Physics 131 – Test 3 – Fall 2007

One-page reminder sheet allowed. Note that $\hbar = 1.06 \times 10^{-34}$ J s, $c = 3 \times 10^8$ m s^{-1}. *Show all work – no credit given if work not shown!*

1. An electron (mass 9.11×10^{-31} kg) with wavelength $\lambda = 1.2 \times 10^{-10}$ m undergoes Bragg diffraction from a single crystal with atomic plane spacing of $d = 2 \times 10^{-10}$ m.
   (a) Calculate the Bragg angles (all of them!) for which constructive interference occurs.
   (b) Calculate the speed of the electron.
2. Write a short discussion on the difficulties of playing soccer in a world where Planck's constant is $\hbar = 1$ kg m^2 s^{-1}.
3. Suppose a particle of mass M moving in the $x - y$ plane is subject to a force with potential energy $U = A(x^2 - y^2)$ where A is a positive constant.
   (a) Compute the vector components of the force on the particle.
   (b) If the particle moves from point 1 $(a, 0)$ to point 2 $(0, a)$ where a is a positive constant, compute the work done by this force.
   (c) If the force derived from U is the only force acting on the particle, compute the particle's change in kinetic energy in going from $(a, 0)$ to $(0, a)$.
   (d) Determine the region of the $x - y$ plane classically accessible to the particle if its total energy $E = 0$.
4. Suppose that a particle has the wave function $\psi(x, t) = \cos(kx) \exp(-i\omega t)$.
   (a) What are the possible values of momentum that the particle could have?
   (b) What are the possible values of the energy?
5. For the following wave functions (k and d are constants), specify which have definite values of the momentum, which have definite values of the parity, and which have neither. In each definite value case specify the actual value of the momentum or parity. Explain your reasoning in each case.
   (a) $\psi = \cos(kx)$.
   (b) $\psi = \sin(kx)$.
   (c) $\psi = \exp(ikx)$.
   (d) $\psi = \exp(ix^2/d^2)$.
6. The energy levels for a particle in a box are evenly spaced in energy.
   (a) What can you infer about the particle? Explain.
   (b) If the spacing of the energy levels is E_0, derive an equation for the size of the box.