ESE-2021
Prelims Paper-I

General Principles of
Design, Drawing & Safety

IES MASTER PUBLICATION

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PREFACE

Giving life to an engineer's dream for the betterment of society involves **Design, Drawing** and **Safety**. With the increasing complexities of economy, as well as the ensuing disruption in IT, besides the stringent safety rules, this inter-disciplinary subject has become quite challenging to comprehend from exam point of view.

Looking at the nature of Engineering Services Examination (ESE), and the level of questions being asked, the conventional approach of preparing through theory and examples is not enough to serve the purpose. The revised and updated edition of **General Principles of Design, Drawing and Safety** attempts to provide logical reasoning through mathematical analysis, gives a clear insight into the concepts, and paints a complete picture in front of you. In line with this, the book has been written in a simple and clear manner.

The book is divided into three major parts (i) Engineering Drawing (ii) Engineering Design and (iii) Engineering Safety. The first part discusses the basic principle of drawing associated with drafting of various points, object, sketches etc. Next, an overview of basic principles of design, types of design, associated governing tools and product development. Finally, basic knowledge need for engineering safety is presented. In addition to the above, UPSC sample papers and questions asked in ESE 2017-2019 are discussed after the completion of relevant topics. For students to determine their level of preparation, self-practice questions have been provided at the end of this book. Students may generally not require any additional study, and may be reasonably confident that all the probable questions and topics are covered in this book.

In their endeavour to give students the best, IES Master has brought about this book in an easy-to-grasp language that gives in a complete clarity of thought. As a result, what students get is their collective wisdom that breaks free the constraints of engineering students in appreciating the basics of Design, Drawing and Safety.

As you flip over the pages of this book, you would come across a slew of diagrams, flow charts, mind maps and tables. This book is a delight for every ESE aspirant as it communicates, connects, and builds upon the exam preparedness right up to the standards of the UPSC.

All care has been taken to make the understanding of this subject more clear and interesting. The credit goes to the entire IES Master team for their continuous support in bringing out this book. All comments and suggestions for further improvement of the book are welcome and will be appreciated.

Bipin Thakur
IES Master Publication
New Delhi

CONTENTS

CHAPTER 1 Introduction to Engineering Drawing

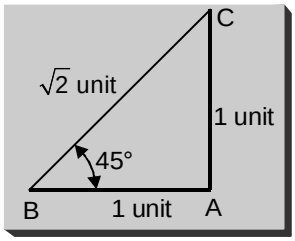
1.1 INTRODUCTION

INSIDE

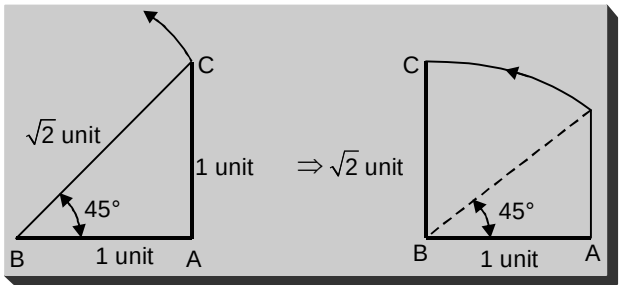
Engineering drawing is a technique of creating graphical representation that contains all necessary information such as dimensions, specifications and notes using which an abstract concept can be transformed into real world object. To realize such concept, basic tools of construction of drawing has to be clearly understood as to what standard has to be followed. There is an international standard on code of practice for drawing which is followed and adopted by Bureau of Indian Standard (BIS). In this chapter, we shall be dealing with drawing instruments and accessories (i.e. drafting tools) which is necessary for engineering drawing.

1.2 DRAWING SHEETS : [IS 10711 : 2001]

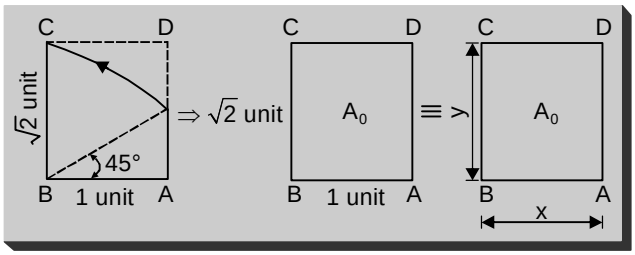
Consider an isosceles triangle ABC of unit length as shown below.



Now rotate BC anticlockwise so that BC becomes perpendicular to AB as shown below.



Now taking AB as one side and BC as another side complete a rectangle ABCD as shown below.



There are two basic principles involved in arriving at the sizes of A_0 sheet

(i) $x : y = 1 : \sqrt{2}$, where, x, y ∈ side

(ii) Surface area (xy) of A_0 sheet is unity i.e., xy = 1

$$\because \quad x:y = \frac{1}{\sqrt{2}}$$

$$\therefore \quad \frac{x}{y} = \frac{1}{\sqrt{2}}$$

$$\Rightarrow \quad y = x\sqrt{2} \quad \text{... (i)}$$

Also, $xy = 1 \Rightarrow x \cdot x\sqrt{2} = 1$ from (i)

$$\Rightarrow x^2 = \frac{1}{\sqrt{2}} \Rightarrow x = \frac{1}{\sqrt{\sqrt{2}}} = \frac{1}{1.189}$$

$$\Rightarrow \quad x = 0.841 \text{ m}$$

$$\therefore \quad y = 0.841\sqrt{2} = 1.189 \text{ m}$$

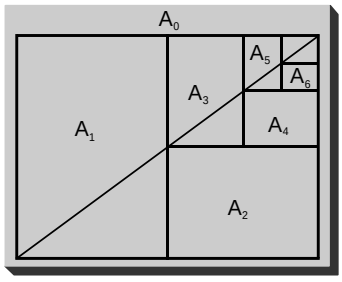
Hence, value of x and y is given as

x = 0.841 m (or) 841 mm

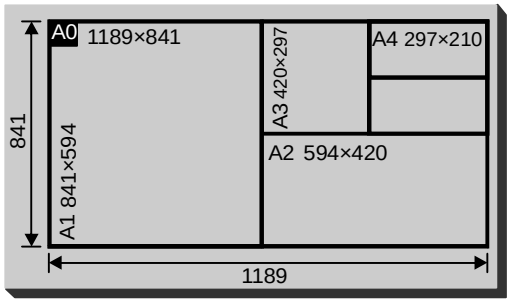
y = 1.189 m (or) 1189 mm

Successive smaller sizes are obtained by halving previous size sheets, with the above constant width to length ratio i.e., $(x : y = 1 : \sqrt{2})$

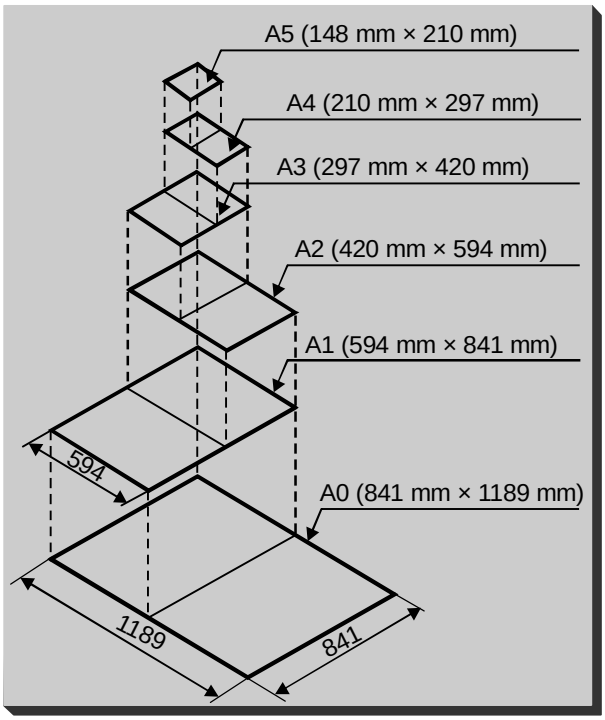
Example :



2-D view



3-D view



Note: The ISO 'A' series of sheet is based on a constant width to length ratio of $1 : \sqrt{2}$.

Application

The relationship of $1 : \sqrt{2}$ is particularly important for reduction onto microfilm, or reduction and enlargement on photocopiers. All metric equipment including microfilm cameras, microfilm printers, photocopiers and even drawing pen sizes are designed around this ratio.

Note: (1) A2 size drawing sheet is preferred for class use.
(2) Recommended size and its designation of ISO 'A' series of sheet is given below.

Table 1.1: Recommended size of drawing sheets

Drawing Sheet (IS 10711 : 2001)	
Designation	**Size (mm) Length × Width**
A0	1189 × 841
A1	841 × 594
A2	594 × 420
A3	420 × 297
A4	297 × 210

1.3 DRAWING BOARD : [IS 1444 : 1989]

It is generally made from soft wood such as white pine, fir, oak, red cedar etc.

- To prevent warping, the board should be made of narrow strips of wood joined together accurately.

- Ebony strip fitted to the left side of drawing board provides the guide for the T-square.

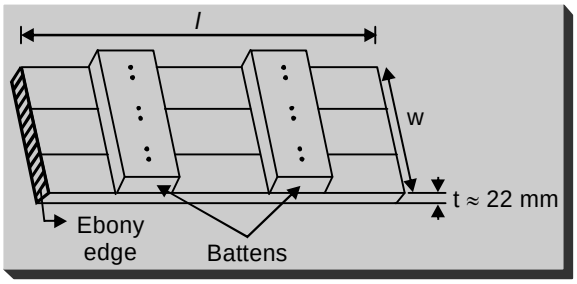


Table 1.2 : Recommended sizes of drawing boards.

Drawing Board (IS 1444 : 1989)		
Designation	**Size (mm) Length × Width**	**Recommended for use with sheet sizes**
D0/B0	1270 × 920	A0
D1/B1	920 × 650	A1
D2/B2	650 × 470	A2
D3/B3	500 × 350	A3

Note: D2 size drawing board is normally used for class work.

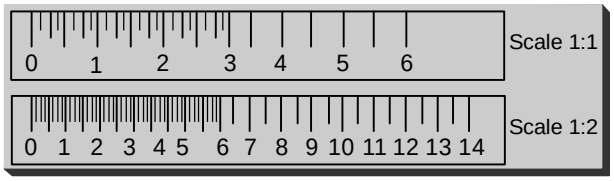
1.4 SCALES

The word 'scale' is usually employed for an instrument used for drawing or measuring the length of a straight line. It is also used to represent the proportion in which the drawing is made with respect to the object. It is used to make full size, reduced size or enlarged size drawing conveniently depending upon the size of the object and that of the drawing sheet. As recommended by Bureau of Indian Standards (BIS) there are eight set of scales. These are designated from M1 to M8 as shown in Table 1.3.

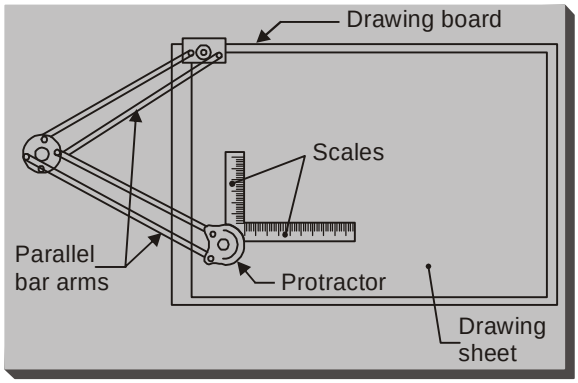
Table 1.3 : Designation and description of Engineer's scale

Designation	Description	Scale
M1	Full size 50 cm to a metre	1 : 1 1 : 2
M2	40 cm to a metre 20 cm to a metre	1 : 2.5 1 : 5
M3	10 cm to a metre 5 cm to a metre	1 : 10 1 : 20
M4	2 cm to a metre 1 cm to a metre	1 : 50 1 : 100
M5	5 mm to a metre 2 mm to a metre	1 : 200 1 : 500
M6	3.3 mm to a metre 1.66 mm to a metre	1 : 300 1 : 600
M7	2.5 mm to a metre 1.25 mm to a metre	1 : 400 1 : 800
M8	1 mm to a metre 0.5 mm to a metre	1 : 1000 1 : 2000

For example, a length designated as 2 cm on a 1 : 2 scale is equal to the length designated as 1 cm on a 1 : 1 scale.

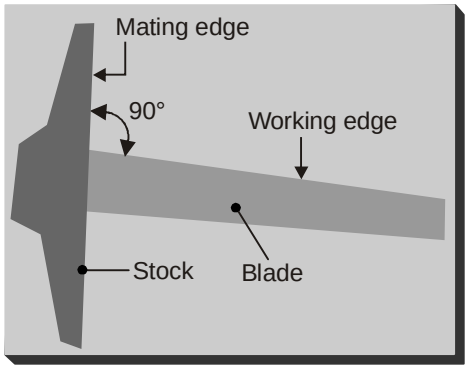


1.5 MINI DRAFTER



- It combines the function of a T-square, set square, scales and protractor.
- It is used for drawing horizontal, vertical, inclined, parallel, perpendicular lines along with its measurement.
- It is also used to trace angle.

1.6 T-SQUARE



It is a T-shape drawing tool whose mating edge slide along width of drawing board with the help of stock. It is useful in drawing primarily horizontal lines and also used for guiding the set squares while drawing vertical or inclined lines.

1.7 SET SQUARE

A pair of right angled triangle is called set squares. A set square has either 45°-45° angle or 30°-60° angle. The 45° set square shown below in fig. (a) is a right-angled triangle having acute angles of 45°. The 30°-