Program Elements -- Introduction

- We can now examine the core elements of programming
- Chapter 3 focuses on:
  - data types
  - variable declaration and use
  - operators and expressions
  - decisions and loops
  - input and output

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Primitive Data Types

- A *data type* is defined by a set of values and the operators you can perform on them
- Each value stored in memory is associated with a particular data type
- The Java language has several predefined types, called *primitive data types*
- The following reserved words represent eight different primitive types:
  - `byte`, `short`, `int`, `long`, `float`, `double`, `boolean`, `char`

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Integers

- There are four separate integer primitive data types
- They differ by the amount of memory used to store them

Type	Storage	Min Value	Max Value
byte	8 bits	-128	127
short	16 bits	-32,768	32,767
int	32 bits	-2,147,483,648	2,147,483,647
long	64 bits	$< -9 \times 10^{18}$	$> 9 \times 10^{18}$

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Floating Point

- There are two floating point types:

Type	Storage	Approximate Min Value	Approximate Max Value
float	32 bits	-3.4×10^{38}	3.4×10^{38}
double	64 bits	-1.7×10^{308}	1.7×10^{308}

- The `float` type stores 7 significant digits
- The `double` type stores 15 significant digits

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Characters

- A `char` value stores a single character from the *Unicode character set*
- A *character set* is an ordered list of characters
- The Unicode character set uses sixteen bits per character, allowing for 65,536 unique characters
- It is an international character set, containing symbols and characters from many world languages

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Characters

- The ASCII character set is still the basis for many other programming languages
- ASCII is a subset of Unicode, including:

uppercase letters	A, B, C, …
lowercase letters	a, b, c, …
punctuation	period, semi-colon, …
digits	0, 1, 2, …
special symbols	&, |, \, …
control characters	carriage return, tab, ...

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Boolean

- A `boolean` value represents a true or false condition
- They can also be used to represent any two states, such as a light bulb being on or off
- The reserved words `true` and `false` are the only valid values for a boolean type

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Wrappers

- For each primitive data type there is a corresponding *wrapper class*. For example:

Primitive Type	Wrapper Class
`int`	`Integer`
`double`	`Double`
`char`	`Character`
`boolean`	`Boolean`

- Wrapper classes are useful in situations where you need an object instead of a primitive type

- They also contain some useful methods

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Variables

- A *variable* is an identifier that represents a location in memory that holds a particular type of data
- Variables must be declared before they can be used
- The syntax of a variable declaration is:

```
data-type variable-name;
```

- For example:

```
int total;
```


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Variables

- Multiple variables can be declared on the same line:

```
int total, count, sum;
```

- Variables can be *initialized* (given an initial value) in the declaration:

```
int total = 0, count = 20;

float unit_price = 57.25;
```

- See `Piano_Keys.java`

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Assignment Statements

- An assignment statement takes the following form:

```
variable-name = expression;
```

- The expression is evaluated and the result is stored in the variable, overwriting the value currently stored in the variable
- See `United_States.java`
- The expression can be a single value or a more complicated calculation

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Constants

- A constant is similar to a variable except that they keep the same value throughout their existence
- They are specified using the reserved word `final` in the declaration
- For example:

```
final double PI = 3.14159;

final int STUDENTS = 25;
```


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Constants

- When appropriate, constants are better than variables because:
  - they prevent inadvertent errors because their value cannot change
- They are better than literal values because:
  - they make code more readable by giving meaning to a value
  - they facilitate change because the value is only specified in one place

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Input and Output

- Java I/O is based on *input streams* and *output streams*
- There are three predefined standard streams:

Stream	Purpose	Default Device
`System.in`	reading input	keyboard
`System.out`	writing output	monitor
`System.err`	writing errors	monitor

- The `print` and `println` methods write to standard output

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Input and Output

- The Java API allows you to create many kinds of streams to perform various kinds of I/O
- To read character strings, we will convert the `System.in` stream to another kind of stream using:

```
BufferedReader stdin = new BufferedReader
    (new InputStreamReader (System.in));
```

- This declaration creates a new stream called `stdin`
- We will discuss object creation in more detail later

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Escape Sequences

- See `Echo.java`
- An *escape sequence* is a special sequence of characters preceded by a backslash (\)
- They indicate some special purpose, such as:

Escape Sequence	Meaning
`\t`	tab
`\n`	new line
`\"`	double quote
`\'`	single quote
`\\`	backslash

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Buffers

- As you type, the characters are stored in an *input buffer*
- When you press enter, the program begins processing the data
- Similarly, output information is temporarily stored in an *output buffer*
- The output buffer can be explicitly *flushed* (sent to the screen) using the `flush` method
- See `Python.java`

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Numeric Input

- Converting a string that holds an integer into the integer value can be done with a method in the `Integer` wrapper class:

```
value = Integer.parseInt (my_string);
```

- A value can be read and converted in one line:

```
num = Integer.parseInt (stdin.readLine());
```

- See `Addition.java` and `Addition2.java`

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Expressions

- An *expression* is a combination of operators and operands
- The arithmetic operators include addition (+), subtraction (–), multiplication (*), and division (/)
- Operands can be literal values, variables, or other sources of data
- The programmer determines what is done with the result of an expression (stored, printed, etc.)

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Division

- If the operands of the `/` operator are both integers, the result is an integer (the fractional part is truncated)
- If one or more operands to the `/` operator are floating point values, the result is a floating point value
- The remainder operator (`%`) returns the integer remainder after dividing the first operand by the second
- The operands to the `%` operator must be integers
- See `Division.java`
- The remainder result takes the sign of the numerator

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Division

Expression	Result
`17 / 5`	`3`
`17.0 / 5`	`3.4`
`17 / 5.0`	`3.4`
`9 / 12`	`0`
`9.0 / 12.0`	`0.75`
`6 % 2`	`0`
`14 % 5`	`4`
`-14 % 5`	`-4`

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Operator Precedence

- The order in which operands are evaluated in an expression is determined by a well-defined *precedence hierarchy*
- Operators at the same level of precedence are evaluated according to their *associativity* (right to left or left to right)
- Parentheses can be used to force precedence
- Appendix D contains a complete operator precedence chart for all Java operators

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Operator Precedence

- Multiplication, division, and remainder have a higher precedence than addition and subtraction
- Both groups associate left to right

Expression: `5 + 12 / 5 - 10 % 3`

Order of evaluation: 3 1 4 2

Result: 6

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Operator Precedence

Expression	Result
`2 + 3 * 4 / 2`	8
`3 * 13 + 2`	41
`(3 * 13) + 2`	41
`3 * (13 + 2)`	45
`4 * (11 - 6) * (-8 + 10)`	40
`(5 * (4 - 1)) / 2`	7

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The if Statement

- The Java *if statement* has the following syntax:

```
if (condition)
    statement;
```

- If the boolean condition is true, the statement is executed; if it is false, the statement is skipped
- This provides basic decision making capabilities

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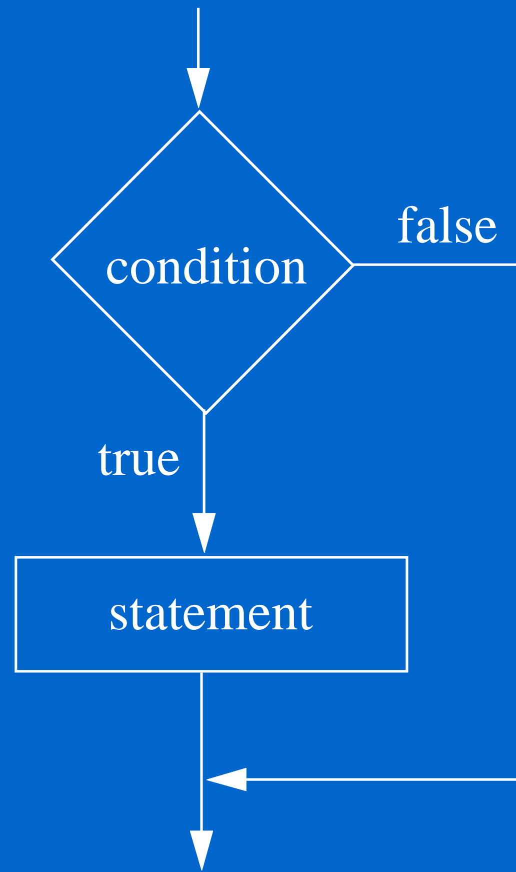
The if Statement



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Boolean Expressions

- The condition of an `if` statement must evaluate to a true or false result
- Java has several equality and relational operators:

Operator	Meaning
`==`	equal to
`!=`	not equal to
`<`	less than
`<=`	less than or equal to
`>`	greater than
`<=`	greater than or equal to

- See `Temperature.java`

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Block Statements

- Several statements can be grouped together into a *block statement*
- Blocks are delimited by braces
- A block statement can be used wherever a statement is called for in the Java syntax
- See `Temperature2.java`

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The if-else Statement

- An `else` clause can be added to an `if` statement to make it an *if-else statement*:

```
if (condition)
    statement1;
else
    statement2;
```

- If the condition is true, statement1 is executed; if the condition is false, statement2 is executed

- See `Temperature3.java` and `Right_Triangle.java`

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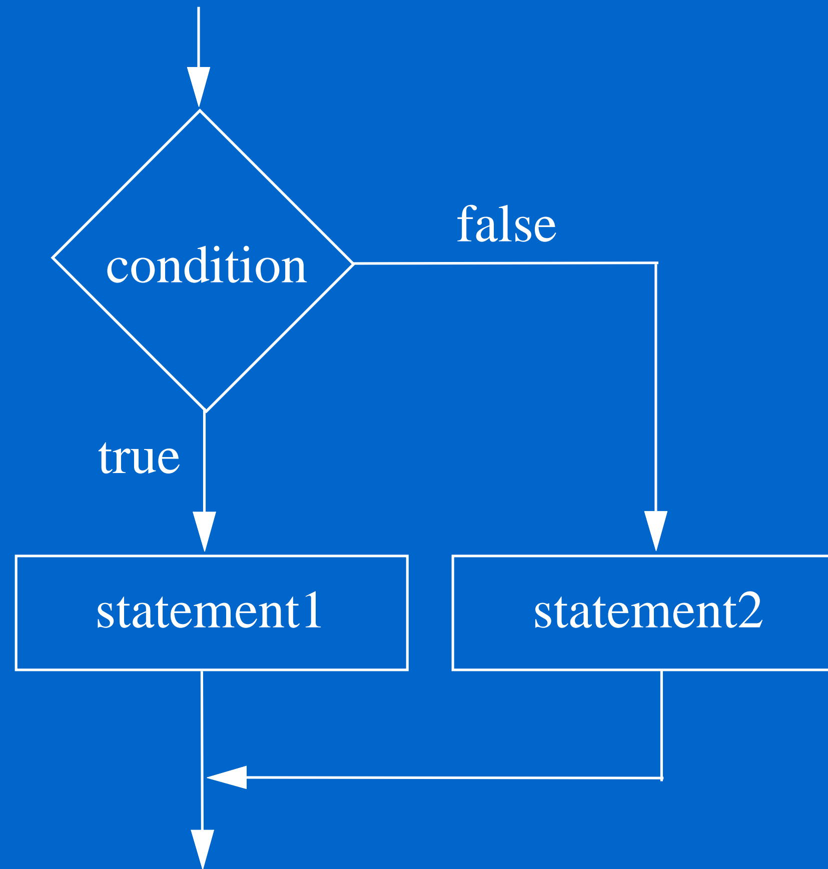
The if-else Statement



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Nested if Statements

- The body of an `if` statement or `else` clause can be another `if` statement
- These are called *nested if statements*
- See `Football_Choice.java`
- Note: an `else` clause is matched to the last unmatched `if` (no matter what the indentation implies)

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The while Statement

- A *while statement* has the following syntax:

```
while (condition)
    statement;
```

- If the condition is true, the statement is executed; then the condition is evaluated again
- The statement is executed over and over until the condition becomes false

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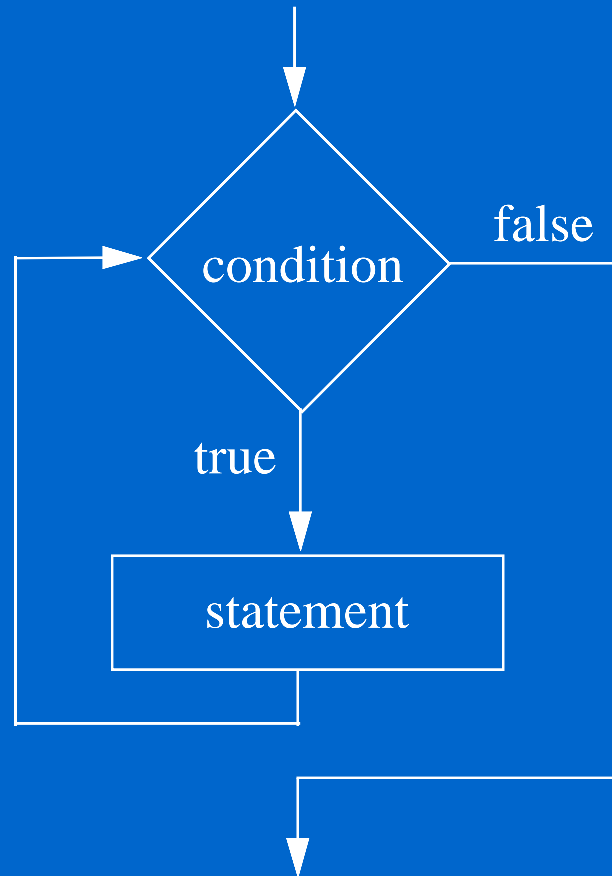
The while Statement



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The while Statement

- If the condition of a `while` statement is false initially, the statement is never executed
- Therefore, we say that a `while` statement executes zero or more times
- See `Counter.java`, `Factors.java`, and `Powers_of_Two.java`

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Infinite Loops

- The body of a `while` loop must eventually make the condition false
- If not, it is an *infinite loop*, which will execute until the user interrupts the program
- This is a common type of logical error -- always double check that your loops will terminate normally
- See `Forever.java`

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Program Development

- The creation of software involves four basic activities:
  - establishing the requirements
  - creating a design
  - implementing the code
  - testing the implementation

- The development process is much more involved that this, but these basic steps are a good starting point

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Requirements

- Requirements specify the tasks a program must accomplish (what to do, not how to do it)
- They often address the user interface
- An initial set of requirements are often provided, but usually must be critiqued, modified, and expanded
- It is often difficult to establish detailed, unambiguous, complete requirements
- Careful attention to the requirements can save significant time and money in the overall project

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Design

- A program follows an *algorithm*, which is a step-by-step process for solving a problem
- The design specifies the algorithms and data needed
- In object-oriented development, it establishes the classes, objects, and methods that are required
- The details of a method may be expressed in *pseudocode*, which is code-like, but does not necessarily follow any specific syntax

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Implementation

- Implementation is the process of translating a design into source code
- Most novice programmers think that writing code is the heart of software development, but it actually should be the least creative
- Almost all important decisions are made during requirements analysis and design
- Implementation should focus on coding details, including style guidelines and documentation

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Testing

- A program should be executed multiple times with various input in an attempt to find errors
- *Debugging* is the process of discovering the cause of a problem and fixing it
- Programmers often erroneously think that there is "only one more bug" to fix
- Tests should focus on design details as well as overall requirements

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Program Development

- See `Average.java`
- Follow the process of requirements analysis, design, implementation, and testing
- There are always multiple ways to design and implement a program
- Any design has advantages and disadvantages; there are always trade-offs
- See `Average2.java`

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