Newton's Cradle – Two Steel Balls

Apparatus

Newton's cradle with only two steel balls

Action

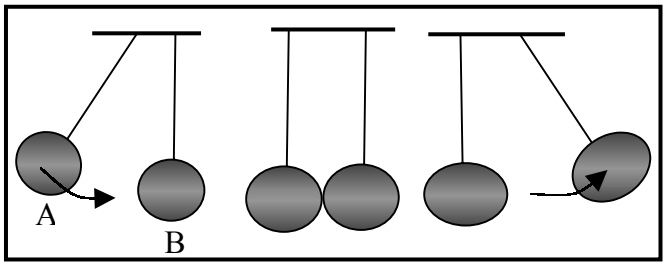
The students swing one of the balls out and observe what happens when it is released and collides with the other ball. They should try to identify the forces acting on the balls and identify an action-reaction force pair. This demonstration is used to demonstrate Newton's third law on the Newton's laws sheets, and conservation of momentum of the Momentum Conservation sheets.

The Physics

When the swung ball collides with the stationary ball is exerts a force on it which accelerates it and causes it to swing outwards. The stationary ball exerts an equal and opposite force on the initially moving ball, which decelerates it, causing it to stop. The action-reaction force pair is the force due to ball A on ball B and the force due to ball B on ball A. Note these forces have opposite directions, equal magnitudes and act on different objects. At all times gravity and tension due to the strings act on the balls, but these are *not* an action-reaction pair.

When the first ball (ball A) swings back and hits the second ball (B) it stops. The second ball swings out. Momentum is conserved, so the change in momentum of ball A must be equal in magnitude and opposite in direction to the change in momentum of ball B. We can write this as $\Delta p_A = - \Delta p_B$.

We also know that $\vec{\mathbf{F}} = \frac{d\vec{p}}{dt}$, which is Newton's second law. Since the momentum changes of the two balls are equal in magnitude and opposite in sign, the forces acting on them must also be equal in magnitude and opposite in sign. This is equivalent to Newton's third law which states that the force exerted by ball A on ball B must be equal and opposite to the force exerted by ball B on ball A, $F_{AB} = - F_{AB}$.



Accompanying sheet

Newton's Cradle – Two Steel Balls

Swing one of the balls out and release it.

What happens?
Is there an action-reaction pair here?
If so, what is it?