

4. Functions

ENEE 140

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<http://ter.ps/enee140>

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Today's Lecture

- Where we've been
 - Variables and constants
 - Variable assignment and operators
 - `ints`, `floats` and `chars`
 - Iterating (`while`, `for`) and branching (`if`)
- Where we're going today
 - Functions
- Where we're going next
 - Integer and floating point arithmetic

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Review: Character Input/Output

- We've seen: reading input character-by-character

```
int c;
c = getchar();
while (c != EOF) {

    ...
    c = getchar();

}
```

Why int?

Read next character

Do something with c
Read next character

- Can compare `chars` and add/subtract offsets

```
c = c + ;           Convert uppercase c to lowercase
if (c >=  && c <=  ) Check if c is uppercase
c = 'D' - 'A';                   c is 
```

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Review: Assignment Operator

- We've seen: the `=` operator returns the value assigned

```
int c;                               int c;
c = getchar();                         while ((c = getchar()) != EOF) {
while (c != EOF) {                     ...
    ...
    c = getchar();
}
```



```
a = b = 0;
```

both `a` and `b` become 0

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Formatted Input and Output

- We've seen:


```
int a = 0;
printf("The value of a is %d\n", a);
```
- You can output data with `printf` and read data from the input with `scanf`
- `printf` format specifiers
 - `%d`: int `%ld`: long
 - `%f`: float, double `%E`: float, double in scientific notation, e.g. 1.5E3
 - `%c`: character `%%`: the '%' character
 - See Table 7.1 in K&R for a complete specification
 - Or type `man 3 printf` on the command line
- Read data from the input


```
int a, b;
scanf("%d %d", &a, &b);
```

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Prompting the User for Input

- Print a message indicating the input expected
- Then read the input

```
int sec;
float gpa;

printf("Enter your section number: ");
scanf("%d", &sec);

printf("Enter your GPA: ");
scanf("%f", &gpa);
```

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A Problem Solved by Programming

- Given a month and a year in the future, print the calendar on a text terminal
 - Example for September 2023

Su	Mo	Tu	We	Th	Fr	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

```
print_cal ( month, year )
{
  print " Su Mo Tu We Th Fr Sa "
  new line
  start ← first-day ( month, year )
  days ← days-in-month ( month, year )
  print-weeks ( start, days )
}
```

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Modularity

- Functions allow you to break down your program's functionality into smaller pieces
- Programs that are made up of many small functions are called **modular**
 - In such programs it's easy to modify one function, without affecting how the rest of the program works
 - Modular code is also easier to read
- Modular programs are the result of **top-down problem solving**
 - Break down the problem you need to solve into smaller sub-problems
 - For each sub-problem, write the prototype of a function that would solve it
 - Write your program by invoking these functions, assuming that they are implemented
 - Then figure out how to implement each function
- Good programming practice: Writing modular code!**

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Functions: What We've Seen So Far

- Functions allow you to encapsulate computation
 - You don't care **how** a job is done; you know **what** is done
- Examples of functions we've seen so far

<code>printf("The value of a is %d\n", a);</code>	print an int variable
<code>c = getchar();</code>	read a character
- You can use these functions in your programs without knowing how they are implemented
- You can also define your own functions
 - Example:


```
int main() {
    ...
    return 0;
}
```

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Defining Your Own Functions

- Function **declaration** (prototype)


```
int square(int param);
```
- Function **definition** (implementation)

<code>int</code>	return type
<code>square(int param)</code>	function name and parameter list
<code>{</code>	
<code>int result;</code>	variable declarations
<code>result = param * param;</code>	statements
<code>return result;</code>	return specification
<code>}</code>	
- Function **invocation** (calling the function in your program)


```
int a = 1+square(2)+square(3);
```

 use the function in an expression
 what is the value of a?
- You must declare or define a function before you invoke it

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Function Parameters and Local Variables

- Function **parameters** (arguments)
 - Parameters must have types (e.g. `int`, `float`) and are specified in the function declaration and definition:
`int pow(int x, int y);` the function takes 2 int parameters
 - When you call a function, you must pass as many parameters as in the prototype
`z = pow(2, 3);` the types must match as well
 - Modifying the arguments inside the function **does not** affect the original variables (“call by value” in textbook)
 - The function operates on a copy of the variable
`int a = 2;`
`my_function(a);` a is still 2, regardless of what happens in the function
- **Variables local to the function**
 - You can declare variables inside the function, like you do in `main()`
- Parameters and local variables **cannot be accessed outside the function**

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Return Values

- The type of the return value is specified in the prototype, before the name of the function
`int pow(int x, int y);` the function returns an int
- It is also possible to write a function that does not return anything
`void` return type is void
`err_msg(int code)` function with int parameter

```
{
  printf("Encountered an error with code %d\n", code);
}
```

 return statement is not needed

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Putting It All Together

Quiz 3, Question 3

- Consider the following function definition

```
int
fun(int a, int b, int c)
{
    printf("%d\n", a);
    printf("%d\n", b);
    return c;
}
```

- What is the last line printed by the following code snippet?

```
int ret = fun(1,2,3);
printf("%d\n", ret);
```

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Modularity: Examples

- Example of top-down problem solving
 - You are asked to write a program that prints a Celsius-Fahrenheit conversion table
 - Imagine that you have a function, which takes a float argument representing the temperature in Fahrenheit degrees, and returns a float with the corresponding Celsius value
 - Write the loop that prints the conversion table
 - Then look up the conversion formula and implement the function
- Helper functions
 - In your assignments, you will often be asked to implement functions that provide a certain functionality
 - It is often a good idea to write additional **helper** functions that you use in your program
 - For example, such helper functions may provide functionality that is useful for several tasks

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Mathematical Functions Available in C

- These functions typically accept and return variables of type double

<code>#include <math.h></code>	must include this header to use the math functions (more on this later)
<code>sin(x);</code>	sine of x (in radians)
<code>cos(x);</code>	cosine of x (in radians)
<code>exp(x);</code>	e^x
<code>log(x);</code>	natural logarithm of x
<code>log10(x);</code>	base 10 logarithm of x
<code>sqrt(x);</code>	square root of x
...	

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Aside: Manual Pages

- You can get help on most functions from the C standard library using the man command on the GRACE machines

<code>man printf</code>	manual page of <code>printf()</code> function
<code>man scanf</code>	manual page of <code>scanf()</code> function

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Coding Style

- Programs are meant to be read by humans
 - Code reviews are a common practice in the industry
- Good coding style makes programs more readable
 - Examples of what **not to do**: <http://www.ioccc.org/>
- There is no “right” coding style
 - Choose a style and be consistent

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Coding Style: Examples

- Explain what the program does in a comment at the top
- Explain what each function does in comments before the function definition
- Use concise, meaningful names for variables and constants
 - If you have many variables, also add short comments describing the purpose of some of the variables
- Follow normal English rules when possible for better readability of your code
 - Write complete sentences in your comments
 - Leave a space after each comma and semicolon (e.g. in printf(), scanf(), for)
 - Leave a space on each side of a binary operator (e.g. =, ==, +)
- Indent code consistently
 - Clion tries to do this automatically
- If you have long, nested {...} blocks, add a comment after the enclosing bracket
 - Indicate which block you are closing (the while block, the if block, etc.)

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Coding Style: More Examples

- Place braces {} in a consistent manner:

```
for (i = 0; i < 100; i++) {  
    statements;  
}
```

} OR

```
for (i = 0; i < 100; i++)  
{  
    statements;  
}
```

- When you prompt the user for input, first print out a message describing what is expected
- Check for errors and corner-cases throughout the program (more about this later)
- Use simple statements as much as possible
 - Avoid statements like `sum = a++ + --b*2`

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Review of Lecture

- What did we learn?

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Next Steps

- Next lecture
 - Integer and floating point arithmetic
- Assignments for this week
 - Read **K&R Chapters 2.5, 2.7, 2.8, 2.10, B2, B11**
 - Note: some of these chapters refer to strings (e.g. `char s[]`), which we'll cover later
 - For now, think of `s[i]` as a character variable
 - Read man pages for `rand()` and `srand()`; try to understand the implementations on page 46
 - Weekly challenge: **read_divide_ints.c**
 - Homework: **enee140_lab04.pdf**, due on Friday at 11:59 pm
 - No quiz next week