Due On: _______________ Name: __________________________

AP Physics 1: Review Packet 05

Problem 1: Five objects of various masses m all start at rest on a frictionless surface. At time time = 0, a constant forward force F is applied to each object for a time t. At the end of the time t, the force is removed. Let d represent the distance that each object travels during the time t while the force is applied. The table shows the values of m, F, t, and d for each of the five objects.

	Mass m	Force F	Time t	Distance d
Object A	2 kg	4 N	3 sec	9 m
Object B	4 kg	2 N	6 sec	9 m
Object C	4 kg	3 N	8 sec	24 m
Object D	8 kg	9 N	2.7 sec	4 m
Object E	3 kg	6 N	5 sec	25 m

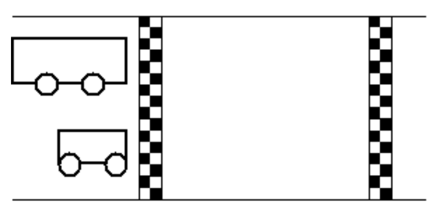
(a) Which object has the same acceleration as Object A while the force is applied? Explain your reasoning.

(b) Which object has the same momentum as Object A after the force is applied? Explain your reasoning.

(c) Which object has the same kinetic energy as Object A after the force is applied? Explain your reasoning.

(d) Which object has the same speed as Object A after the force is applied? Explain your reasoning.

Problem 2: A heavy bus and a light car both start at rest at the starting line of a long race track. At $t = 0$, the race begins. Both vehicles have the same constant net force during the race. After 10 seconds, the car passes the finish line.



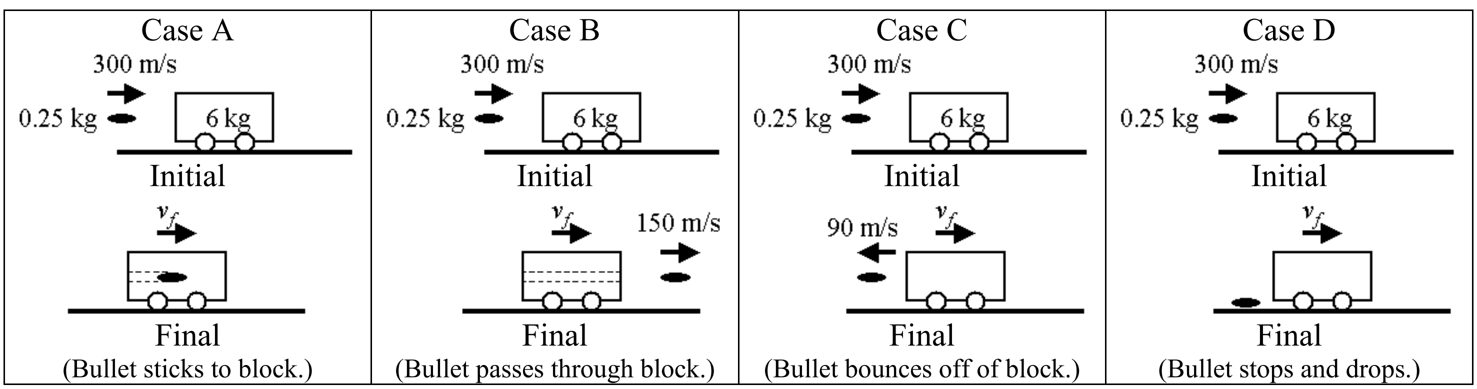
(a) Which vehicle crosses the finish line with more kinetic energy? Explain your reasoning.

(b) Which vehicle crosses the finish line with more momentum? Explain your reasoning.

(c) At time $t = 5$ seconds (while the race is still happening), which vehicle has more kinetic energy? Explain.

(d) At time $t = 5$ seconds (while the race is still happening), which vehicle has more momentum? Explain.

Problem 3: In all four of the cases below, a 0.25 kg bullet strikes a 6 kg block on frictionless wheels. Rank the cases based on the *block's final velocity after the collision*. You may use conservation of momentum to find the final speed in each case.

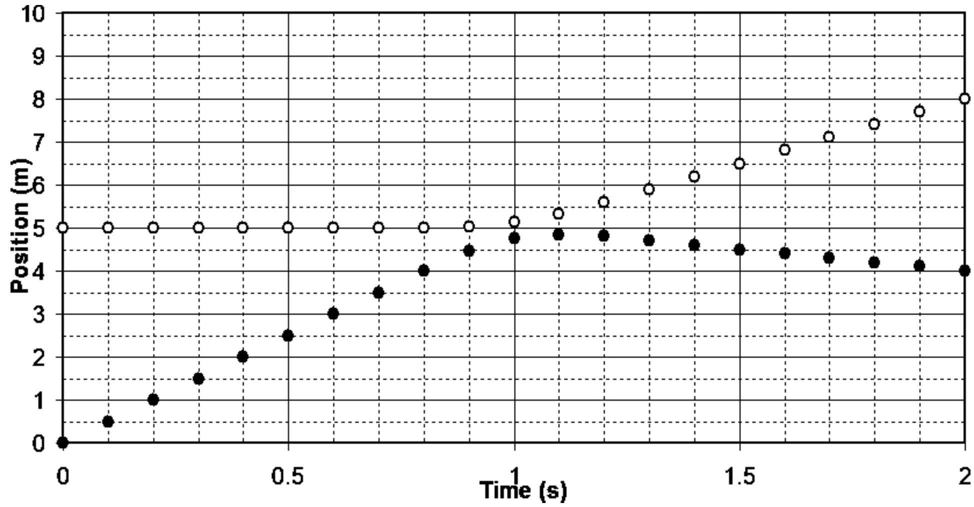


__________ > __________ > __________ > __________

Greatest final speed of the block　　　　　　　　Least final speed of the block

Justify your answer without using any numbers. Your justification must be entirely conceptual and discuss the relationships between changes in momentum in these situations.

Problem 4: Two students conduct an experiment to test the Law of Conservation of Momentum. To do this, they use a white car (mass 0.8 kg) and a black car (mass 0.4 kg). The black car is given initial forward motion and collides with the white car, which is initially at rest. The students use video analysis to create the graph of position vs. time shown above, where black dots represent the black car's position and white dots represent the white car's position.

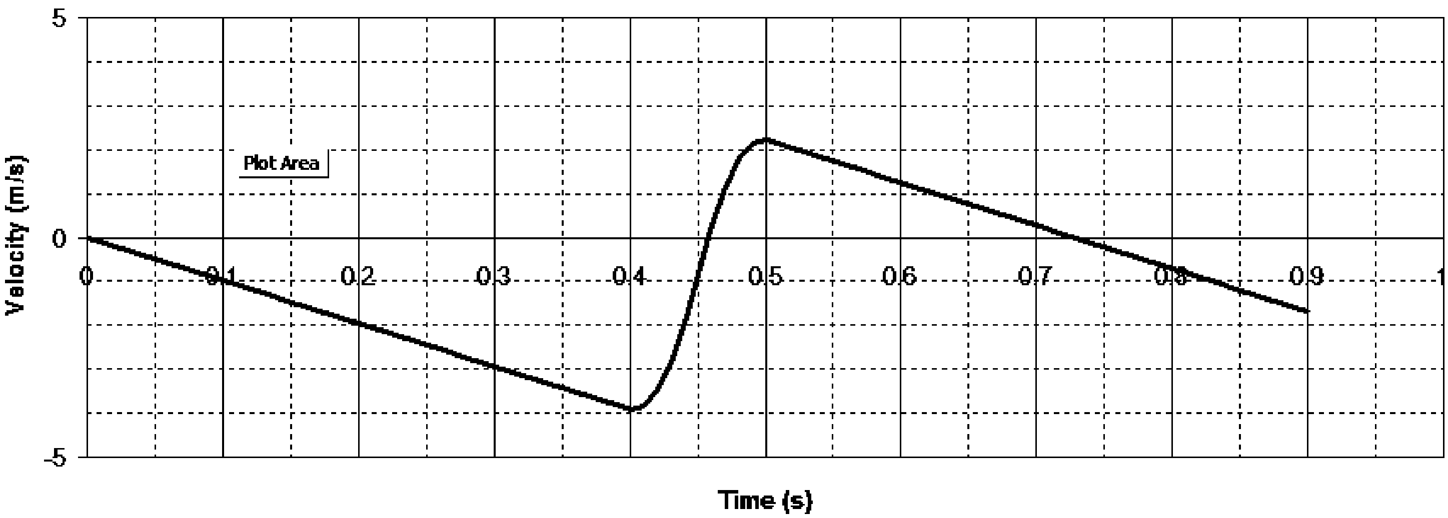


Respond to the following two questions by writing one or more paragraphs that state your answer to the question and your reasoning based on the graph and given data. You may show equations and calculations, but equations and calculations alone are not sufficient to explain your reasoning.

(a) Is momentum conserved in this collision?

(b) Is this collision elastic or inelastic?

Problem 5: A student drops a 6.8 kg bowling ball onto a trampoline and allows the bowling ball to bounce one time. The graph shows the vertical velocity of the bowling ball as a function of time, where upward velocity is considered positive.



(a) How can this graph be used to determine the acceleration of gravity?

For parts (b) and (c), full credit will be awarded only to responses that show equations, calculations, and verbal explanations for how quantities were found from the data.

(b) What is the ball's change in momentum as a result of being in contact with the trampoline?

(c) What average force is applied to the ball while it is in contact with the trampoline?

Momentum Review

IMPORTANT QUANTITIES

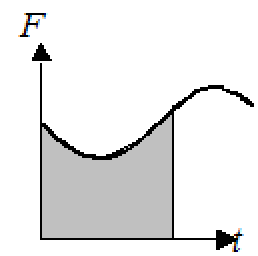
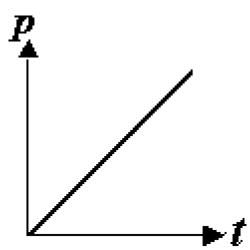
Name	Symbol	Units	Basic Equation
Momentum	**p**	kg•m/s	$\mathbf{p} = m\mathbf{v}$

Name	Symbol	Units	Basic Equation
Impulse	**J** or Δ**p**	kg•m/s	$\Delta\mathbf{p} = m\Delta\mathbf{v} = \mathbf{F}\Delta t$

IMPORTANT EQUATIONS

Name	Equation	Given?	Notes
Conservation of Momentum	$\sum \mathbf{p}_i = \sum \mathbf{p}_f$	No	Use if you are given any problem dealing with a collision. Keep in mind that momentum is a vector, so if an object travels backwards, then it has negative momentum.

IMPORTANT GRAPHS

Name	Graph (Shape)	Notes
Force vs. Time	 (Could be anything)	The area under a force vs. time is equal to impulse. **Impulse is the change in the momentum** of the object the force is applied to. If there is a collision of two objects, the impulse is applied to both objects, but in opposite directions (Newton's Third Law).
Momentum vs. Time		The slope of momentum vs. time is net force, because $\mathbf{F}_{net} = \dfrac{\Delta\mathbf{p}}{\Delta t}$.

IMPORTANT CONCEPTS

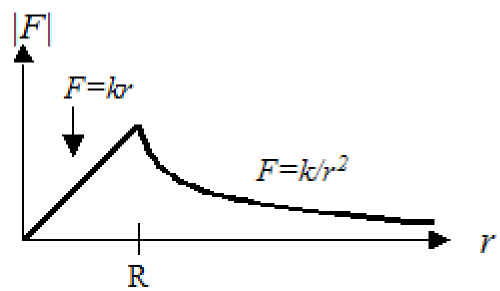
- USE CONSERVATION OF MOMENTUM WHENEVER THERE IS ANY KIND OF COLLISION! DO NOT USE CONSERVATION OF ENERGY!
- An elastic collision is one in which no energy is lost to heat or deformation. In these problems, you must also set up a conservation of energy equation.
- An inelastic collision is one in which some kinetic energy is lost during the collision, but the objects may not stick together. In other words, total kinetic energy before the collision is more than total kinetic energy after the collision.
- A perfectly inelastic collision is one in which the two objects stick together. The most possible energy is lost to heat and deformation during a perfectly inelastic collision.
- DON'T ASSUME that you know that a collision is elastic or inelastic unless you are told.
- DON'T ASSUME that the objects stick together unless you are told.
- When setting up a conservation of momentum equation, remember that a velocity is negative if the object is moving to the left (or down).

Big concept: Use momentum to solve collision problems!

IMPORTANT EQUATIONS

Name	Equation	Given?	Notes
Gravitational force between two masses in space	$F_G = -\frac{GmM}{R^2}$	Yes	The two masses are *m* and *M*. The constant *G* is always given. *R* is the distance of the two objects from center-to-center. Note that the force is negative because it always attracts—gravity never repels.
Gravitational potential energy of two masses in space	$U_G = -\frac{GmM}{R}$	Yes	The potential energy goes down (becomes more negative) when the two objects get closer together (what they want to do).
Acceleration of gravity (gravitational field) of an object	$g = \frac{F_G}{m} = \frac{GM}{R^2}$	No	
Escape Velocity	$v_{esc} = \sqrt{\frac{2GM}{R}}$	No	In order to escape a planet of mass *M* (from a distance *R*), set kinetic energy equal to potential energy and solve.

IMPORTANT GRAPHS

Name	Graph (Shape)	Notes
Magnitude of gravitational force on an object as a function of distance from a planet of radius *R*.		Note that when the object is inside the planet, the force increases linearly as the object nears the surface. However, once the object is outside of the planet, the force decreases as $1/r^2$.

IMPORTANT CONCEPTS

- For circular orbits, the closer the orbiting object is to the massive object, the faster it goes, and the shorter the period of orbit.
- In order to analyze a circular orbit, set centripetal force equal to gravitational force: $\frac{GmM}{R^2} = m\frac{v^2}{R}$
- When an object is in circular orbit, NO WORK IS DONE!
- Inverse-square law: Double the distance, and the force is ¼ as much. Half the distance, and the force is 4 times as much. If the distance is 10 times more, then the force is 1/100 times as much.
- Gravitational field *g* at a point is defined as the ratio of the gravitational force on an object to the mass of the object at that point. The direction of gravitational field is where a mass will feel gravitational force.