

STEP III, 1998, Q10

- 10 Two identical spherical balls, moving on a horizontal, smooth table, collide in such a way that both momentum and kinetic energy are conserved. Let \mathbf{v}_1 and \mathbf{v}_2 be the velocities of the balls before the collision and let \mathbf{v}'_1 and \mathbf{v}'_2 be the velocities of the balls after the collision, where \mathbf{v}_1 , \mathbf{v}_2 , \mathbf{v}'_1 and \mathbf{v}'_2 are two-dimensional vectors. Write down the equations for conservation of momentum and kinetic energy in terms of these vectors. Hence show that their relative speed is also conserved.

Show that, if one ball is initially at rest but after the collision both balls are moving, their final velocities are perpendicular.

Now suppose that one ball is initially at rest, and the second is moving with speed V . After a collision in which they lose a proportion k of their original kinetic energy ($0 \leq k \leq 1$), the direction of motion of the second ball has changed by an angle θ . Find a quadratic equation satisfied by the final speed of the second ball, with coefficients depending on k , V and θ . Hence show that $k \leq \frac{1}{2}$.



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