

# Data and Web Development CC6012NP

7

Normalisation

# Topics

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- **Introduction**
- **Anomalies (Insert, Delete, Update)**
- **Why Normalisation**
- **Functional and Transitive Dependency**
- **Normalisation**
  - Unnormalized Form (UNF)
  - First Normal Form (1NF)
  - Second Normal Form (2NF)
  - Third Normal Form (3NF)

# Introduction

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- Normalization is the process **to get data into simpler form** that truly reflects separate entity types, their attributes and relationships between them to **avoid unnecessary duplication (redundancy) of data**
- Starts from pre-documented sets of attributes and tries to group and regroup them without causing **data inconsistencies** in such a way that **Anomalies are avoided**

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# Anomalies

- **Anomalies** are undesirable side effects or problems that can occur if relations/tables are not in proper normal form.
- **Anomalies fall into three categories:**
  - Insertion Anomaly
  - Deletion Anomaly
  - Update Anomaly

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# Anomalies

Employee_id	Employee_name	Employee_Address	Department_id	De
Emp1	John	Kathmandu	Dep1	IT
Emp2	Alice	Kathmandu	Dep2	Fin
Emp3	David	Dharan	Dep1	IT
Emp4	Jeffery	Biratnagar	Dep1	IT
Emp5	Martha	Chitwan	Dep3	Sal
Emp6	Claudia	Kathmandu	Dep3	Sal

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# Anomalies

- **Insertion Anomaly:**

- Adding new rows forces user to create duplicate data or occurs when we cannot insert new row into relation because some or all of Primary Key value is not known.

- **Deletion Anomaly:**

- Deleting rows may cause loss of data that would be needed for other future rows

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# Anomalies

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- **Update Anomaly:**

- Changing data in row forces changes to other rows because of duplication.
- Update: occurs when we have unnecessary redundancy in the data and we are forced to update several rows.

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# Why Normalisation



Thesaurus . plus

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# Why Normalisation

- Database Design must be efficient (performance-wise).
- Amount of data should be reduced if possible.
- Design should be free of **Update, Insertion** and **Deletion** Anomalies.
- Design must comply with rules regarding Relational Databases.
- Design has to show relevant Relationship between Entities.
- Design should permit simple retrieval, simplify data maintenance and reduce need to restructure data.

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# Functional Dependencies (FD)

- Normalisation is based on analysis of Functional Dependence.
- Functional Dependency is particular Relationship between two Attributes.

Functional Dependency

$A \rightarrow B$

**B** - functionally dependent on **A**

**A** - determinant set

**B** - dependent attribute

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# Functional Dependencies (FD)

- Attribute B is Functionally Dependent upon Attribute A (or a collection of attributes) if a value of A determines a single value of B at any one time.
- Value of one Attribute (collection of attributes) determines value of another Attribute

The following table illustrates  $A \longrightarrow B$ :

A	B
1	1
2	4
3	9
4	16
2	4
7	9

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# Functional Dependencies (FD)

- Notation for this Functional Dependency is:  $A \rightarrow B$
- Notation is read “A determines B” or “B is Functionally Dependent on A”.
- A is called Determinant and B is called object of Dependent.
- Composite Determinant is made up of more than one attribute:  $X, Y \rightarrow Z$

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# Functional Dependencies (FD)

- **Two terms relevant with Composite Determinants**

- **Full Functional Dependency (FFD)**

- If it is necessary to use all attributes of Composite Determinant to identify its object uniquely, we have Full Functional Dependency.

- **Partial Functional Dependency (PFD)**

- Dependency exists if it is necessary to use only subset of Attributes of a Composite Determinant to identify object uniquely.

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# FD - Example

<u>Student-id</u>	<u>Activity</u>	Cost	Proficiency
100	Squash	200	A
100	Swimming	100	B
150	Swimming	100	B
175	Scuba	300	L
175	Aerobics	200	I
200	Squash	200	A
200	Swimming	100	A

- FFD = student-id, activity → proficiency
- PFD = activity → cost

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# FD - Example

<u>Booking_id</u>	<u>Room_id</u>	Guest-name	Roomtype	Price_per_night
B101	R01	John	Deluxe	5000
B102	R01	Minnie	Deluxe	5000
B103	R02	Manon	Suite	9000

- FFD = Booking\_id, Room\_id → Price\_per\_night
- PFD = Room\_id → Roomtype

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# Transitive Dependency (TD)

- Transitive Dependency exists when there is an intermediate dependency. Assume three attributes A, B and C. Further assume that the following functional dependencies exist
  - $A \rightarrow B, B \rightarrow C$
- Then it can be stated that the following transitive dependency also holds
  - $A \rightarrow B \rightarrow C$

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# Transitive Dependency (TD)

Student-id	Accommodation	Fee
100	Perkin	1100
150	Gatehouse	1200
200	Gatehouse	1200
250	Perkin	1100
300	Ingleside	1500

- FD = student-id  $\rightarrow$  accommodation
- FD = student-id  $\rightarrow$  fee
- FD = accommodation  $\rightarrow$  fee
- TD = student-id  $\rightarrow$  accommodation  $\rightarrow$  fee

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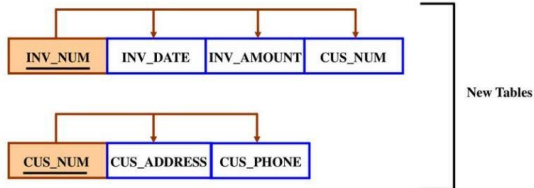
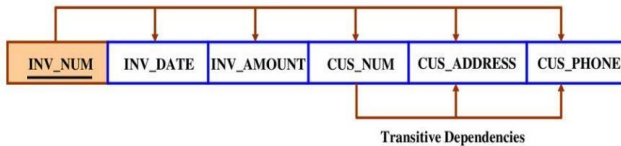
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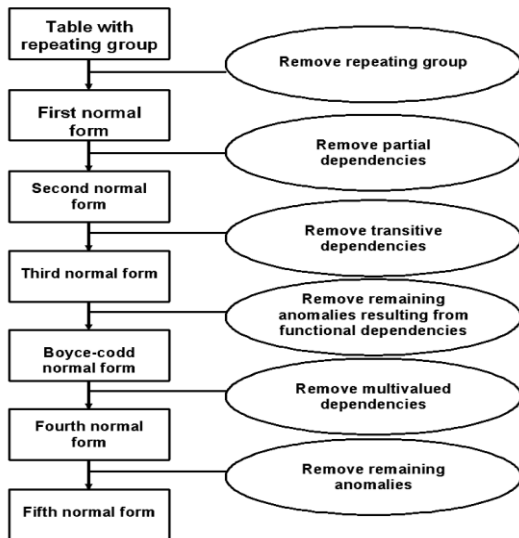
# Transitive Dependency (TD)

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# Steps in Normalisation



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# Steps in Normalisation

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- **Step 1: Un-Normalised Form (UNF)**

- All attributes with repeating groups are included.

- **Step 2: First Normal Form (1NF)**

- Any repeating groups have been separated, so that there is a single valued attribute at the intersection of each row and column of the table.

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# Steps in Normalisation

## • Step 3: Second Normal Form (2NF)

- Any Partial Functional Dependencies have been separated.

## • Step 4: Third Normal Form (3NF)

- Any Transitive Dependencies have been separated.

**Note:** If Relation meets the criteria for 3NF, it also meets criteria for 2NF and 1NF. Most design problems can be avoided if Relations are in 3NF.)

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# Un-normalised Normal Form (UNF)

- Relation is un-normalised if it has not had any normalisation rules applied to it and if it suffers from various anomalies.
- **Sources of un-normalised data are:**
  - Computer Screen Layouts
  - Reports
  - Computer Programs
  - User Manuals

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# An Order Form – Example

Secure Parts Ltd

Customer number: 1489  
Name: Arthur Smith  
Address: 1 Lime Avenue  
Anytown  
ZZ52 5QA

Order number: 0057435  
Order date: 11-Jan-06

product number	product description	unit price	order quantity	line total
T5060	Lock	5.00	5	25.00
PT42	Alarm	20.00	1	20.00
QZE248	Key	2.50	10	25.00

Order total: 70.00

Collection of orders

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# Un-normalized Form (UNF)

Order-no	Order-date	Cust-no	Cust-name	Cust-address	Prod-no	Prod-desc	Unit-price	Ord-qty	Line-total	Order-total
0057435	11-JAN-06	1489	Arthur Smith	1 Lime Avenue Anytown ZZ52 5QA	T5060	Lock	5.00	5	25	70.00
0057435	11-JAN-06	1489	Arthur Smith	1 Lime Avenue Anytown ZZ52 5QA	PT42	Alarm	20.00	1	20.00	70.00
0057435	11-JAN-06	1489	Arthur Smith	1 Lime Avenue Anytown ZZ52 5QA	QZE248	Key	2.50	10	25.00	70.00

# Un-normalised Form (UNF)

Multi-valued

Order-no	Order-date	Cust- no	Cust-name	Cust-address	Prod-no	Prod-desc	Unit-price	Ord-qty	Line-total	Order-total
0057435	11-JAN-06	1489	Arthur Smith	1 Lime Avenue Anytown ZZ52 5QA	T5060, PT42, QZE248	Lock, Alarm,key	5,20,2.5	5,1,10	25,20,25	70.00

# Un-normalised Normal Form(UNF)

Multi-valued attribute group = repeating group

Order-no	Order-date	Cust-no	Cust-name	Cust-address	Prod-no	Prod - desc	Unit-price	Ord-qty	Line-total	Order-total
0057435	11-JAN-06	1489	Arthur Smith	1 Lime Avenue Anytown ZZ52 5QA	T5060,P T4 2, QZE248	Lock, Alarm,key	5,20,2. 5	5,1,10	25,20,25	70.00

Repeating Group = prod-no, prod-desc, unit-price, ord-qty, line-total

A repeating group is an attribute (or set of attributes) that can have multiple values for a single occurrence of the key (single or composite) in a table.

# Applying UNF

1. Write down all attributes from above and name this entity.
2. Choose suitable unique identifier for this entity
3. Show Repeating Group within { }.

ORDER

**ORDER** (order-no, order-date, cust-no, cust-name, cust-address, {prod-no, prod-desc, unit-price, ord-qty, line-total}, order-total)

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# First Normal Form (1NF)

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A table is said to be in 1NF if each column has atomic (single) values.

- Repeating groups should be removed to separate Relation
- 1NF restriction is built into Relational Model
- Advantages of 1NF are simplicity and uniform access

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# Applying 1NF

**ORDER** (order-no, order-date, cust-no, cust-name, cust-address, {prod-no, prod-desc, unit-price, ord-qty, line-total}, order-total)



**ORDER-1** (order-no, order-date, cust-no, cust-name, cust-address, order-total)

**ORDER-LINE-1** (order-no\*, prod-no, prod-desc, unit-price, ord-qty, line-total)



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# Second Normal Form (2NF)

- **Relation is in 2NF if**

- It is in 1NF, and
- All non-key attributes are Fully Functionally Dependent on Primary Key and not on only a part (portion) of Primary Key.
- Attributes that are wholly dependent on only part of Composite identifier should be removed to a separate Relation
- Prohibits situation where each row represents single-valued facts about more than one object.
- Partial FDs on an identifier should be avoided because they result in data redundancy.

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# Second Normal Form (2NF)

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- **Steps to transform into 2NF**

- Identify all Functional Dependencies in 1NF.
- Make each Determinant Primary Key of new Relation.
- Place all attributes that depend on given Determinant in Relation with that Determinant as non-key attributes.

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# Identifying PFDs

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- List all combination of Composite Determinant (Primary Key) and Part of Composite Determinant (Primary Key)
- How are non-key attributes dependent on determinants?

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- order-no, prod-no → ord-qty, line-total
  - prod-no → prod-desc, unit-price
  - order-no →
- 

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# Applying 2NF

**ORDER-1** (order-no, order-date, cust-no, cust-name, cust-address, order-total)

**ORDER-LINE-1** (order-no, prod-no, prod-desc, unit-price, ord-qty, line-total)



**ORDER-2** (order-no, order-date, cust-no, cust-name, cust-address, order-total)

**ORDER-LINE-2** (order-no\*, prod-no\*, ord-qty, line-total)

**PRODUCT-2** (prod-no, prod-desc, unit-price)

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# Second Normal Form (2NF)

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- Relation with only *single attribute* key are already in 2NF
  - $A \rightarrow b, c, d$
- Relation with Composite key may not be in 2NF, as there may be some PDs
  - $X, Y \rightarrow l, m, n$
- Relation that is in First Normal Form will be in Second Normal Form if any one of following conditions apply:
  - Primary Key consists of only one attribute (such as the attribute ORDER-NO in ORDER).
  - No non-key attributes exist in Relation.
  - Every non-key attribute is Functionally Dependent on full set of Primary Key attributes

# Third Normal Form (3NF)

- Relation is in 3NF if
- It is in 2NF, and
  - No Transitive Dependencies.
  - Transitive Dependencies are when
    - $A \rightarrow B \rightarrow C$
    - Thus it can be split into
      - $A \rightarrow B$   
and
      - $B \rightarrow C$ .

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# Third Normal Form (3NF)

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- Attributes that are wholly dependent upon another attribute should be removed to separate Relation.
- Like 2NF, but now we consider FDs on non-key attributes only and do not worry about Key.
- Transitive Dependencies should be avoided because they result in data redundancy.

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# Third Normal Form (3NF)

- Steps to transform into 3NF
  - Create one relation for each Determinant in Transitive Dependency.
  - Make Determinants Primary Keys in their respective relations.
  - Include as non-key attributes those attributes that depend on Determinant
    - order-no  $\rightarrow$  cust-no  $\rightarrow$  cust-name, cust-address
    - order-no  $\rightarrow$  order-date, cust-no, order-total
    - cust-no  $\rightarrow$  cust-name, cust-address


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# Applying 3NF

**ORDER-2** (order-no, order-date, cust-no, cust-name, cust-address, order-total)

**ORDER-LINE-2** (order-no, prod-no, ord-qty, line-total)

**PRODUCT-2** (prod-no, prod-desc, unit-price)



**ORDER-3** (order-no, order-date, cust-no\*, order-total)

**ORDER-LINE-3** (order-no\*, prod-no\*, ord-qty, line-total)

**PRODUCT-3** (prod-no, prod-desc, unit-price)

**CUSTOMER-3** (cust-no, cust-name, cust-address)

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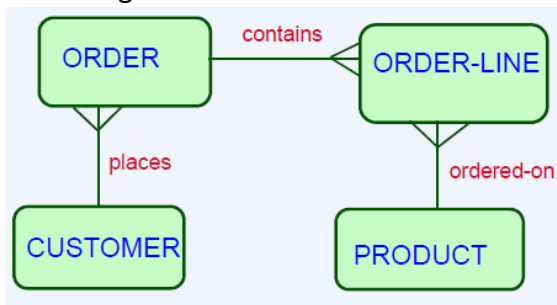
# Third Normal Form (3NF)

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- Entities which are *all-key* OR have only *single non-key* attribute are already in 3NF
  - $A, B \rightarrow$
  - $A \rightarrow b$
- Entities with more than one non-key attribute may not be in 3NF, as there may be some TDs
  - $X, Y \rightarrow l, m, n$
  - $X \rightarrow l, m$

# ER Model Representation

- Final list of 3NF entities can be represented by following ER model:



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# Eliminating Redundancy

Order-no	Order-date	Cust-no	Cust-name	Cust-add	Prod-no	Prod-desc	Price	Qty
0057435	11-01-02	1489	Smith	Anytown	Q2E	Spanner	20.00	5
0057435	11-01-02	1489	Smith	Anytown	PT42	Bolt	2.50	10
0057435	11-01-02	1489	Smith	Anytown	T5060	Hook	5.00	1
0057436	12-01-02	1489	Smith	Anytown	T5060	Hook	5.00	4
0057437	12-01-02	1500	Jones	Somewhere	T5060	Hook	5.00	2

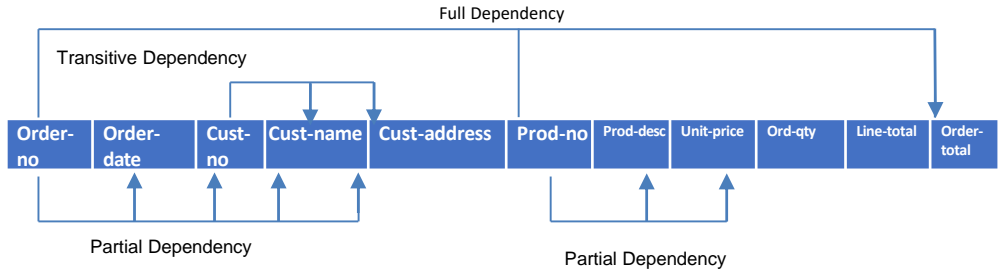
1NF

3NF

2NF

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# Eliminating Redundancy



# Project Allocation Example

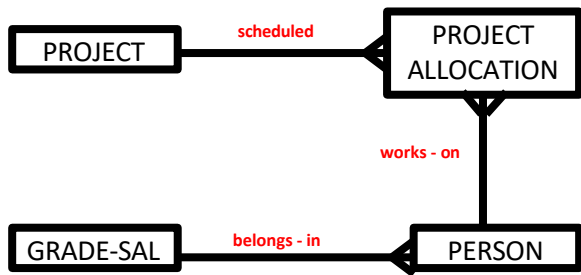
Project Code	Project Type	Description	Person Number	Name	Grade	Salary Scale	Date-join Project	Alloc-time
IC5001	New Dev	Develop Claims System	2146	Jones	A1	4	1/11/20xx	24
IC5001	New Dev	Develop Claims System	3145	Smith	A2	4	2/10/20xx	24
IC5001	New Dev	Develop Claims System	6126	Black	B1	9	7/11/20xx	18
IC5001	New Dev	Develop Claims System	1214	Brown	A2	4	3/10/20xx	12
IC5001	New Dev	Develop Claims System	8191	Green	A1	4	12/11/20xx	18
PAY22	Maint	Maintain Payments	6142	Jacks	A2	4	9/11/20xx	6
PAY22	Maint	Maintain Payments	3169	White	B2	10	4/11/20xx	12
PAY22	Maint	Maintain Payments	6145	Dean	B3	10	8/10/20xx	6

# Normalisation from UNF to 3NF

UNF	1 NF	2 NF	3 NF
<b>Project</b> <u>Project-code</u> Project-type Description {Person-number Name Grade Salary-scale Date-join-project Alloc-time}	<b>Project</b> <u>Project-code</u> Project-type Description  <b>Project-Allocation</b> <u>Project-code*</u> <u>Person-number</u> Name Grade Salary-scale Date-join-project Alloc-time	<b>Project</b> <u>Project-code</u> Project-type Description  <b>Project-Allocation</b> <u>Project-code*</u> <u>Person-number*</u> Date-join-project Alloc-time  <b>Person</b> <u>Person-number</u> Name Grade Salary-scale	<b>Project</b> <u>Project-code</u> Project-type Description  <b>Project-Allocation</b> <u>Project-code*</u> <u>Person-number*</u> Date-join-project Alloc-time  <b>Person</b> <u>Person-number</u> Name Grade*  <b>Grade-Sal</b> <u>Grade</u> Salary-scale

# Project Allocation - ER Model




- Final list of 3NF Relation can be represented by following ER model



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# Summary of Dependencies

## Types of dependency between attributes

Attributes			Dependency
Key		Non - Key	Functional
Part of Key		Non - Key	Partial Functional
Non - Key		Non - Key	Transitive

- Our aim is for key to determine all other non-key attributes.
- Therefore, only first type of dependency is desirable.
- Normalisation ensures that entities are decomposed so that there is only Functional Dependency.

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Any Questions?