October 24, 2014 LB273 Prof. Vashti Sawtelle

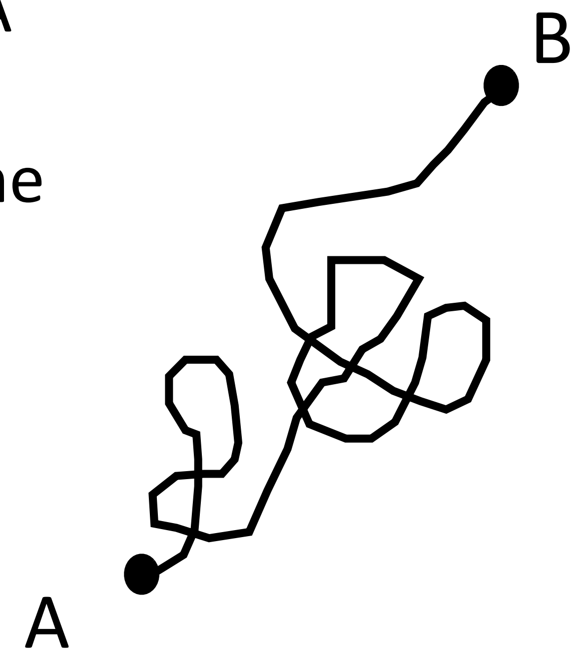
Today's Topics: Energy

Comic: Baldo, *Carlos Castellanos*

Announcements

- Homework Ch 9 &10 due tonight midnight
- Exam 2 on Monday
- Exam correction problem due on Wednesday beginning of class
- Reading Questions for Ch11 due on Tues
- Adjustments of later chapter dates – see course calendar for most up-to-date information

Consider an object moved from point A to point B, as shown. Gravity points down and exerts a constant force on the object. Which of the following statements is true regarding the work done **by gravity**?



A. The x component of the work is always zero, but the y component of the work may not be zero.
B. Gravity must do non-zero work when A and B are not coincident (meaning, not at the same point in space)
C. All that matters when calculating work is the net displacement in the y direction
D. None of the above is true **or** more than one of the above is true

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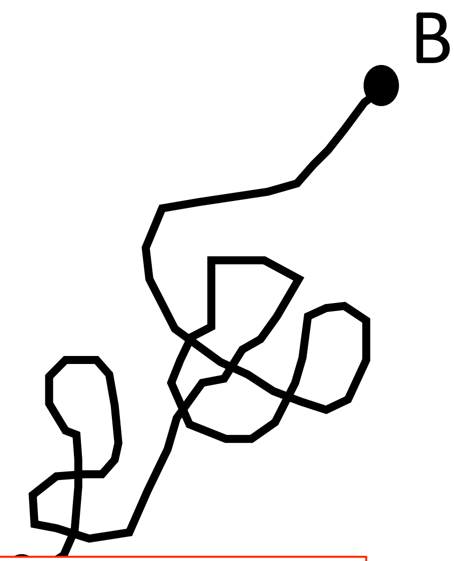


Work is not a vector, so all that matters when calculating work is that the force and the displacement are in the same direction. Since gravity always points in the y direction, the work done is only determined by the y-direction net displacement.

A. The x component of the wo
component of the work ma

B. Gravity must do non-zero v
coincident (meaning, not at the same point in space)

C. All that matters when calculating work is the net displacement in the y direction

D. None of the above is true **or** more than one of the above is true

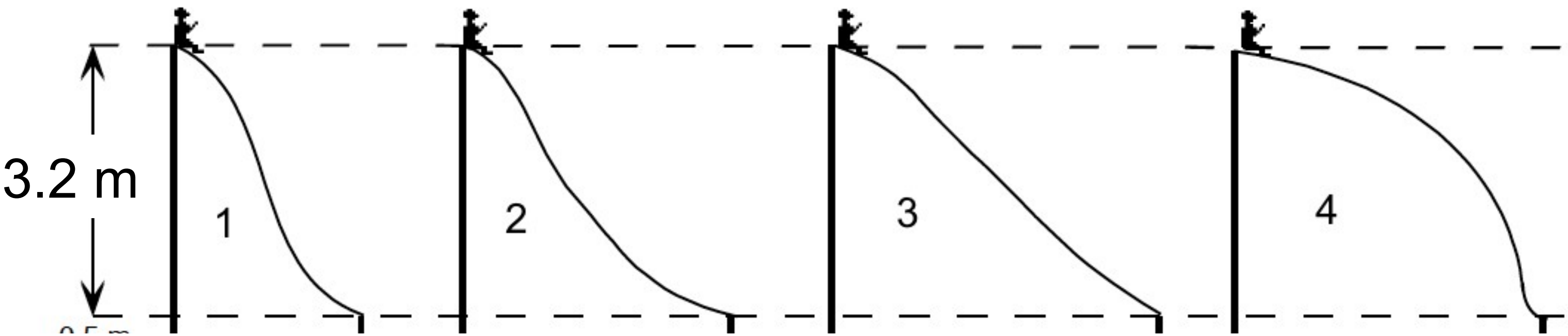
Foothold ideas: Potential Energy

- For some forces between objects (gravity, electricity, springs) the work only depends of the change in relative position of the objects. Such forces are called *conservative*.
- For these forces the work done by them can be written

$$\vec{F} \cdot \Delta\vec{r}_{rel} = -\Delta U$$

- *U* is called a *potential energy* and can be considered an *energy of place belonging to the two objects that can be exchanged with KE.*

A young child wants to select one of the (frictionless) playground slides illustrated below to give her the greatest possible speed when she reaches the bottom of the slide. Which should she choose?



A. 1
B. 2
C. 3
D. 4
E. It doesn't matter. It would be the same for each.

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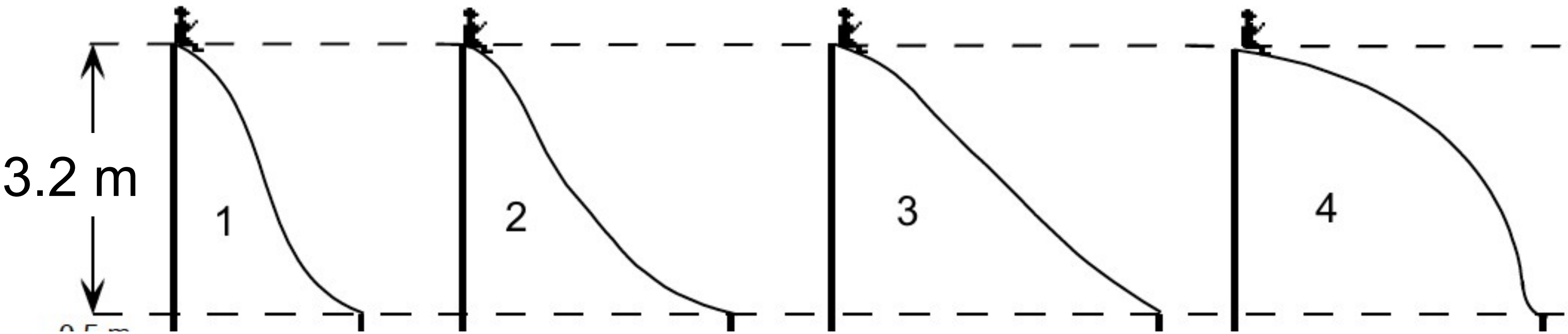
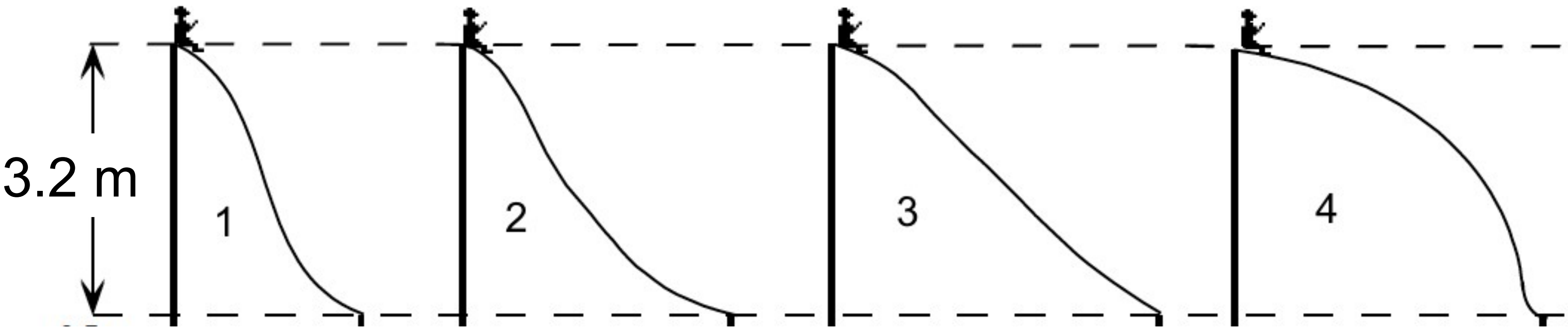


Since energy is conserved, all of the energy she has at the top of the slide will go to kinetic energy at the bottom of the slide (which will determine speed). Since all the slides are the same height the child as the same energy at the top of every slide.

E. It doesn't matter. It would be the same for each.

If the child starts from rest at the top of the slide, calculate her speed at the bottom of the slide



A. 16 m/s
B. 32 m/s
C. 8 m/s
D. 4 m/s
E. We don’t have enough information to answer.

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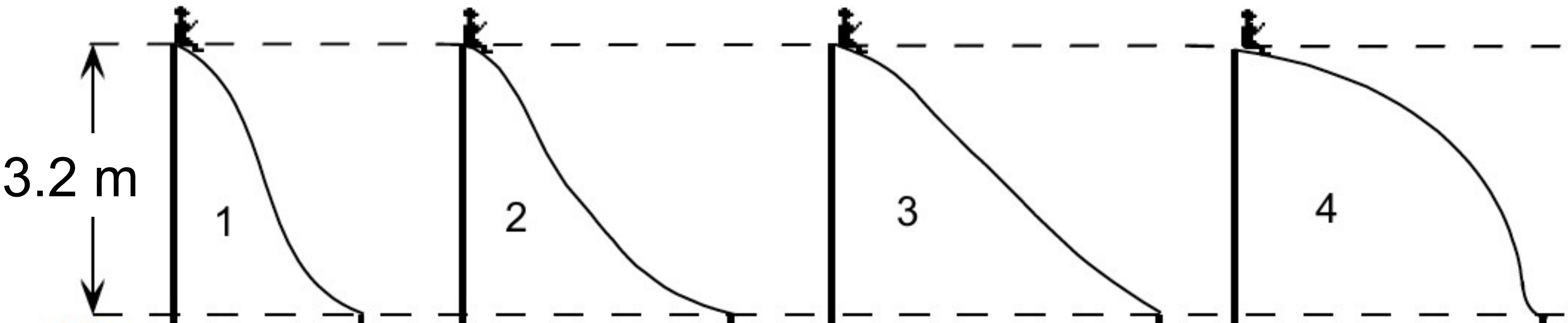
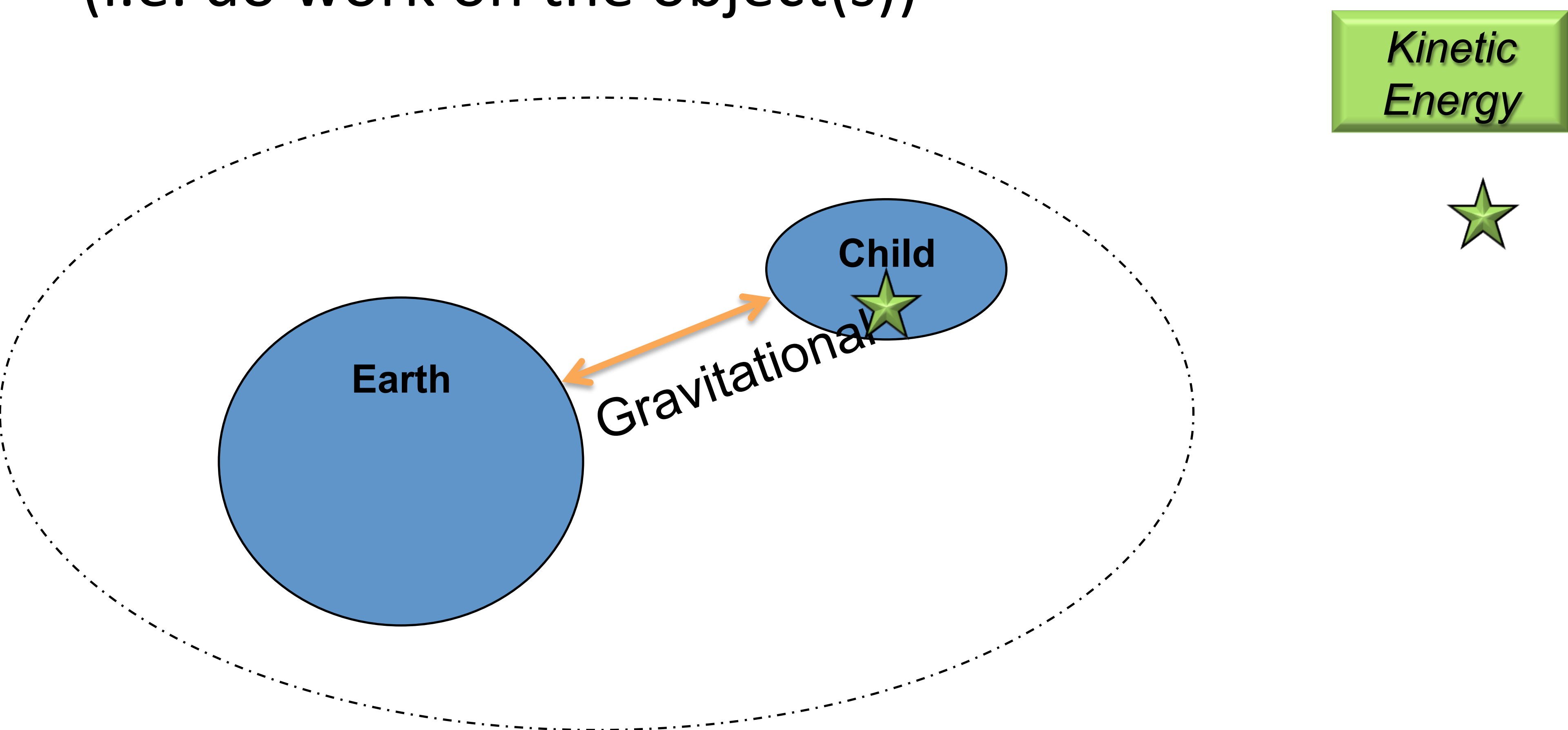


A. 16 m/s
B. 32 m/s
C. 8 m/s
D. 4 m/s

$E_i = E_f$
The initial energy is all gravitational potential and the final energy is all kinetic energy.
$mgh = \frac{1}{2} mv^2$
So the mass cancels out and solving for v I get that v=8 m/s

Energy Conservation for SYSTEM

Total energy of system is conserved unless external forces move object(s) within the system (i.e. do work on the object(s))



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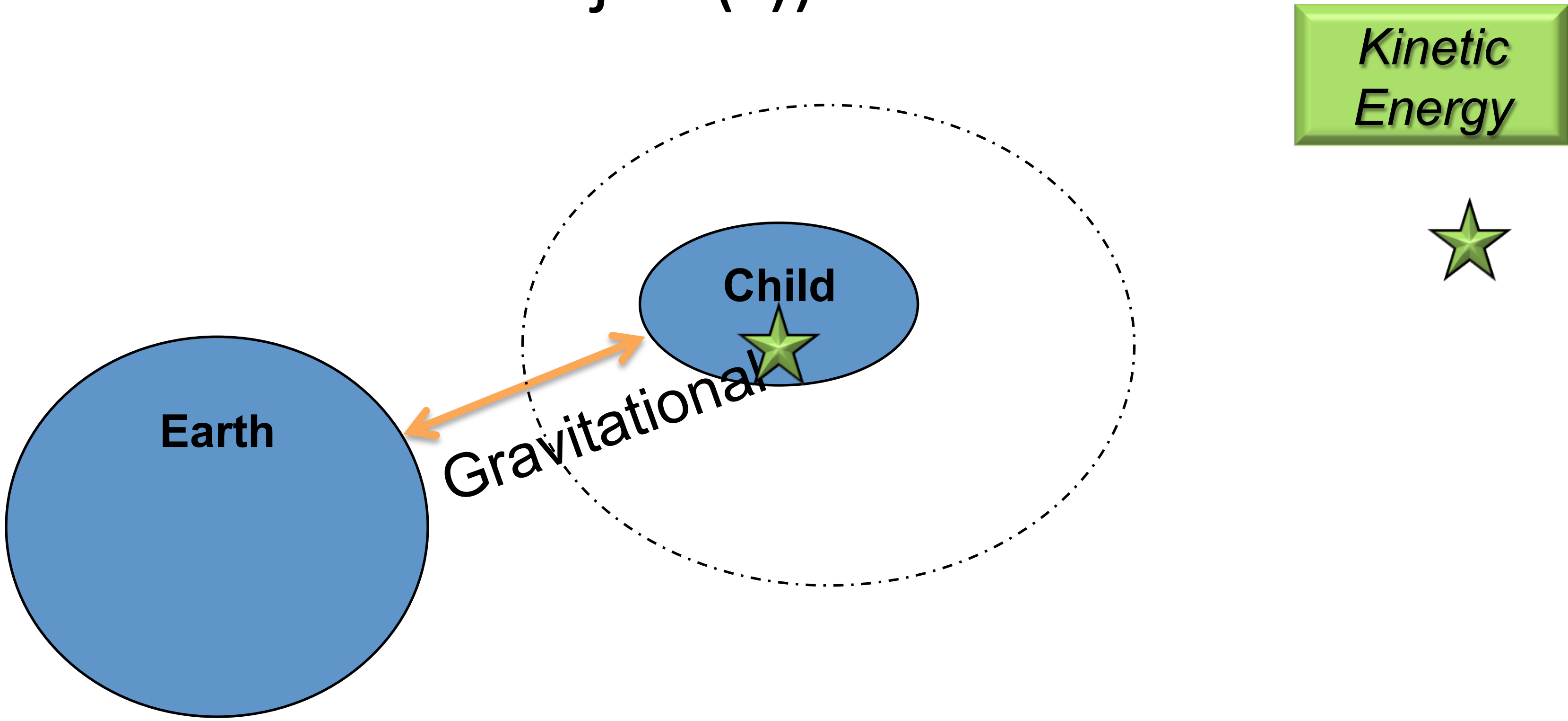
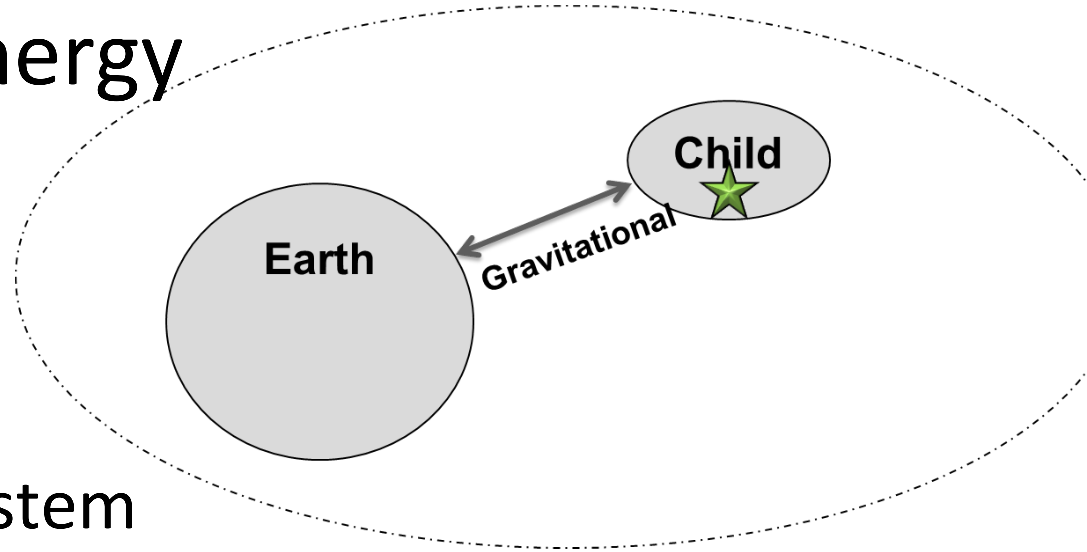


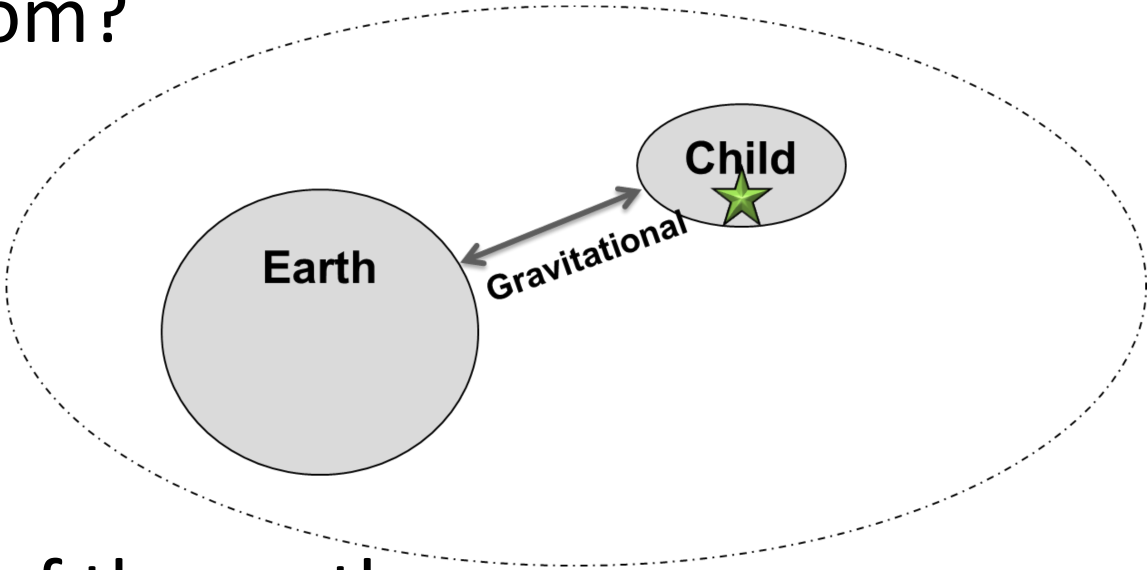
Foothold Principle: Potential Energy



Potential energy:

- Internal energy of a System
- Related to interactions (forces) within the System
- Can turn into kinetic energy (or other energy) when the objects in the system move

Where does kinetic energy of the child come from?



A. Potential energy of the earth
B. Potential energy of the child
C. Another source
D. Potential energy between the earth & child
E. Something else

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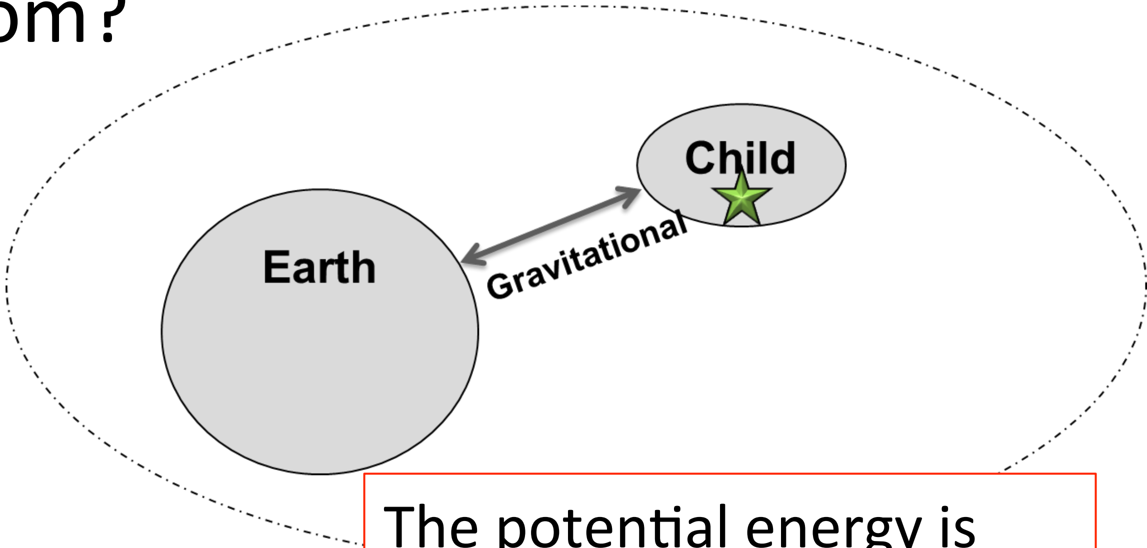


The potential energy is defined as the energy stored in the interaction between two objects.

A. Potential energy of the eart
B. Potential energy of the child
C. Another source
D. Potential energy between the earth & child
E. Something else

Foothold ideas: Potential Energy

- For some forces work only depends on the change in position. Then the work done can be written $\vec{F} \cdot \Delta\vec{r} = -\Delta U$

  U is called a *potential energy*.

- For gravity, $U_{gravity} = mgh$

  For a spring, $U_{spring} = \frac{1}{2} kx^2$

Foothold ideas: Conservation of Mechanical Energy

- Mechanical energy
  - The mechanical energy of a system of objects is conserved if resistive forces can be ignored.

$$\Delta\left(KE + PE\right) = 0$$

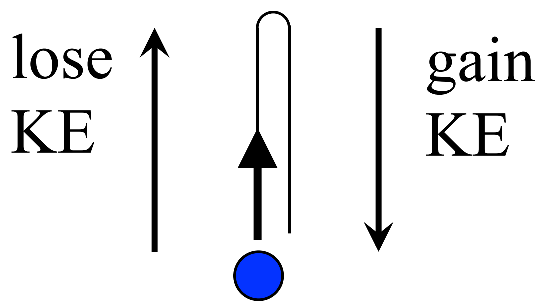
$$KE_{initial} + PE_{initial} = KE_{final} + PE_{final}$$

A spring-loaded toy dart gun is used to shoot a dart straight up in the air. The dart reaches a maximum height of 24 m. The same dart is shot straight up a second time from the same gun, but this time the spring is compressed only half as far before firing. How far up does the dart go this time, neglecting friction and air resistance and assuming an ideal spring?

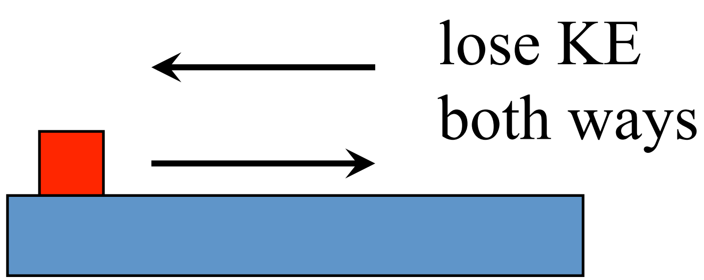
A. 48 m
B. 24 m
C. 12 m
D. 6 m
E. Something else

Conservative forces

- Forces (like gravity or springs) are conservative if when the force takes KE away, you can get it back when you go back to where you started.
- If the kinetic energy that a force takes away can't be restored by going back to where you started it is called non-conservative.
- Compare gravity and friction:



Gravity: Conservative

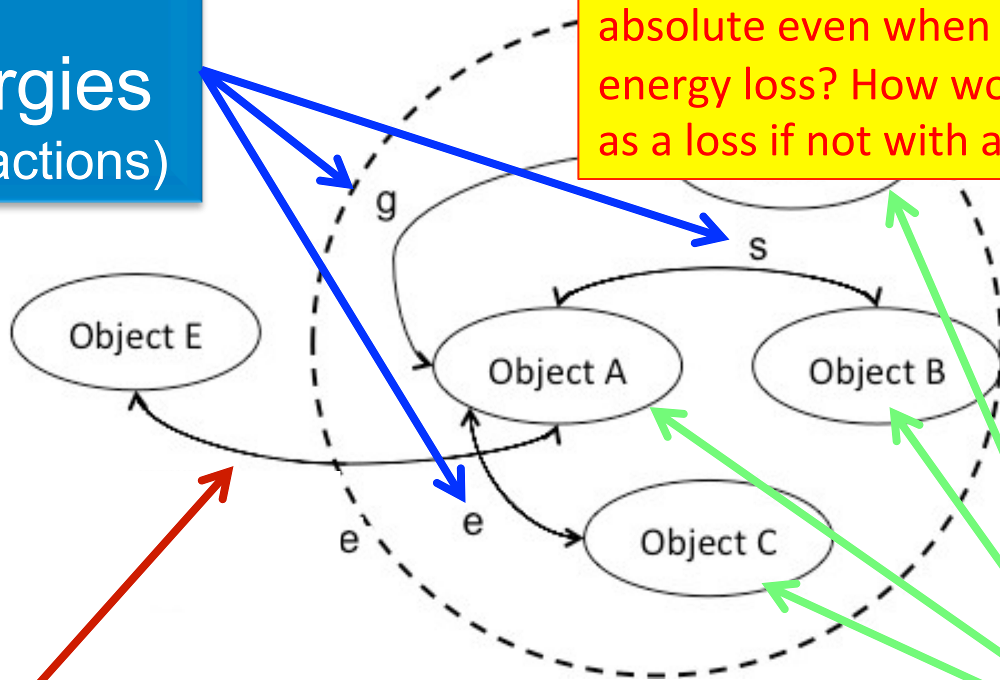


Friction: Non-Conservative

Which Energies add to give Total Mechanical Energy?

YES
Potential Energies
(Conservative Interactions)

Why are changes in energy always absolute even when there is a net energy loss? How would it be expressed as a loss if not with a negative sign?



NO
Work done by Interactions that cross System Boundary

YES
Kinetic Energy
(in general, all objects)

Using Mechanical Energy Conservation

- If resistive forces can be ignored, mechanical energy is conserved
(exchanges with hidden internal energy such as thermal or chemical can be ignored)

$$KE_i + PE_i = KE_f + PE_f$$

- *KE* may refer to one or more objects
PE may refer to one or more interactions.
- If only one object's KE is important and only one interaction matters, this can make things really easy.

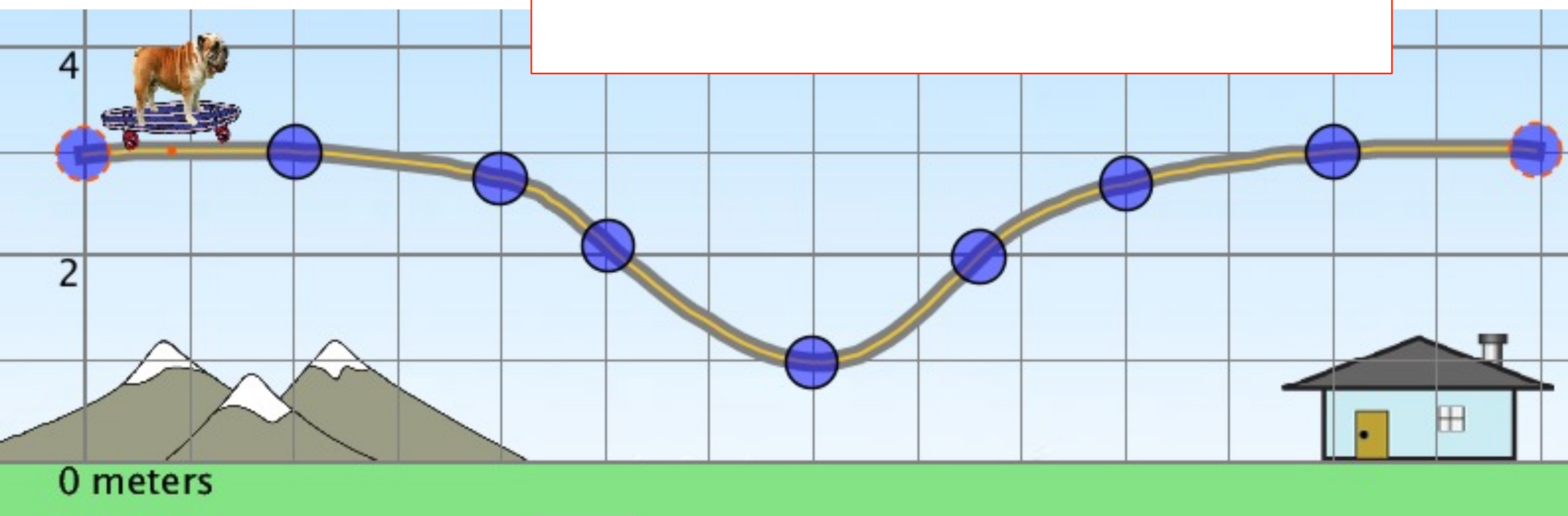
A bulldog on a skateboard is moving very slowly when he encounters a 2 m dip. How fast will be be going when he is at the bottom of the dip? The bulldog and skateboard combined have a mass of 20 kg.

Friction and air drag

A. Very slowly

B. About 2 m/s

These problems all come the PhET simulation:
“Energy Skatepark”
https://phet.colorado.edu/en/simulation/energy-skate-park



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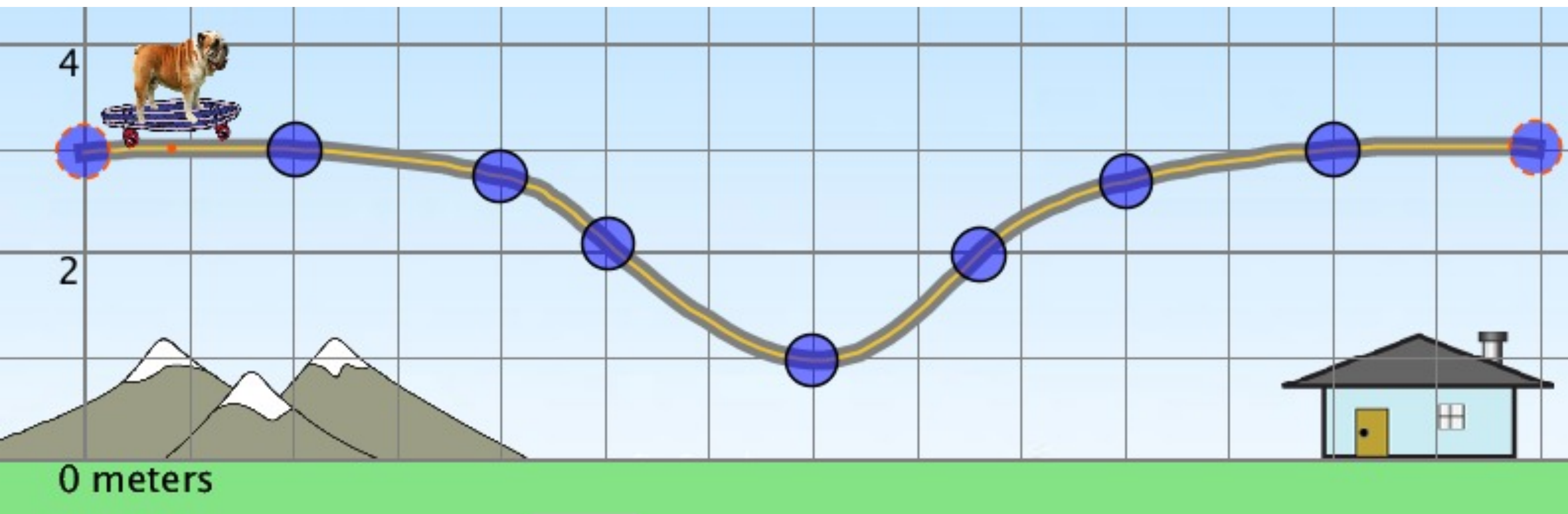
Friction and air drag can be ignored.

A. Very slowly

B. About 2 m/s

C. About 6 m/s

D. You can’t tell from the information given.



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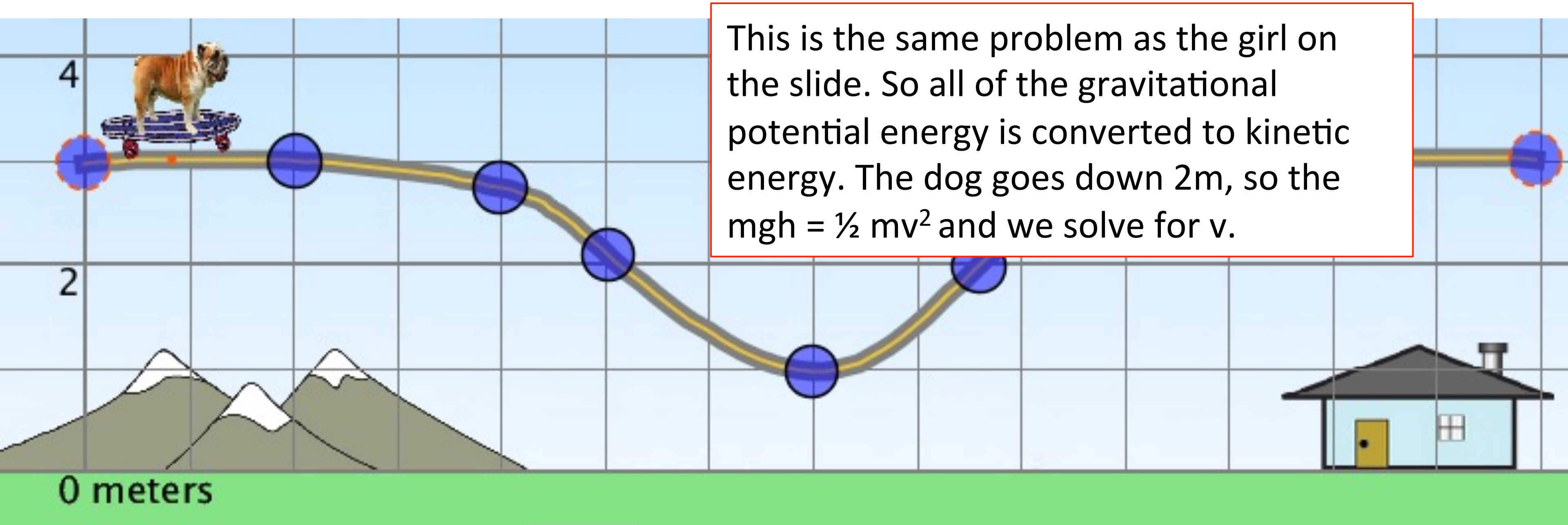
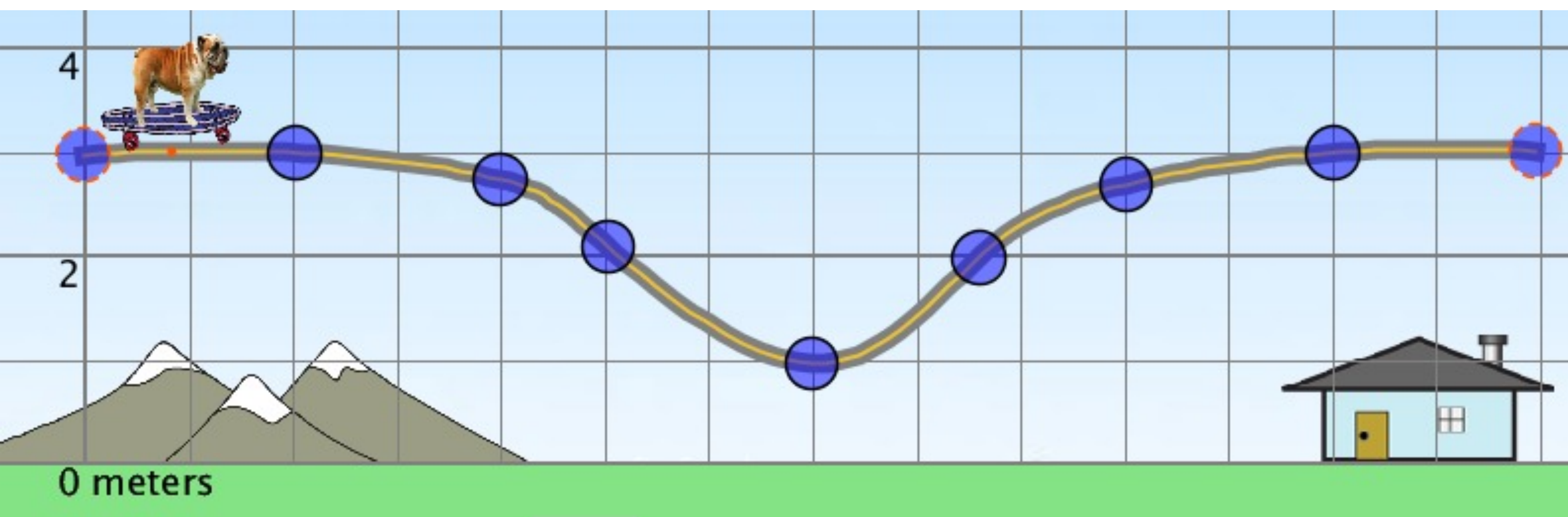


This is the same problem as the girl on the slide. So all of the gravitational potential energy is converted to kinetic energy. The dog goes down 2m, so the $mgh = \frac{1}{2} mv^2$ and we solve for v.

A bulldog on a skateboard is moving very slowly when he encounters a 2 m dip. The bulldog and skateboard combined have a mass of 20 kg. What is their total mechanical energy?

A. Almost zero
B. About 200 Joules
C. About 600 Joules
D. You can't tell from the information given.



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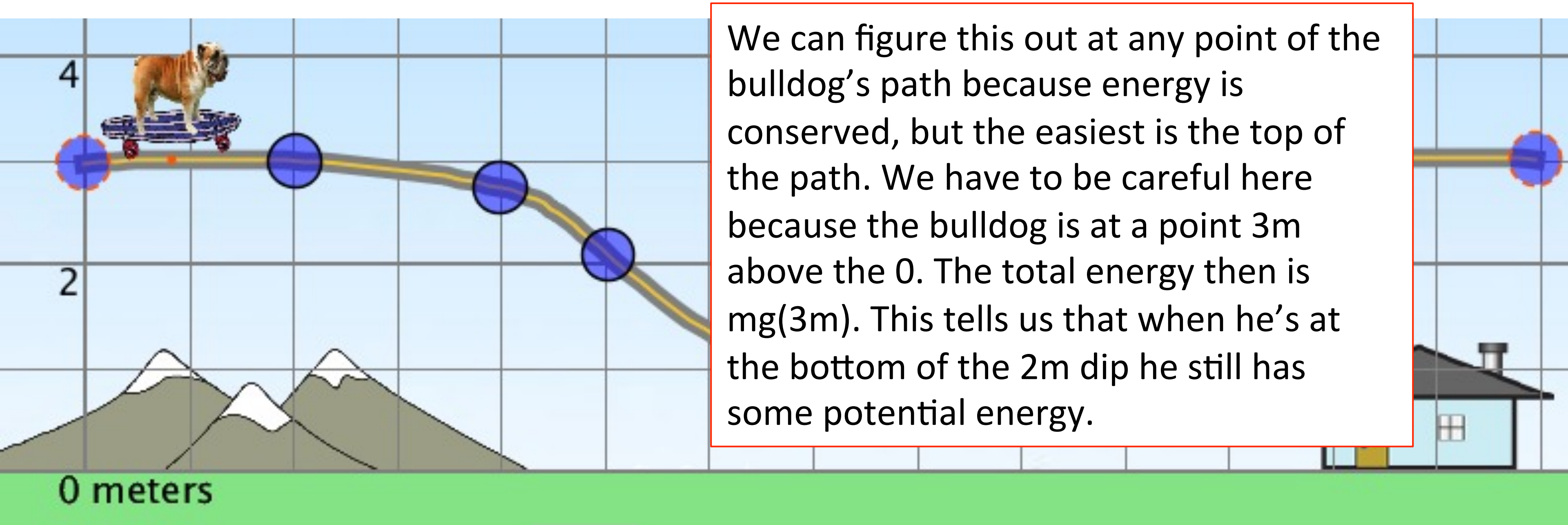

We can figure this out at any point of the bulldog's path because energy is conserved, but the easiest is the top of the path. We have to be careful here because the bulldog is at a point 3m above the 0. The total energy then is mg(3m). This tells us that when he's at the bottom of the 2m dip he still has some potential energy.