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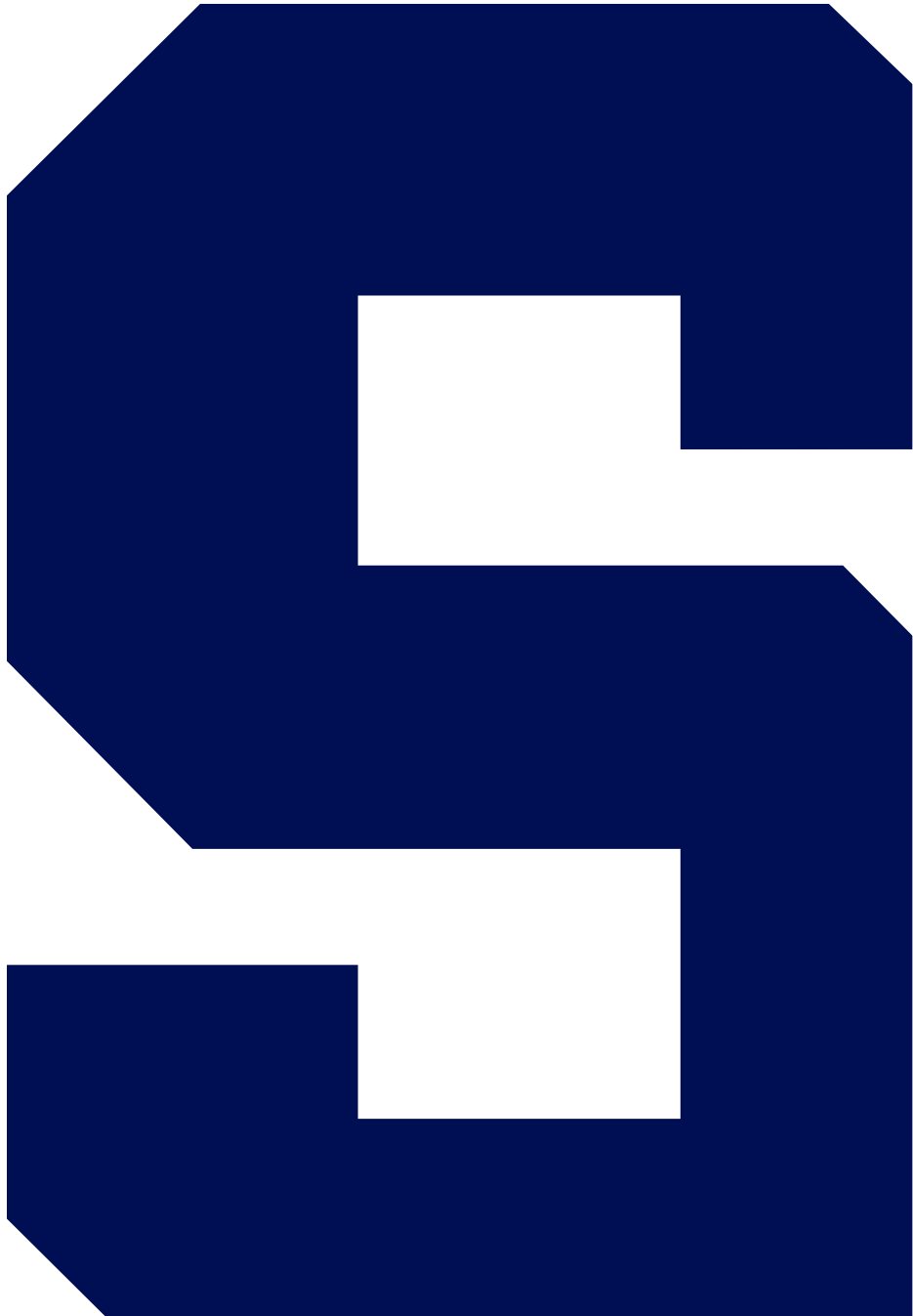


The Relational Model

Agenda

- What is the relational model? Why is it popular?
- What are the elements of the relational model?
- The relational model in a DBMS implementation
- Tables and relations
- Keys
- Data domains
- NULL and flags
- Referential integrity

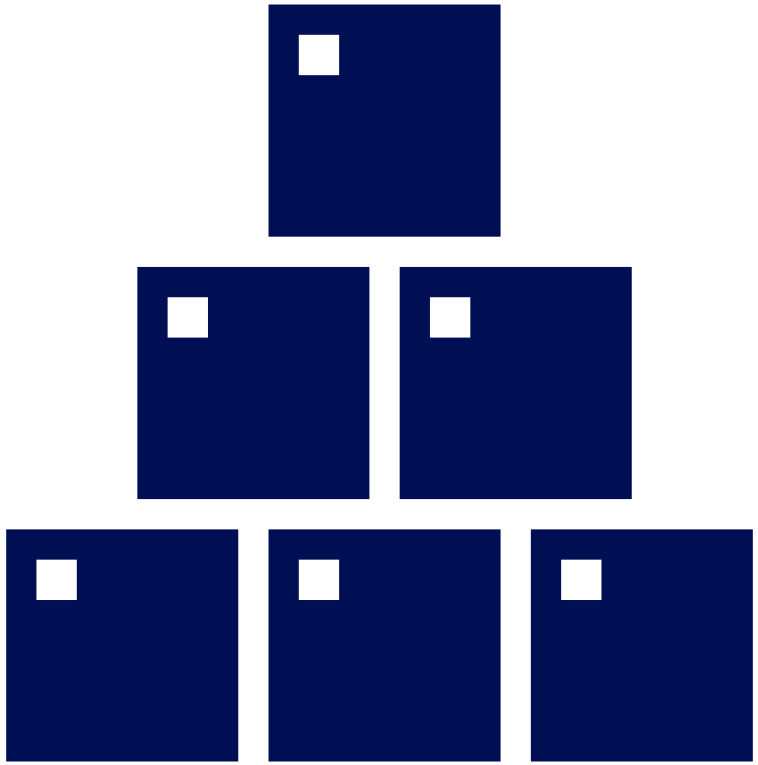
Recall: Popular Implementation Models

Name	Description	Use cases
Relational	Data are stored in structured tables of rows with metadata defining the columns; metadata defines how data in tables connect to one another	Business applications, multiuse
Key value	Data are stored under a key; information can be retrieved by key; little to no metadata	Caching, session management, real-time data
Document	Structured metadata is stored with data in a document; like documents are stored in collections	Content management, master data, search engines
Graph	Data are structured into nodes, edges, and labels; permits for complex relationships among data	Hierarchical data, networked data, social networks
Column-oriented	Tabular data structure with data in columns and metadata in the row, a computationally efficient structure for data analytics	Internet of things data, data analytics, data warehousing
Time series	Tabular data structure in time-order; data are immutable and support high-volume writes	Internet of things, time-oriented analysis, and forecasting

Why Is Relational So Popular?

- Data independence; how the data are stored is independent from how they are accessed
- Uses SQL: an easy-to-learn query language
- 50 years of existence means there are a lot of implementations

Components of the Relational Model



The Relational Model

The End

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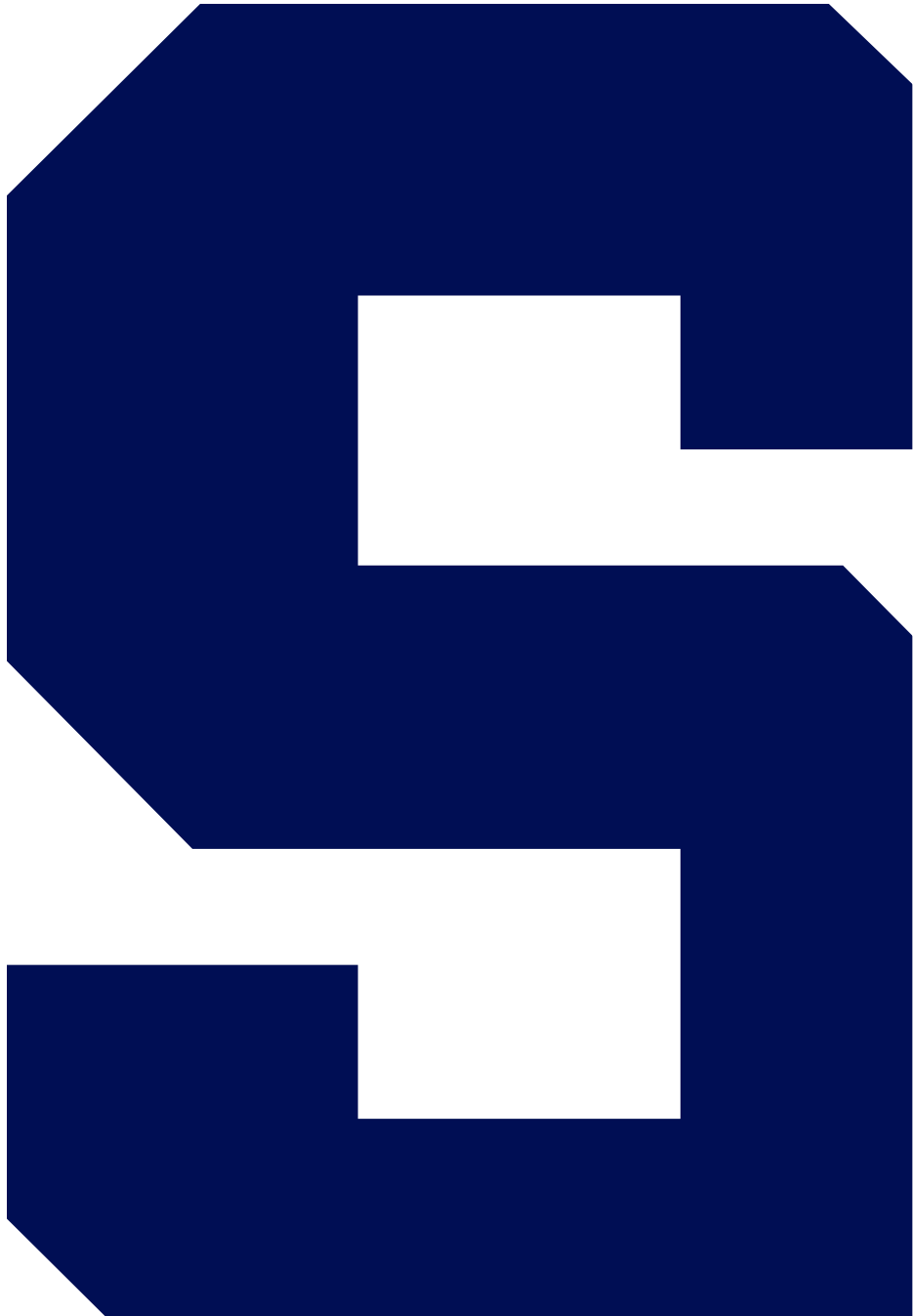


Tables and Relations

Tables

- Two-dimensional persistent data structures in the DBMS
- The table is a collection of items to be stored
- Each row is a distinct item, called a tuple
- Each column is a set of acceptable values, known as a data domain

Electric cars			
Make	Model	Retail price	Range in miles
Chevy	Bolt	$36,620	259
Nissan	Leaf	$34,190	149
Mini	Hardtop2	$29,900	110
Hyundai	Ioniq	$33,045	170

Relations

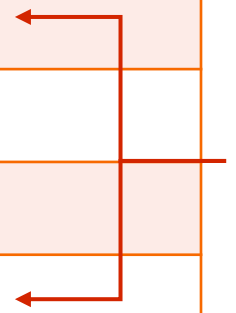
A table is a relation if the data in the row are unique.

This table is a relation.

Electric cars			
Make	Model	Retail price	Range in miles
Chevy	Bolt	$36,620	259
Nissan	Leaf	$34,190	149
Mini	Hardtop2	$29,900	110
Hyundai	Ioniq	$33,045	170

This table is not a relation.

Electric cars			
Make	Model	Retail price	Range in miles
Chevy	Bolt	$36,620	259
Nissan	Leaf	$34,190	149
Mini	Hardtop2	$29,900	110
Hyundai	Ioniq	$33,045	170
Nissan	Leaf	$34,190	149



Tables and Relations

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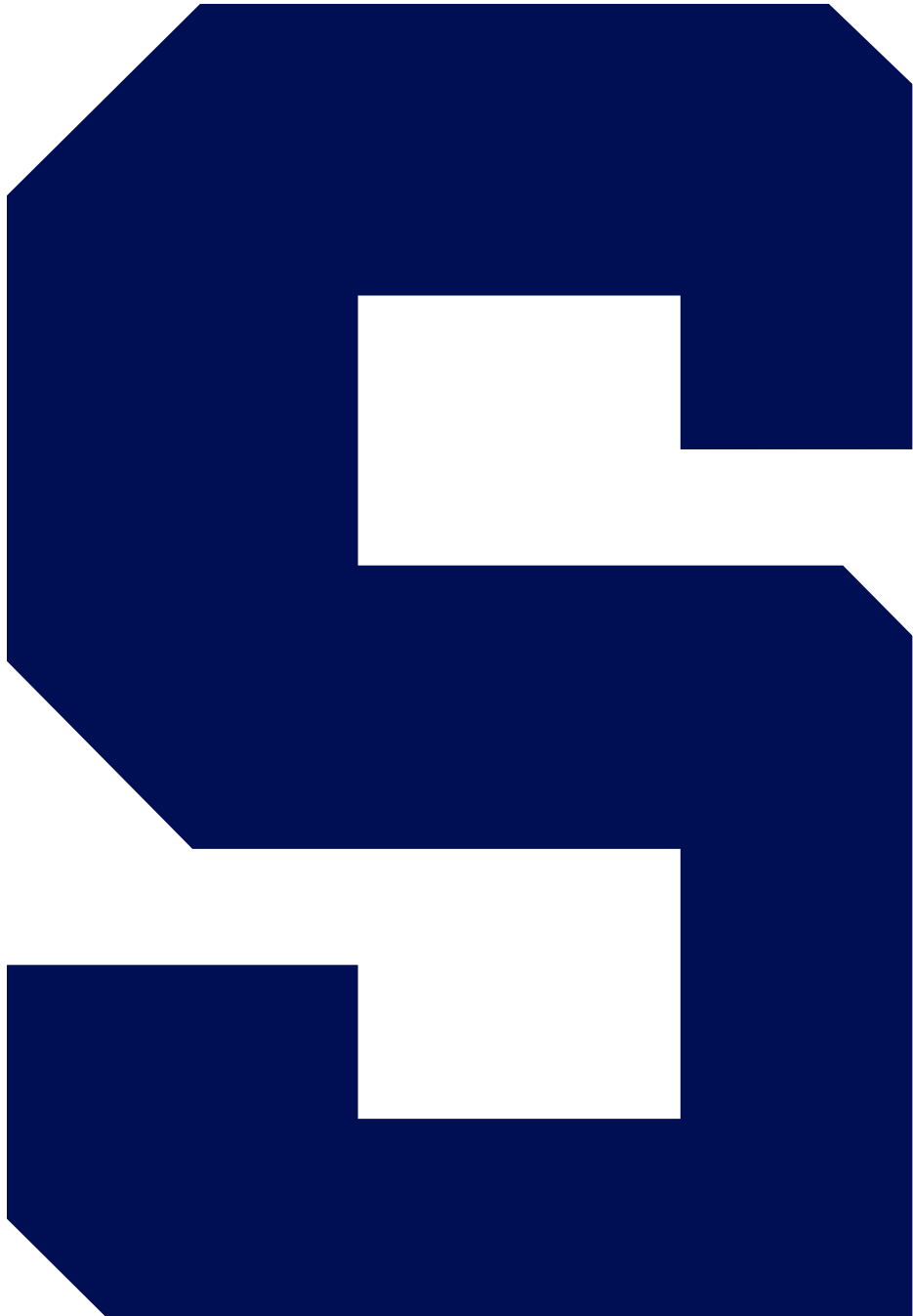
Primary Key Constraint and Entity Integrity

Primary Key Constraint and Entity Integrity

- Entity integrity is a characteristic of a table that ensures it will be a relation.
- We achieve entity integrity with a primary key constraint: a column or set of columns for which each value must be unique and present (NOT NULL).
- There can only be one primary key constraint per table in the DBMS implementation.

Primary Key Constraint
and Entity Integrity

The End



Demo

Tables and Entity Integrity

Demo: Tables and Entity Integrity

- We will use the Adminer web application.
- Let’s create a courses table in the tinyu database.
- Create one column in the table called course_code.
- Add some courses to the course table.
- Edit a course.
- Add the same course, and it’s no longer a relation.
- Use a primary key constraint to set entity integrity forcing it to be a relation.

Demo: Tables and Entity Integrity

The End

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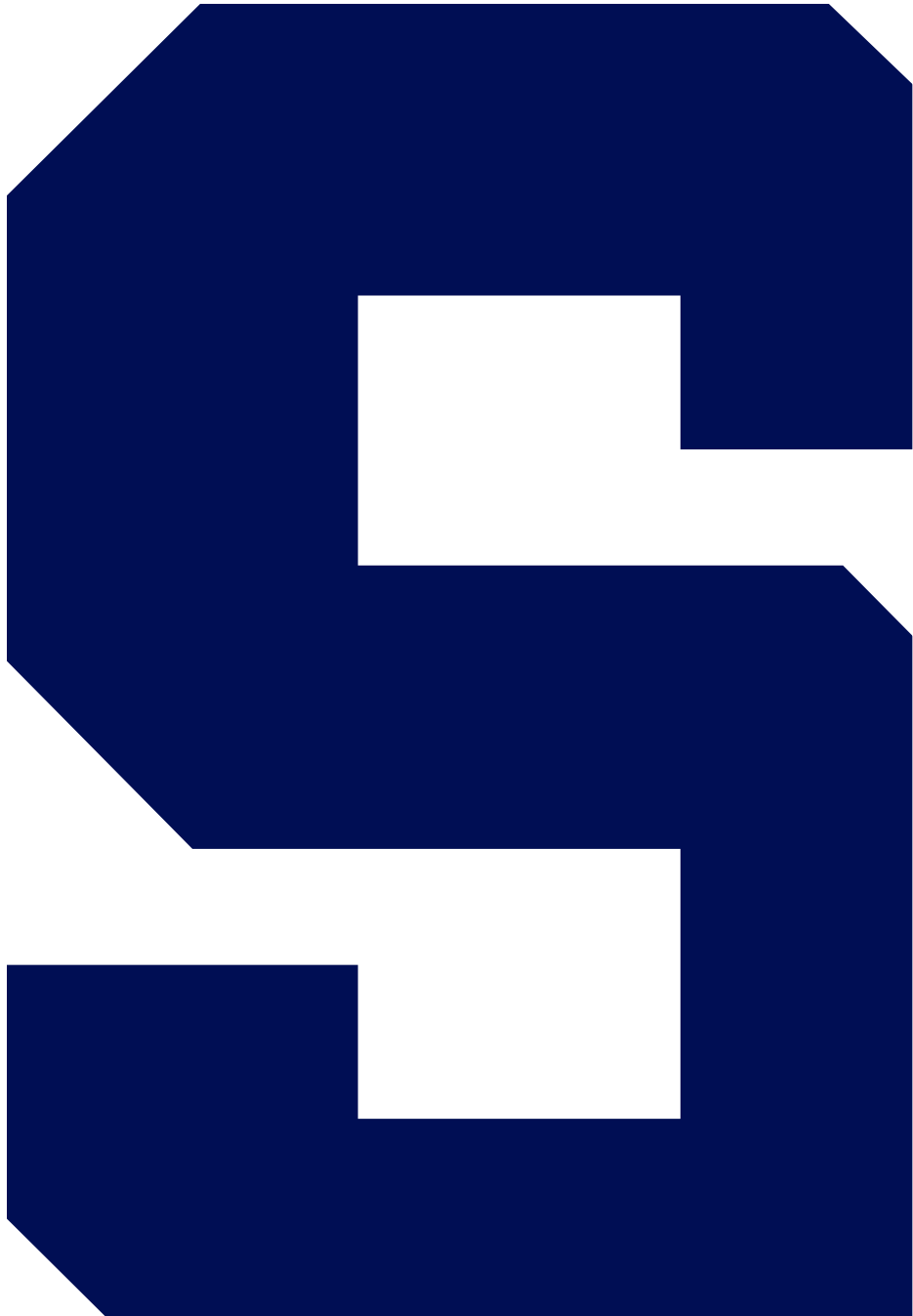

DRY and Entity Integrity

The DRY Rule of Table Design

Designing relational tables is easy!

- Each row represents a singular distinct entity.
- Each attribute in a column is data as fact—a single atomic value.
- No single entity spans more than one row.
- DRY stands for don’t repeat yourself.

DRY and Entity Integrity

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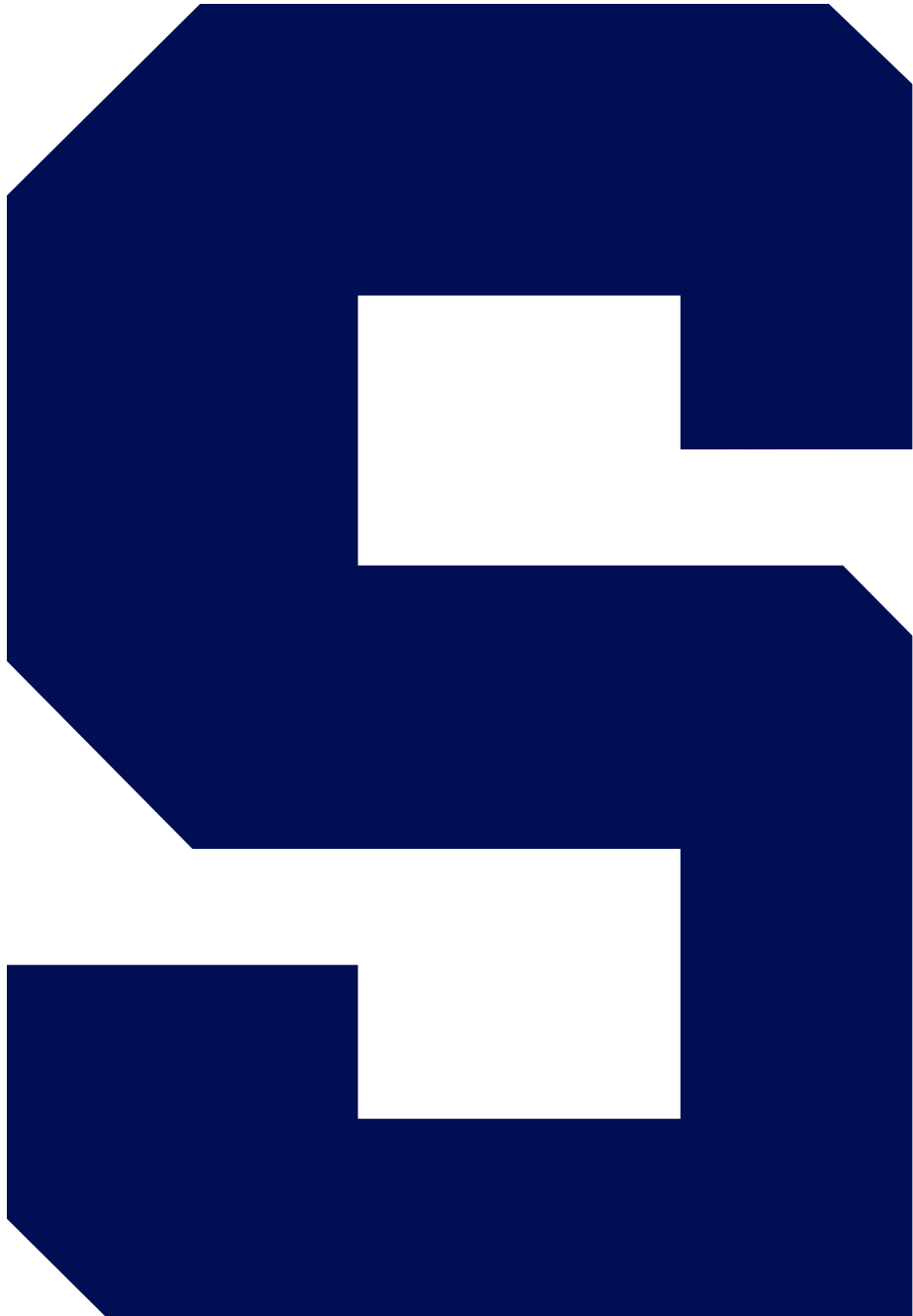
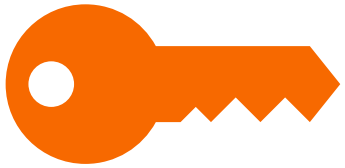
Keys



Keys



- A key is any value in a table that can be used to look up another set of values from the same table or another table.
- Any value can act as a key.
- Some keys are unique. These can be used for entity integrity.

Key Concepts

- Candidate key: any column or set of columns that make the table a relation
- Natural key: column values are unique across the entire data domain, ensures entity integrity (aka business key)
- Surrogate key: a system-generated unique value, such as an automatically incremented integer
- Secondary key: any column used to retrieve data from the table; need not be unique
- Composite key: any key consisting of more than one column; e.g., composite primary key or composite surrogate key

Example of Different Keys

Students					
id	firstname	lastname	email	gpa	year
1	Robin	Banks	rb@uni.edu	4.000	Freshman
2	Victor	Edance	ve@uni.edu	2.404	Freshman
3	Erin	Yortires	ey@uni.edu	2.401	Junior
4	Aurora	Borealis	ab@uni.edu	3.024	Senior
5	Tuck	Androll	ta@uni.edu	3.333	Senior
6	Eura	Quittin	eq@uni.edu	3.372	Senior
7	Willie	Survive	ws@uni.edu	2.608	Sophomore

Which one is the primary key constraint?

Surrogate key

Composite candidate key

Natural key student email

Secondary key: find seniors

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Keys

The End

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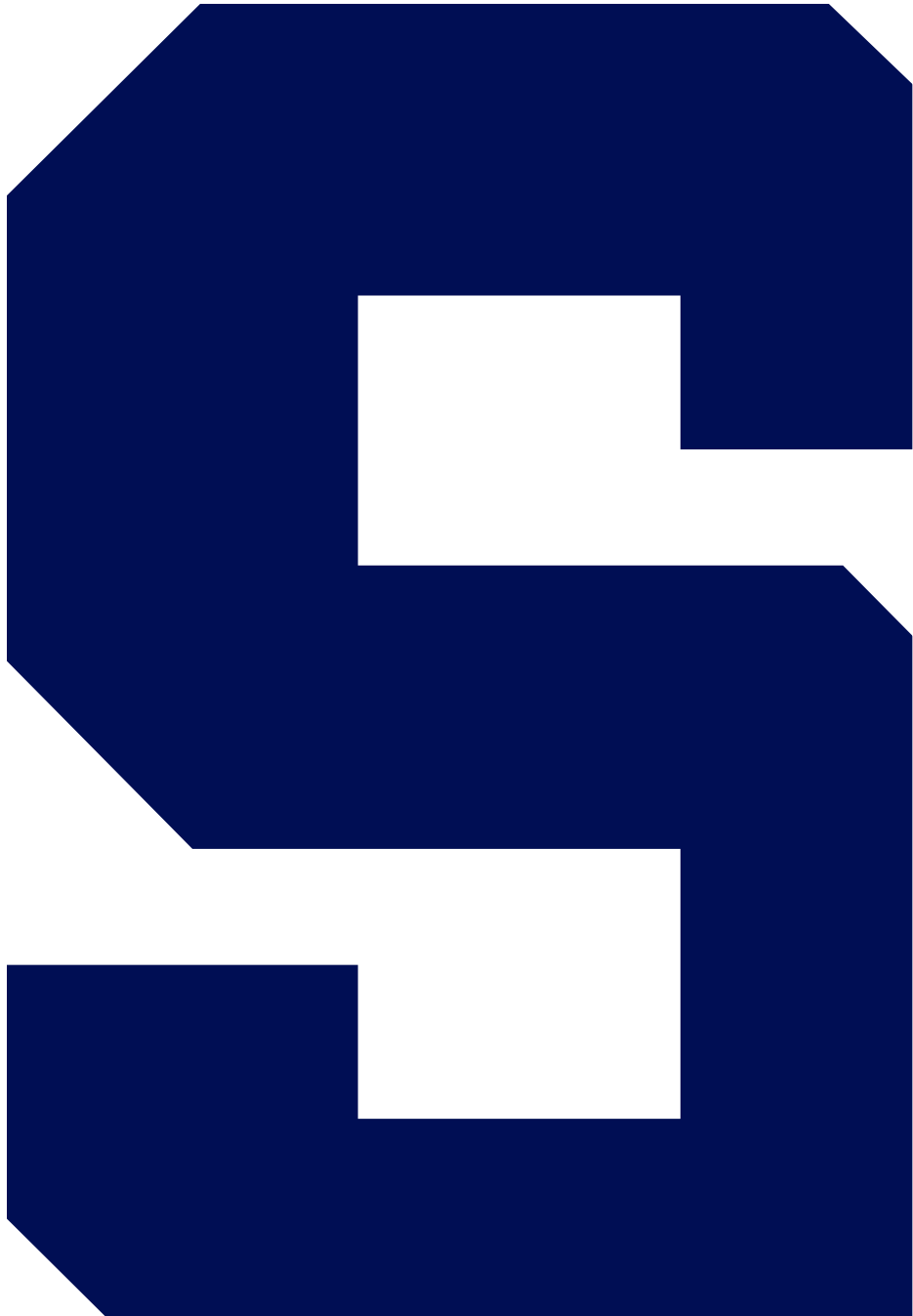


Surrogate Keys

Which Key Should Be the Primary Key?

- Natural keys are good choices.
- Surrogate keys are better because of how the DBMS physically stores data by primary key.

user_email	user_name
mmioff@g.com	Mary Mioff

user_id	user_name
1	Mary Mioff

user_email	user_name
akuss@g.com	Abby Kuss
mmioff@g.com	Mary Mioff

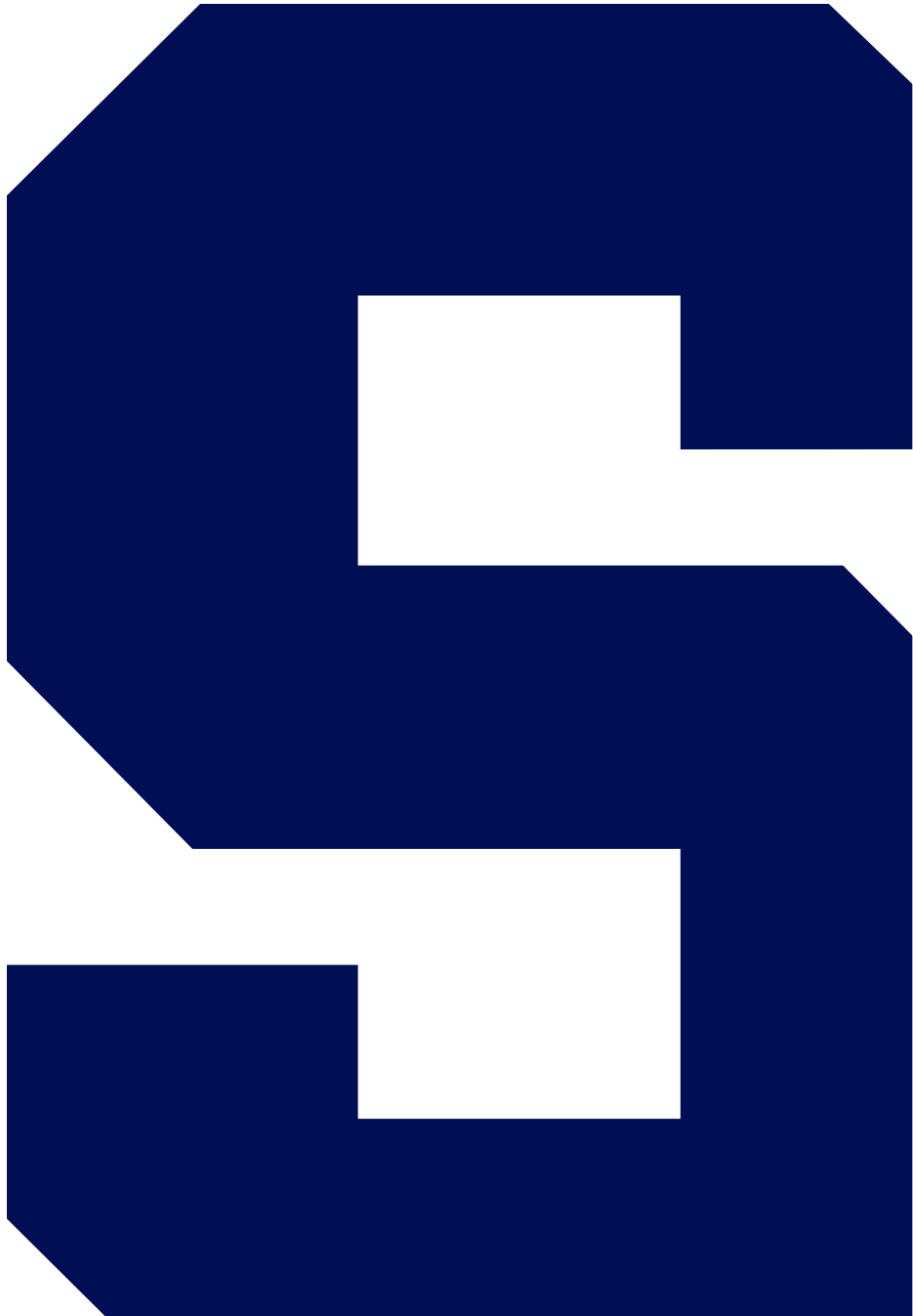
user_id	user_name
1	Mary Mioff
2	Abby Kuss

user_email	user_name
akuss@g.com	Abby Kuss
balott@g.com	Bett Alott
mmioff@g.com	Mary Mioff

user_id	user_name
1	Mary Mioff
2	Abby Kuss
3	Bett Alott

Surrogate Keys

The End



Demo

Surrogate Keys

Demo: Surrogate Key

- We will use the Adminer web application.
- Let’s alter the course table in the tinyu database.
- Add an ID column as a surrogate key.
- Add a course to the table.
- Alter the table and set the primary key to the surrogate key.
- Add the same course, and there’s no problem. We will fix this later in the demo.

Demo: Surrogate Keys

The End

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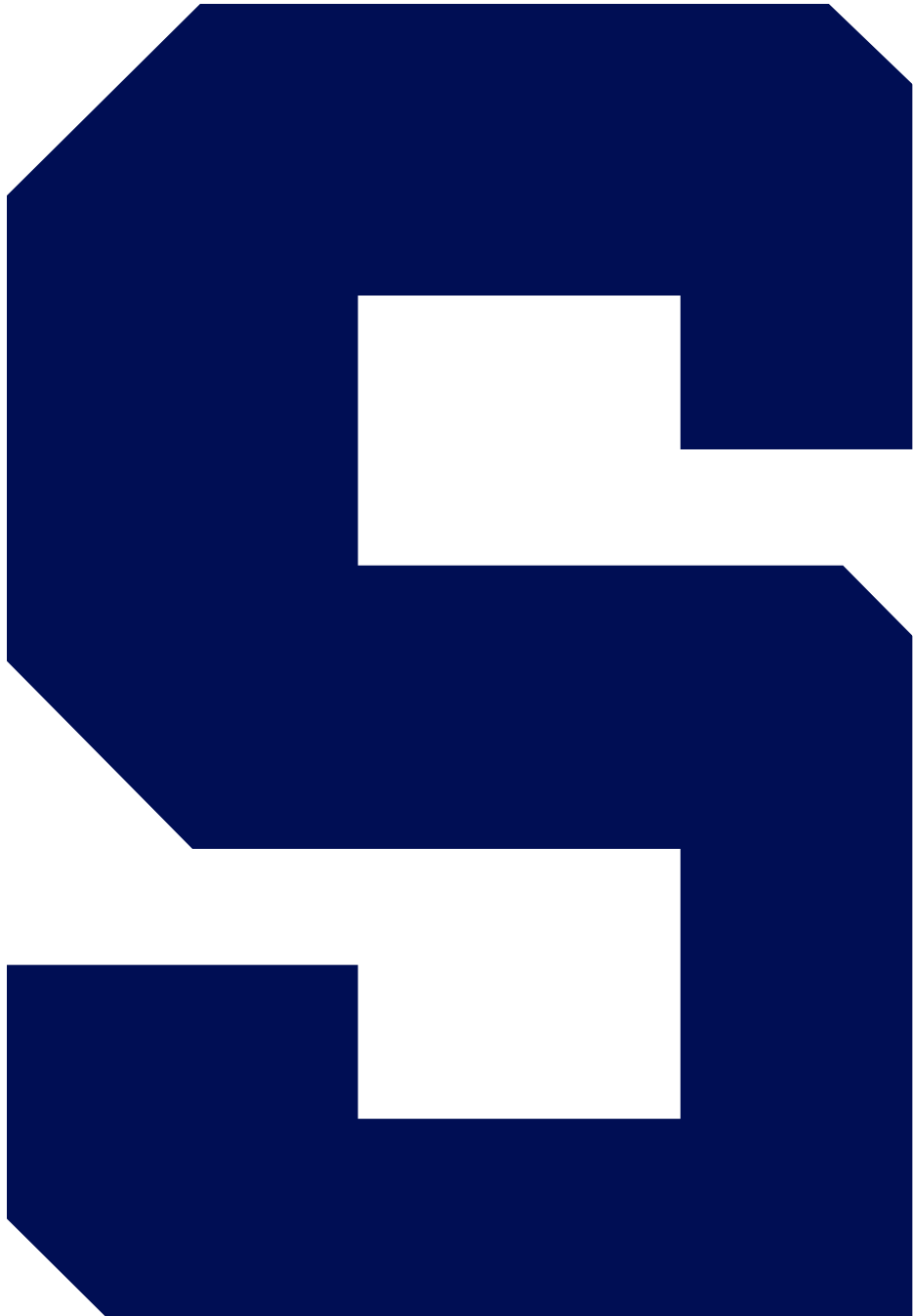
Data Domains



Data Domains

Physical domain: how data in the column are physically stored

Logical domain: acceptable values, implemented through data integrity constraints

Physical Domain: Data Types

Data type	Used for storing data as	Examples
Integer	Integer values	-100, 42, 0
Decimal	Binary encoded decimal	34.90, 12903.4827
Float	Floating point numbers; mantissa and exponent	6.02e23 1.00e3
Char	Fixed length characters of the same size	“NY”, “PA”, “NJ”
Varchar	Varying length characters of a maximum size	“Mike”, “Michael”
Date	Dates	2020-12-25
Time	Times	8:15 PM
Datetime	Dates and times together	2020-01-01 11:59AM

Logical Domain: Data Integrity Constraints

- Unique constraint: functions like a primary key constraint but does not affect the physical order of the data in the table
- Check constraint: an expression that must be true prior to data being written to the database
- Default value constraint: a value used for a data attribute when one is not specified

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Data Domains

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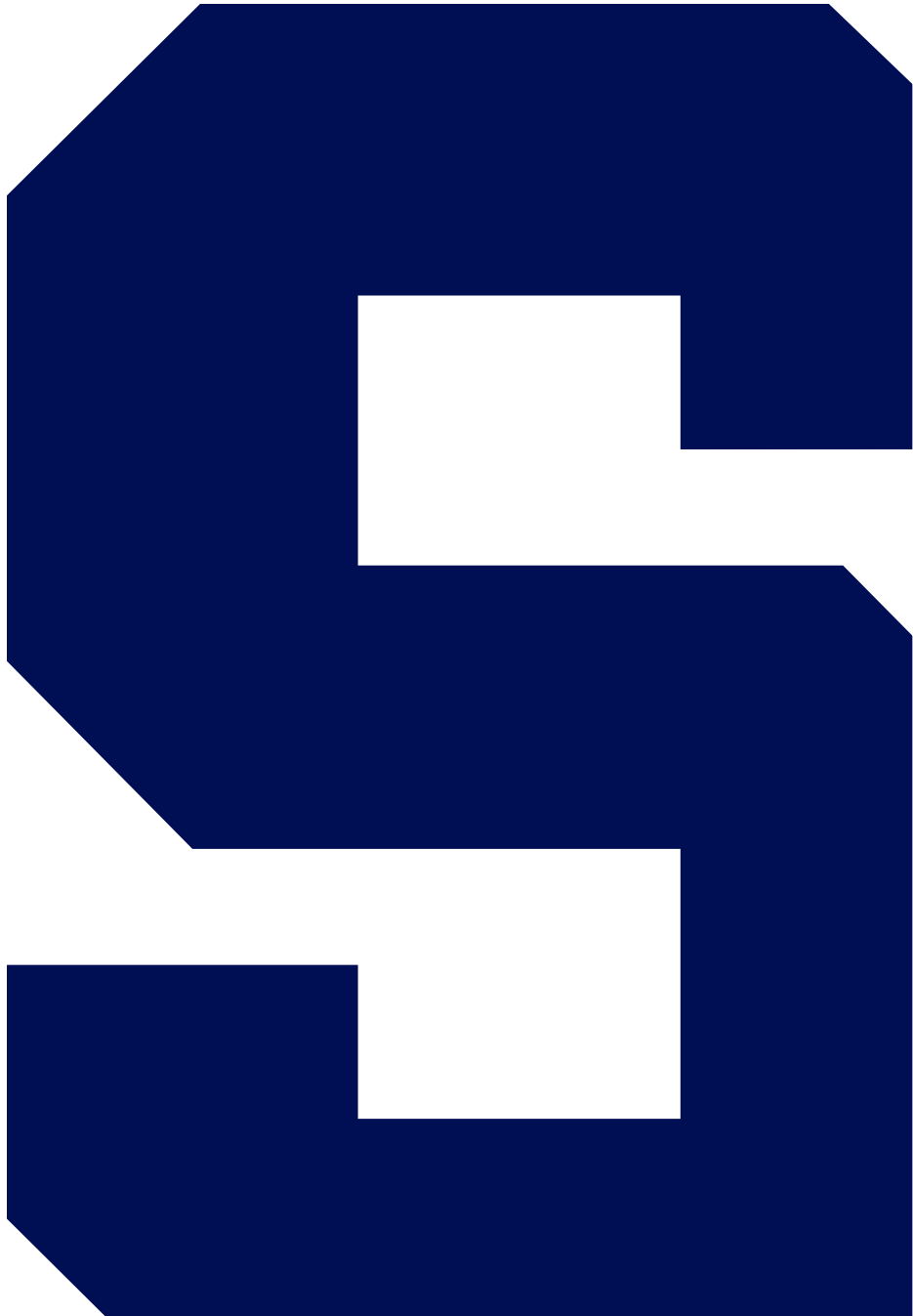

Demo

Data Domains

Demo: Data Domains

- We will use the Adminer web application.
- Let’s alter the course table in the tinyu database.
- Add course_title, course_college, and course_credits columns.
- Add a unique constraint on the course_code column.
- Add a default constraint on the course_credits column to 3.
- Add a check constraint where the course credits must be greater than or equal to 0 and less than or equal to 6.
- Test out the constraints.

Demo: Data Domains

The End

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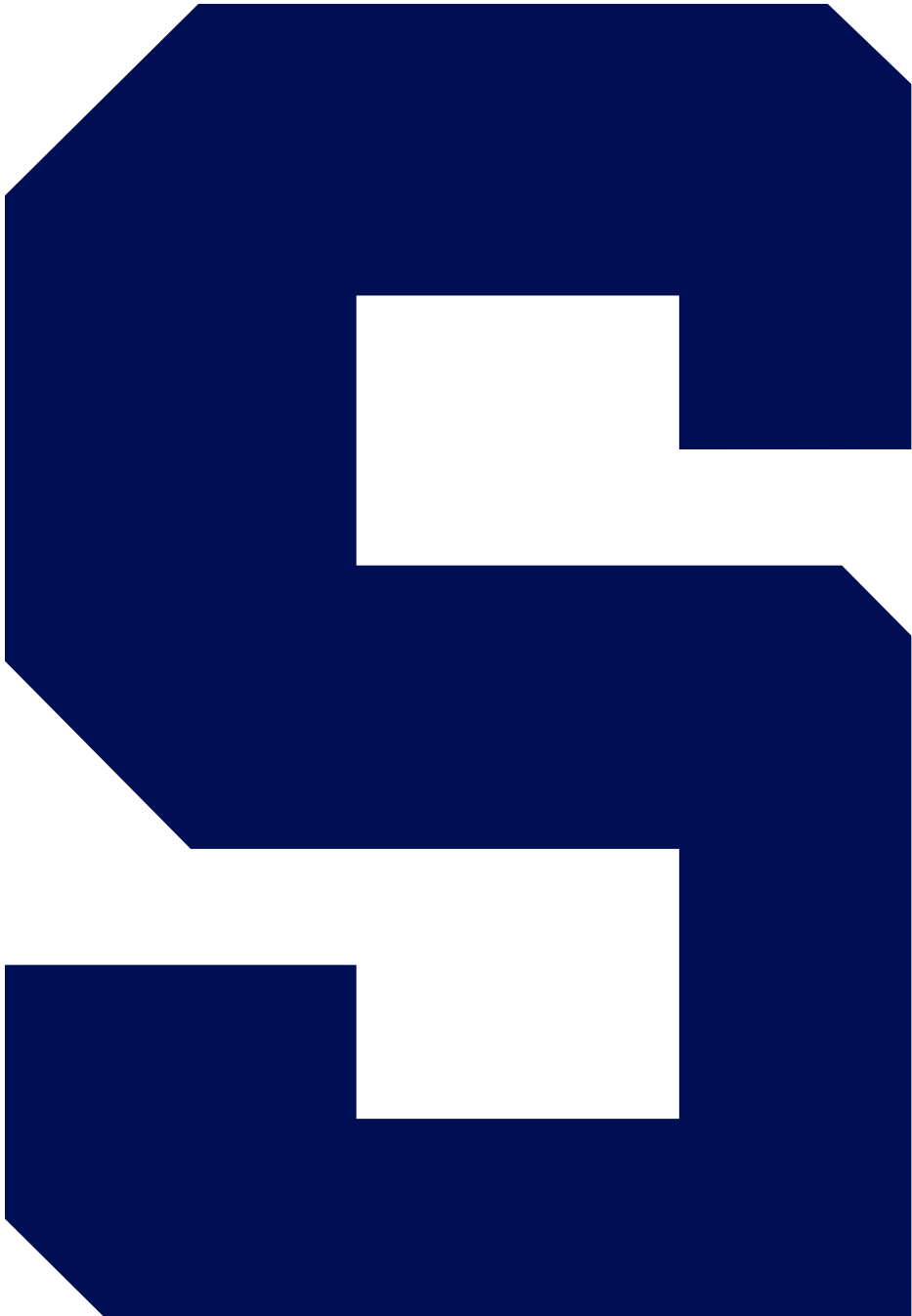
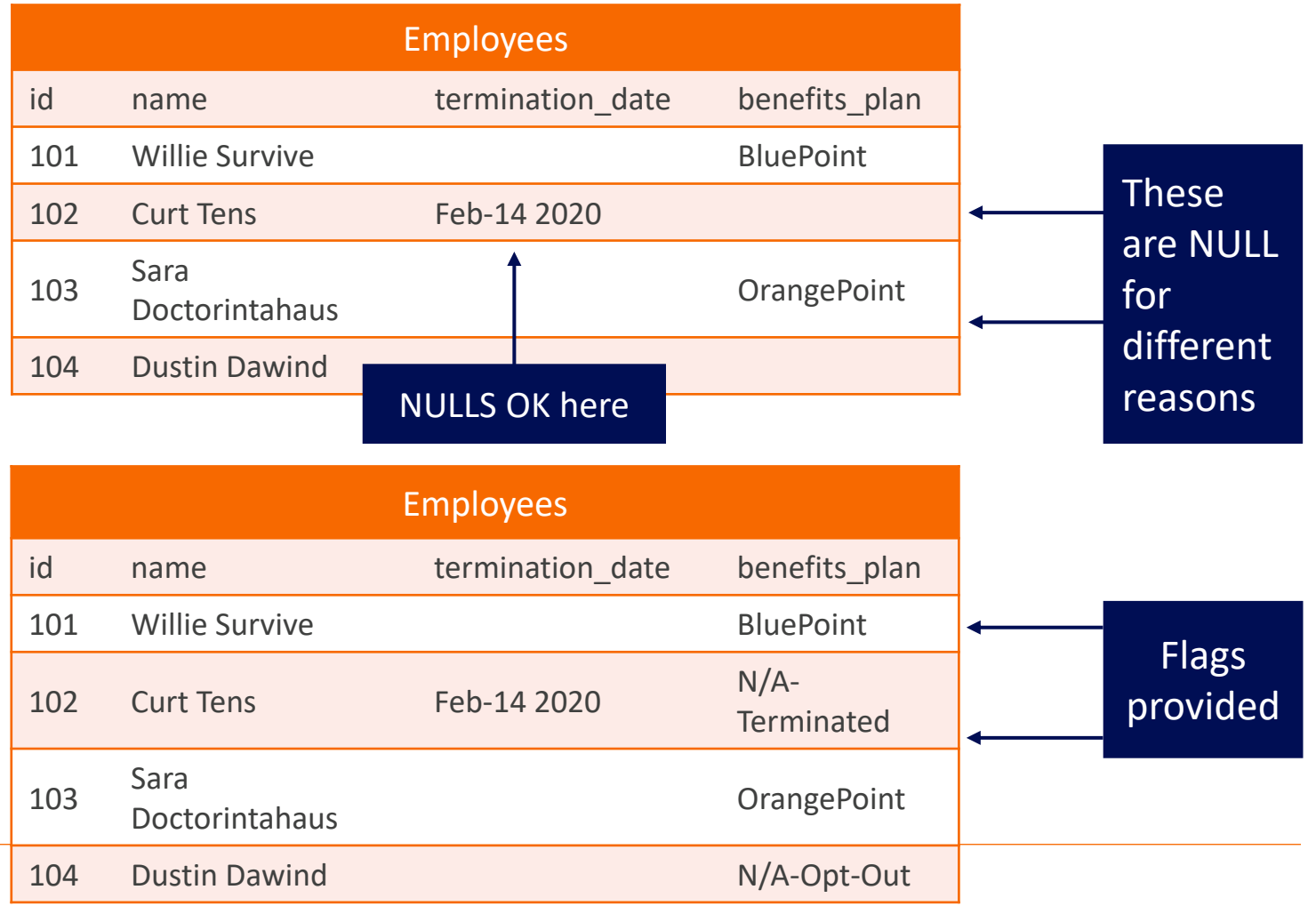


NULL and Flags

NULL and Flags

- NULL is the absence of a value.
- NULL can be problematic in some text columns.
- In this case, we use a flag—a special attribute used in place of NULL.



NULL and Flags

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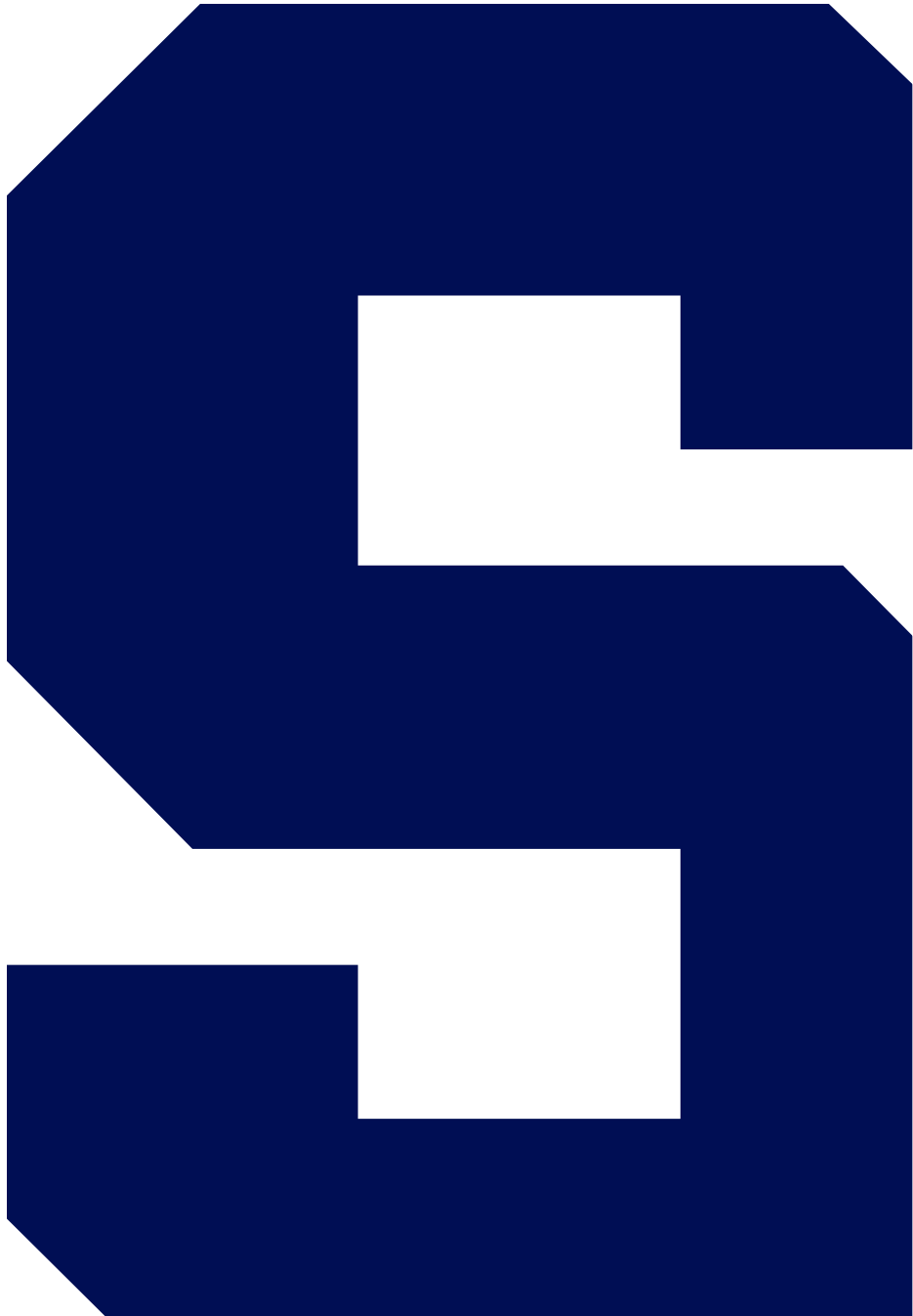
Foreign Keys and Referential Integrity



Foreign Keys and Referential Integrity

- Referential integrity is a characteristic of a column in a table that ensures the values in that column are NULL or come from the values of a primary key column in another table.
- We achieve referential integrity in the DBMS with a foreign key constraint—a constraint on a column in one table which references a primary key column in another.
- There can be several foreign key columns within a table.
- The same primary key can be referenced by several foreign keys.

Example: Foreign Keys and Referential Integrity

Joining tables on PK-FK allows you to match rows in different tables.

Employees					
id	Ssn	firstname	Lastname	hourly_rate	
13	695-25-9623	Sonny	Dayz	$	19.66
33	093-29-8015	Hugh	Japple	$	20.50
36	140-63-5030	Ally	Gator	$	18.97
66	964-09-8650	Aurora	Borealis	$	17.22

id column is set as the primary key constraint of the employees' table. This establishes entity integrity.

Paychecks				
id	payperiod	total_hours	gross_pay	employee_id
7072	3/6/2020	18	$ 341.41	36
7097	3/6/2020	7	$ 137.65	13
7108	3/6/2020	15	$ 258.29	66
7132	3/6/2020	9	$ 184.51	33
7155	3/13/2020	4	$ 78.66	13
7169	3/13/2020	20	$ 344.38	66
7194	3/13/2020	13	$ 246.57	36
7196	3/13/2020	9	$ 184.51	33
7208	3/20/2020	4	$ 75.87	36
7251	3/20/2020	21	$ 361.60	66
7257	3/20/2020	20	$ 393.29	13
7258	3/20/2020	14	$ 287.01	33

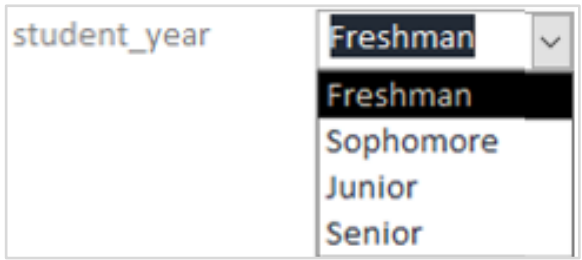
employee_id column is set as the foreign key constraint for the employees' table. Referential integrity states these values must exist as primary keys in employees or be NULL.

Lookup Tables

- Using a foreign key to restrict a column to a set of values
- Lookup tables are used in the UI for choice selection

Students				
id	firstname	lastname	gpa	student_year
1	Robin	Banks	4.000	Freshman
2	Victor	Edance	2.404	Freshman
3	Erin	Yortires	2.401	Junior
4	Aurora	Borealis	3.024	Senior
5	Tuck	Androll	3.333	Senior
6	Eura	Quittin	3.372	Senior
7	Willie	Survive	2.608	Sophomore

Foreign key



Lookup table

Academic_Years	
year_name	sort_order
Freshman	1
Sophomore	2
Junior	3
Senior	4

Primary key

Foreign Keys and Referential Integrity

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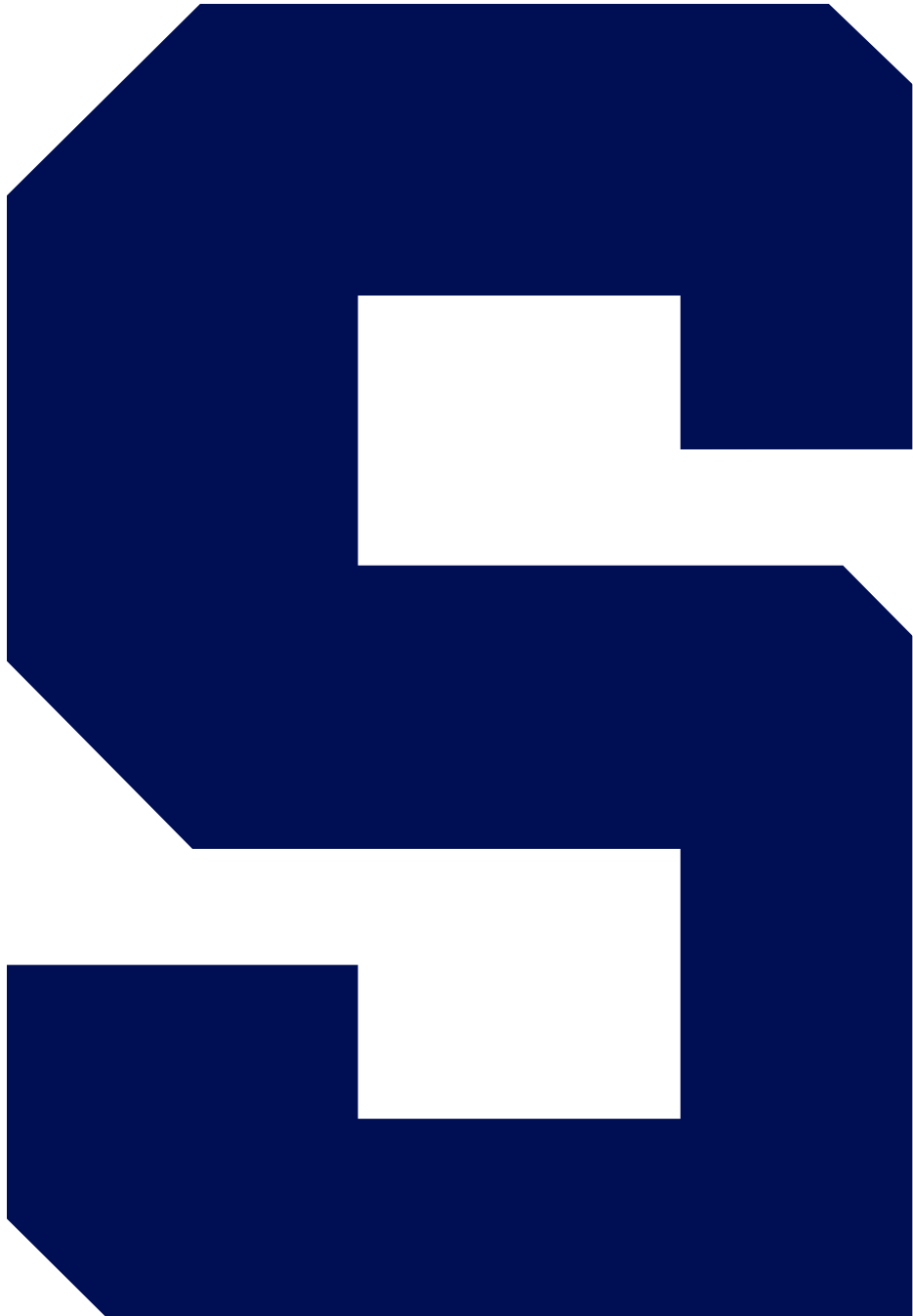

Demo

Foreign Keys

Demo: Foreign Keys

- We will use the Adminer web application.
- Let’s work with the tinyu database.
- Add a college_lookup table to restrict the course_college column in the course table.
- Add colleges to the college_lookup table.
- Demonstrate referential integrity through the foreign key constraint.

Demo: Foreign Keys

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Summary

Summary

- The DBMS table consists of rows and columns.
- It is best practice to have entity integrity on your tables via a primary key constraint.
- The best primary key is a surrogate key.
- Natural keys should have unique constraints set.
- Implement physical domain with data types.
- Implement logical domain through data integrity constraints.
- Use foreign key constraints to ensure referential integrity.

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Summary

The End