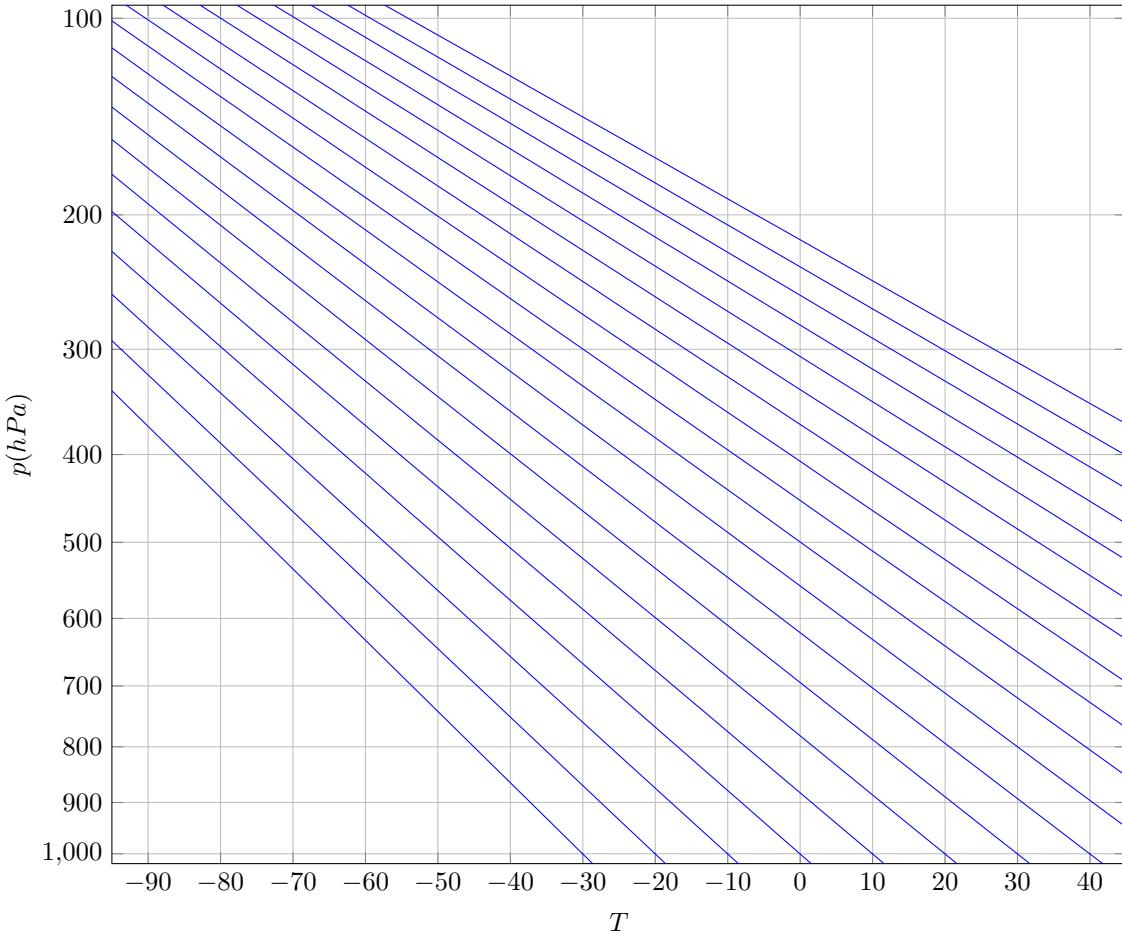


# Stuve diagram in L<sup>A</sup>T<sub>E</sub>X

Dry adiabats calculation

Diagram



## Explanation

Given the following dry adiabats formula<sup>1 2</sup>:

$$\phi = T \cdot \left( \frac{p_0}{p} \right)^k$$

We know that  $\phi$  refers to the  $x$  axis, and  $p$  to the  $y$  axis, so we can rearrange to solve for  $p$ :

$$\frac{\phi}{T} = \left( \frac{p_0}{p} \right)^k$$

$$\left( \frac{\phi}{T} \right)^{\frac{1}{k}} = \frac{p_0}{p}$$

<sup>1</sup>Stull, Roland: *Practical Meteorology: An Algebra-based Survey of Atmospheric Science*, chapter 3, p. 61, equation 3.12, 2018

<sup>2</sup>[www.igf.fuw.edu.pl/m/courses\\_materials.../thermodynamic\\_diagrams.pdf](http://www.igf.fuw.edu.pl/m/courses_materials.../thermodynamic_diagrams.pdf)

$$\begin{aligned} \left(\frac{T}{\phi}\right)^{\frac{1}{k}} &= \frac{p}{p_0} \\ p_0 \cdot \left(\frac{T}{\phi}\right)^{\frac{1}{k}} &= p \\ p &= p_0 \cdot \left(\frac{T}{\phi}\right)^{\frac{1}{k}} \end{aligned}$$

We know that  $\phi$  refers to the  $x$  axis, and  $p$  to the  $y$  axis, while  $p_0$  is the initial pressure with a standart value of 1000 hPa, and  $k$  the Poisson constant, the ratio of the gas constant to the specific heat capacity at constant pressure for an ideal diatomic gas<sup>3</sup>.

$$\phi = x; \quad p = y; \quad p_0 = 1000; \quad k = 0.286$$

We can replace variables:

$$y = 1000 \cdot \left(\frac{T}{x}\right)^{\frac{1}{0.286}}$$

And knowing that temperature should be in Kelvin:

$$y = 1000 \cdot \left(\frac{T + 273.15}{x + 273.15}\right)^{\frac{1}{0.286}}$$

Which gives us a formula to use in the LaTeX diagram.

$$1000 * ((x + 273.15) / (\text{\textbackslash}T + 273.15))^{(1/0.286)}$$

Also, we shoult take into account that in Stuve diagrams we want to draw the dry adiabats as straight lines. Thus  $y$  axis is not logarithmic, but progressing in a ratio of  $y^k$ , or  $y^{0.286}$ .

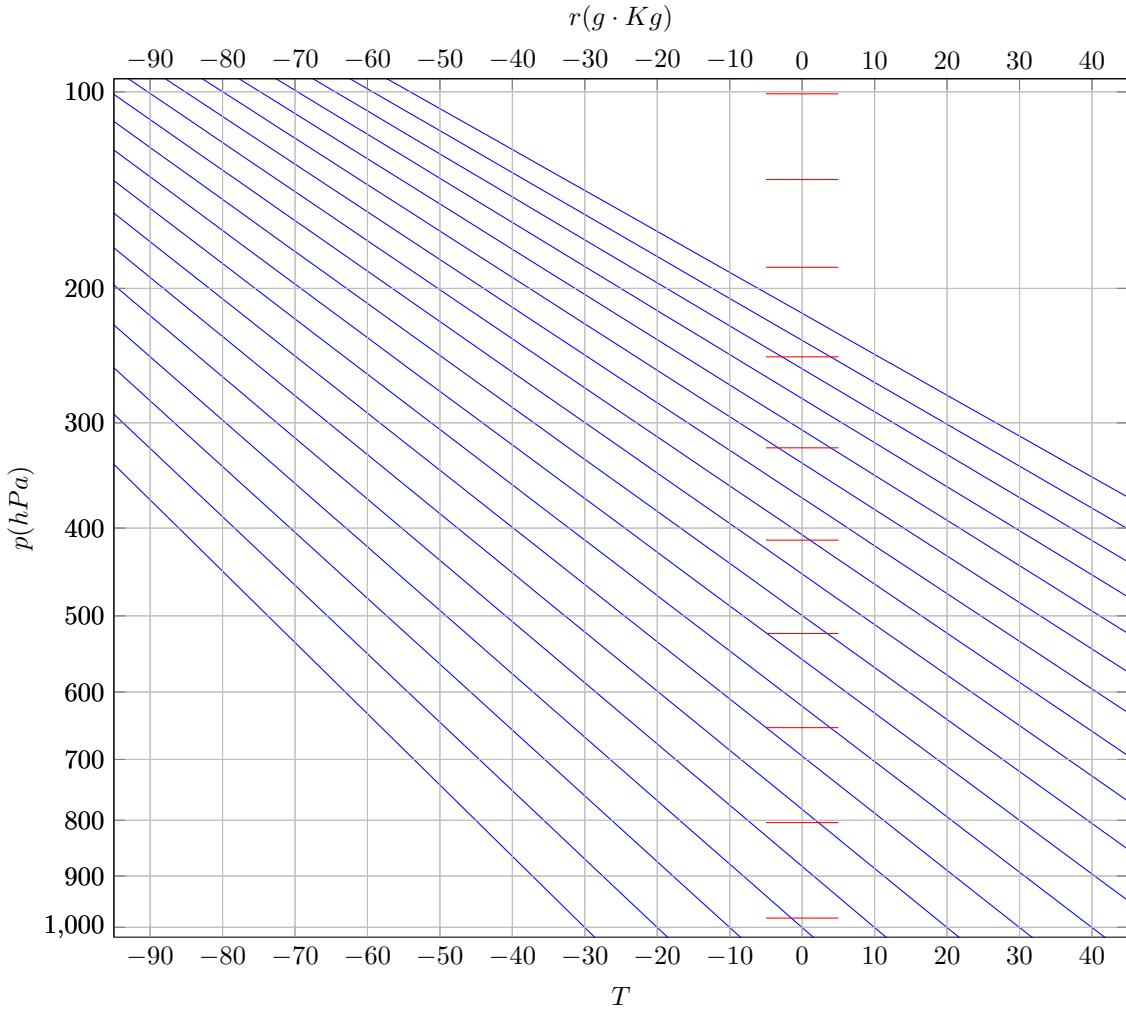
```
\begin{axis}[
  [...]
  y coord trafo/.code={\pgfmathparse{\#1^0.286}},
  y coord inv trafo/.code={\pgfmathparse{\#1^(1/0.286)}},
]
```

---

<sup>3</sup>See <https://resources.eumetrain.org/data/2/28/Content/theta.htm>

## Isohumes calculation (Work in Progress)

### Diagram



### Explanation

Given the following formula<sup>4</sup>:

$$r_s = \epsilon \cdot \frac{e_s(T)}{p - e_s(T)}$$

And assuming that  $e_s(T)$  is the Tetens equation<sup>5</sup>:

$$e_s(T) = 0.61078 \cdot \exp\left(\frac{12.27 \cdot T}{237.3 + T}\right)$$

We know that  $r_s$  refers to the  $x$  axis, and  $p$  to the  $y$  axis.

$$r_s = x; \quad p = y$$

---

<sup>4</sup>See [www.igf.fuw.edu.pl/m/courses\\_materials.../thermodynamic\\_diagrams.pdf](http://www.igf.fuw.edu.pl/m/courses_materials.../thermodynamic_diagrams.pdf)

<sup>5</sup>See [en.wikipedia.org/wiki/Tetens\\_equation](https://en.wikipedia.org/wiki/Tetens_equation)

$$x = \epsilon \cdot \frac{e_s(T)}{y - e_s(T)}$$

Then we can solve for  $y$ :

$$x = \frac{\epsilon \cdot e_s(T)}{y - e_s(T)}$$

$$y - e_s(T) = \frac{\epsilon \cdot e_s(T)}{x}$$

$$y = \frac{\epsilon \cdot e_s(T)}{x} + e_s(T)$$

$$y = \frac{(\epsilon \cdot e_s(T)) + (x \cdot e_s(T))}{x}$$

$$y = \frac{(\epsilon \cdot 0.61078 \cdot \exp(\frac{12.27 \cdot T}{237.3 + T})) + (x \cdot 0.61078 \cdot \exp(\frac{12.27 \cdot T}{237.3 + T}))}{x}$$

We also know that  $\epsilon$  is a constant: the ratio between the gas constant for dry air and the gas constant for water vapor<sup>6</sup>:

$$\epsilon = 0.622$$

We replace  $\epsilon$ :

$$y = \frac{(0.622 \cdot 0.61078 \cdot \exp(\frac{12.27 \cdot T}{237.3 + T})) + (x \cdot 0.61078 \cdot \exp(\frac{12.27 \cdot T}{237.3 + T}))}{x}$$

$$y = \frac{(0.23620100952 \cdot \exp(\frac{12.27 \cdot T}{237.3 + T})) + (x \cdot 0.61078 \cdot \exp(\frac{12.27 \cdot T}{237.3 + T}))}{x}$$

Which we should be able to use in LaTeX:

```
((0.23620100952 * exp((12.27 * \T)/(237.3 + \T))) + (x * 0.61078 * exp((12.27 * \T)/(237.3 + \T))))
```

**WIP**

---

<sup>6</sup>See pressbooks-dev.oer.hawaii.edu/atmo/chapter/chapter-4-water-vapor/