

Activity 1 Solutions: Introduction to Physics 104

1.1 Review of Ratio Reasoning and Efficiency

Your instructor will review ratios and the efficiency of energy processes.

- 1) **Efficiency of light bulbs** Compare the relative efficiencies of an incandescent bulb and a compact fluorescent bulb.

a) Use a wattmeter to measure the power required by an incandescent bulb. _____

b) Measure the power required by a compact fluorescent bulb. _____

- c) Measurements have shown that each of these bulbs produce 3 watts of visible light. Calculate the efficiency of the incandescent bulb.

$$\text{Efficiency} = 3 \text{ watts} / \# \text{ of watts measured in part 1)}$$

- d) Calculate the efficiency of the compact fluorescent bulb.

$$\text{Efficiency} = 3 \text{ watts} / \# \text{ of watts measured in part 2)}$$

- e) How do the efficiencies of the bulbs compare?

The compact fluorescent is much more efficient.

- f) Group Discussion Question: Why is the compact fluorescent bulb so much more efficient than the incandescent bulb?

2) Generating electricity with the exercise bicycle

- a) If five 50-watt bulbs are lit, how many kilowatts of electricity are generated?

$$5 \text{ bulbs} \times \frac{50 \text{ watts}}{\text{bulb}} = 250 \text{ watts} \times \frac{1 \text{ kW}}{1,000 \text{ watts}} = 0.25 \text{ kW}$$

- b) If you ride the bicycle and generate this much electricity for 8 hours, how many kilowatt hours of electricity have you generated?

$$0.25 \text{ kW} \times 8 \text{ h} = 2 \text{ kWh}$$

- c) If you sold the electricity you generated for \$0.10/kWh, how much money would you receive for it?

If electricity costs \$0.10/ kWh, you would make only

$$\frac{\$0.10}{\text{kWh}} \times 2 \text{ kWh} = \$0.20$$

1.2 Linear and Exponential Growth Rates and Exponential Decay

Your instructor will discuss linear and exponential growth and exponential decay.

3) Illustrating exponential decay

Roll the 20 dice in the plastic cup onto your table and remove any dice that land with a "1" showing. Repeat for 20 throws, each time removing any dice showing a "1." After each roll, record below the number of dice left after you remove the dice showing a "1." When each table has completed 20 throws, we will combine the data for all groups.

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

- a) On the graph, using the totals for all groups, plot the number of dice left versus the number of rolls of the dice.

What type of change does this graph line represent? **Exponential decay**

- b) What is the halving time in terms of the number of rolls? _____

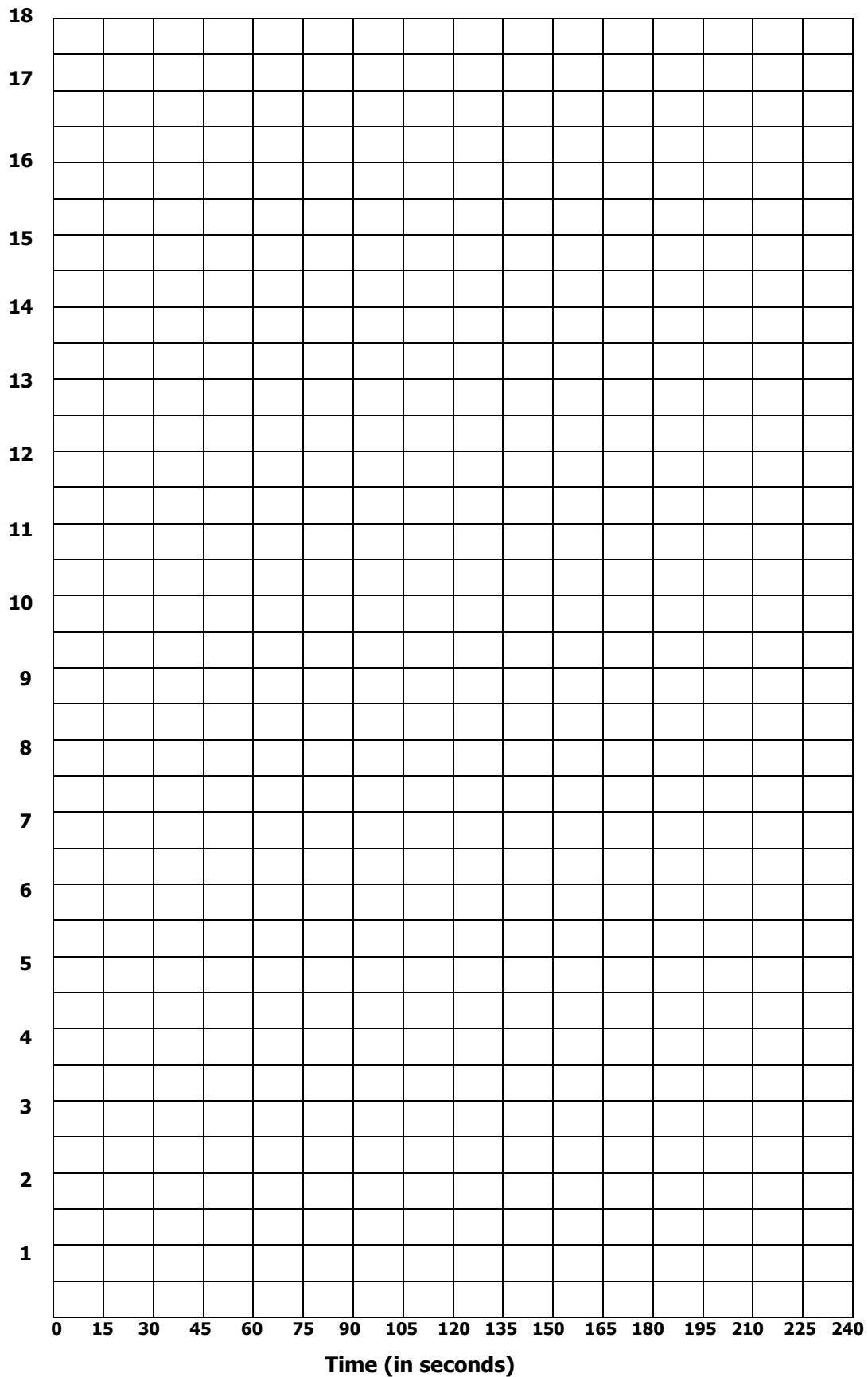
4) Exponential decay of a capacitor

Your instructor will explain how to measure the rate of discharge of a capacitor.

- a) After charging the capacitor, flip the switch to the right to allow the capacitor to discharge through the resistor. At the same time, start the timer. Measure the voltage with a multimeter set to measure DC voltage (V $\overline{=}$) every 15 seconds for four minutes. Record your measurements in the table below.

Time elapsed (Min: Sec)	Voltage (volts)		Time elapsed (Min: Sec)	Voltage (volts)
0:00			2:15	
0:15			2:30	
0:30			2:45	
0:45			3:00	
1:00			3:15	
1:15			3:30	
1:30			3:45	
1:45			4:00	
2:00				

b) Make a graph on the grid below of the voltages you measured versus time elapsed.



c) Use your graph to find the half-life of the capacitor discharge. _____

1.3 How Is Electric Current Generated?

5) Generating an electric current

a) Connect the tan coil of wire to the large galvanometer that measures electric current. Move a magnet near and into the wire coil. What does the galvanometer needle indicate?

A current is induced in the wire when the magnet moves near to and into the coil of wire. The galvanometer measures this current.

b) Hold the magnet still and move the coil of wire. Describe what happens.

The galvanometer again measures current flowing through the wire. The direction of current flow depends on the direction the wire moves relative to the magnet.

c) What happens if neither the magnet nor the wire is moving?

No current flows. One (either the magnet or the wire) must be moving.

d) What must happen in a power plant to generate electricity?

Generators use kinetic energy to spin magnets near coils of wire. Spinning the magnet creates a changing magnetic field through the coil. The changing field induces a current in the wires.

6) Magnetic Force on a Current Your instructor will review induced current and induced magnetic fields.

a) Place a wire between the ends of a large C shaped magnet. Briefly touch the ends of the wire to both terminals of a 3 battery tray. What happens to the wire?

The wire will either jump into the "C" of the magnet or out of it, depending on the direction of the current flowing through the wire.

b) Change the direction of the current flowing through the wire by switching the leads to the battery. Describe what happens when you touch the end of the wire to the battery.

The wire jumps in the opposite direction.

c) What causes the wire to move?

Current in the wire induces a magnetic field around the wire. This magnetic field is attracted to or repelled by the magnetic field of the C magnet.

7) Induced Current and Magnetic Forces Your instructor will demonstrate a large solenoid with an iron core, which is connected to a variable current source.

a) What happens when a solid ring is placed over the solenoid? Why?

The ring levitates (jumps up). The changing magnetic field created by the solenoid induces a changing current in the ring. This current creates a changing magnetic field around the ring. The two magnetic fields repel, causing the ring to jump.

- b) What happens when a ring with a slit is placed over the solenoid? Why?

Nothing happens. The ring does not jump because the slit in the ring creates an open circuit. Current cannot flow around the ring, so the ring has no induced magnetic field around it.

8) Measuring and Calculating Electric Currents

- a) Plug the incandescent light bulb into the wattmeter. Measure the current through the bulb. _____
- b) How many coulombs of charge per second flow through this circuit?

$$Q = I t$$

- c) An electron has a charge of 1.60×10^{-19} coulombs. How many electrons per second move through this circuit?

$$\text{Use } Q \text{ coul} \times \frac{(1 \text{ electron})}{(1.60 \times 10^{-19} \text{ coul})} =$$

1.4 Radiant Energy and the Electromagnetic Spectrum

9) Vibrating electric charges

Your instructor will demonstrate the effect on a radio of electromagnetic radiation produced by vibrating charge.

- a) What happens to the radio broadcast when the radio antenna receives electromagnetic radiation from the spark of the Wimshurst machine?

You hear interference (static), which indicates that energy from the spark has reached the radio.

- b) How did energy from the separated charges on the Wimshurst machine reach the radio?

There is no direct electrical connection between the Wimshurst machine and the radio. Energy produced by the spark (the source) traveled in electromagnetic waves across the room to the radio (the receiver).

- c) We have seen that moving electric charge produces an electric current. What type of energy does vibrating electric charge produce?

Radiant energy (also called electromagnetic radiation)

- 10) **Examples of electromagnetic radiation** Your instructor will demonstrate the different types of radiant energy (electromagnetic radiation)

- a) **Radio waves** Which devices operate using radio waves?

Radio, walkie-talkies, remote control cars

- b) **Microwaves** Which devices use microwaves?

Microwave oven, cellular phones, garage door opener,**c) Infrared radiation**

1) Which devices illustrate infrared radiation?

TV remote, glow coil, infrared camera, radiometer

2) How do we experience this type of electromagnetic radiation? If you closed your eyes, how could you tell if an incandescent light bulb was lit?

We experience infrared radiation as heat (thermal energy). You could feel the heat from a nearby incandescent bulb.

d) Visible light

1) Your instructor will demonstrate a large bulb. Can a bulb that does not appear to be lit radiate energy? If so, what type of radiant energy?

Yes. The bulb emits infrared radiation.

2) Observe the bulb through a diffraction grating as your instructor slowly increases the energy to the bulb.

a) What are the major colors of the light do you observe?

A diffraction grating separates the light into a continuous spectrum of color. When the bulb is dim, the red and orange portions of the spectrum are brighter.

b) Why is the portion of the spectrum just below the visible spectrum named "infrared"?

The infrared portion of the spectrum is just below the visible red portion.

c) What are the major colors you observe when the energy to the bulb is increased further?

When the bulb is bright, the blue and violet portions of the spectrum are brighter.

d) Why is the portion of the spectrum beyond the visible spectrum named "ultraviolet"?

The ultraviolet portion of the spectrum is just beyond the visible violet portion.

e) Ultraviolet light Which devices illustrate ultraviolet radiation?

The "black light" bulbs emit ultraviolet radiation as well as visible violet visible light.

f) X-rays What are some uses of X – ray radiation?

X-rays can penetrate soft body tissue but not bone, allowing a picture of the bone structure. X-rays can be used to diagnose illnesses and treat diseases such as cancer.

- g) Gamma rays** Your instructor will place a sample of radioactive Cobalt-60 near a Geiger counter. What do the sounds from the Geiger counter indicate about Cobalt-60?

The Geiger counter clicks indicate counts of gamma ray radiation. (We will study gamma rays in more detail in a future period.)

- 11) Group Discussion Question:** How are radio waves, microwaves, infrared radiation, visible light, ultraviolet light, X-rays, and gamma rays similar? How are they different?