HISTORICAL MILESTONES IN EVOLUTION OF MANUFACTURING

PERIOD	DATES	METALS AND CASTING	FORMING AND SHAPING	JOINING	TOOLS, MACHINING AND MANUFACTURING SYSTEMS
Egypt: ~ 3100BC to ~ 300 B.C. Greece: ~1100 BC to ~146 B.C. Roman Empire: ~500 B.C. to A.D. 476 Middle Ages: ~476 to 1492 Renaissance: 14th to 16th Centuries	Before 4000 B.C.	Gold, copper, meteoric iron	Hammering		Tools of stone, flint, wood, bone, ivory, composite tools
	4000-3000 B.C.	Copper casting, stone and metal molds, lost-wax process, silver, lead, tin, bronze	Stamping, jewelry	Soldering (Cu-Au, Cu-Pb, Pb-Sn)	Corundum (alumina, emery)
	3000-2000 B.C.	Bronze casting and drawing, gold leaf	Wire by slitting sheet metal	Riveting, brazing	Hoe making, hammered axes, tools for ironmaking and carpentry
	2000-1000 B.C.	Wrought iron, brass			
	1000-1 B.C.	Cast iron, cast steel	Stamping of coins	Forge welding of iron and steel, gluing	Improved chisels, saws, files, woodworking lathes
	A.D. 1-1000	Zinc, steel	Armor, coining, forging, steel swords		Etching of armor
	1000-1500	Blast furnace, type metals, casting of bells, pewter	Wire drawing, gold and silversmith work		Sandpaper, windmill-driven saw
	1500-1600	Cast-iron cannon, tinplate	Water power for metalworking, rolling mill for coinage strips		Hand lathe for wood
	1600-1700	Permanent-mold castings, brass from copper and metallic zinc	Rolling (lead, gold, silver), shape rolling (lead)		Boring, turning, screw-cutting lathe, drill press
Industrial Revolution: ~1750 to 1850	1700-1800	Malleable cast iron, crucible steel (iron bars and rods)	Extrusion (lead pipe), deep drawing, rolling		
	1800-1900	Centrigufal casting, Bessemer process, electrolytic aluminum, nickel steels, babbitt, galvanized steel, powder metallurgy, open-hearth steel	Steam hammer, steel rolling, seamless tube, steel-rail rolling, continuous rolling, electroplating		Shaping, milling, copying lathe for gunstocks, turret lathe, universal milling machine, vitrified grinding wheel

WW I	1900-1920		Tube rolling, hot extrusion	Oxyacetylene; arc, electrical resistance and thermit welding	Geared lathe, automatic screw machine, hobbing, high-speed-steel tools, aluminum oxide and silicon carbide (synthetic)
WW II	1920-1940	Die casting	Tugsten wire from metal powder	Coated electrodes	Tungsten carbide, mass production, transfer machines
	1940-1950	Lost-wax process for engineering parts	Extrusion (steel), swaging, powder metals for engineering parts	Submerged arc welding	Phosphate conversion coatings, total quality control
	1950-1960	Ceramic mold, nodular iron, semiconductors, continuous casting	Cold extrusion (steel), explosive forming, thermomechanical processing	Gas metal-arc, gas tungsten-arc and electroslag welding, explosive welding	Electrical and chemical machining, automatic control
Space Age	1960-1970	Squeeze casting, single- crystal turbine blades	Hyrdoforming, hydrostatic extrusion, electroforming	Plasma-arc and electron-beam welding, adhesive bonding	Titanium carbide, synthetic diamond, numerical control, integrated circuit chip
1970-1990	Compacted graphite, vacuum casting, organically-bonded sand, automation of molding and pouring, rapid solidification, metal-matrix composites, semi-solid metalworking, amorphous metals, shape-memory alloys (smart materials), computer simulation,	Precision forging, isothermal forging, superplastic forming, dies made by computer-aided design and manufacturing, net-shape forging and forming, computer simulation	Laser beam, diffusion bonding (also combined with superplastic forming), surface- mount soldering	Cubic boron nitride, coated tools, diamond turning, ultraprecision machining, computer-integrated manufacturing, industrial robots, machining and turning centers, flexible-manufacturing systems, sensor technology, automated inspection, expert systems, artificial intelligence, computer simulation and optimization	Adhesives, composite materials, semiconductors, optical fibers, structural ceramics, ceramic-matrix composites, biodegradable plastics, electrically-conducting polymers
1990-2000s	Rheocasting, computer-aided design of molds and dies, rapid tooling	Rapid prototyping, rapid tooling, environmentally-friendly metalworking fluids	Friction stir welding, lead-free solders, laser butt-welded (tailored) sheet-metal blanks, electrically-conducting adhesives	Micro- and nanofabrication, LIGA (a German acronym for a process involving lithography, electroplating, and molding), dry etching, linear motor drives, artificial neural networks, six sigma	Nanophase materials, metal foams, advanced coatings, high- temperature superconductors. machinable ceramics, diamond-like carbon