Name ____**Student ID** ___________________ **Score**__________

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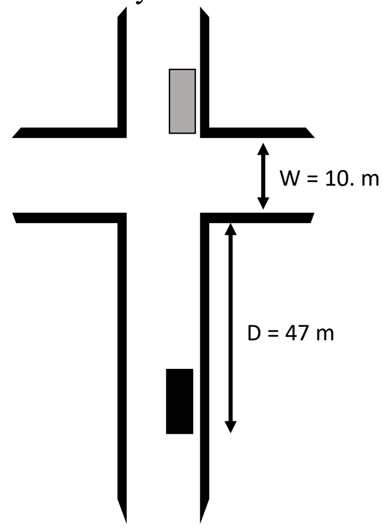
Part I. [40 Points] Please be sure to mark all answers for Multiple Choice problems on your scantron sheet!!

You are an intern for a traffic engineer. Below are some calculations you are asked to perform to help with the design for a traffic light. Assume the following:



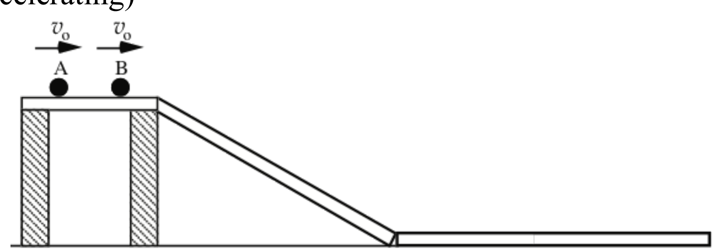
- The speed limit on the road is 35 mph = 16 m/s.
- The intersection has width 10. m.
- Brakes supply an acceleration –4 m/s^2.
- A yellow light lasts 3.0 sec.

1. [5 Points] If a car is driving the speed limit and then applies its brakes, how far will it travel before coming to a stop?
   A. 32 m
   B. 34 m
   C. 38 m
   D. 48 m
   E. 28 m

2. [5 Points] If a car is driving the speed limit and then applies its brakes, how many seconds elapse before it comes to a stop?
   A. 2.0 sec
   B. 3.0 sec
   C. 4.0 sec
   D. 2.5 sec
   E. Some other value

3. [5 Points] A car is driving the speed limit and the back of the car is D = 47 m south of the intersection when the light turns yellow. The driver chooses to keep going and not stop. If the car is to clear the intersection by the time the light turns red 3.0 seconds later, what acceleration (assumed constant) is needed?
   A. 2.0 m/s^2
   B. 1.3 m/s^2
   C. 1.0 m/s^2
   D. 6.0 m/s^2
   E. 0 (the car will clear the intersection without accelerating)

4. [5 Points] Two identical balls rolls along a level track, before reaching an inclined track, and finally another level track. Frictional interactions are negligible. When both balls are on the lower track, will the balls be closer together, the same distance apart, or farther apart than they were on the upper track?

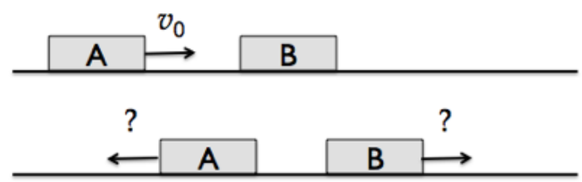


   A. The balls will be closer together on the lower track.
   B. The balls will be the same distance apart on the lower track.
   C. The balls will be farther apart on the lower track.
   D. There is not enough information.

5. [5 Points] Cart X moves to the right at speed v_0 on a level floor of negligible friction. It collides elastically with cart Y, which is initially at rest. After the collision, cart X is moving to the left with speed almost equal to v_0 and Y is barely moving. How does the final momentum of Y, p_{Y_f}, compare to the final momentum of X, p_{X_f}? Consider magnitudes only.

   A. $|p_{Y_f}| > |p_{X_f}|$
   B. $|p_{Y_f}| < |p_{X_f}|$
   C. $|p_{Y_f}| = |p_{X_f}|$
   D. There is not enough information.

6. [5 Points] Two non-identical carts collide elastically on a low-friction track. Cart A initially moves to the right with speed v_0. Cart B is initially at rest. After the collision, cart A is moving to the left. How does the final momentum of A compare to its own initial momentum? Consider magnitudes only.



   A. $|p_{A_f}| > |p_{A_i}|$
   B. $|p_{A_f}| < |p_{A_i}|$
   C. $|p_{A_f}| = |p_{A_i}|$
   D. There is not enough information.

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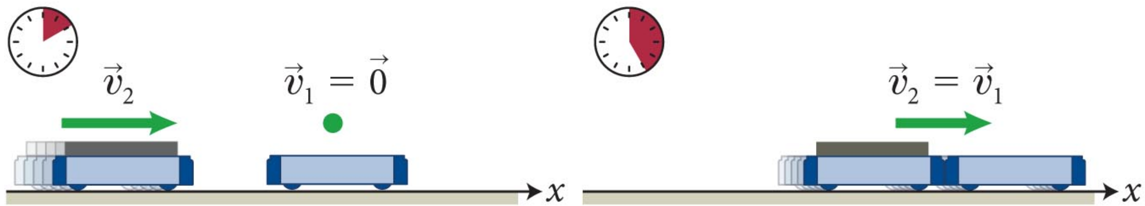
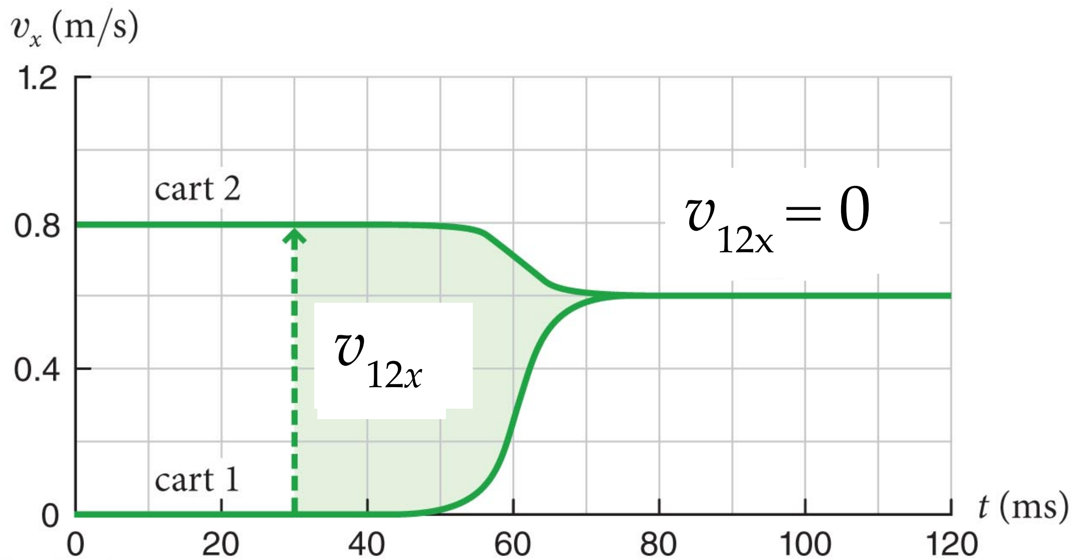
7. [5 Points] The graph below depicts a collision between two carts on a low-friction track. How does the inertia of cart 2 compare to the inertia of cart 1?





A. $m_2 = m_1$
B. $m_2 = 3m_1$
C. $m_2 = \frac{1}{3}m_1 \left(\frac{1}{3}\right) m_1$
D. $m_2 = 4m_1$
E. There is not enough information.

8. [5 Points] You and a friend travel by bicycle from Seattle to Olympia, a distance D. Your friend travels at a steady speed of $v_0.v_o$. For the first part of the trip you travel at $v_0 + 0.01v_0$speed $v_1 = v_o + 0.01v_o$ and for the second part of the trip you travel at $v_0$speed $v_1 = v_o - 0.01v_0.v_o$. If you leave Seattle at the same time and arrive in Olympia at the same time, how far from Seattle were you when you switched speeds?

A. You switched speeds when you were less than 0.5 D from Seattle.
B. You switched speeds when you were 0.5 D from Seattle.
C. You switched speeds when you more than 0.5 D from Seattle.
D. There is not enough information.

Part II. [26 Points] A 0.20 kg softball is traveling at a velocity of 20 m/s to the east relative to Earth. It collides head-on with a 0.50-kg rubber ball traveling at a velocity of 8.0 m/s to the west. The system's kinetic energy, as measured from the Earth reference frame, decreases by 25% because of the collision. Call the east the $+x$ direction.

9. [8 Points] What is the final total momentum of the system $\vec{p}_{ET,f}$ in the reference frame of the earth?

A car is driving by the two balls at a constant velocity of 20 m/s, traveling to the West.

10. [5 Points] What is the center of mass velocity, $\vec{v}_{CM}$, of the softball-rubber ball system in the car's reference frame? Make sure to indicate both magnitude and direction.

11. [8 Points] In the car's reference frame, calculate the change in internal energy $\Delta E_{internal}$ of the collision. Express your answer in Joules.

12. [5 Points] Consider the 2-ball system. Is the magnitude of the change in momentum of the softball $|\Delta\vec{p}_s|$ during the collision in the Earth's reference frame smaller, the same, or larger than in the car's reference frame? Explain.

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Part II: Laboratory Questions

Two carts, Cart A and Cart B, are moving on a level track toward each other and collide elastically. The masses and velocities of the cart are shown in the table.

	Cart A	**Cart B**
mass	400 ± 10 g	m_B
x-component of initial velocity	+ 0.25 ± 0.01 m/s	– 0.35 ± 0.01 m/s
x-component of final velocity	– 0.15 ± 0.01 m/s	+ 0.45 ± 0.01 m/s

9. (4 pts) If the collision lasts 0.05 seconds, which of the following is closest to the magnitude of Cart A's average acceleration during the collision?

A. 20 m/s^2 **B.** 10 m/s^2 **C.** 8.0 m/s^2 **D.** 2.0 m/s^2 **E.** 1.0 m/s^2

10. (4 pts) Which of the following is closest to the mass of Cart B?

A. 0.8 kg **B.** 0.4 kg **C.** 0.3 kg **D.** 0.2 kg **E.** 0.1 kg

11. (4 pts) Which of the following is closest to the magnitude of the change in the center-of-mass velocity of the isolated two-cart system as a result of the collision?

A. 0.0 m/s **B.** 0.3 m/s **C.** 0.4 m/s **D.** 0.6 m/s **E.** 0.8 m/s

12. (4 pts) Now assume that the collision is slightly less than 100% elastic. Which of the following must be TRUE in this case, as compared to a completely elastic collision?

A. The actual change in the center-of-mass velocity would be slightly smaller in a partially inelastic collision than it would be in a completely elastic collision.

B. The actual coefficient of restitution would be slightly larger in a partially inelastic collision than it would be in a completely elastic collision.

C. The magnitude of the change in the mechanical energy of the two cart system would be slightly larger in a partially inelastic collision than it would be in a completely elastic collision.

D. All of the above.

E. None of the above.

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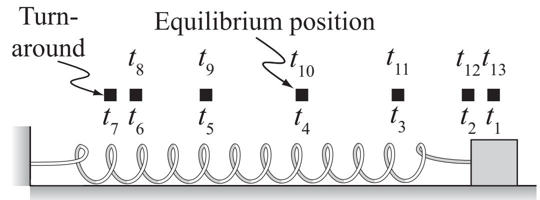
IV. [18 points total] The tutorial question consists of two independent parts, A and B.

A. A block on a frictionless surface is attached to a spring. The block is pulled to the right and released from rest at time t_1. The motion of the center of the block is shown by the dots in the strobe diagram. (The time intervals are equal.) The block turned around at time t_7 and returned to its stretched position at t_{13}.



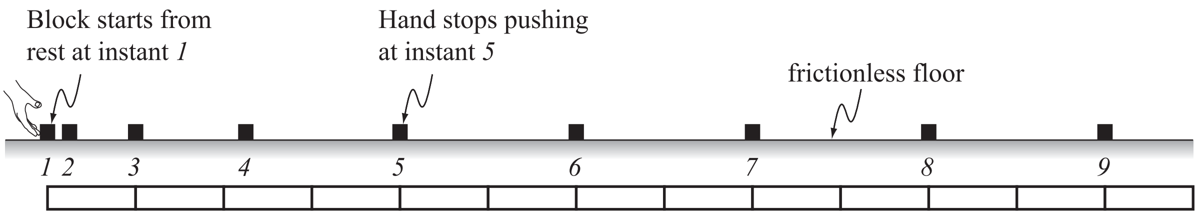
i. [6 pts] Draw a vector indicating the direction of $\vec{a}_{11}$, the instantaneous acceleration of the block at time t_{11}. If $\vec{a}_{11}$ is zero, state so explicitly. Explain how you used the spacing of the dots in the strobe diagram to determine your answer.

Direction of $\vec{a}_{11}$

Suppose the speeds at times t_4 and t_{10} are exactly equal.

ii. [6 pts] Is the magnitude of the **average acceleration** of the block between times t_4 and t_7 *greater than*, *less than*, or *equal to* the magnitude of the **average acceleration** of the block between times t_4 and t_{10}? Explain.

B. A student pushes a block across a level, frictionless floor. The block starts from rest at instant *1*. At instant *5*, the student stops pushing and the block continues to move across the floor. The block is still moving at instant *9*. The motion is shown in a strobe diagram below, in which the positions are shown at instants separated by equal time intervals.



[6 pts] Which of the following expressions represent the magnitude of the *instantaneous* velocity of the block at instant *5*? Select all expressions that are applicable.

Circle your answer or answers: $\dfrac{x_5 - x_1}{t_5 - t_1}$ $\dfrac{x_7 - x_5}{t_7 - t_5}$ $\dfrac{x_9 - x_1}{t_9 - t_1}$ None of these expressions.

Explain your reasoning.