DESCRIPTION

Article contains a few physics problems involving vectors and force.

LEARNING OUTCOMES

Students will:
• see how physics applies to everyday applications in agriculture

READINESS ACTIVITIES

Students should:
• think about how simple chores and work actually involves physics

MATERIALS

• copy of article
• calculator
Applications of Vectors

Some farmers are tightening barb-wire fences. John and Steve are using ropes to pull the fence taut. They are standing at right angles to each other.

John is stronger than Steve and is therefore able to exert more force when pulling on the rope. John can pull with a force of 20 N while Steve can only pull with a force of 13 N. When the fence has been pulled tight, what is the equilibrant force exerted by the barb-wire fence? In other words, how tight is the fence after the men have pulled and secured it?

Solution

\[ R^2 = A^2 + B^2 \]
\[ R^2 = (20)^2 + (13)^2 \]
\[ R^2 = 400 + 169 \]
\[ R^2 = 569 \]
\[ R = 23.85 \]
Physics Problems

After a few weeks have passed, the men begin to notice they did not tighten the fences tight enough. Their livestock is constantly escaping from the field. This time John and Steve decide to try a new strategy.

Now the tree is used as a pulley.

John pulls at an angle of 40° to the fence. Steve pulls at a 100° angle. The forces exerted by the two men have not changed, but the tension on the fence should. What is it now?

Solution

\[ \cos \sigma = \frac{\text{adj}}{\text{hyp}} = F_{1x} \]

\[ F_{1x} = \frac{20 \text{ N}}{20 \text{ N}(\cos 40^\circ)} \]
\[ = (20)(.7660) \]
\[ = 15.32 \]

\[ \sin \sigma = \frac{\text{opp}}{\text{hyp}} = F_{1y} \]

\[ F_{1y} = \frac{20 \text{ N}(\sin 40^\circ)}{20 \text{ N}} \]
\[ = (20)(.6428) \]
\[ = 12.86 \]
\[ \cos \sigma = \frac{\text{adj}}{\text{hyp}} \]

\[
\cos 100^\circ = \frac{F_{2x}}{13N} \]
\[ F_{2x} = (13)(\cos 100^\circ) \]
\[ = -2.26 \]

\[
\sin \sigma = \frac{\text{opp}}{\text{hyp}} \]
\[ \sin 100^\circ = \frac{F_{2y}}{13N} \]
\[ F_{2y} = (13)(\sin 100^\circ) \]
\[ = 12.8 \]

\[
F_x = F_{1x} + F_{2x} = 15.32 + (-2.26) = 13.06
\]

\[
F_y = F_{1y} + F_{2y} = 12.86 + 12.8 = 25.66
\]

\[
F_{\text{net}} = \sqrt{F_x^2 + F_y^2} = \sqrt{(13.06)^2 + (25.66)^2} = \sqrt{170.56 + 658.44} = 28.59 \text{ N}
\]

Thus the tension on the fence should now be 28.59 N.
In this vector problem, hay is being loaded into a hay loft. The barn is 6m high and perpendicular to the ground. If the angle of the escalator to the ground is greater than 55° the hay bales will fall backwards as they are going up. If the angle of the escalator is 30° or less, the escalator would be too long to be sturdy. What are the minimum and maximum lengths that are most suitable for loading the hay into the loft? Don’t forget that the escalator must have an extra meter that goes into the loft of the barn.

**Solution**

\[
\sin \sigma = \frac{\text{opp}}{\text{hyp}} \quad \sin \sigma = \frac{\text{opp}}{\text{hyp}}
\]
\[
\sin 55^\circ = \frac{6m}{E} \quad \sin 30^\circ = \frac{6m}{E}
\]
\[
E = (6)(\sin 55^\circ) \quad E = (6)(\sin 30^\circ)
\]
\[
E = 4.9 \text{ m} \quad E = 3 \text{ m}
\]

Remember, both of these lengths need another meter added on to get into the loft. So the ideal length for the escalator would be between **5.9** and **4** meters.
A hay bailer is able to tie off each bale and then project it at an adjustable angle. Let’s say the hay projector is set at a $45^\circ$ angle. Each bale is projected at an average velocity of 15.0 m/s. Given this, how far behind the bailer will the hay get thrown?

Given: initial velocity, $v_i = +15.0 \text{ m/s}$

initial angle, $\sigma = 45^\circ$

**Solution**

\[ \cos \sigma = \frac{\text{adj}}{\text{hyp}} \]

\[ \cos 45^\circ = \frac{V_x}{15 \text{ m/s}} \]

\[ V_x = (15)(0.7071) = 10.6 \text{ m/s} \]

\[ \sin \sigma = \frac{\text{opp}}{\text{hyp}} \]

\[ \sin 45^\circ = \frac{V_y}{15 \text{ m/s}} \]

\[ V_y = (15)(0.7071) = 10.6 \text{ m/s} \]

Now find the time:

\[ y = Vyt + \frac{1}{2}gt^2 \]

\[ 0 = Vyt + \frac{1}{2}gt^2 \]

\[ -2Vyt = gt^2 \]

\[ t = \frac{-2Vy}{g} = \frac{-2(10.6 \text{ m/s})}{-9.8 \text{ m/s}^2} = 2.16 \text{ seconds} \]

use time to determine distance:

\[ R = Vxt = (10.6 \text{ m/s})(2.16 \text{ s}) = 22.9 \text{ m} \]