**Solutions**

**Problem 1:**
(A) Phase and group velocity: phase velocity: $\omega/k$, group velocity: $d\omega/dk$.
Information (energy) moves with a speed equal to the group velocity.

**Problem2:**
(E) Phase and group velocity: phase velocity: $\omega/k$, group velocity: $d\omega/dk$.
$d\omega/dk = c^2k/ (c^2k^2 + m^2)^{1/2}$

**Problem 3:**
(B) Doppler shift:
For the end moving towards the observer:
$f'_1 = f[(1+v/c)/(1-v/c)]^{1/2} \approx f[1+v/c)]$
For the end moving away from the observer:
$f'_2 = f[(1-v/c)/(1+v/c)]^{1/2} \approx f[1-v/c)]$
Therefore $\Delta f = f'_1 - f'_2 = 2f\, v/c$.
$v = (\Delta f/f)c/2 = (\Delta\lambda/\lambda)c/2 = (1.8*10^{-12}/1.22*10^{-7})*1.5*10^8 = 2213\text{m/s} = 2.2\text{km/s}$

**Problem 4:**
(B) Polarization: For plane polarization the x- and x-components of **E** are in phase or $180^o$ out of phase.

**Problem 5:**
(A) Vector addition.
After a path difference of $2\pi/k = \lambda$ the phases of the x and y components still differ by $\pi$.

**Problem 6:**
(D) This answer is not a solution to the wave equation $\partial^2f/\partial t^2 = v^2\, \partial^2f/\partial x^2$, i.e. it is not a linear superposition of solutions of the form $f(x,t) = f(x \pm vt)$.

**Problem 7:**
(B) Mirrors and thin lenses: $1/x_o + 1/x_i = 1/f$, $M = -x_i/x_o$.