

Notes on PL/SQL

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Procedural Language for Structured Query Language (PL/SQL) lets you write code once and deploy it in the database nearest to data. PL/SQL can simplify application development, optimize execution, and improve resource utilization in the database. The language is a case-insensitive programming language, like SQL.

One of the most important aspects of PL/SQL is its tight integration with SQL. You do not need to rely on any intermediate software “glue” such as ODBC (Open Database Connectivity) or JDBC (Java Database Connectivity) to run SQL statements in your PL/SQL programs. Instead, you just insert the UPDATE or SELECT into your code.

1.1 History

PL/SQL was developed by modeling concepts of structured programming, static data typing, modularity, exception management, and parallel (concurrent) processing found in the Ada programming language. The *Ada* programming language, developed for the United States Department of Defense, was designed to support military real-time and safety-critical embedded systems, such as those in airplanes and missiles. The Ada programming language borrowed significant syntax from the *Pascal* programming language, including the assignment and comparison operators and the single-quote delimiters.

1.2 Basic Structure

PL/SQL is a blocked programming language. Program units can be named or unnamed blocks. Unnamed blocks are known as *anonymous blocks* and are labeled so throughout the handout. The PL/SQL coding style differs from that of the C, C++, and Java programming languages. For example, curly braces do not delimit blocks in PL/SQL.

Anonymous-block programs are effective in some situations. You typically use anonymous blocks when building scripts to seed data or perform one-time processing activities. They are also effective when you want to nest activity in another PL/SQL block’s execution section. The basic anonymous-block structure must contain an execution section. You can also put optional declaration and exception sections in anonymous blocks. The following illustrates an anonymous-block prototype:

```
[DECLARE]
    declaration_statements
BEGIN
    execution_statements
[EXCEPTION]
    exception_handling_statements
END;
/
```

1.2.1 Declaration Block

The declaration block lets you define datatypes, structures, and variables. Defining a variable means that you give it a name and a datatype. You can also declare a variable by giving it a name, a datatype, and a value. You both define and assign a value when declaring a variable.

Structures and cursors can be defined here as well. Structures are compound variables, like collections, record structures, or system reference cursors. Structures can also be locally named functions, procedures, or cursors. Cursors act like little functions. Cursors have names, signatures and a return type - the output columns from a query or SELECT statement. The DECLARE reserved word begins the declaration block, and the BEGIN reserved word ends it.

1.2.2 Execution Block

The execution block lets you process data. It can contain variable assignments, comparisons, conditional operations, and iterations. Also, the execution block is where you access cursors and other named program units. Functions, procedures, and some object types are named program units. You can also nest anonymous-block programs inside the execution block. The BEGIN reserved word starts the exception block, and the optional EXCEPTION or required END reserved word ends it. You must have at least one statement inside an execution block.

1.2.3 Exception Block

The exception handling block lets you manage exceptions. You can both catch and manage them there. The exception block allows for alternative processing; in many ways it acts like combination of a catch and finally block in the Java programming language. The EXCEPTION reserved word starts the section, and the END reserved word ends it.

1.3 Example Programs

Let's write our first minimal block that will do nothing:

```
BEGIN
    NULL;
END;
/
```

This block does nothing except let the compilation phase complete without an error. Compilation, like other languages, requires syntax parsing. The lack of a statement in the block raises a parsing error. Every PL/SQL block must contain something, at least a NULL; statement, or it will fail run-time compilation.

1.3.1 Output

Hers' an example of a "Hello, World!" program:

```
SET SERVEROUTPUT ON SIZE 1000000

BEGIN
    DBMS_OUTPUT.PUT_LINE('Hello, World!');
END;
/
```

Output:

```
Hello, World!
```

To print content on the console, we need to enable the SQL*Plus SERVEROUTPUT variable. This is because whatever we output using the keyword DBMS_OUTPUT.PUT_LINE is internally stored inside a buffer in *Shared Global Area* (SGA) memory area of size 2000 bytes. Here, SIZE sets the size of the buffer. In order to fetch it from that buffer, we need to set the environment variable for the session. Note that, we need to set the environment variable only once for a session.

1.3.2 Input

SQL*Plus supports the use of substitution variables in the interactive console, which are prefaced by an ampersand (&). Substitution variables are variable-length strings or numbers, using which we can take input from the console:

```
DECLARE
    USERNAME VARCHAR2(5);
BEGIN
    USERNAME := '&username';
    DBMS_OUTPUT.PUT_LINE('Hello ' || USERNAME);
END;
/
```

Output:

```
Enter value for username: Alice
old  4:      USERNAME := '&username';
new  4:      USERNAME := 'Alice';
Hello Alice
```

The line starting with old designates where your program accepts a substitution, and new designates the run-time substitution. You can suppress echoing the substitution by using SET VERIFY OFF.

1.3.3 Error Handling

In the last program, assigning a string literal that is too large for the variable fires an exception. Exception blocks manage raised errors. A generic exception handler manages any raised error. You use a WHEN block to catch every raised exception with the generic error handler - OTHERS.

```
DECLARE
    USERNAME VARCHAR2(5);
BEGIN
    USERNAME := '&username';
    DBMS_OUTPUT.PUT_LINE('Hello ' || USERNAME);
EXCEPTION
    WHEN OTHERS THEN
        DBMS_OUTPUT.PUT_LINE(SQLERRM);
END;
/
```

Output:

```
Enter value for username: Charlie
ORA-06502: PL/SQL: numeric or value error: character string buffer too
small
```

CHAPTER 2

VARIABLES, OPERATORS, AND DATATYPES

2.1 Variables

Variable names begin with letters and can contain alphabetical characters, ordinal numbers (0 to 9), the \$, _, and # symbols. Similar to SQL, the names are case-insensitive. Variables have local scope only, meaning they are available only in the scope of a given PL/SQL block. The exception to that rule are nested anonymous blocks. Nested anonymous blocks operate inside the defining block. They can thereby access variables from the containing block. That is, unless you have declared the same variable name as something else inside the nested anonymous block.

A declaration of a number variable without an explicit assignment makes its initial value null. The prototype shows that you can assign a value later in the execution block:

```
DECLARE
    VARIABLE_NAME NUMBER;
BEGIN
    VARIABLE_NAME := 1;
END;
/
```

An explicit assignment declares a variable with a not-null value. You can use the default value or assign a new value in the execution block. Both are demonstrated below:

```
DECLARE
    VARIABLE_NAME NUMBER [:= | DEFAULT] 1;
BEGIN
    VARIABLE_NAME := 1;
END;
/
```

A list of reserved words and keywords, which should not be used as identifier (e.g., variables, functions, cursors, etc.) names are provided in “SYS.V\$RESERVED_WORDS” view.

2.2 Operators

Some common operators are as follows:

Table 2.1: A list of common operators in PL/SQL

Symbol	Type	Description
+	Arithmetic	The addition operator lets you add left and right operands and returns a result.

Symbol	Type	Description
-	Arithmetic	The subtraction operator lets you subtract the right operand from the left operand and returns a result.
*	Arithmetic	The multiplication operator lets you multiply a left operand by a right operand and returns a result.
/	Arithmetic	The division operator lets you divide a left operand by a right operand and returns a result.
**	Arithmetic	The exponential operator raises a left operand to the power designated by a right operand. The operator enjoys the highest precedence for math operators in the language. As a result of that, a fractional exponent must be enclosed in parentheses (also known as expression or list delimiters) to designate order of operation. Without parentheses, the left operand is raised to the power of the numerator and the result divided by the denominator of a fractional exponent.
:=	Assignment	The assignment operator is a colon immediately followed by an equal symbol. It is the only assignment operator in the language. Remember that the left operand for this operator must always be a variable. The right operand can be a value, variable, or function. Functions must return a value when they are right operands. This is convenient in PL/SQL because all functions return values. Functions in this context are also known as expressions
=	Relational	The equal symbol is the comparison operator. It tests for equality of value and implicitly does type conversion where possible. There is no identity comparison operator because PL/SQL is a strongly typed language. PL/SQL comparison operations are equivalent to identity comparisons because you can only compare like typed values.
!=	Relational	There are three not-equal comparison operators: !=, ^=, and <>. They all perform exactly the same behaviors. You can use whichever suits your organizational needs.
>	Relational	Checks if the value of left operand is greater than the value of right operand, if yes then condition becomes true.
<	Relational	Checks if the value of left operand is less than the value of right operand, if yes then condition becomes true.
>=	Relational	Checks if the value of left operand is greater than or equal to the value of right operand, if yes then condition becomes true.
<=	Relational	Checks if the value of left operand is less than or equal to the value of right operand, if yes then condition becomes true.
LIKE	Comparison	Compares a character, string, or CLOB value to a pattern and returns true if the value matches the pattern and false if it does not.
BETWEEN	Comparison	Tests whether a value lies in a specified range.
IN	Comparison	Tests set membership.
IS NULL	Comparison	Returns true if its operand is null, or false otherwise. Comparisons involving null values always yield null.

Symbol	Type	Description
IS EMPTY	Comparison	Allows you to check whether a VARRAY collection variable is empty. Empty means that the collection was constructed without any default elements.
MEMBER OF	Comparison	Lets you find out whether an element is a member of a collection. Only works with collections of scalar SQL datatypes.
AND	Logical	If both the operands are true, then condition becomes true. It also allows you to combine two comparisons into one.
OR	Logical	If any of the two operands are true, then condition becomes true.
NOT	Logical	Used to reverse the logical state of its operand.
.	Association	The component selector is a period, and it glues references together. It is often used to link a schema and a table, a package and a function, or an object and a member method. Component selectors are also used to link cursors and cursor attributes (columns). For example, INSTRUCTOR.SALARY.
@	Association	The remote access indicator lets you access a remote database through database links. It can also be used to run scripts.
:	Association	The host variable indicator precedes a valid identifier name, and designates that identifier as a session-level variable. Session-level variables are also known as <i>bind variables</i> . You use SQL*Plus to define a session-level variable. Only the CHAR, CLOB, NCHAR, NCLOB, NUMBER, NVARCHAR2, REFCURSOR, and VARCHAR2 datatypes are available for session variables.
&	Association	The substitution indicator lets you pass actual parameters into anonymous-block PL/SQL programs. You should never assign substitution variables inside declaration blocks because assignment errors do not raise an error that you can catch in your exception block. You should make substitution variable assignments in the execution block.
%	Association	The attribute indicator lets you link a database catalog column, row, or cursor attribute. You are anchoring a variable datatype when you link a variable to a catalog object, like a table or column.
=>	Association	The association operator is a combination of an equal sign and a greater-than symbol. It is used in name notation function and procedure calls.
	Concatenation	The concatenation operator is formed by combining two perpendicular vertical lines. You use it to glue strings together.

Symbol	Type	Description
()	Delimiter	The list delimiter is used to place a list of comma-delimited numeric or string literals, or identifiers, inside a set of parentheses. You use parentheses to enclose formal and actual parameters to subroutines or to produce lists for comparative evaluations. You can also override order of precedence by enclosing operations in parentheses. Enclosing operations in parentheses lets you override the natural order of precedence in the language.
,	Delimiter	The item separator is a comma and delimits items in lists.
--	Delimiter	In-line comment
/* */	Delimiter	Multi-line comment.
'	Delimiter	The character string delimiter is a single quote. It lets you define a string literal value.
''	Delimiter	The quoted identifier delimiter is a double quote. It lets you access tables created in case-sensitive fashion from the database catalog. This is required when you have created database catalog objects in case-sensitive fashion.
;	Statement	The statement terminator is a semicolon. You must close any statement or block unit with a statement terminator.

2.3 Datatypes

Datatypes in PL/SQL include all SQL datatypes and subtypes. PL/SQL also supports scalar and composite variables. Oracle Database 11g supports character, numeric, timestamp, binary, and row address datatypes. These are also known as SQL datatypes or built-in types because they can be used to define columns in tables and parameter datatypes in PL/SQL.

2.3.1 Scalar Datatypes

Scalar datatypes use the following prototype inside the declaration block of your programs:

```
variable_name DATATYPE [NOT NULL] [:= literal_value];
```

Boolean

The BOOLEAN datatype has three possible values: TRUE, FALSE, and NULL.

```
var1 BOOLEAN; -- Implicitly assigned a NULL value
var2 BOOLEAN NOT NULL := TRUE; -- Explicitly assigned a TRUE value
var3 BOOLEAN NOT NULL := FALSE; -- Explicitly assigned a FALSE value
```

Characters and Strings

The CHAR datatype is used for fixed-length strings. On the other hand, the VARCHAR2 datatype stores variable-length character strings. For each row, Oracle Database stores each value in the column as a variable-length field unless a value exceeds the column's maximum length, in which case Oracle Database returns an error. Using VARCHAR2 and VARCHAR saves on space used by the table.

Remember, the maximum size of both CHAR and VARCHAR2 in PL/SQL is greater than that of SQL. SQL allows for 4000 bytes for CHAR and VARCHAR2, whereas PL/SQL allows up to 32767 bytes. Oracle recommends you use the CLOB datatype to store character strings larger than 4000 bytes.

Difference between CHAR and VARCHAR2: The following program illustrates the memory allocation differences between CHAR and VARCHAR2 datatypes:

```

DECLARE
  C CHAR(32767) := 'hello';
  VC VARCHAR2(32767) := 'hello';
BEGIN
  DBMS_OUTPUT.PUT_LINE('Length of C is ' || LENGTH(c));
  DBMS_OUTPUT.PUT_LINE('Length of VC is ' || LENGTH(VC));
  VC := VC || ' ';
  DBMS_OUTPUT.PUT_LINE('New length of VC is ' || LENGTH(VC));
END;
/

```

Output:

```

Length of c is 32767
Length of vc is 5
New length of vc is 6

```

The output shows that a CHAR variable sets the allocated memory size when defined. The allocated memory can exceed what is required to manage the value in the variable. The output also shows that the VARCHAR2 variable dynamically allocates only the required memory to host its value.

Difference between VARCHAR and VARCHAR2: Both VARCHAR and VARCHAR2 are used to store variable-length character strings. Here are a few differences between them:

Table 2.2: Difference between VARCHAR and VARCHAR2

VARCHAR	VARCHAR2
Can differentiate between NULL and empty string.	Considers both as the same.
ANSI SQL Standard.	Oracle Standard.
Definition may change in future	Definition will not change.

More on VARCHAR2: Globalization support allows the use of various character sets for the character datatypes. It lets you process single-byte and multibyte character data and convert between character sets. Client sessions can use client character sets that are different from the database character set. The length semantics of character datatypes can be measured in bytes or characters.

- **Byte Semantics** treats strings as a sequence of bytes. This is the default for character datatypes.
- **Character Semantics** treat strings as a sequence of characters. A character is technically a codepoint of the database character set.

For single byte character sets, columns defined in character semantics are basically the same as those defined in byte semantics. Character semantics are useful for defining varying-width multibyte strings; it reduces the complexity when defining the actual length requirements for data storage. For example, in a Unicode database (UTF8), you might define a VARCHAR2 column that can store up to five Chinese characters together with five English characters. In byte semantics, this would require $(5 \times 3 \text{ bytes}) + (1 \times 5 \text{ bytes}) = 20 \text{ bytes}$. In character semantics, the column would require 10 characters.

Consider the following example:

```

var1 VARCHAR2(100);      -- Implicitly sized at 100 bytes
var2 VARCHAR2(100 BYTE); -- Explicitly sized at 100 bytes
var3 VARCHAR2(100 CHAR); -- Explicitly sized at 100 characters

```

When we use character space allocation, the maximum size changes depending on the character set of our database. Some character sets use two or three bytes to store characters. We divide the allocated space (let: 32,767) by the number of bytes required per character, which means the maximum character limit for a VARCHAR2 is 16,383 for a two-byte character set and 10,922 for a three-byte character set.

Globalization raises a host of issues with how you use variable-length strings. You should consider using NVARCHAR2 datatypes when managing multiple character sets or Unicode.

Dates and Times

The DATE datatype is the base type for dates, times, and intervals. It contains the actual timestamp of activity. The valid range is any date from January 1, 4712 BCE to December 31, 9999 CE. The most common way to capture a timestamp is to assign the SYSDATE or SYS_TIMESTAMP built-in function. They both return fully qualified dates and contain all field elements of a DATE variable or column.

```
var1 DATE; -- Implicitly assigns a null value
var2 DATE := SYSDATE; -- Explicitly assigns current server timestamp
var3 DATE := SYSDATE + 1; -- Explicitly assigns tomorrow server timestamp
var4 DATE := '29-FEB-08' -- Explicitly assigns leap year day for 2008
```

The TO_DATE() function can convert non-conforming date formats into valid DATE values. Alternatively, the CAST() function also works with the default format mask. The default format masks for dates are DD-MON-RR or DD-MON-YYYY.

You can use TRUNC(date_variable) to extract a date from a timestamp. This is useful when you want to find all transactions that occurred on a particular day. By default, the TRUNC() built-in function shaves off the time, making a date with 00 hours, 00 minutes, and 00 seconds.

```
DECLARE
    D DATE := SYSDATE;
BEGIN
    DBMS_OUTPUT.PUT_LINE(TO_CHAR(TRUNC(D), 'DD-MON-YY HH24:MI:SS'));
END;
/
```

Output:

```
30-OCT-22 00:00:00
```

The EXTRACT() built-in function also lets you capture the numeric month, year, or day from a DATE value.

Numbers

There are four principal number datatypes: BINARY_INTEGER, BINARY_DOUBLE/BINARY_FLOAT, NUMBER, and PLS_INTEGER. We focus on the NUMBER datatype.

The NUMBER datatype uses a custom library provided as part of the Oracle 11g database. It can store numbers in the range of 1.0×10^{-130} to 1.0×10^{126} . It does not raise a NaN (not a number) or infinity error when a literal or computational value is outside the datatype range. The following exceptions occur:

- A literal value below the minimum range value stores a zero
- A literal value above the maximum range raises a compilation error
- A computational outcome above the maximum range raises a compilation error

The NUMBER datatype supports fixed-point and floating-point numbers. Fixed-point numbers are defined by specifying the number of digits (known as the precision) and the number of digits to the right of the decimal point (known as the scale). The decimal point is not physically stored in the

variable because it is calculated by the relationship between the precision and the scale. The default precision of a number is 38.

```
var1 NUMBER;           -- A null number with 38 digits
var2 NUMBER(15);       -- A null number with 15 digits
var3 NUMBER(15, 2);    -- A null number with 15 digits and 2 decimals
```

Large Objects (LOBs)

Large objects provide us with four datatypes: BFILE, BLOB, CLOB, and NCLOB. BFILE is a datatype that points to an external file, which limits its maximum size to 4 gigabytes. The BLOB, CLOB, and NCLOB are internally managed types, and their maximum size is 8 to 128 terabytes, depending on the DB_BLOCK_SIZE parameter value.

LOB columns contain a locator that points to where the actual data is stored. You must access a LOB value in the scope of a transaction. You essentially use the locator as a route to read data from or write data to the LOB column.

2.3.2 Composite Datatypes

There are two composite generalized datatypes: records and collections.

Record

A record, also known as a structure, typically contains a collection of related elements like a normalized database table.

```
DECLARE
    TYPE COORD2D IS RECORD
    (
        X NUMBER DEFAULT 0,
        Y NUMBER DEFAULT 0
    );
    ORIGIN COORD2D;
BEGIN
    DBMS_OUTPUT.PUT_LINE('(' || ORIGIN.X || ', ' || ORIGIN.Y || ')');
END;
/
```

Output:

```
(0, 0)
```

The execution block prints the contents of the record by using dot notation.

It is possible to nest records. You access the names of the nested records by using another component selector.

```
DECLARE
    TYPE FULL_NAME IS RECORD
    (
        FIRST VARCHAR2(10 CHAR) := 'John',
        LAST VARCHAR2(10 CHAR) := 'Doe'
    );
    TYPE employee IS RECORD
    (
        ID NUMBER DEFAULT 1,
        NAME FULL_NAME
    );
    E1 EMPLOYEE;
BEGIN
    DBMS_OUTPUT.PUT_LINE(E1.ID);
    DBMS_OUTPUT.PUT_LINE(E1.NAME.FIRST || ' ' || E1.NAME.LAST);
END;
/
```

Output:

```
1
John Doe
```

Records are extremely useful when working with cursors and collections. Records are exclusively available inside your PL/SQL execution scope. You can define a stored function to returning a record type, but that limits how you can use the function. SQL can only access stored functions when they return SQL datatypes.

Collection

Collections are sets of like things. The things can be scalar variables, large objects, user-defined objects, or records.

```
DECLARE
    TYPE NUMBER_ARRAY IS VARRAY(10) OF NUMBER;
    LIST NUMBER_ARRAY := NUMBER_ARRAY(1, 2, 3, 4, 5, 6, 7, 8, NULL, NULL);
;
BEGIN
    FOR i in 1..LIST.LIMIT LOOP
        DBMS_OUTPUT.PUT('[' || LIST(i) || '] ');
    END LOOP;
    DBMS_OUTPUT.NEW_LINE;
END;
/
```

Output:

```
[1] [2] [3] [4] [5] [6] [7] [8] [] []
```

The program initializes the first eight elements with values and last two with nulls. The declaration allocates space for ten elements by setting all elements to a value, which can include a null. The LIMIT() method returns the maximum size. The LOOP statement is self-explanatory, but we will learn more about it later.

2.3.3 Datatype Indicator

We can declare a variable to be the same type as an attribute of a table. A variable can store the entire row of a table or a single column. For example, consider the following table:

```
CREATE TABLE EMPLOYEE
(
    ID NUMBER(5) NOT NULL,
    DEPT_ID VARCHAR2(20),
    DEPT_NAME VARCHAR2(20) DEFAULT 'HR',
    CONSTRAINT DEPT_ID_RANGE CHECK (DEPT_ID BETWEEN 10 AND 20)
);
```

We can use the datatype mentioned in the table in PL/SQL directly:

```
DECLARE
    EMPREC EMPLOYEE%ROWTYPE;
    ID EMPLOYEE.ID%TYPE;
BEGIN
    EMPREC.ID := NULL;      -- Constraint not inherited
    ID := 10000000002;      -- Invalid, number precision too large
    EMPREC.DEPT_ID := 50;   -- Constraint not inherited
    /* Default value not inherited */
    DBMS_OUTPUT.PUT_LINE('Employee dept name: ' || EMPREC.DEPT_NAME);
END;
/
```

Output:

```
DECLARE
*
ERROR at line 1:
ORA-06502: PL/SQL: numeric or value error: number precision too large
ORA-06512: at line 6
```

As demonstrated by the example, constraints on datatypes are inherited. However, other constraints are not inherited. Even if we set the precision of the right operand of ID variable assignment to less than 6, we get:

```
Employee dept name:
```

That means, default values are not inherited as well.

CHAPTER 3

CONTROL STRUCTURES

Control structures let you make conditional choices, repeat operations, and access data. The IF and CASE statements let you branch program execution according to one or more conditions. Loop statements let you repeat behavior until conditions are met. Cursors let you access data one row or one set of rows at a time.

3.1 Conditional Statements

Conditional statements check whether a value meets a condition before taking action. There are two types of conditional structures in PL/SQL. One is the IF statement, and the other is the CASE statement. The IF statement has two subtypes, *if-then-else* and *if-then-elsif-then-else*. The *elsif* is not a typo but the correct reserved word in PL/SQL. This is another legacy from Pascal and ADA.

3.1.1 IF Statement

IF statements evaluate a condition. The condition can be any comparison expression, or set of comparison expressions that evaluates to a logical true or false. You can use comparison operators and symbols like: AND, BETWEEN, IN, IS EMPTY, IS NULL, IS A SET, LIKE, MEMBER OF, NOT, OR, etc.

All IF statements are blocks in PL/SQL and end with the END IF phrase.

```
DECLARE
  X NUMBER ;
BEGIN
  X := 10;
  IF (X = 0) THEN
    DBMS_OUTPUT.PUT_LINE('The value of x is 0');
  ELSIF (X BETWEEN 1 AND 10 ) THEN
    DBMS_OUTPUT.PUT_LINE('The value of x is between 1 and 10');
  ELSE
    DBMS_OUTPUT.PUT_LINE('The value of x is greater than 10');
  END IF;
END;
/
```

Output:

```
The value of x is between 1 and 10
```

One possible use-case of the IF statements can be categorizing different students:

```
DECLARE
  CGPA NUMBER;
  STUDENT_ID NUMBER := 170042043;
```



```

BEGIN
    SELECT MAX(CGPA) INTO CGPA
        FROM STUDENTS
           WHERE ID = STUDENT_ID;
    IF (CGPA > 3.8) THEN
        DBMS_OUTPUT.PUT_LINE('Brilliant');
    ELSIF (CGPA BETWEEN 3.5 AND 3.8) THEN
        DBMS_OUTPUT.PUT_LINE('Mid Level');
    ELSE
        DBMS_OUTPUT.PUT_LINE('Poor');
    END IF;
END;
/

```

Output:

```
Brilliant
```

3.1.2 Simple CASE Statement

The simple CASE statement sets a selector. A selector is a variable, function, or expression that the CASE statement attempts to match in WHEN blocks. The selector immediately follows the reserved word CASE. You can use any PL/SQL datatype except a BLOB, BFILE, or composite types.

```

DECLARE
    SELECTOR NUMBER := 1;
BEGIN
    CASE SELECTOR
        WHEN 0 THEN
            DBMS_OUTPUT.PUT_LINE('Case 0!');
        WHEN 1 THEN
            DBMS_OUTPUT.PUT_LINE('Case 1!');
        ELSE
            DBMS_OUTPUT.PUT_LINE('No Match!');
    END CASE;
END;
/

```

Output:

```
Case 1!
```

3.1.3 Searched CASE Statements

The selector is implicitly set for a search CASE statement. For example, if we consider the university schema provided in the 'Silberschatz, Korth, Sudarshan - Database System Concepts (7th Edition)' book, the following program can be used to categorize the instructors based on their salaries:

```

SELECT NAME, ID, (CASE TRUE
    WHEN SALARY < 50000 THEN 'Low'
    WHEN SALARY BETWEEN 50000 AND 70000 THEN 'Medium'
    WHEN SALARY > 70000 THEN 'High'
    ELSE 'N/A'
END) SALARY
FROM INSTRUCTOR
ORDER BY NAME;

```

Output:

NAME	ID	SALARY
-----	-----	-----
Brandt	83821	High
Califieri	58583	Medium
Crick	76766	High
Einstein	22222	High
El Said	32343	Medium
Gold	33456	High
Katz	45565	High
Kim	98345	High
Mozart	15151	Low
Singh	76543	High
Srinivasan	10101	Medium
Wu	12121	High

You can omit the TRUE because it is the default selector, but it is recommended that you do not. Putting it in adds clarity.

3.2 Iterative Structures

Iterative statements are blocks that let you repeat a statement or set of statements. There are two types of iterative statements. One guards entry into the loop before running repeatable statements. The other guards exit. An iterative statement that only guards exit guarantees that its code block is always run once and is known as a repeat until loop block.

PL/SQL supports FOR, SIMPLE, and WHILE loops. Loops typically work in conjunction with cursors, but can work to solve other problems, like searching or managing Oracle collections.

3.2.1 LOOP and EXIT Statements

Simple loops are explicit block structures. A simple loop starts and ends with the LOOP reserved word. An EXIT statement or an EXIT WHEN statement is required to break the loop.

If we use conditional statements:

```
DECLARE
    X NUMBER := 10;
BEGIN
    LOOP
        DBMS_OUTPUT.PUT_LINE(X);
        X := X + 10;
        IF X > 50 THEN
            EXIT;
        END IF;
    END LOOP;
    -- Control resumes here, after EXIT
    DBMS_OUTPUT.PUT_LINE('After EXIT, X is: ' || X);
END;
/
```

Output:

```
10
20
30
40
50
After EXIT, X is: 60
```

If we use conditional EXIT WHEN:

```
DECLARE
    X NUMBER := 10;
BEGIN
    LOOP
        DBMS_OUTPUT.PUT_LINE(X);
        X := X + 10;
        EXIT WHEN X > 50;
    END LOOP;
    -- Control resumes here, after EXIT
    DBMS_OUTPUT.PUT_LINE('After EXIT, X is: ' || X);
END;
/
```

Output:

```
10
20
30
40
50
After EXIT, X is: 60
```

Skipping an index value is also possible in Oracle 11g by using the new CONTINUE statement. It signals an immediate end to a loop iteration and returns to the first statement in the loop.

3.2.2 FOR Loop

A FOR .. LOOP is a repetition control structure that allows you to efficiently write a loop that needs to execute a specific number of times. After the body of the for loop executes, the value of the counter variable is increased or decreased. The initial value and the final value of the loop variable or counter can be literals, variables, or expressions, but they must evaluate to numbers. Otherwise, PL/SQL raises the predefined exception VALUE_ERROR. The initial value need not be 1; however, the loop counter increment (or decrement) must be 1. PL/SQL allows to determine the loop range dynamically at run-time.

```
DECLARE
    i NUMBER(2);
BEGIN
    FOR i IN 10 .. 20 LOOP
        DBMS_OUTPUT.PUT_LINE('Value of i: ' || i);
    END LOOP;
END;
/
```

Output:

```
Value of i: 10
Value of i: 11
Value of i: 12
Value of i: 13
Value of i: 14
Value of i: 15
Value of i: 16
Value of i: 17
Value of i: 18
Value of i: 19
Value of i: 20
```

There is no exit statement in the example because one is not required. The exit statement is implicitly placed at the top of the loop. The conditional logic checks whether the range index is less than the top of the range, and it exits when that condition is not met.

By default, iteration proceeds from the initial value to the final value, generally upward from the lower bound to the upper bound. You can reverse this order by using the REVERSE keyword. After each iteration, the loop counter is decremented. Remember that, you must write the range bounds in ascending order.

```
DECLARE
    i NUMBER(2);
BEGIN
    FOR i IN REVERSE 10 .. 20 LOOP
        DBMS_OUTPUT.PUT_LINE('Value of i: ' || i);
    END LOOP;
END;
/
```

Output:

```
Value of i: 20
Value of i: 19
Value of i: 18
Value of i: 17
Value of i: 16
Value of i: 15
Value of i: 14
Value of i: 13
Value of i: 12
Value of i: 11
Value of i: 10
```

3.2.3 WHILE Loop

The WHILE loop differs from the simple loop because it guards entry to the loop, not exit. It sets the entry guard as a precondition expression. The loop is only entered when the guard condition is met. For example, the following program can be used to determine the prime factors of a number:

```
DECLARE
    N NUMBER := 10;
    DIV NUMBER := 2;
BEGIN
    DBMS_OUTPUT.PUT_LINE('The prime factors of ' || N || ' are:');
    WHILE (N > 1) LOOP
        IF (MOD(N, DIV) = 0) THEN
            DBMS_OUTPUT.PUT_LINE(DIV);
            N := TRUNC(N / DIV);
        ELSE
            DIV := DIV + 1;
        END IF;
    END LOOP;
END;
/
```

Output:

```
The prime factors of 10 are:
2
5
```

Here, MOD function is used to determine the modulo and TRUNC function is used to extract the integer portion of the quotient.

Functions and Procedures are two of the key components of PL/SQL stored programming units. Oracle maintains a unique list of stored object names for tables, views, sequences, stored programs, and types. This list is known as a namespace. Functions and procedures are in this namespace.

Stored functions and procedures provide a way to hide implementation details in a program unit. They also let you wrap the implementation from prying eyes on the server tier. However, the main motivation for Functions and Procedures is modular code. Modularization is the process by which you break up large blocks of code into smaller pieces (modules) that can be called by other modules. Modularization of code is analogous to normalization of data, with many of the same benefits and a few additional advantages. With modularization, your code becomes:

- **Reusable:** By breaking up a large program or entire application into individual components that plug-and-play together, you will usually find that many modules are used by more than one other program in your current application. Designed properly, these utility programs could even be of use in other applications!
- **Manageable:** Which would you rather debug: a 1,000-line program or five individual 200-line programs that call each other as needed? Our minds work better when we can focus on smaller tasks. You can also test and debug on a per program scale (called unit testing) before individual modules are combined for a more complicated integration test.
- **Readable:** Modules have names, and names describe behavior. The more you move or hide your code behind a programmatic interface, the easier it is to read and understand what that program is doing. Modularization helps you focus on the big picture rather than on the individual executable statements. You might even end up with that most elusive kind of software: self-documenting code.
- **Reliable:** The code you produce will have fewer errors. The errors you do find will be easier to fix because they will be isolated within a module. In addition, your code will be easier to maintain because there is less of it and it is more readable.

4.1 Procedure

A procedure is a module that performs one or more actions. Because a procedure call is a standalone executable statement in PL/SQL, a PL/SQL block could consist of nothing more than a single call to a procedure. Procedures are key building blocks of modular code, allowing you to both consolidate and reuse your program logic. The following illustrates a procedure prototype:

```
[CREATE [OR REPLACE]]  
PROCEDURE procedure_name [(parameter [, parameter]...)]
```

```

[AUTHID {DEFINER | CURRENT_USER}] {IS | AS}
[PRAGMA AUTONOMOUS_TRANSACTION;]
[local_declarations]
BEGIN
    executable_statements
[EXCEPTION
    exception_handlers]
END [procedure_name];

```

Procedures cannot be right operands. Nor can you use them in SQL statements. You move data into and out of PL/SQL stored procedures through their formal parameter list. Here, parameter modes define the behavior of formal parameters. These parameter modes offer you the ability to use pass-by-value or pass-by-reference formal parameters. The three parameter modes: IN (default), OUT, and IN OUT can be used with any subprogram:

- IN: The value of the actual parameter is passed into the procedure when the procedure is invoked. Inside the procedure, the formal parameter acts like a PL/SQL constant. It is considered read-only, i.e., it cannot be changed.
- OUT: Any value the actual parameter has when the procedure is called is ignored. Inside the procedure, the formal parameter acts like an uninitialized PL/SQL variable and thus has a value of NULL. It can be read from and written to.
- IN OUT: This mode is a combination of IN and OUT.

During the declaration of the parameters in Procedures, you must leave out the constraining part of the declaration.

The following procedure can be used to determine the salary of an instructor given their ID:

```

-- Create procedure
CREATE OR REPLACE
PROCEDURE FIND_SAL(I_ID IN NUMBER, SALARY OUT NUMBER)
AS
BEGIN
    SELECT MAX(SALARY) INTO SALARY
    FROM INSTRUCTOR
    WHERE ID = I_ID;
END;
/

-- Call it from an anonymous block
DECLARE
    AMOUNT NUMBER;
BEGIN
    FIND_SAL(10101, AMOUNT);
    DBMS_OUTPUT.PUT_LINE(AMOUNT);
END;
/

```

Output:

```
65000
```

4.2 Function

A function is a module that returns data through its RETURN clause, rather than in an OUT or IN OUT parameter. Unlike a procedure call, which is a standalone executable statement, a call to a function can exist only as part of an executable statement, such as an element in an expression or the value assigned as the default in a declaration of a variable. Functions are convenient structures because

you can call them directly from SQL statements or PL/SQL programs. They can also be used as right operands because they return a value. Since Functions return explicit values, it is recommended to not use OUT and IN OUT modes with functions. The following illustrates a function prototype:

```
CREATE [OR REPLACE]
FUNCTION function_name [(parameter[, parameter]...)]
RETURN return_type
[AUTHID {DEFINER | CURRENT_USER}] {IS | AS}
[PRAGMA AUTONOMOUS_TRANSACTION;]
[local_declarations]
BEGIN
    executable_statements
[EXCEPTION
    exception_handlers]
RETURN statement;
END [function_name];
```

Both procedures and functions have a name, can take parameters, return values, and be called by many users. They are stored in data dictionary. The difference is that function must return a value, but in a procedure it is optional. Also you cannot call procedures from an SQL statement.

The following program can be used to calculate the compound interest of a loan:

```
-- Declare function
CREATE OR REPLACE
FUNCTION COMPOUND_INTEREST(PA NUMBER, AIR NUMBER, TF NUMBER)
RETURN NUMBER
IS
    CI NUMBER;
BEGIN
    CI := PA * ((1 + (AIR / 100)) ** TF) - PA;
RETURN CI;
END;
/

-- Call it from an anonymous block
BEGIN
    DBMS_OUTPUT.PUT_LINE(COMPOUND_INTEREST(10000, 5, 5));
END;
/
```

Output:

```
2762.815625
```

Here, PA denotes the principle amount, AIR denotes the annual interest rate, TF denotes the compound period (years), and CI denotes the compound interest.

4.3 Parameter Notations

4.3.1 Positional Notation

You use positional notation to call the functions as follows:

```
BEGIN
    DBMS_OUTPUT.PUT_LINE(COMPOUND_INTEREST(10000, 5, 5));
END;
/
```

4.3.2 Named Notation

You call a function using named notation by:


```
BEGIN
    DBMS_OUTPUT.PUT_LINE(COMPOUND_INTEREST(TF => 5, PA => 10000, AIR => 5
));
END;
/
```

4.3.3 Mixed Noration

You call the function by a mix of both positional and named notation by:

```
BEGIN
    DBMS_OUTPUT.PUT_LINE(COMPOUND_INTEREST(10000, TF => 5, AIR => 5));
END;
/
```

There is a restriction on mixed notation. All positional notation of actual parameters must occur first and in the same order as they are defined by the function signature.

4.3.4 Exclusionary Notation

If the formal parameters are defined as optional, you can exclude one or more of the actual parameters. For example, consider the following function:

```
CREATE OR REPLACE
FUNCTION ADD_THREE_NUMBERS
(A NUMBER := 0, B NUMBER := 0, C NUMBER := 0)
RETURN NUMBER
IS
    SUM NUMBER;
BEGIN
    SUM := A + B + C;
RETURN SUM;
END;
/
```

Here, all 3 parameters are optional. So we can write programs like:

```
BEGIN
    DBMS_OUTPUT.PUT_LINE(ADD_THREE_NUMBERS(3, C => 4));
END;
/
```

When you opt to not provide an actual parameter, it acts as if you are passing a null value. This is known as exclusionary notation. Oracle recommends that you should list optional parameters last in function and procedure signatures. They also recommend that you sequence optional variables so that you never have to skip an optional parameter in the list. These recommendations exist to circumvent errors when making positional notation calls.

You cannot really skip an optional parameter in a positional notation call. This is true because all positional calls are in sequence by datatype, but you can provide a comma-delimited null value when you want to skip an optional parameter in the list. However, Oracle 11g now lets you use mixed notation calls. You can now use positional notation for your list of mandatory parameters, and named notation for optional parameters. This lets you skip optional parameters without naming all parameters explicitly.

4.4 Error Handling

When creating a procedure/function, you might face compilation errors. For example, if you execute the following code:

```
/*
  ERRONEOUS CODE.
  PROCEED WITH CAUTION.
  YOU HAVE BEEN WARNED.
*/
CREATE OR REPLACE
PROCEDURE FIND_SAL(I_ID IN NUMBER, SALARY OUT NUMBER)
AS
BEGIN
    SELECT MAX(SALARY) INTO SALARY
    FROM INSTRUCTOR
    WHERE ID = I_ID
END;
/
```

Output:

```
Warning: Procedure created with compilation errors.
```

Very helpful(!) You can use `SHOW ERROR` command (or `SHO ERR` for short) right after the warning message to find out the errors:

```
SHOW ERROR
```

Output:

```
Errors for PROCEDURE FIND_SAL:
```

```
LINE/COL ERROR
```

```
-----
4/5      PL/SQL: SQL Statement ignored
6/29     PL/SQL: ORA-00933: SQL command not properly ended
7/4      PLS-00103: Encountered the symbol "end-of-file" when expecting
          one of the following:
          ( begin case declare end exception exit for goto if loop mod
          null pragma raise return select update while with
          <an identifier> <a double-quoted delimited-identifier>
          <a bind variable> << continue close current delete fetch lock
          insert open rollback savepoint set sql execute commit forall
          merge pipe purge
```

This should help you identify that you missed a semicolon (;) in line 7.

Cursor structures are the return results from SQL `SELECT` statements. In response to any DML statement the database creates a memory area, known as context area, for processing an SQL statement, which contains all information needed for processing the statement, for example, number of rows processed, etc.

A cursor is a pointer to this context area. PL/SQL controls the context area through a cursor. A cursor holds the rows (one or more) returned by a SQL statement. The set of rows the cursor holds is referred to as the active set.

You can name a cursor so that it could be referred to in a program to fetch and process the rows returned by the SQL statement, one at a time. There are two types of cursors:

- Implicit cursor
- Explicit cursor

5.1 Implicit Cursor

Implicit cursors are automatically created by Oracle whenever an SQL statement is executed, when there is no explicit cursor for the statement. Programmers cannot control the implicit cursors and the information in it.

Whenever a DML statement is issued, an implicit cursor is associated with this statement. For `INSERT` operations, the cursor holds the data that needs to be inserted. For `UPDATE` and `DELETE` operations, the cursor identifies the rows that would be affected.

In PL/SQL, you can refer to the most recent implicit cursor as the SQL cursor, which always has the attributes like:

Table 5.1: Implicit Cursors

Attribute	Description
<code>%FOUND</code>	Returns true if an <code>INSERT</code> , <code>UPDATE</code> , or <code>DELETE</code> statement affected one or more rows, or a <code>SELECT INTO</code> statement returned one or more rows. Otherwise, it returns false.
<code>%NOTFOUND</code>	The logical opposite of <code>%FOUND</code> . It returns true if an <code>INSERT</code> , <code>UPDATE</code> , or <code>DELETE</code> statement affected no rows, or a <code>SELECT INTO</code> statement returned no rows.

Attribute	Description
%ISOPEN	Always returns false for implicit cursors, because Oracle closes the SQL cursor automatically after executing its associated SQL statement.
%ROWCOUNT	This attributes returns the number of rows changed by an INSERT, UPDATE, or DELETE statement or the number of rows returned by a SELECT INTO statement.

For example, the following program counts the number of rows affected by the UPDATE statement:

```
DECLARE
    TOTAL_ROWS NUMBER(2);
BEGIN
    UPDATE INSTRUCTOR
        SET SALARY = SALARY + 5000
        WHERE SALARY < 65000;
    IF SQL%NOTFOUND THEN
        DBMS_OUTPUT.PUT_LINE('No instructor satisfied the condition');
    ELSIF SQL%FOUND THEN
        TOTAL_ROWS := SQL%ROWCOUNT;
        DBMS_OUTPUT.PUT_LINE(TOTAL_ROWS || ' instructors updated');
    END IF;
END;
/
```

Output:

```
3 instructors updated
```

5.1.1 Single-Row Implicit Cursors

The SELECT INTO statement is present in all implicit cursors that query data. It works only when a single row is returned by a select statement. You can select a column or list of columns in the SELECT clause and assign the row columns to individual variables or collectively to a record datatype. For example,

```
DECLARE
    -- For one-to-one assignment
    I_ID INSTRUCTOR.ID%TYPE;
    I_NAME INSTRUCTOR.NAME%TYPE;
    I_SALARY INSTRUCTOR.SALARY%TYPE;
    -- For group assignment
    TYPE INSTRUCTOR_RECORD IS RECORD
    (
        I_ID INSTRUCTOR.ID%TYPE,
        I_NAME INSTRUCTOR.NAME%TYPE,
        I_SALARY INSTRUCTOR.SALARY%TYPE
    );
    INS INSTRUCTOR_RECORD;
BEGIN
    -- Individual selection
    SELECT ID, NAME, SALARY
        INTO I_ID, I_NAME, I_SALARY
        FROM INSTRUCTOR
        WHERE ROWNUM < 2;
    DBMS_OUTPUT.PUT_LINE('Name: ' || I_NAME);
    -- Group selection
    SELECT ID, NAME, SALARY
        INTO INS
```

```

        FROM INSTRUCTOR
        WHERE ROWNUM < 2;
    DBMS_OUTPUT.PUT_LINE('Name: ' || INS.I_NAME);
END;
/

```

Output:

```

Name: Srinivasan
Name: Srinivasan

```

5.1.2 Multiple-Row Implicit Cursors

There are two ways you can create multiple-row implicit cursors. The first is done by writing any DML statement in a PL/SQL block. DML statements are considered multiple-row implicit cursors, even though you can limit them to a single row. We already saw that in the UPDATE example. The second is to write an embedded query in a cursor FOR loop rather than defined in a declaration block. For example, the following program can be used to see the names and the monthly salaries of different instructors:

```

BEGIN
    FOR ROW IN (SELECT NAME, SALARY FROM INSTRUCTOR) LOOP
        DBMS_OUTPUT.PUT_LINE('Name: ' || ROW.NAME);
        DBMS_OUTPUT.PUT_LINE('Monthly Salary: ' || TRUNC(ROW.SALARY/12));
    END LOOP;
END;
/

```

Output:

```

Name: Srinivasan
Monthly Salary: 5416
Name: Wu
Monthly Salary: 7500
Name: Mozart
Monthly Salary: 3333
Name: Einstein
Monthly Salary: 7916
Name: El Said
Monthly Salary: 5000
Name: Gold
Monthly Salary: 7250
Name: Katz
Monthly Salary: 6250
Name: Califieri
Monthly Salary: 5166
Name: Singh
Monthly Salary: 6666
Name: Crick
Monthly Salary: 6000
Name: Brandt
Monthly Salary: 7666
Name: Kim
Monthly Salary: 6666

```

5.2 Explicit Cursor

Explicit cursors are programmer-defined cursors for gaining more control over the context area. It should be defined in the declaration section of the PL/SQL block. It is created on a SELECT statement which returns one or more rows. The prototype for declaring explicit cursor are as follows:

```
CURSOR cursor_name IS select_statement;
```

Four steps are required for using explicit cursors:

1. Declaring the cursor for initializing the memory
2. Opening the cursor for allocating memory
3. Fetching the cursor for retrieving data
4. Closing the cursor to release allocated memory.

Static SELECT Cursor

Static SELECT statements return the same query each time with potentially different results. The result change as the data changes in the table or views.

For example, the following program can be used to iterate through department budgets:

```
DECLARE
    D_NAME DEPARTMENT.DEPT_NAME%TYPE;
    D_BUDGET DEPARTMENT.BUDGET%TYPE;
    CURSOR C_DEPT
    IS
        SELECT DEPT_NAME, BUDGET
        FROM DEPARTMENT;
BEGIN
    OPEN C_DEPT;
    LOOP
        FETCH C_DEPT INTO D_NAME, D_BUDGET;
        EXIT WHEN C_DEPT%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(D_NAME || ' ' || D_BUDGET);
    END LOOP;
    CLOSE C_DEPT;
END;
```

Output:

```
Biology 90000
Comp. Sci. 100000
Elec. Eng. 85000
Finance 120000
History 50000
Music 80000
Physics 70000
```

Dynamic SELECT Cursor

Dynamic SELECT statements act like parameterized subroutines. They run different queries each time, depending on the actual parameters provided when they are opened.

This can be achieved in two ways. An explicit cursor query can reference any variable in its scope. When you open an explicit cursor, PL/SQL evaluates any variables in the query and uses those values when identifying the result set. Changing the values of the variables later does not change the result set.

For example, the following program can be used to find the list of courses for a particular credit:

```

DECLARE
  C_TITLE COURSE.TITLE%TYPE;
  C_CREDIT COURSE.CREDITS%TYPE := 4;
  CURSOR C_COURSE
  IS
    SELECT TITLE
      FROM COURSE
     WHERE CREDITS = C_CREDIT;
BEGIN
  OPEN C_COURSE;
  LOOP
    FETCH C_COURSE INTO C_TITLE;
    EXIT WHEN C_COURSE%NOTFOUND;
    DBMS_OUTPUT.PUT_LINE(C_TITLE);
  END LOOP;
  CLOSE C_COURSE;
END;
/

```

Output:

```

Intro. to Biology
Genetics
Intro. to Computer Science
Game Design
Physical Principles

```

The value of C_CREDIT is evaluated and used during opening of the cursor. Even if we change the value after that, it will not affect the rows that are returned.

Relying on local variables can be confusing and more difficult to support the code. Another way can be defining cursors that accept formal parameters. You can create an explicit cursor that has formal parameters, and then pass different parameters to the cursor each time you open it. In the cursor query, you can use a formal cursor parameter anywhere that you can use a constant. Outside the cursor query, you cannot reference the formal cursor parameters. We can rewrite the previous program:

```

DECLARE
  C_TITLE COURSE.TITLE%TYPE;
  CURSOR C_COURSE
  (C_CREDIT COURSE.CREDITS%TYPE)
  IS
    SELECT TITLE
      FROM COURSE
     WHERE CREDITS = C_CREDIT;
BEGIN
  OPEN C_COURSE(4);
  LOOP
    FETCH C_COURSE INTO C_TITLE;
    EXIT WHEN C_COURSE%NOTFOUND;
    DBMS_OUTPUT.PUT_LINE(C_TITLE);
  END LOOP;
  CLOSE C_COURSE;
END;
/

```

Output:

```
Intro. to Biology
Genetics
Intro. to Computer Science
Game Design
Physical Principles
```

The benefit of this approach is that we can open the cursor multiple times using separate parameters to get different information. For example, the following program can identify the students in a certain department who are slacking off by taking lesser number of courses:

```
-- Create procedure for printing student information.
CREATE OR REPLACE
PROCEDURE PRINT_SLACKING_STUDENT
(S_DEPT IN STUDENT.DEPT_NAME%TYPE, S_AVG IN STUDENT.TOT_CRED%TYPE)
IS
    S_NAME STUDENT.NAME%TYPE;
    CURSOR C_STUDENT
    (DEPT STUDENT.DEPT_NAME%TYPE,
    AVERAGE STUDENT.TOT_CRED%TYPE)
    IS
        SELECT NAME
        FROM STUDENT
        WHERE DEPT_NAME = DEPT AND TOT_CRED < AVERAGE;
BEGIN
    OPEN C_STUDENT(S_DEPT, S_AVG);
    DBMS_OUTPUT.PUT_LINE('-----');
    DBMS_OUTPUT.PUT_LINE('Slacking students from ' || S_DEPT);
    DBMS_OUTPUT.PUT_LINE('-----');
    LOOP
        FETCH C_STUDENT INTO S_NAME;
        EXIT WHEN C_STUDENT%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(S_NAME);
    END LOOP;
    CLOSE C_STUDENT;
END;
/

-- Call procedure to find students
DECLARE
    S_AVG STUDENT.DEPT_NAME%TYPE;
BEGIN
    SELECT AVG(TOT_CRED) INTO S_AVG
    FROM STUDENT
    WHERE DEPT_NAME = 'Comp. Sci.';
    PRINT_SLACKING_STUDENT('Comp. Sci.', S_AVG);

    SELECT AVG(TOT_CRED) INTO S_AVG
    FROM STUDENT
    WHERE DEPT_NAME = 'Physics';
    PRINT_SLACKING_STUDENT('Physics', S_AVG);
END;
/
```

Output:


```

-----
Slacking students from Comp. Sci.
-----
Shankar
Williams
Brown
-----
Slacking students from Physics
-----
Snow

```

5.3 Cursor using FOR Loop

The cursor FOR loop is an elegant and natural extension of the numeric FOR loop in PL/SQL. The body of the for loop is executed for each row returned by the query. The benefit of using this loop is that Oracle handles the OPEN, FETCH, and CLOSE internally.

For example, the following program can be used to determine the yearly cost for each department in terms of salary of the instructors:

```

-- Declare function
CREATE OR REPLACE FUNCTION
TOTAL_SALARY(D_NAME INSTRUCTOR.DEPT_NAME%TYPE)
RETURN NUMBER
IS
    CURSOR C_INSTRUCTOR
    IS
        SELECT SALARY
            FROM INSTRUCTOR
            WHERE DEPT_NAME = D_NAME;
    TOTAL NUMBER := 0;
BEGIN
    FOR INS_ROW IN C_INSTRUCTOR
    LOOP
        TOTAL := TOTAL + INS_ROW.SALARY;
    END LOOP;
    RETURN TOTAL;
END;
/

-- Call it from an anonymous block
BEGIN
    DBMS_OUTPUT.PUT_LINE(TOTAL_SALARY('Comp. Sci.'));
END;
/

```

Output:

```
232000
```