Academic Year 2020-21

Tutorial #10

PH100: Mechanics and Thermodynamics

1. Electrons are accelerated in television tubes through potential differences of about 10 kV. Find the highest frequency of the electromagnetic waves emitted when these electrons strike the screen of the tube. What kind of waves are these?

2. X-rays of wavelength 10.0 pm are scattered from a target. (a) Find the wavelength of the x-rays scattered through 45°. (b) Find the maximum wavelength present in the scattered x-rays. (c) Find the maximum kinetic energy of the recoil electrons.

3. The distance between adjacent atomic planes in calcite ($CaCO_3$) is 0.300 nm. Find the smallest angle of Bragg scattering for 0.030-nm x-rays.

4. Obtain an expression for the energy levels (in MeV) of a neutron confined to a one-dimensional box 1.00 x 10-14 m wide. What is the neutron's minimum energy? (The diameter of an atomic nucleus is of this order of magnitude.)

5. A proton in a one-dimensional box has an energy of 400 keV in its first excited state. How wide is the box?

6. The position and momentum of a 1.00-keV electron are simultaneously determined. If its position is located to within 0.100 nm, what is the percentage of uncertainty in its momentum?

7. Which of the following wave functions cannot be solutions of Schrödinger's equation for all values of x? Why not? (a) y =A sec x; (b) y = A tan x; (c) y = A exp(x^2); (d) y = A exp($-x^2$).

8. An eigenfunction of the operator d^2/dx^2 is e^{2x}. Find the corresponding eigenvalue.

9. The wave function of a certain particle is y = A $\cos^2 x$ for -pi/2 < x < pi/2. (a) Find the value of A. (b) Find the probability that the particle be found between x = 0 and x = pi/4.

10. Show that the expectation values $\langle px \rangle$ and $\langle xp \rangle$ are related by

$$\langle px \rangle - \langle xp \rangle = \frac{\hbar}{i}$$

This result is described by saying that p and x do not **commute** and it is intimately related to the uncertainty principle.

11. The formula $y = A \cos \omega(t - x/v)$, as we saw in Sec. 3.3, describes a wave that moves in the $+x$ direction along a stretched string. Show that this formula is a solution of the wave equation, Eq.(5.3).