1. Problem 2.1 in Holton. We have a bit of jargon here. Pressure “tendency” means the local rate of pressure change. Thus we want to evaluate
\[ \frac{\partial p}{\partial t} = \frac{Dp}{Dt} - \mathbf{v} \cdot \nabla p. \]
The data refers to a moving platform, namely a ship. This is fine, as long as the velocity of the ship is used to evaluate the advection term. We are given
\[ \frac{Dp}{Dt}_{\text{ship}} = -\frac{100}{3 \text{ hr}} \text{ Pa}. \]
We are also given enough information to evaluate
\[ \mathbf{v}_{\text{ship}} : \nabla p = 10 \frac{\text{ km}}{\text{ hr}} \times 5 \frac{\text{ Pa}}{\text{ km}} \times \cos(45^0) = 35 \frac{\text{ Pa}}{\text{ hr}}. \]
This also enters the pressure tendency with a negative sign, so both terms are negative. Their sum gives \( \frac{\partial p}{\partial t} = -0.68 \) hPa/hr.

2. Problem 2.2 in Holton. I believe that one needs to assume that \( \frac{\partial T}{\partial x} = 0 \), i.e. that the temperature gradient points exactly southward. Then the angle between the velocity and the temperature gradient is determined, and
\[ \frac{\partial T}{\partial t} = -\mathbf{v} \cdot \nabla T + Q = -20 \frac{\text{ m}}{\text{ s}} \times 3 \text{ K} \times 50 \frac{\text{ km}}{\text{ s}} \times \cos(45^0) + 1 \frac{\text{ K}}{\text{ hr}}. \]
Units of K/hr are convenient because they give numbers of order unity and are intuitively pleasing, so convert the first term by multiplying by 3600 s/hr. In addition, don’t forget to use 1 km = 1000 m. The answer is \( \frac{\partial T}{\partial t} = -2.05 \) K/hr.

3. Problem 2.4 in Holton.

We need to evaluate
\[ \frac{D\mathbf{k}}{Dt} = u \frac{\partial \mathbf{k}}{\partial x} + v \frac{\partial \mathbf{k}}{\partial y}. \]
Consider first
\[ \frac{\partial \mathbf{k}}{\partial y} \]
To evaluate \( \delta \mathbf{k} \) we can draw two unit vectors emanating from the same point, since their directions are determined only by the latitude. Then it is clear that
\[ \delta \mathbf{k} = j \delta \varphi, \]
where \( j \) points northward. Then the derivative
\[
\frac{\partial \mathbf{k}}{\partial y} \approx \frac{\partial \mathbf{k}}{\partial y} = \frac{j \delta \varphi}{a} = \frac{j}{a}.
\]

Similarly, by drawing a polar projection view and considering the angular change of longitude, one can derive

\[
\frac{\partial \mathbf{k}}{\partial x} = \frac{i}{a},
\]

where \( i \) points eastward. Thus altogether,

\[
\frac{D \mathbf{k}}{Dt} = u \frac{\partial \mathbf{k}}{\partial x} + v \frac{\partial \mathbf{k}}{\partial y} = \frac{i}{a} \frac{u}{a} + \frac{j}{a} \frac{v}{a}
\]