Question 1: Join Algorithms.....[190 points]

(i) **[10 points] Join Overview:**
Distinguish between normalization and denormalization.

(ii) **[10 points] Join Overview:**
List a benefit and a drawback of denormalization.

(iii) **[10 points] Join Overview:**
How can you extend the inner equi-join algorithm to a full outer equi-join algorithm?

(iv) **[10 points] Join Overview:**
How does the join operator output depend on the storage model?

(v) **[10 points] Join Overview:**
Distinguish between early and late materialization.

(vi) **[10 points] Join Overview:**
List a benefit and a drawback of late materialization.

(vii) **[10 points] Join Overview:**
Why is R $\times$ S followed by a selection not an effective way to compute a join?

(viii) **[10 points] Nested Loop Join:**
Distinguish between: (1) naive, (2) block, and (3) index nested loop join.

(ix) **[10 points] Nested Loop Join:**
Explain why the smaller table is picked as the outer table in a join algorithm.

(x) **[10 points] Sort-Merge Join:**
Distinguish between nested loop join and sort-merge join.

(xi) **[10 points] Sort-Merge Join:**
What is the worst case time complexity of these algorithms: (1) sort-merge join and (2) nested loop join.

(xii) **[10 points] Sort-Merge Join:**
When is sort-merge join useful?

(xiii) **[10 points] Hash Join:**
When is hash join useful?

(xiv) **[10 points] Hash Join:**
Distinguish between sort-merge join and hash join.

(xv) **[10 points] Hash Join:**
List the contents of the hash table.

(xvi) **[10 points] Hash Join:**
Explain how a bloom filter may be used to accelerate hash join.

(xvii) **[10 points] Grace Hash Join:**
Distinguish between basic hash join and Grace hash join.

Question 1 continues…

(xviii) **[10 points] Grace Hash Join:**
List the phases of Grace hash join.

(xix) **[10 points] Grace Hash Join:**
Explain the connection between external merge sort and external grace hash join algorithm.