

**Homework Problem 3.1**  
(10 points)**Due Tuesday, October 20**  
(at lecture)

3.1 The Fourier transform operator in  $D$  dimensions is defined by

$$F|j\rangle = \frac{1}{\sqrt{D}} \sum_{k=0}^{D-1} e^{2\pi ijk/D} |k\rangle .$$

In this problem we will work with  $D = 4$ .

(a) *Write out* explicitly the action of  $F$  and the parity operator,  $P = F^2$ , on the standard basis states  $|j\rangle$ .

(b) *Find* a complete set of eigenstates and corresponding eigenvalues for  $P$ .

(c) *Find* a complete set of eigenstates and corresponding eigenvalues for  $F$ . If we write the eigenstates in terms of a qubit notation for the basis states, i.e.,  $|j\rangle = |j_1j_2\rangle = |j_1\rangle \otimes |j_2\rangle$ , what can you say about the entanglement of the eigenstates of  $F$ ?