

NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 283 – Modern Physics

Spring 2026

Problem Set #3

Problem Set Due: Thurs., Feb. 5, 2026

Read Krane Chapter **4.1-4.4**, **6.4-6.5**

*There will be a Quiz #1 on Tuesday, February 10*

1. OpenStax University Physics Vol. 3: Section 4.1: Problem 17
2. OpenStax University Physics Vol. 3: Section 4.2: Problem 31
3. OpenStax University Physics Vol. 3: Section 4.3: Problem 37
  
4. Krane (Note: **this is in Chapter 3**): **Problem 24**      **page 90 (draw picture)**
  - (a) Read **Section 3.4** of Krane on the Compton effect. Draw the scattering diagram for a photon scattering from an electron (you may use Krane's picture, Fig. 3.18).
  - (b) Write down the conservation of energy relation for this scattering problem (use the symbols given by Krane in Fig. 3.18).
  - (c) Write down the conservation of momentum relation (for the  $x$  &  $y$ -directions) for this scattering problem.
  - (d) Show explicitly, step-by-step, the relation between the energy of the incident and scattered photons follows:

$$\frac{1}{E'} - \frac{1}{E} = \frac{1}{m_e c^2} (1 - \cos \theta)$$

or, in terms of the wavelengths:

$$\lambda' - \lambda = \frac{h}{m_e c} (1 - \cos \theta)$$

**5. Krane (Chapter 4): Modified Problem 1 below** **page 134 (show derivation)**

Find the de Broglie wavelength of (*express all answers in meters with 4 significant digits*)

- (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 (write answer to 4 significant digits *in meters*)
  - (i) in the relativistic limit
  - (ii) in the nonrelativistic limit
  - (iii) Is it ok to use the nonrelativistic limit? (*note: the kinetic energy is 7 MeV*)
- (c) a 45 GeV electron (write answer to 4 significant digits *in meters*)
  - (i) in the relativistic limit
  - (ii) in the nonrelativistic limit
  - (iii) Is it ok to use the nonrelativistic limit? (*note: the kinetic energy is 45 GeV*)
- (d) an electron moving at  $v = 1.35 \times 10^6 \text{ m/sec}$  (write answer to 4 significant digits)
  - (i) in the relativistic limit *in meters*
  - (ii) in the nonrelativistic limit *in meters*
  - (iii) Is it ok to use the nonrelativistic limit?

**6. Krane (Chapter 4): 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.

**7. Krane (Chapter 4): Problem 34** **page 136 (draw figure)**

**8. Krane (Chapter 6): Problem 19** **page 204 (draw figure)**

**9. Krane (Chapter 6): Problem 22** **page 204 (draw figure)**