

Mathematical Modelling

Physics of projectiles

- Assumptions:
 - Vacuum: No air resistance.
 - Uniform gravity: The earth is flat. Gravity is vertical.
 - Newton's laws: No relativity.
- Model:
 - Horizontal motion independent of vertical.
 - Each second, ball moves right 20 meters.
 - We'll deal with vertical motion separately.

(1) Write in initial values from supervisor:
xVelocity=20; xPosition=0;

[illegible]

(2) Add # above with #
left and above: 20

2		3		4	
xAccel		xVelocity		Position	
add in		add in		add in	
xJerk		xAccel		xVelocity	
	0		20		0
	0				20+0
	0				
	0				
	0				
	0				
	0				

(2) Add # above with #
left and above:

	2	3	4
xAccel			
add in			
xJerk			
0			
0			
0			
0			
0			
0			
0			

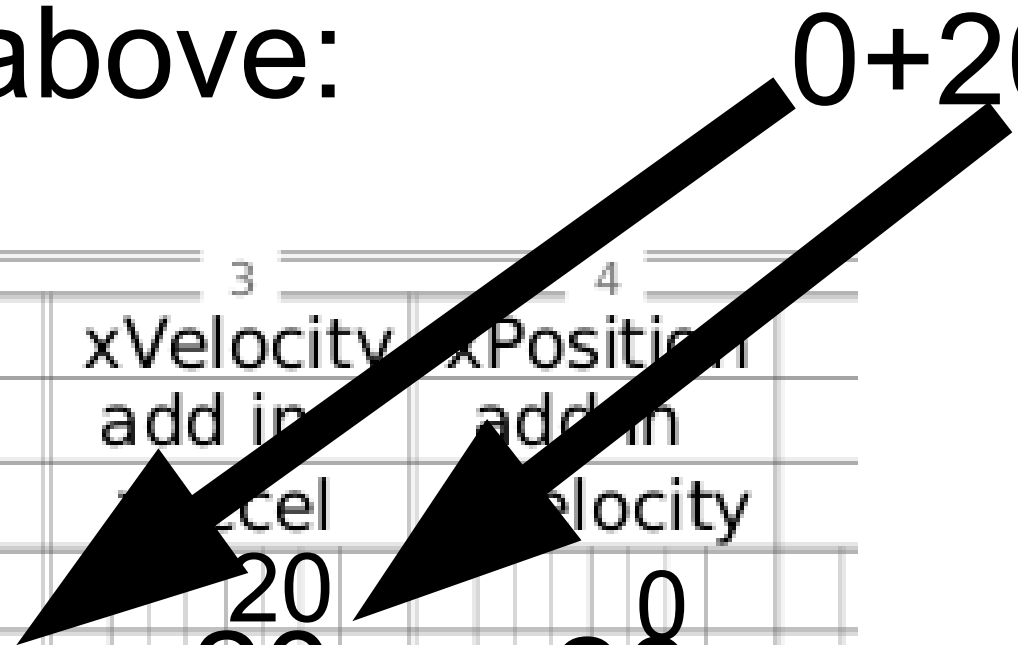
Diagram illustrating the calculation of xVelocity and xPosition from xAccel and xJerk:

- xVelocity is calculated as $0 + 20$ (from xAccel).
- xPosition is calculated as 20 (from xVelocity).

(2) Add # above with #
left and above:

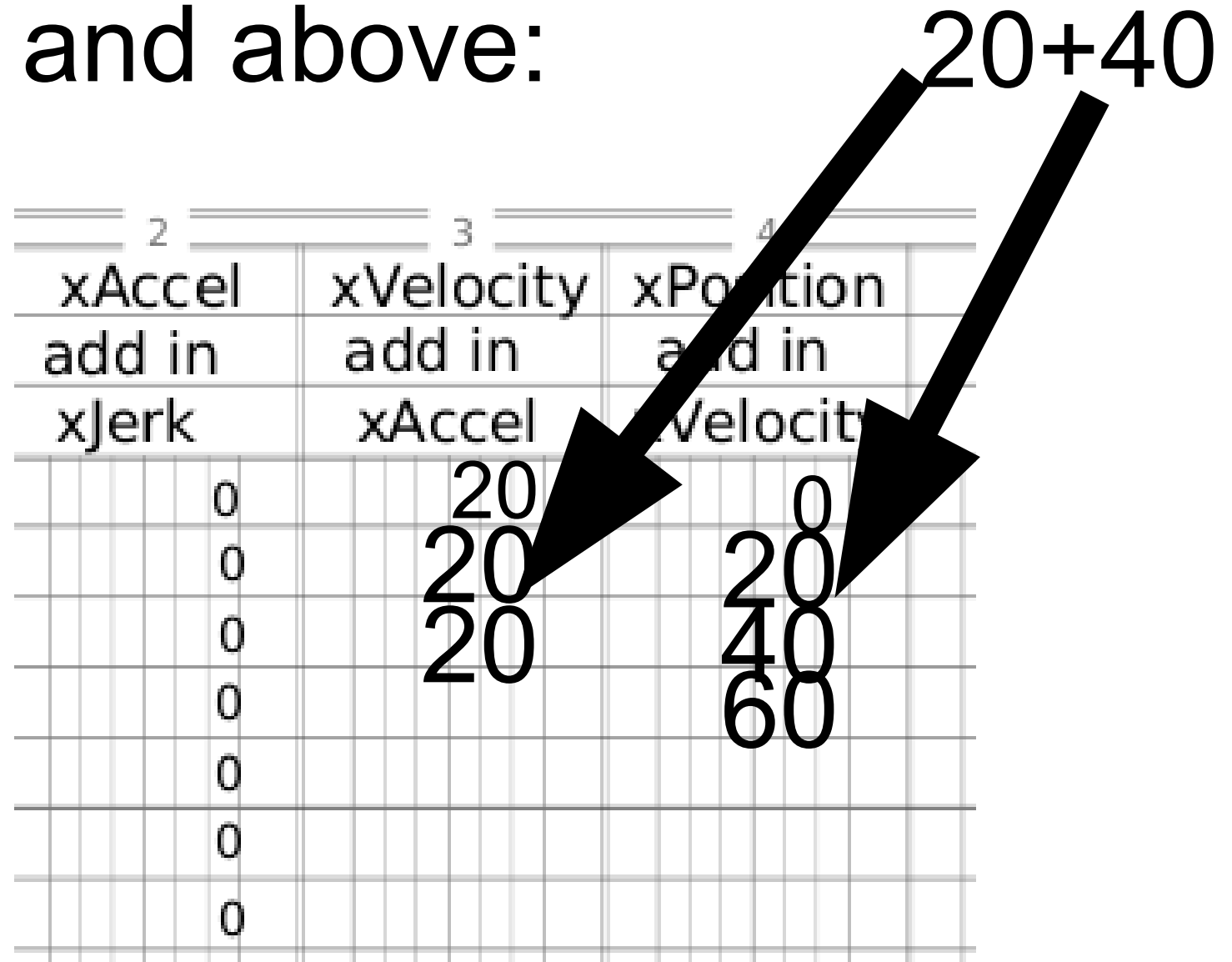
2				3			
xAccel				xVelocity			
add in				add in			
xJerk				xAccel			
			0				0
			0		20		20
			0		20		20
			0				20+20
			0				
			0				
			0				
			0				

(2) Add # above with #
left and above:



	2	3	4
	xAccel	xVelocity	xPosition
	add in	add in	add in
	xJerk	accel	velocity
	0	20	0
	0	20	20
	0	0+20	40
	0		
	0		
	0		
	0		
	0		

(2) Add # above with #
left and above:



2	3	4
xAccel add in xJerk	xVelocity add in xAccel	xPosition add in xVelocity
0	20	0
0	20	20
0	20	40
0		60
0		
0		
0		
0		

20+40

Mathematical Modelling

Physics of projectiles

- Assumptions:
 - Vacuum, uniform vertical gravity, no relativity, horizontal motion is independent of vertical motion.
- Vertical Model (Discretized!)
 - Each second, ball moves up by its current vertical velocity (meters/second)
 - During the first second, the vertical velocity is 50 meters/second.
 - Each second, the vertical velocity changes by gravity's acceleration of -10 meters/second/second.
 - So, eventually the ball falls.

(1) Write in initial values
from supervisor:
 $yVelocity=50$; $yPosition=0$;

Start in the first y:

7	8	9	
yAccel	yVelocity	yPosition	
add in	add in	add in	
yJerk	yAccel	yVelocity	
-10	50	0	1
-10			2
-10			3
-10			4
-10			5
-10			6

(2) Add # above with #
left and above:

7			8			9		
yAccel			yVelocity			yPosition		
add in			add in			add in		
yJerk			yAccel			yVelocity		
	-10			50			0	1
	-10					50+0		2
	-10							3
	-10							4
	-10							5
	-10							6

50+0



(2) Add # above with # -10+50
left and above:

Start in the center:

7	8	9	
yAccel	yVelocity	yPosition	
add in	add in	add in	
yJerk	yAccel	yVelocity	
-10	50	0	1
-10	-10+50	50	2
-10			3
-10			4
-10			5
-10			6

(2) Add # above with #
left and above: $40+50$

Start in the center:

7	8	9	
yAccel	yVelocity	yPosition	
add in	add in	add in	
yJerk	yAccel	yVelocity	
-10	50	0	1
-10	40	50	2
-10		$40+50$	3
-10			4
-10			5
-10			6

(2) Add # above with #
left and above:

Start in the center:

7	8	9	
yAccel	yVelocity	yPosition	
add in	add in	add in	
yJerk	yAccel	yVelocity	
-10	50	0	1
-10	40	50	2
-10	-10+40	90	3
-10			4
-10			5
-10			6

(2) Add # above with #
left and above:

Start in the center:

7	8	9	
yAccel	yVelocity	yPosition	
add in	add in	add in	
yJerk	yAccel	yVelocity	
-10	50	0	1
-10	40	50	2
-10	30	90	3
-10		30+90	4
-10			5
-10			6

(2) Add # above with #
left and above:

Start in the center:

7	8	9	
yAccel	yVelocity	yPosition	
add in	add in	add in	
yJerk	yAccel	yVelocity	
-10	50	0	1
-10	40	50	2
-10	30	90	3
-10	-10+30	120	4
-10			5
-10			6

(2) Add # above with #
left and above:

Start in the center:

7			8			9			
yAccel			yVelocity			yPosition			
add in			add in			add in			
yJerk			yAccel			yVelocity			
		-10			50			0	1
		-10			40			50	2
		-10			30			90	3
		-10			20			120	4
		-10			10			140	5
		-10			0			150	6

0
50
90
120
140
150

Position 0 to position 50
speed was about 50.

Position 50 to position 90
speed was about 40.

Position 90 to position 120
speed was about 30.

Position 120 to position 140
speed was about 20.

Position 140 to position 150
speed was about 10.

What we did: Simulation

- During each second, the ball moves horizontally 20 meters.
- During each second, the ball moves vertically whatever it's current vertical velocity is.
- During each second the ball's current vertical velocity changes by having 10 (meters/second) subtracted.
- **THIS IS NOT PERFECTLY ACCURATE!**
- But: It's accurate enough AND it's easy to compute with numbers.

Let's do it with only 4 variables
Imagine a paper (memory)
shortage!

Horizontal

- `int xVelocity;`
- `int xPosition;`
- `xVelocity = 20;`
- `xPosition = 0;`
- Repeat:
`xPosition = xPosition + xVelocity;`

Let's do it with only 4 variables
Imagine a paper (memory)
shortage!

Vertical

- `int yAccel;`
- `int yVelocity;`
- `int yPosition;`
- `yAccel = -10; yVelocity = 50; yPosition=0;`
- **REPEAT:**
 - `yPostion = yPosition + yVelocity;`
 - `yVelocity = yVelocity + yAccel;`

What if you did the two steps within
the loop body
in reverse order?

Vertical

- int yAccel;
- int yVelocity;
- int yPosition;
- yAccel = -10; yVelocity = 50; yPosition=0;
- REPEAT:
 - yVelocity = yVelocity + yAccel;
 - yPosition = yPosition + yVelocity;

**order
is
reversed!**



yAccel = -10; yVelocity = 50; yPosition=0;

- REPEAT: **(ACTUALLY DO THIS ON PAPER!!)**

yVelocity = yVelocity + yAccel;

yPosition = yPosition + yVelocity;

(A)

yPosition

0

50

90

120

**(numbers from
your spreadsheet)**

(B)

yPosition

0

40

70

90

**(DIFFERENT
numbers from
your spreadsheet)**