Physics Models Used in Design Solutions

Physics of airbags

Driver mass: 50 kg   Speed before: 30 mph (13 m/s)   Speed after: 0 mph

Change in momentum during crash = 50 kg • 13 m/s = 650 kg m/s

Without front airbag

Δ momentum = FORCE • time

When you hit the dashboard, change in momentum happens quickly (assuming 0.01 s), so force is huge.

650 = *0.01 s* • 65,000 N

time = 0.01 s   **force = 65,000 N**

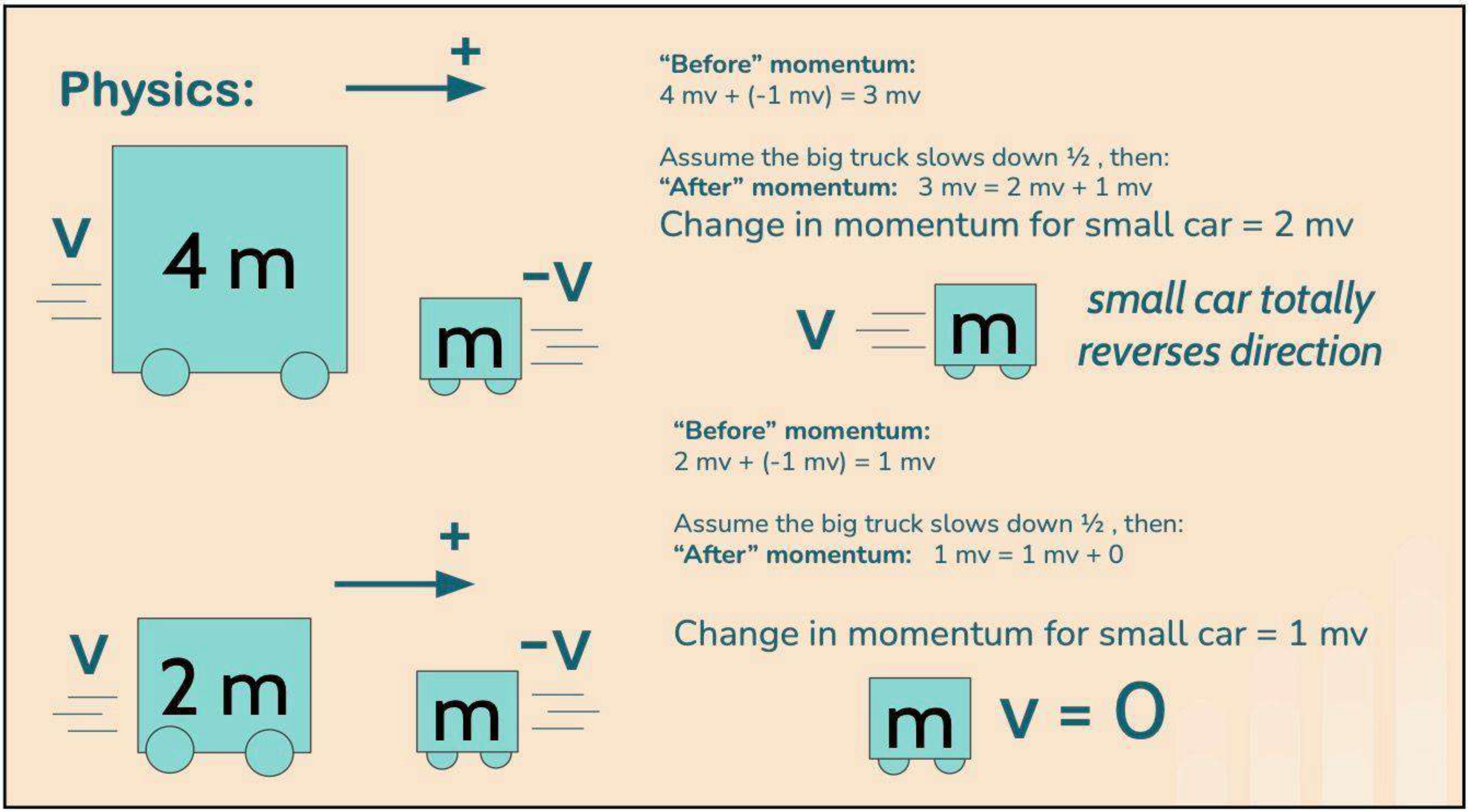
With front airbag

Δ momentum = force • TIME

When you hit an airbag, the change in momentum takes more time (assuming 0.1 s), so force is much less.

650 = *0.1 s* • 6,500 N

time = 0.1 s   **force = 6,500 N**


Physics:
+
V
4 m
-V
m
"Before" momentum:
4 mv + (-1 mv) = 3 mv
Assume the big truck slows down ½ , then:
"After" momentum: 3 mv = 2 mv + 1 mv
Change in momentum for small car = 2 mv
V
m
small car totally reverses direction
+
V
2 m
-V
m
"Before" momentum:
2 mv + (-1 mv) = 1 mv
Assume the big truck slows down ½ , then:
"After" momentum: 1 mv = 1 mv + 0
Change in momentum for small car = 1 mv
m
V = 0

Physics: Speed humps reduce speeds by 10 mph. If we can reduce vehicle speed on Park Ave. from 30 mph to 20 mph, **we can cut the braking distance of cars in half from about 64 ft to 34 ft,** ***assuming 7 m/s/s deceleration.***

30 mph = 13.4 m/s   reaction time = 0.5 s

13.4 m/s • 0.5 s = 6.7 m = 22 ft

13.4 m/s / ***7 m/s/s*** = 1.9 s braking time

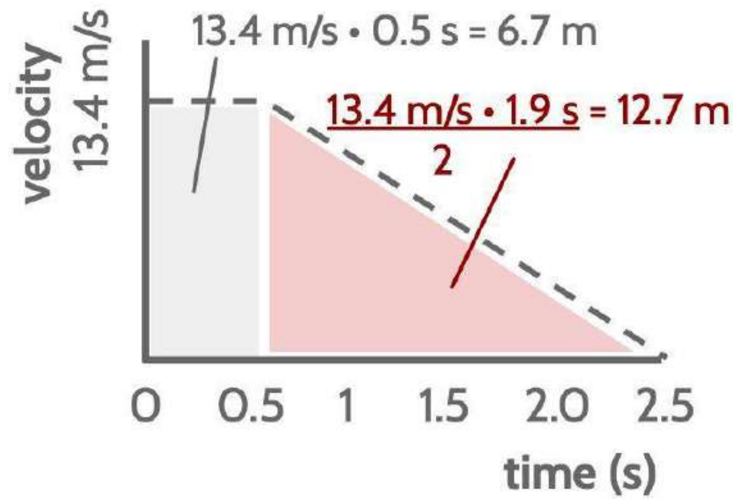
½ (13.4 m/s • 1.9 s) = 12.7 m = 42 ft → 64 ft

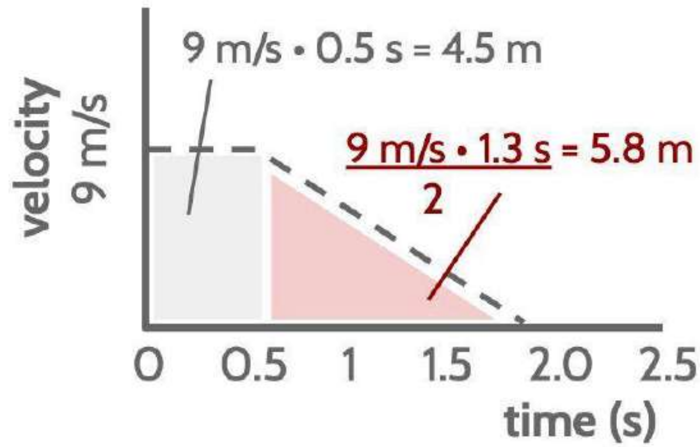
20 mph = 9 m/s   reaction time = 0.5 s

9 m/s • 0.5 s = 4.5 m = 15 ft

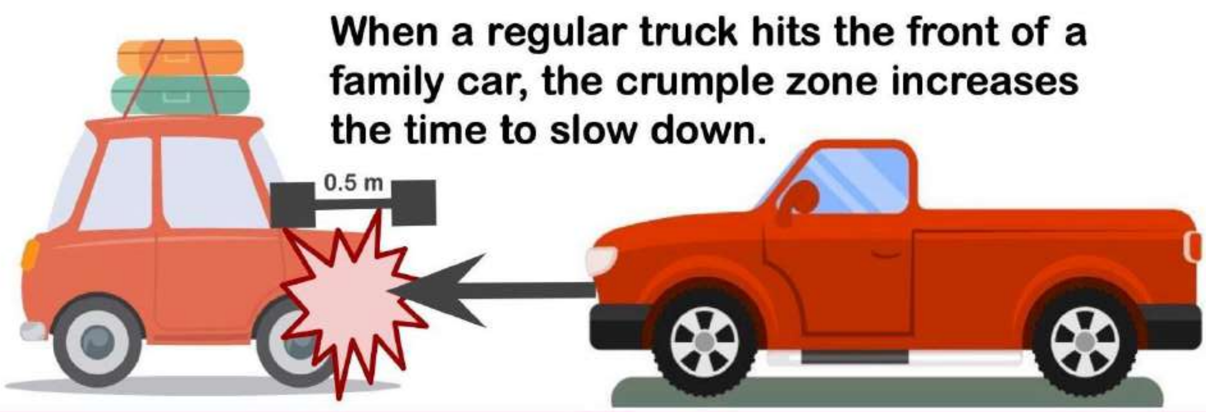
9 m/s / ***7 m/s/s*** = 1.3 s braking time

½ • (9 m/s • 1.3s) = 5.8 m = 19 ft → 34 ft



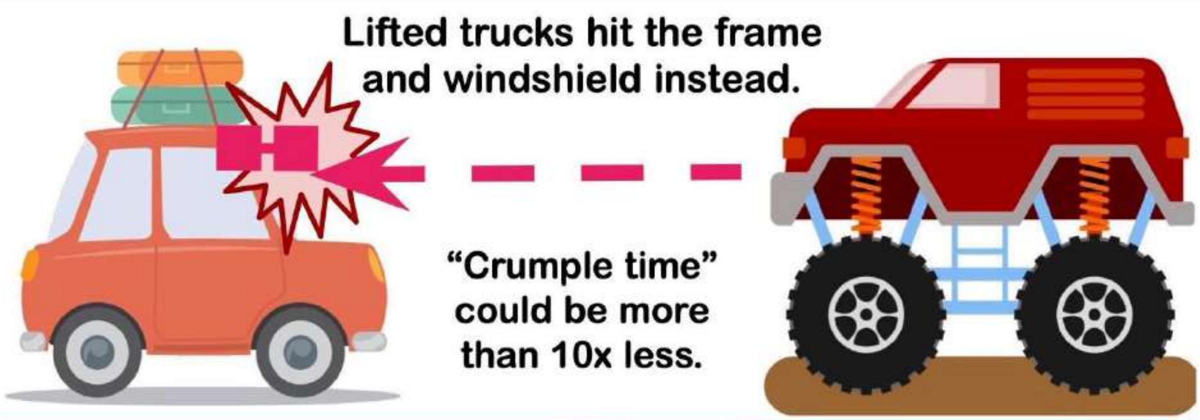


Data Source: US DOT Federal Highway Administration. (2017).; Police Radar Information Center



Physics: When the family car hits a truck, the crumple zone can crumple for the whole slowing time. If this is 0.1 s, then the force on the car to slow it down could be

$F = m \cdot \Delta v / \Delta t$ $\quad$ $1{,}000 \cdot 20 / 0.1 = 200{,}000$ N



Physics: The windshield and the frame of the family car are the only matter in the way of the lifted truck that can crumple to stop it.

$F = m \cdot \Delta v / \Delta t$ $\quad$ $1{,}000 \cdot 20 / 0.01 = 2{,}000{,}000$ N

Image credits: Vectorportal.com