Lecture Videos

Copies of the 1-hour lecture videos shown on Tuesdays at 2:30 are on reserve at the Instructional Media Lab (292-2793)

♦ Located in 060 Denney Hall (in the basement)
♦ Videos can be used only in the Media Lab.
♦ OSU student ID is required.
♦ You must bring your own head phones.

Media Lab hours:

Monday – Thursday: 8:00 am to 9:00 pm

Friday: 8:00 am to 5:00 pm

Saturday: 10:00 am – 2:00 pm

Sunday: closed
Course Materials

Physics 103 Textbooks and Activity Books are sold only at Cop-ez at Tuttle Park Place.

- Located at 2055 Millikin Way in the mall between the parking garages north of the OSU Main Bookstore.

- Cop-ez at Tuttle Park Place is open all day, every day.

Cop-ez at Tuttle Park Place

Parking Garage

Parking Garage

OSU Book Store

Smith Lab

North

19th Avenue
Course Grading Policy

Activity Sheets: 1 point each  18
(You must be present during the entire period to receive credit for the activity sheet.)

Lecture video summaries: 1 point each  8

Assigned exercise questions: _ point each  9

2 Midterm exams: 30 points each  60

Final exam: 45 points  45

Total points:  140

(Note: No make-up exams or early final exams are ever given. If you have a conflict with the exam dates listed in the syllabus, inform your instructor immediately.)
Course Schedule and Assignments

Classes meet **twice each week for a 2-hour class** in 2005 Smith (Mon/Weds or Tues/Thurs)

During class, your instructor will
♦ explain physics concepts
♦ perform demonstrations to illustrate these concepts and
♦ guide you in hands-on activities

Students complete an **activity sheet** in class. These sheets are turned in at the end of class.

Two **homework exercises** are assigned from each chapter. Homework exercises are due at the beginning of the next class. The assigned exercises are listed in the syllabus.

All 103 sections meet on **Tuesdays at 2:30 for a one-hour lecture video** in 1000 McPherson
Students write a summary of the video to turn in at your next class meeting.

Preview of Period 1:
Introduction to the World of Energy

1.1 Ratios and “per”

How can ratios simplify problem solving?
What is the efficiency of a system?

1.2 Using Ratios

How are ratios used to convert units?

1.3 Exponents and Scientific Notation

Why is scientific notation helpful?
How does it work?

1.4 Linear and Exponential Growth

What are the differences between linear and exponential growth rates?
How do graphs illustrate these rates?
Activity 1.1.a: Ratios and “per”

♦ Ratios are fractions, such as 60 miles/1hour (60 miles per hour)

♦ Ratios are useful when making comparisons.

Example:

A truck requires 3 liters of gasoline to travel 15 kilometers. How many kilometers can the truck go on 1 liter of gas?

Solution:

Write the information as a ratio. Simplify the ratio by dividing the numerator by the denominator.

\[
\frac{15 \text{ km}}{3 \text{ liters}} = \frac{5 \text{ km}}{1 \text{ liter}}
\]
Finding the Efficiency of a System

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

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

**Example 1.2**

What is the efficiency of an energy conversion that requires 600 joules of energy to produce 200 joules of useful energy?

\[
\frac{\text{Useful Energy Out}}{\text{Total Energy In}} = \frac{200 \text{ joules}}{600 \text{ joules}} = 0.33 = 33 \%
\]

What happens to the other 400 joules of energy?

Is it possible to get more energy out of a system than you put in?
Act 1.1.d: Uses of Ratios

Ratios often involve the amount of a quantity per unit of time:

- Miles / hour
- Heart beats / minute

Other common ratios involve the cost of an item per unit of the item.

- Cost of gasoline / gallon
- Cost of electricity / kilowatt hour

Ratios allow us to make comparisons more easily.

By looking at the first two rows of data in the table, you cannot easily determine which vehicle gets the best gas mileage.

<table>
<thead>
<tr>
<th>Type of vehicle</th>
<th>Minivan</th>
<th>School Bus</th>
<th>Truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miles driven</td>
<td>218</td>
<td>1,089</td>
<td>37</td>
</tr>
<tr>
<td>Gas used</td>
<td>15 gal</td>
<td>85 gal</td>
<td>2.8 gal</td>
</tr>
<tr>
<td>Miles per gal</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When you use a ratio to calculate the miles per gallon, the comparison is simple.
Activity 1.2: Ratios and Units

How can ratios help solve problems?

♦ Ratios can be used to convert quantities from one unit to another. (For example, miles per hour to meters per second.)

♦ The equality 1 hour = 60 min can be written:

\[
\frac{1 \text{ hour}}{60 \text{ min}} \quad \text{or} \quad \frac{60 \text{ min}}{1 \text{ hour}}
\]

♦ Choose the ratio that allows you to cancel the unwanted units.

Convert 60 miles/1 hour into miles/minute:

\[
\frac{60 \text{ miles}}{1 \text{ hour}} \times \frac{1 \text{ hour}}{60 \text{ min}} = \frac{60 \text{ miles}}{60 \text{ min}} = \frac{1 \text{ mile}}{1 \text{ min}}
\]

(Example 1.3)

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

\[
\frac{60 \text{ miles}}{1 \text{ hour}} \times \frac{1,609 \text{ meters}}{1 \text{ mile}} \times \frac{1 \text{ hour}}{60 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ sec}} = \frac{27 \text{ meters}}{1 \text{ sec}}
\]
Rules for Using Numbers with Exponents

1. When multiplying numbers with exponents, add the exponents
   
   \[ 10^A \times 10^B = 10^{(A + B)} \]

2. When dividing numbers with exponents, subtract the exponents
   
   \[ 10^A / 10^B = 10^{(A - B)} \]

3. Any number to the zero power = 1:

   \[ 6^0 = 1 \]
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.

\[
\begin{align*}
10^1 & = 10 \\
10^2 & = 10 \times 10 = 100 \\
10^3 & = 10 \times 10 \times 10 = 1,000 \\
10^{-1} & = \frac{1}{10} = 0.1 \\
10^{-2} & = \frac{1}{10 \times 10} = 0.01 \\
10^{-3} & = \frac{1}{10 \times 10 \times 10} = 0.001
\end{align*}
\]

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.

\[
0.035 = 3.5 \times 10^{-2}
\]
### Standard Prefixes Denoting Multiples of Ten

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>quad</td>
<td>(quadrillion)</td>
<td>$10^{15}$</td>
</tr>
<tr>
<td>tera</td>
<td>(trillion)</td>
<td>$10^{12}$</td>
</tr>
<tr>
<td>giga</td>
<td>(billion)</td>
<td>$10^9$</td>
</tr>
<tr>
<td>mega</td>
<td>(million)</td>
<td>$10^6$</td>
</tr>
<tr>
<td>kilo</td>
<td>k</td>
<td>$10^3$</td>
</tr>
<tr>
<td>hecto</td>
<td>h</td>
<td>$10^2$</td>
</tr>
<tr>
<td>deka</td>
<td>da</td>
<td>$10^1$</td>
</tr>
<tr>
<td>deci</td>
<td>d</td>
<td>$10^{-1}$</td>
</tr>
<tr>
<td>centi</td>
<td>c</td>
<td>$10^{-2}$</td>
</tr>
<tr>
<td>milli</td>
<td>m</td>
<td>$10^{-3}$</td>
</tr>
<tr>
<td>micro</td>
<td>$\mu$</td>
<td>$10^{-6}$</td>
</tr>
<tr>
<td>nano</td>
<td>n</td>
<td>$10^{-9}$</td>
</tr>
<tr>
<td>pico</td>
<td>p</td>
<td>$10^{-12}$</td>
</tr>
<tr>
<td>femto</td>
<td>f</td>
<td>$10^{-15}$</td>
</tr>
</tbody>
</table>

1 kilogram = $10^3$ grams = $(10 \times 10 \times 10)$ grams = 1,000 grams

1 centimeter = $10^{-2}$ meters = $1/(10 \times 10)$ m = 0.01 meters
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 $2^{nd}$ F before pressing the $10^x$ key.
   
   To enter $8 \times 10^{12}$, press $8 \times 10^x 1 2$
   
   To enter $3 \times 10^{-6}$, press $3 \times 10^x +/- 6$

3. Some calculators use reverse notation. The exponent is entered before the $10^x$ key is pressed.
   
   To enter $3 \times 10^{-6}$, press $3 \times 6 +/- 10^x =$
   
   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 $3 \times 10^{-6}$, press $3 \text{ EE or EXP}$ 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 $3.4 \times 10^8$
## Act. 1.3.e: Energy Content of Fuels

<table>
<thead>
<tr>
<th>Type of Fuel</th>
<th>Energy in joules/kg of fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal (bituminous and anthracite)</td>
<td>$2.9 \times 10^7$</td>
</tr>
<tr>
<td>Crude Oil</td>
<td>$4.3 \times 10^7$</td>
</tr>
<tr>
<td>Gasoline</td>
<td>$4.4 \times 10^7$</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>$5.5 \times 10^7$</td>
</tr>
<tr>
<td>Wood</td>
<td>$1.4 \times 10^7$</td>
</tr>
<tr>
<td>Assorted Garbage and Trash</td>
<td>$1.2 \times 10^7$</td>
</tr>
<tr>
<td>Bread</td>
<td>$1.0 \times 10^7$</td>
</tr>
<tr>
<td>Butter</td>
<td>$3.3 \times 10^7$</td>
</tr>
<tr>
<td>Nuclear fission with Uranium 235</td>
<td>$8 \times 10^{13} = 8,000,000 \times 10^7$</td>
</tr>
</tbody>
</table>

Data from *Energy: An Introduction to Physics* by R.H. Romer, page 583.
Act 1.4: Linear and Exponential Graphs

Fig. 1  Energy Use and Population Growth

Which graph represents exponential growth?
Which represents linear growth?
Linear Growth

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

Linear Population Data

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940</td>
<td>500</td>
<td>1980</td>
<td>1,500</td>
</tr>
<tr>
<td>1950</td>
<td>750</td>
<td>1990</td>
<td>1,750</td>
</tr>
<tr>
<td>1960</td>
<td>1,000</td>
<td>2000</td>
<td>2,000</td>
</tr>
<tr>
<td>1970</td>
<td>1,250</td>
<td>2010</td>
<td>?</td>
</tr>
</tbody>
</table>
Exponential Growth

♦ Exponential growth is not constant. Its graph is an upward curving line.

♦ The amount added changes with each time period.

♦ Exponential growth doubles the amount of the quantity during a fixed time period.

♦ The amount added depends on the initial amount and on the number of time periods.

♦ The doubling time is the length of time required for the quantity to double.

Exponential Energy Use Data

<table>
<thead>
<tr>
<th>Year</th>
<th>Energy (in MJ)</th>
<th>Year</th>
<th>Energy (in MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940</td>
<td>50</td>
<td>1980</td>
<td>800</td>
</tr>
<tr>
<td>1950</td>
<td>100</td>
<td>1990</td>
<td>1,600</td>
</tr>
<tr>
<td>1960</td>
<td>200</td>
<td>2000</td>
<td>3,200</td>
</tr>
<tr>
<td>1970</td>
<td>400</td>
<td>2010</td>
<td>?</td>
</tr>
</tbody>
</table>
Linear and Exponential Growth

<table>
<thead>
<tr>
<th>Year</th>
<th>Linear increase</th>
<th>Exponential increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>1999</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>2000</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>2001</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>2002</td>
<td>9</td>
<td>16</td>
</tr>
</tbody>
</table>
Finding the Slope of a Linear Equation

1) Pick any two points on the line.

2) \[ \text{Slope} = \frac{\text{vertical distance between the points}}{\text{horizontal distance between the points}} \]

3) Using the points circled on the graph,

\[ \text{slope} = \frac{1,500 - 1,000}{1980 - 1960} = \frac{500}{20} \text{ people} \]

\[ = 25 \text{ people/year} \]
Linear and Exponential Equations

Linear growth is expressed by

\[ N = A \times t + B \]

Exponential growth 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 per each elapsed time period.)
**Act 1.3.e: Group Discussion Question:**

If someone gave you $1 and offered to double the amount you have every day, how much would you have on day 7?

<table>
<thead>
<tr>
<th>Day</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$1</td>
</tr>
<tr>
<td>2</td>
<td>$2</td>
</tr>
<tr>
<td>3</td>
<td>$4</td>
</tr>
<tr>
<td>4</td>
<td>$8</td>
</tr>
<tr>
<td>5</td>
<td>$16</td>
</tr>
<tr>
<td>6</td>
<td>$32</td>
</tr>
<tr>
<td>7</td>
<td>$64</td>
</tr>
</tbody>
</table>

\[ N = B \times 2^t = \$1 \times 2^6 = \$64 \]

- **B** = the initial amount = $1
- **t** = the number of time periods elapsed = 6

How much would you have on day 30?

\[ N = B \times 2^t = \$1 \times 2^{29} = \$536,870,912 \]
### Table 1.4: Growth Rates and Doubling Times

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

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 years, what is its rate of growth?
Summary of Period 1

1.2 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.

The **efficiency** of a system is the ratio of the **useful energy out**/**total energy in**

1.3 Using scientific notation simplifies calculations with large or small numbers.

When multiplying, add exponents.

When dividing, subtract exponents.

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

**Exponential growth** doubles the amount of the quantity in a fixed time period.

The **doubling time** is the length of time required for the amount of a quantity to double.
Summary of Period 1, continued

1.5: With linear growth, the amount added is constant.

With exponential growth, the amount added varies for each time period. The amount added depends on the initial amount and on the number of elapsed time periods.

Linear growth is expressed by

\[ N = A \times t + B \]

Exponential growth 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
Period 1 Review Questions

R.1 When using ratios to convert a quantity from one unit to another, how do you decide which value to put in the numerator and which in the denominator of the ratio? Explain your answer with an example.

R.2 State the rules of exponents you used to find the answer to exercise E.3.

R.3 What is another name for:
   a) $2 \times 10^{-2}$ meters?
   b) $6 \times 10^{-6}$ seconds?
   c) $4 \times 10^3$ grams?

R.4 Explain how to tell whether a graph line exhibits linear or exponential growth rates. Does every growth rate fit into one of these two types?

R.5 What determines the amount added during each time period to a quantity that is growing linearly?

R.6 What determines the amount added during each time period to a quantity that is growing exponentially?

R.7 What is the doubling time of a quantity? How long will it take a stock, which increases in value at a rate of 10% per year, to double in value?