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The Fundamentals of C++

Basic programming elements and concepts

Program Organization

- Program statement
  - Definition
  - Declaration
  - Action
- Executable unit
  - Named set of program statements
  - Different languages refer to executable units by different names
    - Subroutine: Fortran and Basic
    - Procedure: Pascal
    - Function : C++

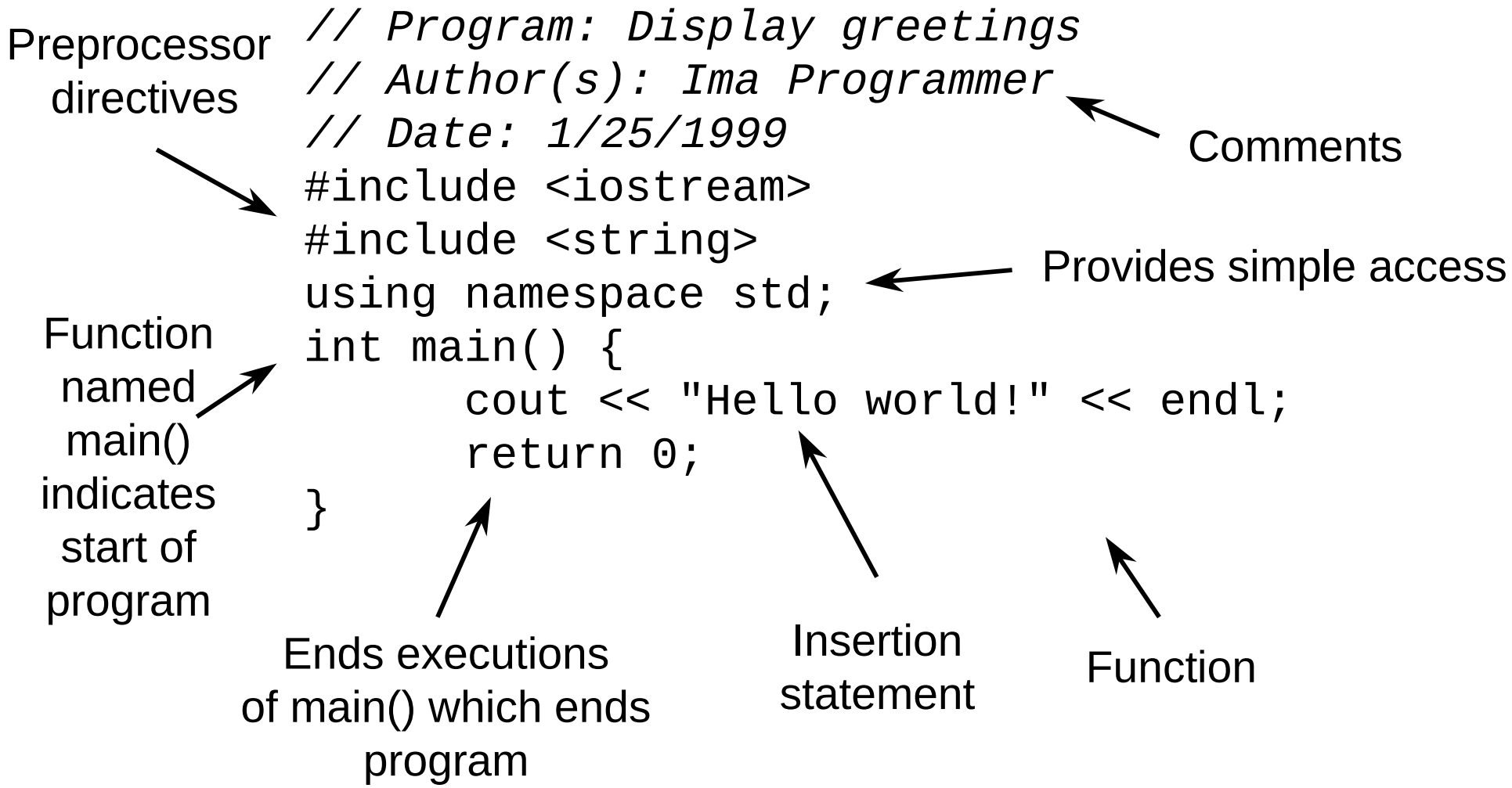
Program Organization

- C++ program
  - Collection of definitions, declarations and functions
  - Collection can span multiple files
- Advantages
  - Structured into small understandable units
  - Complexity is reduced
  - Overall program size decreases

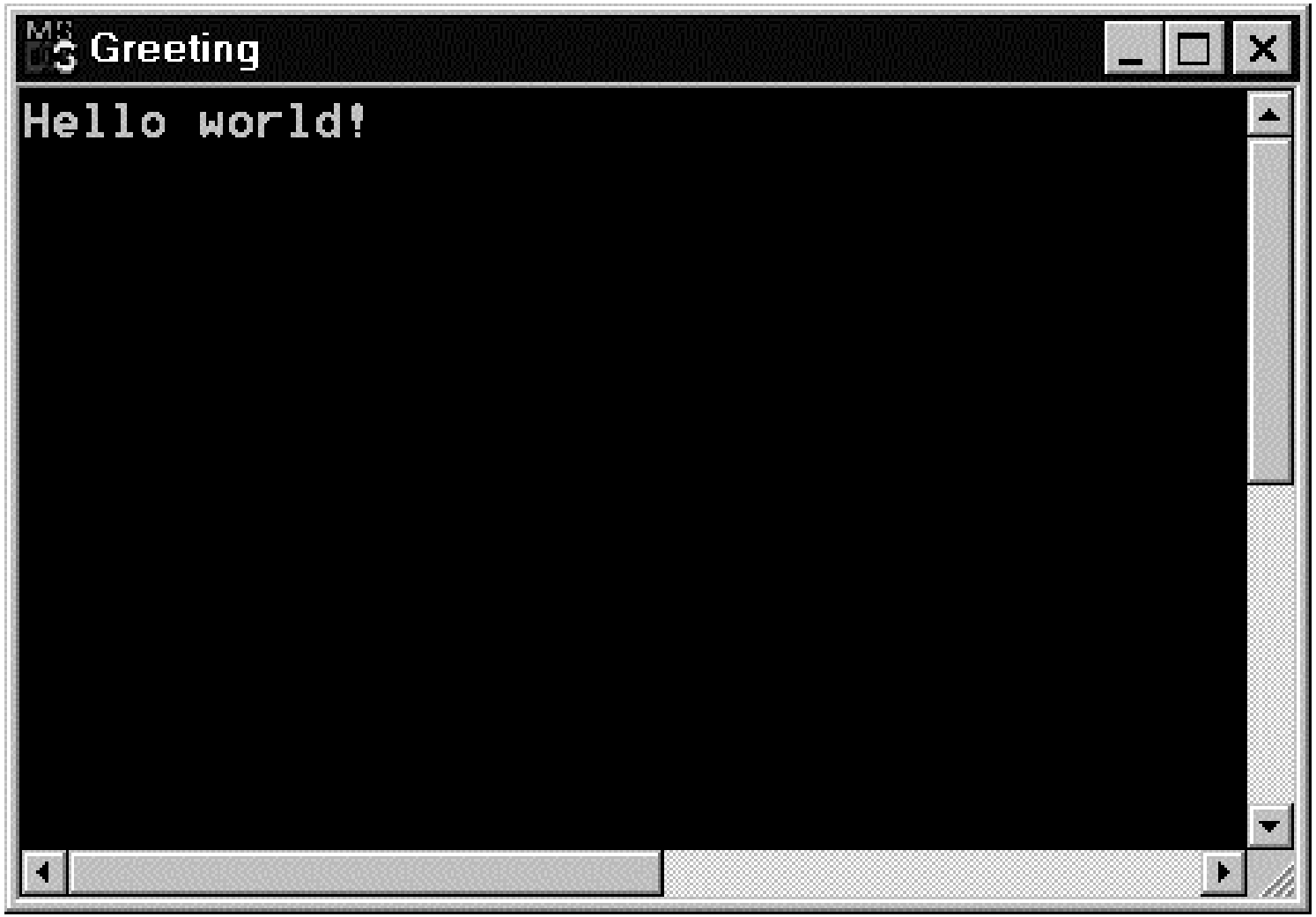
Object

- Object is a representation of some information
  - Name
  - Values or properties
    - Data members
  - Ability to react to requests (messages)!!
    - Member functions
- When an object receives a message, one of two actions are performed
  - Object is directed to perform an action
  - Object changes one of its properties

A First Program - Greeting.cpp



Greeting Output



```
#include <iostream>
#include <string>
using namespace std;
int main() {
   // Extract length and width
   cout << "Rectangle dimensions: ";
   float Length;
   float Width;
   cin >> Length >> Width;
   // Compute and insert the area
   float Area = Length * Width;
   cout << "Area = " << Area << " = Length "
    << Length << " * Width " << Width << endl;
   return 0;
}
```

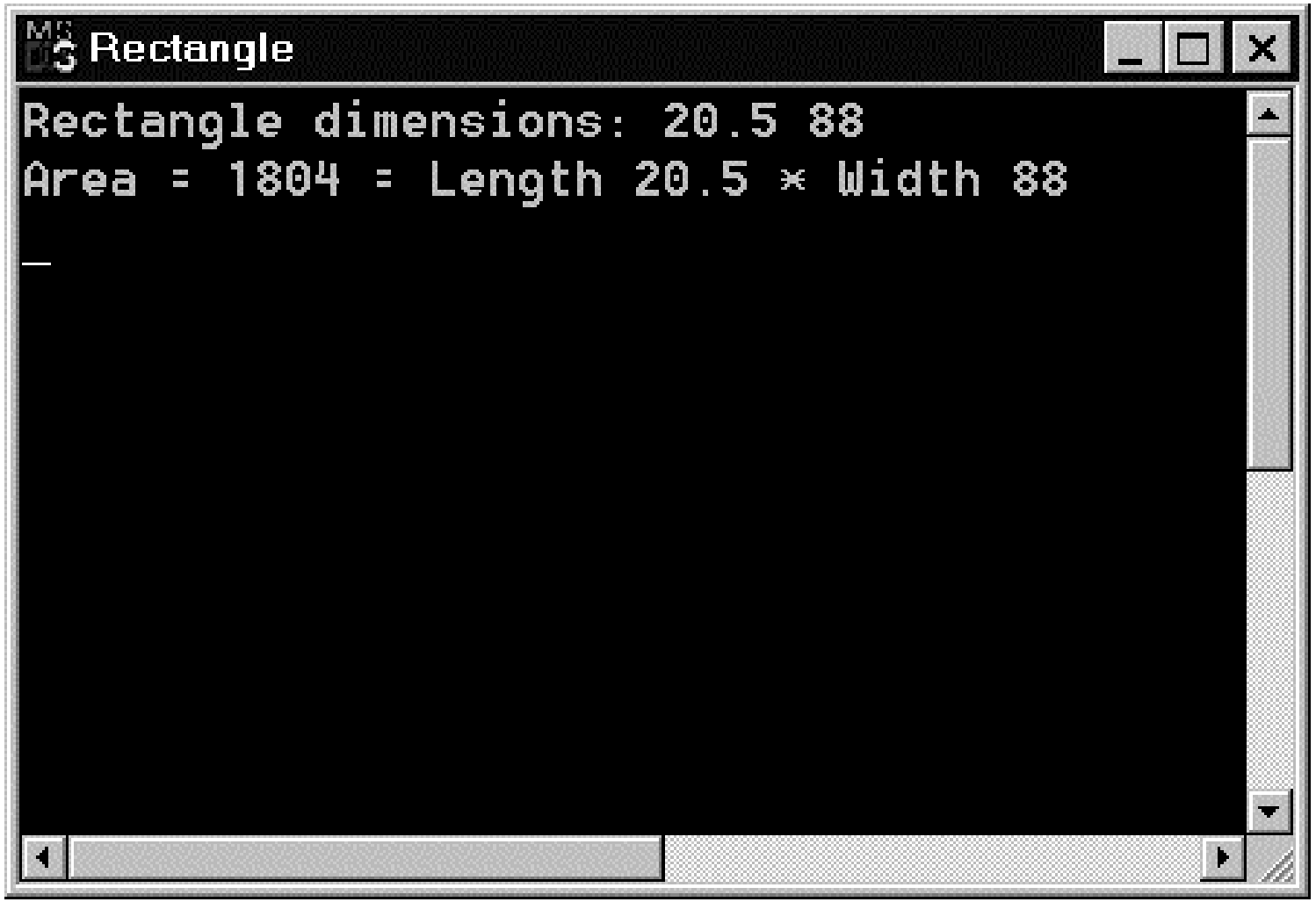
Area.cpp

Definitions

Extraction

Definition with initialization

Area.cpp Output



Comments

- Allow prose or commentary to be included in program
- Importance
  - Programs are read far more often than they are written
  - Programs need to be understood so that they can be maintained
- C++ has two conventions for comments
  - `//` single line comment (preferred)
  - `/*` long comment `*/` (save for debugging)
- Typical uses
  - Identify program and who wrote it
  - Record when program was written
  - Add descriptions of modifications

Fundamental C++ Objects

- C++ has a large number of fundamental or built-in object types
- The fundamental object types fall into one of three categories
  - Integers objects
  - Floating-point objects
  - Character objects

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Integer Object Types

- The basic integer object type is `int`
  - The size of an `int` depends on the machine and the compiler
    - On PCs it is normally 16 or 32 bits
- Other integers object types
  - `short`: typically uses less bits
  - `long`: typically uses more bits
- Different types allow programmers to use resources more efficiently
- Standard arithmetic and relational operations are available for these types

Integer Constants

- Integer constants are positive or negative whole numbers
- Integer constant forms
  - Decimal
  - Octal (base 8)
    - Digits 0, 1, 2, 3, 4, 5, 6, 7
  - Hexadecimal (base 16)
    - Digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a , b, c, d, e, f
- Consider
  - 31 oct and 25 dec

Specifying Syntax

- Need
  - A notation for exactly expressing a programming language element
    - Notation is describing the programming language
    - Notation is not part of the programming language
- Notation must be able to describe
  - Elements that have several forms
  - Elements that are
    - Required
    - Optional
    - Repeated

Notation Conventions

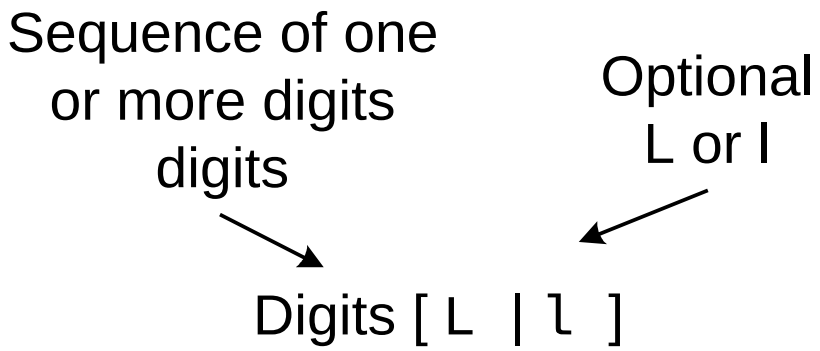
- Parentheses ()
  - Anything surrounded by parentheses must be used
- Braces []
  - Anything surrounded by brackets is optional
- Vertical line |
  - Elements on either side of the line are acceptable
- Ellipsis ...
  - The pattern established before the ellipsis continues
- Specifier
  - Name of a language element

Notation Examples

- NonZeroDigit
  - 1 | 2 | ... 9
- Digit
  - 0 | NonZeroDigit
- OctalDigit
  - 0 | 1 | ... 7
- HexDigit
  - 0 | 1 | ... 9 | A | B | ... F | a | b | ... f
- Digits
  - NonZeroDigit [Digit ... Digit]

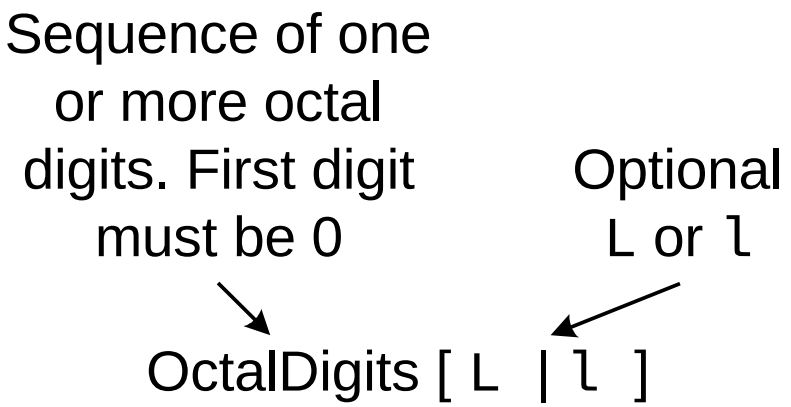
Decimal Constants

- Examples
  - 97
  - 40000L
  - 50000
  - 23a (illegal)
- The type of the constant depends on its size, unless the type specifier is used



Octal Constants

- Examples
  - 017
  - 0577777L
  - 01267333l
  - 01267335
  - 0482 (illegal)
- The type of the constant depends on its size, unless the type specifier is used



Hexadecimal Constants

- Letters represent the hex digits

  a or A - 10 d or D - 13

  b or B - 11 e or E - 14

  c or C - 12 f or F - 15

- Examples
  - 0x2C
  - 0XAC12EL
- The type of the constant depends on its size, unless the type specifier is used

Character Object Types

- Character type **`char`** is related to the integer types
- Characters are encoded using a scheme where an integer represents a particular character
- ASCII is the dominant encoding scheme
  - Examples
    - `' '` encoded as 32
    - `'+'` encoded as 43
    - `'A'` encoded as 65
    - `'Z'` encoded as 90
    - `'a'` encoded as 97
    - `'z'` encoded as 122

Character Operations

- Arithmetic and relational operations are defined for characters types
  - `'a' < 'b'` is true
  - `'4' > '3'` is true
  - `'b' + 2` produces the number that represents `'d'`
  - `'8' - '3'` produces 5
- Arithmetic with characters needs to be done with care
  - `'9' + 3` produces the number that represents `'<'`

Character Constants

- Explicit characters within single quotes

```
'a'
'D'
'*'
```

- Special characters - delineated by a backslash \
  - Two character sequences (sometimes called escape codes) within single quotes
  - Important special characters

    `'\t'` denotes a tab

    `'\n'` denotes a new line

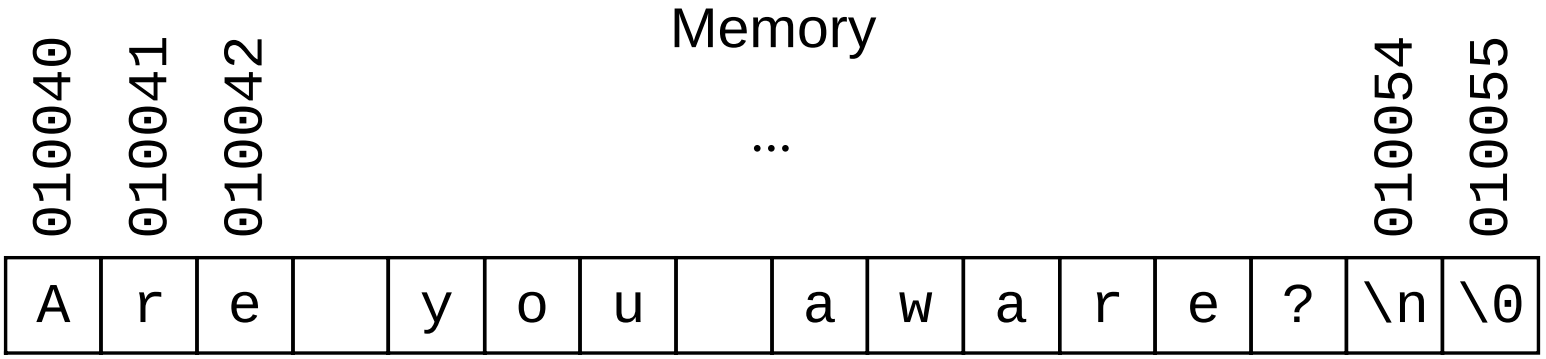
    `'\\'` denotes a backslash

Escape Codes

Character	ASCII Name	Sequence
newline	NL	`\n`
horizontal tab	HT	`\t`
backspace	BS	`\b`
form feed	FF	`\f`
alert or bell	BEL	`\a`
carriage return	CR	`\r`
vertical tab	VT	`\v`
backslash	\	`\\`
single quote	'	`\'`
double quote	"	`\"`
question mark	?	`\?`

Literal String Constants

- A literal string constant is a sequence of zero or more characters enclosed in double quotes
  - `"Are you aware?\n"`
- Individual characters of string are stored in consecutive memory locations
- The null character (`'\0'`) is appended to strings so that the compiler knows where in memory strings ends



Floating-Point Object Types

- Floating-point object types represent real numbers
  - Integer part
  - Fractional part
- The number 108.1517 breaks down into the following parts
  - 108 - integer part
  - 1517 - fractional part
- C++ provides three floating-point object types
  - **`float`**
  - **`double`**
  - **`long double`**

Floating-Point Constants

- Standard decimal notation
  - Digits . Digits [f | F | l | L]

    134.123

    0.15F
- Standard scientific notation
  - Digits . Digits Exponent [f | F | l | L]
  - Where
    - Exponent is (e | E) [+ | -] Digits

      1.45E6

      0.979e-3L
- When not specified, floating-point constants are of type `double`

Names

- Used to denote program values or components
- A valid name is a sequence of
  - Letters (upper and lowercase)
  - Digits
    - A name cannot start with a digit
  - Underscores
    - A name should not normally start with an underscore
- Names are case sensitive
  - MyObject is a different name than MYOBJECT
- There are two kinds of names
  - Keywords
  - Identifiers

Keywords

- Keywords are words reserved as part of the language
  - int, return, float, double
  - They cannot be used by the programmer to name things
  - They consist of lowercase letters only
  - They have special meaning to the compiler

Keywords

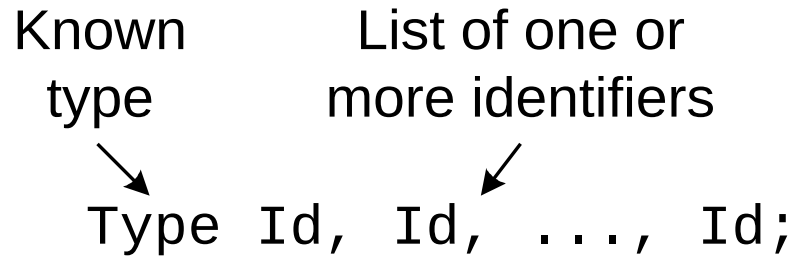
asm	do	if	return	typedef
auto	double	inline	short	typeid
bool	dynamic_cast	int	signed	typename
break	delete	long	sizeof	union
case	else	mutable	static	unsigned
catch	enum	namespace	static_cast	using
char	explicit	new	struct	virtual
class	extern	operator	switch	void
const	false	private	template	volatile
const_cast	float	protected	this	wchar_t
continue	for	public	throw	while
default	friend	register	true	union
delete	goto	reinterpret_cast	try	unsigned

Identifiers

- Identifiers should be
  - Short enough to be reasonable to type (single word is norm)
    - Standard abbreviations are fine (but only standard abbreviations)
  - Long enough to be understandable
    - When using multiple word identifiers capitalize the first letter of each word
- Examples
  - Min
  - Temperature
  - CameraAngle
  - CurrentNbrPoints

Definitions

- All objects that are used in a program must be defined
- An object definition specifies
  - Type
  - Name
- A common definition form



  - Our convention is one definition per statement !

Examples

```
char Response;
int MinElement;
float Score;
float Temperature;
int i;
int n;
char c;
float x;
```

Objects are uninitialized with this definition form

(Value of a object is whatever is in its assigned memory location)

Arithmetic Operators

- Common
  - Addition +
  - Subtraction -
  - Multiplication *
  - Division /
  - Mod %

Write `m*x + b`
not `mx + b`

- Note
  - No exponentiation operator
  - Single division operator
  - Operators are overloaded to work with more than one type of object

Integer Division

- Integer division produces an integer result
  - Truncates the result
- Examples
  - `3 / 2` evaluates to 1
  - `4 / 6` evaluates to 0
  - `10 / 3` evaluates to 3

Mod

- Produces the remainder of the division
- Examples

    5 % 2 evaluates to 1

    12 % 4 evaluates to 0

    4 % 5 evaluates to 4

Operators and Precedence

- Consider mx + b
- Consider `m*x + b` which of the following is it equivalent to
  - `(m * x) + b`
  - `m * (x + b)`
- Operator precedence tells how to evaluate expressions
- Standard precedence order
  - () — Evaluate first, if nested innermost done first
  - * / % — Evaluate second. If there are several, then evaluate from left-to-right
  - + - — Evaluate third. If there are several, then evaluate from left-to-right

Operator Precedence

- Examples

```
1 + 2 * 3 / 4 - 5
```

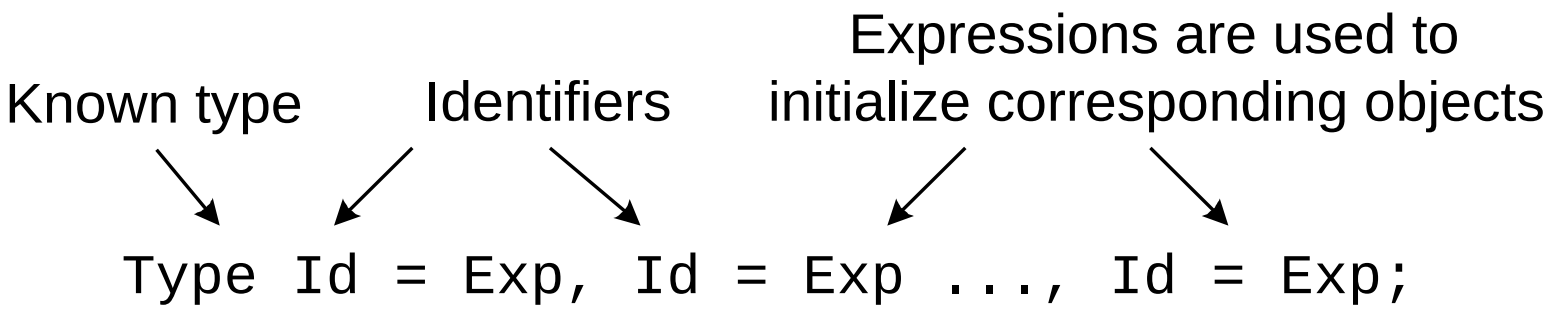
```
2 * 4 / 5 + 3 * 5 % 4
```

```
3.0 * 3 / 4
```

```
(1 + 3) * ((2 + 4 * 6) * 3) / 2 + 2
```

Defining and Initializing

- When an object is defined using the basic form, the memory allotted to it contains random information
  - Good idea to specify its desired value at the same time
    - Exception is when the next statement is an extraction for the object



- Our convention is one definition per statement !

Examples

```
int FahrenheitFreezing = 32;
char LetterGrade = 'A';
cout << "Slope of line: ";
float m;
cin >> m;
cout << "Intercept: ";
float b;
cin >> b;
cout << "X value of interest: ";
float x;
cin >> x;
float y = (m * x) + b;
```

```
// Program 2.11: Compute velocity of car
#include <iostream>
#include <string>
using namespace std;
int main() {
   cout << "All inputs are integers!\n";
   cout << "Start milepost? ";
   int StartMilePost;
   cin >> StartMilePost;

   cout << "Elapsed time (hours minutes seconds)? ”;
   int EndHour;
   int EndMinute;
   int EndSecond;
   cin >> EndHour >> EndMinute >> EndSecond;

   cout << "End milepost? ";
```

```
   int EndMilePost;
   cin >> EndMilePost;
   float ElapsedTime = EndHour + (EndMinute / 60.0)
    + (EndSecond / 3600.0);
   int Distance = EndMilePost - StartMilePost;
   float Velocity = Distance / ElapsedTime;

   cout << "\nCar traveled " << Distance
    << " miles in ";
   cout << EndHour << " hrs " << EndMinute
    << " min " << EndSecond << " sec\n";
   cout << "Average velocity was " << Velocity
    << " mph " << endl;

   return 0;
}
```