

33. A 1000-kg car is pulling a 300-kg trailer. Together the car and trailer have an acceleration of  $2.15 \text{ m/s}^2$  in the forward direction. Neglecting frictional forces on the trailer, determine (a) the net force on the car; (b) the net force on the trailer; (c) the force exerted by the trailer on the car; (d) the resultant force exerted by the car on the road.

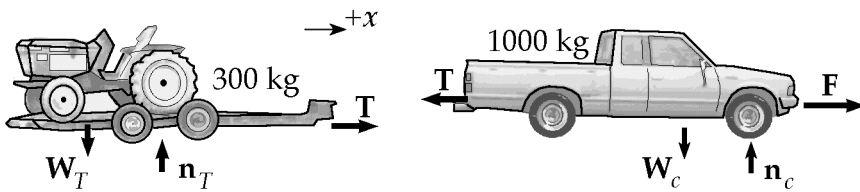
**Solution** Choose the  $+x$  direction to be horizontal and forward with the  $+y$  direction upward. The acceleration of both the car and the trailer then has components of  $a_x = +2.15 \text{ m/s}^2$  and  $a_y = 0$ .

(a) The net force on the car is in the direction of the car's acceleration (in the forward direction) and has the magnitude:

$$(F_{\text{car}})_{\text{net}} = m_{\text{car}}a = (1000 \text{ kg})(2.15 \text{ m/s}^2) = 2.15 \times 10^3 \text{ N} \quad \diamond$$

(b) Likewise, the net force on the trailer is  $(F_{\text{trailer}})_{\text{net}} = m_{\text{trailer}}a$

or  $(F_{\text{trailer}})_{\text{net}} = (300 \text{ kg})(2.15 \text{ m/s}^2) = 645 \text{ N}$  (also in forward direction).  $\diamond$



(c) Consider the free-body diagrams for the car and the trailer. The only horizontal force on the trailer is  $T$ , the tension in the link connecting the car and trailer. Thus,  $T = (F_{\text{trailer}})_{\text{net}} = 645 \text{ N}$  is the magnitude of the force exerted on the trailer by the car. By Newton's third law, the trailer exerts a force

$$T = 645 \text{ N acting in the rearward direction on the car.} \quad \diamond$$

(d) The road exerts the forward force  $F$  and the normal force  $n_c$  on the car. The magnitude of these forces may be found as follows:

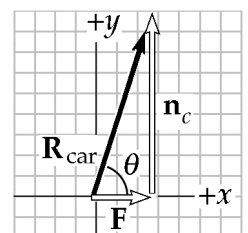
$$\begin{aligned} \sum F_x = ma_x: & \quad F - 645 \text{ N} = (1000 \text{ kg})(+2.15 \text{ m/s}^2) \\ \text{or} & \quad F = 2.80 \times 10^3 \text{ N} \end{aligned}$$

$$\begin{aligned} \sum F_y = ma_y: & \quad +n_c - W_c = 0 \\ \text{so} & \quad n_c = m_{\text{car}}g = (1000 \text{ kg})(9.80 \text{ m/s}^2) = 9.80 \times 10^3 \text{ N} \end{aligned}$$

The resultant force exerted on the car by the road is (by the vector diagram):

$$F = \sqrt{(2.80 \times 10^3 \text{ N})^2 + (9.80 \times 10^3 \text{ N})^2}$$

$$F = 1.02 \times 10^4 \text{ N}$$



$$\begin{aligned} F &= 2.80 \times 10^3 \text{ N} \\ n_c &= 9.80 \times 10^3 \text{ N} \end{aligned}$$

at  $\theta = \tan^{-1}(n_c/F) = \tan^{-1}(3.50) = 74.1^\circ$

By Newton's third law, the resultant force exerted on the road by the car is therefore  $1.02 \times 10^4 \text{ N}$  directed at  $74.1^\circ$  below the negative  $x$  direction (or equivalently at  $15.9^\circ$  to the rear of vertical).  $\diamond$