3. Program Code

All code in the racing-game project written by the two AP CSP students, compiled for use in the AP CSP Create PT, are included. The directory structure of necessary project files (* indicates a file/directory of code that we did not write, and therefore did not include as one of the files below), in order of the included files, is shown below:

```
- node_modules/ *
- package.json
- Procfile
- server.js
- public/
    - index.html
    - game.html
    - js/
        - three.js/ *
        - index.js
        - game.js
        - hostGraphics.js
        - clientGraphics.js
    - css/
        - main.css
        - index.css
        - host.css
        - client.css
    - assets/
        - map/
            - map1.png
            - map2.png
        - blacktop_texture.jpg
        - dawnmountain-xneg.png
        - dawnmountain-xpos.png
        - dawnmountain-yneg.png
        - dawnmountain-ypos.png
        - dawnmountain-zneg.png
        - dawnmountain-zpos.png
        - grass_texture.jpg
        - loading_bg.png
```

`package.json` (information necessary for Node.js); author: Jonathan Lam

```
{
  "name": "racing-game",
  "description": "Multiplayer racing game for AP CSP Create task. Hosted online at
https://racing-game-csp.herokuapp.com with Heroku hosting.",
  "version": "0.0.1",
  "keywords": "multiplayer, racing, game, CSP, computer science principles",
  "dependencies": {
    "express": "4.16.0",
    "express-session": "^1.15.6",
    "express-socket.io-session": "^1.3.2",
    "socket.io": "^2.0.4"
  },
  "repository": {
```

```
    "type": "git",
    "url": "https://www.github.com/jlam55555/racing-game.git"
  },
  "license": "MIT"
}
```

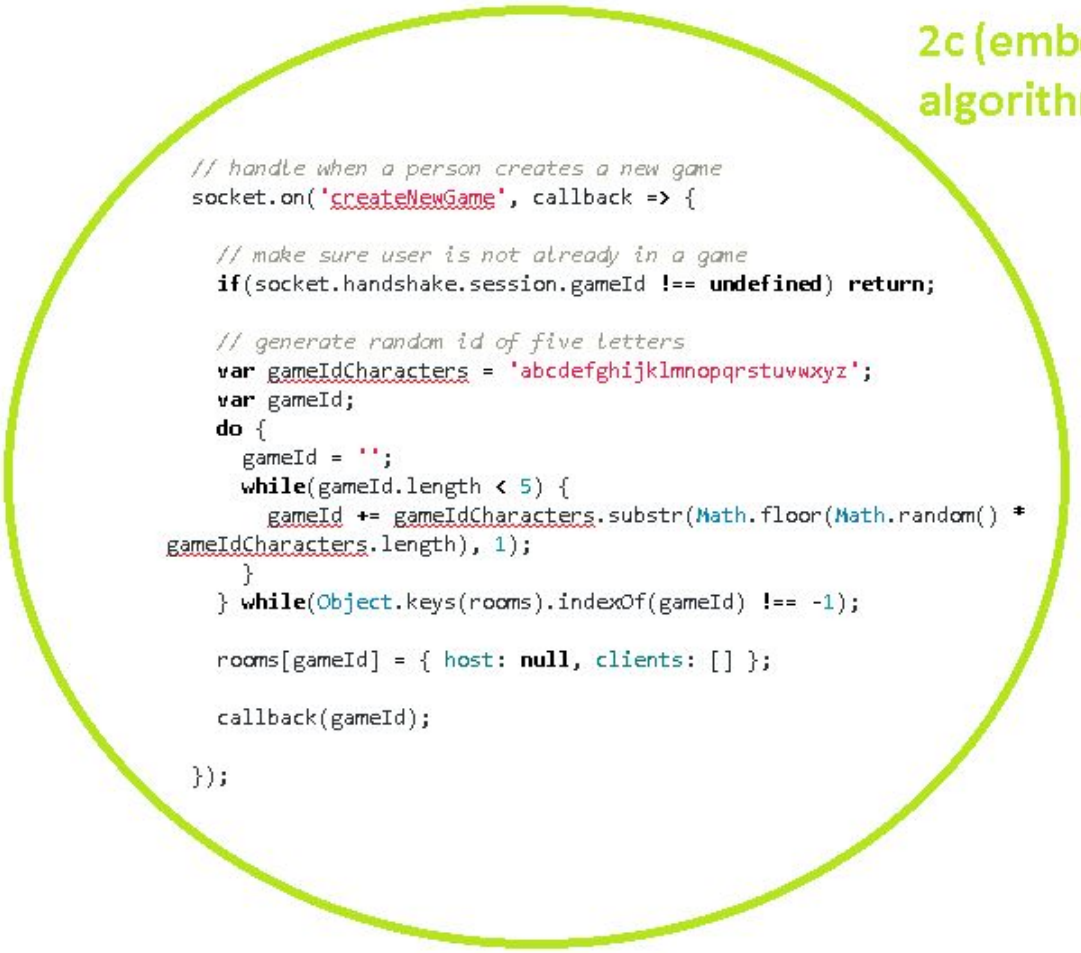
`Procfile` (information necessary for Heroku hosting); author: Jonathan Lam

```
web: node server.js
```

`server.js` (server script; handles routing and socket.io); author: Rahul Kiefer and Jonathan Lam

```
/**
  * Basic app routing using express
  * @author Jonathan Lam
  */

// express and http packages for basic routing
var express = require('express');
var app = express();
var http = require('http').Server(app);

// set port to environment-defined port or 5000 (default)
http.listen(
  process.env.PORT || 5000,
  () => console.log(`Listening on port ${process.env.PORT || 5000}.`));

/**
  * Get socket.io dependency
  * @author Jonathan Lam
  */

// socket.io for real-time WebSocket communication
var io = require('socket.io')(http);
var session = require('express-session')({
    secret: 'test-secret',
    resave: true,
    saveUninitialized: true
});
app.use(session);
var sharedsession = require('express-socket.io-session');
io.use(sharedsession(session, { autoSave: true }));

// callback to listen for io events
io.on('connection', socket => {

  // handle when a person connects
  console.log(`A user with socket id ${socket.id} has connected.`);

  // sync up to express
  socket.handshake.session.socketId = socket.id;
  socket.handshake.session.save();
```

2c (embedded algorithm 1)



```
// handle when a person creates a new game
socket.on('createNewGame', callback => {

  // make sure user is not already in a game
  if(socket.handshake.session.gameId !== undefined) return;

  // generate random id of five letters
  var gameIdCharacters = 'abcdefghijklmnopqrstuvwxyz';
  var gameId;
  do {
    gameId = '';
    while(gameId.length < 5) {
      gameId += gameIdCharacters.substr(Math.floor(Math.random() *
gameIdCharacters.length), 1);
    }
  } while(Object.keys(rooms).indexOf(gameId) !== -1);

  rooms[gameId] = { host: null, clients: [] };

  callback(gameId);

});
```

```
  // check if user is host
  socket.on('isHost', callback => {
    var hostInterval = setInterval(() => {
      socket.handshake.session.reload(() => {
        if(socket.handshake.session.host !== undefined) {
          clearInterval(hostInterval);
          callback(socket.handshake.session.host === true,
socket.handshake.session.socketId);
        }
      });
    }, 50);
  });

  // set a user's name
  socket.on('setName', name => {
    // get room, set name
    var room = rooms[socket.handshake.session.gameId];
    room.clients.find(client => client.socketId === socket.id).name = name;

    // tell sockets to update names
    io.to(socket.handshake.session.gameId).emit('updateUsers',
room.clients.map(client => client.name));
```

```
  });

  // handle device orientation input
  socket.on('deviceOrientation', (forwardSpeed, turnSpeed) => {

    // if not in game return
    if(!socket.handshake.session.gameId) return;

    // get correct client
    var client = rooms[socket.handshake.session.gameId].clients.find(client =>
client.socketId === socket.id);

    // if host return
    if(!client) return;

    // update client acceleration, heading
    // acceleration is limited from -90 to +90
    // heading is converted into radians
    client.acceleration = -Math.max(-90, Math.min(90, forwardSpeed));
    client.turn = Math.PI/180 * turnSpeed;

    // prevent invalid accelerations and turn speeds
    if(client.acceleration < -90 || client.acceleration > 90) client.acceleration =
0;
    if(client.turn < -90 || client.turn > 90) client.turn = 0;
  });

  // handle when a person disconnects
  socket.on('disconnect', () => {
    console.log(`A user with socket id ${socket.id} has disconnected.`);

    // delete room if host
    if(socket.handshake.session.gameId !== undefined && socket.handshake.session.host
=== true) {
      // delete room
      delete rooms[socket.handshake.session.gameId];

      // tell users to go away
      io.to(socket.handshake.session.gameId).emit('terminateGame');
    }

    // delete person if client and if room exists
    else if(socket.handshake.session.gameId !== undefined &&
socket.handshake.session.host === false) {

      // only do if room exists (room may not exist because it is deleted when host
leaves)
      var room = rooms[socket.handshake.session.gameId];
      if(room !== undefined) {

        // delete client from room
        room.clients = room.clients.filter(client => client.socketId !== socket.id);

        // update room host
```

```
        io.sockets.sockets[room.host.socketId].emit('updatedMap', room.clients);

        // update other users
        io.to(socket.handshake.session.gameId).emit('updateUsers',
room.clients.map(client => client.name));
      }
    }

    // also remove from session
    socket.handshake.session.gameId = undefined;
    socket.handshake.session.host = undefined;
    socket.handshake.session.save();
  });

});


/**
  * Do game updates (position, speed, acceleration (friction), and heading
  * (turn)) every 10ms. This happens here to ensure every person moves at the
  * same speed. The friction is calculated as a piecewise function (linear
  * decceleration at high speeds, and a decceleration proportional to the
  * speed at low speeds) to make the driving feel more realistic. The constants
  * and multipliers were determined by trial and error to make the driving
  * feel realistic.
  * <p>
  * Equations:
  * - Update speed:                newSpeed          = oldSpeed + acceleration *
accelerationMultiplier - friction
  * - Friction:                    friction          = { if |newSpeed| >
frictionConstant * 1.5 then newSpeed > 0 ? -frictionConstant : frictionConstant
  *                                                      if |newSpeed| <
frictionConstant * 1.5 then newSpeed * 0.5
  * - Update x position:           newPlayerX        = oldPlayerX +
Math.cos(heading) * speed * speedMultiplier
  * - Update y position:           newPlayerY        = oldPlayerY +
Math.sin(heading) * speed * speedMultiplier
  * - Update heading (direction):  newPlayerHeading  = oldPlayerHeading + turnSpeed
* speed * turnMultiplier
  * @author Jonathan Lam
  */
var accelerationMultiplier = 0.01;    // fraction of the input acceleration that goes
into the accleration
var speedMultiplier = 0.005;          // fraction of the input speed that goes into
the speed
var turnMultiplier = 0.0002;          // fraction of the input turn that goes into
the turn
var highSpeedFrictionConstant = 0.25; // linear decceleration of car at high speeds
var lowSpeedFrictionMultiplier = 0.1; // fraction of the speed that the friction will
go against
setInterval(() => {
  // update every game room
  for(var room of Object.keys(rooms)) {
    for(var client of rooms[room].clients) {
```

```
      // update player speed
      client.speed += client.acceleration * accelerationMultiplier;
      // bound player speed between -180 and +180
      if(client.speed < -90) client.speed = -90;
      if(client.speed > 90) client.speed = 90;

      // calculated simulated friction and add to speed
      var friction = (Math.abs(client.speed) > highSpeedFrictionConstant * 1.5)
        ? (client.speed > 0 ? 1 : -1) * highSpeedFrictionConstant
        : client.speed * lowSpeedFrictionMultiplier;
      client.speed -= friction;

      // update player position (depends on heading)
      client.x += Math.cos(client.heading) * client.speed * speedMultiplier;
      client.y += Math.sin(client.heading) * client.speed * speedMultiplier;

      // update player heading (turn speed is proportional to the speed and angle of
turn)
      client.heading += client.turn * client.speed * turnMultiplier;
    }

    // send data to host
    var socket;
    if(rooms[room].host && (socket = io.sockets.sockets[rooms[room].host.socketId])
!== undefined) {
      socket.emit('updatedMap', rooms[room].clients);
    }
    // send data to clients
    for(var client of rooms[room].clients) {
      if((socket = io.sockets.sockets[client.socketId]) !== undefined) {
        socket.emit('updatedMap', rooms[room].clients);
      }
    }
  }
}, 10);


/**
  * Rooms to allow people to play multiplayer
  * @todo   add verification that server is created, number of people is less than 3
  * @author Jonathan Lam
  */

var rooms = {};
/*
room format: {
  host: [hostId],
  clients: [arrayOfClientIds]
}
client format: {
  name: [name],
  id: [sessionId],
  x: [xPosition],
```

```
  y: [yPosistion],
  z: 0 (for now),
  heading: [heading]
}
*/
```

2c (embedded algorithm 2)

```
app.get('/game/:gameId', (req, res, next) => {

  // send to game file
  res.sendFile(`${__dirname}/public/game.html`);

  // get gameid parameter
  var gameId = req.params.gameId.toLowerCase();
  var socket;

  // sync up to socket to join room (keep refreshing until socketId is updated)
  var syncInterval = setInterval(() => req.session.reload(() => {
    if(req.session.socketId !== undefined && (socket =
io.sockets.sockets[req.session.socketId]) !== undefined) {
      clearInterval(syncInterval);

      // error 1: room does not exist
      if(Object.keys(rooms).indexOf(gameId) === -1) {
        socket.emit('err', `Game room "${gameId}" does not exist.`);
        return;
      }

      // error 2: room has more than four people in it
      if(rooms[gameId].clients.length > 3) {
        socket.emit('err', `Game room "${gameId}" is already full.`);
        return;
      }

      // error 3: user is already in the game
      if(rooms[gameId].clients.find(client => client.sessionId === req.session.id) !==
undefined || (rooms[gameId].host && rooms[gameId].host.sessionId === req.session.id)) {
        socket.emit('err', 'You are already in this game on another tab.');
        return;
      }

      // add gameId to session, session id to game room
      req.session.gameId = gameId;

      // if first person, then host; if not, then client
      if(rooms[gameId].host === null) {
        rooms[gameId].host = {

          sessionId: req.session.id,
          socketId: socket.id
        };
        req.session.host = true;
      } else {
        // create default client
        rooms[gameId].clients.push({
          sessionId: req.session.id,
          socketId: socket.id,
          name: null,
          x: 0,
          y: 0,
          z: 0,
          acceleration: 0,
          speed: 0,
          heading: 0,
          turn: 0
        });
        req.session.host = false;
      }
      req.session.save();

      // join game room
      socket.join(gameId);
      socket.emit('gameId', gameId);
      io.to(gameId).emit('updateUsers', rooms[gameId].clients.map(client =>
client.name));
      console.log(`A user with socket id ${socket.id} has joined the room ${gameId}.`);
    }
  }), 50);
});
```

```
/**
  * Static serving in express for resources (*.css, *.js)
  * @author Jonathan Lam
  */
app.use(express.static('public'));
```

---

public/index.html (HTML for landing page); author: Rahul Kiefer and Jonathan Lam

```
<!--
  Basic HTML layout
  @author Jonathan Lam
  -->
<!doctype html>
<html>
  <head>
    <title>Racing Game</title>

    <!--
      meta tags for site crawling
      @author Jonathan Lam
      -->
    <meta charset='utf-8'>
    <meta name='description' content='Multiplayer racing game for AP CSP Create
task'>
    <meta name='author' content='Jonathan Lam <jonathan.lam@er9.org>, Rahul Kiefer
<rahul.kiefer@er9.org>'>
    <meta name='keywords' content='multiplayer, racing, game, CSP, computer science
principles, jonathan lam, rahul kiefer'>

    <!--
      Set the viewport for responsive web design on mobile
      This doesn't work too well, so commented it out
      @author Jonathan Lam
      -->
    <!-- <meta name='viewport' content='width=device-width, initial-scale=1.0'> -->

    <!--
      include stylesheets
      @author Jonathan Lam
      -->
    <link rel='stylesheet' href='css/main.css'>
    <link rel='stylesheet' href='css/index.css'>

    <!--
      include FontAwesome icon set (to make website look pretty)
      See https://fontawesome.com/ for more information
      @author Jonathan Lam
      -->
    <script defer src='https://use.fontawesome.com/releases/v5.0.8/js/all.js'
integrity='sha384-SlE991lGASHoBfWbelyBPLsUlwY1GwNDJo3jSJO04KZ33K2bwfV9YBauFfnzvynJ'
crossorigin='anonymous'></script>

    <!--
```

```
      include socket.io library for use of WebSockets/long-polling to communicate in
real time with server
      See https://socket.io/ for more information
      @author Jonathan Lam
      -->
    <script src='/socket.io/socket.io.js'></script>

    <!--
      include main script
      @author Jonathan Lam
      -->
    <script src='/js/index.js' defer></script>

  </head>
  <body>

    <!--
      Create a room for hosts
      @author Jonathan Lam
      -->
    <div class='deviceTypeContainer' id='desktopContainer'>

      <!--
        Link to GitHub for information and code
        @author Jonathan Lam
        -->
      <a id='infoLink' title='Click to see more information and the source on
GitHub.' href='https://github.com/jlam55555/racing-game' target='_blank'>
        <i class='fas fa-info-circle'></i>
      </a>

      <div class='deviceTypeIcon'>
        <i class='fas fa-desktop'></i>
      </div>
      <button id='createGame'>CREATE GAME</button>
    </div>

    <!--
      Join a room for mobile
      @author Jonathan Lam
      -->
    <div class='deviceTypeContainer' id='mobileContainer'>
      <div class='deviceTypeIcon'>
        <i class='fas fa-mobile'></i>
      </div>
      <div id='joinGameContainer'>
        <input type='text' id='joinGameId' placeholder='GAME ID'>
        <button id='joinGame'>JOIN GAME</button>
      </div>
    </div>

  </body>
</html>
```

public/game.html (HTML for gameplay page); author: Rahul Kiefer and Jonathan Lam

```
<!--
  Basic HTML layout
  @author Jonathan Lam
  -->
<!doctype html>
<html>
  <head>
    <title>Racing Game</title>

    <!--
      meta tags for site crawling
      @author Jonathan Lam
      -->
    <meta charset='utf-8'>
    <meta name='description' content='Multiplayer racing game for AP CSP Create
task'>
    <meta name='author' content='Jonathan Lam <jonathan.lam@er9.org>, Rahul Kiefer
<rahul.kiefer@er9.org>'>
    <meta name='keywords' content='multiplayer, racing, game, CSP, computer science
principles, jonathan lam, rahul kiefer'>

    <!--
      Set the viewport for responsive web design on mobile
      This didn't work too well, so commented it out for now
      @author Jonathan Lam
      -->
    <!-- <meta name='viewport' content='width=device-width, initial-scale=1.0'> -->

    <!--
      include stylesheets
      @author Jonathan Lam
      -->
    <link rel='stylesheet' href='/css/main.css'>
    <link rel='stylesheet' href='/css/host.css'>
    <link rel='stylesheet' href='/css/client.css'>

    <!--
      include socket.io library
      @author Jonathan Lam
      -->
    <script src='/socket.io/socket.io.js'></script>

    <!--
      include three.min.js library
      See https://threejs.org/ for more information
      @author Rahul kiefer
      -->
    <script src='/js/three.js/three.js'></script>

    <!--
      include THREE.js line library files (not included in main THREE.js library) to
make race track
```

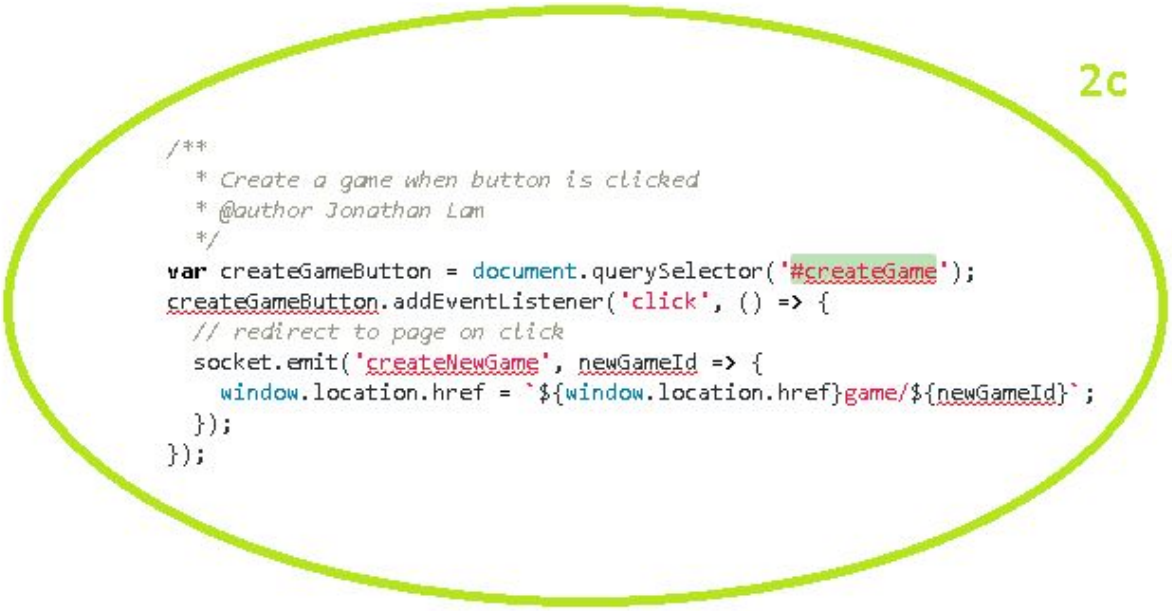
```
      Source:
https://github.com/mrdoob/three.js/tree/cb4c23fea8b667b6126635be64825d0cc1fa5f4b/exam
ples/js/lines
      @author Rahul Kiefer
      -->
    <script src='/js/three.js/line/LineSegmentsGeometry.js'></script>
    <script src='/js/three.js/line/LineGeometry.js'></script>
    <script src='/js/three.js/line/WireframeGeometry2.js'></script>
    <script src='/js/three.js/line/LineMaterial.js'></script>
    <script src='/js/three.js/line/LineSegments2.js'></script>
    <script src='/js/three.js/line/Line2.js'></script>
    <script src='/js/three.js/line/Wireframe.js'></script>

    <!--
      include FontAwesome icon set (to make website look pretty)
      @author Jonathan Lam
      -->
    <script defer src='https://use.fontawesome.com/releases/v5.0.8/js/all.js'
integrity='sha384-S1E991lGASHoBfWbelyBPLsU1wY1GwNDJo3jSJO04KZ33K2bwfV9YBauFfnzvynJ'
crossorigin='anonymous'></script>

    <!--
      Includes the graphics script.
      <p>
      hostGraphics.js is for the computer (host). This includes views for all
players, and sets up the basic scene.
      <p>
      clientGraphics.js is for the mobile device (client). This includes a
simplified, single viewport that is shown on mobile devices.
      @author Rahul Kiefer
      -->
    <script src='/js/hostGraphics.js' defer></script>
    <script src='/js/clientGraphics.js' defer></script>

    <!--
      include main script
      @author Jonathan Lam
      -->
    <script src='/js/game.js' defer></script>

  </head>
  <body>

    <!--
      Controls div on left
      @author Jonathan Lam
      -->
    <div id='controls'>

      <!-- Show names (these are absolutely positioned over the canvas) -->
      <div id='names'></div>

      <!-- Link to return to homepage -->
      <a id='homeLink' href='/' class='vCenter'>
```

```
        <span class='fas fa-chevron-circle-left'></span>
      </a>

      <!-- Shows errors if they exist on entry -->
      <div id='error' class='vCenter'></div>

      <!-- Show game ID -->
      <div id='gameIdContainer' class='vCenter'>
        <span id="gameIdInnerContainer">
          ID: <span id='gameId'></span>
        </span>
      </div>

    </div>

    <!--
      Main canvas on right
      @author Jonathan Lam
    -->
    <div id='game'></div>

  </body>
</html>
```

---

public/js/index.js (script for landing page); author: Jonathan Lam

```
/**
  * This file is for the homepage.
  */

/**
  * Connect to socket.io
  * @author Jonathan Lam
  */
var socket = io();
```




```
/**
  * Join a room when button is clicked
  * @author Jonathan Lam
  */
var joinGameId = document.querySelector('#joinGameId');
var joinGameButton = document.querySelector('#joinGame');
joinGameButton.addEventListener('click', () => {
  if(joinGameId.value.trim() !== '') {
    window.location.href = `${window.location.href}game/${joinGameId.value}`;
  }
})


/**
  * Make recommendation
  * @author Jonathan Lam
  */
// if large window size or deviceorientationevent not supported, recommend host
if(window.innerWidth >= 1920 || !window.DeviceOrientationEvent) {
  document.querySelector('#desktopContainer').classList.add('recommended');
}
// else recommend client
// this double-checks if deviceorientationevent works (and if it doesn't, recommends
desktop)
else {
  if(window.DeviceOrientationEvent) {
    window.addEventListener('deviceorientation', event => {
      if(event.alpha === null) {
        document.querySelector('#desktopContainer').classList.add('recommended');
      } else {
        document.querySelector('#mobileContainer').classList.add('recommended');
      }
    });
```

```
  } else {
    document.querySelector('#mobileContainer').classList.add('recommended');
  }
}
```

---

public/js/game.js (script for gameplay, excluding graphics); author: Rahul Kiefer and Jonathan Lam

```
/**
  * This file is for the game (excluding graphics).
  */


/**
  * Connect to socket.io
  * @author Jonathan Lam
  */
var socket = io();

// get game id to show on element #gameId
socket.on('gameId', gameId => {
  var gameIdText = "";
  var gameIdChars = gameId.split("");
  for(var char of gameIdChars) {
    gameIdText += `<span class='gameIdChar'>${char.toUpperCase()}</span>`;
  }
  document.querySelector('#gameId').innerHTML = gameIdText;
});

/**
  * Get errors on joining room
  * @author Jonathan Lam
  */
socket.on('err', msg => {
  document.querySelector('#gameIdContainer').style.display = 'none';
  document.querySelector('#names').style.display = 'none';
  document.querySelector('#error').textContent = `Error: ${msg}`;
});

/**
  * Get name if client
  * @author Jonathan Lam
  */
var isHost;
var socketId;
socket.emit('isHost', (isHostResponse, socketIdResponse) => {

  if(!isHostResponse) {

    // ask for name, send to server
    var defaultNames = ["Richard","Rasmus","Tony","Aubrey","Don
Juan","Graham","Dennis","George","Ted","Rufus","Rami","Willem","Peter","Zack","Oscar"
,"Rick","Brandon","Charlie","Louie","Phil","Nigel","Earl","Jones","Carl","Jake","Rich
ter","Russell",
                        "Corey","Alex","Ash","Mark","Irvin","Dallas\n "]
```

```
    var name = prompt('What is your name?', defaultNames[Math.floor(Math.random() *
defaultNames.length)]);
    socket.emit('setName', name);

    // set socketId
    socketId = socketIdResponse;

  }

  // set host flag (true if host, false if client)
  isHost = isHostResponse;
});
```

2d

```
/**
  * Update name listing
  * @author Jonathan Lam
  */
var namesElement = document.querySelector('#names');
socket.on('updateUsers', names => {
  /**
    * Position name on top left of correct screen
    * @author Jonathan Lam
    */
  var positions;
  switch(names.length) {
    // one person joined: full screen
    case 1:
      positions = [ [ 0, 0 ] ];
      break;
    // two people in the game: side by side
    case 2:
      positions = [ [ 0, 0 ], [ width/2, 0 ] ];
      break;
    // three people in the game: top two side by side, bottom in center
    case 3:
      positions = [ [ 0, 0 ], [ width/2, 0 ], [ width/4, height/2 ] ];
      break;
    // four people in the game: top two side by side, bottom two side by side
    case 4:
      positions = [ [ 0, 0 ], [ width/2, 0 ], [ 0, height/2 ], [ width/2, height/2 ] ];
      break;
    // nobody joined; no positions
    case 0:
    default:
      break;
  }
  var namesElement = document.querySelector('#names');
  namesElement.innerHTML = '';
  for(var i = 0; i < names.length; i++) {
    var nameDiv = document.createElement('div');
    nameDiv.classList.add('name');
    nameDiv.style.left = positions[i][0] + 40 + 'px'; // added padding 40px
    nameDiv.style.top = positions[i][1] + 40 +
document.querySelector('#controls').clientHeight + 'px';  // added padding 40px
    nameDiv.appendChild(document.createTextNode(names[i] || 'An unnamed driver'));
    namesElement.appendChild(nameDiv);
  }
  // update cars and cameras
  updateCars();
  // if client
  if(isHost !== undefined && !isHost) {
    // overwrite main render function with client one
    overwriteRender(socketId);
    // add .mobile class to controls to transform it
    document.querySelector('#controls').classList.add('mobile');
  }
});
```

```
/**
  * Terminate game (if host leaves)
  * @author Jonathan Lam
  */
socket.on('terminateGame', () => {
  window.location.href = '/';
});

/**
  * If client, get orientation event and send to server
  * Calculates forward speed from gamma (and beta), turn from beta
  * @author Jonathan Lam
  */
window.addEventListener('deviceorientation', event => {

  // only do this for client
  if(isHost) return;

  // adjusting the 'no pedal' position from flat to 45 degrees
  var beta = event.beta;
  var gamma = event.gamma + 45;

  var forwardSpeed = 0, turnSpeed = 0;
  // device facing upwards
  if(Math.abs(beta) < 90) {
    forwardSpeed = gamma;
    turnSpeed = beta;
  }
  // device facing downwards -- put at extreme (-90 or 90)
  else {
    forwardSpeed = gamma < 0 ? 90 : -90;
    turnSpeed = (beta < 0 ? -180 : 180) - beta;
  }

  // send in deviceorientation
  // comment this for testing on desktop
  socket.emit('deviceOrientation', forwardSpeed, turnSpeed);

});
// uncomment this for testing on desktop
// setTimeout( () => socket.emit('deviceOrientation', 10, 50), 1000 );

/**
  * Get all client positions
  * Host will show all
  * Client will show view from just their car
  * @author Jonathan Lam
  */
socket.on('updatedMap', mapData => {
  map = mapData;
});
```

public/hostGraphics.js (main graphics file, graphics for computer screen (host)); author: Rahul Kiefer and Jonathan Lam

```
/**
  * host graphics file
  * <p>
  * Critical functions: init(), animate(), render()
  * @author Rahul Kiefer
  */

/**
  * Use #game as base element
  * width and height are global variables used for the width and height of the
canvas, and are set in the resize handler
  * @author Jonathan Lam
  */
var element = document.querySelector('#game'), width, height;

/**
  * Event handler to update width and height on window resize (canvas resizes
automatically). Also called in init() to initialize width and height.
  * @author Jonathan Lam
  */
function resizeHandler() {

  // update width and height
  width = element.getBoundingClientRect().width;
  height = element.getBoundingClientRect().height;

  // update main camera aspect ratio and renderer size
  camera = new THREE.PerspectiveCamera(75, width / height, 0.1, 1000);
  renderer.setSize(width, height);

}
window.addEventListener('resize', resizeHandler);

/**
  * Create scene and camera
  * @author Rahul Kiefer
  */
var scene = new THREE.Scene();
var camera = new THREE.PerspectiveCamera(75, width / height, 0.1, 1000);

/**
  * Create renderer
  * @author Rahul Kiefer
  */
var renderer = new THREE.WebGLRenderer();
renderer.setSize(width, height);
element.appendChild(renderer.domElement);

/**
  * Car class (a function as per JS standards). Create using 'new Car()'
  * <p>
  * Publicly available fields: .mesh (to change position and rotation)
```

```
  * @param  id The id of the car (the socketId of the client) to correctly match the
client camera to the car
  * @todo   Make member fields private
  * @return undefined
  * @author Rahul Kiefer
  */
function Car(id) {

  /**
    * Set id of car (to attach camera to correct car on mobile)
    * @author Jonathan Lam
    */
  this.id = id;

  /**
    * Draw shape of car, and then extrude
    * @author Rahul Kiefer
    */
  var hoodHeight = 1.25;               // height of a car's hood
  var carHeight = hoodHeight + .75;    // distance between ground and roof

  // drawing the car shape
  this.shape = new THREE.Shape();
  this.shape.moveTo(0, 0);
  this.shape.lineTo(0, hoodHeight);    // from front bottom to front of hood
  this.shape.lineTo(2, hoodHeight);    // from front of hood to windshield
  this.shape.lineTo(2.5, carHeight);   // from bottom of windshield to top of
windshield
  this.shape.lineTo(4.5, carHeight);   // from top of windshield to top of back
window
  this.shape.lineTo(5, hoodHeight);    // from top of back window to bottom of back
window
  this.shape.lineTo(6, hoodHeight);    // from bottom of back window to top of trunk
  this.shape.lineTo(6, 0);             // from top of trunk to bottom of trunk
  this.shape.lineTo(0, 0);

  // use basic extrudegeometry
  this.extrudeSettings = {
    steps: 1,               // extrudegeometry uses one intermediate shape
    amount: 3,              // width of car
    bevelEnabled: false,    // bevel set to false to make the texture (UV) mapping
easier
    // bevelThickness: .5,
    // bevelSize: .5,
    // bevelSegments: 2,
    material: 0,            // first material (texture) in material array is for
sides
    extrudeMaterial: 1      // second material (texture) in material array is for the
front, hood, windshield, top, rear windshield, rear hood, rear (and bottom)
  }
  this.geometry = new THREE.ExtrudeGeometry(this.shape, this.extrudeSettings);

  /**
    * Create materials (lambert textures) with UV mapping for custom extrude geometry
```

```
  * @author Jonathan Lam
  */

// load materials
this.materials = [];
for(var i = 0; i < 2; i++) {
  // texture 1 (sides) is located at /assets/map/map1.png
  // texture 2 (other faces) is located at /assets/map/map2.png
  var texture = new THREE.TextureLoader().load(`/assets/map/map${i+1}.png`);
  if(i == 1) {
    // scaling for the extrude material
    // scale goes from x: 0-2, y: (-2)-1 (this is for the UV mapping to work)
    texture.repeat.set(1/2, 1/3);
    texture.offset.set(0, 2/3);
  } else {
    // scaling for the side material
    // scale goes from x: 0-6, y: 0-2
    texture.repeat.set(1/6, 1/2);
  }
  this.materials.push(new THREE.MeshLambertMaterial({ map: texture }));
}

/**
  * UV mapping for the car texture
  * <p>
  * Brief description of UV mapping: UV mapping is a system to get a 2D image
  * wrapped around a 3D shape. Luckily, this is relatively easy for objects
  * with flat faces (such as this car), which means that we simply have to
  * translate coordinates from the 2D "map" to the 3D geometry.
  * <p>
  *
  *   (0, 1)               (2, 1)     // The map is a square image with
  *   +--------------------+          // the labelled (U, V) coordinates.
  *   |                    |          // These specific (U, V) coordinates
  *   |                    |          // were made to wrap around the car.
  *   |                    |
  *   |                    |
  *   |                    |
  *   |                    |
  *   +--------------------+
  *   (0, -2)              (2, -2)
  *
  * <p>
  * Different 3D triangular "faces" of the car geometry, numbered 12-25, were
  * programatically mapped to the corresponding (U, V) coordinates on the
  * map.
  * <p>
  * Made with a LOT of painstaking trial-and-error. =/ I thought this
  * deserves its own special comment.
  * @author Jonathan Lam
  */

// no change to sides (faceVertexUvs indeces 0-11)
// no change to bottom (faceVertexUvs indeces 26-27)
```

```
  // side lengths correspond to the lengths of the sides of the car's Shape
  var sideLengths = [ 0, 1.25, 2, Math.sqrt(0.5*0.5 + 0.75*0.75), 2,
Math.sqrt(0.5*0.5 + 0.75*0.75), 1, 1.25 ];
  // cumulative lengths correspond to the length of the sides from the start of the
car's Shape
  var cumulativeLengths = sideLengths.map((e, index) => sideLengths.slice(0,
index+1).reduce((accumulator, value) => accumulator + value));
  // positions correspond to the scaled version of the cumulative lengths for the UV
map
  var positions = cumulativeLengths.map(length => length /
cumulativeLengths[cumulativeLengths.length-1] * 2);

  // start from front, go to back (index 25 is front, index 14 is back)
  for(var i = 25; i >= 12; i--) {

    // generate correct set of UV map points in points array
    var points;

    // even face numbers
    if(i % 2 == 0) {
      points = [
        { x: positions[(25-i-1) / 2 + 1], y: 1 },
        { x: positions[(25-i-1) / 2],     y: 1 },
        { x: positions[(25-i-1) / 2 + 1], y: -2 },
      ];
    }
    // odd face numbers
    else {
      points = [
        { x: positions[(25-i) / 2],     y: 1 },
        { x: positions[(25-i) / 2],     y: -2 },
        { x: positions[(25-i) / 2 + 1], y: -2 },
      ];
    }

    // add uv map to geometry
    this.geometry.faceVertexUvs[0][i] = points;
  }

  /**
    * Create mesh and add to scene
    * @author Rahul Kiefer
    */
  this.mesh = new THREE.Mesh(this.geometry, this.materials);
  scene.add(this.mesh);

  /**
    * Attach a camera to a car when car joins
    * Called in updateCars()
    * @author Jonathan Lam
    */
  this.addCamera = camera => {
    this.camera = camera;
```

```
    this.mesh.add(camera);
  };

  /**
    * Remove a car and its associated camera when car leaves
    * Called in updateCars()
    * @author Jonathan Lam
    */
  this.remove = () => {
    this.mesh.remove(this.camera);
    scene.remove(this.mesh);
  };
}

// initial car at 0,0 for testing and as a reference point
// remove in production code
// var car = new Car();

/**
  * Creating multiple views
  * @todo   Make this programatically instead of hardcoding it in, explain position
and rotation metrics
  * @author Jonathan Lam
  */
var views = [
  // car 1: left top [currently: viewing car from front *FIX*]
  {
    left: 0,
    top: 0,
    width: 0.5,
    height: 0.5,
    // position: [3, -15, 1.5], rotation: [Math.PI/2, 0, 0], // BOTTOM (for debug)
    // position: [-10, 1, 1.5], rotation: [0, -Math.PI/2, 0],// FRONT  (for debug)
    // position: [3, 15, 1.5], rotation: [-Math.PI/2, 0, 0], // TOP    (for debug)
    // position: [3, 1, 15], rotation: [0, 0, 0],            // SIDE   (for debug)
    // position: [20, 1, 1.5], rotation: [0, Math.PI/2, 0],  // BACK   (for debug)
    position: [20, 3, 1.5], rotation: [0, Math.PI/2, 0],  // NORMAL (for prod)
    fov: 30,
    enabled: true
  },
  // car 2: right top (looking down on car from above)
  {
    left: 0.5,
    top: 0,
    width: 0.5,
    height: 0.5,
    position: [20, 3, 1.5],
    rotation: [0, Math.PI/2, 0],
    fov: 30
  },
  // car 3: left bottom
  {
    left: 0,
    top: 0.5,
```

```
    width: 0.5,
    height: 0.5,
    position: [20, 3, 1.5],
    rotation: [0, Math.PI/2, 0],
    fov: 30
  },
  // car 4: right bottom
  {
    left: 0.5,
    top: 0.5,
    width: 0.5,
    height: 0.5,
    position: [20, 3, 1.5],
    rotation: [0, Math.PI/2, 0],
    fov: 30
  }
];

/**
  * updateCars() function
  * This is called every time a user enters leaves (upon the 'updateUsers' message
from socket.io (see /public/js/game.js))
  * @return undefined
  * @author Jonathan Lam
  */

// map and car arrays to map (client positions) and cars (Car objects)
var map = [];
var cars = [];

// updateCars function
function updateCars() {

  // remove all cars ("reset" array)
  for(var i = 0; i < cars.length; i++) {
    cars[i].remove();
  }
  cars = [];

  // make new cars ("refresh" the array)
  for(var i = 0; i < map.length; i++) {
    var car = new Car(map[i].socketId);
    // x and y are coordinates on flat plane in server
    // x and z are coordinates on flat plane in three.js
    car.mesh.position.x = map[i].x;
    car.mesh.position.z = map[i].y;
    car.mesh.position.y = map[i].z;
    car.addCamera(views[i].camera);
    cars.push(car);
  }

  // disable all views after view 1 that are enabled
  // i.e., the first view is default, even if no cars; the others are triggered by
multiple people entering the game
```

```
  for(var i = 1; i < views.length; i++) {
    views[i].enabled = i < cars.length;
  }

  /**
    * Set views appropriate to number of cars
    * <p>
    * One car or no cars: full screen
    *
    *
    *
    *
    *
    *
    * <p>
    * Two cars: half screen horizontally
    *
    *
    *
    *
    *
    *
    * <p>
    * Three cars: half screen top, bottom center
    *
    *
    *
    *
    *
    *
    * <p>
    * Four cars: 2 on top, two on bottom
    *
    *
    *
    *
    *
    *
    * <p>
    * This layout was designed to maximize screen usage, keep aspect ratio
reasonable, and keep the same size/AR for all clients.
    * @author Jonathan Lam
    */
  switch(cars.length) {
    case 0:
    case 1:
      // if no cars or one car, set full-screen
      views[0].width = 1.0;
      views[0].height = 1.0;
      break;
    case 2:
      // if two cars, set side by side
      views[0].width = views[1].width = 0.5;
      views[0].height = views[1].height = 1.0;
```

```
+---------+
|         |
|         |
|    1    |
|         |
|         |
+---------+

+----+----+
|    |    |
|    |    |
| 1  | 2  |
|    |    |
|    |    |
+----+----+

+----+----+
| 1  | 2  |
|    |    |
+--+-+-+--+
|  | 3 |  |
|  |   |  |
+--+---+--+

+----+----+
| 1  | 2  |
|    |    |
+----+----+
| 3  | 4  |
|    |    |
+----+----+
```

```
      views[1].left = 0.5;
      break;
    case 3:
      // if three or four cars, set to one-quarter screen size
      views[0].width = views[1].width = views[2].width = 0.5;
      views[0].height = views[1].height = views[3].height = 0.5;
      views[1].left = 0.5;
      views[2].top = 0.5;
      views[2].left = 0.25;
      break;
    case 4:
      views[0].width = views[1].width = views[2].width = views[3].width = 0.5;
      views[0].height = views[1].height = views[3].height = views[3].height = 0.5;
      views[1].left = 0.5;
      views[2].top = 0.5;
      views[2].left = 0.0;
      views[3].top = 0.5;
      views[3].left = 0.5;
      break;
  }
}

/**
  * init() function to set up views, objects
  * @return undefined
  * @author Rahul Kiefer
  */
function init() {

  // initialize width and height
  resizeHandler();

  // create a camera for every view, using views array values
  for(var view of views) {
    var camera = new THREE.PerspectiveCamera(view.fov, width/height, 0.1, 7500);
    camera.position.fromArray(view.position);
    camera.rotation.fromArray(view.rotation);
    view.camera = camera;
  }

  /**
    * Create skybox (side length of 5000)
    * Example used for template: stemkoski.github.io/Three.js/Skybox.html
    * @todo   Change images to match theme
    * @author Jonathan Lam
    */
  var imagePrefix = '/assets/dawnmountain-';
  var directions  = [ 'xpos', 'xneg', 'ypos', 'yneg', 'zpos', 'zneg' ];
  var imageSuffix = '.png';
  var skyGeometry = new THREE.CubeGeometry(5000, 5000, 5000);

  var materialArray = [];
  for (var i = 0; i < 6; i++) {
    materialArray.push(new THREE.MeshBasicMaterial({
```

```
      map: new THREE.TextureLoader().load(imagePrefix + directions[i] + imageSuffix),
      side: THREE.BackSide
    }));
  }
  var skyMaterial = materialArray;
  var skyBox = new THREE.Mesh(skyGeometry, skyMaterial);
  scene.add(skyBox);

  /**
    * Create spot light (sun, directly above)
    * @author Rahul Kiefer
    */
  var spotLight = new THREE.PointLight( 0xffffff );
  spotLight.position.set(0, 1000, 0);

  spotLight.shadow.camera.near = 500;
  spotLight.shadow.camera.far = 10000;

  scene.add(spotLight);

  /**
    * Create ambient light (is this necessary?)
    * @todo   Remove?
    * @author Rahul Kiefer
    */
  var ambLight = new THREE.AmbientLight(0xf5f5f5); //soft white light
  scene.add(ambLight);

  /**
    * Create the floor
    * @author Rahul Kiefer
    */
  var floorTexture = new THREE.TextureLoader().load('/assets/grass_texture.jpg');
  floorTexture.wrapS = floorTexture.wrapT = THREE.RepeatWrapping;
  floorTexture.repeat.set(50, 50);
  var floorMaterial = new THREE.MeshBasicMaterial( { map: floorTexture, side:
THREE.DoubleSide } ); //floor looks better as a MeshBasicMaterial
  var floorGeometry = new THREE.PlaneGeometry(5000, 5000, 10, 10); //floor is
5000x5000 to match skybox
  var floor = new THREE.Mesh(floorGeometry, floorMaterial);
  floor.rotation.x = Math.PI / 2;
  scene.add(floor);

  var track = new THREE.Shape();

  track.moveTo(150,-2500);
  track.lineTo(150,2500);
  track.lineTo(100,2500);
  track.lineTo(100,-2500);
  track.lineTo(150,-2500);

  var trackExtrudeSettings = {
    amount: 5,
    bevelEnabled: false,
```

```
    bevelSegments: 2,
    steps: 1,
    bevelSize: 1,
    bevelThickness: 1
  };

  var trackTexture = new THREE.TextureLoader().load('/assets/blacktop_texture.jpg');
  trackTexture.wrapS = trackTexture.wrapT = THREE.RepeatWrapping;
  trackTexture.repeat.set( 1, 1 );
  var trackMaterial = new THREE.MeshBasicMaterial( {map: trackTexture, side:
THREE.DoubleSide} );
  var trackGeometry = new THREE.ExtrudeGeometry(track, trackExtrudeSettings);
  var raceTrackMesh = new THREE.Mesh( trackGeometry, trackMaterial );

  raceTrackMesh.rotation.x = Math.PI / 2;
  raceTrackMesh.position.y = 0.01; //barely above the ground
  scene.add(raceTrackMesh);

}

/**
  * Function animate() to run the animation
  * This is run on every frame, by window.requestAnimationFrame()
  * @return undefined
  * @author Rahul Kiefer
  */
function animate() {
  // update coordinates of cars
  for(var i = 0; i < map.length; i++) {
    if(cars[i]) {
      // see note above for switched z and y
      cars[i].mesh.position.x = map[i].x;
      cars[i].mesh.position.z = -map[i].y;
      cars[i].mesh.position.y = map[i].z;
      cars[i].mesh.rotation.y = map[i].heading;
    }
  }

  // render views
  render();

  // wait until canvas ready to render
  requestAnimationFrame(animate);
}

/**
  * render() function to render the scene by setting up each viewport (camera) as
appropriate
  * @author Jonathan Lam
  */
function render() {
  for(var view of views) {
    // if disabled, skip
    if(!view.enabled) continue;
```

```
    var camera = view.camera;

    // set viewport
    var viewLeft = Math.floor(width * view.left);
    var viewTop = Math.floor(height * view.top);
    var viewWidth = Math.floor(width * view.width);
    var viewHeight = Math.floor(height * view.height);

    renderer.setViewport(viewLeft, viewTop, viewWidth, viewHeight);
    renderer.setScissor(viewLeft, viewTop, viewWidth, viewHeight);
    renderer.setScissorTest(true);
    renderer.setClearColor(view.background);

    // update camera
    camera.aspect = viewWidth/viewHeight;
    camera.updateProjectionMatrix();

    // render view
    renderer.render(scene, camera);
  }
}

// initialize the scene (both for clients and host)
init();

// begin the simulation/animation/game
animate();
```

---

public/graphics/clientGraphics.js (secondary graphics file for mobile screen (client)); author: Jonathan Lam

```
/**
  * client graphics file
  * <p>
  * Critical functions: render() (overwrite the one in hostGraphics)
  * Initialization is already set up in the main graphics file
  * @author Jonathan Lam
  */

/**
  * Function overwriteRender to overwrite the main render function for a client
  * device.
  * <p>
  * This is called when the user's car is created (after the first updateCars()
  * in the 'updateUsers' websocket event). It replaces the four-car view with a
  * simple view from the windshield of the client's car.
  * @param  id  socketId of the client; used to match the car
  * @return none
  * @author Jonathan Lam
  */
function overwriteRender(id) {

  // create camera
```

```
  var camera = new THREE.PerspectiveCamera(30, width/height, 0.1, 20000);
  camera.position.set(0, 3, 1.5);
  camera.rotation.set(0, Math.PI/2, 0);

  // attach camera to car (match socket ids)
  cars.find(car => car.id === id).addCamera(camera);

  // simple, single camera full-screen viewport
  render = function() {
    renderer.setViewport(0, 0, width, height);
    renderer.render(scene, camera);
  };
}
```

---

public/css/main.css (global CSS rules); author: Jonathan Lam

```
/**
  * Generic page style
  * Applies to both index.html and game.html
  */

/**
  * Import source code pro monospace font for use
  * @author Jonathan Lam
  */
@import url('https://fonts.googleapis.com/css?family=Source+Code+Pro');

/**
  * Set basic styles for all elements and html, body
  * @author Jonathan Lam
  */
* {
  box-sizing: border-box;
}
html, body {
  margin: 0;
  height: 100%;
  font-size: 16px;
  font-family: source code pro, monospace;
}
a, button, select, input {
  outline: none;
  border: none;
  font-size: inherit;
  font-family: inherit;
  color: inherit;
}
button, input {
  border: none;
  padding: 1em;
}
input {
  background-color: #eee;
```

```
}
```

`public/css/index.css` (CSS rules for landing page); author: Jonathan Lam

```css
/**
  * Styles for homepage
  * Applies to index.html
  */

/**
  * Put computer and smartphone divs side by side
  * @author Jonathan Lam
  */
body {
  display: flex;
  flex-direction: row;
  background-image: url('/assets/loading_bg.png');
  background-position: center;
  background-size: cover;
  color: white;
}
#infoLink {
  display: block;
  position: absolute;
  top: 1em;
  left: 1em;
  padding: 0.5em;
  cursor: pointer;
}
.deviceTypeContainer {
  flex-grow: 1;
  flex-basis: 50%;
  display: flex;
  flex-direction: column;
  justify-content: center;
  padding: 3em;
  font-size: 1.25em;
  background-color: rgba(50, 50, 50, 0.8);
}
.deviceTypeIcon {
  font-size: 10em;
  text-align: center;
}
.deviceTypeHeader {
  text-align: center;
}
.deviceTypeContainer.recommended {
  background-color: rgba(0, 0, 0, 0.3);
}
.deviceTypeContainer.recommended::before {
  content: 'RECOMMENDED';
  font-size: 2em;
  margin-bottom: -1em;
  text-align: center;
```

```
  display: block;
  position: relative;
  top: -1em;
}
#joinGameContainer {
  display: flex;
  flex-direction: row;
}
#joinGameId {
  flex-grow: 5;
}
#joinGame {
  flex-grow: 1;
}
button, input {
  background-color: #222;
  border-radius: 0.25em;
  cursor: pointer;
}
```

---

public/css/host.css (CSS rules for host in gameplay): author: Rahul Kiefer and Jonathan Lam

```
/**
  * Styling for the host
  * Applies to game.html
  */

/**
  * Make body a flex element for easy alignment of controls and canvas
  * @author Jonathan Lam
  */
body {
  display: flex;
  flex-direction: column;
}

/**
  * General class for centered vertical align (used for controls)
  * @author Jonathan Lam
  */
.vCenter {
  display: flex;
  flex-direction: column;
  justify-content: center;
}

/**
  * styling the controls
  * @author Jonathan Lam
  */
#controls {
  flex: 0 1 0;
  display: flex;
  flex-direction: row;
```

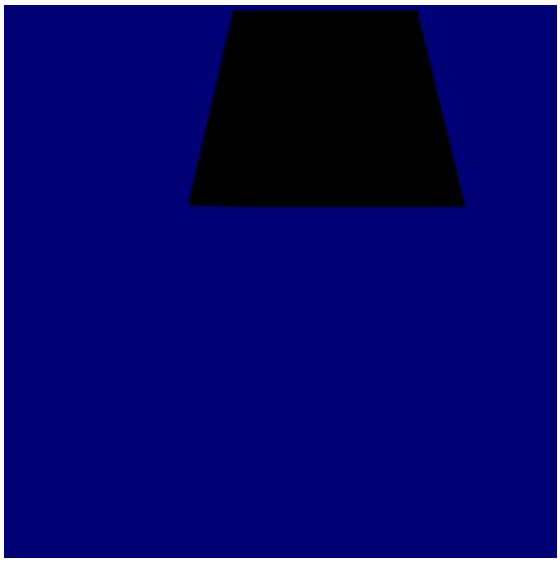
```
  flex-basis: 4em;
  background-color: black;
  color: white;
}
#homeLink {
  flex-basis: 2em;
  font-size: 2em;
  padding: 0.5em;
  transition: background-color 0.2s;
}
#homeLink:hover {
  background-color: darkgrey;
}
#gameIdContainer {
  flex: 1 0 0;
}
#gameIdInnerContainer {
  width: 100%;
  text-align: center;
  font-size: 1.5em;
}
.gameIdChar {
  display: inline-block;
  margin: 0 0.125em;
  padding: 0.25em;
  width: 1.5em;
  text-align: center;
  background-color: darkgrey;
  color: white;
  border-radius: 0.125em;
}

/**
  * styling the canvas and names
  * @author Rahul Kiefer
  */
canvas {
  width: 100% !important;
  height: 100% !important;
  display: block;
}
#game {
  flex: 1 0 0;
  overflow: hidden;
}
#names {
  width: 0;
}
.name {
  position: absolute;
  display: inline-block;
  color: black;
  padding: 0.5em;
  font-size: 1.5em;
```

```
  background-color: rgba(255, 255, 255, 0.5);
  border-radius: 0.125em;
}
```

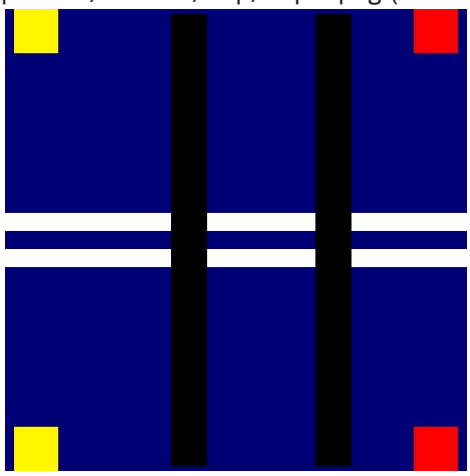
`public/css/client.css` (CSS rules for client in gameplay); author: Jonathan Lam

```
/**
  * Styling for the game client (driver)
  * Applies to game.html
  */

/**
  * Hide #names, #gameIdContainer (only necessary for host)
  * @author Jonathan Lam
  */
#controls.mobile > #names,
#controls.mobile > #gameIdContainer {
  display: none;
}

/**
  * Make back button smaller
  * @author Jonathan Lam
  */
#controls.mobile {
  flex: 0 0 0;
}
#controls.mobile > #homeLink {
  width: 2em;
  height: 2em;
  position: absolute;
  top: 1em;
  left: 1em;
  font-size: 3em;
  border-radius: 100%;
  background-color: rgba(0, 0, 0, 0.25);
}
#controls.mobile > #homeLink:active {
  background-color: transparent;
}
```

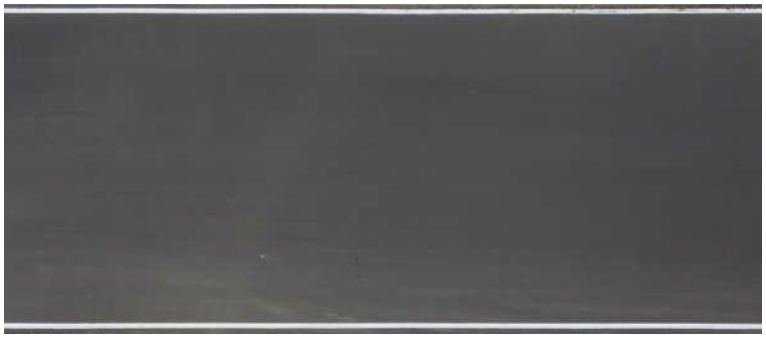
Assets:
`public/assets/map/map1.png` (UV map of car sides); author: Jonathan Lam



`public/assets/map/map2.png` (UV map of car top); author: Jonathan Lam



`public/assets/blacktop_texture.jpg`; downloaded from Internet



`public/map/dawnmountain-*.png` (multiple files); downloaded from Internet

`public/assets/grass_texture.jpg`; downloaded from Internet

`public/assets/loading_bg.jpg`; author: Jonathan Lam