

**Phy114: Electromagnetism, Waves and Radiation
for the Sports Science
Homework Problems
Set #3: Due Wednesday, February 20, 2008**

Note: Students are encouraged to work together and discuss the problems. However, each student must arrive at her/his own final answers. Show all your work. Simply copied homework will result in zero.

1. (15 points) The fastest military jet plane is the [SR-71 Blackbird](#) at a top speed of Mach 3.2 (1 Mach = speed of sound, ~ 340 m/s). Imagine a low-flying [Blackbird](#) approaches a stationary observer on the ground at a speed of Mach 2.0 on a day when the speed of sound is 340 m/s. (a) What is the top speed of the Blackbird in mph? (b) If the engine emits a sound of frequency 3500 Hz, what frequency does the stationary observer receive as the jet plane approaches? (c) As the plane flies away?
2. (10 points) The speed of sound in tissue is about the same as in ocean water, 1500 m/s. An ultrasonic wave sent into blood will be partly reflected back toward the source by blood cells. If the returning echo has a frequency 300 Hz lower than the original 1.5 MHz frequency, what is the velocity of the blood? (*Hint: Note that there are two Doppler shifts here.*)
3. (15 points) (a) Calculate the force between two identical charges of 1.0×10^{-9} C separated by 0.3 cm. These charges are typical of those involved in static electricity. (b) What is the force if the separation is doubled? Tripled? (c) What is the force if the charges are increased by a factor of 5 and the separation is kept at 0.3 cm?
4. (10 points) A hydrogen atom consists of a single proton and a single electron separated by 0.53×10^{-10} m. (a) Calculate the Coulomb force between them. (b) Calculate the acceleration of the electron due to this force and compare the acceleration with that of gravity (g).
5. (10 points) The energy expended by a battery is related to both battery voltage and the amount of charge it moves. (a) Calculate the energy in joules put out by two 1.5 V AA batteries (3V total) that moves 20.0 C of charge through Prof. Jung's laser pointer after 1 hr of operation. (b) Calculate the energy put out by a 12.0 V car battery that moves 1500 C of charge (as it may when starting the car's engine).
6. (10 points) What voltage is needed to accelerate electrons to 0.3% of speed of light, in a situation similar to that of the CRT discussed in the lecture?