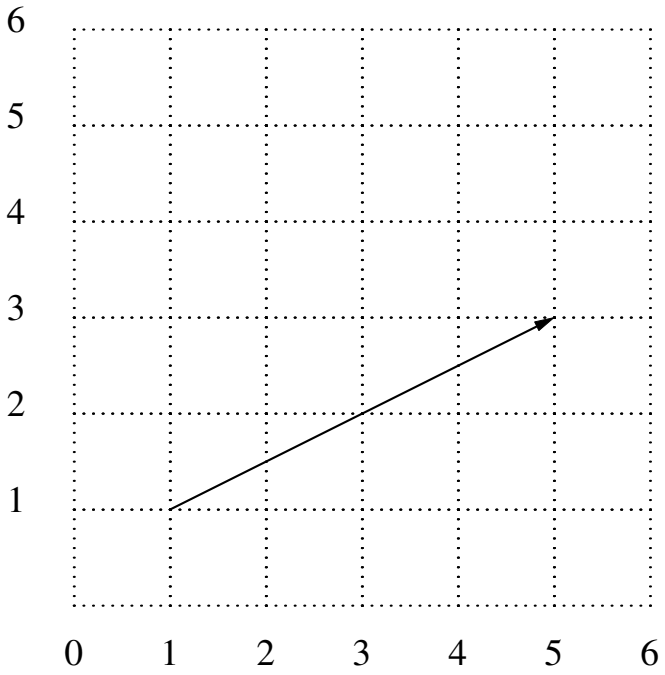
Moving a along a line

- consider the problem of making a barrels appear to roll across a plank
  - this is complicated by the issue of the ramp gradient



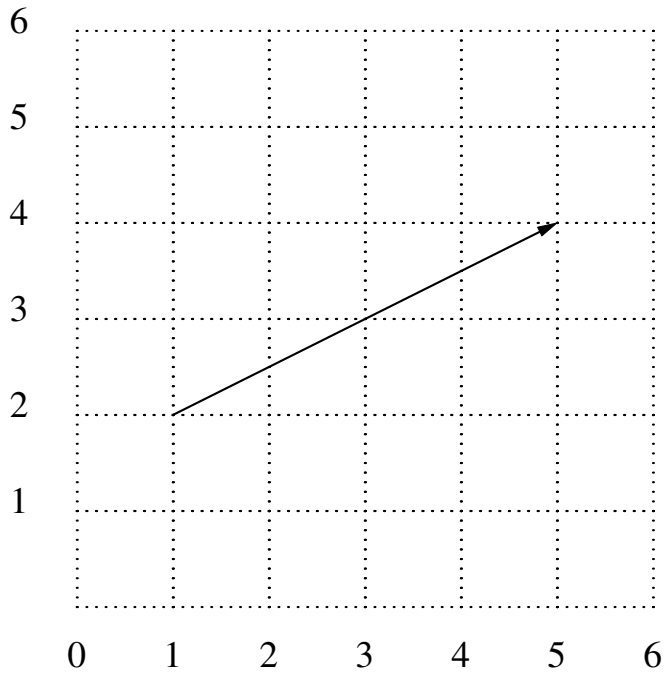
Bresenham's line algorithm

- fortunately Bresenham discovered an algorithm which given two points
  - determines the elements of a 2-dimensional grid that should be selected to best approximate the line

- Bresenham's line algorithm also uses integer arithmetic which adds to its complexity

y = mx + c

- returning to the problem of making a barrel roll down a plank
  - we know the x position, but we need to compute the y value
- we know the start and end points of the ramp



y = mx + c

- in the previous slide the start position is (1, 2) and the end position is (5, 4)
- the dx value is 5-1 = 4
- the dy value is 4-2 = 2
- therefore our gradient *m* is $\frac{dy}{dx}$

$y = mx + c$

- we need to calculate c
- we know the point (1, 2) exists on the line
- using $y = mx + c$
- $2 = 1m + c$
- $2 = \frac{1}{2} + c$
- $c = 2 - \frac{1}{2} = 1 + \frac{1}{2}$

$y = mx + c$

- we could use this formula to calculate the y value given an x value
- $m = \frac{2}{4} = \frac{1}{2}$

y = mx + c

x	y
1	2
2	2.5
3	3
4	3.5
5	4

$y = mx + c$

- notice how we need floating point values to compute it
  - also notice how we calculated the gradient

- Bresenham's algorithm hunts for the correct gradient by using integer arithmetic and by manipulating the numerator and denominator of the fractional value of *m*

Bresenham's algorithm in Python (version 1)

bres0.py

```
#!/usr/bin/env python3

def points (p0, p1):
    x0, y0 = p0
    x1, y1 = p1

    dx = abs(x1-x0)
    dy = abs(y1-y0)
    if x0 < x1:
        sx = 1
    else:
        sx = -1

    if y0 < y1:
        sy = 1
    else:
        sy = -1
    err = dx-dy
```

Bresenham's algorithm in Python (version 1)

bres0.py

```
    while True:
        print x0, y0
        if x0 == x1 and y0 == y1:
            return

        e2 = 2*err
        if e2 > -dy:
            # overshot in the y direction
            err = err - dy
            x0 = x0 + sx
        if e2 < dx:
            # overshot in the x direction
            err = err + dx
            y0 = y0 + sy
```

Bresenham's algorithm in Python (version 1)

- **bres0.py**

```
#
#  test code
#
points ([1, 2], [5, 4])
```

- when we run this we see:

```
$ python3 bres0.py
1 2
2 2
3 3
4 3
5 4
```

Using Bresenham's algorithm to give us the next point

- we need to change the algorithm very slightly so that we can get the next point on demand
  - really a cosmetic change

- probably best to use a class and a few methods

Python implementation of Bresenham's algorithm (version 2)

bres1.py

```
#!/usr/bin/env python3

class bres:
    def __init__ (self, p0, p1):
        self.p0 = p0
        self.p1 = p1
        self.x0 = p0[0]
        self.y0 = p0[1]
        self.x1 = p1[0]
        self.y1 = p1[1]
        self.dx = abs(self.x1-self.x0)
        self.dy = abs(self.y1-self.y0)
```

Python implementation of Bresenham's algorithm (version 2)

bres1.py

```
        if self.x0 < self.x1:
            self.sx = 1
        else:
            self.sx = -1

        if self.y0 < self.y1:
            self.sy = 1
        else:
            self.sy = -1
        self.err = self.dx-self.dy
```

Python implementation of Bresenham's algorithm (version 2)

bres1.py

```
    def get_next (self):
        if self.x0 == self.x1 and self.y0 == self.y1:
            return [self.x1, self.y1]

        self.e2 = 2*self.err
        if self.e2 > -self.dy:
            self.err = self.err - self.dy
            self.x0 = self.x0 + self.sx
        if self.e2 < self.dx:
            self.err = self.err + self.dx
            self.y0 = self.y0 + self.sy
        return [self.x0, self.y0]
```

Python implementation of Bresenham's algorithm (version 2)

bres1.py

```
#
#  test code
#
w = bres ([1, 2], [5, 4])
p = w.get_next ()
print p
while p != [5, 4]:
    p = w.get_next ()
    print p
print p
```

Python implementation of Bresenham's algorithm (version 2)

```
$ python3 bres1.py
[2, 2]
[3, 3]
[4, 3]
[5, 4]
[5, 4]
```

Tidying up the Python interface

- as can be seen in the test code the use of the Python class is ugly
- we can improve this by introducing a method `finished()` which returns `True` if we have reached the end of the line
- we also note there is a slight bug in version 2 as it omits the initial point!

Python implementation of Bresenham's algorithm (version 3)

bres.py

```
#!/usr/bin/env python3

class bres:
    def __init__ (self, p0, p1):
        self.initial = True
        self.end = False
        self.p0 = p0
        self.p1 = p1
        self.x0 = p0[0]
        self.y0 = p0[1]
        self.x1 = p1[0]
        self.y1 = p1[1]
        self.dx = abs(self.x1-self.x0)
        self.dy = abs(self.y1-self.y0)
```

Python implementation of Bresenham's algorithm (version 3)

bres.py

```
        if self.x0 < self.x1:
            self.sx = 1
        else:
            self.sx = -1

        if self.y0 < self.y1:
            self.sy = 1
        else:
            self.sy = -1
        self.err = self.dx-self.dy
```

Python implementation of Bresenham's algorithm (version 3)

bres.py

```
    def get_next (self):
        if self.initial:
            self.initial = False
            return [self.x0, self.y0]

        if self.x0 == self.x1 and self.y0 == self.y1:
            self.end = True
            return [self.x1, self.y1]
```

Python implementation of Bresenham's algorithm (version 3)

bres.py

```
        self.e2 = 2*self.err
        if self.e2 > -self.dy:
            self.err = self.err - self.dy
            self.x0 = self.x0 + self.sx
        if self.e2 < self.dx:
            self.err = self.err + self.dx
            self.y0 = self.y0 + self.sy
        return [self.x0, self.y0]

    def get_current_pos (self):
        return [self.x0, self.y0]

    def finished (self):
        return self.end
```

Python implementation of Bresenham's algorithm (version 3)

bres.py

```
#
#  test code
#
w = bres ([1, 2], [5, 4])
while not w.finished ():
    p = w.get_next ()
    print p
```

Test run of our new Python module bres.py

```
$ python3 bres.py
[1, 2]
[2, 2]
[3, 3]
[4, 3]
[5, 4]
[5, 4]
```

Homework and tutorial work

- comment this code
- use this module `bres.py` together with the `explosions.py` code we looked at last week to generate explosions and track the mouse
- declare a `missile` class which can be given two points: `start`, `end` to traverse along a chosen path
- introduce an `update` method for the missile class which moves the missile onto the next coordinate
- tie these pieces together and allow the mouse to fire off a missile from the left, middle, and right silos