

# Intro, C refresher

CSE 333 Spring 2022

**Instructor:** Hal Perkins

**Teaching Assistants:**

Esau Abraham

Nour Ayad

Ramya Challa

Cleo Chen

Sanjana Chintalapati

Dylan Hartono

Kenzie Mihardja

Brenden Page

Aakash bin Srazali

Justin Tysdal

Julia Wang

Timmy Yang

# Lecture Outline

- ❖ **Course Introduction**
- ❖ **Course Policies**
  - <https://courses.cs.washington.edu/courses/cse333/22sp/syllabus.html>
- ❖ **C Intro**

# To get started...

- ❖ Welcome back. It's all in-person this quarter (but we'll adjust if things need to change for some reason)
- ❖ UW mask policy is optional, but strongly recommended for at least the first couple of weeks
  - No judgement: people can do what they will, and do not read anything into how others do or don't use masks
  - Please be courteous and allow people distance or otherwise help them feel comfortable if asked.
- ❖ Stay healthy! If you do come down with something, please stay home until recovered and not contagious
  - Lectures are on panopto if you do need to miss

# Stay in Touch – Speak up

- ❖ This is a strange world we've been in and there's still a lot of stress for many people
  
- ❖ Please speak up if things aren't (or are!) going well
  - We can often help if we know about things, so stay in touch with TAs, instructor, advising, friends and peers, others
  - Don't try to "tough it out" or pretend it will get better if you just ignore it – speak up!
  
- ❖ We're all in this together but not all in the same way, so please show understanding and compassion for each other and help when you can – both in and outside of class

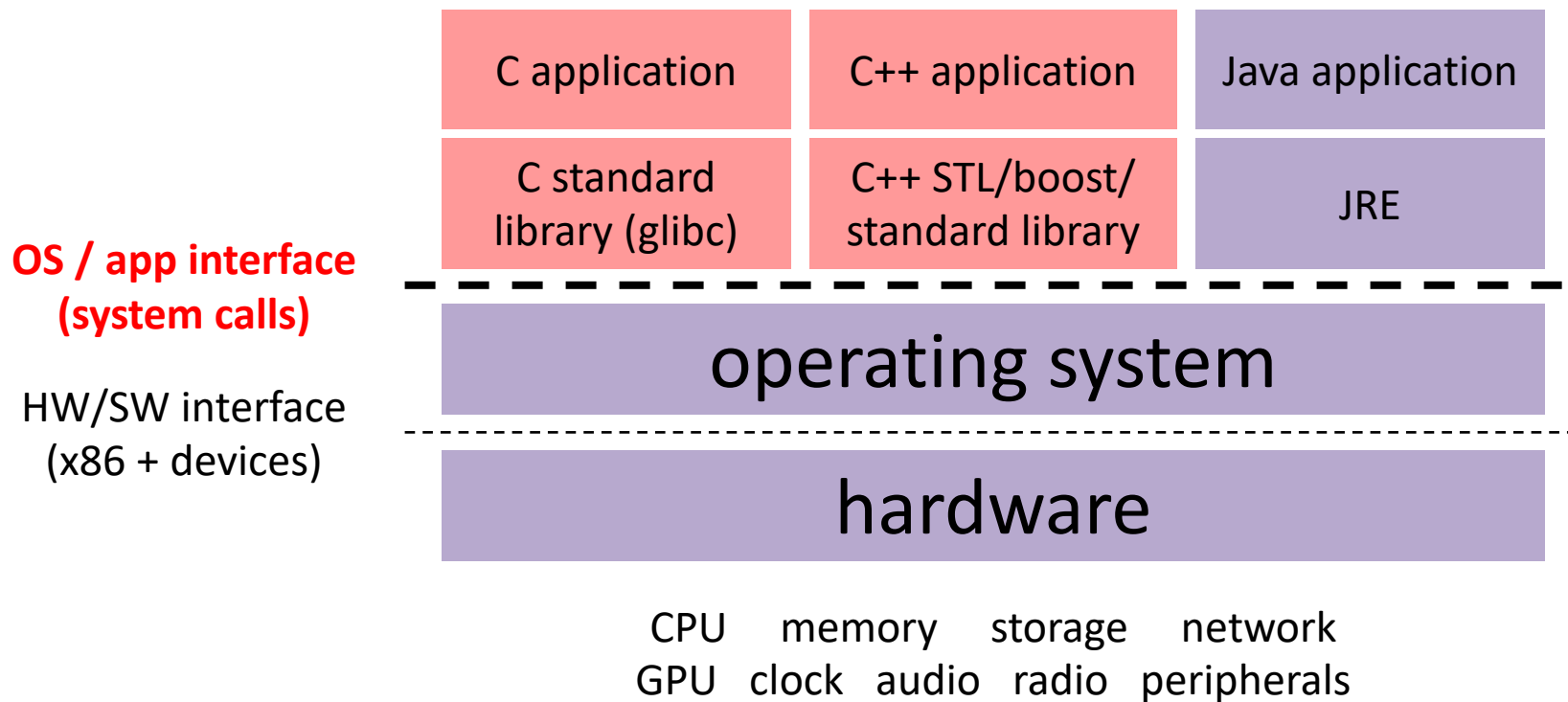
# Introductions: Course Staff

- ❖ Hal Perkins (instructor)
  - Long-time CSE faculty member and CSE 333 veteran
  
- ❖ TAs:
  - Esau Abraham, Nour Ayad, Ramya Challa, Cleo Chen, Sanjana Chintalapati, Dylan Hartono, Kenzie Mihardja, Brenden Page, Aakash bin Srazali, Justin Tysdal, Julia Wang, and Timmy Yang
  - Available in section, office hours, and discussion group
  - An invaluable source of information and help
  
- ❖ Get to know us
  - We are here to help you succeed!

# Introductions: Students

- ❖ ~165 students this quarter
- ❖ Expected background
  - **Prereq:** CSE 351 – C, pointers, memory model, linker, system calls
  - CSE 391 or Linux skills needed for CSE 351 assumed

# Course Map: 100,000 foot view



# Systems Programming

- ❖ The programming skills, engineering discipline, and knowledge you need to build a system
  - **Programming:** C / C++
  - **Discipline:** testing, debugging, performance analysis
  - **Knowledge:** long list of interesting topics
    - Concurrency, OS interfaces and semantics, techniques for consistent data management, distributed systems algorithms, ...
    - Most important: a deep(er) understanding of the “layer below”



# Discipline?!?

- ❖ Cultivate good habits, encourage clean code
  - Coding style conventions
  - Unit testing, code coverage testing, regression testing
  - Documentation (code comments, design docs)
  - Code reviews
- ❖ Will take you a lifetime to learn
  - But oh-so-important, especially for systems code
    - Avoid write-once, read-never code

# Lecture Outline

- ❖ Course Introduction
- ❖ **Course Policies**
  - <https://courses.cs.washington.edu/courses/cse333/22sp/syllabus.html>
  - Summary/highlights here, but you *must* read the full details online
- ❖ C Intro

# Communication

- ❖ **Website:** <http://cs.uw.edu/333>
  - Schedule, policies, materials, assignments, etc.
- ❖ **Discussion:** Ed group linked to course home page
  - Must log in using your **@uw.edu** Google identity (not cse)
  - Ask and answer questions – staff will monitor and contribute
- ❖ **Messages to staff:** use private messages on Ed
  - (**don't** email to instructor or individual TAs if possible – helps us get quick answers for you and coordinate better if it goes to the staff)
- ❖ **Announcements:** will use broadcast Ed messages to send “things everyone must read and know”
- ❖ **Office Hours:** spread throughout the week
  - Schedule posted shortly and will start right away
  - Can also send private message to ED to request individual appointments

# Course Components

- ❖ Lectures (~30)
  - Introduce the concepts; take notes!!!
- ❖ Sections (10)
  - Applied concepts, important tools and skills for assignments, clarification of lectures, exam review and preparation
- ❖ Programming Exercises (~18)
  - Roughly one per lecture, due the morning before the next lecture
  - Coarse-grained grading (0, 1, 2, or 3)
- ❖ Programming Projects (0+4)
  - Warm-up, then 4 “homeworks” that build on each other
- ❖ Midterm (in-class) and final exam
  - Goal is to revisit and internalize concepts

# Grading (tentative)

- ❖ **Exercises:** ~30%
  - Submitted via GradeScope (account info mailed earlier today)
  - Evaluated on correctness and code quality
- ❖ **Projects:** ~45% total
  - Submitted via GitLab; must tag commit that you want graded
  - Binaries provided if you didn't get previous part working or prefer to start with a known good solution to previous parts
- ❖ **Exams:** Midterm: ~10%, Final: ~15%
- ❖ **More details on course website**
  - You **must** read the syllabus there – you are responsible for it

# Deadlines and Student Conduct

- ❖ Late policies
  - Exercises: no late submissions accepted, due 10 am before class
  - Projects: 4 late days for entire quarter, max 2 per project
  - Need to get things done on time – difficult to catch up!
    - But we will work with you if unusual circumstances / problems
  
- ❖ Academic Integrity (**read** the full policy on the web)
  - I trust you implicitly and will follow up if that trust is violated
  - In short: don't attempt to gain credit for something you didn't do and don't help others do so either
  - This does **not** mean suffer in silence – learn from the course staff and peers, talk, share ideas; *but* don't share or copy work that is supposed to be yours

# And off we go...

- ❖ Goal is to figure out setup and computing infrastructure right away so we don't put that off and then have a crunch later in the quarter
- ❖ So:
  - First exercise out today, due Wednesday morning **10 am** before class
  - Warmup/logistics for larger projects in sections Thursday
    - HW0 (the warmup project) published Wednesday afternoon and gitlab repos created then. Feel free to ignore until sections this week and we'll walk through the whole thing.

# Gadgets (1)

- ❖ Gadgets reduce focus and learning
  - Bursts of info (*e.g.* emails, IMs, etc.) are *addictive*
  - Heavy multitaskers have more trouble focusing and shutting out irrelevant information
    - <http://www.npr.org/2016/04/17/474525392/attention-students-put-your-laptops-away>
  - Seriously, you will learn more if you use **paper** instead!!!
    - (even compared to note-taking on a tablet, although that is better than a keyboard, and that is way better than just “watching the show”)



# Gadgets (2)

- ❖ So how should we deal with laptops/phones/etc.?
  - Just say no!
  - No open gadgets during class (really!)
    - Unless you're actually using a tablet or something to take notes
  - Urge to search? – ask a question! Everyone benefits!!
  - You may close/turn off non-notetaking electronic devices now
  - Pull out a piece of paper and pen/pencil instead 😊

# Deep Breath....

- ❖ Any questions, comments, observations, before we go on to, uh, some technical stuff?

# Lecture Outline

- ❖ Course Introduction
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- ❖ **C Intro**
  - **Workflow, Variables, Functions**

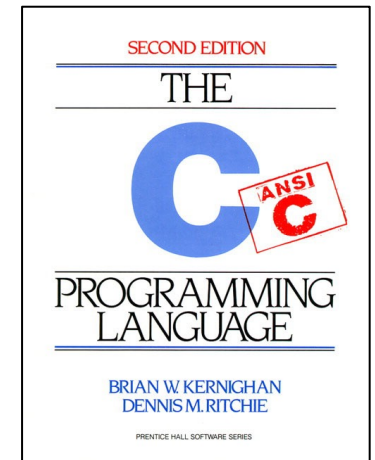
# C

## ❖ Created in 1972 by Dennis Ritchie

- Designed for creating system software
- Portable across machine architectures
- Most recently updated in 1999 (C99) and 2011 (C11) and 2017 (C17)

## ❖ Characteristics

- “Low-level” language that allows us to exploit underlying features of the architecture – **but easy to fail spectacularly (!)**
- Procedural (not object-oriented)
- Typed but unsafe (possible to bypass the type system)
- Small, basic library compared to Java, C++, most others....



# Generic C Program Layout

```
#include <system_files>
#include "local_files"

#define macro_name macro_expr

/* declare functions */
/* declare external variables & structs */

int main(int argc, char* argv[]) {
    /* the innards */
}

/* define other functions */
```

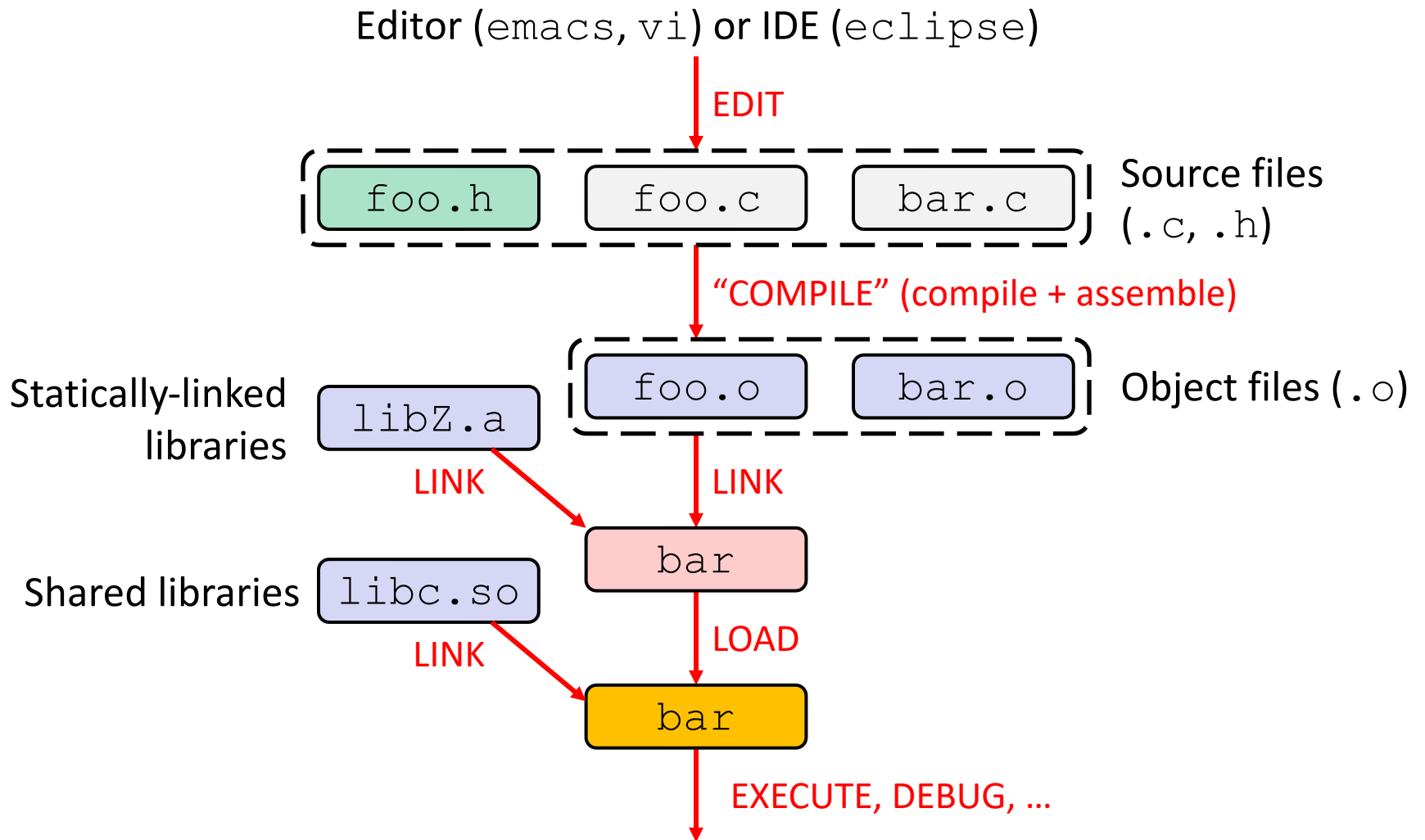
# C Syntax: `main`

- ❖ To get command-line arguments in `main`, use:

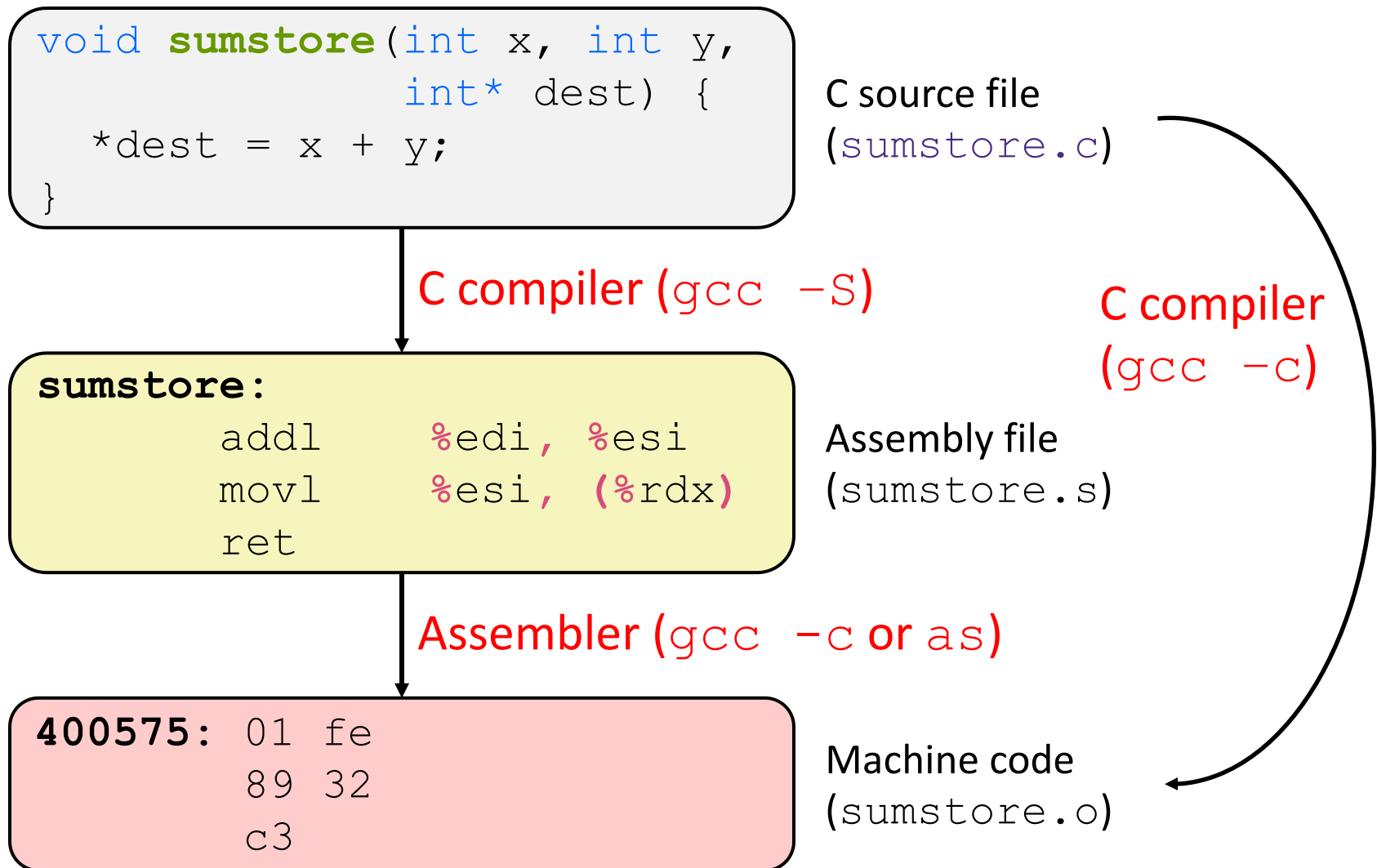
```
int main(int argc, char* argv[])
```

- ❖ What does this mean?
  - `argc` contains the number of strings on the command line (the executable name counts as one, plus one for each argument).
  - `argv` is an array containing *pointers* to the arguments as strings (more on pointers later)
- ❖ Example: `$ foo hello 87`
  - `argc = 3`
  - `argv[0]="foo", argv[1]="hello", argv[2]="87"`

# C Workflow



# C to Machine Code





# When Things Go South...

- ❖ Errors and Exceptions
  - C does not have exception handling (no `try/catch`)
  - Errors are returned as integer error codes from functions
  - Because of this, error handling is ugly and inelegant
  
- ❖ Processes return an “exit code” when they terminate
  - Can be read and used by parent process (shell or other)
    - In main: `return EXIT_SUCCESS`; or `return EXIT_FAILURE`; (e.g., 0 or 1)
  
- ❖ Crashes
  - If you do something bad, you hope to get a “segmentation fault” (believe it or not, this is the “good” option)

# Java vs. C (351 refresher)

- ❖ Are Java and C mostly similar (S) or significantly different (D) in the following categories?
  - List any differences you can recall (even if you put 'S')

Language Feature	S/D	Differences in C
Control structures	S	
Primitive datatypes	S/D	Similar but sizes can differ (char, esp.), unsigned, no boolean, uninitialized data, ...
Operators	S	Java has >>>, C has ->
Casting	D	Java enforces type safety, C does not
Arrays	D	Not objects, don't know their own length, no bounds checking
Memory management	D	Manual (malloc/free), no garbage collection

# Primitive Types in C

❖ Integer types

- `char, int`

❖ Floating point

- `float, double`

❖ Modifiers

- `short [int]`
- `long [int, double]`
- `signed [char, int]`
- `unsigned [char, int]`

C Data Type	32-bit	64-bit	printf
<b>char</b>	1	1	%c
short int	2	2	%hd
unsigned short int	2	2	%hu
<b>int</b>	4	4	%d / %i
unsigned int	4	4	%u
long int	4	8	%ld
long long int	8	8	%lld
<b>float</b>	4	4	%f
<b>double</b>	8	8	%lf
long double	12	16	%Lf
<b>pointer</b>	4	8	%p

Typical sizes – see `sizeofs.c`

# C99 Extended Integer Types

- ❖ Solves the conundrum of “how big is an `long int`?”

```
#include <stdint.h>

void foo(void) {
    int8_t  a; // exactly 8 bits, signed
    int16_t b; // exactly 16 bits, signed
    int32_t c; // exactly 32 bits, signed
    int64_t d; // exactly 64 bits, signed
    uint8_t w; // exactly 8 bits, unsigned
    ...
}
```

Use extended types in most cse333 code

```
void sumstore(int x, int y, int* dest) {
```

```
void sumstore(int32_t x, int32_t y, int32_t* dest) {
```

But int is usually fine for simple ints

# Basic Data Structures

- ❖ C does not support objects!!!
- ❖ **Arrays** are contiguous chunks of memory
  - Arrays have no methods and do not know their own length
  - Can easily run off ends of arrays in C – **security bugs!!!**
- ❖ **Strings** are null-terminated char arrays
  - Strings have no methods, but `string.h` has helpful utilities

```
char* x = "hello\n";
```

x

h	e	l	l	o	\n	\0
---	---	---	---	---	----	----

- ❖ **Structs** are the most object-like feature, but are just collections of fields – no “methods” or functions

# Function Definitions

## ❖ Generic format:

```
returnType fname(type param1, ..., type paramN) {  
    // statements  
}
```

```
// sum of integers from 1 to max  
int sumTo(int max) {  
    int i, sum = 0;  
  
    for (i = 1; i <= max; i++) {  
        sum += i;  
    }  
  
    return sum;  
}
```

# Function Ordering

- ❖ You *shouldn't* call a function that hasn't been declared yet

sum\_badorder.c

```
#include <stdio.h>

int main(int argc, char** argv) {
    printf("sumTo(5) is: %d\n", sumTo(5));
    return 0;
}

// sum of integers from 1 to max
int sumTo(int max) {
    int i, sum = 0;

    for (i = 1; i <= max; i++) {
        sum += i;
    }
    return sum;
}
```

# Solution 1: Reverse Ordering

- ❖ Simple solution; however, imposes ordering restriction on writing functions (who-calls-what?)

sum\_betterorder.c

```
#include <stdio.h>

// sum of integers from 1 to max
int sumTo(int max) {
    int i, sum = 0;

    for (i = 1; i <= max; i++) {
        sum += i;
    }
    return sum;
}

int main(int argc, char** argv) {
    printf("sumTo(5) is: %d\n", sumTo(5));
    return 0;
}
```



## Solution 2: Function Declaration

- ❖ Teaches the compiler arguments and return types; function definitions can then be in a logical order

sum\_declared.c

Hint: code examples from slides are on the course web for you to experiment with

```
#include <stdio.h>

int sumTo(int); // func prototype

int main(int argc, char** argv) {
    printf("sumTo(5) is: %d\n", sumTo(5));
    return 0;
}

// sum of integers from 1 to max
int sumTo(int max) {
    int i, sum = 0;
    for (i = 1; i <= max; i++) {
        sum += i;
    }
    return sum;
}
```

# Function Declaration vs. Definition

- ❖ C/C++ make a careful distinction between these two
- ❖ **Definition:** the thing itself
  - *e.g.* code for function, variable definition that creates storage
  - Must be **exactly one** definition of each thing (no duplicates)
- ❖ **Declaration:** description of a thing
  - *e.g.* function prototype, external variable declaration
    - Often in header files and incorporated via `#include`
    - Should also `#include` declaration in the file with the actual definition to check for consistency
  - Needs to appear in **all files** that use that thing
    - Should appear before first use

# Multi-file C Programs

definition

C source file 1  
(sumstore.c)

```
void sumstore(int x, int y, int* dest) {  
    *dest = x + y;  
}
```

C source file 2  
(sumnum.c)

```
#include <stdio.h>  
  
void sumstore(int x, int y, int* dest);  
  
int main(int argc, char** argv) {  
    int z, x = 351, y = 333;  
    sumstore(x, y, &z);  
    printf("%d + %d = %d\n", x, y, z);  
    return 0;  
}
```

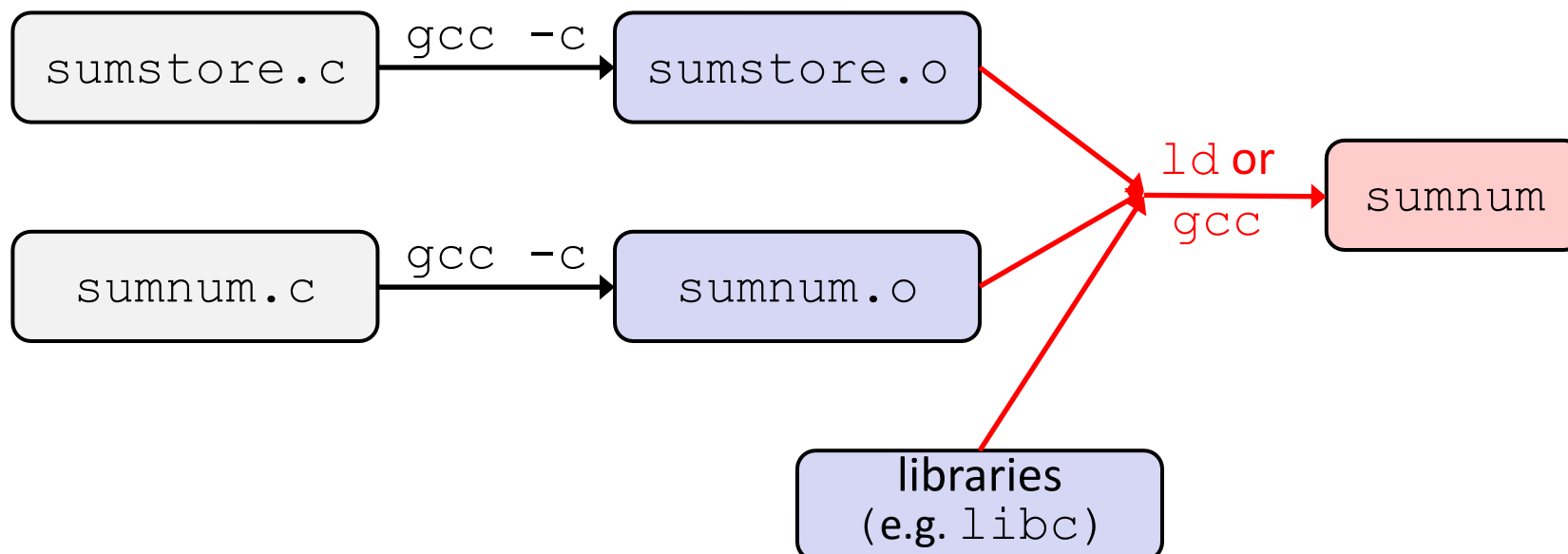
declaration

Compile together:

```
$ gcc -o sumnum sumnum.c sumstore.c
```

# Compiling Multi-file Programs

- ❖ The **linker** combines multiple object files plus statically-linked libraries to produce an executable
  - Includes many standard libraries (e.g. `libc`, `crt1`)
    - A *library* is just a pre-assembled collection of `.o` files



# To-do List

- ❖ Explore the website *thoroughly*: <http://cs.uw.edu/333>
- ❖ Computer setup: CSE labs, attu, or CSE Linux VM
- ❖ Exercise 0 is due 10 am Wednesday before class
  - Find exercise spec on website, submit via Gradescope
  - Sample solution will be posted Wednesday after class
  - Give it your best shot to get it done on time
- ❖ Gradescope accounts created before class today
  - Userid is your uw.edu email address
  - Exercise submission: find CSE 333 22sp, click on the exercise, drag-n-drop file(s)! That's it!!
- ❖ Project repos created and hw0 out by Wed. afternoon
  - All will become clear in sections this week! 😊