This is CS50x

CS50's Introduction to Computer Science

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Lecture 8

The internet

- Today we'll take a look at web programming, using a set of new languages and technologies to build applications that are both **server-side**, running on servers or cloud services, and **client-side**, running on the user's own devices.
- The **internet** is the network of networks of computers, or servers, communicating with one another by sending and receiving data.
  - The original "internet" was established in 1969, called ARPANET (https://en.wikipedia.org/wiki/ARPANET), which connected computers between various institutions.

    - Today, many more cables and server hardware connects all the computers on the internet.
- **Routers** are specialized computers, with CPUs and memory, that routes, or relays, data from one point to another. At home or on campus, for example, we might have routers that accepts data and sends them out.
    - We take a look at a video where staff members "send" an envelope across the screen of a Zoom meeting.
    - A router might have multiple options for what direction to send some data, and there are algorithms that try to figure out that direction.
- **Protocols** are a set of rules or conventions, like a physical handshake for humans , that the world has agreed upon for computers to communicate with.
- **TCP/IP** are two protocols for sending data between two computers. In the real world, we might write an address on an envelope in order to send a letter to someone, along with our own address for a letter in return.
- **IP** stands for internet protocol, a protocol that includes a standard way for computers to address each other. **IP addresses** are unique addresses for computers connected to the internet, such that a packet sent from one computer to another will be passed along routers until it reaches its destination.
    - An IP address might have the format `#.#.#.#`, where each number can have a value from 0 to 255. Each number will be the size of one byte, so the entire address will be 4 bytes, or 32 bits. This means that this version of IP, version 4, can only support a maximum of 4 billion addresses. Another version of IP, version 6, uses 128 bits to support many more possible addresses.
- **TCP**, transmission control protocol, is a protocol for sending and receiving data. TCP allows for a single server, at the same IP address, to provide multiple services through the use of a **port number**, a small integer added to the IP address. For example, HTTP is sent to port number 80, and HTTPS uses port number 443.
    - TCP also allows for a large amount of data, like an image, to be sent in smaller chunks. Each of them might be labeled with a sequence number, as with "part 1 of 4" or "part 2 of 4". And if one of the parts is lost, the recipient can ask for the missing part again.
    - UDP is another protocol for sending data that does not guarantee delivery like TCP, which might be useful for streaming real-time videos or calls, since we don't want to wait for all the packets to be redelivered before we get new ones.
- **DNS**, domain name system, is another technology that translates domain names like cs50.harvard.edu to IP addresses. DNS is generally provided by a server nearby, with a big table in its memory, of domain names and IP addresses.

The web

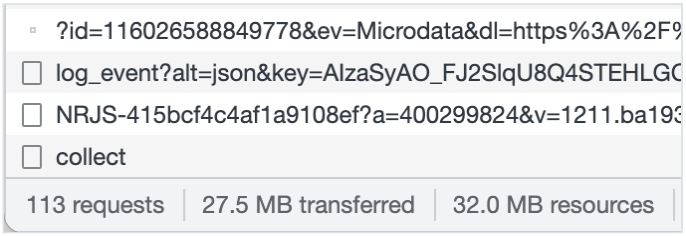
- The internet, with routers, IP, TCP, and DNS, is like the plumbing that allows us to send data from one computer to another. The web is one application that is built on top of the internet.
- **HTTP**, or Hypertext Transfer Protocol, standardizes how web browsers and web servers communicate within TCP/IP packets.
  - **HTTPS** is the secure version of HTTP, ensuring that the contents of packets between the browser and server are encrypted.
- A **URL**, or web address, might look like `https://www.example.com/`.
  - `https://` is the protocol being used.
  - The `/` at the end is a request for the default file. It might also end in something like `/file.html` for a specific file.
  - `example.com` is the domain name. `.com` is a top-level domain name, and others like `.edu` or `.io` indicate what type of website might be hosted there. Today, there are hundreds of top-level domain names, some with restrictions on how they can be used.
  - `www` is the hostname, or subdomain, that refers to one or more specific servers in the domain name. A domain name might include web servers for `www`, or email servers for `mail`, so each subdomain can point to them separately.
  - Together, `www.example.com` is a **fully qualified domain name**, or one that has a specific set of addresses.
- Two commands supported by HTTP include **GET** and **POST**. GET allows a browser to ask for a page or file in a URL, and POST allows a browser to send additional data to the server that is hidden from the URL. Both of these are **requests** we can make to a server, which will provide a **response** in return.
- A GET request will start with:

```
GET / HTTP/1.1
Host: www.example.com
...
```

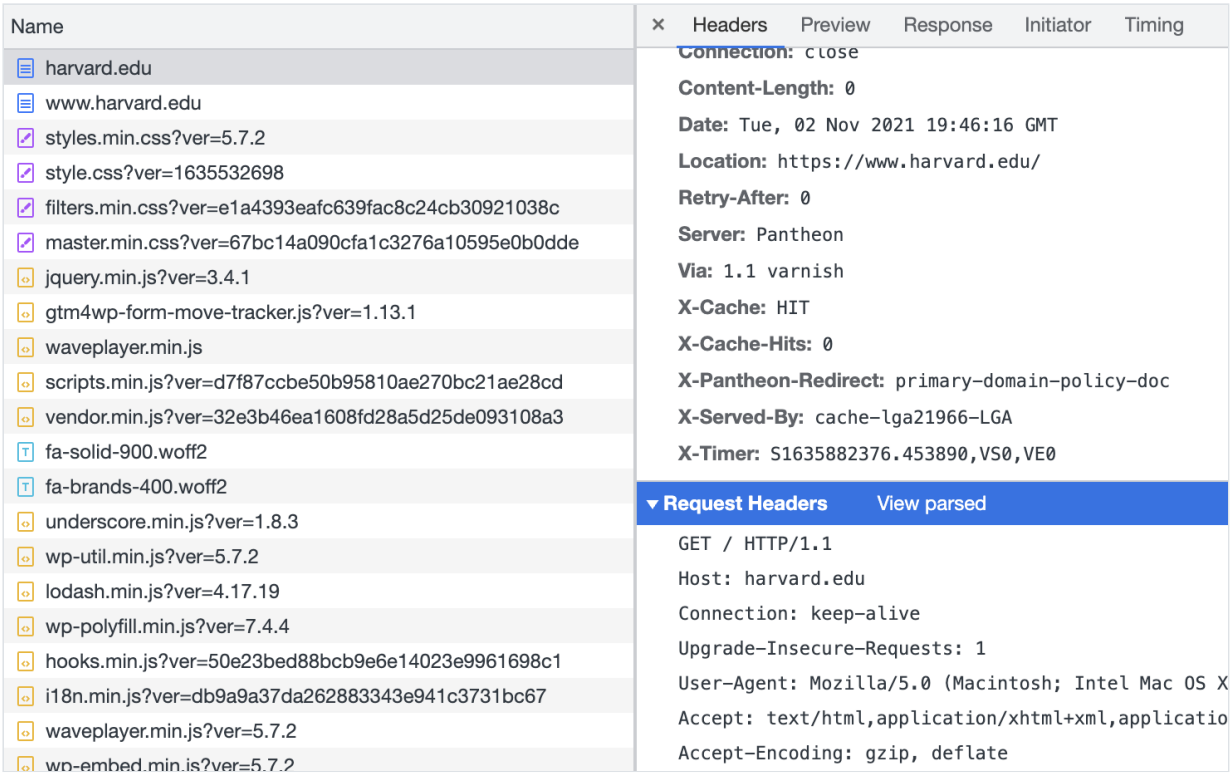
  - The `GET` indicates that the request is for some file, and `/` indicates the default file.
  - There are different versions of the HTTP protocol, so `HTTP/1.1` indicates that the browser is using version 1.1.
  - `Host: www.example.com` indicates that the request is for `www.example.com`, since the same web server might be hosting multiple websites and domains.
- A response for a successful request will start with:

```
HTTP/1.1 200 OK
Content-Type: text/html
...
```

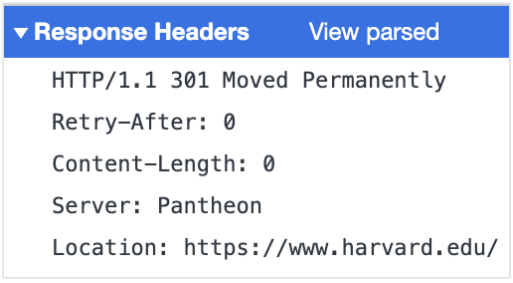
    - The web server will respond with the version of HTTP, followed by a status code, which is `200 OK` here, indicating that the request was valid.
    - Then, the web server indicates the type of content in its response, which might be text, image, or other format.
    - Finally, the rest of the packet or packets will include the content.
- The keys and values, like `Host: www.example.com` and `Content-Type: text/html`, are known as **HTTP headers**.
- We'll type in `http://harvard.edu` in our browser, and see that the address bar has changed to `https://www.harvard.edu` after the page has loaded. Browsers include developer tools, which allow us to see what's happening. In Chrome's menu, for example, we can go to View > Developer > Developer Tools, which will open a panel on the screen. We'll also use an Incognito window, so Chrome doesn't remember our previous requests.
- In the Network tab, we can see that there were over a hundred requests, for text, images, and other pieces of data that were downloaded separately for a single web page. It turns out that our browser made a single request, and the response from the server indicated that we needed to make all those other requests to download the other data on the page:



- If we scroll up in the lists of requests, we can see the request headers for the first request by clicking on the one for `harvard.edu`:



- And we can scroll to see that the server's response actually returned a status code of `301 Moved Permanently`, redirecting our browser from `http://...` to `https://...`:



  - Note that the response includes a `Location:` header for the browser to redirect us to.
- In VS Code's terminal, we can use a command-line tool, `curl`, to see the response headers for a request as well:

```
$ curl -I -X GET http://harvard.edu/
HTTP/1.1 301 Moved Permanently
Retry-After: 0
Content-Length: 0
Server: Pantheon
Location: https://www.harvard.edu/
...
```

- If we visit the new location with `curl`, we see a status code of `200`, as well as a new version of HTTP that we can use:

```
$ curl -I -X GET https://www.harvard.edu/
HTTP/2 200
cache-control: public, max-age=1200
content-type: text/html; charset=UTF-8
```

- And if we try to visit a URL that doesn't exist, we'll see an HTTP status code of `404`:

```
$ curl -I -X GET https://www.harvard.edu/thisfiledoesnotexist
HTTP/2 404
cache-control: no-cache, must-revalidate, max-age=0
content-type: text/html; charset=UTF-8
```

- Other **HTTP status codes** include:
  - `200 OK`
  - `301 Moved Permanently`
  - `302 Found`
  - `304 Not Modified`
  - `307 Temporary Redirect`
  - `401 Unauthorized`
  - `403 Forbidden`
  - `404 Not Found`
  - `418 I'm a Teapot`

        - An April Fool's joke years ago
    - `500 Internal Server Error`
        - Buggy code on a server might result in this status code, like segfaults we might have seen in C.
    - `503 Service Unavailable`
    - ...
- It turns out that `safetyschool.org` redirects to `yale.edu`! Someone must have purchased the domain name and set it to redirect:

```
$ curl -I -X GET http://safetyschool.org
HTTP/1.1 301 Moved Permanently
Server: Sun-ONE-Web-Server/6.1
Date: Tue, 02 Nov 2021 19:59:18 GMT
Content-length: 122
Content-type: text/html
Location: http://www.yale.edu
Connection: close
```

- And `harvardsucks.org` used to be a website with a video of a prank on Harvard (https://youtu.be/YuubOQFB9kk).

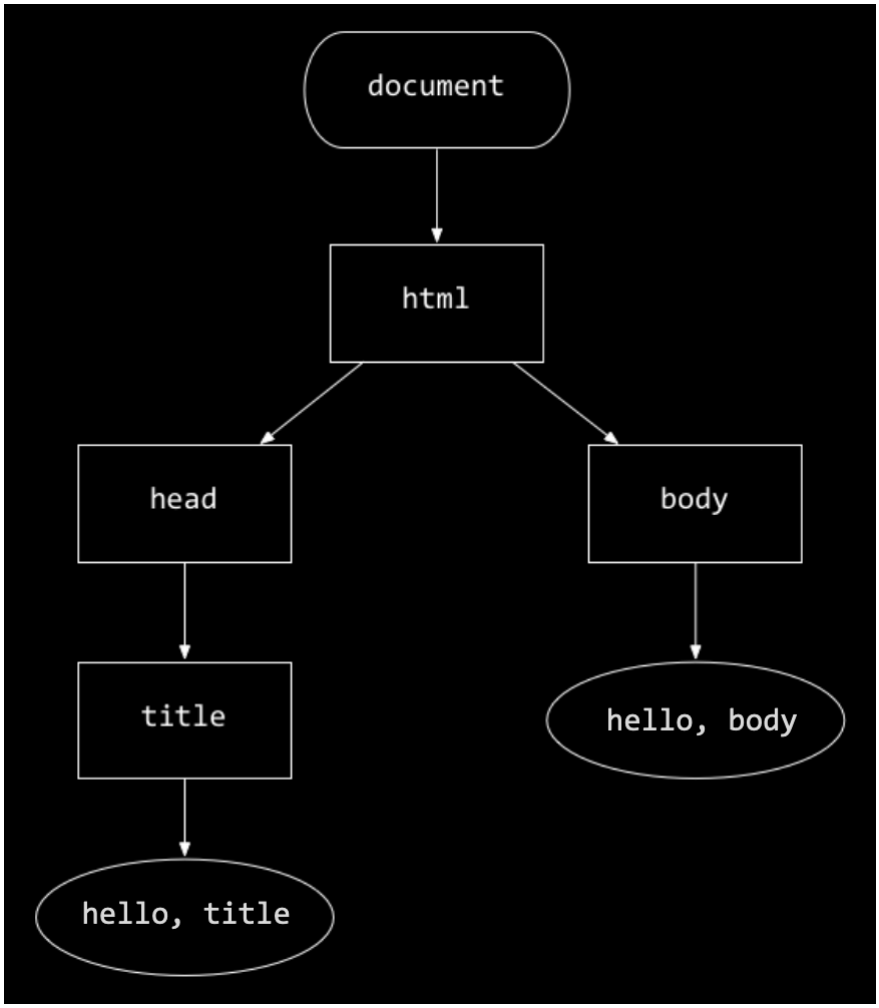
HTML

- Now that we can use the internet and HTTP to send and receive messages, it's time to see what's in the content for web pages. **HTML**, Hypertext Markup Language, is not a programming language, but rather used to format web pages and tell the browser how to display them.
- A simple page in HTML might look like this:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>
            hello, title
        </title>
    </head>
    <body>
        hello, body
    </body>
</html>
```

- Since this page is saved in our instance of VS Code, in the cloud, we can also run our own web server with the `http-server` command, and clicking "Open in Browser" in the notification that appears.

    - This web server will listen on port 8080 instead, since our instance of VS Code is using port 80 already.
- Then, we'll see the file we created, `hello.html`, and we can see our page's content, "hello, world", on the page, and title, "hello, title", in the tab bar.
- Let's look at the HTML again:
    - The first line, `<!DOCTYPE html>`, is a declaration that the page follows the HTML standard.
    - Next is a **tag**, a word in brackets like `<html>` and `</html>`. The first is a start or open tag, and the second is a close tag, which looks almost the same but with a `/` in front of the tag's name. In this case, the tags indicate the start and end of the HTML page. The start tag here has an **attribute** as well, `lang="en"` which specifies that the language of the page will be in English, to help the browser translate the page if needed. Notice that attributes are key-value pairs.
    - Nested within the `<html>` tag are two more tags, `<head>` and `<body>`, which are both like children nodes in a tree. And within `<head>` is the `<title>` tag, the contents of which we see in a tab or window's title in a browser. Within `<body>` is the contents of the page itself, a text node, which we'll see in the main view of a browser as well.
- The page will be loaded into the browser's memory as a data structure, like this tree:



    - Note that there is a hierarchy mapping each tag and its children. Rectangular nodes are tags, while oval ones are text.
- HTML allows us to build the structure of our web pages, and we can look for reference materials online for all the tags and attributes that we can use as building blocks.
- We can use a validator (https://validator.w3.org/#validate_by_input) to check that our HTML is valid.
- We'll take a look at `paragraphs0.html` (https://cdn.cs50.net/2021/fall/lectures/8/src8/paragraphs0.html?highlight):

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>paragraphs</title>
    </head>
    <body>
        <p>
            Lorem ipsum dolor sit amet, consectetur adipiscing elit. Viv
        </p>
        <p>
            Mauris ut dui in eros semper hendrerit. Morbi vel elit mi. S
        </p>
        <p>
            Aenean venenatis convallis ante a rhoncus. Nullam in metus v
        </p>
    </body>
</html>
```

    - With the `<p>` tag, we can indicate that each section of text should be a paragraph.
    - After we save this file, we'll refresh the index of our web server, and then open `paragraphs.html`, to see that each paragraph of text is separated by some spacing.
- We can add headings with tags like `<h1>`, `<h2>`, and `<h3>` in `headings.html` (https://cdn.cs50.net/2021/fall/lectures/8/src8/headings.html?highlight):

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>headings</title>
    </head>

    <body>
        <h1>One</h1>
        <p>
            Lorem ipsum dolor sit amet, consectetur adipiscing elit. Viv
```

```
        </p>

        <h2>Two</h2>
        <p>
            Mauris ut dui in eros semper hendrerit. Morbi vel elit mi. S
        </p>

        <h3>Three</h3>
        <p>
            Aenean venenatis convallis ante a rhoncus. Nullam in metus v
        </p>
    </body>
</html>
```

- Each level of heading has a different size, and we can use up to six levels of headings with `<h6>`.

- We take a look at `list0.html` (https://cdn.cs50.net/2021/fall/lectures/8/src8/list0.html?highlight), where we use the `<ul>` tag to create an unordered list, like bullet points:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>list</title>
    </head>
    <body>
        <ul>
            <li>foo</li>
            <li>bar</li>
            <li>baz</li>
        </ul>
    </body>
</html>
```

- We can also use `<ol>` instead, for an ordered list with numbers.

- Tables start with a `<table>` tag and have `<tr>` tags as rows, and `<td>` tags for individual cells:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>table</title>
    </head>
    <body>
        <table>
            <thead>
                <tr>
```

```
                    <th>Name</th>
                    <th>Number</th>
                </tr>
            </thead>
            <tbody>
                <tr>
                    <td>Carter</td>
                    <td>+1-617-495-1000</td>
                </tr>
                <tr>
                    <td>David</td>
                    <td>+1-949-468-2750</td>
                </tr>
            </tbody>
        </table>
    </body>
</html>
```

- In `image.html` (https://cdn.cs50.net/2021/fall/lectures/8/src8/image.html?highlight), we can upload an image to our instance of VS Code and include it in our page with an `<img>` tag. We can also use the `alt` attribute to add alternative text for accessibility:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>image</title>
    </head>
    <body>
        <img alt="Harvard University" src="harvard.jpg">
    </body>
</html>
```

    - It turns out the image is included at its full size, so we'll use CSS later to set its width and height.
- We can also include videos with `video.html` (https://cdn.cs50.net/2021/fall/lectures/8/src8/video.html?highlight):

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>video</title>
    </head>
    <body>
        <video autoplay loop muted width="1280">
            <source src="halloween.mp4" type="video/mp4">
        </video>
```

```
    </body>
</html>
```

- We'll use HTML attributes to change how our video is displayed. Notice that some attributes are empty, where there is no value.

- We'll embed another page in ours with an inline frame, or iframe:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>iframe</title>
    </head>
    <body>
        <iframe allowfullscreen src="https://www.youtube.com/embed/xvFZ
    </body>
</html>
```

- We can create links in `link1.html` (https://cdn.cs50.net/2021/fall/lectures/8/src8/link1.html?highlight) with the `<a>`, or anchor, tag:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>link</title>
    </head>
    <body>
      Visit <a href="https://www.harvard.edu">Harvard</a>.
    </body>

</html>
```

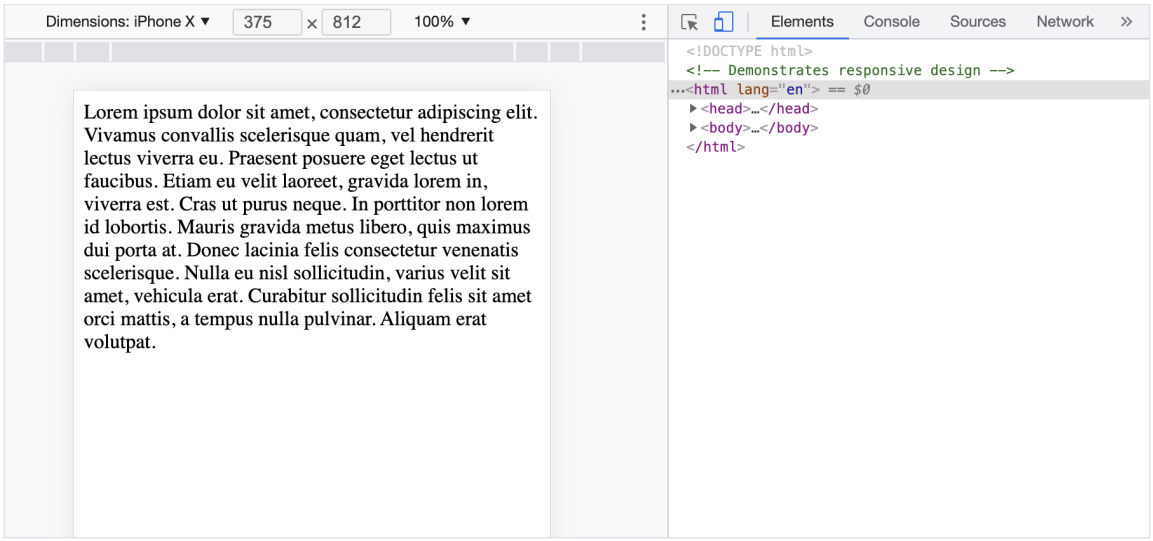
  - The `href` attribute is for a hypertext reference, or simply where the link should take us, and within the tag is the text that should appear as the link.
  - When we visit this page, we can hover over the link, and our browser will show what the URL is.
  - But we could set the `href` to `https://www.yale.edu`, but leave `Harvard` within the tag, which might prank users or even trick them into visiting a fake version of some website. **Phishing** is an act of tricking users, a form of social engineering that includes misleading links.
  - We can link to other pages on our own server with just `image.html` or something similar.

- In `responsive.html` (https://cdn.cs50.net/2021/fall/lectures/8/src8/responsive.html?highlight), we can add attributes to make our page **responsive**, or automatically adapted

for different screen sizes:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <meta name="viewport" content="initial-scale=1, width=device-wi
        <title>responsive</title>
    </head>
    <body>
        Lorem ipsum dolor sit amet, consectetur adipiscing elit. Vivamus
    </body>
</html>
```

- We'll open Chrome's Developer Tools again, and in the top left of the panel, use the icon that looks like mobile devices to simulate a phone:



- It turns out that we can also provide inputs in a request as part of a URL like `https://wwww.example.com/path?key=value`. Here, the `?` indicates that we're adding inputs, which will include one or more key-value pairs.
- If we search for something on Google, we'll see that the URL changes to `https://www.google.com/search?q=cats&...`. Here, the `q` key, for "query", has a value of `cats`, along with other keys and values.
- These inputs are part of GET requests that look like:

```
GET /search?q=cats HTTP/1.1
Host: www.google.com
...
```

  - We can also use POST, to send inputs like usernames and passwords, that should be hidden from the URL.
- In `search0.html` (https://cdn.cs50.net/2021/fall/lectures/8/src8/search0.html?highlight), we can create a form that takes user input and sends it to Google's search engine:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>search</title>
    </head>
    <body>
        <form action="https://www.google.com/search" method="get">
            <input name="q" type="text">
            <input type="submit">
        </form>
    </body>
</html>
```

- First, we have a `<form>` tag that has an `action` of Google's search URL, with a method of GET.
- Inside the form, we have one `<input>`, with the name `q`, and another `<input>` with the type of `submit`. When the second input, a button, is clicked, the form will automatically add the input to the URL.
- So when we open `search.html` in our browser, we can use the form to search via Google.

CSS

- Let's make a home page:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>home</title>
    </head>
    <body>
        <p>
            John Harvard
        </p>
        <p>
            Welcome to my home page!
        </p>
        <p>
            Copyright (c) John Harvard
        </p>
    </body>
</html>
```

    - We have three paragraphs, and we could use `<div>` tags, or divisions, to indicate they are separate areas on our page.
- We can also use HTML tags that add more context to our page:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>home</title>
    </head>
    <body>
        <header>
            John Harvard
        </header>
        <main>
            Welcome to my home page!
        </main>
        <footer>
            Copyright (c) John Harvard
        </footer>
    </body>
</html>
```

- We'll stylize our page by adding a few aesthetics:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>home</title>
    </head>
    <body>
        <header style="font-size: large; text-align: center;">
            John Harvard
        </header>
        <main style="font-size: medium; text-align: center;">
            Welcome to my home page!
        </main>
        <footer style="font-size: small; text-align: center;">
            Copyright &#169; John Harvard
        </footer>
    </body>
</html>
```

    - We'll also use an **HTML entity** to represent the copyright symbol, which will be displayed in our browser as ©.
- In our `<style>` tags, we're using **CSS**, Cascading Style Sheets, another language that tells our browser how to display tags on a page. CSS uses **properties**, or key-value pairs,

like `font-size: large;`.

- We can align all the text at once, instead of repeating ourselves:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>home</title>
    </head>
    <body style="text-align: center;">
        <header style="font-size: large;">
            John Harvard
        </header>
        <main style="font-size: medium;">
            Welcome to my home page!
        </main>
        <footer style="font-size: small;">
            Copyright &#169; John Harvard
        </footer>
    </body>
</html>
```

  - Here, the style applied to the `<body>` tag cascades, or applies, to its children, so all the sections inside will have centered text as well.

- To factor out, or separate our CSS from HTML, we can include styles in the `<head>` tag:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <style>

            body {
                text-align: center;
            }

            header
            {
                font-size: large;
            }

            main
            {
                font-size: medium;
            }

            footer
            {
                font-size: small;
```

```
            }

        </style>
        <title>home</title>
    </head>
    <body>
        <header>
            John Harvard
        </header>
        <main>
            Welcome to my home page!
        </main>
        <footer>
            Copyright &#169; John Harvard
        </footer>
    </body>
</html>
```

- We can use a CSS **type selector** to style each type of tag.

- We can also use a more specific **class selector**:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <style>

            .centered
            {
                text-align: center;
            }

            .large
            {
                font-size: large;
            }

            .medium
            {
                font-size: medium;
            }

            .small
            {
                font-size: small;
            }

        </style>
        <title>css</title>
```

```
    </head>
    <body>
        <header class="centered large">
            John Harvard
        </header>
        <main class="centered medium">
            Welcome to my home page!
        </main>
        <footer class="centered small">
            Copyright &#169; John Harvard
        </footer>
    </body>
</html>
```

- We can define our own CSS **class** with a `.` followed by a keyword we choose, so here we've created `.centered`, `.large`, `.medium`, and `.small`, each with some property.
- Then, on any number of tags in our page's HTML, we can add one or more of these classes with the `class` attribute.

- Finally, we can take all of the CSS for the properties and move them to another file with the `<link>` tag:

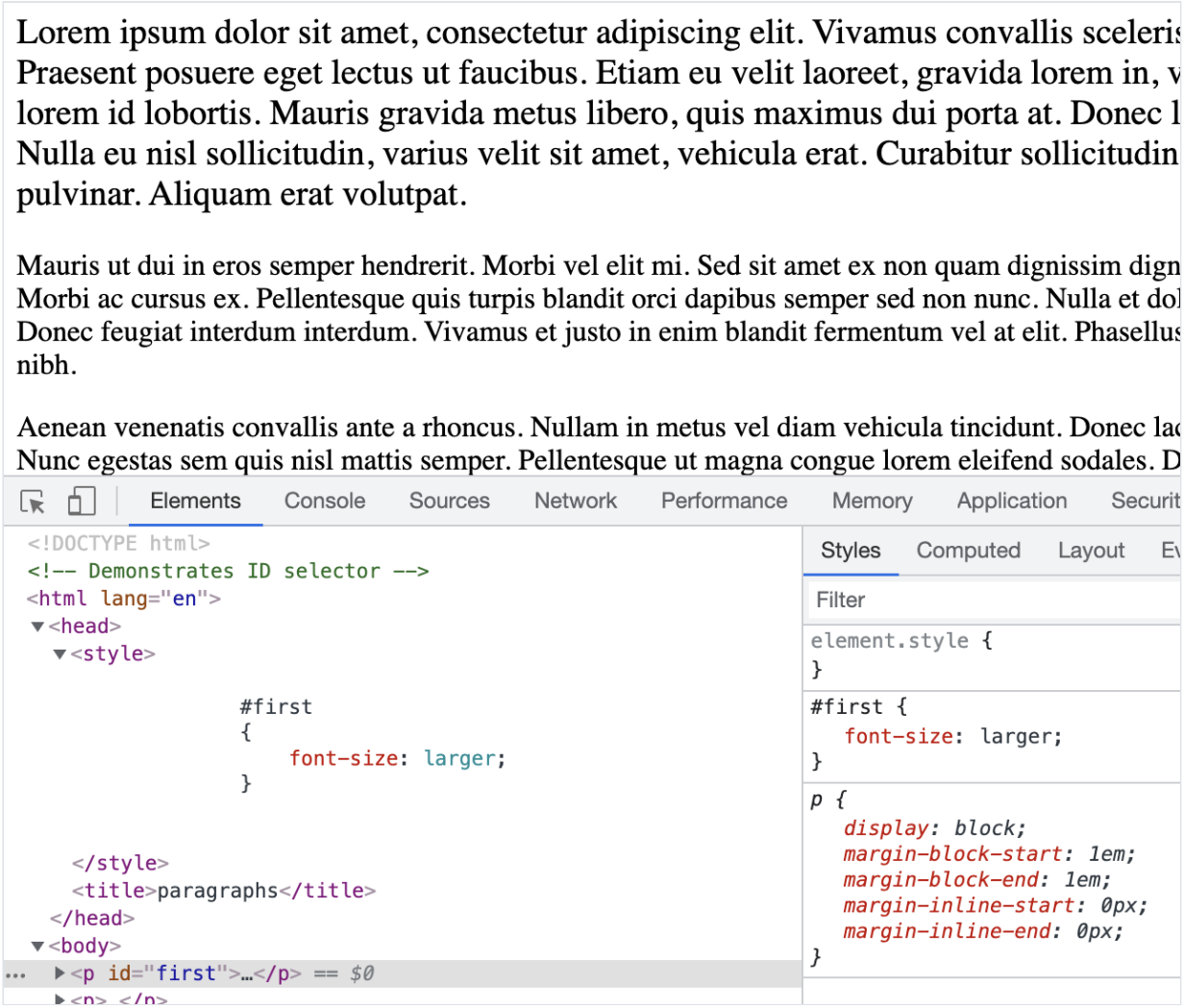
```
<!DOCTYPE html>

<html lang="en">
    <head>
        <link href="home.css" rel="stylesheet">
        <title>home</title>
    </head>
    <body>
        <header class="centered large">
            John Harvard
        </header>
        <main class="centered medium">
            Welcome to my home page!
        </main>
        <footer class="centered small">
            Copyright &#169; John Harvard
        </footer>
    </body>
</html>
```

```
.centered
{
    text-align: center;
}

.large
```

```
{
    font-size: large;
}

.medium
{
    font-size: medium;
}

.small
{
    font-size: small;
}
```

- Now, we have a reusable CSS file.

- CSS also has **ID selectors**, like in `paragraphs1.html` (https://cdn.cs50.net/2021/fall/lectures/8/src8/paragraphs1.html). It turns out that we can use Chrome's Developer Tools here as well. We'll use the Elements tab to see that the `<head>` of this page includes properties for `#first`, an ID in CSS that we can use only once, as well as a HTML tag `<p id="first">` that has the styles applied:



- We can click on an element in the HTML in this panel, and change the style of our page within our browser. We can hover over CSS properties on the right side, and

uncheck or change them. This won't change our original source code, but this will change our browser's copy so we can experiment.

- We can also right-click on anything displayed on the page, and click "Inspect Element" to see it highlighted in the panel for us, where we can make more changes quickly or learn how other pages implement features.

- With CSS, we'll also rely on references and other resources to look up how to use properties as we need them.
- We can use other types of selectors as well:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <style>

            p:first-child
            {
                font-size: larger;
            }

        </style>
        <title>paragraphs</title>
    </head>
    <body>
        <p>
            Lorem ipsum dolor sit amet, consectetur adipiscing elit. Viv
        </p>
        <p>
            Mauris ut dui in eros semper hendrerit. Morbi vel elit mi. S
        </p>
        <p>
            Aenean venenatis convallis ante a rhoncus. Nullam in metus v
        </p>
    </body>
</html>
```

  - Here, we're using `p:first-child` to set properties on the first `<p>` tag.

- We'll look at the style of `link2.html` (https://cdn.cs50.net/2021/fall/lectures/8/src8/link2.html):

```
a {
    color: #ff0000;
    text-decoration: none;
}

a:hover {
```

```
    text-decoration: underline;
}
```

- In `link4.html` (https://cdn.cs50.net/2021/fall/lectures/8/src8/link4.html), we can select tags based on attributes:

```
a
{
    text-decoration: none;
}

a:hover
{
    text-decoration: underline;
}

a[href="https://www.harvard.edu/"]
{
    color: #ff0000;
}

a[href="https://www.yale.edu/"]
{
    color: #0000ff;
}
```

  - The **attribute selectors** will affect tags with those attributes, and we can use `a[href*="harvard.edu"]` to be less specific in our selection, affecting tags with `harvard.edu` anywhere in its `href`.

- A set of CSS conventions and shared styles is known as a **framework**, with classes and components we can quickly use.
- One popular framework is Bootstrap (https://getbootstrap.com/), with components like alerts that we can use with HTML like:

```
<div class="alert alert-warning">
    ...
</div>
```

  - The framework provides the CSS that sets the style for those classes.

- With the help of the documentation on Bootstrap's website, we'll include a `<link>` to its CSS for our page with a table:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <link href="https://cdn.jsdelivr.net/npm/bootstrap@5.1.3/dist/cs
        <title>table</title>
```

```
    </head>
    <body>
        <table class="table">
            <thead>
                <tr>
                    <th>Name</th>
                    <th>Number</th>
                </tr>
            </thead>
            <tbody>
                <tr>
                    <td>Carter</td>
                    <td>+1-617-495-1000</td>
                </tr>
                <tr>
                    <td>David</td>
                    <td>+1-949-468-2750</td>
                </tr>
            </tbody>
        </table>
    </body>
</html>
```

- By adding the `table` class, per the Boostrap documentation, we see that our table is indeed stylized to be easier to read.

- We'll update our search page, too, with styles from Bootstrap:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <link href="https://cdn.jsdelivr.net/npm/bootstrap@5.1.3/dist/cs
    <title>search</title>
    </head>
    <body>
        <div class="container-fluid">

            <ul class="m-3 nav">
                <li class="nav-item">
                    <a class="nav-link text-dark" href="https://about.g
                </li>
                <li class="nav-item">
                    <a class="nav-link text-dark" href="https://store.g
                </li>
                <li class="nav-item ms-auto">
                    <a class="nav-link text-dark" href="https://www.goo
                </li>
                <li class="nav-item">
                    <a class="nav-link text-dark" href="https://www.goo
```

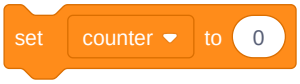
```
                </li>
                <li class="nav-item">
                    <a class="btn btn-primary" href="https://accounts.g
                </li>
            </ul>

            <div class="text-center">
              <img alt="Happy Cat" class="img-fluid w-25" src="cat.gif">
              <form action="https://www.google.com/search" class="mt-4"
                  <input autocomplete="off" autofocus class="form-contro
                  <button class="btn btn-light" type="submit">Google Sea
                  <button class="btn btn-light" name="btnI" type="submit
              </form>

          </div>
        </div>

    </body>
</html>
```

- First, we'll put everything in a `<div>` that can grow to fit the screen.
- Then, we'll create a list with items and classes based on Bootstrap's documentation, to display links and buttons in the header.
- Finally, we'll add an image of a cat to the center of our page, as well as styles for our form.

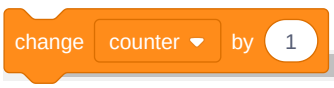
- Even with a framework, we can still write our own CSS styles to change any that we want.

JavaScript

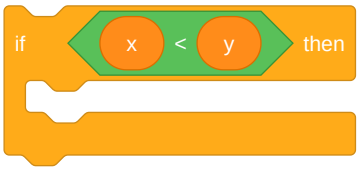
- To write code that can run in users' browsers, or on the client, we'll use a new language, **JavaScript**. The code will still come from our web server, but it will be executed by the user's browser.
- The syntax of JavaScript is similar to that of C and Python for basic constructs:



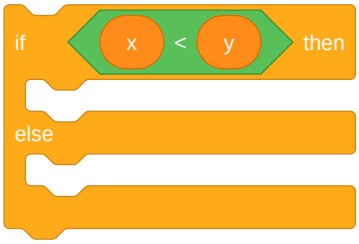

```
let counter = 0;
```



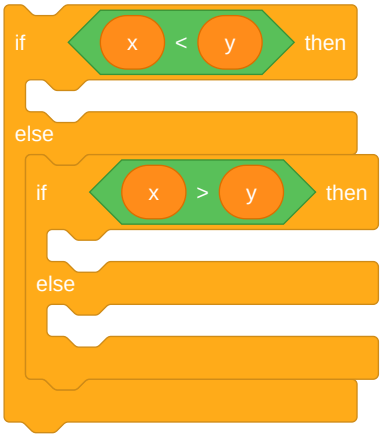

```
counter = counter + 1;
counter += 1;
counter++;
```




```
if (x < y)
{

}
```




```
if (x < y)
{

}
else
{

}
```




```
if (x < y)
{

}
else if (x > y)
{

}
else
{

}
```


```
while (true)
{

}
```


```
for (let i = 0; i < 3; i++)
{

}
```

- Notice that in JavaScript we use `let` to declare variables, without needing to indicate types.

- With JavaScript, we can change the HTML in the browser in real-time. We can use `<script>` tags to include our code directly, or from a `.js` file.
- We'll create another form:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <script>

            function greet()
            {
                alert('hello, there');
            }

        </script>
        <title>hello</title>
    </head>
    <body>
        <form onsubmit="greet(); return false;">
            <input autocomplete="off" autofocus id="name" placeholder="N
            <input type="submit">
        </form>
    </body>
</html>
```

- Here, we won't add an `action` to our form, since this will stay on the same page. Instead, we'll have an `onsubmit` attribute that will call a function we've defined in JavaScript, and use `return false;` to prevent the form from actually being submitted anywhere.
- In the `<head>` tag, we'll have a `<script>` tag with a function that defines a function, `greet`, in JavaScript.
- Now, if we load that page, we'll see `hello, there` being shown when we submit the form.

- Since our input tag, or **element**, has an ID of `name`, we can use it in our code:

```
<script>

    function greet()
    {
        let name = document.querySelector('#name').value;
        alert('hello, ' + name);
    }

</script>
```

  - `document` is a global variable that comes with JavaScript in the browser, and `querySelector` is a function we can use to select a node in the **DOM**, Document Object Model, or the tree structure of the HTML page. After we select the element with the ID `name`, we get the text `value` inside the input, and add it to our alert.
- We can move our function to the bottom of the `<body>` of the page, since we want the rest of the page to load first:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>hello</title>
    </head>
    <body>
        <form>
            <input autocomplete="off" autofocus id="name" placeholder="N
            <input type="submit">
        </form>
        <script>

            function greet()
            {
                let name = document.querySelector('#name').value;
                alert('hello, ' + name);
            }
```

```
            document.querySelector('form').addEventListener('submit', gr

        </script>
    </body>
</html>
```

- Now, we can listen to **events** in JavaScript, which occur when something happens on the page. For example, we can listen to the `submit` event on our `form` element, and call the `greet` function when the event happens.

- We can also use **anonymous functions** in JavaScript:

```
<script>

    document.querySelector('form').addEventListener('submit', function(e
        let name = document.querySelector('#name').value;
        alert('hello, ' + name);
        e.preventDefault();
    });

</script>
```

- We can pass in a function with no name with the `function()` syntax, and it turns out that event handlers in JavaScript get an event variable, `e` by convention, that we can use inside our function. Here, we use `e.preventDefault();` to stop the default behavior of the form.

- We can programmatically change style, too:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <title>background</title>
    </head>
    <body>
        <button id="red">R</button>
        <button id="green">G</button>
        <button id="blue">B</button>
        <script>

            let body = document.querySelector('body');
            document.querySelector('#red').addEventListener('click', fun
            {
                body.style.backgroundColor = 'red';
            });

            document.querySelector('#green').addEventListener('click',
                body.style.backgroundColor = 'green';
```

```
            });

            document.querySelector('#blue').addEventListener('click', fu
                body.style.backgroundColor = 'blue';
            });

        </script>
    </body>
</html>
```

- After selecting an element, we can use the `style` property to set values for CSS properties as well. Here, we have three buttons, each of which has an event listener for the `click` event, that changes the background color of the `<body>` element.

- We can also use JavaScript to make an element "blink", or appear and reappear at an interval:

```
<!DOCTYPE html>

<html lang="en">
    <head>
        <script>

            // Toggles visibility of greeting
            function blink()
            {
                let body = document.querySelector('body');
                if (body.style.visibility == 'hidden')
                {
                    body.style.visibility = 'visible';
                }
                else
                {
                    body.style.visibility = 'hidden';
                }
            }

            // Blink every 500ms
            window.setInterval(blink, 500);

        </script>
        <title>blink</title>
    </head>
    <body>
        hello, world
    </body>
</html>
```

- We can implement a form with autocomplete, using a dictionary of words and an event listener for the `keyup` event:

```
<!DOCTYPE html>

<html lang="en">

    <head>
        <title>autocomplete</title>
    </head>

    <body>

        <input autocomplete="off" autofocus placeholder="Query" type="te

        <ul></ul>

        <script src="large.js"></script>
        <script>

            let input = document.querySelector('input');
            input.addEventListener('keyup', function(event) {
                let html = '';
                if (input.value) {
                    for (word of WORDS) {
                        if (word.startsWith(input.value)) {
                            html += `<li>${word}</li>`;
                        }
                    }
                }
                document.querySelector('ul').innerHTML = html;
            });

        </script>

    </body>
</html>
```

  - If we visit `autocomplete.html` (https://cdn.cs50.net/2021/fall/lectures/8/src8/autocomplete.html) and start typing in the input box, we'll see matching words appear below.

- With `geolocation.html` (https://cdn.cs50.net/2020/fall/lectures/8/src8/geolocation.html), we can ask the browser for a user's GPS coordinates:

```
<!DOCTYPE html>

<html lang="en">
```

```
    <head>
        <title>geolocation</title>
    </head>
    <body>
        <script>

            navigator.geolocation.getCurrentPosition(function(position)
                document.write(position.coords.latitude + ", " + positi
            });

        </script>
    </body>
</html>
```

- Now, we can use those coordinates to see our location on a map.