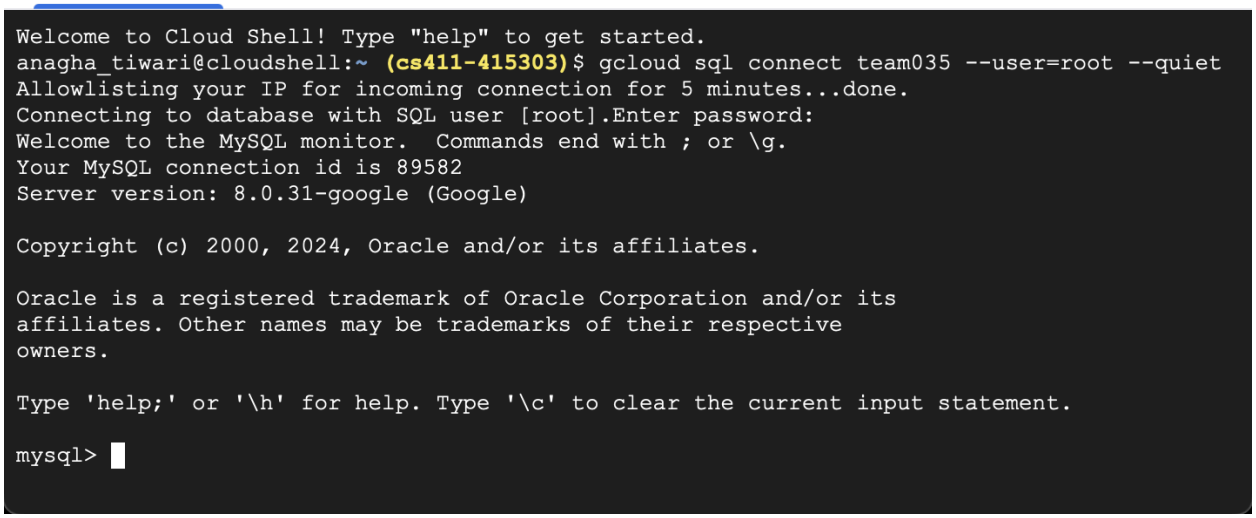
TEAM 035 STAGE 3

Provide a screenshot of the connection (i.e. showing your terminal/command-line information):



DDL Commands:
In total, we have 5 tables. Their DDL command code is shown below:

```
CREATE TABLE User (
UserID VARCHAR(255),
UserName VARCHAR(100),
Password VARCHAR(20),
PRIMARY KEY (UserID)
);

CREATE TABLE Recipe (
   RecipeTitle VARCHAR(225),
   Ingredients TEXT,
   Directions TEXT,
   PRIMARY KEY (RecipeTitle)
);

CREATE TABLE Food (
FoodName VARCHAR(225),
Fat INT,
Protein INT,
Carbs INT,
Measures INT,
Category VARCHAR(255),
PRIMARY KEY (FoodName)
);
```

```
CREATE TABLE Favorites (
FavoriteID VARCHAR(255),
DateAdded int,
UserID VARCHAR(255),
PRIMARY KEY (FavoriteID, UserID)
);

CREATE TABLE MyRecipes (
RecipeTitle VARCHAR(255),
Ingredients TEXT,
Directions TEXT,
UserID VARCHAR(255),
PRIMARY KEY (RecipeTitle, UserID)
);
```

(We know we should use this DDL for the Favorites and MyRecipes table but it did not work on GCP when we put the foreign key in the DDL command so we used DDL command written above.

```
CREATE TABLE Favorites (
FavoriteID VARCHAR(255),
DateAdded int,
UserID VARCHAR(255),
PRIMARY KEY (FavoriteID, UserID),
FOREIGN KEY (UserID) REFERENCES User(UserID)
);

CREATE TABLE MyRecipes (
RecipeTitle VARCHAR(255),
Ingredients TEXT,
Directions TEXT,
UserID VARCHAR(255),
PRIMARY KEY (RecipeTitle),
FOREIGN KEY (UserID) REFERENCES User(UserID)
);
)
```

(In our diagram in Stage 2, we had ThumbsUp as an attribute in MyRecipes. But we decided to remove this since we will rank users with other factor to rank the users such as how many recipes they uploaded as shown in query 4.

Also, we set type of Recipe.Ingredients, Recipe.Directions, MyRecipes.Ingredients, MyRecipes.Directions to JSON ARRAY in Stage 2, but we changed those into TEXT since that JSON ARRAY type caused syntax error.)

```
CREATE TABLE have (
RecipeTitle varchar(255),
FoodName varchar(255),
PRIMARY KEY (RecipeTitle, FoodName));

CREATE TABLE Contains (
FavoriteID varchar(255),
RecipeTitle varchar(255),
PRIMARY KEY (FavoriteID, RecipeTitle));
```

Inserting at least 1000 rows in at least 3 tables. (You should do a count query to show this):
As shown below, our 3 tables: User, Food, and Recipe have at least 1000 rows each.

```
mysql> SELECT COUNT(*) FROM User;
+----------+
| COUNT(*) |
+----------+
|     1100 |
+----------+
1 row in set (0.00 sec)

mysql> SELECT COUNT(*) FROM Food;
+----------+
| COUNT(*) |
+----------+
|     1188 |
+----------+
1 row in set (0.01 sec)

mysql> SELECT COUNT(*) FROM Recipe;
+----------+
| COUNT(*) |
+----------+
|     1127 |
+----------+
1 row in set (0.01 sec)
```

SQL QUERIES:

1. Filter out the recipes using ingredients that contain proteins more than 15g.

Get the average value of protein per category by using Group by. Select the categories that have an average value of proteins that is greater than 15 in the subquery. Then use the selected categories to filter out the recipes that use the ingredients in those categories. Recipe table is joined with Food table by seeing the Food.FoodName is found in Recipe.Ingredients.

This query will be used for the filtering functionality that helps the user to find the recipes that include a specific amount of some nutrition; such as recipes that include carbs less than 10, and recipes that include fat less than 5.

```
SELECT r.RecipeTitle, r.Ingredients, r.Directions
FROM Recipe r JOIN Food f ON r.Ingredients LIKE CONCAT('%', f.FoodName, '%')
WHERE f.Category IN (
    SELECT Category
    FROM Food
    GROUP BY Category
    HAVING AVG(Protein) > 15
) LIMIT 15;
```

```
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
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------------------------------------------------------------------+
| RecipeTitle                    | Ingredients
                                                                                                                                    | Directions


                                                                  |
+--------------------------------+--------------------------------------------------------------------------------------------------------------------------------------------------------------------
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------------------------------------------------------------------+
| Apple Nut Ring                 | ["1 1/3 c. oil", "2 c. sugar", "2 eggs", "3 c. flour", "1/4 tsp. salt", "1 tsp. baking soda", "2 tsp. cinnamon", "1 can apple pie filling", "1 c. chopped pecans"]
                                                                                                                                    | ["Beat together first three ingredients.", "Mix together in separate bowl all dry ingredients.", "Add oi
l mixture to dry mixture.", "Puree apple pie filling and add to mixture along with chopped pecans.", "Bake at 350\u00b0 in greased and floured tube pan for 1 hour and 15 minutes.", "Freezes well."]"
Cream Cheese Fruit Squares,"["1 1/2 c. sugar, divided in half", "1/3 c. butter", "1 1/2 c. graham cracker crumbs", "8 oz. cream cheese", "4 eggs", "1 tsp. vanilla", "1 can fruit topping mix (cherry, blueberry, apple or boysenberry)"]
                                                                                                              |
| Creole Green Beans             | ["1 green pepper, chopped", "1 onion, chopped", "2 tbsp. bacon drippings", "1 tbsp. flour", "1 tsp. salt", "1 tsp. sugar", "dash of paprika", "1 (16 oz.) can tomatoes", "1 (16 oz.) can green peas"]
                                                                                                                                    | ["Saute green pepper and onion in hot bacon drippings until tender. Add flour, salt, sugar and paprika."
, "Stir until blended. Add tomatoes and simmer for about 15 minutes.", "Stir in green peas; heat through and serve."]"
Banana Bread,"["2 eggs", "3 bananas, cut in small pieces", "1 stick butter, cut in small pieces", "1 c. sugar", "1 3/4 c. flour", "3/4 tsp. soda", "1 1/4 tsp. cream of tartar", "1 c. chopped nuts (optional)"]
                                                                                                                                                                                  |
| Cornbread Salad                | ["2 pkg. jiffy cornbread mix, cooked, cooled and crumbled", "1 1/2 c. chopped onion", "1 medium green pepper, chopped", "3 medium firm tomatoes", "8 to 10 slices bacon, cooked, drained and crumbled", "1
1/2 c. cubed light velveeta cheese", "1 1/2 c. salad dressing or mayo", "2 tbsp. mustard", "salt and pepper to taste"]               | ["Mix well and let set overnight.", "Will make 2 quarts and 1 pint.", "You can cut this in half."]"
Ham And Rice Casserole,"["1 can cream of mushroom soup", "1/2 c. milk", "1 1/3 c. precooked rice", "1 c. diced ham"]

                                                                     |
| Corn Okra Casserole            | ["1 green pepper, sliced", "1 onion, sliced", "1/2 lb. bacon, fried and crumbled", "1 can whole kernel corn, drained", "1 can creamed corn", "1 can okra and tomatoes or frozen okra or fresh smothered okr
a (much better)", "8 to 10 oz. grated cheddar cheese"]                                                                               | ["Put in buttered baking dish a layer of okra, layer of creamed corn, layer of onion, green pepper, baco
n and layer of whole kernel corn.", "Top with grated cheese.", "Cover and bake for 1 hour at 375\u00b0. Serves 6 to 8."]"
Apple Crisp Pie,"["1 graham cracker crust", "1 large egg yolk", "5 1/2 c. sliced apples", "1 tbsp. lemon juice", "1/2 c. sugar", "1/4 c. light brown sugar", "3 tbsp. all-purpose flour", "1/4 tsp. salt", "1/2 tsp. ground cinnamon", "1/4 ts
p. ground nutmeg", "3/4 c. all-purpose flour", "1/4 c. sugar", "1/4 c. light brown sugar", "1/3 c. butter"]                                                                 |
| Clam Chowder                   | ["6 to 8 lean slices diced bacon", "2 c. diced, cooked potatoes", "1 c. diced onion", "2 cans minced clams, drained (reserve 1 c. clam juice)", "2 c. half and half", "1 c. water", "2 tbsp. butter", "salt
 and pepper to taste"]                                                                                                               | ["Dice bacon and onion. Saute in soup pot. Add remaining ingredients.", "Heat; do not boil.", "May be th
ickened, if necessary."]"
Easy Cranberry Relish,"["2 small pkg. fresh cranberries", "1 c. sugar (or more if you like)", "1 whole orange", "walnuts"]

                                          |
| Brown Gravy                    | ["4 tbsp. bacon drippings", "1 tsp. salt", "3 tbsp. self-rising flour", "2 c. whole milk"]
                                                                                                                                    | ["Add bacon grease, salt and flour.", "Stir until brown.", "Add milk slowly, stirring until thickens.",
"Serves 8."]"
Italian Pasta And Bean Soup(Pasta E Fagioli),"["1 clove garlic, crushed", "3 tbsp. oil", "1 (16 oz.) can tomatoes or 2 c. chopped fresh tomatoes", "2 (13 3/4 oz.) cans beef broth", "1 tbsp. minced parsley", "1/2 tsp. salt", "1/4 tsp. fres
h ground pepper", "1/8 tsp. basil", "1/8 tsp. oregano", "1 (16 oz.) can white beans, drained", "1/2 lb. ditalini pasta or elbow pasta, cooked \"al dente\"", "grated cheese"]
                                                      |
| Broccoli-Raisin Salad          | ["1 bunch broccoli heads", "2 stems green onion (single stalks) or 1/2 medium whole onion", "1/4 c. sunflower seeds", "1/2 c. raisins", "6 slices bacon, fried and cooled", "1/2 c. mayonnaise", "2 tbsp. v
inegar", "1/8 c. sugar"]                                                                                                             | ["Mix broccoli, onion, sunflower seeds, raisins and bacon."]"
"Low-Fat "French Fries"

                                                                                                             |
| Broccoli Cauliflower Salad     | ["1 head broccoli, chopped", "1/2 head cauliflower, chopped", "red onion, chopped to taste", "shredded low-fat cheese", "bacon bits", "1 c. fat-free miracle whip", "3 pkg. sweet 'n low", "2 tbsp. vinegar
"]                                                                                                                                   | ["Mix together the Miracle Whip, Sweet 'N Low and vinegar.", "Pour over chopped vegetables.", "Add bacon
```

```
onion and bacon.", "Add remaining ingredients. Bake in bean pot at 350\u00b0 for 35 to 40 minutes."]"
Cranberry Relish,"["1 lb. cranberries", "1 c. raisins", "1 2/3 c. sugar", "1 c. water", "1 1/2 tsp. ginger", "1 tsp. cinnamon", "1/2 tsp. cloves", "1/2 c. celery", "1 c. chopped apple"]

                                                                                                                                                                                  |
| Bacon-Flavored Chicken Breasts | ["8 boneless chicken breasts", "1 jar chipped beef", "8 slices bacon", "1 can cream of mushroom soup", "1 c. sour cream"]
                                                                                                                                                                                              | ["Spri
nkle chipped beef in bottom of baking dish.", "Wrap chicken breasts with bacon.", "Mix sour cream and soup together and pour over chicken.", "Bake at 350\u00b0 for about 1 hour."]"
Decadent Fudge Cake,"["1 c. butter or margarine, softened", "1 1/2 c. sugar", "4 eggs", "1/2 tsp. baking soda", "1 c. buttermilk", "2 1/2 c. all-purpose flour", "1 1/2 c. semi-sweet chocola
te mini morsels, divided", "2 (4 oz.) bars sweet baking chocolate, melted and cooled", "1/3 c. chocolate syrup", "2 tsp. vanilla extract", "4 oz. white chocolate, chopped", "2 tbsp. plus 2
tsp. shortening, divided", "chocolate and white chocolate leaves (optional)"] |
| Bacon Nuts                     | ["1 can water chestnuts, drained (8 oz.)", "1/4 c. soy sauce", "1/2 lb. bacon"]
                                                                                                                                                                                              | ["Soak
 water chestnuts in soy sauce for 4 hours.", "Wrap each chestnut in a 1/2 strip of bacon and secure with a toothpick. Broil until brown."]"
Pina Colada Cake,"["1 box duncan hines butter cake mix", "4 eggs", "1/2 c. oil", "1 c. water", "1 can cream of coconut", "1 can crushed pineapple (optional)", "1 large cool whip", "flaked c
oconut"]
                                                                                                                             |
| Bacon Corn Chowder             | ["1/2 lb. bacon, cut in 1/2 inch pieces", "4 medium potatoes, cut in 1/2 inch cubes", "1 medium onion, chopped", "2 c. cream-style corn", "2 c. whole kern
el corn", "2 c. milk", "2 tsp. salt", "pepper to taste"]                                                                                                                                      | ["Cook
 potatoes and drain.", "Fry bacon, then brown onion in fat. Add rest of ingredients.", "Simmer 10 minutes."]"
Quick Freezer Fudge,"["1 box confectioners sugar", "1/2 c. cocoa", "1/4 tsp. salt", "1/4 c. milk", "1 tbsp. vanilla", "1/2 c. butter", "1 c. chopped nuts"]

                                                                                                                                                      |
| Bacon And Egg Breakfast Bake   | ["4 oz. fully cooked canadian bacon or ham, cut into small cubes", "1/2 c. finely chopped muenster, cheddar or monterey jack cheese", "4 eggs", "1 1/2 c.
skim milk", "1/2 tsp. pepper"]                                                                                                                                                                | ["Preh
eat oven to 450\u00b0.", "Spread bacon in bottom of 9-inch pie plate.", "Sprinkle with cheese.", "Beat eggs with milk and pepper. Pour over cheese.", "Bake for 15 minutes.", "Reduce heat to
 350\u00b0. Bake for 10 to 15 minutes longer, until browned and firm in center.", "Place pie plate on wire rack to cool for 10 minutes.", "Cut in wedges.", "Yields 10 servings, 249 calories
 per serving."]"
Spiced Tea,"["1 1/4 c. tang", "1/2 c. sugar", "1/3 c. instant tea", "1/2 tsp. cinnamon", "1/4 tsp. cloves", "dash of salt"]
                                                          |
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15 rows in set (0.01 sec)
```

2. Filter out the recipes that use ingredients from some specific categories (e.g. Dairy products and Seafood is selected).

Filter out ingredients that use ingredients in the Dairy products category.
Join the Food table (where it was filtered out by seeing if the category of the food is Dairy products) with Recipe tables by seeing if the Food.FoodName is included in the Recipe.Ingredients. Then do the same thing for the category Seafood.
Finally, use set operator Intersect to output all of the recipes that use Dairy products and Seafood.

This query will be used to filter out the recipes according to the user's category selection when we give the recipe recommendation on our app.

```
(
SELECT r.RecipeTitle, r.Ingredients, r.Directions
FROM Recipe r
JOIN Food f ON r.Ingredients LIKE CONCAT('%', f.FoodName, '%')
WHERE f.Category = 'Dairy products'
)
INTERSECT
(
SELECT r.RecipeTitle, r.Ingredients, r.Directions
FROM Recipe r
JOIN Food f ON r.Ingredients LIKE CONCAT('%', f.FoodName, '%')
WHERE f.Category LIKE '%Seafood'
) LIMIT 15;
```

RecipeTitle	Ingredients	Directions
Baked Tuna Chow Mein Casserole	["1 c. chopped celery", "1/4 c. chopped onion", "1/4 c. chopped green pepper", "1 tbsp. butter", "1 (7 oz.) can tuna", "1 (10 1/2 oz.) can cream of mushroom soup, thinned with 1/4 c. milk and 1/4 c. water", "3 oz. (1 1/2 c.) chow mein noodles (save 1/3 c. for topping)", "1 can water chestnuts", "3/4 c. (4 oz.) salted cashew nuts", "1/8 tsp. pepper"]	["Heat oven to 350\u00b0.", "Saute celery, onion and green pepper in butter.", "Mix in rest of ingredients; pour into buttered 1 1/2-quart baking dish.", "Sprinkle with 1/3 cup chow mein noodles. Bake 30 minutes.", "Makes 4 to 6 servings."]"
Simple Turkey Casserole	["3 c. cooked turkey", "1 c. diced potatoes", "1 c. cut celery", "1 c. mushroom soup", "cracker crumbs"]	
Battered Fried Fish	["1 (1 lb.) haddock", "salt", "1 egg", "1 1/4 c. evaporated milk", "1 c. flour", "2 tsp. baking powder", "1/4 c. cornmeal"]	["Cut haddock", "into serving-size pieces, sprinkle lightly with salt.", "Mix\t1/4 teaspoon salt with remaining ingredients, dip haddock pieces into", "egg mixture.", "Fry in deep fat at 375\u00b0 for 5 minutes or until brown."]"
Vanilla Pudding	["3/4 c. sugar", "2 c. milk, scalded", "5 round tbsp. flour", "2 eggs, slightly beaten", "dash of salt", "1 tbsp. butter or margarine", "1 tsp. vanilla"]	
Cheesy Salmon Loaf	["1 can salmon, drained and deboned", "1/3 c. celery, chopped", "1/3 c. onion, chopped", "3 eggs", "1 c. cheddar cheese, shredded", "1 tbsp. lemon juice", "1/2 tsp. salt", "1/8 tsp. pepper", "1/2 c. bread crumbs", "1/2 c. mayonnaise"]	["Combine together all ingredients.", "Bake in a loaf pan at 350\u00b0 for about 45 minutes."]"
Tuna Marbels	["1 (8 oz.) can tuna, drained", "1 tbsp. minced onion", "1 tsp. lemon juice", "1/2 tbsp. mustard", "1 egg", "1/2 c. oatmeal", "cracker or bread crumbs"]	
Crab Meat Bisque	["3 cans cream of celery soup", "3 cans milk", "1/2 tsp. old bay seasoning", "1 box cooked, chopped broccoli", "1 stick butter", "1 lb. crab meat"]	["Mix and heat ingredients and add crab meat at the end."]"
Virginia'S Christmas Salad	["1 (3 oz.) cherry jell-o", "1 c. boiling water", "1/4 c. nuts", "1/2 c. chopped celery", "1 can whole cranberry sauce", "1 c. sour cream", "1/2 c. diced apple"]	
Crab Mold(Dip)	["1/4 c. mayonnaise", "1 can cream of mushroom soup", "6 oz. cream cheese", "1 envelope unflavored gelatin", "3 tbsp. cold water", "3 green onions, chopped", "1/4 c. chopped celery", "1 small jar chipped pimentos", "dash of salt and pepper or seasoning of choice (mrs. dash is good)", "1 (7 oz.) can crab meat"]	["Cream mayonnaise and cream cheese together.", "Warm soup in small pan.", "Dissolve gelatin in water and add to soup.", "Add onions, celery, pimentos and seasonings into cream cheese mixture.", "Pour soup into cream cheese mixture; stir well.", "Add crab; mix well. Pour into a mold.", "Refrigerate 1 hour or more.", "Can serve from bowl like a dip or loosen by setting mold in hot water until side of mixture loosens from mold pan, then turn onto dish and serve with crackers or vegetables."]"
Fruit Dip	["3 oz. pkg. instant vanilla pudding", "8 oz. cool whip", "1 tsp. cinnamon", "1/2 tsp. cloves", "1/2 tsp. nutmeg", "2 to 3 tbsp. amaretto"]	
Crab Spread(Appetizer)	["8 oz. cream cheese", "1 tbsp. mayonnaise", "1 tbsp. worcestershire sauce", "1 tsp. lemon juice", "garlic to taste", "parsley flakes", "1 lb. cooked shrimp or crab flakes", "cocktail sauce"]	["Mix all ingredients, except parsley, shrimp (or crab) and cocktail sauce.", "Spread on glass plate.", "Top with cocktail sauce and shrimp (or crab); sprinkle with parsley.", "Serve with chips or crackers."]"
Crispy Baked Onion Rings	["2 large sweet onions", "1 (7 oz.) pkg. corn flakes", "1 tsp. seasoned salt", "2 tsp. sugar", "1 tsp. paprika", "1 c. egg substitute"]	
Crabmeat Au Gratin	["1 can cream of shrimp soup", "1/2 can milk (use soup can)", "1 lb. faux crabmeat", "4 c. celery, chopped", "1/2 c. green pepper, chopped", "2 pimentos, chopped", "2 tbsp. onions, chopped", "1/3 c. slivered almonds", "4 hard-cooked eggs, chopped", "1 c. shredded sharp cheddar cheese", "buttered bread crumbs"]	["Mix everything together, except cheese and crumbs, in casserole.", "Top with cheese, then with bread crumbs.", "Bake at 350\u00b0 for 35 minutes."]"
Hobo Stew	["2 lb. ground beef", "1/4 c. catsup", "1/4 c. mustard", "1/4 c. barbecue sauce", "2 (16 oz.) cans sliced potatoes, drained", "2 (16 oz.) cans pork and beans", "1 (16 oz.) can whole kernel corn, drained", "2 tbsp. minced onion flakes"]	
Egg Rolls	["1/2 head cabbage", "2 large carrots", "1 onion", "2 c. meat (hamburger, shredded pork, chicken, shrimp)", "2 tbsp. soy sauce", "egg roll skins"]	["Shred cabbage.", "Dice carrots and onion.", "Cook meat and drain grease.", "Add vegetables to skillet and stir-fry until crisp-tender.", "Mix in soy sauce.", "Place a heaping tablespoonful of filling in center of each egg roll skin.", "Fold in sides, then fold over long sides, sealing shut with cornstarch and water paste. Deep fry until golden brown.", "Serve with sweet and sour sauce. Any other combination of vegetables may be used."]"
Round Steaks Smothered In Onions	["2 1/2 to 3 lb. round steak", "1 large onion, sliced", "salt and pepper to taste", "1 1/2 c. flour", "3 tbsp. oil"]	
Layered Tuna Salad	["1 1/2 c. miracle whip salad dressing", "1/4 c. green onion, sliced", "2 tsp. dijon mustard", "2 (6 1/2 oz.) cans tuna, drained and flaked", "1 tsp. dill weed (optional)", "4 c. shredded lettuce", "1 1/2 c. (4 oz.) medium shell macaroni, cooked and drained", "2 c. chopped tomatoes", "2 c. chopped cucumber", "1 (10 oz.) pkg. frozen peas, thawed and drained", "6 bacon slices, crisply cooked and crumbled", "1 c. (4 oz.) shredded cheddar cheese"]	["Combine dressing, green onions and mustard; set aside.", "Toss tuna with dill.", "In a 3-quart serving bowl, layer lettuce, shells, cucumber, tomatoes, tuna, peas and bacon.", "Spread dressing mixture over bacon, sealing to edge of bowl.", "Sprinkle with cheese; cover. Chill several hours or overnight.", "Toss to serve.", "Makes 8 servings.", "Prep. Time: 25 minutes plus chilling."]"
Chicken Divan Pot Pie	["2 pet-ritz regular pie crusts", "3 tbsp. oleo", "3 tbsp. flour", "1/4 tsp. pepper", "1/2 c. chicken broth", "1/4 c. milk", "4 oz. (1 c.) shredded american cheese", "2 c. cooked and diced chicken", "1 (10 oz.) pkg. chopped broccoli, thawed and drained"]	
Lobster Sauce	["3 tbsp. butter or oleo", "3 tbsp. flour", "1 tsp. salt", "1/4 tsp. pepper", "1 c. milk", "1/2 c. cream or half and half", "1 to 1 1/2 c. cooked lobster meat"]	["Melt butter.", "Add flour and seasonings.", "Stir until smooth. Add milk and cream slowly; cook over low heat until thickened. Heat slowly.", "Do not let boil."]"
Dandy Candies	["1/3 c. honey", "1/2 c. crunchy peanut butter", "1/2 c. nonfat dry milk"]	
New England Clam Chowder(Serves 6)	["1 pt. clams (bay quahaugs)", "1/4 c. salt pork or bacon, chopped", "1/4 c. chopped onion", "1/2 tsp. salt", "dash of pepper", "1 c. clam liquor (add water to make 1 c.)", "1 c. diced potatoes", "2 c. milk", "parsley for garnish"]	["Drain clams; save liquor and chop.", "Fry salt pork or bacon until lightly brown.", "Add onion and cook until tender.", "Add liquor, potatoes and seasonings.", "Cook 15 minutes until potatoes are tender.", "Add milk and heat thoroughly.", "Stir in chopped clams and warm gently 2 to 5 minutes.", "Garnish with parsley."]"
Cheesecake	["1 large pkg. lemon jello", "2 1/4 c. graham cracker crumbs", "1 cream cheese, softened", "1 can pet milk, chilled", "1 c. sugar"]	
Quick One Dish Meal	["1 box kraft macaroni and cheese", "1 green pepper, chopped", "1 (6 oz.) can tuna", "1 small onion, chopped"]	["Prepare macaroni and cheese as directed; add green pepper, onion and tuna.", "Mix well and let set for 5 or 10 minutes with the lid on."]"
Instant Spiced Russian Tea	["1 c. tang", "1/4 c. sugar", "1/2 c. presweetened lemon flavored instant tea", "1/2 tsp. cinnamon", "1/2 tsp. ground cloves"]	
Salmon Ball	["2 c. (1 lb. can) drained, canned salmon", "1 (8 oz.) pkg. soft cream cheese", "1 tbsp. minced onion", "1/4 tsp. salt", "1 tbsp. lemon juice", "1 tsp. prepared horseradish", "chopped parsley"]	["In bowl, combine all ingredients, except parsley.", "Mix well. Refrigerate about 4 hours or until firm enough to shape into a ball.", "Shape in ball; roll in parsley (and chopped nuts, if desired).", "Refrigerate at least 1 hour before serving.", "Serve with crackers or small slices of rye bread.", "Makes 5-inch ball."]"
Veal Parmesan	["veal patties or beef patties", "mozzarella cheese", "regular cheese", "cottage cheese", "garlic", "any seasoning to match your taste", "ragu sauce"]	
Salmon Casserole Baked In Sour Cream	["1 (1 lb.) can salmon, drained and juice reserved", "1 tbsp. lemon juice", "1/2 tsp. salt", "pepper to taste", "1 c. sour cream", "1/2 tsp. dry dill weed", "1 medium onion, thinly sliced", "1 tbsp. chopped parsley"]	["Place salmon liquid in mixing bowl, add lemon juice, salt, pepper, sour cream and dill weed.", "Mix to smooth sauce.", "Break salmon in large chunks; place in greased 1-quart casserole.", "Pour sour cream sauce over salmon.", "Spread with onion; sprinkle with parsley.", "Cover and bake at 350\u00b0 for 30 minutes.", "Yields 4 servings."]"
Carrie'S Cabbage Soup	["6 c. shredded green cabbage", "1 c. chopped onion", "2 c. diced celery", "1/2 c. diced green pepper", "1/2 tsp. thyme", "1/4 tsp. marjoram", "1 tbsp. anisette", "6 peeled ripe red tomatoes", "2 pkg. dry onion soup mix", "2 cans beef bouillon", "water", "1/4 tsp. tarragon", "2 tbsp. granulated sugar", "8 oz. tomato sauce", "1 lb. ground beef, browned (optional)", "1 lb. sausage (link, polish, italian, kielbasi or ground, browned or precooked)"]	
Salmon Croquettes	["1 (14 3/4 oz.) can pink salmon, drained", "1 1/2 c. mashed potatoes", "1 small onion, grated", "1 large egg", "1/2 tsp. pepper", "1/4 c. packaged bread crumbs", "3 tbsp. vegetable oil"]	["Mix salmon, potatoes, onion, egg and pepper until blended. Form into 8 patties, each about 3/4-inch thick.", "Spread crumbs on waxed paper.", "Gently press patties in crumbs to coat.", "Heat oil in a large nonstick skillet.", "Add patties and cook over medium heat about 4 minutes per side until heated through, golden and crisp. Serves 4."]"
"Croquettes(Chicken, Fish Or Meat)		

15 rows in set (0.37 sec)

3. Show the ranking of recipes according to how many users marked those recipes as favorites.

Group by Contains.RecipeTitle and store the the count of favoriteID for each RecipeTitle into FavoriteCount. Join Favorite and Recipe tables using the Contains table. (many to many relationship, Contains is the relationship table) Then list up the RecipeTitle in descending order by the FavoriteCount.

This will be used to recommend the recipes according to which recipes are popular to the users.

```
SELECT
   c.RecipeTitle,
   COUNT(c.FavoriteID) AS FavoriteCount
FROM
   Contains c
JOIN
   Favorites f ON c.FavoriteID = f.FavoriteID
GROUP BY
   c.RecipeTitle
ORDER BY
   FavoriteCount DESC
LIMIT 15;
```

```
+---------------------------+---------------+
| RecipeTitle               | FavoriteCount |
+---------------------------+---------------+
| No-Bake Nut Cookies       |            12 |
| Creamy Corn               |             3 |
| Reeses Cups(Candy)        |             3 |
| Jewell Ball'S Chicken     |             2 |
| Chicken Funny             |             1 |
| Cheeseburger Potato Soup  |             1 |
| Rhubarb Coffee Cake       |             1 |
| Scalloped Corn            |             1 |
| Nolan's Pepper Steak      |             1 |
| Millionaire Pie           |             1 |
| Double Cherry Delight     |             1 |
| Buckeye Candy             |             1 |
| Quick Barbecue Wings      |             1 |
| Pink Stuff(Frozen Dessert) |             1 |
| Fresh Strawberry Pie      |             1 |
+---------------------------+---------------+
15 rows in set (0.00 sec)
```

4. Show the ranking of users according to how many MyRecipes they uploaded.

Join User and MyRecipes using the right outer join.
Group by UserID to get count of how many RecipeTitle was uploaded by one user and store that count to RecipesUploaded. Then make a list of UserIDs in descending order of that RecipesUploaded.
Return the list of UserName according to that UserID list and show the RecipesUploaded beside the names.

This will be used to show the ranking of users according to the contribution to encourage participation.

```
SELECT
   User.UserName,
   COUNT(MyRecipes.RecipeTitle) AS RecipesUploaded
FROM
   User
RIGHT JOIN
   MyRecipes ON User.UserID = MyRecipes.UserID
GROUP BY
   MyRecipes.UserID
ORDER BY
   RecipesUploaded DESC;
```

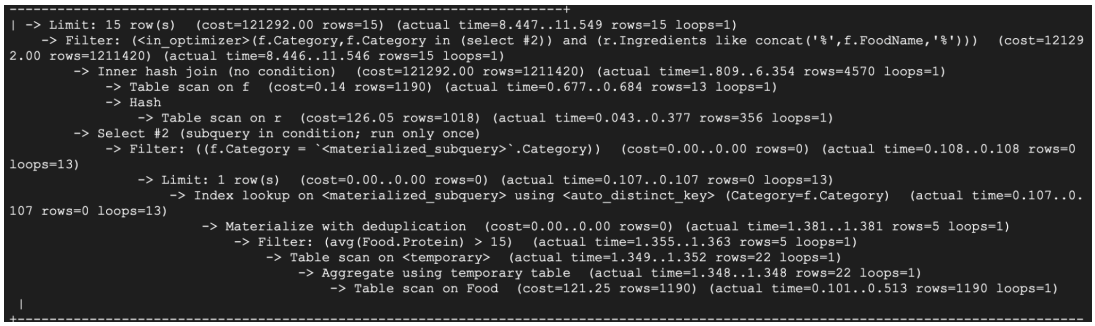
```
+--------------------+-----------------+
| UserName           | RecipesUploaded |
+--------------------+-----------------+
| Matthew Allen      |               8 |
| Mia White          |               6 |
| Olivia Smith       |               5 |
| Logan Campbell     |               4 |
| Charlotte Anderson |               4 |
| Layla Rivera       |               2 |
| Penelope Ramirez   |               1 |
| Ethan Garcia       |               1 |
| William Thomas     |               1 |
| Aria Gonzalez      |               1 |
| Henry Clark        |               1 |
| Ryan Flores        |               1 |
| Avery Young        |               1 |
| Ella Rodriguez     |               1 |
| Alexander Robinson |               1 |
| Addison Parker     |               1 |
| Abigail Lewis      |               1 |
| Victoria Evans     |               1 |
| James Moore        |               1 |
| Sophia Wilson      |               1 |
| Zoey Carter        |               1 |
| Scarlett Walker    |               1 |
| John Sanchez       |               1 |
| Daniel Lee         |               1 |
| Evelyn Martinez    |               1 |
| Nathan Collins     |               1 |
| Gabriel Perez      |               1 |
+--------------------+-----------------+
27 rows in set (0.00 sec)
```

INDEXING ANALYSIS

Advanced Query #1

```
SELECT r.RecipeTitle, r.Ingredients, r.Directions
FROM Recipe r JOIN Food f ON r.Ingredients LIKE CONCAT('%', f.FoodName, '%')
WHERE f.Category IN (
   SELECT Category
   FROM Food
   GROUP BY Category
   HAVING AVG(Protein) > 15
) LIMIT 15;
```

1. Index Design #1: No Index
   Cost: 121292.00 (using Explain Analyze command)



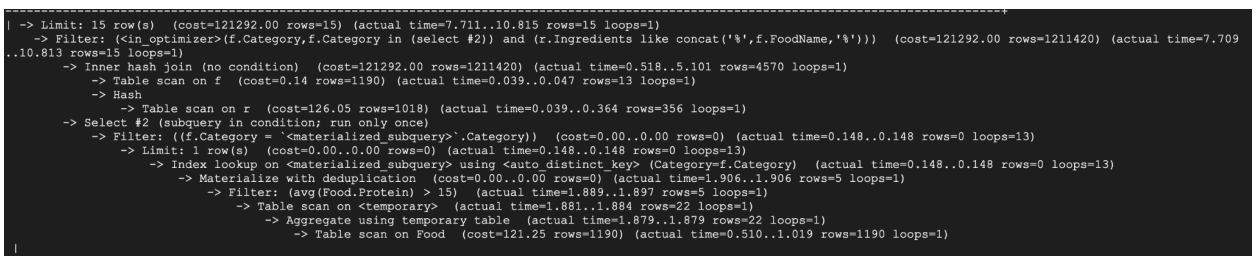
```
-> Limit: 15 row(s)  (cost=121292.00 rows=15) (actual time=8.447..11.549 rows=15 loops=1)
    -> Filter: (<in_optimizer>(f.Category,f.Category in (select #2)) and (r.Ingredients like concat('%',f.FoodName,'%')))  (cost=121292.00 rows=1211420) (actual time=8.446..11.546 rows=15 loops=1)
        -> Inner hash join (no condition)  (cost=121292.00 rows=1211420) (actual time=1.809..6.354 rows=4570 loops=1)
            -> Table scan on f  (cost=0.14 rows=1190) (actual time=0.677..0.684 rows=13 loops=1)
            -> Hash
                -> Table scan on r  (cost=126.05 rows=1018) (actual time=0.043..0.377 rows=356 loops=1)
        -> Select #2 (subquery in condition; run only once)
            -> Filter: ((f.Category = `<materialized_subquery>`.Category))  (cost=0.00..0.00 rows=0) (actual time=0.108..0.108 rows=0 loops=13)
                -> Limit: 1 row(s)  (cost=0.00..0.00 rows=0) (actual time=0.107..0.107 rows=0 loops=13)
                    -> Index lookup on <materialized_subquery> using <auto_distinct_key> (Category=f.Category)  (actual time=0.107..0.107 rows=0 loops=13)
                        -> Materialize with deduplication  (cost=0.00..0.00 rows=0) (actual time=1.381..1.381 rows=5 loops=1)
                            -> Filter: (avg(Food.Protein) > 15)  (actual time=1.355..1.363 rows=5 loops=1)
                                -> Table scan on <temporary>  (actual time=1.349..1.352 rows=22 loops=1)
                                    -> Aggregate using temporary table  (actual time=1.348..1.348 rows=22 loops=1)
                                        -> Table scan on Food  (cost=121.25 rows=1190) (actual time=0.101..0.513 rows=1190 loops=1)
```

   Explanation: We first ran our EXPLAIN ANALYZE command when we did not have any index, so that we would have a baseline to compare our possible indexes.

2. Index Design #2: CREATE INDEX food_cat_idx on Food(Category);
   Cost: 121292

   Explanation: This did not improve the overall cost of the query. We believe that creating an index on the food category key does not affect the overall cost because the category attribute stores non-numerical data that cannot be “naturally ordered,” and would still require a search through every single value.

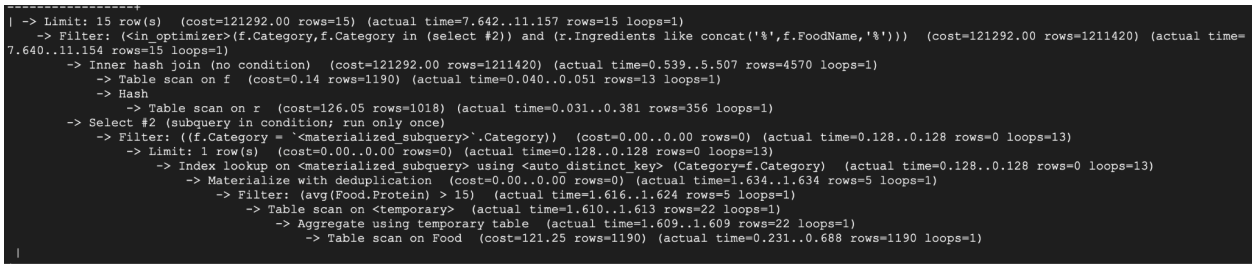
3. Index Design #3: CREATE INDEX food_protein_idx on Food(Protein);
   Cost: 121292.00



```
-> Limit: 15 row(s)  (cost=121292.00 rows=15) (actual time=7.711..10.815 rows=15 loops=1)
    -> Filter: (<in_optimizer>(f.Category,f.Category in (select #2)) and (r.Ingredients like concat('%',f.FoodName,'%')))  (cost=121292.00 rows=1211420) (actual time=7.709..10.813 rows=15 loops=1)
        -> Inner hash join (no condition)  (cost=121292.00 rows=1211420) (actual time=0.518..5.101 rows=4570 loops=1)
            -> Table scan on f  (cost=0.14 rows=1190) (actual time=0.039..0.047 rows=13 loops=1)
            -> Hash
                -> Table scan on r  (cost=126.05 rows=1018) (actual time=0.039..0.364 rows=356 loops=1)
        -> Select #2 (subquery in condition; run only once)
            -> Filter: ((f.Category = `<materialized_subquery>`.Category))  (cost=0.00..0.00 rows=0) (actual time=0.148..0.148 rows=0 loops=13)
                -> Limit: 1 row(s)  (cost=0.00..0.00 rows=0) (actual time=0.148..0.148 rows=0 loops=13)
                    -> Index lookup on <materialized_subquery> using <auto_distinct_key> (Category=f.Category)  (actual time=0.148..0.148 rows=0 loops=13)
                        -> Materialize with deduplication  (cost=0.00..0.00 rows=0) (actual time=1.906..1.906 rows=5 loops=1)
                            -> Filter: (avg(Food.Protein) > 15)  (actual time=1.889..1.897 rows=5 loops=1)
                                -> Table scan on <temporary>  (actual time=1.881..1.884 rows=22 loops=1)
                                    -> Aggregate using temporary table  (actual time=1.879..1.879 rows=22 loops=1)
                                        -> Table scan on Food  (cost=121.25 rows=1190) (actual time=0.510..1.019 rows=1190 loops=1)
```

Explanation: We thought to create an index on the Food Protein key since our WHERE clause includes filtering the average amount of protein > 15. This did not change the overall cost because we believe that the protein attribute wasn't used for inner hashing join operations and neither was it used for table scanning. Further, in our original non-index cost-time analysis, there was no cost for finding the average(food.protein) > 15, which is why we think indexing on protein does not affect overall cost.

4. Index Design #4: CREATE INDEX recipe_ing_idx ON Recipe(Ingredients(255));
   Cost: 121292.00



```
| -> Limit: 15 row(s)  (cost=121292.00 rows=15) (actual time=7.642..11.157 rows=15 loops=1)
    -> Filter: (<in_optimizer>(f.Category,f.Category in (select #2)) and (r.Ingredients like concat('%',f.FoodName,'%')))  (cost=121292.00 rows=1211420) (actual time=
7.640..11.154 rows=15 loops=1)
        -> Inner hash join (no condition)  (cost=121292.00 rows=1211420) (actual time=0.539..5.507 rows=4570 loops=1)
            -> Table scan on f  (cost=0.14 rows=1190) (actual time=0.040..0.051 rows=13 loops=1)
            -> Hash
                -> Table scan on r  (cost=126.05 rows=1018) (actual time=0.031..0.381 rows=356 loops=1)
        -> Select #2 (subquery in condition; run only once)
            -> Filter: ((f.Category = `<materialized_subquery>`.Category))  (cost=0.00..0.00 rows=0) (actual time=0.128..0.128 rows=0 loops=13)
                -> Limit: 1 row(s)  (cost=0.00..0.00 rows=0) (actual time=0.128..0.128 rows=0 loops=13)
                    -> Index lookup on <materialized_subquery> using <auto_distinct_key> (Category=f.Category)  (actual time=0.128..0.128 rows=0 loops=13)
                        -> Materialize with deduplication  (cost=0.00..0.00 rows=0) (actual time=1.634..1.634 rows=5 loops=1)
                            -> Filter: (avg(Food.Protein) > 15)  (actual time=1.616..1.624 rows=5 loops=1)
                                -> Table scan on <temporary>  (actual time=1.610..1.613 rows=22 loops=1)
                                    -> Aggregate using temporary table  (actual time=1.609..1.609 rows=22 loops=1)
                                        -> Table scan on Food  (cost=121.25 rows=1190) (actual time=0.231..0.688 rows=1190 loops=1)
|
```

Explanation: We thought to create an index on the Recipe Ingredients because that is one of the non-primary keys where we do a JOIN operation. However, this does not change the overall cost because Ingredients is of type "TEXT," and doing indexing on such large key types can be inefficient and not change the cost at all. Further, when looking at the no-index original cost analysis, there was actually no cost associated with recipe ingredients lookups, which is why it makes sense that indexing on it would not change anything.

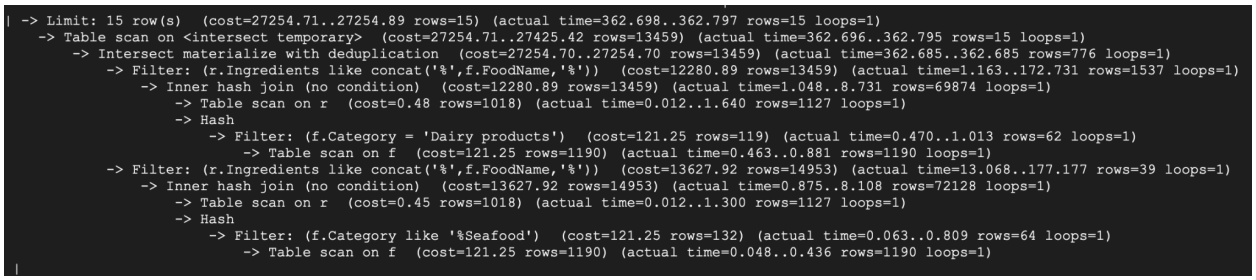
Final Index Design Used: No-Index Configuration (Index Design #1)
We believe that this is the best indexing design since none of the other index designs improved our overall cost, we believe that choosing no index is the best since it avoids the extra memory and time needed to create an unnecessary index that does not change the overall cost of the SQL query. We believe that there are a lot of factors that affect the Cost of the SQL queries, and simply indexing on variables that don't impact the cost outcome would not be very valuable; instead, it would be better to not have any indexing involved as to save computing and memory resources.

Advanced Query #2

```
(
SELECT r.RecipeTitle, r.Ingredients, r.Directions
FROM Recipe r
JOIN Food f ON r.Ingredients LIKE CONCAT('%', f.FoodName, '%')
WHERE f.Category = 'Dairy products'
```

```
)
INTERSECT
(
SELECT r.RecipeTitle, r.Ingredients, r.Directions
FROM Recipe r
JOIN Food f ON r.Ingredients LIKE CONCAT('%', f.FoodName, '%')
WHERE f.Category LIKE '%Seafood'
) LIMIT 15;
```

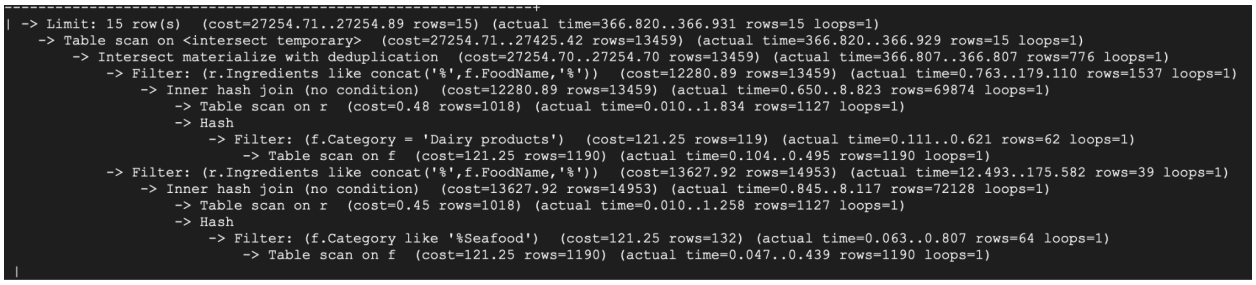
1. Index Design #1: No Index
   Cost: 27254.71 (using Explain-Analyze command)



```
| -> Limit: 15 row(s)  (cost=27254.71..27254.89 rows=15) (actual time=362.698..362.797 rows=15 loops=1)
    -> Table scan on <intersect temporary>  (cost=27254.71..27425.42 rows=13459) (actual time=362.696..362.795 rows=15 loops=1)
        -> Intersect materialize with deduplication  (cost=27254.70..27254.70 rows=13459) (actual time=362.685..362.685 rows=776 loops=1)
            -> Filter: (r.Ingredients like concat('%',f.FoodName,'%'))  (cost=12280.89 rows=13459) (actual time=1.163..172.731 rows=1537 loops=1)
                -> Inner hash join (no condition)  (cost=12280.89 rows=13459) (actual time=1.048..8.731 rows=69874 loops=1)
                    -> Table scan on r  (cost=0.48 rows=1018) (actual time=0.012..1.640 rows=1127 loops=1)
                    -> Hash
                        -> Filter: (f.Category = 'Dairy products')  (cost=121.25 rows=119) (actual time=0.470..1.013 rows=62 loops=1)
                            -> Table scan on f  (cost=121.25 rows=1190) (actual time=0.463..0.881 rows=1190 loops=1)
            -> Filter: (r.Ingredients like concat('%',f.FoodName,'%'))  (cost=13627.92 rows=14953) (actual time=13.068..177.177 rows=39 loops=1)
                -> Inner hash join (no condition)  (cost=13627.92 rows=14953) (actual time=0.875..8.108 rows=72128 loops=1)
                    -> Table scan on r  (cost=0.45 rows=1018) (actual time=0.012..1.300 rows=1127 loops=1)
                    -> Hash
                        -> Filter: (f.Category like '%Seafood')  (cost=121.25 rows=132) (actual time=0.063..0.809 rows=64 loops=1)
                            -> Table scan on f  (cost=121.25 rows=1190) (actual time=0.048..0.436 rows=1190 loops=1)
|
```

   Explanation: We first ran our EXPLAIN ANALYZE command when we did not have any index, so that we would have a baseline to compare our possible indexes.

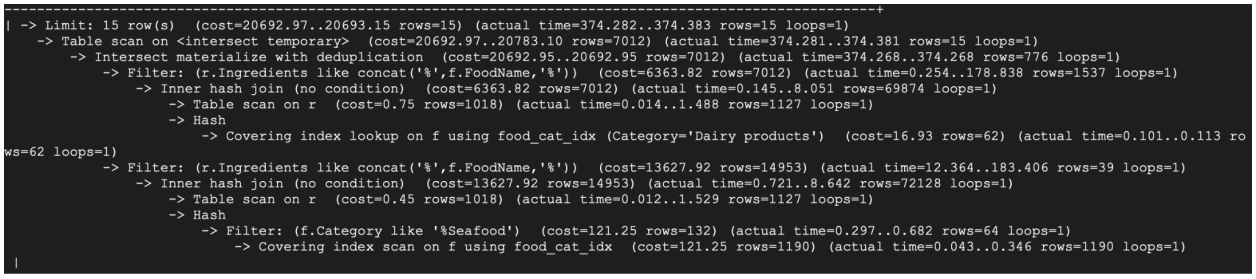
2. Index Design #2: CREATE INDEX recipe_ing_idx ON Recipe(Ingredients(255));
   Cost: 27254.71



```
| -> Limit: 15 row(s)  (cost=27254.71..27254.89 rows=15) (actual time=366.820..366.931 rows=15 loops=1)
    -> Table scan on <intersect temporary>  (cost=27254.71..27425.42 rows=13459) (actual time=366.820..366.929 rows=15 loops=1)
        -> Intersect materialize with deduplication  (cost=27254.70..27254.70 rows=13459) (actual time=366.807..366.807 rows=776 loops=1)
            -> Filter: (r.Ingredients like concat('%',f.FoodName,'%'))  (cost=12280.89 rows=13459) (actual time=0.763..179.110 rows=1537 loops=1)
                -> Inner hash join (no condition)  (cost=12280.89 rows=13459) (actual time=0.650..8.823 rows=69874 loops=1)
                    -> Table scan on r  (cost=0.48 rows=1018) (actual time=0.010..1.834 rows=1127 loops=1)
                    -> Hash
                        -> Filter: (f.Category = 'Dairy products')  (cost=121.25 rows=119) (actual time=0.111..0.621 rows=62 loops=1)
                            -> Table scan on f  (cost=121.25 rows=1190) (actual time=0.104..0.495 rows=1190 loops=1)
            -> Filter: (r.Ingredients like concat('%',f.FoodName,'%'))  (cost=13627.92 rows=14953) (actual time=12.493..175.582 rows=39 loops=1)
                -> Inner hash join (no condition)  (cost=13627.92 rows=14953) (actual time=0.845..8.117 rows=72128 loops=1)
                    -> Table scan on r  (cost=0.45 rows=1018) (actual time=0.010..1.258 rows=1127 loops=1)
                    -> Hash
                        -> Filter: (f.Category like '%Seafood')  (cost=121.25 rows=132) (actual time=0.063..0.807 rows=64 loops=1)
                            -> Table scan on f  (cost=121.25 rows=1190) (actual time=0.047..0.439 rows=1190 loops=1)
|
```

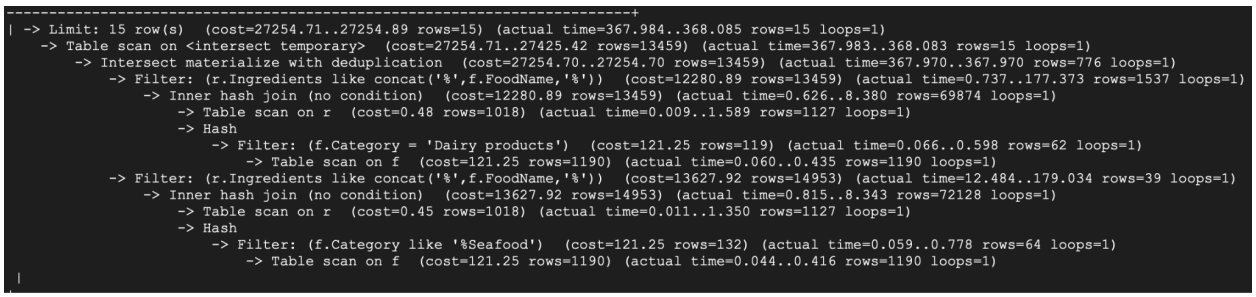
   Explanation: We thought that creating an index on the Recipe ingredients would decrease the overall runtime since the ingredients attribute was used in the “JOIN” clause in this SQL query. However, this does not improve the overall cost because we believe that recipe ingredients don’t have a natural order that would improve the search time and cost.

3. Index Design #3: CREATE INDEX food_cat_idx ON Food(Category);
   Cost: 20692.97



Explanation: We thought of creating an index on the food “Category” key as it is used in the “WHERE” clause of the SQL query. This in fact decreased our overall cost from 27254.71 to 20692.97 because the overall cost to scan the table and hash the food category decreased after adding the index. We expected this to happen, as it would make searching for certain categories in the WHERE clause easier.

4. Index Design #4: CREATE INDEX recipe_dir_idx ON Recipe(Directions(255));
   Cost: 27254.71



Explanation: We thought of creating an index on the Recipe “Direction” key as it is used to filter and select the rows in our SQL queries including with the “INTERSECT” command. This did not decrease the cost of our SQL query, and after further inspection, we saw that the recipe directions were not used in an inner hashing join operation or table scanning functions or loops. It made sense then that the overall cost stayed the same as the indexing did not impact any of these operations.

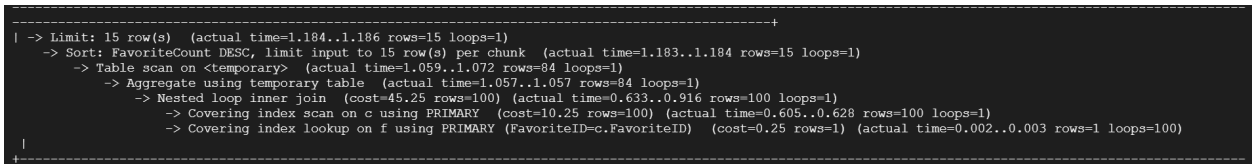
Final Index Design Used: Index Design #3

Out of all 4 configurations, we believe that index design #3 involving an index for the Food Category key is the best configuration, as it decreased our cost from 2725.41 to 20692.97. This makes sense as the cost was originally increasing due to the hash function when searching for a specific category that met a certain condition (as stated in the SQL query). By indexing our category, we could sort the category values and ensure that they were searched in less time and cost than before.

Advanced Query #3

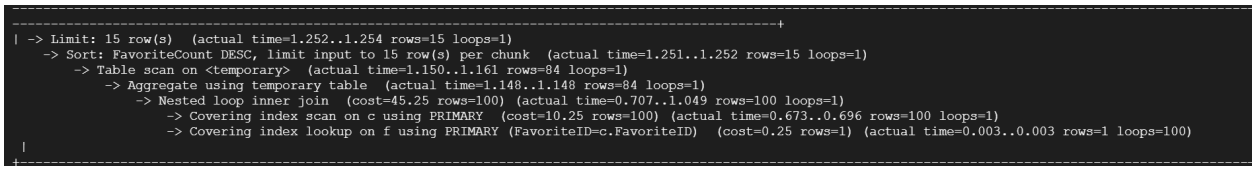
```
SELECT
   c.RecipeTitle,
   COUNT(c.FavoriteID) AS FavoriteCount
FROM
   Contains c
JOIN
   Favorites f ON c.FavoriteID = f.FavoriteID
GROUP BY
   c.RecipeTitle
ORDER BY
   FavoriteCount DESC
LIMIT 15;
```

1. Index Design #1: No Index
   Cost: 45.25



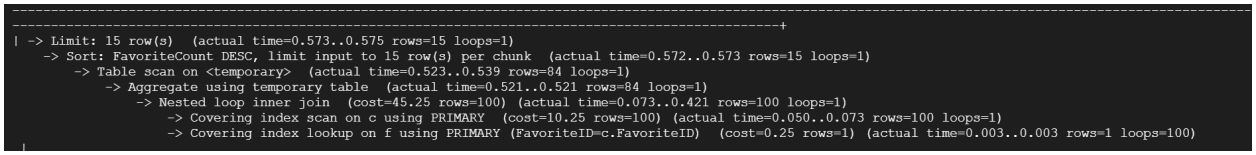
   Explanation: We first ran our EXPLAIN ANALYZE command when we did not have any index, so that we would have a baseline to compare our possible indexes.

2. Index Design #2: CREATE INDEX dateadded_idx on Favorites(DateAdded);
   Cost: 45.25



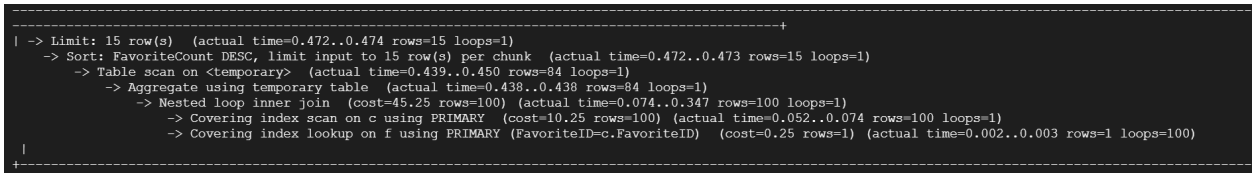
   Explanation: It makes sense why we would not see an improvement in cost with this index. This is because when we perform our inner join, we still need to check each value in the Favorites table with the Contains table, so indexing by DateAdded doesn't change the amount of times we do this. Furthermore, we realize that DateAdded only gives us information about the date of Favorites table, so this does not really help us because even by indexing by information like this, our query still has to go through Favorites and count theme as well as order by our favorite count.

3. Index Design #3: CREATE INDEX food_category_idx on Food(Category);
   Cost: 45.25



   Explanation: I thought that adding this index could help us, since although we do not directly grab from the Food table, we do use the Contains table, which contains the key to the Food table. However, it does make sense why this key would not work, since we still have to go through all the values for our inner join, so indexing by a different attribute does not really change or improve our cost in any way. Since Food table is not even used in our query, it shows us that it most likely would not have any impact on our cost.

4. Index Design #4: CREATE INDEX food_measures_idx on Food(Measures);
   Cost: 45.25



   Explanation: As seen above, we realize that when we use an attribute to index that does not appear in our query, it will not help our cost at all. This makes sense, because we would ideally want to index by some relevant attribute, so that we can improve our costs, searches, and queries. Unfortunately, we are not left with many index options from our query, so using an irrelevant attribute does not improve our cost. Since Food table is not even used in our query, it shows us that it most likely would not have any impact on our cost.

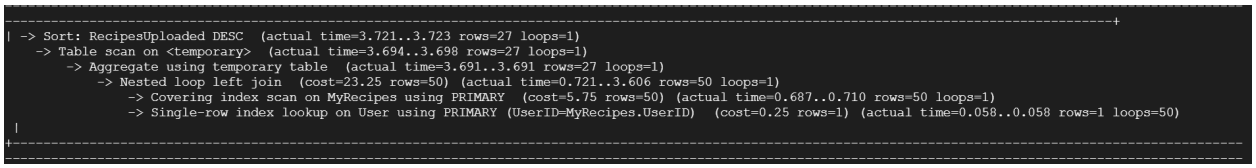
   Final Index Design Used:

Overall, it is realized that we want to select a good index value that is not a primary key and that appears in our table. However, in our original query, we only use two tables, and the attributes from these tables are already primary keys, so we cannot use them in our index. This leads us to use other attributes from the JOIN tables, however we also see that these do not improve our cost since they are not even part of the original query. Overall, it is deemed that finding an index that improves this query is very difficult, since this query utilizes primary keys only. If we wanted to improve this cost from our query, we may want to try utilizing other attributes of the table that are not primary keys, so we can use them as an index value. Because of this, we ultimately find that using no index gives us the same cost as trying to create an index.

Advanced Query #4

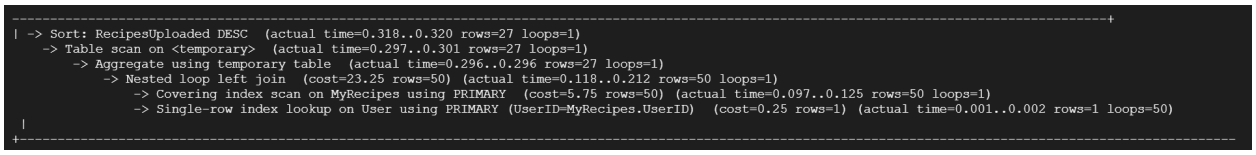
```
SELECT
   User.UserName,
   COUNT(MyRecipes.RecipeTitle) AS RecipesUploaded
FROM
   User
RIGHT JOIN
   MyRecipes ON User.UserID = MyRecipes.UserID
GROUP BY
   MyRecipes.UserID
ORDER BY
   RecipesUploaded DESC;
```

1. Index Design #1: No Index
   Cost: 23.25



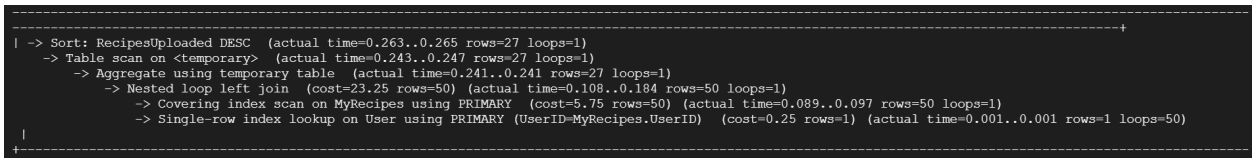
   Explanation: We first ran our EXPLAIN ANALYZE command when we did not have any index, so that we would have a baseline to compare our possible indexes.

2. Index Design #2: CREATE INDEX user_name_idx on User(UserName);
   Cost: 23.25



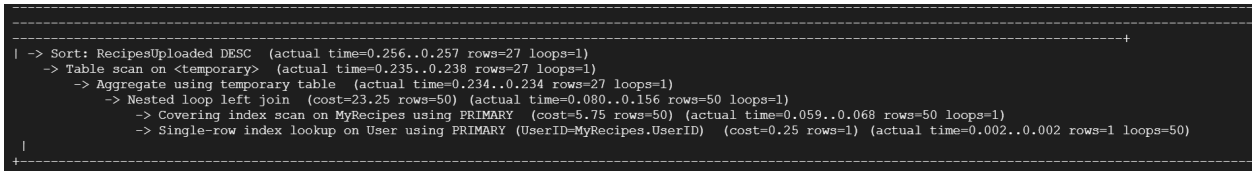
   Explanation: When we tried indexing on UserName, we found that we did not get a cost improvement. Although this is an attribute in our query, it makes sense why we would not see any improvement, because this is just a select attribute, and indexing it does not really change our actual results, since we still have joins and groupbys on other attributes. We end up RIGHT JOINING our MyRecipes table on users, but we compare with userid, so we still have to make this comparison regardless of whether we index on an attribute in the Users table or not, therefore it makes sense that we do not see a cost improvement.

3. Index Design #3: CREATE INDEX password_idx on User(Password);
   Cost: 23.25



   Explanation: We now try indexing on a different attribute of the User table, since we have limited options with this query. We assume we would get similar results to the UserName table because we are again wanting to go through our Users, however indexing by UserName or Password does not help optimize our query at all. We end up RIGHT JOINING our MyRecipes table on users, but we compare with userid, so we still have to make this comparison regardless of whether we index on an attribute in the Users table or not, therefore it makes sense that we do not see a cost improvement.

4. Index Design #4: CREATE INDEX ingredients_idx on Recipe(Ingredients(255));
   Cost: 23.25



   Explanation: We again do not see a cost improvement here. On our RightJOIN, we still rely on the UserIds, and therefore still end up going through all of them, so even though indexing on Ingredients could seem helpful, it does not actually allow us any improvement because we still rely on UserIds to go through, and we cannot index on UserIds because that is a primary key.

   Final Index Design Used:

Overall, we find that not much can be done to improve our costs for this query. One downside of the query is that we utilize a lot of primary keys, and we do not have many tables included in this query, so it is hard to find an index that is part of a table that we use in the query, but also is not a primary key. One way we could improve this, is by joining in more tables and expanding our query a little bit, so that we could introduce some different attributes to index on. Otherwise, as we can see above, all the indexes that we tried did not improve our cost, so this query performs the same with or without an index. This would make sense, because we would probably want to rewrite our query in such a way that we could maximize from an index by using joins. However, in our query, it is quite hard to have an index that is actually beneficial since we require a count and right join that are hard to optimize.