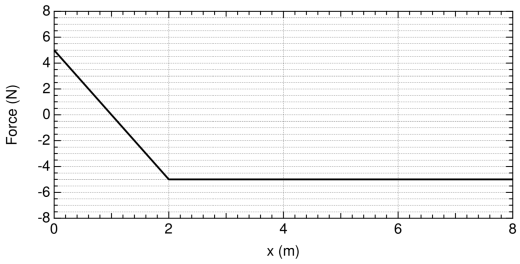
Homework set 04. Physics 141, Fall 2022

Due date: Friday Sept 30, 2022 at noon.
Total of 10 points. On Friction and Energy.

1. (2 points) The only force acting on a 4.0 kg body as it moves along the x axis varies as shown in the Figure. The velocity of the body at $x = 0$ is 6.0 m/s.

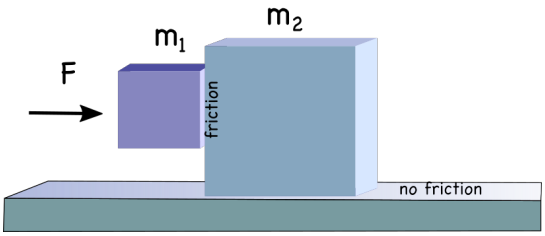


   What is the kinetic energy of the body at $x = 6.5$ m?

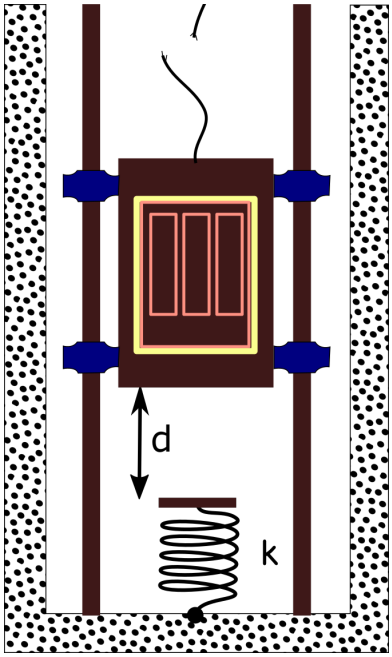
   At what value of x will the body have a kinetic energy of 60.0 J?

   What is the maximum kinetic energy attained by the body between $x = 0$ and $x = 8$ m?

2. (2 points) Two blocks with masses m_1 kg and m_2 kg, shown in the figure, are free to move. The coefficient of static friction between the blocks is μ but the surface beneath m_2 is frictionless. What is the minimum force F required to hold m_1 against m_2?

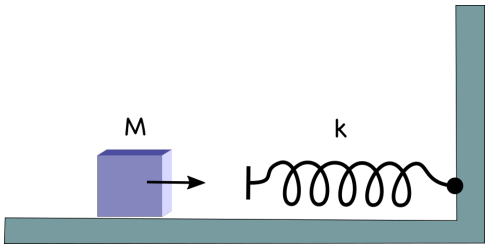


3. (2 points) The cable of an elevator of mass $M = 3110$ kg snaps when the elevator is a rest at one of the floors of a skyscraper. At this point the elevator is a distance $d = 75.8$ m above a cushioning spring whose spring constant is $k = 13300$ N/m. A safety device clamps the elevator against the guide rails so that a constant frictional force of $f_\mu = 13920$ N opposes the motion of the elevator. Find the maximum distance by which the cushioning spring will be compressed.



Hints: The kinetic energy initially is zero and the kinetic energy at the moment when the spring is maximally compressed is zero. This means that the total work done on the elevator between these two moments of time sums to zero. There are three forces operating on the elevator: gravity, the spring force and friction.

4. (2 points) A moving $M = 3.8$ kg block collides with a horizontal spring whose spring constant is $k = 458$ N/m (see Figure). The block compresses the spring a maximum distance of $x = 11.5$ cm from its rest position. The coefficient of kinetic friction between the block and the horizontal surface is $\mu = 0.36$. At the point of maximum spring compression, the block is momentarily at rest (that means it momentarily has zero kinetic energy).



What is the work done by the spring in bringing the block to rest?

How much mechanical energy is being dissipated by the force of friction while the block is being brought to rest by the spring?

What is the speed of the block when it hits the spring?

5. (2 points) The Stanford Linear Accelerator Center (SLAC), located at Stanford University in Palo Alto, California, accelerates electrons through a vacuum tube, $d = 4$ km long. Electrons, which are initially at rest, are subjected to a continuous force of $F = 2\times10^{-12}$ N along the length of the tube and reach speeds very close to the speed of light.

a. Calculate the final energy E, momentum p, and speed v of the electron.

b. Calculate the time (as seen in the lab frame) required for the electron to go the 4 km distance. Hint: if the velocity is close to the speed of light, then you can use the speed of light. Also you can use $dp/dt = F$.

The rest mass of the electron $m_e = 9.1 \times 10^{-31}$ kg.

The speed of light $c = 3.0 \times 10^8$ m/s.