Missiles in Motion: A Study of SUV's
Ideas for a Mini-Unit: A Work in Progress

Major Concept: Forces and Motion

Content	Skills
motion	measuring
force	collecting data
centripetal force	recognizing patterns
momentum	predicting
center of gravity	communicating results
energy transfer	using models

The Challenge:

Sport utility vehicles (SUV's) are the most popular vehicles on the road today. They are rugged, luxurious, and powerful. Most have 4 wheel drives. But are they safe? Recent studies have revealed that SUV's are far more likely to roll over than regular passenger cars in emergency situations where the driver steers to change direction to avoid hitting another car or object. However, in spite of the higher roll-over rate, the occupants of SUV's are more likely to survive crashes than occupants of most passenger cars. When SUV's and passenger cars collide, it is the car that gets the most damage. Consequently, SUV's are being branded by safety advocates as safety hazards in motion. This has prompted manufacturers of some SUV's to consider designs that will make them more safe, both for the occupants of the SUV's as well as the passengers in cars the SUV's might encounter in an accident. But exactly what are features of SUV's that make them unsafe? How are they different from conventional passenger cars that have caused them to be branded a road hazard? The answers are quite obvious if you study the specifications of most SUV's with respect to the physical laws of force and motion.

Your challenge is to investigate the motion and forces of and on an automobile and come up with your recommendations to make SUV's safer for persons riding in SUV's and the persons in the cars that encounter SUV's in a crash.

Preassessment:

1. What are some differences between a sport utility vehicle and a medium-sized passenger car that would affect damage to the vehicle or its passengers in a crash?

2. Why are some vehicles more likely to roll over than others?

3. If you are riding in an automobile and have a head-on crash, what factors most determine if you will survive?

Learning Tasks

Task 1. How does center of gravity, speed, and turn-radius affect a vehicle's ability to roll over or remain on its wheels?

Design a series of experiments using a remote controlled model car to determine how center of gravity, speed, and turn-radius affect the model car's tendency to roll over. Try different turn radii and different speeds. Add weights to the car that will raise its center of gravity. Record the height of the center of gravity from the ground at the point the car rolls over for each turn-radius and speed you try.

Task 2. How will the weight of each of the two vehicles in a head-on or rear-end crash likely affect damage to each vehicle?

Design experiments with the remote model car to determine how adding weights to the car affects its force on impact. Try different impact targets.

Also use the ACES II Energy Transfer Activity to determine the affect of different masses on impact collisions.

Task 3. How will speed affect damage to a vehicle in a crash?

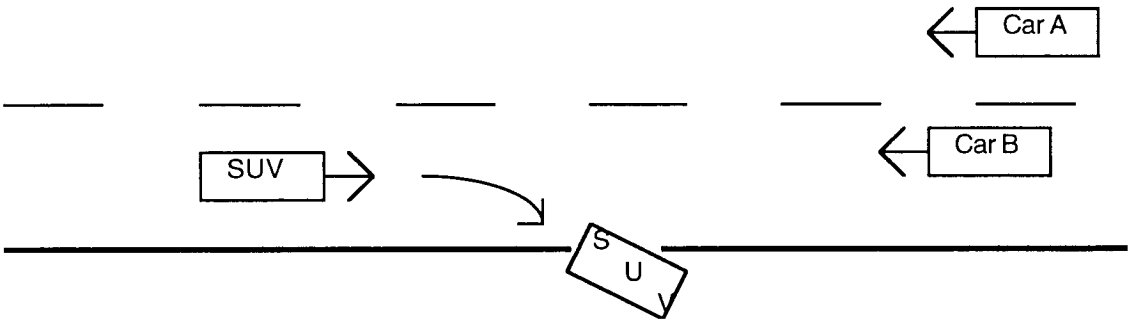
Design crash tests at different speeds and measure the amount of energy transferred at impact using different speeds.

Task 4. How can SUV's be designed so they are safer vehicles?

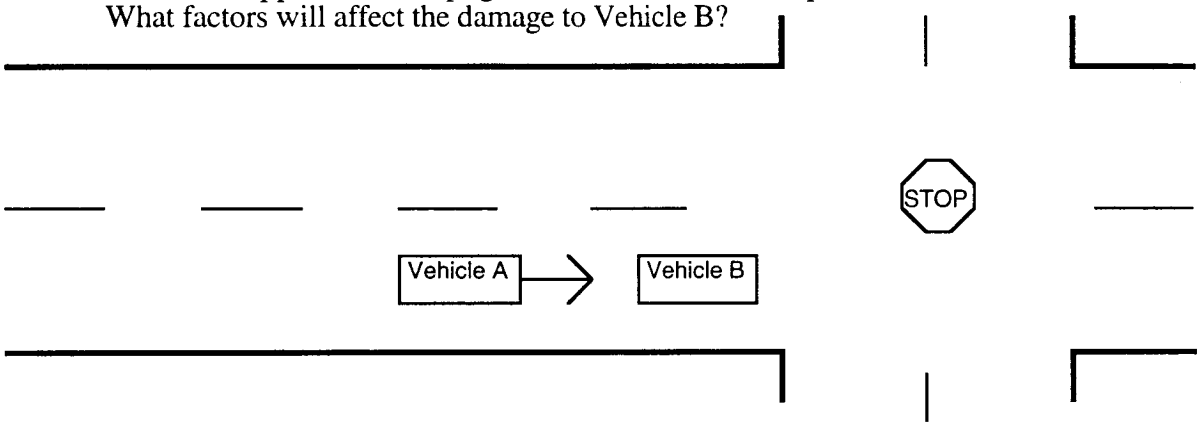
Investigate the specifications of five popular SUV's and five popular passenger cars. Use what you have learned about force and motion to recommend design changes that would make SUV's safer.

Open Response Assessment:

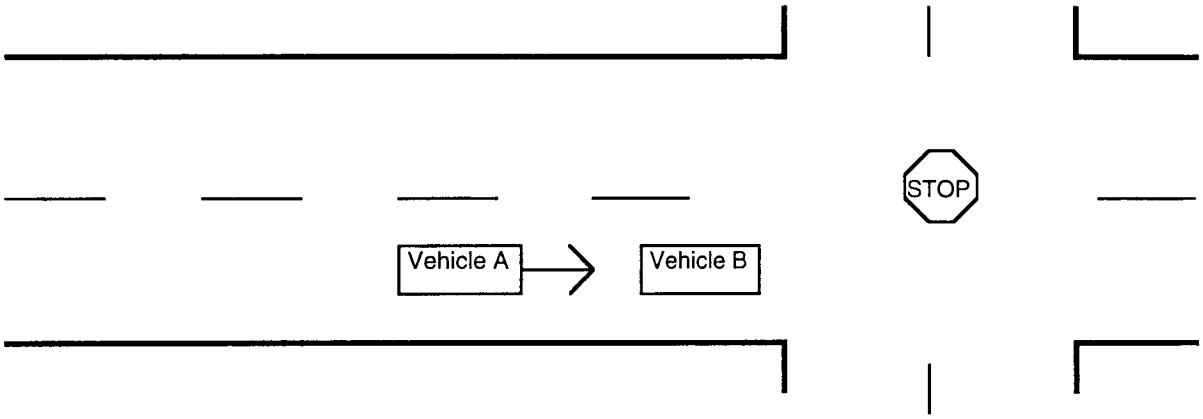
1. A sport utility vehicle (SUV) is moving from left to right at 60 mph and makes a sharp turn to the right, as shown in the diagram below, to avoid a crash with an oncoming car B passing another car A. Describe the forces on the SUV and its occupants during the sharp turn.



2. Vehicle B is stopped at the stoplight. Vehicle A fails to stop and back-ends Vehicle A. What factors will affect the damage to Vehicle B?



3. Vehicle B is stopped at the stoplight. Vehicle A fails to stop and back-ends Vehicle A. Describe how the energy from Vehicle A is transferred to vehicle B.?



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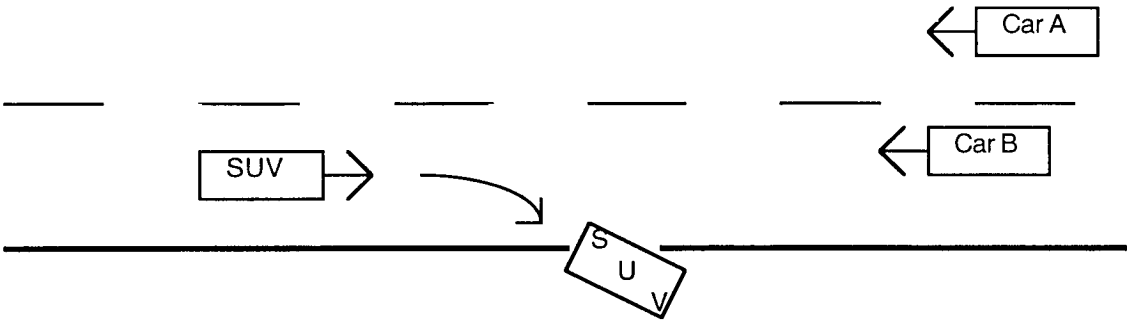

Scoring Guide

Novice	**May infer damage to SUV due to ditches, road signs, fences, trees, or other impediments unnamed in the problem. May place blame on passing vehicle.**
Apprentice	**May get "carried away" in describing damage to the SUV or injury to the occupants. No consideration of forces effecting the vehicle.**
Proficient (Critical Level)	**Writer recognizes the centrifugal forces on the riders and vehicle. May mention "G" forces. May mention speed and vehicle weight as factors. May mention high center of gravity on SUV.**
Distinguished	**Writer refers to high center of gravity on SUV and the effect of high lateral centrifugal forces. May quote "objects in motion tend to remain in motion..." Relates speed and vehicle weight as factors. May mention damage to steering and tires due to added stress caused by turn.**

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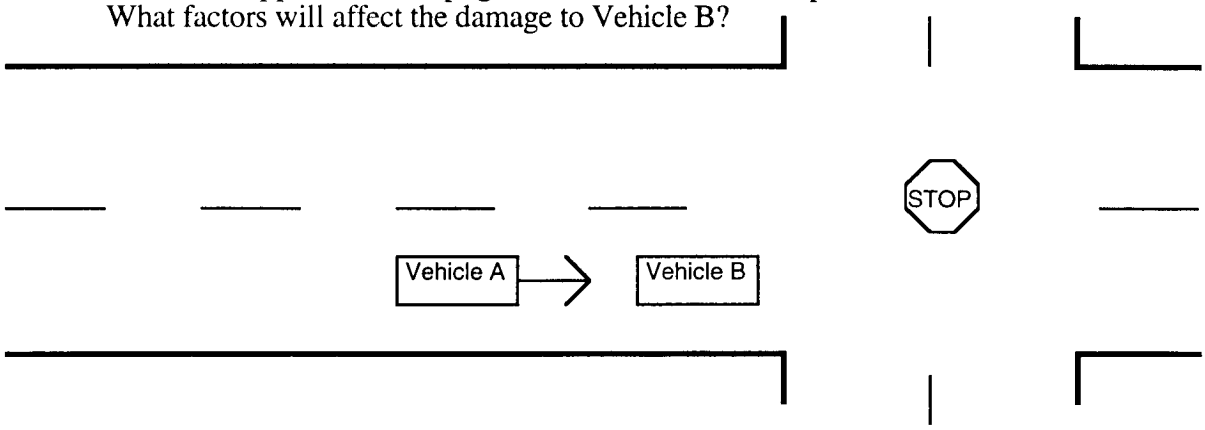

Scoring Guide

Novice	**May describe possible scenarios instead of considering forces effecting the damage.**
Apprentice	**May get "carried away" by damage to vehicle B or injury to the occupants. Little consideration of forces effecting the vehicle.**
Proficient (Critical Level)	**Writer recognizes speed and structure of vehicles as major factors. May mention or explain "backlash" injuries.**
Distinguished	**Writer considers speed, vehicle weight, and vehicle structure as factors. May consider driver reactions, road conditions, bumper height, and centers of gravity. May mention "backlash." May quote scientific law of "objects at rest..."**

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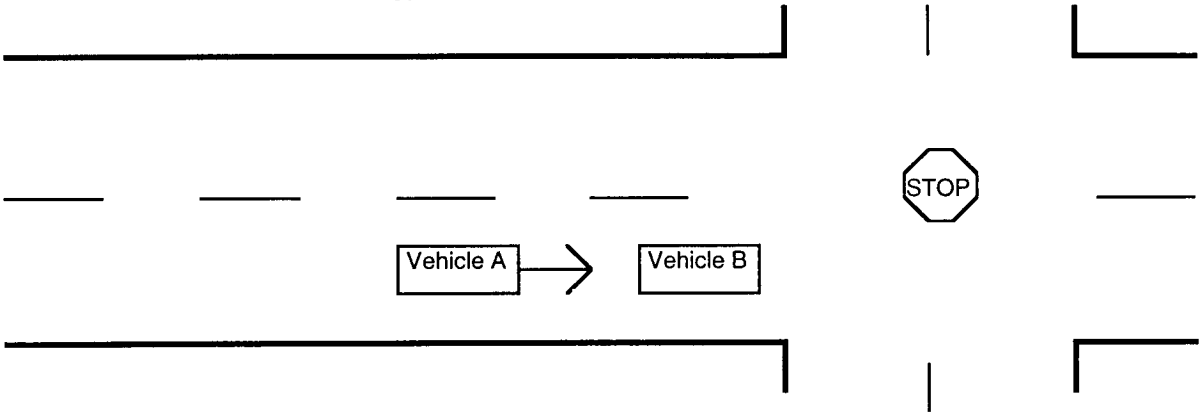

Scoring Guide

Novice	**May describe possible scenarios instead of considering energy transfer.**
Apprentice	**May get "carried away" by damage to vehicle B or injury to the occupants. Little consideration of energy transfer.**
Proficient (Critical Level)	**Writer relates that energy is passed from Vehicle A to Vehicle B and describe effect on Vehicle B..**
Distinguished	**Writer describes energy transfer from Vehicle A to Vehicle B and quotes "energy is not destroyed but is transferred and/or absorbed."**