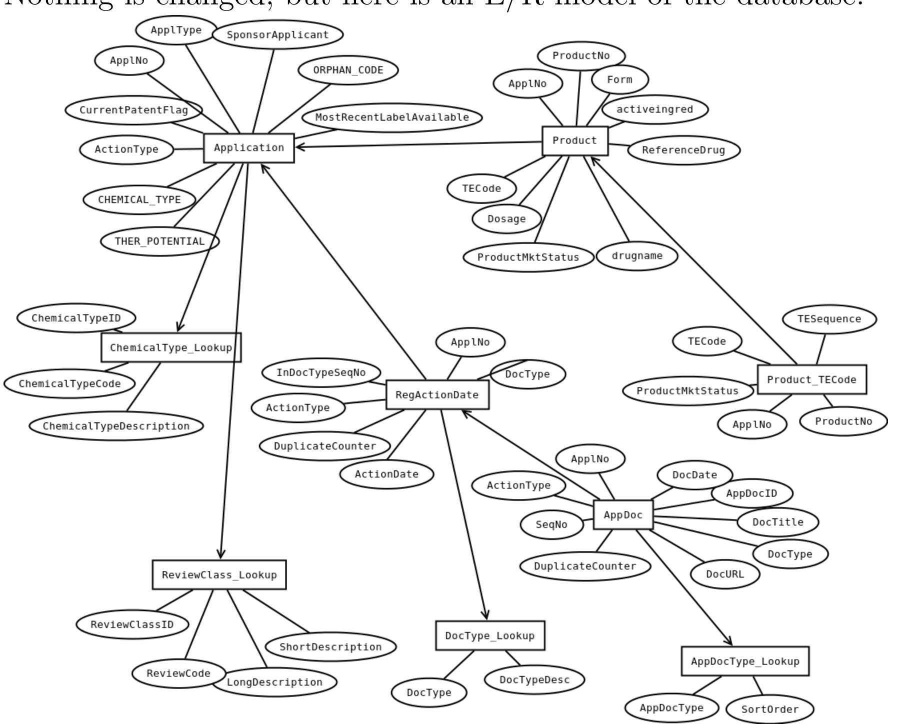
Modeling

1.1

a

Analyze the database and make changes necessary to bring the data into Boyce/Codd Normal Form (thus also into First, Second and Third Normal Form). Draw an E/R model showing the normalized database model, using the kind of model used in the book with entities as rectangles, attributes as ovals and relationship as diamonds connecting entities. The model must visualize the primary keys. Explain what you changed and why.

Nothing is changed, but here is an E/R model of the database:



b

Transform your E/R model into a relational schema. We want to keep information about primary keys in the schema. Foreign keys must be described explicit, like this:

$$mytable(id, name, department)$$
$$FK : department \rightarrow dept(id)$$

The relational schema looks like this:

Application(ApplNo, ApplType, SponsorApplicant, MostRecentLabelAvailable, CurrentPatentFlag, ActionType, CHEMICAL_TYPE, THER_POTENTIAL, ORPHAN_CODE)

Product(ApplNo, ProductNo, Form, Dosage, ProductMktStatus, TECode, ReferenceDrug, drugname, activeingred)
FK: ApplNo → Application(ApplNo)

Product_TECode(ApplNo, ProductNo, TECode, TESequence, ProductMktStatus)
FK: ApplNo → Product(ApplNo)
FK: ProductNo → Product(ProductNo)
FK: ProductMktStatus → Product(ProductMktStatus)

ChemicalType_Lookup(ChemicalTypeID, ChemicalTypeCode, ChemicalTypeDescription)

RegActionDate(ApplNo, ActionType, InDocTypeSeqNo, DuplicateCounter, ActionDate, DocType)
FK: ApplNo → Application(ApplNo)

AppDoc(AppDocID, ApplNo, SeqNo, DocType, DocTitle, DocURL, DocDate, ActionType, DuplicateCounter)

ReviewClass_Lookup(ReviewClassID, ReviewCode, LongDescription, ShortDescription)

DocType_Lookup(DocType, DocTypeDesc)

AppDocType_Lookup(AppDocType, SortOrder)

c

Make a SQL script (a file) with the SQL statements that can create a database from the relational schema in (b. The SQL script should, beside the table definitions, also define primary and foreign keys and not null constraints.

Not assessed.

Functional dependencies and normalization

2.1

Given a relation R(A,B,C,D,E,F). For each set of dependencies (a), (b), (c) find candidate key(s) and normalize to BCNF

$$a)\ A \to DE, B \to F, AB \to C$$

We see that A and B are never mentioned in the right side of the dependencies, therefore they have to be a part of the candidate key as minimum.
We also see that we can get following superkey:
ABCF (A $\to$ DE)
By trimming down, we can get:
ABC (B $\to$ F)
And finally:
AB (AB $\to$ C)
Which means AB is the candidate key for the relation R.

Now we want to normalize it to BCNF.

Since $A \to DE$ is a violation to BCNF in R since it doesn't contain the candidate key we found, we find the closures of A in R which is,

$$R1 = \{A, D, E\}$$

Since there are no occurences of D or E on the left side, we find S1:

$$S1 = (\{A, D, E\},\ \{A \to DE\})$$

Which satisfies BCNF.
Then R2 is $R - R1 + A$:

$$R2 = \{A, B, C, F\}$$

$$S2 = (\{A, B, C, F\},\ \{B \to F, AB \to C\})$$

From S2 we observe that $B \to F$ is a violation of BCNF. We follow the algorithm and get:

$$R3 = \{B, F\}$$

We project the FD's from S2 on R3 and R4:

$$S3 = (\{B, F\},\ \{B \to F\})$$

Which satisfies BCNF.
And the remaining:

$$R4 = \{A, B, C\}$$

$$S4 = (\{A, B, C\},\ \{AB \to C\})$$

Which satisfies BCNF.

$$S1 = (\{A, D, E\},\ \{A \to DE\})$$

$$S3 = (\{B, F\},\ \{B \to F\})$$

$$S4 = (\{A, B, C\},\ \{AB \to C\})$$

The relation is normalized in these schemas.

$$b)\ AB \to C, BD \to EF$$

Again, we see that A, B and D are never mentioned on the right side, so they have to be included in the candidate key as a minimum.
We can get following superkey:
ABDEF (AB $\to$ C)
Which can be trimmed down to:
ABD (BD $\to$ EF)
Therefore ABD is the candidate key, since it can't be trimmed further down.

Now we want to normalize it to BCNF.

We see that $AB \rightarrow C$ is a violation of BCNF. So we find the closures of AB in R:

$$R1 = \{A, B, C\}$$

Since there no occurences of C on the left side in the other FD's, we can determine S1:

$$S1 = (\{A, B, C\},\ \{AB \rightarrow C\})$$

Which satisfies BCNF.
Then R2 is $R - R1 + A, B$:

$$R2 = \{A, B, D, E, F\}$$

$$S2 = (\{A, B, D, E, F\},\ \{BD \rightarrow EF\})$$

Now $BD \rightarrow EF$ is a violation of BCNF. We follow the algoritm and get:

$$R3 = \{B, D, E, F\}$$

We project the FD from S2 on R3 and R4:

$$S3 = (\{B, D, E, F\},\ \{BD \rightarrow EF\})$$

Which satisfies BCNF.

$$R4 = \{A, B, D\}$$

$$S4 = (\{A, B, D\})$$

The relation is now normalized in these schemas.

$$S1 = (\{A, B, C\},\ \{AB \rightarrow C\})$$

$$S3 = (\{B, D, E, F\},\ \{BD \rightarrow EF\})$$

$$S4 = (\{A, B, D\})$$

$$c)\ A \rightarrow C, E \rightarrow F, E \rightarrow AD, AC \rightarrow D$$

We see that B and E are never mentioned on the right side, so they have to be included in the candidate key as a minimum.
Since this case is more obscure, we list what attributes can 'get' to the others.
We see that:

E $\rightarrow$ C, since E $\rightarrow$ AD and A $\rightarrow$ C
This means E is a key for ACDF. We concluded that B had to be in the candidate key as well, therefore BE is a candidate key.

Now we want to normalize it to BCNF.

We rewrite our functional dependencies:

$$A \rightarrow C, AC \rightarrow D$$

Can be rewritten to (transitivity):

$$A \rightarrow CD$$

and

$$E \rightarrow F, E \rightarrow AD$$

Can be written as

$$E \rightarrow ADF$$

So using transitivity we get:

$$E \rightarrow ACDF$$

We see that

$$E \rightarrow ADF$$

is a violation of BCNF. We begin by finding the closures of E in R:

$$R1 = \{A, C, D, E, F\}$$

There are no occurences of the other attributes since there are no more FD's in R, so:

$$S1 = (\{A, C, D, E, F\},\ \{E \rightarrow ACDF\})$$

Which satisfies BCNF.
We get another schema with no FD's:

$$S2 = (\{B, E\})$$

And we get the following schemas for normalization of the relation:

$$S1 = (\{A, C, D, E, F\},\ \{E \rightarrow ACDF\})$$

$$S2 = (\{B, E\})$$

2.2

Consider the relation R(A, B, C, D, E, F) and functional dependencies

$$A \to C$$

$$AC \to D$$

$$E \to F$$

$$D \to B$$

Use chase test to prove that the decomposition of this schema into AC, EF, EAD, and BD is lossless.

The start tableau for the decomposition:

A	B	C	D	E	F
a	b_1	c	d_1	e_1	f_1
a_2	b_2	c_2	d_2	e	f
a	b_3	c_3	d	e	f_3
a_4	b	c_4	d	e_4	f_4

Now we need to use the functional dependencies to prove t = a,b,c,d,e,f, meaning just one of the rows equals t is enough to prove t is in R. Since there already is only one attribute on the right side of the FD's, we begin using the first FD on the table.
We can use the FD $E \to F$ to change row 3 as well as $D \to B$ to change row 4 and the following tableau:

A	B	C	D	E	F
a	b_1	c	d_1	e_1	f_1
a_2	b_2	c_2	d_2	e	f
a	b	c_3	d	e	f
a_4	b	c_4	d	e_4	f_4

We then use $A \to C$ to change row 3:

A	B	C	D	E	F
a	b_1	c	d_1	e_1	f_1
a_2	b_2	c_2	d_2	e	f
a	b	c	d	e	f
a_4	b	c_4	d	e_4	f_4

Row 3 is now equal to t, which proves it's a lossless join.

Relational Algebra

A very simple model for CDs could be modeled by these four relations

$$cd(cdid, title, year, genre)$$

$$track(cdid, position, title, length)$$
$$artist(artistid, artistname)$$
$$trackartist(cdid, position, artistid)$$

where cd hold information on the CD, track hold information about tracks. One track can only belong to exactly on CD, thus the id of the CD together with the position will identify a track. The artist relation hold information of artists. The relation trackartist is a many-to-many relationship between track and artist. Answer the following using relational algebra (a clarification follows each question):

3.1

Find the title and year of all CDs from 1994-1996 that is either in the rock or the blues genre.

Finds the title and year of CD's from 1994, 1995 or 1996 in one of the genres rock or blues.

$\pi_{title,\, year}(\sigma_{year > 1993\ AND\ year < 1997\ AND\ (genre='rock'\ OR\ genre='blues')}(cd))$

3.2

List the titles of all tracks with Michael Jackson from 1999.

R1 = $cd \bowtie trackartist$
R2 = $\pi_{title}(\sigma_{year=1999\ AND\ artistname='Michael\ Jackson'}(R1 \bowtie artist))$

3.3

Find the title and the total length of all CDs with a track titled My song.

Finds the title and length of all tracks (sum) of a CD, where one of the tracks is titled "My song".

R1 = $\pi_{cdid}(\sigma_{title='My\ song'}(track))$
R2 = $R1 \bowtie cd$
R3 = ${}_{cdid}\, G\ {}_{SUM(length)}(R2)$
R4 = $\pi_{title,SUM(length)}(R3 \bowtie cd)$

SQL

Based on the database described in Problem 3, write SQL queries to answer the following (A little clarification text follows the SQL queries if it's unclear):

4.1

Find the titles of all CDs with a title starting with 'Lets'

SELECT title
FROM cd
WHERE title LIKE 'Lets%';

4.2

Find the title of all CDs with a track of 'Madonna'.

SELECT title
FROM cd NATURAL JOIN trackartist NATURAL JOIN artist
WHERE artistname = 'Madonna';

4.3

For each genre list the number of tracks and order the result descending by the number.
Lists the amount of track in each genre from most tracks to fewest tracks.

```
SELECT genre, COUNT(genre)
FROM cd JOIN track ON cd.cdid = track.cdid
GROUP BY genre
ORDER BY COUNT(genre) DESC;
```

4.4

Find the name of actors that have participated in CDs in the genres rock, jazz and dance.

Finds the artists that has made a track from a cd with just one of the 3 given genres. They don't need to have made a song in each genre.

```
SELECT DISTINCT artistname
FROM cd NATURAL JOIN trackartist NATURAL JOIN artist
WHERE genre IN ('rock', 'jazz', 'dance');
```

4.5

What is the title(s) of the longest CD (with the highest total length).

```
SELECT title
FROM cd
WHERE cdid in (
SELECT cdid
FROM track
GROUP BY cdid
HAVING SUM(length) in (
SELECT MAX(SUM(length))
FROM track
GROUP BY cdid));
```

4.6

Find the title, year and genre for all CDs that has more than 5 different artists.

```
SELECT title, year, genre
FROM cd
WHERE cdid IN (
SELECT cdid
FROM (
SELECT cdid, COUNT(DISTINCT artistid)
FROM trackartist
GROUP BY cdid
HAVING COUNT(DISTINCT artistid) > 5));
```

4.7

For each artist that has made CDs together with Fran Sinatra (appearing on tracks on the same CD) list the artists name and the number of times. Order by artist name.

Find the artists who have been on the same cd as Frank Sinatra and lists the artist along the number of times he/she has appeared on the same cd (not the amount of tracks that are on one of the same cd's as Frank Sinatra). Doesn't list Frank Sinatra himself.

```
SELECT artistname, COUNT(artistid)
FROM (
SELECT DISTINCT cdid, artistid, artistname
FROM trackartist NATURAL JOIN artist
WHERE cdid IN (
SELECT cdid
FROM trackartist NATURAL JOIN artist
WHERE artistname='Frank Sinatra') AND artistname!='Frank Sinatra')
GROUP BY artistname
ORDER BY artistname;
```

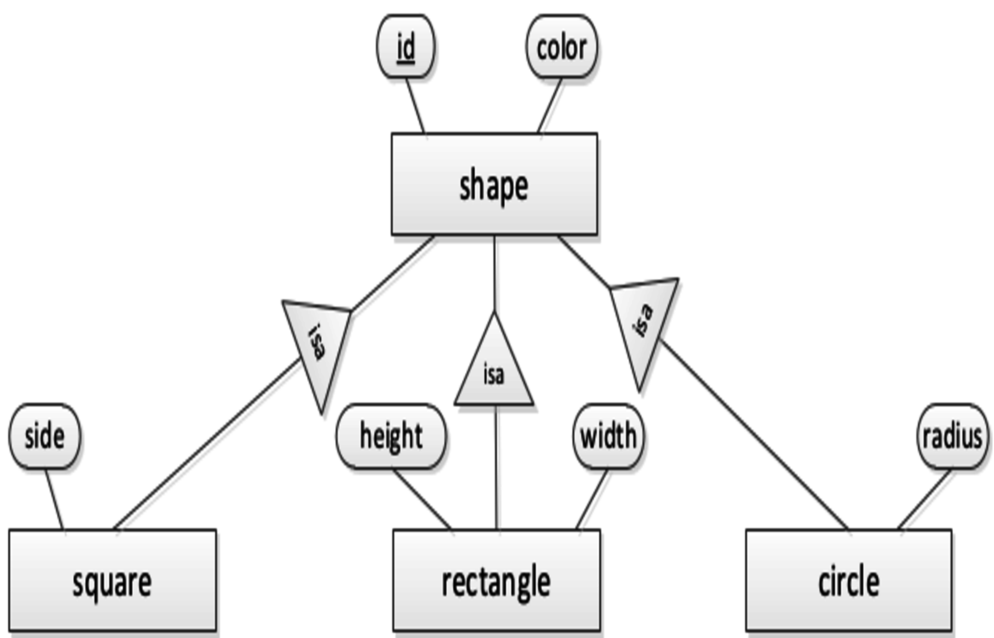
4.8

Find title and year of all CDs that has tracks with at least five different artists who is also appearing on tracks from the album Absolute Music 15

This SQL query finds the title and year of the CD's that has 'at least' 5 different artists and there is at least 5 artists from the same cd that appears on 'Absolute Music 15'. Absolute Music 15 itself is included if it has at least 5 different artists.

```
SELECT title, year
FROM cd
WHERE cdid IN (
SELECT cdid
FROM (
SELECT cdid, artistid
FROM trackartist
WHERE artistid in (
SELECT artistid
FROM cd NATURAL JOIN trackartist
WHERE title ='Absolute Music 15'))
GROUP BY cdid
HAVING COUNT(DISTINCT artistid) > 4);
```

SQL/Modeling



5.1

From the above E/R diagram make relational schemas using each of the following approaches

a) The straight E/R method.

Shape(id, color)
Square(id, side)
Rectangle(id, height, width)
Circle(id, radius)

b) The object − oriented method.

Shape(id, color)
ShapeS(id, color, side)
ShapeR(id, color, height, width)
ShapeC(id, color, radius)
ShapeSR(id, color, side, height, width)

c) The null method.

Shape(id, color, side, height, width, radius)

5.2

Write the SQL statements that will modify data stored in the schemas from 5.1.

a) Add a new red circle with radius 34 *and id* 1234

With the E/R method schema:

INSERT INTO Shape
VALUES (1234, RED);
INSERT INTO Circle
VALUES (1234, 34);

With the object-oriented method schema:

INSERT INTO ShapeC

VALUES (1234, RED, 34);

With the null method schema:

INSERT INTO Shape VALUES(1234, RED, NULL, NULL, NULL, 34);

$b)\, Change\, the\, color\, to\, blue\, for\, the\, shape\, identified\, by\, id$ 4321

With the E/R method schema:

UPDATE Shape
SET color = BLUE
WHERE id = 4321;

With the object-oriented method schema:

UPDATE Shape
SET color = BLUE
WHERE id = 4321;

UPDATE ShapeS
SET color = BLUE
WHERE id = 4321;

UPDATE ShapeR
SET color = BLUE
WHERE id = 4321;

UPDATE ShapeC
SET color = BLUE
WHERE id = 4321;

UPDATE ShapeSR
SET color = BLUE
WHERE id = 4321;

With the null method schema:

UPDATE Shape
SET color = BLUE
WHERE id = 4321;

c) Delete all rectangles with a height between 30 *and* 40.

These will delete rectangles with a height 'between' 30 and 40 and not rectangles with a height of exactly 30 or 40.

With the E/R method schema:

DELETE FROM Rectangle
WHERE height > 30 AND height < 40;

With the object-oriented method schema:

DELETE FROM ShapeR
WHERE height > 30 AND height < 40;

With the null method schema:

DELETE FROM Shape
WHERE height > 30 AND height < 40;