Sample Problems for Modern Physics – Exam I

1. Write wave equation for string.
2. What is wave speed on a string of length 1.00 m, mass $2.00 \times 10^{-4}$ kg under tension 0.60 N?
3. Sketch the first four harmonics of vibration of a string with fixed ends. What is the frequency of the fourth harmonic in the string in the last problem?
4. Write the Hamiltonian *H(p,q)* for a simple harmonic oscillator.
5. Consider the wave solution *q(x,t)* = (*5.00* cm) cos (*0.50 x+ 0.30t*). What is the wavelength, frequency and wavespeed, provided x is in cm and t in seconds?
6. Define f(x)=x for x in (0,π). Find the Fourier sine coefficients in the series $f(x) = \sum_{n=1}^{\infty} a_n \sqrt{\frac{2}{\pi}} \sin nx.$
7. Given the probability density *f(x) = x(1-x)*, for *x* in (0,1), find the mean <x>.
8. What is the expression for the average energy of a free particle of mass m at temperature T?
9. State the Equipartition Theorem.
10. Give Planck's energy distribution for blackbody radiation.
11. Using Wein's Law, $\lambda_{\max} T = 2.9$ mK, determine the peak wavelength radiated from the human body taking its temperature to be $37^{o}$ C. In which part of the electromagnetic spectrum does this lie?
12. An orbiting satellite can become charged by the photoelectric effect when sunlight ejects electrons from the vehicle's outer surface and satellites have to be designed to minimize such charging. If a satellite is coated with platinum, a metal with a particularly large work function of 5.32 eV, what will be the longest wavelength of incident sunlight that can eject an electron?
13. X-rays with wavelength of 0.12 m undergo Compton scattering.
    a. What will be the wavelength of the photons scattered at $30^{o}$?
    b. What is the energy of the scattered electron?
14. What is the kinetic energy of an electron with deBroglie wavelength of 5.0 nm?
15. The Paschen series in the hydrogen spectrum is formed by electron transitions from *n>3* fall down to the *n=3* state.
    a. What will be the longest wavelength in this series?
    b. What is the lower bound of the wavelengths in the series?
    c. In which part of the electromagnetic spectrum will these wavelengths be found?
16. What are the electorn energy and radius of the electron orbit in a Hydrogen atom for *n=4*?