**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Homework 8: Chapter 15, 16 & 17**

**Assigned Date:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **Due Date:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* Show all relevant work for full credit.
* Place boxes around your final answers.
* Report answers with three significant figures, unless stated otherwise.

A couple of metal springs with a metal plate

Description automatically generated with medium confidence**Assigned Problems:**

**15-1.** A mass is suspended from a spring and stretches the spring by .

1. If two of the same identical springs are placed in parallel as shown in figure (a), how far does the mass stretch the combination? [6 pts] [*Answer*:]

For a single spring,

For two of these springs in parallel, they work together to each bear half the weight, and their combined stiffness is double that of a single spring, so the stretch distance is halved. \*Detailed solution at end

1. If two of the same identical springs are placed in series as shown in figure (b), how far does the mass stretch the combination? [6 pts] [*Answer*:]

For two of these springs in series, they work “against” each other, each bearing the weight, and their combined stiffness is half that of the single spring, so the stretch distance is doubled.

1. Calculate the effective spring stiffness constant for a single replacement spring in each case.  
   [6 pts] [*Answer*:]

&

A graph of a function

Description automatically generated**15-2.** A - mass is attached to the end of a spring and set into oscillation on a horizontal frictionless surface by releasing it from a compressed position. The record of time is started when the oscillating mass passes through the equilibrium position and the position of the mass at any time is shown in the drawing. Determine the following:

1. Amplitude, [5 pts]

By inspection of graph,

1. Angular frequency, . [6 pts] [*Answer*:]
2. Stiffness constant, [*Answer*:]
3. Maximum speed of the mass, [*Answer*:]
4. Speed of the mass at [*Answer*:]

At , the slope of the position versus time graph is zero, thus

1. Magnitude of acceleration at [*Answer*:]
2. Mechanical energy of the system. [6 pts] [*Answer*:]

**15-3.** Consider a simple pendulum oscillating on the surface of the Earth.

1. If the period of the oscillation is measured to be , what is the length of the pendulum? [6 pts] [*Answer*:]
2. Now consider sending the same pendulum to Mars. If the period of oscillation is measured on Mars to be , approximate the gravitational acceleration of Mars. [6 pts] [*Answer*:]

**15-4.** Dolphins make sounds in air and water. Consider the following:

1. If a dolphin produces a tone underwater, and the speed of sound in seawater is , what is the wavelength of the sound underwater? [6 pts] [*Answer*:]
2. If the dolphin surfaces and produces the same tone in the air, and the air temperature is , what is the speed of the dolphin’s sound? [6 pts] [*Answer*:]
3. What is the wavelength of the sound in air? [6 pts] [*Answer*:]
4. What is the ratio between the speed in air to the speed in water and the ratio between the wavelength in air to the wavelength in water? [6 pts] [*Answer*:]

1. If the dolphin produces this sound while moving toward a stationary observer at a speed of , what will the stationary observer measure to be the frequency? (Doppler shift)   
   [6 pts] [*Answer*:]

\*Defining the force of **single spring** as,

This single spring is subjected to a weight force,

So, given the mass attached to the spring and the distance over which it was stretched, the stiffness is,

And the original displacement is,

For two springs of the same stiffness in a **parallel configuration** supporting the same weight force, the displacement of both springs is the same as the displacement of an equivalent replacement spring,

The force of the individual springs in parallel,

And the force of the equivalent parallel replacement,

The weight force is supported by,

Then, the individual stretch of the two springs in parallel is,

The stiffness of an equivalent parallel replacement is,

And since, in parallel we have assumed that then

And the stretch of an equivalent parallel replacement (the total stretch of the parallel system),

For two springs of the same stiffness in a **series configuration** supporting the same weight force, the displacement of both springs is half that of the displacement of an equivalent replacement spring,

The force of the individual springs in series,

And the force of the equivalent series replacement,

The weight force is supported by,

Then, the individual stretch of the two springs in series is,

The stiffness of an equivalent series replacement is,

And since, in parallel we have assumed that then

And the stretch of an equivalent series replacement (the total stretch of the series system),

**Summary (For Two Equal Springs Combined in Parallel or Series)**

**In general,**

Verifying using a stiffness proportionality:

Now for the combinations,