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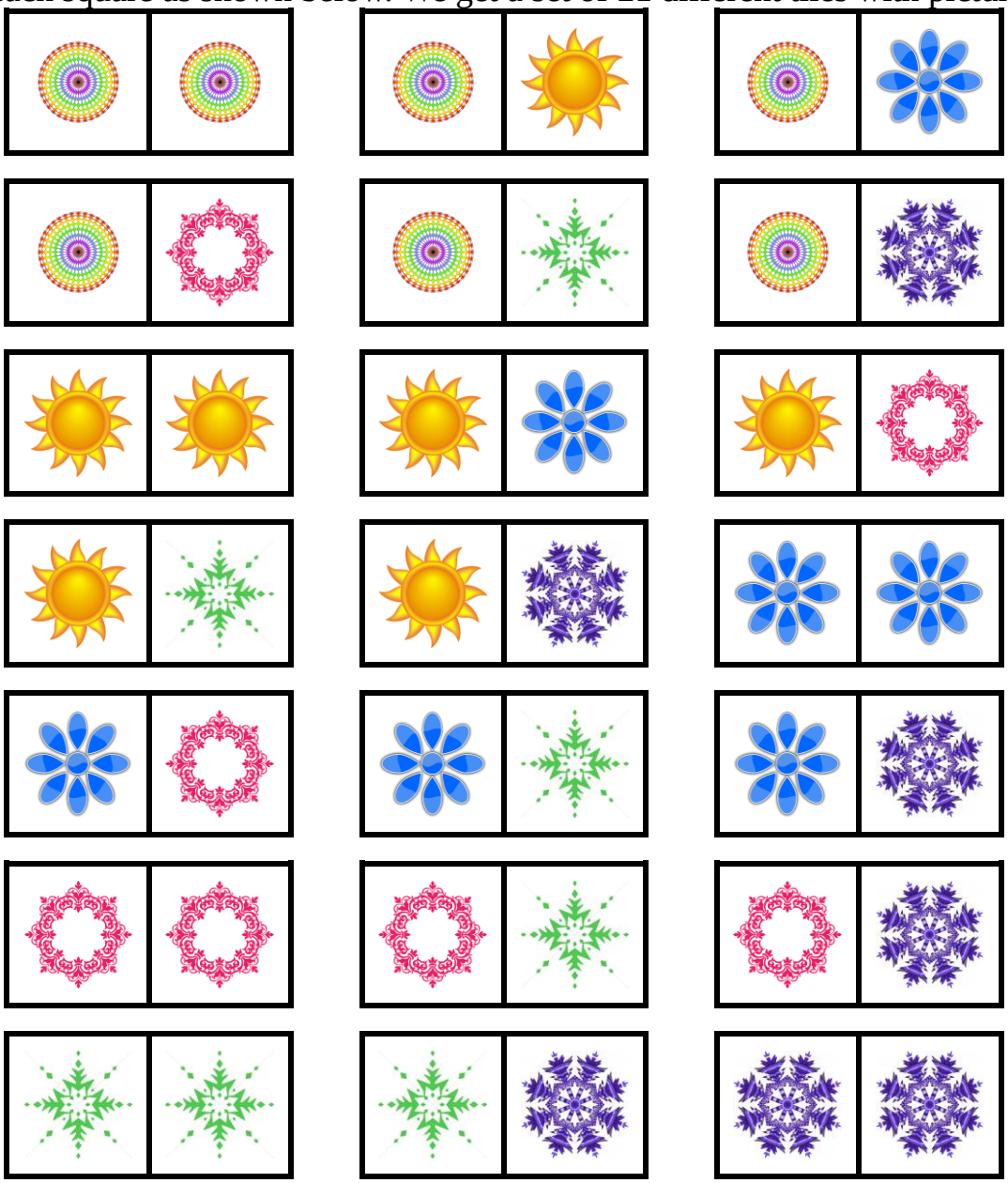
International Mathematics and Science Olympiad 2019

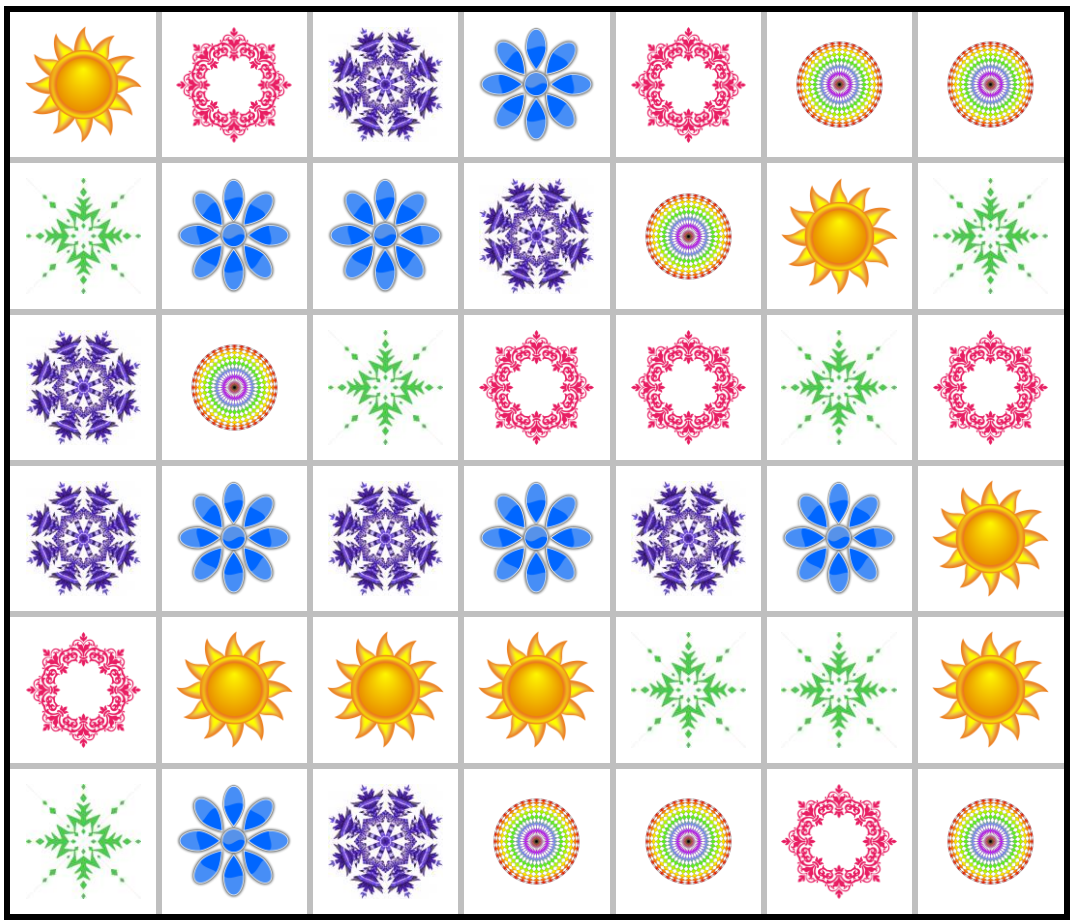
EXPLORATION PROBLEMS

(1) Two six-digit numbers 123459 and 193452 are multiples of 7. Use the digits 1, 2, 3, 4, 5 and 9 each exactly once to form ten more different six-digit numbers that are also multiples of 7.

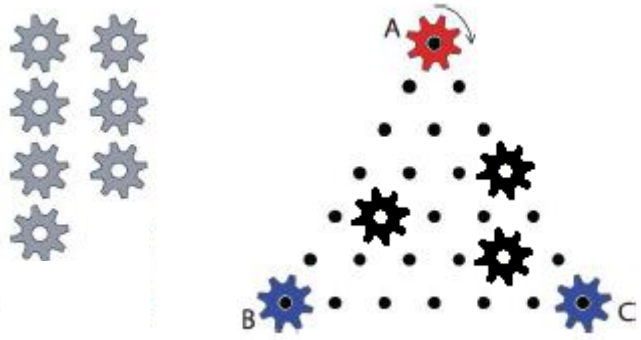
(2) Connect two unit squares side by side to form 2×1 tiles, and draw pictures in each square as shown below. We get a set of 21 different tiles with pictures.



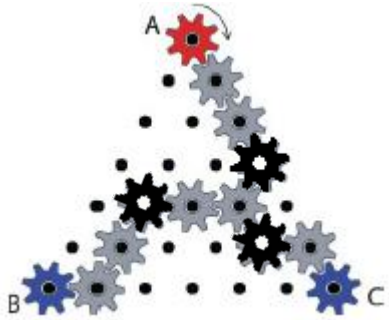
These 21 tiles are placed in a 6×7 grid, as shown in the figure below.
Each tile is used exactly once, it can be rotated and placed in the grid either horizontally or vertically. The borders of the tiles are then erased and one can only see the grid with the pictures. Find the locations of the 21 tiles shown above in the grid below, by drawing the border of each tile.



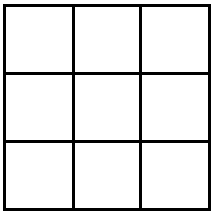
(3) Given the figure below. Find as many ways as possible to put 7 more gears into the triangular board so that we can move the gears B and C simultaneously by moving the gear A. (Gears can be mounted only on the given points and a gear can move another gear only if the two gears are mounted around adjacent dots.)



For example, we can put 7 more gray gears as in the following picture to be able to move the gears B and C simultaneously by moving the gear A.

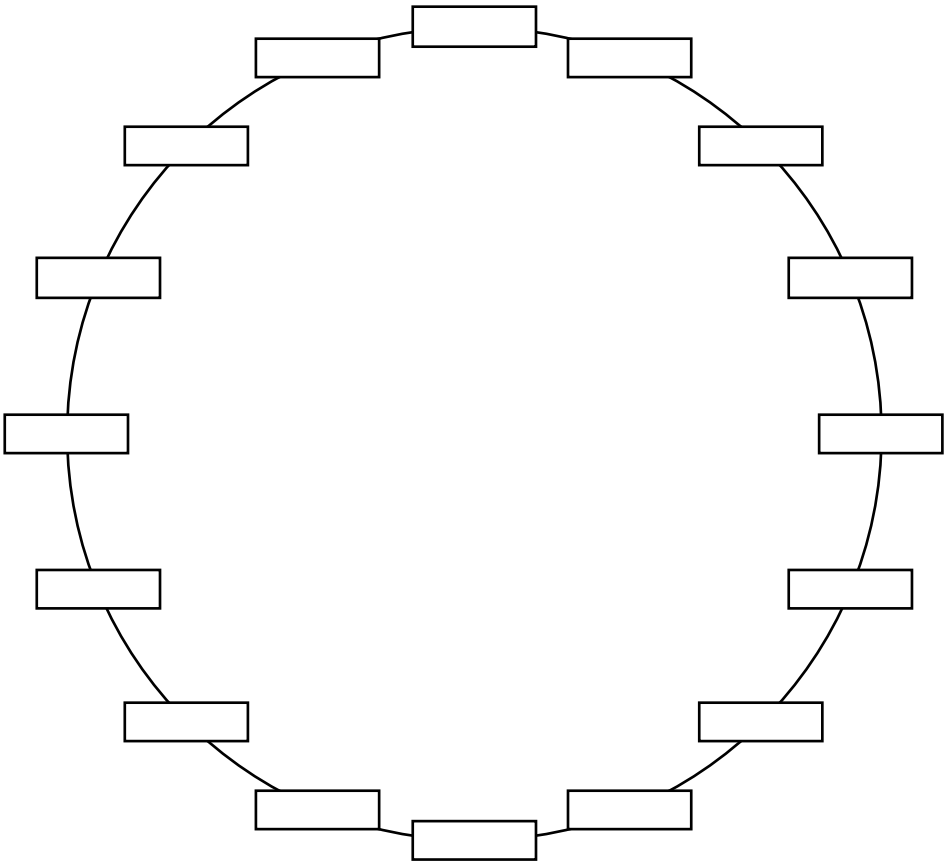


(4) In how many ways can two identical checkers be placed on the 3×3 grid shown in the figure below, so that each checker is placed in only one cell, and each cell has at most one checker? Draw all the possible ways on the answer sheet. (Note: If one can obtain one arrangement from another by rotation, then these two arrangements will be consider as only one arrangement.)

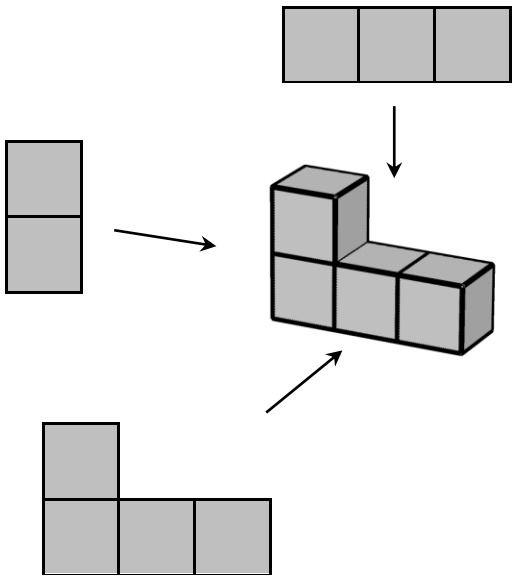


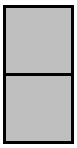
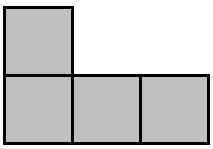
(5) Four digits, each is 0 or 1, are written on each of the following 16 cards. Place them in a circle, so that any two adjacent cards differ in exactly one place. For example, 0101 and 0111 differ in exactly one place, 0101 and 0110 differ in two places. It is not allowed to flip or rotate cards.

↑ 0 0 0 0	↑ 0 1 0 0	↑ 1 0 0 0	↑ 1 1 0 0
↑ 0 0 0 1	↑ 0 1 0 1	↑ 1 0 0 1	↑ 1 1 0 1
↑ 0 0 1 0	↑ 0 1 1 0	↑ 1 0 1 0	↑ 1 1 1 0
↑ 0 0 1 1	↑ 0 1 1 1	↑ 1 0 1 1	↑ 1 1 1 1

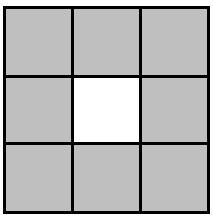
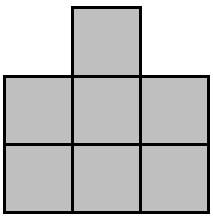


(6) When drawing, engineers use projections to represent 3D objects. For example, the L-shape is represented by three views, which are projections from the front, from the side and from the top.

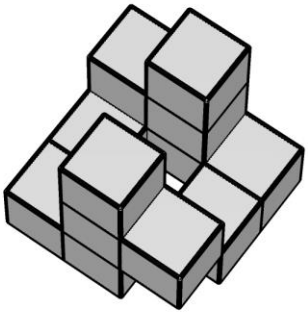


Top view: , side view:  , front view: 

An object has the following top view and front view:

Top view:  and front view: 

Moreover, it is known that the object is composed of 13 unit cubes. These cubes are connected as one piece via face to face adjacencies. Two cubes are face to face adjacent if they have a common face.
For example, the following shape satisfies all previous conditions.



Draw all possible side views of this object on your answer sheet.