

NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 383 – Modern Physics

Spring 2023

Problem Set #4

Problem Set Due: Thurs., Feb. 16, 2023

Read Krane: Chapter 4

There will be a Quiz #1 on Tuesday, February 21

Chapter 4

1. Krane: Problem 1

page 134 (just show calculation)

Find the de Broglie wavelength of

- (a) a nitrogen molecule ($m = 28 \text{ u}$) in air at room temperature (in doing so, show that nonrelativistic mechanics can be used).
- (b) a 7 MeV proton in (i) the relativistic limit and (ii) in the nonrelativistic limit.
(iii) Is it ok to use the nonrelativistic limit?
- (c) a 45 GeV electron in (i) the relativistic limit and (ii) in the nonrelativistic limit.
(iii) Is it ok to use the nonrelativistic limit?
- (d) an electron moving at $v = 1.35 \times 10^6 \text{ m/sec}$ in (i) the relativistic limit and (ii) in the nonrelativistic limit. (iii) Is it ok to use the nonrelativistic limit?

2. Krane: Problem 8

page 135 (draw figure)

3. Krane: Problem 20

page 135 (draw figure and what the electron is doing)

For Part (c), read Section 6.5 (in Chapter 6)—especially examine Figure 6.18.

4. Krane: Problem 27

page 136

Note: Equation 4.23 is the inverse Fourier Transform of the function $A(k)$.

- (a) Solve Krane's problem. (show calculation)
- (b) Make a convenient choice of the width Δx (like the spacing between the first 2 minima of the *envelope* function) of the wave packet, and estimate the uncertainty product $\Delta x \Delta k$. You should be able to verify that $\Delta x \Delta k \geq 1$. (draw figure)

5. Krane: Problem 34

page 136 (draw figure)