Question

In the arrangement of the figure, billiard ball 1 moving at a speed of 3.7 m/s undergoes a glancing collision with identical billiard ball 2 that is at rest. After the collision, ball 2 moves at speed 3.2 m/s, at an angle of θ2 = 31°. What are (a) the magnitude and (b) the direction (angle θ1) of the velocity of ball 1 after the collision?

Solution

Conservation of momentum gives

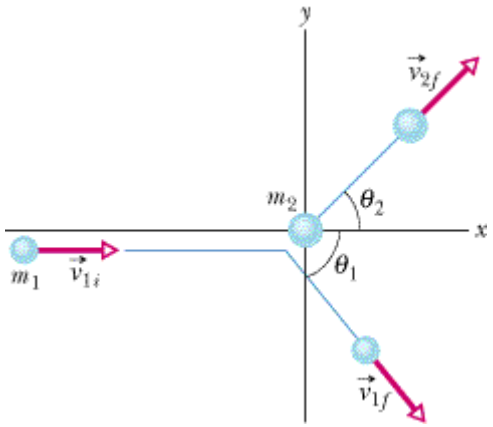
$$\overrightarrow{V_{1\iota}} = \overrightarrow{V_{1f}} + \overrightarrow{V_{2f}}.$$

Since the angle between $\overrightarrow{V_{1\iota}}$ and $\overrightarrow{V_{2f}}$ is θ_2, we can write cosine theorem

$$V_{1f}{}^2 = V_{1i}{}^2 + V_{2f}{}^2 - 2V_{1i}V_{2f}cos(\theta_2),$$

and find $V_{1f} = 1.91\, m/s$.

But from the energy conservation we have that $V_{1i}{}^2 \geqslant V_{1f}{}^2 + V_{2f}{}^2$ or $V_{1f}{}^2 \leqslant V_{1i}{}^2 - V_{2f}{}^2 = 1.86\, m/s$. We arrive at the contradiction, which means that collision described in the question is forbidden.



Picture is taken from https://www.physicsforums.com/threads/billiard-glancing-collision.346776/

Answer

Collision described in the question is forbidden by the low of energy conservation.