Gravitational Fields

Problems Worksheet

Step Up In Physics
Unit 3 and 4
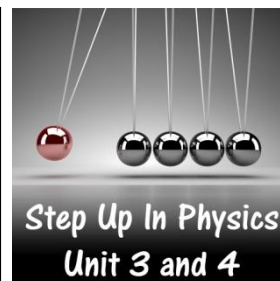
Relevant Data	Gravitational Constant	$6.67 \times 10^{-11} \, \text{m}^3\text{kg}^{-1}\text{s}^{-2}$
	Mass of the Earth	$5.97 \times 10^{24} \, \text{kg}$
	Mass of the Moon	$7.35 \times 10^{22} \, \text{kg}$
	Radius of the Earth	$6.38 \times 10^{6} \, \text{m}$
	Radius of the Moon	$1.74 \times 10^{6} \, \text{m}$
	Mean Earth-Moon distance	$3.84 \times 10^{8} \, \text{m}$

1. What is the size of the force with which the Earth pulls on the Moon?

2. What is the size of the force with which the Moon pulls on the Earth?
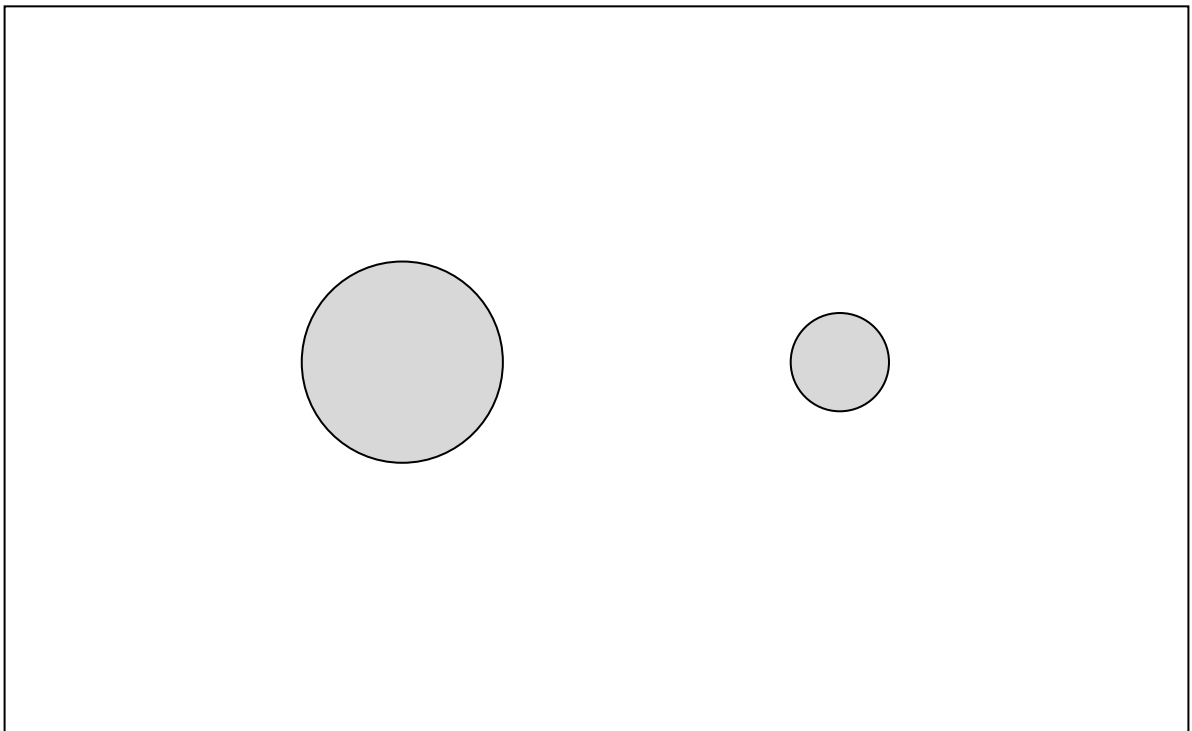
3. The gravitational field strength on the surface of the Earth, or in fact any celestial body, is determined by both mass and density.

    a. Calculate the gravitational field strength on the surface of the Earth.

    b. Compare the gravitational field strength on the surface of the Earth with the surface of the Moon.

c. Explain why both mass and density affect the gravitational field strength at the surface of any celestial body.

d. Explain why the gravitational field strength does not depend on the density of the celestial body as the altitude increases.

4. Draw the gravitational field in the space surrounding the planet and it's moon shown below. Both objects have the same density.

5. Explain what information is contained within a diagram of a gravitational field.

6. Astronauts have performed experiments on the Moon that clearly show a hammer and a feather reaching the surface at the same time when dropped from the same height.
   a. Why is the same observation not made when dropping these items on Earth?

   b. Justify, using relevant physical principles and formulae, why all objects (regardless of their mass) accelerate at the same rate on the Moon.

7. While exploring nearby inhabitable planets, a spaceship feels a gravitational force F at the surface of a planet. What is the force felt at an altitude of twice the radius of the planet compared to at the surface?

8. Calculate the altitude a spaceship needs to reach above Earth such that the force of gravity acting on the spaceship is reduced by 75% compared to when it sits on the surface.

9. Planet Hippo has a mass 1.5 times that of Planet Giraffe but has a radius of only 80% of that compared to Planet Giraffe. What is the gravitational field strength at the surface of Planet Hippo, in terms of the gravitational field strength at the surface of Planet Giraffe?

10. The Sun has a mass of 1.99×10^{30} kg. The Earth orbits around the Sun at a mean distance of 1.50×10^{11} m.
    a. Draw the arrangement of the Earth, it's Moon and the Sun that would result in the largest net gravitational force acting on the Moon.

b. Calculate the magnitude of the net gravitational force in this arrangement.

c. Draw the arrangement of the Earth, it's Moon and the Sun that would result in the smallest net gravitational force acting on the Moon.

d. Calculate the magnitude of the net gravitational force in this arrangement.

e. While solving the previous problems it should have been evident that the Moon is attracted towards the Sun with greater force than towards the Earth. Explain why the Moon does not fly away from the Earth due to this attraction towards the Sun.