Chapter 17

ISOMETRIC PROJECTION

17-1. INTRODUCTION

Isometric projection is a type of pictorial projection in which the three dimensions of a solid are not only shown in one view, but their actual sizes can be measured directly from it.

If a cube is placed on one of its corners on the ground with a solid diagonal perpendicular to the V.P., the front view is the *isometric projection* of the cube. The step-by-step construction is shown in fig. 17-1.

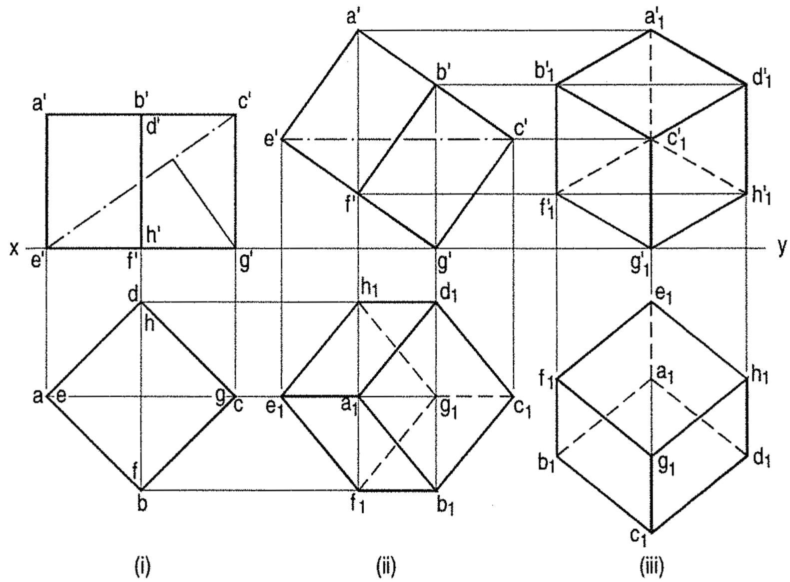

FIG. 17-1

To draw the projections of a cube of 25 mm long edges resting on the ground on one of its corners with a solid diagonal perpendicular to the V.P., assume the cube to be resting on one of its faces on the ground with a solid diagonal parallel to the V.P.

(i) Draw a square *abcd* in the top view with its sides inclined at 45° to *xy*. The line *ac* representing the solid diagonals *AG* and *CE* is parallel to *xy*. Project the front view.

(ii) Tilt the front view about the corner g' so that the line $e'c'$ becomes parallel to xy. Project the second top view. The solid diagonal *CE* is now parallel to both the H.P. and the V.P.

(iii) Reproduce the second top view so that the top view of the solid diagonal, viz. $e_1 c_1$ is perpendicular to xy. Project the required front view.

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Fig. 17-2 shows the front view of the cube in the above position, with the corners named in capital letters. Its careful study will show that:

(a) All the faces of the cube are equally inclined to the V.P. and hence, they are seen as similar and equal rhombuses instead of squares.

(b) The three lines *CB*, *CD* and *CG* meeting at *C* and representing the three edges of the solid right-angle are also equally inclined to the V.P. and are therefore, equally foreshortened. They make equal angles of 120° with each other. The line *CG* being vertical, the other two lines *CB* and *CD* make 30° angle each, with the horizontal.

(c) All the other lines representing the edges of the cube are parallel to one or the other of the above three lines and are also equally foreshortened.

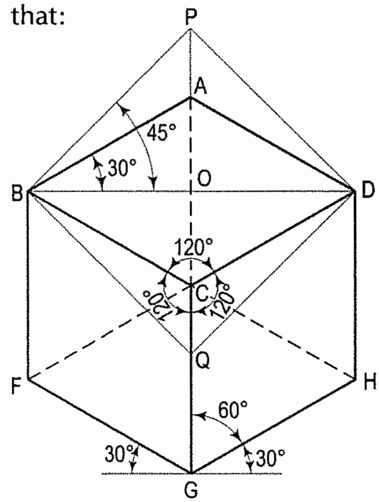

FIG. 17-2

(d) The diagonal *BD* of the top face is parallel to the V.P. and hence, retains its true length.

This chapter deals with various topics of isometric projection as shown below:

1. Isometric axes, lines and planes
2. Isometric scale
3. Isometric drawing or isometric view
4. Isometric graph.

17-2. ISOMETRIC AXES, LINES AND PLANES

The three lines *CB*, *CD* and *CG* meeting at the point *C* and making 120° angles with each other are termed *isometric axes*. The lines parallel to these axes are called *isometric lines*. The planes representing the faces of the cube as well as other planes parallel to these planes are called *isometric planes*.

17-3. ISOMETRIC SCALE

As all the edges of the cube are equally foreshortened, the square faces are seen as rhombuses. The rhombus *ABCD* (fig. 17-2) shows the isometric projection of the top square face of the cube in which *BD* is the true length of the diagonal.

Construct a square *BQDP* around *BD* as a diagonal. Then *BP* shows the true length of *BA*.

$$\text{In triangle } ABO, \quad \frac{BA}{BO} = \frac{1}{\cos 30^\circ} = \frac{2}{\sqrt{3}}$$

$$\text{In triangle } PBO, \quad \frac{BP}{BO} = \frac{1}{\cos 45^\circ} = \frac{\sqrt{2}}{1}$$

$$\frac{BA}{BP} = \frac{2}{\sqrt{3}} \times \frac{1}{\sqrt{2}} = \frac{\sqrt{2}}{\sqrt{3}} = 0.815$$

$$\text{The ratio, } \frac{\text{isometric length}}{\text{true length}} = \frac{BA}{BP} = \frac{\sqrt{2}}{\sqrt{3}} = 0.815 \text{ or } \frac{9}{11} \text{ (approx.).}$$

Thus, the isometric projection is reduced in the ratio $\sqrt{2} : \sqrt{3}$, i.e. *the isometric lengths are 0.815 of the true lengths.*

Therefore, while drawing an *isometric projection*, it is necessary to convert true lengths into isometric lengths for measuring and marking the sizes. This is conveniently done by constructing and making use of an isometric scale as shown below.

(a) Draw a horizontal line *BD* of any length (fig. 17-3). At the end *B*, draw lines *BA* and *BP*, such that $\angle DBA = 30^\circ$ and $\angle DBP = 45^\circ$. Mark divisions of true length on the line *BP* and from each division-point, draw verticals to *BD* meeting *BA* at respective points. The divisions thus obtained on *BA* give lengths on isometric scale.

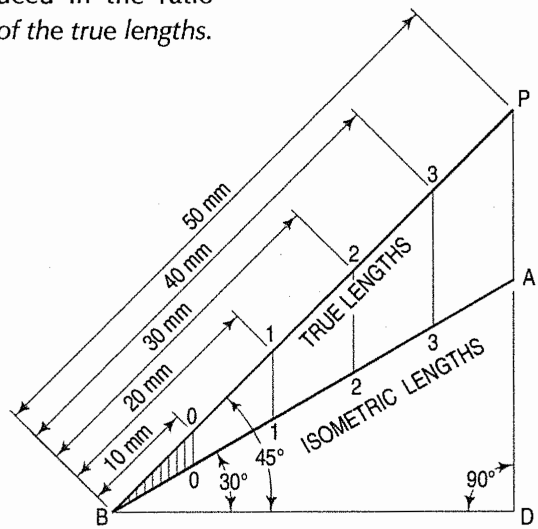

FIG. 17-3

(b) The same scale may also be drawn with divisions of natural scale on a horizontal line *AB* (fig. 17-4). At the ends *A* and *B*, draw lines *AC* and *BC* making 15° and 45° angles with *AB* respectively, and intersecting each other at *C*.

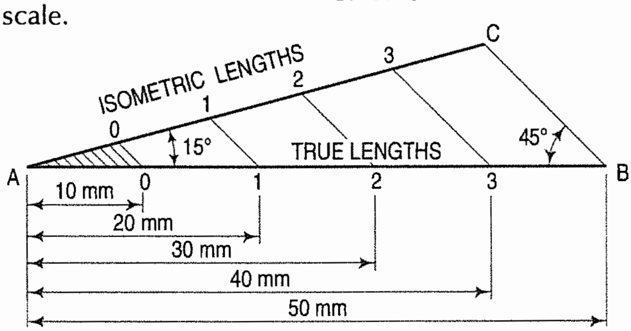

FIG. 17-4

From division-points of true lengths on *AB*, draw lines parallel to *BC* and meeting *AC* at respective points. The divisions along *AC* give lengths to isometric scale.

The lines *BD* and *AC* (fig. 17-2) represent equal diagonals of a square face of the cube, but are not equally shortened in isometric projection. *BD* retains its true length, while *AC* is considerably shortened. Thus, it is seen that lines which are not parallel to the isometric axes are not reduced according to any fixed ratio. Such lines are called non-isometric lines. The measurements should, therefore, be made on *isometric axes and isometric lines only*. The non-isometric lines are drawn by locating positions of their ends on isometric planes and then joining them.

17-4. ISOMETRIC DRAWING OR ISOMETRIC VIEW

If the foreshortening of the isometric lines in an isometric projection is disregarded and instead, the true lengths are marked, the view obtained [fig. 17-5(iii)] will be exactly of the same shape but larger in proportion (about 22.5%) than that obtained by the use of the isometric scale [fig. 17-5(ii)]. Due to the ease in construction and the advantage of measuring the dimensions directly from the drawing, it has become a general practice to use the true scale instead of the isometric scale.

To avoid confusion, the view drawn with the true scale is called *isometric drawing* or *isometric view,* while that drawn with the use of isometric scale is called *isometric projection.*

Referring again to fig. 17-2, the axes *BC* and *CD* represent the sides of a right angle in horizontal position. Each of them together with the vertical axis *CG*, represents the right angle in vertical position. Hence, in isometric view of any rectangular solid resting on a face on the ground, each horizontal face will have its sides parallel to the two sloping axes; each vertical face will have its vertical sides parallel to the vertical axis and the other sides parallel to one of the sloping axes.

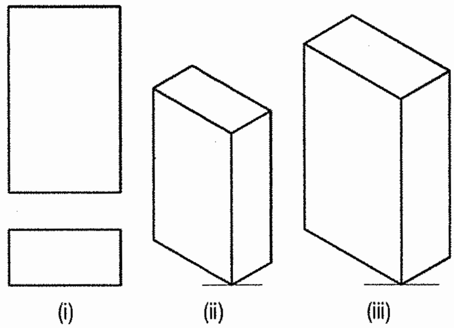

FIG. 17-5

In other words, the vertical edges are shown by vertical lines, while the horizontal edges are represented by lines, making 30° angles with the horizontal. These lines are very conveniently drawn with the T-square and a 30°-60° set-square or drafter.

17-5. ISOMETRIC GRAPH

An isometric graph as shown in fig. 17-6 facilitates the drawing of isometric view of an object. Students are advised to make practice for drawing of isometric view using such graphs. See fig. 17-55 and fig. 17-56 of problem 17-33.

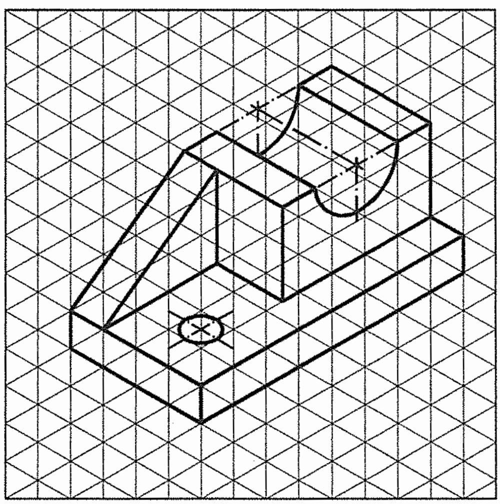

FIG. 17-6

17-6. ILLUSTRATIVE PROBLEMS

The procedure for drawing isometric views of planes, solids and objects of various shapes is explained in stages by means of illustrative problems.

In order that the construction of the view may be clearly understood, construction lines have not been erased. They are, however, drawn fainter than the outlines.

In an isometric view, lines for the hidden edges are generally not shown. In the solutions accompanying the problems, one or two arrows have been shown. They indicate the directions from which if the drawing is viewed, the given orthographic views would be obtained. Students need not show these arrows in their solutions.

17-6-1. ISOMETRIC DRAWING OF PLANES OR PLANE FIGURES

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This book is accompanied by a computer CD, which contains an audiovisual animation presented for better visualization and understanding of the subject. Readers are requested to refer Presentation module 40 for the following problem.

Problem 17-1. *The front view of a square is given in fig. 17-7(i). Draw its isometric view.*

As the front view is a square, the surface of the square is vertical. In isometric view, vertical lines will be drawn vertical, while horizontal lines will be drawn inclined at 30° to the horizontal.

(i) Through any point *d*, draw a vertical line *da* = *DA* [fig. 17-7(ii)].

(ii) Again through *d*, draw a line *dc* = *DC* inclined at 30° to the horizontal and at 60° to *da*.

(iii) Complete the rhombus *abcd* which is the required isometric view. The view can also be drawn in direction of the other sloping axis as shown in fig. 17-7(iii).

Problem 17-2. *If fig. 17-7(i) is the top view of a square, draw its isometric view.*

As the top view is a square, the surface of the square is horizontal. In isometric view, all the sides will be drawn inclined at 30° to the horizontal.

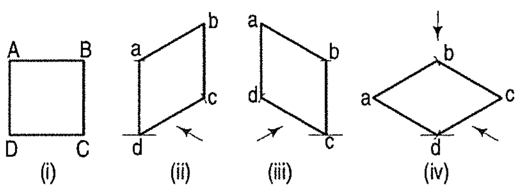

FIG. 17-7

(i) From any point *d* [fig. 17-7(iv)], draw two lines *da* and *dc* inclined at 30° to the horizontal and making 120° angle between themselves.

(ii) Complete the rhombus *abcd* which is the required isometric view.

Problem 17-3. *The top view of a rectangle, the surface of which is horizontal is shown in fig. 17-8(i). Draw its isometric view.*

Draw the required view as explained in problem 17-2 and as shown in either fig. 17-8(ii) or fig. 17-8(iii).

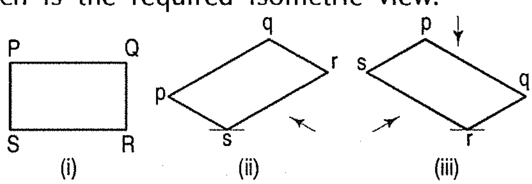

FIG. 17-8

Problem 17-4. *The front view of a triangle having its surface parallel to the V.P. is shown in fig. 17-9(i). Draw its isometric view.*

The surface of the triangle is vertical and the base *ab* is horizontal. *ab* will be drawn parallel to a sloping axis. The two sides of the triangle are inclined.

Hence they will not be drawn parallel to any isometric axis. In an isometric view, angles do not increase or decrease in any fixed proportion. They are drawn after determining the positions of the ends of the arms on isometric lines.

Therefore, enclose the triangle in the rectangle *ABQP*. Draw the isometric view *abqp* of the rectangle [fig. 17-9(ii)].

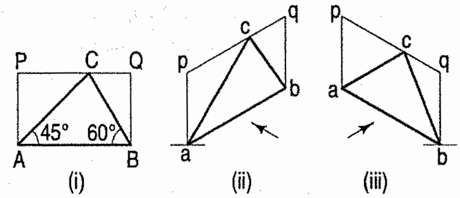

FIG. 17-9

Mark a point *c* in *pq* such that *pc* = *PC*. Draw the triangle *abc* which is the required isometric view. It can also be drawn in the other direction as shown in fig. 17-9(iii).

Problem 17-5. *The front view of a quadrilateral whose surface is parallel to the V.P. is shown in fig. 17-10(i). Draw its isometric view.*

Enclose the quadrilateral in a rectangle *ABEF*.

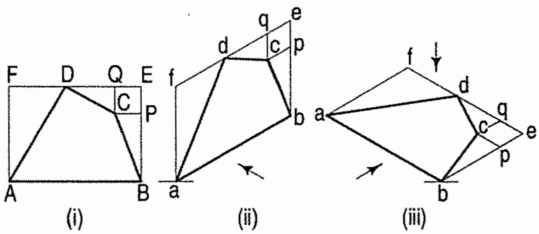

FIG. 17-10

(i) Draw lines *CP* and *CQ* parallel to the sides *FE* and *BE* respectively.

(ii) Draw the isometric view of the rectangle [fig. 17-10(ii)] and obtain the point *d* in *fe* as explained in problem 17-4. Draw the isometric view *cpeq* of the rectangle *CPEQ*.

(iii) Draw the quadrilateral *abcd* which is the required isometric view.

If the given view is the top view of a quadrilateral whose surface is horizontal, i.e. parallel to the H.P., its isometric view will be as shown in fig. 17-10(iii).

Problem 17-6. *If the view given in fig. 17-11(i) is*

(a) *the front view of a hexagon whose surface is parallel to the V.P. or*

(b) *the top view of the hexagon whose surface is horizontal, draw its isometric views.*

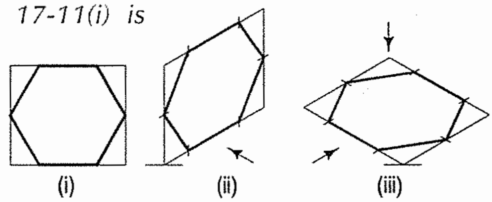

FIG. 17-11

(a) fig 17-11(ii). (b) fig 17-11(iii).

In both cases, the views can be drawn in the other direction also.

Problem 17-7. *Fig. 17-12(i) shows the front view of a circle whose surface is parallel to the V.P. Draw the isometric view of the circle.*

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I. Method of points:

(i) Enclose the circle in a square, touching it in points 1, 2, 3 and 4. Draw the diagonals of the square cutting the circle in points 5, 6, 7 and 8.

(ii) Draw the isometric view of the square [fig. 17-12(ii) and [fig. 17-12(iii)] and on it mark the mid-points 1, 2, 3 and 4 of its sides. Obtain points 5, 6, 7 and 8 on the diagonals as explained in problem 17-5.

Or, after determining the position of one point, draw through it, lines parallel to the sides of the rhombus and obtain the other three points. Draw a neat and smooth curve passing through the eight points viz. 1, 6, 2, 7 etc. The curve is the required isometric view. It is an ellipse.

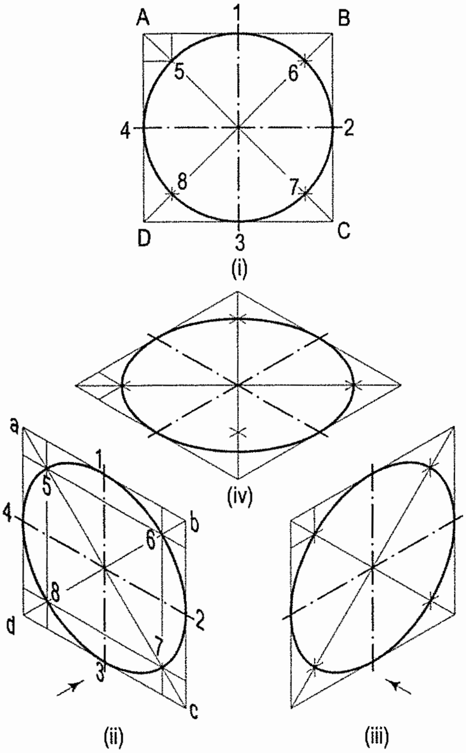


FIG. 17-12

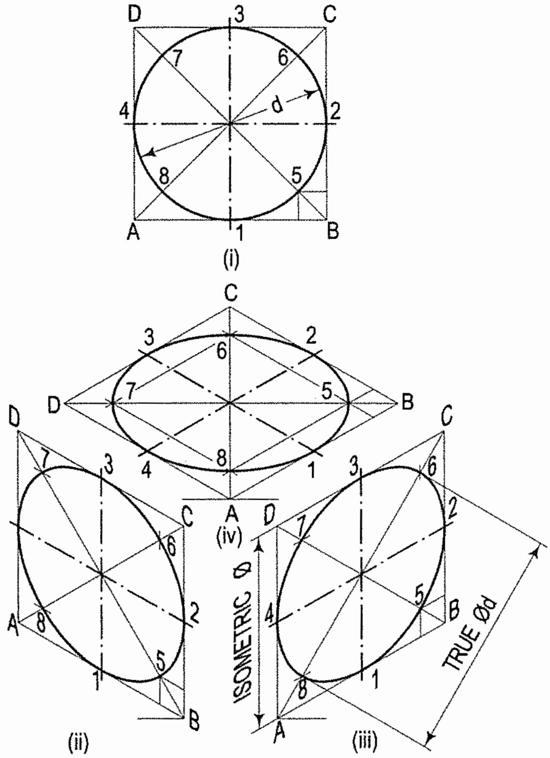


FIG. 17-13

If the view given in fig. 17-12(i) is the top view of a circle whose surface is horizontal, its isometric view will be as shown in fig. 17-12(iv).

As the isometric views have been drawn with the true scale, the major axis of the ellipse is longer than the diameter of the circle.

Fig. 17-13(ii), fig. 17-13(iii) and fig. 17-13(iv) show the isometric projection of the circle drawn with isometric scale. Note that when the length of the side of the rhombus is equal to the isometric diameter of the circle, the length of the major axis of the ellipse is equal to the true diameter of the circle.

II. Four-centre method:

Draw the isometric view of the square [fig. 17-14(i)]. Draw perpendicular bisectors of the sides of the rhombus, intersecting each other on the longer diagonal at points *p* and *q*, and which meet at the 120°-angles *b* and *d*.

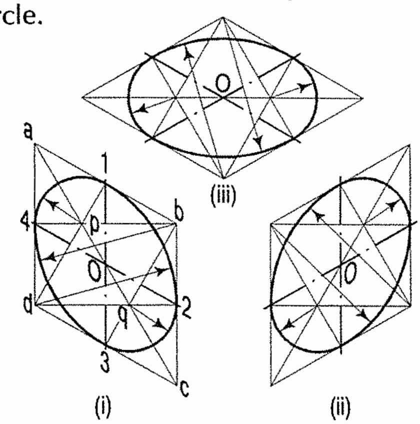


FIG. 17-14

Or, draw lines joining the 120°-angles *b* and *d* with the mid-points of the opposite sides and intersecting each other on the longer diagonal at points *p* and *q*. Two of these lines will be drawn horizontal, while the other two will make 60°-angles with the horizontal. With centres *b* and *d*, draw arcs 3-4 and 1-2 respectively. With centres *p* and *q*, draw arcs 1-4 and 2-3 respectively and complete the required ellipse. Fig. 17-14(ii) shows the ellipse obtained in the rhombus drawn in the direction of the other sloping axis. Fig. 17-14(iii) shows the isometric view of the circle when its surface is horizontal.

The ellipse obtained by the four-centre method is not a true ellipse and differs considerably in size and shape from the ellipse plotted through points. But owing to the ease in construction and to avoid the labour of drawing freehand neat curves, this method is generally employed.

Problem 17-8. *To draw the isometric view of a circle of a given diameter, around a given point.*

Let *O* be the given point and *D* the diameter of the circle.

(a) When the surface of the circle is vertical [fig. 17-14(i)].

(i) Through *O*, draw a vertical centre line and another centre line inclined at 30° to the horizontal, i.e. parallel to a sloping isometric axis. On these lines, mark points 1, 2, 3 and 4 at a distance equal to 0.5*D* from *O*.

(ii) Through these points, draw lines parallel to the centre lines and obtain the rhombus *abcd* of sides equal to *D*.

(iii) Draw the required ellipse in this rhombus by the four-centre method.

By drawing the second centre line parallel to the other sloping axis, the isometric view is obtained in another position as shown in fig. 17-14(ii).

(b) When the surface of the circle is horizontal [fig. 17-14(iii)].

Through *O*, draw the two centre lines parallel to the two sloping isometric axes, i.e. inclined at 30° to the horizontal. Draw the required ellipse as explained in (a) above.

Note: This construction is very useful in drawing isometric views of circular holes in solids.

Problem 17-9. *Fig. 17-15(i) shows the front view of a semi-circle whose surface is parallel to the V.P. Draw its isometric view.*

(i) Enclose the semi-circle in a rectangle. Draw the isometric view of the rectangle [fig. 17-15(ii) and [fig. 17-15(iii)].

(ii) Using the four-centre method, draw the half-ellipse in it which is the required view. The centre for the longer arc may be obtained as shown or by completing the rhombus.

If the view given in fig. 17-15(i) is the top view of a horizontal semi-circle, its isometric view would be drawn as shown in fig. 17-16(i) and fig. 17-16(ii).

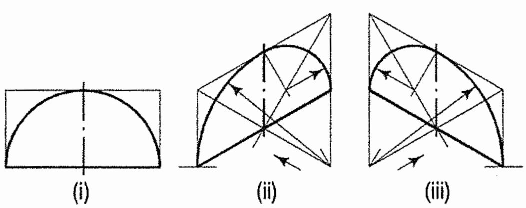


FIG. 17-15

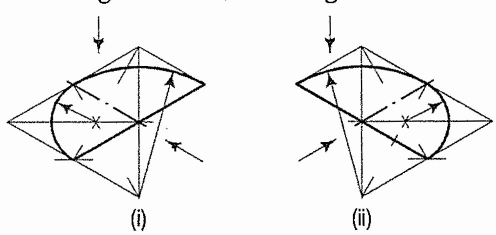


FIG. 17-16

Problem 17-10. *Fig. 17-17(i) shows the front view of a semi-circle whose surface is parallel to the V.P. Draw the isometric view of the semi-circle.*

See fig. 17-17(ii) and fig. 17-17(iii).

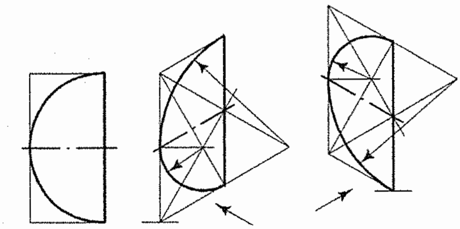


FIG. 17-17

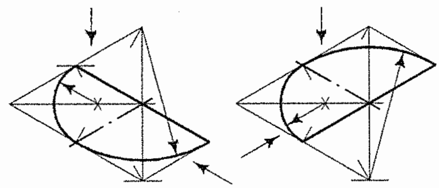


FIG. 17-18

If the view shown in fig. 17-17(i) is the top view of a semi-circle whose surface is horizontal, its isometric view will be as shown in fig. 17-18(i) or fig. 17-18(ii).

Problem 17-11. *Fig. 17-19(i) shows the front view of a plane parallel to the V.P. Draw its isometric view.*

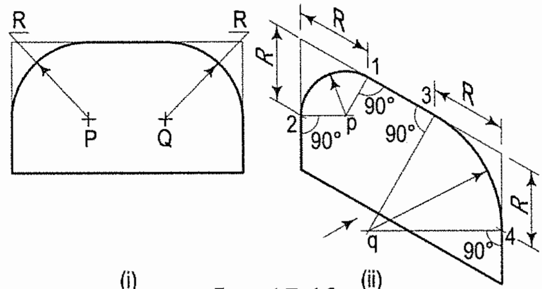


FIG. 17-19

(i) The upper two corners of the plane are rounded with quarter circles. Enclose the plane in a rectangle.

(ii) Draw the isometric view of the rectangle. From the upper two corners of the parallelogram, mark points on the sides at a distance equal to *R*, the radius of the arcs. At these points erect perpendiculars to the respective sides to intersect each other at points *p* and *q*. With *p* and *q* as centres, and radii *p*1 and *q*3, draw the arcs and complete the required view.

It is interesting to note that although the arcs are of the same radius, they are drawn with different radii in their isometric views.

17-6-2. ISOMETRIC DRAWING OF PRISMS AND PYRAMIDS

We have seen that the isometric view of a cube is determined from its orthographic view in a particular position. The three edges of the solid right-angle of the cube are shown by lines parallel to the three isometric axes. A square prism or a rectangular prism also has solid right-angles. Hence, lines for its edges are also drawn parallel to the three isometric axes.

While drawing the isometric view of any solid, the following important points should be carefully noted:

(i) The isometric view should be drawn according to the given views and in such a way that maximum possible details are visible.

(ii) At every point for the corner of a solid, at least three lines for the edges must converge. Of these, at least two must be for visible edges.
Lines for the hidden edges need not be shown, but it is advisable to check up every corner so that no line for a visible edge is left out.

(iii) Two lines (for visible edges) will never cross each other.

Problem 17-12. *Draw the isometric view of a square prism, side of the base 20 mm long and the axis 40 mm long, when its axis is (i) vertical and (ii) horizontal.*

(i) When the axis is vertical, the ends of the prism will be horizontal. Draw the isometric view (the rhombus 1-2-3-4) of the top end [fig. 17-20(i)]. Its sides will make 30°-angles with the horizontal. The length of the prism will be drawn in the third direction, i.e. vertical. Hence, from the corners of the rhombus, draw vertical lines 1-5, 2-6 and 3-7 of length equal to the length of the axis. The line 4-8 should not be drawn, as that edge will not be visible. Draw lines 5-6 and 6-7, thus completing the required isometric view. Lines 7-8 and 8-5 also should not be drawn. Beginning may also be made by drawing lines from the point 6 on the horizontal line and then proceeding upwards.

(ii) When the axis is horizontal, the ends will be vertical. The ends can be drawn in two ways as shown in fig. 17-20(ii) and fig. 17-20(iii). In each case, the length is shown in the direction of the third isometric axis.

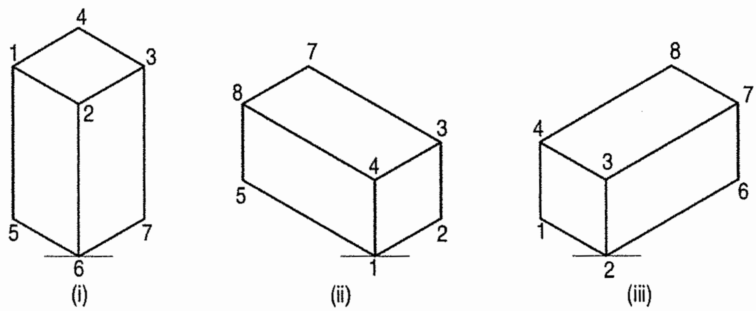


FIG. 17-20

Problem 17-13. *Three views of a block are given in fig. 17-21(i). Draw its isometric view.*

The block is in the form of a rectangular prism. Its shortest edges are vertical. Lines for these edges will be drawn vertical. Lines for all other edges which are horizontal, will be drawn inclined at 30° to the horizontal in direction of the two sloping axes as shown in fig. 17-21(ii).

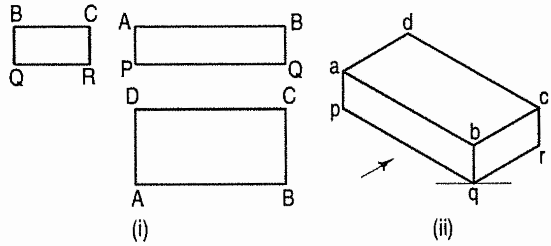


FIG. 17-21

Methods of drawing non-isometric lines.

When an object contains inclined edges which in the isometric view would be shown by non-isometric lines, the view may be drawn by using any one of the following methods:

(i) box method or

(ii) co-ordinate or offset method.

(i) Box method: This method is used when the non-isometric lines or their ends lie in isometric planes. The object is assumed to be enclosed in a rectangular box. Initially, the box is drawn in isometric. The ends of the lines for the inclined edges are then located by measuring on or from the outlines of the box.

Problem 17-14. *Three views of a block are given in fig. 17-22(i). Draw its isometric view.*

(i) Enclose the block in a rectangular box.

(ii) Draw the isometric view of the box [fig. 17-22(ii)].

(iii) Mark points e and *f* on the line *bc* such that be = *BE* and *fc* = *FC*.

(iv) Complete the required view as shown.

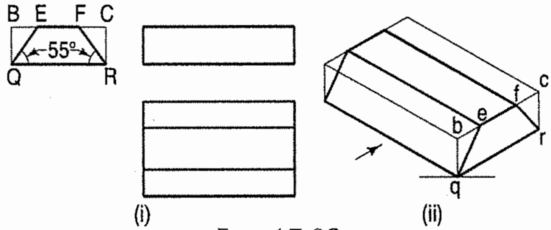


FIG. 17-22

Problem 17-15. *Draw the isometric view of the plate shown in three views in fig. 17-23(i).*

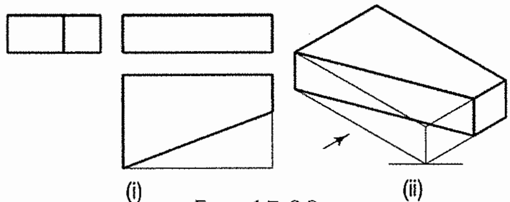


FIG. 17-23

Obtain the required view as explained in problem 17-14 and as shown in fig. 17-23(ii).

This book is accompanied by a computer CD, which contains an audiovisual animation presented for better visualization and understanding of the subject. Readers are requested to refer Presentation module 42 for the following problem.

Problem 17-16. *Draw the isometric view of the frustum of the hexagonal pyramid shown in fig. 17-24(i).*

(i) Enclose the front view and the top view in rectangles.

(ii) Draw the isometric view of the rectangular box [fig. 17-24(ii)]. Locate the six points of the base of the frustum on the sides of the bottom of the box. The upper six points on the top surface of the box are located by drawing isometric lines, e.g. *P*1 and *Q*1 intersecting at a point 1.

(iii) Join the corners and complete the isometric view as shown.

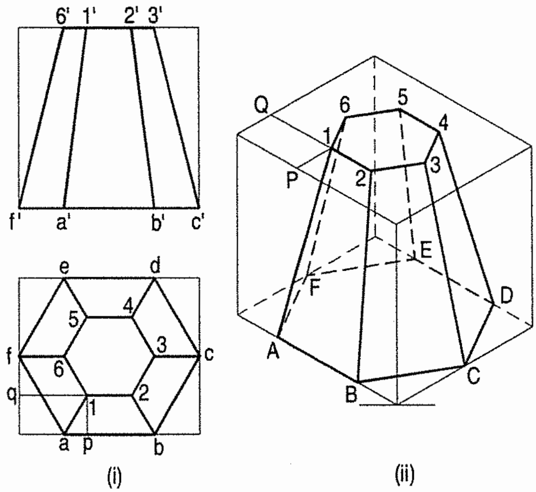


FIG. 17-24

(ii) Co-ordinate or Offset method: This method is adopted for objects in which neither non-isometric lines nor their ends lie in isometric planes.

Perpendiculars are dropped from each end of the edge to a horizontal or a vertical reference plane. The points at which the perpendiculars meet the plane, are located by drawing co-ordinates or offsets to the edges of the plane.

This book is accompanied by a computer CD, which contains an audiovisual animation presented for better visualization and understanding of the subject. Readers are requested to refer Presentation module 43 for the following problem.

Problem 17-17. *Draw the isometric view of the pentagonal pyramid, the projections of which are given in fig. 17-25(i).*

(i) Enclose the base (in the top view) in an oblong.

(ii) Draw an offset *oq* (i.e. *pq*) on the line *ab*.

(iii) Draw the isometric view of the oblong and locate the corners of the base in it [fig. 17-25(ii)].

(iv) Mark a point *Q* on the line *AB* such that *AQ* = *aq*. From *Q*, draw a line *QP* equal to *qo* and parallel to 2*C*. At *P*, draw a vertical *OP* equal to *o'p'*.

(v) Join *O* with the corners of the base, thus completing the isometric view of the pyramid.

Fig. 17-25(iii) shows the isometric view of the same pyramid with its axis in horizontal position.

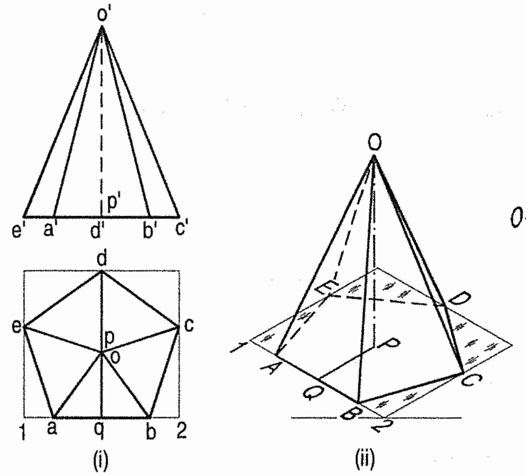


FIG. 17-25

Problem 17-18. *Draw the isometric view of the truncated triangular pyramid shown in fig. 17-26(i).*

(i) Draw the perpendiculars *d' x'*, *e' y'* and *f' z'* the front view and the offsets *dq*, *er* and *fc* in the top view.

(ii) Draw the isometric view of the whole pyramid [fig. 17-26(ii)].

(iii) Transfer the offsets and the verticals to this view and obtain points *D*, *E* and *F* on the lines *OA*, *OB* and *OC* respectively.

(iv) Draw lines *DE*, *EF* and *FD* and complete the required isometric view.

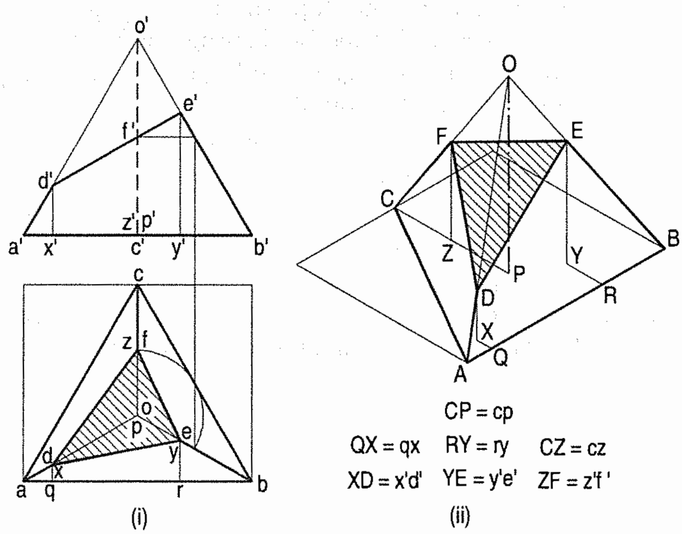


FIG. 17-26

17-6-3. ISOMETRIC DRAWING OF CYLINDERS

Problem 17-19. *Draw the isometric view of the cylinder shown in fig. 17-27(i).*

The axis of the cylinder is vertical, hence its ends are horizontal. Enclose the cylinder in a square prism.

Method I:

Draw the isometric view of the prism [fig. 17-27(ii)]. In the two rhombuses, draw the ellipses by the four-centre method. Draw two common tangents to the two ellipses. Erase the inner half of the lower ellipse and complete the required view.

Method II:

Draw the rhombus for the upper end of the prism [fig. 17-27(iii)] and in it, draw the ellipse by the four-centre method. From the centres for the arcs, draw vertical lines of length equal to the length of the axis, thus determining the centres for the lower ellipse. Draw the arcs for the half ellipse. Draw common tangents, thus completing the required view.

When the axis of the cylinder is horizontal, its isometric view is drawn by method I as shown in fig. 17-28(i).

Fig. 17-28(ii) shows the view drawn by method II, but the axis is shown sloping in the other direction.

Fig. 17-29 and fig. 17-30 respectively show the isometric views (drawn by method II) of a half-cylindrical disc with its axis in vertical and horizontal positions.

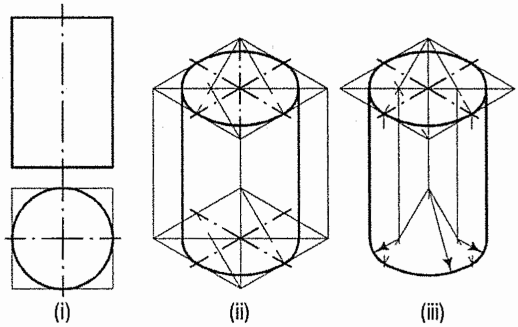


FIG. 17-27

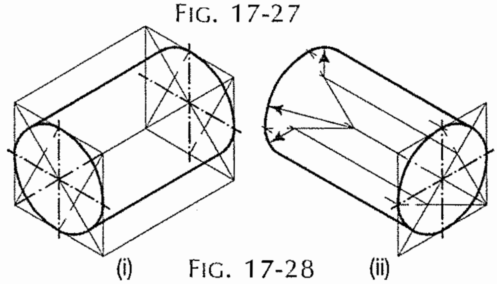


FIG. 17-28

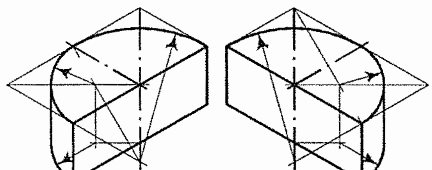


FIG. 17-29

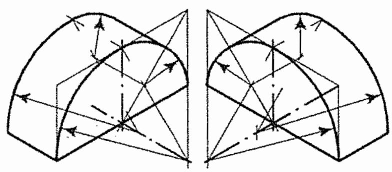


FIG. 17-30

17-6-4. ISOMETRIC DRAWING OF CONES

Problem 17-20. *Draw the isometric view of a cone, base 40 mm diameter and axis 55 mm long (i) when its axis is vertical and (ii) when its axis is horizontal.*

(i) Draw the ellipse for the base [fig. 17-31(i)]. Determine the position of the apex by the offset method.

(ii) Draw tangents to the ellipse from the apex. Erase the part of the ellipse between the tangents and complete the view as shown.

(iii) See fig. 17-31(ii) which is self-explanatory.

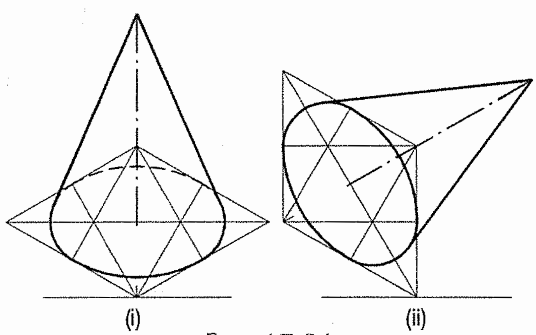


FIG. 17-31

Problem 17-21. *Draw the isometric view of the frustum of a cone shown in fig. 17-32(i).*

(i) Draw the ellipse for the base [fig. 17-32(ii)]. Draw the axis.

(ii) Around the top end of the axis, draw the ellipse for the top.

(iii) Draw common tangents, erase the unwanted part of the ellipse and complete the view as shown.

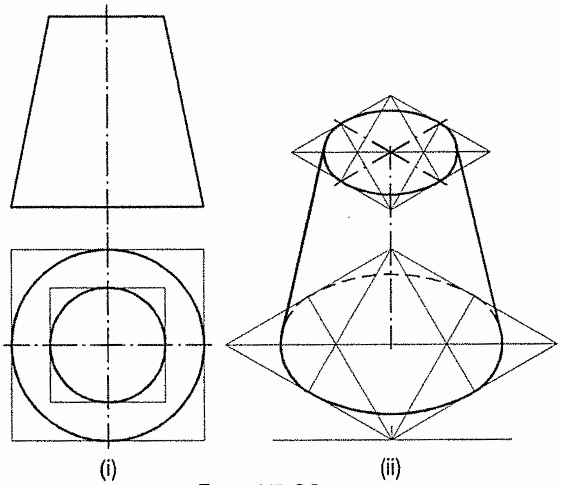


FIG. 17-32

17-6-5. ISOMETRIC DRAWING OF SPHERE

The orthographic view of a sphere seen from any direction is a circle of diameter equal to the diameter of the sphere. Hence, the isometric projection of a sphere is also a circle of the same diameter as explained below.

The front view and the top view of a sphere resting on the ground are shown in fig. 17-33(i). *C* is its centre, *D* is the diameter and *P* is the point of its contact with the ground.

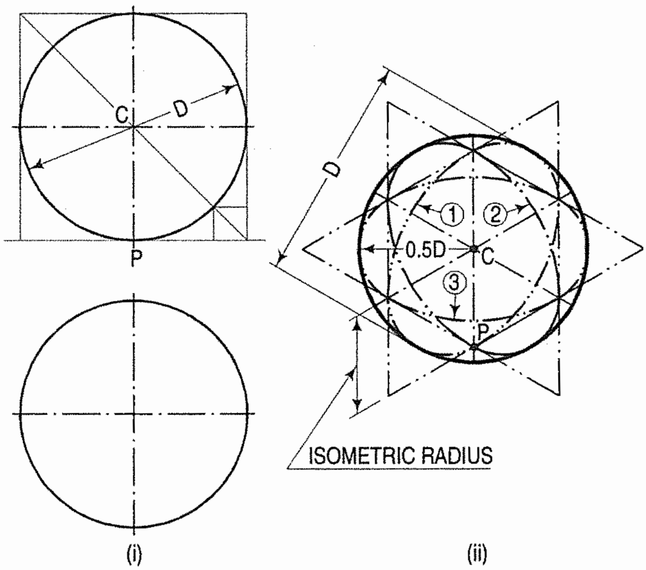


FIG. 17-33

Assume a vertical section through the centre of the sphere. Its shape will be a circle of diameter *D*. The isometric projection of this circle is shown in fig. 17-33(ii) by ellipses 1 and 2, drawn in two different vertical positions around the same centre *C*. The length of the major axis in each case is equal to *D*. The distance of the point *P* from the centre *C* is equal to the isometric radius of the sphere.

Again, assume a horizontal section through the centre of the sphere. The isometric projection of this circle is shown by the ellipse 3, drawn in a horizontal position around the same centre *C*. In this case also, the distance of the outermost points on the ellipse from the centre *C* is equal to 0.5*D*.

Thus, it can be seen that in an isometric projection, the distances of all the points on the surface of a sphere from its centre, are equal to the radius of the sphere.

Hence, the isometric projection of a sphere is a circle whose diameter is equal to the true diameter of the sphere.

Also, the distance of the centre of the sphere from its point of contact with the ground is equal to the isometric radius of the sphere, viz. *CP*.

It is, therefore, of the utmost importance to note that, *isometric scale must invariably be used, while drawing isometric projections of solids in conjunction with spheres or having spherical parts.*

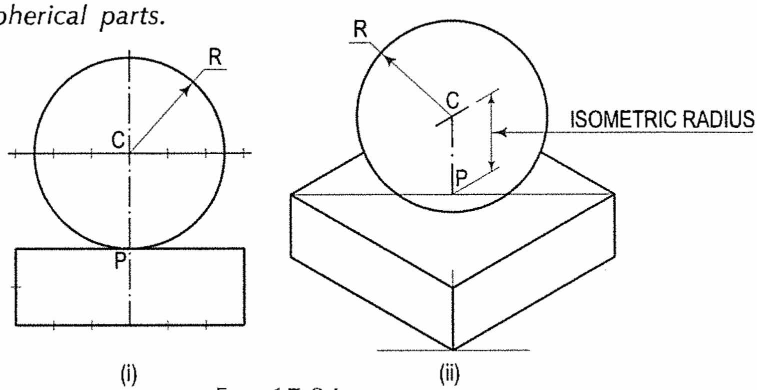


FIG. 17-34

Problem 17-22. *Draw the isometric projection of a sphere resting centrally on the top of a square prism, the front view of which is shown in fig. 17-34(i).*

(i) Draw the isometric projection (using isometric scale) of the square prism and locate the centre *P* of its top surface [fig. 17-34(ii)].

(ii) Draw a vertical at *P* and mark a point *C* on it, such that *PC* = the *isometric radius* of the sphere.

(iii) With *C* as centre and *radius equal to the radius of the sphere*, draw a circle which will be the isometric projection of the sphere.

17-7. TYPICAL PROBLEMS OF ISOMETRIC DRAWING

The solutions given in the following typical problems are mostly self-explanatory. Explanations are however given where deemed necessary. Construction lines are left intact for guidance. Dotted lines for hidden edges have been shown in some views to make the construction more clear. Unless otherwise stated, all dimensions are given in millimetres.

Problem 17-23. *A hexagonal prism having the side of base 26 mm and the height of 60 mm is resting on one of the corner of the base and its axis is inclined to 30° to the H.P. Draw its projections and also prepare the isometric view of the prism in the above stated condition.*

(i) Draw the projections of the prism as shown in figure 17-35.

(ii) Construct the isometric view as shown in fig. 17-36.

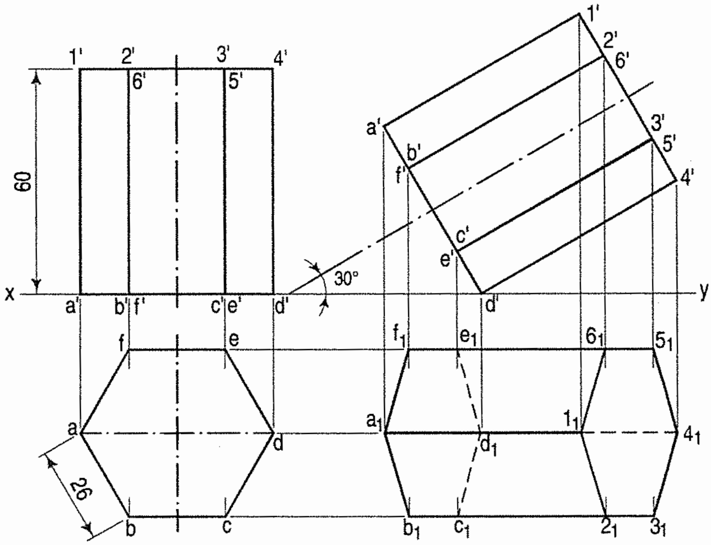


FIG. 17-35

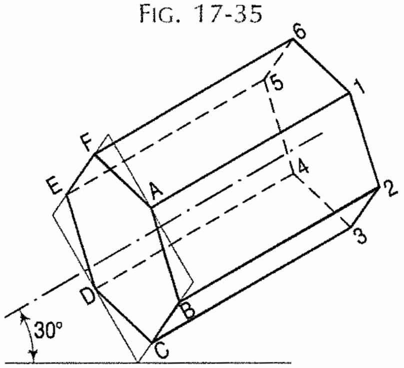


FIG. 17-36

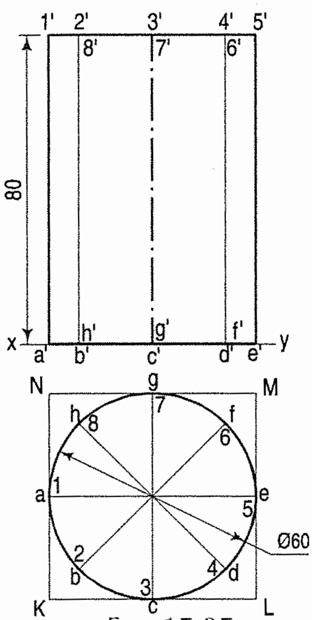


FIG. 17-37

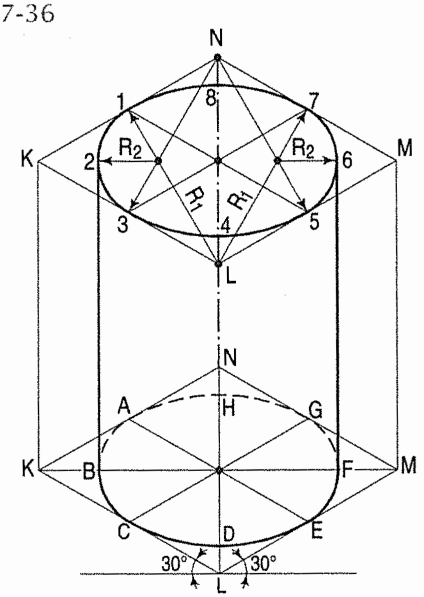


FIG. 17-38

Problem 17-24. (fig. 17-37)**:** *A cylindrical block of base, 60 mm diameter and height 80 mm, standing on the H.P. with its axis perpendicular to the H.P. Draw its isometric view.*

The method shown in fig. 17-38 is self-explanatony.

Problem 17-25. *The projection of pentagonal pyramid is shown in fig. 17-39. Draw its isometric view.*

See fig. 17-40.

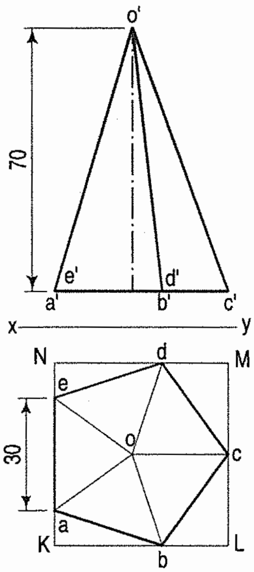


FIG. 17-39

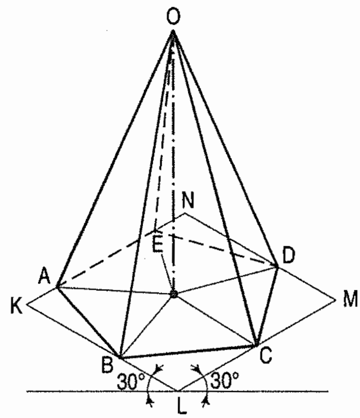


FIG. 17-40

Problem 17-26. *The projection of the frustum of the cone is shown in fig. 17-41. Draw its isometric view.*

See fig. 17-42.

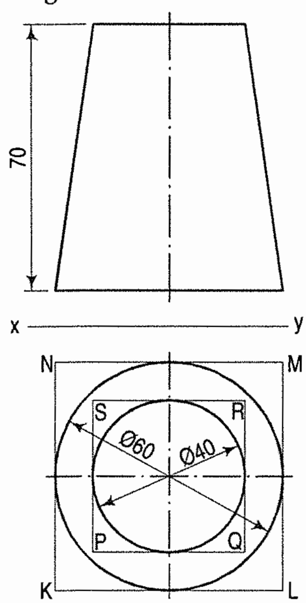


FIG. 17-41

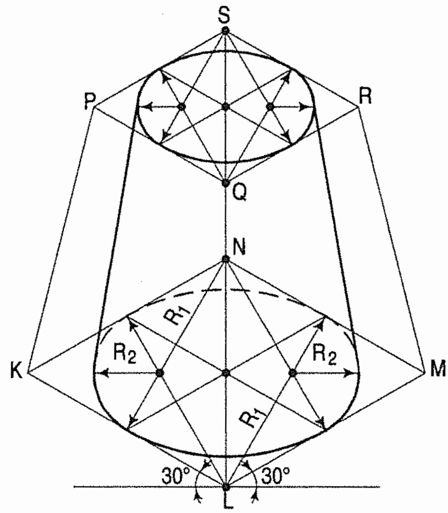


FIG. 17-42

Problem 17-27. *The orthographic projections of the object is shown in fig. 17-43. Draw the isometric view of the object.*

See fig. 17-44.

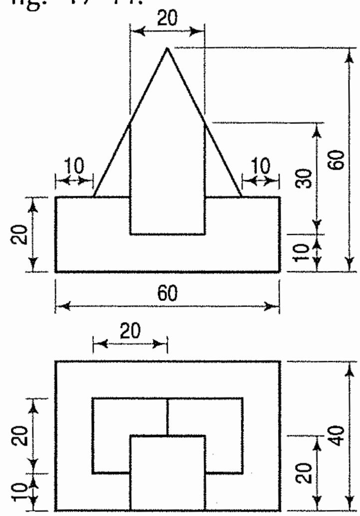


FIG. 17-43

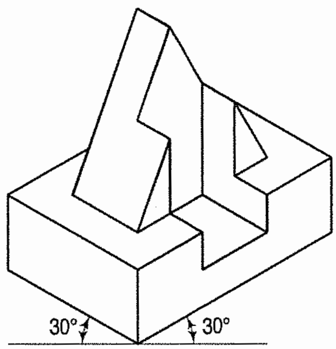


FIG. 17-44

Problem 17-28. *Draw the isometric view of the casting shown in two views in fig. 17-45.*

See fig. 17-46. Lines for the visible lower edges of the rectangular hole should be shown.

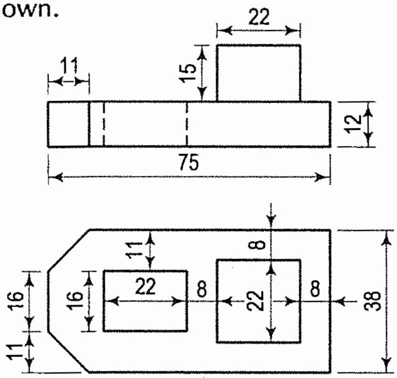


FIG. 17-45

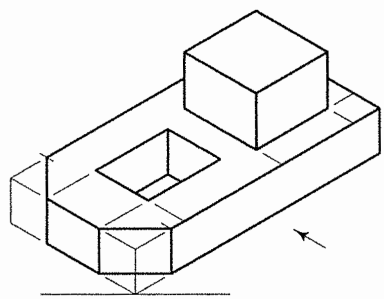


FIG. 17-46

Problem 17-29. *Draw the isometric view of the block, two views of which are shown in fig. 17-47.*

See fig. 17-48. Centres for the arcs for lower circular edges are obtained by drawing vertical lines from the centres for the upper arcs.

Problem 17-30. *Draw the isometric view of the casting, shown in three views in fig. 17-49.*

See fig. 17-50.

Problem 17-31. *Draw the isometric view of the casting, two views of which are shown in fig. 17-51.*

See fig. 17-52.

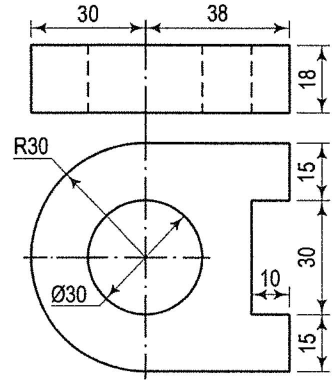


FIG. 17-47

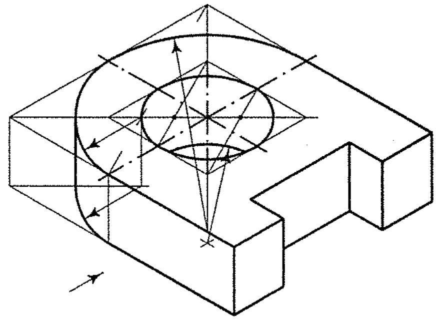
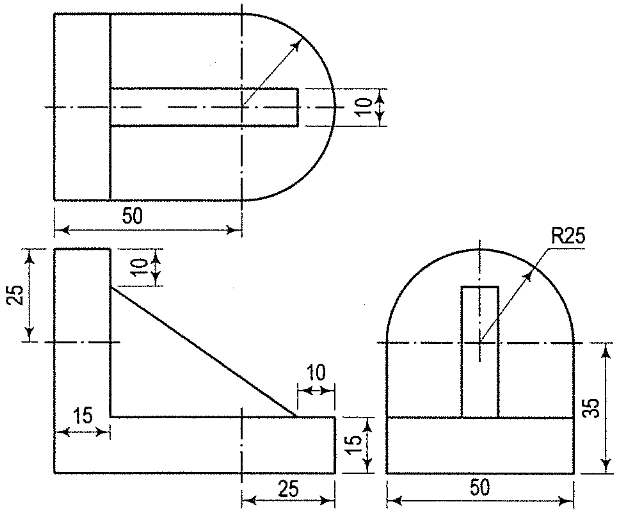


FIG. 17-48



(Third-angle projection)
FIG. 17-49

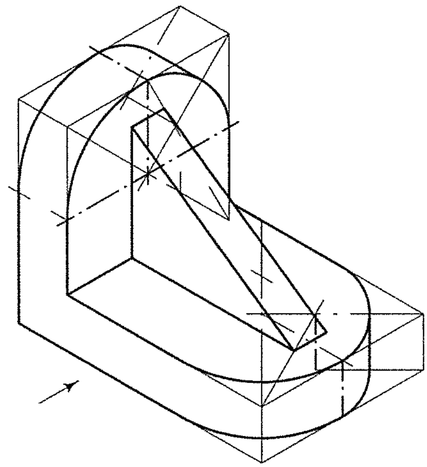
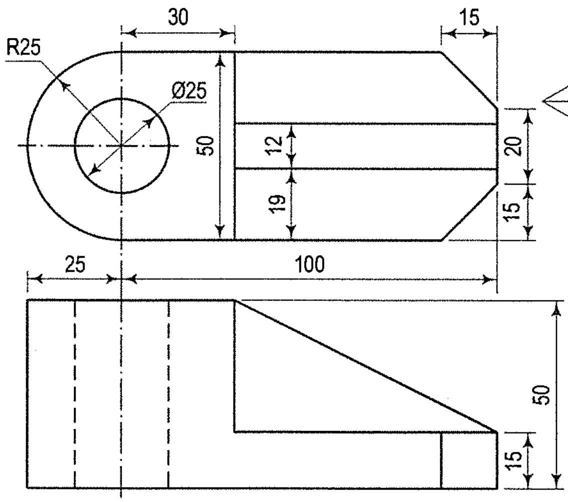


FIG. 17-50



(Third-angle projection)
FIG. 17-51

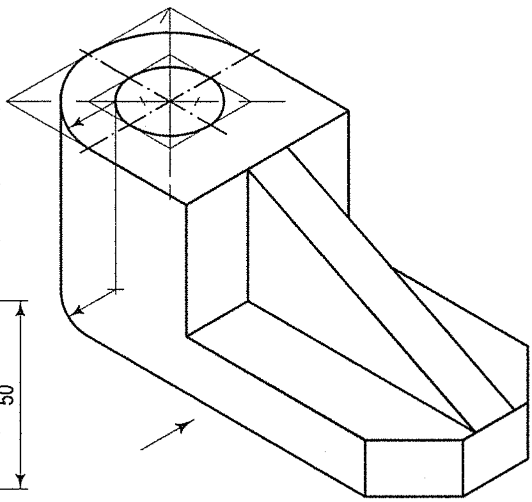


FIG. 17-52

Problem 17-32. *The front view of a board fitted with a letter H and mounted on a wooden post is given in fig. 17-53. Draw its isometric view, assuming the thickness of the board and of the letter to be equal to 3 cm. Scale, half full size. (All dimensions are given in centimeters.)*

See fig. 17-54.

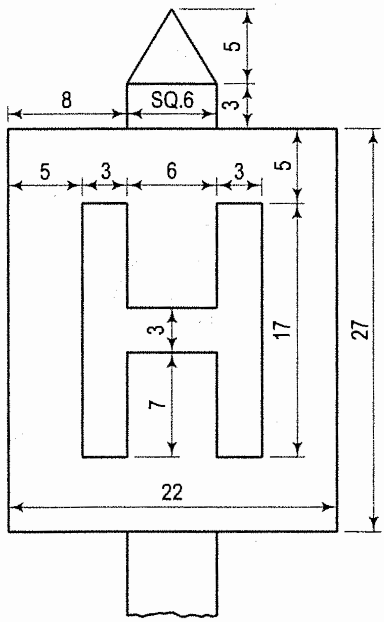


FIG. 17-53

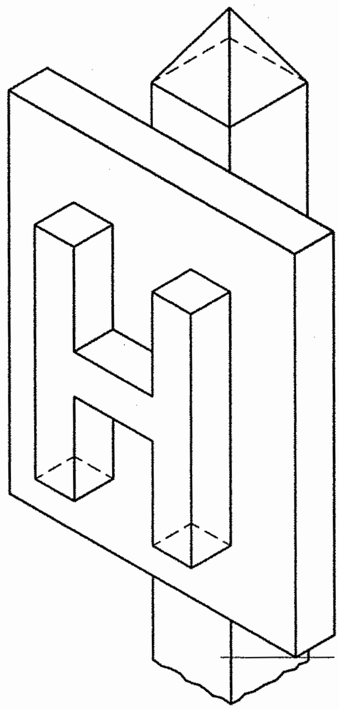


FIG. 17-54

Problem 17-33. *Draw the isometric view of the casting shown in two views in fig. 17-55.*

See fig. 17-56.

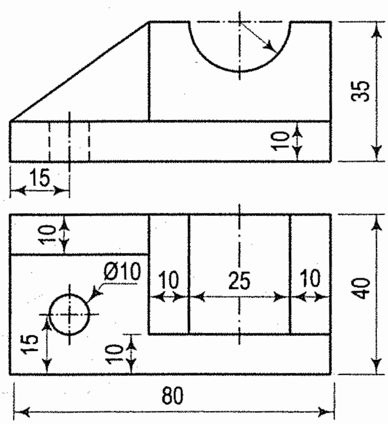


FIG. 17-55

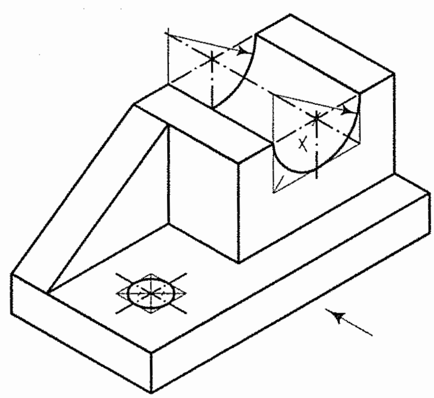


FIG. 17-56

Problem 17-34. *Draw the isometric view of the model of steps, two views of which are shown in fig. 17-57.*

See fig. 17-58.

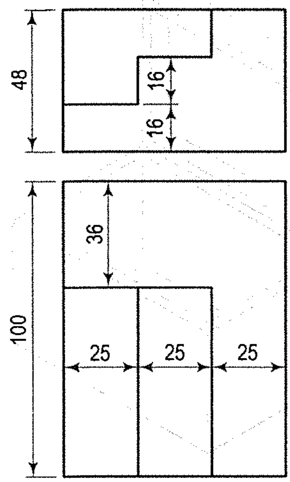


FIG. 17-57

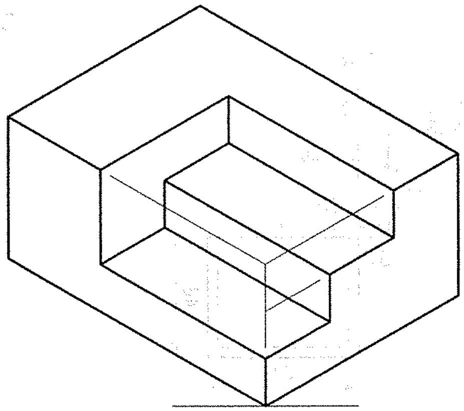


FIG. 17-58

Problem 17-35. *Two pieces of wood joined together by a dovetail joint are shown in two views in fig. 17-59. Draw the isometric view of the two pieces separated but in a position ready for fitting.*

See fig. 17-60.

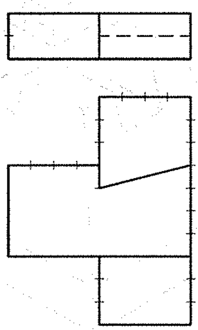


FIG. 17-59

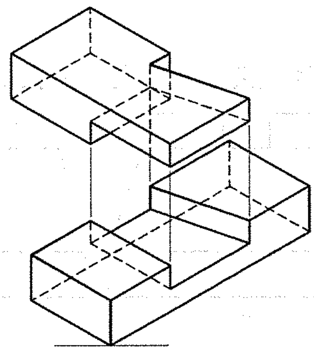


FIG. 17-60

Problem 17-36. *The outside dimensions of a box made of 4 cm thick planks are 90 cm × 60 cm × 60 cm height. The depth of the lid on the outside is 12 cm. Draw the isometric view of the box when the lid is (a) 90° open and (b) 120° open.*

Draw the orthographic view of the box with the lid in required positions as shown in fig. 17-61.

(a) This position is simple to draw in isometric view. Care must, however, be taken to deduct the thickness of the wood for the bottom and the top, when showing in the lines for the inside of the box and the lid (fig. 17-62).

(b) In this position, points *P*, *Q*, *R* etc. for the lid are located by enclosing the lid in the oblong and transferring the same on the isometric view as shown in fig. 17-62. The view is left incomplete to avoid congestion.

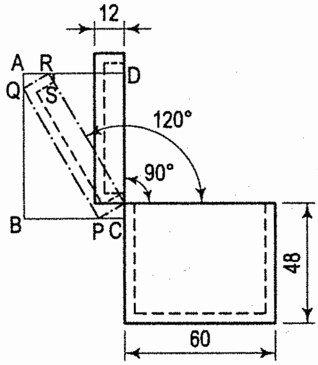


FIG. 17-61

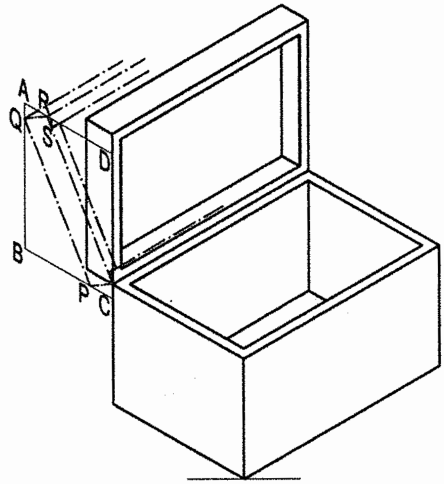


FIG. 17-62

Problem 17-37. *Two views of a cast-iron block are shown in fig. 17-63. Draw its isometric view.*

See fig. 17-64.

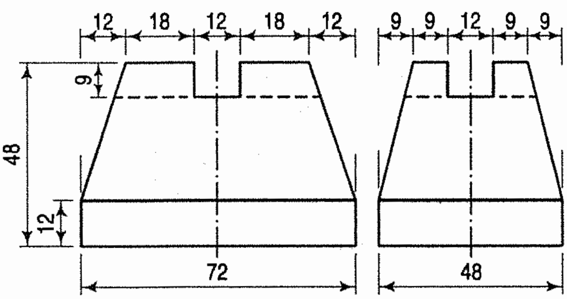


FIG. 17-63

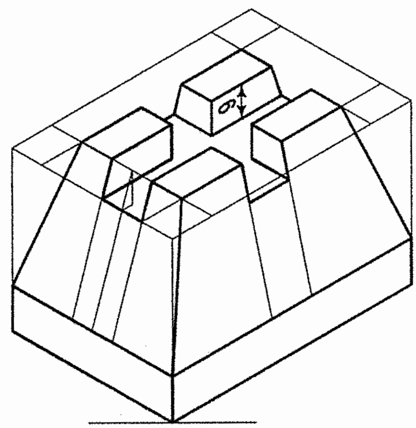


FIG. 17-64

The slope of the lines for the grooves on the outer surface on all the four sides is different and is obtained as shown by construction lines. The depth is measured along vertical lines.

Problem 17-38. *Draw the isometric view of the casting shown in two views in fig. 17-65.*

See fig. 17-66.

Problem 17-39. *Draw the isometric view of the simple moulding shown in fig. 17-67.*

See fig. 17-68.

The points on the curve are located by co-ordinate method. The parallel curve is obtained by drawing lines in the third direction and equal to the thickness of the moulding.

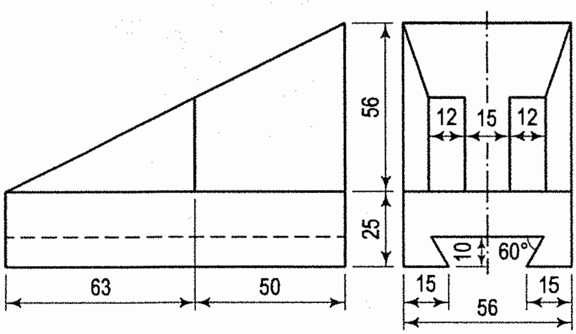


Fig. 17-65

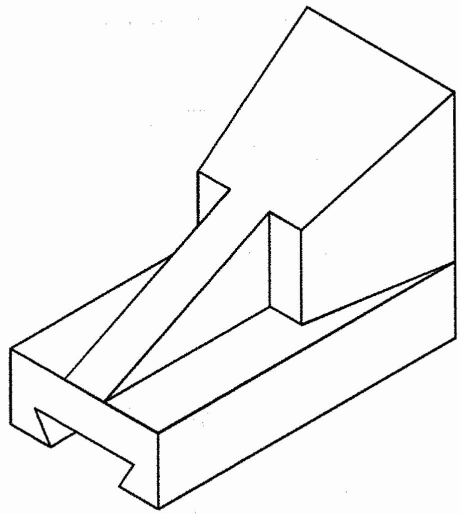


Fig. 17-66

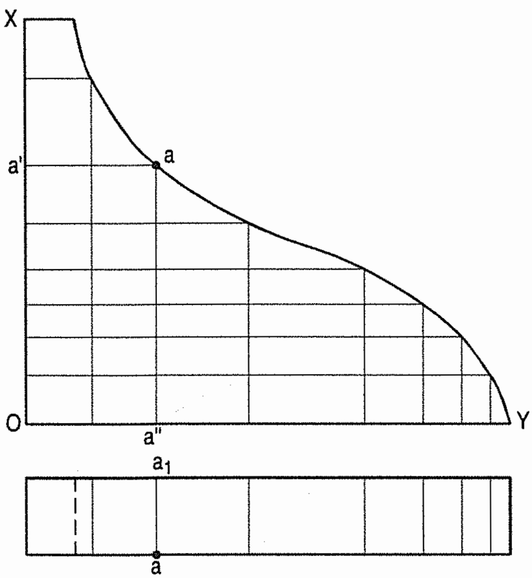


Fig. 17-67

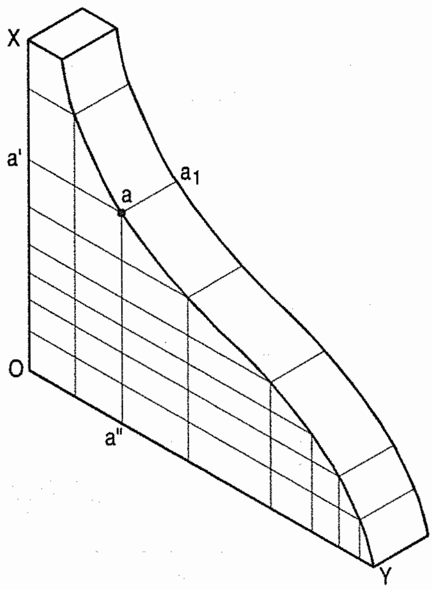


Fig. 17-68

Problem 17-40. *The front view of three solids placed one above the other, with their axes in a straight line is shown in fig. 17-69. Draw the isometric view of the arrangement.*

See fig. 17-70.

In this problem, isometric lengths must be taken for all dimensions except for the radius of the circle for the sphere.

The centre C of the sphere is at a distance equal to the isometric radius from the centre P of the top face of the cone frustum. *The circle for the sphere is drawn with the true radius.*

The ellipse for the section of the sphere is drawn within the rhombus constructed around the point Q on the axis.

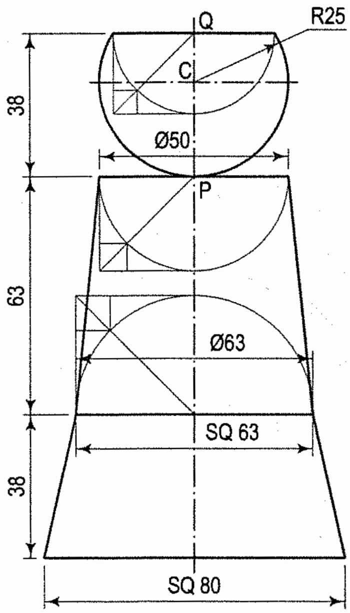


FIG. 17-69

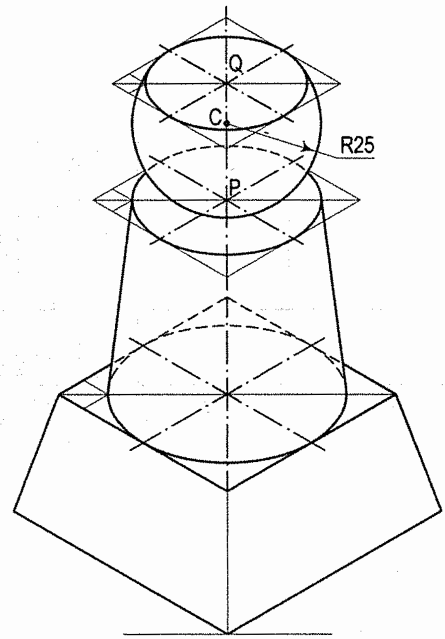


FIG. 17-70

Problem 17-41. *Draw the isometric view of the clamping piece shown in fig. 17-71.*

See fig. 17-72.

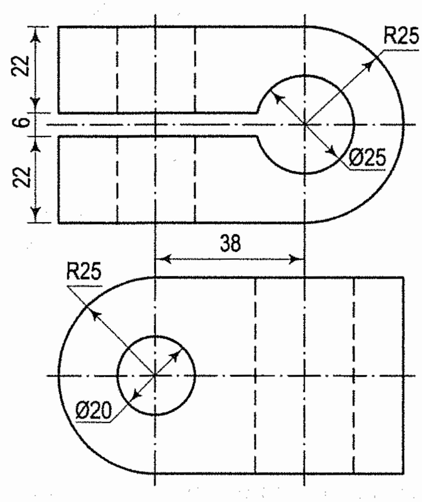


FIG. 17-71

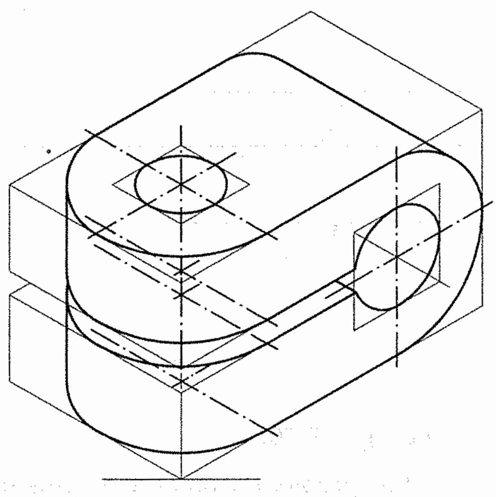


FIG. 17-72

Problem 17-42. (fig. 17-73): *Draw the isometric view of a hexagonal nut for a 24 mm diameter bolt, assuming approximate dimensions. The threads may be neglected but chamfer must be shown.*

See fig. 17-74.

Problem 17-43. *Draw the isometric view of the paper-weight with spherical knob shown in fig. 17-75.*

See fig. 17-76. Isometric scale should be used for all dimensions except for the radius of the circle for the sphere.

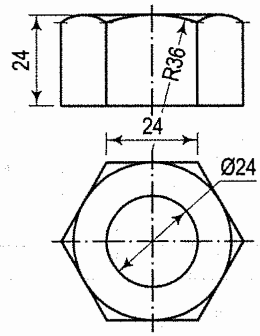


FIG. 17-73

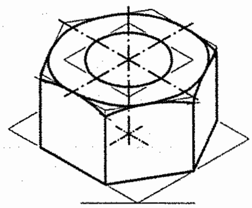


FIG. 17-74

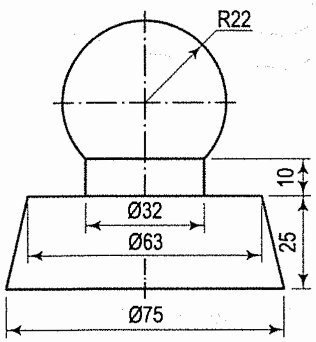


FIG. 17-75

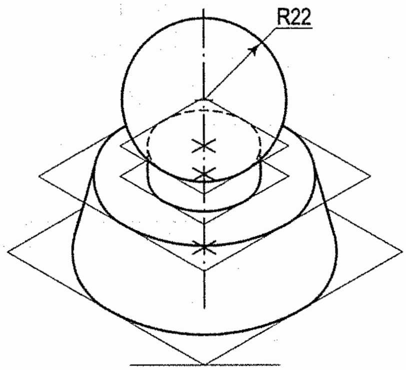


FIG. 17-76

Problem 17-44. (fig. 17-77): *Draw the isometric view of a square-headed bolt 24 mm diameter and 70 mm long, with a square neck 18 mm thick and a head, 40 mm square and 18 mm thick.*

See fig. 17-78.

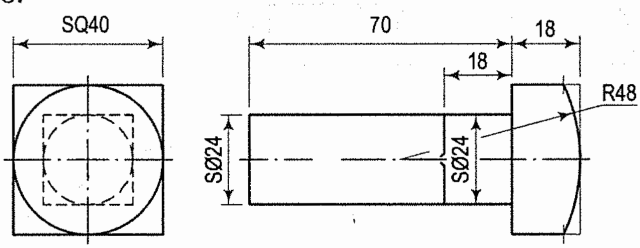


FIG. 17-77

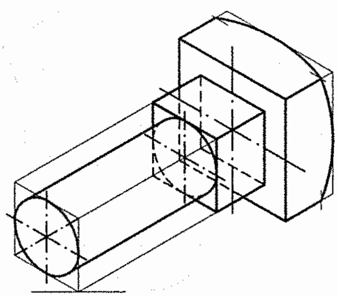


FIG. 17-78

Problem 17-45. *Draw the isometric view of the casting shown in fig. 17-79.* See fig. 17-80.

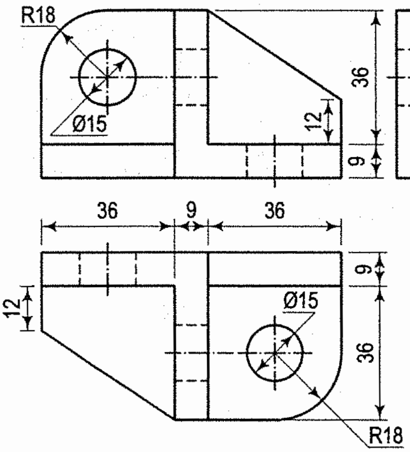


FIG. 17-79

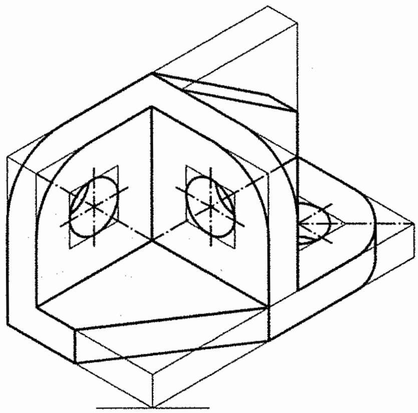


FIG. 17-80

Problem 17-46. *The projections of a casting are shown in fig. 17-81. Draw its isometric view.*

See fig. 17-82.

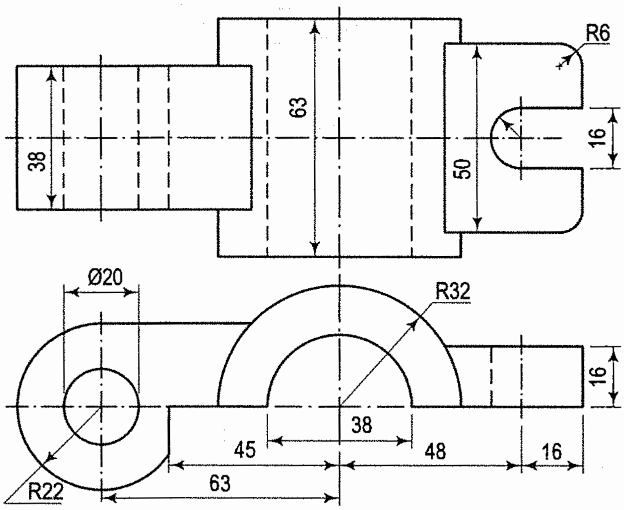


FIG. 17-81

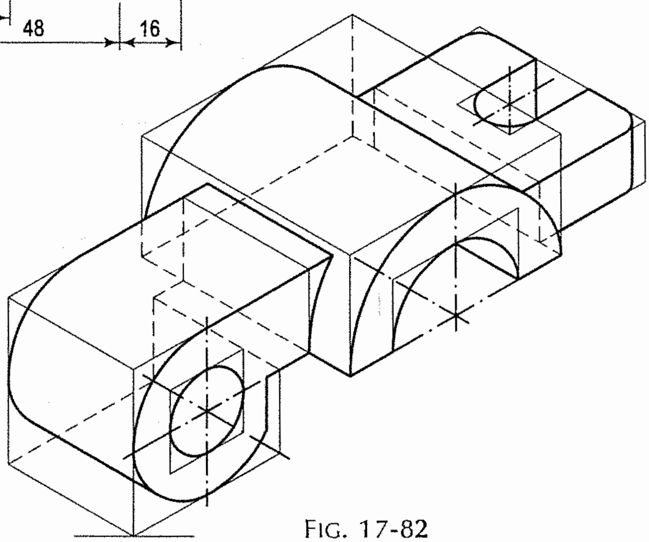


FIG. 17-82

Problem 17-47. *Draw the isometric view of the bracket shown in two views in fig. 17-83.*

See fig. 17-84.

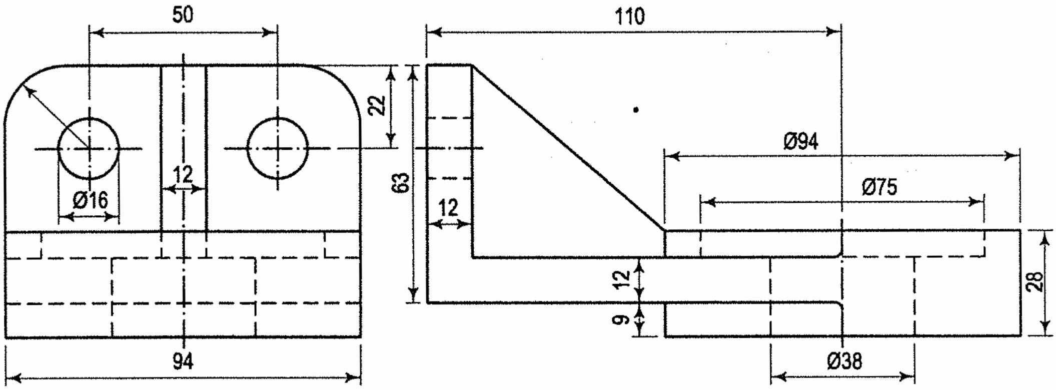


FIG. 17-83

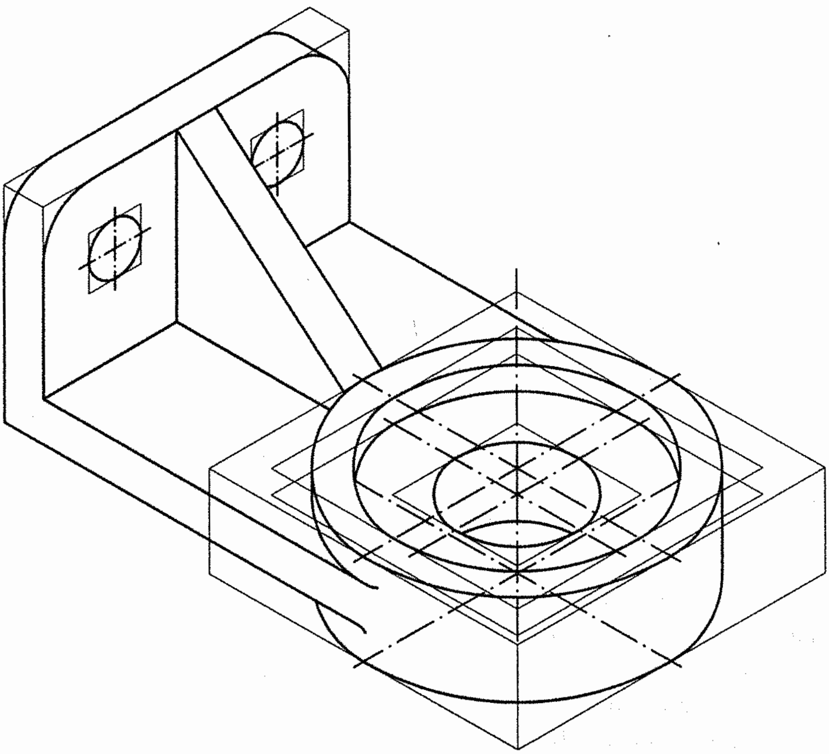


FIG. 17-84

Problem 17-48. *Draw the isometric view of the machine-handle shown in fig. 17-85.*

See fig. 17-86.

All measurements must be in isometric lengths except those for the diameters of spherical parts.

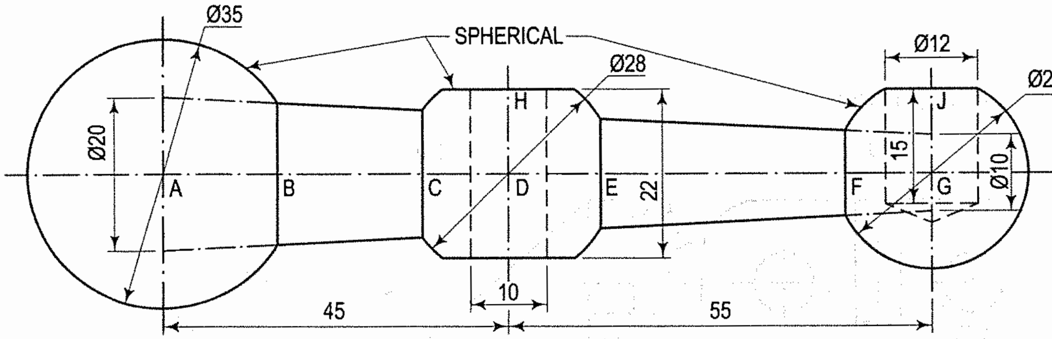


FIG. 17-85

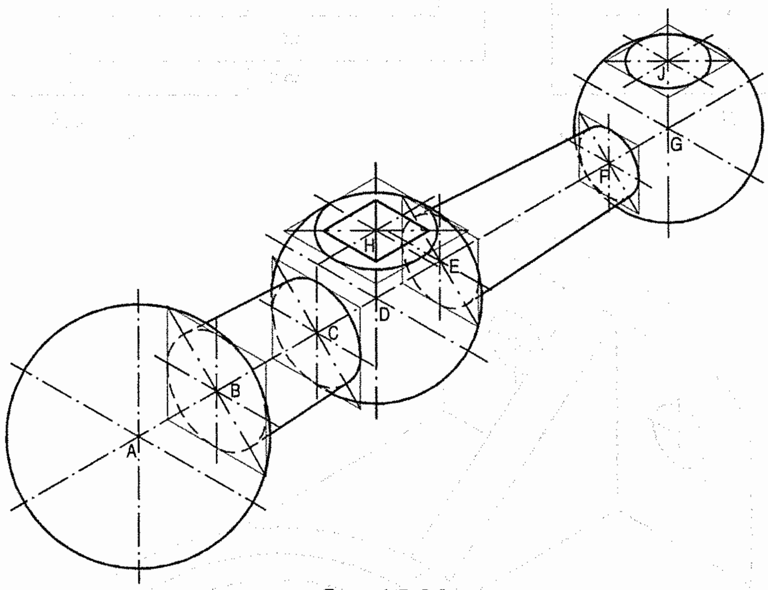


FIG. 17-86

(i) Draw an axis and mark on it the positions of points *A*, *B* etc.

(ii) At points *B*, *C*, *E* and *F*, draw ellipses for circular sections of the conical handle. Ellipses at *B* and *E* will be completely hidden.

(iii) With points *A*, *D* and *G* as centres, draw circles for the spheres, with their respective true radii.

(iv) Mark points *H* and *J* on the vertical axes through *D* and *G* respectively and draw ellipses for the respective sections of the spheres.

(v) Around *H*, draw a rhombus for the square hole.

(vi) The dotted lines for the depth of the holes are omitted.

Problem 17-49. *The front view of a stool having a square top and four legs is shown in fig. 17-87. Draw its isometric view.*

The legs lie along the slant edges of a frustum of a square pyramid (fig. 17-88).

Positions of the connecting horizontal strips between the legs at the top and at the bottom are determined by marking the heights along the axis and then drawing isometric lines upto the line *AB*, which shows the slope of the face of the frustum.

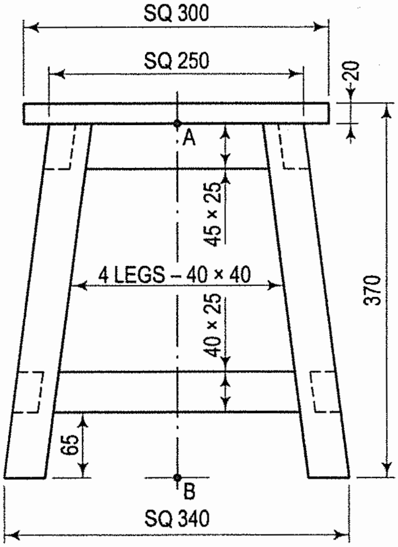


FIG. 17-87

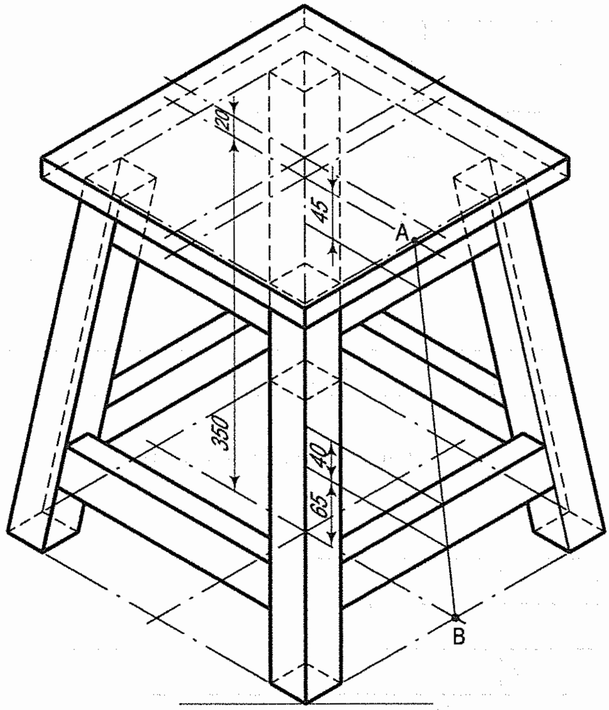


FIG. 17-88

EXERCISES 17

1. Projections of castings of various shapes are given in figs. 17-89 to 17-115. Draw the isometric view of each casting.

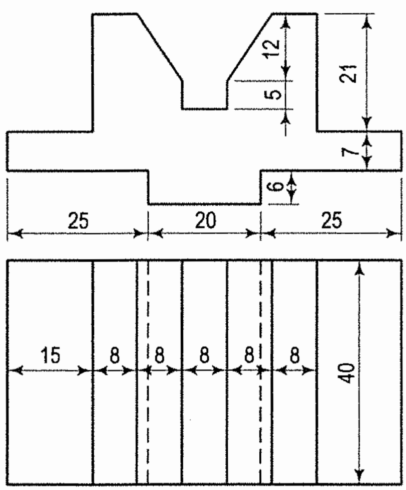


FIG. 17-89

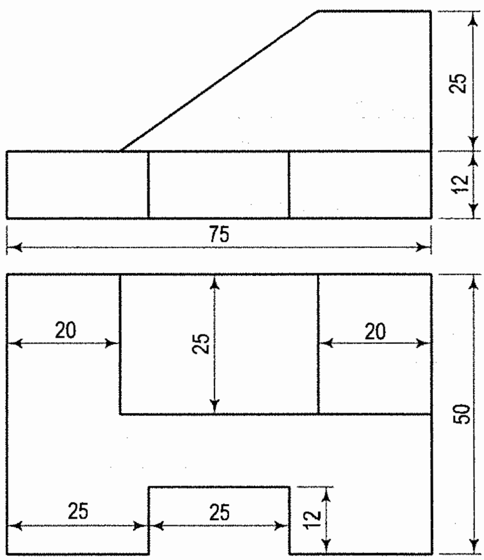
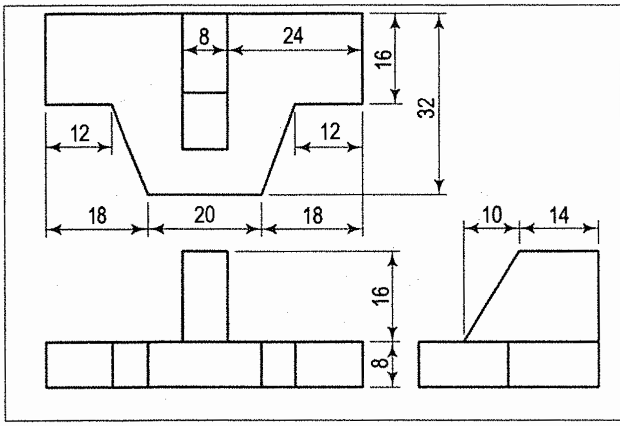


FIG. 17-90



(Third-angle projection)
FIG. 17-91

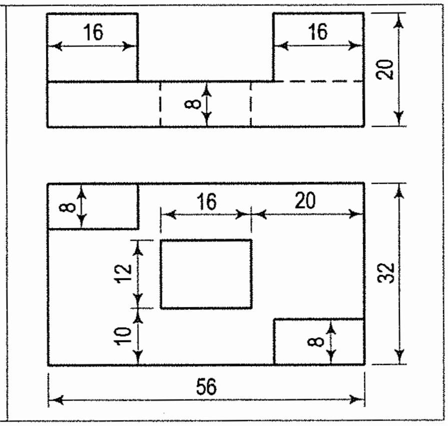


FIG. 17-92

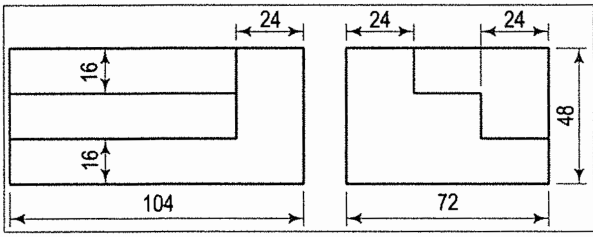


FIG. 17-93

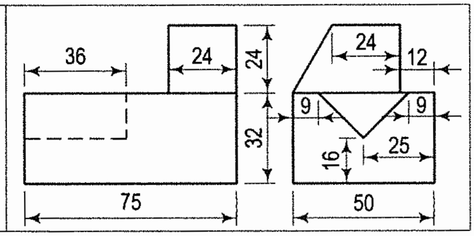
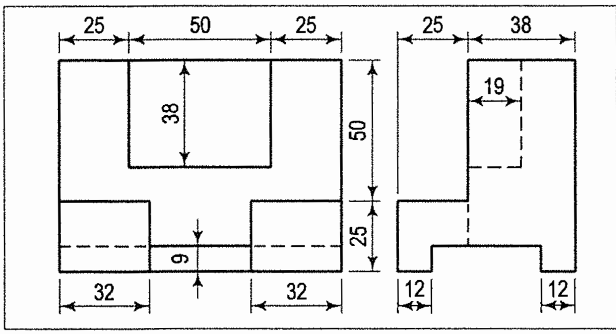
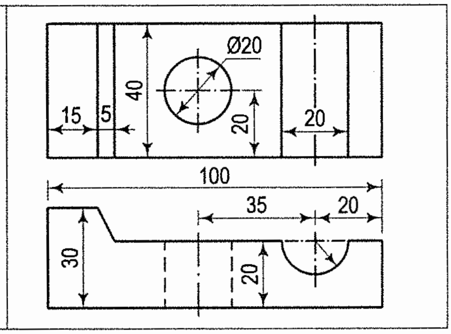


FIG. 17-94



(Third-angle projection)
FIG. 17-95



(Third-angle projection)
FIG. 17-96

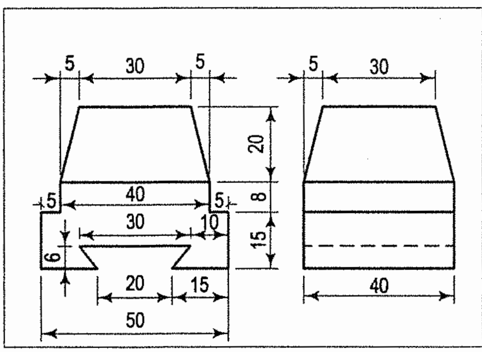


FIG. 17-97

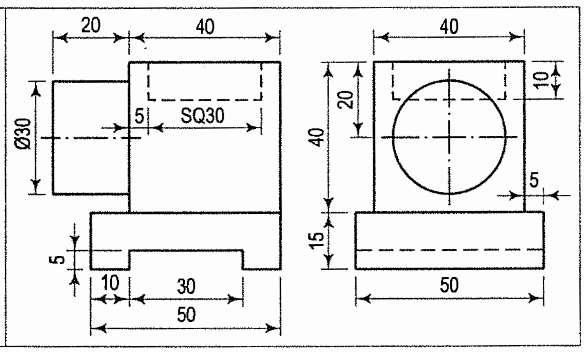


FIG. 17-98

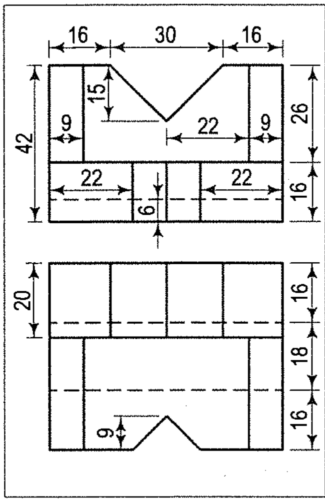


FIG. 17-99

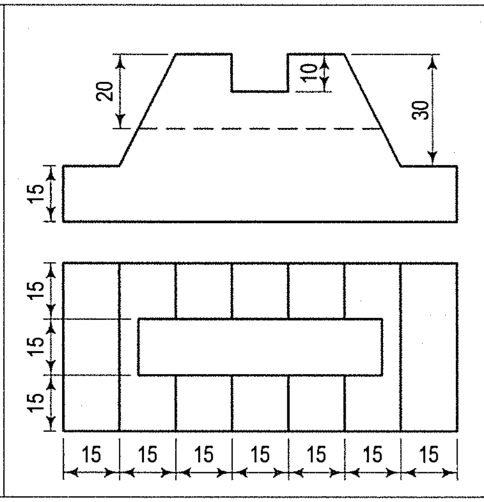


FIG. 17-100

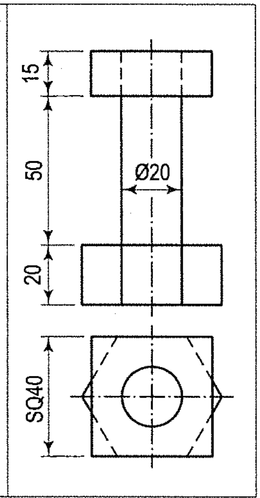


FIG. 17-101

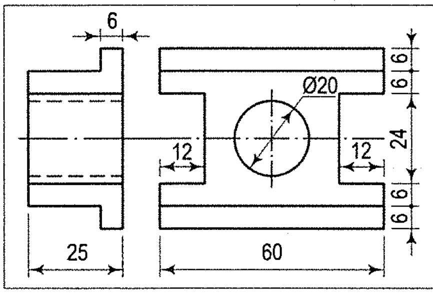


FIG. 17-102

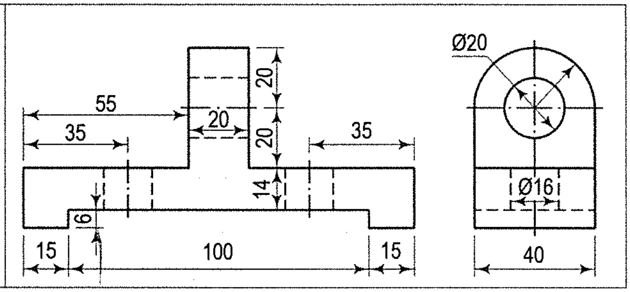


FIG. 17-103

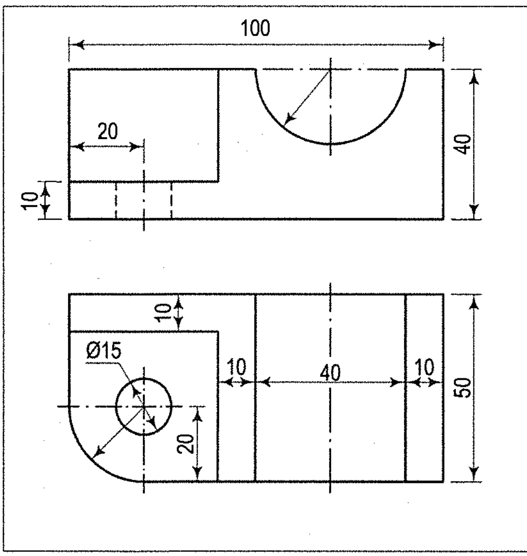
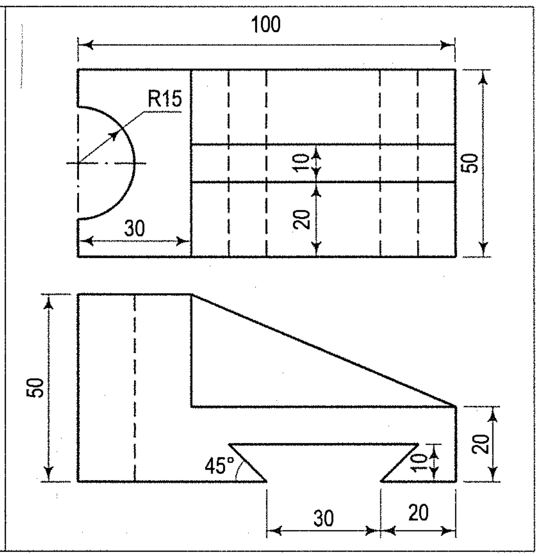


FIG. 17-104



(Third-angle projection)
FIG. 17-105

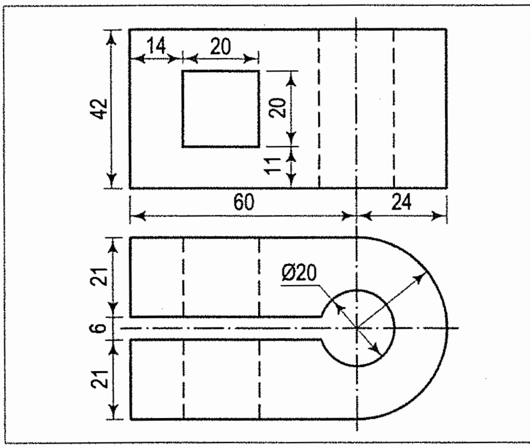
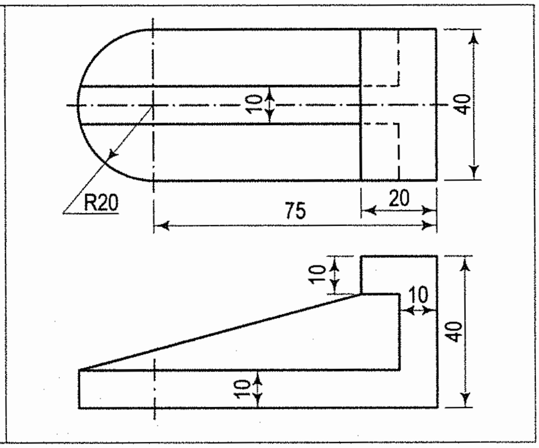


FIG. 17-106



(Third-angle projection)
FIG. 17-107

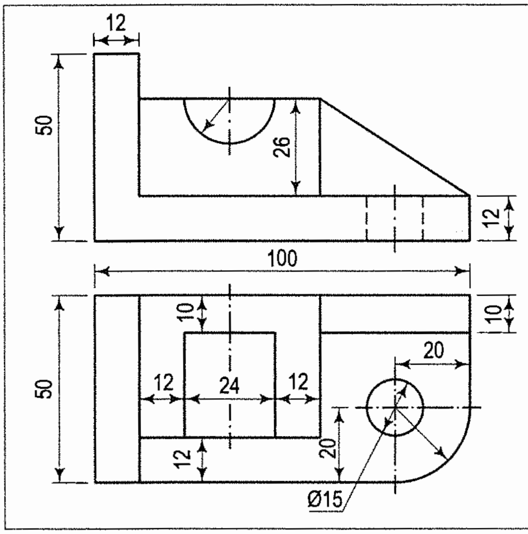
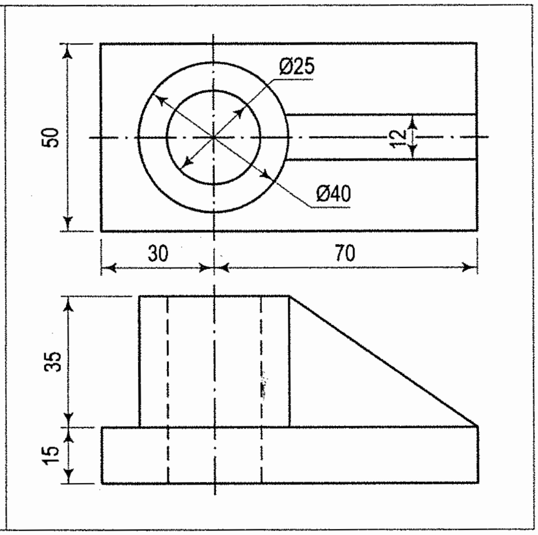


FIG. 17-108



(Third-angle projection)
FIG. 17-109

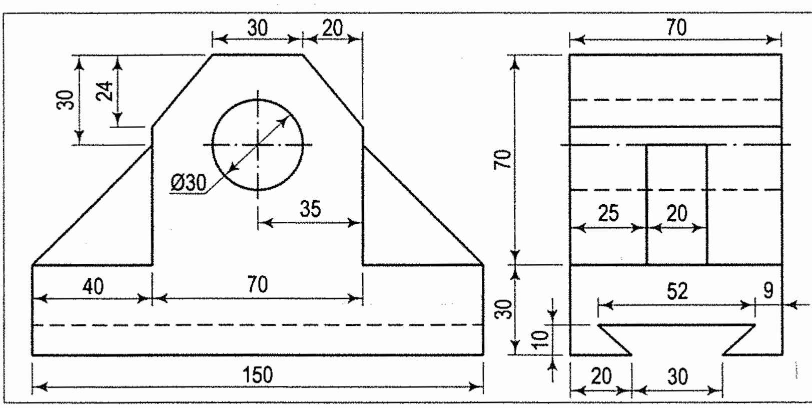


FIG. 17-110

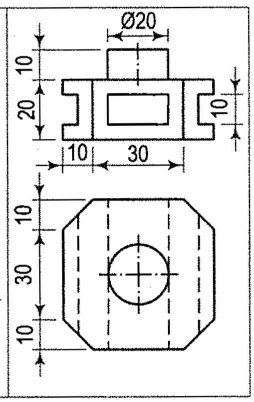
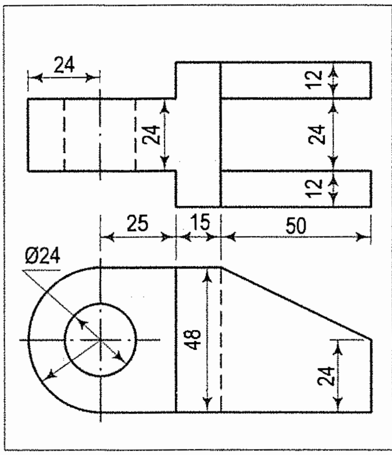


FIG. 17-111



(Third-angle projection)
FIG. 17-112

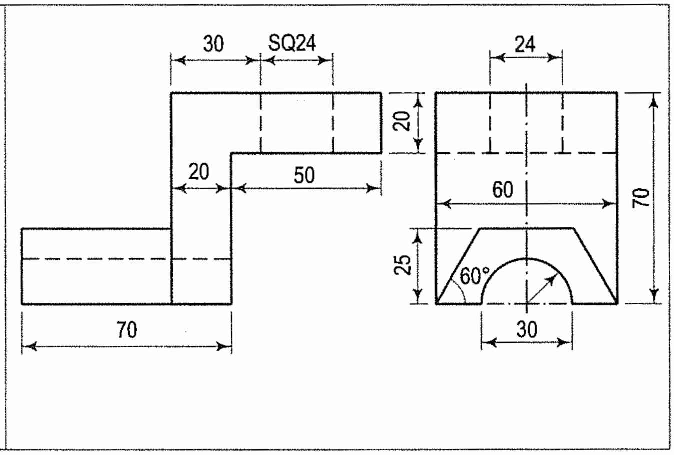


FIG. 17-113

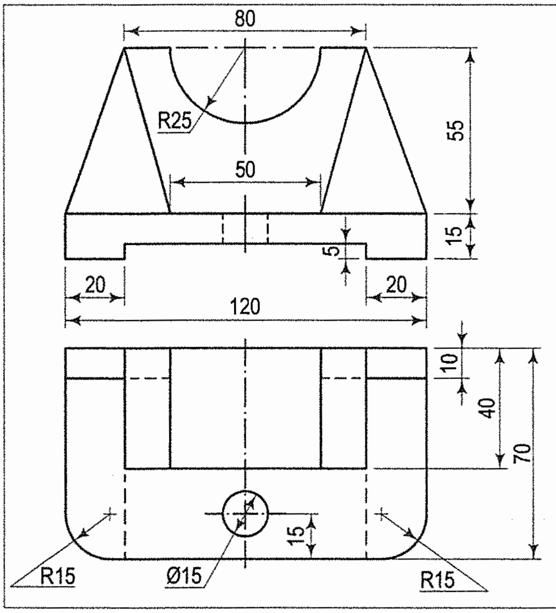


FIG. 17-114

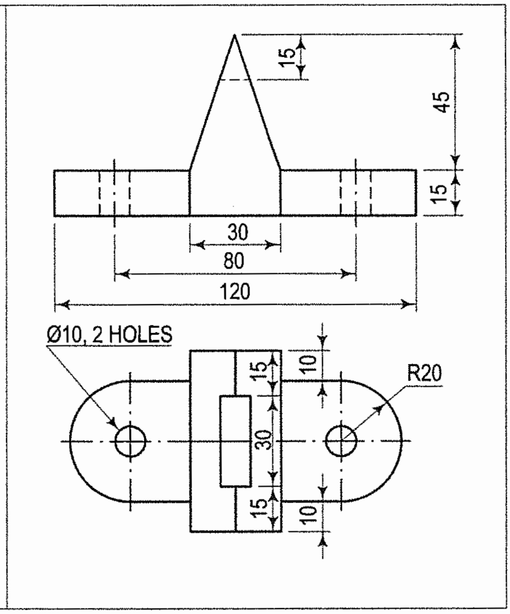
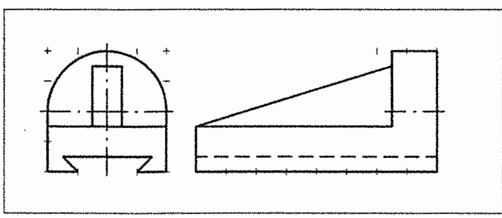


FIG. 17-115

2. Assuming unit length to be equal to 10 mm, draw the isometric views of objects shown in figs. 17-116 to 17-125.



(Third-angle projection)
FIG. 17-116

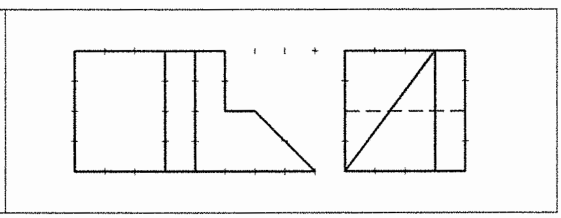


FIG. 17-117

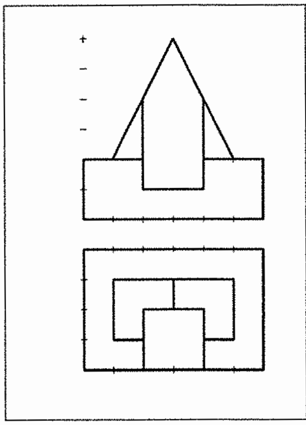


FIG. 17-118

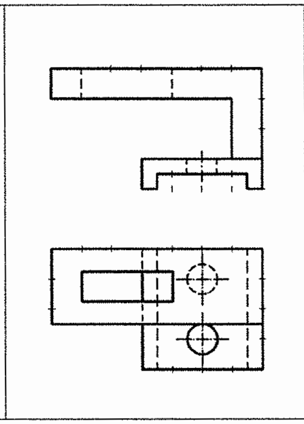


FIG. 17-119

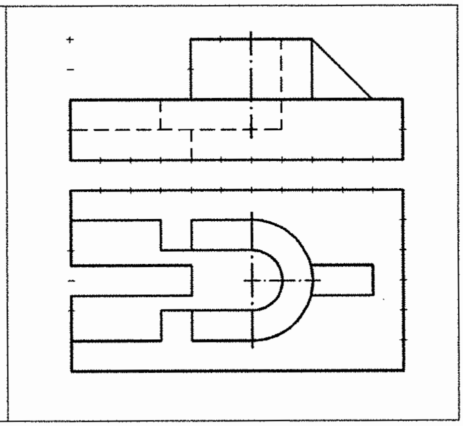
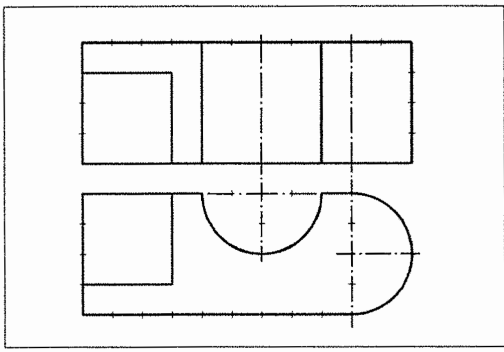


FIG. 17-120



(Third-angle projection)
FIG. 17-121

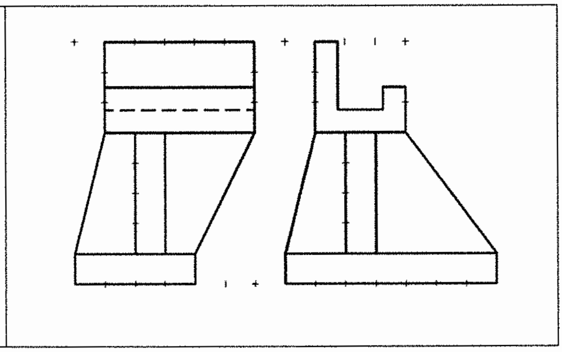


FIG. 17-122

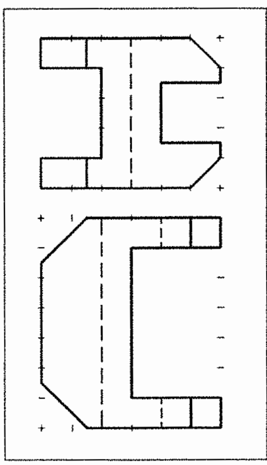
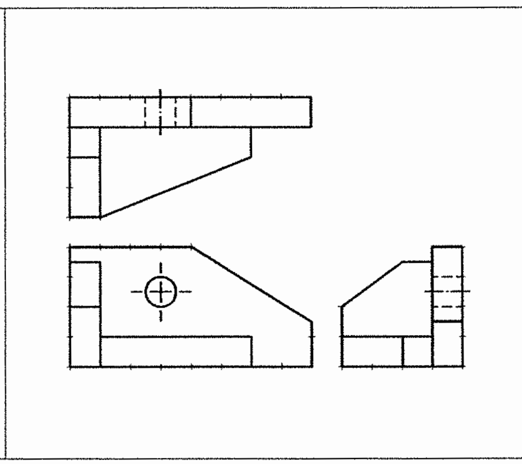


FIG. 17-123



(Third-angle projection)
FIG. 17-124

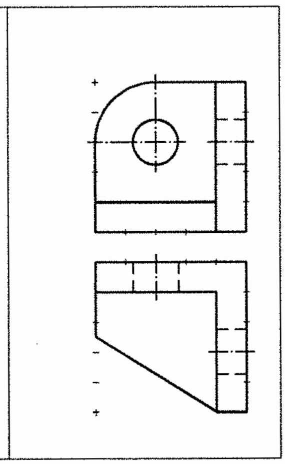


FIG. 17-125

3. Assuming simple graph of 10 mm grid, draw the isometric views of objects shown in fig. 17-126 and fig. 17-127.

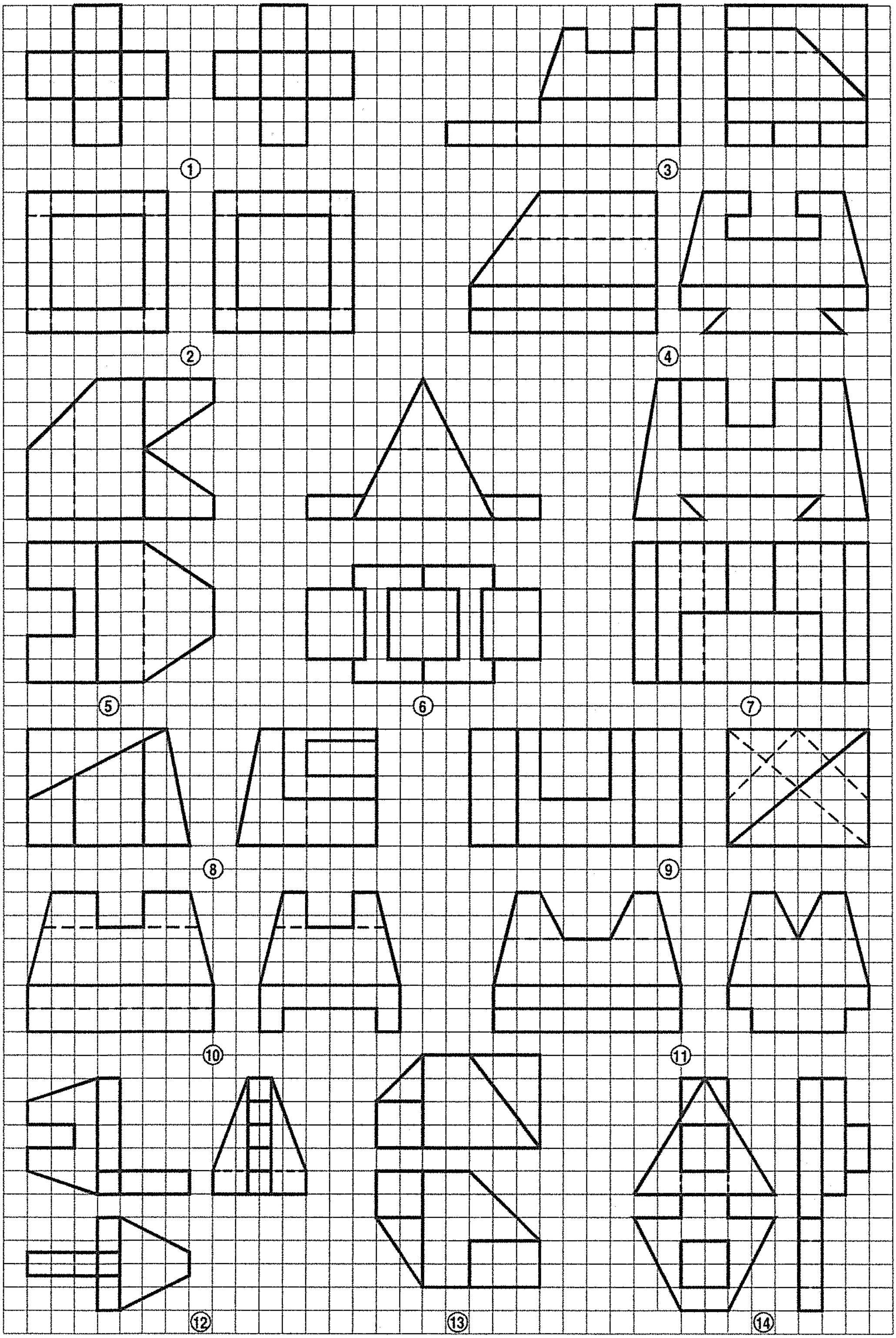


FIG. 17-126

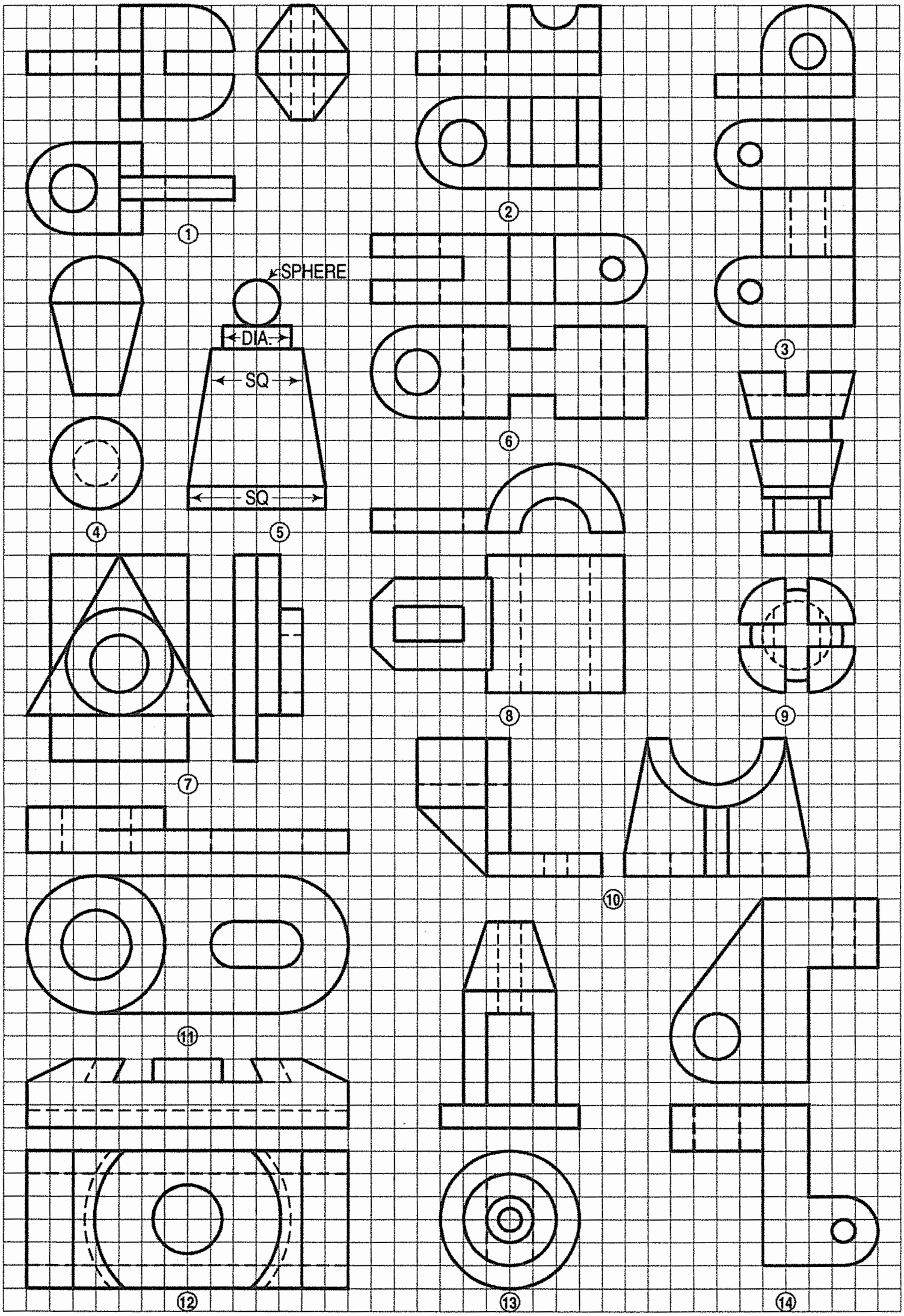


FIG. 17-127

4. Orthographic views of 35 objects with either (i) a line or (ii) lines or (iii) a view missing are given in fig. 17-128. Complete the given views. Also draw freehand, the isometric view of each object.

[*For answer see fig. 17-194.*]

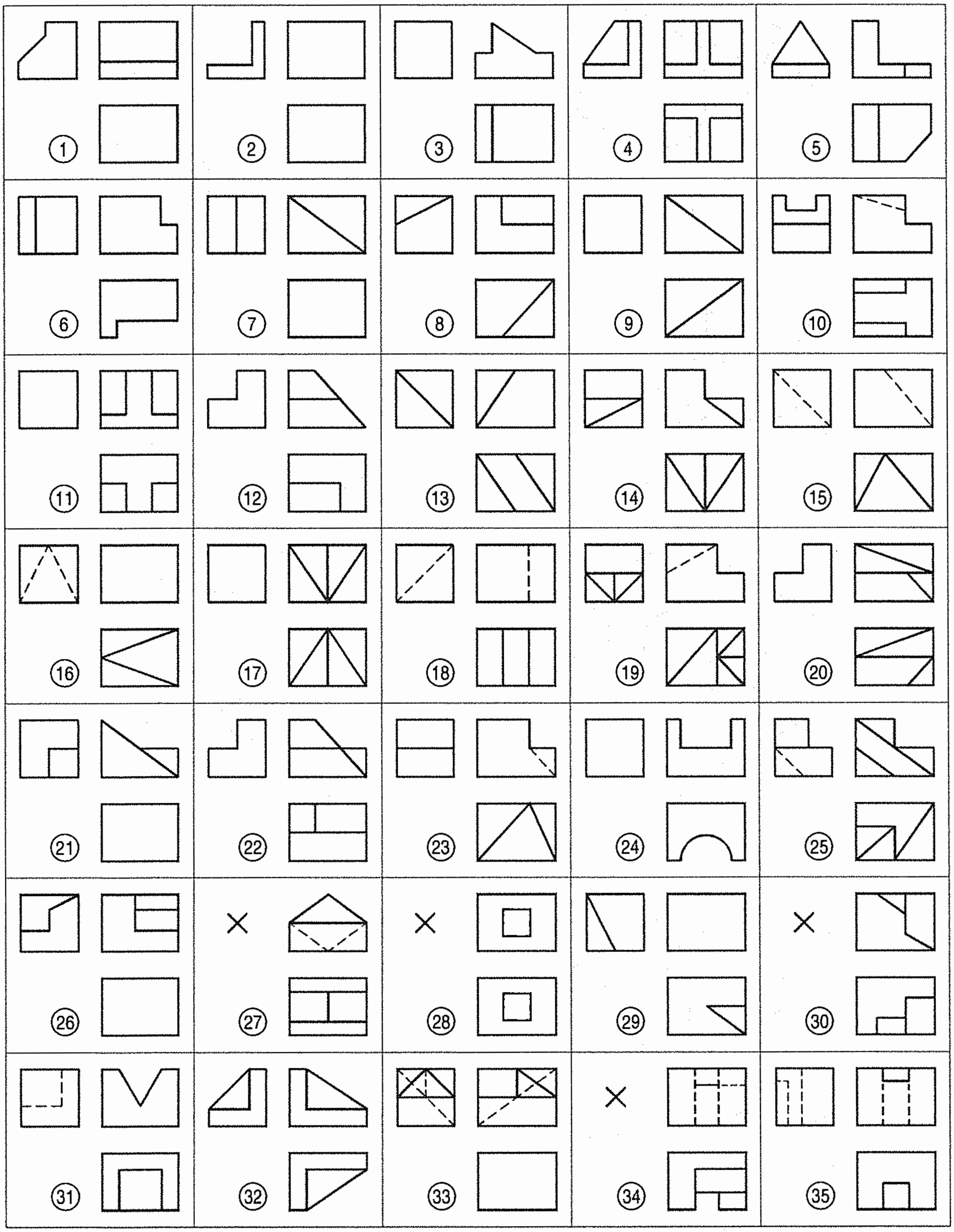
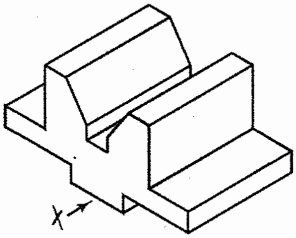
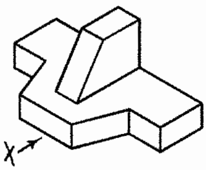


FIG. 17-128

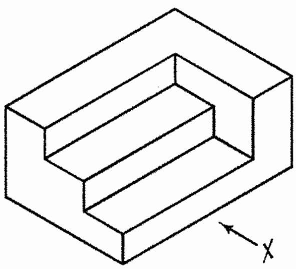
SOLUTIONS TO EXERCISES 17



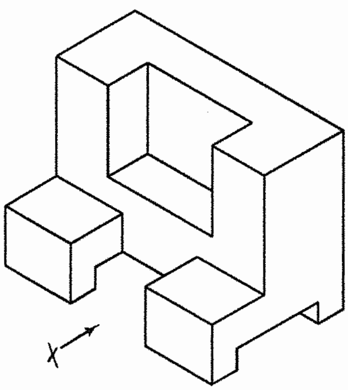
(Ex. 1. Fig. 17-89)
Fig. 17-129



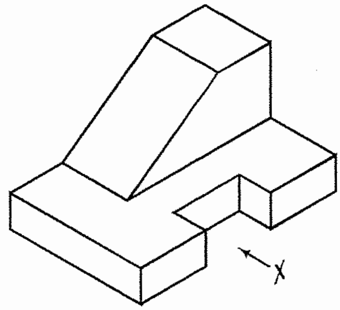
(Ex. 1. Fig. 17-91)
Fig. 17-131



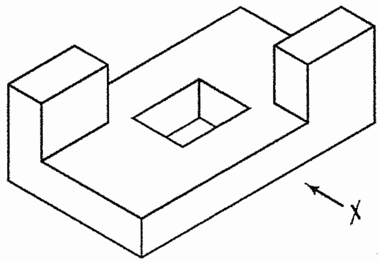
(Ex. 1. Fig. 17-93)
Fig. 17-133



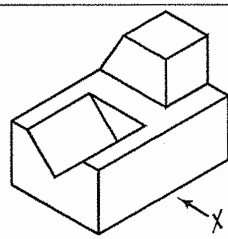
(Ex. 1. Fig. 17-95)
Fig. 17-135



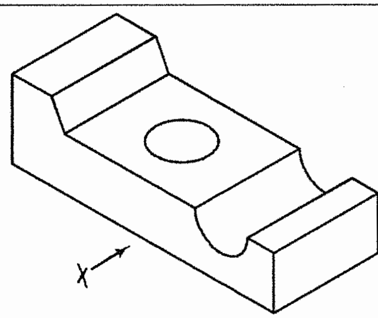
(Ex. 1. Fig. 17-90)
Fig. 17-130



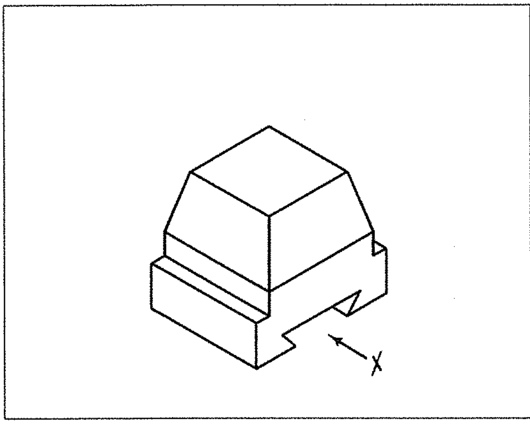
(Ex. 1. Fig. 17-92)
Fig. 17-132



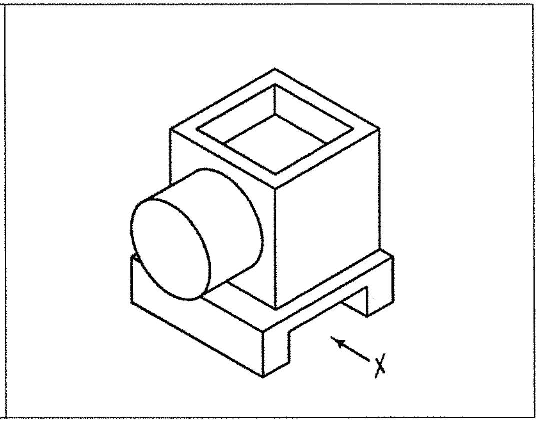
(Ex. 1. Fig. 17-94)
Fig. 17-134



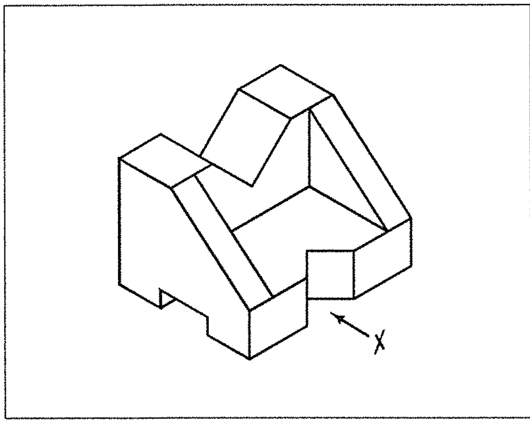
(Ex. 1. Fig. 17-96)
Fig. 17-136



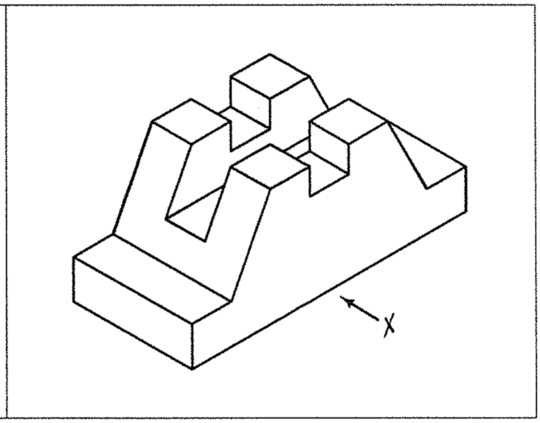
(Ex. 1. Fig. 17-97)
Fig. 17-137



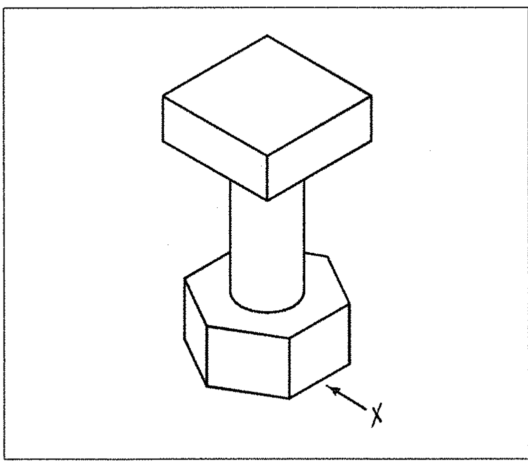
(Ex. 1. Fig. 17-98)
Fig. 17-138



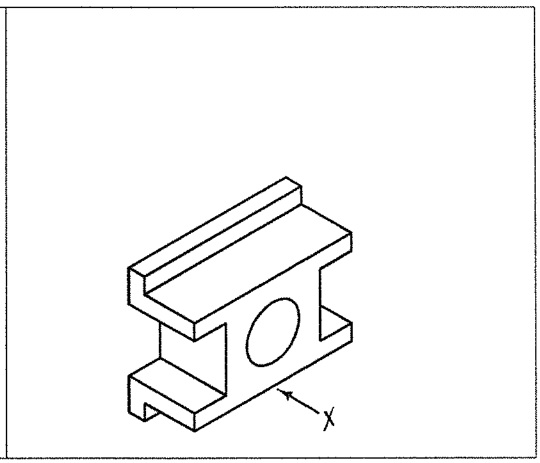
(Ex. 1. Fig. 17-99)
Fig. 17-139



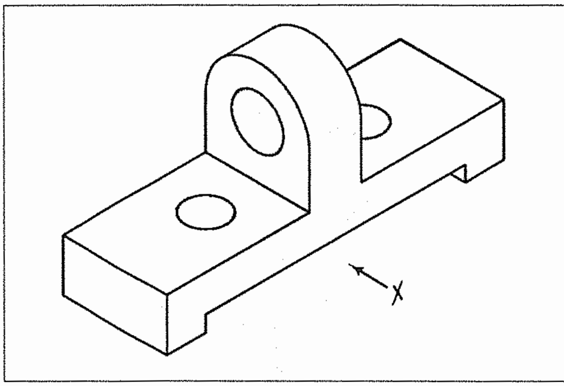
(Ex. 1. Fig. 17-100)
Fig. 17-140



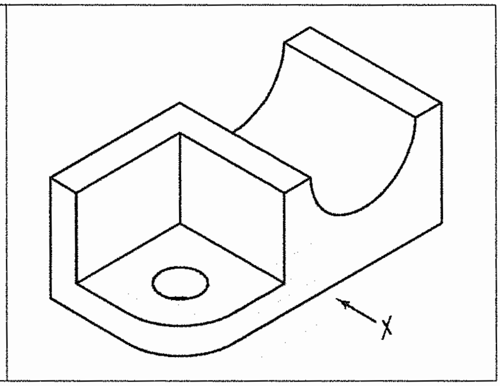
(Ex. 1. Fig. 17-101)
Fig. 17-141



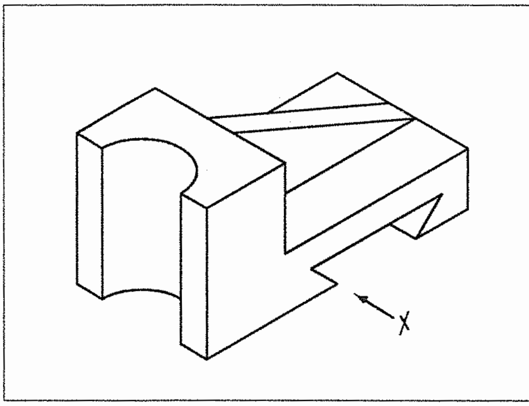
(Ex. 1. Fig. 17-102)
Fig. 17-142



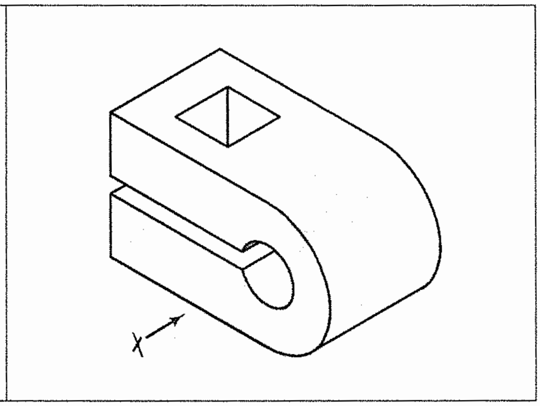
(Ex. 1. Fig. 17-103)
Fig. 17-143



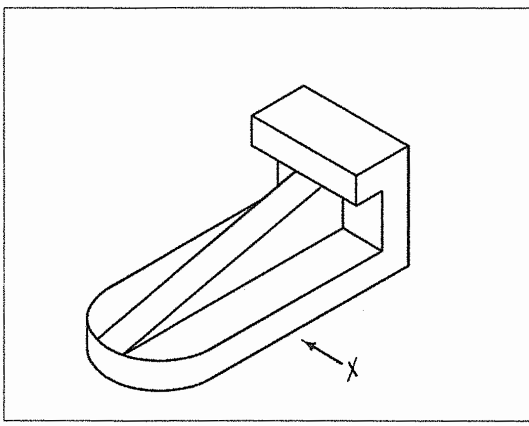
(Ex. 1. Fig. 17-104)
Fig. 17-144



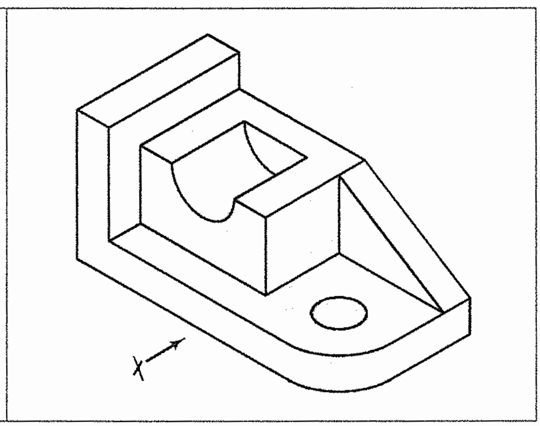
(Ex. 1. Fig. 17-105)
Fig. 17-145



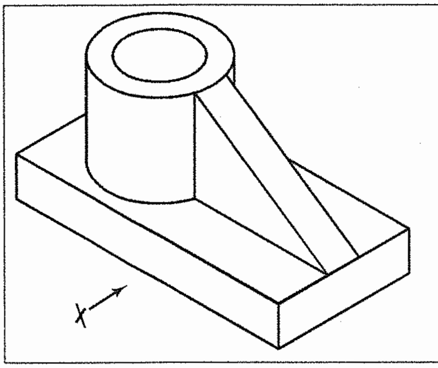
(Ex. 1. Fig. 17-106)
Fig. 17-146



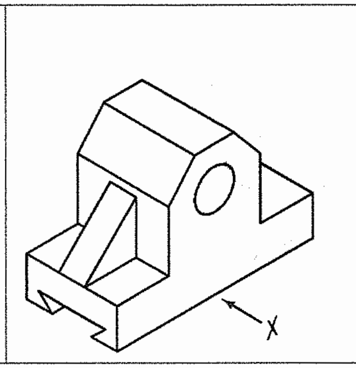
(Ex. 1. Fig. 17-107)
Fig. 17-147



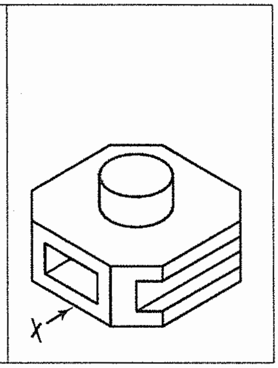
(Ex. 1. Fig. 17-108)
Fig. 17-148



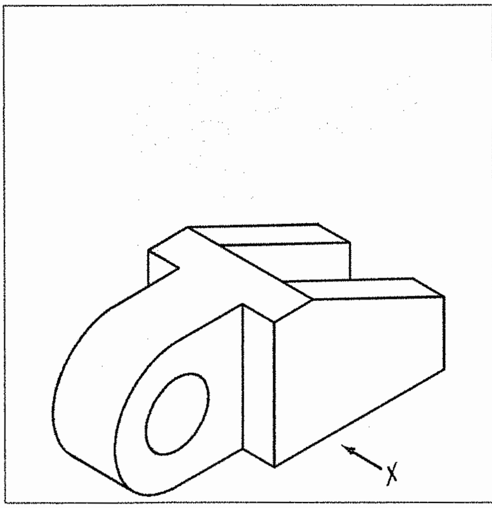
(Ex. 1. Fig. 17-109)
Fig. 17-149



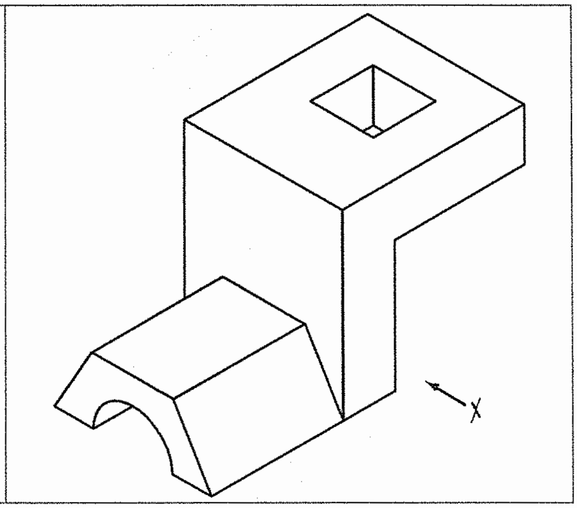
(Ex. 1. Fig. 17-110)
Fig. 17-150



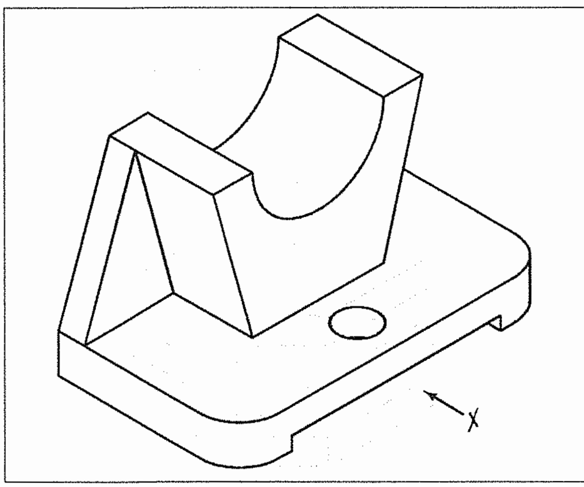
(Ex. 1. Fig. 17-111)
Fig. 17-151



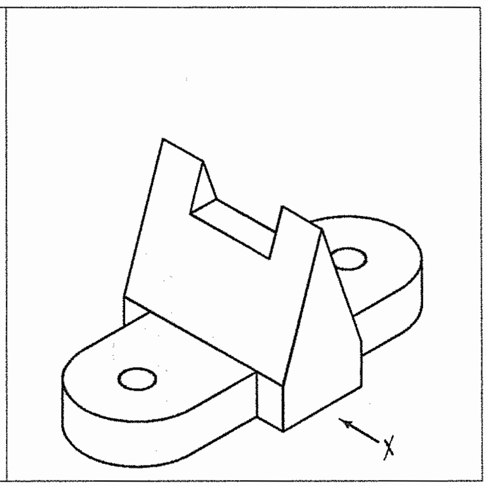
(Ex. 1. Fig. 17-112)
Fig. 17-152



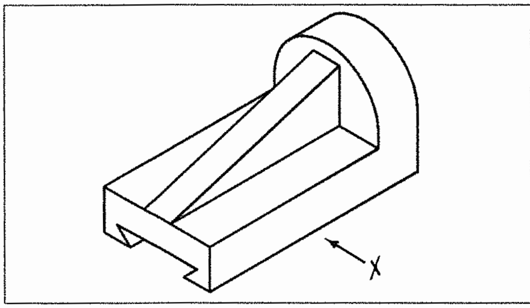
(Ex. 1. Fig. 17-113)
Fig. 17-153



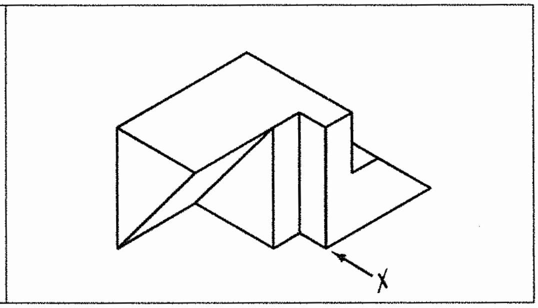
(Ex. 1. Fig. 17-114)
Fig. 17-154



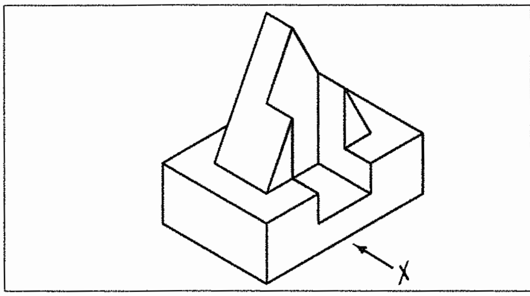
(Ex. 1. Fig. 17-115)
Fig. 17-155



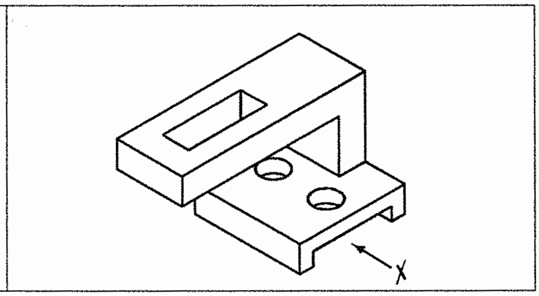
(Ex. 2. Fig. 17-116)
Fig. 17-156



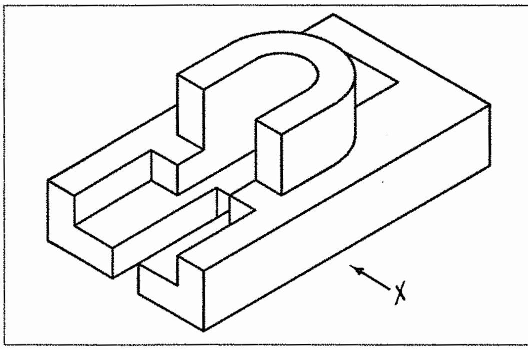
(Ex. 2. Fig. 17-117)
Fig. 17-157



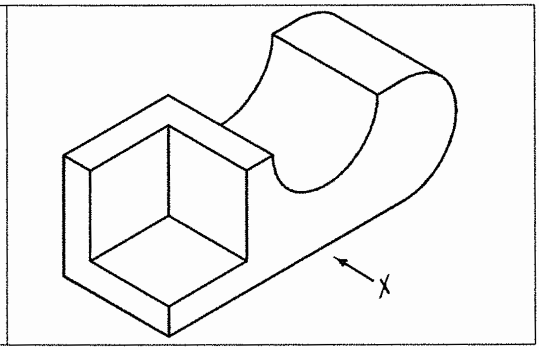
(Ex. 2. Fig. 17-118)
Fig. 17-158



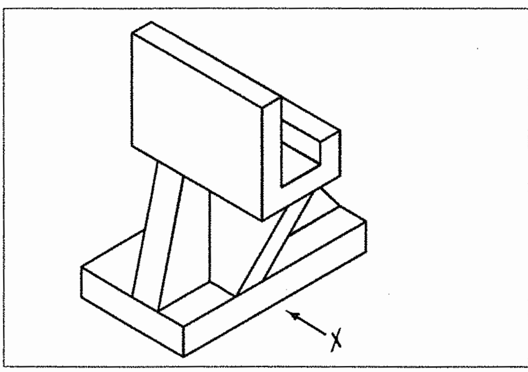
(Ex. 2. Fig. 17-119)
Fig. 17-159



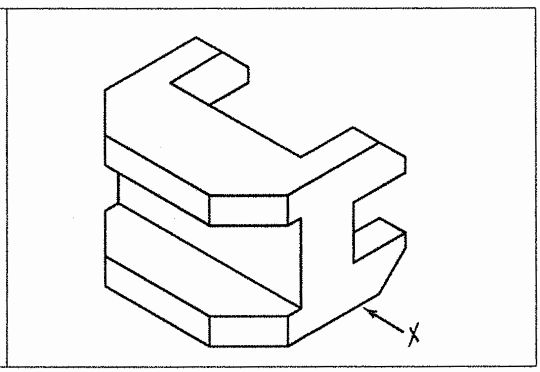
(Ex. 2. Fig. 17-120)
Fig. 17-160



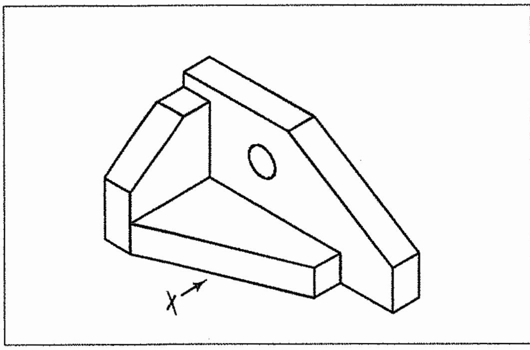
(Ex. 2. Fig. 17-121)
Fig. 17-161



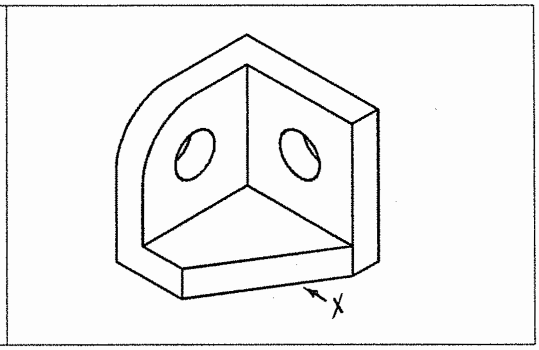
(Ex. 2. Fig. 17-122)
Fig. 17-162



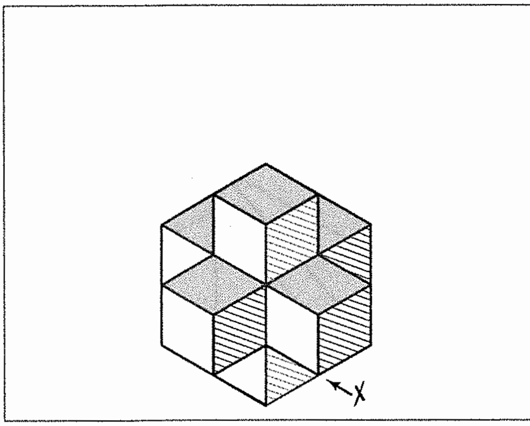
(Ex. 2. Fig. 17-123)
Fig. 17-163



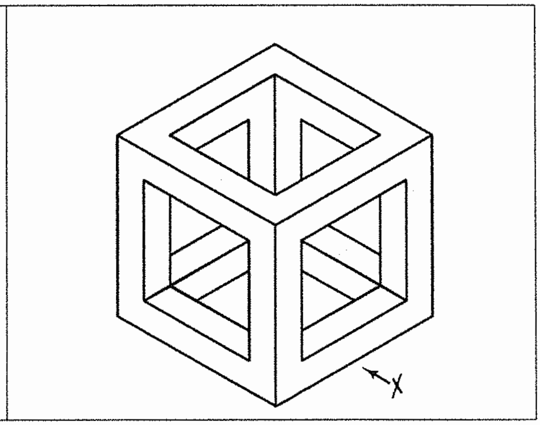
(Ex. 2. Fig. 17-124)
Fig. 17-164



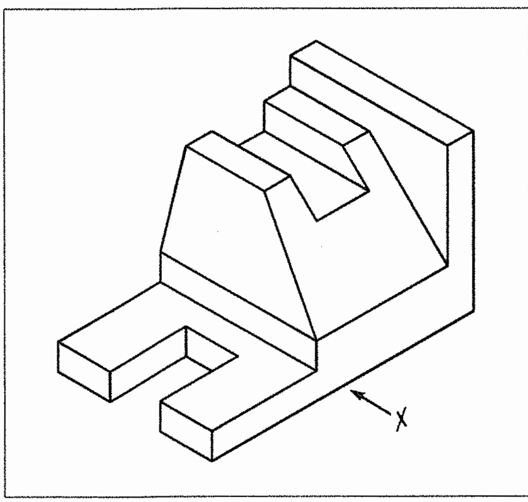
(Ex. 2. Fig. 17-125)
Fig. 17-165



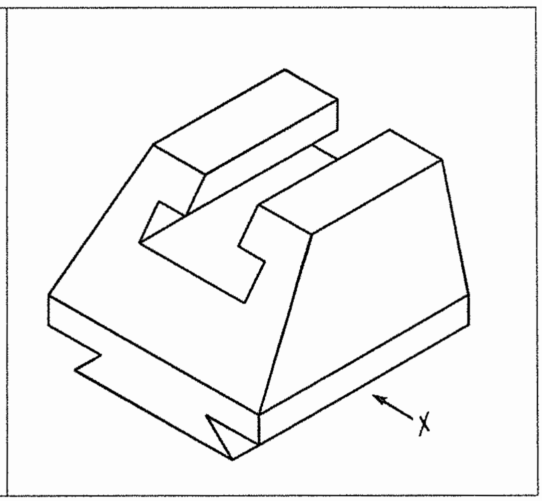
[Ex. 3. Fig. 17-126(1)]
Fig. 17-166



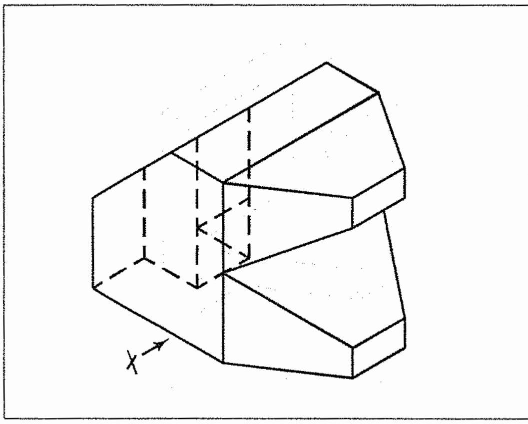
[Ex. 3. Fig. 17-126(2)]
Fig. 17-167



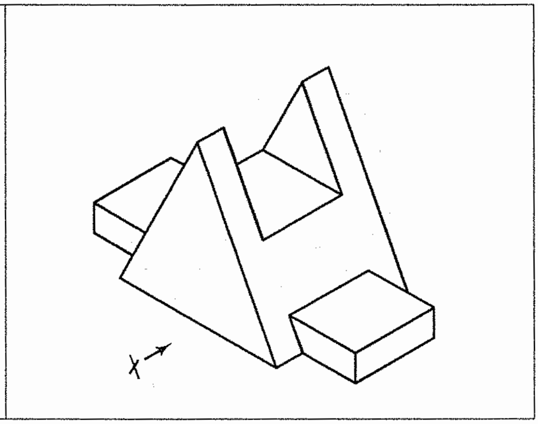
[Ex. 3. Fig. 17-126(3)]
Fig. 17-168



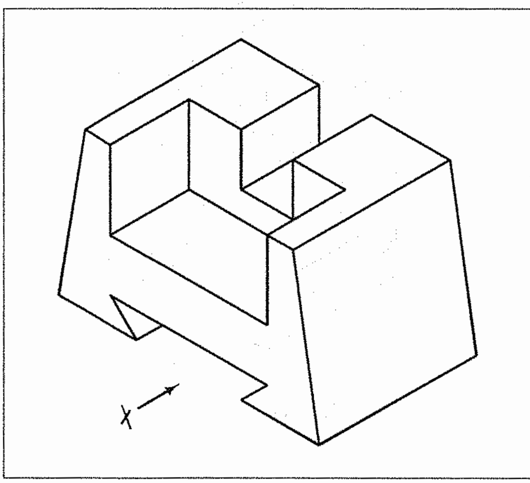
[Ex. 3. Fig. 17-126(4)]
Fig. 17-169



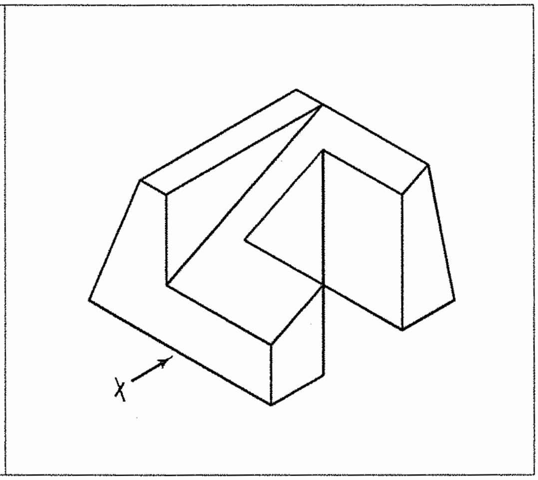
[Ex. 3. Fig. 17-126(5)]
Fig. 17-170



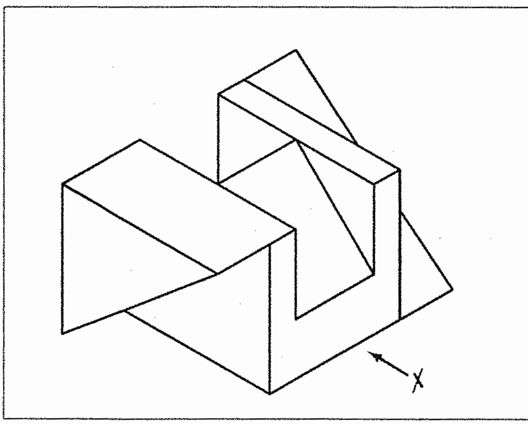
[Ex. 3. Fig. 17-126(6)]
Fig. 17-171



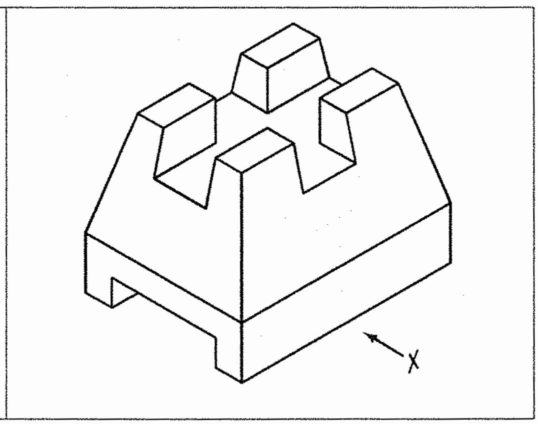
[Ex. 3. Fig. 17-126(7)]
Fig. 17-172



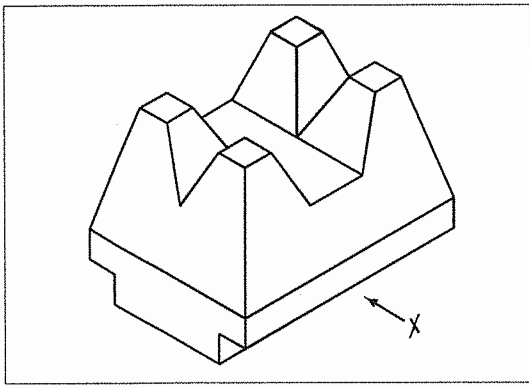
[Ex. 3. Fig. 17-126(8)]
Fig. 17-173



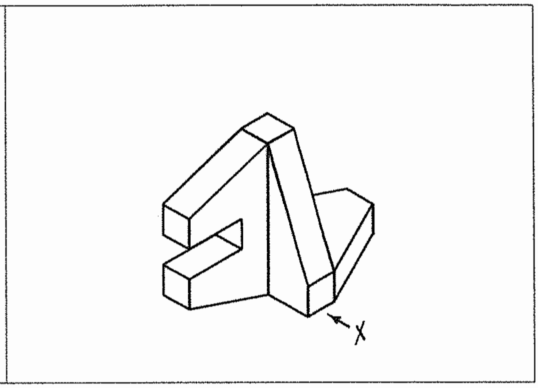
[Ex. 3. Fig. 17-126(9)]
Fig. 17-174



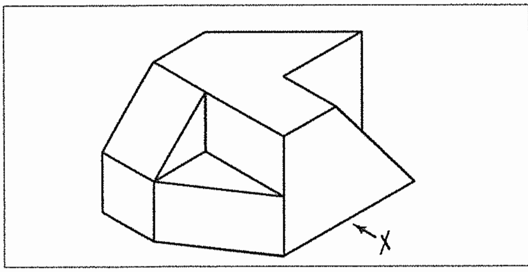
[Ex. 3. Fig. 17-126(10)]
Fig. 17-175



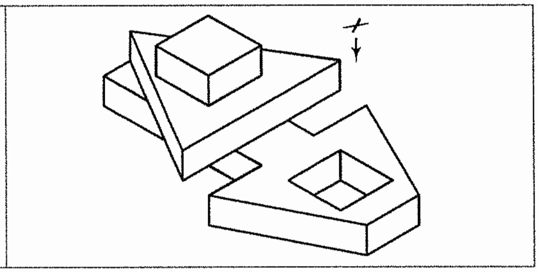
[Ex. 3. Fig. 17-126(11)]
Fig. 17-176



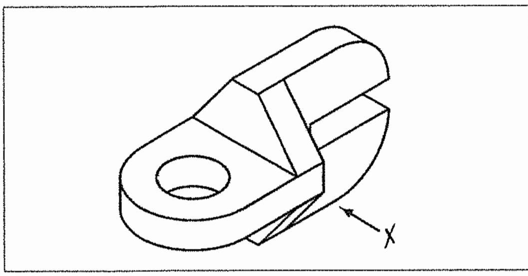
[Ex. 3. Fig. 17-126(12)]
Fig. 17-177



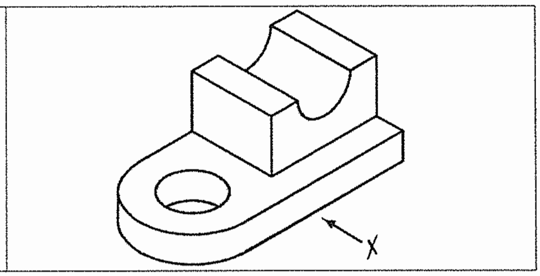
[Ex. 3. Fig. 17-126(13)]
Fig. 17-178



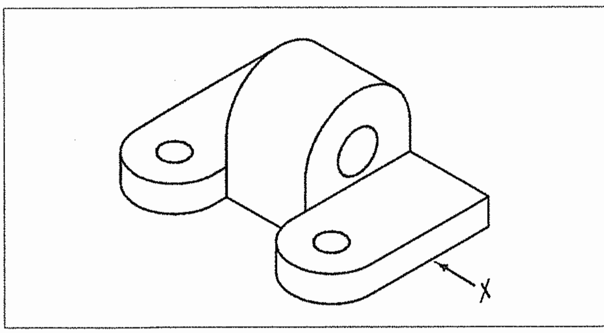
[Ex. 3. Fig. 17-126(14)]
Fig. 17-179



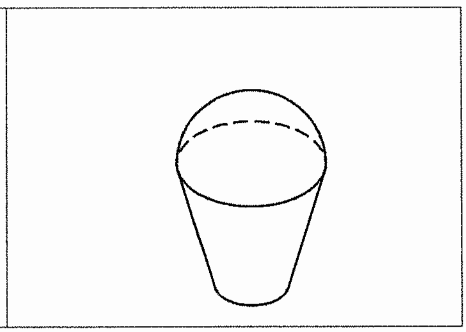
[Ex. 3. Fig. 17-127(1)]
Fig. 17-180



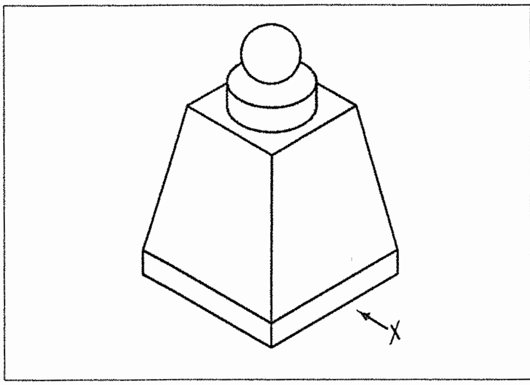
[Ex. 3. Fig. 17-127(2)]
Fig. 17-181



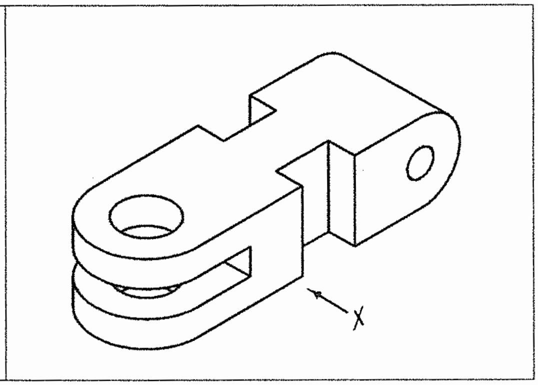
[Ex. 3. Fig. 17-127(3)]
Fig. 17-182



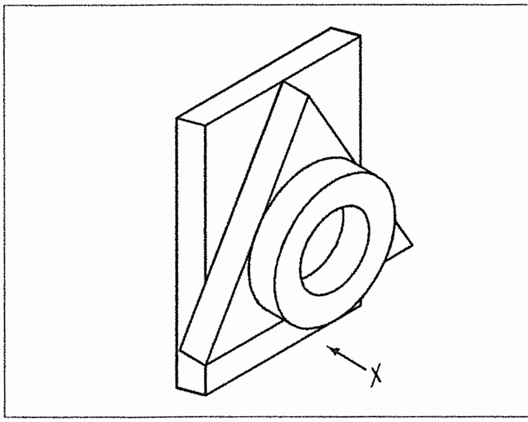
[Ex. 3. Fig. 17-127(4)]
Fig. 17-183



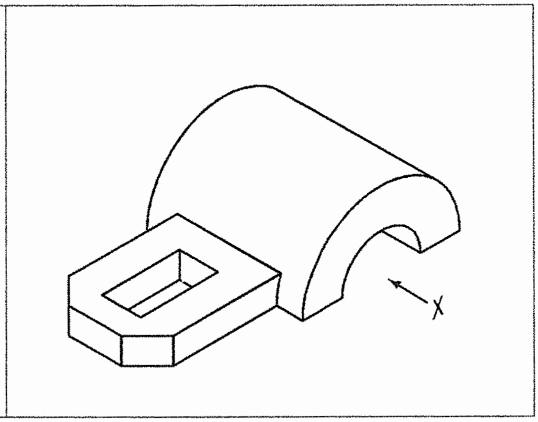
[Ex. 3. Fig. 17-127(5)]
Fig. 17-184



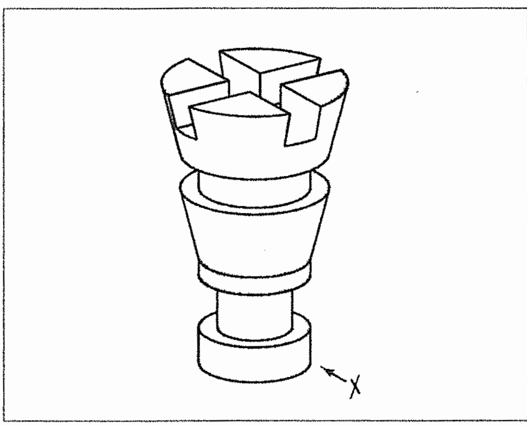
[Ex. 3. Fig. 17-127(6)]
Fig. 17-185



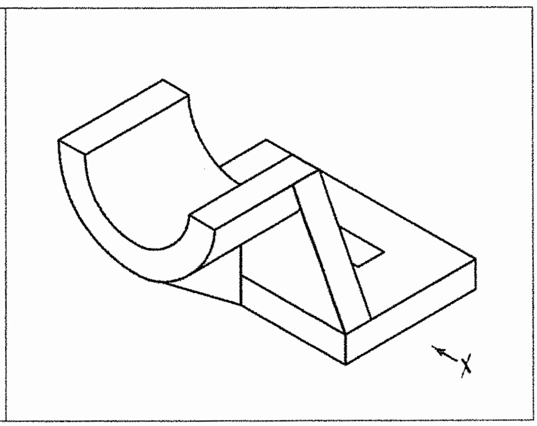
[Ex. 3. Fig. 17-127(7)]
Fig. 17-186



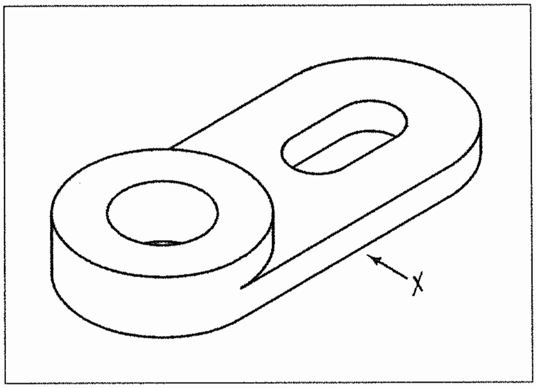
[Ex. 3. Fig. 17-127(8)]
Fig. 17-187



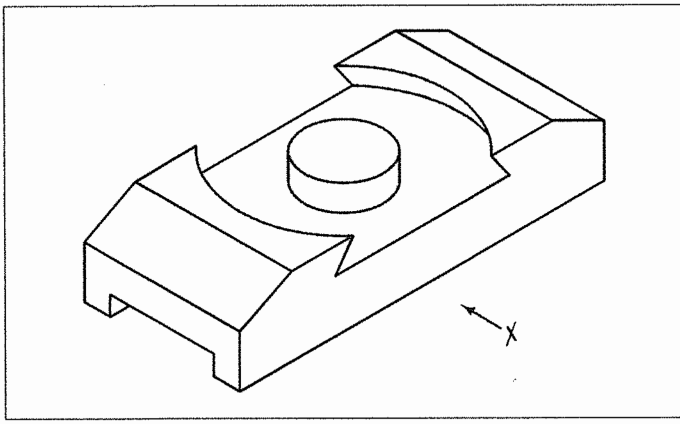
[Ex. 3. Fig. 17-127(9)]
Fig. 17-188



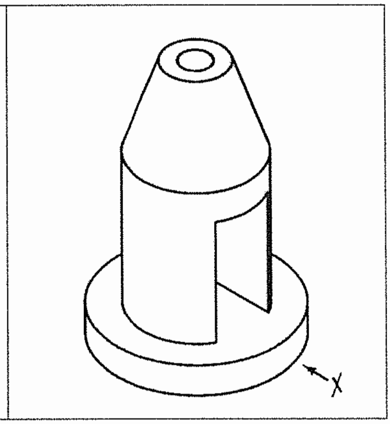
[Ex. 3. Fig. 17-127(10)]
Fig. 17-189



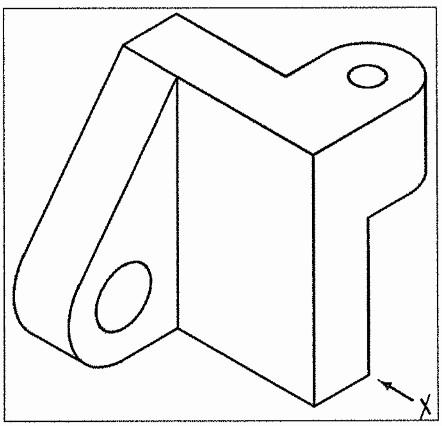
[EX. 3. FIG. 17-127(11)]
FIG. 17-190



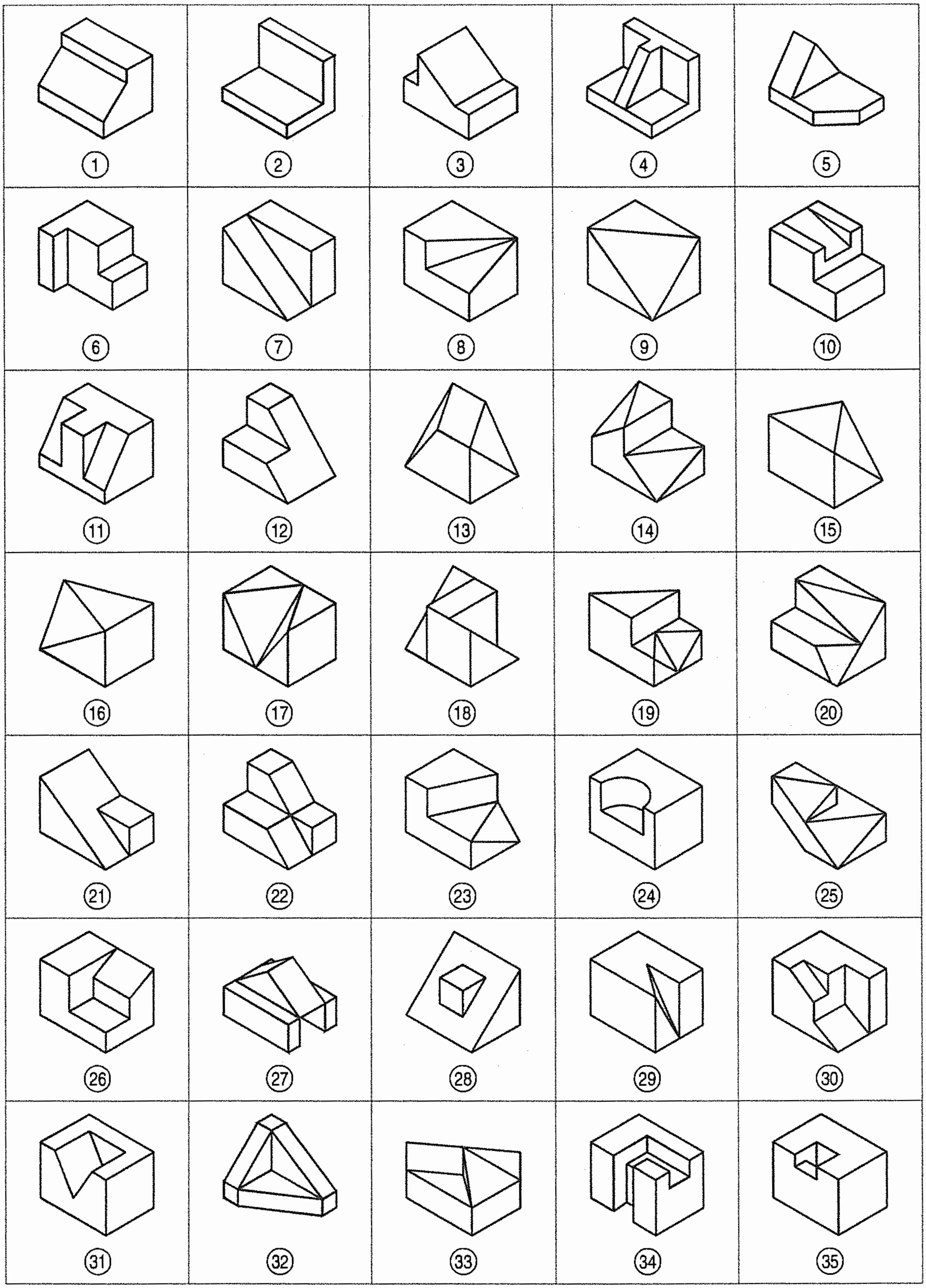
[EX. 3. FIG. 17-127(12)]
FIG. 17-191



[EX. 3. FIG. 17-127(13)]
FIG. 17-192



[EX. 3. FIG. 17-127(14)]
FIG. 17-193



(Ex. 4. Fig. 17-128)
Fig. 17-194