Clec7

Batman fires his hand rockets, which produce an upward force on Batman that increases with time. If Newton's 2nd law gives:

$$\frac{dv}{dt} = (8\ m/s^5) \cdot t^3$$

We can say that Batman's velocity as a function of time is

A) $(32\ m/s^5)\ t^3$
B) $(24\ m/s^5)\ t^2$
C) $(8\ m/s^5)\ t^4$
D) $(2\ m/s^5)\ t^4$
E) Cannot be determined

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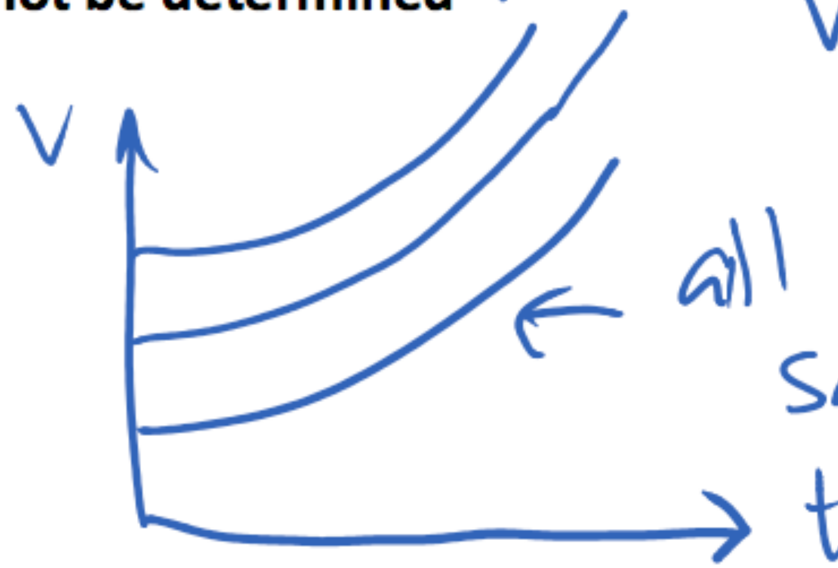
Need to know velocity at $t=0$



all these have same time derivative

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and Batman is initially at rest, we can say that Batman's velocity as a function of time is

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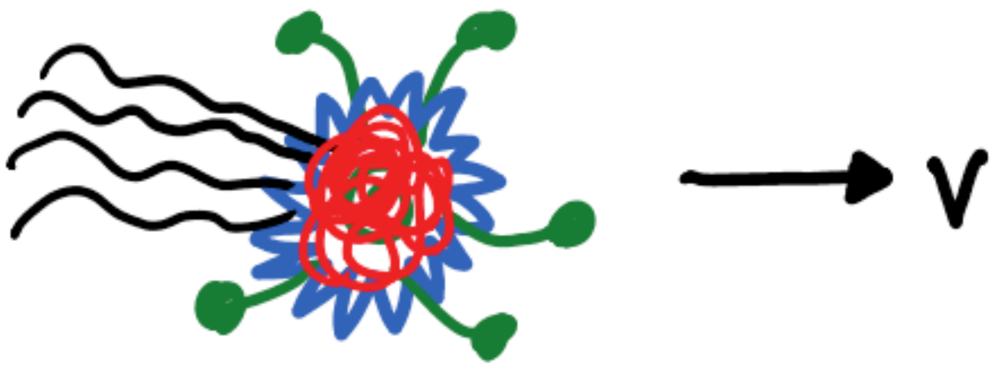
check:
* derivative of this is
$2\ m/s^5 \cdot (4t^3)$
$= 8\ m/s^5 \cdot t^3$

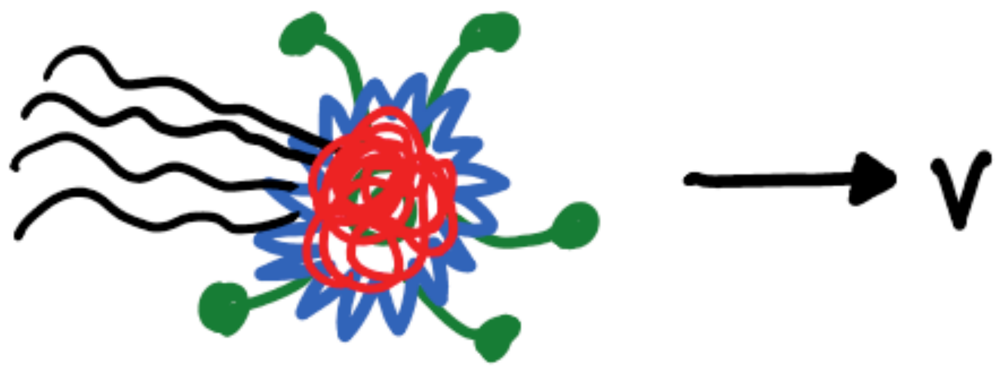
* velocity at $t=0$ is $v=0$.

Worksheet 3b)



An object travels with velocity $v = t^2 \times 3\ m/s^3$.
How far does it travel between t=1s and t=2s?

A) 12m
B) 11m
C) 9m
D) 7m
E) None of the above



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How far does it travel between t=1s and t=2s?

A) 12m

B) 11m

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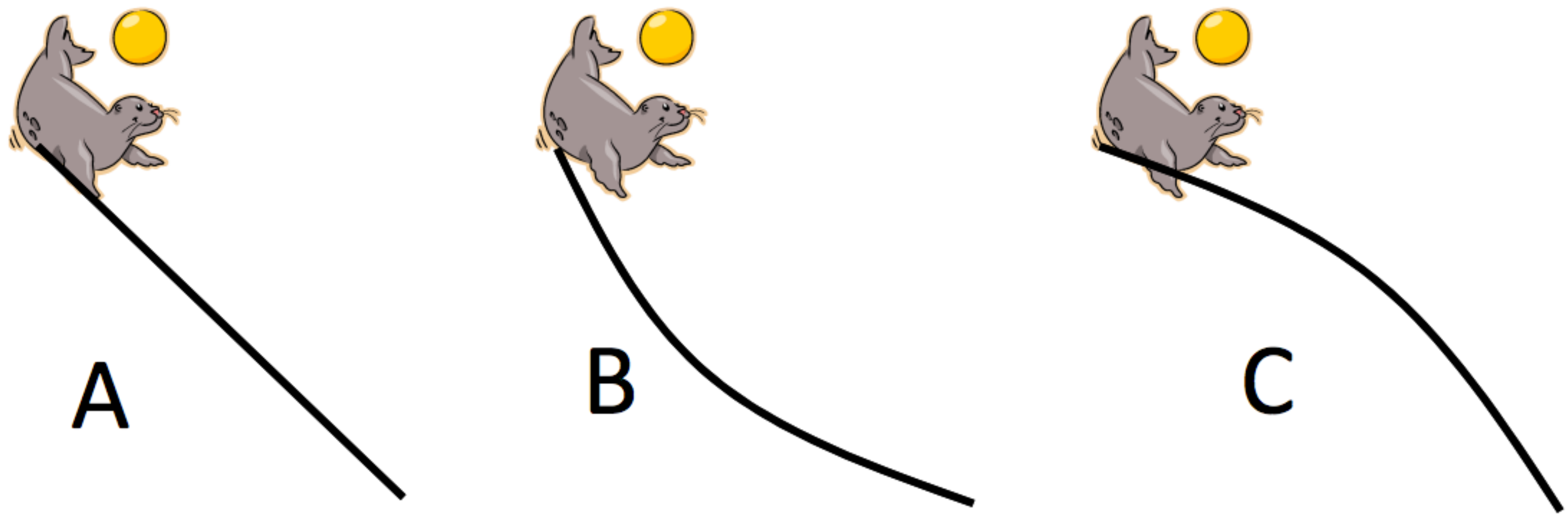
D) 7m

E) None of the above

We are given that $dx/dt = t^2 \times 3\ m/s^3$, so the change in x between t=1s and t=2s (distance travelled) is the integral (area under graph) of $t^2 \times 3\ m/s^3$ between 1s and 2s. One function whose derivative is $t^2 \times 3\ m/s^3$ is $t^3 \times 1\ m/s^3$ so the answer to the integral is the difference $(2s)^3 \times 1\ m/s^3 - (1s)^3 \times 1\ m/s^3$, which gives 7m.

Energy



For which of the three slides is Flipper's speed at the bottom largest (assuming no friction)?

A) A

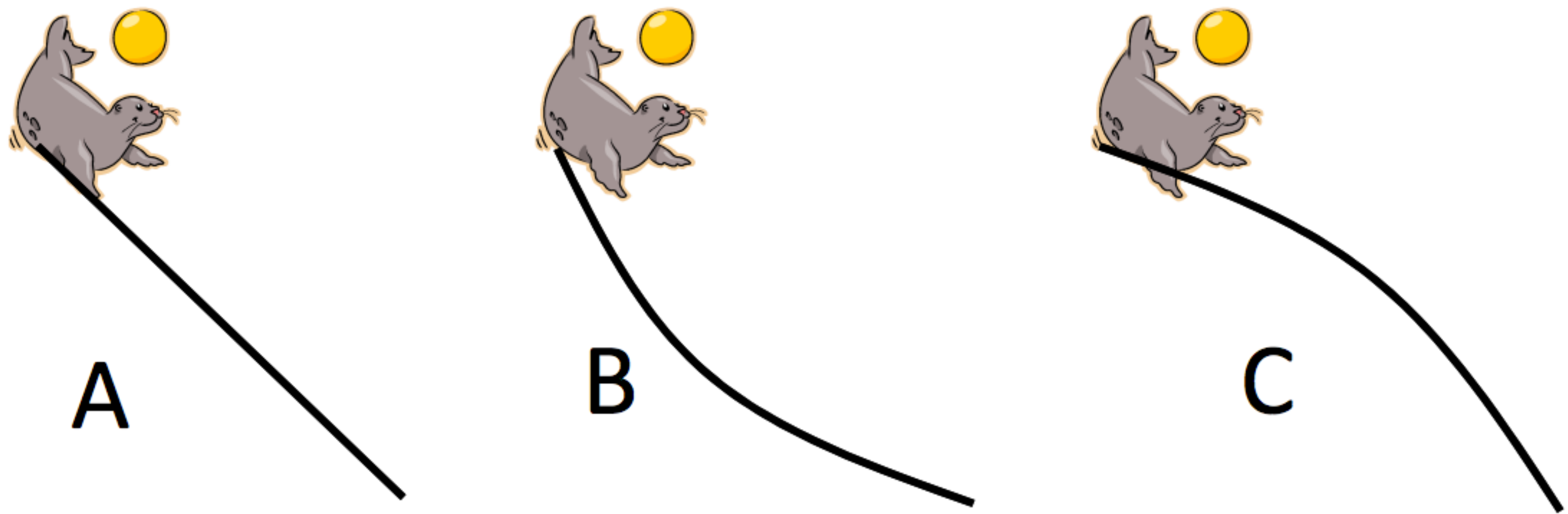
B) B

C) C

D) same for all

E) It depends on the proportion of energy-rich prey species in Flipper's diet, which may in turn depend on natural or human-influenced variations in Flipper's ecosystem.

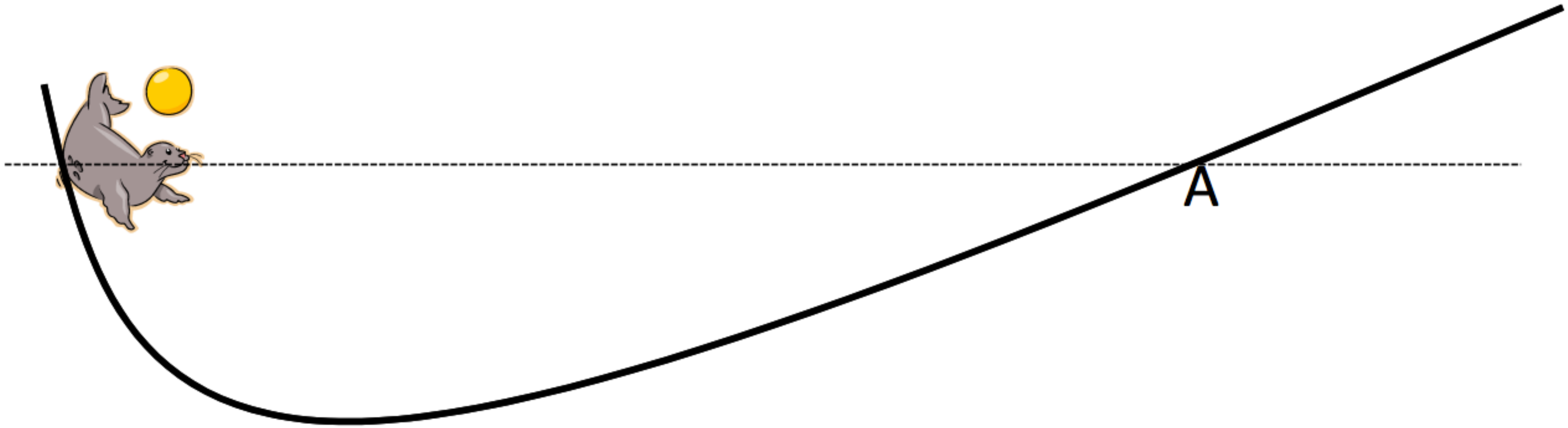
Extra: for which shape of slide does it take the least time to reach the bottom?



For which of the three slides is Flipper's speed at the bottom largest (assuming no friction)?

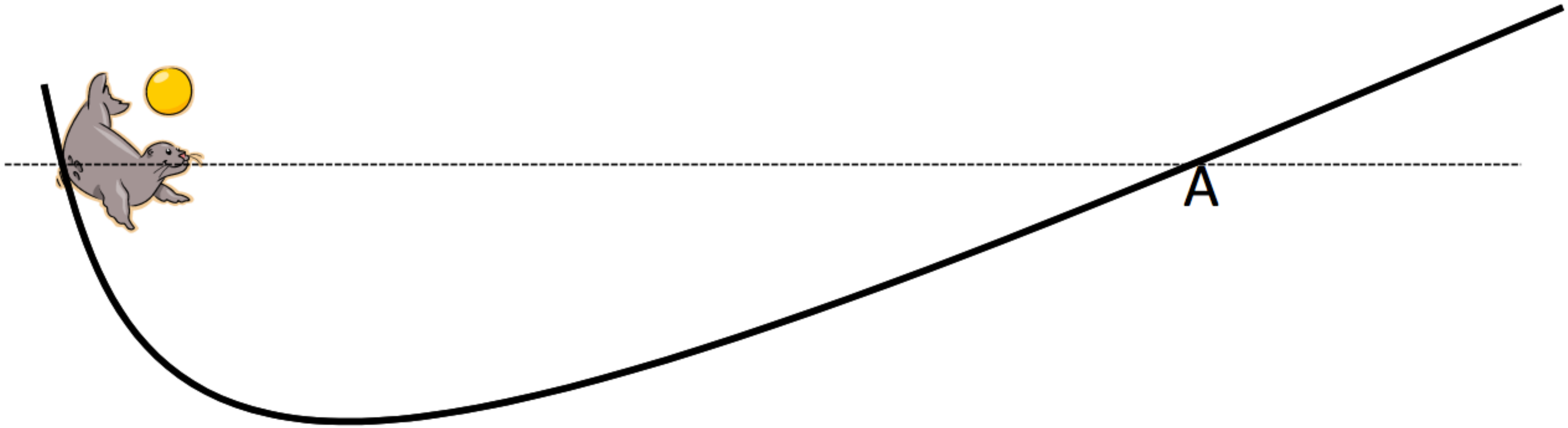
A) A B) B C) C D) same for all

Mechanical energy (kinetic plus potential energy) is conserved since there is no friction (we also ignore air drag). Potential energy decreases by the same amount in each case, since the change in height is the same. Therefore, kinetic energy must increase by the same amount in each case. The speed must be the same in all cases. (The time to reach the bottom is NOT the same for all).



Flipper catches her ball as she slides down the steep part of the ramp. As she slides up the other part, she will stop:

A) at point A
B) past point A
C) before point A
D) can't be determined



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Simple answer: if we assume that mechanical is conserved, the potential energy of the initial configuration is higher than the potential energy of the seal and ball together at A, so they must have some kinetic energy remaining at this point.

In reality, the ball being caught by the seal is an inelastic collision, but one that increases the speed of the seal going down the ramp (since the ball must be moving faster than the seal. This extra kinetic energy results in the seal reaching a higher point than A.

Energy

Emmy Noether says:

For any system with no time-dependent external influences (e.g. an isolated system, or a system in an unchanging field), there is a quantity called ENERGY associated with the system that is unchanging in time.

What's conserved?

1. Flipper floating through empty space?
2. Flipper in a gravitational field?
3. Flipper sliding on table with friction?

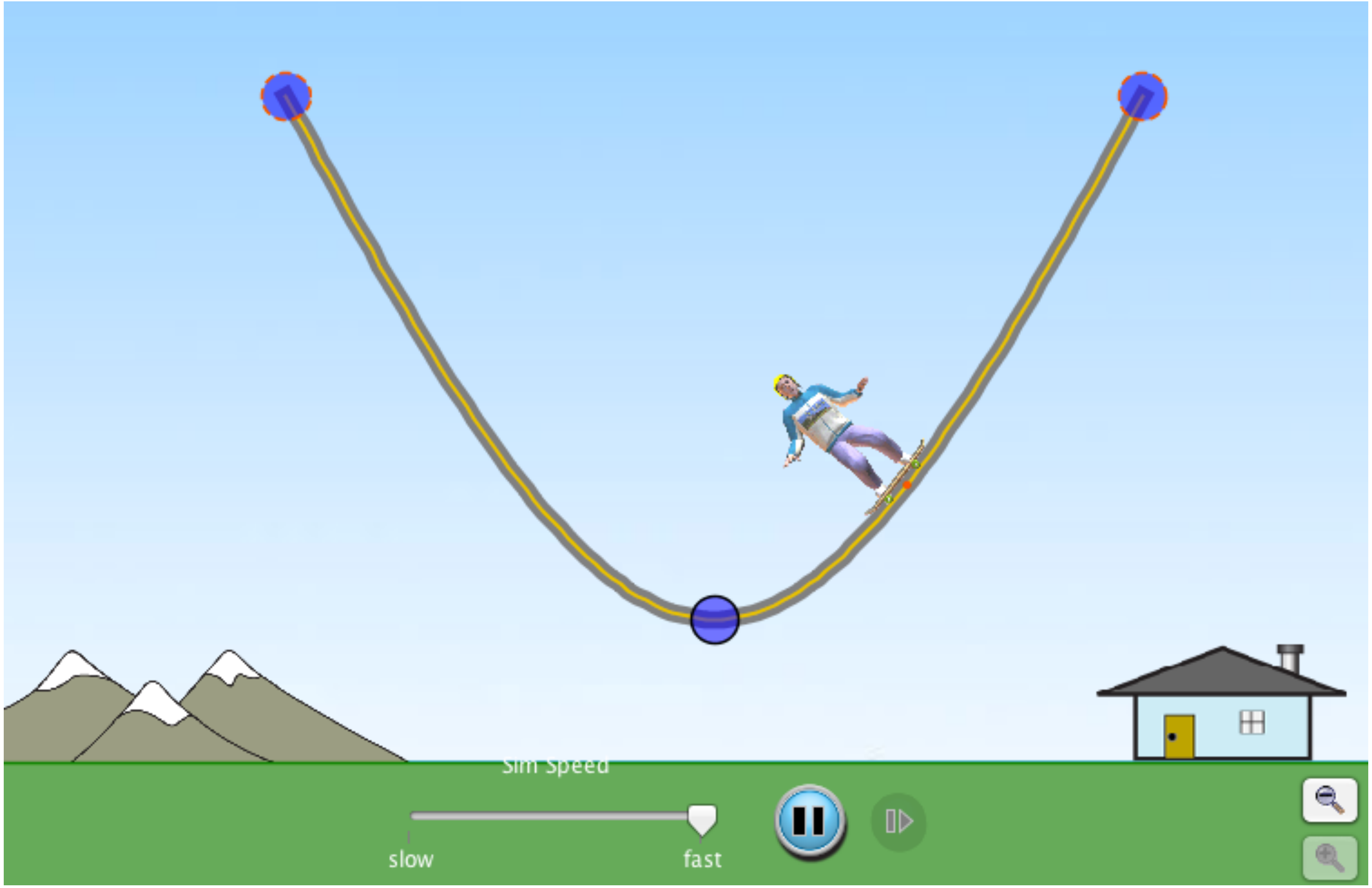
What's conserved?

1. Flipper floating through empty space? **KE**
2. Flipper in a gravitational field? **KE + U**
3. Flipper sliding on table with friction? **KE + U + $E_{thermal}$**

We can almost always enlarge what we consider the system, and determine the conserved energy for that system.

Total Energy Before = Total Energy After

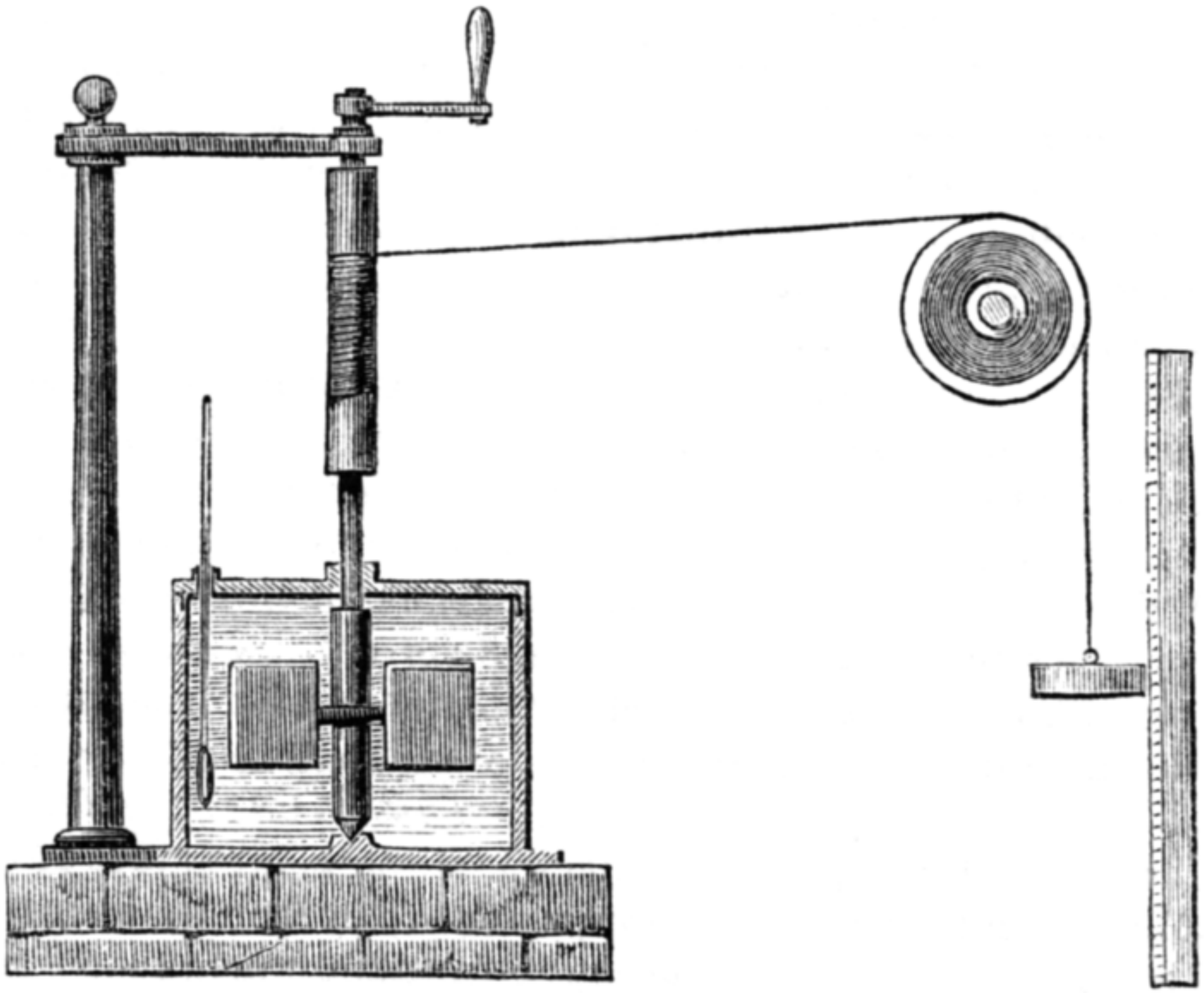
Energy Skate Park

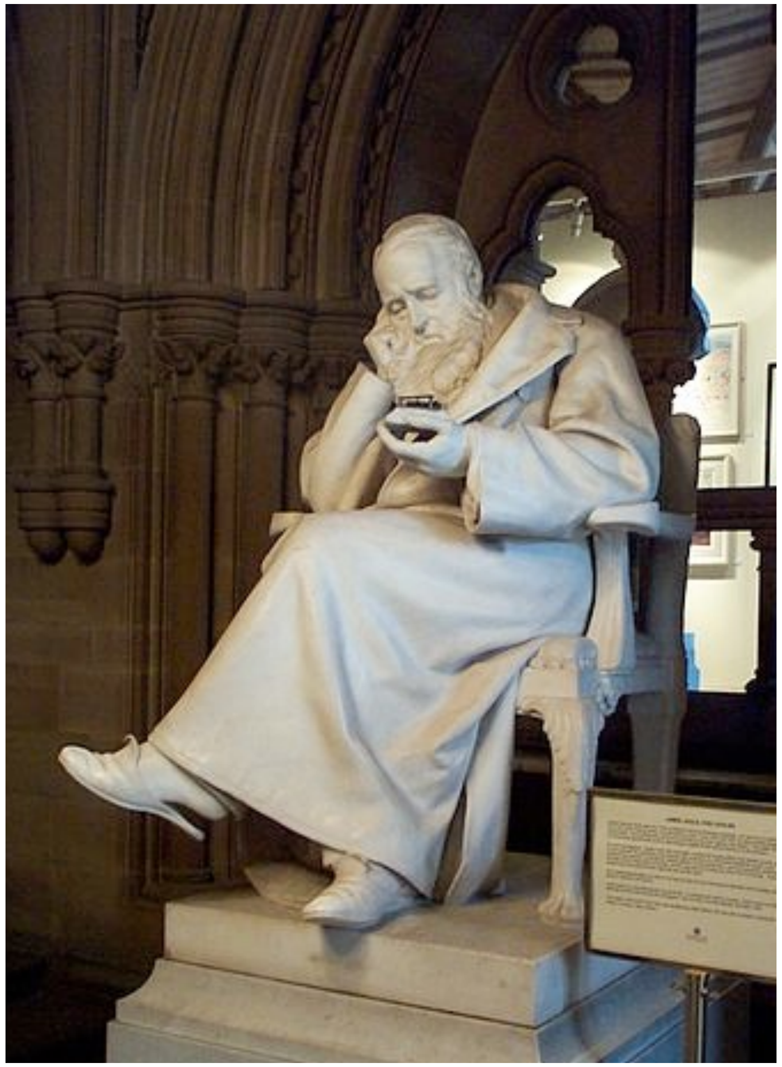


Energy Skate Park PhET

Mechanical Energy to Heat

When Flipper slides along the table, where does the energy go?
This was an important question in the 19th century.





James Prescott Joule (1845)

Relative to the first configuration, the second configuration has:

A) Lower potential energy
B) Higher potential energy
C) The same potential energy
D) Cannot be determined unless we know the velocities of the particles

Come up with a convincing argument based on conservation of energy.

Relative to the first configuration, the second configuration has:

A) Lower potential energy
B) Higher potential energy
C) The same potential energy
D) Cannot be determined unless we know the velocities of the particles

Assuming that none of the particles are moving initially, the configuration on the left will lead to a greater kinetic energy when the particles collide than the one on the right, so it must have higher potential energy.

Alternatively, we would have to add energy to the configuration on the right to get to the configuration on the left (it takes some effort to pull the charges apart), so the configuration on the left must have higher potential energy.