STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names of all students?

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names of all students?

{s[Name]|

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names of all students?

{s[Name]| s ϵ STUDENT}

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the details of all students who are mathematics majors.

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the details of all students who are mathematics majors.

Rephrase this as “Give the details of all students whose major is mathematics.”

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

“Give the details of all students whose major is mathematics.”

$\{s \mid s \in \text{STUDENT} \wedge s[\text{Major}] = \text{'MATH'}\}$

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the names and IDs of all mathematics majors who are juniors.

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the names and IDs of all mathematics majors who are juniors.

Can rephrase this as

“Give the names and IDs of all students whose major is mathematics and whose grade level is junior”

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

“Give the names and IDs of all students whose major is mathematics and whose grade level is junior”

$$\{s[Name],s[STID] \mid s \in STUDENT \wedge s[Major]=\text{‘MATH‘} \wedge s[GradeLevel]=\text{‘JR'}\}$$

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the IDs of all students and the courses they took in Spring 2018.

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the IDs of all students and the courses they took in Spring 2018.

All of the values are available in just the ENROLLMENT relation.

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the IDs of all students and the courses they took in Spring 2018.

{e[STID],e[ClassName]|

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the IDs of all students and the courses they took in Spring 2018.

{e[STID],e[ClassName]| e ϵ ENROLLMENT

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the IDs of all students and the courses they took in Spring 2018.

$\{e[STID], e[ClassName] \mid e \in ENROLLMENT \wedge e[Semester] = \text{‘Spring‘} \wedge e[Year] = \text{‘2018'}\}$

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the names and IDs of all students and the courses they took in Spring 2018.

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the names and IDs of all students and the courses they took in Spring 2018.

Since the student names come from one relation, and the course names come from another, we need two tuple variables, one representing tuples from the STUDENT relation and one representing tuples from the ENROLLMENT relation.

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the names and IDs of all students and the courses they took in Spring 2018.

{s[Name],s[STID],e[ClassName]| s ϵ STUDENT ∧ e ϵ ENROLLMENT

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the names and IDs of all students and the courses they took in Spring 2018.

{s[Name],s[STID],e[ClassName]| s ϵ STUDENT ∧ e ϵ ENROLLMENT

Specify the conditions the courses have to satisfy

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the names and IDs of all students and the courses they took in Spring 2018.

$$\{s[Name], s[STID], e[ClassName] \mid s \in STUDENT \wedge e \in ENROLLMENT \wedge e[Semester] = \text{‘Spring‘} \wedge e[Year] = \text{‘2018'}$$

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the names and IDs of all students and the courses they took in Spring 2018.

$$\{s[Name], s[STID], e[ClassName] \mid s \in STUDENT \wedge e \in ENROLLMENT \wedge e[Semester] = \text{‘Spring‘} \wedge e[Year] = \text{‘2018'}$$

Each STUDENT tuple needs to be linked to an ENROLLMENT tuple via a common STID value, however.

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

Give the names and IDs of all students and the courses they took in Spring 2018.

$$\{s[Name], s[STID], e[ClassName] \mid s \in STUDENT \wedge e \in ENROLLMENT \wedge e[Semester] = \text{‘Spring‘} \wedge e[Year] = \text{‘2018'} \wedge s[STID] = e[STID]\}$$

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the student numbers of all students not yet enrolled in a class?

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the student numbers of all students not yet enrolled in a class?

{s[STID]| s ∈ STUDENT

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the student numbers of all students not yet enrolled in a class?

{s[STID]| s ∈ STUDENT

If a student has not enrolled in a class then there will not be a tuple in ENROLLMENT that has that student's ID.

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the student numbers of all students not yet enrolled in a class?

{s[STID]| s ∈ STUDENT

If a student has not enrolled in a class then there will not ~~be~~ **exist** a tuple in ENROLLMENT that has that student's ID.

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the student numbers of all students not yet enrolled in a class?

$\{s[STID] \mid s \in STUDENT \wedge \neg (\exists e\ (e \in ENROLLMENT\ \wedge\ s[STID] = e[STID]))\}$

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

For each student who took a course give the student's id, name, course taken, and grade in that course.

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

For each student who took a course give the student's id, name, course taken, and grade in that course.

The name and ID of the student can come from a STUDENT tuple variable, while the information of the course and grade will come from an ENROLLMENT tuple.

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

For each student who took a course give the student's id, name, course taken, and grade in that course.

$\{s[STID], s[Name], e[ClassName], e[Grade] \mid s \in STUDENT \wedge e \in ENROLLMENT$

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

For each student who took a course give the student's id, name, course taken, and grade in that course.

$\{s[STID], s[Name], e[ClassName], e[Grade] \mid s \in STUDENT \wedge e \in ENROLLMENT$

The tuples must be connected via equal STID values.

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

For each student who took a course give the student's id, name, course taken, and grade in that course.

$$\{s[STID],s[Name],e[ClassName],e[Grade] \mid s \in STUDENT \wedge e \in ENROLLMENT \wedge s[STID]=e[STID]\}$$

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(**STID**,ClassName,Semester,Year,Grade)

What are the names and IDs of students enrolled in the class "BD445"?

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(**STID**,ClassName,Semester,Year,Grade)

What are the names and IDs of students enrolled in the class "BD445"?

Here, since the names and IDs can come from a STUDENT tuple, we take a different approach.

First we rephrase the query as follows|

“Give the names and IDs of any students for whom there is a tuple in ENROLLMENT with a ClassName of “BD445” and which contains also contains the student’s ID value.”

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(**STID**,ClassName,Semester,Year,Grade)

"Give the names and IDs of any students for whom there is a tuple in ENROLLMENT with a ClassName of "BD445" and which contains also contains the student's ID value."

$\{s[Name],s[STID] \mid s \in STUDENT \wedge \exists e\ (e \in ENROLLENT \wedge e[ClassName] = \text{“BD445”} \wedge s[STID]=e[STID])\}$

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(**STID**,ClassName**,Semester,Year,Grade**)

"Give the names and IDs of any students for whom there is a tuple in ENROLLMENT with a ClassName of "BD445" and which contains also contains the student's ID value."

$\{s[Name],s[STID] \mid s \in STUDENT \wedge \exists e\ (e \in ENROLLENT \wedge e[ClassName] = \text{“BD445”} \wedge s[STID]=e[STID])\}$

Notice that here we did not need to reference a **free** variable e in the leftmost part of our expression (that is, the part before |), but instead we **bound** e to the existential operator $\exists$ in the rightmost portion of the expression.

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and meeting times of the student "PARKS" classes?

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and meeting times of the student "PARKS" classes?

Starting out, we need names and meeting times of classes, so we set that up.

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and meeting times of the student "PARKS" classes?

{c[Name],c[Time] | c ∈ CLASS

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and meeting times of the student "PARKS" classes?

{c[Name],c[Time] | c ∈ CLASS

Now we need to match these with classes that actually had students enrolled in them, so we find the CLASSES that had an ENROLLMENT

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and meeting times of the student "PARKS" classes?

$\{c[Name],c[Time] \mid c \in CLASS \wedge \exists e\ (e \in ENROLLMENT \wedge c[Name] = e[ClassName]$

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and meeting times of the student "PARKS" classes?

$\{c[Name],c[Time] \mid c \in CLASS \wedge \exists e\ (e \in ENROLLMENT \wedge c[Name] = e[ClassName]$

Out of all of these classes, however, we want to further restrict them to those in which there was a student with the name "PARKS" enrolled.

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and meeting times of the student "PARKS" classes?

$$\{c[Name],c[Time] \mid c \in CLASS \wedge \exists e\,(e \in ENROLLMENT \wedge e[ClassName] = c[Name] \wedge \exists s\,(s \in STUDENT \wedge s[Name] = \text{'PARKS'} \wedge s[STID] = e[STID]))\}$$

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and meeting times of the student "PARKS" classes?

$$\{c[Name],c[Time] \mid c \in CLASS \wedge \exists e\,(e \in ENROLLMENT \wedge e[ClassName] = c[Name] \wedge \exists s\,(s \in STUDENT \wedge s[Name] = \text{'PARKS'} \wedge s[STID] = e[STID]))\}$$

Note that the e in e[STID] is not free, but is bound to that of $\exists e$

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every class?

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every class?

First we establish the values we seek and a tuple variable for those values

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every class?

{s[Name],s[STID] | s ∈ STUDENT

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every class?

{s[Name],s[STID] | s ∈ STUDENT

Next we want to examine every class, one-at-a-time

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every class?

$\{s[Name], s[STID] \mid s \in STUDENT \wedge \forall c\ (c \in CLASS$

Next we want to examine every class, one-at-a-time

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every class?

$\{s[Name],s[STID] \mid s \in STUDENT \wedge \forall c\ (c \in CLASS$

Next we want to examine every class, one-at-a-time, and apply two conditions to it:

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every class?

$\{s[Name],s[STID] \mid s \in STUDENT \wedge \forall c\ (c \in CLASS \rightarrow$

Next we want to examine every class, one-at-a-time, and apply two conditions to it:

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every class?

$\{s[Name],s[STID] \mid s \in STUDENT \wedge \forall c\ (c \in CLASS \rightarrow$

Next we want to examine every class, one-at-a-time, and apply two conditions to it:

- The class must have had an ENROLLMENT.

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every class?

$\{s[Name],s[STID] \mid s \in STUDENT \wedge \forall c\ (c \in CLASS \rightarrow \exists e\ (e \in ENROLLMENT \wedge e[ClassName]=c[Name]$

Next we want to examine every class, one-at-a-time, and apply two conditions to it:

- The class must have had an ENROLLMENT.

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every class?

$\{s[Name],s[STID] \mid s \in STUDENT \wedge \forall c\ (c \in CLASS \rightarrow \exists e\ (e \in ENROLLMENT \wedge e[ClassName]=c[Name]$

Next we want to examine every class, one-at-a-time, and apply two conditions to it:

- The class must have had an ENROLLMENT.
- The student whose tuple we are considering must have been among those enrolled in it.

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every class?

$$\{s[\text{Name}],s[\text{STID}] \mid s \in \text{STUDENT} \wedge \forall c\ (c \in \text{CLASS} \rightarrow \exists e\ (e \in \text{ENROLLMENT} \wedge e[\text{ClassName}]=c[\text{Name}] \wedge s[\text{STID}]=e[\text{STID}]))\ \}$$

Next we want to examine every class, one-at-a-time, and apply two conditions to it:

- The class must have had an ENROLLMENT.
- The student whose tuple we are considering must have been among those enrolled in it.

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every class?

$$\{s[\text{Name}],s[\text{STID}] \mid s \in \text{STUDENT} \wedge \forall c\ (c \in \text{CLASS} \rightarrow \exists e\ (e \in \text{ENROLLMENT} \wedge e[\text{ClassName}]=c[\text{Name}] \wedge s[\text{STID}]=e[\text{STID}]))\ \}$$

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every class?

$$\{s[\text{Name}],s[\text{STID}] \mid s \in \text{STUDENT} \wedge \forall c\ (c \in \text{CLASS} \rightarrow \exists e\ (e \in \text{ENROLLMENT} \wedge e[\text{ClassName}]=c[\text{Name}] \wedge s[\text{STID}]=e[\text{STID}]))\ \}$$

Why did we use "$\rightarrow$" instead of "$\wedge$"?

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every MWF8 class?

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every MWF8 class?

The query starts out the same as in the previous problem.

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every MWF8 class?

{s[Name],s[STID] | s ∈ STUDENT ∧ ∀c (c ∈ CLASS

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every MWF8 class?

{s[Name],s[STID] | s ∈ STUDENT ∧ ∀c (c ∈ CLASS

But now we want to qualify the tuple variable c to those that meet MWF8

STUDENT(STID,Name,Major,GradeLevel,Age)

CLASS(Name,Time,Room)

ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every MWF8 class?

$\{s[Name],s[STID] \mid s \in STUDENT \wedge \forall c\ (c \in CLASS \wedge c[Time]='MWF8'$

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every MWF8 class?

{s[Name],s[STID] | s ∈ STUDENT ∧ ∀c (c ∈ CLASS ∧ c[Time]='MWF8'

Now we complete the rest of the query expression as before

STUDENT(STID,Name,Major,GradeLevel,Age)
CLASS(Name,Time,Room)
ENROLLMENT(STID,ClassName,Semester,Year,Grade)

What are the names and IDs of any students who have taken every MWF8 class?

$$\{s[\text{Name}],s[\text{STID}] \mid s \in \text{STUDENT} \wedge \forall c\ ((c \in \text{CLASS} \wedge c[\text{Time}]=\text{'MWF8'}) \rightarrow \exists e\ (e \in \text{ENROLLMENT} \wedge e[\text{ClassName}]=c[\text{Name}] \wedge s[\text{STID}]=e[\text{STID}]))\ \}$$