NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 283 – Modern Physics Spring 2026

Problem Set #1

Problem Set Due: Thurs., Jan. 22, 2026
Read Krane Chapter **2.1-2.4**, **2.6-2.8**

1. **OpenStax University Physics Vol. 2: Section 16.2:** Problem 43
2. **OpenStax University Physics Vol. 2: Section 16.2:** Problem 45

3. **OpenStax University Physics Vol. 3: Section 3.2:** Problem 28

4. Krane: Problem 3 **page 66** (draw picture)

(a) A shift of one fringe in the Michelson–Morley experiment corresponds to a change in the round-trip travel time along one arm of the interferometer by one period of vibration of light (about 2×10^{-15} s) when the apparatus is rotated by 90°. Based on the results of Example 2.3, what velocity through the ether would be deduced from a shift of one fringe? (Take the length of the interferometer arm to be 11 m.)

(b) Also for this problem: show that the first **three nonzero terms** of the Taylor series expansion of $1/(1+x^2)$ for x near 0 is (*show every step of your calculation in detail*):

$$\frac{1}{1+x^2} \approx 1 - x^2 + x^4 + \cdots$$

Use the relation that the Taylor series expansion of $f(x)$ for x near a is

$$f(x) = f(a) + f'(a)(x-a) + \frac{1}{2!}f''(a)(x-a)^2 + \frac{1}{3!}f'''(a)(x-a)^3 + \cdots$$

(see Winkepedia: Google Taylor Series expansion)

5. Krane: Problem 4 **page 66** (draw picture & show reference frames)

The distance from New York to Los Angeles is about 4000km and should take about 40 h in a car driving at 100 km/h.

(a) How much shorter than 4000km is the distance according to the car travelers?

(b) Also for this problem: show that the first **three nonzero terms** of the Taylor series expansion of $\sqrt{1+x^2}$ for x near 0 is (*show every step of your calculation in detail*):

$$\sqrt{1+x^2} \approx 1 + \frac{x^2}{2} - \frac{x^4}{8} + \cdots$$

(c) How much less than 40 h do they age during the trip?

6. Krane Problem 6 **page 66** (draw picture & show reference frames)

7. Krane Problem 32 **page 68** (just show derivation)

8. Krane Problem 44 **page 68** (draw picture & show reference frames)