# Structs & Alignment

## CSE 351 Winter 2024

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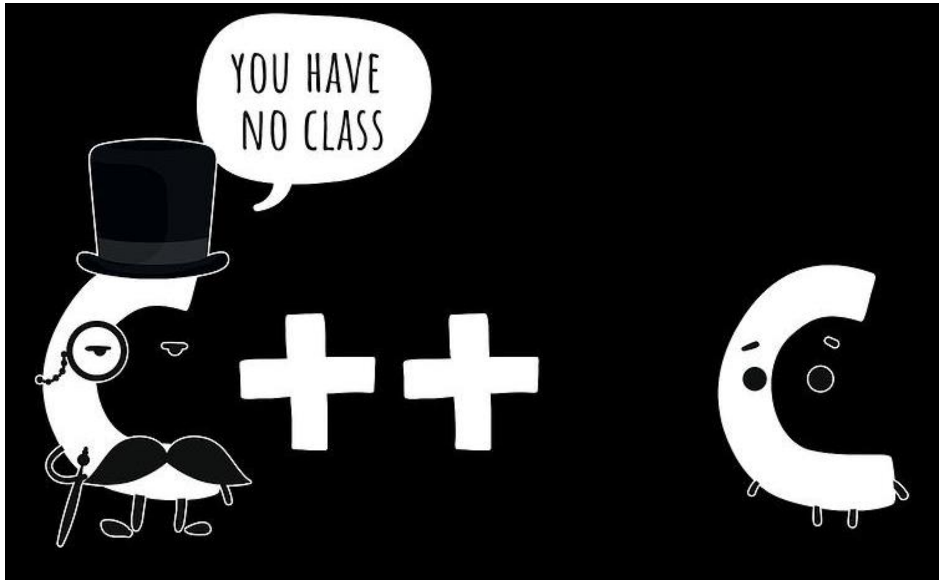

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# Relevant Course Information

- HW11 due tonight, HW12 due Monday, HW13 due Wednesday

- Lab 2 due tonight
- Lab 3 released Monday (2/5) – a shorter lab, due Friday, 2/16

- **Take-home Midterm** (2/8–10)
  - Instructions will be posted on Ed Discussion
  - Gilligan’s Island Rule: discuss high-level concepts and give hints, but not solving the problems together
  - We will be available on Ed Discussion (private posts only) and support hours to answer clarifying questions

# Structs & Alignment

# Lesson Summary

- Alignment
  - Data of alignment requirement (*i.e.*, size) $K$ is considered aligned if its address is a multiple of $K$
  - Arrays have alignment requirement of an individual element, not the total size

- Structures
  - Allocate bytes for fields in order declared by programmer – can make choices to minimize memory allocations
  - Pad in middle to satisfy individual element alignment requirements ($K$)
    - ***Internal* fragmentation**
  - Pad at end to satisfy overall struct alignment requirement ($K_{max}$)
    - ***External* fragmentation**

# Lesson Summary (2/2)

- Learning Objectives:
  - Analyze the memory layout of a struct and minimize its impact on program memory usage.
  - Create, access, and modify array and struct elements in C.

- What lingering questions do you have from the lesson?
  - Chat with your neighbors about the lesson for a few minutes to come up with questions

# Structs & Alignment – Practice

# Polling Questions (1/2)

tag

```
struct ll_node {
  long data;
  struct ll_node* next;
} n1, n2;
```

8B

8B

fields

$K_{max}=8$

two instances

- How much space does (in bytes) does an instance of `struct ll_node` take? $\boxed{16\ B}$

- Which of the following statements are syntactically valid?
  - ✓ `n1.next = &n2;`
    inst ✓ ptr ptr
  - ✗ `n2->data = 351;`
    inst ✗
  - ✓ `n1.next->data = 333;`
    inst ✓ ptr ✓ long
  - ✗ `(&n2)->next->next.data = 451;`
    ptr ✓ ptr ✓ ptr ✗

• . for struct instances (inst), -> for struct pointers (ptr)

# Polling Questions (2/2)

- Minimize the size of the struct by re-ordering the fields:

```
        K
        4   struct old {
              int i;
        2     short s[3];
        8     char* c;
        4     float f;
Kmax = 8    };
```

```
struct new {
  int    i;
  float  f;
  char*  c;
  short  s[3];
};
```

could also switch these (internal vs. external frag)

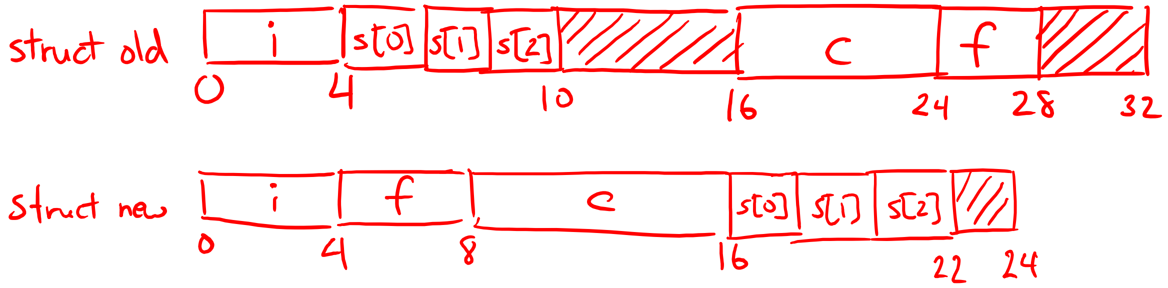
- What is the minimum size of struct new?

A. 22 bytes

[✓ B. 24 bytes]

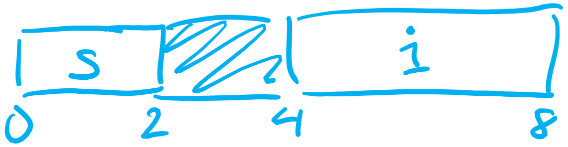
C. 28 bytes

D. 32 bytes



# Homework Setup

struct inner:



- Struct in a struct?
  - It's just another data type, with its own alignment requirement
  - Example:

```
struct outer {
   char c;
   struct inner {
      short s;
      int i;
   } in;
};
```

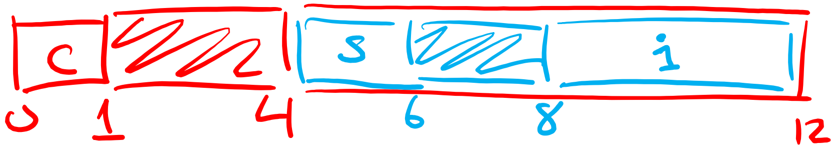
→

```
K struct inner {
2    short s;
4    int i;
  };
K struct outer {
1    char c;
4    struct inner in;
  };
```

$K_{max} = 4$

$K_{max} = 4$

struct outer:



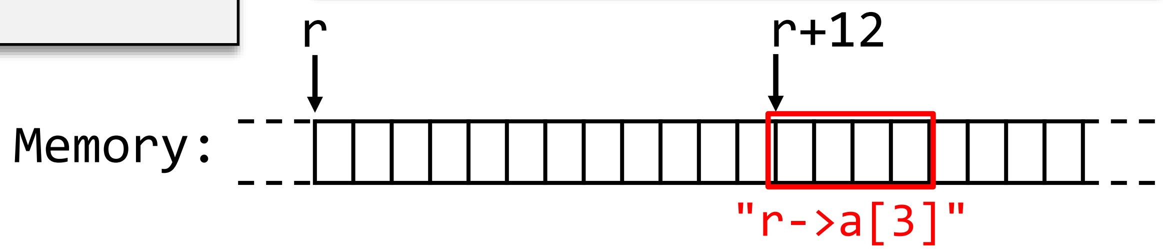
# Structs & Alignment – Context

# Struct Pointers

- Pointers store addresses, which all “look” the same
  - Lab 0 Example: struct instance `Scores` could be treated as array of `int`s of size 4 via pointer casting
  - A struct pointer doesn’t *have* to point to a declared instance of that struct type
- Different struct fields may or may not be meaningful, depending on what the pointer points to
  - This will be important for Lab 5!

```
long get_a3(struct rec* r) {
  return r->a[3];
}
```

```
  movl  12(%rdi), %rax
  ret
```



# Group Work Time

- During this time, you are encouraged to work on the following:
  1) If desired, continue your discussion
  2) Work on the homework problems
  3) Work on the lab (if applicable)

- Resources:
  - You can revisit the lesson material
  - Work together in groups and help each other out
  - Course staff will circle around to provide support