

SHARP INEQUALITIES FOR TRIGONOMETRIC AND HYPERBOLIC FUNCTIONS

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Abstract. We establish several sharp inequalities for trigonometric and hyperbolic functions. Our results sharpen some known inequalities.

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REFERENCES

- [1] M. ABRAMOWITZ AND I. A. STEGUN (EDS), *Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables*, National Bureau of Standards, Applied Mathematics Series **55**, 4th printing, Washington, 1965, 1972.
- [2] G. D. ANDERSON, M. K. VAMANAMURTHY AND M. VUORINEN, *Inequalities for quasiconformal mappings in space*, *Pacific J. Math.* **160** (1993), 1–18.
- [3] G. D. ANDERSON, S.-L. QIU, M. K. VAMANAMURTHY AND M. VUORINEN, *Generalized elliptic integral and modular equations*, *Pacific J. Math.* **192** (2000), 1–37.
- [4] G. D. ANDERSON, M. K. VAMANAMURTHY AND M. VUORINEN, *Conformal Invariants, Inequalities, and Quasiconformal Maps*, New York, 1997.
- [5] M. BECKER AND E. L. STRAK, *On a hierarchy of quolynomial inequalities for $\tan x$* , Univ. Beograd. Publ. Elektrotehn. Fak. Ser. Mat. Fiz. No. **602-633** (1978), 133–138.
- [6] C.-P. CHEN AND W.-S. CHEUNG, *Sharp Cusa and Becker-Stark inequalities*, *J. Inequal. Appl.* **2011**: 136 (2011), doi:10.1186/1029-242X-2011-136.
- [7] J. S. FRAME, *Some trigonometric, hyperbolic and elliptic approximations*, *Amer. Math. Monthly* **61** (1954), 623–626.
- [8] C. HUYGENS, *Oeuvres Completes 1888-1940*, Société Hollandaise des Science, Haga.
- [9] B. J. MALEŠEVIĆ, *One method for proving inequalities by computer*, *J. Ineq. Appl.* **2007**, Article ID 78691.
- [10] B. MALEŠEVIĆ, M. MAKRAĐIĆ AND B. BANJAC, *Some notes on a method for proving inequalities by computer*, <http://arxiv.org/abs/math/0701020>.
- [11] C. MORTICI, *The natural approach of Wilker-Cusa-Huygens inequalities*, *Math. Inequal. Appl.* **14** (2011), 535–541.
- [12] E. NEUMAN AND J. SÁNDOR, *On some inequalities involving trigonometric and hyperbolic functions with emphasis on the Cusa-Huygens, Wilker, and Huygens inequalities*, *Math. Inequal. Appl.* **13** (2010), 715–723.
- [13] S. PONNUSAMY AND M. VUORINEN, *Asymptotic expansions and inequalities for hypergeometric functions*, *Mathematika* **44** (1997), 278–301.
- [14] J. SANDOR AND M. BENCZE, *On Huygens' trigonometric inequality*, *RGMI Res. Rep. Collection* **8**, 3 (2005), Article 14.
- [15] L. ZHU, *A source of inequalities for circular functions*, *Comput. Math. Appl.* **58** (2009), 1998–2004.
- [16] L. ZHU, *Some new inequalities of the Huygens type*, *Comput. Math. Appl.* **58** (2009), 1180–1182.
- [17] L. ZHU AND J. K. HUA, *Sharpening the Becker-Stark inequalities*, *J. Inequal. Appl.* **2010**, Article ID 931275.
- [18] L. ZHU, *Sharp Becker-Stark-type inequalities for Bessel functions*, *J. Inequal. Appl.* **2010**, Article ID 838740.