	Pimpri Chinchwad Education Trust's **Pimpri Chinchwad College of Engineering (PCCoE)** (An Autonomous Institute) Affiliated to Savitribai Phule Pune University (SPPU) ISO 21001:2018 Certified by TUV	
Department: Information Technology **Academic Year**: 2025-26 **Semester:** V		
DESIGN AND ANALYSIS OF ALGORITHMS LABORATORY		

ASSIGNMENT NO.3

Aim:- The aim of this study is to design and implement the Fractional Knapsack algorithm to maximize the total utility value of critical relief supplies transported during emergency flood relief operations. The solution ensures optimal use of limited boat capacity while prioritizing high-utility items such as medicine, food, and drinking water.

Objective:

- To model the flood relief supply transport as an optimization problem.
- To implement the **Fractional Knapsack Algorithm** for maximizing utility value.
- To prioritize **high-utility items** under given weight capacity constraints.
- To allow **fractional selection of divisible items** (e.g., food, water).
- To evaluate efficiency and effectiveness of the greedy approach.

Problem Statement:

Scenario: Emergency Relief Supply Distribution

A devastating flood has hit multiple villages in a remote area. The government, along with NGOs, is conducting an emergency relief operation. A rescue team must transport essential supplies from a relief center to affected villages using a boat with limited capacity `W`.

Each relief item has:

- Weight (wi) in kilograms.
- Utility value (vi) indicating its importance (e.g., medicine > food).
- Some items are divisible (food, water) and can be taken in fractions, while others are indivisible (medical kits, equipment).

As a logistics manager, your tasks are:

1. Implement the Fractional Knapsack algorithm.
2. Prioritize high-utility items while considering the boat's weight limit.
3. Allow partial selection of divisible items.

4. Ensure the boat carries maximum possible critical supplies within `W`.

Explanation:

The **Fractional Knapsack** problem is a classic **Greedy Algorithm** approach where:

- Items are selected based on **utility-to-weight ratio (vi/wi)**.
- Highest ratio items are taken first.
- If an item cannot fit entirely, only a fraction of it is taken (if divisible).
- Process continues until the capacity `W` is filled.

This ensures maximum utility value is achieved under limited capacity.

Algorithm:

Steps:

1. Input the number of items `n` and boat capacity `W`.
2. For each item, read weight `wi` and utility `vi`.
3. Compute the ratio `vi/wi` for each item.
4. Sort items in descending order of ratio.
5. Initialize total value = 0.
6. For each item:
   - If the item can fit entirely → add full weight and value.
   - Else → take fraction of item that fits into remaining capacity.
7. Stop when weight limit `W` is reached.
8. Output maximum utility value and list of selected items.

Pseudocode:

```
struct Item
 { int
 weight; int
 value;
};


double fractionalKnapsack(int W, Item arr[], int n) {
 // Compute ratio and sort
 sort(arr, arr+n, by value/weight ratio descending);


 int currentWeight = 0;
```

```
double finalValue = 0.0;


for (int i = 0; i < n; i++) {
if (currentWeight + arr[i].weight <= W) {
// Take whole item
currentWeight +=
arr[i].weight; finalValue +=
arr[i].value;
}
else {
// Take fraction of item
int remain = W - currentWeight;
finalValue += arr[i].value * ((double) remain / arr[i].weight);  break;
}
}
return finalValue;
}
```

Time Complexity:

- Sorting step: **O(n log n)**
- Iteration over items: **O(n)**
- **Total:** O(n log n)

Space Complexity:

- O(1) (in-place, except for sorting overhead).

Conclusion: The Fractional Knapsack algorithm provides an efficient greedy solution for the emergency relief supply distribution problem. By prioritizing items with the highest utility-to-weight ratio and allowing fractional selection for divisible goods, the algorithm ensures maximum utility within the boat's limited capacity. This makes it highly effective for disaster management scenarios where both time and resources are critical.

Questions:

1. Why is the Fractional Knapsack algorithm suitable for solving the flood relief supply distribution problem, and how does it differ from the 0/1 Knapsack approach?

Ans: Why Fractional Knapsack is suitable for Flood Relief Supply Distribution:

- In a flood relief supply distribution problem, you often need to distribute goods (like food, water, medicine) to different locations, but the total vehicle capacity is limited.
- Fractional Knapsack Algorithm allows you to take fractions of items (for example, part of a food package or some liters of water), so you can always fill the truck as fully as possible**.**

2. Explain how the utility-to-weight ratio (vi/wi) guides the greedy selection process in the Fractional Knapsack algorithm, and why this ensures an optimal solution.

Ans: The utility-to-weight ratio (vi/wi) means how much benefit you get for each kg of weight.

How it works in Fractional Knapsack:

- Calculate vi/wi for each item.
- Sort items by highest vi/wi first.
- Pick the best item first, then the next, until the knapsack (truck) is full.
- If the last item doesn't fit completely, take just part of it.