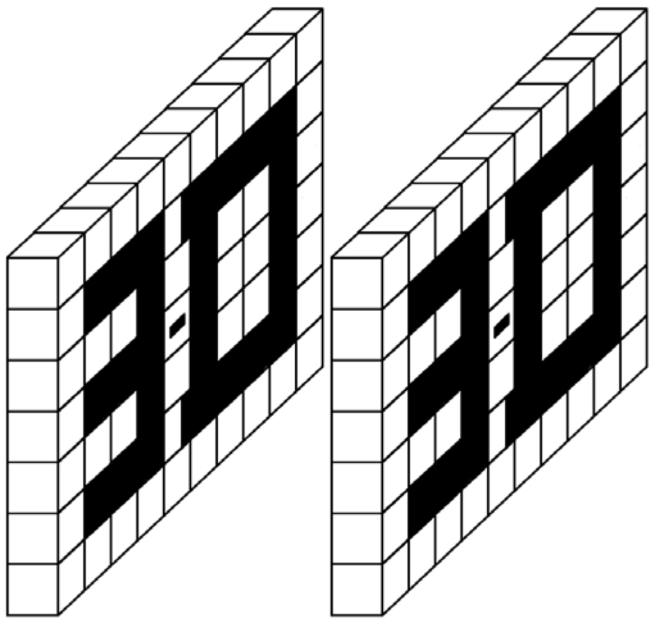
Three Dimensional
– 3D –
Spatial Development



Deductive Rectilinear Understanding
Part 2 of 3

Grades 4 through 12

Blaine A. Helwig

December 2017

Three (3) Dimensional Spatial Development

Deductive Series – Part 2 of 3

Rationale, 3D Unit Scope and Pedagogical Recommendations

Rational – Developing Three (3) Dimensional Spatial Abilities

This unit – Part 2 of 3 – assumes students have successfully completed part one (1) of this three part series on three dimensional – rectilinear spatial development.

These three unit series are designed to build students' (fourth grade and older) spatial ability. A fourth or fifth grader may be able to only complete the first two units of the three; however, if specific students demonstrate an aptitude in this cognitive area, they may be capable of completing all three units. The second part – three (3) dimensional unit is entitled 'Deductive Series – Part 2 of 3' – since the student is transitioning from the general solution to a specific – and singular isometric drawing. Students draws a three dimensional isometric drawing based on its four (4) – two (2) dimensional orthographic projections – Front, Right-Side, Left-Side and Top. Each of the four perspectives are viewed only from that perspective – meaning what can be seen from ONLY that view. The grids are shaded accordingly for each view. A sample problem is provided to illustrate the process.

The third part of this 3 dimensional series is a creative process in which students draw the three (3) dimensional isometric figure and creates the four (4) – two (2) dimensional orthographic projection views. In real world engineering applications, the design-creative stage is frequently an interactive process.

If students are guided and work deliberately through this development spatial rectilinear process, their cognitive ability will be greatly heightened. The benefits of developing three (3) dimensional cognitive ability assist students in the sciences, mathematics, technical applications as well as a general sense of navigating spatial relationships in their daily lives.

Three (3) Dimensional Scope of Deductive Series – Part 2 of 3

The inductive series begins with easier problems and then, gradually increase in difficulty. It is highly recommended that students work through all the problems in sequential order – one maximum per day. The scope of this unit is listed in the table below including a short description and a page location of each section.

Three (3) Dimensional Spatial Development – Induction Series – Part 1 of 3		
1	Rationale, Unit Scope and Pedagogy Recommendations	Pages 1 - 2
2	Sample Problem and Solution	Page 3
3	Student Isometric Mat – (use with interlocking cubes)	Page 4
4	Student Practice Problems 1 through 20	Page 5 - 25
5	Solutions to Student Practice Problems 1 through 20	Pages 26 - 29

Pedagogical Recommendations and Guidance

As in all classrooms, the teacher must consider their own teaching environment to adapt and teach the lessons based on several factors. First, the teacher must consider the grade level. This resource is designed for implementation over a range of grade levels – fourth through twelfth. For instance, a fifth grade teacher may decide to use only part 1 and part 2 of the 3D series at different problem levels. Second, if a class of students is designed by ability groupings (i.e. students classified as 'Talented and Gifted' or a 'STEM class), they may readily adapt to these exercises, regardless of grade level. Lastly, individual students in a self-contained classroom may possess heightened aptitude and readily be taught the enclosed 3D spatial lessons as an individual learning project. Finally, each teacher must evaluate and select the instruction level and implementation that best fit their students' needs when implementing spatial development problems.

The following recommendations are presented as general guidelines to enhance student learning in developing their spatial abilities using this three part resource series.

1.) As with all curricular programs, the teacher should work the problems and study the solutions thoroughly to ensure they completely understand the process prior to classroom implementation.
2.) Is highly recommended that the school purchase interlocking cubic blocks. For example, a thousand (1,000) different color interlocking cubes (i.e. 2 cm) costs approximately $30 dollars on Amazon.com.
3.) Prior to beginning these spatial problems, the teacher may consider building simple 3D isometric figures using the interlocking cubes – only 1 to 3 cubes initially – and students practice creating an isometric view of the objects to help them visualize a 3 dimensional object. This process should be done slowly and considerately – students will struggle at first, including students of heightened academic ability. However, again, with small amounts of deliberate practice, students rapidly become incredibly adept.
4.) The teacher should model this process with the students in a step-by-step process so all students learn to correctly visualize the spatial projection process.
5.) When beginning these problems, the student should build the shape in three (3) dimension using interlocking cubes to visualize the three (3) dimensional isometric figure.
6.) The student can use the isometric student mat (e.g. Xerox on 60 bond weight paper and laminated for multiple school year use). Students should orient their interlocking 3D block figure correctly on the sheet to clearly observe the object from all orthographic projections/views. The student should view the isometric interlocking block figure for each orthographic projection and shade the corresponding cube faces.
7.) It is important to note the eventual goal is for the students to NOT use the interlocking blocks, and they complete the orthographic 2D projections via a mental process. However, with all new conceptual learning, the three (3) dimensional manipulative is essential during the initial stages of spatial learning.
8.) A successful technique is for the teacher to use parent volunteers that have been trained or specifically train 3 to 5 academically high students to assist teachers in the initial lessons. This method ensures that all students receive assistance and attention.
9.) Review the 'Sample Problem and Solution' notes for additional information.
10.) Hidden Lines are extremely important in orthographic projections to provide specific information on the shape of isometric figure that cannot be seen from a specific orthographic projection (i.e. front view, top view, etc.). Many students struggle with hidden lines. A hidden line can be either vertical or horizontal, and it is represented via a dashed line. However, since the grids are all solid black lines, the student can simply label a line segment as a 'hidden line.' See Figure 1 below.

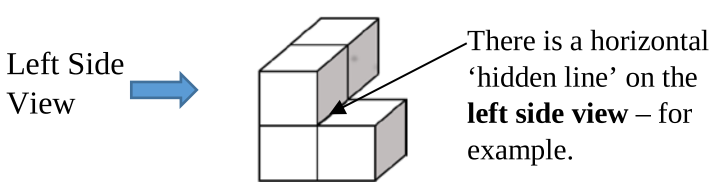


Figure 1

There is also a horizontal 'hidden line' on the **front view** and a vertical 'hidden line' on the **top view**.

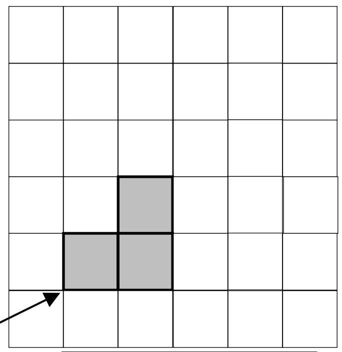
But, there is NOT a horizontal line on the **right side view**. All face edges can be seen in the **right side view**, and the hidden line in the **left side view** is depicted as a solid line segment – in the **right side view**.

Three (3) Dimensional Spatial Development

Deductive Series – Part 2 of 3

SAMPLE PROBLEM WITH SOLUTION

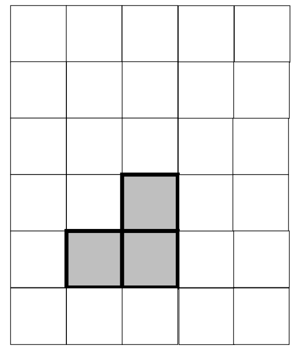
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, **draw** the three (3D) dimensional isometric view. Start the Front View at Point 'A'.



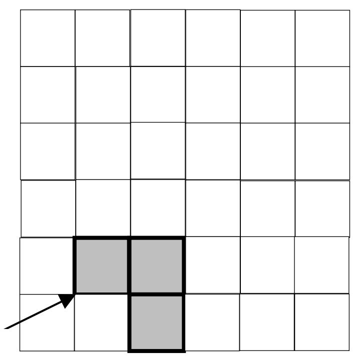
Point 'A'

FRONT VIEW

Note: It is initially recommended that students build the isometric figure with interlocking cubes and then check the orthographic projections for accuracy.

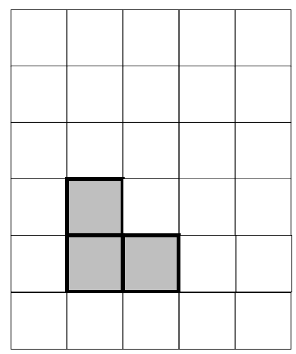


RIGHT SIDE VIEW

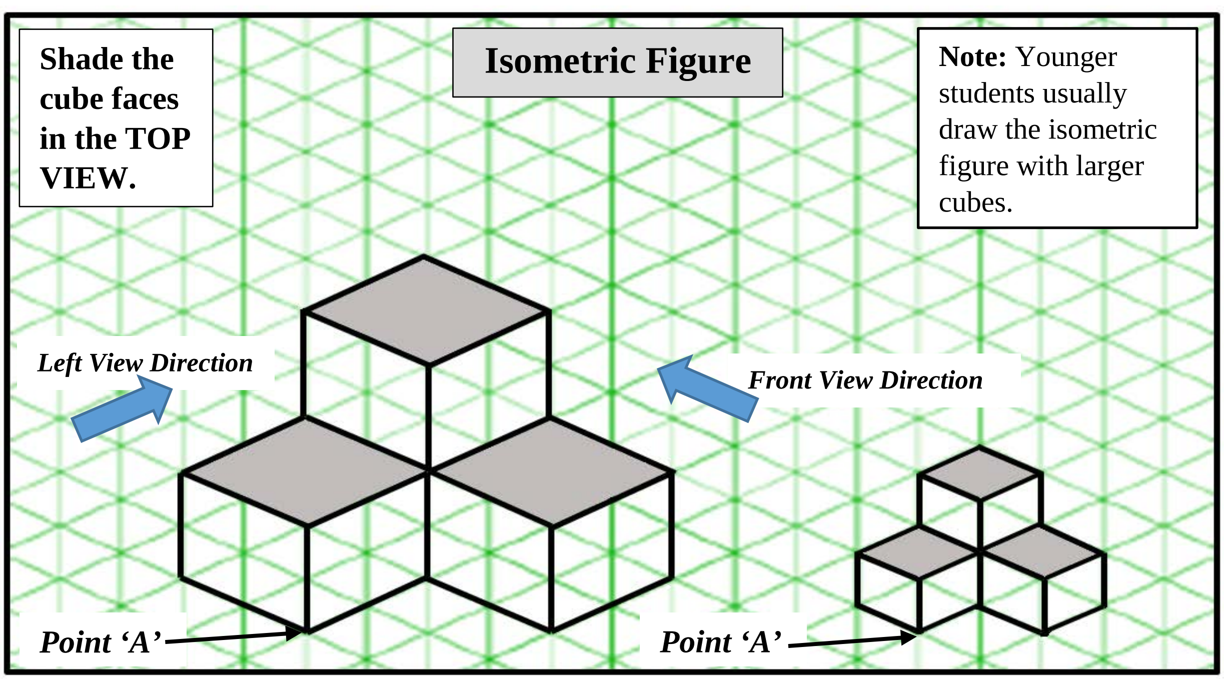


Point 'B'

TOP VIEW



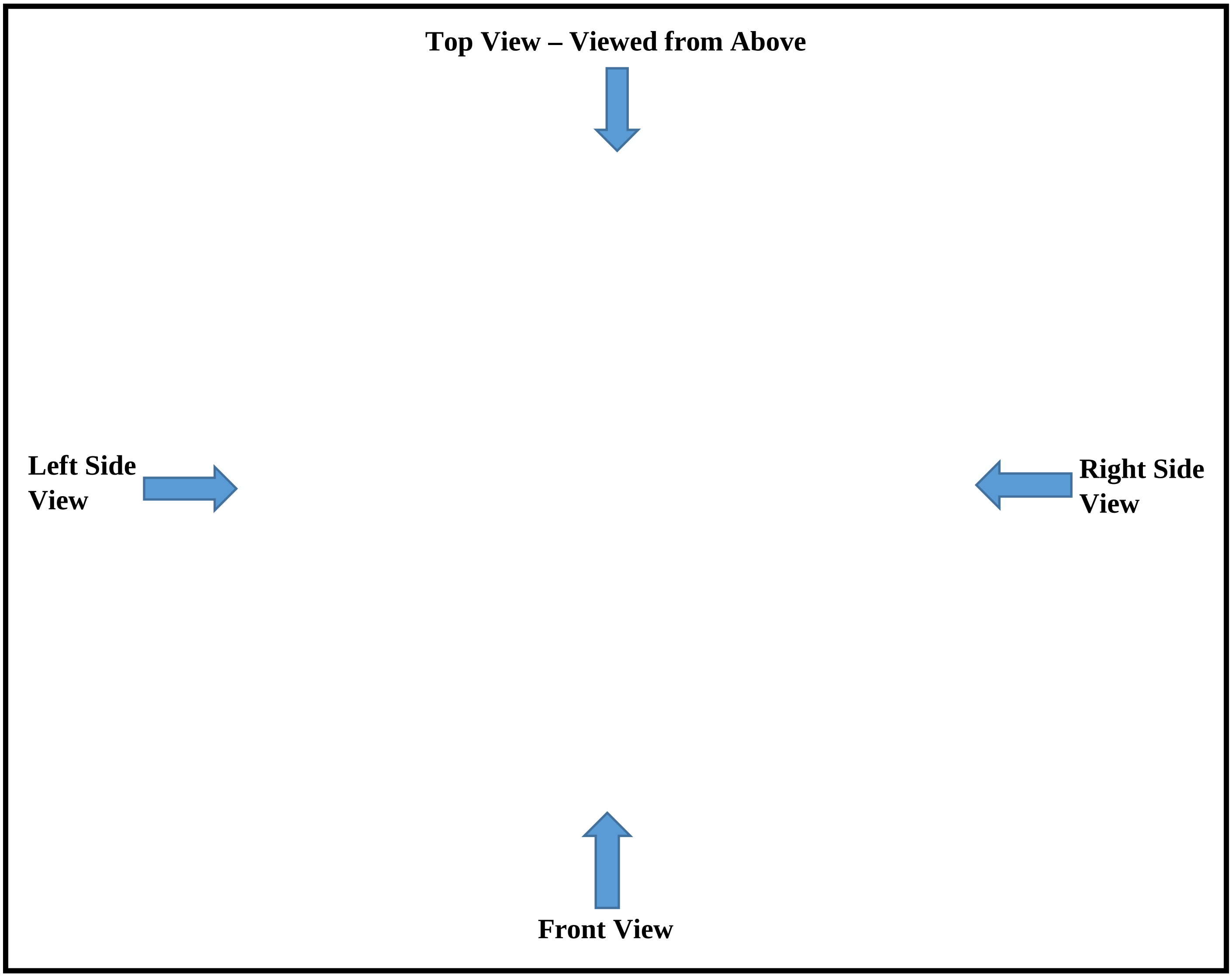
LEFT SIDE VIEW



Three (3) Dimensional Spatial Development

Deductive Series – Part 2 of 3

STUDENT ISOMETRIC MAT



Directions:

Place the isometric figure in the box above with Front of the Isometric Figure correctly facing the 'Front View.'

The 'Top View' is viewed **from** the Front View – as labeled above on the mat.

Turn the Mat – 90 degrees – to the left or right to view the Isometric Figure from either the Left or Right View.

Shade for the FACE of each cube in the correct position on the grid provided at the bottom of the Problem Sheet. Shade the Front View first, starting at point 'A' on the grid.

Student Practice Problems 1 through 20

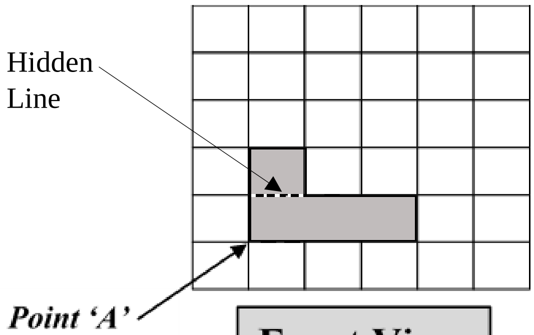
Deductive – Part 2

Three (3) Dimensional Spatial Development

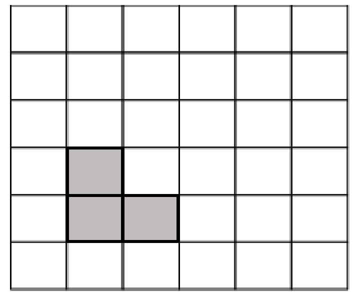
Deductive Series – Part 2 of 3

PROBLEM NUMBER 1

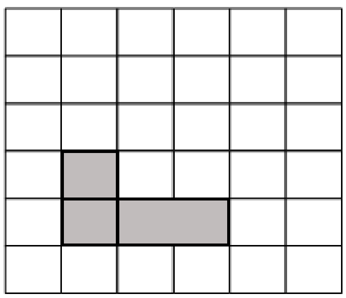
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point ‘A’.



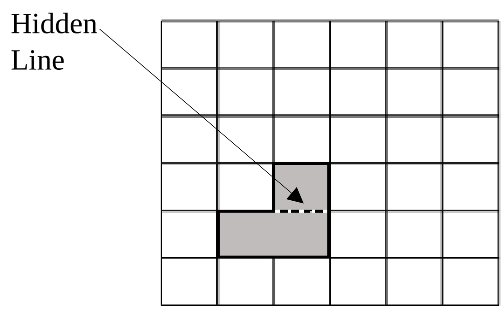
Front View



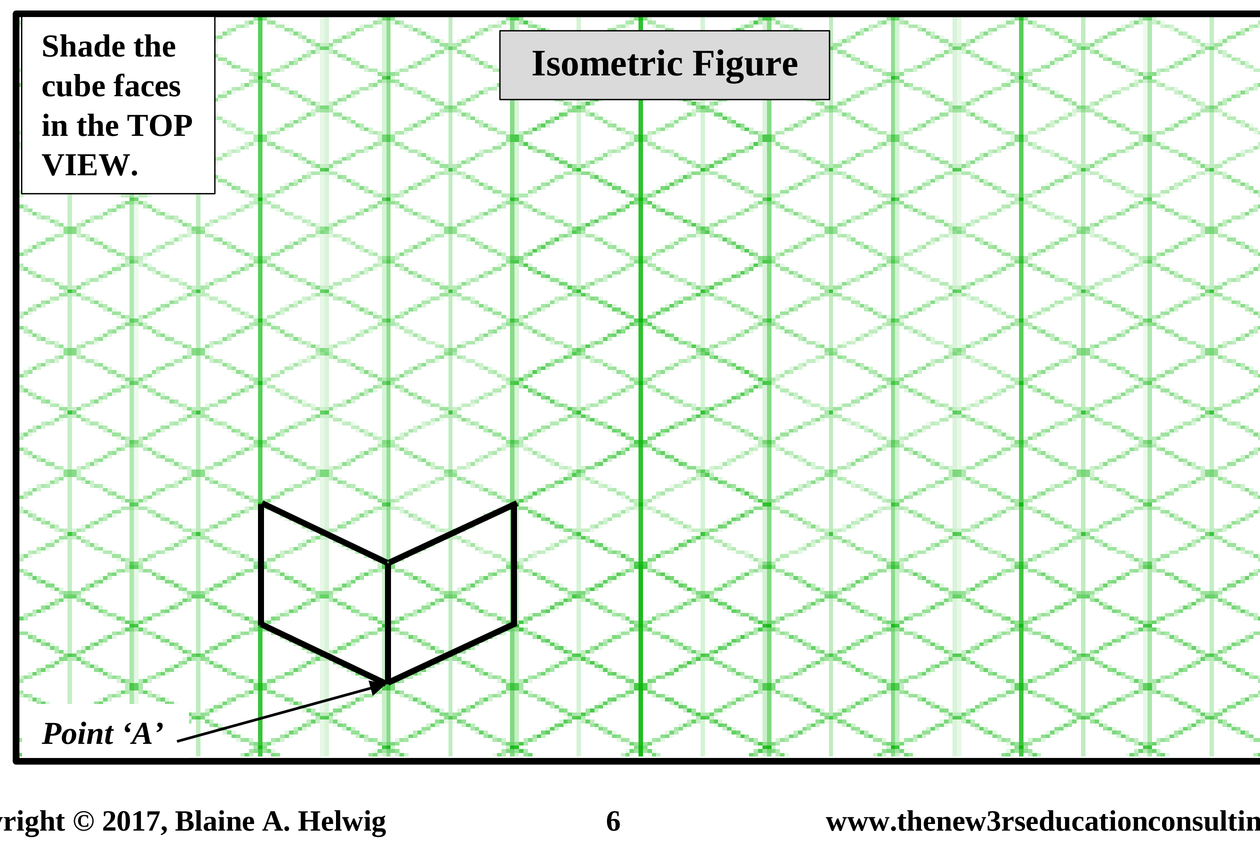
Right Side View



Top View



Left Side View

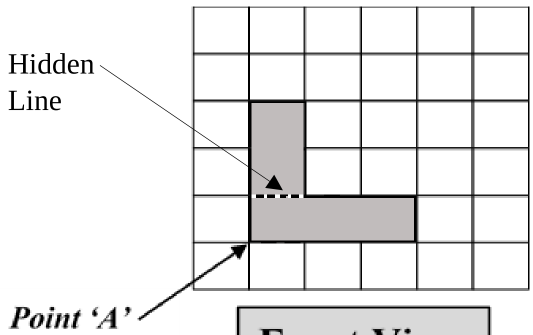


Three (3) Dimensional Spatial Development

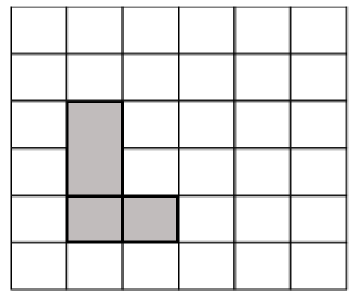
Deductive Series – Part 2 of 3

PROBLEM NUMBER 2

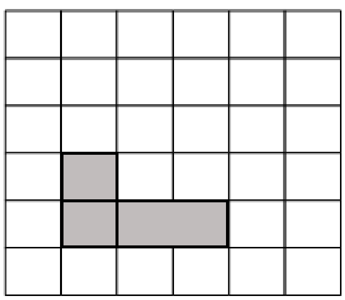
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point 'A'.



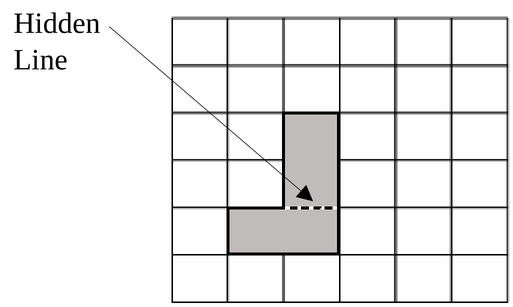
Front View



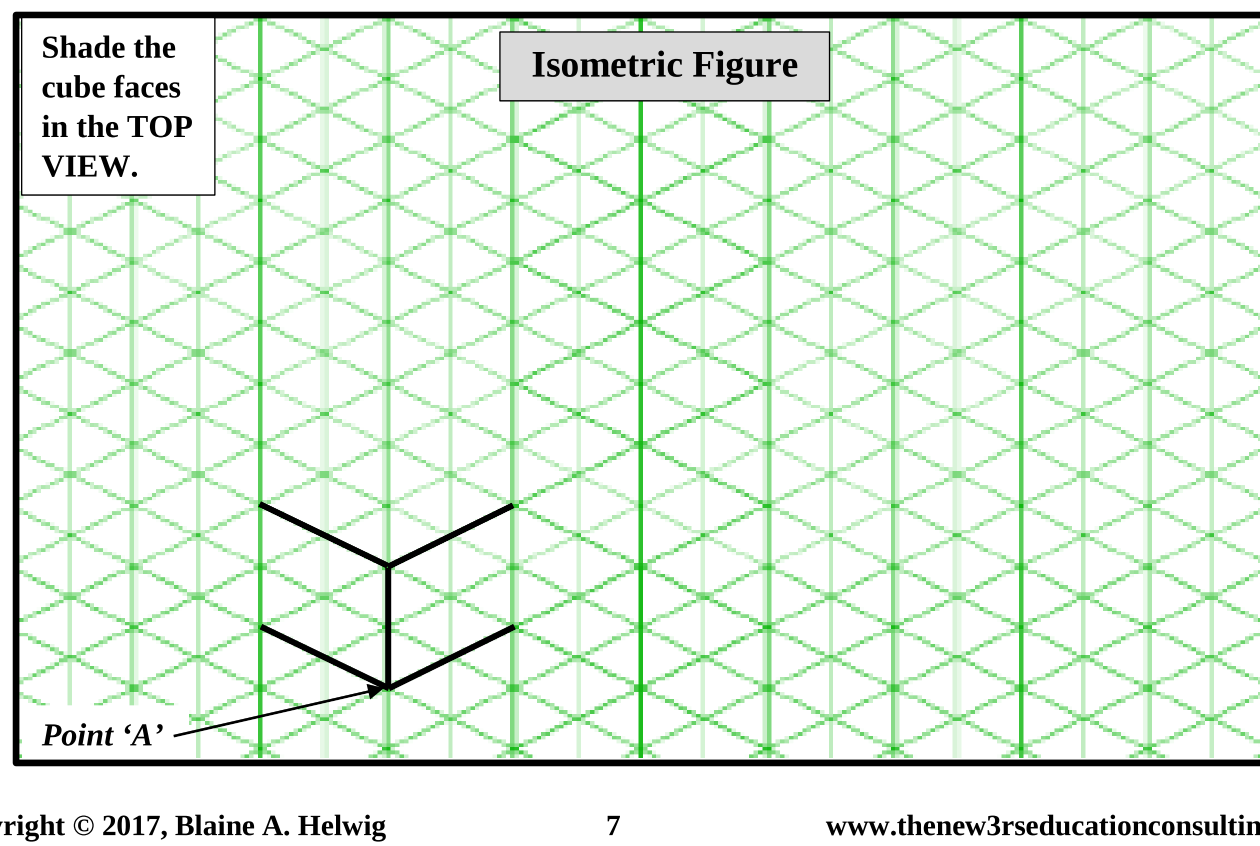
Right Side View



Top View



Left Side View

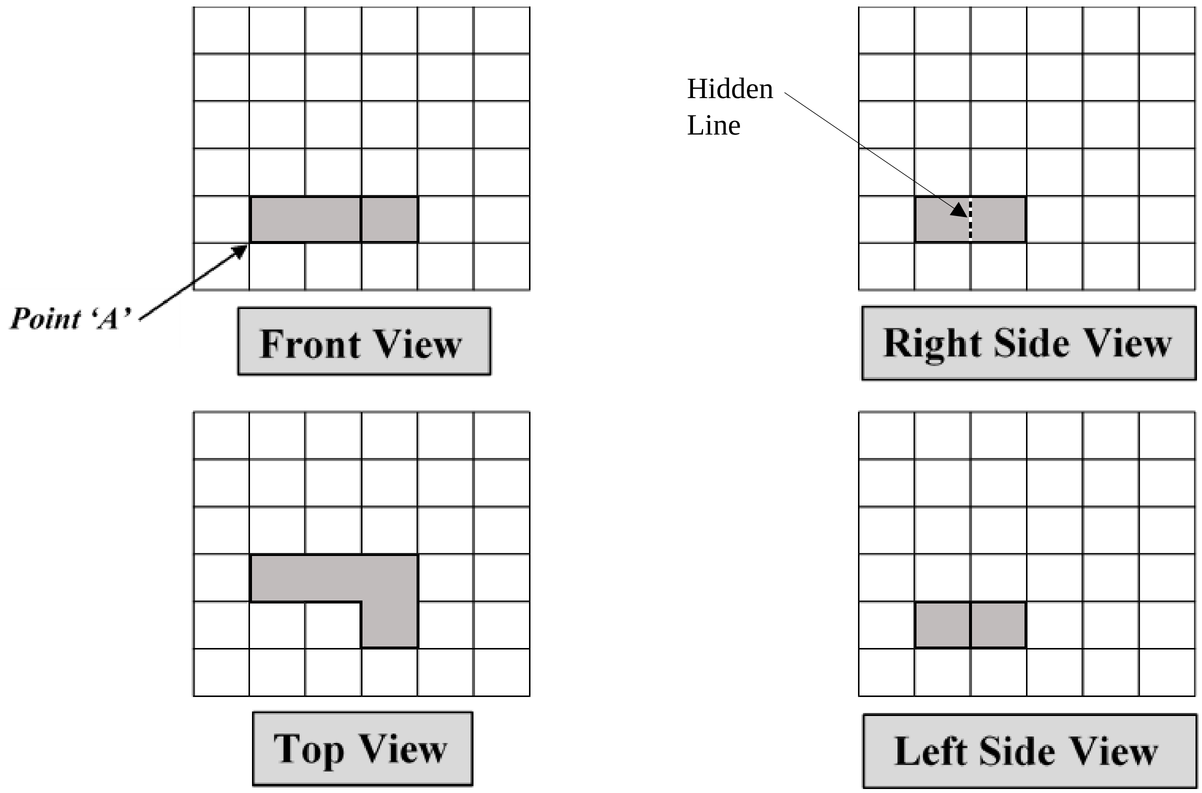


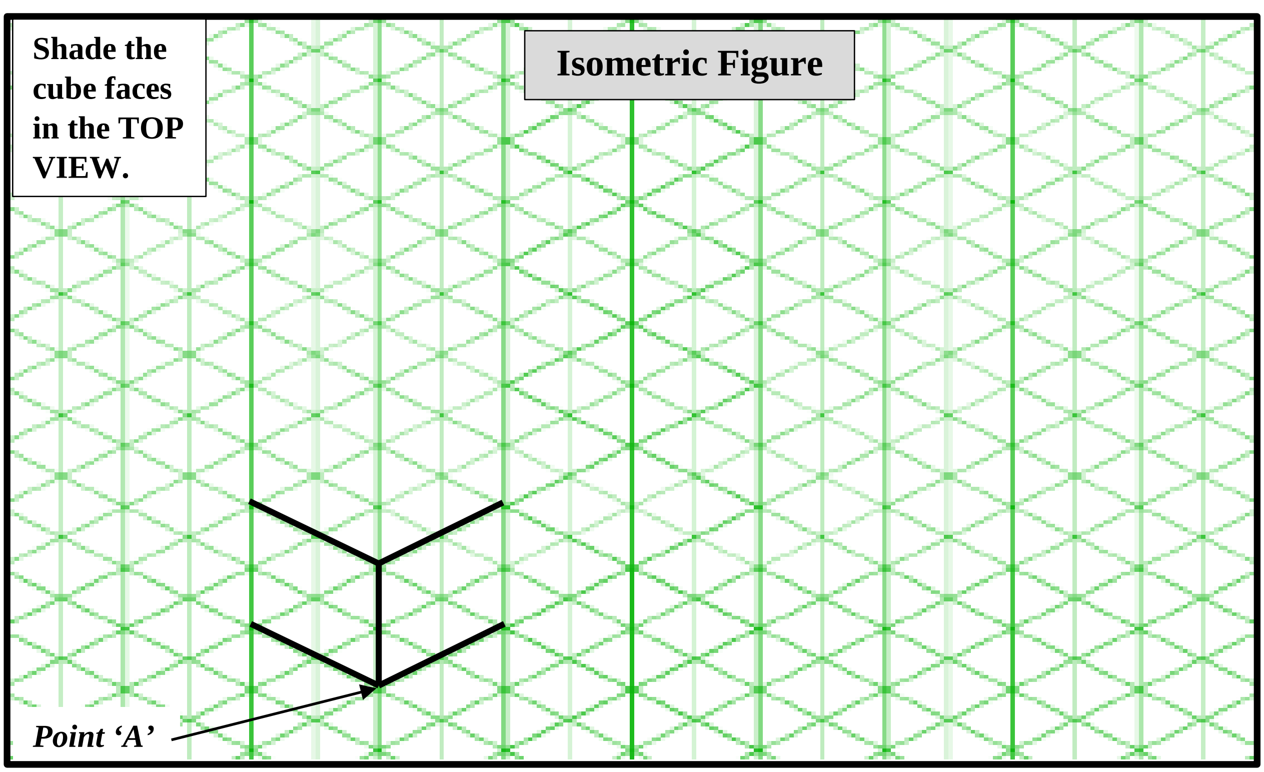
Three (3) Dimensional Spatial Development

Deductive Series – Part 2 of 3

PROBLEM NUMBER 3

Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point ‘A’.



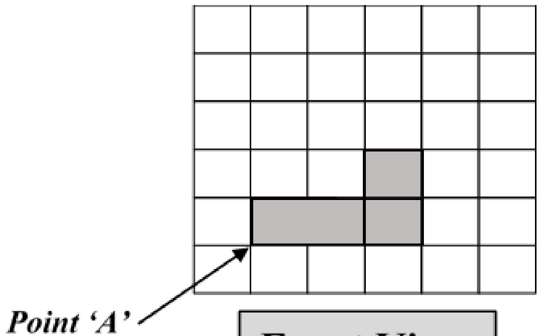


Three (3) Dimensional Spatial Development

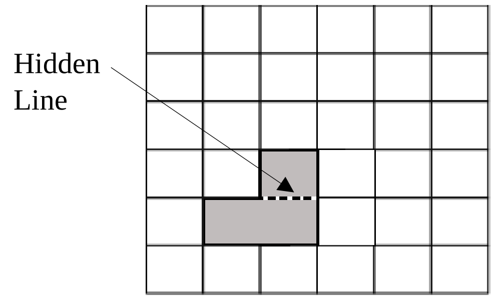
Deductive Series – Part 2 of 3

PROBLEM NUMBER 4

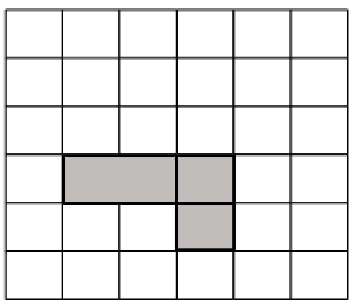
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point 'A'.



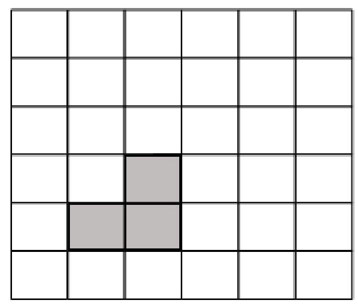
Front View



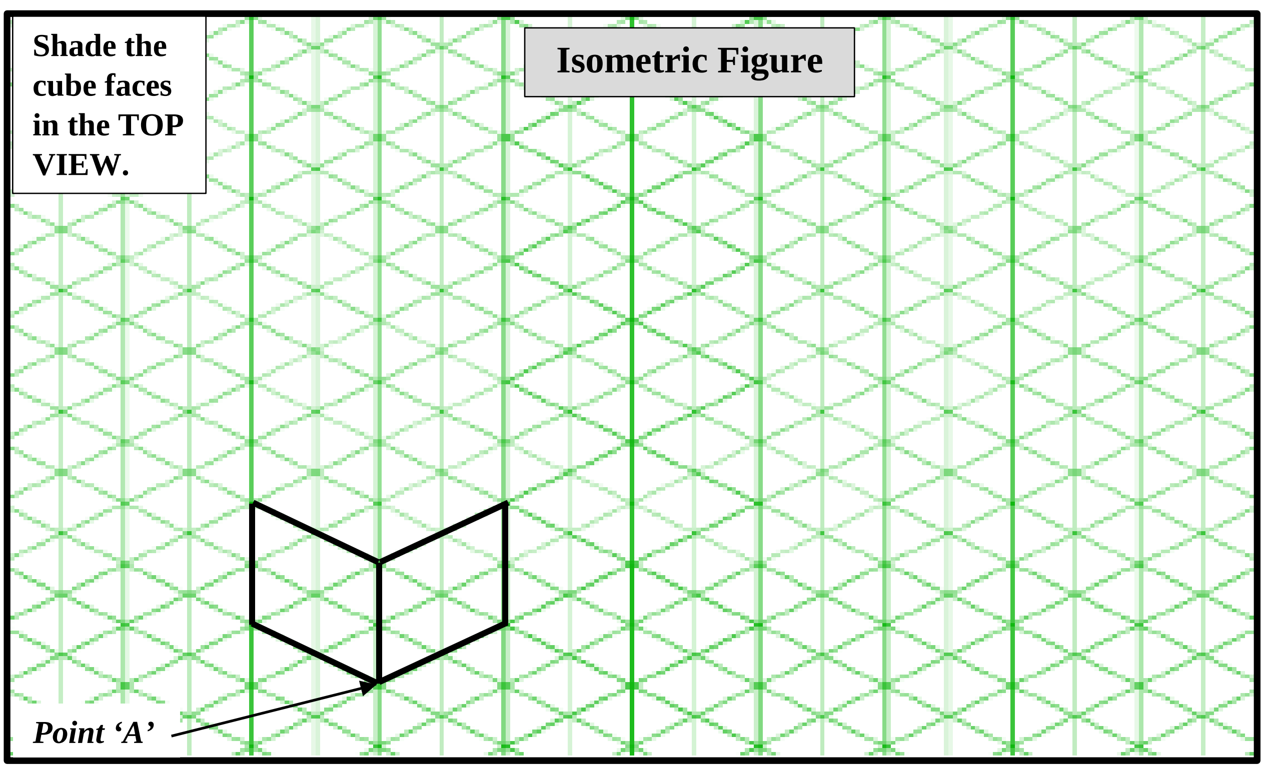
Right Side View



Top View



Left Side View

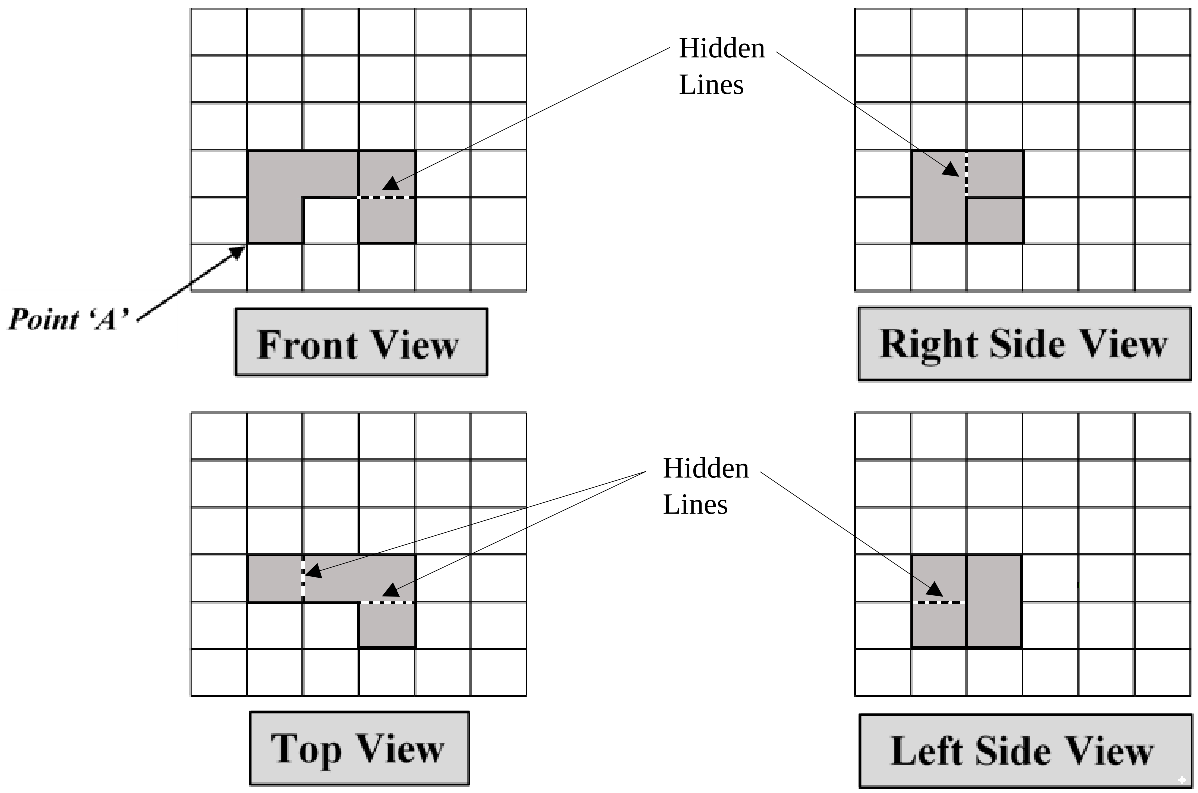


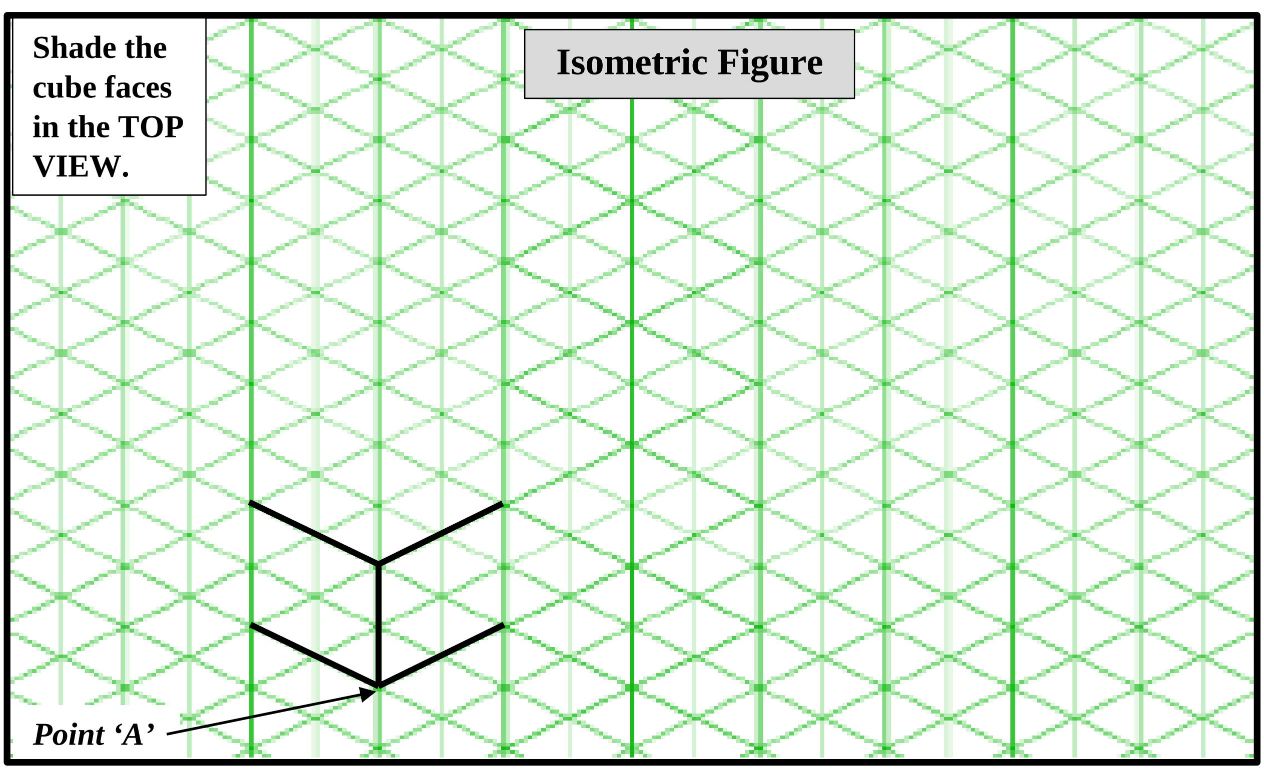
Three (3) Dimensional Spatial Development

Deductive Series – Part 2 of 3

PROBLEM NUMBER 5

Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point 'A'.



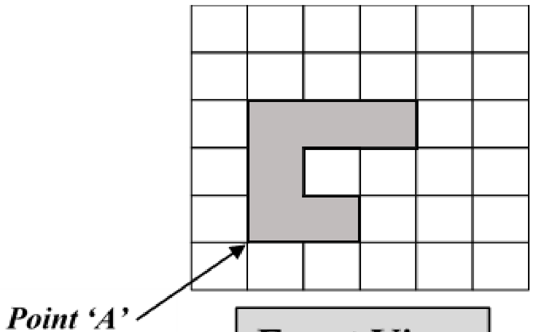


Three (3) Dimensional Spatial Development

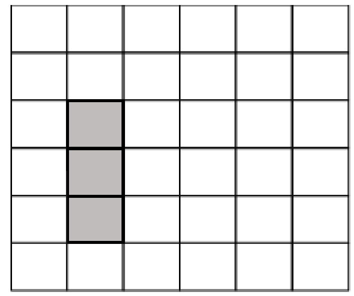
Deductive Series – Part 2 of 3

PROBLEM NUMBER 6

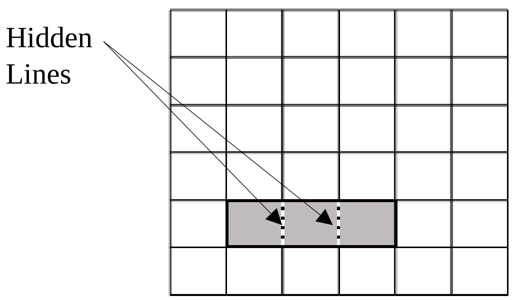
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point 'A'.



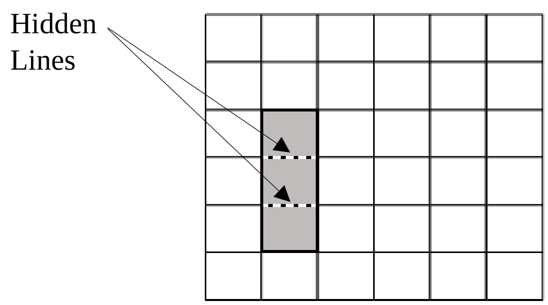
Front View



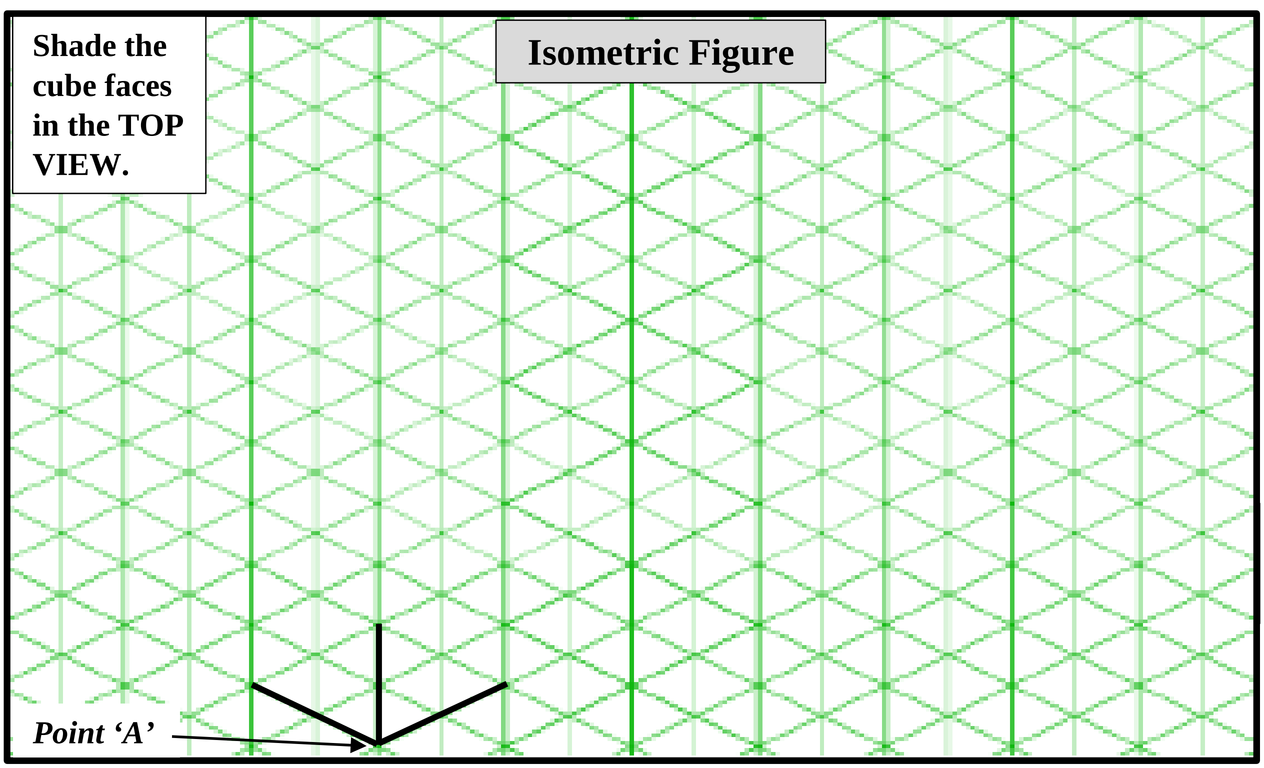
Right Side View



Top View



Left Side View

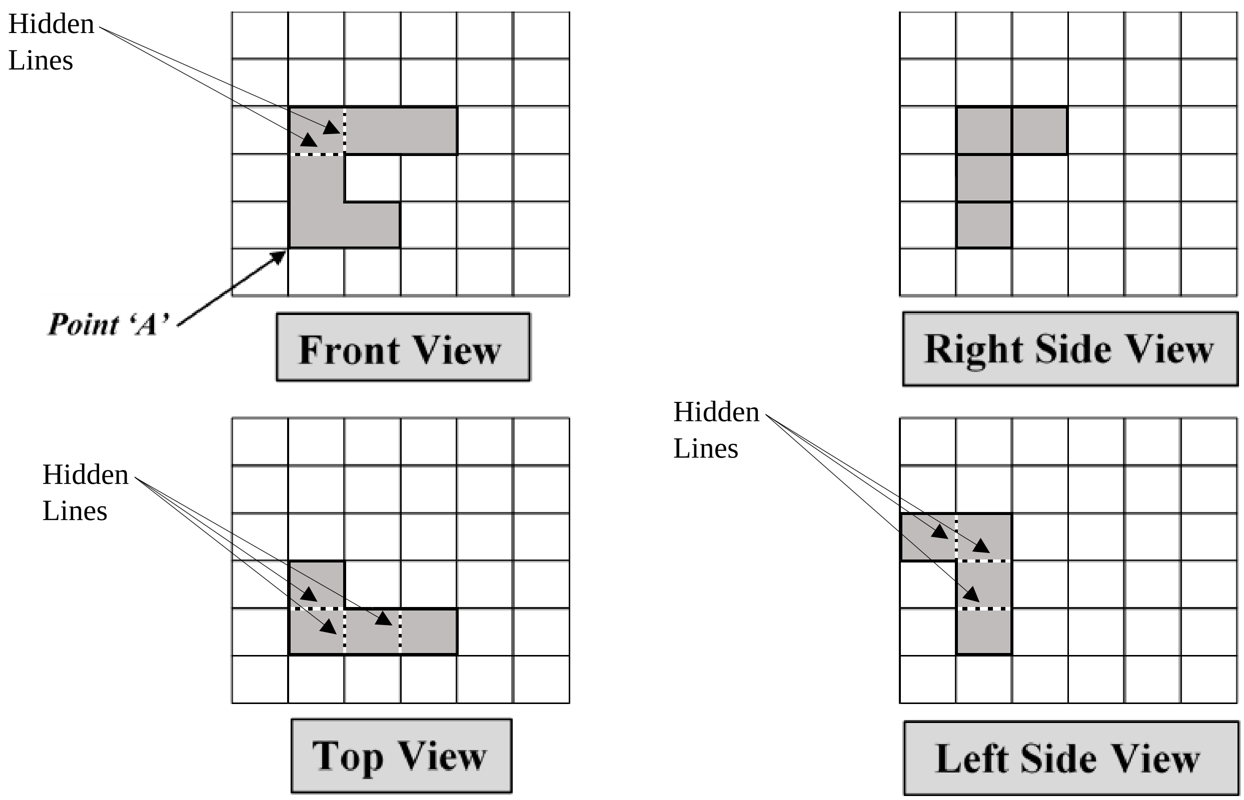


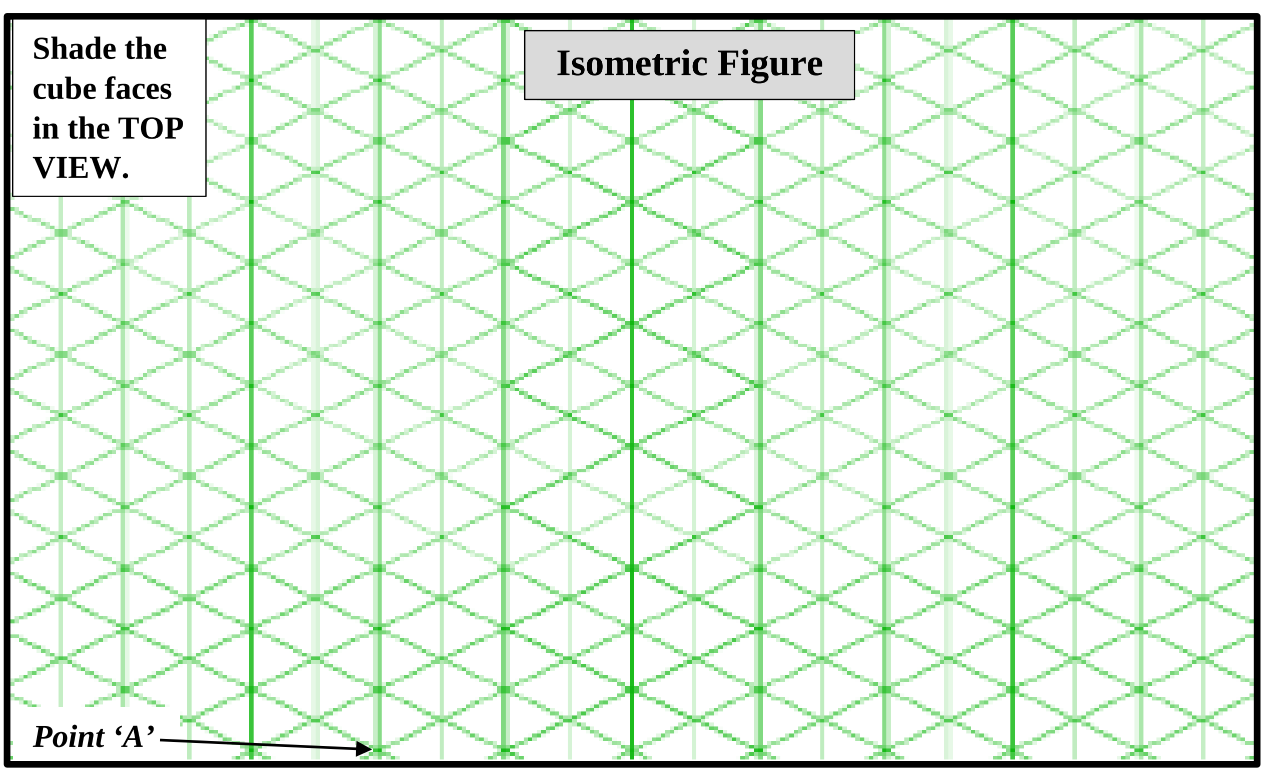
Three (3) Dimensional Spatial Development

Deductive Series – Part 2 of 3

PROBLEM NUMBER 7

Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point 'A'.



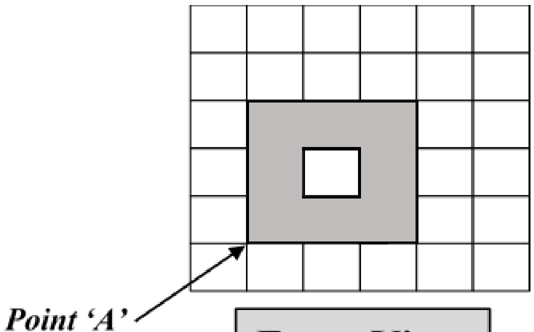


Three (3) Dimensional Spatial Development

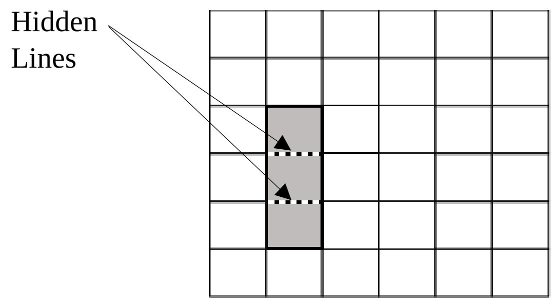
Deductive Series – Part 2 of 3

PROBLEM NUMBER 8

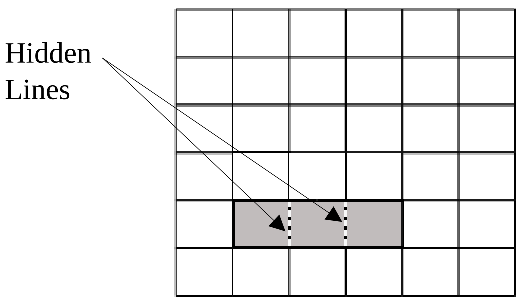
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point 'A'.



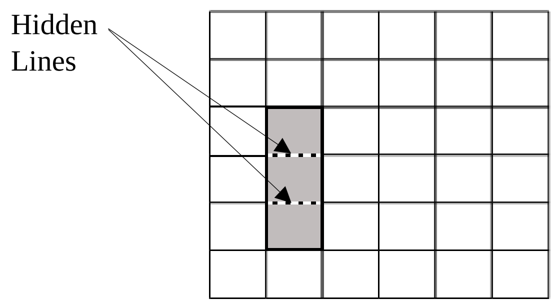
Front View



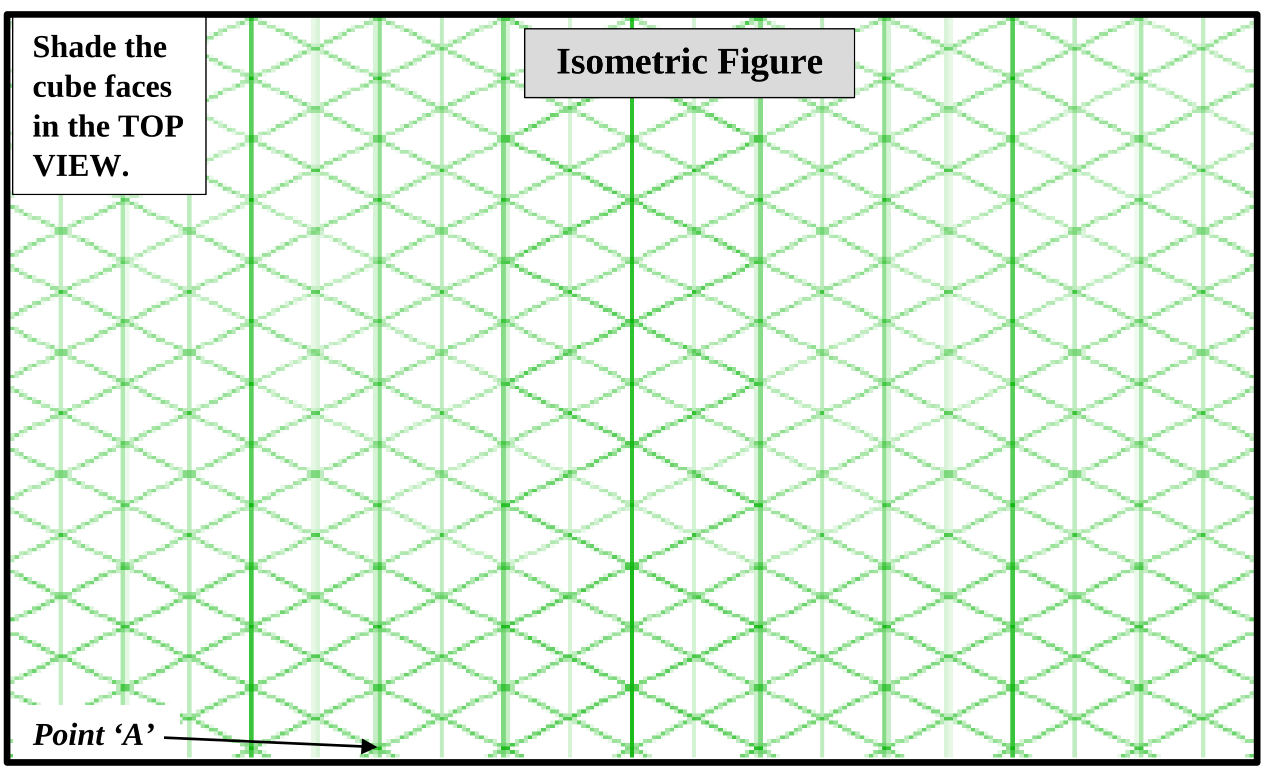
Right Side View



Top View



Left Side View

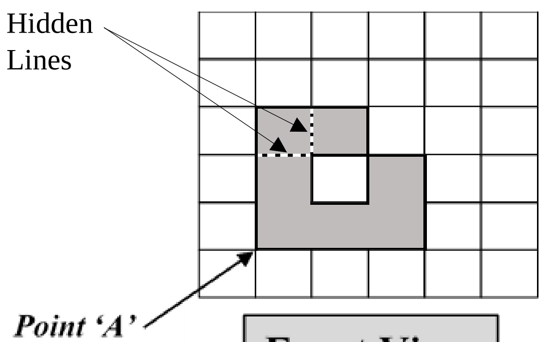


Three (3) Dimensional Spatial Development

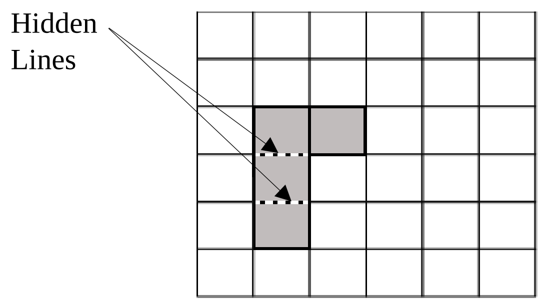
Deductive Series – Part 2 of 3

PROBLEM NUMBER 9

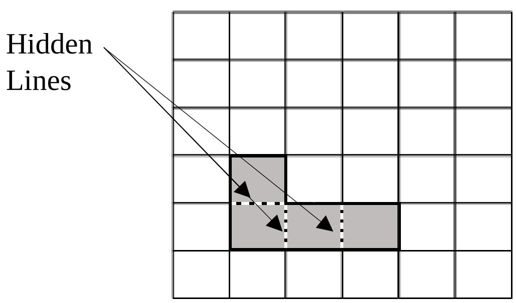
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point ‘A’.



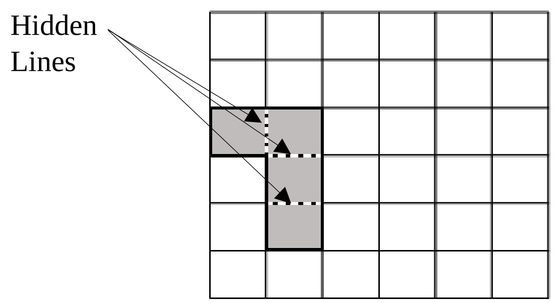
Front View



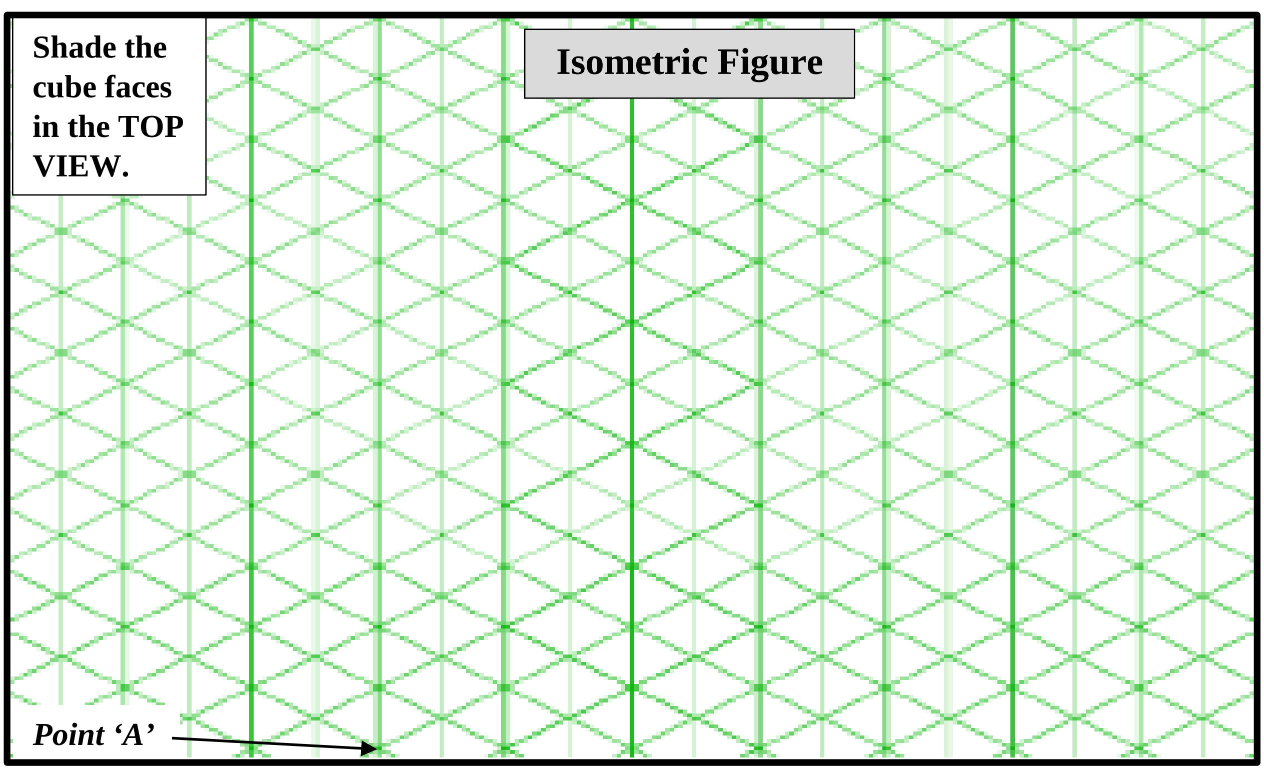
Right Side View



Top View



Left Side View

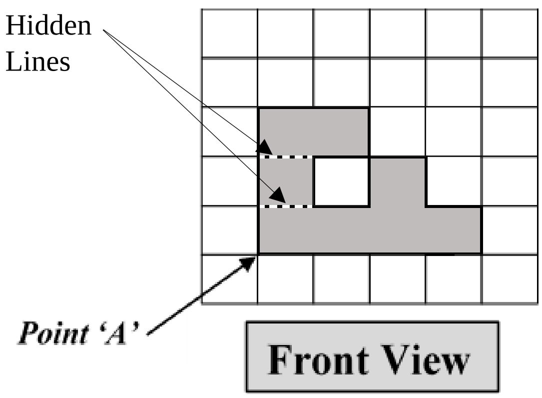


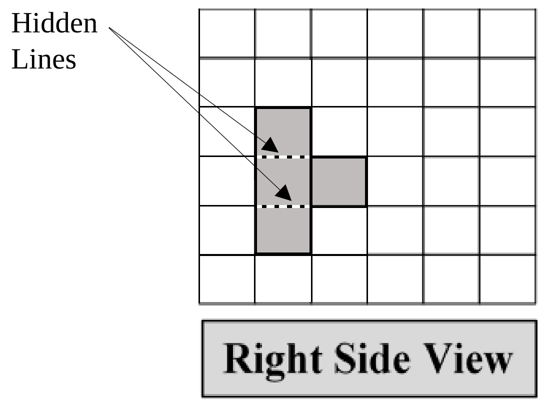
Three (3) Dimensional Spatial Development

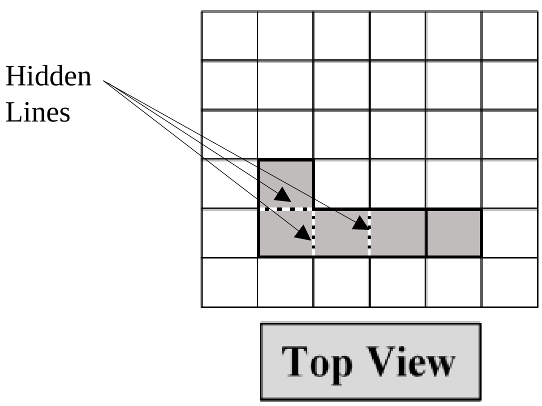
Deductive Series – Part 2 of 3

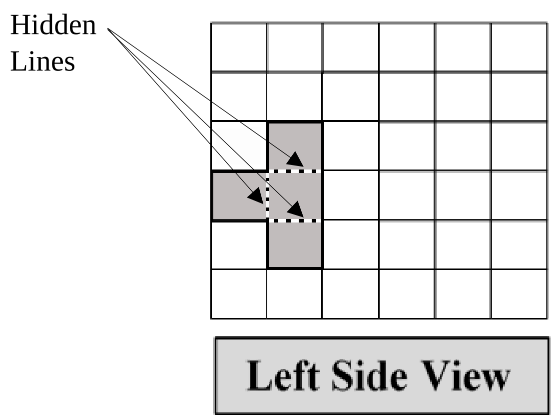
PROBLEM NUMBER 10

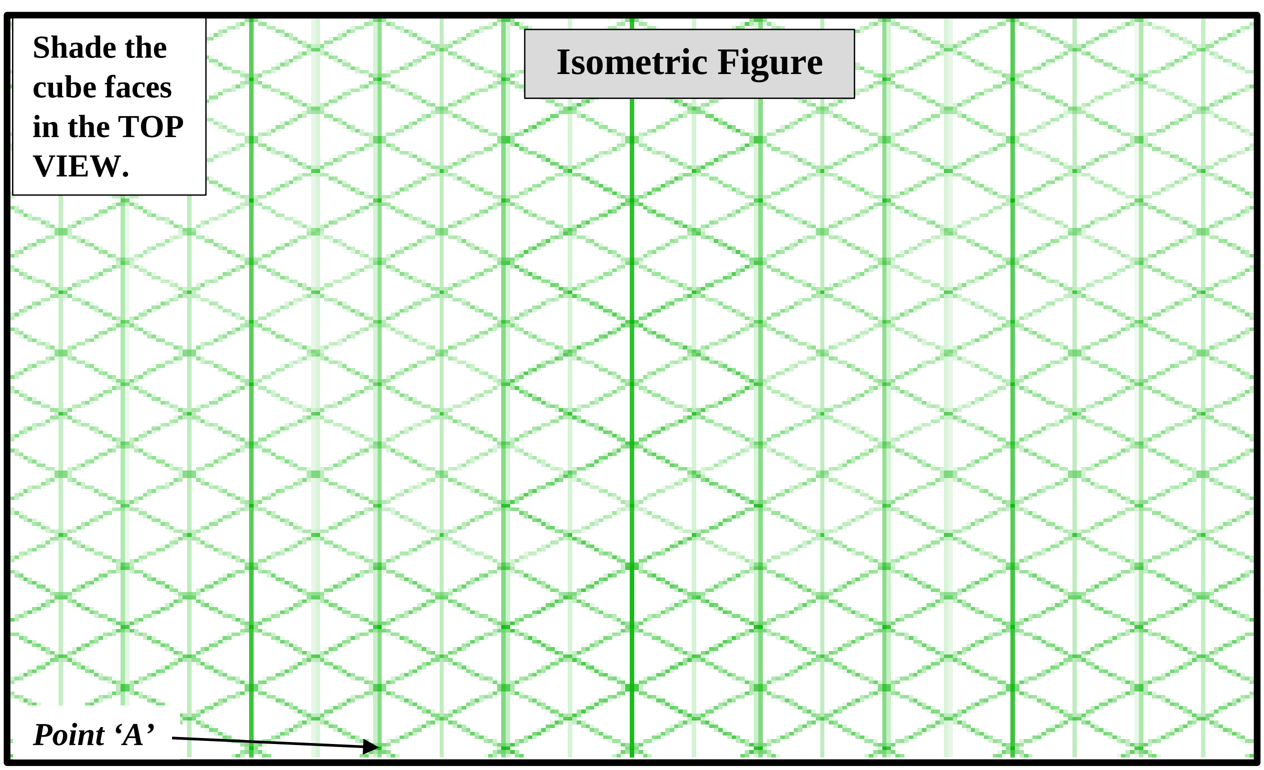
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point 'A'.









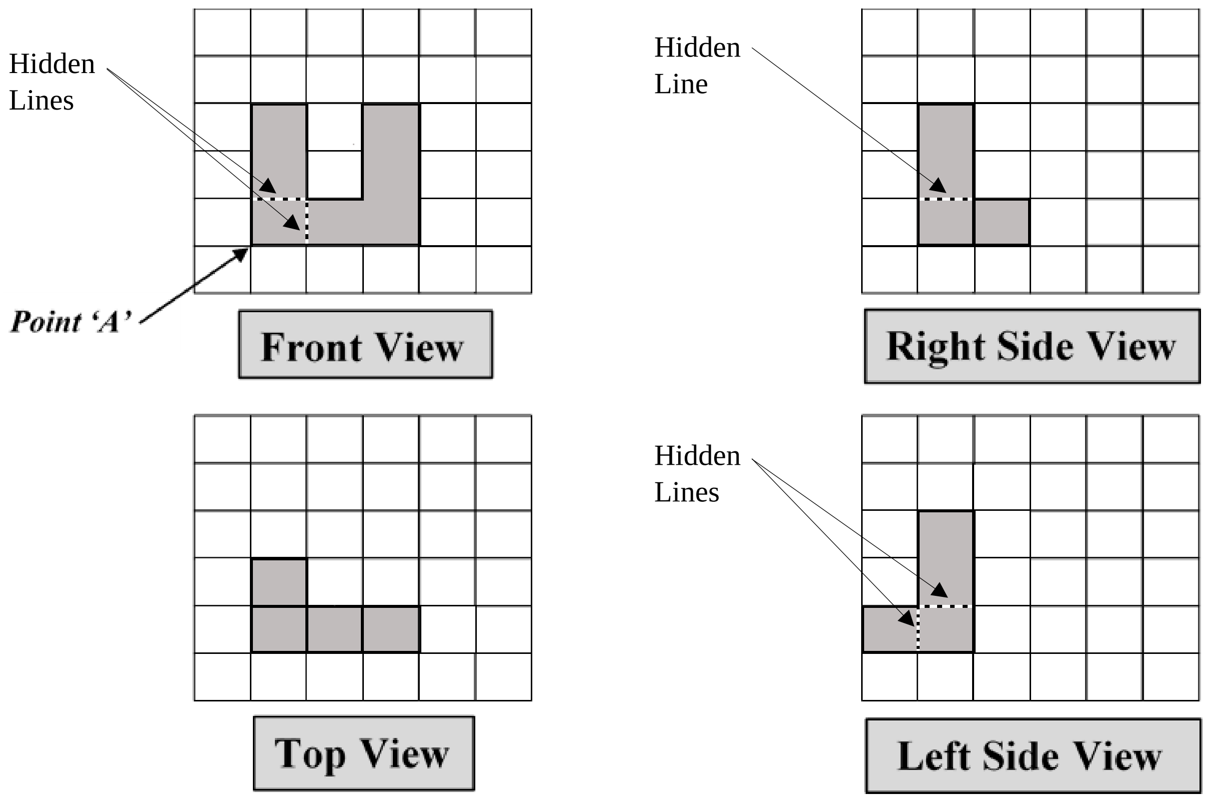


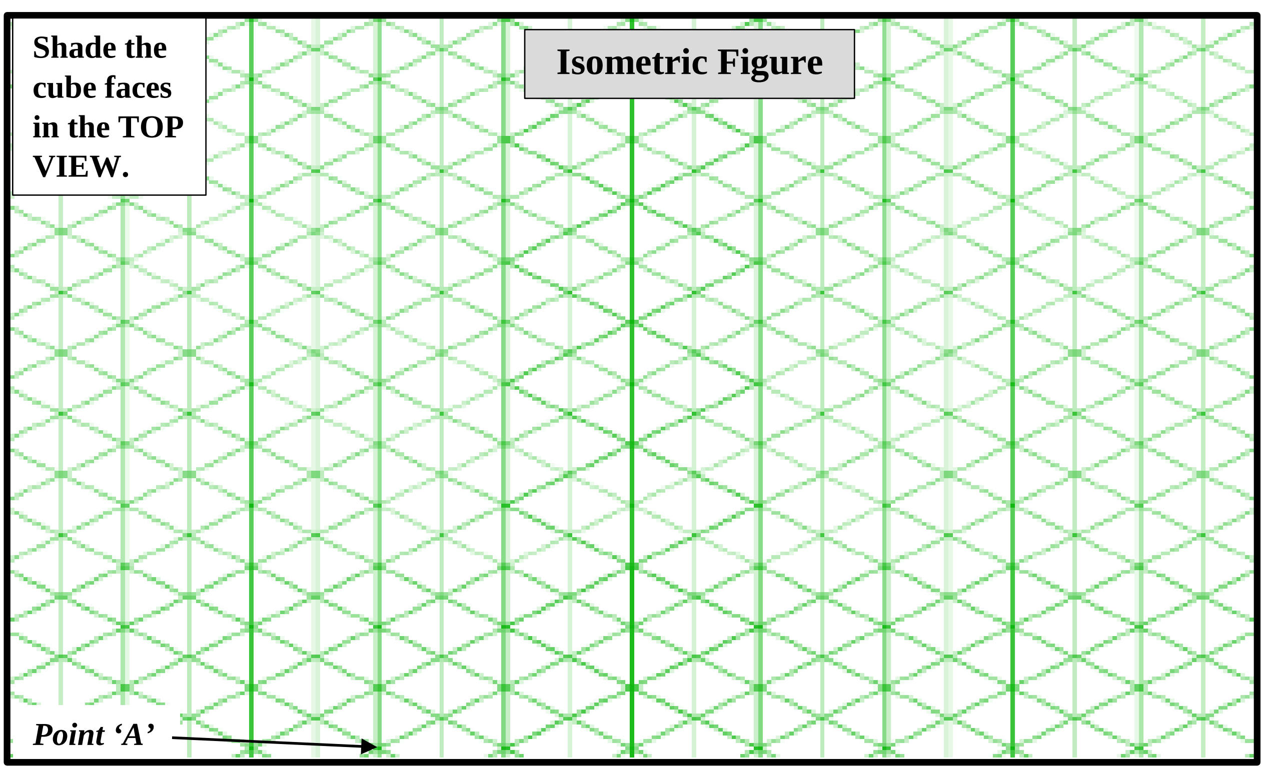
Three (3) Dimensional Spatial Development

Deductive Series – Part 2 of 3

PROBLEM NUMBER 11

Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point 'A'.



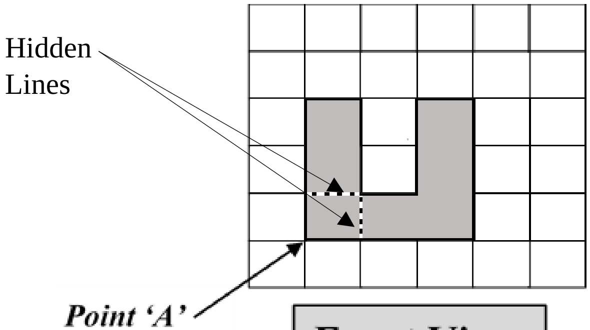


Three (3) Dimensional Spatial Development

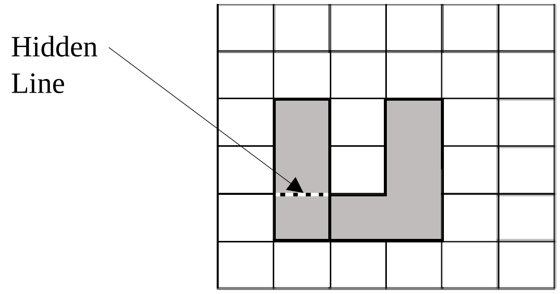
Deductive Series – Part 2 of 3

PROBLEM NUMBER 12

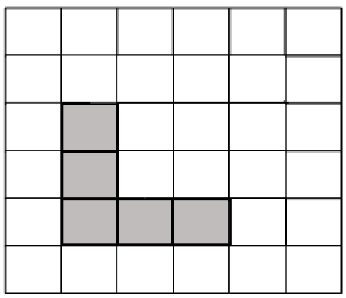
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point 'A'.



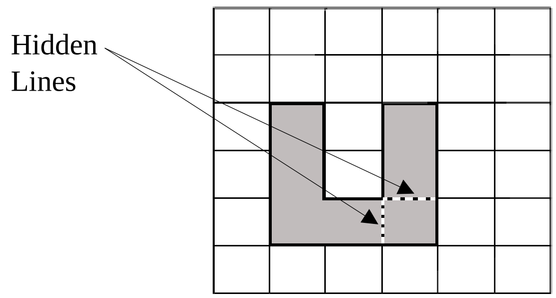
Front View



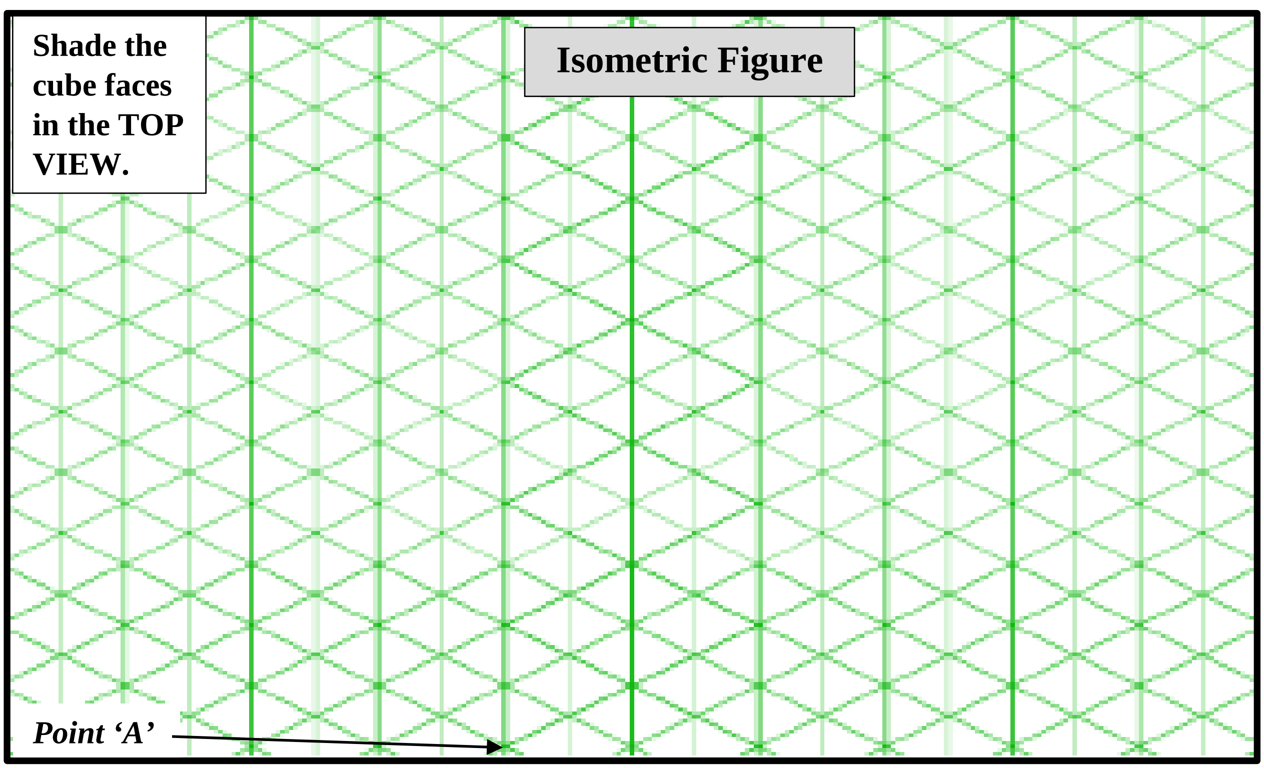
Right Side View



Top View



Left Side View

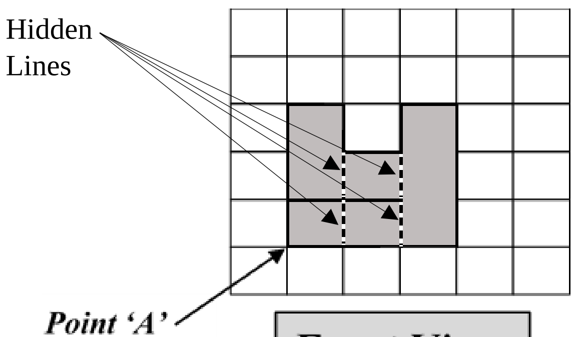


Three (3) Dimensional Spatial Development

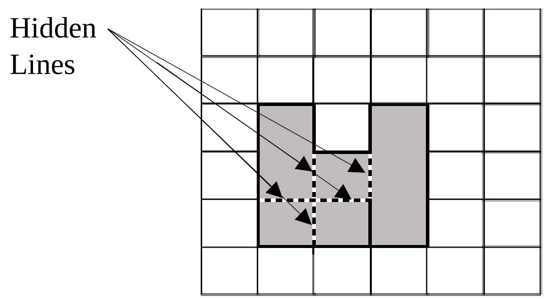
Deductive Series – Part 2 of 3

PROBLEM NUMBER 13

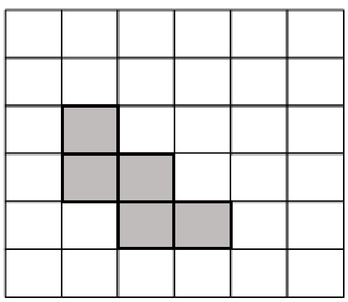
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point 'A'.



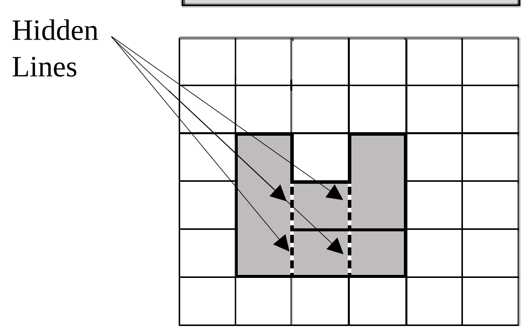
Front View



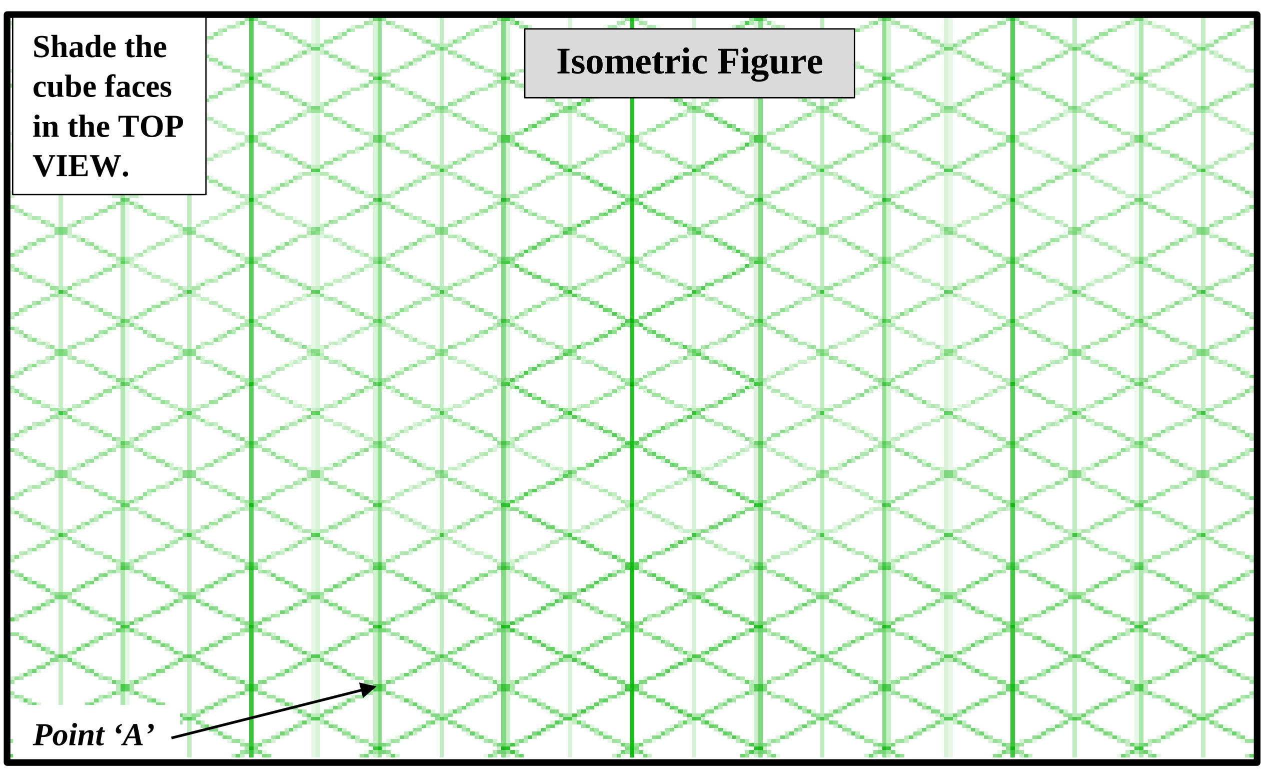
Right Side View



Top View



Left Side View

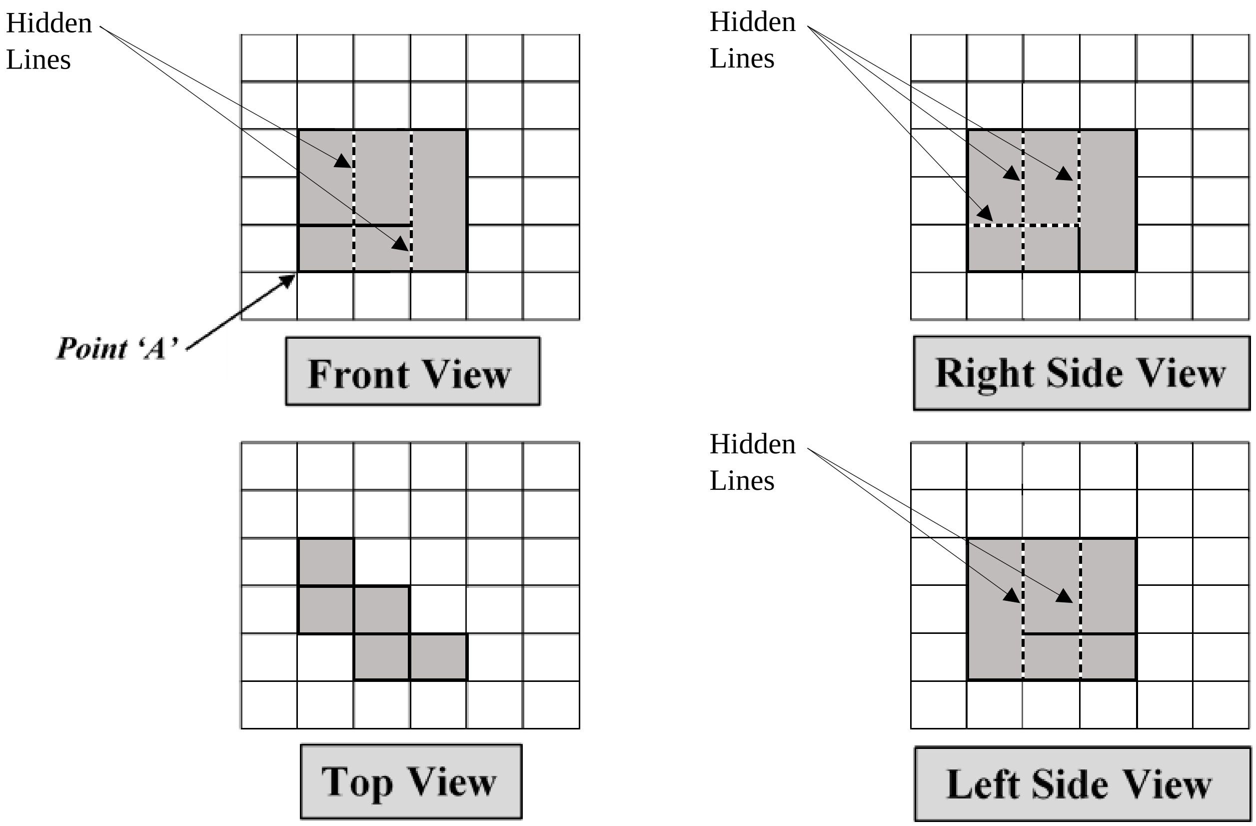


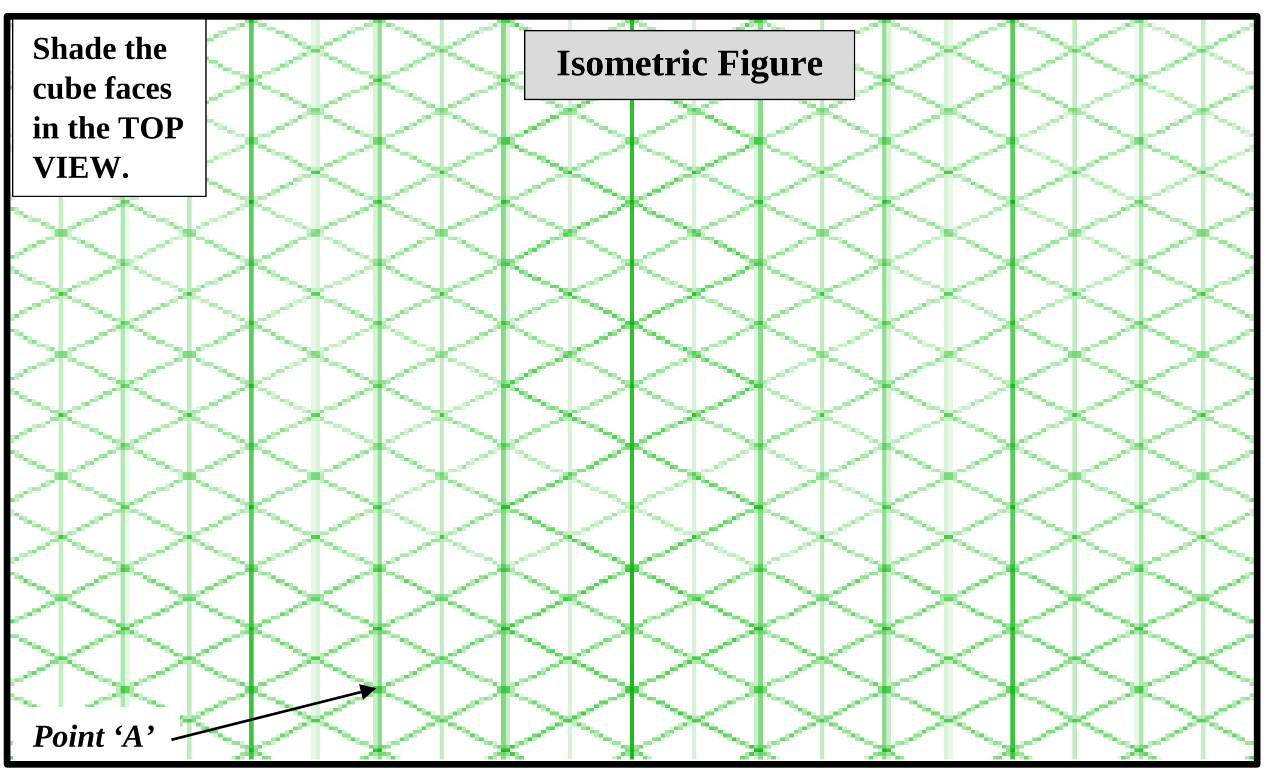
Three (3) Dimensional Spatial Development

Deductive Series – Part 2 of 3

PROBLEM NUMBER 14

Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point ‘A’.



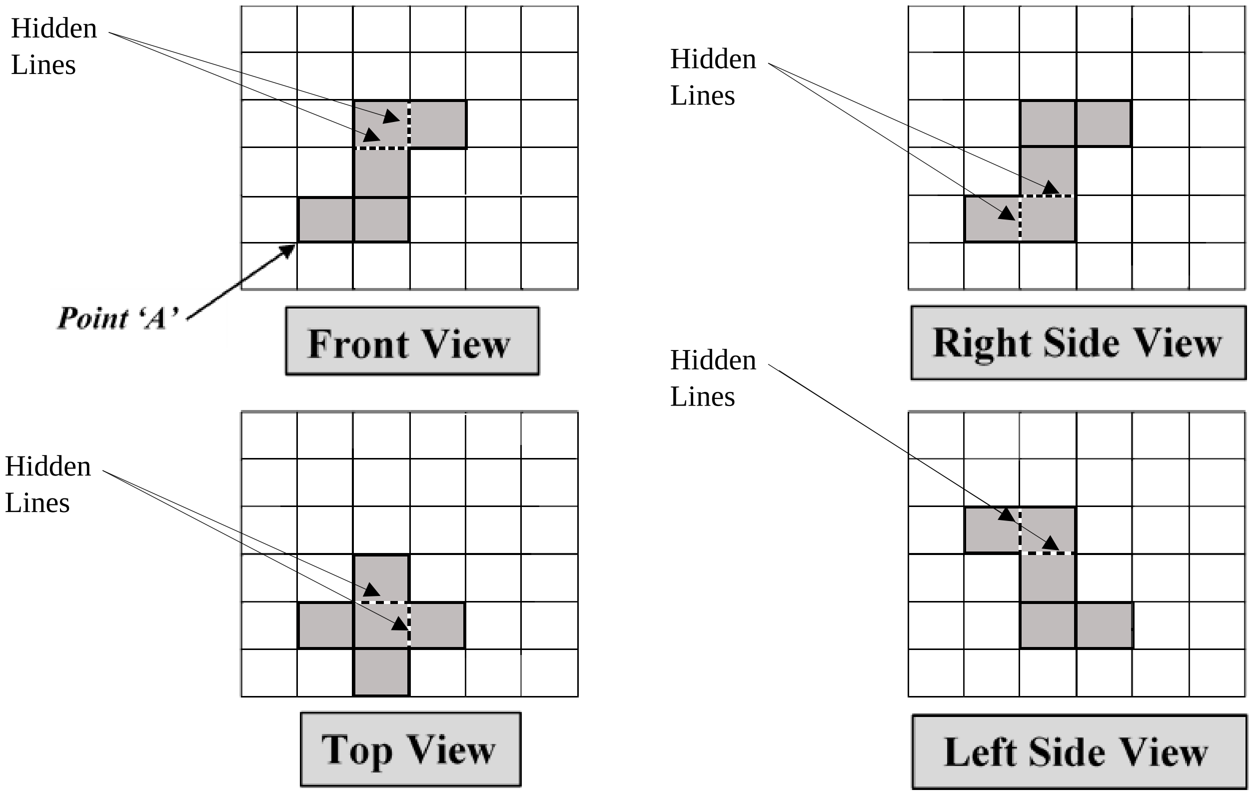


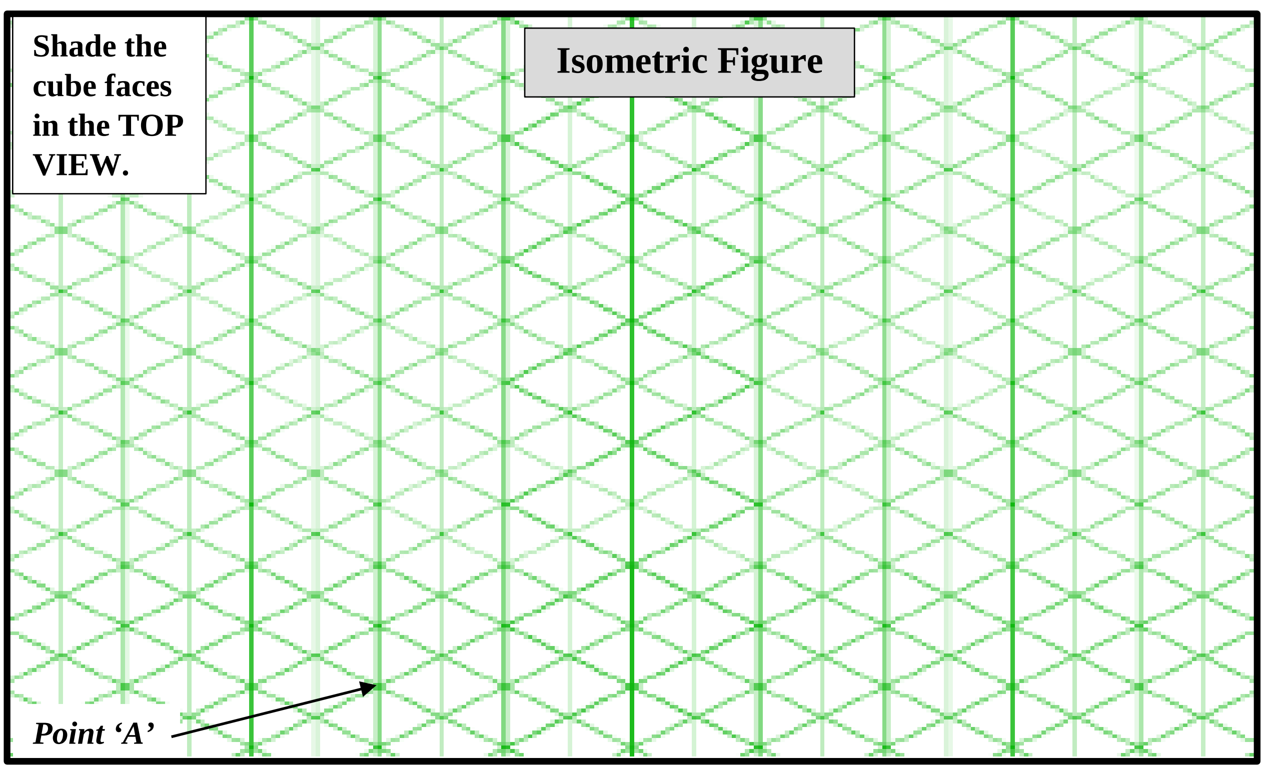
Three (3) Dimensional Spatial Development

Deductive Series – Part 2 of 3

PROBLEM NUMBER 15

Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point ‘A’.



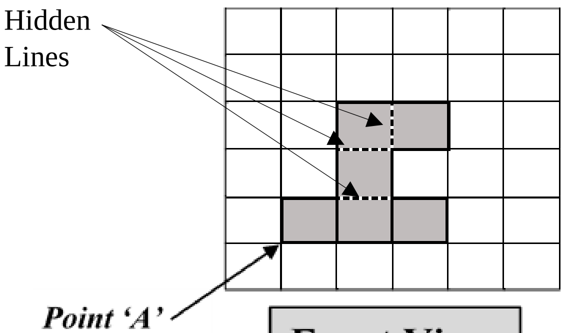


Three (3) Dimensional Spatial Development

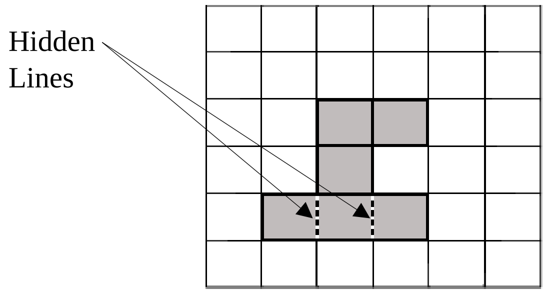
Deductive Series – Part 2 of 3

PROBLEM NUMBER 16

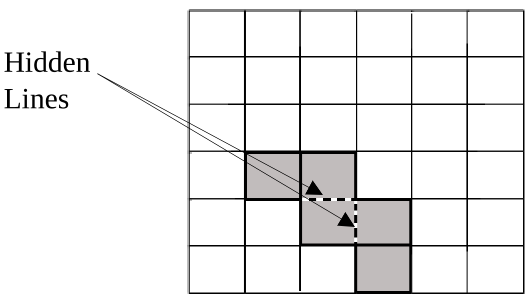
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point 'A'.



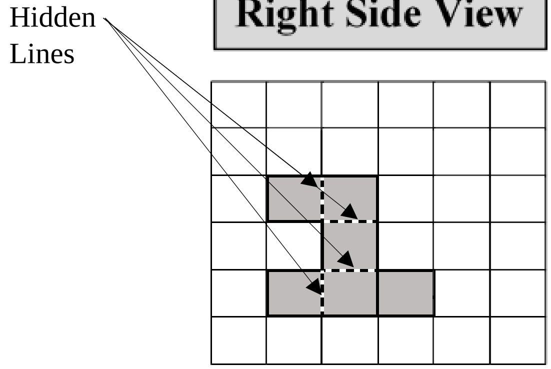
Front View



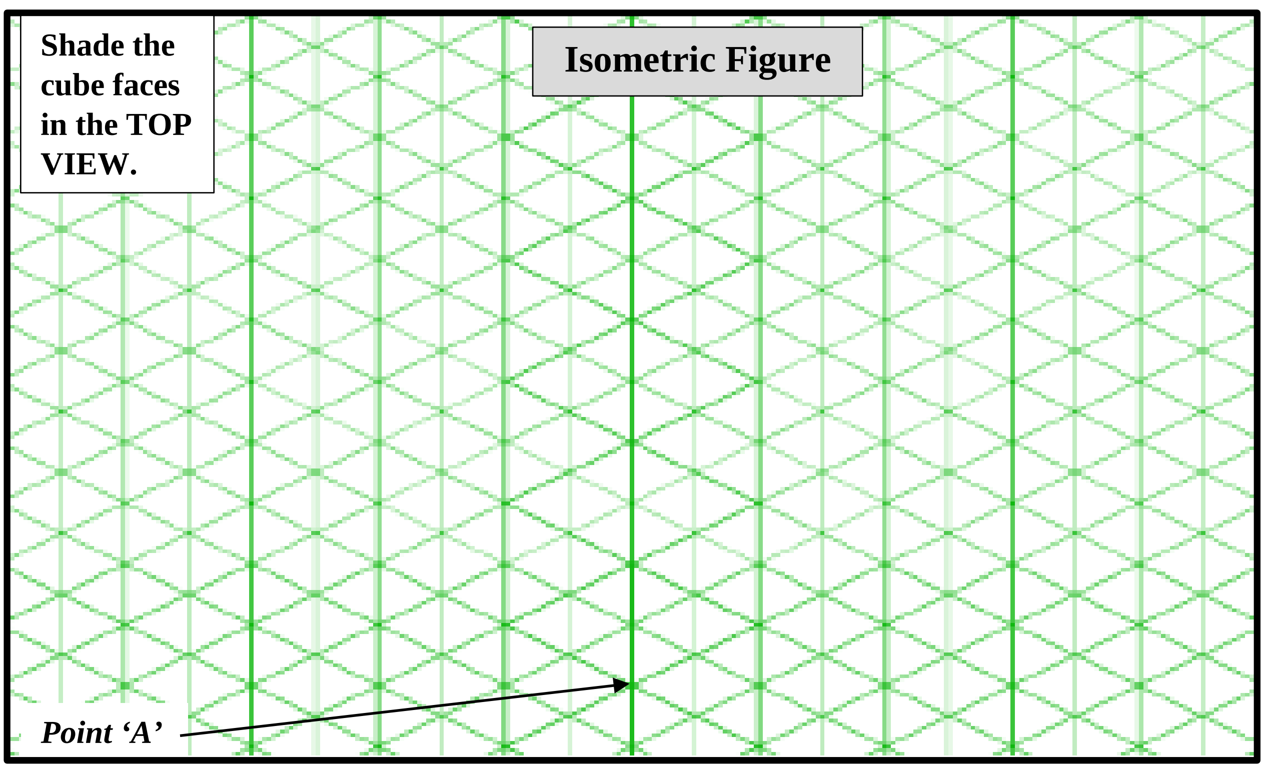
Right Side View



Top View



Left Side View

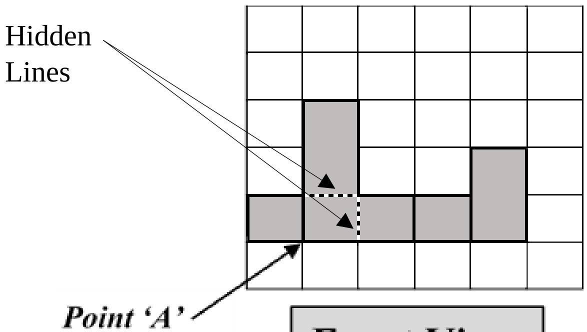


Three (3) Dimensional Spatial Development

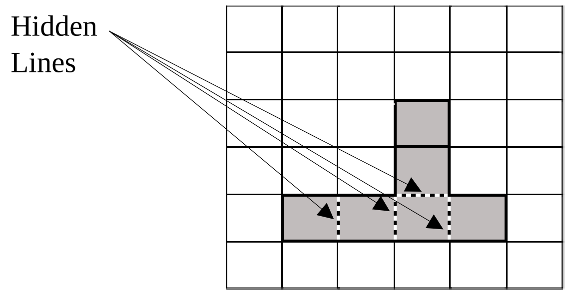
Deductive Series – Part 2 of 3

PROBLEM NUMBER 17

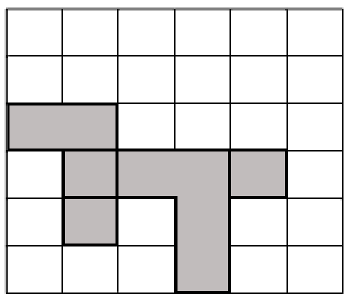
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point 'A'.



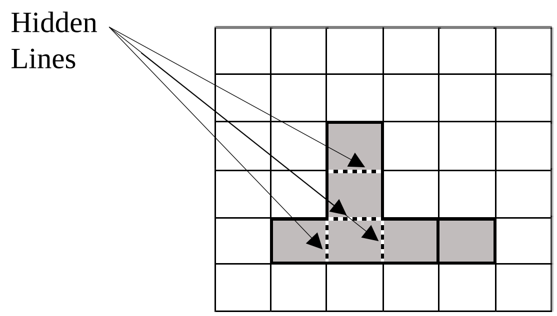
Front View



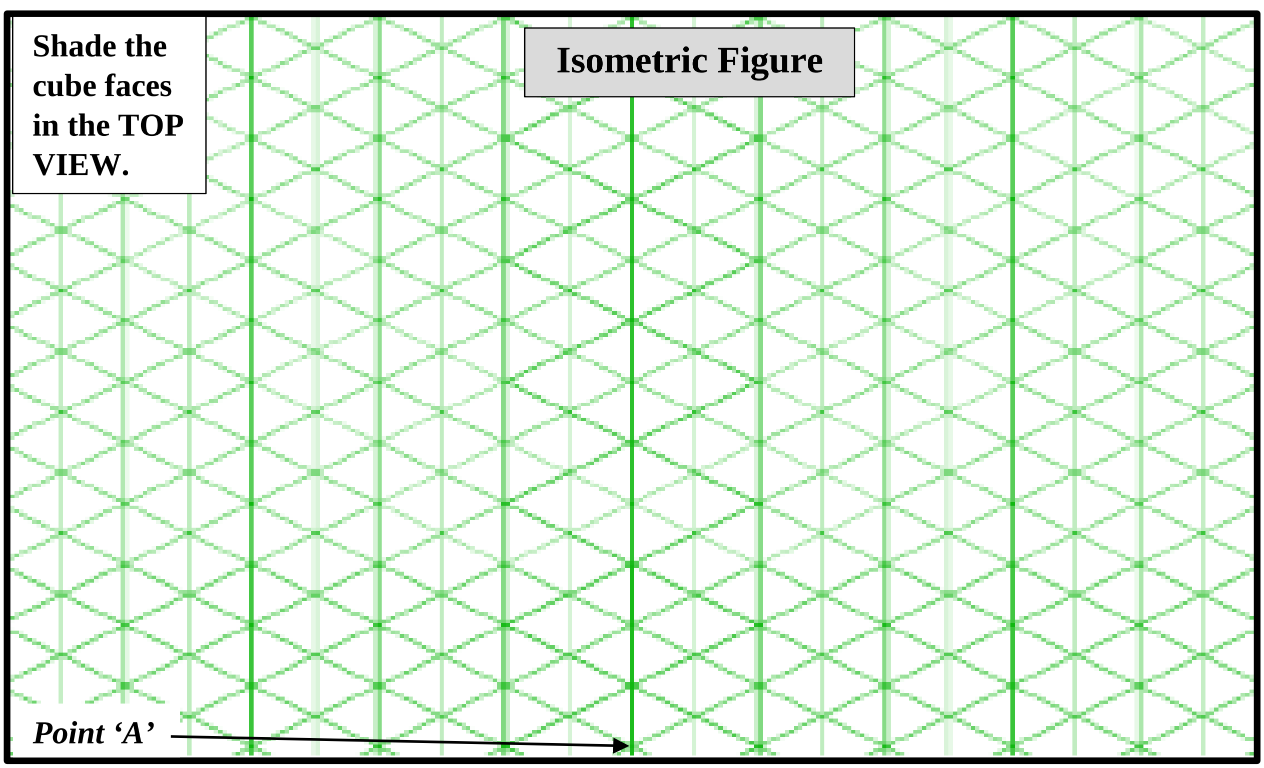
Right Side View



Top View



Left Side View

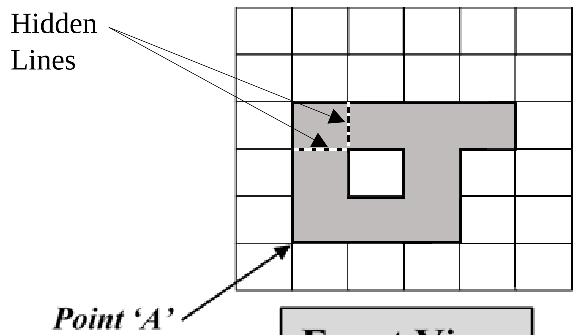


Three (3) Dimensional Spatial Development

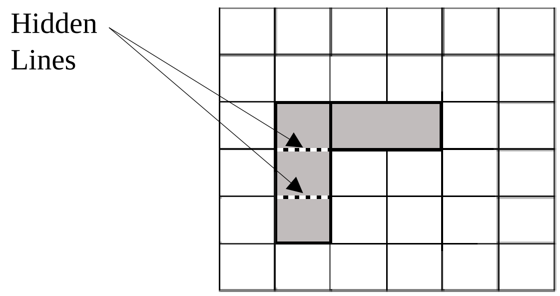
Deductive Series – Part 2 of 3

PROBLEM NUMBER 18

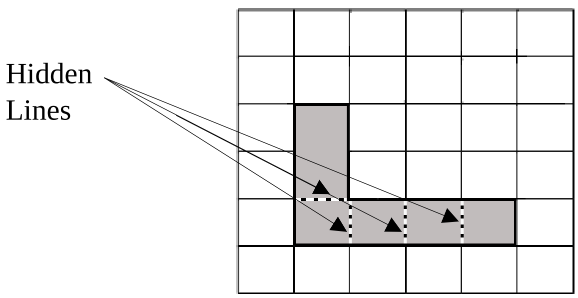
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point 'A'.



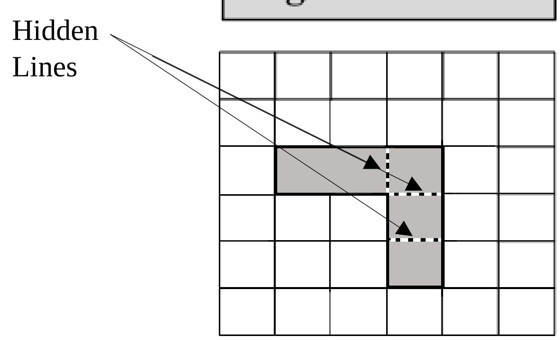
Front View



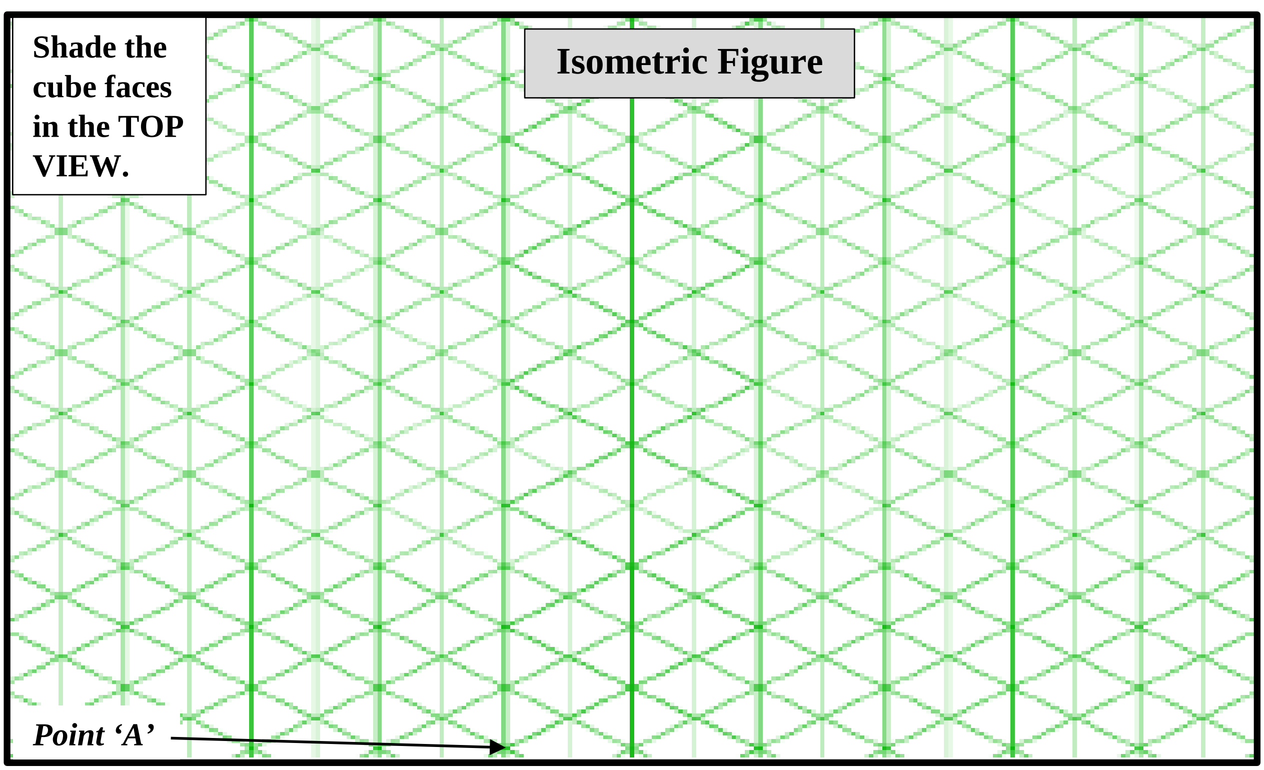
Right Side View



Top View



Left Side View

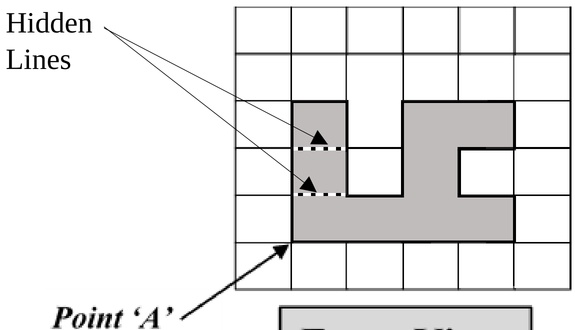


Three (3) Dimensional Spatial Development

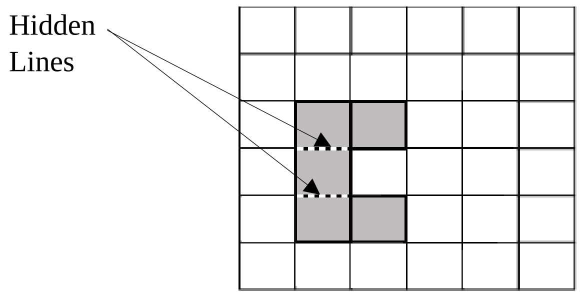
Deductive Series – Part 2 of 3

PROBLEM NUMBER 19

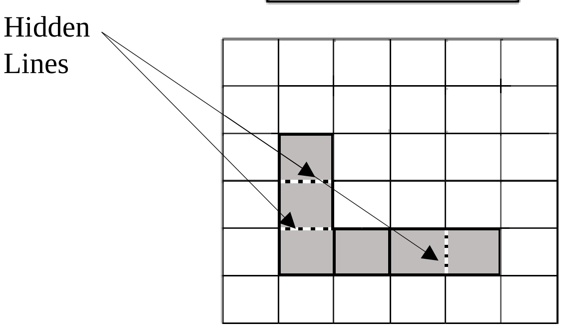
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point ‘A’.



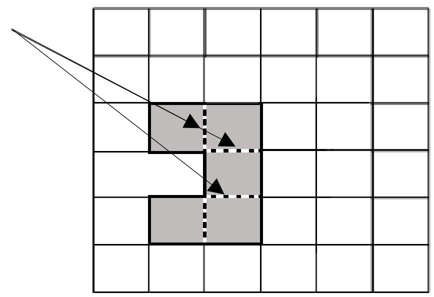
Front View



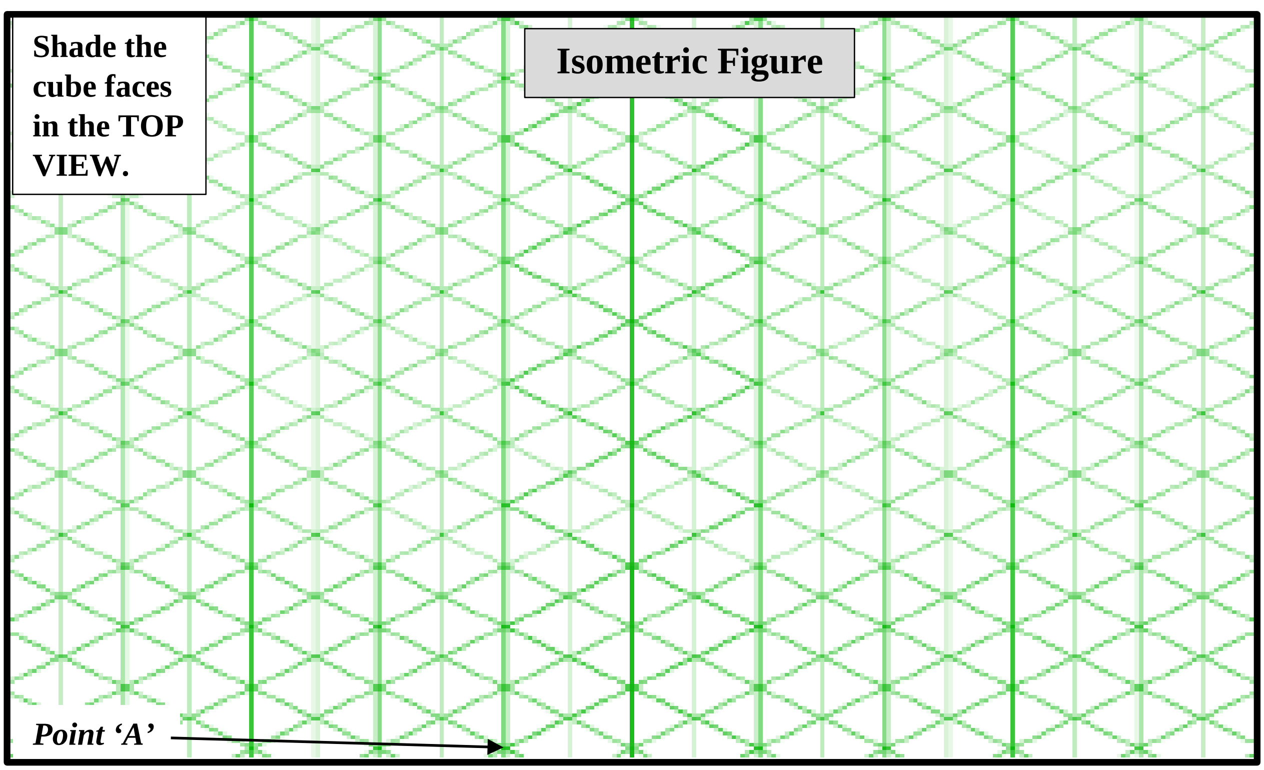
Right Side View



Top View



Left Side View

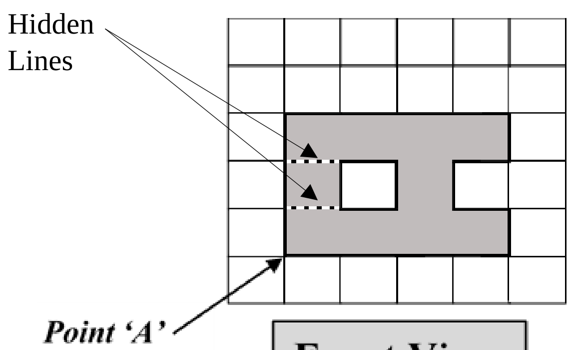


Three (3) Dimensional Spatial Development

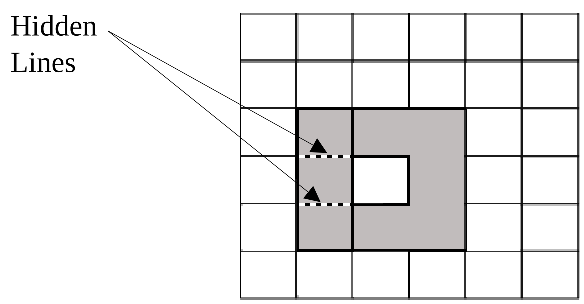
Deductive Series – Part 2 of 3

PROBLEM NUMBER 20

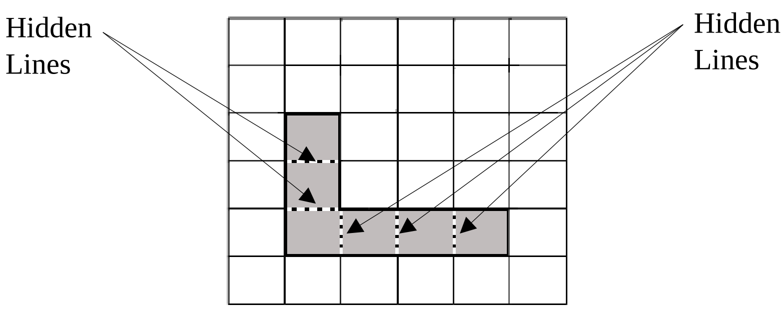
Directions: Based on the shading of the rectangular grid below for the FRONT SIDE, RIGHT SIDE, TOP VIEW and LEFT SIDE, draw the three (3D) dimensional isometric view. Start the Front View at Point ‘A’.



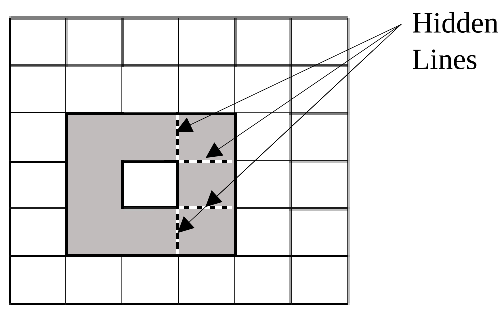
Front View



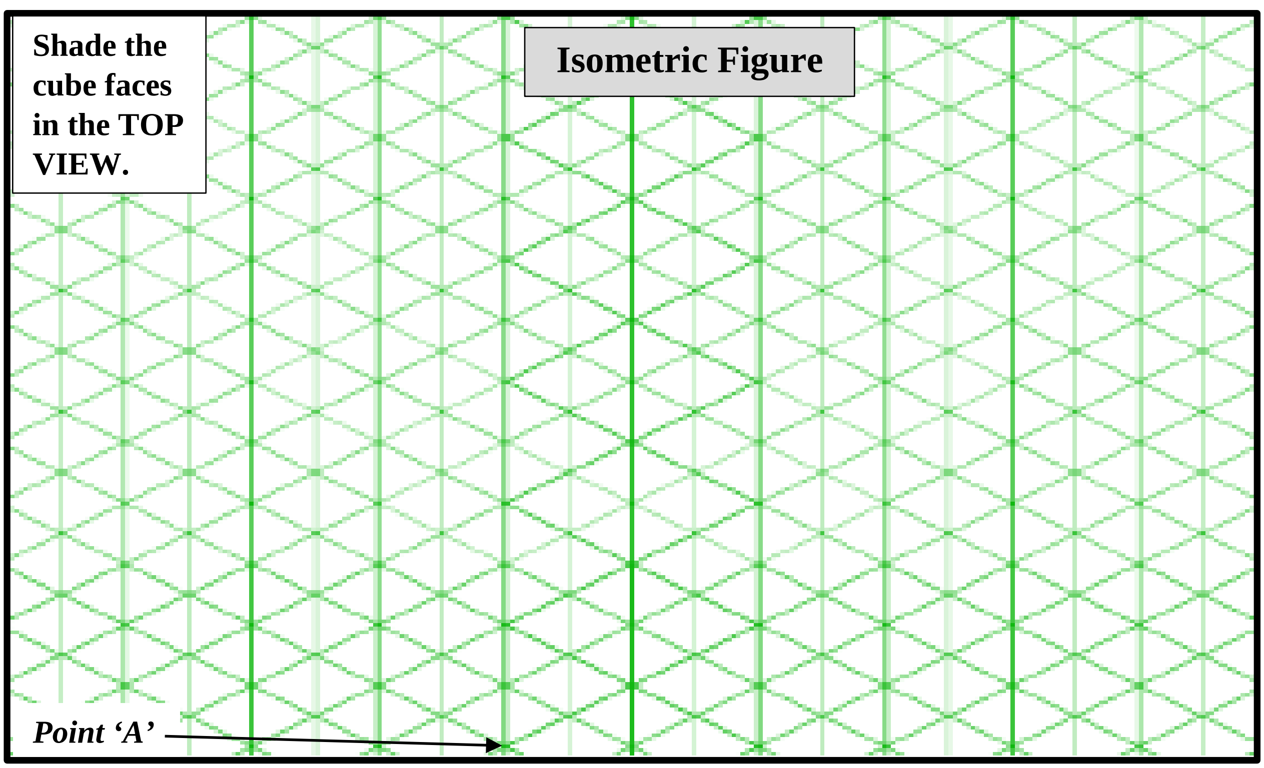
Right Side View



Top View



Left Side View



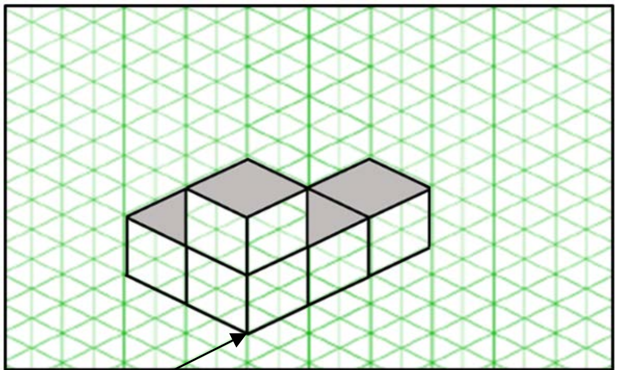
SOLUTIONS

Student Practice Problems 1 through 20

Deductive – Part 2

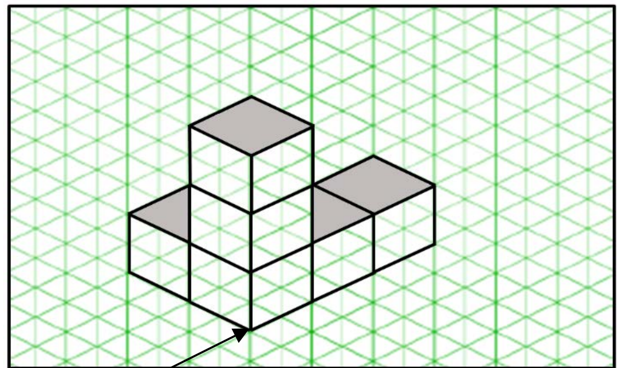
Three (3) Dimensional Spatial Development

Deductive Series – Part 2 of 3



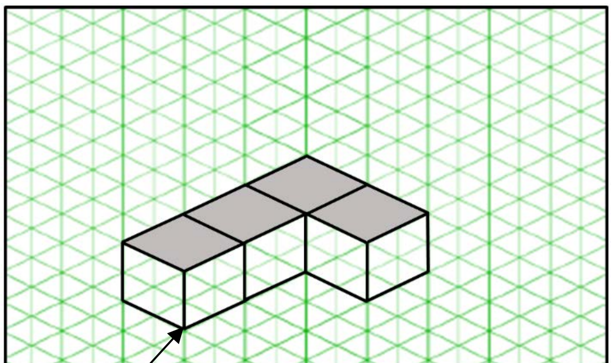
Point 'A'

Problem No. 1



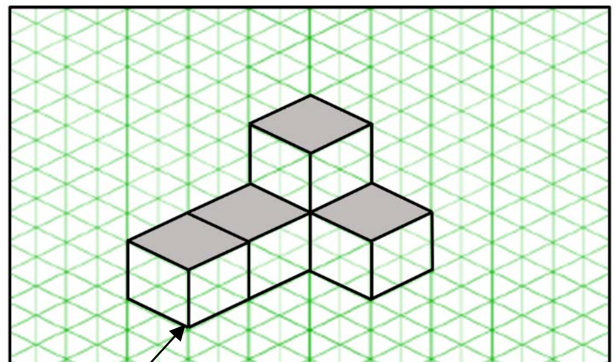
Point 'A'

Problem No. 2



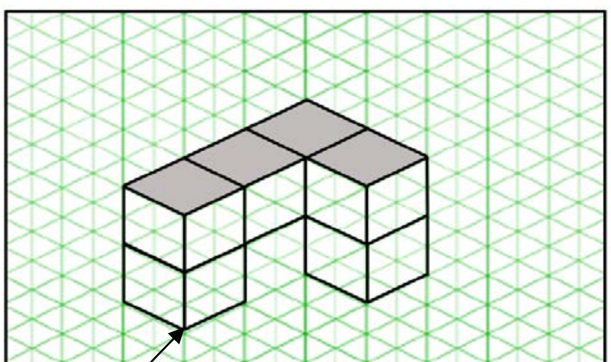
Point 'A'

Problem No. 3



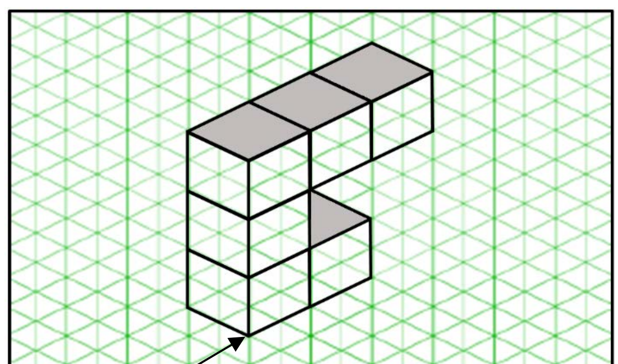
Point 'A'

Problem No. 4



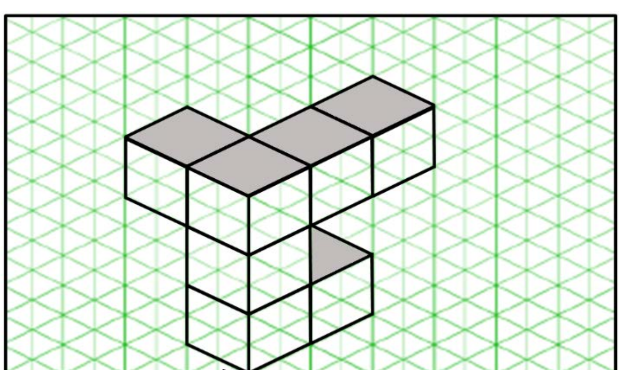
Point 'A'

Problem No. 5



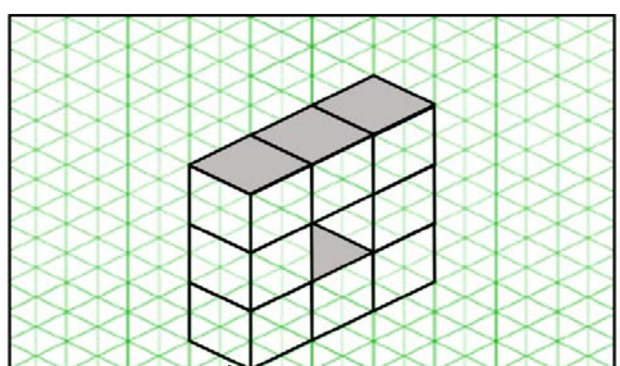
Point 'A'

Problem No. 6



Point 'A'

Problem No. 7

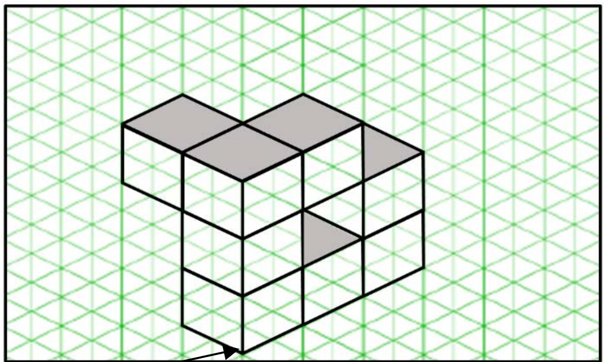


Point 'A'

Problem No. 8

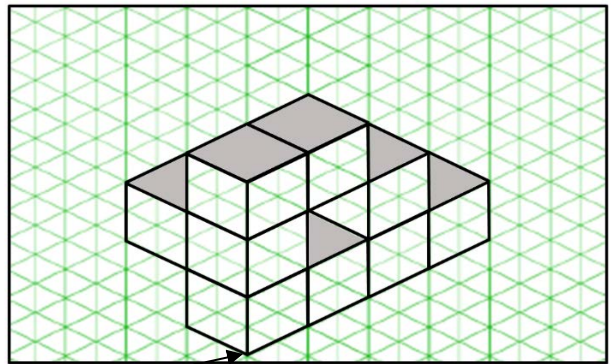
Three (3) Dimensional Spatial Development

Deductive Series – Part 2 of 3



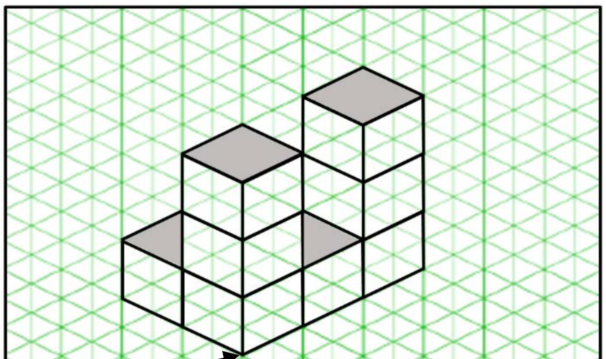
Point 'A'

Problem No. 9



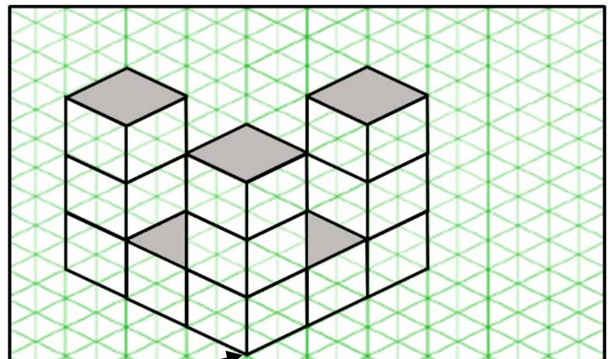
Point 'A'

Problem No. 10



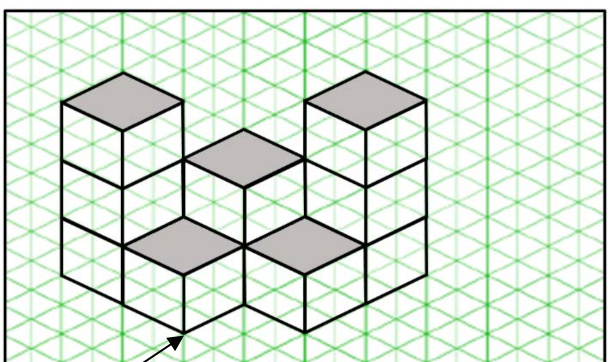
Point 'A'

Problem No. 11



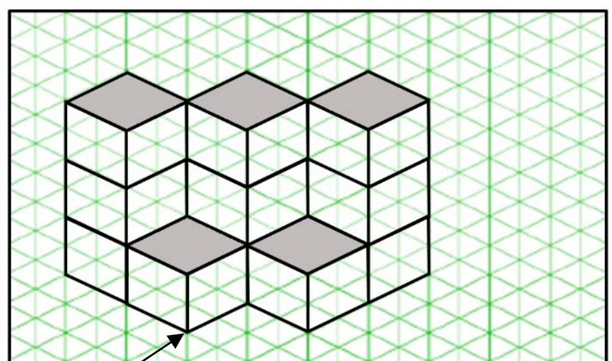
Point 'A'

Problem No. 12



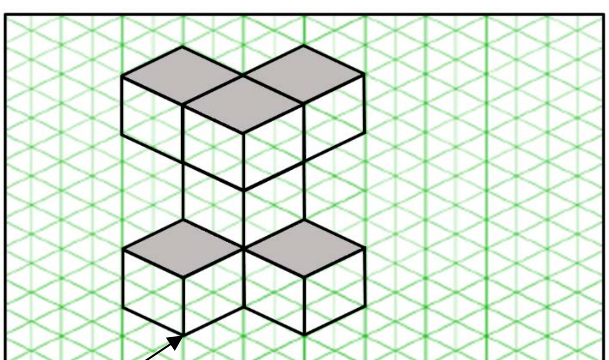
Point 'A'

Problem No. 13



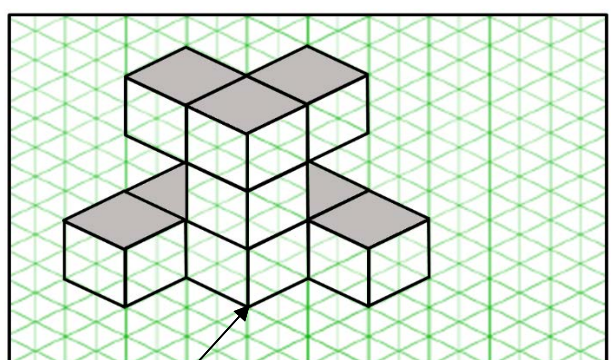
Point 'A'

Problem No. 14



Point 'A'

Problem No. 15

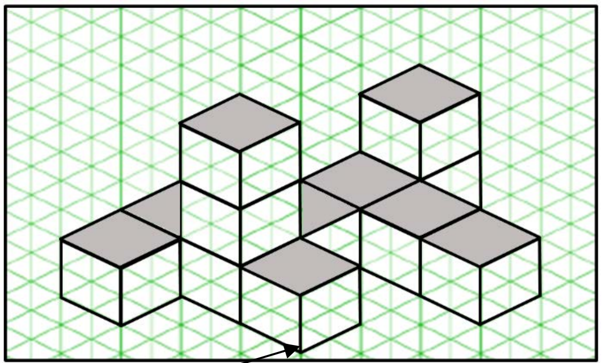


Point 'A'

Problem No. 16

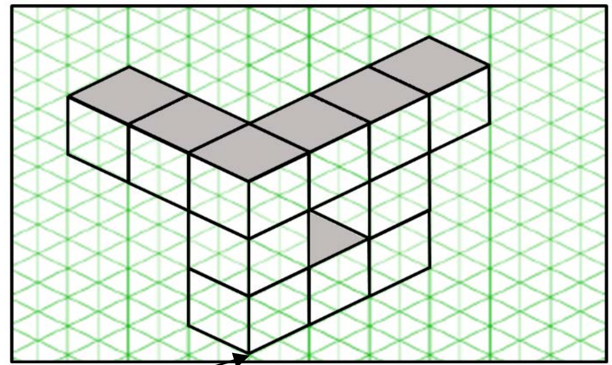
Three (3) Dimensional Spatial Development

Deductive Series – Part 2 of 3



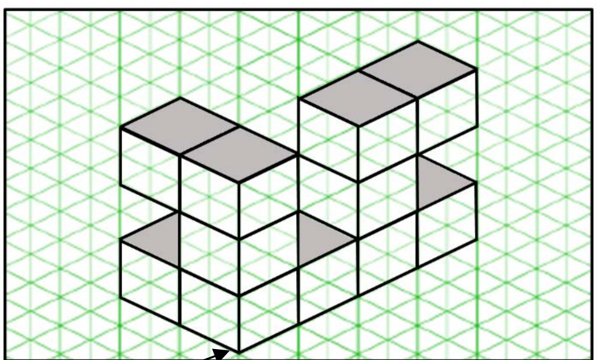
Point 'A'

Problem No. 17



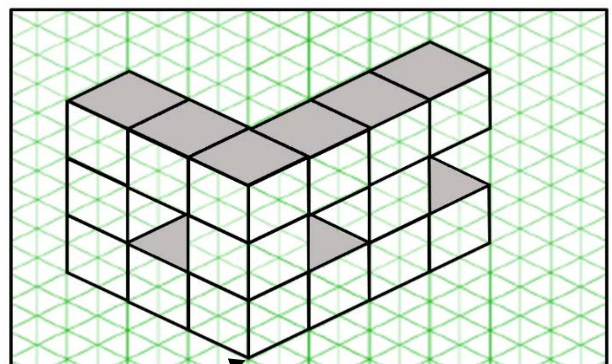
Point 'A'

Problem No. 18



Point 'A'

Problem No. 19



Point 'A'

Problem No. 20