1B Measuring Time and Distance

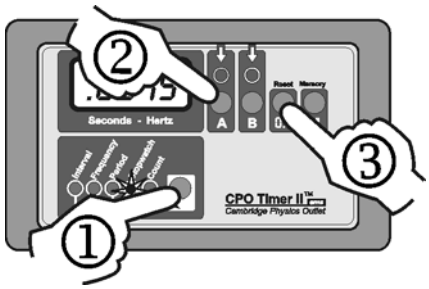
How are time and distance measured and described in physical science?

We describe the universe with measurements. A measurement includes a unit and the quantity. For example, 3 seconds is a measurement of time that includes a unit (seconds) and a quantity (3). This investigation will explore the measurement and units for time and distance.

Materials

- CPO Timer and 2 photogates.
- Metric tape, centimeter ruler or meter stick with millimeter gradations
- Several different books, preferably made with different types of paper.

1 Using the timer as a stopwatch



1. Set the timer to **stopwatch**.
2. Start and stop using the "**A**" button.
3. Reset the stopwatch to zero with the "**O**" button.

The photogate timer allows you to make accurate, precise measurements of time. The timer does different functions and the first one to try is **stopwatch**. Use the button (1) to move the light under the word stopwatch.

A stopwatch measures a **time interval**. The stopwatch is started and stopped with the "**A**" button (2). The display shows time in seconds up to 60 seconds, then changes to show **min:sec** for times longer than one minute.

2 Observing reaction time

The time it takes a signal from your brain to move a muscle is called **reaction time**.

1. This experiment takes two people. One person (the watcher) watches the stopwatch and the other person pushes the buttons. The watcher should think of a number between 5 and 10 seconds and keep the number secret.
2. The second person starts (and stops) the stopwatch *without looking at the display*. The watcher looks at the display and says STOP at the secret number. For example, if the secret number is 6 they should say STOP when the display reaches 6.00 seconds.
3. Repeat the experiment several times and estimate reaction time.

3 Mixed units for time

Time is often given in mixed units including hours, minutes, and seconds. Convert (a) and (b) to seconds then arrange the three measurements from smallest to largest:

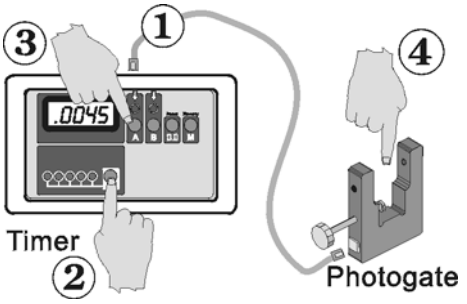
a. 16,000 seconds

b. 250 minutes

c. 4 hours, 23 minutes and 15 seconds (4:23:15)

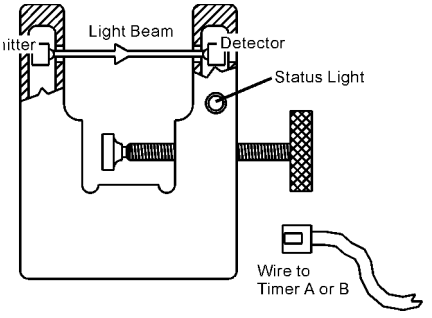
4 Using the photogates

A photogate allows us to use a light beam to start and stop the timer. When the timer is in interval mode, it uses photogates to control the clock.



1. Connect a single photogate to the "**A**" input with a cord.
2. Select **interval** on the timer.
3. Push the "**A**" button and the "**A**" light should come on and stay on.
4. Try blocking the light beam with your finger and observe what happens to the timer.

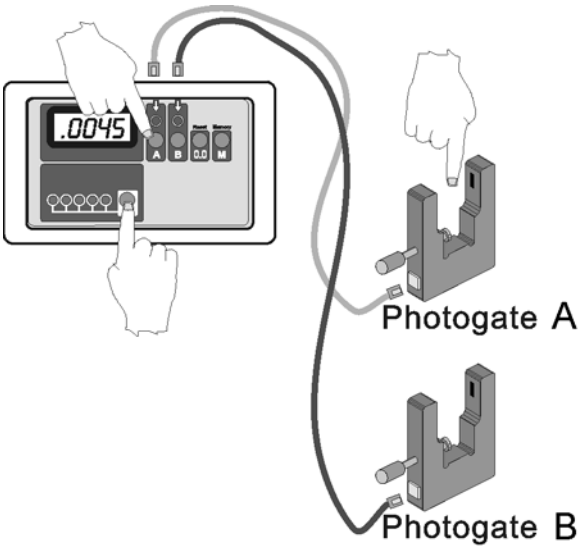
Try your own experiments until you can answer the following questions. Be very specific in your answer. Someone who has never used the timer before should be able to read your answer and know what to do with the light beam to make the clock start and stop.

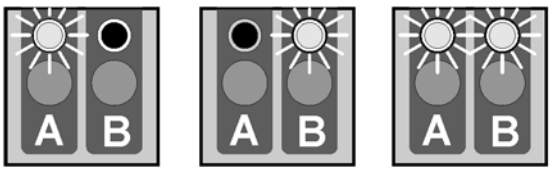


a. Question: How do you start the clock?
b. Question: How do you stop the clock?
c. Question: What time interval has the clock measured?

5 Using the timer with two photogates

1. Connect a second photogate to the socket behind the B button (input B). You should now have two photogates connected to the Timer.
2. Make sure the light on each photogate is green and press the reset button. Pressing reset clears the clocks and also tells the timer to look at its inputs to see which photogates are connected.
3. Use the A and B buttons to turn the A and B lights on and off. The timer does something slightly different for each combination of lights shown in Table 1.
4. Do your own experiments and fill in the rest of Table 1.





What starts and stops the displayed time for each setting of the A and B lights?

Table 1: Timer and photogate rules

A light	B light	How do you start the clock?	How do you stop the clock?	What time interval does the clock measure?
On	Off			
Off	On			
On	On			
Off	Off			

6 Another test to try

If you block the light beam several times in a row, does the time add or does the timer start at zero every time you break the beam? Write a one-sentence answer that also gives the reasons for what you say. For example, "the timer does _____ because_____."

7 Measuring small distances

In science, length is usually measured in units based on the meter. For example, one millimeter is 0.001 meters (or 1/1000 meter). A millimeter may be small, but there are many things in science that are smaller still. Scientists have to measure these things even though they are so small that they cannot be measured directly with the ruler.

1. Describe a way to measure the thickness of a single sheet of paper using a ruler that can measure to a precision of one millimeter.
2. Collect several books and use your technique to measure the thickness of paper in each book.

8 Converting between the metric units of distance

Use the conversion factors below to help you convert your measurement of paper thickness into kilometers, meters, and centimeters. (Converting from mm to km requires 2 steps).

$$\frac{1\text{ m}}{1000\text{ mm}} = 1 \qquad \frac{1\text{ km}}{1000\text{ m}} = 1 \qquad \frac{1\text{ cm}}{10\text{ mm}} = 1$$

9 Measuring distances in different units

1. Measure the length and width of your desk or lab table in centimeters.
2. Measure the length and width of your desk or lab table in millimeters.
3. Measure the length and width of your desk or lab table in inches.

a. Explain why the length measurements have different numerical values even though you were measuring the exact same length.

b. Calculate the width to length ratio (in cm) by dividing the width (cm) by the length (cm). What is the ratio in the other units (mm and inches)? Why are all the answers the same?