

DigiLAB

PHET Colorado: https://phet.colorado.edu/sims/html/gravity-and-orbits/latest/gravity-and-orbits_en.html

Select: **Model**

In this simulation the size, distances, and masses are not to scale!

Click the button PLAY/STOP to start/stop simulation.

Before changing any setting, stop the simulation and reset (button with arrow).

Select SUN-EARTH-MOON

Settings: Zoom MAX, Velocity FAST, check PATH and GRID

Start the simulation and look at the trajectory of the Moon. Indeed, the real motion of the Moon around the Sun, while orbiting the Earth, is called **translational** and looks very beautiful!

Switch off gravity, what happens? **The Earth and the Moon stop interact and move on straight away**

Select EARTH-MOON

Settings: Zoom (automatic), Velocity FAST, check PATH and GRID

Start the simulation and look at the Moon moving around the Earth. Is the Earth moving? **Yes**

Can you explain why? **The center of mass, barycentre, is not in the Earth's center.**

What if the Moon fell down?

Increase slightly the mass of the Earth then start the simulation. Observe, stop, and reset.

Repeat several times until you find the maximum value for the Earth's mass preventing the fall of the Moon

Why does the Moon fall when the mass increases? **Gravity force depends on mass**

Maximum secure value for the Earth's mass:

Stop the simulation, and reset. Double the mass of the Earth... you know the Moon will fall, so change any other parameter of the Moon to prevent its fall!

What did you change? How much?

Students will try changing the mass of the Moon. They need to reduce and not increase it. However, the Moon will fall even setting the smallest value of the mass. So they must think about the distance between Earth and Moon. They should increase the distance to balance the increase of the Earth's mass.

They can use the grid to report how much the distance should be increased.

Select: **To scale**

In this simulation the size, distances, and masses are to scale.
The grid reference is 200 000 km (see the grid below).

Select EARTH-MOON

Settings: Zoom MAX, Velocity NORMAL, check PATH, GRID, GRAVITY

Observe the Moon's revolution around the Earth. Draw the orbit and note down the orbital parameters:

period _____
apogee _____
perigee _____

Stop the simulation, and reset. Double the mass of the Moon: how does the gravity force change? Which is the main consequence? **The force increases and the Moon falls down**

Stop the simulation, and reset. Double the mass of the Earth: what happens now? **The force increases but the Moon still orbits around the Earth, the shape of the orbit changes and the velocity of the Moon too.**

Note down the new orbital parameters:

period _____
apogee _____
perigee _____

Will we lose our Moon?

Settings: Zoom MIN, Velocity FAST, check PATH, GRID

Increase slightly the distance of the Moon starting from 2 grid-squares (approximately 400 000 km) then start the simulation. Observe, stop, and reset.

Repeat several times until you find the maximum distance which still keeps the Moon in orbit.

Solution: 3 grid-squares (approximately 600 000 km)