Counting Methods:

Example:

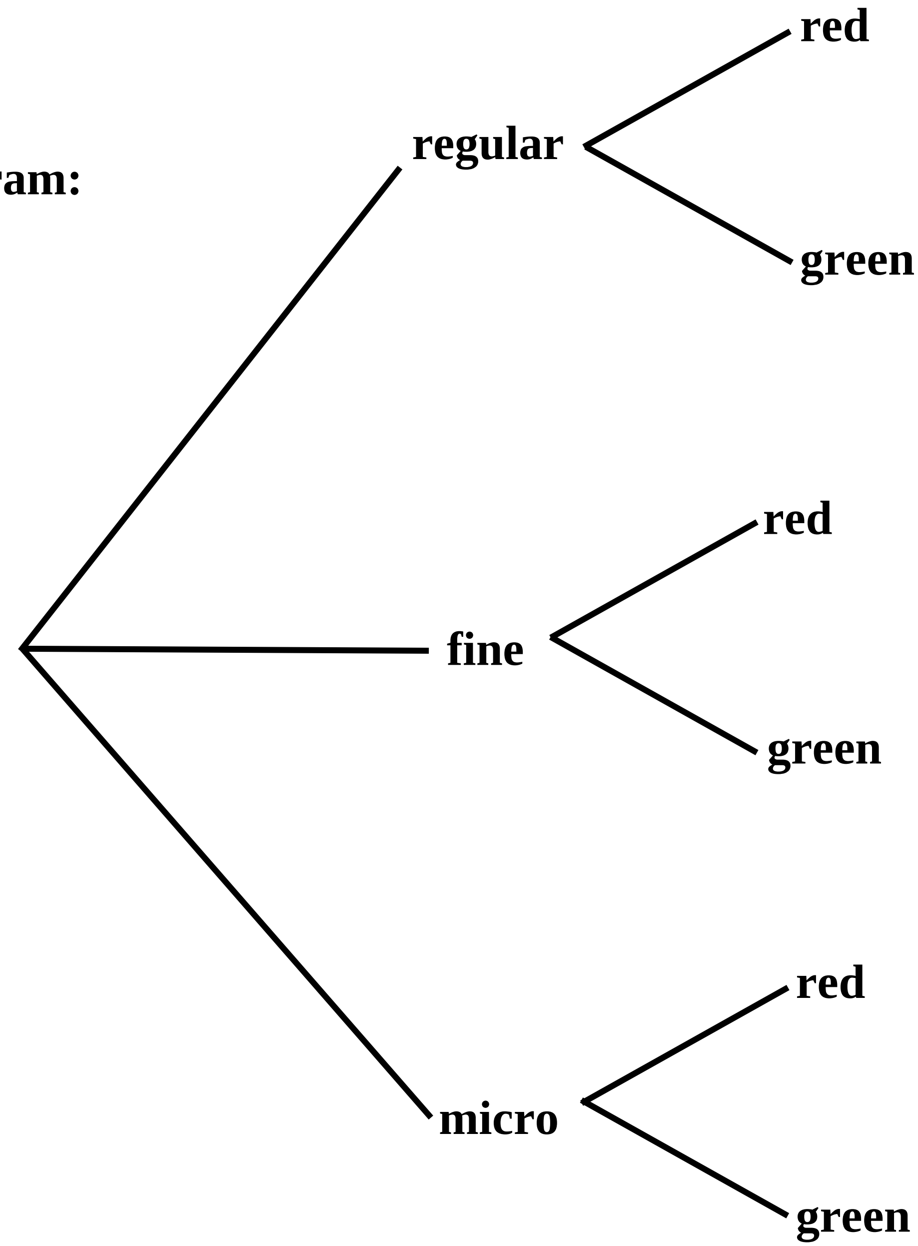
A pen has tip options of regular tip, fine tip, or micro tip, and it has ink color options of red ink or green ink. How many different pens are possible?

Using a table:

	regular	fine	micro
red			
green			

The number of pens possible is the number of cells in the table: 3×2.

Using a Tree Diagram:



The number of pens possible is the number of branch tips on the right: 3×2.

The Fundamental Counting Principle:

If a sequence of decisions is to be made, then the number of different ways of making all the decisions is the product of the number of options for each decision.

Examples:

1. **A meal consists of 1 of 8 appetizers, 1 of 10 entrees, and 1 of 5 desserts. How many different meals are possible?**

2. **In a race with 5 horses, how many different first, second, and third place finishes are possible?**

3. In a certain small state, license plates consist of three letters followed by two digits.

a) How many different plates are possible?

b) How many if letters can’t repeat?

c) How many if digits can’t repeat?

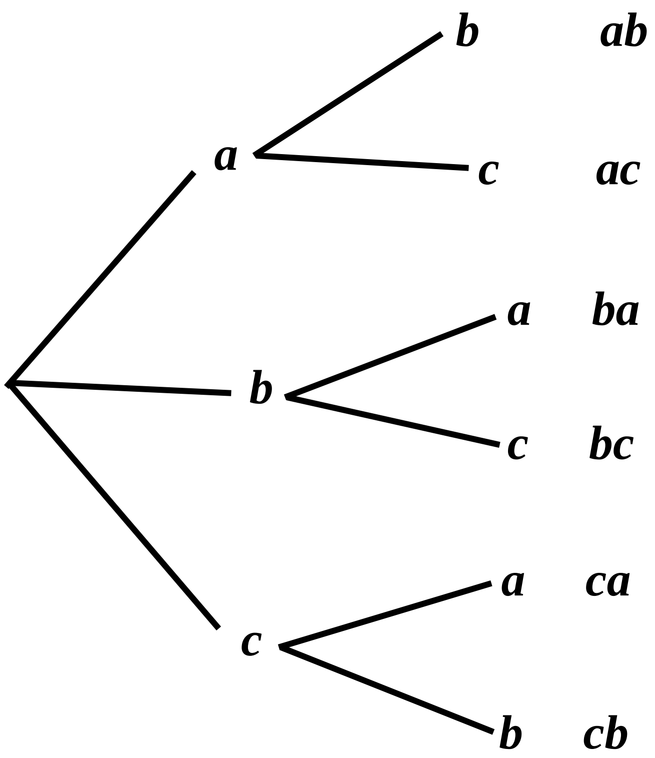
d) How many if no repeats?

Permutations:

A permutation is an arrangement of objects in a particular order.

Example:

Find all the permutations of the objects $\{a, b, c\}$ of size 2.



There are 6 permutations of size 2 from the 3 objects. If we just wanted to know how many, we could have used the Fundamental Counting Principle.

In general, the number of permutations of size *r* from *n* objects is abbreviated as $_nP_r$. So far, we know that $_3P_2 = 6$. There's a nice formula for the value of $_nP_r$ in general, but it involves things called factorials.

<u>Factorials:</u>

$$n! = n\cdot(n-1)\cdot(n-2)\cdot\dots\cdot 2\cdot 1 \text{ or } n! = 1\cdot 2\cdot 3\cdot\dots\cdot(n-1)\cdot n$$

So $1! = 1$**.**

$$2! = 2\cdot 1 = 2$$

$$3! = 3\cdot 2\cdot 1 = 6$$

$$4! = 4\cdot 3\cdot 2\cdot 1 = 4\cdot 3! = 4\cdot 6 = 24$$

$$5! = 5\cdot 4! = 5\cdot 24 = 120$$

$$6! = 6\cdot 5! = 6\cdot 120 = 720$$

By special definition, $0! = 1$**.**

$$_nP_r = \frac{n!}{(n-r)!}$$

Let's check it out for $_3P_2$, which we already know is equal to 6.

$$_3P_2 = \frac{3!}{(3-2)!} = \frac{3!}{1!} = \frac{6}{1} = 6$$

Examples:

1. Five solo singers are to perform their acts at a nightclub on Saturday night. How many different orders of their appearances are possible?

$$_5P_5$$

Or

Fundamental Counting Principle

2. From a group of 6 people, a president, vice-president, and secretary will be selected, how many different selections are possible?

$$_{6}P_{3}$$

Or

Fundamental Counting Principle

3. In a race with 8 horses, how many different first, second, and third place finishes are possible?

$$_{8}P_{3}$$

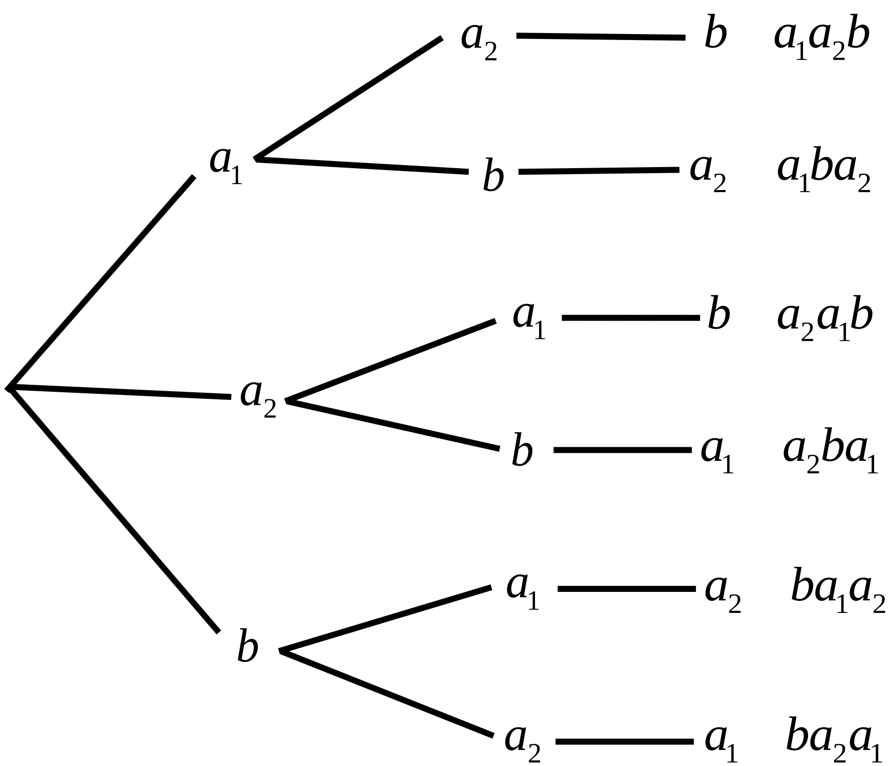
Or

Fundamental Counting Principle

Permutations with duplicated items:

Example:

Find all the permutations of the objects $\{a,a,b\}$.



There are actually just 3 permutations of the objects: *aab*, *aba*, and *baa*. Notice that $3=\frac{3!}{2!}$, and this generalizes into a nice formula for the number of permutations with duplicates.

If there are *n* items with k_1 identical, k_2 identical, …, k_r identical, then the number of permutations of the *n* items is $\dfrac{n!}{k_1!\cdot k_2!\cdot\cdots\cdot k_r!}$.

Examples:

1. How many permutations are there of the letters in the word *million*?

$$\frac{7!}{2!\cdot 2!}$$

2. In how many different ways can the digits of the number 54,446,666 be arranged?

$$\frac{8!}{\qquad}$$