

AGG0012 – Problemas Integrados em Ciências da Terra II

Gravitação
Victor Sacek

The Feynman Lectures on Physics



free to read online!

<http://www.feynmanlectures.caltech.edu/>



The Feynman Lectures on Physics

Feynman • Leighton • Sands



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However, we want to be clear that this edition is only **free to read online**, and this posting does **not** transfer any right to download all or any portion of *The Feynman Lectures on Physics* for any purpose.

This edition has been designed for ease of reading on devices of any size or shape; text, figures and equations can all be zoomed without degradation.¹

Volume I

MAINLY MECHANICS, RADIATION AND HEAT

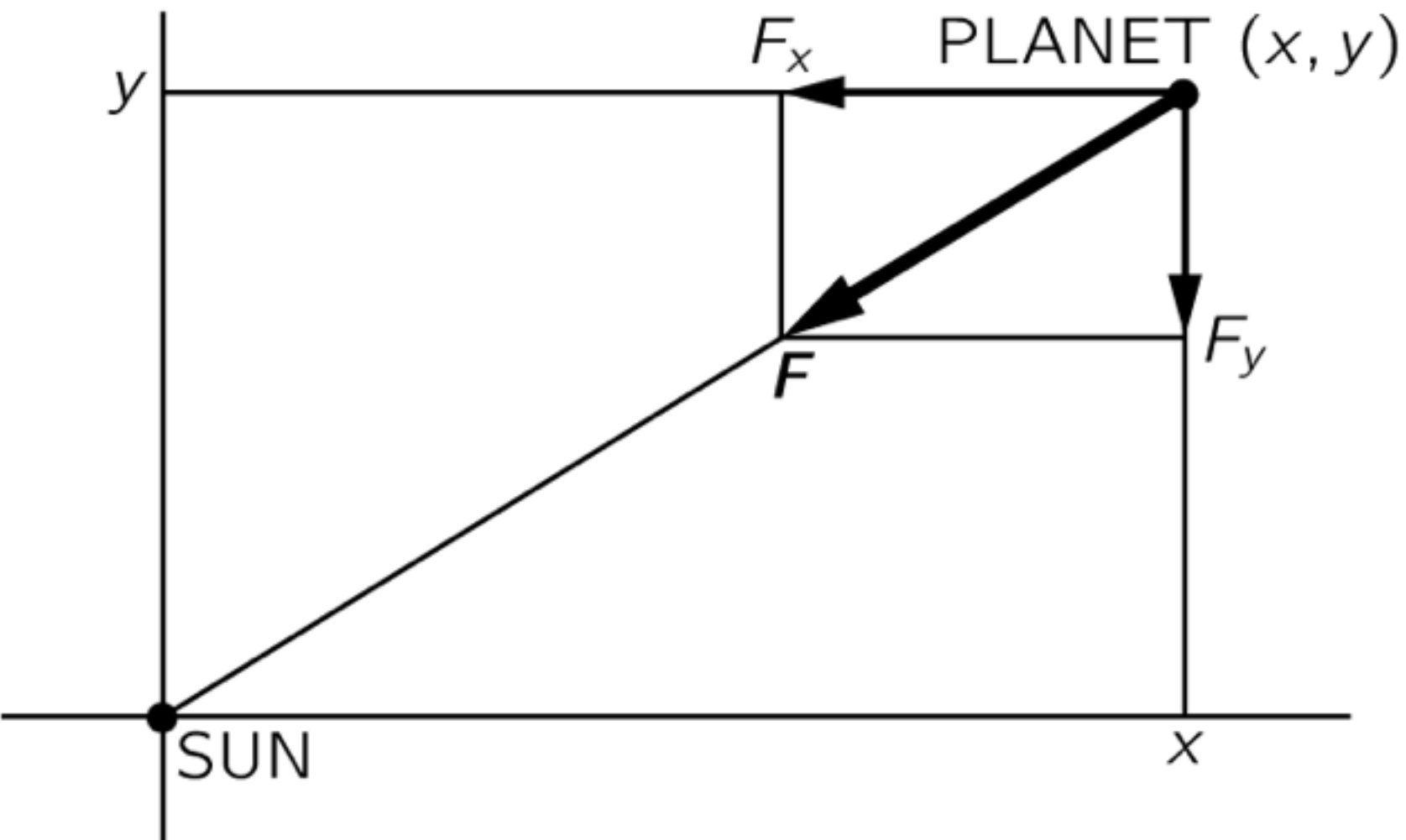
Volume II

MAINLY ELECTROMAGNETISM AND MATTER

Volume III

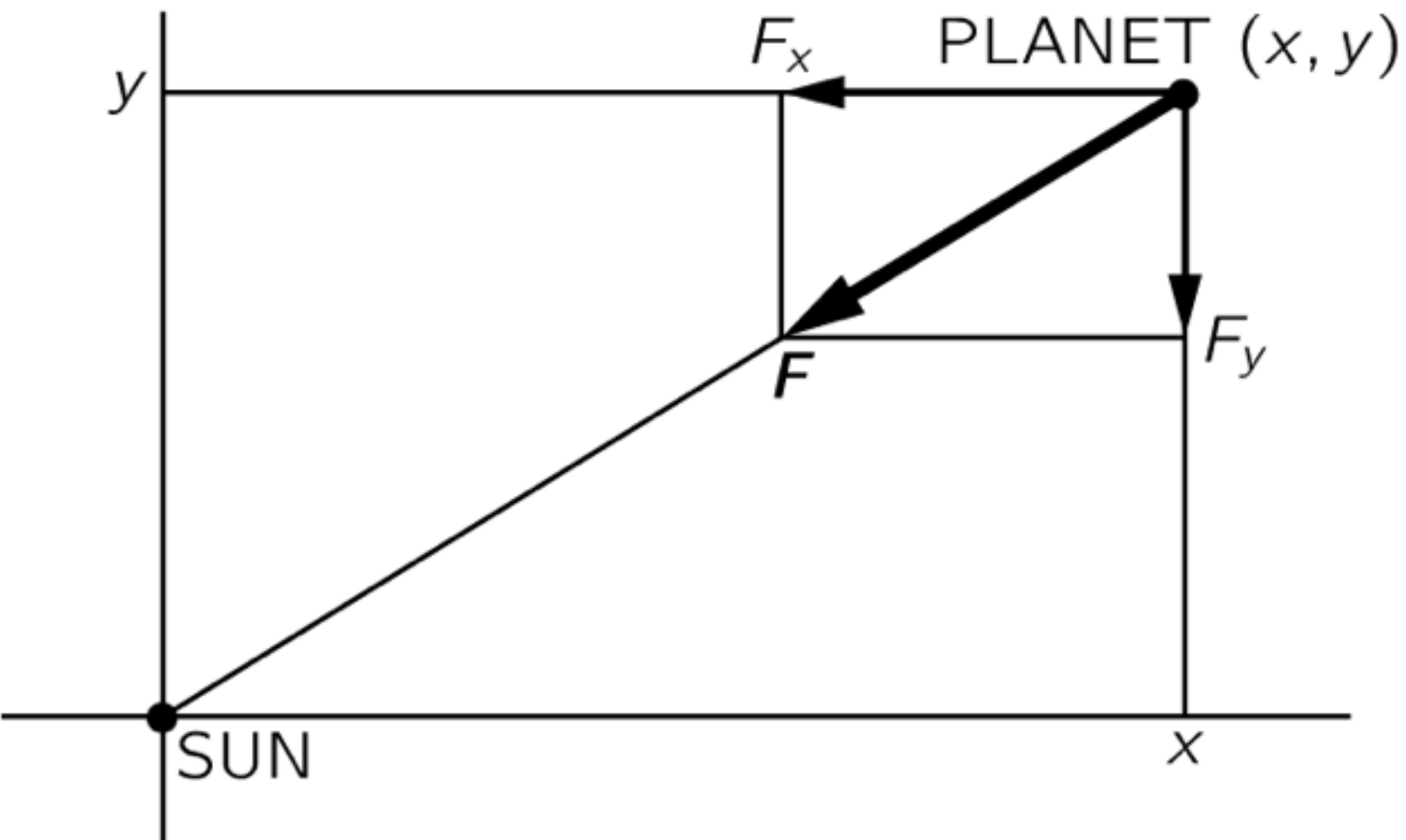
QUANTUM MECHANICS

Gravitação



Gravitação

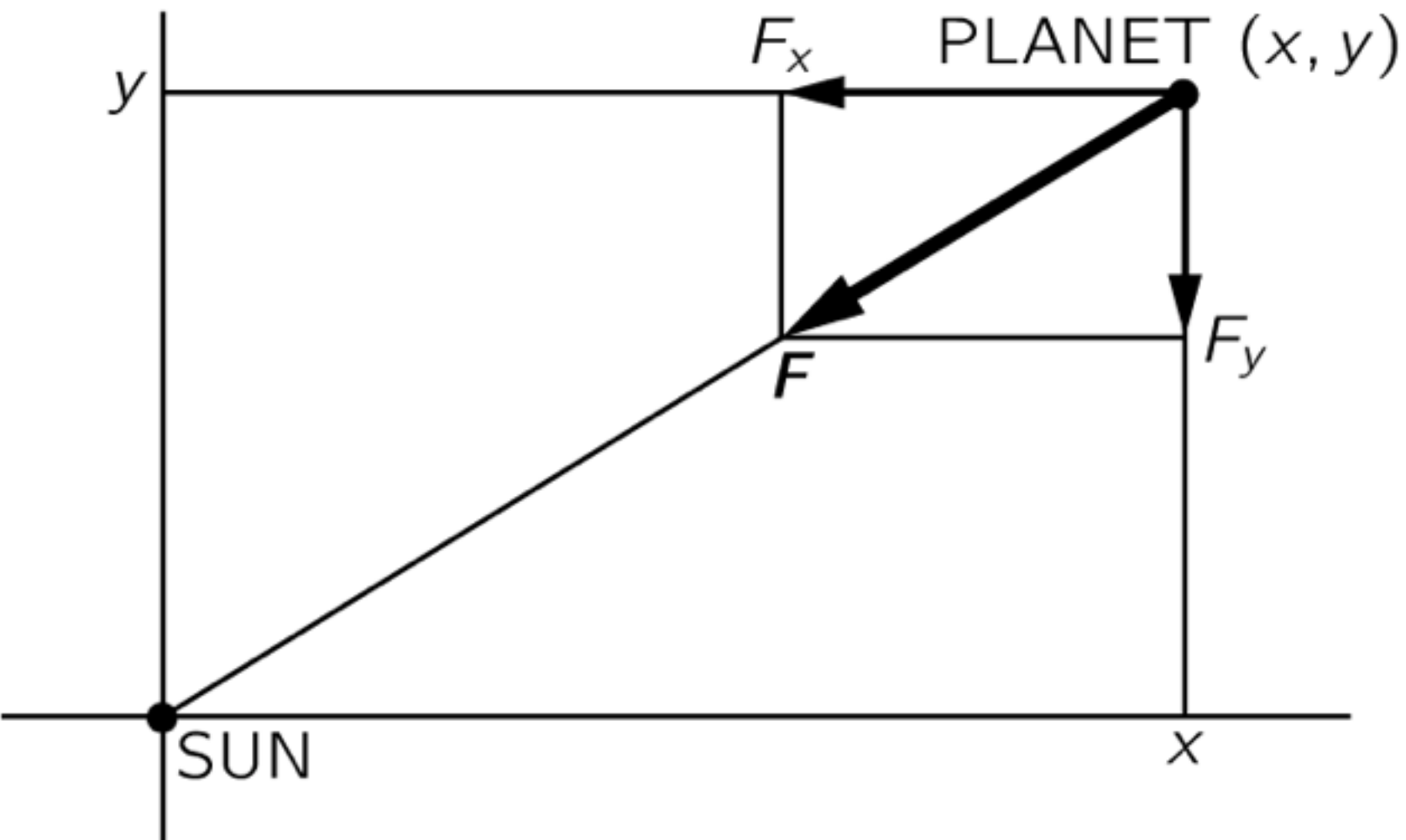
$$\vec{F} = m\vec{a}$$



Gravitação

$$\vec{F} = m\vec{a}$$

$$\vec{F} = m \frac{d\vec{v}}{dt}$$

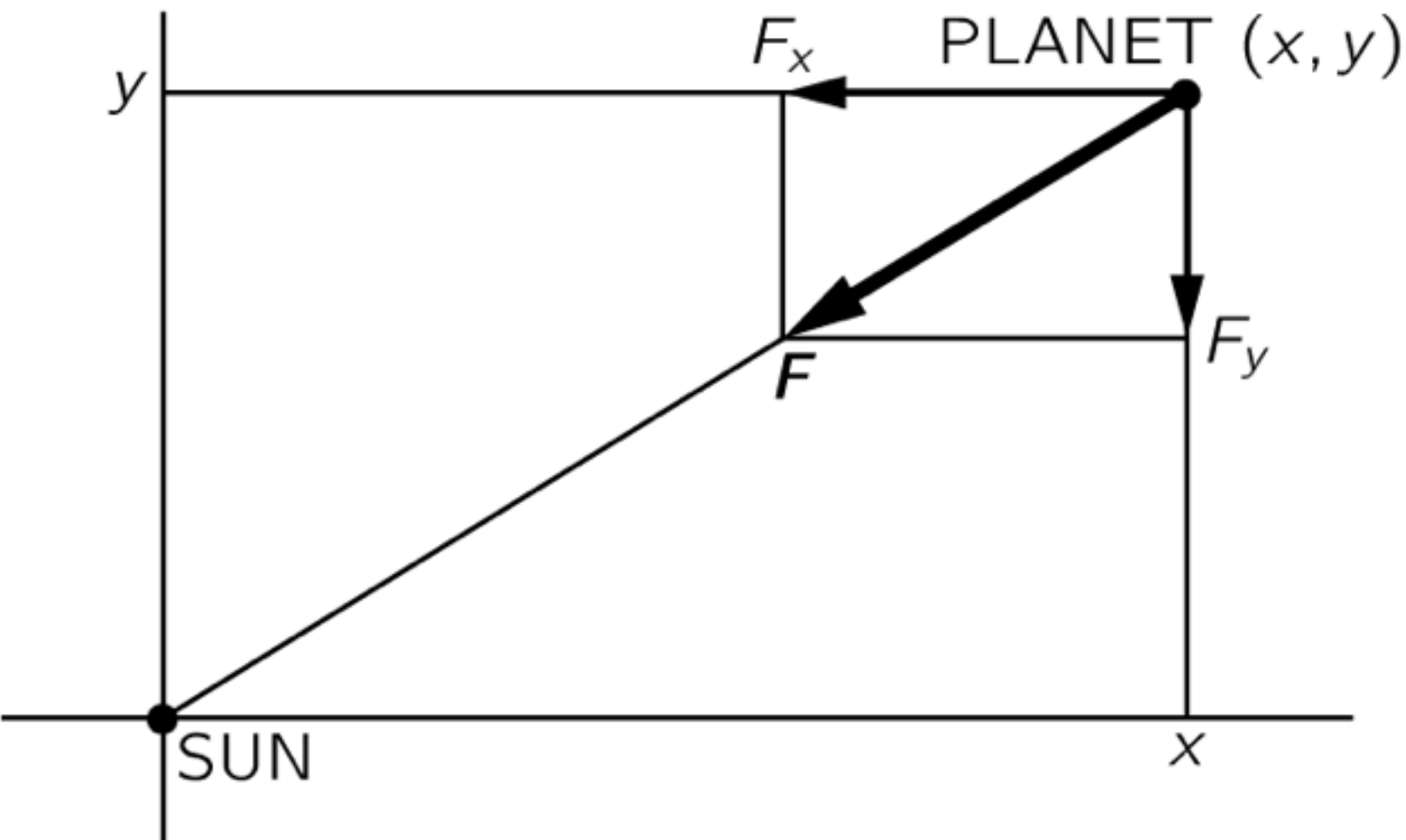


Gravitação

$$\vec{F} = m\vec{a}$$

$$\vec{F} = m \frac{d\vec{v}}{dt}$$

$$-\frac{GMm}{|\vec{r}|^2} \hat{r} = m \frac{d\vec{v}}{dt}$$



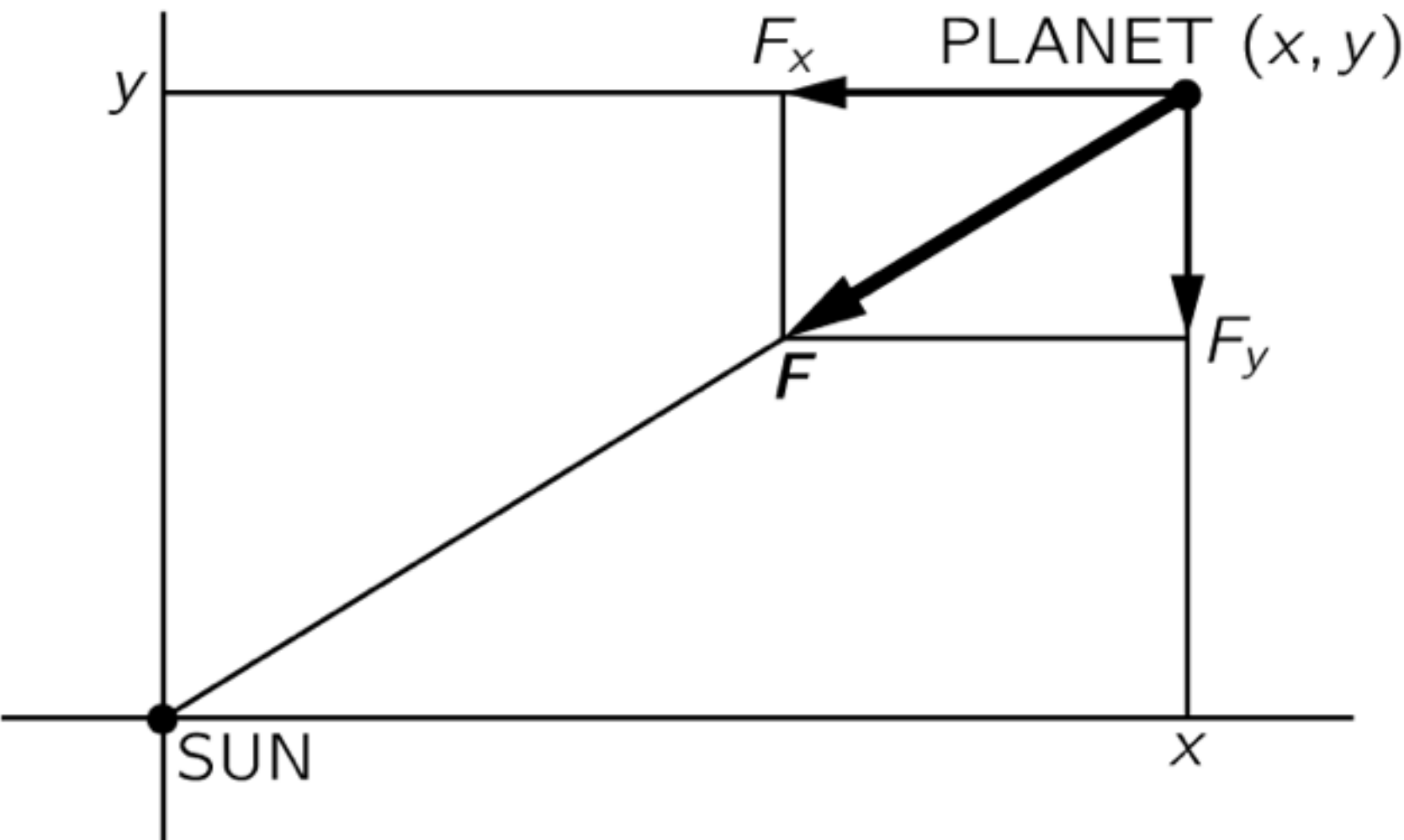
Gravitação

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Gravitação

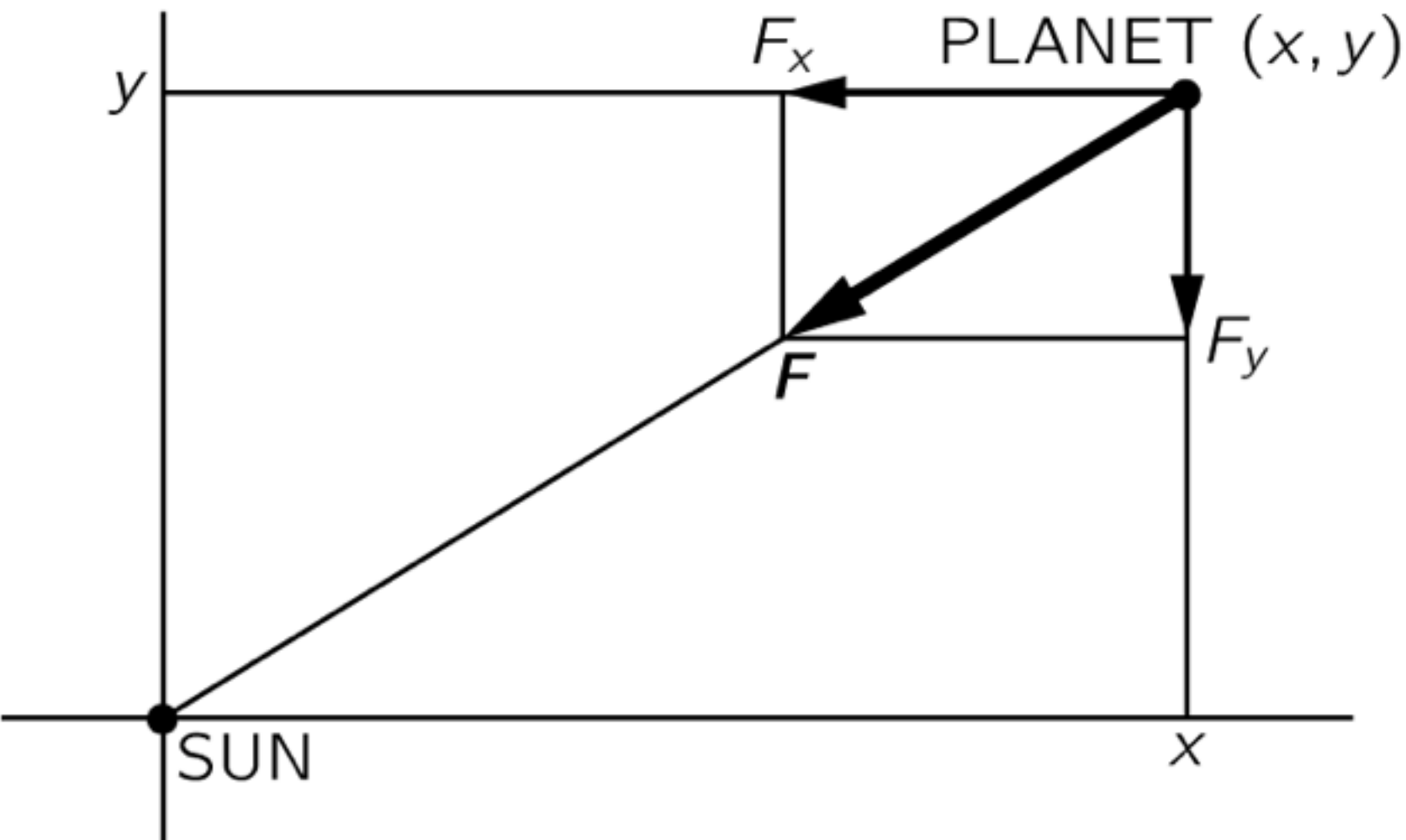
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$$-\frac{GM}{|\vec{r}|^3} \vec{r} = \frac{d\vec{v}}{dt}$$



Gravitação

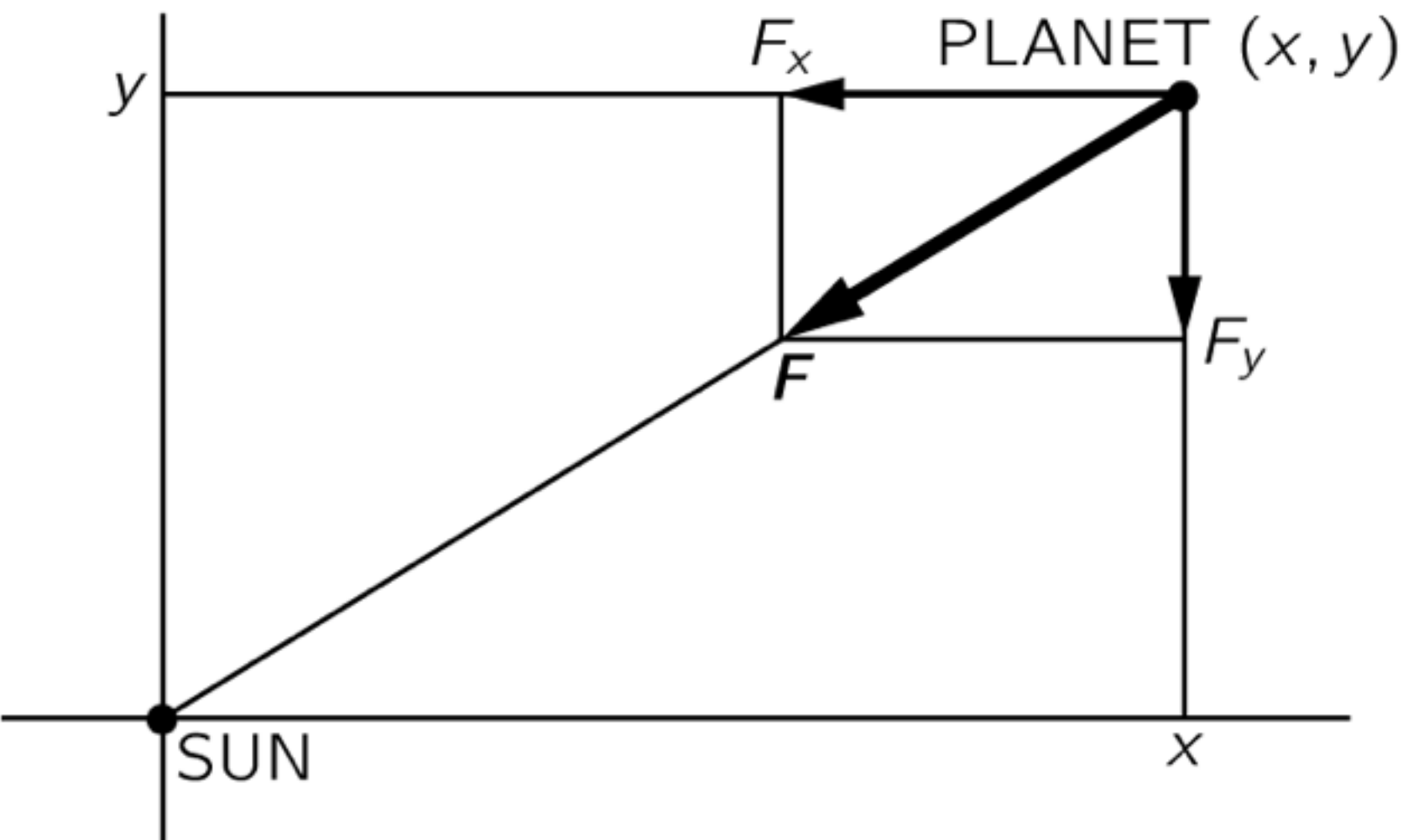
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$$-\frac{GM}{|\vec{r}|^3} \vec{r} = \frac{d\vec{v}}{dt}$$



$$-\frac{GM}{|\vec{r}|^3} x = \frac{dv_x}{dt}$$

Gravitação

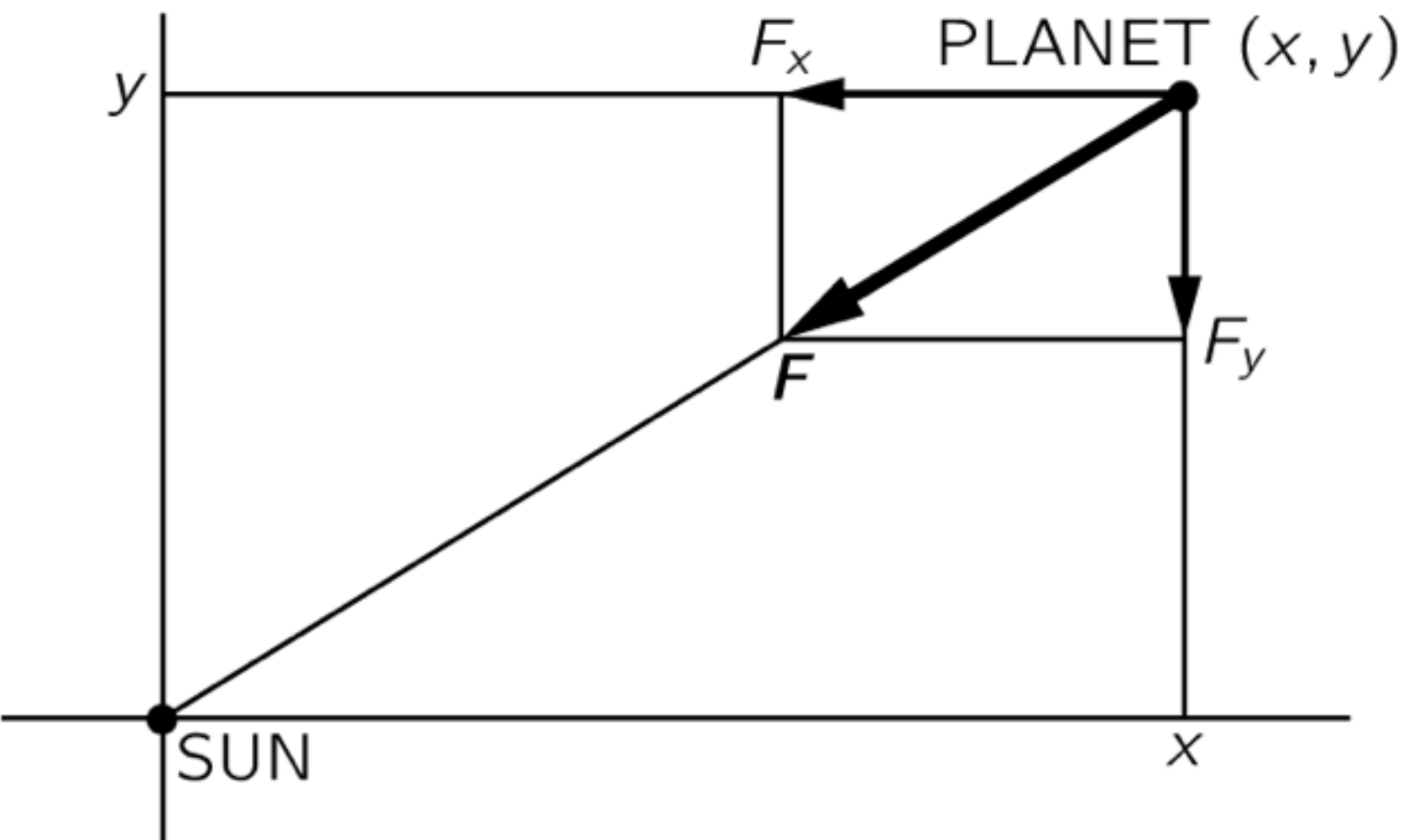
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$$-\frac{GM}{|\vec{r}|^3} \vec{r} = \frac{d\vec{v}}{dt}$$



$$-\frac{GM}{|\vec{r}|^3} x = \frac{dv_x}{dt}$$

$$-\frac{GM}{|\vec{r}|^3} y = \frac{dv_y}{dt}$$

Gravitação

(solução numérica)

$$\frac{dv_x}{dt} = -\frac{GM}{|\vec{r}|^3}x \qquad \frac{dv_y}{dt} = -\frac{GM}{|\vec{r}|^3}y$$

Gravitação

(solução numérica)

$$\frac{dv_x}{dt} = -\frac{GM}{|\vec{r}|^3}x \qquad \frac{dv_y}{dt} = -\frac{GM}{|\vec{r}|^3}y$$

$$|\vec{r}| = \sqrt{x^2 + y^2}$$

Gravitação

(solução numérica)

$$\frac{dv_x}{dt} = -\frac{GM}{|\vec{r}|^3}x \qquad \frac{dv_y}{dt} = -\frac{GM}{|\vec{r}|^3}y$$

$$|\vec{r}| = \sqrt{x^2 + y^2}$$

$$\frac{v_x - v_{x0}}{\Delta t} = -\frac{GM}{|\vec{r}|^3}x$$

Gravitação

(solução numérica)

$$\frac{dv_x}{dt} = -\frac{GM}{|\vec{r}|^3}x$$

$$\frac{dv_y}{dt} = -\frac{GM}{|\vec{r}|^3}y$$

$$|\vec{r}| = \sqrt{x^2 + y^2}$$

$$\frac{v_x - v_{x0}}{\Delta t} = -\frac{GM}{|\vec{r}|^3}x$$

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Gravitação

(solução numérica)

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$$|\vec{r}| = \sqrt{x^2 + y^2}$$

$$\frac{v_x - v_{x0}}{\Delta t} = -\frac{GM}{|\vec{r}|^3}x$$

$$\frac{v_y - v_{y0}}{\Delta t} = -\frac{GM}{|\vec{r}|^3}y$$

$$v_x = v_{x0} - \Delta t \frac{GM}{|\vec{r}|^3}x$$

Gravitação

(solução numérica)

$$\frac{dv_x}{dt} = -\frac{GM}{|\vec{r}|^3}x$$

$$\frac{dv_y}{dt} = -\frac{GM}{|\vec{r}|^3}y$$

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(solução numérica)

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$$v_y = v_{y0} - \Delta t \frac{GM}{|\vec{r}|^3}y$$

$$x = x_0 + \Delta t v_x$$

Gravitação

(solução numérica)

$$\frac{dv_x}{dt} = -\frac{GM}{|\vec{r}|^3}x$$

$$\frac{dv_y}{dt} = -\frac{GM}{|\vec{r}|^3}y$$

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$$x = x_0 + \Delta t v_x$$

$$y = y_0 + \Delta t v_y$$

Gravitação

(solução numérica)

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Gravitação

(solução numérica)

$$x = x_0 + \Delta t v_x$$

$$y = y_0 + \Delta t v_y$$

$$|\vec{r}| = \sqrt{x^2 + y^2}$$

$$v_x = v_{x0} - \Delta t \frac{GM}{|\vec{r}|^3} x$$

$$v_y = v_{y0} - \Delta t \frac{GM}{|\vec{r}|^3} y$$

Gravitação

(solução numérica)

$$x = x_0 + \Delta t v_x$$

$$y = y_0 + \Delta t v_y$$

$$|\vec{r}| = \sqrt{x^2 + y^2}$$

$$v_x = v_{x0} - \Delta t \frac{GM}{|\vec{r}|^3} x$$

$$v_y = v_{y0} - \Delta t \frac{GM}{|\vec{r}|^3} y$$

$$GM \equiv 1$$

Gravitação

(solução numérica)

$$x = x_0 + \Delta t v_x$$

$$y = y_0 + \Delta t v_y$$

$$|\vec{r}| = \sqrt{x^2 + y^2}$$

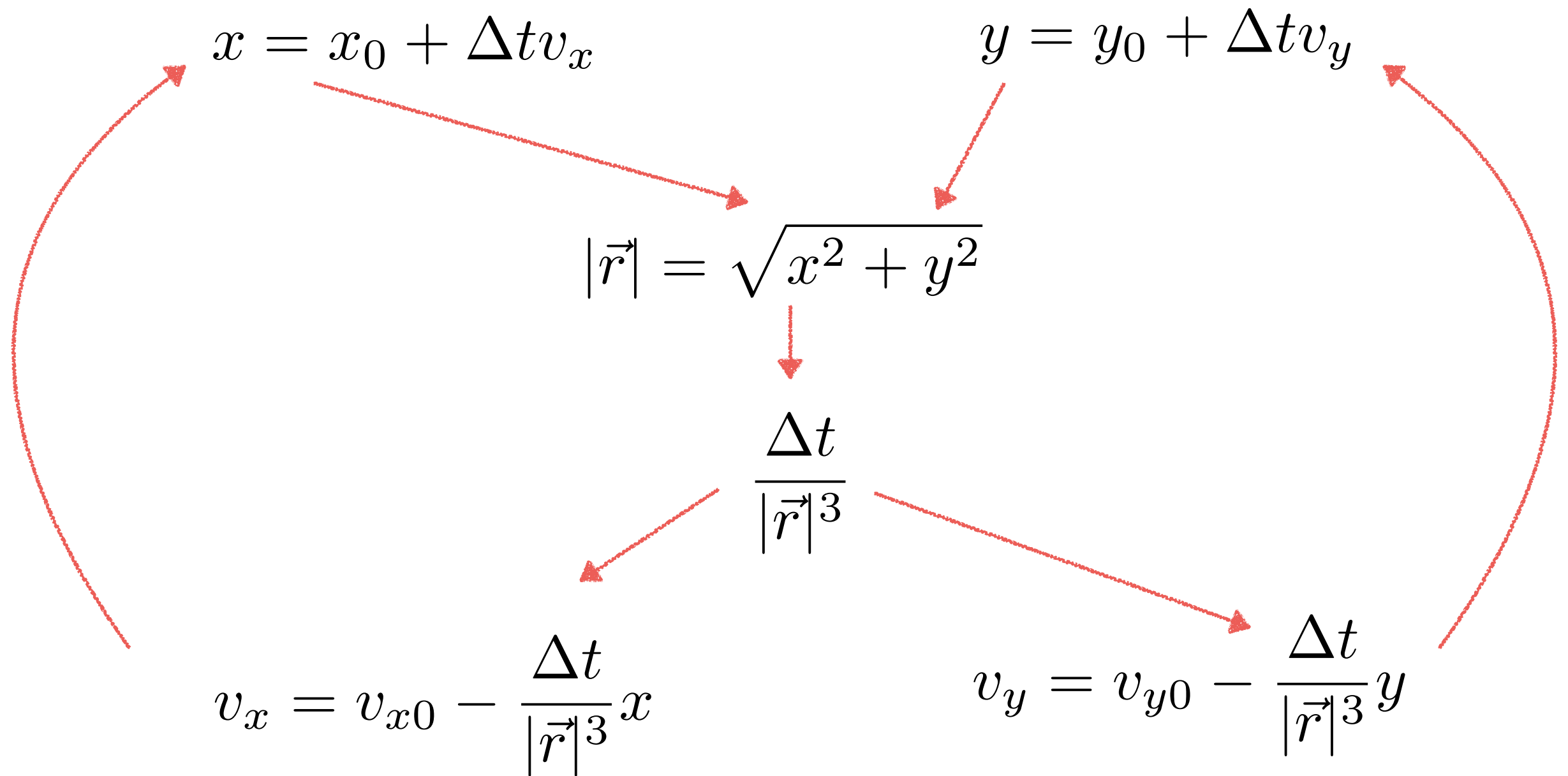
$$v_x = v_{x0} - \Delta t \frac{1}{|\vec{r}|^3} x$$

$$v_y = v_{y0} - \Delta t \frac{1}{|\vec{r}|^3} y$$

$$GM \equiv 1$$

Gravitação (solução numérica)

$$GM \equiv 1$$



Primórdios da computação (o computador humano)

NACA High Speed Flight Station
"Computer Room"



Primórdios da computação (o computador humano)

A COMPUTER WANTED.

WASHINGTON, May 1.—A civil service examination will be held May 18 in Washington, and, if necessary, in other cities, to secure eligibles for the position of computer in the Nautical Almanac Office, where two vacancies exist—one at \$1,000, the other at \$1,400.

The examination will include the subjects of algebra, geometry, trigonometry, and astronomy. Application blanks may be obtained of the United States Civil Service Commission.

The New York Times

NACA High Speed Flight Station
"Computer Room"



http://en.wikipedia.org/wiki/Human_computer

Vamos colocar uma sonda em órbita!

- A partir da posição inicial e velocidade especificada, calcule a órbita da sonda e plote a sua trajetória ao longo do tempo.

$$\Delta t = 0.1$$

$$x_{inicial} = 0.5$$

$$y_{inicial} = 0.0$$

	G1	G2	G3	G4	G5	G6
$v_{x,inicial}$	0.0	0.0	0.0	0.0	-0.4	-0.6
$v_{y,inicial}$	1.3	1.6	1.4	1.65	1.7	1.6