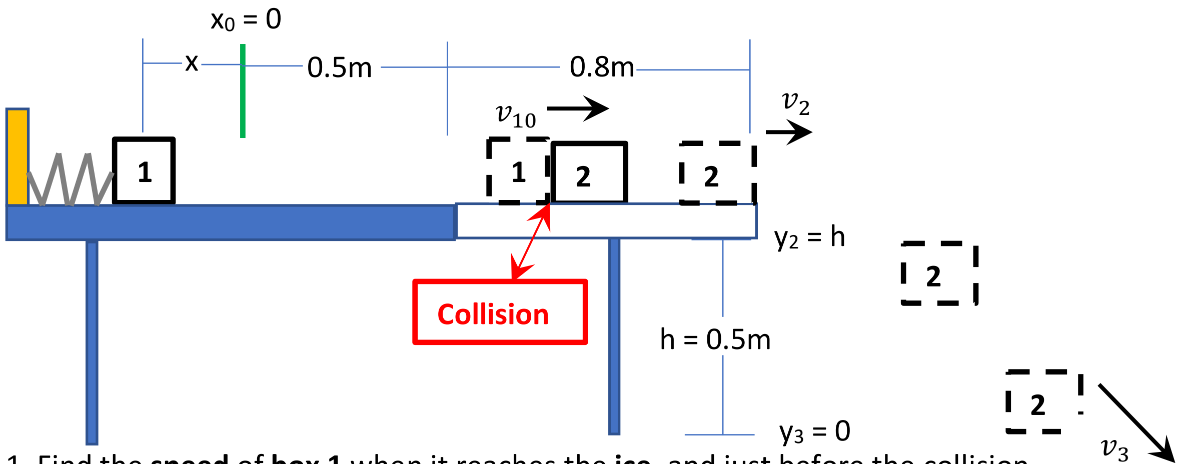
QUIZ 4, PHYS 1211 F2018, November 16, 2018

In the Figure below, **box 1** (m_1 = 1.5 kg) is on a table. An unknown human **compresses** the box and spring ($k = 400\ N \cdot m^{-1}$) by x = 20 cm from **equilibrium** (indicated by the **green line** with x_0 = 0). The **blue portion** has **friction** ($\mu_k = 0.3666$ and $\mu_s = 0.55$), while the clear portion is **ice** (assumed **frictionless**). The dimension of the table is indicated in the diagram. The human then **released** Box 1 (i.e. the box and spring is now allowed to move). Box 1 then moves through the **blue section** to reach the **ice** section with a speed of v_{10}, then it **collides** (indicated by the **red sign**) with **Box 2** (mass m_2 = 3kg). **Box 1** rebounds from the collision with a velocity of $v_1 = 0.5 m \cdot s^{-1}$ to the **left**, and **box 2** move to the right at a speed of v_2. Box 2 then falls off the table hitting the ground at a speed of v_3.



1. Find the **speed** of **box 1** when it reaches the **ice**, and just before the collision.
Use conservation of energy equation 8.35, $W = \Delta E_{mec} + \Delta E_{th} + \Delta E_{int}$, with ΔE_{int} and W = 0:

$$0 = \Delta E_{mec} + \Delta E_{th} = (\Delta K + \Delta U) + f_k L = (K_f - K_i) + (U_f - U_i) + f_k L$$

Initial (i): speed is zero, so kinetic energy is $K_i = 0$, spring is compressed by x = 0.2m, so the potential energy is $U_i = \frac{1}{2} k x^2$. (**1 point**)

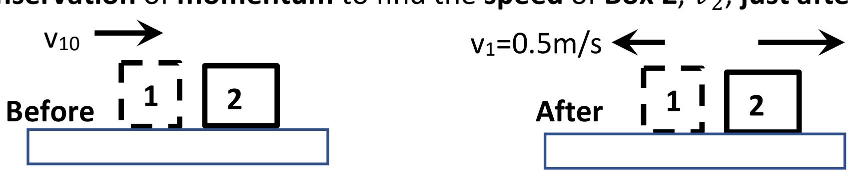
final (f): speed is v_{10} is the quantity we are trying to find, so kinetic energy is $K_f = \frac{1}{2} m_1 v_{10}^2$, spring is not compressed or stretched, so the potential energy is $U_f = 0$. (**1 point**)

Change in Thermal Energy (i.e. friction): $f_k L = m_1 g \mu_k L = 1.5kg \times \left(9.8 \frac{m}{s^2}\right) \times 0.3666 \times 0.7m$, $f_k L = 3.7723J$. (**1 point**). This gives:

$$0 = \frac{1}{2} m_1 v_{10}^2 - \frac{1}{2} k x^2 + m_1 g \mu_k L = \frac{1}{2}(1.5kg) v_{10}^2 - \frac{1}{2}\left(400 \frac{N}{m}\right)(0.2m)^2 + 3.7723J$$

ANSWER: $v_{10} = 2.374 \frac{m}{s}$ (**2 points**)

2. Use **conservation** of **momentum** to find the **speed** of **Box 2**, v_2, **just after** the **collision**.



Use equation 9.43, **initial momentum** $m_1 v_{10} = -m_1 v_1 + m_2 v_2$ **final momentum**.
$(1.5kg)(2.374m/s) = -(1.5kg)(2.374m/s) + (3kg)v_2$(**3 points**)
$v_2 = 1.437m/s$, **moving right** since it is **positive**. (**2 points**)

3. Use **conservation** of **mechanical energy** to find the **speed** of **Box 2**, v_3, just before it hits the ground.
From equation 8.15 and 8.16: $K_2 + U_2 = K_3 + U_3$
I have labeled initial as 2 and final as 3. See the diagram on the previous page.
Initial (2): speed $v_2 = 1.437m/s$, kinetic energy $K_2 = \frac{1}{2}m_2v_2^2$, vertical position y_2 = h = 0.5m (see diagram on previous page), gravitational potential, $U_2 = m_2gy_2$. (**1 point**)
Initial (3): speed v_3 =?, kinetic energy $K_3 = \frac{1}{2}m_2v_3^2$, vertical position y_3 = 0 (see diagram on previous page), gravitational potential, $U_3 = 0$. (**1 point**)

$$K_2 + U_2 = K_3 + U_3 \rightarrow \frac{1}{2}m_2v_2^2 + m_2gy_2 = \frac{1}{2}m_2v_3^2$$

$$v_3 = \sqrt{v_2^2 + 2gy_2} = \sqrt{(1.437m/s)^2 + 2(9.8m \cdot s^{-2})(0.5m)} = 3.44m \cdot s^{-1}$$

(**3 points**) for using the right equation and values, and getting the right answer.
BONUS: Calculate the change in kinetic energy, $\Delta K = K_{final} - K_{initial}$, due to the **collision**. Based on your answer is the **collision elastic**.
Let's go back to the values of question 3: **before (initial) collision**, **box 1**, $v_{10} = 2.374m/s$, and **box 2** is not moving (zero kinetic energy); **after (final) collision**, **box 1**, v_1=0.5m/s, and box 2, $v_2 = 1.437m/s$. (**2 points**)

Final **Initial**

$$\Delta K = \left(\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2\right) - \frac{1}{2}m_1v_{10}^2$$

$$\Delta K = \left(\frac{1}{2}(1.5kg)\left(0.5\frac{m}{s}\right)^2 + \frac{1}{2}(3kg)\left(1.437\frac{m}{s}\right)^2\right) - \frac{1}{2}(1.5kg)\left(2.374\frac{m}{s}\right)^2 = -0.94J$$

(**2 points**) for above
A **collision** is **elastic** only if the **kinetic energy** is **conserved** $\Delta K = 0$. Since $\Delta K < 0$ this is **not** an **elastic collision**. (**1 point**)

OUT of 15 Students can get 20 out of 15