P.PORTO

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TSIW

Syllabus

- Paths
- Shapes in paths:
  - Lines
  - Arcs
  - Curves
- Text
- Animation cycle

Paths

- Unlike SVG, Canvas only supports two primitive shapes: **rectangles** and **paths**
  - All other shapes must be created by combining one or more paths
  - However, Canvas API provides an assortment of path drawing functions which make it possible to compose very complex shapes
- Defining a path on Canvas is like **drawing with a pencil**
- **Path** is a sequence of points, lines or curves (subpaths) to be drawn between the start and end points

Paths

STEPS to make shapes using paths:

1. (Re)Start a new path: `beginPath()`
2. "Move the pencil", i.e. create a set of subpaths (lines, arcs, curves)
3. (optional) Close the path by drawing a line between the endpoint and start point: `closePath()`
4. "Paint", meaning draw the final shape:
   `stroke()` - just the outline
   `fill()`- full form fill

Path methods

`beginPath()`

Starts a new path by emptying the list of sub-paths;
Call this method when you want to create a new path.

`closePath()`

Moves back the pen from the back to the beginning of the current sub-path (by drawing a line);
If the shape has already been closed or has only one point, this function does nothing.

Path methods

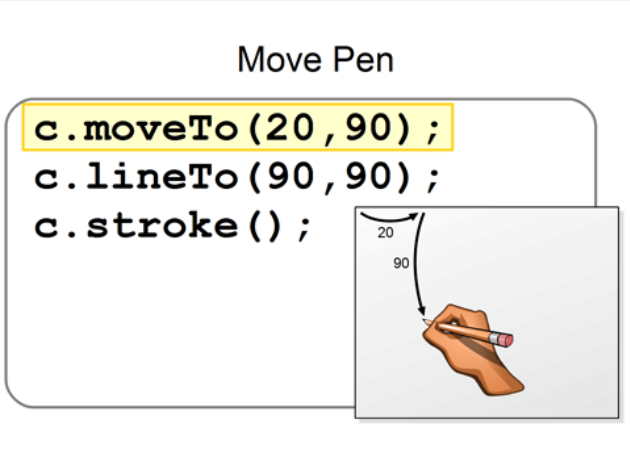
`moveTo(x,y)`
Moves the starting point of a new sub-path to the `(x,y)` coordinates

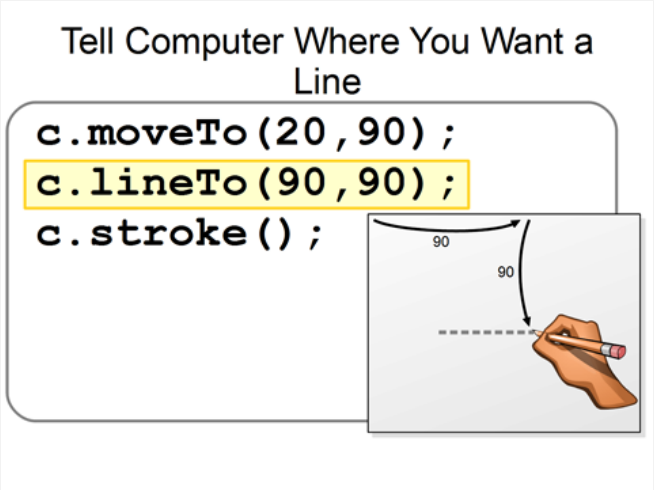
`lineTo(x,y)`
Connects the last point in the current sub-path to the specified `(x,y)` coordinates with a straight line

Paths & Lines

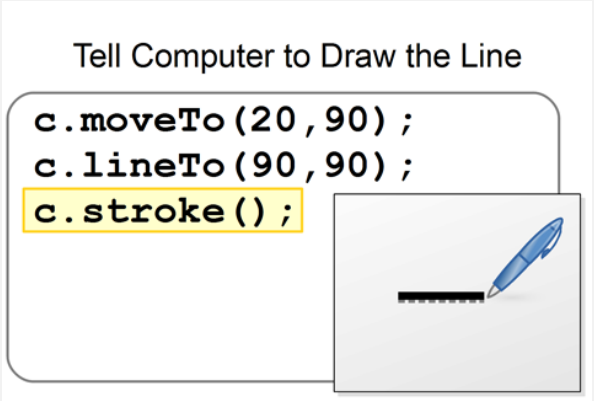
- **Lines**:

1. `moveTo(x,y)`
   mandatory!!!





2. `lineTo(x,y)`



3. `stroke()`

Paths & Lines

- **Lines**:

JavaScript ▾

```
c.moveTo(20,90);
c.lineTo(90,90);
c.lineTo(90,140);
c.lineTo(20,140);
c.lineTo(20,90);
c.lineTo(55,60);
c.lineTo(90,90);
```

Output

Run with JS

Auto-run JS

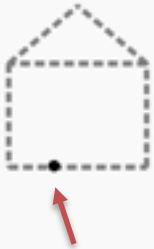
JavaScript ▾

```
c.moveTo(20,90);
c.lineTo(90,90);
c.lineTo(90,140);
c.lineTo(20,140);
c.lineTo(20,90);
c.lineTo(55,60);
c.lineTo(90,90);

c.moveTo(45,140);
```

Output

Run with JS

Auto-run JS



JavaScript ▾

```
c.moveTo(20,90);
c.lineTo(90,90);
c.lineTo(90,140);
c.lineTo(20,140);
c.lineTo(20,90);
c.lineTo(55,60);
c.lineTo(90,90);

c.moveTo(45,140);
c.lineTo(45,115);
c.lineTo(65,115);
c.lineTo(65,140);
c.stroke();
```

Output

Run with JS

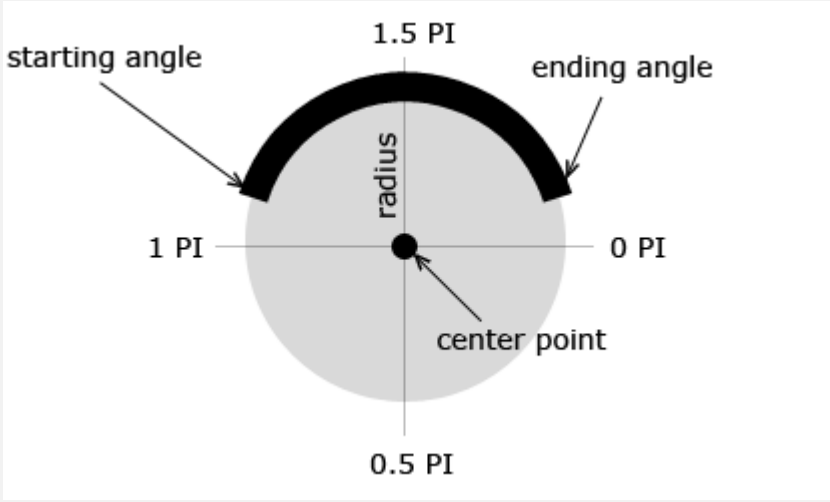
Auto-run JS

Path methods

`arc(cX,cY,r,θi,θf[,dir])`

Adds a circular arc to the current path

- **`cX`**, **`cY`**: center
- **`r`**: radius
- **`θi`**: initial angle (radians)
- **`θf`**: final angle (radians)
- **`dir`**: direction (optional)
  – default value: false (clockwise)



- Use JS module `Math` to convert degrees into radians:
  θ_{rad} `= Math.PI / 180 *` θ_{deg}

Paths & Arcs

```
ctx.beginPath();
ctx.arc(75, 75, 50, 0, Math.PI * 2, true); // Outer circle
ctx.moveTo(110, 75);
ctx.arc(75, 75, 35, 0, Math.PI, false);    // Mouth (clockwise)
ctx.moveTo(65, 65);
ctx.arc(60, 65, 5, 0, Math.PI * 2, true);  // Left eye
ctx.moveTo(95, 65);
ctx.arc(90, 65, 5, 0, Math.PI * 2, true);  // Right eye
ctx.stroke();                              // Paint the path border
```

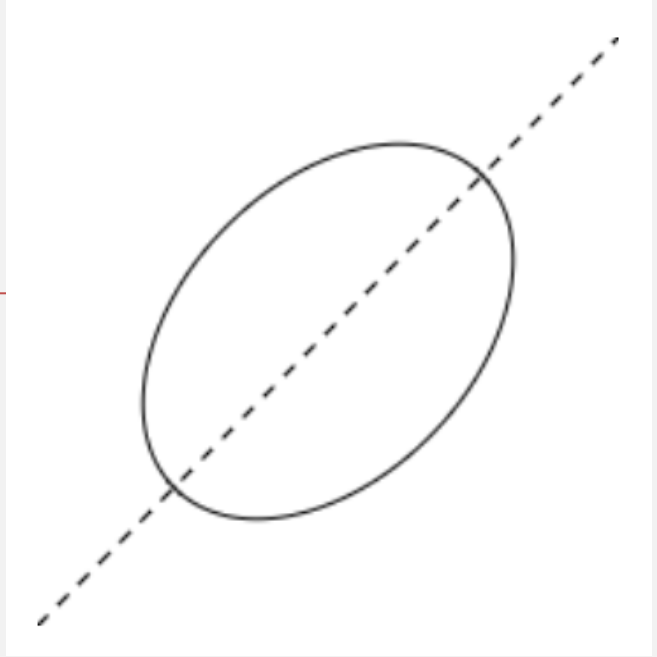
Path methods

`ellipse(cX,cY, rX,rY, rot, θi,θf [,dir])`

- **`cX`**, **`cY`**: center of the ellipse
- **`rX`**, **`rY`**: radius
- **`rot`**: rotation of the ellipse (radians)
- **`θi`**: initial angle (radians)
- **`θf`**: final angle (radians)
- **`dir`**: direction (optional)
  – default value: false (clockwise)

Paths & Ellipses

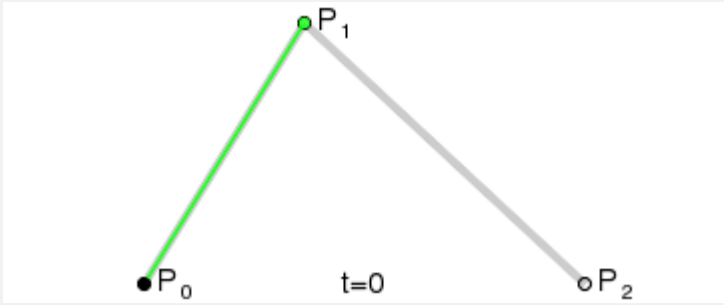
```
// Draw the ellipse
ctx.beginPath();
ctx.ellipse(100, 100, 50, 75, Math.PI / 4, 0, 2 * Math.PI);
ctx.stroke();

// Draw the ellipse's line of reflection
ctx.beginPath();
ctx.setLineDash([5, 5]);
ctx.moveTo(0, 200);
ctx.lineTo(200, 0);
ctx.stroke();
```



Path methods

`quadraticCurveTo(cpX,cpY, x,y)`

- Initial point – P0 – is the current "pencil" position
- **cpX**, **cpY**: control point - P1 - coordinates
- **x**, **y**: final point - P2 - coordinates

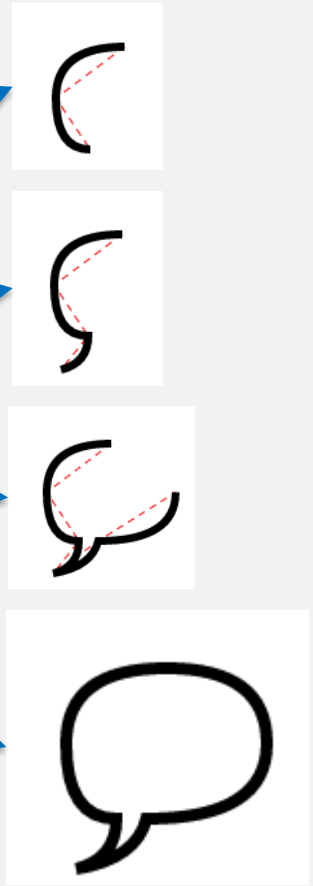


- Interact with the example here

Paths & Curves

- Example using quadratic curves:

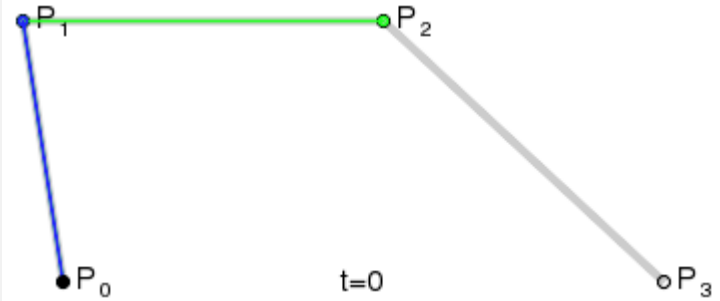
```
ctx.lineWidth = 6;   //increases line width

ctx.beginPath();     //start a new path
ctx.moveTo(75,25);   //sets inicial “pencil” position
ctx.quadraticCurveTo(25,25,25,62.5);
ctx.quadraticCurveTo(25,100,50,100);
ctx.quadraticCurveTo(50,120,30,125);
ctx.quadraticCurveTo(60,120,65,100);
ctx.quadraticCurveTo(125,100,125,62.5);
ctx.quadraticCurveTo(125,25,75,25);

ctx.stroke();        //paint the path border
```



Path methods

`bezierCurveTo(cp1X,cp1Y, cp2X,cp2Y, x,y)`

- Initial point – P0 – is the current "pencil" position
- **`cp1X`**, **`cp1Y`**: control point 1 - P1 – coordinates
- **`cp2X`**, **`cp2Y`**: control point 2 – P2 – coordinates
- **`x`**, **`y`**: final point – P3 - coordinates



- Interact with the example here

Text

- Methods to write something in Canvas:

  `fillText(text,x,y)` or **`strokeText(text,x,y)`**

  - **`text`**: string to be written
  - **`x`**, **`y`**: start position of the text (first character)

- Some important text properties
  - **`font`**: default value - “10px sans-serif”

```
ctx.fillText(ctx.font, 10, 20);
ctx.font = 'italic 20px fantasy';
ctx.fillText(ctx.font, 10, 40);
ctx.font = 'bold 40px Verdana';
ctx.fillText(ctx.font, 10, 80);
ctx.font = '60px Arial';
ctx.fillText(ctx.font, 10, 140);
```

Text

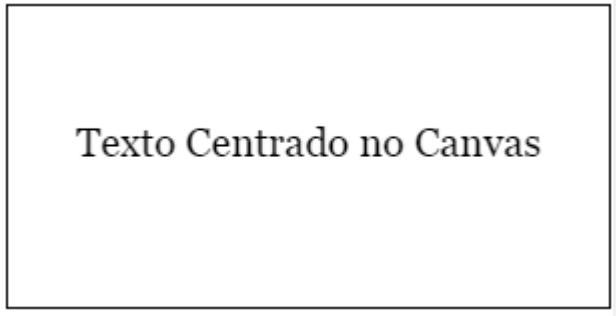
- Some important text properties
  - **textAlign**: horizontal alignment - default value “left”

```
ctx.textAlign = 'center';
ctx.fillText("Hello World!", 300, 40);

ctx.textAlign = 'left';
ctx.fillText("Hello World!", 300, 60);

ctx.textAlign = 'right';
ctx.fillText("Hello World!", 300, 80);
```

Text

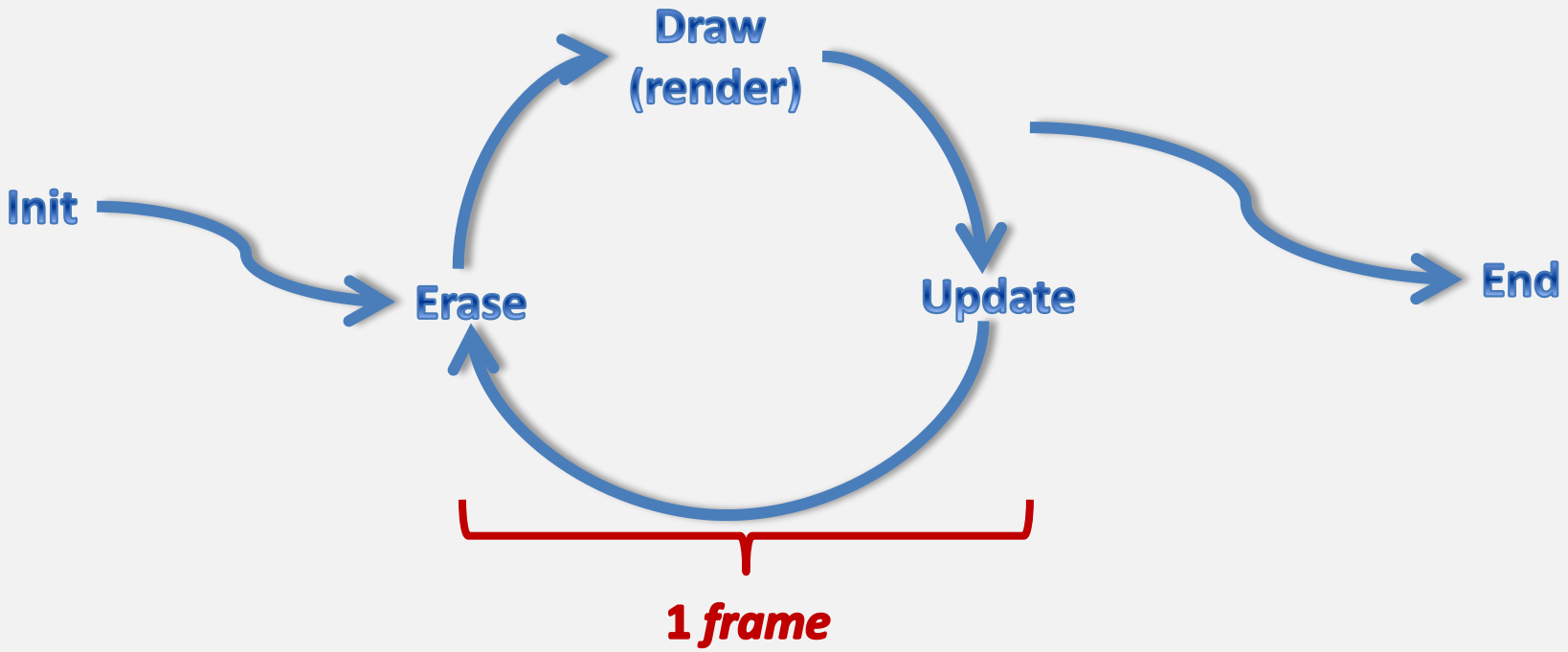
- Some important text properties
  - **textBaseline**: vertical alignment - default value “alphabetic”

```
ctx.font = '20px Georgia';
var text = "Texto Centrado no Canvas";
ctx.textAlign = "center"; //alinhamento horizontal ao centro
ctx.textBaseline = "middle"; //alinhamento vertical ao centro
ctx.fillText (text, canvas.width/2, canvas.height/2);
```



Animation cycle

- Creating a canvas **animation** is no more than drawing multiple times the same object (or objects)
  - just like frames in a video
- A typical animation works in a loop:



Animation cycle

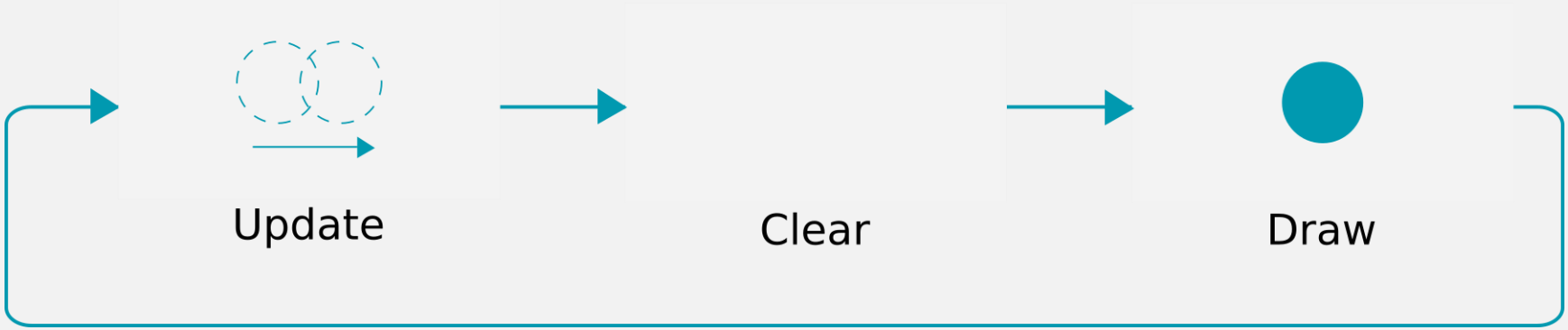
- How to control the animation loop?

`window.setInterval(callback, delay)`

timer that **repeats** `callback` function each delay milliseconds

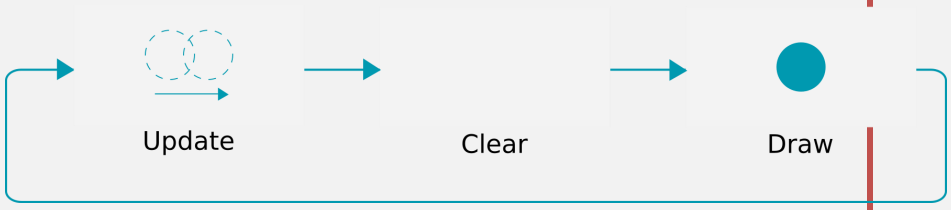
`window.requestAnimationFrame(callback)`

calls `callback` function whenever possible (**only once**)



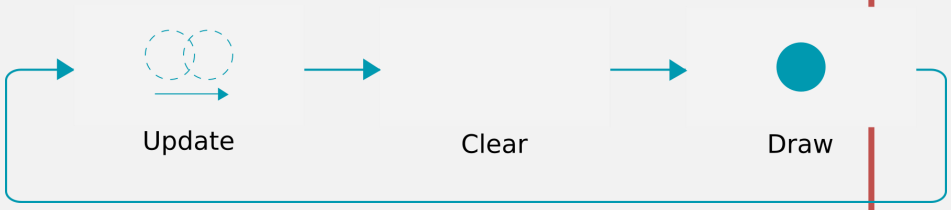
Animation cycle – using timers

```
const canvas = document.querySelector("#canvas");
const ctx = canvas.getContext("2d");

// animation control
let running = true; let timer;

function render(){
     ctx.fillRect(0, 0, canvas.width, canvas.height); // clear Canvas…
     // draw something…
     // update objects in drawing…

     if (!running)
          window.clearInterval(timer); // stop requesting new frames
}

window.onload = function(){
     timer = window.setInterval(render, 10);
};
```



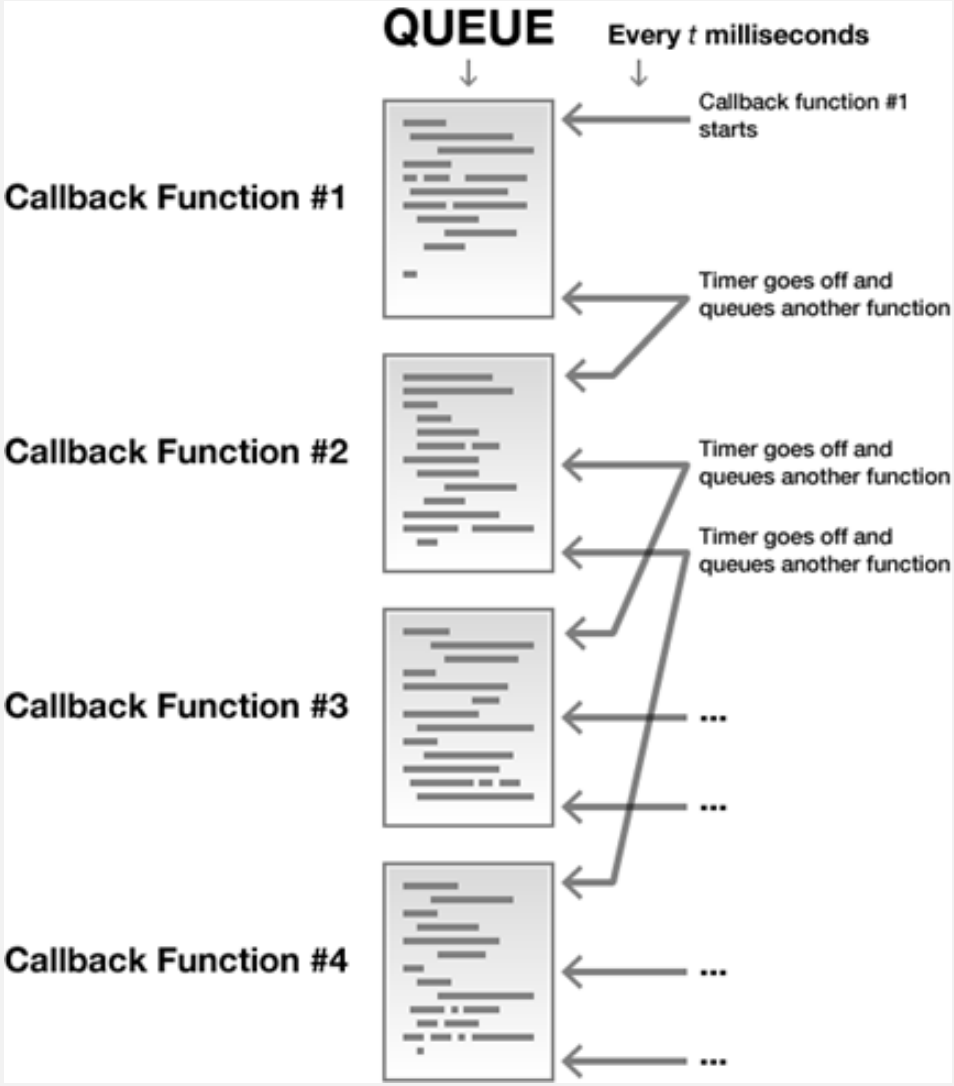
Animation cycle – by frames

```
const canvas = document.querySelector("#canvas");
const ctx = canvas.getContext("2d");

// animation control
let running = true;

function render(){
     ctx.fillRect(0,0, canvas.width, canvas.height); // clear Canvas…
     // draw something…
     // update objects in drawing…

     if (running)
          window.requestAnimationFrame(render); // keep requesting new frames
}

window.onload = render();
```



Animation cycle

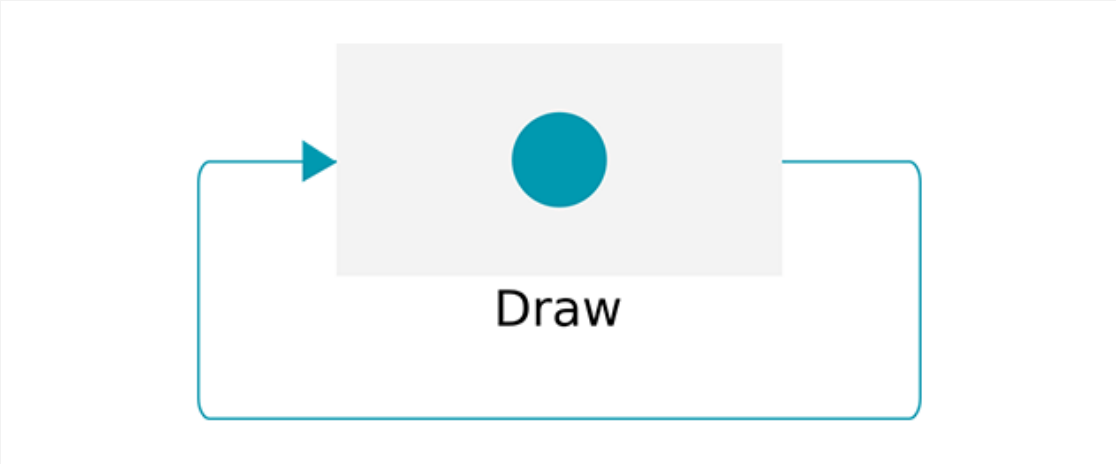
Better performance with
requestAnimationFrame:
If your callback functions take longer than your timers, enqueuing of multiple callback functions can choke up the browser



Animation: Knight Rider example

Download example file from Moodle, and observe the animation:

- When running this code, **`render()`** is now called with a high framerate
- The square is redrawn roughly 60 times per second, depending on the device you run the loop on
- Every frame, a new random color is picked
- This makes it easier to see the animation loop is actually working (but isn't very pleasant to look at)

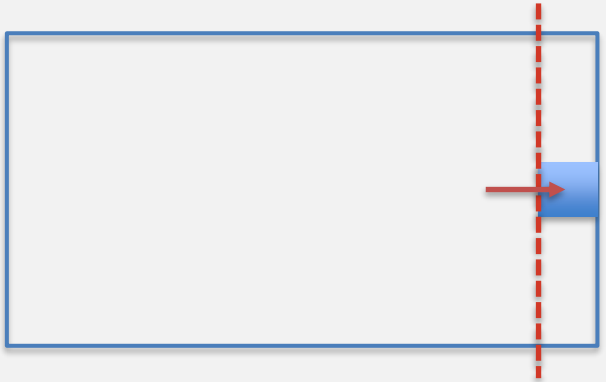


Animation: Knight Rider example

Alter the code so that you complete the following steps:

1. **Decrease** the animation framerate to 10 frames per second
2. **Update** the position of the square, each time it is draw: add 50 pixels to its X-coordinate

`minX = 0`

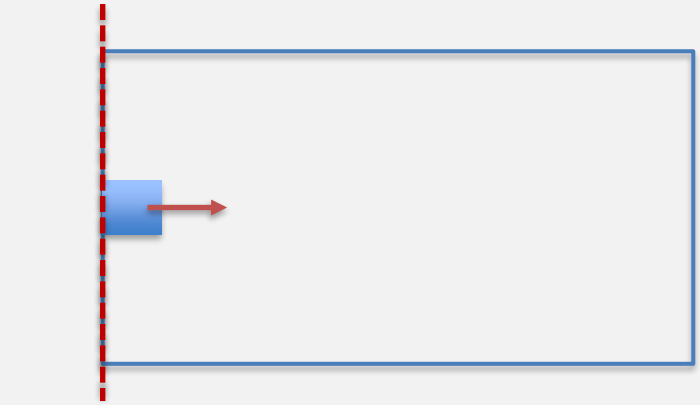


`maxX = canvas.width - square.width`

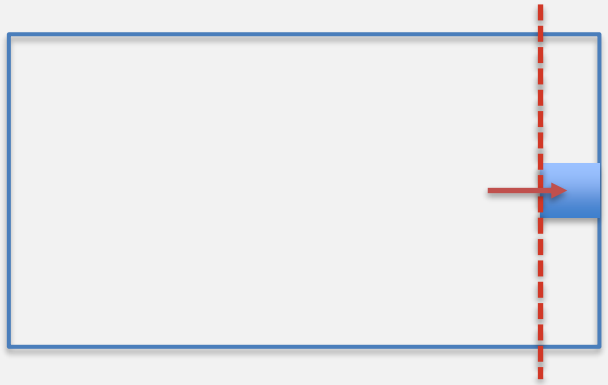
Animation: Knight Rider example

Alter the code so that you complete the following steps:

3. **Clear the Canvas** on each draw call, but by painting it with a rectangle of color `"rgba(51,51,51,0.3)"`
4. Make the square **bounce** between Canvas limits



`minX = 0`

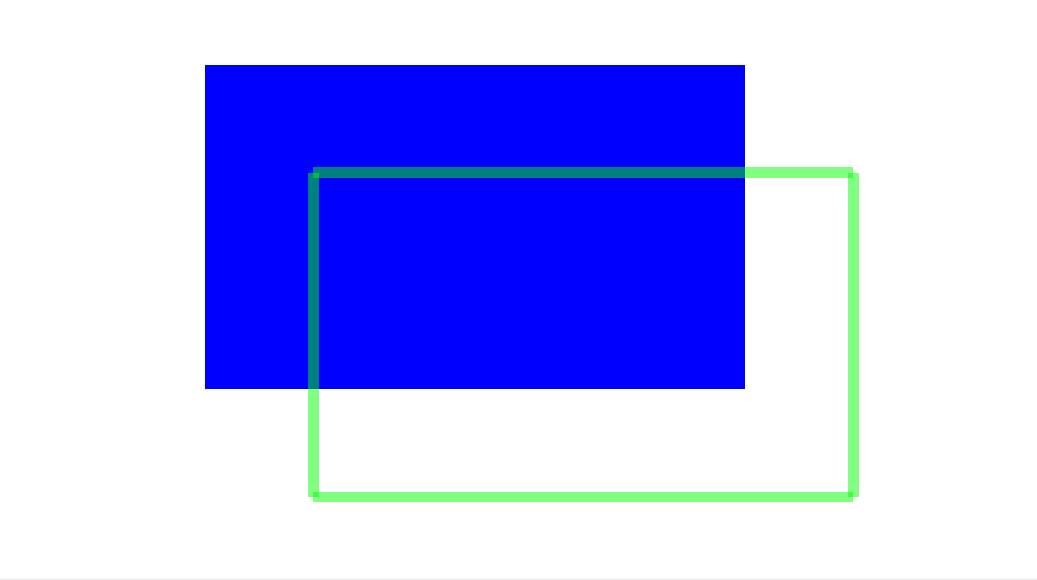


`maxX = canvas.width – square.width`

Try yourself…

Download from Moodle file `Ex01_lines.html` and code the solutions in where you find the comments //TODO

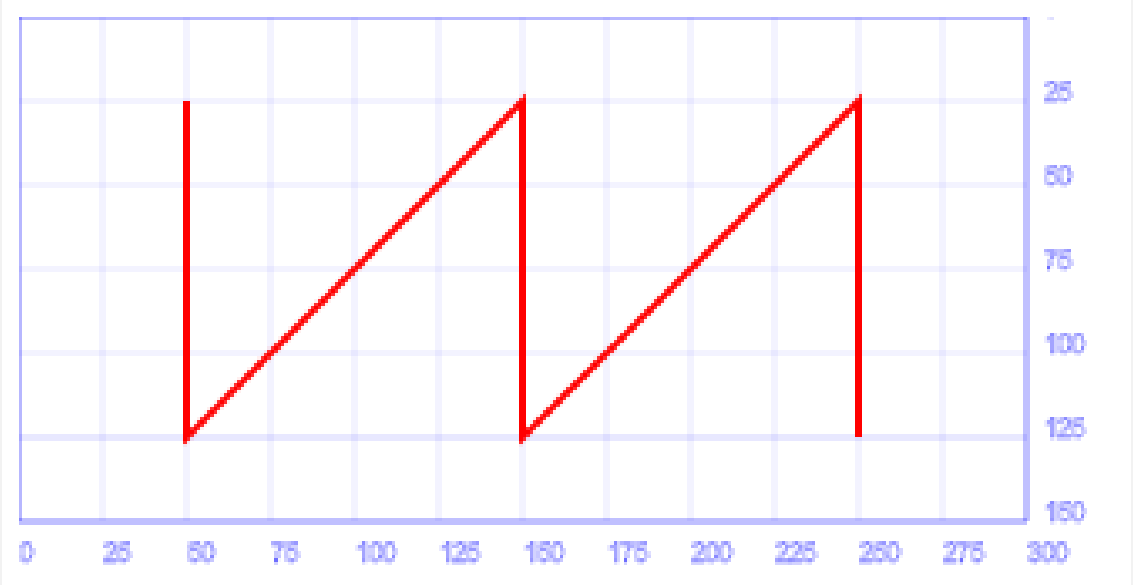
1. Using only lines, draw the following rectangles
   - What happens if you forget to create a new path, before drawing the green rectangle?



Try yourself…

Download from Moodle file `Ex01_lines.html` and code the solutions in where you find the comments //TODO

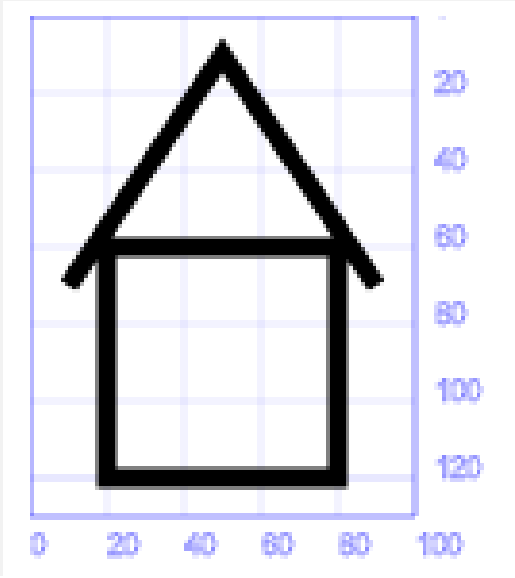
2. Draw the following shape (ignore the grid in image)
   - What happens if you draw the path using `fill()` instead of `stroke()`?



Try yourself…

Download from Moodle file `Ex01_lines.html` and code the solutions in where you find the comments //TODO

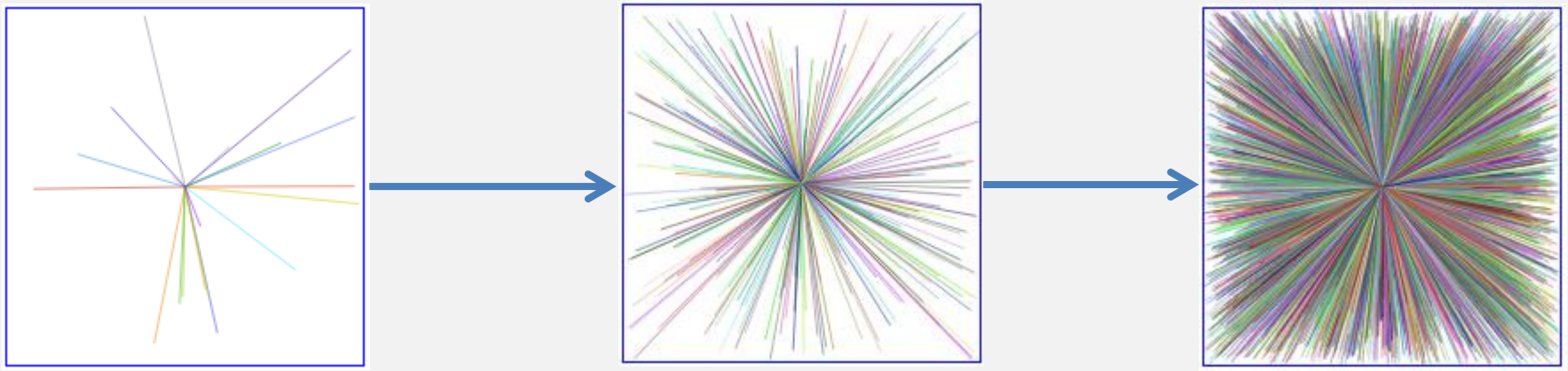
3. Draw the following shape (ignore the grid in image)
   - Use `rect()` to draw the house and two lines for the roof
   - Use property `linewidth` (default = 1) to increase the line contours width



Try yourself…

Download from Moodle file `Ex01_lines.html` and code the solutions in where you find the comments //TODO

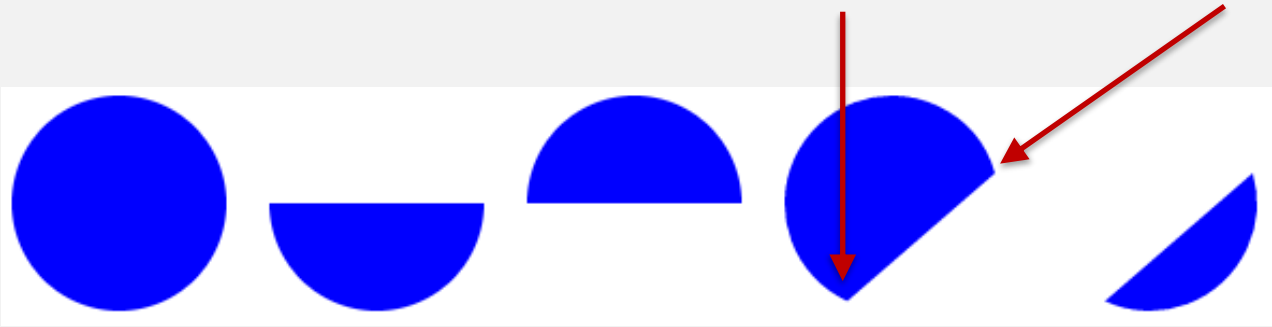
4. Make the following line animation
   - As fast as possible, draw one line per frame
   - Each line starts in the middle of the Canvas, and ends in a random point (inside the Canvas)
   - Each line has its own random color



Try yourself…

Download from Moodle file `Ex02_arcs&curves.html` and code the solutions in where you find the comments //TODO

1. Draw the following figure using arcs
   - For the last two arcs, use angles `3*Math.PI/5` and `9*Math.PI/5`



Try yourself…

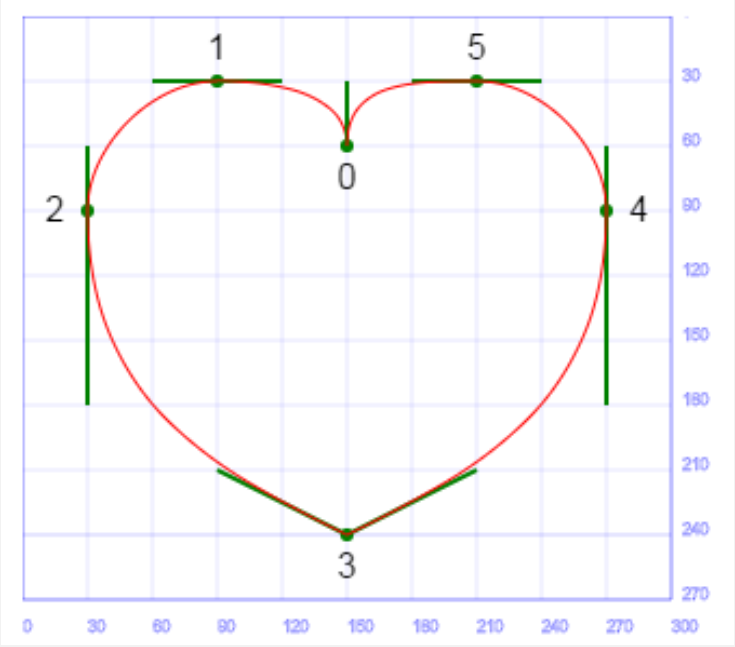
Download from Moodle file `Ex02_arcs&curves.html` and code the solutions in where you find the comments //TODO

2. Draw the Olympic rings
   - Increase the line width using property `lineWidth`
   - All arcs have 40 pixels radii

Try yourself…

Download from Moodle file `Ex02_arcs&curves.html` and code the solutions in where you find the comments //TODO

3. Draw a heart, using 6 Bezier curves
   - Check image for help and the provided code as a start for your solution




```
//start at point 0 - little green circle
ctx.moveTo(150,60);

//1st curve: end at point 1
ctx.bezierCurveTo(150,30,120,30,90,30);

//draw others
//TODO

//stroke heart with red line
ctx.strokeStyle = "red";
ctx.stroke();
```

point 1

Green line end at point 0

Green line end at point 1

Try yourself…

Download from Moodle file `Ex02_arcs&curves.html` and code the solutions in where you find the comments //TODO

4. Let's smile!
   - Use the colored points to guess the shape and use them just for reference (do not draw them!)

     Face: color "lightgrey"

     Eyes

     Mouth
   - All lines have a width of 20 pixels
   - Can you **animate** your smiley, making it shift between a happy and a sad smiley?