

## Chapter 5

P1 (Tipler 5-1). (a) What is the deBroglie wavelength of a 1-g mass at a speed of 1 m per year? (b) What should be the speed of such a mass if its de Broglie wavelength is to be 1 cm?

P2 (Tipler 5-3). Electrons in an electron microscope are accelerated from rest through a potential difference of  $V_0$  so their de Broglie wavelength is 0.04 nm. What is  $V_0$ ?

Q 1 – Consider the function  $g(k) = e^{-\alpha(k-k_0)^2}$  and its transform  $f(x) = \int_{-\infty}^{\infty} dk g(k)e^{ikx}$ . If  $\alpha$  increases then the width of  $|f(x)|^2$

1. increases
2. decreases
3. stays the same
4. depends on the value of  $k_0$ .

P3 (Tipler 5-20) A certain tuning fork vibrates at 880 Hz. If the tuning fork is tapped, causing it to vibrate, then stopped 0.25 sec later, what is the approximate ranges of frequencies contained in the sound pulse that reached your ear?

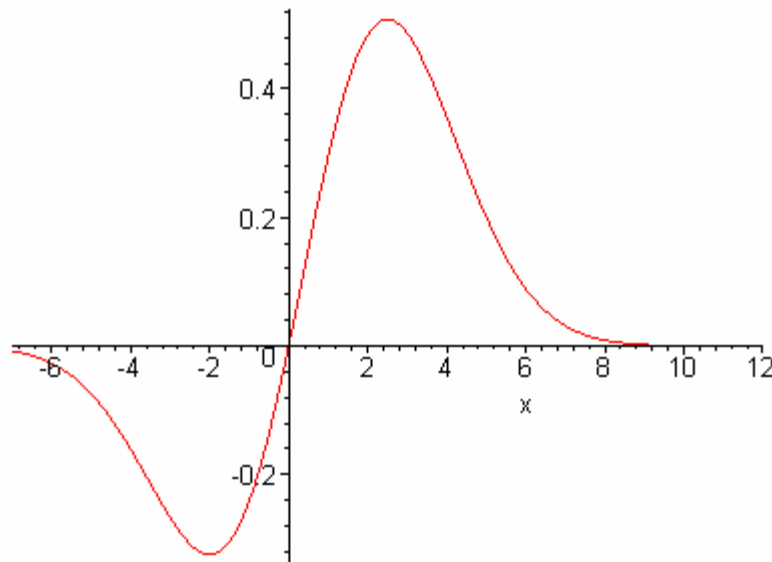
P4 Consider a wave packet for which

$$A(k) = N \quad -K \leq k \leq K$$

$$= 0 \quad \text{everywhere else.}$$

Calculate  $f(x,0)$ , and use some reasonable definition of the width to show indeterminacy is upheld.

Q2 Consider a particle described by the (real) wave state function plotted below at some particular time:



- a) Where are we most likely to find the particle
- b) On which side of the y-axis is it more likely to find the particle?
- c) What is the likelihood that we will find it at  $x > 100$ .

P5. Consider a particle described by a wave function  $\psi(x)$  where the function is 0 for  $x < 0$  and  $x > 3$ , and  $Ax$  for in between 0 and 3.

- a) What is A?
- b) What is the probability of finding the particle exactly at  $x = 2.9$
- c) What is the probability of finding the particle between  $x = 2$  and  $x = 3$ ?

P6 – Physicists (and biophysicists) like to do time resolved spectroscopy. Recently, attosecond laser pulses (actually 650 as) have been made. What is the limit in time resolution one can achieve when working with 300 nm light?

Q3 According to the Heisenberg Uncertainty Principle, there must always be an uncertainty  $\hbar$  in the

- 1. momentum of a particle
- 2. energy of a particle
- 3. Lifetime of a particle
- 4. All of the above
- 5. None of the above.

P7 (Tipler 5-32). In order to locate a particle, e.g. an electron, to within  $5 \times 10^{-12}$  m using electromagnetic waves, the wavelength must be at least this small. Calculate the momentum and energy of a photon with  $\lambda = 5 \times 10^{-12}$  m. If the particle is an electron with  $\Delta x = 5 \times 10^{-12}$  m, what is the corresponding uncertainty in its momentum?

P8 - Use the uncertainty relation to estimate the ground state energy of a harmonic oscillator. The energy is given by

$$E = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 x^2$$