

Which requires more fuel—a rocket going from Earth to the Moon or a rocket coming from the Moon to Earth? Why?

If you could somehow tunnel inside a uniform-density star, would your weight increase or decrease? If, instead, you somehow stood on the surface of a shrinking star, would your weight increase or decrease? Why are your answers different?

If our Sun shrank in size to become a black hole, show from the gravitational force equation that Earth's orbit would not be affected.

54. If Earth were hollow but still had the same mass and same radius, would your weight in your present location be more, less, or the same as it is now? Explain.
55. Some people dismiss the validity of scientific theories by saying that they are “only” theories. The law of universal gravity is a theory. Does this mean that scientists still doubt its validity? Explain.
56. Make up two multiple-choice questions—one that would check a classmate's understanding of the inverse-square law and another that would check a distinction between weight and weightlessness.

PROBLEMS

Suppose you stood atop a ladder so tall that you were 3 times as far from Earth's center as you presently are. Show that your weight would be one-ninth of its present value.

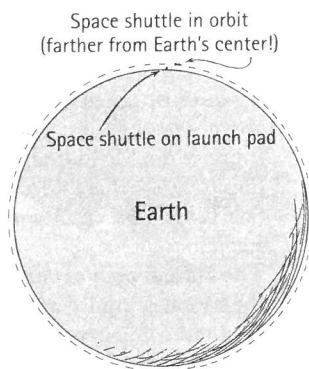
Show that the gravitational force between two planets is quadrupled if the masses of both planets are doubled but the distance between them stays the same.

Show that there is no change in the force of gravity between two objects when their masses are doubled and the distance between them is also doubled.

Find the change in the force of gravity between two planets when distance between them is decreased by 10.

Many people mistakenly believe that the astronauts that orbit Earth are “above gravity.”

Calculate g for space shuttle territory, 200 km



above Earth's surface. Earth's mass is 6.0×10^{24} kg, and its radius is 6.38×10^6 m (6380 km). Your answer is what percentage of 10 m/s^2 ?

- 6. Newton's universal law of gravity tells us that

$$F = G \frac{m_1 m_2}{d^2}. \text{ Newton's second law tells us that } a = \frac{F_{\text{net}}}{m}.$$

- a. With a bit of algebraic reasoning show that your gravitational acceleration toward any planet of mass M a

$$\text{distance } d \text{ from its center is } a = \frac{GM}{d^2}.$$

- b. How does this equation tell you whether or not your gravitational acceleration depends on your mass?



CHAPTER 9 ONLINE RESOURCES



Interactive Figures

1.6, 9.9

Simulations

Motion and Gravity

Orbits

Black Holes

Videos

Newton's Method of Measuring the Attraction

Between Two Masses

Inverse-Square Law

- Apparent Weightlessness
- Weight and Weightlessness
- Gravitational Field Inside a Hollow Planet
- The Weight of an Object Inside a Hollow Planet but Not at Its Center
- Discovery of Neptune

Quizzes

Flashcards

Links

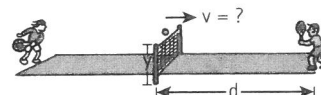
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PROBLEMS

1. A ball is thrown horizontally from a cliff at a speed of 10 m/s. You predict that its speed 1 s later will be slightly greater than 14 m/s. Your friend says it will be 10 m/s. Show who is correct.
2. You're in an airplane that flies horizontally with speed 1000 km/h (280 m/s) when an engine falls off. Neglecting air resistance, assume it takes 30 s for the engine to hit the ground.
 - a. Show that the airplane is 4.5 km high.
 - b. Show that the horizontal distance that the aircraft engine falls is 8400 m.
 - c. If the airplane somehow continues to fly as if nothing had happened, where is the engine relative to the airplane at the moment the engine hits the ground?
3. A cannonball shot with an initial velocity of 141 m/s at an angle of 45° follows a parabolic path and hits a balloon at the top of its trajectory. Neglecting air resistance, show that the cannonball hits the balloon at a speed of 100 m/s.
4. Students in Chuck Stone's lab (Figure 10.5) measure the speed of a steel ball to be 8.0 m/s when launched horizontally from a 1.0-m high tabletop. Their objective is to place a 20-cm tall coffee can on the floor to catch the ball. Show that they score a bull's-eye when the can is placed 3.2 m from the base of the table.
5. At a particular point in orbit a satellite in an elliptical orbit has a gravitational potential energy of 5000 MJ with respect to Earth's surface and a kinetic energy of 4500 MJ. Later in its orbit, the satellite's potential energy is 6000 MJ. What is its kinetic energy at that point?
6. A certain satellite has a kinetic energy of 8 billion joules at perigee (the point at which it is closest to Earth) and

5 billion joules at apogee (the point at which it is farthest from Earth). As the satellite travels from apogee to perigee, how much work does the gravitational force do on it? Does its potential energy increase or decrease during this time, and by how much?

7. Calculate the hang time of a person who moves horizontally 3 m during a 1.25-m high jump. What is the hang time when moving 6 m horizontally during this jump?
- 8. A horizontally moving tennis ball barely clears the net, a distance y above the surface of the court. To land within the tennis court the ball must not be moving too fast.



- a. To remain within the court's border, a horizontal distance d from the bottom of the net, show that the ball's maximum speed over the net is

$$v = \frac{d}{\sqrt{\frac{2y}{g}}}$$

- b. Suppose the height of the net is 1.00 m, and the court's border is 12.0 m from the bottom of the net. Use $g = 10 \text{ m/s}^2$ and show that the maximum speed of the horizontally moving ball clearing the net is about 27 m/s (about 60 mi/h).
- c. Does the mass of the ball make a difference? Defend your answer.

CHAPTER 10 ONLINE RESOURCES

PhysicsPlace.com™

Interactive Figures

- 10.3, 10.4, 10.9, 10.11, 10.13, 10.21, 10.25, 10.33

Tutorials

- Projective Motion
- Orbital Motion

Videos

- Projectile Motion

- More Projectile Motion
- Circular Orbits

Quizzes

Flashcards

Links

EXERCISES

- How many types of atoms can you expect to find in a pure sample of any element?
- How many individual atoms are in a water molecule?
- When a container of gas is heated, what happens to the average speed of its molecules?
- The average speed of a perfume-vapor molecule at room temperature may be about 300 m/s, but you'll find the speed at which the scent travels across the room is much less. Why?
- A cat strolls across your backyard. An hour later, a dog with his nose to the ground follows the trail of the cat. Explain this occurrence from a molecular point of view.
- If no molecules in a body could escape, would the body have any odor?
- Where were the atoms that make up a newborn infant "manufactured"?
- Which of the following is not an element: hydrogen, carbon, oxygen, water?
- Which of the following are pure elements: H_2 , H_2O , He, Na, NaCl, H_2SO_4 , U?
- Your friend says that what makes one element distinct from another is the number of electrons about the atomic nucleus. Do you agree wholeheartedly, partially, or not at all? Explain.
- What is the cause of the Brownian motion of dust particles? Why aren't larger objects, such as baseballs, similarly affected?
- Why don't equal masses of golf balls and Ping-Pong balls contain the same number of balls?
- Why don't equal masses of carbon atoms and oxygen atoms contain the same number of particles?
- Which contains more atoms: 1 kg of lead or 1 kg of aluminum?
- How many atoms are in a molecule of ethanol, C_2H_6O ?
- The atomic masses of two isotopes of cobalt are 59 and 60. (a) What is the number of protons and neutrons in each? (b) What is the number of orbiting electrons in each when the isotopes are electrically neutral?
- A particular atom contains 29 electrons, 34 neutrons, and 29 protons. What is the identity of this element and its atomic number?
- If two protons and two neutrons are removed from the nucleus of an oxygen atom, what nucleus remains?
- What element results if you add a pair of protons to the nucleus of mercury? (See the periodic table.)
- What element results if two protons and two neutrons are ejected from a radium nucleus?
- To become a negative ion, does an atom lose or gain an electron?
- To become a positive ion, does an atom lose or gain an electron?
- You could swallow a capsule of germanium without ill effects. But, if a proton were added to each of the germanium nuclei, you would not want to swallow the capsule. Why? (Consult the periodic table.)
- Helium is an inert gas, meaning that it doesn't readily combine with other elements. What five other elements would you also expect to be inert gases? (See the periodic table.)
- Which of the following elements would you predict to have properties most like those of silicon (Si): aluminum (Al), phosphorus (P), or germanium (Ge)? (Consult the periodic table.)
- A carbon atom, with a half-full outer shell of electrons—four in a shell that can hold eight—readily shares its electrons with other atoms and forms a vast number of molecules, many of which are the organic molecules that form the bulk of living matter. Looking at the periodic table, what other element do you think might play a role like carbon in life forms on some other planet?
- Which contributes more to an atom's mass—electrons or protons? Which contributes more to an atom's size?
- A hydrogen atom and a carbon atom move at the same speed. Which has the greater kinetic energy?
- In a gaseous mixture of hydrogen and oxygen gas, both with the same average kinetic energy, which molecules move faster on average?
- The atoms that constitute your body are mostly empty space, and structures such as the chair you're sitting on are composed of atoms that are also mostly empty space. So why don't you fall through the chair?
- In what sense can you truthfully say that you are a part of every person in history? In what sense can you say that you will tangibly contribute to every person on Earth who will follow?
- What are the chances that at least one of the atoms exhaled by your very first breath will be in your next breath?
- Hydrogen and oxygen always react in a 1:8 ratio by mass to form water. Early investigators thought this meant that oxygen was 8 times more massive than hydrogen. What chemical formula did these investigators assume for water?
- Somebody told your friend that if an antimatter alien ever set foot upon Earth, the whole world would explode into pure radiant energy. Your friend looks to you for verification or refutation of this claim. What do you say?
- Make up a multiple-choice question that will test your classmates on the distinction between any two terms in the Summary of Terms list.

CHAPTER 11 ONLINE RESOURCES

Videos

- Evidence for Atoms
- Atoms Are Recyclable

Quizzes

Flashcards

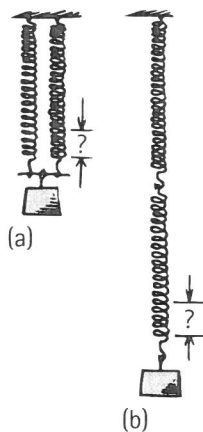
Links



41. Why are mittens warmer than gloves on a cold day? And which parts of the body are most susceptible to frostbite? Why?
42. What is the advantage to a gymnast of being short in stature?
43. How does scaling relate to the fact that the heartbeat of large creatures is generally slower than the heartbeat of smaller creatures?
44. Nourishment is obtained from food through the inner surface area of the intestines. Why is it that a small organism, such as a worm, has a simple and relatively straight intestinal tract, while a large organism, such as a human being, has a complex and extensively folded intestinal tract?
45. The human lungs have a volume of only about 4 L, yet an internal surface area of nearly 100 m^2 . Why is this important, and how is this possible?
46. What does the concept of scaling have to do with the fact that living cells in a whale are about the same size as those in a mouse?
47. Which fall faster, large or small raindrops?
48. Who has more need for drink in a dry desert climate, a child or an adult?
49. Why doesn't a hummingbird soar like an eagle and an eagle flap its wings like a hummingbird?
50. Can you relate the idea of scaling to the governance of small versus large groups of citizens? Explain.

PROBLEMS

1. Show that the density of a 5-kg solid cylinder that is 10 cm tall with a radius of 3 cm is 17.7 g/cm^3 .
2. What is the weight of a cubic meter of cork? Could you lift it? (For the density of cork, use 400 kg/m^3 .)
3. A certain spring stretches 6 cm when a load of 30 N is suspended from it. How much will the spring stretch if 50 N is suspended from it (and it doesn't reach its elastic limit)?
4. Consider a spring that stretches 4 cm when a load of 10 N is suspended from it. How much will the spring stretch if an identical spring also supports the load as shown in (a) and (b)? (Neglect the weights of the springs.)
5. A cube 2 cm on a side is cut into cubes 1 cm on a side.
 - a. How many cubes result?
 - b. What was the surface area of the original cube and what is the total surface area of the eight smaller cubes? What is the ratio of surface areas?
 - c. Show that the surface-to-volume ratio of the smaller cube is twice as great as for the single larger cube.
6. A 19.3-g mass of gold in the form of a cube is 1 cm long on each side (somewhat smaller than a sugar cube). What would be the length of the sides of a cube having twice this mass of gold?
7. In 2009, one of the U.S. government's bailout packages was \$700 billion when gold was worth \$800 per ounce (\$28.20 per gram). Calculate the mass in grams of \$700 billion worth of gold. If this amount of gold were in the shape of a cube, how long would each of its sides be?



CHAPTER 12 ONLINE RESOURCES



Interactive Figure

12.16

Videos

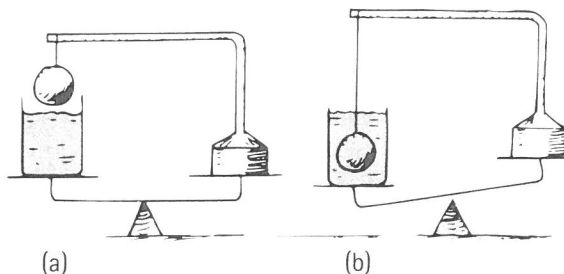
- Scaling
- Surface Area vs. Volume

Quizzes

Flashcards

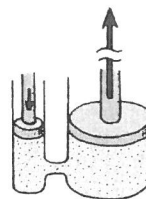
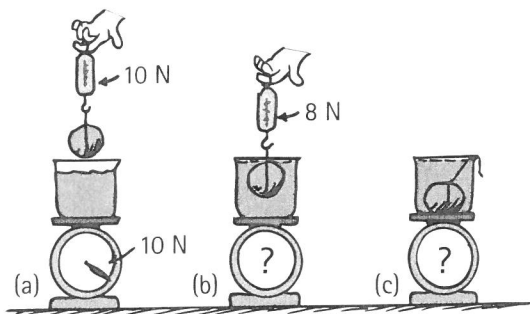
Links

60. The weight of the container of water, as shown in (a), is equal to the weight of the stand and the suspended solid iron ball. When the suspended ball is lowered into the water, as shown in (b), the balance is upset. Challenge your friends and ask if the additional weight needed on the right side to restore balance is greater than, equal to, or less than the weight of the solid iron ball.



PROBLEMS

1. Calculate the average force per nail when Sarah (Figure 13.2), who weighs 120 pounds, lies on a bed of nails and is supported by 600 nails.
2. Suppose that you balance a 5-kg ball on the tip of your finger, which has an area of 1 cm^2 . Show that the pressure on your finger is 50 N/cm^2 , which is 500 kPa .
3. A 6-kg piece of metal displaces 1 L of water when submerged. Show that its density is 6000 kg/m^3 . How does this compare with the density of water?
4. A dike in Holland springs a leak through a hole of area 1 cm^2 at a depth of 2 m below the water surface. How much force must a boy apply to the hole with his thumb to stop the leak? Could he do it?
5. In lab you find that a 1-kg rock suspended above water weighs 10 N. When the rock is suspended beneath the surface of the water, the scale reads 8 N.
 - a. What is the buoyant force on the rock?
 - b. If the container of water weighs 10 N on the weighing scale, what is the scale reading when the rock is suspended beneath the surface of the water?
 - c. What is the scale reading when the rock is released and rests at the bottom of the container?
6. A merchant in Katmandu sells you a solid gold 1-kg statue for a very reasonable price. When you get home, you wonder whether or not you got a bargain, so you lower the statue into a container of water and measure the volume of displaced water. Show that, for pure gold, the volume of water displaced will be 51.8 cm^3 .
7. In the sketch, the small hydraulic piston has a diameter of 2 cm. The large piston has a diameter of 6 cm. For each newton of force applied to the small piston, how many newtons of force are exerted by the large piston?



- 8. Your friend of mass 100 kg can just barely float in fresh-water. Calculate her approximate volume.

CHAPTER 13 ONLINE RESOURCES

Interactive Figures

- 13.9, 13.14

Videos

- Dam
- Buoyancy
- Archimedes' Principle
- Flotation

Quizzes

Flashcards

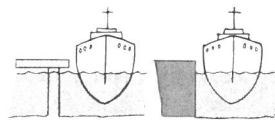
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landings? Why are these flaps pulled in when the airplane has reached cruising speed?

51. How is an airplane able to fly upside down?
52. Why are runways longer for takeoffs and landings at high-altitude airports, such as those in Denver and Mexico City?
53. How will two dangling vertical sheets of paper move when you blow between them? Try it and see.
54. What physics principle underlies these three observations? When passing an oncoming truck on the highway, your car tends to sway toward the truck. The canvas roof of a convertible automobile bulges upward when the car is traveling at high speeds. The windows of older trains sometimes break when a high-speed train passes by on the next track.

55. Wharves are made with pilings that permit the free passage of water. Why would a solid-walled wharf be disadvantageous to ships attempting to pull alongside?



56. Is lower pressure the result of fast-moving air, or is fast-moving air the result of lower pressure? Give one example supporting each point of view. (In physics, when two things are related—such as force and acceleration or speed and pressure—it is usually arbitrary which one we call *cause* and which one we call *effect*.)

PROBLEMS

1. What change in pressure occurs in a party balloon that is squeezed to one-third its volume with no change in temperature?
2. Estimate the buoyant force that air exerts on you. (To do this, you can estimate your volume by knowing your weight and by assuming that your weight density is a bit less than that of water.)
3. A mountain-climber friend with a mass of 80 kg ponders the idea of attaching a helium-filled balloon to himself to effectively reduce his weight by 25% when he climbs. He wonders what the approximate size of such a balloon would be. Hearing of your physics skills, he asks you. Share with him your calculations that show the volume of the balloon to be about 17 m^3 (slightly more than 3 m in diameter for a spherical balloon).
4. On a perfect fall day, you are hovering at low altitude in a hot-air balloon, accelerated neither upward nor downward. The total weight of the balloon, including its load and the hot air in it, is 20,000 N.
 - a. Show that the weight of the displaced air is 20,000 N.
 - b. Show that the volume of the displaced air is 1700 m^3 .
5. Consider an airplane with a total wing surface of 100^2 m^2 . At a certain speed the difference in air pressure below and above the wings is 4% of atmospheric pressure. Show that the lift on the airplane is 400,000 N.
6. The weight of the atmosphere above 1 m^2 of Earth's surface is about 100,000 N. Density, of course, becomes less with altitude. But suppose the density of air were a constant 1.2 kg/m^3 . Calculate where the top of the atmosphere would be.

CHAPTER 14 ONLINE RESOURCES

Videos

- Air Has Weight
- Air Is Matter
- Air Has Pressure
- Buoyancy of Air

Quizzes

Flashcards

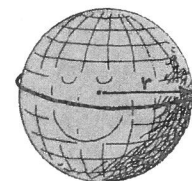
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55. What happens to the volume of water as it is cooled from 3°C to 1°C ?
56. How does the combined volume of the billions and billions of hexagonal open spaces in the structures of ice crystals in a piece of ice compare with the portion of ice that floats above the waterline?
57. State whether water at the following temperatures will expand or contract when warmed a little: 0°C ; 4°C ; 6°C .
58. Why is it important to protect water pipes in the winter so that they don't freeze?
59. If water had a lower specific heat capacity, would ponds be more likely to freeze or less likely to freeze?
60. If cooling occurred at the bottom of a pond instead of at the surface, would the pond freeze from the bottom up? Explain.

PROBLEMS

1. What would be the final temperature of a mixture of 50 g of 20°C water and 50 g of 40°C water?
2. Suppose that a brass rod 1.0 m long expands 0.5 cm when its temperature is increased a certain amount. By how much will a brass rod 100 m long expand with the same change of temperature?
3. Steel expands 11 parts in a million for each 1°C change. Think about the 1.3-km main span of steel for the Golden Gate Bridge. If the span had no expansion joints, show that the span would be 0.21 m longer for a 15°C increase in temperature. [Use the formula $\Delta L = \alpha L_o \Delta T$, where L_o is the original length, α is the "coefficient of expansion" that for steel is $(1/1,000,000)$ per $^{\circ}\text{C}$, and ΔT is the change in temperature.]
4. Consider a 40,000-km steel pipe that forms a ring to fit snugly all around the circumference of the Earth. Suppose people along its length breathe on it so as to raise its temperature 1°C . The pipe gets longer. It also is no longer snug. How high does it stand above ground level? (To simplify, consider only the expansion of its radial distance from the center of Earth, and apply the geometry formula that relates circumference C and radius r , $C = 2\pi r$. The result is surprising!)



CHAPTER 15 ONLINE RESOURCES

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Videos

- Low Temperatures with Liquid Nitrogen
- How a Thermostat Works

Quizzes

Flashcards

Links