CS 338 – Spring 2026
Final Exam
Reference Sheet

1 Schemas

1.1 Company

Relations:

1. **DEPARTMENT**

DNAME	DNUMBER	MGRSSN	MGRSTARTDATE

Sample Data:

DNAME	DNUMBER	MGRSSN	MGRSTARTDATE
Finance	1	123456789	2022-04-19
Human Resources	2	234567890	2018-11-05
Customer Relations	3	345678901	2008-01-22

2. **DEPENDENT**

ESSN	DEPENDENT_NAME	SEX	BDATE	RELATIONSHIP

Sample Data:

ESSN	DEPENDENT_NAME	SEX	BDATE	RELATIONSHIP
123456789	Steve Howe	M	2012-05-11	Son
234567890	Christine Squire	M	2010-12-11	Niece

3. **DEPT_LOCATIONS**

DNUMBER	DLOCATION

Sample Data:

DNUMBER	DLOCATION
1	Waterloo
2	Stratford
3	Brantford

4. **EMPLOYEE**

FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO

Sample Data:

FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO
Alan	D	White	123456789	1977-05-02	123 Twist Lane	M	90000	NULL	1
Joanna	F	Anderson	234567890	1981-10-10	345 Hopkins Court	F	85000	123456789	2
Antonio	K	Kaye	345678901	1975-01-19	789 Bishops Close	M	92000	123456789	3

5. **PROJECT**

PNAME	PNUMBER	PLOCATION	DNUM

Sample Data:

PNAME	PNUMBER	PLOCATION	DNUM
Fragile Album	11	London	1
Relayer Album	12	Sheffield	2
The Yes Album	13	Aylesbury	3

6. **WORKS_ON**

ESSN	PNO	HOURS

Sample Data:

ESSN	PNO	HOURS
123456789	1	20
234567890	2	35

1.2 Apparel

Relations:

1. **PERSON**

PID	FNAME	LNAME	BDATE	SEX	SIZE

Sample Data:

PID	FNAME	LNAME	BDATE	SEX	SIZE
1	Nathan	Tang	2002-05-02	M	L
2	Chistopher	Strand	1985-05-17	M	XL
3	Alexandra	Jones	1991-02-26	F	M

2. **COLOUR**

CID	CNAME

Sample Data:

CID	CNAME
1	Red
2	Green
3	Blue

3. **TSHIRT**

TID	PID	CID

Sample Data:

TID	PID	CID
1	1	1
2	1	1
3	2	3

- **FOREIGN KEY**("PID") REFERENCES "PERSON"("PID"),
- **FOREIGN KEY**("CID") REFERENCES "COLOUR"("CID"),

Note: The TSHIRT table records which person owns which t-shirt.

1.3 Bank

Suppose that

(i) the domain of the SIN attribute is all social insurance numbers, and
(ii) the domain of the Type attribute is { chequing, savings }.

Further suppose that

- The Cheque relation contains the SINs of bank customers who have a chequing account,
- The Savings relation contains the SINs of bank customers who have a savings account, and
- The AllTypes relation contains

Type
chequing
savings

2 Algorithms

2.1 Mapping ERD to Relational Model

1. Map Regular Entity Types
   (a) For each regular (strong) entity type E, create a relation R that includes all the simple attributes of E.
   (b) Primary key (PK) of E becomes PK of R.
2. Map Multivalued attributes
   (a) Suppose A is a multi-valued attribute, belonging to a relation (or attribute) named S.
   (b) Create a new relation, R.
      i. R will include an attribute corresponding to A, plus PK attribute, K, of S.
      ii. Make K a FK to S.K in R.
      iii. Make the PK of R = A + K.
3. Map Weak Entity Types
   (a) For each weak entity type W with owner entity type E, create a relation R and include all simple attributes of W as attributes of R.
   (b) Include the primary key of owner as foreign key of R.
   (c) PK of R = PK of the owner + the partial key of W.
   (d) The Identifying relationship is ignored.
4. Map 1:1 Relationships
   (a) For each 1:1 relationship R, identify the participating relations S and T. Three possible approaches:
      i. Foreign Key approach: If only the participation of S is total, include PK of T as FK in S.
      ii. Merged relation option: If participations of S and T are both total, merging S and T and the relationship into a single relation. One of PK becomes PK of the new relation.
      iii. Cross-reference option: If none is total, set up a third relation C which includes PKs of S and T as FKs. One of the PKs will form the primary key of C.
5. Map 1:N Relationships
   (a) Assume S and T are participants and relation S is at the N-side.
   (b) Include PK of T as FK in S.
   (c) Include any simple attributes of the relationship as attributes of S.
6. Map N:M Relationships
   (a) For each M:N relationship type R, create a new relation C to represent R (S and T are participants).
   (b) Include PKs of S and T as FKs in C.
   (c) Their combination will form the primary key of C.
   (d) Include any simple attributes of R as attributes of C.
7. Map ternary and n-ary Relationships
   (a) For each n-ary relationship type R, create a new relation C to represent R.
   (b) Include PKs of all participants as FKs in C.
   (c) Their combination will form the primary key of C.
   (d) Include any simple attributes of R as attributes of C.

2.2 Normalization

1. We must be given a relation, R, with its set, F, of Functional Dependencies (FDs).
2. Find the candidate keys of R.
3. Look among the given FD's for a BCNF violation $X \to B$.
4. Compute the closure, X^+.
5. X^+ cannot contain all attributes (else X would be a superkey).
6. Replace R by relations with schemas:

$$R1 = X^+ \quad (1)$$
$$R2 = R - X^+ + (X) \quad (2)$$

   (X is the PK in $R1$ and FK in $R2$ referring to $R1$.)
7. Project the given FD's F onto the two new relations.
8. Check whether $R1$ and $R2$ are now in BCNF, based on the projected FDs.
9. If not, repeat the above steps for each of $R1$ and $R2$.