1. Consider the word `unusual`. How many unique subsets of 5 letters (of the 7) exist? How many different strings could be made from 5 of those 7 letters?
   UNUSUAL:
   1 u: $\binom{4}{4}$
   2 us: $\binom{4}{3}$
   3 us: $\binom{4}{2}$
   ANSWER: $u + uu + uuu = \binom{4}{4} + \binom{4}{3} + \binom{4}{2} = 11$

Assuming question asks for all possible combinations of 5 chosen letters from the 7 in unusual:
case 1: 1 u
case 2: 2 us
case 3: 3 us
ANSWER: Unique strings: $5! + \frac{4\times5!}{2!1!1!1!} + \frac{6\times5!}{3!1!1!} = 480$

2. Using a standard deck of playing cards, how many ways are to form a 5-card hand with 2 pairs (i.e. pair of one value, a pair of a different value, and a fifth card of some other value)?
   Pick two values from 13 which will be the pairs. Then choose 2 suits from the four suits for each pair. Then choose any card from the remaining 44 unselected cards.

$$nCr(13, 2) \times nCr(4, 2) \times nCr(4, 2) \times 44$$

   ANSWER: $= 123, 552$ ways

3. A violinist serenades couples at a romantic restaurant. She will play 16 songs in an hour and there are 7 couples. One couple is having a fight and will allow at most 1 song to be played to them before they ask the violist not to return to their table. If we care only about the number of songs each couple receives, how many ways can the songs be distributed amongst the couples.

Case 1:One couple gets one of the 16 songs.
6 remaining couples get 15 songs.

$\binom{15+6-1}{6} = \binom{20}{6} = 38,760$
Case 2: One couple gets 0 of the 16 songs.
6 remaining couples get 16 songs.
$\binom{16+6-1}{6} = \binom{21}{6} = 54,264$

ANSWER: $case1 + case2 = 93,024$

4. There is a Binary Search Tree with 12 nodes. Each node has a distinct value between 1 and 12 . The root has value 3, and its right child has value 9. How many possible Binary Search Trees could this be? Tip: *Try to define how many ways there are to form a BST of 2 nodes. Then try to define how many ways there are to form a BST of 3 nodes (think about the possible insertion order based on rank: smallest, medium, largest)* ***in terms of 2 node trees*** *for certain cases. Continue to do this for 4 node trees (in terms of 3- and 2-node trees for various cases of insertion ordering based on rank) and 5 node trees.*

With root 3, right child 9, our remaining values are 1,2,4,5,6,7,8,10,11,12.
1,2 must be left of root.
4,5,6,7,8 must be sorted right of root, left of 9.
10,11,12 must be sorted to the right of root, right of 9.
Formula to use: $f(n) = \frac{nCr(2n,n)}{n+1}$
$\rightarrow f(2) \cdot f(5) \cdot f(3)$
ANSWER: $\rightarrow 2 \cdot 42 \cdot 5 = 420$ ways

5. 10 friends arrive to get their COVID vaccine during a particular time slot. During that time slot there are 4 identical nurses administering shots, but 1 of the nurses **may** (or **may not**) be scheduled for a break during the time slot in which the friends arrive. Also, how long it takes the nurses to administer a shot varies wildly, so the nurses working during the time slot are guaranteed to serve at least 1 person, but how many additional people they are able to serve is arbitrary. How many different combinations are there for the number of patients served by the nurses?
//logically check every situation

If ALL 4 nurses work:
The most people one nurse can serve is 7. The least is 1. Since the nurses are functionally identical, then the only differentiating factor is number of people served. There is no functional difference between (5,2,1,2) and (5,2,2,1).
A: (7,1,1,1)

B: (6,2,1,1)
C: (5,3,1,1)
D: (5,2,2,1)
E: (4,4,1,1)
F: (4,3,2,1)
G: (4,2,2,2)
H: (3,3,2,2)
I: (3,3,1,3)

$\rightarrow$ 9 ways

If ONLY 3 nurses work:
A: (8,1,1)
B: (7,2,1)
C: (6,3,1)
D: (6,2,2)
E: (5,4,1)
F: (5,3,2)
G: (4,4,2)
H: (4,3,3)

$\rightarrow 8$ ways

ANSWER: Thus there are $9+8$ ways for the nurses to cover everyone $\rightarrow$ 17 ways