

Atmospheric Sciences 336, Fall 2007
Problem Set 3
Due Friday, Oct 5

Problem 1 *There once was a disturbed particle....*

Consider a resting atmosphere with a temperature profile given by

$$T_0(z) = T_s - \Gamma z$$

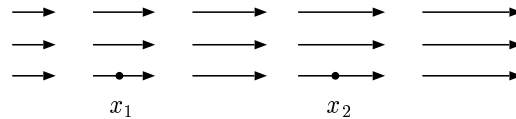
where $T_s = 288$ K and $\Gamma = 6.5$ K/km. Suppose that some sort of disturbance lifts a particle from its resting height of $z = 1000$ m to a disturbed height of $z + \Delta z = 1200$ m.

(a) Estimate the restoring force/mass on the disturbed particle at its displaced height. (Be careful with your units!) Express your answer as a fraction of g (i.e., $2g$, $0.05g$, etc). And which direction is this force?

(b) Is the atmosphere described above stable or unstable? How do you know?

Problem 2 *Stretching in a 1D flow*

Consider points $x_1(t)$ and $x_2(t)$ moving with a one-dimensional flow field described by $\partial u/\partial x = \kappa$, where κ is a positive constant.



(a) We showed in class that positive $\partial u/\partial x$ implies stretching along the x -axis. Consistent with this, show that in the present case the distance between x_1 and x_2 increases exponentially in time. Specifically show that

$$x_2(t) - x_1(t) = (x_2(0) - x_1(0)) e^{\kappa t}$$

(b) Now suppose that $\partial u/\partial x$ is negative. Will the points x_1 and x_2 ever touch? If so, when?

Problem 3 *Let's see, u increases this way...*

Consider a velocity vector field described by

$$\mathbf{u}(x, y) = (u(x, y), v(x, y))$$

Typically we would sketch this field by picking a series of (roughly evenly spaced) points (x, y) and then drawing arrows at these points to represent the corresponding values of $\mathbf{u}(x, y)$. For each of the following, sketch out a vector field that has the indicated properties. Note that there are various correct answers for each case—just pick something consistent.

- (a) $u = 0$, $\partial v/\partial y = 0$, and $\partial v/\partial x > 0$ (b) $u = 0$, $\partial v/\partial x = 0$, and $\partial v/\partial y < 0$
(c) $v = 0$, $\partial u/\partial y < 0$, and $\partial u/\partial x > 0$ (d) $v = 0$, $\partial u/\partial x > 0$, and $\partial u/\partial y > 0$
(e) $\partial u/\partial x > 0$, $\partial u/\partial y = 0$, $\partial v/\partial x > 0$, and $\partial v/\partial y = 0$