

## Homework 4: Functional Dependencies

Attempt this assignment yourself, then when you feel either Lost or Successful, watch this walkthrough video and correct any mistakes you might have made: <https://bit.ly/DB1-A4>

In each of the three following problems, you will be given a relation (R) and set of functional dependencies (F). For each relation you should:

- Draw the dependency diagram (you may use software such as PowerPoint, excel, paint, etc., or you can draw it by hand and take a picture)
- Identify the candidate key(s) using either the synthesis or decomposition method
- Determine if the relation is in 2NF
- Briefly (i.e. one sentence) describe why the relation is or is not in 2NF
- Transform the relation to 2NF and list the FDs and candidate keys for each relation
- Determine if the relation resulting from step e is in 3NF
- Briefly (i.e. one sentence) describe why the relation is or is not in 3NF
- Transform the relation to 3NF and list the FDs and candidate keys for each relation

It is possible that some relations may already be in 2NF or 3NF. In that case no transformation is necessary in steps e or h.

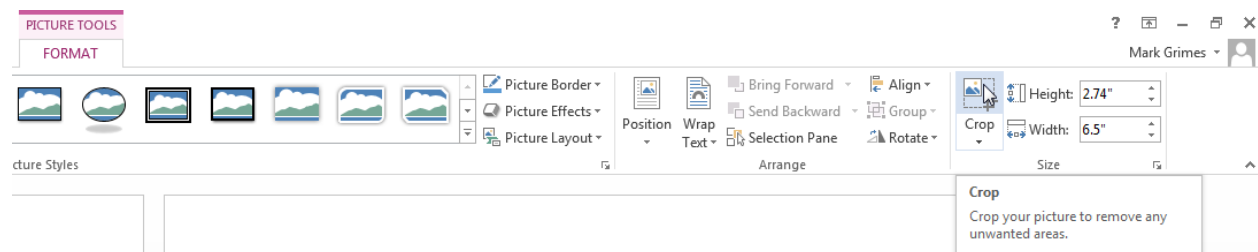
You have three problems. For all three you may use either the synthesis or decomposition method, HOWEVER, you must use each method **at least once**. If you use the same method all three times you will not receive credit for your candidate keys on the third attempt.

You can assume that all relations are already in at least first normal form (1NF) – otherwise they would not be relations at all!

### Tips:

In Word you can make a pretty right arrow by typing two dashes and a greater than sign --> →

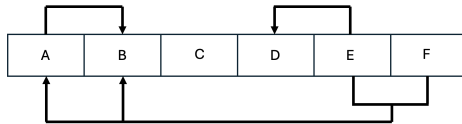
If you hand draw and take pictures of your dependency diagrams, you can “crop” the image by selecting the picture, then clicking the “Format” tab (under the Picture Tools ribbon) and selecting the “Crop” option.



1. Given the relation R (A, B, C, D, E, G) and the function dependencies

- FD1:  $A \rightarrow B$
- FD2:  $E \rightarrow D$
- FD3:  $\{E, G\} \rightarrow \{A, C\}$

1a. Draw the dependency diagram for this relation.



1b. Identify all candidate keys using either the synthesis OR decomposition method. Show each step.

**Synthesis:**

$A^+ : \{A, B\}$

$E^+ : \{E, D\}$

$\{E, G\}^+ : \{E, G, A, C, B, D\}$

CK:  $\{E, G\}$

**Decomposition:**

Superkey:  $\{A, B, C, D, E, G\}$

$K' : \{A, B, C, D, E\}$

$K' \rightarrow G$ ? No!

$K' : \{A, B, C, D, G\}$

$K' \rightarrow E$ ? No!

$K' : \{A, B, C, E, G\}$

$K' \rightarrow D$ ? Yes!

$K' : \{A, B, E, G\}$

$K' \rightarrow C$ ? Yes!

$K': \{A, E, G\}$

$K' \rightarrow B$ ? Yes!

$K': \{E, G\}$

$K' \rightarrow A$ ? Yes!

CK:  $\{E, G\}$

Candidate key(s):

**CK:  $\{E, G\}$**

1c. Is the relation in 2NF?

No!

1d. Why or why not?

Because FD2,  $E \rightarrow D$  is a partial dependency.

1e. Write the relation(s) in 2NF here, the FDs, and candidate keys for each relation. If already in 2NF, just write the relation:

$R_2(D, E)$

FD1:  $E \rightarrow D$

CK: E

$R_1(A, B, C, E, G)$

FD1:  $A \rightarrow B$

FD3:  $\{E, G\} \rightarrow \{A, C\}$

CK:  $\{E, G\}$

1f. Are the relation(s) you provided in question 1e in 3NF?

No!

1g. Why or why not?

Because FD1,  $A \rightarrow B$  is a transitive dependency.

1h. Write the relation(s) in 3NF here, the FDs, and candidate keys for each relation. If already in 3NF, just write the relation(s):

R3(A, B)

FD1:  $A \rightarrow B$

CK: A

R2(D, E)

FD1:  $E \rightarrow D$

CK: E

R1(A, C, E, G)

FD3:  $\{E, G\} \rightarrow \{A, C\}$

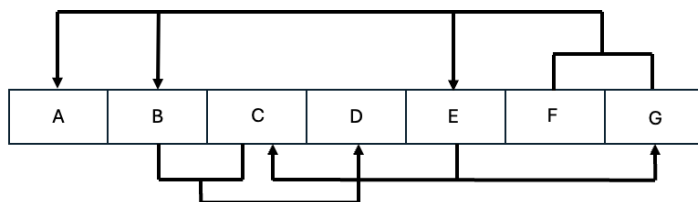
CK: {E, G}

2. Given the relation R(A, B, C, D, E, F, G) and the function dependencies

- FD1:  $E \rightarrow \{C, G\}$
- FD2:  $\{F, G\} \rightarrow \{A, B, E\}$
- FD3:  $\{B, C\} \rightarrow D$

**Note: You will have to infer two additional FDs that are in  $F^+$  before transforming from 2NF to 3NF**

2a. Draw the dependency diagram for this relation



2b. Identify all candidate keys using either the synthesis **OR** decomposition method. Show each step.

**Synthesis:**

$E^+ : \{E, C, G\}$

$\{F, G\}^+ : \{F, G, A, B, E, C, D\}$

$\{B, C\}^+ : \{B, C, D\}$

CK: {F, G} {F, E}

**Decomposition:**

Superkey: {A, B, C, D, E, F, G}

K': {A, B, C, D, E, F}

Does  $K' \rightarrow G$ ? Yes!

K': {A, B, C, D, E}

Does  $K' \rightarrow F$ ? No!

K': {A, B, C, D, F}

Does  $K' \rightarrow E$ ? No!

K': {A, B, C, E, F}

Does  $K' \rightarrow D$ ? Yes!

K': {A, B, E, F}

Does  $K' \rightarrow C$ ? YES!

K': {A, E, F}

Does  $K' \rightarrow B$ ? Yes! (FD1+FD2)

K': {E, F}

Does  $K' \rightarrow A$ ? Yes! (FD1+FD2)

CK: {F, E} {F, G}

Candidate key(s):

**CK: {F, E} {F, G}**

2c. Is the relation in 2NF?

No!

2d. Why or why not?

FD1a,  $E \rightarrow C$  is a partial Dependency.  $E \rightarrow G$ , however, is not a 2NF violation since G is a key attribute.

2e. Write the relation(s) in 2NF here, the FDs, and candidate keys for each relation. If already in 2NF, just write the relation:

$R_2(C, E)$

FD1:  $E \rightarrow C$

CK: E

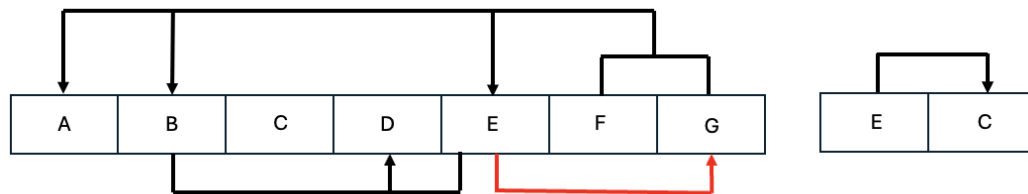
$R_1(A, B, D, E, F, G)$

FD1b:  $E \rightarrow G$

FD2:  $\{F, G\} \rightarrow \{A, B, E\}$

FD3:  $\{B, E\} \rightarrow D$

CK:  $\{F, E\} \{F, G\}$



2f. Are the relation(s) you provided in question 2e in 3NF?

No!

2g. Why or why not?

Because  $\{B, E\} \rightarrow D$  is a transitive dependency.

2h. Write the relation(s) in 3NF here, the FDs, and candidate keys for each relation. If already in 3NF, just write the relation(s):

$R_3(B, D, E)$

FD1:  $\{B, E\} \rightarrow D$

CK:  $\{B, E\}$

R2(C, E)

FD1:  $E \rightarrow C$

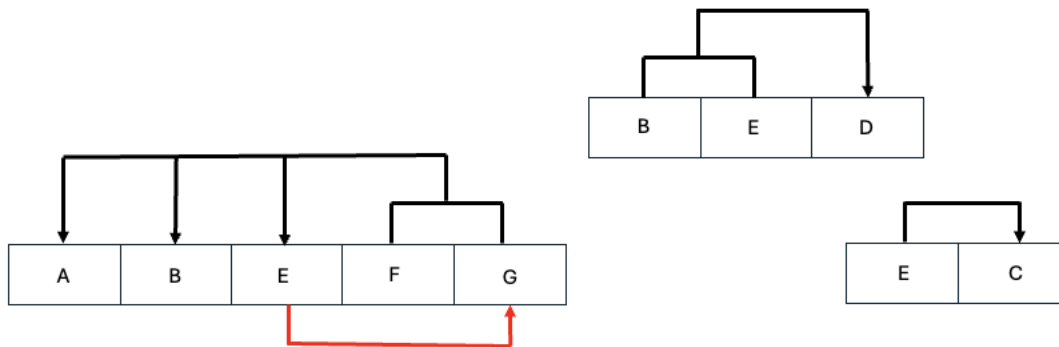
CK: E

R1(A, B, E, F, G)

FD1b:  $E \rightarrow G$

FD2:  $\{F, G\} \rightarrow \{A, B, E\}$

CK:  $\{F, E\} \{F, G\}$



3. Given the relation R(artist, album, year, length, genre, date, concert\_venue, city, state, capacity) and the function dependencies

- FD1: artist  $\rightarrow$  genre
- FD2: {artist, album}  $\rightarrow$  {year, length}
- FD3: {date, concert\_venue}  $\rightarrow$  artist
- FD4: {artist, date}  $\rightarrow$  concert\_venue
- FD5: concert\_venue  $\rightarrow$  {city, state, capacity}

Note: It may be easiest to replace the names of the attributes with letters (A, B, C, ...) when doing the synthesis or decomposition like we have done in class. If you do this, then:

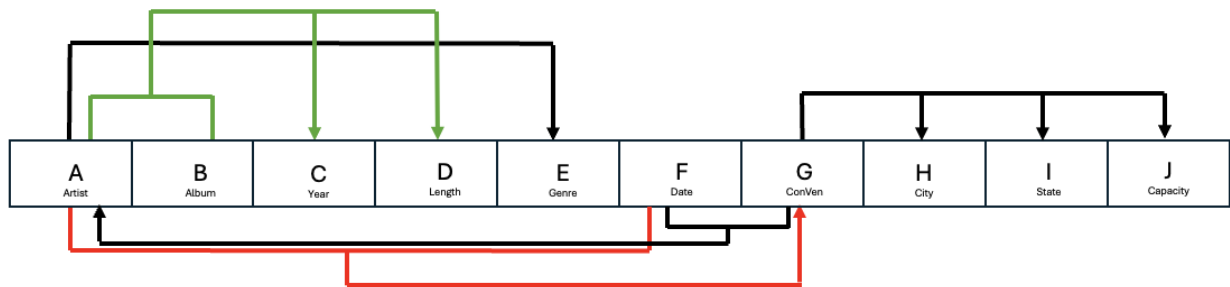
- Indicate what letter is assigned to what attribute.
- Show your candidate keys in steps b, e, and h using the NAMES of the attributes, not the letters

Artist	Album	Year	Length	Genre	Date	ConVen	City	State	Capacity
A	B	C	D	E	F	G	H	I	J

FD1: artist $\rightarrow$ genre FD2: {artist, album} $\rightarrow$ {year, length}	FD1: A $\rightarrow$ E FD2: {A, B} $\rightarrow$ {C, D}
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FD3: {date, concert_venue} $\rightarrow$ artist FD4: {artist, date} $\rightarrow$ concert_venue FD5: concert_venue $\rightarrow$ {city, state, capacity}	FD3: {F, G} $\rightarrow$ A FD4: {A, F} $\rightarrow$ G FD5: G $\rightarrow$ {H, I, J}
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3a. Draw the dependency diagram for this relation.



3b. Identify all candidate keys using either the synthesis OR decomposition method. Show each step.

#### Synthesis:

A+: {A, E}

{A, B}+: {A, B, C, D}

{F, G}+: {F, G, A, E, H, I, J}

{A, F}+: {A, F, G, E}

G+: {G, H, I, J}

{B, F, G}+: {B, F, G, A, E, H, I, J, C, D}

CK: {B, F, G} {B, F, A}

Candidate Key(s):

**CK: {B, F, G} {B, F, A}**

#### Decomposition:

Superkey: {A, B, C, D, E, F, G, H, I, J}

K': {A, B, C, D, E, F, G, H, I}

Does K'  $\rightarrow$  J? Yes! (G  $\rightarrow$  J)



$K': \{A, B, C, D, E, F, G, H\}$

Does  $K' \rightarrow I$ ? Yes! ( $G \rightarrow I$ )

$K': \{A, B, C, D, E, F, G\}$

Does  $K' \rightarrow H$ ? Yes! ( $G \rightarrow H$ )

$K': \{A, B, C, D, E, F\}$

Does  $K' \rightarrow G$ ? Yes! ( $\{A, F\} \rightarrow G$ )

$K': \{A, B, C, D, E\}$

Does  $K' \rightarrow F$ ? No!

$K': \{A, B, C, D, F\}$

Does  $K' \rightarrow E$ ? Yes ( $A \rightarrow E$ )

$K': \{A, B, C, F\}$

Does  $K' \rightarrow D$ ? Yes ( $\{A, B\} \rightarrow D$ )

$K': \{A, B, F\}$

Does  $K' \rightarrow C$ ? Yes ( $\{A, B\} \rightarrow C$ )

$K': \{A, F\}$

Does  $K' \rightarrow B$ ? No!

$K': \{B, F\}$

Does  $K' \rightarrow A$ ? No!

CK:  $\{A, B, F\} \{F, G, B\}$

Candidate Key(s):

**CK: {B, F, G} {B, F, A}**

3c. Is the relation in 2NF?

No

3d. Why or why not?

Because these three FDs are partial dependencies:

FD1:  $A \rightarrow E$

FD2:  $\{A, B\} \rightarrow \{C, D\}$

FD5:  $G \rightarrow \{H, I, J\}$

3e. Write the relation(s) in 2NF here, the FDs, and candidate keys for each relation. If already in 2NF, just write the relation:

R4(G, H, I, J)

FD1:  $G \rightarrow \{H, I, J\}$

CK: G

R3(A, B, C, D)

FD1:  $\{A, B\} \rightarrow \{C, D\}$

CK: {A, B}

R2(A, E)

FD1:  $A \rightarrow E$

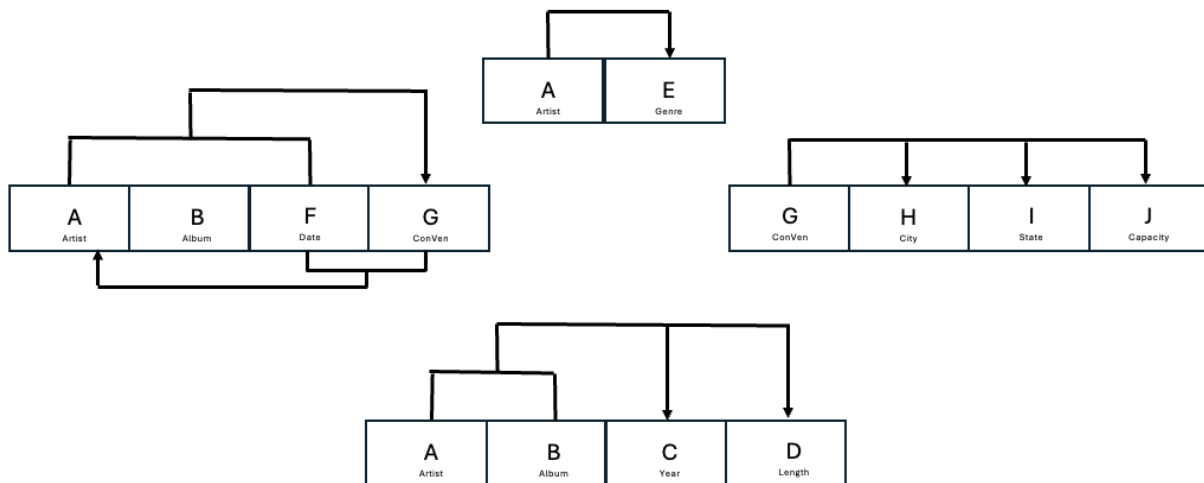
CK: A

R1(A, B, F, G)

FD3:  $\{F, G\} \rightarrow A$

FD4:  $\{A, F\} \rightarrow G$

CK: {B, F, G} {B, F, A}



3f. Are the relation(s) you provided in question 3e in 3NF?

Yes!

3g. Why or why not?

No Transitive Dependencies!

3h. Write the relation(s) in 3NF here, the FDs, and candidate keys for each relation. If already in 3NF, just write the relation(s):

The Answer is same as Question 3e.