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Momentum

1. A moving car has momentum. If it moves twice as fast, its momentum is _____ as much.

2. Two cars, one twice as heavy as the other, move down a hill at the same speed. Compared to the lighter car, the momentum of the heavier car is _____ as much.

3. The recoil momentum of a cannon that kicks is

   (more than) (less than) (the same as)

   the momentum of the cannonball it fires.

4. If a man firmly holds a cannon when fired, then the momentum of the cannonball is equal to the recoil momentum of the

   (cannon alone) (cannon–man system) (man alone).

5. Suppose you are traveling in a bus at highway speed on a nice summer day and the momentum of an unlucky bug is suddenly changed as it splatters onto the front window.

   a. Compared to the force that acts on the bug, how much force acts on the bus?

      (more) (the same) (less).

   b. The time of impact is the same for both the bug and the bus. Compared to the impulse on the bug, this means the impulse on the bus is

      (more) (the same) (less).

   c. Although the momentum of the bus is very large compared to the momentum of the bug, the *change* in momentum of the bus, compared to the *change* of momentum of the bug is

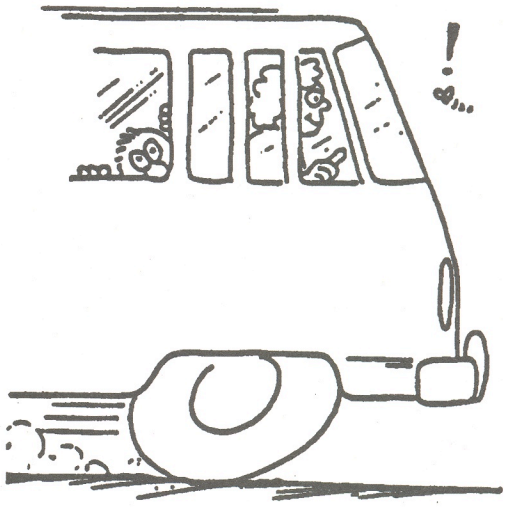
      (more) (the same) (less).

   d. Which undergoes the greater acceleration?

      (Bus) (Both the same) (Bug)

   e. Which, therefore, suffers the greater damage?

      (Bus) (Both the same) (The bug of course!)



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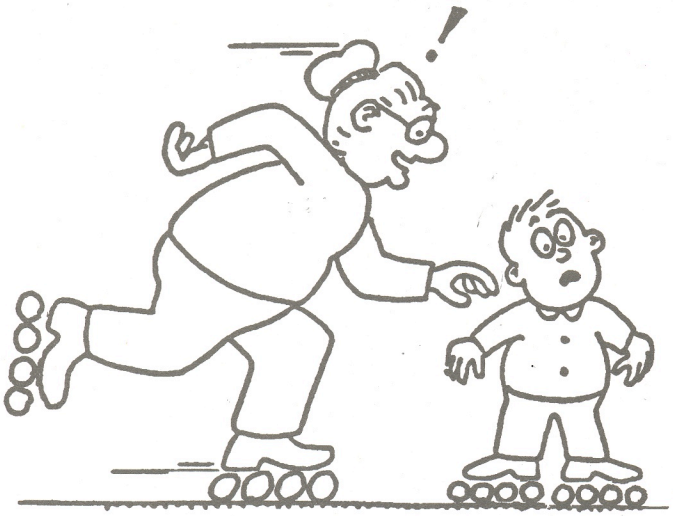
6. Granny whizzes around the rink and is suddenly confronted with Ambrose at rest directly in her path. Rather than knock him over, she picks him up and continues in motion without "braking."



Consider both Granny and Ambrose as two parts of one system. Since no outside forces act on the system, the momentum of the system before collision equals the momentum of the system after collision.

a. Complete the before-collision data in the table below.

BEFORE COLLISION	
Granny's mass	80 kg
Granny's speed	3 m/s
Granny's momentum	_____
Ambrose's mass	40 kg
Ambrose's speed	0 m/s
Ambrose's momentum	_____
Total momentum	_____

b. After collision, does Granny's speed increase or decrease?

_____

c. After collision, does Ambrose's speed increase or decrease?

_____

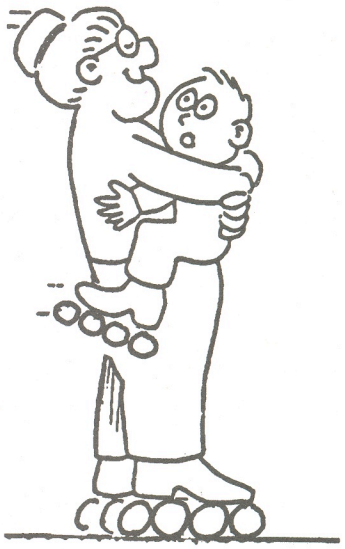
d. After collision, what is the total mass of Granny + Ambrose?

_____

e. After collision, what is the total momentum of Granny + Ambrose?

_____

f. Use the conservation of momentum law to find the speed of Granny and Ambrose together after collision. (Show your work in the space below.)



New speed = _____

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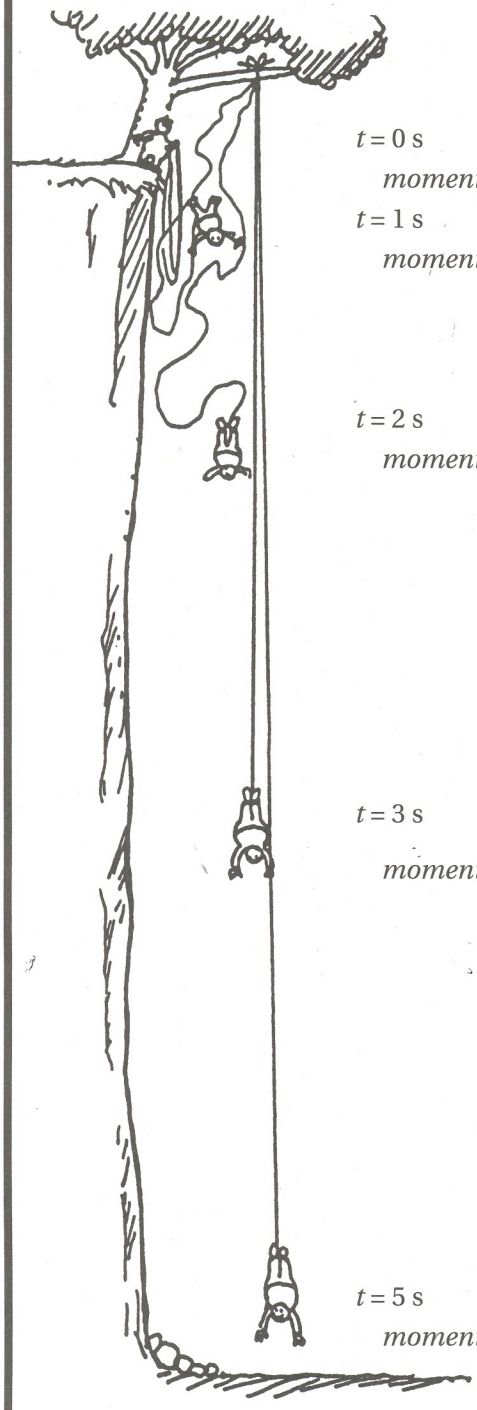
Momentum and Energy



$t = 0$ s $v =$ _____
momentum = _____
$t = 1$ s $v =$ _____
momentum = _____
$t = 2$ s $v =$ _____
momentum = _____
$t = 3$ s $v =$ _____
momentum = _____
$t = 5$ s $v =$ _____
momentum = _____

Bronco Brown wants to put $Ft = \Delta mv$ to the test and try bungee jumping. Bronco leaps from a high cliff and experiences free fall for 3 seconds. Then the bungee cord begins to stretch, reducing his speed to zero in 2 seconds. Fortunately, the cord stretches to its maximum length just short of the ground below.

Fill in the blanks. Bronco's mass is 100 kg. Acceleration of free fall is 10 m/s^2.

Express values in SI units (*distance* in m, *velocity* in m/s, *momentum* in kg·m/s, *impulse* in N·s, and *deceleration* in m/s^2).

The 3-s free-fall distance of Bronco just before the bungee cord begins to stretch

= _____.

Δmv during the 3-s interval of free fall

= _____.

Δmv during the 2-s interval of slowing down

= _____.

Impulse during the 2-s interval of slowing down

= _____.

Average force exerted by the cord during the 2-s interval of slowing down

= _____.

How about *work* and *energy*? How much KE does Bronco have 3 s after his jump?

_____

How much does gravitational PE decrease during this 3 s?

_____

What two kinds of PE are changing during the slowing-down interval?

_____

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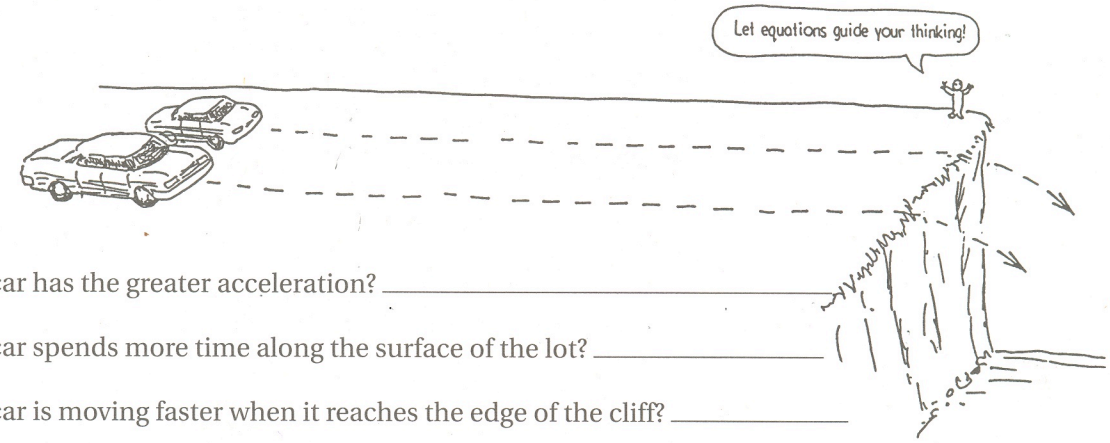
Energy and Momentum

A compact car and a full-size sedan are initially at rest on a horizontal parking lot at the edge of a steep cliff. For simplicity, we assume that the sedan has twice as much mass as the compact car. Equal constant forces are applied to each car and they accelerate across equal distances (we ignore the effects of friction). When they reach the far end of the lot the force is suddenly removed, whereupon they sail through the air and crash to the ground below. (The cars are beat up to begin with, and this is a scientific experiment!)



1. Which car has the greater acceleration? _____

2. Which car spends more time along the surface of the lot? _____

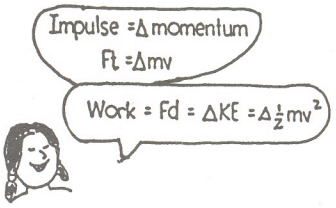
3. Which car is moving faster when it reaches the edge of the cliff? _____

4. Which car has the larger impulse imparted to it by the applied force? Defend your answer.

   _____

5. Which car has the greater momentum at the edge of the cliff? Defend your answer.

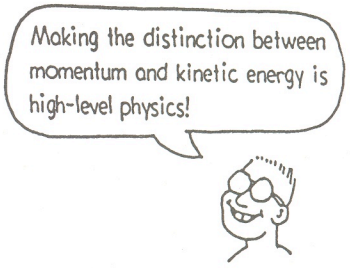
   _____



6. Which car has the greater work done on it by the applied force? Defend your answer in terms of the distance traveled.

   _____

   _____



7. Which car has the greater kinetic energy at the edge of the cliff? Does your answer follow from your explanation of 6? Does it contradict your answer to 4? Why or why not?

   _____

   _____

   _____

8. Which car spends more time in the air, from the edge of the cliff to the ground below? _____

9. Which car lands farthest horizontally from the edge of the cliff onto the ground below? _____

10. Challenge: Suppose the slower car crashes a horizontal distance of 10 m from the ledge. Then at what horizontal distance does the faster car hit?

    _____

    _____

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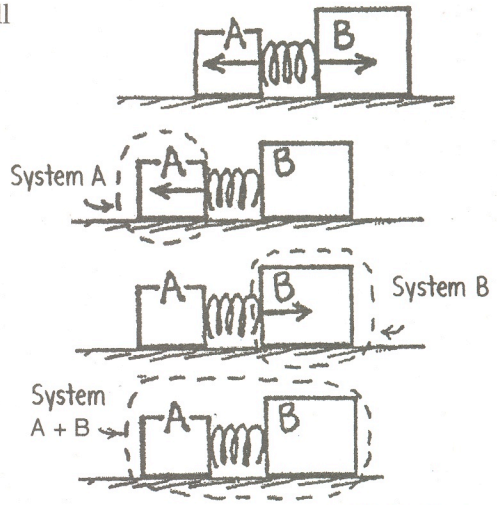
Systems

1. When the compressed spring is released, Blocks A and B will slide apart. There are 3 systems to consider, indicated by the closed dashed lines below—A, B, and A + B. Ignore the vertical forces of gravity and the support force of the table.



   a. Does an external force act on System A? (Y) (N)

      Will the momentum of System A change? (Y) (N)

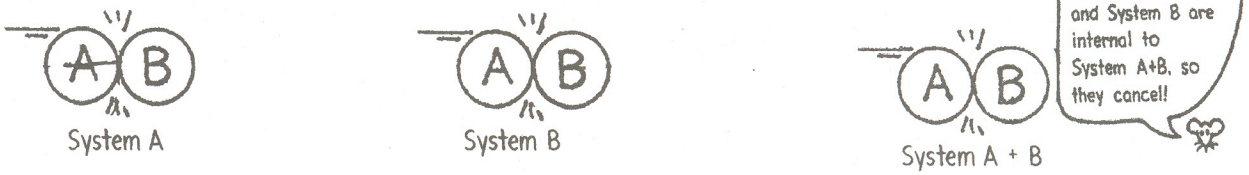
   b. Does an external force act on System B? (Y) (N)

      Will the momentum of System B change? (Y) (N)

   c. Does an external force act on System A + B? (Y) (N)

      Will the momentum of System A + B change? (Y) (N)

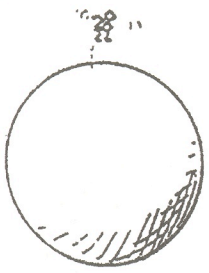
2. Billiard ball A collides with billiard ball B at rest. Isolate each system with a closed dashed line. Draw only the external force vectors that act on each system.



   a. Upon collision, the momentum of System A (increases) (decreases) (remains unchanged).

   b. Upon collision, the momentum of System B (increases) (decreases) (remains unchanged).

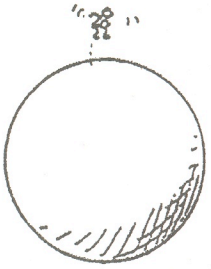
   c. Upon collision, the momentum of System A + B (increases) (decreases) (remains unchanged).



3. a. A girl jumps upward. In the left sketch, draw a closed dashed line to indicate the system of the girl. Is there an external force acting on her? (Y) (N)

      Does her momentum change? (Y) (N)

      Is the girl's momentum conserved? (Y) (N)



   b. In the right sketch, draw a closed dashed line to indicate the system (girl + Earth). Is there an external force acting on the system due to the interaction between the girl and Earth? (Y) (N)

4. A block strikes a blob of jelly. Isolate 3 systems with a closed dashed line and show the external force on each. In which system is momentum conserved?

5. A truck crashes into a wall. Isolate 3 systems with a closed dashed line and show the external force on each. In which system is momentum conserved?

thanx to Cedric Linder

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