Linear Algebra: Steam Table Interpolation

Engineers commonly use standardized tables to look up values necessary for calculations, such as probabilities, material properties, and stress limits. The table below, tabulates some properties of superheated water vapor at a pressure of $p = 0.06\ bar$:

TABLE A-4

Properties of Superheated Water Vapor

T °C	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
p = 0.06 bar = 0.006 MPa (T_{sat} = 36.16°C)				
Sat.	23.739	2425.0	2567.4	8.3304
80	27.132	2487.3	2650.1	8.5804
120	30.219	2544.7	2726.0	8.7840
160	33.302	2602.7	2802.5	8.9693
200	36.383	2661.4	2879.7	9.1398
240	39.462	2721.0	2957.8	9.2982
280	42.540	2781.5	3036.8	9.4464
320	45.618	2843.0	3116.7	9.5859
360	48.696	2905.5	3197.7	9.7180
400	51.774	2969.0	3279.6	9.8435
440	54.851	3033.5	3362.6	9.9633
500	59.467	3132.3	3489.1	10.1336

(Moran 2014)

where ν is the specific volume, u is the specific internal energy, h is the specific enthalpy, and s is the specific entropy. If we want to look up $\nu, u, h,$ or s at $T = 500\ °C$, we can simply read across the bottom row because the table happens to list the properties at that exact temperature. However, if we want to want to find properties at $T = 312.4\ °C$, we need to use a technique called *linear interpolation** to estimate the properties because the table doesn't directly contain the properties at our requested temperature.

*Linear interpolation consists of "filling in the gaps" between known points. It is a form of regression, except the best-fit curve passes through all of the data points.

The `ME2004_InternalEnergyData.mat` file contains tabulated values of the specific internal energy $\left(u, \frac{kJ}{kg}\right)$ as a function of temperature T $(°C)$, pulled directly from the Table above (minus the first row).

1) Use the `interp1()` function to obtain the specific internal energy at $T = 300\ °C$.

2) Use the `interp1()` function to obtain the specific internal energy at the following temperatures: $T = 180{:}\,50{:}\,380\ °C$.

In each case, plot the interpolated point(s) alongside the raw data. Use `interp1()`'s default linear interpolation algorithm (i.e., do not perform nearest-neighbor, piecewise cubic, spline, etc. interpolation).