

**Question 3: Mystery Parcel**

A shop is running a promotion and giving away *mystery parcels*, containing one or more items. As these are promotional, items are not very exciting (items that weigh the same are indistinguishable) and the total weight of items in each parcel is the same. Parcels containing the same combination of items (order does not matter) are themselves indistinguishable.

For advertising purposes the shop wishes to calculate the number of ways it can distribute the parcels.

For example, suppose there are 2 parcels containing a total of 4 items, each item weighing 1, 2 or 3 units. There are 10 different ways the parcels can be distributed. They might be constructed in 8 ways:

1	1	—	1	1
1	2	—	1	2
2	2	—	2	2
1	3	—	1	3
2	3	—	2	3
3	3	—	3	3
3	1	—	2	2
1	1	1	—	3

In each of the first 6 pairings the parcels are indistinguishable, so there is only a single way in which they can be distributed. In each of the last 2 pairings the parcels can be distinguished, so they could each be distributed in 2 different ways; i.e. it can be distinguished which is distributed first.

**3(a) [ 25 marks ]**

Write a program to determine the number of ways parcels can be distributed.

Your program should input four integers in order:  $p$  ( $1 \leq p \leq 5$ ) indicating the number of parcels,  $i$  ( $1 \leq i \leq 10$ ) indicating that items can weigh any integer from 1 to  $i$  inclusive,  $n$  ( $1 \leq n \leq 25$ ) indicating the total number of items in all the parcels, and  $w$  ( $1 \leq w \leq 25$ ) indicating the weight of each parcel.

You should output the number of ways parcels can be distributed. You will not be given input that requires an answer greater than  $2^{31}$ .

**Marks are available for the case where  $p = 1$**

Sample run

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2 3 4 3
3
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**3(b) [ 2 marks ]**

How many ways can 3 parcels, containing a total of 6 items weighing 1, 2 or 3 units, be distributed?

**3(c) [ 6 marks ]**

There are 92378 distinguishable parcels containing 10 items (when  $i = 10$ ) and the shop has created an index of these parcels. Given two parcels, the one with the largest number of weight-10 items appears earliest in the index. If those are equal, the order depends on the number of weight-9 items, and so on. E.g. 8888855555 is before 8888855554 which is before 8888777777.

What is the contents of the parcel at position 50,000? What is the position of the parcel containing one item of each weight from 1 to 10?

**Total Marks: 100**

End of BIO 2017 Round One paper