

## PH-105 Assignment Sheet - 2 (Quantum Mechanics)

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1. Two similar particles of mass  $m$  are connected to each other by a spring of negligible natural length and mass and spring constant  $k$ . The particles are made to rotate in a circle about their common centre of mass, such that the distance between them is  $R$ . Assume that the only force between the particles is the one provided by the spring. Apply Bohrs quantization rule to this system and find the allowed value of  $r$  and the energies in terms of fundamental constants if any, the mass and the spring constant.

Solution :

First of all the velocities of particles will be same and they will be rotating around the midpoint of the line joining them.

Writing force equation

$$kr = mv^2/(r/2) = 2mv^2/r \dots(i)$$

Now angular momentum quantization gives

$$mvr/2 + mvr/2 = mvr = nh/2\pi \dots(ii)$$

Dividing (i) by  $(ii)^2$  gives

$$2/mr^3 = 4\pi^2 kr/n^2 h^2$$

$$r^4 = n^2 h^2 / 2mk\pi^2 \Rightarrow r = (n^2 h^2 / 2mk\pi^2)^{1/4}$$

put this in (i) we get

$$TKE = mv^2 = kr^2/2 = k\sqrt{n^2 h^2 / 2mk\pi^2} / 2 = nh/2\pi \sqrt{k/2m}$$

And Potential Energy is

$$V = 1/2kr^2 = TKE$$

So total energy is

$$E = nh/\pi \sqrt{k/2m}$$