Relative to the ground, a car has a velocity of 16.7 m/s, directed due north. Relative to this car, a truck has a velocity of 25.0 m/s, directed 52.0° north of east. What is the magnitude of the truck's velocity relative to the ground?

Solution:

$V_t -$ velocity of the truck relative to the ground;

$V_{t,c} = 25.0\frac{m}{s} -$ velocity of the truck relative to the car;

$V_c = 16.7\frac{m}{s} -$ velocity of the car relative to the ground;

$\alpha = 52.0° -$ *the angle between the west* $-$ *east direction and the direction of the truck*

Formula for the relative velocity of the track:

$\vec{V}_{t,c} = \vec{V}_t - \vec{V}_c$

$\vec{V}_t = \vec{V}_{t,c} + \vec{V}_c$

The cosine theorem in the triangle ABC ($\beta = 180^o - (90^o - \alpha) = 90^o + \alpha$):

$$V_t = \sqrt{V_{t,c}^2 + V_c^2 - 2V_{t,c} \cdot V_c \cdot \cos\beta} = \sqrt{V_{t,c}^2 + V_c^2 - 2V_{t,c} \cdot V_c \cdot \cos(90^o + \alpha)};$$

$\cos(90^o + \alpha) = -\sin\alpha \Rightarrow$

$$V_t = \sqrt{\left(16.6\frac{m}{s}\right)^2 + \left(25\frac{m}{s}\right)^2 + 2\left(16.6\frac{m}{s}\right) \cdot \left(25\frac{m}{s}\right) \cdot \sin 52° = 39.43\frac{m}{s}}$$

Answer: magnitude of the truck's velocity relative to the ground is $39.43\frac{m}{s}$