CDS 230
Modeling and Simulation I

Module 2

Simple Physics Models

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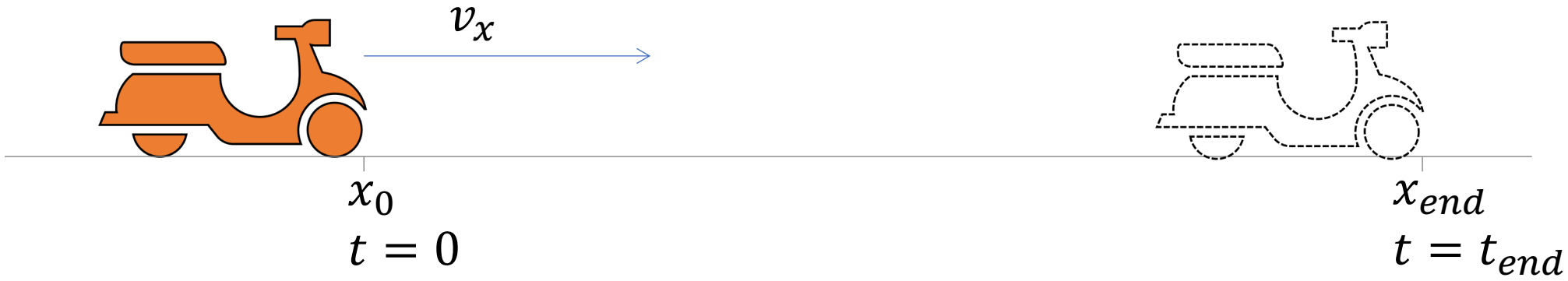
Linear motion

- Based on Newton's first law (i.e., the principle of inertia)
  - An object with to net forces acting upon them will remain still or move with constant speed.



$$x_{end} = x_0 + v_x\, t$$

This equation will determine where an object is after time t_{end}.

Starting location is x_0. Velocity is v_x. The time is t.

Linear motion

$x_{end} = x_0 + v_x\, t$ re-arrange the equation as $t = \frac{x_{end} - x_o}{v_x}$

In this equation, we have the starting position, the ending position, and the velocity.
We can determine the amount of time needed to make journey.

Let's represent this equation in Python

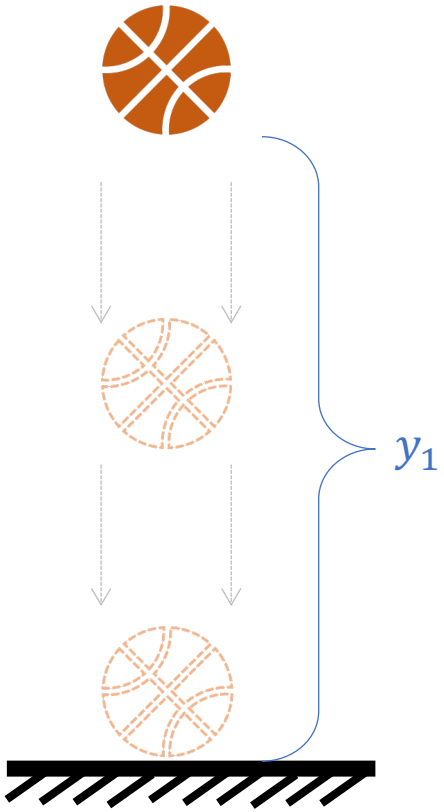
```
x0 = 0
x_end = 10
vx = 1.3
t = (x_end-x0)/vx

print("Time it takes to move from x1 to x2 is ", t, "seconds")
```

```
Time it takes to move from x1 to x2 is  7.692307692307692 seconds
```

Free fall

Watch: https://www.youtube.com/watch?v=E43-CfukEgs



Free fall formula: $y_2 = y_1 + v_y\, t - \frac{1}{2} g\, t^2$

This equation also applies if a person is just dropping something from a height.
In this case y_1 would be a larger number.

Starting height = y_1.
Ending height = y_2 .
Initial velocity = v_y .
Gravity = $g = 9.8$ (For Earth)
Time = t

Free fall (code)

```
y1=50 # initial position
vy=0 # initial velocity
t=3 # time
g=9.8 # gravity

new_position = y1+vy*t-0.5*g*t**2
```

```
print("The new position after free fall is ", new_position)
```

```
The new position after free fall is  5.899999999999999
```

Predicting Time

$$y_2 = y_1 + v_y\, t - \frac{1}{2} g\, t^2$$

Predicting time is a little more involved because there is a t and a t^2 .

This equation is of the form: $a\, t^2 + b\, t + c = 0$

Do you remember the quadratic equation?

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Thus..

$$y_2 = y_1 + v_y\, t - \frac{1}{2} g\, t^2$$

Solving for t becomes:

$$t = \frac{-\mathrm{v_y} \pm \sqrt{v_y^2 + 2g(y_1 - y_2)}}{-g}$$

In Python use ****0.5** for the square root or `math.sqrt()`.
Need two equations for the two cases: $\pm$. One equation will use + and the other equation will use -.

Questions?

Sources:

https://www.britannica.com/science/linear-motion

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