

HADAMARD MATRICES OF ORDERS 116 AND 232¹

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A *Hadamard matrix* H is a square matrix of *ones* and *minus ones* whose row (and hence column) vectors are orthogonal. The order n of a Hadamard matrix is necessarily 1, 2 or $4t$, for some positive integer t . It has been conjectured that this condition ($n=1, 2$ or $4t$) also insures the existence of a Hadamard matrix. Constructions have been given for particular values of n and even for various infinite classes of values. While other constructions exist, those given in (2) and the references of (1) exhaust the previously known values of n . In this note we construct a Hadamard matrix of order 116, the smallest unsolved case. Taking the tensor product of this matrix with the Hadamard matrix of order 2 yields a Hadamard matrix of order 232, also previously unsolved. This leaves $n=188$ as the only unknown case less than 200.

The matrix of order 116 is of the Williamson type, i.e.

$$H = \begin{vmatrix} A & B & C & D \\ -B & A & -D & C \\ -C & D & A & -B \\ -D & -C & B & A \end{vmatrix}$$

where each of A, B, C, D is a symmetric circulant of order 29. We specify the first rows below (here $+$ stands for $+1$ and $-$ for -1).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
A	+	+	-	-	+	-	-	+	-	+	+	+	-	+	+	+	+	-	+	+	+	-	+	-	-	+	-	-	+
B	+	+	+	+	-	+	+	-	+	-	-	-	+	+	+	+	+	-	-	-	+	-	+	+	-	+	+	+	
C	+	+	+	-	-	+	+	-	-	+	-	-	-	-	-	+	-	+	-	-	+	+	-	-	+	-	-	+	
D	+	-	+	-	-	-	+	+	-	-	+	+	+	+	+	+	+	-	+	-	-	+	+	-	-	-	-	+	

REFERENCES

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2. H. Ehlich, *Neue Hadamard-Matrizen*, Arch. Math. **16** (1965), 34-36.

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