

**Phy 352 (Fluid Dynamics) Spring 2013, Problem Set 4**

1. What is the angle of the so-called “Mach cone” formed by an object moving at supersonic speeds?
2. Consider the shock piston problem, where a piston is moving through a closed tube, exciting *weak* acoustic waves. Find the pressure and density everywhere in the tube
3. What is the Riemann invariant for *large* acoustic waves? (derive)
4. Derive the shock jump conditions from the basic conservation equations in terms of
  - (a) the upstream Mach number  $\mathcal{M}_1$
  - (b) the downstream Mach number  $\mathcal{M}_2$
5. How is the two point correlation function related to the mean kinetic energy energy in the turbulent fluctuations?
6. Explicitly show that the quantity  $\epsilon$  is invariant with wavenumber in a turbulent cascade.
7. Carefully go through (and fill in the missing steps in) the derivation that shows the Reynolds stress arising out of turbulent fluctuations acts like a viscous stress for the mean flow.