Setting the derivative equal to zero, we see that \( y = -1/2 \) is an equilibrium point, and a horizontal line is traced out as \( t \) becomes large. For \( t > 1/2 \), the \( y \) value goes to infinity as \( t \) becomes large, while the \( y \) value goes to negative infinity as \( t \) becomes large if one starts at \( t < 1/2 \).

```maple
> with(DEtools):
deq:=diff(y(t),t)=1+2*y(t);
DEplot(ddeq,y(t),t=0..5,y=-2..2);
```

where \( \frac{dy}{dt} = 1 + 2y \)

p. 9 # 9.

We want the derivative to be positive if \( y > 2 \), and negative if \( y < 2 \). Hence, we could take
\[
\frac{d}{dt} y(t) = y(t) - 2.
\]
Checking:

> de := diff(y(t), t) = y(t) - 2;
> DEplot(de, y(t), t=0..5, y=0..4);

We find the critical point by setting the derivative to zero, which gives an a horizontal equilibrium \( y \equiv 0 \). However, solutions increase both below and above \( y = 0 \). For initial values \( y > 0 \), solutions go to plus infinity as \( t \) gets large. On the other hand, for initial values of \( y < 0 \), solution curves rise, then asymptotically approach the solution line \( y \equiv 0 \). Solutions cannot cross the line since a crossing point would have two distinct solutions coming from it, which would violate the Existence and Uniqueness Theorem for nonlinear equations.
p. 11 # 21.

Let \( q(t) \) be the number of grams of the undesirable chemical after \( t \) hours.

During a short period of time \( \Delta t \), 300 \( \Delta t \) gallons flow in to the lake, increasing the quantity of the chemical by \( 0.01 \cdot 300 \Delta t = 3 \) grams.

During the same interval, 300 \( \Delta t \) gallons flow out of the lake, decreasing the quantity of the chemical by \( \frac{q(t) \cdot 300 \cdot \Delta t}{10^6} \) grams.

Hence, the change in the number of grams of the chemical,
\[ \Delta q = \left( 0.01 \cdot 300 - \frac{q(t) \cdot 300}{10^6} \right) \Delta t. \]

Dividing by \( \Delta t \), we get the slope of a secant line on the solution curve. Taking the limit as \( \Delta t \) gets small, we get the slope of the tangent line, i.e., the derivative:

\[ de := \frac{d}{dt} q(t) = 3 - \frac{3}{10000} q(t) \] \hspace{1cm} (1)

We can find the behavior as \( t \) gets large by a direction field plot. Finding the critical point, we see that \( 30000 = 3 \cdot q \), so \( q = 10000 \) is an equilibrium solution. For an initial \( q \) greater than 10000, the derivative becomes negative, and the value of \( q \) falls, but cannot cross 10000. On the other hand, for initial values of \( q \) less than 10000, the value of \( q \) rises, but cannot cross 10000. Hence, regardless of the initial value of \( q \), the limiting amount of the chemical is 10000 grams, which is \( 0.01 \cdot 10^6 \). (If you think about it, after a while all initial amounts of the chemical are flushed out of the system, and the limiting amount is the concentration coming in times the volume of the lake.

We can also use Maple's `dsolve` to derive the same result by solving, then taking the limit as \( t \) goes to infinity.

\[ sol := q(t) = 10000 + e^{-\frac{3}{10000} t} (Q - 10000) \lim_{t \to \infty} q(t) = 10000 \] \hspace{1cm} (2)