



**PH103 : Physics
Tutorial 5**

1. A commonly used potential energy function to describe the interaction between two atoms is the Morse potential

$$V(r) = D \left[1 - e^{-a(r-r_0)} \right]^2 - D,$$

where r_0 is the equilibrium distance, D is the well depth and a controls the width of the potential. For HCl molecule $r_0 = 1.275 \times 10^{-10}$ m, $D = 4.618$ eV, $a = 1.869 \times 10^{10} m^{-1}$.

- a. Find the frequency of small oscillations about equilibrium for HCl molecule? (AMU of Cl is 35)
b. Sketch the $V(r)$ and Force.
2. For small oscillations the period of pendulum is approximately $T \approx 2\pi\sqrt{\frac{l}{g}}$
(a) using $dt = \frac{dx}{v}$, show that the exact expression for T is

$$T = \sqrt{\frac{8l}{g}} \int_0^{\theta_0} \frac{d\theta}{\sqrt{\cos\theta - \cos\theta_0}}.$$

(b) Making use of the identity $\cos\phi = 1 - 2\sin^2\frac{\phi}{2}$, write T in terms of sines. Make a suitable change of variables,

$$\sin x \equiv \frac{\sin\frac{\theta}{2}}{\sin\frac{\theta_0}{2}}.$$

Now expand the integrand in powers of θ_0 and evaluate the resulting integral to show that

$$T = 2\pi\sqrt{\frac{l}{g}} \left(1 + \frac{\theta_0^2}{16} + \dots \right)$$

3. A cylinder of mass M and radius R is rotated in a uniform V groove with constant angular velocity ω . The coefficient of friction between the cylinder and each surface is μ . What torque must be applied to the cylinder to keep it rotating.
4. Evaluate $\iiint 3z dV$ in the region below $x^2 + y^2 + z^2 = 1$ and inside $z = \sqrt{x^2 + y^2}$.