Electrical Discharge Machining (EDM)

- Started in 1940s
- Also called electric discharge or spark erosion machining
- Eroding material in the path of DC electrical discharges that form an arc between a shaped electrode tool and the workpiece in a dielectric (electrically non-conducting) fluid.
- Only for conductive materials
- One of the most accurate manufacturing processes
### Process Capabilities

- Die cavities by use of die-sinking EDM process
- Stepped cavities
- Internal cavities
- Deep small diameter holes, narrow slots, turbine blades and various intricate shapes
- Metal removal rate range from 2 to 400 mm³/min
  - Higher rate, rougher surface
    - Poor surface finish and low fatigue life
  - Therefore, finishing cuts made at low removal rate
- Recent techniques using oscillating electrode, providing very fine surface finish

### Examples of EDM

**Stepped cavities** produced with a square electrode by the EDM process. The workpiece moves in the two principal horizontal directions (x-y), and its motion is synchronized with the downward movement of the electrode to produce these cavities. Also shown is a round electrode capable of producing round or elliptical cavities.

[Image: Schematic illustration of producing an inner cavity by EDM, using a specially designed electrode with a hinged tip, which is slowly opened and rotated to produce the large cavity]
Electrical Discharge Machining

Examples of cavities produced by the electrical-discharge machining process, using shaped electrodes. Two round parts (rear) are the set of dies for extruding the aluminum piece shown in front.

A spiral cavity produced by EDM using a slowly rotating electrode, similar to a screw thread.

Wire EDM

- As much as 50 hours of machining can be performed with one reel of wire
- Wire materials: brass, copper, tungsten, zinc- or brass-coated wires
- Diameter: typically 0.3mm for roughing cuts and 0.20 mm for finishing cuts
- Travel velocity: 0.15 to 9 m/min
- Clear dielectric fluid
Wire EDM

Cutting a thick plate with wire EDM

A computer-controlled wire EDM machine

Laser Beam Machining (LBM)

- Laser as the source of energy
- Highly focused, high intensity melts and evaporates portions of materials in controlled manner
- Variety of metallic and non-metallic materials
**Process Capabilities**

- Machining variety materials
- Drilling holes as small as 5 micrometers and hole depth-to-diameter ratio of 50:1
- Cutting of steel plates as thick as 32 mm
- Widespread use in electronics and automotive industries
- Compete successfully in cutting thin sheet materials with traditional methods (e.g. punching)

**General Applications of Lasers**

<table>
<thead>
<tr>
<th>Application</th>
<th>Laser type</th>
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<tbody>
<tr>
<td>Cutting</td>
<td>PCO2, CWCO2, Nd : YAG, ruby</td>
</tr>
<tr>
<td>Metals</td>
<td>PCO2</td>
</tr>
<tr>
<td>Plastics</td>
<td>CWCO2</td>
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<tr>
<td>Ceramics</td>
<td>PCO2</td>
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<tr>
<td>Drilling</td>
<td>PCO2, Nd : YAG, Nd : glass, ruby</td>
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<tr>
<td>Plastics</td>
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<td>Surface treatment, metals</td>
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</tr>
<tr>
<td>Welding, metals</td>
<td>PCO2, CWCO2, Nd : YAG, Nd : glass, ruby</td>
</tr>
</tbody>
</table>

*Note: P pulsed, CW continuous wave.*
Lasers

- “LASER” : “Light Amplification by Stimulated Emission of Radiation”
- Focused laser beam has high power density.
  - Useful for welding, cutting, heat treating, ...
- Three materials processing lasers
  - Gas (CO$_2$)
  - Solid-state lasers (Nd:YAG)