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Vertical spring-mass system

Student version

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# Vertical spring-mass system

## Introductory questions

In this exercise, you will study energies of a spring - mass system that oscillates. Using *Tracker*, you will determine the different types of energies in the system as a function of time, and then you will analyze the obtained graphs.

1. Pull the mass out of its equilibrium position and let it oscillate. What types of mechanical energies exist in the spring – mass system that oscillates? Write expressions for each type of energy.

a)

b)

c)

2. When each energy reaches its minimum and maximum values, in which position is the mass?

a)

b)

c)

3. Sketch your prediction for $E-t$ graphs (for each energy) for one period of oscillation $T$. Mark the moments when these energies reach maximum and minimum values (for example $T/3$, $T/2$, …).

## Oscillation analysis

1. Record the oscillation of the spring – mass system with your mobile phone. In doing so, make sure that you have an object of known length in the plane of oscillation with which you will make length calibration. The clip should contain the position of the weight when hung on an unstretched spring. The oscillation should be in one dimension with a small amplitude.

2. When cutting the video clip for analysis, select two full oscillations. Determine the calibration length, the origin of the coordinate system, and mark the point mass in all frames. The origin of the coordinate system should be in the lowest position of the weight.

3. In the Tracker, display graphs of kinetic, gravitational potential and elastic potential energy as a function of time.

Enter the values of weight mass $m$, spring constant $k$, gravity acceleration $g$ and weight position $y\_{0}$ when the spring is unstretched (relative to the origin of the coordinate system, ie. relative to the lowest position).

Enter expressions for kinetic, gravitational potential and elastic potential energy.

*Note*: The elastic potential energy of the weight and spring system is $0.5 k (y-y\_{0})^{2}$. The kinetic energy $K$is already defined in the *Tracker* and you can use it.

Insert screenshots of the resulting graphs (you can use the *Snipping tool* or *Paint*).

4. On the obtained graphs, mark the moments in which the kinetic, gravitational potential and elastic potential energies reach minimum and maximum values (for example $T/3$, $T/2$, …).

5. Indicate in which positions is the weight when certain types of energy have maximum and minimum values (for example, equilibrium position, highest vibration position, …).

6. Are your predictions in line with the results of *Tracker* oscillation analysis? Write down your observations.

7. In the Tracker, display a graph of total mechanical energy as a function of time. Insert a screenshot of the graph.

8. Is the obtained graph in line with your expectations? If not, what could be the cause of this disagreement? What can you conclude about the total mechanical energy of the spring - mass system?