

## Reply to M. P. Isom and I. M. Kalkhoran

G. Emanuel\*

University of Oklahoma,  
Norman, Oklahoma 73019-0601

I WANT to thank Isom and Kalkhoran for pointing out several errors concerning a paper by Hayes<sup>1</sup> that appear in Ref. 2. Hayes'

analysis deals with the jump in vorticity across a shock, not just its downstream value. A more grievous mistake stemmed from failing to realize that the unit normal vector  $\hat{n}$  to the shock, defined only at the shock's surface, can be extended into three-dimensional space in a nonunique manner. This extension is essential to calculate, at the surface of the shock, the curl of  $\hat{n}$ . In Ref. 1 an extension is used that yields  $\nabla \cdot \hat{n} = 0$ , whereas the extension used in Ref. 2 has  $\nabla \cdot \hat{n} \neq 0$ . Thus, the curl of  $\hat{n}$ , at the shock, is not unique. Nevertheless, the different approaches that appear in both references produce valid results for the vorticity, or jump in vorticity, at a shock.

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\*Professor, School of Aerospace and Mechanical Engineering, Associate Fellow AIAA.

### References

<sup>1</sup>Hayes, W. D., "The Vorticity Jump Across a Gasdynamic Discontinuity," *Journal of Fluid Mechanics*, Vol. 2, 1957, pp. 595-600.

<sup>2</sup>Emanuel, G., *Analytical Fluid Dynamics*, CRC Press, Boca Raton, FL, 1994, pp. 123, 124.

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