Regis University – Physics 305A – Fall 2019
Lab 8: Energy in Springs

In this lab, we will check our understanding of transformations of energy. Specifically, we will work with kinetic energy ($K = \frac{1}{2}mv^2$), gravitational potential energy ($\Delta U_g = mg\Delta y$), and potential energy stored in a spring ($U_s = \frac{1}{2}k_s s^2$). This lab handout is intentionally a short outline; you are expected to fill in the details of the procedure based on your understanding of the physical principles. This week you're welcome to use whatever calculational tools you prefer – Excel, Google Sheets, Python, etc.

Part 1 – Measuring spring stiffness

There is a general connection between potential energy and force, expressed by $F_x = -\frac{dU}{dx}$. If we apply this to a spring's potential energy, we find that $F_s = -\frac{d}{ds}(\frac{1}{2}k_s s^2) = -k_s s$, a relationship that is often called "Hooke's Law." It indicates that the force exerted by a spring is proportional to the distance by which the spring has been stretched. You should be able to use this relationship to set up an experiment to measure the spring stiffness (often called the "spring constant") k_s for a particular spring by hanging different masses from the spring and measuring by how much it stretches. Specifically, you should determine it from a **graph** of F_s versus s; what do you expect the slope and the intercept of that graph to represent?

In Logger Pro, you can enable an option to display its calculation of the uncertainties on the slope and intercept of a graph. You should collect at least enough data to determine k_s with an uncertainty of less than about 5 percent of the value.

Use this method to determine the stiffness of two different springs, and compare them to their nominal values. Does your measured stiffness agree within the calculated uncertainty? Does the intercept of your graph agree with what you expect, to within its uncertainty?

Part 2 – Conservation of energy

You can hang a known mass from one of the springs that you have now characterized, and you can allow it to bounce up and down. This system is called a "simple harmonic oscillator." Set up your oscillator so that it bounces above an ultrasonic motion detector, which should show you beautiful sinusoidal graphs of the vertical position y and the vertical velocity component v_y versus time. Determine values for K, U_g, and U_s at three points in the motion of the mass:

- the highest point
- the center of the motion
- the lowest point

To what extent does the total energy $K + U_g + U_s$ remain constant over this full cycle?