6. Frog Population The frog population in a small pond grows exponentially. The current population is 85 frogs, and the relative growth rate is 18% per year.

(a) Find a function that models the population after t years.

(b) Find the projected population after 3 years.

(c) Find the number of years required for the frog population to reach 600.

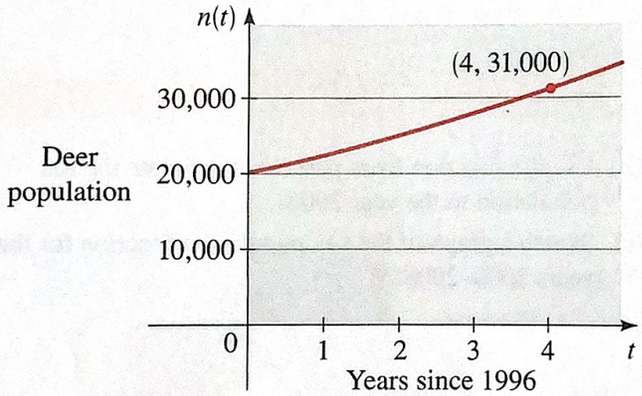
7. Deer Population The graph shows the deer population in a Pennsylvania county between 1996 and 2000. Assume that the population grows exponentially.

(a) What was the deer population in 1996?

(b) Find a function that models the deer population t years after 1996.

(c) What is the projected deer population in 2004?

(d) In what year will the deer population reach 100,000?



8. Bacteria Culture A culture contains 1500 bacteria initially and doubles every 30 min.

(a) Find a function that models the number of bacteria $n(t)$ after t minutes.

(b) Find the number of bacteria after 2 hours.

(c) After how many minutes will the culture contain 4000 bacteria?

9. Bacteria Culture A culture starts with 8600 bacteria. After one hour the count is 10,000.

(a) Find a function that models the number of bacteria $n(t)$ after t hours.

(b) Find the number of bacteria after 2 hours.

(c) After how many hours will the number of bacteria double?

10. Bacteria Culture The count in a culture of bacteria was 400 after 2 hours and 25,600 after 6 hours.

(a) What is the relative rate of growth of the bacteria population? Express your answer as a percentage.

(b) What was the initial size of the culture?

(c) Find a function that models the number of bacteria $n(t)$ after t hours.

(d) Find the number of bacteria after 4.5 hours.

(e) When will the number of bacteria be 50,000?

11. World Population The population of the world was 5.7 billion in 1995 and the observed relative growth rate was 2% per year.

(a) By what year will the population have doubled?

(b) By what year will the population have tripled?

12. Population of California The population of California was 10,586,223 in 1950 and 23,668,562 in 1980. Assume the population grows exponentially.

(a) Find a function that models the population t years after 1950.

(b) Find the time required for the population to double.

(c) Use the function from part (a) to predict the population of California in the year 2000. Look up California's actual population in 2000, and compare.

13. Infectious Bacteria An infectious strain of bacteria increases in number at a relative growth rate of 200% per hour. When a certain critical number of bacteria are present in the bloodstream, a person becomes ill. If a single bacterium infects a person, the critical level is reached in 24 hours. How long will it take for the critical level to be reached if the same person is infected with 10 bacteria?

14–22 ■ These exercises use the radioactive decay model.

14. Radioactive Radium The half-life of radium-226 is 1600 years. Suppose we have a 22-mg sample.

(a) Find a function that models the mass remaining after t years.

(b) How much of the sample will remain after 4000 years?

(c) After how long will only 18 mg of the sample remain?

15. Radioactive Cesium The half-life of cesium-137 is 30 years. Suppose we have a 10-g sample.

(a) Find a function that models the mass remaining after t years.

(b) How much of the sample will remain after 80 years?

(c) After how long will only 2 g of the sample remain?

16. Radioactive Thorium The mass $m(t)$ remaining after t days from a 40-g sample of thorium-234 is given by

$$m(t) = 40e^{-0.0277t}$$

(a) How much of the sample will remain after 60 days?

(b) After how long will only 10 g of the sample remain?

(c) Find the half-life of thorium-234.

17. Radioactive Strontium The half-life of strontium-90 is 28 years. How long will it take a 50-mg sample to decay to a mass of 32 mg?

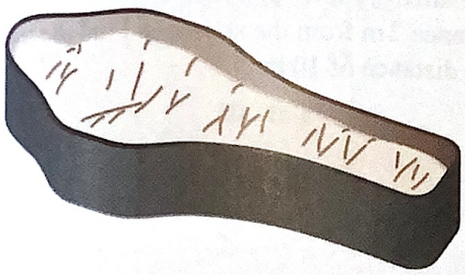
18. **Radioactive Radium** Radium-221 has a half-life of 30 s. How long will it take for 95% of a sample to decay?

19. **Finding Half-life** If 250 mg of a radioactive element decays to 200 mg in 48 hours, find the half-life of the element.

20. **Radioactive Radon** After 3 days a sample of radon-222 has decayed to 58% of its original amount.
(a) What is the half-life of radon-222?
(b) How long will it take the sample to decay to 20% of its original amount?

21. **Carbon-14 Dating** A wooden artifact from an ancient tomb contains 65% of the carbon-14 that is present in living trees. How long ago was the artifact made? (The half-life of carbon-14 is 5730 years.)

22. **Carbon-14 Dating** The burial cloth of an Egyptian mummy is estimated to contain 59% of the carbon-14 it contained originally. How long ago was the mummy buried? (The half-life of carbon-14 is 5730 years.)



23–26 ■ These exercises use Newton's Law of Cooling.

23. **Cooling Soup** A hot bowl of soup is served at a dinner party. It starts to cool according to Newton's Law of Cooling so that its temperature at time t is given by

$$T(t) = 65 + 145e^{-0.05t}$$

where t is measured in minutes and T is measured in °F.
(a) What is the initial temperature of the soup?
(b) What is the temperature after 10 min?
(c) After how long will the temperature be 100 °F?

24. **Time of Death** Newton's Law of Cooling is used in homicide investigations to determine the time of death. The normal body temperature is 98.6 °F. Immediately following death, the body begins to cool. It has been determined experimentally that the constant in Newton's Law of Cooling is approximately $k = 0.1947$, assuming time is measured in hours. Suppose that the temperature of the surroundings is 60 °F.
(a) Find a function $T(t)$ that models the temperature t hours after death.
(b) If the temperature of the body is now 72 °F, how long ago was the time of death?

25. **Cooling Turkey** A roasted turkey is taken from an oven when its temperature has reached 185 °F and is placed on a table in a room where the temperature is 75 °F.
(a) If the temperature of the turkey is 150 °F after half an hour, what is its temperature after 45 min?
(b) When will the turkey cool to 100 °F?

26. **Boiling Water** A kettle full of water is brought to a boil in a room with temperature 20 °C. After 15 min the temperature of the water has decreased from 100 °C to 75 °C. Find the temperature after another 10 min. Illustrate by graphing the temperature function.

27–41 ■ These exercises deal with logarithmic scales.

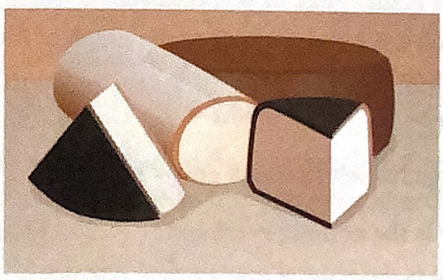
27. **Finding pH** The hydrogen ion concentration of a sample of each substance is given. Calculate the pH of the substance.
(a) Lemon juice: $[H^+] = 5.0 \times 10^{-3}$ M
(b) Tomato juice: $[H^+] = 3.2 \times 10^{-4}$ M
(c) Seawater: $[H^+] = 5.0 \times 10^{-9}$ M

28. **Finding pH** An unknown substance has a hydrogen ion concentration of $[H^+] = 3.1 \times 10^{-8}$ M. Find the pH and classify the substance as acidic or basic.

29. **Ion Concentration** The pH reading of a sample of each substance is given. Calculate the hydrogen ion concentration of the substance.
(a) Vinegar: pH = 3.0
(b) Milk: pH = 6.5

30. **Ion Concentration** The pH reading of a glass of liquid is given. Find the hydrogen ion concentration of the liquid.
(a) Beer: pH = 4.6
(b) Water: pH = 7.3

31. **Finding pH** The hydrogen ion concentrations in cheeses range from 4.0×10^{-7} M to 1.6×10^{-5} M. Find the corresponding range of pH readings.



32. **Ion Concentration in Wine** The pH readings for wines vary from 2.8 to 3.8. Find the corresponding range of hydrogen ion concentrations.

33. **Earthquake Magnitudes** If one earthquake is 20 times as intense as another, how much larger is its magnitude on the Richter scale?

34. **Earthquake Magnitudes** The 1906 earthquake in San Francisco had a magnitude of 8.3 on the Richter scale. At the same time in Japan an earthquake with magnitude 4.9