STAEDTLER® No. 937 811E Engineer's Computation Pad

••20 Figure 9-48 gives an overhead view of the path taken by a 0.165 kg cue ball as it bounces from a rail of a pool table. The ball's initial speed is 2.00 m/s, and the angle θ_1 is 30.0°. The bounce reverses the y component of the ball's velocity but does not alter the x component. What are (a) angle θ_2 and (b) the change in the ball's linear momentum in unit-vector notation? (The fact that the ball rolls is irrelevant to the problem.)

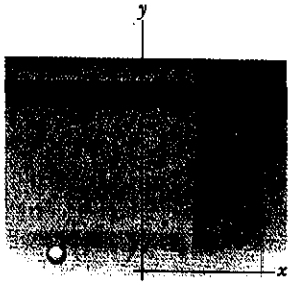
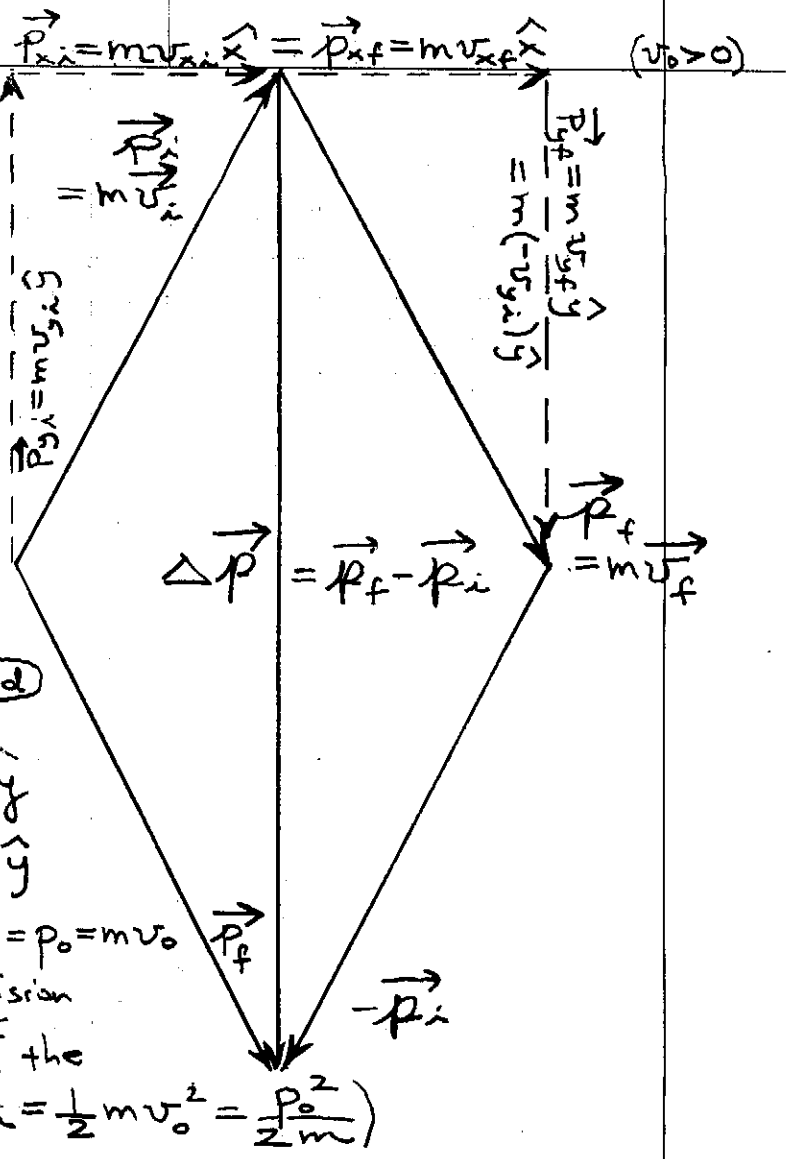


FIG. 9-48 Problem 20.



$\vec{p}_i = p_0 \sin\theta_1 \hat{x} + p_0 \cos\theta_1 \hat{y}$

where $|\vec{p}_i| = p_0 = mv_0$

The Problem states (reversed)

$\vec{p}_f = p_0 \sin\theta_1 \hat{x} + (-p_0 \cos\theta_1)\hat{y}$

also $= p_0 \sin\theta_2 \hat{x} + (-p_f \cos\theta_2)\hat{y}$

Therefore $\theta_1 \equiv \theta_2$ & $p_f = |\vec{p}_f| = p_0 = mv_0$

(This is called an Elastic Collision because the Kinetic Energy of the ball does not change $K_f = K_i = \frac{1}{2}mv_0^2 = \frac{p_0^2}{2m}$)

THE GEOMETRY OF THE DIAGRAM (WITH THE GIVEN CONDITIONS INCORPORATED INTO IT) TELLS US THE SAME CONCLUSION THAT THE ABOVE ANALYTIC WORK DID

$$\Delta\vec{p} \equiv \vec{p}_f - \vec{p}_i = (p_{fx} - p_{ix})\hat{x} + (p_{fy} - p_{iy})\hat{y} = (p_{ix} - p_{ix})\hat{x} + (-p_{iy} - p_{iy})\hat{y}$$
$$= 0\hat{x} + -2p_{iy}\hat{y} = -2p_0 \cos\theta\,\hat{y}$$

LINEAR MOMENTUM-IMPULSE THEOREM: $\Delta\vec{p} = \vec{J}$

$\vec{J}$ is pictured in the Diagram

$$\vec{J} \equiv \int_{\text{over time of Collision}} \vec{F}\,dt \equiv \vec{F}_{AVG}\Delta t \xrightarrow[\text{QUICK COLLISIONS}]{\text{IN LIMIT OF INFINITESIMALLY}} \vec{F}\,dt = d\vec{p}$$

$$\Delta\vec{p} = F_{AVG}\Delta t = \vec{J} \quad \text{or} \quad d\vec{p} = \vec{F}\,dt = \vec{J}$$

$$\vec{F} = \frac{d\vec{p}}{dt} \quad \text{or} \quad \vec{F}_{AVG} = \frac{\Delta\vec{p}}{\Delta t} = \frac{\vec{J}}{\Delta t}$$

THE EXTERNAL FORCE EXERTED BY THE POOL CUSHION ON THE POOL ...

... BALL (FOR A GIVEN $\Delta\vec{p}$ DETERMINED BY ENERGY CONSERVATION) IS INVERSELY PROPORTIONAL TO THE TIME OF COLLISION - (WHICH DEPENDS ON HOW "CUSHIONY" THE TABLE IS).