A 1000-kg car is pulling a 300-kg trailer. Together the car and trailer have an acceleration of 2.15 m/s² 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:

\[
(F_{\text{car}})_{\text{net}} = m_{\text{car}} a_x = (1000 \text{ kg})(2.15 \text{ m/s}^2) = 2.15 \times 10^3 \text{ N}
\]

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

\[
T = 645 \text{ N} \text{ acting in the rearward direction on the car.}
\]

(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:

\[
\sum F_x = m a_x : \quad F - 645 \text{ N} = (1000 \text{ kg})(2.15 \text{ m/s}^2) \quad \text{or} \quad F = 2.80 \times 10^3 \text{ N}
\]

\[
\sum F_y = m a_y : \quad +n_c - W_c = 0 \quad \text{so} \quad n_c = m_{\text{car}} g = (1000 \text{ kg})(9.80 \text{ m/s}^2) = 9.80 \times 10^3 \text{ N}
\]

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

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

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

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).