

**Physics 5150**  
**Homework Set # 10**  
**Due 5 pm Thursday 4/19/2018**

**Problem 1: Sound waves**

*Derive the dispersion relation for sound waves in a neutral gas (e.g., air) with an adiabatic equation of state ( $P \sim \rho^\gamma$ ), using the gas dynamics (fluid) equations. What are the phase and group velocities of these waves?*

**Problem 2: Energy Partitioning in Plasma Oscillations**

*Consider Langmuir's electron plasma oscillations in an unmagnetized cold plasma (treat ions as a stationary uniform neutralizing background,  $n_i = \text{const}$ ,  $u_i = 0$ ). What is the greater: the electron kinetic energy density due to the perturbed electron velocity,  $\mathcal{E}_{\text{kin}} = n_0 m_e |u_{e,1}|^2/2$ , or the energy density of the perturbed electric field,  $\mathcal{E}_{\text{el}} = |E_1|^2/(8\pi)$ , and by what factor? For definiteness, just consider the oscillation amplitudes for both energy density components.*

**Problem 3: Radio Blackout**

*A space capsule making a reentry into the Earth's atmosphere suffers a communication blackout because a plasma is generated by the shock wave in front of the capsule. If the radio operates at a frequency of 300 MHz, what is the minimum plasma density during the blackout?*