ESE 2020
UPSC ENGINEERING SERVICES EXAMINATION
Preliminary Examination

General Studies and Engineering Aptitude

General Principles of Design, Drawing and Importance of Safety

Comprehensive Theory with Practice Questions and ESE Solved Questions

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ESE 2020 Preliminary Examination:
General Principles of Design, Drawing and Importance of Safety

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Preface

The compilation of this book General Principles of Design, Drawing and Importance of Safety was motivated by the desire to provide a concise book which can benefit students to understand the concepts of this specific topic of General Studies and Engineering Aptitude section.

This textbook provides all the requirements of the students, i.e. comprehensive coverage of theory, fundamental concepts and objective type questions articulated in a lucid language. The concise presentation will help the readers grasp the theory of this subject with clarity and apply them with ease to solve objective questions quickly. This book not only covers the syllabus of ESE in a holistic manner but is also useful for many other competitive examinations. All the topics are given the emphasis they deserve so that mere reading of the book clarifies all the concepts.

We have put in our sincere efforts to present detailed theory and MCQs without compromising the accuracy of answers. For the interest of the readers, some notes, do you know and interesting facts are given in the comprehensive manner. At the end of each chapter, sets of practice question are given with their keys, that will allow the readers to evaluate their understanding of the topics and sharpen their question solving skills.

Our team has made their best efforts to remove all possible errors of any kind. Nonetheless, we would highly appreciate and acknowledge if you find and share with us any printing and conceptual errors.

It is impossible to thank all the individuals who helped us, but we would like to sincerely thank all the authors, editors and reviewers for putting in their efforts to publish this book.

With Best Wishes

B. Singh
CMD, MADE EASY
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The main objective of engineering drawing is to communicate shape and size of object precisely. In engineering drawing four methods of projection are commonly used.

1. Orthographic projection
2. Axonometric projection
   (a) Isometric projection
   (b) Diametric projection
   (c) Trimetric projection
3. Oblique projection
   (a) Cabinet projection
   (b) Cavalier projection
   (c) Clinographic projection
   (d) Shades and shadows
4. Perspective projection
   (a) Linear perspective projection
      (i) One point perspective projection
      (ii) Two point perspective projection
      (iii) Three point perspective projection
   (b) Aerial perspective projection

10.1 PRINCIPLE OF ORTHOGRAPHIC PROJECTION

Fig. 10.1 shows that to obtain orthographic projection of an object on a plane straight lines are drawn from various points on the contour of an object perpendicular to the plane. The figure formed by joining, in correct sequence, the points at which these lines meet the plane, is called the Orthographic projection of the object. The lines from the object to the plane are called projectors. In orthographic projection projectors are always parallel to each other and perpendicular to plane of projection.

10.1.1 Four Quadrants
To get complete information about shape and size of an object, orthographic projection of an object are taken on at least two mutually perpendicular planes. Fig. 10.2 shows the Quadrant.

- A quadrant consists of two principle planes of projection inclined to each other at an angle of 90°.
- The vertical reference plane V.P. and the horizontal reference plane H.P. divides the space in four regions. Once front direction of looking and top direction of looking are mentioned then we can define first quadrant, second quadrant, third quadrant, & fourth quadrant as shown in fig. 10.2.
- First quadrant is region of space above H.P. and in front of V.P.
- Second quadrant is region of space above H.P. and behind V.P.
- Third quadrant is region of space below H.P. and behind V.P.
- Fourth quadrant is region of space below H.P. and in front of V.P.

### 10.1.2 Front View or Elevation

From pictorial view in fig. 10.3 we understand that orthographic projection of an object on vertical reference plane is called front view. When projectors are drawn from corner points of object perpendicular to vertical reference plane then figure obtained by joining points of intersection of projectors and vertical reference plane in proper sequence is called front view of object. Front view gives information about width of object and height of object, but it does not give information about thickness of the object.

### 10.1.3 Top View or Plan

![Fig. 10.3](image)

![Fig. 10.4](image)
From pictorial view in fig. 10.4 we understand that orthographic projection of an object on horizontal reference plane is called top view. When projectors are drawn from corner points of object perpendicular to horizontal reference plane then figure obtained by joining points of intersection of projector and horizontal reference plane in proper sequence is called top view or plan of object. Top view gives information about width and thickness of object, but it does not give information about height of the object.

10.1.4 Horizontal Reference Line

Horizontal reference line is the line of intersection of H.P. and V.P. Front view of H.P. is a line which coincides with the Horizontal reference line. Top view of V.P. is a line which coincides with the horizontal reference line.

10.1.5 Why and How to Open the Quadrant?

It is necessary to open the quadrant and make it plane because we want front view, top view and side view of the object on plane sheet.
As per convention as shown in Fig. 10.5 we have to open the quadrant clockwise, we cannot open the quadrant anticlockwise.

As per convention as shown in Fig. 10.6 we have to open the quadrant anticlockwise, and we cannot open the quadrant clockwise.

Hence words clockwise or anticlockwise should not be used. because what is clockwise when looking from one direction appears to be anticlockwise when looked from other direction.

The correct rule for opening the quadrant is keep V.P. fixed and revolve H.P. by 90° so that portion of H.P. in front of V.P. (अगर बाला H.P.) comes below the reference line and portion of H.P. behind V.P. (पीछे बाला H.P.) goes above the reference line.

### 10.1.6 Side Reference Plane and Side View

![Side Reference Plane and Side View](image)

From pictorial view in Fig. 10.7 we understand that side reference plane or profile plane is a plane perpendicular to H.P as well as V.P. When projectors are drawn from corner points of object perpendicular to side reference plane then figure obtained by joining points of intersection of projector and side reference plane in proper sequence is called side view of object. That is Orthographic projection of an object on side reference plane is called side view. Side view gives information about height of object and thickness of object, but it does not give information about width of the object.

### 10.1.7 Side Reference Line

Side reference line is defined as line of intersection of side reference plane and V.P.

### 10.1.8 How to Open the Side Reference Plane?

The rule for opening side reference plane is revolve it about the side reference line so that side view comes by the side of front view as indicated by arrows in Fig. 10.7.

### 10.2 METHODS OF ORTHOGRAPHIC PROJECTION

There are two methods commonly used for making orthographic drawings

1. First angle projection system
2. Third angle projection system
<table>
<thead>
<tr>
<th>First Angle Projection System</th>
<th>Third Angle Projection System</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Fig. 10.8" /></td>
<td><img src="image2" alt="Fig. 10.11" /></td>
</tr>
<tr>
<td><strong>Fig. 10.8</strong> highlights key points about first angle projection method for drawing orthographic projection of an object</td>
<td></td>
</tr>
<tr>
<td>1. Object is kept in first quadrant</td>
<td></td>
</tr>
<tr>
<td>2. Object lies between the observer and reference plane</td>
<td></td>
</tr>
<tr>
<td>3. Reference plane is considered to be opaque.</td>
<td></td>
</tr>
<tr>
<td><img src="image3" alt="Fig. 10.9" /></td>
<td><img src="image4" alt="Fig. 10.12" /></td>
</tr>
<tr>
<td><strong>Fig. 10.9</strong> shows the pictorial view of reference planes opened to get all orthographic views on a single plane.</td>
<td></td>
</tr>
<tr>
<td><img src="image5" alt="Fig. 10.10" /></td>
<td><img src="image6" alt="Fig. 10.13" /></td>
</tr>
<tr>
<td><strong>Fig. 10.10</strong> shows the relative location of orthographic views.</td>
<td></td>
</tr>
<tr>
<td><img src="image7" alt="Fig. 10.11" /></td>
<td><img src="image8" alt="Fig. 10.14" /></td>
</tr>
<tr>
<td><strong>Fig. 10.11</strong> highlights key points about third angle projection method for drawing orthographic projection of an object</td>
<td></td>
</tr>
<tr>
<td>1. Object is kept in third quadrant</td>
<td></td>
</tr>
<tr>
<td>2. Reference plane lies between the observer and object</td>
<td></td>
</tr>
<tr>
<td>3. Reference plane is considered to be transparent.</td>
<td></td>
</tr>
</tbody>
</table>
### First Angle Projection vs. Third Angle Projection

**Key points about location of orthographic views are:**

1. In 3-dimensions top view lies on portion of H.P. in front of V.P. On opening the quadrant it goes below the reference line. Therefore, in orthographic drawing top view goes below the reference line.

2. In orthographic drawing left side comes on the right side of front view and above the horizontal reference line.

**Fig. 10.14**

*Fig. 10.14 shows the symbol for orthographic drawings made in first angle projection system.*

**Fig. 10.15**

*Pictorial view in Fig. 10.15 shows that when a frustum of a cone is positioned in first quadrant such that its axis is parallel to H.P. and V.P. then its front view and left side view are used as symbol for first angle projection system. BIS (Bureau standards) recommends use of first angle projection system.*

**Third Angle Projection**

**Key points about location of orthographic views are:**

1. In 3-dimensions top view lies on portion of H.P. behind V.P. On opening the quadrant portion of H.P. behind V.P. goes above the reference line. Therefore in orthographic drawing top view goes above the reference line.

2. In orthographic drawing left side comes on the left side of front view and below the horizontal reference lines as shown.

**Fig. 10.16**

*Fig. 10.16 shows the symbol for orthographic drawings made in third angle projection system.*

**Fig. 10.17**

*Pictorial view in Fig. 10.17 shows that when a frustum of a cone is positioned in third quadrant such that its axis is parallel to H.P. and V.P. then its front view and left side view are used as symbol for third angle projection system. In USA third angle projection system is recommended by their statutory body.*
10.2.1 Six Orthographic Views of an Object When Kept in First Quadrant

**Fig. 10.18** shows pictorial view of six orthographic projections of an object kept in first quadrant.

**Fig. 10.19** shows six orthographic views of an object kept in first quadrant.
10.2.2 Six Orthographic Views of an Object When Kept in Third Quadrant

Pictorial view in Fig. 10.20 shows six orthographic projections of an object kept in third quadrant.

Fig. 10.21 shows six orthographic views of an object kept in first quadrant.
10.3 AXONOMETRIC PROJECTION

Orthographic view of a solid on a reference plane in which all three mutually perpendicular geometrical axis of solid are visible is called an axonometric view. Some commonly used types of axonometric projection are:

**Isometric projection:** When all three mutually perpendicular geometrical axis of a solid are equally inclined to a reference plane then orthographic projection of solid on that reference plane is called its isometric projection.

**Diometric projection:** When solid is kept such that at least two of its three mutually perpendicular geometrical axis are equally inclined to a reference plane then orthographic projection of solid on that reference plane is called its diometric projection.

**Trimetric projection:** When solid is kept such that all its three mutually perpendicular geometrical axis are inclined to a reference plane at different angles then orthographic projection of solid on that reference plane is called trimetric projection.

10.4 PERSPECTIVE PROJECTION

Perspective projection is three-dimensional representation of an object on a plane surface, as it would appear to the eye when viewed from a fixed position.

---

**Objective Brain Teasers**

**Q.1** In orthographic projections, the xy line is called as
   (a) Reference line  (b) Horizontal line
   (c) Vertical line   (d) All of these

**Q.2** In orthographic projections, the projectors are assumed to be
   (a) perpendicular to each other
   (b) parallel to each other
   (c) diverge from a point
   (d) None of these

**Q.3** The top view of an object is projected on the
   (a) Vertical plane
   (b) Horizontal plane
   (c) Auxiliary plane
   (d) Profile plane

**Q.4** The side view of an object is obtained on the
   (a) Vertical plane
   (b) Horizontal plane
   (c) Auxiliary plane
   (d) Profile plane

**Q.5** Minimum number of orthographic views necessary to show length, width and height of an object are
   (a) 1  (b) 2
   (c) 3  (d) 4

**Q.6** In orthographic views, the height dimension of an object is seen in
   (a) Front and top  (b) Front and side
   (c) Top and side   (d) Front, top and side

**Q.7** The top view of an object should be drawn
   (a) Right or left of the front view
   (b) Below or above the front view
   (c) Below or right of the front view
   (d) Above or left of the front view

**Q.8** In third angle projection method, the relative positions of the object, plane of projection and observer are
   (a) Plane of projection is placed in between
   (b) Object is placed in between
   (c) Observer is placed in between
   (d) May be placed in any order

**Q.9** For orthographic projection method, BIS recommends the following projection
   (a) First angle projection
   (b) Second angle projection
   (c) Third angle projection
   (d) Fourth angle projection
Q.10  Select the correct Front view of the given pictorial view.

(a)  
(b)  
(c)  
(d)  

Q.11  Select the correct Top view of the given pictorial view.

(a)  
(b)  
(c)  
(d)  

Q.12  For the given orthographic projections, identify the correct pictorial view.

Top view  
Front view  
Side view  

(a)  
(b)  
(c)  
(d)
Q.13 Match List-I (Pictorial view) with List-II (Orthographic projections) and choose the correct answer using the codes given below the lists:

List-I

A. 

B. 

C. 

D. 

List-II

1.

2.

3.

4.

Codes:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>b</td>
<td>4</td>
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<tr>
<td>c</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>d</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

Q.14 For the given Top view and Front view orthographic projections, identify the correct pictorial view.

Top View

Front View
Q.15 For the given Top view and Front view orthographic projections, identify the correct pictorial view.

Top View

Front View

Q.16 Find the correct Top view for the given pictorial view.

Q.17 Find the correct Front view for the given pictorial view.
Q.18 Identify correct pictorial view of given orthographic projections

Q.19 What will be the correct Top view of given pictorial view.

<table>
<thead>
<tr>
<th>Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (a)</td>
</tr>
<tr>
<td>6. (b)</td>
</tr>
<tr>
<td>11. (d)</td>
</tr>
<tr>
<td>16. (d)</td>
</tr>
</tbody>
</table>