CSCI 200: Foundational Programming Concepts & Design Lecture 09

Overloading Functions

The Call Stack

Pointers

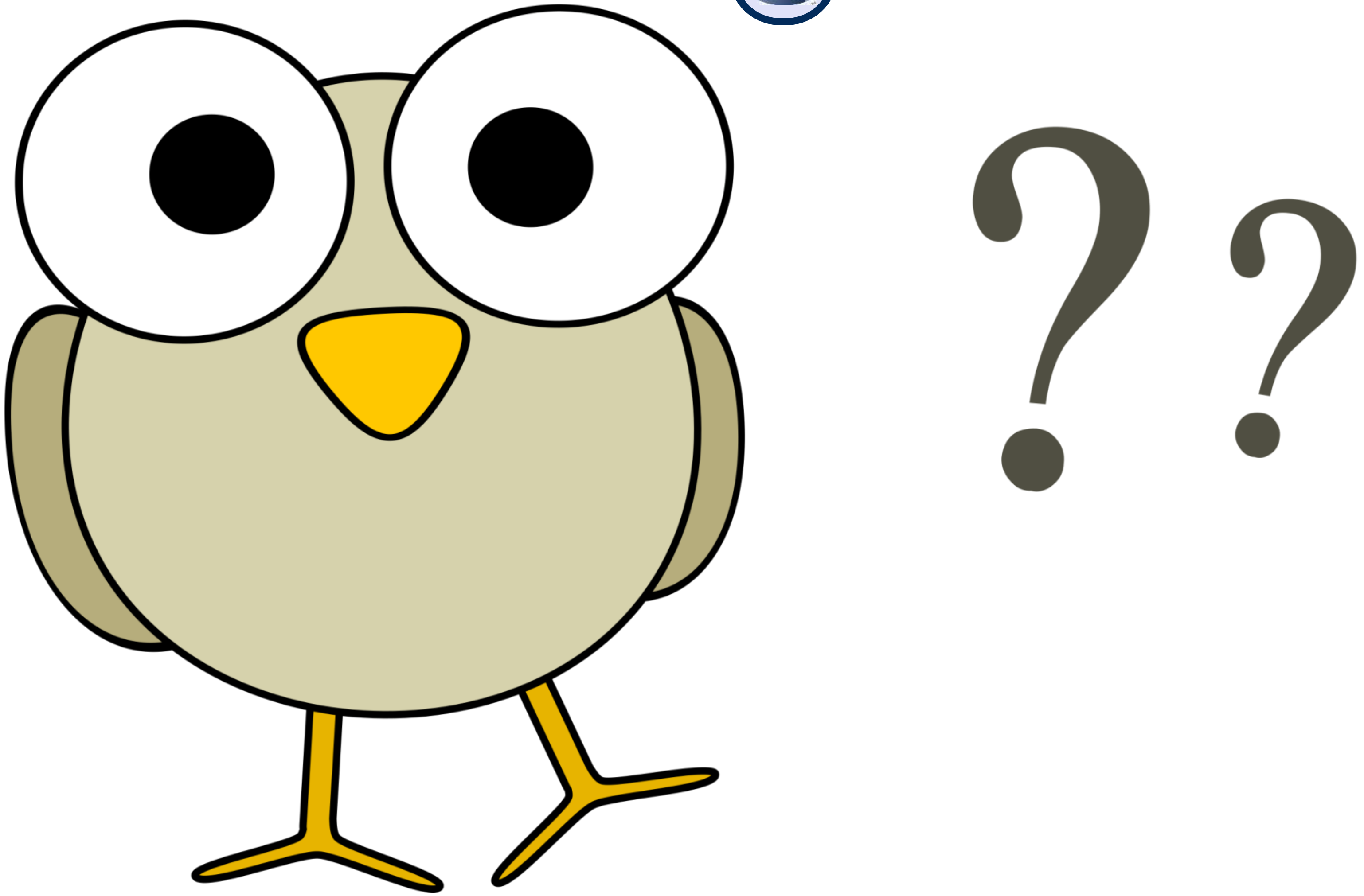
Download starter code

Previously in CSCI 200

- *.h – function declarations
- *.cpp – function definitions

- Makefile
  - SRC_FILES : lists ONLY *.cpp files
  - Dependencies: specify *.cpp and *.h that each object file depends upon
    - `make depend` will autopopulate (if available)

Questions?



Learning Outcomes For Today

- Explain the concept of local & global scope when functions are used within a program.
- Implement various techniques to trace & debug a program.
- Define an overloaded function and recite common usages for overloaded functions.

On Tap For Today

- Overloading Functions
- Function Scope
- Pointers
- Practice

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Overloaded Functions (aka Function Overloading)

- Two or more functions can have the same name IFF
  - The number of parameters differ
  - OR
  - The data type of parameters differ

- Functions must have a different function signature

Quick Quiz: What is the Output?

```
int func(double x)      { return 1; }
int func(int x)         { return 2; }
int func(int x, int y) { return 3; }
int func()              { return 4; }
int main() {
  cout << func(1.5) << " ";
  cout << func(1, 5) << " ";
  cout << func() << " ";
  cout << func(1) << endl;
  return 0;
}
```

```
1

3

4

2
```

Quick Quiz: What is the Output?

```
int func(char x)        { return 1; }
int func(int x)         { return 2; }
int func(int x, int y)  { return 3; }
int func()              { return 4; }
int main() {
  cout << func(1.5) << " ";
  cout << func(1, 5) << " ";
  cout << func() << " ";
  cout << func(1) << " ";
  cout << func('c') << endl;
  return 0;
}
```

Quick Quiz: What is the Output?

```
int func(char x)        { return 1; }
int func(int x)         { return 2; }
int func(int x, int y)  { return 3; }
int func()              { return 4; }
int main() {
  cout << func(1.5) << " ";        // compiler error! call is ambiguous
                                   // candidates are funcA(char), funcA(int)
  cout << func(1, 5) << " ";
  cout << func() << " ";
  cout << func(1) << " ";
  cout << func('c') << endl;
  return 0;
}
```

Quick Quiz: What is the Output?

```
int func(int x, double y) { return 1; }
int func(double x, int y) { return 2; }

int main() {
  cout << func(1.5, 2) << " ";
  cout << func(2, 1.5) << endl;
  return 0;
}
```

```
2

1
```

Quick Quiz: What is the Output?

```
int func(int x, double y)  { return 1; }
char func(int x, double y) { return '1'; }



int main() {
  cout << func(1.5, 2) << " ";
  cout << func(1.5, 2) << endl;
  return 0;
}
```

Quick Quiz: What is the Output?

```
int func(int x, double y)  { return 1; }
char func(int x, double y) { return '1'; } // compiler error!
                          // functions cannot differ in return type only

int main() {
  cout << func(1.5, 2) << " ";
  cout << func(1.5, 2) << endl;
  return 0;
}
```

Actual Example

```
int max(int x, int y) { if(x > y) return x; else return y; }
double max(double x, double y) { if(x > y) return x; else return y; }

int main() {
  cout << max(1, 2) << endl;
  cout << max(1.5, 2.5) << endl;
  return 0;
}
```

```
2
2.5
```

Side Note: Ternary Operator

```
int max(int x, int y) { return (x > y ? x : y); }
double max(double x, double y) { if(x > y) return x; else return y; }

int main() {
  cout << max(1, 2) << endl;
  cout << max(1.5, 2.5) << endl;
  return 0;
}
```

```
2
2.5
```

Stay Tuned!

- We'll see practical examples of overloaded functions coming up

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Call Stack

- Each function call appends to the stack:
  - Address of execution (File and line number)
  - Local variables (includes parameters)
- Each appendage is a “stack frame”
  - Frames create part of our scope
- Use debugger to investigate the call stack

Program Entry Point: main()

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014			
0x40960018			
0x4096001c			
0x40960020			
0x40960024			
0x40960028			
0x4096002c			
0x40960030			
0x40960034			
0x40960038			
0x4096003c			

Evaluate main()

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014			
0x40960018			
0x4096001c	b	3	
0x40960020			
0x40960024			
0x40960028			
0x4096002c			
0x40960030	a	4	
0x40960034			
0x40960038			b 0x4096001c
0x4096003c			a 0x40960030

Pass by Value

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014			
0x40960018			
0x4096001c	b	3	
0x40960020			
0x40960024	c		
0x40960028			
0x4096002c			
0x40960030	a	4	
0x40960034			c 0x40960024
0x40960038			b 0x4096001c
0x4096003c			a 0x40960030

Pass by Value

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014	y	3	
0x40960018			
0x4096001c	b	3	
0x40960020			
0x40960024	c		
0x40960028			
0x4096002c			y 0x40960014
0x40960030	a	4	x 0x40960038
0x40960034			c 0x40960024
0x40960038	x	4	b 0x4096001c
[illegible]			

Evaluate add()

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014	y	3	
0x40960018			
0x4096001c	b	3	
0x40960020			
0x40960024	c		
0x40960028	a		a 0x40960028
0x4096002c			y 0x40960014
0x40960030	a	4	x 0x40960038
0x40960034			c 0x40960024
0x40960038	x	4	b 0x4096001c

Evaluate add()

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014	y	3	
0x40960018			
0x4096001c	b	3	
0x40960020			
0x40960024	c		
0x40960028	a	7	a 0x40960028
0x4096002c			y 0x40960014
0x40960030	a	4	x 0x40960038
0x40960034			c 0x40960024
0x40960038	x	4	b 0x4096001c

Return by Value

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014	y	3	
0x40960018			
0x4096001c	b	3	
0x40960020			
0x40960024	c		
0x40960028	a	7	a 0x40960028
0x4096002c			y 0x40960014
0x40960030	a	4	x 0x40960038
0x40960034			c 0x40960024
0x40960038	x	4	b 0x4096001c

Return by Value

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014		3	
0x40960018			
0x4096001c	b	3	
0x40960020			
0x40960024	c	7	
0x40960028		7	
0x4096002c			
0x40960030	a	4	
0x40960034			c 0x40960024
0x40960038		4	b 0x4096001c
0x4096003c			a 0x40960030

Pass by Value

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014		3	
0x40960018			
0x4096001c	b	3	
0x40960020			
0x40960024	c	7	
0x40960028	d	7	
0x4096002c			
0x40960030	a	4	d 0x40960028
0x40960034			c 0x40960024
0x40960038		4	b 0x4096001c
0x4096003c			a

Pass by Value

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014	x	5	
0x40960018			
0x4096001c	b	3	
0x40960020			
0x40960024	c	7	
0x40960028	d	7	y 0x4096003c
0x4096002c			x 0x40960014
0x40960030	a	4	d 0x40960028
0x40960034			c 0x40960024
0x40960038		4	b 0x4096001c

Evaluate add()

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014	x	5	
0x40960018			
0x4096001c	b	3	
0x40960020			
0x40960024	c	7	a 0x40960034
0x40960028	d	7	y 0x4096003c
0x4096002c			x 0x40960014
0x40960030	a	4	d 0x40960028
0x40960034	a		c 0x40960024
0x40960038		4	b

Evaluate add()

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014	x	5	
0x40960018			
0x4096001c	b	3	
0x40960020			
0x40960024	c	7	a 0x40960034
0x40960028	d	7	y 0x4096003c
0x4096002c			x 0x40960014
0x40960030	a	4	d 0x40960028
0x40960034	a	13	c 0x40960024
0x40960038		4	b

Return by Value

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014	x	5	
0x40960018			
0x4096001c	b	3	
0x40960020			
0x40960024	c	7	a 0x40960034
0x40960028	d	7	y 0x4096003c
0x4096002c			x 0x40960014
0x40960030	a	4	d 0x40960028
0x40960034	a	13	c 0x40960024
0x40960038		4	b

Return by Value

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014		5	
0x40960018			
0x4096001c	b	3	
0x40960020			
0x40960024	c	7	
0x40960028	d	13	
0x4096002c			
0x40960030	a	4	d 0x40960028
0x40960034		13	c 0x40960024
0x40960038		4	b 0x4096001c
0x4096003c		8	a

Return by Value

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014		5	
0x40960018			
0x4096001c	b	3	
0x40960020			
0x40960024	c	7	
0x40960028	d	13	
0x4096002c			
0x40960030	a	4	d 0x40960028
0x40960034		13	c 0x40960024
0x40960038		4	b 0x4096001c
0x4096003c		8	a

Program Terminates

```
int add( int x, int y ) {
    int a;
    a = x + y;
    return a;
}

int main() {
    int a(4), b(3);
    int c = add( a, b );
    int d = add( 5, 8 );
    return 0;
}
```

Address	Identifier	Value	Stack
0x40960014		5	
0x40960018			
0x4096001c		3	
0x40960020			
0x40960024		7	
0x40960028		13	
0x4096002c			
0x40960030		4	
0x40960034		13	
0x40960038		4	
0x4096003c		8	

Running Debugger Part I

- gdb .\HelloWorld.exe
  - b <*#*>
  - run
  - print <*var*>
  - info b
  - step
  - continue
  - kill
  - q
- lldb ./HelloWorld
  - b <*#*>
  - run
  - print <*var*>
  - br l
  - step
  - continue
  - kill
  - q

Running Debugger Part II

- gdb .\HelloWorld.exe
  - b <file.ext:#>
  - bt
  - info locals
  - info args
  - up
  - down
  - frame
  - frame #

- lldb ./HelloWorld
  - b <file.ext:#>
  - bt
  - frame variable
  - up
  - down
  - frame info
  - frame select #
  - target variable

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Pointers

- Pointer denoted by ____________
- Value of a pointer is ____________

Types

- Clockwise winding order resolution
- What is the type of the identifier in each

```
int a;
double b;
int c(int q, int r);
float* d;
float** e;
```

Pointer Values

- Value of a pointer is ____________
- Value pointed at is ______________

```
float* x;
float** y;
int (*z)(int, int);
```

NULL vs. nullptr

- NULL is a C constant equal to zero
- nullptr is a C++ keyword of pointer type

```
#include <cstdlib>

void foo(int x) {}
void foo(int *pX) {}

int main() {
  int x = NULL;         // x has a value of zero 0
  int *pX = NULL;       // pX has a value of zero 0
  int y = nullptr;      // error - cannot convert nullptr_t to int
  int *pY = nullptr;    // pY has a value of 0x0

  foo(NULL);            // error - ambiguous call to foo(int) or foo(int*)
  foo(nullptr);         // calls foo(int*)

  return 0;
}
```

Precedence Table

Category	Precedence	Operator	Associativity
Parenthesis	1	( )	Innermost First
Postfix Unary Operators	2	a++ a-- f()	Left to Right
Prefix Unary Operators	3	++a --a +a -a !a ~a (type)a &a *p new delete	Right to Left
Binary Operators	4	a*b a/b a%b	Left to Right
	5	a+b a-b	
Relational Operators	6	a<b a>b a<=b a>=b	
	7	a==b a!=b	
Bitwise Operators	8	a&b	
	9	a^b	
	10	a|b	
Logical Operators	11	a&&b	
	12	a||b	
Assignment Operators	13	a=b a+=b a-=b a*=b a/=b a%=b a&=b a^=b a|=b	Right to Left

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To Do For Next Time

- Procedural Programming Quiz Monday
  - Functions → yes
  - Pointers → no
- Exam I XC Due Monday
- Exam I in class on Wednesday
  - No Pointers on exam
- Start on L2B