

**BOYCE CODD NORMAL FORM (BCNF)**

- BCNF is the advance version of 3NF. It is stricter than 3NF.
- A table is in BCNF if every functional dependency  $X \rightarrow Y$ , X is the super key of the table.
- For BCNF, the table should be in 3NF, and for every FD, LHS is super key.

**Example:** Let's assume there is a company where employees work in more than one department.

**EMPLOYEE table:**

EMP_ID	EMP_COUNTRY	EMP_DEPT	DEPT_TYPE	EMP_DEPT_NO
264	India	Designing	D394	283
264	India	Testing	D394	300
364	UK	Stores	D283	232
364	UK	Developing	D283	549

**In the above table Functional dependencies are as follows:**

1. EMP\_ID  $\rightarrow$  EMP\_COUNTRY
2. EMP\_DEPT  $\rightarrow$  {DEPT\_TYPE, EMP\_DEPT\_NO}

**Candidate key: {EMP-ID, EMP-DEPT}**

The table is not in BCNF because neither EMP\_DEPT nor EMP\_ID alone are keys.

To convert the given table into BCNF, we decompose it into three tables:

**EMP\_COUNTRY table:**

EMP_ID	EMP_COUNTRY
264	India
264	India

**EMP\_DEPT table:**

EMP_DEPT	DEPT_TYPE	EMP_DEPT_NO
Designing	D394	283
Testing	D394	300
Stores	D283	232
Developing	D283	549

**EMP\_DEPT\_MAPPING table:**

EMP_ID	EMP_DEPT
D394	283
D394	300
D283	232
D283	549

**Functional dependencies:**

1. EMP\_ID → EMP\_COUNTRY
2. EMP\_DEPT → {DEPT\_TYPE, EMP\_DEPT\_NO}

**Candidate keys:**

**For the first table:** EMP\_ID

**For the second table:** EMP\_DEPT

**For the third table:** {EMP\_ID, EMP\_DEPT}

Now, this is in BCNF because left side part of both the functional dependencies is a key.

**Example 2:**

Let us see another one example:

Below we have a college enrolment table with columns `student_id`, `subject` and `professor`.

<code>student_id</code>	<code>subject</code>	<code>professor</code>
101	Java	P.Java
101	C++	P.Cpp
102	Java	P.Java2
103	C#	P.Chash
104	Java	P.Java

As you can see, we have also added some sample data to the table.

In the table above:

- One student can enrol for multiple subjects. For example, student with `student_id` 101, has opted for subjects - Java & C++
- For each subject, a professor is assigned to the student.
- And, there can be multiple professors teaching one subject like we have for Java.

**What do you think should be the Primary Key?**

- Well, in the table above `student_id`, `subject` together form the primary key, because using `student_id` and `subject`, we can find all the columns of the table.
- One more important point to note here is, one professor teaches only one subject, but one subject may have two different professors.
- Hence, there is a dependency between `subject` and `professor` here, where `subject` depends on the `professor` name.
- This table satisfies the **1st Normal form** because all the values are atomic, column names are unique and all the values stored in a particular column are of same domain.
- This table also satisfies the **2nd Normal Form** as there is no **Partial Dependency**.
- And, there is no **Transitive Dependency**, hence the table also satisfies the **3rd Normal Form**.

But this table is not in **Boyce-Codd Normal Form**.

**Why this table is not in BCNF?**

In the table above, student\_id, subject form primary key, which means subject column is a **prime attribute**.

But, there is one more dependency, professor → subject.

And while subject is a prime attribute, professor is a **non-prime attribute**, which is not allowed by BCNF.

**How to satisfy BCNF?**

To make this relation(table) satisfy BCNF, we will decompose this table into two tables, **student** table and **professor** table.

Below we have the structure for both the tables.

**Student Table**

student_id	p_id
101	1
101	2
and so on...	

**And, Professor Table**

p_id	professor	subject
1	P.Java	Java
2	P.Cpp	C++

and so on...

And now, this relation satisfy Boyce-Codd Normal Form.

