

Exercises

- 13.1** Using (13.9), determine the minimum value of $-N^2$ needed to produce convective instability. What is the value of k^2 for which this minimum is achieved?
- 13.2** Using $\sigma = i(-N^2)^{1/2}$, and $N^2 = \frac{g}{T}(\frac{\partial T}{\partial z} + \frac{g}{c_p})$, what must $\frac{\partial T}{\partial z}$ be for $\sigma = \frac{2\pi}{3 \text{ hrs}}i$? What do we learn from this?
- 13.3** For the Orr mechanism with the basic state and initial perturbation given by (13.55) and (13.61), respectively, find the values of m and m_0 such that for $m > m_0$ the perturbation grows before decaying. (The point is that part of (13.61) (*viz.*, (13.62)) decays and part grows; we want to know how large m must be so that the growing part grows more than the decaying part decays.)
- 13.4** (a) Calculate $\bar{u}(z)$ corresponding to two-level neutrality.
 (b) Why does neutrality occur when $\bar{q}_y = 0$ in the bottom layer?
 (c) When a two-level model is unstable, how does the maximum c_i relate to the range of variation of \bar{u} ?
 (d) How is baroclinic instability affected when N^2 is different in the two layers?
- 13.5** There are two classical versions of the baroclinic instability problem: the Charney (1947) problem and the Eady (1949) problem. There is also the pedagogically popular two-level problem considered in this chapter. Actually, the Eady problem is about as easy as the two-level problem. The Eady problem deals with baroclinic instability of a boussinesq fluid on an f -plane (i.e., $\beta = 0$), where the basic state consists in a constant shear, and where the fluid has top and bottom boundaries. In such a fluid, $\bar{q}_y = 0$ in the interior, which greatly simplifies the equations. Investigate the stability properties of the the Eady model. What is the physical nature of the neutral solutions?
- 13.6** It is clear from Section 13.3 that there need not be much mathematical difference between barotropic and baroclinic instability problems. Develop basic states for barotropic models which lead to stability problems

which are mathematically identical to (a) two-level baroclinic models and (b) the Eady model.