PHYS 2305 – Foundations of Physics (Fall 2023)

Problem-Solving Set 5

Week of Oct. 2nd

Problem 1: (6 pts)

A 1500 kg car skids to a halt on a wet road where $\mu_k = 0.5$. How fast was the car travelling if it leaves 65-m long skid marks?

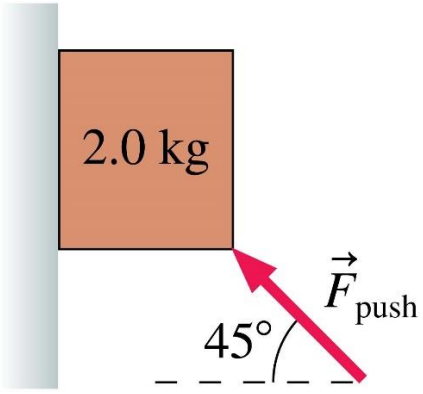
Problem 2: (6 pts)

Seat belts and air bags save lives by reducing the forces exerted on the drivers and passengers in an automobile collision. Cars are designed with a "crumple zone" in the front of the car. In the event of an impact, the passenger compartment decelerates over a distance of 1 m as the front of the car crumples. An occupant restrained by the seat belt or air bag decelerates with the car. By contrast, an unrestrained occupant keeps moving forward with no loss of speed (Newton's 1st law) until hitting the dashboard or windshield. These are unyielding surfaces, and the unfortunate occupant then decelerates over a distance of only 5 mm.

a. A 60-kg person is in a head-on collision. The car's speed at impact is 15 m/s. Estimate the net force on the person if he or she is wearing a seat belt and if the air bag deploys.
b. Estimate the net force that ultimately stops the person if he or she is not restrained by a seat belt or air bag.

Problem 3: (8 pts)

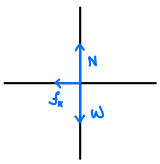
A 2.0 kg wood box slides down a vertical wood wall while you push on it at 45º angle. What magnitude of force should you apply to cause the box to slide down at a constant speed?



Problem 1:

$m = 1500$ kg
$\mu_k = 0.5$
$x = 65$ meters

$w = mg$ $\quad N = mg$
$w = 1500(9.8)$ $\quad N = 1500(9.8)$
$w = -14700$ N $\quad N = 14700$ N



$f_k = \mu_k N$
$f_k = 14700(0.5)$
$f_k = 7350$ N

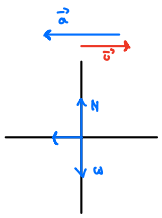
$\vec{\Sigma} F = ma$
$-7350 = 1500(a)$
$\frac{-7350}{1500} = a$
$a = -4.9\ m/s^2$

$a = -4.9\ m/s$
$x = 65$ meters
$v_f = 0\ m/s$
$v_i = ?$

$x_f = x_i + v_i \Delta t + \frac{1}{2} a \Delta t^2$
$65m = 0 + 0 + \frac{1}{2}(-4.9)(t)^2$
$65 = -2.45t^2$
$t = 5.1508$ seconds

$v_f = v_i + a\Delta t$
$0 = v_i + (-4.9)(5.1508)$
$0 = v_i - 25.23892$
$v_i = 25.23892$

Problem 2:



a). $m = 60$ kg
$v = 15\ m/s$
$x = 1$ meter

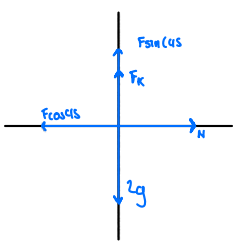
$v_f^2 = v_0^2 + 2a\Delta x$
$0 = 15^2 + 2(a)(1)$
$0 = 225 + 2a$
$-225 = 2a$
$a = -127.5\ m/s^2$

$\Sigma \vec{F} = m\vec{a}$
$F = 60(-127.5)$
$F = -7650$ N

b). $v_f^2 = v_0^2 + 2a\Delta x$
$0 = 15^2 + 2a(0.005)$
$0 = 225 + 0.01a$
$-225 = 0.01a$
$a = -22{,}500\ m/s^2$

$\Sigma F = ma$
$F = 60(-22500)$
$F = -1{,}350{,}000$ Newtons

Problem 3:



$m = 2.0$ kg
$\mu_k = 0.200$
$\theta = 45°$

$F_x = F\cos 45°$
$F_y = F\sin 45°$

X-direction:

$f + F\sin 45° = 2g$
$\mu_k N + F\sin 45° = 2g$
$\mu_k(F\cos 45) + F\sin 45 = 2g$
$F(\mu_k \cos 45 + \sin 45) = 2g$

$F = \frac{2g}{\mu_k \cos 45 + \sin 45}$
$F = \frac{2(9.81)}{(0.200)\cos 45 + \sin 45}$
$F = 23.01$ Newtons