Main Topic	Measurement
Subtopic	Modern Physics
Learning Level	High
Technology Level	Low
Activity Type	Student

Description: Use a quantum model to indirectly determine the mass of a penny, just as Planck and Einstein did for photon energies.

Required Equipment	Film canisters, pennies (newer than 1982), tape, electronic balance
Optional Equipment	Triple-beam balance

Educational Objectives

- Use a quantum model to determine the mass of a penny indirectly, just as Planck and Einstein did for Photon energies.

Concept Overview

Something that is **quantized** exists in multiples of a set quantity. Examples are **charge [1.6 x 10^{-19}C]** or **quantum energies of photons**. **Planck and Einstein** predicted that light existed as discrete bundles called photons. Since they could not see a unit of photon energy, this lab constructs a **model of how quanta was derived** and visualized by scientists. Money is **quantized** into pennies, nickels, dimes, etc. There are **NO** 2-cent or 8-cent coins!

If students have already learned about the quantization of energy and the Planck constant, the Questions section provides a review of this topic. The important relationship is

$$E = h\nu$$

Where E is the photon energy, h is the Planck constant (4.14 x 10^{-15} eV•s) and ν is the frequency of the light emitted. In the case of a green laser, as in the question, the frequency is 523nm.

Lab Tips

Prepare the film canisters using pennies newer than 1982. Before 1982, pennies were 95% copper and 5% zinc. Since 1982, they are 97.6% zinc and 2.4% copper. New pennies have a mass of 2.5 grams. (Older ones have a mass of 3.1 grams.)

Acknowledgement

This lab was contributed by Dwight "Buzz" Putnam, physics teacher, Whitesboro High School, NY.

Quantum Lab

Name: ____________________

Class: ______________________

Goal:

Use a quantum model to determine the mass of a penny indirectly, just as Planck and Einstein did for Photon energies.

Materials:

8 pre-made canisters containing unknown numbers of identical pennies, electronic balance.

Procedure:

1. Obtain **8 film canisters**. **DO NOT OPEN THE CANISTERS!**
2. Each sample has the **mass of the empty canister** written on it. Record this and the canister # in **Table #1** below.
3. Find the **mass of the canister and pennies** by using the balances and record in **Table #1**.

Canister #	Mass of empty can (gms)	Mass of empty can with pennies (gms)

Interpretations:

1. Calculate the mass of pennies in each container by subtracting the mass of the canister from the mass of the canister and pennies. Record in Table #2.
2. Arrange the masses of the pennies from smallest to largest. Record in Table 2.
3. Calculate the difference in masses of each successive group of pennies and record in Table #2.

Canister #	Mass of pennies (gms)	Mass of pennies in ascending order (gms)	Difference in masses of pennies (gms)

Quantum of Mass [Unit of Mass for One Penny] =

4. Using the Quanta of mass you found, find **the NUMBER OF PENNIES IN EACH CANISTER!** Record the # of pennies for each corresponding canister in Table #3.

Example… $$\frac{\text{Mass of Pennies [gms]}}{\text{Quantum of Mass [gms/Penny]}} = \text{\# of Pennies in each canister}$$

Canister #	# of pennies in Canister

Questions:

1. Find the Quantum Energy [in eV's] for a **green** LASER.

2. If a photon has a Quantum Energy of 250 eV's, find the wavelength and type of photon from the Reference Table.