THE UNIVERSITY *of* EDINBURGH
School of Mathematics

Using JSXGraph for diagrams and interactivity

Dr George Kinnear
G.Kinnear@ed.ac.uk
@georgekinnear

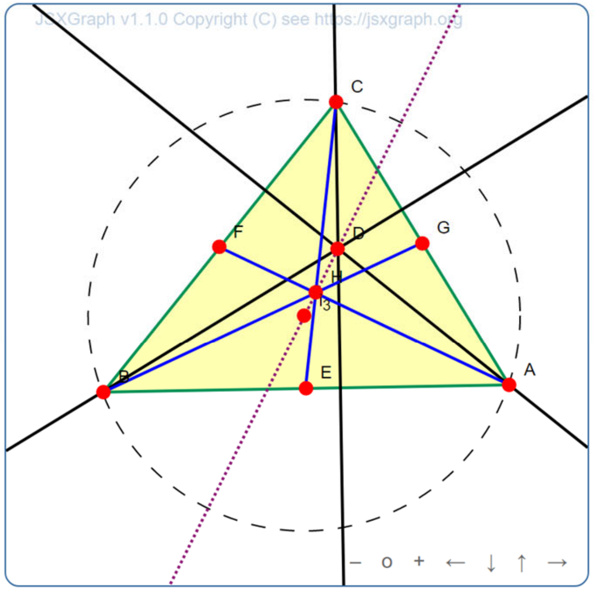
Overview

- JSXGraph and STACK
- Randomisation
- Interactivity

JSXGraph and STACK

JSXGraph

```
var board = JXG.JSXGraph.initBoard('jxgbox', {
                boundingbox: [-1.5, 2, 1.5, -1], keepaspectratio:true
            });

// Triangle ABC
var A = board.create('point', [1, 0]),
    B = board.create('point', [-1, 0]),
    C = board.create('point', [0.2, 1.5]),
    pol = board.create('polygon',[A,B,C], {
        fillColor: '#FFFF00',
        borders: {
            strokeWidth: 2,
            strokeColor: '#009256'
        }
    });

// Perpendiculars and orthocenter i1
var pABC = board.create('perpendicular', [pol.borders[0], C]),
    pBCA = board.create('perpendicular', [pol.borders[1], A]),
    pCAB = board.create('perpendicular', [pol.borders[2], B]),
    i1 = board.create('intersection', [pABC, pCAB, 0]);

// Midpoints of segments
var mAB = board.create('midpoint', [A, B]),
    mBC = board.create('midpoint', [B, C]),
    mCA = board.create('midpoint', [C, A]);

// Line bisectors and and centroid i2
var ma = board.create('segment', [mBC, A]),
    mb = board.create('segment', [mCA, B]),
    mc = board.create('segment', [mAB, C]),
    i2 = board.create('intersection', [ma, mc, 0]);

// Circum circle and circum center
var c = board.create('circumcircle', [A, B, C], {
        strokeColor: '#000000',
        dash: 3,
        strokeWidth: 1,
        center: {
            name: 'i_3',
            withlabel:true,
            visible: true
        }
    });

// Euler line
var euler = board.create('line', [i1, i2], {
                dash:1,
                strokeWidth: 2,
                strokeColor:'#901B77'
            });
```



JSXGraph API REFERENCE EXAMPLES DOWNLOAD DOCS REFERENCES BLOG

Examples

Dynamic Mathematics with JavaScript

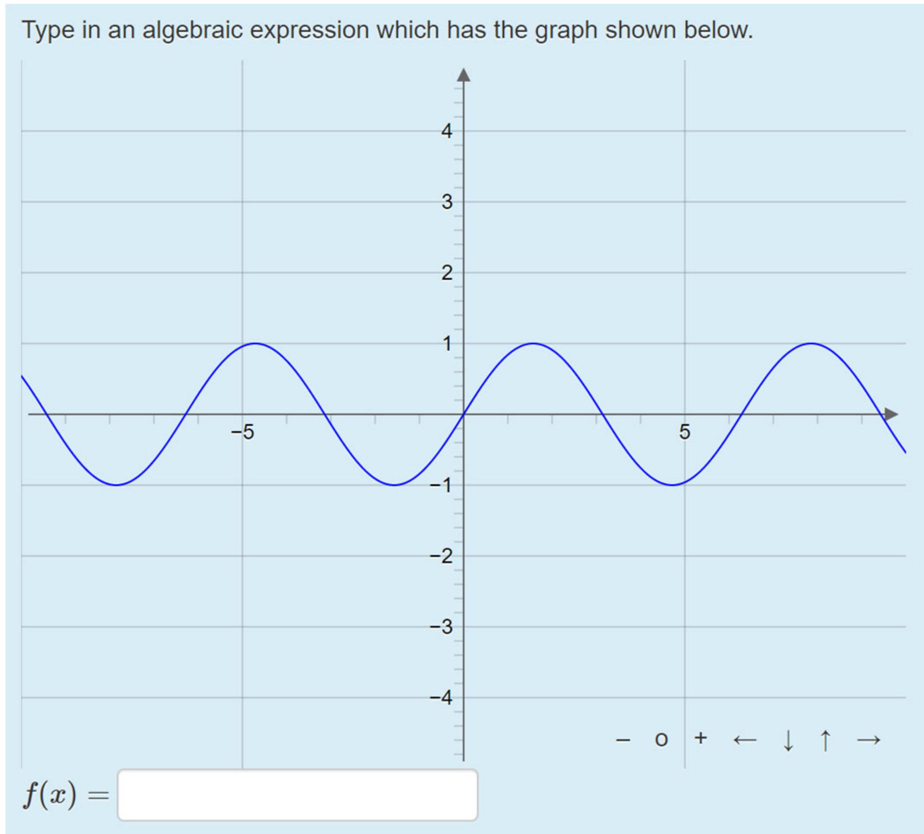
Features

- Euclidean Geometry: Points, lines, circle, intersections, perpendicular lines, angles
- Curve plotting: Graphs, parametric curves, polar curves, data plots, Bezier curves
- Differential equations
- Turtle graphics
- Lindenmayer systems
- Interaction via sliders
- Animations
- Polynomial interpolation, spline interpolation
- Tangents, normals
- Basic support for charts
- Vectors
- ...

http://jsxgraph.org/wp/about/index.html

JSXGraph in STACK

```
a: rand(6)-3;
fx: sin(x)+a;

<p>Type in an algebraic expression which has the
graph shown below.</p>
[[jsxgraph]]
  // boundingbox:[left, top, right, bottom]
  var board = JXG.JSXGraph.initBoard(divid,
                     {boundingbox: [-10, 5, 10, -5],
                     axis: true,
                     showCopyright: false});
  var f = board.jc.snippet('{#fx#}', true, 'x', true);
  board.create('functiongraph', [f,-10,10]);
[[/jsxgraph]]
<p>\(f(x)=\) [[input:ans1]] [[validation:ans1]]</p>
```



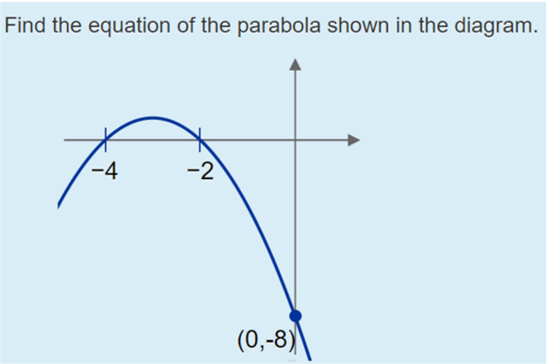
https://stack2.maths.ed.ac.uk/demo2018/question/type/stack/doc/doc.php/Authoring/JSXGraph.md

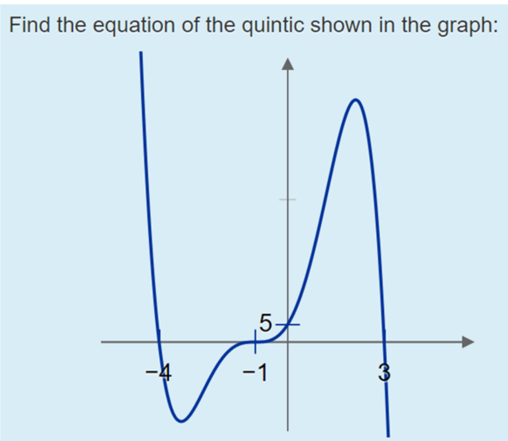
Possible pitfall: comments

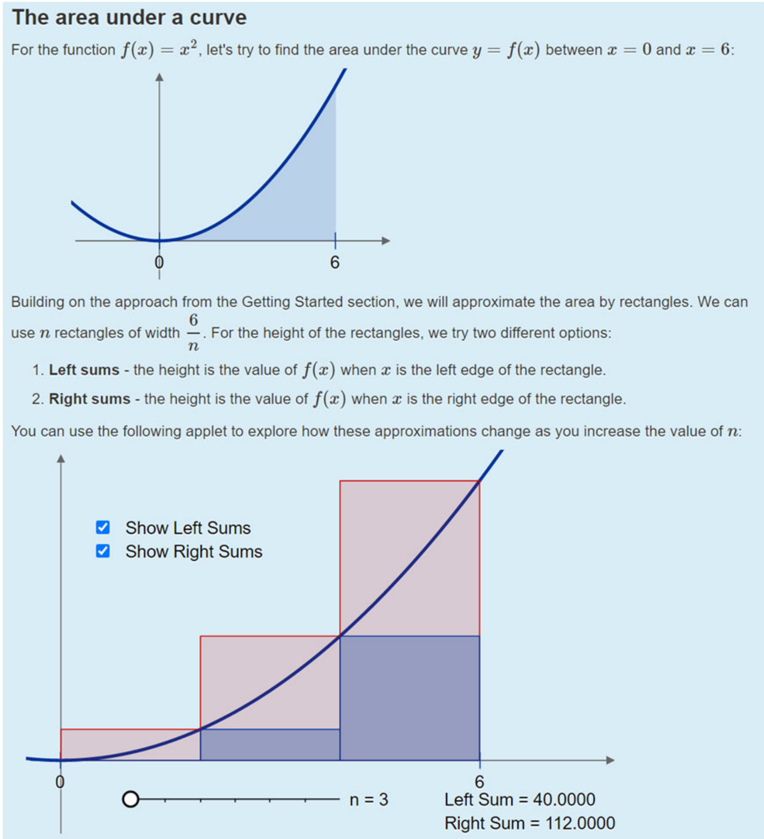
```
<p>Type in an algebraic expression which has the graph shown below.</p>
[[jsxgraph]]
  // boundingbox:[left, top, right, bottom]
  var board = JXG.JSXGraph.initBoard(divid, {boundingbox: [-10, 5, 10, -5], axis: true,
                                              showCopyright: false});
  var f = board.jc.snippet('{#fx#}', true, 'x', true);
  board.create('functiongraph', [f,-10,10]);
[[/jsxgraph]]
<p>\(f(x)=\) [[input:ans1]] [[validation:ans1]]</p>
```

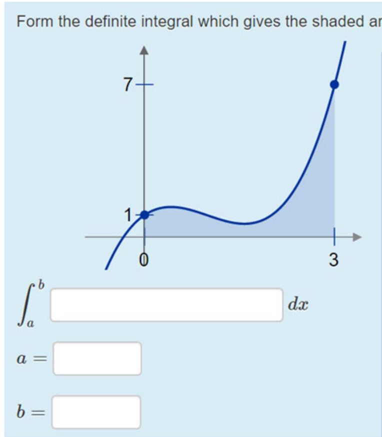
- Sometimes caused import/export problems
- Instead: /* comment */

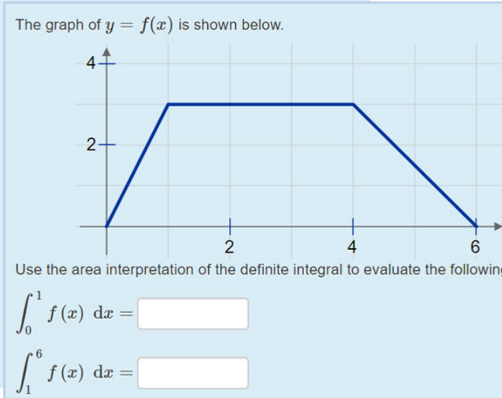
Fundamentals of Algebra and Calculus

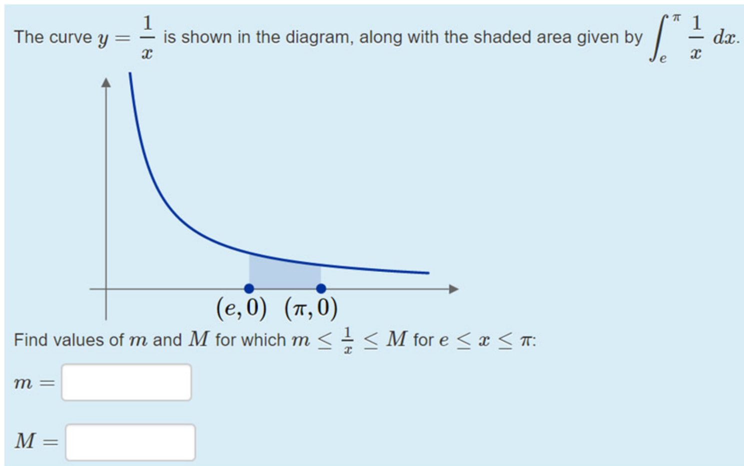












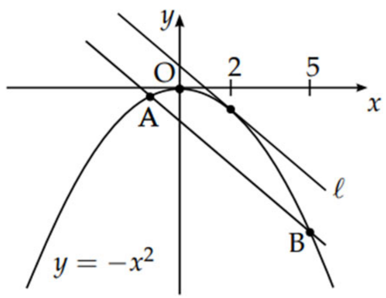
THE UNIVERSITY *of* EDINBURGH
School of Mathematics

Demo available at: https://eams.ncl.ac.uk/moodle/course/view.php?id=5

Randomisation

From one to many

The curve with equation $y = -x^2$ is shown in the diagram below.

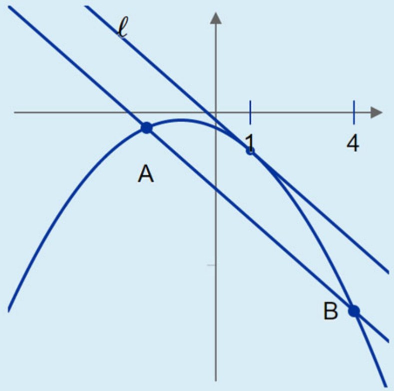


The line ℓ is a tangent to the curve at $x = 2$.

(*a*) Find the gradient of line ℓ.

(*b*) Given that the line through A and B is parallel to ℓ, find the coordinates of A.

The curve with equation $y = -2\,x^2 - 4\,x - 4$ is shown in the diagram below.



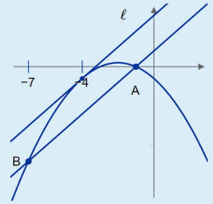
The line ℓ is a tangent to the curve at $x = 1$.

(a) Find the gradient of line ℓ.

(b) Given that the line through A and B is parallel to ℓ, find the coordinates of A.

Enter your answer as a list, e.g. to enter $(1, 2)$ type `[1,2]`

The curve with equation $y = -2\,x^2 - 8\,x - 6$ is shown in the diagram below.



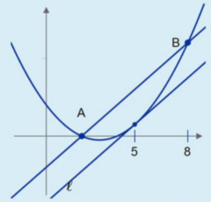
The line ℓ is a tangent to the curve at $x = -4$.

(a) Find the gradient of line ℓ.

(b) Given that the line through A and B is parallel to ℓ, find the coordinates of A.

Enter your answer as a list, e.g. to enter $(1, 2)$ type `[1,2]`

The curve with equation $y = 2\,x^2 - 12\,x + 16$ is shown in the diagram below.



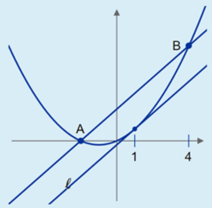
The line ℓ is a tangent to the curve at $x = 5$.

(a) Find the gradient of line ℓ.

(b) Given that the line through A and B is parallel to ℓ, find the coordinates of A.

Enter your answer as a list, e.g. to enter $(1, 2)$ type `[1,2]`

The curve with equation $y = x^2 + 2\,x$ is shown in the diagram below.



The line ℓ is a tangent to the curve at $x = 1$.

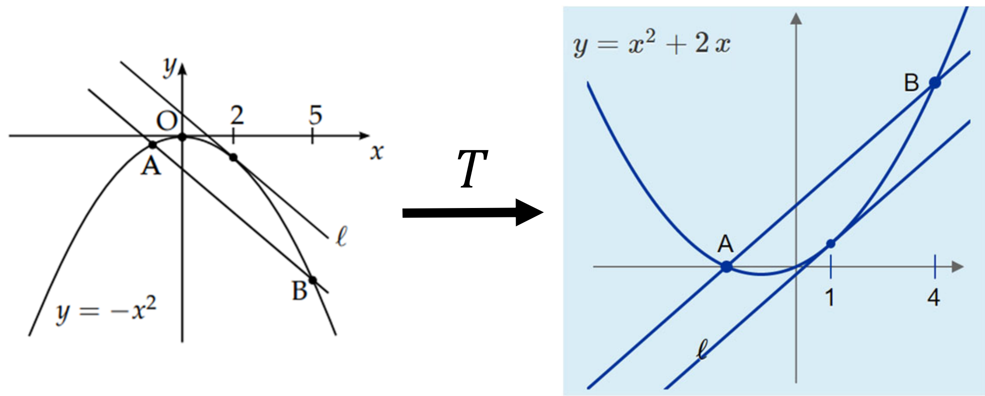
(a) Find the gradient of line ℓ.

(b) Given that the line through A and B is parallel to ℓ, find the coordinates of A.

Enter your answer as a list, e.g. to enter $(1, 2)$ type `[1,2]`

Method: transformation

- Start with a known question and apply a transformation
  - Scaling (c_x and c_y)
  - Translating (t_x and t_y)
- Transform to new coordinates:
  a) points
  b) expressions



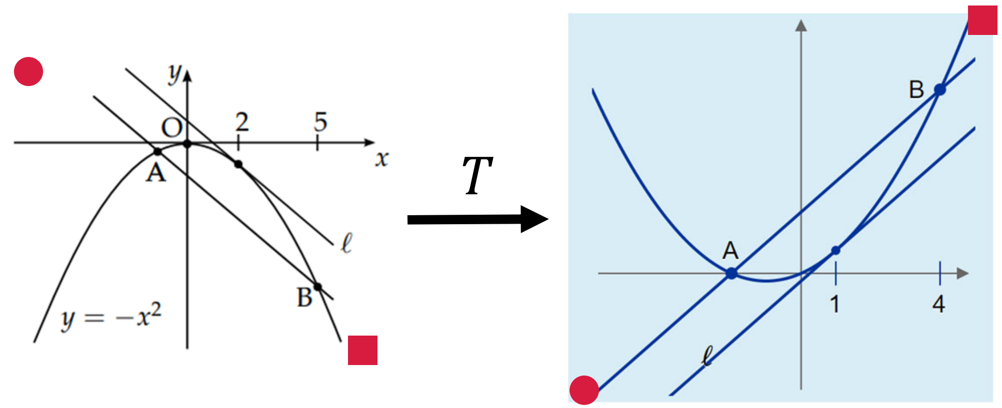
$$T(x, y) = \left(c_x(x + t_x), c_y(y + t_y)\right)$$

a) T(2,-4) = (1,3)

b) TF(y):=expand(ev(T(0,y)[2],x=x/cx-tx));
TF(-x^2) = x^2+2*x

THE UNIVERSITY of EDINBURGH
School of Mathematics

Bounding boxes



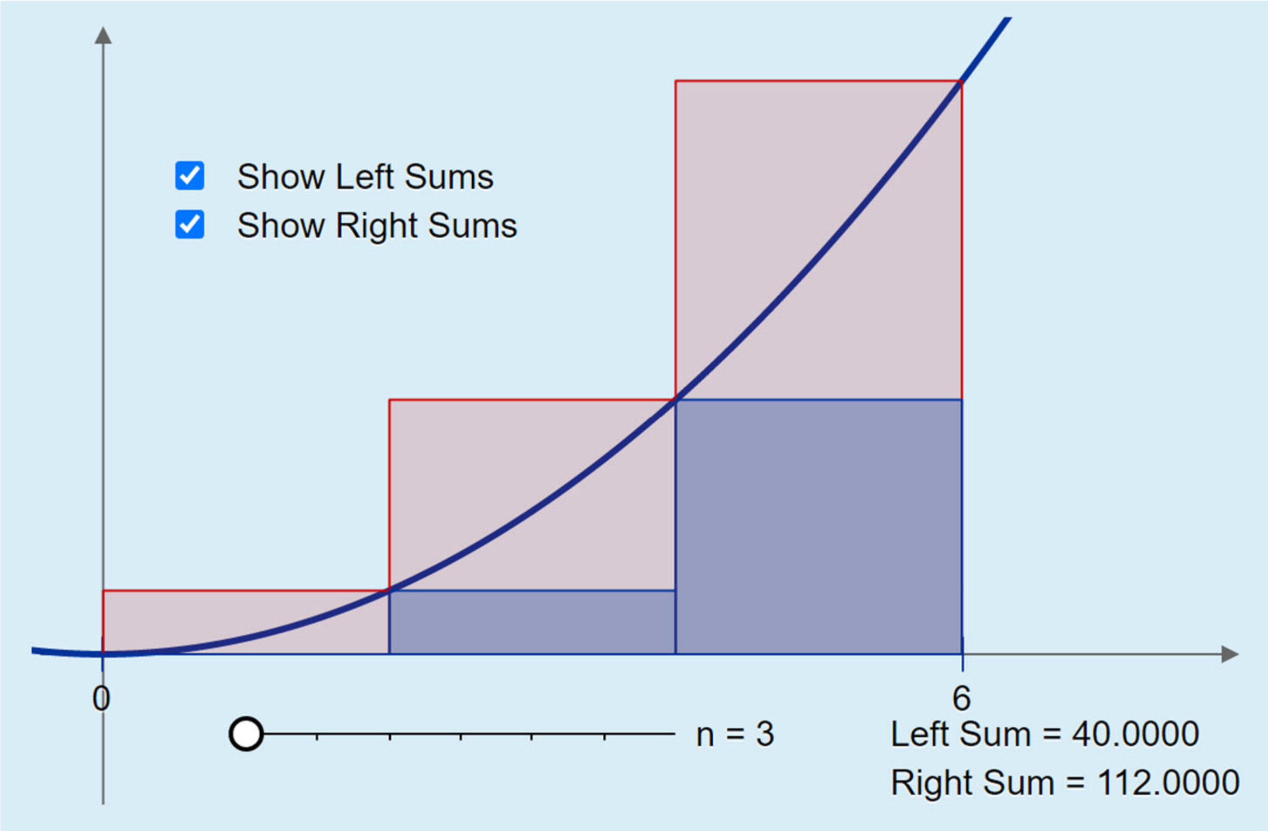

```
bbTL:T(-5,15);
bbBR:T(6,-35);

BBx:[bbTL[1],bbBR[1],-1.5,1.5];
BBy:[bbTL[2],bbBR[2],-1.5,1.5];
BB:[lmin(BBx),lmax(BBy),lmax(BBx),lmin(BBy)];
```

[left, top, right, bottom]

```
var board = JXG.JSXGraph.initBoard(divid, {boundingbox: {#BB#}});
```

Interactivity

Sliders



Show Left Sums
Show Right Sums
0
6
n = 3
Left Sum = 40.0000
Right Sum = 112.0000

Sliders with a task

The function $f(x) = \arctan(x)$ has Maclaurin series $\sum_{n=0}^{\infty} \frac{(-1)^n x^{2n+1}}{2n+1} = x - \frac{x^3}{3} + \frac{x^5}{5} - \frac{x^7}{7} + \cdots$.

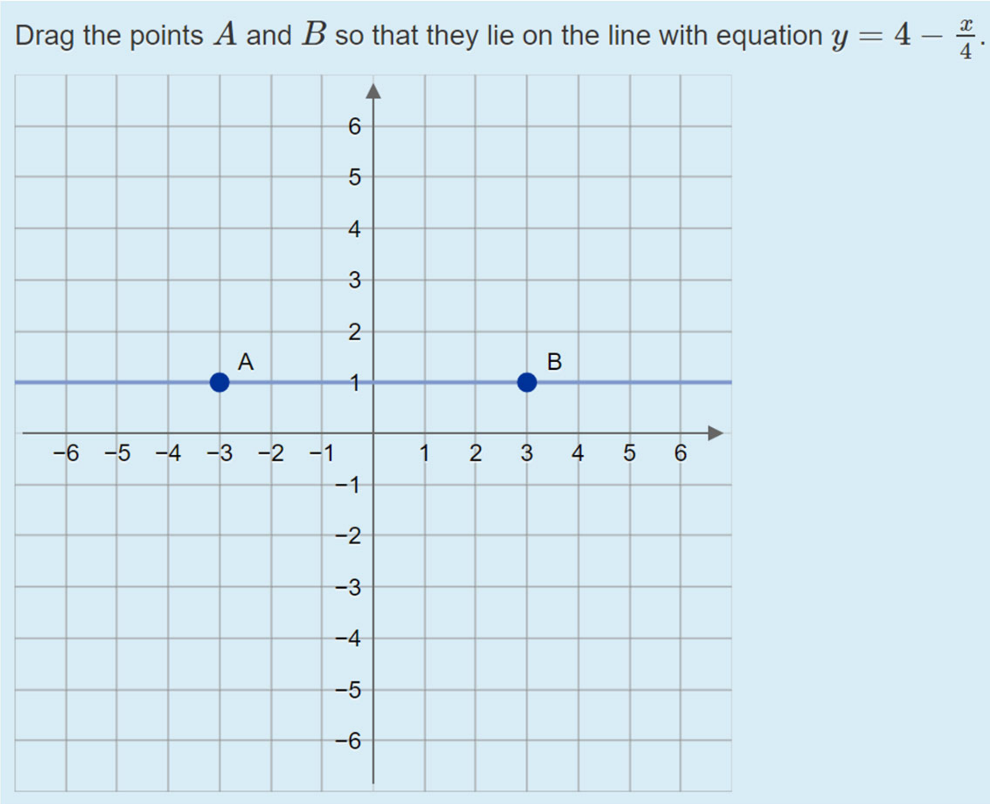
This applet shows what those polynomials look like, with a slider so you can vary the value of N:

Here, you should see that as you increase the value of N, the Maclaurin polynomials do give a better approximation of $f(x)$ for some x values but not for others.

Using the applet, which of the following values appear to be ones for which the Maclaurin series converges?

- [ ] **(a)** -0.5
- [ ] **(b)** 0.5
- [ ] **(c)** -1.5
- [ ] **(d)** 1.5
- [ ] **(e)** 0

Interactive with assessment



- Students drag the points to give their answer
- JavaScript code returns the answer to STACK as a list

THE UNIVERSITY *of* EDINBURGH
School of Mathematics

Based on code from Mikko Vasko (Hochschule Karlsruhe) at the 1st STACK conference

Code in HTML editor

```
var moveThingsAround = function() {
    var i;
    for (i = 0; i &lt; answer.length; i++) {
        answer[i].moveTo([ ans[2*i] , ans[2*i+1] ]);
    };
};
```

Another hack to avoid <

```
function isLessThan(a, b) {
  return Object.is((a-b)%1, -0);
}
for(i = 0; isLessThan(i,sv); i++) {
  val = val + Math.pow(-1, i)*Math.pow(t,2*i+1)/(2*i+1);
}
```

Option 1:

Use the plain-text editor in Moodle.

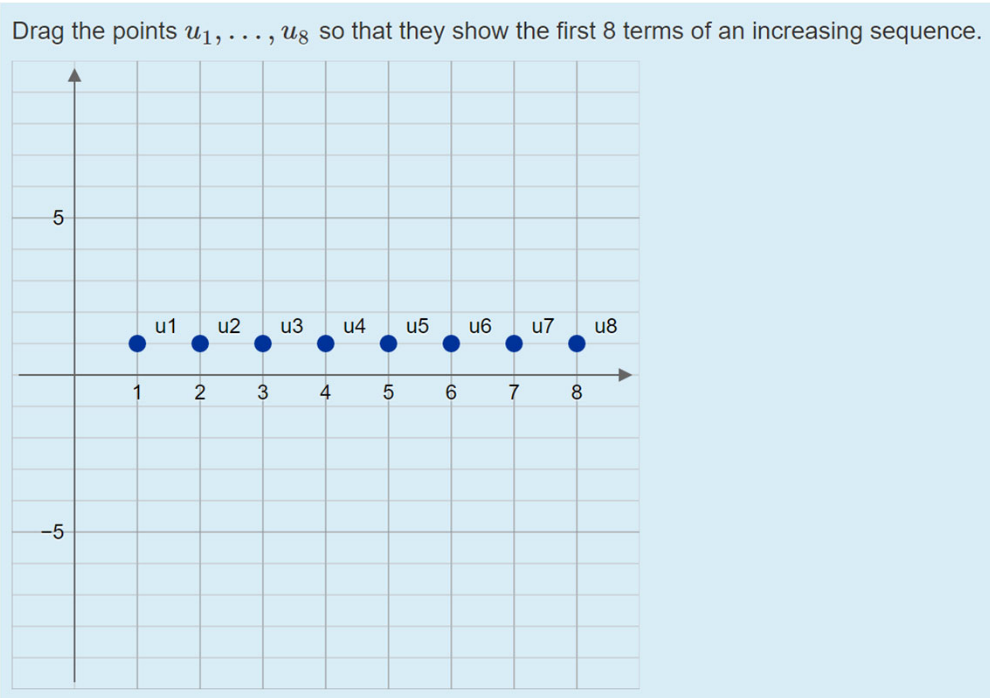
Option 2:

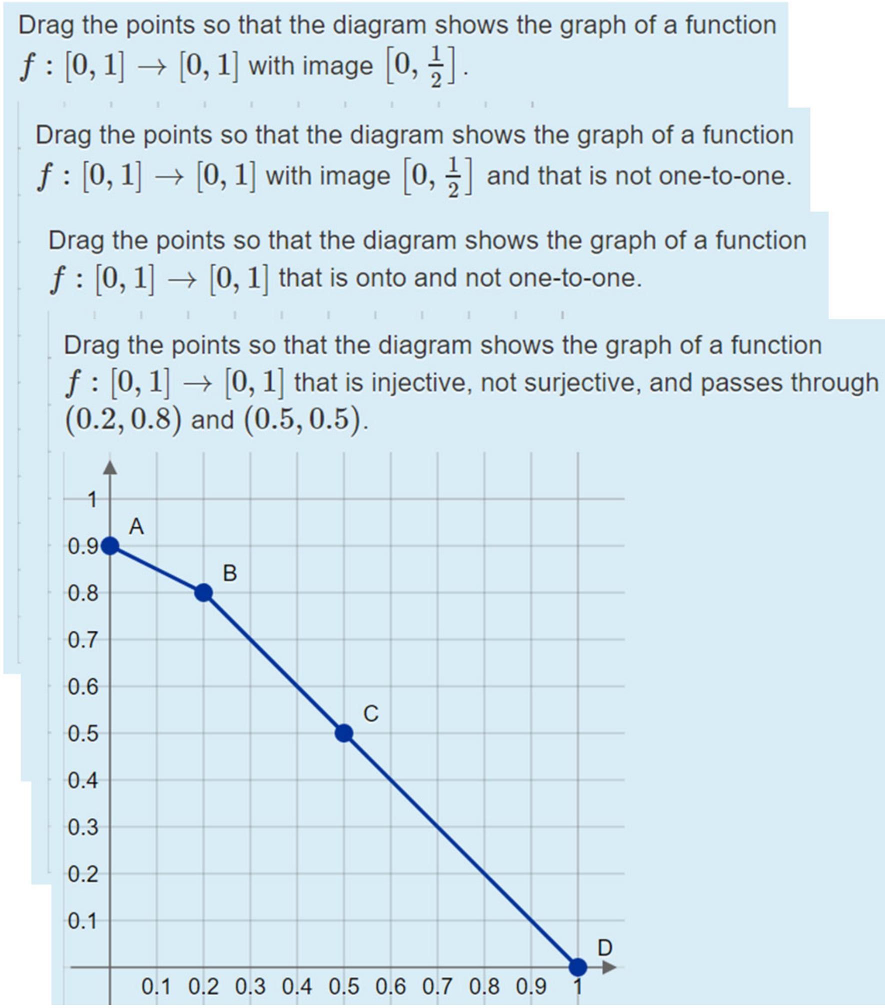
Use alternative JavaScript:

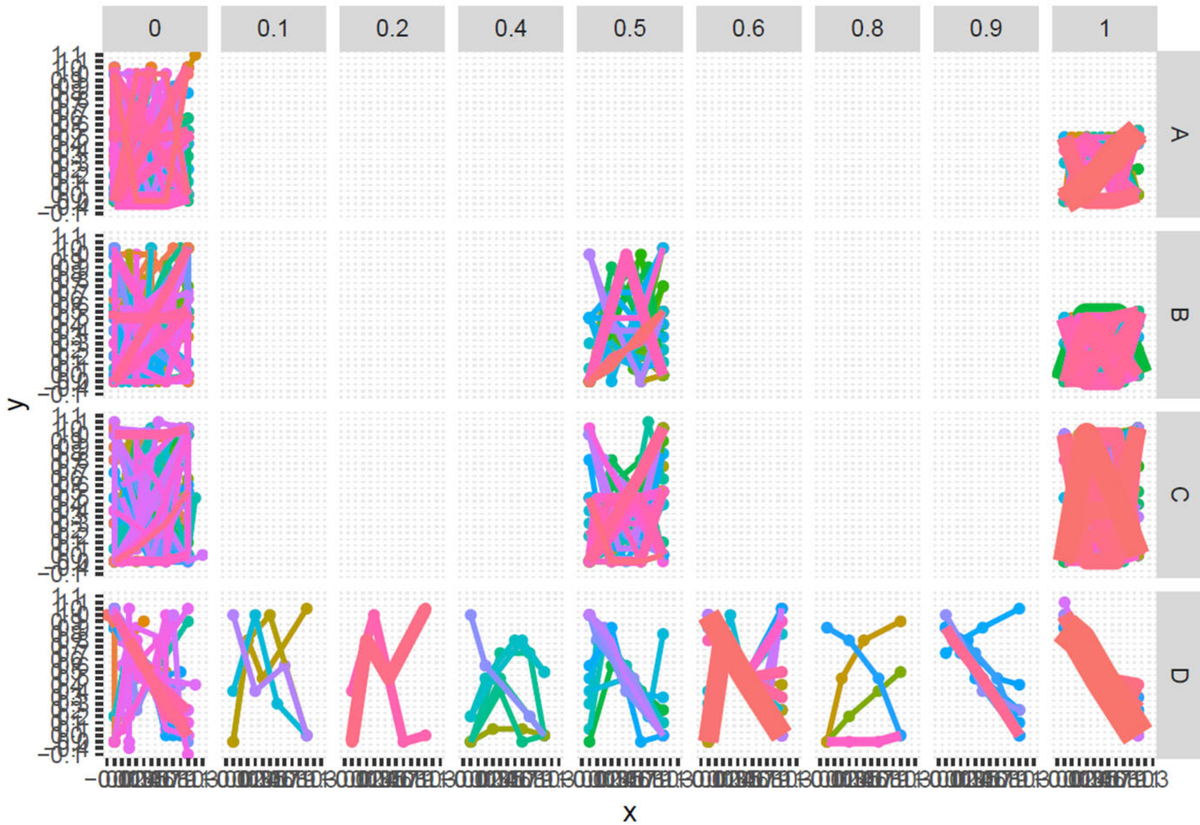
```
var moveThingsAround = function() {
    var i = 0;
    for (let pts of answer) {
        pts.moveTo([ ans[2*i] , ans[2*i+1] ]);
        i++;
    };
};
```

```
for(let i of [1,2,3]) {
  board.create('point', [i, 0]);
}
```

Further examples






0
0.1
0.2
0.4
0.5
0.6
0.8
0.9
1
A
B
C
D
y
x

Thank you!

Dr George Kinnear
G.Kinnear@ed.ac.uk
@georgekinnear
THE UNIVERSITY *of* EDINBURGH
School of Mathematics

Example questions:
https://eams.ncl.ac.uk/moodle/course/view.php?id=5
"Demo: JSXGraph"