ASSIGNMENT 9

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Download all python codes from

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https://github.com/CRAMYATULASI/ASSIGNMENT9/tree/main/ASSIGNMENT9/CODES
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Latex-tikz codes from

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https://github.com/CRAMYATULASI/ASSIGNMENT9/tree/main/ASSIGNMENT9
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1 Question No 2.23

Consider the collision depicted in below fig 1.1 to be between two billiard balls with equal masses $m_1 = m_2$.The first ball is called the cue while second ball is called the target.The billiards player wants to sink the target ball in corner pocket,which is at an angle $\theta_2 = 37°$.Assume that the collision is elastic and frictional,rotational motions are not important.Obtain θ_1.

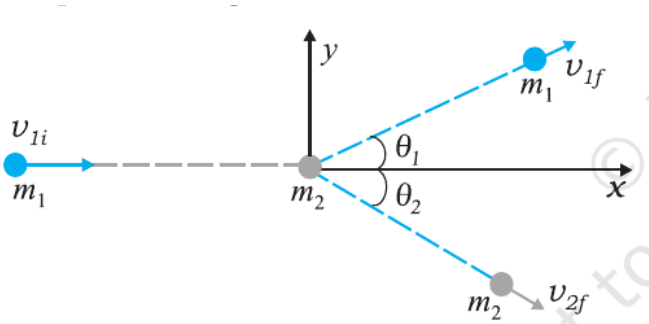

Fig. 1.1: Collision of two billiard balls

2 Solution

Let $\mathbf{v}_{1i}$ and $\mathbf{v}_{2i}$ be the initial velocities of the first ball and the second ball respectively.

$$\mathbf{v_{1i}} = \begin{pmatrix} v_0 \\ 0 \end{pmatrix} \tag{2.0.1}$$

$$\mathbf{v_{2i}} = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \tag{2.0.2}$$

$$\mathbf{v_{1f}} = \begin{pmatrix} v_{1x} \\ v_{1y} \end{pmatrix} \tag{2.0.3}$$

$$\mathbf{v_{2f}} = \begin{pmatrix} v_{2x} \\ v_{2y} \end{pmatrix} \tag{2.0.4}$$

Because, the target ball initially at rest conversation of energy gives,

$$\frac{1}{2}m_1 \|\mathbf{v}_{1i}\|^2 + \frac{1}{2}m_2 \|\mathbf{v}_{2i}\|^2 = \frac{1}{2}m_1 \left\|\mathbf{v}_{1f}\right\|^2 + \frac{1}{2}m_2 \left\|\mathbf{v}_{2f}\right\|^2 \tag{2.0.5}$$

$$\|\mathbf{v}_{1i}\|^2 = \left\|\mathbf{v}_{1f}\right\|^2 + \left\|\mathbf{v}_{2f}\right\|^2 (\because m_1 = m_2) \tag{2.0.6}$$

Applying conversation of momentum to two dimensional collision gives,

$$\mathbf{v_{1i}} = \mathbf{v}_{1f} + \mathbf{v}_{2f} \quad (\because m_1 = m_2) \tag{2.0.7}$$

$$\implies \mathbf{v_{1i}}.\mathbf{v_{1i}} = (\mathbf{v}_{1f} + \mathbf{v}_{2f}).(\mathbf{v}_{1f} + \mathbf{v}_{2f}) \tag{2.0.8}$$

$$\|\mathbf{v}_{1i}\|^2 = \left\|\mathbf{v}_{1f}\right\|^2 + \left\|\mathbf{v}_{2f}\right\|^2 + 2(\mathbf{v_{1f}}.\mathbf{v_{2f}}) \tag{2.0.9}$$

Subtracting (2.0.6) from (2.0.9)

$$2(\mathbf{v_{1f}}.\mathbf{v_{1f}}) = 0 \tag{2.0.10}$$

$$\implies \left\|\mathbf{v}_{1f}\right\| \left\|\mathbf{v}_{2f}\right\| \cos(\theta_1 + \theta_2) = 0 \tag{2.0.11}$$

$$\implies \theta_1 + \theta_2 = 90° \tag{2.0.12}$$

$$\implies \theta_1 + 37° = 90° \quad (\because \theta_2 = 37°) \tag{2.0.13}$$

$$\implies \theta_1 = 53° \tag{2.0.14}$$

$\therefore$ Above result shows that whenever two equal masses undergo a glancing elastic collision and one of them is initially at rest they move at right angles to each other.