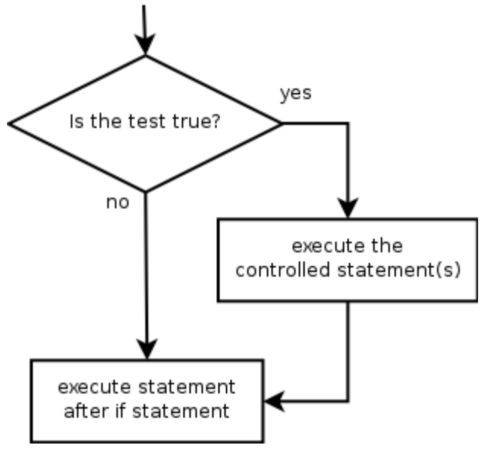
Chapter 3

Branches

The `if` statement

Executes a block of statements only if a test is true

```
if (test) {
    statement;
    ...
    statement;
}
```


Is the test true?
yes
no
execute the controlled statement(s)
execute statement after if statement

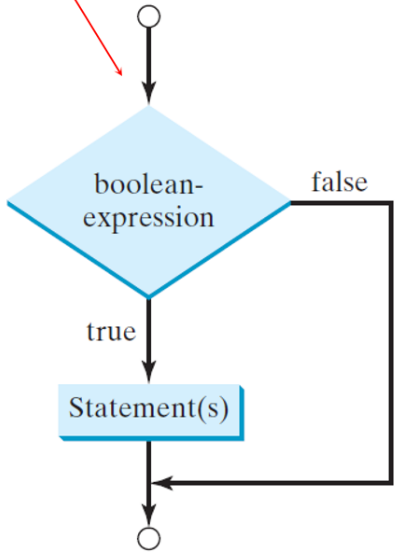
- Example:

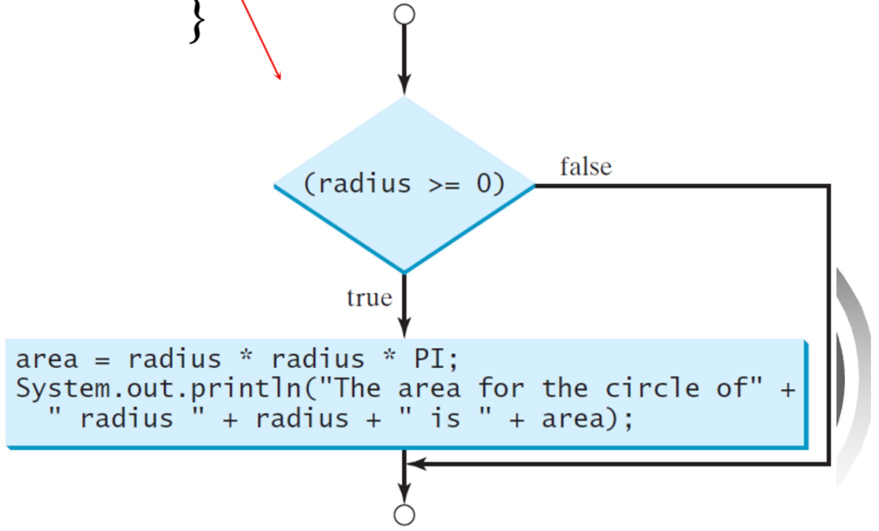
```
double gpa = scnr.nextDouble();
if (gpa >= 2.0) {
    System.out.println("Application accepted.");
}
```

One-way `if` Statements

```
if (boolean-expression) {
  statement(s);
}
```

```
if (radius >= 0) {
  area = radius * radius * PI;
  System.out.println("The area"
    + " for the circle of radius "
    + radius + " is " + area);
}
```



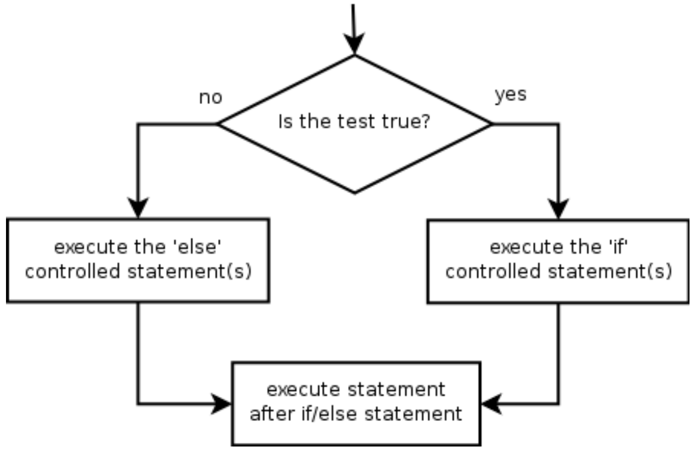


```
area = radius * radius * PI;
System.out.println("The area for the circle of" +
  " radius " + radius + " is " + area);
```

The `if/else` statement

Executes one block if a test is true, another if false

```
if (test) {
    statement(s);
} else {
    statement(s);
}
```



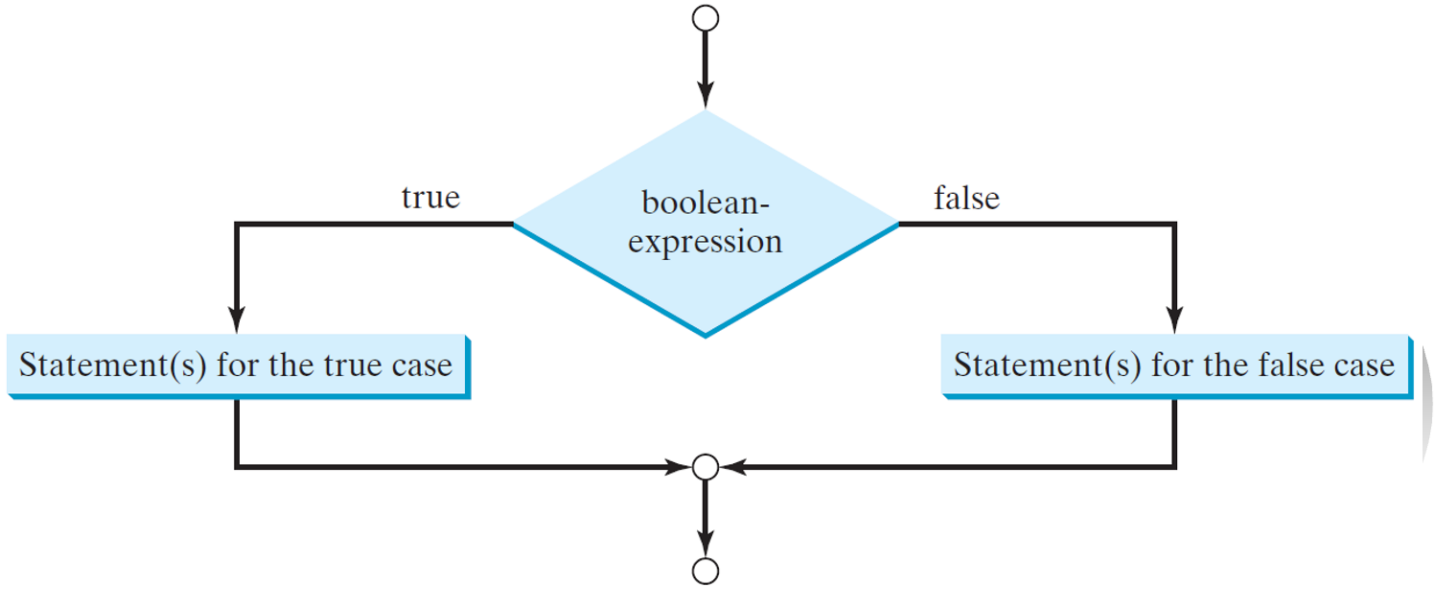
Is the test true?
no
yes
execute the 'else' controlled statement(s)
execute the 'if' controlled statement(s)
execute statement after if/else statement

- Example:

```
double gpa = scnr.nextDouble();
if (gpa >= 2.0) {
    System.out.println("Welcome to Mars University!");
} else {
    System.out.println("Application denied.");
}
```

The Two-way `if` Statement

```
if (boolean-expression) {
  statement(s)-for-the-true-case;
}
else {
  statement(s)-for-the-false-case;
}
```


true
boolean-expression
false
Statement(s) for the true case
Statement(s) for the false case

if-else Example

```
if (radius >= 0) {
  area = radius * radius * 3.14159;

  System.out.println("The area for the “
    + “circle of radius " + radius +
    " is " + area);
}
else {
  System.out.println("Negative input");
}
```

- Example:

```
 if (radius >= 0) {
 area = radius * radius * PI;
         System.out.println("The area for the circle of radius " +
radius + " is " + area);
} else {
         System.out.println("Negative input");
}
```

Note

```
if i > 0 {
  System.out.println("i is positive");
}
```

(a) Wrong

```
if (i > 0) {
  System.out.println("i is positive");
}
```

(b) Correct

```
if (i > 0) {
  System.out.println("i is positive");
}
```

(a)

Equivalent

```
if (i > 0)
  System.out.println("i is positive");
```

(b)

Common Errors:

- if(radius>0); Incorrect
- if(radius>0) {} Correct

Avoiding duplicates

Bad:

```
if (inState) {
  tuition = 5000;
  System.out.println("The tuition is " + tuition);
}
else {
  tuition = 15000;
  System.out.println("The tuition is " + tuition);
}
```

Better:

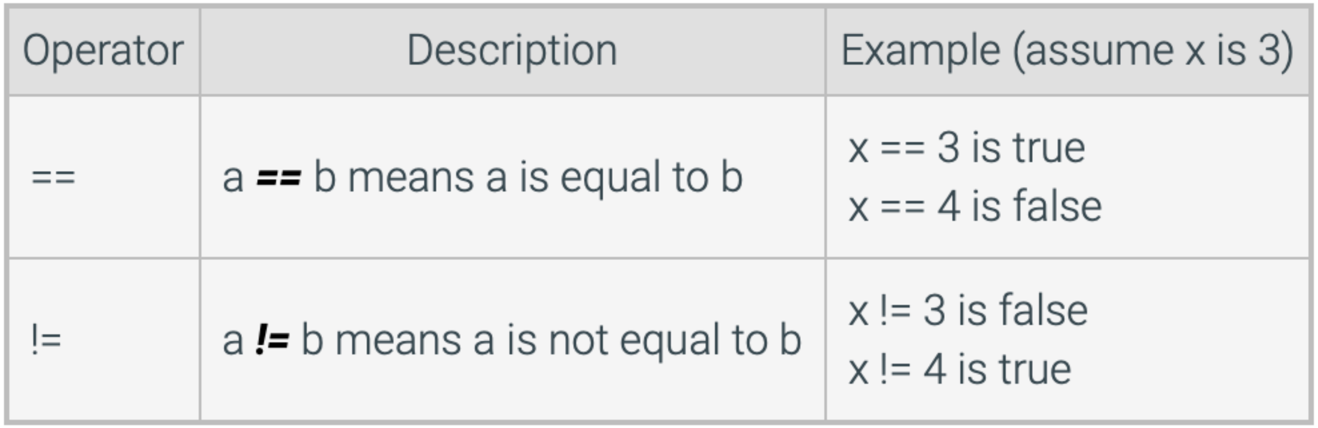
```
if (inState) {
  tuition = 5000;
}
else {
  tuition = 15000;
}
System.out.println("The tuition is " + tuition);
```

- Example:

```
if (number % 2 == 0){
        System.out.println(number + " is even.");
}else{
        System.out.println(number + " is odd.");
 }
```

Boolean

- The ***equality operator*** (**==**) evaluates to true if the left and right sides are equal.
- The ***inequality operator*** (***!*=**) evaluates to true if the left and right sides are not equal, or different.
- An expression involving the equality or inequality operators evaluates to a Boolean value.
- A ***Boolean*** is a type that has just two values: true or false
- The equality testing operator is two equal signs (==), not a single equal sign (=). The latter symbol is for assignment.



Operator	Description	Example (assume x is 3)
==	a **==** b means a is equal to b	x == 3 is true x == 4 is false
!=	a ***!*=** b means a is not equal to b	x != 3 is false x != 4 is true

Relational expressions

Tests use *relational operators*:

Operator	Meaning	Example	Value
`==`	equals	`1 + 1 == 2`	`true`
`!=`	does not equal	`3.2 != 2.5`	`true`
`<`	less than	`10 < 5`	`false`
`>`	greater than	`10 > 5`	`true`
`<=`	less than or equal to	`126 <= 100`	`false`
`>=`	greater than or equal to	`5.0 >= 5.0`	`true`

Assuming x is 1, show the result of the following Boolean expressions:

a) (x > 0)

b) (x < 0)

c) (x != 0)

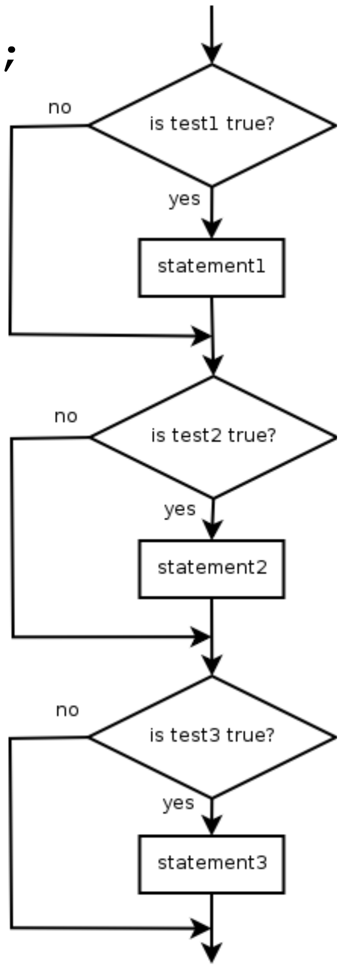
d) (x >= 0)

e) (x != 1)

Misuse of `if`

- What's wrong with the following code?

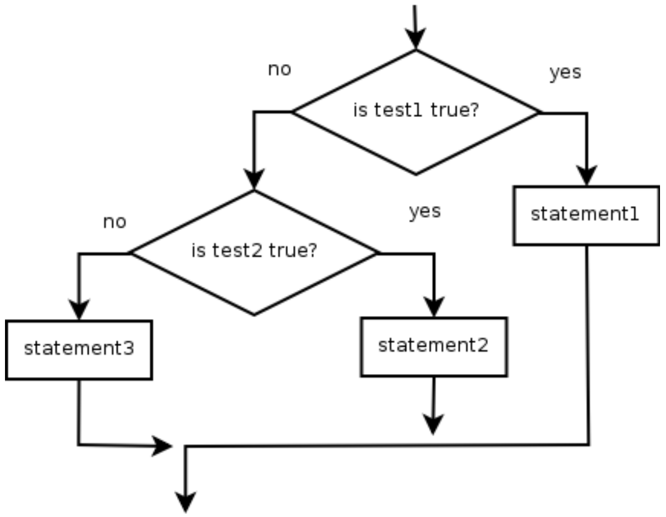
```
Scanner scnr = new Scanner(System.in);
System.out.print("What percentage did you earn? ");
int percent = scnr.nextInt();
if (percent >= 90) {
    System.out.println("You got an A!");
}
if (percent >= 80) {
    System.out.println("You got a B!");
}
if (percent >= 70) {
    System.out.println("You got a C!");
}
if (percent >= 60) {
    System.out.println("You got a D!");
}
if (percent < 60) {
    System.out.println("You got an F!");
}
...
```



Nested `if/else`

Chooses between outcomes using many tests

```
if (test) {
    statement(s);
} else if (test) {
    statement(s);
} else {
    statement(s);
}
```



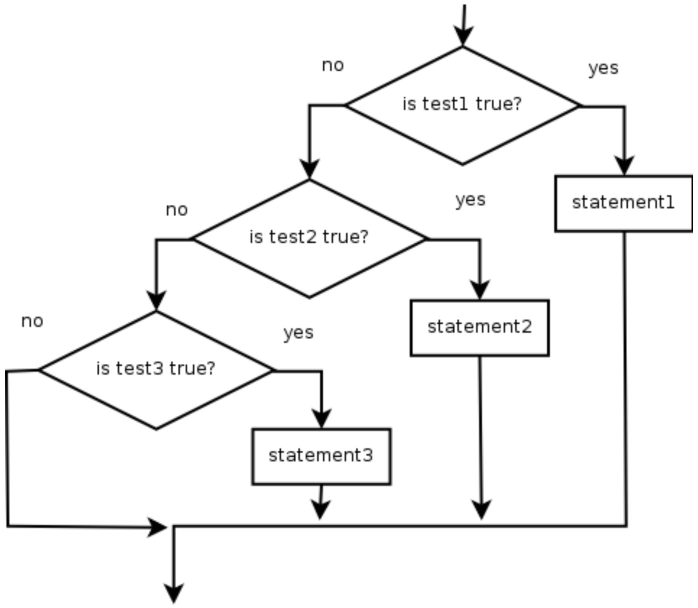
- Example:

```
if (x > 0) {
    System.out.println("Positive");
} else if (x < 0) {
    System.out.println("Negative");
} else {
    System.out.println("Zero");
}
```

Nested `if/else/if`

- If it ends with `else`, exactly one path must be taken.
- If it ends with `if`, the code might not execute any path.

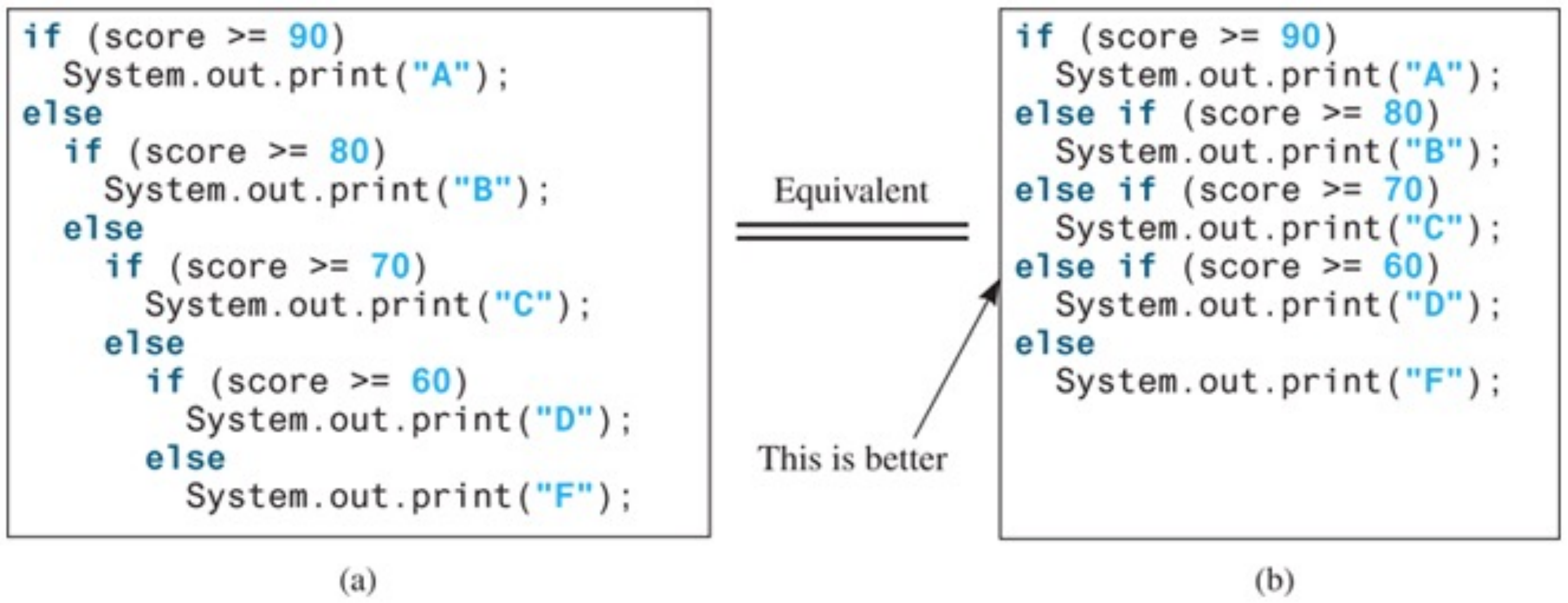
```
if (test) {
    statement(s);
} else if (test) {
    statement(s);
} else if (test) {
    statement(s);
}
```



- Example:

```
if (place == 1) {
    System.out.println("Gold medal!");
} else if (place == 2) {
    System.out.println("Silver medal!");
} else if (place == 3) {
    System.out.println("Bronze medal.");
}
```

Multiple Alternative if Statements



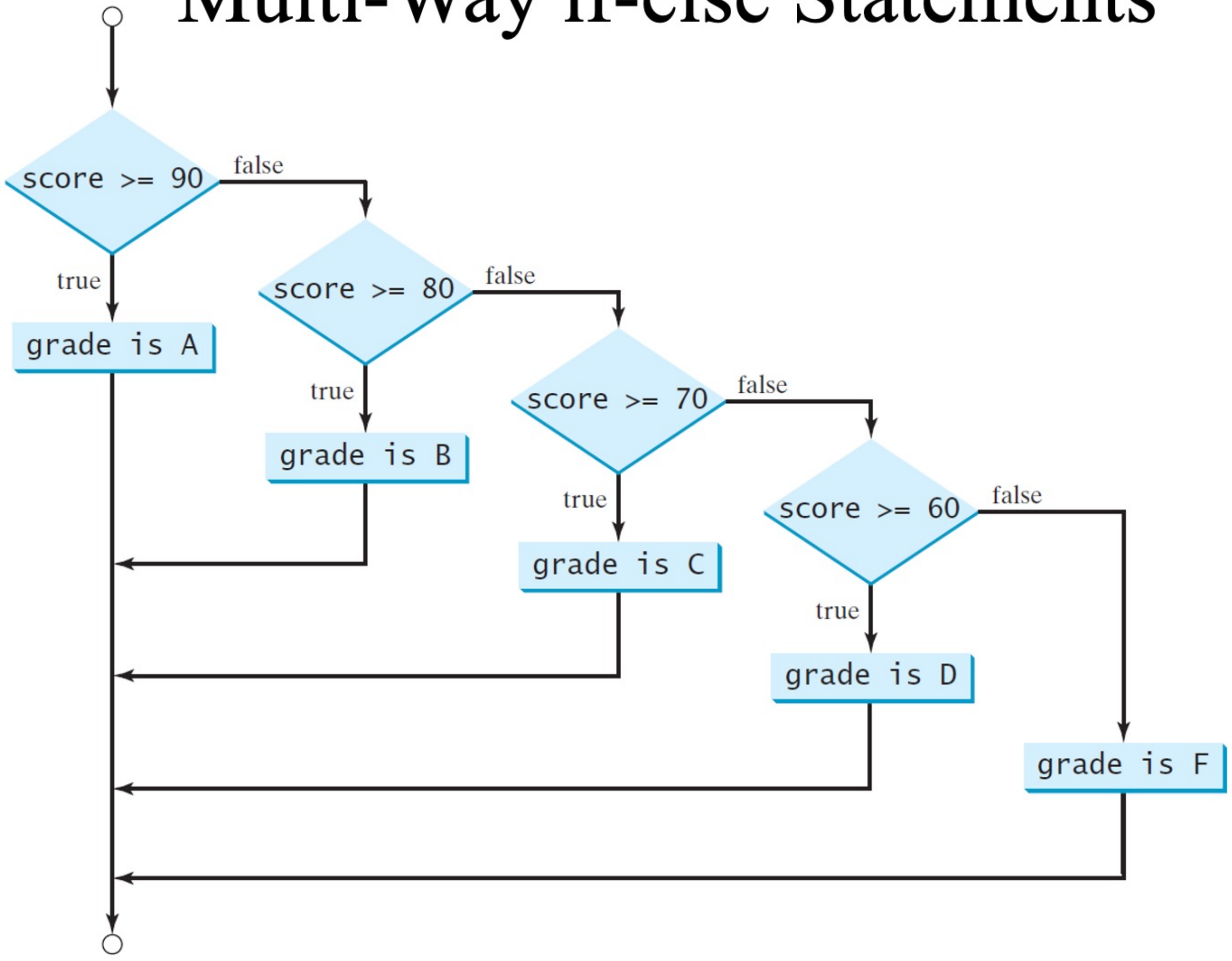
```
if (score >= 90)
  System.out.print("A");
else
  if (score >= 80)
    System.out.print("B");
  else
    if (score >= 70)
      System.out.print("C");
    else
      if (score >= 60)
        System.out.print("D");
      else
        System.out.print("F");
```

(a)

```
if (score >= 90)
  System.out.print("A");
else if (score >= 80)
  System.out.print("B");
else if (score >= 70)
  System.out.print("C");
else if (score >= 60)
  System.out.print("D");
else
  System.out.print("F");
```

(b)

Multi-Way if-else Statements



animation

Trace if-else statement

Suppose score is 70.0

The condition is false

```
if (score >= 90.0)
  System.out.print("A");
else if (score >= 80.0)
  System.out.print("B");
else if (score >= 70.0)
  System.out.print("C");
else if (score >= 60.0)
  System.out.print("D");
else
  System.out.print("F");
```

animation

Trace if-else statement

Suppose score is 70.0

The condition is false

```
if (score >= 90.0)
  System.out.print("A");
else if (score >= 80.0)
  System.out.print("B");
else if (score >= 70.0)
  System.out.print("C");
else if (score >= 60.0)
  System.out.print("D");
else
  System.out.print("F");
```

animation

Trace if-else statement

Suppose score is 70.0

The condition is true

```
if (score >= 90.0)
  System.out.print("A");
else if (score >= 80.0)
  System.out.print("B");
else if (score >= 70.0)
  System.out.print("C");
else if (score >= 60.0)
  System.out.print("D");
else
  System.out.print("F");
```

animation

Trace if-else statement

Suppose score is 70.0

grade is C

```
if (score >= 90.0)
  System.out.print("A");
else if (score >= 80.0)
  System.out.print("B");
else if (score >= 70.0)
  System.out.print("C");
else if (score >= 60.0)
  System.out.print("D");
else
  System.out.print("F");
```

animation

Trace if-else statement

Suppose score is 70.0

Exit the if statement

```
if (score >= 90.0)
  System.out.print("A");
else if (score >= 80.0)
  System.out.print("B");
else if (score >= 70.0)
  System.out.print("C");
else if (score >= 60.0)
  System.out.print("D");
else
  System.out.print("F");
```

Nested `if` structures

- exactly 1 path *(mutually exclusive)*

```
if (test) {
    statement(s);
} else if (test) {
    statement(s);
} else {
    statement(s);
}
```

- 0 or 1 path *(mutually exclusive)*

```
if (test) {
    statement(s);
} else if (test) {
    statement(s);
} else if (test) {
    statement(s);
}
```

- 0, 1, or many paths *(independent tests; not exclusive)*

```
if (test) {
    statement(s);
}
if (test) {
    statement(s);
}
if (test) {
    statement(s);
}
```

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

Scanner input = new Scanner(System.in);
System.out.print("Enter an integer: ");
int number = input.nextInt();
if (number % 5 == 0)
System.out.println("HiFive");
if (number % 2 == 0)
System.out.println("HiEven"):

}
```

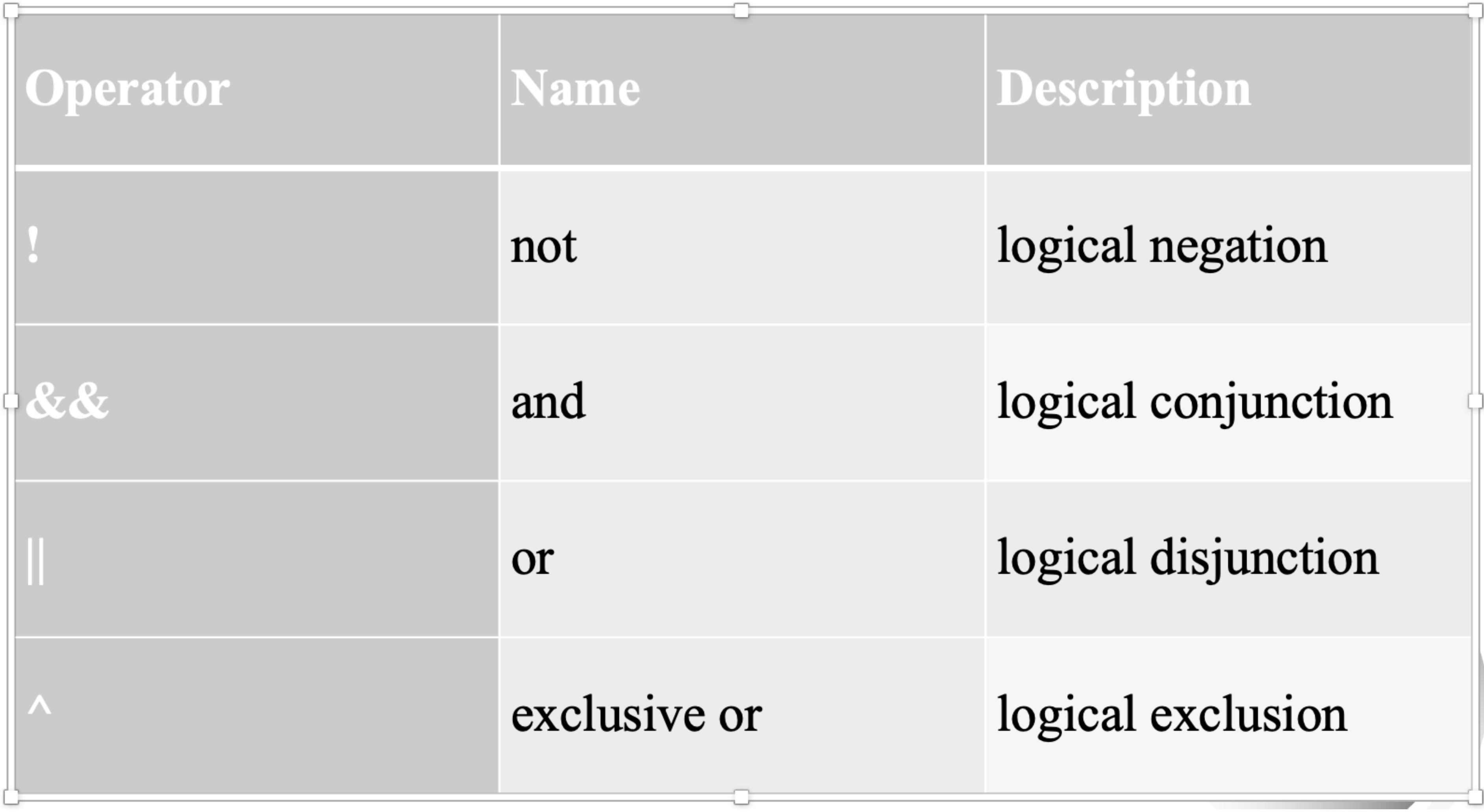
Which nested `if/else`?

- **(1) if/if/if (2) nested if/else (3) nested if/else/if**
  - Whether a user is lower, middle, or upper-class based on income.
    - **(2)** nested `if / else if / else`
  - Whether you made the dean's list (GPA ≥ 3.8) or honor roll (3.5-3.8).
    - **(3)** nested `if / else if`
  - Whether a number is divisible by 2, 3, and/or 5.
    - **(1)** sequential `if / if / if`
  - Computing a grade of A, B, C, D, or F based on a percentage.
    - **(2)** nested `if / else if / else if / else if / else`

Logical Operators

Operator	Name	Description
!	not	logical negation
&&	and	logical conjunction
||	or	logical disjunction
^	exclusive or	logical exclusion

Truth Table for Operator !



Operator	Name	Description
!	not	logical negation
&&	and	logical conjunction
||	or	logical disjunction
^	exclusive or	logical exclusion

Truth Table for Operator &&

p_1	p_2	p_1 && p_2	Example (assume age = 24, weight = 140)
false	false	false	(age <= 18) && (weight < 140) is false, because both conditions are both false.
false	true	false	
true	false	false	(age > 18) && (weight > 140) is false, because (weight > 140) is false.
true	true	true	(age > 18) && (weight >= 140) is true, because both (age > 18) and (weight >= 140) are true.

Truth Table for Operator ||

p_1	p_2	p_1 && p_2	Example (assume age = 24, weight = 140)
false	false	false	(age <= 18) && (weight < 140) is false, because both conditions are both false.
false	true	false	
true	false	false	(age > 18) && (weight > 140) is false, because (weight > 140) is false.
true	true	true	(age > 18) && (weight >= 140) is true, because both (age > 18) and (weight >= 140) are true.

Truth Table for Operator ^

p_1	p_2	p_1 ^ p_2	Example (assume age = 24, weight = 140)
false	false	false	(age > 34) ^ (weight > 140) is true, because (age > 34) is false and (weight > 140) is false.
false	true	true	(age > 34) ^ (weight >= 140) is true, because (age > 34) is false but (weight >= 140) is true.
true	false	true	(age > 14) ^ (weight > 140) is true, because (age > 14) is true and (weight > 140) is false.
true	true	false	

Logical operators

- Tests can be combined using *logical operators*:

Operator	Description	Example	Result
`&&`	and	`(2 == 3) && (-1 < 5)`	`false`
`||`	or	`(2 == 3) || (-1 < 5)`	`true`
`!`	not	`!(2 == 3)`	`true`

- "Truth tables" for each, used with logical values *p* and *q*:

p	q	p && q	p || q
`true`	`true`	`true`	`true`
`true`	`false`	`false`	`true`
`false`	`true`	`false`	`true`
`false`	`false`	`false`	`false`

p	!p
`true`	`false`
`false`	`true`

Logical questions

- What is the result of each of the following expressions?

```
boolean x = true;
boolean y = true;
System.out.println(x&&y);
System.out.println(x||y);
System.out.println(x^y);
System.out.println(!x);
```

Evaluating logic expressions

- Relational operators have lower precedence than math.

```
5 * 7 >= 3 + 5 * (7 - 1)
5 * 7 >= 3 + 5 * 6
35    >= 3 + 30
35    >= 33
true
```

- Relational operators cannot be "chained" as in algebra.

```
2 <= x <= 10
true   <= 10
error!
```

(assume that `x` is `15`)

  - Instead, combine multiple tests with `&&` or `||`

```
2 <= x && x <= 10
true   && false
false
```

Logical questions

- What is the result of each of the following expressions?

```
int x = 42;
int y = 17;
int z = 25;
```

  - `y < x && y <= z`
  - `x % 2 == y % 2 || x % 2 == z % 2`
  - `x <= y + z && x >= y + z`
  - `!(x < y && x < z)`
  - `(x + y) % 2 == 0 || !((z - y) % 2 == 0)`

    - Answers: `true`, `false`, `true`, `true`, `false`

Example

- Here is a program that checks whether a number is divisible by 2 and 3, whether a number is divisible by 2 or 3, and whether a number is divisible by 2 or 3 but not both:

Example

```
System.out.println("Is " + number + " divisible by 2 and 3? " +
  ((number % 2 == 0) && (number % 3 == 0)));

System.out.println("Is " + number + " divisible by 2 or 3? " +
  ((number % 2 == 0) || (number % 3 == 0)));

System.out.println("Is " + number +
  " divisible by 2 or 3, but not both? " +
  ((number % 2 == 0) ^ (number % 3 == 0)));
```

Example

```
Scanner input = new Scanner(System.in);
System.out.print("Enter an integer: ");
int number = input.nextInt();
if (number % 2 == 0 && number % 3 == 0)
   System.out.println(number + " is divisible by 2 and 3.");
if (number % 2 == 0 || number % 3 == 0)
   System.out.println(number + " is divisible by 2 or 3.");
if (number % 2 == 0 ^ number % 3 == 0)
   System.out.println(number +" is divisible by 2 or 3, but not both.");
```