AP Physics C: Mechanics
Unit 3&4: Energy & Momentum

1. A 10-kg ghost is constrained to move along the x-axis. The potential energy U of the ghost is given as a function of its position by:

$$U(x) = \frac{12}{x}$$

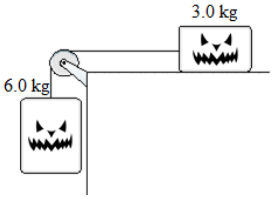
The ghost has an velocity of 2 m/s when x = 1.

a) Find the acceleration of the ghost at x = 4 m. (4 pts)
b) Find the speed of the ghost at x = 4 m. (4 pts)

2. A spooky scarecrow drives a tractor of mass 20 kg. The position of the tractor over time can be given by $x(t) = 4e^{0.5t}$.

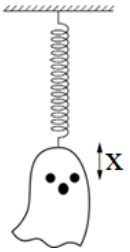
a) Determine an expression for the work done on the tractor as a function of time. (4 pts)
b) Determine an expression for the power delivered to the tractor over time. (4 pts)

3. The two blocks shown are connected by a frictionless pulley. The 3.0 kg block is a on table with friction. The system is released from rest. After the 6.0 kg block falls a vertical distance of 1.5 m, it is found to have a speed of 4.0 m/s. Calculate the work done by friction during this time. (6 pts)



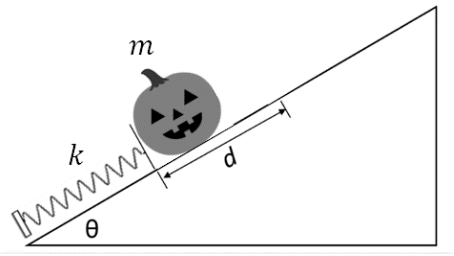
4. A spooky skeleton plays spooky badminton and hits a birdie of mass M that is initially at rest at time t = 0. The skeleton applies a force given by: $F = B\sqrt{t}$, where B is a positive constant. Determine an expression for the velocity of the birdie at t = 2 s. (6 pts)

5. Dr. Acula performs an experiment to determine the spring-constant of a spooky non-linear spring. It is known that the force applied by the spring is of the form $F = 2kx^2$, where x is the distance stretched or compressed. To determine the spring constant, Dr. Acula arranges the spring vertically and hangs ghosts of various masses from the spring as shown, and measures how far the spring stretches from equilibrium. The value of m, the mass of each ghost, and the corresponding x-value, the distance stretched, are given in the table below:

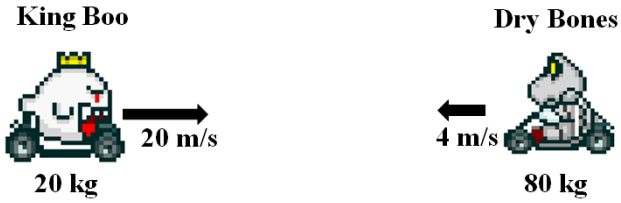


m (kg)	10	20	30	40	50
x (m)	2.0	2.8	3.4	3.9	4.4

a) Which quantities should be graphed in order to yield a straight line whose slope could be used to calculate a numerical value for K? (2 pts)
b) Use the linear relationship from a) to calculate k, the spring constant. (5 pts)
c) The spring is now arranged on an incline ($\theta = 30°$) as shown. The coefficient of kinetic friction on the incline is $\mu = 0.30$. A pumpkin of mass m = 1.0 kg is compressed a distance of x = 0.5 m against the spring and travels a distance of d up the incline. Calculate the value of d. (5 pts)

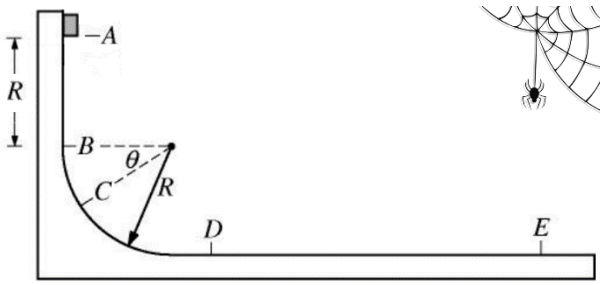


6. King Boo and Dry Bones undergo a spooky elastic collision as shown. King Boo has a mass of 20 kg and drives to the right at 20 m/s while Dry Bones, with a mass of 80 kg, drives towards the left at 4 m/s.

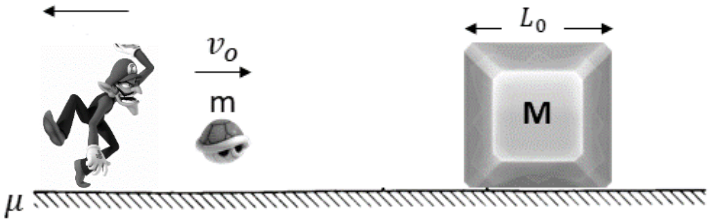


a) Calculate the velocity of center of mass of the King Boo/Dry Bones system. (4 pts)
b) Calculate the velocity of King Boo after the collision. (8 pts)

7. A crate of spiders of mass M that is released from rest at point A as shown and moves along a track to point E. The crate is in free fall between points A and B, which are a distance of R apart, then moves along the circular arc of radius R between points B and D. The track is frictionless from point A to point D. Determine an expression for the normal force on the crate at point C. (8 pts)



8. Waluigi stands on ice, which has a coefficient of sliding friction μ and tosses a turtle shell of mass m at a velocity of v_0 towards a block of snow of mass M. Waluigi throws the shell while standing at rest and recoils opposite the shell. Answer all question below in terms of the variables given in the picture.



a) Waluigi recoils opposite the direction of the shell and travels a distance D on the ice before coming to rest.
i. Determine an expression for Waluigi's recoil speed. (6 pts)
ii. Determine an expression for Waluigi's mass. (4 pts)

Assume that block of ice is not free to move and the resistive force that the block of snow exerts on the turtle shell is constant. In this case, the turtle emerges on the other side of the block with speed $v_0/2$. The block has a thickness of L_0.

b) Determine the direction and magnitude of the impulse of the block on the turtle shell. (4 pts)
c) Determine an expression for the magnitude force the shell experiences inside the ice. (4 pts)