1. **Define machining. Discuss the different types of operations performed on the lathe and drilling machine.**

Machining is a manufacturing process in which a material is removed from a workpiece to give it the desired shape, size, and finish by using cutting tools. It includes a variety of operations such as cutting, drilling, milling, turning, grinding, etc. Machining is essential for producing parts with high precision and accuracy.

2. Operations Performed on a Lathe Machine:

A lathe machine is primarily used for rotating a workpiece against a cutting tool to perform various operations.

A. Common Lathe Operations:

1. Turning: Removing excess material from the outer diameter to reduce the diameter of a workpiece.
2. Facing: Making a flat surface perpendicular to the axis of rotation.
3. Parting (Cutting Off): Cutting the workpiece to a desired length.
4. Grooving: Making a narrow cavity (groove) on the workpiece.
5. Knurling: Producing a diamond-shaped pattern for grip on the surface.
6. Threading: Cutting external or internal threads on a workpiece.
7. Boring: Enlarging a hole that has already been drilled.
8. Drilling: Making a cylindrical hole using a drill bit (with the help of a tailstock).

B. Special Lathe Operations:

1. Taper Turning: Producing a conical shape by gradually reducing the diameter.
2. Forming: Creating complex profiles using a form tool.
3. Chamfering: Cutting a beveled edge on the workpiece.

3. Operations Performed on a Drilling Machine:

A drilling machine is used to create holes in a workpiece using a rotating drill bit. Drilling: Creating round holes in a solid material.

1. Reaming: Finishing the drilled holes to accurate size and improve surface finish.
2. Boring: Enlarging an existing hole using a single-point cutting tool.
3. Counterboring: Enlarging the top part of a hole to a specific diameter to allow the head of a bolt/screw to sit flush.
4. Countersinking: Creating a conical hole to allow screw heads to sit flush with or below the surface.
5. Spot Facing: Smoothing the surface around a hole for proper seating of bolts or nuts.
6. Tapping: Cutting internal threads in a hole.
7. **List important parameters of machining. Discuss different types of milling operations and shaping operations.**

Ans:-

Machining is a process of removing material from a workpiece to achieve the desired shape and size. The quality, efficiency, and precision of machining depend on several **key parameters**, which include:

**Important Machining Parameters:**

| **Parameter** | **Description** |
| --- | --- |
| **Cutting Speed (V)** | The speed at which the cutting tool moves relative to the workpiece surface, usually in m/min or ft/min. |
| **Feed Rate (f)** | The distance the tool advances for each revolution of the workpiece, typically in mm/rev or mm/tooth. |
| **Depth of Cut (d)** | The thickness of material removed in one pass, typically in mm. |
| **Tool Material** | Material of the cutting tool (e.g., HSS, carbide, diamond) affecting tool life and cutting performance. |
| **Workpiece Material** | The type of material being machined (e.g., steel, aluminum, plastic), which influences tool choice and cutting parameters. |
| **Tool Geometry** | Shape and angles of the tool, including rake angle, clearance angle, and nose radius. |
| **Coolant/Lubrication** | Fluids used to reduce heat, friction, and improve surface finish during machining. |
| **Machine Condition and Rigidity** | Stability and precision of the machine tool, affecting vibration and accuracy. |
| **Cutting Force** | Force required to shear material, influencing machine power requirements and tool wear. |

**Common Shaping Operations:**

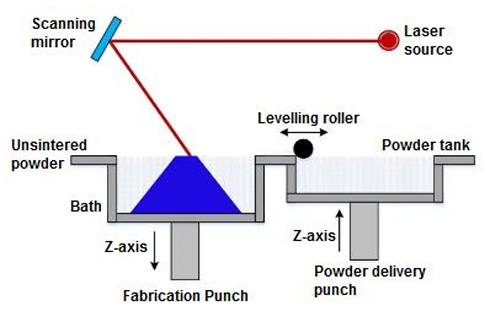
| **Shaping Operation** | **Description** |
| --- | --- |
| **Horizontal Shaping** | Producing horizontal flat surfaces by moving the tool horizontally. |
| **Vertical Shaping** | Producing vertical surfaces by vertical movement of the tool (performed on vertical shapers). |
| **Angular Shaping** | Producing inclined surfaces by tilting the tool or the workpiece. |
| **Irregular (Contour) Shaping** | Shaping irregular or curved profiles with specially designed tools. |
| **Slot and Groove Cutting** | Creating slots, grooves, or keyways using shaping tools. |
| **Internal Shaping (Slotting)** | Shaping internal surfaces or holes, performed on a slotter machine. |

**Differences Between Milling and Shaping:**

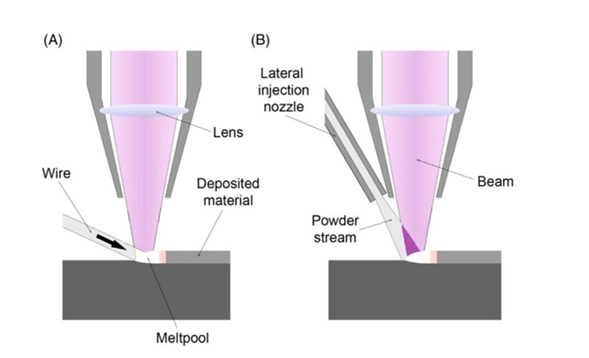
| **Aspect** | **Milling** | **Shaping** |
| --- | --- | --- |
| **Tool Movement** | Rotating multi-point tool | Reciprocating single-point tool |
| **Workpiece Movement** | Usually stationary or fed in specific direction | Stationary during tool stroke |
| **Surface Type** | Flat, curved, irregular, slots, gears | Flat, angular, grooves, internal shapes |
| **Production Rate** | Higher (multi-cutting edges) | Lower (single-point cutting tool) |

1. **How powder bed fusion (PBF) differs from the directed energy deposition (DED) process. Discuss in detail.**

Powder bed fusion (PBF) In PBF, thermal energy selectively fuses regions of a powder bed. Energy source may be in the form of laser, electron beam or indiscriminate electromagnetic energy. PBF techniques utilize a high energy power heat source (thermal printing head) for selective melting and consolidation of build material (powdered form) to fabricate 3D components. In its simplest working, a layer of build material of specified thickness is evenly spread over the build platform. The thickness of this layer generally varies from 30 to 150 μm. Heat source fuses the desired area of deposited layer. Then, the build platform is lowered down followed by spreading of powder and fusion of next layer. Similar steps are repeated to develop 3D objects using PBF.



Directed energy deposition In DED, a focused thermal energy source is utilized to fuse materials by melting as these are being deposited. In its simplest working, DED techniques consist of three units namely a heat source such as laser, electron beam or plasma arc, feedstock unit and substrate bed having motion controls. Initially, a heat source is utilized to generate molten pool and addition/injection of filler material in the form of powder, wire or combination of both occurs. This causes the feedstock materials to fuse and join to form layer-by-layer structures as the molten pool undergoes instantaneous solidification.



1. **List the different stages of 3D printing. Explain extrusion-based 3D printing in detail.**

Creating the CAD model of the Component

Conversion of the CAD model into the STL format (Solid to Layer)

Work piece layout and orientation and support generation

Slicing

Sections fabrication

Supports remove, cleaning and finishing

Extrusion-Based 3D Printing (Detailed Explanation)

Extrusion-based 3D printing, also known as Fused Deposition Modeling (FDM) or Fused Filament Fabrication (FFF), is one of the most widely used 3D printing technologies, especially for polymers and composite materials.

Working Principle:

* Material in the form of thermoplastic filament is fed into a heated nozzle.
* The filament melts inside the nozzle and is extruded through a fine tip.
* The printer's movement system (usually stepper motors) moves the nozzle along X, Y, and Z axes, depositing the molten material according to the sliced layer data.
* As the material is deposited, it cools and solidifies, bonding with the previous layer.
* The object is built layer by layer until the complete 3D shape is formed.

Components of an Extrusion-Based 3D Printer:

| Component | Function |
| --- | --- |
| Filament Spool | Supplies thermoplastic filament (e.g., PLA, ABS, PETG). |
| Extruder (Cold End) | Pulls and pushes filament towards the hot end. |
| Hot End (Nozzle) | Melts the filament and extrudes it as a thin line. |
| Heated Build Platform (Bed) | Holds the part being printed; may be heated to improve adhesion and prevent warping. |
| Stepper Motors | Control the precise movement of the nozzle and build platform. |
| Cooling Fans | Cool down the filament after extrusion for proper solidification. |
| Control System | Reads G-code and controls temperature, motion, and extrusion. |

Materials Used:

* Thermoplastics: PLA, ABS, PETG, Nylon, TPU (flexible).
* Composites: Filaments mixed with carbon fiber, wood, metal particles for specific properties.

Advantages of Extrusion-Based 3D Printing:

✅ Low-cost and widely available. ✅ Easy to operate and maintain. ✅ Supports a wide range of materials. ✅ Suitable for rapid prototyping and functional parts. ✅ Environmentally friendly options (e.g., PLA is biodegradable).

Limitations:

❌ Surface finish may be rough; layer lines are visible. ❌ Mechanical properties may be anisotropic (weaker along Z-axis). ❌ Limited resolution compared to SLA or SLS printers. ❌ Support structures are often needed for overhanging parts.

Applications:

* Prototyping for product development.
* Custom jigs and fixtures.
* Educational models.
* Medical models (e.g., anatomical replicas).
* Functional end-use parts (with reinforced materials).

1. **List the advantages of additive manufacturing. Explain the working principle behind VAT photopolymerization.**

AM promotes faster time to market

Possible to fabricate light weight customized shapes

Can reduce assembly

Supports the fabrication of personalised products

Helps in automation

Better buy-to-fly ratio can be achieved

Facilitates flexible logistics

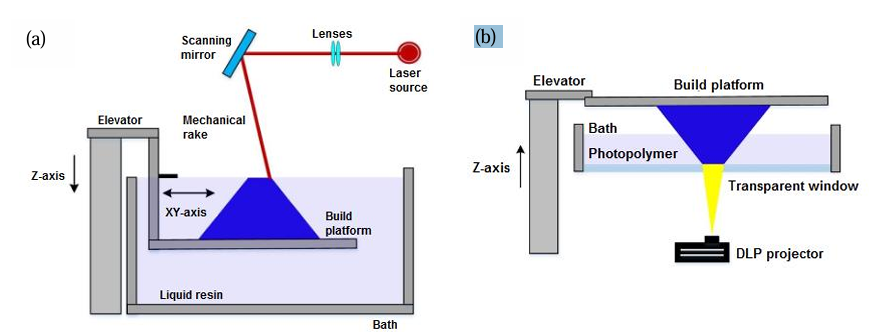
Improved product performance can be attained

AM can lower costs and simplify supply chains

Helps in mass customization

Vat photopolymerization VP is an AM process in which a liquid photopolymer in a vat is selectively cured by light activated polymerization. For a VP system, there are main two system configurations, viz. top down and bottom up. In a top down approach, the position of the platform is just below the surface in the resin. The layer of resin above the surface is cured using light and then the platform is lowered down towards the bottom of the resin tank to allow new resin to flow in and next layer to cure. Figure depicts a top down approach and bottom up approach. In the bottom up approach, the bottom of the resin tank remains transparent and the light strikes from underneath the tank to cure the resin. The build platform then moves upward to allow fresh resin to fill in for the next layer.

Advantages Good surface finish, high speed, adequate accuracy, Drawbacks (b) Figure 2 (a) SLA process (b) DLP process Need of post processing/curing, limitations on raw materials, need of support structures Variations Digital light processing (DLP) Digital light processing (DLP) 3D printing is a resin 3D printing process that uses a light projector rather than a laser to cure liquid resin one layer at a time. Continuous Liquid Interface Production CLIP works by projecting a continuous sequence of UV images generated by a digital light projector through an oxygen-permeable, UV-transparent window below a liquid resin bath. The dead zone above the window maintains a liquid interface below the part. Above the dead zone, the curing part is drawn out of the resin bath.



1. **How expandable mould casting differs from permanent mould casting. Explain with an example for each case.**

| Aspect | Expandable Mould Casting | Permanent Mould Casting |
| --- | --- | --- |
| Mould Usage | Single-use mould; destroyed to remove the casting. | Reusable mould; used repeatedly for multiple castings. |
| Material of Mould | Made from sand, plaster, or ceramic. | Made from metal (e.g., cast iron, steel, graphite). |
| Production Volume | Suitable for low to medium volume production. | Suitable for high volume, repetitive production. |
| Cost of Mould | Low-cost mould, but replaced for each casting. | High initial cost, but low cost per part due to reuse. |
| Surface Finish and Accuracy | Generally rougher surface finish, lower dimensional accuracy. | Better surface finish and higher dimensional accuracy. |
| Complexity of Parts | Can produce complex shapes with intricate details. | Typically for simpler shapes, though cores can add complexity. |
| Examples of Materials Cast | Cast iron, aluminum, bronze, steel (depending on process). | Non-ferrous alloys like aluminum, magnesium, and some steels. |

**Expandable Mould Casting: Explanation and Example**

**Definition:**

Expandable Mould Casting is a casting process where the mould is **broken and discarded** after each casting. It is flexible and suitable for complex shapes.

**Types of Expandable Mould Casting:**

* **Sand Casting**
* **Plaster Mould Casting**
* **Ceramic Mould Casting**
* **Shell Moulding**

**Example — Sand Casting:**

* **Process:**
  1. A pattern of the desired shape is made.
  2. Sand mixed with a binder is packed around the pattern to form the mould.
  3. After removing the pattern, molten metal is poured into the mould cavity.
  4. Once solidified, the sand mould is broken to retrieve the casting.
* Use Case: Engine blocks, pump housings, and machine components.

3. Permanent Mould Casting: Explanation and Example

Definition:

Permanent Mould Casting uses a durable mould made of metal, allowing multiple castings without significant wear. The mould does not need to be rebuilt for each casting.

Types of Permanent Mould Casting:

* Gravity Die Casting
* Pressure Die Casting (High/Low Pressure)
* Slush Casting
* Centrifugal Casting

Example — Gravity Die Casting:

* Process:
  1. A metal mould (die) is prepared and coated with refractory material.
  2. Molten metal is poured into the mould under gravity.
  3. After solidification, the mould is opened, and the part is removed.
  4. The mould is reused for the next casting.

1. **Briefly explain investment casting and centrifugal casting.**

**Invest**

Investment casting is also referred to as lost-wax casting since the pattern is made of wax.

The basic steps of the investment casting process are,

* Production of heat-disposable wax, plastic, or polystyrene patterns
* Assembly of these patterns onto a gating system
* “Investing,” or covering the pattern assembly with refractory slurry
* Melting the pattern assembly to remove the pattern material
* Firing the mold to remove the last traces of the pattern material
* Pouring
* Knockout, cutoff and finishing.

Advantages

1. Most ferrous and non-ferrous metals can be cast. This process is particularly suitable for casting of alloys that are expensive, hard, difficult-to-machine, and have high melting point and high strength.
2. It is possible to produce intricate shaped parts weighing from 1g to 10 kg.
3. It is possible to produce parts as big as 1.5 m in diameter with as thin walls as 1 mm.
4. The parts produced have good surface finish with matte appearance and close dimensional tolerances of the order of ±5microns.
5. The parts produced do not normally need any further machining or finishing operations.
6. Fine grained structure at the outer surface of the casting free of gas and shrinkage cavities and porosity

Disadvantages

1. The moulds can only be used once.
2. The process is comparatively slow.
3. The costs incurred due to the investment material and needed skill of labour are high.
4. The process is generally limited to small size and light weight castings.
5. Contamination of internal surface of castings with non-metallic inclusions
6. Inaccurate internal diameter

Applications

* The process is particularly advantageous for making small precision parts of intricate shapes.
* Typical parts made from this process are mechanical components such as gears, cams, valves, turbine blades, turbo-supercharge buckets and vanes of jet propelled engines.

CENTRIFUGAL

* In centrifugal casting process, the molten metal poured at the center of a rotating mold or die so that the molten metal is distributed by the centrifugal force to the outer regions of the die cavity .
* Because of the centrifugal force, the lighter impurities are crowded towards the center of the case. hat can be removed by machining a thin layer. Orientation of the mold can be horizontal or vertical

**Steps**

1. a mold is set up and rotated along a vertical, or horizontal axis.

2. The mold is coated with a refractory coating.

3. While rotating molten metal is poured in.

4. The metal that is poured in will then distribute itself over the rotating wall.

5. During cooling lower density impurities will tend to rise towards the center of rotation.

6. After the part has solidified, it is removed and finished.

* Typical metals cast are, steel, nickel alloys, copper, aluminum etc.
* In the case of vertical centrifugal casting because of the effect of gravity acting on the liquid metal, casting wall will be thicker at the base than at the top.
* Typical applications are train wheels, Jewelry, Seamless pressure tubes/pipes,bushings, and rings)

**Semicentrifugal casting:**

* In this process, centrifugal force is used to produce non-tubular parts (solid), and not tubular parts.
* Generally the density of metal will be more at the outer sections and not at the center of rotation. So parts in which the center region (less denser region) can be removed by machining (like wheels, pulleys) are usually produced with this method.

1. **What is meant by pattern, mould and core. Explain the steps behind sand casting, its advantage and disadvantages.**

**Pattern:**

* A **pattern** is a **replica or model** of the final object to be cast.
* It is used to **create the mould cavity** in the sand.
* Patterns are made slightly **larger than the final part** to allow for shrinkage of metal upon cooling.
* **Materials used**: Wood, metal, plastic, wax.

📝 **Example**: Wooden pattern of an engine block used to create a mould cavity for casting.

**Mould:**

* A **mould** is a **hollow cavity** formed in sand (or other material) that holds **molten metal** until it solidifies into the desired shape.
* In sand casting, the mould is made by packing sand around the pattern and then removing the pattern.

📝 **Example**: Sand mould cavity formed for casting a pump housing.

**Core:**

* A **core** is a **separate piece** inserted into the mould to create **internal cavities or hollow sections** in the casting.
* Made from **core sand** (sand mixed with binders) to withstand the molten metal's heat.

📝 **Example**: Core used to create internal passages in a valve body casting.

2. Steps Behind Sand Casting Process:

Sand casting is one of the oldest and most versatile casting processes, mainly used for metals like iron, aluminum, and bronze.

Step-by-Step Process:

Step 1: Pattern Making

* Create a pattern of the part to be cast.
* Add allowances (shrinkage, machining).

Step 2: Mould Making

* Place the pattern in a moulding box (flask).
* Pack sand around the pattern tightly (with binder for strength).
* Remove the pattern, leaving a cavity in the shape of the part.

Step 3: Core Making (if needed)

* Make cores for internal cavities.
* Place cores inside the mould cavity.

Step 4: Assembly of Mould

* Assemble cope (top part) and drag (bottom part) of the mould.
* Create gates, runners, and risers for metal flow and gases.

Step 5: Pouring

* Melt the metal in a furnace.
* Pour molten metal into the mould cavity through the sprue.

Step 6: Cooling and Solidification

* Allow metal to cool and solidify in the mould.

Step 7: Mould Breakout

* Break the sand mould to remove the casting.

Step 8: Cleaning and Finishing

* Remove sand, runners, risers.
* Perform surface finishing, machining, and inspection.

✅ 3. Advantages of Sand Casting:

| Advantages |
| --- |
| Suitable for complex shapes and large components. |
| Low cost of mould (sand is inexpensive). |
| Suitable for ferrous and non-ferrous metals. |
| Reusable sand (after processing). |
| Easy to adjust and modify the pattern. |
| Can produce large and heavy parts. |

✅ 4. Disadvantages of Sand Casting:

| Disadvantages |
| --- |
| Rough surface finish (compared to other methods like die casting). |
| Lower dimensional accuracy. |
| Labour intensive process. |
| Requires machining after casting to achieve tolerance. |
| Slow production rate for high-volume production. |
| Defects like porosity, shrinkage, and sand inclusion may occur. |

1. **Briefly explain different types of welding.**

Welding Processes Welding is a process in which two materials, usually metals, and is permanently joined together by coalescence, resulting from temperature, pressure, and metallurgical conditions. The particular combination of temperature and pressure can range from high temperature with no pressure to high pressure with any increase in temperature. Thus, welding can be achieved under a wide variety of conditions and numerous welding processes have been developed and are routinely used in manufacturing. To obtain coalescence between two metals following requirements need to be met: (1) perfectly smooth, flat or matching surfaces, (2) clean surfaces, free from oxides, absorbed gases, grease and other contaminants, (3e) metals with no internal impurities. These are difficult conditions to obtain. Surface roughness is overcome by pressure or by melting two surfaces so that fusion occurs. Contaminants are removed by mechanical or chemical cleaning prior to welding or by causing sufficient metal flow along the interface so that

they are removed away from the weld zone friction welding is a solid state welding technique. In many processes the contaminants are removed by fluxing agents. The production of quality welds requires (1) a satisfactory heat and/or pressure source, (2) a means of protecting or cleaning the metal, and (3) caution to avoid, or compensate for, harmful metallurgical effects.

**1. Arc Welding**

* **Definition**: Welding process that uses an **electric arc** to generate heat for melting and joining metals.
* **Common Types**:
  + **Shielded Metal Arc Welding (SMAW)** / **Stick Welding**
  + **Gas Metal Arc Welding (GMAW)** / **MIG Welding**
  + **Gas Tungsten Arc Welding (GTAW)** / **TIG Welding**
* **Applications**: Construction, shipbuilding, pipelines.

**2. Gas Welding**

* **Definition**: Welding process that uses a **gas flame** (e.g., **oxy-acetylene**) to melt and join metals.
* **Types**:
  + **Oxy-Acetylene Welding (OAW)**
* **Applications**: Sheet metal work, repair jobs, thin sections.

**3. Resistance Welding**

* **Definition**: Welding process that uses **pressure and electric current** to generate heat at the joint for welding.
* **Types**:
  + **Spot Welding**
  + **Seam Welding**
  + **Projection Welding**
* **Applications**: Automotive body panels, metal furniture.

**4. Solid-State Welding**

* **Definition**: Joining process where **no melting** occurs; heat and pressure are applied below the melting point.
* **Types**:
  + **Friction Welding**
  + **Ultrasonic Welding**
  + **Explosion Welding**
* **Applications**: Aerospace components, electrical connections.

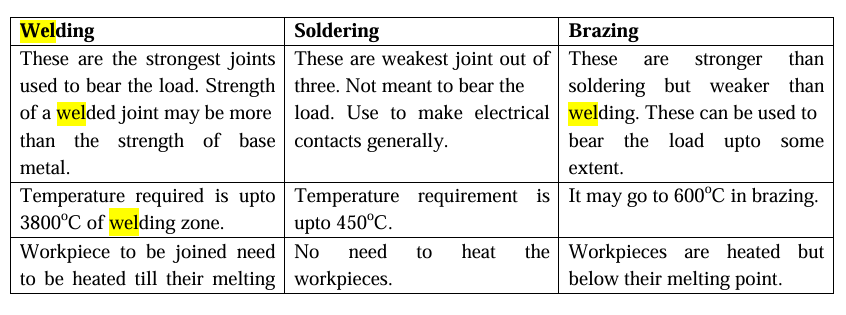
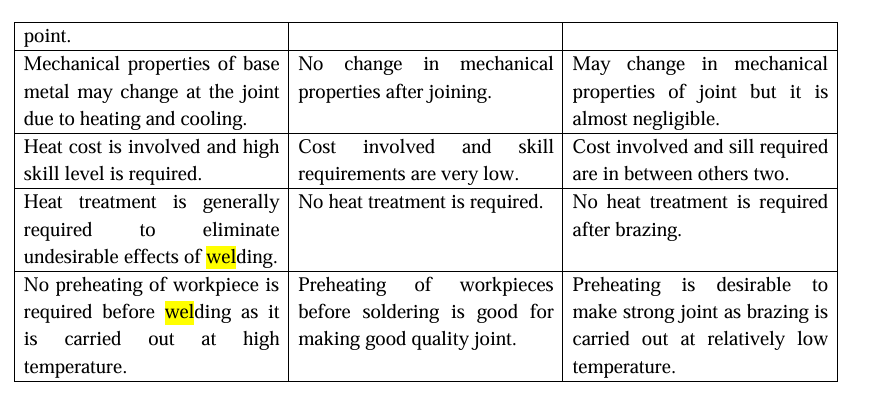
**5. Energy Beam Welding**

* **Definition**: Welding that uses **concentrated beams** of energy to melt and join metals.
* **Types**:
  + **Laser Beam Welding (LBW)**
  + **Electron Beam Welding (EBW)**
* **Applications**: Precision instruments, aerospace, medical devices.

**6. Thermit Welding**

* **Definition**: Uses **exothermic chemical reaction** (thermite reaction) to produce molten metal for welding.
* **Applications**: Rail track joining, heavy machinery repair.

**10.Mention the difference between welding, soldering and brazing.**

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