exercised at least once by one test case
  E.g., make sure to execute each branch in at least one test case

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Code Coverage

- Include boundary test cases: Legal values that lie at the boundary of the set of acceptable inputs
- Tip: Write first test cases before program is written completely → gives insight into what program should do

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3.7 Boolean Variables

- Boolean Variables
  - A Boolean variable is often called a **flag** because it can be either up (`true`) or down (`false`)
  - boolean is a Java data type
    - `boolean failed = true;`
    - Can be either `true` or `false`
- Boolean Operators: `&&` and `||`
  - They combine multiple conditions
  - `&&` is the *and* operator
  - `||` is the *or* operator

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Character Testing Methods

- The `Character` class has a number of handy methods that return a `boolean` value:

```
if (Character.isDigit(ch))
{
   ...
}
```

Character Testing Methods

Method	Examples of Accepted Characters
`isDigit`	0, 1, 2
`isLetter`	A, B, C, a, b, c
`isUpperCase`	A, B, C
`isLowerCase`	a, b, c
`isWhiteSpace`	space, newline, tab

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Combined Conditions: &&

- Combining two conditions is often used in **range checking**
  - Is a value between two other values?
- Both sides of the *and* must be true for the result to be true

```
if (temp > 0 && temp < 100)
{
   System.out.println("Liquid");
}
```

Truth table

A	B	A && B
true	true	true
true	false	false
false	true	false
false	false	false

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Combined Conditions: ||

- If only one of two conditions need to be true
  - Use a compound conditional with an or:

```
if (balance > 100 || credit > 100)
{
  System.out.println("Accepted");
}
```

- If either is true
  - The result is true

A	B	A || B
true	true	true
true	false	true
false	true	true
false	false	false

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The *not* Operator: !

- If you need to invert a boolean variable or comparison, precede it with !

```
if (!attending || grade < 60)
{
   System.out.println("Drop?");
}
```

```
if (attending && !(grade < 60))
{
   System.out.println("Stay");
}
```

A	!A
true	false
false	true

- If using !, try to use simpler logic:

```
if (attending && (grade >= 60))
```

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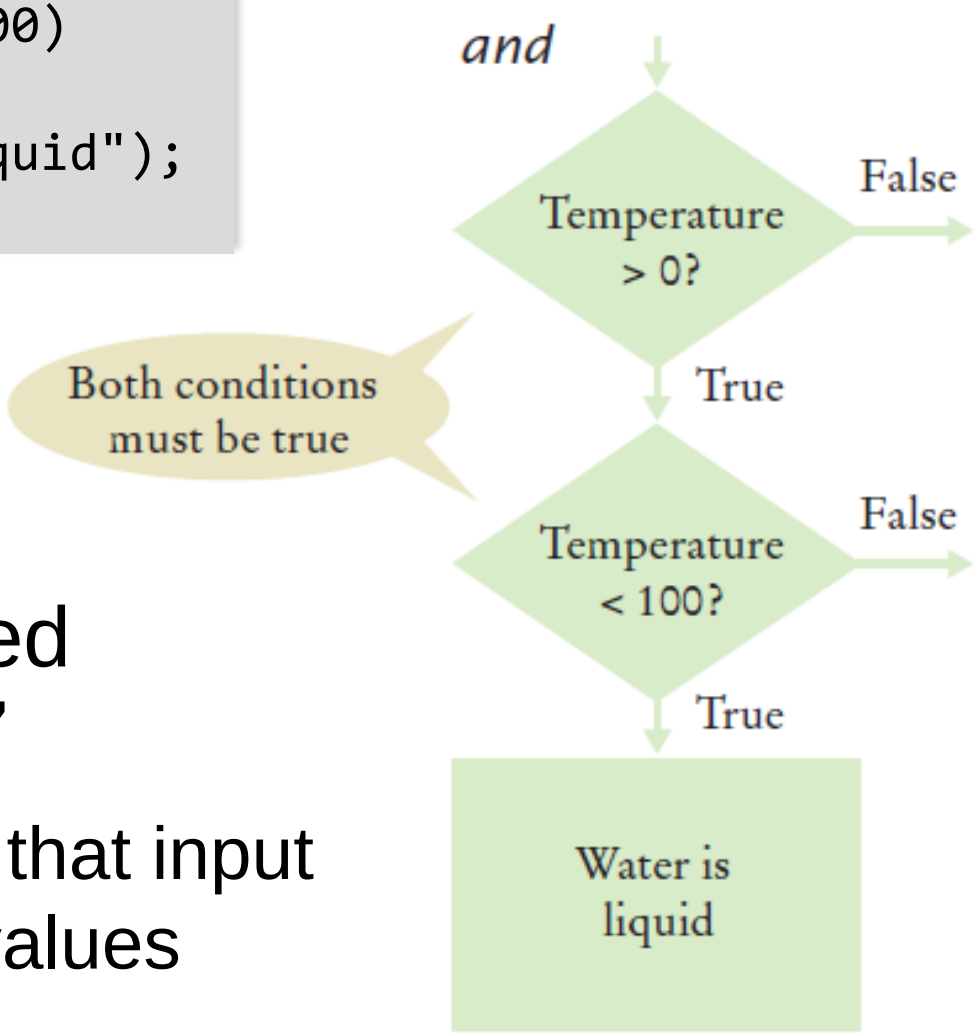
and Flowchart

```
if (temp > 0 && temp < 100)
{
   System.out.println("Liquid");
}
```



- This is often called 'range checking'
  - Used to validate that input is between two values

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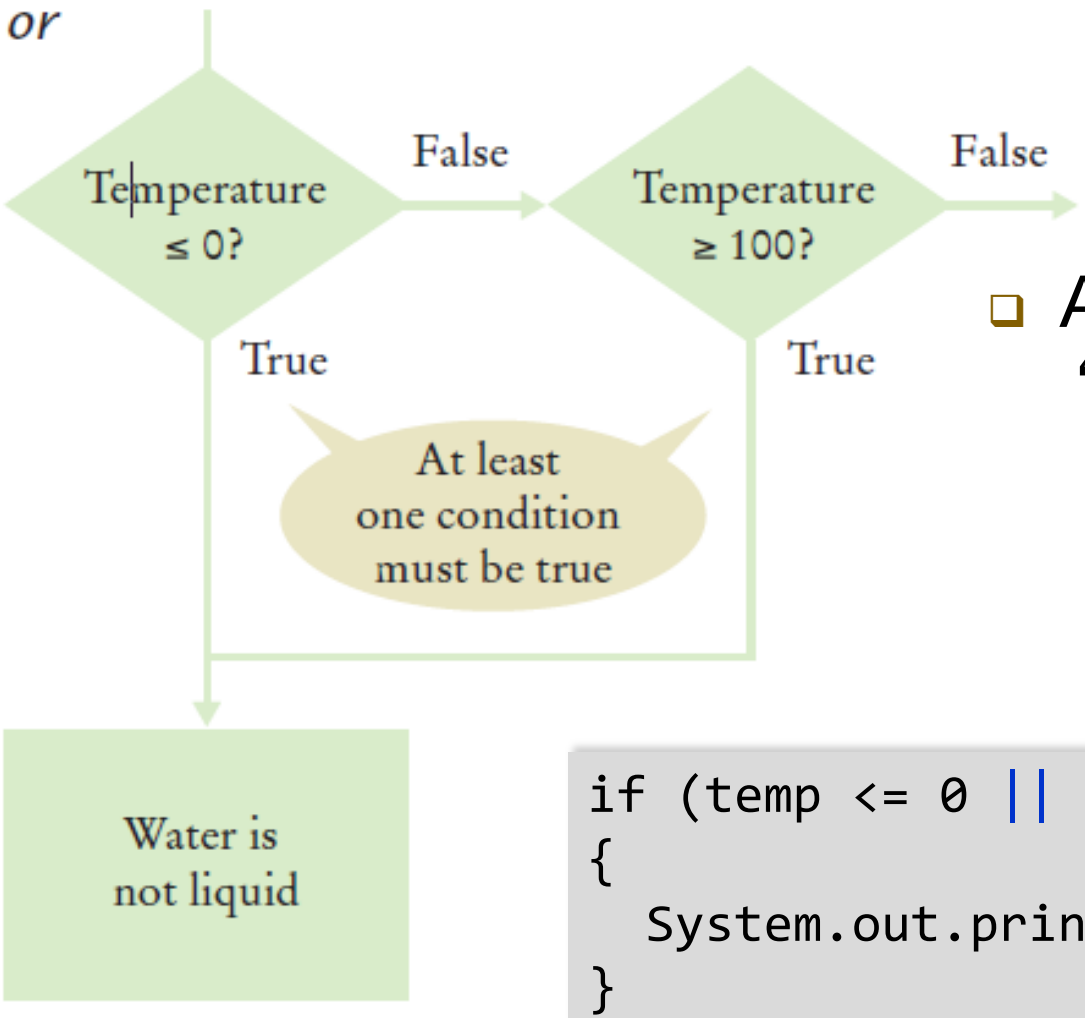
or Flowchart



- Another form of 'range checking'
  - Checks if value is **outside** a range

```
if (temp <= 0 || temp >= 100)
{
  System.out.println("Not Liquid");
}
```

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Boolean Operator Examples

Table 5 Boolean Operator Examples

Expression	Value	Comment
`0 < 200 && 200 < 100`	`false`	Only the first condition is true.
`0 < 200 || 200 < 100`	`true`	The first condition is true.
`0 < 200 || 100 < 200`	`true`	The `||` is not a test for "either-or". If both conditions are true, the result is true.
`0 < x && x < 100 || x == -1`	`(0 < x && x < 100) || x == -1`	The `&&` operator has a higher precedence than the `||` operator (see Appendix B).
		

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Boolean Operator Examples

Table 5 Boolean Operator Examples

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Using Boolean Variables

- `private boolean married;`
- Set to truth value:

```
married = input.equals("M");
```

- Use in conditions:

```
if (married) ... else ...
if (!married) ...
```

- Also called *flag*
- It is considered gauche to write a test such as

```
if (married == true) ... // Don't
```

- Just use the simpler test

```
if (married) ...
```

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Common Error 3.5

- Combining Multiple Relational Operators

```
if (0 <= temp <= 100)  // Syntax error!
```

  - This format is used in math, but not in Java!
  - It requires two comparisons:

```
if (0 <= temp && temp <= 100)
```

- This is also not allowed in Java:

```
if (input == 1 || 2)  // Syntax error!
```

  - This also requires two comparisons:

```
if (input == 1 || input == 2)
```

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Common Error 3.6

Confusing && and || Conditions

- It is a surprisingly common error to confuse && and || conditions.
- A value lies between 0 and 100 if it is at least 0 ***and*** at most 100.
- It lies outside that range if it is less than 0 ***or*** greater than 100.
- There is no golden rule; you just have to think carefully.

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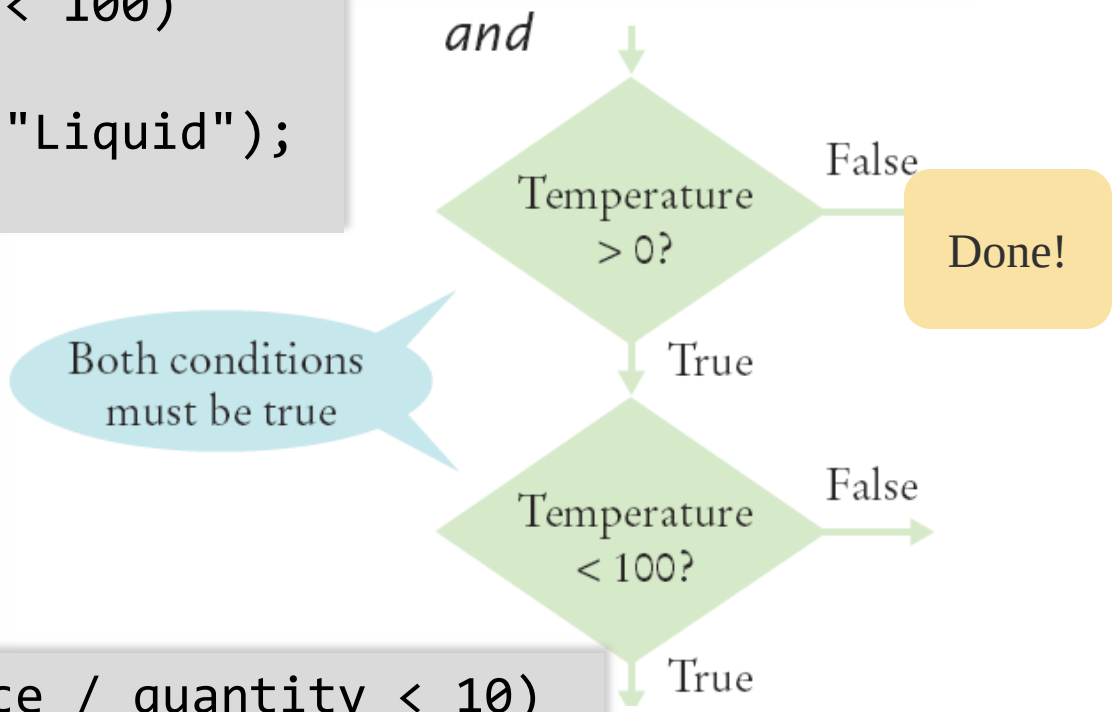
Short-Circuit Evaluation: &&

- Combined conditions are evaluated from left to right
  - If the left half of an *and* condition is false, why look further?

```
if (temp > 0 && temp < 100)
{
   System.out.println("Liquid");
}
```



- A useful example:

```
if (quantity > 0 && price / quantity < 10)
```

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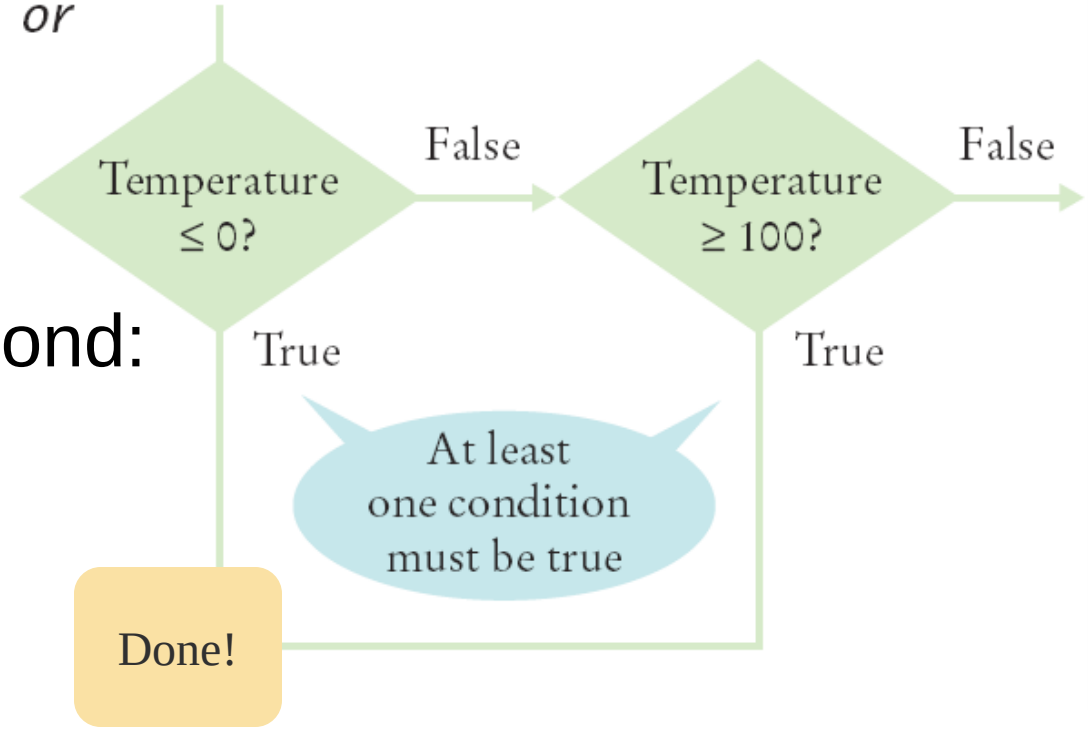
Short-Circuit Evaluation: ||

- If the left half of the *or* is true, why look further?

```
if (temp <= 0 || temp >= 100)
{
  System.out.println("Not Liquid");
}
```

or



- Java doesn't!
- Don't do these second:
  - Assignment
  - Output

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De Morgan's Law

- De Morgan's law tells you how to negate && and || conditions:
  - !(A && B) is the same as !A || !B
  - !(A || B) is the same as !A && !B
- Example: Shipping is higher to AK and HI

```
if (!(country.equals("USA")
    && !state.equals("AK")
    && !state.equals("HI")))
  shippingCharge = 20.00;
```

```
if !country.equals("USA")
  || state.equals("AK")
  || state.equals("HI")
  shippingCharge = 20.00;
```

- To simplify conditions with negations of *and* or *or* expressions, it is usually a good idea to apply De Morgan's Law to move the negations to the innermost level.

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3.8 Input Validation

- Accepting user input is dangerous
  - Consider the Elevator program:
  - The user may input an invalid character or value
  - Must be an integer
    - Scanner can help!
    - `hasNextInt`
      - True if integer
      - False if not

```
if (in.hasNextInt())
{
   int floor = in.nextInt();
   // Process the input value
}
else
{
   System.out.println("Not integer.");
}
```

  - Then range check value
  - We expect a floor number to be between 1 and 20
    - NOT 0, 13 or > 20

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ElevatorSimulation2.java

```
 7  public class ElevatorSimulation2
 8  {
 9     public static void main(String[] args)
10     {
11        Scanner in = new Scanner(System.in);
12        System.out.print("Floor: ");
13        if (!in.hasNextInt())
14        {
15           // Now we know that the user entered an integer
16
17           int floor = in.nextInt();
18
19           if (floor == 13)
20           {
21              System.out.println("Error: There is no thirteenth floor.");
22           }
23           else if (floor <= 0 || floor > 20)
24           {
25              System.out.println("Error: The floor must be between 1 and 20.");
26           }
27           else
28           {
29              // Now we know that the input is valid
```

Input value validity checking

Input value range checking

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ElevatorSimulation2.java

```
30
31             int actualFloor = floor;
32             if (floor > 13)
33             {
34                actualFloor = floor - 1;
35             }
36
37             System.out.println("The elevator will travel to the actual floor "
38                + actualFloor);
39          }
40       }
41       else
42       {
43          System.out.println("Error: Not an integer.");
44       }
45    }
46 }
```

Program Run

```
Floor: 13
Error: There is no thirteenth floor.
```

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Summary: `if` Statement

- The if statement allows a program to carry out different actions depending on the nature of the data to be processed.
- Relational operators (`< <= > >= == !=`) are used to compare numbers and `Strings`.
- Do not use the `==` operator to compare `Strings`.
  - Use the `equals` method instead.
  - The `compareTo` method compares `Strings` in lexicographic order.
- Multiple `if` statements can be combined to evaluate complex decisions.
- When using multiple `if` statements, test general conditions after more specific conditions.

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Summary: Flowcharts and Testing

- When a decision statement is contained inside the branch of another decision statement, the statements are *nested.*
- Nested decisions are required for problems that have two levels of decision making.
- Flow charts are made up of elements for tasks, input/ output, and decisions.
- Each branch of a decision can contain tasks and further decisions.
- Never point an arrow inside another branch.
- Each branch of your program should be covered by a test case.
- It is a good idea to design test cases before implementing a program.

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Summary: Boolean

- The Boolean type `boolean` has two values, true and false.
  - Java has two Boolean operators that combine conditions: `&&` (*and*) and `||` (*or*).
  - To invert a condition, use the `!` (*not*) operator.
  - The `&&` and `||` operators are computed lazily: As soon as the truth value is determined, no further conditions are evaluated.
  - De Morgan's law tells you how to negate `&&` and `||` conditions.
- You can use `Scanner hasNext` methods to ensure that the data is what you expect.

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