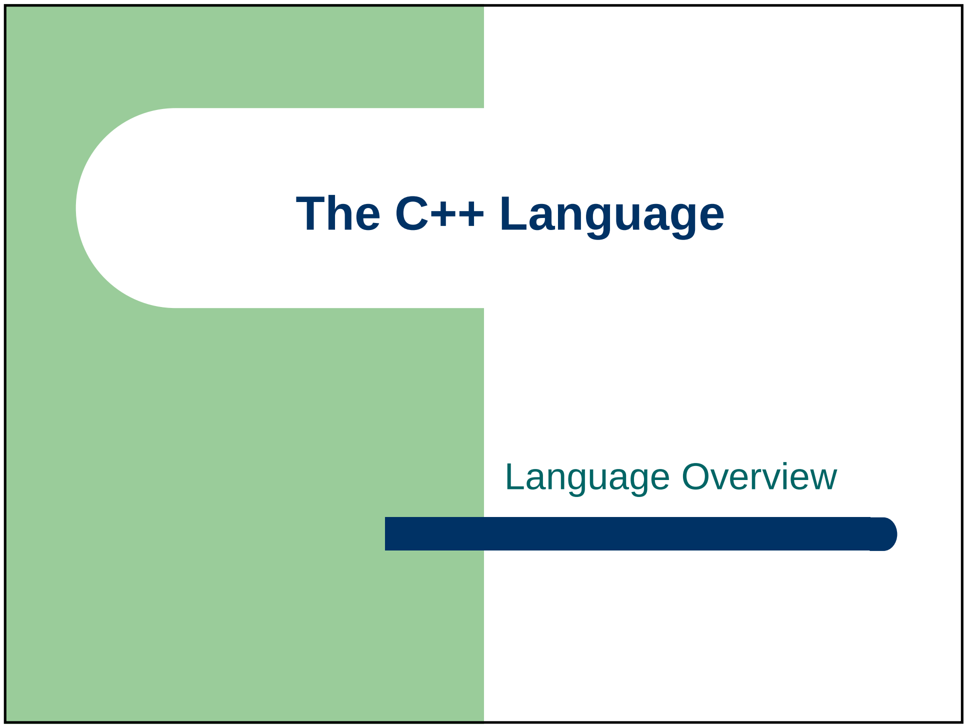
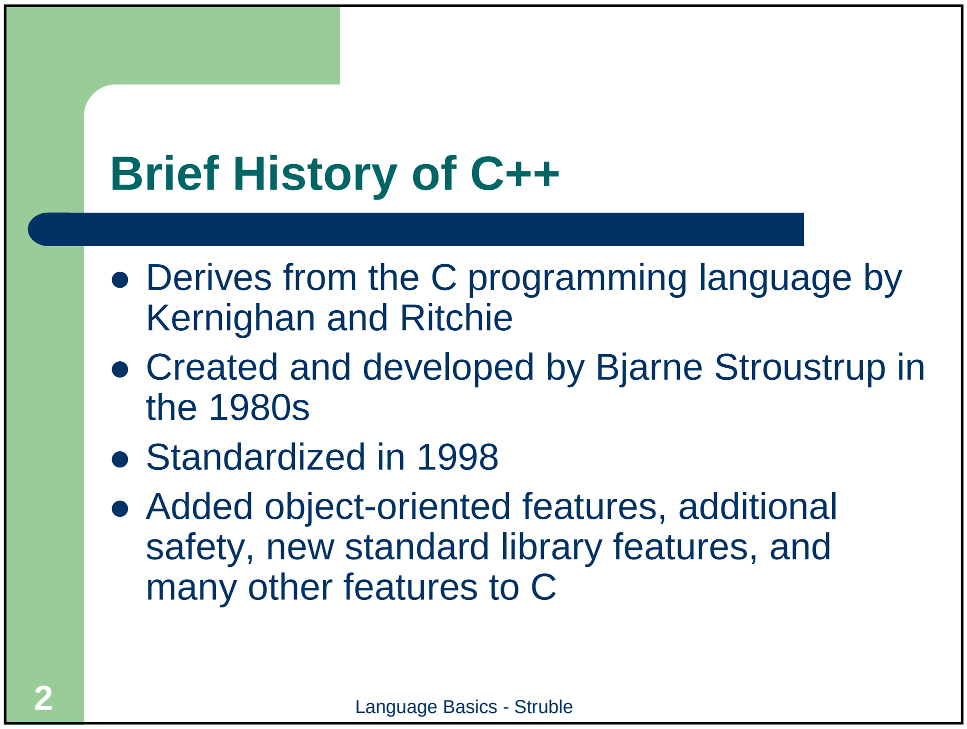


The C++ Language

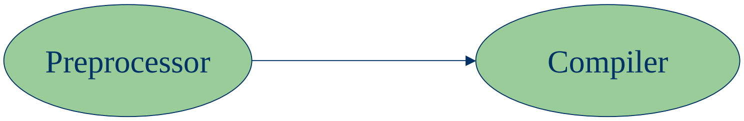
Language Overview



Brief History of C++

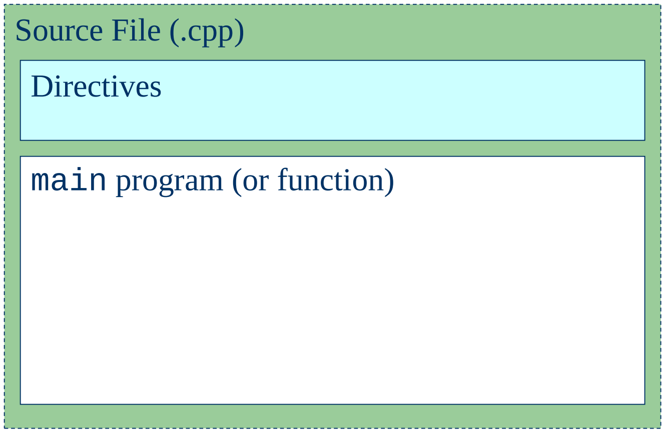
- Derives from the C programming language by Kernighan and Ritchie
- Created and developed by Bjarne Stroustrup in the 1980s
- Standardized in 1998
- Added object-oriented features, additional safety, new standard library features, and many other features to C

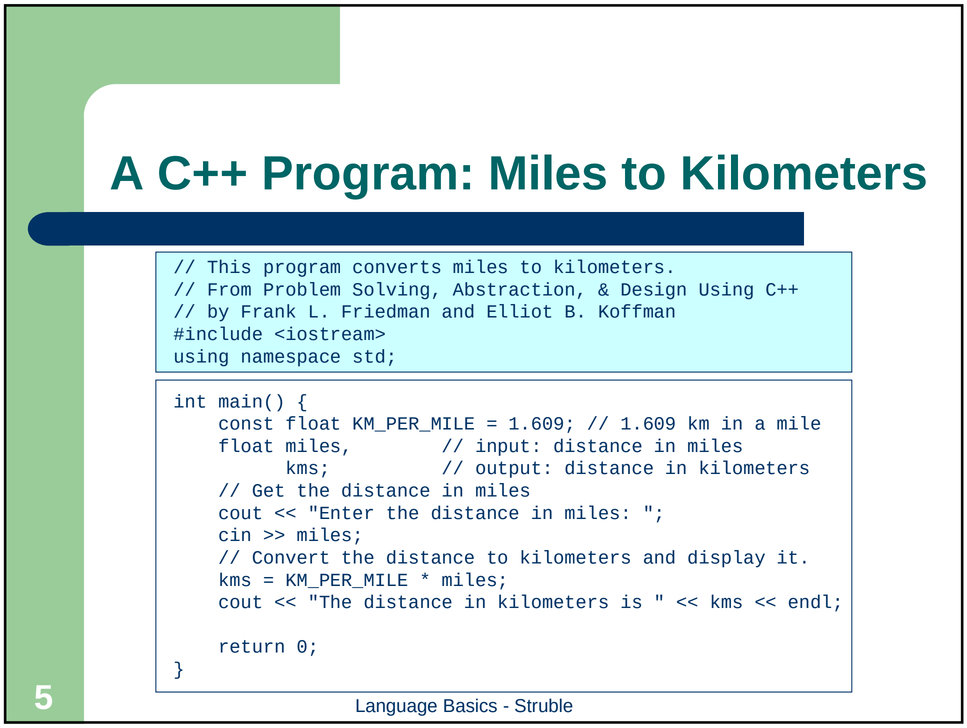
The C++ Compiler



- The *preprocessor* …
  - Incorporates standard C++ features into your computer program.
  - Interprets *directives* given by the C++ programmer

C++ Program Structure



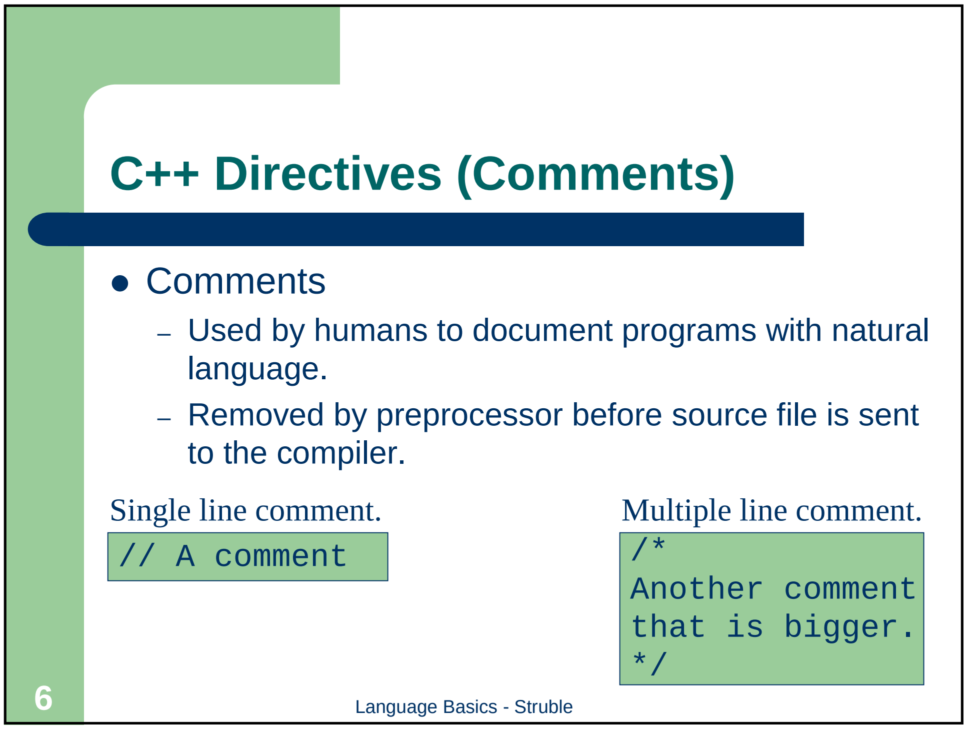


A C++ Program: Miles to Kilometers

```
// This program converts miles to kilometers.
// From Problem Solving, Abstraction, & Design Using C++
// by Frank L. Friedman and Elliot B. Koffman
#include <iostream>
using namespace std;
```

```
int main() {
    const float KM_PER_MILE = 1.609; // 1.609 km in a mile
    float miles,        // input: distance in miles
          kms;          // output: distance in kilometers
    // Get the distance in miles
    cout << "Enter the distance in miles: ";
    cin >> miles;
    // Convert the distance to kilometers and display it.
    kms = KM_PER_MILE * miles;
    cout << "The distance in kilometers is " << kms << endl;

    return 0;
}
```



C++ Directives (Comments)

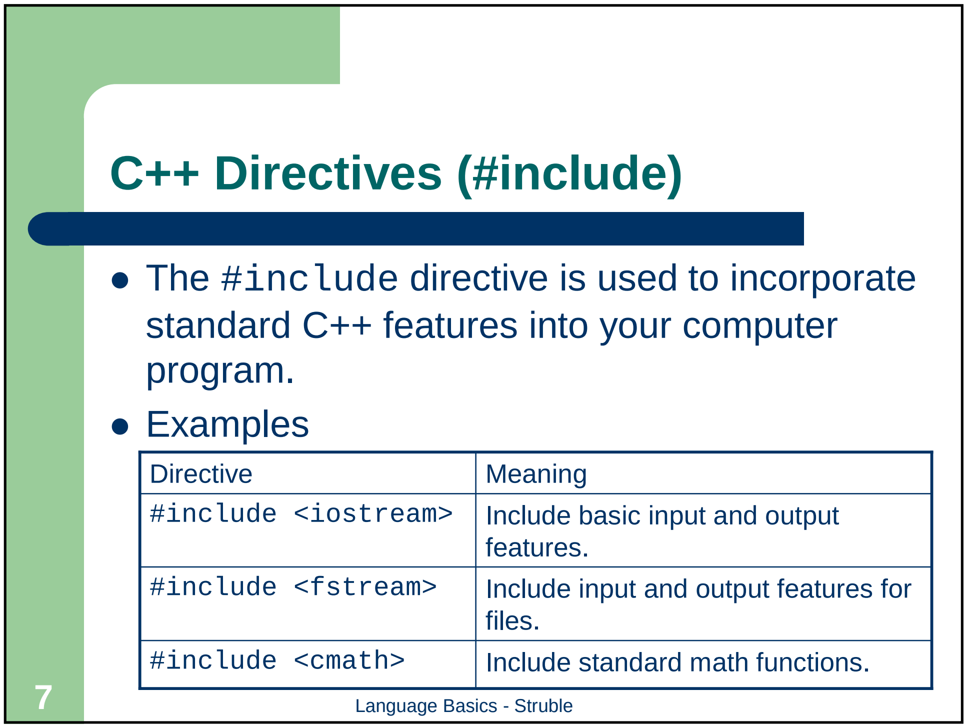
- Comments
  - Used by humans to document programs with natural language.
  - Removed by preprocessor before source file is sent to the compiler.

Single line comment.

```
// A comment
```

Multiple line comment.

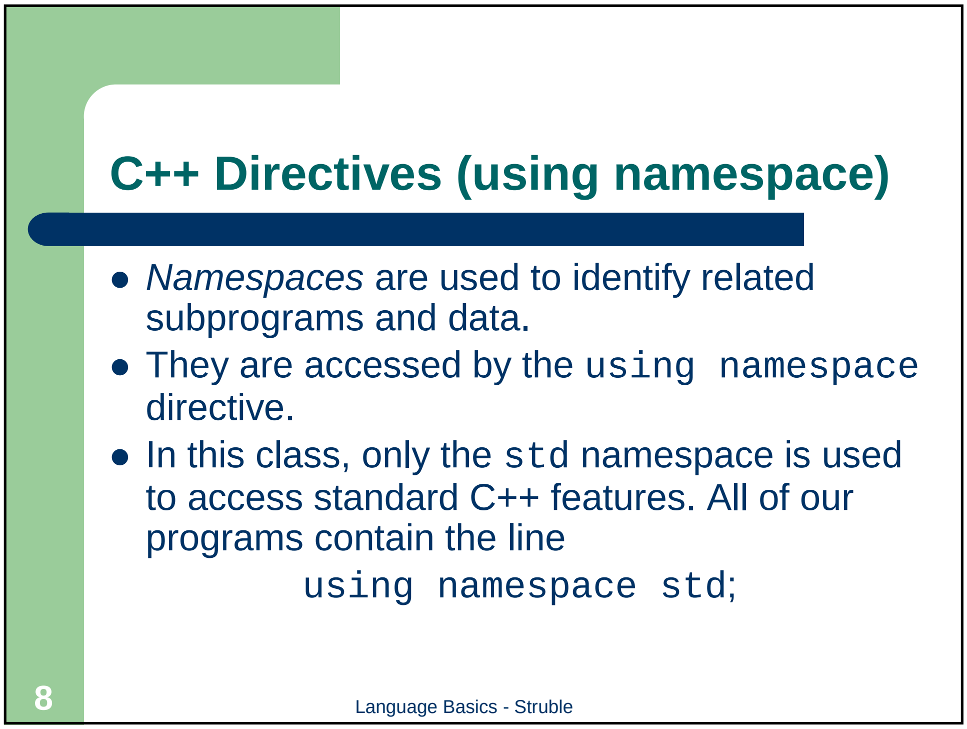
```
/*
Another comment
that is bigger.
*/
```



C++ Directives (#include)

- The `#include` directive is used to incorporate standard C++ features into your computer program.
- Examples

Directive	Meaning
`#include <iostream>`	Include basic input and output features.
`#include <fstream>`	Include input and output features for files.
`#include <cmath>`	Include standard math functions.



C++ Directives (using namespace)

- *Namespaces* are used to identify related subprograms and data.
- They are accessed by the `using namespace` directive.
- In this class, only the `std` namespace is used to access standard C++ features. All of our programs contain the line

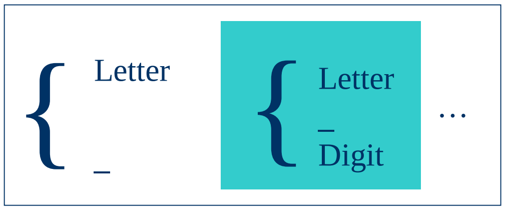
```
        using namespace std;
```

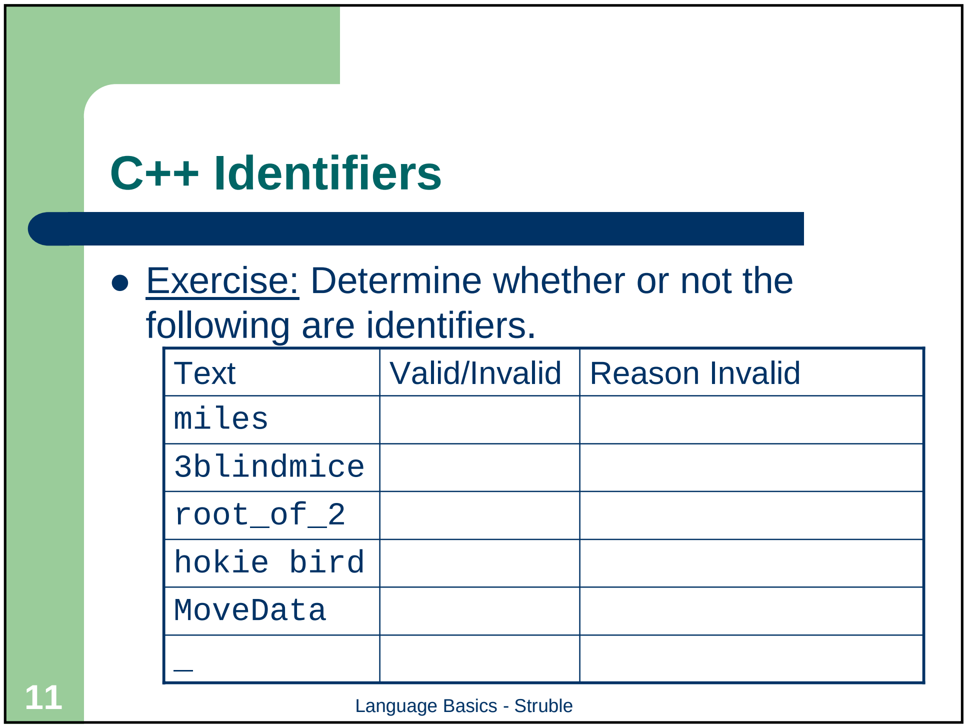
C++ Directives (Example)

```
// This program converts miles to …
// From Problem Solving, Abstraction, …
// by Frank L. Friedman and Elliot …
#include <iostream>
using namespace std;
```

C++ Identifiers

- *Identifiers* are used to name functions (subprograms) and data.
- Starts with a letter or underscore (_), followed by zero or more letters, digits, or underscores
- Syntax template





C++ Identifiers

- Exercise: Determine whether or not the following are identifiers.

Text	Valid/Invalid	Reason Invalid
`miles`		
`3blindmice`		
`root_of_2`		
`hokie bird`		
`MoveData`		
`_`		

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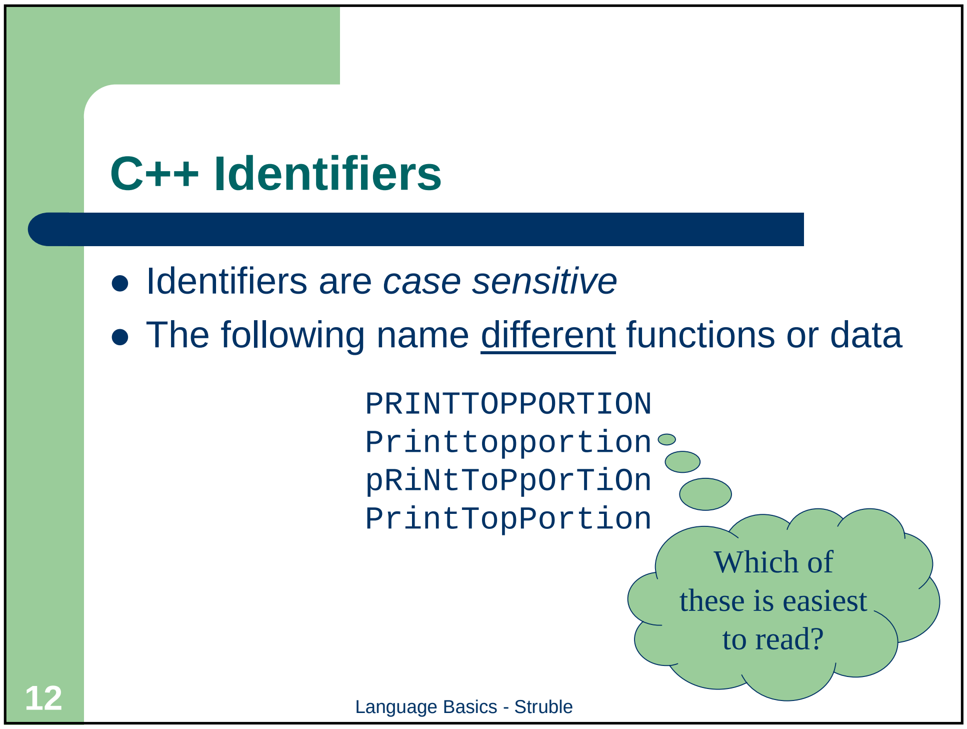

C++ Identifiers

- Identifiers are *case sensitive*
- The following name different functions or data

```
PRINTTOPPORTION
Printtopportion
pRiNtToPpOrTiOn
PrintTopPortion
```

Which of these is easiest to read?

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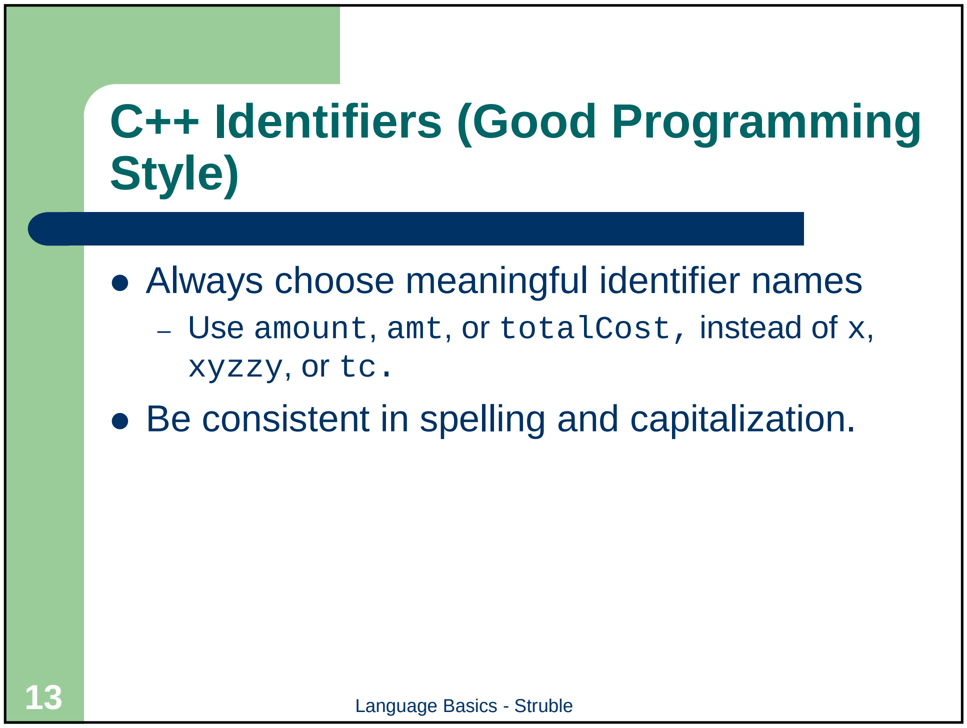
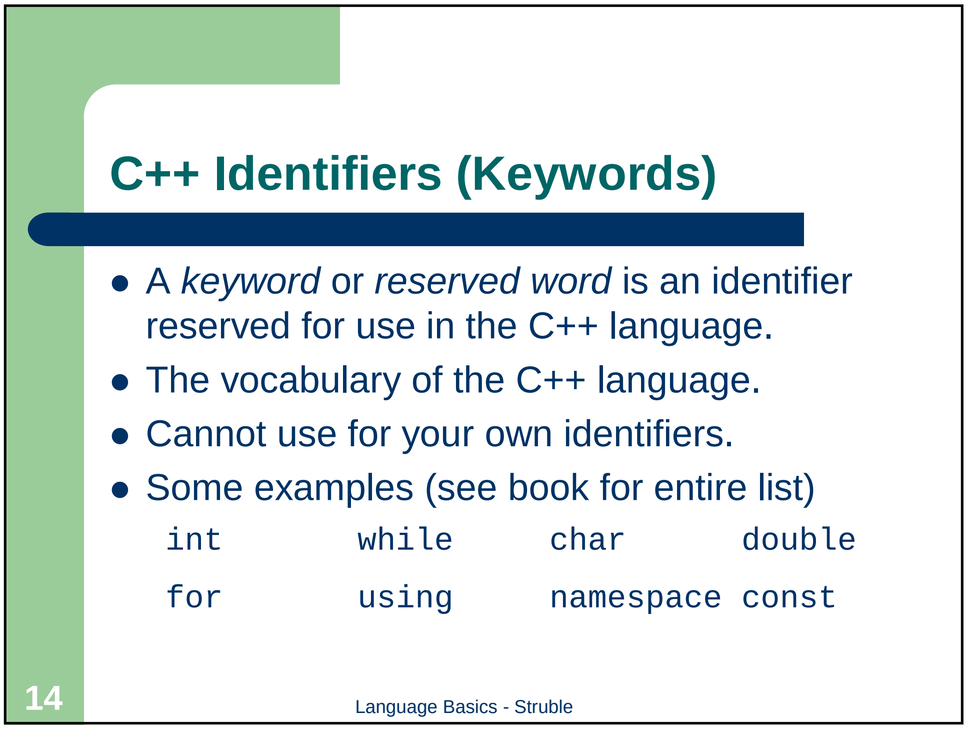


C++ Identifiers (Good Programming Style)

- Always choose meaningful identifier names
  - Use `amount`, `amt`, or `totalCost,` instead of `x`, `xyzzy`, or `tc.`
- Be consistent in spelling and capitalization.



C++ Identifiers (Keywords)

- A *keyword* or *reserved word* is an identifier reserved for use in the C++ language.
- The vocabulary of the C++ language.
- Cannot use for your own identifiers.
- Some examples (see book for entire list)

```
int       while     char      double
for       using     namespace const
```

Main Program

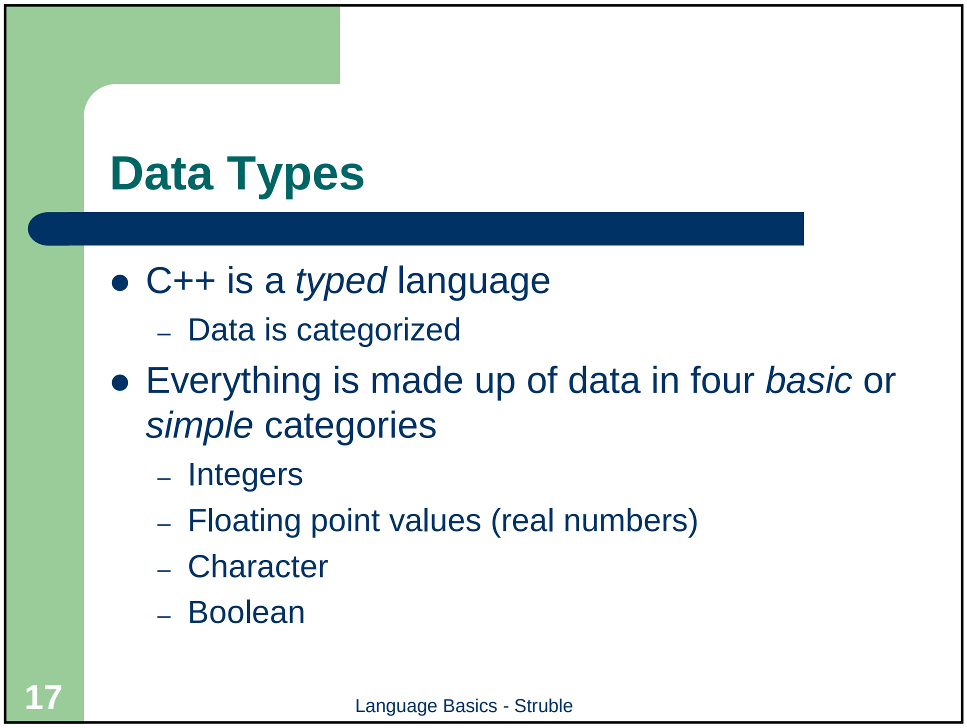
- Starting point for C++ programs
- A collection of sequential statements
- Syntax template

```
int main() {
      Statement
       …
}
```

Main Program (Example)

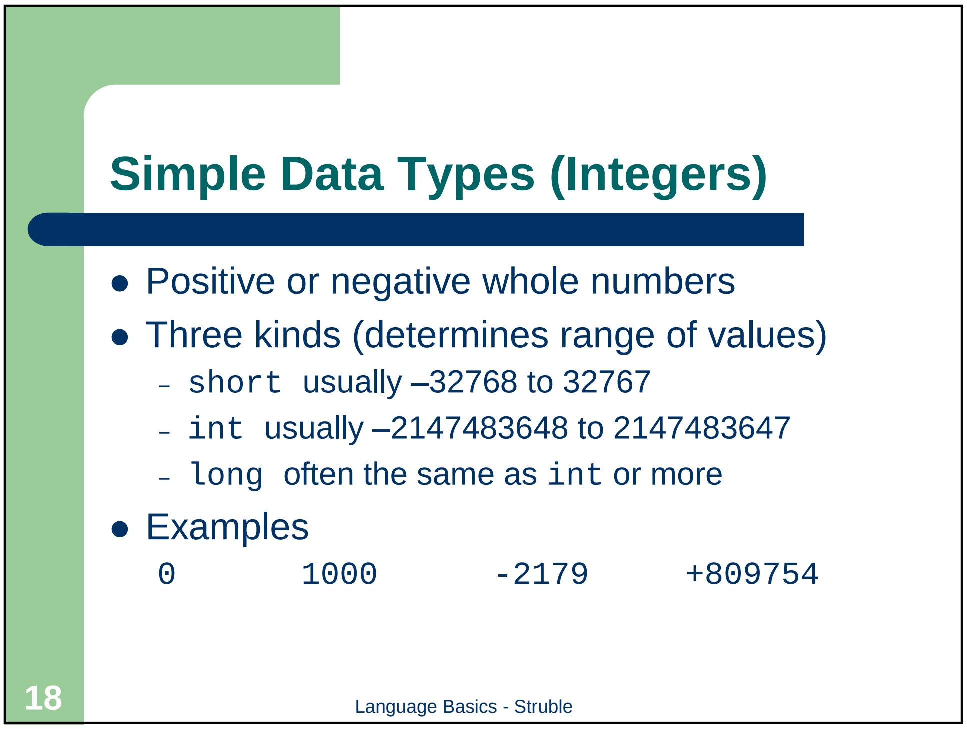
```
int main() {
    const float KM_PER_MILE = 1.609; // 1.609 km in a mile
    float miles,        // input: distance in miles
          kms;          // output: distance in kilometers
    // Get the distance in miles
    cout << "Enter the distance in miles: ";
    cin >> miles;
    // Convert the distance to kilometers and display it.
    kms = KM_PER_MILE * miles;
    cout << "The distance in kilometers is " << kms << endl;

    return 0;
}
```



Data Types

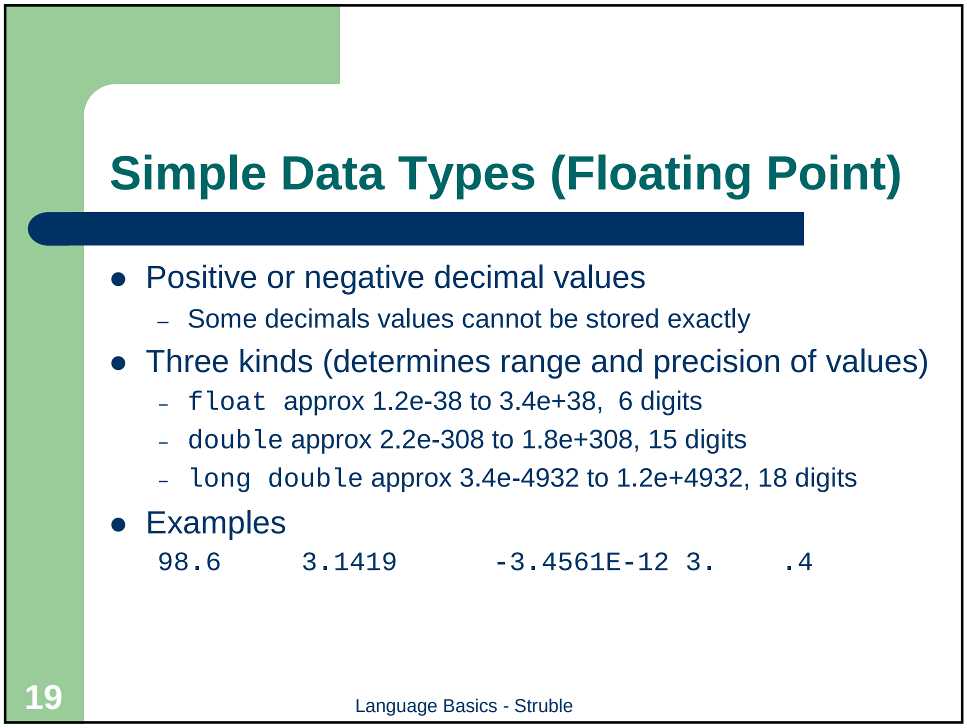
- C++ is a *typed* language
  - Data is categorized
- Everything is made up of data in four *basic* or *simple* categories
  - Integers
  - Floating point values (real numbers)
  - Character
  - Boolean



Simple Data Types (Integers)

- Positive or negative whole numbers
- Three kinds (determines range of values)
  - `short` usually –32768 to 32767
  - `int` usually –2147483648 to 2147483647
  - `long` often the same as `int` or more
- Examples

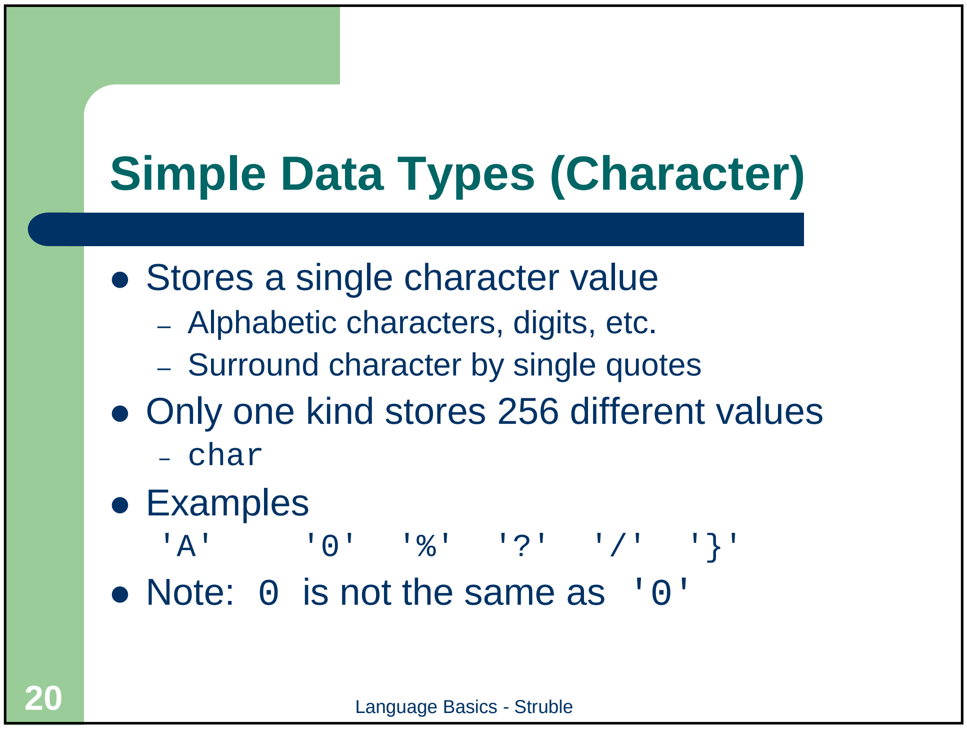
```
0       1000      -2179     +809754
```



Simple Data Types (Floating Point)

- Positive or negative decimal values
  - Some decimals values cannot be stored exactly
- Three kinds (determines range and precision of values)
  - `float` approx 1.2e-38 to 3.4e+38, 6 digits
  - `double` approx 2.2e-308 to 1.8e+308, 15 digits
  - `long double` approx 3.4e-4932 to 1.2e+4932, 18 digits
- Examples

```
98.6     3.1419      -3.4561E-12 3.    .4
```

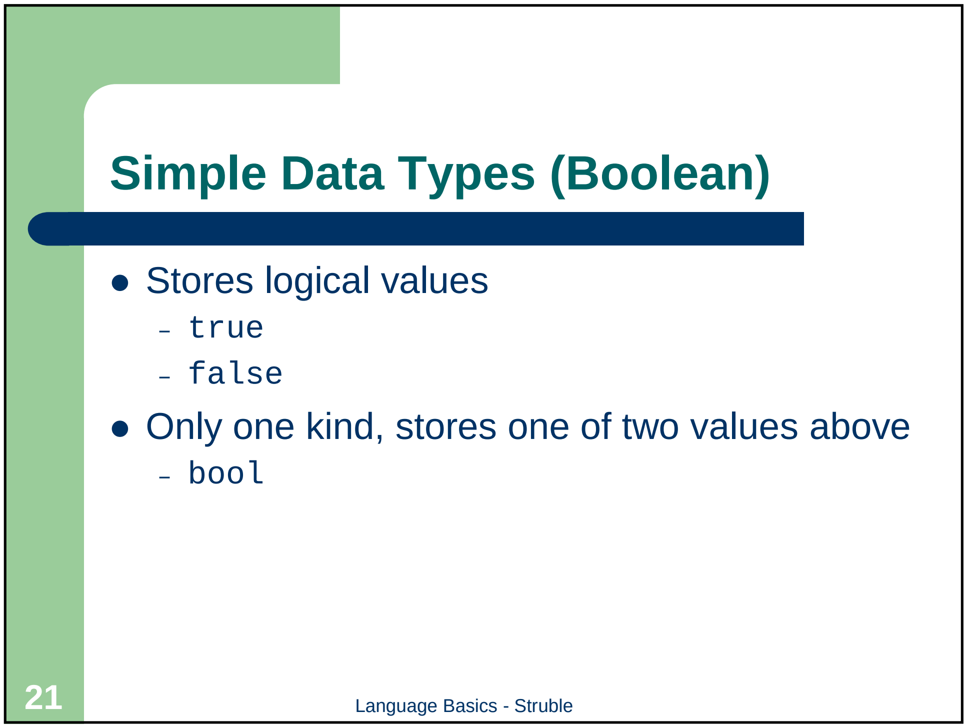


Simple Data Types (Character)

- Stores a single character value
  - Alphabetic characters, digits, etc.
  - Surround character by single quotes
- Only one kind stores 256 different values
  - `char`
- Examples

```
'A'     '0'   '%'   '?'   '/'   '}'
```

- Note: `0` is not the same as `'0'`



Simple Data Types (Boolean)

- Stores logical values
  - `true`
  - `false`
- Only one kind, stores one of two values above
  - `bool`

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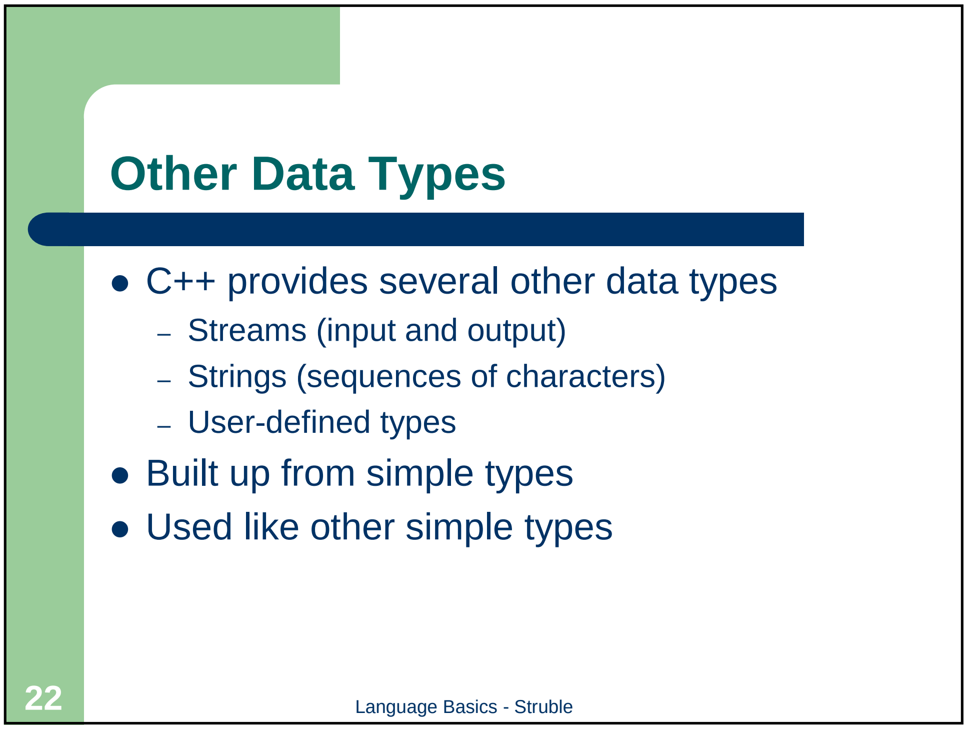
Language Basics - Struble



Other Data Types

- C++ provides several other data types
  - Streams (input and output)
  - Strings (sequences of characters)
  - User-defined types
- Built up from simple types
- Used like other simple types

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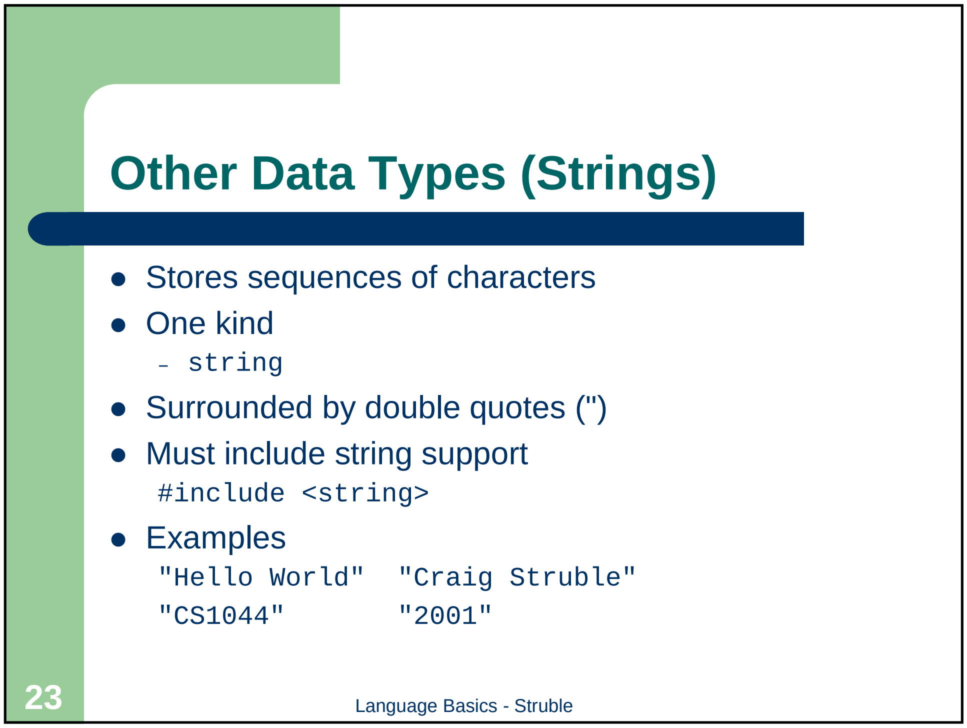
Language Basics - Struble



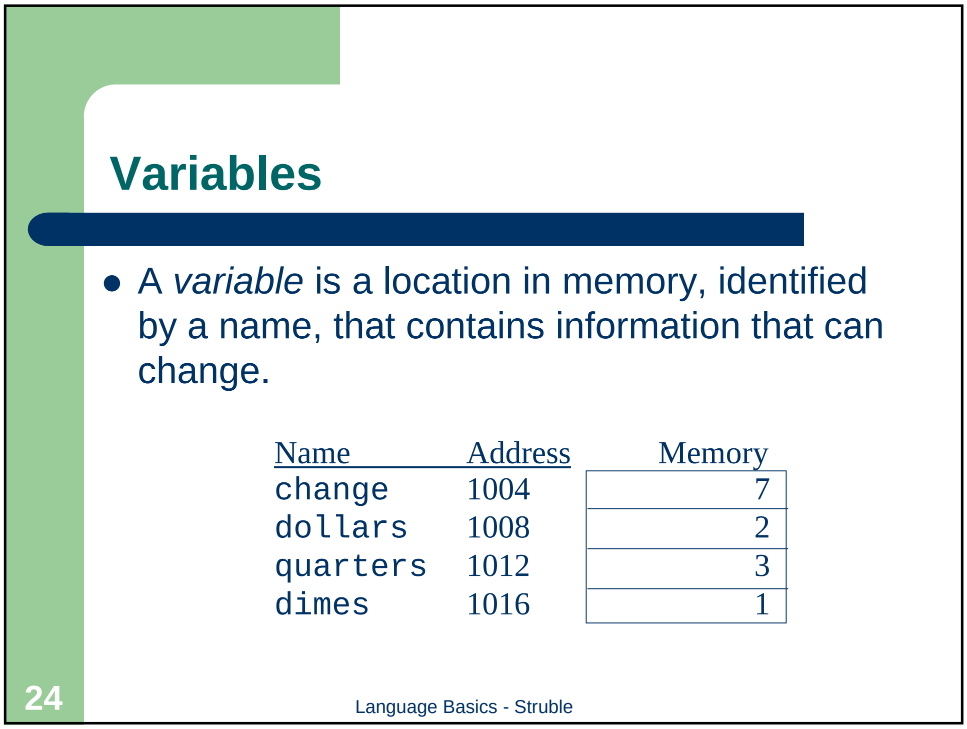
Other Data Types (Strings)

- Stores sequences of characters
- One kind
  - `string`
- Surrounded by double quotes (")
- Must include string support

```
#include <string>
```

- Examples

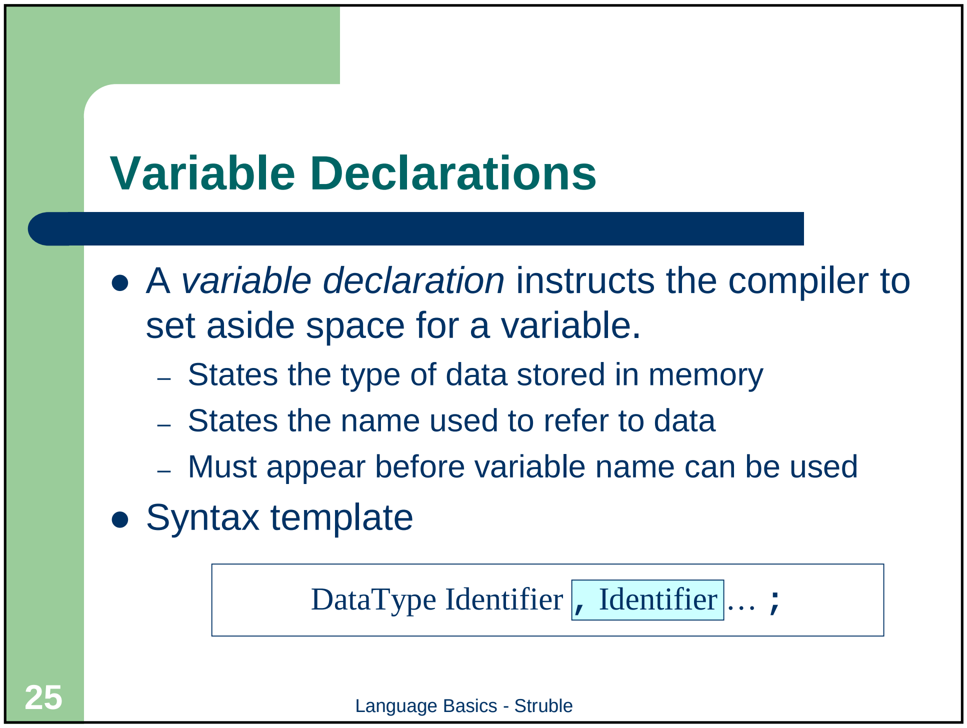
```
"Hello World"  "Craig Struble"
"CS1044"       "2001"
```



Variables

- A *variable* is a location in memory, identified by a name, that contains information that can change.

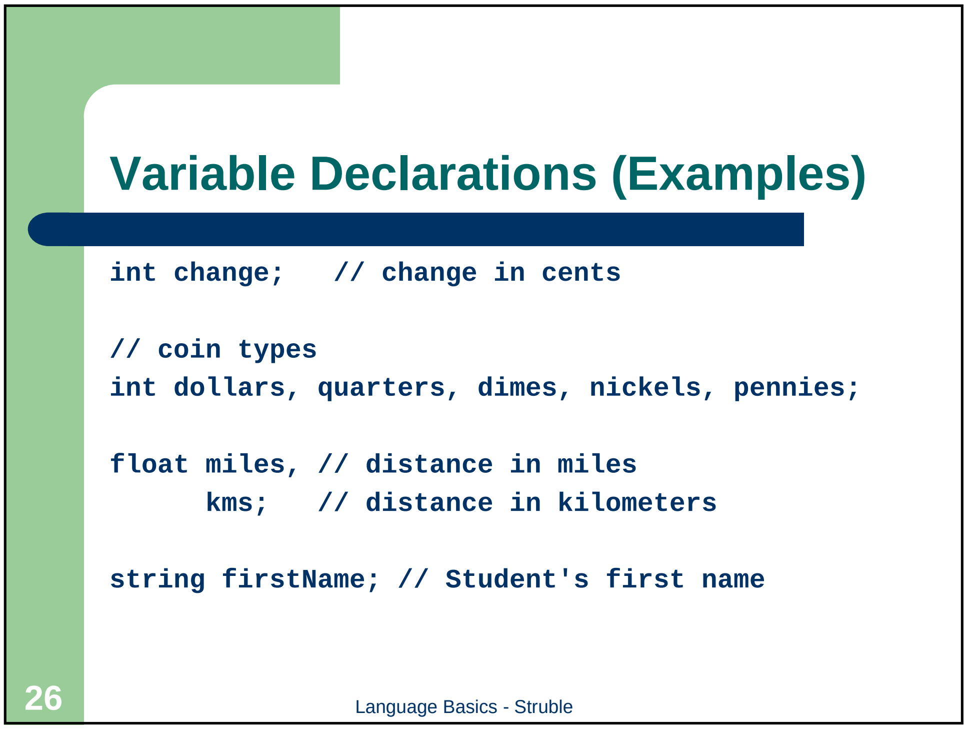
Name	Address	Memory
`change`	1004	7
`dollars`	1008	2
`quarters`	1012	3
`dimes`	1016	1



Variable Declarations

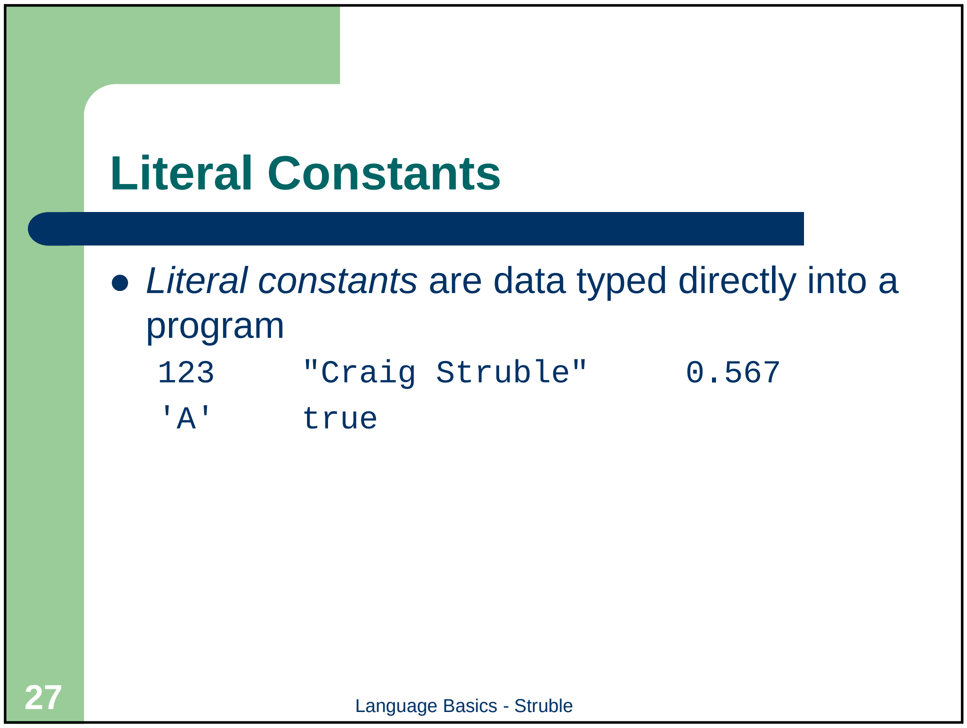
- A *variable declaration* instructs the compiler to set aside space for a variable.
  - States the type of data stored in memory
  - States the name used to refer to data
  - Must appear before variable name can be used
- Syntax template

DataType Identifier , Identifier … ;



Variable Declarations (Examples)

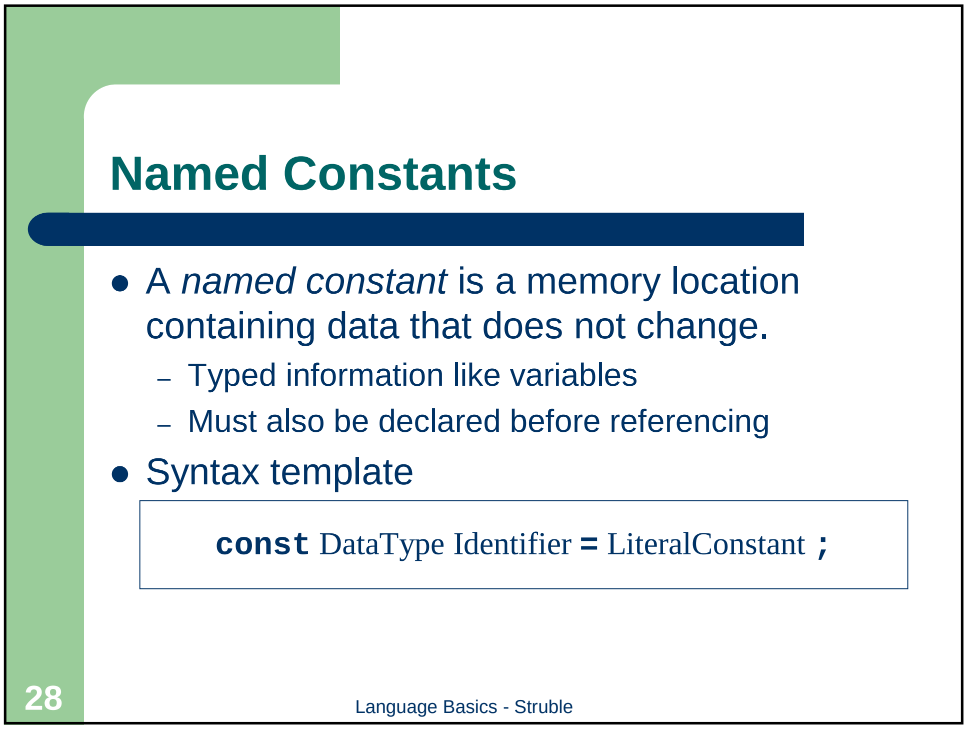
```
int change;    // change in cents

// coin types
int dollars, quarters, dimes, nickels, pennies;

float miles, // distance in miles
      kms;   // distance in kilometers

string firstName; // Student's first name
```



Literal Constants

- *Literal constants* are data typed directly into a program

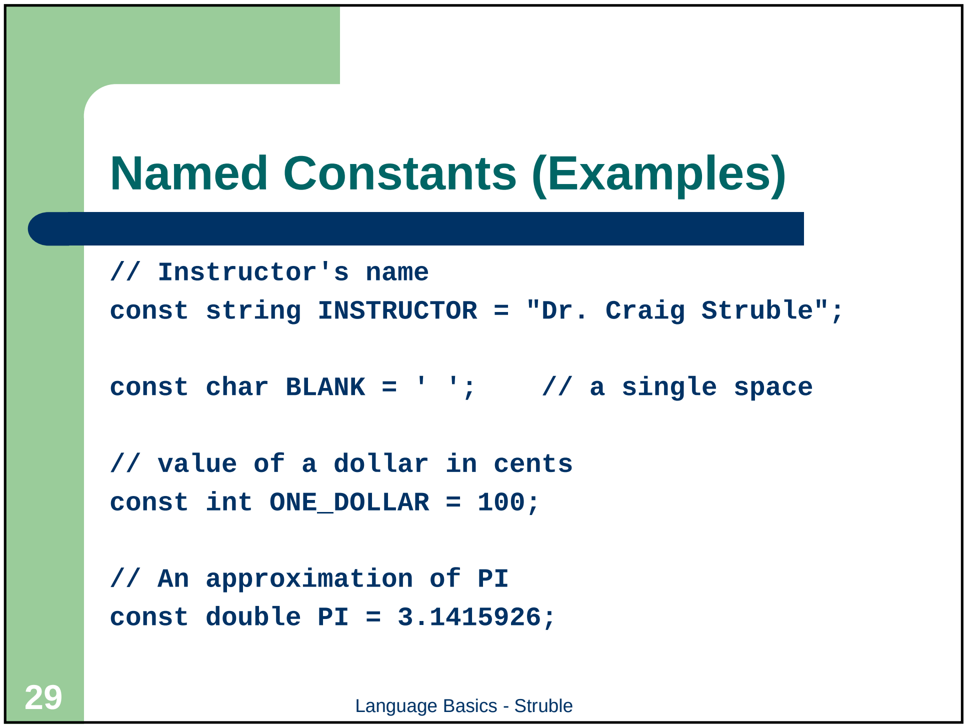
```
123     "Craig Struble"     0.567
'A'     true
```



Named Constants

- A *named constant* is a memory location containing data that does not change.
  - Typed information like variables
  - Must also be declared before referencing
- Syntax template

```
const DataType Identifier = LiteralConstant ;
```



Named Constants (Examples)

```
// Instructor's name
const string INSTRUCTOR = "Dr. Craig Struble";

const char BLANK = ' ';    // a single space

// value of a dollar in cents
const int ONE_DOLLAR = 100;

// An approximation of PI
const double PI = 3.1415926;
```

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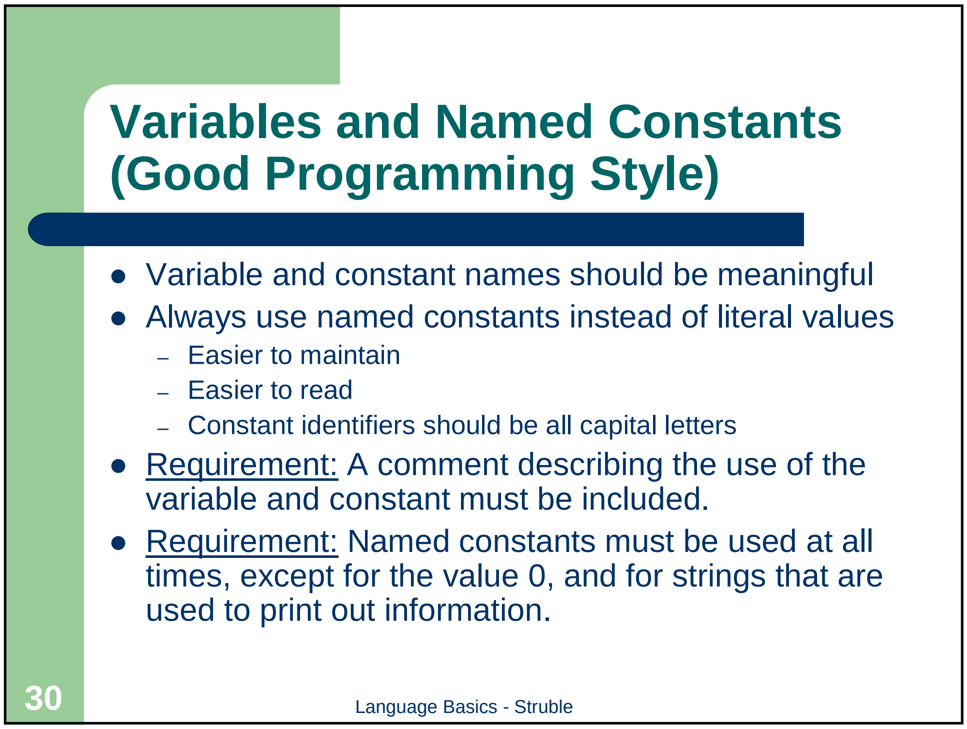
Language Basics - Struble



Variables and Named Constants (Good Programming Style)

- Variable and constant names should be meaningful
- Always use named constants instead of literal values
  - Easier to maintain
  - Easier to read
  - Constant identifiers should be all capital letters
- Requirement: A comment describing the use of the variable and constant must be included.
- Requirement: Named constants must be used at all times, except for the value 0, and for strings that are used to print out information.

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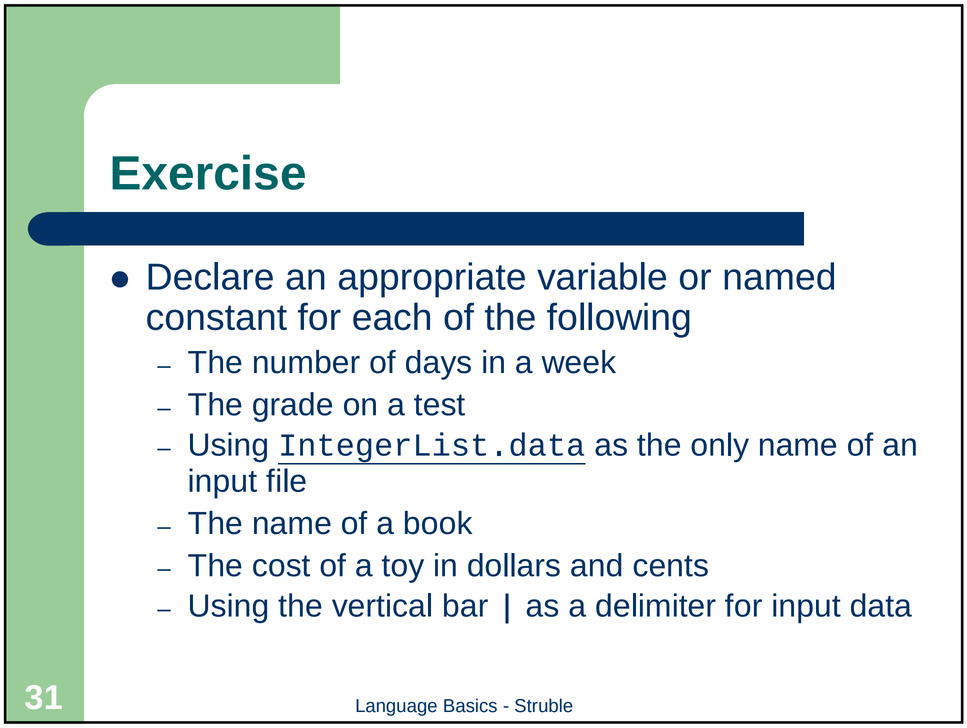
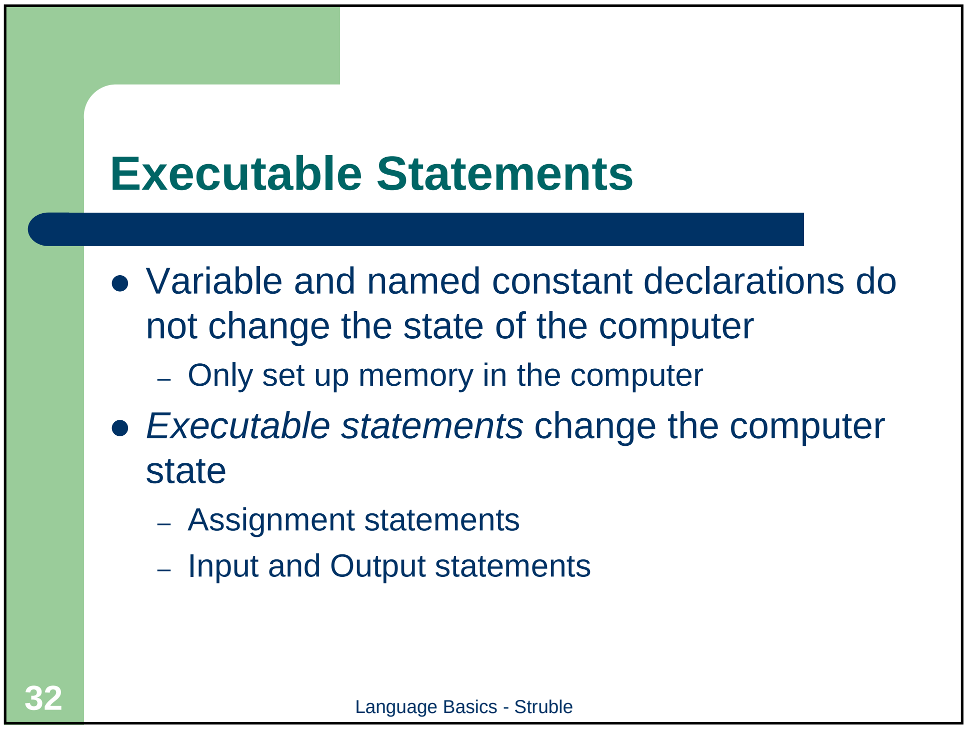
Language Basics - Struble



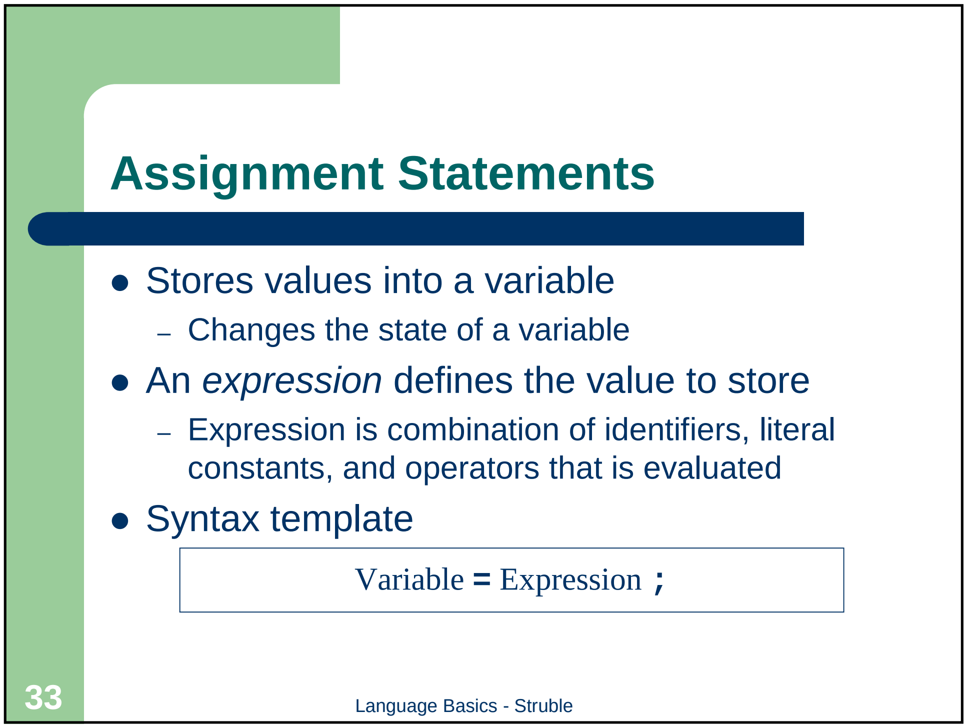
Exercise

- Declare an appropriate variable or named constant for each of the following
  - The number of days in a week
  - The grade on a test
  - Using `IntegerList.data` as the only name of an input file
  - The name of a book
  - The cost of a toy in dollars and cents
  - Using the vertical bar **|** as a delimiter for input data



Executable Statements

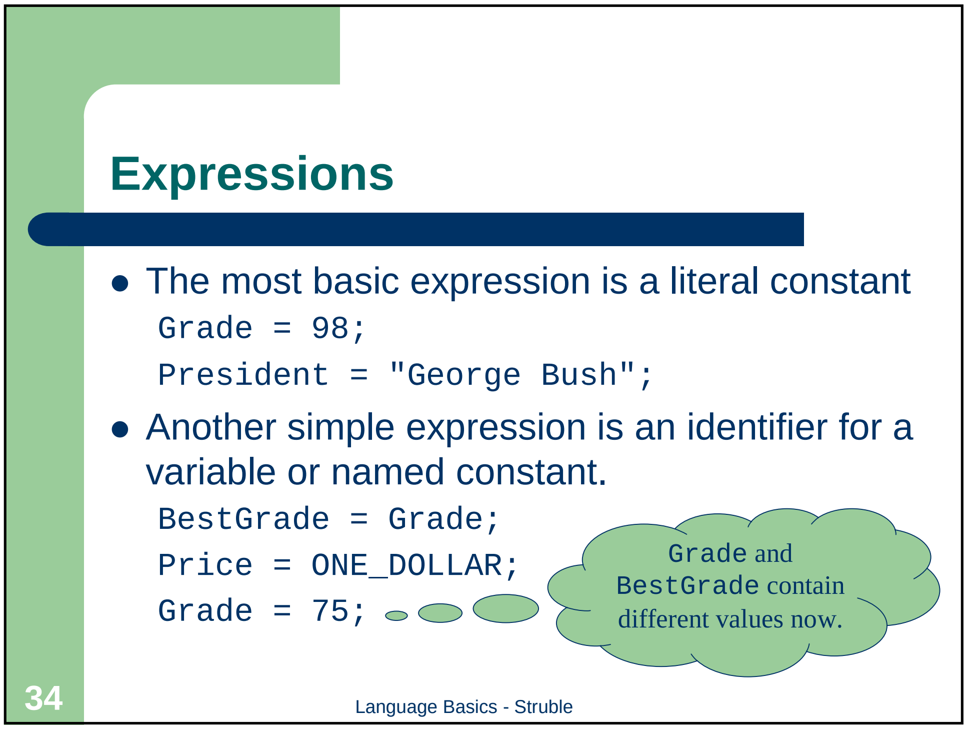
- Variable and named constant declarations do not change the state of the computer
  - Only set up memory in the computer
- *Executable statements* change the computer state
  - Assignment statements
  - Input and Output statements



Assignment Statements

- Stores values into a variable
  - Changes the state of a variable
- An *expression* defines the value to store
  - Expression is combination of identifiers, literal constants, and operators that is evaluated
- Syntax template

```
Variable = Expression ;
```



Expressions

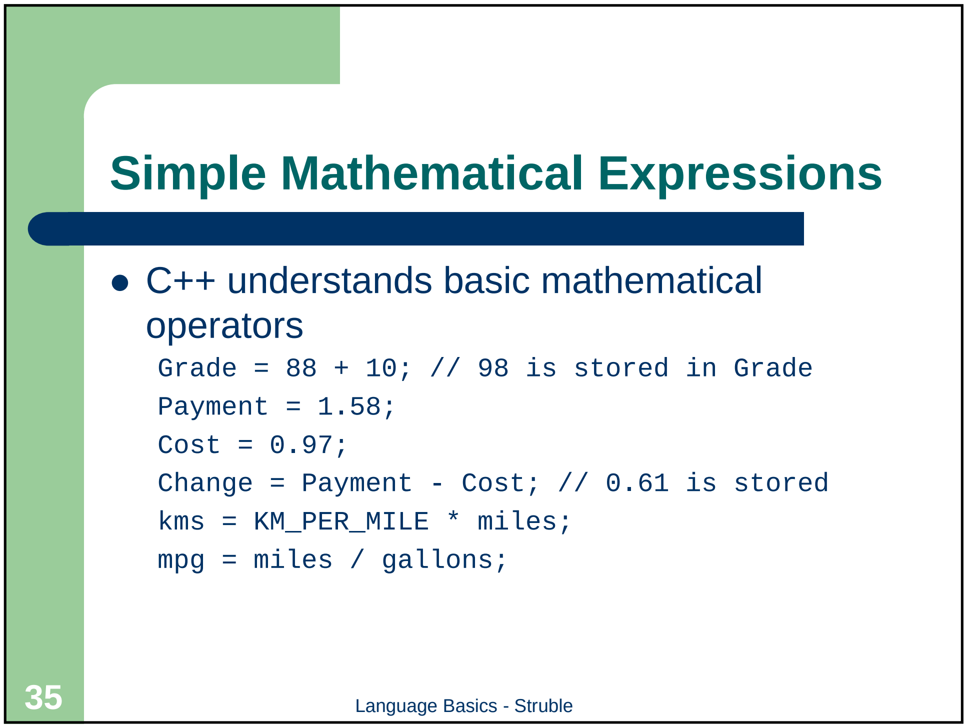
- The most basic expression is a literal constant

```
Grade = 98;
President = "George Bush";
```

- Another simple expression is an identifier for a variable or named constant.

```
BestGrade = Grade;
Price = ONE_DOLLAR;
Grade = 75;
```

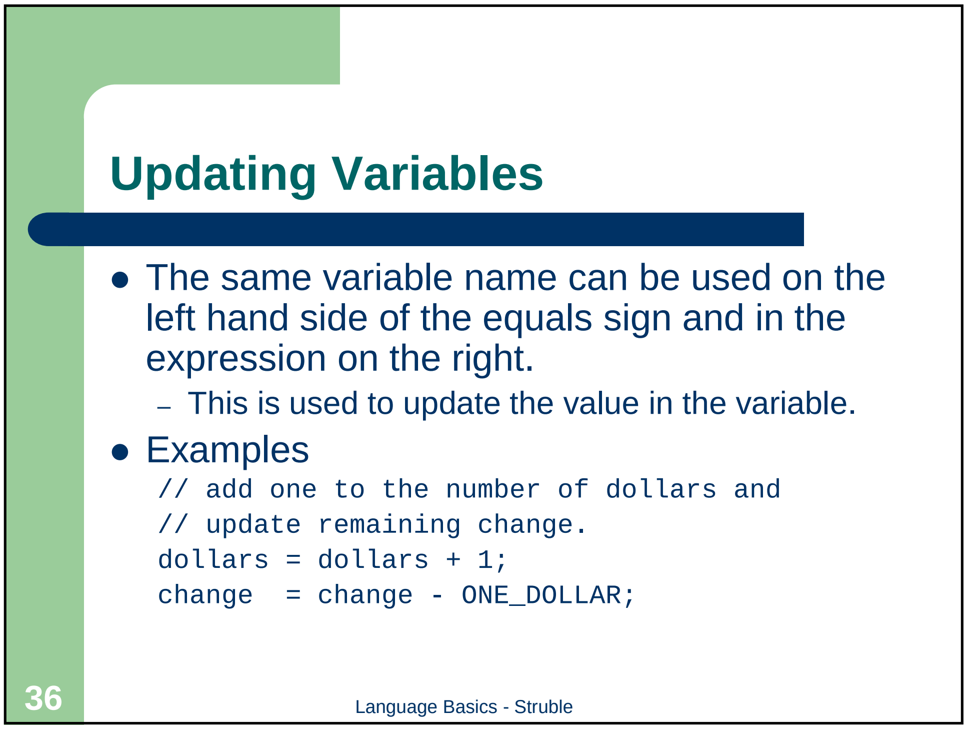
`Grade` and `BestGrade` contain different values now.



Simple Mathematical Expressions

- C++ understands basic mathematical operators

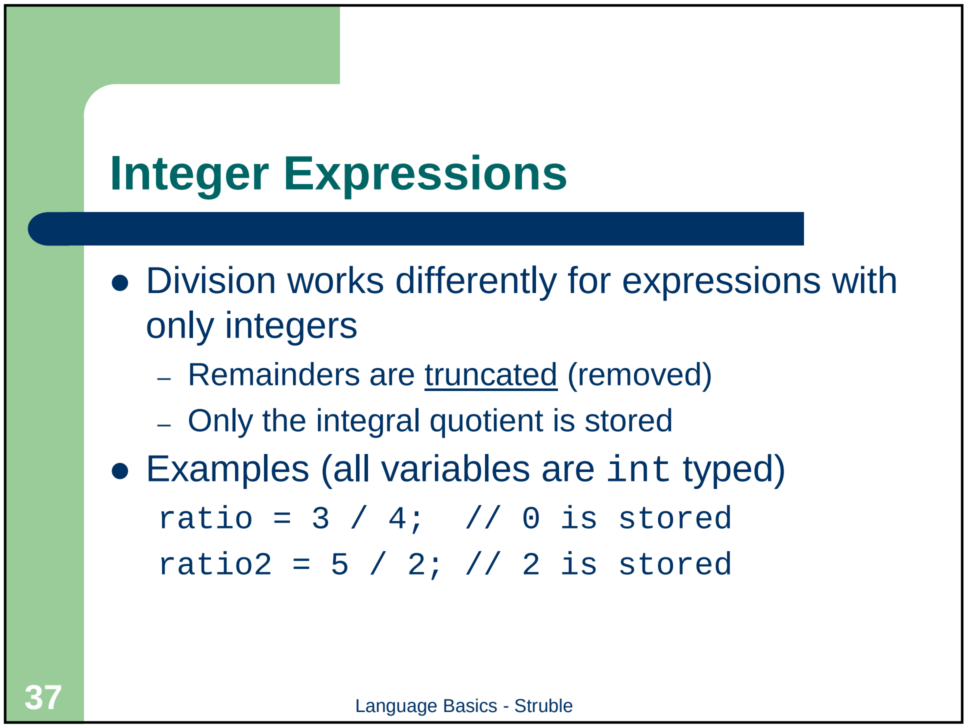
```
Grade = 88 + 10; // 98 is stored in Grade
Payment = 1.58;
Cost = 0.97;
Change = Payment - Cost; // 0.61 is stored
kms = KM_PER_MILE * miles;
mpg = miles / gallons;
```



Updating Variables

- The same variable name can be used on the left hand side of the equals sign and in the expression on the right.
  - This is used to update the value in the variable.
- Examples

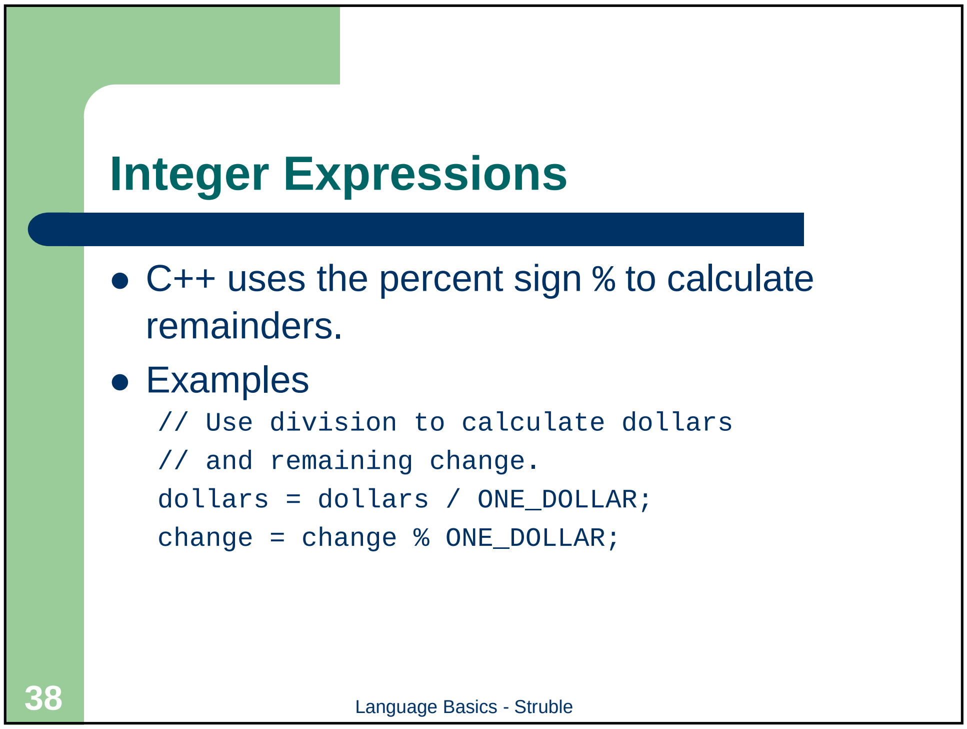
```
// add one to the number of dollars and
// update remaining change.
dollars = dollars + 1;
change  = change - ONE_DOLLAR;
```



Integer Expressions

- Division works differently for expressions with only integers
  - Remainders are truncated (removed)
  - Only the integral quotient is stored
- Examples (all variables are `int` typed)

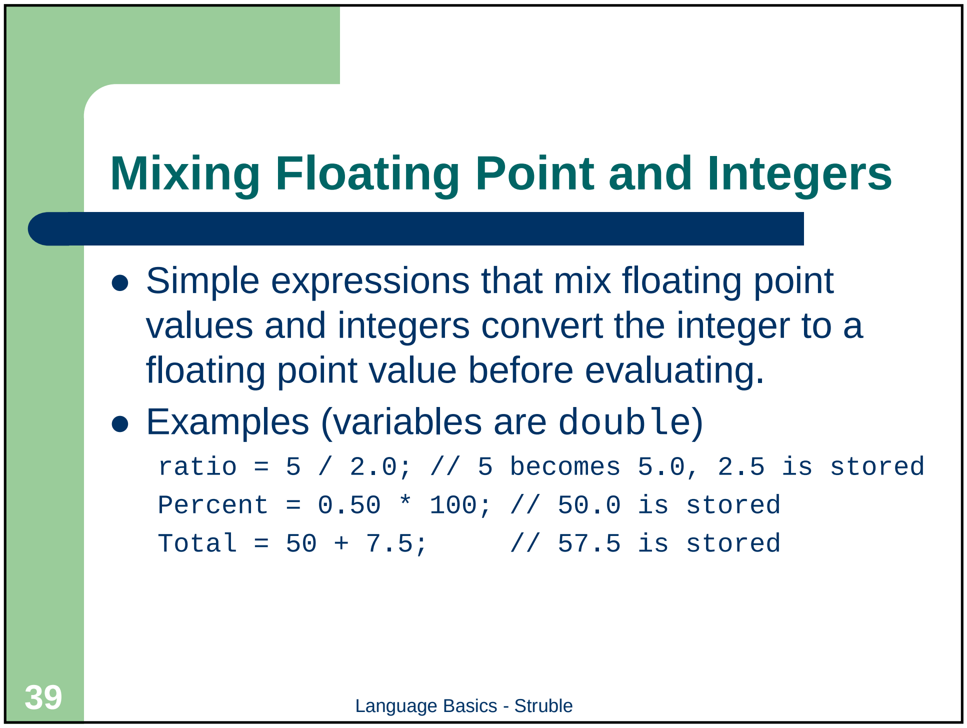
```
ratio = 3 / 4;  // 0 is stored
ratio2 = 5 / 2; // 2 is stored
```



Integer Expressions

- C++ uses the percent sign % to calculate remainders.
- Examples

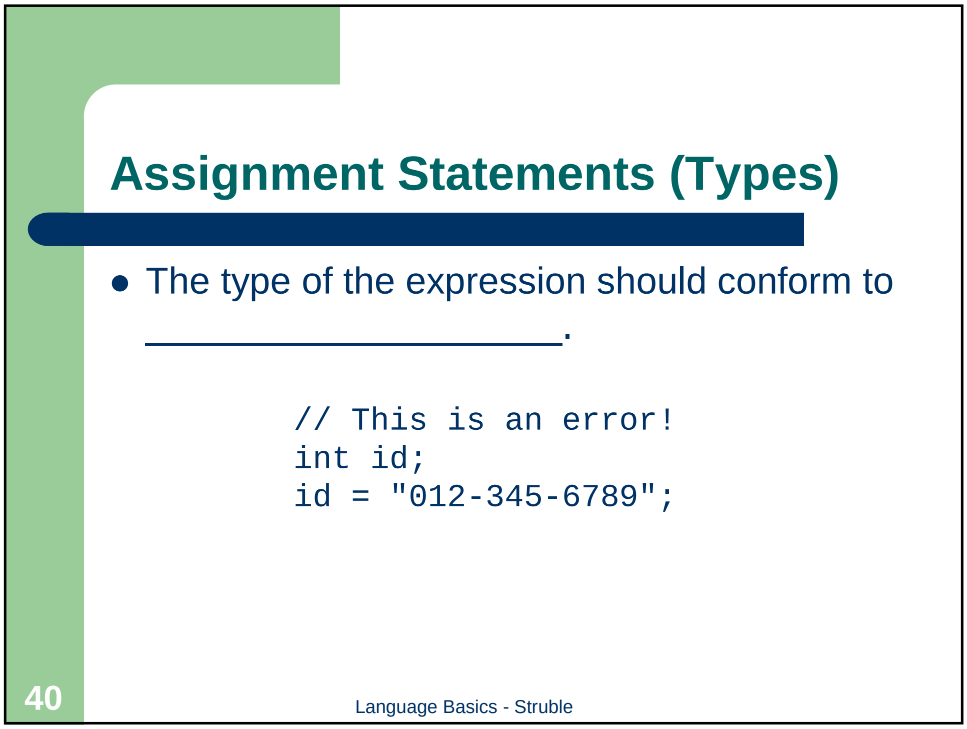
```
// Use division to calculate dollars
// and remaining change.
dollars = dollars / ONE_DOLLAR;
change = change % ONE_DOLLAR;
```



Mixing Floating Point and Integers

- Simple expressions that mix floating point values and integers convert the integer to a floating point value before evaluating.
- Examples (variables are `double`)

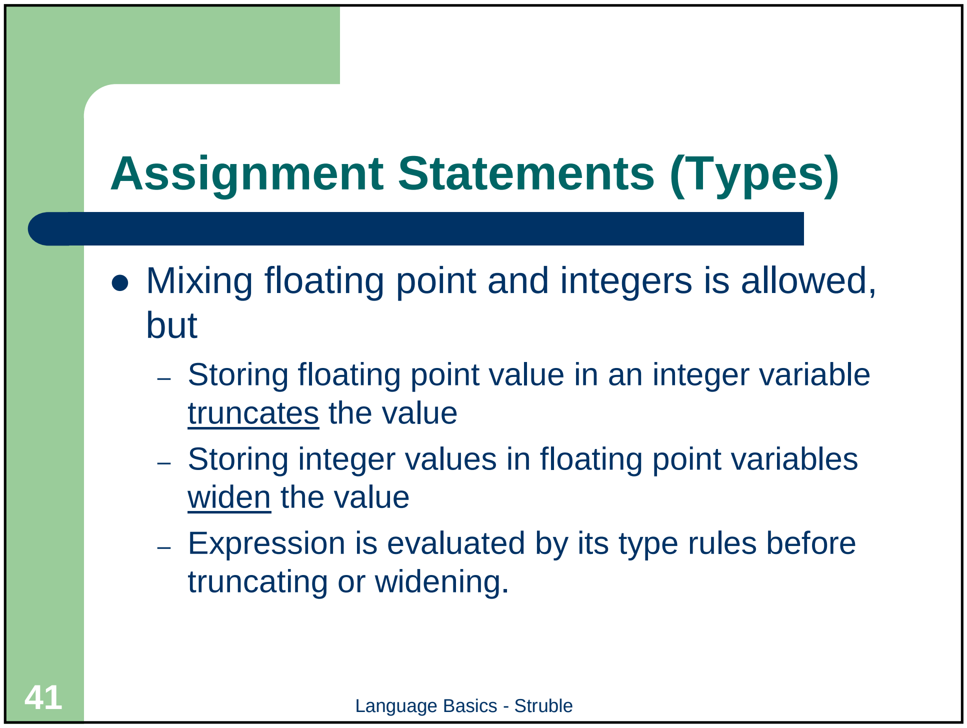
```
ratio = 5 / 2.0; // 5 becomes 5.0, 2.5 is stored
Percent = 0.50 * 100; // 50.0 is stored
Total = 50 + 7.5;     // 57.5 is stored
```



Assignment Statements (Types)

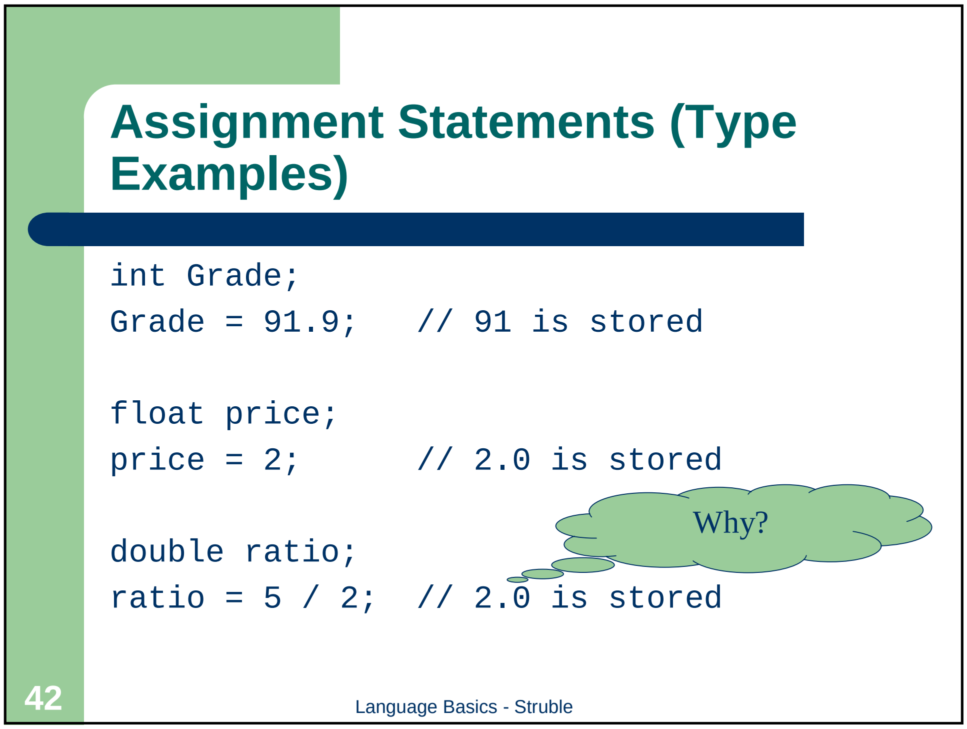
- The type of the expression should conform to ________________________.

```
// This is an error!
int id;
id = "012-345-6789";
```



Assignment Statements (Types)

- Mixing floating point and integers is allowed, but
  - Storing floating point value in an integer variable truncates the value
  - Storing integer values in floating point variables widen the value
  - Expression is evaluated by its type rules before truncating or widening.



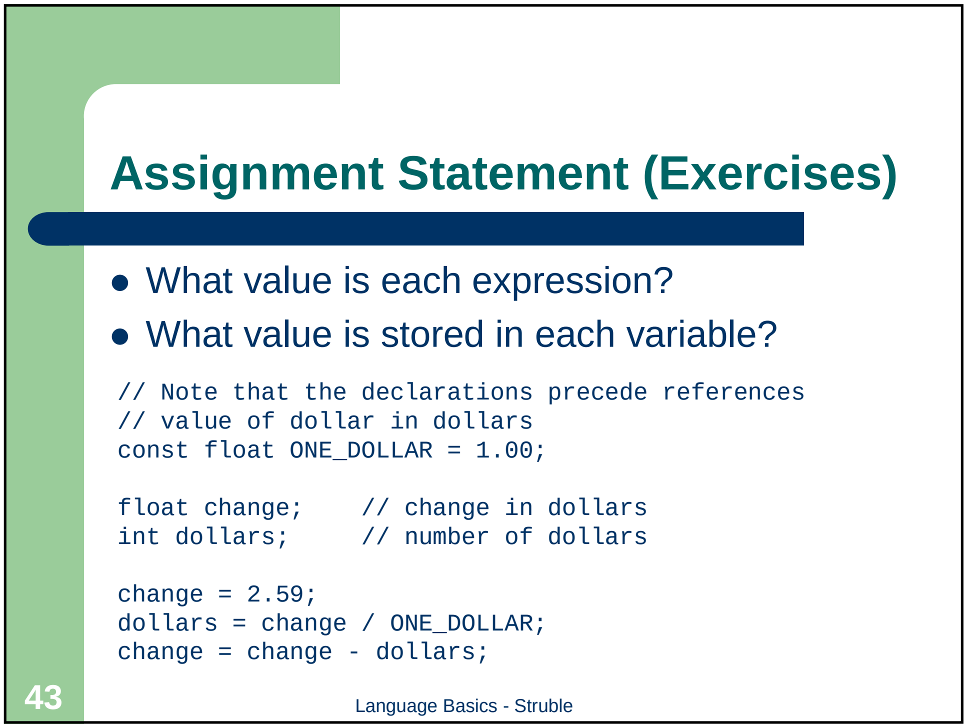
Assignment Statements (Type Examples)

```
int Grade;
Grade = 91.9;   // 91 is stored

float price;
price = 2;      // 2.0 is stored

double ratio;
ratio = 5 / 2;  // 2.0 is stored
```

Why?



Assignment Statement (Exercises)

- What value is each expression?
- What value is stored in each variable?

```
// Note that the declarations precede references
// value of dollar in dollars
const float ONE_DOLLAR = 1.00;

float change;    // change in dollars
int dollars;     // number of dollars

change = 2.59;
dollars = change / ONE_DOLLAR;
change = change - dollars;
```