Period 9 Activity Sheet: Power

Activity 9.1: How Much Power Do Appliances Require?

a) Light Bulbs: Connect the small hand-cranked generator to the 4-bulb tray.

Compare how easily the crank turns when 0, 1, 2, 3, and 4 bulbs are lit. When is the crank easiest and most difficult to turn?

The crank is easiest to turn when no bulbs are lit. As you increase the load by adding bulbs, more power is required to turn the crank.

b) Appliances: Use a wattmeter to measure the power requirements of the light bulb, the hair dryer on low and high settings, the toaster, and mixer. Record your measurements and compare them to the power requirements listed on the appliances.

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Power Measurement</th>
<th>Appliance Wattage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Bulb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hair dryer (high)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hair dryer (low)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toaster</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

c) Electric Drill:

1) Measure the power requirement of the drill. __________________

2) Measure again while squeezing the drill bit with the hand clamp. _____________

3) Explain any difference in power requirements.

When you squeeze the drill bit, you increase the load. The drill must do more work against the force of friction to turn the bit. More power is required to do more work.

Activity 9.2: How Much Power Do You Use for Daily Activities?

a) The Stairs: Using the classroom stairs, a timer, a meter stick, and the scale, find the power a member of your group requires to climb the stairs.

1) Measure the person’s weight in newtons (1 lb = 4.45 newtons) ________________

2) Measure the height of the stairs in meters (1 ft = 0.305 m)_____________________

3) Measure the time in seconds needed to climb the stairs ________________

4) Calculate the person’s gain in potential energy from climbing the stairs.

\[ E_{\text{pot}} = M \ g \ h \]
Activity 9.2, Continued: How Much Power Do You Use for Daily Activities?

5) How much work was done against the force of gravity to climb the stairs?  
   \[
   \text{Work} = \text{Force} \times \text{Distance}. \quad \text{Here, force} = \text{the person's weight in newtons.}
   \]

6) How much power was required when doing this work?  
   \[
   \text{Power} = \frac{\text{Work}}{\text{time elapsed}}
   \]

7) How many horsepower is this? (1 hp = 746 watts)  

8) Is the total power the person used while climbing the stairs more, less, or equal to this amount? Explain your answer:

   In any process, some energy is wasted. In addition to the energy you use to raise your body up the stairs, your body converts some of its stored chemical energy into thermal energy.

b) The Bike: Using the exercise bike connected to 50 watt bulbs and a timer, find how much energy is required to light the bulbs.

1) How many bulbs were lit?  
   \[
   \text{# of bulbs} \times 50 \text{ watts/ bulb}
   \]

2) How long were the bulbs lit?  

3) How much energy did this require?  
   \[
   \frac{\text{E}}{\text{t}} \quad \text{so,} \quad \text{E} = \frac{\text{P} \times \text{t}}{	ext{t}}
   \]

4) Was the total energy you expended on the bike the same, more, or less than the energy needed to light the bulbs? Explain your answer.

   More energy was required. Some of your energy was wasted by frictional forces in the bicycle and the generator.

c) The Hand-Cranked Generator: Using a hand-cranked generator, a light bulb, and a timer, devise your own experiment to calculate the energy required to light the bulb. Describe your experiment. How much energy was required to light the bulb?

   You could connect the light bulb to the generator and time how long the bulb is lit. If you know the wattage of the bulb, you can find the energy using  \[
   \text{E} = \text{P} \times \text{t}
   \]
Activity 9.3: How Much Does Electricity Cost?

a) Measuring Electricity – Reading a Kilowatt Hour Meter
   1) Plug a hair dryer into the kilowatt hour meter and describe what happens to the meter when the dryer is set on “low.”
      
      The disk rotates slowly, measuring the electricity provided to the hair dryer.

   2) What happens when the dryer is set on “high”?
      
      The disk rotates more rapidly, indicating that more electricity is used.

   3) How many kilowatt hours does the dial on your kilowatt hour meter read? __________

b) Calculating the Cost of Electricity – Your Electric Bill
   1) Examine an electric bill. How many kilowatt hours of electricity were used? __________

   2) What was the total cost of the electricity used? __________

   3) Calculate the cost of electricity used per kilowatt hour

      \[
      \text{Total cost of electric bill} \times \frac{1}{\text{kWh of electricity}} = \frac{\text{cost}}{\text{kWh}}
      \]

      __________

c) Conserving Electricity

   Your instructor will demonstrate a compact fluorescent and an incandescent bulb. Compare the brightness of the bulbs.

   1) How many watts of power does each bulb use?
      
      Compact fluorescent ____________ Incandescent ____________

   2) Explain why the compact fluorescent requires less energy to produce the same amount of light.
      
      Both bulbs convert electrical energy into radiant energy in the form of visible light and infrared radiation. The compact fluorescent bulb converts a larger fraction of the energy into visible light and wastes less energy heating the light bulb glass with infrared radiation.

d) Group Discussion Question: You have just moved into an apartment and must decide which electric appliances to purchase. Your apartment is not air conditioned and you hear that the furnace is not very warm in winter. You are on a budget and can spend no more than $1,000 per year for electricity. Using the cost estimates in Table 9.2 in your textbook, decide which appliances you will use.
Activity 9.4: What Is the Difference between Linear and Exponential Growth?

**Figure 1: Electricity Production in the U.S.**

![Graph showing electricity production from 1930 to 1995. The graph illustrates the trend of production increasing over time, with notable periods of linear and exponential growth.](image)

a) Identify the time periods during which the rate of increase in electricity production was approximately linear. **Between 1975 and 1995 the growth in electricity production was approximately linear.**

b) Explain how you determined that this growth was linear. **Between 1975 and 1985 production increased from approximately 2,000 billion kWh to 2,500 billion kWh, an increase of 500 billion kWh. Between 1985 and 1995, production again increased by approximately 500 billion kWh, from 2,500 billion kWh to 3,000 kWh. Production increased by a constant amount during these 10-year periods, so the growth was linear.**

c) Identify the time periods during which the rate of increase in electricity production was approximately exponential. **Between 1955 and 1975 the growth in electricity production was approximately exponential.**

d) Explain how you determined that this growth was exponential. **Between 1955 and 1965, production doubled from approximately 500 billion kWh to 1,000 billion kWh. Between 1965 and 1975, production doubled from approximately 1,000 billion kWh to 2,000 billion kWh. Since production doubled during these periods, the growth was exponential.**

e) What is the doubling time of the exponential growth periods? **10 years**