Q3

"initial"

→

"final": the ball contains { the spring energy, U_s ; the potential energy, U_g ; the kinetic energy, K

Using the energy principle, we can say,

"no compression" → $U_{s,f}$ = 0 ; "at rest" → K_i = 0

$$(\text{final}) \quad U_{s,f} + U_{g,f} + K_f = U_{s,i} + U_{g,i} + K_i \quad (\text{initial})$$

That is,

$$mg(L_0 \sin\theta) + K = \frac{1}{2}k(L-L_0)^2 + mg(L\sin\theta)$$

Thus,

$$\frac{1}{2}mv^2 = \frac{1}{2}k(L-L_0)^2 + mg(L-L_0)\cdot\sin\theta$$

$$mv^2 = k(L-L_0)^2 + 2mg\sin\theta\,|L-L_0|$$

$$v^2 = \frac{k}{m}(L-L_0)^2 + 2g\sin\theta\,|L-L_0|$$

"absolute value" to prevent misunderstanding

$$\therefore \quad v = \sqrt{\frac{k}{m}(L-L_0)^2 + 2g\sin\theta\,|L-L_0|}$$