COMPUTER AIDED MANUFACTURING (CAM)

UNIT 1 (AUTOMATION)

COMPUTER AIDED MANUFACTURING (CAM)

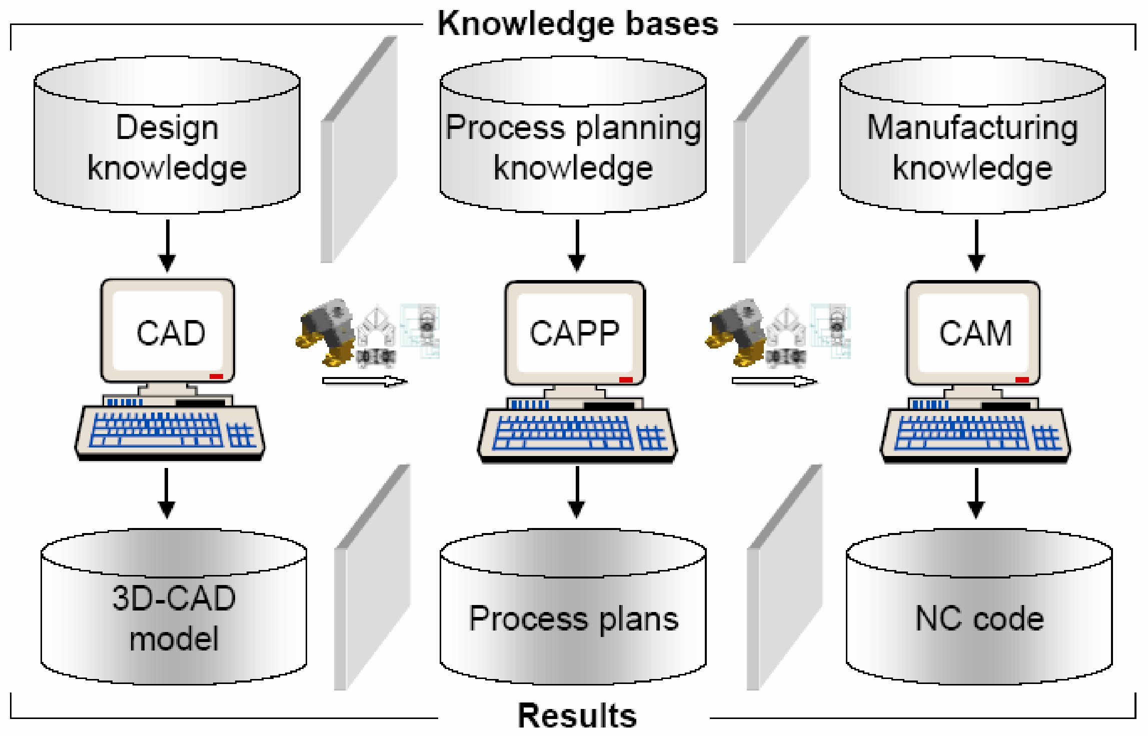
Since the age of the Industrial Revolution, the manufacturing process has undergone many dramatic changes. One of the most dramatic of these changes is the introduction of Computer Aided Manufacturing (CAM), a system of using computer technology to assist the manufacturing process.

Through the use of CAM, a factory can become highly automated, through systems such as real-time control and robotics. A CAM system usually seeks to control the production process through varying degrees of automation. Because each of the many manufacturing processes in a CAM system is computer controlled, a high degree of precision can be achieved that is not possible with a human interface.

The CAM system, for example, sets the tool path and executes precision machine operations based on the imported design. Some CAM systems bring in additional automation by also keeping track of materials and automating the ordering process, as well as tasks such as tool replacement.

COMPUTER AIDED MANUFACTURING (CAM)

CAM Computer Aided Manufacturing involves the use of computer programs specifically designed to create the geometry and tool paths needed for parts to be machined. These tool paths can then be automatically processed into a program specific for the CNC machine to be used.



AUTOMATION

Automation is the technology by which a process or procedure is accomplished without human assistance. It is implemented using a program of instructions combined with a control system that executes the instructions, To automate a process power is required, both to drive the process itself and to operate the program and control system. Although automation can be applied in a wide variety of areas, it is most closely associated with the manufacturing industries.

NEED OF AUTOMATION

Companies undertake projects in manufacturing automation and computer integrated manufacturing for a variety of good reasons. Some of the reasons used to justify automation are the following.

To increase labor productivity, Automating a manufacturing operation usually increases production rate and labor productivity This means greater output per hour of labor input.

To reduce labor cost, Ever-increasing labor cost has been and continues to be the trend in the world's industrialized societies. Consequently, higher investment in automation has become economically justifiable to replace manual operations. Machines are increasingly being substituted for human labor to reduce unit product cost.

To mitigate the effects of labor shortages, There is a general shortage of labor in many advanced nations. and this has stimulated the development of automated operations as a substitute for labor.

To reduce or eliminate routine manual and clerical tasks. An argument can be put forth that there is social value in automating operations that are routine. boring, fatiguing and possible irksome. Automating such tasks serves a purpose of improving the general level of working conditions.

To improve worker safety. By automating a given operation and transferring the worker from active participation in the process to a supervisory role, the work is made safer.

To improve product quality. Automation not only results in higher production rates
than manual operations, it also performs the manufacturing process with greater uni
formity and conformity to quality specifications. Reduction of fraction defect rate is
one of the chief benefits of automation.

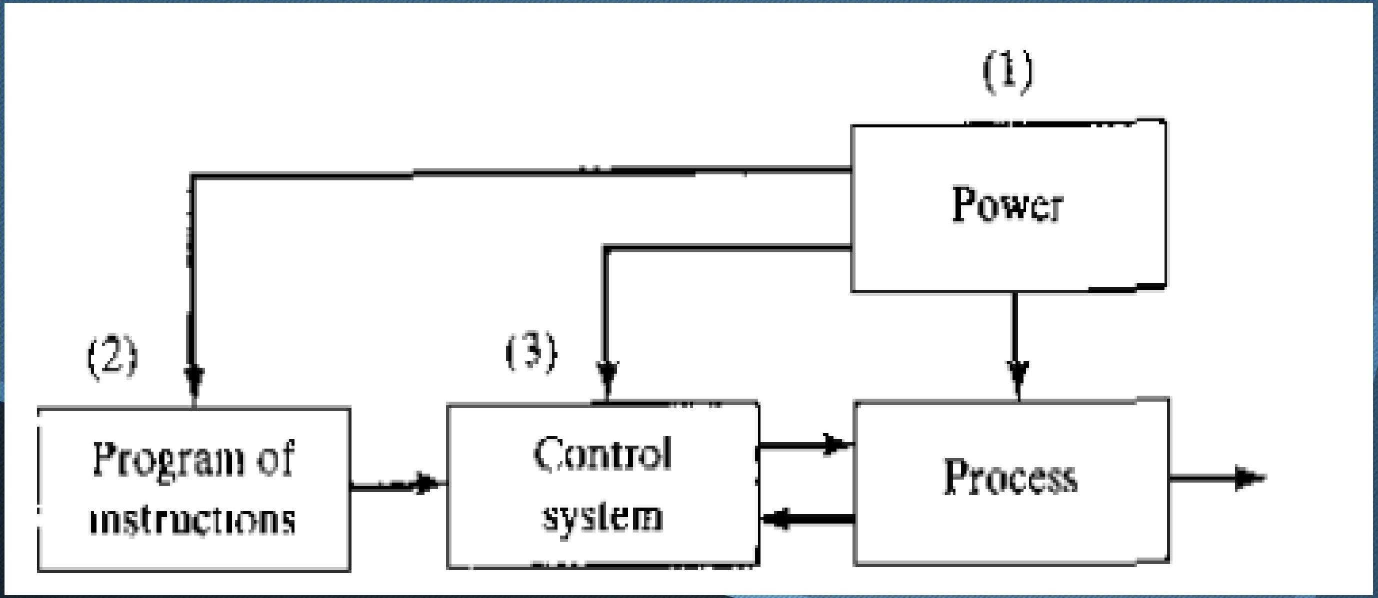
To reduce manufacturing lead lime. Automation helps to reduce the elapsed time between customer order and product delivery, providing a competitive advantage to
the manufacturer for future orders. By reducing manufacturing lead time, the manufacturer also reduces work-in-process inventory.

To accomplish processes that cannot be done manually, Certain operations cannot be
accomplished without the aid of a machine, These processes have requirements for
precision, miniaturization. or complexity of geometry.

BASIC ELEMENTS OF AN AUTOMATED SYSTEM

An automated system consists of three basic elements.

1. ***power*** to accomplish the process and operate the system.
2. a ***program of instructions*** to direct the process.
3. a ***control system*** to actuate the instructions.



Elements of an automated system: (1) power, (2) program of instructions, and (3) control systems.

POWER TO ACCOMPLISH THE AUTOMATED PROCESS

An automated system is used to operate some process, and power is required to drive the process as well as the controls. The principal source of power in automated systems is electricity. Electrical power can be readily converted to alternative energy forms: mechanical, thermal, light, acoustic, hydraulic, and pneumatic.

Process	*Power Form*	*Action Accomplished*
Casting	Thermal	Melting the metal before pouring into a mold cavity where solidification occurs.
Electric discharge machining (EDM)	Electrical	Metal removal is accomplished by a series of discrete electrical discharges between electrode (tool) and workpiece. The electric discharges cause very high localized temperatures that melt the metal.
Forging	Mechanical	Metal workpart is deformed by opposing dies. Workparts are often heated in advance of deformation, thus thermal power is also required.
Heat treating	Thermal	Metallic work unit is heated to temperature below melting point to effect microstructural changes.
Injection molding	Thermal and mechanical	Heat is used to raise temperature of polymer to highly plastic consistency, and mechanical force is used to inject the polymer melt into a mold cavity.
Laser beam cutting	Light and thermal	A highly coherent light beam is used to cut material by vaporization and melting.
Machining	Mechanical	Cutting of metal is accomplished by relative motion between tool and workpiece.
Sheet metal punching and blanking	Mechanical	Mechanical power is used to shear metal sheets and plates.
Welding	Thermal (maybe mechanical)	Most welding processes use heat to cause fusion and coalescence of two (or more) metal parts at their contacting surfaces. Some welding processes also apply mechanical pressure to the surfaces.

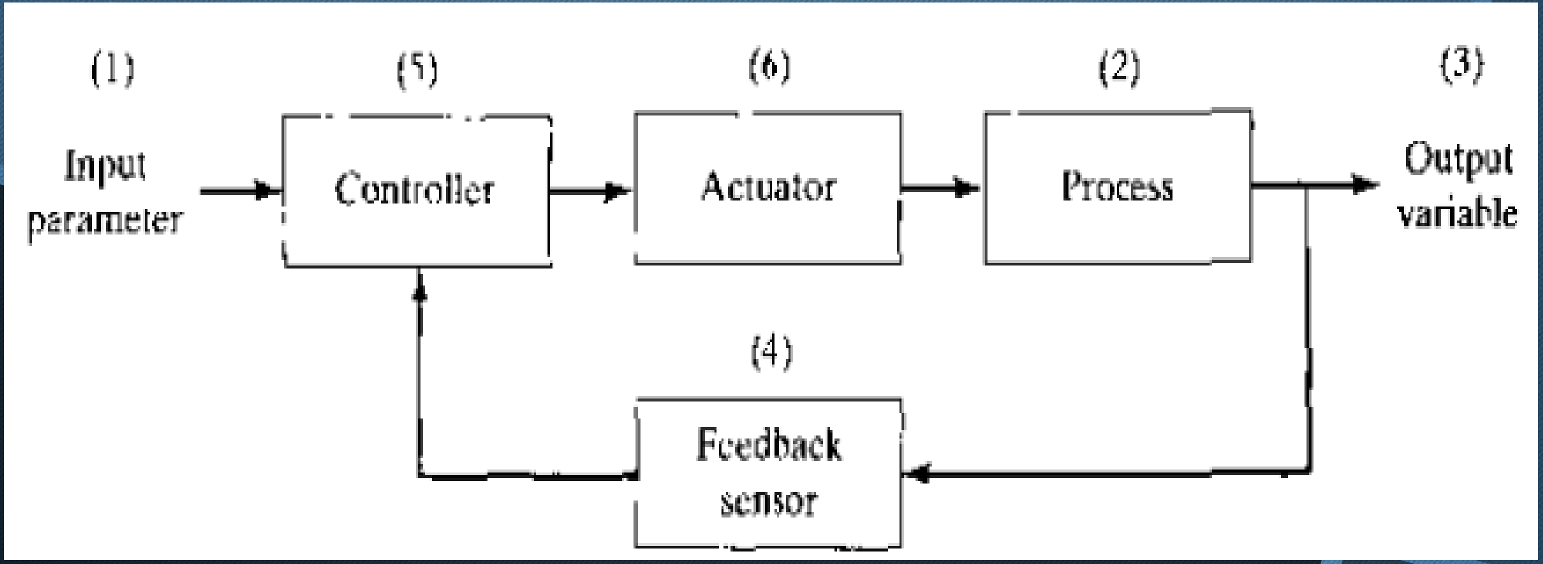
PROGRAM OF INSTRUCTIONS

Program Feature	*Examples or Alternatives*
Steps in work cycle	Example: • Typical sequence of steps: (1) load, (2), process, (3) unload
Process parameters (inputs) in each step	Alternatives: • One parameter versus multiple parameters that must be changed during the step • Continuous parameters versus discrete parameters • Parameters that change during the step; for example, a positioning system whose axes values change during the processing step
Manual steps in work cycle	Alternatives: • Manual steps versus no manual steps (completely automated work cycle) Example: • Operator loading and unloading parts to and from machine
Operator interaction	Alternatives: • Operator interaction versus completely automated work cycle Example: • Operator entering processing information for current workpart
Different part or product styles	Alternatives: • Identical part or product style each cycle (mass or batch production) versus different part or product styles each cycle (flexible automation)
Variations in starting work units	Example: • Variations in starting dimensions or part features

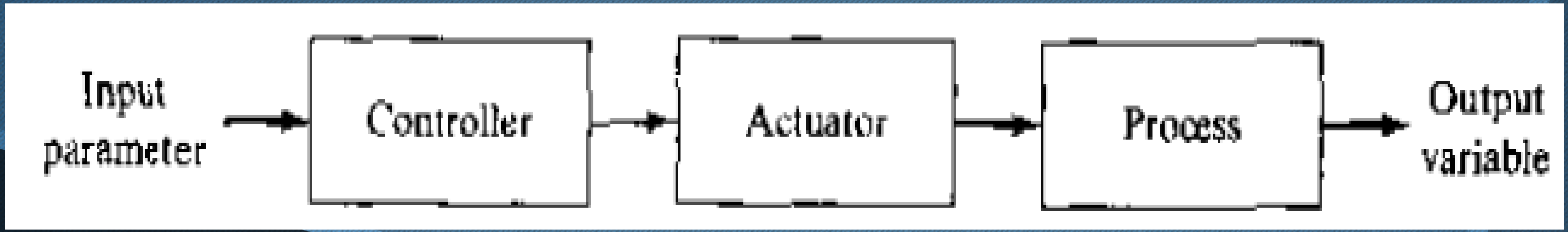
CONTROL SYSTEM

The controls control of an automated system can be either **closed loop or open loop.**

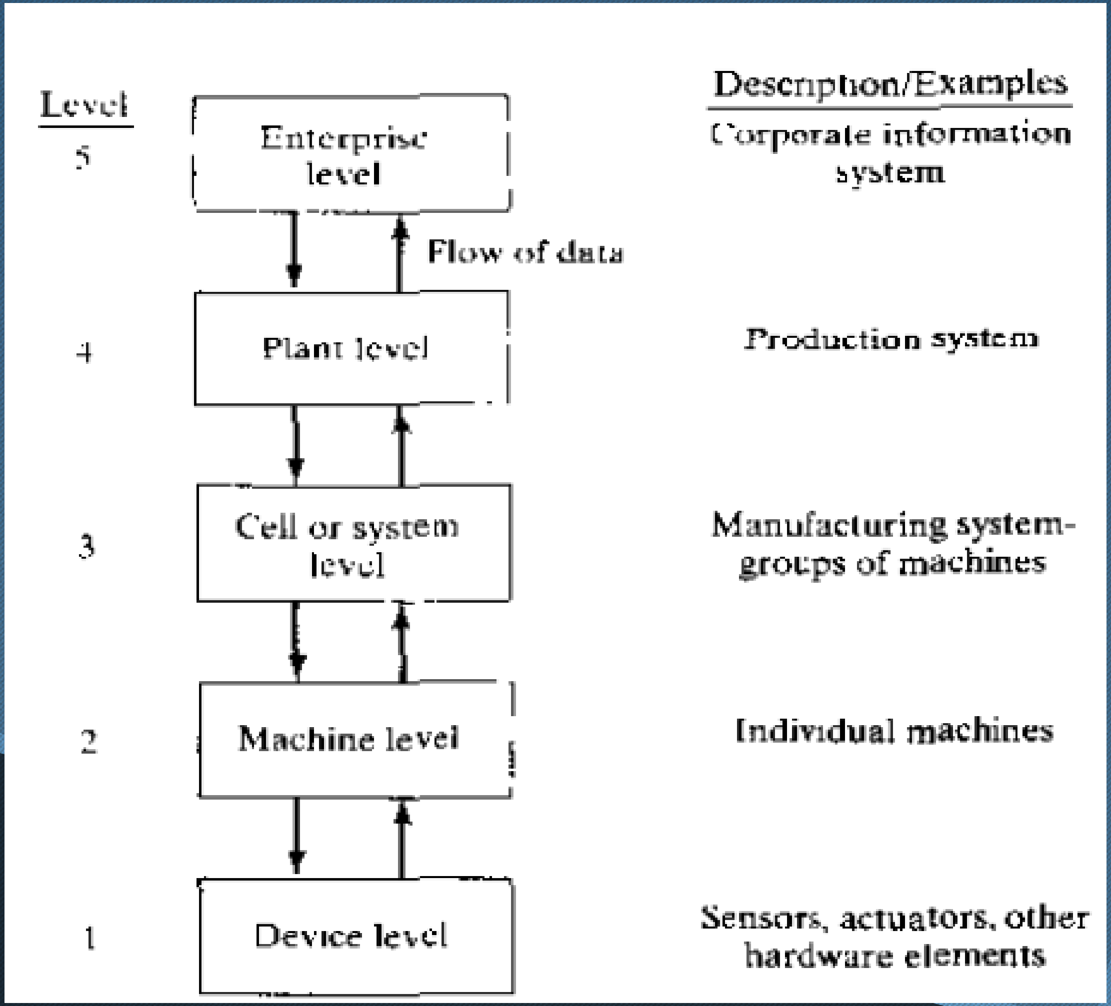
A *closed loop control system,* also known as a *feedback control system.* is one in which the output variable is compared with an input parameter, and any difference between the two is used to drive the output into agreement with the input.



In contrast to the closed loop control system, an *open loop control system* operates
without the feedback loop. In this case, the controls operate without measuring
the output variable. So no comparison is made between the actual value of the output
and the desired input parameter.



LEVELS OF AUTOMATION



1. Device level. This is the lowest level in our automation hierarchy. It includes the actuators, sensors, and other hardware components that comprise the machine level. The devices are combined into the individual control loops of the machine; for example, the feedback control loop for one axis of a CNC machine or one joint of an industrial robot.

2. Machine level. Hardware at the device level is assembled into individual machines. Examples include CNC machine tools and similar production equipment, industrial robots, powered conveyors, and automated guided vehicles. Control functions at this level include performing the sequence of steps in the program of instructions in the correct order and making sure that each step is properly executed.

3. Cell or system level. This is the manufacturing cell or system level, which operates under instructions from the plant level. A manufacturing cell or system is a group of machines or workstations connected and supported by a material handling system, computer. and other equipment appropriate to the manufacturing process. Production lines arc included in this level. functions include part dispatching and machine loading. coordination among machines and material handling system, and collecting
and evaluating inspection data.

4. Plant level. This is the factory or production systems level. It receives instructions from *the* corporate information system and translates them into operational plans for production. Likely functions include: order processing, process planning, inventory control, purchasing, material requirements planning, shop floor control, and quality control.

5. Enterprise level. This is the highest level. Consisting of the corporate information system. It is concerned with all of the functions necessary to manage the company: marketing and sales, accounting, design, research, aggregate planning, and master production scheduling.

STRATEGIES OF AUTOMATION

1. Specialization of operations, The first strategy involves the use of special-purpose equipment designed to perform one operation with the greatest possible efficiency. This is analogous to the concept of labor specialization, which is employed to improve labor productivity

2. Combined operations. Production occurs as a sequence of operations. Complex parts may require dozens, or even hundreds, of processing steps. The strategy of combined operations involves reducing the number of distinct production machines or workstations through which the part must be routed. This is accomplished by performing more than one operation at a given machine, thereby reducing the number of separate machines needed

3. Simultaneous operations A logical extension of the combined operations strategy is to simultaneously perform the operations that are combined at one workstation. In effect, two or more processing (or assembly) operations are being performed simultaneously on the same workpart. thus reducing total processing time.

4. *Integration of operations.* Another strategy is to link several workstations together into a single integrated mechanism, using automated work handling devices to transfer parts between stations. In effect, this reduces the number of separate machines through which the product must be scheduled. with more than one workstation. several parts can be processed simultaneously, thereby increasing the overall output of the system.

5. *Increased flexibility.* This strategy attempts to achieve maximum utilization of equipment for job shop and medium-volume situations by using the same equipment for a variety of parts or products, It involves the use of the flexible automation concepts.

6. *Improved material handling and storage.* A great opportunity for reducing non productive time exists in the use of automated material handling and storage systems. Typical benefits include reduced work-in-process and shorter manufacturing lead times.

7. *On-line inspection,* Inspection for quality of work is traditionally performed after the process is completed. This means that any poor-quality product has already been produced by the time it is inspected. Incorporating inspection into the manufacturing process permits corrections to the process as the product is being made. This reduces scrap and brings the overall quality of the product closer to the nominal specifications intended by the designer.

8, Process control and optimization. This includes a wide range of control schemes intended to operate the individual processes and associated equipment more efficiently.
By this strategy, the individual process times can be reduced and product quality improved.

9. Plant operations control. Whereas the previous strategy was concerned with the control
of the individual manufacturing *process,* this strategy is concerned with control at the plant level. It attempts to manage and coordinate the aggregate operations in
the plant more efficiently. Its implementation usually involves a high level of computer
networking within the factory.

10. Computer-integrated manufacturing (CIM). Taking the previous strategy one level
higher. we have the integration of factory operations with engineering design and the business functions of the firm, CIM involves extensive use of computer applications, computer data bases, and computer networking throughout the enterprise

ADVANTAGES AND DISADVANTAGES OF AUTOMATION

ADVANTAGES

- Replacing human operators in tasks that involve hard physical or monotonous work.

- Replacing humans in tasks performed in dangerous environments such as those with temperature extremes or radioactive and toxic atmospheres.

- Making tasks that are beyond human capabilities easier. Handling heavy or large loads, manipulating tiny objects or the requirement to make products very quickly or slowly are examples of this.

- Production is often faster and labour costs less on a per product basis than the equivalent manual operations.

- Automation systems can easily incorporate quality checks and verifications to reduce the number of out-of-tolerance parts being produced while allowing for statistical process control that will allow for a more consistent and uniform product.

- Economic improvement. Automation can serve as the catalyst for improvement in the economies of enterprises or society. For example, the gross national income and standard of living in Germany and Japan improved drastically in the 20th century, due in large part to embracing automation for the production of weapons, automobiles, textiles and other goods for export.

DISADVANTAGES

• Technology limits. Current technology is unable to automate all desired tasks. Some tasks cannot be easily automated, such as the production or assembly of products with inconsistent component sizes or in tasks where manual dexterity is required. There are some things that are best left to human assembly and manipulation.

• Economic limits. Certain tasks would cost more to automate than to perform manually. Automation is typically best suited to processes that are repeatable, consistent and high volume.

• Unpredictable development costs. The research and development cost of automating a process is difficult to predict accurately beforehand. Since this cost can have a large impact on profitability, it is possible to finish automating a process only to discover that there is no economic advantage in doing so. With the advent and continued growth of different types of production lines, however, more accurate estimates based on previous projects can be made.

• Initial costs are relatively high. The automation of a new product or the construction of a new plant requires a huge initial investment compared to the unit cost of the product. Even machinery for which the development cost has already been recovered is expensive in terms of hardware and labour. The cost can be prohibitive for custom production lines where product handling and tooling must be developed.

• A skilled maintenance department is often required to service and maintain the automation system in proper working order. Failure to maintain the automation system will ultimately result in lost production and/or bad parts being produced.

HISTORY OF AUTOMATION

The history of automation can be traced to the development of basic mechanical device such as the wheel (circa 3200 B.C.), lever, winch (circa 600 B.C.), cam (circa A.D. 1000), screw (A.D. 1405). and gear in ancient and medieval times. These basic devices were refined and used to construct the mechanisms in waterwheels, windmills (circa A.D. 650), and steam engines (A.D. 1765).These machines generated the power to operate other machinery of various kinds, such as flour mills (circa 85 B.C.), weaving machines (flying shuttle, 1733),machine tools (boring mill, 1775),steamboats (1787),and railroad locomotives (1803). *Power,* and the capacity to generate it and transmit it to operate a process, is one of the three basic elements of an automated system.

After his first steam engine in 1765,James Watt and his partner, Matthew Boulton ,made
several improvements in the design. One of the improvements was the flying-ball governor
(around 1785),which provided feedback to control the throttle of the engine. The governor consisted of a ball on the end of a hinged lever attached to the rotating shaft.
The third basic element of an automated system is for the actions of the system of machine
to be directed by a *program of instructions,* One of the first examples of machine programing was jaquard loom in 1800.