UP201: Introductory Physics III

IISc Bangalore

Semester I, 2017–2018

PROBLEM SET 2, FINISH BY: SEPT. 27, 2017

Reading: SJ, Chapter 40.

2/1. **(C) Conceptual ideas:**

(a) SJ-40-Q1[1]
(b) SJ-40-Q2[2]
(c) SJ-40-Q8[8]
(d) SJ-40-Q16[16]
(e) SJ-40-Q21[21]
(f) SJ-40-Q24[24]

2/2. **(C/T) Problems:**

(a) SJ-40-P2[2]
(b) SJ-40-P3[3]
(c) SJ-40-P7[7]
(d) SJ-40-P15[15]
(e) SJ-40-P21[21]
(f) SJ-40-P34[34]
(g) SJ-40-P36[36]
(h) SJ-40-P39[39] (attempt this problem after we have covered relativity)
(i) SJ-40-P51[51]
(j) SJ-40-P52[52]
(k) SJ-40-P61[61]

2/3. **(C) Hamilton and the pendulum:** Write down the Hamiltonian of a simple pendulum (motion confined to a vertical plane) of length ℓ and mass m. Find its equation of motion from the Hamiltonian, and show that it agrees with the result obtained by application of Newton's law. Make a phase portrait of the motion of the simple pendulum.

2/4. **(C) Well...a double well!:** A particle of mass m moves in a potential

$$V(x) = -\frac{1}{2}k_2x^2 + \frac{1}{4}k_4x^4$$

where k_2 and k_4 are positive.

(a) What are the dimensions of k_2 and k_4?

(b) Make a plot of the potential marking all the important points.

(c) Make a phase portrait of the particle.

2/5. **Uncertainty Principle:** Use the uncertainty principle to estimate the ground state energy of a simple harmonic oscillator.

2/6. **Localization vs. Coulomb:** Consider two protons. If they are brought to within a distance of 10^{-15}m, estimate

- Coulomb energy (electrostatics)
- Localization energy (arising from uncertainty principle)

How do you think these two will compare had the two particles been electrons? Verify your argument by an explicit calculation.

2/7. **(C) An Oscillator with a Wall:** Consider a particle of mass m moving in the potential

$$V(x) = \begin{cases} \infty & x \leq 0 \\ \frac{1}{2}m\omega^2 x^2 & x > 0 \end{cases}$$

Using Bohr-Sommerfeld quantization condition obtain the energy levels of the oscillator.(You may wish to make a phase portrait of this)

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