
Math visualization with JSXGraph – an overview

Presentation and workshop

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1 Presentation

1.1 Getting support

1.1.1 Information for beginners

- Video tutorial: <https://youtu.be/0wQPASnq86Y>
- JSXGraph programming book: <https://ipesek.github.io/jsxgraphbook/>
- JSXGraph wiki <https://jsxgraph.org/wiki> with many examples together with source code

1.1.2 Information for intermediate / advanced users

- API docs: <https://jsxgraph.org/docs/>
- Webinar series (7 sessions) in 2020 / 2021: <https://jsxgraph.org/wp/docs/>
- Conferences talks and workshops (with lots of information about *JSXGraph in STACK*)
 - 2020: <https://jsxgraph.org/conf>
 - 2021: <https://jsxgraph.org/conf2021>
 - 2022: <https://jsxgraph.org/conf2022>

1.2 Feature tour



All these examples come with source code

- [Static plots](#)
- [Interactive \(dynamic\) plots](#)
- [Calculus](#)
 - [functions](#)
 - [Lagrange polynomial](#)
 - [Taylor polynomial](#)

- [curves](#)
 - [sequences and series](#)
 - [Riemann sums](#)
 - [differential equations](#)
 - [splines](#)
 - [polygonal chain](#)
- [Geometry](#)
 - [Euclidean geometry](#)
 - [Analytic geometry](#)
 - [Projective geometry \(offside line in football\)](#)
- [Statistics:](#)
 - [boxplots,](#)
 - [Regression I](#)
 - [Regression II](#)
- [Turtle graphics](#)
- [Dynamic MathJax](#)
- [Video embedding](#)
- [Clipping](#)
- [Animations](#)
- [3D](#)
- [More examples](#)

2 Workshop

2.1 Workshop environment

Recommended development process

- 1) use a text editor (like [visual studio code](#)) to create an HTML file and open it in a web browser
 - save the file with ending `.html`
 - to open the file in a web browser, click on the file name in the *windows file explorer* or *Mac OS finder*
 - or install the *open in browser* plug-in of visual studio code
- 2) or develop online in [jsfiddle](#)
 - Click on [save](#) to get a permanent URL of the construction. (do not forget to store the URL somewhere)
 - A simple example: <https://jsfiddle.net/tzsy184q/>



Always keep the *web console* (developer tools) open in the web browser to be informed about errors.

2.2 Include JSXGraph – skeleton page

Listing 2.1: How to include JSXGraph

```
<!doctype html>
<html lang="en">
  <head>
    <meta charset="UTF-8">
    <title>JSXGraph template</title>
    <meta content="text/html; charset=utf-8" http-equiv="Content-Type">

    <!-- Include JSXGraph -->
    <link href="https://cdn.jsdelivr.net/npm/jsxgraph/distrib/jsxgraph.css" rel="
      stylesheet" type="text/css" />
```

```

<script src="https://cdn.jsdelivr.net/npm/jsxgraph/distrib/jsxgraphcore.js"
  type="text/javascript" charset="UTF-8"></script>

<!-- Include MathJax - optional -->
<script src="https://cdn.jsdelivr.net/npm/mathjax@3/es5/tex-ctml.js" id="
  MathJax-script" async></script>
</head>
<body>
<h1>My first JSXGraph page</h1>
<div id="jxgbox" class="jxgbox" style="width:600px; height:600px;"></div>
<script>
  var board = JXG.JSXGraph.initBoard('jxgbox', {boundingbox: [-5, 2, 5, -2]});
</script>

</body>
</html>

```

- The template file at <https://jsfiddle.net/tzsy184q/1/>

Alternative locations of JSXGraph:

- Local copy of `jsxgraphcore.js` and `jsxgraph.css` (download or npm)
- <https://cdn.jsdelivr.net/npm/jsxgraph/distrib/jsxgraphcore.js>
- <https://cdnjs.cloudflare.com/ajax/libs/jsxgraph/1.4.6/jsxgraphcore.js>



Embedding JSXGraph directly from <https://jsxgraph.org/distrib/jsxgraphcore.js> is possible but not recommended

There are two essential parts:

1. The HTML element that contains a JSXGraph construction:

```
<div id="jxgbox" class="jxgbox" style="width:600px; height:600px;"></div>
```

2. The program logic:

```

<script>
  var board = JXG.JSXGraph.initBoard('jxgbox', {boundingbox: [-5, 2, 5, -2]});
</script>

```

2.3 Basic concepts in JavaScript

- JavaScript is embedded with `<script> ... </script>`
- Syntax is related to C.
- Data types:

- Boolean (**true**, **false**)
 - String
 - Number (floats and integers are not distinguished)
 - Function
 - Object, Array
- Strings can be enclosed in '...' or "..."

2.3.1 Variables

Listing 2.2: Declaration of variables

```
var a = 1,
    b, c; // Scope is the surrounding function

let i = 1;
// Scope is the surrounding block
for (let i = 0; i < 10; i++) {
    console.log(i, i * i);
}
```



Using neither **var** nor **let** to declare a variable is possible. The variable will then be global. This should be avoided and may be suppressed in some environments. Put the expression **"use strict"**; at the beginning of the JavaScript code to be warned (in the console) about global variables and other problems with JavaScript.

2.3.2 Math functions

- Math functions, see https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/Math

Listing 2.3: Math functions

```
console.log(Math.cos(0));
```

2.3.3 Functions

- Functions can be treated like any other variables

```
var square = function(x) {
    return x * x;
}
```



```
var cube = (x) => x * x * x;  
console.log(square(3), cube(3));
```

2.3.4 Arrays and objects

- Arrays are zero based

```
var arr = [1, 2, 3, 4];  
console.log(arr[0], arr.length);
```

- Objects can be compared to *associative arrays* in PHP or *dictionaries* in python.

```
var obj = {  
  color: 'green',  
  fillColor: 'yellow'  
};  
console.log(obj.color, obj['fillColor']);
```

2.3.5 Events

- JavaScript is *event based*
- Events can be supplied with eventlistener / eventhandler, see <https://developer.mozilla.org/en-US/docs/Web/API/EventTarget/addEventListener>
- Available events: <https://developer.mozilla.org/en-US/docs/Web/Events>

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

```
document.getElementById('mybutton').addEventListener('click', function(evt) {  
  alert('hello');  
});
```

2.4 JSXGraph

- Documentation: <https://jsxgraph.org/docs/>
- Basic example: <https://jsfiddle.net/WigandR/hgyz32oe/>

2.4.1 The board

```
const board = JXG.JSXGraph.initBoard('jxgbox', {
  boundingbox: [-5, 5, 5, -5],
  axis: true
});
```

2.4.2 Generate a point

```
var p = board.create('point', [2, 1]);
```

```
var p = board.create('point', [2, 1]);
var p2 = board.create('point', [1, 2], {
  name: 'p_2',
  color: 'blue',
  label: {
    color: '#0000ff',
    fontSize: 32
  },
  showInfobox: false
});
```

2.4.3 More on attributes

Listing 2.4: Local change

```
var p = board.create('point', [2, 2], {showInfobox: false});
```

Listing 2.5: Board wide change

```
board.options.point.showInfobox = false;
var p = board.create('point', [2,2]);
```

Listing 2.6: Page wide change

```
JXG.Options.point.showInfobox = false;

const board = JXG.JSXGraph.initBoard('jxgbox', {
  boundingbox: [-5, 5, 5, -5], axis:true
});
var p = board.create('point', [2, 2]);
```

2.4.4 Some dynamic geometry

- point

```
var p = board.create('point', [-2, 1]);
var p2 = board.create('point', [
    () => p.X(),
    function(x) { return p.Y() + 1; }
], {
    name: 'p_2',
    color: 'blue',
    label: {
        color: '#0000ff',
        fontSize: 32
    },
    showInfobox: false
});
```

- <https://jsfiddle.net/tzsy184q/3/>

```
for (let i = 0; i < 100; i++) {
    board.create('point', [
        (Math.random() - 0.5) * 8, (Math.random() - 0.5) * 8
    ], {name: ''});
}

for (let i = 0; i < 100; i++) {
    board.create('point', [
        function() {return (Math.random() - 0.5) * 8; },
        () => (Math.random() - 0.5) * 8
    ], {name: '', color: 'blue'});
}
```

- <https://jsfiddle.net/tzsy184q/4/>
- line, intersections, circle, polygon, clipping

```
var p = board.create('point', [-2, 1]);
var p2 = board.create('point', [
    () => p.X(),
    function(x) { return p.Y() + 1; }
], {
    name: 'p_2',
    color: 'blue',
    visible: function() {
        if (p.X() < 0) {
            return false;
        } else {
            return true;
        }
    },
    label: {
        color: '#0000ff',
```

```

        fontSize: 32
      },
      showInfobox: false
    });

    var li = board.create('line', [p, p2]);
    var ci = board.create('circle', [p, p2]);
    var p3 = board.create('glider', [0, 3, ci]);

    var pol = board.create('polygon', [p, p2, [5, 2], [3, -1]]);
    var ci2 = board.create('circle', [[0, -2], 3]);
    var fill = board.create('curveintersection', [pol, ci2], {fillColor: 'yellow'})
    ;

    var but = document.getElementById('mybutton');
    but.addEventListener('click', function(evt) {
      board.removeObject(p2);
    });

```

- <https://jsfiddle.net/tzsy184q/5/>

2.4.5 Using MathJax in JSXGraph

- Add <https://cdn.jsdelivr.net/npm/mathjax@3/es5/tex-ctrl.js>
- Attribute `useMathjax: true` and double backslash e.g. `\\(\\frac{a}{b}\\)`

2.4.6 Tangent example

- See <https://jsfiddle.net/WigandR/hgyz32oe/>

```

const board = JXG.JSXGraph.initBoard('jxgbox', {
  boundingbox: [-1, 4, 5, -4],
  keepaspectratio: false,
  axis: true
});

var a = board.create('slider', [
  [0, -2.5],
  [4, -2.5],
  [0, 2, 3]
], {
  name: 'a;'
});

var c = board.create('slider', [
  [0, -3.5],
  [4, -3.5],
  [0, 1, 5]
], {name: '&omega;'});

```

```

var fun = function(x) {
  return a.Value() * Math.sin(c.Value() * x );
}

var graph = board.create('functiongraph', [fun, -10, 10], {
  strokeColor: '#00ff00'
});

var p1 = board.create('glider', [0, 0, graph], {name:'P'});
var t = board.create('tangent', [p1]);

```

2.4.7 Math syntax and dynamic MathJax

- If supplied as string, usual math syntax can be used for function terms

```

var board = JXG.JSXGraph.initBoard('jxgbox1', {
  boundingbox: [-5, 5, 8, -5],
  axis: true
});

var a = board.create('slider', [
  [0, -2],
  [5, -2],
  [0, 2, 3]
], {
  name: 'a'
});

var c = board.create('slider', [
  [0, -3],
  [4, -3],
  [0, 1, 5]
], {name: 'c'});

var graph = board.create('functiongraph', ['a * sin(c * x)']);
var p1 = board.create('glider', [0, 0, graph], {name:'P'});
var t = board.create('tangent', [p1]);

var txt = board.create('text', [-3, 3, function() { return p1.X(); }]);
var txt2 = board.create('text', [-4, -3,
  function() { return 'MathJax: \\(\\frac{' + p1.X().toFixed(2) + '}' +
    p1.Y().toFixed(2) + '\\)'; }],
  {useMathjax: true});

```

2.4.8 Axes labeled with π

- <https://jsfiddle.net/zw4bh2mu/2/>
- See also <https://jsxgraph.uni-bayreuth.de/webinar/advanced2.pdf>

```
const board = JXG.JSXGraph.initBoard('jxgbox', {
  boundingbox: [-7, 5, 7, -5], axis:true,
  defaultAxes: {
    x: {
      ticks: {
        scale: 3.1415,
        scaleSymbol: '\u03c0'
      }
    }
  }
});

board.create('functiongraph', ['sin(x)']);
```

