April 23, Week 14

Today: Chapter 13, Newton's Law of Gravity

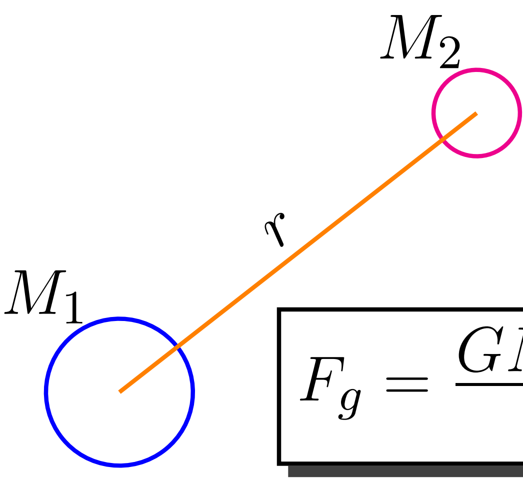
Homework #10 - Due Today at 11:59pm
Mastering Physics: 7 questions from chapter 10.
Written Question: 10.86

Exam #5, Friday, April 27
On Chapters 9 and 10

Review Session: Thursday, April 26, 7:30PM, Room 114 of Regener Hall.

Practice Exam on Website.

Review



$$\boxed{F_g = \frac{GM_1M_2}{r^2}}$$

M_1 - Mass of first object

M_2 - Mass of second object

r - separation distance,
center-to-center for spherical objects

Universal Gravitational Constant:
$G = 6.67 \times 10^{-11}\, N \cdot m^2/kg^2$

Direction

The gravitational force is an “attractive" force $\Rightarrow$ each object feels a force towards the other.

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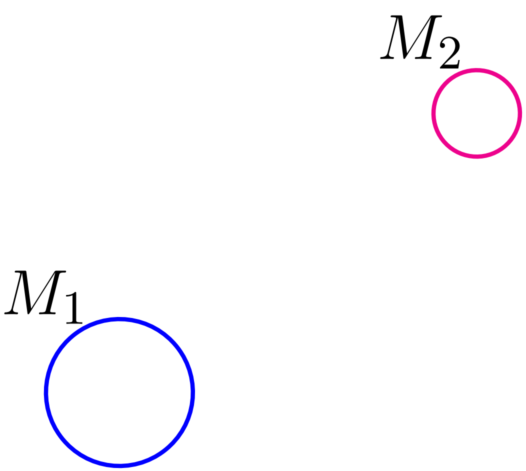

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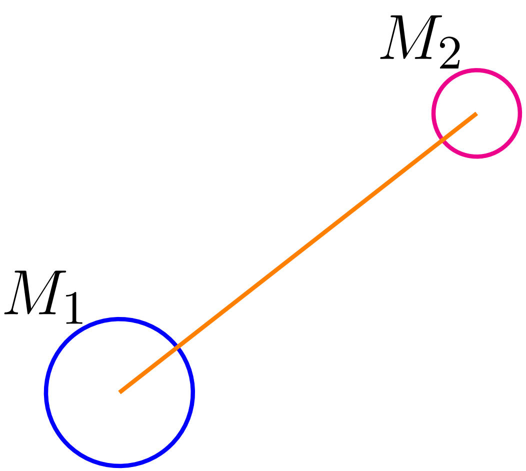

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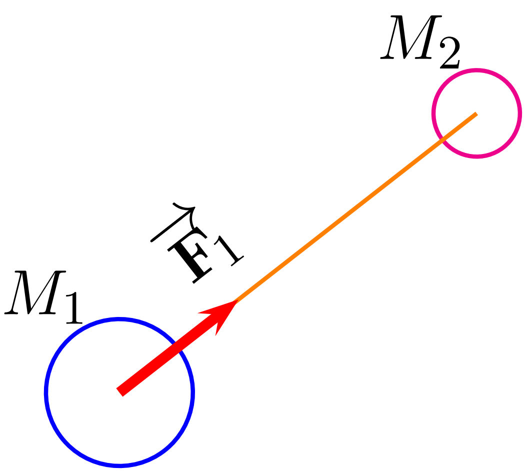
$\overrightarrow{\mathbf{F}}_1$ - Force on 1 due to 2



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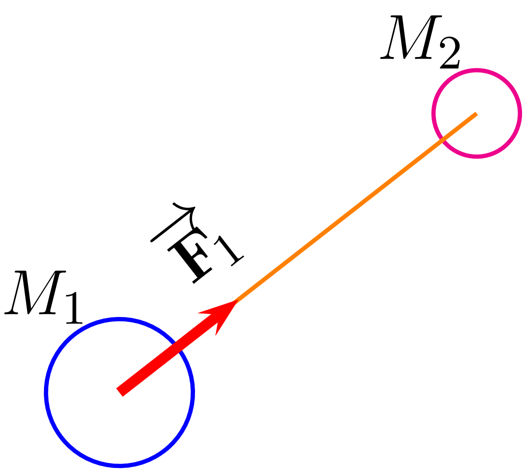

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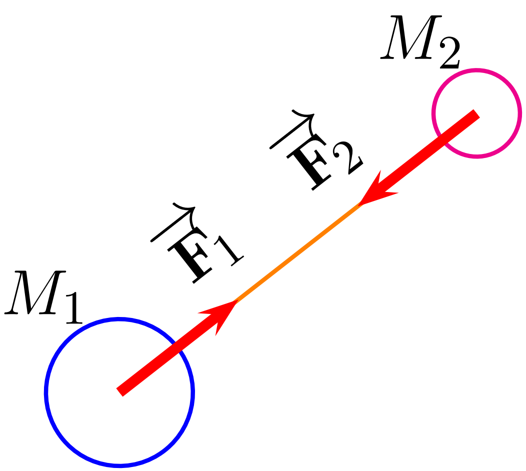

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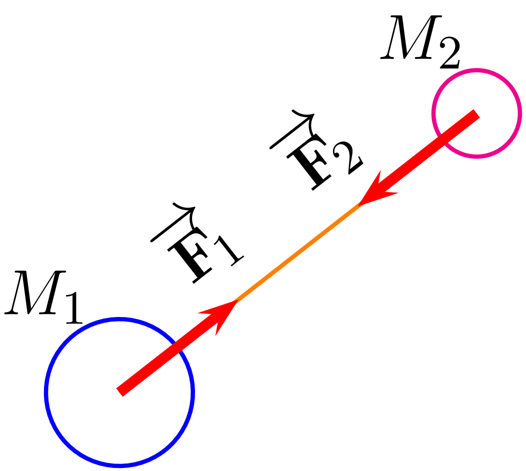

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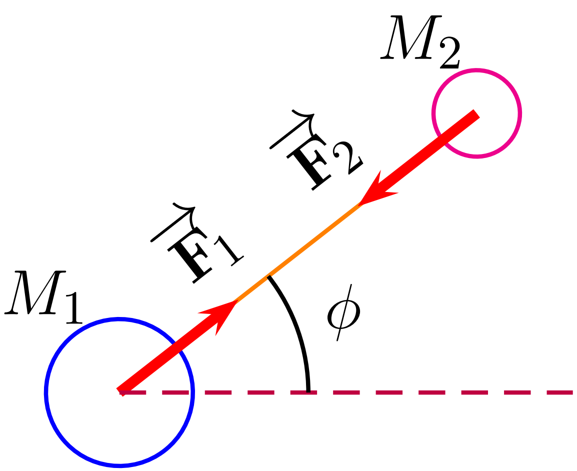

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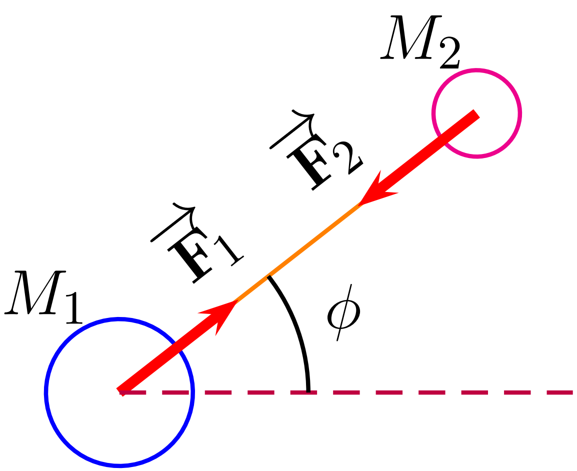

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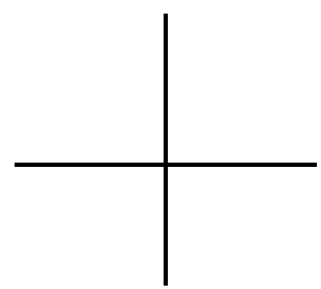
f. b. d. for M_1



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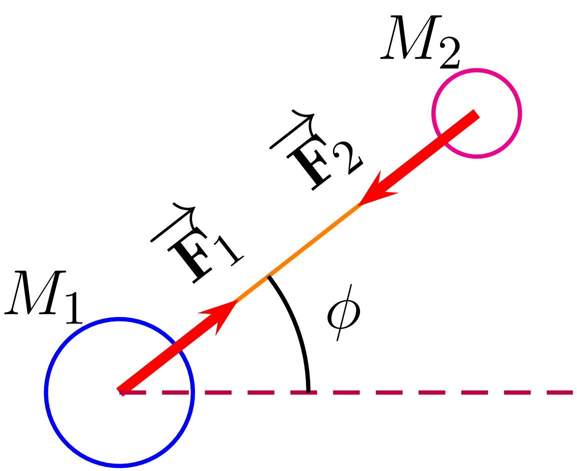

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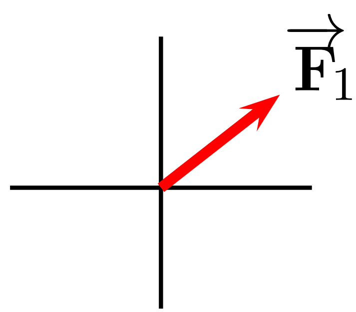

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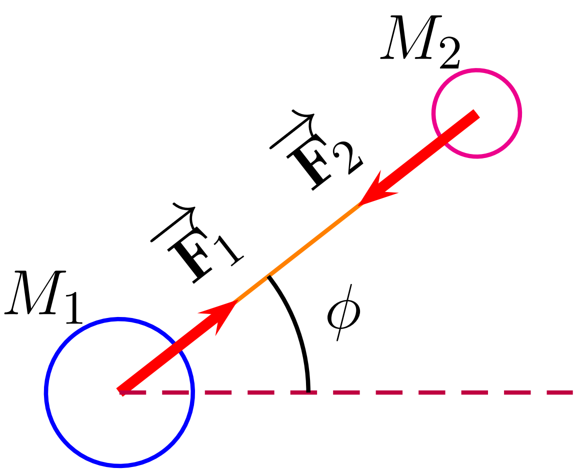

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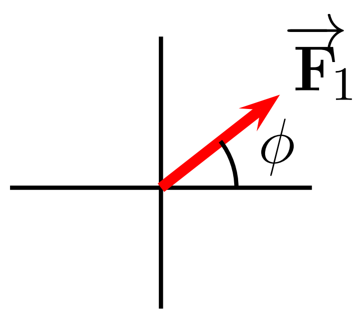
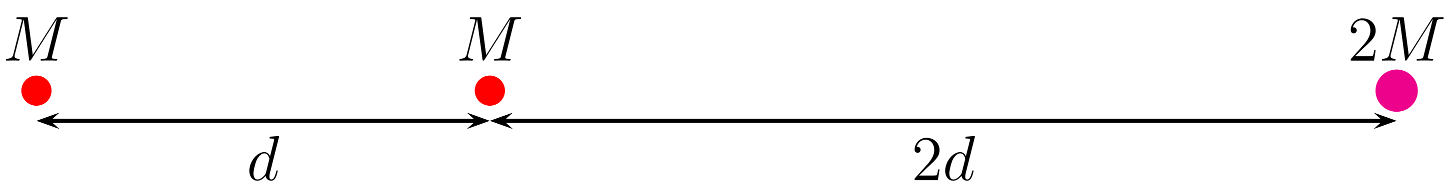


Clicker Quiz

Three masses are arranged in a line with the distance between the second and third double that of the distance between the first and second. If the third mass is twice as large as the other two, what direction is the net gravitational force acting on the middle mass?



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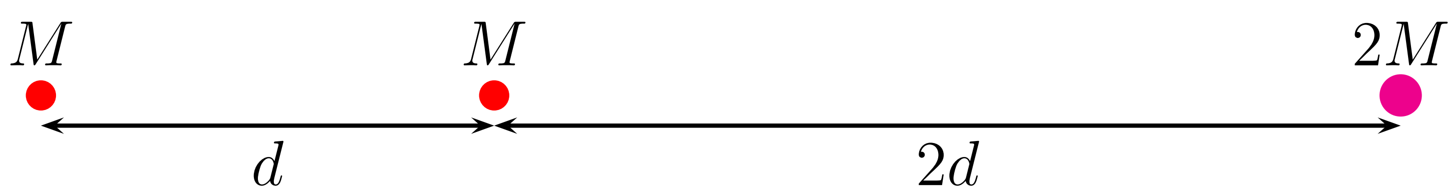

(a) Left

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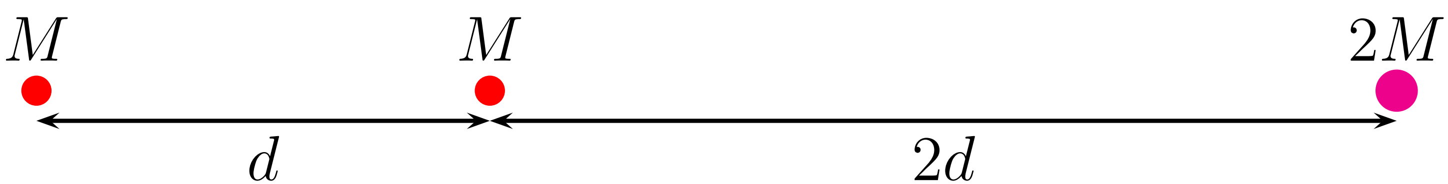

(a) Left (b) Right

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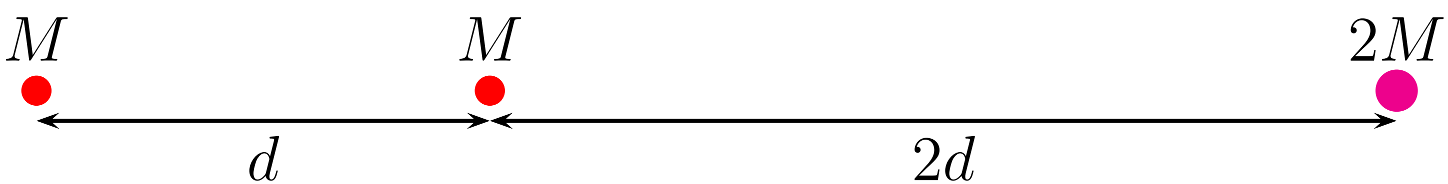

(a) Left (b) Right

(c) Up

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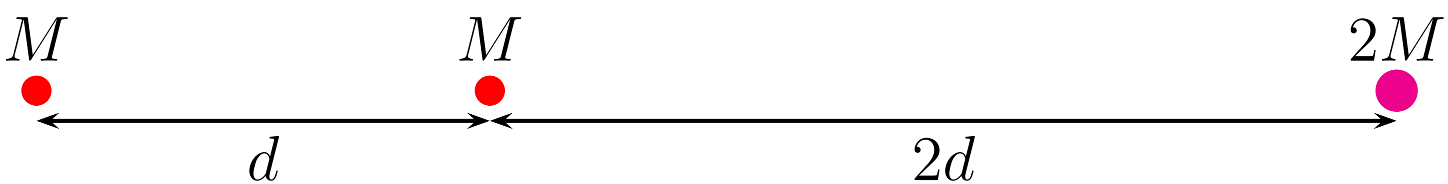

(a) Left (b) Right

(c) Up (d) The net force is zero

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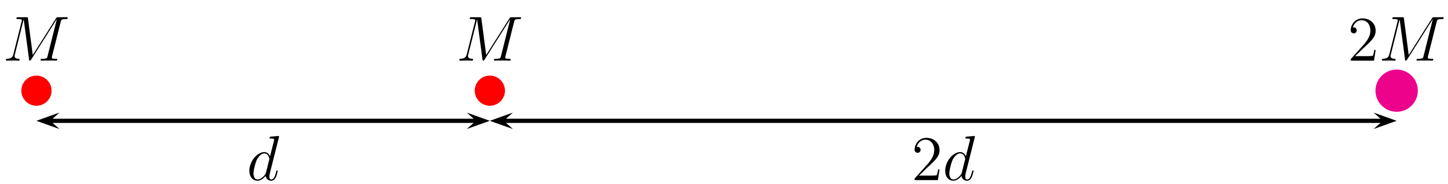

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Weight

<u>Weight</u> - Force due to gravity.

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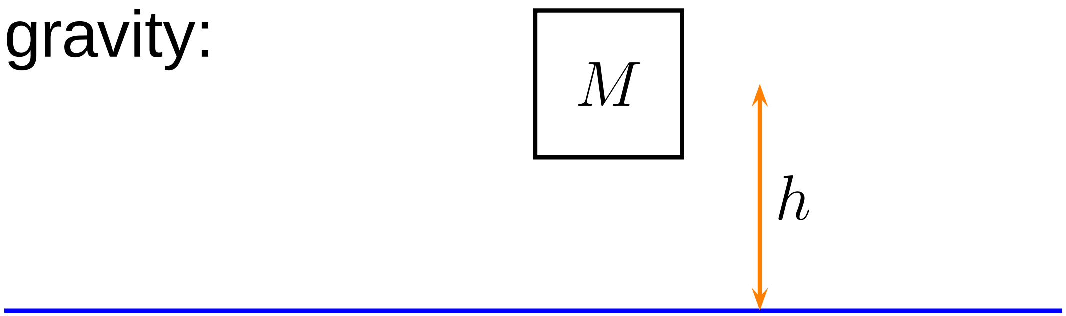

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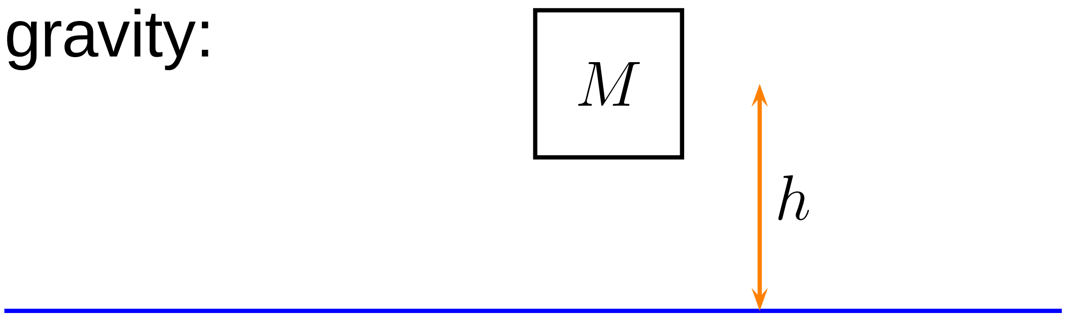

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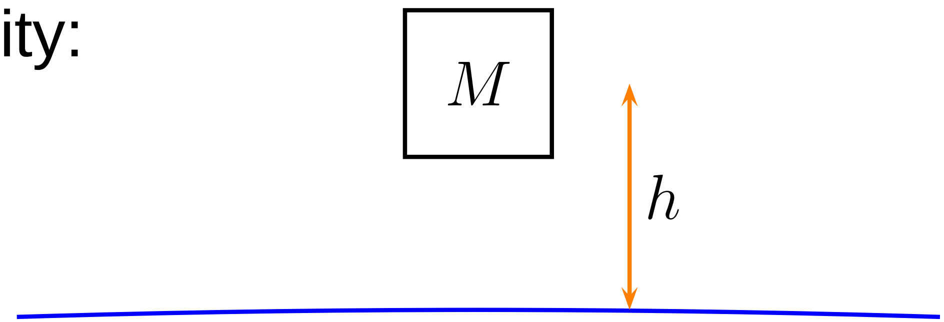

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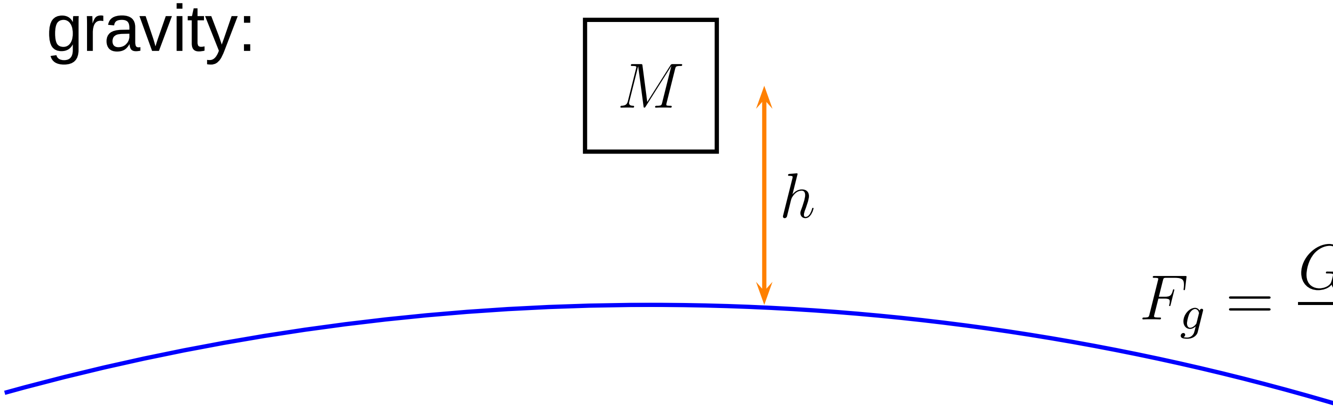

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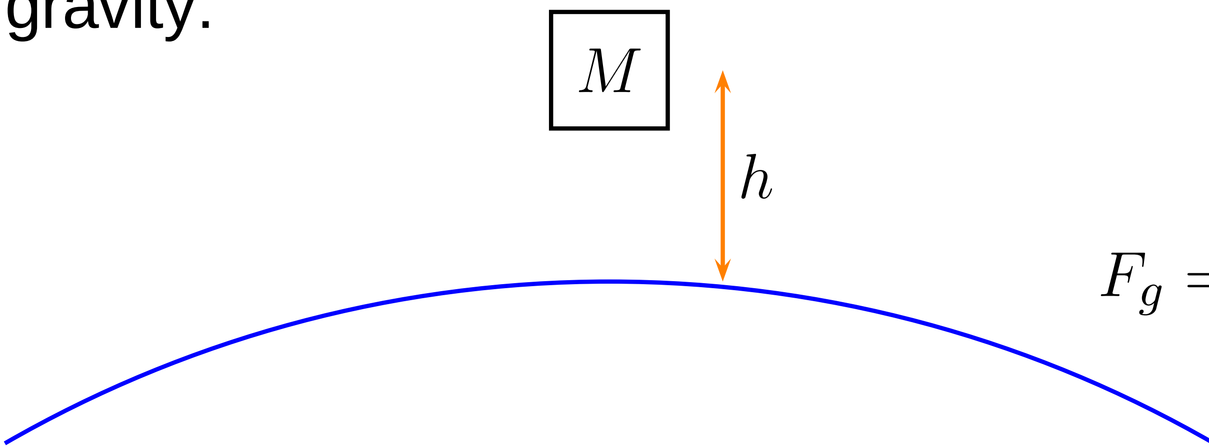

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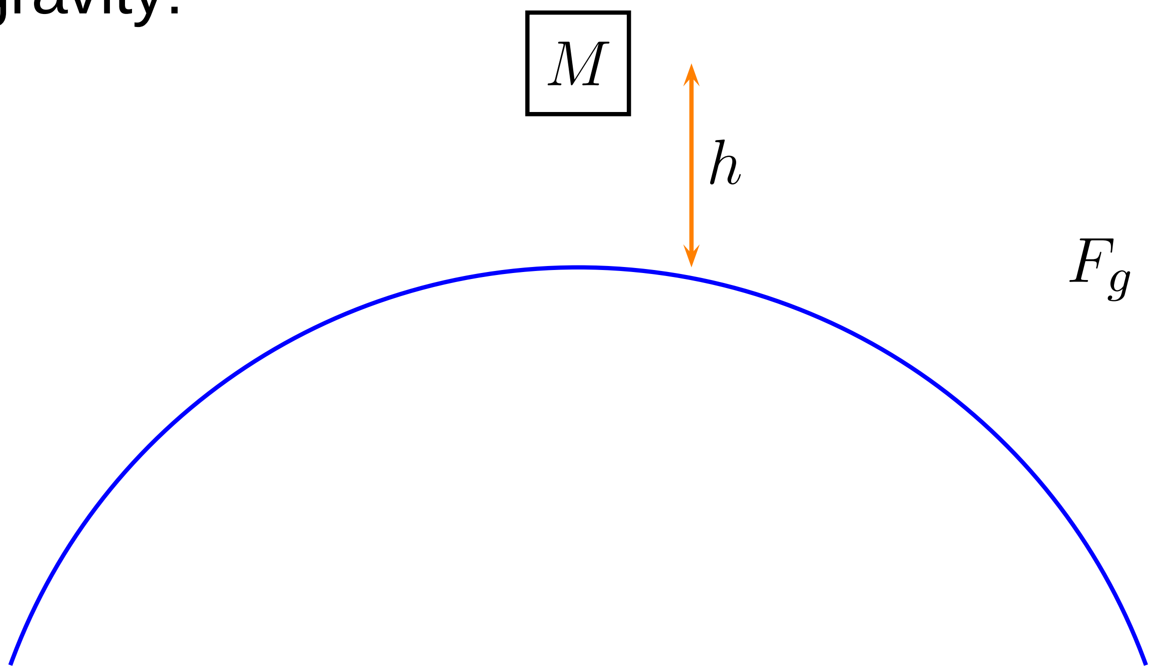

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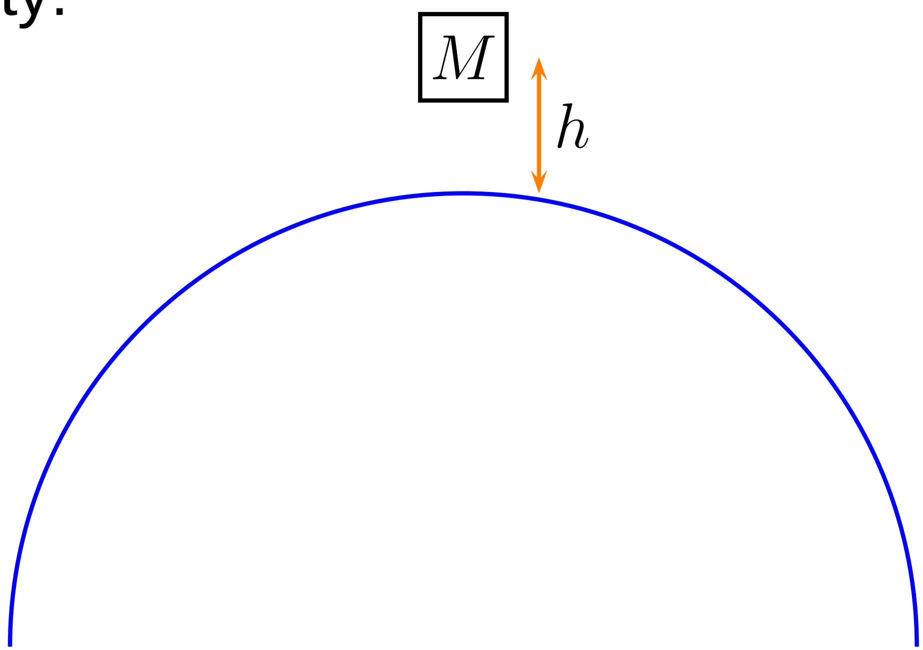

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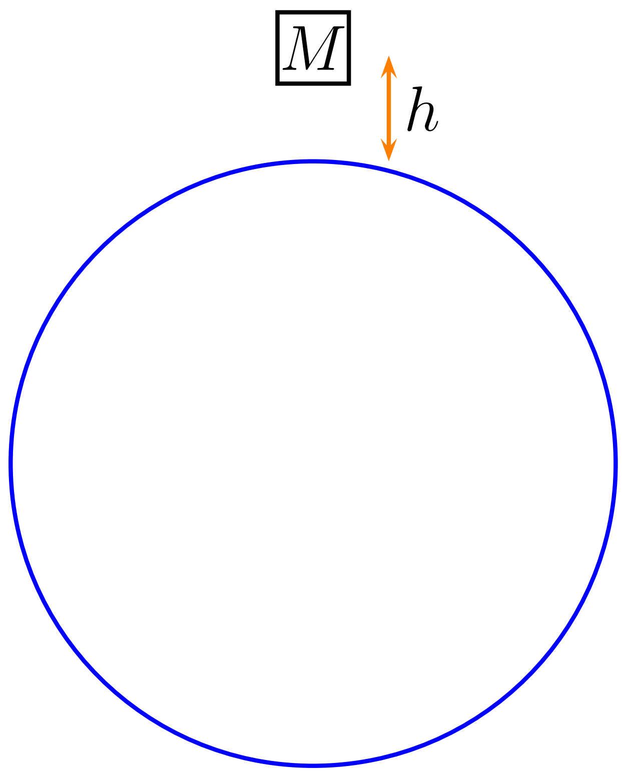

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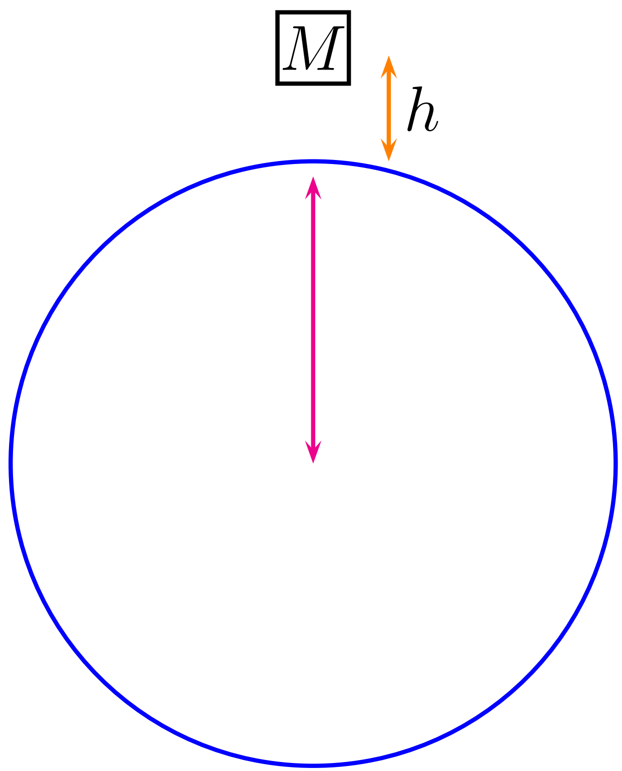

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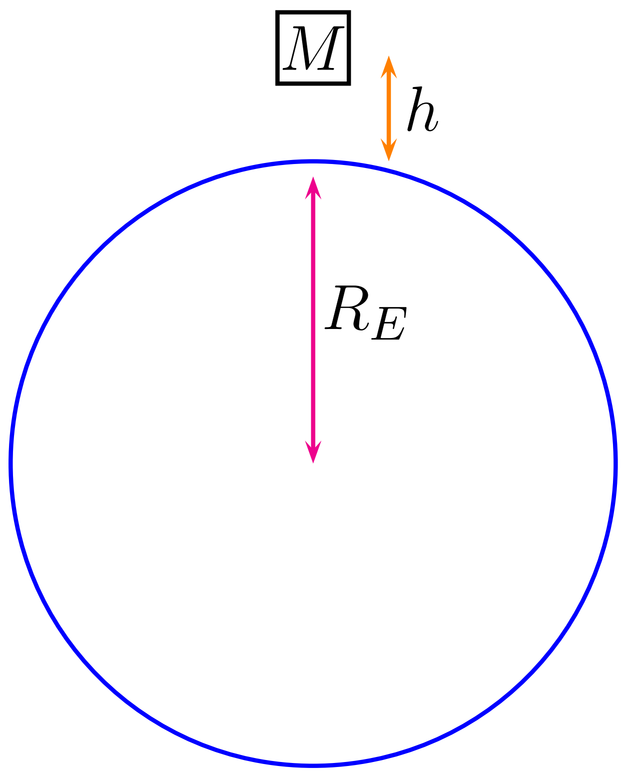

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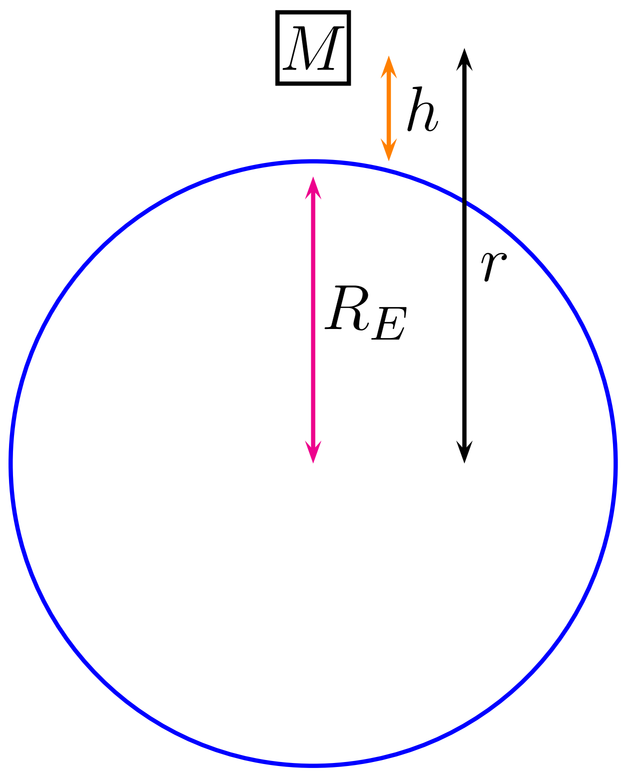

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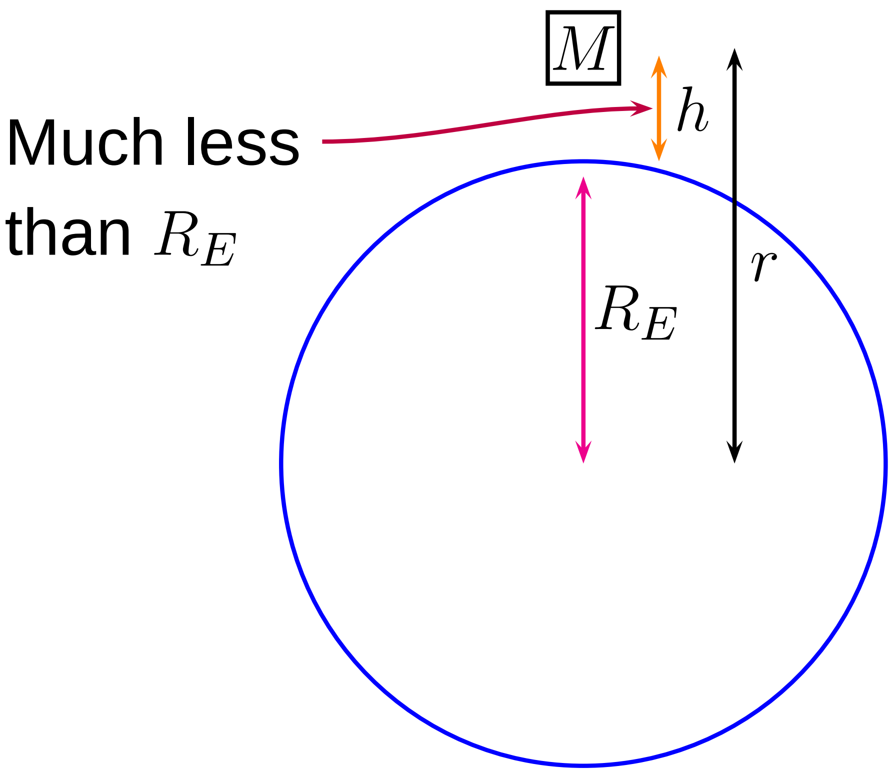

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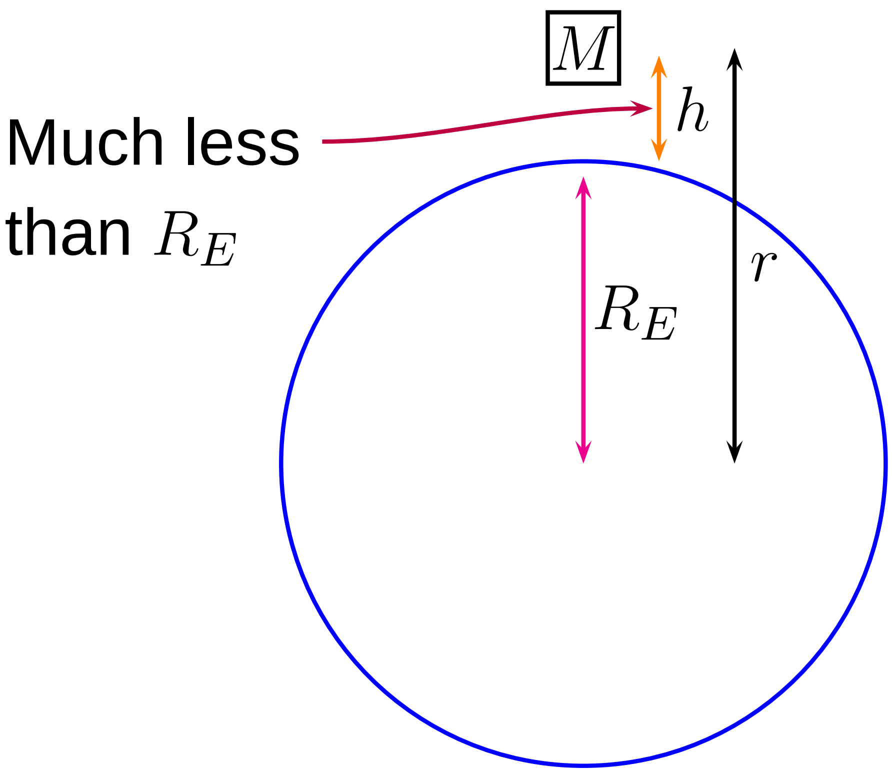

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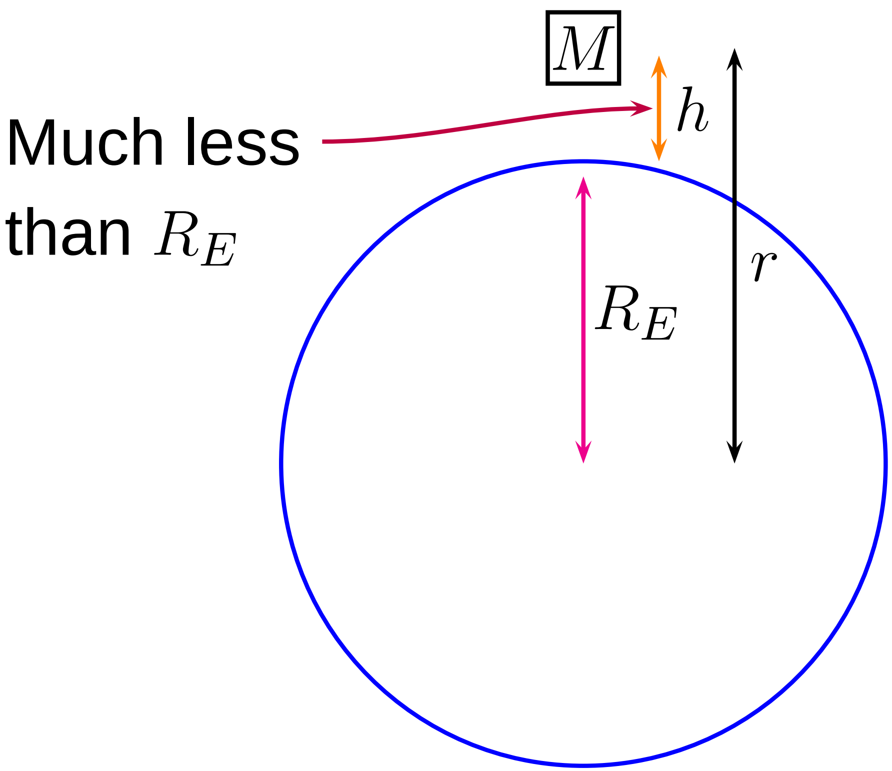

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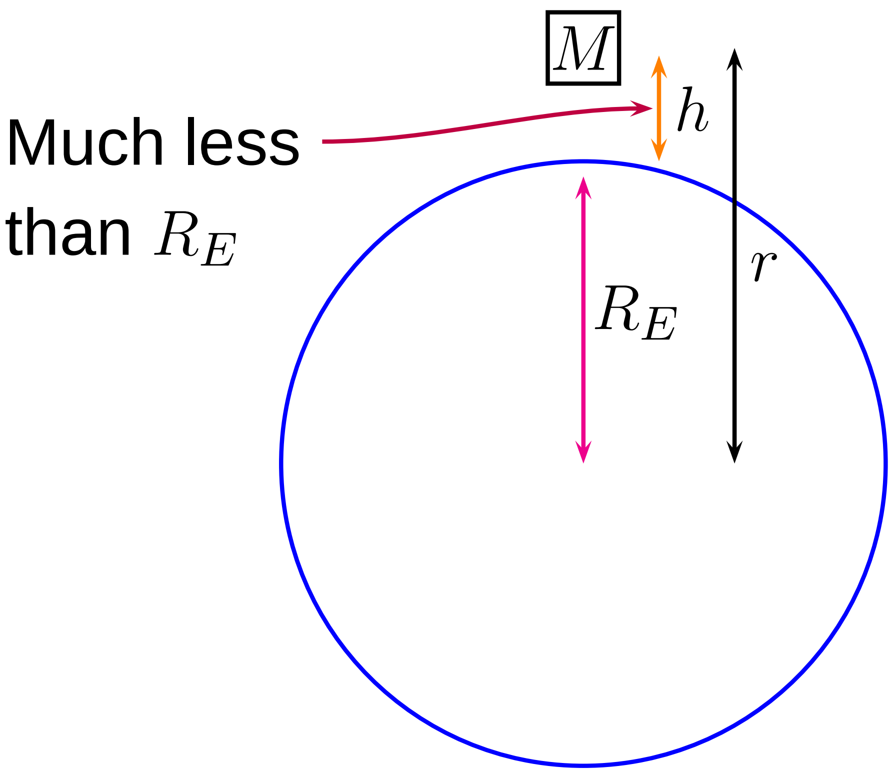

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R_E - Earth's radius

$$r = R_E + h \approx R_E$$

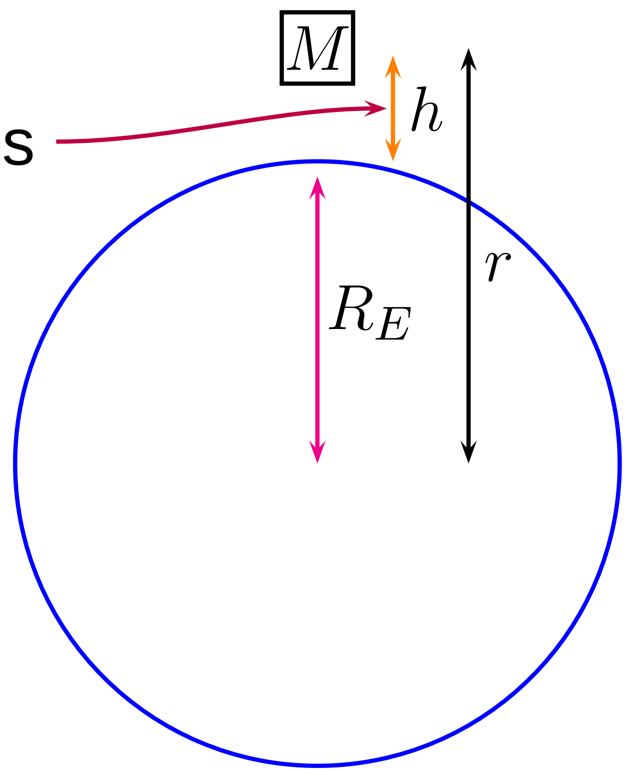
$$F_g = \frac{GM_EM}{R_E^2} = M\left(\frac{GM_E}{R_E^2}\right)$$

Acceleration due to gravity

Weight - Force due to gravity.

To relate what we used before (Mg) to Newton's law of gravity:

Much less than R_E



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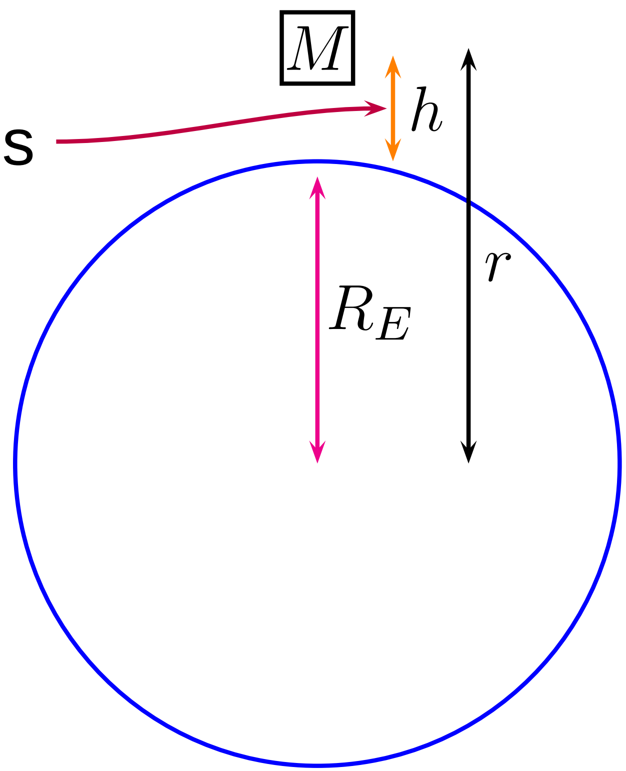

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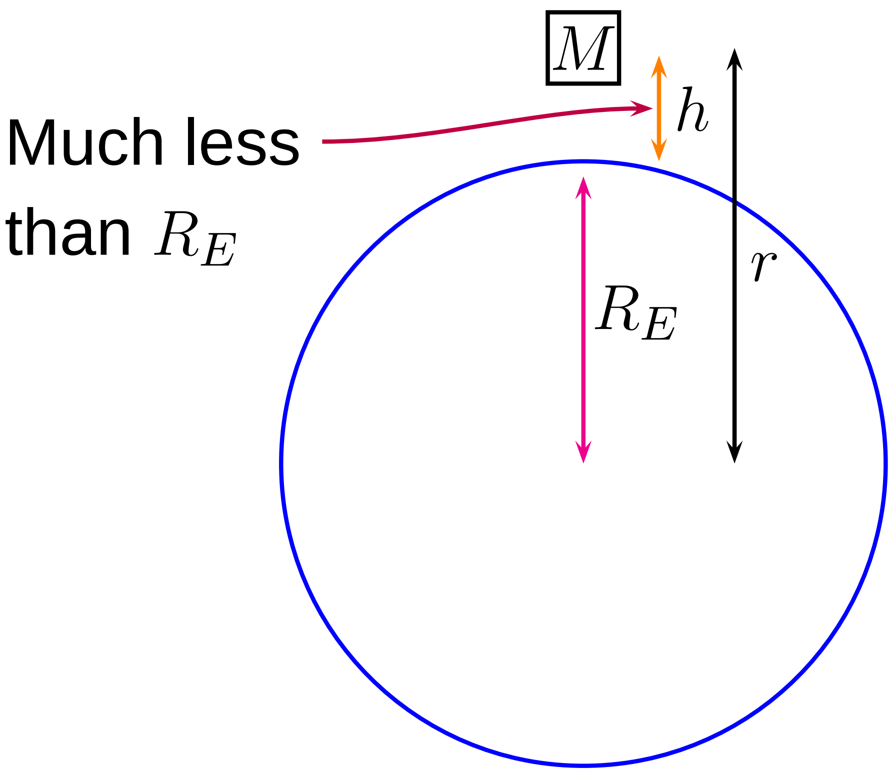

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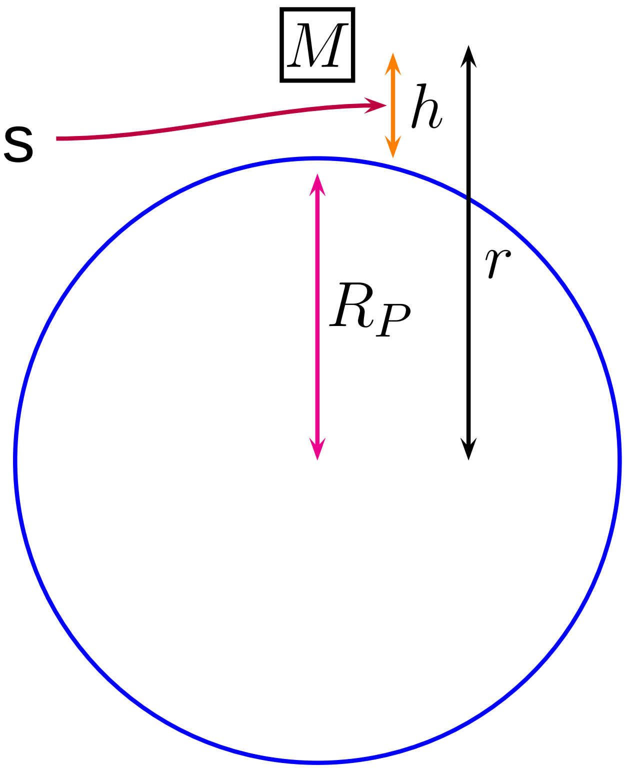
Much less than R_P



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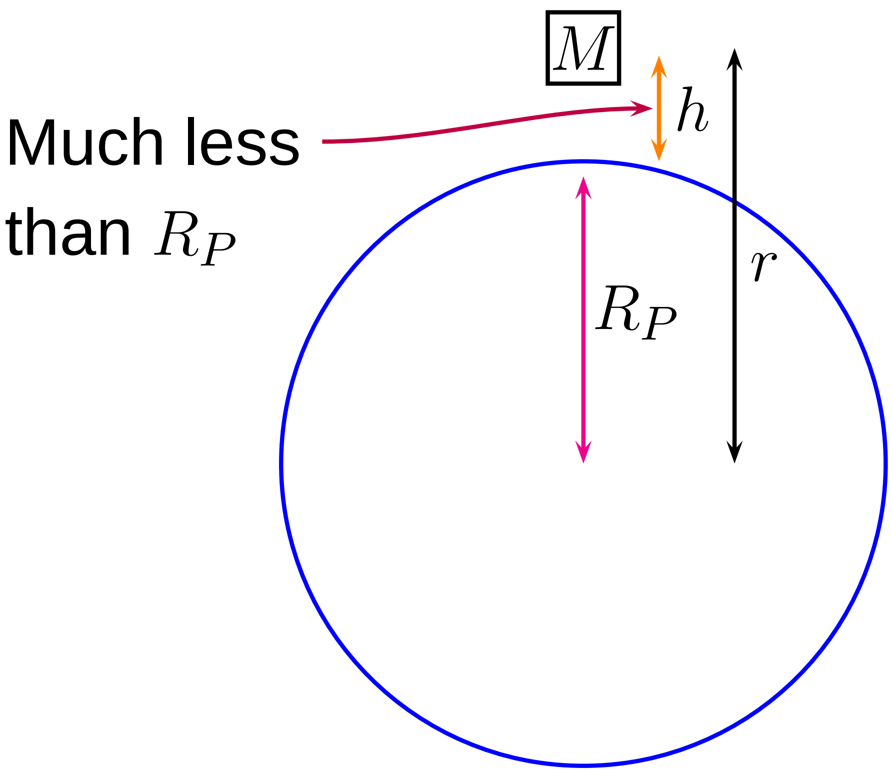

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Acceleration due to gravity on any planet: $\boxed{g = \frac{GM_P}{R_P^2}}$

Gravitational Potential Energy

Our previous equation, $U_g = Mgy$, is valid for distance $y \ll R_P$ (much less than a planet's radius). For distances large compared to the radius, we have to start over.

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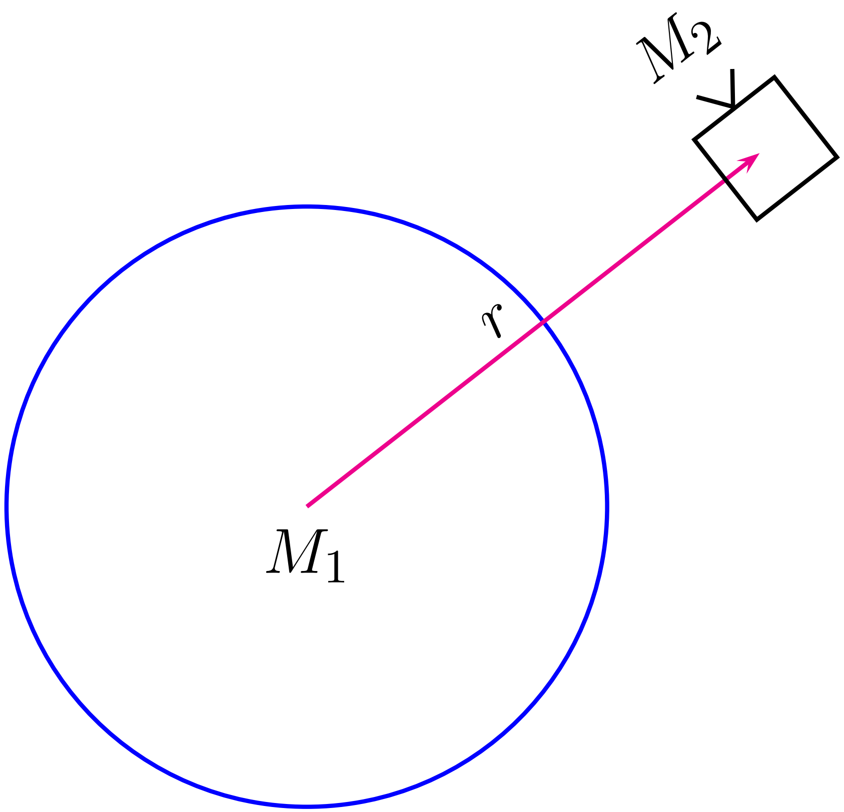

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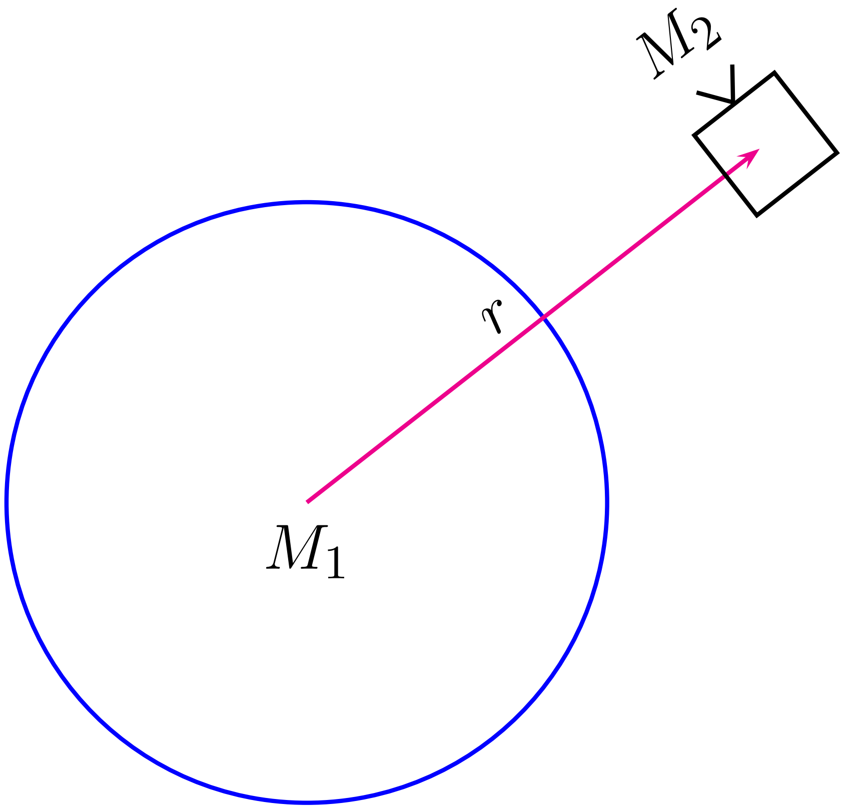

$$W_g = -\Delta U_g$$

$$W_g = \int_{r_1}^{r_2} \overrightarrow{\mathbf{F}}_g \cdot \overrightarrow{d\mathbf{r}}$$

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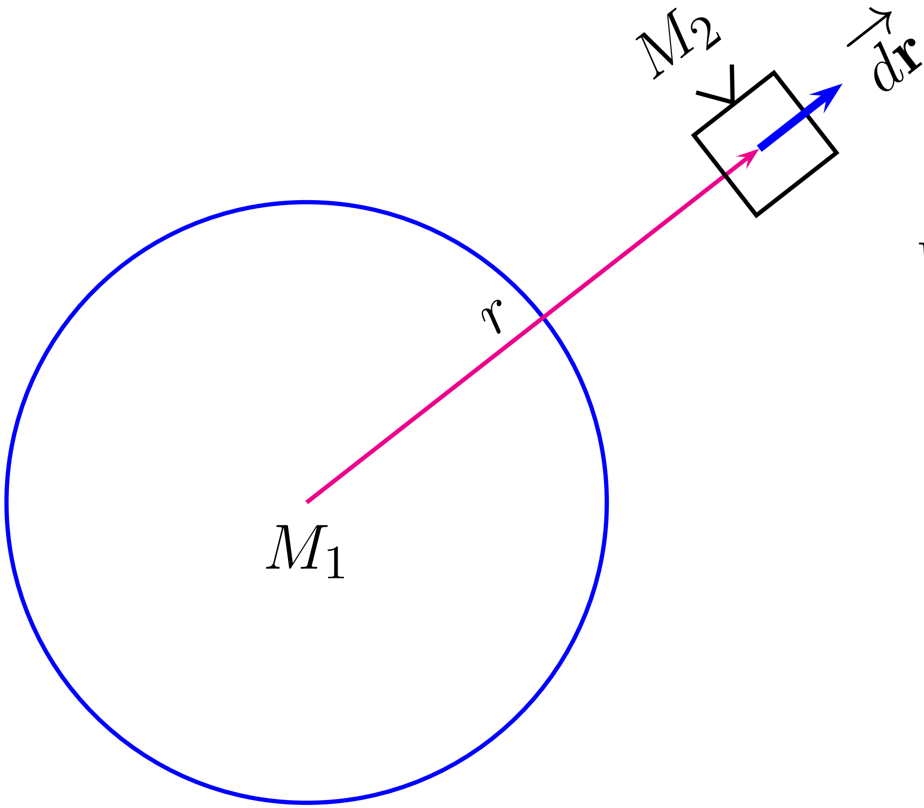

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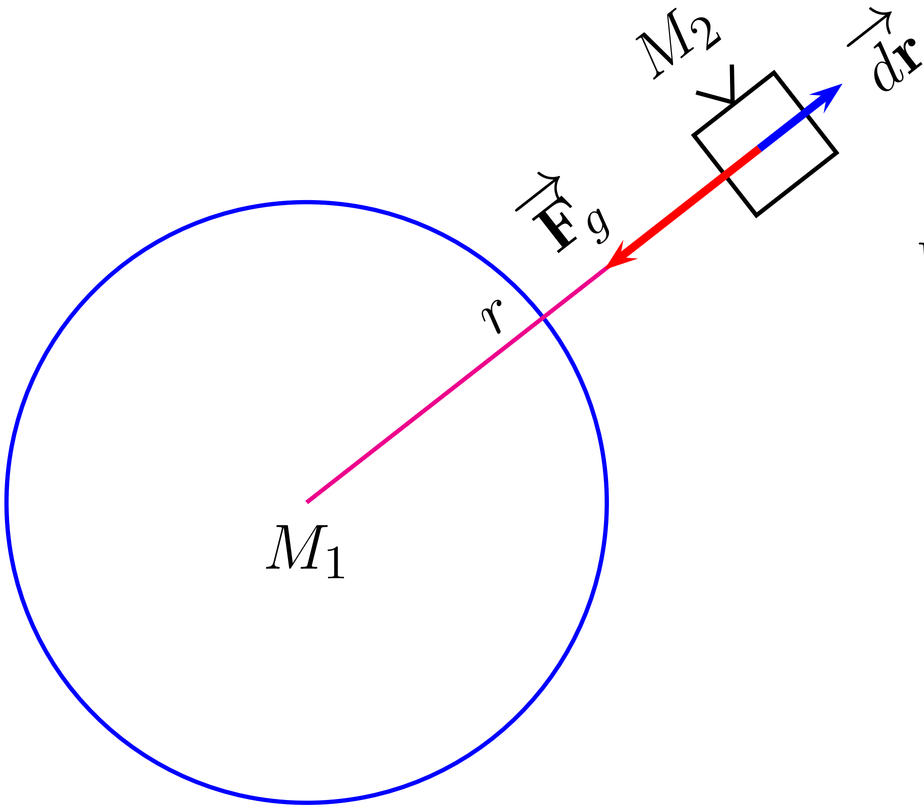

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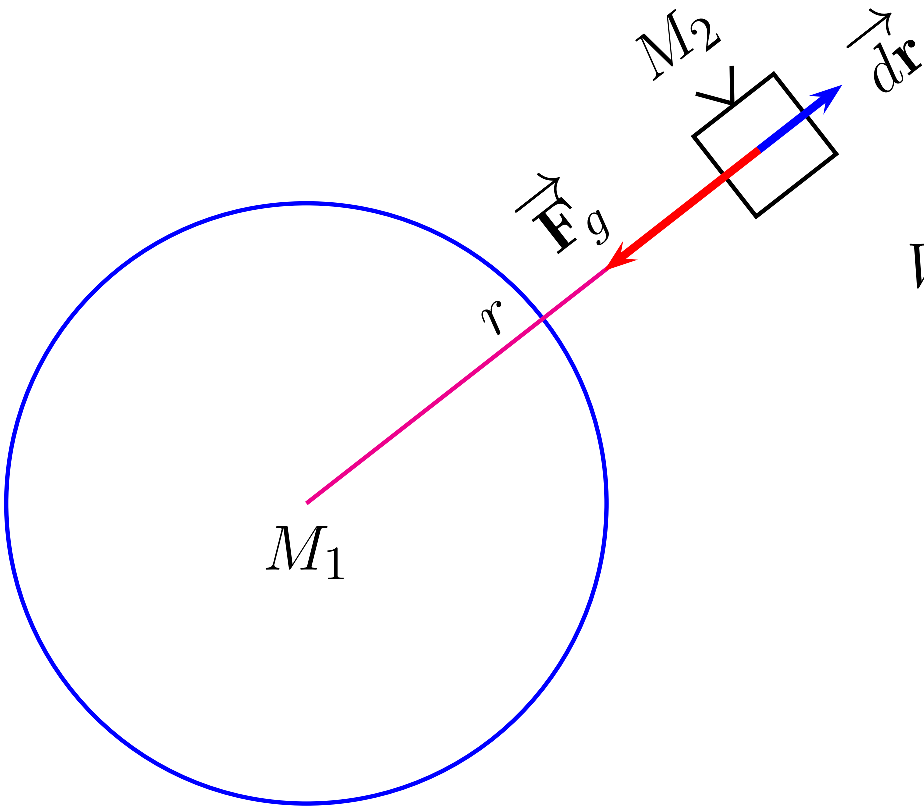

$$W_g = -\Delta U_g$$

$$W_g = \int_{r_1}^{r_2} \overrightarrow{\mathbf{F}}_g \cdot \overrightarrow{d\mathbf{r}} = \int_{r_1}^{r_2} F_g \, dr \cos 180^\circ$$

Gravitational Potential Energy

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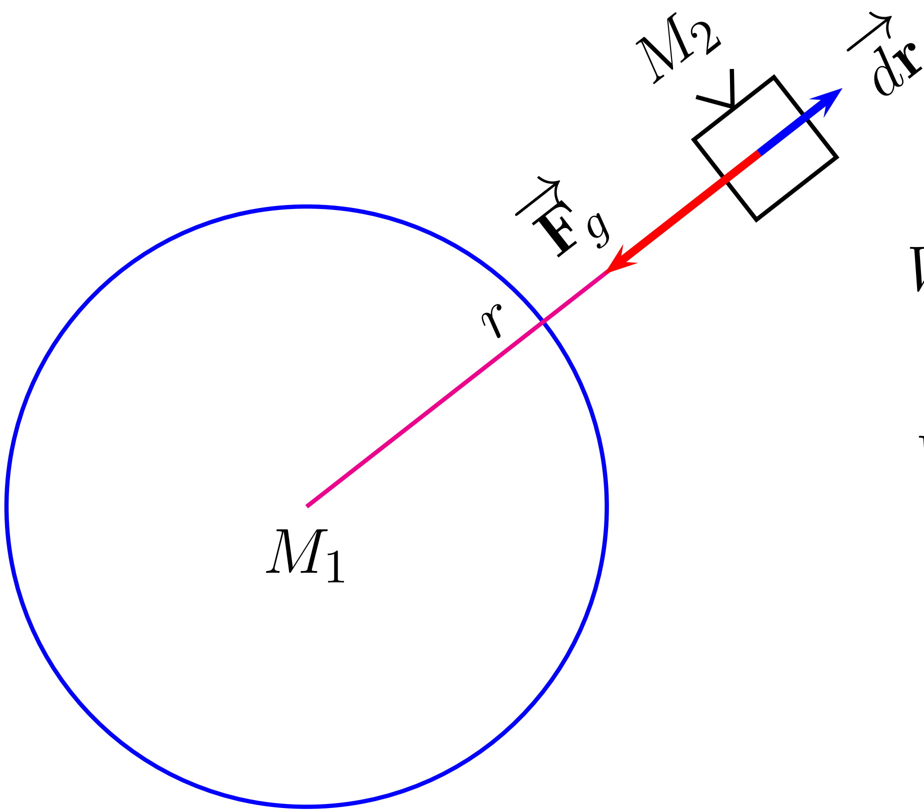

$$W_g = -\Delta U_g$$

$$W_g = \int_{r_1}^{r_2} \overrightarrow{\mathbf{F}}_g \cdot \overrightarrow{d\mathbf{r}} = \int_{r_1}^{r_2} F_g \, dr \cos 180^\circ$$

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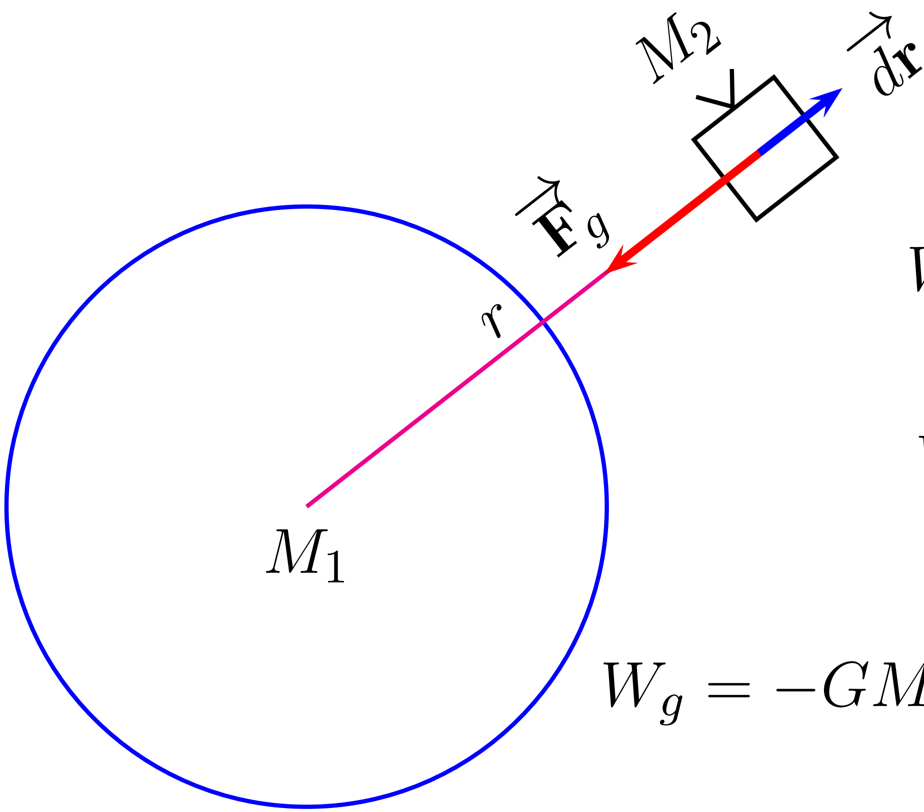

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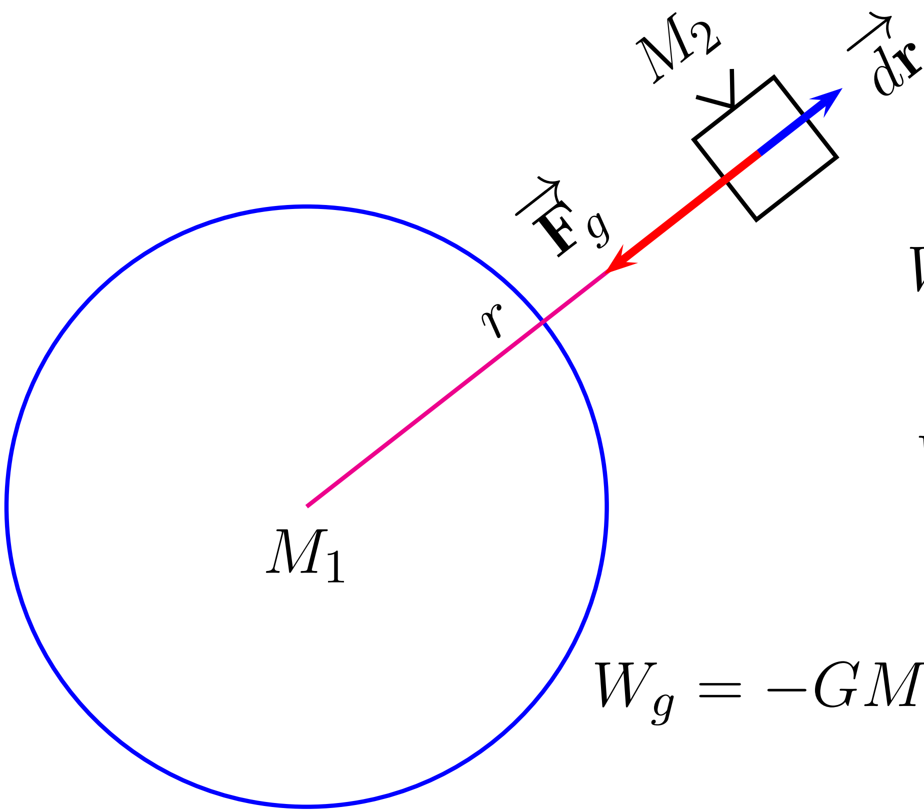

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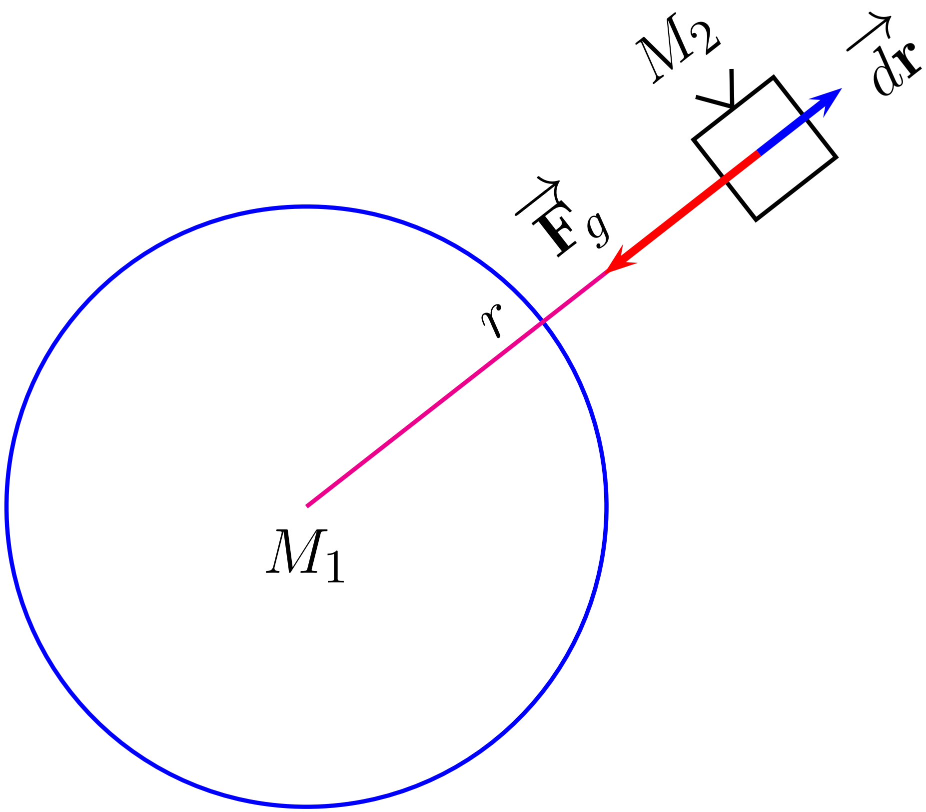

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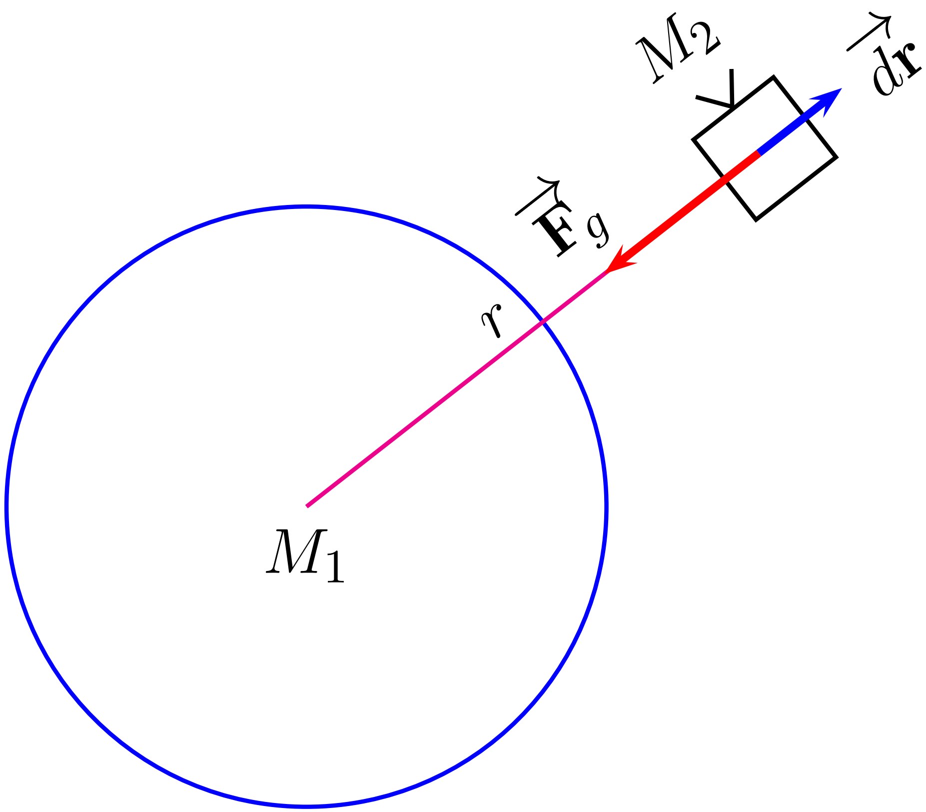

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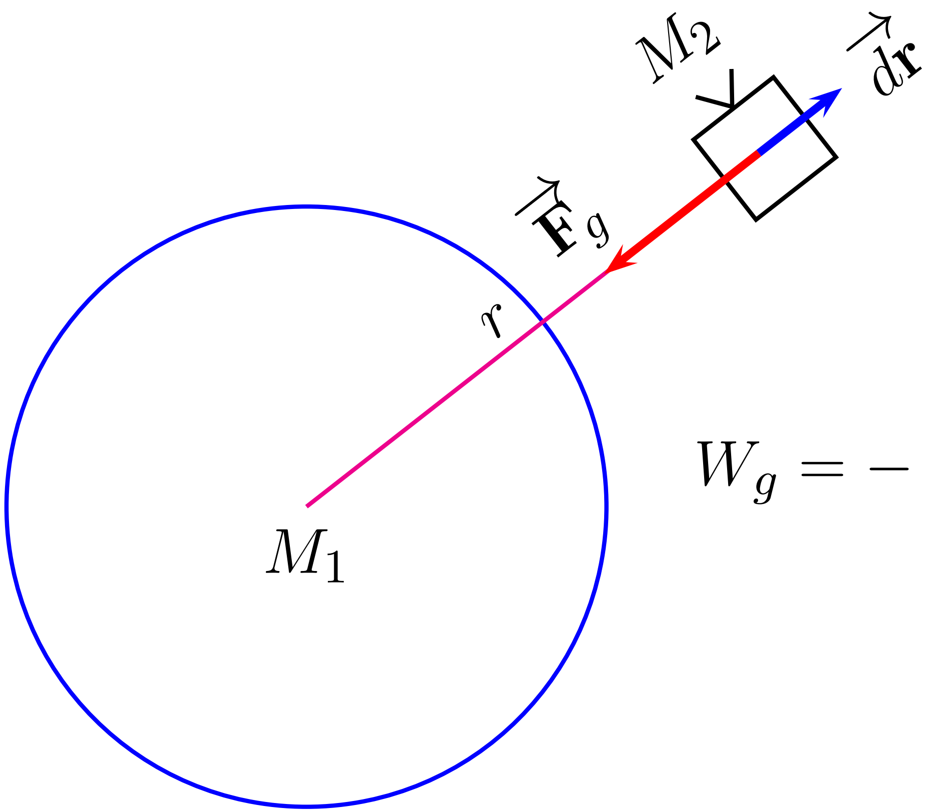

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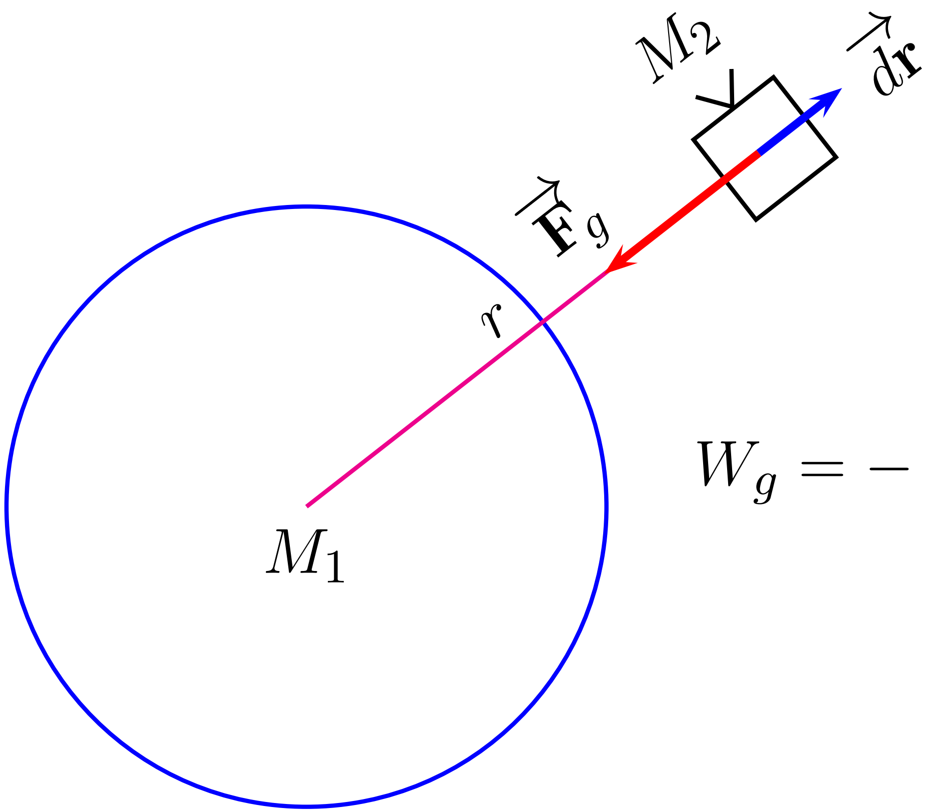

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<u>Escape speed</u> - The initial speed needed by a rocket in order to barely escape from a planet's gravity.

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Example: Find the escape speed from the earth.

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The earth is not flat! It has a curvature of roughly $8000\,m$ to $5\,m$ (horizontal to vertical).

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<u>Satellite</u> - Any projectile with sufficient horizontal velocity to “miss" the ground.