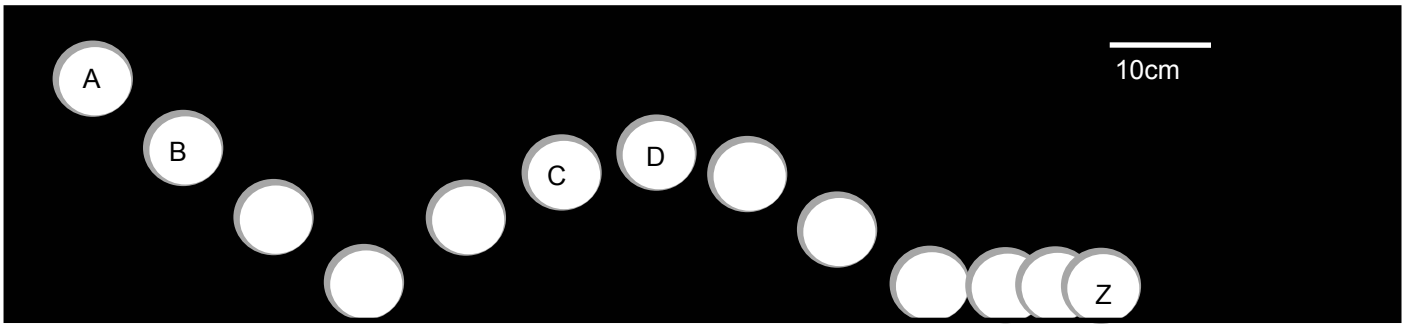
Measuring Short Time Intervals

Sometimes, we have to measure the motion of very fast moving objects. The human eye has limitations in its ability to observe moving objects. Things like speeding bullets or rapidly oscillating pendulums are difficult to measure. There are several techniques to get around this problem. One technique it to use a device called a **Stroboscope**. This is a very precise version of a strobe light. This device is used to observe the motion of rapidly moving objects by capturing its motion on a single piece of photographic paper.

How it works:

- The stroboscope produces bright flashes at fixed time intervals. For example, a stroboscope operating at 20Hz will produce flashes at 0.05s intervals. ($f = \frac{1}{T}$)
- In a darkened room, a camera is setup and the shutter is opened. Each flash from the stroboscope exposes an image on the film at consistent time intervals.
- A meter stick, or something similar, is placed in the field of view of the camera. This is important in order to have a scale to determine the actual distance traveled by the objects in question when studying the photograph after it's developed.
- When the object passes by the camera, the path of the object in motion will be exposed to the film, and later observed as a trail of images.
- The physical distance between each of these images allows one to determine the object's speed since the time between each image is known from the strobe frequency. ($v = \frac{d}{t}$)

Example



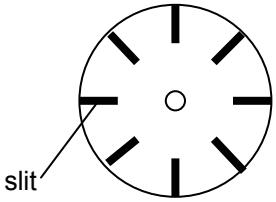
assume the strobe was flashing at 20Hz. Remember $f = \frac{1}{T}$ so $T = \frac{1}{f}$. This gives us a time interval between flashes of $T = \frac{1}{20} = 0.05s$. From this, you can determine the speed of the object at various times

EXERCISE

Using the formula $v = \frac{d}{t}$, find the velocity of the object between points A and B and between C and D. Also, determine how much time it took for the object to travel from A to Z

The Hand Stroboscope

Another less costly device is the hand stroboscope. This device performs a similar function as a regular stroboscope but is much less accurate. The device can be used to determine the frequency of various rapidly moving objects like a pendulum for instance. The eye catches a glimpse of the object each time a slit passes in the field of view. The difficulty is maintaining consistent rotational speed of the scope.



How to use the scope:

- Set the number of exposed slits by aligning the slit wheel. The more slits that are exposed, the more glimpses the eye catches per turn.
- Observe the motion of the object in through the slits as you rotate the scope. Increase the speed of the scope until you see **Two distinct** images that appear to be motionless.
- Now slow the rotation until you only see **one** image in stop motion.
- Once the single image appears motionless, count the number of rotations of the scope over a period of 10s or so. Using this value, determine the **frequency** of the stroboscope. (# of rotations / time).
- To determine the **"look frequency"**, multiply the **Stroboscope frequency** by the **number of exposed slits (Look frequency = Stroboscope frequency X Number of slits).** This is also called the **Stopping frequency.**

Note: The **look frequency** is the same as the **oscillating frequency** of the object in question.

Example: if the stroboscope rotation 20 times in 10s, the stroboscope frequency would be **2Hz** (meaning it rotates twice every second). If the stroboscope was set up so that **4 slits** were exposed, then the eye would catch **4 glances** on **every rotation**; at 2 rotations per second, that makes a total of **8 glance** per second or a **look frequency** of **8 Hz**.

EXERCISE

Using a hand stroboscope, you are able to stop the motion of a pendulum if you rotate the scope 3 times every two seconds. If the scope was set up so that 12 slits were exposed, determine:

a) the look frequency of the scope

b) the stopping frequency

c) the oscillation frequency of the pendulum