Show all your work neatly! The 1 kg ball falls from rest into the spring-operated launcher. When the ball re-enters the barrel, it experiences a constant friction force of 2 N as long as it is in motion in the barrel. The spring (shown in its un-stretched position) has a spring constant \( k = 100 \text{ N/m} \).

1. What is the ball’s location when it momentarily comes to rest after it begins to fall?

Let final compression of spring be \( d \) and set \( h = 0 \) where the ball comes to rest. Then conservation of energy gives

\[
W_{nc} = E_f - E_i
\]

\[
-(f)(1+d) = \frac{1}{2}kd^2 - mg(4+d)
\]

This gives a quadratic in \( d \).

\[
50d^2 - 7.81d - 37.24 = 0
\]

\[
d = \frac{7.81 \pm \sqrt{7.81^2 - 4(50)(-37.24)}}{100} = 0.945 \text{ m}
\]

2. What is the ball’s location when it reaches its maximum velocity?

For this, we just need to calculate where the acceleration first becomes zero, since the ball will be speeding up until it reaches that point (therefore its maximum velocity will occur there). The acceleration becomes zero when the sum of forces becomes zero.

\[
\sum F_y = f + kx - mg = 0
\]

\[
x = \frac{mg - f}{k} = \frac{(1)(9.81) - 2}{100} = 0.0781 \text{ m}
\]

So the ball reaches maximum velocity when the spring has been compressed 7.81 cm.