Lecture 2:
Pre-Graphics

January 26, 2023

During Lecture:

- cameras off
- mute
- use chat
- use reactions

Today

1. Some class mechanics (workbooks) stuff
2. JavaScript tips and Functional Programming
3. Web Basics
4. Event-driven programming (browser model)
5. Event-driven animation

Graphics starts next week... I promise

Reminders / Review

1. Workbook due on Monday
2. Make sure to figure out GIT/GitHub/GitHub Classroom
3. Lots of ways to get help
    - Piazza
    - Consulting hours

Make sure you have the mechanics of workbooks figured out!

Git, GitHub, GitHub classroom, ... - ask for help if you need it!

Workbook timing

- Tuesday lecture - introduce topic
- Tuesday after lecture - Workbook released
- Thursday lecture - material useful for workbook
- Monday - workbook due

Tools

You need 4 things for class:

1. A Web Browser
2. A GIT client
3. A JavaScript IDE
4. A local web server (might be part of #3)

Workbook 1 requires you to get all of these in place!

And to try some JavaScript programming

Advice

1. Get the GIT command line tools working (including SSH)
2. Try Visual Studio Code as an IDE (and local web server)
3. ~~Have a command-line web server (I use `http-server`) in addition to #2~~
4. Start LiveServer on the "root" of the workbook

We have **tutorials** and **videos** on GIT for class, using the debugger, and functional programming (closures).

A Bit of JavaScript

(since it will appear on the slides)

See the **JavaScript in CS559 page**

1. if you are new... it will suggest resources
2. if you are already fluent... there are some rules

Things I Love and Hate About JavaScript

JavaScript is an evolving language... things change

- use the good parts
- understand and avoid the bad parts
- do not pretend it is "some other language"

A JavaScript Survival Example

Principle:

JavaScript is designed to "keep going" in the face of problems

Design Decison:

No error if you leave out a semi-colon

If you forget a semi-colon, the compiler will guess where it is needed!

But, sometimes it guesses wrong

Survival Secret:

Use semi-colons where appropriate (to end statements)

Use an editor that reminds you when you forget

The Tools are Good!

Magic comments for VSCode

```
// @ts-check

/* @param {number} xpos
 */
function box1canvDrawAll(xpos)
```

- Read the course web page on "Typed JavaScript"
- These are **comments** and ignored by the compiler

Variable declarations

JavaScript ~~is~~ **was** not always lexically scoped...

- `var` - old style, "functionally scoped" (hoisted)
  - confusing behavior **do not use**
- `let` - new style, lexically scoped
  - does what you expect from other languages
- `const` - like `let`, but specifies it won't change
  - I should use this more often

Don't use var - it is confusing. Lexical scoping is good.

Dynamically typed

```
let x = 1;
let y = { a: 3};

x = "hello";
x = true;
x = [1,2,3];
x[5] = y;
x[6] = function(a) { return a*6; }
```

Aggressive Coercion

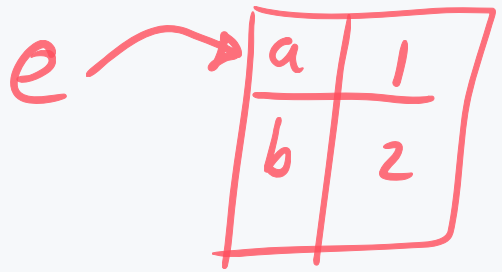
```
/* Aggressive coercerion */
// no errors, but non-sensical results
7+"2";

// coerce the types to a string so they can be compared
7 == "7";

// use "real tests" if you really care...
7 === "7";
```

Truthiness and short-circuiting

```
// undefined, null, zero = all false
undefined ? "yes" : "no";

// useful for defaults (old style)
function say(word) {
    console.log( word || "default" )
}

// empty objects / arrays are still object/arrays
[] ? "true" : "false";
```

Objects are hash tables

```
let e = {};

// backets or dots
e['a'] = 1;
e.b = 2;

// literal notation
let f = { "a":1, "b":2, "c":"c", "e":e };

// no errors!
f.d = 5;                // add a new value
console.log(f.g);       // totally legal - gives "undefined"
```



JavaScript and Object-Oriented Programming

JavaScript has many ways to do OOP

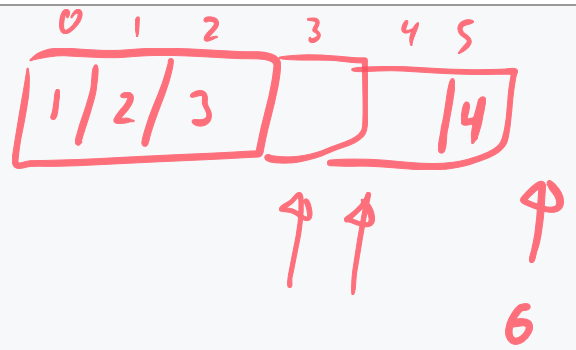
- simple literals
- prototypes
- classes

We'll consider them later...

Beware of `this` - it can mean many different things

Arrays

```
let arr = [1,2,3];
arr.length;
arr[2]
arr[6]
arr[5]=4
```



Loops

```
function say(word) {
    console.log(`says ${word}`);
}

nums = ["one", "two", "three"];
for(let i=0; i<nums.length; i++) {
    say(nums[i]);
}

for(let i of nums) {          // "of" not "in"
    say(i);
}

nums.forEach(say);
```

Function definitions

```
let f = function(a) {return a*2; };

function f(a) {return a*2; }
  // really this is const f = function(a) { return a*2; }
```

f(6) ⇒ 12

Compile and Execution Time

We do not separate execution and compilation

Think of `function` as a function

- it runs the compiler
- it returns a "function object"
- we call the function objects

```
console.log("1");

function sayHi() {
    console.log("3");
}
console.log("2");
sayHi();

const sayHi2 = function() {
    console.log("Hi Again!");
}
sayHi2();
```

1
2
3

Functions are (special) objects

```
let fun1 = function (x) { return x+1; }
function fun2 (x) { return x+2; }

function fun3(f) {
    return f(3);
}
fun3(fun1);
fun3(fun2);
```

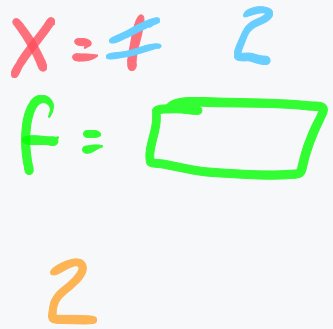
4

5

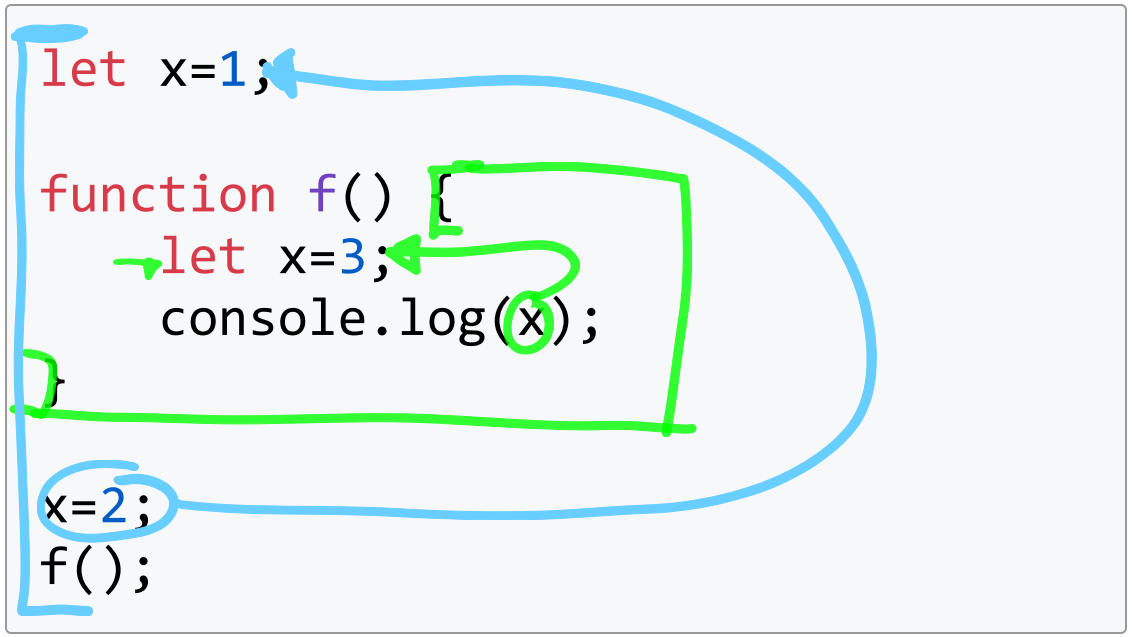
fun3(7)

Definition vs. Execution

```
let x=1;

function f() {
    console.log(x);
}
x=2;
f();
```



Lexical Scope



When a variable is defined, it can be "seen" in a well defined set of places

1. after the definition
2. within the current block
    - blocks inside of blocks are inside the block

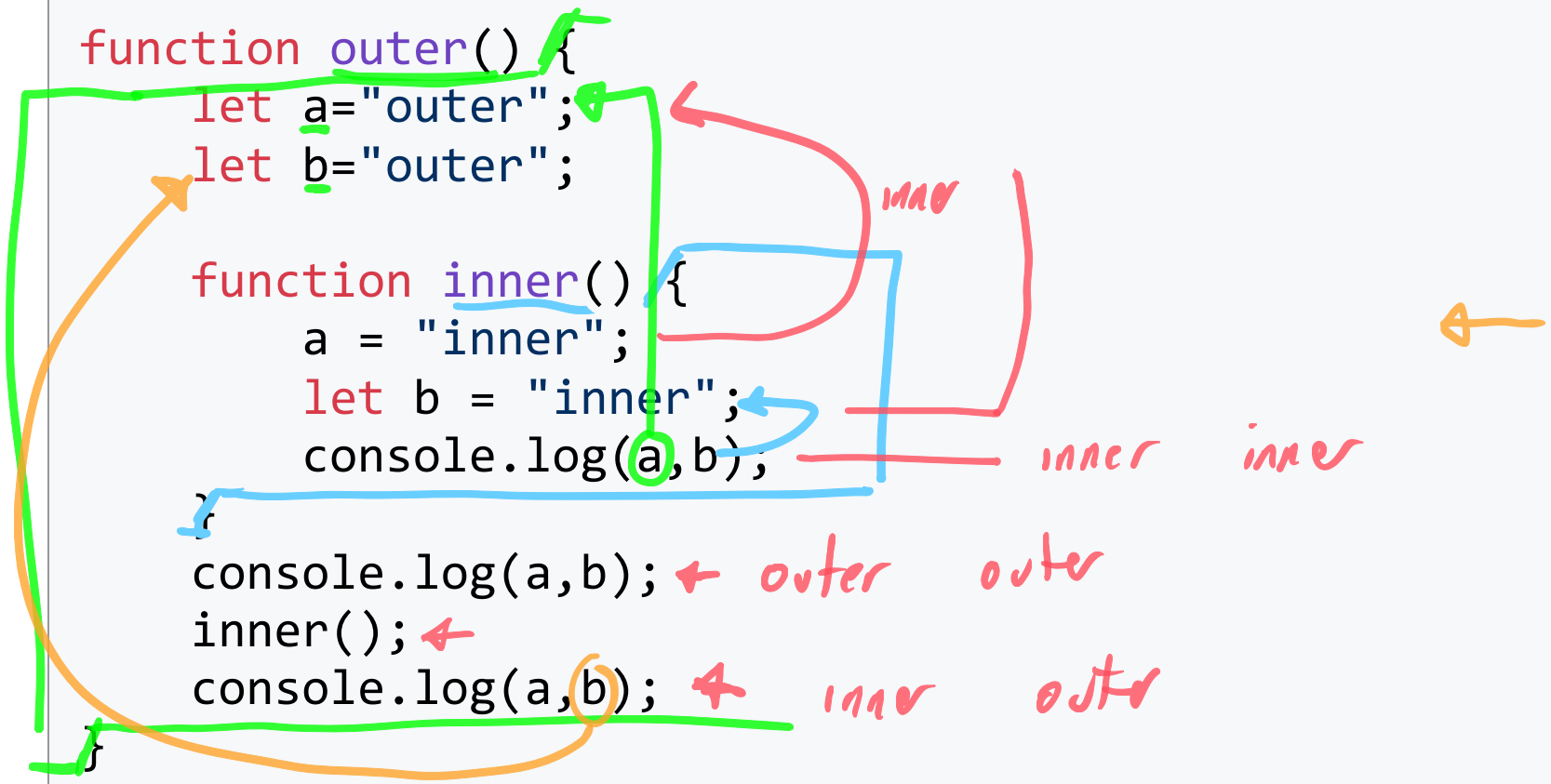
Nested functions, Lexical Scope

```
let a="global";
function test() {
    let a="local";
    if (true) {
        let a = "inner";
        console.log(a)
    }
    console.log(a);
}
test();
console.log(a);
```

Prefer `let` to `var`

Functions inside Functions

```
function outer() {
    let a="outer";
    let b="outer";

    function inner() {
        a = "inner";
        let b = "inner";
        console.log(a,b);
    }
    console.log(a,b);
    inner();
    console.log(a,b);
}
outer();
```



Closures

What happens to variables when a function returns another function?

These are tricky for many students

1. There is a tutorial
2. There is a video lecture (from 2021)

A Closure

```
function outer() {
    let out = "a value";

    function inner() {
        return(out);
    }

    return inner;
}

const x = outer();
console.log( x   ); // prints "function inner"
console.log( x() ); // prints "a value"
```

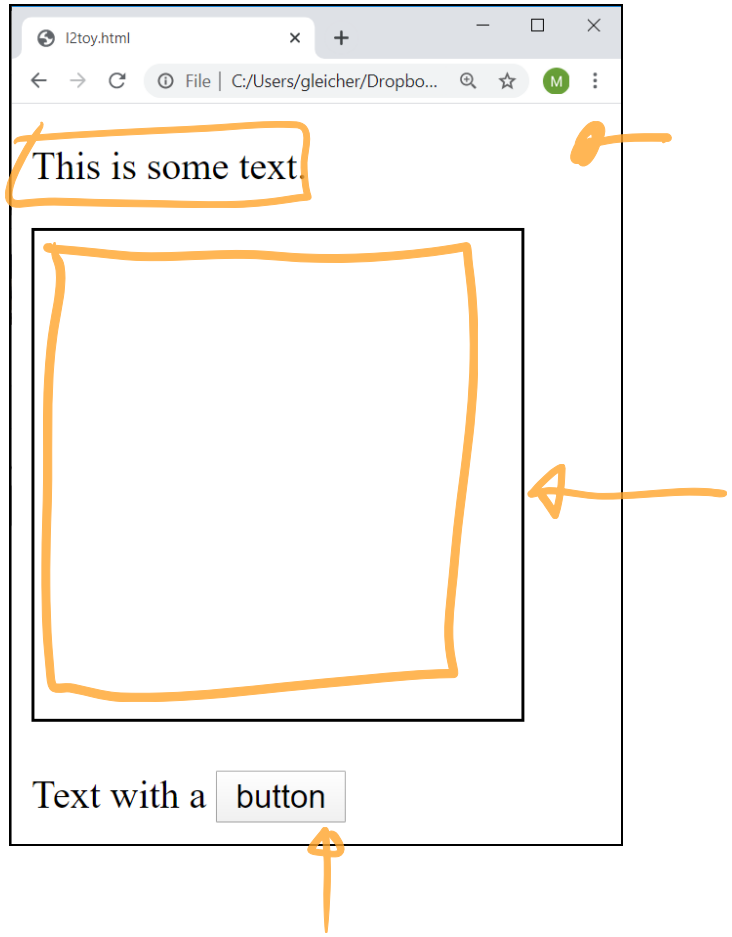
Why Learn Functional Programming?

1. It's cool!
2. It is really useful for even-driven programming

But first...

We need web pages to attach functions to

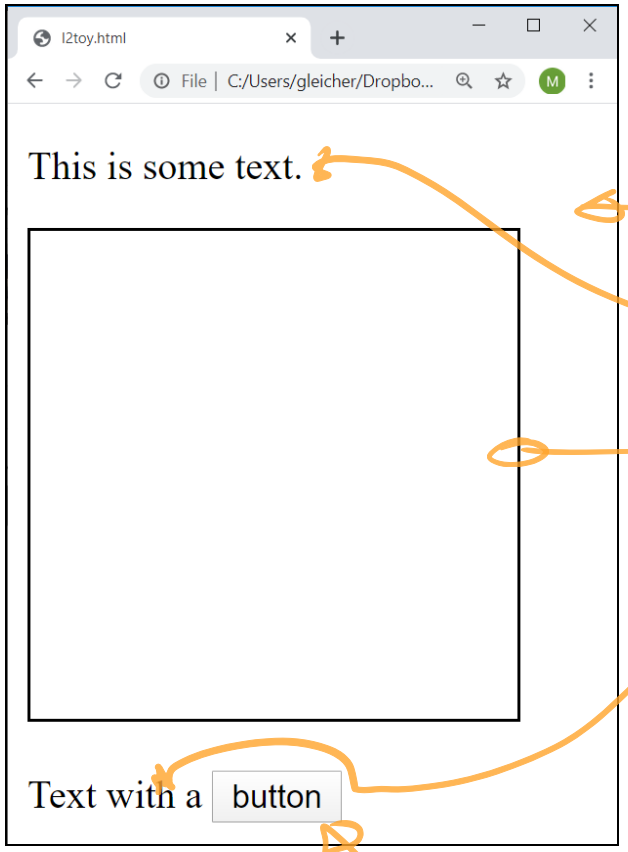
Some Web Basics...



A web page gives us **where** and **when** to draw

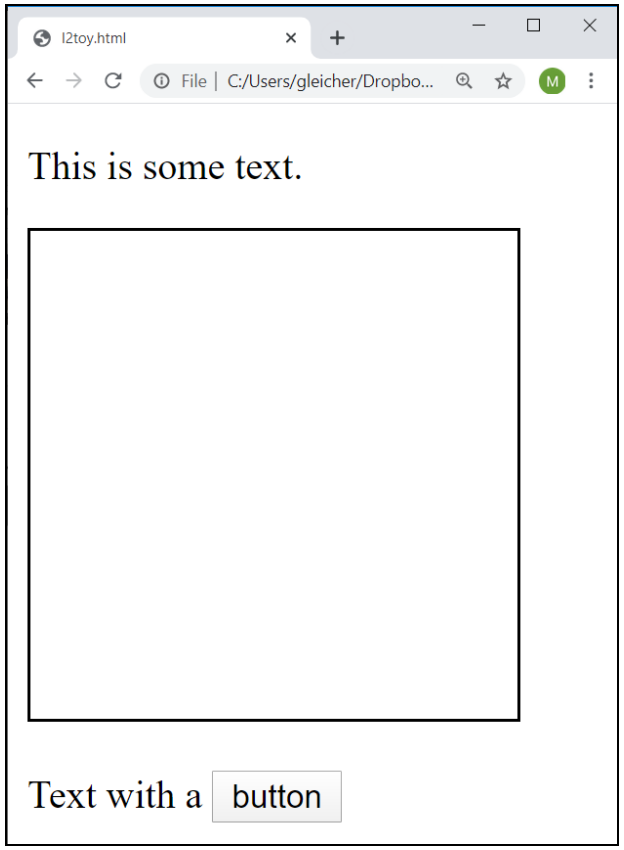
A web page is made of **elements**

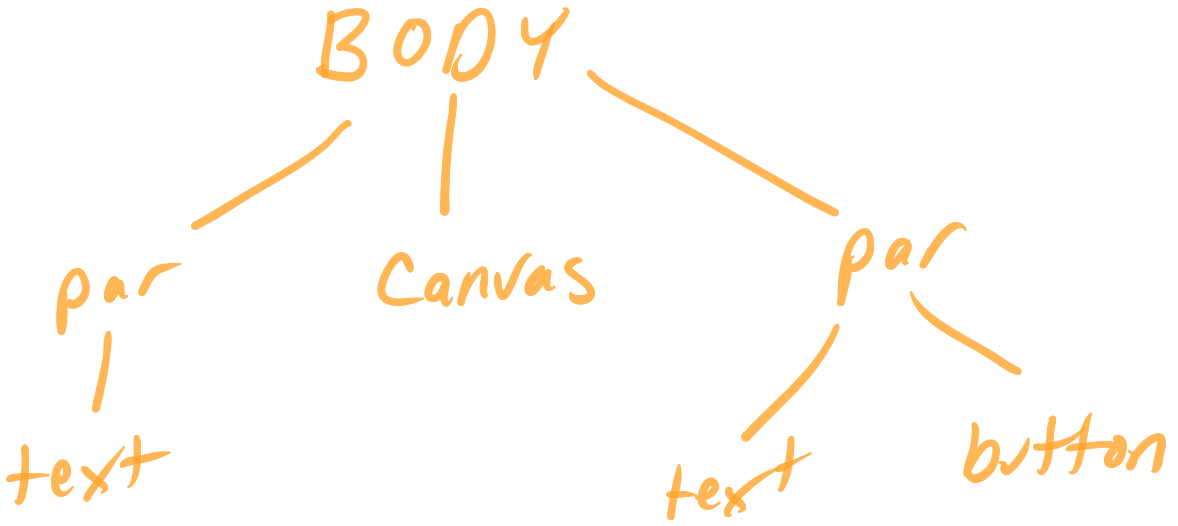
HTML File encodes the page



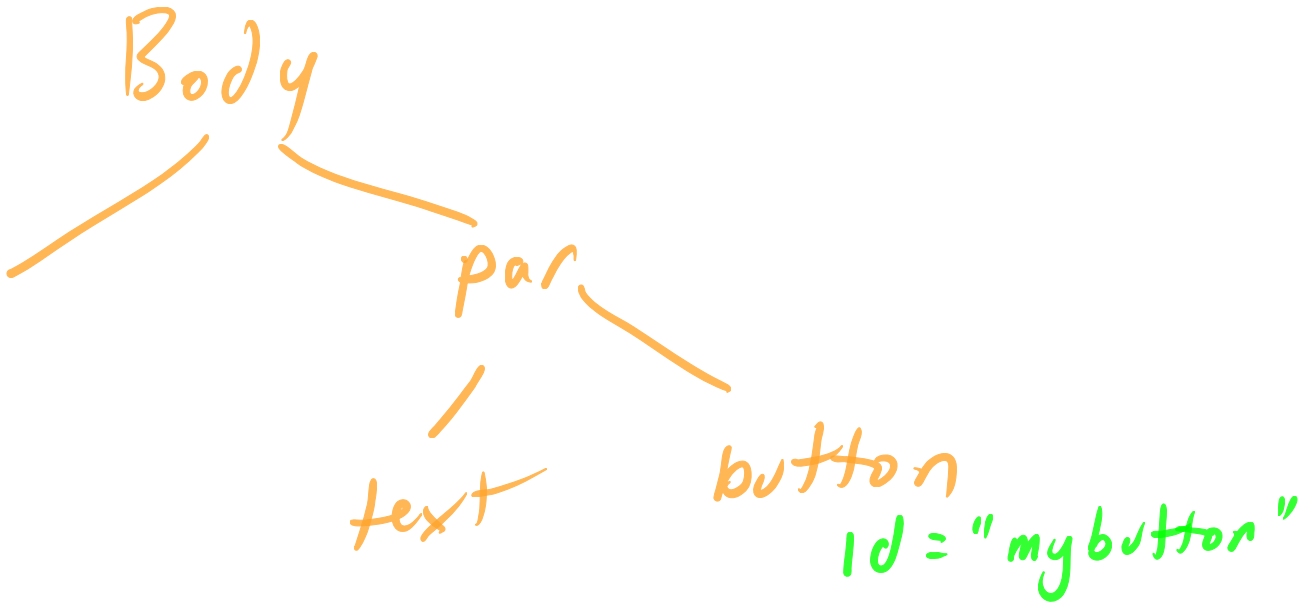

```
<!DOCTYPE html>
<html>

<body>
    <p>This is some text.</p>
    <canvas id="myc" width="200px" height="200px"
            style="border:1px solid black">
    </canvas>
    <p>Text with a <button>button</button></p>
</body>
</html>
```

The Data Structure is the DOM (Tree)





Give an "id" to an element



Why do we care?

Our **programs** will refer to these "elements"

Where do the programs go?

In script elements

```
<script type="module">
    console.log("Hello world!");    // JavaScript!
</script>
```

Or as inline event handlers (mixes languages)

```
<button onclick="console.log('click');">button</button>
```

Or in another file...

```
<script src="file.js" type="module"></script>
```

About that script loading

```
<script src="file.js" type="module" defer></script>
```

1. we give a file to load
2. `"module"` tells the browser to treat the script as a JavaScript **module**
    - allows the use of "modern" JavaScript
    - gives the script its own namespace
3. `defer` tells it to delay execution until everything is loaded
    - makes sure that the page is ready for the code
    - in the "old days" we did this using events (still need that sometimes)
    - more on this in a bit...

When does our code run?

- when an event happens
    - if we attach the code to an event
- "immediately" (when we encounter the script element)
- when the script is done loading

Attaching scripts to objects

```
<button id="mybutton">button</button>
```

Someplace else...

```
<script type="module">
    let button = document.getElementById("mybutton");
    button.onclick = function() {
        console.log("click");
    }
</script>
```

Defensive programming

```
let button = document.getElementById("mybutton");
if (button) {
    button.onclick = function() {
        console.log("click");
    }
} else {
    console.log("there was no button!");
}
```

When does that code run?

```
<script type="module">
let button = document.getElementById("mybutton");
button.onclick = function() {
    console.log("click");
}
</script>
```

- When the button is clicked
- When the script tag is encountered
- When the script tag is interpreted

Timing...

```
<button id="mybutton">button</button>


<script type="module">
let button = document.getElementById("mybutton");
button.onclick = function() {
    console.log("click");
}
</script>
```

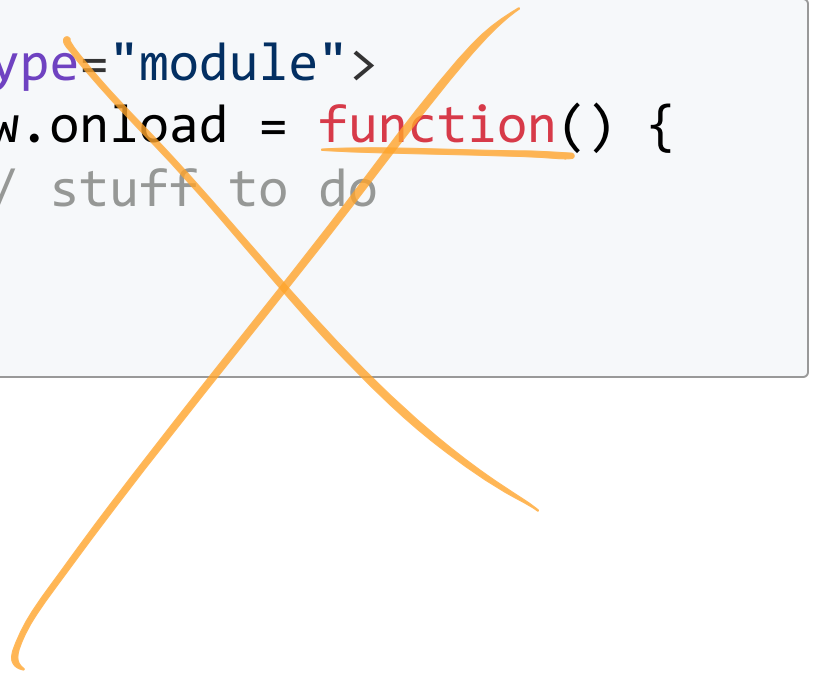
defer

Button must exist before script runs!

(otherwise can't find `mybutton`)

The old way to start

```
<script type="module">
    window.onload = function() {
        // stuff to do
    }
</script>
```



Why?

Why do we did we do this?

Why learn it now?

The "newer way"

```
<script src="file.js" type="module" defer></script>
```

- load the module from the file
- explicitly says "don't execute until the page is loaded"

What if we don't use `defer`?

- `async` is another choice (tries to load in parallel)
- ~~default is unclear (and browser dependent)~~
- this matters more if scripts are slow to load (e.g. from a server)

Back to the main point...

Event-driven Programming

Structure our code by writing functions that are called at **events**

- this is critical for web programming
- this is useful for other interactive graphics programming

We attach **functions** to **events**

Event driven programming

Web browsers are **interactive**

Response to the user - avoid waiting

Respond to **events** (code called when an event happens)

Respond and return to the browser

- need to be ready for the next event
- browsers (historically) are not parallel
- finish 1 event before the next

Simplified Model of a Browser

- Events go into a queue
- Each event gets processed
    - attached code runs (and returns)

Code runs in short snippets (in response to events)

Do a little work, return to browser (so other events can be responded to)

Browsers are (historically) not parallel: 1 event at a time

Therefore:

Most **execution** happens in response to an event

What kinds of event do we attach code to?

- User Events (mouse clicks, movements, etc.)
- `onload` events (`window.onload`) and other special things
- timer events / drawing events

An unusual kind of event

Call this function "some time in the future"

```
window.requestAnimationFrame(func);
```

1. This puts an event on the event queue (other events go first)
2. It will be some time in the future (next "frame")
3. It will happen **after** the current function finishes

a toy example...

```
function f1() {
    console.log("F1");
}

function f2() {
    window.requestAnimationFrame(f1);
    console.log("F2");
}

f2();
```

F2
F1

1. Compile the functions
2. execute `f2`
    i. queue an event to call `f1`
    ii. print "F2"
3. return to browser (event loop)
4. queued `f1` event happens
    i. `f1` gets called
    ii. `f1` prints "F1"

Animation Loops

What if things happen "on their own"

Create movement as a series of steps...

- Draw something 
- Change it a little
- Draw it again ...

We'll talk about the perceptual science of this later...

Why not just a loop?

```
while(1) {
    clear screen
    change things
    draw image
}
```

Why not just a loop?

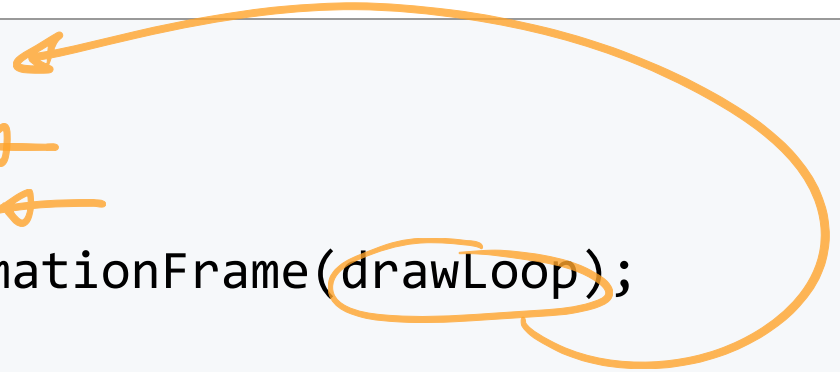
```
while(1) {
    clear screen
    change things
    draw image
    wait until next frame time
}
```

Why not just a loop?

```
while(1) {
    clear screen
    change things
    draw image
    wait until next frame time
    check inputs - respond if needed
    see if there is other stuff to do
    wait until the next frame time
}
```

The clock as an event source

```
function drawLoop() {
    // change things
    // draw something
    window.requestAnimationFrame(drawLoop);
}
drawLoop();
```



A bit of a caveat

```
    window.requestAnimationFrame(func);
```

This **schedules** a call to the function `func` at some point in the future.

1. It schedules 1 call to the function (it does not loop)
2. The time is somewhat variable - "next redraw time"

Variable timing...

```
    window.requestAnimationFrame(func);
```

This occurs "after the next screen refresh"

- most computers = 60 frames per second (16ms)
- Mike's desktop computer = 30 frames per second (33ms)
- some gaming computers = 120, 144, ... frames per second (8ms or less)

This isn't as simple as screen refresh rate...

How to get the timing you want

If you do:

```
    window.requestAnimationFrame(func);
```

The function `func` should take an argument that is the time:

```
let lasttime = 0;
function func(timestamp) {
    // compute how long since last call
    const delta = lasttime ? (timestamp-lasttime) : 0
    lasttime = timestamp;
    // do stuff using the delta
}
```

Summary: Event Driven Programming

1. Write programs by attaching functions to events
2. Schedule events for the future to animate

but, this requires manipulating functions

JavaScript is really good for functional programming