You need only turn in asterisked Additional Problems in class. Remember to show your work in detail for those problems. Complete the online problems using the WebAssign system.

Online Problems
Chapter 11 – Problems 29, 34, 37, 41
Chapter 15 – Problems 15, 19, 39, 58

Additional Problems
A.* Chapter 11 – Problem 16
B.* Chapter 15 – Problem 63
C.* A puck of mass $m$ is mounted between identical springs with force constant $k$ and can slide back and forth on the level frictionless surface as shown. The springs have negligible mass. The puck is displaced from its equilibrium position at Y to position X, at which point it is released from rest. It then oscillates back and forth between positions X and Z. Determine whether each of the following statements is true or false. Show a calculation or explain briefly the reason for each answer.

\[
\begin{align*}
&k & X & Y & Z & k \\
&m
\end{align*}
\]

a) The restoring force exerted by the springs is always proportional to the displacement and in the opposite direction. True or False? Explain.
b) This system is an example of a simple harmonic oscillator. True or False? Explain.
c) If the mass $m$ were doubled while leaving the spring constants $k$ and the initial displacement fixed the period of oscillation would double. True or False? Explain.
d) If the mass $m$ were doubled while leaving the spring constants $k$ and the initial displacement fixed the maximum kinetic energy of the puck would double. True or False? Explain.
e) If the initial displacement were doubled while leaving the spring constants $k$ and the mass $m$ fixed the maximum kinetic energy would double. True or False? Explain.
f) If the left spring constant $k$ were doubled while leaving all other parameters fixed the time required for the puck to travel from Y to X would be shorter than the time required for the puck to travel from Y to Z. True or False? Explain.
D. A pendulum of length $L$ and a bob of mass $m$ is attached to a spring of spring constant $k$. When the bob is directly below the pendulum support the spring is at its equilibrium length.

a) Draw a free-body diagram of the bob when it is displaced from equilibrium. Derive an expression for the restoring force exerted on the pendulum bob. You may assume that the spring remains perpendicular to the pendulum because the angular displacements are small. Hint: Use the small angle approximation ($\sin \theta \approx \theta$) and the relationship between arc length $x$ and angle $\theta$ ($x = L\theta$) to write the gravitational part of the restoring force in terms of $x$.

b) Use Newton’s Second Law of Motion $\vec{F}_{net} = m\ddot{a}$ and your result in part a) to derive an expression of the form

$$-Cx(t) = \frac{d^2x(t)}{dt^2}$$

for the oscillator system, where $C$ is a constant that depends on $k, m, L,$ and $g$.

c) Find an expression for the period of oscillation using the result from part b). Hint: The period is related to the angular frequency of a test function of the form $x(t) = A\cos(\omega t + \delta)$. 