

2D Collisions

EF 151, Class 3-6

Summary

Line of Impact (LOI)

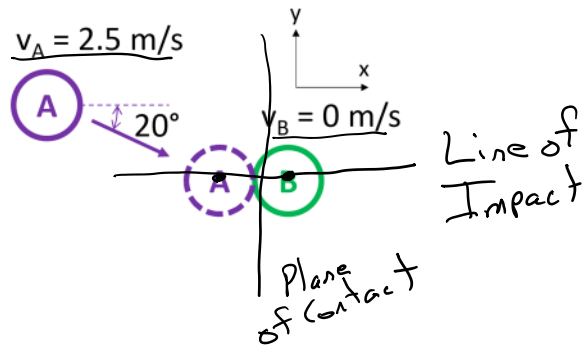
- Conservation of Momentum
- Coefficient of Restitution

Plane of Contact (POC)

- Velocity components remain the same

Perfectly Elastic Collision

Two billiard balls, each with a mass of 0.50 kg, collide in a perfectly elastic collision as shown.

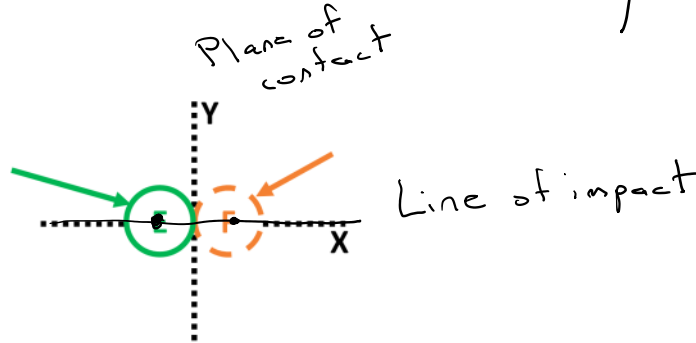


$$\begin{aligned} v_{Ax} &= +2.5 \cos 20^\circ \\ v_{Ay} &= -2.5 \sin 20^\circ \\ v'_{Ax} &= 0 \\ v'_{Ay} &= -2.5 \sin 20^\circ \\ v'_B &= 2.5 \cos 20^\circ \end{aligned}$$

Plane of Contact

Two bowling balls collide as shown.

Which line represents the plane of contact?



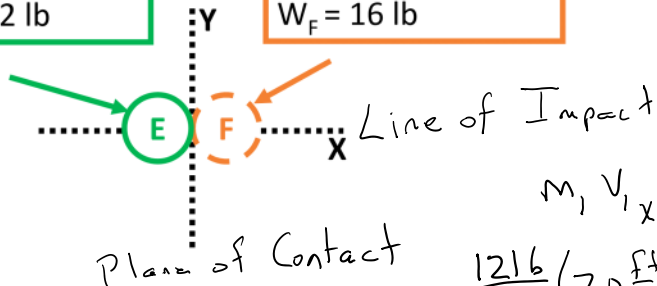
Plane of Contact

The coefficient of restitution between the balls is 0.80.

What is the velocity of Ball E after the collision?

$$\begin{aligned} v_E &= (20\mathbf{i} - 7\mathbf{j}) \text{ ft/s} \\ W_E &= 12 \text{ lb} \end{aligned}$$

$$\begin{aligned} v_F &= (-15\mathbf{i} - 10\mathbf{j}) \text{ ft/s} \\ W_F &= 16 \text{ lb} \end{aligned}$$



$$\begin{aligned} v_{E_y}' &= -7 \text{ ft/s} \\ v_{F_y}' &= -10 \text{ ft/s} \end{aligned}$$

$$\begin{aligned} m_1 v_{1x} + m_2 v_{2x} &= m_1 v_{1x}' + m_2 v_{2x}' \\ \frac{12 \text{ lb}}{g} (20 \frac{\text{ft}}{\text{s}}) + \frac{16 \text{ lb}}{g} (-15 \frac{\text{ft}}{\text{s}}) &= \frac{12 \text{ lb}}{g} v_{1x}' + \frac{16 \text{ lb}}{g} v_{2x}' \\ 0.80 &= \frac{-(v_{1x}' - v_{2x}')}{20 - (-15)} \end{aligned}$$

$$e = \frac{-(v_{1x}' - v_{2x}')}{v_{1x} - v_{2x}}$$

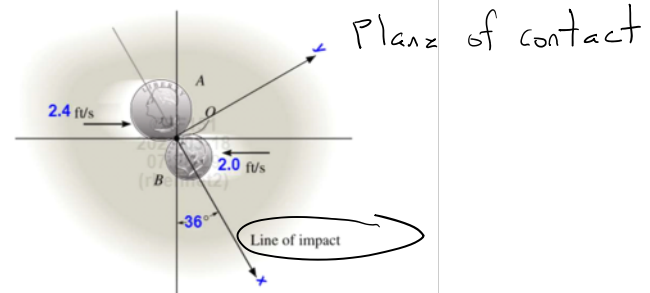
Practice 3-6-1

Two coins A and B have the initial velocities shown just before they collide at point O. Their weights are known, the level surface upon which they slide is smooth, and the coefficient of restitution is $e = 0.71$.

We want to find

- components of the velocities before the impact,
- components of the velocities after the impact,
- speeds of each coin after the impact, and
- the direction of A after impact.

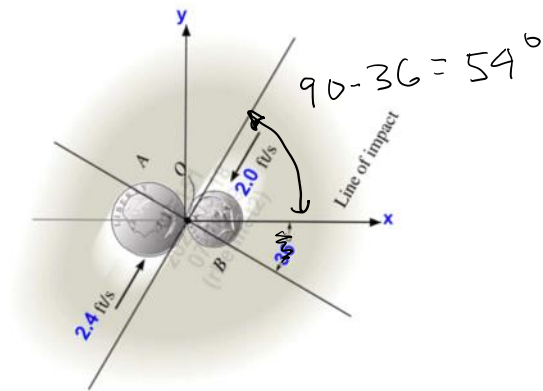
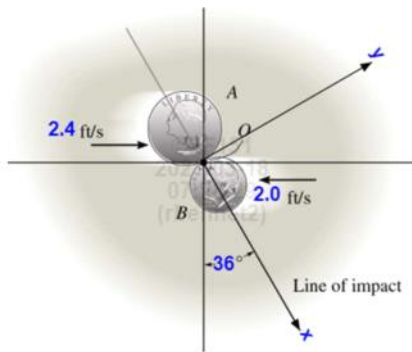
How can we apply the previous problem to this practice problem?



Practice 3-6-1

How can we apply the previous problem to this practice problem?

Suggestion: rotate the system!



Coefficient of Restitution

A regulation tennis ball has to bounce between a height of 53 to 56 inches when dropped from a height of 100 inches onto a concrete floor. Determine the coefficient of restitution.

What is conserved between A and B?

What is conserved between B and C?

$$v'_{ball} = -e v_{ball}$$

$$e = \frac{-(v'_{ball} - v'_{ground})}{v_{ball} - v_{ground}}$$

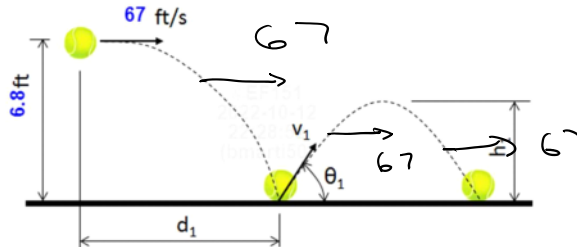
A

D

B C

Practice 3-6-2

A tennis ball is served horizontally from a height of 6.8 ft with a speed of 67 ft/s. The coefficient of restitution between the tennis ball and the ground is 0.69.



We want to find

- (a) the distance before the ball hits the ground the first time,**
- (b) the magnitude of the velocity just after the first bounce,**
- (c) the angle of the velocity with respect to the ground just after the first bounce, and**
- (d) the height of the first bounce.**

Practice 3-6-3

The ball is released from rest at position A, where $h = 0.50$ m and drops to the inclined plane. The plane's angle of inclination (θ) is 26 degrees. The coefficient of restitution for the impact of the ball with the plane is 0.70.

We want to find

- (a) the speed of the ball just before it strikes the inclined plane,**
- (b) the ball's velocity component normal to the plane immediately after the impact,**
- (c) the ball's velocity component parallel to the plane immediately after the impact, and**
- (d) the ball's speed immediately after the impact.**

