Paper 62-2010

An Introduction to SQL in SAS®

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ABSTRACT

SQL is one of the many languages built into the SAS® System. Using PROC SQL, the SAS user has access to a powerful data manipulation and query tool. Topics covered will include selecting, subsetting, sorting and grouping data--all without use of DATA step code or any procedures other than PROC SQL.

THE STRUCTURE OF A SQL QUERY

SQL is a language build on a very small number of keywords:

SELECT	columns (variables) that you want
FROM	tables (datasets) that you want
ON	join conditions that must be met
WHERE	row (observation) conditions that must be met
GROUP BY	summarize by these columns
HAVING	summary conditions that must be met
ORDER BY	sort by these columns

For the vast majority of queries that you run, the seven keywords listed above are all you'll need to know. There are also a few functions and operators specific to SQL that can be used in conjunction with the keywords above.

SELECT is a statement and is required for a query. All the other keywords are clauses of the ***SELECT*** statement. The ***FROM*** clause is the only one that is required. The clauses are always ordered as in the list above and each clause can appear, at most, once in a query.

The nice thing about SQL is that, because there are so few keywords to learn, you can cover a great deal in a short paper. So, let's get on with the learning!

As we go through the paper you will see how much sense the ordering of the SQL clauses makes.

You're telling the program what columns you want to ***SELECT*** and ***FROM*** which table(s) they come. If there is more than one table involved in the query you need to say ***ON*** what columns the rows should be merged together. Also, you might only want rows ***WHERE*** certain conditions are met.

Once you've specified all the columns and rows that should be selected, there may be a reason to ***GROUP BY*** one or more of your columns to get a summary of information. There may be a need to only keep rows in the result set ***HAVING*** certain values of the summarized columns.

Finally, there is often a need to ***ORDER BY*** one or more of your columns to get the result sorted the way you want.

Simply thinking this through as we go through the paper will help you remember the sequence of clauses.

CHOOSING YOUR COLUMNS - THE *SELECT* STATEMENT

The first step in getting the data that you want is selecting the columns (variables). To do this, use the *SELECT* statement:

```
select BookingDate,
       ReleaseDate,
       ReleaseCode
```

List as many columns as needed, separated by commas. There are a number of options that can go along with columns listed in a *SELECT* statement. We'll look at those in detail shortly.

We'll also see that new columns can be created, arithmetic and logical operations can be performed and summary functions can be applied. In short, *SELECT* is a very versatile and powerful statement.

CHOOSING YOUR TABLE – THE *FROM* CLAUSE

The next step in getting that data that you want is specifying the table (dataset). To do this, use the *FROM* clause:

```
select BookingDate,
       ReleaseDate,
       ReleaseCode
from SASclass.Bookings
```

The table naming conventions in the *FROM* clause are the normal SAS dataset naming conventions, since we are referencing a SAS dataset. You can use single-level names for temporary datasets or two-level names for permanent datasets.

These two components (*SELECT* and *FROM*) are all that is required for a valid query. In other words, the query above is a complete and valid SQL query. There are just a couple additions we need to make for SAS to be able to execute it.

USING SQL IN SAS

Now that we know enough SQL to actually do something “legal” (*SELECT* and *FROM*), let’s see how we would use SQL in SAS: *PROC SQL*.

```
proc sql;
  select BookingDate,
         ReleaseDate,
         ReleaseCode
  from SASclass.Bookings;
quit;
```

There are a number of things to notice about the syntax of PROC SQL.

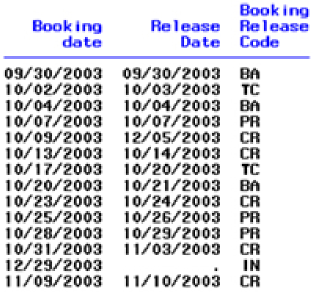
First, note that the entire query (*SELECT…FROM…*) is treated a single statement. There is only one semicolon, placed at the end of the query. This is true no matter how complex the query or how many clauses it contains.

Second, the procedure is terminated with a *QUIT* statement rather than a *RUN* statement. Queries are executed immediately, as soon as they are complete – when it hits the semicolon on the *SELECT* statement. This has a couple of implications: 1) a single instance of *PROC SQL* may contain more than one query and 2) the *QUIT* statement is not required for queries to run.

Finally, SQL statements can only run inside *PROC SQL*. They cannot be embedded in other procedures or in data step code.

By default, the output of the query above would produce these results (see right) in the SAS output window.

The columns are laid out in the order in which they were specified in the *SELECT* and, by default, the column label is used (if it exists).



```
                                Booking
   Booking        Release       Release
      date           Date       Code
----------------------------------------
09/30/2003     09/30/2003       BA
10/02/2003     10/03/2003       TC
10/04/2003     10/04/2003       BA
10/07/2003     10/07/2003       PR
10/09/2003     12/05/2003       CR
10/13/2003     10/14/2003       CR
10/17/2003     10/20/2003       TC
10/20/2003     10/21/2003       BA
10/23/2003     10/24/2003       CR
10/25/2003     10/26/2003       PR
10/28/2003     10/29/2003       PR
10/31/2003     11/03/2003       CR
12/29/2003              .       IN
11/09/2003     11/10/2003       CR
```

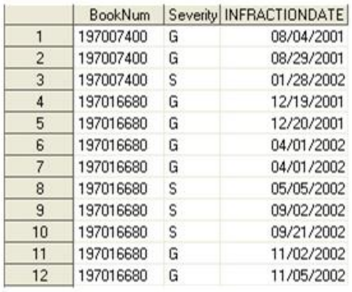
WHAT TO DO WITH THE RESULTS

By default, the results of a query are displayed in the SAS output window. This statement is actually a bit narrow. PROC SQL works just like all other SAS procedures: the results of a SQL *SELECT* are displayed in <u>all</u> open ODS destinations. The following code:

```
ods html body='c:\temp\Bookings.html';
ods pdf file='c:\temp\Bookings.pdf';

proc sql;
  select BookingDate,
         ReleaseDate,
         ReleaseCode
  from SASclass.Bookings;
quit;

ods html close;
ods pdf close;
```

will produce output in all three open ODS destinations – the output window (the LISTING destination is open by default), an HTML file and a PDF file.
You can create a SAS dataset (a table) from the results of the query by preceding the *SELECT* statement with a *CREATE TABLE* statement.

```
proc sql;
  create table ReleaseInfo as
  select BookingDate,
         ReleaseDate,
         ReleaseCode
  from SASclass.Bookings;
quit;
```



	BookNum	Severity	INFRACTIONDATE
1	197007400	G	08/04/2001
2	197007400	G	08/29/2001
3	197007400	S	01/28/2002
4	197016680	G	12/19/2001
5	197016680	G	12/20/2001
6	197016680	G	04/01/2002
7	197016680	G	04/01/2002
8	197016680	S	05/05/2002
9	197016680	S	09/02/2002
10	197016680	S	09/21/2002
11	197016680	G	11/02/2002
12	197016680	G	11/05/2002

The *CREATE TABLE* statement does two things:

1. Creates a new table (SAS dataset).
2. Suppresses the printed output of the query. No matter how many ODS destinations are open, no output is generated.

Notice that the order of columns in the *SELECT* statement not only determines the order in the query output, it also determines the order in a table if *CREATE TABLE* is used.

The naming conventions for tables in the *CREATE TABLE* statement are the same as elsewhere in the SAS System because we're really just creating a SAS dataset.

***SELECT* STATEMENT OPTIONS**

The columns on a SELECT statement can be renamed, relabeled or reformatted.

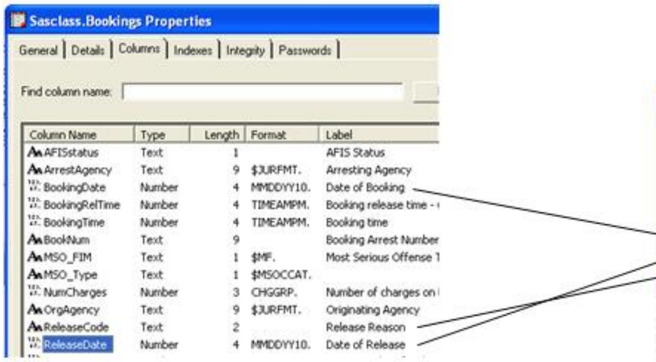
- Rename:use the ***AS*** keyword
- Label: use the ***LABEL=*** keyword
- Format: use the ***FORMAT=*** keyword
- Length: use the ***LENGTH=*** keyword

The following query would create a temporary SAS dataset called ReleaseCodes having three variables:

- BD
- RD
- ReleaseCode

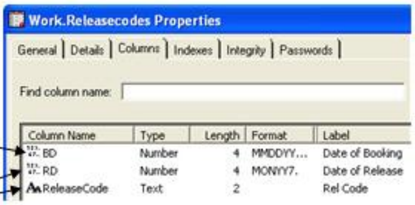
```
proc sql;
  create table ReleaseCodes as
  select BookingDate as BD,
         ReleaseDate as RD format=monyy7.,
         ReleaseCode label='Rel Code'
  from SASclass.Bookings;
quit;
```

By default, all formats and labels are carried over from the original table when a new table is created. In the above query we associated a new format with ReleaseDate, which we renamed RD. We also attached a new label to ReleaseCode. Any other formats or labels would remain as they were.



Column Name	Type	Length	Format	Label
AFISstatus	Text	1		AFIS Status
ArrestAgency	Text	9	$JURFMT.	Arresting Agency
BookingDate	Number	4	MMDDYY10.	Date of Booking
BookingRelTime	Number	4	TIMEAMPM.	Booking release time -
BookingTime	Number	4	TIMEAMPM.	Booking time
BookNum	Text	9		Booking Arrest Number
MSO_FIM	Text	1	$MF.	Most Serious Offense 1
MSO_Type	Text	1	$MSOCCAT.	
NumCharges	Number	3	CHGGRP.	Number of charges on
OrgAgency	Text	9	$JURFMT.	Originating Agency
ReleaseCode	Text	2		Release Reason
ReleaseDate	Number	4	MMDDYY10.	Date of Release

The structure of the original Bookings table.



Column Name	Type	Length	Format	Label
BD	Number	4	MMDDYY...	Date of Booking
RD	Number	4	MONYY7.	Date of Release
ReleaseCode	Text	2		Rel Code

The structure of the slimmed-down Bookings table, with its new column names and formatting

Notice that the attributes of the columns in the new table are the same as those in the original, unless they were changed. Even though we gave BookingDate a new name (BD) the other attributes remain – the same format and label.

There is no restriction on the number of attributes that can be set on a column. A column can be renamed, reformatted and relabeled all at the same time. Simply separate the attribute assignments with spaces – note that, in the query above, ReleaseDate is both renamed and reformatted.

SELECTING ALL COLUMNS – A SHORTCUT

All the columns in a table can be specified using an asterisk (*) rather than a column list. For example,

```
proc sql;
  create table BookingCopy as
  select *
  from SASclass.Bookings;
quit;
```

If you have a number of columns in a table, and you want them all, this shortcut is obviously a time saver.

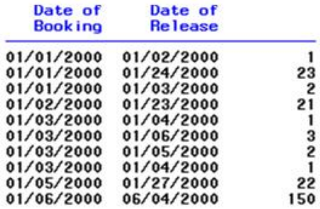
The downside is that you must know your data! If you specify the columns, you know what you're getting. This shortcut can also be a little more problematic when you start working with multiple tables in joins and other set operations.

CREATING NEW COLUMNS

Just as we did to rename a column, the *AS* keyword is used to name a new column. In the above example two existing columns were used to create a new column. Notice that the syntax of the assignment is opposite of a normal arithmetic expression – the expression is on the left side of "AS" (the "equal sign").

The output from the above query would look like this:

```
select BookingDate,
       ReleaseDate,
       ReleaseDate - BookingDate as LOS
from SASclass.Bookings;
```



```
 Date of     Date of
 Booking     Release
───────────────────────────────────
01/01/2000  01/02/2000           1
01/01/2000  01/24/2000          23
01/01/2000  01/03/2000           2
01/02/2000  01/23/2000          21
01/03/2000  01/04/2000           1
01/03/2000  01/06/2000           3
01/03/2000  01/05/2000           2
01/03/2000  01/04/2000           1
01/05/2000  01/27/2000          22
01/06/2000  06/04/2000         150
```

You can see that the new column is labeled "LOS" which would have been the variable name if we'd had a *CREATE TABLE* statement. Without the AS, the column in the output would have had no label, just blank space, and the name of the new column in the new table would be _TEMA001. If you had additional new columns created without AS they would be named _TEMA002, _TEMA003 and so on. You can see the importance of naming your new columns!

Any SAS formats, including picture formats, and informats can be used in a *SELECT* statement. The following *SELECT* statements are all valid:

```
select put(RaceCd,$Race.) as Race,

select input(Bail,BailGroup.) as GroupedBail,…

select put(Infractions,InfractionGrp.) as NumInfractions,…
```

The syntax is exactly the same as using a *PUT* or *INPUT* function in data step code.

CONDITIONAL LOGIC IN THE *SELECT* STATEMENT – THE *CASE* OPERATOR

There is yet another way to create new columns in the *SELECT* statement. While there is no "if…then…else" statement, the *CASE* operator gets close. The syntax of the *CASE* operator is quite simple – a series of *WHEN…THEN* conditions wrapped in *CASE…END AS*.:

```
CASE
  WHEN <condition> THEN <value>
  WHEN <condition> THEN <value>
  ELSE <value>
```

END AS <column name>

The following query selects all the columns from the Infractions table, notice the “*”, and then creates a new column, CheckThese, that is set to “X” for inmate on staff assaults (“IS”) or serious infractions (“S”).

```
select *,
       case
         when InfractionType eq 'IS' then 'X'
         when Severity eq 'S' then 'X'
         else ' '
       end as CheckThese
from SASclass.Infractions;
```

There can be as many *WHEN* conditions as you like and they can contain any valid SAS expression, including logical operators. So, the *CASE* logic above could also have been written as:

```
case
  when InfractionType eq 'IS' or Severity eq 'S' then 'X'
  else ' '
end as CheckThese
```

As the *WHEN* conditions are processed the value is set based on the first condition that is true. For example, let’s change the query above to prioritize the infractions that we want to check on. We want to look at severe inmate on staff assaults first, then other inmate on staff assaults, then other severe infractions. The new CASE logic could be:

```
case
  when InfractionType eq 'IS' and Severity eq 'S' then 1
  when InfractionType eq 'IS' then 2
  when Severity eq 'S' then 3
  else 0
end as CheckThese
```

The order of the conditions is important, since the severe inmate on staff assaults meet all three of our criteria for assigning a value to CheckThese. Just like *IF…THEN…ELSE*, a value is assigned when the first *WHEN* condition is true.

The *ELSE* and AS keywords are optional. If *AS* is omitted the new column will be auto-named, as we saw earlier, starting with _TEMA001.

If *ELSE* is omitted the value of the new column will be set to missing if none of the *WHEN* conditions are met. A note will be included in the SAS log reminding you of this. In our first query there would be no difference in the outcome if the *ELSE* was omitted or not, since we set the value to missing. However, it is good practice to be specific in the assignment of the “default” value. You avoid the note in the log and you make it easier to debug and maintain later on.

If all of the *WHEN* conditions use the same column the column name can be added to the *CASE* operator and omitted from the *WHEN* condition. For example, the following two examples are equivalent:

```
case                                      case Age
  when Age lt 13 then ‘PreTeen’             when lt 13 then ‘PreTeen’
  when Age lt 20 then ‘Teenager’            when lt 20 then ‘Teenager’
  else ‘Old Person’                         else ‘Old Person’
end as AgeGroup                           end as AgeGroup
```

The column name (Age) is simply moved out of the *WHEN* condition and into the *CASE* operator. This is only valid when using a single column.

CHOOSING YOUR ROWS – THE *WHERE* CLAUSE

Now that we’ve selected and created the columns that we want, we might not want all the rows in the table. The *WHERE* clause gives us a way to select rows.

The *WHERE* clause contains conditional logic that determines whether a row will be included in the output of the query. The *WHERE* clause can contain any valid SAS expressions plus a number that are specific to the *WHERE* clause.

Remember, like everything except *SELECT* and *FROM*, that the *WHERE* clause is optional. If it is included in a query it always comes immediately after the *FROM* clause. If we wanted to select rows from the Infractions table for only serious infractions, we could use the following query.

```
select *
from SASclass.Infractions
where Severity eq 'S';
```

The syntax of the *WHERE* clause is one or more conditions that, if true, causes the record to be included in the output of the query. If there is more than one condition to be met, use *AND* and/or *OR* to put multiple conditions together. For example, if we wanted to further restrict the rows selected from the Infractions table to select only serious inmate-on-inmate assaults we just need to add the second condition the *WHERE* clause:

```
select *
from SASclass.Infractions
where Severity eq 'S' and
      InfractionType eq 'II';
```

There is no limit to the number of conditions you can have in your *WHERE* clause.

There is a difference between how SAS handles mismatched data types in *WHERE* clauses and other parts of the language. (This is true whether using *WHERE* in PROC SQL or in a data step or other procedure.) In most cases SAS will perform an automatic type conversion, from character to numeric or vice versa, to make the comparison valid. For example, if NumCharges is a numeric field, the following datastep will execute but the SQL query will not:

```
data DataStepResult;
  set SASclass.Bookings;
  if NumCharges eq '2';
run;

proc sql;
  create table QueryResult as
  select *
  from SASclass.Bookings
  where NumCharges eq '2';
quit;
```

The *IF* statement in the datastep does an automatic conversion of the ‘2’ to numeric and evaluates the expression. A note is written to the log alerting you to this:

```
  NOTE: Character values have been converted to numeric values at the places given by:
(Line):(Column).
```

The *WHERE* clause requires compatible data type and the query above generates an error:

```
  ERROR: Expression using equals (=) has components that are of different data types.
```

The *WHERE* clause data-compatibility requirement is true whether it is used in a SQL query, datastep or other procedure. The error messages written to the log may be different. For example, running the above datastep with a *WHERE* statement rather than an *IF* statement generates a slightly different error message (though the step still fails to execute):

```
data DataStepResult;
  set SASclass.Bookings;
  where NumCharges eq '2';
run;
```

```
  ERROR: Where clause operator requires compatible variables.
```

SPECIAL *WHERE* CLAUSE OPERATORS

There are a number of operators that can be used only in a *WHERE* clause or statement. Some of them can add great efficiency and simplicity to your programming as they often reduce the code needed to perform the operation.

- **THE *IS NULL* AND *IS MISSING* OPERATORS**

You can use the *IS NULL* or *IS MISSING* operators to return rows with missing values. The advantage of *IS NULL* (or *IS MISSING*) is that the syntax is the same whether the column is a character or numeric field.

```
select *
from  SASClass.Charges
where SentenceDate is null;
```

Note: IS MISSING is a SAS-specific extension to SQL.

In most database implementations there is a distinction between empty (missing) values and null values. Null values are a unique animal and compared successfully to anything but other null values. You need to be aware of how nulls values are handled if you are using SQL in a non-SAS environment.

THE *BETWEEN* OPERATOR

The BETWEEN operator allows you to search for a value that is between two other values.

```
select *
from SASClass.Bookings
where BookingDate between '1jul2001'd and '30jun2002'd;
```

When using *BETWEEN*, be aware that the end points are included in the results of the query. In the example above, 7/1/2001 and 6/30/2002 are both included.

The column used with *BETWEEN* can be numeric or character. There are dangers in using character fields in any non-equality comparison. You need to know the collating sequence that your operating system uses (i.e., is “a” greater than or less than “A”) and how any unfilled values are justified (i.e., “ a” is not the same as “a ”).

There is an interesting behavior of the *BETWEEN* operator. The values are treated as the boundaries of a range and are automatically placed in the correct order. This means that the following two conditions produce the same result:

```
where ADPmonth between '1jul2001'd and '30jun2002'd

where ADPmonth between '30jun2002'd and '1jul2001'd
```

The order of the *BETWEEN* values is not important, though it is recommended that they be specified in the correct sequence for ease of understanding and maintainability.

THE *CONTAINS* OPERATOR

You can search for a string inside another string with the CONTAINS operator. The following query would return all rows where ChargeDesc contains “THEFT” – for example, “AUTO THEFT”, “THEFT 2”, “PROPERTY THEFT”.

```
select *
from SASClass.Charges
where ChargeDesc contains 'THEFT';
```

Like other SAS sting comparisons it is case sensitive. To make the comparison case insensitive you can use the UPCASE function. The new WHERE clause:

```
where upcase(ChargeDesc) contains 'THEFT'
```

would also return “Car Theft” and “Theft of Property”.

The *CONTAINS* condition does not need to be a separate “word” in the column value. So, the above query would also return “THEFT2” and “AUTOTHEFT”.

THE *LIKE* OPERATOR

You can do some rudimentary pattern matching with the LIKE operator.

○ _ (underscore)	matches any single character
○ % (percent sign)	matches any number of characters (even zero)
○ other characters	match that character

The *WHERE* clause below says, “Give me all rows where the charge description has the characters ‘THEFT’ with any number of characters before or after.”

```
where ChargeDesc like '%THEFT%';
```

Does this sound familiar? It will return the exact same rows as *CONTAINS* “THEFT” would. But, *LIKE* is much more powerful! With *LIKE* you can specify, to a degree, where you want your search string to be found. Let’s take the example above and look for “THEFT” in a number of places in the charge description.

```
where ChargeDesc like 'THEFT%';
```

This would return any charge descriptions that starts with the work “THEFT” and is followed by anything else. Values like “THEFT”, “THEFT 2” and “THEFT-AUTO” would all be found.

```
where ChargeDesc like '%THEFT';
```

This *WHERE* would return all rows that <u>ends</u> with the word “THEFT” and starts with anything else. Again, “THEFT” would be a valid value, as would “AUTO THEFT” and “3RD DEGREE THEFT”. It would not return “AUTO THEFT 3” as we made no provision for anything to come after “THEFT”.

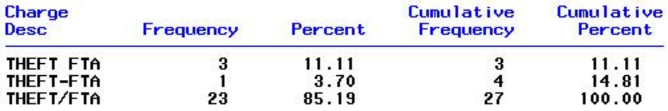
```
where ChargeDesc like '%_THEFT';
```

Now, this *WHERE* is similar to the one above, except that now there must be at least one character before “THEFT”. This would exclude rows with the value “THEFT” from the result set. What would be the difference if we replaced the underscore with a space? Remember, the underscore means <u>any</u> character and the space would mean a space. So, the underscore would return “AUTO THEFT” and “AUTO-THEFT” whereas the space would only return “AUTO THEFT”.

Let’s look at one more example. Suppose we were interested in finding those people who had a previous theft charge and never showed up for court. Now they are being booked into jail for failing to appear for their theft charge. We can find that by looking for “THEFT” and “FTA” (failure to appear). We can use the following *WHERE* clause to find them:

```
where ChargeDesc like 'THEFT_FTA';
```

Here are the results of that query:

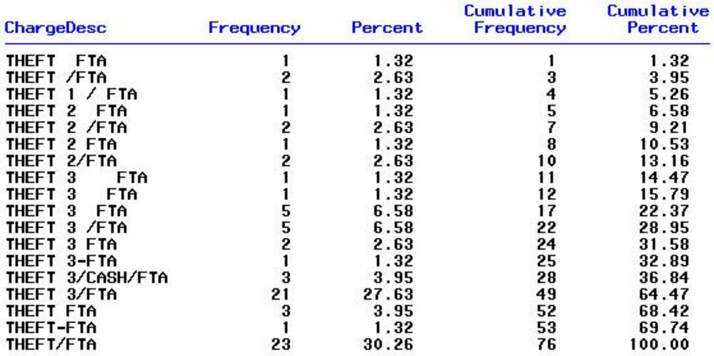


```
Charge                                           Cumulative    Cumulative
Desc         Frequency      Percent               Frequency       Percent

THEFT FTA            3        11.11                       3         11.11
THEFT-FTA            1         3.70                       4         14.81
THEFT/FTA           23        85.19                      27        100.00
```

This doesn’t look too bad. We found all the rows that had a “THEFT” and “FTA” separated by any single character. We found some with a space, some with a dash and some with a slash. However, what if not all the booking officers use that convention (single character between the two words) when they enter the charge description? Look at the results of the next WHERE:

```
where ChargeDesc like 'THEFT%FTA';
```

Notice that the original values are still there, but we pick up a lot more possibilities. It pays to know your data!



```
                                                    Cumulative    Cumulative
ChargeDesc             Frequency       Percent       Frequency       Percent

THEFT  FTA                     1          1.32               1          1.32
THEFT /FTA                     2          2.63               3          3.95
THEFT 1 / FTA                  1          1.32               4          5.26
THEFT 2  FTA                   1          1.32               5          6.58
THEFT 2 /FTA                   2          2.63               7          9.21
THEFT 2 FTA                    1          1.32               8         10.53
THEFT 2/FTA                    2          2.63              10         13.16
THEFT 3    FTA                 1          1.32              11         14.47
THEFT 3   FTA                  1          1.32              12         15.79
THEFT 3  FTA                   5          6.58              17         22.37
THEFT 3 /FTA                   5          6.58              22         28.95
THEFT 3 FTA                    2          2.63              24         31.58
THEFT 3-FTA                    1          1.32              25         32.89
THEFT 3/CASH/FTA               3          3.95              28         36.84
THEFT 3/FTA                   21         27.63              49         64.47
THEFT FTA                      3          3.95              52         68.42
THEFT-FTA                      1          1.32              53         69.74
THEFT/FTA                     23         30.26              76        100.00
```

- **SOUNDS LIKE**

The “sounds like” operator (=*) uses the Soundex algorithm to match like character values. A little background on the Soundex algorithm will help in determining when and where you might use it.

The Soundex algorithm encodes a character string, usually a name, according to rules originally developed by Margaret K. Odell and Robert C. Russel in 1918. The method was patented in 1918 and 1922. It was used extensively in the 1930’s by WPA crews working to organize Federal Census data from 1880 to 1920. It is widely used in genealogical software and other applications where name searching and matching is paramount.

The algorithm returns a character string composed of a single letter followed by a series of digits. The rules for calculating the value are as follows:

- Retain the first letter in the argument and discard the following letters:
    - A E H I O U W Y
- Assign the following numbers to these classes of letters:

  1: B F P V
  2: C G J K Q S X Z
  3: D T
  4: L
  5: M N
  6: R
- If two or more adjacent letters have the same classification from Step 2, then discard all but the first. (Adjacent refers to the position in the word prior to discarding letters.)

For example,

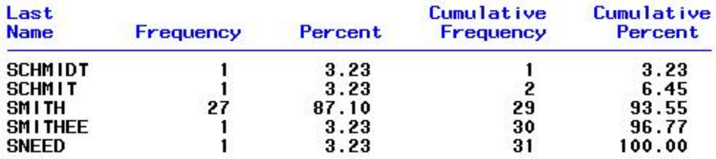
```
select LastName, FirstName
from SASClass.Inmates
where LastName =* 'Smith';
```

Using the above rules, what is the value of "SMITH" that we used in the query above?

Step 1 – retain the first letter ("S") and eliminate the "I" and "H": SMT
Step 2 – "M" gets a value of 5 and "T" gets a value of 3

So, "SMITH" has a Soundex value of "S53".

Let's look at the results of our example query and check some of the values that were returned:



```
Last                                 Cumulative    Cumulative
Name       Frequency     Percent      Frequency      Percent
--------------------------------------------------------------
SCHMIDT            1        3.23              1         3.23
SCHMIT             1        3.23              2         6.45
SMITH             27       87.10             29        93.55
SMITHEE            1        3.23             30        96.77
SNEED              1        3.23             31       100.00
```

"SNEED" and "SCHMIDT" seem a bit far removed from "SMITH", in spelling anyway – let's follow the same steps as above to give them a value.

SNEED:
Step 1 – retain the first letter ("S") and eliminate the "E": SND
Step 2 – "N" gets a value of 5 and "D" gets a value of 3
SNEED = "S53"

SCHMIDT
Step 1 – retain the first letter ("S") and eliminate the "H" and "I": SCMDT
Step 2 – eliminate the duplicate value letters (S/C, both 2, and D/T, both 3): SMD
Step 3 – "M" gets a value of 5 and "D" gets a value of 3
SCHMIDT="S53"

Soundex is most useful for matching English-based names. It is less useful for other strings and there are other algorithms for phonetic matching – they are just not built into SAS' SQL!

ONE MORE WORD ABOUT *WHERE*

All that we've learned about *WHERE* clauses so far can be applied to columns that are not in the *SELECT* list of columns. This can be a handy way of subsetting a table, but can make debugging a bit more challenging since you cannot confirm that your selection logic worked properly. The examples above are quite simple, but a complicated *WHERE* with a number of columns referenced and multiple *AND*s and *OR*s could pose a problem. It is generally good practice to initially include the *WHERE* columns in the *SELECT* statement so that the logic can be verified. Then those columns can be removed later.

DATASET OPTIONS IN THE *FROM* CLAUSE

Any dataset option is valid on the tables in the *FROM* clause. As the example below shows, the *WHERE* clause in the query and the *WHERE* option on the table in the *FROM* clause return are both valid and return identical results.

```
select *                                select *
from SASClass.Inmates                   from SASClass.Inmates(where=(Sex eq 'M'));
where Sex eq 'M';
```

There are a couple situations where the use of dataset options may be preferred to the equivalent syntax in the query itself. Both have to do with columns that are named with SQL reserved words. Suppose that our charge data had a court case number stored in a column named Case and we wanted to get a set of rows that had a value in that field. The following query fails.

```
create table WithCaseNumber as
select *
from ChargeData
where year(BookingDate) eq 2004 and
      Case ne '';
```

We can't use the column name Case in the *SELECT* statement or *WHERE* clause because it is a reserved word. But, we a couple ways we can get around this using dataset options.

We can rename the column with a *RENAME* option or use, like in the example at the top of the page, use a *WHERE* option. Either of the following queries would produce the desired results.

```
select *
from ChargeData(rename=(Case=CaseNumber)
where year(BookingDate) eq 2004 and
      CaseNumber ne '';

select *
from ChargeData(where=(Case ne ‘’))
where year(BookingDate) eq 2004;
```

SORTING YOUR DATA

Up to now, everything we've seen of SQL could be done in a single datastep. So far, we've looked at *SELECT*, *FROM* and *WHERE*. These all play a role in determining what information is going to be included in the results of the query. The *ORDER BY* clause takes the rows selected by those three and sorts them. The *ORDER BY* clause is optional and if it is used it must follow the *WHERE* clause, if used, or the *FROM* clause, if *WHERE* is not used.

```
select *
from SASClass.Charges
where ChargeType eq ‘A’
order by FIM;
```

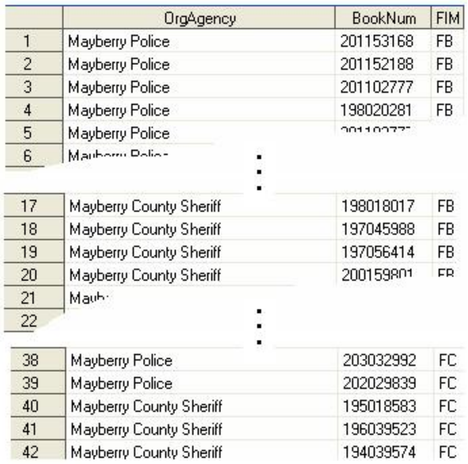
This query would select all the assault charges and sort them by the type of warrant (FIM: felony, investigation, misdemeanor).

As you can probably guess, the syntax of the *ORDER BY* clause is similar to the *BY* statement of PROC SORT. The column, or columns, you want the rows sorted by are listed with multiple columns separated by commas.

Let's say that we wanted to be a bit more selective in our sorting above and we wanted to look at a list of the agencies that caused the inmate to come to jail for each warrant type. We can just add another column, OrgAgency, to the order list.

```
select OrgAgency format=$Agency.,
        BookNum,
        FIM
 from SASclass.Charges
 where ChargeType eq 'A'
 order by FIM,OrgAgency;
```

Now our results are sorted by warrant type and then by agency: first all the felonies by agency, then all the investigations by agency, then all the misdemeanors by agency. Here are some partial results:



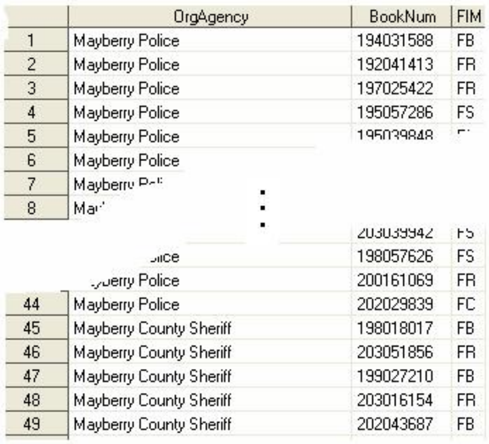
	OrgAgency	BookNum	FIM
1	Mayberry Police	201153168	FB
2	Mayberry Police	201152188	FB
3	Mayberry Police	201102777	FB
4	Mayberry Police	198020281	FB
5	Mayberry Police		
6			
⋮			
17	Mayberry County Sheriff	198018017	FB
18	Mayberry County Sheriff	197045988	FB
19	Mayberry County Sheriff	197056414	FB
20	Mayberry County Sheriff		
21			
22			
⋮			
38	Mayberry Police	203032992	FC
39	Mayberry Police	202029839	FC
40	Mayberry County Sheriff	195018583	FC
41	Mayberry County Sheriff	196039523	FC
42	Mayberry County Sheriff	194039574	FC

Look closely at the results and you'll see that we probably didn't quite get what we wanted. We forgot that there are multiple types of each warrant type: "FB", "FC", etc. for felonies and so on. There is a sorted list of agencies for each of the subtypes.

What we probably wanted was a list of all the agency values are together regardless of the subtype of warrant. How would we do this with PROC SORT? You'd have to make a new column that had only the first character of the warrant type and sort by that. Or, you could create a format that mapped all the warrant types to that first character. The point is that there would be another step involved.

Why mention this unless there's a way to do it with SQL? Well, here's a powerful feature of *ORDER BY* in SQL: you can use functions in the *ORDER BY* clause. This allows us to get the results below by tweaking our query just slightly.

```
select OrgAgency format=$Agency.,
        BookNum,
        FIM
 from SASclass.Charges
 where ChargeType eq 'A'
 order by substr(FIM,1,1),
         OrgAgency;
```



	OrgAgency	BookNum	FIM
1	Mayberry Police	194031588	FB
2	Mayberry Police	192041413	FR
3	Mayberry Police	197025422	FR
4	Mayberry Police	195057286	FS
5	Mayberry Police		
6	Mayberry Police		
7			
8			
⋮			
		198057626	FS
		200161069	FR
44	Mayberry Police	202029839	FC
45	Mayberry County Sheriff	198018017	FB
46	Mayberry County Sheriff	203051856	FR
47	Mayberry County Sheriff	199027210	FB
48	Mayberry County Sheriff	203016154	FR
49	Mayberry County Sheriff	202043687	FB

Now we are just sorting by the first character of the warrant type and then by agency. We didn't need to create another column or do any additional steps to get what we wanted.

Alphabetic Sorting

We've just looked at the ability to use functions in the ORDER BY clause. Now, let's see how to take advantage of that to perform a task that is commonly desired.

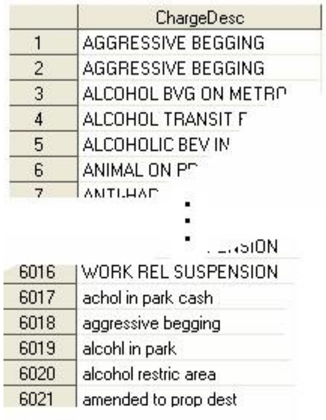
Let's say our booking officers were willy-nilly in the way that they entered the charge description: sometimes all upper-case and sometimes all lower-case. If we wanted a sorted list of charge, we could use *ORDER BY* to get that list.

```
select ChargeDesc
from MixedCase
order by ChargeDesc;
```

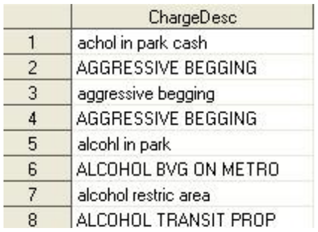
Sorted by charge description, but the results are far from what we want.

We have "AGGRESSIVE BEGGING" at the top of the list, but it's also more than 6,000 rows down as "aggressive begging" – a conundrum with PROC SORT for years! Again, we could create a new variable and sort by that or use a function in the ORDER BY clause to get the desired order.

```
select ChargeDesc
from MixedCase
order by upper(ChargeDesc);
```



	ChargeDesc
1	AGGRESSIVE BEGGING
2	AGGRESSIVE BEGGING
3	ALCOHOL BVG ON METR
4	ALCOHOL TRANSIT
5	ALCOHOLIC BEV IN
6	ANIMAL ON P
7	
⋮	
6016	WORK REL SUSPENSION
6017	achol in park cash
6018	aggressive begging
6019	alcohl in park
6020	alcohol restric area
6021	amended to prop dest



	ChargeDesc
1	achol in park cash
2	AGGRESSIVE BEGGING
3	aggressive begging
4	AGGRESSIVE BEGGING
5	alcohl in park
6	ALCOHOL BVG ON METRO
7	alcohol restric area
8	ALCOHOL TRANSIT PROP

There are a some things to notice about this new result:

- the results are now in the desired order
- the original case has not been changed – that is determined by the *SELECT* statement
- there can be a "randomness" to the groups of values – look at "aggressive begging"
- officers don't always spell that well – (achol, alcohl)

Note: if you want to get rid of the "randomness" and group all the upper case together ("AGGRESSIVE BEGGING") and all the lower case together ("aggressive begging") you can sort by both the upper-cased column and the original column.

```
select ChargeDesc
from MixedCase
order by upper(ChargeDesc),
         ChargeDesc;
```

Now, within each charge description the upper case values will be first, followed by the lower case values. No more "randomness"!

You'll notice that all the queries above give a strange note in the log:

```
NOTE: The query as specified involves ordering by an item that doesn't appear in its SELECT clause.
```

This is because the upper-cased value of ChargeDesc was never named in the *SELECT* statement, only in the *ORDER BY* clause.

Note: the *UPPER* and *LOWER* functions are SQL standard functions and cannot be used in elsewhere in SAS. They operate the same as the SAS *UPCASE* and *LOWCASE* functions. *UPCASE* and LOWCASE can also be used in SQL queries.

THE *DESC* OPTION OF *ORDER BY*

The default sort order is ascending. To get a descending sort, use the *DESC* option following the column name.

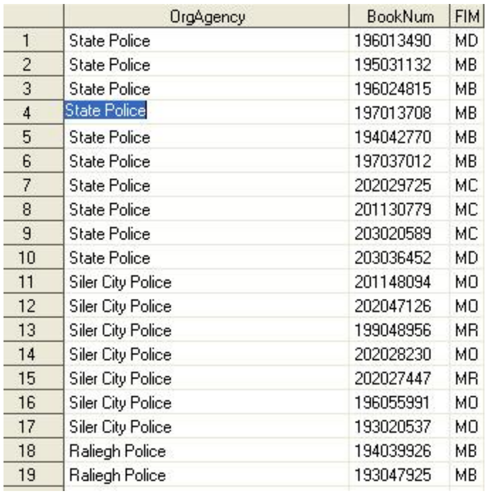
```
select OrgAgency,
       BookNum,
       FIM
from SASclass.Charges
where ChargeType eq 'A'
order by substr(FIM,1,1) desc,
         OrgAgency;
```

This is the same query we used to get a list of agencies in warrant type order. By default, the felonies ("F…") came first. Now, the misdemeanors ("M…") will come first, followed by investigations ("I…") and felonies.

The *DESC* option can be added to as many columns as needed, always following the column name and before the comma or semicolon. For example, to list the agencies in reverse order and keep misdemeanors listed first we simply add another *DESC*:

```
select OrgAgency format=$Agency.,
        BookNum,
        FIM
 from SASclass.Charges
 where ChargeType eq 'A'
 order by substr(FIM,1,1) desc,
           OrgAgency desc;
```

The resulting table would be something like this (see right). The misdemeanors come first and within the misdemeanors, the agencies are in descending order.



	OrgAgency	BookNum	FIM
1	State Police	196013490	MD
2	State Police	195031132	MB
3	State Police	196024815	MB
4	State Police	197013708	MB
5	State Police	194042770	MB
6	State Police	197037012	MB
7	State Police	202029725	MC
8	State Police	201130779	MC
9	State Police	203020589	MC
10	State Police	203036452	MD
11	Siler City Police	201148094	MO
12	Siler City Police	202047126	MO
13	Siler City Police	199048956	MR
14	Siler City Police	202028230	MO
15	Siler City Police	202027447	MR
16	Siler City Police	196055991	MO
17	Siler City Police	193020537	MO
18	Raliegh Police	194039926	MB
19	Raliegh Police	193047925	MB

Note: the placement and spelling of the descending option is different than PROC SORT. In that procedure, the *DESCENDING* option precedes the variable name.

AGGREGATE FUNCTIONS

You can use aggregate (or summary) functions to summarize the data in your tables. These functions can act on multiple columns in a row or on a single column across rows. Here is the list of aggregate functions.

`Avg`	average of values	• `NMiss`	number of missing values
`Count`	number of non-missing values	• `Prt`	probability of a greater absolute value of Student's t
`CSS`	corrected sum of squares	• `Range`	range of values
`CV`	coefficient of variation	• `Std`	standard deviation

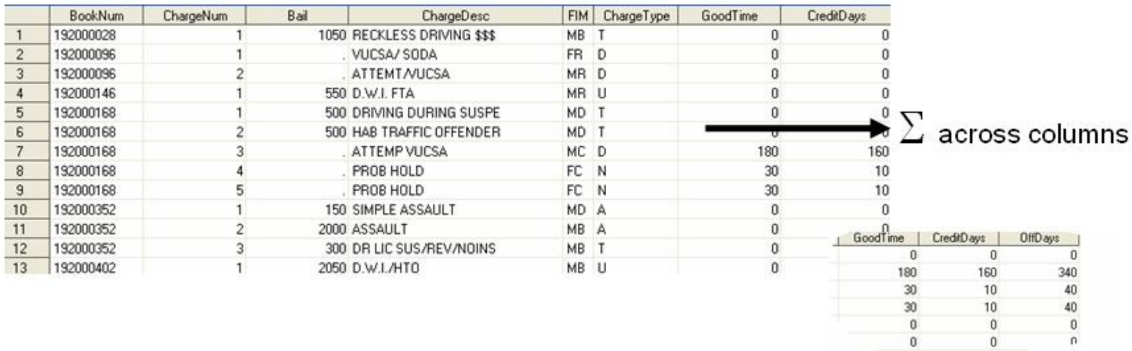
Freq	(same as Count)
Max	maximum value
Mean	(same as Avg)
Min	minimum value
N	(same as Count)
StdErr	standard error of the mean
Sum	sum of values
T	Student's t value for testing that the population mean is 0
USS	uncorrected sum of squares
Var	Variance

Note: the *SUMWGT* function is not listed here as there is no provision for a *WEIGHT* statement in SQL and the results of *SUMWGT* are the same as *COUNT*.

We've already looked at using SAS functions in a *SELECT* statement to create new columns based on the value of an existing column. Aggregate functions create new columns as well, either by summarizing columns across a single row or by summarizing a column down multiple rows.

If more than one column is included in the function argument list then that operation is performed for each row in the table. In the table below, each row in the Charges table gets a new column, OffDays, that is the sum of GoodTime and CreditDays.

```
select *,
       sum(GoodTime,CreditDays) as OffDays
from SASClass.Charges;
```

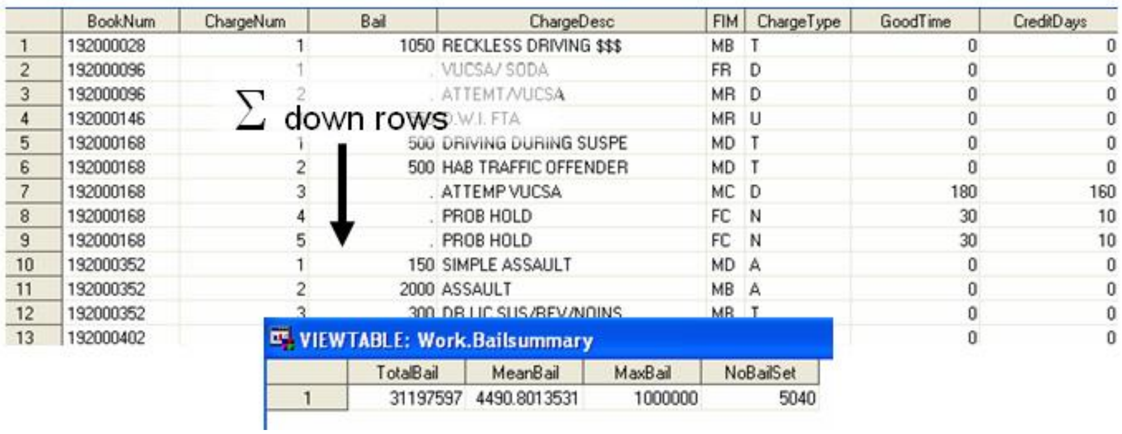


	BookNum	ChargeNum	Bail	ChargeDesc	FIM	ChargeType	GoodTime	CreditDays
1	192000028	1	1050	RECKLESS DRIVING $$$	MB	T	0	0
2	192000096	1	.	VUCSA/ SODA	FR	D	0	0
3	192000096	2	.	ATTEMT/VUCSA	MR	D	0	0
4	192000146	1	550	D.W.I. FTA	MR	U	0	0
5	192000168	1	500	DRIVING DURING SUSPE	MD	T	0	0
6	192000168	2	500	HAB TRAFFIC OFFENDER	MD	T	0	0
7	192000168	3	.	ATTEMP VUCSA	MC	D	180	160
8	192000168	4	.	PROB HOLD	FC	N	30	10
9	192000168	5	.	PROB HOLD	FC	N	30	10
10	192000352	1	150	SIMPLE ASSAULT	MD	A	0	0
11	192000352	2	2000	ASSAULT	MB	A	0	0
12	192000352	3	300	DR LIC SUS/REV/NOINS	MB	T	0	
13	192000402	1	2050	D.W.I./HTO	MB	U	0	

GoodTime	CreditDays	OffDays
0	0	0
180	160	340
30	10	40
30	10	40
0	0	0
0	0	0

If the argument list contains a single column the operation is performed down all the rows in the table. The following query would summarize Bail, in a number of different ways, for the entire table. Notice that the results of this query is a single row containing the sum, mean and maximum values of Bail, as well as the number of rows with a missing value for the Bail column.

```
select sum(Bail) as TotalBail,
       mean(Bail) as MeanBail,
       max(Bail) as MaxBail,
       nmiss(Bail) as NoBailSet
from SASclass.Charges;
```



	BookNum	ChargeNum	Bail	ChargeDesc	FIM	ChargeType	GoodTime	CreditDays
1	192000028	1	1050	RECKLESS DRIVING $$$	MB	T	0	0
2	192000096	1	.	VUCSA/ SODA	FR	D	0	0
3	192000096	2	.	ATTEMT/VUCSA	MR	D	0	0
4	192000146			W.I. FTA	MR	U	0	0
5	192000168	1	500	DRIVING DURING SUSPE	MD	T	0	0
6	192000168	2	500	HAB TRAFFIC OFFENDER	MD	T	0	0
7	192000168	3	.	ATTEMP VUCSA	MC	D	180	160
8	192000168	4	.	PROB HOLD	FC	N	30	10
9	192000168	5	.	PROB HOLD	FC	N	30	10
10	192000352	1	150	SIMPLE ASSAULT	MD	A	0	0
11	192000352	2	2000	ASSAULT	MB	A	0	0
12	192000352	3	300	DR LIC SUS/REV/NOINS	MB	T	0	0
13	192000402						0	0

VIEWTABLE: Work.Bailsummary

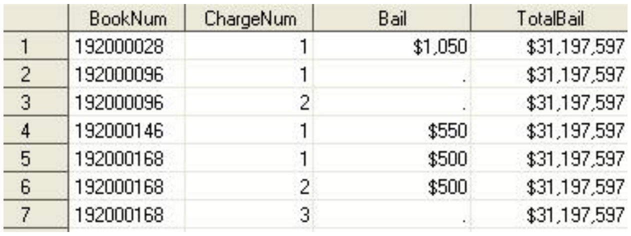
	TotalBail	MeanBail	MaxBail	NoBailSet
1	31197597	4490.8013531	1000000	5040

Note: you can reference as many aggregate functions as you need in a single query and they don't all have to act on the same column.

You'll notice in the preceding query that no columns were listed other than those using the aggregate functions. Remember, we're telling SQL to summarize down all the columns in the table. How would it be interpreted if we asked for some other columns as well? For instance,

```
select BookNum,
       ChargeNum,
       Bail format=dollar15.,
       sum(Bail) as TotalBail format=dollar15.
from SASClass.Charges;
```

The query is saying two things, "Give me the booking number and bail amount for all the rows in the table" and "Give me the sum total of bail for the whole table." One of those questions would return back 11,000+ rows while the other would return one. The actual result is that both requests are granted. First, the summary function will be computed and the total bail will be calculated. Then, that result will be attached, as a new column, to every row in the output.



	BookNum	ChargeNum	Bail	TotalBail
1	192000028	1	$1,050	$31,197,597
2	192000096	1	.	$31,197,597
3	192000096	2	.	$31,197,597
4	192000146	1	$550	$31,197,597
5	192000168	1	$500	$31,197,597
6	192000168	2	$500	$31,197,597
7	192000168	3	.	$31,197,597

You'll also get a note in the log telling you that the query had to run through things more than once:

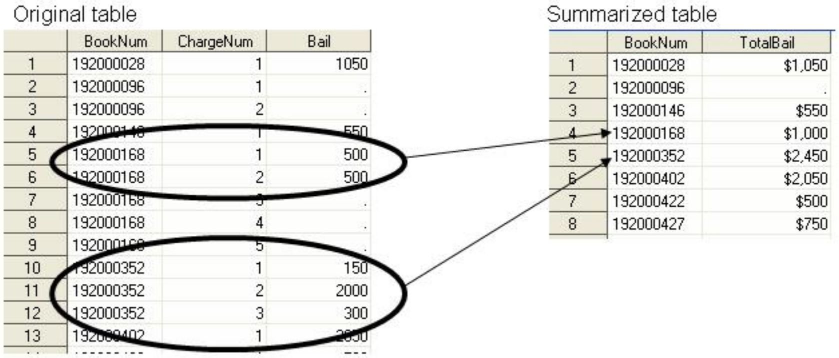
```
NOTE: The query requires remerging summary statistics back with the original data.
```

THE *GROUP BY* CLAUSE

By default, summary functions work across all the rows in a table. You can summarize groups of data with the GROUP BY clause. For example,

```
select BookNum,
       sum(Bail) as TotalBail
from SASClass.Charges
group by BookNum;
```

Partial results of the query above are shown here:



Original table

	BookNum	ChargeNum	Bail
1	192000028	1	1050
2	192000096	1	.
3	192000096	2	.
4	192000146	1	550
5	192000168	1	500
6	192000168	2	500
7	192000168	3	.
8	192000168	4	.
9	192000168	5	.
10	192000352	1	150
11	192000352	2	2000
12	192000352	3	300
13	192000402	1	2050

Summarized table

	BookNum	TotalBail
1	192000028	$1,050
2	192000096	.
3	192000146	$550
4	192000168	$1,000
5	192000352	$2,450
6	192000402	$2,050
7	192000422	$500
8	192000427	$750

Notice that there is now one row per booking number and that the bail amounts have been summarized. Remember from the previous section that without the *GROUP BY* clause the table total bail would have been added to each row of the table.

The *GROUP BY* clause also orders the rows by the values of the grouped columns. We'll see later that there is also an *ORDER BY* clause if you to specify a different sort order.

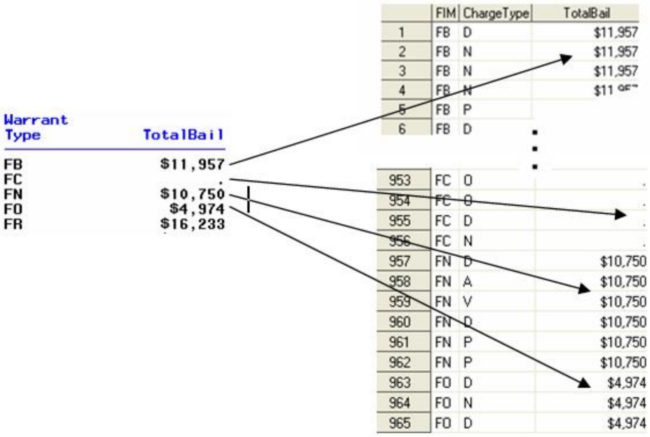
There is no requirement that the order of *GROUP BY* columns matches the order of the *SELECT* columns.

You will almost always want to include all non-summary columns from your *SELECT* statement in the *GROUP BY* clause. Let's look at the following query to see what happens if you do not.

```
select FIM,
       ChargeType,
      mean(Bail) as TotalBail format=dollar15.
from SASclass.Charges
group by FIM;
```

This query will pass through the table twice and do the following:

- calculate the mean bail for each value of FIM (pass 1)
- return all rows of the original table (pass 2)



```
Warrant
Type          TotalBail

FB              $11,957
FC                    .
FN              $10,750
FO               $4,974
FR              $16,233
```

	FIM	ChargeType	TotalBail
1	FB	D	$11,957
2	FB	N	$11,957
3	FB	N	$11,957
4	FB	N	$11,957
5	FB	P	
6	FB	D	
⋮			
953	FC	O	.
954	FC	O	.
955	FC	D	.
956	FC	N	.
957	FN	D	$10,750
958	FN	A	$10,750
959	FN	V	$10,750
960	FN	D	$10,750
961	FN	P	$10,750
962	FN	P	$10,750
963	FO	D	$4,974
964	FO	N	$4,974
965	FO	D	$4,974

- ordered by FIM
- with the appropriate value (FIM-specific) of TotalBail attached to each row

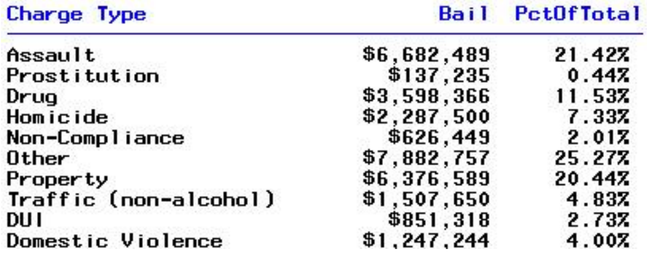
Notice that the FIM total bail has been added to each row. Chances are, however, that this is not what you wanted from the query and you need to add the charge type to the *GROUP BY* clause.

We mentioned a few pages back that there are instances where eliminating or having an incomplete *GROUP BY* can be used to your advantage. Let's assume that we have a table with one row per charge type containing the total bail. We can make use of the summary behavior to get the percent of total bail that each charge type represents. This query

```
select ChargeType format=$Charge.,
       Bail format=dollar15.,
       Bail / sum(Bail) as PctOfTotal format=percent9.2
from BailGroups;
```

adds the table total bail to each row of the table. Instead of using this as a separate field, as we've done in the past, we can use this value in an expression to calculate the percentage of total bail.

As we've seen before this query will make two passes through the table – first to calculate the total bail and then to write out each row of the table.



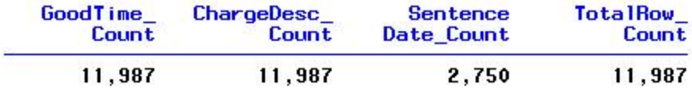
```
Charge Type                        Bail  PctOfTotal

Assault                      $6,682,489      21.42%
Prostitution                   $137,235       0.44%
Drug                         $3,598,366      11.53%
Homicide                     $2,287,500       7.33%
Non-Compliance                 $626,449       2.01%
Other                        $7,882,757      25.27%
Property                     $6,376,589      20.44%
Traffic (non-alcohol)        $1,507,650       4.83%
DUI                            $851,318       2.73%
Domestic Violence            $1,247,244       4.00%
```

THE SPECIAL CASE OF *COUNT()*

The *COUNT* function is a little different than other summary functions in a couple different ways. First, it can accept either a character or numeric column name as the argument – the other functions require a numeric column. The *COUNT* function returns the number of non-missing values of the specified column. Secondly, you can pass an asterisk (*) to the function and get a count of the total number of rows in the table (or group).

The following query counts non-missing value rows for two numeric columns (GoodTime and SentenceDate), a character column (ChargeDesc) and counts all the rows in the table (*).

```
select count(GoodTime) as GoodTime_Count format=comma7.,
       count(ChargeDesc) as ChargeDesc_Count format=comma7.,
       count(SentenceDate) as SentenceDate_Count format=comma7.
       count(*) as TotalRow_Count format=comma7.
from SASclass.Charges;
```

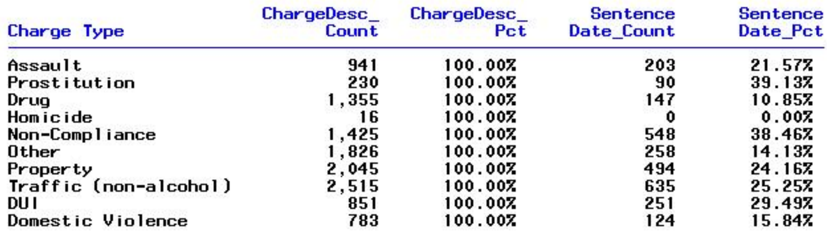


```
  GoodTime_    ChargeDesc_      Sentence     TotalRow_
      Count          Count    Date_Count         Count

     11,987         11,987         2,750        11,987
```

We can see from the output that there are no missing values for good time days or charge description but, as would be expected, there are a number of missing values for the sentence date.

We can mix and match the scope of *COUNT* (column-specific counts vs total counts) in the same query. This query gets the column-specific non-missing counts and divides them by the total row count to get the percentage of non-missing values. We're also using a *GROUP BY* clause, so the counts will be specific to each value of charge type.

```
select ChargeType format=$Charge.,
       count(ChargeDesc) as ChargeDesc_Count format=comma7.,
       count(ChargeDesc) / count(*) as ChargeDesc_Pct format=percent9.2,
       count(SentenceDate) as SentenceDate_Count format=comma7.,
       calculated SentenceDate_Count / count(*) as SentenceDate_Pct format=percent9.2
from SASclass.Charges
group by ChargeType;
```



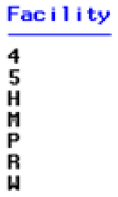
```
                             ChargeDesc_   ChargeDesc_    Sentence      Sentence
Charge Type                       Count           Pct   Date_Count      Date_Pct

Assault                             941       100.00%          203        21.57%
Prostitution                        230       100.00%           90        39.13%
Drug                              1,355       100.00%          147        10.85%
Homicide                             16       100.00%            0         0.00%
Non-Compliance                    1,425       100.00%          548        38.46%
Other                             1,826       100.00%          258        14.13%
Property                          2,045       100.00%          494        24.16%
Traffic (non-alcohol)             2,515       100.00%          635        25.25%
DUI                                 851       100.00%          251        29.49%
Domestic Violence                   783       100.00%          124        15.84%
```

Note: There is one other difference between *COUNT* and other aggregate functions. In other aggregate functions passing multiple column names to the function causes it to calculate the desired statistic across those columns for each row in the table. The *COUNT* function is not designed to operate across columns and will not produce meaningful results if multiple columns are passed to it.

THE *DISTINCT* OPERATOR

While *DISTINCT* isn't really a summary function, we'll discuss it here because it has some of the properties of a summary function.

```
select distinct Facility
from SASClass.Bookings;
```

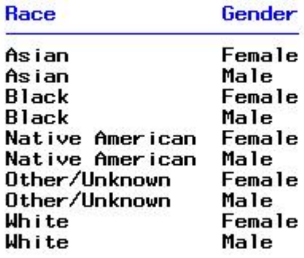


```
Facility

4
5
H
M
P
R
W
```

The first query above would return a list of all the unique values of facility:

No counts, just a list. You can have more than one column listed after the *DISTINCT* operator and you would get a list of all combinations of the columns. If a column had a permanent format associated with it, or you used the *FORMAT* option to assign a format, the distinct value list would have formatted values. For instance, this query returns formatted values of the unique combinations of race and sex.

```
select distinct Race format=$Race.,
                Sex format=$Gender.
from SASclass.Inmates;
```

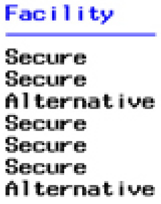


```
Race               Gender

Asian              Female
Asian              Male
Black              Female
Black              Male
Native American    Female
Native American    Male
Other/Unknown      Female
Other/Unknown      Male
White              Female
White              Male
```

<u>Note</u>: When multiple columns are listed with *DISTINCT*, only the actual value combinations are returned – not all possible combinations. If, in the Inmates table used above, there were no Native American females that row would not be in the result set.

There is a danger when using formatted values and *DISTINCT*. The distinct value list is built on the actual, unformatted data and then the formats are applied when the data is presented. If there are multiple raw values assigned to the same formatted value your distinct list may not look so distinct.

```
select distinct Facility as Facility format=$Secure.
from SASclass.Bookings;
```

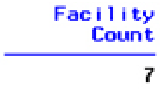


```
Facility

Secure
Secure
Alternative
Secure
Secure
Secure
Alternative
```

If you look at the distinct facilities list from the first example you can see that we end up with the same number of "distinct" values in the list. If you matched up the rows in the two outputs you can conclude that the values "4", "5", "M", "P", "R" are formatted "Secure" and "H" and "W" are formatted "Alternative".

The following query demonstrates the use of *DISTINCT* within the *COUNT* function. This query will return the number of unique values of Facility – in this case, 7.

```
select count(distinct Facility)
from SASClass.Bookings;
```



```
Facility
   Count

       7
```

<u>Note</u>: you cannot list more than one column in the COUNT function. If you wanted the number of distinct combinations of race and gender in your data the following query would generate an error:

```
select count(distinct Race,
                      Sex)
```

```
    from SASclass.Inmates;
```

You could get the count by concatenating the two columns into one and getting a count of that value. For instance,

```
    select count(distinct Race||Sex)
    from SASclass.Inmates;
```

The query above returns a value of 10, which we can see from the example above is the number of values of race and gender.

THE *CALCULATED* KEYWORD

There is an important timing feature of SQL to keep in mind before we discuss the *CALCULATED* option. The *SELECT* statement and *WHERE and GROUP BY* clauses are acting on columns as they "come into" the query. The *ORDER BY* , and soon to be discussed *HAVING*, clauses which act on columns as they "leave" the query. This means that *SELECT*, *WHERE* and *GROUP BY* all need to reference columns that are in the tables referenced in the query.

In an earlier query we used the *SUM* function to add good time and credit days to get a new column, OffDays. We might try to write a query to select records that had some "off days" as follows:

```
    create table OffDays as
    select *,
           sum(GoodTime,CreditDays) as OffDays
    from SASClass.Charges
    where OffDays gt 0;
```

We would have seen an error because the *WHERE* clause doesn't know what OffDays is – it's not in the Charges table.

The *CALCULATED* option is simply a shortcut to SQL to say, "replace this with the expression that created this new column." The following two *WHERE* clauses are equivalent:

```
    create table OffDays as
    select *,
           sum(GoodTime,CreditDays) as OffDays
    from SASClass.Charges
    where sum(GoodTime,CreditDays) gt 0;


    where calculated OffDays gt 0;
```

You must also use *CALCULATED* in the *SELECT* statement if you want to reference another column that was created in the *SELECT* statement. let's say we wanted to create another column that was simply a flag ("*") turned on if the new OffDays column was greater than zero. The following query creates the OffDays column and then references it to create the flag, OffDayFlag.

```
    select *,
           sum(GoodTime,CreditDays) as OffDays,
           case
             when calculated OffDays gt 0 then '*'
             else ' '
           end as OffDayFlag
    from SASClass.Charges;
```

One other thing to note about using *CALCULATED* column references. The column must have been created in the *SELECT* prior to its being referenced with a *CALCULATED* option. Switching the order of the columns in the query above would cause an error. Remember, that *CALCULATED* tells SQL to "replace the name with the expression" – if the expression hasn't been seen yet, the substitution cannot happen.

RELATIVE COLUMN REFERENCING – A *GROUP BY* SHORTCUT

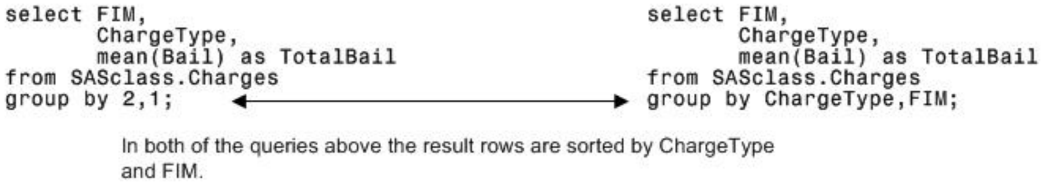
Instead of using column names in the GROUP BY clause you can use the column position. The following two *GROUP BY* clauses are equivalent:

```
select FIM,
       ChargeType,
       mean(Bail) as TotalBail
from SASClass.Charges
group by 1,2;

group by FIM, ChargeType;
```

Relative column referencing is often a nice little time saver. All you have to do is use the position of the column you want rather than the column name. If is most useful when you're grouping on calculated columns and you don't want to type "calculated" over and over again.

There are a couple warnings about using relative referencing.

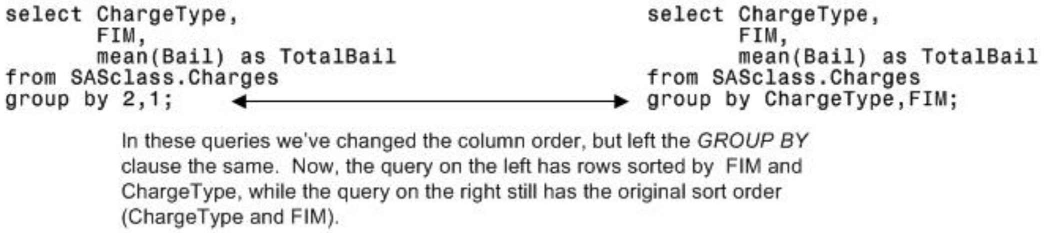
- First, it can be a bit of a troubleshooting issue as you have to look back and forth between the *SELECT* and *GROUP BY* to see what columns you're really grouping on.
- Second, if you decide to switch the order of the columns in your *SELECT* statement, the row order in the result set may also change. Take the example above:



```
select FIM,
       ChargeType,
       mean(Bail) as TotalBail
from SASclass.Charges
group by 2,1;
```

```
select FIM,
       ChargeType,
       mean(Bail) as TotalBail
from SASclass.Charges
group by ChargeType,FIM;
```

In both of the queries above the result rows are sorted by ChargeType and FIM.



```
select ChargeType,
       FIM,
       mean(Bail) as TotalBail
from SASclass.Charges
group by 2,1;
```

```
select ChargeType,
       FIM,
       mean(Bail) as TotalBail
from SASclass.Charges
group by ChargeType,FIM;
```

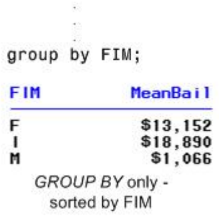
In these queries we've changed the column order, but left the *GROUP BY* clause the same. Now, the query on the left has rows sorted by FIM and ChargeType, while the query on the right still has the original sort order (ChargeType and FIM).

Just some things to keep in mind when you use relative referencing rather than column name referencing in the *GROUP BY* clause.

GROUP BY AND *ORDER BY* TOGETHER

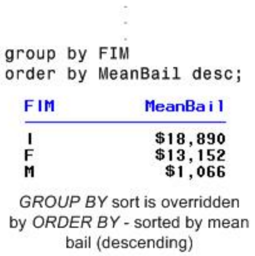
The *GROUP BY* clause has an implied sort and the results are displayed in that order. If you use both *GROUP BY* and *ORDER BY* in the same query, the *ORDER BY* determines the sorted order of the result.

You can see the results of the two methods in the query snippets below. The first results are grouped by the type of warrant (FIM) and are displayed in the alphabetical order of the values of that column ("F", "I", "M"). In the second query the ORDER BY clause which will sort the result in descending order of mean bail.



```
group by FIM;

FIM          MeanBail

F             $13,152
I             $18,890
M              $1,066
```

GROUP BY only - sorted by FIM



```
group by FIM
order by MeanBail desc;

FIM          MeanBail

I             $18,890
F             $13,152
M              $1,066
```

GROUP BY sort is overridden by *ORDER BY* - sorted by mean bail (descending)

THE *HAVING* CLAUSE

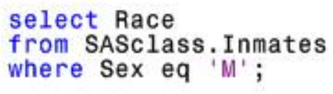
To select rows based on the results of a summary function, use the *HAVING* clause. The *HAVING* clause is similar to the *WHERE* clause in that it allows you to select rows to keep in the result set of your query. It is an optional clause and is placed after the *GROUP BY* clause.

```
select BookingMonth,
       sum(NumCharges) as TotalCharges
from SASClass.Charges
group by BookingMonth
having TotalCharges gt 275;
```

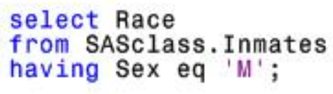
In the query above the *HAVING* condition (TotalCharges > 275) is evaluated after the query has run and the rows have been grouped and then only rows that meet the condition are written to the result set.

It's important to stress the difference between *HAVING* and *WHERE*. The *WHERE* clause selects rows as they come into the query. It has to reference columns that exist in the query table or are calculated using columns in the query tables. It cannot reference summary columns. *HAVING*, on the other hand, references summary columns as the rows go out of the query.

What happens if you use *HAVING* on non-summary columns? A lot depends on the rest of the *SELECT*. If you do not have any summary columns, the *WHERE* and *HAVING* clauses will produce identical results. For example, these two queries produce exactly the same result.



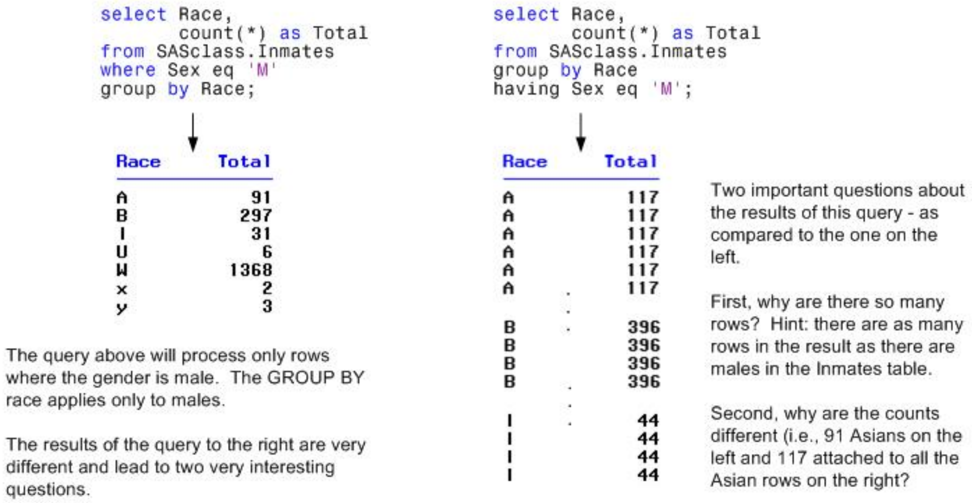
```
select Race
from SASclass.Inmates
where Sex eq 'M';
```



```
select Race
from SASclass.Inmates
having Sex eq 'M';
```

There is no summarization of rows, so the values going in and the values coming out of the query are the same.

There are some big differences, however, when there is a summary function in the *SELECT* statement and the *HAVING* clause references a non-summary column. Let's look at the queries below.



```
select Race,
       count(*) as Total
from SASclass.Inmates
where Sex eq 'M'
group by Race;
```

```
Race       Total
A             91
B            297
I             31
U              6
W           1368
x              2
y              3
```

The query above will process only rows where the gender is male. The GROUP BY race applies only to males.

The results of the query to the right are very different and lead to two very interesting questions.

```
select Race,
       count(*) as Total
from SASclass.Inmates
group by Race
having Sex eq 'M';
```

```
Race       Total
A            117
A            117
A            117
A            117
A            117
A     .      117
      .
      .
B     .      396
B            396
B            396
B     .      396
      .
I     .       44
I             44
I             44
I             44
```

Two important questions about the results of this query - as compared to the one on the left.

First, why are there so many rows? Hint: there are as many rows in the result as there are males in the Inmates table.

Second, why are the counts different (i.e., 91 Asians on the left and 117 attached to all the Asian rows on the right?

Let's think about those questions. If *HAVING* references a non-summary column that is not in the *SELECT* it "adds" it to the list of columns. So, the query on the right above is equivalent to this one, except that the sex column is not kept.

```
select Race,
       sex,
       count(*) as Total
from SASclass.Inmates
group by Race
having sex eq 'M';
```

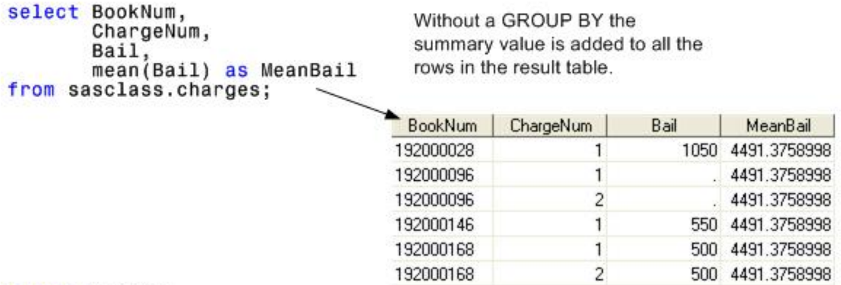
Remember that when a *GROUP BY* clause is incomplete? The entire table is returned to the result set and the summarized value is added to every row. So, we get the total number of rows for each race and that value is added back to each row. Then, the *HAVING* is applied and the male rows are kept. The result set contains all the male rows with the count for all the rows.

Can you see why we want to reserve *HAVING* for summary column filtering and *WHERE* for non-summary column filtering?

SUMMARY FUNCTIONS IN *HAVING*

We just saw that there is a big danger in using non-summary columns in the *HAVING* clause. However, using summary columns in the *HAVING* that are not in the *SELECT* can be a very handy thing.

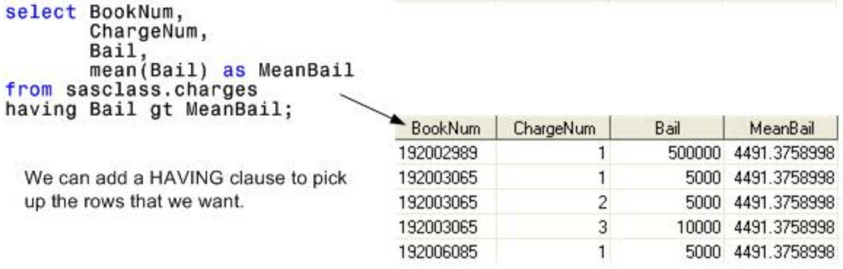
Let’s look at a way to get all the charges that have a bail amount greater than the mean amount.



```
select BookNum,
       ChargeNum,
       Bail,
       mean(Bail) as MeanBail
from sasclass.charges;
```

Without a GROUP BY the summary value is added to all the rows in the result table.

BookNum	ChargeNum	Bail	MeanBail
192000028	1	1050	4491.3758998
192000096	1	.	4491.3758998
192000096	2	.	4491.3758998
192000146	1	550	4491.3758998
192000168	1	500	4491.3758998
192000168	2	500	4491.3758998

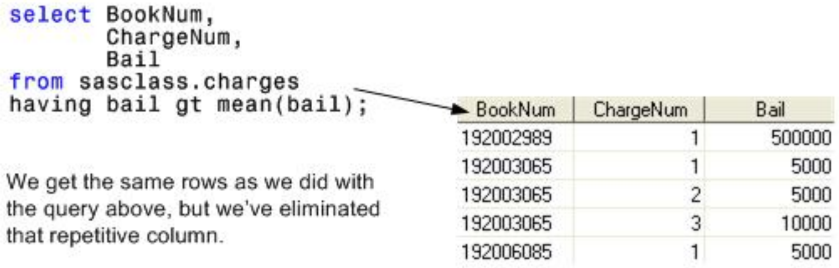


```
select BookNum,
       ChargeNum,
       Bail,
       mean(Bail) as MeanBail
from sasclass.charges
having Bail gt MeanBail;
```

BookNum	ChargeNum	Bail	MeanBail
192002989	1	500000	4491.3758998
192003065	1	5000	4491.3758998
192003065	2	5000	4491.3758998
192003065	3	10000	4491.3758998
192006085	1	5000	4491.3758998

We can add a HAVING clause to pick up the rows that we want.

But, we don’t really need that mean bail column repeated on every row in the table. Well, we can put the summary function in the *HAVING* clause rather than in the *SELECT* and get the same result.

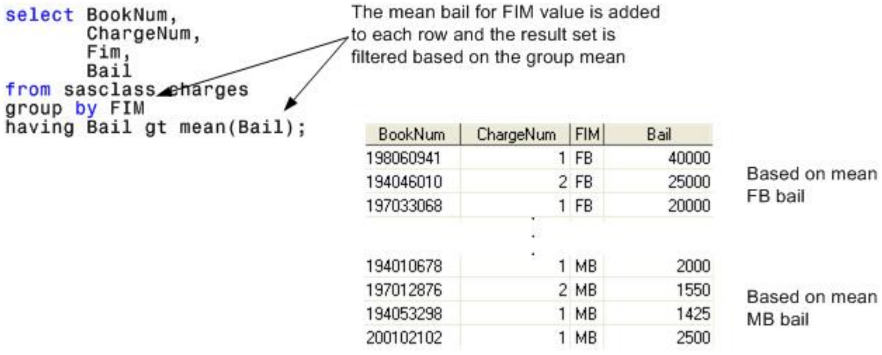


```
select BookNum,
       ChargeNum,
       Bail
from sasclass.charges
having bail gt mean(bail);
```

BookNum	ChargeNum	Bail
192002989	1	500000
192003065	1	5000
192003065	2	5000
192003065	3	10000
192006085	1	5000

We get the same rows as we did with the query above, but we’ve eliminated that repetitive column.

We can go a step further here. By adding an incomplete *GROUP BY* clause, one which does not reference all the columns in the *SELECT* statement, and keep a summary function in a HAVING clause we can filter our result set based on the grouped values of the summary statistic. If, in the example above, we wanted to get charges that had a bail higher than the mean bail for the warrant type of the charge we could add FIM to the *SELECT* and a *GROUP BY*. Just as above, the mean bail would be implicitly added to each row, but this time it would be the mean of the *GROUP BY* column.



```
select BookNum,
       ChargeNum,
       Fim,
       Bail
from sasclass.charges
group by FIM
having Bail gt mean(Bail);
```

The mean bail for FIM value is added to each row and the result set is filtered based on the group mean

BookNum	ChargeNum	FIM	Bail
198060941	1	FB	40000
194046010	2	FB	25000
197033068	1	FB	20000
	. . .		
194010678	1	MB	2000
197012876	2	MB	1550
194053298	1	MB	1425
200102102	1	MB	2500

Based on mean FB bail

Based on mean MB bail

CONCLUSION

It’s amazing what you can do with those seven keywords and a few options. The power of SQL to organize, summarize and order your data all in one query can save you considerable time in developing your applications.

You can learn a lot about SQL and its implementation in SAS in just a few pages, but there is so much more: multiple table joins, embedded queries, passing queries to other databases, etc. I hope that this paper has whetted your appetite for learning more about SQL.

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