

CS 4530: Fundamentals of Software Engineering

Module 09: React Hook Patterns

Adeel Bhutta and Mitch Wand
Khoury College of Computer Sciences

Learning Objectives for this Module

- By the end of this module, you should be able to:
 - Explain the basic use cases for useEffect
 - Explain when a useEffect is executed, and when its return value is executed
 - Construct simple custom hooks and explain why they are useful.
 - Be able to explain the three core steps of a test (assemble, act, assess) can map to UI component testing

Lesson 9.1 useEffect

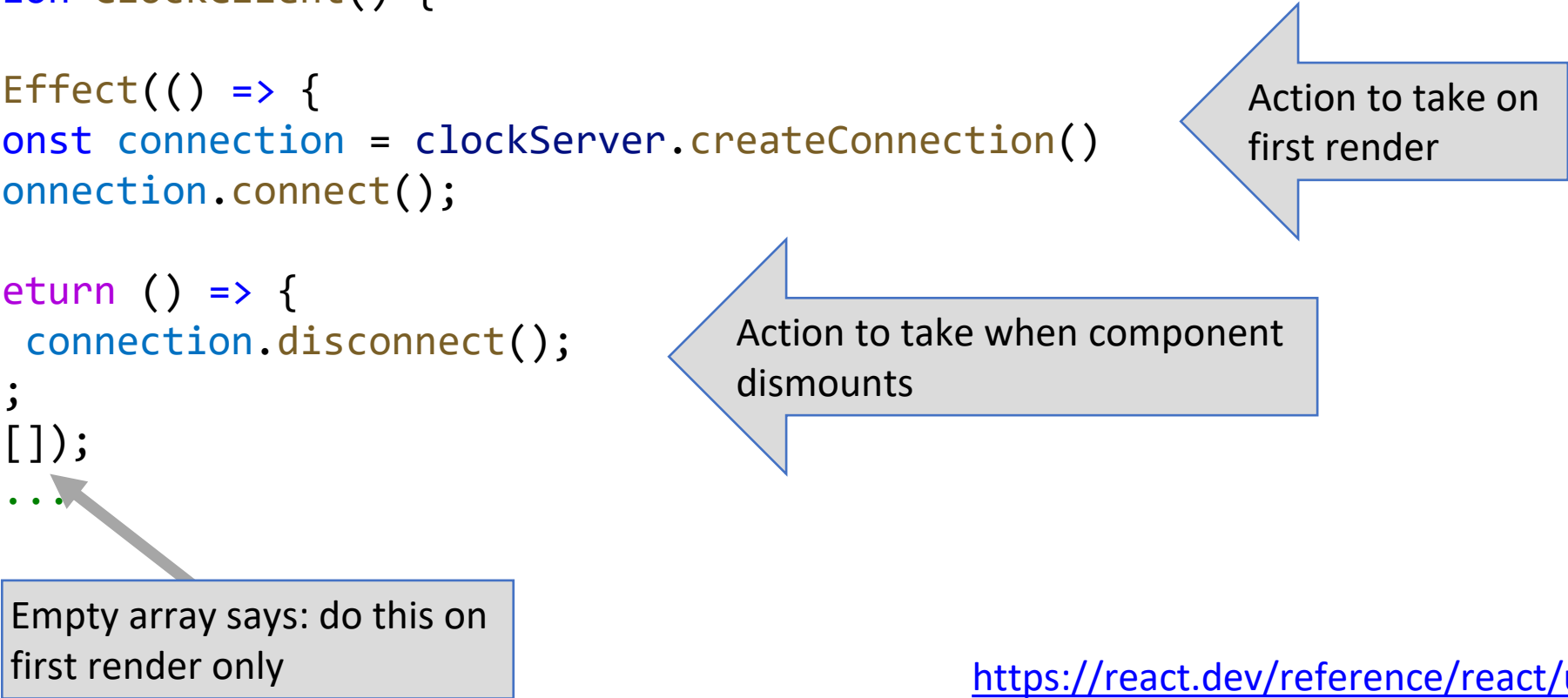
useEffect is a mechanism for synchronizing a component with an external system

```
import { clockServer } from './clock.js';

function ClockClient() {

  useEffect(() => {
    const connection = clockServer.createConnection()
    connection.connect();

    return () => {
      connection.disconnect();
    };
  }, []);
  // ...
}
```



Action to take on first render

Action to take when component dismounts

Empty array says: do this on first render only

<https://react.dev/reference/react/useEffect>

An external system means any piece of code that's not inside your React component

- An event in the lifecycle of a component, like `render`.
- A timer managed with `setInterval` and `clearInterval`
- An event subscription like a chat server
- A call to fetch data from an external web site
- An external animation library
- A piece of business logic in an app that is external to your component

A real example: a display that connects to a self-ticking clock

src/app/Components/SimpleClockDisplay.tsx

```
export default function ClockDisplay(props: {  
  name: string, key: number,  
  clock: IClock,  
  handleDelete: () => void,  
  handleAdd: () => void,  
})  
{  
  const [localTime, setLocalTime] = useState(0)  
  const incrementLocalTime = () => setLocalTime(localTime => localTime + 1)  
  const clock = props.clock  
  
  useEffect(() => {  
    const listener1 = () => { incrementLocalTime()  
    clock.addListener(listener1)  
    return () => {  
      clock.removeListener(listener1)  
    }  
  }, [])
```

The parent provides the clock

On first render, add this listener to the clock

On dismount, remove the listener.

Display logic will come later...

Our app will have three displays of the clock

```
import * as React from 'react'; import { useState } from 'react';
import ClockDisplay from '../../Components/ClockDisplay'
import SingletonClock from '../../Classes/SingletonClockFactory'
function doNothing() { }
```

```
export default function App() {
  const [clock, _] = useState(SingletonClock.getInstance(1000));
```

```
  return (
    <VStack>
      <ClockDisplay key={1} name={"Clock A"} clock={clock}
        handleAdd={doNothing} handleDelete={doNothing}
      />
      <ClockDisplay key={2} name={"Clock B"} clock={clock}
        handleAdd={doNothing} handleDelete={doNothing}
      />
      <ClockDisplay key={3} name={"Clock C"} clock={clock}
        handleAdd={doNothing} handleDelete={doNothing}
      />
    </VStack>
  );
}
```

Next, let's look at the clock

```
type Listener = () => void
```

```
class Clock implements IClock{

  private _listeners: Listener[] = []
  private _notifyAll() {this._listeners
    .forEach(eachListener => {eachListener()})}

  public addListener(listener: Listener) {---}
  public removeListener(listener: Listener) {---}

  get nListeners () {return this._listeners.length}

  private _timer : NodeJS.Timeout
  private _interval : number
  public id : string

  public constructor(interval: number) {
    this.id = nanoid(4)
    this._interval = interval;
    this.start()
  }
}
```

```
  public start() {
    console.log(`Clock ${this.id} starting`)
    this._timer = setInterval(() => {
      this._tick();
    }, this._interval);
  }

  private _tick() {
    this._notifyAll();
  }

  public stop() {
    console.log(`Clock ${this.id} stopping`)
    clearInterval(this._timer);
  }
}
```


We'll make the clock a singleton in the usual way

src/Classes/SingletonClockFactory.ts

```
export default class SingletonClockFactory {  
  
    private static theClock: Clock | undefined = undefined  
  
    private constructor () {SingletonClockFactory.theClock = undefined}  
  
    public static instance (interval:number) : Clock {  
        if (SingletonClockFactory.theClock === undefined) {  
            SingletonClockFactory.theClock = new Clock(interval)  
        }  
        return SingletonClockFactory.theClock  
    }  
}
```

Let's look at <ClockDisplay> again

```
export default function ClockDisplay(props: {
  name: string; key: number; clock: IClock;
  handleDelete: () => void; handleAdd: () => void;
}): JSX.Element {
  const [localTime, setLocalTime] = useState(0);
  const incrementLocalTime = () => { setLocalTime((localTime) => localTime + 1); };

  const listener1 = () => { incrementLocalTime(); };
  const clock = props.clock;

  useEffect(() => {
    clock.addListener(listener1);
    console.log(`ClockDisplay ${props.name} is mounting`);
    return () => {
      console.log("ClockDisplay " + props.name + " is unmounting");
      clock.removeListener(listener1);
    };
  }, []);
}
```



business logic

ClockDisplay, part 2: the display logic

```
function handleStop() { clock.stop(); }  
function handleStart() { clock.start(); }
```

```
return (  
  <HStack>  
    <Box>Clock: {props.name}</Box>  
    <Box>Clock ID: {clock.id} </Box>  
    <Box>Time = {localTime}</Box>  
    <Box>nlisteners = {clock.nListeners}</Box>  
    <Button aria-label={"start"} onClick={handleStart}>Start</Button>  
    <Button aria-label={"stop"} onClick={handleStop}>Stop</Button>  
    <IconButton aria-label={"delete"} onClick={props.handleDelete}  
      icon={<AiOutlineDelete />}  
    />  
    <IconButton aria-label={"add"} onClick={props.handleAdd}  
      icon={<AiOutlinePlus />}  
    />  
  </HStack>  
>);
```



display logic

Clock: Clock A Time = 11 nlisteners = 3



Clock: Clock B Time = 11 nlisteners = 3



Clock: Clock C Time = 11 nlisteners = 3



Elements Console Sources >> ⚙️ ⋮ ✕

⏮ ⏭ top ▼ 🔍 Filter All levels ▼ ⚙️

No Issues

ClockDisplay Clock A is mounting [SimpleClockDisplay.tsx:24](#)

ClockDisplay Clock B is mounting [SimpleClockDisplay.tsx:24](#)

ClockDisplay Clock C is mounting [SimpleClockDisplay.tsx:24](#)



useEffect's Dependencies Control Its Execution

- `useEffect` takes an optional array of dependencies
- The effect is only executed if one or more of the values in the dependency change (e.g. by a setter)
- Special Cases:
 - `[]` means run only on first render
 - No argument means run on every render

Example (Part 1)

```
export default function App() {  
  const [n, setN] = useState(0)  
  const [m, setM] = useState(0)  
  
  // runs only on first render.  
  useEffect(() => {  
    console.log('useEffect #1 is run only on first render')}, [])  
  
  useEffect(() => {  
    console.log('useEffect #2N is run only when n changes')}, [n])  
  
  useEffect(() => {  
    console.log('useEffect #2M is run when m changes')}, [m])  
  
  useEffect(() => {  
    console.log('useEffect #2MN is run when m or n changes')  
  }, [m,n])  
  
  // runs on every render  
  useEffect(() => {  
    console.log('useEffect #3 is called on every render')})  
  
  // observe that effects run in order of definition
```

Example (part 2)

```
function onClickN() {
  console.log('Clicked n!');
  setN(n => n + 1);
}

function onClickM() {
  console.log('Clicked m!');
  setM(m => m + 1);
}

return (
  <VStack>
    <Heading>useEffect demo #1</Heading>
    <Text> n is {n} </Text>
    <Button onClick={onClickN}>Increment n</Button>
    <Text> m is {m} </Text>
    <Button onClick={onClickM}>Increment m</Button>
  </VStack>
)
```

Demo

useEffect demo #1

n is 1

Increment n

m is 0

Increment m

Elements Console Sources Network >>

top Filter All levels No Issues

useEffect #1 is run only on first render	useEffect-demo.tsx:18
useEffect #2N is run only when n changes	useEffect-demo.tsx:27
useEffect #2M is run when m changes	useEffect-demo.tsx:31
useEffect #3A is called on every render	useEffect-demo.tsx:36
useEffect #3B is called on every render	useEffect-demo.tsx:41
useEffect #3C is called on every render	useEffect-demo.tsx:46
Clicked n!	useEffect-demo.tsx:52
useEffect #2N is run only when n changes	useEffect-demo.tsx:27
useEffect #3A is called on every render	useEffect-demo.tsx:36
useEffect #3B is called on every render	useEffect-demo.tsx:41
useEffect #3C is called on every render	useEffect-demo.tsx:46

>

When is the cleanup function executed?

- In general, the cleanup function is executed sometime before the next time the hook is run.
- For the first-time-only case, this means when the component is dismantled.
- Let's look at useEffect demo again, this time with noisy cleanups.

```
function cleanup(message: string) {return () => {console.log('cleanup: ' + message)}}}
```

```
export default function App() {  
  const [n, setN] = useState(0)  
  const [m, setM] = useState(0)  
  
  useEffect(() => {  
    console.log('useEffect #1 is run only on first render')  
    return cleanup('useEffect #1')  
  }, [])  
  
  useEffect(() => {  
    console.log('useEffect #2N is run only when n changes')  
    return cleanup('useEffect #2N')  
  }, [n])  
  
  ... // other effects
```

useEffect demo with CleanUps

n is 1

Increment n

m is 0

Increment m

Elements Console Sources Network >> Filter All levels No Issues

useEffect #1 is run only on first render [useEffect-demoWithCleanUps.tsx:20](#)

useEffect #2N is run only when n changes [useEffect-demoWithCleanUps.tsx:25](#)

useEffect #2M is run when m changes [useEffect-demoWithCleanUps.tsx:32](#)

useEffect #3A is called on every render [useEffect-demoWithCleanUps.tsx:38](#)

useEffect #3B is called on every render [useEffect-demoWithCleanUps.tsx:44](#)

Clicked n! [useEffect-demoWithCleanUps.tsx:56](#)

cleanup: useEffect #2N [useEffect-demoWithCleanUps.tsx:10](#)

cleanup: useEffect #3A [useEffect-demoWithCleanUps.tsx:10](#)

cleanup: useEffect #3B [useEffect-demoWithCleanUps.tsx:10](#)

useEffect #2N is run only when n changes [useEffect-demoWithCleanUps.tsx:25](#)

useEffect #3A is called on every render [useEffect-demoWithCleanUps.tsx:38](#)

useEffect #3B is called on every render [useEffect-demoWithCleanUps.tsx:44](#)

>

Lesson 9.2 Custom Hooks

Custom Hooks

- REACT lets us combine `useState` and `useEffect` to build custom hooks.
- Custom Hooks let us separate business logic from display logic

Example: useClock

```
export function useClock (listener1: () => void) : IClock {  
  const clock = SingletonClockFactory.getInstance(1000)  
  useEffect(() => {  
    clock.addListener(listener1)  
    return () => {  
      clock.removeListener(listener1)  
    }  
  }, []);  
  return clock  
}
```

Using useClock

```
import { useClock } from '../Hooks/useClock';

export function ClockDisplay(props: {
  name: string, key: number,
  handleDelete: () => void, handleAdd: () => void,
  noisyDelete?: boolean
}) {
  const [localTime, setLocalTime] = useState(0)
  const incrementLocalTime = () => setLocalTime(localTime => localTime + 1)
  const clock:IClock = useClock(incrementLocalTime)

  return (
    <HStack>
      <Box>Clock: {props.name}</Box>
      <Box>Time = {localTime}</Box>
      <Box>nlisteners = {clock.nListeners}</Box>
      <IconButton aria-label={'delete'} onClick={props.handleDelete} icon={<AiOutlineDelete />} />
      <IconButton aria-label={'add'} onClick={props.handleAdd} icon={<AiOutlinePlus />} />
    </HStack>
  )
}
```

A somewhat larger example: ToDoList

```
export default function ToDoApp () {  
  const [todoList, setTodolist] = useState<ToDoItem[]>([])  
  const [itemKey, setItemKey] = useState<number>(0) // first unused key  
  
  function handleAdd (title:string, priority:string) {  
    if (title === '') {return} // ignore blank button presses  
    setTodolist(todoList.concat({title: title, priority: priority, key: itemKey}))  
    setItemKey(itemKey + 1)  
  }  
  
  function handleDelete(targetKey:number) {  
    const newList = todoList.filter(item => item.key !== targetKey)  
    setTodolist(newList)  
  }  
  
  return (  
    <VStack>  
      <Heading>TODO List</Heading>  
      <ToDoItemEntryForm onAdd={handleAdd}/>  
      <ToDoListDisplay items={todoList} onDelete={handleDelete}/>  
    </VStack>  
  )  
}
```



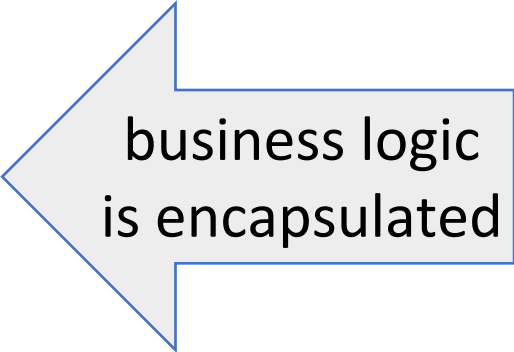
business logic



display logic

Refactoring ToDoList

```
export default function ToDoApp () {  
  
  const {todoList, handleAdd, handleDelete} = useToDoItemList()  
  
  return (  
    <VStack>  
      <Heading>TODO List</Heading>  
      <ToDoItemEntryForm onAdd={handleAdd}/>  
      <ToDoListDisplay items={todoList} onDelete={handleDelete}/>  
    </VStack>  
  )  
}
```



business logic
is encapsulated

The hook encapsulates the business logic

```
export default function useToDoItemList () {  
  const [todoList,setTodolist] = useState<ToDoItem[]>([])  
  const [itemKey,setItemKey] = useState<number>(0)    // first unused key  
  
  function handleAdd (title:string, priority:string) {  
    if (title === '') {return}    // ignore blank button presses  
    setTodolist(todoList.concat({title: title, priority: priority, key: itemKey}))  
    setItemKey(itemKey + 1)  
  }  
  
  function handleDelete(targetKey:number) {  
    const newList = todoList.filter(item => item.key !== targetKey)  
    setTodolist(newList)  
  }  
  
  return {todoList: todoList, handleAdd: handleAdd, handleDelete: handleDelete}  
}
```

The hook is like a class managing a piece of state

```
export default function useToDoItemList () {  
  const [todoList, setTodolist] = useState<ToDoItem[]>([])  
  const [itemKey, setItemKey] = useState<number>(0) // first unused key  
  
  function handleAdd (title:string, priority:string) {  
    if (title === '') {return} // ignore blank button presses  
    setTodolist(todoList.concat({title: title, priority: priority, key: itemKey}))  
    setItemKey(itemKey + 1)  
  }  
  
  function handleDelete(targetKey:number) {  
    const newList = todoList.filter(item => item.key !== targetKey)  
    setTodolist(newList)  
  }  
  
  return {todoList: todoList, handleAdd: handleAdd, handleDelete: handleDelete}  
}
```

handleAdd and handleDelete
are the only methods for
manipulating the state

The hook's state becomes part of its user's state.

```
export default function useToDoItemList () {  
  const [todoList, setTodolist] = useState<ToDoItem[]>([])  
  const [itemKey, setItemKey] = useState<number>(0) // first unused key  
  
  function handleAdd (title:string, priority:string) {  
    if (title === '') {return} // ignore blank button presses  
    setTodolist(todoList.concat({title: title, priority: priority, key: itemKey}))  
    setItemKey(itemKey + 1)  
  }  
  
  function handleDelete(targetKey:number) {  
    const newList = todoList.filter(item => item.key !== targetKey)  
    setTodolist(newList)  
  }  
  
  return {todoList: todoList, handleAdd: handleAdd, handleDelete: handleDelete}  
}
```

calling these setters redisplay
the whole component

The Rules of Hooks

1. Only call hooks at the top level

- Not within loops, inside conditions, or nested functions
- Rationale: The order of hooks called must always be the same each time a component renders

2. Only call hooks from React Components or Custom Hooks

- Not from any other helper methods or classes
- Rationale: React must know the component that the call to the hook is associated with

```
export function LikeButton() {  
  const [isLiked, setIsLiked] = useState(false);  
  const [count, setCount] = useState(0);  
  ...  
}
```

React knows which `useState` is which by tracking calls to them from components in the render tree

We Use Two ESLint Rules for React Hooks

- You should not violate the rules of hooks. These linter plugins help detect violations
- React-hooks/rules-of-hooks
 - Enforces that hooks are only called from React functional components or custom hooks
- React-hooks/exhaustive-deps
 - Enforces that all variables used in useEffects are included as dependencies

Lesson 9.3 Testing your REACT components

Testing React components

- The AAA pattern ("Assemble/Act/Assess") still applies
- Need a test double for the React system
 - render components into a "virtual dom" or into a captive web browser
- The FakeStackOverflow codebase uses Cypress, a popular tool for end-to-end testing.

"Testing Library" <https://testing-library.com> is another test system for React. It is compatible with many UI libraries and many testing frameworks

<https://docs.cypress.io/guides/end-to-end-testing/writing-your-first-end-to-end-test>

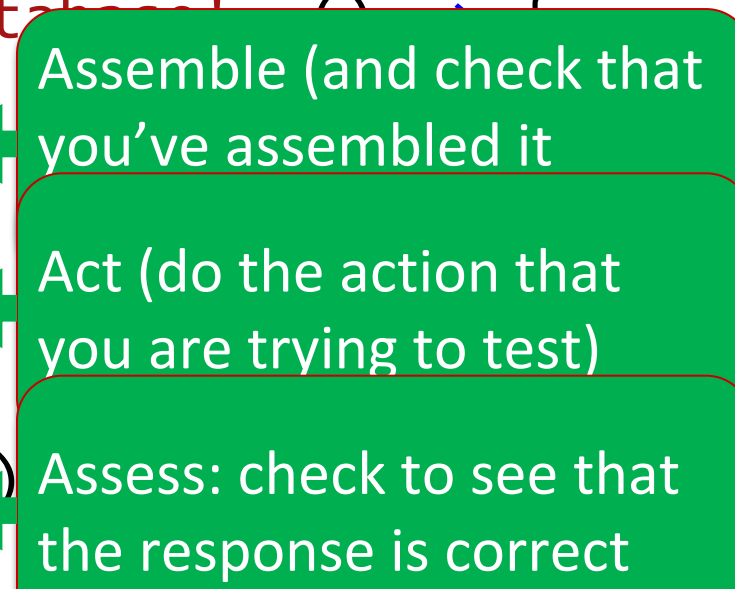
Cypress commands work on a "virtual DOM"

<code>.visit()</code>	Visit a remote URL. Many tests begin with this command.
<code>.contains()</code>	Select a DOM element by text content.
<code>.get()</code>	Find DOM elements by selector
<code>.click()</code>	Click a DOM element.
<code>.type()</code>	Type into a DOM element.

These will fail if the specified element does not exist

Recall: Most tests are in AAA form: Assemble/Act/Assess

```
test('addStudent should add a student to the database', () => {  
  // const db = new DataBase ()  
  expect(db.nameToIDs('blair')).toEqual([])  
  
  const id1 = db.addStudent('blair');  
  
  expect(db.nameToIDs('blair')).toEqual([id1])  
});
```



The diagram illustrates the AAA (Assemble/Act/Assess) test pattern using three green callout boxes with arrows pointing to specific lines of code in the test function:

- Assemble (and check that you've assembled it)**: Points to the first expectation, `expect(db.nameToIDs('blair')).toEqual([])`, which verifies the initial state of the database.
- Act (do the action that you are trying to test)**: Points to the action line, `const id1 = db.addStudent('blair');`, which performs the operation being tested.
- Assess: check to see that the response is correct**: Points to the second expectation, `expect(db.nameToIDs('blair')).toEqual([id1])`, which verifies the result of the action.

A typical cypress test

```
it("5.1 | Created new answer should be displayed at the top of the answers page",  
  () => {  
    const answers = [  
      "Test Answer 1",  
      A1_TXT,  
      A2_TXT,  
    ];  
    cy.visit("http://localhost:3000");  
    cy.contains(Q1_DESC).click();  
    cy.contains("Answer Question").click();  
    cy.get("#answerUsernameInput").type("joym");  
    cy.get("#answerTextInput").type(answers[0]);  
    cy.contains("Post Answer").click();  
    cy.get(".answerText").each(($el, index) => {  
      cy.contains(answers[index]);  
    });  
    cy.contains("joym");  
    cy.contains("0 seconds ago");  
  });
```

Assemble (and check that
you've assembled it
correctly)

Act (do the action that
you are trying to test)

Assess: check to see that
the response is correct

run with: npx cypress run

Learning Objectives for this Lesson

- By the end of this lesson, you should be able to:
 - Explain the basic use cases for `useEffect`
 - Explain when a `useEffect` is executed, and when its return value is executed
 - Construct simple custom hooks and explain why they are useful.
 - Be able to explain the three core steps of a test (assemble, act, assess) can map to UI component testing