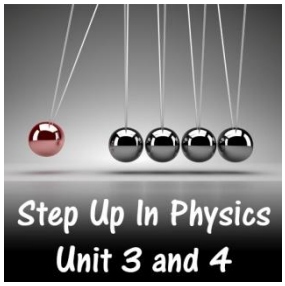
Matter as a Wave

Problems Worksheet



1. An electron is accelerated at 1.82×10^{6} ms^{-2} until it reaches a speed of 3.65×10^{5} ms^{-1}. Calculate the wavelength of the electron.

2. Calculate the wavelength of an proton with 8.50 eV of kinetic energy.

3. De Broglie's PhD thesis, written in 1924, was the first introduction to the wave-particle duality of matter.

    a. Briefly describe what the term wave-particle duality of matter is referring to.

    b. State the two properties of a particle that determine the wavelength of that particle.

    c. With reference to your answer to part (b), explain why wave behaviour is not observed in every day experiences, such as drops of rain falling through the gaps between wooden planks on a bridge.

4. Particle X has a de Broglie wavelength of 2.60×10^{-9} m. Particle Y's mass is twice as heavy as particle X and is moving at a 70.0 % of the speed of particle X. Calculate the de Broglie wavelength of Particle Y.

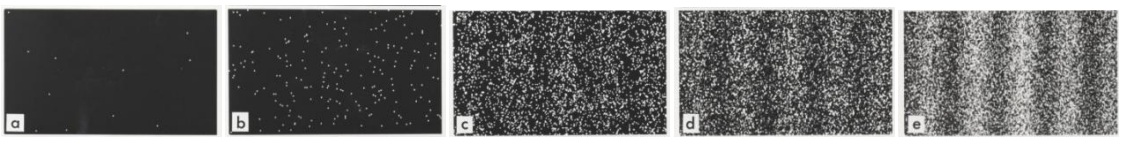
5. Young's double slit experiment is used as evidence of the wave nature of light but it can also be used to show the wave nature of matter.

    a. Explain how Young's double slit experiment shows the wave nature of light.

    b. Explain how Young's double slit experiment shows the wave nature of matter.

6. Compare the size of the wavelength of a proton to an electron that are both travelling at the same speed.

7. It is often stated in introductory quantum physics lectures that the exact position of a particle is unknown until it is detected. This is because while not being observed, small particles display characteristic of waves. When Physicists try to detect the matter wave, the matter seems to behave more like a particle with a definitive location. When a single electron is incident upon two thin slits it will be detected on the other side by a detection screen. After many electrons are passed through the slits in this manner one at a time, a diffraction pattern emerges from the variable density of the electron hits on the screen. An example of the diffraction pattern that builds up over time is shown below.



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   a. Describe why the diffraction pattern is evidence of the wave nature of the electrons as they pass through the slits. Note that only a single electron is incident upon the slits at any one time.

   b. Describe why the detection of the electrons on the screen is evidence of the particle nature of the electron.

c. In an attempt to show the wave nature of the electron, a Physicist places two more detectors, one at each slit, to show the electron is passing through both slits at the same time as a wave. Describe what the Physicist would observe at all three detectors when a single electron approaches the slits.