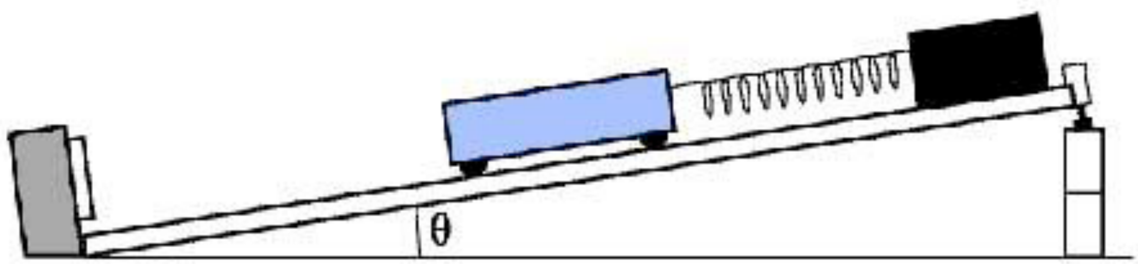
PSET 5 Energy (we will work on some of these together in class, but you are responsible for being able to do them all.)

Block-spring on a rough surface .
A block of mass m slides along a horizontal table with speed v_o. At $x=0$ it hits a spring with spring constant k . At this point, the spring is neither stretched nor compressed. As the block moves, the spring gets compressed. The surface on which the block moves exerts a friction force on it. The coefficient of friction is μ.
Find the change in mechanical energy of the block from $x=0$ till it first momentarily comes to rest.

Variation: Block-spring on a rough surface of variable friction ($\mu = bx$).
A block of mass m slides along a horizontal table with speed v_o. At $x=0$ it hits a spring with spring constant k . At this point, the spring is neither stretched nor compressed. As the block moves, the spring gets compressed. The surface on which the block moves exerts a friction force on it. The coefficient of friction is *variable* and is given by $\mu = bx$, where b is a positive constant.
Find the change in mechanical energy of the block from $x=0$ till it first momentarily comes to rest.

Spring-ramp-cart-
An ideal spring is attached to a support at the upper end of a ramp. The spring constant of the spring is k . The un-stretched length of the spring (without the cart attached to it) is l_o. The other end of the spring is now attached to a cart of mass m that can move on the ramp. The ramp is inclined at an angle θ from the horizontal.



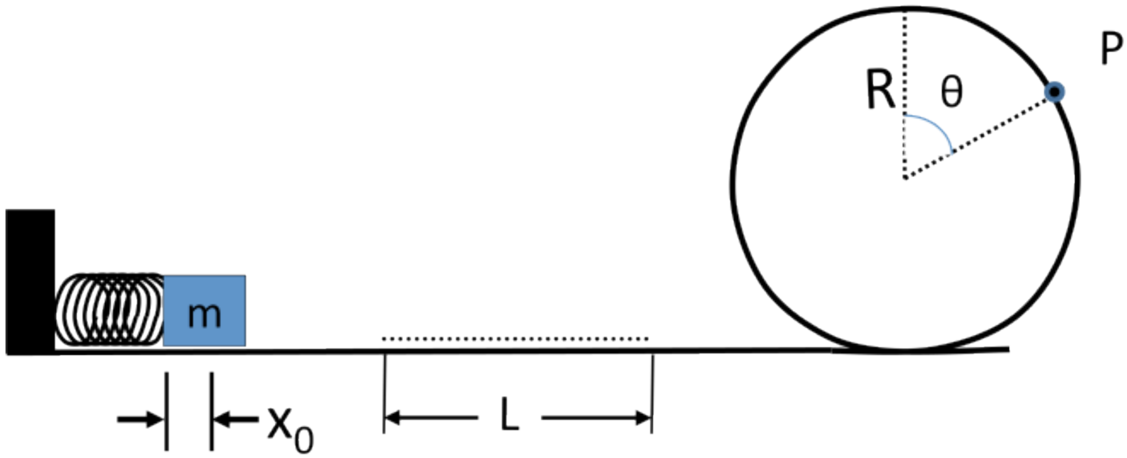
a) When the cart is attached to the spring, the spring stretches slightly to a new length $l > l_0$ to hold the cart in equilibrium. Find the length l in terms of the given quantities: l_0 , m, k , θ and g .

b) Now the cart is moved up the ramp so that the spring is compressed a distance d_1 from the un-stretched length l_0 . Then the cart is released from rest. As the cart moves down the ramp, the spring stretches a maximum distance of d_2 from its starting (compressed position), after which the cart turns around and comes back up the ramp. Assuming there is no friction between the cart and the ramp, what is the speed of the cart when the spring has first returned to its un-stretched length l_0 ?

c) Assuming there is a constant coefficient of friction μ between the cart and the ramp, what is the speed of the cart when the spring has first returned to its un-stretched length l_0 ?

Loop – the – loop ride with friction.

A mass m is fired using a spring (with a spring constant k) that is initially compressed to a distance x_0 beyond its relaxed length. The mass encounters a rough surface of length L and a coefficient of kinetic friction μ_k, the surface of the track is otherwise frictionless. The mass then goes up a loop of radius R. What should x_0 be if the mass is to fall off the loop at point P? Give the answer in the quantities given: k, L, θ, R, μ_k.

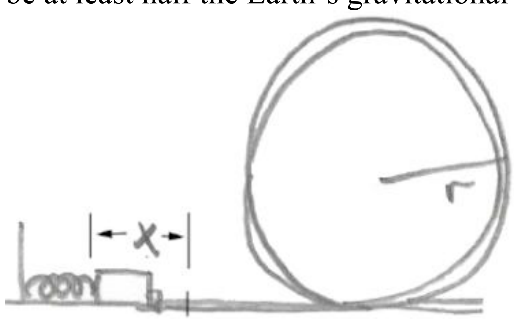


Spring launched loop-the-loop ride with human constraints

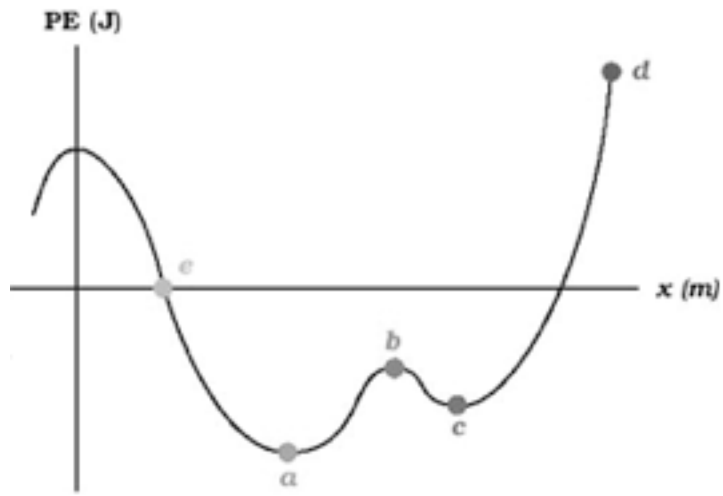
An amusement park development company hires you to help in the design of the following ride. A 500-kg cart, including the passengers, is initially at rest. When a spring is released, the cart is launched for a trip around a loop-the-loop whose radius is r =10 m. The system should be designed to satisfy two conditions.

1) During launching by the spring, the acceleration of the passengers should not exceed 10g (g is the gravitational acceleration).

2) The force exerted by the track and the cart when inverted at the top of the loop should be at least half the Earth's gravitational force on the cart.



Energy diagram
Consider the following sketch of potential energy as a function of position. The particle's total energy is shown by line E.



a) At which of the points: a, b, c, d or e, is the particle's velocity a maximum?

b) At which of the points is it zero? Briefly explain your answers.