# PHYSICS 4, CHAPTER 3
# ADDITIONAL PROBLEMS

**1**. What is the de Broglie wavelength of an electron with a kinetic energy of 120 eV?

**2**. The wavelength of the yellow spectral emission line of sodium is 590 nm. At what kinetic energy would an electron have that wavelength as its de Broglie wavelength?

**3**. Assume that an electron is moving along an x axis and that you measure its speed to be $2.05 \times 10^6$ m/s, which can be known with a precision of 0.50%.
What is the minimum uncertainty (as allowed by the uncertainty principle in quantum theory) with which you can simultaneously measure the position of the electron along the x axis?

**4**. The uncertainty in the position of an electron along an x axis is given as 50 pm, which is about equal to the radius of a hydrogen atom. What is the least uncertainty in any simultaneous measurement of the momentum of this electron?

**5**. An electron and a 0.020 0-kg bullet each have a velocity of magnitude 500 m/s, accurate to within 0.010 0%. Within what lower limit could we determine the position of each object along the direction of the velocity?

**6.** A 0.500-kg block rests on the frictionless, icy surface of a frozen pond. If the location of the block is measured to a precision of 0.150 cm and its mass is known exactly, what is the minimum uncertainty in the block's speed?

**7.** The average lifetime of a muon is about 2 ms. Estimate the minimum uncertainty in the rest energy of a muon.

**8**. An electron is confined to a one-dimensional, infinitely deep potential energy well of width
L = 100 pm.
(a) What is the smallest amount of energy the electron can have?
(b) How much energy must be transferred to the electron if it is to make a quantum jump from its ground state to its second excited state?
(c) If the electron gains the energy for the jump from energy level $E_1$ to energy level $E_3$ by absorbing light, what light wavelength is required?
(d) Once the electron has been excited to the second excited state, what wavelengths of light can it emit by de-excitation?

**9**. A ground-state electron is trapped in the one-dimensional infinite potential well with width L = 100 pm.
(a) What is the probability that the electron can be detected in the left one-third of the well ($x_1 = 0$ to $x_2 = L/3$)?
(b) What is the probability that the electron can be detected in the middle one-third of the well (between $x_1 = L/3$ and $x_2 = 2L/3$)?

**10**. The ground-state energy of an electron trapped in a one dimensional infinite potential well is 2.6 eV. What will this quantity be if the width of the potential well is doubled?

**11**. An electron is trapped in a one-dimensional infinite potential well. For what
(a) higher quantum number and
(b) lower quantum number
is the corresponding energy difference equal to the energy of the n = 5 level?
(c) Show that no pair of adjacent levels has an energy difference equal to the energy of the n = 6 level.

**12**. An electron is trapped in a one-dimensional infinite potential well that is 100 pm wide; the electron is in its ground state. What is the probability that you can detect the electron in an interval of width $\Delta x = 5.0$ pm centered at x =
(a) 25 pm,
(b) 50 pm, and
(c) 90 pm?

**13.** (a) Use the quantum-particle-in-a-box model to calculate the first three energy levels of a neutron trapped in an atomic nucleus of diameter 20.0 fm.
(b) Explain whether the energy-level differences have a realistic order of magnitude.

**14.** An electron that has an energy of approximately 6 eV moves between infinitely high walls 1.00 nm apart. Find
(a) the quantum number $n$ for the energy state the electron occupies and
(b) the precise energy of the electron.
**15.** An electron is contained in a one-dimensional box of length 0.100 nm.
(a) Draw an energy-level diagram for the electron for levels up to $n = 4$.
(b) Photons are emitted by the electron making downward transitions that could eventually carry it from the $n = 4$ state to the $n = 1$ state. Find the wavelengths of all such photons.
**16.** A ruby laser emits 694.3-nm light. Assume light of this wavelength is due to a transition of an electron in a box from its $n = 2$ state to its $n = 1$ state. Find the length of the box.
**17.** A laser emits light of wavelength $\lambda$. Assume this light is due to a transition of an electron in a box from its $n = 2$ state to its $n = 1$ state. Find the length of the box.
**18**. A particle in a one-dimensional box of length $L$ is in its first excited state, corresponding to $n = 2$. Determine the probability of finding the particle between $x = 0$ and $x = L/4$.