1. Let \( f : E \to \mathbb{R} \) be uniformly continuous. Fill in the details to show that the extension function \( F \) defined on a the closure of \( E \) is well-defined and that it is continuous on all the closure.

2. Let \( X \) be any set and define \( \mathcal{M} \) by \( A \in \mathcal{M} \) if and only if \( A \) is countable or \( A^c \) is countable. Prove that \( \mathcal{M} \) is a \( \sigma \)-algebra.

3. Let \( \mathcal{M}_i \) be a \( \sigma \)-algebra for each \( i \in I \). Prove \( \mathcal{M} = \bigcap_{i \in I} \mathcal{M}_i \) is a \( \sigma \)-algebra.

4. Prove that if the union of two \( \sigma \)-algebras in \( X \) is an algebra, then it is a \( \sigma \)-algebra.