Physics 1C, Summer Session I, 2011
Final Exam

Instructions: Do any 8 problems. Please do all work on separate sheets of paper, and hand in everything you want to be graded. Clearly mark the problems that you want graded, and box the answers.

1. A mass on a spring undergoes simple harmonic motion. The speed of the mass is given by the following expression:

$$v(t) = - (0.35m/s) \sin \left[(12.6s^{-1})t \right]$$

(a) What is the frequency of the mass's motion?

(c) What is the total energy of the harmonic oscillator?

2. A string with a mass per unit length of $0.050kg/m$ is tied down at both ends, 1 meter apart, and held under tension. The fundamental frequency of the string is $120hz$.

(a) What is the 5th harmonic frequency?

(b) What would be the fundamental frequency if the tension was doubled?

3. A jet aircraft flying 300 meters overhead produces a sound intensity level of 110 decibels on the ground. What is the total power produced in sound waves, in watts?

(a) What is the intensity level of this sound, in decibels, when heard from a distance of 20 kilometers?

(b) What is the total power emitted by the aircraft in the form of sound waves?

4. When sound strikes a cliff, it is observed to be fully reflected unless the angle between the direction of the sound and the normal to the cliff surface is less than 6.2 degrees. For angles less than 6.2 degrees, some of the sound is absorbed by the cliff. If the speed of sound in air is 330 *m/s*, what is the speed of sound in the rock of the cliff?

5. An object is placed $20cm$ in front of a divergent lens with a focal length of -10*cm*. A second divergent lens, with a focal length of -15*cm*, is placed $20cm$ behind the first lens.

(a) Draw a ray diagram for this situation.

(b) Calculate the position of the final image and the magnification.

6. A loudspeaker is located some distance L from an observer and 6 meters away from a sound-reflecting wall. The observer is also 6 meters away from the wall. When the sound reflects from the wall, it undergoes no phase change since the speed of sound in the wall is higher than in air. If the sound from the loudspeaker has a frequency of $120hz$, at what distances from the loudspeaker is the sound quieter due to destructive interference between the sound and the echo? Give all locations for $L < 20$ meters. The speed of sound in air is 330 m/s.
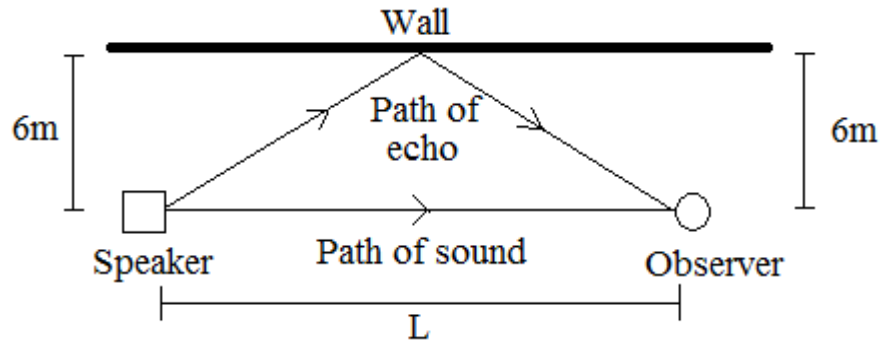
7. Unstable particles are produced traveling with a speed of $0.962c$. The particles travel an average distance of $1.2cm$ from the source before decaying. What is the lifetime of the particles in the frame where they are at rest?

8. Two beams of protons collide head-on in a particle accelerator. In the lab frame, the protons in each beam have a kinetic energy of 4.00 GeV. The rest energy of a proton is 0.938 GeV.

(a) Find the speed of the protons relative to the lab, as a fraction of c?

(b) Find the speed of the protons in one beam relative to the protons in the other beam.

9. A beam of electrons is accelerated through a voltage V. The beam is incident on a crystal with lattice spacing of $0.22nm$. The angle between the central maximum and the first diffraction peak on the screen is 16 degrees. What is the accelerating voltage V?

10. A muon decays via the weak interaction into three particles. One of these is an electron.

(a) What must the other two particles be? Use conservation of lepton number for each generation of leptons.

(b) Draw a Feynman diagram for this process.