**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.

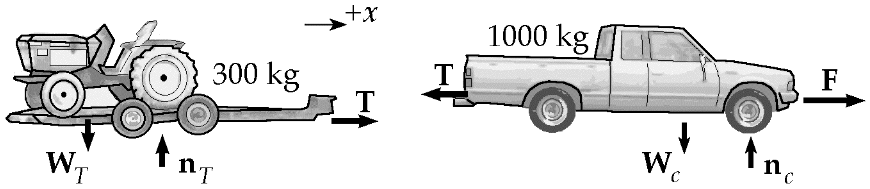
**Solution** Choose the $+x$ direction to be horizontal and forward with the $+y$ direction upward. The acceleration of both the car and the trailer then has components of $a_x = +2.15\ \text{m/s}^2$ and $a_y = 0$.

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

$$(F_{\text{car}})_{\text{net}} = m_{\text{car}}a = (1000\ \text{kg})(2.15\ \text{m/s}^2) = 2.15\times10^3\ \text{N}$$ ◊

(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). ◊




(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. ◊

(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:

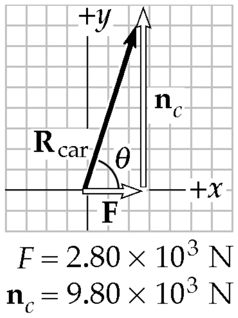
$\sum F_x = ma_x$: $\quad F - 645\ \text{N} = (1000\ \text{kg})(+2.15\ \text{m/s}^2)$

or $\quad F = 2.80\times10^3\ \text{N}$

$\sum F_y = ma_y$: $\quad +n_c - W_c = 0$

so $\quad n_c = m_{\text{car}}g = (1000\ \text{kg})(9.80\ \text{m/s}^2) = 9.80\times10^3\ \text{N}$

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




$$F = \sqrt{(2.80\times10^3\ \text{N})^2 + (9.80\times10^3\ \text{N})^2}$$

$$F = 1.02\times10^4\ \text{N}$$

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

By Newton's third law, the resultant force exerted on the road by the car is therefore $1.02\times10^4\ \text{N}$ directed at 74.1° below the negative $x$ direction (or equivalently at 15.9° to the rear of vertical). ◊