(a) Give an activation record structure that accommodates this new structure. Use the basic activation record model given above in question III.

(b) Give the activation record for the procedure:

```
A procedure
    integer I;
    integer A[N];
    integer J;
```

when the procedure A is entered with the global variable N having the value 4. Assume that the activation record starts at location 1700.

(b) What code needs to be executed when A is entered in addition to the normal code needed to create a new activation record?

VII [10]. Give a symbol table organization for a language (like NIP with nested scopes) that allows for: (a) Quick lookup for any name; and (b) ability to print a global list of all names in alphabetical order.

Justify your decisions. There is no one correct answer, but the reasoning behind each decision will count towards "correctness."

If the array is allocated so that the first element begins at location 500:

(a) What element of A is at location 500?

(b) What is the virtual origin of A?

(b) Give the expression that gives the address of the element A[I,J].

V [10]. Read the following grammar (*carefully*):

$S \rightarrow E$	S.val = E.val
	E.num = 1
$E \rightarrow E * T$	E_1.val = 2*E_2.val + 2*T.val
	E_2.num = E_1.num+1
	T.num = E_1.num+1
$E \rightarrow T$	E.val = T.val
	T.num = E.num+1
$T \rightarrow T + P$	T_1.val = T_2.val + P.val
	T_2.num = T_1.num+1
	P.num = T_1.num+1
$T \rightarrow P$	T.val = P.val
	P.num = T.num+1
$P \rightarrow (E)$	P.val = E.val
	E.num = P.num
$P \rightarrow i$	P.val = i/P.num

(a) Which attributes are inherited and which are synthesized?

(b) What is S.val for the string?: 3

(c) What is S.val for the string?: 2+(4*3)

V [10]. (a) For each fragment on the left below, describe the optimization technique that results in the fragment on the right.

	initial	**final**
(1)	A=B+C D=B+C	A=B+C D=A
(2)	B=2.0*A	B=A+A
(3)	FOR I= 1 TO 10 DO A[I]=B+C END	T=B+C FOR I = 1 TO 10 DO A[I]=T END
(4)	A*B*C*D	(A*B)*(C*D)
(5)	I=10 J=2*I	I=10 J=20

(b) Reverse Polish prefix has been proposed as a suitable internal form for compiler design. It is the Polish prefix form, reversed. That is, for the expression I/J the prefix form is / I J. However, the reverse Polish prefix will be this form *reversed*: J I /. Why is this a good format for code generation on typical voin Neumann architecture computers (like the HAC 430)?

VI [15]. Assume that NIP allowed the declaration: integer A[N]; where the size of the array was evaluated when the procedure containing the declaration is entered.

I [15].
(a) Show that the language generated by the following grammar:

$$S \rightarrow a\ S\ a \mid a$$

is a regular language.

(b) Give the deterministic finite state automaton for the regular expression:

$$(a \mid b\ )^* \mid (a\ b)^*$$

(c) Can this language for a subset of expressions be recognized by a regular grammar? Explain, and explain the major difference between this grammar and the full expression grammar.

$E \rightarrow E + T \mid T$
$T \rightarrow T * P \mid P$
$P \rightarrow i$

II [15]. Consider the grammar:

$S \rightarrow X\ 1 \mid 2\ X\ 3 \mid Y\ 3 \mid 2\ Y\ 1$
$X \rightarrow 0$
$Y \rightarrow 0$

(a) Is the grammar LR(1)? If, give tables; if not, why not?

(b) Is the grammar LALR(1)? If, give tables; if not, why not?

III [15]. Assume NIP activation records contain (in order):

End of stack pointer
Dynamic Link
Return address
Static link
Local data storage

Consider the NIP program fragment:

```
A procedure
integer X;

        B procedure
        integer Y;

                C procedure
                integer Z;
                Z := 1;
                Y := Z+1;
                X := Y+Z;
                write(X,Y,Z)
        call C
call B
```

(a) Assume that the activation record for procedure A begins at location 1000. Give the stack contents from 1000 on at the point of the write statement in procedure C.

(b) Assume you only have 3 registers - M, N, and P. Assume register P always points to the current activation record. Give the typical machine code that would be generated for the above statement: X := Y+Z.

IV [10]. Assume each object of Pascal type "zork" takes 8 bytes of storage. Consider the declaration:

```
var A: array[5..10, 6..20] of zork;
```

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May 22, 1991
10:30 am

Answer all questions in the exam book. Before you are told to start, do the following:

1. Put your name on the exam book. Only answers in this book will be graded.

2. If you want your grade posted with your social security number, then you must do all of the following: Inside the front cover of the exam book write: "Post my grade with my social security number." and then sign your name under this statement. If you do not do all of this, no grade will be posted. Grades should be available outside of room 4121 AVW by Tuesday afternoon, May 28.

DO NOT OPEN THIS EXAM PAST THIS FRONT PAGE UNTIL TOLD TO DO SO.