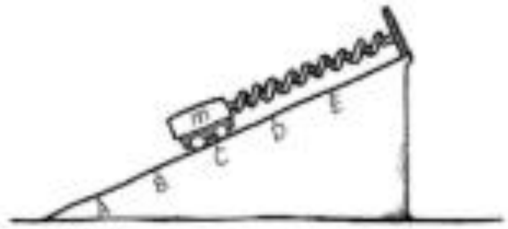
NAME ______________________ DATE ____________

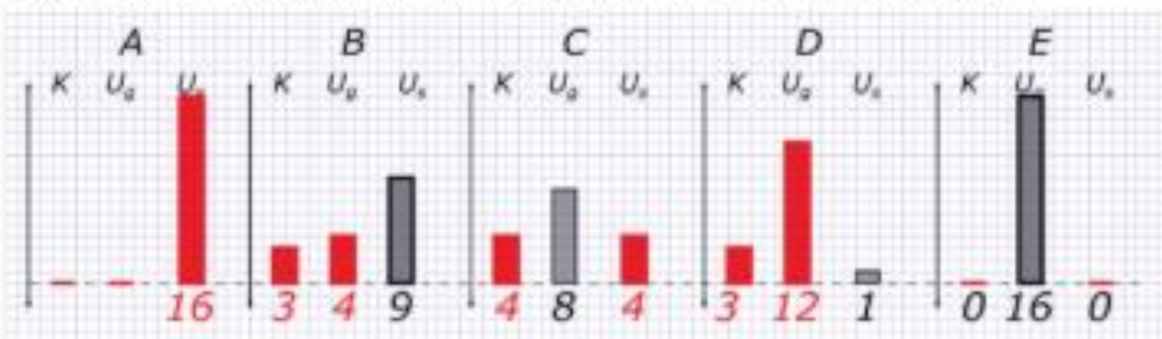
Scenario

A cart of mass m is attached to an ideal spring that can stretch and compress equally well. The natural length of the spring without the cart is at point E. The cart and spring rest on a smooth angled track. The cart is pulled to position A and released. The cart then moves toward position E, where it reverses direction and returns again to position A.



Using Representations

PART A: Sketch energy bar charts for the cart-spring-Earth system at the five labeled points. Choose point A to be equal to zero height for gravitational potential energy. (Some of the bars have been sketched for you.)



Analyze Data

PART B: Write a short narrative explaining the thought process that allowed you to fill in the bar charts in Part A.

At point A, the mechanical energy is all elastic potential energy since point A was given as zero height (hence zero gravitational potential energy, and the cart has not yet started moving, so the kinetic energy also is equal to zero). At point B, there will be kinetic energy, gravitational potential energy, and spring potential energy. The gravitational potential energy increases linearly with height, so it will gain 4 units of gravitational potential at every marked height, while the spring potential will decrease quadratically, and the kinetic energy will balance the spring and gravitational potential energy so that the total mechanical energy will always equal 16 units. At point C, there will be kinetic energy, gravitational potential energy, and spring potential energy.

At point D, there will be kinetic, gravitational potential energy, and spring potential energy.
At point E, there will be only gravitational potential energy, since the cart has come to rest, and this is the original equilibrium position of the spring.

PART C: Do the energy bar charts depend on whether the cart is moving left (down the track) or right (up the track)? Explain.

No, there is the same change in energy in each case, regardless of whether the cart is moving up or down the track.

PART D: As the cart moves from A to E, the total energy of the system should be the same at each labeled point. Explain why this is the case. If your energy bar charts do not show this relationship, then make corrections to your bar charts.

There are no net external forces doing work on the Earth-cart-spring system, so the total mechanical energy of the system is conserved.

PART E: As the cart moves from A to E, the gravitational potential energy should increase by the same amount between each labeled point. Explain why this is the case. If your energy bar charts do not show this relationship, then make corrections to your bar charts.

The gravitational potential energy $U_g = mgh$ is directly proportional to the change in height of the cart, so as h increases, the gravitational potential energy of the Earth-cart system increases directly.

PART F: As the cart moves from E to A, the spring potential energy should increase quadratically between each labeled point. Explain why this is the case. If your energy bar charts do not show this relationship, then make corrections to your bar charts.

The spring potential energy increases quadratically because the spring potential energy is proportional to x squared, so every time that x increases, the spring potential energy increases by a factor of x squared. $U_s = \frac{1}{2}kx^2$.