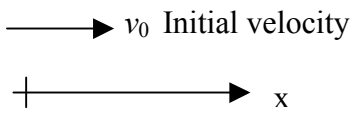
Spring 2001 Physics 2048 Test 3 solutions

Problem 2 (Estimation Problem: 15 points)

Use momentum-impulse theorem



$$\Delta\vec{p}_{car} = \vec{I}_{car}$$

$$\left|\vec{I}_{car}\right| = \left|\int_{t_1}^{t_2} \vec{F}_{car}^{\,net}\, dt\right| = \frac{1}{2} F_{\max}\, \Delta t$$

$$\Delta\vec{p} = m\vec{v}_f - m\vec{v}_0$$

$\Delta p_x = mv_{xf} - mv_{x0}$, note that the final velocity is in the opposite direction of the initial velocity

so $v_{xf} = -\alpha\, v_{x0}$, , where α = 90%

$$\Delta p_x = m(v_{xf} - v_{x0}) = m[(-\alpha\, v_{x0}) - v_{x0}] = -(1+\alpha)mv_{x0}$$

Taking the magnitude of Δp_x and setting it equal to the magnitude of the impulse

$$(1+\alpha)mv_{x0} = \frac{1}{2} F_{\max}\, \Delta t$$

$$F_{\max} = 2(1+\alpha)\, mv_{x0} / \Delta t$$

Given:

v_{x0} = 25 mi/hr * 0.62 km/hr * 1 hr/3600 sec * 1000 m/ km = 4.306 m/s

α = 0.90

Estimate time interval and mass of the car

Reasonable estimates 500 kg < m < 3000 kg for mass

0.2 s < Δt < 1 s for time interval

Let m = 1000 kg and Δt = 0.5 s

$F_{\max} = 2(1+\alpha)\, mv_{x0} / \Delta t$ = 2 (1 + 0.90) (1000 kg) (4.306 m/s) / (0.5 s) = 33,000 N = 33 kN