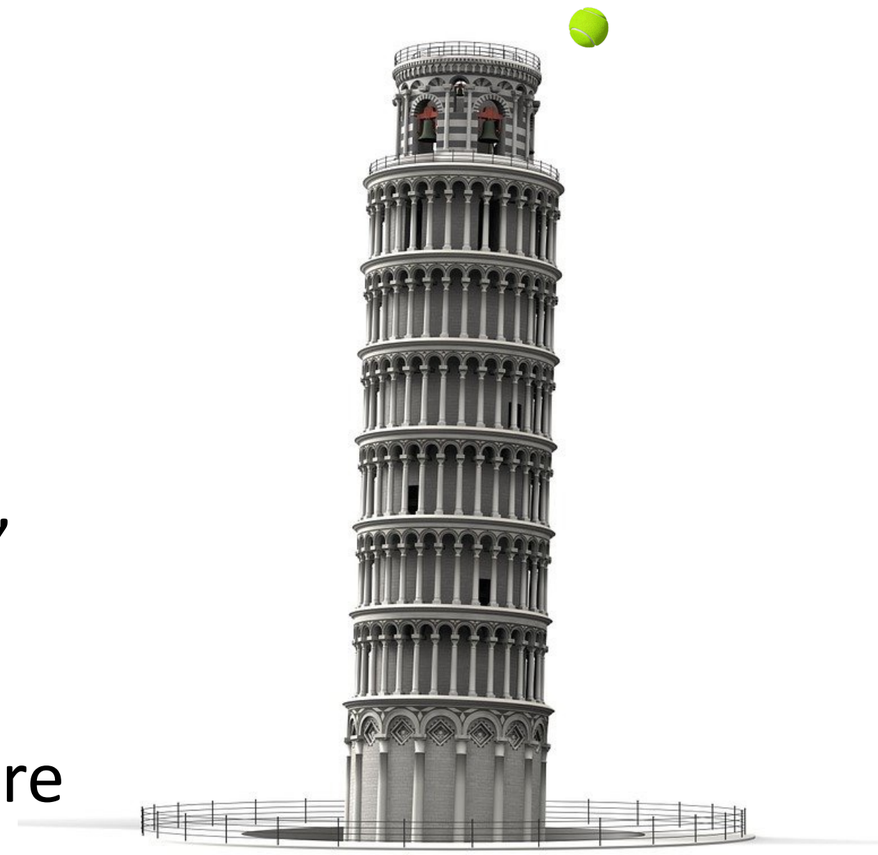
Raul Barrea
@PhysicsSensei

Object in Free Fall with initial Velocity

Throw a tennis ball from the top of a tower

You climb to the top of a tower, 70.0 m above the ground. You throw a tennis ball with initial velocity

$v_i = +10.0\ \frac{m}{s}$, from the top of the tower.



1. Calculate the maximum height the ball can go,
2. Calculate how long it takes to reach that height,
3. Calculate how long it takes for the ball to hit ground.
4. Calculate the final velocity of the ball right before hitting ground.

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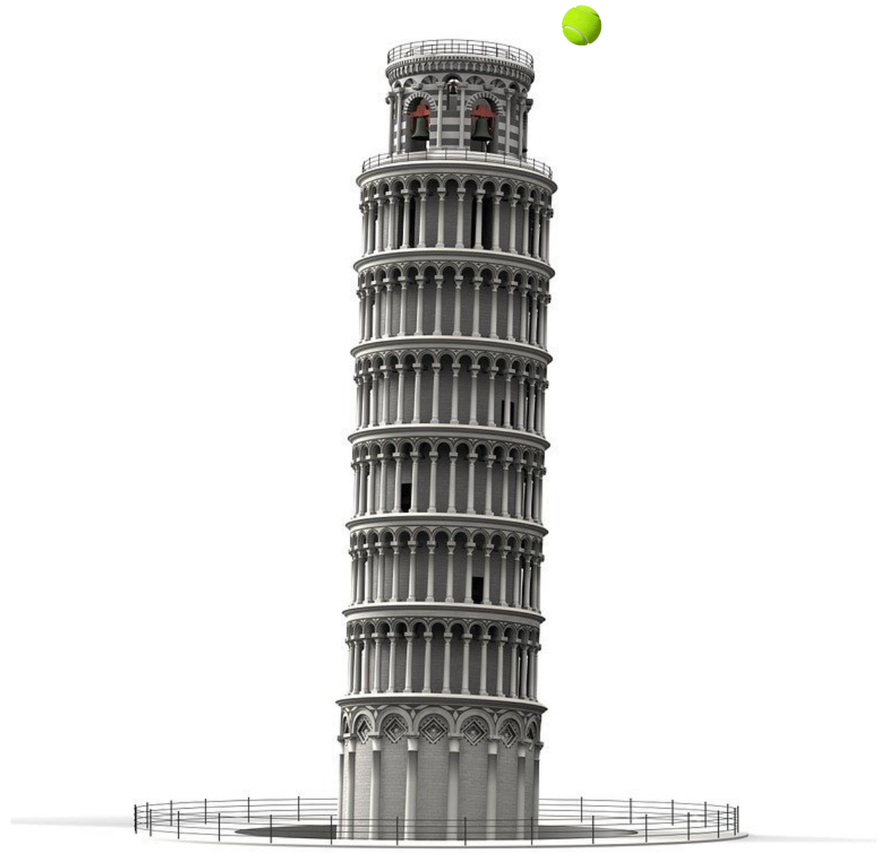
Basic steps to solve this problem

1) Read the problem
2) Draw a diagram
3) Write down info
4) Choose equation
5) Solve for the unknowns
6) Check your answers



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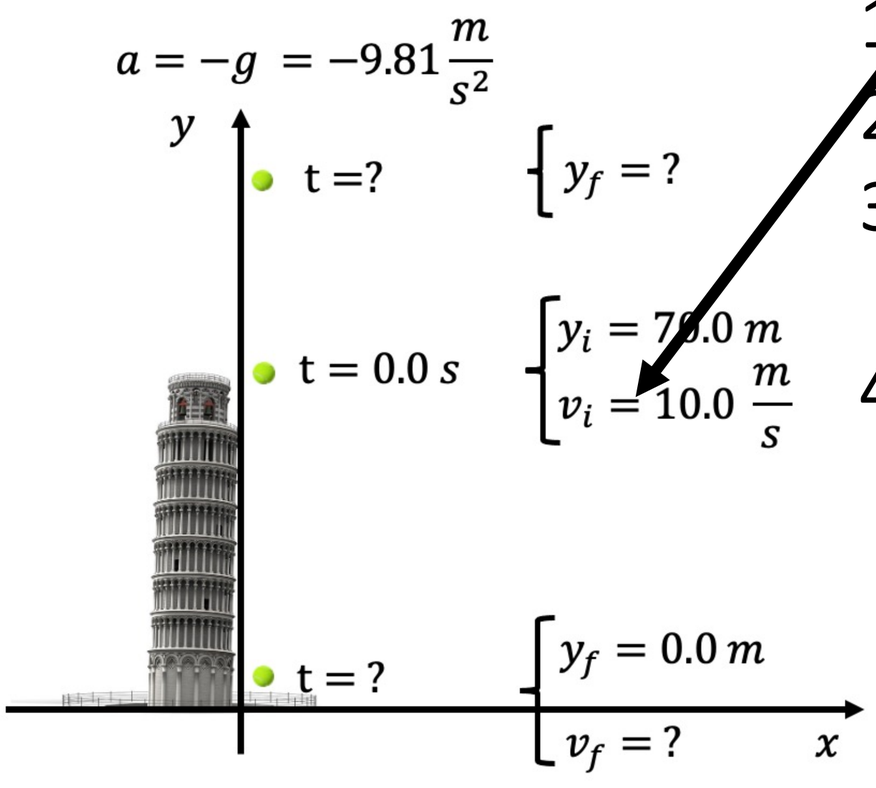

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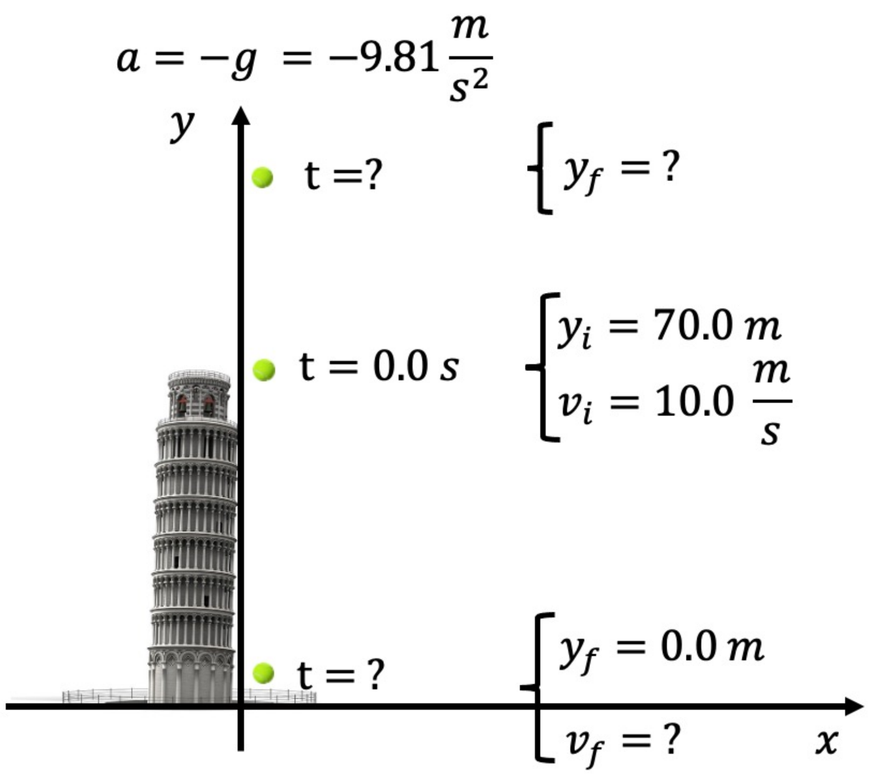

Equations

$$y_f = y_i + v_i \cdot t + \frac{1}{2} \cdot a \cdot t^2$$

$$v_f = v_i + a \cdot t$$

$$v_f{}^2 = v_i{}^2 + 2 \cdot a \cdot \Delta y$$

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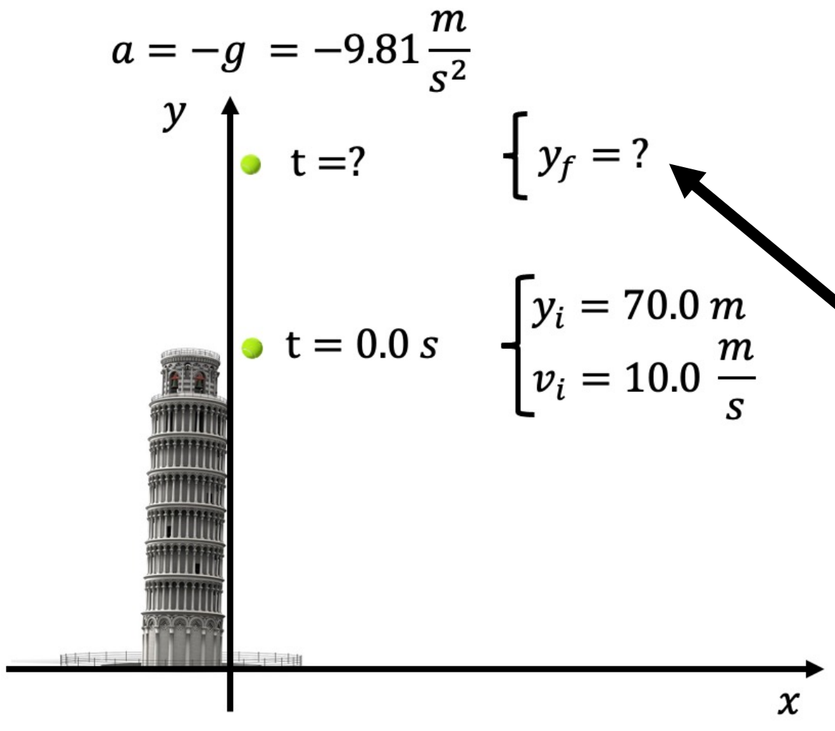

Calculate the maximum height the ball can go

$$v_f{}^2 = v_i{}^2 + 2 \cdot a \cdot \Delta y$$

$$0 = (10.0\frac{m}{s})^2 + 2 \cdot (-9.81\frac{m}{s^2}) \cdot \Delta y$$

$$\Delta y = \frac{(10.0\frac{m}{s})^2}{2 \cdot (9.81\frac{m}{s^2})}$$

$$\Delta y = 5.10\ m$$

$$y_f = 70.0\ m + 5.10\ m$$

$$y_f = 75.1\ m$$

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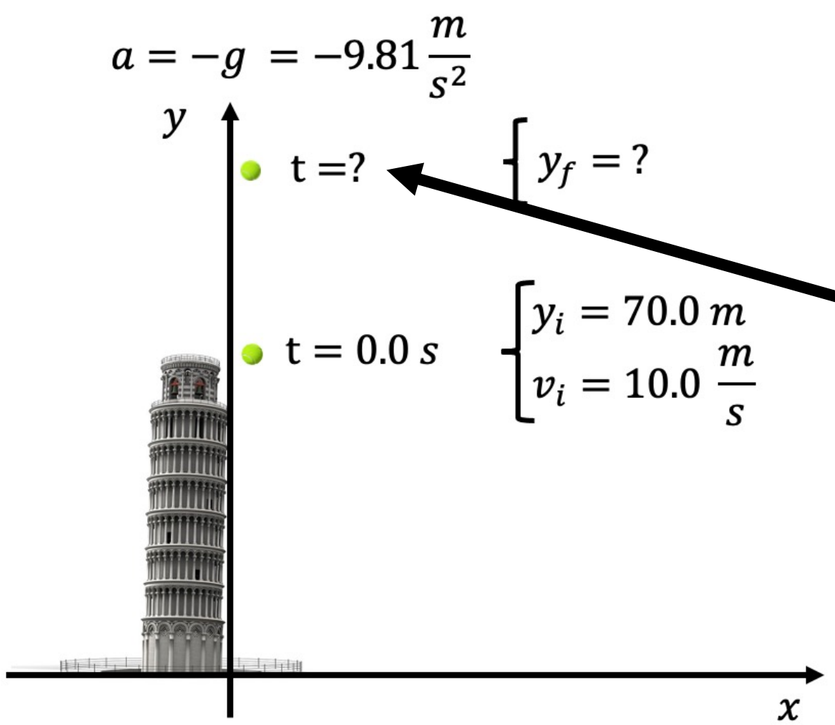
Calculate how long it takes to reach that height

$$v_f = v_i + a \cdot t$$

$$0 = 10.0\,\frac{m}{s} + (-9.81\,\frac{m}{s^2}) \cdot t$$

$$t = \frac{10.0\,\frac{m}{s}}{9.81\,\frac{m}{s^2}}$$

$$t = 1.02\ s$$



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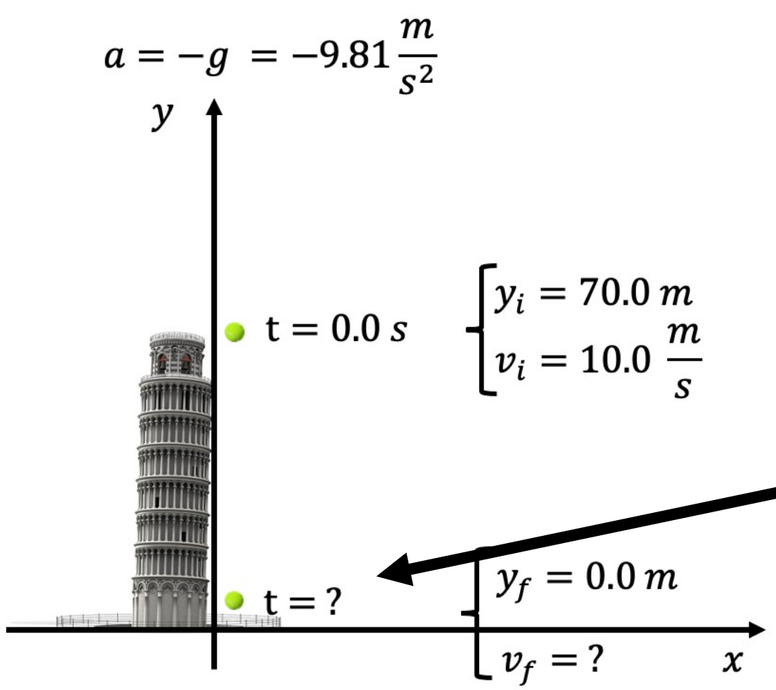
Calculate how long it takes for the ball to hi

$$y_f = y_i + v_i \cdot t + \frac{1}{2} \cdot a \cdot t^2$$

$$0 = 70.0\,m + 10.0\frac{m}{s} \cdot t + \frac{1}{2} \cdot (-9.81\frac{m}{s^2}) \cdot t^2$$



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

$$t_1 = 4.93\ s$$

~~$t_2 = -2.89\ s$~~

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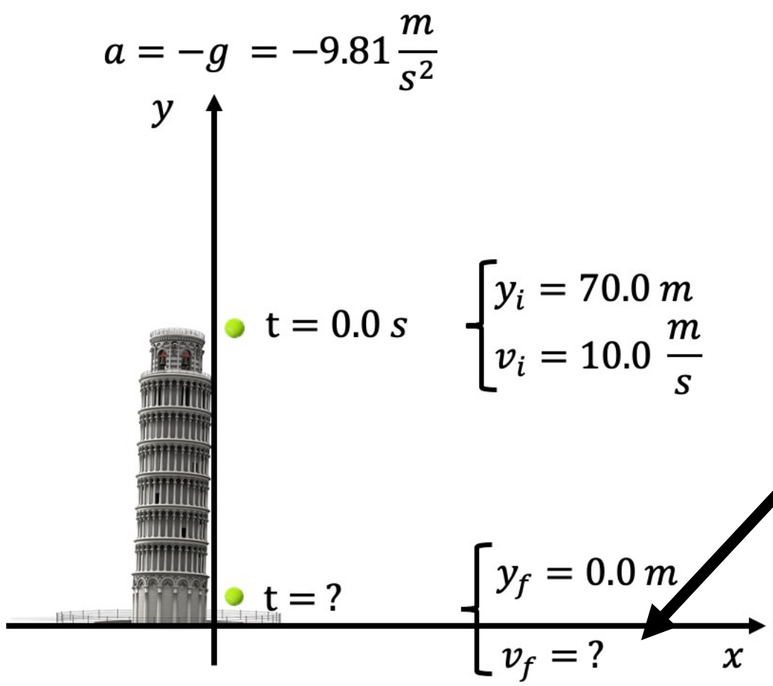
Calculate the final velocity of the ball right before hitting ground

$$v_f = v_i + a \cdot t$$

$$v_f = 10.0\frac{m}{s} + (-9.81\frac{m}{s^2}) \cdot (4.93s)$$

$$v_f = -38.4\ \frac{m}{s}$$



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