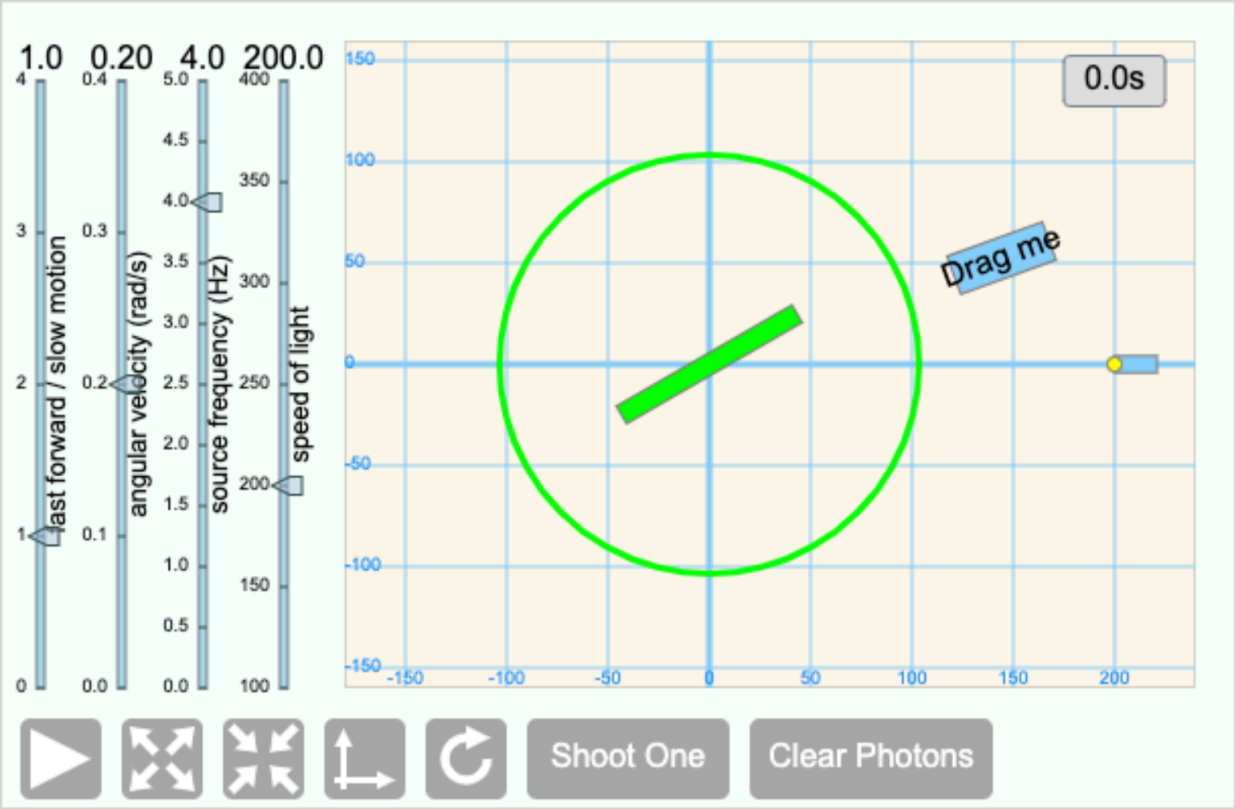
Simulation - Speed of Light



Simulation Link

http://physicsmonster.org/content/simulation/simulation_relativity/index.html#id_section_speed_of_light

Introduction

This simulation illustrates the theory behind the lab Speed of Light, in which the speed of light is measured by a mirror rotating at high speed, causing slight deviation in a reflected beam of laser.

The speed of light is greatly slowed down and is adjustable in the simulation to illustrate the concepts.

Theory

Angular velocity:

$\omega = \frac{\Delta\theta}{\Delta t}$

Frequency:

$f = \frac{\omega}{2\pi}$

Prelab

1. Use the law of reflection (angle of incidence = angle of reflection) to show that when a plane mirror rotates by $\Delta\theta_{mirror}$, the reflected beam will rotate by $\Delta\theta_{detector} = 2\Delta\theta_{mirror}$. Your proof should include figures.
2. Write down the time Δt_{return} it takes for a photon to bounce off the rotating mirror at the center, hit the circular mirror of radius r and return to the rotating mirror for a second time. Write your answer in terms of the radius r, and the speed of light c.
3. Find $\Delta\theta_{mirror}$ for the duration of time Δt_{return}. Write your answer in terms of the radius r, angular velocity of the rotating mirror ω, and the speed of light c.
4. Use your results above to write the speed of light c in terms of ω, r, and $\Delta\theta_{detector}$.
5. Rewrite your results above to write the speed of light c in terms of f, r, and $\Delta\theta_{detector}$.

Procedure

1. While fixing the speed of light in the simulation c_{sim}, try about seven different ω in the simulation and record $\Delta\theta_{detector}$. Collect your data in Table 1.
2. Change to a different values of c and fill in Table 2 - 5.

Data

Table 1: Photon deflection at different angular velocity of rotating mirror.

$c_{sim} =$				
$\omega(rad/s)$	$\Delta\theta_{detector}(\circ)$	$\Delta\theta_{detector}(rad)$	$c_{measured}\,(m/s)$	Percentage difference

Table 2: Photon deflection at different angular velocity of rotating mirror.

$c_{sim} =$				
$\omega(rad/s)$	$\Delta\theta_{detector}(\circ)$	$\Delta\theta_{detector}(rad)$	$c_{measured}\,(m/s)$	Percentage difference

Table 3: Photon deflection at different angular velocity of rotating mirror.

$c_{sim} =$				
$\omega(rad/s)$	$\Delta\theta_{detector}(\circ)$	$\Delta\theta_{detector}(rad)$	$c_{measured}\,(m/s)$	Percentage difference

Table 4: Photon deflection at different angular velocity of rotating mirror.

$c_{sim} =$				
$\omega(rad/s)$	$\Delta\theta_{detector}(\circ)$	$\Delta\theta_{detector}(rad)$	$c_{measured}\,(m/s)$	Percentage difference

Table 5: Photon deflection at different angular velocity of rotating mirror.

$c_{sim} =$				
$\omega(rad/s)$	$\Delta\theta_{detector}(\circ)$	$\Delta\theta_{detector}(rad)$	$c_{measured}\,(m/s)$	Percentage difference

Analysis

1. Use the equation you derived in the pre-lab to calculate the speed of light based on your measurement, i.e. $c_{measured}$. Calculate the percentage difference with c_{sim}.
2. Plot ω vs $\Delta\theta_{detector}(rad)$ for each of the tables above *in the same graph* (here is a tutorial on how to do it: https://youtu.be/Tw1T-Eqx_LU?si=-1OkoQccPH70Uo66). Theoretically, what do you expect the slopes to be?
3. Use the slopes of the graph to deduce the speed of light c_{slope}, one for each table.
4. Compare c_{slope} with c_{sim} for each table.

Questions

1. In a real world experiment, $c \approx 3 \times 10^{8} m/s$, $r \sim 10m$, $\Delta\theta_{detector} \sim 10^{-4} rad$. What is the approximate frequency f of the rotating mirror needed?