



Note: Figure not drawn to scale.

2. A block of mass m starts at rest at the top of an inclined plane of height h , as shown in the figure above. The block travels down the inclined plane and makes a smooth transition onto a horizontal surface. While traveling on the horizontal surface, the block collides with and attaches to an ideal spring of spring constant k . There is negligible friction between the block and both the inclined plane and the horizontal surface, and the spring has negligible mass. Express all algebraic answers for parts (a), (b), and (c) in terms of m , h , k , and physical constants, as appropriate.

- (a)
- Derive an expression for the speed of the block just before it collides with the spring.
 - Is the speed halfway down the incline greater than, less than, or equal to one-half the speed at the bottom of the inclined plane?

_____ Greater than _____ Less than _____ Equal to

Justify your answer.

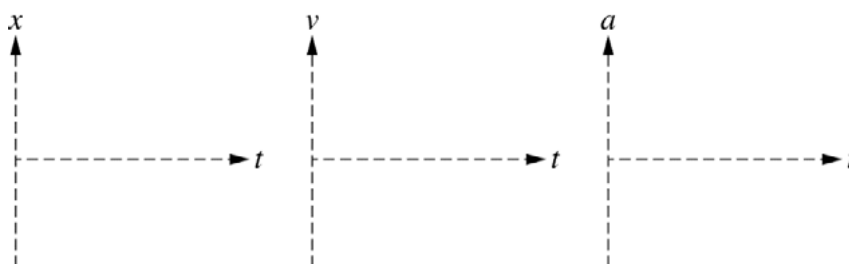
- (b) Derive an expression for the maximum compression of the spring.
- (c) Determine an expression for the time from when the block collides with the spring to when the spring reaches its maximum compression.

The block is again released from rest at the top of the incline, and when it reaches the horizontal surface it is moving with speed v_0 . Now suppose the block experiences a resistive force as it slides on the horizontal surface.

The magnitude of the resistive force F is given as a function of speed v by $F = \beta v^2$, where β is a positive constant with units of kg/m .

- (d)
- Write, but do NOT solve, a differential equation for the speed of the block on the horizontal surface as a function of time t before it reaches the spring. Express your answer in terms of m , h , k , β , v , and physical constants, as appropriate.
 - Using the differential equation from part (d)i, show that the speed of the block $v(t)$ as a function of time t can be written in the form $\frac{1}{v(t)} = \frac{1}{v_0} + \frac{\beta t}{m}$, where v_0 is the speed at $t = 0$.

- (e) Sketch graphs of position x as a function of time t , velocity v as a function of time t , and acceleration a as a function of time t for the block as it is moving on the horizontal surface before it reaches the spring.





Mech.2.

A block of mass $2M$ rests on a horizontal, frictionless table and is attached to a relaxed spring, as shown in the figure above. The spring is nonlinear and exerts a force $F(x) = -Bx^3$, where B is a positive constant and x is the displacement from equilibrium for the spring. A block of mass $3M$ and initial speed v_0 is moving to the left as shown.

- (a) On the dots below, which represent the blocks of mass $2M$ and $3M$, draw and label the forces (not components) that act on each block before they collide. Each force must be represented by a distinct arrow starting on, and pointing away from, the appropriate dot.

Block of Mass $2M$

Block of Mass $3M$



The two blocks collide and stick to each other. The two-block system then compresses the spring a maximum distance D , as shown above. Express your answers to parts (b), (c), and (d) in terms of M , B , v_0 , and physical constants, as appropriate.

- (b) Derive an expression for the speed of the blocks immediately after the collision.
(c) Determine an expression for the kinetic energy of the two-block system immediately after the collision.
(d) Derive an expression for the maximum distance D that the spring is compressed.

(e)

- i. In which direction is the net force, if any, on the block of mass $2M$ when the spring is at maximum compression?

☐ Left ☐ Right ☐ The net force on the block of mass $2M$ is zero.

Justify your answer.

- ii. Which of the following correctly describes the magnitude of the net force on each of the two blocks when the spring is at maximum compression?

☐ The magnitude of the net force is greater on the block of mass $2M$.
☐ The magnitude of the net force is greater on the block of mass $3M$.
☐ The magnitude of the net force on each block has the same nonzero value.
☐ The magnitude of the net force on each block is zero.

Justify your answer.

- (f) Do the two blocks, which remain stuck together and attached to the spring, exhibit simple harmonic motion after the collision?

☐ Yes ☐ No

Justify your answer.