FDDP
Classical Mechanics - Tutorial 1

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1. A cannon launches a projectile at an angle of θ, with an initial speed of v_0. Find the projectile's trajectory, velocity, and range.

2. (2-9.) Consider a projectile fired vertically in a constant gravitational field. For the same initial velocities, compare the times required for the projectile to reach its maximum height:

   i. for zero resisting force

   ii. for a resisting force proportional to the instantaneous velocity of the particle

3. (2-52) A particle of mass m moving in one dimension has potential energy $U(x) = U_0[2(x/a)^2 - (x/a)^4]$, where U_0 and a are positive constants.

   i. Find the force $F(x)$ which acts on the particle.

   ii. Sketch $U(x)$. Find the positions of stable and unstable equilibrium.

   iii. What is the angular frequency ω of oscillations about the point of stable equilibrium? [Hint : Taylor expansion]

   iv. What is the minimum speed the particle must have at the origin to escape to infinity?

   v. At $t = 0$ the particle is at the origin and its velocity is positive and equal in magnitude to the escape speed of part (d). Find $x(t)$ and sketch the result.

4. (3-4) Consider a simple harmonic oscillator.

   i. Calculate the time averages of the kinetic and potential energies over one cycle, and show that these quantities are equal. Why is this a reasonable result?

   ii. Calculate the space averages of the kinetic and potential energies. Sketch both graphs and discuss the results.