



香港電腦奧林匹克競賽
Hong Kong Olympiad in Informatics

J241 - Watermelon Game

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2024-02-17

Background

Problem idea by microtony

Preparation by microtony

microtony does not have a Nintendo Switch so he never played the game

Inspired by “0 score speedrun”



Problem Statement

Box is W -units wide and infinitely tall ($W \leq 10^6$)

Fruits are squares with side length $1, 2, \dots, T$ ($T \leq W$)

Given N fruits and drop location, ($N \leq 10000$)

Determine if the first and only merge happens when the last (N -th) fruit is dropped

Drop

- Drop fruits one by one
- The i -th fruit has type L_i and position X_i units from the left edge of the box
- Stops falling when the bottom side touches a fruit or bottom of the box

W T N

$$L_i \quad X_i$$

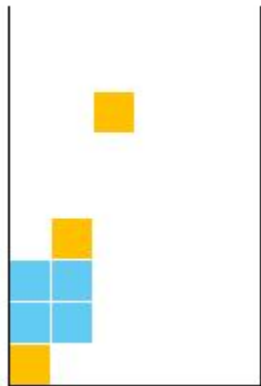
4 2 4

1 0

2 0

1 1

1 2



8 3 7

3 2

2 0

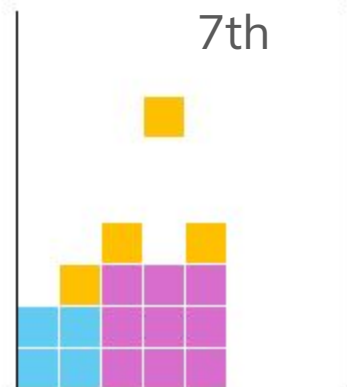
1 1

1 2

14

1 3

3 5



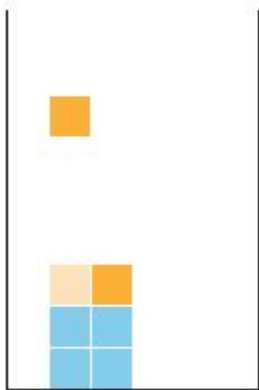
Merge

Requirements:

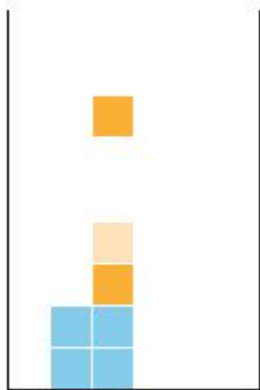
- Two fruits of the same type
- Two sides of at least length 1 touch

What happens after the merge does not matter, as the game will end immediately

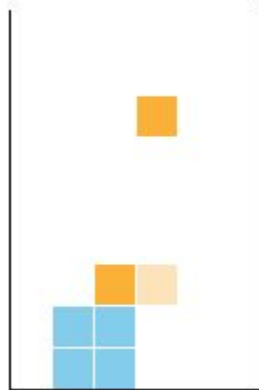
Which side of the dropping fruit touches another fruit?



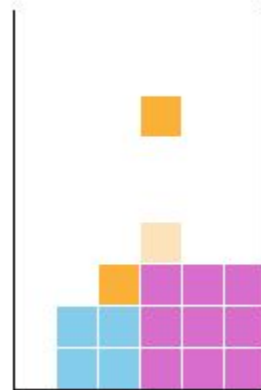
Right side



Bottom side



Left side



No merge

Statistics

J241 - Watermelon Game	77	100	29.129	27.553	8: 58	16: 41	7: 38	32: 19	25: 9	12: 2
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First solved by dbscarsonho @ 00:35

2 contestants got 100

Basic Program Structure

```
int GetFinalScore() {  
    ...  
}
```

```
int main() {  
    ...  
    cout << (GetFinalScore() == n ? "Yes" : "No") << endl;  
}
```

Subtask 1 (8 points)

$$N = 2$$

$$T \leq 2$$

First, check whether the fruits of are the same type

If they are NOT the same type ... No

If they are type 1 and $\text{abs}(X2 - X1) \leq 1$... Yes

If they are type 2 and $\text{abs}(X2 - X1) \leq 2$... Yes

Otherwise ... No

Subtask 3 (8+7=15 points)

$$N = 2$$

$$T \leq 10^6$$

First, check whether the fruits of are the same type

If they are NOT the same type ... No

If $\text{abs}(X_2 - X_1) \leq L_1$... Yes

Otherwise ... No

Subtask 2 (16 points)

$N \leq 10000$

$T = 1$

Use a 1D array to store whether there is a fruit

For each fruit, check positions X_{i-1} , X_i , X_{i+1}

Handle carefully when $X_i = 0$ or $W-1$

Sample 2

```
5 1 3
1 2
1 0
1 4
```



How to determine whether two line segments overlap

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Heat Event 初賽
Junior Group 初級組

7. Given a function **f** that takes the coordinates of two horizontal line segments as parameters, where:

給予函數 **f**，其參數為兩條橫線線段，當中：

- line segment *a* connects two points (ax_1, ay) and (ax_2, ay) and it is guaranteed that $ax_1 \leq ax_2$.
線段 *a* 連接兩點 (ax_1, ay) 和 (ax_2, ay) ，保證 $ax_1 \leq ax_2$ 。
- line segment *b* connects two points (bx_1, by) and (bx_2, by) and it is guaranteed that $bx_1 \leq bx_2$.
線段 *b* 連接兩點 (bx_1, by) 和 (bx_2, by) ，保證 $bx_1 \leq bx_2$ 。

Complete **f** **WITHOUT** using any function calls, so that it returns **true** if and only if *a* and *b* share at least one point.

在不調用任何函數的情況下完成函數 **f**，使其返回 **true** 當且僅當 *a* 和 *b* 共享至少一點。

Pascal

```
function f(ay, ax1, ax2, by, bx1, bx2: longint):
    boolean;
begin
    f := _____ J _____
end;
```

C / C++

```
bool f(int ay, int ax1, int ax2,
       int by, int bx1, int bx2) {
    return _____ J _____;
}
```

```
ay == by && (ax1 <= bx1 && ax2 >= bx1 || bx1
             <= ax1 && bx2 >= ax1) //
ay == by && ax1 <= bx2 && bx1 <= ax2 //
ay == by && !(ax1 > bx2 || bx1 > ax2)
```

Not needed in this task

Answer 答案: _____ J _____ (2 marks 分)

Subtask 4 (8+32=40 points)

$N \leq 20$

$W \leq 20$

Use a 2D array to store the game state

Required height of the box = $20 \times 20 = 400$

For each fruit $i = 1..N$

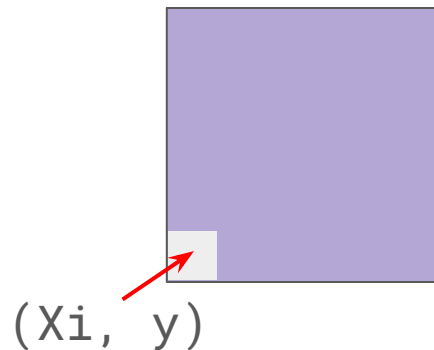
For $y = 400$ down to 0

If any side touches another fruit of the same type

Report score = i

If bottom side touches another fruit or bottom of box

Store fruit position in array and break



Subtask 5 (8+32+25=65 points)

$N \leq 500$

$W \leq 2000$

Not enough memory to store the game state in 2D.

Drop: Where the fruit will stop falling.

Solution: 1D array to store the top of each x position (all fruit types)

Merge: Whether the fruit will touch a fruit of the same type

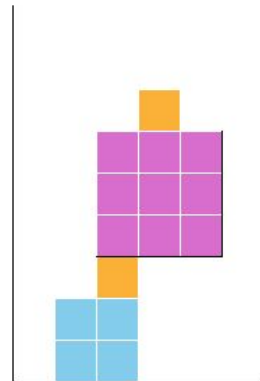
Solution: 2D array to store the top of each x position **per** fruit type

Drop: linear search row 0

Merge: linear search row L_i

If no merge happens, update row 0 and row L_i

Time complexity: $O(WN)$

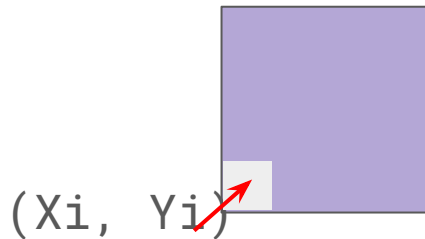


0	0	2	6	7	6	0
1	0	0	3	7	0	0
2	0	2	2	0	0	0
3	0	0	6	6	6	0

Subtask 6 (100 points)

$N \leq 10000$

$W \leq 10^6$



Instead of storing the state of the box, store the y-position of the fruits.

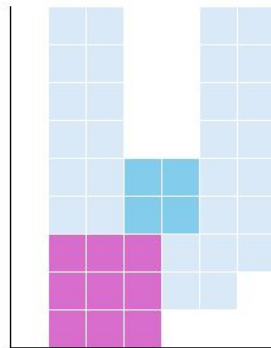
Drop: First assume that the fruit will fall to the bottom of the box by setting $Y_i = 0$

Check all previous fruits: If $(X_i, X_i + L_i)$ overlap with $(X_j, X_j + L_j)$, then $Y_i = \max(Y_i, Y_j + L_j)$

Merge: Check all previous fruits of the same type ($L_i == L_j$)

	X condition	Y condition
Left side	$X_i == X_j + L_i$	$Y_i < Y_j + L_i$
Right side	$X_i == X_j - L_i$	$Y_i < Y_j + L_i$
Bottom side	$X_i < X_j + L_i \ \&\& \ X_i + L_i > X_j$	$Y_i == Y_j + L_i$

Time complexity: $O(N^2)$



Closing Remarks

Common mistakes: Integer overflow ($NW > 2^{31}$)

6 contestants got 88 points because of this

Challenge: Solve this problem with $O(N \lg W)$ time complexity

Hint: Build on top of Subtask 5's solution