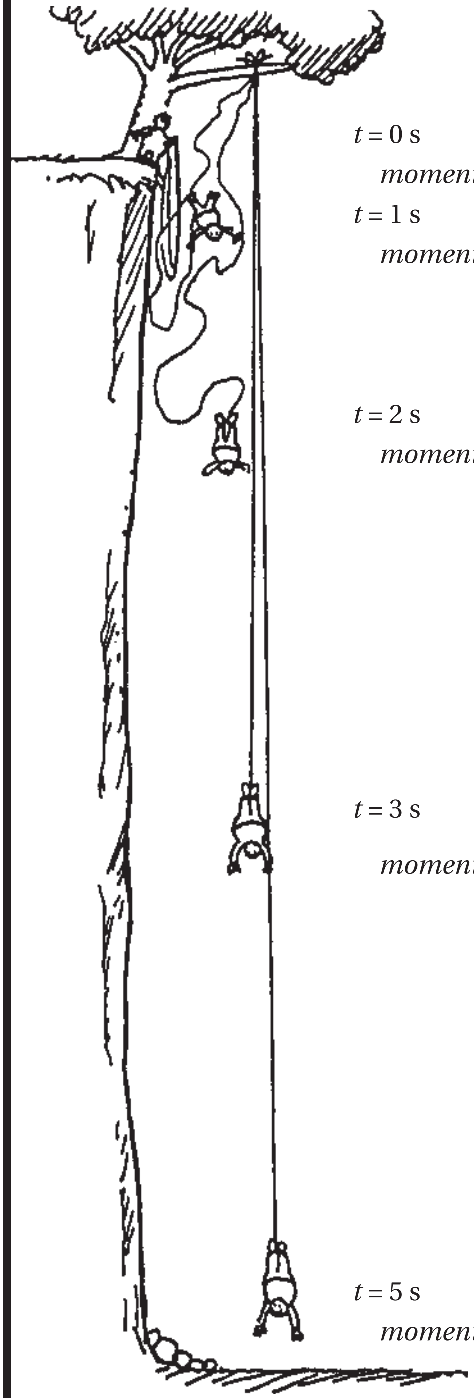
Concept-Development Practice Page **9-3**

Momentum and Energy



$t = 0$ s v = 0 m/s
momentum = 0 kg·m/s

$t = 1$ s v = 10 m/s
momentum = 1000 kg·m/s

$t = 2$ s v = 20 m/s
momentum = 2000 kg·m/s

$t = 3$ s v = 30 m/s
momentum = 3000 kg·m/s

$t = 5$ s v = 0 m/s
momentum = 0 kg·m/s

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

= 45 m.

Δmv during the 3-s interval of free fall

= 3000 kg·m/s.

Δmv during the 2-s interval of slowing down

= 3000 kg·m/s.

Impulse during the 2-s interval of slowing down

= 3000 N·s.

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

= 1,500 N.

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

45,000 J

How much does gravitational PE decrease during this 3 s?

45,000 J

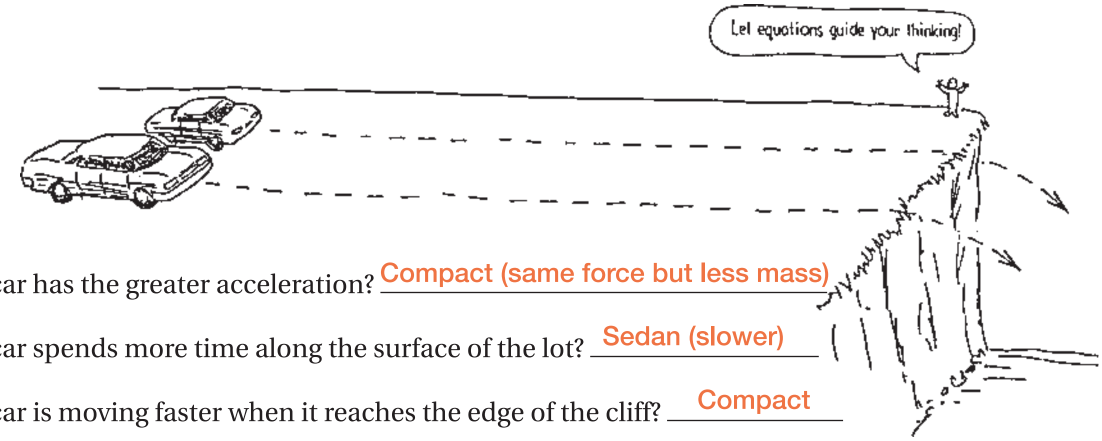
What two kinds of PE are changing during the slowing-down interval?

Gravitational and elastic potential energies

CONCEPTUAL PHYSICS

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!)



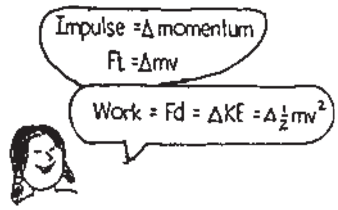
1. Which car has the greater acceleration? Compact (same force but less mass)

2. Which car spends more time along the surface of the lot? Sedan (slower)

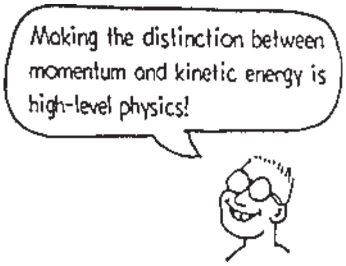
3. Which car is moving faster when it reaches the edge of the cliff? Compact

4. Which car has the larger impulse imparted to it by the applied force? Defend your answer.
   Sedan; same force applied over a longer time produces more impulse.

5. Which car has the greater momentum at the edge of the cliff? Defend your answer.
   Sedan; greater impulse means greater change in momentum.



6. Which car has the greater work done on it by the applied force? Defend your answer in terms of the distance traveled.
   Same work on each, because the product of force and distance is the same.



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?
   Same KE for each; this follows from 6 where work done is same on each. No contradiction because greater momentum of sedan is due to its greater mass.

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

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

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?
    14.1 m; the compact moves $\sqrt{2}$ faster horizontally than the sedan. [Equal KEs at top; $1/2(2m)v^2 = 1/2\, mV^2$, where $V = \sqrt{2}\, v$, or 1.41 times faster (and farther horizontally in the same time).]