Extra Problems
Fall 2018

Although we only assigned 10 homework assignments to be graded, below are some additional questions that may be worth solving to ensure that you are keeping up with the material and ready for the test. These will not be collected, but I would suggest working through at least some of these.

1. A wedge of height H and wedge-angle θ has a number of different items move down it.

   a) If a solid uniform sphere of radius R and mass M starts from rest at the top of the wedge and rolls down the wedge without slipping, how long does it take the sphere to reach the bottom of the wedge?

   b) If a uniform disk of radius R and mass M starts from rest at the top of the wedge and rolls down the wedge without slipping, how long does it take the disk to reach the bottom of the wedge?

   c) If a uniform hoop of radius R and mass M starts from rest at the top of the wedge and rolls down the wedge without slipping, how long does it take the hoop to reach the bottom of the wedge?

   d) If a mass (irrelevant shape) of radius R and mass M starts from rest at the top of the wedge and slides frictionlessly down the wedge, how long does it take the mass to reach the bottom of the wedge?

2. An undamped, undriven oscillator reaches maximal displacement from equilibrium A and has maximal velocity $v_\circ$. In terms of these two variables and fundamental constants *only*, what is:

   a) The period of oscillation?

   b) The frequency of oscillation?

   c) The angular frequency of oscillation?

3. A 0.850 kg object attached to a spring with a force constant of 12.35 N/m vibrates in simple harmonic motion with an amplitude of 18.45 cm. Calculate:

   a) The maximum speed of the object.

   b) The maximum acceleration of the object.

   c) The speed of the object when it is 13.25 cm from its equilibrium position.

   d) The acceleration of the object when it is 13.25 cm from its equilibrium position.

   e) The amount of time required for the object to move from 3.2 cm from its equilibrium position to 8.4 cm from its equilibrium position. (Technically, there are a lot of possible answers to part (e) since the motion repeats itself; I want the shortest time possible given the other parameters of the problem).

4. Grandfather (e.g. pendulum) clocks can often be approximated by a simple pendulum of length ℓ having a point mass m at the end of a rod. For sake of simplicity, we will start by assuming the rod itself is rigid but massless.

   a) If the goal is to have the pendulum undergo two full oscillations per second, how long must the rod be? (You should give me a numerical answer to this one).

   b) Many real pendulum clocks have the ability to use a screw to slightly adjust the length of the rod to adjust for thermal expansion. Let us say you have a pendulum clock that is supposed to have the pendulum undergo two full oscillations per second, but you find that – by comparing it to a trustworthy reference clock – the pendulum clock is 7 seconds fast every day. Should you use the screw to make the length of the rod longer or shorter?

   c) How much do you need to change the length of the rod by in part (b) so that the pendulum clock keeps accurate time?

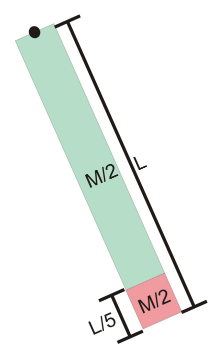
5. Some semesters, we run an experiment called the "ballistic pendulum" lab, where we explore inelastic collisions, energy conservation, angular motion, and oscillations all at once. Here's a setup that explores some of those same ideas.

   We will use the figure below to represent a physical pendulum that can be viewed as a simplified version of the ballistic pendulum setup. The physical pendulum will be made of two equal-mass components, each having mass $M/2$. The black circle at the top of the figure indicates the pivot point. The center of mass of the system is designed to be at the intersections of the two pieces of the physical pendulum, and exists at a distance of $4L/5$ from the pivot.

   a) What is the angular frequency (ω) of small oscillations for this system? (You may assume that the pendulum is a very thin rod, so you don't have to worry about the "width" of the arm, just its length). Leave your answer in terms of L, M, g, and any other necessary natural constants.

   b) If we had a simpler system – a simple pendulum with a bob of mass M and an arm of length $4L/5$ – what would be the angular frequency of small oscillations for this system? (Leave your answer again in terms of L, M, g, and any other necessary natural constants).

   c) Which of your answers (a) or (b) is greater?



6. A mass-spring system of mass M and spring constant k is oscillating on a frictionless horizontal table-top at its natural (angular) frequency $\omega_\circ$ with amplitude A. At the instant the mass is stretched its furthest from equilibrium, you clip on a second mass M onto the top of the first mass, so now a mass of $2M$ is being oscillated by a spring of spring constant k.

   a) What is the ratio $\frac{E(\text{before new mass added})}{E(\text{after new mass added})}$?

   b) What is the ratio $\frac{v_{\max}(\text{before new mass added})}{v_{\max}(\text{after new mass added})}$? ($v_{\max}$ indicates maximal velocity).

   c) What is the ratio $\frac{\text{Oscillation period before new mass added}}{\text{Oscillation period after new mass added}}$?

7. A circular hoop hangs from a nail on a barn wall. The mass of the hoop is 3 kg and its radius is 20 cm. If the hoop is displaced slightly by a passing breeze, what is the period of the resulting oscillations?

8. A little googling told me that it takes about 6.5 GPa of pressure to crush a human skull. (Im sure Im on a watch-list now). Some more googling told me that it takes about 300 psi to completely crush a (full) soda can. The depth of the ocean at its deepest point is about 11000 meters.

   a) If we believe the numbers above, is it possible to crush a human skull by bringing it to the bottom of the ocean? Justify your answer with an appropriate calculation.

   b) How deep would you have to place a full soda-can in the ocean so that it would be crushed?

   c) How deep would have have to go in the ocean so that the total pressure above you (atmospheric + water pressure) would equal twice standard atmospheric pressure?

9. The highest sea-level-equivalent atmospheric pressure ever recorded on Earth was about 108380 Pa. If you wanted to reliably measure this pressure with a water barometer, how tall would the barometer have to be (at minimum, in feet)?

10. The density of wood (ash) can vary from tree to tree, but well treat it as about 580 kg/m 3 . The density of gasoline is about 770 kg/m 3 . If you have a piece of ash wood floating in a pool of gasoline, what fraction of the wood would be visible above the water?

11. The density of aluminum is about 2700 kg/m 3 . What is the magnitude of the buoyant force on a 4.0 cm x 4.0 cm x 4.0 cm cube of aluminum submerged in a pool of glycerol (density of 1250 kg/m 3).

12. A long, cylindrical pipe has radius $r = 8$ cm.

    a) If this pipe has water flowing in it at a rate of 200 L/min, how fast is the water moving?

    b) The pipe suddenly constricts from its initial radius of 8 cm to a smaller radius. What would the smaller radius have to be if the water now starts moving at half the speed of sound in air? (In other words, now the water will be moving at 172 m/s).

    c) If the pressure in the pipe is equal to 0.1 atm when it is at the thinner radius (your solution to part (b) above), what was the pressure in the pipe when it was at the 8 cm radius? (You can assume the pipe remains horizontal and in both cases we are talking about the pressure in the middle of the cross-section).

13. The density of aluminum is about 2700 kg/m^3 . The density of glycerol is about 1250 kg/m^3 . A uniform aluminum sphere with diameter 4.0 cm is submerged in glycerol and dropped.

   a) What is the magnitude of the buoyant force on the aluminum sphere?
   b) What is the net force on the sphere of aluminum in the glycerol, assuming no drag force?
   c) In reality, there is a drag force on such a sphere falling in glycerol, and it depends on the speed of the sphere. An object is said to be falling at its "terminal velocity" if the total net force on the object is equal to 0. Let us assume the drag force on a sphere with diameter D to be $3\pi\mu Dv$ with μ equal to the viscosity of the fluid (for glycerol this is 1.412 kg/(m s)) and v the fall velocity of the sphere. The force is directed against the direction of the movement so in this case the drag force would point upward (against the direction of the spheres fall). Find the terminal fall-velocity of the 4 cm diameter aluminum sphere in glycerol.

I have answers to each of the above questions somewhere if you need them, though not all in one easy-to-find organized place. Additional studying from textbook questions (most textbooks give the answers to the odd-numbered problems in the back) is always a good idea. Since some of you have asked me to supply suggested questions, here are ones that – upon brief glance – like to me like good problems from the last few chapters we will be covering this semester. That being said, I haven't worked these out. I'm glad to take a look at them if you'd like, but I'll be going into them pretty much cold. Also note that I'm kind of guessing which thermodynamics topics we will get to. There is a very real chance that we won't have talked about some of these topics at all and, of course, then I wouldn't test you on them.

Serway and Jewett:
Chapter 12, problems 5, 9, 17, 19, 23, 25, 27, 31, 37, 47, 65, 67
Chapter 15, problems 5, 9, 21, 23, 25, 29, 37, 41, 51, 55
Chapter 16, problems 3, 37, 45, 47, 55
Chapter 17, problems 5, 9, 13, 27, 67, 87
Chapter 18, problems 1, 5, 9, 29, 39

Halliday and Resnick:
Chapter 14, problems 1, 5, 13, 31, 33, 37, 45, 51, 61, 71, 73, 79, 85
Chapter 15, problems 3, 9, 17, 19, 25, 27, 33, 47, 51 , 57, 63, 83, 85, 103
Chapter 18, problems 5, 23, 31, 37
Chapter 19, problems 19, 23, 29, 35, 55
Chapter 20, problems 3, 23, 59, 71