PHYS-2020: General Physics II
Problem Set 3, Spring 2025

There are two sections to this Problem Set, the first section of problems are located on the textbook publisher's *WebAssign* web site:

https://webassign.com

These problems will be graded and must be completed by 6:00 p.m. on Friday, April 4, 2025. **Start working on these problems immediately once they are posted on *WebAssign*. Don't wait until the last day to start them. One never knows when the network will go down, and you will not be able to use this as an excuse for not doing your *WebAssign* problems.** As a matter of fact, there will be no allowed excuses for not doing your *WebAssign* homework.

Once you click on the *WebAssign* web site above, click on the "Enter Class Key" button on the upper right of this web page. The class key for this course is:

etsu 9516 9316

A Quick Start Guide for using this web site can be found on the course web page. Should you need additional assistance with *WebAssign*, you can contact Technical Support information at:

https://webassign.com/support/student-support/

via the web or

1-800-354-9706

by telephone.

---

1. A rope is attached between two vertical walls and a spring is attached to this rope at the halfway point and to the floor. As a result, the spring pulls the rope downward such that both sides of the rope make an angle of 32.5° to the horizontal at the point where the spring is attached. (a) If the tension on either side of the rope is 210 N and the spring constant is 5.60×10^4 N/m, how far must the spring be stretched with respect to its equilibrium position? (b) Now replace the rope with two identical springs such that the system makes the same V shape as described above. If the stretch of each of these new springs is twice that of the original spring, what must be the spring constant of these new springs?

2. At an outdoor market, a bunch of bananas attached to the bottom of a vertical spring of force constant 16.0 N/m is set into oscillatory motion with an amplitude of 20.0 cm. It is observed that the maximum speed of the bunch of bananas is 40.0 cm/s. What is the weight of the bananas in newtons?

3. A "seconds" pendulum is one that moves through its equilibrium position once each second. (The period of the pendulum is 2.000 s.) The length of a seconds pendulum is 0.9927 m at Tokyo and 0.9942 m at Cambridge, England. What is the ratio of the free-fall accelerations at these two locations?

4. Tension is maintained in a string attached to a mass hanging from a pulley (see the diagram in the solutions). The observed wave speed is $v = 24.0$ m/s when the suspended mass is $m = 3.00$ kg. (a) What is the mass per unit length of the string? (b) What is the wave speed when the supported mass is $m = 2.00$ kg?

5. A sound wave has a frequency of 700 Hz in air and a wavelength of 0.50 m. What is the temperature of the air?

6. The intensity level of an orchestra is 85 dB. A single violin achieves a level of 70 dB. How does the intensity of the sound of the full orchestra compare with that of the violin's sound?

7. A skyrocket explodes 100 m above the ground. Three observers are spaced 100 m apart, with the first (A) directly under the explosion. (a) What is the ratio of the sound intensity heard by observer A to that heard by the middle observer (B)? (b) What is the ratio of the sound intensity heard by observer A to that heard by the farthest-right observer (C)?

8. At rest, a car's horn sounds the note A (440 Hz). The horn is sounded while the car is moving down the street. A bicyclist moving in the same direction with one-third the car's speed hears a frequency of 415 Hz. (a) Is the cyclist ahead or behind the car? (b) What is the speed of the car?

9. Two loudspeakers are placed above and below each other 3.00 m apart and are driven by the same source at a frequency of 500 Hz. (a) What minimum distance should the top speaker be moved back in order to create destructive interference between the speakers? (b) If the top speaker is moved back twice the distance calculated in part (a), will there be constructive or destructive interference? Why?

10. A 0.300 g wire is stretched between two points 70.0 cm apart. If the tension in the wire is 600 N, find the frequencies of the wire's first, second, and third harmonics.

11. The human ear canal is about 2.8 cm long. If it is regarded as a tube that is open at one end and closed at the eardrum, what is the fundamental frequency around which we would expect hearing to be most sensitive? Take the speed of sound to be $34\underline{0}$ m/s.

12. A particular electromagnetic wave traveling in vacuum has a magnetic field amplitude of 1.5×10^{-7} T. Find (a) the electric field amplitude and (b) the average power per unit area associated with the wave.

13. What are the wavelength ranges in (a) the AM radio band (540 – 1600 kHz) and (b) the FM radio band (88 – 108 MHz)?

14. The "size" of the *nucleus* in Rutherford's model of the atom is about 1.0 fm $= 1.0 \times 10^{-15}$ m. (a) Determine the repulsive electrostatic force between the two protons separated by this distance. (b) Determine (in MeV) the electrostatic potential energy of these two protons.

15. A hydrogen atom is in the first excited state ($n = 2$). Using the Bohr theory of the atom, calculate (a) the radius of the orbit, (b) the linear momentum of the electron, (c) the angular momentum of the electron, (d) the kinetic energy, (e) the potential energy, and (f) the total energy.

16. Analyze the Earth-Sun system by following the Bohr model, where the gravitational force between the Earth (mass m) and the Sun (mass M) replaces the Coulomb force between the electron and proton (so that $F = GMm/r^2$ and PE $= -GMm/r$). Show that (a) the total energy of the Earth in an orbit of radius r is given by $E = -GMm/2r$, (b) the radius of the nth orbit is given by $r_n = r_\circ n^2$, where $r_\circ = 10^{-138}$ m, and (c) the energy of the nth orbit is given by $E_n = -E_\circ/n^2$, where $E_\circ = G^2M^2m^3/2\hbar^2 = 1.71 \times 10^{182}$ J. (d) Using the Earth-Sun orbit radius of $r = 1.49 \times 10^{11}$ m, determine the value of the quantum number n for the Earth. (e) Should you expect to observe quantum effects in the Earth-Sun system? Why?

17. The orbital radii of a hydrogen-like atom is given by the equation

$$r_n = \frac{n^2\hbar^2}{Zm_e k_e e^2}\,.$$

What is the radius of the first Bohr orbit in (a) He^+, (b) Li^{2+}, and Be^{3+}?