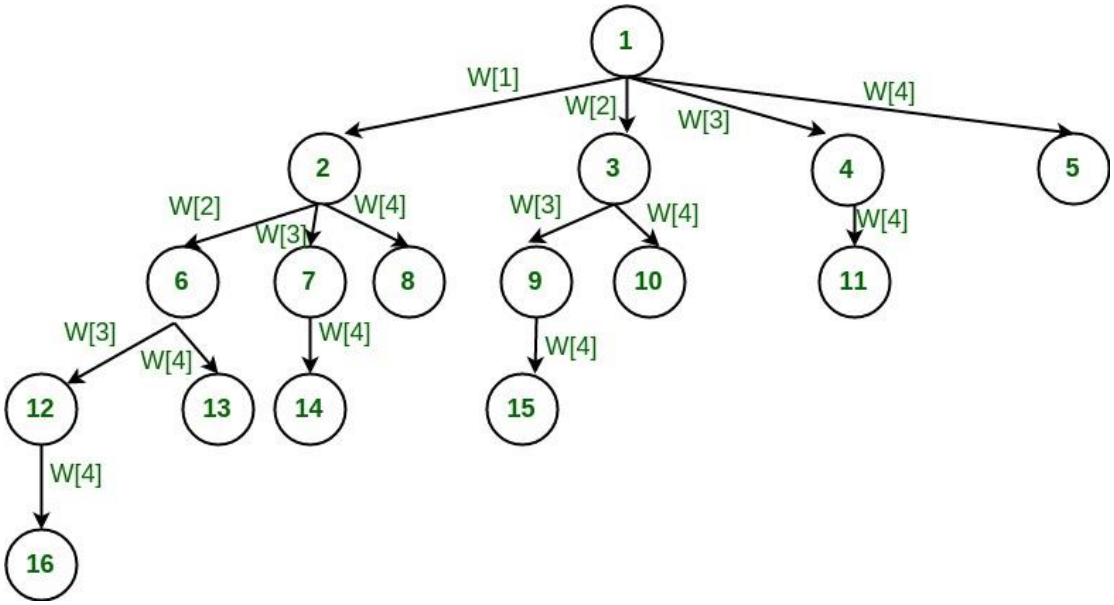
EXPERIMENT 9 : SUM OF SUBSETS

AIM: Write a program to obtain all the possible subsets of w ={15, 22, 14, 26, 32, 9, 16, 8} that sum to 53.

THEORY:

Subset sum problem is to find subset of elements that are selected from a given set whose sum adds up to a given number K. We are considering the set contains non-negative values. It is assumed that the input set is unique (no duplicates are presented).

Backtracking can be used to make a systematic consideration of the elements to be selected. Assume given set of 4 elements, say **w[1] … w[4]**. Tree diagrams can be used to design backtracking algorithms. The following tree diagram depicts approach of generating variable sized tuple.



In the above tree, a node represents function call and a branch represents candidate element. The root node contains 4 children. In other words, root considers every element of the set as different branch. The next level sub-trees correspond to the subsets that includes the parent node. The branches at each level represent tuple element to be considered. For example, if we are at level 1, tuple_vector[1] can take any value of four branches generated. If we are at level 2 of left most node, tuple_vector[2] can take any value of three branches generated, and so on…

For example the left most child of root generates all those subsets that include w[1]. Similarly the second child of root generates all those subsets that includes w[2] and excludes w[1].

As we go down along depth of tree we add elements so far, and if the added sum is satisfying explicit constraints, we will continue to generate child nodes further. Whenever the constraints are not met, we stop further generation of sub-trees of that node, and backtrack to previous node to explore the nodes not yet explored. In many scenarios, it saves considerable amount of processing time.

The tree should trigger a clue to implement the backtracking algorithm (try yourself). It prints all those subsets whose sum add up to given number. We need to explore the nodes along the breadth and depth of the tree. Generating nodes along breadth is controlled by loop and nodes along the depth are generated using recursion (post order traversal). Pseudo code given below,

```
if(subset is satisfying the constraint)
    print the subset
    exclude the current element and consider next element
else
    generate the nodes of present level along breadth of tree and
    recur for next levels
```

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```
#include <stdio.h>
#include <stdlib.h>

#define ARRAYSIZE(a) (sizeof(a))/(sizeof(a[0]))

static int total_nodes;

// prints subset found
void printSubset(int A[], int size)
{
    for(int i = 0; i < size; i++)
    {
        printf("%*d", 5, A[i]);
    }

    printf("\n");
}

// qsort compare function
int comparator(const void *pLhs, const void *pRhs)
{
    int *lhs = (int *)pLhs;
    int *rhs = (int *)pRhs;

    return *lhs > *rhs;
}

// inputs
// s            - set vector
// t            - tuplet vector
// s_size       - set size
// t_size       - tuplet size so far
// sum          - sum so far
// ite          - nodes count
// target_sum   - sum to be found
void subset_sum(int s[], int t[],
                int s_size, int t_size,
                int sum, int ite,
                int const target_sum)
{
    total_nodes++;

    if( target_sum == sum )
    {
        // We found sum
        printSubset(t, t_size);
```

```
        // constraint check
        if( ite + 1 < s_size && sum - s[ite] + s[ite+1] <= target_sum )
        {
            // Exclude previous added item and consider next candidate
            subset_sum(s, t, s_size, t_size-1, sum - s[ite], ite + 1,
target_sum);
        }
        return;
    }
    else
    {
        // constraint check
        if( ite < s_size && sum + s[ite] <= target_sum )
        {
            // generate nodes along the breadth
            for( int i = ite; i < s_size; i++ )
            {
                t[t_size] = s[i];

                if( sum + s[i] <= target_sum )
                {
                    // consider next level node (along depth)
                    subset_sum(s, t, s_size, t_size + 1, sum + s[i], i +
1, target_sum);
                }
            }
        }
    }
}

// Wrapper that prints subsets that sum to target_sum
void generateSubsets(int s[], int size, int target_sum)
{
    int *tuplet_vector = (int *)malloc(size * sizeof(int));

    int total = 0;

    // sort the set
    qsort(s, size, sizeof(int), &comparator);

    for( int i = 0; i < size; i++ )
    {
        total += s[i];
    }

    if( s[0] <= target_sum && total >= target_sum )
    {
```

```
        subset_sum(s, tuplet_vector, size, 0, 0, 0, target_sum);

    }

    free(tuplet_vector);
}

int main()
{
    int weights[] = {15, 22, 14, 26, 32, 9, 16, 8};
    int target = 53;

    int size = ARRAYSIZE(weights);

    generateSubsets(weights, size, target);

    printf("Nodes generated %d\n", total_nodes);

    return 0;
}
```

Output:

```
8 9 14 22
8 14 15 16
15 16 22
Nodes generated 68
```

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EXPERIMENT 10:

AIM: Given a text txt[0..n-1] and a pattern pat[0..m-1], write a program that prints all occurrences of pat[] in txt[]. You may assume that n > m.

THEORY:

Rabin-Karp algorithm slides the pattern one by one. Rabin Karp algorithm matches the hash value of the pattern with the hash value of current substring of text, and if the hash values match then only it starts matching individual characters. So Rabin Karp algorithm needs to calculate hash values for following strings.

1) Pattern itself.

2) All the substrings of the text of length m.

Since we need to efficiently calculate hash values for all the substrings of size m of text, we must have a hash function which has the following property.

Hash at the next shift must be efficiently computable from the current hash value and next character in text or we can say **hash(txt[s+1 .. s+m])** must be efficiently computable from **hash(txt[s .. s+m-1])** and **txt[s+m]** i.e.,

hash(txt[s+1 .. s+m])= rehash(txt[s+m], hash(txt[s .. s+m-1]))

and rehash must be O(1) operation.

The hash function suggested by Rabin and Karp calculates an integer value. The integer value for a string is the numeric value of a string.

For example, if all possible characters are from 1 to 10, the numeric value of "122" will be 122. The number of possible characters is higher than 10 (256 in general) and pattern length can be large. So the numeric values cannot be practically stored as an integer. Therefore, the numeric value is calculated using modular arithmetic to make sure that the hash values can be stored in an integer variable (can fit in memory words). To do rehashing, we need to take off the most significant digit and add the new least significant digit for in hash value. Rehashing is done using the following formula.

hash(txt[s+1 .. s+m]) = (d (hash(txt[s .. s+m-1]) – txt[s]*h) + txt[s + m]) mod q

hash(txt[s .. s+m-1]) : Hash value at shift s.

hash(txt[s+1 .. s+m]) : Hash value at next shift (or shift s+1)

d: Number of characters in the alphabet

q: A prime number

h: d^(m-1)

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```
#include<stdio.h>
#include<string.h>

// d is the number of characters in the input alphabet
#define d 256

/* pat -> pattern
    txt -> text
    q -> A prime number
*/
void search(char pat[], char txt[], int q)
{
    int M = strlen(pat);
    int N = strlen(txt);
    int i, j;
    int p = 0; // hash value for pattern
    int t = 0; // hash value for txt
    int h = 1;

    // The value of h would be "pow(d, M-1)%q"
    for (i = 0; i < M-1; i++)
        h = (h*d)%q;

    // Calculate the hash value of pattern and first
    // window of text
    for (i = 0; i < M; i++)
    {
        p = (d*p + pat[i])%q;
        t = (d*t + txt[i])%q;
    }

    // Slide the pattern over text one by one
    for (i = 0; i <= N - M; i++)
    {

        // Check the hash values of current window of text
        // and pattern. If the hash values match then only
        // check for characters one by one
        if ( p == t )
        {
            /* Check for characters one by one */
            for (j = 0; j < M; j++)
            {
                if (txt[i+j] != pat[j])
                    break;
            }
```

```
            // if p == t and pat[0...M-1] = txt[i, i+1, ...i+M-1]
            if (j == M)
                printf("Pattern found at index %d \n", i);
        }

        // Calculate hash value for next window of text: Remove
        // leading digit, add trailing digit
        if ( i < N-M )
        {
            t = (d*(t - txt[i]*h) + txt[i+M])%q;

            // We might get negative value of t, converting it
            // to positive
            if (t < 0)
            t = (t + q);
        }
    }
}

int main()
{
    char txt[] = "GEEKS FOR GEEKS";
    char pat[] = "GEEK";

      // A prime number
    int q = 101;

      // function call
    search(pat, txt, q);
    return 0;
}
```

Output:

```
Pattern found at index 0
Pattern found at index 10
```

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Time Complexity: O(nm)