

# Normalization Form

# Sales Records:

Cust Name	Item	Shipping Address	Newsletter	Supplier	Supplier Phone	Price
Alan Smith	Xbox One	35 Palm St, Miami	Xbox News	Microsoft	(800) BUY-XBOX	250
Roger Banks	PlayStation 4	47 Campus Rd, Boston	PlayStation News	Sony	(800) BUY-SONY	300
Evan Wilson	Xbox One, PS Vita	28 Rock Av, Denver	Xbox News, PlayStation News	Wholesale	Toll Free	450
Alan Smith	PlayStation 4	47 Campus Rd, Boston	PlayStation News	Sony	(800) BUY-SONY	300

- 1st Normal Form**
- Each cell to be Single valued
  - Entries in a column are same type
  - Rows uniquely identified - Add Unique ID, or Add more columns to make unique  
(Note: The order of the rows and the order of the columns are irrelevant)

Primary Key

Cust ID	Cust Name	Item	Shipping Address	Newsletter	Supplier	Supplier Phone	Price
at_smith	Alan Smith	Xbox One	35 Palm St, Miami	Xbox News	Microsoft	(800) BUY-XBOX	250
roger25	Roger Banks	PlayStation 4	47 Campus Rd, Boston	PlayStation News	Sony	(800) BUY-SONY	300
wilson44	Evan Wilson	Xbox One	28 Rock Av, Denver	Xbox News	Microsoft	(800) BUY-XBOX	250
wilson44	Evan Wilson	PS Vita	28 Rock Av, Denver	PlayStation News	Sony	(800) BUY-SONY	200
am_smith	Alan Smith	PlayStation 4	47 Campus Rd, Boston	PlayStation News	Sony	(800) BUY-SONY	300

? X

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wilson44	Evan Wilson	PS Vita	28 Rock Av, Denver	PlayStation News	Sony	(800) BUY-SONY	200
am_smith	Alan Smith	PlayStation 4	47 Campus Rd, Boston	PlayStation News	Sony	(800) BUY-SONY	300

## 2nd Normal Form - All attributes (Non-Key Columns) dependent on the key

Primary Key

Cust ID	Cust Name	Shipping Address	Newsletter
at_smith	Alan Smith	35 Palm St, Miami	Xbox News
roger25	Roger Banks	47 Campus Rd, Boston	PlayStation News
wilson44	Evan Wilson	28 Rock Av, Denver	Xbox News
wilson44	Evan Wilson	28 Rock Av, Denver	PlayStation News
am_smith	Alan Smith	47 Campus Rd, Boston	PlayStation News

Primary Key

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Xbox One	Microsoft	(800) BUY-XBOX	250
PlayStation 4	Sony	(800) BUY-SONY	300
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Primary Key

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PlayStation 4	Sony	(800) BUY-SONY	300
PS Vita	Sony	(800) BUY-SONY	200

Primary Key

Primary Key

Cust ID	Item
at_smith	Xbox One
roger25	PlayStation 4
wilson44	Xbox One
wilson44	PS Vita
am_smith	PlayStation 4



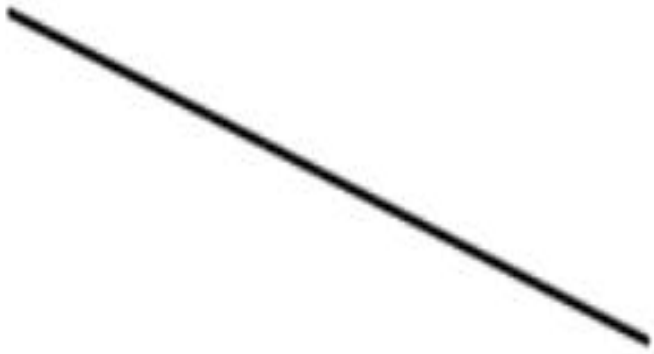
Primary Key

Cust ID	Cust Name	Shipping Address	Newsletter
at_smith	Alan Smith	35 Palm St, Miami	Xbox News
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Primary Key

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PlayStation 4	Sony	(800) BUY-SONY	300
PS Vita	Sony	(800) BUY-SONY	200



Primary Key

Primary Key

Cust ID	Item
at_smith	Xbox One
roger25	PlayStation 4
wilson44	Xbox One
wilson44	PS Vita
am_smith	PlayStation 4

**3rd Normal Form** - All Fields (columns) can be determined Only by the Key in the table and and no other column

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roger25	Roger Banks	47 Campus Rd, Boston	PlayStation News
wilson44	Evan Wilson	28 Rock Av, Denver	Xbox News
wilson44	Evan Wilson	28 Rock Av, Denver	PlayStation News
am_smith	Alan Smith	47 Campus Rd, Boston	PlayStation News

Primary Key

Foreign Key

Item	Supplier	Price
Xbox One	Microsoft	250
PlayStation 4	Sony	300
PS Vita	Sony	200

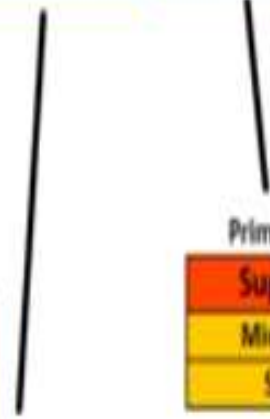
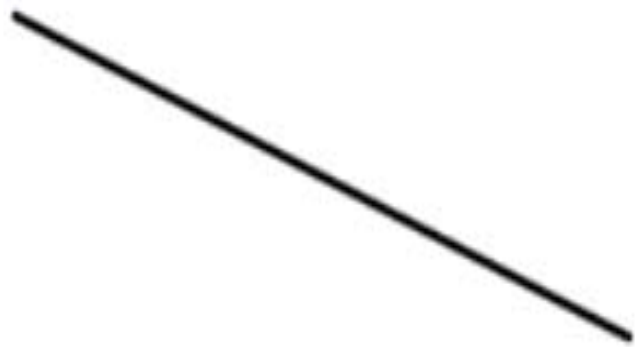
Primary Key

Supplier	Supplier Phone
Microsoft	(800) BUY-XBOX
Sony	(800) BUY-SONY

Primary Key

Primary Key

Cust ID	Item
at_smith	Xbox One
roger25	PlayStation 4
wilson44	Xbox One
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Primary Key

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roger25	Roger Banks	47 Campus Rd, Boston	PlayStation News
wilson44	Evan Wilson	28 Rock Av, Denver	Xbox News
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am_smith	Alan Smith	47 Campus Rd, Boston	PlayStation News

Primary Key

Foreign Key

Item	Supplier	Price
Xbox One	Microsoft	250
PlayStation 4	Sony	300
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Primary Key

Supplier	Supplier Phone
Microsoft	(800) BUY-XBOX
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Primary Key

Primary Key

Cust ID	Item
at_smith	Xbox One
roger25	PlayStation 4
wilson44	Xbox One
wilson44	PS Vita
am_smith	PlayStation 4

## 4th Normal Form - No multi-valued dependencies

### Customer Table

Primary Key

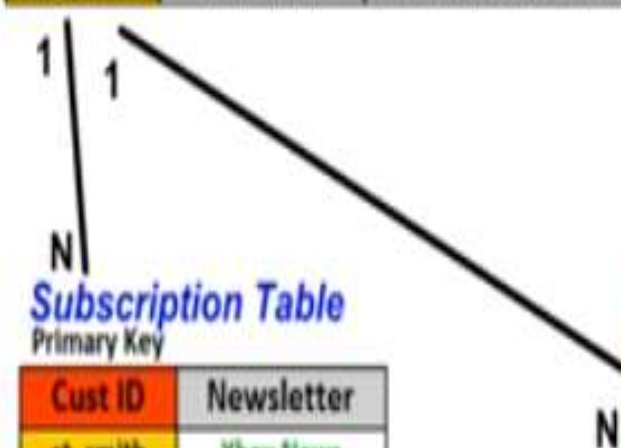
Cust ID	Cust Name	Shipping Address
at_smith	Alan Smith	35 Palm St, Miami
roger25	Roger Banks	47 Campus Rd, Boston
wilson44	Evan Wilson	28 Rock Av, Denver
am_smith	Alan Smith	47 Campus Rd, Boston

### Item Table

Primary Key

Foreign Key

Item	Supplier	Price
Xbox One	Microsoft	250
PlayStation 4	Sony	300
PS Vita	Sony	200



### Subscription Table

Primary Key

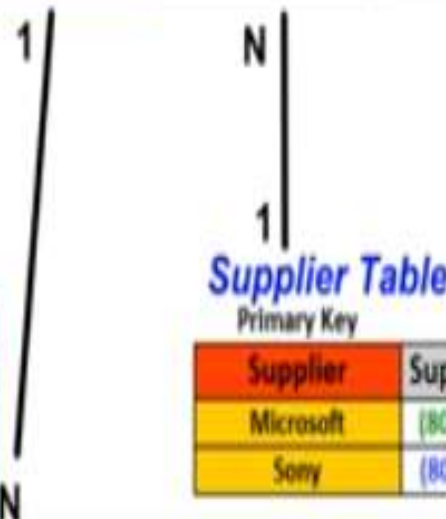
Cust ID	Newsletter
at_smith	Xbox News
roger25	PlayStation News
wilson44	Xbox News
wilson44	PlayStation News
am_smith	PlayStation News

### Sales Invoice Table

Primary Key

Primary Key

Cust ID	Item
at_smith	Xbox One
roger25	PlayStation 4
wilson44	Xbox One
wilson44	PS Vita
am_smith	PlayStation 4



### Supplier Table

Primary Key

Supplier	Supplier Phone
Microsoft	(800) BUY-XBOX
Sony	(800) BUY-SONY



# Fifth Normal Form (5NF)

- The *Fifth Normal Form* concerns dependencies that are obscure and beyond the scope of this text.
- Condition:
  - ✓ R is already in 4NF
  - ✓ It can't be further non loss decomposed.

Join Dependency:

if and only if every legal instance  $\gamma(R)$  is equal to join of its projections on  $R_1, R_2, \dots, R_n$ .

$\pi_{R_1}(R) \bowtie \pi_{R_2}(R) \bowtie \dots \bowtie \pi_{R_n}(R) = R$   
(order of join doesn't matter)

## Example of Join Dependency:

Agent	Company	Product
Aman	C1	Pen drive
Aman	C1	MIC
Aman	C2	SPEAKER
Mohan	C1	SPEAKER

$R_1 \swarrow \searrow R_2$  (Agent | Product)  
Agent | Company      $R_1 \bowtie R_2 = \textcircled{R}$

$R_3$  (Company | Product)

$R_1 \bowtie R_2 \bowtie R_3 = R$  (J.D)

$R_1$	
Agent	Company
Aman	C1
Aman	C2
Mohan	C1

$R_2$	
Agent	Product
Aman	Pendrive
Aman	MIC
Aman	Speaker
Mohan	Speaker

$R_3$	
Comp.	Prod.
C1	P-D
C1	MIC
C1	Speaker
C2	Speaker

$R_1 \bowtie R_2$

Agent	Company	Product
Aman	C1	P-D
Aman	C1	MIC
Aman	C1	Speaker
Aman	C2	P-D
Aman	C2	MIC
Aman	C2	Speaker
Mohan	C1	Speaker

7:35 / 13:38

## Boyce-Codd Normal Form (BCNF)

(Every BCNF is a 3NF but vice-versa is not true)

- Extension of 3NF on strict terms.

A relation is in BCNF if atleast one of the Cond<sup>n</sup> holds:

- $X \rightarrow Y$  is a trivial F.D.
  - $X \rightarrow Y$ , then  $X$  is a Superkey.
- [ Difference b/w BCNF and 3NF ]

Q1)  $R(ABC)$  'R' is in 3NF  
F:  $\{AB \rightarrow C, C \rightarrow A\}$  or BCNF.

$(AB)^+ = ABC, (BC)^+ = BCA.$

C.K. AB and BC.

$(AB) \rightarrow C \rightarrow$  BCNF.

$(C) \rightarrow A \rightarrow$  3NF but not in

BCNF.

$R(ABCDEFGHIJ)$

F:  $\{AB \rightarrow C, A \rightarrow DE, B \rightarrow F, F \rightarrow GH, D \rightarrow IJ\}$

Decompose it into BCNF. (C.K. AB.)

$(AB)^+ = ABCDEFGHIJ.$

$AB \rightarrow C \rightarrow$  BCNF.

$R_1(ABC) \quad R_2(DEFGHIJ)$

$AB \rightarrow C$

$f \rightarrow GH, D \rightarrow IJ$



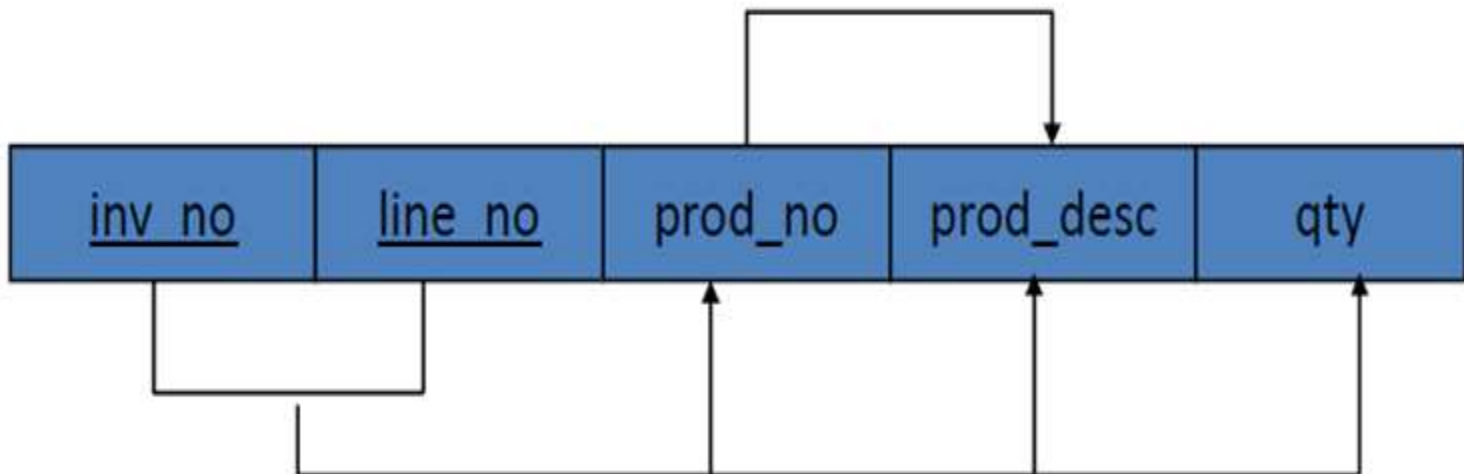
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BCNF.

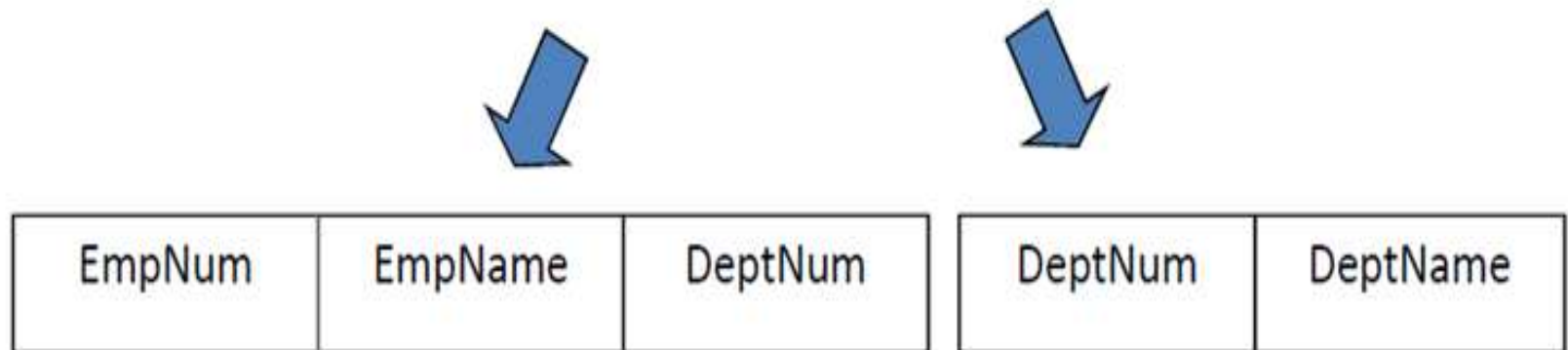


# Activity

Is the following relation in 2NF?



We correct the situation by decomposing the original relation into two 3NF relations. Note the decomposition is *lossless*.



Verify these two relations are in 3NF.

## Fill in the Blanks

1. 1NF is considered the .....
2. 2NF is ..... than 1NF
3. .... is stronger than 2NF
4. BCNF is considered the .....
5. Any relation that is in B....., is in 3NF

# Answer

- 3NF
- 2NF
- Atomic, better, 3NF, stronger than 3NF, BCNF



# First Normal Form (1NF)

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The official qualifications for 1NF are:

1. Each attribute name must be unique.
2. Each attribute value must be single.
3. Each row must be unique.
4. There is no repeating groups.

▶ **Additional:**

- ▶ Choose a primary key.

▶ **Reminder:**

A primary key is *unique, not null, unchanged*. A primary key can be either an attribute or combined attributes.

# First Normal Form

The following is **not** in 1NF

<u>EmpNum</u>	EmpPhone	EmpDegrees
123	233-9876	
333	233-1231	BA, BSc, PhD
679	233-1231	BSc, MSc

EmpDegrees is a multi-valued field:

employee 679 has two degrees: *BSc* and *MSc*

employee 333 has three degrees: *BA*, *BSc*, *PhD*

To obtain 1NF relations we must, without loss of information, replace the above with two relations - see next slide

# First Normal Form

**Employee**

EmpNum	EmpPhone
123	233-9876
333	233-1231
679	233-1231

**EmployeeDegree**

EmpNum	EmpDegree
333	BA
333	BSc
333	PhD
679	BSc
679	MSc

An outer join between Employee and EmployeeDegree will produce the information we saw before

## Second Normal Form (2NF)

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The official qualifications for 2NF are:

1. A table is already in 1NF.
2. All nonkey attributes are fully dependent on the primary key.

*All partial dependencies are removed to place in another table.*

# Second Normal Form

Consider this **InvLine** table (in 1NF):

<u>InvNum</u>	<u>LineNum</u>	ProdNum	Qty	InvDate
---------------	----------------	---------	-----	---------

InvNum, LineNum  $\longrightarrow$  ProdNum, Qty

There are two candidate keys.

Qty is the only non-key attribute, and it is dependent on InvNum

InvNum  $\longrightarrow$  InvDate

InvLine is only in  
**1NF**

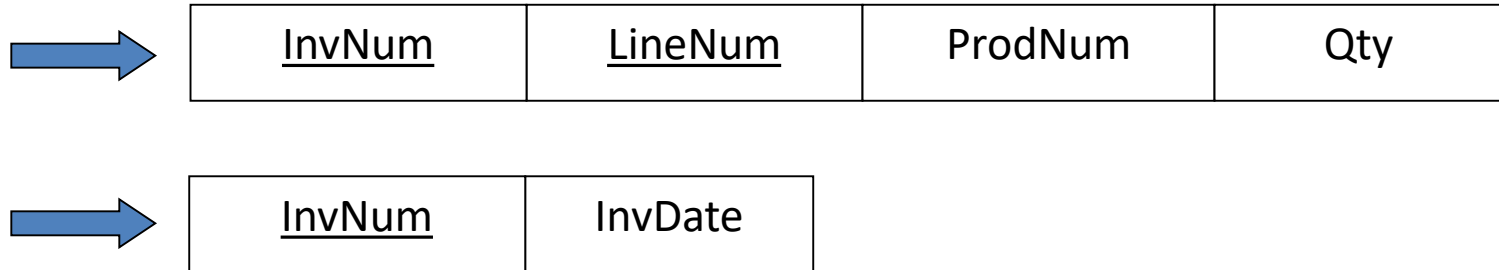
# Second Normal Form

## InvLine

<u>InvNum</u>	<u>LineNum</u>	ProdNum	Qty	InvDate
---------------	----------------	---------	-----	---------

The above relation has redundancies: the invoice date is repeated on each invoice line.

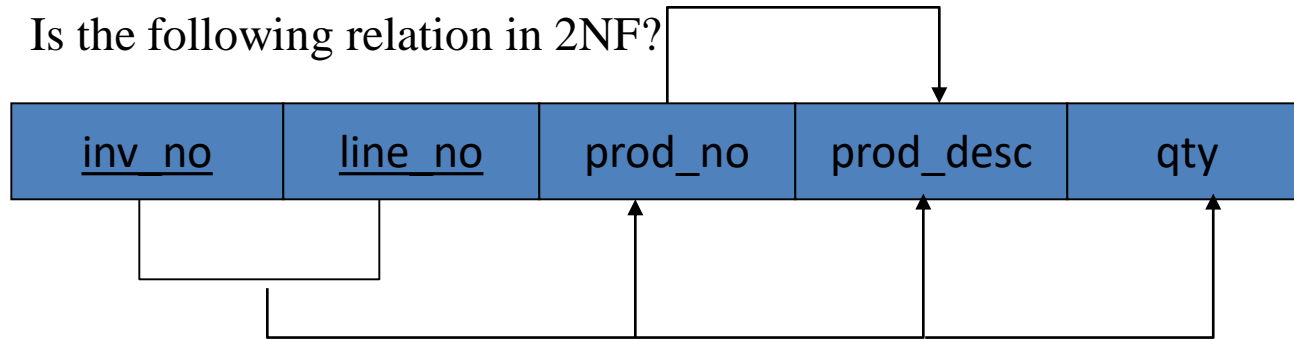
We can *improve* the database by decomposing the relation into two relations:



Question: What is the highest normal form for these relations? 2NF? 3NF? BCNF?

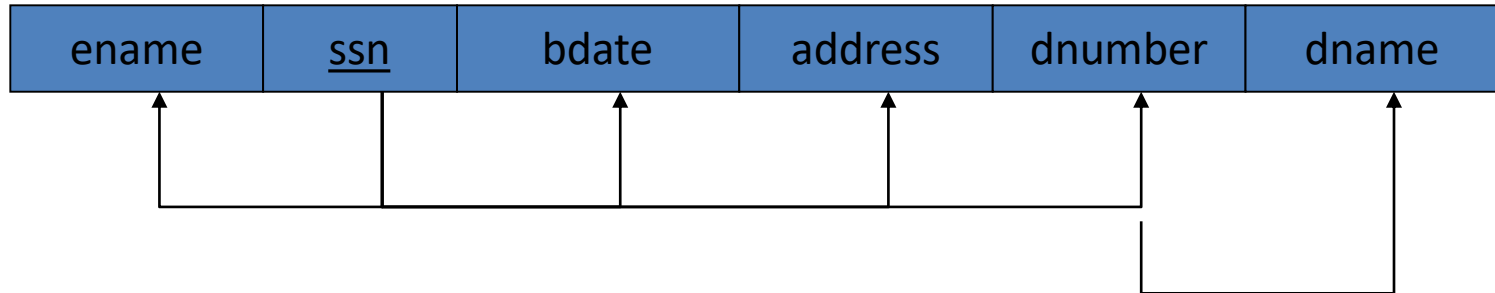
## ACTIVITY

Is the following relation in 2NF?



2NF, but not in 3NF, nor in BCNF:

### EmployeeDept



since `dnumber` is not a candidate key and we have:

`dnumber`  $\rightarrow$  `dname`.



# Third Normal Form

## Third Normal Form

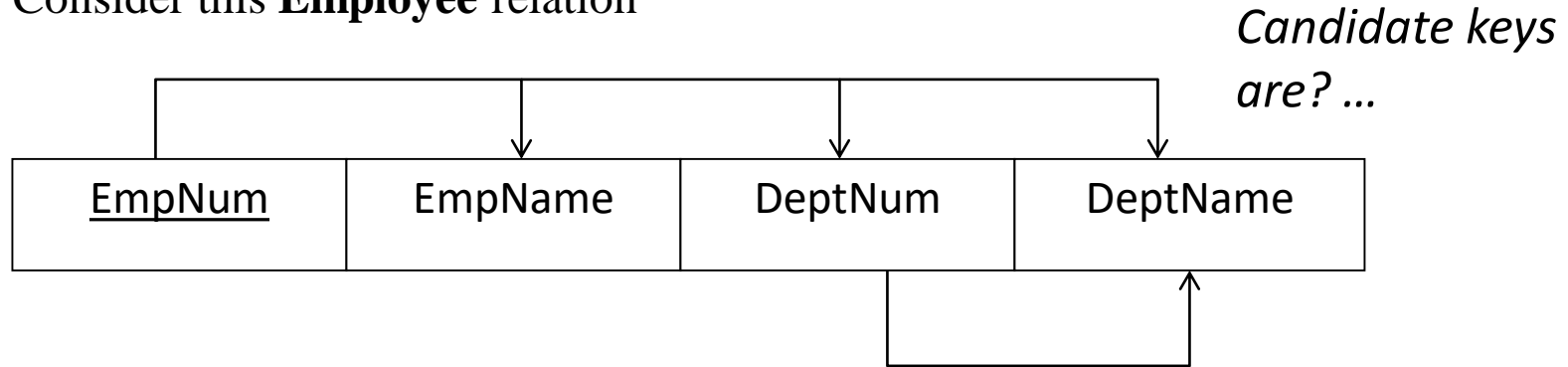
- A relation is in **3NF** if the relation is in 1NF and all determinants of *non-key* attributes are candidate keys

That is, for any functional dependency:  $X \rightarrow Y$ , where  $Y$  is a non-key attribute (or a set of non-key attributes),  $X$  is a candidate key.

- This definition of 3NF differs from BCNF only in the specification of non-key attributes - 3NF is weaker than BCNF. (BCNF requires all determinants to be candidate keys.)
- A relation in 3NF will not have any transitive dependencies of non-key attribute on a candidate key through another non-key attribute.

# Third Normal Form

Consider this **Employee** relation



EmpName, DeptNum, and DeptName are non-key attributes.

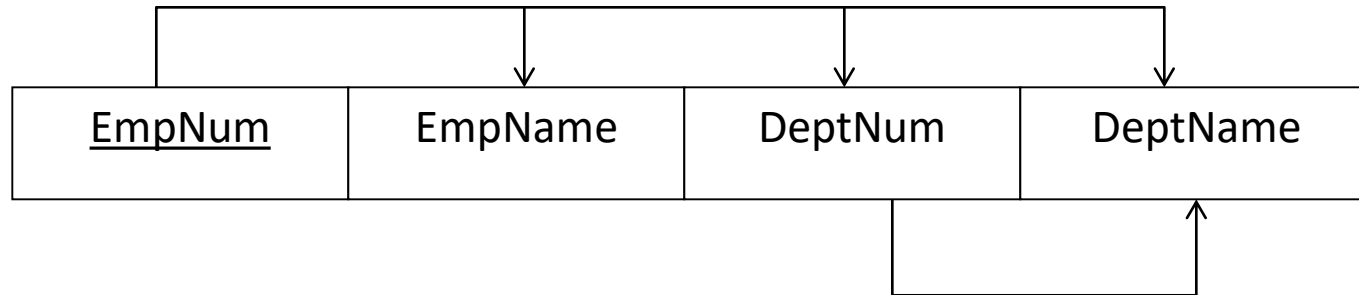
DeptNum determines DeptName, a non-key attribute, and DeptNum is not a candidate key.

Is the relation in 3NF? ... no

Is the relation in BCNF? ... no

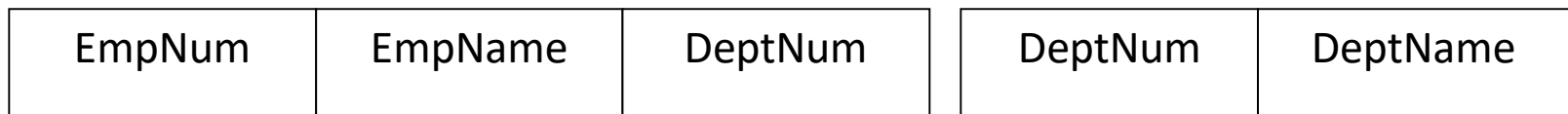
Is the relation in 2NF? ... yes

# Third Normal Form



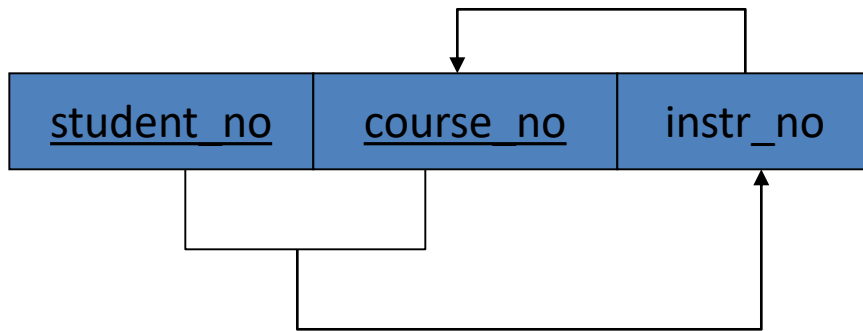
## ACTIVITY

We correct the situation by decomposing the original relation into two 3NF relations. Note the decomposition is *lossless*.



Verify these two relations are in 3NF.

In 3NF, but not in BCNF:

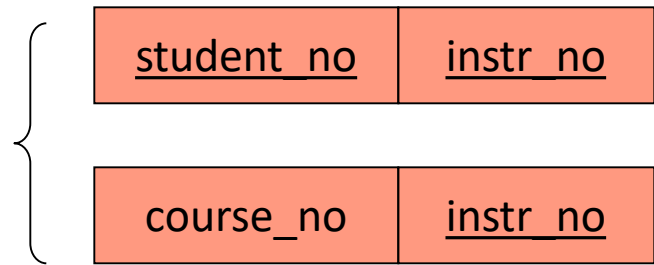
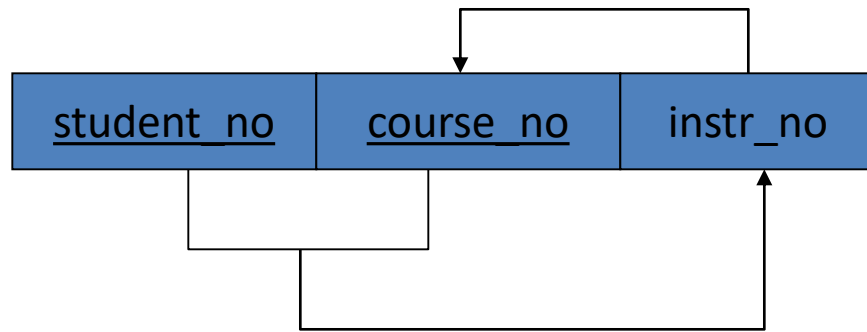


*Instructor teaches one course only.*

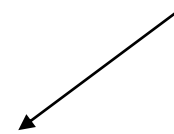
*Student takes a course and has one instructor.*

$\{\text{student\_no}, \text{course\_no}\} \rightarrow \text{instr\_no}$   
 $\text{instr\_no} \rightarrow \text{course\_no}$

since we have  $\text{instr\_no} \rightarrow \text{course\_no}$ , but  $\text{instr\_no}$  is not a Candidate key.



BCNF



$\{\text{student\_no}, \text{instr\_no}\} \rightarrow \text{student\_no}$   
 $\{\text{student\_no}, \text{instr\_no}\} \rightarrow \text{instr\_no}$   
 $\text{instr\_no} \rightarrow \text{course\_no}$

# Fourth Normal Form (4NF)

- To be in *Fourth Normal Form (4NF)* the relation must be in BCNF and the relation may not contain multi-valued dependencies.