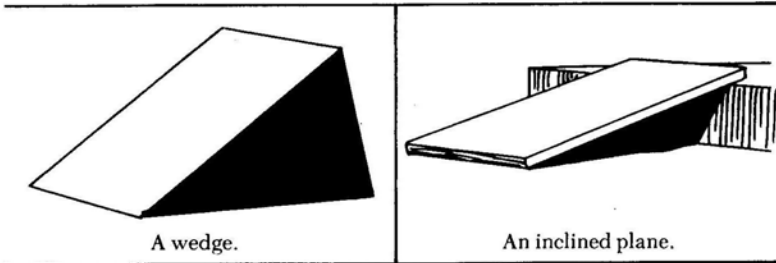


Engineering: The application of scientific principles to practical ends. An *engineer* is a member of the engineering profession, though the term also refers to people who operate or maintain certain kinds of equipment—a locomotive engineer on a railroad for example. In the latter use, the person referred to is a highly trained technician rather than a professional engineer.

Empirical Information: Information that is based on observation and experience rather than on theoretical knowledge.

Wedge: A triangular-shaped piece of material with one very acute angle. It is one of the simple basic machines used for tightening or levering.



A wedge.

An inclined plane.

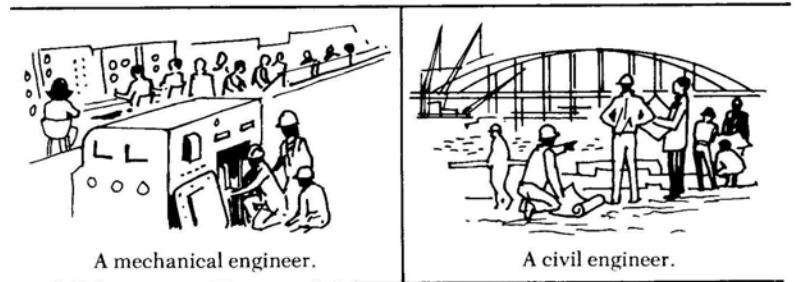
Inclined Plane: A surface at an angle less than 90° from the horizontal. It is another simple or basic machine used to raise or lower a load by rolling or sliding.

Quantification: Giving numerical values to information.

Horsepower: A measure used in the English-speaking countries for the work performed by a machine. It was devised in the eighteenth century by James Watt and equals 33,000 foot-pounds per minute.

Mechanical Advantage: The ratio of the output force of a machine to the input force necessary to work the machine.

Mechanical Engineering: The branch of engineering that deals with machines and their uses. *Industrial engineering* is a branch of this field that deals with the use of machines in industrial environments such as factories.

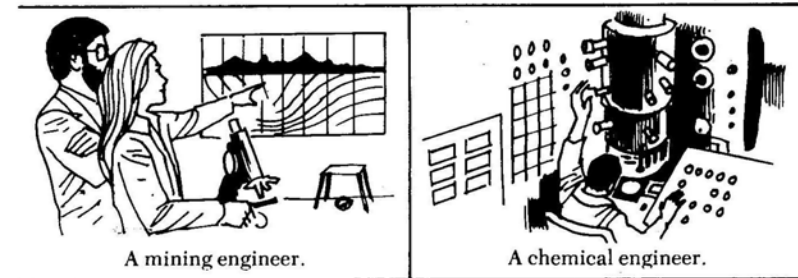


A mechanical engineer.

A civil engineer.

Civil Engineering: The branch of engineering that deals with the design and building of structures intended to be stationary—buildings, dams, and bridges, for example.

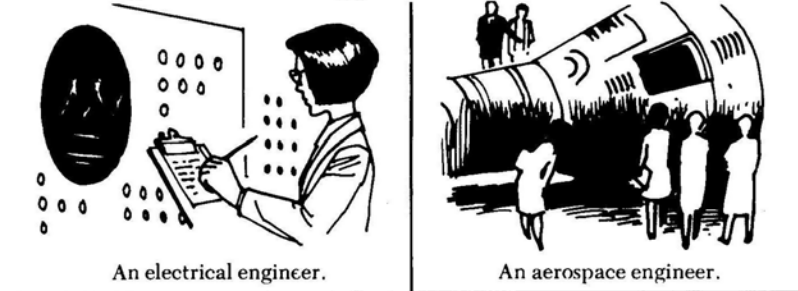
Mining and Metallurgy: The branch of engineering that deals with extracting materials from the earth and refining them.



A mining engineer.

A chemical engineer.

Chemical Engineering: The branch of engineering that deals with processes involving reactions among the elements, the basic natural substances. *Petroleum engineering* deals specifically with processes involving petroleum.



An electrical engineer.

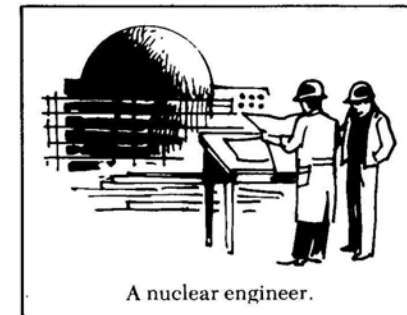
An aerospace engineer.

Electrical and Electronic Engineering: The branch of engineering that deals with the effects and processes resulting from the behavior of tiny particles of matter called electrons.

Aerospace Engineering: A branch of engineering that deals with flight in the earth's atmosphere or in space.

Nuclear Engineering: A modern branch of engineering that deals with the processes resulting from the break-up of some particles of matter.

Systems Engineer: An engineer who coordinates the work of other engineers from different disciplines who are involved in one project.



A nuclear engineer.

THE BASIC MACHINES

Special Terms

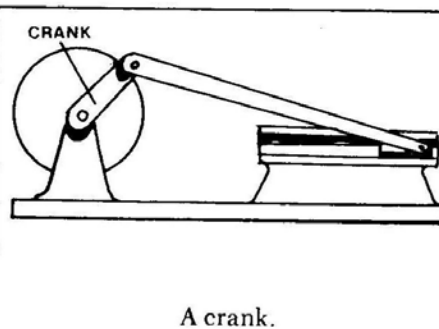
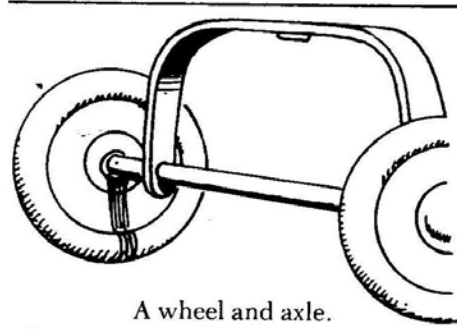
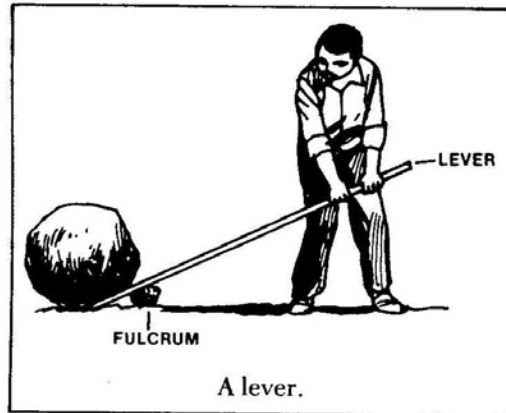
Lever: A basic machine consisting of a rigid piece or bar that turns on a point.

Fulcrum: The point on which a lever turns.

Effort End: The point where force is applied to a lever.

Load End: The point where there is resisting force on a lever.

Wheel and Axle: A basic machine consisting of a wheel that rotates on a shaft called the axle.



Crank: A bent shaft or arm for transmitting motion or changing from rotary to reciprocating motion and vice versa.

Pulley: A basic machine consisting of a wheel with a grooved rim through which a rope, wire, or chain is passed.

Block: A pulley contained in a housing; the combination of a fixed and a movable block together with a rope is known as a *block and tackle*.

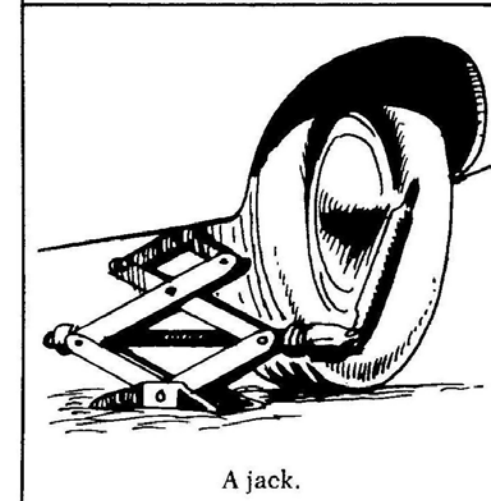
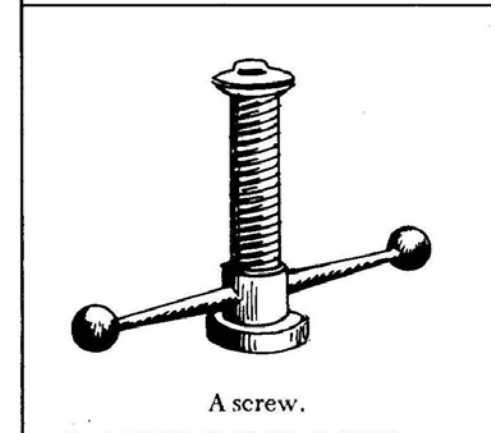
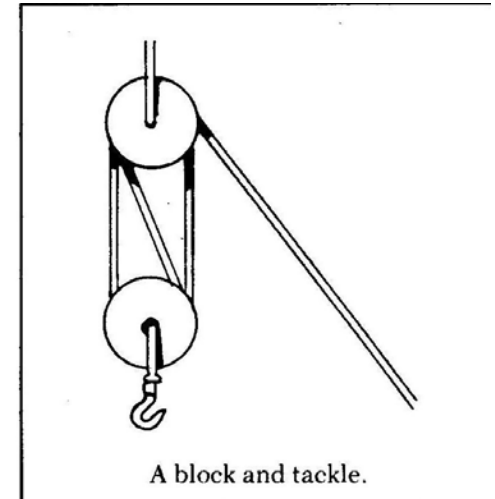
Wedge: A basic machine consisting of a piece of material tapering to a thin edge.

Inclined Plane: A basic machine; at its simplest a surface at an angle to the horizon.

Screw: A basic machine sometimes described as a helical inclined plane or a cylinder with a helical groove around the outer surface.

Helix: The corkscrew-shaped figure that results from wrapping the line of an inclined plane around a cylinder; the plural is *helices*.

Jack: A device used to raise heavy weights for short distances.



MACHINE COMPONENTS

Special Terms

Mechanism: A component of a machine that transmits or changes motion.

Kinematics: A branch of the science of mechanics that deals with aspects of motion apart from considerations of mass and force.

Gear: A wheel with teeth that can engage another wheel with teeth; gears work in pairs to transmit or change motion.

Axial Motion: Motion around an axis, the line around which a wheel rotates.

Spur Gear: A gear with straight teeth parallel to the axis.

Pinion: The smaller member of a pair of gears or the smallest gear of a series; gear is used to designate the larger member.

Helical Gear: A gear with teeth cut in the shape of a helix.

Herringbone Gear: A helical gear with two sets of teeth at equal but opposite angles to each other.

Bevel Gear: A gear with teeth slanted at an angle to the plane of the wheel itself.

Worm Gear: A mechanism consisting of a gear that meshes with a *worm*, a screw with helical teeth.

Rack and Pinion: A gear mechanism composed of a rack (a straight bar with teeth) and a pinion (a spur gear).

Cam: A rotating or sliding piece of machinery that acts as part of a pair to impart or receive motion.

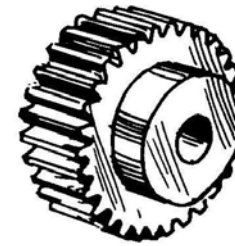
Follower: The other part of a cam mechanism, usually a rod and shaft that receives and transmits motion from the cam.

Linkage: A mechanism consisting of rods connected to each other by joints that permit motion.

Spring: An elastic material that returns to its original shape after being forced out of that shape.

Leaf Spring: A spring made of strips, rather than a spiral, of elastic material which is usually metal.

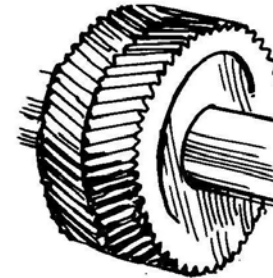
Ratchet: A mechanism that works with a *pawl*. The ratchet is a bar or wheel with inclined teeth; the pawl is usually a rod that can drop between the teeth to permit motion in only one direction.



A spur gear.



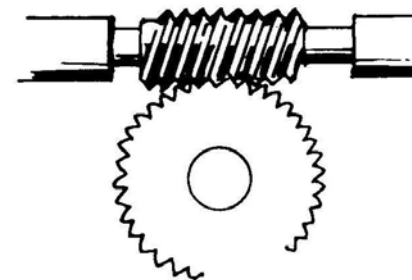
A helical gear.



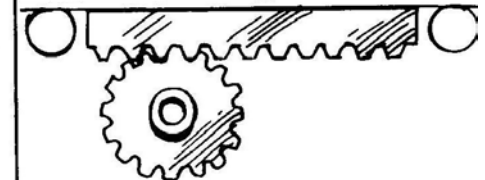
A herringbone helical gear.



A bevel gear.



A worm gear.



A rack and pinion.

MACHINES AND WORK

Special Terms

Machine: A device that applies force to accomplish an objective.

Force: An effort that results in change in motion or stress.

Work: The effect of a force multiplied by the distance through which it is exerted.

Block and Tackle: A variation of one of the basic machines; it uses the principle of a lever.

Prime Mover: A machine which converts energy from a natural source like water, wind, steam, or petroleum into mechanical energy or electricity. Most electric motors are *not* prime movers.

Foot-pound: Work is usually measured in terms of foot-pounds in the English-speaking countries. One foot-pound is a force of one pound through a distance of one foot in the direction of the force.

Linear Motion: Motion in a straight line; technically it is known as *translation*.

Reciprocating Motion: A linear motion that goes back and forth in the same path.

Rotary Motion: Motion in a circular path.

Torque: A force which produces *torsion*, a twisting stress or rotary motion.

Efficiency: A machine's ratio between work output and energy input.

Friction: The resistance to relative motion produced by two moving bodies in contact with each other.

Power: The rate or speed at which work is performed.

Newton: The unit of force required to accelerate one kilogram one meter per second per second.

Joule: An international metric measure of energy; one joule is approximately three-quarters of a foot-pound.

Watt: An international metric measure of power equal to one joule per second; 746 watts are equal to one horsepower.

Kilowatt: A thousand watts; approximately $1\frac{1}{3}$ horsepower in the English system.

INDUSTRIAL ENGINEERING AND AUTOMATION

Special Terms

Industrial Engineering: The subdivision of mechanical engineering that deals with the use of machines in industrial or manufacturing processes.

Mass Production: Manufacturing of large quantities of exactly similar products with each worker in the plant usually performing only a limited number of operations on the product.

Assembly Line: An arrangement of equipment, machines, and workers so that work passes in a line until the product is assembled.

Automation: The process of operating and controlling mechanical devices by automatic means without action by human beings.

Program: A step-by-step sequence that breaks a task into its individual parts; it determines the processes in an automated system.

Action Elements: The components of an automated system that perform the actual work.

Mechanical Handling Devices: Another term for the action elements in an automated system.

Sensing Devices: Devices that measure the value of a physical quantity such as temperature, pressure, flowrate, or thickness.

Feedback: Information is sent from the sensing device to an instrument where it is compared with a reference value to generate an error signal; the return of this error signal to control the process is known as feedback.

Decision Element: The part of an instrument that compares the information from the sensor with the reference value to generate the error signal.

Control Element: The part of an automated system that carries out the instructions given by the decision element.

Friction: The resistance to relative motion of two bodies moving in contact with each other.

Coefficient of Friction: The constant ratio of the friction to the force pressing the surfaces together.

Static Friction: The resistance to motion between two bodies in contact with each other but at rest.

Sliding Friction: The resistance to continued motion when one body has started to move.

Rolling Friction: The resistance to motion when one or more bodies is rotating or rolling, but not on the same axis.

Babbitt Metal: An alloy or mixture of tin, copper, and antimony with a low coefficient of friction.

Teflon: A plastic containing fluorine with a low coefficient of friction.

Antimony: A metalloid element, silvery-white, brittle yet soft with the unusual quality of expanding when solidified; used as a constituent of alloys.

Lubrication: Application of a substance, usually oil or grease (a *lubricant*) to reduce friction.

Polymers: Long, heavy, complex molecules forming repeating structural units that occur in many plastics.

Bearing: That part of a machine which supports parts in relative motion.

Ball Bearings: Bearings containing small round balls, sometimes known as *anti-friction bearings*.

Cage: A device to hold and separate bearings.

Races: Rings within which cages of bearings are sealed.

Roller Bearings: Bearings with rolling elements in the shape of cylinders or *tapered* cylinders or *needles*; they have a greater load-carrying capacity but more friction than ball bearings of similar size.

Non-contact Bearings: Bearings that touch only at rest; in motion they are separated by gas or fluid.

Brakes and Braking Devices: Devices to slow and control motion in a machine, usually through some form of friction.

Drum Brake: A braking device with friction material pressing on the inside of a metal drum.

Fading: Lowering the coefficient of friction in a braking device.

Disk Brake: A braking device of metal disks which can be brought into contact against friction pads.

Clutch: A device by which different parts of a machine can be connected or disconnected without bringing the parts to rest.

Disk Clutch: A clutching device that uses disks lined with friction material and no lubrication.

STEAM ENGINES

Special Terms

Steam: The invisible vapor into which water is changed when it is heated to the boiling point.

Boiler: A vessel in which water is boiled to produce steam.

Condense: To return to a liquid state, as when steam reverts to water. The process is *condensation* and a device that causes the process to take place is a *condenser*.

Vacuum: A space devoid of matter. Vacuums are *partial*, not complete.

Valve: A device that opens or closes to control the flow of liquids or gases.

Piston: A rod or disk that can move up or down within a hollow cylinder.

Walking Beam: A lever that works on the seesaw principle, with input on one side and output on the other side of the fulcrum.

Crankshaft: A shaft driving or driven by a crank.

Sun-and-Planet Gears: An arrangement in which a smaller gear (the planet) rotates around a larger gear (the sun).

Safety Valve: A valve that opens automatically when steam or other pressure exceeds a predetermined amount.

Internal Combustion Engine: A heat engine in which combustion (burning of fuel) takes place within a cylinder, as in engines that burn gasoline. Steam engines are not internal combustion engines.

Turbine: A rotating machine with blades set and kept in motion by water, steam, or gas.

Generator: A machine that produces energy by rotating through a magnetic field; the shaft of the generator is often turned by a turbine.

THE INTERNAL COMBUSTION ENGINE

Special Terms

- Four-stroke Engine:** A device in which the piston makes four strokes or movements, two up and two down, for each charge of fuel.
- Carburetor:** A device in which gasoline is changed into a vapor and mixed with air.
- Spark Plug:** An apparatus that forms a spark causing the gas and air mixture in an internal combustion engine to burn.
- Flywheel:** A heavy wheel attached to the crankshaft that stores energy to help the piston make the first, second, and fourth strokes in a four-stroke cycle.
- Camshaft:** A device to control the valves that let gases in and out of the cylinder.
- Ignition System:** The devices that ignite, or set on fire, the fuel in an internal combustion engine.
- Glider:** An aircraft that flies without power, using air currents and gravity.
- Radial Engine:** An internal combustion engine used for aircraft; the cylinders are set around a center point like the radii of a circle.
- Diesel Engine:** An internal combustion engine that compresses air until it becomes so hot that burning occurs when fuel is injected into the cylinder; no ignition spark is needed.

GAS TURBINES AND OTHER TYPES OF ENGINES

Special Terms

- Gas Turbine Engine:** An internal combustion engine in which combustion drives a turbine with blades similar to those of a steam turbine.
- Turboprop Engine:** A gas turbine engine in which the turbine drives a shaft that turns a propeller.
- Turbojet Engine:** An engine in which gases pass through a turbine and are expelled from the rear of the engine; this thrust pushes the machine forward. Also known as a *jet*.
- Blower:** A device for the intake and compression of air in gas turbine and some kinds of jet engines.
- Fanjet Engine:** The common type of jet engine in commercial aircraft; the blower is a complex version of an electric fan.
- Pulsejet Engine:** A jet engine with an air intake using lateral valves that pulse or vibrate.
- Ramjet Engine:** A jet engine in which air is forced in under extremely high pressure.
- Petrochemical Products:** Products made from petroleum by chemical processes, including some kinds of plastics.
- Nuclear Fission:** The splitting or fission of the nucleus, the central part of an atom; a result of the fission is energy.
- Nuclear Fusion:** The joining or fusion of the nuclei of different atoms; a result of the process is release of a great deal of energy.
- Hot-air Engine:** An engine using heated air to push down a piston; also known as the *Stirling engine*.
- Rotary Engine:** An internal combustion engine producing rotary instead of reciprocating motion; the best known type is called the *Wankel engine* after its inventor.
- Rotor:** A machine component which revolves, thereby producing rotary motion.