EECS 367 & ROB 320/511 Lab
Pendularm (assignment 2) code overview

Autorob Lab
Git-ting Started with Git

Michigan EECS 367 *Introduction to Autonomous Robotics* | ROB 320/511 *Robot Operating Systems*

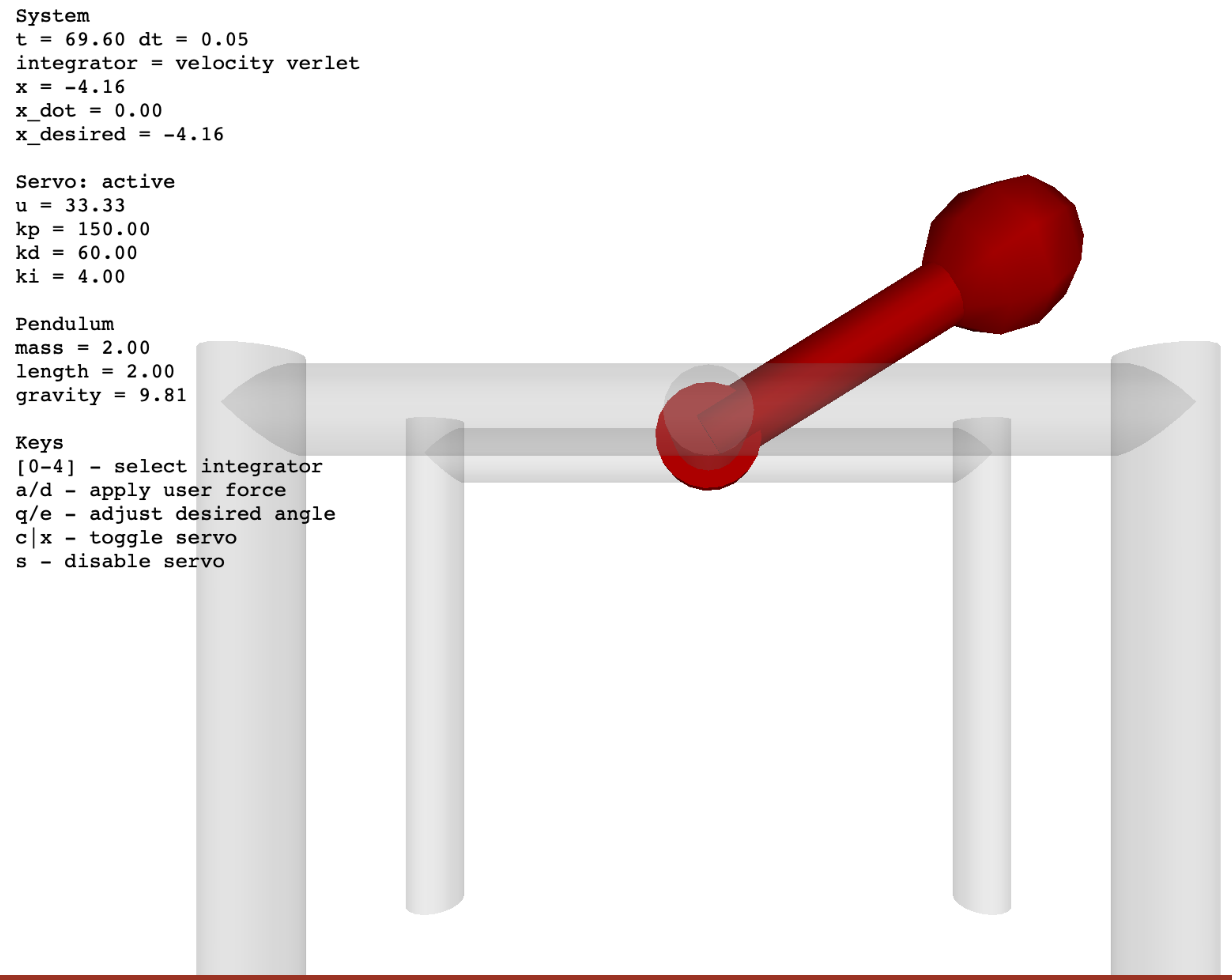
Administrative

- Assignment#0 is due
    - Grade.js: Check, Check - Partial Credit, Due, Broken
- Assignment #1 is due Monday, January 30th
- Jiayao (Vanessa) will become the CI Grader Queen

Lab Takeaways

1. Assignment overview
2. Stencil walkthrough
3. Pendularm demo
4. Coding considerations

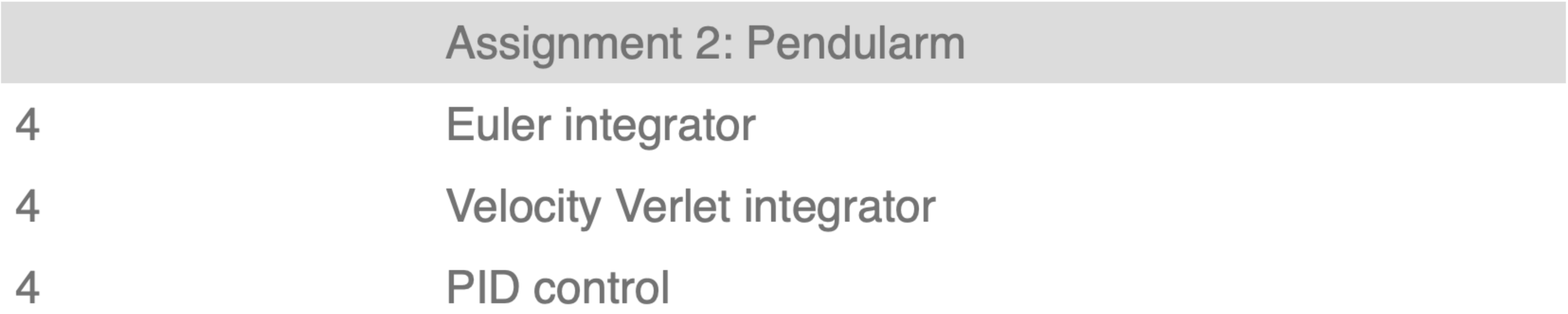
Pendularm Overview



```
System
t = 69.60 dt = 0.05
integrator = velocity verlet
x = -4.16
x_dot = 0.00
x_desired = -4.16

Servo: active
u = 33.33
kp = 150.00
kd = 60.00
ki = 4.00

Pendulum
mass = 2.00
length = 2.00
gravity = 9.81

Keys
[0-4] - select integrator
a/d - apply user force
q/e - adjust desired angle
c|x - toggle servo
s - disable servo
```

We will be implementing a servo controller for the pendularm!

Pendularm Overview



	Assignment 2: Pendularm
4	Euler integrator
4	Velocity Verlet integrator
4	PID control

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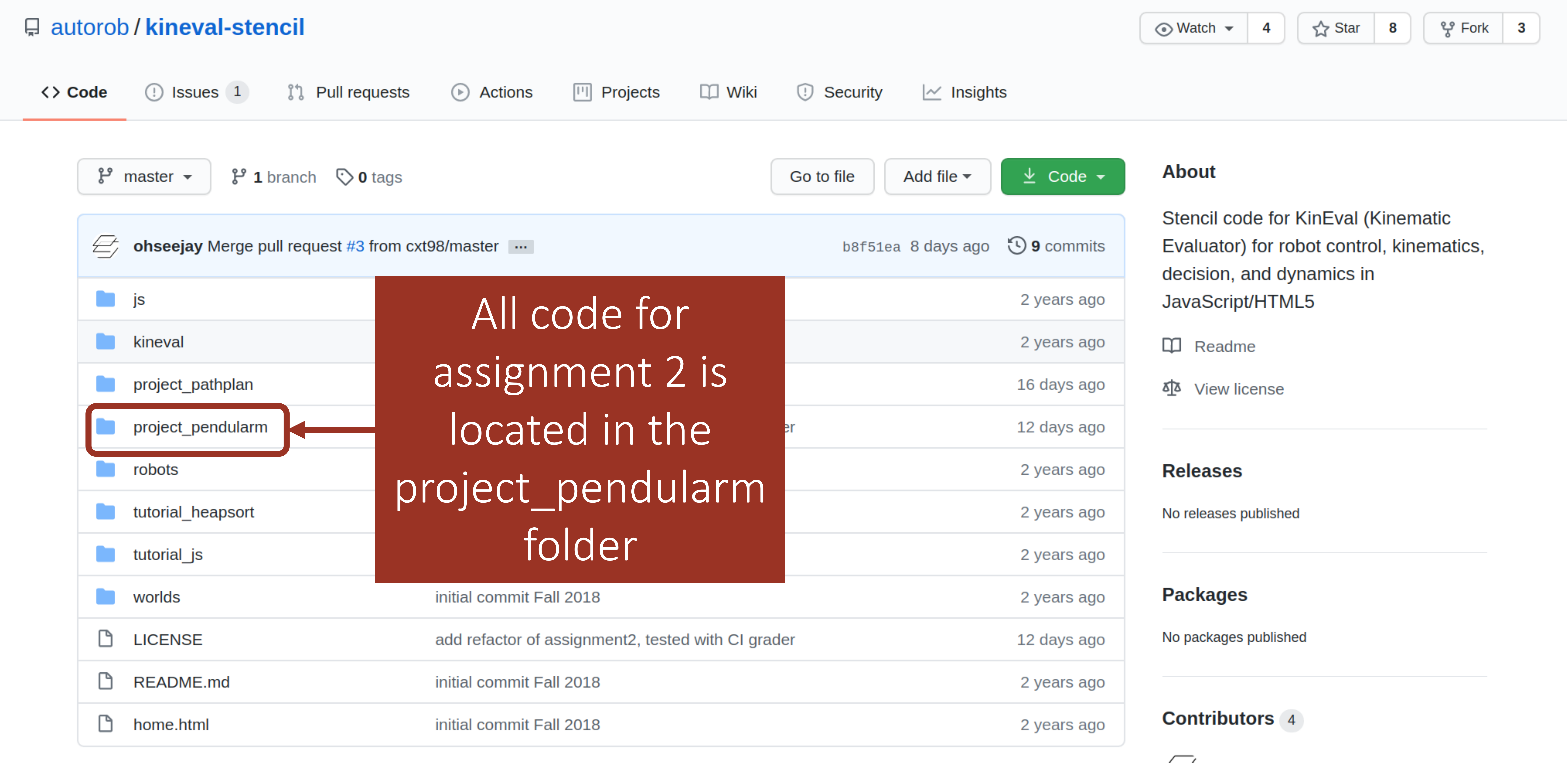
Stencil Walkthrough



autorob / kineval-stencil

ohseejay Merge pull request #3 from cxt98/master … b8f51ea 8 days ago 9 commits

js		2 years ago
kineval		2 years ago
project_pathplan		16 days ago
project_pendularm	…er	12 days ago
robots		2 years ago
tutorial_heapsort		2 years ago
tutorial_js		2 years ago
worlds	initial commit Fall 2018	2 years ago
LICENSE	add refactor of assignment2, tested with CI grader	12 days ago
README.md	initial commit Fall 2018	2 years ago
home.html	initial commit Fall 2018	2 years ago

About

Stencil code for KinEval (Kinematic Evaluator) for robot control, kinematics, decision, and dynamics in JavaScript/HTML5

Readme

View license

Releases

No releases published

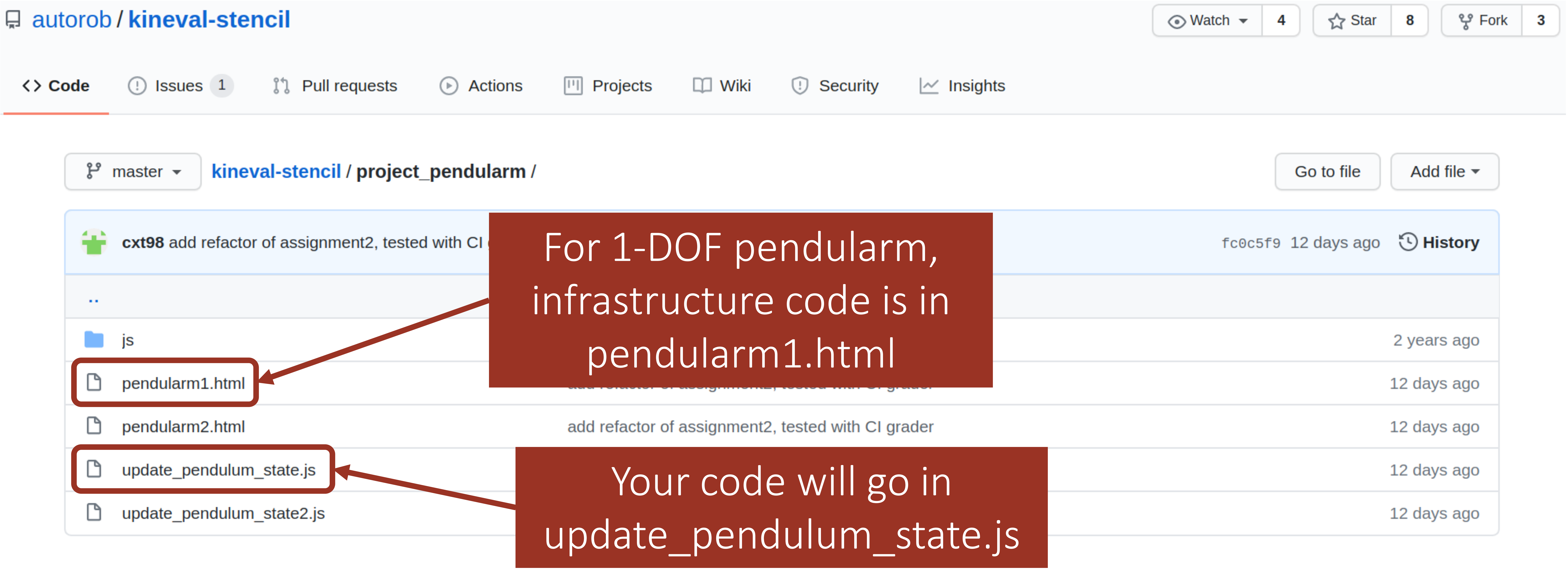
Packages

No packages published

Contributors 4

All code for assignment 2 is located in the project_pendularm folder

Stencil Walkthrough



autorob / **kineval-stencil**

kineval-stencil / **project_pendularm** /

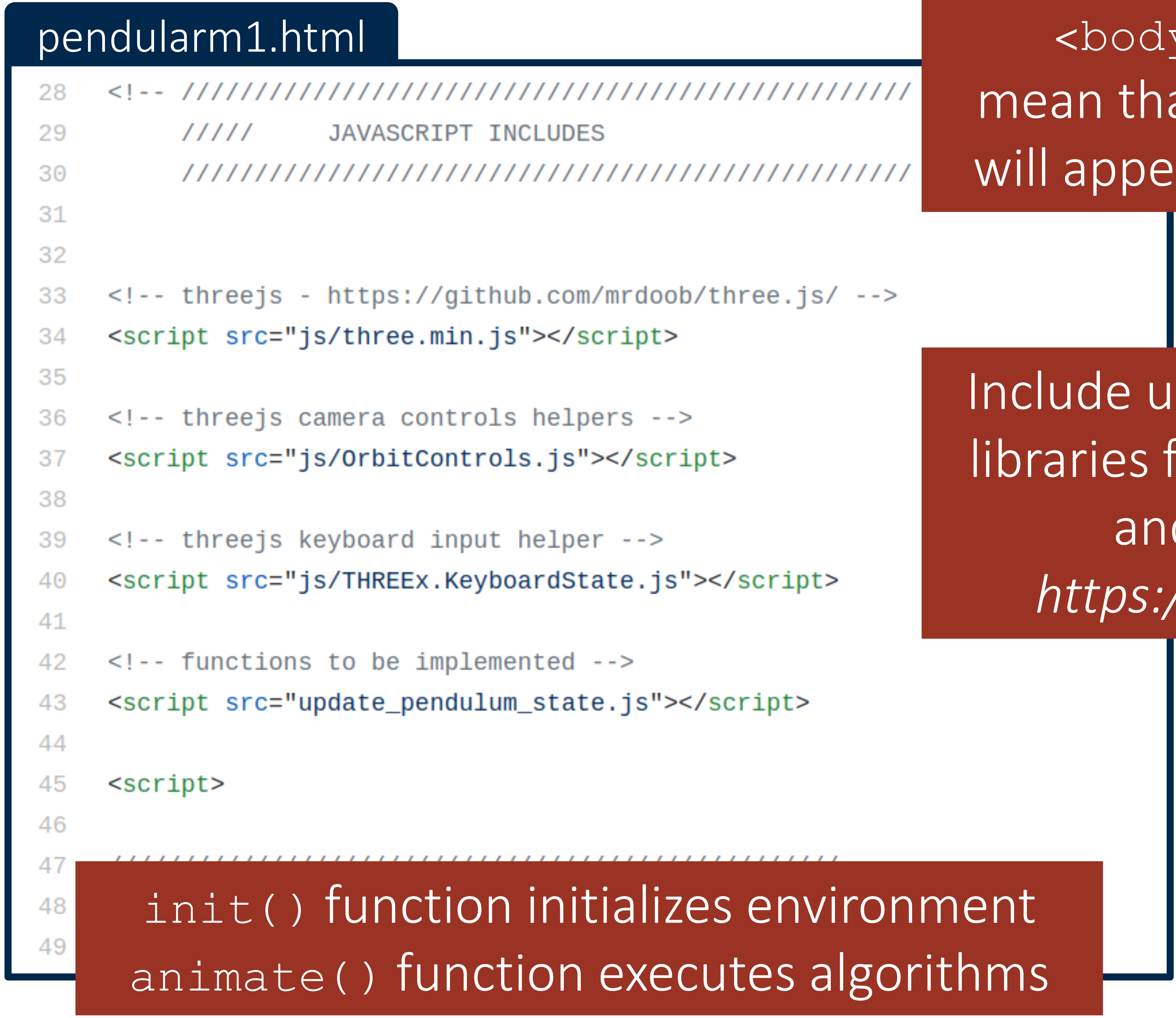
cxt98 add refactor of assignment2, tested with CI — fc0c5f9 12 days ago

..		
js		2 years ago
pendularm1.html	add refactor of assignment2, tested with CI grader	12 days ago
pendularm2.html	add refactor of assignment2, tested with CI grader	12 days ago
update_pendulum_state.js		12 days ago
update_pendulum_state2.js		12 days ago

For 1-DOF pendularm, infrastructure code is in pendularm1.html

Your code will go in update_pendulum_state.js

Stencil Walkthrough



pendularm1.html

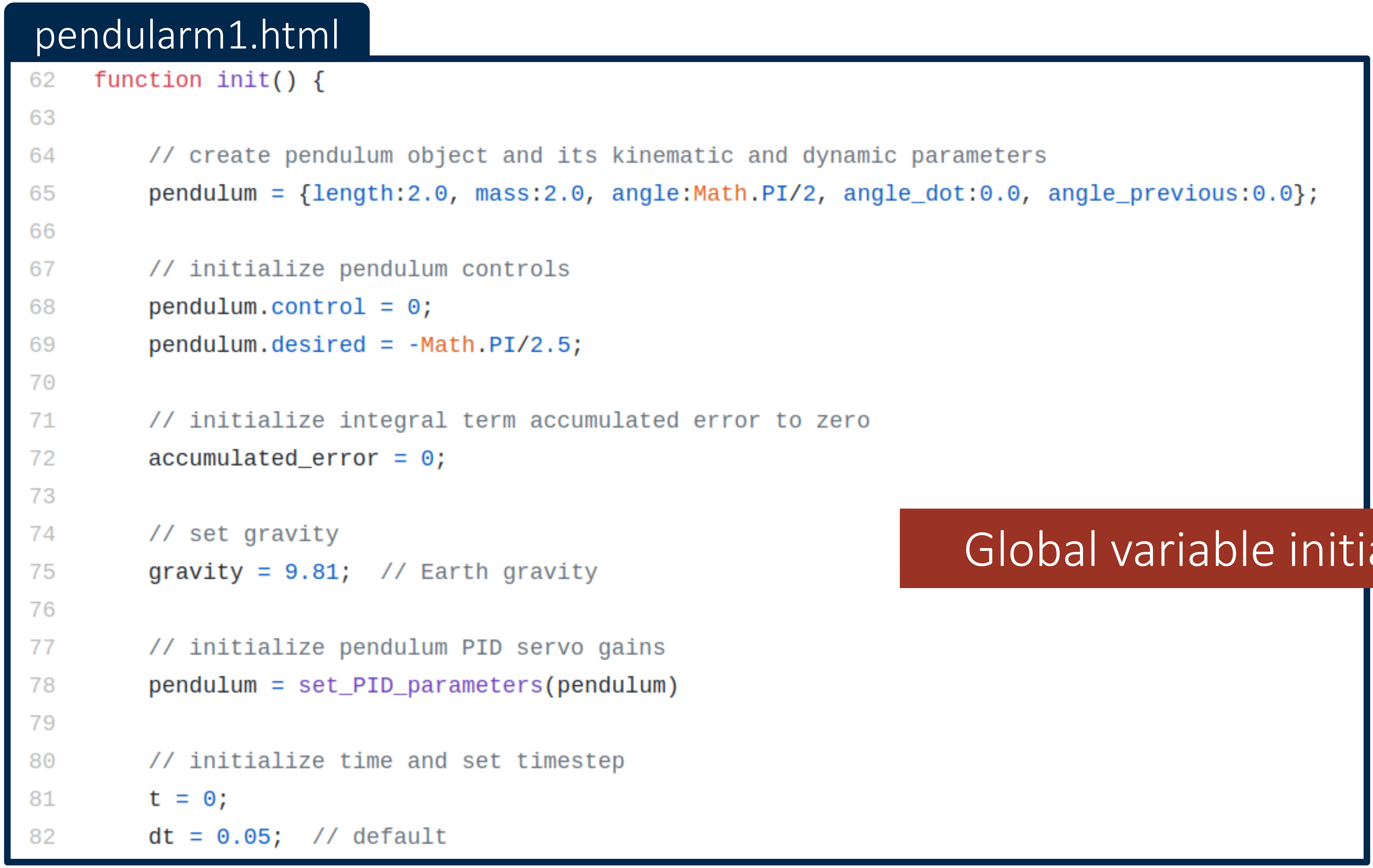
```
<!-- //////////////////////////////////////////////////
     /////     JAVASCRIPT INCLUDES
     //////////////////////////////////////////////////


<!-- threejs - https://github.com/mrdoob/three.js/ -->
<script src="js/three.min.js"></script>

<!-- threejs camera controls helpers -->
<script src="js/OrbitControls.js"></script>

<!-- threejs keyboard input helper -->
<script src="js/THREEx.KeyboardState.js"></script>

<!-- functions to be implemented -->
<script src="update_pendulum_state.js"></script>

<script>

```

`<html>` open tag
`<body>` open tag
mean that what follows
will appear on webpage

Include useful JavaScript libraries for visualization and control
https://threejs.org

`init()` function initializes environment
`animate()` function executes algorithms

Stencil Walkthrough



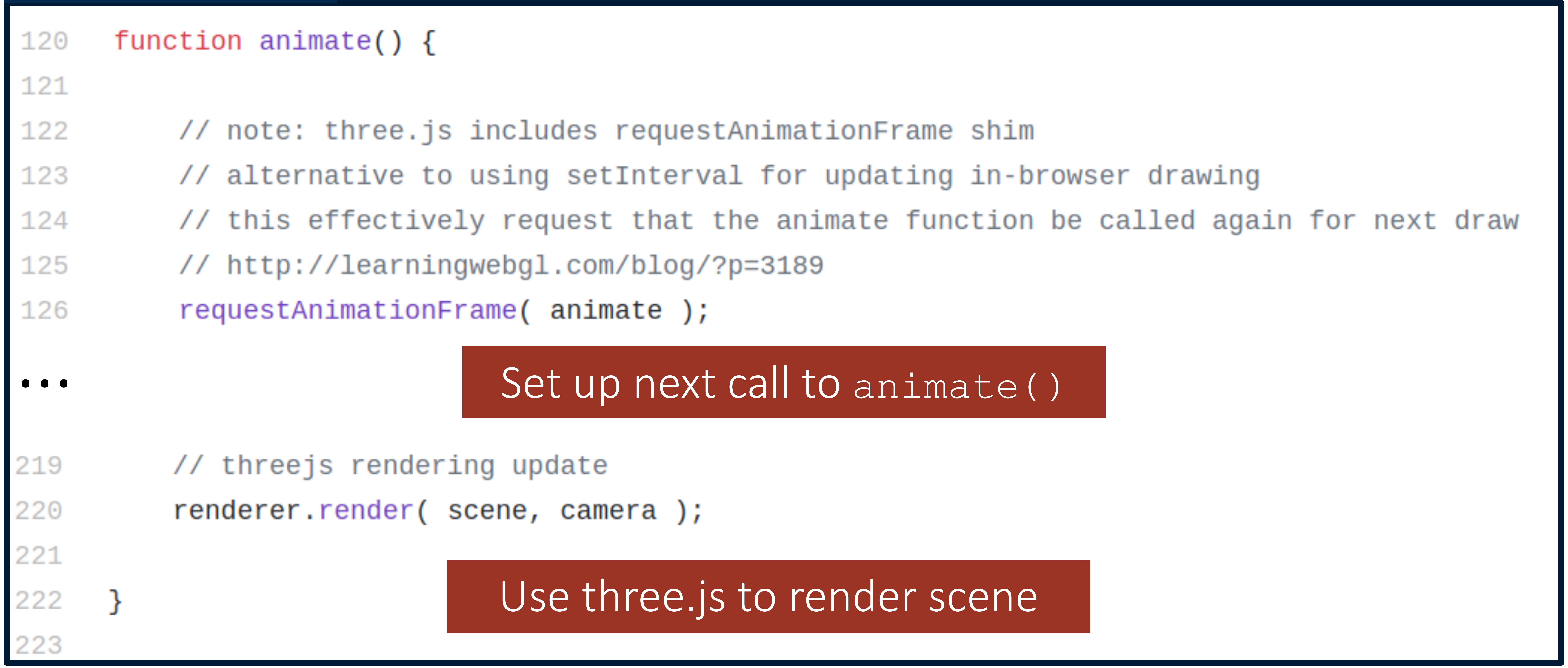
pendularm1.html

```
function init() {

    // create pendulum object and its kinematic and dynamic parameters
    pendulum = {length:2.0, mass:2.0, angle:Math.PI/2, angle_dot:0.0, angle_previous:0.0};

    // initialize pendulum controls
    pendulum.control = 0;
    pendulum.desired = -Math.PI/2.5;

    // initialize integral term accumulated error to zero
    accumulated_error = 0;

    // set gravity
    gravity = 9.81;  // Earth gravity

    // initialize pendulum PID servo gains
    pendulum = set_PID_parameters(pendulum)

    // initialize time and set timestep
    t = 0;
    dt = 0.05;  // default
```

Global variable initialization

Stencil Walkthrough

pendularm1.html



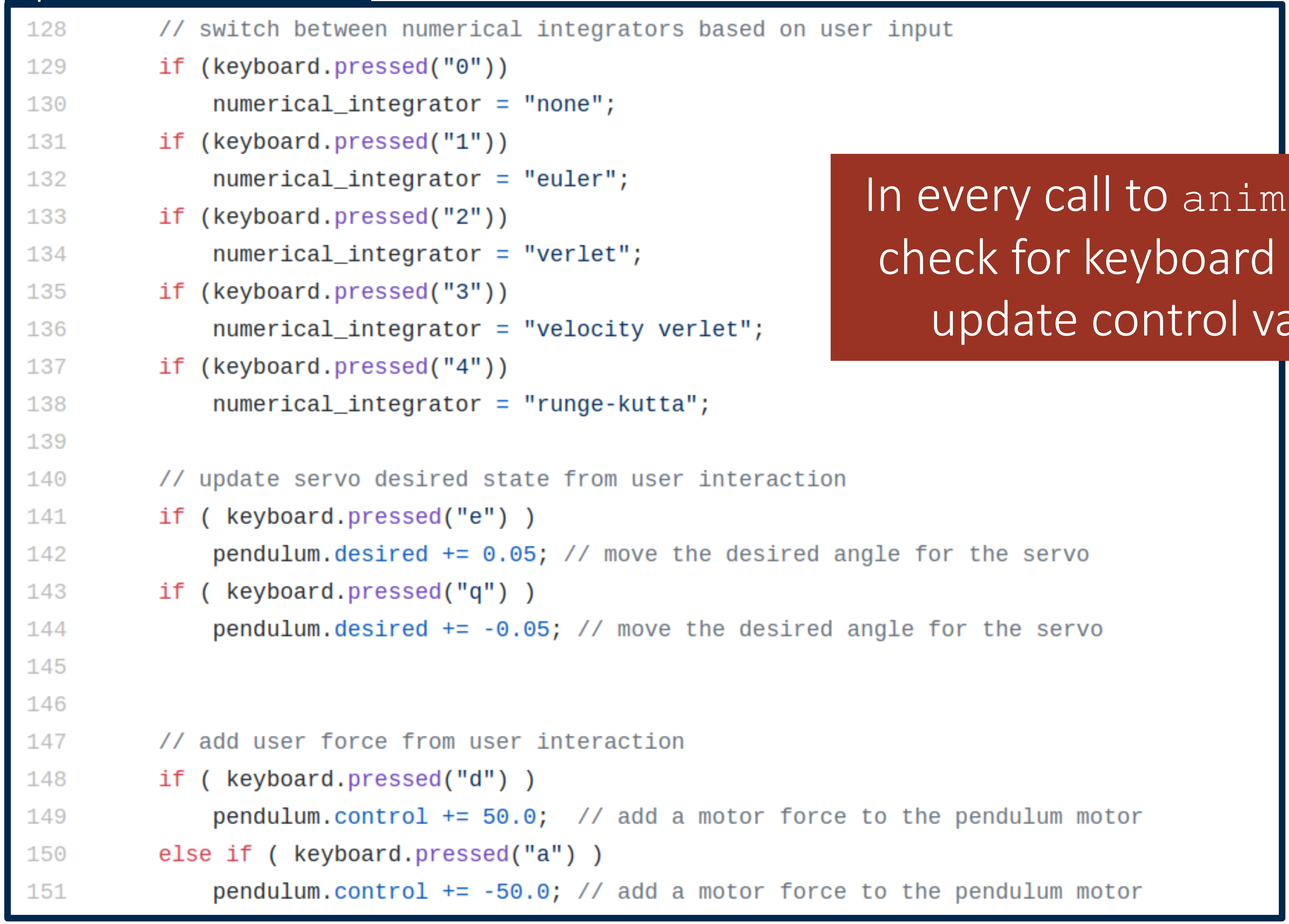
```
function animate() {

    // note: three.js includes requestAnimationFrame shim
    // alternative to using setInterval for updating in-browser drawing
    // this effectively request that the animate function be called again for next draw
    // http://learningwebgl.com/blog/?p=3189
    requestAnimationFrame( animate );
...
    // threejs rendering update
    renderer.render( scene, camera );

}
```

Set up next call to `animate()`

Use three.js to render scene

Stencil Walkthrough

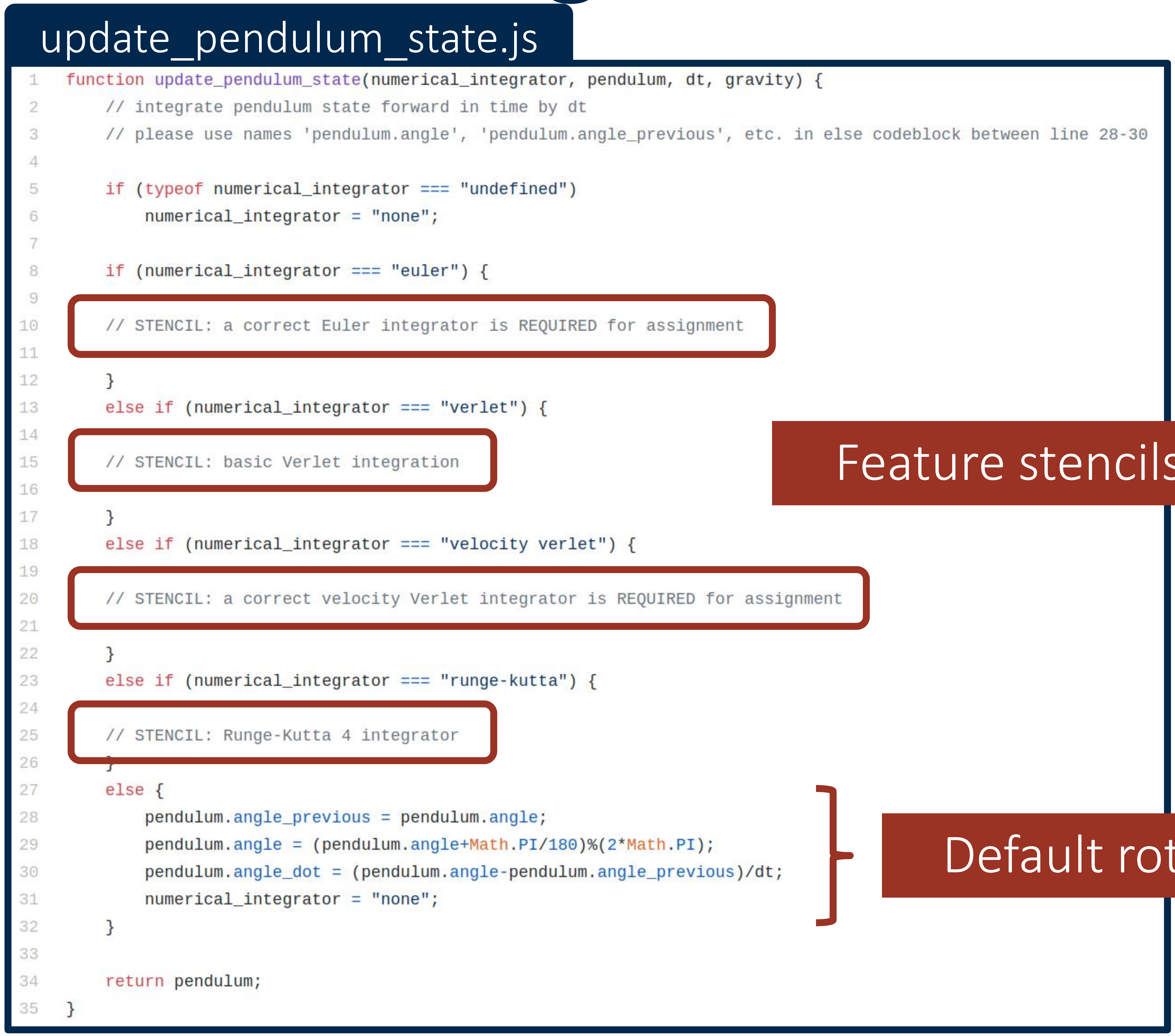
pendularm1.html



```
    // switch between numerical integrators based on user input
    if (keyboard.pressed("0"))
        numerical_integrator = "none";
    if (keyboard.pressed("1"))
        numerical_integrator = "euler";
    if (keyboard.pressed("2"))
        numerical_integrator = "verlet";
    if (keyboard.pressed("3"))
        numerical_integrator = "velocity verlet";
    if (keyboard.pressed("4"))
        numerical_integrator = "runge-kutta";

    // update servo desired state from user interaction
    if ( keyboard.pressed("e") )
        pendulum.desired += 0.05; // move the desired angle for the servo
    if ( keyboard.pressed("q") )
        pendulum.desired += -0.05; // move the desired angle for the servo


    // add user force from user interaction
    if ( keyboard.pressed("d") )
        pendulum.control += 50.0;  // add a motor force to the pendulum motor
    else if ( keyboard.pressed("a") )
        pendulum.control += -50.0; // add a motor force to the pendulum motor
```

In every call to `animate()`, we check for keyboard input and update control variables

Stencil Walkthrough



update_pendulum_state.js

```
1  function update_pendulum_state(numerical_integrator, pendulum, dt, gravity) {
2      // integrate pendulum state forward in time by dt
3      // please use names 'pendulum.angle', 'pendulum.angle_previous', etc. in else codeblock between line 28-30
4
5      if (typeof numerical_integrator === "undefined")
6          numerical_integrator = "none";
7
8      if (numerical_integrator === "euler") {
9
10     // STENCIL: a correct Euler integrator is REQUIRED for assignment
11
12     }
13     else if (numerical_integrator === "verlet") {
14
15     // STENCIL: basic Verlet integration
16
17     }
18     else if (numerical_integrator === "velocity verlet") {
19
20     // STENCIL: a correct velocity Verlet integrator is REQUIRED for assignment
21
22     }
23     else if (numerical_integrator === "runge-kutta") {
24
25     // STENCIL: Runge-Kutta 4 integrator
26     }
27     else {
28         pendulum.angle_previous = pendulum.angle;
29         pendulum.angle = (pendulum.angle+Math.PI/180)%(2*Math.PI);
30         pendulum.angle_dot = (pendulum.angle-pendulum.angle_previous)/dt;
31         numerical_integrator = "none";
32     }
33
34     return pendulum;
35 }
```

Feature stencils

Default rotation

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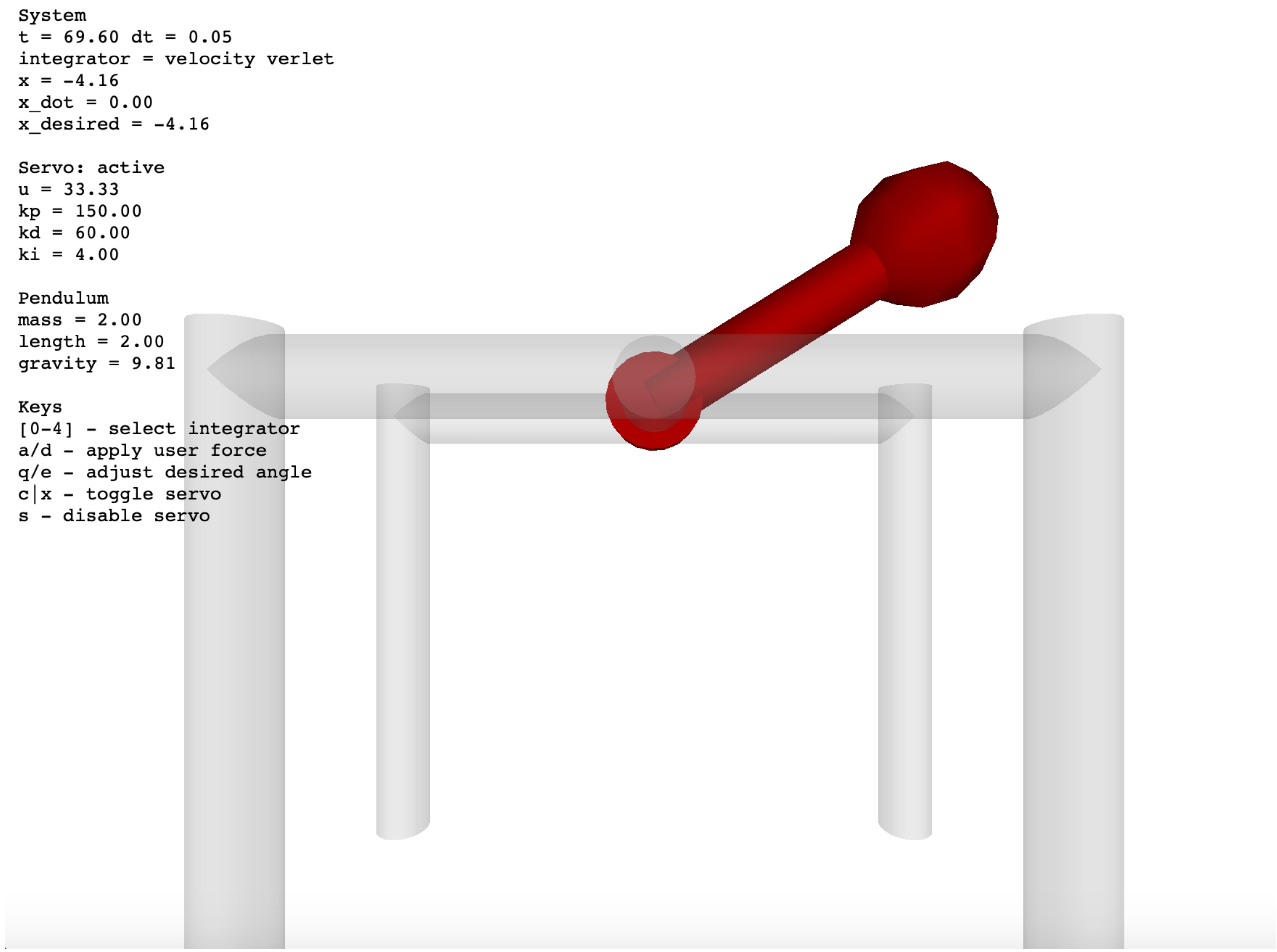
Pendularm Demo



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Coding Considerations

These concepts are optional, meant to help you on programming assignments

Concepts to consider for writing readable, easily debug-able code:

1. Use comments where complicated
2. Add whitespace for readability
3. Local variables to store indices/raw data
4. Helper functions that reduce code duplication

Using Comments

WITHOUT COMMENTS

```
var x = data;
var y = -1;
for (i=0; i<x.length; ++i){
   if (y<x[i]){
      y = x[i];
   }
}
```

WITH COMMENTS

```
// initialize data and min value so far
var x = data;
var y = -1;
// iterate over items in array x
for (i=0; i<x.length; ++i){
   // if current item in array is less than
   // min value so far
   if (y<x[i]){
      // update min value
      y = x[i];
   }
}
```

Using Whitespace

WITHOUT WHITESPACE

```
for (i=0; i<x.length; ++i){
   for (j=0; j<x[i].length; ++j){
      y = doStuff(i,j, x);
      doMoreStuff(y);
   }
}
```

WITH WHITESPACE AND COMMENTS

```
// iterate over every element in array x
for (i=0; i<x.length; ++i){
   for (j=0; j<x[i].length; ++j){

      // perform computation with current
      // position in x
      y = doStuff(i,j, x);

      // use result to do more stuff
      doMoreStuff(y);
   }
}
```

Local Variables for Temp Storage

COMPLICATED INDEX

Input: `G, node`

```
// index offset of neighbor
var offset = [0, 1];

// index into G at neighbor
G[node.i+offset[0]][node.j+offset[1]]
```

READABLE INDEX

Input: `G, node`

```
// index offset of neighbor
var offset = [0, 1];

// calculate indices and store in local var
var nbr_i = node.i+offset[0];
var nbr_j = node.j+offset[1];

// index into G at neighbor
G[nbr_i][nbr_j]
```

Helper Functions

DUPLICATED CODE

Input: `G, node`

```
//index into neighbors
nbr_u = G[node.i][node.j-1];
nbr_r = G[node.i+1][node.j];
nbr_d = G[node.i][node.j+1];
nbr_l = G[node.i-1][node.j];
…
//index into neighbors again
nbr_u = G[node.i][node.j-1];
nbr_r = G[node.i+1][node.j];
nbr_d = G[node.i][node.j+1];
nbr_l = G[node.i-1][node.j];
```

SINGLE FUNCTION, MULTIPLE CALLS

Input: `G, node`

```
function getNeighbors(node){
   nbr_u = G[node.i][node.j-1];
   nbr_r = G[node.i+1][node.j];
   nbr_d = G[node.i][node.j+1];
   nbr_l = G[node.i-1][node.j];

   return [nbr_u, nbr_r, nbr_d, nbr_l];
}
```

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