Period 1: Review of Physics 103

1.1 Ratios and "per"

How can ratios be used for problem solving?

1.2 Efficiency

How are ratios used to calculate efficiency?

1.3 Exponents and Scientific Notation

How is scientific notation used?

1.4 Exponential Growth and Decay

What is the difference between exponential growth and exponential decay?

How do graphs illustrate these rates?

Activity 1.1: Ratio Reasoning

Ratios are fractions, such as 20 miles/1 gallon of gas (20 miles per gallon).

- **Ratios are useful when making comparisons.**

  If a truck requires 3 liters of gasoline to travel 15 kilometers, how many kilometers per liter does the truck get?

$$\frac{15\text{ km}}{3\text{ liters}} = \frac{5\text{ km}}{\text{liter}}$$

- **Ratios allows you to convert units.**

  There are 1,609 meters per 1 mile. Use ratios to convert 60 miles per hour into meters per second.

$$\frac{60\ \cancel{\text{miles}}}{1\ \cancel{\text{hour}}} \times \frac{1{,}609\text{ meters}}{1\ \cancel{\text{mile}}} \times \frac{1\ \cancel{\text{hour}}}{3{,}600\text{ sec}} = \frac{27\text{ meters}}{1\text{ sec}}$$

- **Ratios may involve the amount of a quantity per unit of time. This ratio is called a rate.**

Miles / hour

Using Ratios to Calculate the Cost of Electricity or Gas

Example 1: **Find the total cost of electricity**

If electricity costs 7.5 cents/kWh, what is the cost of 0.44 kWh of electricity?

$$0.44\ \cancel{\text{kWh}} \times \frac{\$0.075}{\cancel{\text{kWh}}} = \$0.033$$

Example 2: **Find the cost per kilowatt hour**

If 0.44 kWh of electricity costs 3.3 cents, what is the cost of electricity per kWh?

$$\$0.033 \times \frac{1}{0.44\ \text{kWh}} = \frac{\$0.075}{\text{kWh}}$$

Example 3: **Find the kWh used.**

If electricity costs 7.5 cents/kWh, how many kWh can you buy for 3.3 cents?

$$\cancel{\$}\,0.033 \times \frac{1\ \text{kWh}}{\cancel{\$}0.075} = 0.44\ \text{kWh}$$

The same type of calculation may be used to find the cost per 100 cubic feet (ccf) of natural gas.

Act 1.2: Using Ratios to Find Efficiency

Efficiency is a ratio of two quantities.

In terms of energy, efficiency is the ratio of the useful energy out of the system per total energy put into the system.

$$\text{Efficiency} = \frac{\text{Useful Energy Out}}{\text{Total Energy In}}$$

Efficiency can also be written as the ratio of two amounts of work in units of joules

$$\text{Efficiency} = \frac{\text{Work Out}}{\text{Work In}}$$

or efficiency can be the ratio of two amounts of power in units of watts:

$$\text{Efficiency} = \frac{\text{Power Out}}{\text{Power In}}$$

Measuring Power with a Wattmeter

1) Plug the wattmeter into the power strip and turn it on.

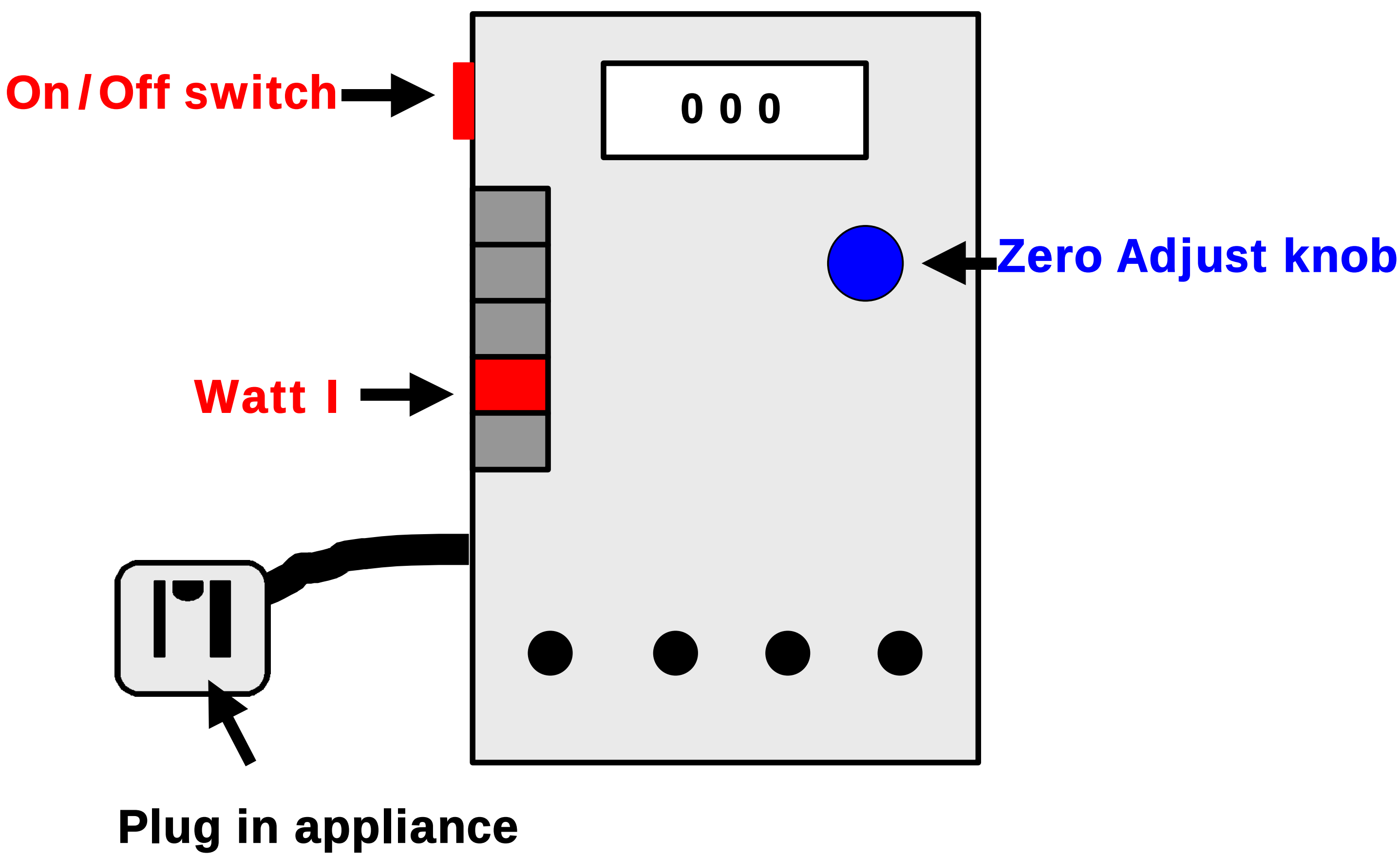
2) Press the "Watt I" button.

3) Clear the meter by adjusting the Zero Adjust knob until the display reads 0 0 0.

4) Plug the appliance into the outlet in the cord attached to the wattmeter.

5) Read the power requirement.

6) Turn the meter OFF when you finish!



Activity 1.3: Scientific Notation

- Scientific notation uses the base 10 raised to an exponent.
- The exponent shows the number of times that 10 is multiplied by itself.

$10^{1} = 10$

$10^{2} = 10 \times 10 = 100$

$10^{3} = 10 \times 10 \times 10 = 1{,}000$

$10^{-1} = 1/10 = 0.1$

$10^{-2} = 1/(10 \times 10) = 0.01$

$10^{-3} = 1/(10 \times 10 \times 10) = 0.001$

1) For numbers equal to or greater than one (positive exponents), count the places the decimal point is shifted to the **left.**

$$2{,}600.0 = 2.6 \times 10^{3}$$

2) For numbers less than one (negative exponents), count the number of places the decimal point is shifted to the **right.**

$$0.035 = 3.5 \times 10^{-2}$$

Rules for Using Numbers with Exponents

1. When **multiplying** numbers with exponents, **add** the exponents

$$10^{A} \times 10^{B} = 10^{(A + B)}$$

$$10^{2} \times 10^{-3} = 10^{(2 + (-3))} = 10^{-1} = 1/10 = 0.1$$

2. When **dividing** numbers with exponents, **subtract** the exponents

$$10^{A} / 10^{B} = 10^{(A - B)}$$

$$10^{2} / 10^{-3} = 10^{(2 - (-3))} = 10^{5} = 100{,}000$$

3. When raising numbers with an exponent to a power, multiply the exponents.

$$(10^{A})^{B} = 10^{(A \times B)}$$

$$(10^{3})^{2} = 10^{(2 \times 3)} = 10^{6} = 1{,}000{,}000$$

4. Any number to the zero power = 1:

$$10^{0} = 1 \quad 237^{0} = 1$$

Scientific Notation and Calculators

1. To enter a number in scientific notation, press the 10^X key and enter the exponent.

2. If the 10^X symbol is above a key, press [2nd F] before pressing the 10^X key.

   To enter 8×10^{12}, press [8] [X] [10^X] [1] [2]

   To enter 3×10^{-6}, press [3] [X] [10^X] [+/-] [6]

3. Some calculators use reverse notation. The exponent is entered before the 10^X key is pressed.

To enter 3×10^{-6}, press [3] [X] [6] [+/-] [10^X] [=]

The TI-25X solar calculators use reverse notation.

4. If your calculator has an EE or EXP key, press that key and then enter the exponent.

To enter 3×10^{-6}, press [3] [EE] or [EXP] and [+/-] [6]

5. A calculator's [y^X] key does NOT give powers of 10.

   For example, 3.4^8 is NOT the same as 3.4×10^8

Some Useful Equations...

Kinetic energy of motion: $E_{kin} = \frac{1}{2} M v^2$

E_{kin} = kinetic energy (joules)

M = mass (kilograms)

v = speed (meters/sec)

acceleration: $a = (V_{final} - V_{initial}) / t$

a = acceleration (meters/sec^2)

v = speed (meters/sec)

t = time (seconds)

Newton's second law: $F = M a$

F = net force (newtons)

M = mass (kilograms)

a = acceleration (meters/sec^2)

Gravitational force: $$F = \frac{G M_1 M_2}{D^2}$$

F = Gravitational force (newtons)

M_1 = Mass of object 1 (kilograms)

M_2 = Mass of object 2 (kilograms)

D = Distance between the centers of mass of the objects (meters)

G = Gravitational constant of the universe
6.67×10^{-11} (N m^2/kg^2)

Electric Current

$$\text{Current} = \frac{\text{Amount of Charge moved}}{\text{Elapsed Time}}$$

$$I = \frac{Q}{t}$$

I = current (in amperes)

Q = charge (in coulombs)

t = time elapsed (in seconds)

How much charge must flow to provide a current of 10 amps for 20 seconds?

Solve the current equation for *Q* by multiplying both sides by *t*:

$$Q = I\ t = 10 \text{ amps} \times 20 \text{ sec} = 200 \text{ coul}$$

Induced Current and Magnetism

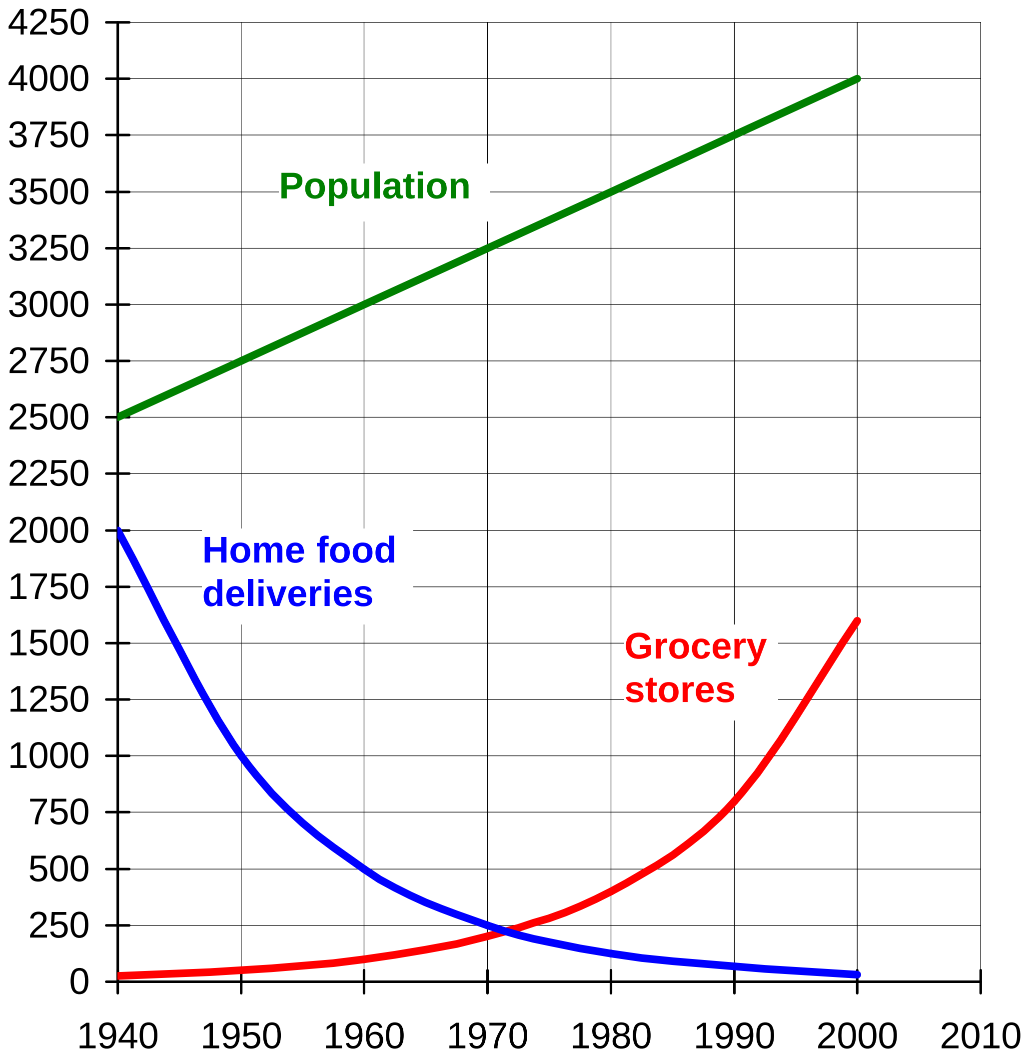
A changing magnetic field induces a current in a wire.

The induced current in the wire induces a magnetic field around the wire.

The induced magnetic field around the wire interacts with the original changing magnetic field, producing a repulsive force on the wire.

Act 1.4: Linear and Exponential Graphs

Trends in Grocery Shopping



How has the population grown since 1940?

How has home delivery of food changed?

How has the number of stores selling food changed?

Act 1.4: Growth Rates

Linear Growth

- Linear growth is constant. Its graph is a straight line because the same amount is added during each time period.
- The amount added is independent of the initial amount and the number of elapsed time periods.

Exponential Growth

- The graph of exponential growth is has an upward curving line because the amount added increases with each time period.
- Exponential growth doubles the amount of the quantity during a fixed time period, the doubling time.

Exponential Decay

- The graph of exponential growth is has a downward curving line because the amount added decreases with each time period.
- Exponential decay cuts in half the amount of the quantity during a fixed time period, the halving time.

Growth Rate Equations

Linear growth is expressed by

$$N = A \times t + B$$

Exponential growth is expressed by

$$N = B \times 2^{t}$$

Exponential decay is expressed by

$$N = B \times 2^{-t}$$

where N = the amount of the quantity

A = the amount of increase per time period

B = the initial amount

t = the number of time periods elapsed

(We assume there is one doubling or one halving per each elapsed time period.)

Growth Rates and Doubling Times

Annual Growth Rate (in percent)	Doubling Time (in years)		Annual Growth Rate (in percent)	Doubling Time (in years)
0	Infinite		20	3.8
1	69.7		30	2.6
2	35.0		40	2.1
3	23.4		50	1.7
4	17.7		60	1.5
5	14.2		70	1.3
6	11.9		80	1.2
7	10.2		90	1.1
8	9.0		100	1.0
9	8.0		200	0.6
10	7.3		300	0.5
12	6.1		400	0.4
14	5.3		900	0.3
16	4.7		9900	0.15
18	4.2			

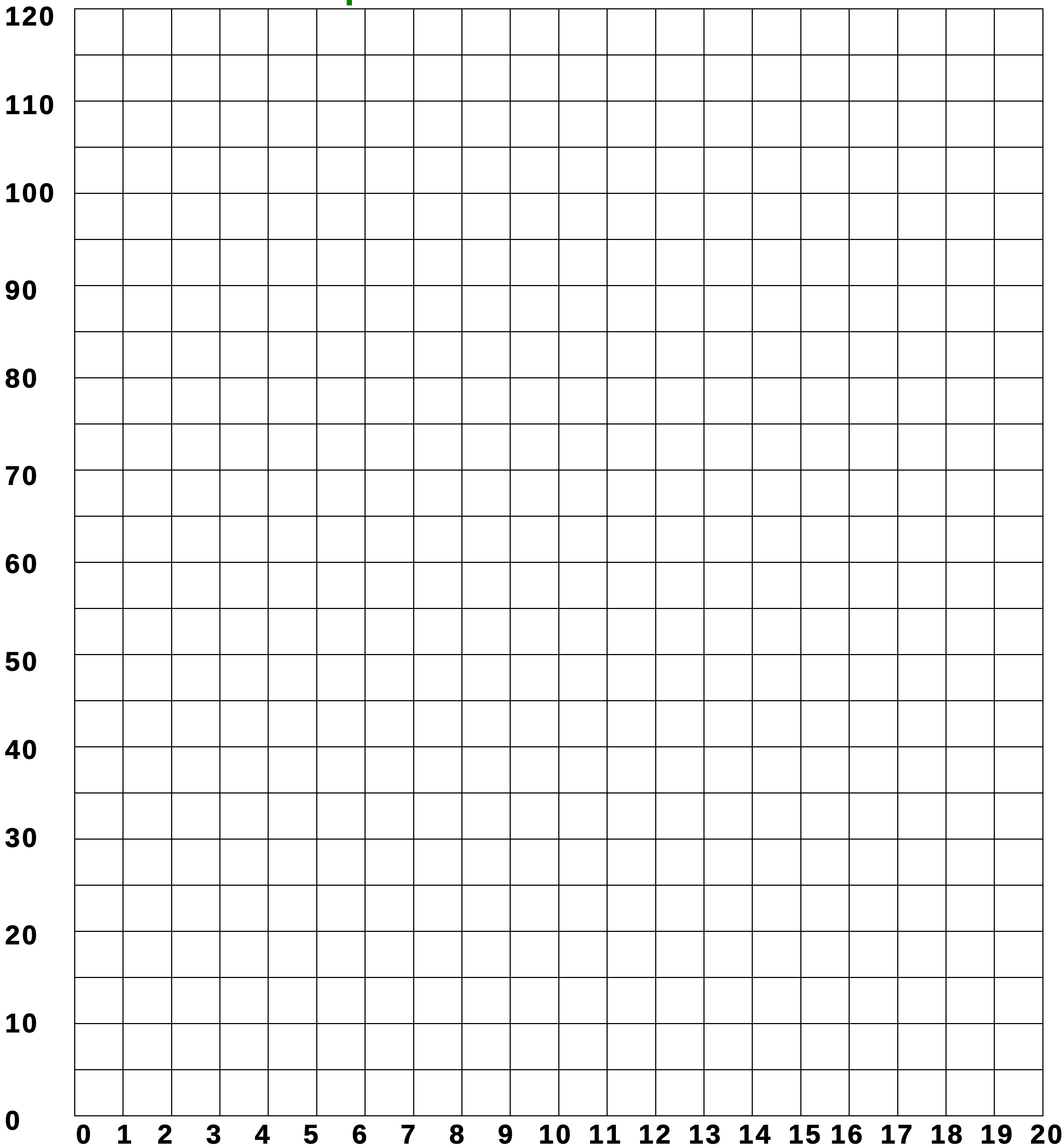
a) **If you invest $1,000 at 10% interest compounded annually, how long will it take for your money to double to $2,000?**

b) **If a stock doubles in value every 2.1 years, what is its rate of growth?**

Act. 1.5 Dice left after each roll

Roll	Table 1	Table 2	Table 3	Table 4	Table 5	All tables
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Act. 1.5 Graph of dice left after each roll



Summary of Period 1

1.2-1.3 The concept of *per* is represented by a ratio: one quantity divided by another.

When converting units, use ratios that allow you to cancel the unwanted units.

Ratios can be used to find rates or efficiencies.

1.4 Powers of 10 simplify calculations with large or small numbers. When multiplying, add exponents. When dividing, subtract exponents.

1.5 Linear growth adds a constant amount of the quantity during each time period.

$$N = A \times t + B$$

Exponential growth doubles the amount of the quantity in a fixed time period called the doubling time. $N = B \times 2^{t}$

Exponential decay reduces the amount of the quantity in a fixed time period called the halving time. $N = B \times 2^{-t}$

where N = the amount of the quantity

A = the amount of increase per period

B = the initial amount

t = the number of time periods elapsed

Period 1 Review Questions

R.1 **When using ratio reasoning to solve a problem, how do you decide which value to put in the numerator and which in the denominator of each ratio? Explain your answer by finding the cost of operating a 1,000 watt microwave oven for 15 minutes per day every day for a year, if electricity costs $0.10 / kWh.**

R.2 **Explain how to tell whether a graph exhibits linear or exponential growth rates. Does every growth rate fit into one of these two types?**

R.3 **What determines the amount added during each time period to a quantity that is growing linearly? What determines the amount added during each time period to a quantity that is growing exponentially?**

R.4 **What is the doubling time of a quantity? How long will it take a stock that increases in value at a rate of 10 % per year to double in value?**

R.5 **What is the halving time of a quantity? How long will it take a stock that decreases in value at a rate of 12 % per year to reach one-half of its original value?**