

## 15-122: Principles of Imperative Computation

Recitation Week 10

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### C Contracts: REQUIRES(), ENSURES(), ASSERT()

#### Everything has an address!

Well, anything you can name—all variables and functions.

We can use the address of operator, `&`, to find what this address is.

This is useful if we want to modify a variable in place.

#### Checkpoint 0

```
1 #include <stdio.h>
2 #include "lib/contracts.h"
3
4 void bad_mult_by_2(int x) {
5     x = x * 2;
6 }
7 void mult_by_2(int* x) {
8     REQUIRES(x != NULL);
9     *x = *x * 2;
10 }
11 int main () {
12     int a = 4;
13     bad_mult_by_2(a);
14     printf("%d\n", a);
15     mult_by_2(&a);
16     printf("%d\n", a);
17     return 0;
18 }
```

What is the output when this code is run? Why?

#### switch statements

A switch statement is a different way of expressing a conditional. The general format of this looks like:

```
1 switch (e) {
2     case c1:
3         // do something
4         break;
5     case c2:
6         // do something else
7         break;
8     // ...
9     default:
10        // do something in the default case
11        break;
12 }
```

Each `ci` should evaluate to a constant integer type (this can be of any size, so `chars`, `ints`, `long long ints`, etc).

For example, consider this function that moves on a board. It takes direction ('l', 'r', 'u', or 'd') and prints an English description of the direction.

```
1 void print_dir(char c) {
2     switch (c) {
3         case 'l':
4             printf("Left\n");
5             break;
6         case 'r':
7             printf("Right\n");
8             break;
9         case 'u':
10            printf("Up\n");
11            break;
12         case 'd':
13            printf("Down\n");
14            break;
15         default:
16            fprintf(stderr, "Specify a valid direction!\n");
17            break;
18     }
19 }
```

The break statements here are important: If we don't have them, we get fall-through, which is often useful, but can lead to unanticipated results.

Here's some code that takes a positive number at most 10 and determines whether it is a perfect square. The behavior here is called fall-through.

```
1 int is_perfect_square(int x) {
2     REQUIRES(1 <= x && x <= 10);
3     switch (x) {
4         case 1:
5         case 4:
6         case 9:
7             return 1;
8             break;
9         default:
10            return 0;
11            break;
12     }
13 }
```

## Checkpoint 1

```
1 #include <stdio.h>
2 #include <stdlib.h>
3 int main(int argc, char** argv) {
4     if (argc > 1) {
5         int a = atoi(argv[1]);
6         switch (a % 2) {
7             case 0:
8                 printf("x is even!\n");
9             default:
10                printf("x is odd!\n");
11        }
12    }
13    return 0;
14 }
```

What's wrong with this code? How would you fix it?

## structs that aren't pointers

We've almost always used *pointers* to structs previously in this class.

We can also just use structs, without the pointer. We set a field of a struct with dot-notation, as follows:

```
1 #define ARRAY_LENGTH 10
2 struct point {
3     int x;
4     int y;
5 };
6 int main () {
7     struct point a;
8     a.x = 3;
9     a.y = 4;
10    struct point* arr = xmalloc(ARRAY_LENGTH * sizeof(struct point));
11    // Initialize the points to be on a line with slope 1
12    for (int i = 0; i < ARRAY_LENGTH; i++) {
13        arr[i].x = i;
14        arr[i].y = i;
15    }
16 }
```

The notation we've used throughout the semester to access a field of a pointer to a struct is `p->f`. This is just syntactic sugar for `(*p).f`.

## Casting pointers to ints and signed to unsigned

Casting from pointers to integers and signed values to unsigned values is implementation-defined in C. (That is, C does not mandate the way that compilers should handle these details. For Lab 9, we'll use the behaviors that GCC defines.)

A few details:

The GCC documentation specifies how casting from pointers to ints works:

<http://gcc.gnu.org/onlinedocs/gcc-4.3.5/gcc/Arrays-and-pointers-implementation.html#Arrays-and-pointers-implementation>

In Lab 9 (the C0 Virtual Machine), we'll provide you with `INT(p)` and `VAL(x)` to cast between integers and pointers.

Make sure to review the lecture notes for more details on casting.

## Checkpoint 2

What's wrong with each of these pieces of code?

a)

```
1 int* add_dumb(int a, int b) {
2     int x = a + b;
3     return &x;
4 }
```

b)

```
1 int main () {
2     int* A = calloc(10, sizeof(int));
3     for (int i = 0; i < 10 * sizeof(int); i++) {
4         *(A + i) = 0;
5     }
6     free(A);
7     return 0;
8 }
```

c)

```
1 void add_one(int a) {
2     a = a + 1;
3 }
4 int main() {
5     int x = 1;
6     add_one(x);
7     printf("%d\n", x);
8     return 0;
9 }
```

d)

```
1 int main() {
2     int x = 0;
3     if (x = 1)
4         printf("woo\n");
5     return 0;
6 }
```

e)

```
1 int main() {
2     char s[] = {'a', 'b', 'c'};
3     printf("%s\n", s);
4     return 0;
5 }
```

f)

```
1 int main () {
2     char* y = "hello!";
3     char* x = malloc(7 * sizeof(char));
4     strncpy(x, y, strlen(y));
5     printf("%zu\n", strlen(x));
6     free(x);
7     return 0;
8 }
```

g)

```
1 int foo(char* s) {
2     printf("The string is %s\n", s);
3     free(s);
4 }
5 int main() {
6     char* s = "hello";
7     foo(s);
8     return 0;
9 }
```