



Algorithms and Data Structures

Laboratory work #1

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Classes plan

1. Problem #1296 "Hyperjump"
2. Problem #1155 "Troubleduons"
3. Task for homework
4. Students prepare solution for problem #1296 and pass Timus tests
5. Collecting reports for problem #1296

Problem #1296

"Hyperjump"



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- Link to the problem's description
<https://acm.timus.ru/problem.aspx?space=1&num=1296&locale=en>
- The sequence of integers p_i represents field intensities at different moments in time.
- If the alpha-phase begins at moment i and ends at moment j , then the value of gravity potential accumulated will be equal to the sum of sequence elements at places from i -th to j -th inclusive.
- The only line of output contains the largest possible value of the gravity potential that can be accumulated by a hyperspacecraft during the alpha phase.

Problem #1296

"Hyperjump"



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| N | 10 |
|----------|-----|
| p_1 | 31 |
| p_2 | -41 |
| p_3 | 59 |
| p_4 | 26 |
| p_5 | -53 |
| p_6 | 58 |
| p_7 | 97 |
| p_8 | -93 |
| p_9 | -23 |
| p_{10} | 84 |

- Investigate sample 1
- Find subsequence with greatest sum
- Subsequence can go through the negative value, if it become greater later
- For this sample correct output is 187

Problem #1296

"Hyperjump"



| m | p | n=1 | n=2 | ... |
|-----|-----|-----|-----|-----|
| 1 | 31 | 31 | - | |
| 2 | -41 | -10 | -41 | |
| 3 | 59 | 49 | 18 | |
| 4 | 26 | 75 | 44 | |
| 5 | -53 | 22 | -9 | |
| 6 | 58 | 80 | 49 | |
| 7 | 97 | 177 | 146 | |
| 8 | -93 | 84 | 53 | |
| 9 | -23 | 61 | 30 | |
| 10 | 84 | 145 | 114 | |
| Max | | 177 | 146 | ... |

- **Solution 1.** Check all possible subsequences

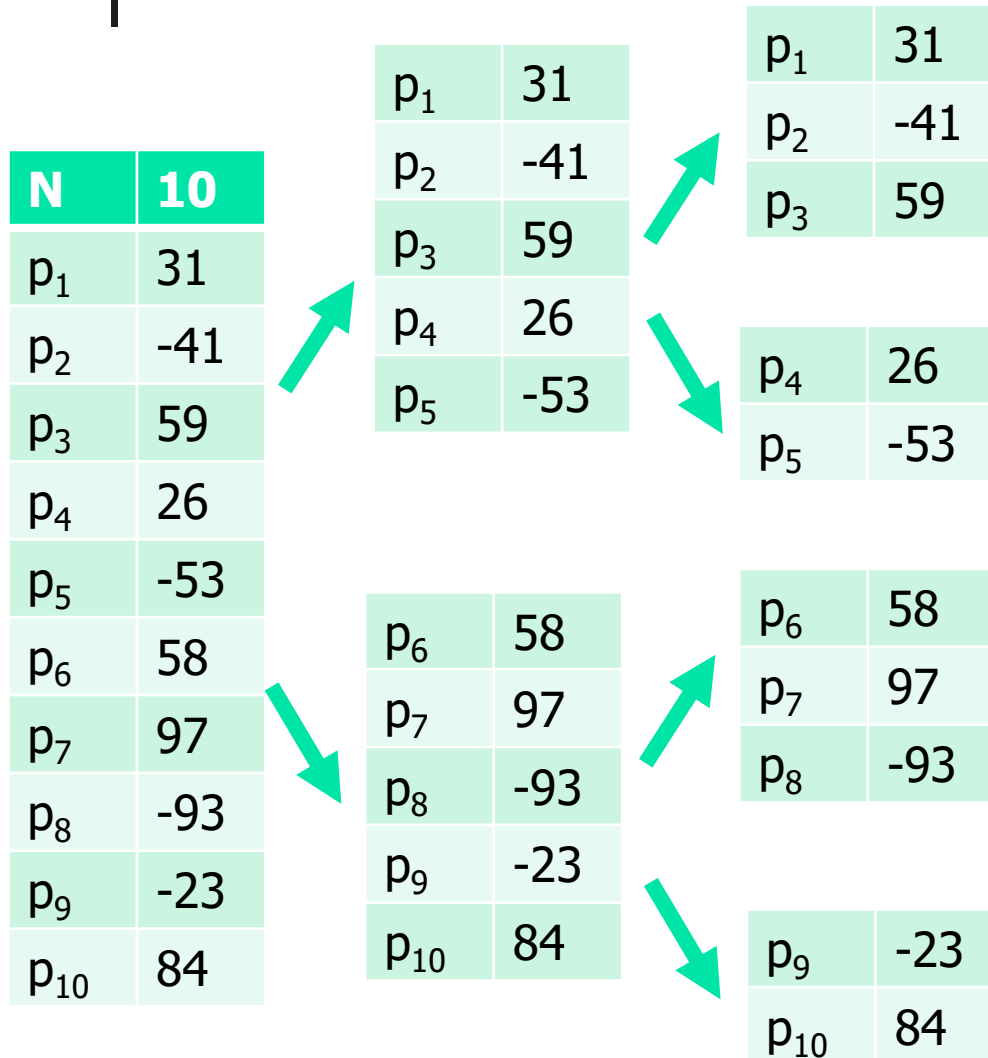
- We can find maximum from sums of each subsequence

$$Res = \max\left(\sum_{i=n}^m p_i\right), \text{ where } 1 \leq n \leq 10, n \leq m \leq 10$$

- Let's fill the table!
- What are disadvantages of this solution?
- Complexity is $O(n^2)$

Problem #1296

"Hyperjump"



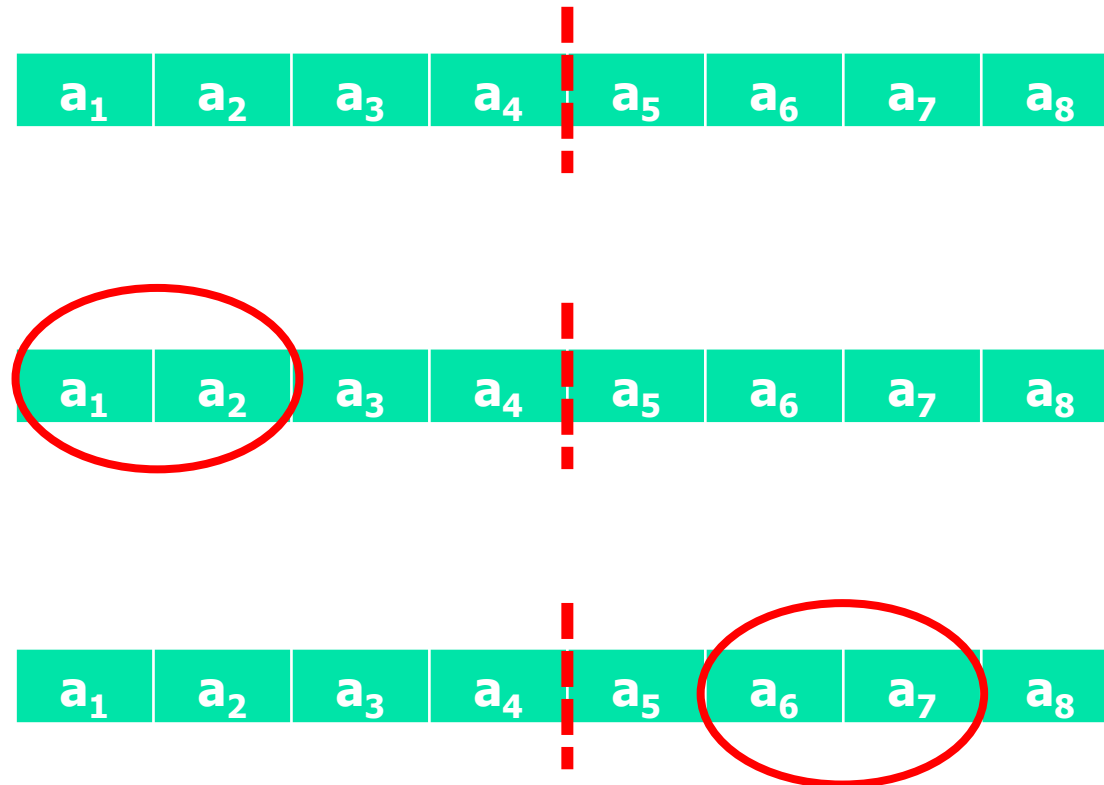
- **Solution 2.** Divide and conquer!
- Paradigm "Divide and conquer" suggests to split the problem on smaller problems, solve them separately and then merge results
- Use recursion
- How to merge?

Problem #1296

"Hyperjump"



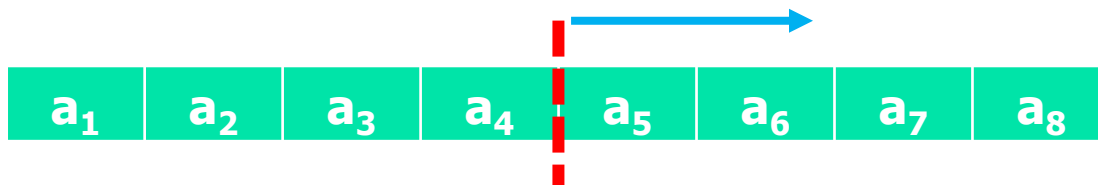
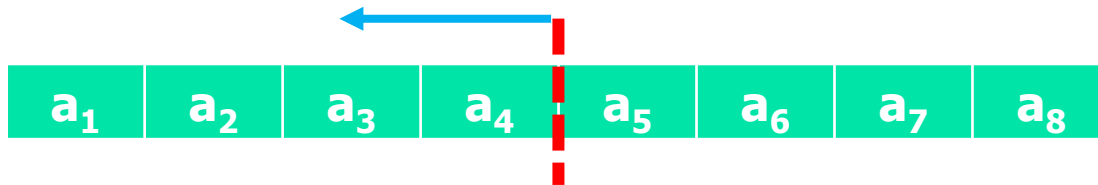
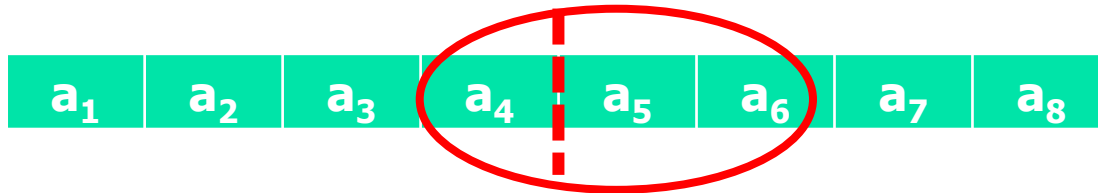
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- Let's check arbitrary subsequence after merge
- Where maximum subsequence can be?
- Case 1. Maximum subsequence lies fully in the left part
- Case 2. Maximum subsequence lies fully in the right part

Problem #1296

"Hyperjump"



- Case 3. Maximum subsequence lies in both parts
- How to calculate it?
- Step 1 – find maximum subsequence starting from the center to the left
- Step 2 – find maximum subsequence starting from the center to the right
- Step 3 – sum them

Problem #1296

"Hyperjump"



Current max = 58

| | |
|-------|----|
| p_6 | 58 |
|-------|----|

Left max = 58

| | |
|-------|----|
| p_7 | 97 |
|-------|----|

Current max = 97

Right max = 97

| | |
|-------|----|
| p_6 | 58 |
| p_7 | 97 |

Middle max = 155

- For one-element subsequence – return this element

Current max = 155

| | |
|-------|----|
| p_6 | 58 |
| p_7 | 97 |

Left max = 155

| | |
|-------|-----|
| p_8 | -93 |
|-------|-----|

Current max = 0

Right max = 0

| | |
|-------|-----|
| p_6 | 58 |
| p_7 | 97 |
| p_8 | -93 |

Middle max = 155

- Otherwise – check "left", "right" and "middle" subsequences
- Let's apply these rules

Problem #1296

"Hyperjump"



Current max = 75

| | |
|-------|-----|
| p_1 | 31 |
| p_2 | -41 |
| p_3 | 59 |
| p_4 | 26 |
| p_5 | -53 |

Left max = 75

| | |
|----------|-----|
| p_1 | 31 |
| p_2 | -41 |
| p_3 | 59 |
| p_4 | 26 |
| p_5 | -53 |
| p_6 | 58 |
| p_7 | 97 |
| p_8 | -93 |
| p_9 | -23 |
| p_{10} | 84 |

Middle max = 187

Current max = 155

| | |
|-------|-----|
| p_6 | 58 |
| p_7 | 97 |
| p_8 | -93 |

Left max = 155

| | |
|----------|-----|
| p_6 | 58 |
| p_7 | 97 |
| p_8 | -93 |
| p_9 | -23 |
| p_{10} | 84 |

Right max = 155

| | |
|----------|-----|
| p_9 | -23 |
| p_{10} | 84 |

Current max = 84

Right max = 84

Middle max = 123

- Answer: 187
- Disadvantages?
- Complexity?

Problem #1296

"Hyperjump"



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| N | 10 | Sum | Max |
|-------|-----|---------------------|-----|
| p_1 | 31 | 31 | 31 |
| p_2 | -41 | $-10 \Rightarrow 0$ | 31 |
| p_3 | 59 | 59 | 59 |

- **Solution 3.** Dynamic – Kadane's algorithm
- Go through all elements, sum them and save maximum value of sum
- Negative sum is useless, replaced with 0

Problem #1296

“Hyperjump”



| N | 10 | Sum | Max |
|-----------------|-----|--------|-----|
| p ₁ | 31 | 31 | 31 |
| p ₂ | -41 | -10=>0 | 31 |
| p ₃ | 59 | 59 | 59 |
| p ₄ | 26 | 85 | 85 |
| p ₅ | -53 | 32 | 85 |
| p ₆ | 58 | 90 | 90 |
| p ₇ | 97 | 187 | 187 |
| p ₈ | -93 | 94 | 187 |
| p ₉ | -23 | 71 | 187 |
| p ₁₀ | 84 | 155 | 187 |

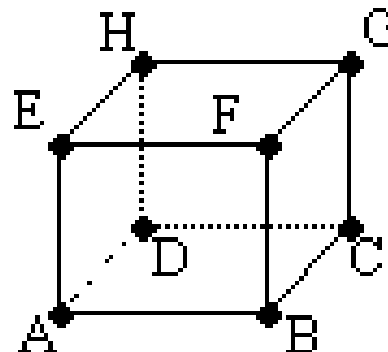
- **Solution 3.** Dynamic – Kadane’s algorithm
- Go through all elements, sum them and save maximum value of sum
- Negative sum is useless, replaced with 0
- Complexity?

Problem #1155

"Troubleduons"



- Link to the problem's description
<https://acm.timus.ru/problem.aspx?space=1&num=1155&locale=en>
- Experimental set consists of eight cameras, situated in the vertices of a cube. Cameras are named as A, B, C, ..., H. It is possible to generate or annihilate two troubleduons in neighboring cameras. You should automate the process of removing troubleduons.

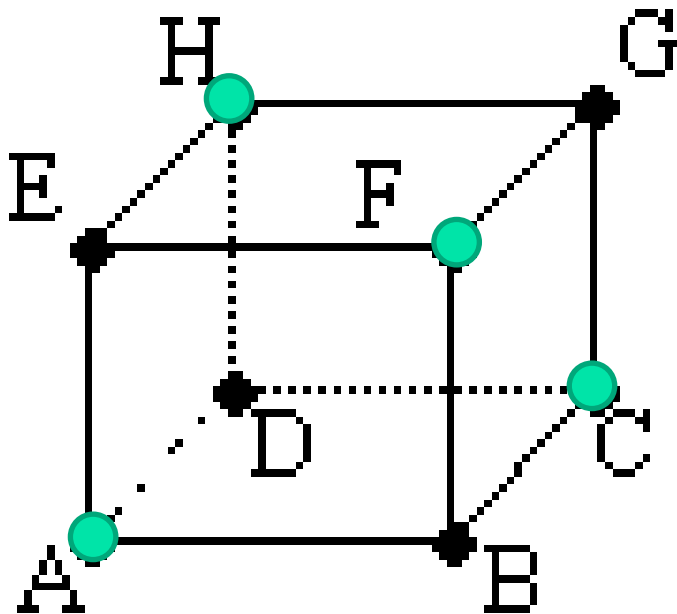


Problem #1155

"Troubleduons"



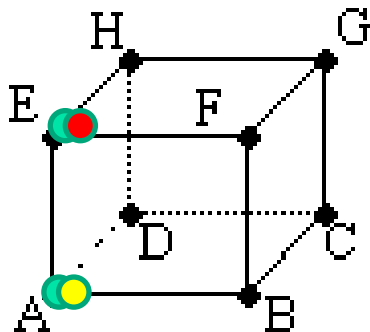
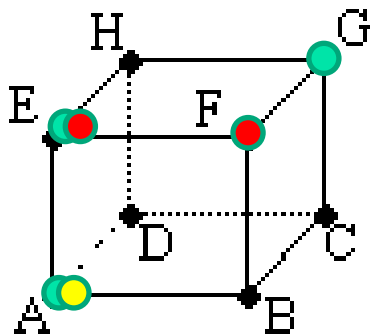
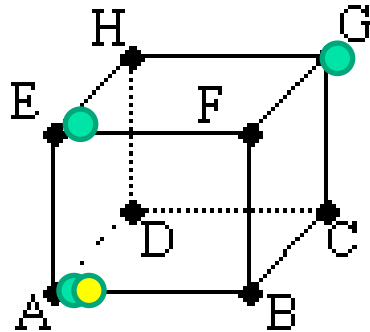
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- When problem has no solution, and we can return IMPOSSIBLE?
- Two sets of vertices: ACFH and BDEG
- $A + C + F + H = B + D + E + G$

Problem #1155

“Troubleduons”



■ Moving troubleduons between vertices of the same group:

- Vertex G has no troubleduons in adjacent vertices, but vertex E has one (image 1)
- Create troubleduons in vertex and adjacent to both E and G (EF on image 2)
- Annihilate troubleduons for vertices F and G (image 3)
- We “move” troubleduon between vertices G and E



Task for homework

You can solve following problems to get extra 2 points for each problem:

1. Problem #1155 "Troubleduons"

<https://acm.timus.ru/problem.aspx?space=1&num=1155&locale=en>

Solution of this problem was already explained

2. Problem #1005 "Stone Pile"

<https://acm.timus.ru/problem.aspx?space=1&num=1005&locale=en>

N.B. Report for this problem should contain explanation, what limitations have your algorithm



Current task

1. Prepare source code to solve problem #1296 "Hyperjump"
<https://acm.timus.ru/problem.aspx?space=1&num=1296&locale=en>
2. Pass tests on Timus system for this problem
<https://acm.timus.ru/submit.aspx?space=1&num=1296>
3. Prepare a report with algorithm complexity and explanation
Use [template.docx](#) to prepare report and send it to
hduitmo.ads@yandex.ru with correct subject



Thank you!