N9.18 is a crude estimate of when you would reach terminal velocity, obtained just by setting g t = v_T. That is the intersection of a line with slope -g with the terminal velocity line that is horizontal below.

N9.19 is a plug-in, but we have gone far further and solved Problem N9D.4, which began by suggesting we have Mathematica or Wolfram Alpha do the following integral:

In[ ]:= $\text{Integrate}\left[\frac{1}{1-\frac{v^2}{c^2}}, \{v, 0, \text{vFinal}\}\right]$

Out[ ]=

$c\,\text{ArcTanh}\left[\frac{\text{vFinal}}{c}\right]$ if $\text{Re}\left[\frac{c}{\text{vFinal}}\right] > 1 \,||\, \text{Re}\left[\frac{c}{\text{vFinal}}\right] < -1 \,||\, \frac{c}{\text{vFinal}} \notin \mathbb{R}$

In[ ]:=
```
c = N[200 000 / 3600];
g = 9.8
```

Out[ ]=

9.8

In[ ]:=
```
c
```

Out[ ]=

55.5556

The tanh function is sinh over cosh, where sinh $x = \frac{e^x - e^{-x}}{2}$ and cosh $x = \frac{e^x + e^{-x}}{2}$.

The arctanh relation to tanh is directly analogous to the arctan's relation to tan.

So we take Tanh of both sides of the equation that Mathematica found us and get

In[ ]:=
```
v[t_] := -c Tanh[g t / c]
```

Then we plot it:

In[ ]:=
```
Plot[{-g t, v[t], -c}, {t, 0, 20}, PlotRange → {{0, 20}, {0, -c}}]
```

Out[ ]=