Virtual Learning

Physics

Kepler's Laws

May 12, 2020

Physics

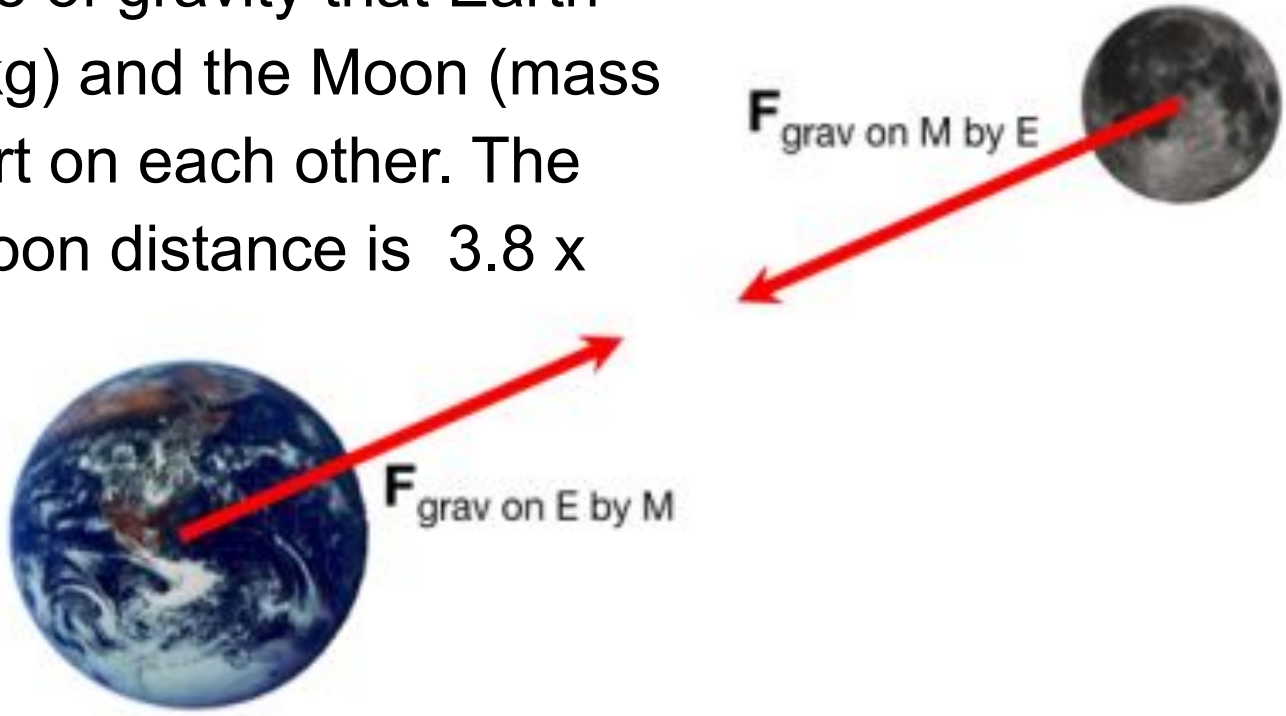
Kepler's Laws: May 12,2020

Objective/Learning Target:

Students will examine Kepler's Laws and use them solve problems.

Quick Review #1

Calculate the force of gravity that Earth (mass 6.0 x 10^{24} kg) and the Moon (mass 7.4 x 10^{22} kg) exert on each other. The average Earth–Moon distance is 3.8 x 10^{8} m.

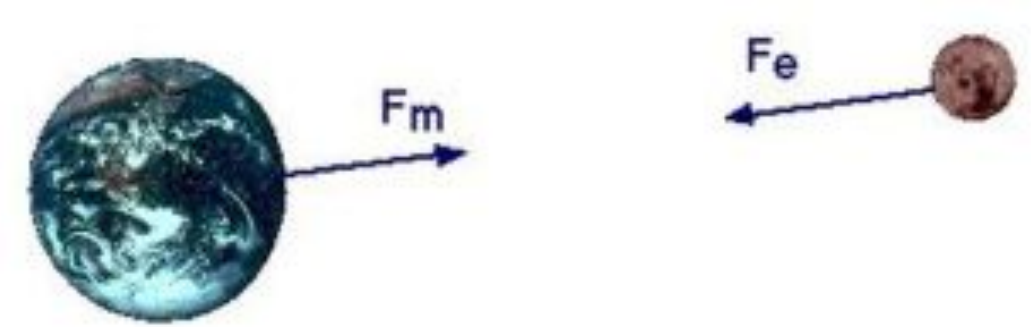


Quick Review #1

$$F = G\frac{mM}{r^2}$$

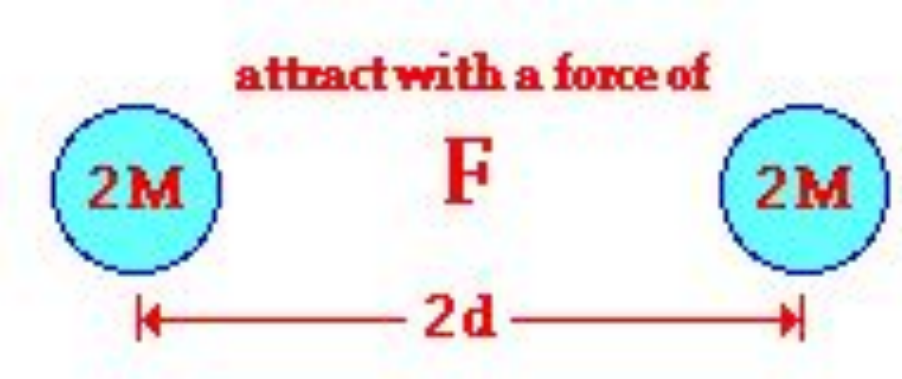
$$= (6.67 \times 10^{-11} Nm^2/kg^2) \times \frac{6.0 \times 10^{24} kg \times 7.4 \times 10^{22} kg}{(3.8 \times 10^{8}\ m)^2}$$

$$= 2.1 \times 10^{20}\ N$$



Quick Review #2

What is the change in the force of gravity between two objects when both of their masses are doubled and the distance between them is also doubled?



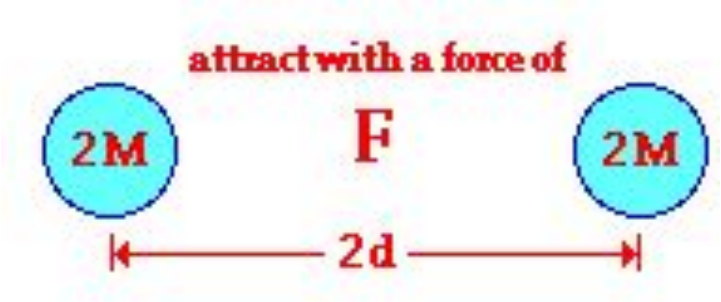
Quick Review #2 Answer

$$F = G\frac{mM}{r^2}$$

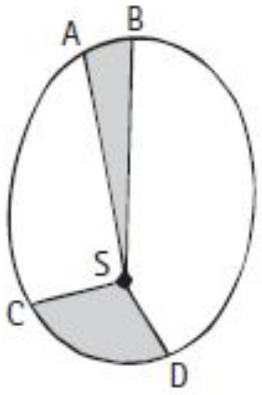
So now double the masses and the distance

$$F = G\frac{2m2M}{(2r)^2} = G\frac{4mM}{4(r)^2} = G\frac{mM}{r^2}$$

So the force remains the same.



Newton's Universal Law of Gravitation



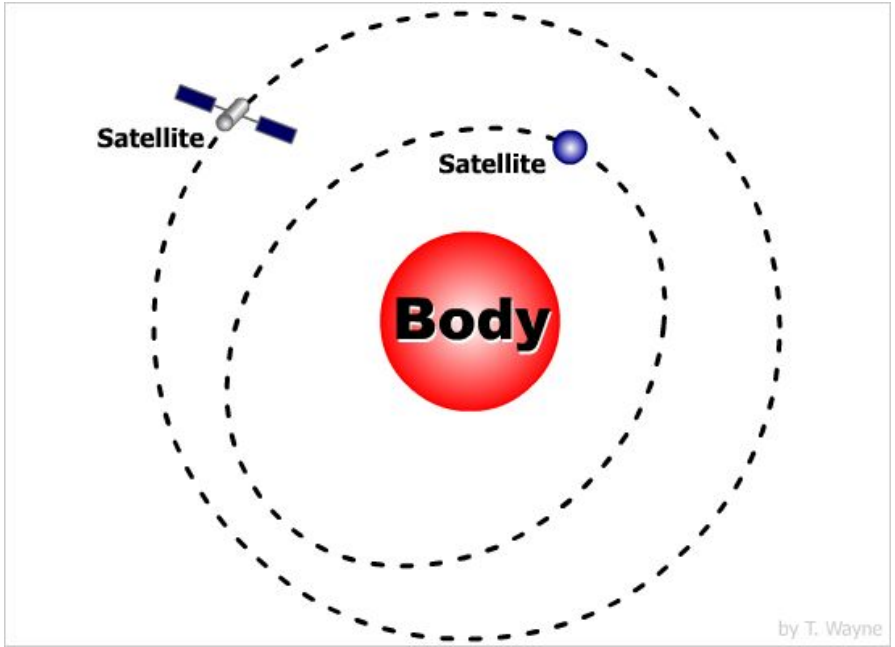
Link:[Kepler's Laws]

Directions:

- Read through Kepler's Laws.
- Work through any examples on a separate piece of paper before you scroll down to the solution.
- On a separate piece of paper complete the practice problems on the following slides.
- Check your answers.
- For additional practice check out the conceptual questions and the problems and exercises in the table of contents for the online text linked above.

Practice Problem #1

Satellite A is 5 times farther from a planet than satellite B. If it takes satellite A 22 weeks to complete a full orbit around the planet, how long will it take satellite B to travel around the planet once?



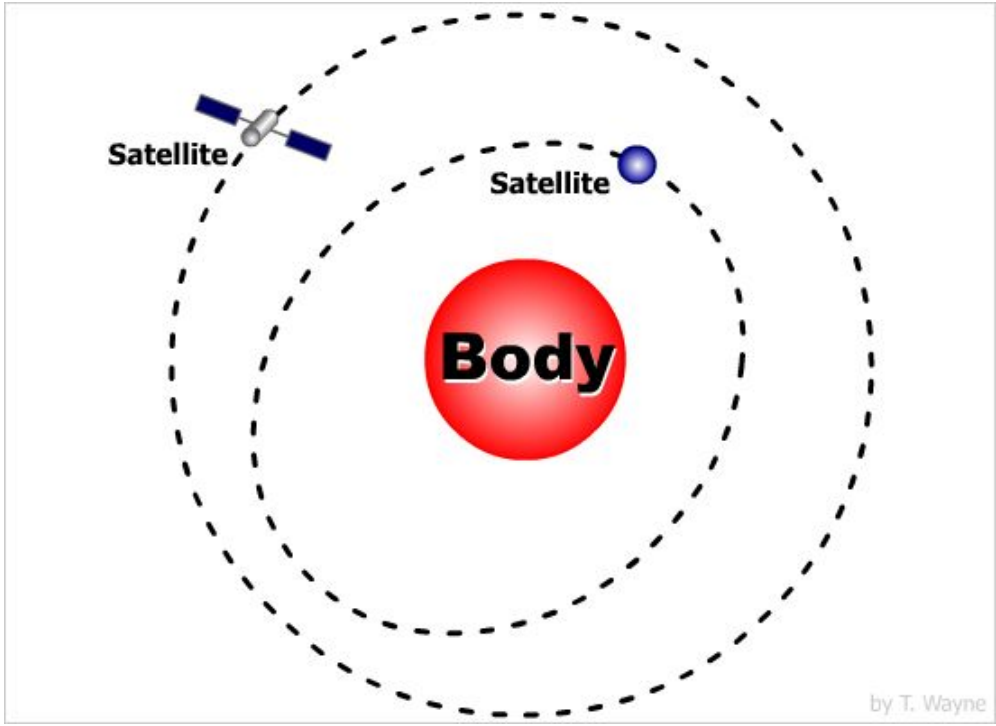
Practice Problem #1 Answer

$T_1^2 / (r_1^3) = (T_2^2) / (r_2^3)$.

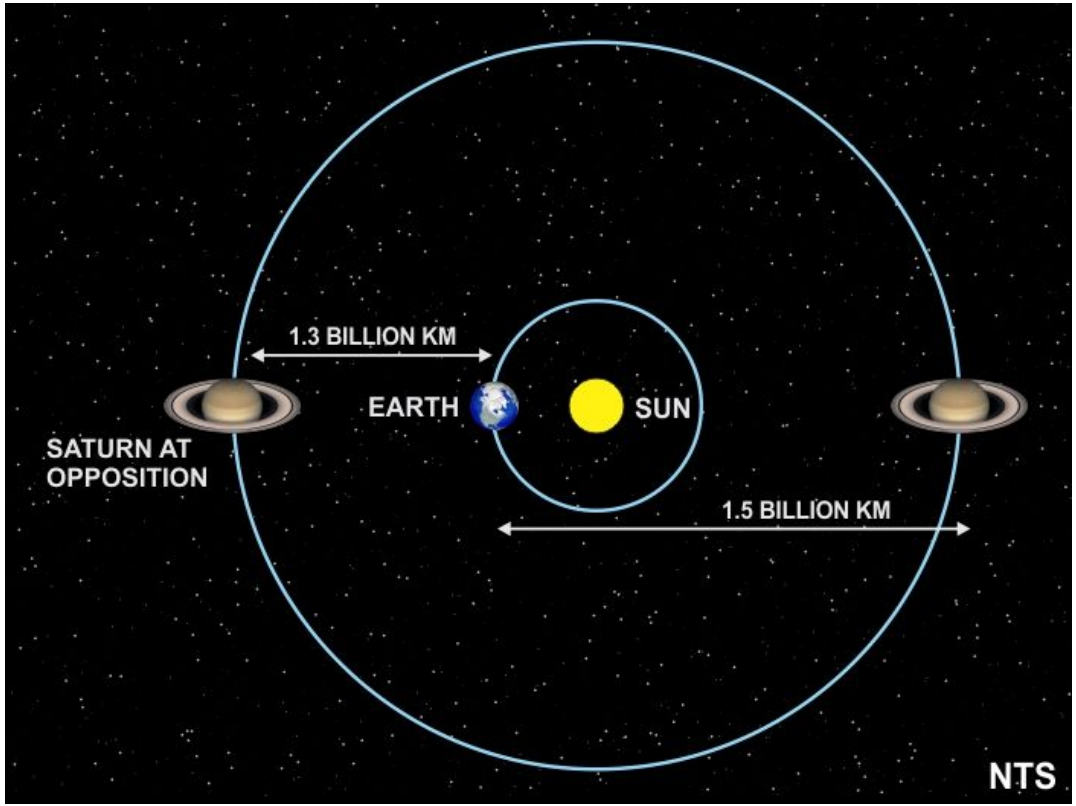
Now substitute the values given

$22^2/5^3 = x^2/1^3$

Thus, x = 1.97 or 2 weeks



Practice Problem #2



If Saturn is, on average, 9 times farther from the Sun than the Earth is, how long is its year in terms of Earth years?

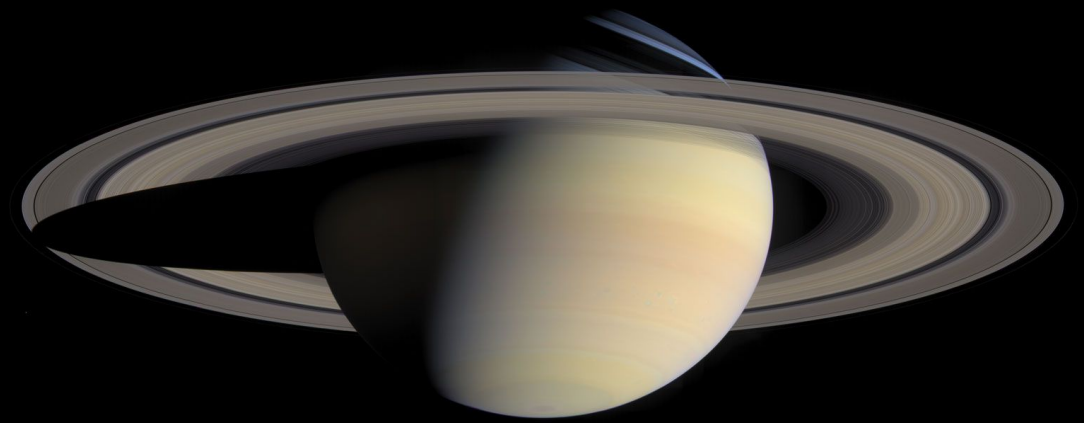
Practice Problem #2 Answer

$T_1^2 / (r_1^3) = (T_2^2) / (r_2^3)$.

Now substitute the values given

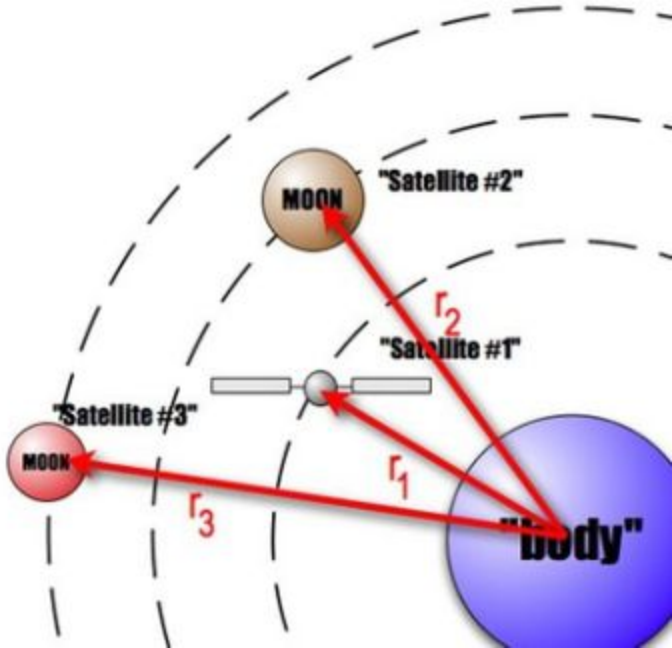
$1^2/1^3 = x^2/9^3$

so we solve for x and get $x = \sqrt{(9^3)} = 27$



Practice Problem #3

Satellite A is 7 times farther from a planet than satellite B. If it takes satellite B 4 weeks to complete a full orbit around the planet, how long will it take satellite A to travel around the planet once?



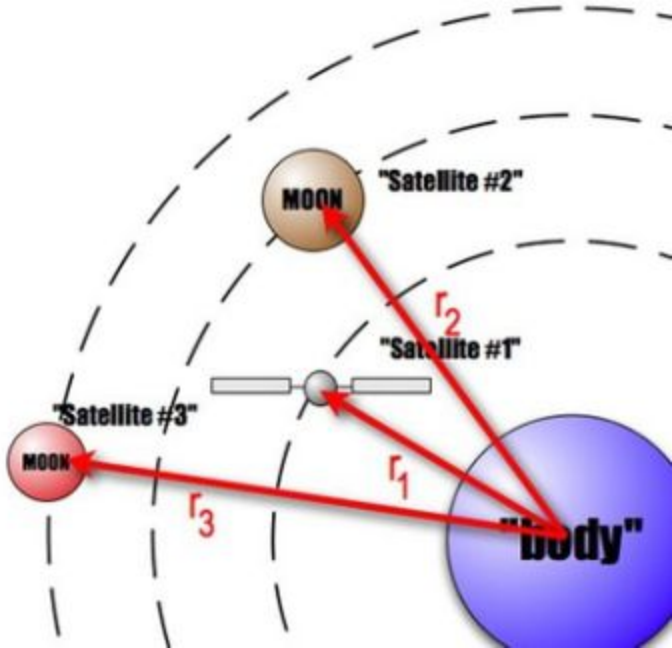
Practice Problem #3 Answer

$T_1^2 / (r_1^3) = (T_2^2) / (r_2^3)$.

Now substitute the values given

$x^2/7^3 = 4^2/1^3$

Thus, x = 74 weeks



Additional Practice

For additional explanation and more practice problems visit the following site.

[Kepler's Laws - Physics Classroom]