

PHY 3221 : Intermediate Mechanics, Spring 2003

January 24th, 2003

Assignment # 3

(due Friday January 31st, 2003, at the beginning of class)

1. Problem 2.37 of Marion and Thornton's book.
2. Problem 2.24 of Marion and Thornton's book.
3. Problem 2.26 of Marion and Thornton's book.
4. Problem 2.43 of Marion and Thornton's book.
5. The potential energy for a vibrating diatomic molecule can be approximated by the following function:

$$U(x) = U_0 \left[1 - e^{-(x-x_0)/\delta} \right]^2 - U_0$$

where x is the separation distance between the two constituent atoms, and x_0 , U_0 and δ are parameters chosen to describe the observed behavior of a particular molecule (the meaning of these parameters becomes clearer in solving the problem).

- (a) Does the system admit any equilibrium point? If yes, is the equilibrium stable or unstable? Justify your answer showing full work. What is the meaning of x_0 and U_0 in the parameterization of $U(x)$?
- (b) Draw a qualitative sketch of the function $U(x)$ and describe the relative motion of the two atoms (i.e. the vibrations of the molecule) when the energy of the system is: $E = -U_0$, $-U_0 < E < 0$, and $E \geq 0$.
- (c) What is the force that each atom exerts on the other?
- (d) Show that for separation distances x close to x_0 the potential energy is parabolic and the force is linear and always directed towards the equilibrium point (restoring force). (Remember that the Taylor expansion of the exponential function about a given point x_0 is: $\exp(x - x_0) = 1 + (x - x_0) + (x - x_0)^2/2 + O((x - x_0)^3)$).