Midterm 1

- Everything through end of normalization / FDs on Sept 28
- Topics:
  - E-R diagrams
    - cardinality
    - participation
    - converting to relations
      - minimizing
  - Relational Algebra
    - understanding
    - evaluating
    - writing
  - SQL
    - understanding
    - evaluating
    - writing
  - Normalization
    - keys of various stripes
    - functional dependences
    - Armstrong's Axioms
      - Additional axioms
    - Canonical covers
    - Extraneous attributes
    - BCNF decomposition
    - 3NF
Midterm 1

- What materials you are responsible for:
  - everything discussed in class
  - everything on slides
  - everything in quizzes
  - everything in assignments
  - all reading you needed to do in order to do the above

- What are the questions like?
  - definitions / short answer
  - SQL queries <=> RA
  - reduce E/R diagram to relation schema
  - functional dependences
    - Armstrongs axioms, auxiliary axioms
  - BCNF, 3NF

- 75 minutes, closed everything, in class.
Quiz 3

Q10
0.1 Points

What is the result of:

```sql
with t as (select A from R),
    t2 as (select * from R where B = 10)
(select * from t) intersect (select A from t2)
```

- (a, b, c)
- [a, a, b, c, c]
- (b, c, c)
- (a, b)

Quiz 3

Q11
0.2 Points

Consider two create table statements:

```sql
create table R (a integer primary key);
create table S (b integer primary key,
    c integer references R(a) on update cascade);
```

What will happen when a tuple in R is updated or deleted (the answer may be different for the two)?

Explanation
The default on delete is that the deletion fails. An update cascade causes table S's 'c' to change to the new value.

Q12
0.2 Points

Are the following two queries equivalent? Why or why not? Assume R.a is an integer attribute.

1. select * from R where R.a > 1;
2. (select * from R) except (select * from R where R.a <= 1);

Explanation
No because of NULLs. For example, if all a=NULL, first returns empty set, second returns all tuples.
Q13

1. \( \pi_B(\sigma_{B=c}(R)) \)
2. \( \pi_C(R) - \pi_{R,C}(\sigma_{R_1,C<R_1,C}(R \times (\rho_{R_1}(R)))) \)

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha )</td>
<td>a</td>
<td>1</td>
</tr>
<tr>
<td>( \beta )</td>
<td>b</td>
<td>2</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>c</td>
<td>1</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>a</td>
<td>3</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>c</td>
<td>3</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>a</td>
<td>2</td>
</tr>
<tr>
<td>( \beta )</td>
<td>b</td>
<td>2</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>c</td>
<td>2</td>
</tr>
<tr>
<td>( \beta )</td>
<td>c</td>
<td>2</td>
</tr>
</tbody>
</table>

(1) is \{c\}. More interestingly, if the projection was to A, the answer would be \( \alpha, \beta \), and \( \gamma \). (2)'s answer \{1\}.

Quiz3

Q14
0.2 Points

Suppose we have three relations \( r(A, B), s(B, C), \) and \( t(B, D) \), with all attributes declared as not null. Consider the expression:

\[
(r \text{ natural left outer join } s) \text{ natural left outer join } t
\]

Give instances of relations \( r, s, \) and \( t \) such that in the result of the expression, attribute \( C \) has a null value but attribute \( D \) has a non-null value.

EXPLANATION
\[
\begin{align*}
\text{r} &\{ (x, y) \} \\
\text{s} &\{ (2, y) \} \\
\text{t} &\{ (0, z) \} \\
gives &\{ (x, null, y, z) \}
\end{align*}
\]

Q15
0.2 Points

For three relations \( R(A, B), S(B, C), \) and \( T(C, D) \), write relational algebra expressions to generate the following relations:

1. \( Q(A, D) \) where \( R \) and \( S \) are joined on condition \( R.B > S.B \), and \( S \) and \( T \) have a natural join.
2. \( Q(A, C) \) to find all \( (A, C) \) pairs such that \( R.B = S.B \), and \( S.C \) does not have a matching tuple in \( T \).

In both cases, use only the basic relational operations.

EXPLANATION
\[
\begin{align*}
Q1 &\leftarrow \pi_{A,D} (\sigma_{R.B > S.B}(R \times S) \bowtie T) \\
Q2 &\leftarrow \pi_{A,C} (R \bowtie (S - \pi_{B,C}(S \bowtie T)))
\end{align*}
\]

Note that natural joins are both commutative and associative.
Think of this as prereq and courses. We've defined this as many-to-one, with total participation. It might seem that rel could be removed, but we'd want a table like this:

<table>
<thead>
<tr>
<th>COURSE</th>
<th>PREREQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>425</td>
<td>412</td>
</tr>
<tr>
<td>425</td>
<td>424</td>
</tr>
</tbody>
</table>

*but note that “COURSE” is the key; it may not be duplicated.*
Quiz 4

Q7
10 Points
Convert the following E/R diagram into a minimal relational scheme, i.e., a relational schema that has fewest possible relations that captures the E/R model. Assume total participation of $S$ in both relationship sets.

```
R
  attr1
  attr2

rel1
  attr4

S
  attr3

rel2
  attr1
```

**EXPLANATION**
- Bold face means primary key attribute
- R(attr1, attr2), S(attr3, attr4, attr1)
- rel2(attr1, attr3)

- rel1 may be removed because:
  - many-to-one with total part on many side

- rel2 can not be removed because many-to-many

Quiz 5 q2

Q2
5 Points
Consider relation instance shown below, and functional dependencies: (1) $C \rightarrow B$, (2) $BCD \rightarrow A$.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

- FD 1 holds on this relation instance but FD 2 doesn't
- FD 2 holds on this relation instance but FD 1 doesn't.
- Both FDs hold on this relation instance.
- Neither FD holds on this relation instance.
Quiz 5 q3.1

Consider a relation R(A, B, C, D, E, F), and the follow:
A → BCD
BC → DE
AB → F
B → D
DF → A

Q3.1
2 Points

What is the attribute set closure of B, i.e., $(B)^+ \ ?$
- B
- BD
- BDA
- BDF
- ABCDEF

$(B)^+ = B = BD \ (B \rightarrow D)$

Quiz 5 q3.2

Q3.2
2 Points

What is the attribute set closure of A, i.e., $(A)^+ \ ?$
- A
- ABCD
- AB
- AF
- ABCDEF

$(A)^+ = A = ABCD \ (A \rightarrow BCD)
= ABCDE \ (BC \rightarrow DE)
= ABCDEF \ (AB \rightarrow F)$
Quiz 5 q3.3

What is the attribute set closure of BF, i.e., $(BF)^+$?

- BF
- ABF
- BFD
- BFC
- ABCDEF

$(BF)^+$ = BF
  = BFD   (B → D)
  = BFDA  (DF → A)
  = BFDAC (A → BCD)
  = BFDACE (BC → DE)

Quiz 5 q3.4

Is $AC → F$ a valid FD on this relation?

- Yes
- No

$(AC)^+$ = AC
  = ABCD   (A → BCD)
  = ABCDE  (BC → DE)
  = ABCDEF (AB → F)

yep, $(AC)^+$ include F
Consider a relation \( R(A, B, C, D, E) \), and the following FDs on it:

- \( A \rightarrow CD \)
- \( C \rightarrow ABE \)
- \( BC \rightarrow A \)
- \( AE \rightarrow B \)

**Quiz 5 q4.1**

### Q4.1

**3 Points**

Which of the following is an extraneous attribute in the FD: \( C \rightarrow ABE \) (i.e., can be removed without changing closure assuming the rest of the FDs are not modified)?

May be more than one correct answer, select all that apply.

- [ ] A
- [ ] B
- [ ] C
- [ ] E

### A extra? \( F' \)

- \( A \rightarrow CD \)
- \( C \rightarrow BE \)
- \( BC \rightarrow A \)
- \( AE \rightarrow B \)

\( (C)^+ = C \)

\( = CBE \)

\( = CBEA \) yes

### B extra? \( F' \)

- \( A \rightarrow CD \)
- \( C \rightarrow AE \)
- \( BC \rightarrow A \)
- \( AE \rightarrow B \)

\( (C)^+ = C \)

\( = CAE \)

\( = CAEB \) yes

### E extra? \( F' \)

- \( A \rightarrow CD \)
- \( C \rightarrow AB \)
- \( BC \rightarrow A \)
- \( AE \rightarrow B \)

\( (C)^+ = C \)

\( = CAB \)

\( = CABD \) no

---

**Quiz 5 q4.3**

Canonical cover has the following requirements:

- \( F \) logically implies \( F_c \)
- \( F_c \) logically implies \( F \)
- no extraneous attributes
- each left side of \( F_c \) is unique

*Please make it easier on the graders and use the algorithm in Figure 8.9*

- \( A \rightarrow CD, C \rightarrow ABE, BC \rightarrow A, AE \rightarrow B \)
- \( A \rightarrow CD, C \rightarrow AE, BC \rightarrow A, AE \rightarrow B \) (B extra)
- \( A \rightarrow CD, C \rightarrow AE, BC \rightarrow A, A \rightarrow B \) (E extra)
- \( A \rightarrow BCD, C \rightarrow AE, BC \rightarrow A \) (merge)
- \( A \rightarrow BCD, C \rightarrow AE, C \rightarrow A \) (B extra)
- \( A \rightarrow BCD, C \rightarrow AE \) (merge)

note that you still have to check all attributes on right sides of last two FDs, to make sure no extraneous

\( \sigma \) is extraneous in \( \alpha \) iff:

- \( F \rightarrow F' \), or
- \( (\alpha - \sigma)^+ \) includes \( \beta \) under \( F \)

\( \sigma \) is extraneous in \( \beta \) iff:

- \( F' \rightarrow F \), or
- \( \alpha^* \) includes \( \sigma \) in \( F' \)
Quiz 5 q5

Show Composition:
If $\alpha \rightarrow \beta$ and $\gamma \rightarrow \phi$, then $\alpha \gamma \rightarrow \beta \phi$

Augment $\alpha \rightarrow \beta$ to get $\alpha \gamma \rightarrow \beta \gamma$
Augment $\gamma \rightarrow \phi$ to get $\beta \gamma \rightarrow \beta \phi$
Trans: $\alpha \gamma \rightarrow \beta \gamma \rightarrow \beta \phi$

σ is extraneous in $\alpha$ iff:
- $F \rightarrow F'$, or
- $(\alpha - \sigma)^*$ includes $\beta$ under $F$

σ is extraneous in $\beta$ iff:
- $F' \rightarrow F$, or
- $\alpha^*$ includes $\sigma$ in $F'$

Quiz 5 q8

For the above schema, which of the following is NOT a lossless decomposition?
- R1(A, B, C), R2(B, C, D, E)
- R1(A, C, D), R2(B, D, E)
- R1(A, C, D), R2(A, C, B, E)
- R1(A, B, D, E), R2(B, C)

Lossless iff intersection of attributes defines key on at least one:

- R1(A, B, C) no FDs, key is {ABC}, R2(B, C, D, E): B→DE holds, BC is key, intersection of ABC and BCDE is BC, which is key on R2. ==> LOSSLESS
- R1(A, C, D) D→AC, key is {D}, R2(B, D, E): B→DE holds, B is key, intersection of ACD and BDE is D, key for REL1. ==> LOSSLESS
- R1(A, C, D) D→AC, key is {D}, R2(A, C, B, E): AE→C holds, ABE is key, intersection of ACD and ABCE is AC, not a key ==> LOSSY
- R1(A, B, D, E) B→DE, key is {B}, R2(B, C): no FDs, BC is key, intersection of ABDE and BC is B, is a key. ==> LOSSLESS
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