Lecture 4

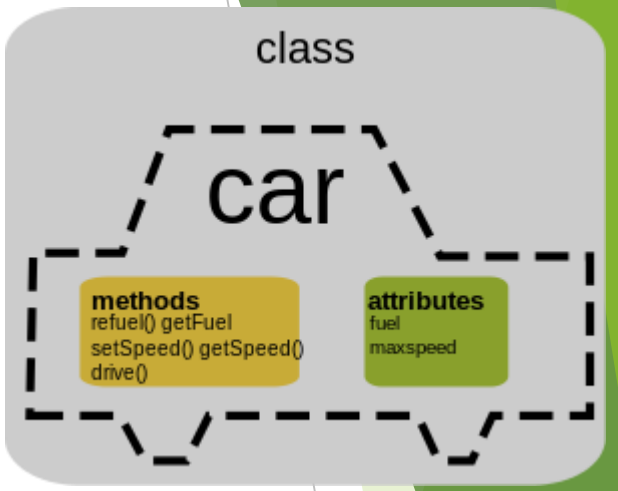
Object Oriented Programming

- What are the 3 pillars?

Object Oriented Programming

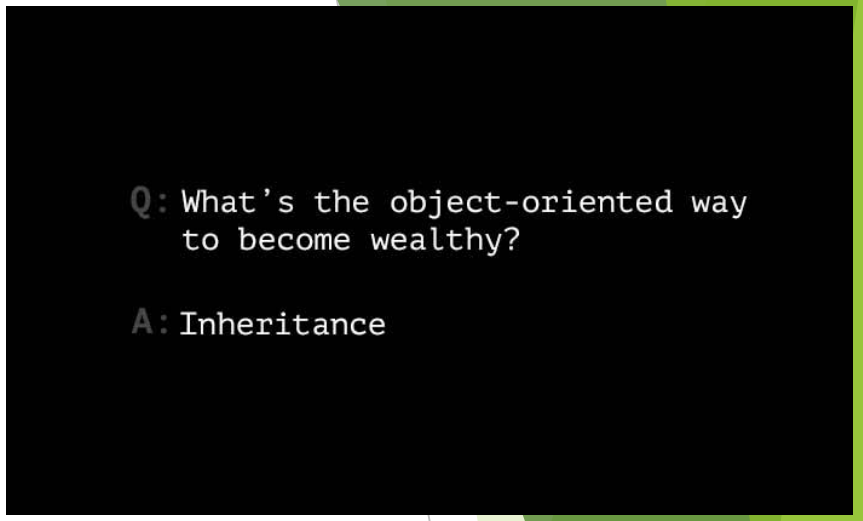
- What are the 3 pillars?
  - Encapsulation
  - Inheritance
  - Polymorphism

Object Oriented Programming



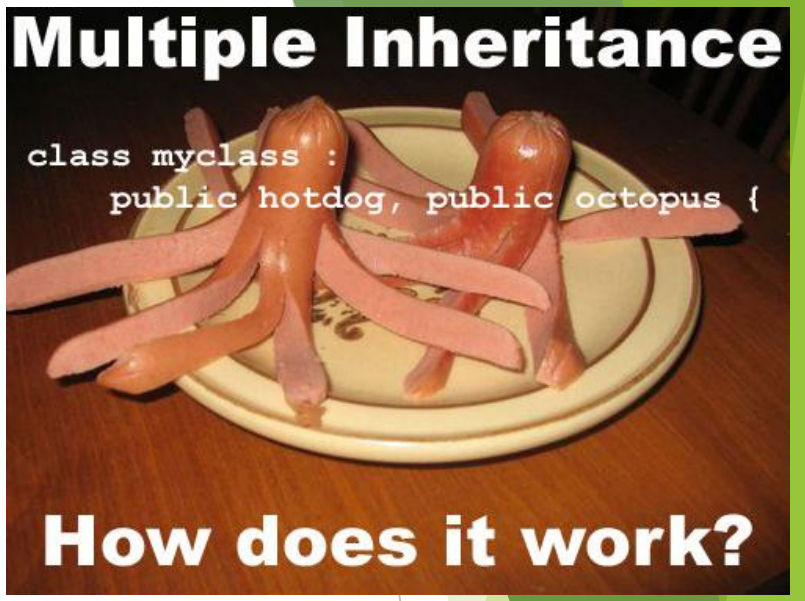
- What are the 3 pillars?
  - Encapsulation
    - Incorporation of data & operations into one package (a class)
    - Data can only be accessed through that package
    - “Information Hiding”
  - Inheritance
  - Polymorphism

Object Oriented Programming



- What are the 3 pillars?
  - Encapsulation
  - Inheritance
    - Allows programmers create new classes based on an existing class
    - Methods and attributes from the parent class are inherited by the newly-created class
    - New methods and attributes can be created in the new class, but don't affect the parent class's definition
  - Polymorphism

Object Oriented Programming



- What are the 3 pillars?
  - Encapsulation
  - Inheritance
  - Polymorphism
    - Allows creation of methods which describe the way to do some general function (Example: The “drive” method in the automobile class)
    - Polymorphic methods can adapt to specific types of objects.
    - E.g. Abstract methods in Java

Is JavaScript an OOP language?

- Well, not really …
- JavaScript is known as an "object-inspired" language
- It uses objects by way of supporting inheritance and encapsulation, but it doesn't provide support for polymorphism.

“Object-Oriented” JavaScript

- More like “Object-Inspired” JavaScript
- We can create new, custom, re-usable objects in JavaScript that include their own methods, properties and events.
- Consider the following problem: “I want to record the colour, brand, horsepower and price of several cars.”

Solution:

- Without OOP Design:
  - Uses parallel arrays
  - Can be confusing
    - Difficult to keep track of which car has which colour, brand, etc.
- With OOP Design:
  - Calls to an API that contains the custom car object
  - Much cleaner code
  - Re-usable object

Javascript Object

- An *object* is a unique entity in a script and/or web page.
- An *object* has:
  - O*bject properties*
  - *Object methods*
  - Can react to *events* in that object's environment
- A property is a characteristic that describes an object.
  - Similar to an adjective in grammar.
  - Properties are given values (hair colour is a property; i.e. brown or red)
- A *method* is something an object can do.
  - Similar to a verb in grammar.

Javascript Comments

- In lab submissions, make sure to include comments
  - Marks will be deducted for inadequately commented code

Javascript Object and Constructors

- Have seen some already
- JavaScript has a library of "blueprints“/constructor methods available to it that define the nature of some objects.

Creating a variable

1 2 3

```
var userName = new String(“Dilbert”);
```

What's going on?

1. The reserved word "**var**" tells JavaScript to allocate some space in memory for a variable.
2. We give a label to that variable, giving it the name **userName**.
3. The "**=**" means *"gets the value off"* in programming. It does NOT mean "equals."

Creating a Variable

4 5

```
var userName = new String("Dilbert");
```

4. The reserved word "**new**" is called an *instance operator* and it tells JavaScript to expect that we'll be creating a new *instance* of object from an existing "blueprint", in this case, from the String blueprint.
5. We use the constructor method **String()** to copy the string blueprint to our **userName** variable.

Creating a Variable

6

```
var userName = new String("Dilbert");
```

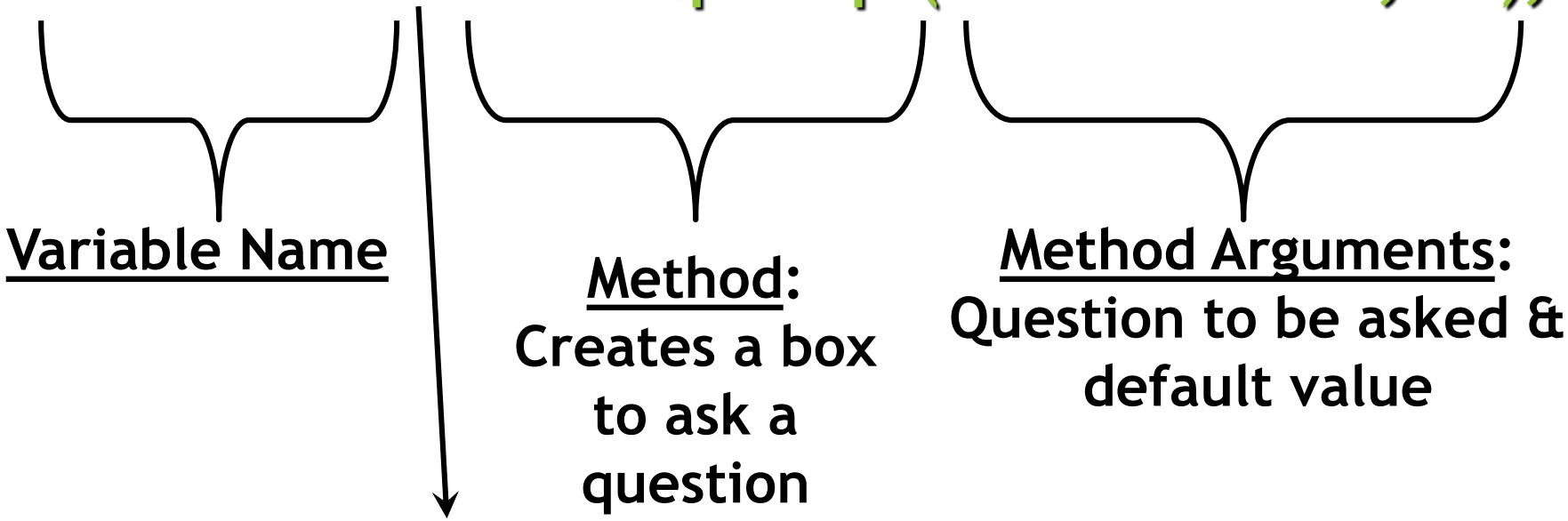
6. The String() method allows us to supply an optional *initial value* for our new string. If we choose to, we need to supply a value that is of string-type. This is called *variable initialization*. Notice the word "Dilbert" is in quotations? The quotations are a way of identifying the word as a string. When we give a variable its first value, we also *type* the variable. JavaScript is an *implicitly typed* language.

Creating Variables for Primitives

- For any of JavaScript's *primitive data types* (strings, integers, floats, Booleans), you can create a variable without calling on the constructor:
  var userName = "Dilbert";
- Although this is syntactically correct, try using constructor methods. Why? Since other, more formal, languages (like Java) demand constructors.
- Good to get used to the habit of using them in JavaScript.
- Practice makes perfect!

Variable Assignment: Input

```
userName = window.prompt("Your name?", "");
```



Variable Name

Assignment Operator:
"Gets the value of"

Method:
Creates a box to ask a question

Method Arguments:
Question to be asked & default value

Dot Operator

- Did you notice in the previous example that the window object connected to its prompt method using a period? The period is called a *dot operator*.
- A dot operator is a way of showing how things are connected to objects. In the previous example, the dot operator connected the window object to its prompt method.

JS Variables and User-Defined Functions

- For some functionality, you cannot achieve by only using the built-in functions.
- You can define a function as follows:
  - Functions are declared using the function reserved word
  - The return value is not declared, nor are the types of the arguments

```
Var myVar = value;
function <function_name> (parameters)
{
        // code segments;
}
```

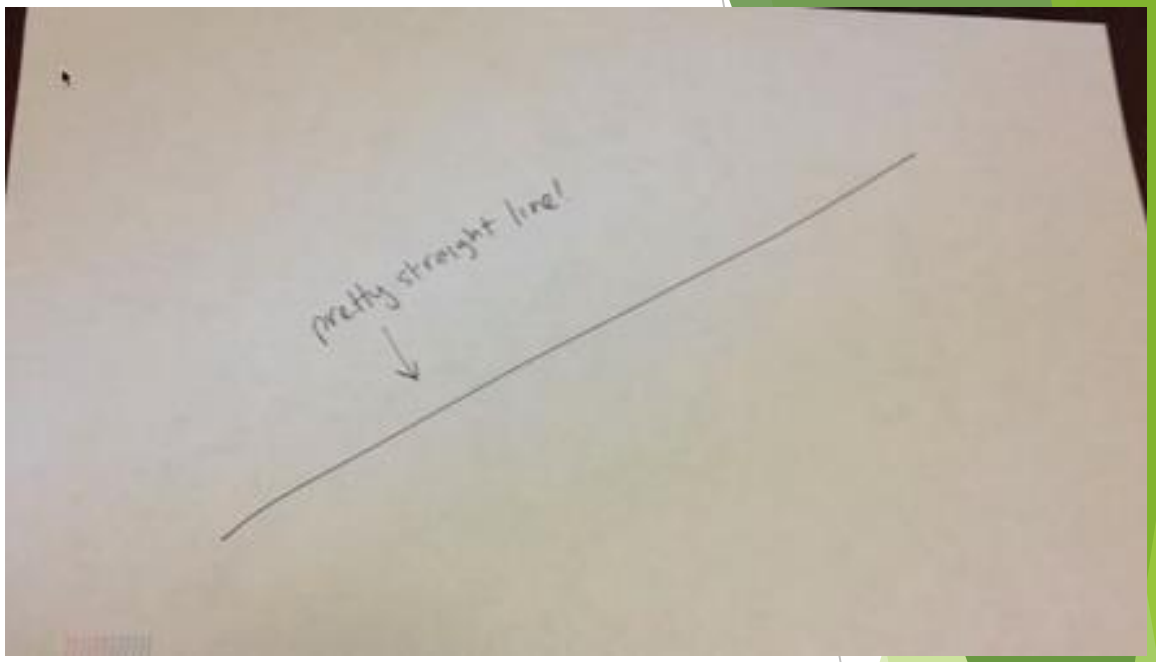
JS Objects

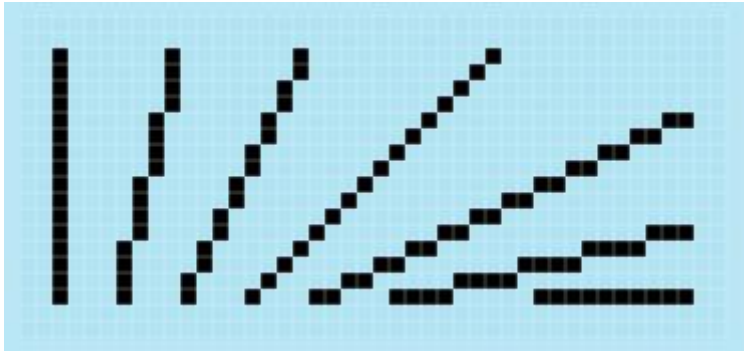
```
Var myVar = value;
function <function_name> (parameters)
{
        // code segments;
}
```

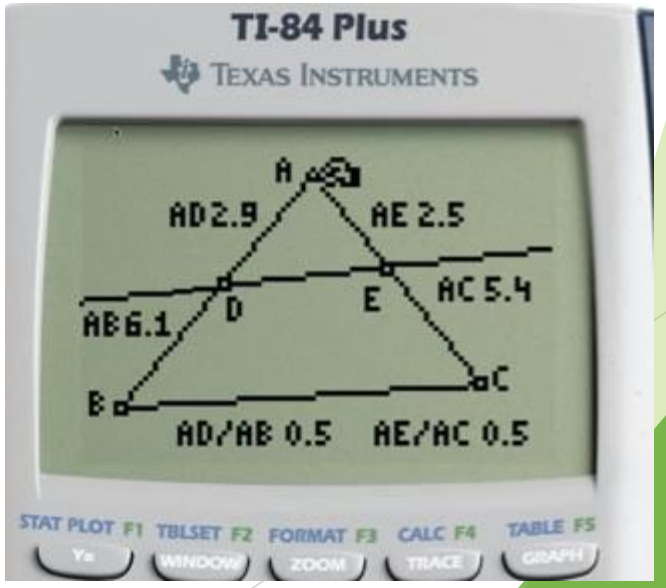
```
Var myObject = {
    myVar : value,
    <function_name> : function(parameters)
    {
        // code segments;
    }
}
```

Line drawing

- Bad at drawing lines
- Very hard
- Computers are also bad at drawing lines

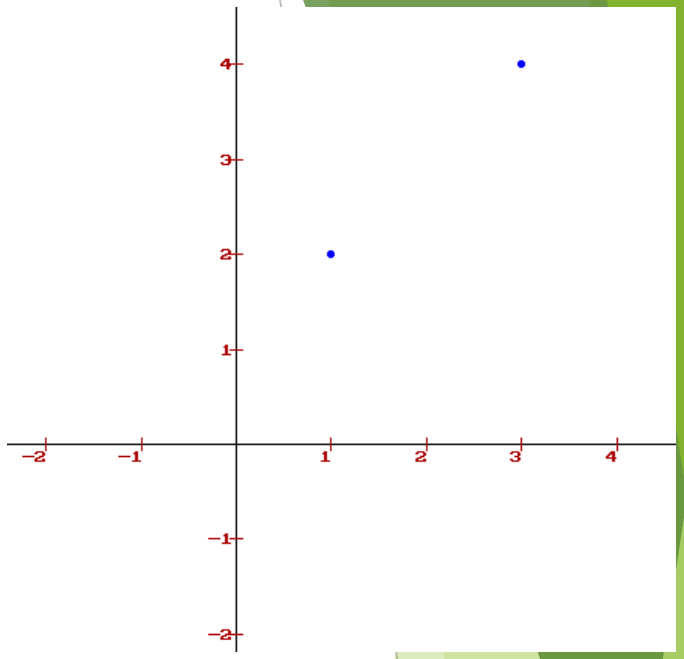






Drawing lines – Naïve line drawing

- Equation of a line
  - Given 2 points $(x_1, y_1) = (1,2)$, $(x_2, y_2) = (3,4)$
  - m corresponds to slope = $m = \frac{rise}{run} = \frac{y_2 - y_1}{x_2 - x_1}$
  - m=1, b=1
  - Try the points $(x_1, y_1) = (-3,5)$, $(x_2, y_2) = (2,-6)$



y=mx + b

- Where the line crosses the y axis, also called the y intercept.
- Value of y, the y axis runs up and down.
- Slope.
- Value of x, the x axis runs horizontally.

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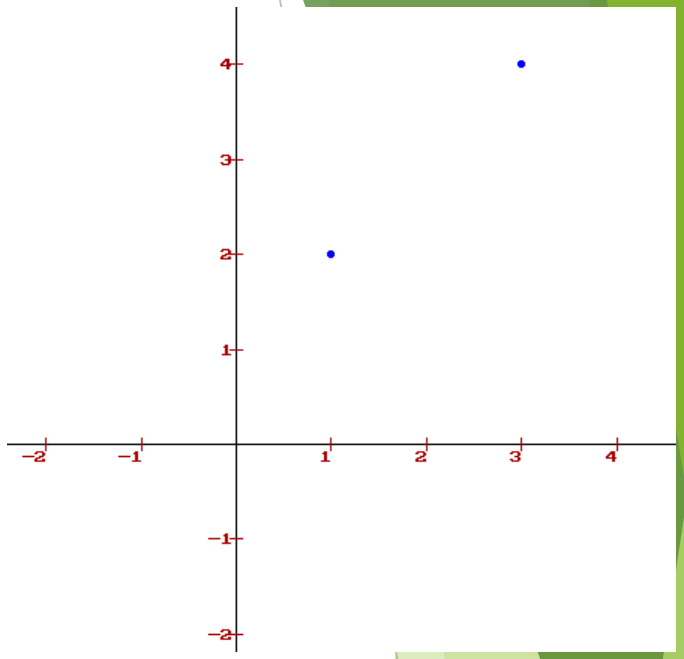
  - m=1, b=1
  - Try the points $(x_1, y_1) = (-3,5)$, $(x_2, y_2) = (2,-6)$
  - m = -11/5, b = -8/5



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- Where the line crosses the y axis, also called the y intercept.
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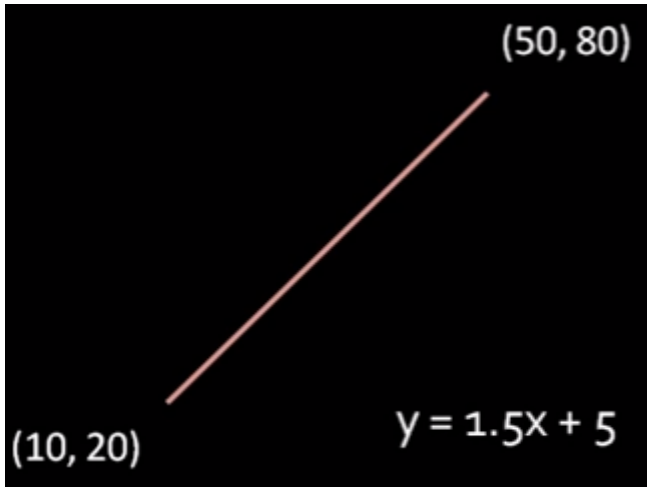
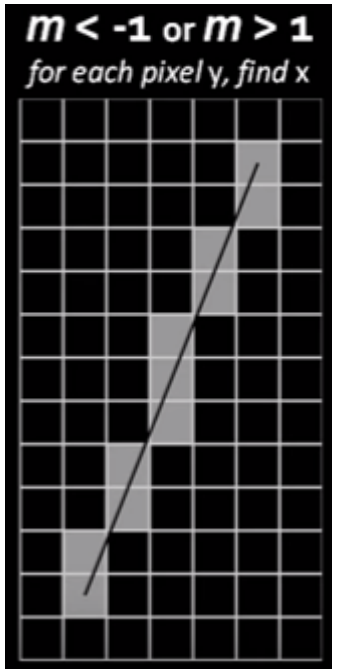
Drawing lines – Naïve line drawing

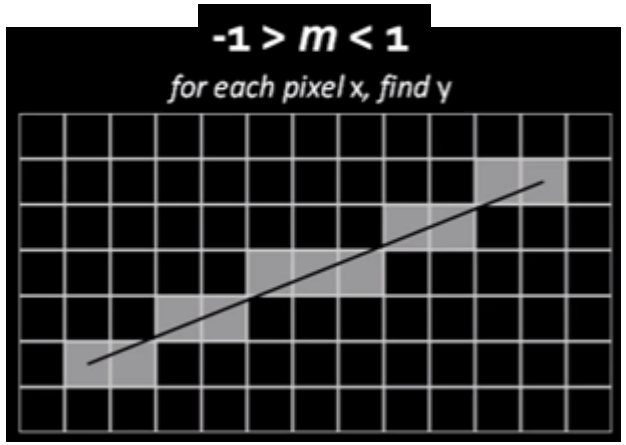
- Equation of a line
- Work it out.



Drawing lines – Naïve line drawing

- Line drawing in computer graphics can be distinguished into two cases:
  - $|m| > 1$
  - $|m| < 1$
  - where $|m|$ corresponds to the absolute value of m.





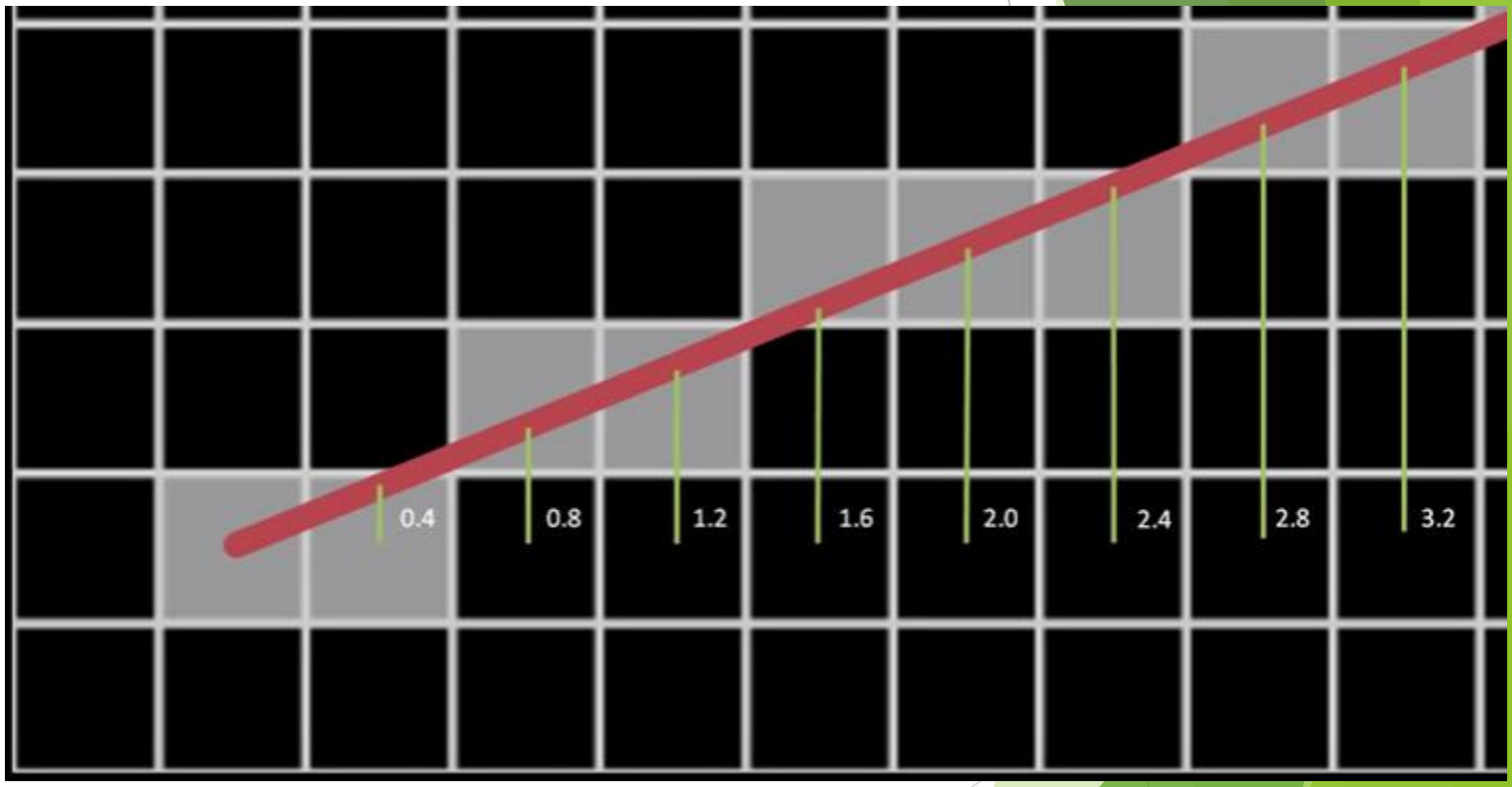

```
m = float(y2-y1)/(x2-x1);    //slope
b = y1 - (m *x1);    //y-intercept
int x=0, y=0;    //index variables

if m <= 1 && m >= -1{
    for(int x = x1; x < x2; x++)
    {
        y = round((m*x)+b);
        plot(x,y);
    }
}
else{
    for(int y = y1; y < y2; y++)
    {
        x = round((y-b)/m);
        plot(x,y);
    }

}
```

Drawing lines – Bresenham algorithm

- Named after Jack Bresenham – invented in 1962 in IBM
- Equation of a line involves multiplication and division which is computationally expensive
- Bresenham algorithm is much more efficient only using addition, subtraction and bit shifting
- Slope (m) is only calculated once.
  - Again two scenarios - $|m| > 1$ and $|m| < 1$
  - $|m| < 1$ - For each subsequent x pixel, the slope is added to the y coordinate to get its value
  - $|m| \geq 1$ - For each subsequent y pixel, the inverse of the slope is added to the x coordinate to get its value

Drawing lines – Bresenham algorithm

- E.g. for a slope of 0.4
- Then rounding can be applied
- In practice, rounding is avoided as it's computationally expensive
  - How rounding is avoided is not covered for now
  - A few more optimisations but the above covers the key concept



Lab

- Ball and pizza object and animation
- Encapsulate ball/pizza into object with resize, move and draw methods

HTML5 Canvas Animation

- Until now, the biggest limitation is, that once a shape gets drawn, it stays that way.
- If we need to move it we have to redraw it and everything that was drawn before it.
- It takes a lot of time to redraw complex frames and the performance depends highly on the speed of the computer

HTML5 Canvas Basic Animation Steps

- Clear the canvas
  - Unless the shapes you'll be drawing fill the complete canvas (for instance a backdrop image), you need to clear any shapes that have been drawn previously. The easiest way to do this is using the clearRect() method.
- Draw animated shapes
  - The step where you do the actual frame rendering.
- Controlling an animation:
  - requestAnimationFrame(callback)
  - Tells the browser that you wish to perform an animation and requests that the browser call a specified function to update an animation before the next repaint.

requestAnimationFrame(callback) - ball.html

```
<script type="text/javascript">
  // Gets a handle to the element with id canvasOne.
  var canvas = document.getElementById("canvas-for-ball");
  // Get a 2D context for the canvas.
  var ctx = canvas.getContext("2d");

  // The vertical location of the ball.
  var y = 10;
  // A function to repeat every time the animation loops.
  function repeatme() {
    // Draw the ball (stroked, not filled).
    ctx.beginPath();
    ctx.arc(50, y, 3, 0, 2 * Math.PI);
    ctx.stroke();

    // Update the y location.
    y += 1;
    window.requestAnimationFrame(repeatme);
  }
  // Get the animation going.
  repeatme();
</script>
```

Lab Instructions (Week 4)

- Put a border around the canvas so that we can see its edges.
- Given ball.html, Stop the ball moving when it hits the bottom of the canvas.
  - You might use an if statement for this purpose.
  - Experiment with the speed of the ball – varying ‘ymov’ (where ymov corresponds with speed)
- Clear the canvas at each step of the animation, so that only one copy of the ball is visible at a time. You can use the clearRect method for this.
  - ctx.clearRect(left, top, width, height);
- Represent the ball as an object, rather than by a global y value and hard-coded x and r values.
- Change the code so that the ball starts moving up the way once it reaches the bottom of the screen – (reverse speed).
- Change the code so that the ball bounces from the bottom to the top of the screen, and back again, repeatedly.

Lab Instructions (Week 4)

- Give the ball a horizontal velocity, as well as a vertical one, and have it bounce off the left and right sides of the canvas also.
- Change the code so that the pizza from lab 2 rather than the ball bounces
- Advanced:
  - Have the ball rotate in a realistic manner as it traverses the sreen. Use the rotate function developed as part of Lab 2 to achieve this. Reverse the direction of the rotation when the ball/pizza strikes the wall
  - Give the ball/pizza a downwards acceleration, so that it gets faster as it falls, and slower as it ascends.
- Material:
  - Mozilla's docs on Window.requestAnimationFrame() - https://developer.mozilla.org/en-US/docs/Web/API/window/requestAnimationFrame

Lab Submission

- Submit 3 separate HTML files and 1 Word file containing 3 screenshots
  - Lab 1 – demonstrating drawing rectangles, circles, transparency, CSS border, Canvas resizing, Pacman
  - Lab 2 – demonstrating a ball object with resize, move and draw functions. Also applying same functions to drawing a pizza with 7 slices
  - Lab 3 – demonstrating ball and pizza animation (as described above)
  - Screenshots of each of the 3 labs
- Submission Deadline: October 15th @23:00
- Marks will be awarded for well-commented, well-indented code
- Code must run direct from HTML file – no console input should be necessary
- Marks will be deducted for lateness, not following above instructions.