ECS 36A, May 26, 2023

Announcements

1. Homework 4 will be out by Monday
2. If you want us to look at something on the midterm, please send the note *through Gradescope*; otherwise it’s very hard to change grades and validate that everything is correct at the end of the quarter

A Quick Review of Pointers

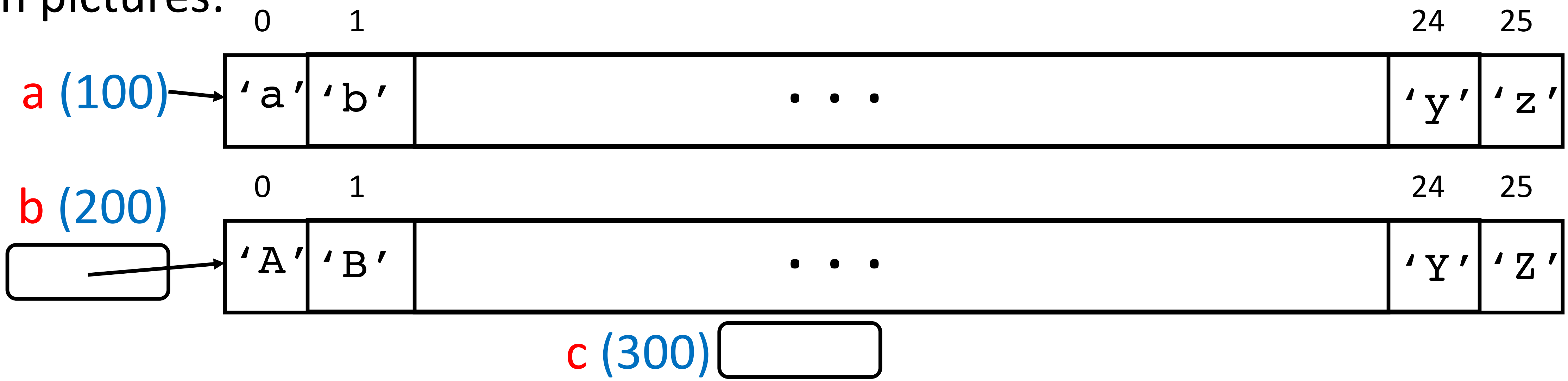
- A pointer is simply an address
  - It’s just like a constant or variable
- A pointer constant cannot be changed
  - int pc [30];   /* here pc is a pointer constant and cannot be changed */
- A pointer variable can be changed
  - int *p;   /* here p is a pointer variable and can be changed */

Midterm Question 8

- Setup:

```
char a[27] = "abcdefghijklmnopqrstuvwxyz";
char *b = "ABCDEFGHIJKLMNOPQRSTUVWXYZ";
char c;
```

- In pictures:

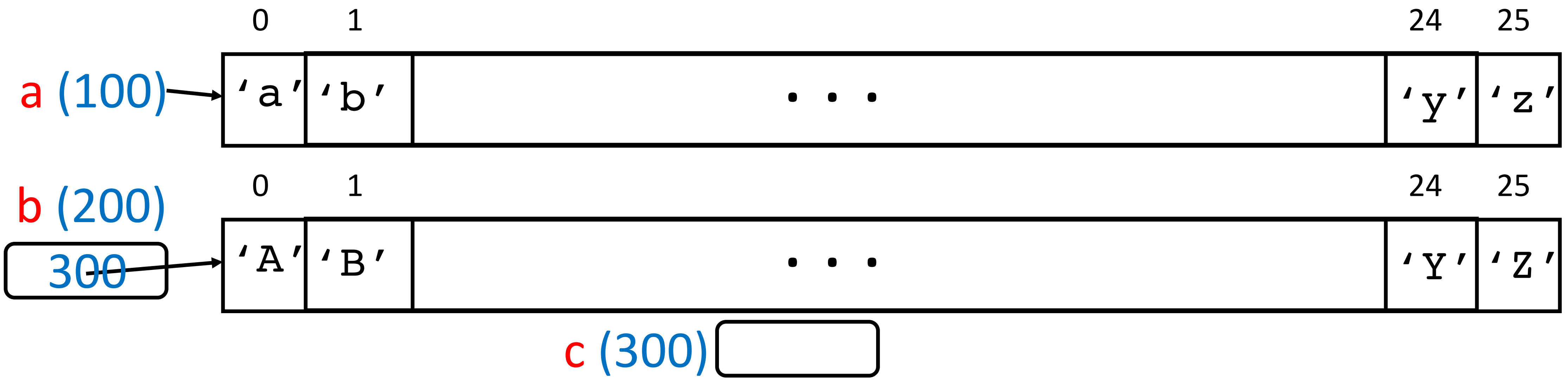


Midterm Question 8(a)

- Question:

```
b = &c;
```

- Answer: The value stored in `b` changes to the address of `c`

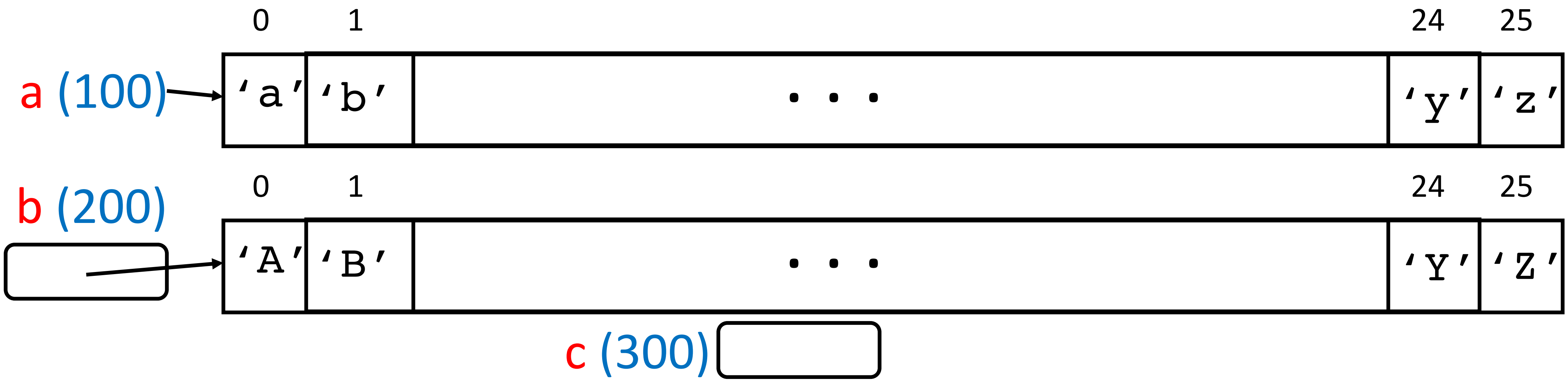


Midterm Question 8(b)

- Question:

```
a = b;
```

- Answer: a is a pointer *constant*, has no storage allocated to it like b does, and so cannot be changed. So this is an illegal assignment.

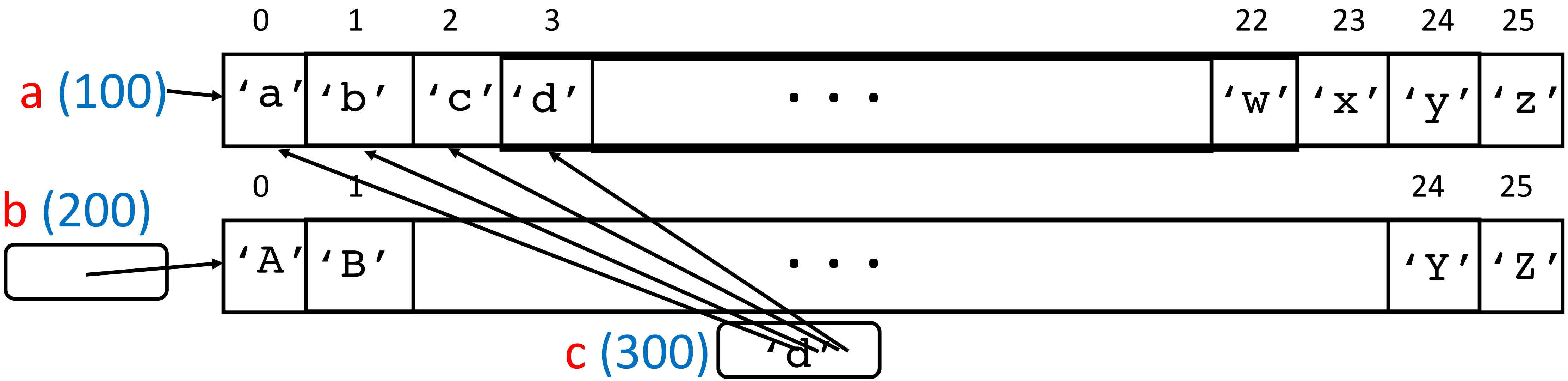


Midterm Question 8(c)

- Question:

```
c = *(a + 3);
```

- Answer: `c` becomes what is in the fourth element of `a` (counting from 0)

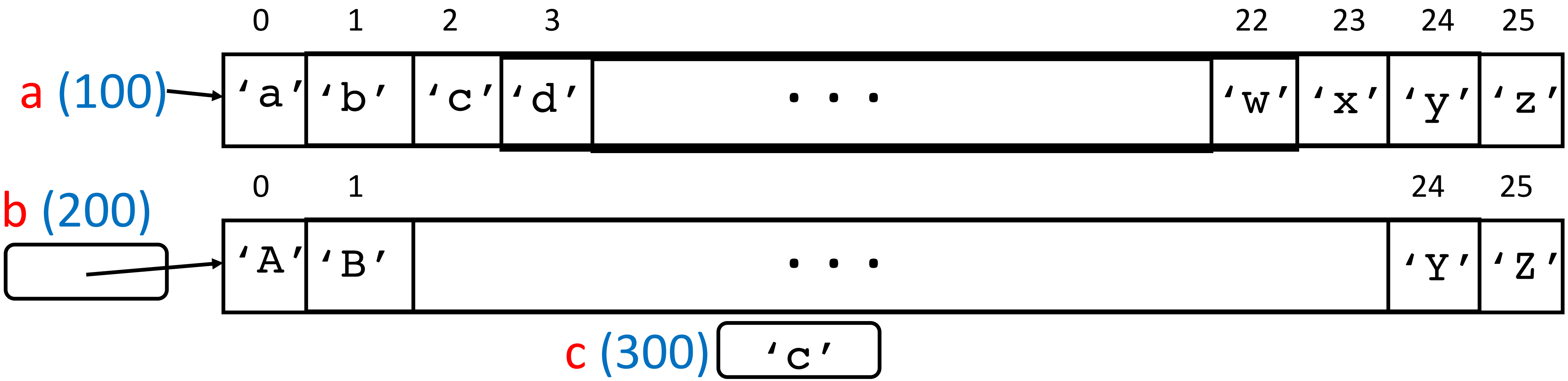


Midterm Question 8(d)

- Question:

```
c = 2[a];
```

- Answer: `c = 2[a] = *(2+a) = *(a+2) = a[2] = 'c'`

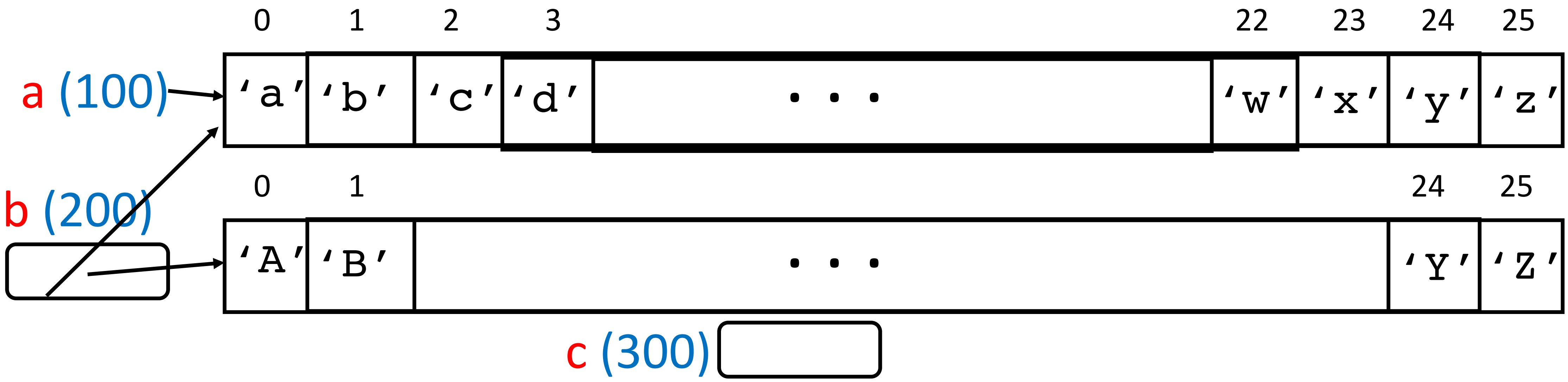


Midterm Question 8(e)

- Question:

```
b = a; c = b[25];
```

- Answer: `c = 2[a] = *(2+a) = *(a+2) = a[2] = 'c'`



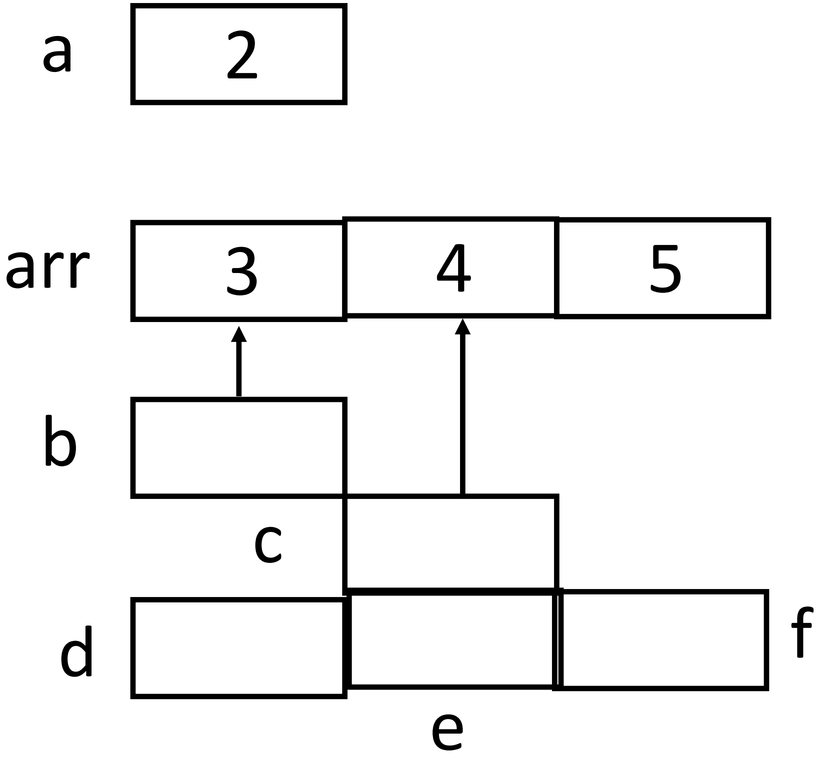
Midterm Question 9

```
int testandinc(int x)
{ return(x++); }

int p1testandinc(int *x)
{ return(*x++); }

int p2testandinc(int *x)
{ return((*x)++); }
```

```
int a = 2;
int arr[3] = { 3, 4, 5 };
int *b = arr;
int *c = &arr[1];
d = testandinc(a);
e = p1testandinc(b);
f = p2testandinc(c);
```

Midterm Question 9

```
int a = 2;
int arr[3] = { 3, 4, 5 };
int *b = arr;
int *c = &arr[1];
d = testandinc(a);
e = p1testandinc(b);
f = p2testandinc(c);
```

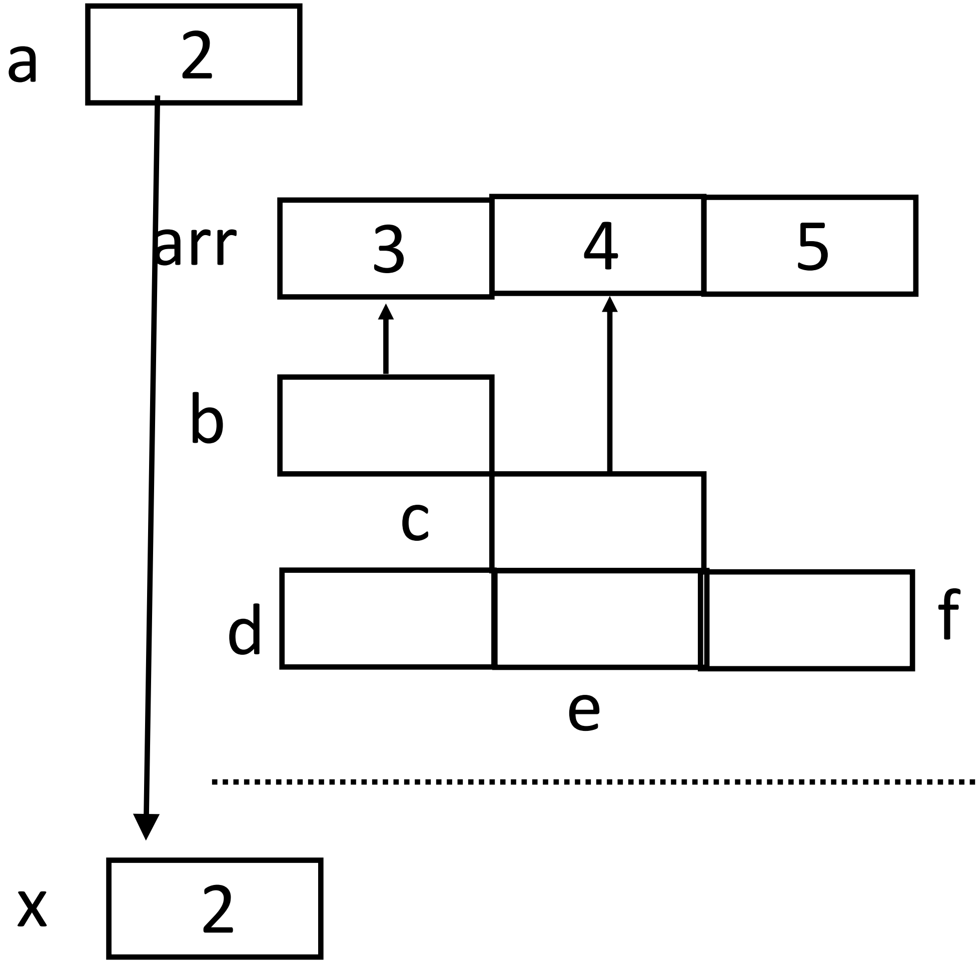


Approach

- Go through the program, and then get the values

Midterm Question 9

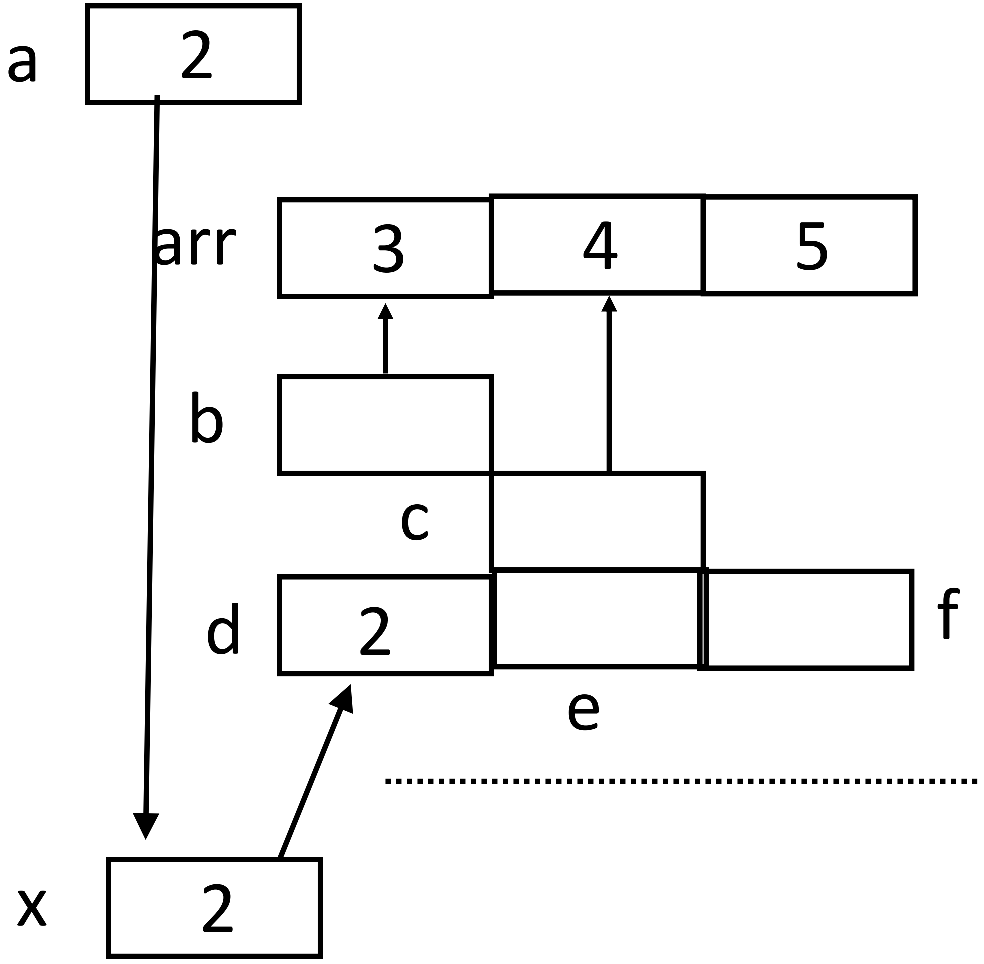
```
int testandinc(int x)
{
        return(x++);
}

. . .

d = testandinc(a)
```



Midterm Question 9

```
int testandinc(int x)
{
        return(x++);
}
. . .
d = testandinc(a)
```

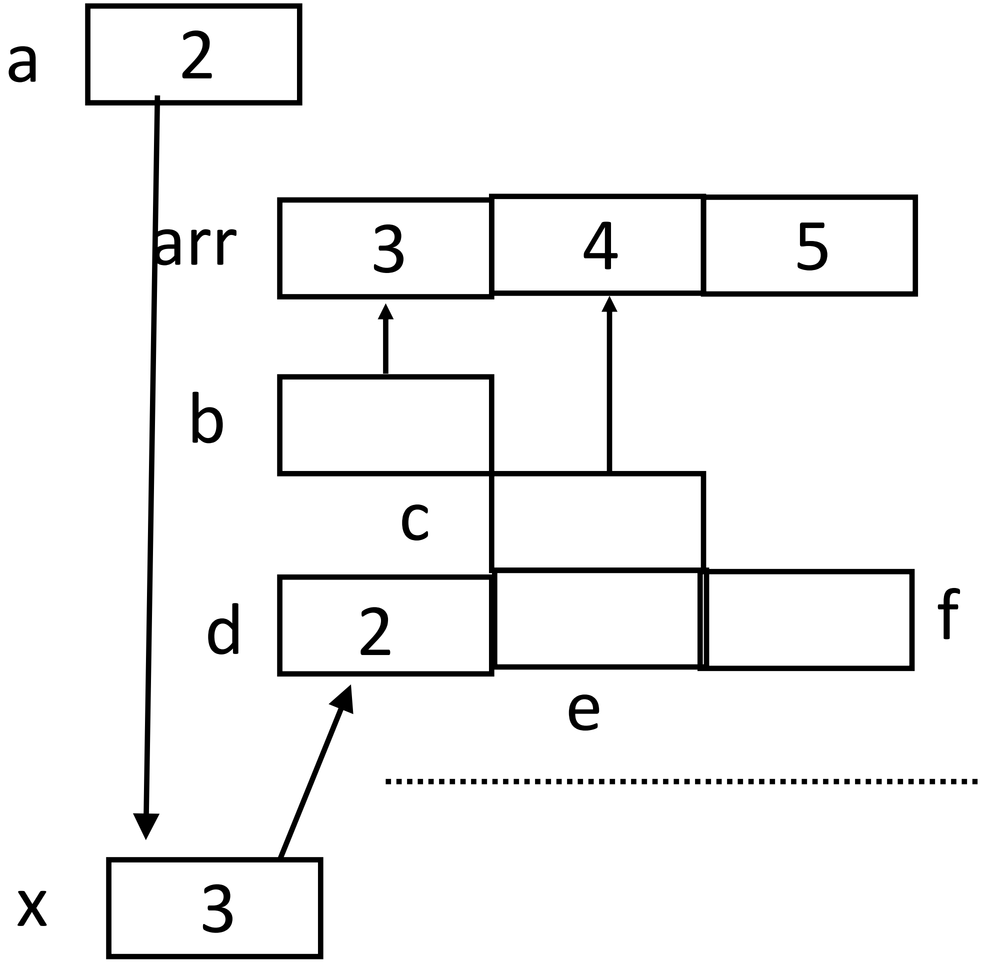
Return value of `x`



Midterm Question 9

```
int testandinc(int x)
{
       return(x++);
}
. . .
d = testandinc(a)
```

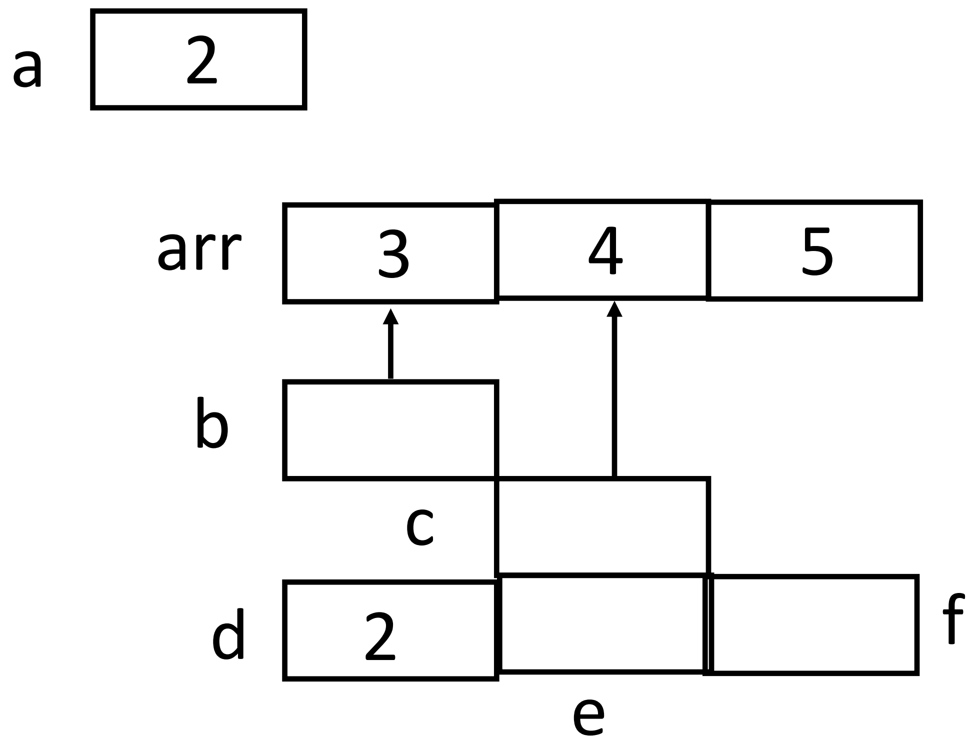
Add 1 to the value of x



Midterm Question 9

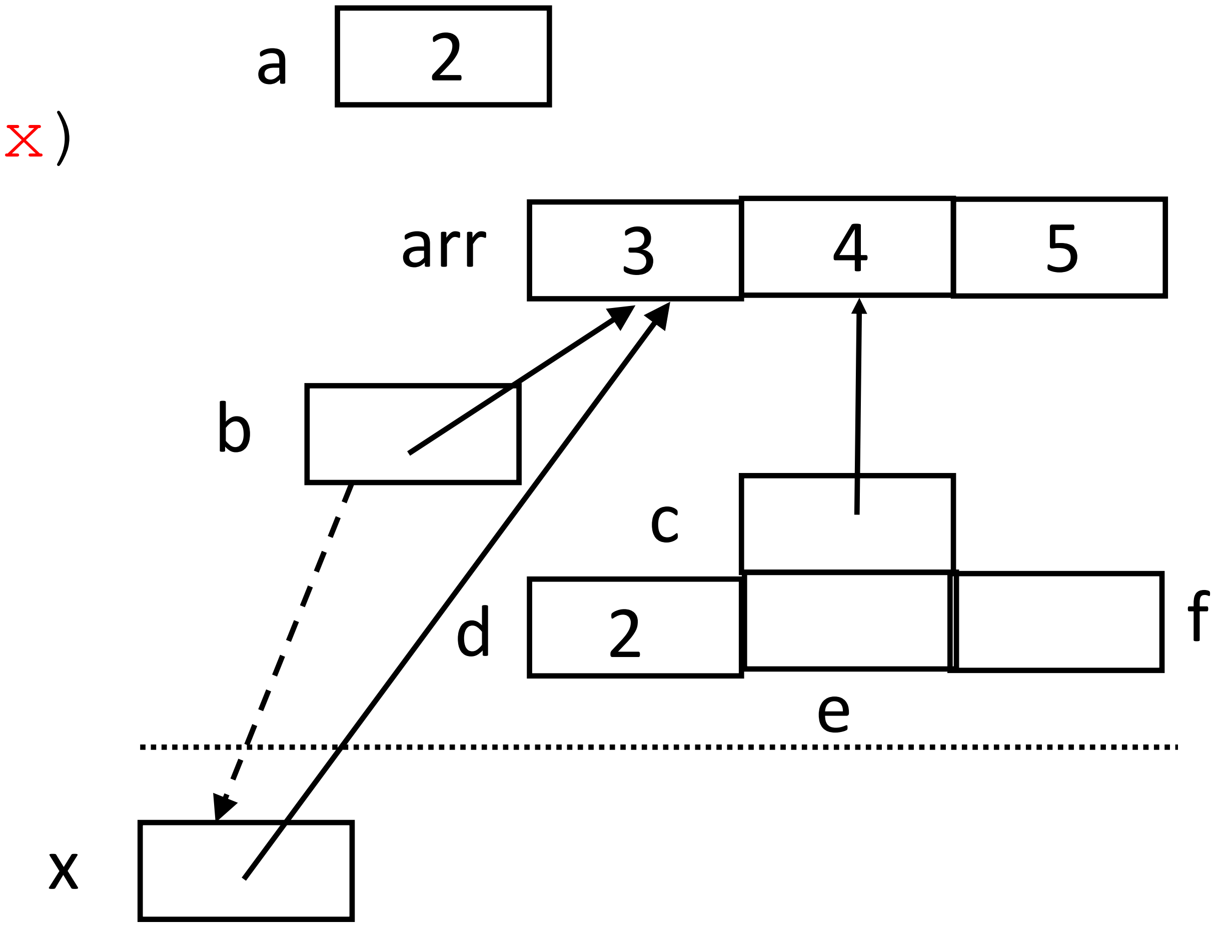
```
int testandinc(int x)
{
        return(x++);
}
. . .
d = testandinc(a)
```

Function ends



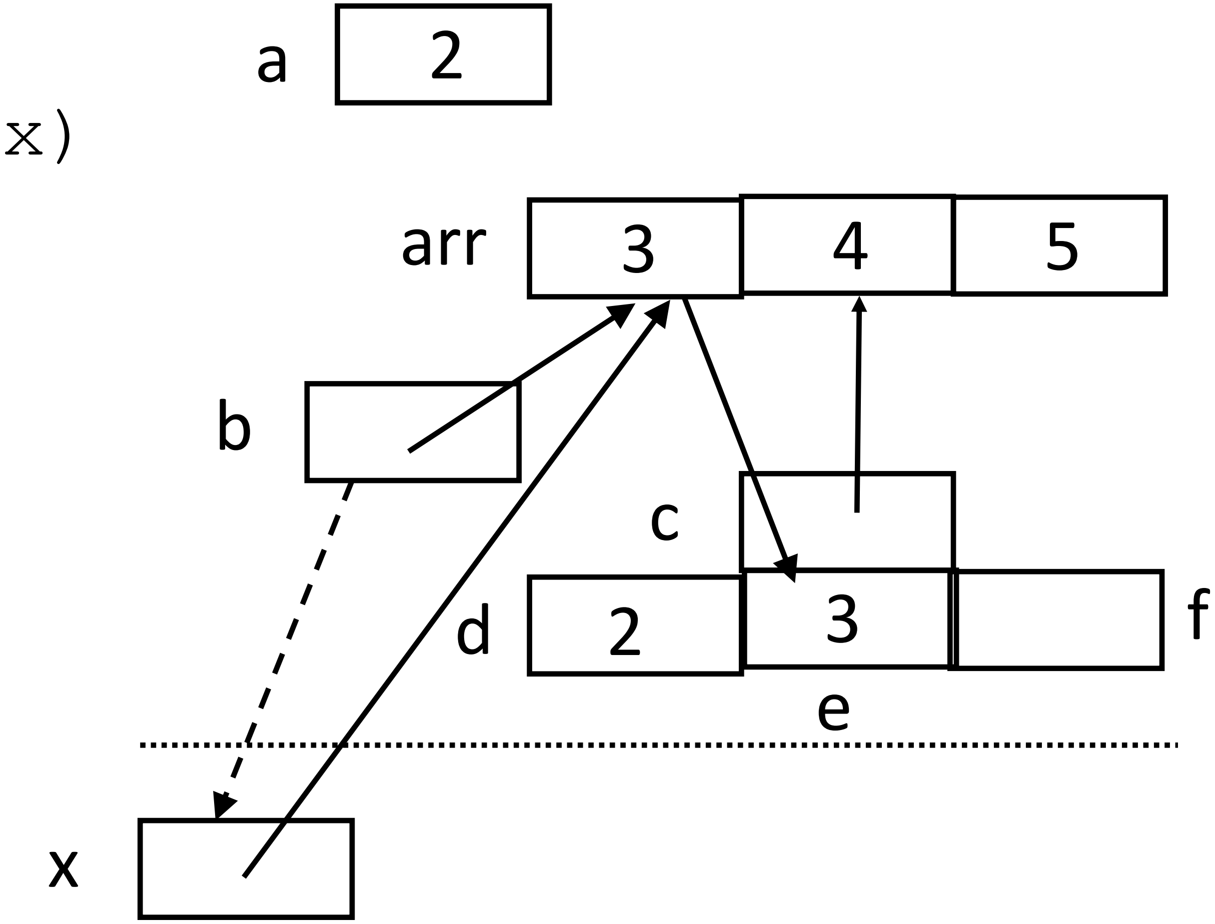
Midterm Question 9

```
int p1testandinc(int *x)
{
        return(*x++);
}


. . .


e = p1testandinc(b)
```



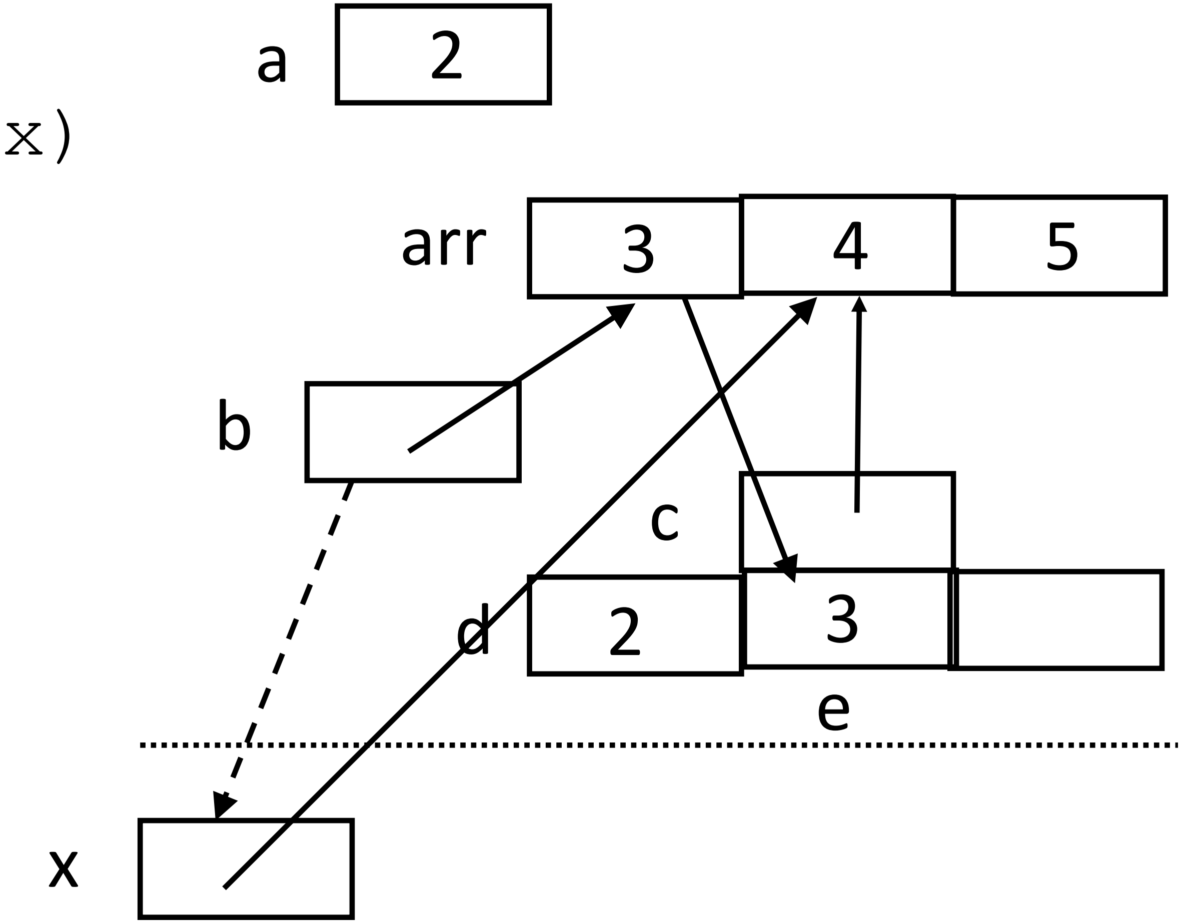
Midterm Question 9

```
int p1testandinc(int *x)
{
      return(*x++);
}


.  .  .


e = p1testandinc(b)
```



Midterm Question 9

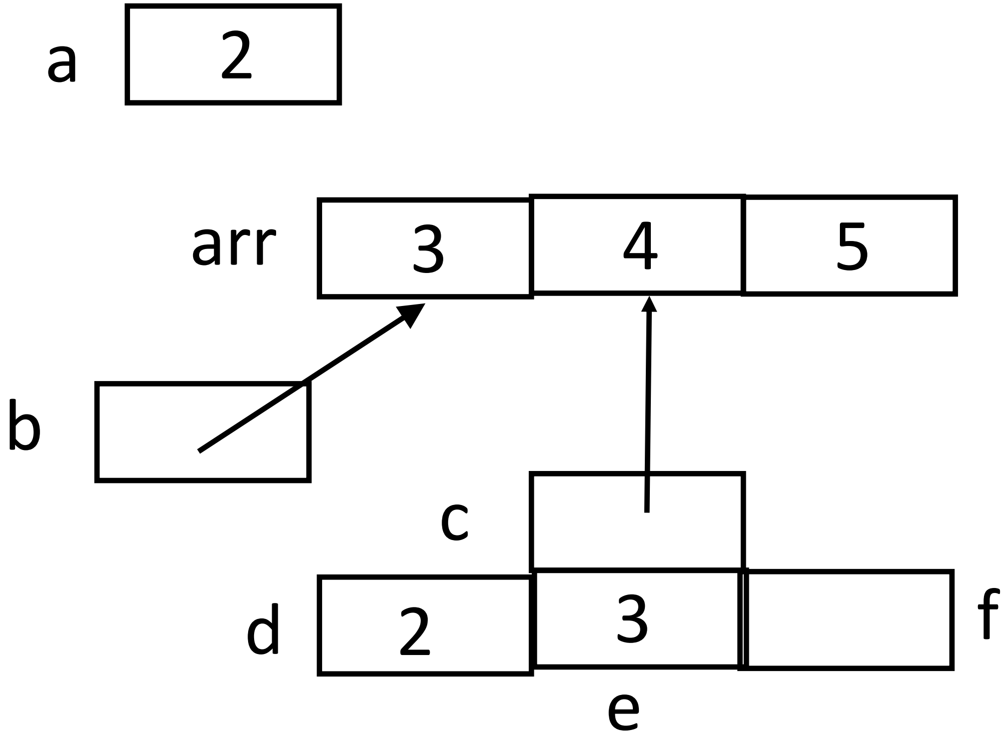
```
int p1testandinc(int *x)
{
        return(*x++);
}


. . .


e = p1testandinc(b)
```



Midterm Question 9

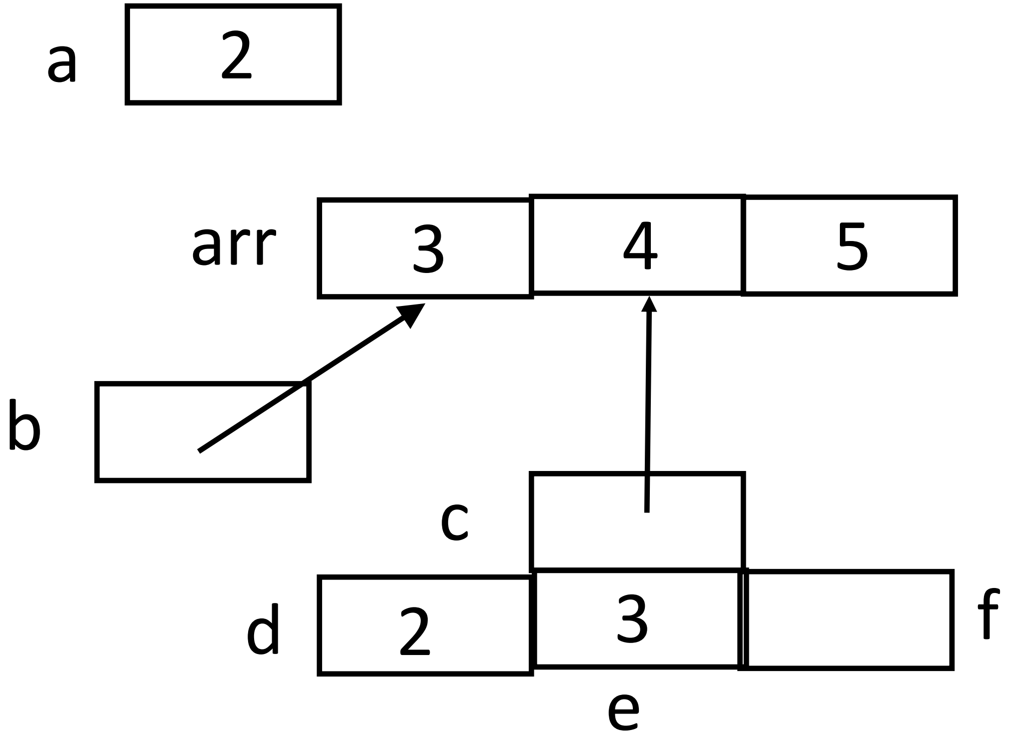
```
int p1testandinc(int *x)
{
        return(*x++);
}
. . .
e = p1testandinc(b)
```

Function ends



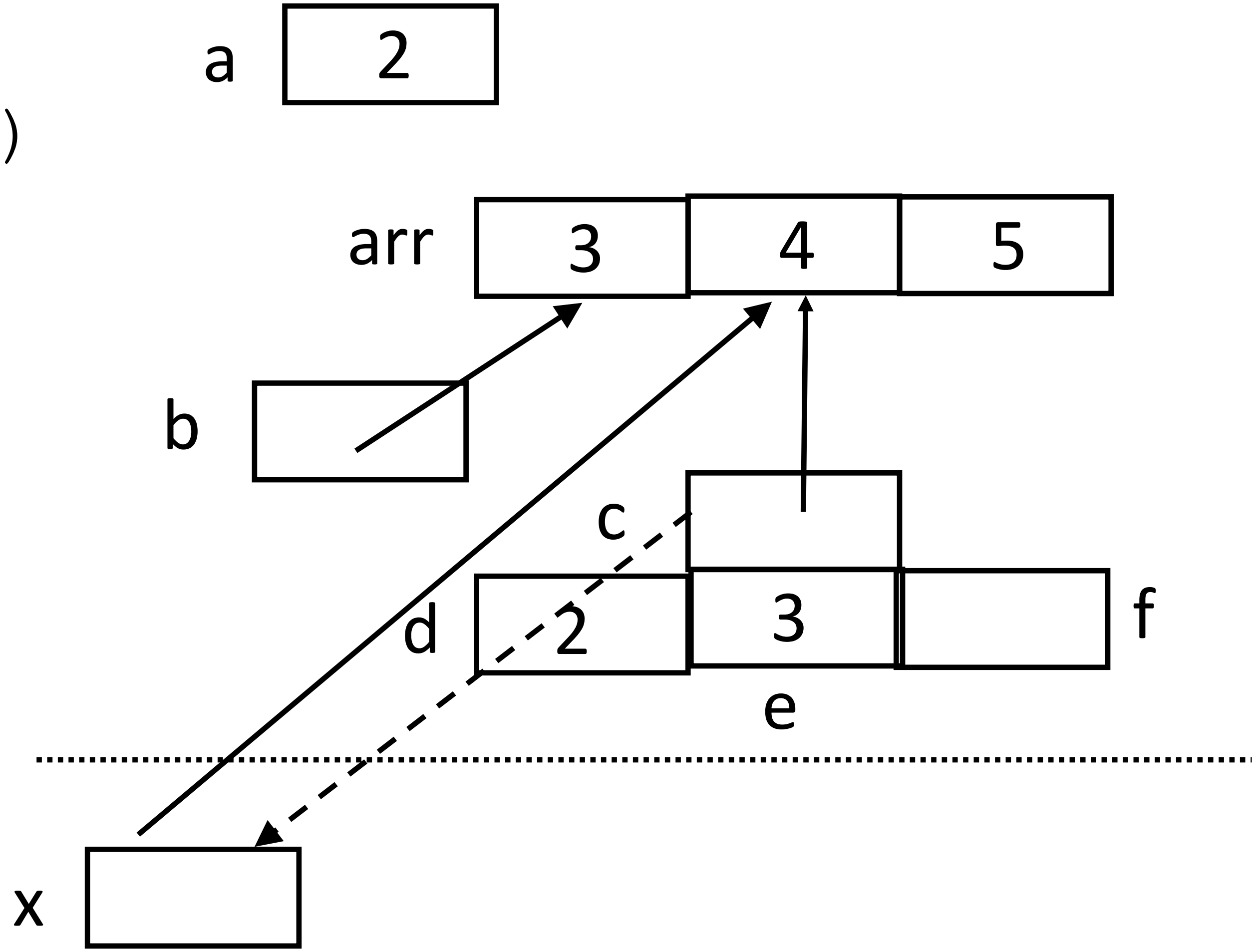
Midterm Question 9

```
int p2testandinc(int *x)
{
    return((*x)++);
}


. . .


f = p2testandinc(c)
```



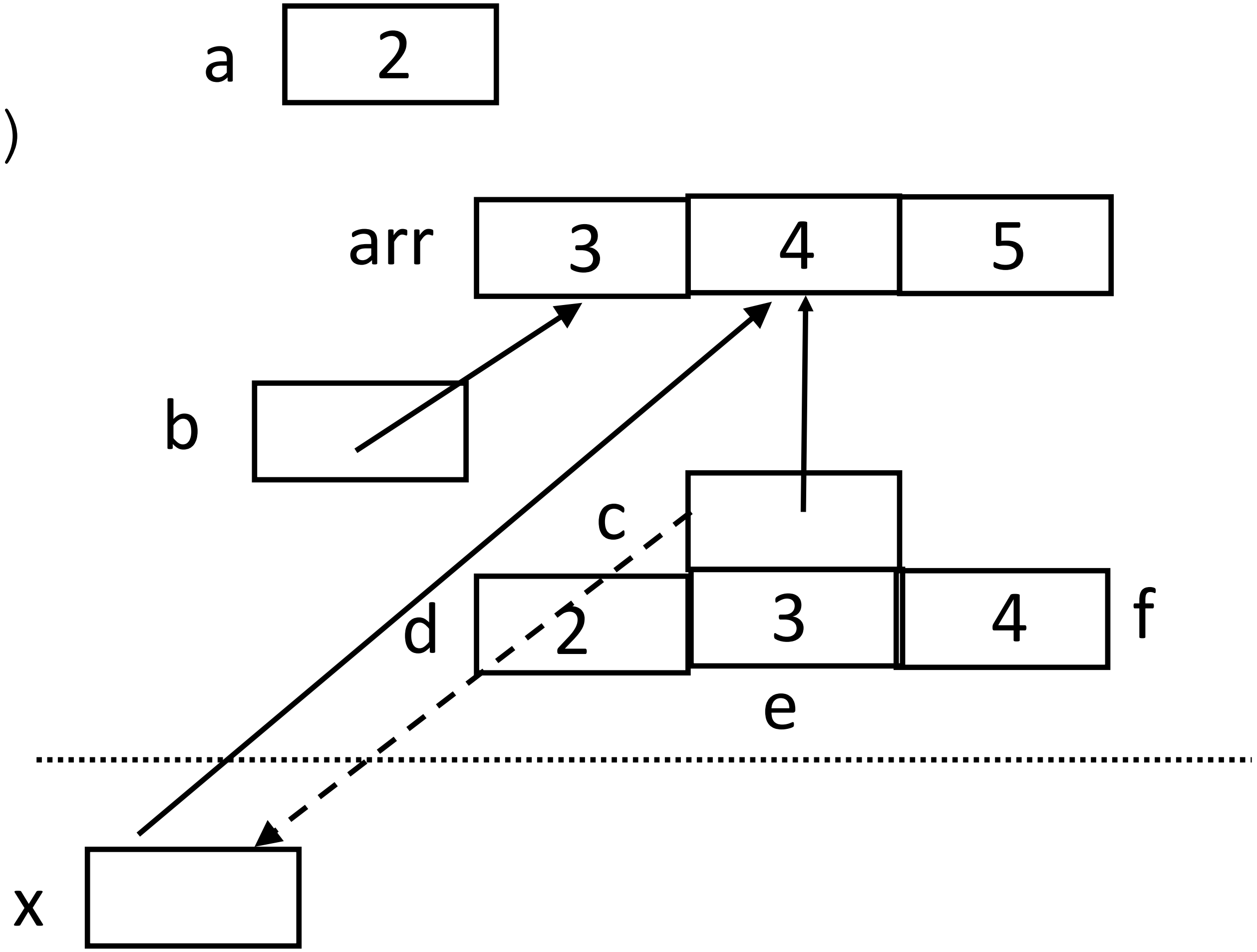
Midterm Question 9

```
int p2testandinc(int *x)
{
        return((*x)++);
}


. . .


f = p2testandinc(c)
```



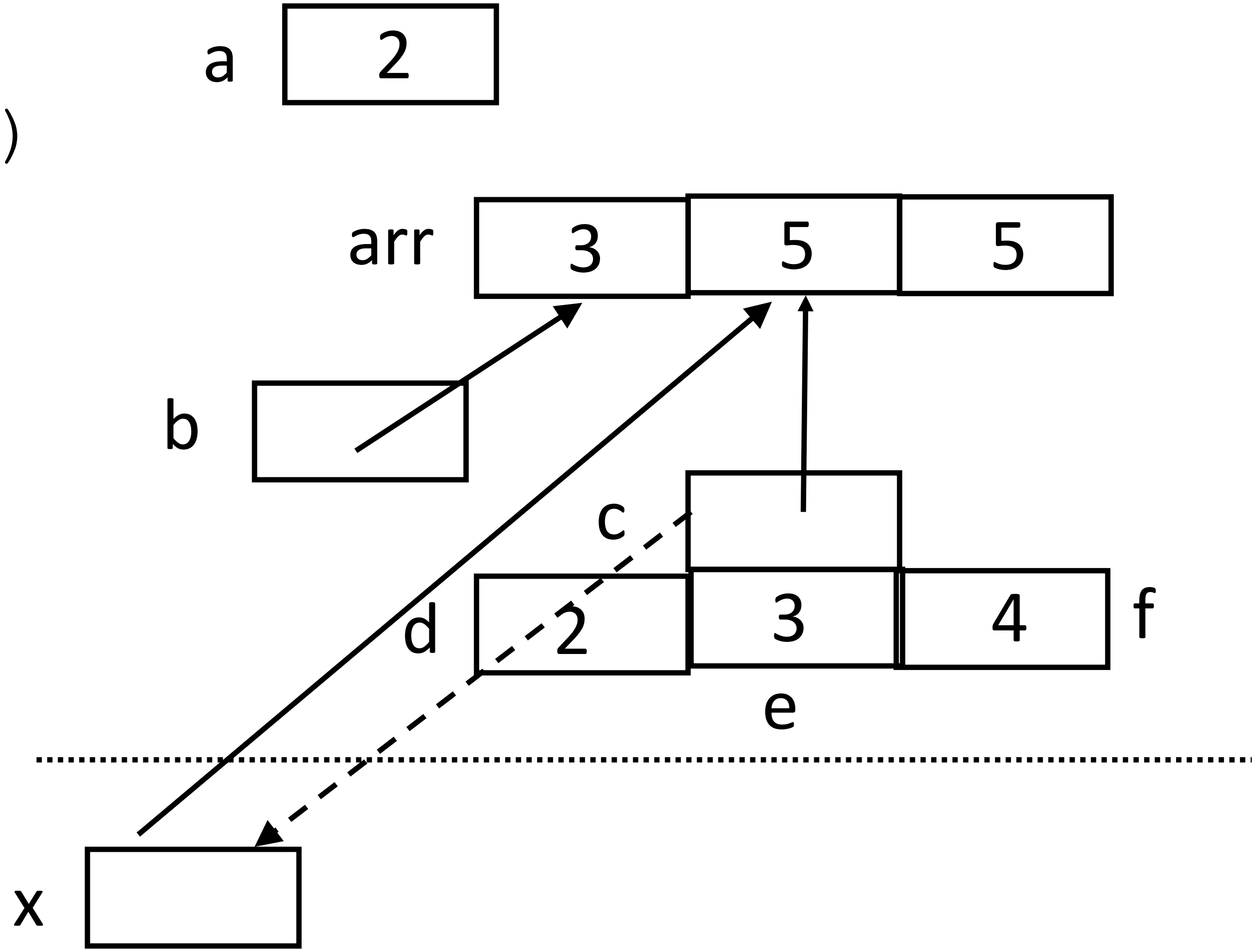
Midterm Question 9

```
int p2testandinc(int *x)
{
        return((*x)++);
}

. . .

f = p2testandinc(c)
```



Midterm Question 9

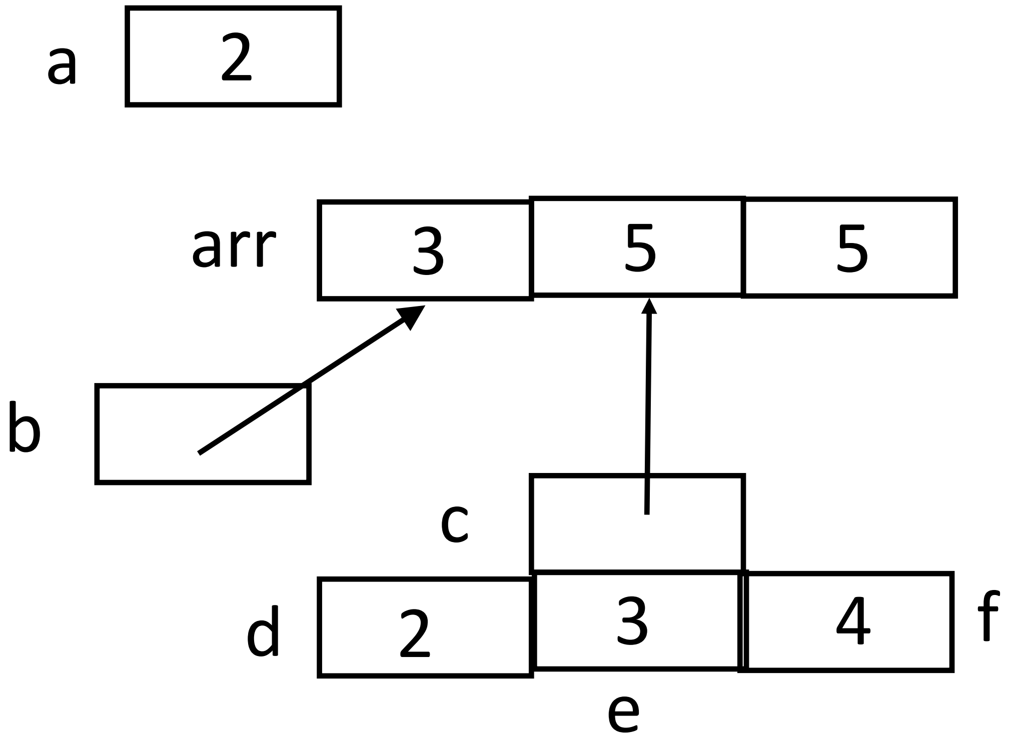
```
int p2testandinc(int *x)
{
    return((*x)++);
}


. . .


f = p2testandinc(c)
```



Midterm Question 9

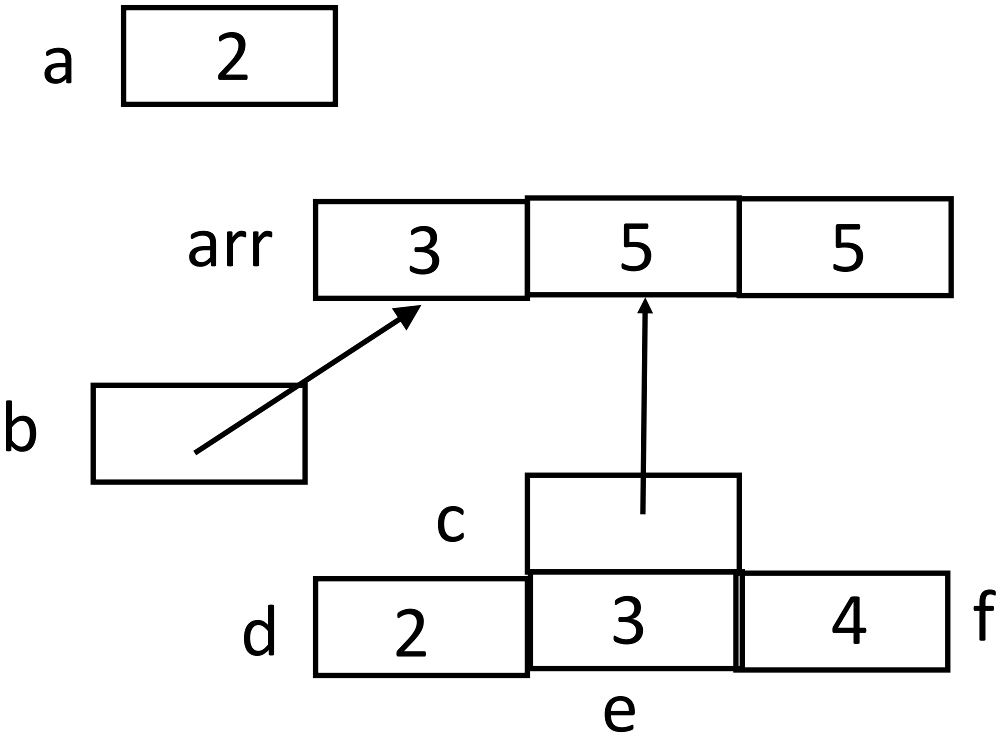
```
int p2testandinc(int *x)
{
    return((*x)++);
}
. . .
f = p2testandinc(c)
```

Function ends



Midterm Question 9 Answers

variable	value
`a`	`2`
`b`	`arr` *or* `&arr[0]`
`c`	`arr+1` *or* `&arr[1]`
`d`	`2`
`e`	`3`
`f`	`4`
`arr[0]`	`3`
`arr[1]`	`5`
`arr[2]`	`5`



Rules for Pointers

- Treat a pointer like a constant or a variable
  - If it's used as an array name, assume it's a constant
  - Otherwise, assume it's a variable
  - Note: in a function parameter list, it's a variable, even if declared as an array
- A pointer p is an *address*
  - *p is the *value* stored at the address in p
  - &x is the address of the variable x
  - You can't take the address of a constant, so this is illegal: char c[10]; d = &c;
- Draw pictures! They are very helpful

More C Library Functions

- time
- (pseudo)random numbers
- string functions
- memory functions
- math functions

Get Time

- Use system call time_t time(time_t **tick*)
  - If *tick* is NULL, then the current time is returned
  - Time measured in seconds from the epoch (Jan 1, 1970, 00:00:00)
- To get time as a string: char *ctime(&*tick*)
  - On success, generates a string of the following form:

    Sun Sep 16 01:03:52 1973

    (This has a trailing nnewline)
  - On failure, it returns NULL

Time Structure

```
struct tm {
        int tm_sec;         /* 0-59 seconds */
        int tm_min;         /* 0-59 minutes */
        int tm_hour;        /* 0-23 hour */
        int tm_mday;        /* 1-31 day of month */
        int tm_mon;         /* 0-11 month */
        int tm_year;        /* 0- year - 1900 */
        int tm_wday;        /* 0-6 day of week (Sunday = 0) */
        int tm_yday;        /* 0-365 day of year */
        int tm_isdst;       /* flag: daylight savings time in effect */
        long tm_gmtoff;     /* offset from GMT in seconds */
        char **tm_zone;     /* abbreviation of timezone name */
};
```

Getting Structure Values for Time

- struct tm *localtime(const time_t **timep*): fills in local time
- struct tm *gmtime(const time_t **timep*): fills in GMT (UTC) time
  - Here *timep* is a pointer to what *time* returns
- char *asctime(struct tm **tm*): return a ctime-type string for *tm*
- time_t mktime(struct tm *tm): return time since the epoch given by *tm*

Random Numbers

- int rand(void)
  - Generate pseudorandom number between 0 and RAND_MAX inclusive
  - **This function is dangerous — avoid it!!** In older versions, it is *not* pseudorandom in the low order bits. (On newer Linux systems, it's OK)
- long random(void)
  - Generate pseudorandom number between 0 and 2^{31}–1 inclusive
- All require a starting point – called a *seed*

Random Number Seeds

- void srand(unsigned int seed)
  - Initialize the *rand*() pseudorandom number generator with *seed*
- void srandom(unsigned int seed)
  - Initialize the *random*() pseudorandom number generator with *seed*
- Pick *seed* as randomly as possible
- There are defaults, useful for regenerating the same sequence for debugging
  - rand/srand default seed is 1
  - random/srandom default seed is 1

String Functions

- strcpy, strcat, strcmp, strncpy, strncat, strncmp, strlen
  - You’ve seen these
- char *strdup(char *s): make a duplicate of string s
  - Space is malloc’ed
- char *strchr(char *s, int c): return pointer to first occurrence of character c in s; NULL if not there
- char *strrchr(char *s, int c): like strchr, but points to last occurrence
- char *strstr(char *s, char *t): like strchr, but looks for first occurrence of string *t*

String Functions

- char *strtok(char *s, char *delim): breaks a string into a sequence of 0 or more nonempty tokens (substrings)
    - On first call, s points to string to be parsed
    - On subsequent calls for the same string, set s to NULL
    - delim is a string of characters that delimit tokens
    - strtok returns NULL when there are no more tokens to return
    - strtok *always* returns a nonempty token
    - Warning: strtok overwrites delimiters with ‘\0’, so don’t give it a read-only string
- int strcasecmp(char *a, char *b): useful for homework; look it up

Memory Functions

- void *memcpy(void *dest, void *src, unsigned int n): copy n bytes from src to dest
    - Behavior undefined if src, dest overlap
- int memcmp(void *s1, void *s2, unsigned int n): compare first n bytes of s1 and s2; returns negstive, zero, positive depending on whether s1 is less than, equal to, greater than s2

Math Functions

- double floor(double d), double ceil(double d): round d down, up to the nearest integer
- double log(double d), double log10(double d): return the natural log, base 10 log of d
- double exp(double d), double pow(double m, double e): return e^{d}, m^{e}
- double sin(double d): compute sine of *d* in radians
  - same with cos, tan
- double atan(double x): return principal value of arctan of d
  - In range [–π/2, +π/2)
- double atan2(double x, double y): return arctan of y/x
  - Handles cases where x is 0; returns value in range [-π, π]