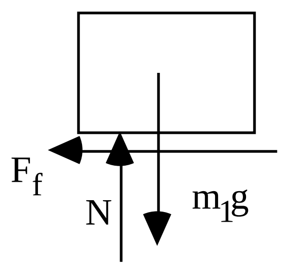
220A Solutions

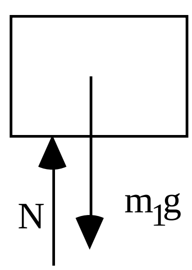
Assignment 6

Problem A. Draw the free-body diagram. The truck is moving to the right and slowing down, so the acceleration is to the left. If the box does not slip, its acceleration is to the left. That means that the net force must be to the left. The net force is the frictional force.



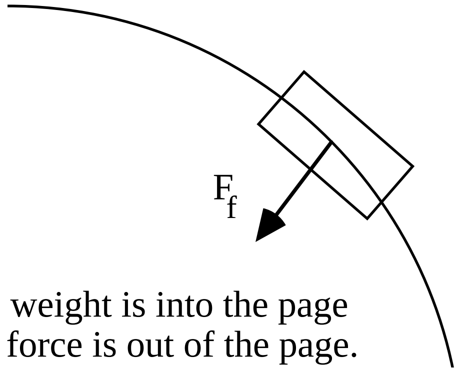
Truck moving right and slowing down.

If the truck is moving to the right and going 100 km/h, the acceleration is constant so the net force is zero and the diagram is as follows:



Truck moving right at constant velocity.

5-35. Draw the free-body diagram. This is a top view with the weight going into the page and the normal force out of the page.



Top view. The weight is into the page and the normal force is out of the page.

Since there is no acceleration in the vertical direction, N = mg which means that the maximum frictional force is $\mu_s$mg. Since the car is going in a circle, the acceleration is v^2/R and the 2nd law is

$$\mu_s mg = ma = mv^2/R$$

The mass cancels, so the mass of the car does not matter. Solving for v

$$v^2 = \mu_s g\ R = (0.55)\cdot 9.8\ m/s^2 \cdot 80\ m = 431\ m^2/s^2$$
$$v = \pm\ 20.8\ m/s.$$

5-40. If the acceleration due to gravity is larger than v^2/R, then the passengers fall out. The critical speed is reached when the two accelerations are equal

$$v^2/R = g$$

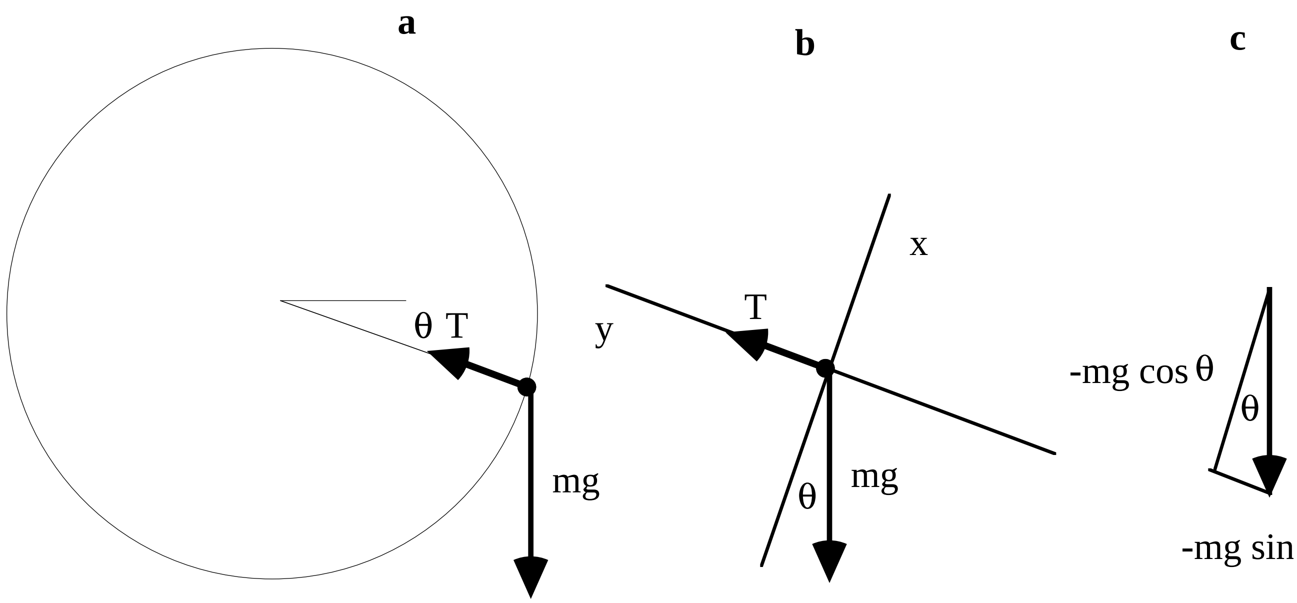
which means that $v = \sqrt{Rg} = \sqrt{8\ m\cdot 9.8\ m/s^2} = 8.85\ m/s$

5-73. The frictional force is $-\ \mu_k N = -\ \mu_k mg$ which means that the acceleration is $-\ \mu_k g$. The acceleration is constant so $v^2 = v_0^2 + 2a_x(x - x_0) = v_0^2 + 2(-\ \mu_k g)(x - x_0)$

$$v^2 = (20m/s)^2 + 2(-0.8)\cdot 9.8\ m/s^2(15m - 0) = 164\ m^2/s^2$$

so the motorcycle emerges from the sand with a speed of v = 12.8 m/s.

5-94. Draw the free-body diagram in **a**. The coordinate system is shown in **b** and the resolution of mg into components in **c**. Make sure you understand which angle is θ in b and c; review problem 4-40.



The net force in the y-direction $\Sigma F_y = T - mg \sin\theta$ and in the x-direction, $\Sigma F_x = -mg \cos\theta$. This is a more interesting problem than all of the previous ones because there is acceleration in both x- and y-directions. Take them one at a time. In the y-direction, the 2nd law is

$$T - mg \sin\theta = ma_y = m\, v^2/R \qquad (1)$$

where the final equality comes from the fact that the particle is moving in a circle.

In the x-direction, the 2nd law is

$$-mg \cos\theta = ma_x \qquad (2)$$

where the final equality comes from the fact that the particle is moving in a circle. The physics is over and now comes the math. Equations 1 and 2 look like pairs of equations that we have seen before, so we suspect two equations and two unknowns; however, if we reason it through, we see that it is simpler than that. We are given the speed, the angle, and the radius which determines T from eq 1 and a_x from eq 2. Thus

$T = mg \sin\theta + m\, v^2/R = 1\text{ kg}(9.8\text{ m/s}^2)\sin 30° + 1\text{ kg}(6\text{ m/s})^2/0.8\text{ m} = 49.9\text{ N}.$

and the tangential acceleration is

$$a_x = -\, g \cos 30 = -\, 8.49\text{ m/s}^2.$$

The radial acceleration is

$$a_y = v^2/R = (6\ \text{m/s})^2/0.8\ \text{m} = 45\ \text{m/s}^2.$$