Period 1: Introduction to Physics 104

1.1 Ratios and efficiency

How can ratios be used for problem solving and to calculate efficiency?

1.2 Exponential Growth and Decay

What is the difference between exponential growth and exponential decay?

1.3 Electric Chage and Current

How is electric generated?

1.4 Radiant Energy and the Electromagnetic Spectrum

What do radio waves, microwaves, infrared radiation, visible light, ultraviolet light, X-rays, and gamma rays have in common?

Review of Ratio Reasoning and Efficiency

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

- Ratios are useful when making comparisons.

  15 km/ 3 liters = 5 km/ liter

- Ratios allow you to convert units.

$$\frac{45 \text{ miles}}{1 \text{ hour}} \times \frac{1{,}609 \text{ meters}}{1 \text{ mile}} \times \frac{1 \text{ hour}}{3{,}600 \text{ sec}} = \frac{20 \text{ meters}}{\text{sec}}$$

- Ratios can be used to find the cost of using electrical energy:

$$\frac{\$0.10}{\text{kWh}} \times 0.600 \text{ kW} \times 2 \text{ h} = \$0.12$$

- Efficiency is the ratio of the useful energy out of the system per total energy put into the system.

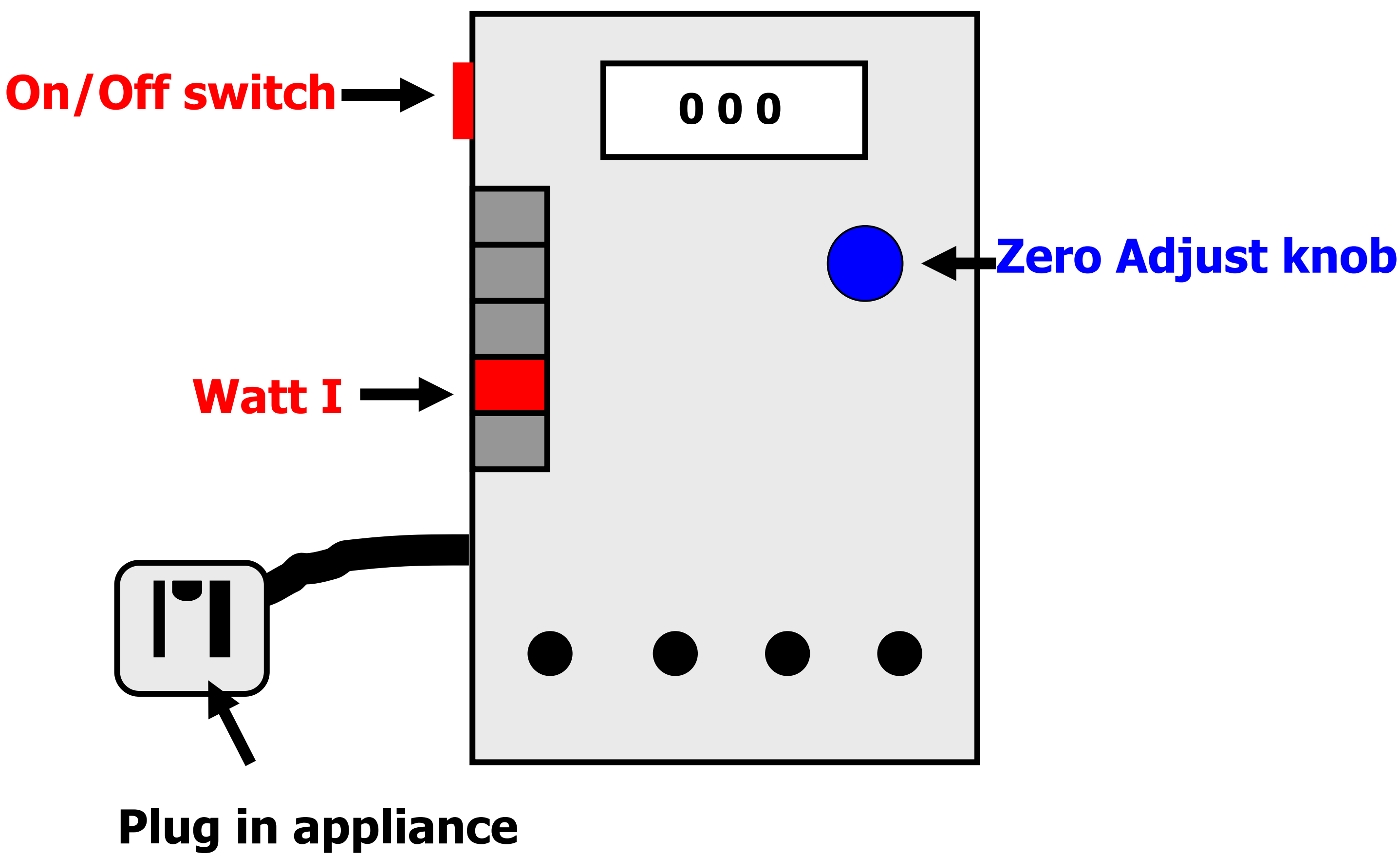
$$\textbf{Efficiency} = \frac{\textbf{Useful Energy Out}}{\textbf{Total Energy In}}$$

  Efficiency can also be written as the ratio of power in units of watts:

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

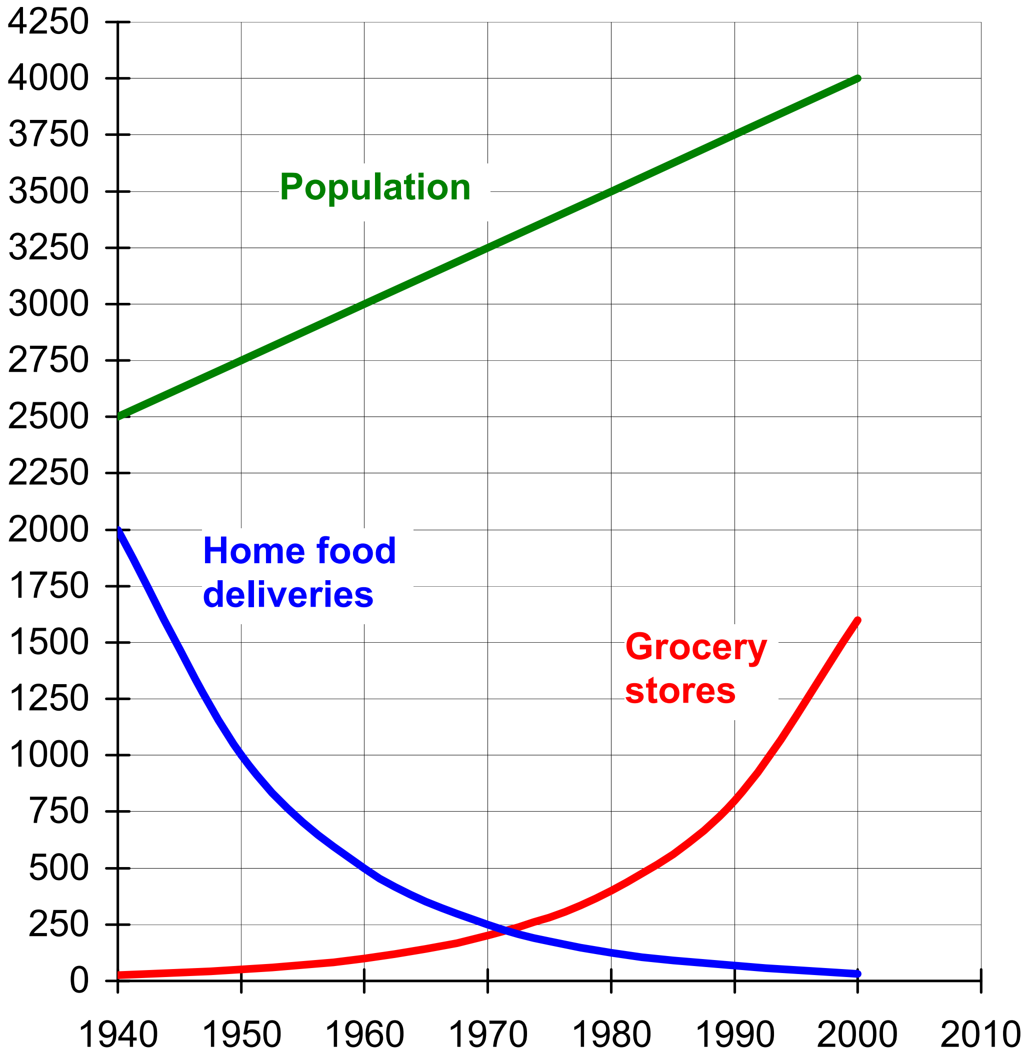
Measuring Power with a Wattmeter

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!



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?

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

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

Exponential growth is expressed by

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

Exponential decay is expressed by

$$N = B \times 2^{-a} = B \times (1/2^{a})$$

where N = the amount of the quantity

A = the amount of increase per time period

B = the initial amount

a = 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			

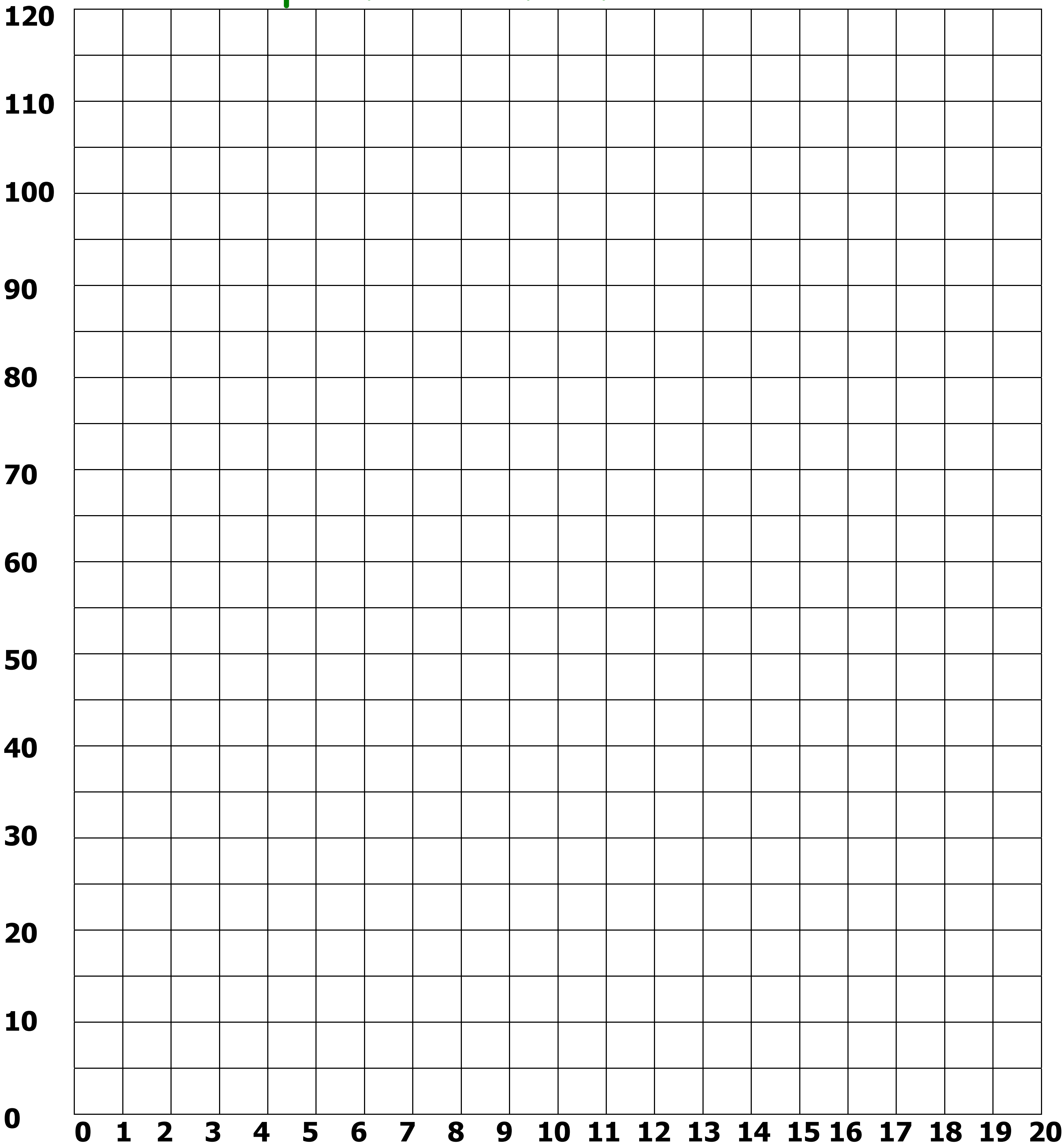
a) If you invest $1,000 at 10% interest compounded annually, how long will it take for your money to double to $2,000?

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

Act. 1.2 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. 1.2 Graph of dice left after each roll



Electric Charge and Capacitors

Electric charge can be positive or negative.

Charges of the same sign repel each other and charges of the opposite sign attract.

Electrical forces result from the repulsion or attraction between charges.

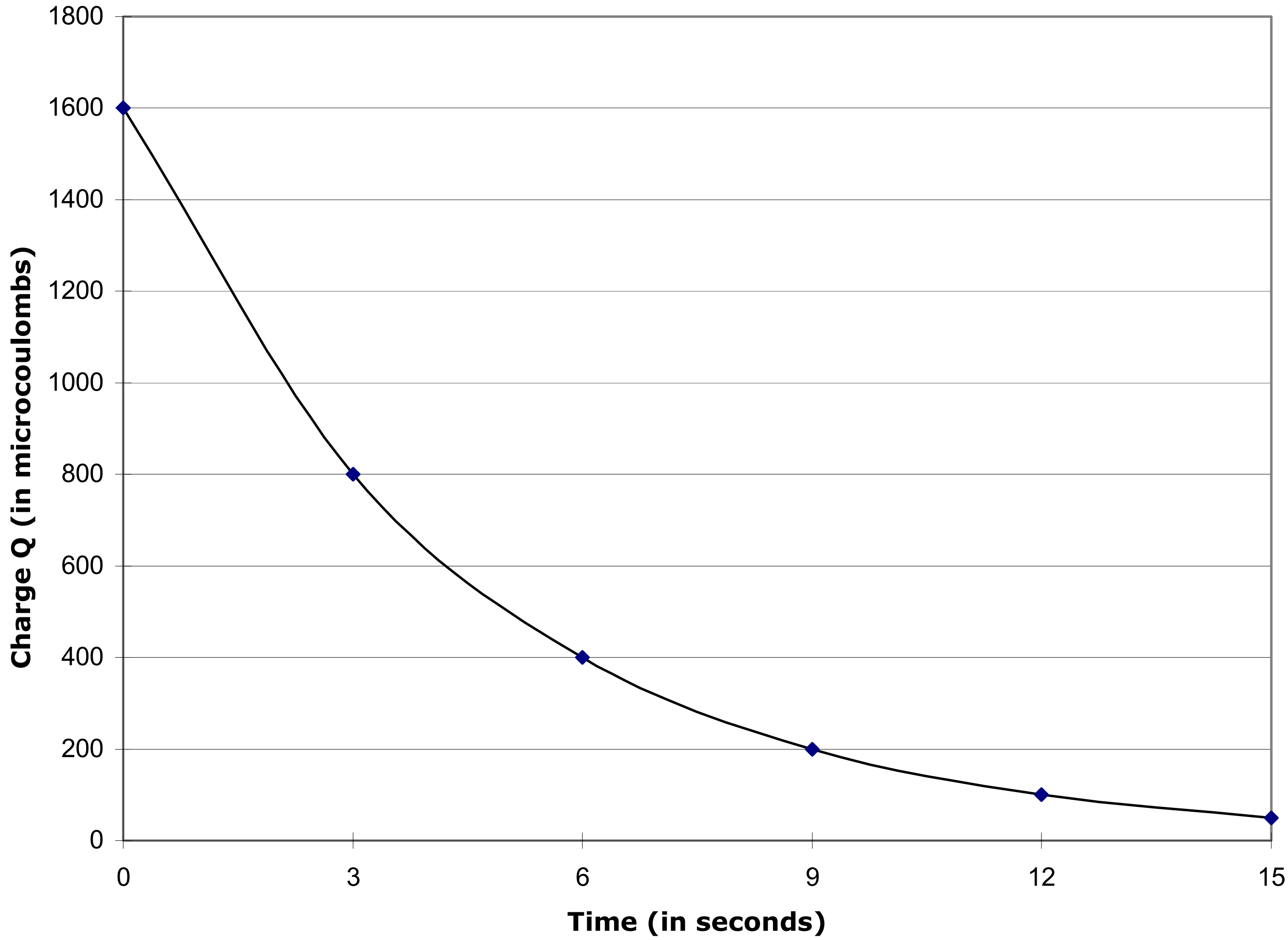
Electric charge Q is measured in units of coulombs (coul.)

The amount of electrical energy per charge is the voltage V of the charge.

Capacitors store electric charge. Their charge-holding capability is called capacitance, C, which is measured in farads.

$$C = Q / V$$

Discharge of a capacitor



What is the half-Life of the capacitor discharge?

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.

- All moving charges are surrounded by magnetic fields.
- A changing magnetic field induces a current in a nearby wire.
- When a changing magnetic field induces a current in a wire, the current induces a second magnetic field around the wire.
- The force between these two magnetic fields is repulsive and can do work.

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)

To find how much charge flows per second, use $Q = It$

To find how many electrons per second flow through the circuit, use a ratio formed from the equality:

$$1 \text{ electron} = 1.60 \times 10^{-19} \text{ coul.}$$

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

Electromagnetic Spectrum of Radiant Energy

Radiant energy (or electromagnetic radiation) is produced when electric charges vibrate.

The electromagnetic spectrum can be divided into types of radiant energy based on the wavelength and frequency of the radiation.

In order, from longest wavelength to the shortest, the spectrum consists of:

- Radio waves used for radio and TV transmission.
- Microwaves used for communication and in microwave ovens.
- Infrared radiation, which we experience as thermal energy.
- Visible light waves are a small portion of the spectrum
- Ultraviolet light that causes skin tanning
- X – rays used in medical applications
- Gamma rays produced in some nuclear reactions.

Summary of Period 1

1.2 The efficiency of a system can be found from the ratio of the power out /power in

1.4 Linear growth adds a constant amount of the quantity each time period. $N = A \times a + B$

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

Exponential decay halves the amount of the quantity in a fixed time period called the halving time. $N = B \times 2^{-a} = B \times (1/2^{a})$

1.5 Electric charge Q is measured in units of coulombs (coul.)

The amount of electrical energy per charge is the voltage V of the charge.

Capacitors store separated positive and negative electric charge. Their charge-holding capability is called capacitance, C, measured in farads. $C = Q / V$

The graph of the discharge of a capacitor is representative of exponential decay.

Summary of Period 1, continued

Electric current I is the flow of electric charge measured in amperes (amps)

$$I = Q / t$$

1.6 Radiant energy (or electromagnetic radiation) is produced when electric charges vibrate.

In order, from longest wavelength to the shortest, the spectrum radiant energy is:

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Period 1 Review Questions

R.1 **When using ratios to solve a problem, how do you decide which value to put in the numerator and which in the denominator of the ratio?**

How much does it cost to use a 1,000 watt microwave for 15 min/day if electricity is $0.10/kWh?

R.2 **How can you tell if a graph exhibits linear growth, exponential growth, or exponential decay? Does every growth rate fit into one of these types?**

R.3 **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?

R.4 **How does electric charge produce electrical energy (electricity)? How does charge produce electromagnetic radiation?**

R.5 **Give examples of each of the forms of radiant energy: radio waves, microwaves, infrared radiation, visible light, ultraviolet light, X-rays, and gamma rays.**