

Nanyang Technological University  
Joker  
Reference Book



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# 1 String

## 1.1 KMP

```

1 std::vector<int> kmp(std::string s) {
2     int n = s.length();
3     std::vector<int> pi(n);
4     for (int i = 1; i < n; ++i) {
5         int j = pi[i - 1];
6         while (j && s[i] != s[j]) {
7             j = pi[j - 1];
8         }
9         if (s[i] == s[j]) {
10             j++;
11         }
12         pi[i] = j;
13     }
14     return pi;
15 }

```

## 1.2 Z-function

```

16 std::vector<int> z_function(std::string s) {
17     int n = s.length();
18     std::vector<int> z(n);
19     z[0] = n;
20     for (int i = 1, l = 0, r = 0; i < n; ++i) {
21         if (i <= r && z[i - l] < r - i + 1) {
22             z[i] = z[i - l];
23         } else {
24             z[i] = std::max(0, r - i + 1);
25             while (i + z[i] < n && s[z[i]] == s[i + z[i]]) {
26                 z[i]++;
27             }
28         }
29         if (i + z[i] - 1 > r) {
30             l = i, r = i + z[i] - 1;
31         }
32     }
33     return z;
34 }

```

## 1.3 AC 自动机

```

const int maxn = 200005;

int ans[maxn];

struct Aho_Corasick {
    std::vector<int> id[maxn];
    int son[maxn][26];
    int fail[maxn];
    int val[maxn];
    int cnt;

    Aho_Corasick() {
        cnt = 0;
        memset(son, 0, sizeof(son));
        memset(fail, 0, sizeof(fail));
        memset(val, 0, sizeof(val));
    }

    void insert(std::string s, int _id) {
        int now = 0;
        for (auto c : s) {
            const int x = c - 'a';
            if (!son[now][x]) {
                son[now][x] = ++cnt;
            }
            now = son[now][x];
        }
        id[now].push_back(_id);
    }

    std::vector<int> fas[maxn];

    void build() {
        std::queue<int> q;
        for (int i = 0; i < 26; ++i) {
            if (son[0][i]) {
                q.push(son[0][i]);
            }
        }
        while (!q.empty()) {
            int now = q.front();
            q.pop();

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```

77     for (int i = 0; i < 26; ++i) {
78         if (son[now][i]) {
79             fail[son[now][i]] = son[fail[now]][i];
80             q.push(son[now][i]);
81         } else {
82             son[now][i] = son[fail[now]][i];
83         }
84     }
85 }
86 }
87
88 void getval(std::string s) {
89     int now = 0;
90     for (auto c : s) {
91         now = son[now][c - 'a'];
92         val[now]++;
93     }
94 }
95
96 void build_fail_tree() {
97     for (int i = 1; i <= cnt; ++i) {
98         fas[fail[i]].push_back(i);
99     }
100 }
101
102 void dfs(int now = 0) {
103     for (auto x : fas[now]) {
104         dfs(x);
105         val[now] += val[x];
106     }
107     if (!id[now].empty()) {
108         for (auto x : id[now]) {
109             ans[x] = val[now];
110         }
111     }
112 }
113 };
114
115 Aho_Corasick ac;
116
117 int n;
118
119 int main() {
120     std::cin >> n;

```

```

    for (int i = 1; i <= n; ++i) {
        std::string s;
        std::cin >> s;
        ac.insert(s, i);
    }
    ac.build();
    std::string s;
    std::cin >> s;
    ac.getval(s);
    ac.build_fail_tree();
    ac.dfs();
    for (int i = 1; i <= n; ++i) {
        std::cout << ans[i] << std::endl;
    }
    return 0;
}

```

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```

## 1.4 manacher

```

int n;
char s[N], ss[N];
int len[N];
void Manacher(char *s, int n) {
    For(i, 0, n+1)
        len[i] = 0;
    int mx = 1;
    For(i, 1, n) {
        len[i] = max(1, min(mx + len[mx] - i, len[mx * 2 - i]));
        while (s[i - len[i]] == s[i + len[i]])
            len[i]++;
        if (i + len[i] > mx + len[mx])
            mx = i;
    }
}
int solve(char *s, int n) {
    ss[0] = '#', ss[1] = '*';
    For(i, 1, n) {
        ss[i << 1] = s[i];
        ss[i << 1 | 1] = '*';
    }
    ss[n * 2 + 2] = '$';
    Manacher(ss, n * 2 + 1);
}

```

```

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```

```

160     int ans=0;
161     For(i,1,n*2+1)
162         ans=max(ans,len[i]-1);
163     return ans;
164 }

```

## 1.5 SA

```

165 struct SuffixArray {
166     static const int N = 1000005; // the length of the string
167
168     int n, m, cnt[N], sa[N], rk[N], id[N];
169
170     void radixSort() {
171         for (int i = 0; i < m; ++i) {
172             cnt[i] = 0;
173         }
174         for (int i = 0; i < n; ++i) {
175             ++cnt[rk[i]];
176         }
177         for (int i = 1; i < m; ++i) {
178             cnt[i] += cnt[i - 1];
179         }
180         for (int i = n - 1; ~i; --i) {
181             sa[--cnt[rk[id[i]]]] = id[i];
182         }
183     }
184
185     bool cmp(int x, int y, int l) {
186         return id[x] == id[y] && id[x + l] == id[y + l];
187     }
188
189     template<typename T>
190     void initSA(T first, T last) {
191         n = last - first, m = 0;

```

```

192         for (int i = 0; i < n; ++i) {
193             rk[i] = *(first + i);
194             m = std::max(m, rk[i] + 1);
195             id[i] = i;
196         }
197         radixSort();
198         for (int l = 1, p = 0; p < n && l < n; m = p, l <= 1) {
199             p = 0;
200             for (int i = n - 1; i < n; ++i) {
201                 id[p++] = i;
202             }
203             for (int i = 0; i < n; ++i) {
204                 if (sa[i] >= l && p < n) {
205                     id[p++] = sa[i] - l;
206                 }
207             }
208             radixSort();
209             for (int i = 0; i < n; ++i) id[i] = rk[i];
210             p = 1, rk[sa[0]] = 0;
211             for (int i = 1; i < n; ++i) {
212                 if (!cmp(sa[i - 1], sa[i], l) && p < n) ++p;
213                 rk[sa[i]] = p - 1;
214             }
215         }
216     }
217 } SA;
218
219 int main() {
220     n = readStr(s);
221     SA.initSA(s, s + n);
222     for (int i = 0; i < n; ++i) {
223         print(SA.sa[i] + 1, '_');
224     }
225     putchar('\n');
226 }

```