



MR301: Concepts in Materials Science I
Materials Research Centre, IISc Bangalore
Semester I, 2005–2006

PROBLEM SET 1

- 1/1. **Whither Materials Science? (Part II)** To find out, read Reviews of Modern Physics, **71** (1999) S331.
- 1/2. **Some Hamiltonian muscle flexing!** For the following potentials in 1D, write down the Hamiltonian function for a particle of mass $m = 1$. From Hamilton's equations solve for the trajectories and represent them in phase space (using a computer if you like)! In each case, the initial conditions are given in brackets
- (a) $V(x) = \frac{1}{2}x^2$ ($x(0) = 0, p(0) = 1$)
- (b) $V(x) = \sin^2(x)$ ($x(0) = 0, p(0) = 1/100$)
- 1/3. **Oh, that ball dropping:** A ball of mass m is dropped from a height h . Using Hamiltonian formalism, solve for the speed of the ball when it hits the ground.
- 1/4. **But of course, the pendulum:** Find the natural frequency of a simple pendulum using Hamilton's formalism. This is problem for you to understand the concept of generalised coordinates.
- 1/5. **A constrained pendulum!:** Suppose that the pendulum is placed symmetrically between two vertical walls separated by a distance $2a$. Taking the length of the rod of the pendulum as ℓ ($\ell > a$) and mass of the particle as m , draw the phase trajectories.
- 1/6. **Force the strength of magnetism:** If you take a meter long copper wire and apply a voltage of 1 volt across it, what will be the drift velocity of the electrons? Now for this drift velocity, calculate the magnitude of the force on the electron due to a magnetic field of 1 Tesla applied perpendicular to the wire. What do you learn?
- 1/7. **Refractive index:** How are dielectric constant and permeability of a material related to the refractive index of a material? To find out, solve Maxwell's equations in matter. Check out the relation for some of your favourite transparent materials.
- 1/8. **Alternative life style:** We know (or at least hope so) that the conductivity is given as $\sigma_0 = \frac{ne^2\tau}{m}$ for a d. c. electric field. Listing any assumptions, show that the a. c. conductivity for an electric field oscillating with frequency ω is given by $\sigma(\omega) = \frac{\sigma_0}{1 + \omega^2\tau^2}$. Make a plot of $\sigma(\omega)$ vs. ω for copper. For what range of ω is this a reasonable estimate?
- 1/9. **Transparent gold! :** Gold in jewelery is golden in colour (it better be, else your jewelry is likely to be fake...well, even if it is golden in colour it is likely to be fake...). However, "very thin" films of gold coated on glass are dull gray and even transparent (You can ask your colleague Venkatesan of MRC to show you these films if you wish).
- (a) Why does the "very thin" gold film become transparent?
- (b) How "very thin" must the film be for it to have some transparency?