In this pre-lecture exercise you’ll consider greedy algorithms for two problems, Unbounded knapsack and scheduling. Here are the two problems:

**Problem 1: Unbounded knapsack.** You have access to an unlimited supply of items $a_1, \ldots, a_n$. Item $a_i$ has weight $w_i$ and value $v_i$. You want to fill a knapsack of weight $W$ with items (repetitions are allowed) so that (a) the sum of the items in your knapsack is at most $W$ and (b) the value of the items in your knapsack is as large as possible. (We saw this problem in Lecture 13, along with a DP solution).

**Problem 2: Activity selection.** There are activities $a_1, \ldots, a_n$ that you would like to do. Activity $i$ starts at time $s_i$ and finishes at time $f_i$. In order to do activity $i$, you will be occupied for the whole range $[s_i, f_i]$, and cannot do any other activity. Out of this set of tasks, you’d like to find out the maximum number of activities possible.

For example, if there were four tasks, with $(s_1, f_1) = (1, 5)$, $(s_2, f_2) = (3, 7)$, $(s_3, f_3) = (6, 9)$ and $(s_4, f_4) = (2, 4)$, then the picture would be:

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  0 1 2 3 4 5 6 7 8 9 10
a_1
| | | | | | | | | | |
| | | | a_2 | | | | | | |
| | | | | | | | a_3 | | |
| | | | | | | a_4 | | | |
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and the optimal solution would be two activities. You could either do $a_1$ and $a_3$, or $a_4$ and $a_3$.

1. We saw a DP solution for problem 1 in class last week. Your friend suggests a different algorithm. They reason: “the best thing to do is to take the item that has the biggest value/weight ratio. Since repetitions are allowed, just take as many copies of this best item as can fit in your knapsack.”

Do you think your friend’s reasoning is correct?

2. In the question above, what if you are allowed to take fractional items? (That is, you may take $1/4$ of item $a_i$, with weight $w_i/4$ and value $v_i/4$).

Do you think your friend’s reasoning is correct?

3. Your friend has a similar sort of reasoning for problem 2. They argue: “The best thing to do is to choose the activity (that’s not blocked by previous activity choices) with the smallest finishing time. That way, you get to do an activity and leave as much room as possible for future activities.” That is, your friend suggests that you first choose the activity with the smallest finishing time, then next choose the activity that’s not blocked with the smallest finishing time, and so on until you can’t choose activities anymore.

Do you think your friend’s reasoning is correct?