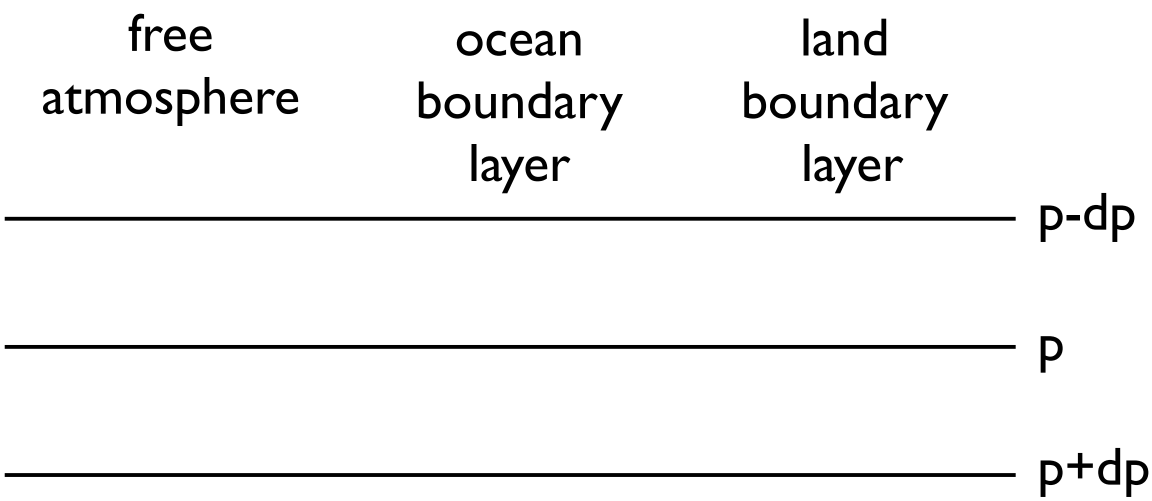
Atmos 5220/6220
Midterm Exam sample problems

A list of equations and physical constants follows the problems.

1. (a) Turbulence can be created by two processes. What are they?

   (b) Turbulence can be destroyed by two processes. What are they?

2. Draw arrows to represent the horizontal wind vectors for the given horizontal pressure field and flow regimes.



3. Find u_* (friction velocity) and z_0 (roughness height) from the following wind profile measurements made during statically neutral conditions at sunset:

z (m)	$\bar{u}$ (m/s)
2	2.3
10	3.9

4. (a) In the surface layer, how does the vertical gradient of wind speed change as the stability increases?

(b) In the surface layer, how does the mechanical production of turbulence kinetic energy change as the stability increases?

(c) In the surface layer, how does the buoyancy production or loss of turbulence kinetic energy change as the stability increases?

5. (6 points) Given: surface vertical turbulent flux of temperature $(\overline{w'\theta'})_s = 0.1$ K m s^{-1}, boundary layer thickness $z_i = 0.8$ km, friction velocity $u_* = 0.2$ m s^{-1}, and $T = 300$ K, calculate and explain the significance of the values of the:
(a) convective velocity scale, w_*,

(b) Obukhov length, L, and

(c) convective time scale.

Useful equations and constants

Constants:

$0°$ C $= 273.16$ K
$g = 9.8$ m s^{-2} (acceleration of gravity)
$\rho_w = 1000$ kg m^{-3} (density of liquid water)
$c_w = 4186$ J kg^{-1} K^{-1} (specific heat capacity of liquid water)
$c_p = 1004$ J kg^{-1} K^{-1} (specific heat at constant pressure for dry air)
$c_v = 717$ J kg^{-1} K^{-1} (specific heat at constant volume for dry air)
$R_d = c_p - c_v = 287$ J kg^{-1} K^{-1} (gas constant for dry air)
$R^* = 8.31$ J mol^{-1} K^{-1} (universal gas constant)
$m_d = 28.97$ g mol^{-1} (mean molecular weight of dry air)
$m_v = 18.02$ g mol^{-1} (molecular weight of water vapor)
$k = 0.4$ (von Karman constant)
$L_v = 2.5 \times 10^6$ J kg^{-1} (latent heat of vaporization)