Recitation 3.4 Review

Each table will be assigned one of the following problems. Work out the solution to the problem, and then present it to the class.

1. A True Physics Problem:
A true physicist does not like to deal with anything related to reality, but rather just hypothetical problems. We have a hypothetical 0.5 kg mass attached to a spring with stiffness 200 N/m. The mass is released from rest at a displacement of 0.02 m. Determine the velocity and acceleration when the mass has moved halfway back to its equilibrium position. Also find the total energy, kinetic energy, and potential energy at his position.

2. An Alabama Car:
The shock absorbers in an old car with mass 1000 kg are completely worn out. When a 980 N person climbs slowly into the car, it deforms 2.8 cm. The car is now towed down the road (with the person inside) to where it will be put on cinder blocks. The car hits a bump, and starts oscillating up and down with an amplitude of 6.3 cm. Determine the maximum velocity and acceleration of the car.

3. The Lump of Clay:
A block with a mass \( M \) is moving horizontally on a frictionless surface. It is attached to a horizontal spring with stiffness \( k \) and is moving with simple harmonic motion with an amplitude \( A \). At the instant when the block passes through the equilibrium position, a lump of clay with mass \( m \) is dropped vertically onto the block and sticks to it. Find the new amplitude and period.

4. The Silently Ringing Bell:
A large bell is hung from a wooden beam so it can swing back and forth. The center of mass of the bell is 0.60 m below the pivot, the bell has a mass of 34.0 kg, and the moment of inertia of the bell about its center of mass is 5.8 kg-m\(^2\). The clapper is a 1.8 kg mass attached to one of a slender rod that has length \( L \). What should be the length of the clapper rod for the bell to ring silently, that is, for the period of the oscillation of the bell to equal to that of the clapper?

5. TRECS, or is that T. rex?
All walking animals, including humans, have a natural walking frequency, which is the number of steps per minute that is most comfortable. Suppose this natural walking pace corresponds to the leg acting as a physical pendulum. We will model the leg as a uniform rod pivoted at the hip joint. Back in the day, *Tyrannosaurus rex*, had a leg length of 3.1 m and a stride length of 4.0 m (the distance from one footprint to the next print of the same foot). These values are confirmed both by fossil records and by Dr. Bennett, who is old enough to remember the day. Estimate the walking speed of *T. rex*, and compare it to a human walking speed.

6. The Geeeeologist:
One end of a nylon rope is tied to a stationary support at the top of a vertical mine shaft 80 m deep. The rope is stretched taut by a 20 kg box of rocks attached at is lower end. The mass of the rope is 2 kg. The geologist at the bottom of the mine signals to his colleague at the top by jerking the rope sideways. How long does it take for this signal to reach the top (ignore the tension due to the mass of the rope)? If the geologist gives the rope transverse simple harmonic motion with a frequency of 2 Hz, how many cycles of waves are there in the ropes length? If we include the mass of the rope, what is the wave speed at the top of the rope?
7. **Soap on a Rope:**
Three pieces of rope, each of length $L$, are joined together end to end to make a combined rope of length $3L$. The first piece has mass per unit length $\mu_1$, the second piece has $\mu_2 = 4\mu_1$, and the third piece has $\mu_3 = \mu_1/4$. If the combined rope is under tension $F$, how much time does it take a transverse wave to travel the entire length $3L$? Give your answer in terms of $L$, $F$, and $\mu_1$. In which part of the rope does the wave travel the fastest? Does the time depend on the order in which the three ropes are joined together?

8. **The World's Largest Bass Viol:**
In an effort to get your name into the Guinness Book of World Records you set out to build a bass viol with strings that have a length of 5 m between fixed points. One string has a linear mass density of 40 g/m and a fundamental frequency of 20 Hz (about the lowest frequency the human ear can hear). Calculate the tension in the string. The strings are to be made of steel, which has a density of 7800 kg/m$^3$. What is the stress in the steel? If we double the area of the string, and still wanted to have a fundamental frequency of 20 Hz, what would be the stress is the steel?

9. **Guitar String:**
A guitar string is vibrating in its fundamental mode, with nodes at each end. The length of the string is 0.386 m. The maximum transverse acceleration of the middle point is $8.4 \times 10^3$ m/s$^2$ and the maximum transverse velocity is 3.8 m/s. What are the fundamental frequency (Hz) and the amplitude of the guitar string? What is the wave speed for the transverse waves on the guitar string?