WELCOME TO PERIOD 18

Homework Exercise #17 is due today.

Midterm 2 is Wed, Oct 31, 7:00 – 8:10 pm over periods 9 – 17 and videos 3 and 4. Same room as Midterm 1.

Review session: Tues, Oct 30, 6:30 – 7:30 pm in 2005 SM

• How has the demand for electricity grown?

• How can you safely use electricity?

• Remember to put away your phone. No calls or texting during class.
Linear and exponential growth

Which graph line represents linear growth?

Which line represents exponential growth?
**Linear Growth**

1) Linear growth is **constant**. Its graph is a straight line.

2) The **same** amount is added during each time period.

3) The amount added is **independent** of the initial amount and number of time periods.

**Exponential Growth**

1) Exponential growth is **not constant**. Its graph is an upward curving line.

2) The amount added **changes** with each time period.

3) The amount added **depends** on the initial amount and on the number of time periods.
1) Exponential growth **doubles** the amount of the quantity during a fixed time period.

2) The **doubling time** is the length of time required for the quantity to double.
Find doubling time of an exponential graph

1) Pick a point on the exponential graph.
2) Move up the graph line to the point where the quantity has doubled.
3) Read the elapsed time between these points on the horizontal axis.
4) Repeat steps 2) and 3) to find the next doubling time.
5) If the doubling times are equal, the graph is exponential growth.
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.)
Getting rich quick?

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?
• \[
N = B \times 2^t = \$1 \times 2^{29} = \$536,870,912
\]
# 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>

What interest rate is needed to grow $1,000 to $2,000 in 9 years?
Electricity production in the U.S.

What portions of the graph are approximately linear? Exponential?
Electricity production in the U.S.
Annual Electricity Production in the U.S.
Power Surge

1) **Fossil fuels:** How many tons of carbon dioxide does the average American family’s actions release into the atmosphere each year? Why is this a bad thing?

2) **Solar energy:** Of the 100,000 terra watts of energy the Sun provides to the Earth, how much of that is used by the Earth’s inhabitants? How is it used? How do solar cells work?

3) **Nuclear power:** What can cause the melt down of a nuclear reactor core? What has been proposed to reduce the chance of a meltdown?

4) **Biodiesel fuels:** Does burning biodiesel fuel add carbon dioxide to the atmosphere? What advantages are there to biodiesel fuels over fossil fuels?

5) **Wind energy:** What are the advantages and disadvantages of wind energy? How many wind turbines equal the energy from one nuclear power plant?
Electrical safety and joule heating

- When current flowing through wires encounters resistance, some electrical energy heats the wire.

- The larger the current, the greater the joule heating. If the current is large enough, joule heating can start a fire.

\[ P_{joule} = I^2 R \]

- A dangerously large current can result from reducing circuit resistance by:

  1) creating a short circuit or
  2) adding resistors in parallel.
Electrical safety: fuses

Fuses: If a dangerously large current flows through a circuit, joule heating melts the fuse and opens the circuit.

Solder melts at a low temperature. The piece of solder represents a fuse in this circuit.

To create a short circuit, attach a red or black connecting wire between points A and B.
Fuses and circuit breakers prevent fires by opening the circuit if the current becomes dangerously large.

A large current can cause enough joule heating to reach the combustion temperature of nearby materials.

If joule heating in a wire reaches a dangerous temperature,

A **fuse melts** and opens the circuit.  

A **circuit breaker switch flips** and opens the circuit.
Preventing electrical fires

- Don’t lay electric cords under carpeting. Keep cords away from water and heat.
- Disconnect appliances by pulling on the plug, not on the cord. Replace worn cords.
- Never break off the third safety prong on a plug. Use an adapter.
- If a switch or an outlet becomes warm, replace it immediately.
- If an appliance catches on fire, unplug it immediately, if possible, or turn off the main power switch.
- Never put water on an electrical fire.
Polarized plugs

Polarized plugs have one wide blade and one narrow blade. Electrical outlets have a narrow and wide slots to fit the plug.

“Hot” current (usually 120 volts) enters the appliance through one of the plug blades. Neutral current (0 volts) returns from the appliance to the outlet through the other blade.

Test your power strip to see which opening is “hot”

One end of the tester is attached to your power strip.

Carefully place the loose end of the tester into the wide and narrow slots of the outlet. When placed in the “hot” slot, the tester bulb lights.
Polarized plugs

- The polarized plug blades fit into an electrical outlet in only one way, so current can flow in only one direction through the circuit.

- Polarized plugs allow appliances to be designed to reduce the risk of shock by the placement of the “hot” connection.

- In a lamp socket, the “hot” connection is placed at the bottom of the socket because the lamp user is less likely to touch the bottom than the side of the socket.
3-prong plugs

The third safety prong connects the appliance case to ground.

- If a short circuit inside the appliance allows current to reach the appliance case, the safety ground prong may drain enough current to ground to create a current surge that trips the circuit breaker or blows the fuse.

- **Never remove the third prong!** Use an adapter to connect a 3-prong plug to a 2-slot outlet.
More safety devices

Instead of a third prong, some appliances have **double insulated cases**. If a short circuit occurs inside an appliance, insulating material in the appliance case prevents shock by separating the case from the current.

- **Ground fault interrupters (GFCI)** detect current leaking from the circuit and break the circuit if current leaks. A GFCI measures the “hot” current leaving an outlet and the neutral current returning. If the amount of these currents are not equal, the GFCI prevents electric shock by opening the circuit.
Hair dryer in the bathtub

- The two meter leads represent your feet in a bathtub.
- Measure the voltage when the two leads (your feet) are close together and when they are far apart.
- If an appliance falls into a bathtub, is it more dangerous to be standing with feet together or lying down in the tub?
Effects of electric shock

<table>
<thead>
<tr>
<th>Current</th>
<th>Effect on the Human Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001 amp</td>
<td>Barely detectable</td>
</tr>
<tr>
<td>0.005 amp</td>
<td>Painful</td>
</tr>
<tr>
<td>0.01 amp</td>
<td>Paralyzes some muscles making it hard to let go of the conductor.</td>
</tr>
<tr>
<td>0.02 amp</td>
<td>Paralyzes breathing muscles. Can be fatal if sustained.</td>
</tr>
<tr>
<td>0.1 amp</td>
<td>Can cause ventricular fibrillation in the heart, which usually continues after the current stops. Death is likely.</td>
</tr>
</tbody>
</table>
Preventing electric shock

✓ Keep appliances away from water. If an appliance falls into water, unplug it before reaching for it – even if the appliance is turned off. Don’t use a wet appliance.

✓ Don’t touch an appliance with a metal object.

✓ Unplug lamps before changing a bulb and appliances before working on them.

✓ If someone is being shocked, call 911 for help.

1) Turn off the power at the circuit breaker or fuse box if you can do so safely.

2) Use great caution if you try to move a live wire from a person. Do so only using a non-conducting object such as glass, plastic, or DRY wood.

3) Make sure you are standing on a dry surface.
BEFORE THE NEXT CLASS…

✔ Read textbook chapter 19

✔ Complete Homework Exercise 18

✔ Bring a blank Activity Sheet 19 to class.

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