MECH230 - Fall 2024
Recommended Problems - Set 10

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Collision Consider a system of two colliding particles in the plane. Take $\mathbf{t}$ to be a unit vector tangent to the plane of collision and $\mathbf{n}$ be a unit vector perpendicular to the plane of collision. In our simplified model, we assume that all the collision forces lie along $\mathbf{n}$.

During the collision of two particles A and B, the linear momentum of the system of two particles is conserved

$$\mathbf{G}_A + \mathbf{G}_B = \mathbf{G}'_A + \mathbf{G}'_B \tag{1}$$

where the $(')$ denotes the post collision quantities.

Also during collision, the linear momentum of each individual particle along $\mathbf{t}$ is conserved

$$\mathbf{G}_A \cdot \mathbf{t} = \mathbf{G}'_A \cdot \mathbf{t}, \tag{2}$$
$$\mathbf{G}_B \cdot \mathbf{t} = \mathbf{G}'_B \cdot \mathbf{t}. \tag{3}$$

Finally, the coefficient of restitution e is experimentally obtained and relates the pre-impact and post-impact velocities through

$$e = -\frac{\mathbf{v}'_B \cdot \mathbf{n} - \mathbf{v}'_A \cdot \mathbf{n}}{\mathbf{v}_B \cdot \mathbf{n} - \mathbf{v}_A \cdot \mathbf{n}}. \tag{4}$$

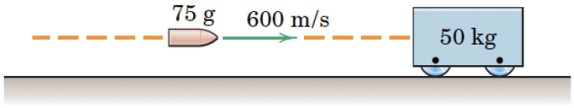
A collision is termed elastic is $e = 1$ and plastic if $e = 0$.

Assuming that the pre-impact velocities and the directions $\mathbf{t}$ and $\mathbf{n}$ are known, we can solve for the four scalar unknowns that are the postimpact velocities using the four scalar equations: (1) projected along $\mathbf{n}$ and (2-4).

These problems are taken from J. L. Meriam, L. G. Kraige, and J. N. Bolton (MKB), Engineering Mechanics: Dynamics, Ninth Edition, Wiley, New York, 2018.

1. [MKB 03-142]

3/142 A 75-g projectile traveling at 600 m/s strikes and becomes embedded in the 50-kg block, which is initially stationary. Compute the energy lost during the impact. Express your answer as an absolute value $|\Delta E|$ and as a percentage n of the original system energy E.



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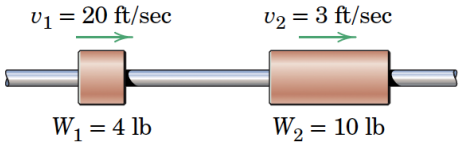
2. [MKB 03-196]

3/196 Compute the final velocities v_1' and v_2' after collision of the two cylinders which slide on the smooth horizontal shaft. The coefficient of restitution is $e = 0.8$.



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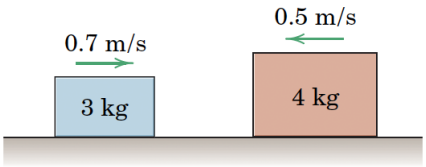
3. [MKB 03-197]

3/197 The two bodies have the masses and initial velocities shown in the figure. The coefficient of restitution for the collision is $e = 0.3$, and friction is negligible. If the time duration of the collision is 0.025 s, determine the average impact force which is exerted on the 3-kg body.



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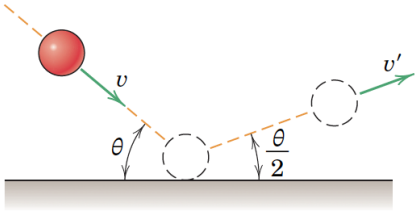
4. [03-201]

3/201 Determine the value of the coefficient of restitution e for which the outgoing angle is one-half of the incoming angle θ as shown. Evaluate your general expression for $\theta = 40°$.



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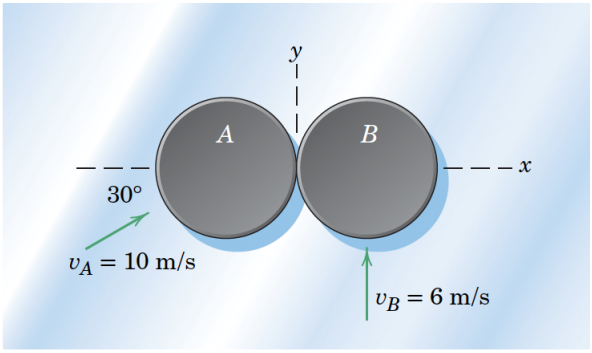
5. [03-212]

3/212 Two identical hockey pucks moving with initial velocities v_A and v_B collide as shown. If the coefficient of restitution is $e = 0.75$, determine the velocity (magnitude and direction θ with respect to the positive x-axis) of each puck just after impact. Also calculate the percentage loss n of system kinetic energy.



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