NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 283 – Modern Physics Fall 2025

Problem Set #9

Problem Set Due: Thurs., Nov. 20, 2025
Read Krane: Chapter 10

1. **OpenStax University Physics Vol. 3: Section 2.5:** Problem 67
2. **OpenStax University Physics Vol. 3: Section 2.7:** Problem 87
3. **OpenStax University Physics Vol. 3: Section 2.7:** Problem 89

4. Consider the case in which 6 non-interacting particles share 8 units of energy (where each particle is restricted to hold only integer units of energy). Draw the energy level diagram for the macrostates (see Fig. 10.3), and use the statistical methods outlined in Krane:

   (a) Treat the particles as identical but distinguishable. Calculate the *normalized* probabilities of finding a particle with 8,7,6,5,4,3,2,1, and 0 units of energy. That is, calculate $f(E=8), f(E=7), f(E=6), \ldots, f(E=0)$. Plot $f(E)$ verses E. This distribution is the Maxwell-Boltzmann distribution.

   (b) Treat the particles as identical but indistinguishable. Calculate the normalized probabilities of finding a particle with 8,7,6,5,4,3,2,1, and 0 units of energy. That is, calculate $f(E=8), f(E=7), f(E=6), \ldots, f(E=0)$. Plot $f(E)$ verses E. This distribution is the Bose-Einstein distribution.

   (c) Treat the particles as identical but indistinguishable and obeying the Pauli Exclusion Principle. Calculate the normalized probabilities of finding a particle with 8,7,6,5,4,3,2,1, and 0 units of energy. That is, calculate $f(E=8), f(E=7), f(E=6), \ldots, f(E=0)$. Plot $f(E)$ verses E. This distribution is the Fermi-Dirac distribution.

5. **Krane: Problem 10** **page 337** (show figure)
6. **Krane: Problem 12** **page 337** (just show calculation)
7. Derive Equation 10.52 (the average energy of a free electron gas at absolute zero, $T = 0$)
8. **Krane: Problem 24** **page 338**
   (sketch $N(E)$ vs. E and clearly show where E_F lies)

Problem #9 is on the next page:

9. Quiz #3, Problem #4 (worth 25 points)

posted on the Physics 283 Website: www.niu.edu/brown

use Microsoft Word to draw the ray diagram (using “insert”,”shapes”,”line”)
do the numerical lens calculations to show that the ray tracing results are correct.