CSE 333 Section AB

I/O, POSIX, and System Calls! (w/ Yifan & Travis)

Logistics

Due TODAY:

Homework 1 @ 9 pm

Due Monday:

Exercise 6 @ 11 am

POSIX

Posix is a family of standards specified by the IEEE. These standards maintains compatibility across variants of Unix-like operating systems by defining APIs and standards for basic I/O (file, terminal, and network) and for threading.

1) What does POSIX stand for?

   Portable Operating System Interface

2) ` Why might a POSIX standard be beneficial? From an application perspective? Versus using the C stdio library?

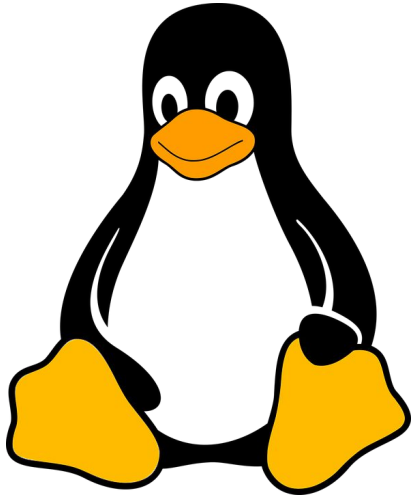
- **More explicit control since read and write functions are system calls and you can directly access system resources.**
- **POSIX calls are unbuffered so you can implement your own buffer strategy on top of read()/write().**
- **There is no standard higher level API for network and other I/O devices**

Review from Lecture

```
ssize_t read(int fd, void *buf, size_t count)
```

An error occurred	`result = -1` `errno = error`
Already at EOF	`result = 0`
Partial Read	`result < count`
Success!	`result == count`

New Scenario - Messy Roommate



- The Linux kernel is now your roommate
- There are N pieces of trash in the room
- There is a single trash can, `char bin[N]`
  - (For some reason, the trash goes in a particular order)
- You can tell your roommate to pick it up, but he/she is unreliable

New Scenario - Messy Roommate

`NumTrash pickup(roomNum, trashCan, Amount)`

"*I tried to start cleaning, but something came up*" (got hungry, had a midterm, room was locked, etc.)	`NumTrash == -1` `errno == excuse`
"*You told me to pick up trash, but the room was already clean*"	`NumTrash == 0`
"*I picked up some of it, but then I got distracted by my favorite show on Netflix*"	`NumTrash < Amount`
"*I did it! I picked up all the trash!*"	`NumTrash == Amount`

`NumTrash pickup(roomNum, trashCan, Amount)`

`NumTrash == -1, errno == excuse`
`NumTrash == 0`
`NumTrash < Amount`
`NumTrash == Amount`

How do we get the room clean?

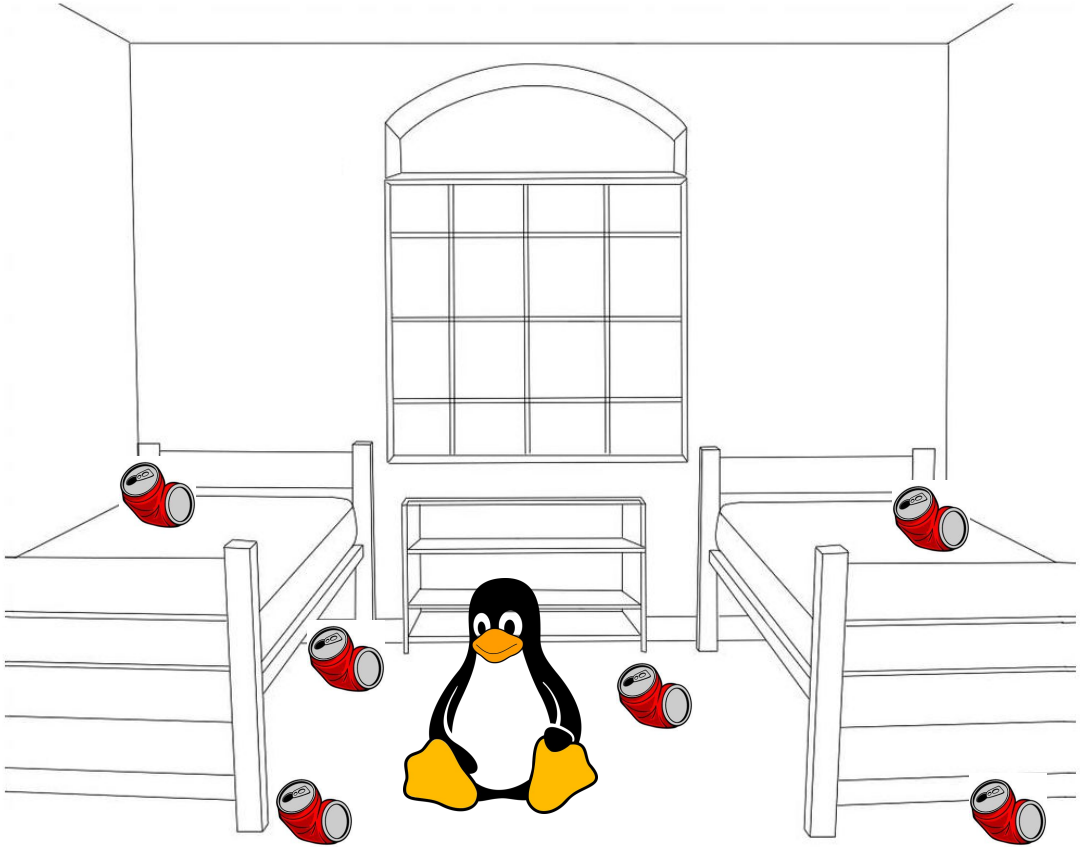
- Use a loop. What's the (high level) goal?
  - Pick up all N pieces of trash
- What if the roommate returns -1 with an excuse?
  - If it's a valid excuse, stop telling them to pick up trash
  - If it's not, start over at the top of the loop
- What if the room is already clean?
  - Stop telling the roommate to pick up trash
- What if the roommate only picked up some of it?
  - Record how much they picked up, and tell them to pick up the rest
- What if the roommate picked up everything you asked?
  - Our goal has been reached!

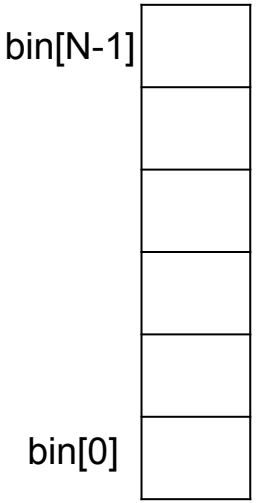
That's it!

How do we get the room clean?

```
NumTrash pickup(roomNum, trashCan, Amount)
```

`NumTrash == -1, errno == excuse`
`NumTrash == 0`
`NumTrash < Amount`
`NumTrash == Amount`



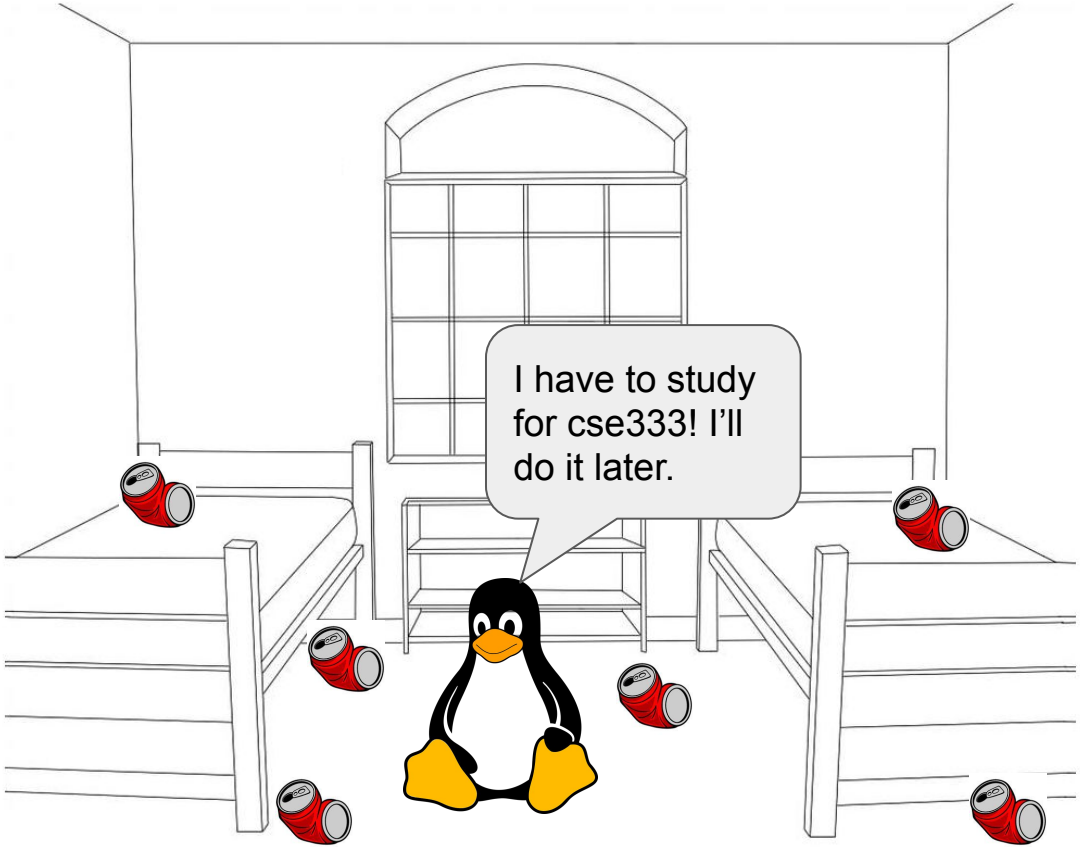


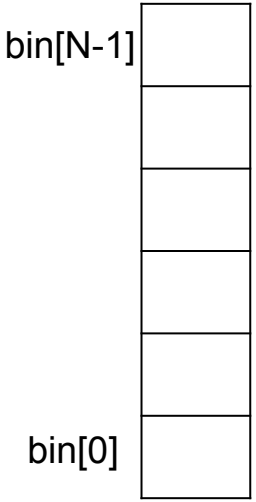
What do we do in the following scenarios?

How do we get the room clean?

```
NumTrash pickup(roomNum, trashCan, Amount)
```

`NumTrash == -1, errno == excuse`
`NumTrash == 0`
`NumTrash < Amount`
`NumTrash == Amount`



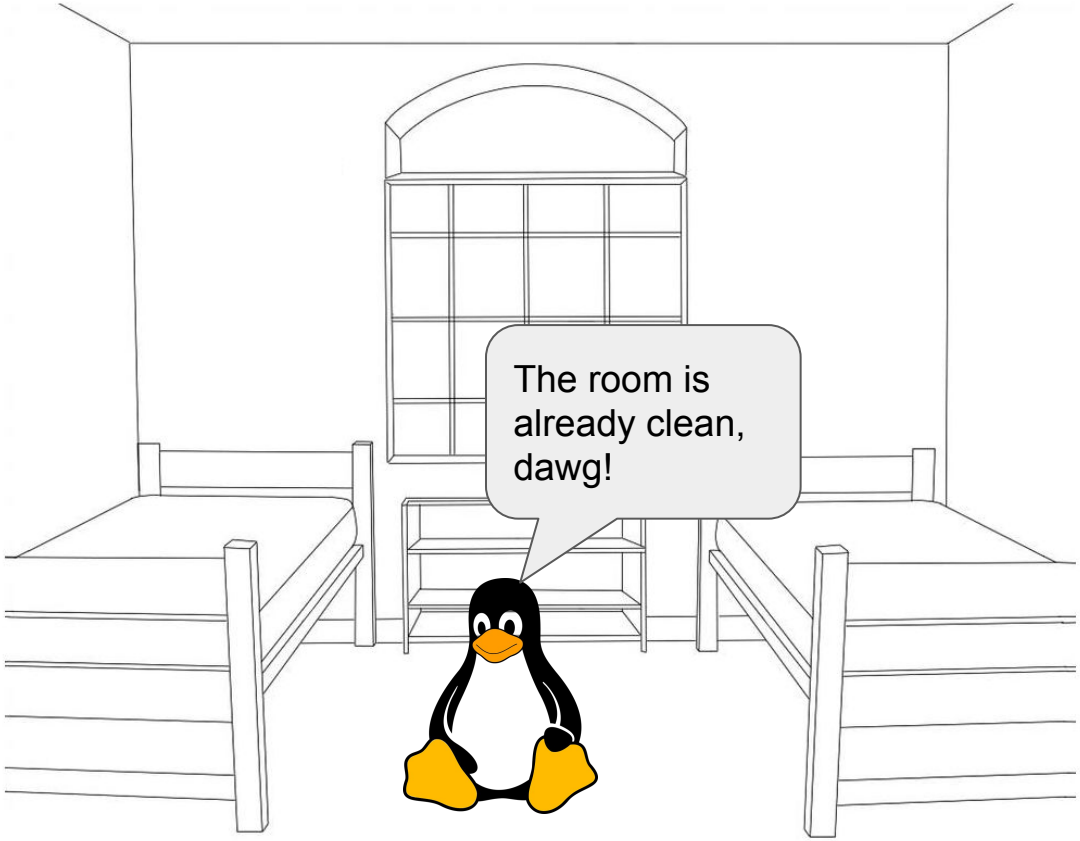


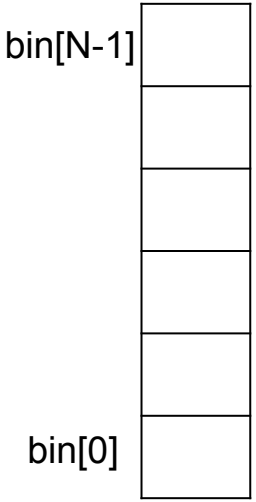
Decide if the excuse is reasonable, and either let it be or ask again.

How do we get the room clean?

```
NumTrash pickup(roomNum, trashCan, Amount)
```

`NumTrash == -1, errno == excuse`
`NumTrash == 0`
`NumTrash < Amount`
`NumTrash == Amount`



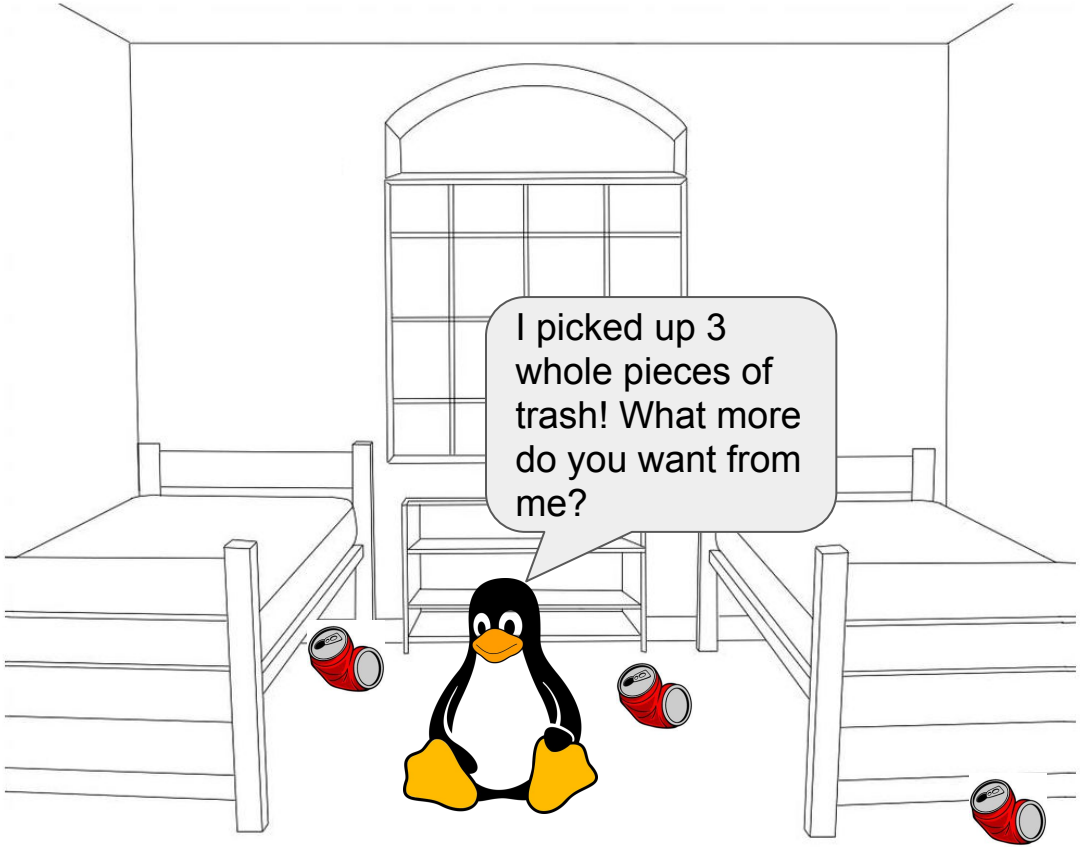


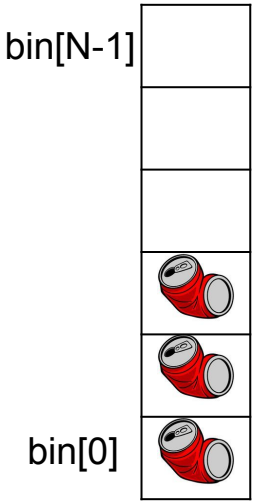
Stop asking them to clean the room! There's nothing to do.

How do we get the room clean?

```
NumTrash pickup(roomNum, trashCan, Amount)
```

`NumTrash == -1, errno == excuse`
`NumTrash == 0`
`NumTrash < Amount`
`NumTrash == Amount`



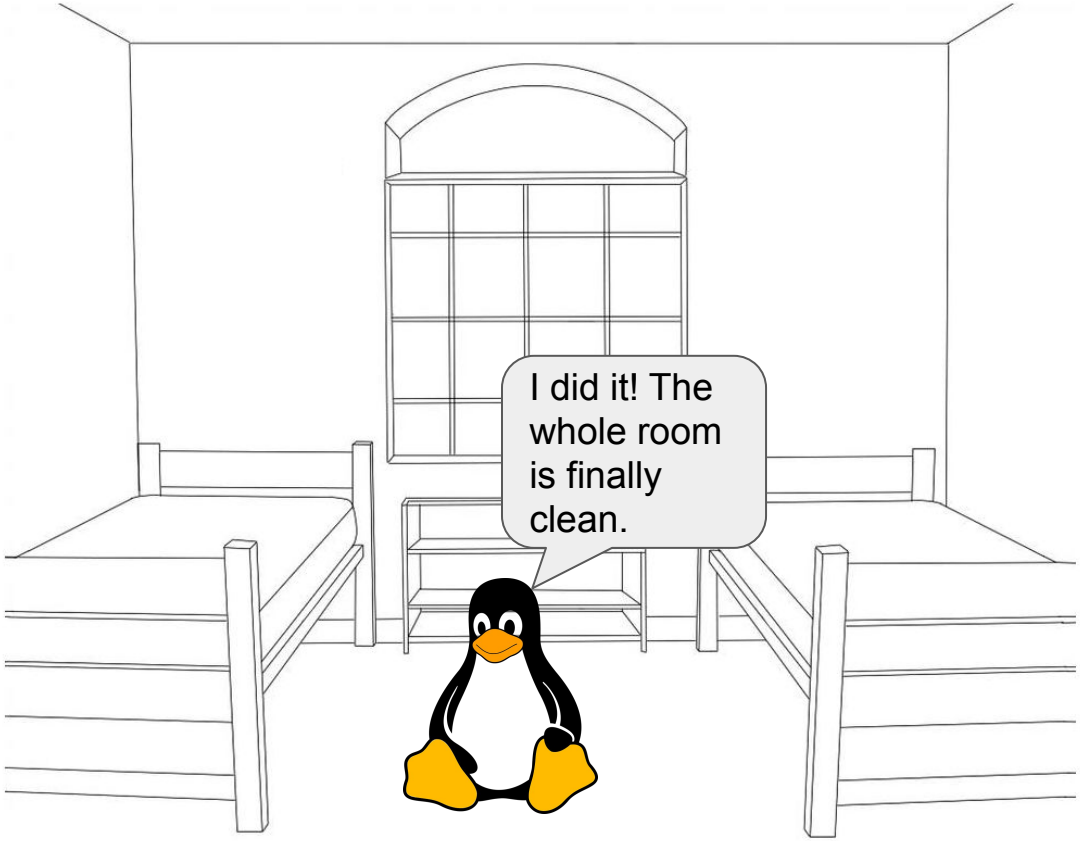


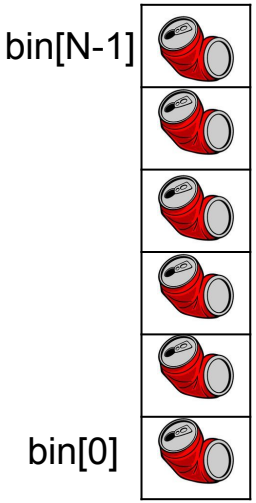
Ask them again to pick up the rest of it.

How do we get the room clean?

```
NumTrash pickup(roomNum, trashCan, Amount)
```

`NumTrash == -1, errno == excuse`
`NumTrash == 0`
`NumTrash < Amount`
`NumTrash == Amount`





They did what you asked, so stop asking them to pick up trash.

How do we get the room clean?

```
int pickedUp = 0;
while ( ____________ ) {




}
```

`NumTrash pickup(roomNum, trashCan, Amount)`

`NumTrash == -1, errno == excuse`
`NumTrash == 0`
`NumTrash < Amount`
`NumTrash == Amount`

How do we get the room clean?

NumTrash pickup(roomNum, trashCan, Amount)

NumTrash == -1, errno == excuse
NumTrash == 0
NumTrash < Amount
NumTrash == Amount

```
int pickedUp = 0;
while ( pickedUp < N ) {
    NumTrash = pickup( room, bin + pickedUp, N - pickedUp )
    if ( NumTrash == -1 ) {
        if ( excuse not reasonable )
            ask again
        stop asking and handle the excuse
    }
    if ( NumTrash == 0 )  // we overestimated the trash
         stop asking since the room is clean
    add NumTrash to pickedUp
}
```

How do we get the room clean?

`NumTrash pickup(roomNum, trashCan, Amount)`

`NumTrash == -1, errno == excuse`
`NumTrash == 0`
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```
int pickedUp = 0;
while ( pickedUp < N ) {
    result = pickup( room, bin + pickedUp, N - pickedUp )
    if ( result == -1 ) {
        if ( errno == E_BUSY_NETFLIX )
            continue;
        break;
    }
    if ( result == 0 )
         break;
    pickedUp += result;
}
```

Some Final Notes...

We assumed that there were exactly N pieces of trash (N bytes of data that we wanted to read from a file). How can we modify our solution if we don't know N?

(Answer): Keep trying to `read(...)` until we get 0 back (EOF / clean room)

We determine N dynamically by tracking the number of bytes read until this point, and use `malloc` to allocate more space as we read.

There is no one true loop.
Tailor your POSIX loops to the specifics of what you need!

Back to the worksheet (Q3)

```
int fd = _____;  // open 333.txt
int n = ....;
char *buf = ..... ; // Assume buf initialized with size n
int result;

_____;   // initialize variable for loop

...   // code that populates buf happens here

while (_____) {

    result = write(_____,_____,_____);

    if (result == -1) {
        if (errno != EINTR) {
            // a real error happened, return an error result
            _____;  // cleanup
            perror("Write failed");
            return -1;
        }
        continue;  // EINTR happened, so loop around and try again
    }
   _____;  // update loop variable
}
_____; // cleanup
```

```
int fd = open("333.txt", O_WRONLY);  // open 333.txt
int n = ....;
char *buf = ..... ; // Assume buf initialized with size n
int result;

char *ptr = buf;   // initialize variable for loop

...   // code that populates buf happens here

while (ptr < buf + n) {

    result = write(fd, ptr, buf + n - ptr);

    if (result == -1) {
        if (errno != EINTR) {
            // a real error happened, return an error result
            close(fd);  // cleanup
            perror("Write failed");
            return -1;
        }
        continue;  // EINTR happened, so loop around and try again
    }
   ptr += result;  // update loop variable
}
close(fd); // cleanup
```

More Posix!

4) Why is it important to store the return value from the `write()` function? Why do we not check for a return value of 0 like we do for `read()`?

5) Why is it important to remember to call the `close()` function once you have finished working on a file?

More Posix!

4) Why is it important to store the return value from the `write()` function? Why do we not check for a return value of 0 like we do for `read()`?

write() may not actually write all the bytes specified in count.
Writing adds length to your file, so you don't need to check for end of file.

5) Why is it important to remember to call the `close()` function once you have finished working on a file?

More Posix!

4) Why is it important to store the return value from the `write()` function? Why do we not check for a return value of 0 like we do for `read()`?

write() may not actually write all the bytes specified in count.
Writing adds length to your file, so you don't need to check for end of file.

5) Why is it important to remember to call the `close()` function once you have finished working on a file?

In order to free resources i.e. other processes can acquire locks on those files.

Exercise:

6) Given the name of a file as a command-line argument, write a C program that is analogous to `cat`, *i.e.* one that prints the contents of the file to `stdout`. Handle any errors!
Example usage: "./filedump <path>" where <path> can be absolute or relative.

```
int main(int argc, char** argv) {
  /* 1. Check to make sure we have a valid command line arguments */




  /* 2. Open the file, use O_RDONLY flag */




  /* 3. Read from the file and write it to standard out. Try doing
        this without using printf() and instead have write() pipe to
        Stdout (take a look at STDOUT_FILENO). It might be helpful
        to initialize a buffer variable (of size 1024 bytes should be
        fine) to pass in to read() andwrite(). */









  /*4. Clean up */


}
```

```
int main(int argc, char** argv) {
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        to initialize a buffer variable (of size 1024 bytes should be
        fine) to pass in to read() andwrite(). */
```

```
  /*4. Clean up */


}
```

```
int main(int argc, char** argv) {
  if (argc != 2) {
    fprintf(stderr, "Usage: ./filedump <filename>\n");
    exit(1);
  }
  int fd = open(argv[1], O_RDONLY);
  if (fd == -1) {
    fprintf(stderr, "Could not open file for reading\n");
    exit(1);
  }
  char buf[SIZE];
  ssize_t len;
  do {
    len = read(fd, buf, SIZE);
    if (len == -1) {
      if (errno != EINTR) {
        close(fd);
        perror(NULL);
        exit(1);
      }
      continue;
    }
    size_t total = 0;
    ssize_t wlen;
    while (total < len) {
      wlen = write(1, buf + total, len - total);
      if (wlen == -1) {
        if (errno != EINTR) {
          close(fd);
          perror(NULL);
          exit(1);
        }
        continue;
      }
      total += wlen;
    }
  } while (len > 0);
  close(fd);
  return 0;
}
```