Lecture 2 - 6/2/2022

Hidden Files

Hidden files begin with a period. A period represents the current directory. To see hidden files, use this command:

```
`ls -al`.
```

- If you do this in your home directory, you will see that there are many configuration files. In my case, I have all this:

  ```
  total 61
  drwxr-xr-x. 8 sprakash users 2048 Jun  2 21:26 .
  drwxr-xr-x. 7 root     mail  2048 May 25  2021 ..
  lrwxr-xr-x. 1 sprakash users   58 May 31 21:41 216 ->
  /afs/glue/class/summer12022/cmsc/216/0101/student/sprakash
  lrwxr-xr-x. 1 sprakash users   48 May 31 21:41 216public ->
  /afs/glue/class/summer12022/cmsc/216/0101/public
  -rw-r--r--. 1 sprakash users  282 May 31 22:05 .aliases
  -rw-r--r--. 1 sprakash users  178 May 25  2021 .bash_aliases
  -rw-r--r--. 1 sprakash users  573 May 25  2021 .bash_environment
  -r--r--r--. 1 sprakash users 1538 May 25  2021 .bash_logout
  -rw-r--r--. 1 sprakash users  256 May 25  2021 .bash_logout.mine
  -rw-r--r--. 1 sprakash users  303 May 25  2021 .bash_path
  -r--r--r--. 1 sprakash users 2387 May 25  2021 .bashrc
  -rw-r--r--. 1 sprakash users  353 May 25  2021 .bashrc.mine
  -r--r--r--. 1 sprakash users 2352 May 25  2021 .cshrc
  -rw-r--r--. 1 sprakash users  420 May 31 21:41 .cshrc.mine
  -rw-r--r--. 1 sprakash users 1664 May 25  2021 .dashmenurc
  drwx------. 3 sprakash users 2048 Jun  2 01:57 .dbus
  -rw-r--r--. 1 sprakash users  498 May 25  2021 .emacs
  drwx------. 3 sprakash users 2048 Jun  1 15:49 .emacs.d
  -rw-r--r--. 1 sprakash users  534 May 25  2021 .environment
  -rw-r--r--. 1 sprakash users   95 May 25  2021 .fvwm2rc
  -rw-------. 1 sprakash users  613 Jun  2 21:26 .history
  -rw-r--r--. 1 sprakash users    0 Jun  2 21:26 .hushlogin
  drwxr-xr-x. 3 sprakash users 2048 Mar 16  2006 .kde
  -rw-r--r--. 1 sprakash users   86 May 25  2021 .kermrc
  drwxr-xr-x. 3 sprakash users 2048 May 31 11:34 .local
  -r--r--r--. 1 sprakash users 1761 May 25  2021 .login
  -r--r--r--. 1 sprakash users 1524 May 25  2021 .logout
  -rw-r--r--. 1 sprakash users  258 May 25  2021 .logout.mine
  drwx------. 2 sprakash users 2048 May 25  2021 Mail
  -rw-r--r--. 1 sprakash users   11 May 25  2021 .mh_profile
  -rw-r--r--. 1 sprakash users  370 May 31 21:41 .path
  -r--r--r--. 1 sprakash users 1757 May 25  2021 .profile
  -rw-r--r--. 1 sprakash users  118 May 25  2021 .reqrc
  ```

```
drwx------. 2 sprakash users 2048 Jun  2 21:25 .ssh
-rwxr-xr-x. 1 sprakash users  835 May 25  2021 .startup.X
-rw-r--r--. 1 sprakash users  613 May 25  2021 .twm.menus
-rw-r--r--. 1 sprakash users 1609 May 25  2021 .twmrc
-rw-------. 1 sprakash users  912 Jun  2 02:39 .viminfo
-rw-r--r--. 1 sprakash users  954 May 17  2006 welcome
-rw-------. 1 sprakash users  481 Jun  2 21:25 .Xauthority
-rwxr-xr-x. 1 sprakash users 1269 May 25  2021 .xinitrc
-rwxr-xr-x. 1 sprakash users  132 May 25  2021 .xserverrc
lrwxr-xr-x. 1 sprakash users    8 May 25  2021 .xsession -> .xinitrc
```

Dang that's a lot of files that I didn't know about.

The command `pwd` shows the path of where you are.

Input and Output

Let's create a sample file `p1.c` such that:

```c
#include <stdio.h>

int main(void) {
    int x, y;

    scanf("%d%d", &x, &y);
    printf("The values are %d %d\n", x, y);

    return 0;
}
```

We can compile this program using `gcc` and run it such that this will be our output:

```
10 20
The values are 10 20
```

Input Redirection

Let's try to change the input from the user to a file. To do this, lets create a file using the command

```
vi data.txt
```

Here, we will put this data in:

```
10 20
```

So now, the file `data.txt` contains the text `10 20` that represents our data.

To run our program using this file as our input, we can run this command:

```
a.out < data.txt
```

When we do this, our terminal shows:

```
grace7:~/216: a.out < data.txt
The values are 10 20
```

Notice I left in the command line to show everything I've done for this run.

What we have done here is called **input redirection**.

Output Redirection

We can also redirect our ouptut from the CLI to a file. To do this, we could run the program like this:

```
grace7:~/216: a.out < data.txt > results.txt
```

This way, the program's input is `data.txt`, and the output goes to a file called `results.txt`. Using `ls`, we can see that the file `results.txt` was created.

When we run the command

```
cat results.txt
```

we will see the output of our program in the `results.txt` file:

```
grace7:~/216: cat results.txt
The values are 10 20
```

Note: before we run this program againl, we must remove the `results.txt` file using this command:

```
rm results.txt
```

Exercise: `draw_figures`

In `216public/exercises/draw_figures/`, we see many files.

```
grace7:~/216public/exercises/draw_figures: ls
colors_in_c.c    public02.output  public04.output  public06.output
public01.in      public03.in      public05.in
public01.output  public03.output  public05.output
public02.in      public04.in      public06.in
```

These are the files that show the inputs and exptected outputs of our program.

When we work on this exercise, we can use input and output redirection to run out program like this:

```
a.out < public01.in > t
```

where t is our output file.

Command: `diff`

In our environment, there is a command which can compare two files. Suppose we want to see if a file `r` is the same as a file `public01.out`. We can run the command:

```
diff public01.output r
```

If there is no output from this line, then the two files are identical. Otherwise, it will tell you what the difference is.

This command will help us to see if the output from our program matches the expected output as shown in files such as `public01.output` and `public02.output`.

Transfer Files to and from Grace

In MobaXTerm, you can transfer files to and from Grace by using the `SFTP` feature. Do this by:

- Go to `Sessions` dropdown in the menu bar
- Hit `New Session`
- Click `SFTP`
- After logging in this way, you will see that you can drag and drop files like Windows File Explorer

Mac Users can use transfer files using another protocol.'

File Transfer Protocol: `scp` (secure copy)

I use `scp` to copy files through SSH on different machines. To do this on Grace, open a terminal on your local machine. Enter a command that follows this structure:

```
scp -P 22 sprakash@grace.umd.edu:~/216/p1.c ./Desktop/p1.c
```

obiously, change my username to yours, the path of the file to the path of your file, the name of the file to the name of your file, and the path for where you want the file to wherever you wish for it to be.

Alternatively, you can open your local terminal in wherever you want the file to go. Then you don't need to write the path for where you want the file to go, only the file name.

For example, this also works:

```
C:\Users\Sashu\Desktop>scp -P 22 sprakash@grace.umd.edu:~/216/p1.c p1.c
```

Why you want to develop your own code?

Copied from `C-Language-III.pdf` slides

- “Company TA” - Remember there is no such thing as the ”company ta” you need to develop the skills you will need later on (both for classes and future employer)
- Constant Help - It is OK to be assisted by TAs, but if you are constantly asking for TA help it is best if you talk to us to address any problems you might be experiencing
- Debug Your Own Programs - You are expected to debug your own programs. We will help you, but you need to do most of the work
- Skills Will Develop The More Independent You Are - Your programming skills will increase as you rely less and less on TAs
- Exams and quizzes will have questions based on your projects. If you don’t complete the projects by yourself you will not be able to answer those questions
- Please read the information available here.

Incremental code development

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- **Most important rule for code development** – Regardless of the language you are using, **incremental code development** (add code, test, then add more) it is extremely important
- You will know if you are following incremental code development if you can answer the following questions:
    1. Up to what point my code was working?
    2. What did I added that just made my code stop working?
- Compiler can generate errors that are hard to interpret
- Look at the number of errors for the following program when compiled using the gcc settings for the course

Example: `error.c`

This example code shows why incremental code development is important.

```
// Mary
#include <stdio.h>
int main() {
```

```
    printf("Done\n");
    return 0;
}
```

When we compile this code using `gcc`, it outputs several large error messages. It's difficult to comprehend all this, so if we made sure to test our program at each increment of development, we can find the cause of problems easier, since not much will have changed.

Comma operator

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- Yes, the comma is an operator
- Evaluates left operand, then right operand
- Value of expression with commas is the value of the last operand
- Comma operator has lowest precedence of all operators
- For the following code, what gets stored in `i` after each statement? What does each statement evaluate to?

  ```
  i = 1, 2, 3, 4;
  i = (1, 2, 3, 4);
  ```

Example: `comma_op.c`

Take a look at this code which shows what the comma operator does:

```
#include <stdio.h>

int main() {
   int i, j = 2, k = 3;

   i = (1, ++j, ++k);
   printf("i: %d\n", i);
   printf("j: %d\n", j);
   printf("k: %d\n", k);

   /* Resetting j, k */
   printf("\nWithout parentheses\n");
   j = 2;
   k = 3;
   i = 1, ++j, ++k;
   printf("i: %d\n", i);
   printf("j: %d\n", j);
   printf("k: %d\n", k);

   return 0;
}
```

As you can see, the line

```
i = (1, ++j, ++k);
```

Has three instructions, separated by commas, and this is somehow evaluated to a value that is given to `i`. The comma operator returns the value of the last expression, in this case, `++k`. So, `i` will have whatever value results from `++k`.

On the other hand, when used without parenthasis such as

```
i = 1, ++j, ++k;
```

`i` is given the value of 1, and the other statements also run. The values of those statements are useless in that line because `i` is not affected by them.

C Program memory organization

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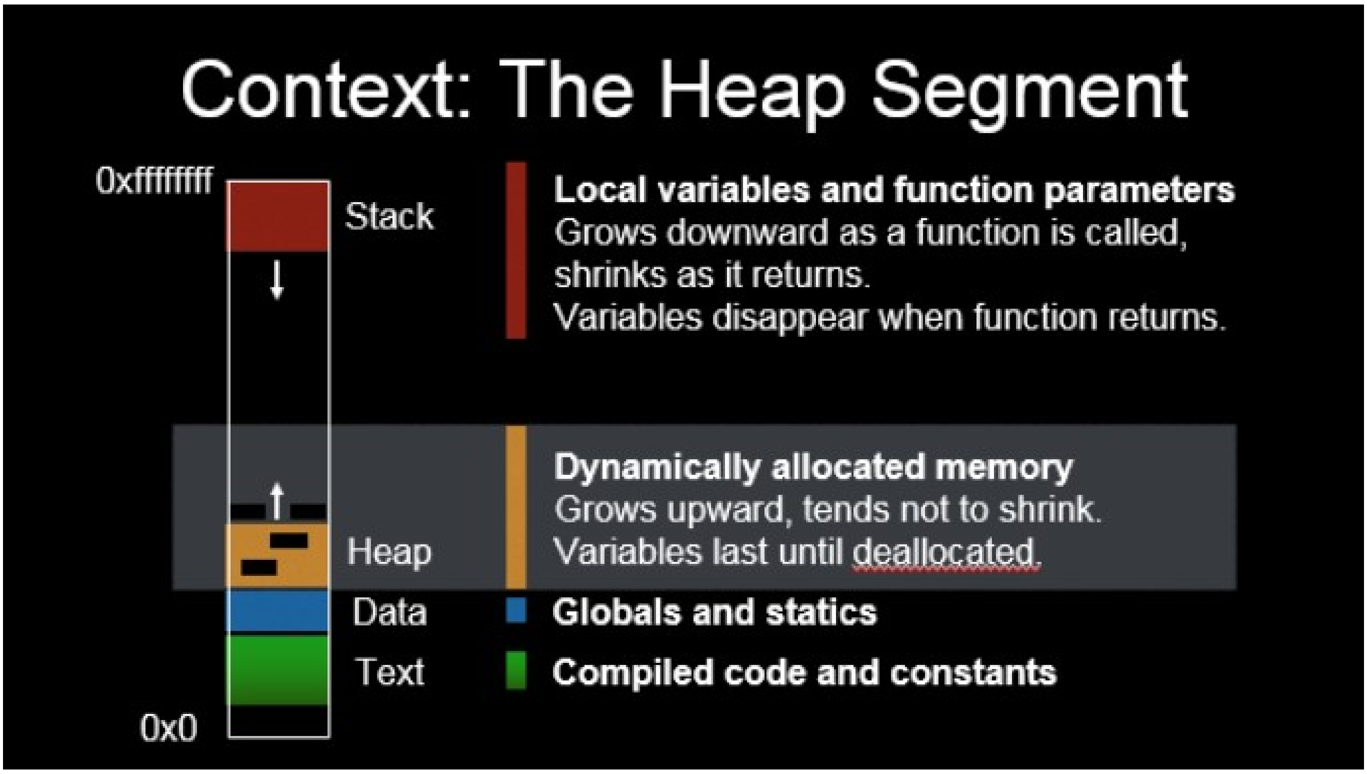

Identifier scope

- C has two main types of scope
  - **Block scope**: a variable declared inside a block is visible only within the block (includes nested blocks inside that block)
  - **File scope**: an identifier declared outside of any block is visible everywhere in the file after the declaration
- A **Global variable** is a variable defined outside of a function with file scope

  - Avoid them; use them only if absolutely necessary
  - Global variables are initialized by default to 0
- Scope applies both to global variables and function names
  - A function is visible from its point of definition on

Example: `global.c`

Let's take a look at this example code:

```c
#include <stdio.h>

/* Notice the global variables convention (g_) */
int g_years = 10;  /* What if we don't initialize it? */

void process() {
   /* Following printf will not compile */
   /* printf("g_salary in process() %f\n", g_salary); */
   g_years++;
}

double g_salary = 3000.00; /* Visible from this point on */

int main() {
   printf("g_years before process() call: %d\n", g_years);
   process();
   printf("g_years after process() call: %d\n", g_years);
   printf("g_salary in main() %f\n", g_salary);

   return 0;
}
```

A global variable is visible during the entire duration of the program, once it is declared. Notice `g_years` is a global variable, and it's named using `g_` by convention.

- The code will not compile if `process()` tried to access `g_salary` because global variables are only visible from their point of declaration onwards.
- The default variable for a global variable is `0`, whereas the default value for a local variable is garbage.
- Global variables are file scope.

Storage

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- How long is memory allocated for a variable?
- After the following function returns, is there any guarantee that the value 5 will stay at the spot in memory at which it was stored?

  ```c
  int example(int i) {
    int j = 5;
  ```

```
    return i + j;
  }
```

- There are two types of storage:
    - **Automatic**: the previous variable j has automatic storage, meaning it is no longer maintained after its function returns
        - Default for block-scoped variables
    - **Static**: variable exists throughout the entire life of the program
        - Global variables have this kind of storage
        - Initializations to static variables occur only once
        - We can make block-scoped variables static

Example: `static.c`

```c
#include <stdio.h>

void compute_automatic(int x);
void compute_static(int x);

void compute_automatic(int x) {
   int value = 100;

   printf("(automatic) x: %d, value: %d, sum: %d \n", x, value, value + x);

   ++value;
}

void compute_static(int x) {
   /* Initialization to a 100 will take place only once, when the */
   /* function is called the first time */
   static int value = 100; /* What would happen if we don't initialize it? */

   printf("(static) x: %d, value: %d, sum: %d \n", x, value, value + x);

   ++value;
}

int main() {
   compute_automatic(1);
   compute_automatic(1); /* calling function again */

   compute_static(1);
   compute_static(1); /* calling function again */

   return 0;
}
```

It's important to note that the line

```
static int value = 100;
```

will only run once. So, if the function `compute_static` is called a second time, the value of `value` will be 101, not 101.

- For this reason, it's recommended to avoid using this in general, although there may be some justified ways to use it.

Identifier linkage

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- What happens if we encounter two instances of the same identifier across different files?
- A function named `foo()` in `file1.c` can cause problems if there's a function named `foo()` in `file2.c`
- We can resolve these types of conflicts by changing the linkage of the functions
- **Linkage**:
    - A property of an identifier that determines if multiple declarations of that identifier refer to the same object
    - Extent to which an identifier (e.g., variable or function name) can be shared by different parts of a program
- To better understand linkage, let’s see how we can organize C code across several C file
    - Example: linkage_example/functions directory
        - Why we want to split code across several files?
    - Example: linkage_example/variables directory

Example: `functions`

Let's take a look at the directory `functions` in `linkage_example`:

```
grace10:~/<2>Week01/C-Language-III-Code/linkage_example/functions: ls
main.c   README.txt   support.c
```

Here, let's `cat README.txt` to see its contents. Reading `README` files can be beneficial because they are meant to be read before the use of a software.

```
grace10:~/<2>Week01/C-Language-III-Code/linkage_example/functions: cat README.txt
To compile:

gcc main.c support.c
```

This `README` file gives some information on how to compile the code.

Before we do so, lets take a look at the file `support.c`:

```
grace10:~/<2>Week01/C-Language-III-Code/linkage_example/functions: cat support.c
```

```
#include <stdio.h>

/*
 * 1. What happens if you add static at the beginning?
 * 2. What happens if you add extern?
 *
 */

/* Function definition */
/* Prints sum of value from 1 up to limit */
void print_sum(int limit) {
   int sum = 0, k = 1;

   while (k <= limit) {
      sum += k;

      k++;
   }
   printf("The sum of %d is %d\n", limit, sum);
}
```

This file has a function `print_sum` which prints a the sum of values from 1 to a `limit`.

Now, lets take a look at the file `main.c`.

- This file can be named anything, but it's called `main.c` for the purposes of this example

```
grace10:~/<2>Week01/C-Language-III-Code/linkage_example/functions: cat main.c
```

```
#include <stdio.h>

/*
 * 1. What happens if you add static at the beginning of the prototype?
 * 2. What happens if you add extern at the beginning of the prototype?
 * 3. What happens if you remove the prototype?
 */

void print_sum(int limit); /* Prototype */

int main() {
   print_sum(4);

   return 0;
}
```

This file makes use of the `print_sum` funciton defined in the other file.

To make this work, we must compile using the information provided in the `README.txt` file.

```
gcc main.c support.c
```

Then, if we run the outputted `a.out`, we'll see that we get this output:

```
The sum of 4 is 10
```

The program worked as expected. What did `gcc` do?

- `gcc` is not also a compiler, but also a linker. In Nelson's terms, it takes all the ingredients and stirs them in the pot.
- The linker finds the code for `printf()` if it is needed.
- The compiler generated machine code for each file, then links them together.

Let's continue looking at the file `main.c`.

- We see that we have a prototype:

  ```
  void print_sum( int limit); /* Prototype */
  ```

  - This prototype tells us and the compiler that there is a function elsewhere called `print_sum` that has this signature.
- By default, functions have an external linkage, which means that such functions in one file can be accessed from any other file.
  - So, the functions in `support.c` can be accessed by `main.c`.

Suppose, in `support.c`, we added the keyword `static` to `print_sum` such that `support.c` looks something like this:

```
#include <stdio.h>
static void print_sum(int limit) {
   int sum = 0, k = 1;

   while (k <= limit) {
      sum += k;

      k++;
   }
   printf("The sum of %d is %d\n", limit, sum);
}
```

Now, if we compile the code, we get an error:

```
gcc main.c support.c
support.c:11:13: warning: `print_sum` defined but not used [-Wunused-function]

  static void print_sum( int limit) {
              ^
/tmp/ccAjuXHRs.o: In function `main`:
/afs/glue.umd.edu/.../functions/main.c:12: undefined reference to 'print_sum'
collect2: error: ld returned 1 exit status
```

As we can see, main is calling `print_sum` but there is no `print_sum` that is accessible by it.

To make `print_sum` accessible externally, we give it the default keyword `extern` such that `support.c` looks like this:

```
#include <stdio.h>
extern void print_sum(int limit) {
   int sum = 0, k = 1;

   while (k <= limit) {
      sum += k;

      k++;
   }
   printf("The sum of %d is %d\n", limit, sum);
}
```

It's important to note that the `extern` keyword is the default visibility assigned to functions, so there is no need to write it at all in the signature of a function.

With this or the default signature, the code compiles and runs properly.

The use of `static` functions in C is similar to the use of `private` functions in Java, where we need to use functions as supports without them being visible/useable by users.

Example: `variables`

Similar to linkages in functions, we can address linkages in the context of variables

Let's take a look at the `variables` directory in `linkage_example`:

```
grace10:~/<2>Week01/C-Language-III-Code/linkage_example/variables: ls
main.c   README.txt   support.c
```

Let's take a look at the file called `main.c`

```
grace10:~/<2>Week01/C-Language-III-Code/linkage_example/variables: cat main.c
```

```c
#include <stdio.h>

/*
 * 1. What happens if we remove extern?
 * 2. What happens if we assign a value to g_computers ?
 * 3. What happens if we assign a value to g_computers having a extern?
 * 4. What if we remove the extern and assign a value to g_computers?
 */

/* Declaration */
extern int g_computers;

/* Function prototype */
void process();

int main() {
   printf("Before calling process %d\n", g_computers);
   process();
   printf("After calling process %d\n", g_computers);

   return 0;
}
```

The line:

```c
extern int g_comptuers;
```

looks like a global variable, but to see what it's doing, let's wee what the program is doing.

The program has a function called `process()`, which isn't in `main.c`. It's in `support.c`, so let's take a look at that too:

```
grace10:~/<2>Week01/C-Language-III-Code/linkage_example/variables: cat support.c
```

```c
#include <stdio.h>

/* When you assign a value you define the variable */
int g_computers = 200;

void process() {
   g_computers++;
}
```

```
```

Here, we see that the function increases the global variable `g_computers` by 1 everytime it is called.

In C, when we give a variable a value, we are "defining" it, which means we allocate space in memory for it.

The terms

- Declaration
- Definition

are different.

Let's revisit the `main.c` code. We can see that the lines

```
/* Declaration */
extern int g_computers;
```

Declare there to be an `int` variable called `g_computers`. However, the word `extern` makes this declaration such that the variable is defined elsewhere - in this case, in `support.c`. The linker will take care of this linkage.

Suppose we changed `support.c` and added `static` to the defined variable, `g_computers`. The file would look something like this:

```
#include <stdio.h>

static int g_computers = 200;

void process() {
   g_computers++;
}
```

And now, the code will not compile. The compiler will throw an error such as this:

```
gcc *.c

/tmp/...: In function `main`:
/afs/glue.umd.edu/.../variables/main.c:19: undefined reference to ;'g_computers'
collect2: error: ld returned 1 exit status
```

Let's see what this error message means.

- In function main, we have an "undefined referece to `g_computers`.
  - This means that although there is an `extern` **declaration**, it has not been **defined**.
- collect2: error: ld
  - `ld` is the linker. Since it reterned an `exit` status, we can see that it was unable to complete its linkages.

Some things to note:

- If we were to change

  ```
  int g_computers = 200;
  ```

  to

  ```
  int g_computers;
  ```

  our output would change to reflect that global variables are initialized with the value of 0. The program would still work, but it will start at 0 instead of 200.
- If we were to remove `extern` from

  ```
  extern int g_computers;
  ```

  the program will still work the same way, since `extern` is used by default even if it's not added there by the programmer.
- If we made `main.c` to have

  ```
  /* Declaration */
  int g_computers = 10;
  ```

  AND support.c to have:

  ```
  int g_computer = 20;
  ```

  When we compile the program, we will get this error:

  ```
  gcc *.c
  /tmp/...:(.data+0x0): multiple definition of `g_computers`
  /tmp/...:     ...     : first defined here
  collect2: errpr: ld retured 1 exit status
  ```

  This shows that by setting a value, we are defining.

Interesting Nelson Quote:

"This class is brought to you by Starbucks" - Nelson.

Interesting Unix Commands:

Here are some interesting Unix commands that can be used.

`finger`

The command `finger` lets you `finger` someone on a server such that you can get some information about their user.

For example, if I were to `finger` myself:

```
grace10:~: finger sprakash
Login: sprakash                         Name: Sashwath Prakash
Directory: /afs/glue.umd.edu/home/glue/s/p/sprakash/home        Shell: /bin/tcsh
On since Fri Jun 10 02:56 (EDT) on pts/0 from [REDACTED IP]
   7 seconds idle
No mail.
No Plan.
```

`ps`

The `ps`, or process command, lets you see what processes someone is running. For example, you can use this with the flags `-fu` to see what someone is doing:

```
grace10:~: ps -fu sprakash
UID        PID  PPID  C STIME TTY          TIME CMD
sprakash  7052  7035  0 02:56 ?        00:00:00 sshd: sprakash@pts/0
sprakash  7057  7052  0 02:56 pts/0    00:00:00 -tcsh
sprakash 22405  7057  0 04:17 pts/0    00:00:00 ps -fu sprakash
```

To see all the processes on the system, we can use

```
grace10:~: ps -e
  PID TTY          TIME CMD
    1 ?        02:55:24 systemd
    2 ?        00:00:30 kthreadd
    4 ?        00:00:00 kworker/0:0H
    6 ?        00:03:16 ksoftirqd/0
    .
    .
    .
```

`who am i`

This command tells you who you are

```
grace10:~: who am i
sprakash pts/0        2022-06-10 02:56 (REDACTED IP)
```

`who`

This command tells you who is on the same machine as you

```
grace10:~: who
sprakash pts/0        2022-06-10 02:56 (REDACTED IP)
ishi     pts/1        2022-06-09 23:27 (REDACTED IP)
```

`cal`

This command gives you a nice looking calendar

```
grace10:~: cal
      June 2022
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
```

But the date is somehow highlighted on an ssh client.

`date`

This command tells you the date

```
grace10:~: date
Fri Jun 10 04:24:46 EDT 2022pep
```

`mesg y`

Lets you enable your messages

`write $user`

Lets you write to a user by replacigng `$user` with their username.

Enumerated types

Back to learning about C

- We can use these to represent things that only take on certain values
- Values equalt to 0, 1, 2... based on order of definition.
- Values can be set by programmer to things other than 0, 1, 2...
- Based on intergers, but don't mix enums with intergers unless absolutely necessary.

```c
#include <stdio.h>

int main () {
    enum Suit {
        SPADES, HEARTS,
        DIAMONDS = 42, CLUBS
    };

    enum Suit suit1, suit2;

    suit1 = SPADES;

    suit2 = CLUBS;

    if (suit1 < suit2)
        printf("Spades are furst.\n");
    else
        printf("Clubs are first.\n");
    printf("Spades = %d, Clubs = %d\n", suit1, suit2);

    return 0;
}
```

You'll see that `SPADES = 1`, and `CLUBS = 43`.

Lvalues and Rvalues

- An `rvalue` is anything that can appear on the right side of an assignment statement
  - Virtually any expression
- An `lvalue` is anything that can appear on the left side of an assignment statement
  - Values that represent a place to store a values (e.g., variables, array entry)
- The right and left sides of an assignment statement are treated differently.
  - Right hadn side is a value, left hadn side is a location to store a value (an address)

Typecasting

- In c, we can have **explicit** and **implicit** type conversions.
- We can have explicit conversion using casting:

  ```c
  float f = 3.45;
  int x = (int)f;
  ```

- C performs integer promotions
  - Small integer types (e.g., **char**, **short**) in expression sare converted to **int**.
- Arithmetic operators require their operands to be of same type to perform the operation.
  - C ompiler performs type conversios automatically (**implicit type conversions**) when an expression involves different types.
- When two operands of different types are involved in an expression, the lower rank operand will be converted to the data type of the higher rank. For example, if we have a double and a float expression, the float will be converted to a double. The following types are ordered from high to low rank:
  - long double
  - double
  - float
  - unsigned long int
  - long int
  - unsigned int
  - int
  - char, short
- Reference
- Note: `char` and `short` is converted to `int`, then it is compared to the other.
- Implicit casting also takes place during assignments and when calling a function with an argument that does not match the parameter
- Be careful and avoid mixing types unless you are sure is safe.
- Do not ignore compiler warnings and pay attention to messages generated by tools