Exam for CSE 480 (2016)

Answer the questions in the spaces provided on the page. If you run out of room for an answer, continue on the back of the page.

- DO NOT START THE EXAM UNTIL TOLD TO DO SO
- You only need to answer 5 of the 6 questions.
- On one of the questions make a large slash through it, which indicates that it should not be graded.
- On every page (including the first and last page), write your first and last name, before answering the question. Unnamed pages may be lost.
- If you start to answer a question and then change your mind, please cross out the attempt and write DO NOT Grade across it.

![Diagram of how to write good code](https://xkcd.com/844/)
Question 1: Transaction Modes ............................................... 4 points

Below is a sequence of SQL commands.

After the statement is completed by the associated connection, write which connections are holding each type of lock in the table. If no connection holds a type of lock, leave it blank. No locks are held at the start of the following sequence of SQL commands. A connection can only hold one lock at a time.

If an error should be raised, write ERROR on all three columns for that statement and skip to the next statement (pretending that the error causing statement didn’t happen).

<table>
<thead>
<tr>
<th>ID</th>
<th>SQL statement</th>
<th>Shared</th>
<th>Reserved</th>
<th>Exclusive</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>CREATE TABLE ...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>CREATE VIEW ...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>BEGIN IMMEDIATE TRANSACTION;</td>
<td>Z</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>SELECT ...</td>
<td></td>
<td>Z</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>BEGIN TRANSACTION;</td>
<td>Z</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>SELECT ...</td>
<td>X</td>
<td>Z</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>SELECT ...</td>
<td>X</td>
<td>Z</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>ROLLBACK TRANSACTION;</td>
<td>Z</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>COMMIT TRANSACTION;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>BEGIN EXCLUSIVE TRANSACTION;</td>
<td>Z</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>UPDATE ...</td>
<td></td>
<td>Z</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>SELECT ...</td>
<td>ERROR</td>
<td>ERROR</td>
<td>ERROR</td>
</tr>
<tr>
<td>X</td>
<td>BEGIN TRANSACTION;</td>
<td></td>
<td>Z</td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>COMMIT TRANSACTION;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>BEGIN TRANSACTION;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>SELECT ...</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>SELECT ...</td>
<td>X</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>INSERT ...</td>
<td>X</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>COMMIT TRANSACTION;</td>
<td>ERROR</td>
<td>ERROR</td>
<td>ERROR</td>
</tr>
</tbody>
</table>

Points earned: __________ out of a possible 4 points
Question 2: Legal Optimistic Schedules ................................. 4 points
Below is a time line of when two transactions ($T_x$ and $T_y$) performed actions on the database.

1. $T_x$ begins transaction
2. $w_x(B)$
3. $r_x(A)$
4. $T_y$ begins transaction
5. $r_y(C)$
6. $r_x(B)$
7. $w_y(A)$
8. $T_x$ commits transaction
9. $r_y(C)$
10. $T_y$ commits transaction

For proposed action, indicate if that action were added (in isolation from the other proposed actions) would the resulting schedule result in physically unrealizable behavior.

(a) $w_x(C)$ between steps 4 and 5 √ Legal ○ Physically Unrealizable
(b) $w_y(B)$ between steps 4 and 5 ○ Legal √ Physically Unrealizable
(c) $r_x(A)$ between steps 5 and 6 √ Legal ○ Physically Unrealizable
(d) $r_x(C)$ between steps 5 and 6 ○ Legal √ Physically Unrealizable
(e) $w_y(B)$ between steps 6 and 7 ○ Legal ○ Physically Unrealizable
(f) $w_x(C)$ between steps 6 and 7 ○ Legal ○ Physically Unrealizable
(g) $r_x(A)$ between steps 7 and 8 ○ Legal ○ Physically Unrealizable
(h) $r_x(D)$ between steps 7 and 8 ○ Legal ○ Physically Unrealizable

Points earned: __________ out of a possible 4 points
Question 3: Converting E/R Diagram................................. 4 points

Below is an E/R representing information about types of vehicles.

(a) (3 points) Write a relational database schema representing the E/R diagram. Be sure to combine relations when possible. Use the E/R method to create relations for the subclasses.

Solution:

- vehicle(id, weight, num_passengers)
- wheeled(id, number)
- human_powered(id, recreational)
- all_terrain(id, road_legal)
- tire(brand, diameter, vehicle_id)

(b) (1 point) Write another relational database schema representing the E/R diagram. Be sure to combine relations when possible. This time use the nulls method to create relations for the subclasses.

Solution:

- vehicle(id, weight, num_passengers, number, recreational, road_legal)
- tire(brand, diameter, vehicle_id)

Points earned: __________ out of a possible 4 points
Question 4: Lossless Joins .............................................................. 4 points

Here’s a relation (R), its attributes and its functional dependencies (F):

\[
R(A, B, C, D, E)
\]

\[
B \ D \rightarrow A
\]

\[
A \ E \rightarrow B
\]

\[
B \rightarrow C
\]

(a) (2 points) Which of the following sets of relations maintain the lossless join property?

- \( R_1(ABD), R_2(ABCE) \)
- \( R_1(ABDE), R_2(BC) \)
- \( R_1(ABEC), R_2(ABDE) \)
- \( R_1(BD), R_2(ABCE) \)

(b) (1 point) Which of the following attributes sets are superkeys for R?

- \( \{ABCDE\} \)
- \( \{CDE\} \)
- \( \{ABCD\} \)
- \( \{ABDE\} \)

(c) (1 point) Which of the following sets of relations are entirely in Boyce-Codd Normal Form?

- \( R_1(ABD), R_2(ABE), R_3(BC), R_4(AE) \)
- \( R_1(ABD), R_2(ABE), R_3(BC), R_4(AE), R_5(ACE) \)
- \( R_1(AD), R_2(ABC) \)
- \( R_1(CDB), R_2(ABCDE) \)

Points earned: __________ out of a possible 4 points
Question 5: Multiple Types of Locks .................................................. 4 points

Below are three transactions (and six total actions). Unlocks can only happen after all the actions in a transaction have taken place (strict two-phase locking). For this problem, there are shared locks \((sl_1(A))\) and exclusive locks \((xl_1(A))\) and either/both are unlocked with \((u_1(A))\). Below is the order of each of the action are interleaved. For each part, output the necessary locks and unlocks that the transaction should perform to make the action take place (don’t forget to include the action itself).

<table>
<thead>
<tr>
<th></th>
<th>(T_1)</th>
<th>(T_2)</th>
<th>(T_3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(r_1(X))</td>
<td>(w_2(Y))</td>
<td>(w_3(Z))</td>
</tr>
<tr>
<td>2</td>
<td>(w_1(Y))</td>
<td>(w_3(Y))</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>(w_1(X))</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) \(T_1: \ r_1(X)\)

Solution: \(sl_1(X); r_1(X);\)

(b) \(T_2: \ w_2(Y)\)

Solution: \(xl_2(Y); w_2(Y); u_2(Y);\)

(c) \(T_1: \ w_1(Y)\)

Solution: \(xl_1(Y); w_1(Y);\)

(d) \(T_3: \ w_3(Z)\)

Solution: \(xl_3(Z); w_3(Z);\)

(e) \(T_1: \ w_1(X)\)

Solution: \(xl_1(X); w_1(X); u_1(X); u_1(Y);\)

(f) \(T_3: \ w_3(Y)\)

Solution: \(xl_3(Y); w_3(Y); u_3(Z); u_3(Y);\)

Points earned: __________ out of a possible 4 points
Question 6: Precedence ................................................................. 4 points

(a) (2 points) What are the conflicts (between actions of different transactions) and implied transaction precedence for the following schedule:

\[ r_1(A); w_1(A); r_2(C); r_3(C); w_3(B); r_2(B); r_1(B); r_2(A); \]

Solution:

- \( w_1(A); r_2(A); \Rightarrow T_1 < T_2 \)
- \( w_3(B); r_2(B); \Rightarrow T_3 < T_2 \)
- \( w_3(B); r_1(B); \Rightarrow T_3 < T_1 \)

(b) (1 point) Draw the Precedence Graph for the schedule.

Solution:

(c) (1 point) What is a conflict-equivalent serial schedule for this schedule? If there isn’t one, just say so.

Solution: \( T_3; T_1; T_2; \)

Or:

\( r_3(C); w_3(B); r_1(A); w_1(A); r_1(B); r_2(C); r_2(A); \)

Points earned: ____________ out of a possible 4 points
If you have finished early, feel free to bring your exam to an instructor.
Or you can draw a picture of your favorite Pokémon.
Or you can write a haiku about your love of Boyce-Codd Normal Form.

<table>
<thead>
<tr>
<th>Question</th>
<th>Points</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transaction Modes</td>
<td>4</td>
<td></td>
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<tr>
<td>Legal Optimistic Schedules</td>
<td>4</td>
<td></td>
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<tr>
<td>Converting E/R Diagram</td>
<td>4</td>
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<td>Lossless Joins</td>
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<td>Multiple Types of Locks</td>
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