Physics 131- Fundamentals of Physics for Biologists I

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Quiz 10 review

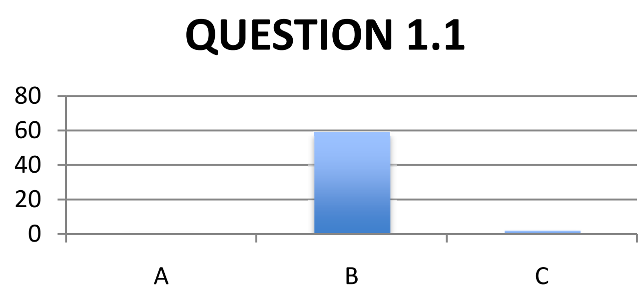
Energy

Quiz 10

1. Two hoses, one of 20-mm diameter, 1 meter in length, the other of 10-mm diameter and also 1 meter in length are connected one behind the other to a faucet.

1.1 (3 pts) At the open end of the hose, the flow of water measures 10 liters per minute. Through which hose does the water flow at higher speed?

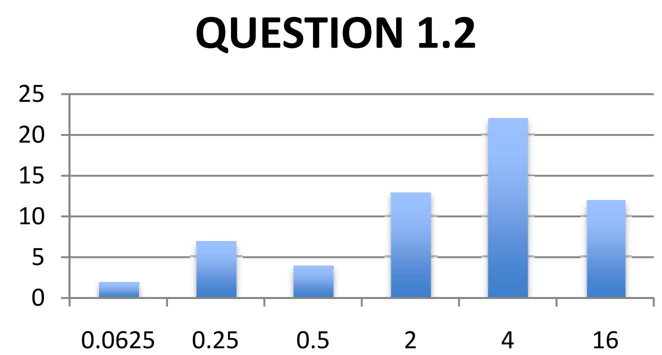
A. The 20-mm hose
B. The 10-mm hose
C. The flow speed is the same in both cases.
D. The answer depends on which of the two hoses comes first in the flow.



Quiz 10

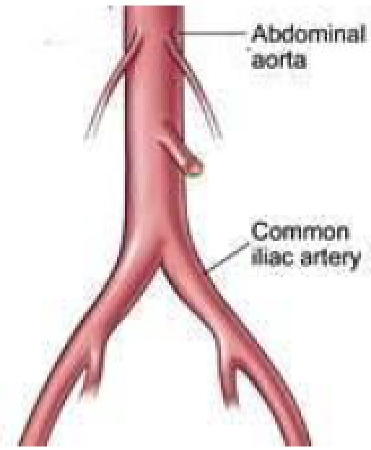
1.2 (3 pts) If the 20 mm hose is connected after (downstream from) the 10 mm hose in the flow, the drop in pressure from the beginning to the end of the 10 mm diameter hose is ____________ times the drop in pressure from the beginning to the end of the 20 mm hose.

16 times

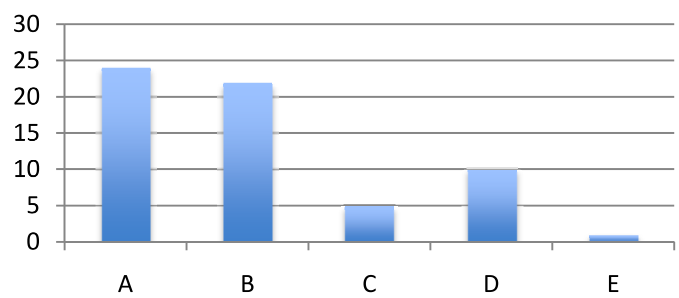


Quiz 10

2. (2 pts) The main blood vessel carrying blood out of your heart is the aorta. It carries blood down towards the legs. In your abdomen it splits into two, the common iliac arteries. The diameter of a typical aorta is 2 cm, while the iliac arteries typically have diameters of about 1 cm. A typical value for the speed of the blood in the aorta is $v_A = 30$ cm/s when the heart is contracting. While this is occurring, the speed of the blood flowing in the iliac arteries will be closest to



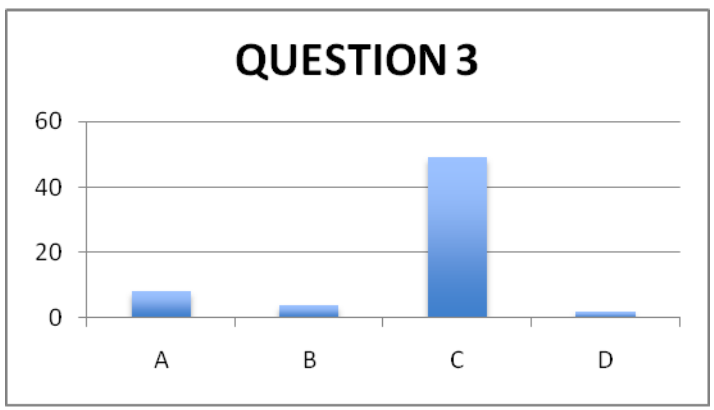
- A. 120 cm/s
- B. 60 cm/s (circled)
- C. 30 cm/s
- D. 15 cm/s
- E. 7.5 cm/s
- F. It's not close to any of these



Quiz 10

3. (2 pts) Consider two identical pails of water filled to the brim. One pail contains only water, the other has a piece of wood floating in it. Which pail has the greater weight?

A. the pail without the wood
B. the pail with the wood
C. they have the same weight
D. there is not enough information to tell



$$\Delta v \frac{\Delta x}{\Delta t} = \frac{F^{net} \Delta x}{m}$$

$$\langle v \rangle \Delta v = \frac{F^{net} \Delta x}{m}$$

$$\frac{v_i + v_f}{2}(v_f - v_i) = \frac{F^{net} \Delta x}{m}$$

$$\tfrac{1}{2}(v_f^2 - v_i^2) = \frac{F^{net} \Delta x}{m}$$

$$\tfrac{1}{2} m(v_f^2 - v_i^2) = F^{net} \Delta x$$

Definitions:

Kinetic energy = $\tfrac{1}{2} mv^2$

Work done by a force F = $F \; \Delta x$

Result

$$\Delta(\tfrac{1}{2} mv^2) = F^{net} \; \Delta x$$

Work Energy Theorem

Dimensions and Units of Energy and Work

- $[1/2\ mv^2] = M\text{-}(L/T)^2 = ML^2/T^2$
- $1\ kg\text{-}m^2/s^2 = 1\ N\text{-}m = 1$ Joule
- Other units of energy are common (and will be discussed later)
  - Calorie
  - eV (electron Volt)

Foothold ideas: Kinetic Energy and Work

- Newton's laws tell us how velocity changes. The Work-Energy theorem tells us how speed (independent of direction) changes.
- Kinetic energy = $\frac{1}{2}mv^2$
- Work done by a force = $F_x \Delta x$ or $F_{\parallel} \Delta r$ (part of force parallel to displacement)
- Work-energy theorem: $\Delta(\frac{1}{2}mv^2) = F_{\parallel}^{net} \Delta r$

Momentum vs. energy

- If we are changing the motion of two interacting objects so the momentum of each change in the same way, it might be useful to look at the KE in terms of that momentum.

$$\vec{p}_A = \Delta\vec{p}_A = -\Delta\vec{p}_B = -\vec{p}_B$$

- Suppose each starts with 0 momentum and they move as a result of each other's forces.

$$KE_A = \tfrac{1}{2} m_A v_A^2 = \tfrac{1}{2}\frac{\left(m_A^2 v_A^2\right)}{m_A} = \frac{p_A^2}{2m_A}$$

$$KE_B = \tfrac{1}{2} m_B v_B^2 = \tfrac{1}{2}\frac{\left(m_B^2 v_B^2\right)}{m_B} = \frac{p_B^2}{2m_B}$$

If each object gets the same momentum, which has bigger KE?

1. The object with the bigger m.
2. The object with the smaller m.
3. The have the same KE.

s. energy

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When you go 80 mph on the beltway rather than 20 mph on campus, when you slam on the breaks as hard as you can, how much further do you skid on the beltway than on campus? (don’t try this at home)

1. same distance
2. 2 times the distance
3. 4 times the distance
4. 8 times the distance
5. 16 times the distance

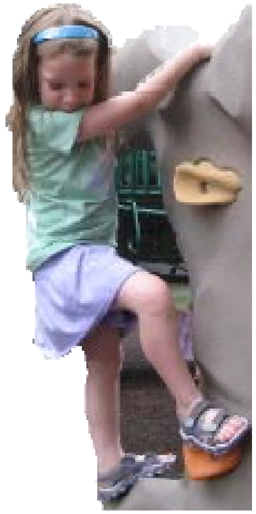
Foothold ideas: Potential Energy

- 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.*

Foothold ideas: Potential Energy



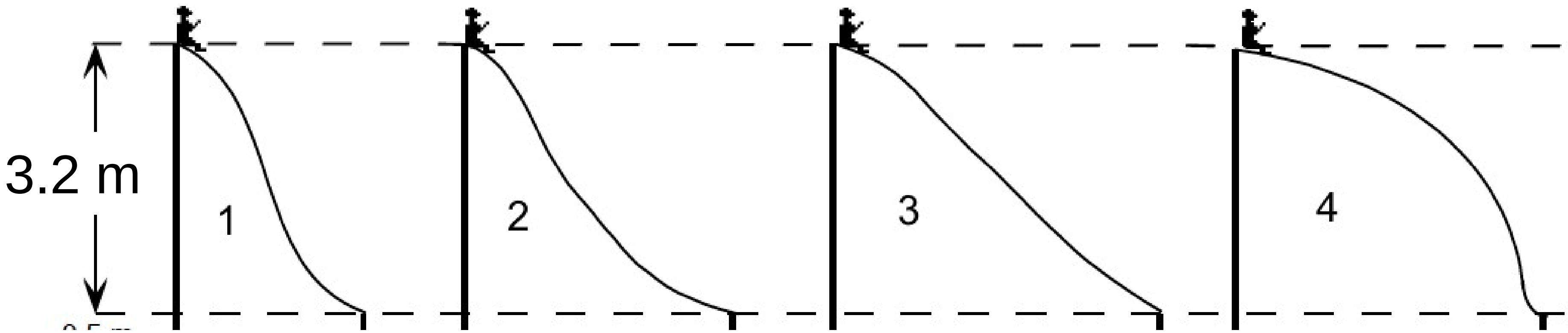
- For some forces work only depends on the change in position. Then the work done can be written
$$\vec{F} \cdot \Delta\vec{r} = -\Delta U$$
U is called a *potential energy*.

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

  For a spring, $U_{spring} = ½\, kx^2$

  For electric force, $U_{electric} = k_C Q_1 Q_2 / r_{12}$

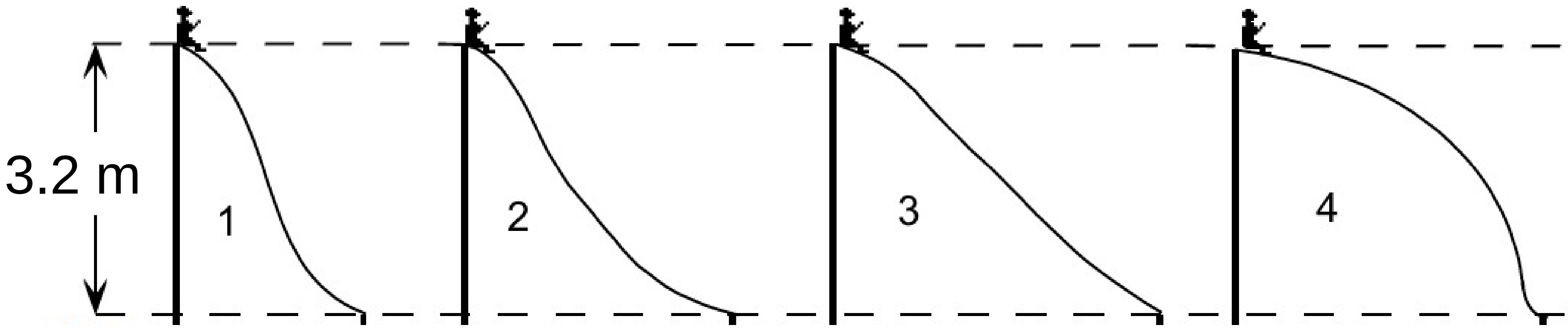
A young girl wants to select one of the (frictionless) playground slides illustrated below to give her the greatest possible speed when she reaches the bottom of the slide. Which should she choose?



1. 1
2. 2
3. 3
4. 4
5. She should jump straight down
6. It doesn't matter. It would be the same for each.

Whiteboard, TA & LA

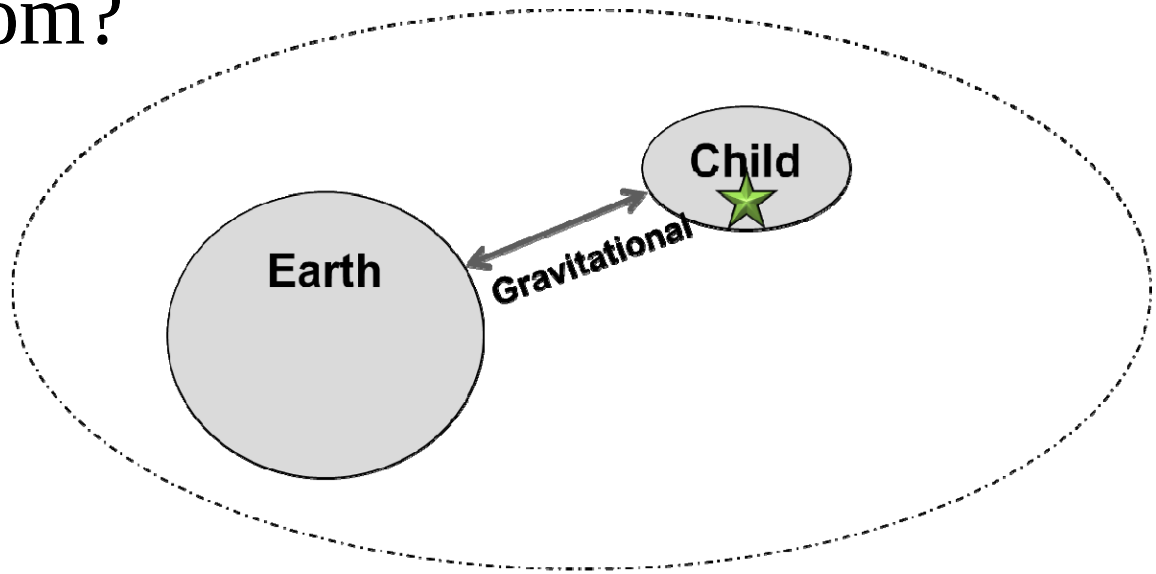
If the girl starts from rest at the top of the slide, calculate the speed of the girl at the bottom of the slide



1. 16 m/s
2. 32 m/s
3. 8 m/s (circled)
4. 4 m/s
5. Depends on the weight of the girl
6. We do not have enough information

Whiteboard, TA & LA

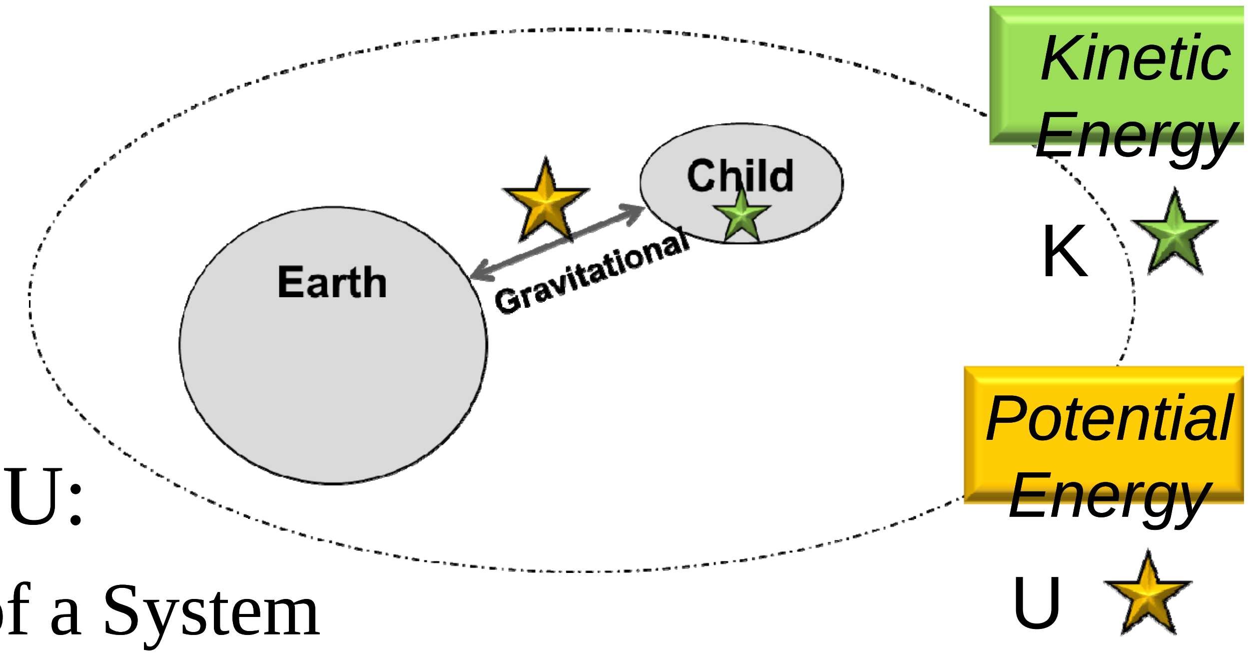
Where does kinetic energy of the child come from?



1. Potential energy of the earth
2. Potential energy of the child
3. Another source

From the potential energy of the interaction

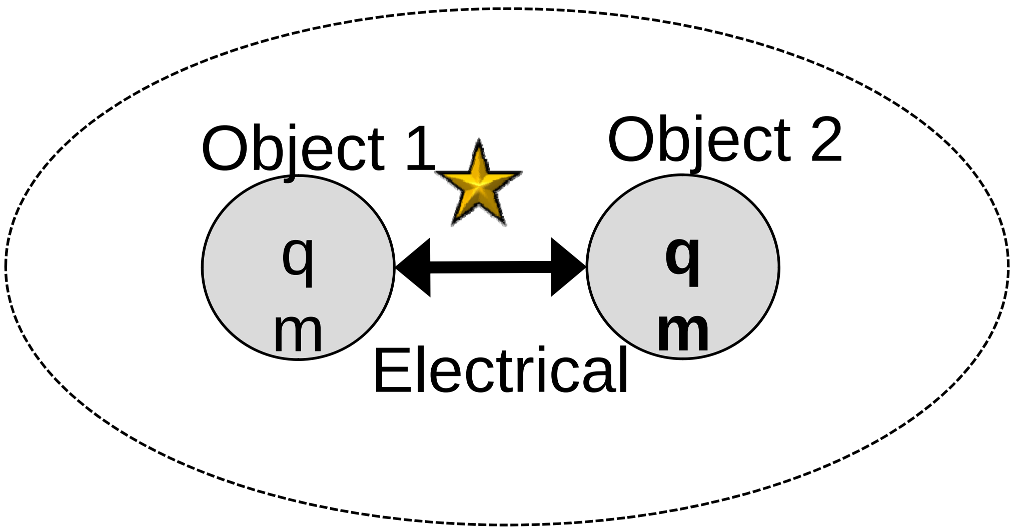
Foothold Principle: Potential Energy



Potential energy U:

- 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
- **Stored in INTERACTION (line between objects)**

Lets look at electrical force moving objects



"Initial": t_1

Objects at rest

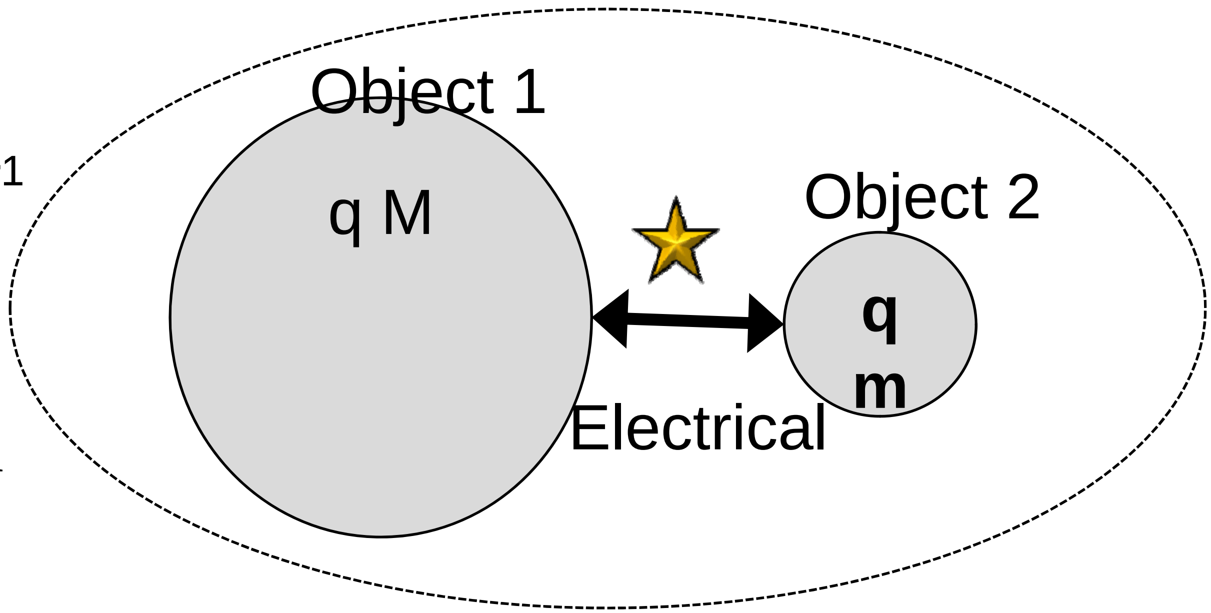
Potential energy U ★

Where does the potential energy go when the charges move apart?

Whiteboard, TA & LA

Now lets make object 1 1000 times heavier

"Initial": t_1



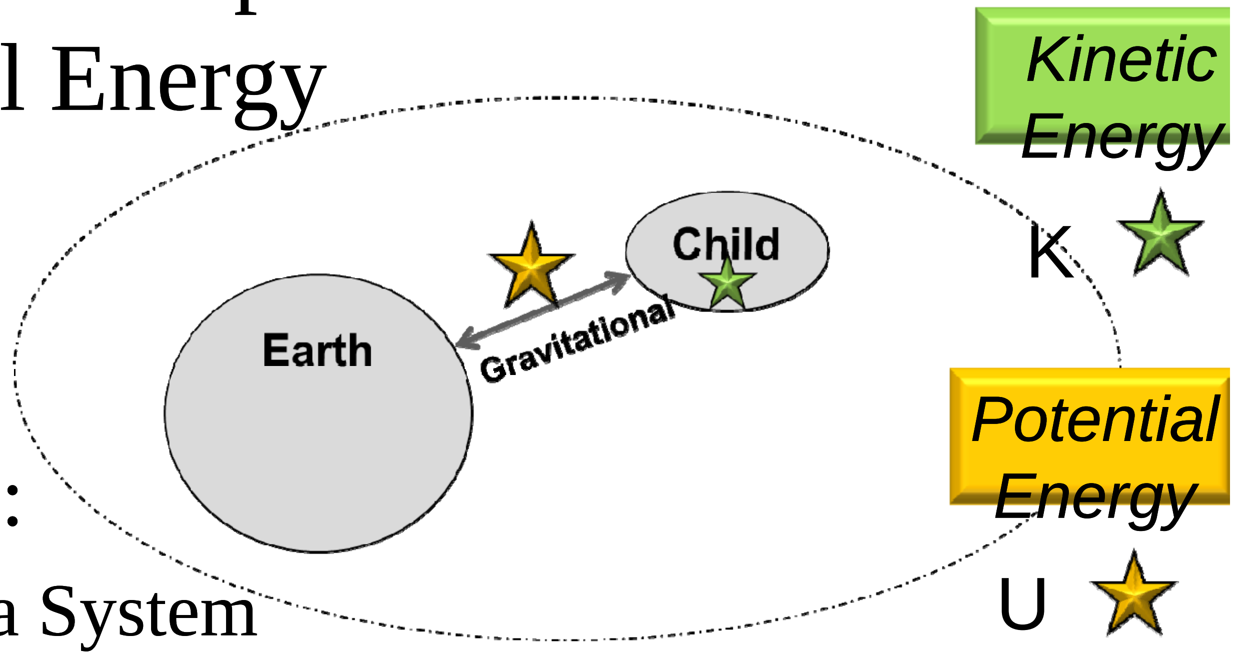
M=1000m

Does object 2 get more kinetic energy?

Object 2 gets 1000 times more kinetic energy than object 1

Whiteboard, TA & LA

Foothold Principle: Potential Energy

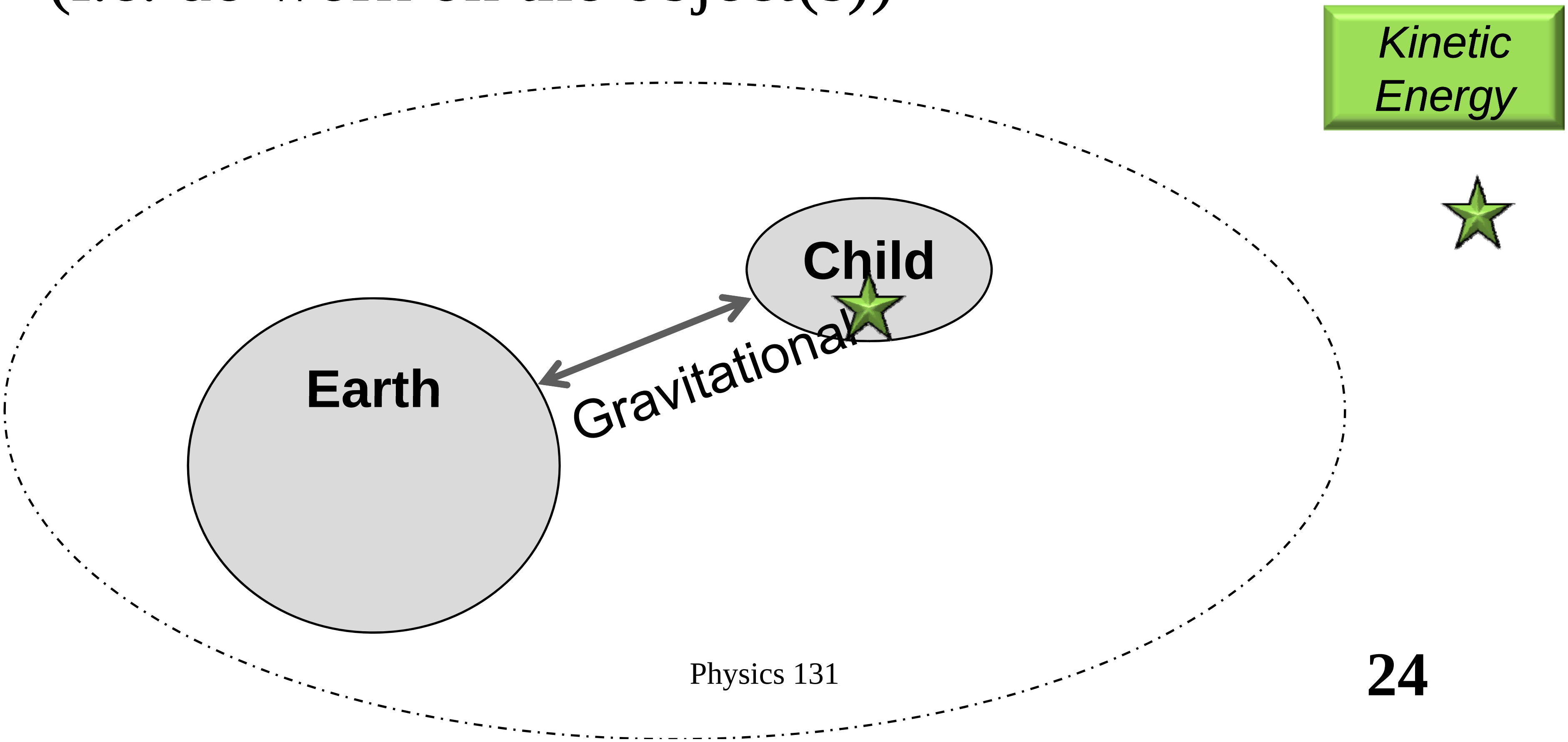


Potential energy U:

- 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
- Stored in INTERACTION (line between objects)
- **The object that moves more gets/supplies more of the potential energy!**

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))



A rock is dropped from the top of a 40 m tall building. What is the rock's speed when it has fallen halfway to the ground?

1. 10 m/s
2. 20 m/s
3. 40 m/s
4. 80 m/s
5. Depends on the mass of the rock
6. We do not have enough information

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, $U_{spring} = ½\, kx^2$

  For electric force, $U_{electric} = k_C Q_1 Q_2 / r_{12}$

Foothold ideas: Conservation of Mechanical Energy

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

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

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

- Thermal energy
  - Resistive forces transform coherent energy of motion (energy associated with a net momentum) into *thermal energy* (energy associated with internal chaotic motions and no net momentum)

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?

1. 96 m
2. 48 m
3. 24 m
4. 12 m
5. 6 m
6. 3 m
7. Something else

Foothold ideas: Conservation laws

- Momentum
  - The momentum of a system of objects is conserved IF the external forces acting on them cancel.

$$\Delta\left(\sum_{n=1}^{N}\vec{p}_n^{\,initial}\right)=0$$

$$\sum_{n=1}^{N}\vec{p}_n^{\,initial}=\sum_{n=1}^{N}\vec{p}_n^{\,final}$$

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

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

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