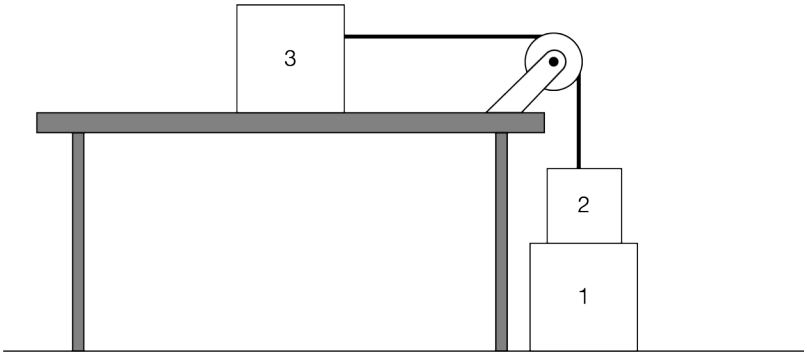
Unit 2 Progress Check: FRQ

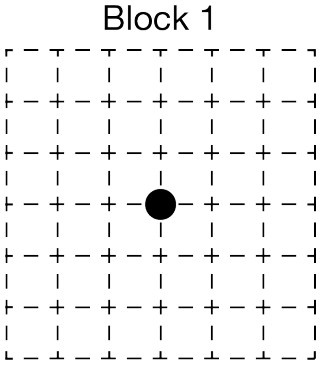
1. This question is a long free-response question. Show your work for each part of the question.



Block 1 is resting on the floor with block 2 at rest on top of it. Block 3, at rest on a smooth table with negligible friction, is attached to block 2 by a string that passes over a pulley, as shown above. The string and pulley have negligible mass.

(a)

i. On the dot that represents block 1, draw and label the forces (not components) exerted on block 1. Each force must be represented by a distinct arrow starting on, and pointing away from, the dot. Draw the relative lengths of all arrows to reflect the relative magnitudes of the forces.



ii. On the dot that represents block 2, draw and label the forces (not components) exerted on block 2. Each force must be represented by a distinct arrow starting on, and pointing away from, the dot. Draw the relative lengths of all arrows to reflect the relative magnitudes of the forces.

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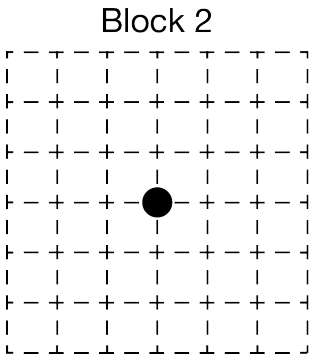


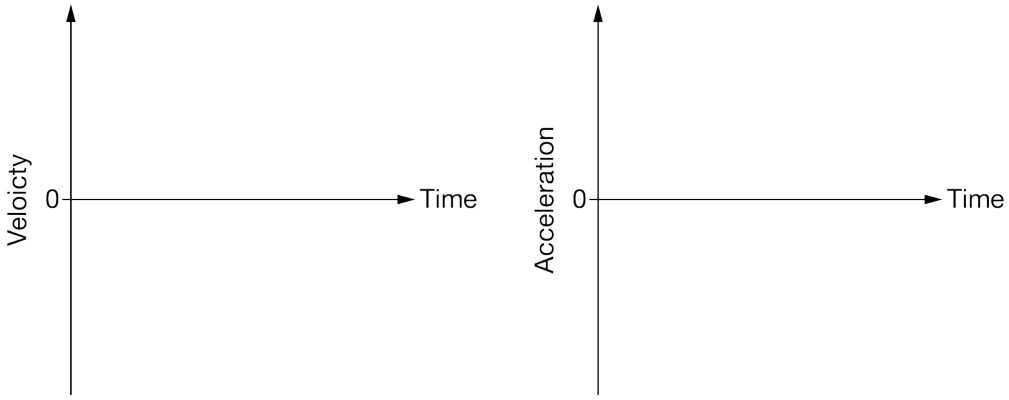
(b) Block 1 is removed without disturbing block 2.

i. Consider the scenario where the mass m_3 of block 3 is greater than the mass m_2 of block 2. Without using equations, make a claim about the motion of block 3 in terms of balanced or unbalanced forces.

ii. Derive an equation for the acceleration of block 3 for any arbitrary values of m_3 and m_2. Express your answer in terms of m_3, m_2, and physical constants as appropriate.

(c) Describe in what way your answer to part (b)(ii) is or is not consistent with your claim in part (b)(i).

(d) On the axes below, sketch graphs of the velocity and the acceleration of block 2 after block 1 has been removed. Take the time to be zero immediately after block 1 has been removed.



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2. This question is a short free-response question. Show your work for each part of the question.

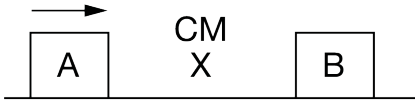

Figure 1

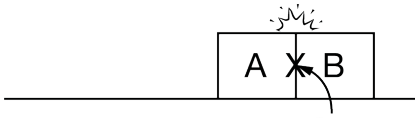

Figure 2

Two identical blocks, A and B, are on a horizontal surface, as shown above. There is negligible friction between the surface and the blocks. As shown in Figure 1, block A is initially moving toward block B with speed $v_A = v_0$ and block B is initially at rest. Figure 2 shows the blocks in contact as they collide a short time later. In both figures, the location of the center of mass of the two-block system is indicated by the X that is labeled CM.

(a)

i. On each of the dots, which represent the blocks while they are in contact during the collision, draw a single arrow to indicate the direction of the net force, if any, exerted on each block. The net force must be represented by a distinct arrow starting on, and pointing away from, the appropriate dot. If the net force is zero for either block, write "zero" under the dot representing that block.



Block A Block B

ii. During the time that the blocks are in contact, describe whether the center of mass of the two-block system is speeding up, slowing down, or staying the same.

____ Speeding up ____ Slowing down ____ Staying the same

Briefly describe, in terms of a basic law of physics, whether the center of mass of the two-block system is speeding up, slowing down, or staying the same.

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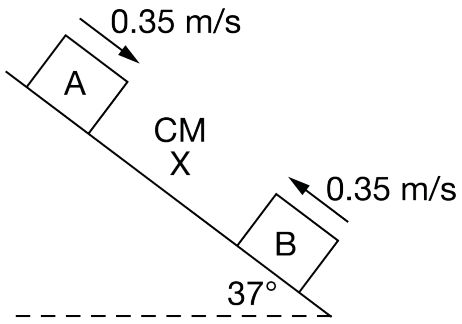

Figure 3

(b) The surface is tilted to an angle of 37 degrees from the horizontal, as shown above in Figure 3. The blocks are each given a push so that at the instant shown, they are moving toward each other.

i. Each block has a mass of $0.20\ \text{kg}$. Calculate the magnitude of the net force exerted on the two-block system at the instant shown above.

ii. At the instant shown in Figure 3, the blocks are moving toward each other with the same speed of $0.35\ \text{m/s}$. The blocks collide 0.50 seconds later. What is the speed of the two-block system's center of mass just before the blocks collide?