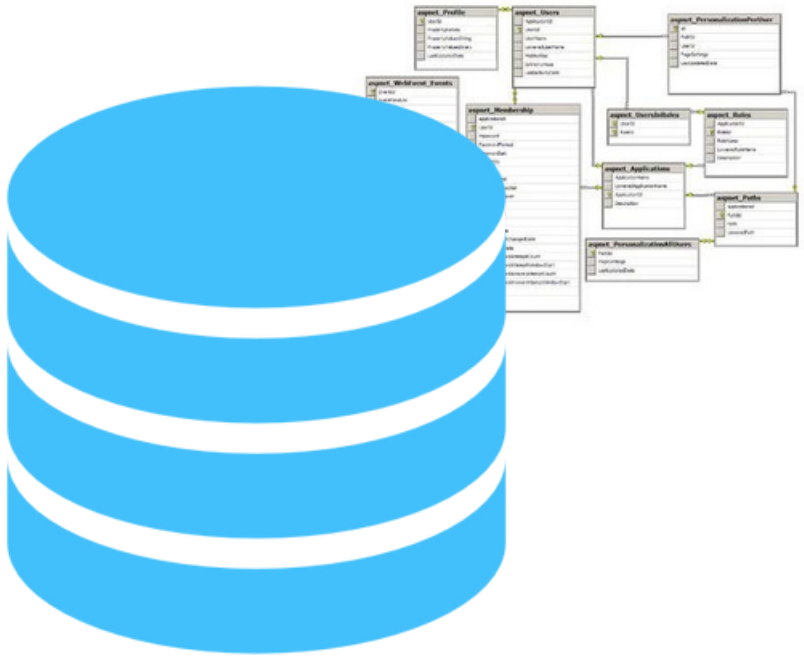


Introduction to SQL Server Database Administration

Agenda

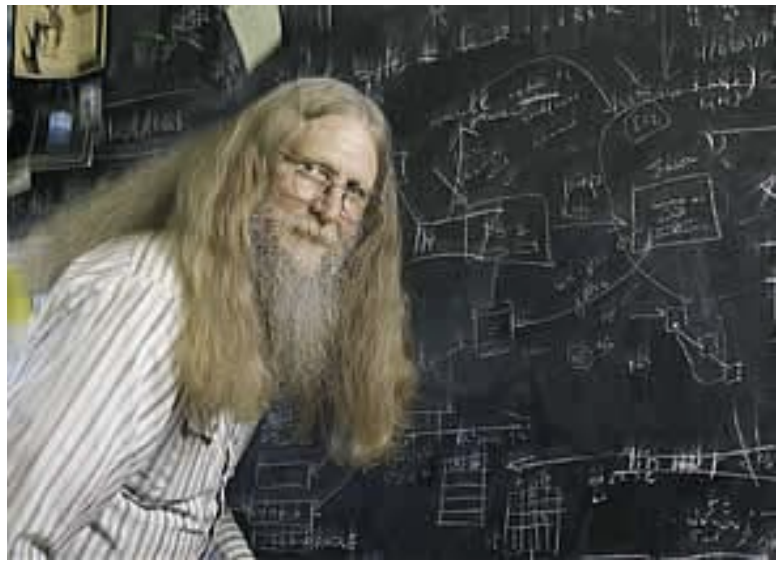
- Exactly what is a DBMS?
- Security Management
- Introducing SQL Server Manager System (SSMS)
- Administrative Tasks

oAdding a new user
oChanging a password
○ Re-enabling a locked out account
oGranting/Denying Access to a DB
○Granting/Denying Access to a Tableo
oCreating a New Database
○ Deleting a Database

oCreating a Table
oQuick Tutorial on Data Types
○ Deleting a Table
oSetting the Primary Key
Backing Up the Database
oRestoring a Full Backup
○ Database Indexes Tutorial
○ Data Encryption

Buckle Your Seatbelt

We have a lot to cover in a relatively short timeframe



“Relational databases form the bedrock of western civilization”

A Little Vocabulary

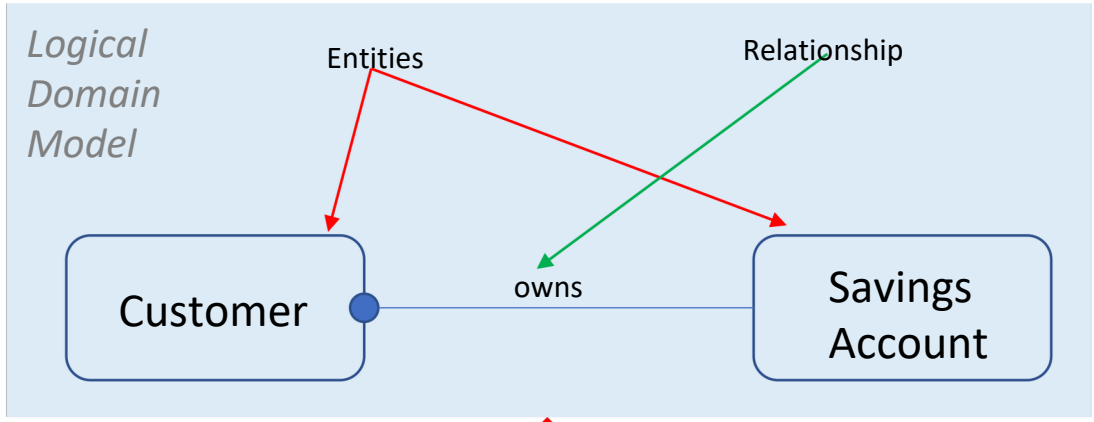
Schema:
an underlying organizational pattern or structure; conceptual framework

- In a database, a schema is a description of a particular collection of data, using the given data model
- For SQL Server, the data model is the *relational model*

What Makes Up A Relational Database (RDB)?

An RDB:

- Is a collection of data tables Some
- tables model entities Some tables
- model relationships They capture a
- *relational*model of the problem domain



equivalent models

primary key

Customer

CNum	Name
123	John Smith
561	Jo Williams
497	Sally Smith

foreign key foreign key

Owns

CNum	SNum
123	991
561	1033
497	567

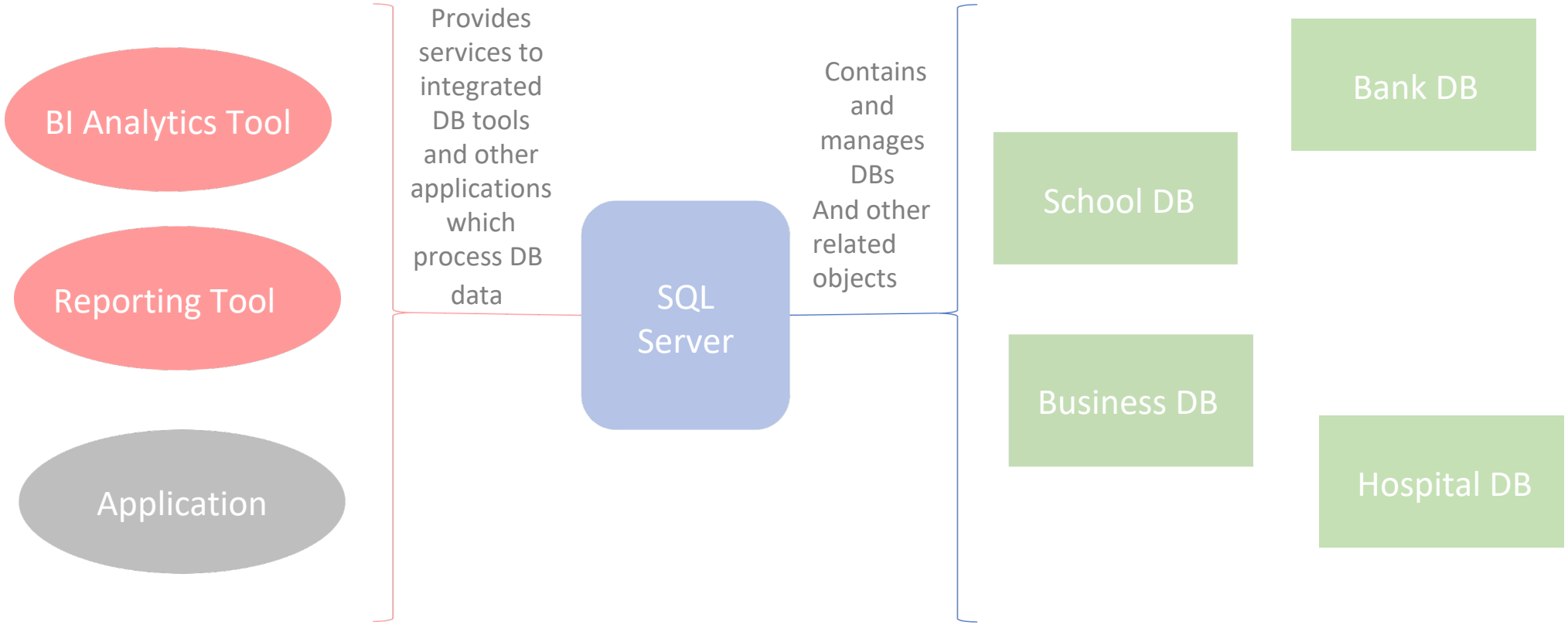
primary key

Savings Account

SNum	Amount
991	104.56
1033	5601.23
567	908.77

Relational Domain Model

What is a Database Management System?



A *Database Management System (DBMS)* like SQL Server is a piece of software designed to store and manage multiple RDBs

What exactly does a DBMS manage?

- Basic responsibilities of a DBMS:
  - Processes queries to provide structure access to data in DBs
  - Enforces secured access to tables and other DB objects
  - Provides the ability to create stored procedures, functions, and triggers
  - Creates and maintains indices on columns
  - Backs up and recovers the DBs
  - Imports and exports data
  - Creates and maintains DBs, schemas, indices, and other metadata
  - Logs event information
  - And *much more*

Some of the *"Much More"*

- Tools for performance analysis, tuning, report generation, and trouble shooting
- The ability deploy high availability configurations of the DBs
- The ability to do data mirroring
- Integration with reporting, BI, and analytic tools
- Integration of R procedures into DB stored procedures
- The ability to cluster multiple DBMSs
- *And*still more depending on the version and brand of the DBMS

Since this is a basic course in SQL Server, these topics are not covered.

Security Management: User, Groups, and Rights

- Access to data in table/columns is controlled by the security model
- The model is based on three kinds of entities:
  - Users / Logins
  - Rights / Privileges
  - Groups/Roles
- The diagram below lays out the three entities used to manage and enforce DB security:

Group/Role:

- A collection of users
- Can have rights associated with it that users inherit with membership

User/Login:

- Account assigned to an individual*
- A user can belong of one or more
- groups
  Can have rights specifically granted directly to them

Right/Privilege:

- Grant or deny the ability to affect a database object
- (*table, column, index, etc.)*
  The four basic rights are listed below plus “no rights”:
  - Read
  - Write
  - Delete
  - Execute (does not apply to data entities)

*exception to this rule, account assigned to an application

The SA

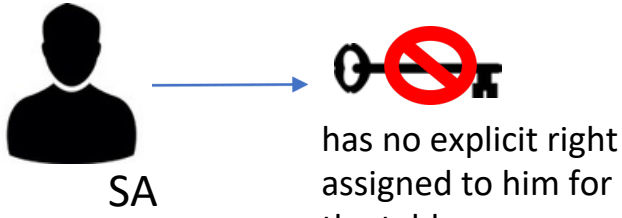
- There is a single user account “SA” (system administrator) which is all powerful in the DBMS
- The SA:
  - effectively “owns” the DBMS
  - has *all* rights to control *all* entities in DBMS
  - and is therefore a very dangerous account (more later)

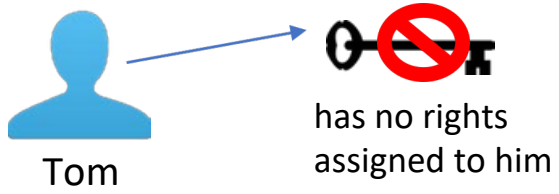
Access Security Example

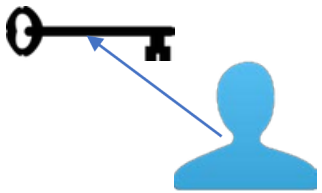
A DB table:

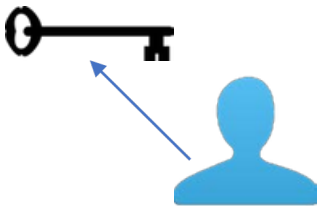
Customer

CNum	Name
123	John Smith
561	Jo Williams
497	Sally Smith









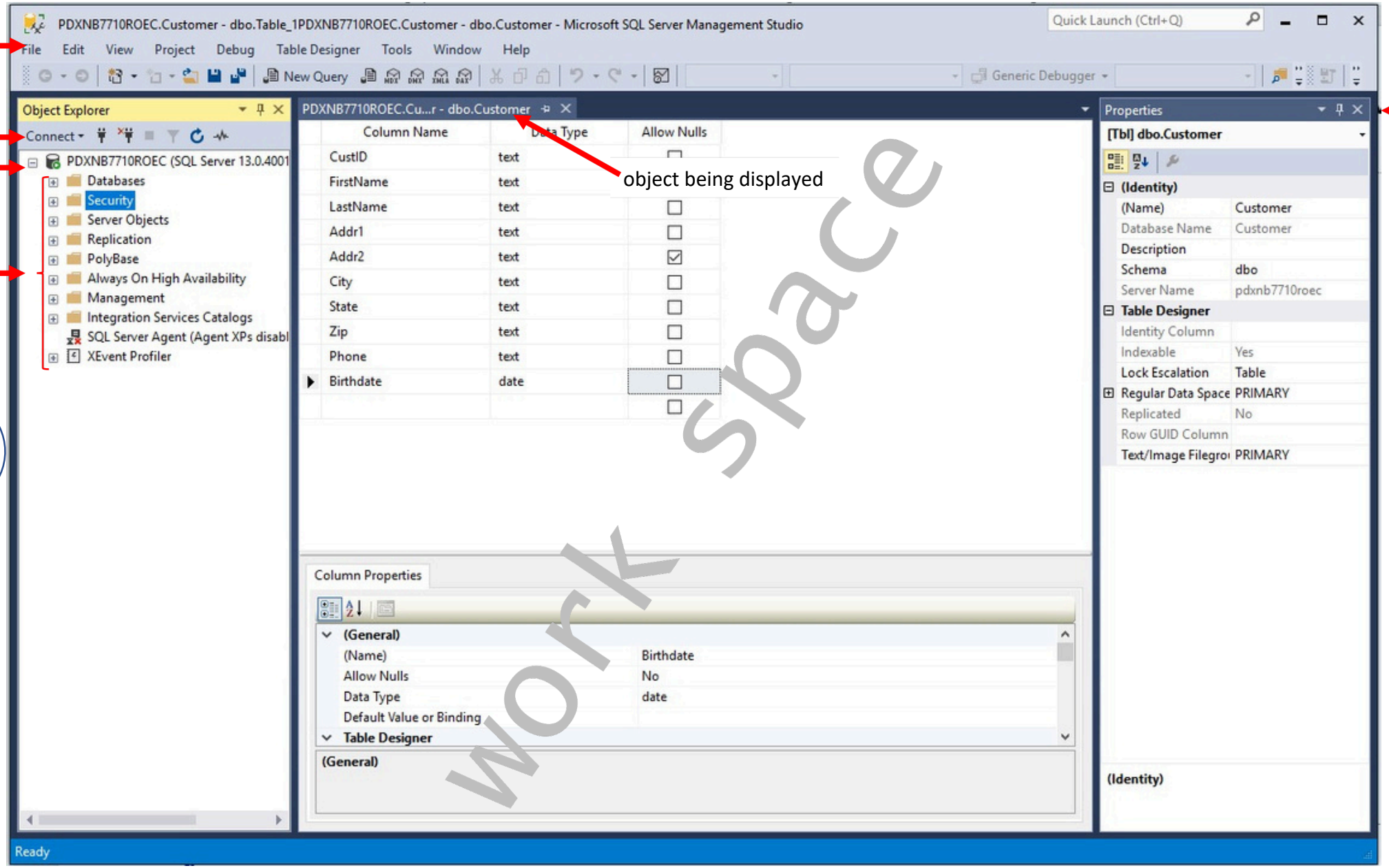
Pop Quiz

Who can write to the table?
Who can delete the table?
Who could query data for a report?

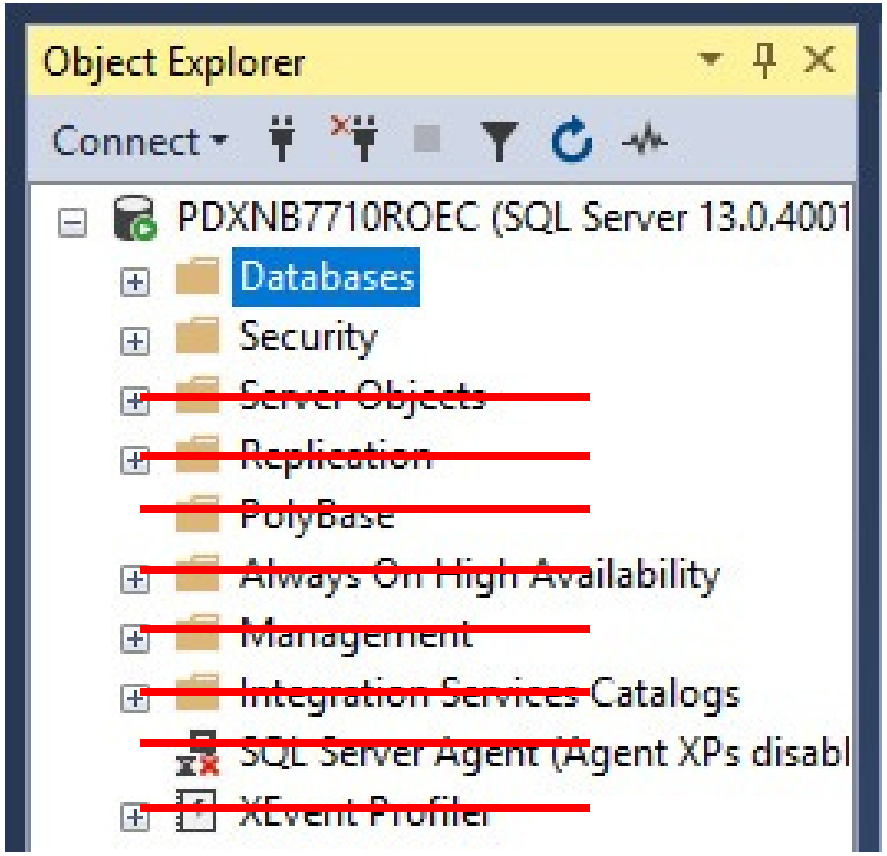
• Some Best Practices for Security

- Beware the SA account!
  - •This account can overwrite or delete *anything*in the DBMS –this includes metadata the DBMS must have to function correctly
  - •We're all human and can make mistakes, mistakes by the SA can destroy the DBMS
  - •So, *DON'T*log into the SA account unless you must be in it to get a task done
  - •And, once you finish the task(s), log out immediately!
- Grant users as few rights as possible --this is preventative medicine to avoid mistakes
- Groups are a good way to assign rights
  - •Groups often map well to organization units (i.e., departments, project teams)
  - •People in the same group often need exactly or mostly the same rights
  - If a group needs to have its rights adjusted you only have to adjust the group not all the users individually –great time saver

SQL Server Management Studio (SSMS) Console



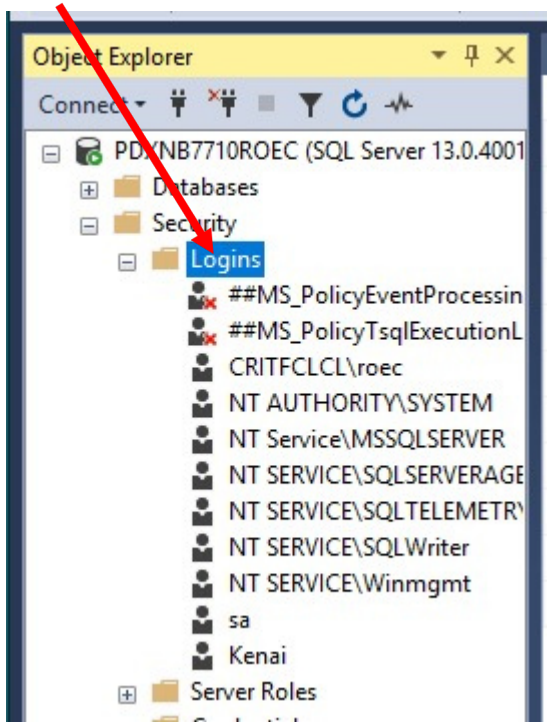
Don't Panic!



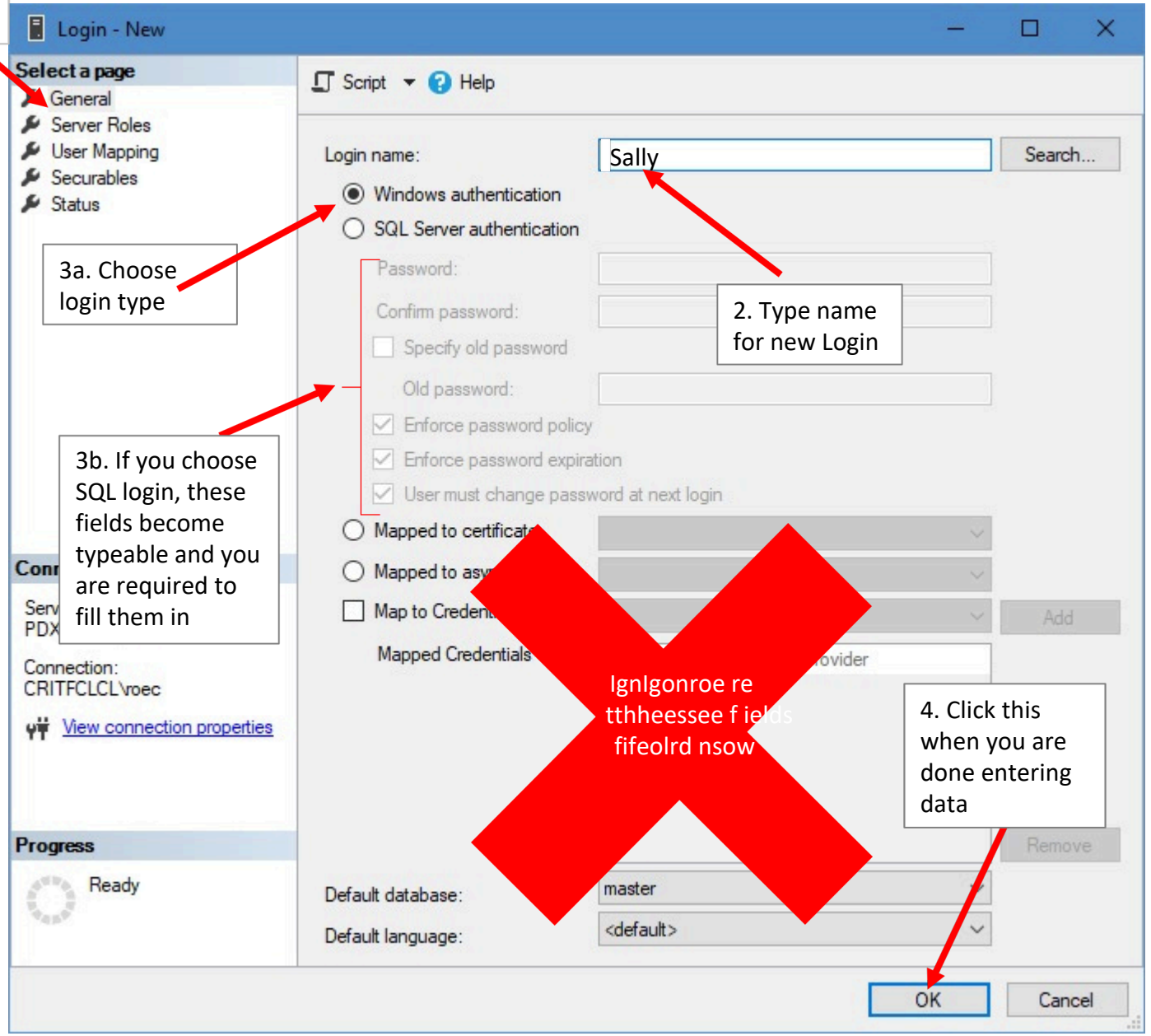
- Since this is a beginning course, we are only going to concentrate on:
  - Databases
  - Security
- For basic applications, these are the only two areas you need to do work in
- Others areas could be part of a more advanced course --maybe next year

Adding a New User (Login)

Dropdown Security and Right click on Logins>New Login from the dropdown menu that appears



1. Click on “General” to get this form



3a. Choose login type

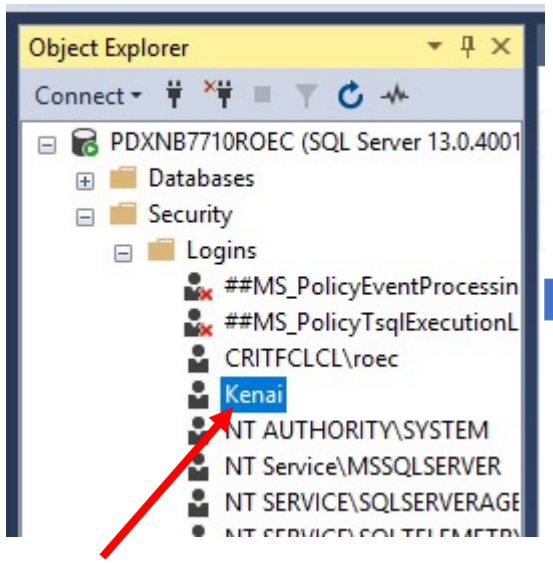
2. Type name for new Login

3b. If you choose SQL login, these fields become typeable and you are required to fill them in

IgnIgonroe re tthheessee f ields fifeolrd nsow

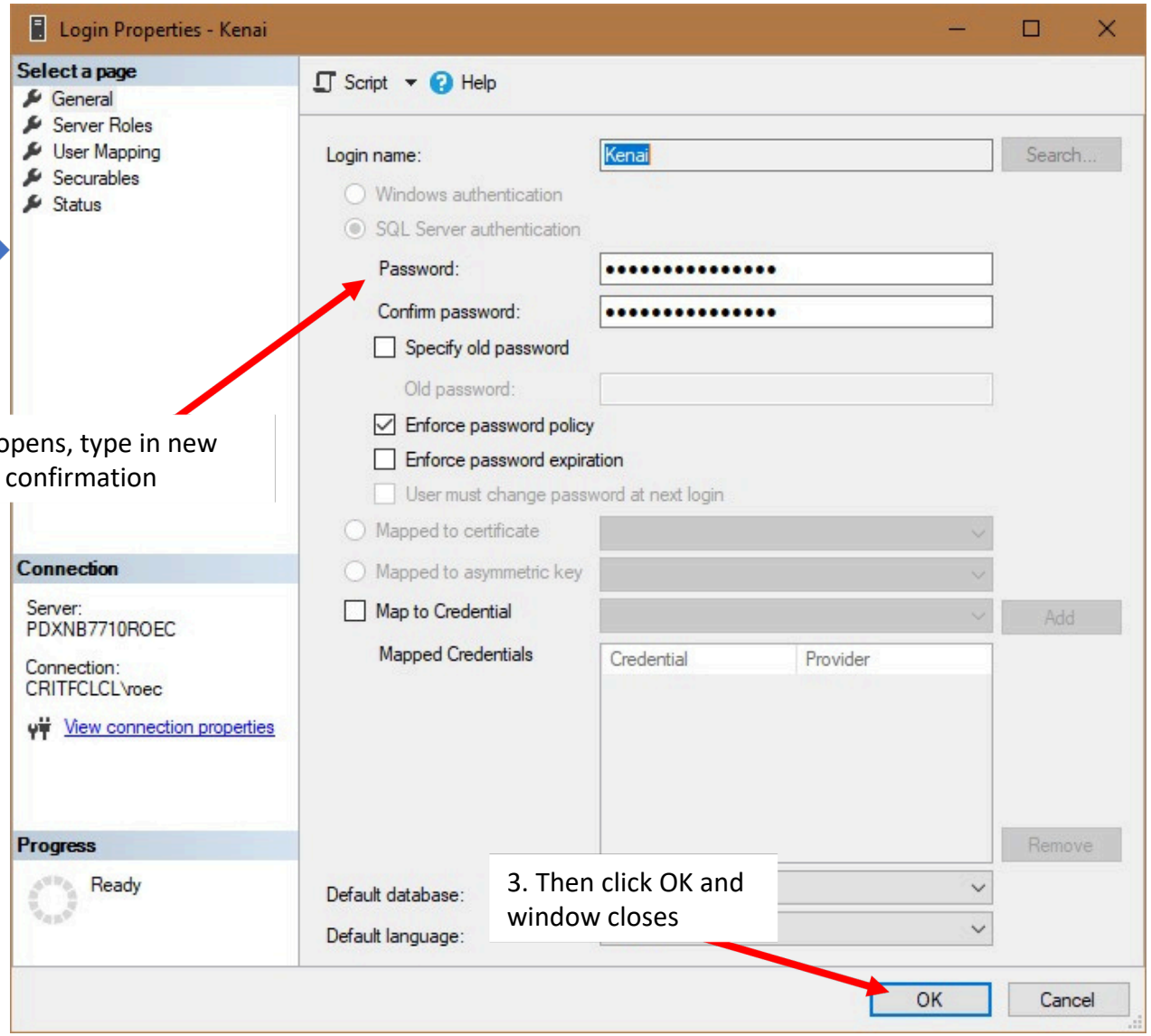
4. Click this when you are done entering data

Changing a Password



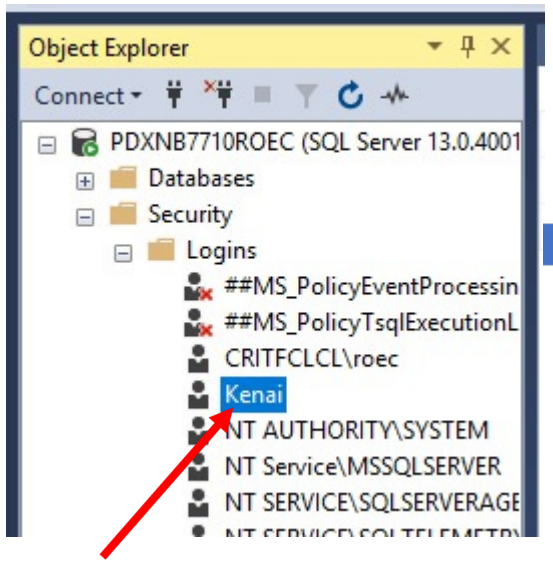
1. Drop down Security->Logins and double click on the account needing to be reset

2. When window opens, type in new password and the confirmation



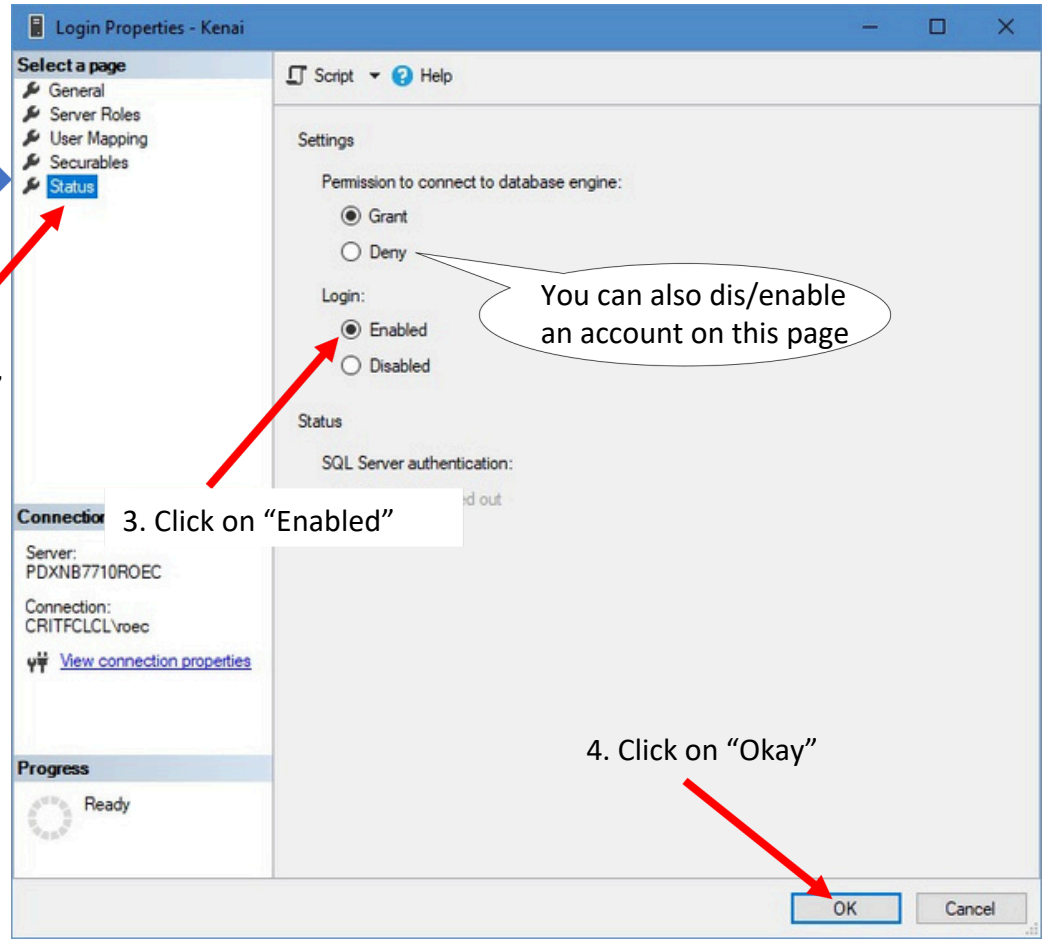
3. Then click OK and window closes

Re-enabling a Locked Out User Account



1. Drop down Security->Logins and double click on the account needing to be reset

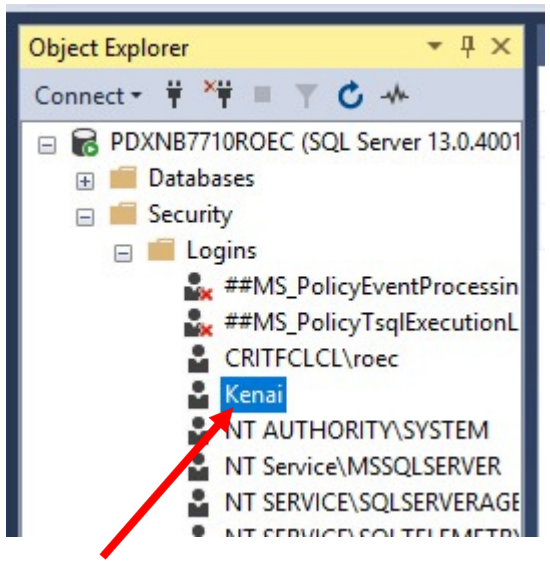
2. Click on “Status”



3. Click on “Enabled”

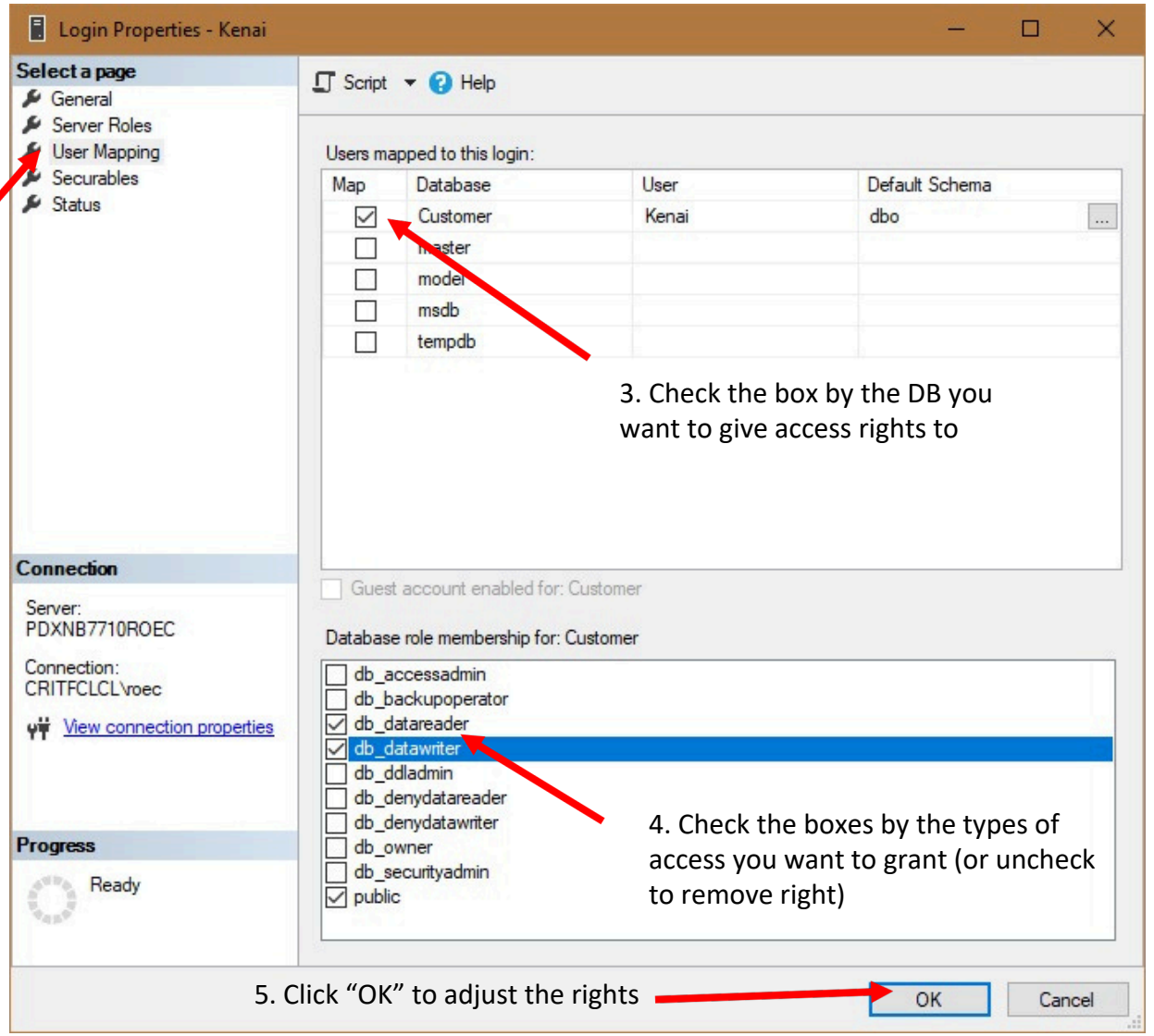
4. Click on “Okay”

Granting/Denying Access to a DB



1. Drop down Security->Logins and double click on the account needing to be reset

2. Click on “User Mapping”

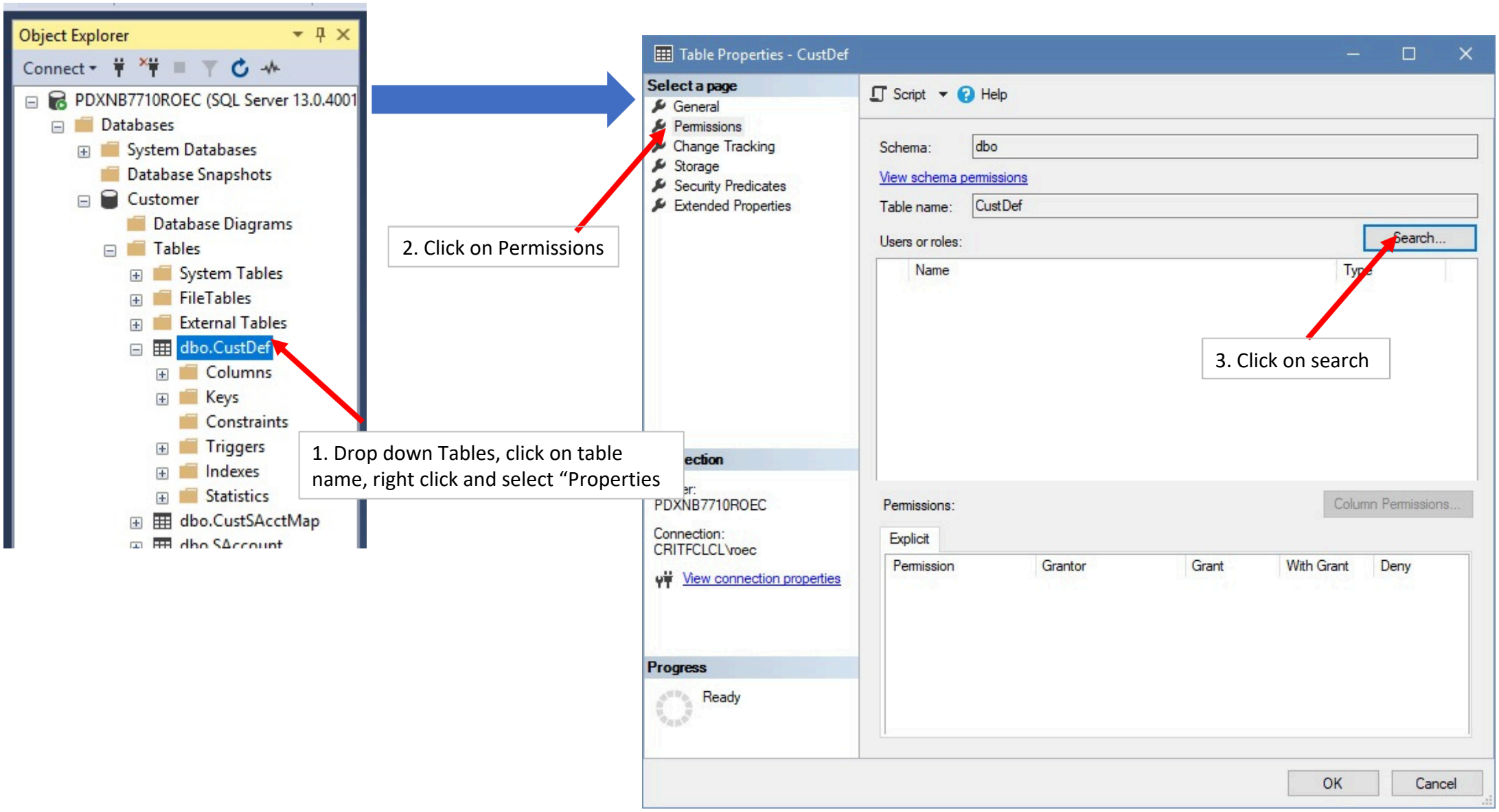


3. Check the box by the DB you want to give access rights to

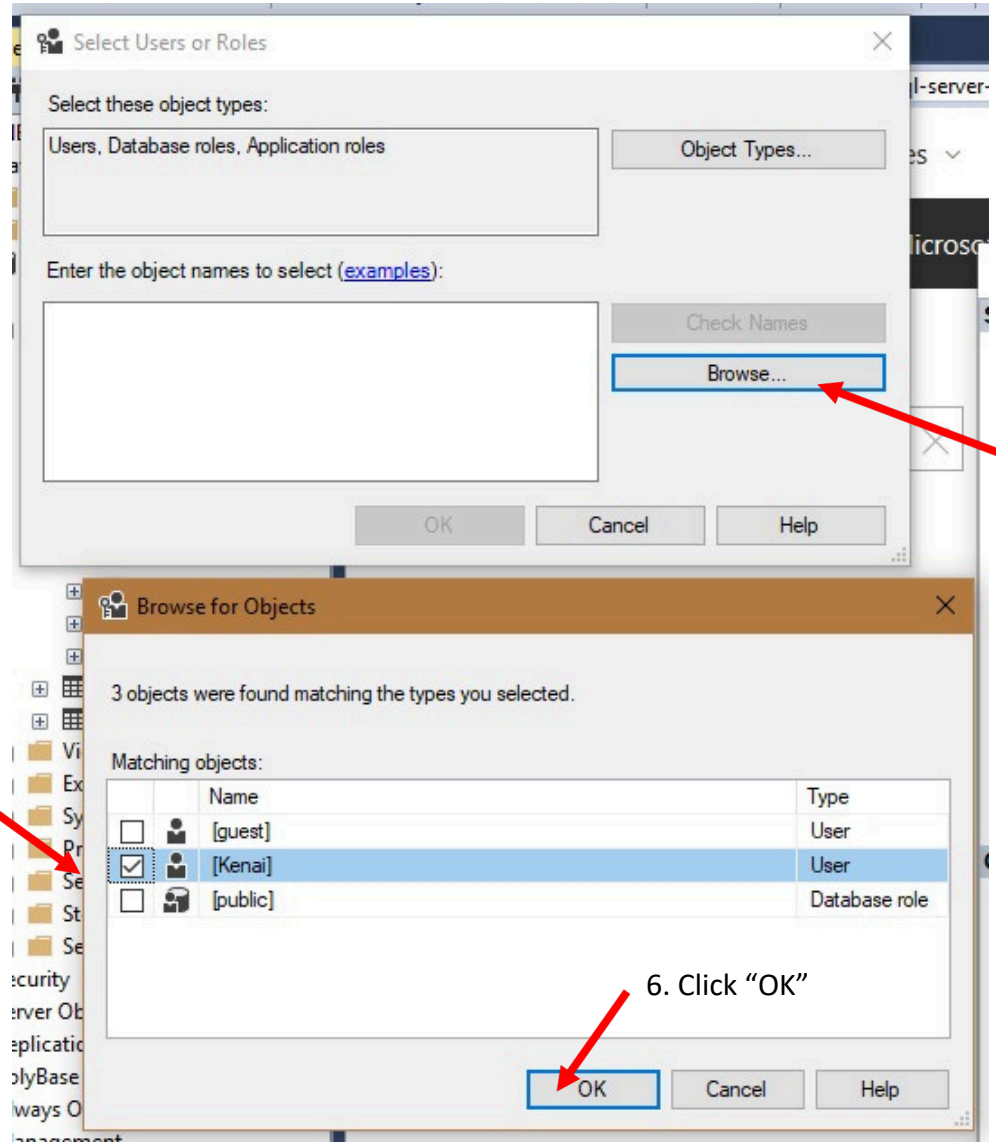
4. Check the boxes by the types of access you want to grant (or uncheck to remove right)

5. Click “OK” to adjust the rights

Granting/Denying Access to a Specific Table



Granting/Denying Access to a Specific Table (cont)

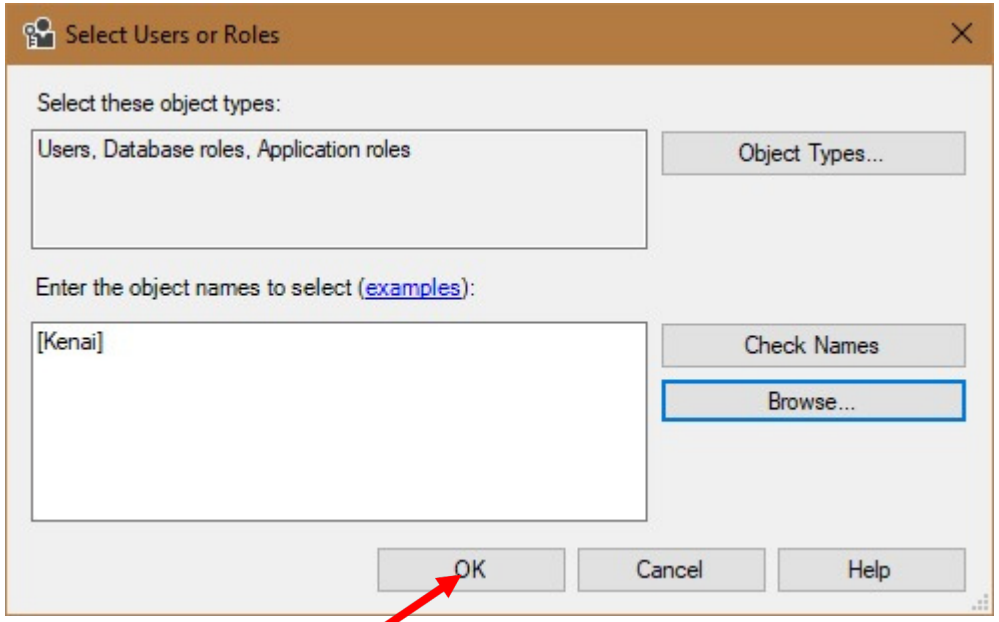


4. Click on browse

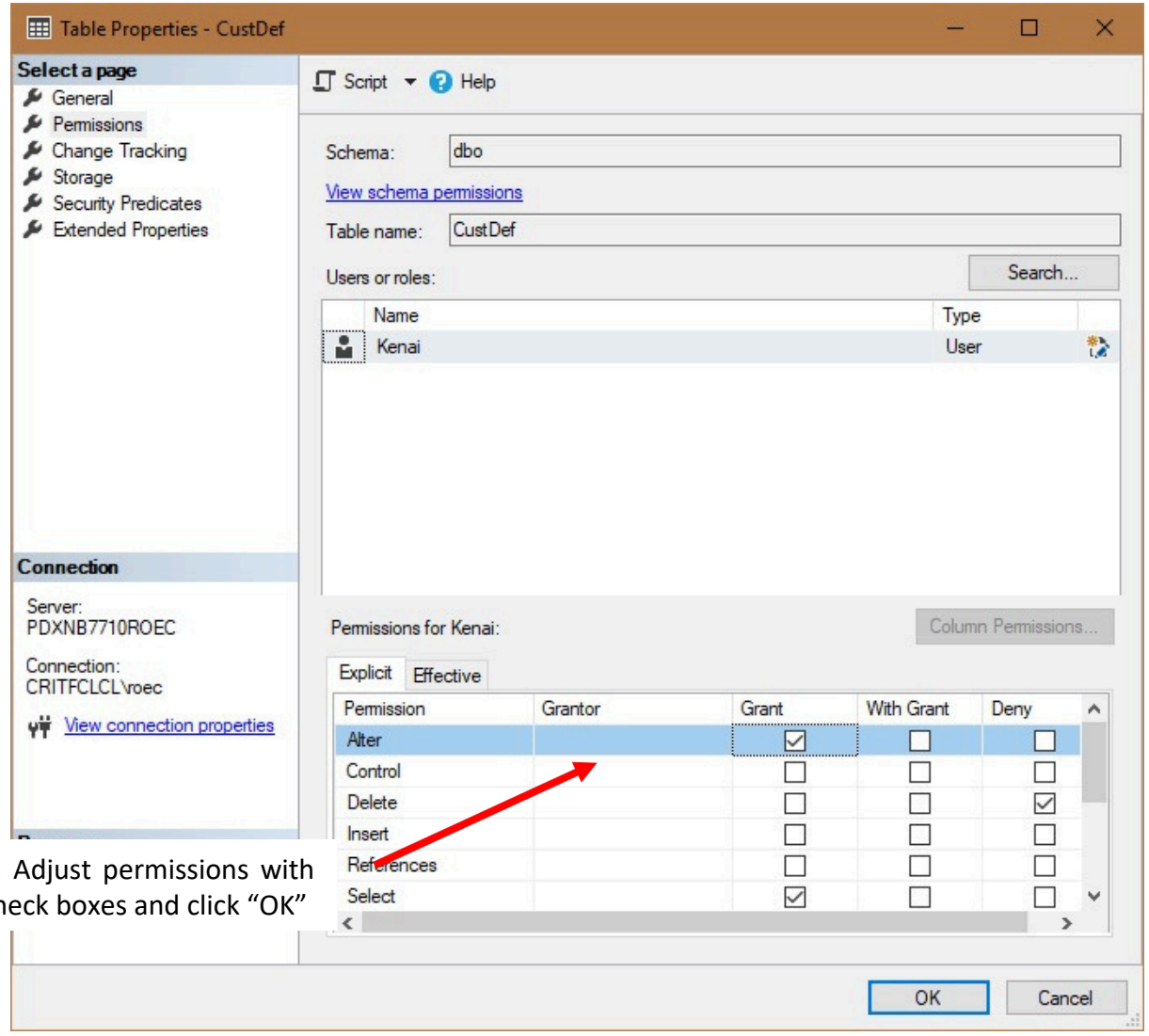
5. Check the box next to user you want to adjust table permissions for

6. Click “OK”

Granting/Denying Access to a Specific Table (cont)



8. Click “OK”



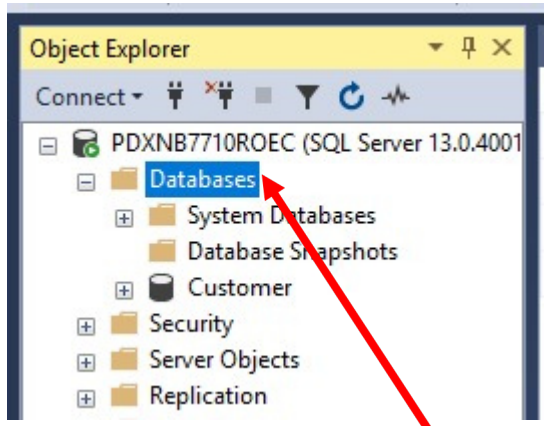
9. Adjust permissions with check boxes and click “OK”

SQL: Grant and Deny

- Security objects can have their characteristics modified directly by using T-SQL
- See commands:
  - GRANT
  - DENY
    - CREATE ROLE
    - ALTER ROLE
    - DELETE ROLE
- Examples can be found in the documentation
- This allows you to write scripts or functions to carry out security adjustments
- See T-SQL reference at: https://docs.microsoft.com/en-us/sql/t-sql/language-reference

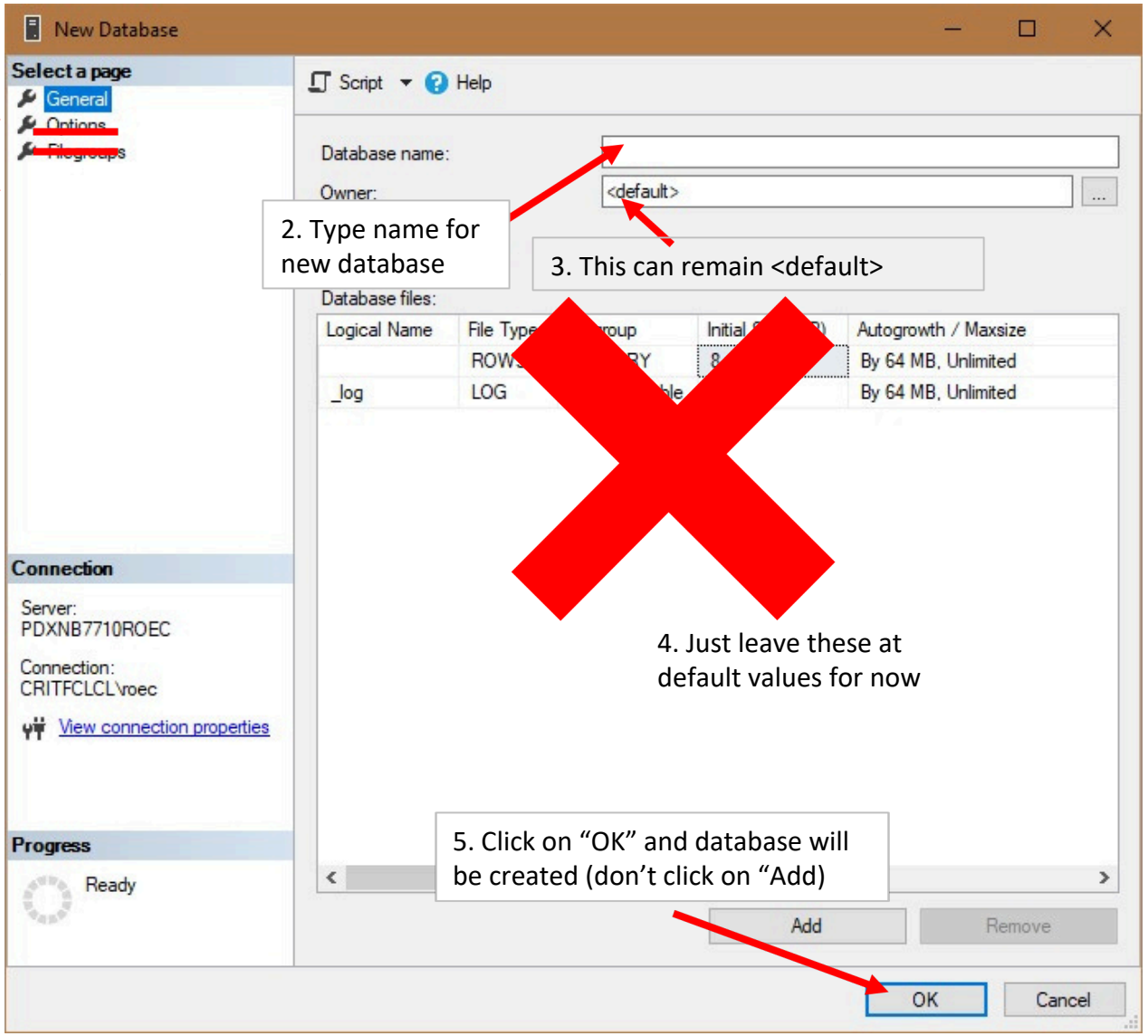
Creating a New Database

Note: you can only create a database if you have been given the right to do so



1. Click on Databases >New Database

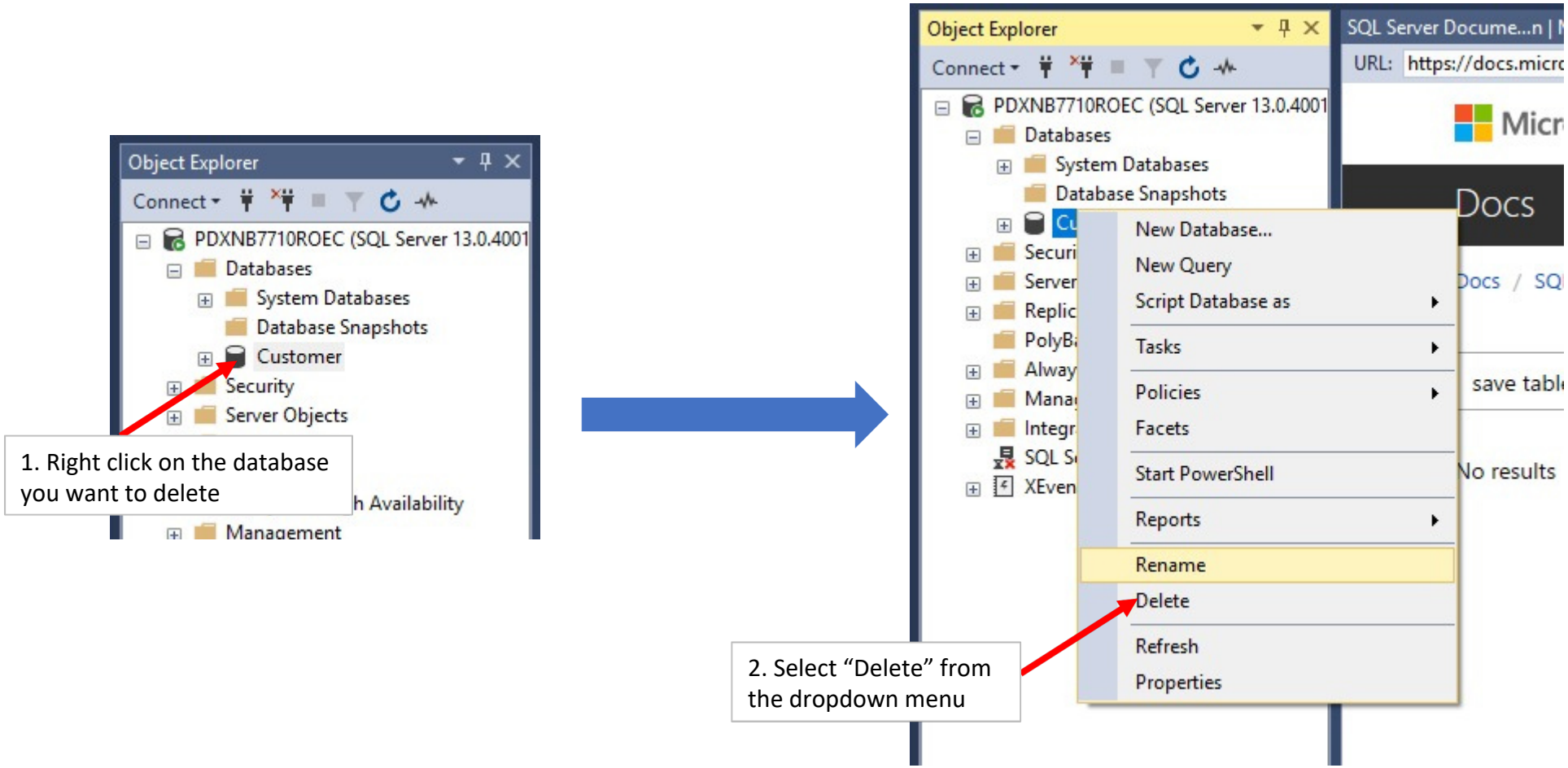
Ignore these two options



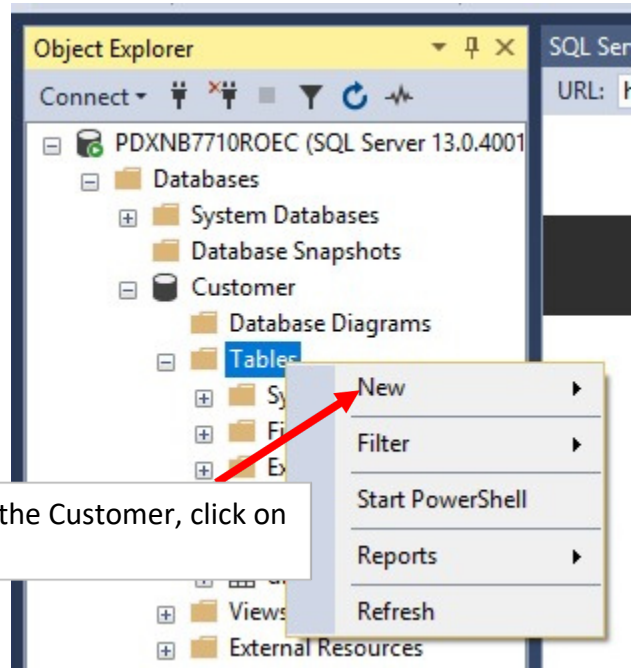
This creates a DB that is essentially an empty container. Columns added in a separate operation

Deleting a Database

Note: you can only delete a database if you have been given the right to do so



Creating a Table



1. Dropdown the Customer, click on Tables>New

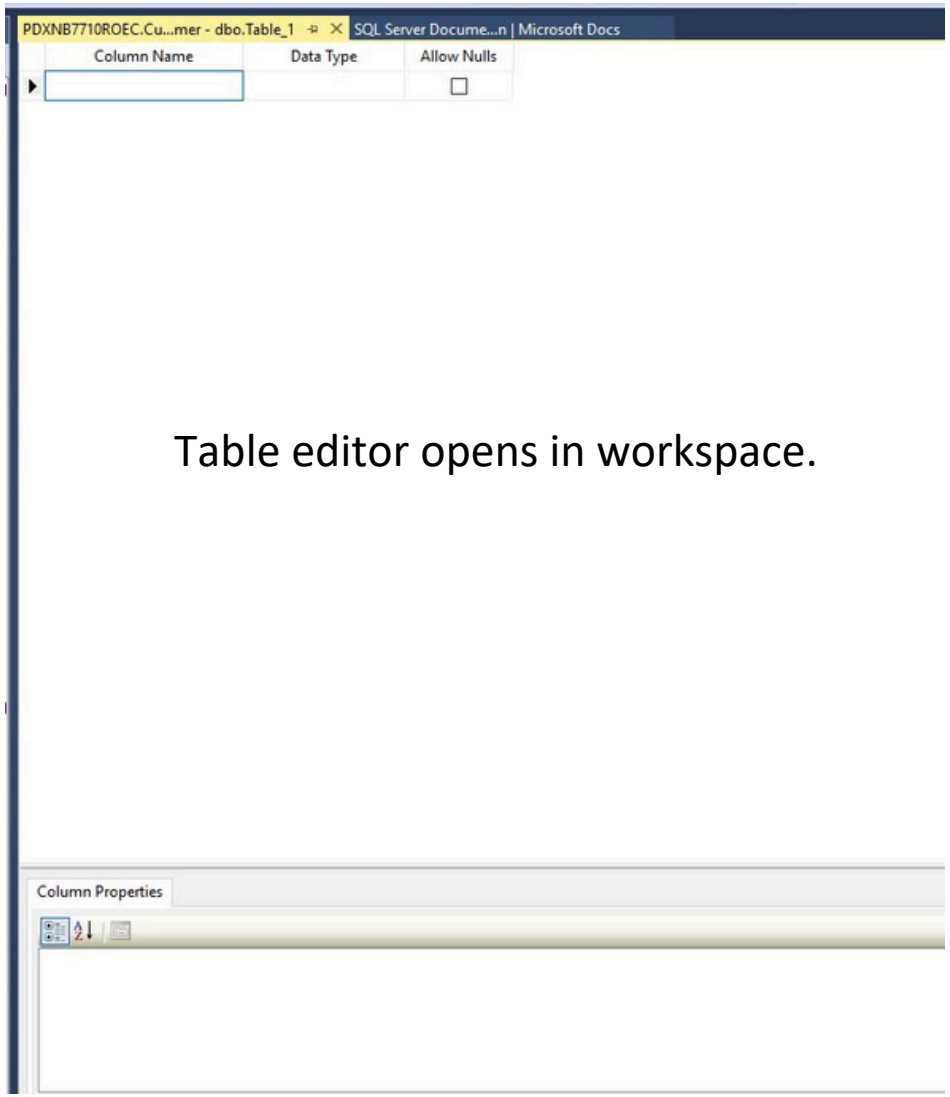
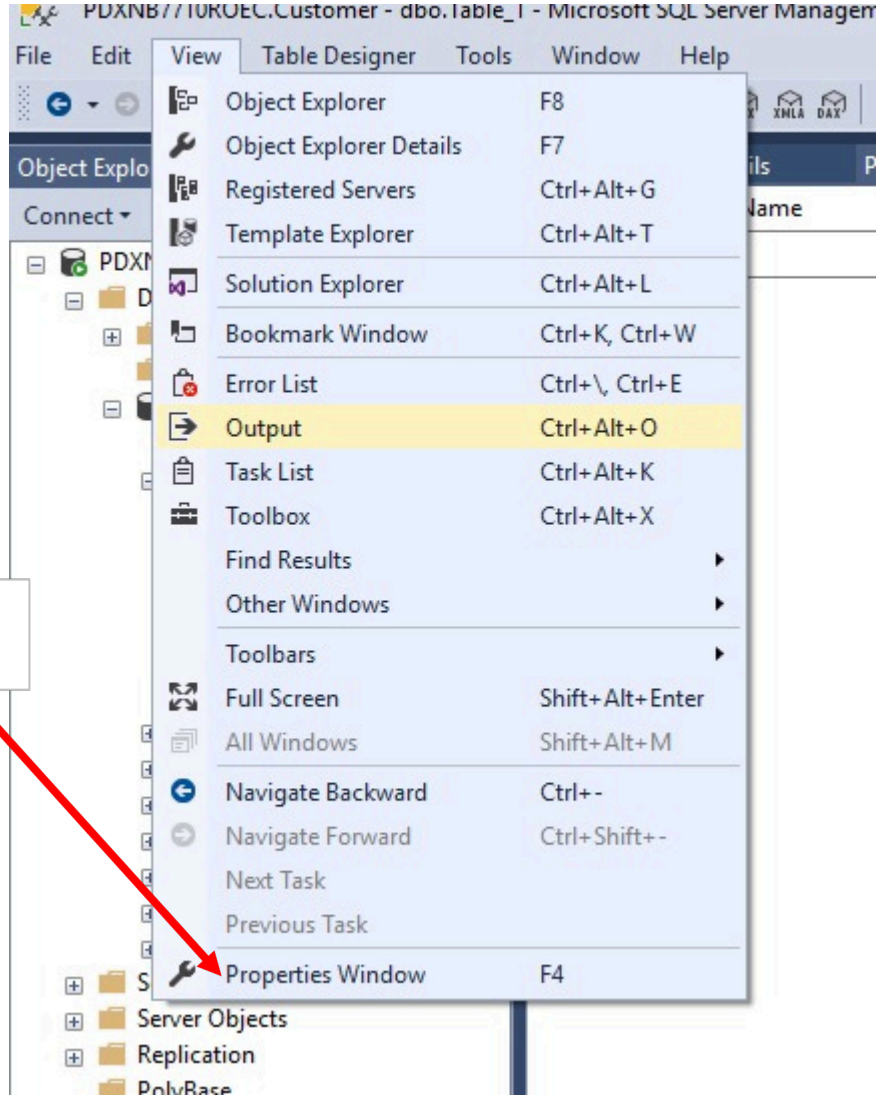
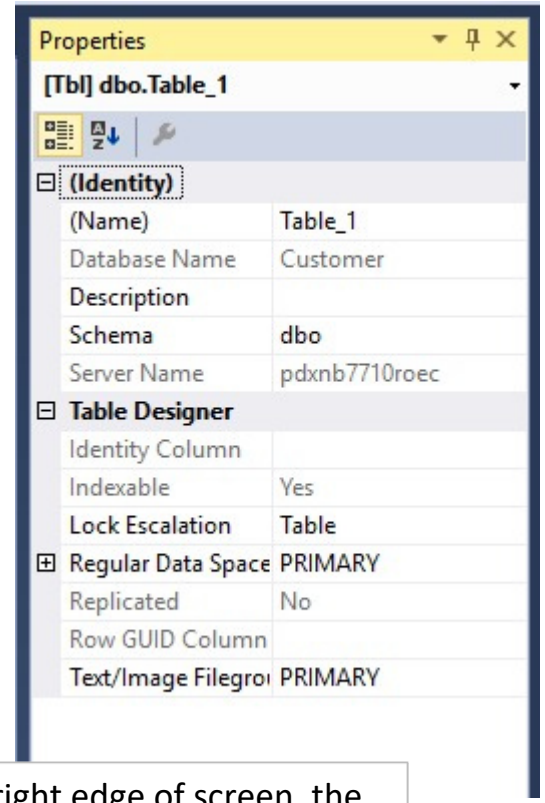


Table editor opens in workspace.

Creating a Table (cont)

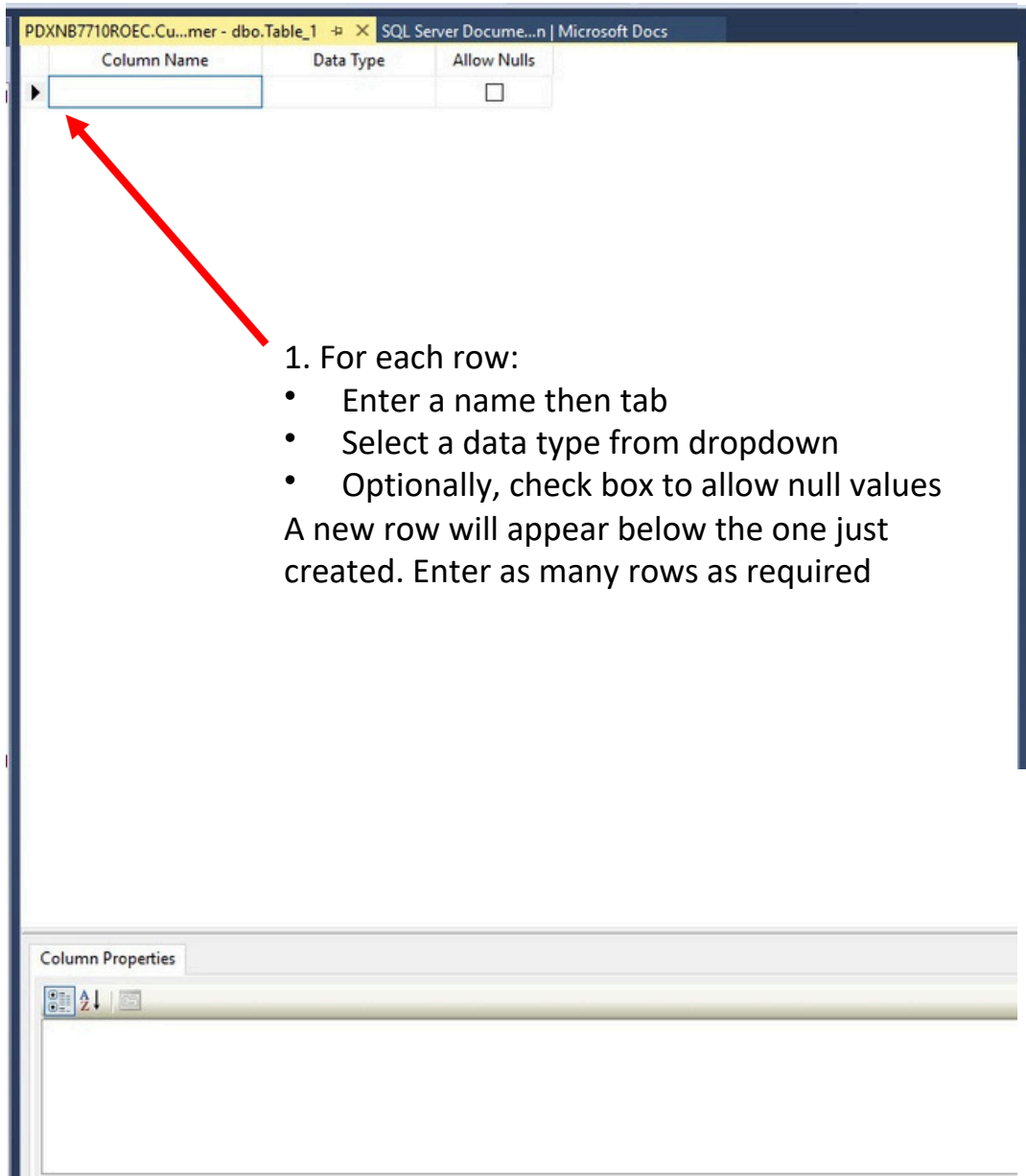


1. On toolbar, click on View>Properties Window



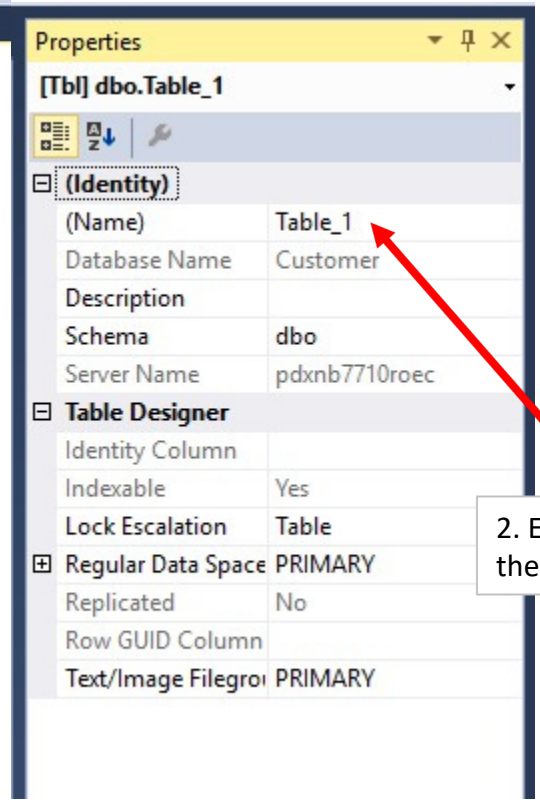
2. On right edge of screen, the Properties window displays and shows properties of new table

Creating a Table (cont)



1. For each row:
- Enter a name then tab
- Select a data type from dropdown
- Optionally, check box to allow null values

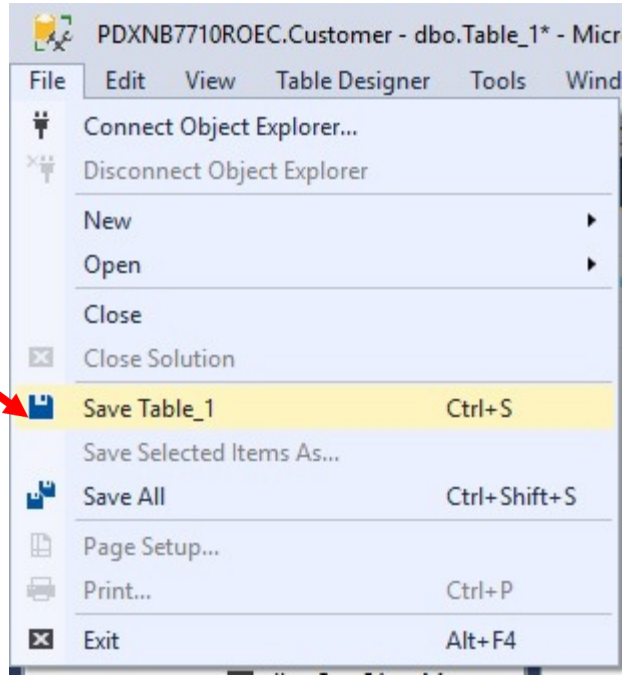
A new row will appear below the one just created. Enter as many rows as required



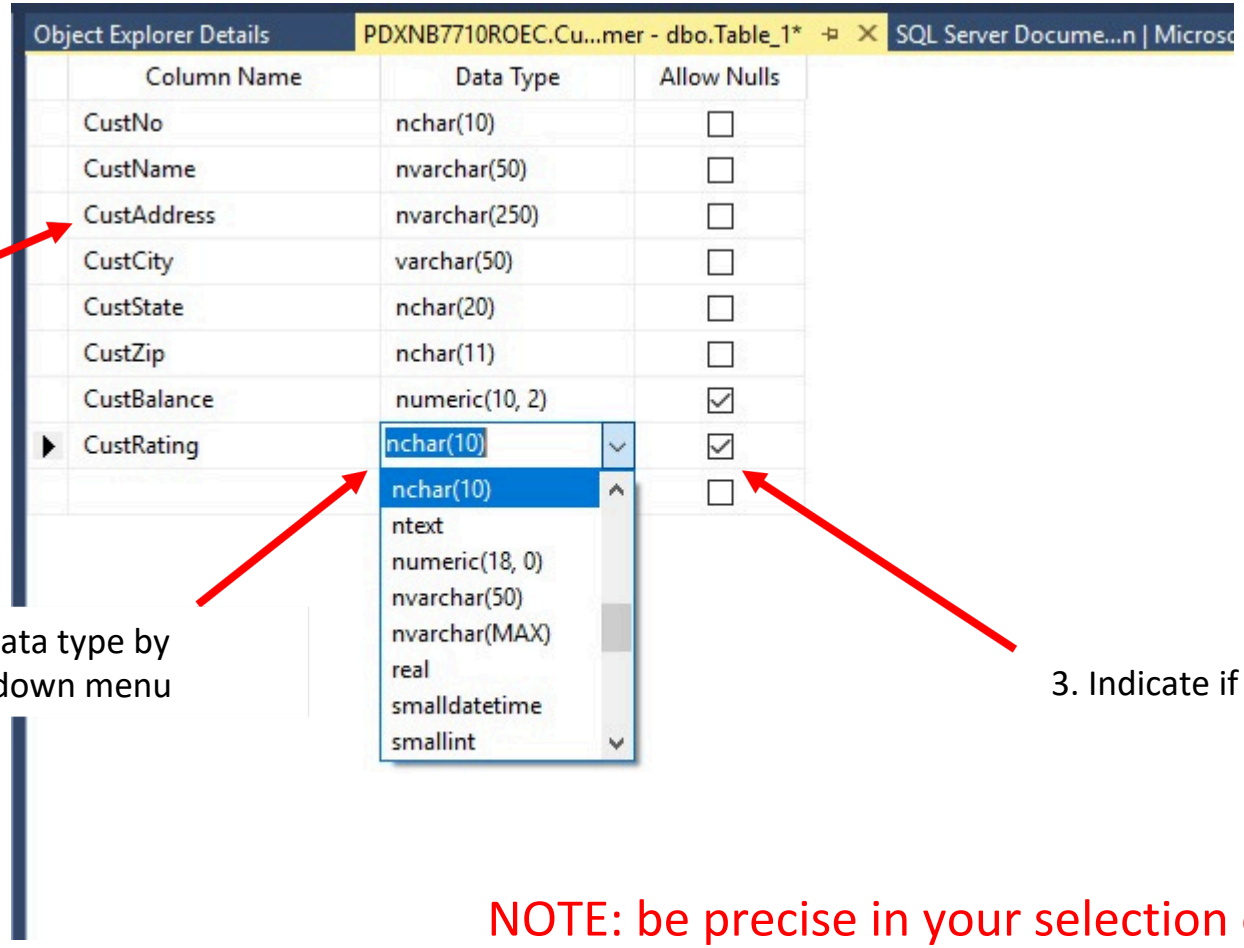
2. Enter the name of the new table here

Creating a Table (cont)

On the toolbar, dropdown the File menu and click on “Save Table_1” (actual new table name will appear)



Details: Entering a New Column



1. Type in column name

2. Select data type by dropping down menu

3. Indicate if null values are acceptable

NOTE: be precise in your selection of data type, it can drastically affect how much storage a DB takes

Quick Tutorial on Data Types

Data Type Categories

Data types in SQL Server are organized into the following categories:

Exact numerics	~~Unicode character strings~~
Approximate numerics	Binary strings
Date and time	Other data types
Character strings	

Exact Numerics

bigint	numeric
bit	smallint
decimal	smallmoney
int	tinyint
money	

Approximate Numerics

float	real

Date and Time

date	datetimeoffset
datetime2	smalldatetime
datetime	time

Character Strings

char	varchar
text	

Unicode Character Strings

Other Data Types

cursor	timestamp
hierarchyid	uniqueidentifier
sql_variant	xml
table	

Unicodeis a computing industry standard for the consistentencoding, representation, and handling oftextexpressed in most of the world'swriting systems. Not needed in CRITFC at this time.

Quick Tutorial on Data Types (cont)

Consider the following examples:

- Need to store the number 10,234,443.22
  - Store as char(13): 13 bytes = 10 numeric character and 3 punctuations
  - Store as float: 4 bytes (but only 7 significant digits --loss of precision)
  - Store as float(53): 8 bytes (15 significant digits –no loss of precision)
  - Store as char(50): 13 bytes + 37 unused bytes --wasted

- Need to store the string “John Jerry Smith” (16 characters)
  - Store as char(256): 16 bytes + 240 unused bytes
  - Store as vchar(20): 16 bytes + 2 bytes
  - Store as vchar(MAX): 16 bytes + 2 bytes

- So, imagine XYZ’s customer database has 4,000,000 customer names averaging 16 characters. What are the storage demands?:
    - For char(256): 4x106* 256 = 1.024x109
    - For vchar(20): *not feasible*, some names are over 20 characters
    - For vchar(MAX): 4x106* 18 = 72x106 (only 7% of the char(256) size)

- So, choice of *data type matters*especially for large data bases
  - It affects disk space requirements
  - It also can have a **large**effect on performance so chose types with care

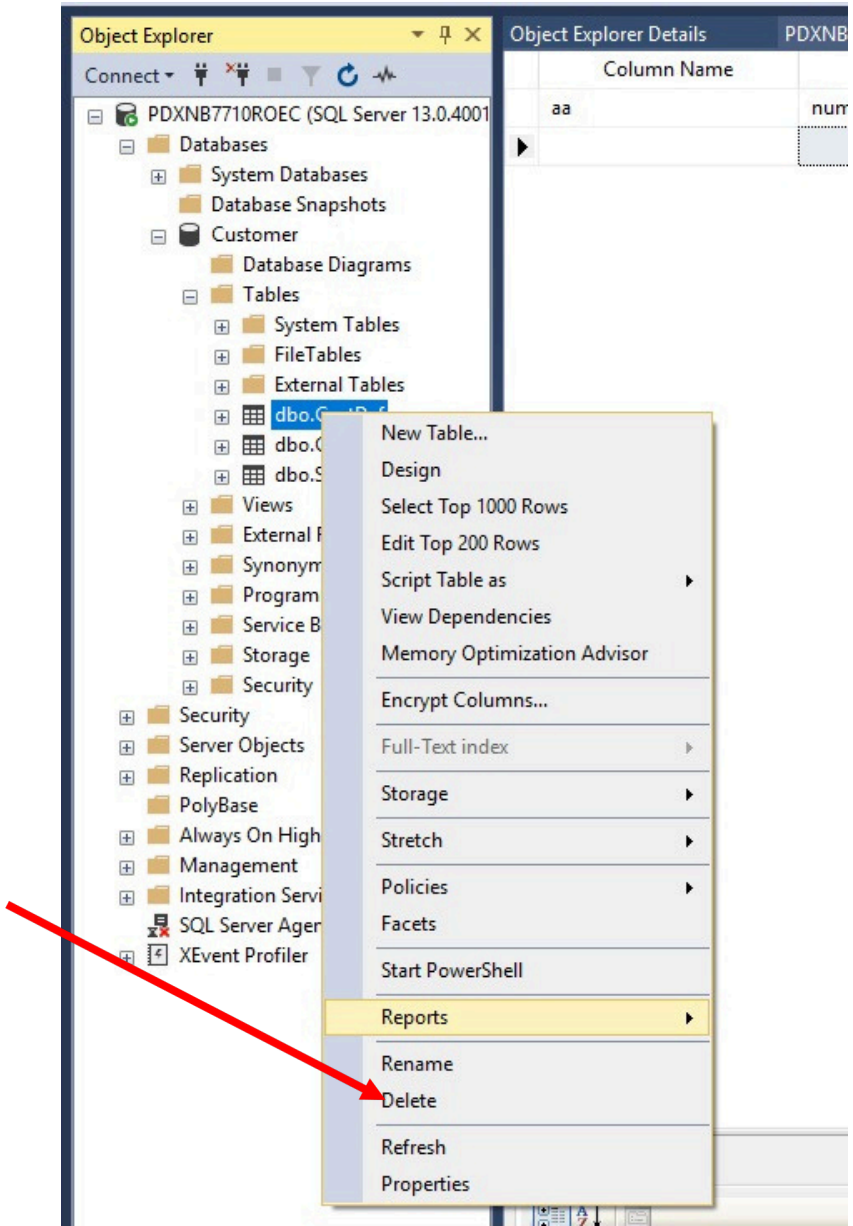
Tips on Selecting Types

- Do not store Boolean values as the words “true”/”false”, use thebit data type
- If the exact size a string column should be fixed (example: customer id), use char(n) where n is
- the size
- If a field will hold a monetary value, use smallmoneyor moneydepending on how large
- number will be
- If a string field will vary in length use varchar(n) where n is the maximum size it can be
- If you need a floating point number and the value is in the range +/-2*109 and it has 7 or
- fewer significant digit use float
- If you need a floating point number and the value is outside of the range +/-2*109 or it has 8
- or more significant digits use real(53)
- If the field holds a time, use time
- If the field holds a date, use date
- If the field holds a timestamp, use timestamp
- If the field holds a date and time use datetime
  If the field holds an integer < +/-32,768 use a smallint
  If the field holds an integer between +/-32,768 and +/-2,147,483,648 use int
  If the field holds an integer between +/-2,147,483,648 and +/-9,223,372,036,854,775,808 use bigint
  If the field holds an integer > +/-9,223,372,036,854,775,808 you are out of luck (or resort to real(53) but you will loose accuracy)

Deleting a Table

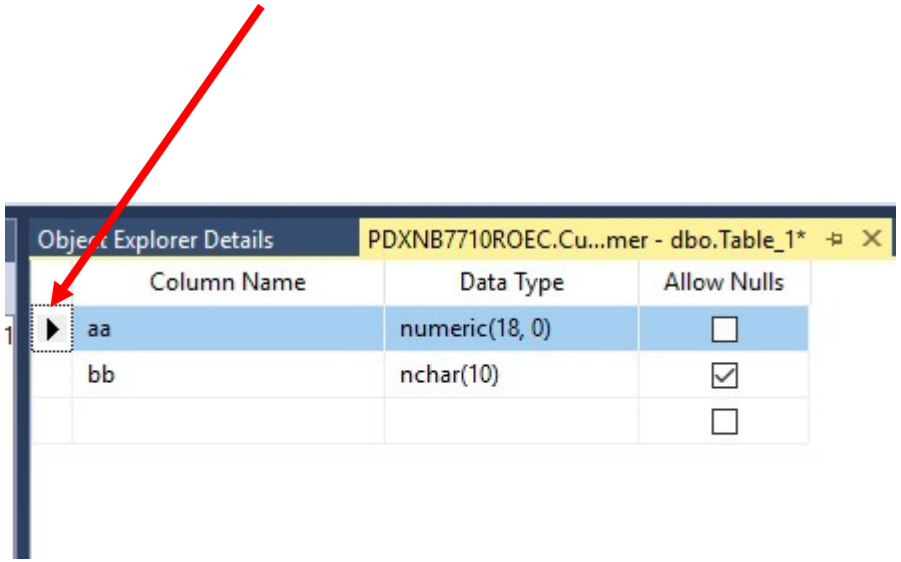
Note: adding, modifying, or deleting a table is only possible is you have been granted rites to do so

Click on the table you want to delete to dropdown menu and select “Delete”

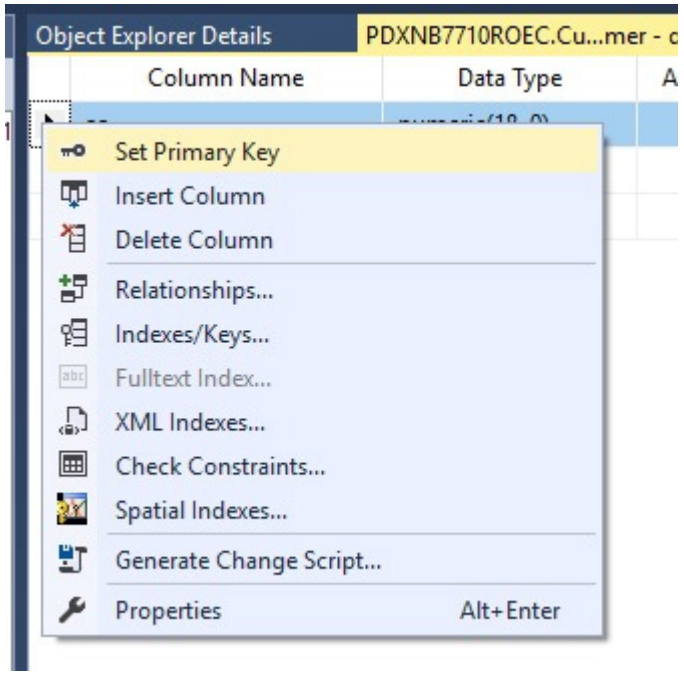


Setting the Primary Key

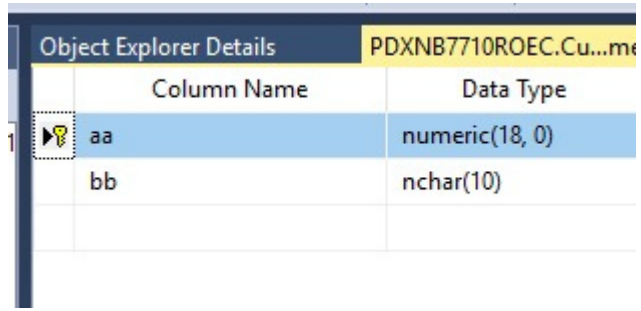
1. Click on the row to be the key and it highlights in blue. Right click on the triangle to the left of the column name.



2. Dropdown appears, select “Set Primary Key”



3. Key icon appears in that row



Backing Up the DBMS

- Backups are a very critical activity in the administration of a DBMS
- If some corruption were to occur in the DBMS (and this sometimes happens), restoring the
- DBMS from a backup is the only remedy
- Backups should be scheduled to run automatically daily
- At least weekly, a complete backup should be stored at a secure remote site
  It is critical that backup media be tested regularly by doing a “practice” restore
  - Backup media degrades over time
  - Problems with the devices used to create the backup can result in corrupt backup media
- It is now possible to backup directly into the cloud
  - Avoids using media like tape, backup is from local disk to cloud disk
  - In AWS, all data is automatically backed up –so this is a good secure remote backup
  - strategy
    CRITFC is going run a POC of this possibility this year and share out the approach and findings

Backup Strategies

- Backups are usually run in the dead of the night when they do not negatively affect machine performance for users
- The most straightforward strategy is to backup the entire DBMS each night
- Unfortunately, this is not always possible
  - A very large DBMS might take too many hours to complete overnight
  - Some corporations have world wide operations so there is no “dead” time
- A common strategy is to use incremental backups

Backup Strategies (cont)

Complete Backup

The entire DBMS is backed up in one fell swoop

- Advantages
  - Only have to restore a single file
- Disadvantages
  - Can take a very long time to complete backup

Incremental Backup

The entire DBMS is backed up once a week (over weekend likely). The other six days an incremental backup is made capturing only the things that *changed*during the last 24 hours. This is a very common backup strategy.

- Advantages
  - Incremental backups can be pretty fast
- Disadvantages
  - First must restore weekly complete backup and then all the incremental backups to date
  - Potentially longer recovery

Proviso

Backup and restore is actually a deeply technical subject and we just cannot do it justice in the time available, so:

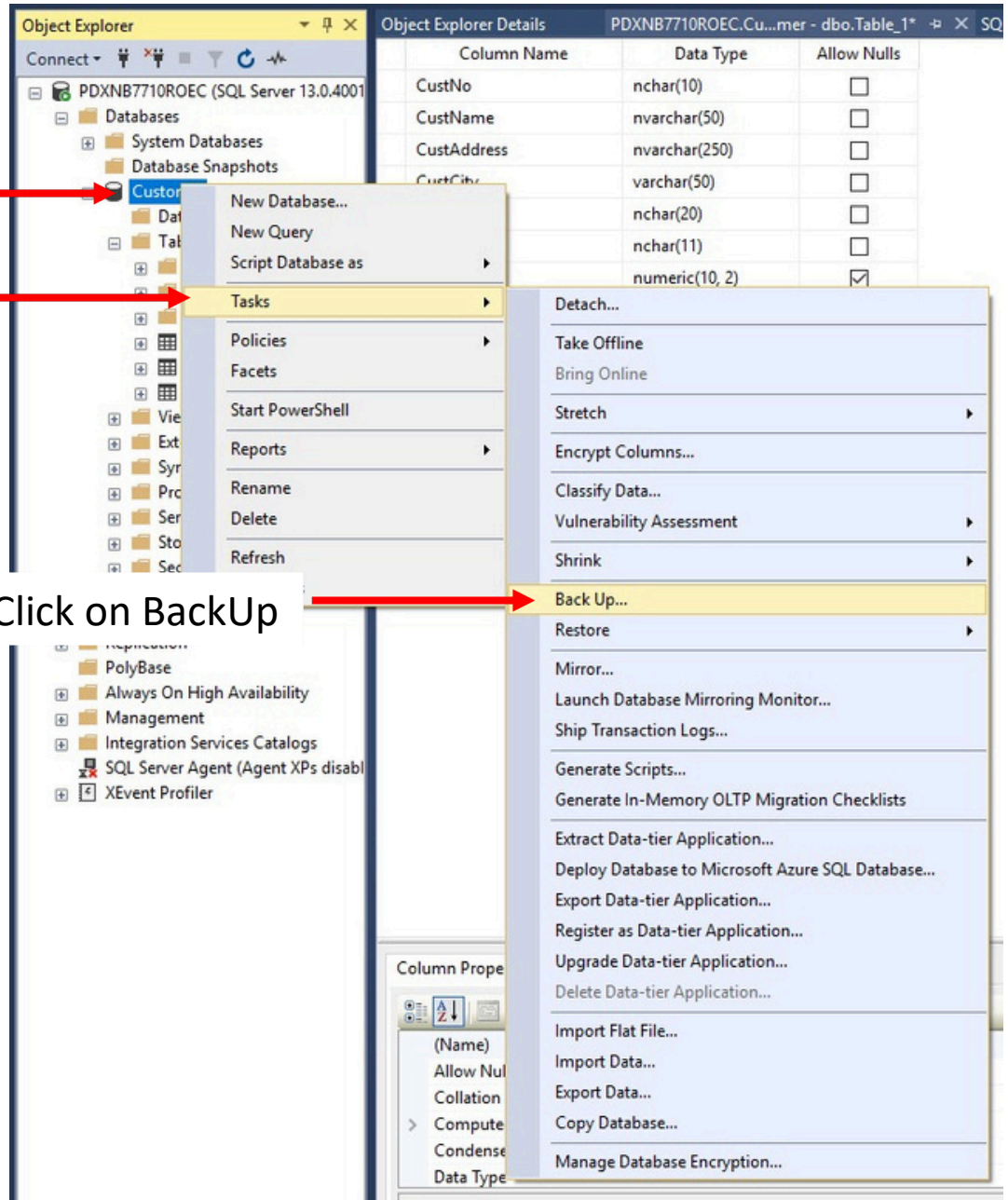
- We are going to present the most straightforward cases of a full backup and recovery
- The next workshop on advanced SQL will delve a little deeper into the subject
- If people still want more, we can always dive deep in the next workshop

How to do A Full Backup

1. Click on the DB you wish to backup

2. Click on Tasks

3. Click on BackUp



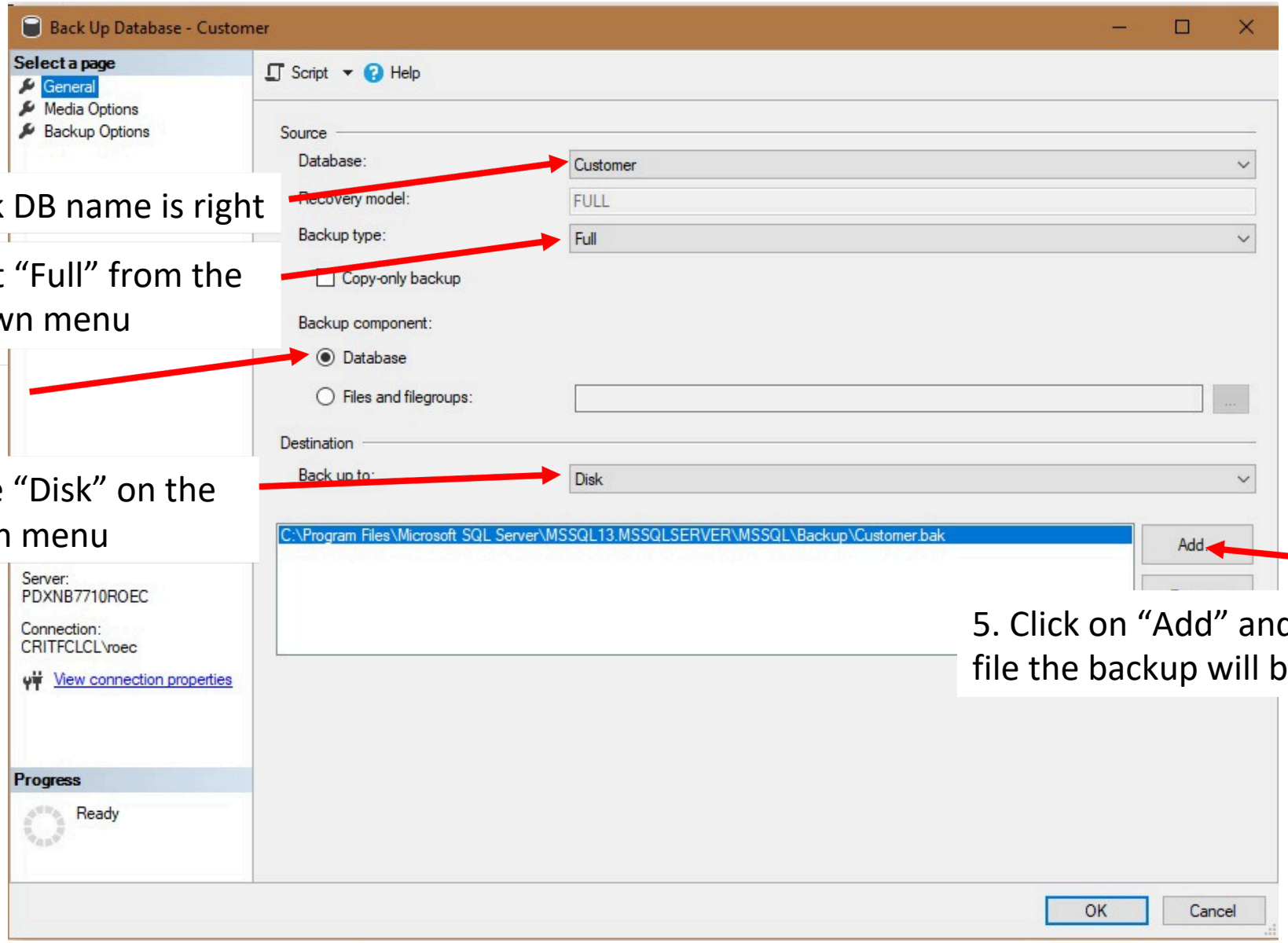
How to do A Full Backup (cont)

1. Check DB name is right

2. Select “Full” from the dropdown menu

3. Make sure Database is selected

4. Choose “Disk” on the dropdown menu



5. Click on “Add” and enter path to file the backup will be put in

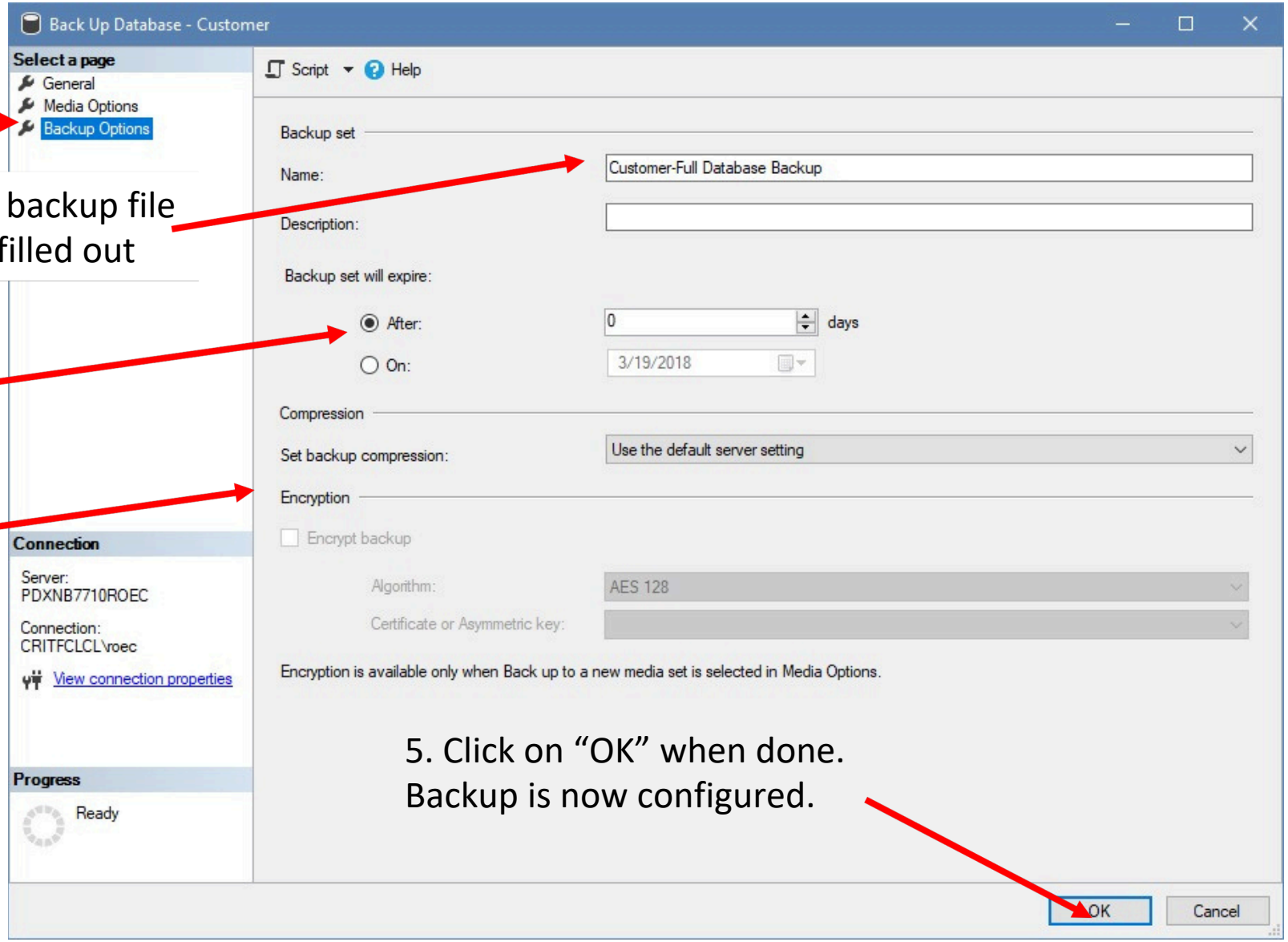
How to do A Full Backup (cont)

1. Click on “Backup Options”

2. Enter descriptive name for backup file also “Description” should be filled out

3. Select “After” or “On” and enter appropriate data

4. Ignore encryption for now



5. Click on “OK” when done. Backup is now configured.

To Know More

For more in depth information on backups go to this page:

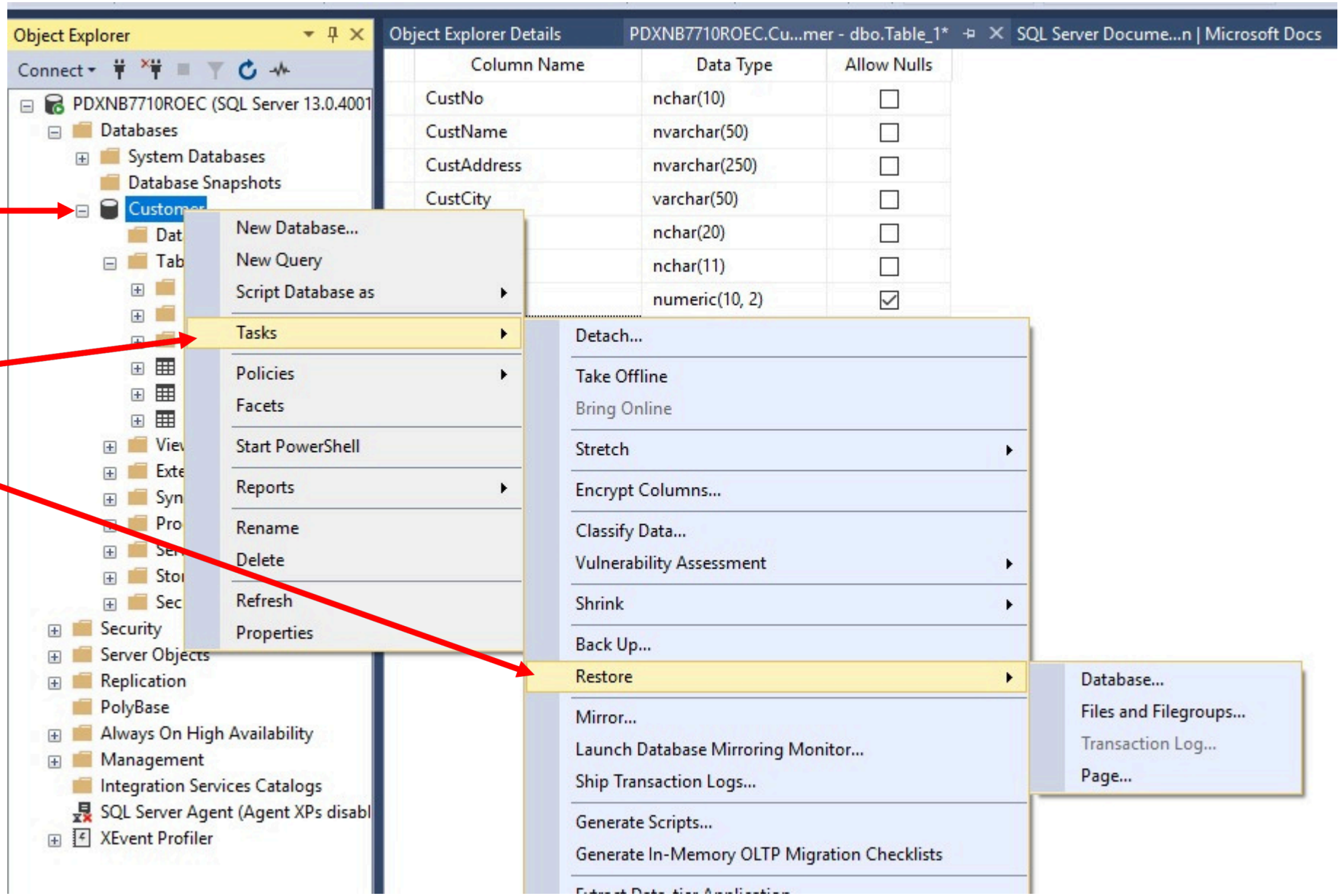
https://docs.microsoft.com/en-us/sql/relational-databases/backup-restore/create-a-full-database-backup-sql-server

Restoring a Full Backup

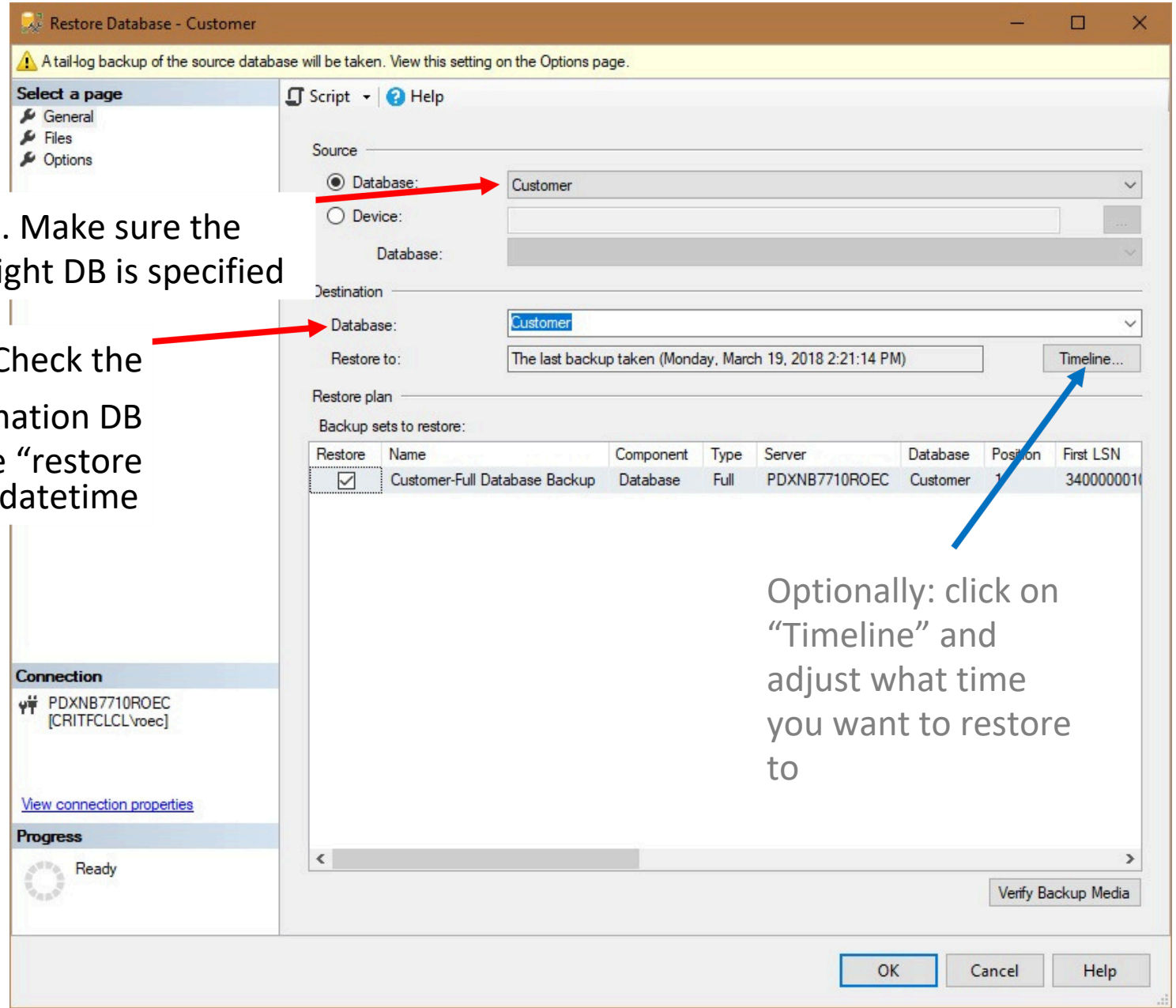
1. Select DB to restore and right click

2. Click on “Tasks”

3. Select Restore>Database



Restoring a Full Backup



1. Make sure the right DB is specified

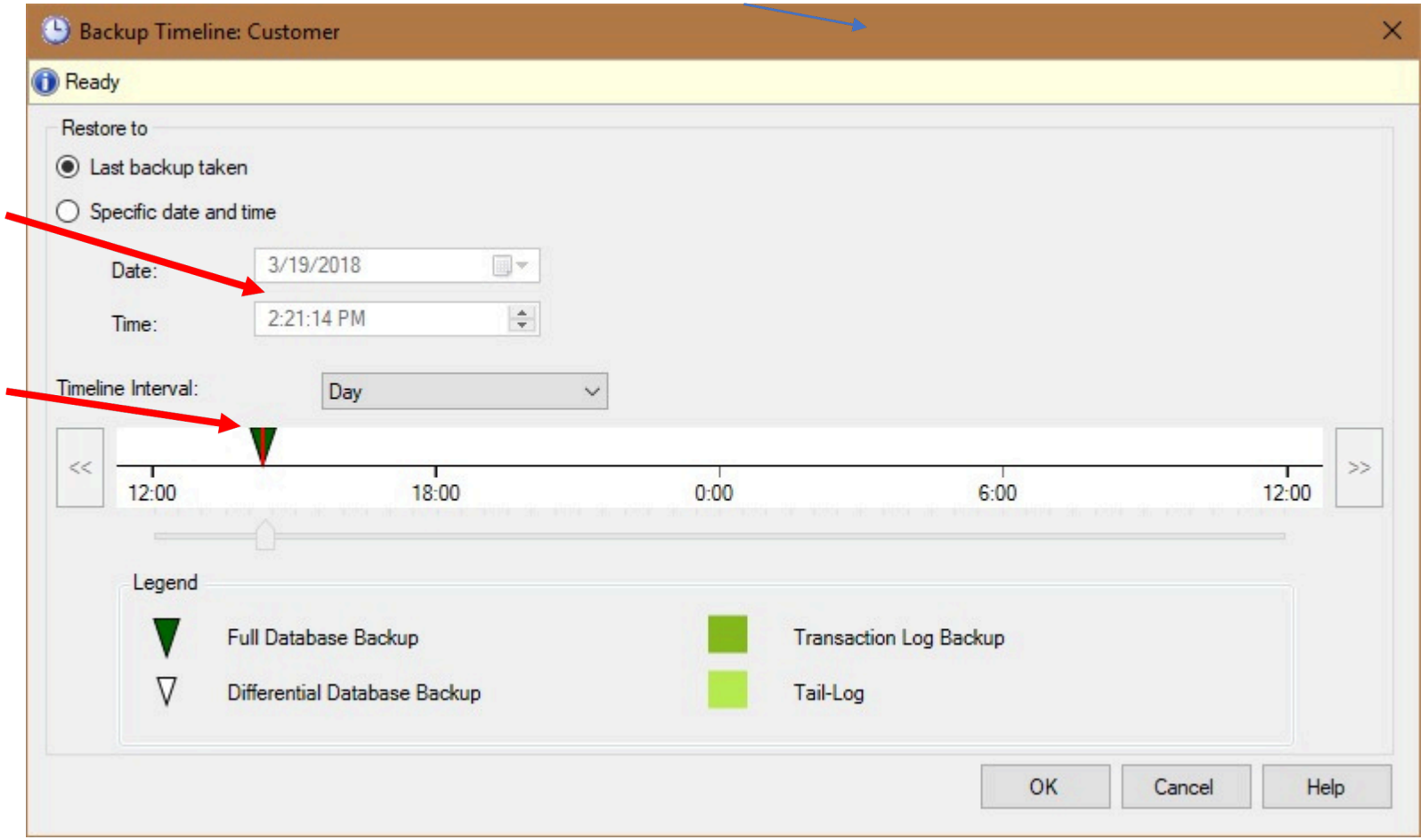
2. Check the destination DB and the “restore to” datetime

Optionally: click on “Timeline” and adjust what time you want to restore to

Adjusting Recovery Timeline

You can adjust date and time in these fields

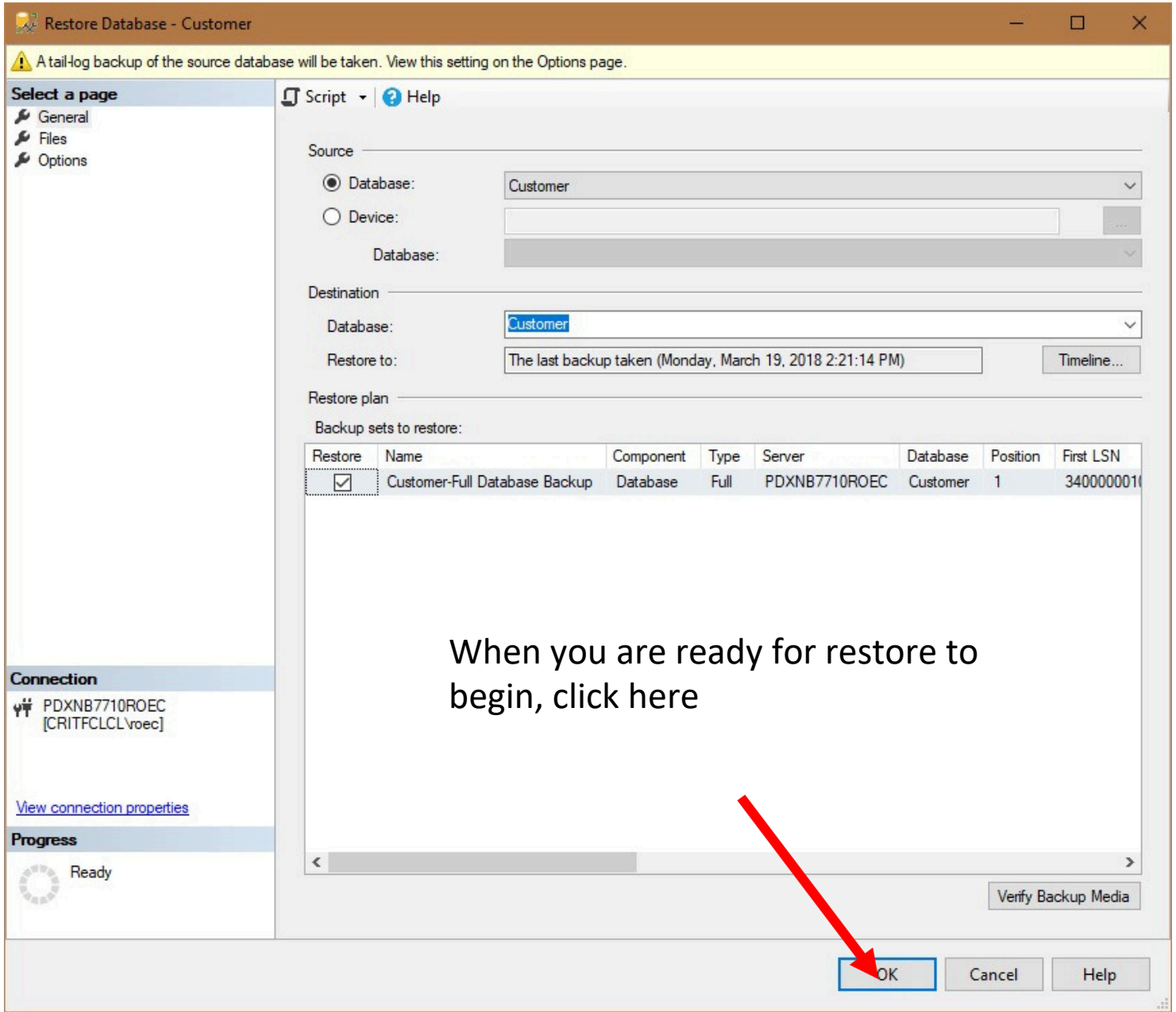
The Timeline Interval is a graphical depiction Backup activities. Use it to decide what point to restore up to



Pop Quiz

Why might you want ***not*** to restore entire backup?

Restoring a Full Backup



To Know More

Go to:

https://docs.microsoft.com/en-us/sql/relational-databases/backup-restore/restore-a-database-backup-using-ssms

One More Thing

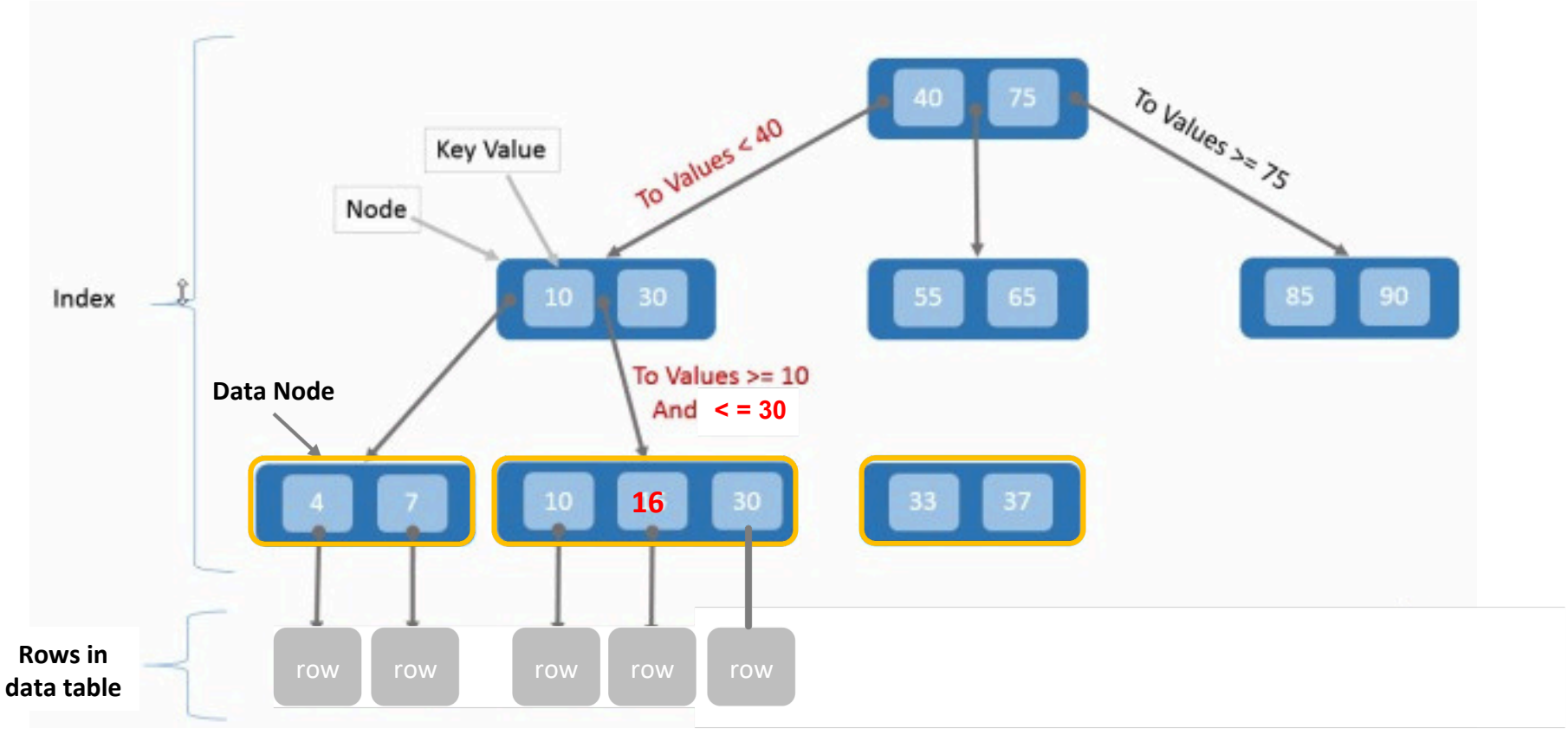
Backup and recovery can be completely controlled by writing SQL scripts

What is a database index?

A**database index**is adata structurethat improves the speed of data retrieval operations on adatabase tableat the cost of additional writes and storage space to maintain the index data structure

How Indexes Work

- The diagram below represents an index structure
- This structure-type is known as a “btree”
- The index is maintained by the DBMS as an object separate from the DB



What row has the key value 16?

Indexing

Indexes are key to having a performant DB. Why? Consider example below:

- Suppose you have a table with a column called UCustId(unique customer id) where it is guaranteed to each and every ID in the column is unique
- Let's say you have a million customers –so one million rows of data
- You need to find the customer with id 789536
- With a straightforward linear search your worst case scenario is what you want to find is in the last row and you have to look at each record in the table to find it which means one million comparisons
- If you build an index on UCustIdyou worst case is that you have to look at about log(1,000,000) or 6 comparisons
- If each comparison takes 1 ms(10-3s) the linear search case takes 1000 sec or 16.7 min to run
- The indexed search takes 6 s or .1 m do it -so it is 167 times faster
- Conclusion: *critical data searched often **needs**to be indexed*
- Good example of columningneeding an index: primary keys on tables

The Costs Associated with Indexing

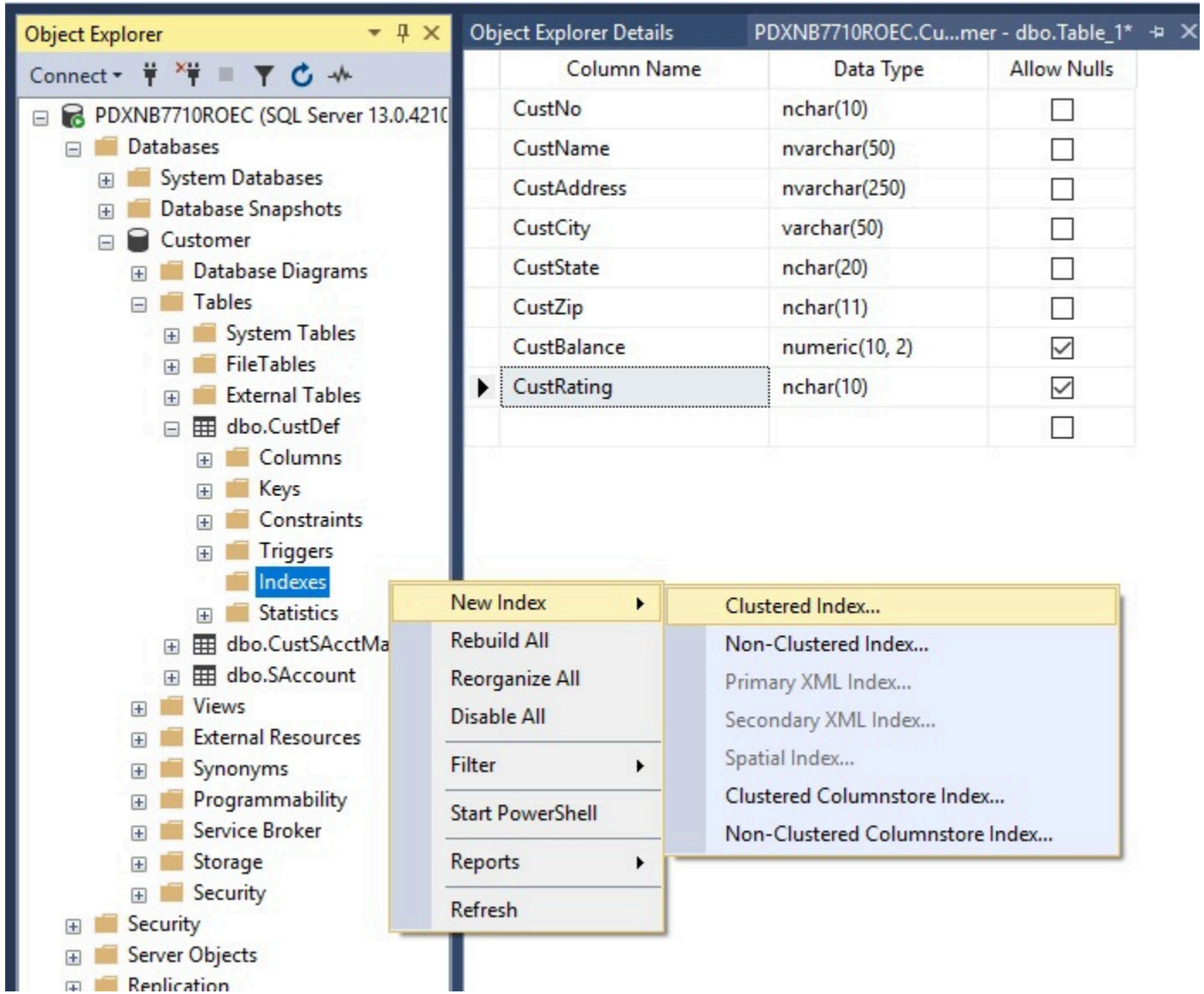
- Indexing is not for free
  - It can take quite a while to build an index and table may unavailable during at least part of the time it is being built
  - Each time a row is added or removed (and sometimes just modified) the index has to be updated as well as the table and it can be costly
  - Indexes require regular maintenance, i.e., running a defragmentation utility on them or even rebuilding them with different constraints
  - Even with indexes, very large tables may have performance problems and other actions may need to be taken to reach DB performance goals
  - Indexes sometimes go corrupt and have to be rebuilt –which can adversely affect production while this happens
  - When indexes go corrupt, it sometimes can be *very*hard to diagnose this as the root cause
  - When queries include some kind of string pattern matching, indexes sometimes cannot be used and the query defaults to linear search

A Few Indexing Guidelines

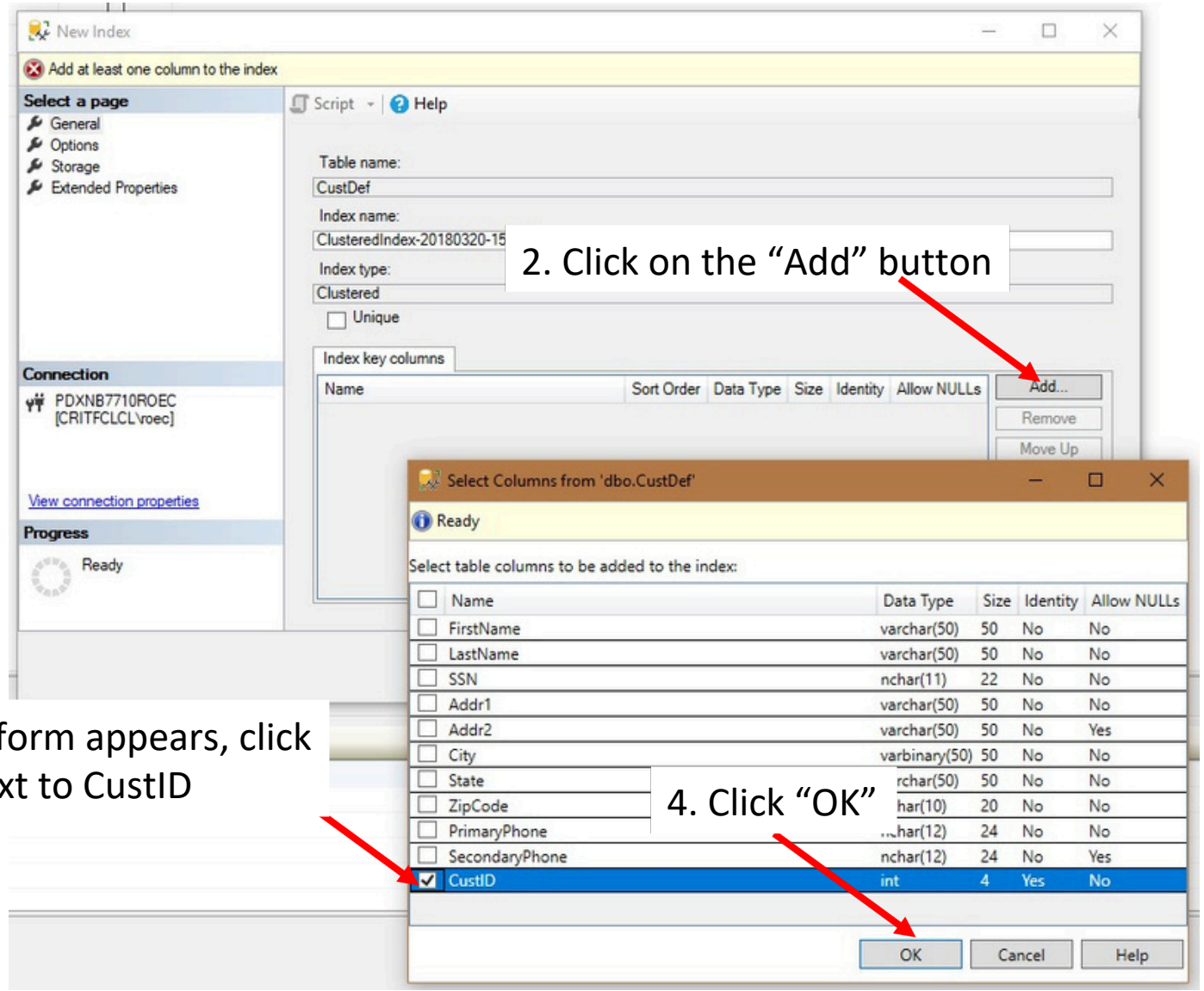
- Small databases probably don’t need indexes
- Small tables in a DB of any size don’t need indexes
  - Example: a table that holds the 25 car colors available for the Chevy F10 pickup
- Primary keys in large tables (> 100,000) definitely need indexes (primary keys are normally unique)
- Foreign keys that are used frequently in WHERE clauses or other clauses will benefit from an index
- Columns other the primary or foreign keys in very large tables that are commonly referenced in WHERE or other clauses can benefit from indexes

Creating An Index

1. Right click on the DB Customer>Tables>dbo.CustDef>Indexes>New Index>Clustered Index

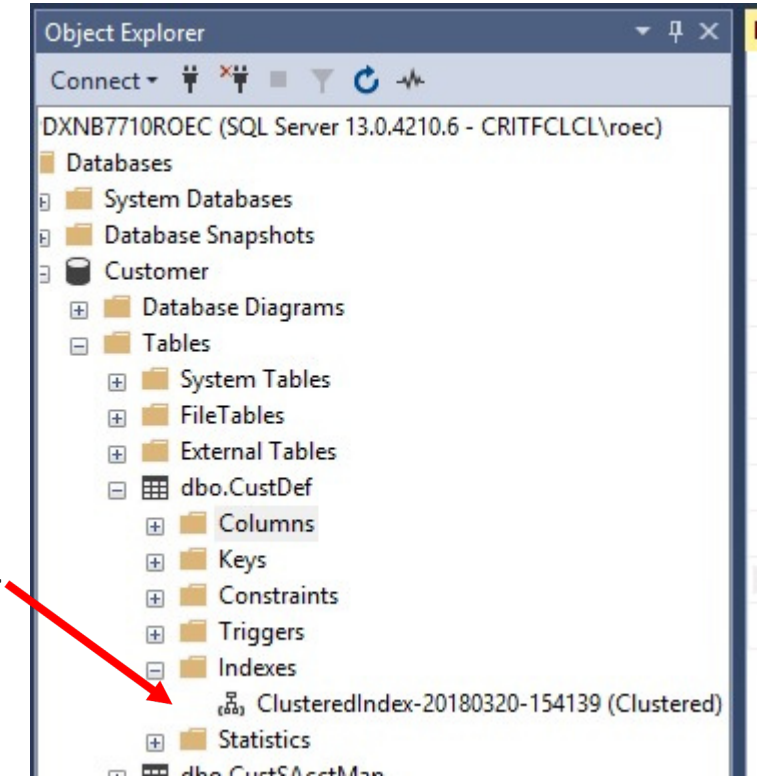


Creating An Index (cont)



Creating An Index (cont)

New index appears in Indexes folder



Data Encryption

- Beyond users, rites, and passwords another form of data protection is encryption
- SQL Server can encrypt at two levels:
  - You can encrypt individual columns in a table
  - You can encrypt an entire database (requires SQL Server 2017 Enterprise Edition)
- Is the encryption easy to crack?

> Breaking a symmetric 256-bit key by brute force requires 2128times more computational power than a 128-bit key. Fifty supercomputers that could check a billion billion(1018) AES keys per second (if such a device could ever be made) would, in theory, require about 3×**1051years**to exhaust the 256-bit key space. Wikipedia

- Encryption is complex subject and we do not have the time to get deep into this today. It could be the subject of a separate seminar later.

NOTE: the age of the universe is estimated to be about 13.7 billion (13.7 * 109) years…

That’s all folks!