

# Tutorial 5

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**Task 1.** Let  $\omega = e^{\frac{\pi i}{8}}$ . Then the IFT matrix in the group  $\mathbb{Z}_{16}$  looks like this:

$$\frac{1}{4} \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & \omega & \omega^2 & \omega^3 & \omega^4 & \omega^5 & \omega^6 & \omega^7 & -1 & -\omega & -\omega^2 & -\omega^3 & -\omega^4 & -\omega^5 & -\omega^6 & -\omega^7 \\ 1 & \omega^2 & \omega^4 & \omega^6 & -1 & -\omega^2 & -\omega^4 & -\omega^6 & 1 & \omega^2 & \omega^4 & \omega^6 & -1 & -\omega^2 & -\omega^4 & -\omega^6 \\ 1 & \omega^3 & \omega^6 & -\omega & -\omega^4 & -\omega^7 & \omega^2 & \omega^5 & -1 & -\omega^3 & -\omega^6 & \omega & \omega^4 & \omega^7 & -\omega^2 & -\omega^5 \\ 1 & \omega^4 & -1 & -\omega^4 & 1 & \omega^4 & -1 & -\omega^4 & 1 & \omega^4 & -1 & -\omega^4 & 1 & \omega^4 & -1 & -\omega^4 \\ 1 & \omega^5 & -\omega^2 & -\omega^7 & \omega^4 & -\omega & -\omega^6 & \omega^3 & -1 & -\omega^5 & \omega^2 & \omega^7 & -\omega^4 & \omega & \omega^6 & -\omega^3 \\ 1 & \omega^6 & -\omega^4 & \omega^2 & -1 & -\omega^6 & \omega^4 & -\omega^2 & 1 & \omega^6 & -\omega^4 & \omega^2 & -1 & -\omega^6 & \omega^4 & -\omega^2 \\ 1 & \omega^7 & -\omega^6 & \omega^5 & -\omega^4 & \omega^3 & -\omega^2 & \omega & -1 & -\omega^7 & \omega^6 & -\omega^5 & \omega^4 & -\omega^3 & \omega^2 & -\omega \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & -\omega & \omega^2 & -\omega^3 & \omega^4 & -\omega^5 & \omega^6 & -\omega^7 & -1 & \omega & -\omega^2 & \omega^3 & -\omega^4 & \omega^5 & -\omega^6 & \omega^7 \\ 1 & -\omega^2 & \omega^4 & -\omega^6 & -1 & \omega^2 & -\omega^4 & \omega^6 & 1 & -\omega^2 & \omega^4 & -\omega^6 & -1 & \omega^2 & -\omega^4 & \omega^6 \\ 1 & -\omega^3 & \omega^6 & \omega & -\omega^4 & \omega^7 & \omega^2 & -\omega^5 & -1 & \omega^3 & -\omega^6 & -\omega & \omega^4 & -\omega^7 & -\omega^2 & \omega^5 \\ 1 & -\omega^4 & -1 & \omega^4 & 1 & -\omega^4 & -1 & \omega^4 & 1 & -\omega^4 & -1 & \omega^4 & 1 & -\omega^4 & -1 & \omega^4 \\ 1 & -\omega^5 & -\omega^2 & \omega^7 & \omega^4 & \omega & -\omega^6 & -\omega^3 & -1 & \omega^5 & \omega^2 & -\omega^7 & -\omega^4 & -\omega & \omega^6 & \omega^3 \\ 1 & -\omega^6 & -\omega^4 & -\omega^2 & -1 & \omega^6 & \omega^4 & \omega^2 & 1 & -\omega^6 & -\omega^4 & -\omega^2 & -1 & \omega^6 & \omega^4 & \omega^2 \\ 1 & -\omega^7 & -\omega^6 & -\omega^5 & -\omega^4 & -\omega^3 & -\omega^2 & -\omega & -1 & \omega^7 & \omega^6 & \omega^5 & \omega^4 & \omega^3 & \omega^2 & \omega \end{pmatrix}.$$

Use this to compute (or check) the orders of the elements of the group  $\mathbb{Z}_{15}^*$ .