

PHYSICS 101A – HOMEWORK SET 5

Due in class Wednesday, 11/26/08.

Most of the answers are provided with the problems.

Reading: Tipler and Llewellyn, Chapter 5.

- 1.) Problem 5.1 (Answer: a) 2.1×10^{-23} m; b) 2.1×10^{-21} m/y)
- 2.) Problem 5.4 (Answer to a) 0.0183 nm)
- 3.) Consider a Bragg plane in a crystal of lattice spacing D canted at an angle α relative to a beam of incident radiation characterized by a wavelength λ (for a precise definition of the angle α and lattice parameter D , see Figure 5-4 in the text).
 - a) As suggested in class, derive the Bragg condition for constructive interference

$$n\lambda = D \sin 2\alpha$$

by considering two different rays in the incoming wavefront which are *coincident* upon reflection from successive Bragg planes.

b) What energy incident electron (in eV) will produce an $n=1$ Bragg peak at 50° for a lattice parameter $D = 0.215\text{nm}$? (Answer: 55.2 eV)

- 4.) Problem 5.14
- 5.) Problem 5.17 (Answers: 50 m/s for b) and c); $5\pi\text{m}$ for d)
- 6.) Problem 5.20 (0.6 Hz)
- 7.) Problem 5.27 (6.6×10^{-9} eV)
- 8.) A mass of $1\text{ }\mu\text{g}$ has a speed of 1 cm/s . If its speed is uncertain by 1%, what is the order of magnitude of the minimum uncertainty on its position? (10^{-21} m)
- 9.) Problem 5.40. Note that this energy associated with localization will be known as the ‘zero point energy’ when we take up quantum mechanics. (21 MeV for the neutron)
- 10.) Problem 5.44; do a), b), and c), but skip d) and e). (Answer to c): 11.0 nm)
- 11.) Problem 5.50 (a) 140.4 MeV; b) 4.7×10^{-24} s; c) 1.4 fm). You can ignore part d).
- 12.) Problem 5.52. For this one, skip the text’s b), and instead b) plug in numbers for a 10 gram ping-pong ball dropped from a height of 1 meter, with a release uncertainty of $\Delta x = 1$ micron. c) For what value of the release uncertainty is the targeting uncertainty ΔX minimized, and what is the minimum ΔX ? Hint: The targeting uncertainty will be given by the ‘quadrature’ sum of the contributions from the release (Δx) and momentum-induced (Δq) uncertainties: $\Delta X^2 = \Delta x^2 + \Delta q^2$. (Answers: b) $1\text{ }\mu\text{m}$; c) $6.9 \times 10^{-17}\text{m}$ and $9.8 \times 10^{-17}\text{m}$; here I am using the strict form $\Delta x \Delta p = h/4\pi$) [MORE ON REVERSE...]

Interesting question (do not hand in): if the target is an identical ping-pong ball, and no energy is lost in the collision, approximately how many bounces might you expect the two ping-pong balls to be limited to (due to the uncertainty principle) before the bouncing ball falls outside the radius of the target ball? Remember that if the first ball doesn't fall *exactly* on top of the second ball, it will be deflected slightly when it bounces due to the curvature of the balls.