Unbounded Knapsack (Repetition of items allowed)

Given a knapsack weight **W** and a set of **n** items with certain value val_i and weight wt_i, we need to calculate minimum amount that could make up this quantity exactly. This is different from classical Knapsack problem, here we are allowed to use unlimited number of instances of an item.

Examples:

```
Input : W = 100
        val[]  = {1, 30}
        wt[] = {1, 50}
Output : 100
There are many ways to fill knapsack.
1) 2 instances of 50 unit weight item.
2) 100 instances of 1 unit weight item.
3) 1 instance of 50 unit weight item and 50
   instances of 1 unit weight items.
We get maximum value with option 2.

Input : W = 8
        val[] = {10, 40, 50, 70}
        wt[]  = {1, 3, 4, 5}
Output : 110
We get maximum value with one unit of
weight 5 and one unit of weight 3.
```

Recommended: Please solve it on "*PRACTICE* " first, before moving on to the solution.

Its an unbounded knapsack problem as we can use 1 or more instances of any resource. A simple 1D array, say dp[W+1] can be used such that dp[i] stores the maximum value which can achieved using all items and i capacity of knapsack. Note that we use 1D array here which is different from classical

knapsack where we used 2D array. Here number of items never changes. We always have all items available.

We can recursively compute dp[] using below formula

```
dp[i] = 0
dp[i] = max(dp[i], dp[n-wt[j]] + val[j]
                   where j varies from 0
                   to n-1 such that:
                   wt[j] <= i

result = d[W]
```

Below is the implementation of above idea.

C++

```
// C++ program to find maximum achievable value
// with a knapsack of weight W and multiple
// instances allowed.
#include<bits/stdc++.h>
using namespace std;

// Returns the maximum value with knapsack of
// W capacity
int unboundedKnapsack(int W, int n, int val[], int wt[])
{
    // dp[i] is going to store maximum value
    // with knapsack capacity i.
    int dp[W+1];
    memset(dp, 0, sizeof dp);

    int ans = 0;

    // Fill dp[] using above recursive formula
    for (int i=0; i<=W; i++)
      for (int j=0; j<n; j++)
         if (wt[j] <= i)
            dp[i] = max(dp[i], dp[i-wt[j]]+val[j]);

    return dp[W];
}

// Driver program
int main()
{
    int W = 100;
    int val[] = {10, 30, 20};
    int wt[] = {5, 10, 15};
    int n = sizeof(val)/sizeof(val[0]);

    cout << unboundedKnapsack(W, n, val, wt);

    return 0;
}
```

Run on IDE

Java

```java
// Java program to find maximum achievable
// value with a knapsack of weight W and
// multiple instances allowed.
public class UboundedKnapsack {

    private static int max(int i, int j) {
            return (i > j) ? i : j;
    }

    // Returns the maximum value with knapsack
    // of W capacity
    private static int unboundedKnapsack(int W, int n,
                                int[] val, int[] wt) {

        // dp[i] is going to store maximum value
        // with knapsack capacity i.
        int dp[] = new int[W + 1];

        // Fill dp[] using above recursive formula
        for(int i = 0; i <= W; i++){
            for(int j = 0; j < n; j++){
                if(wt[j] <= i){
                    dp[i] = max(dp[i], dp[i - wt[j]] +
                                val[j]);
                }
            }
        }
        return dp[W];
    }

    // Driver program
    public static void main(String[] args) {
        int W = 100;
        int val[] = {10, 30, 20};
        int wt[] = {5, 10, 15};
        int n = val.length;
        System.out.println(unboundedKnapsack(W, n, val, wt));
    }
}
// This code is contributed by Aditya Kumar
```

Run on IDE

Output:

```
300
```

Asked in: Amazon,Google

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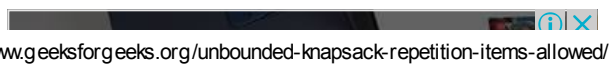

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