CSC 405
Computer Security

Web Security

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(Derived from slides by Giovanni Vigna and Adam Doupe)

HTML

- Original HTML had
  - images
  - tables
  - font sizes
  - …
- Content was static

Yahoo! Deutschland  Weekly Picks

Search Options

Yellow Pages - People Search - City Maps -- News Headlines - Stock Quotes - Sports Scores

- **Arts** - - *Humanities*, *Photography*, *Architecture*, *...*
- **Business and Economy [Xtra!]** - - *Directory*, *Investments*, *Classifieds*, *...*
- **Computers and Internet [Xtra!]** - - *Internet*, *WWW*, *Software*, *Multimedia*, *...*
- **Education** - - *Universities*, *K-12*, *Courses*, *...*
- **Entertainment [Xtra!]** - - *TV*, *Movies*, *Music*, *Magazines*, *...*
- **Government** - - *Politics [Xtra!]*, *Agencies*, *Law*, *Military*, *...*
- **Health [Xtra!]** - - *Medicine*, *Drugs*, *Diseases*, *Fitness*, *...*
- **News [Xtra!]** - - *World [Xtra!]*, *Daily*, *Current Events*, *...*
- **Recreation and Sports [Xtra!]** - - *Sports*, *Games*, *Travel*, *Autos*, *Outdoors*, *...*
- **Reference** - - *Libraries*, *Dictionaries*, *Phone Numbers*, *...*
- **Regional** - - *Countries*, *Regions*, *U.S. States*, *...*
- **Science** - - *CS*, *Biology*, *Astronomy*, *Engineering*, *...*
- **Social Science** - - *Anthropology*, *Sociology*, *Economics*, *...*
- **Society and Culture** - - *People*, *Environment*, *Religion*, *...*

Yahoo! New York - Yahoo! Shop - Yahooligans!

Yahoo! Japan - Yahoo! Internet Life - Yahoo! San Francisco

source: https://web.archive.org/web/19961017235908/http://www2.yahoo.com/

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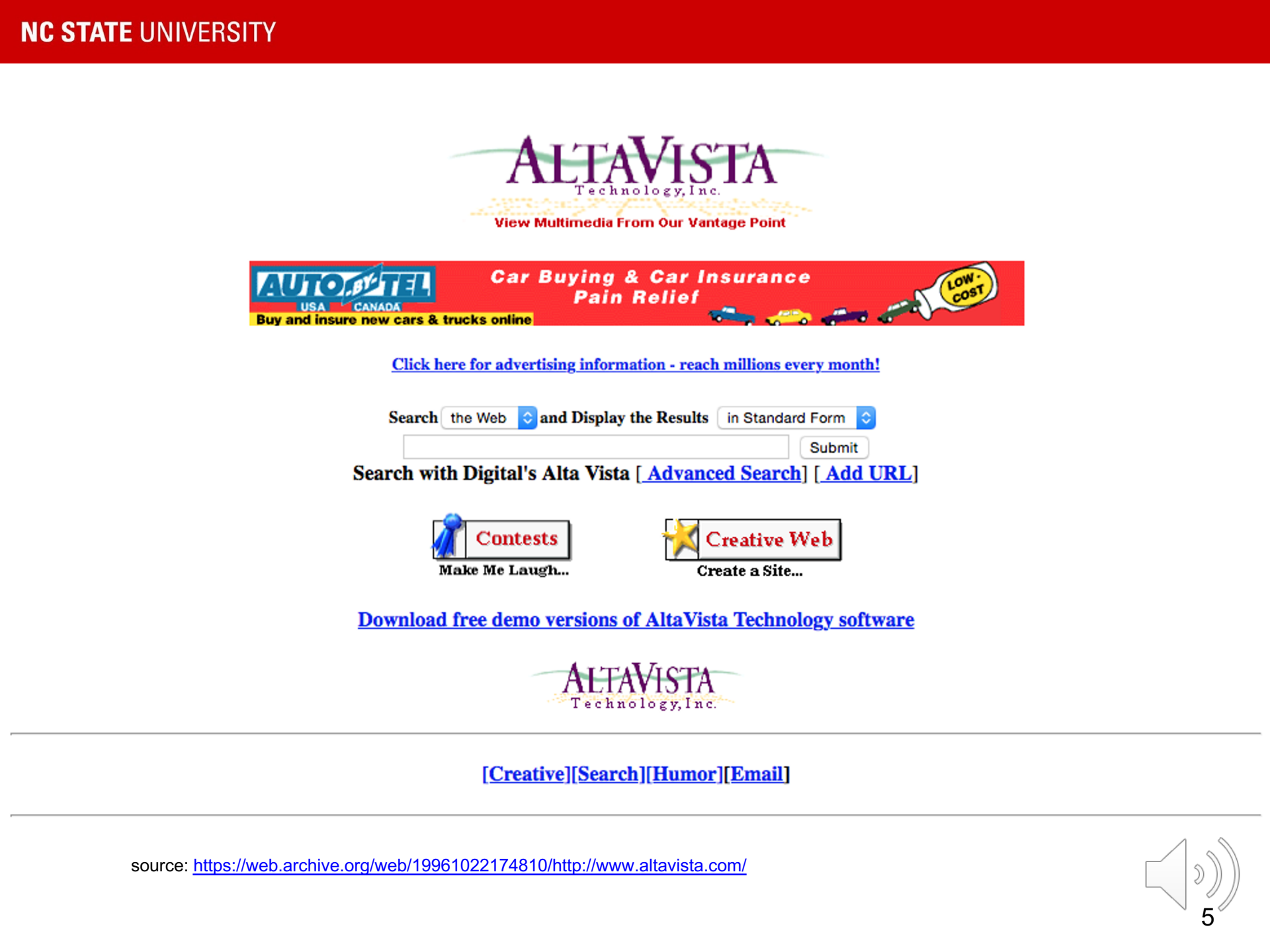
Your Account

Check the status of your orders or change the email address and password you have on file with us. Please note that you **do not** need an account to use the store. The first time you place an order, you will be given the opportunity to create an account.



source: https://web.archive.org/web/19961022174810/http://www.altavista.com/

source: https://web.archive.org/web/19981202230410/http://www.google.com/

HTML Design

- HTML designed to describe a text document with hyperlinks to other documents
- How to do fancy animations or pretty web pages?

JavaScript

- Client-Side scripting language for interacting and manipulating HTML
- Created by Brendan Eich at Netscape Navigator 2.0 in September 1995 as "LiveScript"
- Renamed to "JavaScript" in December 1995 and is (from the Netscape Press Release)
  - "announced JavaScript, an open, cross-platform object scripting language for the creation and customization of applications on enterprise networks and the Internet"
- JavaScript is a (from wikipedia) "prototype-based scripting language with dynamic typing and first-class functions"
  - Does this sound like Java?
- Questions over why the name change
  - Marketing ploy to capitalize on the "hot" Java language?
  - Collaboration between Sun and Netscape?
- By August 1996, Microsoft added support for JavaScript to Internet Explorer
  - Microsoft later changed the name to JScript to avoid Sun's Java trademark
- Submitted to Ecma International for standardization on November 1996
- ECMA-262, on June 1997, standardized first version of ECMAScript

JavaScript

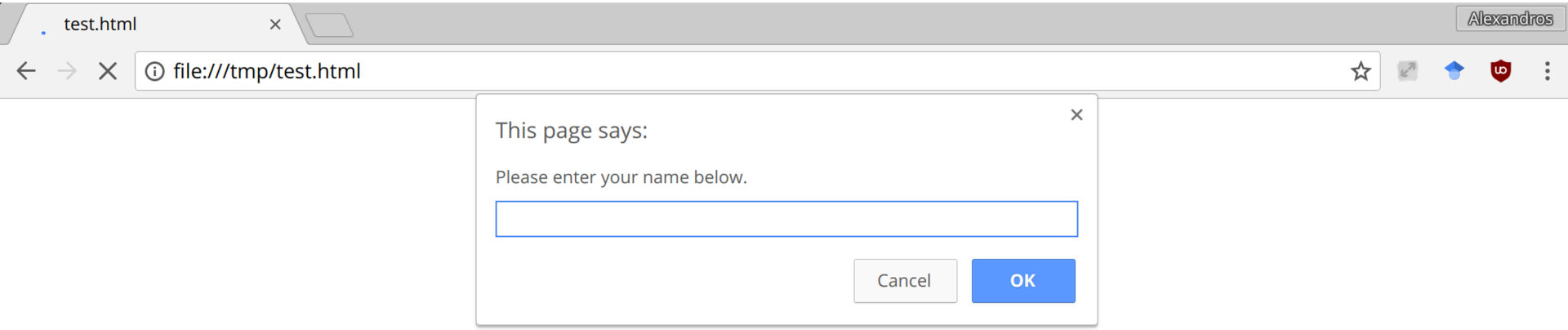
- Lingua franca of the web
- Eventually supported by all browsers
- Language organically evolved along the way

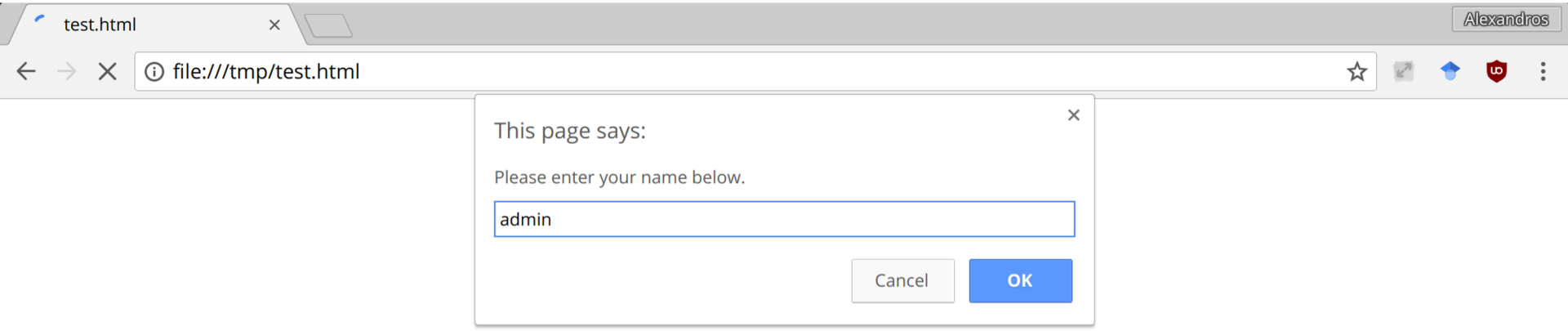
JavaScript

- Code can be embedded into HTML pages using the `script` element and (optionally storing the code in HTML comments)

```
<script>
<!--
var name = prompt('Please enter your name below.', '');
if (name == null) {
  document.write('Welcome to my site!');
}
else {
  document.write('Welcome to my site ' + name + '!');
}
-->
</script>

<script type="text/javascript">
<script language="javascript">
```


test.html
Alexandros
file:///tmp/test.html
This page says:
Please enter your name below.
Cancel
OK


test.html
Alexandros
file:///tmp/test.html
This page says:
Please enter your name below.
admin
Cancel
OK

Welcome to my site admin!

JavaScript

- You can also include external JavaScript files in your HTML
  - As opposed to the inline JavaScript that we saw in the previous example
- `<script src="<absolute or relative URL"></script>`
- When the browser parses this HTML element, it automatically fetches and executes the JavaScript before continuing to parse the rest of the HTML
  - Semantically equivalent as if the JavaScript was directly in the page

Document Object Model (DOM)

- The Document Object Model is a programmatic interface in JavaScript to the manipulation of client-side content
- Created a globally accessible in JavaScript `document` object
  - The document object is used to traverse, query, and manipulate the browser's representation of the HTML page as well as handle events
- DOM 0, released in 1995 with original JavaScript
  - Very basic
- Intermediate DOM began in 1997 with Microsoft and Netscape releasing incompatible improvements to DOM
- W3C stepped in and started to define standards
  - DOM 1, October 1998
  - DOM 2, November 2000
  - DOM 3, April 2004
  - DOM is now a W3C Living Standard, and various snapshots of the standard will turn into DOM4

DOM Example

```
<!DOCTYPE html>
<html>
 <head>
   <meta charset="UTF-8">
   <title>DOM Example</title>
 </head>
 <body>
  <h1>DOM Example</h1>
   <div id='insert_here'>
   </div>
 </body>
 <script>
   var hr = document.createElement('HR');
   document.getElementById('insert_here').appendChild(hr);
 </script>
</html>
```

DOM Example

Using the DOM

- Coding proper DOM access in a cross-browser approach is a nightmare
  - Some highlights from http://stackoverflow.com/questions/565641/what-cross-browser-issues-have-you-faced
    - "Internet Explorer does not replace   or HTML char code 160, you need to replace its Unicode equivalent \u00a0"
    - "In Firefox, a dynamically created input field inside a form (created using document.createElement) does not pass its value on form submit."
    - "document.getElementById in Internet Explorer will return an element even if the element name matches. Mozilla only returns element if id matches."
- jQuery is an amazing library that provides a uniform interface and handles all the DOM cross-browser compatibilities
- Today the situation is match better and compatibility has greatly improved

Browser Object Model (BOM)

- Programmatic interface to everything outside the document (aka the browser)
- No complete standard (the term BOM is colloquial)
- Examples
  - window.name = "New name"
  - window.close()
  - window.location = "http://example.com"

JavaScript vs. DOM and BOM

- JavaScript the language is defined separate from the DOM and BOM
  - DOM has its own specification, and much of the BOM is specified in HTML5 spec
- In the web context, these are often confused, because they are used together so often
- However, now with JavaScript popping up all over the place, it's an important distinction
  - Server-side code using Node.js
  - Database queries (MongoDB)
  - Flash (ActionScript, which has its own DOM-like capabilities)
  - Java applications (javax.script)
  - Windows applications (WinRT)

JavaScript – Object-based

- Almost everything in JavaScript is an object
  - Objects are associative arrays (hash tables), and the properties and values can be added and deleted at run-time

```
var object = {test: "foo", num: 50};
object['foo'] = object;
console.log(object[object['test']]);
object.num = 1000;
console.log(object['num']);
```

```
> var object = {test: "foo", num: 50};
< undefined
> object['foo'] = object;
< ▼ Object {test: "foo", num: 50, foo: Object} i
    ▶ foo: Object
      num: 1000
      test: "foo"
    ▶ __proto__: Object
> console.log(object[object['test']]);
   ▶ Object {test: "foo", num: 50, foo: Object}
< undefined
> object.num = 1000;
< 1000
> console.log(object['num']);
   1000
< undefined
>
```

JavaScript – Recursion

```
function factorial(n) {
    if (n === 0) {
        return 1;
    }
    return n * factorial(n - 1);
}
console.log(factorial(5));
120
```

http://en.wikipedia.org/wiki/JavaScript

JavaScript – Anonymous Functions and Closures

```
var createFunction = function() {
    var count = 0;
    return function () {
        return ++count;
    };
};
var inc = createFunction();
inc();
inc();
inc();
var inc2 = createFunction();
inc2();
```

```
> var createFunction = function() {
      var count = 0;
      return function () {
          return ++count;
      };
  };
< undefined
> var inc = createFunction();
< undefined
> inc();
< 1
> inc();
< 2
> inc();
< 3
> var inc2 = createFunction();
< undefined
> inc2();
< 1
>
```

JavaScript – Runtime Evaluation

- JavaScript contains features to interpret a string as code and execute it
  - eval
  - Function
  - setTimeout
  - setInterval
  - execScript (deprecated since IE11)

```
var foo = "bar";
eval("foo = 'admin';");
console.log(foo);
var x = "console.log('hello');";
var test = new Function(x);
test();
```

```
> var foo = "bar";
< undefined
> eval("foo = 'admin';");
< "admin"
> console.log(foo);
  admin                                          VM49:1
< undefined
> var x = "console.log('hello');";
< undefined
> var test = new Function(x);
< undefined
> test()
  hello                                          VM54:2
< undefined
>
```

JavaScript Uses – Form Validation

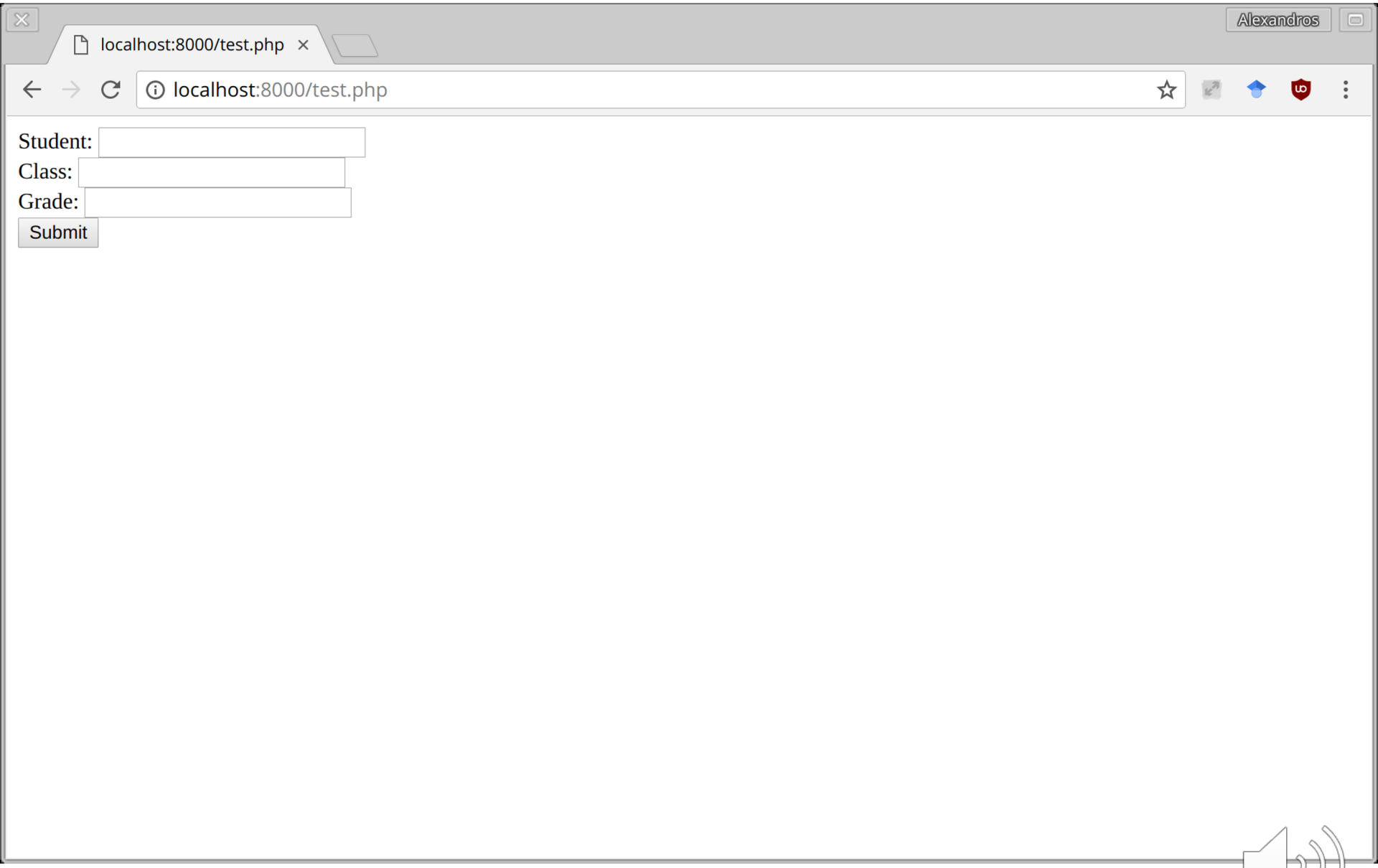
- How to validate user input on HTML forms?
- Traditionally requires a round-trip to the server, where the server can check the input to make sure that it is valid

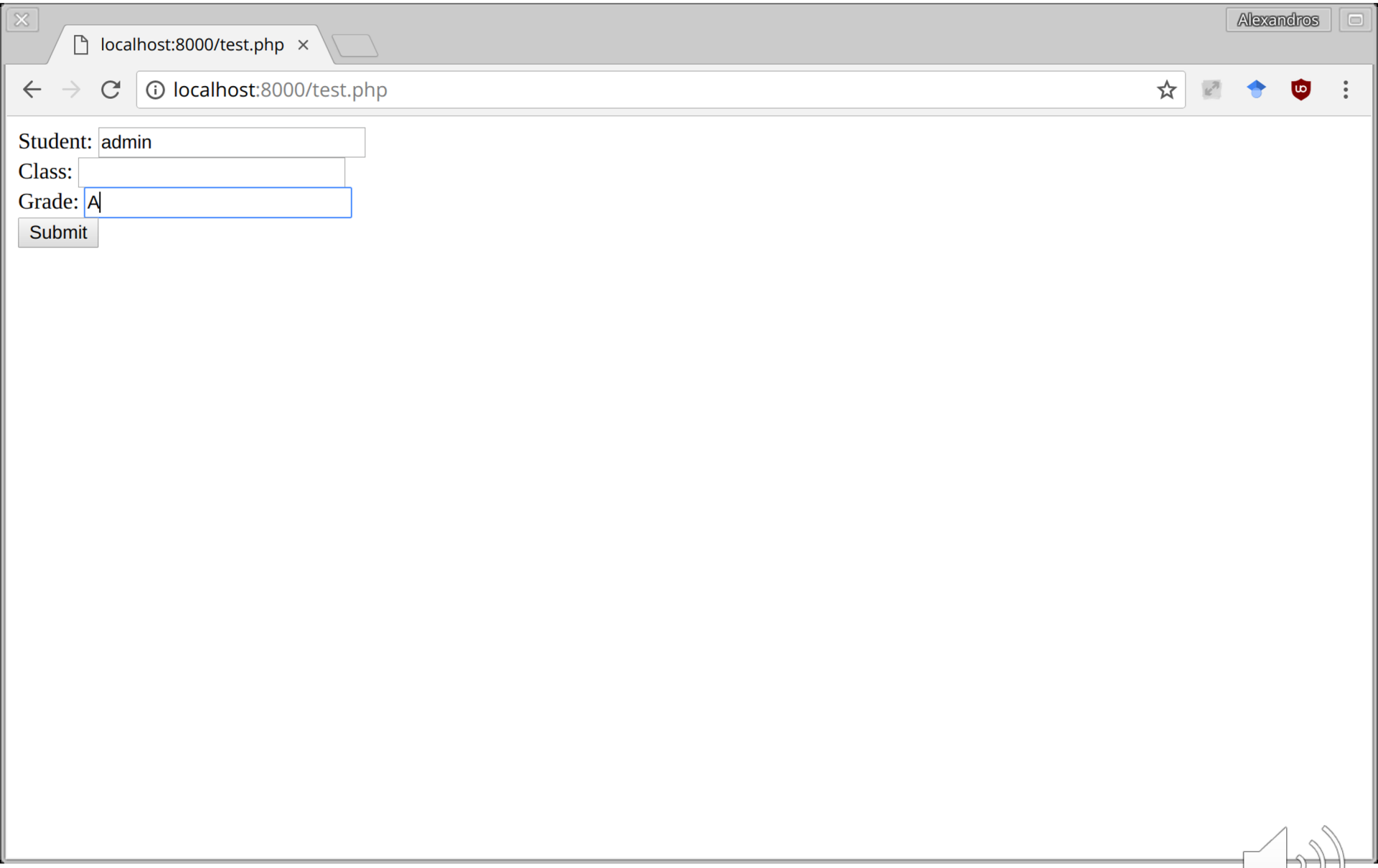
JavaScript Uses – Form Validation

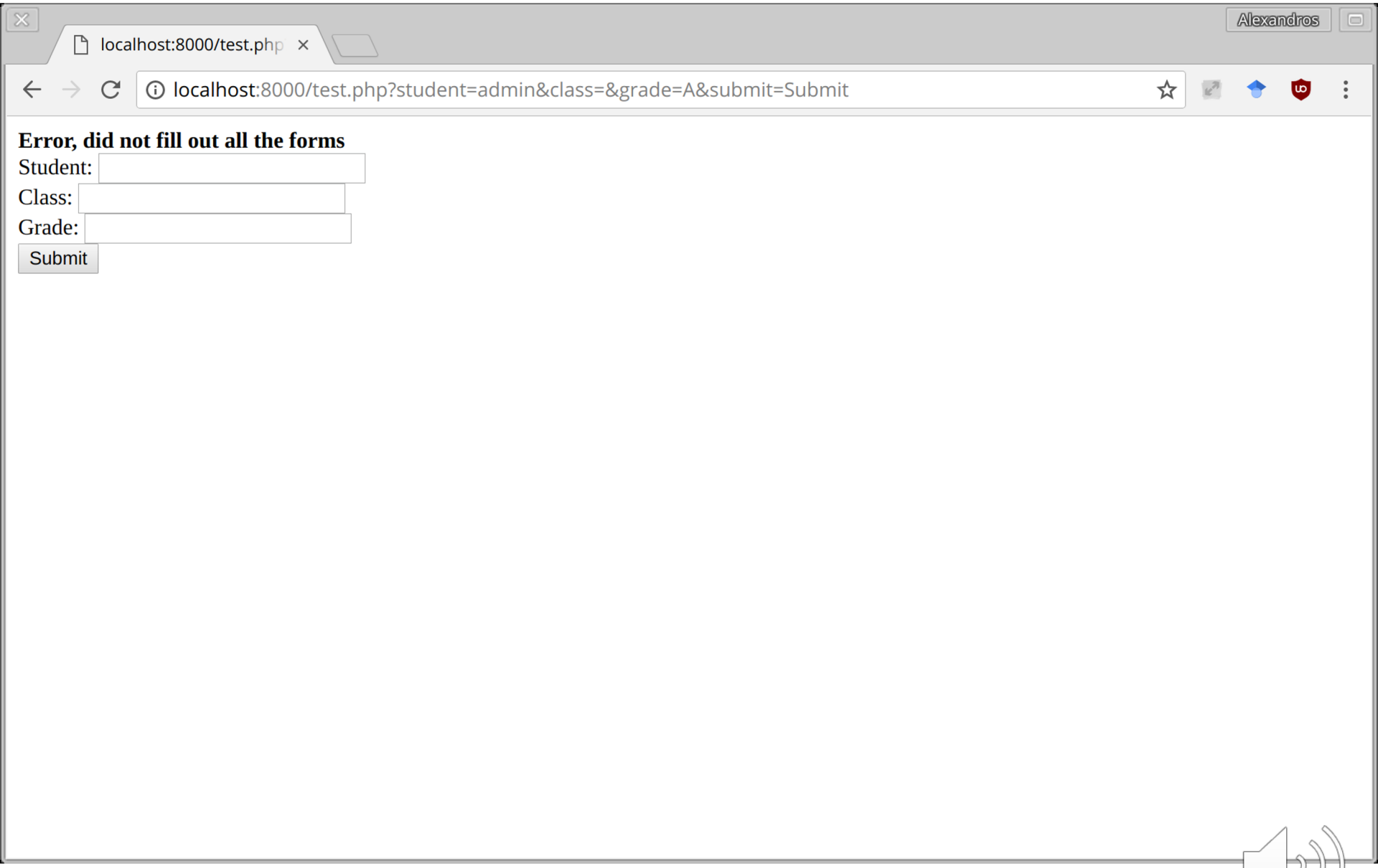
```
<?php
if ($_GET['submit']) {
  $student = $_GET['student'];
  $class = $_GET['class'];
  $grade = $_GET['grade'];
  if (empty($student) || empty($class) || empty($grade)) {
            echo "<b>Error, did not fill out all the forms</b>";
  }
  else if (!($grade == 'A' || $grade == 'B' || $grade == 'C' ||
               $grade == 'D' || $grade == 'F')) {
            echo "<b>Error, grade must be one of A, B, C, D, or F</b>";
  }
  else { echo "<b>Grade successfully submitted!</b>";
  }
} ?>
<form>
 Student: <input type="text" name="student"><br>
 Class:  <input type="text" name="class"><br>
 Grade:  <input type="text" name="grade"><br>
 <input type="submit" name="submit">
</form>
```

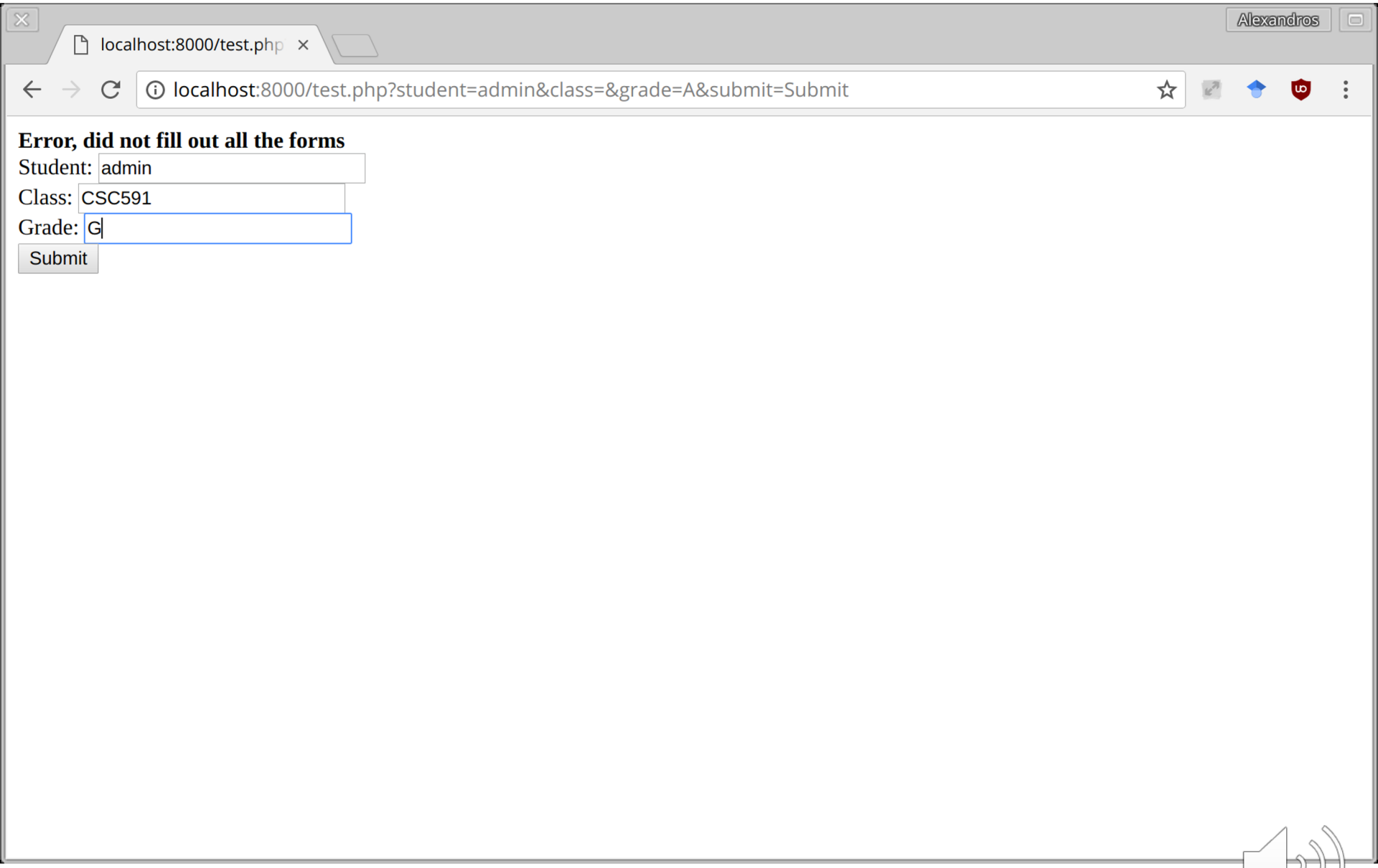
Quick tip:

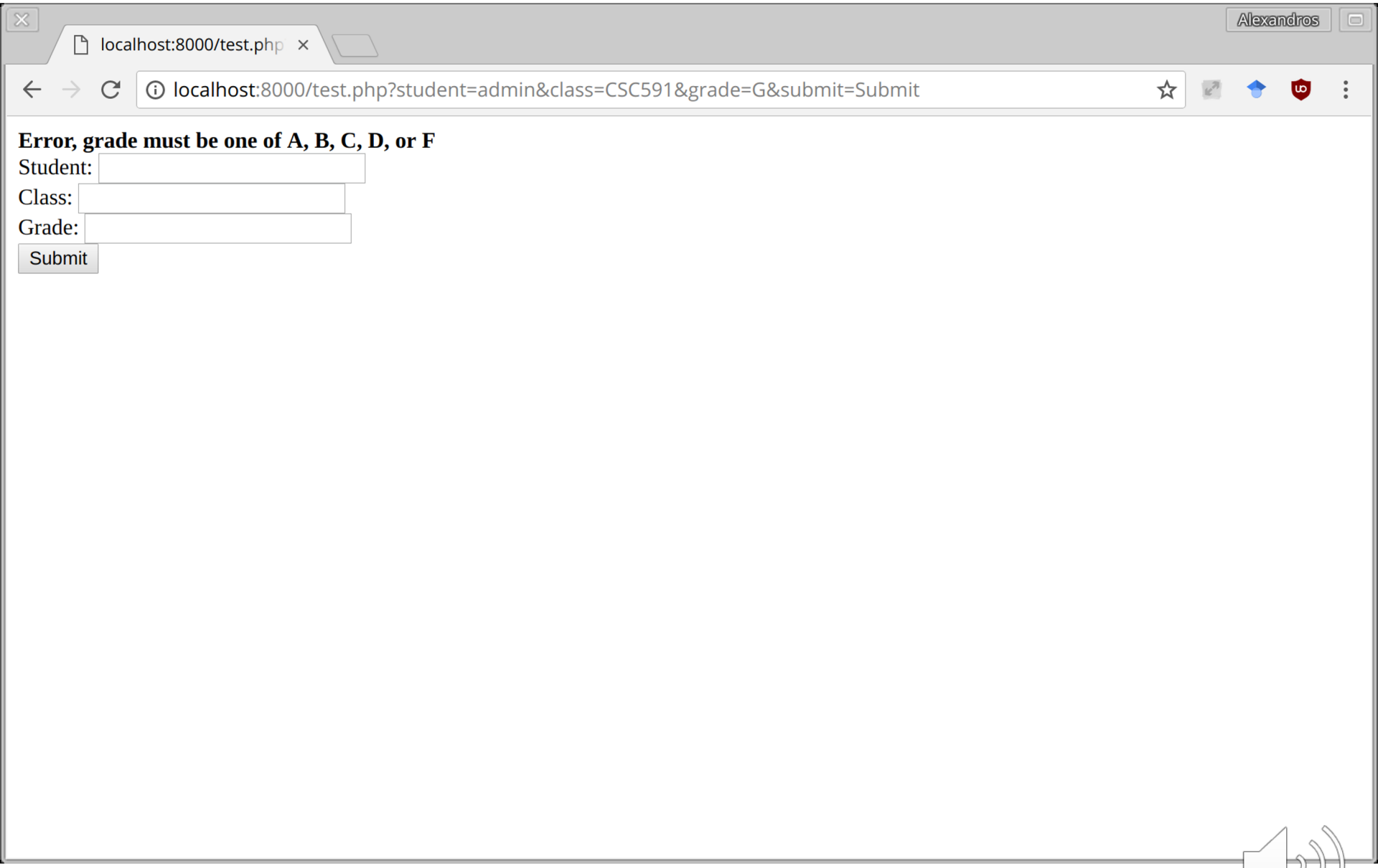
```
$ cd /var/www/public_html
$ php -S localhost:8000
```

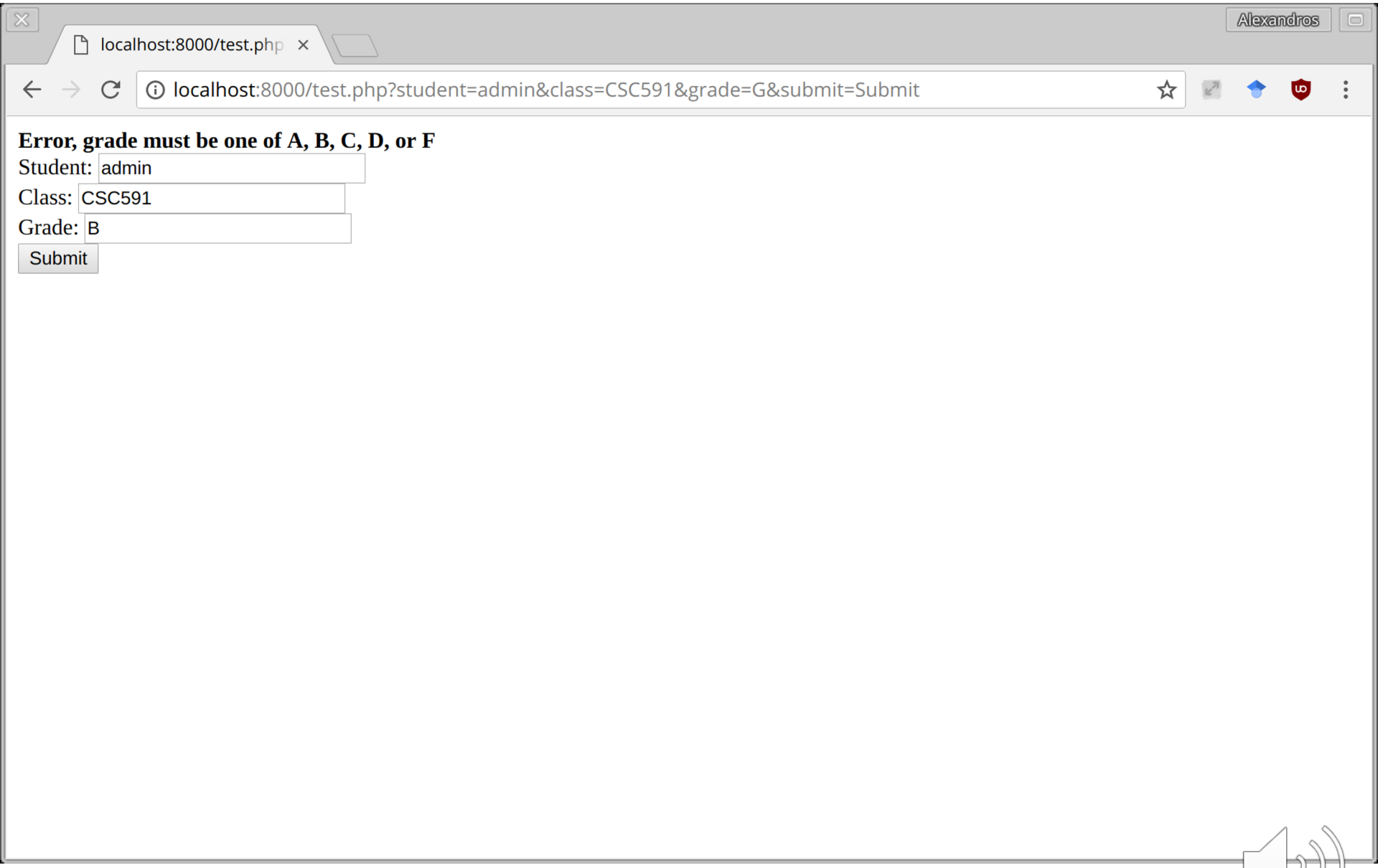

Alexandros
localhost:8000/test.php
localhost:8000/test.php
Student:
Class:
Grade:
Submit

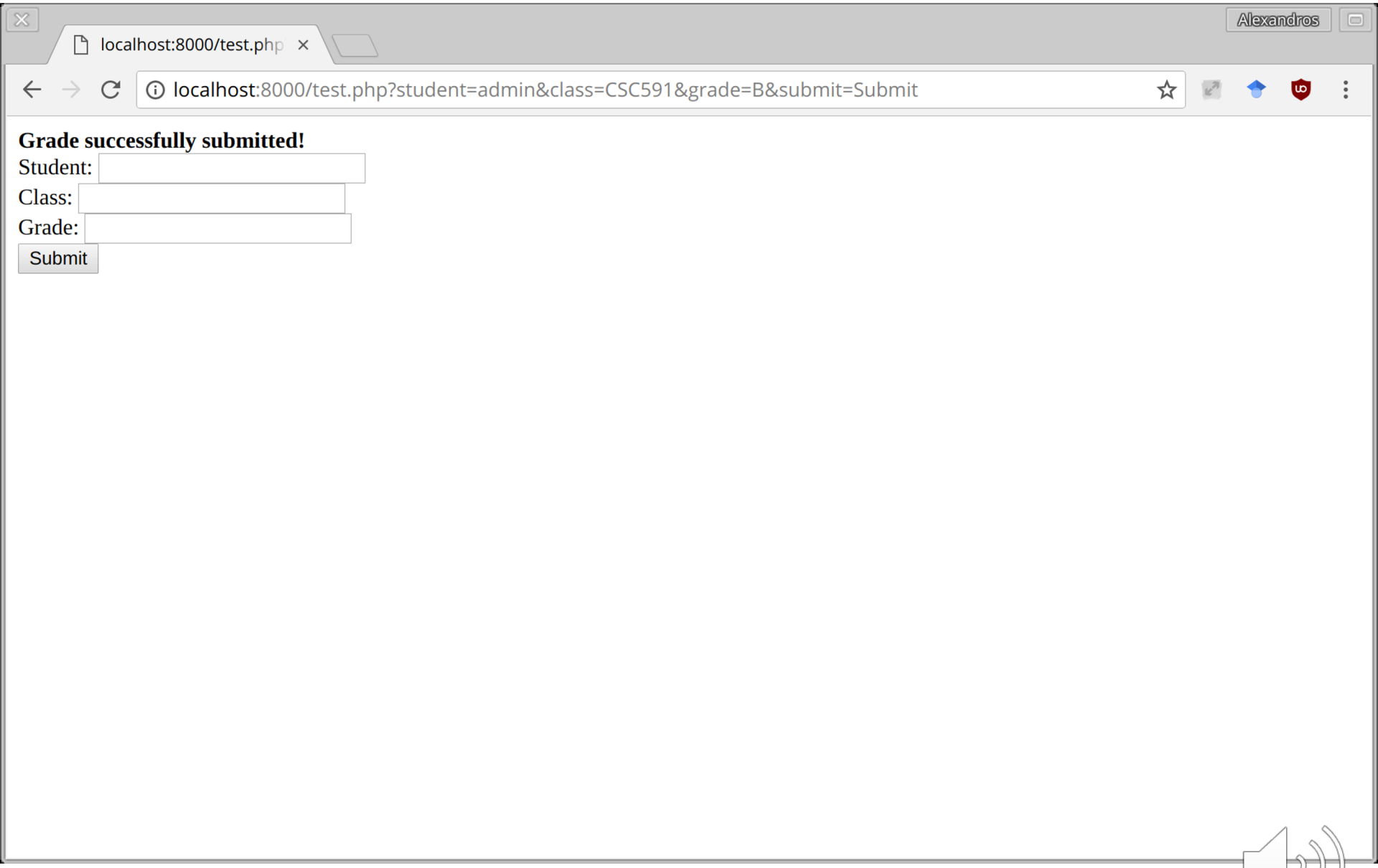

Alexandros
localhost:8000/test.php
localhost:8000/test.php
Student: admin
Class:
Grade: A
Submit


Alexandros
localhost:8000/test.php
localhost:8000/test.php?student=admin&class=&grade=A&submit=Submit
Error, did not fill out all the forms
Student:
Class:
Grade:
Submit


Alexandros
localhost:8000/test.php
localhost:8000/test.php?student=admin&class=&grade=A&submit=Submit
Error, did not fill out all the forms
Student: admin
Class: CSC591
Grade: G
Submit


Alexandros
localhost:8000/test.php
localhost:8000/test.php?student=admin&class=CSC591&grade=G&submit=Submit
Error, grade must be one of A, B, C, D, or F
Student:
Class:
Grade:
Submit


Alexandros
localhost:8000/test.php
localhost:8000/test.php?student=admin&class=CSC591&grade=G&submit=Submit
Error, grade must be one of A, B, C, D, or F
Student: admin
Class: CSC591
Grade: B
Submit


Alexandros
localhost:8000/test.php
localhost:8000/test.php?student=admin&class=CSC591&grade=B&submit=Submit
Grade successfully submitted!
Student:
Class:
Grade:
Submit

form_validation_regular.php

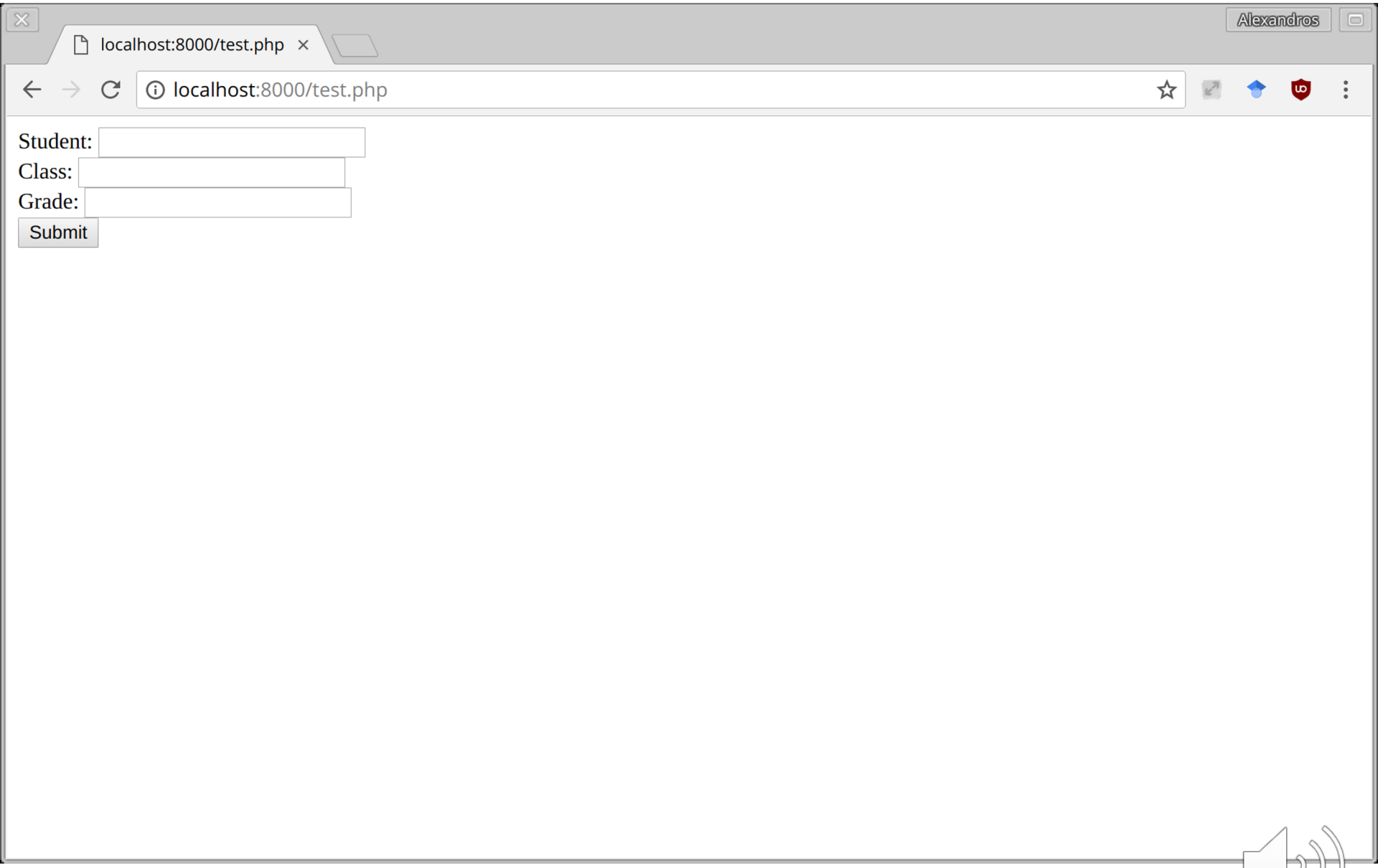
empty class field

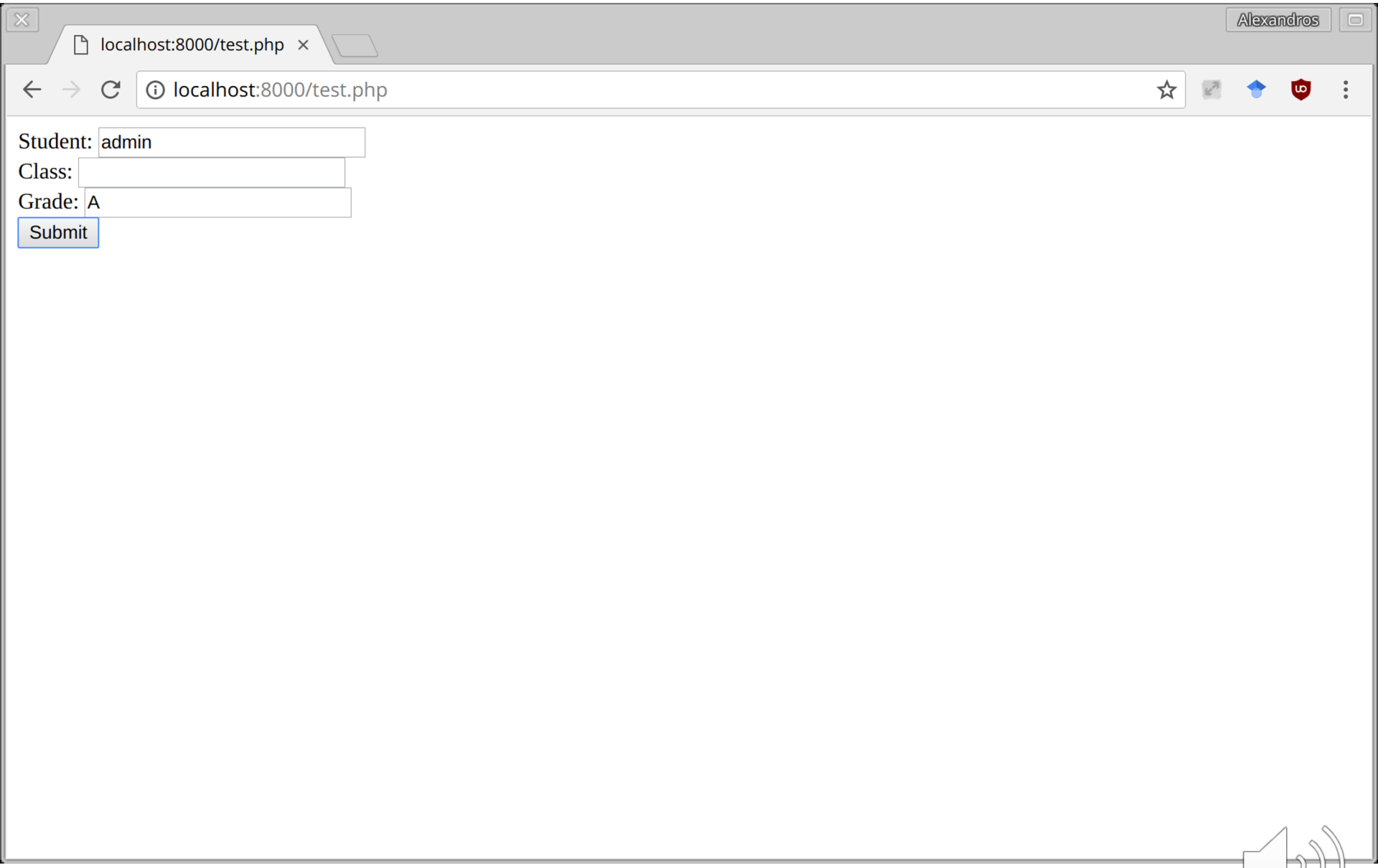
wrong grade format

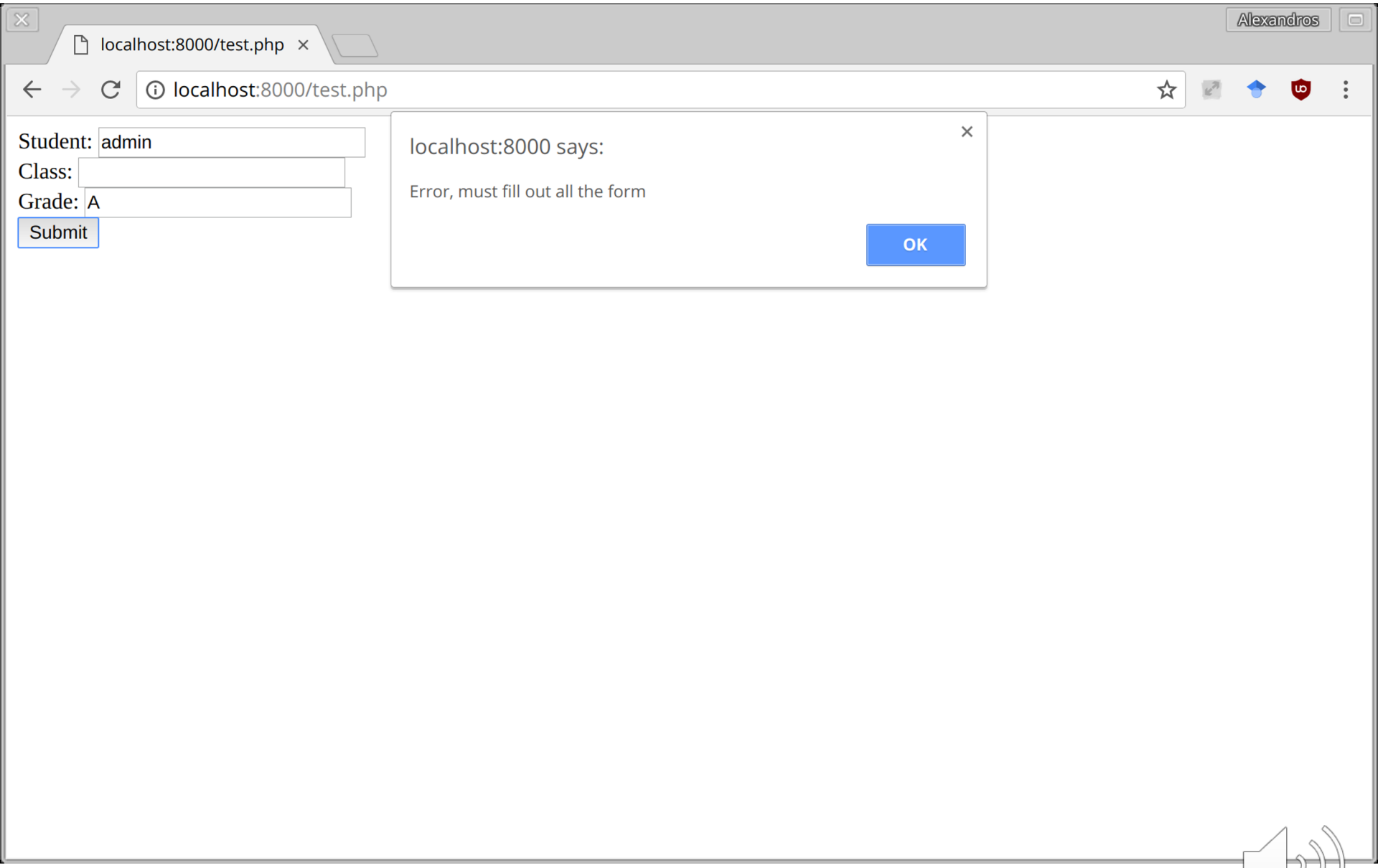
correct submission

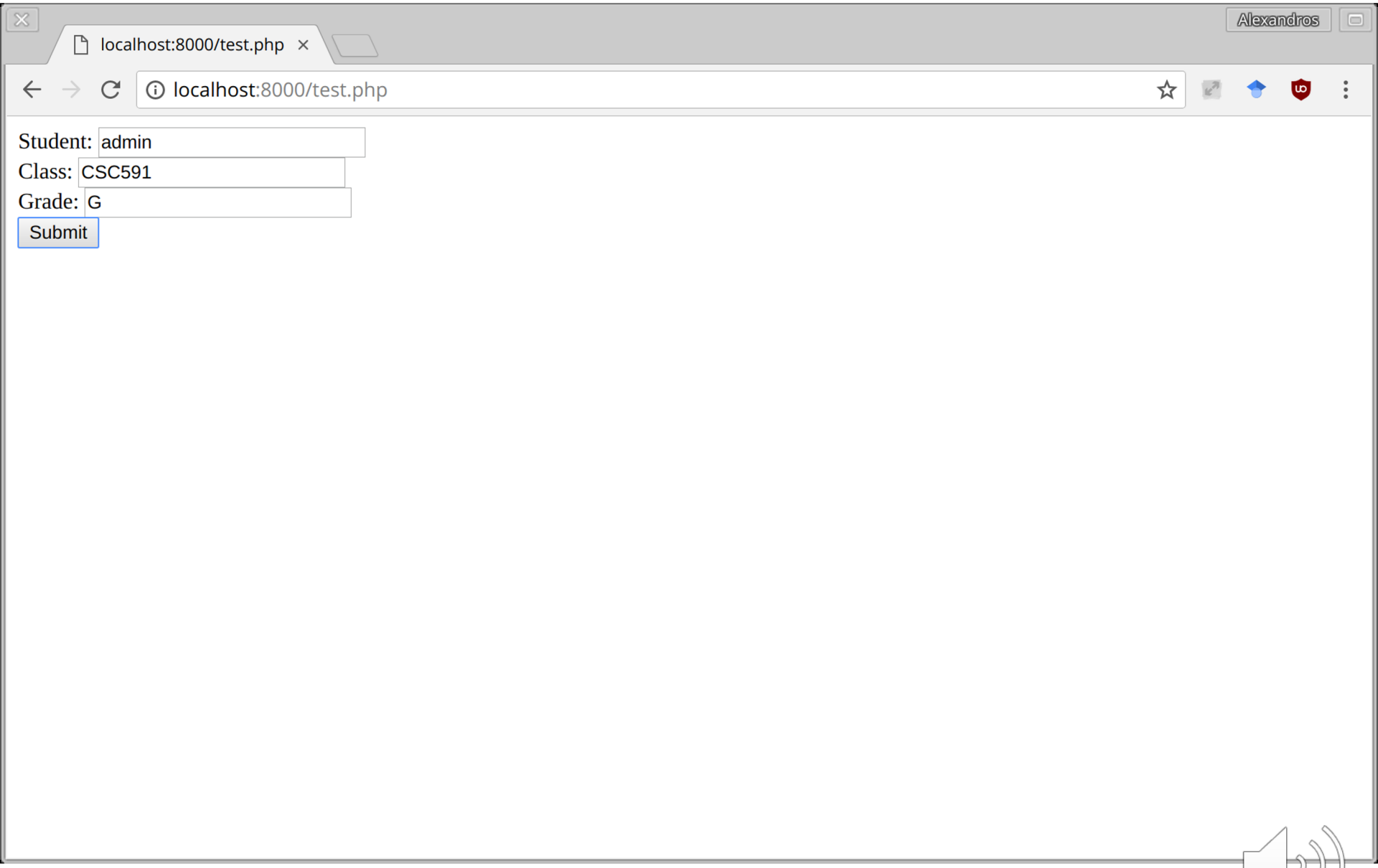
JavaScript Uses – Form Validation

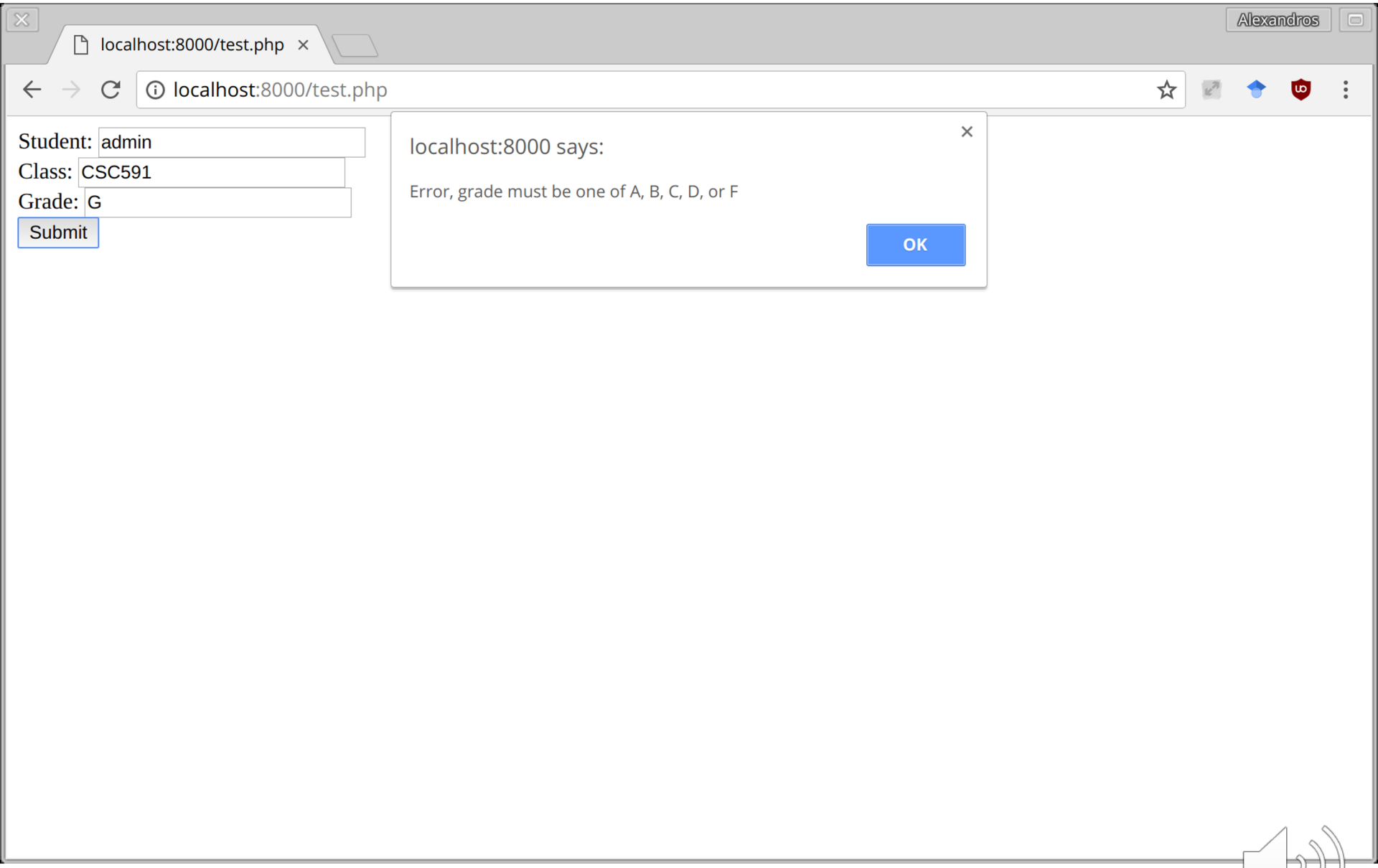
```
<script>
function check_form() {
  var form = document.getElementById("the_form");
  if (form.student.value == "" || form.class.value == "" || form["grade"].value == ""){
            alert("Error, must fill out all the form");
            return false;
  }
  var grade = form["grade"].value;
  if (!(grade == 'A' || grade == 'B' || grade == 'C' ||
        grade == 'D' || grade == 'F')) {
            alert("Error, grade must be one of A, B, C, D, or F");
            return false;
  }
  return true;
}
</script>
<form id="the_form" onsubmit="return check_form()">
 Student: <input type="text" name="student"><br>
 Class:  <input type="text" name="class"><br>
 Grade:  <input type="text" name="grade"><br>
 <input type="submit" name="submit">
</form>
```

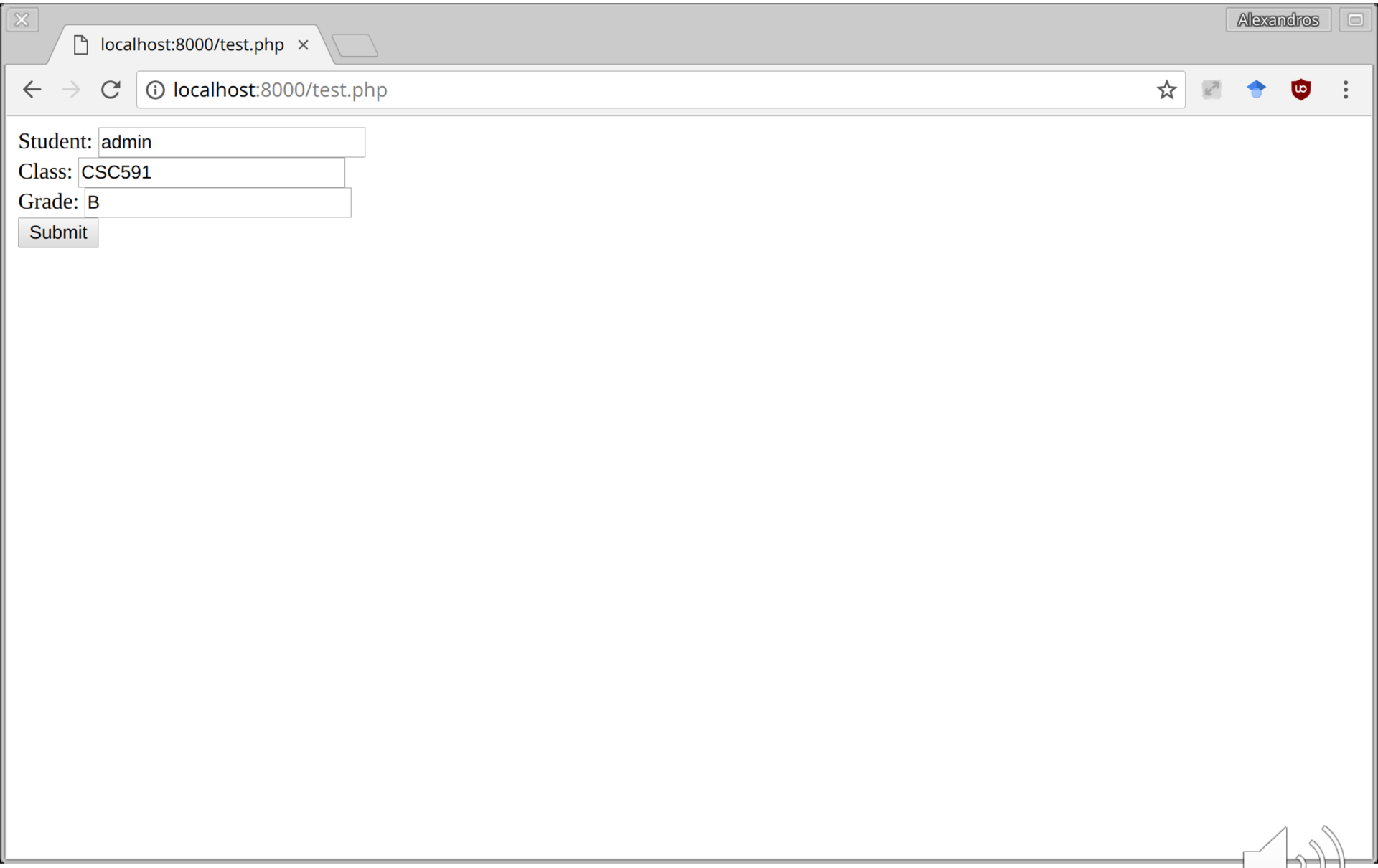

Alexandros
localhost:8000/test.php
localhost:8000/test.php
Student:
Class:
Grade:
Submit

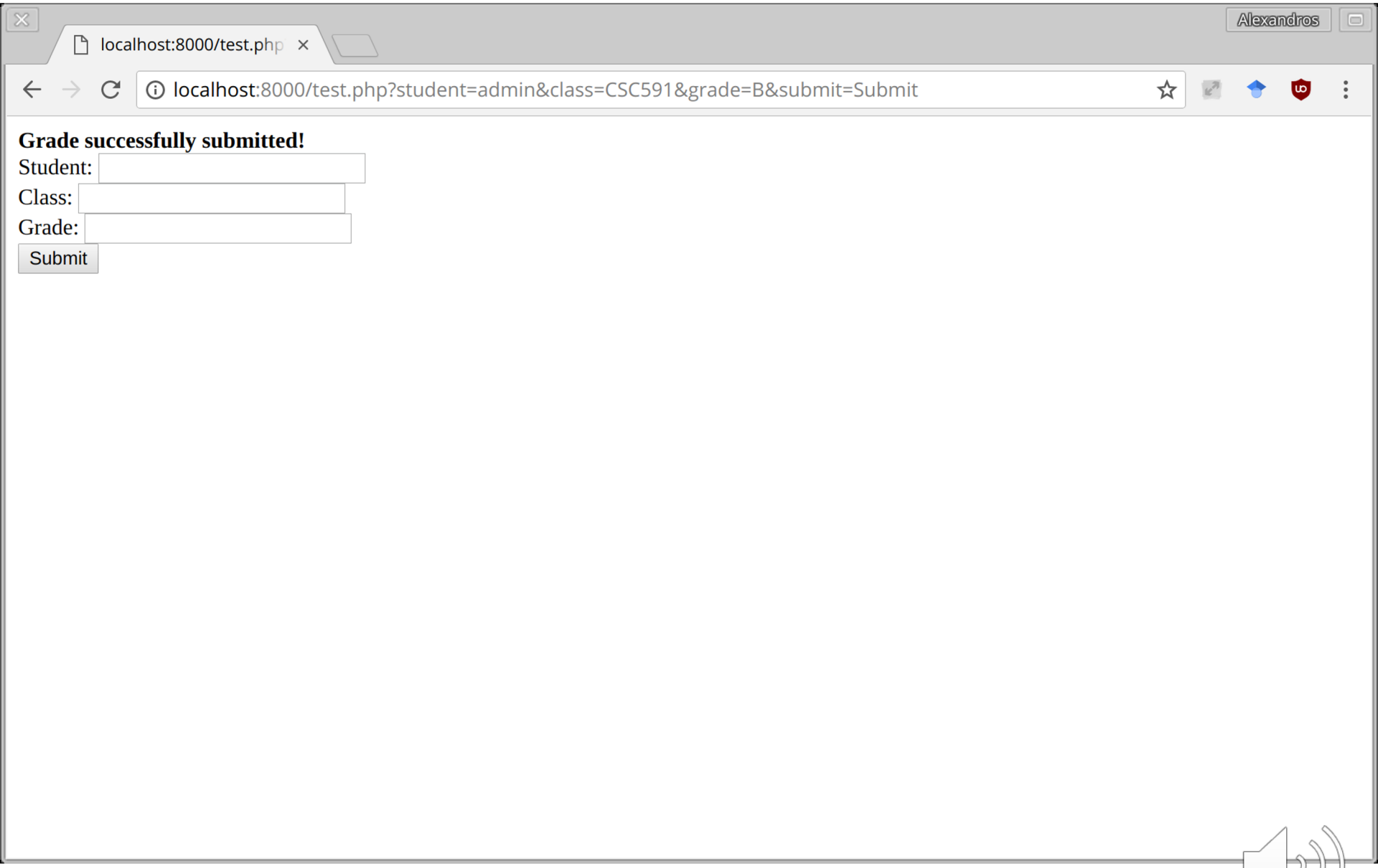

Alexandros
localhost:8000/test.php
localhost:8000/test.php
Student: admin
Class:
Grade: A
Submit

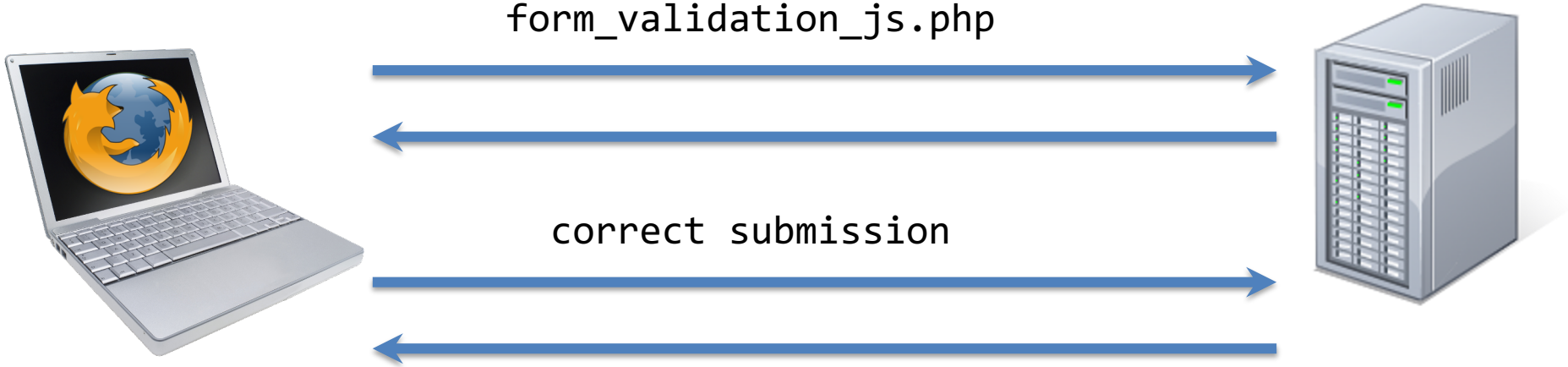

Alexandros
localhost:8000/test.php
localhost:8000/test.php
Student: admin
Class:
Grade: A
Submit
localhost:8000 says:
Error, must fill out all the form
OK


Alexandros
localhost:8000/test.php
localhost:8000/test.php
Student: admin
Class: CSC591
Grade: G
Submit


Alexandros
localhost:8000/test.php
localhost:8000/test.php
Student: admin
Class: CSC591
Grade: G
Submit
localhost:8000 says:
Error, grade must be one of A, B, C, D, or F
OK


Alexandros
localhost:8000/test.php
localhost:8000/test.php
Student: admin
Class: CSC591
Grade: B
Submit


Alexandros
localhost:8000/test.php
localhost:8000/test.php?student=admin&class=CSC591&grade=B&submit=Submit
Grade successfully submitted!
Student:
Class:
Grade:
Submit


form_validation_js.php
correct submission

Client-Side Validation

- Now that we're doing validation on the client, can we get rid of all those PHP checks in our server-side code?
  - No!
  - No guarantee that client-side validation is performed
    - User disables JavaScript
    - Command-line clients
- Otherwise, users could enter arbitrary data that does not conform to your validation
  - Could lead to a security compromise or not
- So the validation must remain on the server-side and the client-side
  - Brings up another problem, how to perform consistent validation when server-side and client-side written in different languages

source: https://github.com/OWASP/CheatSheetSeries/blob/master/cheatsheets/AJAX_Security_Cheat_Sheet.md