# Functions

# Objectives

After completing this lesson, you should be able to do the following:

- Differentiate between a procedure and a function
- Describe the uses of functions
- Create stored functions
- Invoke a function
- Remove a function




In this lesson, you learn how to create, invoke, and maintain functions.

# Overview of Stored Functions

A function:

- Is a named PL/SQL block that returns a value
- Can be stored in the database as a schema object for repeated execution
- Is called as part of an expression or is used to provide a parameter value for another subprogram
- Can be grouped into PL/SQL packages




A function is a named PL/SQL block that can accept parameters, be invoked, and return a value. In general, you use a function to compute a value. Functions and procedures are structured alike. A function must return a value to the calling environment, whereas a procedure returns zero or more values to its calling environment. Like a procedure, a function has a header, a declarative section, an executable section, and an optional exception-handling section. A function must have a `RETURN` clause in the header and at least one `RETURN` statement in the executable section.

Functions can be stored in the database as schema objects for repeated execution. A function that is stored in the database is referred to as a stored function. Functions can also be created on client-side applications.

Functions promote reusability and maintainability. When validated, they can be used in any number of applications. If the processing requirements change, only the function needs to be updated.

A function may also be called as part of a SQL expression or as part of a PL/SQL expression. In the context of a SQL expression, a function must obey specific rules to control side effects. In a PL/SQL expression, the function identifier acts like a variable whose value depends on the parameters passed to it.

Functions (and procedures) can be grouped into PL/SQL packages. Packages make code even more reusable and maintainable. Packages are covered in the lessons titled “Creating Packages” and “Working with Packages.”

# Creating Functions

The PL/SQL block must have at least one RETURN statement.

```
CREATE [OR REPLACE] FUNCTION function_name
 [(parameter1 [mode1] datatype1, . . .)]
RETURN datatype IS|AS
 [local_variable_declarations;
  . . .]
BEGIN
  -- actions;
  RETURN expression;
END [function_name];
```

PL/SQL Block




## Syntax for Creating Functions

A function is a PL/SQL block that returns a value. A RETURN statement must be provided to return a value with a data type that is consistent with the function declaration.

You create new functions with the CREATE FUNCTION statement, which may declare a list of parameters, must return one value, and must define the actions to be performed by the standard PL/SQL block.

You should consider the following points about the CREATE FUNCTION statement:

- The REPLACE option indicates that if the function exists, it is dropped and replaced with the new version that is created by the statement.
- The RETURN data type must not include a size specification.
- The PL/SQL block starts with a BEGIN after the declaration of any local variables and ends with an END, optionally followed by the *function_name*.
- There must be at least one RETURN *expression* statement.
- You cannot reference host or bind variables in the PL/SQL block of a stored function.

**Note:** Although the OUT and IN OUT parameter modes can be used with functions, it is not good programming practice to use them with functions. However, if you need to return more than one value from a function, consider returning the values in a composite data structure such as a PL/SQL record or a PL/SQL table.

# The Difference Between Procedures and Functions

| Procedures | Functions |
|---|---|
| Execute as a PL/SQL statement | Invoke as part of an expression |
| Do not contain `RETURN` clause in the header | Must contain a `RETURN` clause in the header |
| Can pass values (if any) using output parameters | Must return a single value |
| Can contain a `RETURN` statement without a value | Must contain at least one `RETURN` statement |

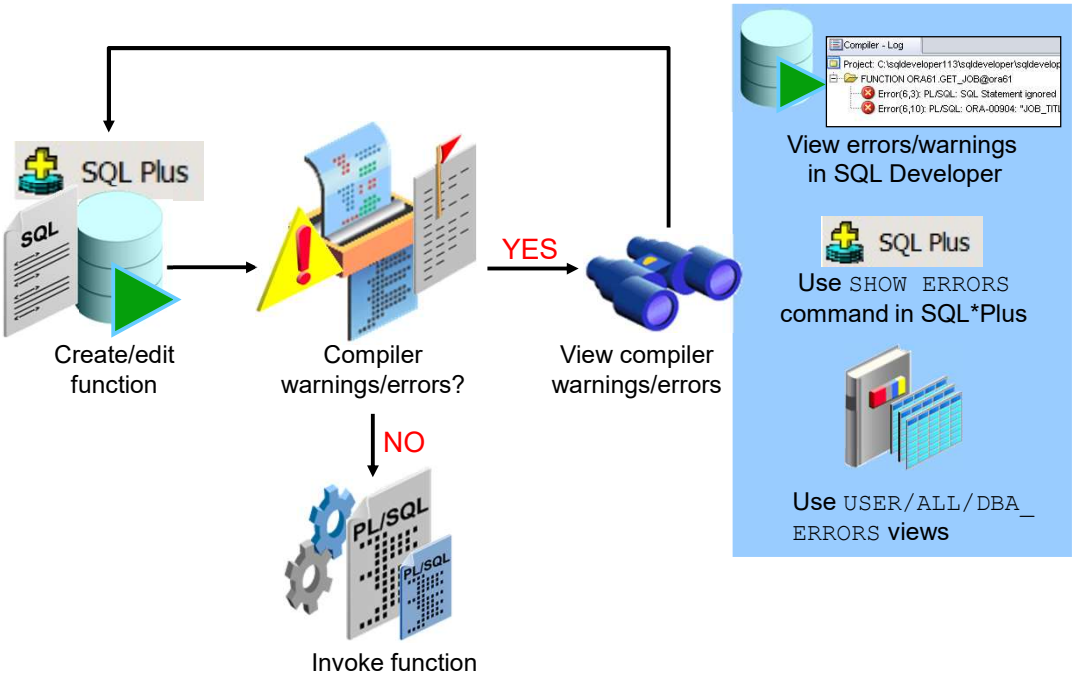



You create a procedure to store a series of actions for later execution. A procedure can contain zero or more parameters that can be transferred to and from the calling environment, but a procedure does not have to return a value. A procedure can call a function to assist with its actions.

**Note:** A procedure containing a single `OUT` parameter would be better rewritten as a function returning the value.

You create a function when you want to compute a value that must be returned to the calling environment. A function can contain zero or more parameters that are transferred from the calling environment. Functions typically return only a single value, and the value is returned through a `RETURN` statement. Functions used in SQL statements should not use `OUT` or `IN OUT` mode parameters. Although a function using output parameters can be used in a PL/SQL procedure or block, it cannot be used in SQL statements.

# Creating and Running Functions: Overview







The diagram in the slide illustrates the basic steps involved in creating and running a function:

1. Create the function using SQL Developer's Object Navigator tree or the SQL Worksheet area.
2. Compile the function. The function is created in the database. The `CREATE FUNCTION` statement creates and stores source code and the compiled *m-code* in the database. To compile the function, right-click the function's name in the Object Navigator tree, and then click Compile.
3. If there are compilation warning or errors, you can view (and then correct) the warnings or errors using one of the following methods:
   a. Using the SQL Developer interface (the Compiler – Log tab)
   b. Using the `SHOW ERRORS` SQL*Plus command
   c. Using the `USER/ALL/DBA_ERRORS` views
4. After successful compilation, invoke the function to return the desired value.

## Creating and Invoking a Stored Function Using the CREATE FUNCTION Statement: Example

```
CREATE OR REPLACE FUNCTION get_sal
 (p_id employees.employee_id%TYPE) RETURN NUMBER IS
  v_sal employees.salary%TYPE := 0;
  BEGIN
    SELECT salary
    INTO   v_sal
    FROM   employees
    WHERE  employee_id = p_id;
    RETURN v_sal;
  END get_sal;
/
```

```
FUNCTION GET_SAL compiled
```

```
-- Invoke the function as an expression or as
-- a parameter value.

EXECUTE dbms_output.put_line(get_sal(100))
```

```
anonymous block completed
24000
```




### Stored Function: Example

The `get_sal` function is created with a single input parameter and returns the salary as a number. Execute the command as shown, or save it in a script file and run the script to create the `get_sal` function.

The `get_sal` function follows a common programming practice of using a single `RETURN` statement that returns a value assigned to a local variable. If your function has an exception section, then it may also contain a `RETURN` statement.

Invoke a function as part of a PL/SQL expression because the function will return a value to the calling environment. The second code box uses the SQL*Plus `EXECUTE` command to call the `DBMS_OUTPUT.PUT_LINE` procedure whose argument is the return value from the function `get_sal`. In this case, `get_sal` is invoked first to calculate the salary of the employee with ID 100. The salary value returned is supplied as the value of the `DBMS_OUTPUT.PUT_LINE` parameter, which displays the result (if you have executed a `SET SERVEROUTPUT ON`).

**Note:** A function must always return a value. The example does not return a value if a row is not found for a given `id`. Ideally, create an exception handler to return a value as well.

# Using Different Methods for Executing Functions

```
-- As a PL/SQL expression, get the results using host variables

VARIABLE b_salary NUMBER
EXECUTE :b_salary := get_sal(100)
```

```
anonymous block completed
B_SALARY
-----
24000
```

```
-- As a PL/SQL expression, get the results using a local
-- variable
SET SERVEROUTPUT ON
DECLARE
  sal employees.salary%type;
BEGIN
  sal := get_sal(100);
  DBMS_OUTPUT.PUT_LINE('The salary is: '|| sal);
END;
/
```

```
anonymous block completed
The salary is: 24000
```




If functions are well designed, they can be powerful constructs. Functions can be invoked in the following ways:

- **As part of PL/SQL expressions:** You can use host or local variables to hold the returned value from a function. The first example in the slide uses a host variable and the second example uses a local variable in an anonymous block.

# Using Different Methods for Executing Functions

```
-- Use as a parameter to another subprogram

EXECUTE dbms_output.put_line(get_sal(100))
```

```
anonymous block completed
24000
```

```
-- Use in a SQL statement (subject to restrictions)

SELECT job_id, get_sal(employee_id)
FROM employees;
```

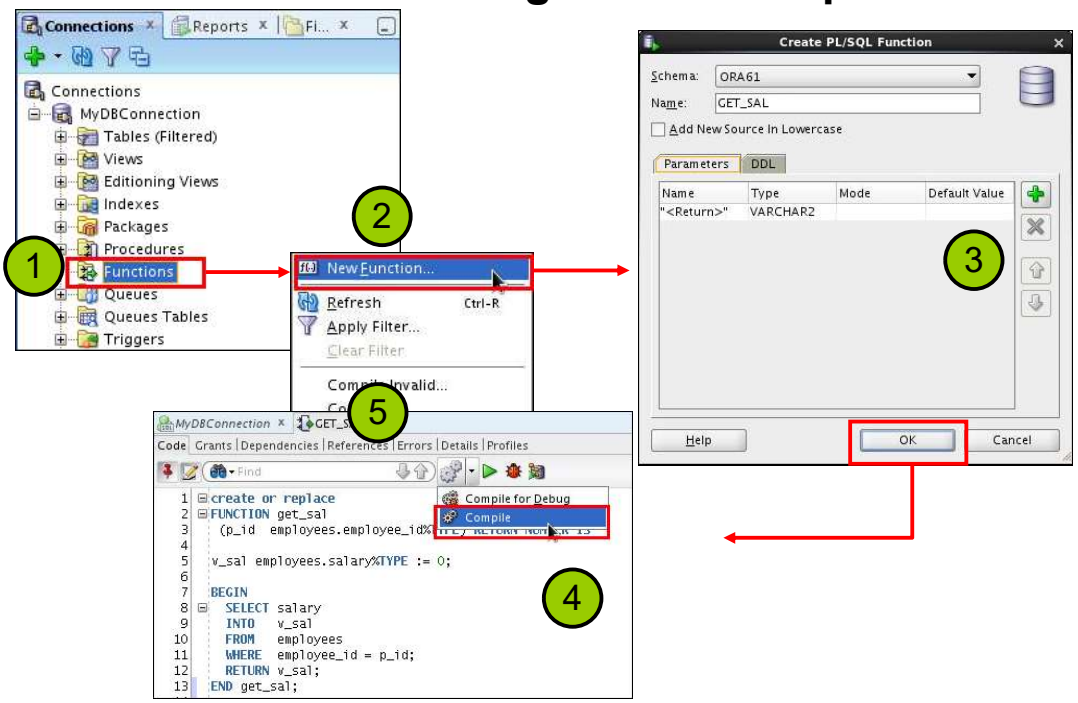
```
JOB_ID     GET_SAL(EMPLOYEE_ID)
---------- --------------------
AC_ACCOUNT                 8300
AC_MGR                    12008
AD_ASST                    4400
AD_PRES                   24000
...
ST_MAN                     6500
ST_MAN                     5800

107 rows selected
```




- **As a parameter to another subprogram:** The first example in the slide demonstrates this usage. The `get_sal` function with all its arguments is nested in the parameter required by the `DBMS_OUTPUT.PUT_LINE` procedure. This comes from the concept of nesting functions as discussed in the course titled *Oracle Database: SQL Fundamentals I*.
- **As an expression in a SQL statement:** The second example in the slide shows how a function can be used as a single-row function in a SQL statement.

# Creating and Compiling Functions Using SQL Developer







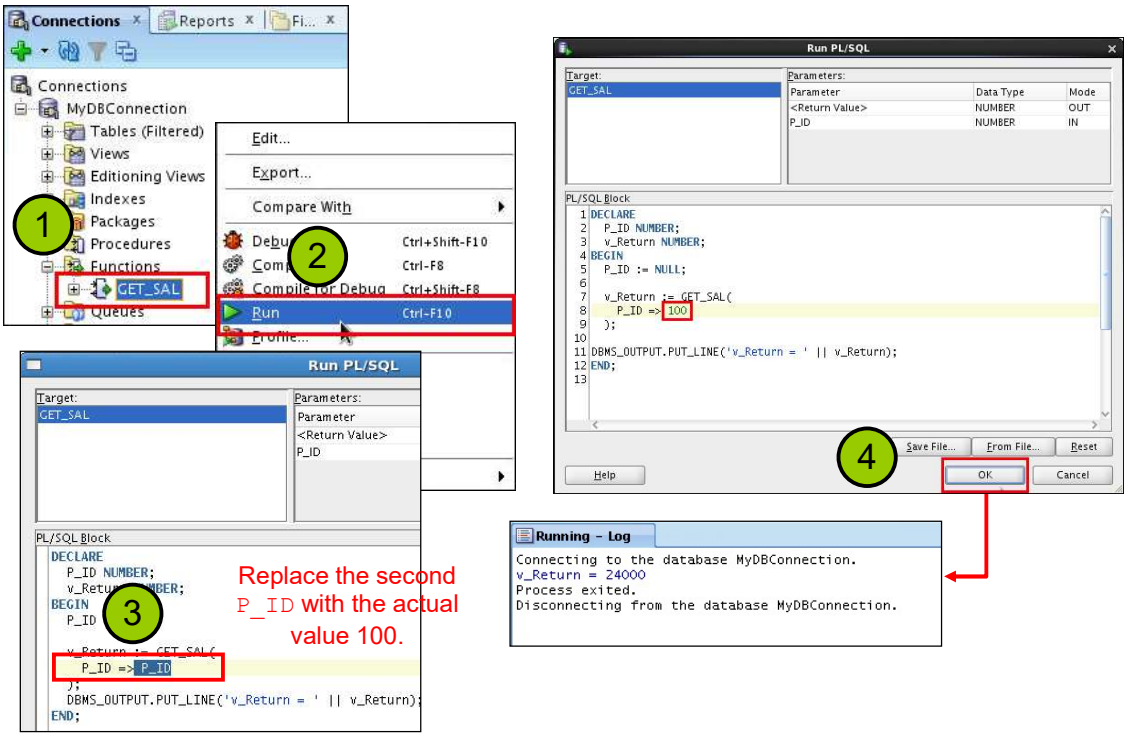
You can create a new function in SQL Developer using the following steps:

1. Right-click the **Functions** node.
2. Select **New Function** from the shortcut menu. The **Create PL/SQL Function** dialog box is displayed.
3. Select the schema, function name, and the parameters list (using the **+** icon), and then click **OK**. The code editor for the function is displayed.
4. Enter the function's code.
5. To compile the function, click the **Compile** icon.

**Note**

- To create a new function in SQL Developer, you can also enter the code in the SQL Worksheet, and then click the Run Script icon.
- For additional information about creating functions in SQL Developer, access the appropriate online help topic titled "Create PL/SQL Subprogram Function or Procedure."

# Executing Functions Using SQL Developer







You can execute a function in SQL Developer using the following steps:

1. Click the **Functions** node.
2. Right-click the function's name, and then select **Run**. The **Run PL/SQL** dialog box is displayed.
3. Replace the second parameter name with the actual parameter value as shown in the slide example.
4. Click OK.

# Advantages of User-Defined Functions in SQL Statements

- Can extend SQL where activities are too complex, too awkward, or unavailable with SQL
- Can increase efficiency when used in the `WHERE` clause to filter data, as opposed to filtering the data in the application
- Can manipulate data values




SQL statements can reference PL/SQL user-defined functions anywhere a SQL expression is allowed. For example, a user-defined function can be used anywhere that a built-in SQL function, such as `UPPER()`, can be placed.

**Advantages**

- Permits calculations that are too complex, awkward, or unavailable with SQL. Functions increase data independence by processing complex data analysis within the Oracle server, rather than by retrieving the data into an application
- Increases efficiency of queries by performing functions in the query rather than in the application
- Manipulates new types of data (for example, latitude and longitude) by encoding character strings and using functions to operate on the strings

# Using a Function in a SQL Expression: Example

```
CREATE OR REPLACE FUNCTION tax(p_value IN NUMBER)
 RETURN NUMBER IS
BEGIN
   RETURN (p_value * 0.08);
END tax;
/
SELECT employee_id, last_name, salary, tax(salary)
FROM   employees
WHERE  department_id = 100;
```

```
FUNCTION TAX compiled
EMPLOYEE_ID LAST_NAME                 SALARY TAX(SALARY)
----------- ------------------------- -------- -----------
        108 Greenberg                  12008      960.64
        109 Faviet                      9000         720
        110 Chen                        8200         656
        111 Sciarra                     7700         616
        112 Urman                       7800         624
        113 Popp                        6900         552

6 rows selected
```




## Function in SQL Expressions: Example

The example in the slide shows how to create a `tax` function to calculate income tax. The function accepts a `NUMBER` parameter and returns the calculated income tax based on a simple flat tax rate of 8%.

To execute the code shown in the slide example in SQL Developer, enter the code in the SQL Worksheet, and then click the **Run Script** icon. The `tax` function is invoked as an expression in the `SELECT` clause along with the employee ID, last name, and salary for employees in a department with ID `100`. The return result from the `tax` function is displayed with the regular output from the query.

# Calling User-Defined Functions in SQL Statements

User-defined functions act like built-in single-row functions and can be used in:

- The `SELECT` list or clause of a query
- Conditional expressions of the `WHERE` and `HAVING` clauses
- The `CONNECT BY`, `START WITH`, `ORDER BY`, and `GROUP BY` clauses of a query
- The `VALUES` clause of the `INSERT` statement
- The `SET` clause of the `UPDATE` statement




A PL/SQL user-defined function can be called from any SQL expression where a built-in single-row function can be called as shown in the following example:

```
SELECT employee_id, tax(salary)
FROM   employees
WHERE  tax(salary) > (SELECT MAX(tax(salary))
                      FROM employees
                      WHERE department_id = 30)
ORDER BY tax(salary) DESC;
```

```
EMPLOYEE_ID TAX(SALARY)
----------- -----------
        100        1920
        101        1360
        102        1360
        145        1120
        146        1080
        201        1040
        205      960.64
        108      960.64
        147         960
        168         920

10 rows selected
```

# Restrictions When Calling Functions from SQL Expressions

- User-defined functions that are callable from SQL expressions must:
  - Be stored in the database
  - Accept only `IN` parameters with valid SQL data types and PL/SQL-specific data types
  - Return valid SQL data types and PL/SQL-specific data types
- When calling functions in SQL statements:
  - You must own the function or have the `EXECUTE` privilege
  - You may need to enable the `PARALLEL_ENABLE` keyword to allow a parallel execution of the SQL statement




The user-defined PL/SQL functions that are callable from SQL expressions must meet the following requirements:

- The function must be stored in the database.
- The function parameters must be `IN` and of valid SQL data types and PL/SQL-specific data types.
- The functions must return data types that are valid SQL data types and PL/SQL-specific data types such as `BOOLEAN`, `RECORD`, or `TABLE`.

The following restrictions apply when calling a function in a SQL statement:

- Parameters must use positional notation or named notation.
- You must own or have the `EXECUTE` privilege on the function.
- You may need to enable the `PARALLEL_ENABLE` keyword to allow a parallel execution of the SQL statement using the function. Each parallel slave will have private copies of the function's local variables.

Other restrictions on a user-defined function include the following: It cannot be called from the `CHECK` constraint clause of a `CREATE TABLE` or `ALTER TABLE` statement. In addition, it cannot be used to specify a default value for a column. Only stored functions are callable from SQL statements. Stored procedures cannot be called unless invoked from a function that meets the preceding requirements.

## Controlling Side Effects When Calling Functions from SQL Expressions

Functions called from:

- A SELECT statement cannot contain DML statements
- An UPDATE or DELETE statement on a table T cannot query or contain DML on the same table T
- SQL statements cannot end transactions (that is, cannot execute COMMIT or ROLLBACK operations)

**Note:** Calls to subprograms that break these restrictions are also not allowed in the function.




To execute a SQL statement that calls a stored function, the Oracle server must know whether the function is free of specific side effects. The side effects are unacceptable changes to database tables.

Additional restrictions apply when a function is called in expressions of SQL statements:

- When a function is called from a SELECT statement or a parallel UPDATE or DELETE statement, the function cannot modify database tables.
- When a function is called from an UPDATE or DELETE statement, the function cannot query or modify database tables modified by that statement.
- When a function is called from a SELECT, INSERT, UPDATE, or DELETE statement, the function cannot execute directly or indirectly through another subprogram or SQL transaction control statements such as:
  - A COMMIT or ROLLBACK statement
  - A session control statement (such as SET ROLE)
  - A system control statement (such as ALTER SYSTEM)
  - Any DDL statements (such as CREATE) because they are followed by an automatic commit

# Restrictions on Calling Functions from SQL: Example

```
CREATE OR REPLACE FUNCTION dml_call_sql(p_sal NUMBER)
   RETURN NUMBER IS
BEGIN
  INSERT INTO employees(employee_id, last_name,
                email, hire_date, job_id, salary)
  VALUES(1, 'Frost', 'jfrost@company.com',
         SYSDATE, 'SA_MAN', p_sal);
  RETURN (p_sal + 100);
END;
```

```
UPDATE employees
  SET salary = dml_call_sql(2000)
WHERE employee_id = 170;
```

```
FUNCTION DML_CALL_SQL compiled
Error starting at line 127 in command:
UPDATE employees
 SET salary = dml_call_sql(2000)
WHERE employee_id = 170
Error report:
SQL Error: ORA-04091: table ORA61.EMPLOYEES is mutating, trigger/function may not see it
ORA-06512: at "ORA61.DML_CALL_SQL", line 4
04091. 00000 -  "table %s.%s is mutating, trigger/function may not see it"
*Cause:    A trigger (or a user defined plsql function that is referenced in
           this statement) attempted to look at (or modify) a table that was
           in the middle of being modified by the statement which fired it.
*Action:   Rewrite the trigger (or function) so it does not read that table.
```

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The `dml_call_sql` function in the slide contains an `INSERT` statement that inserts a new record into the `EMPLOYEES` table and returns the input salary value incremented by 100. This function is invoked in the `UPDATE` statement that modifies the salary of employee 170 to the amount returned from the function. The `UPDATE` statement fails with an error indicating that the table is mutating (that is, changes are already in progress in the same table). In the following example, the `query_call_sql` function queries the `SALARY` column of the `EMPLOYEES` table:

```
CREATE OR REPLACE FUNCTION query_call_sql(p_a NUMBER)
   RETURN NUMBER IS
   v_s NUMBER;
 BEGIN
   SELECT salary INTO v_s FROM employees
   WHERE employee_id = 170;
   RETURN (v_s + p_a);
 END;
```

When invoked from the following `UPDATE` statement, it returns the error message similar to the error message shown in the slide:

```
UPDATE employees SET salary = query_call_sql(100)
WHERE employee_id = 170;
```

## Named and Mixed Notation from SQL

- PL/SQL allows arguments in a subroutine call to be specified using positional, named, or mixed notation.
- For long parameter lists, with most having default values, you can omit values from the optional parameters.
- You can avoid duplicating the default value of the optional parameter at each call site.

## Named and Mixed Notation from SQL: Example

```
CREATE OR REPLACE FUNCTION f(
  p_parameter_1 IN NUMBER DEFAULT 1,
  p_parameter_5 IN NUMBER DEFAULT 5)
RETURN NUMBER
IS
 v_var number;
BEGIN
  v_var := p_parameter_1 + (p_parameter_5 * 2);
  RETURN v_var;
END f;
/
```

```
SELECT f(p_parameter_5 => 10) FROM DUAL;
```





### Example of Using Named and Mixed Notation from a SQL Statement

In the example in the slide, the call to the function `f` within the SQL `SELECT` statement uses the named notation. Before Oracle Database 11*g*, you could not use the named or mixed notation when passing parameters to a function from within a SQL statement. Before Oracle Database 11*g*, you received the following error:

```
SELECT f(p_parameter_5 => 10) FROM DUAL;


ORA-00907: missing right parenthesis
```

# Viewing Functions Using Data Dictionary Views

```
DESCRIBE USER_SOURCE
```

```
DESCRIBE user_source
Name Null Type
---- ---- --------------
NAME      VARCHAR2(128)
TYPE      VARCHAR2(12)
LINE      NUMBER
TEXT      VARCHAR2(4000)
```

```
SELECT  text
FROM    user_source
WHERE   type = 'FUNCTION'
ORDER   BY line;
```

| | TEXT |
|---|---|
| 1 | FUNCTION dml_call_sql(p_sal NUMBER) |
| 2 | FUNCTION tax(p_value IN NUMBER) |
| 3 | FUNCTION query_call_sql(p_a NUMBER) RETURN NUMBER IS |
| 4 | FUNCTION get_sal |
| 5 | RETURN NUMBER IS |
| 6 | RETURN NUMBER IS |
| 7 | (p_id employees.employee_id%TYPE) RETURN NUMBER IS |
| 8 | v_s NUMBER; |

. . .

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The source code for PL/SQL functions is stored in the data dictionary tables. The source code is accessible for PL/SQL functions that are successfully or unsuccessfully compiled. To view the PL/SQL function code stored in the data dictionary, execute a `SELECT` statement on the following tables where the `TYPE` column value is `FUNCTION`:

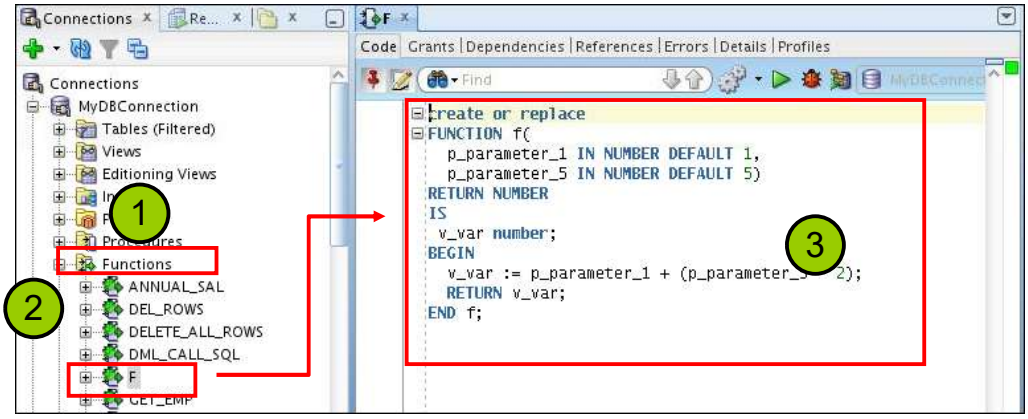
- The `USER_SOURCE` table to display the PL/SQL code that you own
- The `ALL_SOURCE` table to display the PL/SQL code to which you have been granted the `EXECUTE` right by the owner of that subprogram code

The second example in the slide uses the `USER_SOURCE` table to display the source code for all the functions in your schema.

You can also use the `USER_OBJECTS` data dictionary view to display a list of your function names.

**Note:** The output of the second code example in the slide was generated using the Execute Statement (F9) icon on the toolbar to provide better-formatted output.

# Viewing Functions Information Using SQL Developer







To view a function's code in SQL Developer, use the following steps:

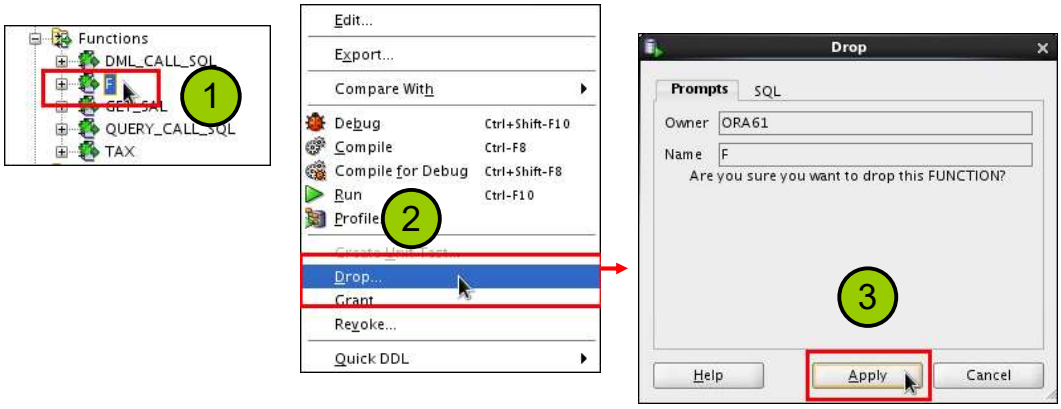
1. Click the **Functions** node in the **Connections** tab.
2. Click the function's name.
3. The function's code is displayed in the **Code** tab as shown in the slide.

# Removing Functions: Using the DROP SQL Statement or SQL Developer

- Using the DROP statement:

```
DROP FUNCTION f;
```

- Using SQL Developer:







## Removing Functions

### Using the DROP statement

When a stored function is no longer required, you can use a SQL statement in SQL*Plus to drop it. To remove a stored function by using SQL*Plus, execute the DROP FUNCTION SQL command.

### Using CREATE OR REPLACE Versus DROP and CREATE

The REPLACE clause in the CREATE OR REPLACE syntax is equivalent to dropping a function and re-creating it. When you use the CREATE OR REPLACE syntax, the privileges granted on this object to other users remain the same. When you DROP a function and then re-create it, all the privileges granted on this function are automatically revoked.

### Using SQL Developer

To drop a function in SQL Developer, right-click the function name in the **Functions** node, and then select **Drop**. The **Drop** dialog box is displayed. To drop the function, click **Apply**.

# Quiz

A PL/SQL stored function:

a. Can be invoked as part of an expression
b. Must contain a `RETURN` clause in the header
c. Must return a single value
d. Must contain at least one `RETURN` statement
e. Does not contain a `RETURN` clause in the header




**Answer: a, b, c, d**

# Summary

In this lesson, you should have learned how to:

- Differentiate between a procedure and a function
- Describe the uses of functions
- Create stored functions
- Invoke a function
- Remove a function




A function is a named PL/SQL block that must return a value. Generally, you create a function to compute and return a value, and you create a procedure to perform an action.

A function can be created or dropped.

A function is invoked as a part of an expression.