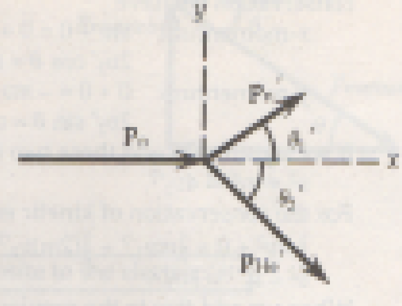
43. Using the coordinate system shown, for momentum conservation we have



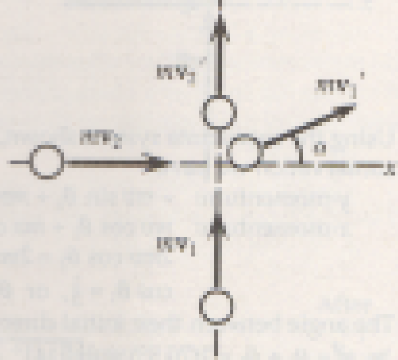
x: $m_n v_n + 0 = m_n v_n' \cos \theta_1' + m_{He} v_{He}' \cos \theta_2'$;
$m_n(6.2 \times 10^5 \text{ m/s}) = m_n v_n' \cos \theta_1' + 4m_n v_{He}' \cos 45°$, or
$v_n' \cos \theta_1' = (6.2 \times 10^5 \text{ m/s}) - 4v_{He}' \cos 45°$.
y: $0 + 0 = -m_n v_n' \sin \theta_1' + m_{He} v_{He}' \sin \theta_2'$;
$0 = -m_n v_n' \sin \theta_1' + 4m_n v_{He}' \sin 45°$, or
$v_n' \sin \theta_1' = 4v_{He}' \sin 45°$.

For the conservation of kinetic energy, we have
$\frac{1}{2}m_n v_n^2 + 0 = \frac{1}{2}m_n v_n'^2 + \frac{1}{2}m_{He} v_{He}'^2$;
$m_n(6.2 \times 10^5 \text{ m/s})^2 = m_n v_n'^2 + 4m_n v_{He}'^2$, or
$v_n'^2 + 4v_{He}'^2 = 3.84 \times 10^{11} \text{ m}^2/\text{s}^2$.

We have three equations in three unknowns: θ_1', v_n', v_{He}'. We eliminate θ_1' by squaring and adding the two momentum results, and then combine this with the energy equation, with the results:

$\theta_1' = 76°$, $v_n' = 5.1 \times 10^5$ m/s, $v_{He}' = 1.8 \times 10^5$ m/s.

44. Using the coordinate system shown, for momentum conservation we have



x: $0 + mv_2 = mv_1' \cos \alpha + 0$;
$3.7 \text{ m/s} = v_1' \cos \alpha$.
y: $mv_1 + 0 = mv_1' \sin \alpha + mv_2'$;
$2.0 \text{ m/s} = v_1' \sin \alpha + v_2'$, or
$v_1' \sin \alpha = 2.0 \text{ m/s} - v_2'$.

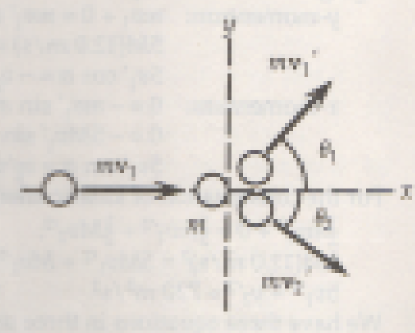
For the conservation of kinetic energy, we have
$\frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 = \frac{1}{2}mv_1'^2 + \frac{1}{2}mv_2'^2$;
$(2.0 \text{ m/s})^2 + (3.7 \text{ m/s})^2 = v_1'^2 + v_2'^2$.

We have three equations in three unknowns: α, v_1', v_2'. We eliminate α by squaring and adding the two momentum results, and then combine this with the energy equation, with the results:

$\alpha = 0°$, $v_1' = 3.7$ m/s, $v_2' = 2.0$ m/s.

The two billiard balls exchange velocities.

45. Using the coordinate system shown, for momentum conservation we have



x: $mv_1 + 0 = mv_1' \cos \theta_1 + mv_2' \cos \theta_2$, or
$v_1 = v_1' \cos \theta_1 + v_2' \cos \theta_2$;
y: $0 + 0 = mv_1' \sin \theta_1 - mv_2' \sin \theta_2$, or
$0 = v_1' \sin \theta_1 - v_2' \sin \theta_2$.

For the conservation of kinetic energy, we have
$\frac{1}{2}mv_1^2 + 0 = \frac{1}{2}mv_1'^2 + \frac{1}{2}mv_2'^2$;
$v_1^2 = v_1'^2 + v_2'^2$.

We square each of the momentum equations:
$v_1^2 = v_1'^2 \cos^2 \theta_1 + 2v_1'v_2' \cos \theta_1 \cos \theta_2 + v_2'^2 \cos^2 \theta_2$;
$0 = v_1'^2 \sin^2 \theta_1 - 2v_1'v_2' \sin \theta_1 \sin \theta_2 + v_2'^2 \sin^2 \theta_2$.

If we add these two equations and use $\sin^2 \theta + \cos^2 \theta = 1$, we get
$v_1^2 = v_1'^2 + 2v_1'v_2'(\cos \theta_1 \cos \theta_2 - \sin \theta_1 \sin \theta_2) + v_2'^2$.

If we subtract the energy equation, we get
$0 = 2v_1'v_2'(\cos \theta_1 \cos \theta_2 - \sin \theta_1 \sin \theta_2)$, or $\cos \theta_1 \cos \theta_2 - \sin \theta_1 \sin \theta_2 = 0$.

We reduce this with a trigonometric identity:
$\cos \theta_1 \cos \theta_2 - \sin \theta_1 \sin \theta_2 = \cos(\theta_1 + \theta_2) = 0$,
which means that $\theta_1 + \theta_2 = 90°$.