Intermediate Programming

Day 5

Outline

- Exercise 4
- `sizeof`
- ASCII characters
- Arrays
- C strings
- Review questions

Exercise 4

- Declare variables

gpa_simple.c

```
int main()
{
        char grade;             // Letter grade
        float credits;          // Credits for the course
        int count = 1;          // Iteration counter
        float gpa;              // Final GPA
        float value;            // Grade on 4.0 scale
        float valueSum = 0;     // Credit-weighted sum of grades
        float creditSum = 0;    // Sum of credits

        // Everything else
}
```

Exercise 4

- Print header

gpa_simple.c

```
int main()
{
	// Declare variables

	printf( "Welcome to the GPA calculator!\n" );
	printf( "Enter grade and credits for each course below (ctrl-d to end):\n" );

	// Everything else
}
```

Exercise 4

- Repeatedly prompt, read, and prompt for more (while the getting's good)

gpa_simple.c

```
int main()
{
	// Declare variables
	// Print header

	printf( "course %d: " , count );			// Ask for initial input
	while( scanf( " %c%f" , &grade , &credits )==2 )	// Test for valid input
	{
		// Transform the input character to a numerical value

		printf( "course %d: " , count );		// Ask for more input
	}

	// Everything else
}
```

Exercise 4

- Transform the input character to a numerical value

gpa_simple.c

```
int main()
{
	// Declare variables
	// Print header

	printf( "course %d: " , count );                    // Ask for initial input
	while( scanf( " %c%f" , &grade , &credits )==2 )  // Test for valid input
	{
		switch( grade )            // Convert letter grade to 4.0 scale
		{
			case 'A': value = 4.f; break;
			case 'B': value = 3.f; break;
			...
			default: printf( "uh oh: unrecognized grade\n" ); return 1;
		}

		// Accumulate the values

		printf( "course %d: " , count );                // Ask for more input
	}

	// Everything else
}
```

Exercise 4

- Accumulate the value and credits

gpa_simple.c

```
int main()
{
	// Declare variables
	// Print header

	printf( "course %d: " , count );                    // Ask for initial input
	while( scanf( " %c%f" , &grade , &credits )==2 )  // Test for valid input
	{
		// Transform the input character to a numerical value

		valueSum += value * credits;  // Accumulate credit-weighted grades
		creditSum += credits;         // Accumulate weights
		printf( "course %d: " , count );                // Ask for more input
	}

	// Everything else
}
```

Exercise 4

- Compute the GPA, if possible, print, and determine status

gpa_simple.c

```
int main()
{
	// Declare variables
	// Print header
	// Repeatedly prompt, read, process, and accumulate

	if( creditSum>0 )		// Check if there were any credits
	{
		gpa = valueSum / creditSum;		// Get the credit-weighted average
		printf( "\nGPA is %f\n" , gpa );
		if( gpa>3.5 ) printf( "Dean's list\n" );
		else if( gpa<=2.5 ) printf( "Uh-oh, Academic Probation...\n" );
	}
	else printf( "No credits attempted; no GPA to report\n" );


	 return 0;
}
```

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Last time

- Integer types:
  - [unsigned] char: [un]signed character (typically 1 byte)
  - [unsigned] int: [un]signed integer (typically 4 bytes)

- Floating-point types:
  - float: single-precision floating point number (typically 4 bytes)
  - double: double-precision floating point number (typically 8 bytes)

https://en.wikipedia.org/wiki/C_data_types

sizeof operator

- To determine the size of a type, you can use **sizeof**.

```
#include <stdio.h>
int main(void)
{
        int x = 75;
        printf( "Size of char: %d\n" , sizeof( char ) );
        printf( "Size of int: %d\n" , sizeof( x ) );
        return 0;
}
```

```
>> ./a.out
Size of char: 1
Size of int: 4
>>
```

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Characters

- Character type
  - a char variable holds a single character:
    - char digit = '4'; // Has value 52
    - char bang = '!'; // Has value 33
  - These *must* be single quotes; double quotes are for strings, not chars
  - Behind the scenes, char is just like int:

    char digit = '4'-1;

    digit now contains the character '3' (and has value 51)

ASCII

- The ASCII standard governs the mapping between characters and integers.

Dec	Hex	Oct	Chr	Dec	Hex	Oct	HTML	Chr	Dec	Hex	Oct	HTML	Chr	Dec	Hex	Oct	HTML	Chr
0	0	000	NULL	32	20	040	&#032;	Space	64	40	100	&#064;	@	96	60	140	&#096;	`
1	1	001	SoH	33	21	041	&#033;	!	65	41	101	&#065;	A	97	61	141	&#097;	a
2	2	002	SoTxt	34	22	042	&#034;	"	66	42	102	&#066;	B	98	62	142	&#098;	b
3	3	003	EoTxt	35	23	043	&#035;	#	67	43	103	&#067;	C	99	63	143	&#099;	c
4	4	004	EoT	36	24	044	&#036;	$	68	44	104	&#068;	D	100	64	144	&#100;	d
5	5	005	Enq	37	25	045	&#037;	%	69	45	105	&#069;	E	101	65	145	&#101;	e
6	6	006	Ack	38	26	046	&#038;	&	70	46	106	&#070;	F	102	66	146	&#102;	f
7	7	007	Bell	39	27	047	&#039;	'	71	47	107	&#071;	G	103	67	147	&#103;	g
8	8	010	Bsp	40	28	050	&#040;	(	72	48	110	&#072;	H	104	68	150	&#104;	h
9	9	011	HTab	41	29	051	&#041;	)	73	49	111	&#073;	I	105	69	151	&#105;	i
10	A	012	LFeed	42	2A	052	&#042;	*	74	4A	112	&#074;	J	106	6A	152	&#106;	j
11	B	013	VTab	43	2B	053	&#043;	+	75	4B	113	&#075;	K	107	6B	153	&#107;	k
12	C	014	FFeed	44	2C	054	&#044;	,	76	4C	114	&#076;	L	108	6C	154	&#108;	l
13	D	015	CR	45	2D	055	&#045;	-	77	4D	115	&#077;	M	109	6D	155	&#109;	m
14	E	016	SOut	46	2E	056	&#046;	.	78	4E	116	&#078;	N	110	6E	156	&#110;	n
15	F	017	SIn	47	2F	057	&#047;	/	79	4F	117	&#079;	O	111	6F	157	&#111;	o
16	10	020	DLE	48	30	060	&#048;	0	80	50	120	&#080;	P	112	70	160	&#112;	p
17	11	021	DC1	49	31	061	&#049;	1	81	51	121	&#081;	Q	113	71	161	&#113;	q
18	12	022	DC2	50	32	062	&#050;	2	82	52	122	&#082;	R	114	72	162	&#114;	r
19	13	023	DC3	51	33	063	&#051;	3	83	53	123	&#083;	S	115	73	163	&#115;	s
20	14	024	DC4	52	34	064	&#052;	4	84	54	124	&#084;	T	116	74	164	&#116;	t
21	15	025	NAck	53	35	065	&#053;	5	85	55	125	&#085;	U	117	75	165	&#117;	u
22	16	026	Syn	54	36	066	&#054;	6	86	56	126	&#086;	V	118	76	166	&#118;	v
23	17	027	EoTB	55	37	067	&#055;	7	87	57	127	&#087;	W	119	77	167	&#119;	w
24	18	030	Can	56	38	070	&#056;	8	88	58	130	&#088;	X	120	78	170	&#120;	x
25	19	031	EoM	57	39	071	&#057;	9	89	59	131	&#089;	Y	121	79	171	&#121;	y
26	1A	032	Sub	58	3A	072	&#058;	:	90	5A	132	&#090;	Z	122	7A	172	&#122;	z
27	1B	033	Esc	59	3B	073	&#059;	;	91	5B	133	&#091;	[	123	7B	173	&#123;	{
28	1C	034	FSep	60	3C	074	&#060;	<	92	5C	134	&#092;	\	124	7C	174	&#124;	|
29	1D	035	GSep	61	3D	075	&#061;	=	93	5D	135	&#093;	]	125	7D	175	&#125;	}
30	1E	036	RSep	62	3E	076	&#062;	>	94	5E	136	&#094;	^	126	7E	176	&#126;	~
31	1F	037	USep	63	3F	077	&#063;	?	95	5F	137	&#095;	_	127	7F	177	&#127;	Delete

charstable.com

ASCII

Q: What does this print?

```
#include <stdio.h>
int main( void )
{
        char char_0 = '0';
        int int_0 = char_0 - '0';
        printf( "Character printed as character: %c\n" , char_0 );
        printf( "Character printed as integer: %d\n" , char_0 );
        printf( "Integer printed as integer: %d\n" ,  int_0 );
}
```

```
>> ./a.out
Character printed as character: 0
Character printed as integer: 48
Integer printed as integer: 0
>>
```

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Static arrays

- Static arrays are declared/accessed using square brackets:

```
#include <stdio.h>
int main(void)
{
        int values[2];
        values[0] = 0;
        values[1] = 130;
        printf( "Array values: %d %d\n" , values[0] , values[1] );
        return 0;
}
```

```
>> ./a.out
Array values: 0 130
>>
```

Static arrays

- Static arrays are declared/accessed using square brackets:
- C/C++ **does not** stop you from accessing values outside the array:

```
#include <stdio.h>
int main(void)
{
        int values[2];
        values[0] = 0;
        values[1] = 130;
        printf( "Array values: %d %d\n" , values[0] , values[2] );
        return 0;
}
```

```
>> ./a.out
Array values: 0 0
>>
```

Static arrays

- Static arrays are declared/accessed using square brackets:
- C/C++ **does not** stop you from accessing values outside the array

```
#include <stdio.h>
int main(void)
{
        int values[2];
        values[0] = 0;
        values[1] = 130;
        printf( "Array values: %d %d\n" , values[0] , values[1024] );
        return 0;
}
```

```
>> ./a.out
Array values: 0 813401299
>>
```

Static arrays

- Static arrays are declared/accessed using square brackets:
- C/C++ **does not** stop you from accessing values outside the array

```
#include <stdio.h>
int main(void)
{
        int x = 100;
        int values[2];
        int y = 100;
        values[0] = 0 ; values[1] = 1 ; values[2] = 2;
        printf( "values = { %d , %d  } , y = %d\n" , values[0] , values[1] , y );
        return 0;
}
```

```
>> ./a.out
values = { 0 , 1 } , y = 2
>>
```

Static arrays

- Static arrays are declared/accessed using square brackets:
- C/C++ **does not** stop you from accessing values outside the array

```
#include <stdio.h>
int main(void)
{
        int x = 100;
        int values[2];
        int y = 100;
        values[0] = 0 ; values[1] = 1 ; values[1000000] = 2;
        printf( "values = { %d , %d  } , y = %d\n" , values[0] , values[1] , y );
        return 0;
}
```

```
>> ./a.out
Segmentation fault (core dumped)
>>
```

Static arrays

- Static arrays are declared/accessed using square brackets:
- C/C++ **does not** stop you from accessing values outside the array:
- You can declare and assign array values at the same time
  - The array size is automatically determined from the assignment
  - The values are never in an undefined state.

```
#include <stdio.h>
int main(void)
{
        int values[] = { 0 , 130 };
        printf( "Array values: %d %d\n" , values[0] , values[1] );
        return 0;
}
```

```
>> ./a.out
Array values: 0 130
>>
```

Static arrays

- You can determine the size of a static array using the **sizeof** operator

```
#include <stdio.h>
int main(void)
{
        int values[] = { 0 , 130 };
        printf( "Array size: %d\n" , sizeof( values ) );
        return 0;
}
```

```
>> ./a.out
Array size: 8
>>
```

Q: Why does the array have size 8 if it only has two entries?

Outline

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Strings

- Strings are arrays of null-terminated characters
  - The null termination is required to indicate where the string ends
    - The character '\0' has value 0, so either is fine

```
#include <stdio.h>
int main(void)
{
        char str[] = { 'h' , 'e' , 'l' , 'l' , 'o' , '\0' };
        printf( "str: %s\n" , str );
        return 0;
}
```

```
>> ./a.out
str: hello
>>
```

Strings

- Strings are arrays of null-terminated characters
  - The null termination is required to indicate where the string ends
    - The character '\0' has value 0, so either is fine
    - The character '\n' is a new-line
    - The character '\t' is a tab
    - The character '\"' is a quote
    - etc.

```
#include <stdio.h>
int main(void)
{
        char str[] = { 'h' , 'e' , 'l' , 'l' , 'o' , '\0' };
        printf( "str: %s\n" , str );
        return 0;
}
```

```
>> ./a.out
str: hello
>>
```

Strings

- Strings are arrays of null-terminated characters
  - The null termination is required to indicate where the string ends
- Can use double-quotes to assign the string value

```
#include <stdio.h>
int main(void)
{
        char str[] = "hello";
        printf( "str: %s\n" , str );
        return 0;
}
```

```
>> ./a.out
str: hello
>>
```

Strings

- Strings are arrays of null-terminated characters
  - The null termination is required to indicate where the string ends
- Can use double-quotes to assign the string value
  - Multiple quoted strings are merged into one long string
    - Makes it possible to split text across multiple lines

```
#include <stdio.h>
int main(void)
{
        char str[] = "hel"
                     "lo";
        printf( "str: %s\n" , str );
        return 0;
}
```

```
>> ./a.out
str: hello
>>
```

String functions (declared in `string.h`)

- **strlen**: Get the length of a string

```
#include <stdio.h>
#include <string.h>
int main( void )
{
        char str[] = "hello";
        printf( "string length : %d\n" , strlen( str ) );
        return 0;
}
```

```
>> ./a.out
string length: 5
>>
```

String functions (declared in `string.h`)

- **strlen**: Get the length of a string

```
#include <stdio.h>
#include <string.h>
int main( void )
{
        char str[] = "hello";
        printf( "string length / size: %d %d %s\n" , strlen( str ) , sizeof( str ) , str );
        return 0;
}
```

```
>> ./a.out
string length / size: 5 6 hello
>>
```

Q: Why are the length and size different?

String functions (declared in `string.h`)

- **strlen**: Get the length of a string

```
#include <stdio.h>
#include <string.h>
int main( void )
{
        char str[] = "hello";
        str[2] = 0;
        printf( "string length: %d %s\n" , strlen( str ) , str );
        return 0;
}
```

```
>> ./a.out
string length: 2 he
>>
```

String functions (declared in `string.h`)

- **`strcpy`**: Copy the contents of one string into the other
  - The target must be large enough to store the source and its null-terminator

```
#include <stdio.h>
#include <string.h>
int main(void)
{
        char source[] = "hello";
        char target[6];
        strcpy( target , source );
        printf( "string: %s\n" , target );
        return 0;
}
```

```
>> ./a.out
string: hello
>>
```

String functions (declared in `string.h`)

- **strcmp**: Compare two strings
  - returns < 0: If the first string comes before the second
  - returns > 0: If the second string comes before the first
  - returns 0: if the strings are equal

```
#include <stdio.h>
#include <string.h>
int main(void)
{
        char str1[] = "hello";
        char str2[] = "goodbye";
        printf( "compare( %s , %s ) = %d\n" , str1 , str2 , strcmp( str1 , str2 ) );
        return 0;
}
```

```
>> ./a.out
compare( hello , goodbye ) = 1
>>
```

String functions (declared in `string.h`)

- `strtok`: Tokenizes a string
- `strcat`: Concatenates two strings
- and much much more

http://www.cplusplus.com/reference/cstring/

String functions (declared in `stdlib.h`)

- `atoi`: converts a string into an integer
- `atof`: converts a string into a (double-precision) floating point value

```
#include <stdio.h>
#include <stdlib.h>
int main(void)
{
        char str[] = "120";
        int i = atoi( str );
        double d = atof( str );
        printf( "%s -> %d : %f\n" , str, i , d );
        return 0;
}
```

```
>> ./a.out
120 -> 120 : 120.000000
>>
```

Outline

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Review questions

1. When we declare an array in C, what are the initial values?

Undefined

Review questions

2. What is the ASCII (Unicode) table?

A mapping between characters and integer values

Review questions

3. What is a null terminator? What is the ASCII value?

A character whose integer value is zero, indicating the end of a string

Review questions

4. Consider a c-string as "ab\0cd\0", what is the string length?

2

Review questions

5. How do we check if two c-strings are the same? In addition, are these two strings the same: "ab\0cd\0" and "ab\0"?

Read through the strings together until hitting the first null terminator:

- Return true if
  - The characters read up to the null terminator are the same, and
  - Both strings have a null terminator in the same position
- Otherwise return false

Yes

Exercise 5

- Website -> Course Materials -> Exercise 5