CS 241: Systems Programming
Lecture 14. Structures

Fall 2025

Prof. Stephen Checkoway

struct

```
struct Course {
    department: String,
    number: i32,
    section: i32,
    instructor: String,
}

fn main() {
    let cs241 = Course {
        department: String::from("CSCI"),
        number: 241,
        section: 1,
        instructor: String::from("Stephen Checkoway"),
    };
}
```

struct

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    department: String,
    number: i32,
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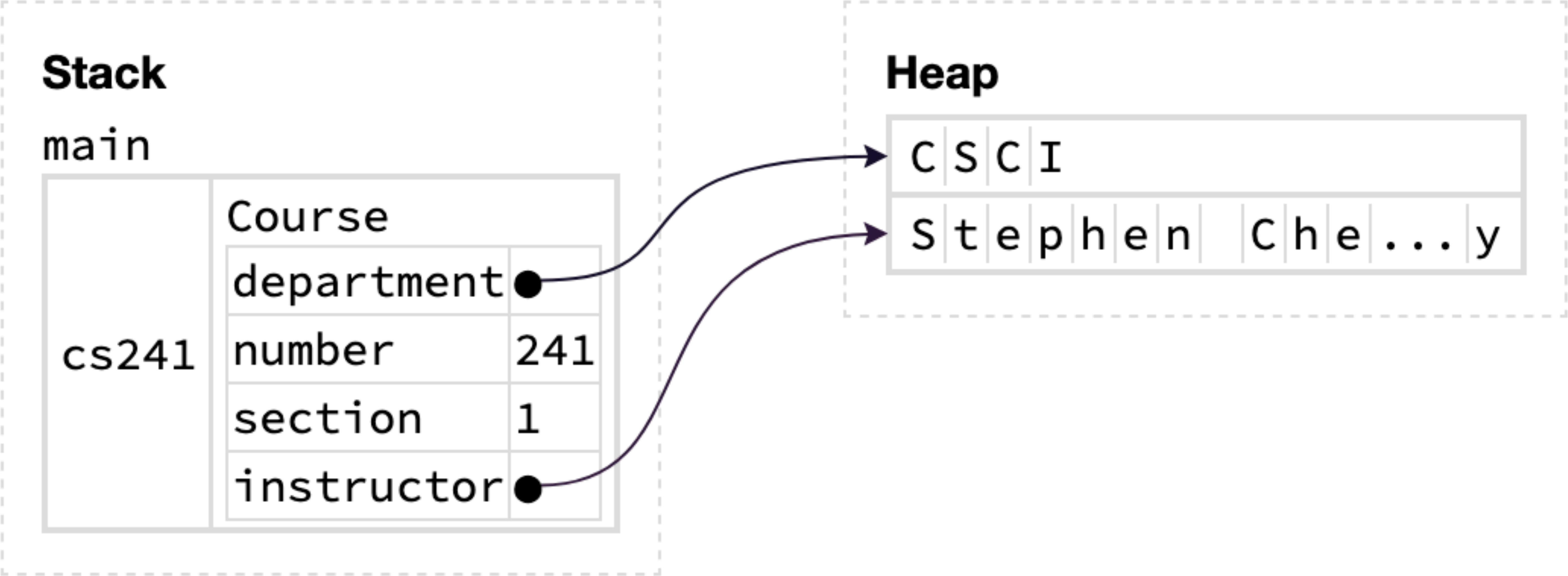

Accessing members

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    department: String,
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    section: i32,
    instructor: String,
}

fn main() {
    let cs241 = Course {
        department: String::from("CSCI"),
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    };
    println!("{} {}", cs241.department, cs241.number);
}
```

Modifying a member

```rust
struct Course {
    department: String,
    number: i32,
    section: i32,
    instructor: String,
}

fn main() {
    let mut cs241 = Course {
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        number: 241,
        section: 1,
        instructor: String::from("Stephen Checkoway"),
    };

    cs241.department = String::from("Computer Science");
}
```

Old department String was dropped (and its contents deallocated)

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    department: String,
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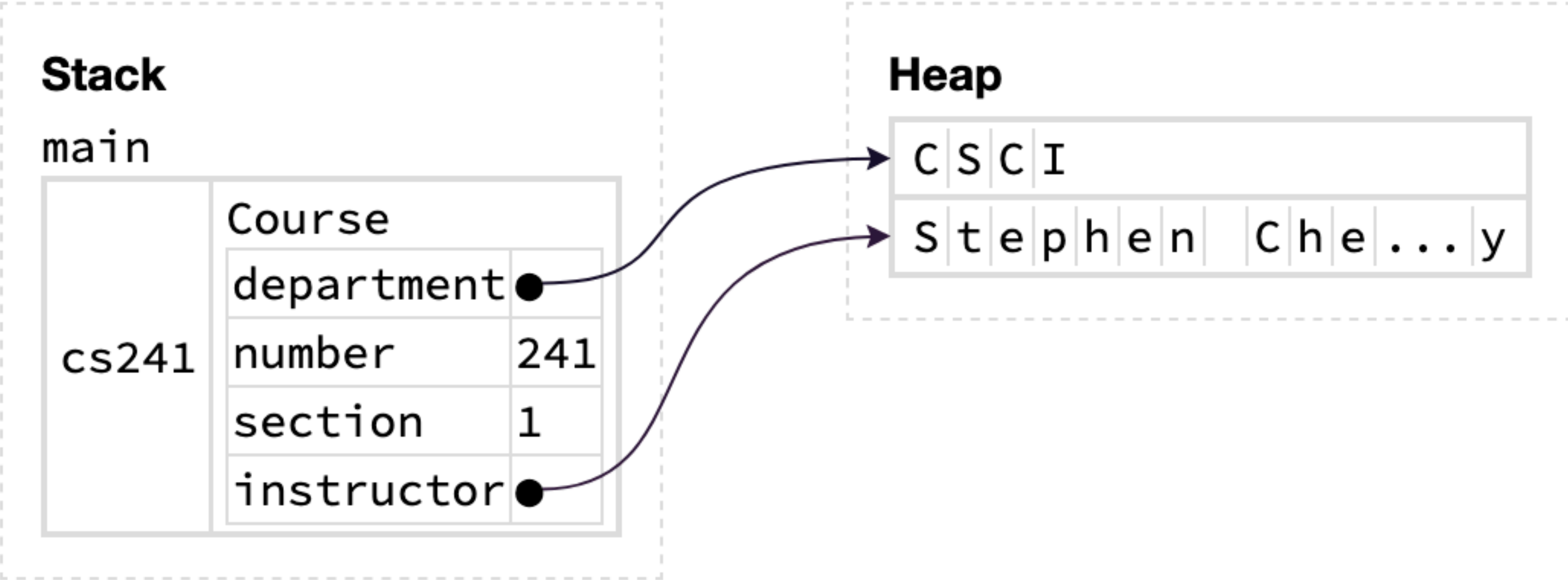

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    cs241.department = String::from("Computer Science");
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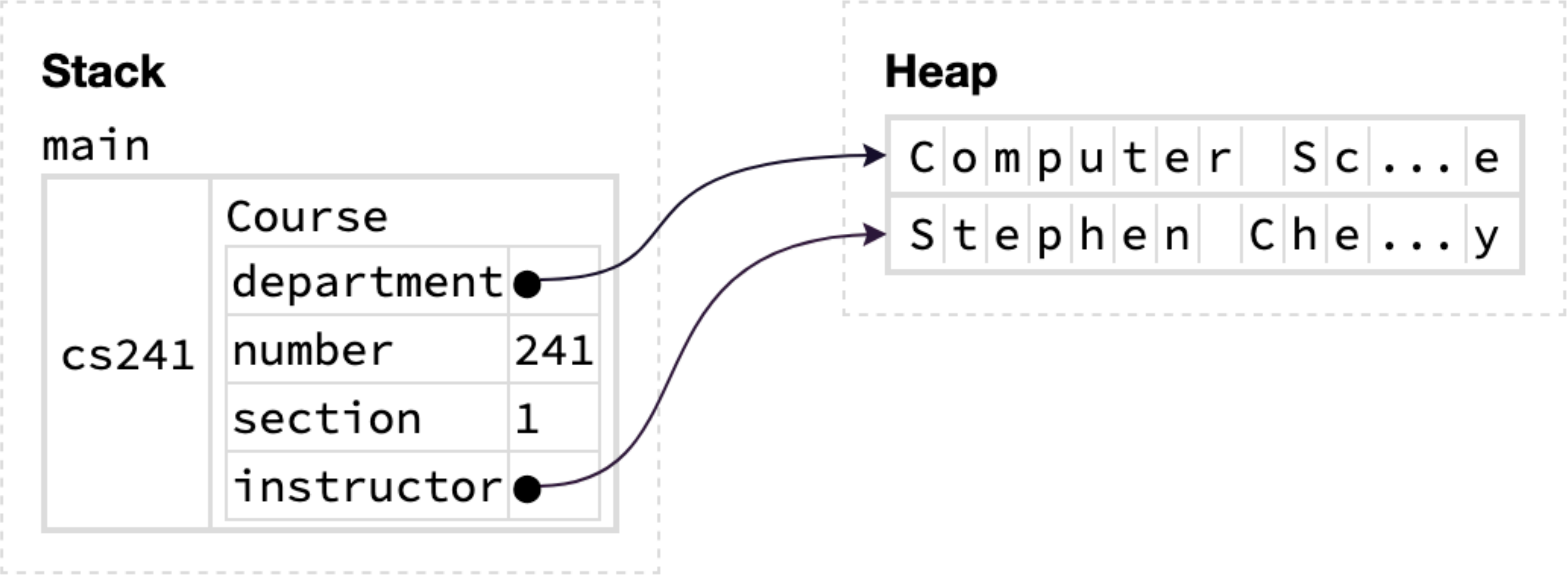

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Field init shorthand

```rust
fn new_course(department: &str, number: i32) -> Course {
    Course {
        department: department.to_string(),
        number, // <- No need to write number: number
        section: 1,
        instructor: String::from("Staff"),
    }
}

fn main() {
    let cs241 = new_course("CSCI", 241);
    println!("{} {}", cs241.department, cs241.number);
}
```

You're designing a program for interacting with social media and you want to represent posts using a Post structure you're designing. Each Post needs an account name, contents, and a number of "likes." The account name and contents never change, but the number of likes can. Which structure definition best models this?

```
// A
struct Post {
    account: String,
    contents: String,
    likes: u64,
}
```

```
// B
struct Post {
    account: String,
    contents: String,
    likes: mut u64,
}
```

```
// C
struct Post {
    String account;
    String contents;
    u64 likes;
}
```

```
// D
struct Post {
    account: readonly String,
    contents: readonly String,
    likes: u64,
}
```

Update syntax

```
fn main() {
    let cs241 = new_course("CSCI", 241);
    let cs241_2 = Course {
        instructor: String::from("Mary Hogan"),
        section: 2,
        ..cs241
    };
}
```

Moves all of the remaining fields from cs241 into cs241_2 and drops cs241

What will this code print out?

A. CSCI Mary Hogan

B. CSCI Cynthia Taylor

C. This code will not compile

```
fn main() {
  let cs241 = Course {
  department: String::from("CSCI"),
  number: 241,
  section: 1,
  instructor: String::from(“Mary Hogan”),
  };

  let cs241_2 = Course {
  instructor: String::from("Cynthia Taylor"),
  section: 2,
  ..cs241
  };
  println!("{} {}", cs241.department, cs241_2.instructor);
}
```

Tuples

Tuples let us group multiple, heterogeneous types together

They have fixed size (no adding or removing elements)

```
let val: (i32, char, f64) = (42, '🦀', 6.022e23);
```

Tuples can be built from any types

Tuple structs

```rust
struct Point(i32, i32);

fn main() {
    let p = Point(4, 5);
    println!("{} {}", p.0, p.1);
}
```

Create an new instance by giving the name and field values

Refer to fields using .0, .1, .2, etc., just like tuples

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For arrays and Vecs and Results, we printed the debug representation with println!("{cs241:?}")

error[E0277]: `Course` doesn't implement `Debug`

Deriving Debug

We can ask Rustc to produce an implementation of the Debug trait for us

```rust
#[derive(Debug)]
struct Course { … }

fn main() {
    let cs241 = new_course("CSCI", 241);
    println!("{cs241:?}");
    println!("{cs241:#?}");
}
```

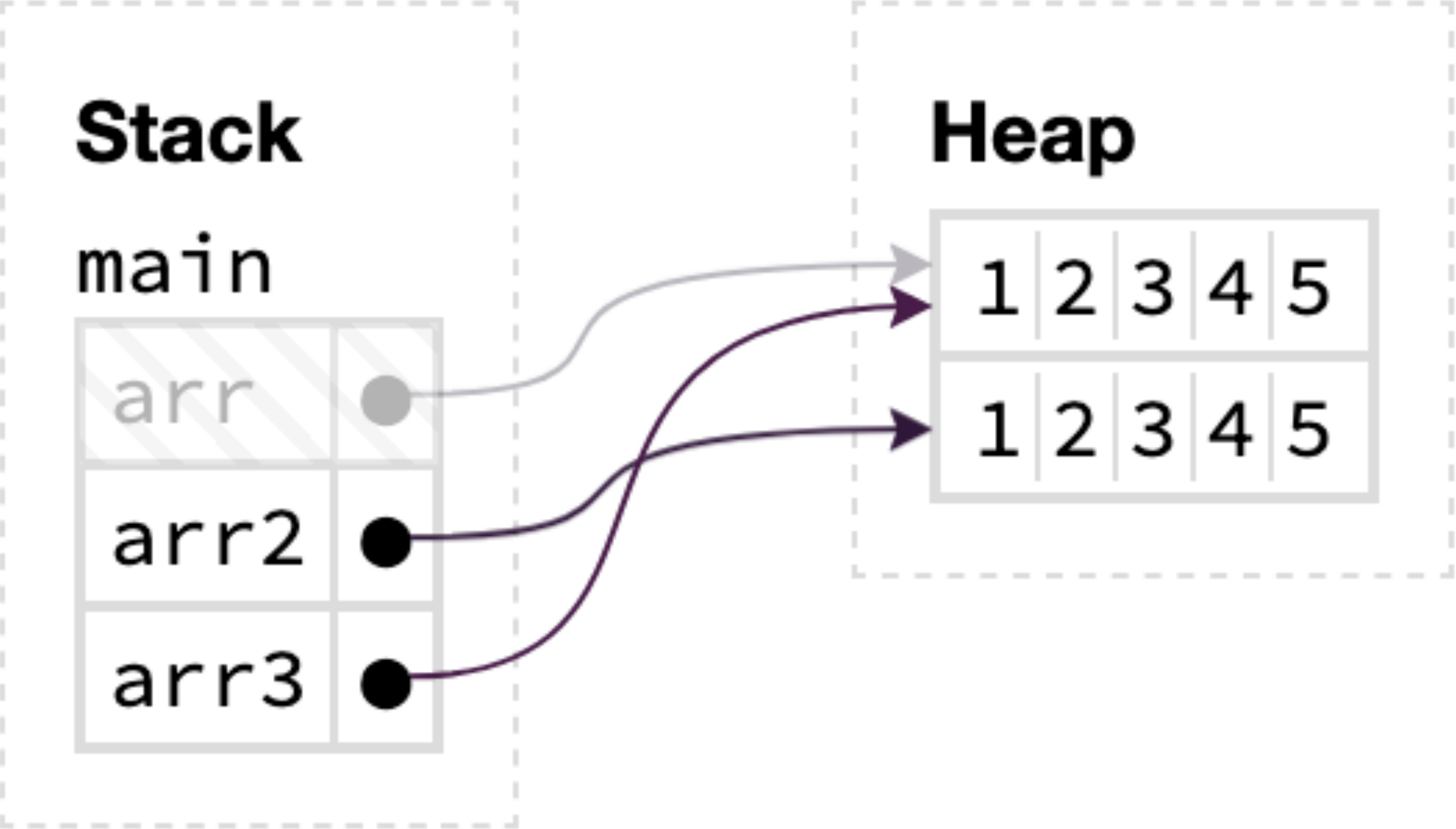
```
Output:
Course { department: "CSCI", number: 241, section: 1, instructor: "Staff" }
Course {
    department: "CSCI",
    number: 241,
    section: 1,
    instructor: "Staff",
}
```

Making copies via clone

The Clone trait has a .clone() method that makes a deep copy of objects

```
fn main() {
    let arr = vec![1, 2, 3, 4, 5];
    let arr2 = arr.clone();
    let arr3 = arr;
}
```

Most types implement Clone



Deriving Clone

```rust
#[derive(Debug, Clone)]
struct Course {
    department: String,
    number: i32,
    section: i32,
    instructor: String,
}
```

All of the members’ types must implement Clone in order to derive Clone

Methods

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We've used a bunch of examples of methods already including

- `.len()` for slices
- `.push()` for Strings and Vecs
- `.push_str()` for Strings
- `.chars()` to get an iterator over characters in a String
- `.iter()` to get an iterator over a collection (like a Vec)

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- `fn foo(&self) {}` self is a shared reference to the instance
- `fn foo(&mut self) {}` self is a mutable reference to the instance
- `fn foo(self) {}` foo takes ownership of the instance

Methods taking shared refs

```
impl Course {
    fn name(&self) -> String {
        format!("{} {}", self.department, self.number)
    }

    fn full_name(&self) -> String {
        format!("{} {}-{}", self.department, self.number, self.section)
    }
}

fn main() {
    let cs241 = new_course("CSCI", 241);
    println!("{}", cs241.name());
}
```

Methods taking mutable refs

```
impl Course {
    fn set_instructor(&mut self, instructor: &str) {
        self.instructor = instructor.to_string();
    }
}

fn main() {
    let mut cs241 = new_course("CSCI", 241);
    cs241.set_instructor("Mary Hogan");
    println!("{}", cs241.instructor);
}
```

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- The type can be copied (like `i32`, `usize`, `bool`)
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i32 (and other integer types) have a bunch of methods that take self

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Many types have `.into_foo()` methods that return implementation details

- String has `fn into_bytes(self) -> Vec<u8>`

Getters and setters are methods for getting or setting the value of a field. Imagine we have the following struct with a getter and a setter for the url field. Which of the three possible self parameters should we use for the url() and set_url() methods?

```
struct Foo {
    url: String,
}

impl Foo {
    fn url(SELF) -> &str { &self.url }
    fn set_url(SELF, url: String) { self.url = url; }
}
```

	url()	set_url()
A	&self	&mut self
B	self	mut self
C	self	&self
D	&mut self	&mut self
E	&self	&self

Method calls are syntactic sugar

```
cs241.set_instructor("Mary Hogan");
println!("{}", cs241.name);
```

is the same as

```
Course::set_instructor(&mut cs241, "Mary Hogan");
println!("{}", Course::name(&cs241));
```

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We can also have associated functions that don’t take an instance as an argument

- These are typically constructor functions
- Most types have a `new()` associated function that returns a new instance of the type

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- These are typically constructor functions
- Most types have a `new()` associated function that returns a new instance of the type

Inside the `impl` block we can refer to the type as `Self`

Constructor

```
impl Course {
    fn new(department: &str, number: i32) -> Self {
        Self {
            department: department.to_string(),
            number,
            section: 1,
            instructor: String::from("Staff"),
        }
    }
}

fn main() {
    let cs241 = Course::new("CSCI", 241);
    println!("{}", cs241.name());
}
```

Examples from the standard library

- String::new() — Creates a new, empty String
- Vec::new() — Creates a new, empty Vec
- Vec::with_capacity(100) — Creates a new, empty Vec with capacity 100
- HashMap::new() — Creates a new, empty HashMap
- BufReader::new(inner) — Creates a new BufReader around some underlying type that implements the Read trait