Async Computation

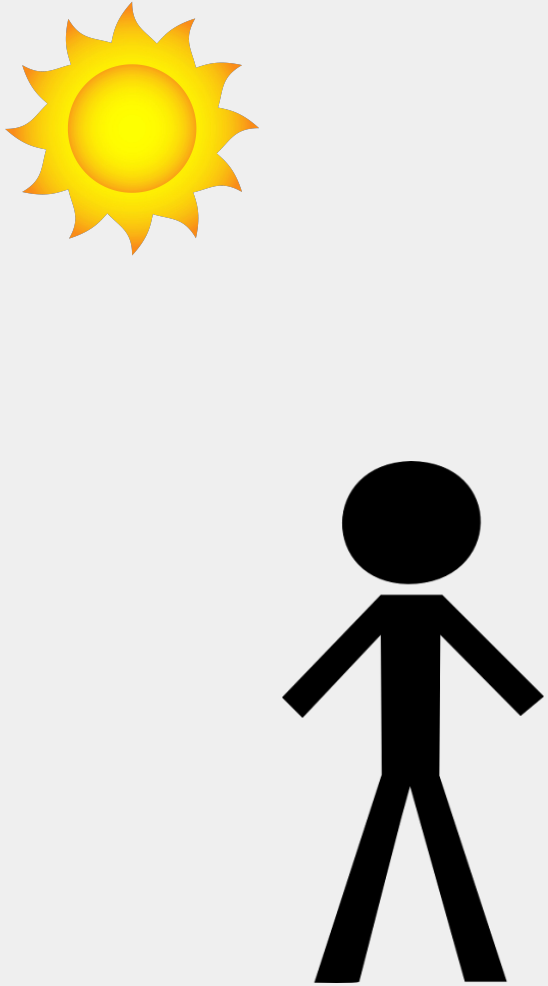
Nicholas Tsao

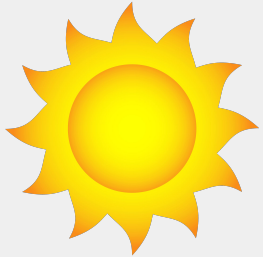
Synchronous

Happens consecutively, one after another

Asynchronous

Happens later at some point in time



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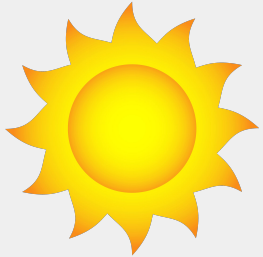
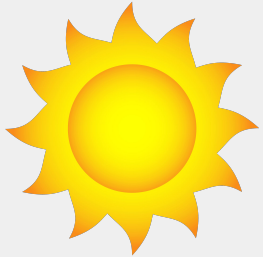



I want 5 snow cones


ICE CREAM
FRESHLY MADE




Can I have 5 snow cones?


ICE CREAM
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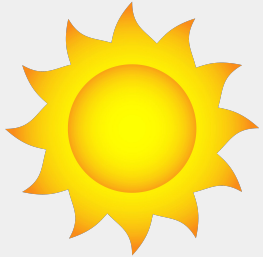
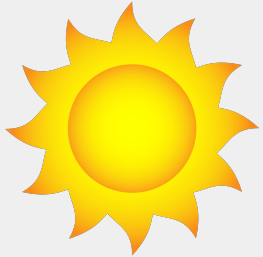


Ok.

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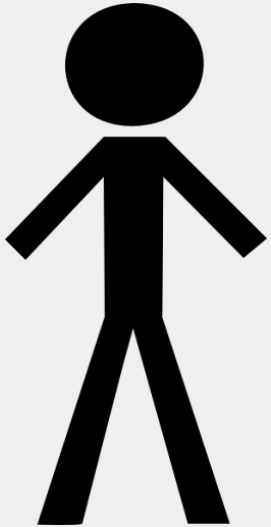

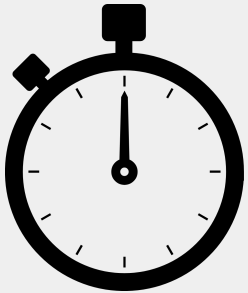

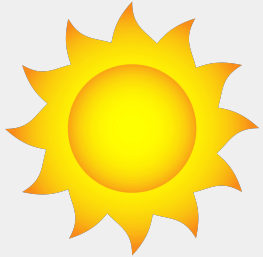


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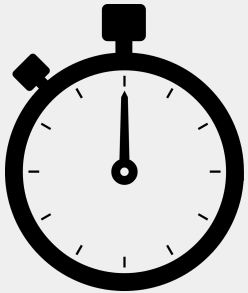

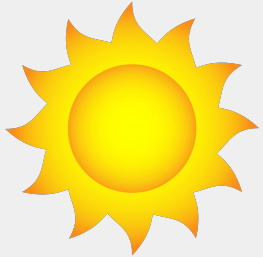


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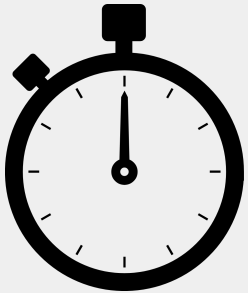

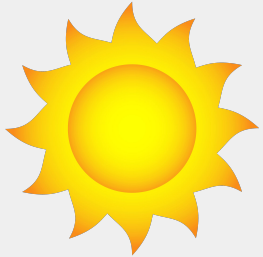


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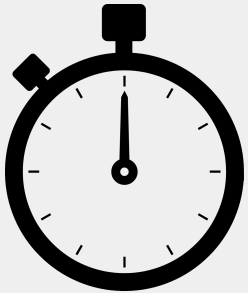

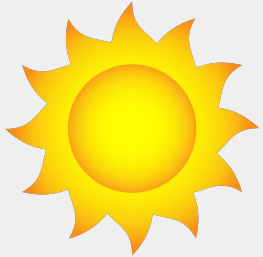


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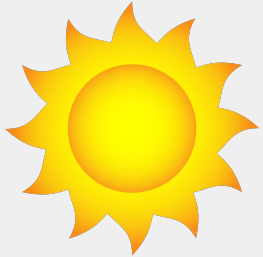


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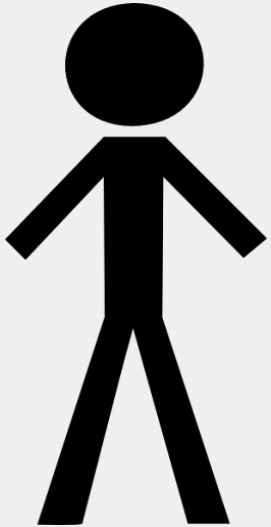
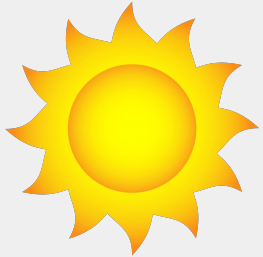
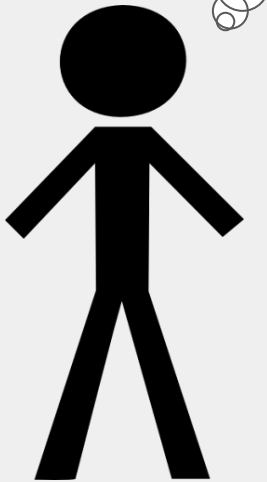
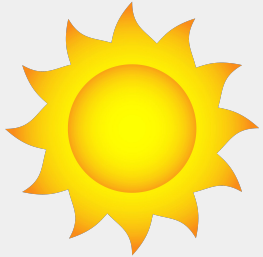


What if there is more than one truck?

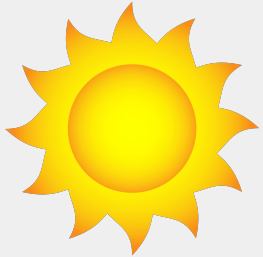


I want 5 snow cones





Can I have 5 snow cones?




Can I have 5 snow cones?


ICE CREAM
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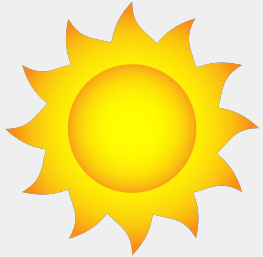
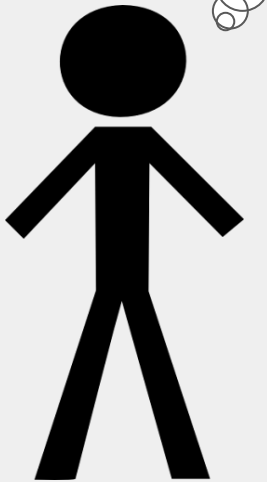
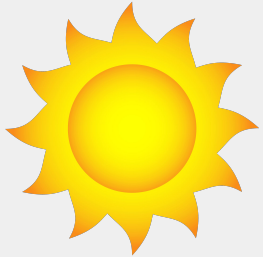
Can we do better?



I want 5 snow cones






Can I have 2 snow cones?


ICE CREAM
FRESHLY MADE


ICE CREAM
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ICE CREAM
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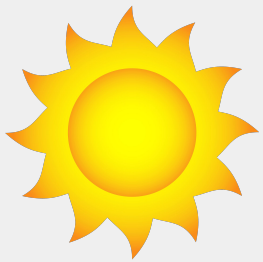

Ok.


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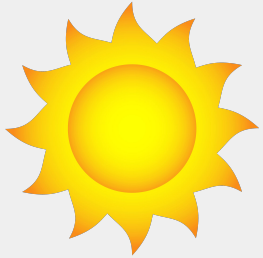


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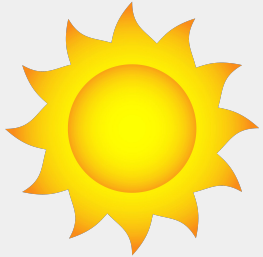
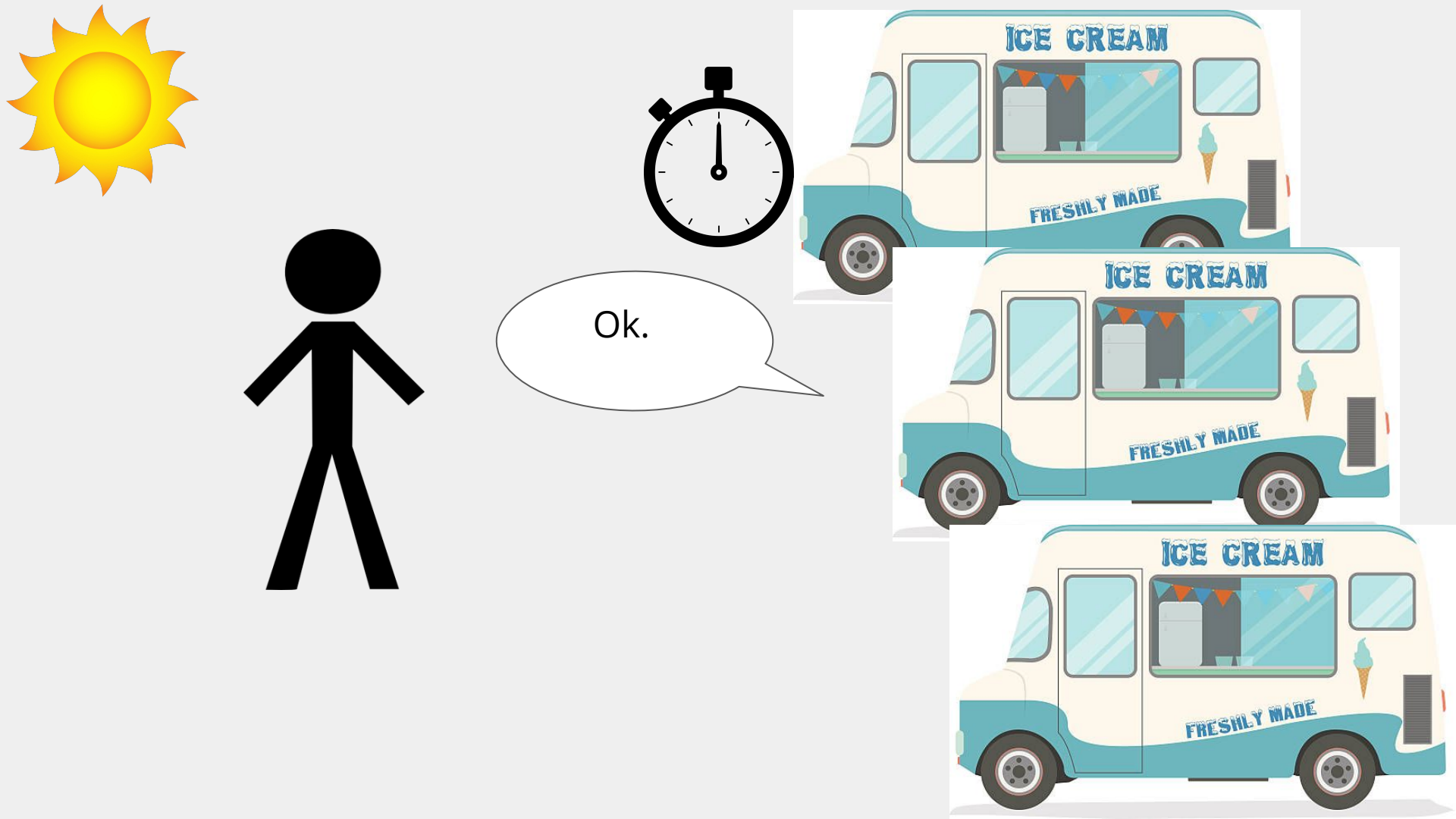


Can I have 2 snow cones?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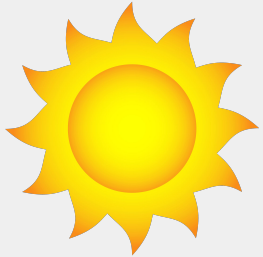


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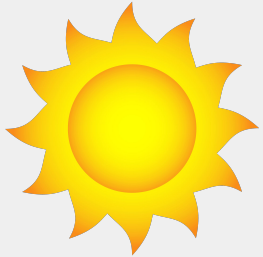


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Can I have 1 snow cone?


ICE CREAM
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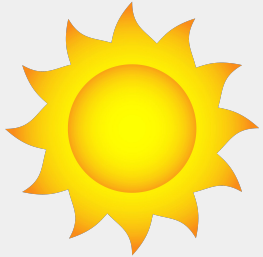


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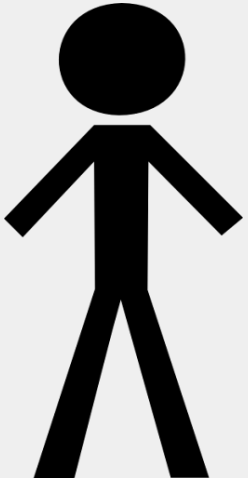

Ok.


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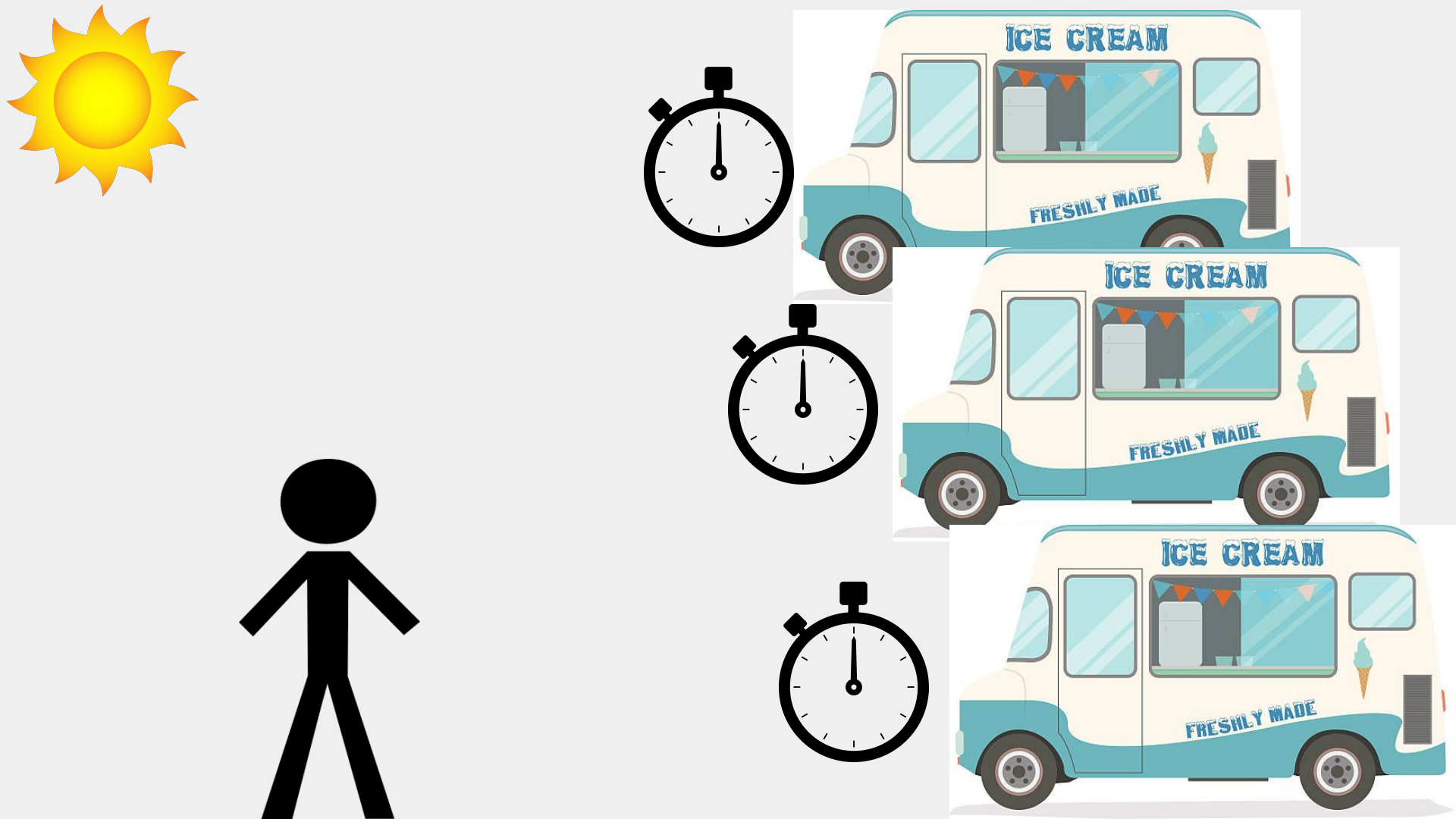
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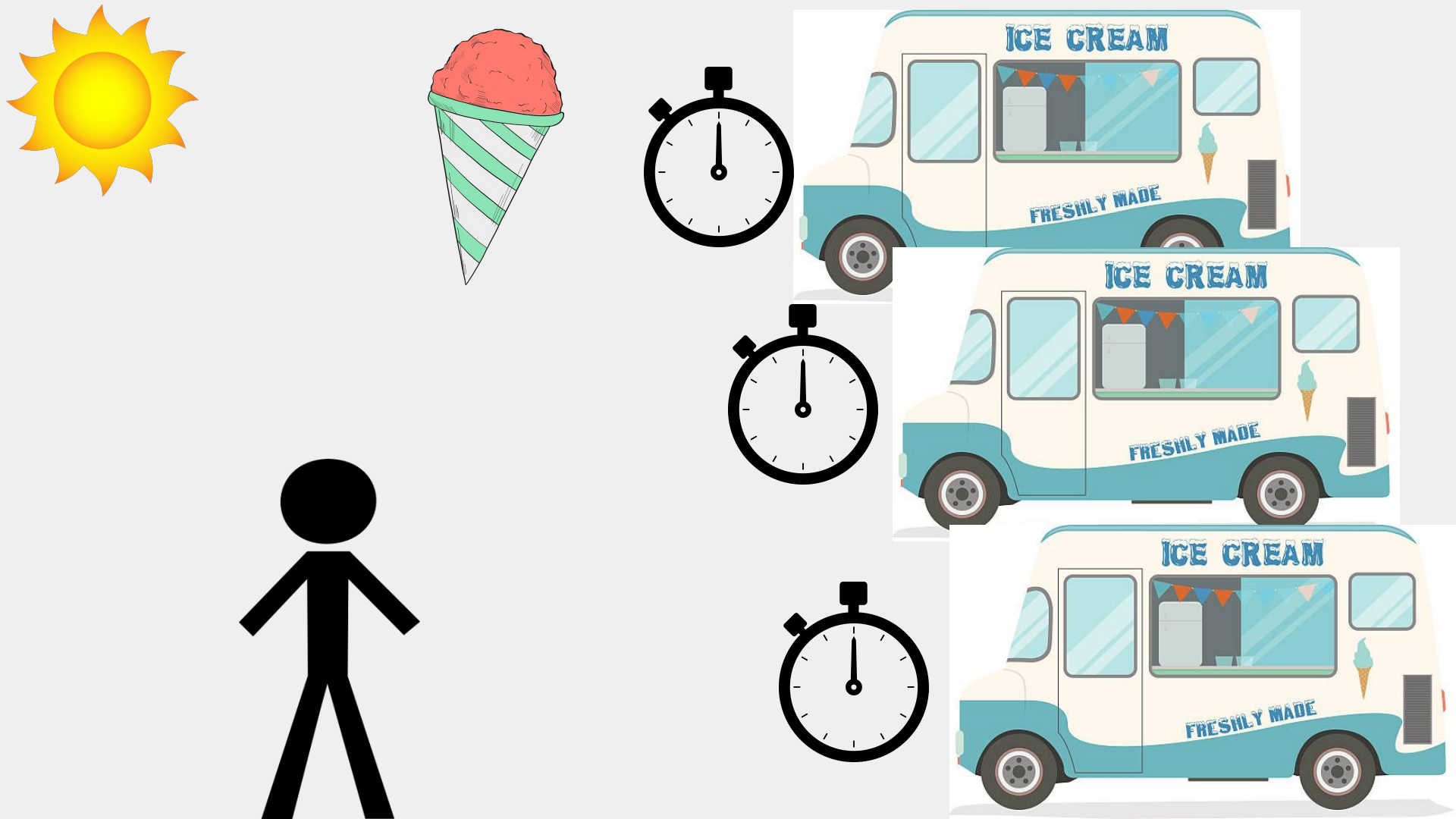
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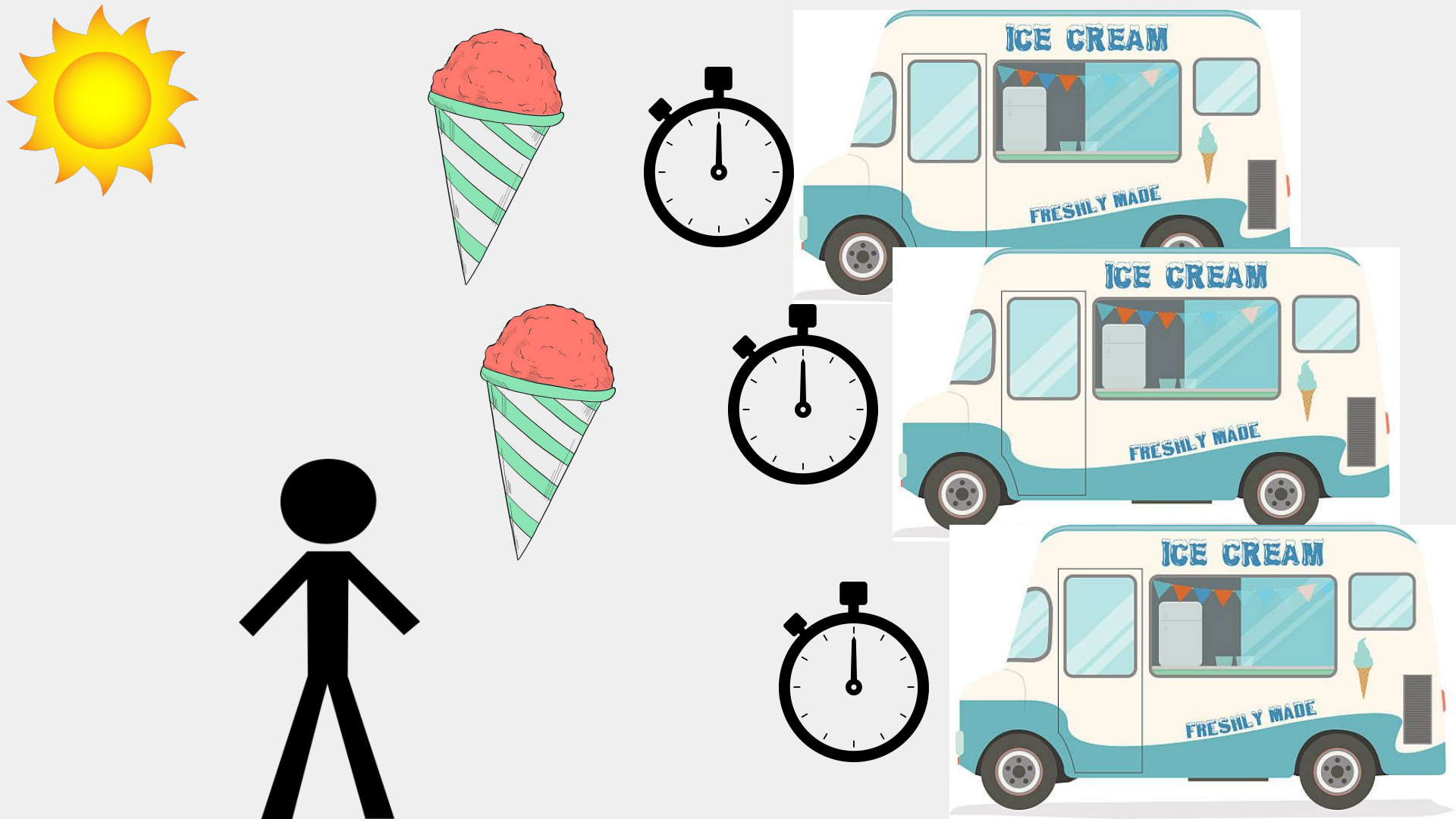
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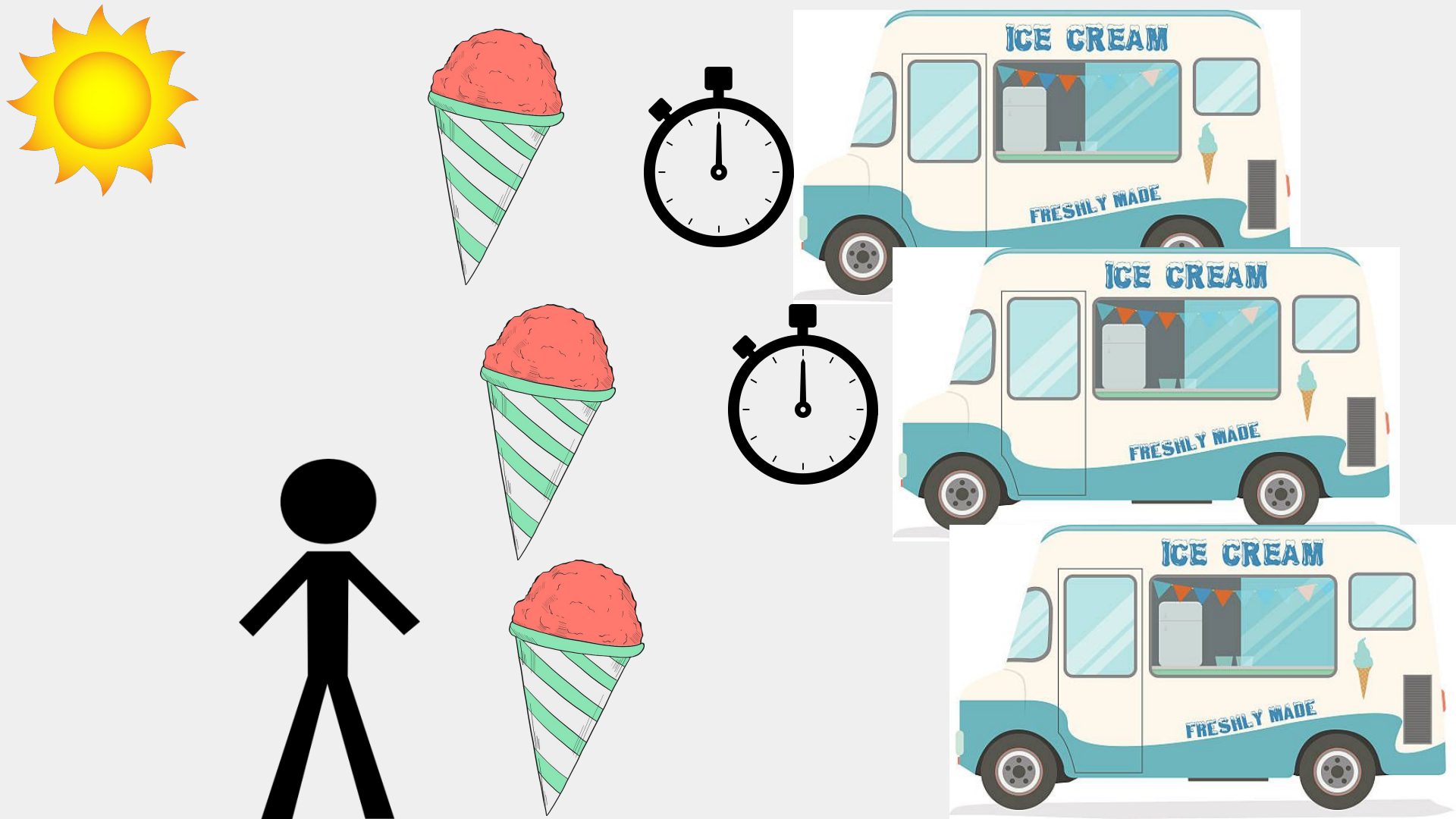
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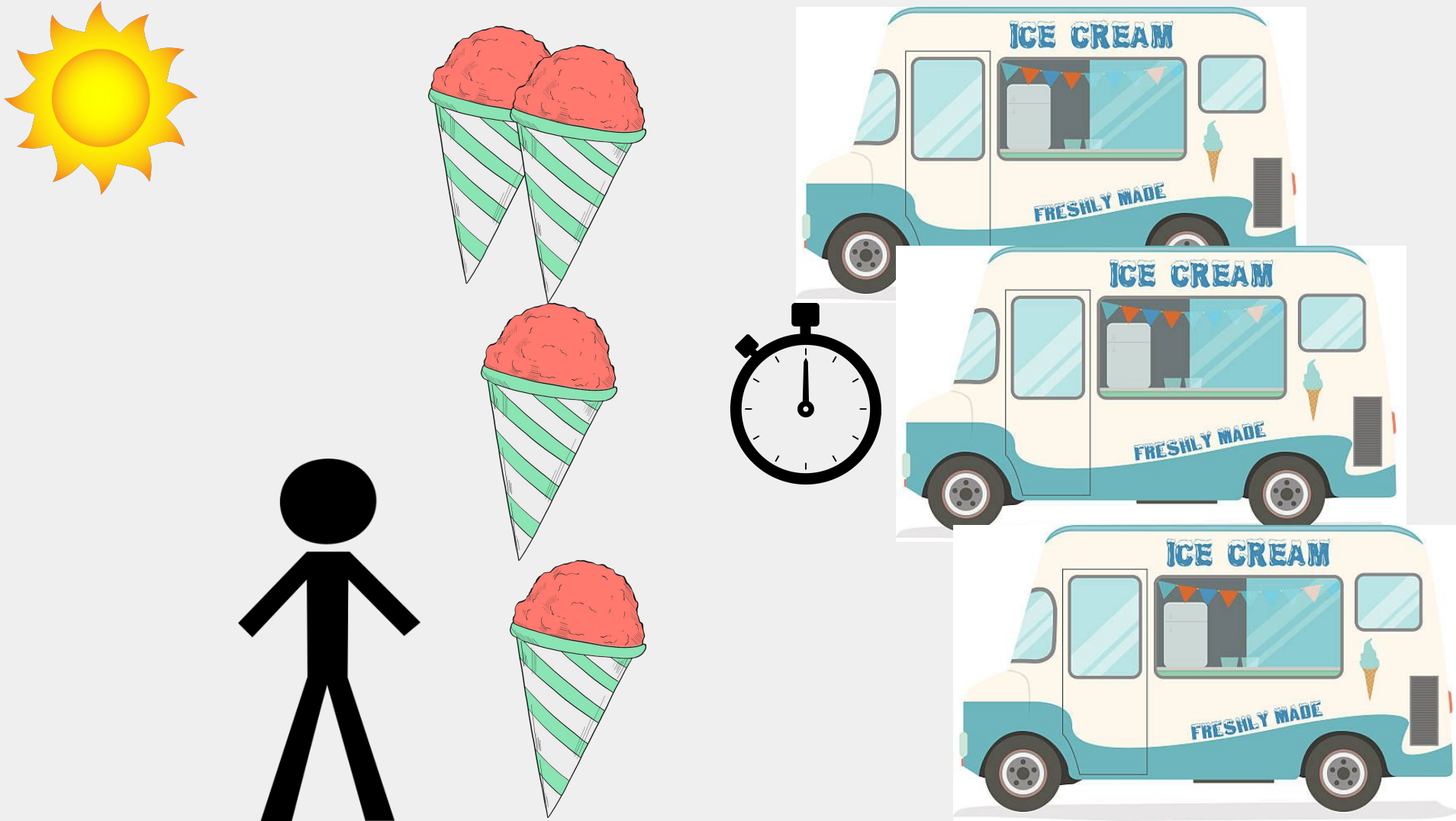
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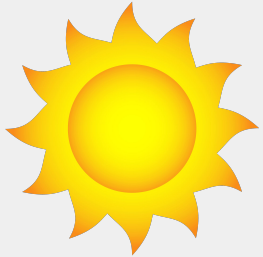

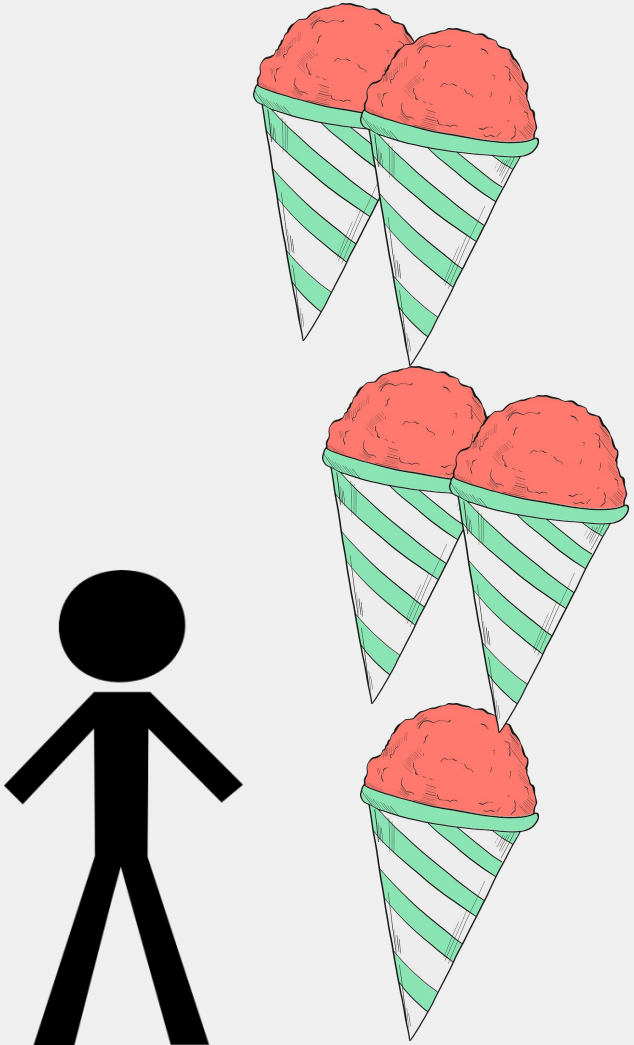


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Promises

Promises

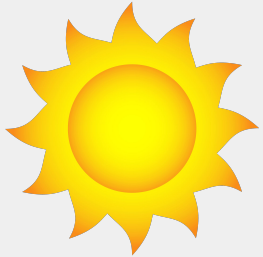
- A promise is an object in JavaScript
- Represents some asynchronous task

Promises exist in three states

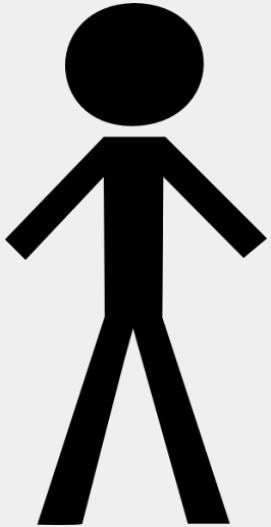
- **Pending** - initial state (neither fulfilled nor rejected)
- **Fulfilled** - the operation completed successfully
- **Rejected** - the operation failed

(Asynchronous function: Make snow cone)

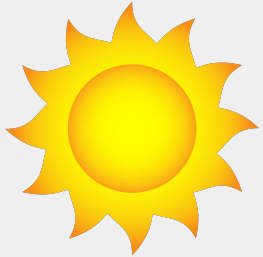
You call an asynchronous function to do some asynchronous task.

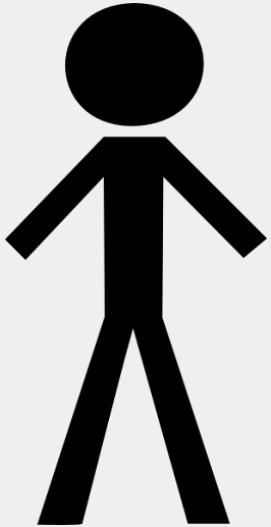


Ok. (I'm working on it.)

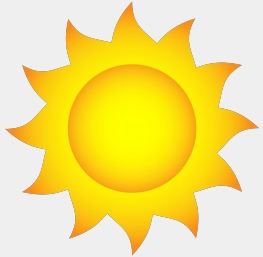


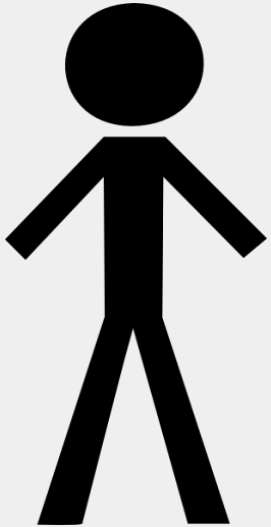
The asynchronous function immediately returns a promise. It "promises" to give you a snow cone later.



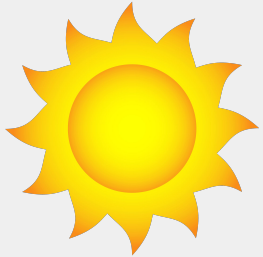


The promise is **pending** (the task is not done yet).



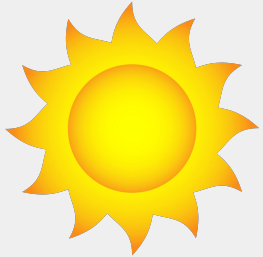


The asynchronous task has finished. The promise has resolved into an actual value (the snow cone). The promise is now **fulfilled**.

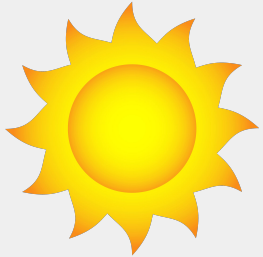


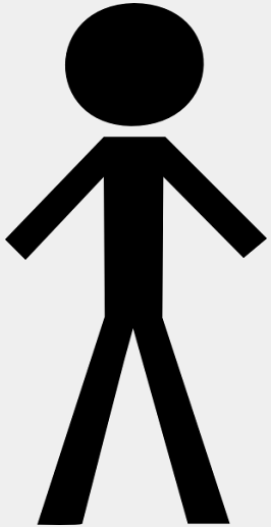

Can I have a snow cone?


ICE CREAM
FRESHLY MADE

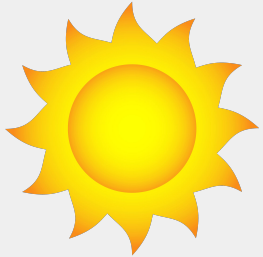


Ok.



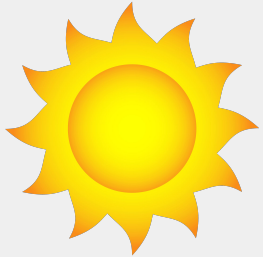


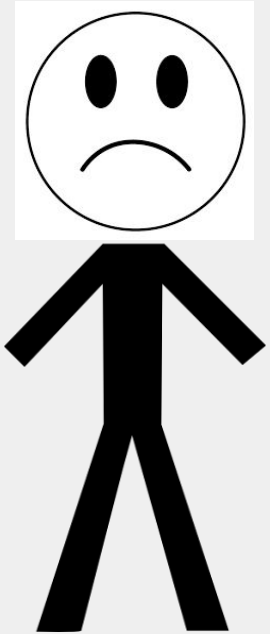
(Promise **pending**)



Sorry, we have no more ice.

The asynchronous function ran into some error. It cannot fulfill the promise. Promise **rejected**.






ICE CREAM
FRESHLY MADE

Promises in JavaScript

What do promises look like?

```
useEffect(() => {
  get("/api/stories").then((storyObjs) => {
    setStories(storyObjs);
  });
}, []);
```

What do promises look like?

```
useEffect(() => {
  const stories = get("/api/stories");
  console.log(stories);
}, []);
```

```
useEffec  const stories: Promise<any>
  const stories = get("/api/stories");
  console.log(stories);
```

```
▶ Promise {<pending>}
```

Handle promises with .then() and .catch()

.then()

```
useEffect(() => {
  get("/api/stories").then((storyObjs) => {
    setStories(storyObjs);
  });
}, []);
```

Once the promise is **fulfilled**, do stuff (call a callback function).
Returns a promise.

.catch()

```
useEffect(() => {
  get("/api/stories").then((storyObjs) => {
    setStories(storyObjs);
  }).catch((err) => {
    console.log("this is so sad: ", err.message);
  });
}, []);
```

Once the promise is **rejected**, do stuff (call a callback function). Returns a promise.

Chaining promises

.then() returns a promise, so we can do .then() again, and again, and again... (same goes for .catch())

```
getPromise().then((value) => {
    console.log("first promise resolved, let's do some stuff");
}).then((value) => {
    console.log("second promise resolved, let's do more stuff");
}).then((value) => {
    console.log("third promise resolved, :)");
}).catch((err) => {
    console.log("oops i am sad now :(")
});
```

Async / Await

Doing stuff with promises

You can’t compute with pending promises

```
const a = slowNumber(9);
const b = slowNumber(10);

console.log(a + b);
```

(slowNumber(x) returns the number x after 1 second)

JS doesn’t wait for the promises to resolve before continuing.

```
[object Promise][object Promise]
```

JS doesn’t know what a and b are when it does this addition. It just sees 2 pending promises.

Await

- You can’t do computation with pending promises
- Wait for the promise to resolve
- Get the value that it resolves to

Using await

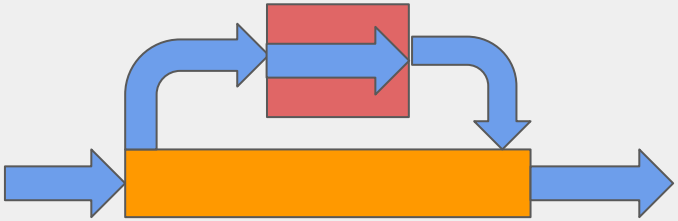
```
const a = slowNumber(9);
const b = slowNumber(10);

console.log(await a + await b);
```

await waits for the promise to **resolve** and uses that value

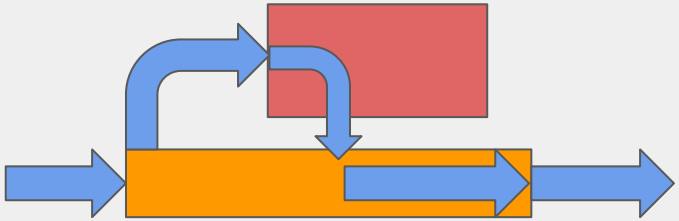
However, if you type this directly into VSCode, it will **NOT** work. It just gives an error when you try to run.

Asynchronous functions

- Functions that return control back to the caller before computation is done



synchronous



asynchronous

Asynchronous functions

- Functions that return control back to the caller before computation is done
- Can be made as a callback function () => {}

```
useEffect(() => {
  get("/api/stories").then((storyObjs) => {
    setStories(storyObjs);
  });
}, []);
```

Asynchronous functions

- Functions that return control back to the caller before computation is done
- Can be made as a callback function () => {}
- **OR** with the **async** keyword
  - Works with function, arrow functions, class methods, etc.

```
async function slowNumber(x) {
    sleep(1000);
    return x;
}
```

Only asynchronous functions can use await

Await returns control back to the caller

Await is like a temporary return that reactivates once the promise it is waiting for has resolved (then it takes control back).

Using await

Notably, the outermost level of our program is **NOT** an async function, so it **CANNOT** use await. However, it will wait to resolve any promises at the end of the program before exiting.

```
async function main() {
    const a = slowNumber(9);
    const b = slowNumber(10);

    console.log(await a + await b);
}
main();
```

This prints 19 (as expected).

Using multiple promises

Many promises

```
1   const promise1 = get('/api/comments', { parent: parentId1 });
2   const promise2 = get('/api/comments', { parent: parentId2 });
3   const promise3 = get('/api/comments', { parent: parentId3 });
4   const promise4 = get('/api/comments', { parent: parentId4 });
5   const promise5 = get('/api/comments', { parent: parentId5 });
6
7   const promises = [promise1, promise2, promise3, promise4, promise5];
```

Promise.all()

```
1   const promise1 = get('/api/comments', { parent: parentId1 });
2   const promise2 = get('/api/comments', { parent: parentId2 });
3   const promise3 = get('/api/comments', { parent: parentId3 });
4   const promise4 = get('/api/comments', { parent: parentId4 });
5   const promise5 = get('/api/comments', { parent: parentId5 });
6
7   const promises = [promise1, promise2, promise3, promise4, promise5];
8
9   Promise.all(promises).then((allResults) => {
10    // All results represents a list with the result of each promise
11  }).catch((err) => {
12    // Catch and report any error
13  });
```

Returns a promise that resolves to array of results of input promises

Promise.race()

```
1   const promise1 = get('/api/comments', { parent: parentId1 });
2   const promise2 = get('/api/comments', { parent: parentId2 });
3   const promise3 = get('/api/comments', { parent: parentId3 });
4   const promise4 = get('/api/comments', { parent: parentId4 });
5   const promise5 = get('/api/comments', { parent: parentId5 });
6
7   const promises = [promise1, promise2, promise3, promise4, promise5];
8
9   Promise.race(promises).then((firstResult) => {
10    // Do something with the first result
11  }).catch((err) => {
12    // Catch and report any error
13  });
```

Returns a promise that fulfills or rejects with the first promise that fulfils or rejects

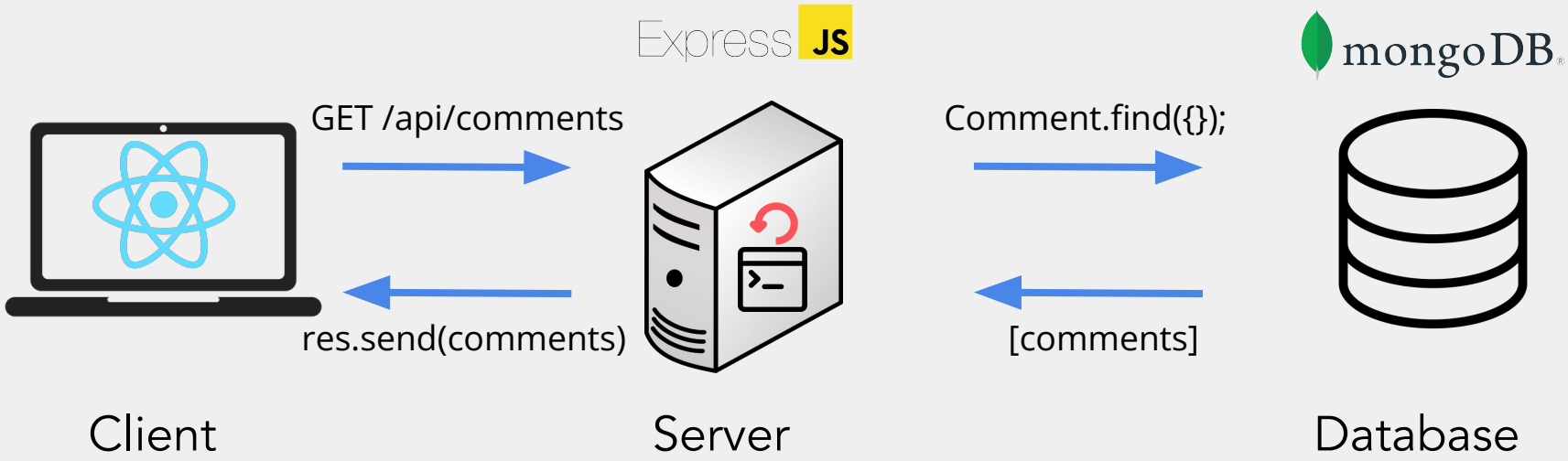
Promise.any()

```
1   const promise1 = get('/api/comments', { parent: parentId1 });
2   const promise2 = get('/api/comments', { parent: parentId2 });
3   const promise3 = get('/api/comments', { parent: parentId3 });
4   const promise4 = get('/api/comments', { parent: parentId4 });
5   const promise5 = get('/api/comments', { parent: parentId5 });
6
7   const promises = [promise1, promise2, promise3, promise4, promise5];
8
9   Promise.any(promises).then((anyResult) => {
10    // Do something with the any result regardless if all others fail
11  }).catch((err) => {
12    // Catch and report any error
13  });
```

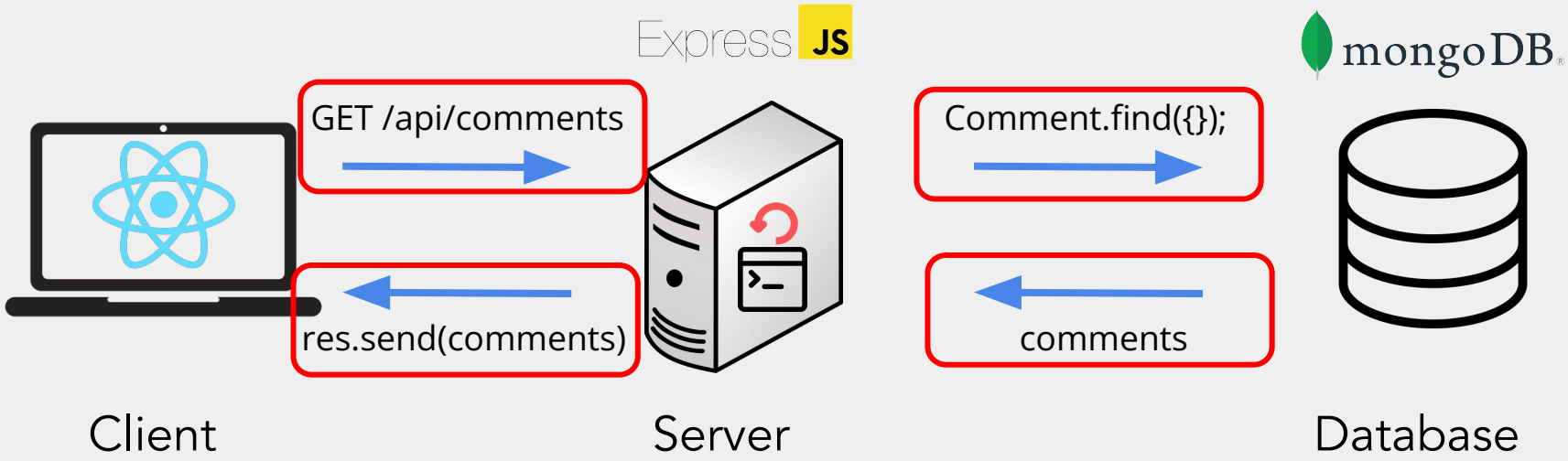
Returns a promise that resolves when any of the input promises fulfills

Why Async?

Communicating between different devices



Unable to guarantee how long it will take to communicate between multiple machines



Client - Server Communication

```
useEffect(() => {
  get("/api/stories").then((storyObjs) => {
    setStories(storyObjs);
  });
}, []);
```

```
router.get("/stories", (req, res) => {
  // empty selector means get all documents
  Story.find({}).then((stories) => res.send(stories));
});
```

Client - Server Communication

(in utilities.js in catbook)

```
export function get(endpoint, params = {}) {
  const fullPath = endpoint + "?" + formatParams(params);
  return fetch(BASE_URL + fullPath)
    .then(convertToJSON)
    .catch((error) => {
      // give a useful error message
      throw `GET request to ${fullPath} failed with error:\n${error}`;
    });
}
```

Client - Server Communication

```
export function post(endpoint, params = {}) {
  return fetch(BASE_URL + endpoint, {
    method: "POST",
    headers: { "Content-type": "application/json" },
    body: JSON.stringify(params),
  })
    .then(convertToJSON) // convert result to JSON object
    .catch((error) => {
      // give a useful error message
      throw `POST request to ${endpoint} failed with error:\n${error}`;
    });
}
```

Client - Server Communication

(in Feed.js)

```
useEffect(() => {
  document.title = "News Feed";
  get("/api/stories").then((storyObjs) => {
    let reversedStoryObjs = storyObjs.reverse();
    setStories(reversedStoryObjs);
  });
}, []);
```

Server - Database Communication

In server.js (in catbook)

```
// connect to mongodb
mongoose
  .connect(mongoConnectionURL, {
    useNewUrlParser: true,
    useUnifiedTopology: true,
    dbName: databaseName,
  })
  .then(() => console.log("Connected to MongoDB"))
  .catch((err) => console.log(`Error connecting to MongoDB: ${err}`));
```

Rendering the Front End (React)

Things like setState()

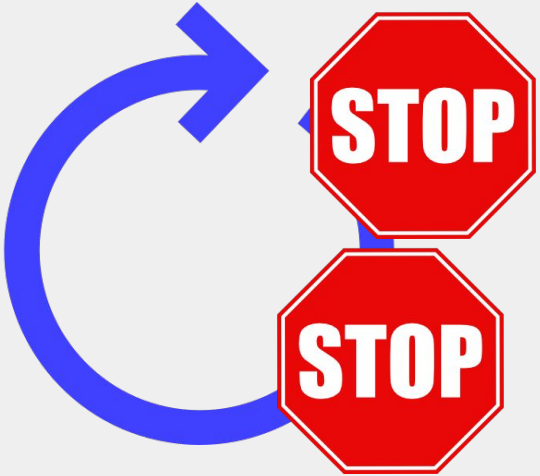
```
const addNewStory = (storyObj) => {
  setStories([storyObj].concat(stories));
};
```

JavaScript Event Loop

Handles everything including things like button presses, inputs, etc.

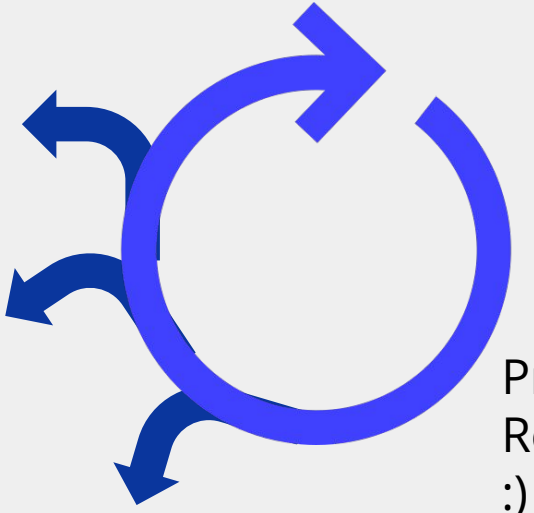
JavaScript Event Loop

Handles everything including things like button presses, inputs, etc.



Synchronous functions

Unresponsive :(



Preserves Responsiveness :)

Asynchronous functions

Background Tasks

You can run background tasks without stopping the user from interacting with the front end.

- Fetching data (e.g. loading new posts on facebook)
- Downloads / uploads
- Run some big computation
- Play music or video (playing music or video on youtube / spotify still lets you click around on other stuff)
- And many more!

Making your own promises

```
import Q from 'q';

async function timeout(milliseconds) {
    const deferred = Q.defer();
    setTimeout(function () {
        deferred.resolve();
        // or we could call deferred.reject(new Error(...)) to reject the promise instead
    }, milliseconds);
    return deferred.promise; // this is the promise that we make
}

timeout(10);
```

Recap

Recap

- Promises have 3 states:
  - **Pending** - initial state (neither fulfilled nor rejected)
  - **Fulfilled** - the operation completed successfully
  - **Rejected** - the operation failed

Recap

Handle promises using .then() and .catch()

- Return promises and can be chained together

```
useEffect(() => {
  get("/api/stories").then((storyObjs) => {
    setStories(storyObjs);
  }).catch((err) => {
    console.log("this is so sad: ", err.message);
  });
}, []);
```

Recap

- Use **await** keyword to wait for promises to resolve
- Use **async** keyword to define asynchronous functions
- You MUST wrap every **await** within an **async** function

Recap

Use async when we don’t know how long something will take:

- Client-server communication
- Server-database communication
- React Front End
- Background Tasks

Make your own promises with Q.deferred

Thanks!

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Meta is on zoom

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