COMP10002 Workshop Week 8

It’s about Assignment 1

	ASS1: **Progress?** Marking rubric – some specific topics? Q&A?
	? • string searching, KMP & BMH • do 7.16 • Q&A on ASS1 &other exercises ? • ASS1 • Q&A
LAB	Finish ass1 during this workshop or today! Submissions close at **6pm this Friday**. Done ass1? Implement 7.16, then exercises from lec06
LMS	**Workshops**: • ***Your most important goal this week is to complete Assignment 1.*** • Submission is **via the LMS Assignment 1** page, and **not** by grok

Your assignment1:

A- All done

B- only stages 1+2 fully done

C- only stage 1 fully done

D- none of the above

String Searching

Input:

A (normally long) text `T[0..n−1]`. Example: `T= “SHE SELLS SEA SHELLS`”, with n=20

A (normally short) text pattern `P[0..m−1]`. Example: `P=“HELL`”, `m=4`.

Output:

index `i` such that `T[i..i+m−1]=P[0..m−1`], or NOTFOUND

Algorithms:

- Naïve: brute force, complexity `O(nm)`

  max number of character comparisons = `(n−m+1)*m`

  Note: `strcmp` also compares strings character-by-character
- BMH: also `O(mn)` but practically fast `m<<n`
- KMP: `2n+m` iteration max → `O(n+m)`

String matching: the task

Input:

- a text `T[]` such as “`abab yxy aababcb`”
- a pattern `P[]` such as “`ababc`”

Ouput

- first position where P appears in T, or NOTFOUND

Output for the example:

- 10
- how many (pattern) shifts?
- how many comparisons?)

String matching: KMP & BMH

Both algorithms:

- start with aligning P with the start of T
- repeatedly shift P to the right as far as possible by comparing P with T character-by-character

a	b	a	b	y	a	y	b		a	a	b	a	b	c	a
a	b	a	b	c											

- *The number of positions to shift totally depends on P and hence is pre-computed at the start (with complexity O(m))*

But

- KMP compare pattern (with text) from *left to right*, why?
- BMH compare pattern (with text) from *right to left*, why?

String matching: KMP & BMH

- KMP compare pattern (with text) from left to right, why?

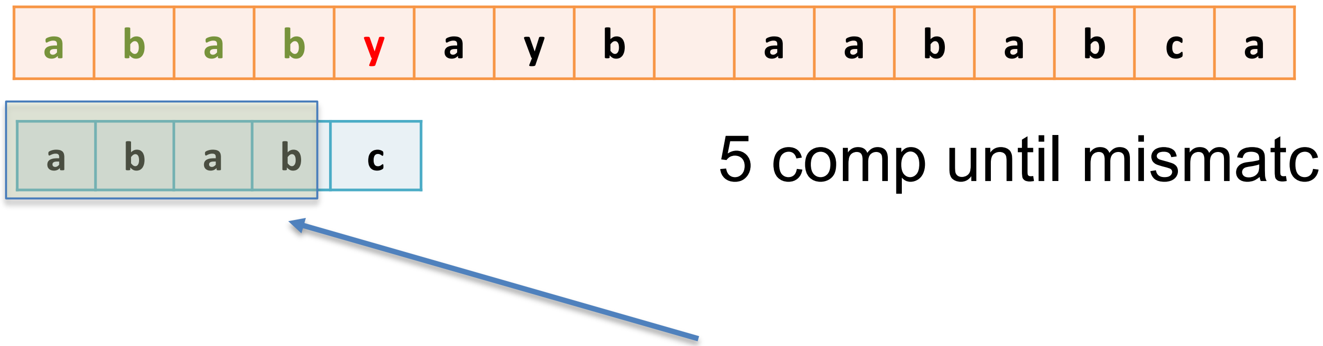
  because the letters K,M,P are in alphabetic order 😀

- BMH compare pattern (with text) from right to left, why?

  but the letters B,M,H are not 😀

How to run KMP *manually*

Compare T with P from left to right

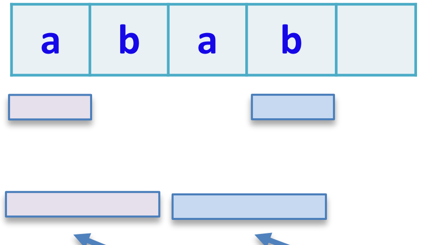


a	b	a	b	y	a	y	b		a	a	b	a	b	c	a

a	b	a	b	c

5 comp until mismatch;

When mismatch, examine **only** the *matched part* of P to decide the shift:



a	b	a	b	

prefix “a”, suffix “b”: not matched
prefix “ab”, suffix “ab”: matched, length= 2

and shift P to the right s positions where so that:

s= length of the largest matching between *prefix* and *suffix*
(can be pre-computed just using the pattern)

How to run KMP *manually*

a	b	a	b	y	a	y	b		a	a	b	a	b	c	a

a	b	a	b	c

max: prefix ”ab” matches suffix “ab”

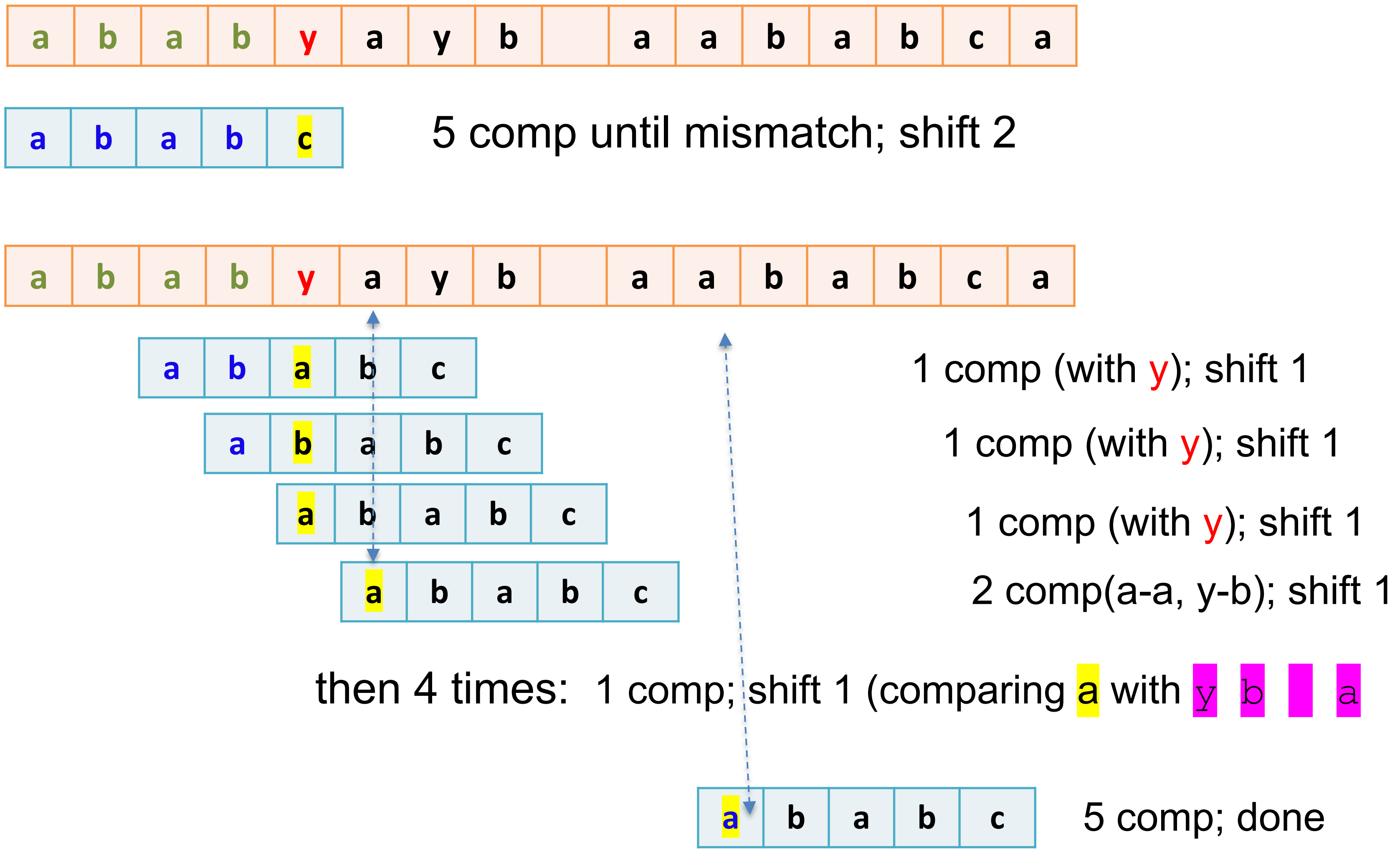
shift P for that prefix-suffix match (shift 2)
Then repeat the process from the *mismatched position* in **T** ie. from the first y,
ie. from comparing **y** with **a** here

a	b	a	b	y	a	y	b		a	a	b	a	b	c	a
		a	b	a	b	c									

(here, shift 1 because no prefix-suffix matcth in “ab”)

Note: if the matched part of P <= 1 char, or has no prefix-suffix match, just shift P by 1 position

How to run KMP *manually*



a	b	a	b	y	a	y	b		a	a	b	a	b	c	a

a	b	a	b	c

5 comp until mismatch; shift 2

a	b	a	b	y	a	y	b		a	a	b	a	b	c	a

a	b	a	b	c

1 comp (with y); shift 1

a	b	a	b	c

1 comp (with y); shift 1

a	b	a	b	c

1 comp (with y); shift 1

a	b	a	b	c

2 comp(a-a, y-b); shift 1

then 4 times: 1 comp; shift 1 (comparing a with y b   a

a	b	a	b	c

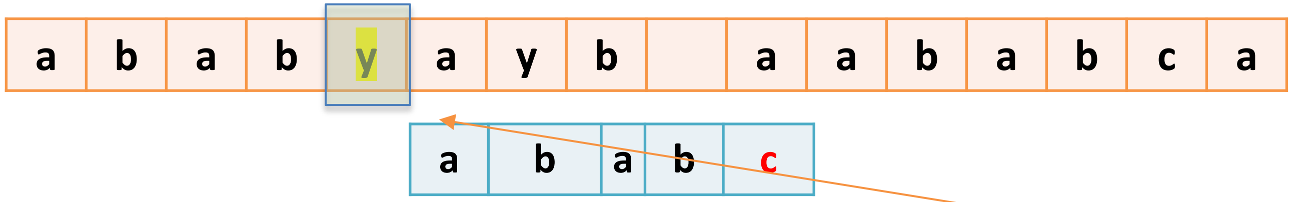
5 comp; done

Understand the BMH algorithm

```
First align the pattern P with the text T.

Loop:
      Start from the right end of the pattern, and work to the left, comparing P[i] with the corresponding
      character in T
      if  mismatched:
          shift pattern P to the right [ how many positions?]
      else
          FOUND

return NOTFOUND
```



a	b	a	b	y	a	y	b		a	a	b	a	b	c	a

a	b	a	b	c

SHIFT m=5 because
y not in P

- The shifts depends on the rightmost-examined T, here y
- Shift pattern P to the right at least 1 position and until that y matches with a character in P (here: shift 5 because no match is possible)

How to run BMH *manually*

a	b	a	b	y	a	y	b		a	a	b	a	b	c	a
a	b	a	b	c											

SHIFT m=5
because y not in P

1 comp until mismatch
no matter where mismatch happens, the shift is totally decided by the rightmost examined char of T y

Shift until having the first match of character on P with that rightmost y
(here, no match found)

a	b	a	b	y	a	y	b		a	a	b	a	b	c	a
					a	b	a	b	c						

1 comp, SHIFT 2 = distance from last a to

a	b	a	b	y	a	y	b		a	a	b	a	b	c	a
							a	b	a	b	c				
								a	b	a	b	c			
										a	b	a	b	c	

BMH Algorithm Review

The task: Seaching for a pattern `P` (such as “HELL” that has length m=5) in a text `T` (such as “SHE SELLS SEA SHELLS”, having length n=20).

The Algorithm:

need to do a pre-processing of the pattern before performing the search

normally, $|P| \ll |T|$, this step doesn’t affect the overall complexity

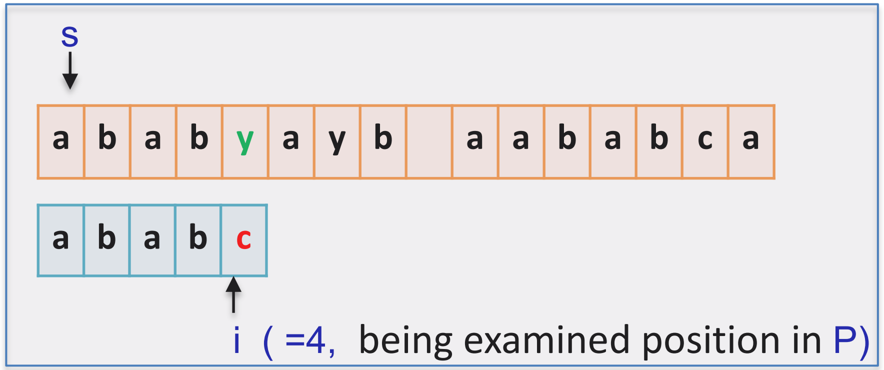
BMH: pre-processing

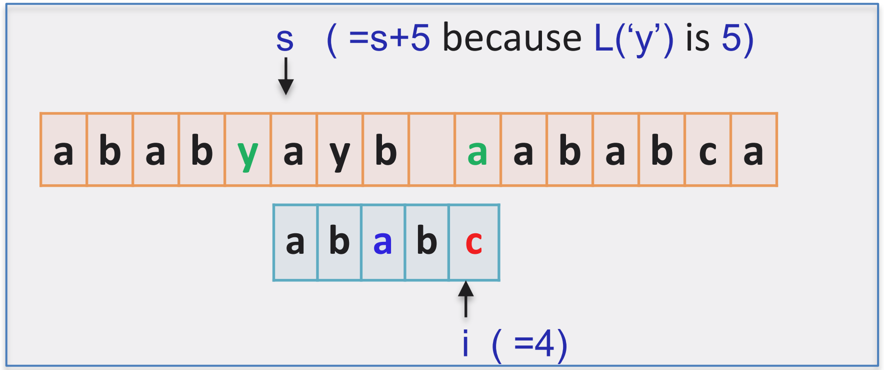
***Pre-processing**:* build `L[x]` for every possible character `x`, ie. for all x from the alphabet (in the lecture, the alphabet has σ symbols), by:

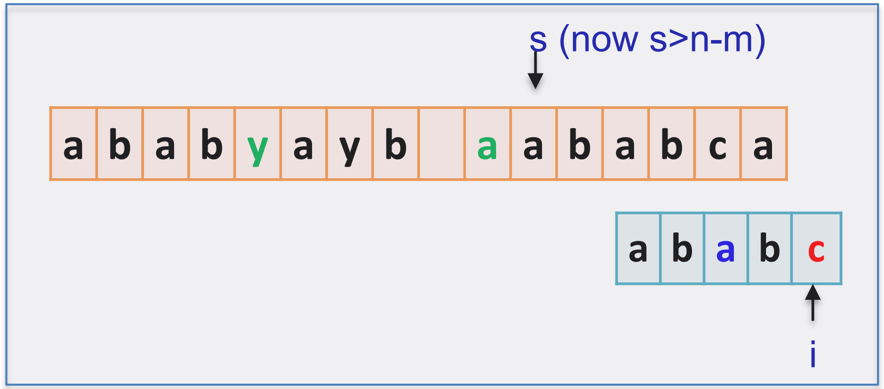
1. first, set `L[x]= m` for all `x`, then
2. for each character `x` in `P`, *except for the last one*: `L(x)` = distance from the last appearance of `x` to the end of `P`

```
for $v \leftarrow 0$ to $\sigma - 1$
    $L[v] \leftarrow m$
for $i \leftarrow 0$ to $m - 2$
    $L[P[i]] = m - i - 1$
```

BMH - searching


s
a b a b y a y b a a b a b c a
a b a b c
i (=4, being examined position in P)





```
s=0;        // current start of P in T
i= m-1;     // current position in P
c= T[s+m-1];  // the pilot character

while (s+i not passing the end of T){
  if (mismatched at P[i]) {
    s = s + L[c];
    i = m-1;
    c= T[s+m-1];
  } else {
    if (i==0)
      return s;
    else
      i--;
  }
}
return NOTFOUND;
```

```
$s, i \leftarrow 0, m - 1$
while $s \leq n - m$
    if $T[s+i] \neq P[i]$
        $s, i \leftarrow s + L[T[s+m-1]], m - 1$
    else if $i = 0$
        return $s$
    else
        $i \leftarrow i - 1$
return $not\_found$
```

Assignment 1 or 7.16 + exercises from lec06.pdf

7.12 (palindrome),
7.14 (atoi),
7.15 (anagram, similar to Exercise 3)
7.16 (word frequencies)

7.03: sorts the array then removes duplicates
7.08: k'th smallest in array
7.x2: Count distinct values
7.x3: Longest ascending run

Exercise 1 Write a function `is_subsequence(char *s1, char *s2)` that returns 1 if the characters in `s1` appear within `s2` in the same order as they appear in `s1`. For example, `is_subsequence("bee", "abbreviate")` should be 1, whereas `is_subsequence("bee", "acerbate")` should be 0.

Exercise 2 Ditto arguments, but determining whether every occurrence of a character in `s1` also appears in `s2`, and 0 otherwise. For example, ", `is_subset("bee "rebel")` should be 1, whereas `is_subset("bee", "brake")` should be 0.

Exercise 3 Write a function `is_anagram(char *s1, char *s2`) that returns 1 if the two strings contain the same letters, possibly in a different order, and 0 otherwise, ignoring whitespace characters, and ignoring case. For example, `is_anagram("Algorithms", "Glamor Hits")` should return 1.

Exercise 4 Write a function `next_perm(char *s)` that rearranges the characters in a string argument and generates the lexicographically next permutation of the same letters. For example, if the string `s` is initially `"51432"`, then when the function returns s should be `"52134”`.

Exercise 5 If the two strings are of length `n` (and, if there are two, `m`), what is the asymptotic performance of your answers to Exercises 1–4?

Additional Slides

Ass1: Q&A make sure that you understand the tasks

Carefully read the spec and the marking rubric

Read the Discussion Forum and:

- *answer if you are confident,*
- *post **new** questions if needed*

Ass1: Maximize Your Mark

Check your code against the marking rubric

Examine the 2020 sample solution: you still can learn something from here even if you don’t understand the task and the code.

Questions on marking rubric?

Section E: Academic Honesty

missing Authorship Declaration at top of program, -5.0;

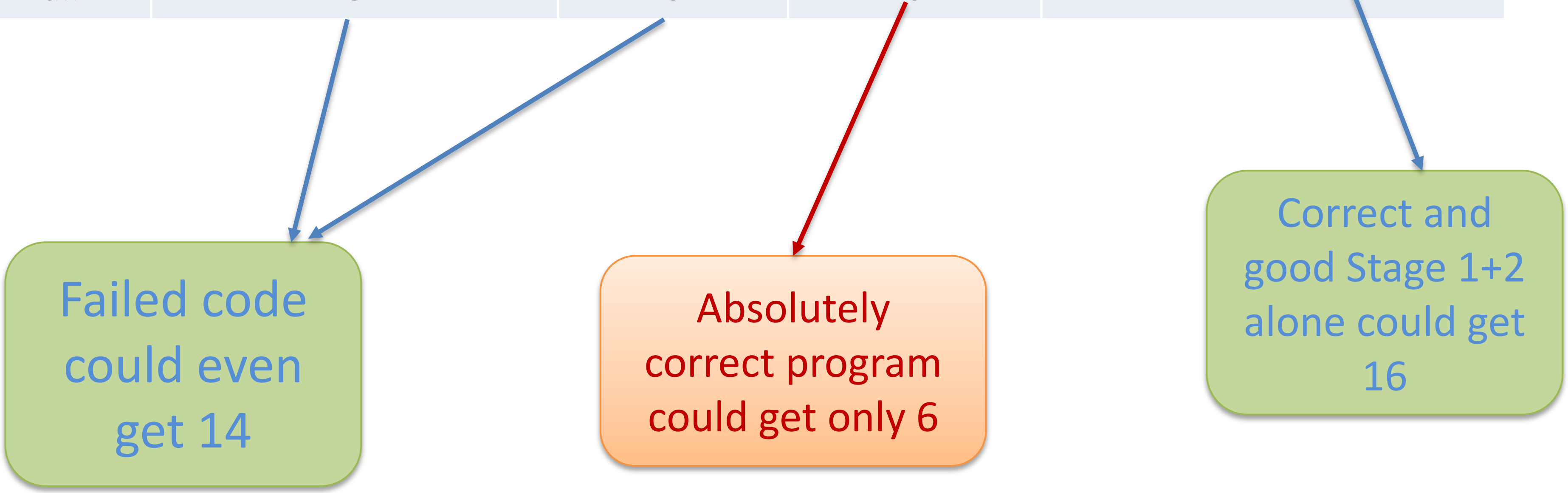
significant overlap detected with another student's submission, -10.0;

use of external code without attribution (minor), -2.0;

use of external code without attribution (major), -10.0;

Marking Rubric: The importance of Style & Structure

Stage	Presentation	Structure	Execution	max accumulated mark
1	+6	+4	+2	12
2	+1	+1	+2	16
3	+1	+1	+2	20
all	8	6	6	



Failed code could even get 14

Absolutely correct program could get only 6

Correct and good Stage 1+2 alone could get 16

ASS1 Marking Rubric: a few keys in Presentation

- use of magic numbers, -0.5;
- #defines not in upper case, -0.5;
- bad choices for variable names, -0.5;
- bad choice for function names, -0.5;

use #define for meaningful constants
#define-ed names should be in upper case
variable names in lower case (except single-letter array name)
variable names should be expressive

- absence of function prototypes, -0.5;

add function prototypes before main()
no function implementation before main()!

- inconsistent bracket placement, -0.5;
- inconsistent indentation, -0.5;

you can use sample programs in lectures as the model

- excessive commenting, -0.5;
- insufficient commenting, -0.5;

each function header should have a comment
add comments for non-trivial code segment

•lack of whitespace (visual appeal), -0.5;
•lines >80 chars, -0.5;

•other issue: minor -0.5, major -1.0

•comment at end that says "algorithms are fun", +0.5;
•overall care and presentation, +0.5;

DO IT !
Easy way to get back 0.5 or 1 mark

ASS1 Marking Rubric: a few keys in Structure

- global variables, -0.5;

Global variables are NOT allowed!

- main program too long or too complex, -0.5;
- functions too long or too complex, -0.5;
- overly complex function argument lists, -0.5;

- function should not be long
- and should not have too many arguments

- insufficient use of functions, -0.5;
- duplicate code segments, -0.5;

- when having a few line, or a complicated line similarly-duplicated, think about creating a new function!

- overly complex algorithmic approach, -1.0;

- avoid too many levels of nesting `if and` loops
- don't make the marker wonder too much to understand your code!

- unnecessary duplication/copying of data, -0.5;

- For example, think carefully before you copy an array!

- other structural issue: minor -0.5, major -1.0;

overly complex algorithmic approach, -1.0;

Examples of overly complicated:

sort the data when not actually required

too many levels of nested loops/if

duplicate code segments: turn similar segments into a function

having 2 or more lines similar? Think if you should form a new function.

ASS1 Marking Rubric: a few keys in Execution

failure to compile, -6.0;

unnecessary **warning messages** in compilation, -2.0;

Your program might be compiled OK in your computer, without any warning.
But it might have compiler errors or warnings on the testing machine.
→ carefully check with grok, and check again when submitting

incorrect Stage X layout or values in any test, -0.5 ;

different Stage X layout or values in any test, -0.5 ;

X can be: 1, 2, 3a, 3b

Again, check the verification report!
When testing compare your outputs with expected outputs using command `diff`:

```
./ass1 alice feet < data1.txt > out1.txt
diff out1.txt data1-S1-out.txt
```

Desirable outcome: EMPTY output from command `diff`.
If you have non-empty output:
+ The lines starting with < is from the first file of the `diff`
+ The lines starting with > is from the second file
+ You can just do the testing submit to see the diff

Assignment 1: testing

TESTING IN YOUR COMPUTER

Using redirection when running/testing your program:

```
./myass1 < test0.txt > test0-myout.txt
```

Your program’s output must be the same as the expected, ie. the command

```
diff test0-myout.txt test0-out.txt
```

must give empty output (that is, no difference).

Remember that your code might work well on the 4 supplied data sets, but fail on some other…

A better check in your computer, that not only test for correctness, but also for compilation warnings:

- *copy* `Makefile` *from grok to your directory*
- *run “*`make`*” for compiling*
- *run “*`make test0`*”, “*`make test1,` *“*`make test2`*”, “*`make test3`*” to run the tests*

or you can copy your code to grok and do the testing there.

Compiler warnings: -2.0

If you don't use make (why not?), you should test for compilation warning with (command copied from Makefile):

```
clang -Wall -Wextra -Werror -Wno-newline-eof -Wno-unused-parameter -pedantic
-std=c99 -ferror-limit=1 -o myass1 myass1.c
```

and the above command must give no warning messages at all!

Assignment 1 testing: seems OK even before the submission

```
bash$ ./myass1 < test0.txt > test0-myout.txt
bash$ diff test0-myout.txt test0-out.txt
bash$
```

must give empty output (that is, no difference).

Understand the output from the above `diff`*,*

```
bash$ diff test2-myout.txt test2-out.txt
5d4
< operation not available yet
7c6
< register b: 123,456,789
---
> register b: 2,592,592,569
9d7
```

line starting with < is from the left file (ie. our output)
here: our line is not identical to the expected

line starting with > is from the right file (ie. expected output)
here: we missed 1 blank line in our output

Ex 7.16 and others

Combine Alistair’s `getword.c` and `words.c` into one `.c` file, then change it to meet the requirement of Ex 7.16.

Case Study & Ex 7.16 – The Task

Use the program of Figures 7.13 and 7.14 of the textbook (`words.c` and `getword.c` on Page 4 of lec06.pdf).

Design and implement a program that reads text from `stdin`, and writes a list of the distinct words that appear, together with their frequencies.

First step:

Make sure you understand the task, that you can imagine what's the input and output.

Case Study & Ex 7.16 – Understanding The Task

Design and implement a program that reads text from stdin, and writes a list of the distinct words that appear, together with their frequencies.

Sample texts:

```
A cat in a hat!
+-abc 10e12 e 1abc #e#abc.abcdefghijklm=xyz
```

Input = ?

- How to get the input text?

Output= ?

- How to store output, which data structure?
- And how to produce output?

Assumptions/limits:

- What's a *word*?
- Other assumptions?

Case Study & Ex 7.16 – Alistair’s getword

```
int getword(char W[], int limit) {
  int c, len=0;
  /* first, skip over any non alphabetics */
  while ((c=getchar()) != EOF && !isalpha(c)) {
      /* 12+34 aWord ?-? is the first word */
  }
  if (c==EOF)  return EOF;

  /* ok, first character of next word has been found */
  W[len++] = c;
  while (len<limit && (c=getchar())!=EOF && isalpha(c)) {
    /* 12+34 aWord ?-? is the first word */
    W[len++] = c;
  }

  /* now close off the string */
  W[len] = '\0` ;   // W is the string aWord
  return 0;
}
```

Alistair’s words.c

```
#define MAXCHARS 10
  /* Max chars per word */
#define MAXWORDS 1000
  /* Max distinct words */


typedef char word_t
            [MAXCHARS+1];
  /* word_t word; now is
     equivalent to
  char word [MAXCHARS+1];
  */

int getword(word_t W,
            int limit);

#include "getword.c"


int
main(int argc,
     char *argv[]) {
```

```
  word_t one_word, all_words[MAXWORDS];
  int numdistinct=0, totwords=0, i, found;

  while (getword(one_word, MAXCHARS) != EOF) {
    totwords = totwords+1;
    /* linear search in array of previous words...*/
    found = 0;
    for (i=0; i<numdistinct && !found; i++) {
      found = (strcmp(one_word, all_words[i]) == 0);
    }
    if (!found && numdistinct<MAXWORDS) {
       strcpy(all_words[numdistinct], one_word);
       numdistinct ++;
    }
    /* NB - program silently discards words after
       MAXWORDS distinct ones have been found */
  }

  printf("%d words read\n", totwords);
  for (i=0; i<numdistinct; i++) {
    printf("word #%d is \"%s\"\n", i, all_words[i]);
  }
  return 0;
}
```

Some small, esay, but important topics

typedef

argc, argv

Program arguments

Write a program sum that accept two numbers and print out their sum. Example of execution:

```
$ ./sum 12 5
12.00 + 5.00 = 17.00
```

```
?: int main(int argc, char *argv[])
```