Gravity at a Distance

Read, mark, and graph how gravitational force changes.

PHY.2.10 "Apply the effects of the universal gravitation law to generate a digital/physical graph, and interpret the forces between two masses, acceleration due to gravity, and planetary motion (e.g., situations where g is constant…"

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Circle the force and orbit-speed equations, underline the reason g can be treated as constant during a short fall, and number the table's force entries from 1 (weakest) to 4 (strongest). Use your marks to connect distance, force, and motion.

A Probe Moves Outward

1. Imagine a small probe moving farther from Earth's center while its mass stays fixed. Newton's law gives $F = GMm/r^2$, where M is Earth's mass, m is the probe's mass, and r is their center-to-center distance. The table sets the force at one Earth radius equal to one unit. Earth radii measure distance from the center, not height above the ground.

FORCE ON THE PROBE AT DIFFERENT DISTANCES

Distance from Earth's center (Earth radii)	Force (relative units)
1	1
2	1/4
3	1/9
4	1/16

2. Doubling either mass doubles the gravitational force at a fixed distance. Doubling the center-to-center distance instead cuts that force to one-fourth. Force can be graphed against distance, with distance on the horizontal axis and force on the vertical axis. Join plotted values with a smooth curve rather than straight steps because gravity changes continuously.

3. Near Earth's surface, a short fall changes distance from Earth's center by a tiny fraction, so gravitational acceleration g can be treated as constant. A falling object's gravitational force grows with its mass, but acceleration is force divided by that same mass. For a circular orbit, gravity supplies the inward acceleration, and required speed follows $v^2 = GM/r$.

2 ANSWER WITH EVIDENCE

Use the passage

1. At 2 Earth radii, how many times as strong is the probe's gravitational force as it is at 4 Earth radii? Use the table.

2. At 3 Earth radii, the probe is replaced by one with three times its mass. What is the new force in relative units?

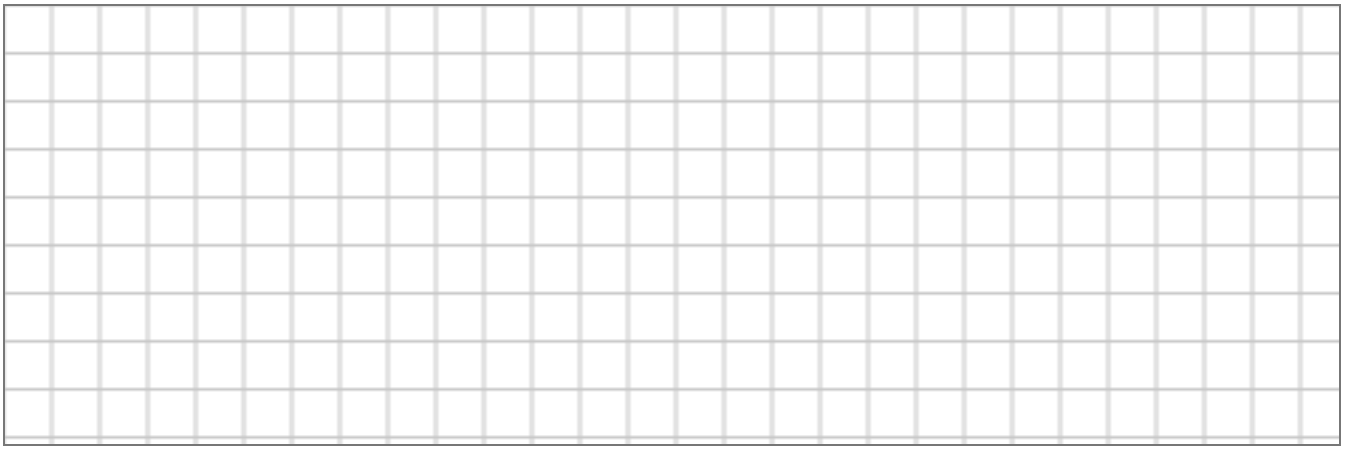
3. A 2 kg ball and a 5 kg ball begin falling near Earth's surface. Ignore air resistance. Which has the greater gravitational force, and how do their accelerations compare?

4. Two probes circle Earth at radii of 2 and 8 Earth radii. How does the speed needed for the smaller circular orbit compare with the speed needed for the larger one?

3 YOUR TURN

Your own words

Imagine a planet with four times Earth's mass but the same radius. On the grid, graph the force on the same probe at distances of 1, 2, 3, and 4 Earth radii, using the table's relative force unit. Label both axes, plot the four calculated points, draw a smooth curve, and write one sentence explaining its shape.



ANSWER KEY

Gravity at a Distance

PART 1 · READ AND MARK

Circle the force and orbit-speed equations, underline the reason g can be treated as constant during a short fall, and number the table's force entries from 1 (weakest) to 4 (strongest). Use your marks to connect distance, force, and motion. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	At 2 Earth radii, how many times as strong is the probe's gravitational force as it is at 4 Earth radii? Use the table.	**Four times as strong: (1/4) ÷ (1/16) = 4.**
2	At 3 Earth radii, the probe is replaced by one with three times its mass. What is the new force in relative units?	**1/3 relative unit, because 3 × 1/9 = 1/3.**
3	A 2 kg ball and a 5 kg ball begin falling near Earth's surface. Ignore air resistance. Which has the greater gravitational force, and how do their accelerations compare?	**The 5 kg ball has 2.5 times the gravitational force. Both have the same acceleration because each ball's force and mass increase by the same factor.**
4	Two probes circle Earth at radii of 2 and 8 Earth radii. How does the speed needed for the smaller circular orbit compare with the speed needed for the larger one?	**The probe at 2 Earth radii needs twice the speed. From $v^2 = GM/r$, its speed squared is four times as great, so its speed is twice as great.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Horizontal axis: distance from the planet's center (Earth radii). Vertical axis: force (relative units). Plot (1, 4), (2, 1), (3, 4/9), and (4, 1/4), then draw a smooth decreasing curve through them. The curve drops because gravitational force decreases with the square of the distance.

Accept equivalent fractions or decimals for force values and reasonable plotting precision. The new planet's mass multiplies each table force by four at the same center-to-center distance.