Inspiring Greatness
ISD
INDEPENDENCE SCHOOL DISTRICT

Virtual Learning

Physics

Gravity and Orbits

May 14, 2020

Physics

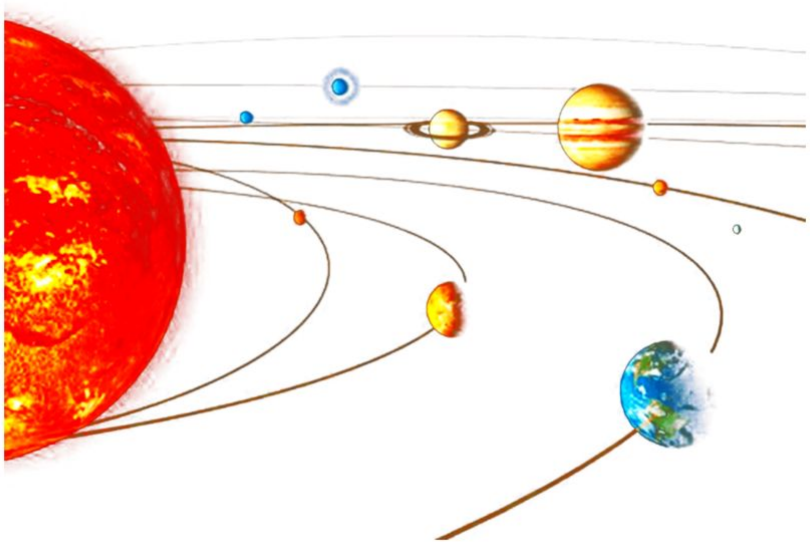
Gravity and Orbits: May 14,2020

Objective/Learning Target:

Students will use a computer simulation to explore Gravity and orbits.

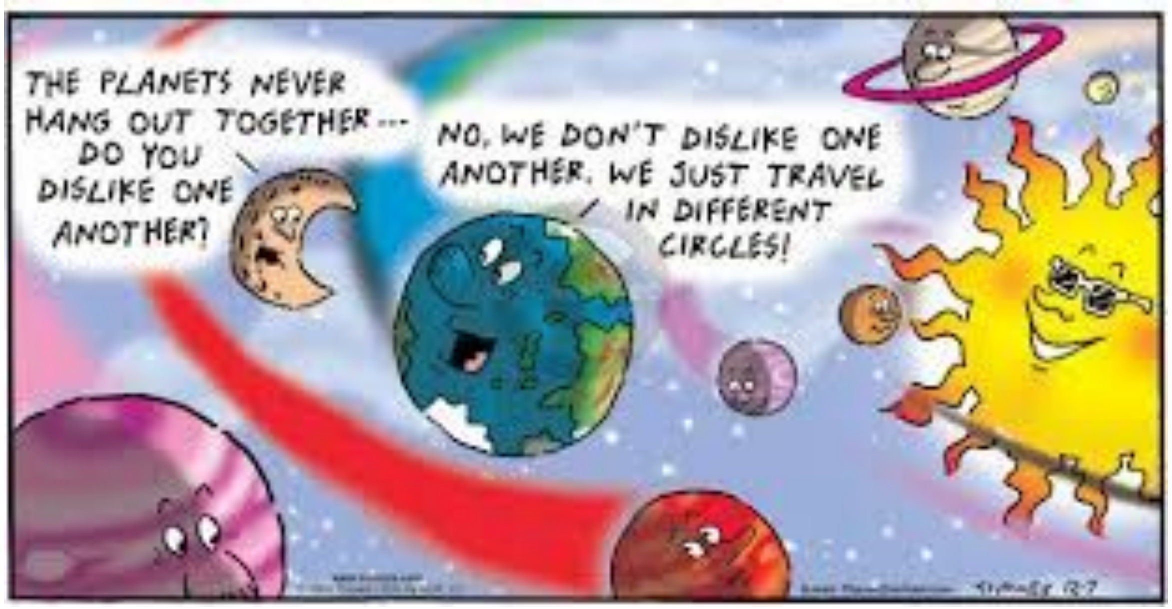
Quick Review #1

If the gravitational forces of the sun on the planets suddenly disappeared, in what kind of paths would the planets move?



Quick Review #1 Answer

Tangentially in straight-line paths.



Quick Review #2

True or false:

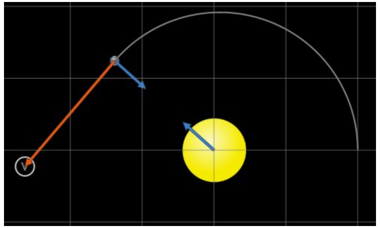
Space vehicles orbit at altitudes in excess of 150 km to be above both gravity and Earth’s atmosphere.

Quick Review #2 Answer

False.

What satellites are above is the atmosphere and air resistance—not gravity! It's important to note that Earth's gravity extends throughout the universe in accord with the inverse-square law.

Gravity and Orbits



Introduction

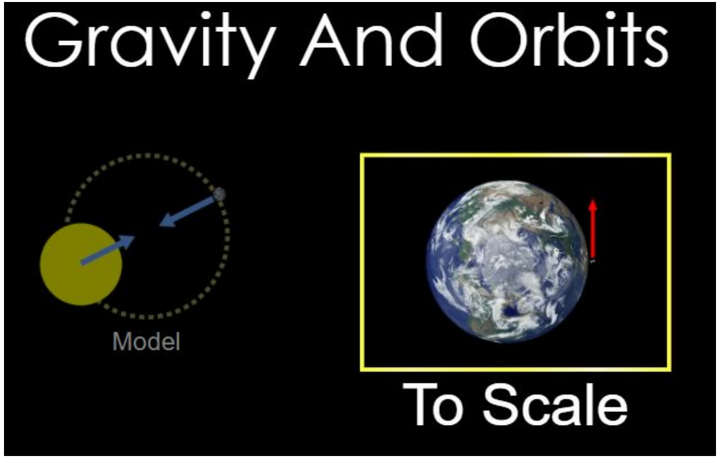
You will use a computer simulation today to investigate Gravity and Orbits. Since this is "inquiry based", you're not supposed to know everything going in, but learn as we walk through the lesson. **You must read the following slides carefully.** Let's get started!

Gravity and Orbits

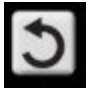
Website:[Gravity and Orbits]

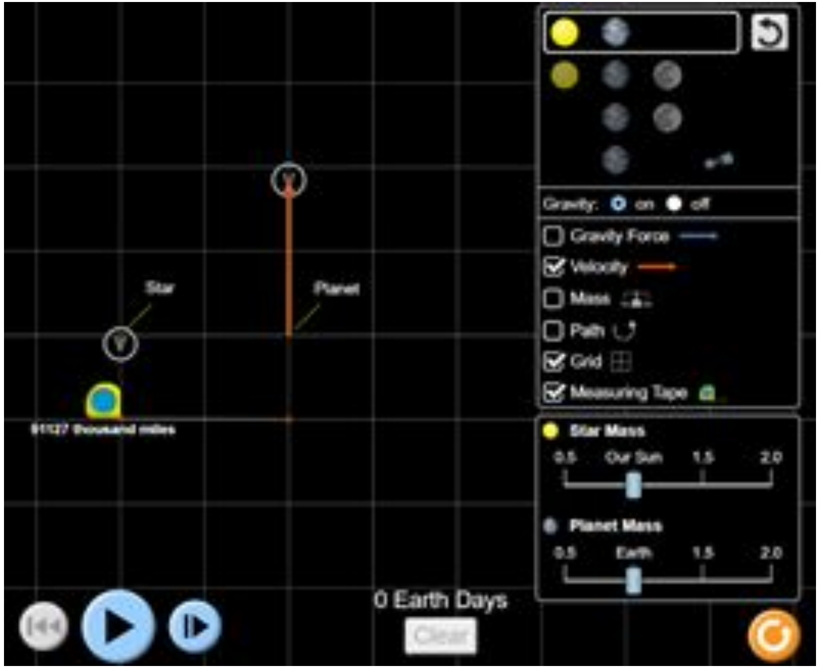
Make sure to use the HTML5 version.

Select To Scale to get started.



Gravity and Orbits Two Boxes

1. Make sure you are in “To Scale” mode.
2. Select Sun and Earth (top choice). Make sure Velocity, Grid, and Measuring Tape are selected (like the diagram to the right). Earth should be **<u>two boxes</u>** from the Sun.
3. Click the big blue Play arrow . Click the Fast Motion and Slow Motion arrows to see what effect they have. Use these two buttons as needed. Click the big blue stop button. Click the grey reset button in the upper right. (This is the only reset button you will ever use.) 
4. Determine the speed of the Earth in m/s when it is in this initial orbit of **<u>two boxes</u>** from the Sun. Describe your plan and show your work.



Gravity and Orbits One Box

5. Click Reset . Move the Earth so it is **one box** from the Sun. (Note: one box side equals about 46,000,000 miles.) Do **not** change the length of the velocity vector. Predict what will happen to the Earth and Sun when you hit Play.

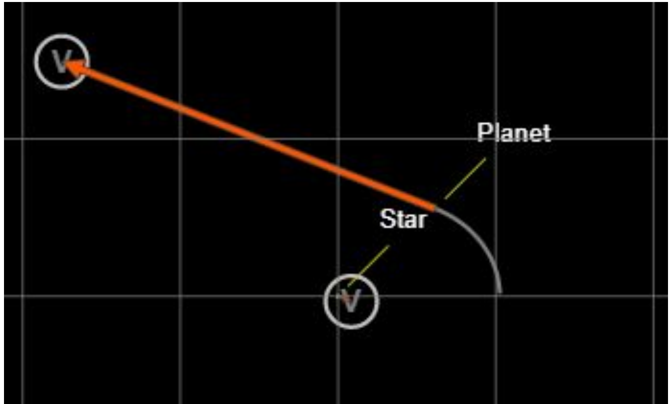
6. Click Play . What do you observe about the motions of the Earth and Sun? Why does the Earth move in this way?

7. Click Reset . Stretch or shrink the velocity vector so, when you click Play , the orbit is circular. First use trial and error. Once you get close let the planet make one full trip and hit pause then adjust the arrow as needed and let run again one full trip, pausing at the starting point to make your adjustments. How can you quickly tell if the orbit is circular?

Gravity and Orbits One Box

8. Use the general formulas for gravitational force and centripetal force to derive the relationship between speed (v) and orbital radius (r) for circular orbits.

9. Use this formula to determine the speed in m/s that will result in a circular orbit when Earth is **one box** from the Sun.

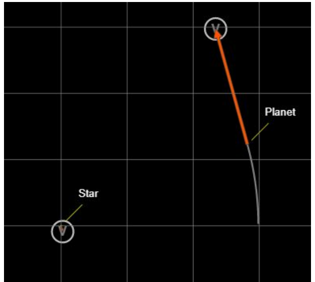


Gravity and Orbits Three Boxes

10. Click Reset . Move the Earth so it is **<u>three boxes</u>** from the Sun. Do **not** change the length of the velocity vector. Predict what will happen to the Earth and Sun when you hit Play.

11. Click Play . What do you observe about the motions of the Earth and Sun? Compare what you observed with the one box motion you observed before.

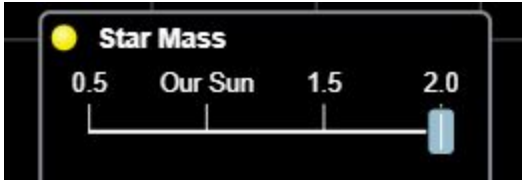
12. Click Reset . Stretch or shrink the velocity vector so, when you click Play , the orbit is circular. First use trial and error. Use the formula you derived in item 8 to determine the speed in m/s that will result in a circular orbit when the Earth is **<u>three boxes</u>** from the Sun.



Gravity and Orbits More Massive Sun

13. Click Reset . Change the mass of the Sun to **2.0 Solar masses**. Predict what will happen to the Earth and Sun when you hit Play.

14. Click Play . What do you observe about the motions of the Earth and Sun? Why does the Earth move in this way?



15. Click Reset . Stretch or shrink the velocity vector so, when you click Play , the orbit is circular. Use the formula you derived in item 8 to determine the speed that will result in a circular orbit when the Sun is **2.0 Solar masses**.

Gravity and Orbits Less Massive Sun

16. Click Reset . Change the mass of the Sun to **<u>0.5 Solar masses</u>**. Predict what will happen to the Earth and Sun when you hit Play.

17. Click Play . What do you observe about the motions of the Earth and Sun? Compare what you observed with the more massive Sun motion you observed above.

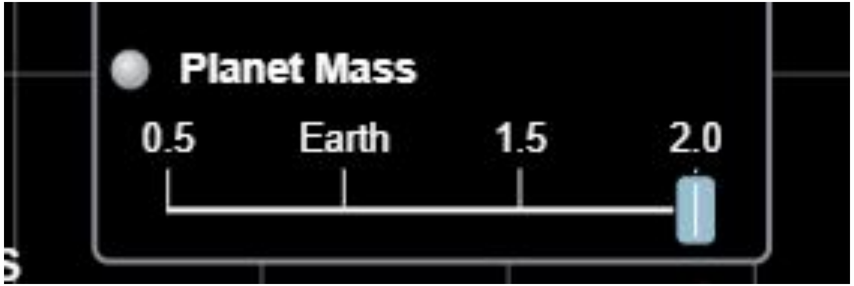
18. Click Reset . Stretch or shrink the velocity vector so, when you click Play , the orbit is circular. Use the formula you derived in item 8 to determine the speed that will result in a circular orbit when the Sun is **<u>0.5 Solar masses</u>**.

Gravity and Orbits More Massive Earth

19. Click Reset . Change the mass of the Earth to **<u>2.0 Earth masses</u>**. Predict what will happen to the Earth and Sun when you hit Play.

20. Click Play . What do you observe about the motions of the Earth and Sun? Why does the Earth move in this way?

21. Click Reset . Stretch or shrink the velocity vector so, when you click Play , the orbit is circular. Use the formula you derived in item 8 to determine the speed that will result in a circular orbit when the Earth is **<u>2.0 Earth masses</u>**.

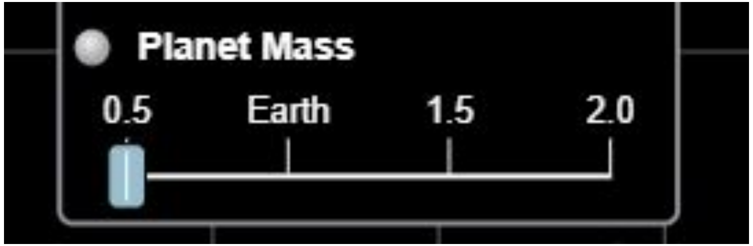


Gravity and Orbits Less Massive Earth

22. Click Reset . Change the mass of the Earth to **<u>0.5 Earth masses</u>**. Predict what will happen to the Earth and Sun when you hit Play.

23. Click Play . What do you observe about the motions of the Earth and Sun? Compare what you observed with the more massive Earth motion you observed above.

24. Click Reset . Stretch or shrink the velocity vector so, when you click Play , the orbit is circular. Use the formula you derived in item 8 to determine the speed that will result in a circular orbit when the Earth is **<u>0.5 Earth masses</u>**.



Gravity and Orbits Application

25. Which of the tested parameters affect the speed of the orbiting object?

26. Describe the main condition(s) for circular orbits.

27. Suppose someone showed you the orbital speed and orbital radius of something orbiting the Sun. How could you determine if the object had a circular (or very close to circular) orbit?

Gravity and Orbits Answers

4. Speed = distance / time = circumference / time

Average radius of orbit = (91258000 + 94624000) = 92941000 miles

$$\text{Speed} = \frac{2\pi(92940001\text{miles})}{365 \text{ days}} \times \frac{1 \text{ day}}{24r} \times \frac{1 \text{ hr}}{3600 \text{ s}} \times \frac{1609 \text{ m}}{1 \text{ mile}} = 29795 \text{ m/s}$$

5. The Earth will get pulled into the sun.

6. The earth gets pulled very close to the sun and into a very small orbit and the sun also gets pulled and starts travelling is a small circle

7. Looking at the grid there should be equal number of squares between the Earth and Sun as it orbits.

Gravity and Orbits Answers

8. $F = G\frac{mM}{r^2}$ & $F = \frac{mv^2}{r}$ so… $\frac{GmM}{r^2} = \frac{mv^2}{r} \rightarrow v = \sqrt{(GM/r)}$

9. $v = \sqrt{(GM/r)} = \sqrt{\frac{(6.67 \times 10^{-11} Nm^2/kg^2)(1.989 \times 10^{30}\ kg)}{7.4 \times 10^{10} m}} = 42341\ m/s$

10. The Earth will have a larger elliptical path.

11. The sun seems motionless and it takes a long time for the earth to make one full lap.

12. $v = \sqrt{(GM/r)} = \sqrt{\frac{(6.67 \times 10^{-11} Nm^2/kg^2)(1.989 \times 10^{30}\ kg)}{2.22 \times 10^{11} m}} = 24446\ m/s$

Gravity and Orbits Answers

13. The earth will have a small orbit

14. The earth is a small elliptical orbit and the sun moves in small circles as it gets pulled by the earth. The earth's smaller orbit is due to the increased gravity of the much larger sun.

15. $v = \sqrt{(GM/r)} = \sqrt{\dfrac{(6.67 \times 10^{-11} Nm^2/kg^2)(2)(1.989 \times 10^{30}\ kg)}{7.4 \times 10^{10} m}} = 84682\ m/s$

16. The earth will have a much larger elliptical path.

17. The earth flew off the screen and did not return, must have a very large elliptical path

18. $v = \sqrt{(GM/r)} = \sqrt{\dfrac{(6.67 \times 10^{-11} Nm^2/kg^2)(.05)(1.989 \times 10^{30}\ kg)}{7.4 \times 10^{10} m}} = 21171\ m/s$

Gravity and Orbits Answers

19. Heavier earth might get pulled into smaller orbit?

20. Moved the same as it did when it was a normal mass, based on our formula the orbit is independent of the earth's mass.

21. $v = \sqrt{(GM/r)} = \sqrt{\dfrac{(6.67 \times 10^{-11} Nm^2/kg^2)(1.989 \times 10^{30}\ kg)}{7.4 \times 10^{10} m}} = 42341\ m/s$

22. Nothing will happen, it will remain in the same orbit as before.

23. Moved in the same orbit as one earth mass.

24. $v = \sqrt{(GM/r)} = \sqrt{\dfrac{(6.67 \times 10^{-11} Nm^2/kg^2)(1.989 \times 10^{30}\ kg)}{7.4 \times 10^{10} m}} = 42341\ m/s$

Gravity and Orbits Answers

25. The mass of the sun and the distance from the sun.

26. To have a circular orbit you must satisfy the formula $v = \sqrt{(GM/r)}$. So as the mass of the sun or the radius of orbit changes the tangential velocity must also change.

27. Plug the radius into the formula and see if the orbital speeds match. If they do then it is a circular orbit.

Additional Practice

Return to the simulation and work with the moon and earth system and repeat the experiment you just did with the earth and sun.