

NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 283 – Modern Physics

Fall 2025

Problem Set #1

Problem Set Due: Thurs., Sept. 4, 2025

Read Krane Chapter 2

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  $2 \times 10^{-15}$  s) when the apparatus is rotated by  $90^\circ$ . 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 terms** of the Taylor series expansion of  $1 / (1 + x^2)$  for  $x$  near 0 is (*show every step of your calculation in detail*):

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

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

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

(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 terms** of the Taylor series expansion of  $\sqrt{1+x^2}$  for  $x$  near 0 is (*show every step of your calculation in detail*):

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

- (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)