

Homework 7.1 – Introduction to Quantum Theory

Name: _____

Exercise 7A.5 (b) (10 points)

Calculate the energy of a photon and the energy per mole of photons for radiation of wavelength (i) 200 *nm* (ultraviolet), (ii) 150 *pm* (X-ray), (iii) 1.00 *cm* (microwave)

Exercise 7A.11 (a) (5 points)

To what speed must an electron be accelerated for it to have a de Broglie wavelength of 3.0 *cm*?

Exercise 7A.12 (a) (5 points)

The ‘fine-structure constant,’ α , plays a special role in the structure of matter; its approximate value is $1/137$. What is the de Broglie wavelength of an electron travelling at αc , where c is the speed of light?

Exercise 7B.2 (b) (5 points)

Normalize (to 1) the wavefunction e^{-ax} in the range $0 \leq x \leq \infty$, with $a > 0$

Problem 7B.7 (10 points)

A normalized wavefunction for a particle confined between 0 and L in the x direction is $\Psi = (2/L)^{1/2} \sin(\pi x/L)$. Suppose that $L = 10.0 \text{ nm}$. Calculate the probability that the particle is (a) between $x = 4.95 \text{ nm}$ and 5.05 nm , (b) between $x = 1.95 \text{ nm}$ and 2.05 nm , (c) between $x = 9.90 \text{ nm}$ and 10.00 nm , (d) between $x = 5.00 \text{ nm}$ and 10.00 nm

Exercise 7C.2 (a) (10 points)

Identify which of the following functions are eigenfunctions of the operator d/dx : (i) $\cos(kx)$; (ii) e^{ikx} ; (iii) kx ; (iv) e^{-ax^2} . Give the corresponding eigenvalue where appropriate

Exercise 7C.3 (a) (5 points)

Functions of the form $\sin(n\pi x/L)$, where $n = 1, 2, 3, \dots$ are wavefunctions in a region of length L (between $x = 0$ and $x = L$). Show that the wavefunctions with $n = 1$ and 2 are orthogonal; you will find the necessary integrals in the *Resource section*. (*Hint*: Recall that $\sin(n\pi) = 0$ for integer n) (*Even Better Hint*: Some integrals can be solved by symmetry arguments)

Exercise 7C.3 (b) (5 points)

For the same system as in Exercise E7C.3(a) show that the wavefunctions with $n = 2$ and $n = 4$ are orthogonal

Exercise 7C.9 (a) (5 points)

Calculate the minimum uncertainty in the speed of a ball of mass 500 g that is known to be within $10\text{ }\mu\text{m}$ of a certain point on a bat. What is the minimum uncertainty in the position of a bullet of mass 5.0 g that is known to have a speed somewhere between $350.000\text{ }01\text{ m s}^{-1}$ and $350.000\text{ }00\text{ m s}^{-1}$?

The Waves

By Virginia Woolf

I see nothing.

We may sink and settle
on the waves.

The sea will drum
in my ears.

The white petals
will be darkened
with sea water.

They will float
for a moment
and then sink.

Rolling over
the waves will
shoulder me under.

Everything falls in a
tremendous shower,
dissolving me.