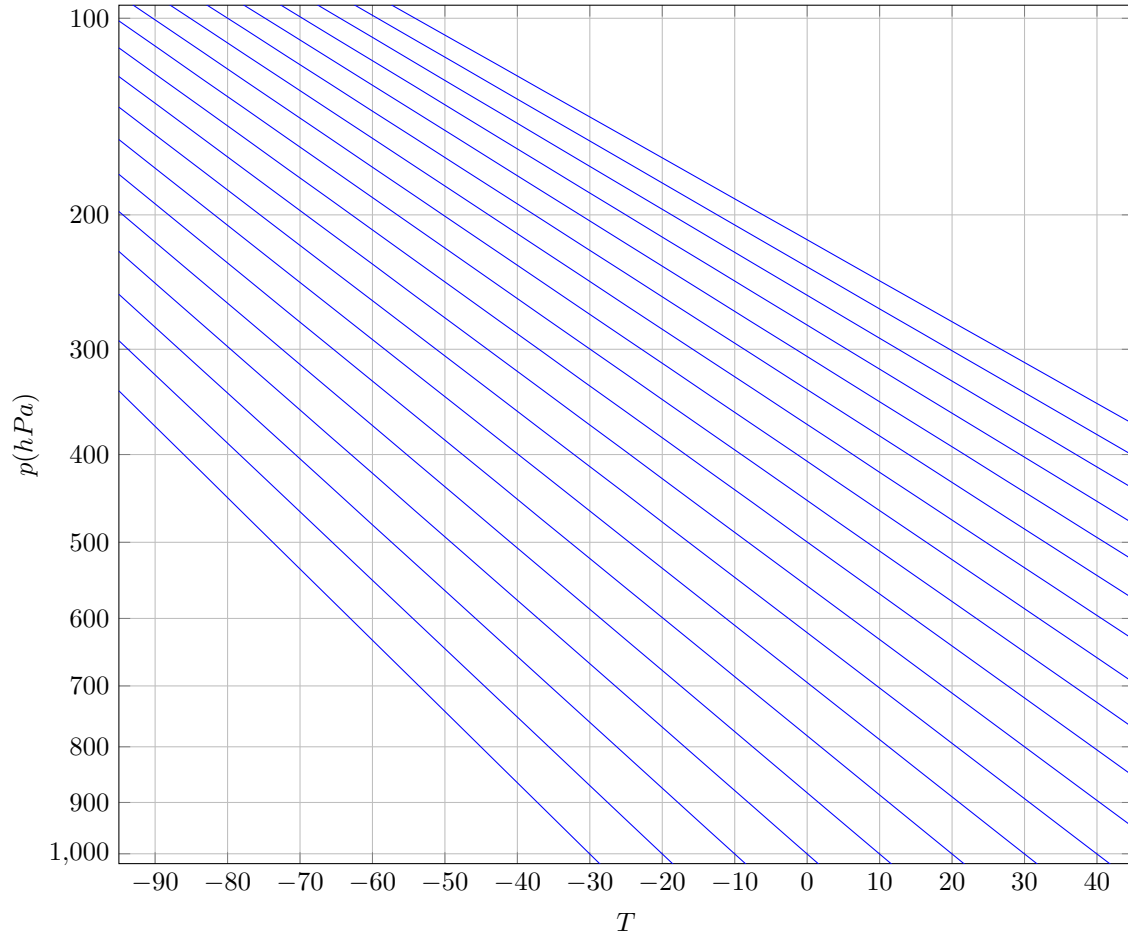# Stuve diagram in LaTeX

Dry adiabats calculation

Diagram

Explanation

Given the following dry adiabats formula[1]:

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

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

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

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

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[1]See https://www.igf.fuw.edu.pl/m/courses_materials.../thermodynamic_diagrams.pdf

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

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

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

We know that ϕ 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[2].

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

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) / (\T + 273.15))^(1/0.286)
```
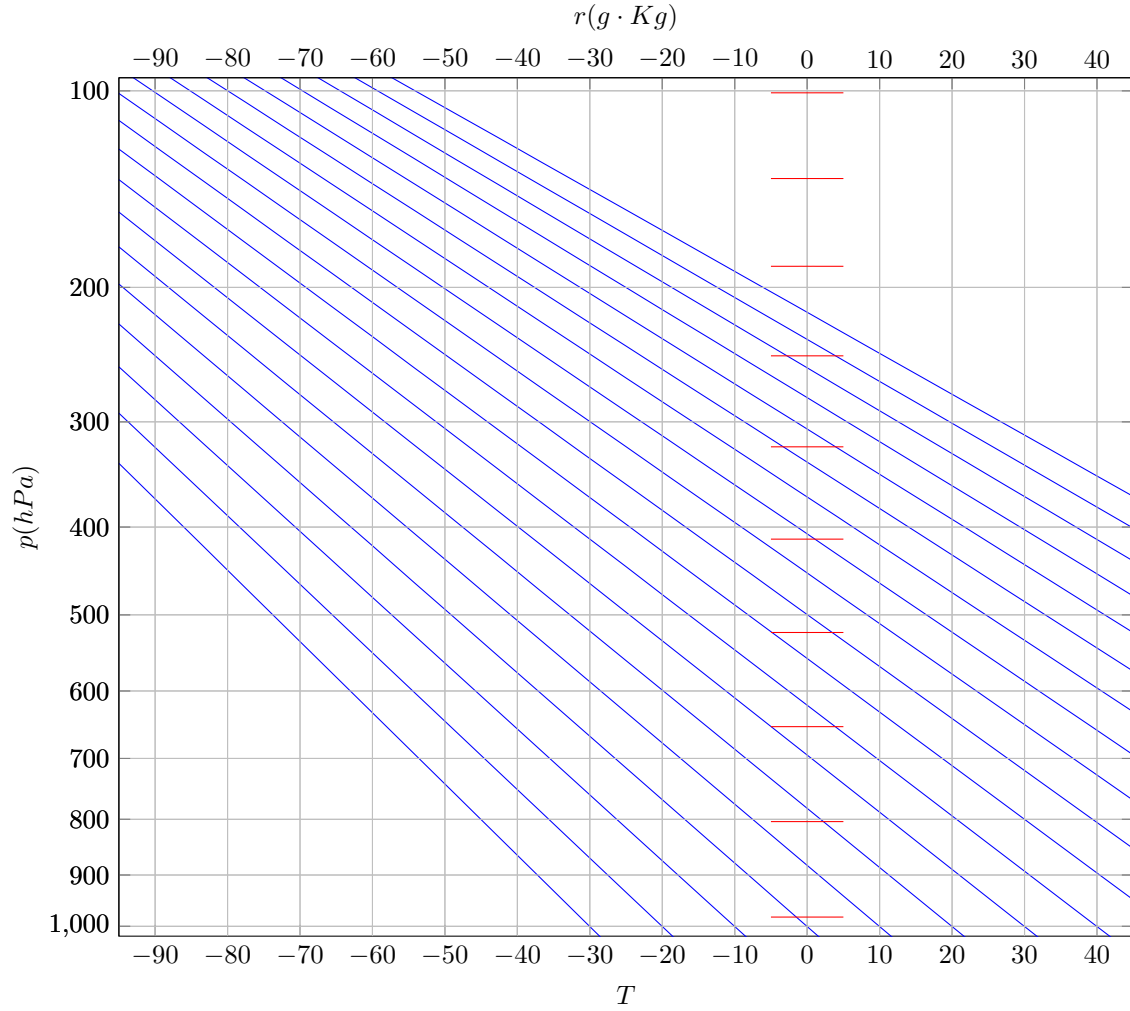
Also, we shoult take into account that in Stuve diagrams we want to draw the dry adiabats as straight lines. Thus y axis is not logarithmic, but progressing in a ratio of $y^{0.286}$.

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

---

[2]See https://resources.eumetrain.org/data/2/28/Content/theta.htm

Isohumes calculation (Work in Progress)

Diagram

Explanation

Given the following formula[3]:

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

And asuming that e_s is the Tetens equation[4]:

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

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

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

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[3] See https://www.igf.fuw.edu.pl/m/courses_materials.../thermodynamic_diagrams.pdf

[4] See 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 ϵ is a constant: the ratio between the gas constant for dry air and the gas constant for water vapor[5]:

$$\epsilon = 0.622$$

We replace ϵ:

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

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

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)))
```

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[5]See pressbooks-dev.oer.hawaii.edu/atmo/chapter/chapter-4-water-vapor/