The de Broglie wavelength is the wavelength, $\lambda$, associated with an object and is related to its momentum and mass.

**Introduction**

In 1923, Louis de Broglie, a French physicist, proposed a hypothesis to explain the theory of the atomic structure. By using a series of substitution, de Broglie hypothesizes particles to hold properties of waves. Within a few years, de Broglie's hypothesis was tested by scientists shooting electrons and rays of light through slits. What scientists discovered was the electron stream acted the same was as light proving de Broglie correct.

**Deriving the de Broglie Wavelength**

De Broglie derived his equation using well established theories through the following series of substitutions:

De Broglie first used Einstein's famous equation relating matter and energy:

$$ E = mc^2 \label{0} $$

with

- $E$ = energy,
- $m$ = mass,
- $c$ = speed of light

Using Planck's theory which states every quantum of a wave has a discrete amount of energy given by Planck's equation:

$$ E = h \nu \label{1} $$

with

- $E$ = energy,
- $h$ = Planck's constant ($6.62607 \times 10^{-34}$ J s),
- $\nu$ = frequency

Since de Broglie believed particles and wave have the same traits, he hypothesized that the two energies would be equal:

$$ mc^2 = h \nu \label{2} $$

Because real particles do not travel at the speed of light, De Broglie submitted velocity $(\nu)$ for the speed of light $(c)$.

$$ mv^2 = h \nu \label{3} $$

Through the equation $\lambda$, de Broglie substituted $v/\lambda$ for $\nu$ and arrived at the final expression that
relates wavelength and particle with speed.

\[ mv^2 = \frac{hv}{\lambda} \quad \text{(Equation 4)} \]

Hence

\[ \lambda = \frac{hv}{mv^2} = \frac{h}{mv} \quad \text{(Equation 5)} \]

A majority of \textit{Wave-Particle Duality} problems are simple plug and chug via Equation \ref{5} with some variation of canceling out units.

\textbf{Example (PageIndex{1})}

Find the de Broglie wavelength for an electron moving at the speed of \(5.0 \times 10^6\) \(\text{m/s}\) (mass of an electron is \(9.1 \times 10^{-31}\) \(\text{kg}\)).

\textbf{SOLUTION}

\[ \lambda = \frac{h}{p} = \frac{h}{mv} = \frac{6.63 \times 10^{-34} \text{J} \cdot \text{s}}{(9.1 \times 10^{-31} \text{ kg})(5.0 \times 10^6 \text{ m/s})} = 1.46 \times 10^{-10} \text{m} \]

Although de Broglie was credited for his hypothesis, he had no actual experimental evidence for his conjecture. In 1927, Clinton J. Davisson and Lester H. Germer shot electron particles onto a nickel crystal. What they saw was the diffraction of the electron similar to waves diffraction against crystals (x-rays). In the same year, an English physicist, George P. Thomson fired electrons towards thin metal foil providing him with the same results as Davisson and Germer.