1. Dumbbell *(6 points)*

1) During the first collision, we can neglect the effect of the spring, because during the collision time, the balls almost don't move, hence the spring doesn't deform. Two absolutely elastic identic balls exchange velocity during a central collision. So, the first ball will remain at rest, and the second one will obtain the velocity v. So, the velocity of the centre of mass of the dumbbell is $v/2$.

2) After the impact, the dumbbell will oscillate in the system of reference of its centre of mass with circular frequency $\omega = \sqrt{2k/m}$ (balls oscillate so that the middlepoint of the spring is at rest; twice shorter spring has a twice larger stiffness).

Due to the energy conservation law, the only way for the fourth ball to acquire the velocity v is such that all the other balls remain at a complete rest after the interaction. Therefore, before the impact of the third and fourth balls, the third ball must have velocity v (and the second ball must be at rest). This is the opposite phase of the moment, when the dumbbell started its motion. Hence, the travel time t of the dumbbell must be a half-integer multiple of the period $T = 2\pi\sqrt{m/2k}$. For that phase of oscillation, the spring is, again, undeformed, i.e. the travel distance of the centre of mass is also L. So, $2L/v = T\left(n + \frac{1}{2}\right)$, hence

$$L = \pi v \left(n + \frac{1}{2}\right) \sqrt{m/2k}.$$