Announcements

- Homework
  - WebWorK 12 due tonight
  - Video Homework posted for the weekend
- I'm making good progress grading your tests while my other class takes a test today, so results hopefully soon
- Grade reports updated this weekend
- Polling: `rembold-class.ddns.net`

Review Question

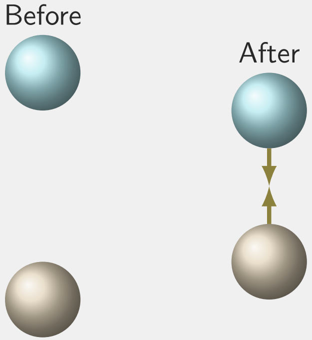
Suppose we have the situation where two particles start a distance apart and stationary, but when released the two particles accelerate towards each other. No other outside forces act on the particles. What could be said about the changes in energy of the two particle system?

A) $\Delta U > 0$

B) $\Delta U < 0$

C) $\Delta K + \Delta U < 0$

D) $\Delta K + \Delta U > 0$



Moon Problems

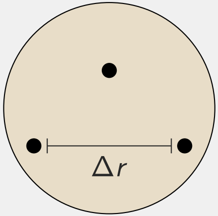
Suppose the Moon were to suddenly lose all its tangential speed, causing it to plummet directly towards the Earth. Approximately how fast would it be traveling when it struck the Earth's surface? The mass of the Earth is 5.97×10^{24} kg, the mass of the Moon is 7.35×10^{22} kg, the radius of the Earth is 6371 km, the radius of the Moon is 1737 km, and the current distance between them is 385 000 km.

Why Potential Energy?

- What is the benefit of looking at potential energy over just calculating the work??
- For forces for which we can define a potential energy, we know that:
  - ΔU depends only on the separation of the pairs of particles, not on their exact position
  - Potential energy goes to zero as the strength of the interactions would go to zero
  - Attractive forces will yield negative changes in potential energy, repulsive forces will yield positive changes potential energy as the distance between particles shrinks
  - Path Independence!

Rigid Bodies

- In rigid bodies, interior particles are fixed with respect to one another
- If separation doesn't change, ΔU should equal 0
- True regardless if moving or rotating
- This lets us return to ignoring the interior bits *of rigid objects*



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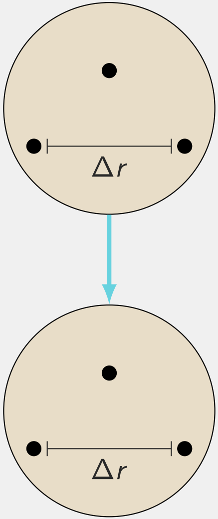

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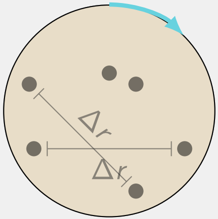
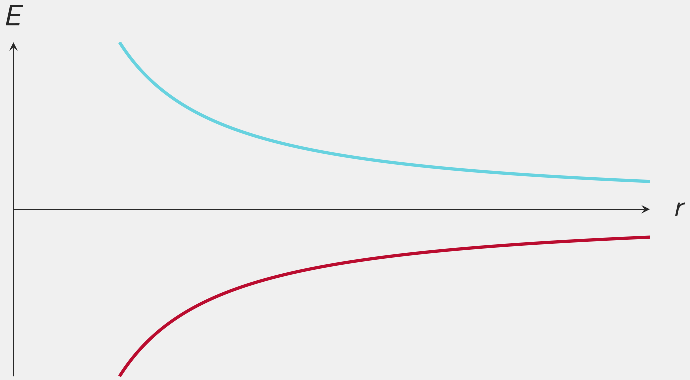


Attraction and Repulsion at a Glance

- Potential Energy of both fundamental forces goes to zero at extreme distances:

$$U_{gravity} = -G\frac{m_1 m_2}{r}, \quad U_{electric} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r}$$



Follow Your Own Path

- Potential energy only depends on the separation
  - *Not* on the particular path taken between the two points
- Thus the change in potential energy between two points is *always constant*, regardless of the path traveled!
- This is a huge reason why potential energy is nice to use!
  - Calculating the exact work meaning knowing the path traveled
  - A curved path would mean doing all the integration
  - Potential energy lets us always consider the easiest path to calculate!
- Means the change in potential energy of something that moves round trip must be 0!

Path Independence of Gravity

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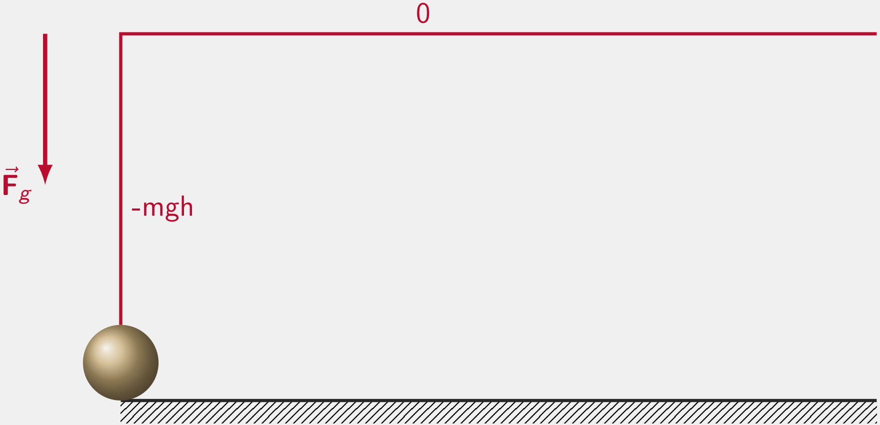

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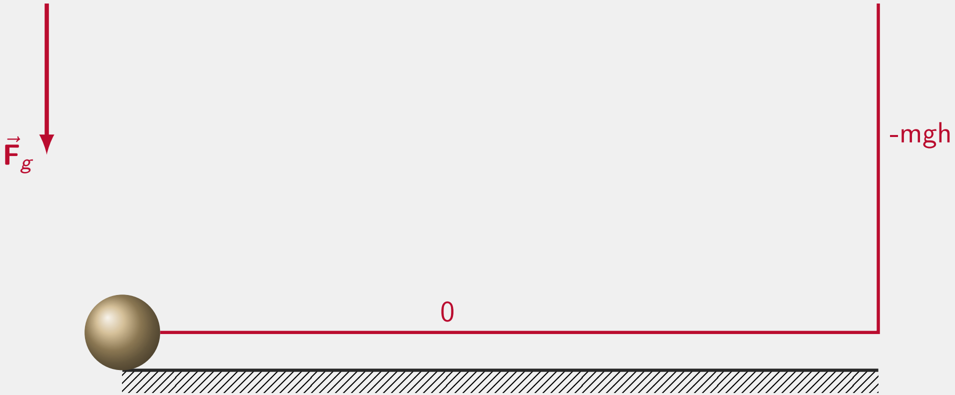

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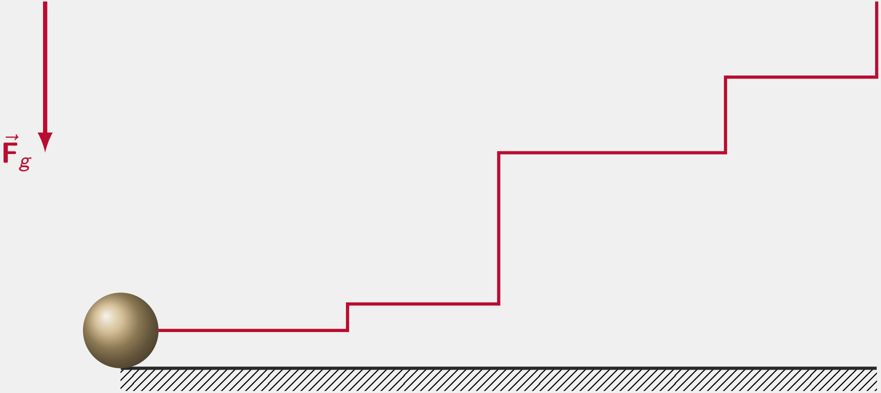


What about Friction?

- May notice that we do not have a potential energy related to friction
- Friction is *always* path dependent!
  - Chiefly because the force changes direction based on our motion
- Also have the issue in that we can't really talk about friction of point particles
  - Always the result of microscopic springs, so need a host of particles to even consider it
- Would still consider energy lost to friction as work done by the surroundings

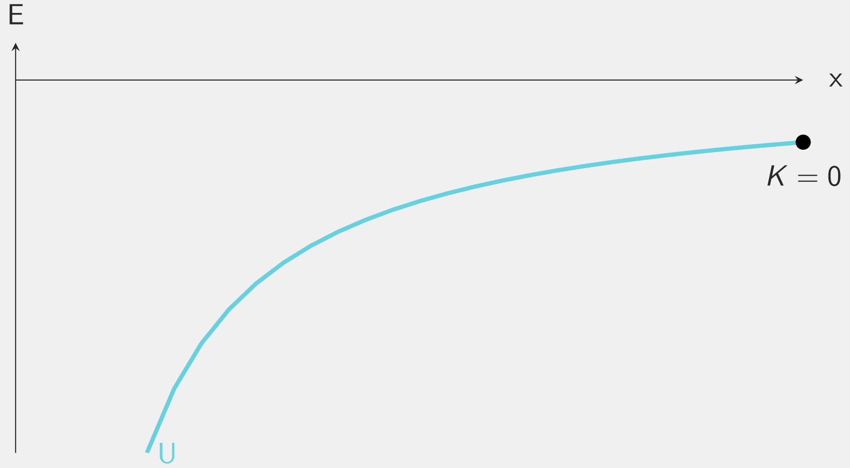
A Weird Rollercoaster

Suppose we have a rollercoaster in which we drop down an incline, cross a rough patch, and then are slowed to a stop by the electrostatic repulsion between a large charge and our charged cart. Suppose we start on a 30 m high hill. Our cart has a mass of 200 kg when loaded and a charge of 10 mC. The repulsion bumper has a charge of 50 mC and is located 100 m in the x-direction from the carts starting point. We'll be crossing a 10 m rough stretch with a coefficient of kinetic friction of 0.6. How far from the bumper will we come to a stop?

Getting Visual

- Looking at potential energy curves can often times be an excellent way of gaining a great understanding about a system in a short condensed manner
- Worth our time now to get used to all the information we can extract from them
- We'll generally assume when looking at these that:
  - Systems are isolated (no work by surroundings)
  - System's mass does not change

A Potential Energy Curve



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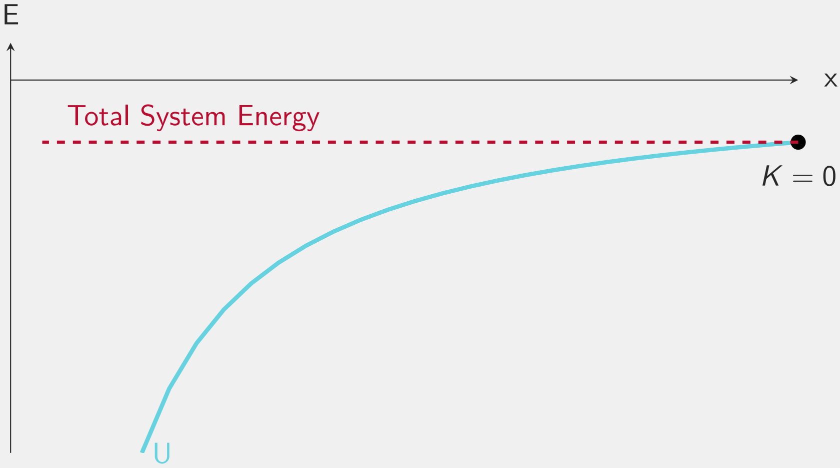

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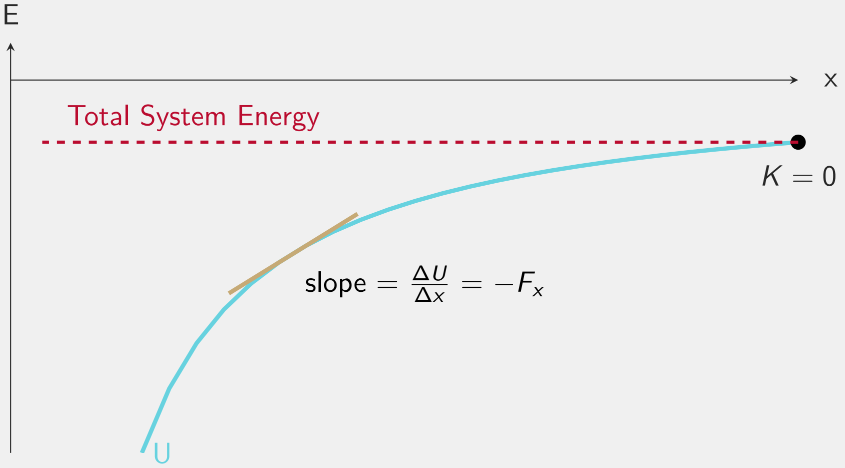

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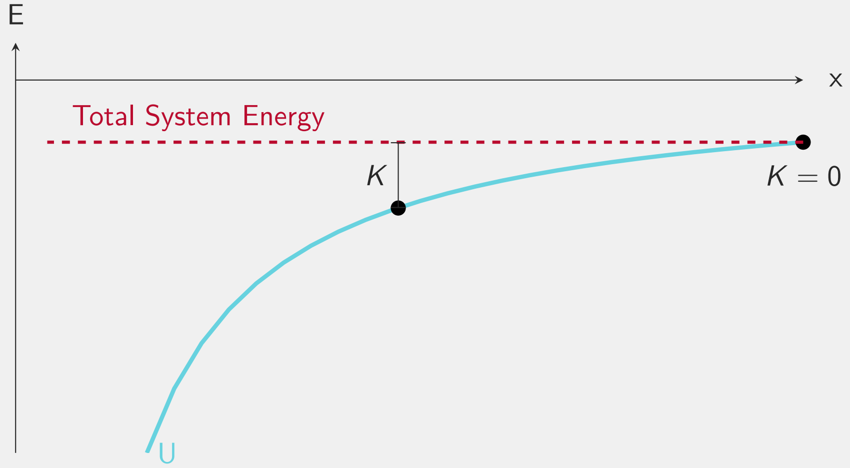

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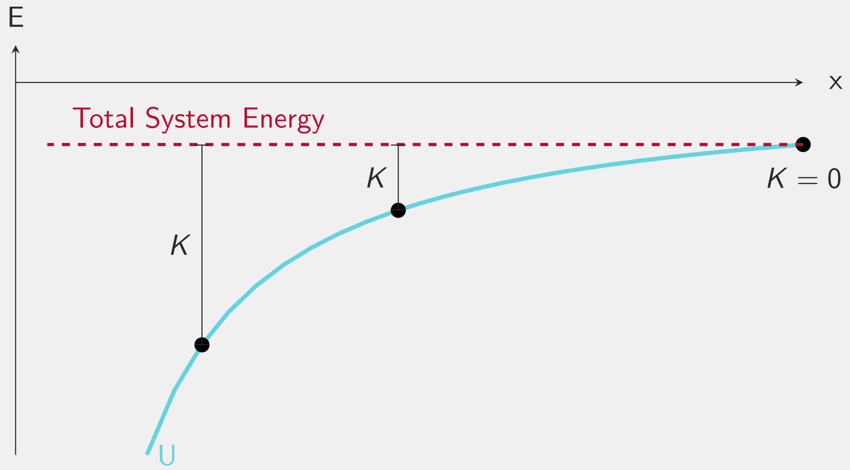
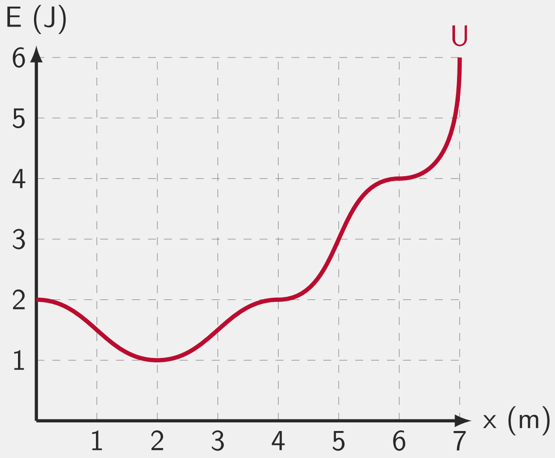


Understanding Check

A mass starts at $x = 2$ with an initial kinetic energy of 2 J. If the particle was initially traveling in the positive x direction, at what point does it come to a stop (at least momentarily)?

A) 4 m
B) 5 m
C) 6 m
D) 7 m



Your Turn!

At its closest point (perihelion) the Earth is 1.471×10^8 km from the Sun, while at its furthest point (aphelion) it is 1.521×10^8 km away. The Earth has a mass of 5.97×10^{24} kg and a total energy $(K + U)$ of -2.666×10^{33} J. If the Sun has a mass of 1.99×10^{30} kg, determine the velocity of Earth both at perihelion and aphelion.