Space – The Final Frontier

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Credit: Hubble Telescope/NASA

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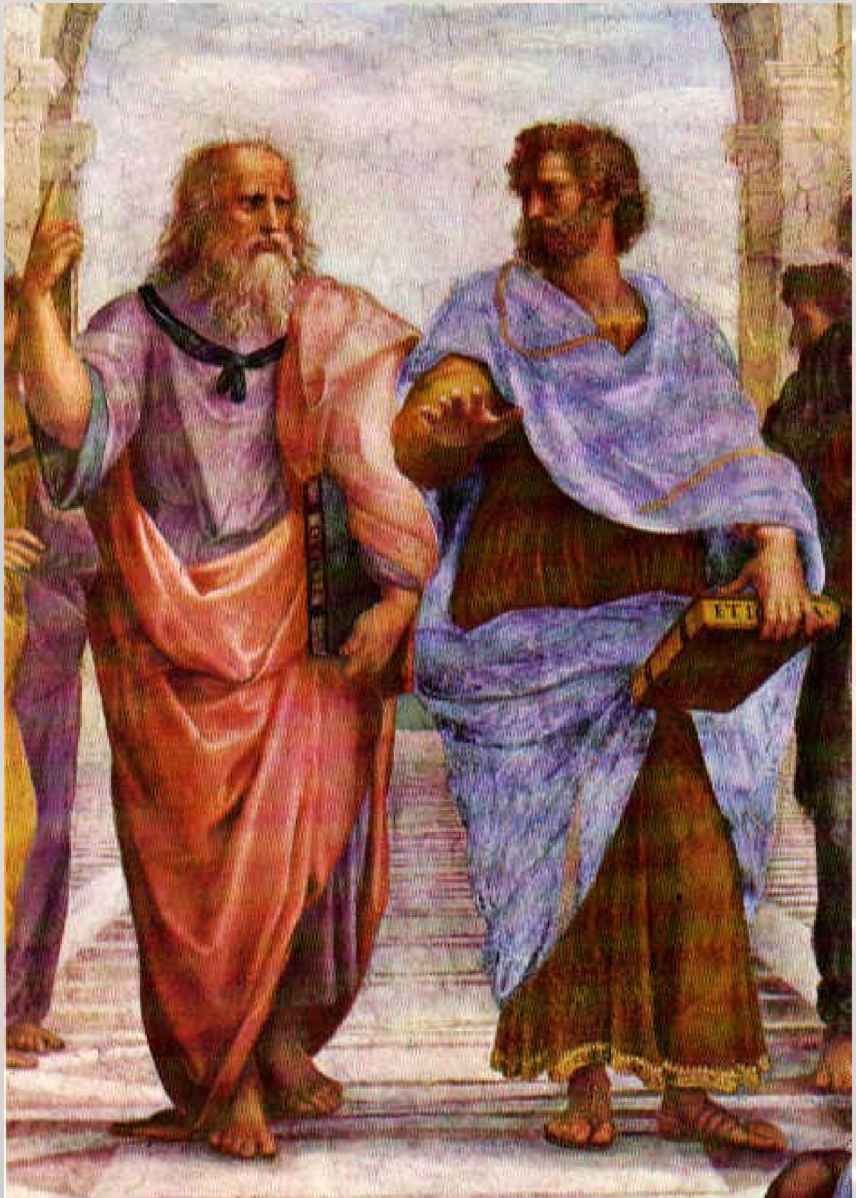
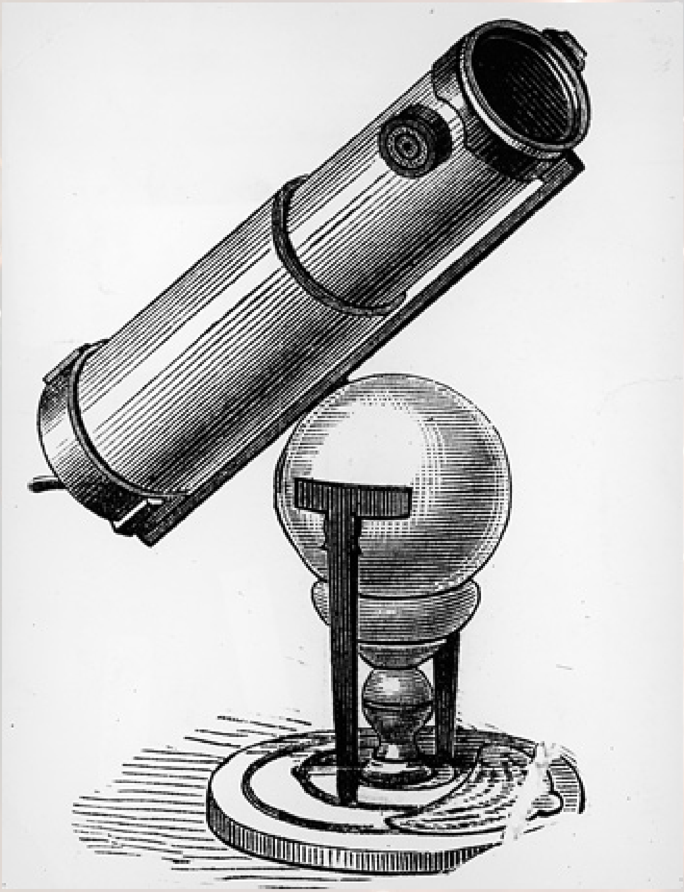
The Fascinating Cosmos



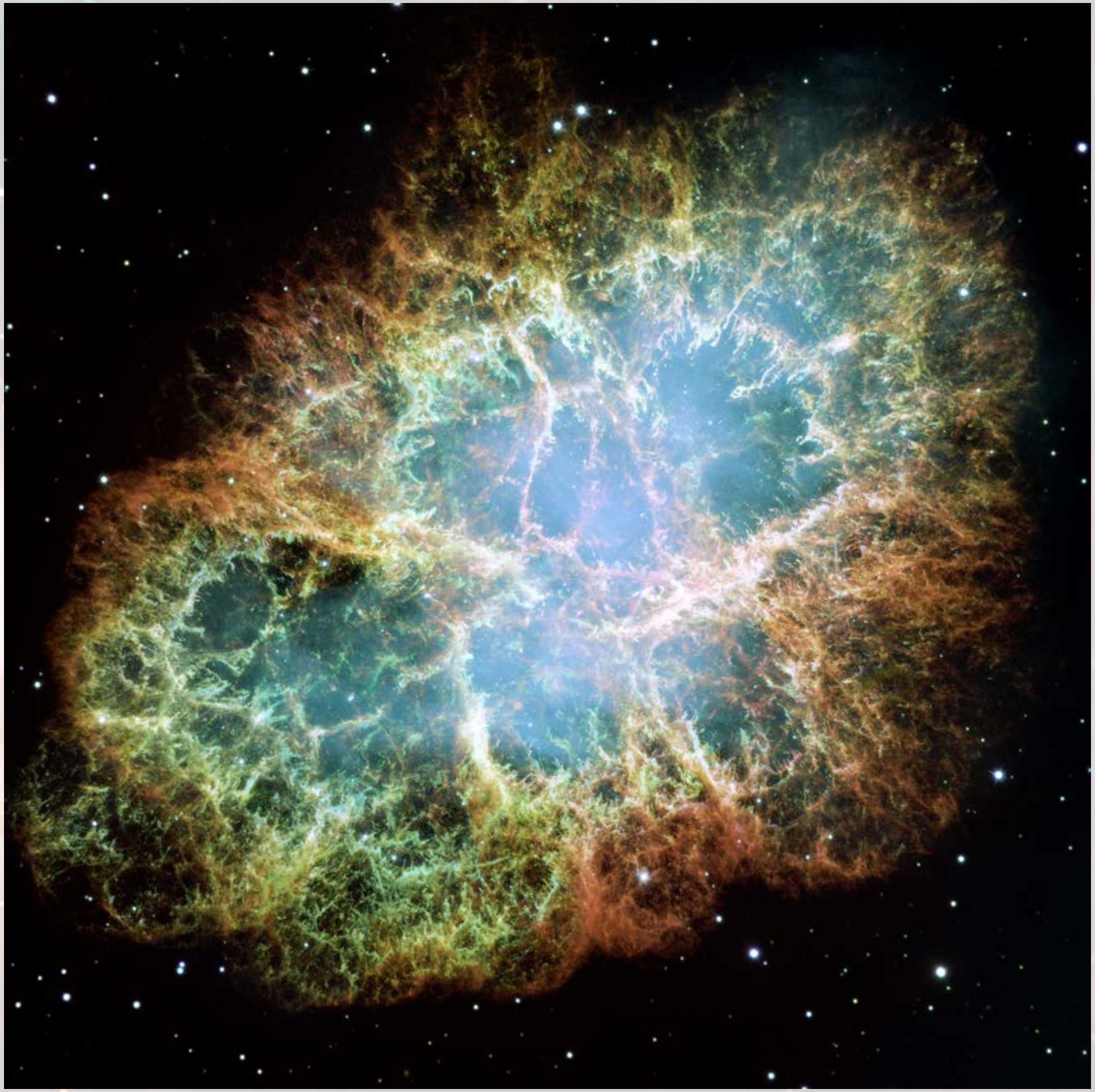
Credit: Zebu.uoregon.edu

Credit: Grant – Celestial Orbs in the Latin Middle Ages

The Fascinating Cosmos



Credit:Hulton Archive/Getty Images



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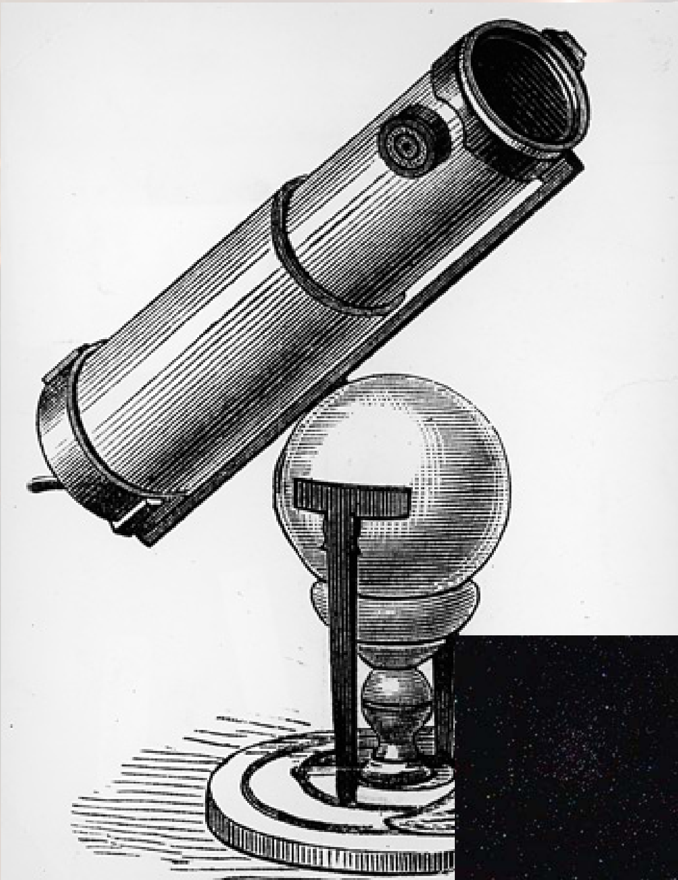

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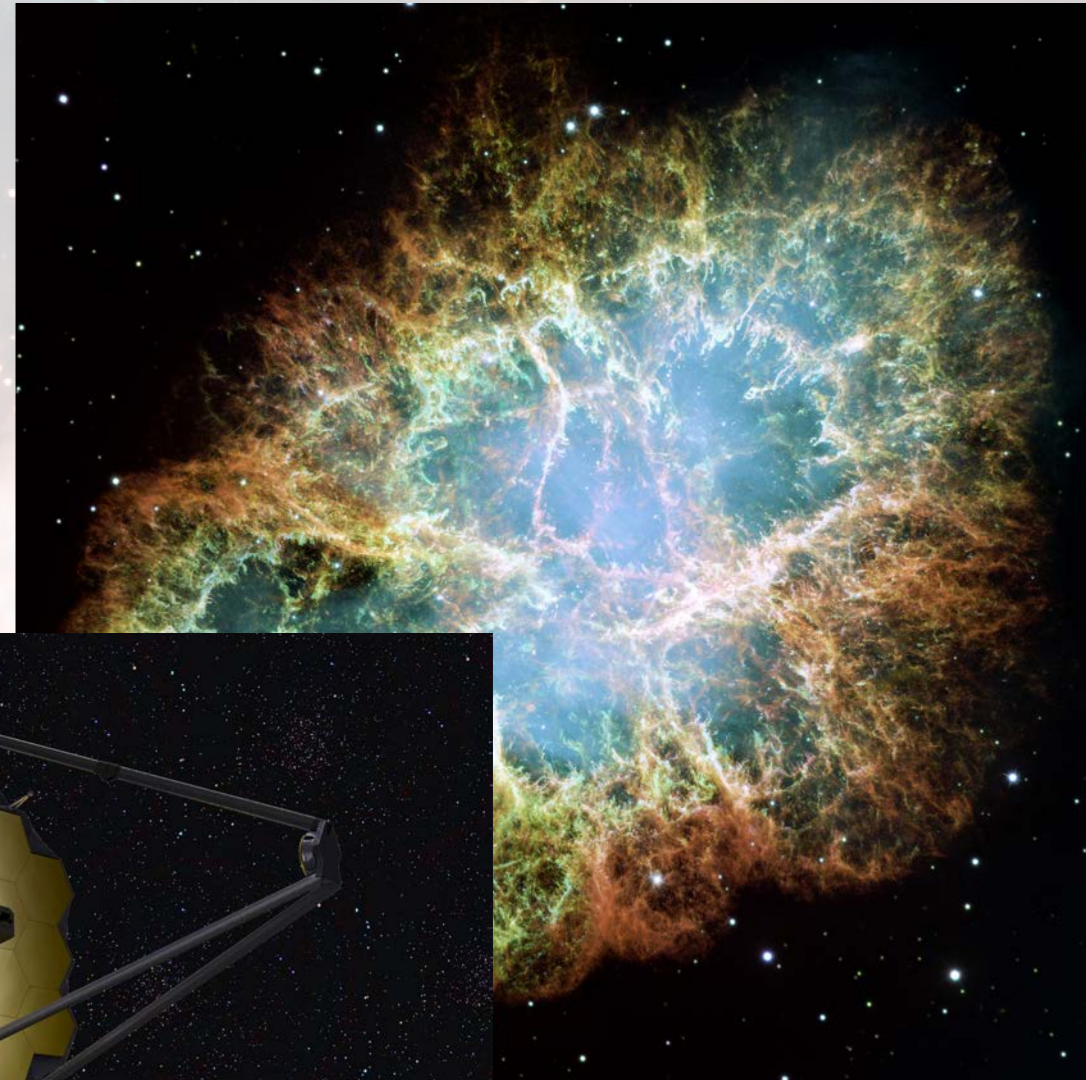

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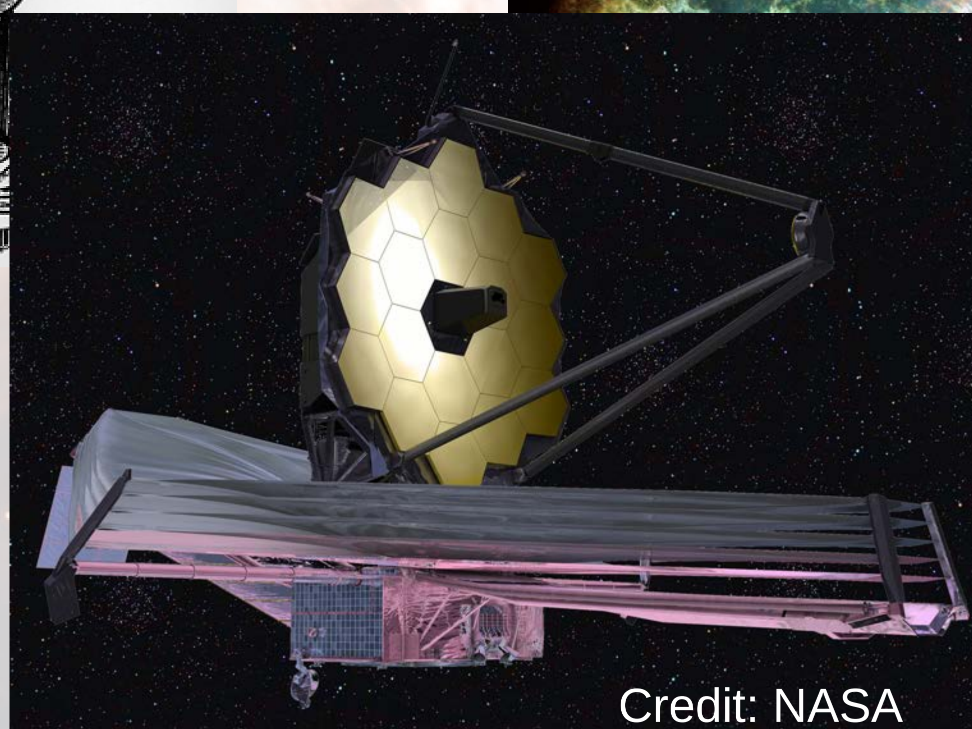

Credit: NASA

Newtonian Gravity

Law of Universal Gravitation: $$F_g = \frac{Gm_1 m_2}{d^2}$$

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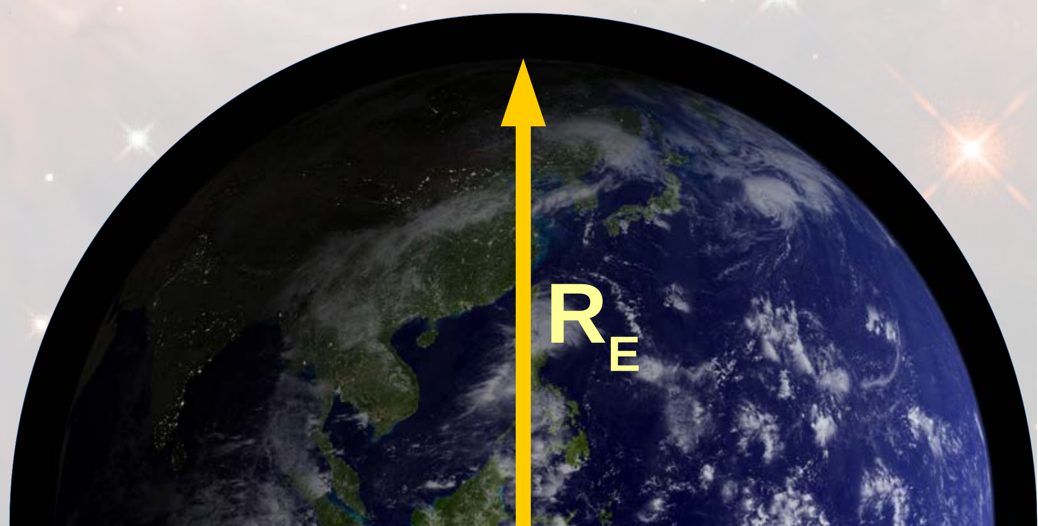

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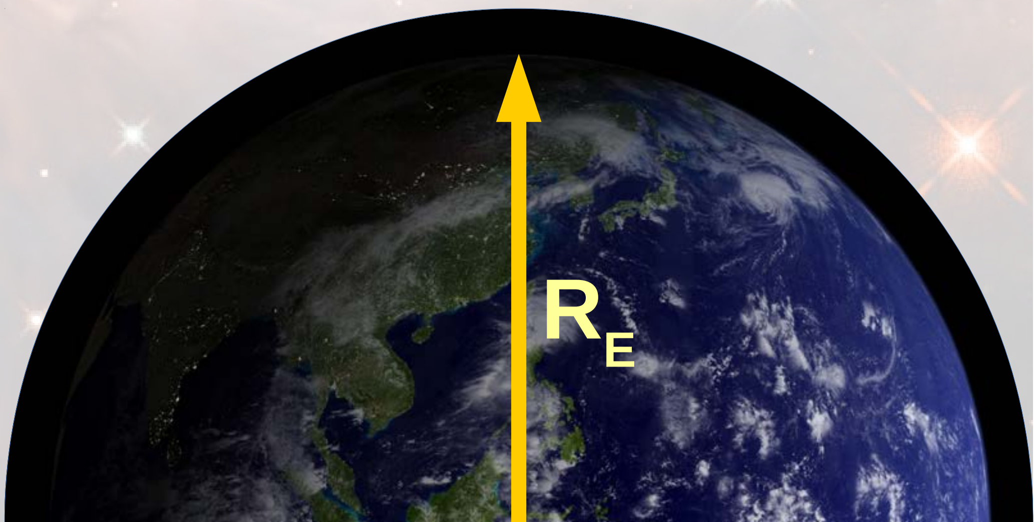
$$F_g = \frac{G M_E}{R_E^2} m = mg$$



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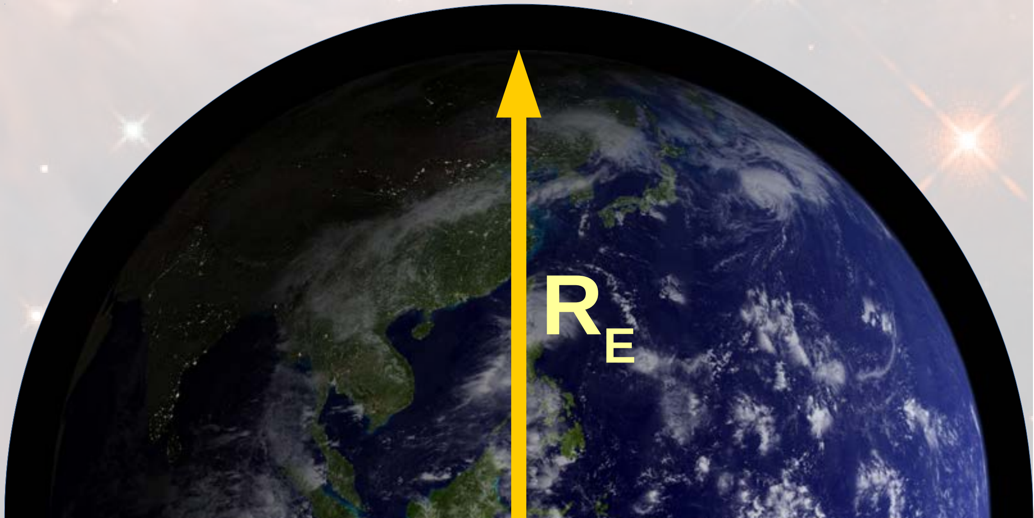

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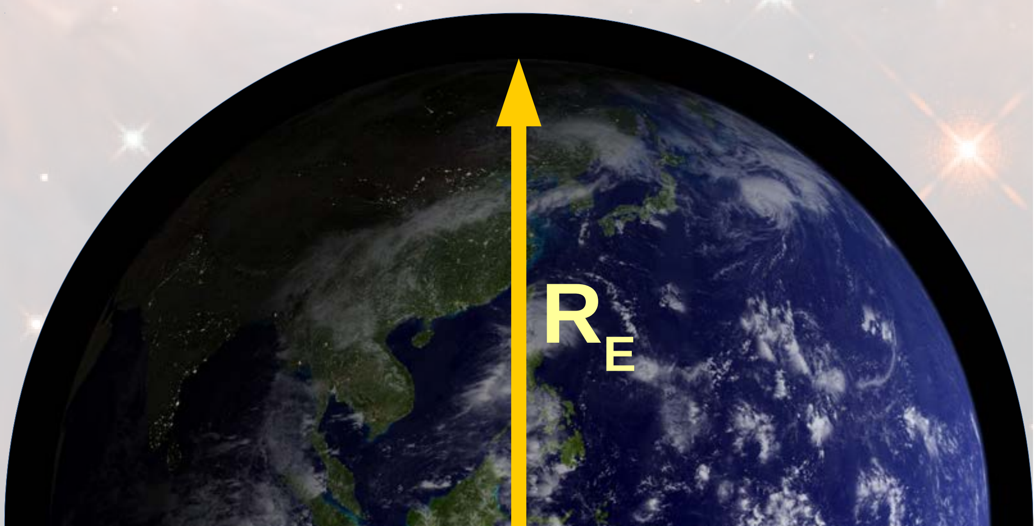

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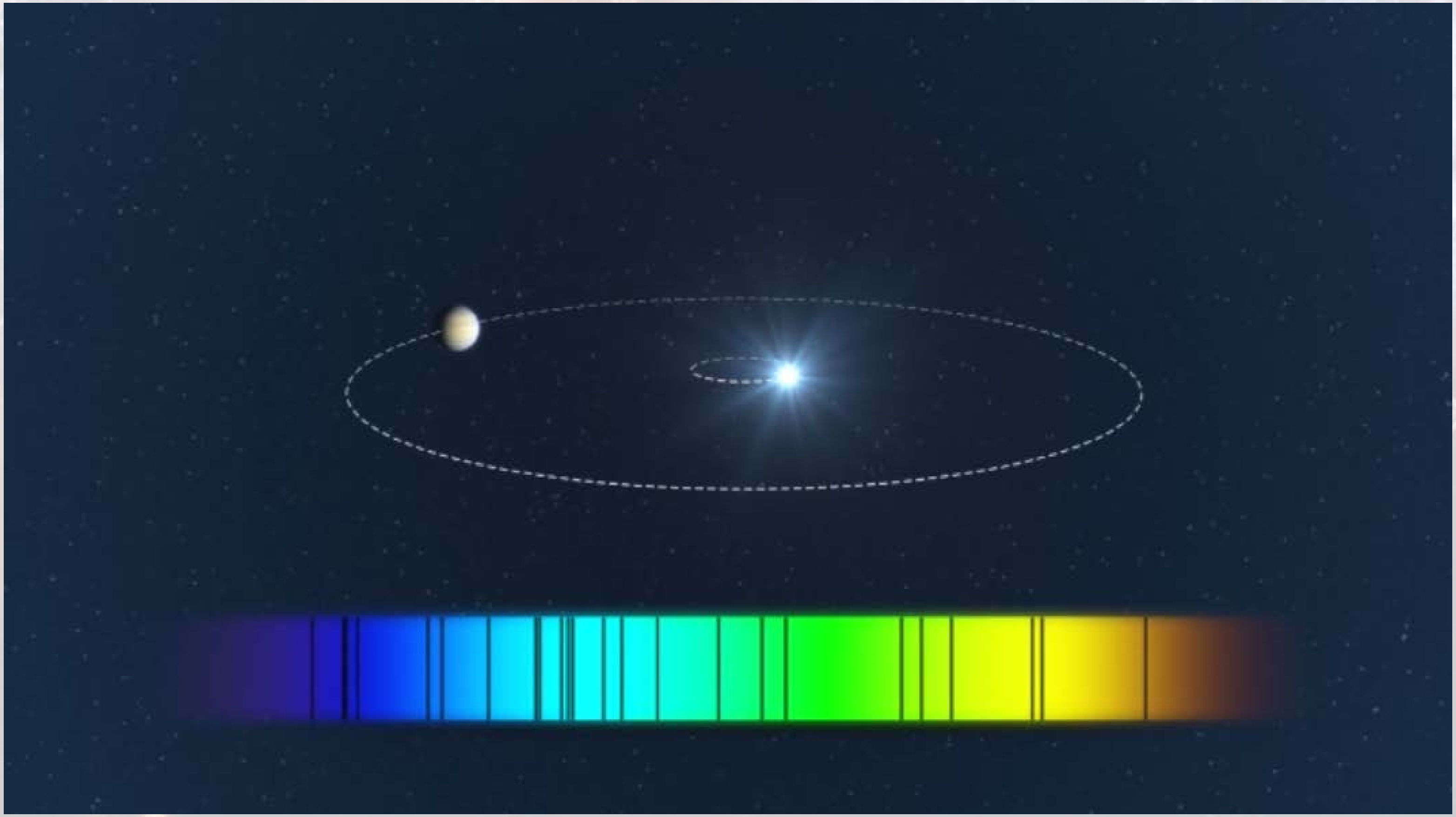

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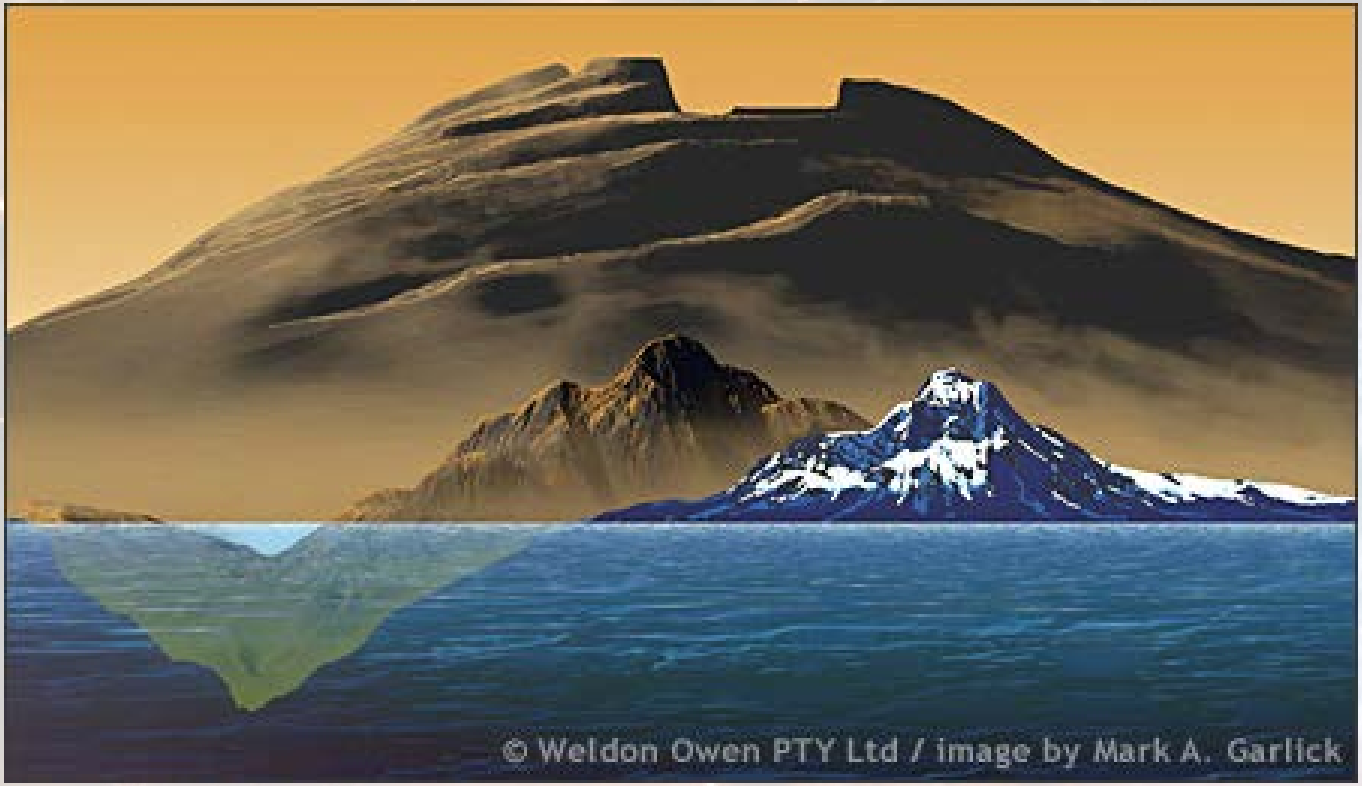
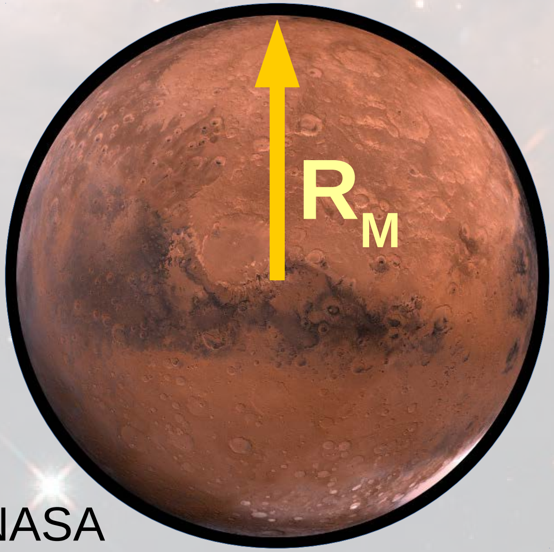




Credit: NASA

Newtonian Gravity

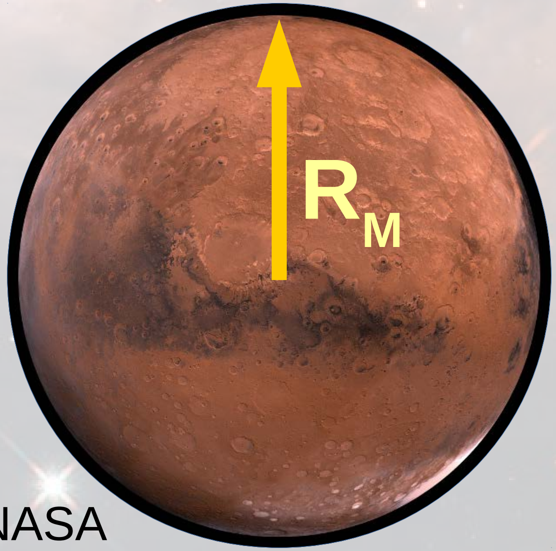
$$g = \frac{GM_{Mars}}{R^2_{Mars}}$$

$$M_{Mars} = 6.42 \times 10^{23}\ kg$$

$$R_{Mars} = 3389.5\ km$$

$$H_{OM} = 21.2km$$

$$G = 6.67 \times 10^{-11}\ m^3 kg^{-1} s^{-2}$$



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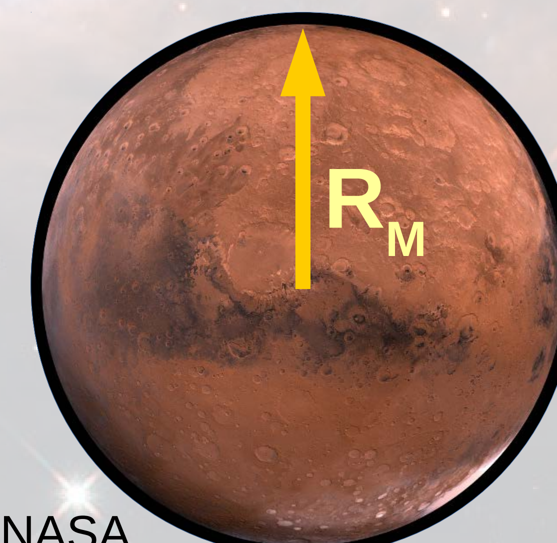

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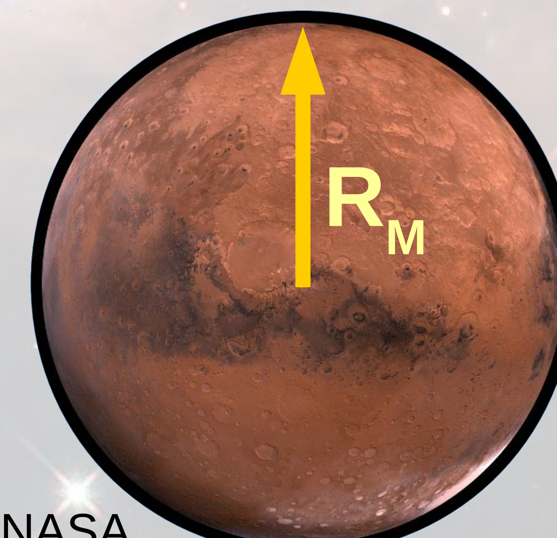
$$g = 3.73\, ms^{-2}$$



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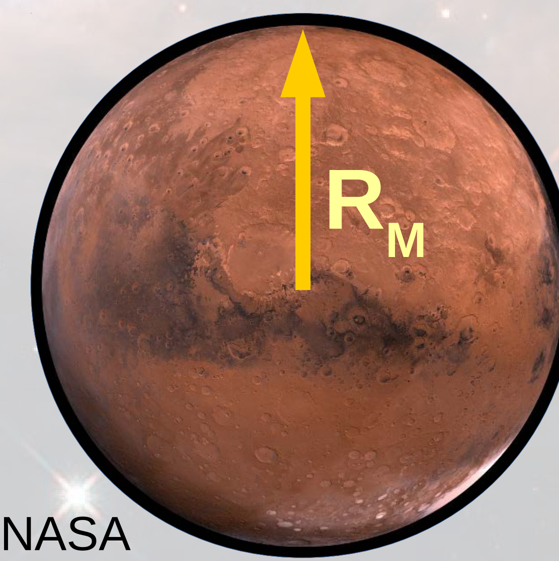
Sanity Check!!



Credit: NASA

Newtonian Gravity

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$$g = \frac{GM_{Mars}}{\left(R_{Mars} + H_{OM}\right)^2}$$

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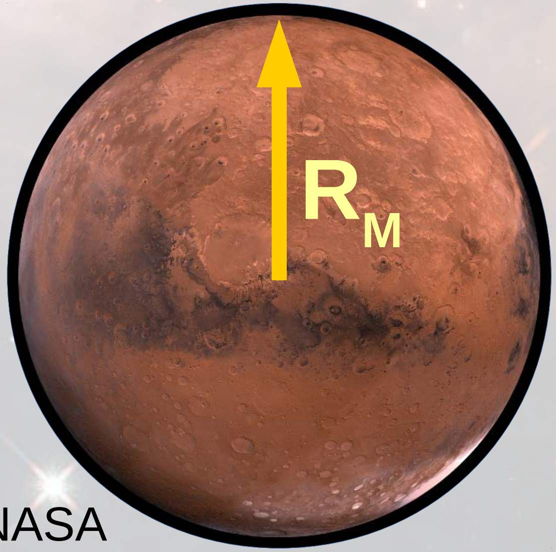

Credit: NASA

Newtonian Gravity

$$g = \frac{GM_{Mars}}{(R_{Mars} + H_{OM})^2}$$

$$g = \frac{6.67 * 10^{-11} * 6.42 * 10^{23}}{(3410.7 * 10^3)^2}$$

$M_{Mars} = 6.42 \text{ x } 10^{23}$ kg

$R_{Mars} = 3389.5$ km

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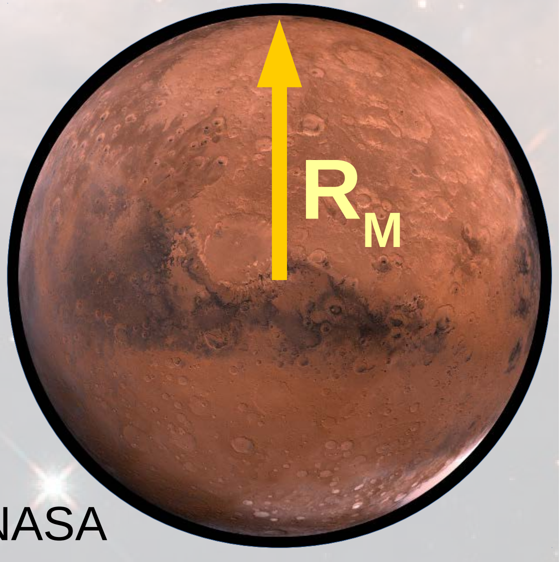
$G = 6.67 \text{ x } 10^{-11} m^3 kg^{-1} s^{-2}$



Credit: NASA

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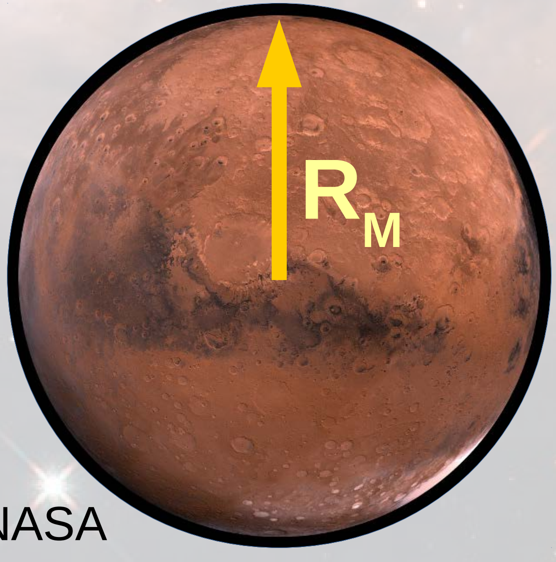

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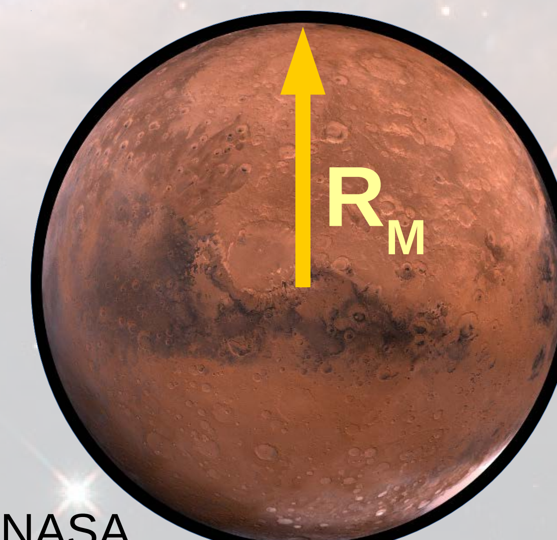
$$\boxed{g = 3.73\, ms^{-2}}$$



Credit: NASA

Significant Figures

$M_{Mars} = 6.42 \text{ x } 10^{23} \text{ kg}$

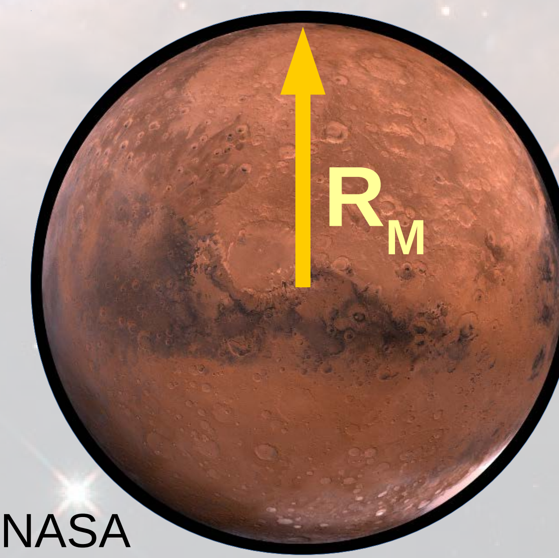
$R_{Mars} = 3389.5 \text{ km} = 3.3895\text{x}10^{3}\text{km}$ (5 sig. figs)

$H_{OM} = 21.2\text{km} = 2.12\text{x}10^{1}\text{km}$ (3 sig. figs)

$G = 6.67 \text{ x } 10^{-11} \text{ m}^{3}\text{kg}^{-1}\text{s}^{-2}$

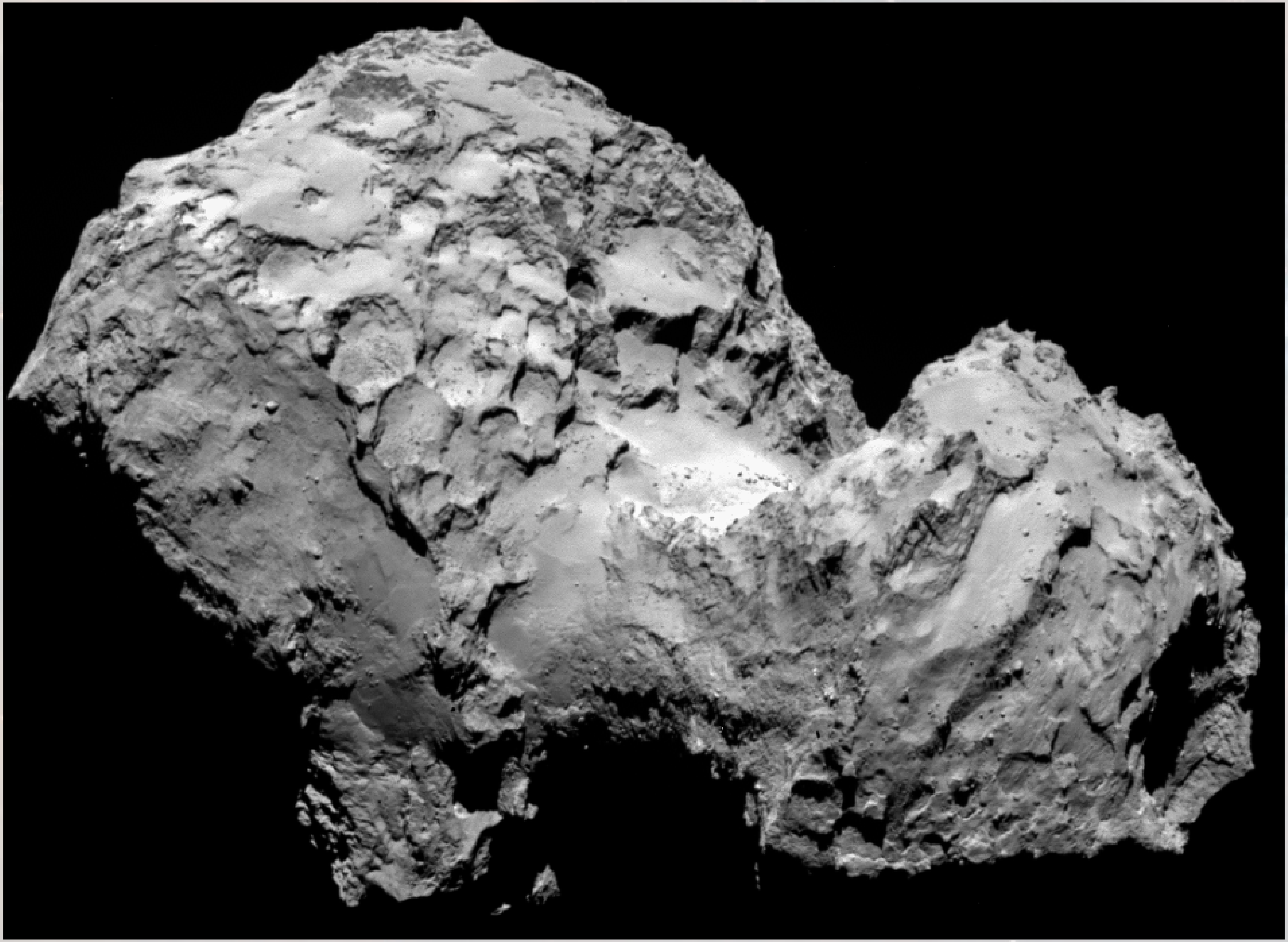
Another example:

$0.061 \text{ m} = \underline{6.1}\text{x}10^{-2} \text{ m}$ (2 sig. figs)



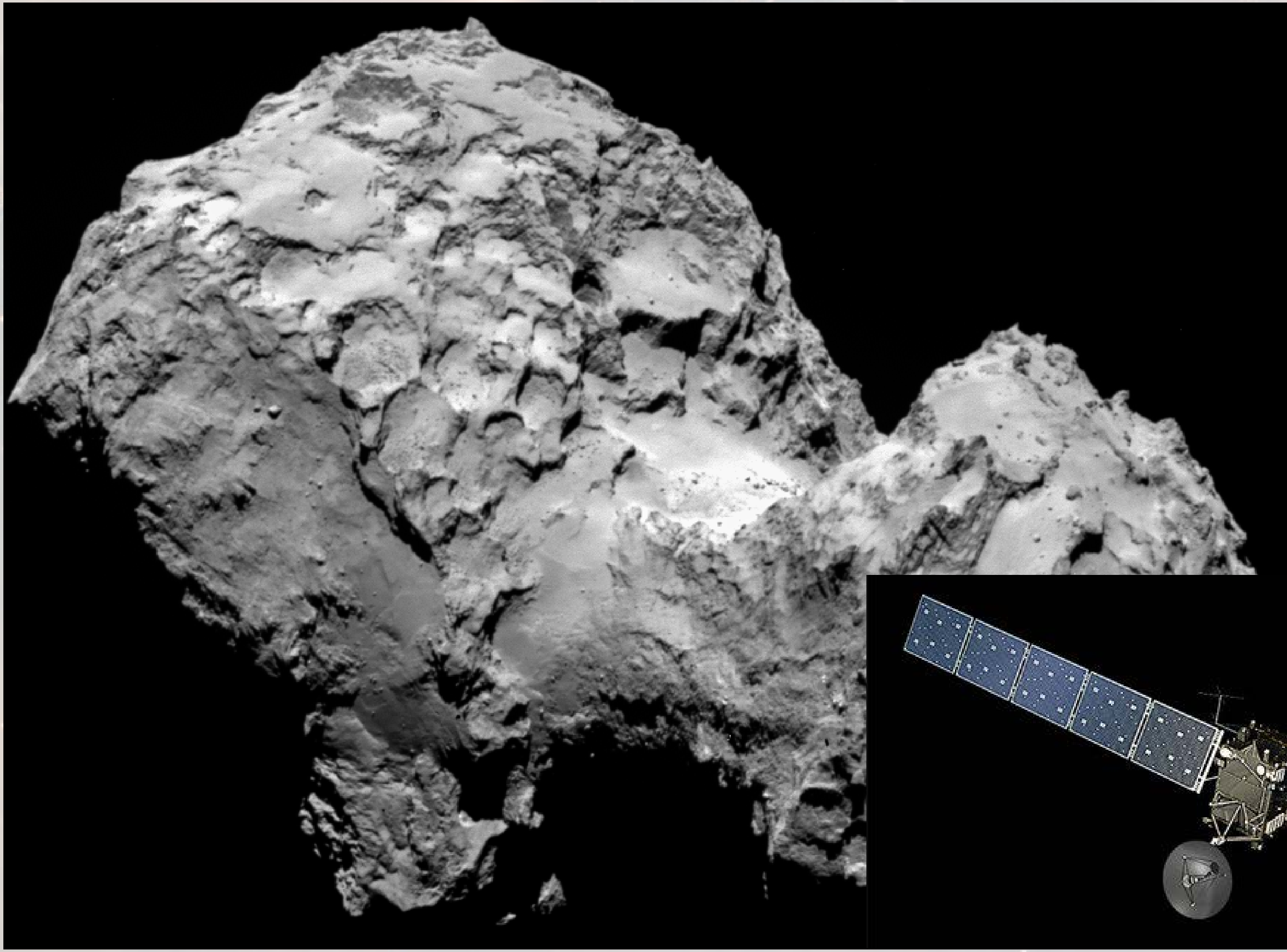
Credit: NASA

Rosetta - 67P



Credit: ESA – Rosetta Mission

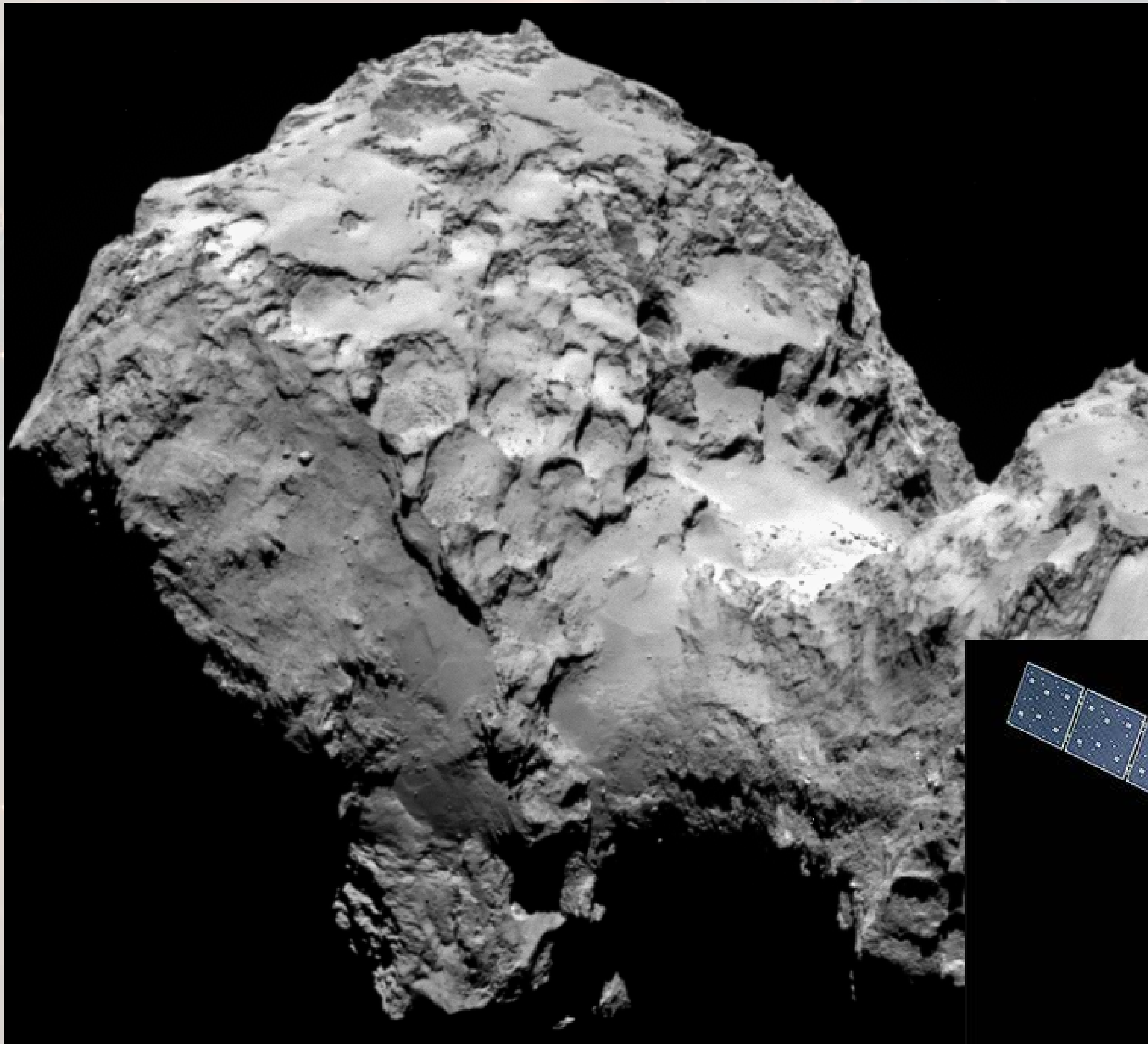
Rosetta - 67P



Credit: ESA – Rosetta Mission

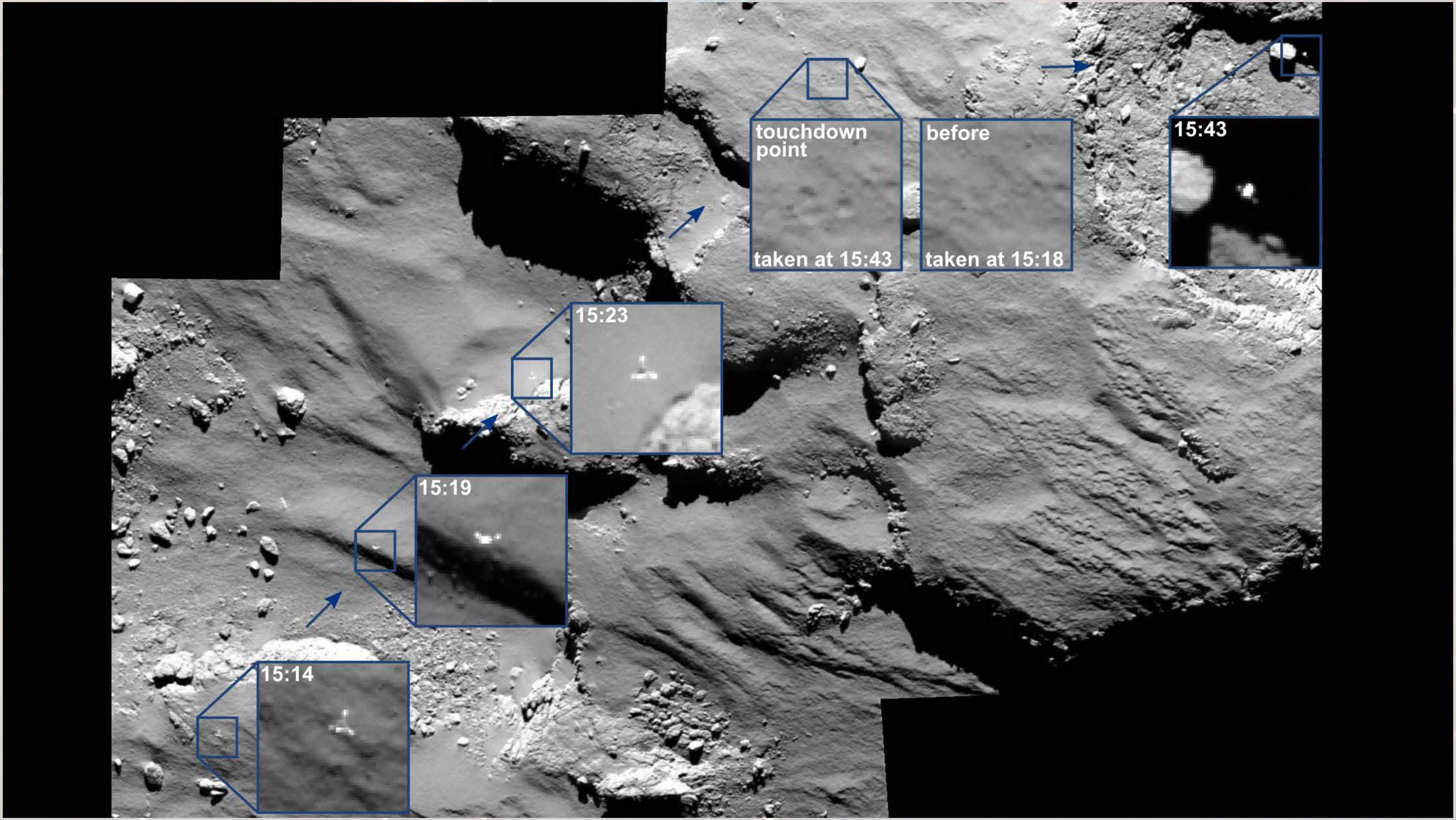
Rosetta - 67P

Credit: Nokia



Credit: ESA – Rosetta Mission

Rosetta - 67P



Credit: ESA – Rosetta Mission

Rosetta - 67P

$\rho = M/V$

$$V = \frac{4\pi R^3}{3}$$

$\rho = 0.4\ g/cm^3$

$M_{67P} = 1x10^{13}\ kg$

$G = 6.67\ x\ 10^{-11}\ m^3 kg^{-1} s^{-2}$

Rosetta - 67P

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$\rho = 0.4\ x\ 10^{-3}\ kg/1x10^{-6}\ m^3$
$= 0.4\ x\ 10^3\ kg/m^3$

Rosetta - 67P

$\rho = M/V$

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$$M = \frac{4\pi R^3 \rho}{3}$$

$$1 x 10^{13} = \frac{4\pi R^3 \rho}{3}$$

$$R = \sqrt[3]{\frac{3 * 1 x 10^{13}}{4\pi * 0.4 x 10^3}} = 2 x 10^3 m$$

$\rho = 0.4\ g/cm^3$

$M_{67P} = 1x10^{13}\ kg$

$G = 6.67\ x\ 10^{-11}\ m^3 kg^{-1} s^{-2}$

$\rho = 0.4\ x\ 10^{-3}\ kg/1x10^{-6}\ m^3$

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Rosetta - 67P

$$g_c = \frac{GM_{67P}}{(R_{67P})^2}$$

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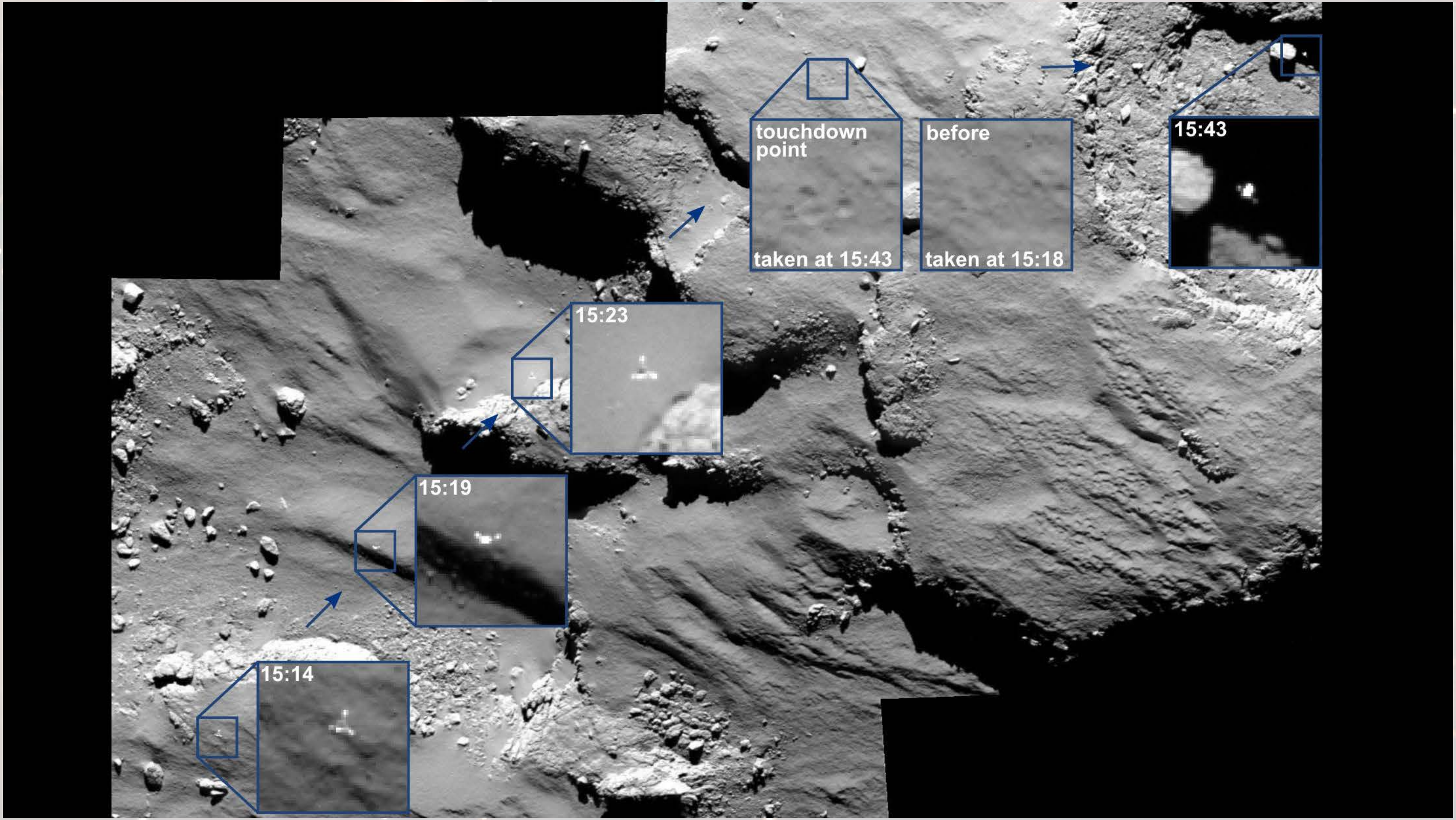
$$g_c = 2\,x\,10^{-4}\, ms^{-2}$$

$$\frac{g_c}{g_E} = \frac{2\,x\,10^{-4}}{9.8} = 2\,x\,10^{-5}$$

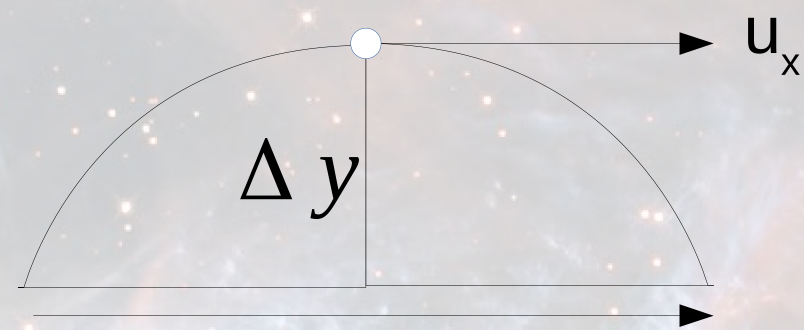
Rosetta - 67P



Credit: ESA – Rosetta Mission

Rosetta – 67P

Double checking with Galileo and Projectile Motion



t_{total} = 2 hrs = 7200 s

$$\Delta y = u_y t + \frac{1}{2} a t^2$$

$$\Delta y = 0 + \frac{1}{2} g_c t^2$$

$$\Delta y = 1\,km$$

$$u_y = 0\ ms^{-1}$$

$$t = 3600\ s$$

Rosetta – 67P

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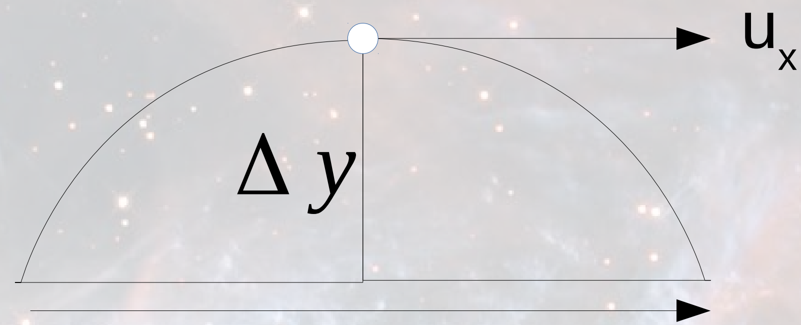

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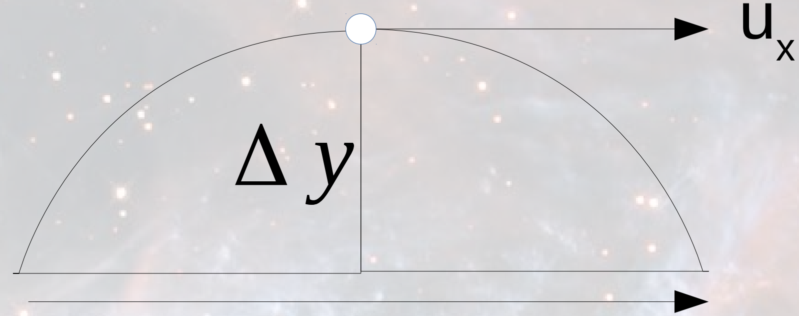

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Rosetta – 67P

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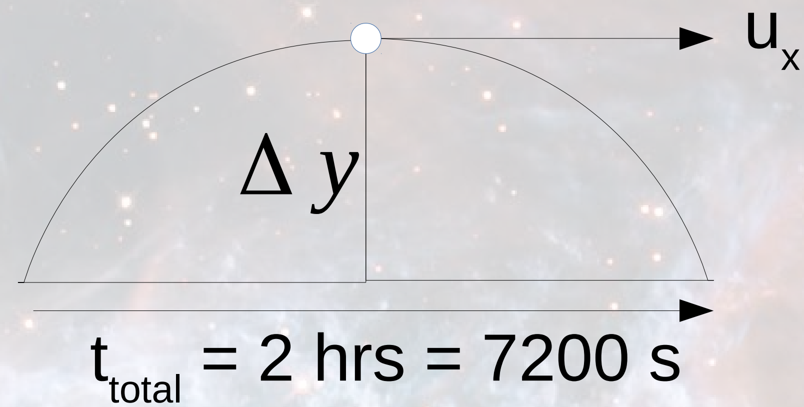

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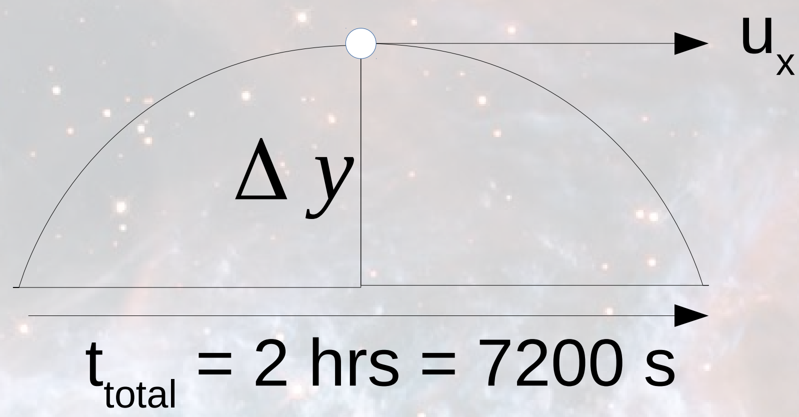

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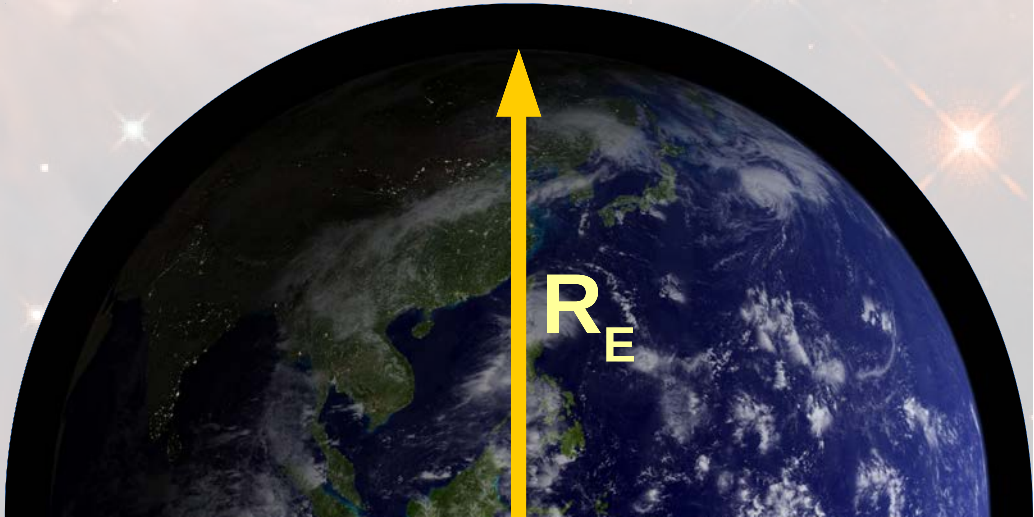
$$\frac{g_c}{g_E} = \frac{2 x 10^{-4}}{9.8} = 2 x 10^{-5}$$

Gravitational Potential Energy

$$W = Fd$$

$$W = F_g d$$

$$W = mgd$$



Credit: NASA

Gravitational Potential Energy

$$E_p = W_{d=\infty \to r}$$

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Gravitational Potential Energy

$$E_p = W_{d=\infty \rightarrow r}$$

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$$W = \frac{GM}{d^2} m\, d$$

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Gravitational Potential Energy

$$E_p = W_{d=\infty \rightarrow r}$$

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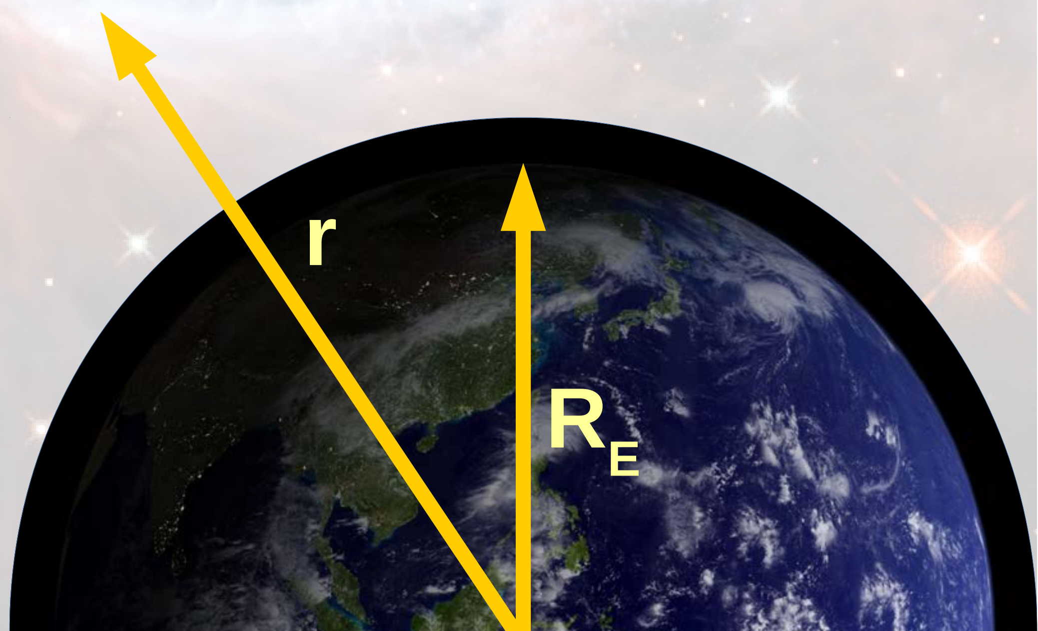
$$W = \frac{GM}{d^2} m\, d$$

$$E_p = 0 - \frac{GM}{r^2} m\, r$$



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Gravitational Potential Energy

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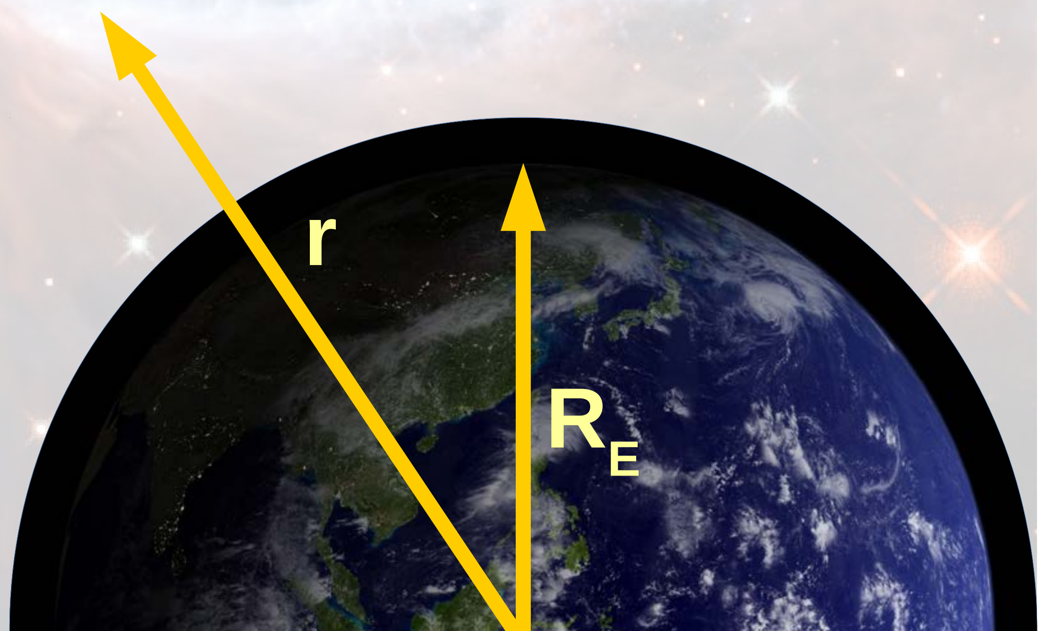
$$E_p = 0 - \frac{GM}{r^2} m\, r$$

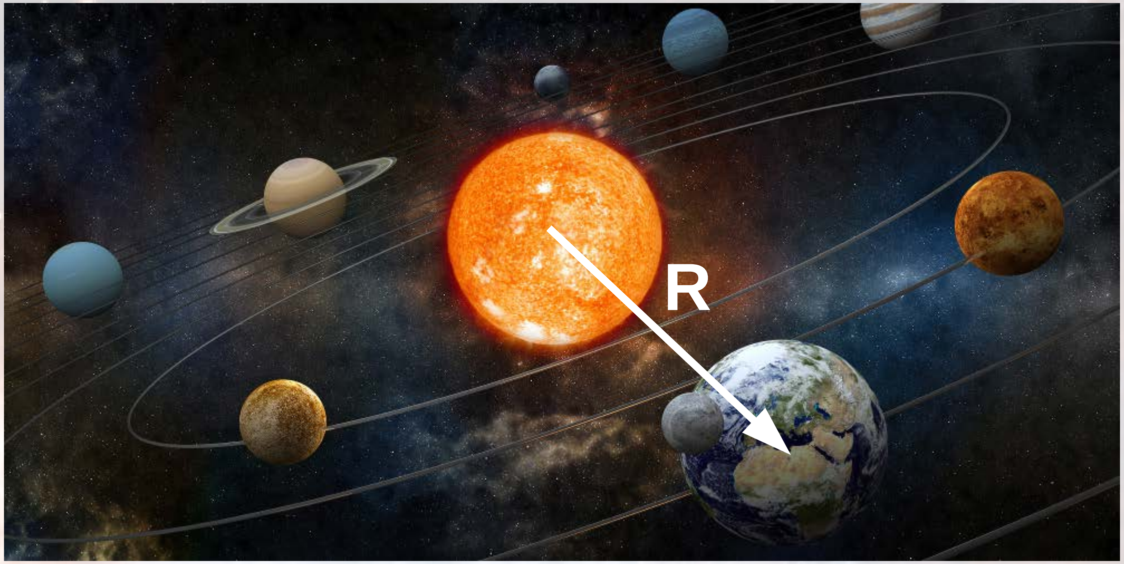
$$E_p = -\frac{GM}{r} m$$



Credit: NASA

Gravitational Potential Energy

$$E_p = -\frac{GM_\odot}{R} M_E$$



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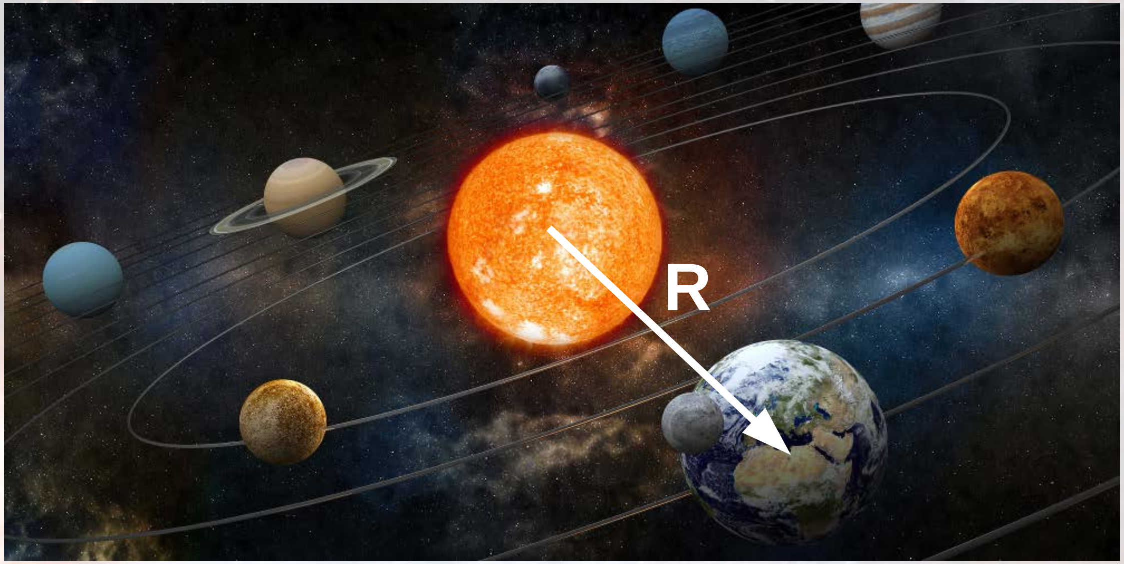
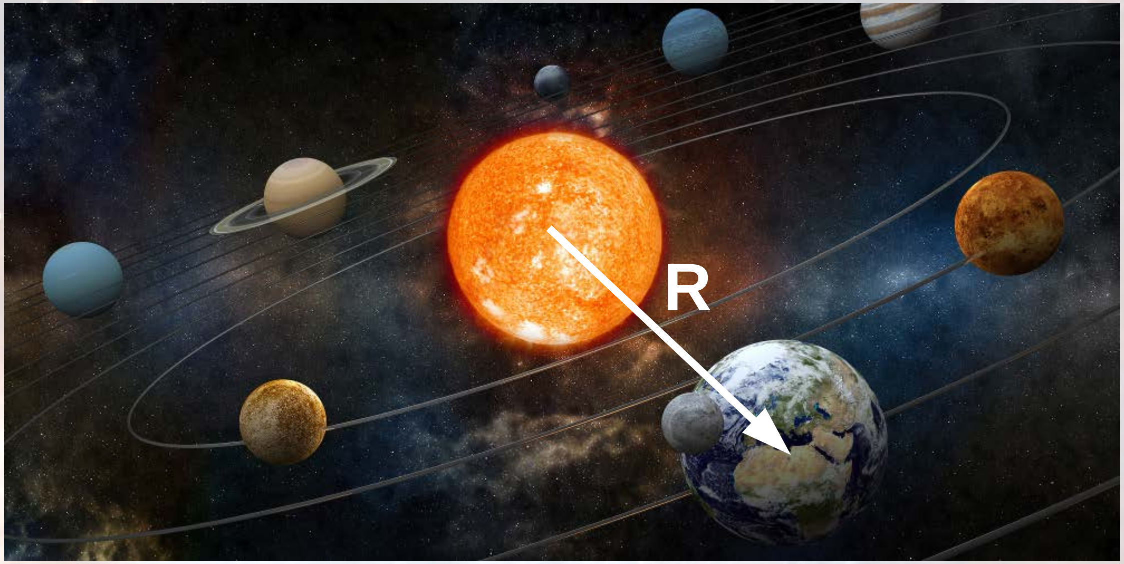


$$M_{\odot} = 1.989 \, x \, 10^{30} \, kg$$
$$M_E = 5.97 \, x \, 10^{24} \, kg$$
$$R = 1.5 \, x \, 10^{8} \, km$$

Gravitational Potential Energy

$$E_p = -\frac{GM_\odot}{R} M_E$$



$$M_\odot = 1.989\,x\,10^{30}\,kg$$
$$M_E = 5.97\,x\,10^{24}\,kg$$
$$R = 1.5\,x\,10^{8}\,km$$

$$E_p = -5.28\,x\,10^{33}\,J$$

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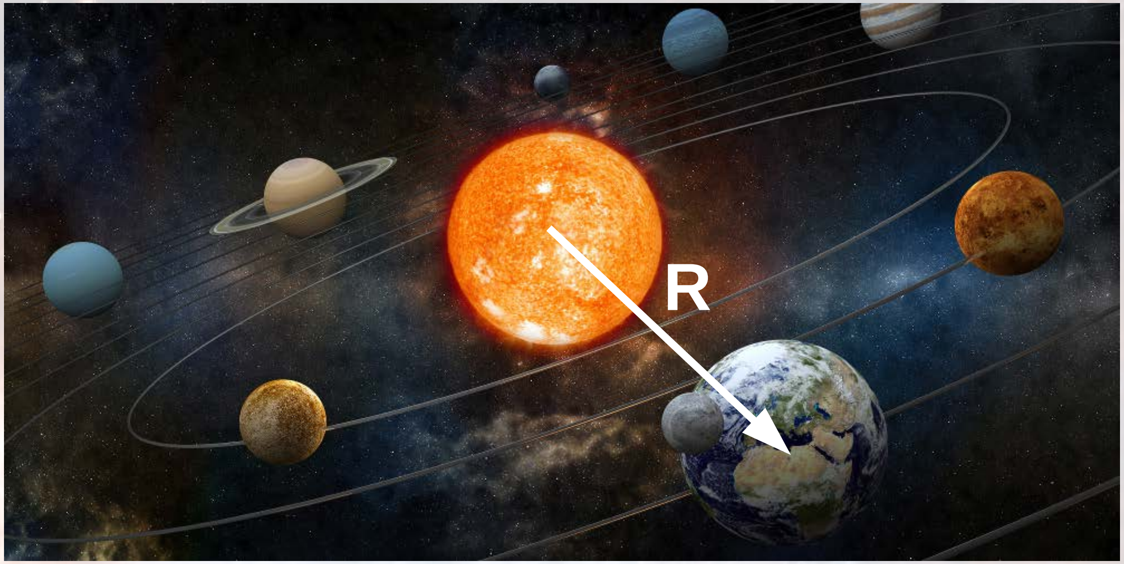

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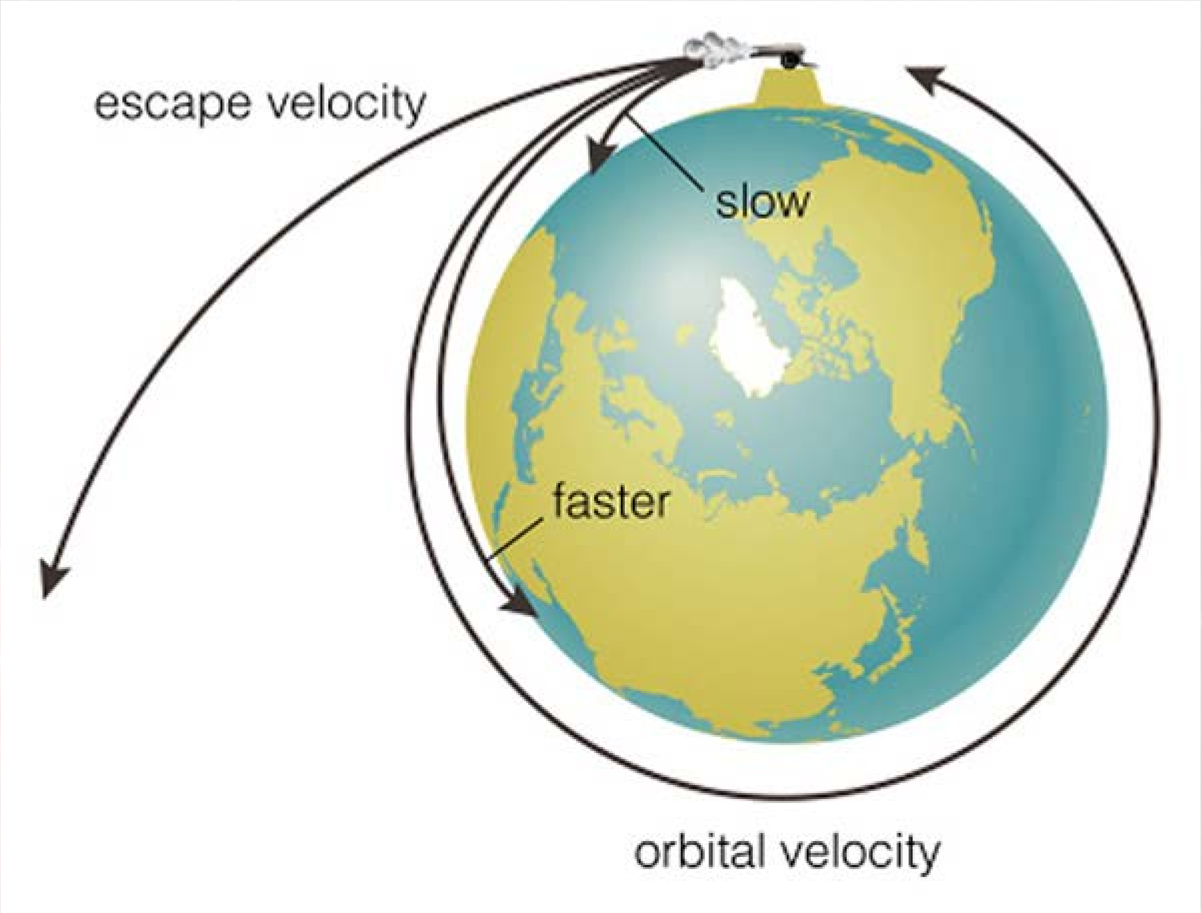
$$E_p = -5.28 \, x \, 10^{33} \, J$$

Equivalent to setting off every nuke on Earth every second for 250 000 years or the energy released from the surface of the Sun in 160 days.

Rocket Science!

To reach orbit:

$$KE = E_p$$



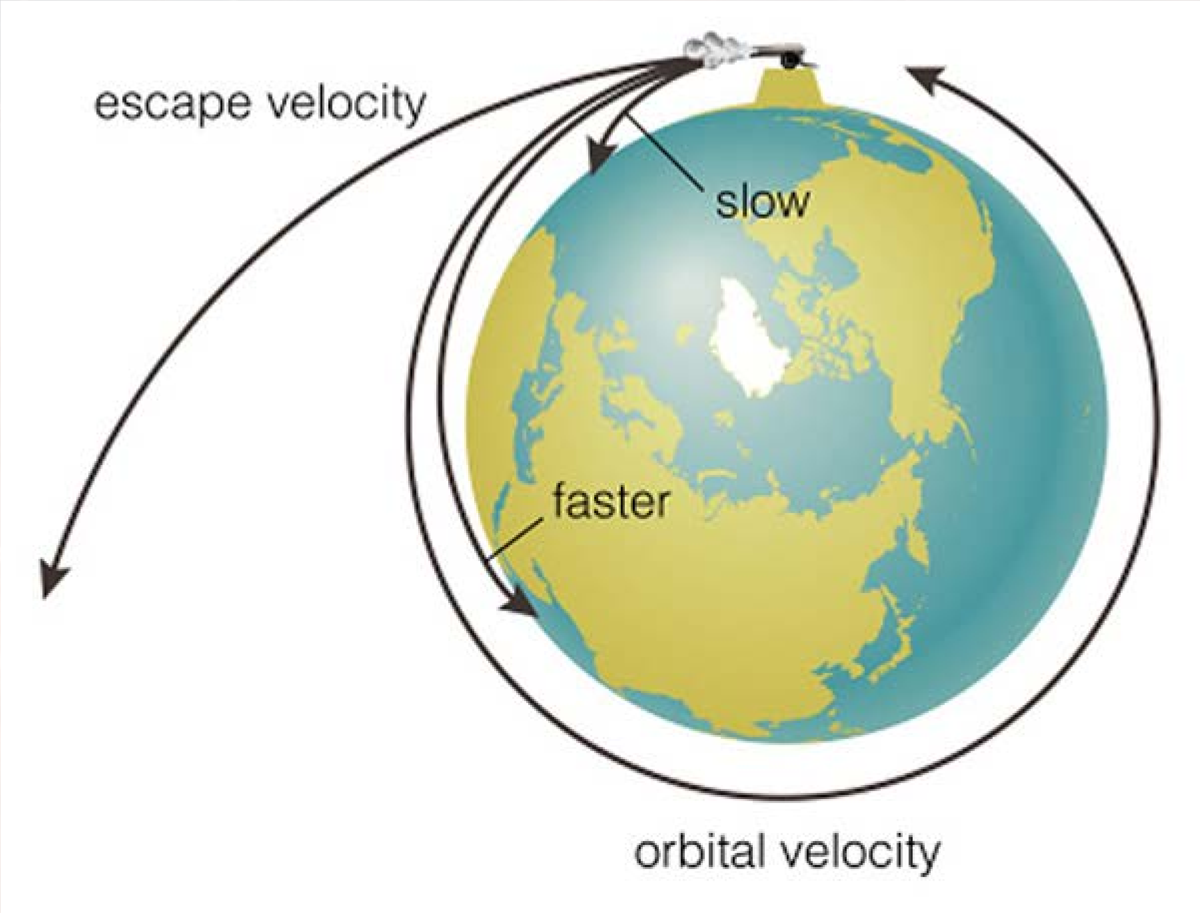
Credit: ustudy.in

Rocket Science!

To reach orbit:

$$KE = E_p$$

$$\frac{mv^2}{2} = \frac{GMm}{r}$$



Credit: ustudy.in

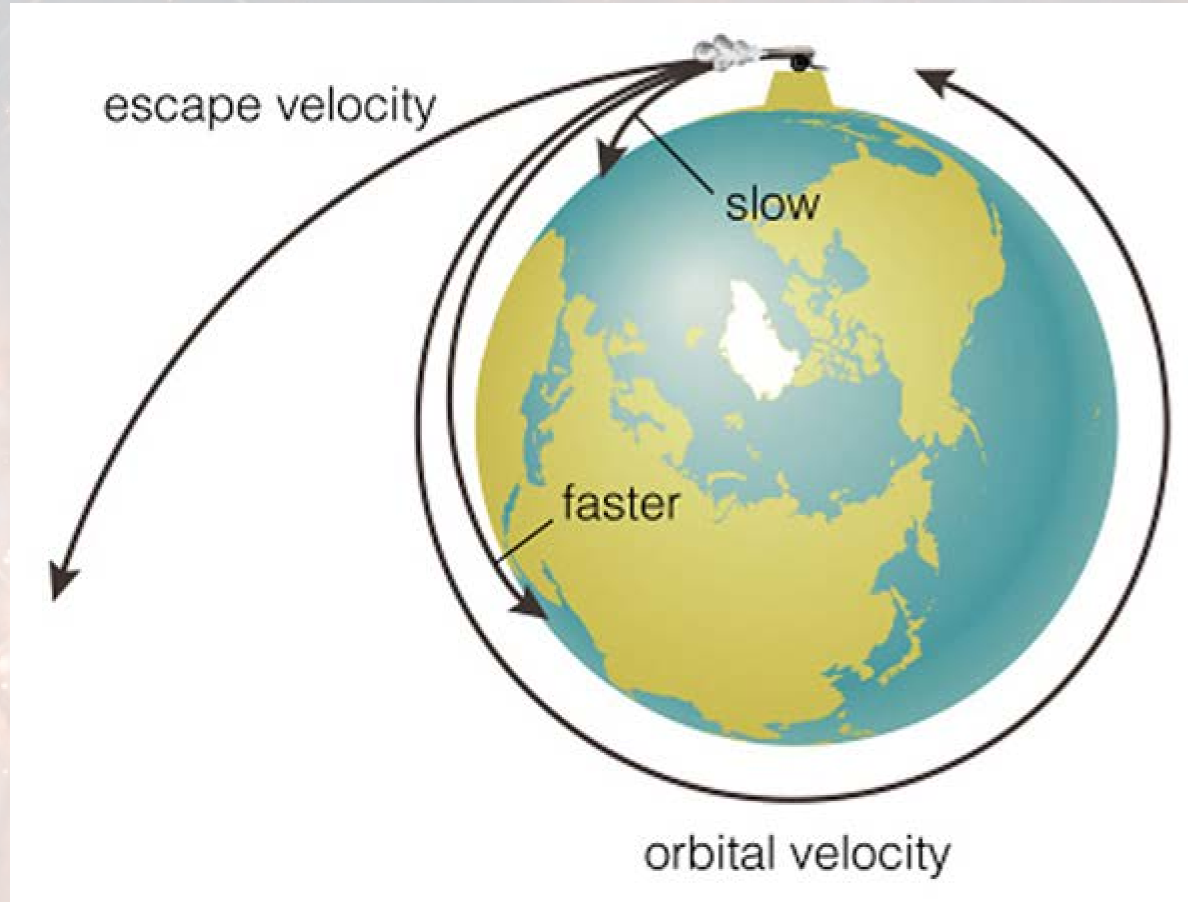
Rocket Science!

To reach orbit:

$$KE = E_p$$

$$\frac{mv^2}{2} = \frac{GMm}{r}$$

$$v_{orb} = \sqrt{\frac{2GM}{r}}$$



Credit: ustudy.in

Rocket Science!

To reach escape velocity:

$$KE \geq E_p$$

Credit: hdwallpapers.in

Rocket Science!

To reach escape velocity:

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Rocket Science!

To reach escape velocity:

$$KE \geq E_p$$

$$\frac{mv^2}{2} \geq \frac{GMm}{r}$$

$$v_{esc} \geq \sqrt{\frac{2GM}{r}}$$

Credit: hdwallpapers.in

Rocket Science!

To reach escape velocity:

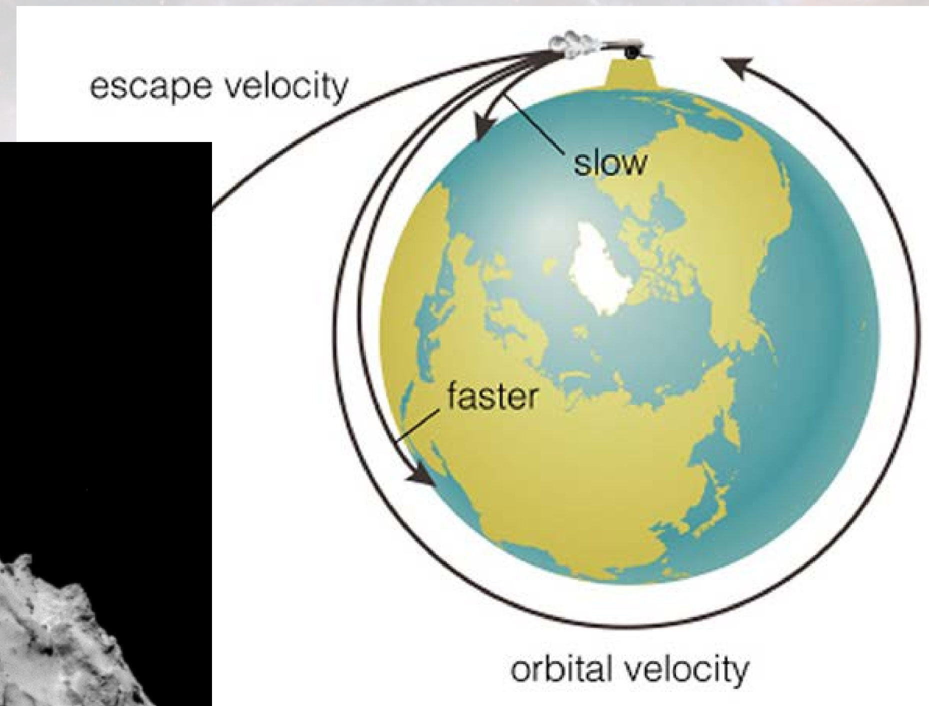
$$KE \geq E_p$$

$$\frac{mv^2}{2} \geq \frac{GMm}{r}$$

$$v_{esc} \geq \sqrt{\frac{2GM}{r}}$$

$$v_{esc} \geq \sqrt{\frac{2GM_{\odot}}{R_{1\,AU}}} \geq 42000\,ms^{-1}$$

Credit: hdwallpapers.in



escape velocity
slow
faster
orbital velocity