EECS-317 Data Management and Information Processing

Lecture 4 – GROUP BY and INNER JOINs

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Announcements

- First HW assignment is due Monday night.

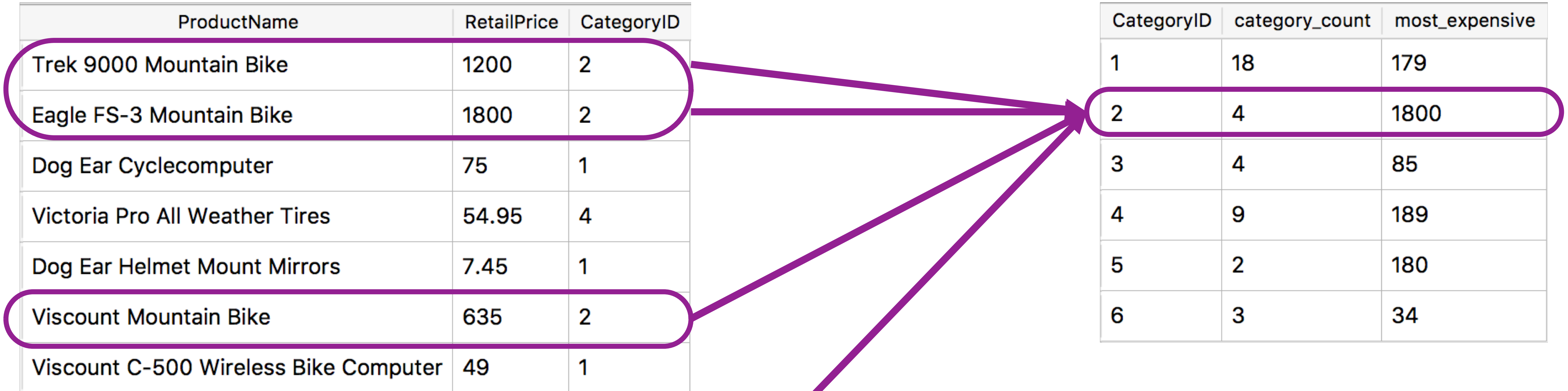
Last lecture: Integer division, aggregation, subqueries

- When dividing two **integers**, the result is always rounded down.
  - You may have to multiply by 1.0 in your SQL formulas to convert to **floats**.
- COUNT, SUM, MIN, MAX, AVG are **aggregation** functions
  - Operate on all rows unless GROUP BY is used.
- **Subqueries** can be used to replace a single value, list of values, or an entire table in a parent query.
- Answered ten sample questions in class.

GROUP BY explained

- GROUP BY combines multiple rows into one row in the result.
- Rows with the same value for the *grouping criterion* are grouped.
- An aggregation function should be applied.

```
SELECT CategoryID, COUNT(*) AS category_count,
       MAX(RetailPrice) AS most_expensive_price
  FROM Products GROUP BY CategoryID;
```



ProductName	RetailPrice	CategoryID
Trek 9000 Mountain Bike	1200	2
Eagle FS-3 Mountain Bike	1800	2
Dog Ear Cyclecomputer	75	1
Victoria Pro All Weather Tires	54.95	4
Dog Ear Helmet Mount Mirrors	7.45	1
Viscount Mountain Bike	635	2
Viscount C-500 Wireless Bike Computer	49	1

CategoryID	category_count	most_expensive
1	18	179
2	4	1800
3	4	85
4	9	189
5	2	180
6	3	34

The GROUP BY expression

“GROUP BY **x**” means:

- Each row in the output will represent many aggregated rows having the same value for **x**.
- Thus, the number of rows in the result is the number of distinct values taken by **x** (after the WHERE filtering).
- Usually it’s just the name of a column, but it can be an arbitrary expression.

SELECT category, AVG(price) FROM product **GROUP BY category**

Table "product"

id	name	price	category
1	Quart Skim Milk	2.49	3
2	Rye Bread	1.99	1
3	1lb Butter	5.99	3
4	32oz Yogurt	4.99	3
5	Navel Orange (each)	0.89	2
6	Pineapple (each)	1.99	2
7	English Muffins	3.99	1
8	Spinach (bunch)	1.49	2
9	Carrots (lb bag)	0.99	2
10	Dozen Eggs	2.49	3

Output

category	AVG(price)
1	2.99
2	1.34
3	3.99

This is a typical GROUP BY example.

SELECT price, COUNT(*)
FROM product **GROUP BY price** ORDER BY price

Table “product”

id	name	price	category
1	Quart Skim Milk	2.49	3
2	Rye Bread	1.99	1
3	1lb Butter	5.99	3
4	32oz Yogurt	4.99	3
5	Navel Orange (each)	0.89	2
6	Pineapple (each)	1.99	2
7	English Muffins	3.99	1
8	Spinach (bunch)	1.49	2
9	Carrots (lb bag)	0.99	2
10	Dozen Eggs	2.49	3

Output

price	COUNT(*)
0.89	1
0.99	1
1.49	1
1.99	2
2.49	2
3.99	1
4.99	1
5.99	1

This is a typical GROUP BY example.

```
SELECT category, price
FROM product GROUP BY category
```

Table "product"

id	name	price	category
1	Quart Skim Milk	**2.49**	3
2	Rye Bread	**1.99**	1
3	1lb Butter	5.99	3
4	32oz Yogurt	4.99	3
5	Navel Orange (each)	**0.89**	2
6	Pineapple (each)	1.99	2
7	English Muffins	3.99	1
8	Spinach (bunch)	1.49	2
9	Carrots (lb bag)	0.99	2
10	Dozen Eggs	2.49	3

Output

category	price
1	1.99
2	0.89
3	2.49

This GROUP BY is weird. ☹

It's missing an aggregation function (like SUM, MIN, etc.). It prints a random price for each category.

SELECT id, name FROM product **GROUP BY id**

Table “product”

id	name	price	category
1	Quart Skim Milk	2.49	3
2	Rye Bread	1.99	1
3	1lb Butter	5.99	3
4	32oz Yogurt	4.99	3
5	Navel Orange (each)	0.89	2
6	Pineapple (each)	1.99	2
7	English Muffins	3.99	1
8	Spinach (bunch)	1.49	2
9	Carrots (lb bag)	0.99	2
10	Dozen Eggs	2.49	3

Output

id	name
1	Quart Skim Milk
2	Rye Bread
3	1lb Butter
4	32oz Yogurt
5	Navel Orange (each)
6	Pineapple (each)
7	English Muffins
8	Spinach (bunch)
9	Carrots (lb bag)
10	Dozen Eggs

This GROUP BY is useless because **id** is always different. ☹

SELECT AVG(price)
FROM product **GROUP BY "hello"**

Table "product"

id	name	price	category
1	Quart Skim Milk	2.49	3
2	Rye Bread	1.99	1
3	1lb Butter	5.99	3
4	32oz Yogurt	4.99	3
5	Navel Orange (each)	0.89	2
6	Pineapple (each)	1.99	2
7	English Muffins	3.99	1
8	Spinach (bunch)	1.49	2
9	Carrots (lb bag)	0.99	2
10	Dozen Eggs	2.49	3

Output

AVG(price)
2.73

This GROUP BY is weird. ☹ "hello" is the same for every row, so it always aggregates all rows to one output row.

AVG would have given the same result without any GROUP BY.

SELECT category=2, AVG(price) FROM product **GROUP BY category=2**

Table "product"

id	name	price	category
1	Quart Skim Milk	2.49	3
2	Rye Bread	1.99	1
3	1lb Butter	5.99	3
4	32oz Yogurt	4.99	3
5	Navel Orange (each)	0.89	2
6	Pineapple (each)	1.99	2
7	English Muffins	3.99	1
8	Spinach (bunch)	1.49	2
9	Carrots (lb bag)	0.99	2
10	Dozen Eggs	2.49	3

Output

category=2	AVG(price)
0 *(false)*	3.6566667
1 *(true)*	1.34

This is an advanced GROUP BY example.

It divides the rows into two groups, those with category=2 in one group and everything else in the other group.

Prints the average price of fruits & vegetables vs the average price of other foods.

What if you need to combine data from multiple tables?

1. **`FROM`** chooses <u>the table of interest</u>
2. `WHERE` throws out irrelevant rows
3. `GROUP BY` identifies rows to combine
4. `SELECT` tells what values to return (allowing math and aggregation)
5. `HAVING` throws out irrelevant rows (after aggregation)
6. `ORDER BY` sorts
7. `LIMIT` throws out rows based on their position in the results

A subquery can draw data from another table, but JOINs are a more powerful way to use multiple tables.

JOINs create ***virtual*** tables from several tables

- Normalizing this staff directory left us with three tables
- This split eliminated redundant information, but now we have to look in three different tables to answer some questions.

staff			
id	***name***	***room***	***departmentId***
11	Bob	100	1
20	Betsy	100	2
21	Fran	101	1
22	Frank	102	4
35	Sarah	200	5
40	Sam	10	7
54	Pat	102	2

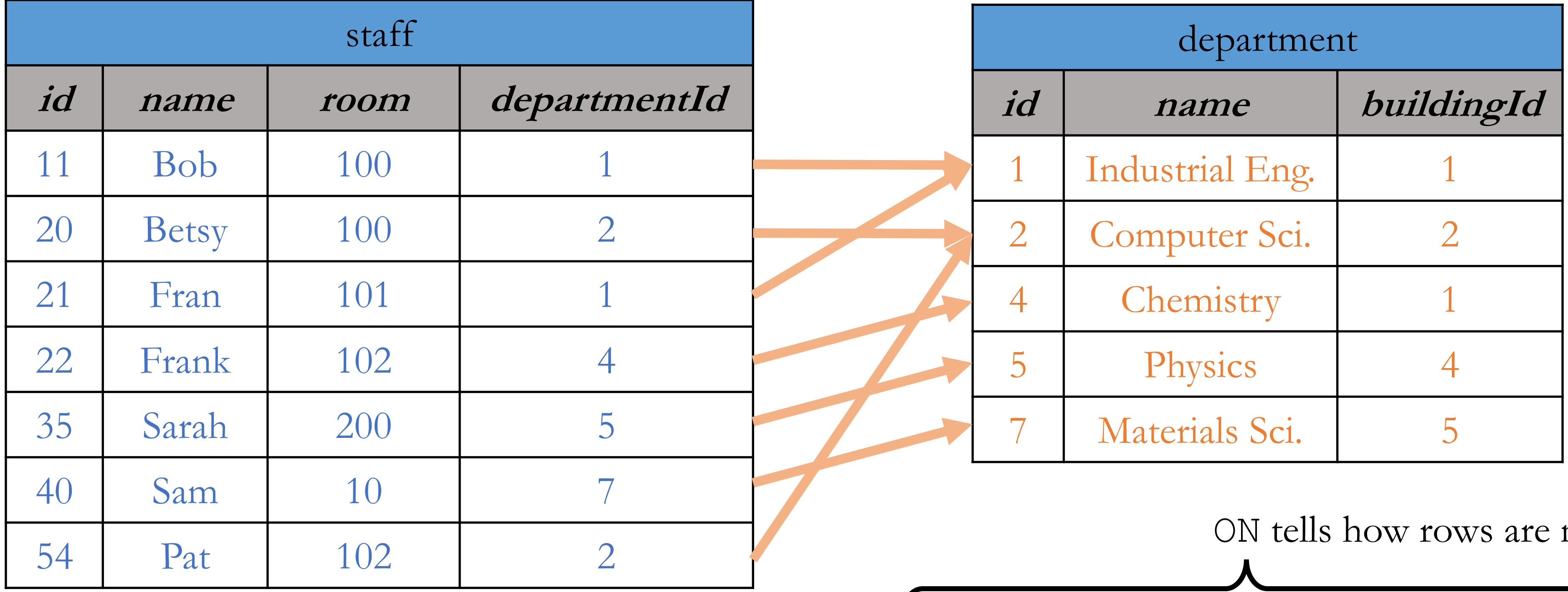
department		
id	***name***	***buildingId***
1	Industrial Eng.	1
2	Computer Sci.	2
4	Chemistry	1
5	Physics	4
7	Materials Sci.	5

building		
id	***name***	***faxNumber***
1	Tech	1-1000
2	Ford	1-5003
4	Mudd	1-2005
5	Cook	1-3004
6	Garage	1-6001

What if we want to print the staff directory?

staff					
id	***name***	***department***	***building***	***room***	***faxNumber***
11	Bob	Industrial Eng.	Tech	100	1-1000
20	Betsy	Computer Sci.	Ford	100	1-5003
21	Fran	Industrial Eng.	Tech	101	1-1000
22	Frank	Chemistry	Tech	102	1-1000
35	Sarah	Physics	Mudd	200	1-2005
40	Sam	Materials Sci.	Cook	10	1-3004
54	Pat	Computer Sci.	Ford	102	1-5003

We can generate a virtual table like this with INNER JOIN



staff			
id	***name***	***room***	***departmentId***
11	Bob	100	1
20	Betsy	100	2
21	Fran	101	1
22	Frank	102	4
35	Sarah	200	5
40	Sam	10	7
54	Pat	102	2

department		
id	***name***	***buildingId***
1	Industrial Eng.	1
2	Computer Sci.	2
4	Chemistry	1
5	Physics	4
7	Materials Sci.	5

ON tells how rows are matched

```
SELECT * FROM staff JOIN department ON staff.departmentId=department.id
```

staff.***id***	staff.***name***	***staff.room***	staff.***departmentId***	department.***id***	department.***name***	department.***buildingId***
11	Bob	100	1	1	Industrial Eng.	1
20	Betsy	100	2	2	Computer Sci.	2
21	Fran	101	1	1	Industrial Eng.	1
22	Frank	102	4	4	Chemistry	1
35	Sarah	200	5	5	Physics	4
40	Sam	10	7	7	Materials Sci.	5
54	Pat	102	2	2	Computer Sci.	2

How JOIN builds a composite table

```
SELECT * FROM staff JOIN department
              ON staff.departmentId=department.id
```

Start with the first table (staff)

Join with rows from the 2nd table (department) that match according to the `ON` columns

staff.***id***	staff.***name***	***staff.room***	staff.***departmentId***	department.***id***	department.***name***	department.***buildingId***
11	Bob	100	1	1	Industrial Eng.	1
20	Betsy	100	2	2	Computer Sci.	2
21	Fran	101	1	1	Industrial Eng.	1
22	Frank	102	4	4	Chemistry	1
35	Sarah	200	5	5	Physics	4
40	Sam	10	7	7	Materials Sci.	5
54	Pat	102	2	2	Computer Sci.	2

Just print the columns we need

```
SELECT staff.id, staff.name, staff.room,
       department.name, department.buildingId
  FROM staff JOIN department
       ON staff.departmentId=department.id
```

staff.*id*	staff.*name*	staff.*room*	department.*name*	department.*buildingId*
11	Bob	100	Industrial Eng.	1
20	Betsy	100	Computer Sci.	2
21	Fran	101	Industrial Eng.	1
22	Frank	102	Chemistry	1
35	Sarah	200	Physics	4
40	Sam	10	Materials Sci.	5
54	Pat	102	Computer Sci.	2

Reorder and **rename** the columns

```
SELECT staff.id AS staffID, staff.name AS name,
       department.name AS department,
       department.buildingId AS buildingId, staff.room AS room
  FROM staff JOIN department
       ON staff.departmentId=department.id
```

staffId	*name*	*department*	*buildingId*	*room*
11	Bob	Industrial Eng.	1	100
20	Betsy	Computer Sci.	2	100
21	Fran	Industrial Eng.	1	101
22	Frank	Chemistry	1	102
35	Sarah	Physics	4	200
40	Sam	Materials Sci.	5	10
54	Pat	Computer Sci.	2	102

JOIN to the third table

```
SELECT staff.id AS staffId, staff,name, department.name AS department,
       building.name AS building, staff.room AS room,
       building.faxNumber AS faxNumber
  FROM staff JOIN department
       ON staff.departmentId=department.id
       JOIN building ON department.buildingId=building.id
```

staffId	*name*	*department*	*building*	*room*	*faxNumber*
11	Bob	Industrial Eng.	Tech	100	1-1000
20	Betsy	Computer Sci.	Ford	100	1-5003
21	Fran	Industrial Eng.	Tech	101	1-1000
22	Frank	Chemistry	Tech	102	1-1000
35	Sarah	Physics	Mudd	200	1-2005
40	Sam	Materials Sci.	Cook	10	1-3004
54	Pat	Computer Sci.	Ford	102	1-5003

Who teaches the largest class & what is the average grade?

- Instructor names are in **Staff** table
- Instructor→class assignments are in **Faculty_Classes** table.
- Class enrollments are in **Student_Schedules** table
- Can use two subqueries to answer the first part of the question:
  - Get the largest class:
    ```
    SELECT ClassID FROM Student_Schedules GROUP BY ClassID ORDER BY COUNT(*) DESC LIMIT 1;
    ```
  - Get the instructor ID of that class:
    ```
    SELECT StaffID FROM Faculty_Classes WHERE ClassID=…
    ```
  - Get the instructor name:
    ```
    SELECT StfFirstName, StfLastName FROM Staff WHERE StaffID=…
    ```

```
SELECT StfFirstName, StfLastName FROM Staff
WHERE StaffID=
(SELECT StaffID FROM Faculty_Classes WHERE ClassID=
  (SELECT ClassID FROM Student_Schedules
   GROUP BY ClassID ORDER BY COUNT(*) DESC LIMIT 1));
```

Who teaches the largest class & what is the average grade?

- *Alternative approach:*
  Use JOINs to create a composite table listing instructors, classes, and their average grades:

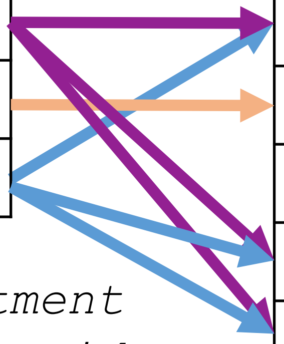
```
SELECT Student_Schedules.ClassID, StfLastname, AVG(Grade)

FROM Student_Schedules
  JOIN Faculty_Classes ON
    Student_Schedules.ClassID=Faculty_Classes.ClassID
  JOIN Staff ON
    Faculty_Classes.StaffID = Staff.StaffID

GROUP BY Student_Schedules.ClassID
ORDER BY COUNT(*) DESC LIMIT 1;
```

Using INNER JOIN, what if rows don't match one-to-one?

staff			
id	***name***	***room***	***departmentId***
11	Bob	100	1
20	Betsy	100	2
21	Fran	101	1



department		
id	***name***	***buildingId***
1	Industrial Eng.	1
2	Computer Sci.	2
4	Chemistry	1
1	Physics	4
1	Materials Sci.	5

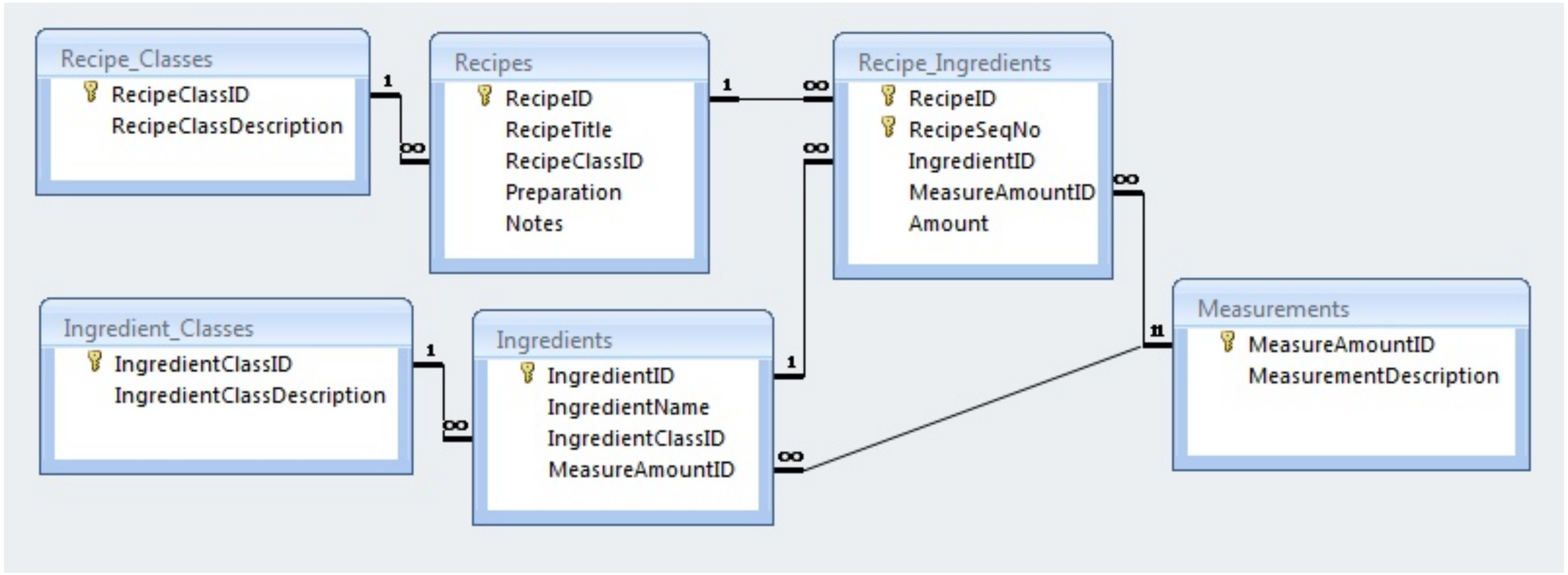
In output,

- multiple matches leads to multiple rows.
- no matches leads to no rows

```
SELECT * FROM staff JOIN department
ON staff.departmentId=department.id
```

staff.***id***	staff.***name***	***staff.room***	staff.***departmentId***	department.***id***	department.***name***	department.***buildingId***
11	Bob	100	1	1	Industrial Eng.	1
11	Bob	100	1	1	Physics	4
11	Bob	100	1	1	Materials Sci.	5
20	Betsy	100	2	2	Computer Sci.	2
21	Fran	101	1	1	Industrial Eng.	1
21	Fran	101	1	1	Physics	4
21	Fran	101	1	1	Materials Sci.	5

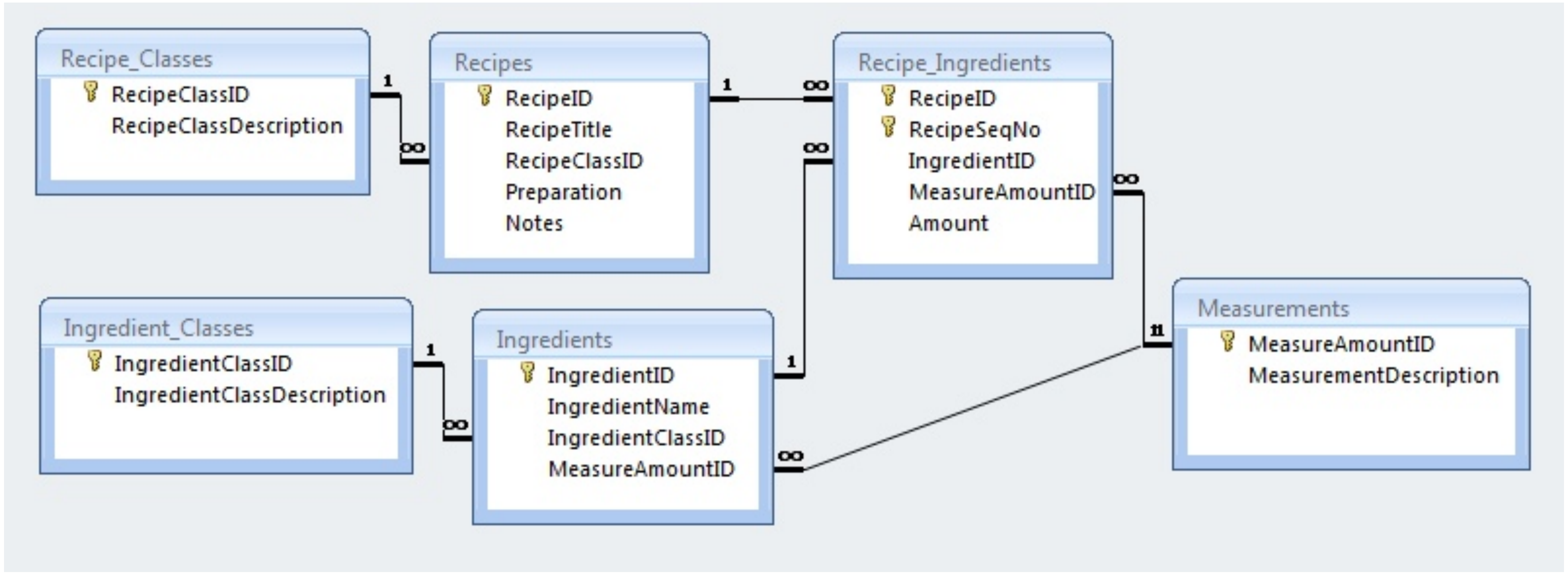
(Recipes.sqlite) Print the recipe for Irish Stew (RecipeID = 1)



(Recipes.sqlite) Print the recipe for Irish Stew (RecipeID = 1)

```
SELECT RecipeSeqNo, Amount,
  Measurements.MeasurementDescription, IngredientName
FROM
  Recipe_Ingredients JOIN Ingredients
    ON Recipe_Ingredients.IngredientId
       = Ingredients.IngredientID
  JOIN Measurements
    ON Recipe_Ingredients.MeasureAmountID
       = Measurements.MeasureAmountID
WHERE RecipeId=1
ORDER BY RecipeSeqNo;
```

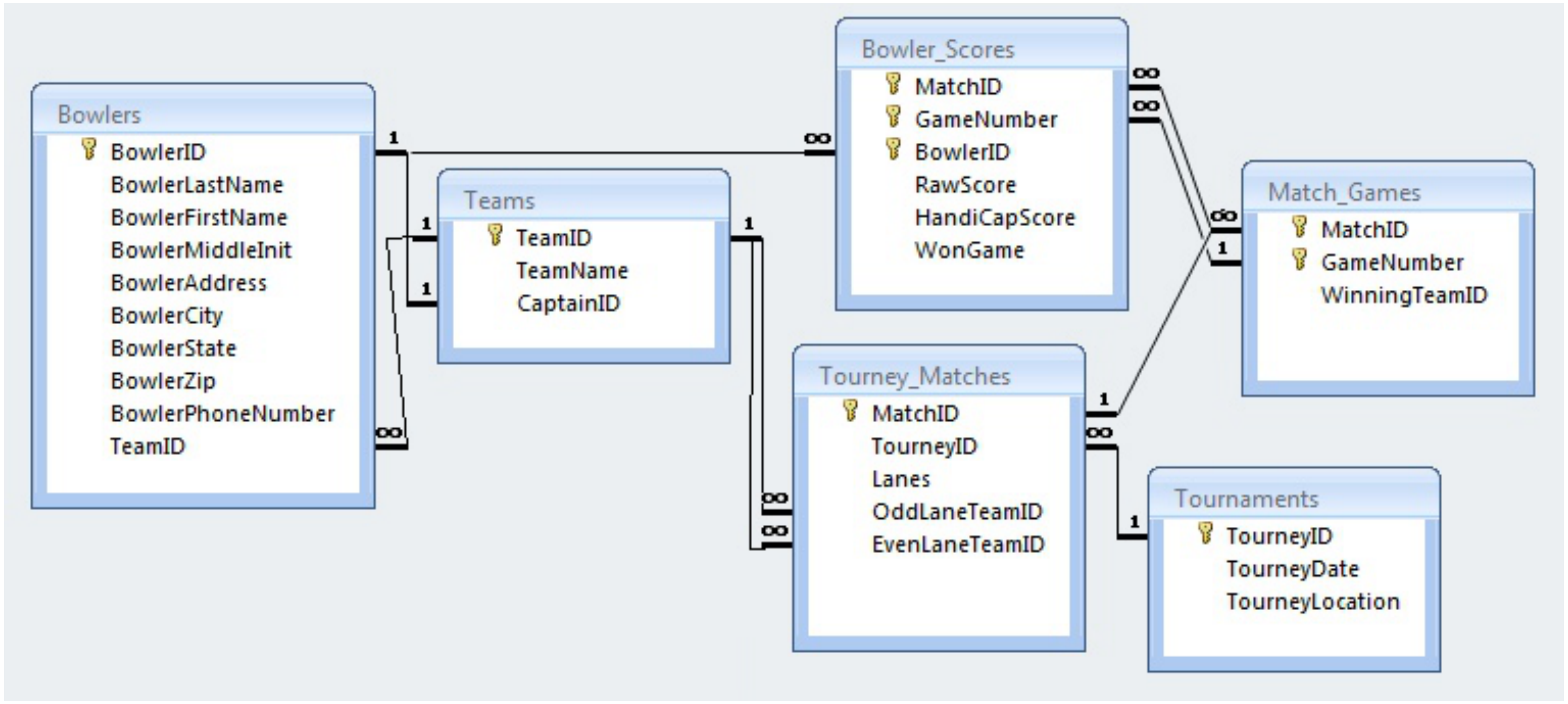
What is the name of the recipe with the most ingredients?
(Can be done with either a subquery or a JOIN)



What is the name of the recipe with the most ingredients?

```
SELECT RecipeTitle, COUNT(*) AS numIngredients
FROM
  Recipe_Ingredients JOIN Recipes
    ON Recipes.RecipeID
       = Recipe_Ingredients.RecipeID
ORDER BY numIngredients DESC
LIMIT 1
GROUP BY Recipes.RecipeID
```

(BowlingLeague.sqlite) Print a schedule of all the team matchups over the whole season (Date, Location, TeamName, TeamName)

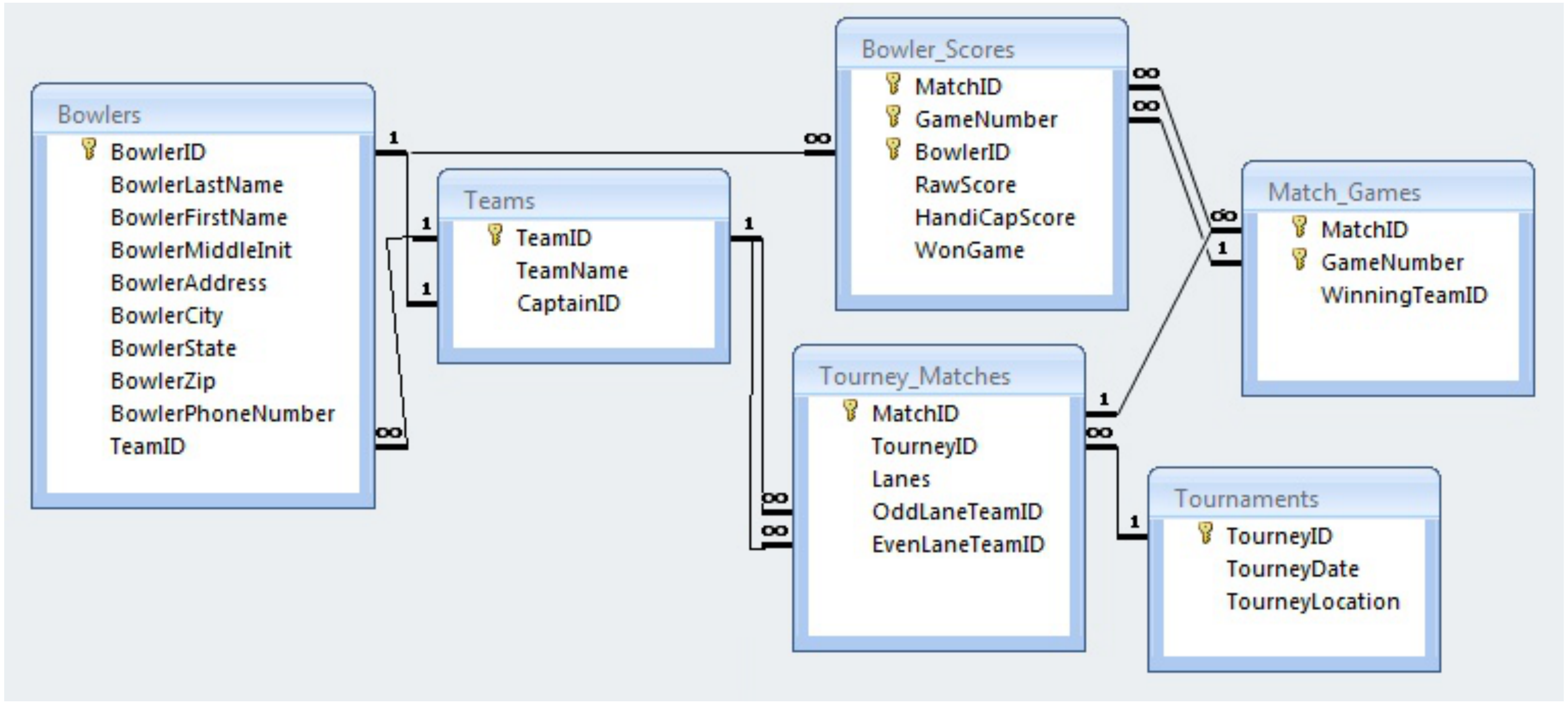


Print a schedule of all the team matchups over the whole season (Date, Location, TeamName, TeamName)

```
SELECT TourneyDate, TourneyLocation, OddTeam.TeamName,
       EvenTeam.TeamName

FROM
  Tourney_Matches JOIN Tournaments
    ON Tourney_Matches.TourneyID = Tournaments.TourneyID
  JOIN Teams AS OddTeam
    ON OddLaneTeamID=OddTeam.TeamID
  JOIN Teams AS EvenTeam
    ON EvenLaneTeamID = EvenTeam.TeamID
```

Print game results for Tournament #1, including bowler names, team names, & raw score



Print game results for Tournament #1, including bowler names, team names, & raw score

```
SELECT
   Bowler_Scores.MatchID, GameNumber, TeamName,
   BowlerFirstName || " " || BowlerLastName AS Bowler,
   RawScore
FROM
   Bowler_Scores JOIN Tourney_Matches
      ON  Bowler_Scores.MatchID = Tourney_Matches.MatchID
   JOIN Bowlers
      ON Bowlers.BowlerID = Bowler_Scores.BowlerID
   JOIN Teams
      ON Bowlers.TeamID = Teams.TeamID
WHERE TourneyId=1
```