IT-234 – database concepts

UNIT 3 – THE PHYSICAL DATABASE MODEL

overview

The physical data is a fully attributed data model that is dependent on a specific version of a database (e.g., SQL Server, Oracle, Microsoft Access, etc.).

That technology may be an XML file, a spreadsheet, a relational database management system, or a NoSQL data storage system.

overview

For your purposes, you will implement a logical design into a physical model for a Microsoft SQL Server database.

You will learn the design features of the SQL Server Management Studio used to create a database schema.

Microsoft SQL Server and SQL Server Management Studio (SSMS) must be installed to complete the assignments for this unit.

overview

In this unit, you are also going to create two instances of the Movies database using a provided database design diagram.

You will use Microsoft SQL Management Studio Designer tools to establish the first instance.

The second instance will be implemented using Structured Query Language (SQL) statements.

overview

The Designer is fine for prototyping, but in a production environment, you want to be able to replicate the work on many different machines.

You would not want to manually use the Designer on each installation, which would be impossible!

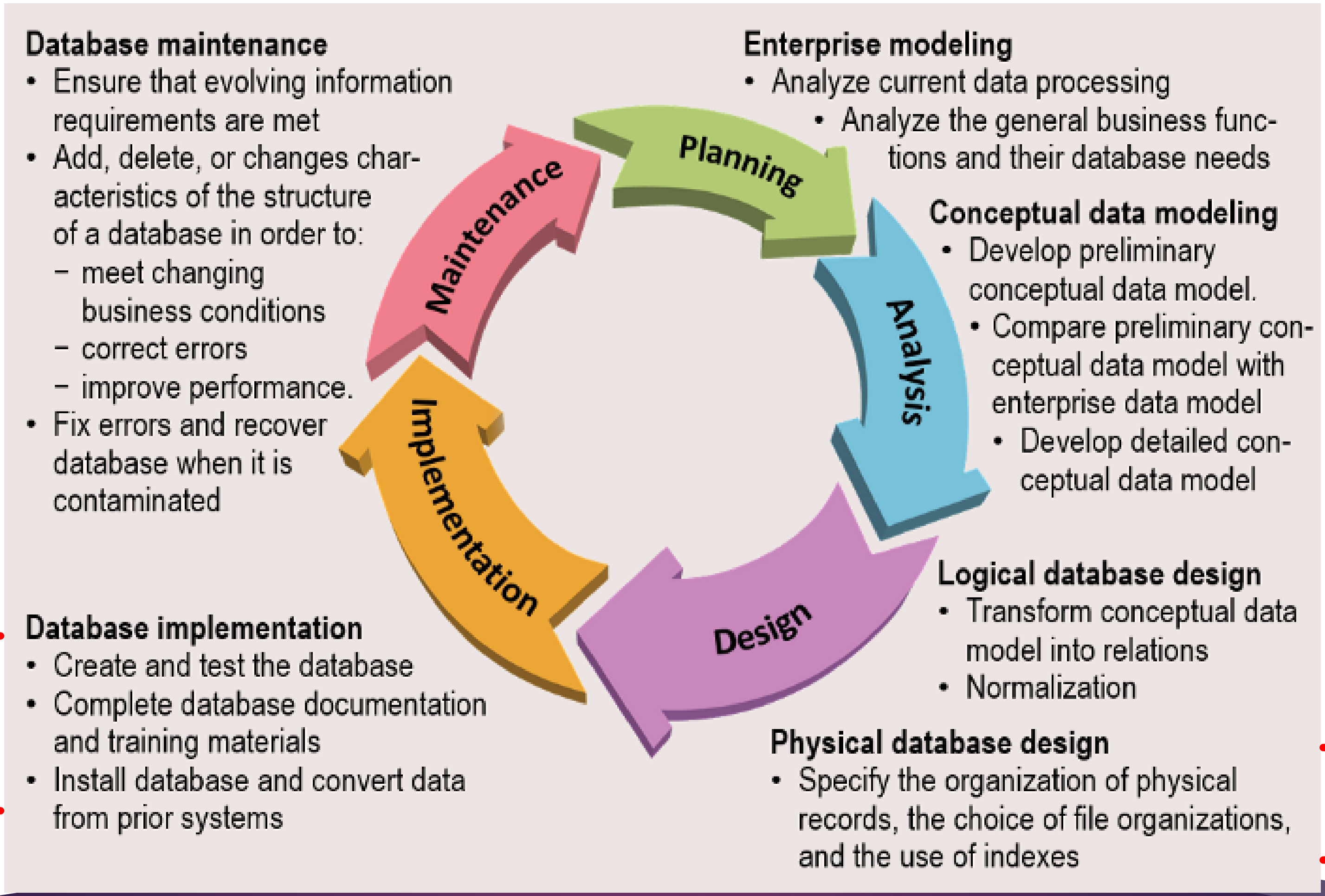
The solution? -> SQL script files.

The designer uses SQL in the background to perform database work.

overview

After completing this unit, you should be able to:

- Describe the elements to be included in the physical data model.
- Create the database using the Designer tools in Microsoft SQL Server Management Studio (SSMS).
- Associate column names, data type, and number of characters for each attribute.
- Identify the primary keys for each of the tables.
- Recognize any foreign keys required for each of the tables.
- Identify the elements of the physical data model to create a database schema.
- Use CREATE keyword to generate databases, tables, columns, keys.



Database maintenance
- Ensure that evolving information requirements are met
- Add, delete, or changes characteristics of the structure of a database in order to:
  - meet changing business conditions
  - correct errors
  - improve performance.
- Fix errors and recover database when it is contaminated

Enterprise modeling
- Analyze current data processing
  - Analyze the general business functions and their database needs

Conceptual data modeling
- Develop preliminary conceptual data model.
  - Compare preliminary conceptual data model with enterprise data model
    - Develop detailed conceptual data model

Logical database design
- Transform conceptual data model into relations
- Normalization

Physical database design
- Specify the organization of physical records, the choice of file organizations, and the use of indexes

Database implementation
- Create and test the database
- Complete database documentation and training materials
- Install database and convert data from prior systems

Database life cycle

During the physical design phase, you make decisions about the database environment (database server), application development environment, database files organization, physical database objects, etc.

Physical design phase is a very technical stage of the database design process.

The result of this phase is a physical design specification that is used to build and deploy your database solution.

The Physical Model

The Physical Model

Operates at lowest level of abstraction, describing the way data are saved on storage media such as disks or tapes

Software and hardware dependent

Requires that database designers have a detailed knowledge of the hardware and software used to implement database design

The Physical Model

Physical data modeling involves transforming the logical model from a purely business design to a design optimized to run in a particular environment.

Physical database design diagram represents the actual design blueprint of a relational database.

The Physical Model

The physical database design diagram represents how data should be structured and related in a specific DBMS

So, it is important to consider the convention and restriction of the DBMS you use when you are designing physical diagrams/documentation.

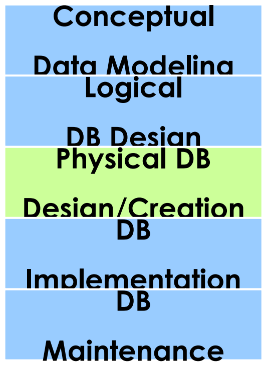
This means that an accurate use of data type is needed for entity columns and the use of reserved words has to be avoided in naming entities and columns.

The Physical Model

Things that must be considered when doing physical modeling include the specific RDBMS, the hardware environment, the data access frequency and the data access paths.

Physical data modeling involves adding properties, such as space, free space and indexes.

- Select DBMS
- Select storage devices
- Determine access methods
- Design files and indexes
- Determine database distribution
- Specify update strategies



The Physical Model

Physical data independence

Physical data independence refers to the immunity of the conceptual/logical models to changes in the physical model.

The logical schema stays unchanged even though changes are made to file organization or storage structures, storage devices or indexing strategy.

Physical data independence

Physical data independence deals with hiding the details of the storage structure from user applications.

External applications should not be involved with these issues, since there is no difference in operations carried out against the data.

Physical data independence

Due to physical independence, the changes below will not impact the conceptual/logical design.

- Using a new storage device like hard drive or magnetic tapes
- Modifying the file organization technique in the database
- Switching to different data structures.
- Changing the access method.
- Modifying indexes.
- Changes to compression techniques or hashing algorithms.
- Change of Location of Database from say C drive to D drive

Key Terms Review

Database: The term database describes a collection of data organized in a manner that allows access, retrieval, and use of that data.

Database Management System (DBMS): A database management system, such as Access, is software that allows you to use a computer to:

- Create a database
- Add, change, and delete data in the database
- Ask and answer questions concerning the data in the database
- Create forms and reports using the data in the database

Key Terms Review

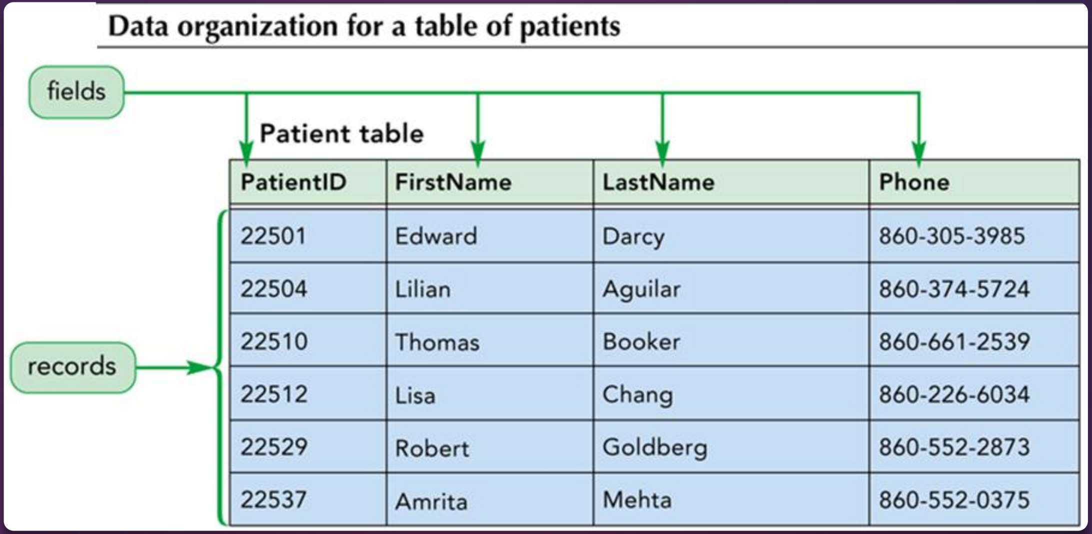
Relational Database: In a relational database, such as those maintained by Access, a database consists of a collection of tables, each of which contains information on a specific subject.

Record: The rows in the tables are called records.

Field: A field contains a specific piece of information within a record.

Primary Key: A unique identifier also is called a primary key.

Data Type: Each field has a data type. This indicates the type of data that can be stored in the field.



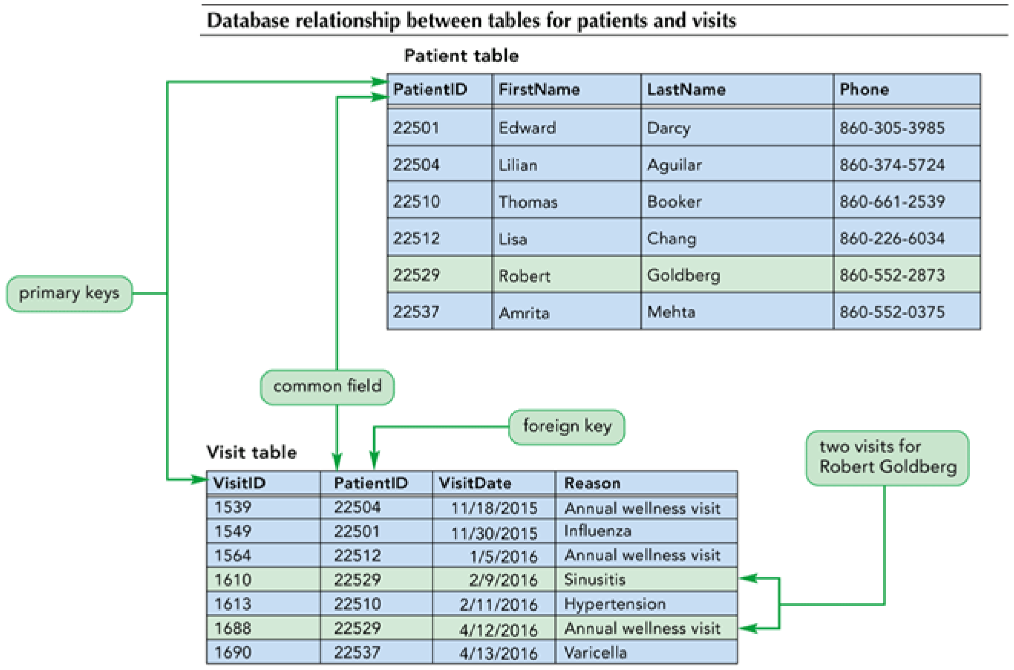
PatientID	FirstName	LastName	Phone
22501	Edward	Darcy	860-305-3985
22504	Lilian	Aguilar	860-374-5724
22510	Thomas	Booker	860-661-2539
22512	Lisa	Chang	860-226-6034
22529	Robert	Goldberg	860-552-2873
22537	Amrita	Mehta	860-552-0375

TABLE FIELDS AND RECORDS

DATABASES AND RELATIONSHIPS

- A relational database is a collection of related tables
- Records in the separate tables are connected through a common field
- A primary key is a field, or a collection of fields, that uniquely identify each record in a table
- Including the primary key from one table as a field in a second table to form a relationship between the two tables, it is called a foreign key in the second table

Database relationship between tables for patients and visits

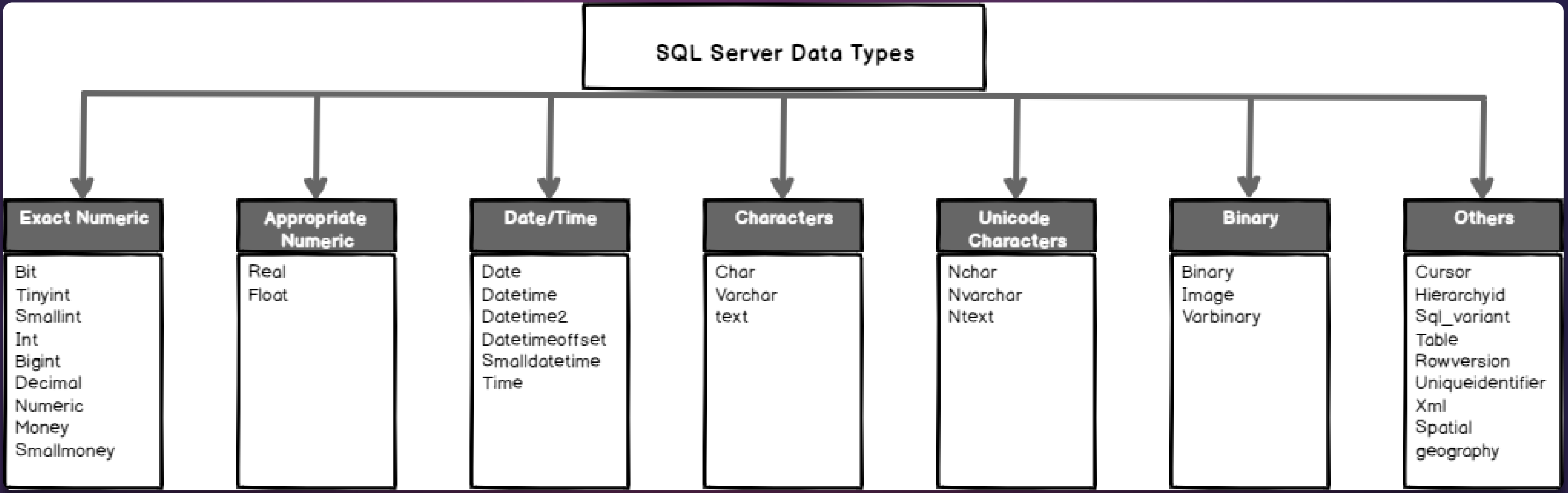


Patient table

PatientID	FirstName	LastName	Phone
22501	Edward	Darcy	860-305-3985
22504	Lilian	Aguilar	860-374-5724
22510	Thomas	Booker	860-661-2539
22512	Lisa	Chang	860-226-6034
22529	Robert	Goldberg	860-552-2873
22537	Amrita	Mehta	860-552-0375

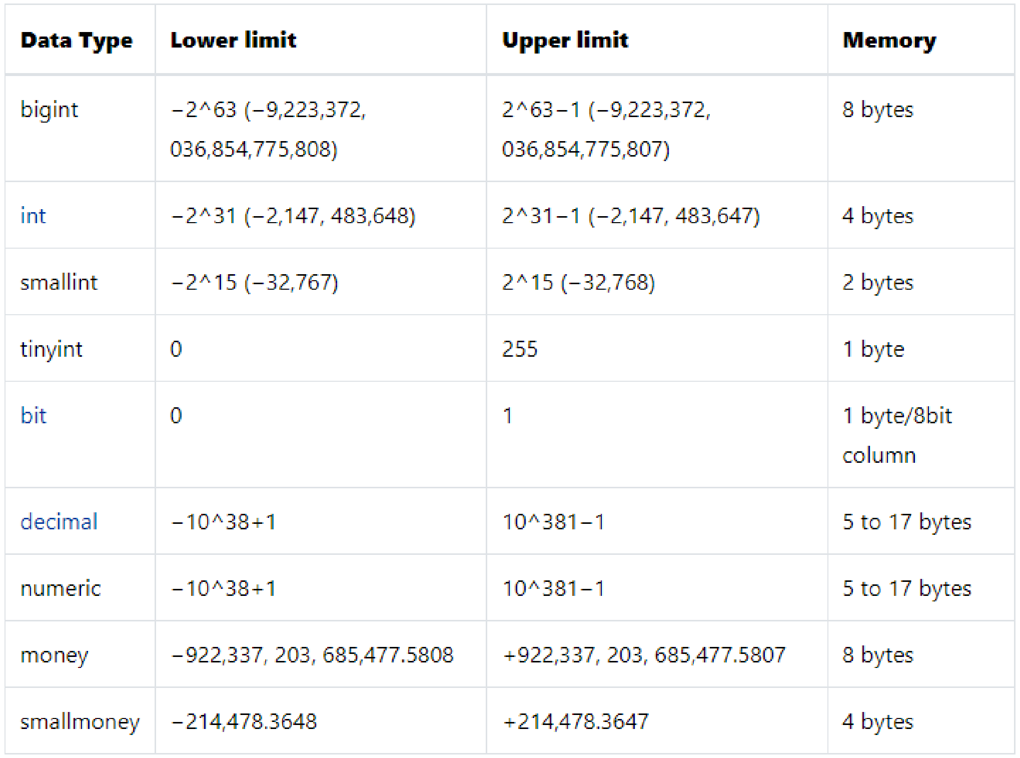
Visit table

VisitID	PatientID	VisitDate	Reason
1539	22504	11/18/2015	Annual wellness visit
1549	22501	11/30/2015	Influenza
1564	22512	1/5/2016	Annual wellness visit
1610	22529	2/9/2016	Sinusitis
1613	22510	2/11/2016	Hypertension
1688	22529	4/12/2016	Annual wellness visit
1690	22537	4/13/2016	Varicella

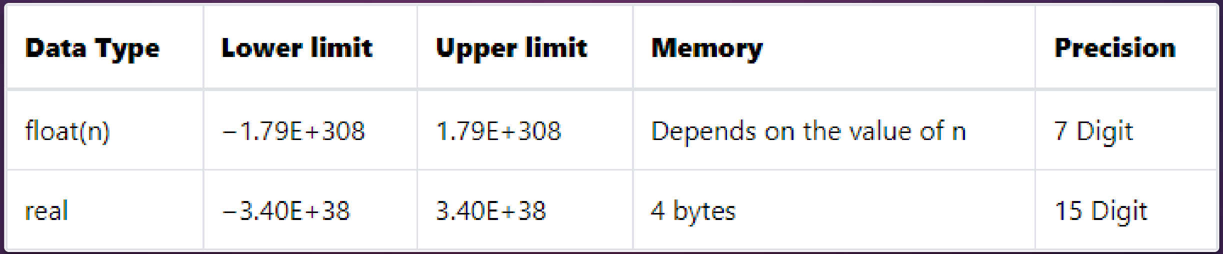

SQL Server Data Types
Exact Numeric
Bit
Tinyint
Smallint
Int
Bigint
Decimal
Numeric
Money
Smallmoney
Appropriate Numeric
Real
Float
Date/Time
Date
Datetime
Datetime2
Datetimeoffset
Smalldatetime
Time
Characters
Char
Varchar
text
Unicode Characters
Nchar
Nvarchar
Ntext
Binary
Binary
Image
Varbinary
Others
Cursor
Hierarchyid
Sql_variant
Table
Rowversion
Uniqueidentifier
Xml
Spatial
geography

Data Types

Data Types Exact numeric data types



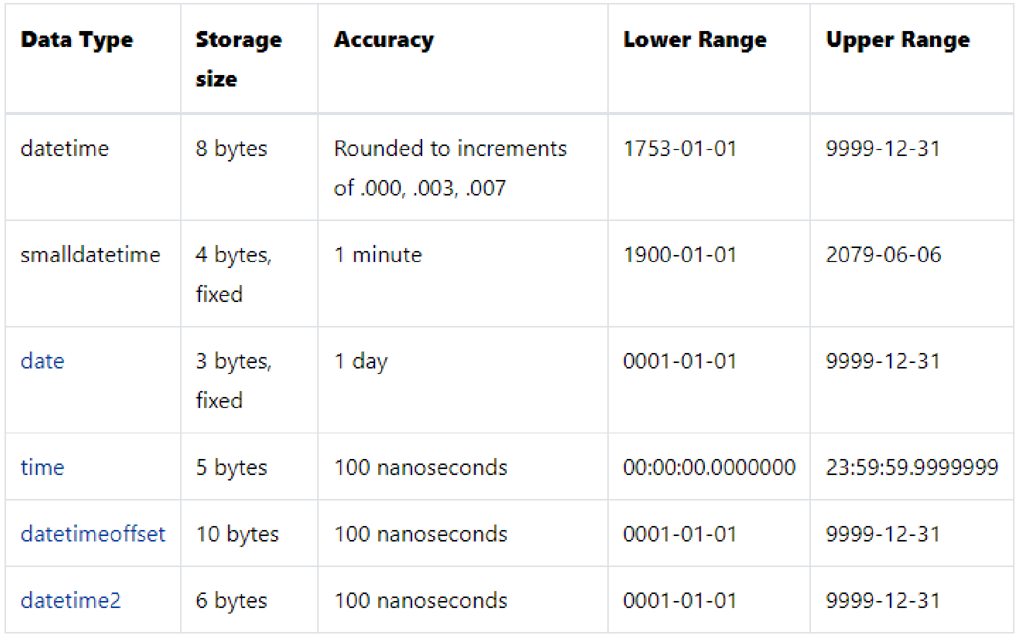
Data Type	Lower limit	Upper limit	Memory
bigint	−2^63 (−9,223,372, 036,854,775,808)	2^63−1 (−9,223,372, 036,854,775,807)	8 bytes
int	−2^31 (−2,147, 483,648)	2^31−1 (−2,147, 483,647)	4 bytes
smallint	−2^15 (−32,767)	2^15 (−32,768)	2 bytes
tinyint	0	255	1 byte
bit	0	1	1 byte/8bit column
decimal	−10^38+1	10^381−1	5 to 17 bytes
numeric	−10^38+1	10^381−1	5 to 17 bytes
money	−922,337, 203, 685,477.5808	+922,337, 203, 685,477.5807	8 bytes
smallmoney	−214,478.3648	+214,478.3647	4 bytes



Data Type	Lower limit	Upper limit	Memory	Precision
float(n)	−1.79E+308	1.79E+308	Depends on the value of n	7 Digit
real	−3.40E+38	3.40E+38	4 bytes	15 Digit

Data Types Approximate numeric data types

Data Types Date & Time data types



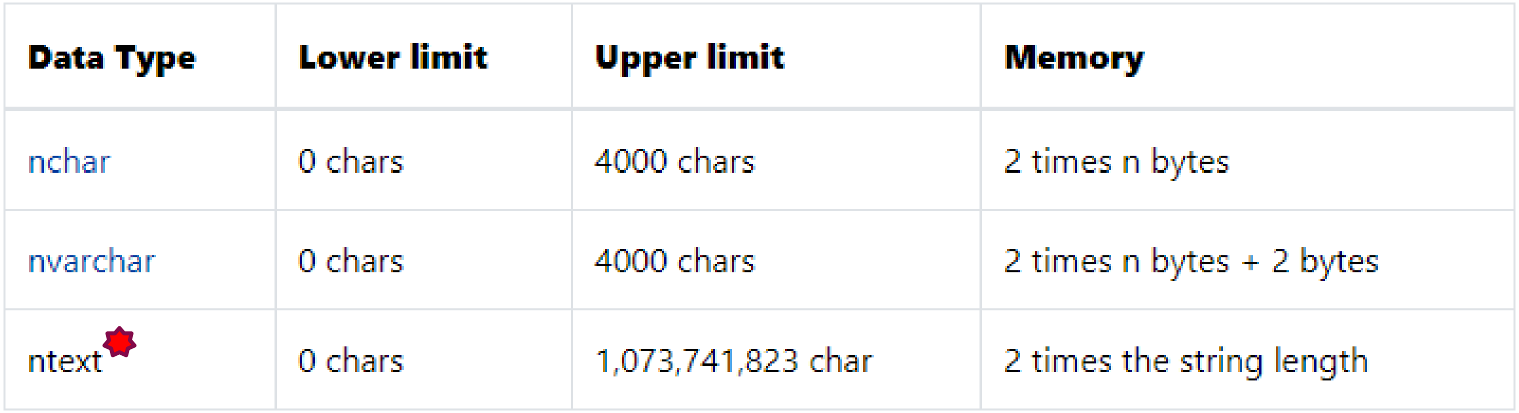
Data Type	Storage size	Accuracy	Lower Range	Upper Range
datetime	8 bytes	Rounded to increments of .000, .003, .007	1753-01-01	9999-12-31
smalldatetime	4 bytes, fixed	1 minute	1900-01-01	2079-06-06
date	3 bytes, fixed	1 day	0001-01-01	9999-12-31
time	5 bytes	100 nanoseconds	00:00:00.0000000	23:59:59.9999999
datetimeoffset	10 bytes	100 nanoseconds	0001-01-01	9999-12-31
datetime2	6 bytes	100 nanoseconds	0001-01-01	9999-12-31

Data Type	Lower limit	Upper limit	Memory
char	0 chars	8000 chars	n bytes
varchar	0 chars	8000 chars	n bytes + 2 bytes
varchar (max)	0 chars	2^31 chars	n bytes + 2 bytes
text ✸	0 chars	2,147,483,647 chars	n bytes + 4 bytes

✸ Deprecated data type

Data Types
Character strings data types

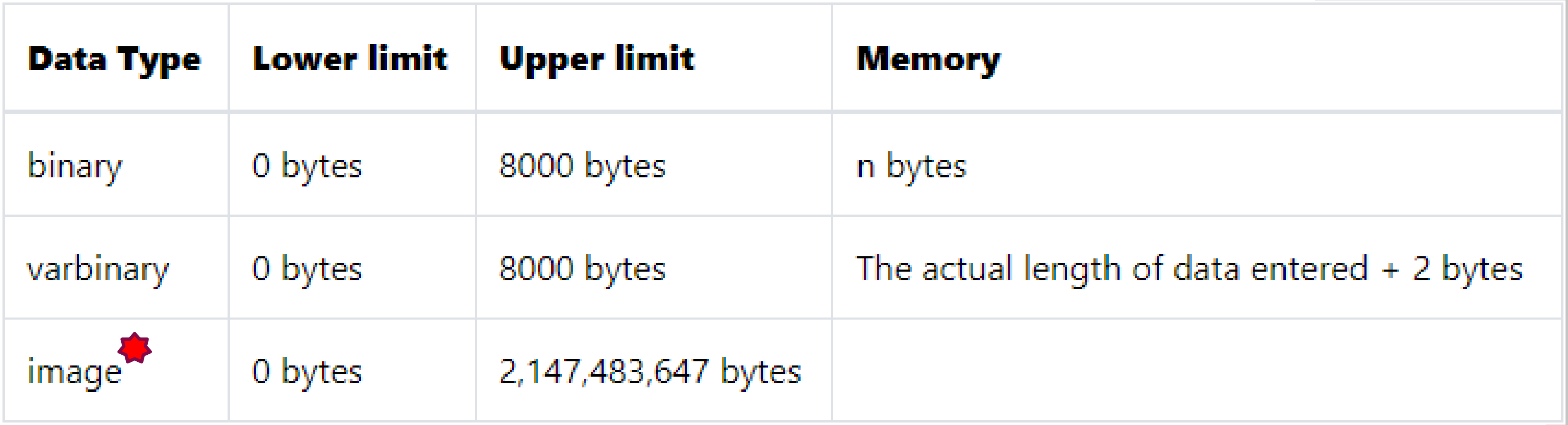
Data Types
Unicode character string data types



Data Type	Lower limit	Upper limit	Memory
nchar	0 chars	4000 chars	2 times n bytes
nvarchar	0 chars	4000 chars	2 times n bytes + 2 bytes
ntext ✸	0 chars	1,073,741,823 char	2 times the string length

✸ Deprecated data type

Data Types
Binary data types

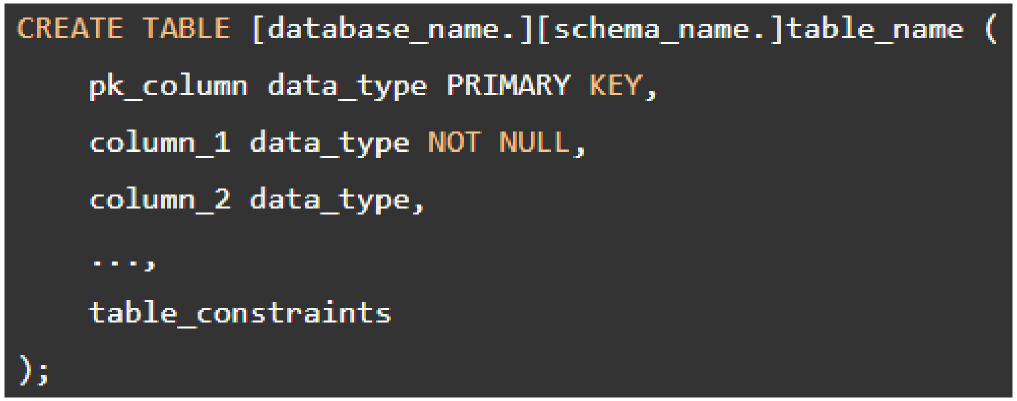


Data Type	Lower limit	Upper limit	Memory
binary	0 bytes	8000 bytes	n bytes
varbinary	0 bytes	8000 bytes	The actual length of data entered + 2 bytes
image ✸	0 bytes	2,147,483,647 bytes	

✸ Deprecated data type

DATA DEFINITION LANGUAGE (DDL)

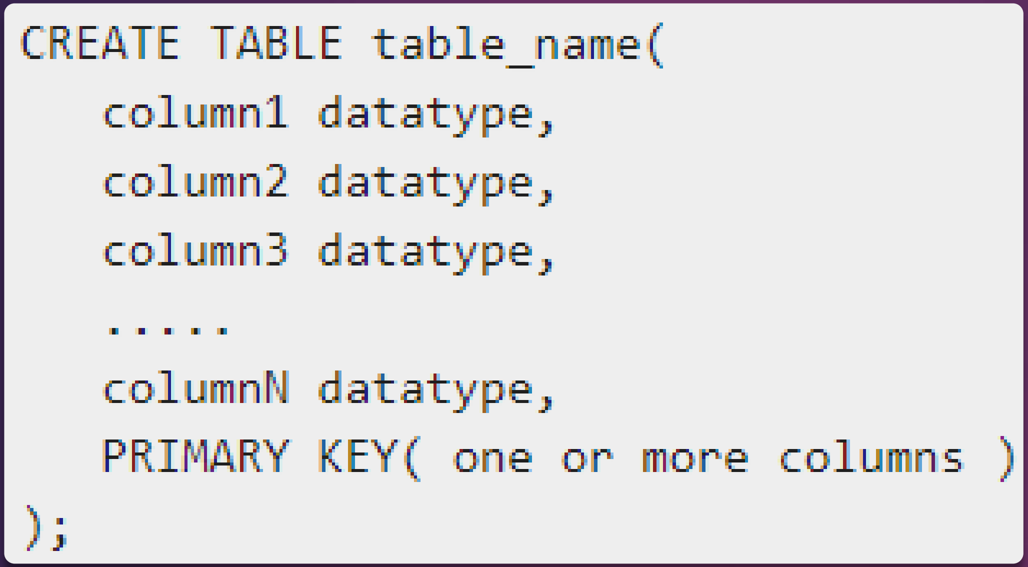
- The CREATE TABLE statement is used to create a new table in a database.
- Syntax:



```
CREATE TABLE [database_name.][schema_name.]table_name (
    pk_column data_type PRIMARY KEY,
    column_1 data_type NOT NULL,
    column_2 data_type,
    ...,
    table_constraints
);
```

DATA DEFINITION LANGUAGE (DDL)

ALTERNATE SYNTAX:



```
CREATE TABLE table_name(
   column1 datatype,
   column2 datatype,
   column3 datatype,
   .....
   columnN datatype,
   PRIMARY KEY( one or more columns )
);
```

DATA DEFINITION LANGUAGE (DDL)

CREATE TABLE EXAMPLES:

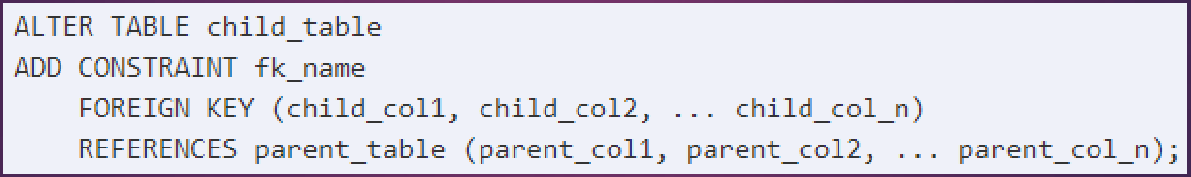
```
Create Table Director
(
     DirectorID INT IDENTITY(1,1) NOT NULL,
     Director_FirstName VARCHAR(15),
     Director_LastName VARCHAR(25) NOT NULL,
     CONSTRAINT Director_PK PRIMARY KEY (DirectorID)
);
GO
```

```
Create Table Movies(
     MovieID INT Identity(1,1) NOT NULL,
     Title VARCHAR(35) NOT NULL,
     DirectorID INT NOT NULL,
     StarID INT NOT NULL,
     GenreID INT NOT NULL,
     Rating NUMERIC(3,1) NOT NULL,
     CONSTRAINT Movies_PK PRIMARY KEY (MovieID)
);
GO
```

DATA DEFINITION LANGUAGE (DDL)

The ALTER TABLE statement can be used to add foreign key constraints.

Syntax:

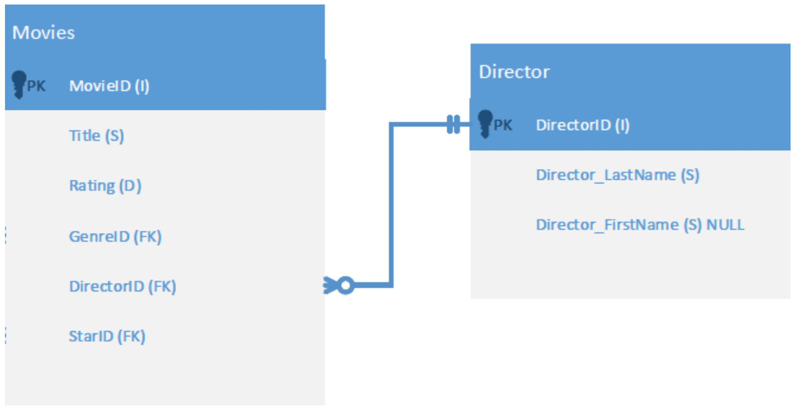


```
ALTER TABLE child_table
ADD CONSTRAINT fk_name
    FOREIGN KEY (child_col1, child_col2, ... child_col_n)
    REFERENCES parent_table (parent_col1, parent_col2, ... parent_col_n);
```

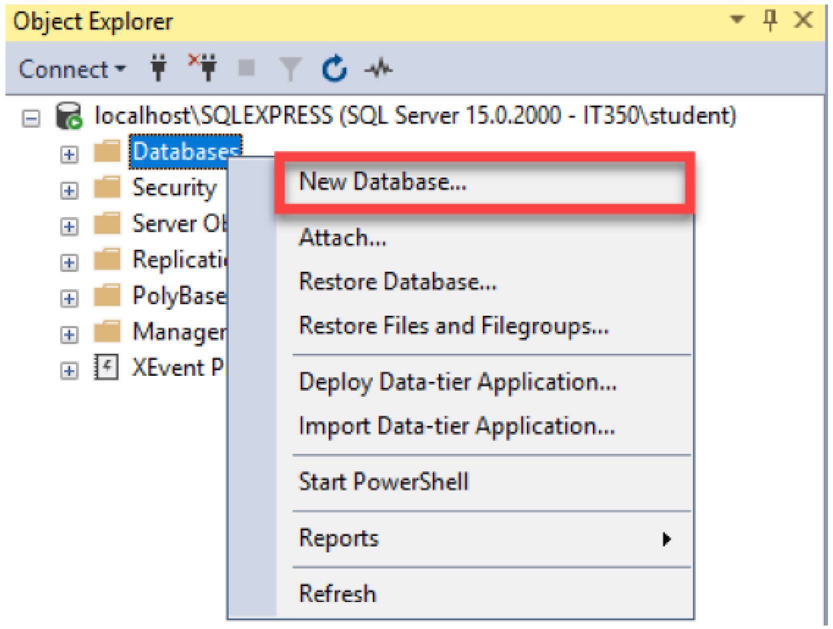
DATA DEFINITION LANGUAGE (DDL)

ALTER TABLE EXAMPLE:

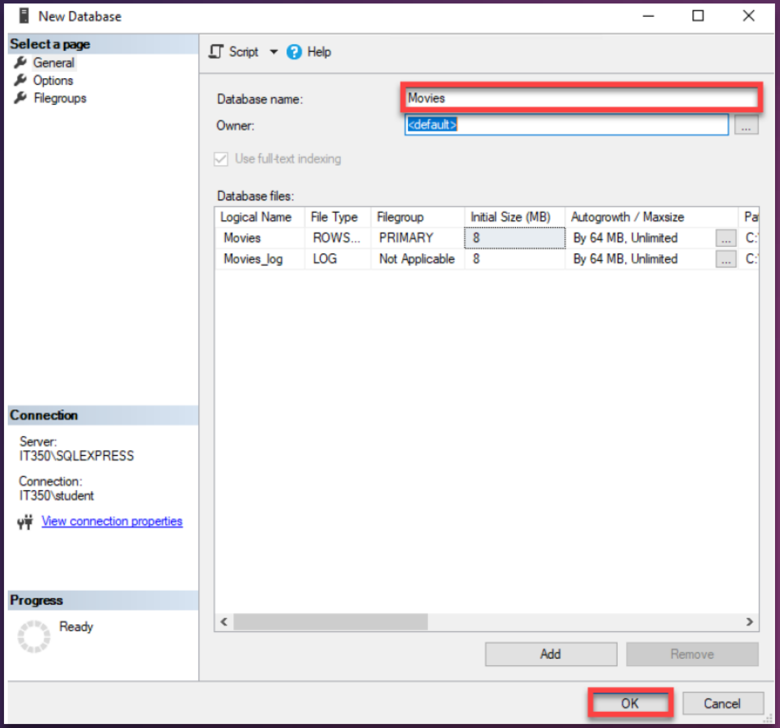
```
ALTER TABLE Movies
ADD CONSTRAINT Movies_FK1
FOREIGN KEY (DirectorID) REFERENCES Director(DirectorID);
GO
```



In Microsoft SQL Server Management Studio (SSMS), right-click on the **Databases** item in the Object Explorer panel and select **New Database** in the right-click menu.



DATABASE GENERATION USING SSMS


New Database

Select a page
- General
- Options
- Filegroups

Script Help

Database name: Movies

Owner: <default>

Use full-text indexing

Database files:

Logical Name	File Type	Filegroup	Initial Size (MB)	Autogrowth / Maxsize	Pa
Movies	ROWS...	PRIMARY	8	By 64 MB, Unlimited	C:
Movies_log	LOG	Not Applicable	8	By 64 MB, Unlimited	C:

Connection

Server:
IT350\SQLEXPRESS

Connection:
IT350\student

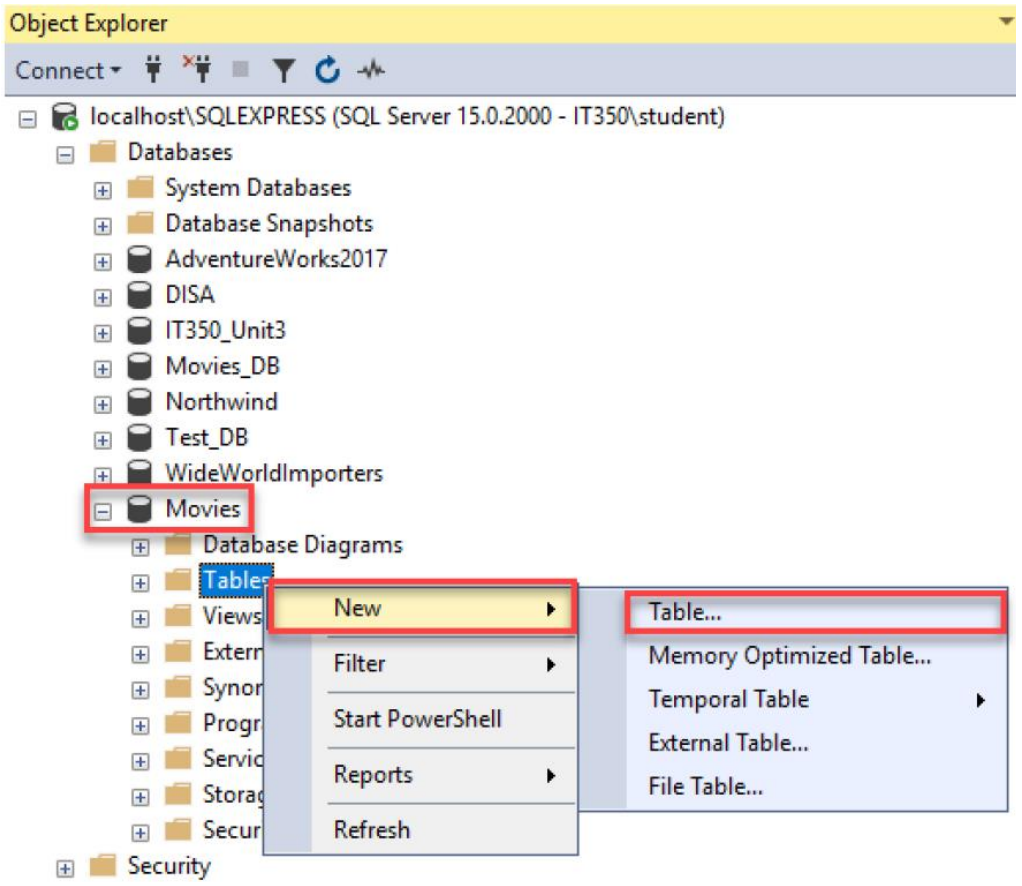
View connection properties

Progress

Ready

The **New Database** window will appear. Enter **Movies** in the ***Database Name*** text field. Leave all other fields as they are and click **OK**.

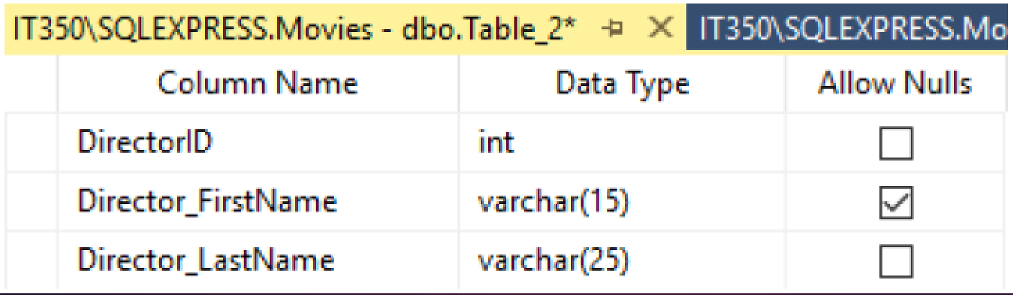
DATABASE GENERATION USING SSMS



DATABASE GENERATION USING SSMS

You now see the database listed under **Databases** in the Object Explorer panel. Expand the **Movies** database tree by clicking on the ⊞ button next to the **Movies** label. Right-click on the **Tables** item under **Movies** and select **NEW --> TABLE** from the right-click menu to add a new table.

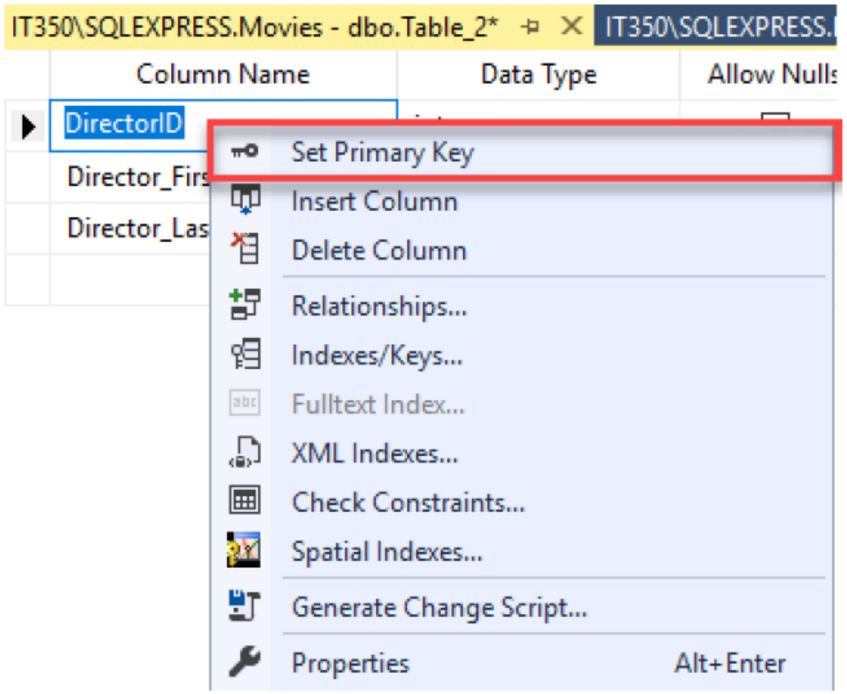
The screenshot below shows what to enter for the **Director** table in the SSMS Designer window. Do not allow nulls for the **DirectorID** and **Director_LastName** attributes (i.e., leave the **Allow Nulls** checkbox blank for these attributes).



Column Name	Data Type	Allow Nulls
DirectorID	int	☐
Director_FirstName	varchar(15)	✓
Director_LastName	varchar(25)	☐

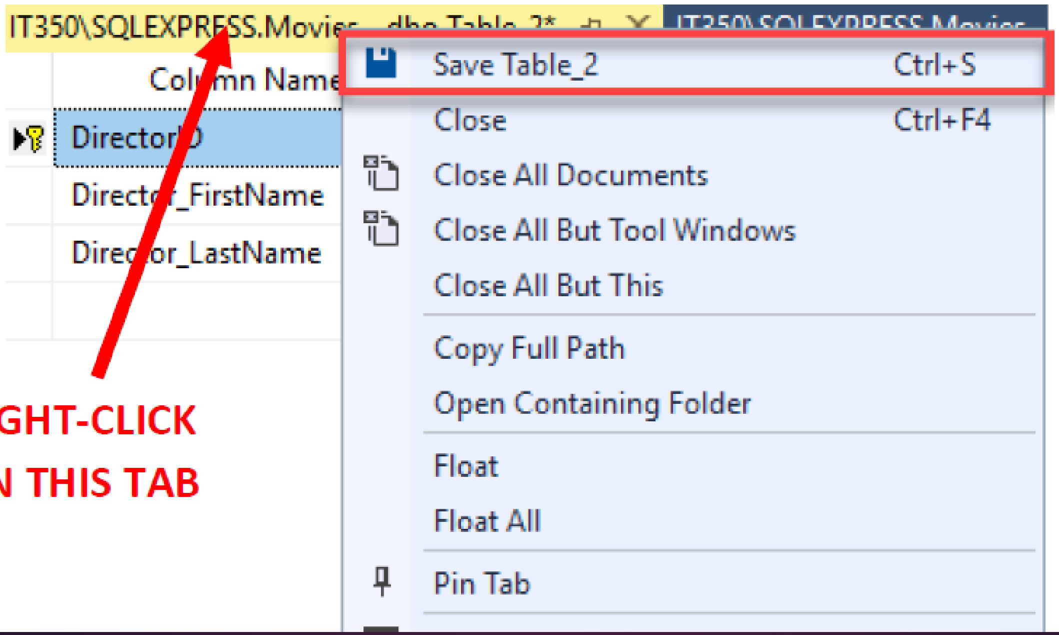
DATABASE GENERATION USING SSMS

Right-click on the **DirectorID** attribute and select **Set Primary Key** from the right-click menu. This will establish the **DirectorID** attribute as the primary key for the table.

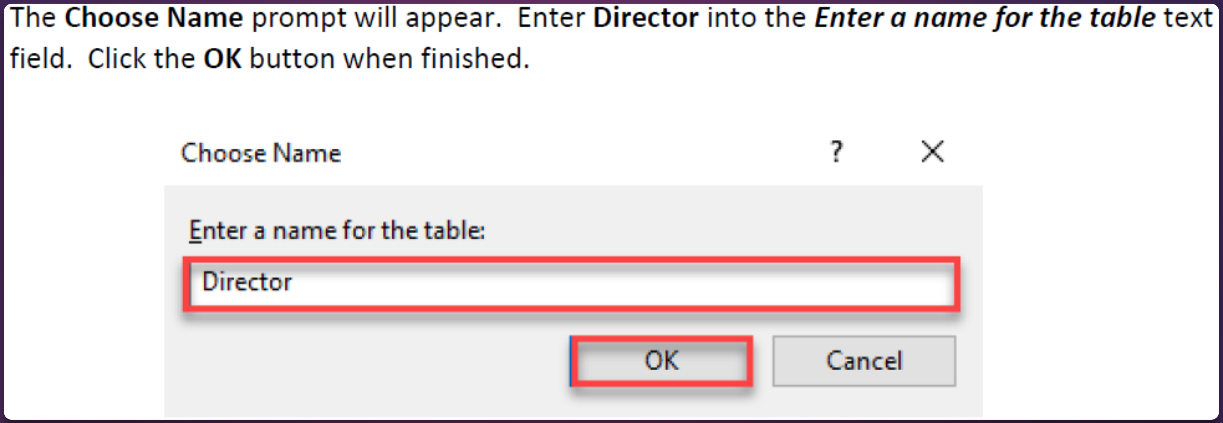


DATABASE GENERATION USING SSMS

Right-click on the Designer window tab and select the **Save** option from the right-click menu.



DATABASE GENERATION USING SSMS


The **Choose Name** prompt will appear. Enter **Director** into the ***Enter a name for the table*** text field. Click the **OK** button when finished.

Choose Name

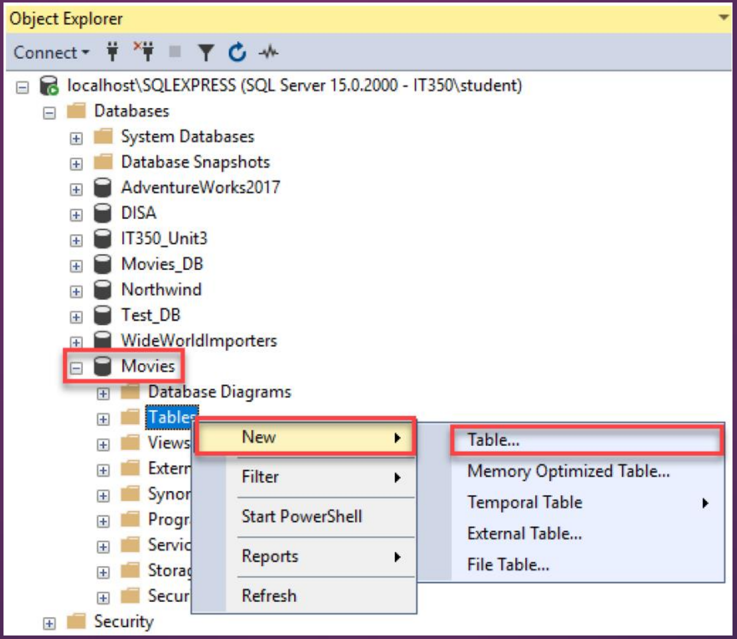
Enter a name for the table:

Director

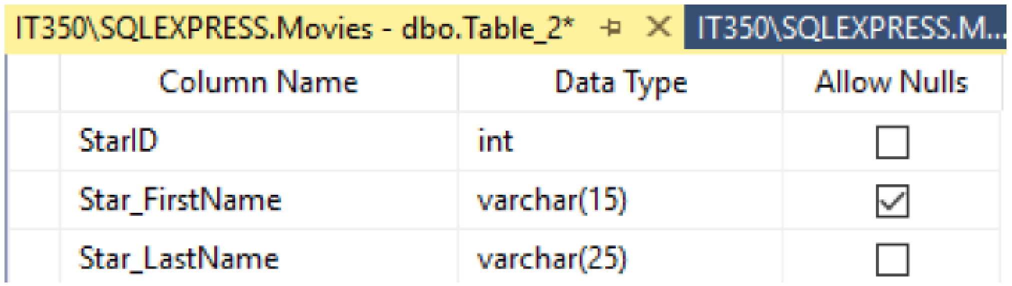
DATABASE GENERATION USING SSMS

DATABASE GENERATION USING SSMS

Right-click on the **Tables** items under **Movies** and select **NEW --> TABLE** from the right-click menu to add a new table.



The screenshot below shows what to enter for the **Star** table in the SSMS Designer window. Do not allow nulls for the **StarID** and **Star_LastName** attributes (i.e., leave the **Allow Nulls** checkbox blank for these attributes).

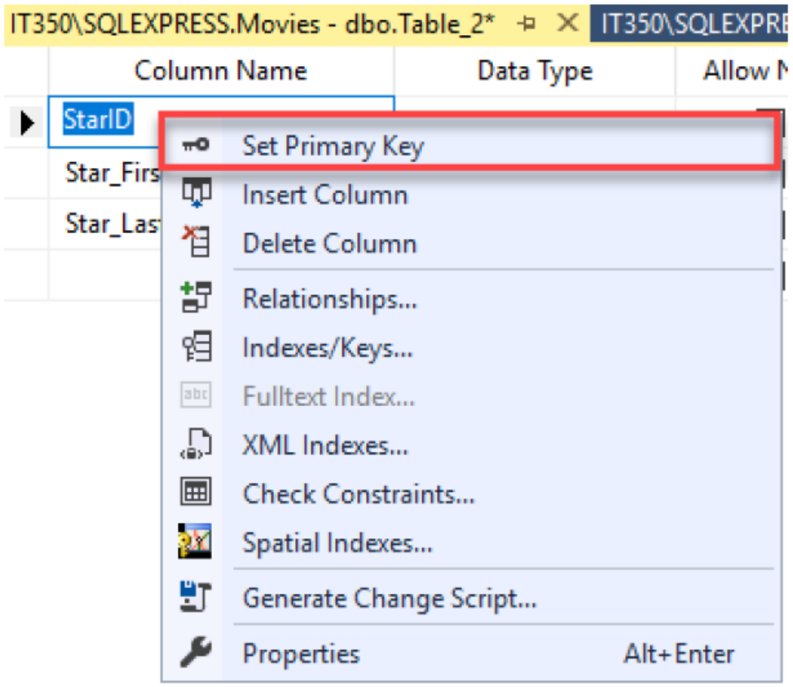


Column Name	Data Type	Allow Nulls
StarID	int	☐
Star_FirstName	varchar(15)	☑
Star_LastName	varchar(25)	☐

DATABASE GENERATION USING SSMS

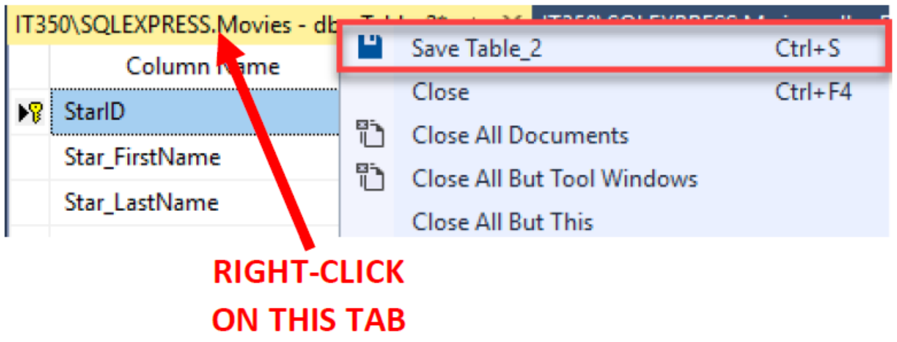
DATABASE GENERATION USING SSMS

Right-click on the **StarID** attribute and select **Set Primary Key** from the right-click menu. This will establish the **StarID** attribute as the primary key for the table.

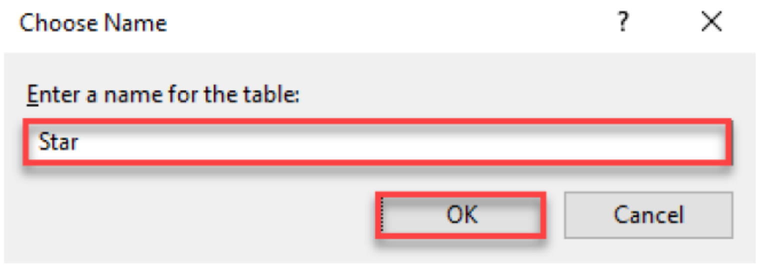


DATABASE GENERATION USING SSMS

Right-click on the Designer window tab and select the **Save** option from the right-click menu.

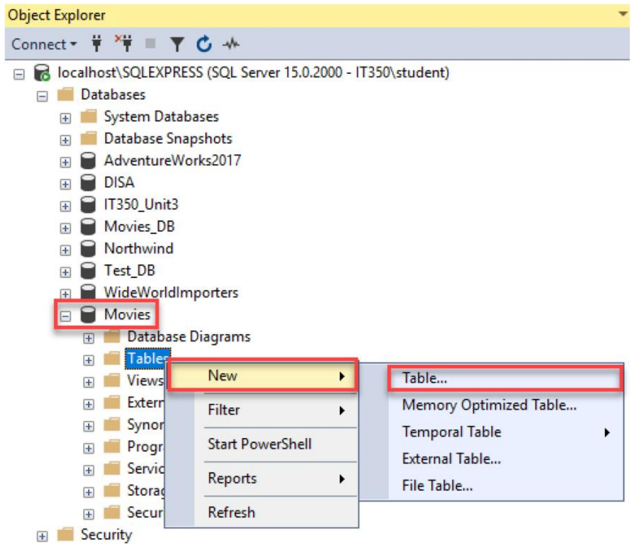


The **Choose Name** prompt will appear. Enter **Star** into the ***Enter a name for the table*** text field. Click the **OK** button when finished.



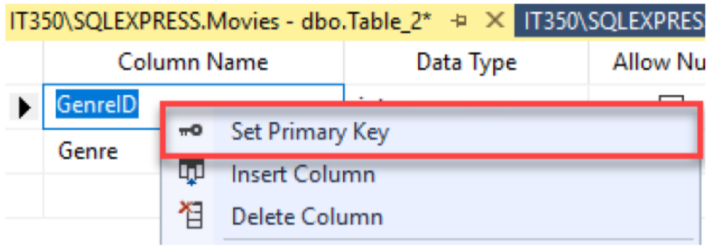
DATABASE GENERATION USING SSMS

Right-click on the **Tables** items under **Movies** and select **NEW --> TABLE** from the right-click menu to add a new table.

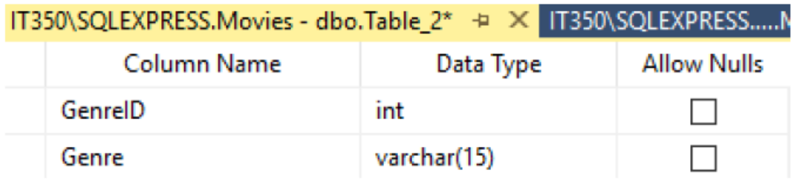


DATABASE GENERATION USING SSMS

Right-click on the **GenreID** attribute and select **Set Primary Key** from the right-click menu. This will establish the **GenreID** attribute as the primary key for the table.

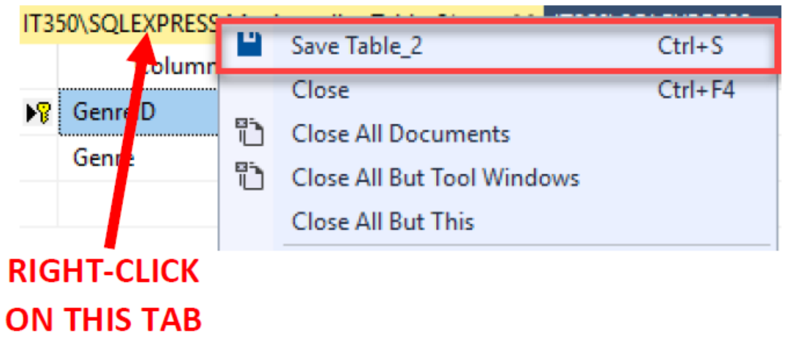


The screenshot below shows what to enter for the **Genre** table in the SSMS Designer window. Do not allow nulls for the **GenreID** and **Genre** attributes (i.e., leave the **Allow Nulls** checkbox blank for these attributes).

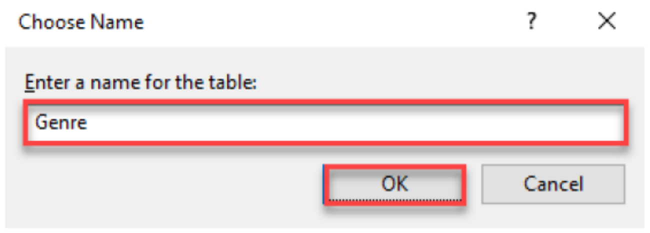


Column Name	Data Type	Allow Nulls
GenreID	int	☐
Genre	varchar(15)	☐

Right-click on the Designer window tab and select the **Save** option from the right-click menu.

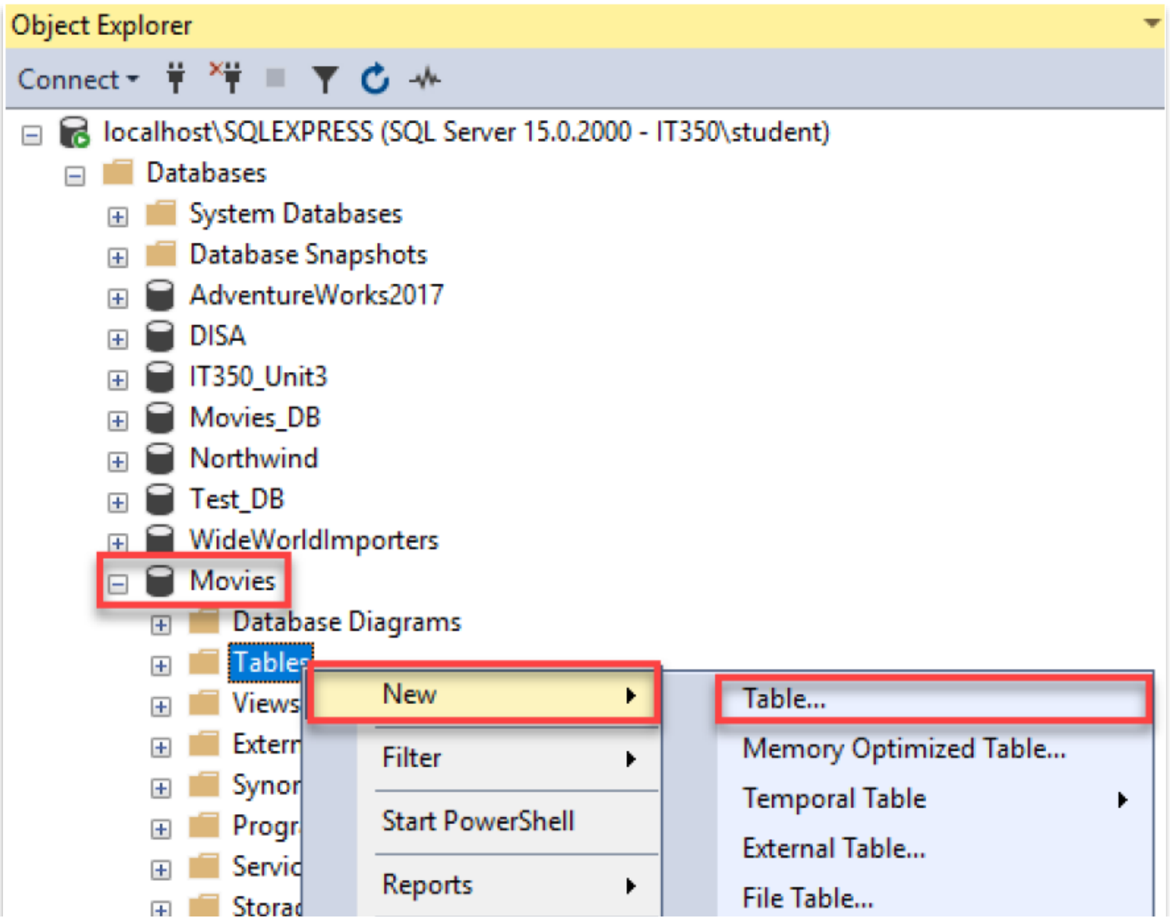


The **Choose Name** prompt will appear. Enter **Genre** into the ***Enter a name for the table*** text field. Click the **OK** button when finished.



Enter a name for the table: Genre

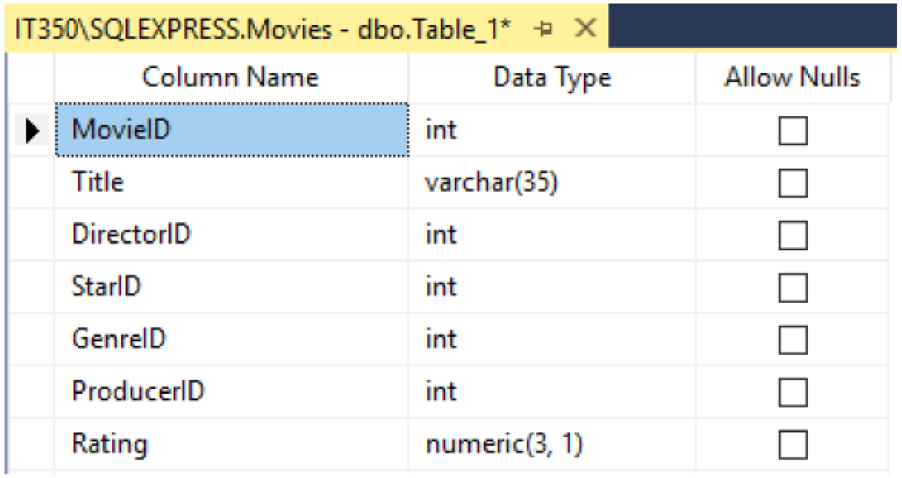
DATABASE GENERATION USING SSMS



Right-click on the **Tables** items under **Movies** and select **NEW --> TABLE** from the right-click menu to add a new table.

DATABASE GENERATION USING SSMS

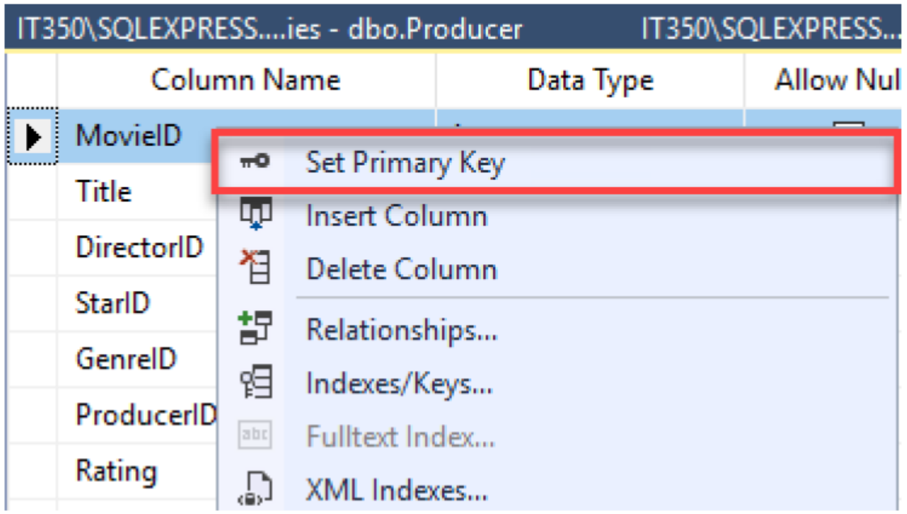
This screenshot below shows what to enter for the **Movies** table in the Designer window. Do not allow nulls for any of the table attributes (i.e., leave the checkbox blank for all attributes).


IT350\SQLEXPRESS.Movies - dbo.Table_1*

Column Name	Data Type	Allow Nulls
MovieID	int	☐
Title	varchar(35)	☐
DirectorID	int	☐
StarID	int	☐
GenreID	int	☐
ProducerID	int	☐
Rating	numeric(3, 1)	☐

DATABASE GENERATION USING SSMS

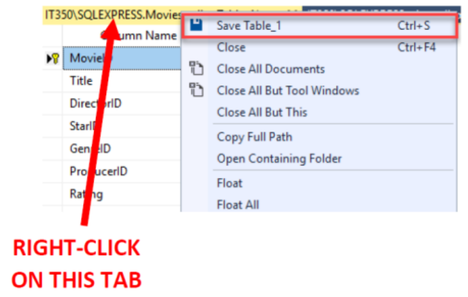
Right-click on the **MovieID** attribute and select **Set Primary Key** from the right-click menu. This will establish the **MovieID** attribute as the primary key for the table.



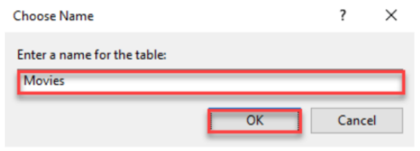
DATABASE GENERATION USING SSMS

DATABASE GENERATION USING SSMS

Right-click on the Designer window tab and select the **Save** option from the right-click menu.

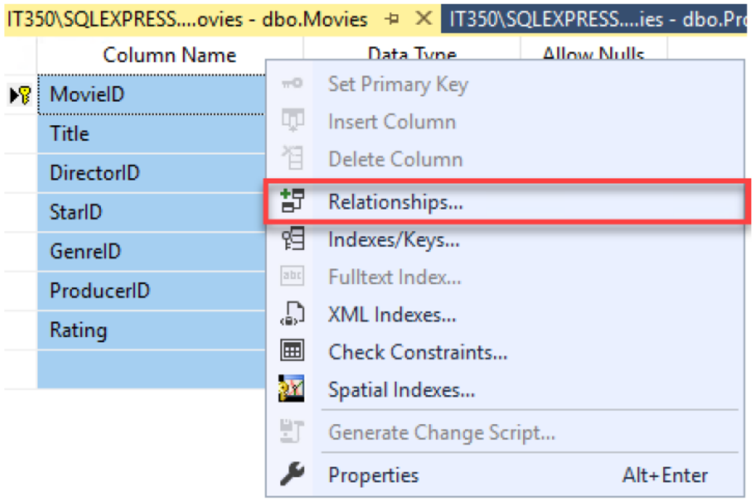


The **Choose Name** prompt will appear. Enter **Movies** into the ***Enter a name for the table*** text field. Click the **OK** button when finished.



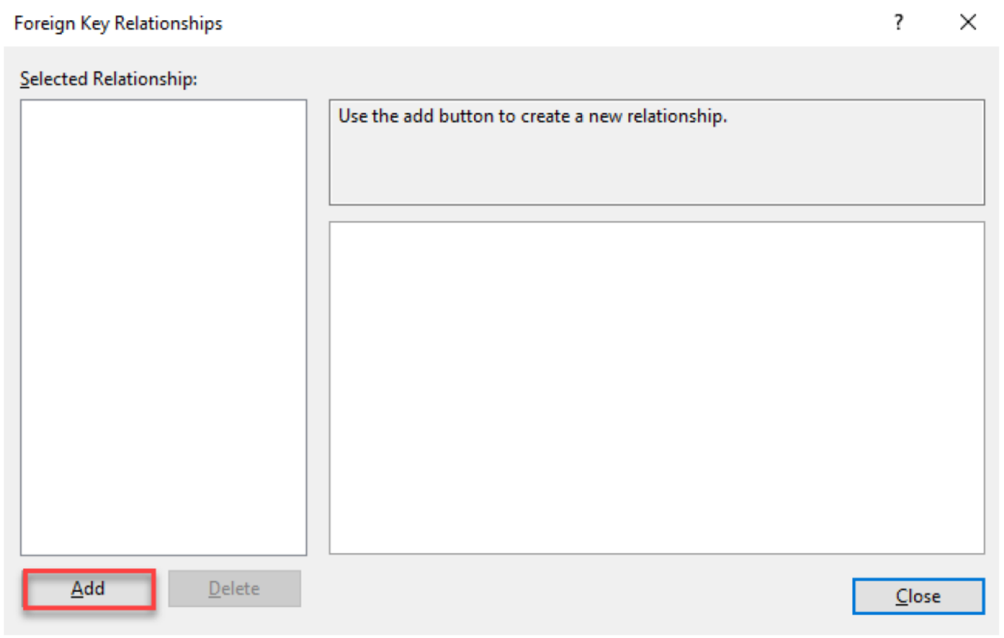
DATABASE GENERATION USING SSMS

You will now need to establish the foreign key constraints within the **Movies** database. All of the foreign key constraints need to be applied to the **Movies** table. Right-click on an area within the Microsoft SSMS Designer window containing the **Movies** table structure and select the **Relationships** option in the right-click menu.



DATABASE GENERATION USING SSMS

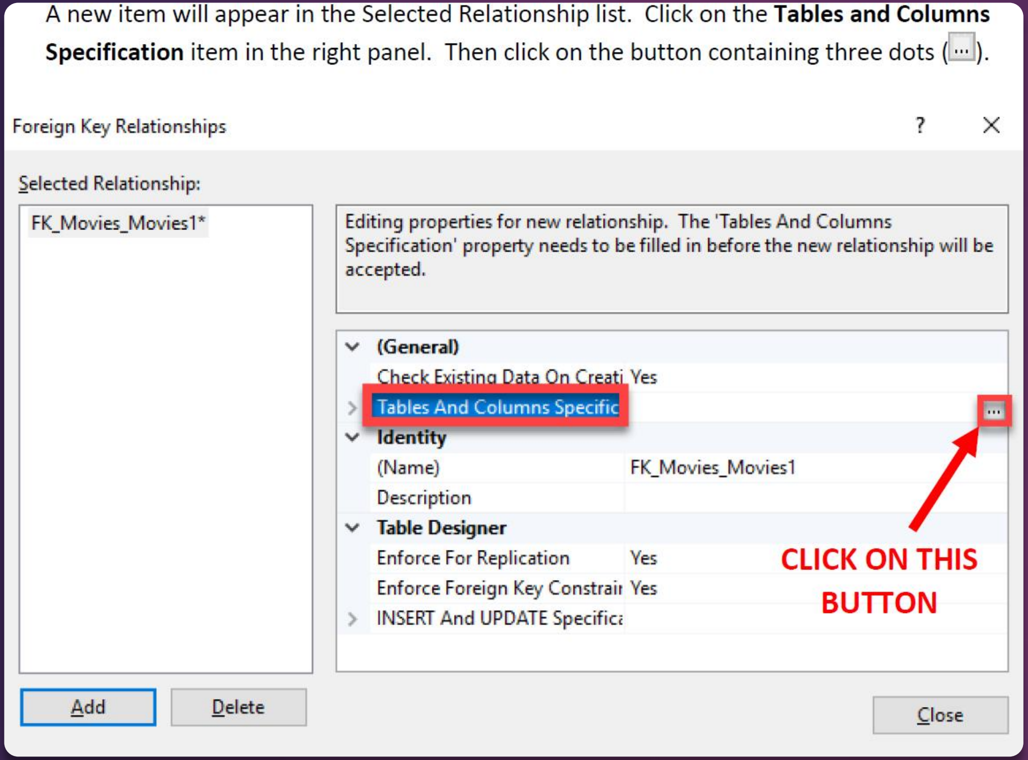
The **Foreign Key Relationships** window will appear. Click on the **ADD** button.


Foreign Key Relationships

Selected Relationship:

Use the add button to create a new relationship.

DATABASE GENERATION USING SSMS



A new item will appear in the Selected Relationship list. Click on the **Tables and Columns Specification** item in the right panel. Then click on the button containing three dots (...).

Foreign Key Relationships

Selected Relationship:

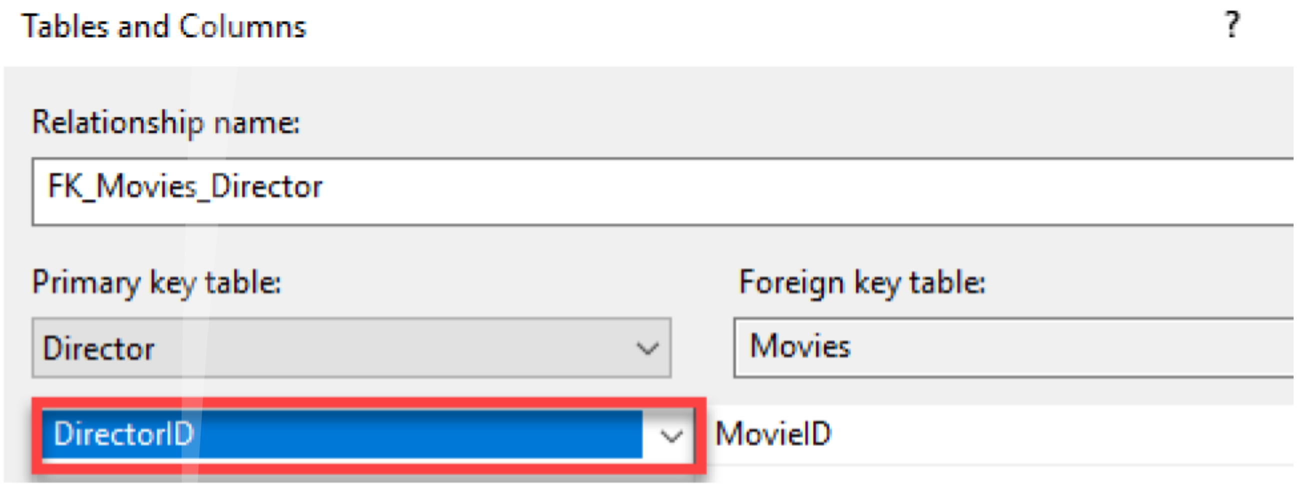
FK_Movies_Movies1*

Editing properties for new relationship. The 'Tables And Columns Specification' property needs to be filled in before the new relationship will be accepted.

(General)	
Check Existing Data On Creati	Yes
Tables And Columns Specific	...
Identity	
(Name)	FK_Movies_Movies1
Description	
Table Designer	
Enforce For Replication	Yes
Enforce Foreign Key Constrai	Yes
INSERT And UPDATE Specific	

DATABASE GENERATION USING SSMS

Click on the ***Primary Key Table*** attribute drop-down box and select **DirectorID**.



Tables and Columns

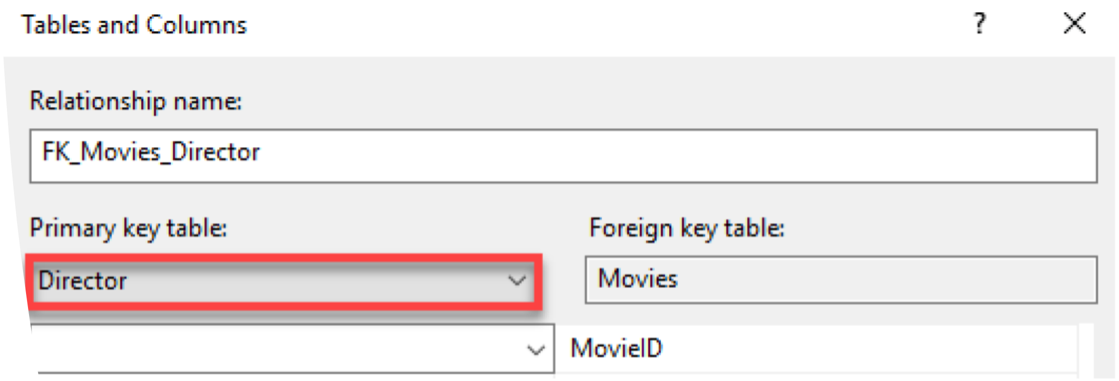
Relationship name: FK_Movies_Director

Primary key table: Director

Foreign key table: Movies

DirectorID	MovieID

The **Tables and Columns** window will appear. Change the ***Primary Key Table*** entry to **Director**.



Tables and Columns

Relationship name: FK_Movies_Director

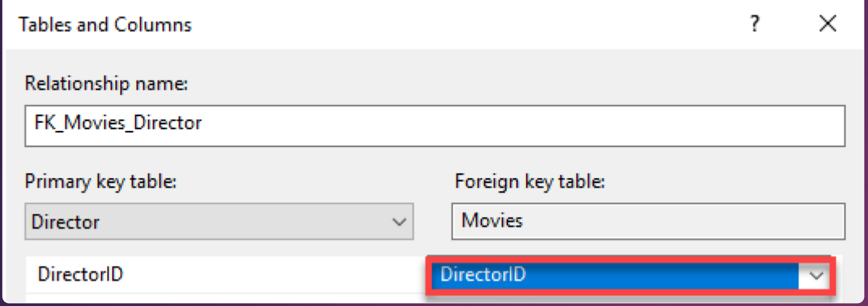
Primary key table: Director

Foreign key table: Movies

	MovieID

DATABASE GENERATION USING SSMS

Click on the ***Foreign Key Table*** attribute drop-down box and select **DirectorID**.



Tables and Columns

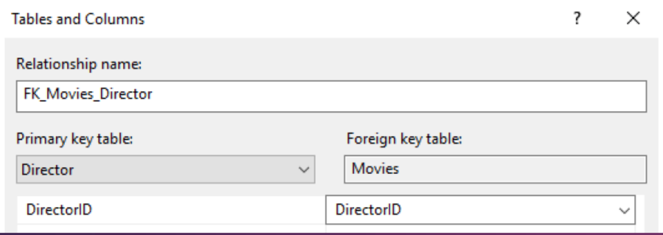
Relationship name: FK_Movies_Director

Primary key table: Director

Foreign key table: Movies

Director	Movies
DirectorID	DirectorID

Click on the **OK** button to establish the foreign key to primary key relationship between the **Movies** and **Director** tables.



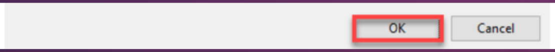
Tables and Columns

Relationship name: FK_Movies_Director

Primary key table: Director

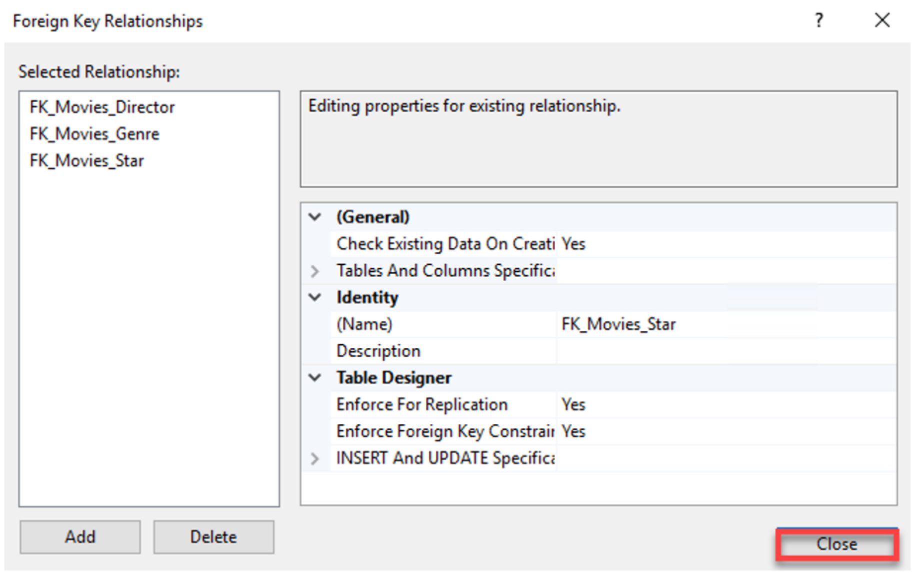
Foreign key table: Movies

Director	Movies
DirectorID	DirectorID



DATABASE GENERATION USING SSMS

Repeat the foreign key creation steps to establish the foreign key to primary key relationships between the remaining tables. Use the database design diagram provided with the unit assignment to denote the remaining relationships. When finished, click on the **CLOSE** button in the **Foreign Key Relationships** window.

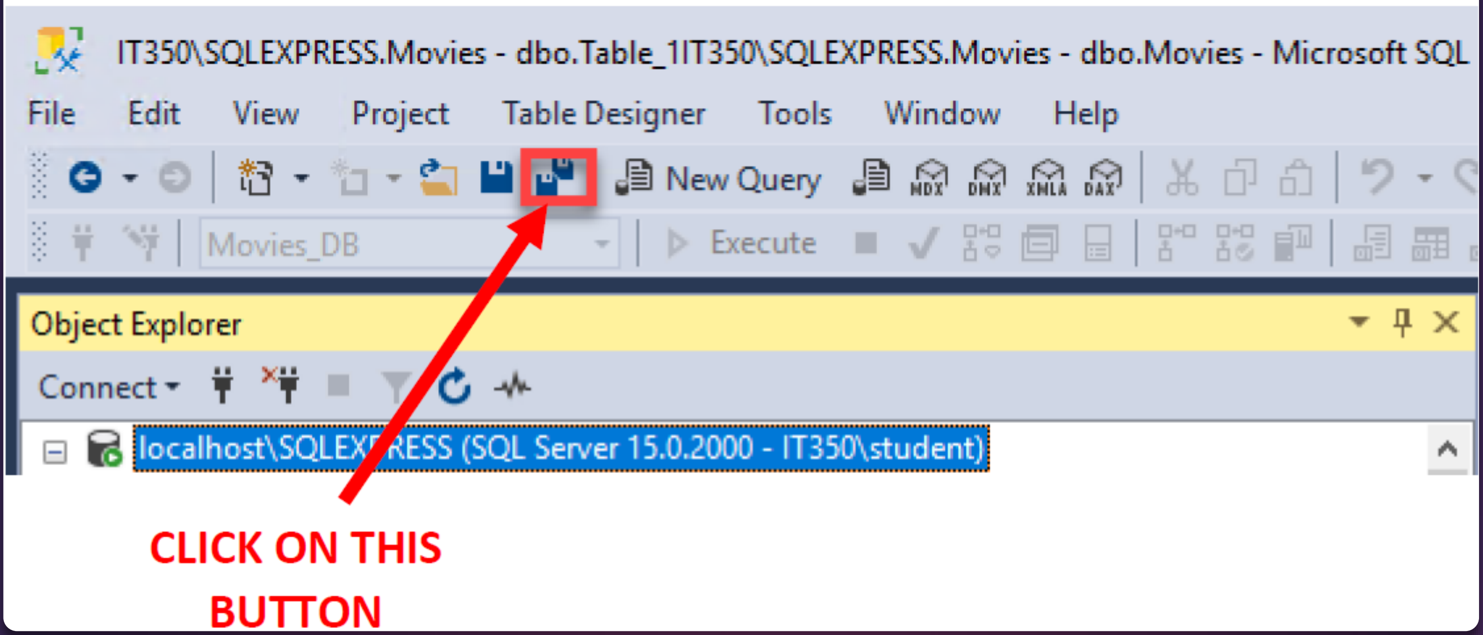


FK_Movies_Director
FK_Movies_Genre
FK_Movies_Star

Editing properties for existing relationship.

(General)	
Check Existing Data On Creati	Yes
Tables And Columns Specifica	
Identity	
(Name)	FK_Movies_Star
Description	
Table Designer	
Enforce For Replication	Yes
Enforce Foreign Key Constrair	Yes
INSERT And UPDATE Specifica	

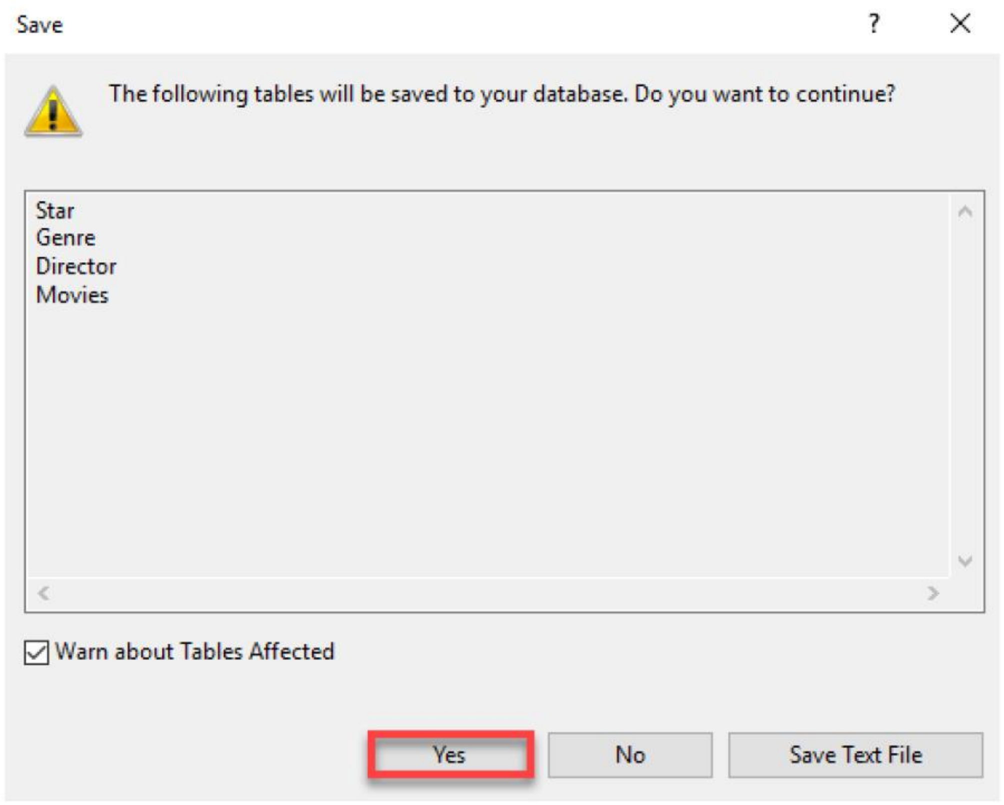
Click on the **Save All** (💾) button in the top menu bar of Microsoft SSMS.


IT350\SQLEXPRESS.Movies - dbo.Table_1IT350\SQLEXPRESS.Movies - dbo.Movies - Microsoft SQL
File
Edit
View
Project
Table Designer
Tools
Window
Help
New Query
MDX
DMX
XMLA
DAX
Movies_DB
Execute
Object Explorer
Connect
localhost\SQLEXPRESS (SQL Server 15.0.2000 - IT350\student)
CLICK ON THIS BUTTON

DATABASE GENERATION USING SSMS

DATABASE GENERATION USING SSMS

The **Save** prompt will appear. Click on the **Yes** button.

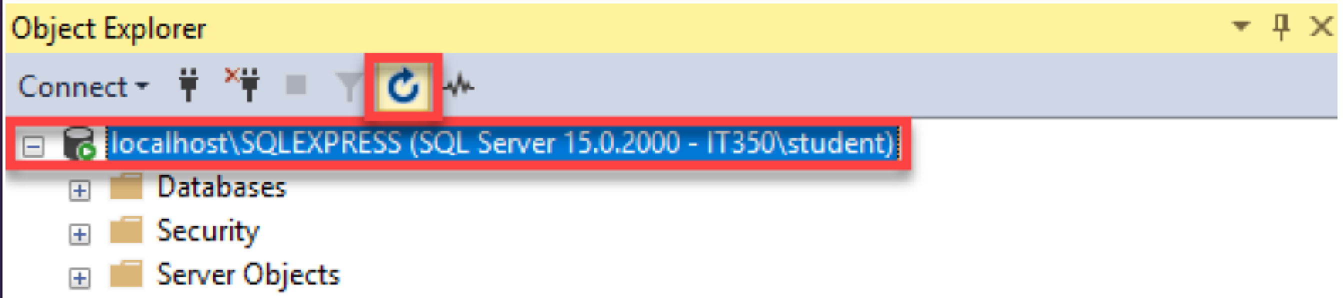

Save

The following tables will be saved to your database. Do you want to continue?

Star
Genre
Director
Movies

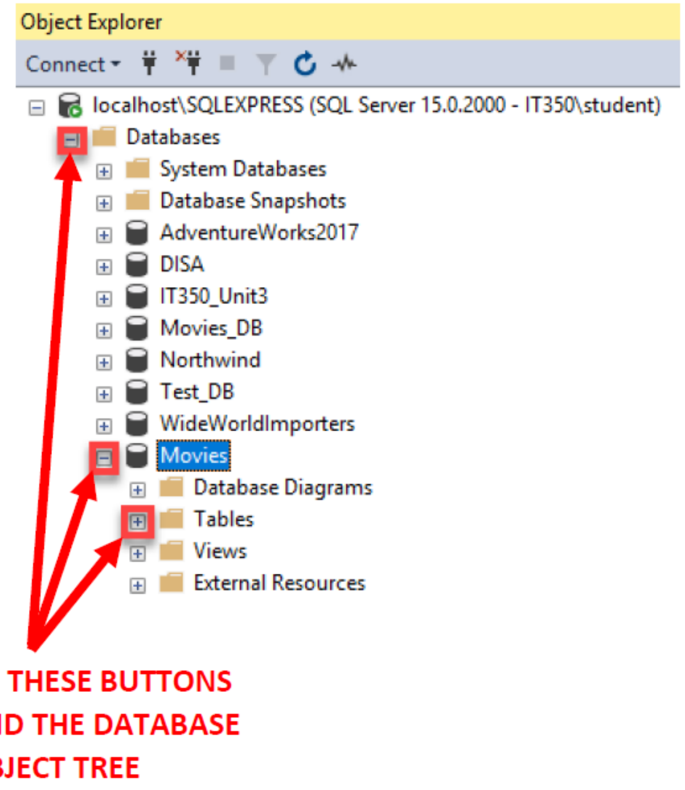
☑ Warn about Tables Affected

In the Object Explorer panel, select the server instance item at the very top of the object tree. Then click on the refresh button (↻) to refresh the list of database objects.



DATABASE GENERATION USING SSMS

In the Object Explorer panel, expand the list of tables by clicking on the ⊞ buttons next to the **Databases**, **Movies**, and **Tables** items.

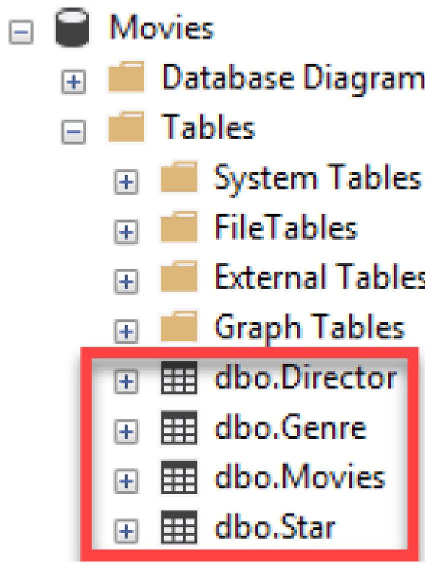


CLICK ON THESE BUTTONS TO EXPAND THE DATABASE OBJECT TREE

DATABASE GENERATION USING SSMS

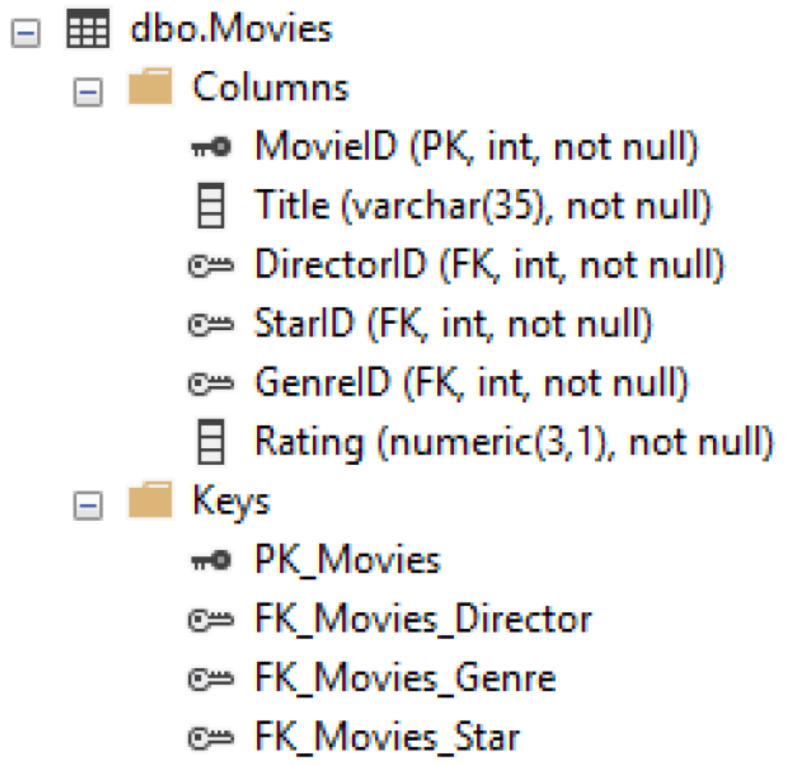
DATABASE GENERATION USING SSMS

The list of tables created should now appear under the **Tables** item in the Object Explorer tree.



DATABASE GENERATION USING SSMS

You can verify the establishment of foreign and primary key constraints by navigating further into the Object Explorer tree.



```
dbo.Movies
  Columns
    MovieID (PK, int, not null)
    Title (varchar(35), not null)
    DirectorID (FK, int, not null)
    StarID (FK, int, not null)
    GenreID (FK, int, not null)
    Rating (numeric(3,1), not null)
  Keys
    PK_Movies
    FK_Movies_Director
    FK_Movies_Genre
    FK_Movies_Star
```