

# Órbita planetaria

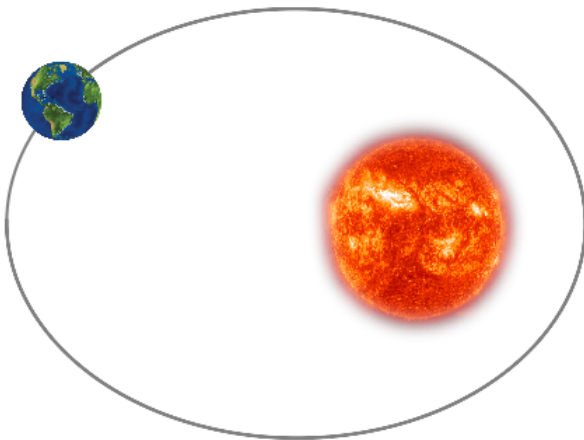
UNSAM Programa

Universidad Nacional de San Martín - UNSAM - Adaptado de Exactas Programa

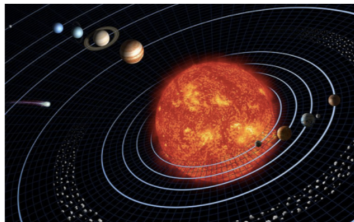
Verano 2020

## Objetivo:

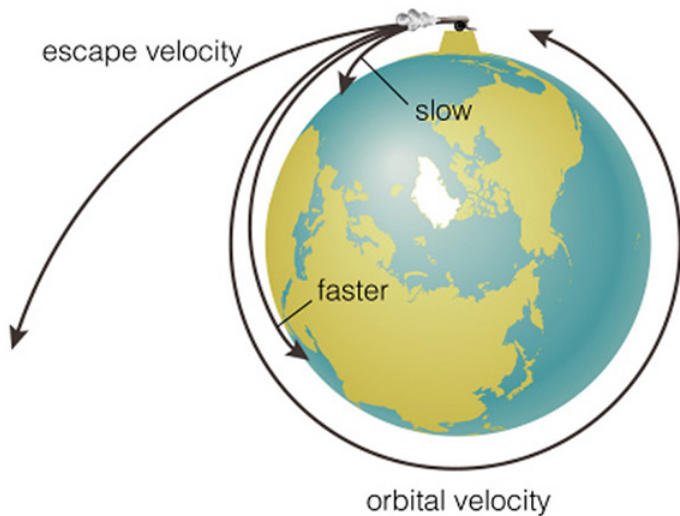
Hacer un programa que **calcule** y **grafique** la trayectoria de la Tierra alrededor del Sol



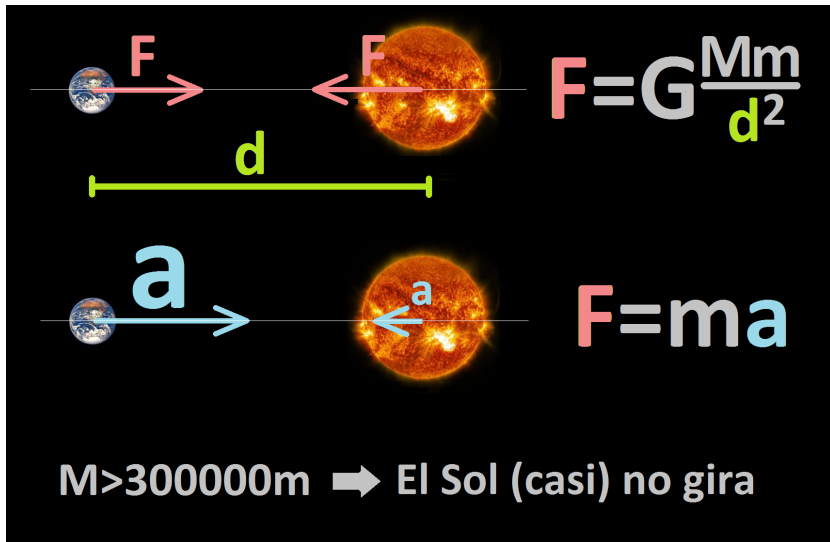
# Ley de gravitación **universal**



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## Ley de gravitación universal



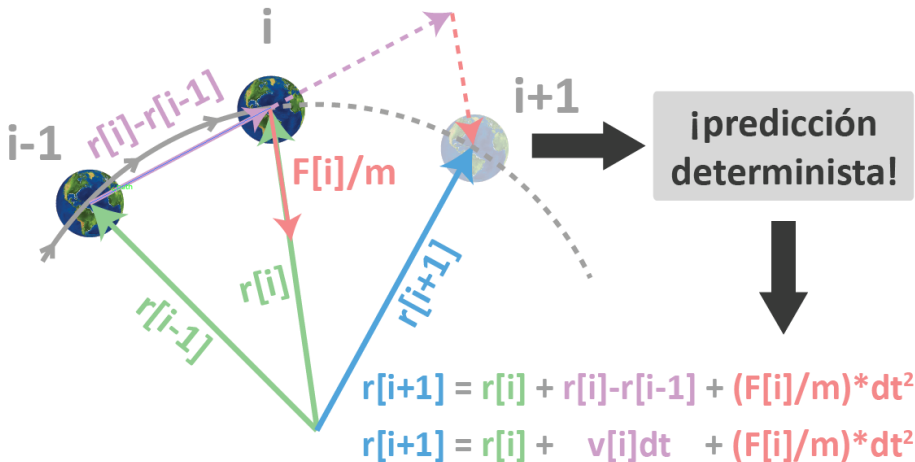
The diagram illustrates the relationship between gravitational force, distance, and acceleration in the context of Earth and the Sun.

**Top Diagram:** Shows Earth and the Sun. A red arrow labeled  $F$  points from Earth towards the Sun, and another red arrow labeled  $F$  points from the Sun towards Earth. A green double-headed arrow labeled  $d$  indicates the distance between them. To the right, the equation  $F = G \frac{Mm}{d^2}$  is shown, with  $F$  in red,  $G$  in grey,  $M$  and  $m$  in white, and  $d^2$  in green.

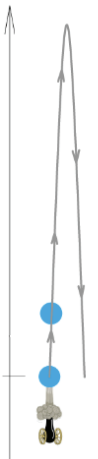
**Bottom Diagram:** Shows Earth and the Sun. A blue arrow labeled  $a$  points from Earth towards the Sun, and another blue arrow labeled  $a$  points from the Sun towards Earth. To the right, the equation  $F = ma$  is shown, with  $F$  in red,  $m$  in white, and  $a$  in blue.

**Text at the bottom:**  $M > 300000m \Rightarrow$  El Sol (casi) no gira

# Algoritmo de Verlet



## Ejemplo sencillo: Tiro Vertical



The diagram on the left shows a vertical axis labeled  $y(\text{mts})$ . A grey parabolic trajectory is plotted, starting from a cannon at the bottom, reaching a peak, and returning to the ground. Two blue dots are marked on the upward path. A red arrow points downwards, indicating the direction of the gravitational force.

Force equation:  $F = mg$

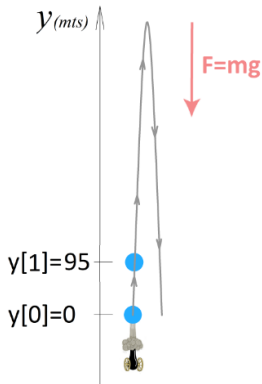
Gravitational force equation:  $F[i] = G \frac{M_T m}{d^2} = \underbrace{G \frac{M_T m}{R_T^2}}_g = \overset{\sim 10}{9,8 \frac{\text{mts}}{\text{seg}^2}} m$

Position update equation:  $r[i+1] = r[i] + \underbrace{r[i] - r[i-1]} + (F[i]/m) * dt^2$

Simplified position update equation:  $r[i+1] = 2 * r[i] - r[i-1] - g * dt^2$

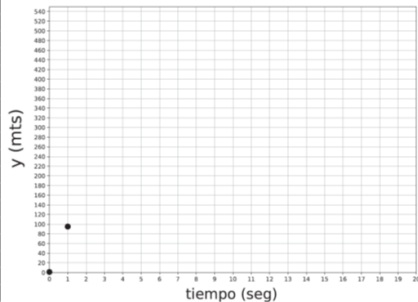
Velocity update equation:  $y[i+1] = 2 * y[i] - y[i-1] - g * dt^2$

# Juego de hoy: probemos Verlet!



Iteracion	tiempo (seg)	y (mts)
0	0	0
1	1	95
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

$$tiempo[i + 1] = tiempo[i] + dt$$
$$y[i + 1] = 2 * y[i] - y[i - 1] - g * dt^2$$





## Este tipo de cálculos se hacían...



Katherine Johnson:  
matemática de la NASA



## Órbita de la Tierra: ¿Cómo escribimos la **aceleración vectorial**?

