PRINTING MATERIALS
Preface

This book of Printing Materials covers all the topics in a clear and organized format for the Second year Diploma in Printing Technology students as prescribed by the Directorate of Technical Education, Chennai, Tamilnadu. It is confidently believed that this book furnishes the students the necessary study material. The topics covered were neatly illustrated for better understanding of the students.

The book is prepared step-by-step lessons in large, eye pleasing calligraphy make it suitable for both direct one-to-one tutoring and regular classroom use. The highlight of this book is its simple English with clear and easy explanation of each topic.

All the topics are explained with supporting diagram for diploma level students to understand effectively.

This book majorly deals with Composition of Paper and Pulping Process, Manufacturing of Paper and Board, Paper, Board - Types, Sizes and Properties, Printing Inks - Composition and Manufacturing and Ink Drying and Ink Problems etc.

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UNIT I

COMPOSITION OF PAPER AND PULPING PROCESS

1.1 Introduction

Paper plays an important role in the modern world. For many years, it has been the chief medium for the communication of knowledge and ideas in a permanent form, so essential to the development of commerce, industry and education. There has been an increasing demand as a medium for protection and display of goods in the packaging industry. Without paper it is hard to imagine a printing industry for its present stage of development. Although, there is a growing amount of printing being carried out on plastic and metal substrates, paper is likely to be the printer most important basic material.

What is paper?

Paper consists of a compact web, of felting of vegetable fibres, usually in the form of a thin flexible sheet. The fibres are reduced to a pulp by grinding, heating etc., and are diluted with water in a vat. Pulp from the vat is then poured on to a moving wire mesh, from which the water drains away leaving a felted sheet. This is then pressed and dried.

Paper is a flat material produced from plant fibers that are mechanically or chemically treated or thermo-mechanically treated with chemicals. It is a wide flat structure generated by natural agglutination and felting of fibers and having a grammage (surface related mass) of 7g/m² (7 GSM) upto about 150g/m² (150 GSM).

What is Pulp?

- Pulp is a lignocellulosic fibrous material prepared by chemically or mechanically separating cellulose fibres from wood, fiber crops or waste paper.
- The wood fiber sources required for pulping are "45% sawmill residue, 21% logs and chips, and 34% recycled paper".
- Pulp is one of the most abundant raw materials worldwide.
Composition of Paper

Raw materials for manufacturing of paper

- **Soft Wood** - Like spruce & pine which have a long fibre
- **Hard Wood** - Short Fibre. Not very suitable for paper making. Gives trouble in barking and chipping. Eucalyptus, Acacia, Albizia & wattle trees are more suitable hard wood trees for paper making and do have a very high rate of growth
- **Grasses** - Several types of long grasses like bamboo sabai grass, sarkanda etc. are used
- **Straws** - In India rice, wheat straw, bagasse and corn straw are used for paper pulp making. Straw has been reported as suitable for paper making
- **Cotton Linters** - Its a seed hair from cotton plant after extracting cotton. Only small proportion of raw cotton in form of short fibre linters comes directly to paper mills
- **Cotton Rags** - This gives more strength in paper or paper board
- **Linen** - Linen fibre is derived from the bast tissue of the stem of the flax plant, cultivated extensively in USA, Russia, Hungary, France, Belgium & Ireland
- **Hemp** - It comes to paper maker in the form of spinning waste, twine, cordage, ropes etc. Hemp is the bast tissue of an annual shrub growth extensively found in India, Russia & America
- **Manila** - Fibre occurs in the leaves of a plant of the plantain family that grows in the Phillipines Islands
- **Sisal Hamp** - The fibre comes from the leaves of the plant Agave Sisalana and is used for making rope & twine
- **Waste Paper** - The demand of waste paper for manufacturing of paper is increasing every day. Utilization of this would reduce load on demand of fresh fibres. About 80% of the waste paper is used in the manufacture of paper boards. Small scale units depend almost entirely on waste paper as raw material. In India the use of recycled fibre is only 20 percent compared to 40% in developed countries.
Nature of Paper

Paper may be thin or thick, smooth or rough, hard or soft, strong or weak, white or colored, transparent or opaque. With the hundreds of different kinds of paper available today, there is a paper suitable for every process, any job and all purposes. The correct selection of paper and its suitability for use in the printing processes are important because paper is the material used in printing which can be felt as well as seen in the finished product. The selection of a paper may therefore enhance or lower the quality and appearance of a job.

1.2 FIBROUS MATERIALS

Cellulose fibres can be regarded as the common building brick of the paper. It may be of a blade of grass or in the trunk of the largest tree. In a few materials like cotton and linen, the cellulose exists in a purer form.

Although almost any plant material can be used for paper making the following requirements are to be considered to enable to use commonly for paper making.

The plant must be abundant and cheap, even to the extent that it must be of no use for any other manufacture, i.e., waste product. If a plant, it must grow in accessible places. It should grow quickly so that it can be replaced after use.

It must contain a high proportion of cellulose fibres and its structure must be such that these fibres can be isolated from the rest of the plant material, with reasonable ease and without undue expenditure of chemicals or heat.

The fiber itself when isolated should be suitable for paper making. In general this means that it should be long and strong and should develop strength on heating. At the same time it should be capable of being bleached to a good colour without undue loss of strength.

Different kinds of Fibrous Materials

Fibres have the form of long usually Hollow tubes. They range in length from 1 to 7.50 mm and in width from 0.01 to 0.05 mm according to the plant in which they occur. They are essentially made up of cellulose, a chemical compound of carbon, hydrogen and oxygen formed by the plant as it grows.
Common paper making fibres

Cotton Fibres

The purest form of natural cellulose is the second hair of the cotton plant. When the boll (or seed pod) is ripe it bursts open and the hair cottonseeds can be picked. The cotton used in textiles also comes back to the paper-maker in the form of discarded rags. These are the main sources of cotton for papermaking. Rags vary considerably in quality and prices are therefore carefully sorted. The badly soiled and worn grades are especially suitable for making blotting paper. The best new white cuttings from the textile mills are suitable for the highest grades of paper especially hand made. Such papers include high-grade writings, currency and legal paper.

Linen:

It is obtained from the last tissues of the flax plant but as with cotton, the paper-maker receives only the rejects or waste and discarded rags from mills. This material is best suited for thin strong papers like bank notes and airmail paper.

Wood:

Wood fibres are largely used in paper making as raw material. Spruce, pine, deciduous, aspen, eucalyptus, bench, birch, are some of the pulps made from these trees. The pulp is clean, white bulky opaque and uniform sheet, which is particularly suitable for printing paper. A pure form of wood pulp obtained by cutting wood into small pieces and subjecting it to chemical treatment. This removes the natural gums and resin leaving a soft pure pulp.

The category of wood pulp is mechanical wood pulp or ground wood pulp. It is so called because; the wood logs are mechanically ground down almost to saw dust. The shortness of fibres caused by this drastic grinding process and the impurities left in the pulp produce a paper lacking in strength and of poor colour. Papers produced from chemical wood pulp are stronger cleaner paper.

Esparto grass:
Grows in North Africa and Spain. It is harvested by pulling (not cutting) and handpicked to remove most of the impurities. Esparto grass combined with wood or rag pulp makes a good writing paper.

**Straw:**

The stems of the common cereal of which wheat is the most important from the pulp-making aspect although wet and benley straws can be used. Straw is sometimes used with rag to make thin writing paper like banks and bonds paper. The straw gives a film rattle and a hard surface and a high bursting strength. The straw cooked with time has been used in the unbleached state for many years for the production of straw boards.

**Manila:**

A plant from Philippine Islands gives a very characteristic. It is therefore used for wrapping tissues cigarette papers, bank note papers. It can be bleached to a good colour.

**Jute:**

The best tissue of an annual Indian Plant it is widely used in sack making (gunny) and it is in this form that it comes to pulp mill. It is used for thin wrapping.

**Bagasse:**

It is the fibrous residue from the sugarcane after extracting the juice. It is suitable for corrugated paper and board.

**Bamboo:**

It was developed as a source of paper pulp in India. It is widely used with grasses. Its general characteristic resembles that of esparto.

**Ramie or china grass:**

A special fiber, gives the pulp for making thin strong paper such as Bible paper.

**Categories of Fibres**

The four main categories of fibre are:

- Animal fibres - leather, silk
- Mineral fibres - glass, mica, asbestos
- Man-made fibres - nylon, rayon, synthetics
- Vegetable fibres - The main source of fibres for paper making.

**Vegetable fibres include:**
- **Stem fibres**, eg woods (softwood, hardwood); bast (flax, hemp, jute); grasses (esparto, straw, bagasse)
- **Leaf fibres**, eg. manilla, sisal
- **Fruit fibres**, eg. Seed hairs (cotton); pods (kapod); husks (cour).

**Characteristics of softwood pulps and hardwood pulps:**

<table>
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<th>Description</th>
<th>Hardwood</th>
<th>Softwood</th>
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<td>1.</td>
<td>Type of tree</td>
<td>Oaks, beeches, poplars, birches and eucalyptus</td>
<td>Mainly pine and spruce</td>
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<td>2.</td>
<td>Type of fibre</td>
<td>Short</td>
<td>Long</td>
</tr>
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<td>3.</td>
<td>Average length of fibres</td>
<td>1mm</td>
<td>3mm</td>
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<td>4.</td>
<td>Features</td>
<td>Achieving bulk, smoothness, opacity</td>
<td>Providing additional strength. Also suitable for writing and printing</td>
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<td>5.</td>
<td>Typical products</td>
<td>Writing papers, printing papers, tissue papers</td>
<td>Shipping containers, grocery bags, corrugated boxes</td>
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Hardwood and softwood fibres can be blended into a single paper, to achieve a desired combination of strength, whiteness, writing surface or other required characteristics.

The mixed characteristics of recovered fibres makes them particularly suited to applications such as newsprint and increasingly, packaging. Many different types of paper are included in recovered paper.

**1.3 MANUFACTURE OF PAPER**
The papermaking process can be divided into three distinct elements:

1. Pulping
2. Papermaking and
3. Finishing
1. Pulping process

Paper is made from the cellulose fibres that are present in hardwood and softwood trees. Whether using wood or recovered paper, the first step is to dissolve the material into pulp.

Regardless of the type of pulping process used, the wood or recovered paper is broken down into its component elements so that the fibres can be separated. The pulping results in a mass of individual fibres being produced. The fibres are then washed and screened to remove any remaining fibre bundles. The water is then pressed out and the residue is dried.

The pulp is then ready to be used directly or it can be bleached and made into white paper. In an 'integrated paper mill' the pulp will be fed directly to a paper machine. Alternatively, it will be dried and pressed into bales ready for use as a raw material in paper mills worldwide.

The pulp-making process

1. Timber and debarking
2. Chipping machine and pulping process
3. Cleaning and bleaching
4. Washing and drying

Pulp is graded and classified according to: the method of the production (e.g. chemical or mechanical pulp); the species of tree used (e.g. softwood or hardwood); and by level of processing (e.g. bleached or unbleached). Pulp generated from recovered paper is similarly graded.
Three basic methods of pulping wood fibre can be used:

A. **Mechanical pulping** removes the lignin from the fibres by physical means;

B. **Mechanical / Chemical pulping** removes the lignin by a mixture of physical and chemical means; and

C. **Chemical pulping** removes the lignin by entirely chemical methods.

D. **Recycled or deinked pulp (DIP)** removing printing inks and other unwanted elements.

### A. Mechanical pulping

The most basic form of mechanical pulp is produced from coniferous softwood trees only (mainly spruce). After felling the trees are selected, cut into suitable lengths and debarked in a rolling, open drum called a tumbler drum debarker.

The debarked logs are forced against a revolving grindstone in hot water. While water is being sprayed on simultaneously, the individual fibres are ripped out of the wood and are crushed, scored, pressed, turn off, and sheared by the grindstone surface. The resulting mixture of pulp and water is sent over a series of increasingly fine screens, which remove any remaining lumps until the final mixture is well dissolved.
Plain and basic mechanical pulp produced in this way is known as stone ground wood pulp (SGW) to differentiate it from the somewhat purer mechanical/chemical pulps (below).

**Stone Groundwood pulp:** mechanically grinds the wood into relatively short fibres.

**End-use:** the resulting pulp is used mainly in newsprint and wood-containing papers, such as lightweight coated (LWC) and super-calendered papers.

**Process variables include:** stone surface, speed, pressure, temperature, and consistency, type of wood.

**Advantages** include extremely high yield process with low effluent level. The resulting pulp cannot be used on its own to make printing paper but is the majority furnish (80% or so) for low-grade newsprint. It has good opacity, high bulk, good printability and is cheap.

**Disadvantages** are low surface brightness and shade, lack of strength and durability, rapid discoloration and weakening with age due to the high residual lignin content.
B. Mechanical/chemical pulping

A number of processes have been devised to produce mechanical pulps, which are purer than the basic SGW product.

As distinct from SGW they mainly involve the use of woodchips as the starting point of the process sequence rather than whole logs.

The first common step in the process is that, after cutting and debarking, the logs (or wood scraps) are fed into a chipper, which reduces them to chips, a few millimeters in length.

End-use: this pulp has properties suited to tissue manufacture. Some chemi-thermo mechanical pulp is used in printing and writing grades.

1. Refiner mechanical pulp (RMP)

The chips are passed continuously through a series of disc refiners in water. The machines grind the chips into smaller and smaller pieces until they form a pulp, which can be screened and bleached in the same cycle of operations as for conventional SGW pulp.

Advantages: wider range of woods can be used, waste wood and sawn timber scraps can be used, more automated and so less manpower required, slightly purer pulp results.

Disadvantages: as for SGW but slightly reduced discoloration with ageing and slightly stronger tensile strength.

Also known as refiner ground wood pulp: RGP

2. Thermo-mechanical pulp (TMP)

This pulp is being used more and more to make paper or paper board in which the presence of non-fibrous material is not objectionable.
The chips are steamed at 135°C to soften the lignin before they are passed through a similar system of disc refiners. This allows an easier separation of the lignin and less damage to the fibres. Increasing amounts of TMP are being used to produce newsprint.

Thermo-mechanical pulp (TMP): the wood particles are softened by steam before entering a pressurised refiner.

**Advantages:**

Stronger pulp basis, use of wider range of trees, faster drainage, reductions in debris. In finished papers, smoothness and porosity improved, less discoloration with age.

**Disadvantages:**

Lower yield, lower brightness and opacity, softer surface therefore increased risks of Tinting or fluffing when printing.

3. **Chemi-thermomechanical pulp (CTMP)**

A process one stage beyond TMP: a chemical stage is added which substantially dissolves the lignins in the woodchips before they are refined.

**Advantages:**

In finished papers, quite close in quality to many wood free grades, long fibre length, good strength, good brightness. Very high yield process (sometimes called high-yield pulp).

**Disadvantages:**

Expensive to produce, often little cheaper than wood free pulp, finished papers liable to some discoloration.
4. **Bio-chemi-thermomechanical pulp: (BCTMP)**

Variant of CTMP using biological processes along with chemical. Advantages and disadvantages much as CTMP but easier disposal of effluent, fewer chemicals used.

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**C. Chemical Pulping**

Chemical pulp is the fibre material obtained from wood (chips) and other vegetable raw materials (e.g., annuals including hemp, jute, esparto, straw, cotton) by chemical digestion.

The aim of chemical pulping is to reduce or dissolve the lignins in the wood by chemical rather than physical means. In this way the fibres separate more cleanly from each other and fewer impurities remain in the final stock.

Chemical pulping yields the purer and stronger forms of pulp known as wood free (i.e., free of ground wood pulp). As much as the chemical treatment itself, the absence of mechanical forces which tear and bruise the fibres means that fibre lengths can be maintained and a stronger, more resilient paper be manufactured.

**Two main processes are used:**

1. The sulfate (or alkaline) method - digestion of chips in a caustic soda lye
2. The sulfite (or acid) method - digestion in acid.
Most modern pulp mills run the more environmentally friendly sulfate method, the sulfite method is the older traditional one.

**i.) Sulfate process**
An alkaline process, sometimes known as the kraft process, it can be used for softwoods and hardwoods equally.

Approximately 85% of the chemical pulp produced worldwide is *sulfate pulp*.
Caustic soda (sodium hydroxide - NaOH), sodium sulfide (Na$_2$S) known as white liquor are cooked with a continuous feed of woodchips inside a continuous digester (Kamyr digester).

During combustion sodium sulfate is reduced to sodium sulfide by the organic carbon in the mixture:

1. \[ \text{Na}_2\text{SO}_4 + 2 \text{C} \rightarrow \text{Na}_2\text{S} + 2 \text{CO}_2 \]

This liquid is mixed with calcium oxide, which becomes calcium hydroxide in solution, to regenerate the white liquor used in the pulping process through an equilibrium reaction:

2. \[ \text{Na}_2\text{S} + \text{Na}_2\text{CO}_3 + \text{Ca(OH)}_2 \rightleftharpoons \text{Na}_2\text{S} + 2 \text{NaOH} + \text{CaCO}_3 \]

After only 2-3 hours the fibres separate easily and so maintain their full lengths, yielding a pulp which will form strong and will form paper. The process yield is high and effluent disposal relatively easy. This pulp has a lower degree of whiteness.

Sulphate (or Kraft) pulp: pulp produced by cooking wood chips in pressure vessels in the presence of sodium hydroxide (soda) liquor. The pulp may be unbleached or bleached.

**End-use:** widespread uses - pulp used for graphic papers, tissue and carton board, wrappings, sack and bag papers, envelopes and other speciality papers.

**ii). Sulfite process**
The sulfite process produces wood pulp which is almost pure cellulose fibers by using various salts of sulfurous acid to extract the lignin from wood chips in large pressure vessels called digesters. The salts used in the pulping process are either sulfites (SO$_3^{2−}$), or bisulfites (HSO$_3^{−}$), depending on the pH. The counter ion can be sodium (Na$^+$), calcium (Ca$^{2+}$), potassium (K$^+$), magnesium (Mg$^{2+}$) or ammonium (NH$_4^+$).

The pulping liquor for most sulfite mills is made by burning sulfur with the correct amount of oxygen to give sulfur dioxide, which is then absorbed into water to give sulfurous acid.

\[ \text{S} + \text{O}_2 \rightarrow \text{SO}_2 \]

\[ \text{SO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{SO}_3 \]
The cooking liquor is prepared by adding the counter ions as hydroxides or carbonates. The relative amounts of each species present in the liquid depend largely on the relative amounts of sulfurous used. For monovalent (Na⁺, K⁺ and NH₄⁺) hydroxides, MOH:

\[
\begin{align*}
H_2SO_3 + MOH & \rightarrow MHSO_3 + H_2O \\
MHSO_3 + MOH & \rightarrow M_2SO_3 + H_2O
\end{align*}
\]

**Sulphite pulp:** produced by cooking pre-cut wood chips in a pressure vessel in the presence of bisulphite liquor. The pulp may be either bleached or unbleached.

**End-use:** ranges from newsprint, printing and writing papers, to tissue and sanitary papers.

**Advantages** of chemical pulping: stronger and longer-lasting papers with better colour, better brightness.

**Disadvantages:** much more expensive than mechanical or mechanical/chemical pulping, lower yield, more effluent problems, reduced choice of tree stock.

**D. Recycled or deinked pulp (DIP)**

Recycled pulp is also called deinked pulp (DIP). DIP is recycled paper which has been processed by chemicals, thus removing printing inks and other unwanted elements and freed the paper fibres. The process is called deinking.

DIP is used as raw material in papermaking. Many newsprint, toilet paper and facial tissue grades commonly contain 100 percent deinked pulp and in many other grades, such as lightweight coated for offset and printing and writing papers for office and home use, DIP makes up a substantial proportion of the furnish.
1.4 Bleaching

Pulp is bleached for a number of reasons. To produce high quality paper a pulp is required which does not discolour during storage or go yellow when exposed to sunlight, and which retains its strength. Bleaching achieves all three requirements and has the additional advantage of improving absorption capacity, removing any small pieces of bark or wood left behind as well as giving a high level of purity.

Two main sets of chemicals are used in bleaching: those relating to chlorine, and those relating to oxygen and hydrogen peroxide. In many countries the use of chlorine for bleaching is under attack from environmentalist legislation. Oxygen and hydrogen peroxide bleaching processes are more environmentally friendly and are gaining in use.

The degree of bleaching which a pulp will undergo is affected by the qualities required in the final paper. Processing variables include: dwell time, bleach temperatures, the condition of the unbleached fibre.

Multistage Bleaching
Here, chlorine is passed into the pulp-water mixture. The chlorine reacts with the small amount of lignin still remaining.

The chlorinated lignin is then removed by treatment with caustic soda (NaOH).

The final bleaching is carried out with calcium hypochlorite. The caustic soda and calcium hypochlorite mixture oxidizes the small amount of colored materials in the fibres to colorless materials.

By this process, the pulp becomes nearly white. The above is an example of multistage bleaching involving three stages.

Bleaching of sulfate pulp uses more than three stages, with chlorine dioxide (ClO₂), being used in the final stages to improve the brightness.

**Stock preparation**

Stock preparation means the whole sequence of final processes which must take place to reliquary the pulp, add to it any chemicals or other loadings or fillers needed and bring it to the final furnish (recipe) and consistency required for the papermaking machine. In short, stock preparation includes fiber refining and the blending of fibrous and non-fibrous materials into the desired proportions for the papermaking furnish.
In an integrated pulp and paper mill (i.e., one in which the pulping and papermaking facilities are on the same site) finished pulps are kept in liquid state and are pumped to the stock preparation area of the paper mill directly.

In non-integrated pulp mills, the final slush pulp mixture is drained over a gauze covered cylinder or series of drying screens, is pressed out, and is finally sheeted for transport in bales to the paper mill.

**Breaking**

Breaking is the process of returning the pulp sheets to liquid form. It is carried out in a hyrapulper or slusher, a large circular metal tank in which the sheets of pulp are dissolved and mixed in water.

This is the point at which a number of other ingredients will be added.

1) Sizing Agents:
Addition of some sticky substances to the fibres, and loading materials to bind them together is called sizing.

The sizing materials are added inside the furnish to improve a paper’s water-resistance and prevent ink from ‘feathering’ on its surface when the paper is printed.

Sizing gives paper an improved finish, reduce fluffing.

The quantity of size used varies with the grade of paper being produced:

- **unsized**: eg blotting paper
- **slack size**: gives fast ink penetration, eg newsprint
- **medium sized**: a compromise between excessive absorption and speedy drying, eg uncoated book stock
- **hard sized**: as used for offset litho cartridge papers.

The traditional substances used are rosin, alum and casein. Alum (aluminum sulphate), however, is mildly acidic and as alternatives a number of synthetic, chemically neutral sizes have been developed which replace the traditional rosin/alum formula.

2) **Loadings, fillers, and coloring materials**:

These are minerals or compounds added to the stock to improve the opacity, formation, printability, dimensional stability or other characteristics in the finished paper. Printings and writings paper commonly contain up to 15% - 25% of fillers by weight. Other papers, designed for strength and rugged use, such as bond and ledger papers, may contain only 2% - 6% of fillers. The most common fillers are:

- **china clay**: to give a smooth surface for printing (especially for illustration printing) and to accelerate ink drying. Unique combination of firm, smooth, pliant properties
- **calcium carbonate**: for hardness, opacity and whiteness. Increasingly common alternative to china clay to give properties of brightness, light fastness and opacity, but has a tendency to blacken when calendered and is very abrasive
- **titanium dioxide**: for opacitying but very expensive. Has the effect of reducing the permanence of the paper and the efficiency of any OBAs present (see below). Often used in conjunction with china clay or calcium carbonate

**OBAs/FWAs**: Optical Brightness Agents/Fluorescent Whitening Agents. Mineral compounds used to improve whiteness and fluorescence

- **wet strengths**: chemicals used to improve this property. Include sulphuric acid, formaldehydes, polyamides.

3) **Chemical additives**

- **antifoamers**: to disperse the froth or foam produced during stock preparation
retention aids: to keep the fillers in the paper from falling through the wire of the papermaking machine (see below). Include sodium silicate, gum

slimicides: chemicals to keep down the presence of slime-producing microbes. Include chlorine, chloramines

Colouring materials
Dustiffs / Pigments, and whitening agents are added to improve the whiteness of paper or to produce colored papers.

4) Refining (beating)
This makes the fibers, more flexible and increases their surface by fibrillating (roughening or fraying) them so that more area is available for bonding.

From the hydropulper the stock is pumped through a series of cone refiners. These are enclosed conical containers inside which a series of metal blades rotate from a central shaft against static blades built inside the outer casing.

The fibres are mechanically modified: they are teased apart, separated and fibrillated so that their walls collapse and become fragmented.

The purpose of refining is to make the fibres spread and absorb more water, as this will enable them to bond more readily on the wire of the papermaking machine at the next stage.

The time allowed for the refining stage is critical in determining the characteristics of the finished sheet:

prolonged refining reduces the length of the fibres dramatically and beats water into them so that on the wire of the paper machine they will bond without air and produce a paper like greaseproof paper excessively short refining will not fibrillate the fibres in the pulp enough to allow them to mesh tightly on the wire, and the result will be a soft, bulky sheet like blotting paper.
UNIT I

2 Marks Questions

1. **What is paper?**
   Paper consists of a compact web, of felting of vegetable fibres, usually in the form of a thin flexible sheet.

2. **State the raw materials used for Paper Manufacturing.**

3. **State the raw materials used for Board Manufacturing.**

4. **State the importance of loading materials.**
   Loading materials are added to the stock to improve the opacity, formation, printability, and dimensional stability of the finished paper.

5. **What is sizing?**
   Addition of some sticky substances to the fibres, and loading materials to bind them together is called sizing.

6. **State the importance of sizing materials.**
   The sizing materials are added inside the furnish to improve a paper’s water resistance and prevent ink from ‘feathering’ on its surface when the paper is printed.

7. **State the various pulping process.**
   (i). Mechanical pulping (ii). Mechanical / chemical pulping (iii). Chemical pulping.

8. **State the mechanical method of pulping wood fibres.**
   Mechanical pulping removes the lignin from the fibres by physical means.

9. **Expand about TMP, CTMP, BCTMP.**
   - Thermo-mechanical pulp (TMP),
   - Chemi-thermomechanical pulp (CTMP),
   - Bio-chemi-thermomechanical pulp (BCTMP)

10. **What are the common paper making fibres?**
    Cotton fibres, Linen, wood, Esparto grass, Straw, Manila, Jute, Bagasse, Bamboo

11. **What are the main characteristics of softwood pulp?**
    Long Fibres, and strength

12. **What are the main characteristics of hardwood pulp?**
    Short Fibres, good bulk, opacity and Softness.

13. **State the advantages of Mechanical Pulping.**
    Advantages: extremely high yield process with low effluent level. It has good opacity, high bulk, good printability and is cheap.
14. **State the disadvantages of Chemical Pulping.**

Disadvantages: much more expensive than mechanical or mechanical/chemical pulping, lower yield, more effluent problems, reduced choice of tree stock.

15. **State some colour additives used during paper making.**

Dystuffs / Pigments, and whitening agents are added to improve the whiteness of paper or to produce colored papers.

**3 Marks Questions**

1. **What are cellulose fibres?**

Cellulose fibres can be regarded as the common building brick of the paper. It may be of a blade of grass or in the trunk of the largest tree. In a few materials like cotton and linen, the cellulose exists in a purer form.

2. **State the processes involved in producing sulfite pulp.**

Calcium bisulfite and sulfurous acid in water are introduced into a digestion tower filled with woodchips. The chips and the liquid are cooked together for between six and twenty-four hours to extract the cellulose fibres. Compared with the sulfate process the yield is low.

A close variant of the sulfite process is the bisulfite process in which the calcium bisulfite is replaced by sodium, magnesium or ammonium bisulfite.

3. **State the differences between Mechanical wood pulp and Chemical wood pulps.**

Mechanical pulping removes the lignin from the fibres by physical means; Mechanical / chemical pulping removes the lignin by a mixture of physical and chemical means; and Chemical pulping removes the lignin by entirely chemical methods.

4. **State the processes involved in producing sulfate pulp.**

Caustic soda (sodium hydroxide - NaOH), sodium sulfide (Na2S) are cooked with a continuous feed of woodchips inside a continuous digester (Kamyr digester). After only 2 -3 hours the fibres separate easily and so maintain their full lengths, yielding a pulp which will form strong and will form paper. The process yield is high and effluent disposal relatively easy. This pulp has a lower degree of whiteness.

5. **Write the characteristics of fibrous materials.**

Fibres have the form of long usually Hollow tubes. They range in length from 1 to 7.50 mm and in width from 0.01 to 0.05 mm according to the plant in which they occur. They are essentially made up of cellulose, a chemical compound of carbon, hydrogen and oxygen formed by the plant as it grows.

6. **What is bleaching of pulp? What are its advantages? (or) State the objectives of bleaching process.**

The objective of bleaching is to brighten, whiten, purify and stabilize the pulp with minimum harm to the fibre. This can be done continuously or batch wise. Most modern bleaching is carried out as a multi-stage process.
7. **What is stock preparation?**

Stock preparation means the whole sequence of final processes which must take place to re-liquefy the pulp, add to it any chemicals or other loadings or fillers needed and bring it to the final furnish (recipe) and consistency required for the papermaking machine. In short, stock preparation includes fiber refining and the blending of fibrous and non-fibrous materials into the desired proportions for the papermaking furnish.

### 10 Marks Questions

1. Explain the manufacturing process of Mechanical and Chemical Pulps.
2. Write short notes on (i) Bleaching   (ii) Breaking   (iii) Refining
3. What is fibrous material? Explain common fibers used in paper making process.
4. Explain the various kinds of Mechanical/Chemical Pulp and write down its advantages and disadvantages.
5. Explain about manufacturing process of paper.
6. Describe the various operations involved in stock preparation of papermaking.
UNIT II
MANUFACTURING OF PAPER AND BOARD

2.1 OPERATION IN PAPER MAKING MACHINE

After stock preparation the treated liquid is now ready for release on to the paper machine.

The design of machine used for practically all paper production (as opposed to card or board production) is the Fourdrinier.

Fourdrinier machines have two main process areas: a wet end, consisting of a wire section and a pressing section; and a dry end, consisting of a dryer section and a calender section.

**Wet end**

At this stage the stock is 99% water, 1% fiber and filler. It is delivered uniformly on to a moving mesh belt through a head box (flow box).

**Head box**

*Many types include:* open head flow box, hydraulic flow box, pressurized flow box, vacuum flow box. The flow box keeps the dispersed and prevents them from flocculating (clogging together) so that a consistent and even formation can be achieved.

**Slice**
A gate slice or projection slice projects an even amount of fiber on to the wire in its cross-direction. Adjustments affect the substance and bulk of the finished paper. Fibers tend to align in the direction of flow, giving a paper its characteristic grain or machine direction. (The direction at 90 degrees to this, across the wire, is known as the cross direction.)

**The wire**

The wire is a moving belt, across which the fibers have been distributed. The stock flows along the wire and the excess water (white water) drains through to leave the embryo web of paper on its surface.

**Felt and Wire sides**

Paper produced on a fourdriner papermaking machine has a wireside and a feltside.

The wire side is the side, which is in contact with the moving wire on the wet end of the machines.

The other side is called the feltside because it comes in contact with a felt material during the drying of the web or the top side.

**Types of wire include:**

- **phosphor bronze:** these were the original types used
- **synthetic:** have replaced phosphur bronze wires and are used for almost all grades.

The wire is the drainage and forming element of the machine. Synthetic wires are used because of greater stability, better control over de-watering, reduced wire mark and longer life. Drainage is aided by table rolls, foils, suction boxes which draw the white water down by suction.

The two surfaces of the newly forming paper have visually different characteristics:

- **wireside:** the under side with a poorer surface, rougher due to the drainage of the excess water in the stock through the machine wire. Also known as the underside or wrong side
- **feltside:** the upper side, often smoother since the longer (denser) fibers tend to settle first. Also called the top side or right side.
**Dandy roll**

The dandy roll is a hollow roll with a variety of possible coverings, but usually metal wire.

Its main functions are:

i) Consolidate the sheet by compacting the fibers

ii) Apply or create watermarks, which are permanent visual designs placed in the paper by making the fibers more translucent makes that are embossed or soldered into the dandy roll wire leave an impression - watermarks – while rotating into the wet web. Elevations result in light water marks, and sinks (from compaction of pulp) in dark water marks, also referred to as “light shade water marks”.

iii) Give a flatter top surface and improve the distributing the fibers more evenly.

Marks that are embossed or soldered into the dandy roll wire leave an impression - watermarks - while rotating into the wet web. Elevations result in light water marks, and sinks (from compaction of pulp) in dark water marks, also referred to as “light shade water marks”.

Dandy roll coverings (supported sleeves) give finish characteristics to this side of the web, eg wove, laid, watermark, etc.

**Press section (Wet Pressing Section)**

At the end of the paper wire the embryo paper web ‘jumps the gap’ to the press section of the machine. It is transferred on to an endless felt belt which passes through a series of rollers which compact the fibers and remove as much water as possible. In this process the moisture content is reduced to 60-70%. The amount of pressure and the dwell in the press section both affect the final bulk and the final finish of the paper: open, bulky book antiques need less pressing, smooth MF printings need more.
**Drying section**

The web passes through graded steam-heated drying cylinders with low temperature cylinders initially and high temperature cylinders further down the line. If the early banks of cylinders become too hot this can cause such problems as picking, cockling and dye migration. The web is supported around the cylinders by further belts made of felt. At the end of the drying section the moisture content is down to a final 2-8%.

**Additional operations during the drying process may include:**

**Surface sizing:** sometimes called pigmenting, this involves the application of size to the surface of the paper (as distinct from into the furnish, where it is added at the breaking stage). This is done to improve the porosity of the surface.
SURFACE SIZING

*Machine calendering:* the use of polished steel rollers at the end of the paper-making machine to give a smooth finish known as MF, or machine finish

*Machine glazing (MG):* a smoothly polished cylinder which gives a high finish to one side of the paper.

**2.2 PAPER FINISHING**

A variety of ‘off machine’ options are available after the base paper has been made. A number of operations may be carried out on a paper after it has been rolled up on the machine before it is despatched. These operations give the ‘finish’ or surface properties of paper. These are important to the printer for printing. The term ‘finish’ describes the final surface or texture, softness and gloss of paper.

*Supercalendering*

Distinct from machine calendering. The finished web is passed through further highly polished steel and fiber packed rollers which give it a polished, smooth surface. Papers treated in this way are known as sc papers.
Coating

Coating a paper increases its opacity; improves surface smoothness and ink hold out (important for litho printing, and especially for illustration printing); and greatly enhances ink gloss.

The two main coating mixes used are china clay, precipitated calcium carbonate (chalk). China clay has unique properties of smoothness, hardness yet pliability; calcium carbonate is bright and white, but distinctly more abrasive. An alkaline substance, it cannot be used in 'acid' papers which contain alum/rosin sizing. China clay is inert and can be used in papers with any furnish.

Binding agents include casein, starch, synthetic resins or latex compounds (now most common). These allow the coating mix to be thicker but still easy flowing, and provide a flexible coating receptive to a good gloss with calendering.

Other additives may include pine oil (to minimise frothing) and preservatives or wax to enhance gloss.

Coating processes

The different coating methods possible give a range of options in coat weight, in coat density (which affects the rate of ink penetration), in the degree of smoothness achieved and in the degree of print gloss and density. Coating may be carried out on or off the papermaking machine.

Some common methods are:

1. Roll coating: a light coating is transferred to the paper by roller
2. **Blade coating**: a faster process which produces good print quality with less coating. A thin steel blade spreads the coating to produce a flat even surface. Either left as a matt finish or supercalendered to produce a gloss finish. Combines good quality with reasonable cost and is the most common coating method.

3. **Air-knife coating**: the coating is leveled and the excess removed by a stream of compressed air (air knife). Can produce high coating weights. With a good base paper, produces good print quality - with minimum supercalendering. It is a faster process than brush coating and has replaced it for producing art paper.
4. **Brush coating**: the coating is distributed over the base stock by a series of brushes, some stationary, some oscillating. Replaced by other methods except in very specialist applications.

5. **Cast coating**: the coating is dried by passing the coated paper under pressure over a hot, highly polished cylinder, leaving it with a perfectly smooth, high gloss surface.
without the need to compact the coating by super calendering. Produces excellent ink receptivity.
a Cast-coating method
1 Application unit
2 Paper web, uncoated
3 Impression roller
4 Paper web, precoated on one side
5 Cast-coating cylinder
6 Paper web, cast-coated on one side
Slitting: Paper reels of the full deckle (paper machine width) are slit and rewound to the desired width and diameter for the printing press.

Sheeting: Sheetling is usually performed by paper mills but can also be handled by specialist paper converters.

The two main methods are:

- **rotary trimming**: a rotary trimming machine cuts the web at predetermined intervals
- **precision sheeting**: a more accurate, often computerized, version of rotary trimming which has now largely replaced it.

**Mill conditioning**

This is an extremely important process: its purpose is to allow the paper to stabilize its moisture content before it is packed. If a paper is packed with too much moisture still inside it, the excess moisture will start to leave the sheet into the atmosphere from the outside edges outwards, so causing the edges to dry out and tighten up while the center of the stack remains baggy. This is known as tight edges. If on the contrary a paper is packed with insufficient moisture, the outside edges of the stack will start to take in moisture from the atmosphere while the inside of the stack remains taut, so causing wavy edges.

2.3 Packing and delivery

**The following precautions are always worth taking:**

- **Packets** where possible specify moisture-proof wrappers, so long as they are strong enough to avoid splitting when handled. Sheets are usually packed in 1,000s or parts of 1,000 depending on the quality and weight of packet. The size, substance and weight of each packet should be clearly labeled.
Pallets must be strong enough to carry the load required, should allow four-way entry by a standard fork lift truck, and have feet strong enough to allow safe stacking. The pallet base should be flat and even and be slightly bigger than the sheet size to avoid edge damage. Binding straps should not be too tight in order to avoid distortion or damage. Waterproof wrappers or shrink wrapping should be used around the outside of the finished stack.

Covers secured to the flat ends where metal cores are not used, seasoned wood or plastic plugs should be fitted to cores to prevent damage if dropped. Reels should be stored on end to avoid distortion.

Marks Full description on all packets/pallets/reels is very important and should include:

✓ quality, quantity
✓ size
✓ grammage
✓ colour
✓ making order number
✓ grain direction.

On reels it is important also to indicate the unwind direction and whether the reel is wound topside in or out (ie whether the feltside as opposed to the wireside faces inward or outward).
Handmade paper for specialist use is made sheet by sheet with the wire immersed in a hand-held wooden frame (deckle). It is generally of special furnish, traditionally rag content. The resulting properties include high permanence and durability.

It is usual in the making of handmade paper for the deckle edges to be left uncut (feathered edges) and for traditional characteristics such as watermarks to be included. Its manufacture requires craft skills which are extremely expensive. It is only feasibly specified for top quality specialist purposes such as craft printing and binding, or for artist’s paper.

Handmade paper is traditionally made in three finishes ranging in decreasing smoothness from HP (Hot Pressed), through NOT (Not Hot Pressed), to Rough.

2.4 Board making Process

Board is usually defined as paper above an agreed substance (220-225gsm in UK; 250gsm in many other countries). It can be single ply or multi-ply. The multi-ply structure consists of top liner, under liner, middle, and back liner. Much of the making process is similar to paper. Points to note include:
Raw materials for manufacturing of Board

Wood chips, shavings, and sawdust typically make up the raw materials for fiberboard. However, with recycling and environmental issues becoming the norm, waste paper, corn silk, bagasse (fibers from sugarcane), cardboard, cardboard drink containers containing plastics and metals, telephone directories, and old newspapers are being used.

The above-mentioned fibrous material can either come from fresh (virgin) sources (e.g. wood) or from recycled waste paper. Around 90% of virgin paper is made from wood pulp. It is now mandatory in many countries for paper-based packaging to be manufactured wholly or partially from recycled material.

Furnish

Basically the same as for paper, ranging from high quality bleached pulps down to recycled waste paper. Stock treatment is basically the same as for paper. If waste paper is used, more cleaning and screening may be required. Board is generally given a lesser degree of beating/refining in order to ensure efficient drainage.

The liner plies are often given conventional beating and refining to develop their strength while the middle stock is hardly given any mechanical treatment, just simply broken then lightly refined.

Manufacture

In multi-ply board, the plies may be combined on-machine or off-machine.

In the case of on-machine boards, either Fourdrinier or vat process machines may be used.

In the case of the Fourdrinier manufacturing process, the board is built up on the wire from a series of Inverform units, each of which contains a headbox depositing successive layers on each other.
The vat board-maker, on the other hand, consists of a number of vats or cylinder units, in-line, in each of which revolves a large hollow cylinder. Each cylinder picks up a layer of stock and deposits it on the underside of a moving felt, which carries the first ply of board. The layers are built up progressively; and at the end of the wire the board is removed for drying.

In the case of off-line finishing, the resulting boards are known as pasted boards to distinguish them from the homogenous product, which comes off a single machine. A number of webs of board are unreeled in parallel to each other; adhesive is applied to the top surface of all but the top sheet; and a pressing cylinder finally brings all the reels together, joining them to create a single reel of thicker board. The edges are slit to provide flush edges to the new reel.
Finishing

The range of operations in finishing correspond to those for paper and can include calendering; supercalendering; coating; slitting; sheeting; conditioning; and finally packing for despatch.
UNIT II

2 Marks Questions

1. What is Super Calendaring?
   Distinct from machine calendaring. The finished web is passed through further highly polished steel and fiber packed rollers which give it a polished, smooth surface. Papers treated in this way are known as SC papers.

2. What are the points to be considered while choosing paper for Letterpress Printing?
   Papers used for letterpress printing must have smoothness, absorbency, opacity, and compressibility.

3. State the desirable properties of cellulose which are to be used for papermaking.
   Cellulose fibers can be regarded as the common building brick of the paper. It may be of a blade of grass or in the trunk of the largest tree. In a few materials like cotton and linen, the cellulose exists in a purer form.

4. How will you choose paper for Offset Printing Process?
   When paper is choose for offset printing the paper must have good surface strength and good dimensional stability.

5. State the uses of text paper in Printing.
   News print printing and Bible printing

6. How is paper tested for Offset Printing?
   This paper must have good surface strength, good dimensional stability.

7. Define Wet end.
   At this stage the stock is 99% water, 1% fiber and filler. It is delivered uniformly on to a moving mesh belt through a headbox (flow box).

8. Define wire.
   The wire is a moving belt, across which the fibers have been distributed. The stock flows along the wire and the excess water (white water) drains through to leave the embryo web of paper on its surface.

9. What is machine glazing?
   A smoothly polished cylinder which gives a high finish to one side of the paper.

10. State the types of coating method.
    Roll coating, blade coating, air-knife coating, brush coating and cast coating.

11. What are the finishing operations in paper and board making machine?
    Calendering, supercalendering, coating, slitting, sheeting, conditioning and finally packing for dispatch.

12. What are the points to be considered while choosing paper for Gravure Printing?
Gravure printing smoothness is the most important property in this process, should not contain abrasive material.

13. Mention the name of paper making machine.
   Fourdrinier Machine.

14. Write down what are the types of head box used in paper making machine.
   Open head flow box, hydraulic flow box, pressurized box, vacuum flow box.

3 Marks Questions

1. State the functions of Dandy roll.
   The dandy roll is a hollow roll with a variety of possible coverings, but usually metal wire. Its main functions are:
   I. to consolidate the sheet by compacting the fibers
   II. to apply or create watermarks
   III. to give a flatter top surface and improve the distributing the fibers more evenly.

2. What is wireside and feltside?
   The wireside is the side which is in contact with the moving wire on the wet end of the machines.
   The otherside is called the feltside - because it comes in contact with a felt material during the drying of the web or the top side.

3. What are uses of Drying section in Paper making machine?
   The web passes through graded steam-heated drying cylinders with low temperature cylinders initially and high temperature cylinders further down the line. At the end of the drying section the moisture content of paper is down to a final 2-8%.

4. What is Slice?
   A gate slice or projection slice projects an even amount of fiber on to the wire in its cross-direction. Adjustments affect the substance and bulk of the finished paper. Fibers tend to align in the direction of flow, giving a paper its characteristic grain or machine direction. (The direction at 90 degrees to this, across the wire, is known as the cross direction.)

5. State the difference between slitting and sheeting.
   Slitting is paper reels of the full deckle (paper machine width) are slit and rewound to the desired width and diameter for the printing press.
   Sheeting is usually performed by paper mills but can also be handled by specialist paper converters. Machine cut the web into paper.

10 Mark Questions
1. Explain briefly the various stages in paper making process.
2. Explain the operations in papermaking machine.
3. Explain the process involved in manufacturing of paper.
4. Explain about raw materials for manufacturing board.
5. Explain briefly the precautions taking in packing and delivery of paper.
UNIT III

PAPER, BOARD – TYPES, SIZES AND PROPERTIES

3.1 CLASSIFICATIONS OF PAPER FOR PRINTING

Paper can be separated into four main categories:

1. Printing papers of wide variety.
2. Wrapping papers for the protection of goods and merchandise. This includes wax and kraft papers.
3. Writing paper suitable for stationery requirements. This includes ledger, bank, and bond paper.
4. Specialty papers including cigarette paper, toilet tissue, and other industrial papers.

I. Printing paper

All paper for printing must be receptive to ink and have reasonable strength, opacity and colour. A certain minimum strength is required for the actual printing operation, but beyond that come the varying demands made on the printed product during its lifetime. For example, although strength and durability are important in the short life of a newspaper, they are essential for the pages of a reference book. If the paper lacks good opacity printed matter shows through on the other side of the sheet (Show Through). The effect is particularly objectionable when the paper is printed on both sides.

Newsprint

This comes from groundwood pulp and usually runs on open web presses. It can be sheetfed, but runs slowly due to lack of body and impurities that lead to frequent cleanings of plates and blankets. The impurities also make this very inexpensive stock opaque but likely to yellow with age.

Inexpensive paper made primarily of mechanically ground wood pulp rather than chemical pulp is known as newsprint. It has a shorter lifespan than other papers but newsprint is cheap to produce in bulk and is the least expensive paper that can withstand normal printing processes. Newsprint has a basic size of 24" x 36".

Coated papers:

A coated stock has a surface coating that has been applied to make the surface more receptive for the reproduction of text and images in order to achieve sharper detail and improved color density. By adding a coated clay pigment, the objective of coating the stock is to improve the smoothness and reduce the absorbency.

Coated paper finishes can be categorized as matte, dull, cast, gloss, and high gloss. The coating can be on both sides of the stock (coated two sides, "C2S") or on one side only (coated one side, "C1S"). From these subcategories, paper stocks are then separated into types such as offset, bond, cover, index, and vellum bristol.
1) **Gloss art paper** is coated on both sides with china clay or chalk and calendered to give a very high smoothness and gloss.
   - It is used for the printing of halftones and color, and high-quality magazines and promotional material.
   - The base paper of cheaper coated papers can contain groundwood or recycled fiber.

2) **Matt art or silk-finish coated paper**, is produced in a similar way to art paper by coating with china clay or chalk, but the calendering process is only used to consolidate the surface rather than to produce a high gloss.
   - The surface has a matt appearance but still gives excellent reproduction of black and white halftones and four-color images without the glare effect from gloss interfering with the ease of reading the text portions of the publication.

3) **Blade-coated cartridge paper** is midway between being an uncoated and a matt art paper.
   - Has a lighter coating than art and matt art paper, but reproduces halftones well.
   - Used for some magazine work and illustrated books.

4) **Chromo paper** is coated on only one side and is used for posters, proofing work, and the printing of book jackets and labels.

5) **Cast-coated papers** are characterized by exceptionally high gloss.
   - Cast-coated papers are used in the production of prestigious cartons or covers for presentation material, and corporated annual reports.

**Uncoated (woodfree)**

Uncoated stock is paper that has no coated pigment applied to reduce the absorbency or increase the smoothness. The uncoated finishes can be described as vellum, antique, wove, or smooth.
   - This paper is still made from wood pulp, but it is produced by the chemical, rather than the mechanical process.
   - To be described as woodfree, the chemical wood pulp content should be at least 90%.
   - Strong sheets with good whiteness are produced for use as general printing and writing papers, stationery, copying papers, and magazine papers.
   - These grades will take color, but with not such good results as coated qualities.
   - Includes: “bond” paper with fine formation (used for stationery), and “bank” that is a lighter weight version of bond.

**Tree-free Paper**
• Plants, such as hemp, kenaf and bamboo, that yield fiber faster than trees.
• Agricultural waste such as sugar cane, straw from wheat and rice, and byproducts from coffee, banana and coconut plants.

RECYCLED PAPER
Contains a percentage of fibers made from either post-consumer waste (wastepaper) or pre-consumer waste (cleaner paper waste, known as “broke”, from printers or the paper mill itself).

HANDMADE PAPER
• Small amounts of paper are still made by hand for prestigious applications such as letterheads, limited-edition books, and artists’ paper, where completely random orientation of fibers is important, particularly for watercolor paintings.
• The process is very slow and expensive, as each sheet has to be handproduced.

MOLD-MADE PAPER
This is a high quality grade of paper usually made from cotton rag pulp on a cylinder mold machine, rather than a Fourdrinier machine (paper making machine).

Acid-free PAPER
• Acid-free is paper with a pH rating of 7 or higher rating of alkalinity. It has a much longer life expectancy, and is used for books and other publications that are intended to last in good condition.
• It is treated to neutralize the acids that occur naturally in wood pulp. Where paper is not acid-free, it can yellow and deteriorate over time.

Cartridge papers
• These are tough, hard, sized papers that were originally used in the production of cartridges. The term has been extended to most rough-surfaced heavy papers, such as papers used for drawing and painting.

ANTIQUE
• This relates to bulky paper with a naturally rough finish (antique wove), similar to that of an uncalendered handmade paper.
• Used in the production of books.

ANTIQUE LAID
• This has a different surface characteristic as it shows the laid lines and chain marks of the roll within the surface.
• Not suitable for halftones or line work with large solid areas of color or fine detail.

ENGLISH AND SMOOTH FINISHES
• Although uncoated, these are often used for publications that contain black-and-white halftones or color work.
• The smoothness of these finishes provides a receptive surface for the reproduction of fine line illustrations and photographs.

**PAPERS FOR DIGITAL PRINTING**
• Many digital presses use toners instead of conventional offset inks, and these react with heat as the image is fused onto the paper.
• Coated stocks can cause problems in electrographic printing, as the coating acts as an insulator.
• The moisture levels are more critical in digital printing.

**II. Writings paper**
Writing paper is usually finished with a smooth surface and sized and that can be written on with ink.

Writing papers must have good strength, colour, and surface finish. They must have a consistently good appearance and be sufficiently sized to prevent water based ink from passing in. The highest quality writing, drawing and blotting papers are made from rag. The lowest quality writing papers contain a high proportion of mechanical wood.

**Banks**
Bank paper is a thin strong writing paper of less than 50g/m2 commonly used for typewriting and correspondence.

**Bonds**
Bond paper is a high quality durable writing paper similar to bank paper but having a weight greater than 50 g/m2. It is used for letterheads and other stationery and as paper for electronic printers. Widely employed for graphic work involving pencil, pen and felt-tip marker. It is largely made from rag pulp which produces a stronger paper than wood pulp.

**Manifold and onion skin paper**
*Manifold* is a very thin bank paper, usually about the substance of 30g/m² and sometimes called *flimsy*.

It was in popular use when many carbon copies of typewritten or handwritten matter were required to be made at the same time. They are also used for special forms, airmail stationery, light weight reports and catalogues.

*Airmail* is a lightweight paper of better furnish, but similar weight and its name indicates its use.

**Ledger or Account paper**
This is another kind of writing paper used for ledgers, strong, generally azure in shade (light blue), water marked and well finished without glaze. All such papers are sized to take writing ink, the best are tub-sized, the others engine sized. Grammages available are from 85 to 120 g/m$^2$. The best grades are hand made from rags. Account book paper are also known as ledger paper and are available in a wider range of sizes.

**Duplicators**

Duplicators are a type of paper produced for use with duplicating machines, for which the characteristics of softness, matt finish and a certain degree of absorbency are required for a good impression.

Duplicating papers are really unglazed writings of short-fibre furnish, containing only a small amount of size and somewhat resembling blotting paper, except that they are neither so thick nor so soft. Semi-absorbent, half-sized duplicators contain slightly higher proportions of size and, therefore, have a higher degree of resistance to ink. They are made white or tinted, wove or laid, and the better grades are watermarked. Duplicator paper is normally only available in 70g/m$^2$ and 80g/m$^2$.

**III. Wrappings paper**

Wrapping papers are primarily required to give protection where strength is important. The fibres should be long and beaten in such a way that they form a strong inter-meshed structure.

Kraft paper is familiar popular wrapping paper in brown colour. Bleaching is omitted since it tends to reduce the strength. The strongest kraft paper contains sulphate pulp. They are produced in various colours and may be machine glazed. The M.G. papers are widely used in making paper bags.

**Cover papers**

Cover is a generic term given to a wide range of strong-coloured papers suitable for use as covers for booklets, brochures and so on. Cover papers are usually thick papers with good folding and wearing qualities. They may be plain or finished with embossed surface, such as hammer, ripple, leather and cambric.

**Cover board**

Cover board is a thicker form of covering material, produced by pasting together two sheets of cover paper on a twin-wire machine. It is used when a more rigid material is required. The laminated versions can be a different colour each side and are usually finished by specialist houses, not by the mills themselves.

**IV. Speciality papers**

These are papers intended for specific purposes. Examples include:

**Carbonless/self copy paper**
This paper, where a range of white and coloured stock has been specially coated to produce an image in blue or black when pressure is applied. It is made up into sets with a top sheet coated on its underside, middle sheets coated differently on both sides, with the bottom sheet coated on the face only. Papers are available in sheet and reel form in grammages ranging from 40 to 240g/m².

**Gummed papers**

These are available in dry gummed paper, which have to be wet for application, and are available in a wide range of finishes including MF, cast coated, chromo and coloured. A very wide range of self-adhesive papers and foils is also available in sheet and reel form.

Other speciality papers include fluorescent, cloth-lined, mottled parchment, metallic/foil surface, glassine/vegetable parchment and embossed finishes papers.

**Different types of boards**

When the substance of paper exceeds 220 grammes per sq. meter it should be considered a board. There is a wide range of white and tinted board used for printing and packaging.

Paper Board is a general term to describe the heavier weight grades of paper. The thickness at least is tenth-thousand of inch (0.01"). The paper board is the most common substrate used in the packaging industry of making boxes, folding carton, shipping container and other consumer product packages.

**Pulp board**

Pulp board is manufactured in a single web-like paper and has an underside and topside. Twin-wire pulp boards are even-sided, being formed from two webs on the machine. Quality varies with furnish, which may be mechanical, woodfree or a mixture, and the finish is usually matt or supercalendered. White and tinted boards are produced from approximately 200 to 750 microns.

**Index board**

Index board is used for card-index systems and office-records and is produced in a range of tints and substances similar to pulp board, which it closely resembles. Index boards are made on both single-wire and twin-wire machines with a high machine finish to give a good printing and writing surface.

**Paste board**

Paste board is more rigid than pulp board, having a middle of the required thickness lined on both sides with white or tinted lining paper. It is produced in thicker substances than pulp board.

**Triplex board**
Triplex board is made up of three layers while *duplex board* consists of two plies or webs which are similarly combined in a moist state on the machine, but differ in quality or colour. A paste board should be distinguished from, say, a white-lined folding box board made on a cylinder-mould machine in which one vat contains a white pulp while the others may have recycled or mechanical pulp, all of which come together to form one web on the machine. Calliper ranges from 280 microns up to a high as 2500 microns.

**Coated art boards**

Coated art boards are pulp or paste board coated on one or both sides.

**Cloth-lined and cloth-centre boards**

*Cloth-lined* and *cloth-centre boards* are used when extra strength is required. The former consists of a board backed with linen canvas or linen and the latter of three layers with the cloth at the centre-lined on both sides with thin board or paper.

**Strawboard**

Strawboard was traditionally made from straw pulp and is a solid cheap board used in bookbinding, not for printing. *Millboard* and *chipboard* have similar uses but are superior in quality to strawboard.

**Carton boards**

*Carton boards* are predominantly of a multi-ply construction. A further feature of carton boards is the rigorous testing carried out on the materials during production and subsequent conversion into cartons. The areas covered include conditioning, grammage, thickness, moisture content, board stiffness, internal tear strength, brightness/whiteness, water absorption, print colour, print register, light fastness, print rub resistance, carton crease quality, cutting quality, bar coding, odour and taint influencing flavour of the product.

**Chip boards**

*Chip boards* are made entirely from wastepaper pulps. All though of similar quality to straw boards, they are less rigid but have better folding properties.

**Mill boards**

*Mill boards* are made by allowing a layer of wet pulp wind round the cylinder several times when the correct number of plies has been brought together. The web of pulp feeding the cylinder is cut. The sheets are pressed and dried, then milled between rollers. This process is slow and expensive. That are used for ledgers, suit cases, and stiffeners in boots and shoes.

**Art board and Chromo board**

*Art board and Chromo board* are similar to art and chromo paper but of heavier substance, being pulp or paste board coated on both or one side.

**Specialist boards, including non-cellulose-based materials**
Like papers, there is a wide range of speciality boards produced for specific needs and applications. These include:

**Metallic finished boards**

Metallic finished boards, which are mainly used for high-end quality packaging, are produced by applying and/or laminating a metallic finish to base boards resulting in a range of colours, some with holographic patterns.

**Foam centred boards**

Foam centred boards, which are used predominantly for display purposes, consist of a foam centre with a variety of finishes including plain white surface, self adhesive single- or double-sided, also aluminium backed.

**Beermat boards**

Beermat boards, which take the form of two-sided bleached highly absorbent board.

**Corrugated boards**

Corrugated boards, which are mainly used for packaging, box and case construction, also point-of-sale work, are constructed in fluted form - ie - with a middle sandwich of a continuous series of waves or arches of material giving the board the properties of rigidity and cushioning, with white or brown paper lining one or both sides.

In addition to the above cellulose fibre based types of board, there is a wide range of plastic-based sheets or boards, including:

**PVC**

PVC sheets in a wide range of finishes including clear, white, opaque, gloss and matt, plus foamed.

**Polypropylene**

Polypropylene is available in a wide range of finishes and forms such as fluted in white and black-matt and gloss, also colours; extruded and/or embossed in pearl, sand finish, clear and a wide range of colours.

PVC, polypropylene and other plastic-based products such as polyester and polystyrene in sheet form are used for a wide range of products including file covers, cartons, promotional displays, coasters, disk and mouse mats, promotional document wallets and cases.

**Some common paper and cardboard grammages**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>gsm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon copy and airmail paper</td>
<td>25</td>
<td>-</td>
<td>40</td>
</tr>
<tr>
<td>Thin printing paper</td>
<td>28</td>
<td>-</td>
<td>60</td>
</tr>
<tr>
<td>Newsprint</td>
<td>36</td>
<td>-</td>
<td>60</td>
</tr>
<tr>
<td>Endless paper</td>
<td>40</td>
<td>-</td>
<td>170</td>
</tr>
</tbody>
</table>
Illustration printing paper and cardboard  
| 55  -  400 gsm |

Writing and typewriter paper  
| 60  -  90 gsm |

Book paper  
| 60  -  120 gsm |

Uncoated offset paper and cardboard  
| 60  -  300 gsm |

Art print paper  
| 90  -  350 gsm |

Postcard board  
| 150  -  300 gsm |

Index board  
| 190  -  400 gsm |

Boxboard  
| 200  -  500 gsm |

3.2 CHOICE OF APPROPRIATE QUALITY OF PAPER FOR DIFFERENT PRINTING PROCESS

Each of the different printing processes requires certain characteristics in a substrate to function effectively.

**Papers for Letterpress Printing:**

Papers used for letterpress printing must have smoothness, absorbency, opacity, and compressibility.

Papers used for letterpress printing may range from a tissue paper to a thick board. The impression is obtained under controlled pressure. The paper is forced against the inked image for transfer of ink to paper.

For fine screen halftone reproduction by letterpress printing, coated paper is a necessity. Letterpress cannot print fine screen half-tones on rough surfaced papers. The finer the halftone screen, the smoother the paper surfaces should be.

**Paper for Offset Lithography Printing:**

This paper must have good surface strength, good dimensional stability.

Offset Lithography, unlike letterpress printing, is capable of using a wide variety of printing paper and other stock including paper boards, metal foils, binders cloth and many other materials. Coarse or purposely textured papers can be well printed by offset lithography; due to the resilient nature of the rubber blanket. Coated papers and boards are widely used for process colour jobs. As lithography is a chemical printing process, and that the papers must possess certain special characteristics.

The moisture content and the acidity are two of the points to be checked for trouble-free offset printing especially when printing coated papers.

**Sheet-fed offset litho** requires an uncoated paper which is well engine- and surfacesized with a firm surface and little loose fiber. Coated stocks do not normally have any problems with loose surface fibers. Long-grain paper gives less problem with dimensional
stability - however, previous comments on short -grain running on low grammage papers should be noted.

**Heat-set web-offset** has an upper limit of paper grammage of 135g/ m² when it is to be folded, with little limitation on sheeted work. Coated paper ideally should have a low moisture content as blistering of the paper surface may occur as the paper passes through the drying oven.

**Cold-set web- offset** requires a soft-sized absorbent paper.

**Paper for Gravure Printing:**

Paper must be smooth and paper should not contain abrasive material.

Photo gravure printing, like offset, can print on a wide variety of materials . If magazine and newspapers are printed by gravure then a high-grade (glazed) newsprint is used. For sheet-fed gravure better grades of papers are used. In printing for packaging, metallic foils and a variety of plastic films are used. For gravure printing, softness, smoothness and uniform thickness of paper are important requirement. Web ribbon folding is often restricted to not more than 90g/m².

**Paper for Screen Printing:**

Papers used for screen printing should not be too absorbent.

Paper is one of the many printing materials used for screen printing. It is possible by screen printing to print on paper with any kind of finish or embossing. The end use of screen printed product often determines the kind and quality of paper used for screen printing. Paper must be thick for screen printing to avoid curling during drying. This can happen because of the heavy layer of ink film on paper deposited during screen printing.

**Paper for Flexography Printing:**

Flexography is one method of printing words and images onto foil, plastic film, corrugated board, paper, paperboard, cellophane, or even fabric. In fact, since the flexographic process can be used to print on such a wide variety of materials, it is often the best graphic arts reproduction process for package printing. Flexography prints equally well on coated, uncoated or plastic films.

**Paper for Digital Printing:**

Digital printing has been identified by paper / board mills and merchants as an important sector which has tremendous growth potential. Paper / boards are therefore being developed and the range extended to meet this demand for a wide spectrum of substrates in sheet and web form. One of the main properties required in a paper /board suitable for digital printing is low moisture content which should be around 3 to 5% rather than the 5 to 8% associated with conventional paper and boards. A further property required is the need for the substrate to be smooth to ensure the toner is distributed evenly, along with the ability
to hold a controlled level of resistance due to the high electrical charges the substrates are exposed to in their passage through the digital printing system.

A range of papers/boards has been developed to suit the wide spectrum of printer systems now used in the modern office environment. Paper and boards are identified as being suitable or guaranteed, covering, for example, photocopiers, high volume copiers, colour copiers, laser printers, plan printers, thermal wax printers, mono and colour ink jet, thermal fax and plain paper fax.

3.3 PAPER AND BOARD SIZES

ISO PAPER SIZES

The most common system of paper sizes in the UK and Europe is the ISO standard. Most people are familiar with the A series which includes A4 (highlighted on the chart) the usual letterhead size. The C series is for envelopes - A C4 envelope being ideal for holding an A4 sheet. There is also a B series which provides intermediate sizes for the A series but this is rarely used. DL is a special size for envelopes designed to accept A4 paper folded in three.

The aspect ratio of ISO paper sheets is 1 to 1.414 (The square root of 2). This gives them a unique property: If you cut a sheet into two the resulting halves are the same proportions as the original. In other words a sheet of A4 when halved gives you two sheets of A5. All A size papers have the same proportions. The largest sheet in this series is A0 which is 841mm x 1189mm and just happens to be one square meter in area (ISO paper sizes are rounded to the nearest millimeter).

ISO International Paper Size Standard

All sizes are given in millimeters.
ISO International Paper Size Standard - A Series

<table>
<thead>
<tr>
<th>A Series Formats</th>
<th>B Series Formats</th>
<th>C Series Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>4A0 1682 × 2378</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>2A0 1189 × 1682</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>A0 841 × 1189</td>
<td>B0 1000 × 1414</td>
<td>C0 917 × 1297</td>
</tr>
<tr>
<td>A1 594 × 841</td>
<td>B1 707 × 1000</td>
<td>C1 648 × 917</td>
</tr>
<tr>
<td>A2 420 × 594</td>
<td>B2 500 × 707</td>
<td>C2 458 × 648</td>
</tr>
<tr>
<td>A3 297 × 420</td>
<td>B3 353 × 500</td>
<td>C3 324 × 458</td>
</tr>
<tr>
<td>A4 210 × 297</td>
<td>B4 250 × 353</td>
<td>C4 229 × 324</td>
</tr>
<tr>
<td>A5 148 × 210</td>
<td>B5 176 × 250</td>
<td>C5 162 × 229</td>
</tr>
<tr>
<td>A6 105 × 148</td>
<td>B6 125 × 176</td>
<td>C6 114 × 162</td>
</tr>
<tr>
<td>A7 74 × 105</td>
<td>B7 88 × 125</td>
<td>C7 81 × 114</td>
</tr>
<tr>
<td>A8 52 × 74</td>
<td>B8 62 × 88</td>
<td>C8 57 × 81</td>
</tr>
<tr>
<td>A9 37 × 52</td>
<td>B9 44 × 62</td>
<td>C9 40 × 57</td>
</tr>
<tr>
<td>A10 26 × 37</td>
<td>B10 31 × 44</td>
<td>C10 28 × 40</td>
</tr>
</tbody>
</table>

BRITISH PAPER SIZES
### Name of Paper Size

<table>
<thead>
<tr>
<th>Name of Paper Size</th>
<th>Size (inches)</th>
<th>Double (inches)</th>
<th>Quad (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foolscap</td>
<td>13.5 x 17</td>
<td>17 x 27</td>
<td>27 x 34</td>
</tr>
<tr>
<td>Crown</td>
<td>15 x 20</td>
<td>20 x 30</td>
<td>30 x 40</td>
</tr>
<tr>
<td>Demy</td>
<td>18 x 23</td>
<td>23 x 36</td>
<td>36 x 46</td>
</tr>
<tr>
<td>Royal</td>
<td>20 x 25</td>
<td>25 x 40</td>
<td>40 x 50</td>
</tr>
<tr>
<td>Imperial</td>
<td>22 x 30</td>
<td>30 x 44</td>
<td>44 x 60</td>
</tr>
</tbody>
</table>

### Description of papers and boards

A correct description for any substrate should indicate:

- Type of paper/board
- Colour and finish
- Size
- Grammage/ calliper.

For example: printing/white art/SRA1 (640 x 900mm)/140g/m².
In the case of boards, they may be sold by:

- \( \text{g/m}^2 \), or caliper, such as 200, 230, 250, 380 microns (0.2, 0.23, 0.25, 0.38mm), or
- Sheet thickness, such as two-sheet, three-sheet or four-sheet.

**Paper by Weight**

- The weight of paper is usually measured in grams per square inch (gsm).
- This is form of measurements allows the user to compare different types of paper in a standard way.
- A piece of paper that is 100gsm will be thicker than a piece of paper that is 80gsm no matter what type of paper is used.
- Another way of measuring the weight of paper in pounds (lb) and is the basis weight of a ream (usually 500 sheets) of paper.

### 3.4 PAPER AND BOARD PROPERTIES - RUNNABILITY PROPERTIES AND PRINTABILITY PROPERTIES

**Runnability and Properties**

Runnability is the paper’s ability to be printed without causing problems in the mechanics of the printing operation.

These are the properties / characteristics that have an effect on the running and speed at which the sheet or web runs through the press when printing the job.

**Printability and Properties**

The printability of a paper’s surface can be defined as the degree to which its surface properties enhance the production of high-quality prints by a particular printing process.

Printability is the extent to which paper properties will lend themselves to the time reproduction of copy by the printing process used.

These are the properties / characteristics that primarily affect the optical quality of a product.

**Runnability Properties**

1. Tear Resistance
2. Tensile Strength
3. Bursting Strength
4. Folding Endurance
5. Stiffness
6. Basis Weight and Grammage
7. Caliper and Bulk
8. Wire and Felt sides
9. Moisture Content and Relative Humidity
10. Dimensional Stability
11. Grain Direction

1) Tear resistance

Paper's ability to resist tearing while going through various stages of production such as printing, folding, book binding and miscellaneous bindery operations.

Tearing resistance/ strengths is the ability of the paper to withstand any tearing force when it is subjected to. It is measure in both MD & CD, expressed in mN (mili Newton).

Tear Factor: TAPPI standards require that the tear factor be expressed in units of dm². If the tearing strength = a gf and that the basis weight = b gf/m². The tear factor is then

\[
\text{Tear Factor} = \frac{\text{tearing strength}}{\text{basis weight}} = 100\frac{a}{b} \text{ dm}^2
\]

Tear Index: like tear factor, is defined as tearing strength divided by basis weight. The tear index, however, must be expressed in units of mN/(gf/m²). As before, suppose that tearing strength = a gf and basis weight = b gf/m². The tear index is then given by

\[
\text{Tear Index} = \frac{\text{tearing strength}}{\text{basis weight}} = 9.81\frac{a}{b} \text{ mN/(g/m}^2)\]

Tensile Strength

The ability of the paper to withstand the stress and strain applied to it before breaking down and pulling apart.

The tensile force required to produce a rupture in a strip of paper or paperboard, measured in MD & CD, expressed in kN/m. Tensile strength is indicative of fiber strength, fiber bonding and fiber length. Tensile strength can be used as a potential indicator of resistance to web breaking during printing or converting.
**Bursting strength**

The amount of uniform pressure required to pull a sheet of paper apart.

Bursting strength tells how much pressure paper can tolerate before rupture. It is important for bag paper.

Bursting strength is measured as the maximum hydrostatic pressure required to rupture the sample by constantly increasing the pressure applied through a rubber diaphragm on 1.20 - inch diameter (30.5 mm) sample.

Bursting strength depends on basis weight of paper. To normalized the bursting strength for various paper, bursting strength is reported as

- **Burst Index** = Bursting Strength (kPa)/ Grammage (g/m²) or
- **Burst Factor** = Bursting Strength (g/cm²)/ Grammage (g/m²) or
- **Burst Ratio** = Bursting Strength (lb/inch²)/ Basis Weight (lbs/ream)

**Folding Endurance**

The ability of the paper to hold up to multiple foldings before breaking.

Double Fold is the paper's capability of withstanding multiple folds before it breaks. It is defined as the number of double folds that a strip of 15 mm wide and 100 mm length can withstand under a specified load before it breaks.
Folding endurance is log of double fold at base 10 (Folding Endurance = Log 10 (Double Folds)). Folding endurance has been useful in measuring the deterioration of paper upon aging. It is important for printing grades where the paper is subjected to multiple folds like in books, maps, or pamphlets. Fold test is also important for carton, box boards, ammonia print paper, and cover paper etc. High folding endurance is a requirement in Bond, Ledger, Currency, Map, Blueprint and Record Papers. Currency paper has highest folding endurance (>10,000). Long and flexible fibers provide high folding endurance.

**Stiffness**

A property of paper to resist bending and its ability to support its own weight when handled.

Stiffness is the measure of force required to bend a paper through a specified angle. Stiffness is an important property for box boards, corrugating medium and to certain extent for printing papers also. A lumpy and flimsy paper can cause feeding and delivery problems in larger sheet presses. A sheet that is too stiff will cause problems in copier machines where it must traverse over, under, and around feed rollers. Bond papers also require certain stiffness to be flat in typewriters etc.

**Grammage or basis weight**

The basis weight of paper based on weight in grams per square meter of paper, abbreviated g/m2 or gsm.
International sizes of paper are stocked in a standard range of grammages. Printing and writing papers are stocked in a restricted range of grammages, the actual grammages varying according to the country of manufacture and type of paper.

The mass per unit area of paper / card is measured in grams per square metre (g/m²). This is called grammage, although most people refer to it as weight. Office copier paper is usually 80g/m² (80gsm), A4 in size and ordered in reams (packets) of 500 sheets. However, card thickness (sometimes called ‘caliper’) is generally measured in micrometers (microns).

**GSM to basis weight calculator**

Formula: gsm/1.48 = basis weight in lbs

Example:
Convert 60 gsm paper to basis weight in lbs

60 gsm/1.48 = 40 lbs

**Thickness or caliper**

Measurement of the thickness of paper, expressed in thousandths of an inch (points or mils). The caliper can also be expressed in pages per inch (ppi), pages per centimeter (ppc) or thousandths of a millimeter (microns). Caliper is also the name of the tool used to measure the thickness.

For a given basis weight, thickness determines how bulky or dense paper is. A well beaten/refined pulp, short fiber pulp such as hard wood or straw pulp, highly filled or loaded paper will show lower thickness for given basis weight.
Thickness or Caliper of paper is measured with a micrometer as the perpendicular distance between two circular plane parallel surfaces under a pressure of 1 kg./ CM². Uniform caliper is good for good roll building and subsequent printing. Variations in caliper can affect several basic properties including strength, optical and roll quality. Thickness is important in filling cards, printing papers, condenser paper, saturating papers etc.

**Felt and Wire sides**

Paper produced on a fourdriner papermaking machine has a wire side and a felt side.

The wire side is the side which is in contact with the moving wire on the wet end of the machines.

In papermaking, it is the side of the paper next to the wire on the paper machine. The under side of the paper.

Wire side and top side described above are in reference to single ply paper. In case of multi-ply paper/board, every ply will have wire side and top side. The top side of topmost layer will be top side and wire side of bottommost layer is wire side of multi-ply board. Different type of fibers, fillers and chemicals are used in different layers for techno-economical reasons.
The other side is called the feltside - because it comes in contact with a felt material during the drying of the web or the top side.

The top side of the paper as it is formed on the wire as it goes through the paper machine. It is the side recommended for the best printing results.

In case of paper to be printed on one side only, best results are obtained by printing on felt side. Postage stamps are printed on wire side and then gummed on felt side, where the smoothness is helpful for attaining an even application.

**Moisture Content**

The amount of moisture present and measurable in paper. The amount of moisture in a sheet of paper will vary according to the surrounding conditions and to the amount of moisture that is added during manufacturing and during the printing process. The moisture content of the paper can affect its runnability, printability and its physical strength. Generally, a range of 3% to 7% is average for the moisture content present in paper stock.

\[
MC = \frac{\text{Weight of Water}}{\text{Weight of Wood}} \times 100\%
\]

**Relative Humidity**

The level of moisture in the air. The humidity will affect the paper and other printing products, which may cause problems in the printing process.

\[
\text{Relative Humidity} = \frac{\text{actual vapor density}}{\text{saturation vapor density}} \times 100\%
\]

**Dimensional stability**

Papers ability to maintain its form and not stretch and shrink as a result of environmental changes, such as temperature and humidity.
Dimensional stability of paper can be improved by avoiding fiber to absorb moisture. Well sized papers have better dimensional stability.

Grain direction

The grain of the paper refers to the direction of the fibers in a sheet of paper. In paper, the direction in which the fibers line up during the manufacturing process. It is easier to fold, bend, or tear the paper along the same direction of the fibers. Cut sheet laser printers generally use long grain paper in which the grain runs parallel to the long side of the paper, resulting in better performance through the laser printer.

Long Grain

When the fibers in paper run parallel to the long dimension of the paper. For 8 1/2" x 11", long grain would mean the grain runs the 11" direction.

Short Grain

When the fibers in paper run perpendicular to the long dimension of the paper. For 8 1/2" x 11", short grain would mean the grain runs the 8 1/2" direction.

Paper grain, a function of fiber orientation and drying stresses, runs in the direction that paper travels through the paper machine. Papermakers refer to fiber orientation as being either in the machine direction (grain direction) or cross-machine direction. Printers refer to grain direction as being grain-short (or cross grain) and grain-long (or with the grain). Paper is referred to as being grain-long if the grain runs parallel to the press cylinders.
One way to determine the grain direction of paper is to gently place a piece of paper on the surface of water (it is important to keep the top side of the paper dry). As the paper floats on the water, the side in contact with the water will begin to wet and the paper will start to curl. The grain direction of the paper runs parallel to the curl.

**Smoothness**

The even and consistent continuity of the paper’s surface. How the paper receives the ink is affected by the smoothness of the surface.

Smoothness is concerned with the surface contour of paper. It is the flatness of the surface under testing conditions which considers roughness, levelness, and compressibility. In most of the uses of paper, the character of the surface is of great importance. It is common to say that paper has a "smooth" or a "rough" texture.

Smoothness of the paper will often determine whether or not it can be successfully printed. Smoothness also gives eye appeal as a rough paper is unattractive.
PRINTABILITY PROPERTIES

- Brightness and Whiteness
- Color
- Gloss
- Opacity
- Ink Absorbency
- Pick Resistance

Brightness

Refers to the percent of light reflected back from a sheet of paper as measured by a light meter reading. Contrast is reduced and highlights are not as strong when paper with a lower brightness is used for a printed piece.

Brightness is defined as the percentage reflectance of blue light only at a wavelength of 457 nm. Whiteness refers to the extent that paper diffusely reflects light of all wavelengths throughout the visible spectrum.

Gloss

Paper with a gloss finish, usually used for higher quality printing.

It is the specularly and diffusely reflected light component measurement against a known standard. Gloss is important for magazine advertisements printing. The level of gloss desired is very dependent on the end use of the paper. Gloss and smoothness are different properties and are not dependent on each other.
Opacity

A measure used to describe how much the paper will block the ink from showing through the sheet.

Opacity is the ability of the paper to block transmitted light. The instrument used to measure this property, takes a measurement of the light reflected by the sample placed in front of a white standard ratioed against a measurement of the light reflected by the sample placed in front of a black standard.

Oil absorbency or Ink absorbency

The property of paper that determines the amount of ink penetrating the paper and the rate at which it is absorbed after contact with paper.

A simple method of measuring oil absorbency is to spread a thick film of oil on to paper surface for a fixed times and the assess the amount that has been absorbed.

Pick Strength : (Pick resistance)
The lifting of fibers out of the paper due to the ink being too tacky. It causes small white dots in the solid areas of the printing is called picking.

A measure of the surface strength of the sample or surface resistance to picking. Pick occurs due to poor internal bonding strength, making it susceptible to adherence to grade wax sticks (Dennison). This test is valid only for uncoated board or paper.

**Picking / parts breaking off**

“Picking” is a tearing-out of coating particles or fibres from the paper surface due to too high forces during colour cleaving.

3.5 PAPER PROBLEMS

**Powdering problem**

Powdering occurs when the ink film pulls some filler particles from an uncoated sheet or coating particles from a coated sheet. Anti-Offset Powder is sprayed on the sheet as it comes off the press to prevent the ink from transferring to the back side of the next sheet.

**Piling problem**
**Piling** is also a lifting of mineral particles, but it is the dampening solution - not the ink - that is the cause. Piling happens when the ink fails to transfer from the blanket to the paper.

Piling/Tail-edge pick occurs when ink builds up on the blanket, rollers, or/and plate until it eventually lifts off a portion of the image or pulls the fibres or coating from the sheet.

**Linting:** Accumulation of fibers from uncoated stocks onto plates, blankets and/or ink train rollers.

**Picking:** Lifting of the coating from coated stocks onto plates, blankets and/or ink train rollers.

If ink is too tacky, or if the coating is defective, bits of coating/fibre are pulled from the paper’s surface. This material adheres to the blanket and leaves a colour void, or surface crater, in the printed sheet where the pick-out first occurred. Subsequent sheets show partial filling, or may continue to show absence of one or more colours.

**Dusting:**
Loose dust particles on the paper surface adhere to the blanket, take on ink and print as dark specks, or show up as voids in print.

**Dusting** is the picking up of loose particles that were created by a dull slitter wheel or cutting blade and scattered between the sheets. In this instance the fault lies not with the paper’s structure, but rather with its subsequent handling, either at the mill or later.
UNIT III

2 Marks Questions

1. **What is Board?**
   When the substance of paper exceeds 220 grammes per sq. meter it should be considered a board.

2. **What are chip boards?**
   Chip boards are made entirely from wastepaper pulps. All though of similar quality to straw boards, they are less rigid but have better folding properties.

3. **Explain nomenclature of Paper and Board.**
   (Write kinds of paper and Board)

4. **Write the important of Grain Direction.**
   Running direction of paper during production.

5. **Define the terms – Runnability of papers.**
   Runnability is the paper’s ability to be printed without causing problems in the mechanics of the printing operation.

6. **Define Printability of Papers.**
   The printability of a paper’s surface can be defined as the degree to which its surface properties enhance the production of high-quality prints by a particular printing process.

7. **Define Grain Direction.**
   Running direction of paper during production is called grain direction.

8. **What the classifications of paper for printing?**
   Printing paper, Writing paper, wrapping paper, Specialty papers.

9. **Name of the different types of Board?**
   Pulp board, coated art board, straw board, carton board, art board, chromo board, corrugated board.

10. **Expand GSM & RH.**
    Grammage per square meter, Relative humidity.

11. **Write down size of A5 and A3 paper.**
    A3 – 297 x 420 mm (A4 – 210 x 297 mm)
    A5 – 148 x 210 mm

12. **What is the size of Demy Sheet?**
    Demy – 18 x 23 inches

13. **Write name of the paper size is 20 x 30 inches.**
    Double Crown (Crown Size – 15 20 inches)

14. **Write the difference between long grain direction and short grain direction.**
Long grain direction – fiber orientation parallel to the length side of a sheet.
Short grain direction – fiber orientation parallel to the narrow side of the sheet.

15. Name any two paper related problems.
   Powering and pilling problem, linting, dusting and picking problem.

16. How to measure the ink absorbency?
   Spread a thick film of oil (ink) on to paper surface for a fixed times and the assess the
   amount that has been absorbed.

17. Define folding endurance.
   If a strip of paper is subjected to continuous folding under tension it will naturally
   break. The number of folds which cause the break provides a measure of the folding
   resistance or folding endurance of a paper.

18. Mention the grammages of newsprint paper.
   36 – 60 gsm.

19. What is the main advantage of ISO paper sizes?
   This gives them a unique property. The most common system of paper sizes in the
   UK and Europe is the ISO standard.

3 Marks Questions

1. What is Straw Board?
   Strawboard was traditionally made from straw pulp and is a solid cheap board used
   in bookbinding, not for printing. Millboard and chipboard have similar uses but are
   superior in quality to strawboard.

2. What is Pulp Board?
   Pulp board is manufactured in a single web-like paper and has an underside and
topside. Twin-wire pulp boards are even-sided, being formed from two webs on the
machine. Quality varies with furnish, which may be mechanical, wood free or a
mixture, and the finish is usually matt or supercalendered. White and tinted boards
are produced from approximately 200 to 750 microns.

3. Discuss about dimensional stability of paper.
   Dimensional stability is the property of paper that relates to the percentage of
   strength of shrinkage caused by varying relative humidity (RH). It also covers
   dimensional changes that are due to mechanical stresses imposed during printing
   operation. Good register among colors can be maintained only if paper has good
   dimensional stability.

4. Define opacity of paper.
   Opacity is the property of preventing objects on or in contact with the other side being
   seen from the front side. If both sides are to be printed or written, opacity is very
   important for a paper especially for book and magazine paper.

5. Define bursting strength of paper.
This is measured by clamping the paper sample with a rubber diaphragm (thin sheet of rubber) between two rings. The rubber diaphragm is gradually inflated until the paper bursts. The pressure developed for bursting the paper is a measure of the bursting strength of the paper. A dial records the pressure at the moment of bursting. The bursting strength is taken as the mean of 20 tests readings in terms of kg. per square cm. (kg./Cm2).

6. **What is Corrugated Board?**

Corrugated boards, which are mainly used for packaging, box and case construction, also point-of-sale work, are constructed in fluted form - ie - with a middle sandwich of a continuous series of waves or arches of material giving the board the properties of rigidity and cushioning, with white or brown paper lining one or both sides.

7. **State the causes for linting and dusting.**

One of the problems is linting, a situation that can occur on a sheet with adequate surface strength. Whereas picking is the separation of clumps of fibers from the sheet, linting is the lifting of an occasional fiber that did not really become part of the sheet's surface structure. Although not as severe at first as picking, during a long run the accumulation of these individual fibers can severely hurt print quality.

8. **State the causes for dusting.**

Dusting is the picking up of loose particles that were created by a dull slitter wheel or cutting blade and scattered between the sheets. In this instance the fault lies not with the paper’s structure, but rather with its subsequent handling, either at the mill or later.

### 10 Marks Questions

1. Write short notes on (i) Brightness (ii) Opacity (iii) International Paper Sizes
2. State the properties, which affect runnability and printability of papers. (or) State the properties of paper and boards used in print finishing operation.
3. State the characteristics of paper. Define the terms Runnability, and Brightness.
4. Explain in detail about printability of paper.
5. Describe in detail about Runnability of paper.
6. Write short notes on: (i) Pick resistance (ii) Folding endurance (iii) Tensile strength (iv) Ink absorbency.
7. Explain the different kinds of Printing Board.
8. Write notes on
   a. Moisture content and Relative Humidity
   b. Dimensional Stability
   c. Grain Direction of paper.
9. What is Printability and Run ability related to paper? Explain the Printability properties of paper.
10. How does Density and Moisture content affect run ability of paper?

11. Write the sizes of national and international papers. Explain how grain direction and dimensional stability affect multi-colour printing.


13. Briefly explain about paper related problems and remedies.

14. Explain briefly the different types of board. Explain the speciality papers.

15. State the types of paper used in printing and quality of paper for different printing process.

16. Describe the various factors which determine paper selection for printing process.
UNIT IV
PRINTING INKS – COMPOSITION AND MANUFACTURING

4.1 Raw materials used for manufacturing of Printing Inks:

Components of printing inks

Printing inks are, according to their viscosity, divided into

- Liquid inks
- Paste inks.

Liquid inks are employed in gravure and flexo printing, while paste inks are used in letterpress and lithography. Screen inks are intermediate between paste and liquid inks.

CLASSIFICATION OF PRINTING INKS BY VISCOSITY

Basically, all printing inks are made up of

- Colourant
- Vehicle (or varnish)
- Solvent
- Additives.

The function of printing ink is to produce a permanent colored image on paper or other material. The printed image is seen by our eyes and conveyed to our mind to grasp its meaning.

Printing inks are composed of

i) Colorants - Pigments, dyes
ii) Binders - Varnishes (or) Vehicles which consist of oils, resins or alkyds
iii) Carrier Substances - Solvents
iv) Driers
v) Ink Additives or Modifiers

Colourants

Colourants are grouped into

- pigments (tiny crystals, insoluble in the vehicle) and
- dyestuffs (soluble).

In printing inks, pigments are used almost exclusively, save with flexo inks.

Pigments, by their chemical nature, are further divided into

- inorganic pigments
- organic pigments.

Furthermore, there are metallic pigments, pearlescent pigments, fluorescent pigments, and others more.

Pigments are usually referred to by their Colour Index name or formula number (e.g. P.Y. 12, CI No. 21090 = Pigment Yellow 12, formula number 21090).

Dyes (or Dyestuffs)

are soluble in the material they are used in.

They are rather scarce in printing inks, but they are of some importance in flexo inks and for some special applications, e.g. heat transfer printing, invisible (i.e. fluorescent) inks, and cheque security inks.

Some of these dyestuffs, called basic dyes, are quite popular because of their high tinctorial strength and brilliant shades, but they soon fade when exposed to light. They also need some mordant, which helps to make the prints more resistant to water.

As basic dyes usually are soluble in water, they are a bit more frequent in water-based inks than elsewhere.

One of the most popular dyes is eosine, which is well known from the teachers' red fountain pen ink; it also shows a strong yellow-green fluorescence.

Pigments

Inorganic pigments

account for the achromatic inks.

The most important white pigment is titanium dioxide, which serves to make white inks; calcium carbonate, also a white pigment, is only used as an extender.

The most important pigment at all is carbon black, as it is the only pigment used in the manufacture of the most important printing ink, the black one.
There are several processes to form carbon black; they all rely on the thermal
decomposition or the incomplete burning of hydrocarbons such as fuel oil or natural gas.
"Furnace black" and "channel black" are produced most frequently.

As inks containing carbon black as the only pigment show a brown shade, Milori Blue
is added to counter that.

**Organic pigments**

account for the coloured inks.

Inorganic coloured pigments are very rarely used nowadays, as they usually contain
toxic heavy metals (chromium, cadmium, lead, etc.).

For green and blue shades, phtalocyanine pigments are employed. These molecules
contain a very stable system of aromatic rings.

For red and yellow inks, azo pigments are most frequently used. Their formula
contains the azo group, \(-\text{N}=\text{N}\)-.

The human body is able to cleave the azo group into the compounds which it is made
of, thus producing aromatic amines, some of which are carcinogenic.

Hence, under EC legislation, azo dyestuffs are to be regarded as carcinogenic, too, if
the underlying amine is. With pigments, the risk is considered very small; whether it is nil
remains to be seen.

Molecules absorb light in the visible range if there is a conjugated system of double
bonds in the molecule, that is, if single and double bonds alternate.

The most simple example to illustrate this are polyenes of the type

\[
\text{H}_3\text{C}-(\text{CH}::\text{CH}::\text{CH}_2)_n::\text{H}
\]

**Comparison of Pigments and Dyes**

1. Pigments are solid particles and / or molecular agglomerates that must be
   held in suspension in the base liquid. Pigments are organically or inorganically colored,
   white, or black substances that are insoluble in the vehicle. Dyes are organic compounds
   that are dissolved in the system during application, which are present in molecular form.

2. Pigments always require a vehicle for binding them to the substrate. Dyes in
   most applications connect themselves directly to the substrate surface. The disadvantage
   with most dyes is their limited light - fastness. With respect to light fastness and stable ink
   impression, pigment based inks are advantageous.

3. Pigments as base materials are basically cheaper than dyes yet require
greater expenditure when being processed into ink: dispersing agents must be added to
pigments so that they do not agglomerate. Dyes are, in contrast, dissolved and do not
deposit themselves in the liquid.
Vehicles (or varnishes)

serve to bring the pigment in a printable form and fix it onto the printing stock.

The use of the terms "vehicle","varnish" and "binder" is somewhat confusing. Some say, a varnish is made up of a binder and a vehicle; others say, vehicle and varnish are the same.

The components of the vehicle mainly depend on the drying process and hence on the printing process envisaged.

The function of vehicle is

i) to hold the pigments together,

ii) to carry it from fountain (duct to the form through rollers),

iii) to carry it from the form to the surface of the paper or other material.

Binders

Binders, i.e. that part of the vehicle which remains on the printing stock, may be

* just dissolved in some suitable solvent, which is removed after printing (suitable substances usually are called resins),
* formed from the vehicle or parts of it by means of a chemical reaction, or
* a mixture of both.

In cases 2 and 3, the formation of the binder may, in part, be performed in the manufacture of the varnish.

Resin

Resin is the comprehensive expression for a broad selection of naturally occuring, semi-synthetic or synthetic materials which are employed as (e.g) binders for printing inks.

Chemically, they are polymers. They are solids or rather viscous liquids. Most of them are of a non-crystalline structure.

Natural resins include

* rosin from pine trees, which can be separated into turpentine oil and colophony. Colophony is an amber, hard and brittle substance. Its main constituent is abietic acid.

* It cannot be used as such, but must be chemically modified, e.g. esterified with glycerol or reacted with maleic or fumaric acid anhydrides.

* asphalt, which is the residue when crude oil or coal tar are destilled. They are very dark and hence can only be used for black inks. There are naturally occuring materials of a similar composition (e.g. gilsonite).
shellac is made from the secretion of an insect. Its special property is its solubility in methylated spirit and, after saponification, in water. Its importance has declined.

Semi-synthetic resins include

alkyd esters. These are polyesters made of (e.g.) phthalic acid esters and glycerol, which are modified with some fatty acid. Depending on the fatty acid employed, the alkyd may be "drying" or "non-drying".

chemically modified cellulose, such as

- nitrated cellulose
- ethyl cellulose
- sodium carboxymethyl cellulose
- etc.

Synthetic resins are virtually innumerable.

Important examples include

- acrylic resins
- polyvinyl acetate
- polyvinyl alcohol
- polyamide resins
- polyurethane resins
- epoxy resins

Solvents

are used to dissolve the binders of printing inks. They are also used, by the manufacturer and by the printer, to adjust the viscosity of the ink to the printer's requirements.

The solvents used in printing inks include mineral oil, other aliphatic and aromatic hydrocarbons, ketones, esters, and alcohols. These substances do not take part in any chemical reaction.

Important examples include

- toluene, xylene
- mineral oil 280/310 (boiling point range, °C)
- mineral spirits 80/110, 100/140
- acetone, methyl ethyl ketone (MEK)
• methyl isobutyl ketone (MIBK)
• ethyl acetate, isopropyl acetate
• n-propyl acetate, isobutyl acetate
• methoxy propanol, ethoxy propanol
• methanol, ethanol, iso-propanol, n-propanol
• water

Next to their chemical nature and, hence, their solubilizing properties, the boiling point is the most crucial property when choosing suitable solvents.

In a sense, the "drying oils" in chemically drying inks and the reactive fluids in UV-curing systems also are solvents; they serve every purpose of a non-reactive solvent, although in the end they are not removed, but become part of the binder.

Evaporating solvents are a major source of environmental pollution by printing plants. They should be recovered or, at least, destroyed.

Additives

make up only a few percent of the total ink, but may have tremendous effects on the performance of the ink. They are the best part of the manufacturers' know how.

Additives include

• Optical brighteners
• Driers
• Anti-skinning agents
• Adhesion promoters
• Waxes
• Plasticizers
• Surfactants
• Defoaming agents
• Biocides
• Deodorants
• Micro-encapsulated perfumes

Optical brighteners

are used to make inks more brillant.
They are fluorescent chemicals similar to fluorescent pigments; they absorb ultraviolet light and usually transform the energy contained into blue or bluish-green light.

As the eye (or the brain) regards bluish white as particularly white, such inks are perceived as extremely brilliant.

**Driers**

usually are cobalt or manganese compounds. These heavy metals act as catalysts to accelerate oxidative drying.

The oxidation of drying oils can be speeded up by adding a small amount of driers. They are soaps of such metals as cobalt, manganese, lead, cerium, or zirconium.

Drier concentration in printing inks may range from 0.5% to 5%. Driers are supplied in liquid or paste form.

**Cobalt Drier (liquid):** This is the most powerful drier. Liquid driers starts drying from the surface of the printed ink film and produced a surface which is not ink-receptive to over printing. They should always be used in the final colour. The main disadvantage of liquid drier is that they discolour tints and white ink.

**Manganese and lead drier (Paste Driers):** These are prepared by grinding manganese and lead in linseed oil varnish. Paste driers are useful when slow and controlled drying is required or when a printed image is to be overprinted with some other colour. The printed ink film dries uniformly with addition of paste driers.

**Perborate or "Grapho" driers:** These are oxidizers that furnish oxygen to speed up drying. They are completely different from conventional drier and can only be added to the ink immediately before printing.

**Anti-skinning agents**

are employed to prevent the ink from drying on the printing machine.

For this purpose, among others, phenols are employed. These chemicals are more readily oxidized than the drying oils contained in the ink and consume the oxygen. So the drying of the ink does not start until the anti-skinning agent is exhausted - even if the printer would like them to do so now.

**Adhesion promoters**

Titanium chelates, among others, from chemical bonds between binder and printing stock. Both must contain hydroxyl (-OH) groups.

**Waxes**

may be natural or synthetic in nature. They are employed to improve mar-resistance, slip and water repellancy of the print.
The term "wax" is used for any material suitable for these purposes, whatever its chemical nature (polyethylene waxes, other hydrocarbon waxes, teflon waxes, beeswax, carnauba wax, etc.)

Waxes are usually employed as pastes.

**Plasticizers**

are used to make the dried film of printing ink more flexible.

Their mode of action has been explained in the general polymer section. The plasticizers used in printing inks usually are esters of medium sized alcohols with phthalic acid (dioctyl phthalate, DOP, being the most important of all), citric acid, stearic acid, etc.

**Surfactants**

are employed to reduce surface tension and thus to minimize wetting problems, especially with difficult printing stocks.

**Defoaming agents**

may become necessary if surfactants are contained in the ink. Usually silicones are employed.

**Biocides**

prevent microbial degradation of printing inks.

Conditions in a printing ink are not so hostile to microbial life as one might expect. This is particularly true for water-based inks.

**Deodorants**

do not prevent, but mask unpleasant odours.

Some manufacturers even add peppermint, lavender, or vanillin aroma to their inks.

**Micro-encapsulated perfumes**

may be liberated by rubbing the print with one's nail. They are usually contained in coatings. So a print of roses smells of roses, etc.

These inks, however, lose their fragrance fairly quick.

**Manufacturing of Printing Inks:**

Ink manufacturing (Figure 5-10) is complex and requires extensive chemical and printing process knowledge as well as specialized ink manufacturing equipment use. While there a number of manufacturing methods, most share these basic phases of production: formulating, premixing, milling, filtration, and testing.
Formulating Since formulation of inks is the ink manufacturer's responsibility, the subject is presented only briefly here. A typical sheetfed ink contains the following materials:

- Pigment: carbon black, phthalo blue, rubine, or other
- Varnish: long-oil alkyd, phenolic, or urethane litho varnish
- Drier: cobalt and manganese salts
- Solvent: heatset oil, 535°F (280°C)
- Modifier: wax compound for rub resistance

These standard inks dry primarily by polymerization, a chemical reaction that is initiated by oxygen and catalyzed by cobalt and manganese ions from the drier.

The formulation of inks involves the selection and proportioning of ingredients. These decisions are made in accordance with the intended use of the ink. However, there are some general categories of ingredients that are common to most lithographic inks, including pigments, vehicles, additives, and drying agents (driers).

**Premixing** Premixing is particularly important when inks are made from dry pigments. The dry pigment is formed of large clumps of particles called aggregates or agglomerates. These aggregates must be broken down and reduced in size as the pigment is wet with the vehicle. The initial dispersion involves premixing the dry pigment with the vehicle using a mechanism consisting of rotating mixing blades. This process thoroughly wets the dry pigment. The second stage of premixing involves adding more oil and resin to form a "mill base", Figure 5-11.
Unlike dry pigments, flush pigments are predispersed in the vehicle and therefore require less rigorous premixing. Inks made from flush pigments may go directly to milling after mixing the primary ingredients.

**Milling** The mill base still contains large agglomerates that must be further broken down. Also, the addition of other ingredients like waxes and driers can be done at this stage. In many cases, this done in a shot mill, which is made up of a chamber, rotating disks, and shot pellets. The ink is forced into the chamber and the rotating disks move the metal pellets through the ink, breaking the pigment down.

Another device used for milling is the three-roll mill, Figure 5-12, which shears the ink as it passes between the rolls, which rotate at different speeds. This shearing breaks up the pigment agglomerates into microscopic particles so that each becomes completely surrounded and wet by the varnish. Milling also "classifies" the pigment, permitting finely dispersed pigment to flow through the mill and retaining or holding back coarser pigment particles. The ground ink is taken off the high-speed roll by a doctor blade. A thorough job of grinding may require as many as three passes through the mill, depending on whether the pigment is soft or hard and how easily it is wet by the varnish (Figure 5-13).
Milling is costly, and inks can be made less expensive by reducing the amount of milling. This, however, causes several problems including reduced color strength and coarser pigment. Large pigment particles in the ink may cause premature plate wear and scratches in the plate. Since the pigment is the most expensive part of the ink, and uniform dispersion is accomplished by extensive milling, high-quality inks cost more.

**Filtration** After milling, ink may be put through a series of filtration steps to remove any oversized particles. The filtration system consists of bag filters that have decreasing pore sizes, from 150 microns down to microns. In some cases (particularly when manufacturing inks from dry pigments), an electromagnetic filter is used as a part of the filtration system to eliminate metal fragments.

**Testing** The finished ink can be tested for a wide variety of properties. Those particularly, tack, fineness of grind (pigment particle size), and water pickup (emulsification rate). Once the product is assured of meeting requirements, the ink is packaged for shipping.

**4.2 GENERAL CHARACTERISTICS AND REQUIREMENTS OF PRINTING INKS :**

**CHARACTERISTICS OF INK or (PROPERTIES)**
i) Good colour strength

ii) Light fastness

iii) Fastness to chemicals

iv) Resistance to heat

v) Fine particle size

vi) Ability to be dispersed in the vehicle

vii) Wettability, non-abrasiveness

viii) Flow properties

**CLASSIFICATION OF PRINTING INKS BY CHEMICAL NATURE**

- SOLVENT BASED
- WATER BASED
- OIL BASED

The pigment content, depending on the colour tone, is between 5% and approximately 30%. Those organic pigments which give the printing inks (Process inks) the desired colour (hue) are most important for the printing industry. They can be grouped into the two main categories of chromatic (colour) pigments and black pigments.

The main inorganic pigments are:

- White pigment (e.g. titanium dioxide)
- Metal effect pigment (gold and silver bronzes)
- Pearlescent pigment
- Fluorescent pigment (for day light luminous colours)
Printing Inks

- **Colourant**: Dye or pigment selected for fastness properties
- **Binder**: Properties such as heat resistance, adhesion, gloss, low odour, flexibility, durability, product resistance, hardness
- **Additives**: Special properties such as scratch, slip, scuff
- **Solvents**: To dissolve the binder & give good working properties on the press

Printing ink consists of:

(i) Dyes or pigments or the colouring matter dissolved in a fluid medium.
(ii) Solvent or vehicle - by this the colour is conveyed to and secured on paper.
(iii) Drier is used to control the drying time of the ink.

The general properties and essential characteristics demanded of a good printing ink are:

(i) It shall be capable of being deposited in a thin layer on the printing surface.
(ii) It shall not unduly deform in shape during the transfer to its final position.
(iii) The ink in its final position shall have the correct colour value.
(iv) It shall adhere permanently to the surface on which it is printed.

The ink must print sharply, clearly and give legible print of the desired colour. It must dry sufficiently fast to enable the printed sheet to be handled within a reasonable time. There should be no setoff or smudging. The ink should be economical and print sufficient number of copies sufficient on a per kilograms of ink.

The stages in the life of a printing ink are:

i) Storage
ii) Distribution
iii) Impression
iv) Drying

Nearly all inks set to a solid condition on storage. It is important that the thickening should not go so far as that it cannot be liquefied economically, easily by a mechanical agitator before the ink must be broken down in the first place by very gentle mechanical action of the duct except in rare cases where a mechanical agitator is used.
The action of the distributing rollers effects the complete break-down of the ink structure. The distribution mechanism of the machine involves splitting the ink into finer and finer films. These must still remain transferable from their penultimate position on the printing surface to the paper. Further, the ink should not unduly dry up during the time, which may be several hours, i.e., on the machine.

The ink must have sufficient tack to allow itself to be split in this way and also to withstand impression without being subject to undue lateral displacement as a result of applied pressure. Consistency of the ink has to be adjusted for the working speed of the machine and to avoid plucking the paper. Higher running speeds need thinner inks.

Selecting the Right Ink For the Job

Each printing process requires the use of an ink developed specifically for that process. Letterpress, gravure, lithographic, and screen-process inks are specially formulated to match the requirements of the printing process. For example, letterpress inks are designed to distribute evenly over and adhere well to raised plate surfaces. Gravure inks are quite fluid and dry rapidly.

Lithographic inks are formulated so as not to absorb or combine with the fountain solution in the press. And inks used for screen-process printing will have the consistency of thick paint, which is usually required in this process.

Another consideration when selecting an ink is the eventual use of the printed item. For example, ink on items used outdoors must be able to withstand the weather. Ink printed on fabrics should hold up under repeated washings. Food packages should be printed with an odorless ink. And products that will be handled by young children must be printed with non-toxic inks.

4.3 INKS FOR DIFFERENT PRINTING PROCESSES
Letterpress Printing Inks:

Letterpress printing uses viscous inks whose principal components are organic and inorganic pigments and varnishes. Letterpress requires a paste ink, then only it will not run into the counters of type or the etched depression of blocks.

These inks also possess a fair degree of tack so that they will distribute evenly on the press and transfer properly from the forme to paper. They are long in nature i.e., ink can be drawn out into fairly long threads between the fingers.

**LETTER PRESS INKS:**

- PASTE INKS
- OIL BASED
- OXIDATION DRYING
- USED FOR PAPER, BOARD AND LABELS
- CAN BE RADIATION CURED
- WFT: 2—3 MICRONS

On paper and card letterpress inks dry like offset printing inks, both physically through absorption and afterwards chemically by oxidation. With printing on non-absorbent materials such as transparent paper or metallic paper, the drying takes place solely through oxidation when using “foil inks”.

For newspaper web printing based on the letterpress printing technology (not very widely used) printing inks of medium viscosity are used whose principal components are cheap carbon black pigments and mineral oils. Here, the drying takes place solely physically through absorption of the inks into the very absorbent newspaper printing paper.
Flexographic Printing Inks:

Flexographic inks are liquid inks. Inks have very low viscosity, they are in the viscosity range of 0.05 - 0.5 Pa s and form an ink layer of up to about 1 mm.

Flexographic inks are very fluid and flow so easily that if they were transported or stored at their working viscosity levels, their pigment material would settle out. To maintain pigment suspension flexographic inks are shipped in a concentrated form and then let down (diluted) by the printer when needed for a given job. This dilution can be done with either a reducer, (which is no more than a blend of inks solvents) or an extender (which is basically the ink without its colorant, i.e., pigment material).

FLEXOGRAPHIC INKS:

- LIQUID INKS
- SOLVENT BASED & WATER BASED
- EVAPORATION DRYING OR RADIATION CURED
- USED FOR PAPER, KRAFT, LABELS, FILM AND FOIL
- CAN BE RADIATION CURED
- WFT: 3—5 MICRONS
- DUE TO PLATE LIMITATIONS, NO HARD SOLVENTS LIKE KETONES AND HYDROCARBONS CAN BE USED
- USUAL PRINTING VISCOSITY: 20 –22 SEC ZAHN CUP NO 2

The setting of the ink viscosity is particularly important for attaining good printing quality:

The following are requirements:

- no squeezing away of the ink on the edges of the raised image areas.
- sufficiently good ink thickness,
- good ink splitting and filling of the cells on the screen roller.

The type of solvents also plays a critical role in flexographic printing. The following solvents are predominantly used in flexographic printing:

- ethyl acetate
- alcohol (alcohol is usually added to promote better adhesion to the substrate)
- water

Inks containing water (i.e., water as solvent which are environment friendly) are used in package printing.

For label printing UV inks are most frequently used.
**Gravure (Intaglio) Printing Inks:**

Gravure printing requires a liquid ink (viscosity = 0.05 - 0.2 Pa.s, even as low as 0.01 Pa.s in publication gravure printing), which can fill the image forming cells of the gravure cylinder at high print speed.

Gravure inks are simpler in composition and manufacture compared to offset inks from a process point of view. The range of workable inks is very large.

Solvents are particularly important in gravure - they ensure the low viscosity of the ink and they also change the pigment concentration / optical ink density. The following factors are important for selecting solvents:

- boiling point,
- evaporation number,
- flash point,
- explosion limit,
- odour,
- work safety, and
- ecological compatibility

Completely different solvents have to be used for Publication Gravure and Gravure Package Printing. This is mainly because of the very varied requirements of individual packaging.

**ROTOGRAVURE INKS**

- **LIQUID INKS**
- **WATER BASED AND SOLVENT BASED INKS**
- **EVAPORATION DRYING, UV IS POSSIBLE**
- **USED FOR PAPER, FILM, FOIL, ALUMINUM AND PUBLICATION PRINTING**
- **CAN BE RADIATION CURED**
- **WFT: 5—7 MICRONS**
- **NO RESTRICTION ON SOLVENT USE (OTHER THAN REQUESTED BY CONSUMER)**
- **USUAL PRINTING VISCOSITY 14--16 SEC ZAHN CUP 2**

The use of printing inks that can be diluted with water plays a subordinate role in publication gravure with today’s technology.

**Offset (Planographic) Printing Inks:**
For offset printing, highly viscous, paste inks are necessary (dynamic viscosity = 40 to 100 Pa.s).

The ink must be structured in such a way that the drying components in the ink do not harden while being spread over the rollers in the inking unit or at the subsequent transport stations such as the printing plate and blanket.

Furthermore, the printing ink for conventional offset printing (with dampening solution and ink) must be able to "store" a certain portion of dampening solution.

Due to the multitude of requirements on the finished printed product and the nature of the substrates, the percentage content of the individual ink components varies considerably.

Offset inks are somewhat heavier and shorter than letterpress inks. They possess much tack when pressed between fingers, they break with short threads than letterpress inks.

OFFSET INKS:

• PASTE INKS
• OIL BASED
• OXIDATION DRYING
• USED FOR PAPER, BOARD AND LABELS
• CAN BE RADIATION CURED
• WFT: 2—3 MICRONS
• DRY OFFSET CAN BE USED FOR POLYSTYRENE CUPS
• WEB OFFSET CAN BE USED FOR NEWS PAPERS

With offset printing inks, the following are of particular significance:

high transparency (due to the subtractive mixing of inks with overprinting);
characteristics for printability and pressroom runnability such as flow properties, drying, brilliance / gloss, emulsification, pile behavior, abrasion resistance.

ink acceptance of the substrate, and in overprinting, the suitability to wet-on-wet printing.

Based on these requirements, an entire range of ink classes is offered for offset printing.

Screen Printing Inks:

Screen Printing Ink should have a fairly non-oily consistency. Screen Inks must break with a short thread between fingers without being tacky or gumming.

Screen Printing Inks must be formulated to adhere well to a wide variety of substrates. Therefore a number of different types of inks are used.
SILK SCREEN INKS:

- PASTE INKS
- CAN BE OIL BASED/ SOLVENT BASED/
- CAN BE OXIDATION DRYING/ CHEMICAL DRYING
- MOST VERSATILE PRINTING PROCESS
- CAN BE RADIATION CURED
- WFT: 12---50 MICRONS

When printing on plastic material, screen printing inks are similar to gravure inks and flexographic inks in their composition.

The viscosity must be matched to the desired ink, layer thickness and the fineness of the mesh.

For paper and card, however, matte and glossy printing inks of an oil or varnish based are used.

UV inks are sometimes used in screen printing.

It is characteristic for screen printing that it is possible to transfer a thick ink layer of upto 12 micron and more.

4.4 INK PROPERTIES

Properties required of inks:

Many factors influence the printing performance of an ink. To meet all of the required characteristics, an ink must contain pigments, resins and/or varnish, drier, and additives carefully selected by the ink maker. Inks must be suited to the substrate being printed, they must provide the required product resistance, and they must provide all of these properties economically. Of the greatest significance are color and color strength, drying properties, and emulsification properties.

Visual (COLOR) PROPERTIES:

When we refer to ink color, we are most often speaking of hue or shade—whether the ink is red or blue or green or purple. Secondarily, we might describe its strength or saturation, also termed chroma. Thirdly, we might indicate how light or dark it is—a reference to its purity or value.
The amount of pigment used affects an ink's color strength, and the type of vehicle used can affect both the hue and the value of the ink color. The color of the vehicle itself, its ability to wet the pigment articles, and even the chemical interaction between the vehicle and pigment can affect the shade or purity.

**Ink opacity** - ability to hide the color beneath it. Sometimes, an ink with little opacity is needed, such as when overlapping two colors to create a third color. Other times, very opaque ink is needed to completely cover any color under it. The opacity must be suited in the use of the ink. Opacity is tested by spreading a sample of ink with an ink knife over a wide black line printed on a sheet of paper. The amount of covering is then compared to a standard to determine if the opacity is correct.
Ink transparency- refers to the opposite of opaque. A transparent ink does not hide the color beneath it, but mixes with it to create a third color. All inks used to print full color work must be transparent. The choice of colorant and the degree to which it is dispersed through the vehicle are the most important factors in determining the transparency or opacity of an ink.

Transparent ink

Opaque ink

With transparent inks, the substrate is responsible for scattering; with opaque inks, the pigments scatter the light.

Gloss – refers to an ink’s own ability to reflect light, and depends upon the lay or smoothness of the ink film on the substrate surface. Generally, the higher the ratio of vehicle to colorant, the smoother the lay, and the higher the gloss. Application of a thicker ink film tends to improve gloss while penetration into the substrate tends to reduce.

Flow (Runnability) Properties of Printing Inks:

Runnability is a term unique to printing. It applies to the trouble-free interaction between the ink and the press, the paper and the press, and finally, the ink and paper. Body, temperature stability, length, tack, adhesion and drying all contribute to the runnability of an ink and are primarily a function of the vehicle system used in the ink.

Body – refers to the consistency, stiffness or softness of an ink.

Viscosity is a related term that refers to the flow characteristics of soft or fluid inks. Ink body and viscosity requirements vary widely by printing process. In general, letterpress and offset lithographic inks are fairly thick or “viscous” (much like paste or honey). On press, they move through a series of rollers called the ink train where the action of the rollers spreads the ink into a thin film for transfer to the blanket and/or plate and onto the substrate.
Temperature stability – in an ink is important in allowing it to withstand the heat generated by the friction that occurs as the ink moves through the rotating rollers and cylinders. If an ink vehicle is not sufficiently stable, the increased temperature can have a deleterious effect on an ink’s body and therefore on its runnability.

Ink Length – describes an ink’s tendency to form long threads when stretched or pulled. Long inks flow well but form long filaments that have a tendency to sling or mist, especially on high-speed presses. Short inks have the consistency of butter and flow poorly. They tend to build up on rollers, plates or blankets. Inks with the best runnability are neither excessively long nor short.

Ink length is a more traditional, but still widely used, quantity to describe the viscosity of an ink. The most simple instrument to assess the length of an ink is a broadblade spatula.

Tack – refers to the stickiness of the ink, and it must be correct so that the ink will stick to the rollers of the press and not fly off, but still transfer from roller to roller, from roller to plate, from plate to blanket, and from blanket to paper.

Tack may be described as the ability of the ink to act as an adhesive. It is by definition the force required to split an ink film between two rollers.

Working Properties of Printing Inks

Fineness of grind

Fineness of grind for paste inks is usually assessed using the "grindometer". Liquid inks are examined under the microscope.

Abrasion

Abrasion occurs on a gravure cylinder, because the ink contains pigment agglomerates; this must not exceed a preset value.
Colour and colour strength

Colour and colour strength must meet the requirements. There are several test instruments of different levels of sophistication. For paste inks, the printability tester is quite popular.

Drying time

Drying time is tested especially for paste inks containing drying oils.

Rub resistance

Rub resistance is tested by pressing and rubbing some standard material against the ink film and given in arbitrary units. There are several standardized instruments for this purpose.

Packaging-related properties

Packaging engineers and advertising people are very demanding folks to printers and inkmakers.

Among others, the following properties are assessed by more or less standardized tests:

- sealing ability
- sealing strength
- adhesion of printed films after laminating
- residual solvent
- bleeding of colourant
- migration of other constituents
- resistance to packaged material
- odour transfer to packaged material
- heat resistance
- deep freeze resistance

4.5 Ink Types

Nearly all types of ink can be placed into one of two main categories:

Standard Printing Inks:

- Web offset ink (heatset and non-heatset),
- Sheet-fed ink,
- Soybean based ink,
- Process ink for color printing, and others.

Specialty Inks:

- Metallic,
AGPC, SIVAKASI

PRINTING MATERIALS

- Fluorescent,
- Security,
- Phosphorescent, and others.

**A) Ink types – based on substrate**

- **Matt inks**: These inks when printed give little or no gloss or shining. They are ordinary inks.
- **Gloss Inks**: These inks when printed produce a shiny finish. Gloss inks should be printed with less pressure to avoid undue penetration of varnish on smooth and coated papers. Then only glossy effect can be obtained.
- **Opaque inks**: Inks which have the quality hiding anything over which they are printed are known as "Opaque Inks". Due to the initiations in the thickness of the ink film, it is not possible to completely blot out (hide) the underprint.
- **Transparent Inks**: These inks allow anything to show through on which they print over.
- **Dobbing and books inks**: These inks are manufactured for printing on a variety of papers. They are available in different grades.

**B) Ink types – based on drying**

**Web Offset Non-Heatset Ink**

The non-heatset variety of web offset printing ink is a common type of ink used on web presses for newspaper and business forms printing. Non-Heatset ink is printed on absorbent, uncoated paper stock. Coated stocks should not be used with this type of ink because the paper will not completely absorb the ink, resulting in excess smudging and smearing.

**Web Offset Heatset Ink**

The heatset variety of web offset ink contains special varnishes that help the ink dry when heat is applied. Heatset presses are equipped with drier units for this purpose. Due to the varnishes, the ink printed on the paper is highly flammable, so the drying units must be specially built and properly maintained to avoid potential hazards. The main advantage of heatset ink is a printed product with a higher degree of quality.

**Quickset Ink**

Quickset ink contains a special varnish to speed the drying process. Unlike heatset ink, quickset ink does not require a heat source for proper drying and curing. The ink will not dry out on the press, but will dry quickly after it has been printed onto the substrate.

The are four basic processes that allows quickset ink to dry depending on the formulation: evaporation, absorption, oxidation, and polymerization. Newer types of quickset ink have a
greater proportion of antioxidants and higher boiling-point distillates, which evaporate more slowly, so the absorption process plays a greater role with the newer inks. All four processes share equally in the ink curing process with older ink types.

Uncoated paper stocks are best suited for quickset ink. This is because the low viscosity distillates and antioxidants are quickly absorbed by the substrate, which leaves the remaining pigment and vehicle to dry quickly on the surface.

Sheet-fed Ink

Sheet-fed ink is manufactured specifically for sheet-fed presses and usually has a higher tack than web offset inks. The reason for this is that most sheet-fed presses run at slower speeds than web presses and a higher tack is necessary to provide the necessary quality.

Rubber-base Ink

Ink formulated with a rubber base is a good choice when flexibility in the printing process is important. Rubber-base ink can be printed on coated and uncoated paper and it dries quickly. It is most often used on small sheet-fed presses.

Soybean-base Ink

Soybean-base ink is becoming a popular alternative to petroleum-base ink because of the ease in which it is used and because it is environmentally friendly. Soy-base ink prints and handles similar to petroleum-base ink, but it is much less toxic because of the soybean oil. The soybean ink is biodegradable, meaning that it is eventually broken down and is much less hazardous to the environment. Some soy inks may contain petroleum additives, so if a client requires 100% soy-based ink for a print application, it is important to be fully informed on the type of soy ink that is used.

Water-base Ink

Water-base ink has been around for awhile, but it is still not as popular as other ink types. The usage of water-base ink may increase as environmental laws get tougher on the acceptable VOC (Volatile Organic Compounds) emissions generated from petroleum-base ink. Water-base ink emits no VOC’s. It is safe to work with and the print quality is comparable to other ink types. Water-base ink is used mainly in flexography and gravure printing. It is a good choice for printers and customers who want their projects manufactured with nontoxic materials.

Laser Ink

Laser ink is specially formulated to withstand the extreme heat of the laser printer. If conventional ink is used for the preprinted portion of a document (such as an invoice or statement), the ink will melt in a laser printer because of the excessive heat produced by the laser printer. This results in damage to the preprinted document and possible damage to the laser printer because of ink adhering to the internal parts of the printer.

UV (Ultraviolet) Ink
Ultraviolet ink is formulated to cure and dry when exposed to a UV light source, unlike conventional ink, which dries through evaporation and absorption. Instead of being absorbed into the paper, the UV ink remains on the surface until it is exposed to the UV rays, which instantaneously transforms the ink into a hard film. UV ink can be applied to many types of substrates including paper, metal, vinyl, and glass.

**Process Ink Colors**

Process ink colors are used in Four Color Process Printing. Cyan, magenta, yellow, and black are the colors necessary for this process and are formulated differently for different types of printing processes.

**High-Fidelity Ink Colors**

High-fidelity ink colors are used in an advanced form of color printing, combining the standard four process colors of cyan, magenta, yellow, and black, with two more colors - usually orange and green. This allows for a greater color range, increased subtlety in the gradations of color, and additional vibrancy.

**B) Ink types – based on chemistry**

**Non-porous Ink**

Non-porous ink is used for printing on substrates, such as metal or plastic, that do not allow ink to be absorbed into the material. Because the printing surface of these materials is nonabsorbent, the ink dries solely through oxidation rather than absorption.

**Metallic Ink**

Metallic ink provides a distinctive look to a variety of print applications. The ink is produced by blending different types of metallic powders into the ink mixture, such as aluminum powder to create a silver appearance and bronze powder to create a gold appearance. Some metallic inks can nearly duplicate the look of foil on some applications without the need to purchase the additional equipment required for foil stamping.

Metallic ink is more challenging for the press operator to control than conventional ink. One reason for this is that the metallic powder blended into the ink mixture cannot be ground as fine as other pigments because the metallic ink will lose its luster. The larger particles create problems on the press, especially with the offset lithography process. To overcome some of the special print problems, some printers do a double hit (running the piece through the press a second time to apply another coat of ink to strengthen the coverage).

Most printers require an upcharge for the use of metallic ink on an application because the ink is more expensive to produce and makes the print job more time consuming. Metallic ink tends to have a much shorter shelf life than standard ink.

**Magnetic Ink**

Magnetic ink is comprised of a petroleum-base ink blended with magnetic iron oxide particles. The magnetic iron oxide particles allow documents printed with this type of ink to be read and sorted by electronic scanning equipment. Checks are an example of a
document printed with magnetic ink. The MICR (Magnetic Ink Character Recognition) number at the bottom of the check is the only portion of the check printed with the magnetic ink. The remaining copy on the check is printed with standard ink to ensure that no other printed area on the check interferes with the ability of the scanner to read the magnetic MICR number.

**Fluorescent Ink**

Fluorescent is another type of ink that can provide a distinctive look for a variety of print applications. Fluorescent ink colors are most often printed on labels, posters, and signs that are used for alerting people to hazards or attracting their attention to advertising pieces.

There are several points to consider when using fluorescent colors. The ink tends to fade quickly, so they should be kept out of direct sunlight. Because of their tendency to fade, fluorescent inks have a short shelf life. Another point to consider is that fluorescent ink is very transparent, so it may require a double hit (a second run through the press) in order to achieve the desired results. In spite of this potential problem, fluorescent ink is a good choice for creating emphasis and increased visibility.

**Phosphorescent Ink**

Applications printed with phosphorescent inks acquire a "glow in the dark" property after the phosphorescent area has been exposed to light. The length of time that an application will glow in the dark depends upon the ink ingredients and the length of time that the application is exposed to light. In some cases, a 10-30 minute exposure to light can yield an afterglow of up to 12 hours. The ingredients of phosphorescent ink are nontoxic and are free of radioactive additives. It is very useful for road signs, sporting goods, exit signs, safety products, toys, and novelty items.

**Pearlescent Ink**

Pearlescent ink is a specialty ink that is used to add highlights and depth to the printed area of an application. It is able to provide an almost 3-dimensional effect to some applications.

**Edible Ink**

Edible ink is used on print applications that may come into contact with food or the ink may be part of the food product and therefore it must be made of totally nontoxic ingredients. An example where edible inks are used would be in the monogramming found on some confectionery items. Because the inks are used on food items, they are strictly regulated by the government.

**Scratch and Sniff Ink**

Also known as a microencapsulated ink, scratch and sniff ink releases a fragrance when the microcapsules are broken. The scratch and sniff ink is commonly used in magazines for perfume advertisements. When the consumer scratches the surface of the designated area of the ad, the capsules are broken, releasing the fragrance.

**Medical Device Ink**
Ink used for printing on medical devices is made of nontoxic ingredients so that direct printing on noninvasive surgical and medical disposable items is possible.

**Moisture Resistant Ink**

Moisture resistant ink is most often used for different types of packaging or for applications that may be used outdoors.

**Security Ink**

There are a variety of inks that provide added security features to print applications. Some security inks allow documents to be created that are tamper proof, while the use of other types of security inks prevent documents from being copied. Security inks include the following varieties:

- Coin Reactive
- Bleeding
- Erasable
- Heat Reactive
- Visible Infrared
- Optically Variable
- Pen Reactive
- Penetrating
- Photochromic
- Solvent/Chemical Reactive
- Thermochromic
- Water Fugitive
- UV Invisible Fluorescent

**Desensitizing Ink**

Desensitizing ink is a transparent ink that is applied to the face of CF (Coated Front) and/or CFB (Coated Front and Back) carbonless paper in order to deactivate the CF coating. The use of desensitizing ink is important when an application requires that handwritten or imprinted data not be transferred through the various pages of a carbonless form in specific areas.

**Electronic Ink**

Electronic ink can be transformed from bright white to dark and then back to bright white again with a small electrical charge. The ink consists of plastic microcapsules that contain both dark dye and white ink chips. The microcapsules are sandwiched between thin layers of flexible material, which substitutes for traditional paper. When an electrical charge is applied, some of the white chips float to the top of some capsules to create a white surface and in
other capsules, the white chips remain at the bottom allowing the dark fluid to remain visible. Different characters are created by applying the electrical charge under different combinations of capsules. After the initial electrical charge is applied, no further charge is required to hold the image in place, (unlike a computer monitor, which requires a constant stream of energy in order to display an image). The content of the flexible page can be changed instantly and then be held on the page for as long as necessary. Although, this technology is still being perfected, it could be a major advancement in variable imaging and in the reduction of paper usage for some print applications.
UNIT IV

2 Marks Questions

1. Define pigment.
   Pigment is a powder. It gives color to the ink. For certain inks liquid dyes are used. Example flexographic inks. Pigments are insoluble in vehicles. They are therefore dispersed.

2. What you mean be Viscosity?
   Viscosity means resistance to flow. This is related to the term body.

3. What you mean by Tack of an ink?
   This term ‘tack’ refers to the stickness of inks. In other words it is the force required to split an ink film, between two surfaces.

4. Give an example for low viscosity ink.
   Flexography ink.

5. How did Screen printing ink dry?
   Evaporation, Oxidation, Heat curing, Ultraviolet curing.

6. State the qualities of inks required for flexographic printing.
   Flexographic inks are liquid inks. Inks have very low viscosity, they are in the viscosity range of 0.05 - 0.5 Pa.s and form an ink layer of upto about 1 mm.

7. Write any two constituents of Printing ink.
   Colorants, Driers

8. How do gravure and flexographic inks dry?
   Cooling and Evaporation

9. Explain the characteristics and features of flexographic inks.
   Flexographic inks are liquid inks. Inks have very low viscosity, they are in the viscosity range of 0.05 - 0.5 Pa.s and form an ink layer of upto about 1 mm.

10. Briefly explain the types of ink.
    Nearly all types of ink can be placed into one of two main categories:
    i. Standard Printing Inks: web offset ink (heatset and non-heatset), sheet-fed ink, soya bean based ink, process ink for color printing, and others.
    ii. Specialty Inks: metallic, fluorescent, security, phosphorescent, and others.

11. Why are driers added in printing inks?
    For quick ink drying.

12. Define driers.
    The oxidation of drying oils can be speeded up by adding a small amount of driers. They are soaps of such metals as cobalt, manganese, lead, cerium, or zircornium. Drier
concentration in printing inks may range from 0.5% to 5%. Driers are supplied in liquid or paste form.

13. **What are pigments?**

Pigment is a powder. Pigments are obtained from a variety of organic and inorganic sources. The most common pigment is carbon - black (soot) used for black inks is the organic pigment.

14. **State some ink additives (Modifiers).**

Plasticizers, Waxes, Wetting agents, Anti setoff compounds, Shortening compounds, Reducers, Stiffening agents, Antiskinning agents.

15. **What are solvents?**

Petroleum hydrocarbons

16. **What is an UV ink?**

Ultraviolet ink.

17. **What is vehicle?**

Vehicle is the fluid into which the pigment is dispersed. It consist of a varnish and additives.

18. **Define solvents.**

These are inflammable liquids capable of dissolving other materials. The solvents which are used in printing inks are able to dissolve resins, oils and waxes.

**3 Marks Questions**

1. **What is called Crystallization?**

Some inks notably the quick-drying, hard-drying inks based on chinawood or tung oil, dry to form a hard impervious surface that will not trap uniformy or accept other ink. This problem is called Crystallization.

2. **Define the Terms: Gloss ink**

Paper is the most important factor in the printing of gloss inks; best results are obtained with high-grade coated and enamel papers. But inks greatly affect the gloss of the print. The resin component, the oil or solvent, and the pigment all affect gloss. Generally, synthetic resins of high molecular weight that do not penetrate into the paper pores provide good holdout, enhancing the gloss.

3. **Write a note on Driers used for Printing Inks.**

The oxidation of drying oils can be speeded up by adding a small amount of driers. They are soaps of such metals as cobalt, manganese, lead, cerium, or zircornium. Drier concentration in printing inks may range from 0.5% to 5%. Driers are supplied in liquid or paste form.

4. **What are the constituents of Printing Inks?**

Printing inks are constituents of
i) Colorants - Pigments, dyes
ii) Binders - Varnishes (or) Vehicles which consist of oils, resins or alkyds
iii) Carrier Substances - Solvents
iv) Driers
v) Ink Additives or Modifiers

5. **What are the properties (characteristics) of good Printing Inks?**

1) Good colour strength
2) Light fastness
3) Fastness to chemicals
4) Resistance to heat
5) Fine particle size
6) Ability to be dispersed in the vehicle
7) Wettability, non-abrasiveness
8) Flow properties

6. **Define (i) Mass tone (ii) Undertone (iii) Crystallization.**

Mass tone: The appearance of an ink in bulk. Opaque inks nearly print in bulk colour. Transparent ink will look darker in bulk than the printing colour.

Undertone: Undertone is the appearance of colour in a thin film.

Crystallization: ‘Crystallation’ is a defect caused by the first down ink drying too much and repelling the succeeding colours. If ink has no receptivity, crystallization should not be confused with “Crystallization” in chemistry.

7. **Write the ink drying methods for the following printed products.**

i) Newspaper – Penetration
ii) Newspaper Inserts / Supplements - Precipitation
iii) Books - Penetration
iv) Magazines - Penetration & Precipitation
v) Brochures - Absorption & Penetration
vi) Packaging film - Gellation
vii) Corrugated paper - Precipitation

8. **Write short notes on: Heatset ink**

The heatset variety of web offset ink contains special varnishes that help the ink dry when heat is applied. Heatset presses are equipped with drier units for this purpose. Due to the varnishes, the ink printed on the paper is highly flammable, so the drying units must be specially built and properly maintained to avoid potential hazards. The main advantage of heatset ink is a printed product with a higher degree of quality.

9. **Why are solvents used in ink manufacturing?**
These are inflammable liquids capable of dissolving other materials. The solvents which are used in printing inks are able to dissolve resins, oils and waxes. Solvents have the capacity of entering between the smallest particles of solids and change them from solid to liquid state. If they are added to existing solutions of solids they make the solutions even much more liquid. Solvents are the main components of vehicles that dry evaporation (Gravure and Flexographic inks). The most commonly used solvents in the manufacturing of lithographic inks are petroleum hydrocarbons called heatset oils.

10. State the differences between opaque inks and transparent inks.

Opaque inks: Inks which have the quality hiding anything over which they are printed are known as "Opaque Inks". Due to the initiations in the thickness of the ink film, it is not possible to completely blot out (hide) the underprint.

Transparent inks: These inks allow anything to show through on which they print over.

11. Explain the function of pigments in printing inks.

Pigment is a powder. It gives color to the ink. Pigments are insoluble in vehicles. They are therefore dispersed. Pigments are obtained from a variety of organic and inorganic sources.

12. State the essential properties of pigments.

Pigment is a powder. It gives color to the ink. Pigments are insoluble in vehicles. They are therefore dispersed. Pigments are obtained from a variety of organic and inorganic sources. The specific gravity, particle size, wettability, opacity or transparency, colour and tinting strength, and their effect on drying vary with different pigments. Normally pigments have a particle size of 0.1 to 2 mm. A pigment particle can consist of several million molecules.

13. State the function of vehicles.

a. to hold the pigments together,
b. to carry it from fountain (duct to the forme through rollers),
c. to carry it from the forme to the surface of the paper or other material.

14. How will you Manufacture inks for offset printing?

With offset printing inks, the following are of particular significance:

High transparency (due to the subtractive mixing of inks with overprinting); Characteristics for printability and pressroom runnability such as flow properties, drying, brilliance / gloss, emulsification, pile behaviour, abrasion resistance. Ink acceptance of the substrate, and in overprinting, the suitability to wet-on-wet printing.

10 Marks Questions

1. Write short notes on (i) Hue (ii) Viscosity (iii) Tack, and (iv) Pigments.
2. State the qualities of ink required for offset and flexographic printing.
3. What are the necessary information to be furnished to the ink maker while ordering inks.
4. State the qualities of inks used for Letterpress and Offset Printing.
5. Explain the sequential operation of Ink Manufacturing.
6. Vehicles play a vital role in Printing Inks. Explain.
7. Explain the various additives used in ink manufacture.
8. State the composition of printing ink.
9. Write an essay on ink manufacturing process.
10. How will you manufacture inks for offset printing?
11. Explain briefly the different types of inks.
12. What is the difference between Gravure inks and Screen inks? Explain.
5.1 INK DRYING METHODS:

In all major printing processes, printing ink is applied to the paper or other material as a liquid. The liquid is then converted to a solid state as soon as possible after impression. Therefore, drying of printing ink means ‘change of ink from the liquid to solid state’. This change takes place in two stages in certain kinds of inks. The first stage is ‘setting’ and the second is ‘hardening’ of the ink films. Setting of ink is a condition which allows printed sheets to be handled without smudging the print. A properly set ink film, therefore will not be rubbed off, set-off or damaged during handling in the following operations. Hardening of ink film means that the ink has reached the end of its chemical or physical change or that the ink film has become as hard as it should be. Drying of printing ink involves a number of chemical and physical actions which depend on the nature of the vehicle. There are about seven drying methods.

1. Penetration/Absorption of the vehicle into the printing materials
2. Oxidation of the vehicle
3. Polymerization of the vehicle
4. Evaporation of solvents in the vehicle
5. Gellation of the vehicle
6. Solidification of the vehicle by cooling
7. Precipitation of vehicle solids

Most printing inks dry by two or more of the above drying methods.

1. **Drying by penetration or absorption or filtration**: Penetration is achieved by the interaction of printing ink and substrate. It depends on the carrier viscosity of the printing ink, the vehicle, and the absorption capacity of the substrate. All inks printed on absorbent materials also dry by penetration. Penetration takes place by absorption of the vehicle of the ink into the paper leaving the dry pigment on the surface.
Strictly speaking, the ink is not being converted into a solid but becomes an integral part of paper used and into it. For penetration drying ink, the vehicle must be thin enough to penetrate into paper. The paper should also be extremely porous to absorb the vehicle into it and hold the pigment particles on the surface of the paper. Cold - set inks used for web offset newspaper printing dry in this way. The penetration process is carried out in a split second and the drying process is finished.

2. **Drying by Oxidation**: A chemical form of drying in which the ink vehicle takes oxygen from the air in a chemical reaction which causes it to harden, thus binding the pigment with it. This is the chief way by which conventional sheetfed letterpress and sheetfed offset inks dry.

The ink layer on the sheet to be linked should be supplied with sufficient oxygen in the delivery pile. The necessary space between the sheets can be increased by powdering, and oxygen can then diffuse in the piles. Powdering serves to support drying in the pile, and also to avoid smearing the image on the underside of the top sheet.

3. **Drying by polymerization**: Polymerization means combining of small molecules into larger, more complex molecules. When the simple or smaller molecules produce a fluid, polymerization generally results in a solid. Inks made of drying oils when exposed to the atmosphere, the process of combining molecules continuous until a hard and flexible film is
produced. This kind of drying is related to oxidation because it is also a chemical process. Inks which dry by polymerization always contain a small amount of driers. Printing ink driers speed up the drying process as they acts as oxygen-carriers. Polymerization drying takes place in letterpress, offset lithography (metal decoration) and screen printing (ceramic and glass printing) processes. In air drying inks, polymerization and oxidation take place at the same time.

4. Drying by evaporation: The printing ink consists of several components such as resins, pigments, and solvents, the drying of which is achieved partly by evaporation. The solvent evaporates when a printing ink is dried by evaporation. The drying process is determined by the heat and material transport in the boundary film on the surface of a liquid (Printing ink). Inks with vehicles consisting of a hard resin dissolved in a volatile solvent dry by evaporation. After printing the solvent evaporates leaving the resin, binding the pigment on the surface of the paper. Evaporation of solvent may happen naturally or may be speeded up with the aid of heat, blown up air etc.
Therefore, heating via heat radiators and/or hot air is to be combined with optimum air conduction. "Suspension dryers" are mainly used as drying units in web offset. The web is routed contact free through these dryers without guiding elements. This is achieved by a well directed blower stream in the hot air dryer.

It is the most important method of drying in Heat-set Web offset, Screen, Gravure and flexographic printing processes. They often use non-absorbent material such as metal foils, plastic films.

5. **Drying by gellation**: Quick-set inks set by gellation. Inks that contain a vehicle consisting of penetrating oil and plasticizing (film forming) varnish dry by gellation. Ink film when transferred to paper, the penetrating oil is drained into the paper, leaving the plasticizing varnish to bind the pigment to the surface. Such inks are limited in their use to special applications.

6. **Drying by solidification (cooling)**: Inks having dyes or pigments dispersed or dissolved in waxes are solid at room temperature but become liquid at a higher temperature. They are printed on heatset presses. When the printed ink comes in contact with cool paper surface, it is cooled and becomes solid. Carbon papers printed by letterpress and gravure dry by this process.
7. Drying by Precipitation: Precipitation means separation of solid matter from a solution. Water-based inks, with vehicle or water insoluble resin dissolved in a water-soluble vehicle (solvent glycel) dry by precipitation. The printed sheet is given a spray of a mist of water vapor, the water-receptive (soluble) solvent accepts the moisture and loses its ability to hold resin liquid form. The water insoluble resin is separated from the solution thus binding the pigment on to the surface of the paper.

Such inks are called “steam-set” inks or moisture-set” inks. Such special inks are used for printing food package materials as they have to be free from odors and also on web-offset presses for magazine printing.

### Methods by which Inks Set and Dry

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<th>Method</th>
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5.2. VARIOUS INK PROBLEMS AND THEIR REMEDIES
INK PROBLEMS

1) Mottle:

Problem: Solid areas not of uniform density, resulting in uneven appearance.

Cause:

1. Non-uniform stock surface
2. Improper printing pressure
3. Improperly set or worn form rollers
4. Improper ink/water balance
5. Worn blanket

Solution:

1. Consult paper manufacturer to change stock; consult ink manufacturer for ink for less penetration, strength
2. Adjust printing pressure
3. Adjust rollers to proper setting; replace if necessary
4. Adjust to proper ink/water balance
5. Replace blanket

2) Chalking:

Problem: Ink pigment does not bind to stock.

Cause:

1. Ink vehicle penetrates stock too quickly
2. Insufficient drier in ink for particular stock
3. Stock too acidic
4. Ink too strong (ink film too thin)
5. Fountain solution pH too low
6. Ink film too soft; no hold-out

Solution:

1. Bind ink to paper with overprint varnish or sealing size
2. Consult ink manufacturer regarding new ink for particular stock
3. Change stock; consult ink manufacturer to reformulate ink for particular stock
4. Consult ink manufacturer to weaken ink
5. Adjust fountain solution to proper pH/conductivity (pH 4.0-4.5)
6. Consult ink manufacturer regarding new ink for more hold-out
3) **Chemical Ghosting:**

**Problem:** Chemical Ghosting or Gas Ghosting: A large solid on the back-up side of a sheet shows excessive gloss opposite the ink on the side printed first.

**Cause:**

1. Large solids printed on a back-up form
2. Lifts too large
3. First side backed-up too soon after being run
4. Inks too glossy

**Solution:**

1. Print heavy form first and lighter form on back-up side
2. Run small lifts when backing up the sheets
3. Hold lifts three days (per GATF) before printing back-up side
4. Fan sheets before printing back-up side; keep lifts in sequence for backup; keep lifts away from excessive heat or cold; run sheets through press without printing to supply fresh air before printing back-up side; on small, expensive runs, slip-sheet stock while printing back-up side.

4) **Mechanical Ghosting:**

**Problem:** A light or dark print of another part of an image appears in large solids or dense halftones.

**Cause:**

1. Poor job layout
2. Ink film too thin
3. Ink too transparent

**Solution:**

1. Improve job layout
2. Consult ink manufacturer to weaken ink for heavier film
3. Consult ink manufacturer to reformulate ink for greater opacity

5) **Trapping**

**Problem:** Cannot achieve good coverage.

**Cause:**

1. Tack of inks out of sequence
2. Improperly balanced ink strength
3. Improper ink viscosities
4. Hue error or gray balance not keyed to color separations
5. Unequal press stability of inks; succeeding inks tack up quicker than preceding inks
6. Additive in ink creates film, preventing subsequent inks from adhering
7. Improper ink/water balance
8. Poor ink transfer from blanket
9. Improper register
10. Process color prints do not match supplied proofs

**Solution:**
1. Adjust inks to have progressively lower tack
2. Adjust inks to have progressively heavier film for optimum trap
3. Adjust inks to have progressively lower viscosity
4. Coordinate efforts between suppliers
5. Consult ink / blanket manufacturer
6. Adjust to proper ink/water balance

**6) Hickeys:**

**Problem:** Donut-shaped white spots on printed surface. Donut shaped hickies indicate particulate.

**Cause:**
1. Dried ink particles
2. Roller particles
3. Dampener cover particles
4. Plate particles
5. Foreign particles

**Solution:**
1. Avoid ink skin when handling ink; cover exposed ink; clean press well and often; remove dried ink from fountain edges and roller ends
2. Recondition rollers and drums; replace if necessary
3. Replace sleeves and rollers if necessary
4. Check plates for loose coatings or shavings; remove all coatings during processing
5. Improve housekeeping: a) check air systems for circulation of dust, b) vacuum overhead fixtures, c) hang plastic sheeting over press and d) use less spray powder

7) Picking:
Problem: Lifting of the coating from coated stocks onto plates, blankets and/or ink train rollers.

Cause:
1. Too much water reaching paper
2. Excessive lint, surface trash, coating dust on stock
3. Base stock picks
4. Pressure too high for ink/stock combination
5. Blankets too tacky
6. Ink too tacky for stock

Solution:
1. Adjust to proper ink/water balance
2. Consult paper manufacturer
3. Reject stock if necessary; change to more lint- or pick-resistant stock
4. Adjust impression pressure and repack to manufacturer specifications
5. a) Consult blanket manufacturer, b) Treat blanket or change to less tacky blanket, or c) Change blanket wash
6. Consult ink manufacturer to adjust ink for less tack

8) Piling:
Problem: Build-up of ink on printing plates.

Cause:
1. Paper problems
2. Ink is waterlogged
3. Poorly ground ink contains coarse pigment
4. Improperly packed cylinders
5. Improperly set or worn rollers
6. Blankets too tacky

Solution:
1. Adjust dampener settings; consult ink manufacturer
2. Consult ink manufacturer to rework ink
3. Check specifications and adjust cylinders
4. Check specifications and adjust rollers; replace if necessary
5. a) Consult blanket manufacturer, b) Treat blanket or change to less tacky blanket, or c) Change blanket wash

9) **Ink Setoff:**

Problem: Set-Off: Ink transfers to the backside of the sheet above.

![Diagram](image)

**Cause:**

1. Ink dries too slowly
2. Insufficient spray powder
3. Lifts too heavy
4. Rough handling of loads

**Solution:**

1. Increase powder application
2. Run shorter lifts; tray the lifts
3. Do not drop or jerk loads

10) **Tinting:**

Problem: Emulsified ink transfers to printed sheet as background tint.

**Cause:**

1. Ink bleeds into fountain solution
2. Improper concentration of fountain solution
3. Improper ink/water balance
4. Pressure between plate and blanket too high
5. Improper setting or durometer of dampener or ink rollers
6. Ink insufficiently resistant to water
7. Improperly exposed or developed plates
8. Prolonged use of detergent, washup solution
9. Paper coating contaminates ink train

Solution:
1. Adjust concentration of alcohol/alcohol substitute in fountain solution; consult ink manufacturer to reformulate ink with non-bleeding pigment
2. Adjust fountain solution to proper pH/conductivity (pH 4.0-4.5)
3. Adjust to proper ink/water balance
4. Adjust pressure to manufacturer specifications
5. Adjust dampener and ink rollers to manufacturer specifications; check durometer of rollers and replace if necessary
6. Make sure ink is on-standard; consult ink manufacturer to reformulate if necessary
7. a) Replace plates if necessary, b) adjust plate making process, and c) store plates away from moisture and humidity
8. Wash-up, remove detergent with water or petroleum solvent, and change solution
9. Use low-tack ink, low water setting and low pressure setting

11) Scummimg :
Problem: Non-image area of lithographic plate accepts ink in random areas.

Cause:
1. Low alcohol (or alcohol substitute) content in dampening system
2. Glazed blanket, ink rollers or dampening rollers
3. Excessive printing pressure
4. Ink body too greasy, spreads into non-printing areas
5. Plate improperly processed or exposed to light
6. Fountain solution highly bichromated
7. Ink too soft
8. Improper pH of fountain solution
9. Improperly set or worn dampening rollers
10. Ink rollers overheated

**Solution:**

1. Adjust to proper alcohol concentration
2. Clean blanket and rollers thoroughly and recondition to manufacturer specifications
3. Reduce printing pressure to proper levels
4. Make sure ink is on-standard; consult ink manufacturer to reformulate ink if necessary
5. Desensitize or re-make plate; adjust plate making process
6. Adjust fountain solution to proper pH/conductivity (pH 4.0-4.5)
7. Consult ink manufacturer for stiffer ink
8. Adjust fountain solution to proper pH/conductivity (pH 4.0-4.5)
9. Adjust rollers to proper pressure; replace cover if necessary
10. Check for worn bearings and replace if necessary; adjust roller pressure

**12) Stripping :**

**Problem:** Rollers do not accept ink.

**Cause:**

1. Fountain solution too acidic
2. Excess water in press
3. Desensitized metal vibrator rollers
4. Glazed form roller
5. Excessive gum in fountain solution
6. Ink too strong
7. Ink too water-resistant

**Solution:**

1. Adjust fountain solution to proper pH/conductivity (pH 4.0-4.5)
2. Reduce dampener setting
3. Clean, copperize rollers; use less gum in fountain solution
4. Remove rollers from press, de-glaze appropriately and rinse
5. Re-copperize rollers; use less gum in fountain solution
6. Consult ink manufacturer

**13) Strike through and show through**
Strike-through results when the ink vehicle penetrates and stains the sheet so that the printing is easily visible in the reverse side. This is the fault of the ink and the paper.

Show-through is visibility of printing from the reverse side due to lack of opacity of the paper.

**Cause:**

1. The ink film printed is very thin, it may occur in very lightweight or porous stocks of paper.

2. If strike-through does take place, it is due to a strong penetrating vehicle in the ink, specially dark colored vehicle are prone to strike-through.

3. In such a case, order an ink with a relatively non-penetrating light colored vehicle.

**Solution:**

1. Sometimes a stronger ink printed with a thinner film will decrease or eliminate strike-through.

2. If strike-through occurs, it will affect the printing on the reverse side, the ink receptivity on this side will change causing an imperfect ink lay, giving a mottled appearance.
UNIT V

2 Marks Questions

1. Explain Drying of ink by polymerization?
   Polymerization means combining of small molecules into larger, more complex molecules.

2. Explain the Term: (i) Set-off
   Printed ink film transfers to back of next sheet. Solution: (i) Replace with quicker setting ink (ii) Apply infrared heater.

3. Explain the Term: Trapping
   Trapping is the efficient transfer of ink from an offset blanket to a printed ink film.

4. Explain the Term: Dry Trapping
   Some inks notably the quick-drying, hard-drying inks based on china wood or Tung oil, dry to form a hard impervious surface that will not trap uniformly or accept other ink. This problem is called dry trapping.

5. Explain the Term: Wet Trapping
   Failure of ink on one blanket to adhere to the print from a previous unit on a multicolor press is called a wet trapping problem.

6. Define the Terms: Emulsification.
   Water emulsifies into ink, producing weak color and unprinted spots

7. What is piling?
   Piling means accumulation of material (usually dried ink or paper coating) on to the blanket or plate.

8. What is Linting?
   Linting means an undesired pattern in the printing caused by accumulation of lint on the offset blanket.

9. What is called Mottle?
   Mottle is irregular and unwanted variation in color or gloss of the printed ink.

10. What is show-through?
    Dried printed ink produces unacceptable color on reverse side is called show-through.

11. State the reasons for ink set-off.
    Ink setoff, occurs when too much ink is run when the ink is too soft, or when the ink does not set quickly enough.

3 Marks Questions

1. Explain the Term : Scumming
   Scumming occurs when the background area of the plate takes ink instead of remaining clean. The ink adheres to the plate and is not readily wiped off with a cloth.
Bad ink formulation, poorly chosen pigment, dirty dampeners, improperly set form rollers, too much pressure between blanket and plate, a poorly desensitized plate, unsuitable paper, and improperly prepared lithographic film are among the causes of scumming.

2. **What is Hicks?**

Hickeys are caused by dirt: dirt from the ink, dirt from the paper, and dirt from the press or the pressroom. Controlling hickeys means keeping the press and the pressroom scrupulously clean, making sure that the paper and ink are clean, and handling the ink with care. Ink returned to the can by the pressman must be handled with care to keep dirt and air out of the ink.

3. **Define the Term Tinting.**

Tinting is caused by ink emulsifying in the dampening solution and results from a poorly formulated ink or one that has been softened excessively. The usual remedy is to change inks.

4. **What is setting of ink? (or) Define drying.**

In all major printing processes, printing ink is applied to the paper or other material as a liquid. The liquid is then converted to a solid state as soon as possible after impression. Therefore, drying of printing ink means ‘change of ink from the liquid to solid state’. This change takes place in two stages in certain kinds of inks. The first stage is ‘setting’ and the second is ‘hardening’ of the ink films. Setting of ink is a condition which allows printed sheets to be handled without smudging the print.

10 Marks Questions

1. Describe the various methods by which printing inks dry.
2. State various ink problems and their remedies.
3. Explain the drying characteristics of ink.
4. Write short notes on
   (i) Trapping (ii) Color (iii) Gloss (iv) Scumming
5. Write notes on
   (i) Scumming (ii) Set-off (iii) Mechanical Ghosting
6. Write short notes on
   (i) Trapping (ii) Hickeys (iii) Viscosity
7. Write notes on
   (i) Viscosity (ii) Chemical ghosting (iii) Stripping
8. Write any five ink problems and state the remedies for the same.
9. State explain the following ink problems and their remedies (i) Set-off (ii) Stripping (iii) Tie keys (iv) Mechanical ghosting (v) Trapping
10. Explain the various ink drying methods. Write in detail any two ink drying methods.