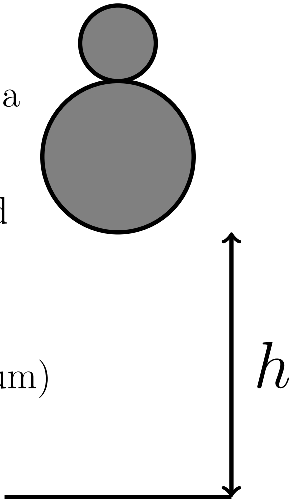
Studio 8: Combining Physics Concepts



Warm-Up Activity

- A tennis ball and a basketball are dropped from a height h as shown.
- Our system is the tennis ball, the basketball, and the Earth.

Energy/Momentum is …
(answer twice; once for energy and once for momentum)

(A) … conserved, because energy/momentum is always conserved.

(B) … conserved, because the net force on the system is zero.

(C) … conserved, because the work done on the system is zero.

(D) … not conserved, because energy is never conserved.

(E) … not conserved, because the net force on the system is not zero.

(F) … not conserved, because the work done on the system is not zero.

A Deeper Model for Interactions

- Quantities
  - Energy E
  - Work $W = \int_{r_i}^{r_f} \vec{F} \cdot d\vec{r}$
  - Kinetic Energy $K = \frac{1}{2}mv^2$
  - Potential Energy $U =$ depends on interaction

    You have to tell everyone where zero PE is!
    * Gravity $U_g = mgy$
    * Spring $U_{sp} = \frac{1}{2}kx^2$
  - Momentum $\vec{p} = m\vec{v}$
  - Impulse $\vec{J}_{net} = \int_{t_i}^{t_f} \vec{F}^{net} dt$
- Laws
  - Work-energy theorem $W_{\text{net,ext}} = \Delta E_{\text{total}}$
  - Impulse-momentum theorem $\vec{J}_{net} = \Delta\vec{p}$

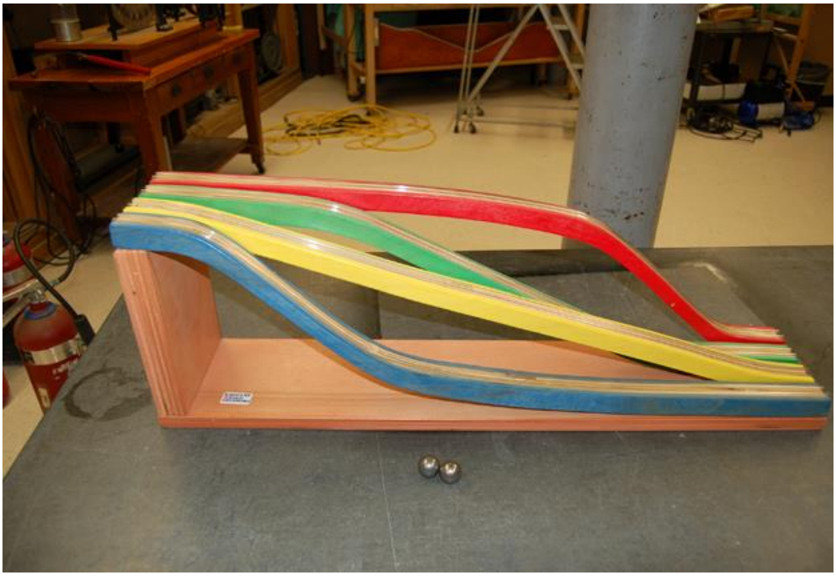
S8-1: Ball Drop – Height

- A tennis ball and a basketball are dropped from a height h as shown.
- Our system is the tennis ball, the basketball, and the Earth.
- If the basketball does not bounce at all, how high does the tennis ball go?
  - Basketball Mass: $M = 0.6$ kg
  - Basketball Radius: $R \approx 11.5$ cm
  - Tennis Ball Mass: $m = 0.04$ kg
  - Drop Height: $h = 0.5$ m

S8-2: Ball Drop – Force

- A tennis ball and a basketball are dropped from a height h as shown.
- During the collision with the ground, which takes 0.2 s, you may want to choose a different system.
  - What is the speed of each ball right before the basketball hits the ground?
  - What is the speed of the tennis ball right after it leaves the basketball?
  - What force did the ground exert on the basketball?

S8-3: Frictionless Track

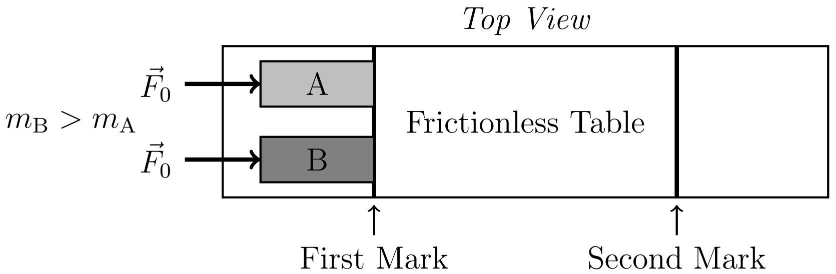


Use the understanding you have built about the energy for a ball moving along a frictionless track to predict **which ball will reach the end of the track first.**

- Explain your reasoning.
- Each ball starts at rest at the top of the track, and the tracks are nearly the same length.

S8-4: Carts on a Track

- Two carts, A and B, are initially at rest on a level, frictionless table. A constant force of magnitude F_0 is exerted on each cart as it travels between two marks. Cart B has a greater masss than cart A.



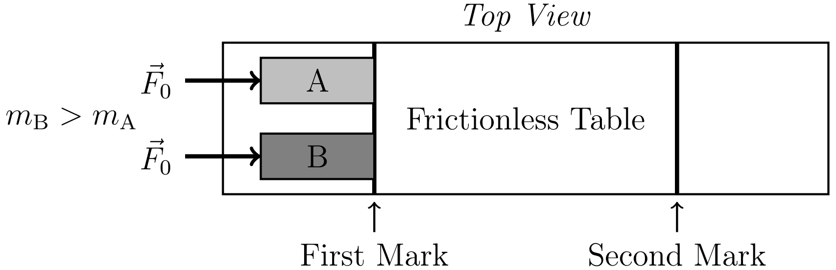
- Three students discuss the final momentum and kinetic energy of each cart.

  (1) *"Since the same force is exerted on both carts, the cart with the smaller mass will move quickly, while the cart with the larger mass will move slowly. The momentum of each cart is equal to its mass times its velocity."*

  (2) *"This must mean that the speed compensates for the mass and the two carts have equal final momenta."*

  (3) *"I was thinking about the kinetic energies. Since the velocity is squared to get the kinetic energy, but mass isn't, the cart with the bigger speed must have more kinetic energy."*

- Do you agree or disagree with the statements made by each student?
- Which cart takes longer to travel between the two marks? Explain your reasoning.
- Determine if the magnitude of the final momentum of cart A is *greater than*, *less than*, or *equal to* that of cart B.
- Determine if the final kinetic energy of cart A is *greater than*, *less than*, or *equal to* that of cart B.
- Reflect on your initial thoughts about the three students above.



Main Ideas

- The work-energy and impulse-momentum theorems can be used to solve a broad array of problems.