CONCEPT: Universal Law of Gravitation

● Newton's Universal Law of Gravitation: *All* objects in the universe _____.

$F_G =$ _____

- Universal Gravitation Constant (G) = _____ $\left[\frac{\mathbf{m^3}}{\mathbf{kg \cdot s^2}}\right]$

  - *Not little g! ← local constant*

- **r** is the distance between _____.

- Gravitational forces are directed along _____ connecting 2 objects.

EXAMPLE: Two 30-kg spheres are separated by 5m. What is the gravitational force between them?

PRACTICE: Two spheres are separated by 10m. If the lighter 40kg sphere feels a gravitational force of 1.6×10^{-9} N, what is the mass of the heavier sphere?

EXAMPLE: Two spheres of mass 10kg and 25kg are positioned 5 m apart. Suppose you place a third sphere directly in between the two spheres, so that all objects were on the same line. How far from the 10kg mass would you have to place this third sphere so the net gravitational force on it was zero?

PRACTICE: Two spheres of mass 300kg and 500kg are placed in a line 20cm apart. If another sphere of mass 200kg is placed between them, 8cm from the 300kg-sphere, what is the net gravitational force on the 200-kg sphere?

CONCEPT: Center-of-Mass Distance

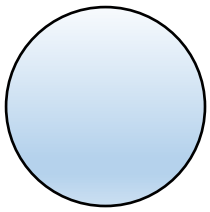
● From the Universal Law of Gravitation, "**r**" is center-of-mass distance between 2 objects**.** What if 1 object is *really* big?

Point Masses

$$F_G = \frac{Gm_1m_2}{r^2}$$

Planets (Large objects)

$F_G =$ _____



Distance **r** = _____

R = _____ **h** = _____

- Capital letters → _____

- Lowercase letters → _____

EXAMPLE**:** At what height above Earth is the gravitational force on a 1000-kg satellite equal to 1000N?

GRAVITATIONAL CONSTANTS

$G = 6.67\times10^{-11}\ \frac{m^3}{kg\cdot s^2}$

$M_E = 5.97\times10^{24}$ kg

$R_E = 6.37\times10^{6}$ m

● Pro Tip**:** When looking for **R** or **h,** solve for **r** first**,** *then* use **r = R + h.**

EXAMPLE: Two identical solid spheres of mass 10kg and 60cm in diameter rest on a table, with their surfaces touching. Calculate the gravitational force between them.

PRACTICE: A 2,000-kg spacecraft is blasting away from the surface of an unknown planet the same size as the Earth. At 1500km above the surface, an instrument onboard reads the gravitational force to be 18000 N. What is the planet's mass?

GRAV. CONSTANTS
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