THE BCS PROFESSIONAL EXAMINATIONS
Certificate in IT

October 2006

Examiners' Report

Software Development

Question 1

1. The serial file <rpifile> contains a sequence of records. Each record contains a year (integer) and its retail price index (real), starting from 1947.

a) Write a record and file description for <rpifile>. State which language you use. **(5 marks)**

b) Develop an algorithm which accepts two year values, startyr and endyr, reads the appropriate retail price index data from <rpifile> and prints a table (see below) of Inflation Factors (IF) between startyr and endyr. Each IF entry in the table is computed by rpi[across year] / rpi[down year]. Thus if the startyr was 1960 and endyr was 1965 the table would be as shown below. Particularly note the diagonal line of '1.00' values, which means that £1.00 was worth £1.00 in the same year. The algorithm must have at least two stages of development and need not be developed beyond the point at which coding/testing would be possible. **(25 marks)**

	1960	1961	1962	1963	1964	1965
1960	**1.00**	0.96	0.92	0.91	0.86	0.84
1961	1.05	**1.00**	0.97	0.95	0.90	0.88
1962	1.08	1.03	**1.00**	0.98	0.93	0.91
1963	1.10	1.05	1.02	**1.00**	0.94	0.93
1964	1.17	1.12	1.08	1.06	**1.00**	0.98
1965	1.19	1.14	1.10	1.08	1.02	**1.00**

Table of Inflation Factors

Answer Pointers

```
Initial Algorithm
File assignments
INPUT firstyr  lastyr
Locate first and last years from <rpifile> for table
Count records on <rpifile> between firstyr and lastyr → howmany
{write table}
Loop to write columns
   BEGIN
      Get year for one row = tabyr
      WRITE year of table column
      FOR loop {writes one row of table}
      BEGIN
         CALCULATE table entry → avalue
         WRITE avalue
      END
   NEWLINE
END

Development
{Count records on <rpifile> between firstyr and lastyr → howmany}
WHILE rpirec.yr <= lastyr DO
   BEGIN
```

```
        ct ← ct + 1
        rpi[ct] = rpirec.rpindex
        READ(rpifile,rpirec)
    END
howmany ← ct

{write table}
FOR down = howmany DOWNTO 1 DO
    BEGIN
        tabyr = lastyr - down + 1
        WRITE(tabyr – needs format)
        FOR across = howmany DOWNTO 1 DO
        BEGIN
            avalue ← rpi[across] / rpi[down];
            WRITE(avalue – needs format)
        END
```

The complete Pascal program is given below. Students were not expected to put it all together but their answers may contain some of the detail in the program.

```
PROGRAM rpitable(INPUT,OUTPUT,rpifile);
{prints table of RPI index between specified years}
CONST max = 30;
TYPE and file descriptions from (a) above
VAR ct,howmany,firstyr,lastyr,tabyr,across,down:INTEGER; avalue:REAL;
   rpirec: rpitype;  rpi:ARRAY[1..max] OF REAL;
BEGIN
WRITELN('prints table of retail price index values between specified years');
WRITELN('used input from <rpifile>');WRITELN;
ASSIGN(rpifile, 'C:\PROPAS\sources\rpifile');
RESET(rpifile);
WRITELN('input first year'); READ(firstyr);
READ(rpifile,rpirec);
WHILE rpirec.yr < firstyr DO READ(rpifile,rpirec);
IF rpirec.yr = firstyr THEN WRITELN('initial  record located')
    ELSE WRITELN('error in input year');
ct := 0;
WRITELN('input last year'); READ(lastyr);
WHILE rpirec.yr <= lastyr DO
    BEGIN
        ct := ct + 1;
        rpi[ct] := rpirec.rpindex;
        READ(rpifile,rpirec)
    END;
WRITELN;
WRITELN(ct:3,'  records read from file');
howmany := ct;
WRITE(' ':6);
FOR ct :=firstyr TO lastyr DO WRITE(ct:4,' ':2); WRITELN;
(* write table *)
FOR down := howmany DOWNTO 1 DO
    BEGIN
    tabyr := lastyr - down + 1;
    WRITE(tabyr:4,' ':2);
    FOR across := howmany DOWNTO 1 DO
        BEGIN
            avalue := rpi[across] / rpi[down];
            WRITE(avalue:4:2, ' ':2)
        END;
    WRITELN
    END;
WRITELN('table complete')
END.
```

```
CLOSE(rpifile,False)
END.
```

Question 2

2. *a)* The code given below incorporates <testrange>, a procedure which is called recursively. Dry run the code with input values num = 7 lo = 3 hi = 5; use the line numbers in your answer. **(18 marks)**

Line number

```
1  PROCEDURE testrange (n, r1, r2 : INTEGER;    inrg:BOOLEAN)
2  IF r1 = n THEN inrg = TRUE
3     ELSE   IF  r1 > r2  THEN inrg = FALSE
4              ELSE  { p1 = NEXT( r1) }
5                         testrange( n,p1,r2,inrg )
   END {recursive procedure}
6  BEGIN   {top level – execution begins here}
7  READ( num, lo, hi )
8  testrange( num, lo, hi, test )
9  IF test = TRUE THEN PRINT (num  “lies inside range”)
10    ELSE PRINT (num “lies outside range”)
11 END.
```

Information: NEXT(number) is the value following <number> in its sequence. Thus NEXT(3) = 4.

b) Re-write the given code with better identifier names and input prompts to make it generally more meaningful. State which language you use. **(12 marks)**

Answer Pointers
a)

Identify changing variables: Most changes occur with r1, r2 and p1 in the <testrange> procedure. Likewise with lo, hi and test at the top level.

DRY RUN TABLE

← .. ..Procedure.. .. .. →← ..top level .. .. →

line	Instr	r1	R2	p1	IF conditn	IF conditn	lo	hi	Test	Out/other
6	?	?	?	?	?		?	?	?	Start
7	READ						3	5		num=7
8	First call									
1	Param	3	5							N=7
2	IF (outer)				False					
3	IF (inner)					False				
4				4						
5	rec. call									
1	Param.pass	4	5							
2	IF (outer)				False					
3	IF (inner)					False				
4		5	5	5						
5	rec. call									
1	Param.pass									
2	IF (outer)				False					
3	IF (inner)					False				
4				6						
5	Rec. call									
1	Param.pass	6	5							
2	IF (outer)				False					
3	IF (inner)					TRUE				
8	Return						6	5	True	

9	IF(top)				False					
10	PRINT	6	5	6			6	5	True	Out:7 lies outside range

Answer Pointers

b)

```
   PROGRAM test(INPUT,OUTPUT);
{program uses recursive procedure <testrange>. To detect if an input number lies within a
particular range of integer values}
VAR number, lower, upper : INTEGER;  test : BOOLEAN;
      PROCEDURE testrange (tstnum, low, high : INTEGER;
                           inrange:BOOLEAN);
           IF low = tstnum THEN inrange = TRUE
               ELSE   IF  low > high  THEN inrange = FALSE
                        ELSE  newp1 = NEXT( low)
                              testrange( n,newp1,high,inrange )
           END; {recursive procedure}
           BEGIN   {top level - execution begins here}
                  WRITELN("input lower and higher bounds of range");
                  READ( lower, higher );
                  WRITELN("input number to be tested");
                  READ(num);
                  testrange( num, lower, higher, test );
                  IF test THEN WRITELN (num:3,  "lies inside range")
                      ELSE PRINT (num:3, "lies outside range")
           END.
```

Question 3

3. *a)* Choose either version A (written in C) or version B (written in Pascal) which perform identical operations and state the final values of the variables v, w, x, y, z. **(15 marks)**

Version A	Version B
v=0; w=0; x=0; y=0; z=0;	v:=0; w:=0; x:=0; y:=0; z:=0;
for(i=0;i<10;i++){	for i:=0 step 1 to 9 do begin
v++;	v:=v+1;
w=w+i;	w:=w+i;
}	end;
if(v>=10)	if v>=10
x=5;	then x:=5;
for(i=0;i<10;i++){	for i:=0 step 1 to 9 do begin
if(i>x)	if i>x
y++;	then y:=y+1
}	end;
for(i=10;i>5;i--)	for i:=10 step -1 to 6 do
z=z+i;	z:=z+i
Note: In this example, after each time through the loop, the loop variable i is incremented by 1.	

b) All the entries in an array SHUFFLE need to be moved one place earlier except the first entry which needs to be moved to the end.

SHUFFLE									
Before									
20	**4**	**44**	**3**	**18**	**5**	**6**	**57**	**9**	**7**
After									
4	**44**	**3**	**18**	**5**	**6**	**57**	**9**	**7**	**20**

Write a section of code to accomplish this task in a programming language known to you. **(15 marks)**

Answer Pointers

a)

v=10
w=45
x=5
y=4
z=40

with appropriate working 15 marks

b) Expect something like:

```
int save,i;
save=SHUFFLE[0];
for(i=9;i>0;i--)
            SHUFFLE[i-1]=SHUFFLE[i];
SHUFFLE[9]=save;
```

15 marks

Question 4

4. *a)* What is the key difference between a compiler and an interpreter? **(5 marks)**

b) Give an example of a simple conditional (if statement) with a syntax error in it and give the expected error message that might be obtained from a compiler or interpreter. **(5 marks)**

c) Give an example of a simple assignment statement that will cause a run-time error and give the expected error message that might be obtained from a compiler or interpreter. **(5 marks)**

d) State ONE advantage of a using compiler in preference to an interpreter. **(5 marks)**

e) State ONE advantage of using an interpreter in preference to a compiler. **(5 marks)**

f) A programmer submits a program containing many syntax errors first to a compiler and then to an interpreter. If you saw the responses of the systems, how could you decide which was the compiler and which was the interpreter? **(5 marks)**

Answer Pointers

a) compiler translates all high-level source to low-level before executing anything. Interpreter translates a phrase and exectes it, then translates and executes some more, etc

b) if x>y) x=1;
expected syntax error message
"(" expected after if
[or equivalent in other languages]

c) x=y/0;
expected run-time error message
number overflow, attempting to divide by 0

d) compiled code runs faster

e) quicker to start to execution

f) compiler will typically give a long list of all errors found, interpreter will be content to point out first error [30 marks]

Question 5

5. A serial file named <primenos> contains a series of <limit> values, each of which is how many prime numbers there are below a particular value. Write a program to read the number of primes between <st> and <fin> values where <st> and <fin> are requested interactively and compare it to the value obtained from FUNCT(limit) which is defined as limit / LOG(limit). **(12 marks)**

Answer Pointers

```
Algorithm
Assign file <primenos>

PRINT ‟ input lower and higher limits for prime table”
INPUT st  fin
ct = 0
FOR loop = st TO fin DO
     READ aprime from <primenos>
       WHILE NOT end-of-file <primenos> AND (?)DO
           INCREMENT ct
       ENDWHILE
     PRINT ct aprime
     rfunct = limit / LOG (base e)[limit]
     PRINT ‟function” rfunct ‟ rounded to”  ROUND(rfunct);
END
```

(6 marks)

```
PROGRAM primetab(INPUT,OUTPUT,primenos);
{program computes the number of primes below <limit> and compares it to
 FUNCT(limit) where FUNCT(x) = x / ln(x)                               }
VAR ct,limit,aprime,st,fin : INTEGER;   rfunct:REAL;
    primenos:FILE OF INTEGER;
BEGIN
   WRITELN('howmany primes below an input..J.B.WILFORD September 2004');
   ASSIGN(primenos,'C:\PROPAS\SOURCES\primenos');
   RESET(primenos); ct := 0; aprime := 1;
   WRITELN('input the low   limit for prime count');READ(st);
   WRITELN('input the upper limit for prime count');READ(fin);
   FOR loopct := st TO     fin DO
   BEGIN
       WHILE (NOT EOF(primenos)) AND (aprime < loopct) DO
           BEGIN
                READ(primenos,aprime);
                ct := ct + 1;
                WRITELN(ct:3,' ':3,aprime:3)
           END;
       WRITELN;
       WRITELN('number of primes below ',limit:3, ' were ',ct:3);
       rfunct := limit / LN(limit);
       WRITELN('function ',rfunct:6:2,' rounded to ',ROUND(rfunct):3);
   END;
CLOSE(primenos,true)
END.
```

(6 marks)

Question 6

6. Write a program which reads interactively the area of a rectangle (Area) and its perimeter (Perim) and which calculates the associated sides called a and b. The necessary equations are:

a = Area / b
b = (Perim + SQRT(Perim*Perim – 16*Area)) / 4

Note: SQRT returns the positive square root value. **(12 marks)**

Answer Pointers

a)

Area = a * b thus a = Area / b

Substituting in Perim = 2*a + 2 * b

Perim = 2 * Area/b + 2 * b

Multiplying by (b) Perim * b = 2 * Area + 2 * b^2

Thus we have a quadratic in (b) whose roots are

Root1 = [Perim + SQRT(Perim2 – 4*2 *2)]/(2 * 2)

Root2 = [Perim - SQRT(Perim2 – 4*2 *2)]/(2 * 2)

b)

```
PROGRAM rectside(INPUT,OUTPUT);
{program finds values of rectangle sides [a,b] from given input area A = ab
and perimeter Perim = 2(a + b)}
VAR Area,Perim,a,b:REAL;
BEGIN
   WRITELN('CALCULATE RECTANGLE SIDES FROM AREA AND PERIMETER');
   WRITELN('INPUT AREA'); READ(Area);
   WRITELN('INPUT PERIMETER');  READ(Perim);
   b := (Perim + SQRT(Perim*Perim - 16*Area))/4;
   a := Area/b;
   WRITELN('side1 = ',a:6:2, '    side 2 = ',b:6:2);
END.
```

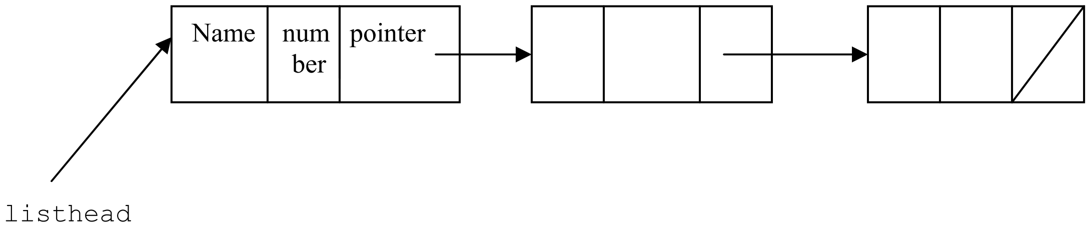
Question 7

7. *a)* A linked list has two data items and one pointer. Show how it may be represented by a diagram with appropriate pointers. **(3 marks)**

b) Such a list contains a name (20 characters) and a telephone number (six digits). Give a declaration for a member of this list. State which language you use. **(3 marks)**

c) Write code to search the list for a particular telephone number requested interactively. If the number is found the name is to be output otherwise the message ‘unable to find number’ is output. **(6 marks)**

Answer Pointers



b)

```
TYPE ptr  = ^node;
     Node = RECORD
     Name : ARRAY[1..20] OF CHAR;
   Phonenum : INTEGER;
   Next : ptr
      END;
```

c)

Algorithm/pseudocode

```
Declarations (as above)
Setuplist(head)
READ phoneo
WHILE NOT end-of-list AND notfound DO
    IF list.phonenum = phoneo Then found = TRUE
       ELSE traverse list
    IF found THEN WRITE list.name, list.phonenum
        ELSE WRITE 'unable to find number'
END
```

(6 marks)

Complete PASCAL program with setuplist procedure
(all of this is not expected in student answers but these may contain some of the detail shown below)

```
PROGRAM  numserch (INPUT,OUTPUT);
{sets up linked list of names & phone numbers then searches list for input
number}
CONST namelength = 20;
TYPE ptr  = ^node;
            Node = RECORD
            Name : ARRAY[1..20] OF CHAR;
           Phonenum : INTEGER;
           Next : ptr
              END;
VAR found:BOOLEAN; phoneo,act:INTEGER; head,member:ptr;

PROCEDURE setuplist(VAR thehead:ptr);
{sets up linked list of names and associated phone numbers)}
VAR aphone,ct:INTEGER;  member:ptr;
BEGIN
WRITELN('input last item for list ');  READ(aphone); READLN;
WHILE aphone <> 0 DO
   BEGIN
    NEW(member);
    WRITELN('input name <20 chars> ');
    FOR ct := 1 TO namelength DO READ(member^.Name[ct]);
    READLN;
    member^.Phonenum :=aphone;
    member^.next := thehead;
    thehead := member;
    WRITELN('input next number for list : 0 to finish ');
    READ(aphone)
   END
END;
BEGIN  {top level}
WRITELN('program to search list for input phone number');
head := NIL;
setuplist(head); found := FALSE;
WRITELN(' input wanted phone number '); READ(phoneo);
```

```
WHILE ((member <> NIL) AND (NOT found)) DO
              BEGIN
              IF list^.phonenum = phoneo THEN found := TRUE
                ELSE member := member^.next
              END;
IF found THEN
        BEGIN
           FOR act := 1 TO namelength DO WRITE(member^.name[act]);
           WRITELN(' corresponds to ',member^.phonenum:6)
        END
ELSE WRITELN('unable to find number');
WRITELN('program ends')
END.
```

Question 8

8. A part-time lecturer's pay is fixed for the year with a quoted standard number of worked hours for each of the months September through to May. This data is stored on a file <payfile> where each record contains:

month name (3 characters)
hours worked (integer)
calculated pay (real number)

a) Write a suitable data structure to hold this information. **(3 marks)**

b) The lecturer keeps a monthly tally of actual hours worked to compare with the quoted hours. Develop a program which compares the expected monthly pay to that expected from hours actually worked, and the difference in pay between what he/she actually gets from the quoted hours and what he/she ought to have from the hours actually worked. The hours actually worked for a particular month are input interactively. **(9 marks)**

Answer Pointers

```
PROGRAM lectpay(INPUT,OUTPUT,lectcmpay);
{Program to read monthly calculated pay for a part-time lecturer
and compare it with pay actually earned per hour worked }
CONST monthmax = 9;
TYPE monthtype = (Sep,Oct,Nov,Dec,Jan,Feb,Mar,Apr,May);
lectype = RECORD
    month: monthtype;
    hours,pay:REAL
    END;

VAR  monthpay:ARRAY[monthtype] OF lectype; calcrec:lectype;
     diff:REAL; ct,amonth:INTEGER;
     monthsub: monthtype; lectmpay: FILE OF lectype;
BEGIN
WRITELN('program to compare calculated and earned part-time lecturers pay');
WRITELN(' needs file <lectcmpay> with real pay stored in record form as
above');WRITELN;
monthsub := Sep; ct := 1;
WHILE ct <= monthmax DO
   BEGIN
    amonth:= ORD(monthsub) + 1;
    WRITELN('input pay for month ',amonth:2);
    READ(monthpay[monthsub].pay);
    monthsub := SUCC(monthsub);
    ct := ct + 1
   END;
{write table captions}
WRITELN('month calc.pay  actual pay  diff.');
ASSIGN(lectmpay, 'E:\WPASCAL\lectmpay');
RESET(lectmpay);  monthsub := Sep;
  WHILE NOT eof(lectmpay) DO
```

```
    BEGIN
      READ(lectmpay,calcrec);
      diff := monthpay[monthsub].pay - calcrec.pay;
      amonth := ORD(monthsub) + 1;
      WRITELN(amonth:2,' ':3,calcrec.pay:6:2,' ':3,
          monthpay[monthsub].pay:6:2,' ':3,diff:6:2);
      monthsub := SUCC(monthsub)
    END;
WRITELN('pay calculations complete - program ends');
CLOSE(lectmpay, False)
END.
```

Question 9

9. A typical web page is divided up with a narrow strip at the top and bottom and at each side leaving a large area in the middle.

a) Sketch this layout and describe one way that it can be achieved. **(4 marks)**

b) Give a typical use for the parts of the page by considering the homepage of an e-commerce site selling to the general public. **(4 marks)**

c) State briefly another way in which the same layout effect can be achieved and give a reason why this method might not be favoured. **(4 marks)**

Answer Pointers

a) Sketch

Can be achieved with frameset consisting of 5 frames 4 marks

b)

Use of parts
Top strip - banner: logo & company name
Left-hand strip - navigation deeper into site
Right-hand strip - advertising
Bottom strip - navigation (site map)
Central part - main window. Navigation controls change the content of this window.
1 mark each for any 4, total 4 marks

c) Can also be achieved as a single page by using tables or inline frames.

Might not be favoured because every page has to contain and re-render the banner 4 marks

[Note students may answer a) and c) in reverse in which case the negative point for frames is the problem with bookmarks and back buttons etc]

Question 10

10. Suppose there are 300 employees in a company and an address list is maintained using a sequential file with the name of the employee being the key field. Suppose (for simplicity) that the names are evenly distributed over the alphabet.

a) give (or estimate) the minimum, maximum and average number of keys that will need to be accessed to find the address of a particular employee from the sequential file. **(4 marks)**

b) Now suppose that the file is made into an indexed sequential file with a single level index. The index groups are defined by initial letter of name, with 3 initial letters per group, i.e. A-C, D-F, G-I, etc.

i) give (or estimate) the minimum, maximum and average number of keys that will need to be accessed to find the correct group in the index. **(4 marks)**

ii) give (or estimate) the minimum, maximum and average number of keys that will need to be accessed to find the address in the main file once the index has been consulted. **(4 marks)**

Answer Pointers

a)

(i) 300 records, sequential

No of key comparisons: min 1, max 300, ave 150 4 marks

b)

(i) 26 letters in groups of 3 -> 9 groups in index each group containing approx the same number of keys

No of key comparisons in index: min 1, max 9, ave 5

(ii) 300 employees in 9 groups -> ~33 employees per group

No of key comparisons in main file group: min 1, max 33, ave 17 8 marks

Question 11

11. Consider the following function called findmax together with a single test case:

```
int findmax(int low, high){
/* specification: find smallest value in array v
    between index low and index high inclusive */
  int max; /* holds the maximum value found so far */
  int i; /* loop counter */
  max=100;
  for ( i=low; i<high; i++)
    if( v[i] > max )
      max=v[i];
  return(max);
}

test case: v[1]=55; v[2]=4; v[3]=16; low=1; high=3;
```

a) What is the essential difference between black-box and white-box testing the function findmax? **(6 marks)**

b) In what way would the error in the function findmax show up under black-box testing? **(3 marks)**

c) In what way would the error in the function findmax show up under white-box testing? **(3 marks)**

Answer Pointers

a) In black box testing the function findmax is available as an executable and it can be run to see if the results obtained match the expected results.

In white-box testing the source code of findmax is available and so the code can be dry-run line-by-line to look for errors 6 marks

b) under black-box testing the result of running findmax with the test case data is 100. This is incorrect as the expected result is 55 as defined by the specification.

c) under white-box testing the assignment of 100 to max is immediately suspect as it violates the definition of the meaning of the variable max. This is in fact the error.

Question 12

12. *a)* Name and briefly describe the main function of TWO items of system software. **(6 marks)**

b) Name and briefly describe the main function of TWO items of application software. **(6 marks)**

Answer Pointers

a) Plenty to choose from, might expect compiler, print spooler, file manager, scheduler, web server, database server, etc.

(1 for name, 2 for function)x2 = 6 marks

b) might expect spreadsheet, word processor, text editor, graphics editor, personal diary/planner, web browser, etc. (1 for name, 2 for function)x2 = 6 marks