

# ESE-2021 Prelims Paper-I

## General Principles of Design, Drawing & Safety



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## **IES MASTER PUBLICATION**

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**First Edition** : 2016

**Second Edition** : 2017

**Third Edition** : 2018

**Fourth Edition** : 2019

**Fifth Edition** : 2020

# 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

Section	Description	Page No.
	<i>Preface</i>	(iii)
	<b>Engineering Drawing</b>	<b>01-130</b>
<b>Chapter 1</b>	<b>INTRODUCTION TO ENGINEERING DRAWING</b>	<b>1 – 9</b>
	1.1 Introduction .....	1
	1.2 Drawing Sheets .....	1
	1.3 Drawing Board .....	2
	1.4 Scales .....	3
	1.5 Mini Drafter .....	3
	1.6 T-Square .....	3
	1.7 Set Square .....	3
	1.8 Protractor .....	4
	1.9 Compass .....	4
	1.10 Dividers .....	5
	1.11 Drawing Pencil .....	5
	1.12 French Curves .....	5
	1.13 Layout of a Drawing Sheet.....	6
<b>Chapter 2</b>	<b>LINES, LETTERING AND DIMENSIONING</b>	<b>10 – 22</b>
	2.1 Lines .....	10
	2.2 Lettering .....	11
	2.3 Dimensioning .....	12
	2.4 Methods of Dimensioning .....	13
	2.5 Arrangement of Dimensions .....	14
	2.6 Dimensioning of Various Objects .....	14
	2.7 Symbols and Abbreviations Used in Dimensioning .....	17
	2.8 General Rules of Dimensioning .....	17
<b>Chapter 3</b>	<b>GEOMETRICAL CONSTRUCTIONS</b>	<b>23 – 27</b>
	3.1 Introduction .....	23
	3.2 Basic Geometrical Shapes .....	23

<b>Chapter 4</b>	<b>SCALES</b>	<b>28 – 33</b>
	4.1 Introduction .....	28
	4.2 Size of Scale .....	28
	4.3 Representative Fraction (R.F.) .....	29
	4.4 Units of Length and their Conversion .....	29
	4.5 Types of Scales .....	30
<b>Chapter 5</b>	<b>ENGINEERING CURVES</b>	<b>34 – 59</b>
	5.1 Introduction .....	34
	5.2 Conic Sections or Conics .....	34
	5.3 Special Curves .....	41
	5.4 Plane Curves .....	41
	5.5 Space Curve .....	54
<b>Chapter 6</b>	<b>THEORY OF PROJECTIONS</b>	<b>60 – 75</b>
	6.1 Introduction .....	60
	6.2 Projection Methods .....	60
<b>Chapter 7</b>	<b>PROJECTIONS OF POINTS</b>	<b>76 – 83</b>
	7.1 Introduction .....	76
	7.2 Locations of a Point .....	77
	7.3 Summary .....	81
<b>Chapter 8</b>	<b>PROJECTIONS OF LINES</b>	<b>84– 99</b>
	8.1 Introduction .....	84
	8.2 BIS Conventions for Projection of Lines .....	84
	8.3 Different Orientation of Lines and their Projections .....	84
	8.4 Traces of a Line .....	94
	8.5 Auxiliary Plane Projection Method .....	95
<b>Chapter 9</b>	<b>PROJECTION OF PLANES</b>	<b>100 – 106</b>
	9.1 Introduction .....	100
	9.2 Orientation of Planes and their Projections .....	100
	9.3 Suspended Planes .....	104
<b>Chapter 10</b>	<b>PROJECTIONS OF SOLIDS</b>	<b>107 – 118</b>
	10.1 Introduction .....	107
	10.2 Right Solid .....	107
	10.3 Frustums and Truncated Solid .....	108
	10.4 Orientation of Solid and their Projections .....	109

	10.5	Suspended Solids .....	112
	10.6	Section of Solids .....	113
	10.7	Intersection of Surfaces of Solids .....	114
<b>Chapter 11</b>		<b>DEVELOPMENT OF SURFACES</b>	<b>119 – 123</b>
	11.1	Introduction .....	119
	11.2	Methods of Development of Lateral Surfaces .....	120
<b>Chapter 12</b>		<b>COMPUTER AIDED DESIGN</b>	<b>124 – 130</b>
	12.1	Computer Aided Design (CAD) .....	124
	12.2	Basic Elements of a CAD System .....	124
	12.3	Major Benefits of CAD .....	124
	12.4	Major CAD Software Products .....	125
	12.5	AutoCAD .....	125
		<b>Engineering Design</b>	<b>131-228</b>
<b>Chapter 1</b>		<b>INTRODUCTION</b>	<b>131 – 137</b>
	1.1	Types of Engineering Design .....	131
	1.2	Importance of Engineering Design .....	132
	1.3	The Design Process .....	132
<b>Chapter 2</b>		<b>CONCEPTUAL DESIGN</b>	<b>138 – 147</b>
	2.1	Introduction .....	138
	2.2	Problem Definition .....	138
	2.3	Gather Information .....	141
	2.4	Concept Generation .....	141
	2.5	Evaluation Method .....	147
<b>Chapter 3</b>		<b>EMBODIMENT &amp; DETAIL DESIGN</b>	<b>148 – 151</b>
	3.1	Introduction .....	148
	3.2	Detail Design .....	150
	3.3	Design Reviews .....	151
<b>Chapter 4</b>		<b>SYSTEM ENGINEERING AND PRODUCT DEVELOPMENT</b>	<b>152 – 162</b>
	4.1	Introduction .....	152
	4.2	Product Development .....	153
	4.3	What is Robust Design .....	158

<b>Chapter 5</b>	<b>PROBLEM-SOLVING TOOLS</b>	<b>163 – 171</b>
	5.1 Introduction .....	163
	5.2 Problem Definition .....	163
	5.3 Cause Finding .....	164
	5.4 Solution Planning and Implementation .....	166
<b>Chapter 6</b>	<b>MISCELLANEOUS</b>	<b>172 – 228</b>
	6.1 Stresses and Strains .....	172
	6.2 Shearing Stress .....	173
	6.3 Normal Strain .....	173
	6.4 Stress and Strain in Simple Bar .....	173
	6.5 Deformation ( $\delta$ ) of Member Under Axial Load .....	174
	6.6 Composite Bars .....	175
	6.7 Problem Involving Temperature Change .....	176
	6.8 Poisson's Ratio .....	177
	6.9 Some Standard Results of Slopes ( $\theta$ ) and Deflections ( $\Delta$ ) .....	177
	6.10 Maximum Bending Stress at a Section .....	180
	6.11 Spring .....	181
	6.12 Thick Shell and Thin Shell .....	184
	6.13 Foundation .....	186
	6.14 The Retaining Structure .....	191
	6.15 Cofferdam .....	192
	6.16 Trusses .....	193
	6.17 Arches .....	194
	6.18 Cables .....	194
	6.19 Beam .....	195
	6.20 Slab .....	195
	6.21 Column .....	195
	6.22 Plate Girders .....	195
	6.23 Gantry Girders .....	196
	6.24 Coulomb's Law of Electrostatics .....	196
	6.25 Electric Intensity (E) .....	197

6.26	Electric Dipole .....	197
6.27	Electric Dipole Moment (P) .....	197
6.28	Electric Flux .....	197
6.29	Electric Potential .....	197
6.30	Electrical Potential Energy .....	197
6.31	Reactance (X) .....	197
6.32	Circuit Elements .....	198
6.33	Transformers .....	199
6.34	Transformer Losses .....	199
6.35	Synchronous Motors .....	200
6.36	Induction Motors .....	200
6.37	Shaft .....	200
6.38	Keys .....	203
6.39	Splines .....	203
6.40	Types of Welded Joints .....	204
6.41	Friction Clutches .....	204
6.42	Belt Drives .....	206
6.43	Bearing .....	208
6.44	Governor .....	211
6.45	Gear .....	212
6.46	Gyroscope .....	214
6.47	Design for X (DFX) .....	214

## **Engineering Safety**

**229-324**

<b>Chapter 1</b>	<b>ACCIDENT, HAZARD AND HAZARD ANALYSIS</b>	<b>229 – 236</b>
	1.1 Safety .....	229
	1.2 What is an Accidents .....	230
	1.3 Hazard .....	230
<b>Chapter 2</b>	<b>RISK ANALYSIS AND MANAGEMENT</b>	<b>237 – 241</b>
	2.1 Risk Management .....	237
	2.2 Risk Analysis Process and Methods .....	239
	2.3 Role of 'IT' in Health and Safety Management .....	239



2.4	Social Dimension of Risk-Contemporary Thinking .....	240
2.5	Evaluating Risk in Design .....	240
2.6	Risk Control Measures .....	240
<b>Chapter 3</b>	<b>HUMAN FACTORS IN SAFETY</b>	<b>241 – 244</b>
3.1	Job Stress .....	241
3.2	Occupational Stressors and Workplace Stress Effects .....	241
3.3	Physical Stress Influencing Factors .....	242
3.4	Human Operator's Stress Characteristics .....	242
3.5	Worksite Analysis Program for Human Factors .....	242
<b>Chapter 4</b>	<b>SAFETY MANAGEMENT PRINCIPLES</b>	<b>244 – 251</b>
4.1	Introduction .....	244
4.2	Safety Management Principles .....	244
4.3	Responsibilities Non-Safety Managers .....	246
4.4	Safety Committees .....	246
4.5	Improving the Workplace Ergonomics .....	247
4.6	Safety Audit .....	248
4.7	Safety Survey .....	250
4.8	Emergency Preparedness and Response Planning (EPRP) in Major Accident Hazard Factories .....	250
<b>Chapter 5</b>	<b>INITIATIVES TOWARDS SAFETY – GOI</b>	<b>252 – 255</b>
5.1	Existing Set-up of Occupational Safety and Health in the Workplace in India .....	252
5.2	Government Bodies Dealing with OSH Regulations .....	252
5.3	National Level Autonomous Bodies/Organizations Connected with Occupational Safety & Health .....	254
5.4	12 <sup>th</sup> Five Year Plan Schemes in Respect to Safety .....	255
<b>Chapter 6</b>	<b>SAFETY IN CONSTRUCTION</b>	<b>256 – 298</b>
6.1	Safety Practices at Work Places .....	256
6.2	Indian Regulations .....	257
6.3	Excavation Work .....	257
6.4	Scaffolds and Ladders .....	262
6.5	Structural Work, Laying of Reinforcement & Concreting .....	268
6.6	Road Work .....	271

6.7	Cutting and Welding .....	272
6.8	Working in Confined Space .....	277
6.9	Working at Heights .....	278
6.10	Handling and Lifting Equipment .....	279
6.11	Vehicle Movement in Construction Work .....	282
6.12	Demolition .....	283
6.13	Radiography .....	286
6.14	Grit Shot/Slag Blasting/Spray Painting .....	287
6.15	Tunneling .....	287
6.16	Safety Practices Adopted for Working with Construction Machinery .....	289

**Chapter 7**

	<b>MISCELLANEOUS</b>	<b>299 – 324</b>
7.1	Occupational Health Problem .....	299
7.2	International Labour Organization (ILO) .....	300
7.3	OSHA [Occupational Safety and Health Administration] .....	300
7.4	Work on Tall Chimneys .....	300
7.5	Boiler Safety .....	301
7.6	Nuclear Safety .....	303
7.7	Fire Safety .....	303
7.8	Dam Safety .....	304
7.9	Guidelines on Safety in Road Construction Zones .....	306
7.10	Safety in Building .....	311

# CHAPTER

# 1

# Introduction to Engineering Drawing

## 1.1 INTRODUCTION

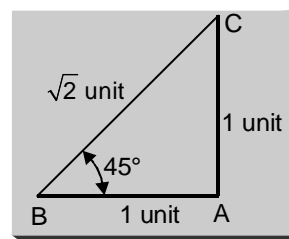
### INSIDE

- 1.1 Introduction
- 1.2 Drawing Sheets
- 1.3 Drawing Board
- 1.4 Scales
- 1.5 Mini Drafter
- 1.6 T-Square
- 1.7 Set Square
- 1.8 Protractor
- 1.9 Compass
- 1.10 Dividers
- 1.11 Drawing Pencil
- 1.12 French Curves
- 1.13 Layout of a Drawing Sheet

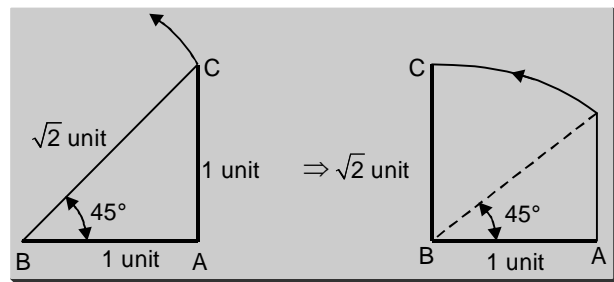
Engineering drawing is a technique of creating graphical representation that contains all necessary information such as dimensions, specifications and notes using which an abstract concept can be transformed into real world object. To realize such concept, basic tools of construction of drawing has to 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]

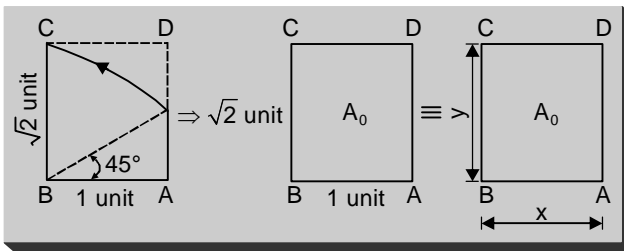
Consider an isosceles triangle ABC of unit length as shown below.



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,  $x, y \in$  side  
 (ii) Surface area ( $xy$ ) of  $A_0$  sheet is unity i.e.,  $xy = 1$

$$\begin{aligned} \therefore x : y &= \frac{1}{\sqrt{2}} \\ \therefore \frac{x}{y} &= \frac{1}{\sqrt{2}} \\ \Rightarrow y &= x\sqrt{2} \quad \dots (i) \end{aligned}$$

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

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

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

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

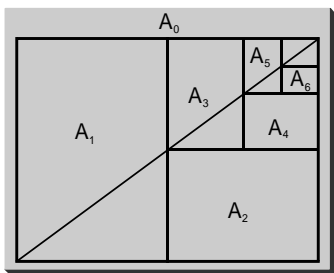
Hence, value of  $x$  and  $y$  is given as

$$x = 0.841 \text{ m} \quad (\text{or}) \quad 841 \text{ mm}$$

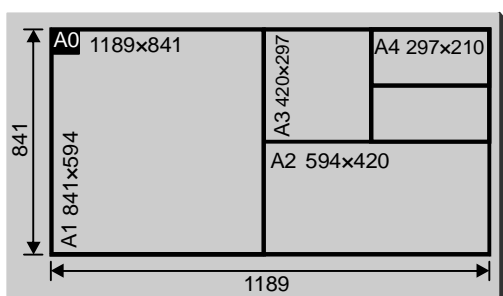
$$y = 1.189 \text{ m} \quad (\text{or}) \quad 1189 \text{ mm}$$

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

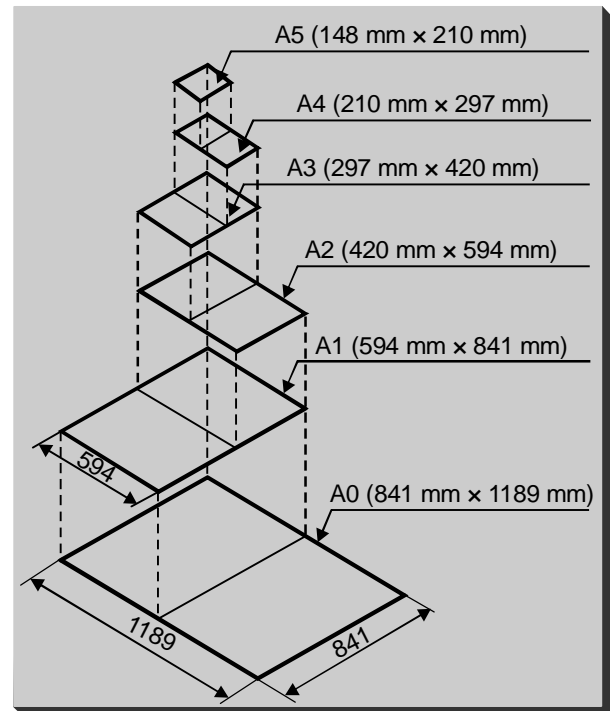
**Example :**



**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.

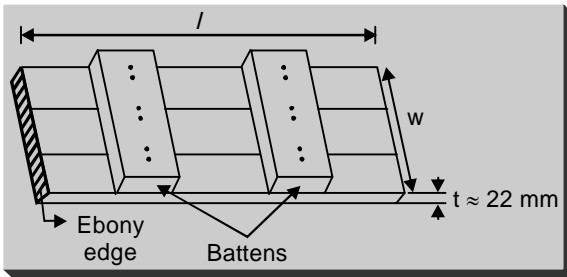


Table 1.2 : Recommended sizes of drawing boards.

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.

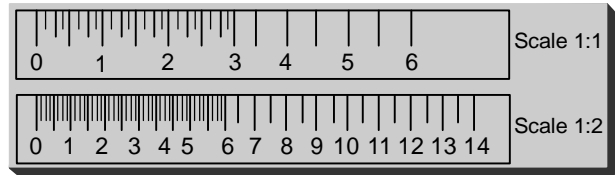
### 1.4 SCALES

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.

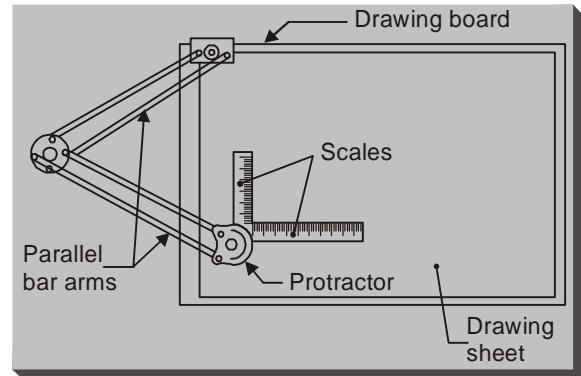
Table 1.3 : Designation and description of Engineer's scale

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

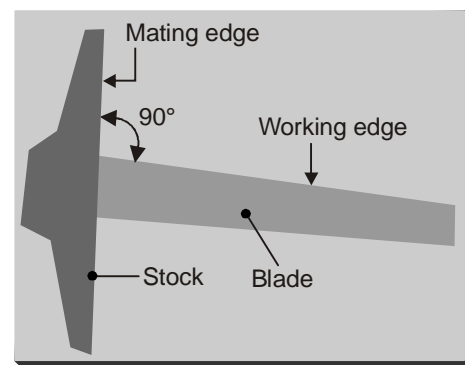


### 1.5 MINI DRAFTER



- 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°-