Lecture 4

Intro to C:
Pointers and Arrays

Administrivia

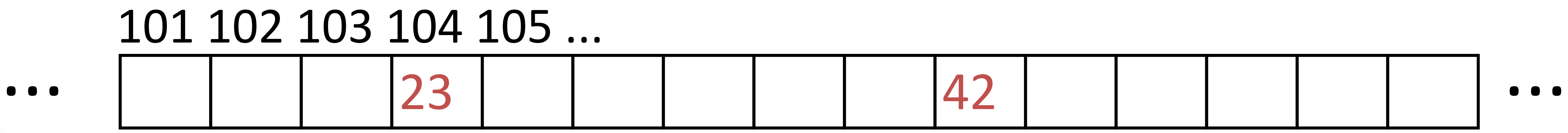
- Teaching Assistants: Let’s try that again.
- Lectures are recorded. Waitlist/Concurrent Enrollment may have to view recordings. But please assume you are in.
- My office hours: Monday 11-12, 424 SDH.
- People with *university-related time conflict* with lectures should contact the head GSIs.
- Let head GSIs know about exam conflicts by the end of this week.

Agenda

- Pointers
- Arrays in C

Address vs. Value

- Consider memory to be a single huge array
    - Each cell of the array has an address associated with it
    - Each cell also stores some value
    - For addresses do we use signed or unsigned numbers? Negative address?!
- Don't confuse the address referring to a memory location with the value stored there

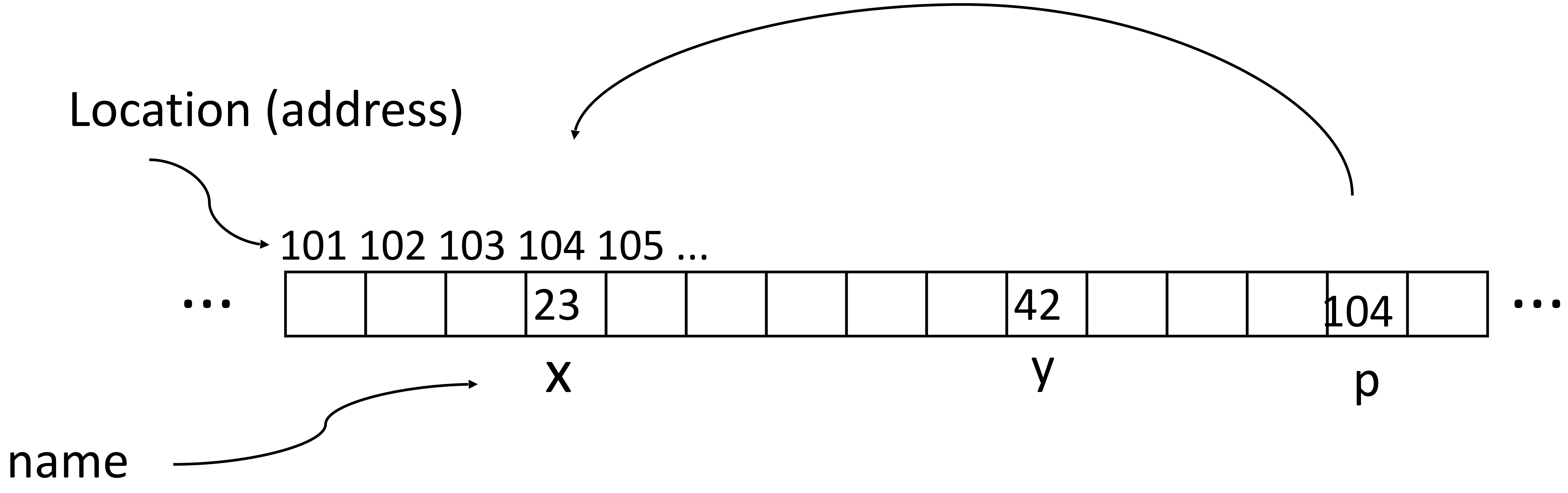


101 102 103 104 105 ...

… 23 42 …

Pointers

- An *address* refers to a particular memory location; e.g., it points to a memory location
- *Pointer*: A variable that contains the address of a variable



Pointer Syntax

- `int *p;`
  - Tells compiler that variable p is address of an `int`
- `p = &y;`
  - Tells compiler to assign address of `y` to `p`
  - `&` called the “address operator” in this context
- `z = *p;`
  - Tells compiler to assign value at address in `p` to `z`
  - `*` called the “dereference operator” in this context

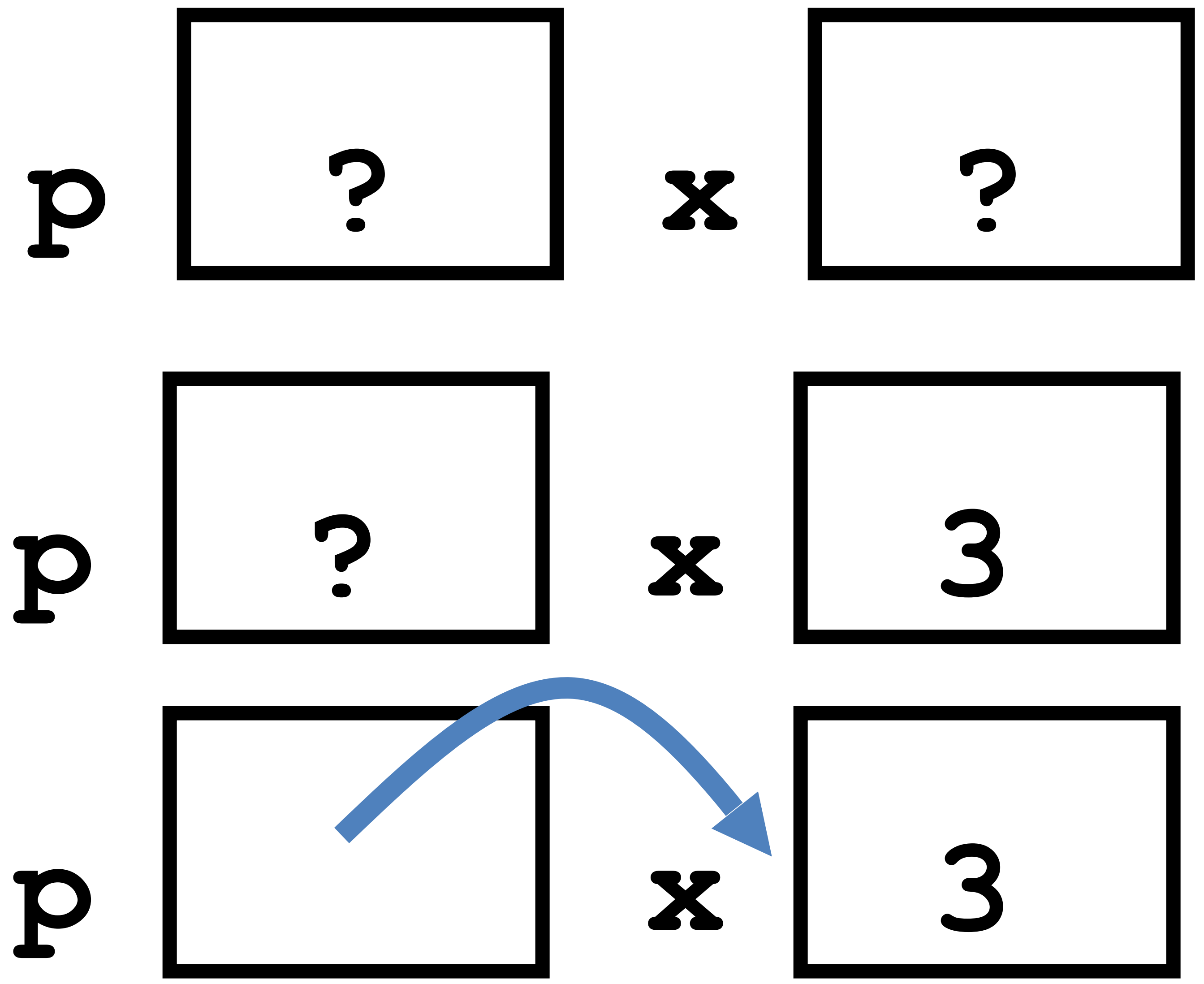
Creating and Using Pointers

- How to create a pointer:

& operator: get address of a variable

```
int *p, x;        x = 3;

                  p = &x;
```



Note the "*****" gets used 2 different ways in this example. In the declaration to indicate that **p** is going to be a pointer, and in the **printf** to get the value pointed to by **p**.

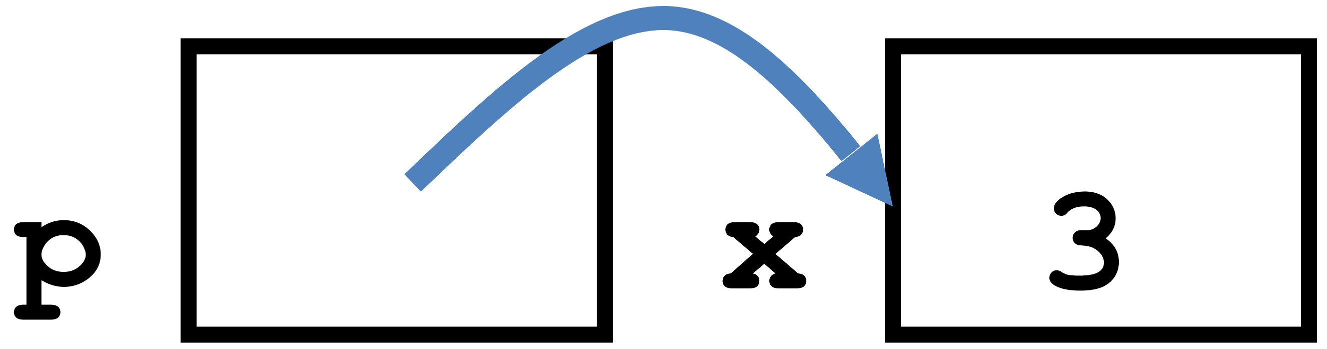
- How get a value pointed to?

"*****" (dereference operator): get the value that the pointer points to

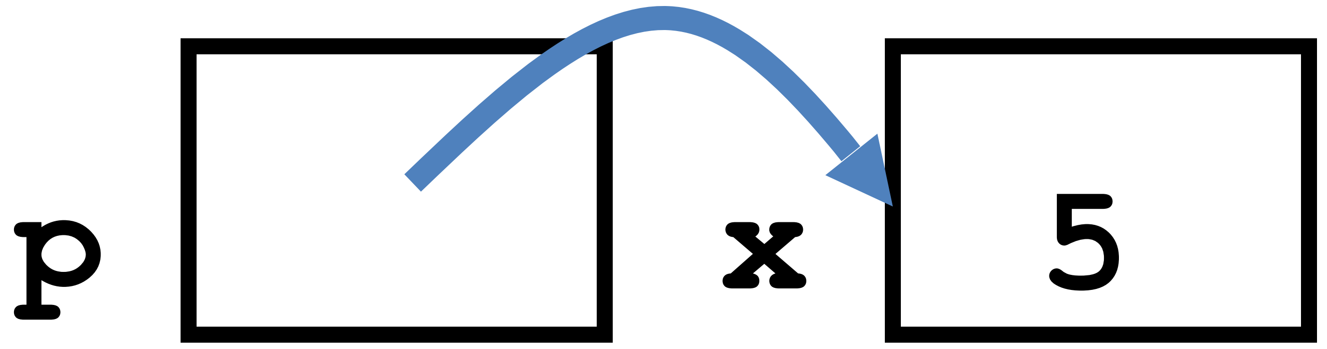
```
printf("p points to %d\n",*p);
```

Using Pointer for Writes

- How to change a variable pointed to?
  - Use the dereference operator `*` on left of assignment operator `=`



`*p = 5;`



Pointers and Parameter Passing

- Java and C pass parameters "by value": Procedure/function/method gets a copy of the parameter, *so changing the copy cannot change the original*

```
void add_one (int x)
{
    x = x + 1;
}
int y = 3;
add_one(y);
```

y remains equal to 3

Pointers and Parameter Passing

- How can we get a function to change the value held in a variable?

```
void add_one (int *p)
{
    *p = *p + 1;
}
int y = 3;

add_one(&y);
```

y is now equal to 4

Types of Pointers

- Pointers are used to point to any kind of data (**`int`**, **`char`**, a **`struct`**, etc.)
- Normally a pointer only points to one type (**`int`**, **`char`**, a **`struct`**, etc.).
  - void * is a type that can point to anything (generic pointer)
  - Use **`void *`** sparingly to help avoid program bugs, and security issues, and other bad things!

More C Pointer Dangers

- *Declaring a pointer just allocates space to hold the pointer – it does not allocate the thing being pointed to!*
- Local variables in C are not initialized, they may contain anything (aka “garbage”)
- What does the following code do?

```
void f()
{
    int *ptr;
    *ptr = 5;
}
```

Pointers and Structures

```
typedef struct {
    int x;
    int y;
} Point;

Point p1;
Point p2;
Point *paddr;
```

```
/* dot notation */
int h = p1.x;
p2.y = p1.y;

/* arrow notation */
int h = paddr->x;
int h = (*paddr).x;

/* This works too */
p1 = p2;
```

Pointers in C

- Why use pointers?
  - If we want to pass a large struct or array, it's easier / faster / etc. to pass a pointer than the whole thing
  - In general, pointers allow cleaner, more compact code
- So what are the drawbacks?
  - Pointers are probably the single largest source of bugs in C, so be careful anytime you deal with them
    - Most problematic with dynamic memory management—coming up next week
    - Dangling references and memory leaks

Why Pointers in C?

- At time C was invented (early 1970s), compilers often didn't produce efficient code
  - Computers 25,000 times faster today, compilers better
- C designed to let programmer say what they want code to do without compiler getting in way
  - Even give compilers hints which registers to use!
- Today's compilers produce much better code, so may not need to use pointers in application code
- Low-level system code still needs low-level access via pointers

Video: Fun with Pointers

https://www.youtube.com/watch?v=6pmWojisM_E

Peer Instruction Time

```
void foo(int *x, int *y)
{
   int t;
    if ( *x > *y ) { t = *y; *y = *x; *x = t; }
}
int a=3, b=2, c=1;
foo(&a, &b);
foo(&b, &c);
foo(&a, &b);
printf("a=%d b=%d c=%d\n", a, b, c);
```

Result is:

A: **a=3 b=2 c=1**

B: **a=1 b=2 c=3**

C: **a=1 b=3 c=2**

D: **a=3 b=3 c=3**

E: **a=1 b=1 c=1**