What is your experience with C before this class? (C++ does not count)

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Q1

~Code~
340

CS 340

C without the ++ (0b01)

What percentage of the class do you think has successfully written a program in C?

Updates

1. MP 0 is out
2. MP 1 is out

Feb 3rd

3. HW 0 is due Wednesday at midnight
4. Clickers for week 1 uploaded on PL

C without the C++

LGs:

- Be able to read and understand C code
- Be able to write C code from scratch

1. Why C
2. Memory Foundations Review
3. Structs
4. Data in C/C++
5. Dynamic Memory
6. BST Example

But why C?

lower-level - doesn't have advanced features

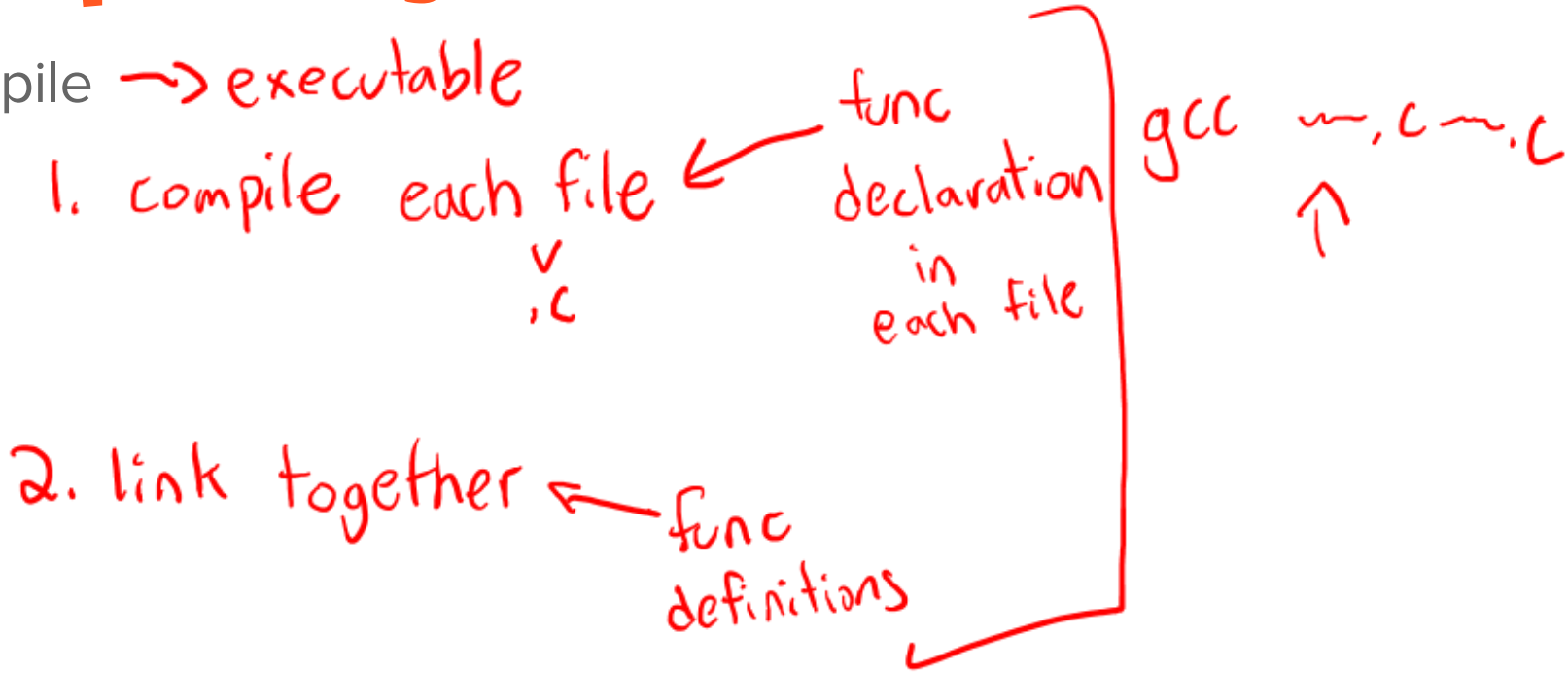
C networking, security, embedded systems, OS

↓

pie req

[Review] Running a C/C++ file

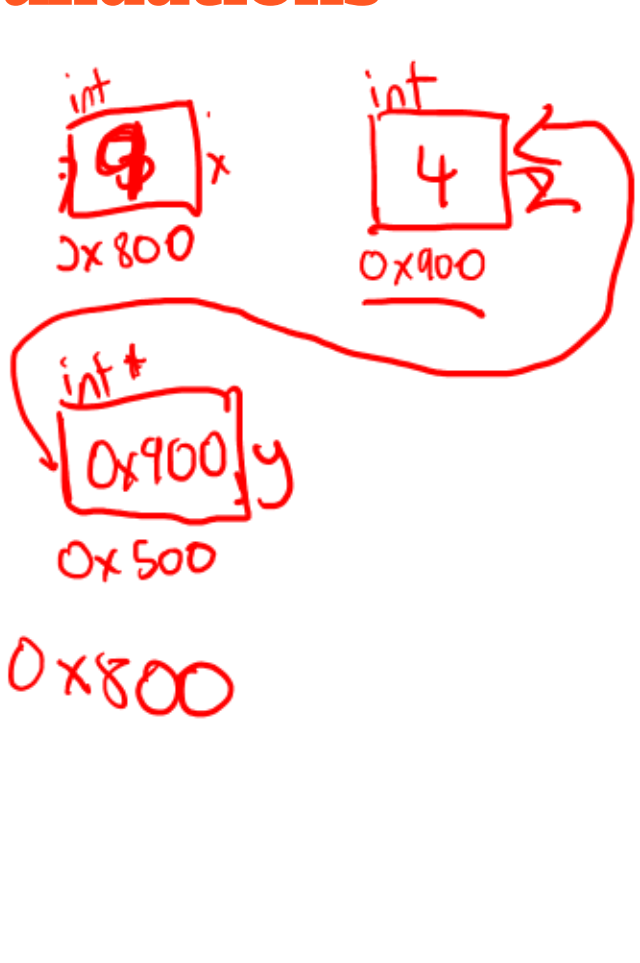
1. Compile → executable



2. Run executable file ./a.out

[Review] Memory Foundations

```
int x = 3;
int z = 4;
int *y = &x;
printf("%x", y);
*y = 9;
y = &z;
```



[Review] Memory Foundations w/Functions

```
void foo(int x, int *ptr){
    *ptr = 11;
}

int main(){
    int y = 5;
    int x = 10;
    foo(x, &y);

}
```

How is C different from C++?

1. No classes
2. No Templates
3. No function or operator overloading
4. No new or delete
5. No pass-by-reference
6. No standard C++ library → strings
   vectors
   cin/cout

How confused/nervous are you to code in C without the ++ features?

No classes

Structs

no member functions

Is this valid C code?

```
4   struct food {
5       int amount;
6       int age;
7
8       int can_eat(){
9           if(amount > 0 && age < 10){
10              return 1;
11          }
12          return 0;
13      }
14  };
```

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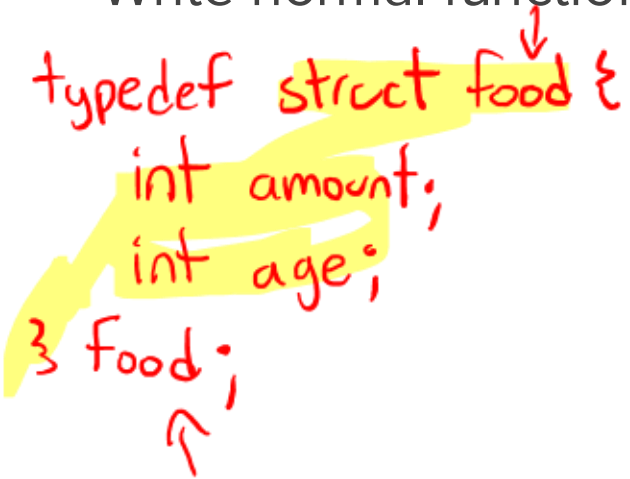
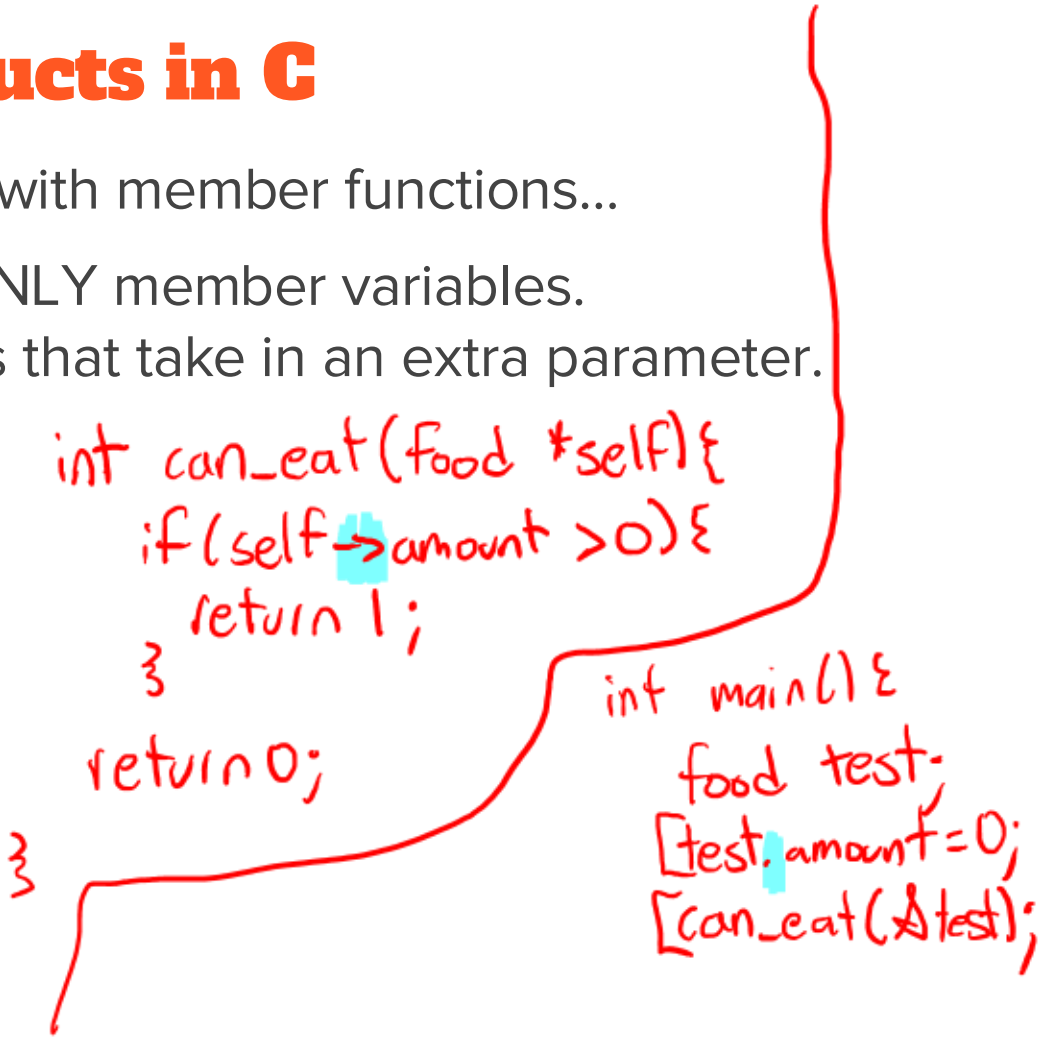
NO

Working with Structs in C

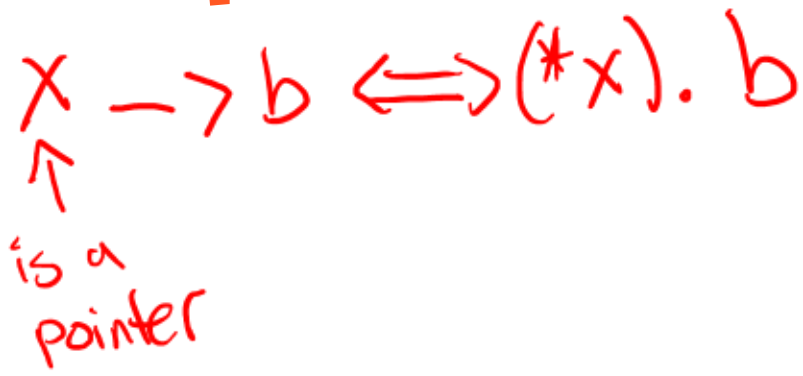
Instead of making a class with member functions...

- Create a struct with ONLY member variables.
- Write normal functions that take in an extra parameter.





[Review] -> versus .



What would go in each box?

```
4   typedef struct food {
5       int amount;
6       int *age;
7   } food;
8
9   int main(){
10      int x = 5;
11      struct food fd;
12      fd.amount = 2;
13      fd.age = &x;
14      food *fd_p = &fd;
15      *(fd_p.age) = 7;
16  }
```

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```c
typedef struct food {
    int amount;
    int age;
} food;

void food_init(food *self, int am){
    self->amount = am;
    self->age = 0;
}
```

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A

```c
int main(){
    food fd;
    food_init(&fd, 2);
}
```

B

```c
int main(){
    food fd(2);
}
```

X

C

```c
int main(){
    food fd = food_init(&fd, 2);
}
```

Data in C/C++

Data Stored as Bytes

Physically, computer hardware...

To make binary more practical we...

8 bits → 1 byte

Data types have a size (in bytes)...

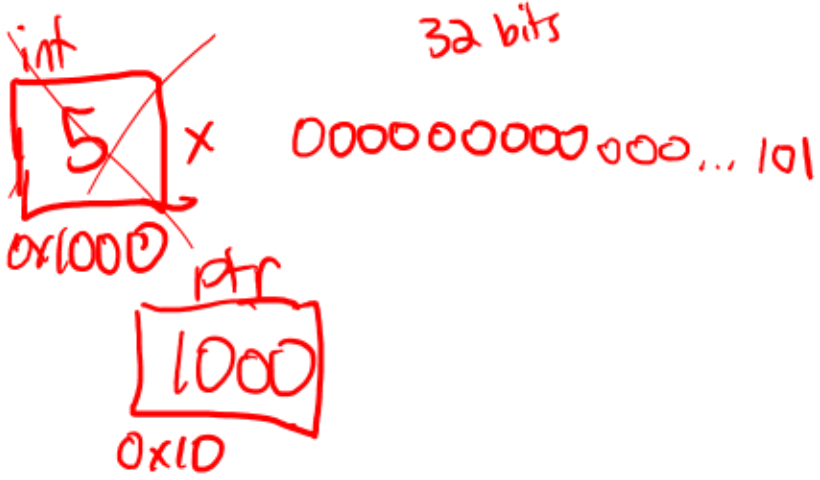
char = 1 byte = 8 bits

int = 4 byte = 32 bits

Data Stored as Bytes

```
int x = 5
int *ptr = &x;
```

An address is a number



If a pointer is 8 bytes, how many bits is it?

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Q6

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64

0 0 1 0 1 0 1 . . .

Dynamic Memory

[Review] What is Dynamic Memory

request memory at run time

- flexible to change memory used while the code is running

- control objects life time

//allocates size bytes on the heap and returns a
//pointer to that memory location on the heap.
void *malloc(size_t size);

4

sizeof(int)

int *ptr = malloc(4);

//frees the memory at ptr from the heap
void free(void *ptr);

free(ptr);

What is wrong?

```
1   #include <stdlib.h>
2
3   int main(){
4       int x = 5;
5       int *ptr = malloc(sizeof(int));
6       ptr = &x;
7       free(ptr);
8   }
```

Memory error

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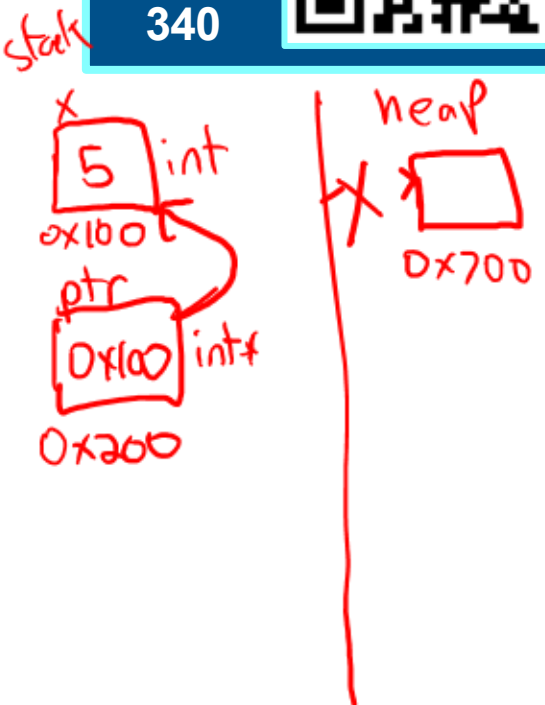


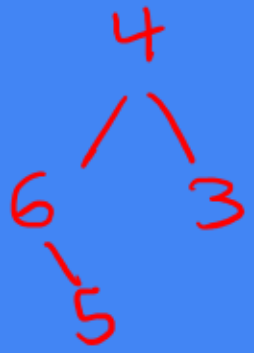
[Review] What are some common memory management errors?

Finding Memory Errors

shell

```
valgrind --leak-check=full --show-leak-kinds=all ./exec
```

```
==10389== HEAP SUMMARY:
==10389==     in use at exit: 24 bytes in 1 blocks
==10389==   total heap usage: 1 allocs, 0 frees, 24 bytes allocated
==10389==
==10389== 24 bytes in 1 blocks are definitely lost in loss record 1 of 1
==10389==    at 0x488545C: malloc (vg_replace_malloc.c:446)
==10389==    by 0x4006C3: add_node_helper (bst.c:21)
==10389==    by 0x40076B: add_node (bst.c:37)
==10389==    by 0x40080B: main (bst.c:58)
==10389==
==10389== LEAK SUMMARY:
==10389==    definitely lost: 24 bytes in 1 blocks
==10389==    indirectly lost: 0 bytes in 0 blocks
==10389==      possibly lost: 0 bytes in 0 blocks
==10389==    still reachable: 0 bytes in 0 blocks
==10389==         suppressed: 0 bytes in 0 blocks
==10389==
==10389== For lists of detected and suppressed errors, rerun with: -s
==10389== ERROR SUMMARY: 1 errors from 1 contexts (suppressed: 0 from 0)
```



BST Example

What goes in the box?

```
5   typedef struct node {
6     struct node *left;
7     struct node *right;
8     int datum;
9   } node;
10
11  typedef struct bst {
12    struct node *root;
13  } bst;
14
15  void init_bst(bst *self){
16      [redacted]
17  }
```

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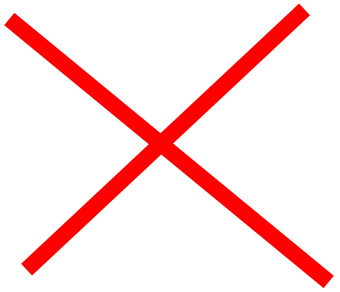
self->root = NULL;

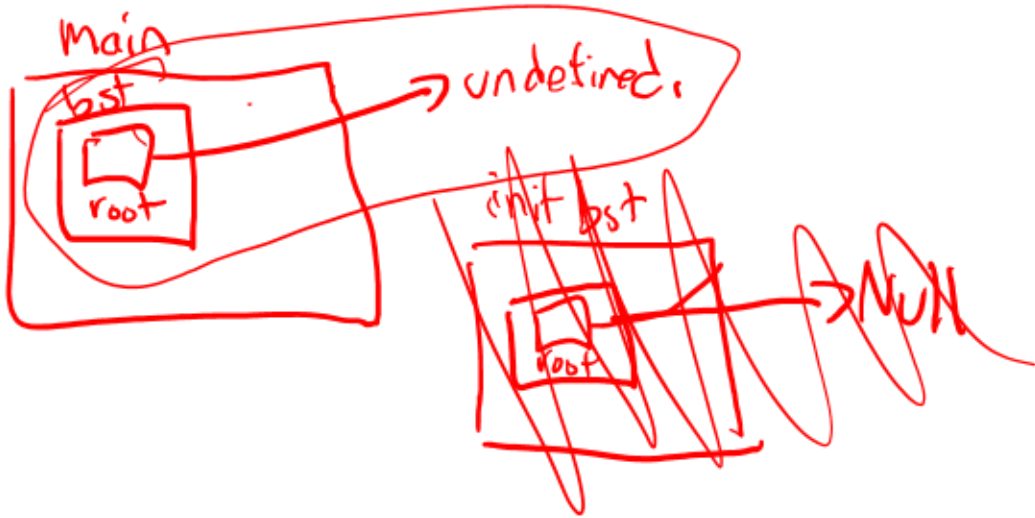
```c
typedef struct node {
  struct node *left;
  struct node *right;
  int datum;
} node;

typedef struct bst {
  struct node *root;
} bst;

void init_bst(bst self){
    self.root = NULL;
}
```

```c
int main() {
    bst b;
    init_bst(b);
    return 0;
}
```





```c
typedef struct node {
  struct node *left;
  struct node *right;
  int datum;
} node;

typedef struct bst {
  struct node *root;
} bst;

void init_bst(bst *self){
    self->root = NULL;
}
```

```c
int main() {
    bst b;
    init_bst(&b);
    return 0;
}
```

What goes in the box?

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```
void add_node(bst *self, int data){
    self->root = add_node_helper(self->root, data);
}
```

```
19  node *add_node_helper(node *node_ptr, int data){
20      if(node_ptr == NULL){
21          node *tmp = malloc(          );
22          tmp->left = NULL;
23          tmp->right = NULL;
24          tmp->datum = data;
25          return tmp;
26      }
```

sizeof(node)

Given the code so far, does bst have any member functions?

Is the default constructor called?

```
40  int main() {
41      bst b;
42      add_node(&b, 4);
43      add_node(&b, 2);
44      add_node(&b, 3);
45      return 0;
46  }
```

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```
typedef struct bst {
  struct node *root;
} bst;
```

Is a destructor called for bst?

```
40  int main() {
41      bst b;
42      add_node(&b, 4);
43      add_node(&b, 2);
44      add_node(&b, 3);
45      return 0;
46  }
```

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```
typedef struct bst {
  struct node *root;
} bst;
```

```
40  void bst_pop_all(                ){
41      
42      
43      
44      
45      
46      
47      
48  }
49
50  void bst_destruct(               ){
51      
52  }
```

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Q13

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```
typedef struct bst {
  struct node *root;
} bst;
```

```
typedef struct node {
  struct node *left;
  struct node *right;
  int datum;
} node;
```

Finding Memory Errors

valgrind --leak-check=full --show-leak-kinds=all ./exec

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