Solar PV System Installation and Maintenance

Level-II

Learning Guide -14

Unit of Competence	Perform Bench Work
Module Title	Performing Bench Work
LG Code	EIS PIM2 M05 LO1 LG-14
TTLM Code	EIS PIM2 TTLM 0120V1

LO1. Layout and mark dimensions/ features on work piece

Instruction Sheet	Learning Guide: - 14

This learning guide is developed to provide you the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:-

- Basic shop mathematics
- Selecting materials
- Marking dimensions/features using bench work tools and equipment.
- Safety procedures and personal protective devices.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to:-**

- How to apply using basic shop mathematics
- Identify basic bench work materials
- Exercise marking dimensions/features using bench work tools and equipment.
- Follow safety procedures and use personal protective devices

Learning Instructions:-

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information Sheet 1, Sheet 2, Sheet 3, Sheet 4, Sheet 5 in pages 3, 27, 45 & 51 and 54 respectively.
4. Accomplish the Self-check 1, Self-check 2, Self-check 3, Self-check 4 and self-check 5 in pages 26, 43, 50, and 53 and 67 respectively
5. If you earned a satisfactory evaluation from the “operation sheet 1 ” proceed to Operation 69
6. Do the “LAP test” on page 70

Information Sheet-1	Basic Shop Mathematics

1.1 Introduction

Mathematics is a universal language that has evolved over thousands of years. It draws on contributions from every civilization and corner of the world—from the ancient worlds of the Middle East, Greece, and Rome, to India, China, Russia, Africa, and pre-Columbian Mayan culture.

In Vocational Mathematics it is a fundamental assumption that functional understanding of numbers and arithmetical skills is a basic competence in line with reading and writing skills in a number of common and specific qualifications in the semi-skilled labor market.

A mathematical understanding or skill is functional when the mathematical ideas or techniques can be used for solving a task or a problem in everyday life.

1.1.1. Basic Arithmetic Operations

Addition and subtraction are operations in the *additive process*. Multiplication and division are closely related to addition and subtraction, and are therefore also part of the additive process.

- **Addition and Subtraction**

When numbers are added, the sequence of addition may be taken in any order. For example, 3 + 2 + 7 + 8 = 20. Rearranging the sequence does not change the result: 2 + 3 + 8 + 7 = 20 and 8 + 3 + 7 + 2 = 20.

EXAMPLE 1.4: ***Addition and Subtraction Operations***

Solve using steps: 90 – 15 + 10 – 5

Solution:

STEP 1: 90 – 15 = 75

STEP 2: 75 + 10 = 85 **STEP 3:** 85 – 5 = 80

- **Series Multiplication and Division**

A series of multiplications may be performed in any sequence.

For instance: 2 × 5 × 7 × 3 = 210; also, 7 × 2 × 3 × 5 = 210.

However, a series of divisions *must be done in the sequence given:*

For instance: 90 ÷ 15 ÷ 3 =?

By steps: 90 ÷ 15 = 6

6 ÷ 3 = 2.

If the sequence is not followed, an error will be made; for instance:

15 ÷ 3 = 5

90 ÷ 5 = 18,

This is not the correct answer to the original problem.

- **Short and Long Division**

Two methods of division are used in arithmetic. The first, called “short division,” is used when the divisor has only one digit. The second, called “long division,” is used when the divisor has two or more digits. Examples 1.5 and 1.6 illustrate these methods.

EXAMPLE 1.5: ***Short Division***

Divide 636 by 6.

STEP 1: Determine whether the divisor 6 will divide the first digit of the dividend 636. It will since it is not greater than this digit. The result of division is 1, which is placed under the 6.

6 636

1

STEP 2: Determine whether the divisor 6 will divide the second digit of the dividend. Since 6 will not divide 3, a zero is placed under the 3.

6 636

10

STEP 3: The 3 is now taken with the third digit 6 to become 36. The divisor 6 divides 36 and the quotient 6 is placed under the 6. The answer is 106.

6 636

106

EXAMPLE 1.6: ***Long Division***

Divide 6048 by 56.

Solution:

STEP 1: Set up the problem by placing a division symbol over the dividend 6048 with the divisor 56 to the left.

56 6048

1

STEP 2: Start from the left of the dividend and find the smallest string of digits that the divisor will divide. In this case, the number is 60. Place the quotient 1 above the division symbol directly over the 0 of 60.

```
    1
  ┌
56 6048
```

STEP 3: Multiply the divisor 56 by the quotient 1 and place the answer under the dividend found in Step 2.

```
    1
  ┌
56 6048
   56
```

STEP 4: Subtract the product, 56, from the first two digits of the number above it, 60.

```
    1
  ┌
56 6048
  —
   56
    4
```

STEP 5: Bring down the next digit in the dividend to form a partial remainder, 44.

```
    1
  ┌
56 6048
  —
   56
   44
```

STEP 6: Divide the divisor 56 into the partial remainder 44 and place the quotient above the division symbol. Since 56 cannot divide 44, a zero is placed to the right of the 1.

```
   10
  ┌
56 6048
  —
   56
   44
```

STEP 7: Bring down the next digit in the dividend to form a new partial remainder, 448.

```
      10
   ┌────
56 6048
 —
   56
   448
```

STEP 8: Divide 56 into the partial remainder 448 and place the quotient above the division symbol.

```
     108
   ┌────
56 6048
 —
   56
   448
```

STEP 9: Multiply the divisor 56 by the quotient 8 and place the product below the partial remainder.

```
     108
   ┌────
56 6048
 —
   56
   448
   448
```

STEP 10: Subtract the product, 448, from the previous partial remainder, 448.

```
     108
   ┌────
56 6048
 —
   56
   448
 ——
   448
     0
```

In many problems the answer may have a *remainder;* that is, the divisor is not a factor of the dividend. The remainder is handled as shown in Example 1.7.

EXAMPLE 1.7: ***Division with a Remainder***

Divide 4789 by 25.

The answer is:

```
      191
   ┌──────
25 4789
   —
    25
    228
   ——
    225
     39
   ——
     25
     14
```

Since we have used all of the digits given in the problem and are not left with a zero at the bottom, the leftover 14 is the remainder. The final result is written as:-

$$191\ \frac{14}{25}$$

- **Rules of Ordering in Mathematics - BODMAS**

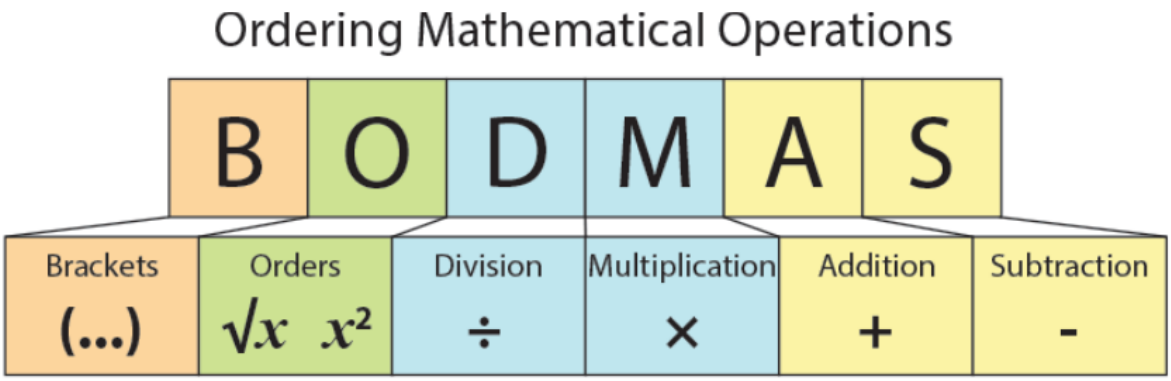


Figure 1: Bodimas Rule

- **Order of Mixed Operations**

In most technical mathematics problems several different operations need to be performed. To arrive at the correct answer, the operations must be performed in the proper sequence. The rules for the proper sequence are known as the *order of operations*.

As a simple example of applying the correct order of operations to a problem, consider this: 7 + 2 × 4 – 6 + 15 ÷ 3 – 2.

The correct way to group the operations is 7 + (2 × 4) – 6 + (15 ÷ 3) – 2, wherein the portions in ( ) are done first, working from left to right.

7+ (2 x 4) -6 + (15 ÷ 3) 2 = 7+ 8 - 6 + (15÷ 3) - 2	multiplication
= 7+ 8 - 6 +5 – 2	division
= 15 - 6 + 5 – 2	addition
= 9 +5 – 2	subtractions
= 14 – 2	addition
= 12	subtraction

Operations are performed in a specific sequence: Multiplication and division are done first, in the order they appear, left to right. Then addition and subtraction are done in the order they appear, left to right.

This is called the **MDAS** rule for **M**ultiplication, **D**ivision, **A**ddition, **and Subtraction**.

We often combine numbers with several operations somewhat automatically. Usually parentheses are included, but if no order is intended other than **MDAS**, the parentheses may be left out. That is why knowing the order of operations is so important.

When an operational order is intended other than the order provided by the MDAS rule, *grouping symbols* are necessary. Grouping symbols include parentheses, brackets, and braces. Accordingly, we must add "**P**—Parentheses" to the memory device to get **PMDAS**. Operations in parentheses are always taken care of first.

For example, if the previous problem were written with parentheses inserted as shown, the answer would have been different:

$(7 + 2) \times 4 – 6 + 15 \div (3 – 2) = 9 \times 4 – 6 + 15 \div 1 = 36 – 6 + 15 = 30 + 15 = 45$

Grouping symbols may be "nested," that is, one set may appear within another set. Often when this happens, other symbols—namely, brackets [ ] and braces { }—further define the order. For example,

$\{7 – [3 \times (4 – 2)] \div 2\} + 1 = \{7– [3 \times 2] \div 2\} + 1$

$= \{7 – 6 \div 2\} + 1$

$= \{7 – 3\} +1$

$= 4 + 1$

$= 5$

Finally, we insert "**E**—Exponents" in the phrase, so that if any term inside or outside the parentheses is raised to an exponent, the exponent is taken before the other operations. Exponents are discussed in Chapter 6. The phrase is now **PEMDAS**, which stands for: **P**arentheses, **E**xponents, **M**ultiplication, **D**ivision, **A**ddition, and **S**ubtraction.

*A mnemonic device for remembering the order of operations is the phrase, "**P**lease **E**xcuse **M**y **D**ear **A**unt **S**ally."*

1.1.2. Fraction and Decimal numbers

- ✓ A fraction is either a proper fraction or an improper fraction.
- ✓ A proper fraction is a number representing a part of a whole. This whole may be a single object or a group of objects. An improper fraction is a number in which numerator is greater than denominator.
- ✓ A mixed fraction is a combination of a natural number and a proper fraction.

✓ Two fractions are multiplied by multiplying their numerators and denominators separately and writing the product as : -

- $\boldsymbol{product\ of\ \frac{numerators}{denominators}\ \ Example,\frac{2}{5}\times\frac{3}{4}=\frac{2\times3}{5\times4}=\frac{6}{20}}$

✓ A fraction acts as an operator 'of '. For example, $\boldsymbol{\frac{1}{3}\ of\ 3\ is\frac{1}{3}\times3=1}$

✓ The product of two proper fractions is less than each of the fractions, for example

- $\boldsymbol{\frac{1}{2}\times\frac{1}{3}=\frac{1}{6}\ and\frac{1}{6}is\ less\ than\ both\frac{1}{2}and\frac{1}{3}}$

✓ The product of a proper and an improper fraction is less than the improper fraction and greater than the proper fraction. For example,

- $\boldsymbol{\frac{1}{2}\times\frac{3}{2}=\frac{3}{4}\ and\frac{3}{4}is\ less\ than\frac{3}{2}\ but\ \ greater\ than\frac{1}{2}}$

✓ The product of two improper fractions is greater than the two fractions. For example,

- $\boldsymbol{\frac{3}{2}\times\frac{7}{4}=\frac{21}{8}\ and\ \frac{21}{8}is\ greater\ \ than\ both\ \frac{3}{2}\ \ and\frac{7}{4}}$

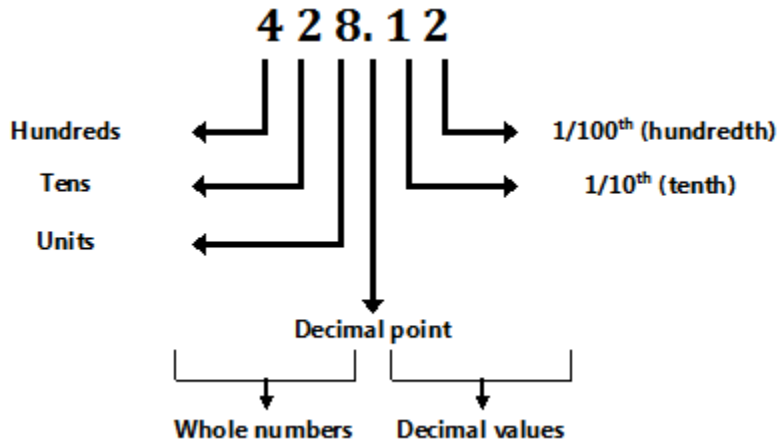
✓ The reciprocal of a non-zero fraction is obtained by interchanging its numerator and denominator. For example, $\boldsymbol{reciprocal\ of\ \frac{3}{2}\ is\frac{2}{3}}$

✓ While dividing a whole number by a fraction, we multiply the whole number with the reciprocal of that fraction. For example, $\boldsymbol{3\ \div\frac{1}{2}=3\times\frac{2}{1}}$

✓ While dividing a fraction by a natural number, we multiply the fraction by the reciprocal of the natural number. For example $\boldsymbol{\frac{1}{4}\ \div2=\frac{1}{4}\times\frac{1}{2}}$

✓ While dividing one fraction by another fraction, we multiply the first fraction by the reciprocal of the other. For example $\boldsymbol{\frac{1}{2}\ \div\frac{1}{3}=\frac{1}{2}\times\frac{3}{1}}$

✓ Decimal is a way of writing numbers where each digit represents the different power of 10 .It also needs a decimal point (dot) to separate the integral and fractional parts of a number.



✓ While multiplying two decimal numbers, first multiply them as whole numbers. Count the number of digits to the right of the decimal point in both the decimal numbers. Add the number of digits counted. Put the decimal point in the product by counting the number of digits equal to sum obtained from its rightmost place. For example, $1.2 \times 1.24 = 1.488$.

✓ To multiply a decimal number by 10, 100 or 1000, we move the decimal point in the number to the right by as many places as many zeros (0) are the right of one. For example, 1.33 × 10 = 13.3.

✓ To divide a decimal number by a natural number, we first take the decimal number as natural number and divide by the given natural number. Then place the decimal point in the quotient as in the decimal number. For example, $\frac{1.2}{4} = 0.3$

✓ To divide a decimal number by 10, 100 or 1000, shift the decimal point in the decimal number to the left by as many places as there are zeros over 1, to get the quotient. For example, $\frac{1.34}{100} = 0.0134$

✓ While dividing one decimal number by another, first shift the decimal points to the right by equal number of places in both, to convert the divisor to a natural number and then divide. For example, $\frac{1.44}{1.2} = \frac{14.4}{12} = 1.2$

1.1.3. **Percentages and ratios**

Percentages are used to give a common standard and are fractions having the number 100 as their denominators. For example, 25 percent means

$$\frac{25}{100}\ i.e\frac{1}{4}\ and\ is\ writen\ as\ 25\%$$

Example 1. Express as percentages: (a) 1.875 and (b) 0.0125

A decimal fraction is converted to a percentage by multiplying by 100. Thus,

(a) 1.875 corresponds to 1.875 × 100%, i.e. **187.5%**

(b) 0.0125 corresponds to 0.0125 × 100%, i.e. **1.25%**

Example 2. Express as percentages:

$$a)\ \ \frac{5}{16}\ \ and\ \ b)\ \ 1\frac{2}{5}$$

To convert fractions to percentages, they are (i) converted to decimal fractions and (ii) multiplied by 100

$$a)\ \ by\ division,\ \ \frac{5}{16} = 0.3125, hence\ \frac{5}{16} corespondes\ to\ 0.3125 \times\ 100\%, i.e\ 31.25\%$$

$$b)\ similarly,\ \ 1\frac{1}{5} = 1.4\ , when\ expressed\ as\ a\ decimal\ fraction.$$

$$Hence\ 1\frac{2}{5} = 1.4 \times 100\% = 140\%$$

Ratio is a way to show a relationship between two items. We are always counting and comparing items in our daily lives: hours at work versus hours away from work, number of yogurts we have eaten versus the number of yogurts still in the refrigerator, and so on. Ratios simply help us compare two items, objects, or amounts. Proportion compares two equal ratios in a mathematical equation. We use proportion to either increase or decrease one part of the ratio in the equation so that the unit expressed or found is in the same relationship with the other part of the specific ratio and so that this ratio, when completed, shows the same relationship as the other ratio.

A **ratio**, which is a comparison of two numbers by division, is the quotient obtained when the first number is divided by the second, nonzero number. Since a ratio is the quotient of two numbers divided in a definite order, care must be taken to write each ratio in its intended order. For example, the ratio of 3 to 1 is written

$$\frac{3}{1} as\ a\ fraction\ or\ 3:1\ using\ a\ colon\ , while\ teh\ ratio\ of\ 1\ to\ 3\ is\ written$$

$$\frac{1}{3} as\ a\ fraction\ or\ 1:3\ using\ a\ colon\ , in\ general, teh\ ratio\ of\ a\ to\ b\ can\ be\ expressed\ as$$

$$\frac{a}{b} \quad or \quad a \div b \quad or \quad a:b$$

To find the ratio of two quantities, both quantities must be expressed in the same unit of measure before their quotient is determined. For example, to compare the value of a nickel and a penny, we first convert the nickel to 5 pennies and then find the ratio, which is or 5 : 1.Therefore, a nickel is worth 5 times as much as a penny. The ratio has no unit of measure.

Equivalent ratios

Since the ratio is a fraction, we can use the multiplication property of 1 to find many **equivalent ratios**. For example:

$$\frac{5}{1}=\frac{5}{1}\times\frac{2}{2}=\frac{10}{2} \qquad \frac{5}{1}=\frac{5}{1}\times\frac{3}{3}=\frac{15}{3} \qquad \frac{5}{1}=\frac{5}{1}\times\frac{x}{x}=\frac{5x}{1x}\ (x\neq 0)$$

From the last example, we see that 5*x* and l*x* represent two numbers whose ratio is 5 : 1. In general, if *a*, *b*, and *x* are numbers ($b \neq 0$, $x \neq 0$), *ax* and *bx* represent two numbers whose ratio is *a* : *b* because

$$\frac{a}{b}=\frac{a}{b}\times 1=\frac{a}{b}\times\frac{x}{x}=\frac{ax}{bx}$$

Also, since a ratio such as $\frac{24}{16}$ is a fraction, we can divide the numerator and the denominator of the fraction by the same nonzero number to find equivalent ratios. For example:

$$\frac{24}{16}=\frac{24\div 2}{16\div 2}=\frac{12}{8} \qquad \frac{24}{16}=\frac{24\div 4}{16\div 4}=\frac{24}{16}=\frac{24\div 8}{16\div 8}=\frac{3}{2}$$

A ratio is expressed in **simplest form** when both terms of the ratio are whole numbers and when there is no whole number other than 1 that is a factor of both of these terms. Therefore, to express the ratio in simplest form, we divide both terms by 8, the largest integer that will divide both 24 and 16.Therefore, in simplest form is$\frac{3}{2}$.

Continued Ratio Comparisons can also be made for three or more quantities.

For example, the length of a rectangular solid is 75 centimeters, the width is 60 centimeters, and the height is 45 centimeters. The ratio of the length to the width is 75: 60, and the ratio of the width to the height is 60: 45.

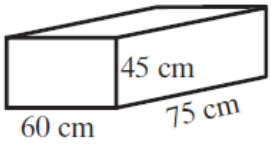


Figure 2: Comparisons of length, width and height

We can write these two ratios in an abbreviated form as the continued ratio 75: 60: 45.

A **continued ratio** is a comparison of three or more quantities in a definite order. Here, the ratio of the measures of the length, width, and height (in that order) of the rectangular solid is 75: 60: 45 or, in simplest form, 5: 4: 3.

In general, the ratio of the numbers *a*, *b*, and *c* (*b* ≠ 0, *c* ≠ 0) is *a: b: c*.

1.1.4. Conversion of units (English to metric)

- **Common Mathematical symbols**

As with any language, mathematics has established rules and terminology.

These are written with symbols—a sort of mathematical alphabet that is used to construct complicated expressions and convey abstract concepts in a compact, unambiguous form. Unlike the English alphabet, which has twenty-six symbols, the mathematical language has numerous symbols and is not recited in any particular order.

Many common mathematical symbols are listed in Table 1.1. Become familiar with these symbols and refer to them throughout this book.

Greek letters are often used to represent angles. Greek letters, such as π (pi) in the familiar circle formulas, are sometimes used to represent operations, constants, or variables. Part of the Greek alphabet that is commonly used in mathematics is given in

Table 1: Symbols

Symbol	What It Represents
+	Adding sign: Often referred to as the plus sign or the addition sign
-	Subtracting sign: Often referred to as the minus sign
x	Multiplication sign: Often referred to as the times or times table sign
÷	Division sign: To divide
=	Equal sign
| |	Absolute value
≠	Not equal to
( )	Parenthesis
[ ]	Square brackets
%	Percent sign: Out of 100
∑	Big sum sign: Summation
√	Square root sign
<	Inequality sign: Less than
>	Inequality sign: Greater than
!	Factorial
θ	Theta
π	Pi
≅	Approximately
Ø	Empty set
∠	Angle sign
!	Factorial sign
∴	Therefore
∞	Infinity

Conversion of units is the conversion between different units of measurement for the same quantity, typically through multiplicative conversion factors.

Table 2: units of measurement

STANDARD CONVERSION TABLE – ENGLISH TO METRIC				
Symbol	To convert from	Multiply by	To determine	Symbol
		LENGTH		
IN	inch	25.4	millimeters	mm
FT	feet	0.3048	meters	m
YD	yards	0.9144	meters	m
MI	miles	1.609344	kilometers	km
		AREA		
SI	square inches	645.16	square millimeters	mm^2
SF	square feet	0.09290304	square meters	m^2
SY	square yards	0.83612736	square meters	m^2
A	acres	0.4046856	hectares	ha
MI^2	square miles	2.59	square kilometers	km^2
		VOLUME		
CI	cubic inches	16.387064	cubic centimeters	cm^3
CF	cubic feet	0.0283168	cubic meters	m^3
CY	cubic yards	0.764555	cubic meters	m^3
GAL	gallons	3.78541	liters	L
OZ	fluid ounces	0.0295735	liters	L
MBM	thousand feet board	2.35974	cubic meters	m^3
		MASS		
LB	pounds	0.4535924	kilograms	kg
TON	short tons (2000 lbs)	0.9071848	metric tons	t
		PRESSURE AND STRESS		
PSF	pounds per square foot	47.8803	pascals	Pa
PSI	pounds per square inch	6.89476	kilopascals	kPa
PSI	pounds per square inch	0.00689476	megapascals	Mpa
		DISCHARGE		
CFS	cubic feet per second	0.02831	cubic meters per second	$m^3/_s$
		VELOCITY		
FT/SEC	feet per second	0.3048	meters per second	m/s
		INTENSITY		
IN/HR	inch per hour	25.4	millimeters per hour	mm/hr
		FORCE		
LB	pound (force)	4.448222	newtons	N
		POWER		
HP	horsepower	746.0	watts	W
		TEMPERATURE		
°F	degrees Fahrenheit	5 X (°F – 32)/9	degrees Celsius	°C
		DENSITY		
lb/ft^3	pounds per cubic foot	16.01846	kilograms per cubic meter	kg/m^3
		ACCELERATION		
g	freefall, standard	9.807	meters per second squared	m/s^2

TO CONVERT FROM METRIC TO ENGLISH, DIVIDE BY THE ABOVE CONVERSION FACTORS.

1.1.5. Trigonometric functions

Relationship between Degrees and Radians

Radian is defined as an angle subtended at the center of a circle for θ which the arc length is equal to the radius of that circle (see Fig.1).

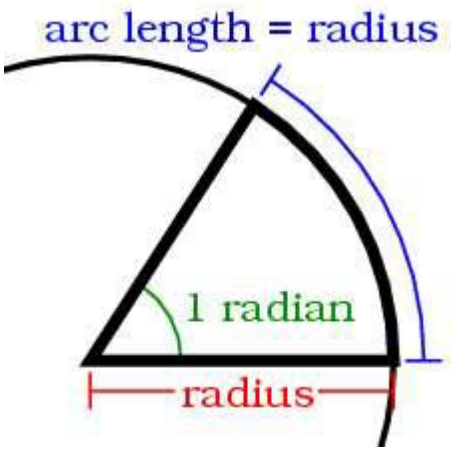


Fig1: Definition of a radian.

The circumference of the circle is equal to 2πR, where R is the radius of the circle. Consequently, 360°=2π radians. Thus, 1 radian=360°/2π ≈ 57.296°

1° = (2π/360) radians ≈ 0.01745 radians

- **The Unit Circle**

  In mathematics, a unit circle is defined as a circle with a radius of 1. Often, especially in applications to trigonometry, the unit circle is centered at the origin (0,0) in the coordinate plane. The equation of the unit circle in the coordinate plane is

  $x^2 + y^2 = 1$.

  As mentioned above, the unit circle is taken to be 360°, or 2π radians. We can divide the coordinate plane, and therefore, the unit circle, into 4 quadrants. The first quadrant is defined in terms of coordinates by x>0, y>0, or, in terms of angles, by 0°<θ<90°, or 0<θ<π/2. The second quadrant is defined by x<0, y>0, or 90°<θ<180°, or π/2<θ<π. The

third quadrant is defined by x<0, y<0, or 180°<θ<270°, or π<θ<3π/2. Finally, the fourth quadrant is defined by x>0, y<0, or 270°<θ<360°, or 3π/2<θ<2π.

- **Trigonometric Functions**

Definitions of Trigonometric Functions for a Right Triangle

A right triangle is a triangle with a right angle (90°) (See Fig.2).

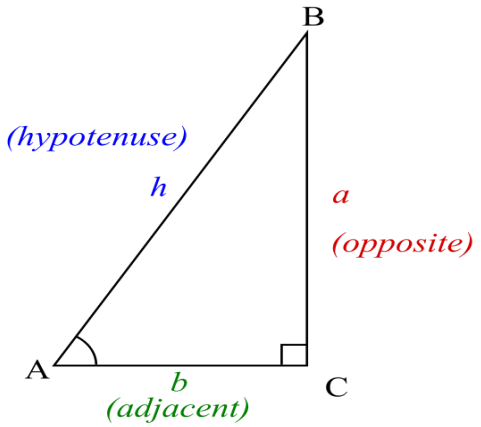


Figure 3: Right triangle.

For every angle in the triangle, there is the side of the triangle adjacent θ to it (from here on denoted as “adj”), the side opposite of it (from here on denoted as “opp”), and the hypotenuse (from here on denoted as “hyp”), which is the longest side of the triangle located opposite of the right angle. For angle θ, the trigonometric functions are defined as follows:

$$sine\ of\ \theta = sin\theta = \frac{opp}{hyp}$$

$$cosine\ of\ \theta = cos\theta = \frac{adj}{hyp}$$

$$tangent\ of\ \theta = tan\theta = \frac{sin\theta}{cos\theta} = \frac{opp}{adj}$$

$$cotangent\ of\ \theta = cos\theta = \frac{1}{tan\theta} = \frac{cos\theta}{sin\theta} = \frac{adj}{opp}$$

$$secant\ of\ \theta = sec\theta = \frac{1}{cos\theta} = \frac{hyp}{adj}$$

$$cosecant\ of\ \theta = csc\theta = \frac{1}{sin\theta} = \frac{hyp}{opp}$$

- **Definitions of Trigonometric Functions for a Unit Circle**

  In the unit circle, one can define the trigonometric functions cosine and sine as follows. If (x,y) is a point on the unit circle, and if the ray from the origin (0,0) to that point (x,y) makes an angle θ with the positive x-axis, (such that the counterclockwise direction is considered positive), then,

  $\cos\theta = x/1 = x$

  $\sin\theta = y/1 = y$

  Then, each point (x,y) on the unit circle can be written as (cosθ, sinθ). Combined with the equation $x2 + y2 = 1$, the definitions above give the relationship sin2θ+cos2θ=1. In addition, other trigonometric functions can be defined in terms of x and y:

  $\tan\theta = \sin\theta/\cos\theta = y/x$

  $\cot\theta = \cos\theta/\sin\theta = x/y$

  $\sec\theta = 1/\cos\theta = 1/x$

  $\csc\theta = 1/\sin\theta = 1/y$

Fig.3 below shows a unit circle in the coordinate plane, together with some useful values of angle θ, and the points (x,y)=(cosθ, sinθ), that are most commonly used (also see table in the following section).

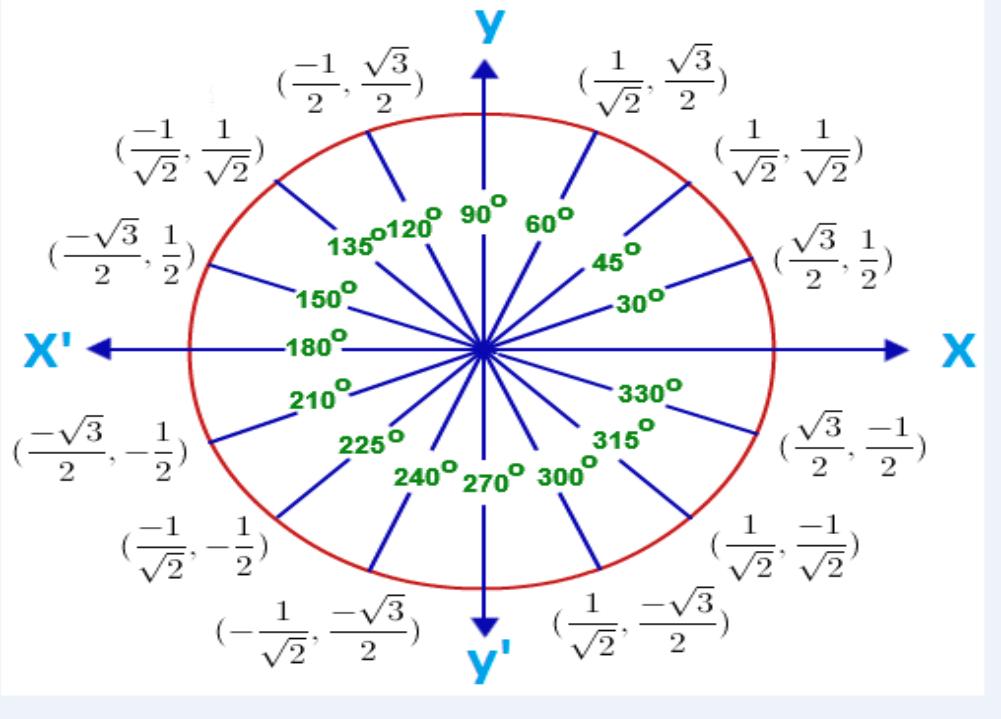


Figure 4: Most commonly used angles and points of the unit circle.

Note: For θ in quadrant I, sinθ>0, cosθ >0; for θ in quadrant II, sinθ>0, cosθ<0; for θ in quadrant III, sinθ<0, cosθ<0; and for θ in quadrant IV, sin θ

Exact Values for Trigonometric Functions of Most Commonly Used Angles

θ in degrees	θ in radians	sinθ	cosθ	tanθ
0	0	0	1	0
30	$\frac{\pi}{6}$	$\frac{1}{2}$	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{3}}{3}$
45	$\frac{\pi}{4}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{2}}{2}$	1
60	$\frac{\pi}{3}$	$\frac{\sqrt{3}}{2}$	$\frac{1}{2}$	$\sqrt{3}$
90	$\frac{\pi}{2}$	1	0	undefined
180	π	0	-1	0
270	$\frac{3\pi}{2}$	-1	0	undefined
360	2π	0	1	0

Figure 5: Angle Description

Note: Exact values for other trigonometric functions (such as cotθ, secθ, and cscθ) as well as trigonometric functions of many other angles can be derived by using the following sections.

θ'	sinθ'	cosθ'	tanθ'	θ'	sinθ'	cosθ'	tanθ'
90°+θ π/2+θ	cosθ	−sinθ	-cotθ	90°−θ π/2-θ	cosθ	sinθ	cotθ
180°+θ π+θ	-sinθ	-cosθ	tanθ	180°−θ π−θ	sinθ	-cosθ	-tanθ
270°+θ 3π/2+θ	-cosθ	sinθ	-cotθ	270°−θ 3π/2-θ	-cosθ	-sinθ	cotθ
k(360°)+θ k(2π)+θ k=integer	sinθ	cosθ	tanθ	k(360°)−θ k(2π)−θ k=integer	-sinθ	cosθ	-tanθ

Figure 6: Trigonometric Functions of Any Angle θ' in Terms of Angle θ in Quadrant I

1. **Trigonometric Functions of Negative Angles**

$$\sin(-\theta) = -\sin\theta$$

$$\cos(-\theta) = \cos\theta$$

$$\tan(-\theta) = -\tan\theta$$

2. **Some Useful Relationships among Trigonometric Functions**

$$\sin^2\theta + \cos^2\theta = 1$$

$$\sec^2\theta - \tan^2\theta = 1$$

$$\csc^2\theta - \cot^2\theta = 1$$

3. **Double Angle Formulas**

$$\sin 2\theta = 2\sin\theta\cos\theta$$

$$\cos 2\theta = \cos^2\theta - \sin^2\theta = 1 - 2\sin^2\theta = 2\cos^2\theta - 1$$

$$\tan 2\theta = \frac{2\tan\theta}{1-\tan^2\theta}$$

4. **Half Angle Formulas**

Note: in the formulas in this section, the "+" sign is used in the quadrants where the respective trigonometric function is positive for angle θ/2, and the "-" sign is used in the quadrants where the respective trigonometric function is negative for angle θ/2.

$$\sin\frac{\theta}{2} = \pm\sqrt{\frac{1-\cos\theta}{2}}$$

$$\cos\frac{\theta}{2} = \pm\sqrt{\frac{1+\cos\theta}{2}}$$

$$\tan\frac{\theta}{2} = \pm\sqrt{\frac{1-\cos\theta}{1+\cos\theta}} = \frac{\sin\theta}{1+\cos\theta} = \frac{1-\cos\theta}{\sin\theta}$$

5. Angle Addition Formulas

Note: in this and the following section, letters A and B are used to denote the angles of interest, instead of the letter θ.

$$\sin(A \pm B) = sinAcosB \pm cosAsinB$$

$$\cos(A \pm B) = cosAcosB \mp sinAsinB$$

$$\tan(A \pm B) = \frac{tanA \pm tanB}{1 \mp tanAtanB}$$

$$\cot(A \pm B) = \frac{cotAcotB \mp 1}{cotB \pm cotA}$$

6. Sum, Difference and Product of Trigonometric Functions

$$sinA + sinB = 2\sin\left(\frac{A+B}{2}\right)\cos\left(\frac{A-B}{2}\right)$$

$$sinA - sinB = 2\sin\left(\frac{A-B}{2}\right)\cos\left(\frac{A+B}{2}\right)$$

$$cosA + cosB = 2\cos\left(\frac{A+B}{2}\right)\cos\left(\frac{A-B}{2}\right)$$

$$cosA - cosB = -2\sin\left(\frac{A+B}{2}\right)\sin\left(\frac{A-B}{2}\right)$$

$$sinAsinB = \frac{1}{2}[\cos(A-B) - \cos(A+B)]$$

$$cosAcosB = \frac{1}{2}[\cos(A-B) + \cos(A+B)]$$

$$sinAcosB = \frac{1}{2}[\sin(A-B) + \sin(A+B)]$$

Selfe-Check-1	Written test

I. Choose the best answer for the following questions

1. 24 ÷ 3 + 4 × 5 – 6 =_____

   A. 23 B. 18 C. 22 D. 24

2. Kebede is dividing $1\frac{3}{4}kg$ of sweets equally among her seven friends. How much does each friend receive?

   A. $\frac{3}{4}kg$ B. $\frac{1}{4}kg$ C. $\frac{1}{2}kg$ D. $\frac{3}{28}kg$

3. If $\frac{3}{4}$ of a number is 12, the number is

A. 9 B. 16 C. 18 D. 32

4. COS 45= _____?

   A. 0 B. √2/2 C. 1 D. √3/2

5. SINE60= _____?

   A. 0 B. √2/2 C. 1 D. √3/2

Note: **Satisfactory rating 4 and above points, Unsatisfactory - below 4 points**

.

Score = _____

Rating: _____

Information Sheet 2	Using Linear measuring tools

2.1 Introduction

- Most people's first contact with linear measurement is with a steel rule or a tape measure.
- However, today's engineer has a choice of wide range of instruments to choose from right from purely mechanically operated instruments to digital electronics instruments.
- One has to only consider the nature of application and cost of measurement to decide which instrument is the best for an application.
- This chapter covers a broad range of linear measurement instruments from a simple steel rule up to digital calipers and micrometers.

2.1.1. Design of Linear Measurement Instruments

- The measuring accuracy of line graduated instruments depends on the original accuracy of line graduations. Excessive thickness or poor definition of graduated lines affects the accuracy of readings captured from the instrument.
- Any instrument incorporating a scale is a suspect unless it is provided compensation against wear.
- Attachments can enhance the versatility of instruments. However, every attachment used along with an instrument, unless properly deployed, may contribute to accumulated error. Wear and tear of attachments can also contribute to errors.
- Instruments such as calipers depend on the feel of the user for their precision. Good quality of the instrument promotes reliability, but ultimately skill of the user ensures accuracy.
- The principle of alignment states that the line of measurement and the line of dimension being measured should be coincident. This principle is fundamental to good design and ensures accuracy and reliability of measurement.
- Dial versions of instruments add convenience in reading. Electronic versions provide digital readouts which are even easier to read.
- One important element of reliability of an instrument is its readability.

2.1.2. Surface Plate

A surface plate is a hard, solid and horizontal flat plate, which is used as the reference plane for precision inspection, marking out and precision tooling set up.

Since surface plate is used as the datum for all measurements on a job, it should be finished to a high degree of accuracy.

The surface plates are made either from cast iron or granite.

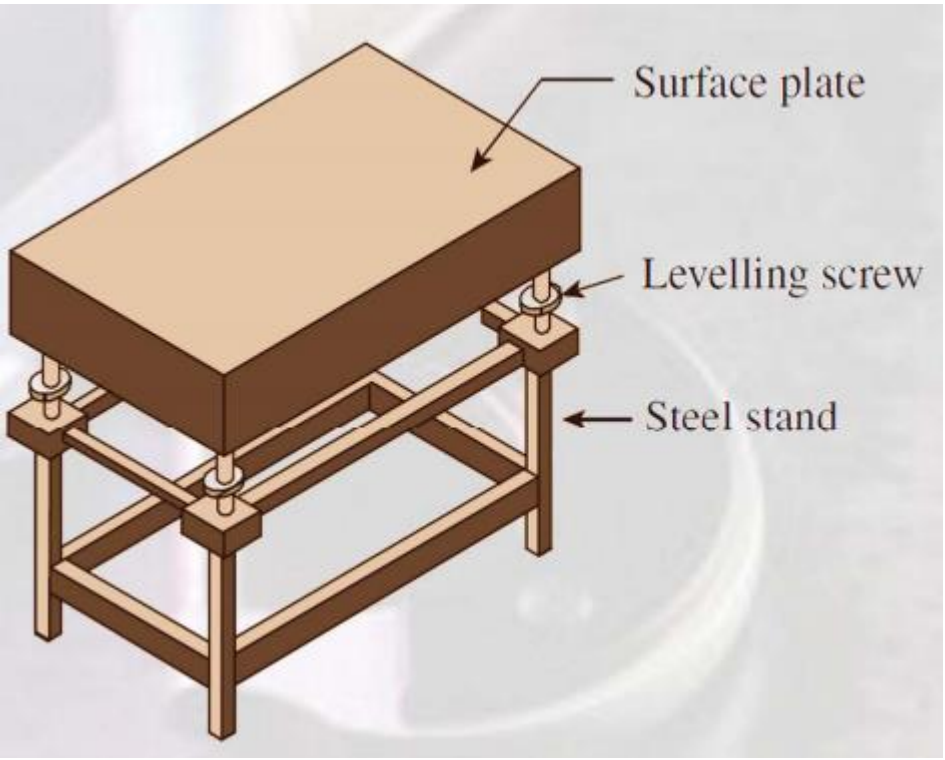


Figure 7: surface plate

2.1.3. Mechanical Properties of Metals

The mechanical properties that determine the behavior of metals under applied forces. These properties are most important for the designing point of view.

- ✓ **Strength:** Ability of a material to resist loads without failure.

- ✓ **Tensile Strength:** Ability of a material in tension to withstand stress without failure.
- ✓ **Shear Strength:** Ability of a material to withstand transverse loads without fracture.
- ✓ **Elasticity:** Property of material which enables it to regain its original shape after deformation with in the elastic limit.
- ✓ **Stiffness:** Property of material which enables it to resist deformation.
- ✓ **Plasticity** : Ability of material to be deformed permanently without fracture even after removal of force
- ✓ **Ductility:** Ability of a material to deform plastically without rupture under tensile load.
- ✓ **Malleability:** Property which enables the metal to withstand deformation by a compressive load without fracture.
- ✓ **Brittleness:** Property of the material of sudden fracture without any appreciable deformation.
- ✓ **Hardness:** Property of the material which enables it to resist abrasion, indentation, machining and scratching.
- ✓ **Toughness:** Ability of material to absorb maximum energy upto fracture takes place.
- ✓ **Fatigue:** Failure of material under repeated (cyclic) loads or fluctuating loads.
- ✓ **Weld ability :** Ability of a material to be joined by welding
- ✓ **Cast ability** : Property of a metal which indicates the ease with which it can be cast into different shapes and sizes from its liquid state

2.1.4. Ferrous metals

Ferrous metals are iron base metals which include all variety of pig iron, cast iron wrought iron and steels. The ferrous metals are those which have iron as their main constituents. The ferrous metals commonly used in engineering practice are cast iron, wrought iron, steel and alloy steels. The basic principal raw material for all ferrous metals is pig iron which is obtained by smelting iron ore, coke and limestone, in the blast furnace. The principal iron ores with their metallic contents.

Table 3: Types of Iron Ore (minerals)

S.No.	Iron ore	Color	Iron %
1.	Haematite (Fe_3O_4)	Red	70%
2.	Magnetite (Fe_2O_3)	Black	72%
3.	Limonite	Brown	62.5%
4.	Siderite	Brown	48%

- **Cast Iron**

  Pig iron re-melted and there by refined together with definite amount of lime stone, steel scrap and spoiled castings in cupola. It contains 2-4% carbon, a small percentage of silicon, Sulphur, phosphorus and manganese.

- **Properties of Cast Iron:**

  - ✓ It has good fluidity
  - ✓ It can be easily machined
  - ✓ It is brittle in nature
  - ✓ It is resistance to deformation
  - ✓ It is wear resistant.

- **Uses of Cast Iron**

  - ✓ It is used in making pipes
  - ✓ It is used for making machine bodies
  - ✓ It is used in making automotive industry parts

- **Mild steel and Properties of Mild Steel**

  - ✓ It has low fluidity.

- ✓ It has good tensile strength.
- ✓ It is ductile
- ✓ It can be cold worked easily.

- **Uses**

- ✓ It is used for making structures
- ✓ It is used for making nuts and bolts
- ✓ It is used for making machine components.
- ✓ It is used for making boiler plates

- **High carbon steels**

  High carbon steels have more than 0.60% carbon i.e. 0.6 - 0.9% carbon. It is generally used for making parts requiring strength, hardness and wear resistance.

  Properties of High Carbon Steels

  - ✓ It has good strength
  - ✓ It has high toughness
  - ✓ It has increased wear resistance.

  Uses

- ✓ It is used for making Drop hammers
- ✓ It is used for making Screw drivers
- ✓ It is used for making laminated Springs
- ✓ It is used for making gears
- ✓ It is used for making piston rings

- **Alloy steels**

  Steel is a metal alloy consisting mostly of iron, in addition to small amount of carbon, depending upon the grade and quality of the steel. Alloy steel is any type of steel to which one or more

elements besides carbon have been added to produce a desired physical properties. The most common alloying elements added to steel are Chromium, Nickel, manganese, silicon, Vanadium etc. . . .

Properties of Alloy Steel

- ✓ High Strength
- ✓ High corrosion resistance
- ✓ High wear resistance
- ✓ Good toughness.

Uses

- ✓ It is used for making Aero plane parts
- ✓ It is used for making automobile parts
- ✓ It is used for railway track work
- ✓ It is used for making locomotive parts

- **Stainless steel**

It contains 18% chromium, 8% nickel, 0.06% to 0.12% carbon. They are called stainless because in the presence of oxygen, they develop a thin adherent film of chromium oxide that protects the metal from corrosion.

Properties of Stainless Steel

- ✓ It has high corrosion resistance.
- ✓ It has high strength
- ✓ Good toughness
- ✓ It possess nonmagnetic properties.
- ✓ It can be rolled.

Uses

- ✓ It is used for making surgical instruments.
- ✓ It is used for making utensils
- ✓ It is used for making containers for pharmaceutical industries.
- ✓ It is used for making springs.

2.2. Non-ferrous Materials

The basic knowledge of non-ferrous metals and their properties is of great significance for any work bench operations. Non-ferrous metals contain metals other than iron as their main constituents such as- aluminum, copper, zinc, magnesium, lead, tin, nickel and their alloys and nonmetallic materials. Various non-ferrous alloys are copper base (brass, Bronze), aluminum base alloys (duralumin, Y-alloy, hindalium, magnalium), nickel alloys (Inconel, Monel and ni-chrome), tin base alloys (bearing or antifriction alloys). The non-ferrous metals are used for the following purposes namely resistance to corrosion, special electrical and magnetic properties , softness, facility of cold working, fusibility, ease of casting, good formability, low density and attractive color. The properties and uses of various non-ferrous metals are given in the following articles.

- **Copper**

Copper is easily identified from all other metals due to reddish in color and is extracted from copper pyrites.

Properties of Copper:

- ✓ It is relatively soft.
- ✓ It is very malleable and ductile
- ✓ It is very good conductor of heat and electricity.
- ✓ It is very flexible.

Uses of Copper

- ✓ It is used for making electrical cables.
- ✓ It is used for making kitchen vessels
- ✓ It is used for making pipes which are used in refrigerators.
- ✓ It is used making for ornaments.

- **Brass**

  It is basically refers to a yellowish alloy of copper and zinc and it comprises of 65% copper and 35% zinc. There are various classes of brass, depending on the proportion of copper and zinc are available for various uses. The melting point of brass ranges from 800^{O}C - 1000 ^{O}C

Properties of Brass

- ✓ It is non-corrosive
- ✓ Air, water and some acids do not affect it.
- ✓ It is poor conductor of electricity.

Uses

- ✓ It is used for making utensils.
- ✓ It is used for manufacturing ornaments.
- ✓ It is used in hydraulic fittings, pump lining, in making bearing and bushes.
- ✓ It is used in making locks.

- **Bronze**

  It is alloy of copper and tin. The composition range is 5-25% tin and 75 to 95% copper. The corrosion resistances of bronzes are superior than brasses.

Properties of Bronze

- ✓ It is comparatively hard
- ✓ It is resistance to surface wear
- ✓ It can be casted into wires and sheets
- ✓ It has high strength.

Uses

- ✓ It is used in hydraulic fittings, pump linings,
- ✓ It is used in making utensils, bearings, bushes, sheets, rods, wire etc

- **Tin**

Although it is used in small amounts, tin is an important metal. Tin is used as protective layer on the sheet metal. It is obtained from tin stone.

Properties of Tin

- ✓ It is white soft metal
- ✓ Good resistance to acid corrosion
- ✓ Low strength
- ✓ It is malleable and ductile.
- ✓ It does not corrode at both dry and wet climates.

Uses

- ✓ It is used as a coating on steel containers for preservation of food products
- ✓ It is used in making thin foils and as an alloying element in the manufacture of bearings

- **Zinc**

It is fourth most utilized industrially after iron, Aluminum and copper. It is used for galvanizing the steel sheet or wire as it serves as anode to protect from corrosion attack.

Properties of Zinc

- ✓ It is soluble in copper
- ✓ Low melting point and high fluidity.
- ✓ High corrosion resistance
- ✓ It is ductile and malleable.

Uses

- ✓ It is used for die casting
- ✓ It is used for production of brass
- ✓ It is used in battery cells for making dry batteries
- ✓ It is used as protective coating in iron and steel against rusting

- **Gun Metal**

Gun metal contains 10%tin, 88% copper and 2% zinc. Zinc is added to clean the metal and increase fluidity. It is not suitable for being worked in the cold state.

Properties of Gun Metal

- ✓ It is highly anti corrosive
- ✓ It has good machinability
- ✓ It has good hardenability.

Uses

- ✓ It is used for casting guns and cannons.
- ✓ It is used for boiler fitting.
- ✓ It is used for making bearings.
- ✓ It is used for making glands in centrifugal pumps

White Metal

White metal contains copper-tin-antinomy and it contain 88% tin, 8% antimony and 4 % copper.

Properties

- ✓ It is a soft metal with low coefficient of friction
- ✓ It has little strength

Uses

It is the most common bearing metal used into cast iron boxes when the bearing is subjected to high pressure and load

- **Aluminum**

Aluminum is most abundant metal in the earth crust. It is silvery white in color. It makes up about 8% by weight of the earth's solid surface Aluminum is remarkable for its low density and ability to resist corrosion

Properties of Aluminum

- ✓ It is a good conductor of heat and electricity.
- ✓ It is very light in weight.
- ✓ In pure state is very weak and soft

Uses

- ✓ It is used for making automobile parts
- ✓ It is used for ornamental purpose
- ✓ It is used for making aircraft parts
- ✓ It is used for making bars, tubes & rivets

- **Low-alloy Steels**

  Low-alloy steels constitute a category of ferrous materials that exhibit mechanical properties superior to plain carbon steels as the result of additions of alloying elements such as nickel, chromium, and molybdenum. Total alloy content can range from 2.07% up to levels just below that of stainless steels, which contain a minimum of 10% **Cr**.

  For many low-alloy steels, the primary function of the alloying elements is to increase hardenability in order to optimize mechanical properties and toughness after heat treatment. In some cases, however, alloy additions are used to reduce environmental degradation under certain specified service conditions.

  As with steels in general, low-alloy steels can be classified according to:

  - ***Chemical composition*****,** such as nickel steels, nickel-chromium steels, molybdenum steels, chromium-molybdenum steels
  - ***Heat treatment*****,** such as quenched and tempered, normalized and tempered, annealed.

  Because of the wide variety of chemical compositions possible and the fact that some steels are used in more than one heat-treated, condition, some overlap exists among the alloy steel classifications. In this article, four major groups of alloy steels are addressed: (1) low-carbon quenched and tempered (QT) steels, (2) medium-carbon ultrahigh-strength steels, (3) bearing steels, and (4) heat-resistant chromium-molybdenum steels.

- **Low-carbon quenched and tempered steels**

  Combine high yield strength (from 350 to 1035 MPa) and high tensile strength with good notch toughness, ductility, corrosion resistance, or weld ability. The various steels have different combinations of these characteristics based on their intended applications. However, a few steels, such as HY-80 and HY-100, are covered by military specifications. The steels listed are used primarily as plate. Some of these steels, as well as other, similar steels, are produced as forgings or castings.

- **Medium-carbon ultrahigh-strength steels**

Are structural steels with yield strengths that can exceed 1380 MPa. Many of these steels are covered by SAE/AISI designations or are proprietary compositions. Product forms include billet, bar, rod, forgings, sheet, tubing, and welding wire.

- **Bearing steels**

  Used for ball and roller bearing applications are comprised of low carbon (0.10 to 0.20% **C**) case-hardened steels and high carbon (-1.0% C) through-hardened steels. Many of these steels are covered by SAE/AISI designations.

- **Chromium-molybdenum heat-resistant steels**

  Contain 0.5 to 9% **Cr** and 0.5 to 1.0% **Mo**. The carbon content is usually below 0.2%. The chromium provides improved oxidation and corrosion resistance, and the molybdenum increases strength at elevated temperatures. They are generally supplied in the normalized and tempered, quenched and tempered or annealed condition. Chromium-molybdenum steels are widely used in the oil and gas industries and in fossil fuel and nuclear power plants.

2.3. PLATES & SHEETS (PLAIN PATTERNED)

Steel Plates and Steel Sheets are rolled, flat, carbon steel products which falls under rolled Steel Materials product line. Steel Plates/ Sheets are rolled from slabs. Steel Plates are thick materials where Steel Sheets are tending to have thinner thickness ranges. Steel Plates/Sheets are produced in different sizes and different appearances (patterns) with respect to the process they were subjected to. Steel Plates/Sheets are used in construction, lifting & excavating, energy & power, shipbuilding. Manufacturers supplies Steel Plates/ Sheets for every purpose in different dimensions, patterns and sizes.

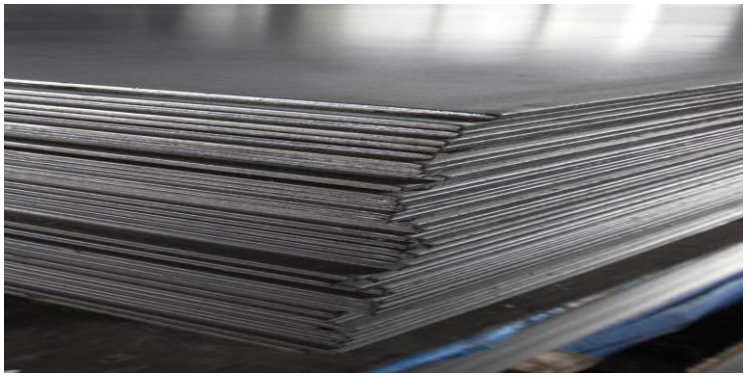


Figure 8: PLATES & SHEETS (PLAIN PATTERNED)

- **Rolled Steel Materials / Hot Rolled Steel Plates & Sheets**Serials / Hot Rolled Steel Plates & Sheets
  Hot Rolled Steel Plates are carbon steel flat materials which are produced by putting slabs into a hot rolling mill. Hot Rolled Steel Plates have greater thickness than sheets or piles.

  Hot Rolled Steel Sheets are flat carbon steel products that are rolled from slabs in a hot rolling mill which tend to have thinner dimensions than plates. Hot Rolled Steel Plates/Sheets are used in construction, lifting & excavating, energy & power, shipbuilding. Manufacturers supply Hot Rolled Steel Plates/Sheets under supreme quality policies for its clients.

- **Product Range**

  Hot Rolled Plates: 1,5 to 200 mm thickness & width of 1000 mm to 3000 mm

  Thickness: From 8 mm up to 120 mm

  Width: 1500 mm / 1800 mm / 2000 mm

  Length: 6000 mm / 12000 mm

  Packing: In loose.

  Quality: In various internationally well-known standards including ASTM, BS, DIN, EURONORM, GOST, JIS, ISO, SAE, etc.

2.4. Safety Precautions

- ✓ Never wear loose clothing, ties and shirts with long sleeves.
- ✓ Keep the shop floor clean and free from oil and grease.
- ✓ Do not use blunt or dull tool, it slips and causes injury.
- ✓ While using chisels, see that cutting is performed in the direction away from the body.
- ✓ Keep hands away from moving parts.
- ✓ There must be sufficient light and ventilation at work place.
- ✓ Exhaust fans should be provided to remove smokes and fumes.
- ✓ Use proper tools according to the nature of the job.
- ✓ Use of shoes and apron is essential.
- ✓ Never carry tools in pocket

Self-Check-2	Written test

Choose the best answer by circling the correct letter

1. What is the composition of brass?
   A. 65% copper and 35% zinc
   B. 65% aluminum and 35% zinc
   C. 55% copper and 25% zinc
   D. None of the above
2. What is the composition of bronze?
   A. 55% copper and 25% zinc
   B. 5-25% tin and 75 to 95% copper
   C. 65% aluminum and 35% zinc
   D. A & B are correct

3. Which one of the following is correct about Shear Strength property of metal
   A. Ability of a material to resist loads without failure
   B. Ability of a material in tension to withstand stress without failure.
   C. Ability of a material to withstand transverse loads without fracture.
   D. Property of material which enables it to resist deformation
   E. All

4. Which one of the following is correct about the properties of high carbon steels
   A. It has increased wear resistance
   B. It has high toughness
   C. It has good strength
   D. All of the above are correct

5. Which one of the following is true about law alloy steels?
   A. Low-alloy steels constitute a category of ferrous materials
   B. The primary function of the alloying elements is to increase hardenability in order to optimize mechanical properties and toughness after heat treatment.
   C. Low-alloy steels constitute a category of non-ferrous materials
   D. A & B are correct

Note: **Satisfactory rating 3 and above points, Unsatisfactory - below 2 points**

Score = _____

Rating: _____

Information Sheet-3	Safety procedures and personal protective devices

4.1 General Safety Precautions while Working in a Workshop

- One should not leave the machine ON even after the power is OFF and until it has stopped running completely. Someone else may not notice that the machine is still in motion and be injured.
- Operator should not talk to other industrial persons when he is operating a machine.
- One should not oil, clean, adjust or repair any machine while it is running. Stop the machine and lock the power switch in the OFF position.
- One should not operate any machine unless authorized to do so by the authorize person in the shop.
- Always check that work and cutting tools on any machine are clamped securely before starting.
- The floor should be kept clean and clear of metal chips or curls and waste pieces. Scraps and chips or curls may cut through a shoe and injure the foot.
- Defective guards must be replaced or repaired immediately.
- One should not operate any machinery when the supervisor or instructor is not in the shop.
- All set screws should be of flush or recessed type. Projecting set screws are very dangerous because they catch on sleeves or clothing.
- One should not try to stop the machine with hands or body.
- Only trained operator should operate machine or switches as far as possible.
- Always take help for handling long or heavy pieces of material.
- Always follow safe lifting practices
- No one should run in the shop at work time.
- Always keep your body and clothes away from moving machine parts. Get first aid immediately for any injury.
- Never talk to anyone while operating the machine, nor allow anyone to come near you or the machine.
- Stop the machine before making measurements or adjustments.

- Operator should concentrate on the work and must not talk unnecessarily while operating the machines.
- Never wear necktie, loose sweater, wristwatch, bangles, rings, and loose fitting clothing while working in workshop.
- Always wear overcoat or apron.
- Stop machines before attempting to clean it.
- Make sure that all guards are in their place before starting to operate a machine.
- Do not attempt to operate a machine until you have received operating instructions.
- Be thoroughly familiar with the 'stop' button and any emergency stop buttons provided on the machines. Remove burrs, chips and other unwanted materials as soon as possible. They can cause serious cuts.
- Do not leave loose rags on machines.
- Wash your hands thoroughly after working to remove oils, abrasive particles, cutting fluid, etc.
- Report all injuries to the foreman, howsoever small. Cuts and burns should be treated immediately.
- Keep the work area clean.
- Keep your mind on the job, be alert, and be ready for any emergency.
- Always work in proper lighting.
- On should not lean against the machines.
- Introduction to Basic Manufacturing Processes and Workshop Technology

4.2 Safety Precautions while Working with Different Hand Tools

- **Screw Drivers**
  - ✓ When working on electrical equipment use only a screw driver with an approved handle.
  - ✓ One should wear goggles when re-sharpening screw-driver tips.
  - ✓ Screws with burred heads are dangerous and must be replaced or the burrs removed with file or an abrasive cloth.
  - ✓ One should use the correct tip of screw drivers while screwing. Too arrow or too wide tip will damage the work.

- **Wrenches**
  - ✓ One should not hammer a wrench to loosen a stubborn fastener, unless the tool has been specially designed for such treatment.
  - ✓ Always pull on a wrench. One can have more control over the tool if pulling instead of pushing and there is less chance of injury.
  - ✓ It is dangerous practice to lengthen the wrench handle for, additional leverage. Use a larger wrench.
  - ✓ Choose a wrench that fit properly. A loose fitting wrench may slip and round off the corners of the bolt head and nut.
  - ✓ When using wrenches clean grease or oil from the floor in the work area. This will reduce the possibility of slipping and losing balance.
- **Hammers**
  - ✓ One should not operate the hammer unless its head is tightly fixed to the handle.
  - ✓ Place the hammer on the bench carefully. A falling hammer can cause serious foot injuries.
  - ✓ Never strike two hammers together. The faces are very hard and the blow might cause a chip to break off.
  - ✓ Never hold the hammer too far on the handle when striking a blow.
  - ✓ Unless the blow is struck squarely, the hammer may glance of the work.

4.3 Safety Precautions while Working with Different Cutting Tools

- **Files**
  - ✓ One should always use a file card to clean the file. Never use your hand. The chips may penetrate in hand and cause a painful infection.
  - ✓ One should not use a file without a handle.
  - ✓ Short burns formed in filling may cause serious cuts. Always use a piece of cloth to wipe the surface being field.

- ✓ Files are highly brittle and should never be used as a hammer otherwise the file will break.
- ✓ Never hammer on a file. It may shatter and chips fly in all directions.

- **Chisels**
  - ✓ One should always hold the chisel in such a manner that the hammer blow may not miss the chisel to injure your hand. Industrial Safety 41
  - ✓ Edges of metal cut with the chisel are often sharp and cause bad cuts.
  - ✓ Flying chips are dangerous. Wear transparent plastic safety goggles and use a shield, when using a chisel, to protect yourself and those working near you.
  - ✓ Sharp edges of chisels are removed by grinding or filing.
  - ✓ Mushroomed head of the chisel should be removed by grinding.
- **Saws**
  - ✓ One should not test the sharpness of the blade by a running a finger across the teeth.
  - ✓ One should not brush away the chips with your hand.
  - ✓ All hard blades can shatter and produce flying chips. Wear your toggles.
  - ✓ One should not be sure that the blade is properly tensioned.
  - ✓ Store the saw so that you will not accidentally reach into the teeth when you pick it up.
  - ✓ If the blade breaks while you are on cutting stroke, your hand may strike the works and cause an injury. Therefore saw operator should work carefully.
- **Reamers**
  - ✓ One should remove all bars from the reamed holes.
  - ✓ Never use your hands to remove chips and cutting fluids from the reamer and work. One should use a piece of cotton waste.
- **Taps and Dies**
  - ✓ One should use a brush to clean away chips formed by hand threading. Never use your hand.
  - ✓ One should always wear goggles if the tap, die or threaded piece is to be cleaned with compressed air.

- ✓ Tap operator should also be careful that other person working in the area also wearing goggles.
- ✓ Handle broken taps as you would handle broken glass. They are sharp edges and are dangerous to handle.
- ✓ Wash your hands after using cutting fluid. Skin-rashes caused by some cutting fluids can develop into a serious skin disorder if they are left on the skin for a long period.
- ✓ Take care of any cuts immediately. Infection may occur when injuries are not properly treated.

- **(F) Abrasives**
  - ✓ If the lathe is used for polishing make sure that the machine is protected from the abrasive grains that fall from the polishing wheels during polishing. They can cause rapid wear of the precision parts.
  - ✓ One should not rub fingers or hand across a piece that has just been polished by abrasive.
  - ✓ Cuts and burns should always be treated immediately by using first aid facility.
  - ✓ One should remove all abrasive particles by washing them thoroughly after the polishing operation.

Self-Check-3	Written test

I.Say true or false for the following questions

1. One should not operate any machine unless authorized to do so by the authorize person in the shop
2. Take care of any cuts immediately. Infection may occur when injuries are not properly treated.
3. Defective guards must be replaced or repaired after a day
4. Stop machines before attempting to clean it
5. Files are highly brittle and should never be used as a hammer otherwise the file will break

Note: **Satisfactory rating 2 and above points, Unsatisfactory - below 2 points**

Score = _____

Rating: _____

Information Sheet 4	Selecting materials

4.1 introductions

Material selection is a step in the process of designing any physical object. In the context of product design, the main goal of material selection is to minimize cost while meeting product performance goals

Systematic selection of the best material for a given application begins with properties and costs of candidate materials. For example, a thermal blanket must have poor thermal conductivity in order to minimize heat transfer for a given temperature difference. It is essential that a designer should have a thorough knowledge of the properties of the materials and their behavior under working conditions. Some of the important characteristics of materials are : strength, durability, flexibility, weight, resistance to heat and corrosion, ability to cast, welded or hardened, machinability, electrical conductivity, etc.

4.2 Workbench top material ideas

Plastic and laminate tops are also ideal surfaces if you're working with chemicals or in a lab setting as the plastic material cleans clean easily. Plastic and laminate workbenches are fairly sturdy, although they aren't built to withhold quite as much weight as wood or steel workbenches and aren't nearly as durable

Outdoor Street Furniture, Commercial Recycling Bins, Road Safety Bollards and Litter Bin Manufacturers.

Either direct or through an established network of Authorised Distributors, Glasdon International Limited markets the various street furniture products of all the Glasdon Group Companies. With a multi-lingual support team operating from a dedicated international sales office, a high level of service is delivered to customers around the world.

Customer care and new product innovation have established Glasdon as a market leading street furniture manufacturer and supplier. Product quality is essential to ensuring longevity and value for

money, which is why we strive to supply customers with high-quality, durable products that will stand the test of time. Our commercial and public benches are a prime example of products designed for the toughest of environments. You can find out more in this FAQ where we explore the sustainable materials used in our park benches: Which materials do Glasdon use for their seats and benches?

Finding a product that suits your waste management needs can present its own challenges, which is why we offer a fantastic Live Chat feature with industry experts ready and waiting to help. Our News and FAQ portfolios also contain expert advice including How to Choose the Right Litter Bin for Your Environment, as well as customer case studies to provide an insight into the Glasdon-Customer journey.

We have an established network of distributors throughout the world, through which thousands of customers have been supplied with high-quality products, from trash receptacles to road safety equipment. Find a distributor near you or contact us directly to find out more information about our wide range of street furniture and safety products.

Self-Check-4	Written test

Say true or false

1. Systematic selection of the best material for a given application begins with properties and costs of candidate materials
2. . Plastic and laminate workbenches are fairly sturdy, although they aren't built to withhold quite as much weight as wood or steel.

Information Sheet 5	Marking dimensions/features using bench work tools and equipment

3.1 Introduction

The layout of metal is the procedure of measuring and marking material for cutting, drilling, or welding. Accuracy is essential in layout work. Using incorrect measurements results in a part being fabricated that does not fit the overall job. This is a waste of time and material. In most cases, you should use shop drawings, sketches, and blueprints to obtain the measurements required to fabricate the job being laid out. Your ability to read and work from blueprints and sketches is vital in layout work.

3.2 Measurement and marking

Vital aims of this exercise are transfer of drawing measurements to the work piece, marking with scribe and do center punching. Measuring and marking on work piece is the process of scribing center points, circles, arcs or straight lines on given metal to indicate the shape of the object, area on metal that need to be removed during machining process and position of the holes to be drilled.

- **Calipers**

  These are used for measuring and transferring the inside or outside dimensions for components. These are also used for comparing the sizes with existing standards. The following types of calipers are most widely used in workshops

- **Outside Calipers**

  It is used for measuring outside dimensions of cylindrical shapes and the thickness of metal pieces. It has two steel legs bent inwards.

Figure 9: Outside calipers

- **Inside Calipers**

  It is used to measure the diameter of holes and width of key ways or recesses. Its legs are bent outwards.

Figure 10: Inside calipers

- **Verner caliper**

  These are widely used for precision measurement of length, thickness, depth and inside and outside diameters. With Vernier caliper we can achieve accuracy up to 0.02 mm.

  Basic tools for linear measurement are a ruler and Vernier caliper as shown in **Figure 11**. It can be used to measure linear distance, circle diameter and part thickness.

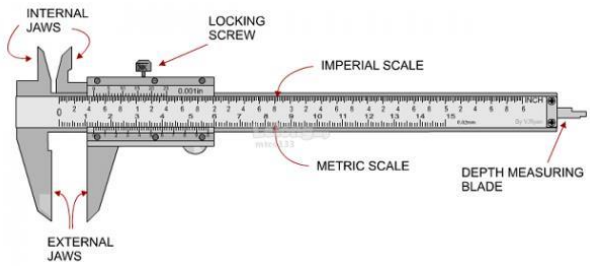


Figure 11:: Vernier caliper

- **Micrometer**

  Micrometer is a precision tool used to measure external or internal dimensions such as diameters and thickness, with an accuracy up to 0.01 mm.

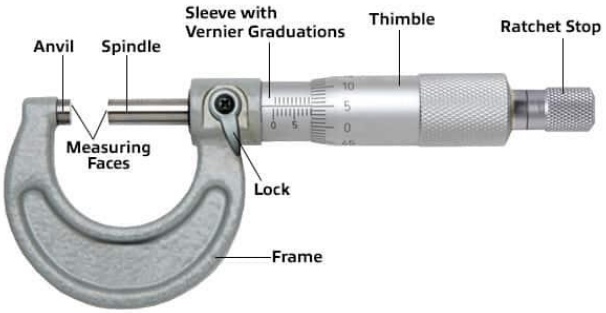


Figure 12: Micrometer

- **L square**

  Then, another important measurement is angular measurement. Normally using ‘L’ square as shown in **Figure 2** and can serve several purposes including laying out lines on metal and checking two surfaces for right angle (90 degrees).

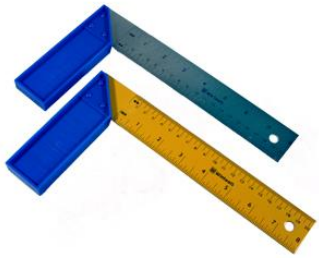


Figure 13: L square

- **Steel Rule**

  Steel rules are manufactured in a variety of types and lengths; each of which is designed for measuring or laying out different work. Available in lengths from 100mm to 1000mm.

Figure 14: steel rule

- **Combination Square**

  This is one of the most useful and convenient tools for laying out small work. It is used as a square for measuring or laying out 90° or 45° angles. A spirit level is mounted in the stock. Available in 300mm lengths.

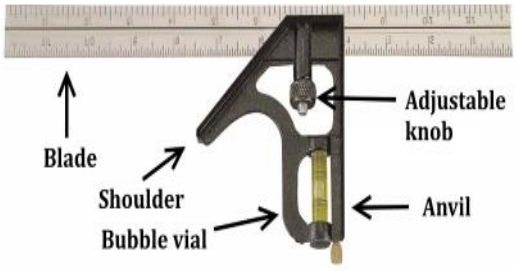


Figure 15: combination square

- **Protractor**

  This is a device for measuring and laying out angles from the edge of the work. This protractor consists of a head and a movable blade. The head of the protractor has a semicircular scale graduated from zero to 180°.

Figure 16: Protractor

Tape Rule

It is very popular for measuring and laying out large jobs. Available in various lengths.

Figure 17: Tape rule

- **Trammel Points**

  These are used for scribing large arcs and circles. They are manufactured in various types with two straight, removable legs tapered to needle points and attached to separated heads or holders. The heads or holders slide on wood or steel beams and are held in place by thumb screws. Either of the points can be removed and often one point has adjustment for fine settings. A special clamp for a pencil can be attached to one of the points.

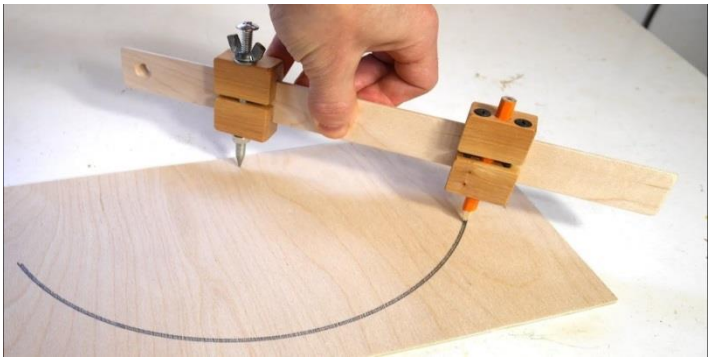


Figure 18: Trammel point

- **Scriber**

  This is used to mark lines on metal. It can be used in conjunction with a straight edge and square.

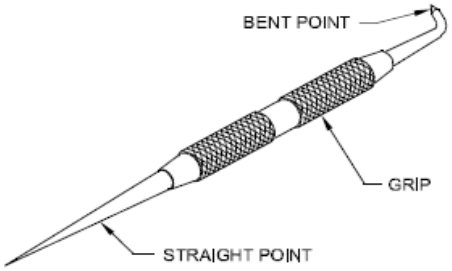


Figure 19: Scriber

- **Dividers**

  This is made with each straight leg tapered to a needle point. Dividers are manufactured in various sizes and types and are used to space off equal distances, to divide lines into equal parts and to scribe arcs and circles. Spring loaded screw dividers are also available. Supplied in lengths from 150mm to 500mm. Spring dividers are also available in sizes from 75mm to 300mm.

Figure 20: Dividers

- **Centre Punch**

  Similar in design to the prick punch except that the tapered point is ground to an angle of 90° included. They are available in various shapes and sizes and are used for locating centers for drilling etc.

Figure 21: set of center punches

- **Striking tools- Hammers**

  Hand hammers are also called striking tools used to strike the job. They are made of forged steel of various sizes and shapres to suit various purposes like punching, chipping, marking, bending and riveting.

Figure 22: Parts of Hand Hammer

A hammer consists of four parts namely Face, Peen, Cheek and eye hole.

- **Face**: It is the striking portion polished well and is given slight convexity to avoid spoilage of the surface of the metal to be hammered.
- **Peen**: It is the other end of the head and is made into different shapes to suit various operations.
- **Cheek**: Middle portion of the hammer head.
- **Eye-Hole**: It is made oval or elliptical in shape to accommodate the handle.depending upon the shape of the peen, hand hammers are classified as 1) Ball peen hammer 2) Cross peen hammer 3) Straight peen hammer.

- **Ball Peen Hammer:** It has a flat striking face and ball shaped peen which is hardened and polished. This hammer is chiefly used for chipping and riveting.

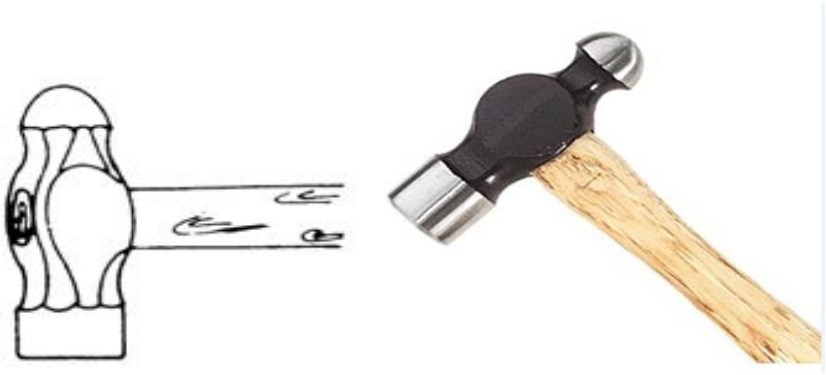


Figure 23: Ball Pen Hammer

- **Cross - Peen Hammer:** It has wedged shape peen across the eye. It is used for bending, stretching, hammering into shoulders.

Figure 24: Cross-Pen Hammer

- **Straight Peen Hammer:** This is similar to cross peen hammer except that the peen in this case is parallel to eye. It is used for stretching and peening the metal.

Figure 25: Straight Peen Hammer

- **Soft Hammer or Mallet:** These are soft hammers used give light blows where the work surface must not be damaged. They are made of either rubber, plastic or wood.

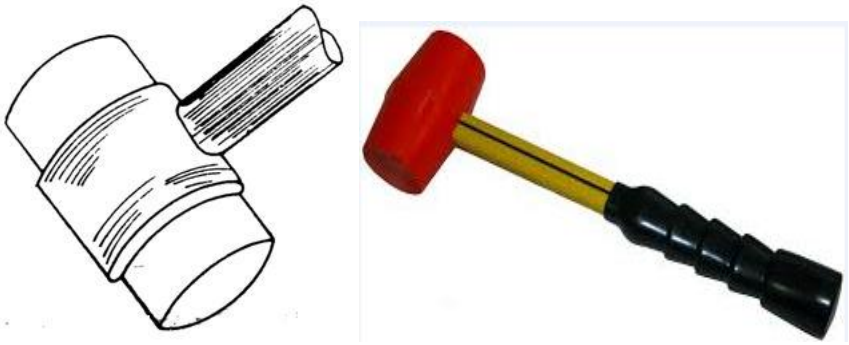


Figure 26: Soft Hammer

- **Straight Snips:** Standard snips for cutting of noble materials such as zinc or copper or compound action for cutting of harder materials being often used in the industry such as stainless steel or isobar. With a standard or higher quality, snips meet most of the cutting requirements for fine metal sheet work: long and continuous in full metal sheet, shaving and notching cuts, circular cuts...

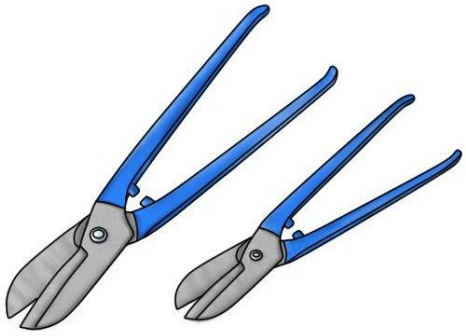


Figure 27: Straight snips

- **Bench shear:** also known as a lever shear, is a bench mounted shear with a compound mechanism to increase the mechanical advantage. It is usually used for cutting rough shapes out of medium-sized pieces of sheet metal, but cannot do delicate work.

Figure 28: bench shear

- **An anvil**: is a metalworking tool consisting of a large block of metal (usually forged or cast steel), with a flattened top surface, upon which another object is struck (or "worked").

Figure 29: Anvil

- **Example on how to use some of measuring and marking tools**

  Now that you have been introduced to dividers and trammel points let us learn how to use them. Constructing a 90-degree, or right, angle is not difficult if you have a true, steel square. Suppose that you have no square or that your square is off, and you need a right angle for a layout. Using your dividers, a scriber, and a straightedge, draw a base line similar to AB in *Figure 22*. Set the dividers for a distance greater than one-half AB; then, with A as a center, scribe arcs like those labeled C and D. Next, without changing the setting of the dividers, use B as a center, and scribe another set of arcs at C and D. Draw a line through the points where the arcs intersect and you have erected perpendiculars to line AB, forming four 90-degree, or right, angles. You have also bisected or divided line AB into two equal parts.

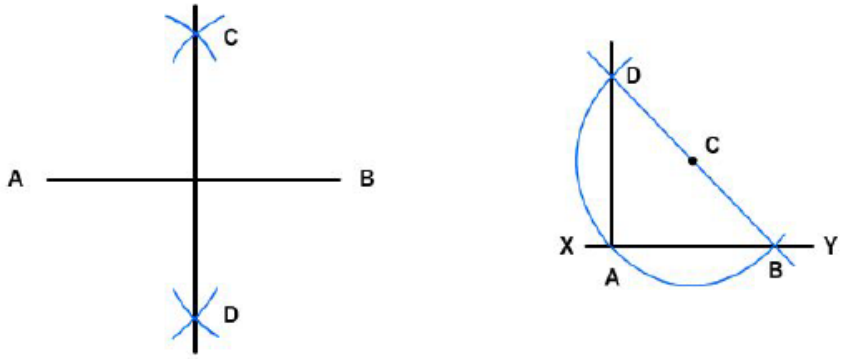


Figure 30: creating a 90^0 by bisecting and angle a given point

Start with line XY, with A as a point to fabricate a perpendicular to form a right angle. Select any convenient point that lies somewhere within the proposed 90-degree angle. In *Figure 30,* that point is C. Using C as the center of a circle with a radius equal to CA, scribe a semicircular arc, as shown in *Figure 30*. Lay a straightedge along points B and C and draw a line that will intersect the other end of the arc at D. Next, draw a line connecting the points D and A and you have fabricated a 90-degree angle. This procedure may be used to form 90-degree corners in stretch-outs that are square or rectangular, like a drip pan or a box.

Using the required width of the pan for the other dimensions, draw the fourth side parallel to the base line, connecting the two perpendiculars that you have fabricated. Set the dividers for marking off the depth of the drip pan. Use a steel scale to measure off the correct radius on the dividers. Using each corner for a point, swing a wide arc, like the one shown in the second step in *Figure 13*. Extend the lines as shown in the last step in *Figure 13,* and complete the stretch-out by connecting the arcs with a scriber and straightedge.

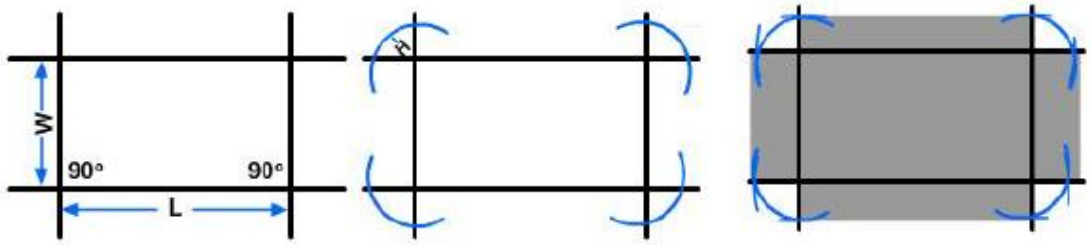


Figure 31: Laying out a drip pan with dividers.

Self-Checks-5	Written test

Choose the best answer

1. The purpose of scriber is to:-
   A. Layout fine lines on a metal surface
   B. Provide a starting point for a drill
   C. Measure the angularity of a surface with a side bar
   D. Extract filings from a file

2. Which one of the following is not true about calipers?
   A. Used to measure outside dimensions of cylindrical shapes and the thickness of metal pieces.
   B. Widely used for precision measurements
   C. Used to measure the diameter of holes and width of key ways or recesses.
   D. None of the above

3. Which one of the following tool is used in measuring and laying out angles from the edge of the work?
   A. Caliper
   B. Scriber
   C. Rule
   D. Protractor

4. Which one of the following tool is used for locating centers for drilling?
   A. Scriber
   B. Rule
   C. Center punch
   D. Caliper

5. Which of the following is the best application for trammel points?

A. Layout of a very small circle

B. Layout of a very large square surface or parallelogram

C. Layout of a very large circle

D. Layout of chamfers on bores and holes

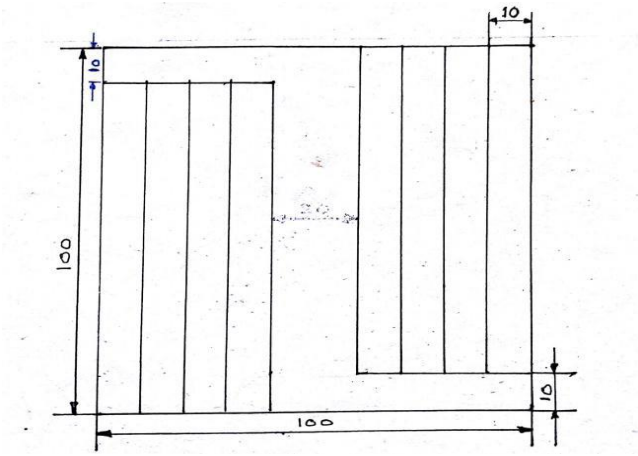
Note: **Satisfactory rating 3 and above points, Unsatisfactory - below 3 points**

Score = _____

Rating: _____

Operation sheet LO1	Marking & cutting sheet metals

Operation Title: Marking & cutting sheet metals



AIM: To practice marking and cutting on a given sheet.

MATERIALS REQUIRED: G.I sheet of size 110 X 110mm of 26swg

Step -1. Wear appropriate personal protective equipment

Step -2. Prepare and plan work place

Step -3 Select appropriate equipment and tools

Step -4 Perform the given project accurately

Step-5 Check the edges of sheet for straightness and perpendicularity with the help of try square.

Step-6 Mark the necessary lines to practice straight line cutting.

Step-7 Cut the sheet along the marked lines using straight snips and straighten the sheet by the mallet.

Step-8 Check the dimensions and finish the model

LAP Test	Practical Demonstration

Name: _____ **Date:** _____

Time started: _____ **Time finished:** _____

Instructions: given necessary templates, tools & materials you are required to perform the following tasks with _____ hrs.

Task1. Determining dimensioning, marking and cutting on a given sheet

List of Reference Materials

1. Thomas Achatz, p.e., Technical shop mathematics third edition, 2005 industrial press inc. new york
2. https://study.com/academy/topic/basic-arithmetic-operations.html (video)
3. http://ncert.nic.in/ncerts/l/gemp102.pdf
4. https://www.youtube.com/watch?v=m6LYf0BdPKM (video)
5. http://www.hufsd.edu/assets/pdfs/academics/algebra_text/Chapter06.pdf
6. http://bolvan.ph.utexas.edu/~vadim/Classes/2014s/TrigReview.pdf
7. https://www.youtube.com/watch?v=cMqetVG8vRU (video)
8. http://bieap.gov.in/Pdf/AEPaperI.pdf
9. https://blogpuneet.files.wordpress.com/2013/07/introduction-to-basic-manufacturing-processes-and-workshop-technology.pdf
10. https://www.youtube.com/watch?v=-BIx_OsfbCk (video)
11. https://www.youtube.com/watch?v=m6LYf0BdPKM (video)
12. **https://study.com/academy/topic/basic-arithmetic-operations.html (Video)**

Solar PV System Installation and Maintenance

Level-II

Learning Guide -15

Unit of Competence	Perform Bench Work
Module Title	Performing Bench Work
LG Code	EIS PIM2 M05 LO2 LG-15
TTLM Code	EIS PIM2 TTLM 0120V1

LO2. Cut, chip and file flat, rectangular or round blocks

Instruction Sheet	Learning Guide:-15

This learning guide is developed to provide you the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:-

- Clamping work pieces in work holding devices.
- Cutting, chipping or filling Work pieces
- Replacing defective hack saw blades
- Performing bench work operations

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to:-**

- How to use bench work holding devices
- Exercise cutting, chipping or filling Work pieces
- Exercise replacing defective hack saw blades
- Exercise bench work operations

Learning Instructions:-

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information Sheet 1, Sheet 2, Sheet 3, Sheet 4, in pages74, 80, 92, and 98 respectively.
4. Accomplish the Self-check 1, Self-check 2, Self-check 3, Self-check 4 in pages 79,90,97, and 103 respectively
5. If you earned a satisfactory evaluation from the “Sorption sheet1” proceed to Operation 104
6. Do the “LAP test” on page 105

Information Sheet-1	Clamping work pieces in work holding devices

1.1 Holding Devices or Vices

In most of the metal cutting operations quite a large number of forces will be involved. So it is necessary that the work must be secured highly so that it does not move when subjected to the cutting forces. Therefore, holding the job is an important aspect of all metal cutting operations. A vice is a work holding device used to grip the job tightly. Different types of vices are used for various purposes. They include

- Bench vice
- Pipe vice
- Hand vice
- Pin vice
- Tool maker's vice

1.2 Bench vice

This is most commonly used tool for holding the work. It has two jaws one of which is fixed to the bench and other slides with the aid of square screw and a box nut arrangement. The outer end of screw carries a handle, and a collar prevents the screw from coming out of the unit while rotating. The sliding jaw moves close to the fixed jaw to hold the work and the tightening force is exerted by further rotation of handle. The working faces of jaws are serrated to give additional grip.

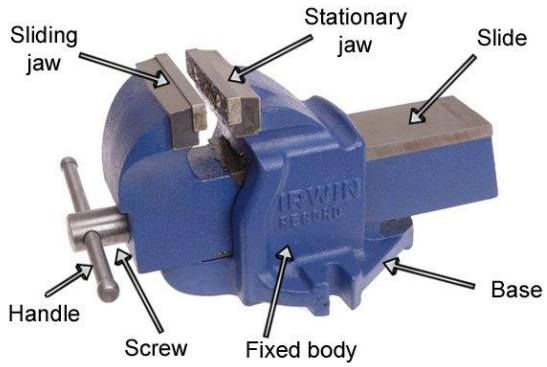


Figure 32: Bench vise

1.3 Pipe Vice

It is generally used for holding round sections, tubes and pipes etc. It has two serrated jaws, one is fixed and the other is moved by rotation of handle. It is used in lumping work and it grips the circular objects at four points on its surfaces.

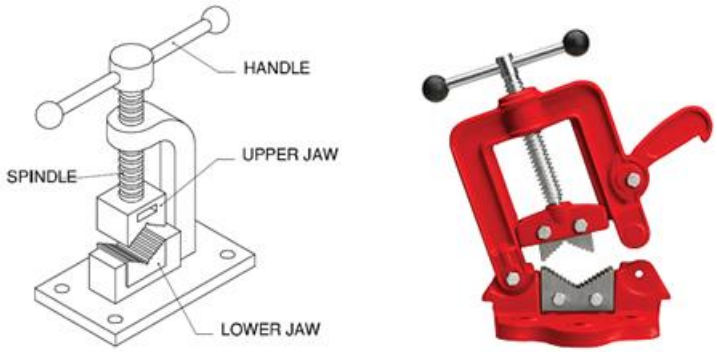


Figure 33: Pipe Vice

1.4 Hand vice

It is used for gripping small objects like screw, rivets, and keys when they are inconvenient to hold by the bench vice. It has two legs made of Mild steel which holds two jaws at the top and are hinged together at the bottom .A spring is provided between these legs to keep them away. The work is held between the serrated jaws by means of a wing nut and screw.

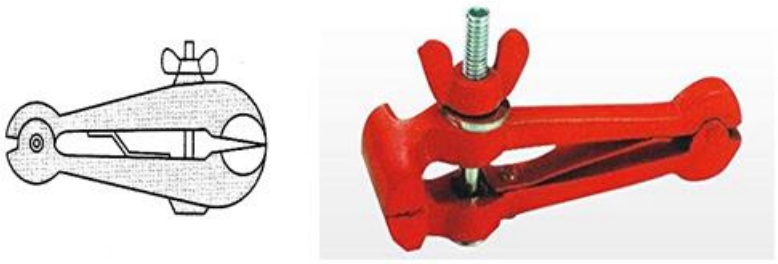


Figure 34: Hand Vice

2.2 Pin vice

It is used for holding small parts such as wires, nails and pins. It consists of three jaw self-centering chuck which is operated by turning the handle to hold work.

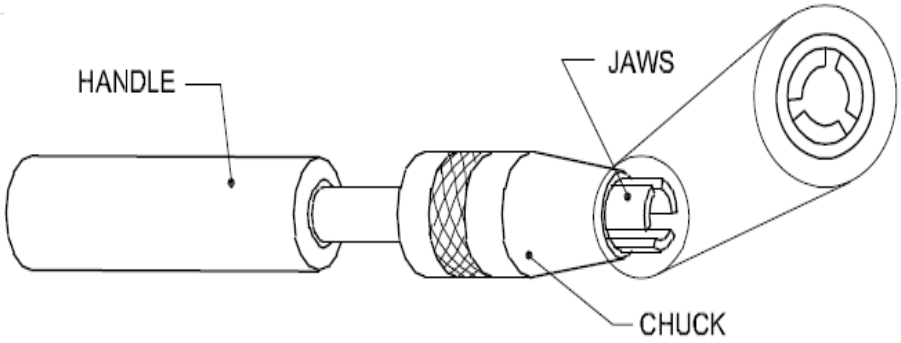


Figure 35: Pin Vice

1.6 Tool makers vice

It is a small vice made of mild steel used for holding small jobs which requires fitting or drilling. It is used by tool and die makers and silver smiths to hold small jobs.

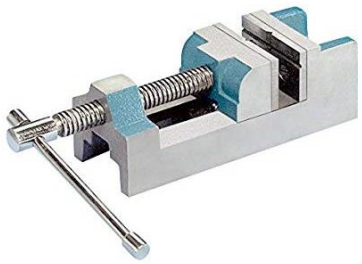


Figure 36: Tool Maker's vice

1.7 A few good pointers to start and Applies to almost all work holding jobs

- Metal-on-metal-on-metal. To clamp is to put things in compression. If the clamping force is not directly supported, there will be bending moments created. This will cause distortion in parts in the best case, and can cause parts to fly away with spring energy if the clamp lets go.
- Clean Clamping. Clamping is compression. Debris, especially chips from previous operations, will cause damage when caught between the clamp and the work piece. It will also let the work move, and may result in the work slipping out and flying away.
- Tip of the Clamp. Clamps need to clamp in compression. It is very important that ONLY the clamp tip touches the work. This ensures that the force is directed straight down through the work, keeping everything in direct compression.
- No Twist. Cutting forces will generate forces in many directions. Engineers are expected to understand where these forces will be directed and design Work Holding setups and devices accordingly. Failure to do so will result in ruined work and/or injury as the improperly restrained forces cause the work to pivot about the clamp.
- Where's that tool going? Work Holding must not interfere with the movement of the cutter doing the cutting. Check the cutter path BEFORE starting to cut.

- What's under the tool? Cutters will cut the machines as easily as the work. If the cutting operation is through the work, be mindful of what the cutter will be cutting under the work. Consumable materials can be placed under the work to support it, especially in the case of thin and delicate work. Precision milling in sheet metal is an example of this.
- Just enough force. Over clamping can cause elastic distortions of the work which leads to loss of accuracy as well as damage to finished surfaces. Severe over clamping crushes work. Under clamping will let the work fly. Clamping in compression (metal-onmetal- on-metal) causes the minimum distortion. Consider using clamping intermediates like brass shim stock to save surface finish.
- Support Structure. If work does not have a solid cross-section, then creative use of screw jacks, pieces of material, or other objects may be used to achieve metal-on-metal-on-metal clamping.
- Clamp near Cutting. Clamps are most effective when placed as near as possible to the cutting action.

Self-Check-1	Written test

I. Say true or false for the following question below

1. A vice is a work holding device used to grip the job tightly.
2. It is a small vice made of mild steel used for holding small jobs which requires fitting or drilling is called Tool makers vice
3. Pin vice is used for holding small parts such as wires, nails and pins
4. Hand vice is used for gripping small objects like screw, rivets, and keys when they are inconvenient to hold by the bench vice
5. Pipe Vice is generally used for holding round sections, tubes and pipes

Note: **Satisfactory rating 3 and above points, Unsatisfactory - below 3 points**

Score = _____

Rating: _____

Information Sheet 2	Cutting, Chipping or filing work pieces

2.1 Cutting tools

Cutting tools plays a most important role in removing excess metal from the job to obtain desired finished part. The various cutting tools used in fitting are:

- Chisels
- Hacksaws
- Files
- Scrapers

2.2 Chisels

Cold chisels are used for cutting thin sheets and to remove excess material from large surfaces .In this case the surface finish and accuracy are usually poor. Parts of chisel: It consists of following parts:-

Head: The head is tapered towards top and made tough to with stand hammer blows

Body or Shank: The cross section of the shank is made hexagonal or octagonal to have grip while working.

Point or Cutting Edge: The cutting edge is hardened and tempered and made to specified angle. The hardening followed by tempering makes the chisel to maintain its sharp edge.

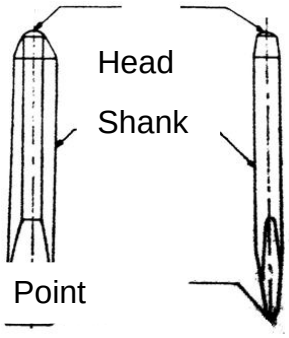


Figure 37: parts of chisel

There are many verities of chisels used for chipping work by a fitter. Some very commonly used forms are Flat, Cross-cut, Round nose and Diamond point.

All the chisels are forged from bar stock of carbon steel, to the desired shape and the cutting edge ground to the correct angle.

The forging operation is followed by annealing, hardening and tempering to make chisel body tough and obtain a sharp cutting edge.

Full length of the chisel is never hardened, only a small length about the cutting edge (say about 20 to 30 mm) is hardened.

The included angle at the cutting edge varies between 40 and 70, depending upon the material on which it is to be used. Approximate values of cutting angles for common materials are as follows:

- Brass and copper 40
- Wrought iron 50
- Cast iron and general cutting work 60
- Steel (cast) 70

A flat chisel is a general purpose chisel which is most widely used in cutting work, chipping large surface, cutting metal sheets, rods, bar stocks and similar other purposes. Since it cuts the metal in cold state it is also frequently known as cold chisel.

A round nose chisel is used for drawing the eccentric hold back to correct center which has run off-center during drilling operation. Another specific use of this type of chisel is in cutting oil grooves and channels in bearings and pulley bushes and cleaning small round corners.

A cross cut is a comparatively narrow chisel having its cutting edge slightly broader than the blade. It is made to keep the blade free when the chisel is used to cut deep groove into the metal. Normal widths of the cutting edge vary from 3 mm to 12 mm. This chisel is used to cut parallel grooves on large surfaces, before chipping by means of a flat chisel, cutting key ways, etc.

A diamond point chisel is a special purpose chisel used for chipping rough plates and cutting cast iron pipes, cutting ‘V’ grooves, chipping sharp corners, squaring up corners of previously cut slots and cleaning angles.

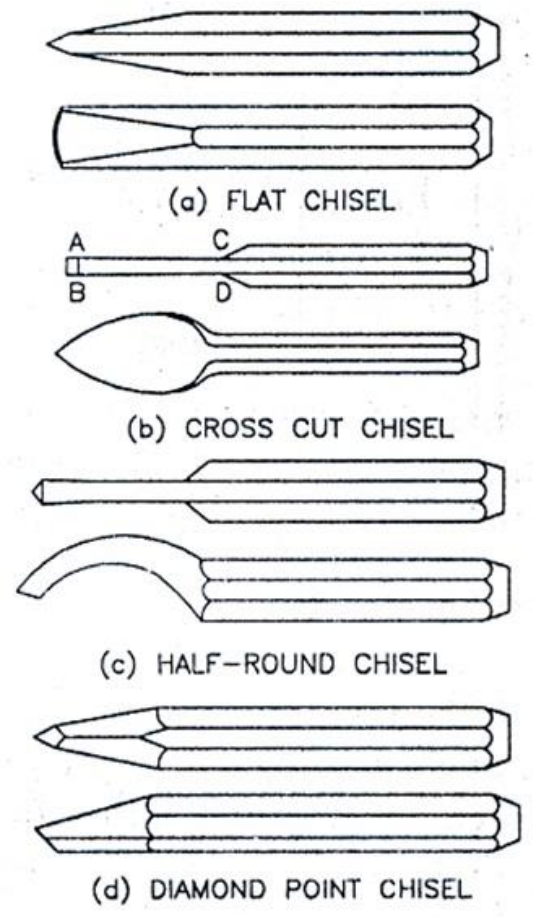


Figure 38: various chisels

2.3 Hack-Saw

It is a basic hand cutting tool used for cutting unwanted material. It is used for cutting metals and making recesses prior to filing or chipping. It is also used for cutting slots and contours.

Parts of Hack saw: It consists of the following parts.

- Metal frame
- Blade
- Handle.
- Wing nut
- Screw

The frame is made to hold the blade tightly. They are made in two types.

- The solid frame hack saw in which the length cannot be changed.
- The adjustable frame in which the frame can be adjusted to hold the blades of different lengths

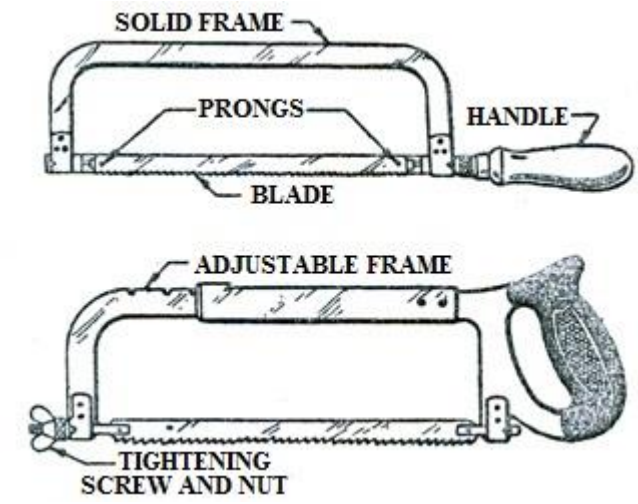


Figure 39: Hack saw

2.3 Hacksaws blade:

It is thin, narrow steel strip made of high carbon steel or low alloy steel or high speed steel. The blade has two pin holes at the ends which fits over two pins which project from the stand that slides in and out of the frame end. Tightening the wing nut at the front end tensions the blade sufficiently to prevent it from flexing when cutting. The blade must be fitted such that teeth points away from the handle so that cut takes on the forward stroke.

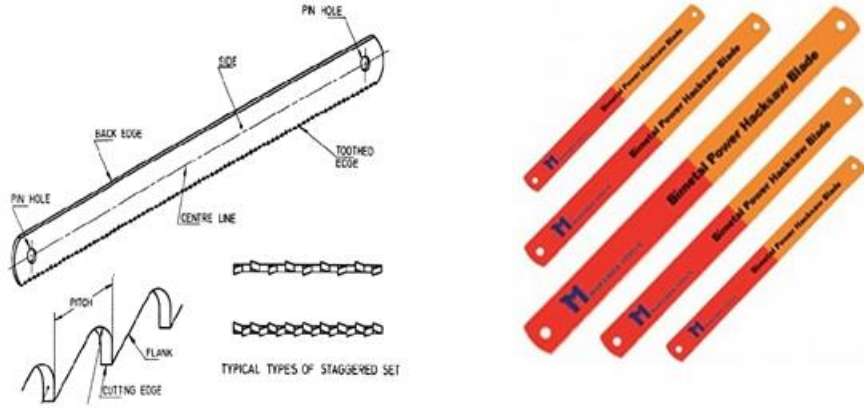


Figure 40: Hack saw blade

2.4 Files

Files of different types are the principal hand tools used by a fitter. All the files, irrespective of their shape, size and grade, essentially consist of two main parts, viz., a toothed blade and a pointed tang, which is fitted in a handle. Files are generally forged out of high carbon steel, followed by cutting of teeth, hardening and tempering etc. Common shapes of the files available are flat, hand, square, pillar, round, half round, triangular, knife edge, etc.

These files are manufactured in different varieties and their classification is governed by the following factors: effective length- i.e. excluding the length of tang, shape or form of the cross-section, depth, spacing and cut of teeth

Length of the files varies according to the need but the most commonly used lengths range from 10 cm to 30 cm and they cover almost all sorts of filing work done by hand.

Length between 10 cm and 15 cm are generally used for fine work, between 15 cm and 25 cm for medium sized work and above 25 cm for all general and large sized jobs.

Square file which carried double cut teeth on all the four faces and is normally made tapered for about one-third of its length near the end opposite to the tang.

Triangular file which normally carries single cut teeth on all the faces and is made tapered towards the end for about two-third of its length near the tip. The cross-section is an equilateral triangle.

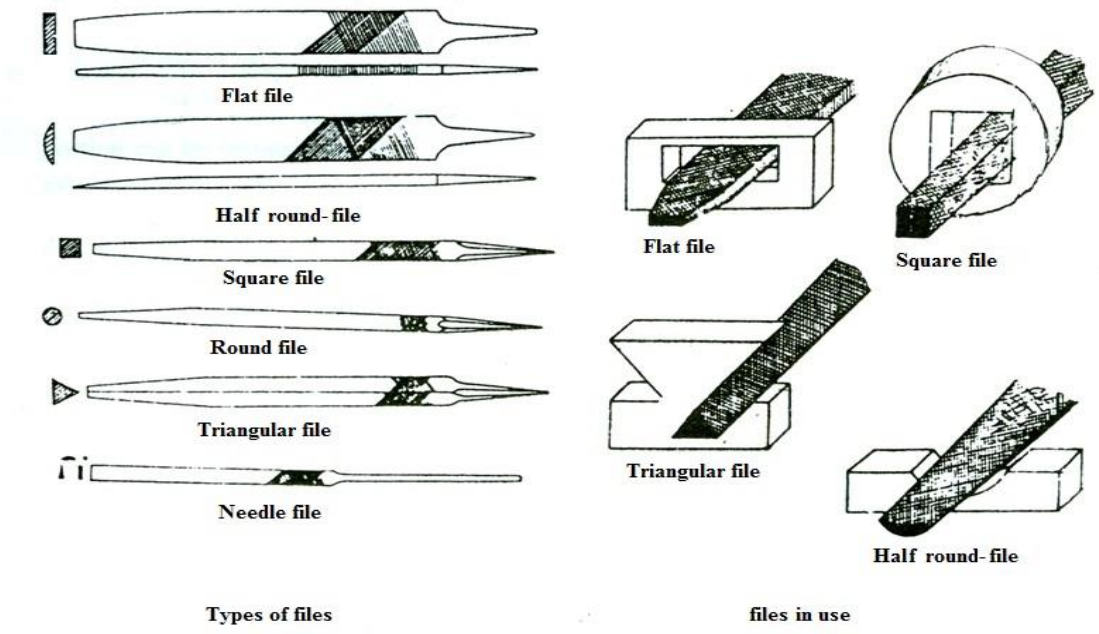


Figure 41: Files

Teeth of the files may single cut or double cut. Single teeth are parallel and at angle of 60ºto the center line of the file. Double cut files have two sets of teeth, the overcut teeth are cut at angle of 60º and the uppercut at 75º to 80º to the center line. Files are also further classified according to the coarseness or spacing between the rows of teeth.

- Rough (R) with 10 to 4.5 cuts per 10 mm length
- Bastard (B) with 18 to 6 cuts per 10 mm length
- Second cut (SC) with 21 to 11 cuts per 10 mm length
- Smooth (S) with 30 to 15 cuts per 10 mm length
- Dead smooth (DS) with 35 to 28 cuts per 10 mm length
- Super smooth (SS) with 63 to 40 cuts per 10 mm length

2.5 Filing Operation

Hand files are normally held in both hands. The file is held flat against the surface it is to cut / smooth. The file is then pushed forward and it cuts on the forward stroke. It is then lifted away from the metal and returned to the starting point for the next push forward. This is called ‘through filing’

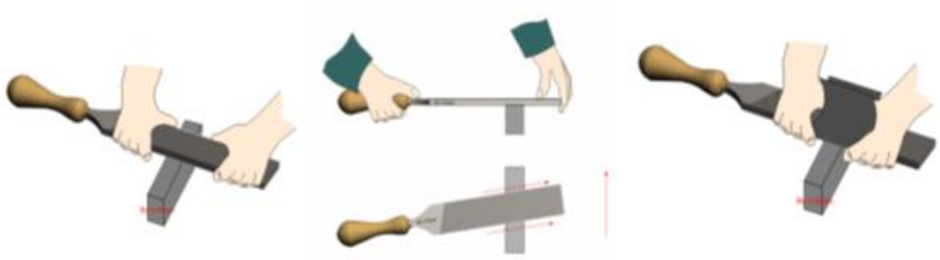


Figure 42: ways of had filings

2.6 Scrapers

These are used to shaving off thin slices of metal to make a fine and smooth surface which is not possible with a file or chisel. This is made of good quality forged steel and its cutting edge is usually made thin, made from old files.

- **Parts of Scrapers**
  - ✓ Cutting edge with rounded corners: The cutting edge is hardened without tempered to make hard.
  - ✓ Blade: The broad part of a scraper
  - ✓ Tang: The narrow part which fits into wooden handle.
  - ✓ Wooden handle: That fits into tang to have grip while scrapping

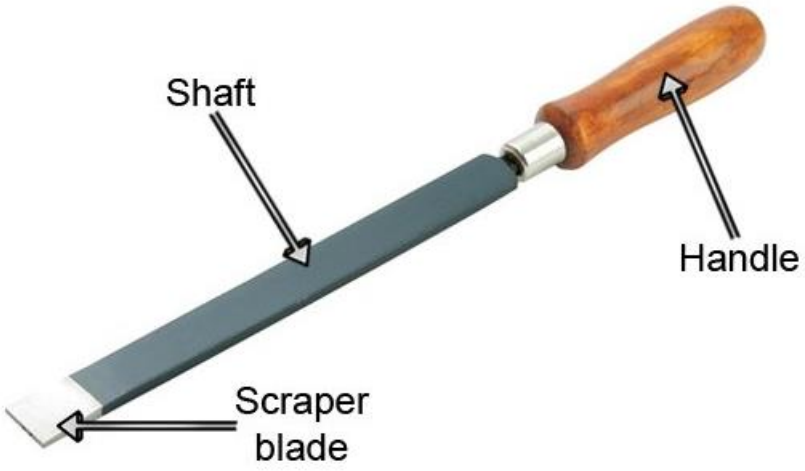


Figure 43: Parts of Scrapper

According cross section, the scrapers are classified into three types. They are

- Flat Scraper
- Triangular Scraper
- Half round scraper.

- **Flat Scraper**

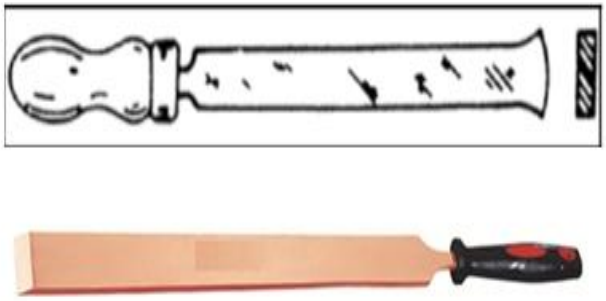


Figure 44: Flat Scrapper

This type of scraper is used for scapping plane surfaces or slots and the cutting edge at the ends of the balde is curved. The corners are rounded to prevent deep scratches on finished surface. It also helps to scrap the metal exactly at the desired spot.

- **Triangular Scraper**

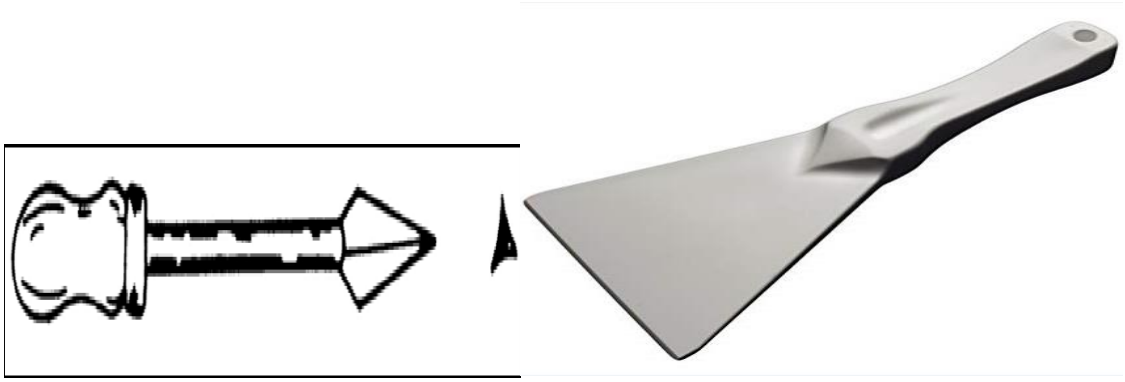


Figure 45: Triangular Scrapper

It has three cutting edges and is made from old triangular files used to scrap round or curved surfaces and to remove sharp corners.

- **Half round Scraper:**

  It is used for finishing curved surfaces and chamfering holes and removing burrs.

Figure 46: Half round Scraper

Self-Check-2	Written test

Choose the best Answer

1. The best way to clean the filings from a file is to apply:
   a) A solvent and air blast
   b) A file card
   c) Back filing against the file cutting edges
   d) Emery cloth with an oil medium

2. Deep scratches found in the work piece after filing is the result of:
   a) A very sharp file
   b) Pinning (filings edged in the teeth)
   c) Excessive cutting pressure
   d) Using chalk as a dry lubricant

3. Which one of the following tool is used for cutting:-
   a) Hack saw
   b) Chisel
   c) File
   d) All are correct

4. Which one of the following is true about chisels
   a) Chisels are not cutting tool
   b) All the chisels are forged from bar stock of carbon steel
   c) Chisels are used for chipping work
   d) All except a

5. Which one of the following tool is used to shaving off thin slices of metal to make a fine and smooth surface.
   a) Hack saw
   b) File
   c) Chisel
   d) Scrapers
   e) All are correct

Score = _____

Rating: _____

Note: **Satisfactory rating 4 and above points, Unsatisfactory - below 4 points**

Information Sheet-3	Replacing defective Hack Saw Blades

3.1 Replacing defective hack saw blades

- **How to change a junior hacksaw blade**

  Please note: How this is done may vary depending on the make and model. One method is shown below

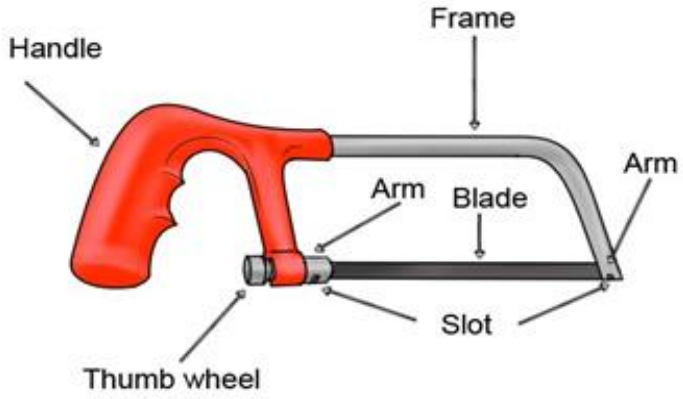
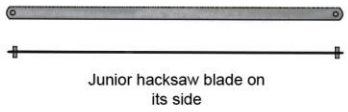


Figure 47:: parts of Hack saw

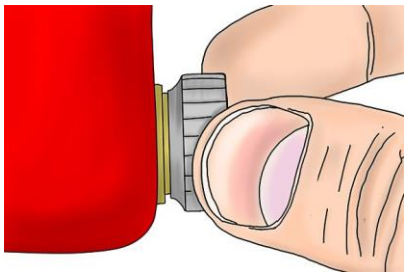
3.2 How is the blade attached?



A junior hacksaw has a small removable blade mounted in a metal frame. Like all frame saws, the blade must be held taut in order to cut efficiently

Figure 48: Junior Hack saw

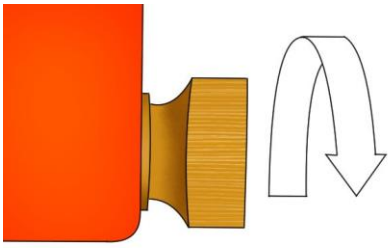
Junior hacksaw blades have a small pin on each end. These pins are designed to fit into two slots on the arms of the hack saw, one slot is located at the end of the frame furthest from the handle. The other slot is located on small metal bar on the



When the thumb wheel is turned, the metal bar pulls the blade tight, stretching it in the frame

Figure 49:Thumb

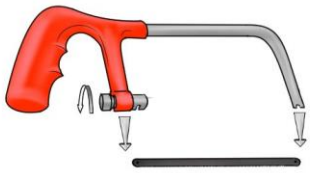
Removing the blade



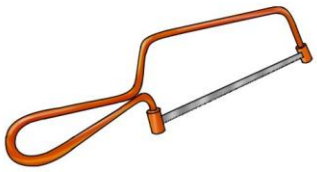
0Step 1 - Turn thumb wheel anti-clockwise

To remove the blade, locate the thumb wheel and turn it in an anti-clockwise direction

Figure 50:turn thumb



The thumb wheel controls the blade tension
Turning it in an anti-clockwise direction pushes the metal bar forwards, releasing the blade and allowing it to drop out of the slots.



No thumbwheel?

Some other designs of junior hacksaw have a simple metal frame which holds the blade in the same way, using two slots on the frame's arms, into which the blade fits it to drop out of the slots.

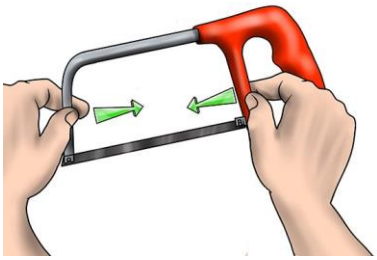
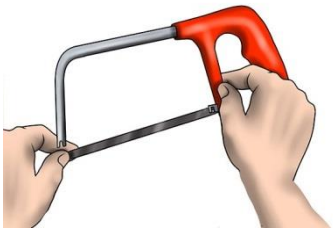


Figure 51: Compress frame

Step 1 - Compress frame

To remove a blade, grip the hand in your dominant hand and place your other hand over the end of the saw, holding the blade loosely.

Use both hands to push both sides of the frame inwards towards each other



This will cause the blade to slacken and come loose.

Installing the blade

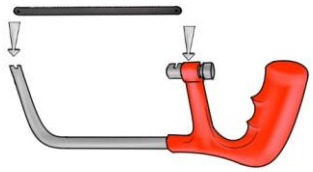


Figure 52: wheel anti-clockwi

Step 1 - Turn thumb wheel anti-clockwise

Turn the thumb wheel in an anti-clockwise direction until you are able to place the blade into the two slots on the body of the saw.

Step 2 - Insert blade

Place the blade in the frame with the teeth pointing away from the handle, towards the end of the saw.

This is sometimes easier to do if the junior hacksaw is upside down

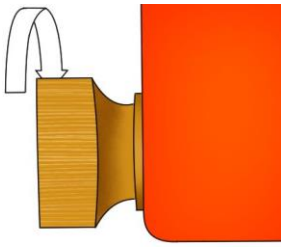
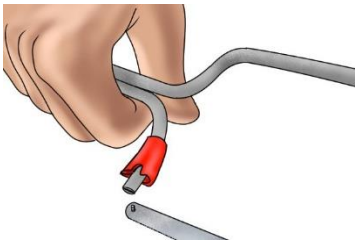


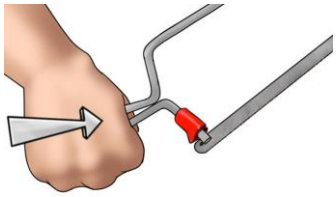
Figure 53: wheel clockwise

Step 3 - Turn thumb wheel clockwise

Once the blade is in place, tighten it by turning the thumb wheel in a clockwise direction. This will pull the metal bar back, stretching the blade taut in the frame



To insert a blade, you must compress the frame as shown above, then slot the blade into the arm of the frame, before releasing it



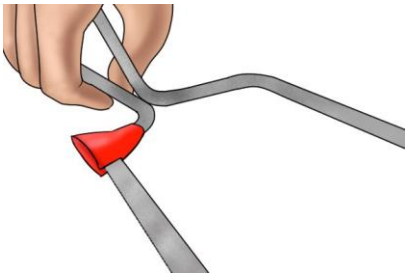


Figure 54: blade renewed

If your saw has a protective cover to go on the end of the blade, ensure it is replaced when the blade is renewed.

Self-Check -3	Written test

I. Say True Or False For The Following Questions Below

1. A junior hacksaw has a small removable blade mounted in a metal frame
2. Turn thumb wheel clockwise Once the blade is in place, tighten it by turning the thumb wheel in a clockwise direction

Note: **Satisfactory rating 2 and above points, Unsatisfactory - below 1points**

Score = _____

Rating: _____

Information Sheet-4	Performing bench work operation

4.1 Performing bench work operations

- **Bench Work Processes**

Bench work involves following hand operations to finish the work to desired shape and size with required accuracy.

- ✓ Marking
- ✓ Chipping
- ✓ Sawing
- ✓ Filing
- ✓ Draw filing
- ✓ Threading
- ✓ Grinding

a. Some common bench work processes are described here

- **Marking**

✓It is the basic and one of the most important operations in bench work.

✓It should be remembered that how accurately and carefully one tries to perform other operations it will be of no help until and unless the piece has been properly and accurately marked.

✓Sufficient care should be exercised in performing this operation to obtain a desired fitting of the components.

✓Marking on the work can be done by setting out dimensions with the help of a working drawing.

✓The surface to be marked is coated with either the paste of red lead or chalk and allowed to dry.

✓After that, the work is held in a clamp, if it is round. If the work is too thin, it is normally

✓supported against an angle plate keeping the surface to be marked in a vertical plane. Lines in horizontal direction are scribed by means of a scribing gauge.

✓Lines at right angles to this can be drawn easily by first turning the work through 90 and then using the scriber.

✓ Lines can easily be marked with the help of a try square. Circles and arcs on flat surfaces are inscribed by means of dividers.

- **Chipping**
  - It is the operation employed for removing the excess metal by means of cold chisels.
  - To have a properly chipped surface it is essential that the same cutting angle should be maintained throughout the operation.
  - In case the surface is too large it is advisable to cut grooves along the whole surface by means of a cross cut chisel and then chip off the remaining metal.
  - The cutting angles of the chisels differ for different metals.
  - Frequent lubrication and cooling of the cutting edge, while taking heavy cuts for removing large amount of metal, it helps considerably in chipping the metal easily and more effectively.
  - To the correct cutting angle of the chisel, proper gripping of the chisel and the hammer and correct standing position of the operator play a significant part.
  - The chisel should be firmly gripped in one hand leaving about 3 to 5 cm length above the thumb of the hand, and hammer should be held near the end of the handle to ensure more power in the blows.
  - The operator should stand erect with his two feet sufficiently apart to balance his own weight equally on both the feet.
  - The operator should always see the cutting edge of the chisel and not the top of the same.

- **Sawing**

  - ✓ This operation is performed in fitting shop for cutting different metal pieces to the desired size and shape, usually prior to other operations such as filing, drilling, scraping, etc.
  - ✓ It is also employed for cutting metal pieces of required length out of the bar stock.
  - ✓ For sawing, the saw blade should be properly fitted, and stretched to have the proper tension, in such a way that the cutting teeth always point away from the operator so as to cut the metal in forward stroke.
  - ✓ Sawing should be done steadily and slowly.
  - ✓ An average speed of about 50 strokes per minute is a good practice.
  - ✓ Sufficient pressure should be exerted in the forward stroke and this be relieved during the backward stroke.
  - ✓ It is advisable to use a coolant throughout the operation. A new blade should not be directly used on a hard metal.

- **Filing**

  ✓Similar to the saw blades, most of the files have their teeth pointing away from the operator such that they cut during the forward stroke.

  ✓The pressure of the hand in filing should also be applied only during the forward stroke and relieved during the return stroke.

  ✓Beginners particularly should be careful enough to practice correct movement of file.

  ✓It should always be more in a perfect horizontal plane for obtaining a truly plane and smooth surface.

  ✓As far as possible, try to use full length of the file during the operation.

  ✓Moving the file diagonally on a flat surface always yields best results. A coarse pitched file should be employed when enough metal is to be removed, followed by finishing with a smooth file.

- **Draw filing**

  ✓When the surface is to be finally finished by filing only and no other operation, like scraping, is to follow the filing operation, a special method of filing, called Draw filing, is employed for finishing the surface.

  ✓A flat file of fine cut is used for this operation.

  ✓It should be ensured before use that the file teeth are free from metal particles,

  ✓Otherwise a numbers of scratches will be produced on the surface. It is usual to employ a file card quite frequently for cleaning the file teeth both before use as well as during use.

  ✓For draw filing operation the file is held flat on the surface between the two hands.

  ✓The file must move forward and backward. Flatness and evenness of the surface should be checked quite frequently during the operation.

For final finishing, it is a common practice to rub a chalk piece over the entire surface of the file. This helps in producing a finely finished surface.

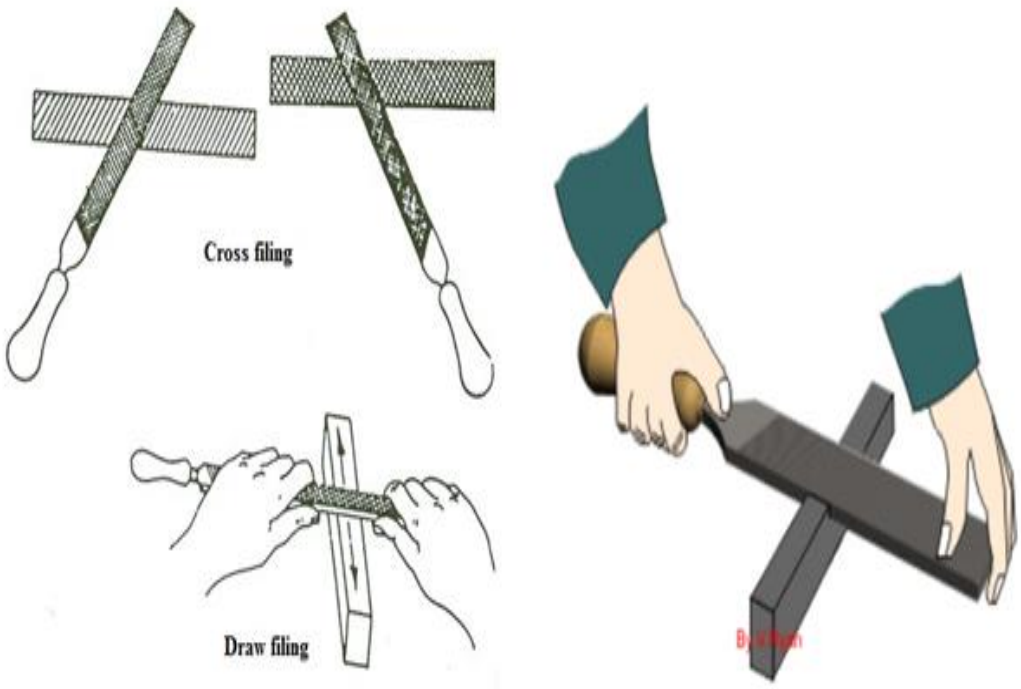


Figure 55: Cross and draw filing

Self-Check -4	Written test

I. SAY TRUE OR FALSE FOR THE FOLLOWING QUESTIONS

1. Chipping is the operation employed for removing the excess metal by means of cold chisels.
2. Sawing should be done steadily and slowly
3. Beginners particularly should be careful enough to practice correct movement of file.
4. Marking is the basic and one of the most important operations in bench work
5. Draw filing operation the file is held flat on the surface between the two hands.

Note: **Satisfactory rating 2 and above points, Unsatisfactory - below 2 points**

Answer sheet

Score = _____

Rating: _____

Operation sheet	Smooth rectangular locks of mild steel

Operation Title: Smooth rectangular locks of mild steel

Aim: To prepare 2 smooth rectangular locks of mild steel having dimensions 5.5 x 5 **x** 0.4 cm3 from the given piece of metal.

Tools Required: Bench Vice, hacksaw, try square, hand file, surface plate and scale and a scriber

Procedure:

Step -1. Wear appropriate personal protective equipment

Step -2. Prepare and plan work place

Step -3 Select appropriate equipment and tools

Step -4 Perform the given project accurately

Step-5 Placed the work pieces on the table and using scriber drawn straight lines Parallel on it 55 mm apart.

Step -6 Fixed the work pieces firmly in the jaws of the vice.

Step -7 Cut along the marked line using a hacksaw.

Step -8 the cut out work pieces was now again placed firmly between the jaws of the vice in such a way that a small portion of one of its edges is above the level of the jaw.

Step -9 now filing was done by using a hand file.

Step -10 Using try, square, it should be ensured that all the edges of the work pieces are at the right angles to adjacent edges.

Step -11 Placed the work on one of the faces on the surface plate and moved it along its surface to check the area on the work where strain has accumulated. File them properly.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary materials, tools and measuring instruments you are required to perform the following tasks within 1 hour.

Task 1. Describe common bench work processes

List of Reference Materials

1. http://bieap.gov.in/Pdf/AEPaperI.pdf
2. https://blogpuneet.files.wordpress.com/2013/07/introduction-to-basic-manufacturing-processes-and-workshop-technology.pdf
3. http://egyankosh.ac.in/bitstream/123456789/29752/1/Unit-2.pdf
4. Michael Kelly, TRADE OF Industrial Insulation PHASE 2, Sheet Metal and Insulation Fundamentals UNIT: 3, Measuring, Marking & Cutting Out, SOLAS 2014
5. **https://www.youtube.com/watch?v=QrwpSZJYCCE (video)**

Solar PV System Installation and Maintenance

Level-II

Learning Guide -16

Unit of Competence	Perform Bench Work
Module Title	Performing Bench Work
LG Code	EIS PIM2 M05 LO-3 LG-16
TTLM Code	EIS PIM2 TTLM 0120V1

LO3. Drill, ream and lap holes

Instruction sheet 1	Learning Guide: - 16

This learning guide is developed to provide you the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:-

- Drilling, reaming, spot-facing and lapping hole.
- Performing holes making sequence
- Performing operations using safety procedures

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to:-**

- Perform Drilling, reaming, spot-facing and lapping hole
- Performing holes making sequence
- Performing operations using safety procedures

Learning Instructions:-

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information Sheet 1, Sheet 2, Sheet 3,sheet 4 in pages 109, 113,121 and 127 respectively.
4. Accomplish the Self-check 1, Self-check 2, Self-check 3,self-check in pages 112, 120, and 125 and 128 respectively
5. If you earned a satisfactory evaluation from the “operation sheet proceed to Operation 129
6. Do the “LAP test” in page 130

Information Sheet-1	Standard symbols isometric and drawing

1.1. Standard symbol

Each set standard conventions for architectural symbols. Since many new and different types of construction materials, appliances and fixtures are continually being developed and used in construction; many architectural drafters will use symbols of their own design and show their meaning in a legend or symbol chart on the drawing. While there are some different symbols being used, there is an overall acceptance of the symbol conventions.

As a general rule when a symbol is not clear or a new type of material is to be noted on a drawing, a notation should be used with the symbol. This will clarify the communication to the builders. It must be remembered that architectural working drawings must be read by many persons in the building trades. Everything must be clear so no guess work will be involved with the design, ordering of materials or construction phases

1.2. Orthographic drawings

Like abbreviations, symbols are used instead of words on drawings to save space. There are a lot of them, but they're standardized (drawn the same way) to avoid confusion, so don't worry. Some of them look a lot like what they represent. For example, the symbol:

Nearly all drawings used on a construction project are orthographic drawings. They are preferred because more details can be shown. These drawings are created using Orthographic projection, a process by which an object or structure is described using various views. Each view defines one face, or side, of the object. The views of an Orthographic drawing are projected at a right angle (90^0)to each other. The best way to visualize this is by cutting and unfolding a cardboard box as Shown in Figure

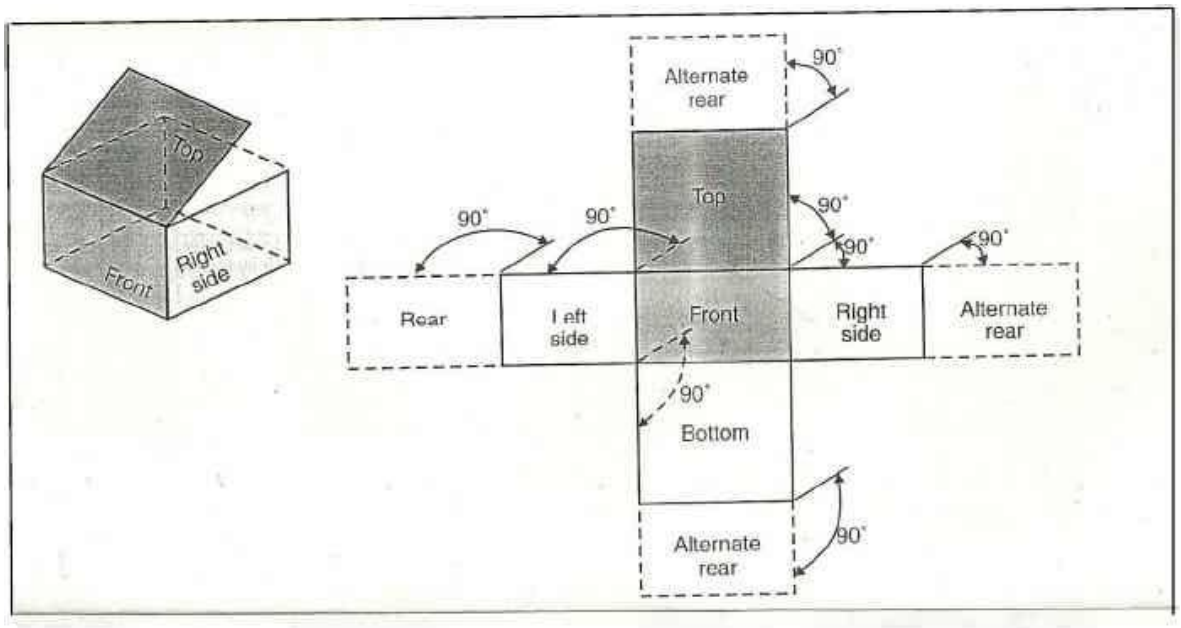


Figure 56: Projection of Orthographic Views

1.3. FOUNDATION PLAN

The foundation plan shows:

- Thickness and width of all footings whether strip or isolated
- Thickness of foundation walls
- Size of columns and concrete slab
- Thickness of concrete slab
- Thickness and width of slab thickening - when required to support load bearing walls.

The size and type of reinforcement for concrete footings and slabs is often stated adjacent to the foundation plan. Foundation plans are drawn to a scale of 1:100 and any dimensions are in millimeters. Figure 12 is an example of a typical foundation plan for a brick veneer dwelling.

1.4. Orthographic Projection

Everyday objects have three (3) dimensions, for example:

- Length
- Breadth or width
- Height.

All of the objects in can be represented pictorially, but the drawings can get very

Cluttered when additional information is added, so another method is used where the object is Represented by drawing a series of different views. This is called orthographic Projection

Self-Check -1	Written test

I. Say true or false for the following questions below

1. Abbreviations, symbols are used instead of words on drawings to save space.
2. Thickness and width of slab thickening - when required to support load bearing walls

Information Sheet- 2	Preparing drawing specifications for Drilling, reaming, spot-facing and lapping Hole.

1.1Introduction

Though drilling machine is designed to make straight and accurate holes, it is used for many other operations. Major operations that are carried out on a drilling machine are explained below:

1.2 Drilling

The operation of drilling consists of producing a hole in an object by forcing a rotating drill against it. The same result is carried out in some machines by holding the drill stationary and rotating the work as on the lathe.

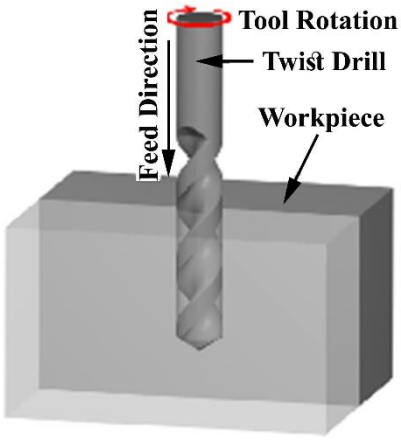


Figure 57: drilling

- **Boring**. It is the operation of enlarging a hole that has already been drilled or bored with a single point tool. It also rectifies the error of drilling, if any.

- **Counter Boring**. It is the operation of enlarging one end of a drilled hole. The enlarged hole is connected to the original one and it is flat at the bottom. It is done to set bolt head and nuts below the surface.

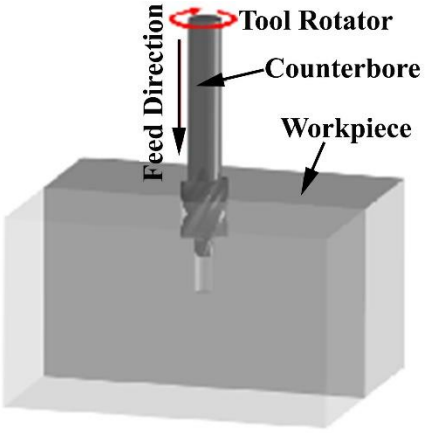


Figure 58: boring

- **Spot Facing**. To finish off a small surface around a drilled hole is known as spot facing. It is carried out to give a proper seating to bolts and nuts.

Figure 59: spot facing

- **Drill Bits**

  A drill is a cutting tool for making through hole in a metal piece and usually it has two cutting edges set an angle with axis. It does not produce accurate hole. There are three types of drills.

- ✓ Flat Drill
- ✓ (b) Straight Fluted Drill
- ✓ (c) Twist Drill

- **Flat Drill**: It is a simple drill used for producing holes in softer materials like wood and plastic. This is made of high carbon steel and has two cutting edges.

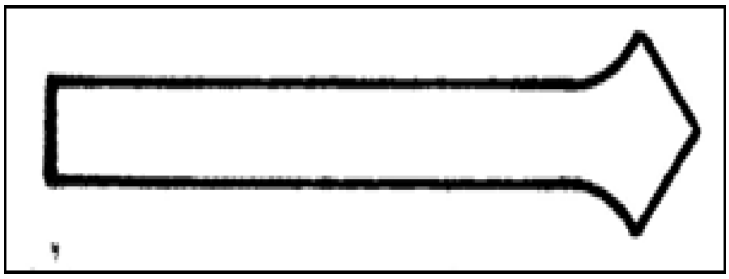


Figure 60: flat drill

- **Straight Fluted Drill:** It has two cutting edges and two straight flutes used for drilling brass and non-ferrous metals.

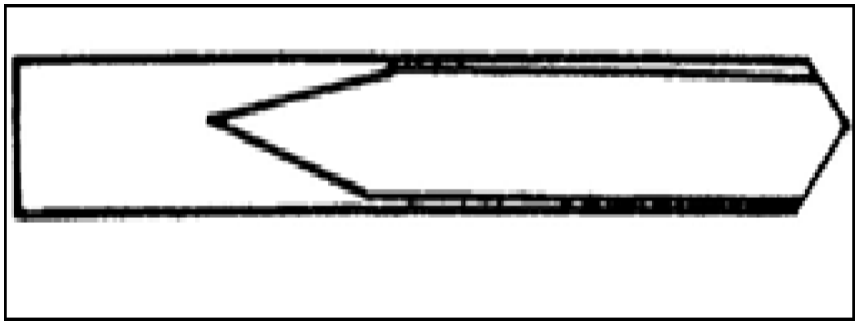


Figure 61: straight fluted drill

- **Twist Drill bit:** This is most commonly used cutting tool in workshop. It has two cutting edges and two helical grooves which admits coolant and allows the chips to escape during the drilling. These are made of high speed steel.

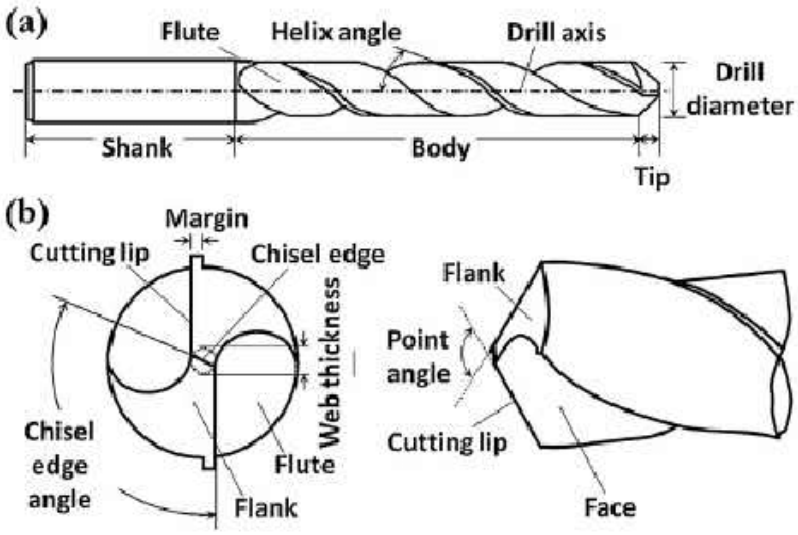


Figure 62: Twist Drill bit

- **Sensitive drilling machine**

  It is a small drilling machine is mounted on a bench in which feed is hand operated, and the cutting force applied is determined by sense of feel of the operator. The parts of sensitive drilling machine as shown below. It consists of a vertical column, a work table, head supporting the motor and driving mechanism, and a vertical spindle for driving and rotating the drill.

  The work is mounted on the work table which may be raised or lowered by the clamp to accommodate work pieces of different sizes. The driving mechanism consists of V-belt drive from machine spindle to drill spindle. Three or four speed stepped cone pulley is provided to give various speed ranges. The spindle is designed and mounted in a sleeve such that the spindle rotates and simultaneously moves up and down to provide feed for drill. This is achieved by a rack and pinion mechanism.

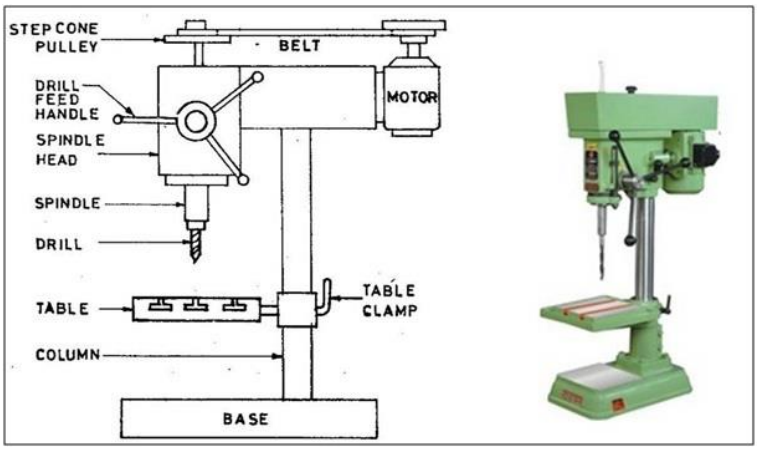


Figure 63: Sensitive Drilling Machine

- **Radial Drilling Machine**

  Radial drilling machines are used for drilling heavy work pieces, where it is easier to move the drill rather than work and especially for the jobs where high degree of accuracy is required. It consists of base, column, radial arm, drill head and driving mechanism. The arm of radial drilling machine can be swing around the column to any position and angle. A wide range of spindle speeds, together with automatic feed of the spindle, makes the radial drilling machine suitable for drilling large castings. For lowering or raising the radial arm, a separate motor is provided. The work can be firmly champed on the table having T-slots. The table is fixed to the base. The radial arm and the spindle can be adjusted without disturbing the work setting.

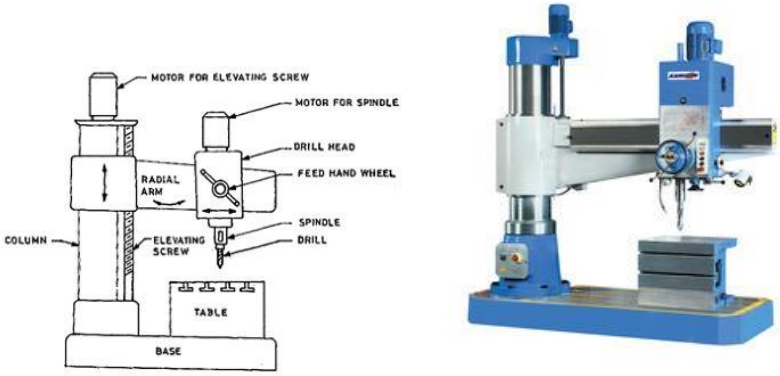


Figure 64: Radial Drilling Machine

- **Reaming**

  It is the operation of enlarging a machined hole to proper size to a smooth finish. A reamer is an accurate tool and is not designed to remove much metal. Allowance for reaming should not exceed 0.015 inches. A drill does not produce accurate hole and it must be finished by finishing tool called reamer. When an accurate hole with a smoother finish a required a reamer is used. Hence the reamer can only follow the drilled hole and removes very small amount of metal to make it smooth

  There are two types of reamers

  - ✓ Hand Reamers
  - ✓ Machine Reamers

- **Hand Reamer:** This reamer is turned by hand called hand reamer. The shank has a square tang so that a tap wrench can be used to turn the reamer in to work. These are available with straight or helical flutes.

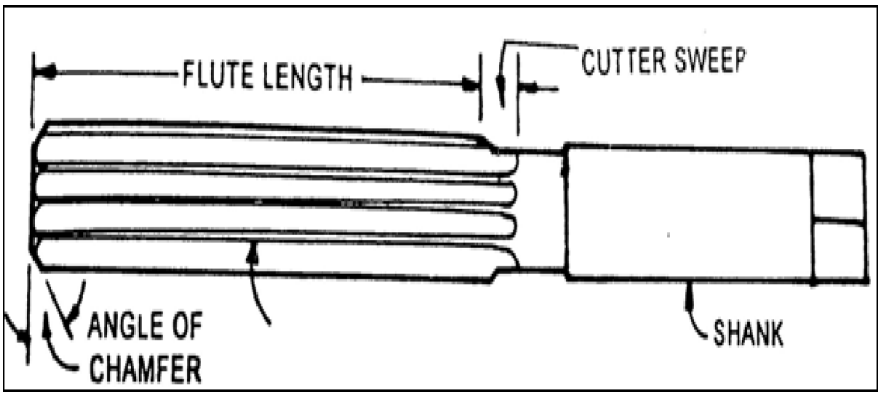


Figure 65: Hand Reamer

- **Machine Reamers:** These are used to turn by the machine called machine reamers. Its shank is tapered which fits directly in the internal taper of the machine spindle. These are also available with straight shanks which are held and driven by drill chuck.

Figure 66: Machine Reamer

- **Lapping**

  It is the operation of sizing and finishing small diameter hole already hardened by removing a very small amount of material by using a lap. There are many kinds of lapping tools. The copper head laps are commonly used. The laps fit in the hole and are moved up and down while it revolves.

Figure 67: Lapping tools

Self-Check -2	Written test

II. Say true or false for the following questions below

1. Lapping is the operation of sizing and finishing small diameter hole already hardened by removing a very small amount of material by using a lap
2. Flat Drill has two cutting edges and two straight flutes used for drilling brass and non-ferrous metals.
3. Reaming is the operation of enlarging a machined hole to proper size to a smooth finish.
4. Radial drilling machines are used for drilling heavy work pieces
5. Straight Fluted Drill is a simple drill used for producing holes in softer materials like wood and plastic

Note: **Satisfactory rating 4 and above points, Unsatisfactory - below 3 points**

Score = _____

Rating: _____

Information Sheet-3	Performing holes making sequence

2.1 Performing holes making sequence

In machining, a hole is a cylindrical feature that is cut from the work piece by a rotating cutting tool that enters the work piece axially. The hole will have the same diameter of the cutting tool and match the geometry (which may include a pointed end). Non-cylindrical features, or pockets, can also be machined, but they require end milling operations not hole-making operations. While all machined holes have the same basic form they can still differ in many ways to best suit a given application. A machined hole can be characterized by several different parameters or features which will determine the hole-making operation and tool that is required.

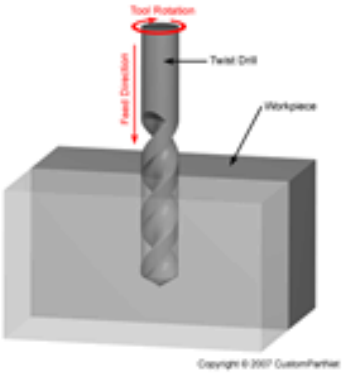
- **Diameter** - Holes can be machined in a wide variety of diameters, determined by the selected tool. The cutting tools used for hole-making are available in standard sizes that can be as small as 0.0019 inches and as large as 3 inches. Several standards exist including fractional sizes, letter sizes, number sizes, and metric sizes. A custom tool can be created to machine a non-standard diameter, but it is more cost effective to use the closest standard sized tool.
- **Tolerance** - In any machining operation, the precision of a cut can be affected by several factors, including the sharpness of the tool, any vibration of the tool, or the buildup of chips of material. The specified tolerance of a hole will determine the method of hole-making used, as some methods are suited for tight-tolerance holes.
- **Depth** - A machined hole may extend to a point within the work piece, known as a blind hole, or it may extend completely through the work piece, known as a through hole. A blind hole may have a flat bottom, but typically ends in a point due to the pointed end of the tool. When specifying the depth of a hole, one may reference the depth to the point or the depth to the end of the full diameter portion of the hole. The total depth of the hole is limited by the length of the cutting tool.

- **Recessed top** - A common feature of machined holes is to recess the top of the hole into the work piece. This is typically done to accommodate the head of a fastener and allow it to sit flush with the work piece surface. Two types of recessed holes are a counter-bore, which has a cylindrical recess, and a countersink, which has a cone-shaped recess.
- **Threads** - Threaded holes are machined to accommodate a threaded fastener and are typically specified by their outer diameter and pitch. The pitch is a measure of the spacing between threads and may be expressed in the English standard, as the number of threads per inch (TPI), or in the metric standard, as the distance in millimeters (mm) between threads.

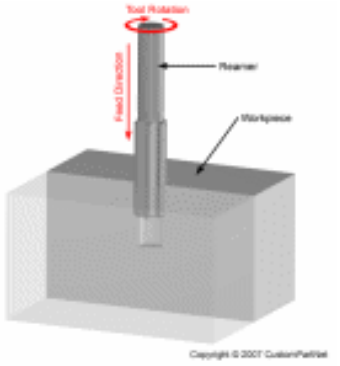
2.2 Hole-making operations

Several hole making operation exists, each using a different type of cutting tool and forming a different type of hole.

Drilling - A drill bit enters the work piece axially and cuts a blind hole or a through hole with a diameter equal to that of the tool. A drill bit is a multi-point tool and typically has a pointed end. A twist drill is the most commonly used, but other types of drill bits, such as a center drill, spot drill, or tap drill can be used to start a hole that will be completed by another operation

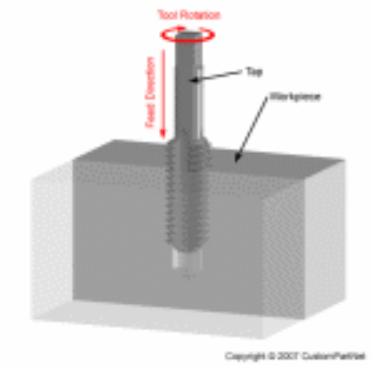


Reaming - A reamer enters the work piece axially and enlarges an existing hole to the diameter of the tool. A reamer is a multi-point tool that has many flutes, which may be straight or in a helix. Reaming removes a minimal amount of material and is often performed after drilling to obtain both

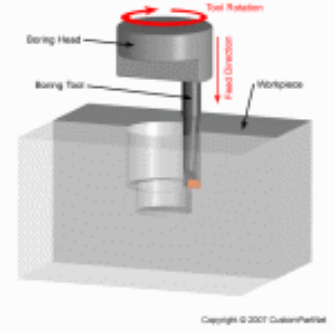


a more accurate diameter and a smoother internal finish.

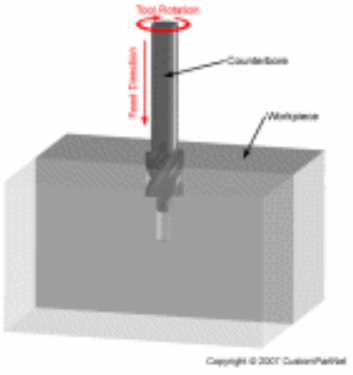
- Tapping - A tap enters the work piece axially and cuts internal threads into an existing hole. The existing hole is typically drilled by the required tap drill size that will accommodate the desired tap. The tap is selected based on the major diameter and pitch of the threaded hole. Threads may be cut to a specified depth inside the hole (bottom tap) or the complete depth of a through hole (through tap).



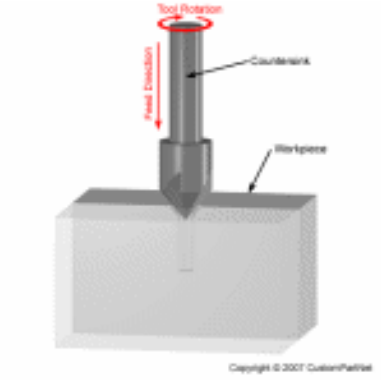
- Boring - A boring tool enters the work piece axially and cuts along the internal surface of an existing hole to enlarge the diameter or obtain more precise dimensions. The boring tool is a single-point cutting tool, which can be set to cut the desired diameter by using an adjustable boring head.



- Counter boring - A counter bore tool enters the work piece axially and enlarges the top portion of an existing hole to the diameter of the tool. Counter boring is often performed after drilling to provide space for the head of a fastener, such as a bolt, to sit flush with the work piece surface. The counter boring tool has a pilot on the end to guide it straight into the existing hole.



Countersinking - A countersink tool enters the work piece axially and enlarges the top portion of an existing hole to a cone-shaped opening. Countersinking is often performed after drilling to provide space for the head of a fastener, such as a screw, to sit flush with the work piece surface. Common included angles for a countersink include 60, 82, 90, 100, 118, and 120 degrees.



Self-Check -3	Written test

Choose the best answer:-

1. Which one of the following operation is correct to enlarge a hole to a proper size to a smooth finish
    a) Drilling
    b) Reaming
    c) Tapping
    d) Lapping

    1. ----- A countersink tool enters the work piece axially and enlarges the top portion of an existing hole to a cone-shaped opening.

    a) Drilling
    b) Counter boring
    c) Spot facing
    d) All

2. Which one of the following is correct sequence of drilling operation
    a) Reaming-drilling-Lapping –boring
    b) Drilling –lapping-Reaming-boring
    c) Lapping-drilling-reaming-boring
    d) Drilling-Reaming-Boring-Lapping

3. Which one of the following is correct about Lapping operation
    a) removing a very small amount of material by using reamers

b) it is the operation of enlarging machined holes

c) it is the operation of making a hole

d) none of the above

4. which one of the following is part of a twisted drill bit

a) edge

b) shank

c) body

d) b and c are correct

Note: **Satisfactory rating 4 and above points, Unsatisfactory - below 3 points**

Score = _____

Rating: _____

Information Sheet-4	Performing operations using safety procedures

3.1 Performing operations using safety procedures

- **GENERAL DRILLING MACHINE SAFETY**

Drilling machines are one of the most dangerous hand operated pieces of equipment in the shop area. Following safety procedures during drilling operations will help eliminate accidents, loss of time, and materials. Listed below are safety procedures common to most types of drilling machines found in the machine shop.

✓Do not support the workplaces by hand. Use a holding device to prevent the work piece from being tom from the operator's hand

✓Never make any adjustments while the machine is operating.

✓Never clean away chips with your hand. Use a brush.

✓Keep all loose clothing away from turning tools.

✓Make sure that the cutting tools are running straight before starting the operation.

✓Never place tools or equipment on the drilling tables.

✓Keep all guards in place while operating.

✓Ease up on the feed as the drill breaks through the work to avoid damaged tools or workplaces.

✓Remove all chuck keys and wrenches before operating.

✓Always wear eye protection while operating any drilling machines

Self-Check -4	Written test

Say true or false for the following questions below

1. Drilling machines are one of the most dangerous hand operated pieces of equipment in the shop area.
2. Make sure that the cutting tools are running straight before starting the operation of drilling machine.

Note: **Satisfactory rating 2 and above points, Unsatisfactory - below 1 points**

Score = _____

Rating: _____

Operation sheet	Hole-making operations

Operation Title: Hole-making operations

Aim: Hole-making operations

Tools Required: Bench Vice, hacksaw, drilling machine, sport facing, reamers, tap

Procedure

Step -1. Wear appropriate personal protective equipment

Step -2. Prepare and plan work place

Step -3 Select appropriate equipment and tools

Step -4 Perform the given project accurately

Step-5 Prepare a metal work piece size 50x50x10 mm

Step-6 Preform Hole making operation with the right sequence.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary materials, tools and measuring instruments you are required to perform the following tasks within 1 hour.

Task 1. Operate the drilling machine

List of Reference Materials

1. http://www.qhunt.com/2015/10/what-are-operations-carried-out-by.html
2. https://www.wikihow.com/Ream-a-Hole
3. **https://www.wikihow.com/Ream-a-Hole (how to ream a hole includes video)**

Solar PV System Installation and Maintenance

Level-II

Learning Guide -17

Unit of Competence	Perform Bench Work
Module Title	Perform Bench Work
LG Code	EIS PIM2 M05 LOT 4 LG-17
TTLM Code	EIS PIM2 TTLM 0120V1

LO4. Cut threads using tap and stock and die

Instruction sheet 4	Learning Guide: - 17

This learning guide is developed to provide you the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:-

- Cutting thread to fit gage or mating screw
- Cutting thread with the recommended tapping sequence
- Performing thread cutting operations using safety procedures

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to:-**

- Perform Cutting thread to fit gage or mating screw
- Performing Cutting thread with the recommended tapping sequence
- Performing thread cutting operations using safety procedures

Learning Instructions:-

7. Read the specific objectives of this Learning Guide.
8. Follow the instructions described below 3 to 6.
9. Read the information written in the information Sheet 1, Sheet 2, Sheet 3, in pages 134, 137 and 143 respectively.
10. Accomplish the Self-check 1, Self-check 2, Self-check 3, in pages 136, 142 and 149 respectively
11. If you earned a satisfactory evaluation from the “Operation sheet” proceed to Operation 150
12. Do the “LAP test” on page 151

Information Sheet-1	using safety procedures to Perform thread cutting operations

3.1 Safe operating procedures

- **Threading Tools**

DO NOT use any hand tool unless a teacher has instructed you in its safe use and operation and has given permission

Safety glasses must be worn at all times in ITD practical workshops

Appropriate protective footwear is also required in all ITD workshops

This range of hands tools will usually include the following:

Figure 68: Tools

- ✓ Taps – *tapered, intermediate and bottoming or plug*
- ✓ Tap wrench and “T” wrench
- ✓ Button dies and die nuts
- ✓ Die wrench or die stock

- **OPERATIONAL SAFETY CHECKS**
  - ✓ It is important to choose the right thread cutting tool for the job. They will vary widely, and are all designed for specific purposes, for producing both internal and external threads.
  - ✓ Always wear appropriate eye protection when using any of the thread cutting tools.
  - ✓ Avoid misuse and abuse of these precision thread cutting tools.
  - ✓ All taps, dies and die nuts should have their thread diameter and thread pitch clearly indicated – *e.g.* the correct tool to cut a 10mm Ø thread with a 1.5mm pitch will be marked as: *M10 x 1.5*
  - ✓ Use a suitable cutting lubricant for all tapping, threading and reaming operations. This will vary dependent on the material being cut, i.e. steel, steel alloys, cast iron, aluminum, etc.
  - ✓ When tapping an internal thread, the tap drill size must be calculated – *i.e. drill = Ø – pitch*
  - ✓ The cutting action should be backed off every half turn to break off (and clear) the waste from the thread being created

- **HOUSEKEEPING**
  - ✓ Leave the work area in a safe, clean and tidy condition.
  - ✓ Clean and return all threading tools to their appropriate storage containers.
  - ✓ Inspect all cutting edges and internal flutes for apparent damage or dullness. Poorly maintained cutting tools may seize or produce an inferior thread if they are in poor condition.

- **POTENTIAL HAZARDS AND RISKS**

  ■ Lacerations from sharp cutting edges ■ Pinch and squash ■ Eye injuries

Self-Check -1	Written test

Say true and false the following question below

1. In housekeeping leave the work area in a safe, clean and tidy condition.
2. In safety operation It is important to choose the right thread cutting tool for the job
3. DO NOT use any hand tool unless a teacher has instructed you in its safe use and operation and has given permission

Note: **Satisfactory rating 3 and above points, Unsatisfactory - below 2points**

Score = _____

Rating: _____

Information Sheet-2	Cutting thread to fit gage or mating screw

1.1 Making a Screw Thread

Machine screws are extensively used for securing parts. The number of different types and sizes of machine screws, nuts & bolts prohibit the possibility of introducing them all here so the following information addressed the elementary information only.

1.2 Types of Threads

Almost all of the thread have triangle shaped threads. On the other hand, square shaped and trapezoid shaped threads are used moving machinery which need high accuracy, such as a lathe.

In respect to thread standards, there are a metric thread (M), a parallel thread for piping (PF), a taper thread for piping (PT), and an unified thread (UNC, UNF). The following information is related metric threads, because they are the most widely used in Japan and many countries around the world.

1.3 Terms used for Threads

One of the most important terms used is that of the outer diameter. In the case of a metric thread, the bolt is named in accordance with its outer diameter e.g a bolt with a 5 mm outer diameter is known as an M5 boltThe "Pitch" of the tread is another important feature of a thread. The pitch is defined as the interval (distance) between adjoining threads. E.g. Nuts & bolts must have the same pitch as well as diameter if they are going to be used together.

The principles of cutting threads in nuts and bolts is that the bolt (male thread) is usually cut from a rod of material which has the same diameter has the intended finished bolt. The nut is made from a larger stock which has a hole drilled through it that is slightly larger than that of the rod diameter. A thread of the same pitch is then cut which results in two mating threads. The same principles apply for cutting holes in places and other work pieces. (Such an in the cylinder.)

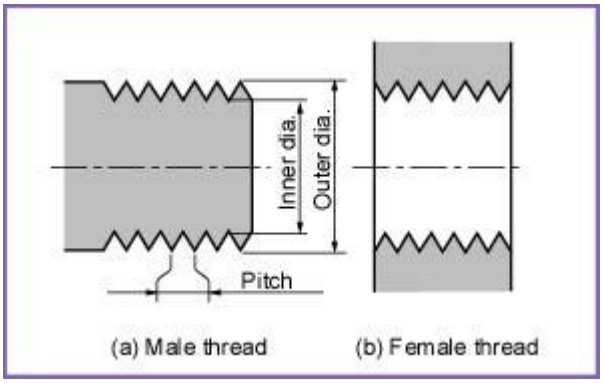


Figure 69: Terms of screw

- **Screw Thread Terminology**

The common terms and definitions below are used in screw thread work and will be used in discussing threads and thread cutting.

- ✓ **External or male thread** is a thread on the outside of a cylinder or cone.
- ✓ **Internal or female thread** is a thread on the inside of a hollow cylinder or bore.
- ✓ **Pitch** is the distance from a given point on one thread to a similar point on a thread next to it, measured parallel to the axis of the cylinder. The pitch in inches is equal to one divided by the number of threads per inch.
- ✓ **Lead** is the distance a screw thread advances axially in one complete revolution. On a single-thread screw, the lead is equal to the pitch. On a double-thread screw, the lead is equal to twice the pitch, and on a triple-thread screw, the lead is equal to three times the pitch (Figure 2).
- ✓ **Crest** (also called "flat") is the top or outer surface of the thread joining the two sides.
- ✓ **Root** is the bottom or inner surface joining the sides of two adjacent threads.

- ✓ **Side** is the surface which connects the crest and the root (also called the flank).

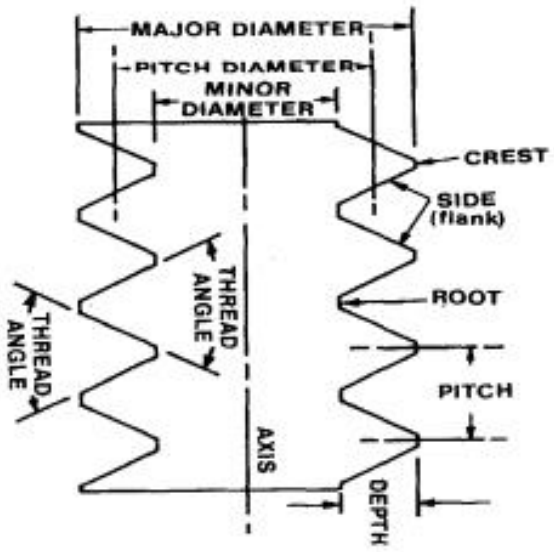


Figure 70: Screw thread terminology.

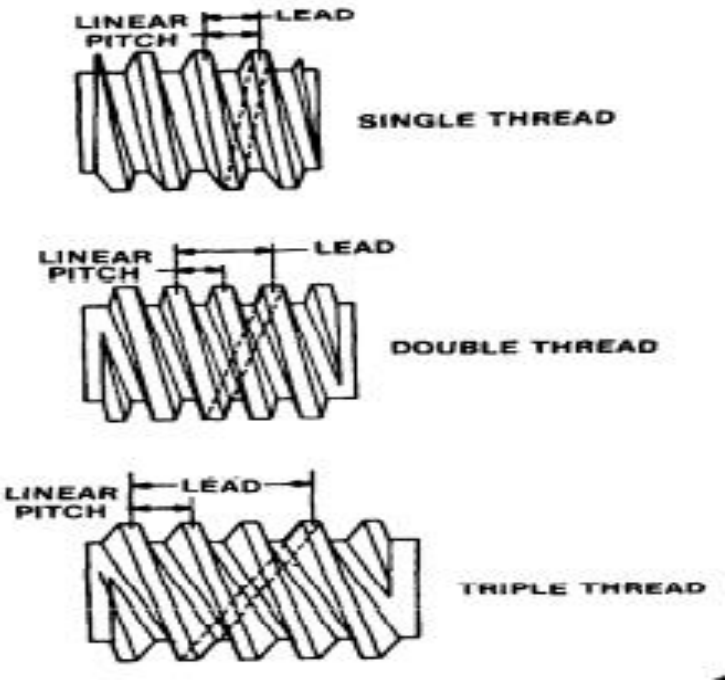


Figure 71: Screw thread types.

- ✓ **Angle of the thread** is the angle formed by the intersection of the two sides of the threaded groove.
- ✓ **Depth** is the distance between the crest and root of a thread, measured perpendicular to the axis.
- ✓ **Major diameter** is the largest diameter of a screw thread.
- ✓ **Minor diameter** is the smallest diameter of a screw thread.
- ✓**Pitch diameter** is the diameter of an imaginary cylinder formed where the width of the groove is equal to one-half of the pitch. This is the critical dimension of threading as the fit of the thread is determined by the pitch diameter (Not used for metric threads).
- ✓ **Threads per inch** are the number of threads per inch may be counted by placing a rule against the threaded parts and counting the number of pitches in 1 inch. A second method is to use the screw pitch gage. This method is especially suitable for checking the finer pitches of screw threads.
- ✓ **A single thread** is a thread made by cutting one single groove around a rod or inside a hole. Most hardware made, such as nuts and bolts, has single threads. Double threads have two grooves cut around the cylinder. There can be two, three, or four threads cut around the outside or inside of a cylinder. These types of special threads are sometimes called multiple threads.
- ✓ **A right-hand thread** is a thread in which the bolt or nut must be turned to the right (clockwise) to tighten.

- ✓ **A left hand thread** is a thread in which the bolt or nut must turn to the left (counterclockwise) to tighten.
- ✓ **Thread fit** is the way a bolt and nut fit together as to being too loose or too tight.
- ✓ **Metric threads** are threads that are measured in metric measurement instead of inch measurement.

- **Screw and Clearance Hole**

  Screws are typically used for securing mating parts. When two pieces are joined together using screws, one piece is made with threads, and another piece is made with clearance holes, which have bigger diameters than that of the screws. If the diameter of the clearance hole is too small, the piece cannot be assembled as the screw will not fit through the hole. Also, if the diameter of the clearance hole is too big, the piece will be loose as the hole will provide a sloppy fit. Therefore, we must provide make suitable diameter clearance holes. As a "rule of thumb", the diameter of the clearance hole has more 10 % than the diameter of the screw. For examples, the clearance hole for a M3 screw has 3.2 mm or 3.5 mm diameter. The clearance hole for a M4 screw has 4.2 mm or 4.5 of diameter. And we would make a hole with 5.5 mm of diameter for a M5 screw.

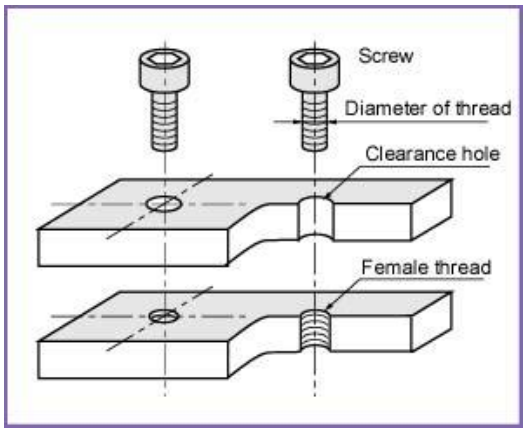


Figure 72: Screws and Clearance Hole

Self-Check -2	Written test

I. Say true or false for the following questions below

1. A single thread is a thread made by cutting one single groove around a rod or inside a hole
2. Thread fit is the way a bolt and nut fit together as to being too loose or too tight.
3. Angle of the thread is the angle formed by the intersection of the two sides of the threaded groove.
4. Depth is the distance between the crest and root of a thread, measured perpendicular to the axis.
5. Major diameter is the largest diameter of a screw thread.
6. Minor diameter is the smallest diameter of a screw thread.
7. Pitch diameter is the diameter of an imaginary cylinder formed where the width of the groove is equal to one-half of the pitch

Note: **Satisfactory rating 5 and above points, Unsatisfactory - below 4 points**

Score = _____

Rating: _____

Information Sheet-3	Cutting thread with the recommended tapping sequence

2.1 Thread Making Process

When we make the male thread, generally we use a die tool. When we make the female thread, we use a tap tool. If we do not have the suitable tools, we can also make the thread using a lathe.

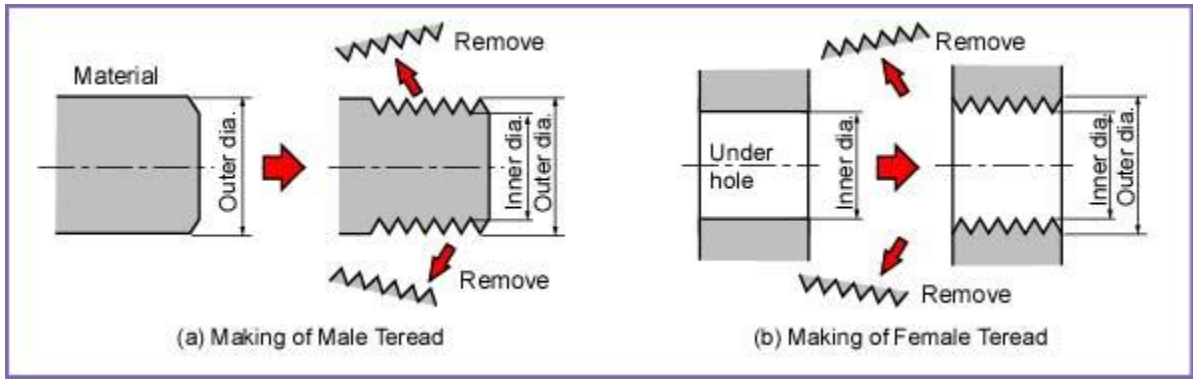


Figure 73: Imagine of Thread Cutting Processing

- **Caution**

  When we make the threads using the tap or the die, care should be taken in respect for the following.

  - ✓ Start the thread with a perpendicular positioning of the tap or the die.
  - ✓ Turn the tap or die in quarter turns and "back off" quarter turns to remove melat chips so that they don't clog the tool.
  - ✓ Always use a cutting oil.

- **Tread cutting using a Hand Tap**

  Figure 3 shows taps which are used to make female threads. They are usually used with a tap handle as shown in Figure 4. In respect to the tread cutting process, we first, make a hole with suitable diameter and suitable depth (see Table 1). Next, we start to turn the tap in a clockwise

direction.

There are typically three types of taps used as seen in figure 3. Of the three tap types there is a tapered tap to facilitate the initial thread cutting, an intermediate type that is used to progress the thread after it has been started and then finally, a "Bottoming" thread which is used to obtain the full thread depth when cutting a thread that does not go the whole of the way through the piece.

Taps can be easily broken and if the tap is broken in the work piece, it can be almost impossible to remove. It is therefore, very prudent to take care to ensure that metal chips do not build-up in the tap and also that the tap does not overheat as a result of the cutting process through the use of a cutting lubricant.

Figure 74: Tap and Die

Figure 75: Taps

Figure 76: A Tap with a Tap handle and Thread Cutting using a Tap

- **Recommended Tap Hole Size**

Table 1 lists diameters of hole sizes for metric female threads and piping threads (PT, PF). Please note that the diameter of the hole equals the approximate difference of the diameter of the thread and the thread pitch. It may be necessary to allow a greater hole clearance if for example we were making a thread in hard stainless steel

Table 4: Recommended Tap Hole Size

Metric threads		Piping threads		
Name	Under hole dia. (mm)	Name	Outer dia. (mm)	Under hole dia. (mm)
M2	1.6	PF1/8	9.7	8.6
M3	2.5	PF1/4	13.2	11.5
M4	3.3	PF3/8	16.7	15.0
M5	4.2	PF1/2	21.0	19.0
M6	5.1	PT1/8	(9.7)	8.2
M8	6.8	PT1/4	(13.2)	11.0
M10	8.6	PT3/8	(16.7)	14.5
M12	10.3	PT1/2	(21.0)	18.0

- **More on Taps**

  A tap is a screw like tool which has threads like a bolt and three or four flutes cut across the thread which is used to produce internal threads. The edges of the thread formed by the flutes are the cutting edges. The lower part of the tap is somewhat tapered so that it can well attack the walls of the drill hole.

  Hand taps are usually made in sets of three (1) Taper tap (2) Second tap
- **Bottom tap.**
- **Taper Tap:** In this tap about six threads are tapered and is used to start the thread, so that the threads are formed gradually as the tap is turned into the hole.

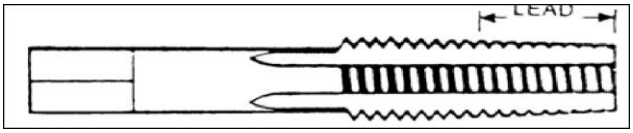


Figure 77: Taper Tap

- **Second tap:** It is tapered back from the edge about three or four threads used after taper tap. It has been used to cut the threads as far as possible

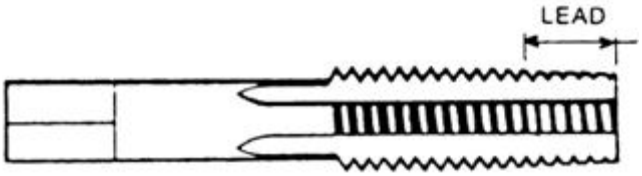


Figure 78: Second Tap

- **Bottom Tap:** It has full threads for the whole of its length. This is used to finish the work prepared by the other two taps.

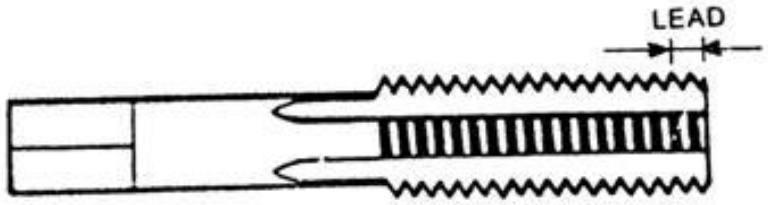


Figure 79: Bottom Tap

- **Cutting using a Hand Die**

  Figure 9 shows a die and a die handle which are used to make male threads. The procedure of the threading is the same of the taps. But it is more difficult to start the thread cutting process than with tapping as dies do not have an equivalent to a tapered starting tap with perpendicular than the tapping.The thread cutting process using a die usually typically results in a smaller diameter of the original piece so care needs to be taken in selecting the correct size stock. If the stock is too small, this will result in a shallow thread depth resulting in an unsatisfactory thread. The die also created a bevel on the thread which is necessary for a close fit.

  If you have a lathe, the job of cutting a thread can be easier as it is possible to use the "STOPPED" lathe to assist in starting the thread as shown in figure 10. The die is pushed by the drill chuck aligned perpendicularly to the piece and after. After enough thread is cut, the drill chuck is removed and the die handle is then turned by hand.

Figure 80: A Die and A Die Handle

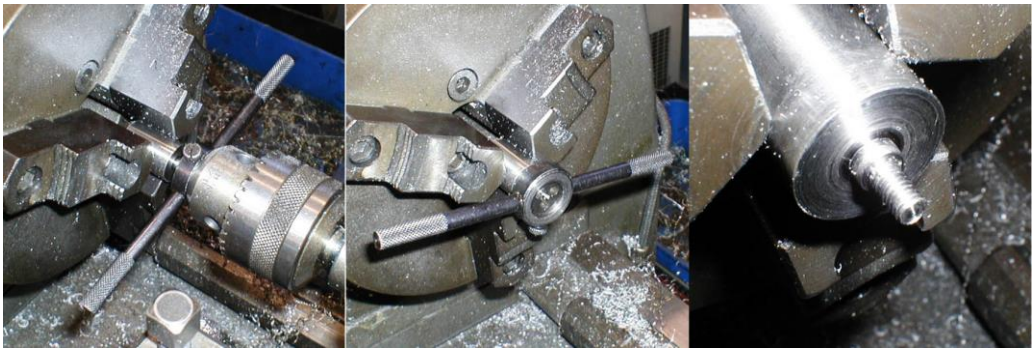


Figure 81: Thread making using die

- **More on Dies**

  It is a circular disc of hardened tool steel used to make external threads on a round rod or bolts with a die and stock. Die has a hole containing threads and flutes which form cutting edges. These are mainly two types

  1. Solid Die 2. Adjustable Die.

  - ✓ **Solid Die:** It is one which has fixed dimension and cannot be adjusted for smaller or large diameter. It is used for recutting damaged threads and may be driven by suitable wrench.
  - ✓ **Adjustable Die:** It can be set to cut larger and smaller diameters. It has a split through one side and a slight adjustment is possible with the help of set screw.

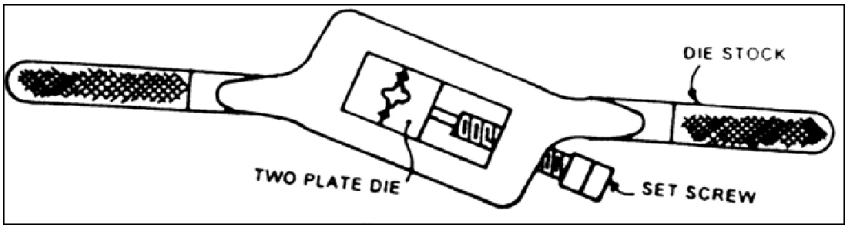


Figure 82: Two - Plate Di

Self-Check -3	Written test

I. Say true or false for the following question below

1. Solid Die is used for recutting damaged threads and may be driven by suitable wrench
2. Adjustable Die It can be set to cut larger and smaller diameters
3. A tap is a screw like tool which has threads like a bolt and three or four flutes cut across the threads which are used to produce internal threads.

Note: **Satisfactory rating 2 and above points, Unsatisfactory - below 1 points**

Score = _____

Rating: _____

Operation sheet	Male and Female Thread-making operations

Operation Title: Male and Female Thread-making

Aim: Male and Female Thread-making operations

Tools Required: Hand tap, Die

Procedure

Step -1. Wear appropriate personal protective equipment

Step -2. Prepare and plan work place

Step -3 Select appropriate equipment and tools

Step -4 Perform the given project accurately

Step-5 Prepare two units metal work piece rode size diam20mmx 100mm length

Step-6 Perform male and female thread making operation with the right tapping and die sequence.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary materials, tools and measuring instruments you are required to perform the following tasks within 1 hour.

Task 1. House keeping and perform thread making

List of Reference Materials

1. https://smithy.com/machining-handbook/chapter-3/page/24
2. https://www.nmri.go.jp/oldpages/eng/khirata/metalwork/basic/bolt/index_e.html

Solar PV System Installation and Maintenance

Level-II

Learning Guide -18

Unit of Competence	Perform Bench Work
Module Title	Perform Bench Work
LG Code	EIS PIM2 M05 LO-5 LG-18
TTLM Code	EIS PIM2 TTLM 0120V1

LO5. Off-hand grind cutting tools

Instruction Sheet	Learning Guide: - 18

This learning guide is developed to provide you the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:-

- Honing cut edges free of burrs.
- Sharpening cutter to conform to specifications.
- Grounding Cutters using appropriate cooling agents.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to:-**

- Perform Honing cut edges free of burrs
- Performing Sharpening cutter to conform to specifications
- Performing Grounding Cutters using appropriate cooling agents

Learning Instructions:-

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information Sheet 1, Sheet 2, Sheet 3, Sheet 4, in pages 155, 159, 164 & 167 respectively.
4. Accomplish the Self-check 1, Self-check 2, Self-check 3, Self-check 4 in pages 158, 162, 166, and 170 respectively

Information Sheet-1	**Using Safety procedures and personal protective devices to perform Cutting tool grinding**

1.1 introduction

Always Wear Personal Protective Equipment

Never use the grinder without wearing all the personal protective equipment and clothing such as goggles, helmets, masks, ear protection, gloves, leather aprons etc. Also ensure that the personal protective equipment and tools are in proper condition before using them

1.2. "off-guard" Cutting tool grinding

saying to have a hand which is completely different from the real one , to put the opponents off their guard or set them on their guard , ' or , ' in a preliminary match of motor sports , running in a far worse time than the real ability as a strategy for putting the rivals off guard , ' and so on

1.3. Off-hand grinding Cutting tool

General grinding, Tool grinding, Snagging or floor/bench grinding, Industrial and Foundry applications, Billet & Slab grinders, Portable or mobile grinding applications, Straight/**off**-**hand grinding**, Angle grinders, cut off wheels, Resinous Diamond Wheels, Dressing sticks and devices, Saw and other sharpening, Mounted Points in a variety of shapes & sizes, Cup Wheels and reinforced and non-reinforced disks.

1.4. Cutting and Grinding Safety

Cutting and grinding is performed on many jobsites. The following are a list of safety precautions that must be followed to prevent injury or property damage.

- Stay alert and watch what you are doing. Do not use tool while tired or under the influence of drugs, alcohol or medication. A moment of inattention when operating power tools may result in serious personal injury.
- Loose clothes, gloves, jewelry or long hair can be caught in moving parts. Keep them away.
- Avoid accidental starting. Be sure switch is off before plugging in. Carrying tools with your finger on the switch or plugging in tools that have the switch on invites accidents.
- Do not overreach. Keep proper footing and balance at all times. Proper footing and balance enable better control of the tool in unexpected situations.
- Always wear safety glasses, face shield, protective gloves, suitable protective clothing, hard hat, steel toe boots and hearing protection and dust mask if necessary. Keep other employees away while operating power tools.
- Always use proper guard with grinding wheel, it protects operator from broken wheel fragments. Turn the wheel guard so that the closed area is towards the operator.

1.5. Personal protective equipment (PPE) is protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection. The hazards addressed by protective equipment include physical, electrical, heat, chemicals, biohazards, and airborne particulate matter. Protective equipment may be worn for job-related occupational safety and health purposes, as well as for sports and other recreational activities. "Protective clothing" is applied to traditional categories of clothing, and "protective gear" applies to items such as pads, guards, shields, or masks, and others.

The purpose of personal protective equipment is to reduce employee exposure to hazards when engineering controls and administrative controls are not feasible or effective to reduce these risks to acceptable levels. PPE is needed when there are hazards present. PPE has the serious limitation that it does not eliminate the hazard at the source and may result in employees being exposed to the hazard if the equipment fails.

Safety is the state of being "safe" (from French *sauf*), the condition of being protected from harm or other non-desirable outcomes. Safety can also refer to the control of recognized hazards in order to achieve an acceptable level of risk.

PPE means personal protective equipment or equipment you use to guarantee your (own) safety.

Figure 83 ; protective device

Instruction Sheet	Learning Guide: - 24

I. Say true or false for the following questions below

1. PPE Is protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection.
2. SOP Means personal protective equipment or equipment you use to guarantee your (own) safety.
3. First aid is emergency care and treatment of an injured or ill person before complete Medical and surgical treatment can be secured.

Information Sheet-2	**Honing cut edges free of burrs**

1.1 Deburring tools

A deburring tool is designed to remove sharp edges and burrs from drilled holes and pipework. Burrs and sharp edges can form on work pieces during manufacturing processes like drilling holes and it's often beneficial to remove them. Hand-held deburring tools are designed to be used by hand to remove burrs from the edges of holes.

Figure 84: hand held deburring tools

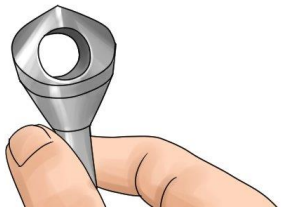


Figure 85: deburring cutter

Deburring cutters are used in machines (e.g. pillar drills, lathes) and hand-held drills and are used to remove burrs from edges.

Deburring tool applications

A deburring tool removes burrs from around the edge of a hole or entrance in a workpiece and creates a chamfered edge

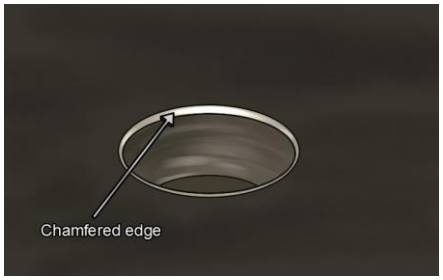


Figure 86: chamfered edge

Deburring tools are used to smooth out the rough edges produced during the manufacturing process.

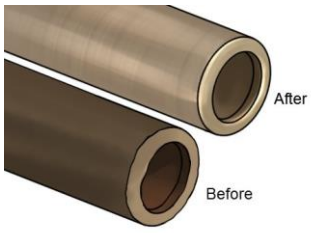


Figure 87: smoothed edge

A deburring tool can also be used to remove chatter marks from machining.

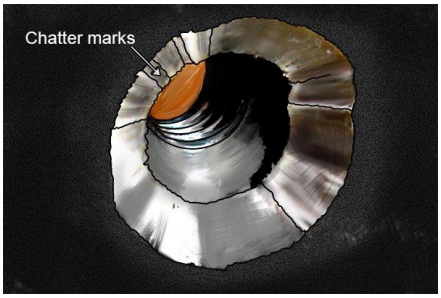


Figure 88: chatter marks

What materials can deburring tools be used on?

Deburring tools are designed to be used on plastic, nylon, copper, wood and many other non-metallic materials as well as mild steel, mild cast iron and aluminum.

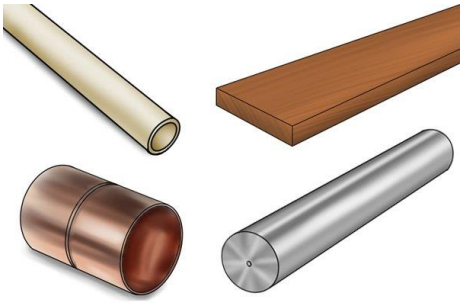


Figure 89: materials

If used on much harder materials (e.g. hardened steel), the deburring tool could chip or break, as the metal you are cutting will be harder than the tool.

Figure 90: hard steel material

What do burrs look like?

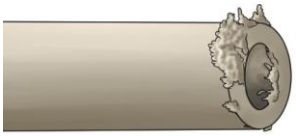


Figure 91: plastic piping burr

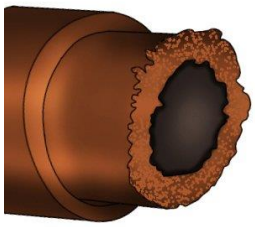


Figure 92: copper piping burr

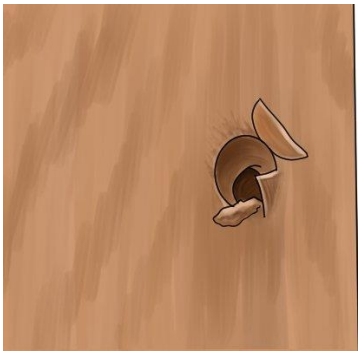


Figure 93: burrs on wood

Figure 94: Metal piping burr

https://www.wonkeedonkeetools.co.uk/de-burring-tools/what-is-a-deburring-tool/

Self-Check -2	Written test

Say true or false for the following question below

1. A deburring tool is designed to remove sharp edges and burrs from drilled holes and pipework
2. Deburring tools are designed to be used on plastic, nylon, copper, wood and many other non-metallic materials as well as mild steel, mild cast iron and aluminum.

Note: **Satisfactory rating 2 and above points, Unsatisfactory - below 1 points**

Score = _____

Rating: _____

Information Sheet-3	Sharpening cutter to conform to specifications

2.1 Sharpening deburring tools

If the deburring cutter tools edge becomes blunt, one of the following tools can be used to lightly dress the cutting edge. **Please note:** The edge should only be dressed lightly; if the tool is sharpened too much, the cutting edge angle may be altered and this will affect the cutting ability of the tool.

- **Die grinder**

  A hand-held tool, used for polishing, buffing, grinding and sanding of materials. A die grinder can be used on many different materials (e.g. metal, wood, plastic) and there are different head attachments available depending on the work needing to be done.

Figure 95: Die grinder

- **Diamond file**

  A diamond file has a very fine file blade, with a diamond abrasive (small grains of diamond). This provides a very hard, tough abrasive for sharpening and dulling edges on metals.

Figure 96: diamond file

- **Diamond lap**

  A diamond lap is similar to the diamond file, although the lap is bigger in size, and is designed for larger filing applications (e.g. dressing the edge of a larger sized deburring cutter).

Figure 97: Diamond lap

Self-Check -3	Written test

Say true or false for the following question below

1. Die grinder is a hand-held tool, used for polishing, buffing, grinding and sanding of materials
2. Diamond file provides a very hard, tough abrasive for sharpening and dulling edges on metals.
3. Diamond lap is bigger in size and designed for larger filing applications

Note: **Satisfactory rating 2 and above points, Unsatisfactory - below 1points**

Score = _____

Rating: _____

Information Sheet-4	Grounding cutters using appropriate cooling agents

3.1 Wet Grinding

Wet grinding is a milling process used to produce powder or paste from a solid using a liquid such as water. It can also be used in an abrasive process to reform hard objects. There are numerous items that can be processed in this way, including grains and ores. Such techniques are used for both domestic and industrial tasks. When used in industrial settings, a wet technique is often more economical than dry grinding. Wet grinding is a process that has been around for a long time. The process was once executed using the mechanical energy of stones.

When grinding on water cooled grinding wheel, the wheel runs in a bath of water. The wheel carries the water continuously to the grinding surface, thus cooling it and eliminating the risk of overheating. The grinding wheel runs between 50–130 rpm, depending on its diameter. A larger wheel runs with a lower axle speed than a small one. The low peripheral speed ensures that the water is not thrown off by the centrifugal force. 13 The reduction of the high rpm of the motor (you cannot run a standard electric motor at a low rpm) can be achieved with a worm gear, gear belts or with a friction gear. Since you need a reduction gear, wet grinders are more expensive than bench grinders, which do not have a reduction gear. It is desirable to be able to lower and remove the water trough for cleaning. Particles from the steel and the stone will form a hard mass unless they are cleaned away regularly. The surface finish after wet grinding is finer than with dry grinding. Often honing is not required after wet grinding. The grinding operation on a wet grinding wheel is easy to control, as the stone runs slowly and the risk of accidents is minimal due to the low rpm. The wet grindstone does not produce sparks, which means that it can be operated in areas of high fire risk such as wood working shops.

There is also no risk of the stone shattering and injuring people. Wet grindstones were originally natural sandstone and gave a very finely ground surface. In recent years man-made stones have been developed. These are ceramic ally made and have abrasives of aluminum-oxide. Man-made

stones grind much faster and usually have a coarser grinding surface. Although the grinding time it-self is longer on wet grinders compared to bench grinders, the total time for grinding and honing of a tool is much shorter. This is because the need for honing after grinding is greatly reduced or eliminated.

Figure 98: wet grinder

- **Dry Grinding**

  Dry grinding is the process where the particle size of a substance is reduced without liquid. This process is a common early step in several raw material processing fields and in the production of ethanol. In many cases, dry grinding is a very simple process, often only requiring a few steps. Dry grinding is generally much less expensive than wet grinding.

Figure 99: dry grinder

A common way to break down ores and other hard raw materials for further processing, dry grinding requires material being placed into a grinder or grate mill for reduction where it is pulverized by physical force. There are specialized machines used for different substances, but they all work in a similar set of ways. Depending on the type of machine used, the primary force may come from the machine or from the other material—when the machine is the motivator; the material is crushed by impacts with large metal hammers. If the other material is the primary grinder, then the machine typically is made of a large rolling drum, like a giant clothes dryer. The material rolls around inside and bangs against the walls and other particles until it breaks down to the required size.

Air reduction is an important step in some forms of dry grinding. When the particle size is small enough, air will keep the material trapped in suspension. This keeps the material from being sorted or stored. An air reduction chamber pulls the air from the system, but leaves the suspended material behind to settle.

The last step in the dry grinding process is sorting based on size. Material that is too large is returned to the grinding step to go through the machinery again. Material of the proper size goes on to the next step in the refinement process.

Ethanol production also uses dry grinding, but it has a longer process that has many steps in common with wet grinding. After the corn is broken down, often through machine force in a hammer mill, it goes into a storage chamber where it is kept wet. This allows the material to ferment and eventually become ethanol. Left over material that has the proper structure is allowed to dry and is put through the mill again.

Self-Check -4	Written test

Say true or false for the following question below

1. Wet grinding is a milling process used to produce powder or paste from a solid using a liquid such as water
2. Dry grinding is the process where the particle size of a substance is reduced without metal

Note: **Satisfactory rating 2 and above points, Unsatisfactory - below 1points**

Score = _____

Rating: _____

List of Reference Materials

1. Wet Grinding Cement Grouting Technology in Geotechnical Engineer (Chinese Edition) (Chinese), Paperback – December 1, 2013
2. The Essential Home-Ground Flour Book: Learn Complete Milling and Baking Techniques, Includes 100 Delicious Recipes, by Sue Becker (Author)May 10, 2016
3. Metal Cutting Theory and Practice 3rd Edition, Kindle Edition by David A. Stephenson (Author), John S. Agapiou (Author), April 6, 2016