

# THE PERIODIC TIME OF A PENDULUM IS CONSTANT

## TOPIC:

Dynamics

## SCIENTIST:

Galileo Galilei 1564–1642

## INTRODUCTION:

One of Galileo's earliest scientific discoveries was made in 1581, the year he entered the University of Pisa to study medicine. He was attending a service in Pisa Cathedral when his attention was distracted by the swinging of a lamp suspended from the ceiling by a long chain. By paying closer attention, Galileo noticed something unusual. Although the *length* of the swing decreased with time, the *time taken* for the lamp to complete one to and fro movement apparently stayed the same. To test his observation Galileo used his own pulse rate as a timer. He counted how many beats it took the lamp to complete one oscillation (one complete backward and forward movement), then repeated the procedure as the oscillations of the lamp gradually died away. Inspired by this chance discovery, Galileo used a simple pendulum (a pendulum is a relatively heavy body suspended from a fixed point by a nonextendable support) to investigate the regularity of its swing; this is the experiment you will repeat now. He proved that the periodic time of the pendulum (the time taken for each oscillation) was constant and was independent of the amplitude (length) of the swing. He suggested that because of this property, pendulums could be used in clocks to regulate the measurement of time. However, Galileo did not draw up plans for making a pendulum clock until just before his death, some fifty years after his original discovery. The first successful pendulum clock was constructed by Dutch scientist Christiaan Huygens (1629–1695) in 1657.

## TIME NEEDED:

30 minutes

## MATERIALS:

ring stand with clamp  
cork from a wine bottle  
small, sharp knife  
cutting board  
strong thread, approximately 1 m

golf ball or spherical brass/lead bob, 4–5 cm in diameter  
Fun tak®  
stopwatch

## Original Materials:

Galileo would have suspended a simple lead or brass bob (sphere) from a fixed point. He would have timed the oscillations, as he did in the church, by counting the number of pulse beats.

### *Safety Precautions*

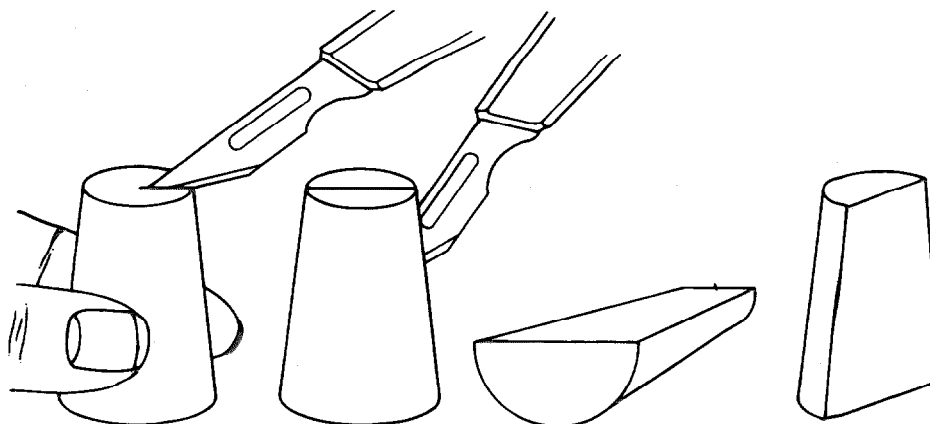
Please read and copy the safety precautions at the beginning of this book. Be careful when using the knife to cut the cork.

## PROCEDURE:

1. Take the cork and hold it between finger and thumb, larger end downward, on the cutting board.

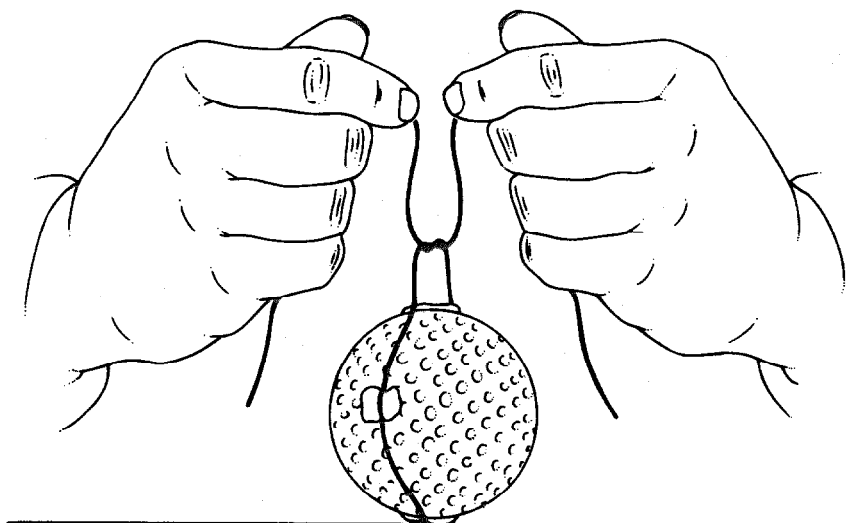
2. Carefully use the knife to cut a slit from top to bottom from one edge of the cork to its center (see figure 1). Turn the cork around and repeat the process so that the cork is cut into two halves.

Figure 1



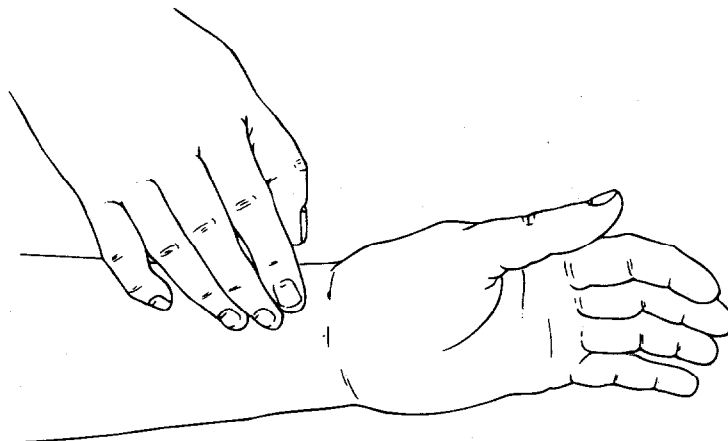
3. Put four small pieces of Fun tak® on opposite poles of the golf ball/bob (see figure 2).
4. Tie the thread around the golf ball/bob, making sure it passes through the Fun tak® so that the thread does not slip off (see figure 2). Tie it firmly and make a knot to secure it.

Figure 2



5. Make 5 or 6 more turns of the thread around the golf ball/bob in the same direction as before. Tie the thread firmly and, again, make a knot to secure the thread.
6. Take the other end of the thread and “sandwich” it between the two halves of the cork.
7. Now clamp the two halves of the cork (with the thread in between) together vertically in the clamp attached to the ring stand. Adjust the height of the clamp to its maximum so that the pendulum can swing freely.
8. Pull the pendulum bob to one side and release it, ensuring that it swings in one plane—*i.e.*, goes to and fro following the same straight path. Make a note of your observations as the pendulum swings.
9. Relax for five minutes so that your pulse rate steadies.
10. Find your pulse by pressing two fingers on the artery next to your wrist (see figure 3).
11. Set the pendulum swinging. Put your fingers on your wrist to find your pulse. Every third oscillation (to and fro movement) count the number of pulse beats that occur during that oscillation. Continue until the pendulum stops moving, making a note of the number.

Figure 3



12. Repeat step 11 but this time use the stopwatch. Start and stop the stopwatch at the beginning and end of every third oscillation. Make a note of the time taken for each oscillation timed.

### ANALYSIS:

1. What did you observe after you had set the pendulum swinging?
2. How many pulse beats did you record for each oscillation of the pendulum that you timed? Did the number stay the same for each oscillation or did it vary?
3. How many seconds did you record for each oscillation of the pendulum that you timed using the stopwatch? Did the number stay the same for each oscillation or did it vary?
4. What is the advantage of using a stopwatch over counting pulse beats as a method of timing?
5. What conclusion can you draw from this experiment?

### OUR FINDINGS:

See Section VIII.

## SPECIAL SAFETY NOTE TO EXPERIMENTERS

Each experiment includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is absolutely necessary that you read, copy, and remain mindful of the General Safety Precautions that follow this note.

Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following basic safety guidelines the *entire* time you are performing the experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. We made this choice for one reason: We want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each experiment you are preparing to perform, and that you will *remember* them. Except in rare instances, these precautions will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not say **BE CAREFUL WITH HOT LIQUIDS** or **DON'T CUT YOURSELF WITH THE KNIFE** does not mean that you should be careless when simmering water or stripping an electrical wire. It does mean that when you see a special note to be careful, it is extremely important that you pay attention to it.

If you ever have a question about whether a procedure or material is dangerous, wait to perform it until you find out for sure that it is safe.

## GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking unnecessary risks can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone.

### PREPARING:

- Clear all surfaces before beginning experiments
- Read the instructions before you start
- Know the hazards of the experiments and anticipate dangers

### PROTECTING YOURSELF:

- Follow the directions step-by-step; do only one experiment at a time
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eye wash, and first-aid kit
- Make sure there is adequate ventilation
- Do not horseplay
- Wear an apron and goggles
- Do not wear contact lenses, open shoes, loose clothing, or loose hair
- Keep floor and work space neat, clean, and dry
- Clean up spills immediately
- Never eat, drink, or smoke in laboratory or work space
- Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult

**USING EQUIPMENT WITH CARE:**

- Set up apparatus far from the edge of the desk
- Use knives and other sharp or pointed instruments with caution
- Pull plugs, not cords, when removing electrical plugs
- Don't use your mouth to pipette; use a suction bulb
- Clean glassware before and after use
- Check glassware for scratches, cracks, and sharp edges
- Clean up broken glassware immediately
- Do not use reflected sunlight to illuminate your microscope
- Do not touch metal conductors
- Use only low voltage and current materials such as lantern batteries
- Be careful when using stepstools, chairs, and ladders

**USING CHEMICALS:**

- Never taste or inhale chemicals
- Label all bottles and apparatus containing chemicals
- Read labels carefully
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves)
- Do not touch chemical solutions
- Wash hands before and after using solutions
- Wipe up spills thoroughly

**HEATING SUBSTANCES:**

- Use goggles, apron, and gloves when boiling water
- Keep your face away from test tubes and beakers
- Never leave apparatus unattended
- Use safety tongs and heat-resistant mittens
- Turn off hot plates, bunsen burners, and gas when you are done
- Keep flammable substances away from heat
- Have fire extinguisher on hand

**FINISHING UP:**

- Thoroughly clean your work area and glassware
- Be careful not to return chemicals or contaminated reagents to the wrong containers
- Don't dispose of materials in the sink unless instructed to do so
- Wash your hands
- Clean up all residue and put in proper containers for disposal
- Dispose of all chemicals according to all local, state, and federal laws

**BE SAFETY CONSCIOUS AT ALL TIMES**