Lecture 05-1: Table Design and Constraints

DATA 503: Fundamentals of Data Engineering

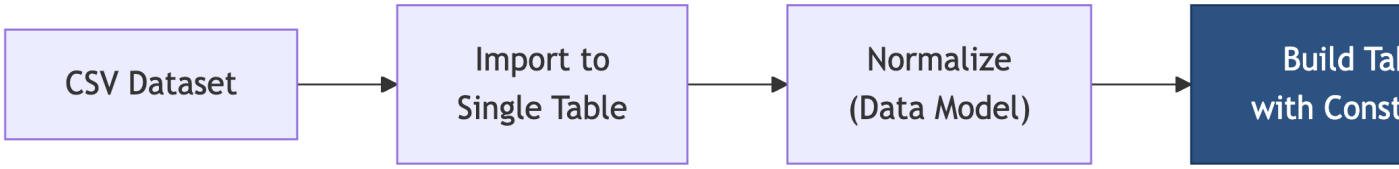
Lucas P. Cordova, Ph.D.

2026-02-09

This lecture covers the practical implementation of database table design in PostgreSQL. After learning to normalize data and design relational schemas, we now focus on building those tables with proper constraints. Topics include naming conventions, primary keys (natural vs surrogate), foreign keys and referential integrity, CHECK constraints, UNIQUE constraints, NOT NULL constraints, modifying tables with ALTER TABLE, and speeding up queries with indexes. A music catalog dataset serves as the running example throughout.

Table of contents

1 From Design to Implementation

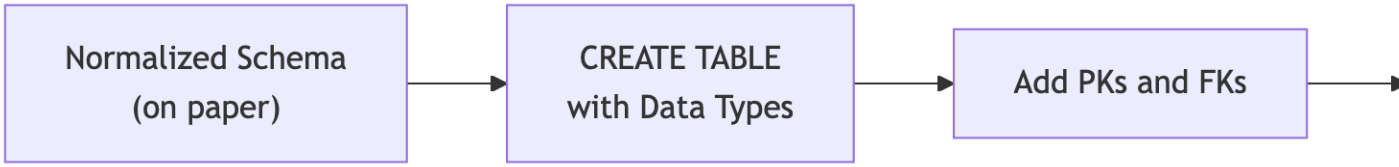


You have learned to import raw data into a single table and design a normalized schema. Now we build the tables that bring that design to life. Think of it as the difference between an architect's blueprint and actually pouring the concrete.

1.1 The Data Engineering Pipeline

1.1.1 What Comes Next

Today we learn the DDL (Data Definition Language) skills to **implement** your normalized designs:



After today, the next step is migrating data from your staging table into the new structure using INSERT, UPDATE, and DELETE.

1.2 Our Running Example: A Music Catalog

1.2.1 The Scenario

You work for a streaming service that just acquired a catalog of albums from a defunct record distributor. The data arrived as a single CSV file spanning six decades of music, from Fleetwood Mac to Beyonce. Your job is to normalize it and build proper tables.

Here is a sample of what you received:

cata-log_id	artist_name	album_ti-tle	re-lease_year	genre	label	dura-tion_min	decade
CAT-1001	Fleetwood Mac	Rumours	1977	Rock	Warner Bros	39.4	1970s
CAT-1002	Fleetwood Mac	Tango in the Night	1987	Rock	Warner Bros	45.1	1980s
CAT-1003	The Beatles	Abbey Road	1969	Rock	Apple	47.4	1960s
CAT-1004	The Beatles	Abbey Road	1969	Rock	Apple	47.4	1960s
CAT-1005	Led Zepplin	Led Zeppelin IV	1971	Rock	At-lantic	42.5	1970
CAT-1006	Beyonce	Lemonade	2016	R&B	Columbia	45.7	2010s
CAT-1007	Beyonce	Renais-sance	2022	Pop	Columbia	42.1	20s

catalog_id	artist_name	album_title	release_year	genre	label	duration_min	decade
CAT-1008	Radiohead	OK Computer	1997	Alternative	Parlophone	53.4	1990s
CAT-1009	the rolling stones	Sticky Fingers	1971	Rock	Rolling Stones	46.3	1970s
CAT-1010	Whitney houston	The Bodyguard	1992	Pop	Arista	56.8	1990s
CAT-1011	OutKast	Stankonia	2000	Hip-Hop	LaFace	72.9	2000s
CAT-1012	Outkast	Aquemini	1998	Hip-Hop	LaFace	72.6	1990s

If you are already counting problems in that table, good. We will deal with them next time. Today we focus on building the target schema.

1.2.2 The Staging Table

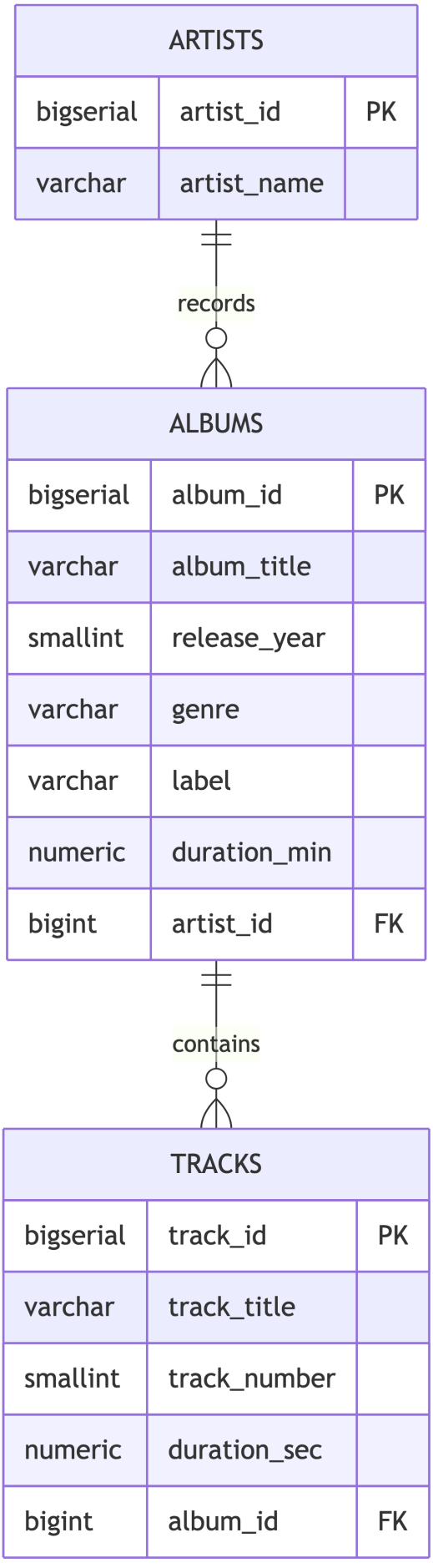
First, we import the CSV into a flat staging table:

```
CREATE TABLE music_catalog (
    catalog_id varchar(20) CONSTRAINT catalog_key PRIMARY KEY,
    artist_name varchar(200),
    album_title varchar(200),
    release_year smallint,
    genre varchar(50),
    label varchar(100),
    duration_min numeric(5,1),
    decade varchar(10)
);

COPY music_catalog
FROM '/path/to/album_catalog.csv'
WITH (FORMAT CSV, HEADER, DELIMITER ',');
```

This staging table holds raw, denormalized data. It is a holding pen, not a home.

1.2.3 Identifying Entities

Looking at the data, we can identify distinct entities:


ARTISTS
bigserial
artist_id
PK
varchar
artist_name
records
ALBUMS
bigserial
album_id
PK
varchar
album_title
smallint
release_year
varchar
genre
varchar
label
numeric
duration_min
bigint
artist_id
FK
contains
TRACKS
bigserial
track_id
PK
varchar
track_title
smallint
track_number
numeric
duration_sec
bigint
album_id
FK

The staging table mixes artist data with album data in every row. Normalization separates them into distinct tables with relationships.

1.2.4 The Normalized Target

Our goal is three tables:

- `artists` – one row per unique artist
- `albums` – one row per unique album, linked to an artist
- `tracks` – one row per track, linked to an album

The staging table gets us to `artists` and `albums`. Track data would come from a separate source, but we will build the table structure anyway. In the real world, schemas are built for the data you expect, not just the data you have.

Now let us learn the DDL skills to build these tables properly.

1.3 Naming Conventions

1.3.1 Why Naming Matters

Good naming conventions make your database self-documenting. A well-named schema tells you what it contains without reading a single comment.

Bad naming leads to:

- Confusion when writing queries
- Bugs from misremembering column names
- Onboarding headaches for new team members
- Passive-aggressive comments in code reviews

1.3.2 PostgreSQL Naming Rules

PostgreSQL has specific rules for identifiers (table and column names):

- Can contain letters, digits, and underscores
- Must begin with a letter or underscore
- Are case-insensitive by default (folded to lowercase)
- Maximum length of 63 characters

```sql
-- These all refer to the SAME table:
CREATE TABLE artists (...);
CREATE TABLE Artists (...);  -- Error: already exists!
CREATE TABLE ARTISTS (...);  -- Error: already exists!
```

PostgreSQL treats your shouting the same as your whispering.

1.3.3 The Case Sensitivity Trap

PostgreSQL folds unquoted identifiers to lowercase. If you use double quotes, the name becomes case-sensitive:

```sql
CREATE TABLE "Artists" (...);  -- Creates "Artists" (capital A)
SELECT * FROM artists;          -- Looks for "artists" (lowercase)
SELECT * FROM "Artists";        -- Finds "Artists" (capital A)
```

> **Warning**
>
> Avoid double-quoted identifiers. They create maintenance headaches because every query must use the exact casing with quotes. You will curse your past self at 2 AM.

1.3.4 Best Practices for Naming

Convention	Example	Avoid
Use snake_case	`release_year`	`releaseYear`, `ReleaseYear`
Be descriptive	`artist_name`	`art_nm`
Use plurals for tables	`artists`, `albums`	`artist`, `album`
Include context	`duration_min`	`data_column_7`
Prefix dates	`report_2026_01_15`	`15_01_2026_report`

1.3.5 Naming: Tables vs Columns

1.3.5.1 Tables

Tables represent collections of entities. Use plural nouns:

- `artists` (not `artist`)
- `albums` (not `album`)
- `tracks` (not `track`)

1.3.5.2 Columns

Columns represent attributes. Use singular, descriptive names:

- `artist_name` (not `artist_names`)
- `release_year` (not `years_released`)
- `duration_min` (not `dur`)

1.3.5.3 Junction Tables

For many-to-many relationships, combine both table names:

- `artist_genres`
- `album_tracks`
- `playlist_songs`

1.4 Primary Keys

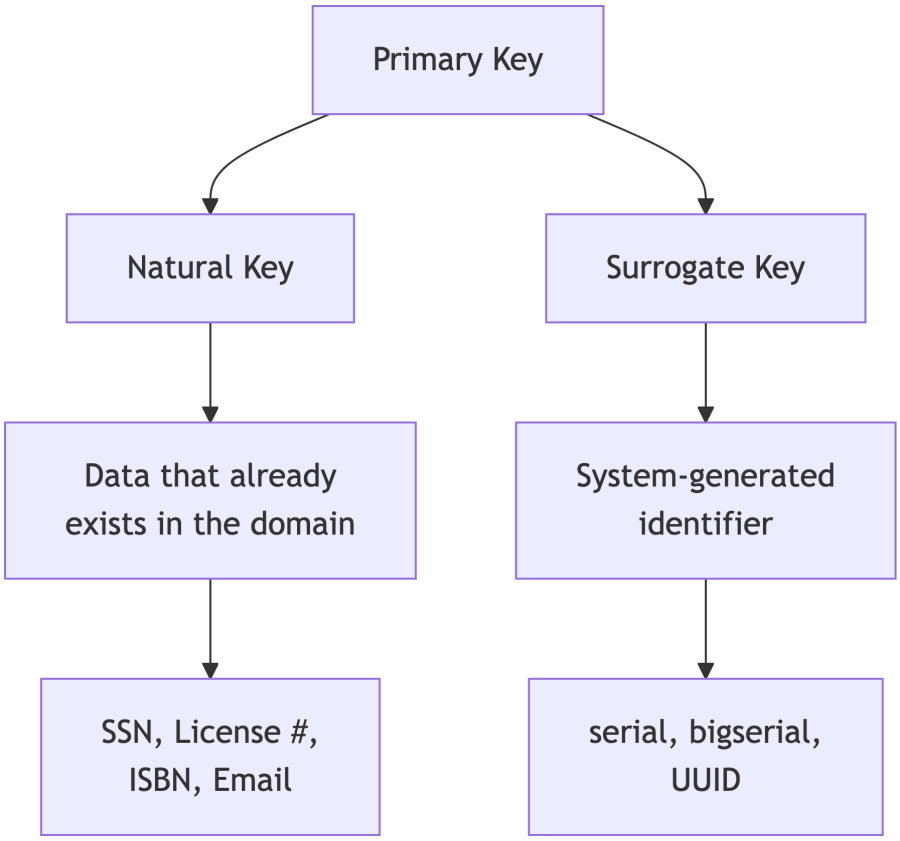
1.4.1 Recap: What Is a Primary Key?

A **primary key** uniquely identifies each row in a table. It provides:

- **Uniqueness:** No two rows share the same key value
- **Non-nullability:** The key value cannot be NULL
- **Identity:** A reliable way to reference a specific row

Every table in a well-designed database should have a primary key.

1.4.2 Two Approaches to Primary Keys



1.4.3 Natural Keys

A **natural key** uses data that already exists and naturally identifies the entity.

```
CREATE TABLE natural_key_example (
    license_id varchar(10) CONSTRAINT license_key PRIMARY KEY,
    first_name varchar(50),
    last_name varchar(50)
);
```

Here `license_id` is a real-world identifier. Each person has exactly one, and it is unique. In theory. In practice, natural keys have a habit of being less unique than you were promised.

1.4.4 Natural Keys: Testing Uniqueness

Let us see what happens when we violate the primary key:

```
INSERT INTO natural_key_example (license_id, first_name, last_name)
VALUES ('T229901', 'Lynn', 'Malero');

INSERT INTO natural_key_example (license_id, first_name, last_name)
VALUES ('T229901', 'Sam', 'Tracy');
```

The second INSERT fails:

```
ERROR: duplicate key value violates unique constraint "license_key"
DETAIL: Key (license_id)=(T229901) already exists.
```

The database enforces uniqueness automatically. It is polite about it, but firm.

1.4.5 Natural Keys: Music Catalog Example

Could we use a natural key for our `albums` table? The `catalog_id` from the staging data is a candidate:

```
CREATE TABLE albums (
    catalog_id varchar(20) CONSTRAINT album_key PRIMARY KEY,
    album_title varchar(200) NOT NULL,
    release_year smallint,
    genre varchar(50)
);
```

This works if every album has a unique catalog code. But what if the same album is reissued with a new code? Or acquired from a different distributor with a different code? Natural keys work until the real world gets creative.

1.4.6 Composite Natural Keys

Sometimes no single column is unique, but a combination is:

```
CREATE TABLE natural_key_composite_example (
    student_id varchar(10),
    school_day date,
    present boolean,
    CONSTRAINT student_key PRIMARY KEY (student_id, school_day)
);
```

A student can only have one attendance record per day. Neither `student_id` nor `school_day` is unique alone, but together they form a unique identifier.

1.4.7 Composite Keys: Testing Uniqueness

```
INSERT INTO natural_key_composite_example (student_id, school_day, present)
VALUES(775, '1/22/2017', 'Y');

INSERT INTO natural_key_composite_example (student_id, school_day, present)
VALUES(775, '1/23/2017', 'Y');  -- OK: different day

INSERT INTO natural_key_composite_example (student_id, school_day, present)
VALUES(775, '1/23/2017', 'N');  -- FAILS: same student + day
```

```
ERROR: duplicate key value violates unique constraint "student_key"
DETAIL: Key (student_id, school_day)=(775, 2017-01-23) already exists.
```

1.4.8 Surrogate Keys

A **surrogate key** is a system-generated value with no real-world meaning:

```
CREATE TABLE artists (
    artist_id bigserial,
    artist_name varchar(200) NOT NULL,
    CONSTRAINT artist_key PRIMARY KEY (artist_id)
);
```

PostgreSQL's `serial` types auto-generate incrementing integers:

Type	Range
`smallserial`	1 to 32,767
`serial`	1 to 2,147,483,647
`bigserial`	1 to 9.2 quintillion

1.4.9 Surrogate Keys: Auto-Increment in Action

```
INSERT INTO artists (artist_name)
VALUES ('Fleetwood Mac'),
       ('The Beatles'),
       ('Beyonce');
```

```
5
6 SELECT * FROM artists;
```

```
 artist_id |  artist_name
-----------+---------------
         1 | Fleetwood Mac
         2 | The Beatles
         3 | Beyonce
```

Notice we never specified `artist_id`. PostgreSQL generated it automatically. One less thing to argue about in a design meeting.

1.4.10 Natural vs Surrogate: When to Use Which

Factor	Natural Key	Surrogate Key
Meaning	Has real-world meaning	Meaningless identifier
Stability	Can change (email, name)	Never changes
Size	Varies (could be long)	Fixed, compact
Performance	Depends on data type	Fast (integer)
Universality	Not always available	Always available

> **Tip**
>
> **Practical guidance:** Use surrogate keys (`serial`/`bigserial`) as primary keys for most tables. If a natural key exists and is truly stable (ISBN, SSN), consider it. When in doubt, surrogate wins. Nobody has ever been fired for using a serial primary key.

1.4.11 Two Syntax Styles for PRIMARY KEY

You can declare a primary key inline or as a table constraint:

1.4.11.1 Inline (Column Level)

```
1 CREATE TABLE artists (
2     artist_id bigserial CONSTRAINT artist_key PRIMARY KEY,
3     artist_name varchar(200) NOT NULL
4 );
```

Best for single-column keys.

1.4.11.2 Table Level

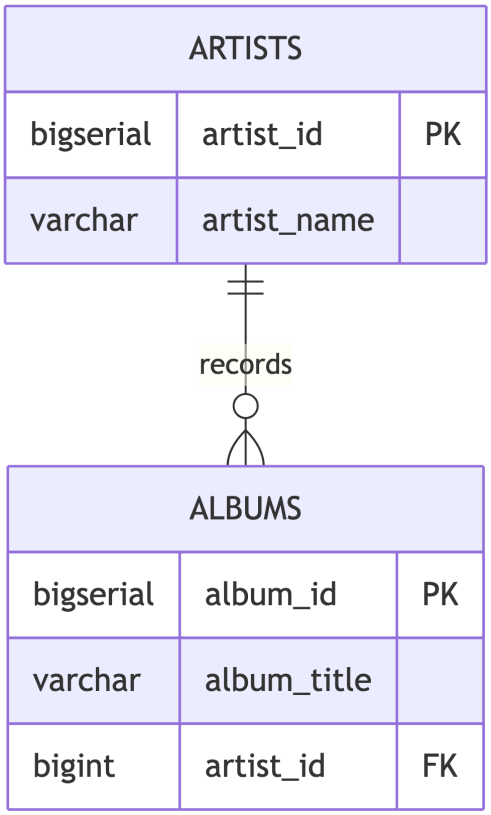
```
CREATE TABLE artists (
    artist_id bigserial,
    artist_name varchar(200) NOT NULL,
    CONSTRAINT artist_key PRIMARY KEY (artist_id)
);
```

Required for composite keys. Also works for single-column keys.

1.5 Foreign Keys

1.5.1 Connecting Tables with Foreign Keys

A **foreign key** is a column in one table that references the primary key of another table. It enforces **referential integrity**: you cannot reference a row that does not exist.



1.5.2 Creating Foreign Key Relationships

```
CREATE TABLE artists (
    artist_id bigserial,
    artist_name varchar(200) NOT NULL,
    CONSTRAINT artist_key PRIMARY KEY (artist_id)
);

CREATE TABLE albums (
    album_id bigserial,
    album_title varchar(200) NOT NULL,
    release_year smallint,
    artist_id bigint REFERENCES artists (artist_id),
    CONSTRAINT album_key PRIMARY KEY (album_id)
);
```

The `REFERENCES` keyword creates the foreign key relationship. It is essentially a contract: "I promise this value exists over there, and I would like the database to hold me to it."

1.5.3 Foreign Keys: Enforcing Referential Integrity

```
-- This works: artist_id 1 exists
INSERT INTO artists (artist_name) VALUES ('Fleetwood Mac');

INSERT INTO albums (album_title, release_year, artist_id)
VALUES ('Rumours', 1977, 1);
```

```
-- This FAILS: artist_id 999 does not exist
INSERT INTO albums (album_title, release_year, artist_id)
VALUES ('Phantom Album', 2025, 999);
```

```
ERROR: insert or update on table "albums" violates foreign key
constraint "albums_artist_id_fkey"
DETAIL: Key (artist_id)=(999) is not present in table "artists".
```

1.5.4 What Happens When You Delete a Parent Row?

By default, PostgreSQL prevents deleting a row from the parent table if child rows reference it. This protects data integrity but can be inconvenient.

ON DELETE CASCADE tells PostgreSQL to automatically delete child rows when the parent is deleted:

```sql
CREATE TABLE tracks (
    track_id bigserial,
    track_title varchar(200) NOT NULL,
    album_id bigint REFERENCES albums (album_id)
        ON DELETE CASCADE,
    CONSTRAINT track_key PRIMARY KEY (track_id)
);
```

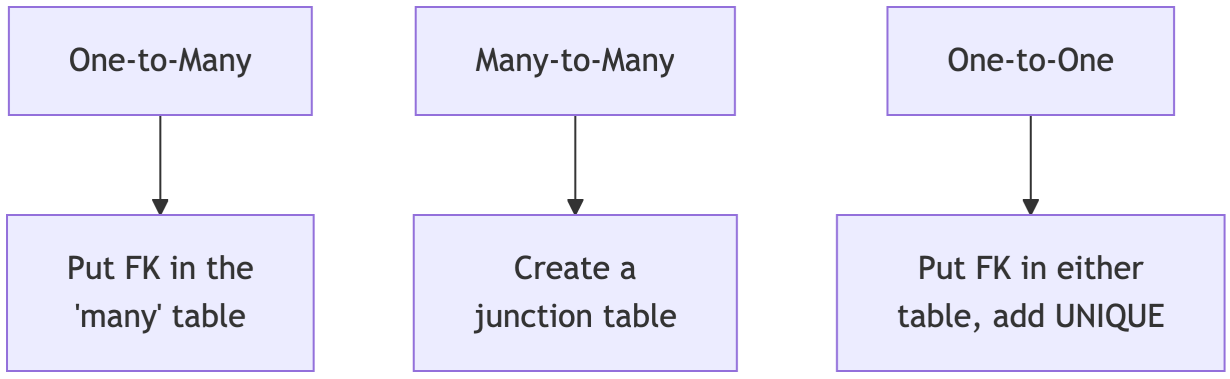
Delete an album, and all its tracks vanish with it. This is appropriate when child rows have no meaning without the parent.

1.5.5 ON DELETE Options

Option	Behavior
`RESTRICT` (default)	Prevent deletion if children exist
`CASCADE`	Delete children automatically
`SET NULL`	Set foreign key to NULL in children
`SET DEFAULT`	Set foreign key to default value in children

> **Warning**
>
> Use `CASCADE` carefully. Deleting one artist could cascade through albums and tracks, removing far more data than intended. CASCADE is the database equivalent of pulling a loose thread on a sweater.

1.5.6 Foreign Key Design Patterns



One-to-Many: An artist has many albums. Put `artist_id` in the `albums` table.

Many-to-Many: Artists perform in many genres; genres have many artists. Create `artist_genres` with FKs to both.

One-to-One: An artist has one biography. Put `artist_id` in `biographies` with a UNIQUE constraint.

1.6 CHECK Constraints

1.6.1 Validating Data with CHECK

A `CHECK` constraint ensures that column values meet a logical condition. If the condition evaluates to `false`, the row is rejected.

```
CREATE TABLE albums (
    album_id bigserial,
    album_title varchar(200) NOT NULL,
    release_year smallint,
    genre varchar(50),
    duration_min numeric(5,1),
    artist_id bigint REFERENCES artists (artist_id),
    CONSTRAINT album_key PRIMARY KEY (album_id),
    CONSTRAINT check_year_range
        CHECK (release_year BETWEEN 1900 AND 2100),
    CONSTRAINT check_duration_positive
        CHECK (duration_min > 0)
);
```

1.6.2 CHECK: Practical Examples

CHECK constraints can enforce a wide variety of business rules:

```
-- Genre must be from a known list
CONSTRAINT check_genre
    CHECK (genre IN ('Rock', 'Pop', 'Hip-Hop', 'R&B',
           'Country', 'Electronic', 'Alternative', 'Jazz'))

-- Release year must be reasonable
CONSTRAINT check_year_range
    CHECK (release_year BETWEEN 1900 AND 2100)

-- Track number must be positive
CONSTRAINT check_track_positive
```

```
    CHECK (track_number > 0)

-- Duration must be within reason
CONSTRAINT check_duration
    CHECK (duration_sec BETWEEN 1 AND 7200)
```

1.6.3 When to Use CHECK Constraints

Scenario	Example
Enumerated values	`genre IN ('Rock', 'Pop', 'Jazz')`
Numeric ranges	`release_year BETWEEN 1900 AND 2100`
Comparison between columns	`end_date > start_date`
Non-negative values	`duration_min > 0`
String patterns	`email LIKE '%@%.%'`

> **Tip**
>
> CHECK constraints catch bad data at the database level, regardless of which application inserts it. This is your last line of defense. Applications come and go, but the database remembers.

1.7 UNIQUE Constraints

1.7.1 Enforcing Uniqueness Beyond the Primary Key

A `UNIQUE` constraint ensures no duplicate values exist in a column (or combination of columns), separate from the primary key.

```
CREATE TABLE artists (
    artist_id bigserial CONSTRAINT artist_key PRIMARY KEY,
    artist_name varchar(200) NOT NULL,
    CONSTRAINT artist_name_unique UNIQUE (artist_name)
);
```

This prevents inserting two artists with the same name. Whether that is desirable depends on whether you believe there is only one "John Williams" in the music industry. (There are at least two famous ones.)

1.7.2 UNIQUE: Testing the Constraint

```
INSERT INTO artists (artist_name) VALUES ('Beyonce');
INSERT INTO artists (artist_name) VALUES ('Beyonce');
```

```
ERROR: duplicate key value violates unique constraint "artist_name_unique"
DETAIL: Key (artist_name)=(Beyonce) already exists.
```

1.7.3 Composite UNIQUE Constraints

Sometimes uniqueness requires multiple columns. An album title is not unique by itself (many artists have a self-titled album), but the combination of artist and title should be:

```
CREATE TABLE albums (
    album_id bigserial CONSTRAINT album_key PRIMARY KEY,
    album_title varchar(200) NOT NULL,
    release_year smallint,
    artist_id bigint REFERENCES artists (artist_id),
    CONSTRAINT album_artist_unique UNIQUE (album_title, artist_id)
);
```

Now two different artists can both have "Greatest Hits," but the same artist cannot have two albums with the same title.

1.7.4 UNIQUE vs PRIMARY KEY

Feature	PRIMARY KEY	UNIQUE
Uniqueness	Yes	Yes
Allows NULL	No	Yes (one NULL per column)
Per table	Only one	Multiple allowed
Creates index	Yes	Yes

A table has one primary key but can have many UNIQUE constraints. Use UNIQUE for candidate keys that are not the primary key.

1.8 NOT NULL Constraints

1.8.1 Requiring Values with NOT NULL

`NOT NULL` prevents a column from containing NULL values. This is essential for columns that must always have data:

```
CREATE TABLE artists (
    artist_id bigserial,
    artist_name varchar(200) NOT NULL,
    CONSTRAINT artist_key PRIMARY KEY (artist_id)
);
```

Any INSERT that omits `artist_name` (or sets it to NULL) will fail. An artist without a name is not an artist. It is a mystery.

1.8.2 When to Use NOT NULL

Apply NOT NULL to columns where missing data would be meaningless or harmful:

Always NOT NULL	Often Nullable
`artist_name`	`label` (indie releases)
`album_title`	`genre` (might be ambiguous)
`track_title`	`duration_min` (might be unknown)
Foreign keys (usually)	`release_year` (might be disputed)
`track_number`	Notes, descriptions

> **Tip**
>
> Default to NOT NULL and only allow NULLs when there is a legitimate reason for missing data. This catches bugs early. Future you will appreciate the strictness, even if present you finds it annoying.

1.9 Modifying Tables with ALTER TABLE

1.9.1 Adding and Removing Constraints

You do not always get the design right on the first try. Nobody does. If you did, you would be suspicious. `ALTER TABLE` lets you modify constraints after creation:

```sql
-- Remove a constraint
ALTER TABLE artists
    DROP CONSTRAINT artist_name_unique;

-- Add a constraint back
ALTER TABLE artists
    ADD CONSTRAINT artist_name_unique UNIQUE (artist_name);
```

1.9.2 ALTER TABLE: NOT NULL

NOT NULL constraints use a different syntax because they are column properties, not named constraints:

```sql
-- Remove NOT NULL
ALTER TABLE albums
    ALTER COLUMN genre DROP NOT NULL;

-- Add NOT NULL back
ALTER TABLE albums
    ALTER COLUMN genre SET NOT NULL;
```

1.9.3 Common ALTER TABLE Operations

Operation	Syntax
Drop constraint	`ALTER TABLE t DROP CONSTRAINT c;`
Add constraint	`ALTER TABLE t ADD CONSTRAINT c ...;`
Drop NOT NULL	`ALTER TABLE t ALTER COLUMN col DROP NOT NULL;`
Set NOT NULL	`ALTER TABLE t ALTER COLUMN col SET NOT NULL;`
Add column	`ALTER TABLE t ADD COLUMN col type;`
Drop column	`ALTER TABLE t DROP COLUMN col;`
Rename column	`ALTER TABLE t RENAME COLUMN old TO new;`
Rename table	`ALTER TABLE t RENAME TO new_name;`

1.9.4 ALTER TABLE in Practice

A common workflow when evolving a database:

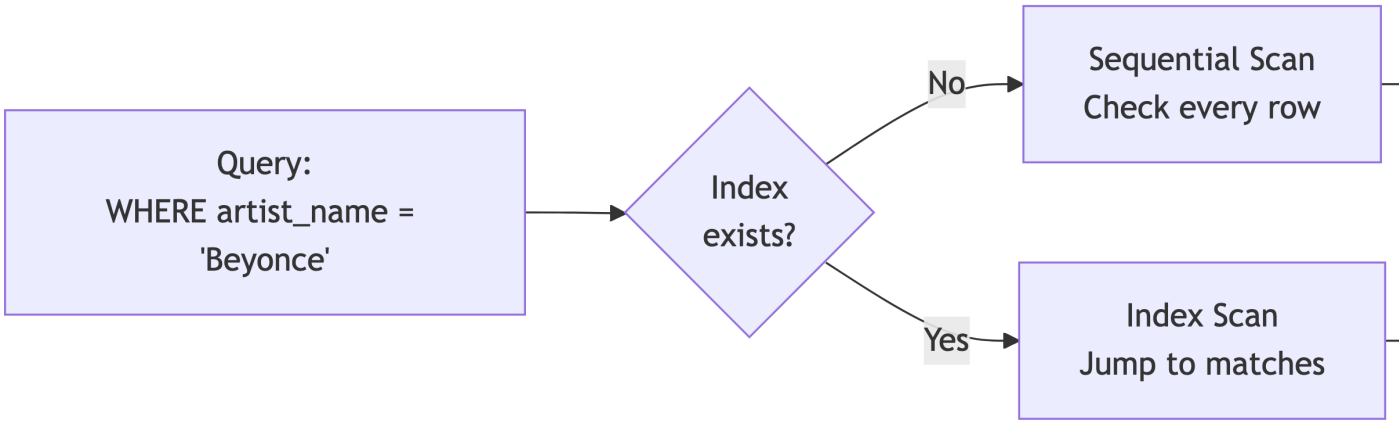

```sql
-- Scenario: You realize albums need a label column you forgot
ALTER TABLE albums
    ADD COLUMN label varchar(100);

-- And genre should be required after all
ALTER TABLE albums
    ALTER COLUMN genre SET NOT NULL;
```

1.10 Speeding Things Up: Indexes

1.10.1 What Is an Index?

An **index** is a data structure that speeds up data retrieval at the cost of additional storage and slower writes.

Think of it like the index at the back of a textbook: instead of reading every page to find "normalization," you look it up in the index and jump directly to the right page. Databases without indexes are just very patient.



1.10.2 Without an Index: Sequential Scan

PostgreSQL reads every single row in the table:

```sql
EXPLAIN ANALYZE SELECT * FROM music_catalog
WHERE artist_name = 'Beyonce';
```

```
Seq Scan on music_catalog
  (cost=0.00..20730.68 rows=12 width=46)
  (actual time=0.055..289.426 rows=8 loops=1)
  Filter: ((artist_name)::text = 'Beyonce'::text)
  Rows Removed by Filter: 601
Planning time: 0.617 ms
Execution time: 289.838 ms
```

On a large catalog, scanning every row adds up. Now imagine a thousand users searching simultaneously.

1.10.3 Creating an Index

```sql
CREATE INDEX idx_albums_artist ON albums (artist_id);
CREATE INDEX idx_tracks_album ON tracks (album_id);
CREATE INDEX idx_albums_genre ON albums (genre);
```

These build B-tree indexes (the default) on frequently queried columns.

1.10.4 When to Create Indexes

Create Index When	Skip Index When
Column used in WHERE clauses	Table is small (< 1000 rows)
Column used in JOIN conditions	Column has few distinct values
Column used in ORDER BY	Table has heavy INSERT/UPDATE load
Foreign key columns	You rarely query the column

Tip

PostgreSQL automatically creates indexes on PRIMARY KEY and UNIQUE columns. You only need to manually create indexes on other frequently queried columns.

1.10.5 EXPLAIN ANALYZE: Your Performance Detective

`EXPLAIN ANALYZE` shows you exactly how PostgreSQL executes a query:

```
EXPLAIN ANALYZE SELECT * FROM albums
WHERE genre = 'Rock';
```

Key things to look for:

- **Seq Scan:** Reading every row (potentially slow)
- **Index Scan / Bitmap Index Scan:** Using an index (fast)
- **Execution time:** Total query time in milliseconds
- **Rows Removed by Filter:** How many rows were checked but not returned

1.10.6 Managing Indexes

```
-- Create an index
CREATE INDEX idx_name ON table_name (column_name);

-- Create a multi-column index
CREATE INDEX idx_name ON table_name (col1, col2);

-- Remove an index
DROP INDEX idx_name;
```

Indexes are not free:

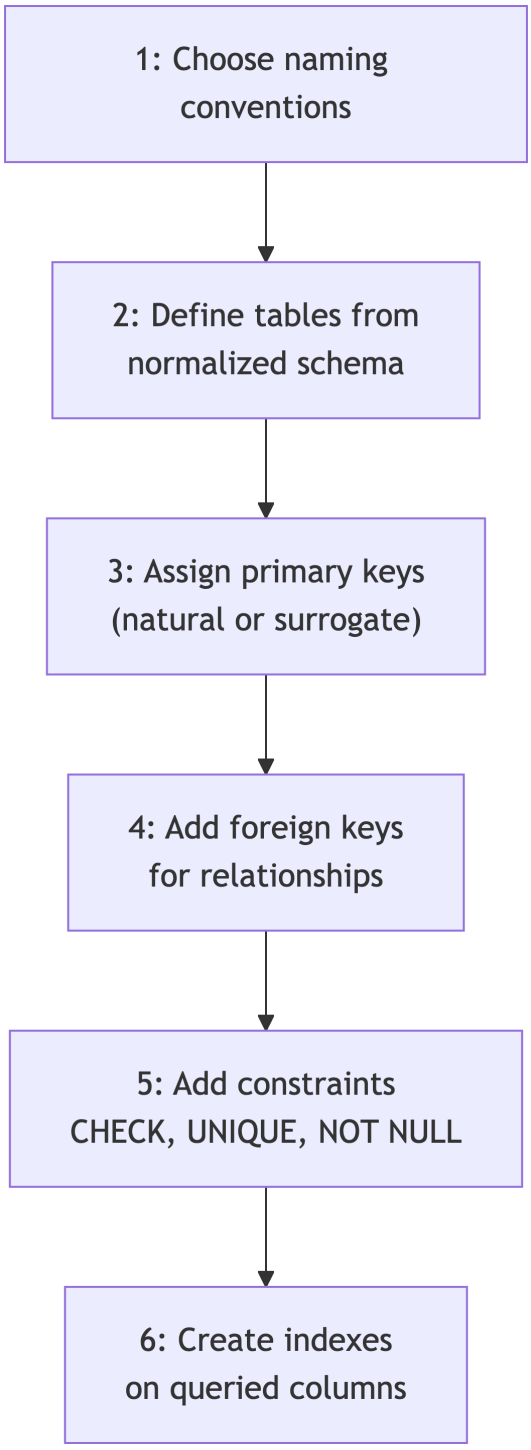
- They consume disk space
- They slow down INSERT, UPDATE, and DELETE operations
- Too many indexes can hurt overall performance

Balance is key. Index the columns you query most. Indexing everything is like highlighting every word in a textbook. At that point, nothing is highlighted.

1.11 Building the Music Catalog Schema

1.11.1 Putting It All Together

Now we apply everything we have learned to build the normalized music catalog tables. The staging table holds the raw import. These tables hold the clean, structured data.


1: Choose naming conventions
2: Define tables from normalized schema
3: Assign primary keys (natural or surrogate)
4: Add foreign keys for relationships
5: Add constraints CHECK, UNIQUE, NOT NULL
6: Create indexes on queried columns

1.11.2 The Artists Table

```
CREATE TABLE artists (
    artist_id bigserial,
    artist_name varchar(200) NOT NULL,
    CONSTRAINT artist_key PRIMARY KEY (artist_id),
    CONSTRAINT artist_name_unique UNIQUE (artist_name)
);
```

Key decisions:

- Surrogate key (`bigserial`) because artist names can change or have variations
- `artist_name` is NOT NULL and UNIQUE (every artist needs a name, and we do not want duplicates after cleaning)

1.11.3 The Albums Table

```
CREATE TABLE albums (
    album_id bigserial,
    album_title varchar(200) NOT NULL,
    release_year smallint,
    genre varchar(50),
    label varchar(100),
    duration_min numeric(5,1),
    artist_id bigint NOT NULL REFERENCES artists (artist_id),
    CONSTRAINT album_key PRIMARY KEY (album_id),
    CONSTRAINT check_year_range
        CHECK (release_year BETWEEN 1900 AND 2100),
    CONSTRAINT check_duration_positive
        CHECK (duration_min > 0),
    CONSTRAINT album_artist_unique
        UNIQUE (album_title, artist_id)
);
```

Key decisions:

- `artist_id` is NOT NULL (every album must have an artist)
- CHECK on year range catches obvious errors
- Composite UNIQUE on title + artist prevents duplicate albums per artist
- `genre` is nullable (some albums defy classification, and our staging data has NULLs)

1.11.4 The Tracks Table

```
CREATE TABLE tracks (
    track_id bigserial,
    track_title varchar(200) NOT NULL,
    track_number smallint NOT NULL,
    duration_sec numeric(6,1),
    album_id bigint NOT NULL REFERENCES albums (album_id),
    CONSTRAINT track_key PRIMARY KEY (track_id),
    CONSTRAINT check_track_number
        CHECK (track_number > 0),
    CONSTRAINT check_track_duration
        CHECK (duration_sec > 0),
    CONSTRAINT track_album_unique
        UNIQUE (track_number, album_id)
);
```

Key decisions:

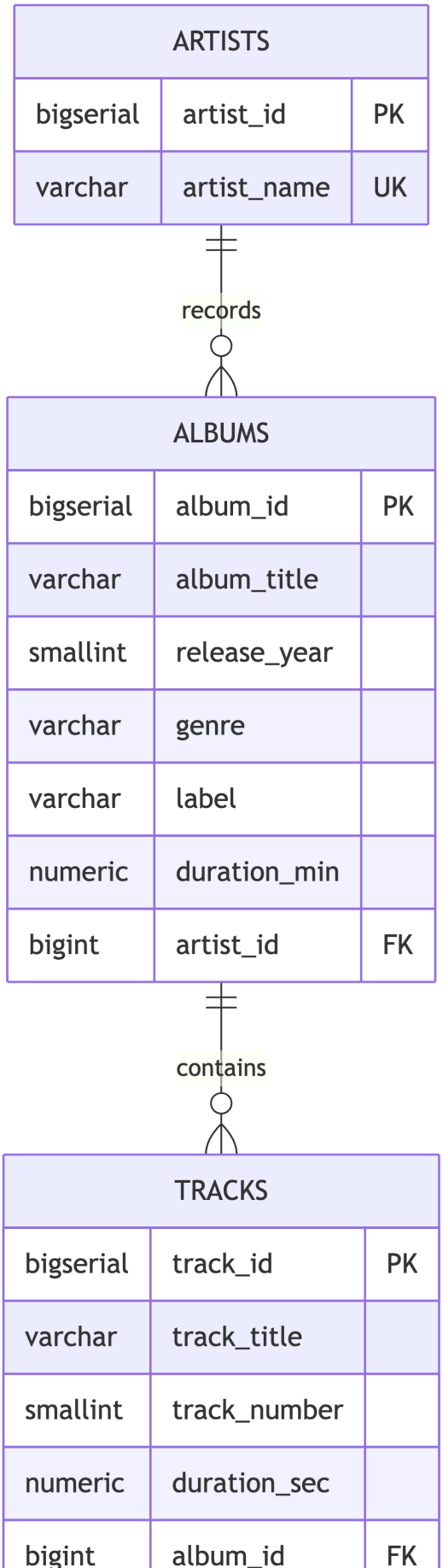
- `album_id` is NOT NULL (every track belongs to an album)
- Composite UNIQUE on track_number + album prevents duplicate track numbers within an album
- `duration_sec` is nullable (metadata is not always complete)

1.11.5 Indexes for Common Queries

```
-- Speed up lookups by artist (for album listings)
CREATE INDEX idx_albums_artist ON albums (artist_id);

-- Speed up lookups by album (for track listings)
CREATE INDEX idx_tracks_album ON tracks (album_id);

-- Speed up genre-based browsing
CREATE INDEX idx_albums_genre ON albums (genre);

-- Speed up searches by release year
CREATE INDEX idx_albums_year ON albums (release_year);
```

Foreign key columns and frequently filtered columns are good index candidates.

1.11.6 The Complete Schema



Three tables, proper constraints, indexes on the right columns. The staging table holds 609 rows of messy data. These tables are ready to hold the clean version.

1.11.7 Constraints Summary

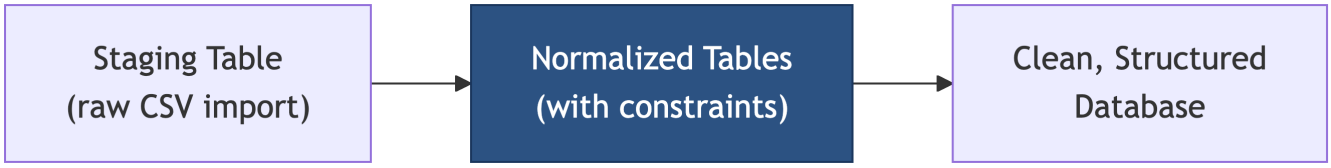
Constraint	Purpose	Syntax
PRIMARY KEY	Unique row identifier	`CONSTRAINT name PRIMARY KEY (col)`
FOREIGN KEY	Referential integrity	`col type REFERENCES table (col)`
CHECK	Value validation	`CONSTRAINT name CHECK (expr)`
UNIQUE	No duplicates	`CONSTRAINT name UNIQUE (col)`
NOT NULL	Requires a value	`col type NOT NULL`

1.11.8 What Is Next

Now that you can **build** tables with proper constraints, the next step is **inspecting and migrating data** from the staging table into the new structure.

Next time we will:

- Audit the staging data for quality issues (spoiler: there are many)
- Fix inconsistencies with UPDATE
- Migrate data into our normalized tables using INSERT INTO … SELECT
- Wrap it all in transactions for safety



1.12 References

1.12.1 Sources

1. DeBarros, A. (2022). *Practical SQL: A Beginner's Guide to Storytelling with Data* (2nd ed.). No Starch Press. Chapter 7: Table Design That Works for You.

2. PostgreSQL Documentation. “CREATE TABLE.” https://www.postgresql.org/docs/current/sql-createtable.html

3. PostgreSQL Documentation. “Indexes.” https://www.postgresql.org/docs/current/indexes.html

4. PostgreSQL Documentation. “Constraints.” https://www.postgresql.org/docs/current/ddl-constraints.html