一元多项式的加减运算

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1. 实验题目：

1.5⑤ 一元稀疏多项式计算器

【问题描述】

设计一个一元稀疏多项式简单计算器。

【基本要求】

一元稀疏多项式简单计算器的基本功能是：

(1) 输入并建立多项式；

(2) 输出多项式，输出形式为整数序列：$n,c_1,e_1,c_2,e_2,\ldots,c_n,e_n$，其中 n 是多项式的项数，c_i 和 e_i 分别是第 i 项的系数和指数，序列按指数降序排列；

(3) 多项式 a 和 b 相加，建立多项式 $a+b$；

(4) 多项式 a 和 b 相减，建立多项式 $a-b$。

【测试数据】

(1) $(2x+5x^8-3.1x^{11})+(7-5x^8+11x^9)=(-3.1x^{11}+11x^9+2x+7)$

(2) $(6x^{-3}-x+4.4x^2-1.2x^9)-(-6x^{-3}+5.4x^2-x^2+7.8x^{15})$
$=(-7.8x^{15}-1.2x^9+12x^{-3}-x)$

(3) $(1+x+x^2+x^3+x^4+x^5)+(-x^3-x^4)=(1+x+x^2+x^5)$

(4) $(x+x^3)+(-x-x^3)=0$

(5) $(x+x^{100})+(x^{100}+x^{200})=(x+2x^{100}+x^{200})$

(6) $(x+x^2+x^3)+0=x+x^2+x^3$

(7) 互换上述测试数据中的前后两个多项式

【实现提示】

用带表头结点的单链表存储多项式，多项式的项数存放在头结点。

【选作内容】

(1) 计算多项式在 x 处的值。

(2) 求多项式 a 的导函数 a'。

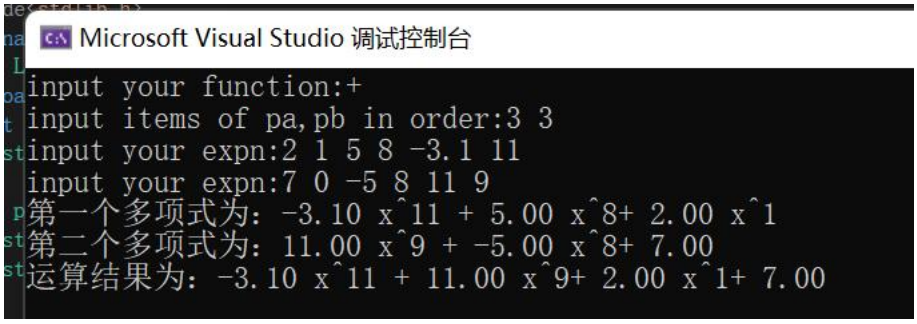
(3) 多项式 a 和 b 相乘，建立乘积多项式 ab。

(4) 多项式的输出形式为类数学表达式。例如，多项式 $-3x^8+6x^3-18$ 的输出形式为 $-3x\hat{}\ 8+6x\hat{}\ 3-18$，$x^{15}+(-8)x^7-14$ 的输出形式为 $x\hat{}\ 15-8x\hat{}\ 7-14$。注意，系数值为 1 的非零次项的输出形式中略去系数 1，如项 $1x^8$ 的输出形式为 x^8，项 $-1x^3$ 的输出形式为 $-x^3$。

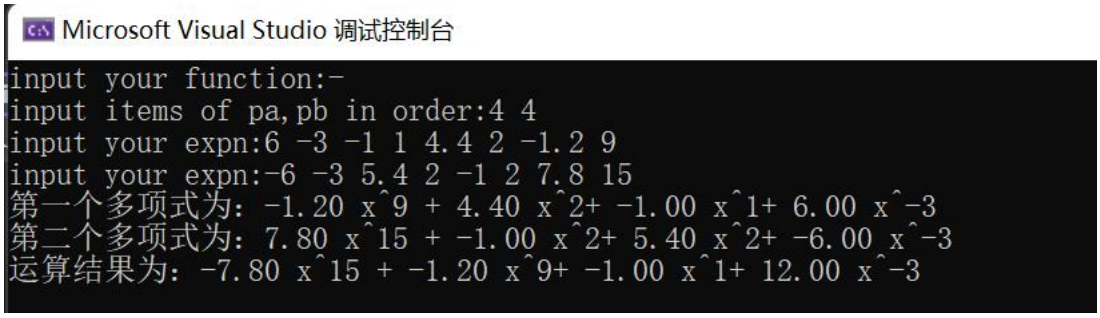
(5) 计算器的仿真界面。

2. 运行结果：

(1)

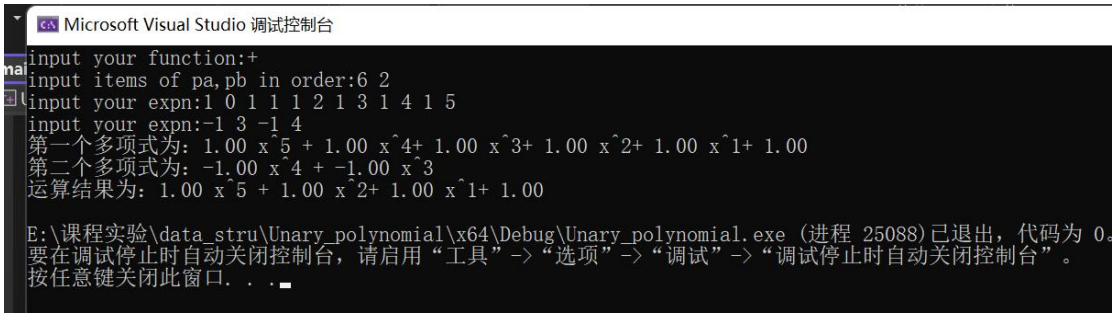


(2)

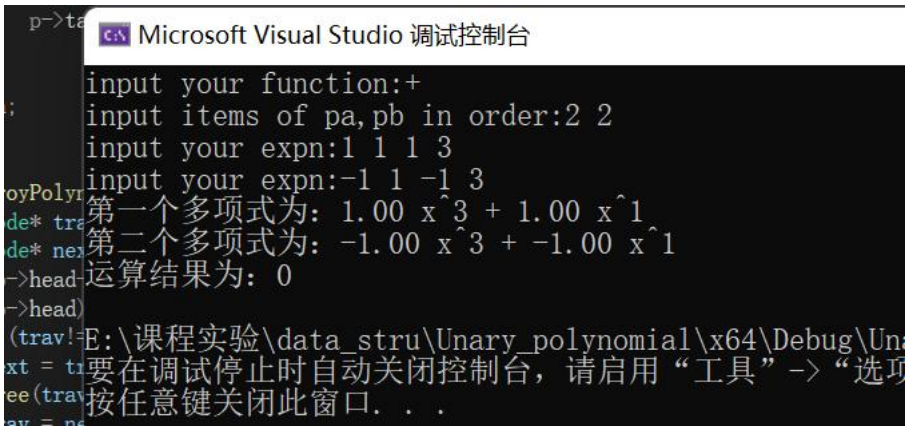


相等的时候只后移 pb 指针，pa 指针不动即可

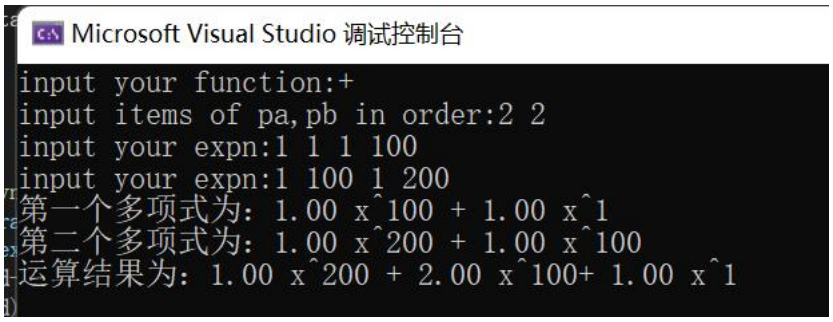
(3)



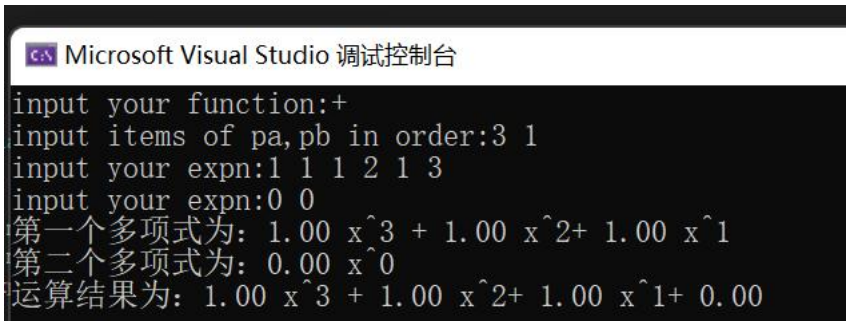
(4)



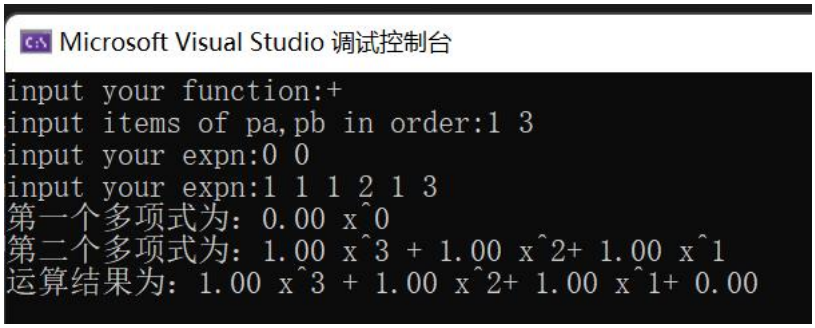
(5)



(6)



(7)



3. 代码分析：

ListNode 为多项式链表的结点，polynomial 为多项式;

```
#include<stdio.h>
#include<stdlib.h>
 using namespace std;
struct ListNode {
    float coef; //系数
    int expn;
    ListNode* next;
};
struct polynomial {
    ListNode* head;
    ListNode* tail;
};
```

根据输入项数从键盘读取输入为结点参数，并建立多项式链表，p 为链表指针:

```
13  void CreatePolyn(polynomial* p,int m) {
14      float coef;
15      int expn;
16      p->head = (ListNode*)malloc(sizeof(ListNode));
17      p->tail = (ListNode*)malloc(sizeof(ListNode));
18      printf("input your expn:");
19      if (m == 0) {
20          p->head->next = NULL;
21          p->tail = NULL;
22          printf("\n");
23      }
24      for (int i = 0; i < m; i++) {
25          scanf_s("%f %d", &coef, &expn);
26          ListNode* node = (ListNode*)malloc(sizeof(ListNode));
27  //      if (node == NULL)   return;
28          node->coef = coef;
29          node->expn = expn;
30          if (i == 0) {
31              p->head->next = node;
32              p->tail = node;
33              node->next = NULL;
34          }
35          else {
36              p->tail->next = node;
37              node->next = NULL;
38              p->tail = node;
39          }
40      }
41      return;
42  }
```

顺序打印链表：

```c
void PrintPolyn(polynomial* p) {
//  printf("p->head:%d\n", p->head);
//  printf("p->head->next:%d\n", p->head->next);
//  printf("p->tail:%d\n", p->tail);
//  printf("input unary_polynomial:");
    ListNode* trav = (ListNode*)malloc(sizeof(ListNode));
//  ListNode* next = (ListNode*)malloc(sizeof(ListNode));
    trav = p->head->next;
//  printf("  trava is:%d", trav);
    if (trav == NULL) {
        printf("0\n");
        return;
    }
    printf("%.2f x^%d ", trav->coef, trav->expn);
    trav = trav->next;
    while (trav != NULL) {
        if (trav->expn == 0)    printf("+ %.2f ", trav->coef);
        else printf("+ %.2f x^%d", trav->coef, trav->expn);
        trav = trav->next;
    }
    printf("\n");
}

int PolynLength(polynomial* p) {    //返回多项式项数
    int item = 0;
    ListNode* trav = (ListNode*)malloc(sizeof(ListNode));
    trav = p->head;
    while (trav != NULL) {
        trav = trav->next;
        item++;
    }
    return item;
}
```

链表相加——分三种情况考虑，指数相等时类似状态机转入另外两个状态或结束循环：

```
void AddPolyn(polynomial* pa, polynomial* pb) {
    ListNode* trava = (ListNode*)malloc(sizeof(ListNode));
    ListNode* trava_ah = (ListNode*)malloc(sizeof(ListNode));
    ListNode* travb = (ListNode*)malloc(sizeof(ListNode));
//  ListNode* travb_ah = (ListNode*)malloc(sizeof(ListNode));
    ListNode* tema = (ListNode*)malloc(sizeof(ListNode));
    ListNode* temb = (ListNode*)malloc(sizeof(ListNode));
    trava_ah = pa->head;
//  travb_ah = pb->head;
    trava = pa->head->next;
    travb = pb->head->next;
//用头结点不用考虑pa只有一项
    while (trava != NULL && travb != NULL) {
        if (trava->expn > travb->expn) {    //trava指数小于travb，将travb插入到trava与trava_ah之间,并释放travb_ah,
            temb = travb->next;
            trava_ah->next = travb;
            travb->next = trava;
            trava_ah = travb;
            travb = temb;
        }
//trava->next==travb->expn isn't thoroughly considered
        else if (trava->expn < travb->expn) {
            while (trava->next != NULL && trava->next->expn <= travb->expn) {
                trava_ah = trava;
                trava = trava->next;    //trava<travb<trava->next||trava->next=NULL,trava->travb->trava->next;
            }
            if (trava->expn == travb->expn) {
                goto equal;
            }
            tema = trava->next;
            trava->next = travb;
            temb = travb->next;
            travb->next = tema;
            trava_ah = travb;   //travb成为trava->next的ah
            trava = tema;
            travb = temb;
        }
        else {
        equal:
            trava->coef += travb->coef;
            if (trava->coef == 0) {
                tema = trava->next;
                trava_ah->next = tema;
                free(trava);
                trava = tema;
            }
//          else {
//              trava_ah = trava;
//              trava = trava->next;
//          }
            temb = travb->next;
            free(travb);
            travb = temb;
        }
    }
//trava==NULL或travb==NULL
    if (trava == NULL) {
        trava_ah->next = travb;
    }
    free(pb->head);
    free(pb);
}
```

链表相减，与链表相加差不多，区别如下：

1. 插入时需要把系数*（-1）
2. 指数相同为相减

```
173 void SubPolyn(polynomial* pa, polynomial* pb) {
174     ListNode* trava = (ListNode*)malloc(sizeof(ListNode));
175     ListNode* trava_ah = (ListNode*)malloc(sizeof(ListNode));
176     ListNode* travb = (ListNode*)malloc(sizeof(ListNode));
177     //  ListNode* travb_ah = (ListNode*)malloc(sizeof(ListNode));
178     ListNode* tema = (ListNode*)malloc(sizeof(ListNode));
179     ListNode* temb = (ListNode*)malloc(sizeof(ListNode));
180     trava_ah = pa->head;
181     //  travb_ah = pb->head;
182     trava = pa->head->next;
183     travb = pb->head->next;
184     //用头结点不用考虑pa只有一项
185     while (trava != NULL && travb != NULL) {
186         if (trava->expn > travb->expn) {    //trava指数小于travb，将travb插入到trava与trava_ah之间,并释放travb_ah,
187             travb->coef = travb->coef * (-1);
188             temb = travb->next;
189             trava_ah->next = travb;
190             travb->next = trava;
191             trava_ah = travb;
192             travb = temb;
193         }
194         //trava->next==travb->expn isn't thoroughly considered
195         else if (trava->expn < travb->expn) {
196             while (trava->next != NULL && trava->next->expn <= travb->expn) {
197                 trava_ah = trava;
198                 trava = trava->next;    //trava<travb<trava->next||trava->next=NULL,trava->travb->trava->next;
199             }
200             if (trava->expn == travb->expn) {
201                 goto equal;
202             }
203             travb->coef *= (-1);
204             tema = trava->next;
205             trava->next = travb;
206             temb = travb->next;
207             travb->next = tema;
208             trava_ah = travb;   //travb成为trava->next的ah
209             trava = tema;
210             travb = temb;
211         }
212         else {
213         equal:
214             trava->coef -= travb->coef;
215             if (trava->coef == 0) {
216                 tema = trava->next;
217                 trava_ah->next = tema;
218                 free(trava);
219                 trava = tema;
220             }
221 //          else {
222 //              trava_ah = trava;
223 //              trava = trava->next;
224 //          }
225             temb = travb->next;
226             free(travb);
227             travb = temb;
228         }
229     }
230     //trava==NULL或travb==NULL
231     if (trava == NULL) {
232         trava_ah->next = travb;
233     }
234     free(pb->head);
235     free(pb);
236 }
```

翻转链表，输入时为按指数升序，翻转为按指数降序来输出:

```
153  int invert_list(polynomial* p) {    //when p至少有一项
154      if (p->head->next == NULL)  return 0;
155      ListNode* trav1 = (ListNode*)malloc(sizeof(ListNode));
156      ListNode* trav2 = (ListNode*)malloc(sizeof(ListNode));
157      ListNode* stor = (ListNode*)malloc(sizeof(ListNode));
158      trav1 = p->head->next;
159      trav2 = trav1->next;
160      while (trav2 != NULL) {
161          stor = trav2->next;
162          trav2->next = trav1;
163          trav1 = trav2;
164          trav2 = stor;
165      }
166      stor = p->head->next;
167      p->head->next = trav1;
168      p->tail = stor;
169      stor->next = NULL;
170      return 1;
171  }
```

该程序主函数：

```
237
238  int main() {
239      polynomial* pa = (polynomial*)malloc(sizeof(polynomial));
240      polynomial* pb = (polynomial*)malloc(sizeof(polynomial));
241      char func;  //指示"+","-"法
242      int item_a, item_b;
243      printf("input your function:");
244      scanf_s("%c", &func);
245      printf("input items of pa,pb in order:");
246      scanf_s("%d %d", &item_a, &item_b);
247      CreatePolyn(pa, item_a);
248      CreatePolyn(pb, item_b);
249      invert_list(pa);
250      printf("第一个多项式为：");
251      PrintPolyn(pa);
252      invert_list(pa);
253      invert_list(pb);
254      printf("第二个多项式为：");
255      PrintPolyn(pb);
256      invert_list(pb);
257      if (func == '+')    AddPolyn(pa, pb);
258      else    SubPolyn(pa, pb);
259      invert_list(pa);
260      printf("运算结果为：");
261      PrintPolyn(pa);
262      return 0;
263  }
```