Group Problem

While laying on the South Oval grass on a beautiful spring day, you notice two African swallows flying toward each other, both of them carrying coconuts. The first swallow is flying north horizontally with a speed of 20 m/s and the other swallow is flying south horizontally at the same height with a speed of 15 m/s. The mass of the first swallow is 0.27 kg and the mass of his coconut is 0.80 kg. The mass of the second swallow is 0.22 kg, and her coconut has a mass of 0.70 kg. Because the swallows are also enjoying the spring day and not really noticing where they are going they collide and lose their coconuts. Immediately after the collision, the first coconut travels 10° west of south with a speed of 13 m/s, and the second coconut moves 30° east of north with a speed of 14 m/s. The two birds are very startled, get tangled up, and stop flapping their wings as they travel off together.

a) What is the velocity of the tangled birds (magnitude and direction) immediately after the collision?
b) Would the result be the same for European swallows?

Context-Rich Problems: Solutions Outline

FOCUS the PROBLEM

Draw a picture of the situation including ALL the information given in the problem.

$v_{1i} = 20\ m/s$ $\quad v_{2i} = 15\ m/s$

$m_{1s} = .27\ kg$ $\quad m_{1c} = .80\ kg$

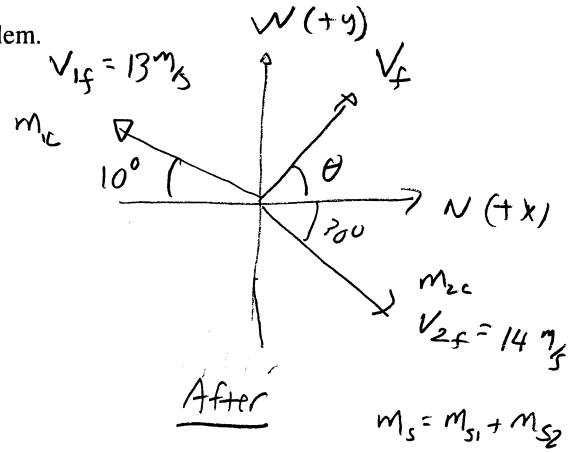
$m_1 = m_{1s} + m_{1c}$

north $\rightarrow$ $\leftarrow$ south

$m_{2s} = .22\ kg$ $\quad m_{2c} = .70\ kg$

$m_2 = m_{2s} + m_{2c}$

Before



Question(s): What is the problem asking you to find?

What is the velocity of the tangled birds after collision

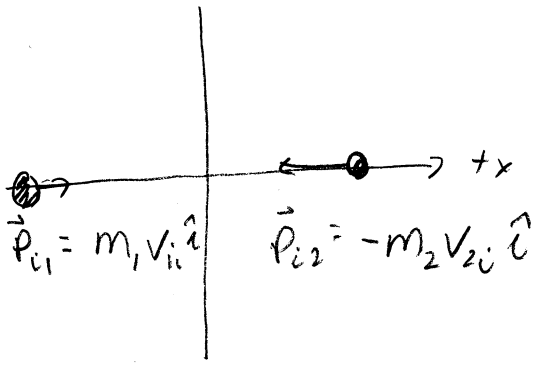
Approach: Outline the approach you will use.

Use cons. of momentum in 2 dimensions

DESCRIBE the PHYSICS

Draw physics diagram(s) and define ALL quantities uniquely.

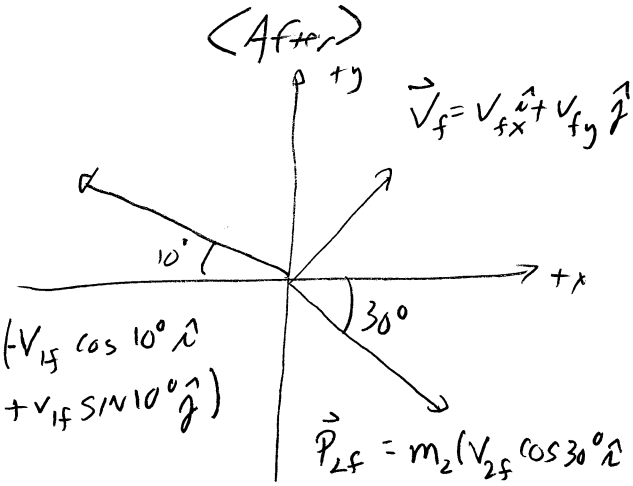
<Before>



<IMPULSE>

none

<After>



Which of your defined quantities is your Target variable(s)?

v_f

Quantitative Relationships: Write equations you will use to solve this problem.

$\vec{I} = \Delta\vec{p}$ $\qquad \vec{p} = m\vec{v}$

PLAN the SOLUTION

Construct Specific Equations (Same Number as Unknowns)

in x:

$$m_1 v_{1i} - m_2 v_{2i} = -m_1 v_{1f} \cos 10^\circ + m_2 v_{2f} \cos 30^\circ + m_s v_{fx}$$

(1) $$v_{fx} = \frac{m_1 v_{1i} - m_2 v_{2i} + m_1 v_{1f} \cos 10^\circ - m_2 v_{2f} \cos 30^\circ}{m_s}$$

in y:

$$0 = m_1 v_{1f} \sin 10^\circ - m_2 v_{2f} \sin 30^\circ + m_s v_{fy}$$

(2) $$v_{fy} = -\frac{m_1 v_{1f} \sin 10^\circ + m_2 v_{2f} \sin 30^\circ}{m_s}$$

$$v_f = \sqrt{v_{fx}^2 + v_{fy}^2} \qquad \theta = \tan^{-1} \frac{v_{fy}}{v_{fx}}$$

Execute plan for (1) & (2)

$$v_{fx} = (1.07\,kg)(20\,m/s) - (0.92\,kg)(15\,m/s) + (1.80\,kg)(13\,m/s)(\cos 10^\circ) - (1.70\,kg)(14\,m/s)(\cos 30^\circ) \div 0.490\,kg = 19.09\,m/s$$

$$v_{fy} = \frac{-(1.80\,kg)(13\,m/s)(\sin 10^\circ) + (1.70\,kg)(14\,m/s)(\sin 30^\circ)}{0.490\,kg} = 6.31\,m/s$$

Check Units

Units for (1) and (2) are $\frac{[L]}{[T]}$

EXECUTE the PLAN

Calculate Target Quantity(ies)

$$v_f = \sqrt{v_{fx}^2 + v_{fy}^2} = \sqrt{(19.09\,m/s)^2 + (6.31\,m/s)^2} = \boxed{20\,m/s}$$

$$\theta = \tan^{-1} \frac{v_{fy}}{v_{fx}} = \tan^{-1}\left(\frac{6.31}{19.09}\right) = \boxed{18^\circ \text{ West of North}}$$

EVALUATE the ANSWER

Is Answer Properly Stated?

Yes, magnitude (with units) and direction

Is Answer Unreasonable?

No, it is similar to initial velocity

Is Answer Complete?

No, part (b) The result would be the same with European swallows, but we all know they don't carry coconuts

(extra space if needed)