

This directory contains comma-separated- or tab-separated-values files to accompany *Skin-Friction and Forced Convection from Rough and Smooth Plates* by Aubrey Jaffer.

Table 1 Sources of friction measurements

Source	Filename	Pr_∞	$Re \geq$	$Re \leq$	\pm	Count
[1, 2, 3] Churchill	Churchill-smooth.tsv	0.71	1.0×10^5	1.0×10^9		9
[1, 2, 3] Churchill	Churchill-local.tsv	0.71	1.0×10^5	1.0×10^{10}		11
[4] Žukauskas & Šlančiauskas	ZSSF.csv, group 3	55.2	3.6×10^5	1.1×10^7		5
[4] Žukauskas & Šlančiauskas	ZSSF.csv, group 2	5.42	3.6×10^5	2.4×10^6		8
[4] Žukauskas & Šlančiauskas	ZSSF.csv, group 1	2.78	7.2×10^5	4.4×10^6		8
[4] Žukauskas & Šlančiauskas	ZSSF.csv, group 0	0.71	7.6×10^5	3.2×10^6		9
[5, 6, 7] Gebers	Gebers.csv		7.4×10^5	3.3×10^7		33
[8] Pimenta et al.	Pimenta-et-al.dat	0.71	3.8×10^5	5.8×10^6	10%	19
[9] Bergstrom et al.	Bergstrom-SM.dat	0.71	1.6×10^6	4.6×10^6	5%	4
[9] Bergstrom et al.	Bergstrom-SGL.dat	0.71	1.6×10^6	4.7×10^6	9%	4
[9] Bergstrom et al.	Bergstrom-SGML.dat	0.71	1.6×10^6	4.7×10^6	9%	4
[9] Bergstrom et al.	Bergstrom-SGM.dat	0.71	1.6×10^6	4.7×10^6	9%	4
[9] Bergstrom et al.	Bergstrom-SGS.dat	0.71	1.6×10^6	4.7×10^6	9%	4
[9] Bergstrom et al.	Bergstrom-WML.dat	0.71	1.6×10^6	4.7×10^6	9%	4
[9] Bergstrom et al.	Bergstrom-WMM.dat	0.71	1.6×10^6	4.7×10^6	9%	4
[9] Bergstrom et al.	Bergstrom-WMS.dat	0.71	1.6×10^6	4.7×10^6	9%	4
[9] Bergstrom et al.	Bergstrom-PL.dat	0.71	1.6×10^6	4.7×10^6	9%	4
[9] Bergstrom et al.	Bergstrom-PM.dat	0.71	1.6×10^6	4.7×10^6	9%	4
[9] Bergstrom et al.	Bergstrom-PS.dat	0.71	1.6×10^6	4.7×10^6	9%	4

Note: Churchill [1] extracted its measurements from Smith and Walker [2] and Spalding and Chi [3].

The Gebers [5, 6] skin-friction measurements were captured from a graph in Schlichting [7] by measuring the distance from each point to the graph's axes, then scaling to the graph's units using the "Engauge" software.

Table 2 Sources of convection measurements

Source	Filename	Pr_∞	$Re \geq$	$Re \leq$	\pm	Count
[10] Kestin et al.	Kestin.csv, group 1	0.7	3.8×10^4	3.5×10^5		13
[10] Kestin et al.	Kestin.csv, group 2	0.7	4.3×10^4	2.9×10^5		7
[11] Reynolds et al.	Reynolds.csv	0.71	8.2×10^4	1.1×10^6	4%	22
[4] Žukauskas & Šlančiauskas	UHF.csv, group 2	0.71	1.1×10^4	8.2×10^5	5%	10
[4] Žukauskas & Šlančiauskas	UHF.csv, group 1	0.71	1.1×10^4	8.2×10^5	5%	10
[4] Žukauskas & Šlančiauskas	UHF.csv, group 0	0.71	1.1×10^4	8.2×10^5	5%	10
[4] Žukauskas & Šlančiauskas	UHF.csv, group 4	6.57	4.0×10^3	2.2×10^5	10%	19
[4] Žukauskas & Šlančiauskas	UHF.csv, group 3	6.57	5.0×10^3	2.2×10^5	10%	15
[4] Žukauskas & Šlančiauskas	UHF.csv, group 6	108.	3.0×10^4	3.0×10^5	5%	17
[4] Žukauskas & Šlančiauskas	UHF.csv, group 5	257.	1.2×10^4	1.1×10^5	5%	17
[4] Žukauskas & Šlančiauskas	ZSCV.csv, group 0	0.71	1.1×10^5	6.3×10^5	5%	16
[4] Žukauskas & Šlančiauskas	ZSCV.csv, group 3	0.71	1.7×10^5	7.5×10^5	5%	19
[4] Žukauskas & Šlančiauskas	ZSCV.csv, group 1	5.8-7.1	1.4×10^6	2.3×10^6	10%	5
[4] Žukauskas & Šlančiauskas	ZSCV.csv, group 4	2.9-7.2	2.1×10^5	6.4×10^6	10%	21
[4] Žukauskas & Šlančiauskas	ZSCV.csv, group 5	2.0-5.8	1.8×10^5	1.4×10^6	10%	40
[4] Žukauskas & Šlančiauskas	ZSCV.csv, group 2	75-246	5.0×10^4	7.0×10^5	5%	40
[4] Žukauskas & Šlančiauskas	ZSCV.csv, group 6	80-205	1.1×10^5	3.6×10^5	5%	11
[4] Žukauskas & Šlančiauskas	ZSCV.csv, group 7	92-317	2.7×10^4	7.5×10^5	5%	29
present apparatus $\varepsilon = 3.00$ mm	3mm/mixed-dn.dat	0.71	2.3×10^3	9.3×10^4	3-7%	13
present apparatus $\varepsilon = 1.04$ mm	1mm/mixed-dn.dat	0.71	2.0×10^3	6.8×10^4	2-6%	14

Rough surface convection measurements were obtained from an apparatus built for this investigation, which measured average convection in air at $2300 < Re < 93000$. The fields are Re , Ra , $\pm\%$, θ , ψ , Pr , and \overline{Nu} . $\pm\%$ is the RSS combined measurement uncertainty.

The remaining measurement data-sets were manually entered from tables in the cited works. Several obvious single-digit typographical errors were corrected.

Table 3 Other data sources

Source	Filename	What	Low	High	Count
[4] Žukauskas & Šlančiauskas	fluids.csv, group 1	air	20°C	90°C	8
present work	fluids2.csv, group 1	air	10°C	100°C	46
[4] Žukauskas & Šlančiauskas	fluids.csv, group 2	water	20°C	90°C	8
present work	fluids2.csv, group 2	water	10°C	100°C	46
[4] Žukauskas & Šlančiauskas	fluids.csv, group 3	transformer oil	30°C	120°C	10
present work	fluids2.csv, group 3	transformer oil	10°C	100°C	46

Žukauskas and Šlančiauskas [4] is the source for fluid properties `fluids.csv`. This investigation calculated more accurate fluid properties in `fluids2.csv`, which were used in the error calculations.

1. References

- [1] Stuart W. Churchill. Theoretically based expressions in closed form for the local and mean coefficients of skin friction in fully turbulent flow along smooth and rough plates. *International Journal of Heat and Fluid Flow*, 14(3):231 – 239, 1993, doi:10.1016/0142-727X(93)90053-P.
- [2] D. W. Smith and J. D. Walker. Skin friction measurements in incompressible flow. Technical Report R-26, NASA, Washington, DC, 1959.
- [3] D. B. Spalding and S. W. Chi. The drag of a compressible turbulent boundary layer on a smooth flat plate with and without heat transfer. *Journal of Fluid Mechanics*, 18(1):117143, 1964, doi:10.1017/S0022112064000088.
- [4] A. Žukauskas and A. Šlančiauskas. *Heat Transfer in Turbulent Fluid Flows*. Hemisphere Publishing Corp, Washington, DC, 1987.
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- [7] Hermann Schlichting. *Boundary-Layer Theory*. McGraw Hill, New Delhi, seventh edition, 2014. Translated by Kestin, J.
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- [10] J. Kestin, P.F. Maeder, and H.E. Wang. Influence of turbulence on the transfer of heat from plates with and without a pressure gradient. *International Journal of Heat and Mass Transfer*, 3(2):133–154, 1961, doi:10.1016/0017-9310(61)90076-X.
- [11] W. C. Reynolds, W. M. Kays, and S. J. Kline. Heat transfer in the turbulent incompressible boundary layer, part 4 – effect of location of transition and prediction of heat transfer in a known transition region. Technical Report NASA-MEMO-12-4-58W, NASA, Washington, DC, USA, 1958.