CS 33

Introduction to C
Part 2

Why “pass by value”?

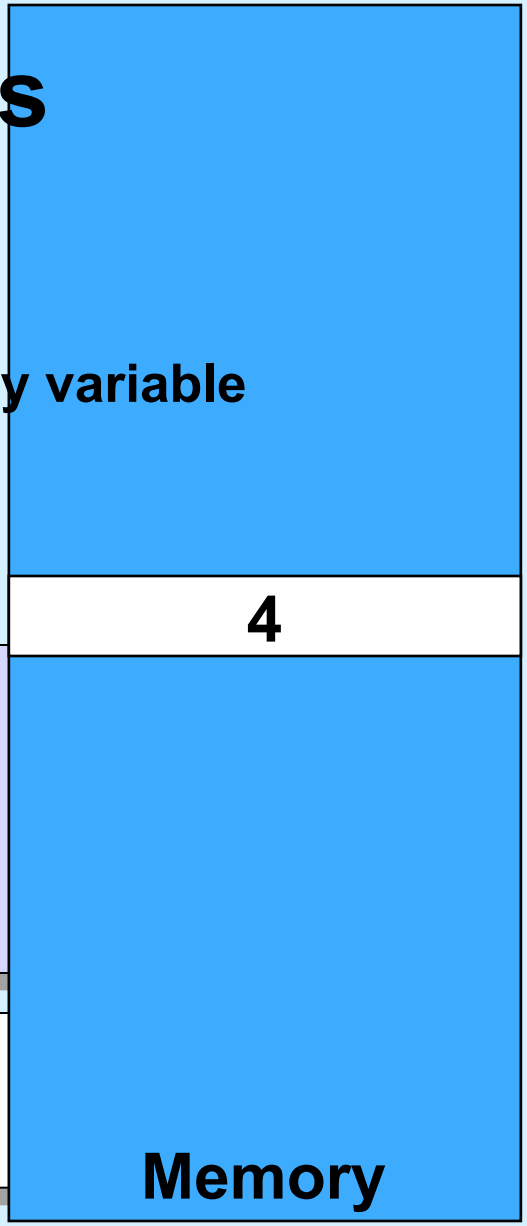
- **Fortran, for example, passes parameters “by reference”**
- **Early implementations had the following problem (shown with C syntax):**

```
int main() {
    function(2);
    printf("%d\n", 2);
}
void function(int x) {
    x = 3;
}
```

```
$ ./a.out
3
```

Memory addresses

- In C
  - you can get the memory address of any variable
  - just use the magical operator &




```
int main() {
    int a = 4;
    printf("%u\n", &a);
}
```

```
$ ./a.out
3221224352
```

C Pointers

- What is a C pointer?
  - a variable that holds an address
- Pointers in C are “typed” (remember the promises)
  - pointer to an int
  - pointer to a char
  - pointer to a float
  - pointer to <whatever you can define>
- C has a syntax to declare pointer types
  - things start to get complicated …

C Pointers

p is a pointer to an int

if you follow p, you find an int

```
int main() {
    int *p;
    int a = 4;
    p = &a;
    printf("%u\n", p);
}
```

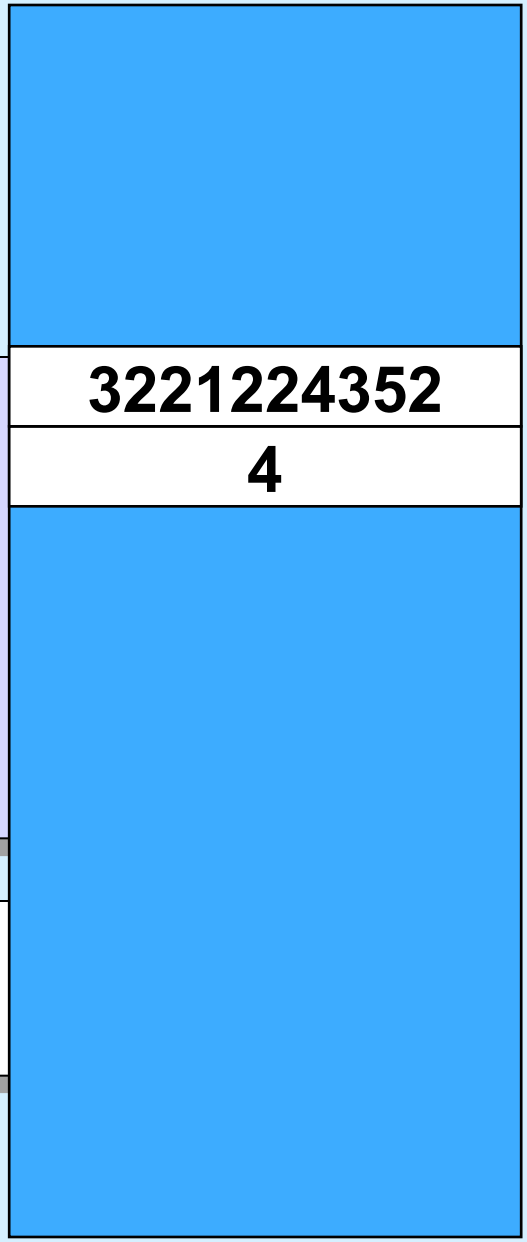
p takes the address of a

```
$ ./a.out
3221224352
```

C Pointers

```
int main() {
    int *p;
    int a = 4;
    p = &a;
    printf("%u\n" ,p);
}
```

```
$ ./a.out
3221224352
```



Can you guess what &p is?

C Pointers

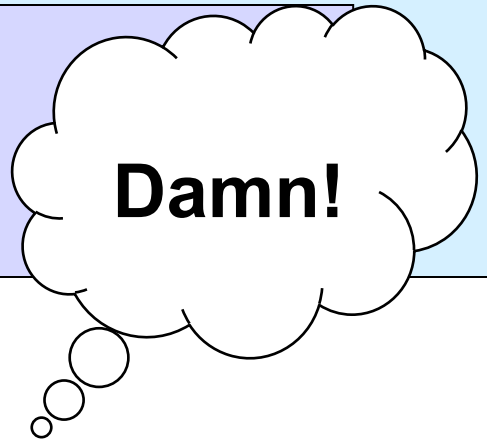
- Pointers are typed
  - the type of the objects they point to is known
  - there is one exception (see later)
- Pointers are first-class citizens
  - they can be passed to functions
  - they can be stored in arrays and other data structures
  - they can be returned by functions

Swapping

What does this do?

```
void swap(int *i, int *j) {
    int *tmp;
    tmp = j; j = i; i = tmp;
}
int main() {
    int a = 4;
    int b = 8;
    swap(&a, &b);
    printf("a:%d  b:%d\n", a, b);
}
```

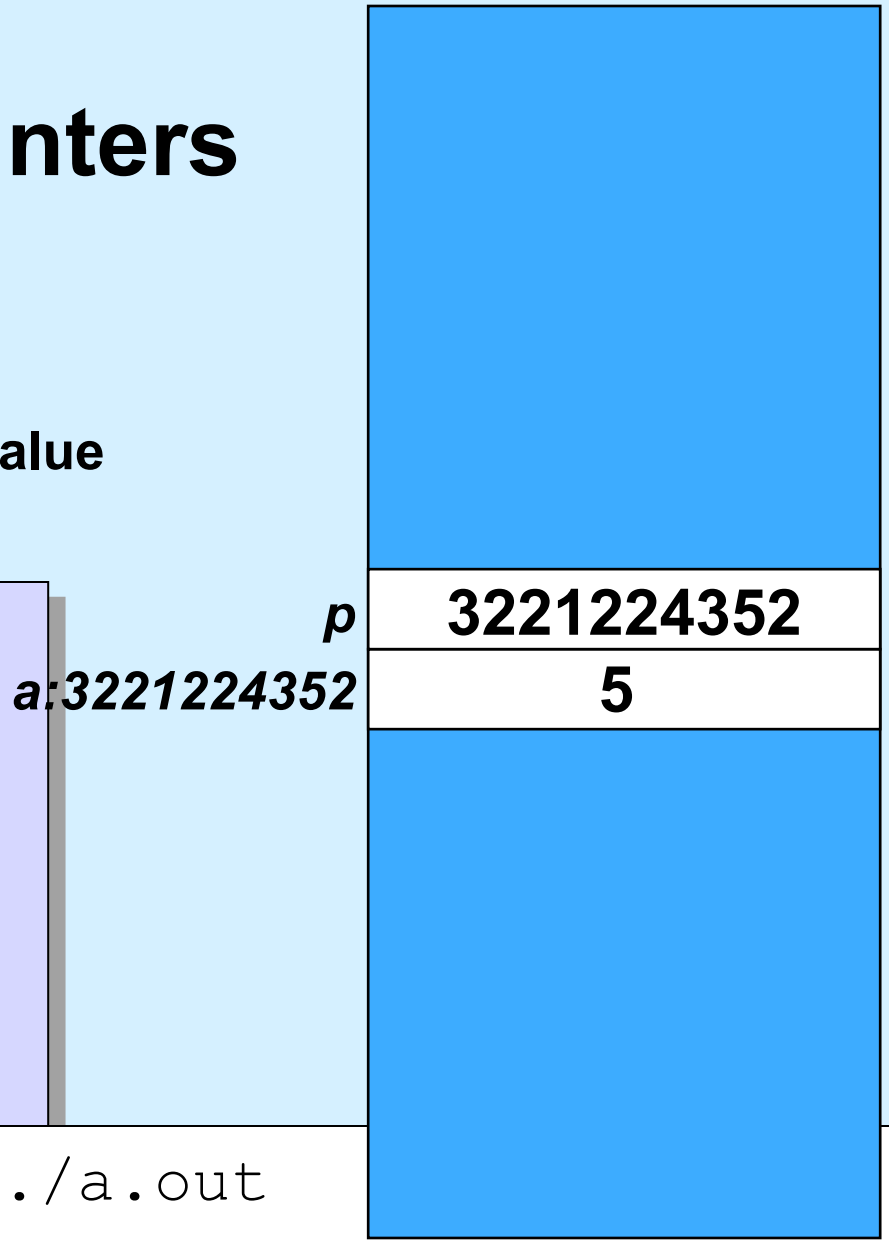
```
$ ./a.out
a:4  b:8
```



C Pointers

- **Dereferencing pointers**
  - **accessing/modifying the value pointed to by a pointer**

```
int main() {
    int *p;
    int a = 4;
    p = &a;
    printf("%d\n", *p);
    *p = *p + 1;
    printf("%d\n", *p);
}
```




```
$ ./a.out
4
5
```

Dereferencing C Pointers

```
int main() {
    int *p;
    int a = 4;
    p = &a;
    printf("%d\n", *p);
    *p = *p + 1;
    *p += 3;
    printf("%d\n", a);
}
```

```
$ ./a.out
4
8
```

Swapping

```
void swap(int *i, int *j) {
    int tmp;
    tmp = *j; *j = *i; *i = tmp;
}
int main() {
    int a = 4;
    int b = 8;
    swap(&a, &b);
    printf("a:%d  b:%d\n", a, b);
}
```

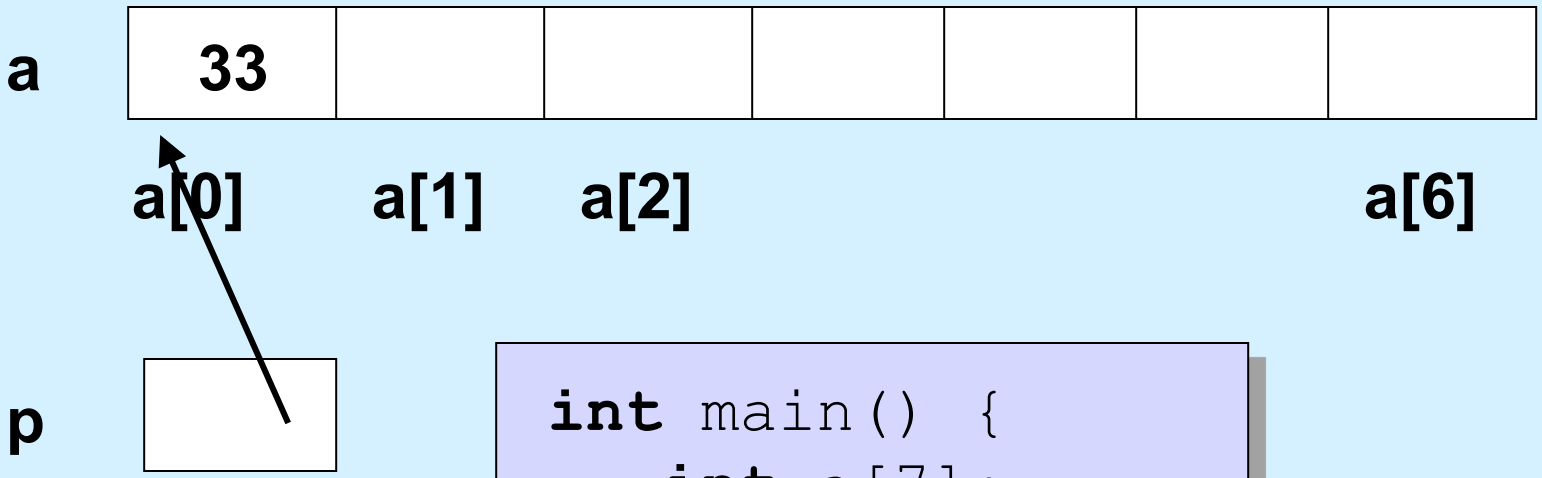
Quiz 1

```
int doubleit(int *p) {
    *p = 2*(*p);
    return *p;
}
int main() {
    int a = 3;
    int b;
    b = doubleit(&a);
    printf("%d\n", a*b);
}
```

What's printed?

a) 0
b) 12
c) 18
d) 36

Pointers and Arrays

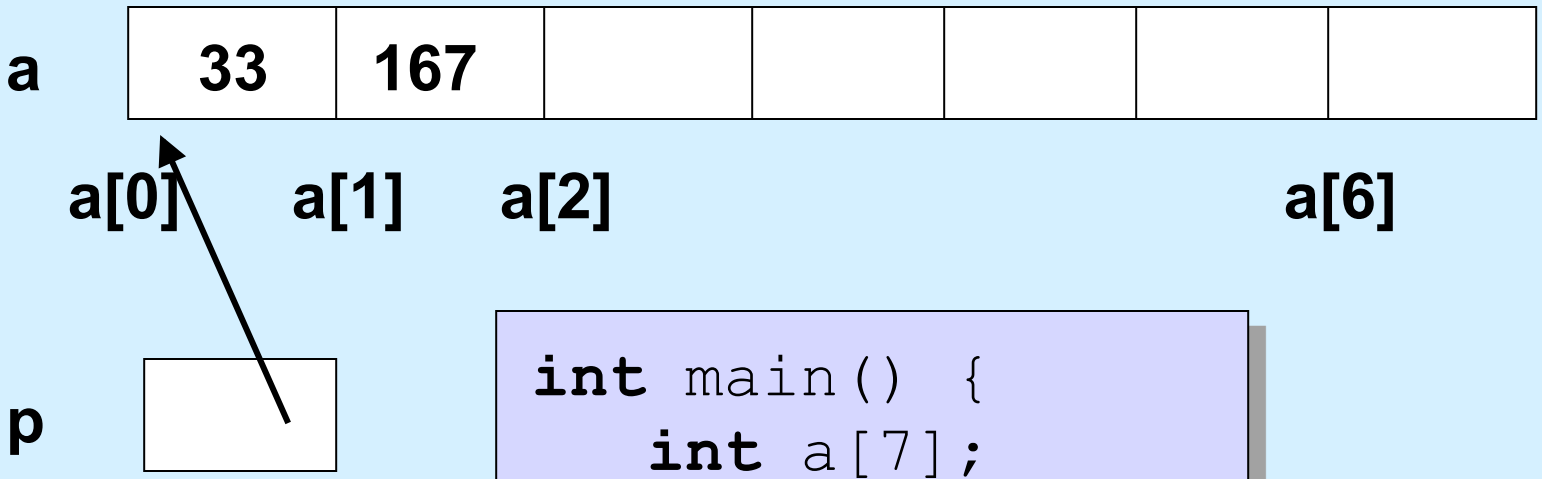



```
int main() {
    int a[7];
    int *p;
    p = &a[0];
    *p = 33;
}
```

Pointer Arithmetic

Pointers can be incremented/decremented

- **what this does to the pointer depends on its type**

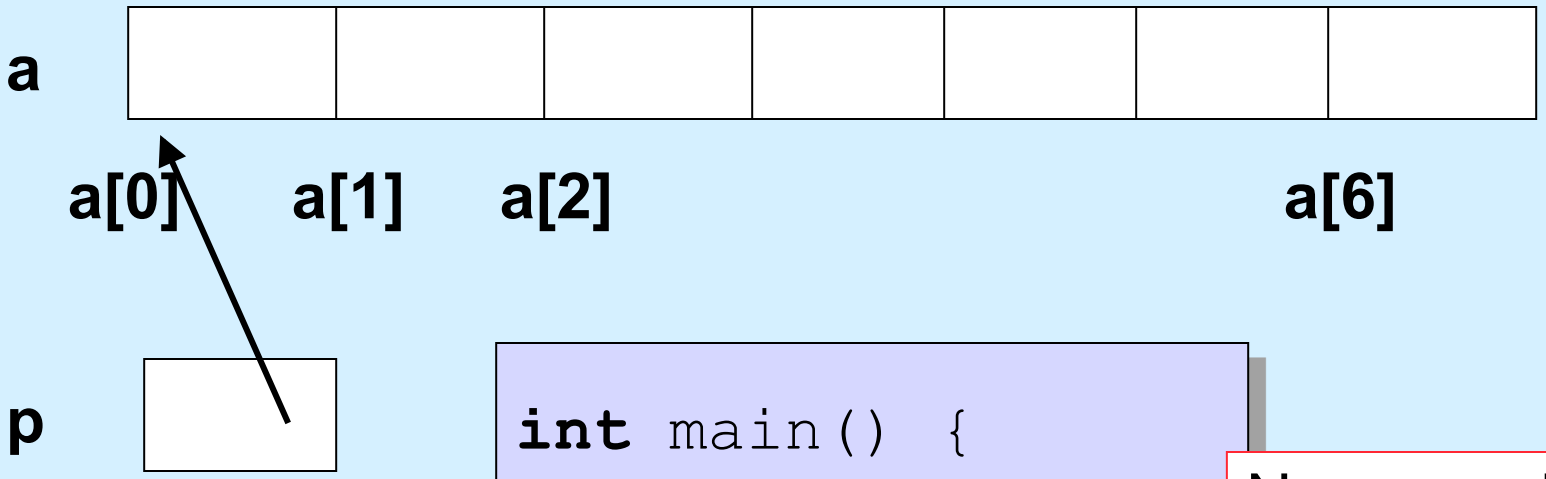



```
int main() {
    int a[7];
    int *p;
    p = &a[0];
    *p = 33;
    *(p+1) = 167;
}
```

Pointer Arithmetic

Pointers can be incremented/decremented

– **what this does to the pointer depends on its type**



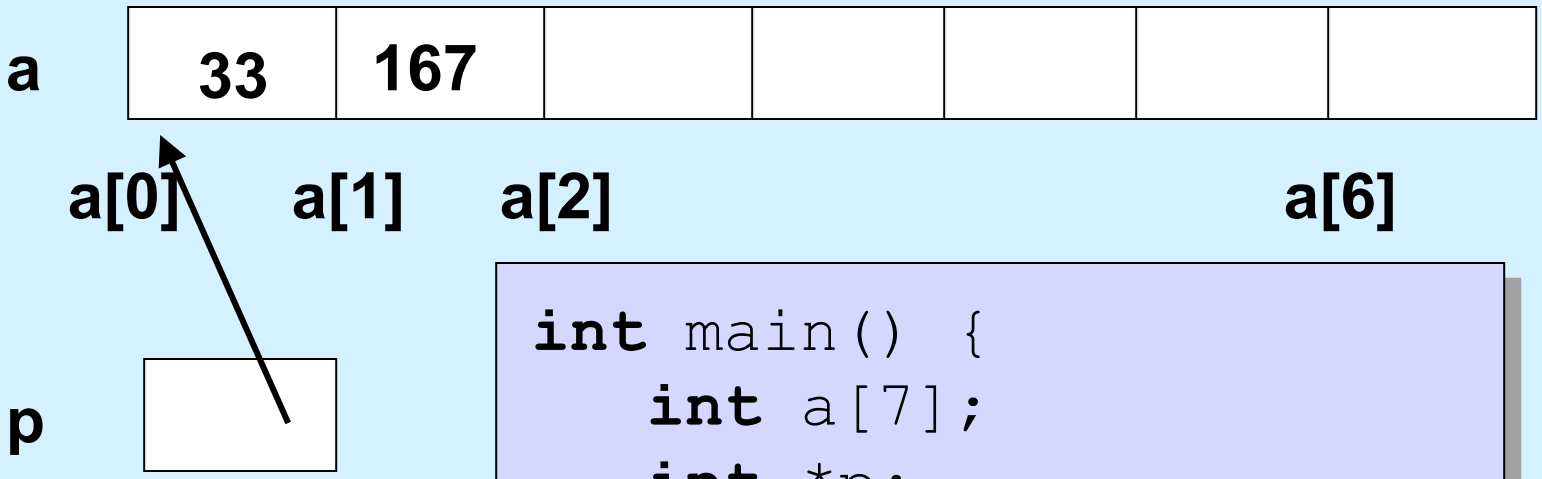

```
int main() {
    int a[7];
    int *p;
    p = &a[0];
}
```

Now `p` and `a` have the same value

Pointer Arithmetic

Pointers can be incremented/decremented

- **what this does to the pointer depends on its type**




```
int main() {
    int a[7];
    int *p;
    p = a;
    *p = 33;
    p[1] = 167;
}
```

Pointers and Arrays

```
p = &a[0];
```
can also be written as
```
p = a;
```

```
a[i];
```
really is
```
*(a+i)
```

- **This makes sense, yet is weird and confusing ...**
  - `p` **is of type** `int *`
    - **it can be assigned to**

```
int *q;
p = q;
```

  - `a` **sort of behaves like an** `int *`
    - **but it can't be assigned to**

```
a = q;
```

Pointers and Arrays

- An array name represents a pointer to the first element of the array
- Just like a literal represents its associated value
  - in:

```
x = y + 2;
```

    - » "2" is a *literal* that represents the value 2
  - can't do

```
2 = x + y;
```

Literals and Procedures

```
int proc(int x) {
    x = x + 4;
    return x * 2;
}

int main() {
    result = proc(2);
    printf("%d\n", result);
    return 0;
}
```

initialized with a copy of the argument

Arrays and Procedures

```
int proc(int *a, int nelements) {
    // sizeof(a) == sizeof(int *)
    int i;
    for (i=0; i<nelements-1; i++)
        a[i+1] += a[i];
    return a[nelements-1];
}

int main() {
    int array[50] = ... ;
    // sizeof(array) == 50*sizeof(int)
    printf("result = %d\n", proc(array, 50));
    return 0;
}
```

initialized with a copy of the argument

Equivalently ...

```
int proc(int a[], int nelements) {
    // sizeof(a) == sizeof(int *)
    ...

}

int main() {
    int array[50] = ... ;
    // sizeof(array) == 50*sizeof(int)
    printf("result = %d\n", proc(array, 50));
    return 0;
}
```

No need for array size, since all that's used is pointer to first element

Quiz 2

```
int proc(int a[], int nelements) {
    int b[5] = {0, 1, 2, 3, 4};
    a = b;
    return a[1];
}

int main() {
    int array[50];
    printf("result = %d\n",
       proc(array, 50));
    return 0;
}
```

This program prints:

a) 0
b) 1
c) 2
d) nothing: it doesn't compile because of a syntax error

Quiz 3

```
int proc(int a[], int nelements) {
    int b[5] = {0, 1, 2, 3, 4};
    a = b;
    return a[1];
}

int main() {
    int array[5] = {4, 3, 2, 1, 0};
    proc(array, 50);
    printf("%d\n", array[1]);
    return 0;
}
```

This program prints:

a) 0
b) 1
c) 2
d) 3