# Introduction to Mechanical Engineering

## What is Engineering:

**Engineering** is the discipline, art, skill and profession of acquiring and applying scientific, mathematical, economic, social and practical knowledge to design and build structures, machines, devices, systems, materials and processes that safely realize improvements to the lives of people.

The American Engineers Council for Professional Development (ECPD, the predecessor of ABET has defined "engineering" as:

The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behaviour under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property.

> ***Scientists study the world as it is; engineers create the world that has never been.***
>
> **—Theodore von Kármán**

"Engineering is quite different from science. Scientists try to understand nature. Engineers try to make things that do not exist in nature. Engineers stress invention. To embody an invention the engineer must put his idea in concrete terms and design something that people can use. That something can be a device, a gadget, a material, a method, a computing program, an innovative experiment, a new solution to a problem, or an improvement on what is existing. Since a design has to be concrete, it must have its geometry, dimensions, and characteristic numbers. Almost all engineers working on new designs find that they do not have all the needed information. Most often, they are limited by insufficient scientific knowledge. Thus they study mathematics, physics, chemistry, biology and mechanics. Often they have to add to the sciences relevant to their profession. Thus engineering sciences are born."

Although engineering solutions make use of scientific principles, engineers must also take into account safety, efficiency, economy, reliability and constructability or ease of fabrication, as well as legal considerations such as patent infringement or liability in the case of failure of the solution.

## Who are Mechanical Engineers:

The field of mechanical engineering encompasses the properties of forces, materials, energy, fluids, and motion, as well as the application of those elements to devise products that advance society and improve people's lives.

The definition of mechanical engineering:

*The branch of engineering that encompasses the generation and application of heat and mechanical power and the design, production and use of machines and tools.*

*Is a branch of engineering concerned with the design, construction and operation of machines and machinery.*

*The branch of engineering that specializes in the design, production and uses of* ***machines****.*

Mechanical engineers are known for their broad scope of expertise and for working on a wide range of machines. Just a few examples include the microelectromechanical acceleration sensors used in automobile air bags; heating, ventilation, and air-conditioning systems in offi ce buildings; heavy off-road construction equipment; hybrid gas-electric vehicles; gears, bearings, and other machine components; artificial hip implants; deep-sea research vessels; robotic manufacturing systems; replacement heart valves; non-invasive equipment for detecting explosives; and interplanetary exploration spacecraft. Based on employment statistics, mechanical engineering is the third largest discipline among the five traditional engineering fields, and it is often described as offering the greatest flexibility of career choices. In 2008, approximately 238,700 people were employed as mechanical engineers in the United States, a population representing over 15% of all engineers. The discipline is closely related to the technical areas of industrial (240,500 people), aerospace (71,600), and nuclear (16,900) engineering, since each of those fields evolved historically as a spin-off from mechanical engineering. Together, the fields of mechanical, industrial, aerospace and nuclear engineer account for about 36% of all engineers. More than half of the current mechanical engineering jobs are in industries that design and manufacture machinery, transportation equipment, computer and electronic products, and fabricated metal products. Emerging fields like biotechnology, materials science, and nano technology are expected to create new job opportunities for mechanical engineers. The U.S. Bureau of Labor Statistics predicts an increase of nearly 10,000 mechanical engineering jobs by the year 2016. A degree in mechanical engineering can also be applied to other engineering specialties, such as manufacturing engineering, automotive engineering, civil engineering, or aerospace engineering.

While mechanical engineering often is regarded as the broadest of the traditional engineering fields, there are many opportunities for specialization in the industry or technology that interests you. For example, an engineer in the aviation industry might focus her career on advanced technologies for cooling turbine blades in jet engines or fly-by-wire systems for controlling an aircraft’s flight. Above all else, mechanical engineers make hardware that works. An engineer’s contribution to a company or another organization ultimately is evaluated based on whether the product functions as it should. Mechanical engineers design equipment, it is produced by companies, and it is then sold to the public or to industrial customers. In the process of that business cycle, some aspect of the customer’s life is improved, and society as a whole benefits from the technical advances and additional opportunities that are offered by engineering research and development.

## Mechanical Engineering’s Top Ten Achievements:

Mechanical engineering isn’t all about numbers, calculations, computers, gears, and grease. At its heart, the profession is driven by the desire to advance society through technology. The American Society of Mechanical Engineers (ASME) surveyed its members to identify the major accomplishments of mechanical engineers. This professional society is the primary organization that represents and serves the mechanical engineering community in the United States and internationally. This top ten list of achievements, summarized in Table, can help you better understand who mechanical engineers are and appreciate the contributions they have made to your world. In descending order of the accomplishment’s perceived impact on society, the following milestones were recognized in the survey:

1. The automobile
2. The Apollo program
3. Power generation
4. Agricultural mechanization
5. The airplane
6. Integrated-circuit mass production
7. Air conditioning and refrigeration
8. Computer-aided engineering technology
9. Bioengineering
10. Codes and standards

**The Automobile:** The development and commercialization of the automobile were judged as the profession’s most significant achievement in the twentieth century. Two factors responsible for the growth of automotive technology have been high-power, lightweight engines and efficient processes for mass manufacturing. German engineer Nicolaus Otto is credited with designing the first practical four-stroke internal-combustion engine. After untold effort by engineers, it is today the power source of choice for most automobiles. In addition to engine improvements, competition in the automobile market has led to advances in the areas of safety, fuel economy, comfort, and emission control. Some of the newer technologies include hybrid gas-electric vehicles, antilock brakes, run-fl at tires, air bags, widespread use of composite materials, computer control of fuel-injection systems, satellite-based navigation systems, variable valve timing, and fuel cells.


The ASME recognized not only the automobile’s invention but also the manufacturing technologies behind it. Through the latter, millions of vehicles have been produced inexpensively enough that the average family can afford one. Quite aside from his efforts of designing vehicles, Henry Ford pioneered the techniques of assembly-line mass production that enabled consumers from across the economic spectrum to purchase and own automobiles. Having spawned jobs in the machine tool, raw materials, and service industries, the automobile has grown to become a key component of the world’s economy. From minivans to stock car racing to Saturday night cruising, the automobile—one of the key contributions of mechanical engineering—has had an ubiquitous influence on our society and culture.

**The Apollo Program:** In 1961, President John F. Kennedy challenged the United States to land a man on the Moon and return him safely to Earth. The first portion of that objective was realized fewer than ten years later with the July 20, 1969 landing of Apollo 11 on the lunar surface. The three-man crew of Neil Armstrong, Michael Collins, and Buzz Aldrin returned safely several days later. Because of its technological advances and profound cultural impact, the Apollo program was chosen as the second most influential achievement of the twentieth century.

The Apollo program was based on three primary engineering developments: the huge three-stage Saturn V launch vehicle that produced some 7.5 million pounds of thrust at lift off, the command and service module, and the lunar excursion module, which was the first vehicle ever designed to be flown only in space. It’s stunning to put the rapid pace of Apollo’s development in perspective. Only 66 years after Wilbur and Orville Wright made their first powered flight, millions of people around the world witnessed the first lunar landing live on television.

The Apollo program is perhaps unique among engineering achievements in the way that it combined technological advances and the spirit of exploration. Indeed, the photographs of Earth that have been taken from the perspective of space have changed how we view ourselves and our planet. Apollo, planetary exploration, communications satellites, and even sophisticated weather forecasting would have been impossible without the initiative and dedicated effort of thousands of mechanical engineers.

**Power Generation:** One aspect of mechanical engineering involves designing machinery that can convert energy from one form to another. Abundant and inexpensive energy is recognized as an important factor behind economic growth and prosperity, and the generation of electrical power is recognized as having improved the standard of living for billions of people across the globe. In the twentieth century, entire societies changed as electricity was produced and routed to homes, businesses, and factories.

Although mechanical engineers are credited with having developed efficient technologies to convert various forms of stored energy into more easily distributed electricity, the challenge to bring power to every man, woman, and child around the globe still looms for mechanical engineers.

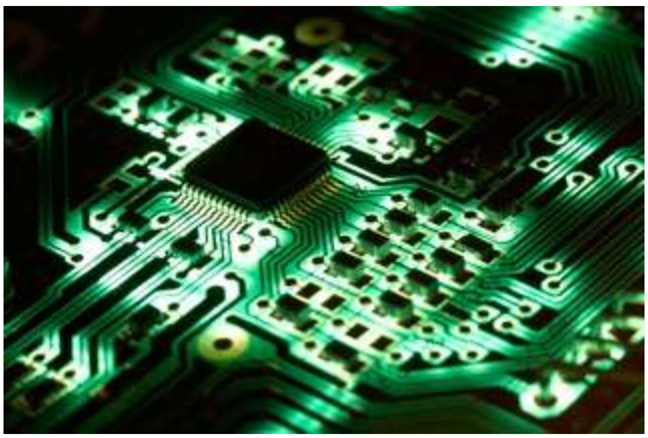
Mechanical engineers manipulate the stored chemical energy of such fuels as coal, natural gas, and oil; the kinetic energy of wind that drives electricity-producing turbines; the nuclear energy in electrical plants, ships, submarines, and spacecraft; and the potential energy of water reservoirs that feed hydroelectric power plants. Some of the issues that factor into power generation are the cost of the fuel, the cost of constructing the power plant, the potential emissions and environmental impact, around the-clock reliability, and safety. The large-scale generation of electrical power is a prime example of the need for engineers to balance technology, social, environmental, and economic considerations. As the supply of natural resources diminishes and as fuels become more expensive in terms of both cost and the environment, mechanical engineers will become even more involved in developing advanced power-generation technologies, including solar, ocean, and wind power systems.

**Agricultural Mechanization:** Mechanical engineers have developed technologies to improve significantly the efficiency in the agricultural industry. Automation began in earnest with the introduction of powered tractors in 1916 and the development of the combine, which greatly simplified harvesting grain. Decades later, research is underway to develop the capability for machines to harvest a field autonomously, without any human intervention using advanced machinery, GPS technology, and intelligent guidance and control algorithms. Other advances include improved weather observation and prediction, high-capacity irrigation pumps, automated milking machines, and the digital management of crops and the control of pests. As those technologies became widespread, people began to take advantage of social, employment, and intellectual opportunities in sectors of the economy other than agriculture. The technology of agricultural mechanization enabled many other advances in other economic sectors including shipping, trade, food and beverage, and healthcare.

**The Airplane:** The development of the airplane and related technologies for safe powered flight were also recognized by the American Society of Mechanical Engineers as a key achievement of the profession. Commercial passenger aviation has created travel opportunities for business and recreational purposes, and international travel in particular has made the world become a smaller and more interconnected place. Early explorers and settlers required 6 months to cross North America by oxen teams; the journey took 2 months by steamboat and stagecoach; and a train could complete the trip in about 4 days. Today, the journey takes 6 hours by commercial jet and is safer and more comfortable than it has ever been.


Mechanical engineers have developed or contributed to nearly every aspect of aviation technology. One of the main contributions has been in the area of propulsion. Early airplanes were powered by piston-driven internal-combustion engines, such as the 12-horsepower engine that was used in the first Wright Flyer. By contrast, the General Electric Corporation's engines that power some Boeing 777 jetliners can develop a maximum thrust of over 100,000 pounds-force. Advancements in high-performance military aircraft include vectored turbofan engines that enable the pilot to redirect the engine's thrust for vertical take offs and landings. Mechanical engineers design the combustion systems, turbines, and control systems of such advanced jet engines. By taking advantage of testing facilities such as wind tunnels, they have also spearheaded the design of turbines, development of control systems, and discovery of lightweight aerospace-grade materials, including titanium alloys and graphite fiber-reinforced epoxy composites.

**Integrated-Circuit Mass Production:** The electronics industry has developed remarkable technologies for miniaturizing integrated circuits, computer memory chips, and microprocessors. The mechanical engineering profession made key contributions during the twentieth century to the manufacturing methods involved in producing integrated circuits. While the vintage 8008 processor that was first sold by the Intel Corporation in 1972 had 2500 transistors, the current Tukwila processor from Intel has over 2 billion transistors. This exponential rate of growth in the number of components that can be assembled on a silicon chip is often referred to as Moore's law, named after Intel's cofounder Gordon Moore. Based on past developments, this observation states that the number of transistors that can be placed on integrated circuits is expected to double every 18 months. That prediction was made in 1965, and it still holds true, although engineers and scientists are increasingly pushing up against fundamental physical limits.



Mechanical engineers design the machinery, alignment systems, advanced materials, temperature control, and vibration isolation that enable integrated circuits to be made at the nanometer scale.

The same manufacturing technology can be used to produce other machines at the micro or nano level. Using these techniques, machines with moving parts can be made so small that they are imperceptible to the human eye and can be viewed only under a microscope. As shown in Figure, individual gears can be fabricated and assembled into geartrains that are no bigger than a speck of pollen.

**Air Conditioning and Refrigeration:** Mechanical engineers invented the technologies of efficient air conditioning and refrigeration. Today, these systems not only keep people safe and comfortable, but also preserve food and medical supplies in refrigeration systems. Like other infrastructures, we typically do not recognize the value of air conditioning until it is gone. In a record European heat wave during the summer of 2003, for instance, over 10,000 people—many elderly—died in France as a direct result of the searing temperatures.

Mechanical engineers apply the principles of heat transfer and energy conversion to design refrigeration systems that preserve and store food at its source, during transportation, and in the home. We regularly purchase food that was grown thousands of miles away, perhaps even in a different country, with confidence that it is fresh.

Although mechanical refrigeration systems had been available as early as the 1880s, their application was limited to commercial breweries, meat-packing houses, ice-making plants, and the dairy industry. Those early refrigeration systems required significant amounts of maintenance, and they were also prone to leaking hazardous or flammable chemicals, rendering them inappropriate for use in a home. The development of the refrigerant Freon in 1930 was a major turning point for the commercialization of safe residential refrigeration and air conditioning. Since that time, the use of Freon largely has been supplanted by compounds that do not contain chlorofluorocarbons, which are now known to degrade the Earth's protective ozone layer.

**Computer-Aided Engineering Technology:** The term "computer-aided engineering" (CAE) refers to a wide range of automation technologies in mechanical engineering, and it encompasses the use of computers for performing calculations, preparing technical drawings, simulating performance, and controlling machine tools in a factory. Over the past several decades, computing and information technologies have changed the manner in which mechanical engineering is practiced. Most mechanical engineers have access to advanced computer-aided design and analysis software, information databases, and computer-controlled prototyping equipment. In some industries, these CAE technologies have replaced traditional paper-based design and analysis methods.

In large multinational corporations, design teams and technical information are distributed around the world, and computer networks are used to design products 24 hours a day. As an example, the Boeing 777 was the first commercial airliner to be developed through a paperless computer-aided design process. The 777's design began in the early 1990s, and a new computer infrastructure had to be created specifically for the design engineers. Conventional paper-and-pencil drafting services were nearly eliminated. Computer-aided design, analysis, and manufacturing activities were integrated across some 200 design teams that were spread over 17 time zones. Because the plane had over 3 million individual components, making everything fi t together was a remarkable challenge. Through the extensive usage of CAE tools, designers were able to check part-to-part fi ts in a virtual, simulated environment before any hardware was produced. By constructing and testing fewer physical mock-ups and prototypes, the aircraft was brought to market more quickly and more economically than would have otherwise been possible. Current CAE tools are being developed for diverse computing platforms including leveraging mobile devices, cloud computing technologies, and virtual machines.

**Bioengineering:** The discipline of bioengineering links traditional engineering fields with the life sciences and medicine. Engineering principles, analysis tools, and design methods are applied to solve problems that occur in biological systems. Although bioengineering is considered an emerging field, it ranked in the American Society of Mechanical Engineer's top ten list not only for the advances that have already been made, but also for its future potential in addressing medical and health-related problems. One objective of bioengineering is to create technologies to expand the pharmaceutical and healthcare industries, including drug discovery, genomics, ultrasonic imaging, artificial joint replacements, cardiac pacemakers, artificial heart valves, robotically assisted surgery, and laser surgery. For instance, mechanical engineers apply the principles of heat transfer to assist surgeons with cryosurgery, a technique in which the ultralow temperature of liquid nitrogen is used to destroy malignant tumours. Tissue engineering and the development of artificial organs are other fields where mechanical engineers contribute, and they often work with physicians and scientists to restore damaged skin, bone, and cartilage in the human body.

**Codes and Standards:** The products that engineers design must connect to, and be compatible with, the hardware that is developed by others. Because of codes and standards, you can have confidence that a stereo will plug into an electrical outlet in California just as well as it does in Florida and that the outlet's voltage will be the same; that the gasoline purchased next month will work in your car just as well as the fuel purchased today; and that the socket wrench purchased at an automobile parts store in the United States will fit the bolts on a vehicle that was manufactured in Germany. Codes and standards are necessary to specify the physical characteristics of mechanical parts so that others can clearly understand their structure and operation.

Many standards are developed through consensus among governments and industry groups, and they have become increasingly important as companies compete internationally for business. Codes and standards involve collaboration among trade associations, professional engineering societies such as the American Society of Mechanical Engineers, testing groups such as Underwriters Laboratories, and organizations such as the American Society of Testing and Materials. The safety of bicycle and motorcycle helmets, the crash protection features of automobiles and child safety seats, and the fi re resistance of home insulation are just some applications for which these guidelines help engineers to design safe products.

## CAREER PATHS:

Now that we have introduced the field of mechanical engineering and some of the profession's most significant contributions, we next turn to the career options where future mechanical engineers will face the global, social, and environmental challenges around the world. Because such a wide variety of industries employ mechanical engineers, the profession does not have a one-size-fits-all job description.

Mechanical engineers can work as designers, researchers, and technology managers for companies that range in size from small start-ups to large multinational corporations. To give you a glimpse of the range of available opportunities, mechanical engineers can:

- Design and analyse any component, material, module, or system for the next generation of automobiles
- Design and analyse medical devices, including aids for the disabled, surgical and diagnostic equipment, prosthetics, and artificial organs
- Design and analyse efficient refrigeration, heating, and air-conditioning systems
- Design and analyse the power and heat dissipation systems for any number of mobile computing and networking devices
- Design and analyse advanced urban transportation and vehicle safety systems

- Design and analyse sustainable forms of energy that are more readily accessible by nations, states, cities, villages, and people groups
- Design and analyse the next generation of space exploration systems
- Design and analyse revolutionary manufacturing equipment and automated assembly lines for a wide range of consumer products
- Manage a diverse team of engineers in the development of a global product platform, identifying customer, market, and product opportunities
- Provide consultant services to any number of industries, including chemical, plastics, and rubber manufacturing; petroleum and coal production; computer and electronic products; food and beverage production; printing and publishing; utilities; and service providers
- Work in public service for such governmental agencies as the National Aeronautics and Space Administration, Department of Defense, National Institute of Standards and Technology, Environmental Protection Agency, and national research laboratories
- Teach mathematics, physics, science, or engineering at the high school, 2-year college, or 4-year university level
- Pursue significant careers in law, medicine, social work, business, sales, or finance

Historically, mechanical engineers could take either a technical track or a management track with their careers. However, the lines between these tracks are blurring as emerging product development processes are demanding knowledge not only about technical issues but also about economic, environmental, customer, and manufacturing issues. What used to be done in co-located teams using centrally located engineering expertise is now done by globally distributed teams taking advantage of engineering expertise in multiple geographic regions, lower-cost processes, global growth opportunities, and access to leading technologies.

Job openings historically labelled as “mechanical engineer” now include a number of diverse titles that refl ect the changing nature of the profession. For example, the following job position titles all required a degree in mechanical engineering (taken from a leading job Web site):

- Product engineer
- Design engineer
- Systems engineer
- Power engineer
- Manufacturing engineer
- Packaging engineer
- Renewable energy consultant
- Electro-mechanical engineer
- Applications engineer
- Facilities design engineer
- Product applications engineer
- Mechanical product engineer
- Mechanical device engineer
- Energy efficiency engineer
- Process development engineer
- Mechatronics engineer

- Project capture engineer
- Sales engineer
- Plant engineer

Aside from requiring technical knowledge and skills, landing a job, keeping a job, and progressing upward through one's career will depend on a number of skills that, at first glance, might appear to be nontechnical in nature. Mechanical engineers must be capable of taking initiative when handling work assignments, efficiently finding answers to problems, and accepting additional responsibility with success. A quick survey of engineering positions on any job Web site will demonstrate that employers place significant value on the ability of a mechanical engineer to communicate to a wide range of backgrounds and in all forms of verbal and written media. In fact, companies looking to hire engineers routinely note effective communication as the most important nontechnical attribute for aspiring engineers. The reason is quite simple—at each stage of a product's development, mechanical engineers work with a wide range of people: supervisors, colleagues, marketing, management, customers, investors, and suppliers. An engineer's ability to discuss and explain technical and business concepts clearly, and to interact well with co-workers, is critical. After all, if you have an outstanding and innovative technical breakthrough, but you are unable to convey the idea to others in a convincing manner; your idea is not very likely to be accepted.

## Three Main Streams of Mechanical Engineering:

According to the areas of specialisation in Mechanical Engineering, the various streams are identified which are as follows:

1. Thermal Engineering

2. Machine Design

3. Manufacturing Engineering

## Thermal Engineering:

Heating or cooling of processes, equipment, or enclosed environments are within the purview of thermal engineering.

One or more of the following disciplines may be involved in solving a particular thermal engineering problem:

- Thermodynamics
- Fluid mechanics
- Heat transfer
- Mass transfer

## Manufacturing Engineering:

Manufacturing engineering is a discipline of engineering dealing with different manufacturing practices and includes the research, design and development of systems, processes, machines, tools and equipment. The manufacturing engineer's primary focus is to turn raw materials into a new or updated product in the most economic, efficient and effective way possible.

## Machine Design:

Machine is a device manufactured to reduce the efforts of humans. Machines can be either powered or non-powered using mechanical principles. Machines which require power usually use electrical energy such as fans, Washing machines, watches operated by a cell, Mixers, grinders etc. Machines which do not require power or electrical energy, for example: Nail cutter, screw driver, scissors, Chain pulley blocks, Screw jack. You see from the above examples, mechanical energy is magnified to get greater force in some machines, while we apply some small force in some, thus easing the efforts of human beings.

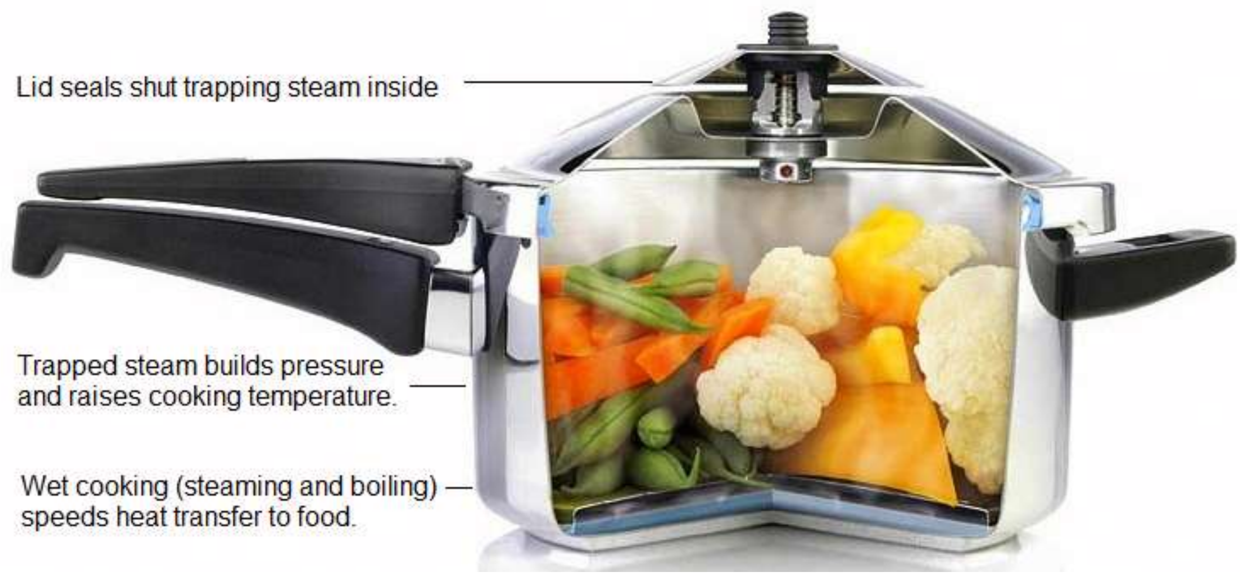
The process of designing the above machines is called machine design. Machine design follows a set of procedure which is mentioned as below:

1. Need analysis.
2. Market survey
3. Idea Screening
4. Arriving at required specifications.
5. Formations of specifications.
6. Translating them into machine drawing using Cad tools.
7. Manufacturing the same and assembling them.
8. Testing and releasing to market.

The first two are usually done Market survey team. $7^{th}$ activity is done by Manufacturing engineers. $8^{th}$ activity will be a part of Manufacturing and sales engineers. Activity 3, 4, 5 and 6 are done by design engineers. Some of the courses a mechanical engineer learns as a part of machine design are:

- Statics.
- Strength of Materials.
- Computer Aided Drawing.
- Computer Aided Engineering and Analysis
- Vibrations.
- Dynamics.
- Kinematics.
- Materials Science.

## Case Study: Pressure Cooker



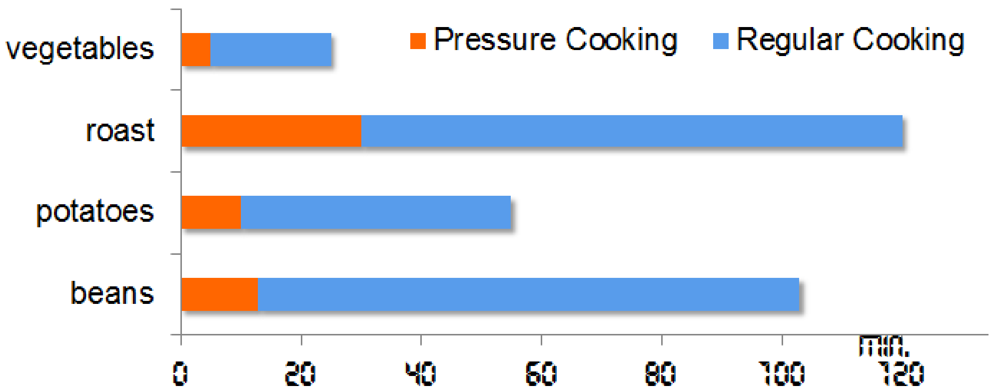

Technically, a pressure cooker is a pot with a special lid that seals shut to stop steam from escaping. Liquid boils inside and the steam has nowhere to go while more steam is being generated by the boil – this raises the internal pressure. The rise in pressure directly correlates to a raise in temperature.

Boiling water can never go over 212°F/100°C no matter how high the flame under the pot. But in the pressure cooker, the temperature can rise to 250°F/121°C. The higher cooking temperature reduces the cooking time.

The sealed lid prevents vapour and its heat from escaping, so a boil can be maintained at low vs. high flame.

Wet cooking methods (like steaming boiling and braising) transfer heat more efficiently to food than dry cooking methods (sautéing, baking and roasting).

Foods cook 70-90% faster in the pressure cooker. Chickpeas are ready in 13 minutes under pressure instead of an hour and a half, a fall-apart tender roast is ready in 30 minutes, instead of 1 1/2 to 2 hours, potatoes in 10 instead of 45 minutes and most other vegetables only require 5 minutes or less to be fully cooked!




The sealed lid and shorter cooking time translate into using less fuel to cook. But the pressure cooker also needs less heat (using a low flame while cooking under pressure vs. a high or medium flame during the whole cooking time).

This means that foods cooked in the pressure cooker use 70-90% less energy than those cooked in traditional cookware. That's a similar energy savings to switching from traditional light bulbs to energy-efficient bulbs.

**How is pressure cooker manufactured?**

Refer to the video given to you or from the link provided below

https://www.youtube.com/watch?v=dgX06cx9xPw

The process flow diagram of the entire manufacturing is indicated in the figure 3.

**Where are the three main streams of Mechanical Engineering merged in Pressure Cooker and its manufacturing?**

Design Aspects:

The design engineer will be considering below mentioned some aspects concerned with design of pressure cooker.

- What should be the thickness of the sheet used for forming cooker?
- What should be the weight of the dead weight to be put on main safety valve?
- What should be the stiffness of the spring in main safety valve?
- What should be the stiffness of the spring in the backup valve?

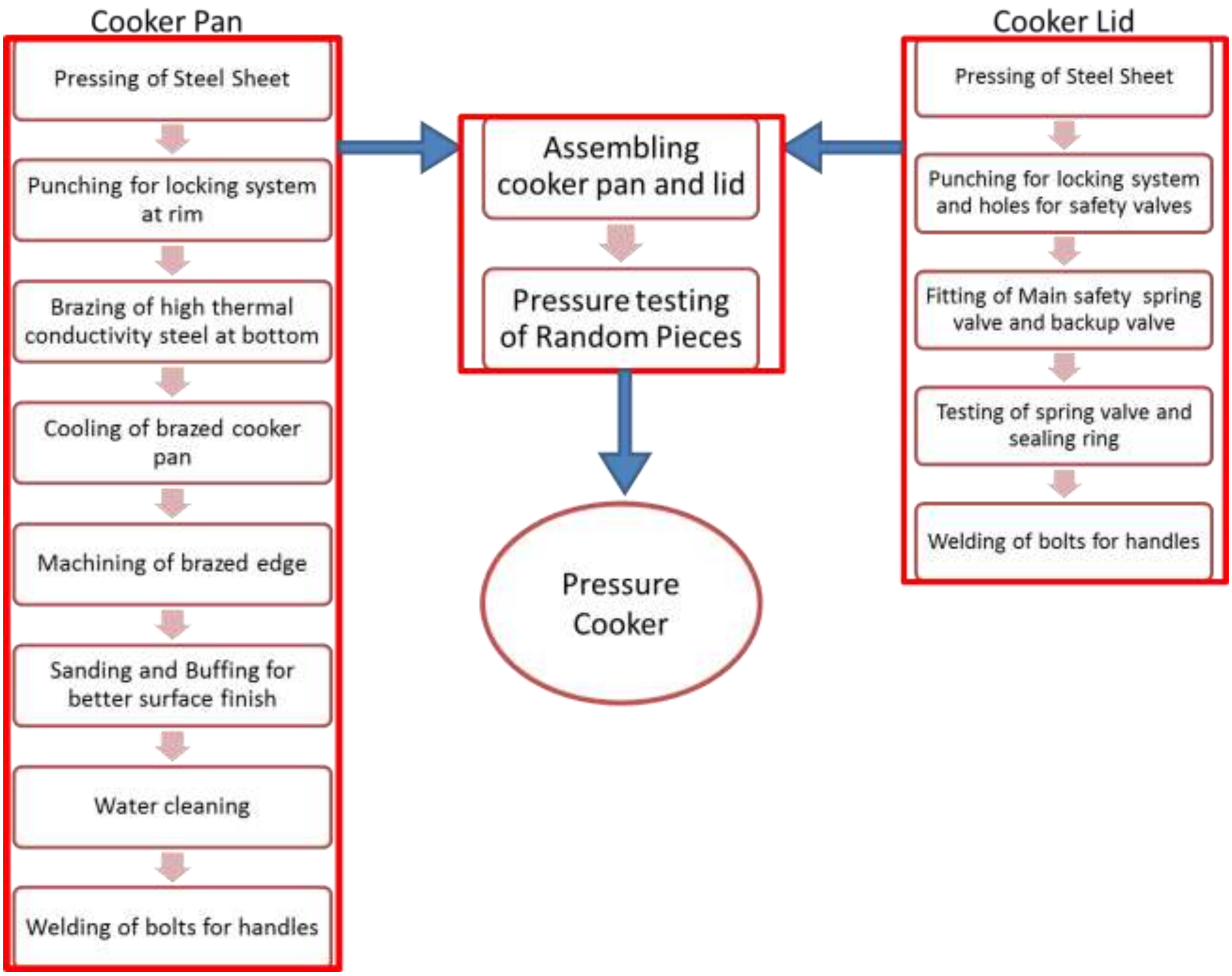



Figure: Process Flow of Manufacturing of pressure cooker.

Thermal Aspects:

The thermal engineer will be considering below mentioned some thermal aspects concerned with pressure cooker.

- What should be the maximum pressure to be achieved within the cooker for safe utility?
- What will be the maximum temperature attainable in the cooker?
- How to increase the thermal conductivity between the stove and cooker?

Manufacturing Aspects:

The manufacturing or production engineer will be considering below mentioned some aspects concerned with manufacturing of pressure cooker.

- What material should be selected for the pressure cooker?

- Which type of machine is best suited for the pressing, punching, welding, brazing and many more operations involved in production of cooker?
- Which process is efficient and low cost?
- What should be packing system?
- What amount of processes will be automated?
- How many manual workforce is required?

**Where are the other streams of engineering involved in manufacturing of pressure cooker?**

We have already seen how mechanical engineer is involved making ready a pressure cooker in the above sub heading. In this section we will try to understand how other major streams of engineering are involved.

Civil Engineering:

- Construction of industry and structural base of various machinery.
- Water supply systems.
- Storage facilities for various chemicals in liquid and gaseous forms at varied temperatures.

Electrical Engineering:

- Drive motors for working of the various machinery.
- Safety aspects concerned with electrical systems in industry.

Electronics Engineering:

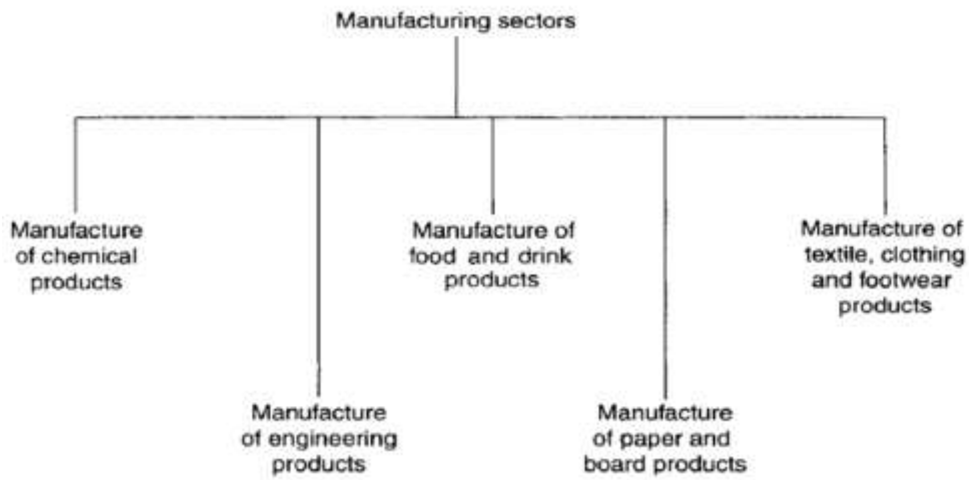
- Automation needs electronic circuitry.
- Various sensors in the entire process for monitoring.

Computer Engineering:

- Automation.

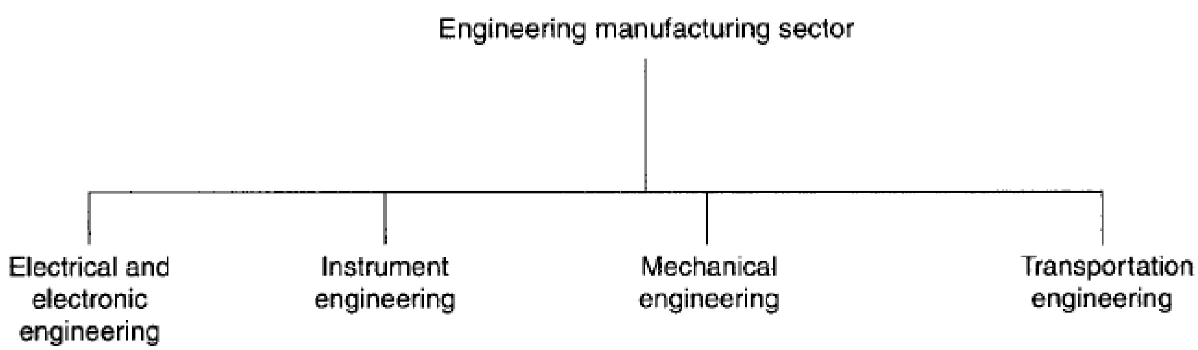
<u>**Main Manufacturing Sector:**</u>

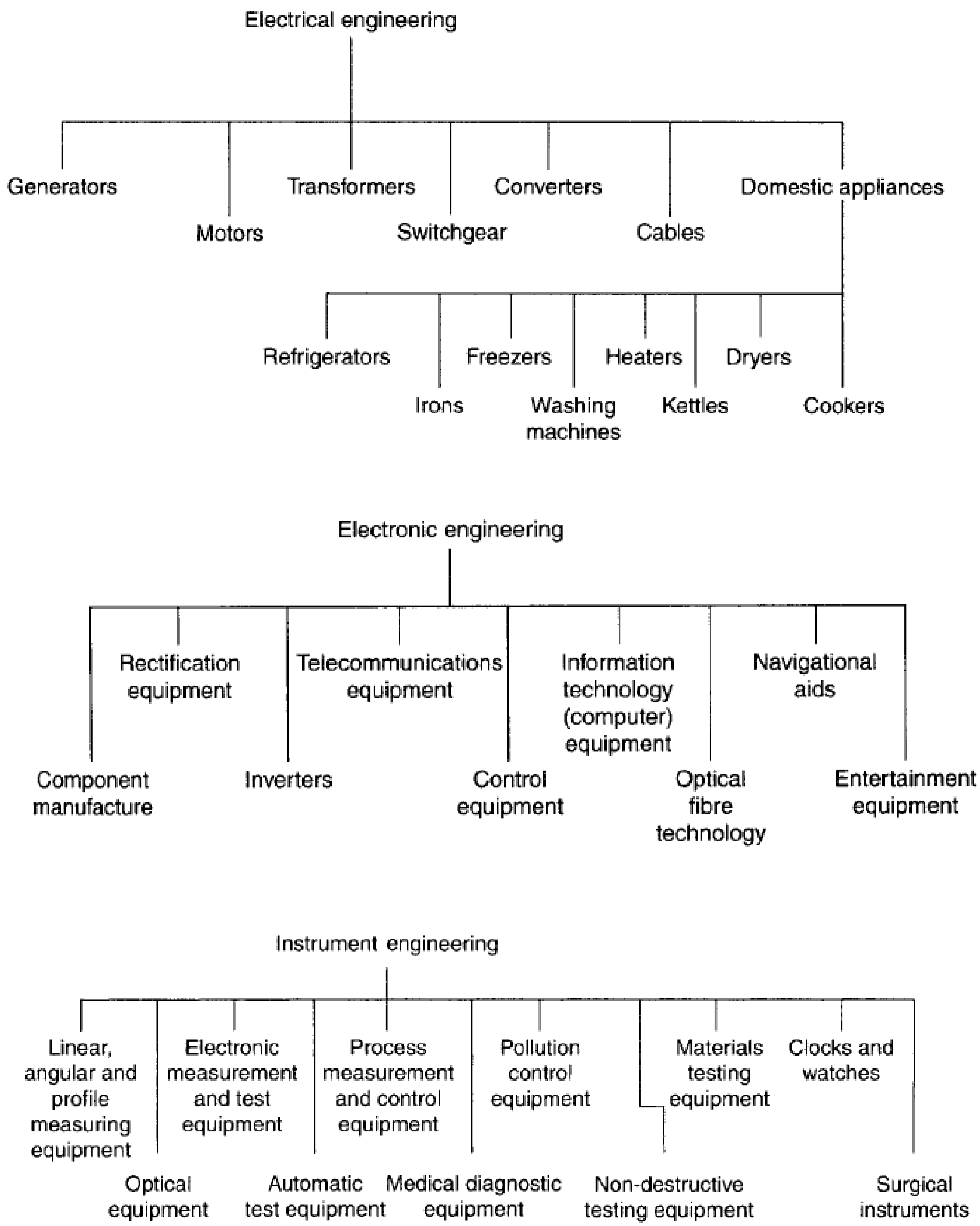
Manufacturing industry is still vital to the Indian economy. The income generated by manufacturing and the hundreds of thousands of jobs which the manufacturing industry creates is still essential if the India is to sustain an acceptable level of employment and pay its way in the world. Increasingly, however, we are becoming dependent on the income generated by the service industries of IT, banking, insurance, etc. Manufacturing takes many different forms. To make the industry easier to study, we will break it down into six main sectors. These sectors are shown in figure below.



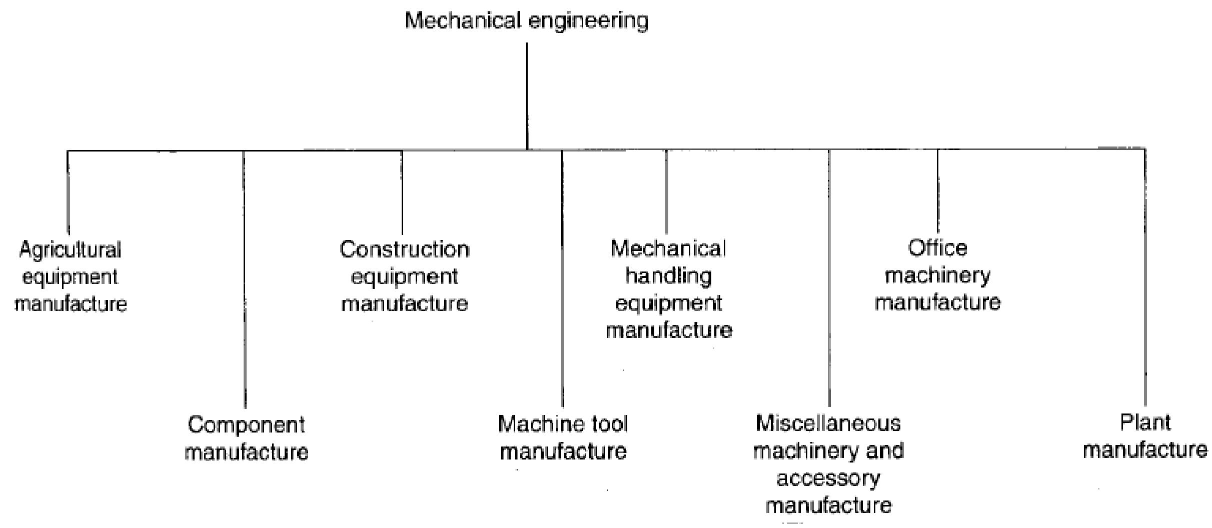

**Manufacture of Engineered products:**

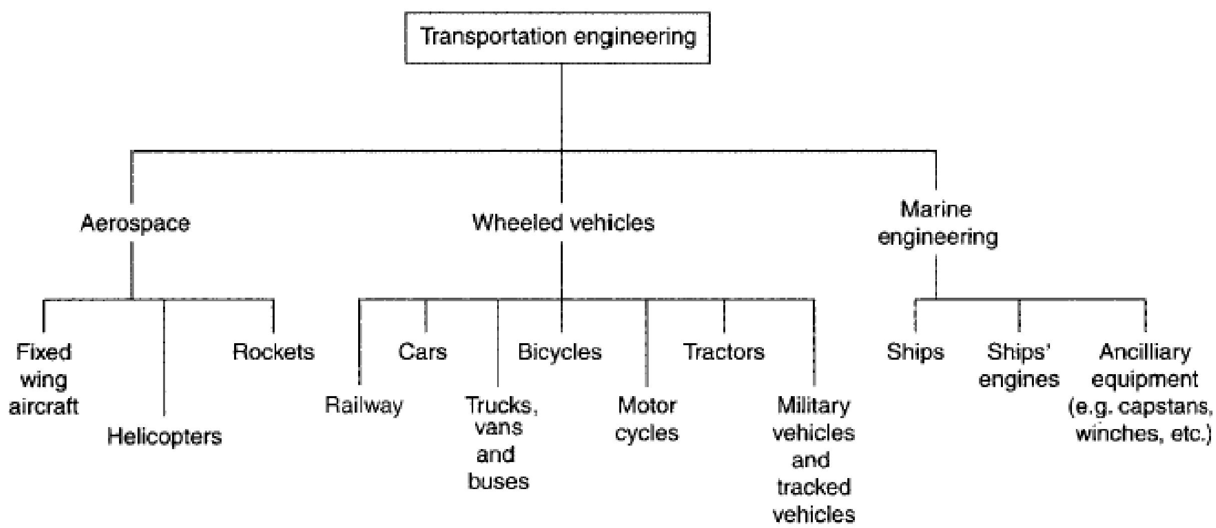
The engineering industry is very diverse and we need to divide it up into a number of subsectors in order to simplify our study of it. The main subsectors are shown in Figures below.





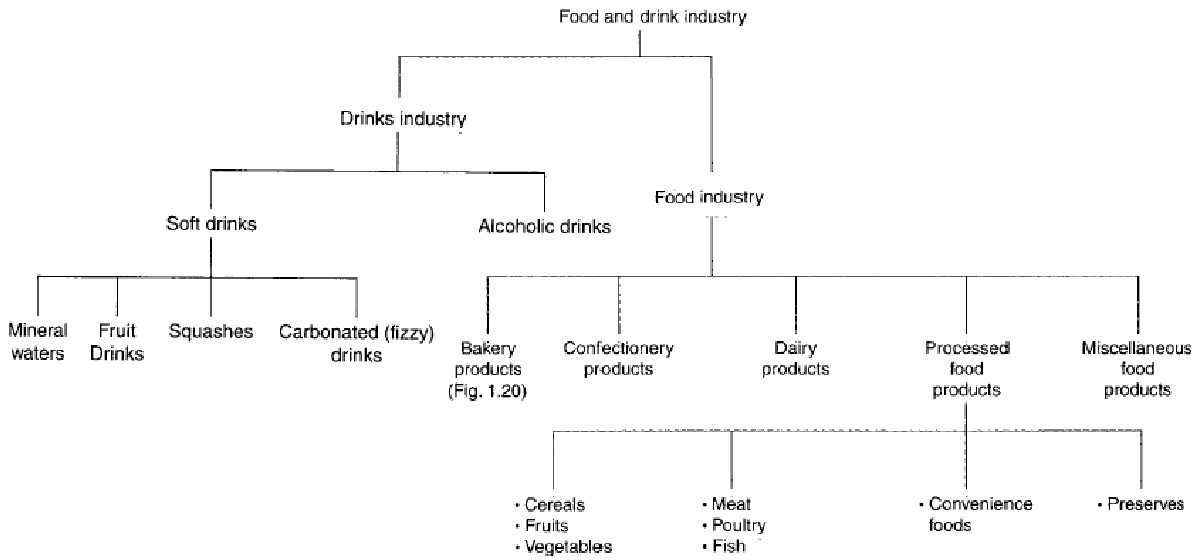
Electrical engineering
Generators
Motors
Transformers
Switchgear
Converters
Cables
Domestic appliances
Refrigerators
Irons
Freezers
Washing machines
Heaters
Kettles
Dryers
Cookers
Electronic engineering
Component manufacture
Rectification equipment
Inverters
Telecommunications equipment
Control equipment
Information technology (computer) equipment
Optical fibre technology
Navigational aids
Entertainment equipment
Instrument engineering
Linear, angular and profile measuring equipment
Optical equipment
Electronic measurement and test equipment
Automatic test equipment
Process measurement and control equipment
Medical diagnostic equipment
Pollution control equipment
Non-destructive testing equipment
Materials testing equipment
Clocks and watches
Surgical instruments



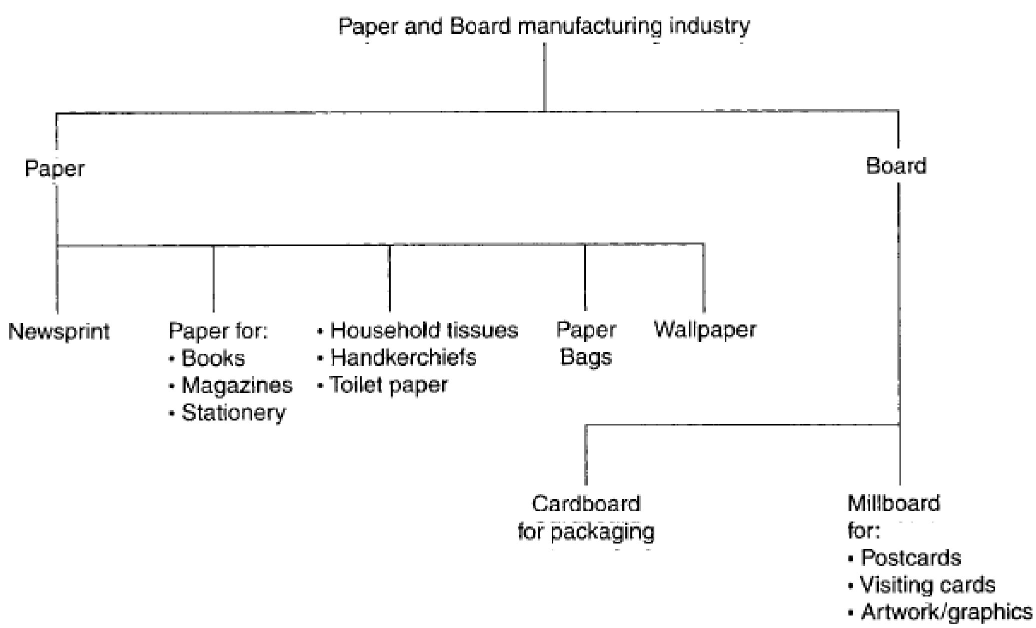

**Manufacture of food and drinks products:**

The food and drink industries are also extremely diverse. The main subsectors are shown in Figure below.



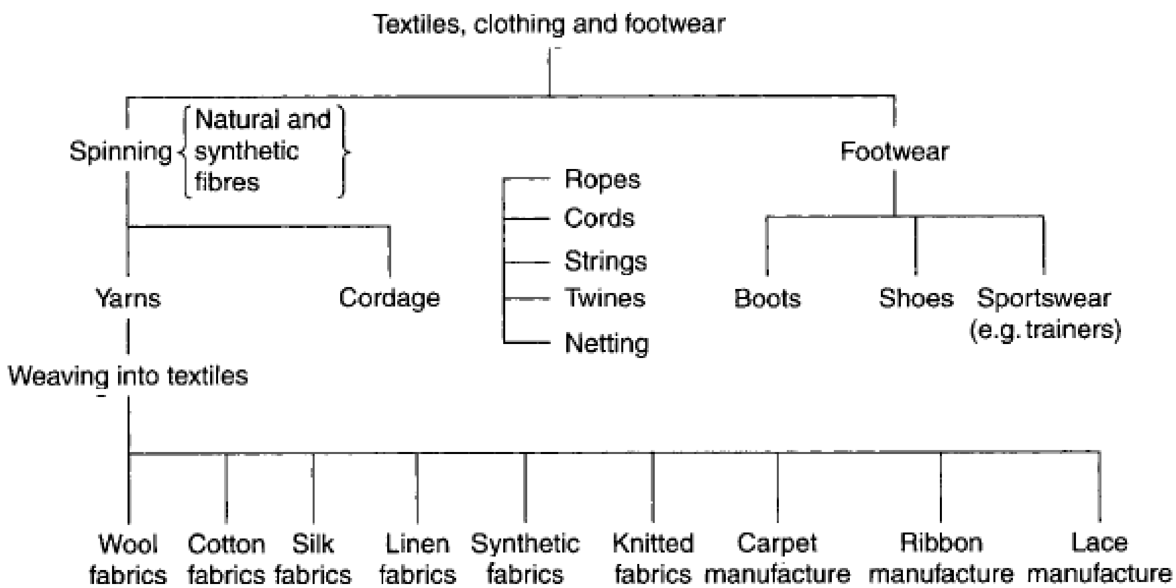

**Manufacture of paper and board products:**

This sector of the manufacturing industry produces the paper for newspapers and books, writing paper, wrapping and packing papers, toilet rolls, kitchen paper and tissues. It also makes boards, boxes, bags and all manner of packaging, as well as such things as wallpaper. The industry divides into two sub-sectors, one sub-sector making paper and the other involved in the manufacture of boards (cardboards and mill boards), as shown in Figure below. An expanding sub-sector of the paper and card manufacturing industry is involved in the recycling of waste paper to reduce the demand on traditional sources of raw materials, such as softwood forests.



**Manufacture of textile clothing and footwear products:**

The manufacture of many textiles and articles of clothing and footwear has increasingly moved abroad to countries where costs are lower. It is necessary to break down this sector into a number of sub-sectors as shown in the below figure.



## DEFINITION of 'Gross Domestic Product - GDP':

Gross Domestic Product (GDP) is the broadest quantitative measure of a nation's total economic activity. More specifically, GDP represents the monetary value of all goods and services produced within a nation's geographic borders over a specified period of time.

Though GDP is usually calculated on an annual basis. It includes all of private and public consumption, government outlays, investments and exports less imports that occur within a defined territory.

**GDP = C + G + I + NX**

"**C**" is equal to all private consumption, or consumer spending in a nation's economy.

Consumption:
-- Durable goods (items expected to last more than three years)
-- Nondurable goods (food and clothing)
-- Services

"**G**" is the sum of government spending.

Government Expenditures:
-- Defense
-- Roads
-- Schools

"**I**" is the sum of all the country's businesses spending on capital.

Investment Spending:
-- Non-residential (spending on plants and equipment), Residential (single-family and multi-family homes)
-- Business inventories

"**NX**" is the nation's total net exports, calculated as total exports minus total imports. (NX = Exports - Imports)

Net Exports:
-- Exports are added to GDP
-- Imports are deducted from GDP

**Types of GDP:**

**Nominal GDP**: Nominal GDP is the market value (money-value) of all final goods and services produced in a geographical region, usually a country.

**Real GDP:** Real GDP is a macroeconomic measure of the value of output economy, adjusted for price changes. The adjustment transforms the nominal GDP into an index for quantity of total output. (Also known as Constant GDP)

**Note:**
1. Real GDP offers a better perspective than nominal GDP when tracking economic output over a period of time. When people use GDP numbers, they are often talking about nominal GDP, which can be defined as the total economic output of a country. This output is measured at current price levels and currency values, without factoring in inflation.
2. When GDP declines for two consecutive quarters or more, by definition the economy is in a recession.

## GDP (nominal) of Different Countries:

| | | |
|---|---|---|
| 1 | United States | 17,419,000 |
| 2 | China | 10,360,105[n 2] |
| 3 | Japan | 4,601,461 |
| 4 | Germany | 3,852,556 |
| 5 | United Kingdom | 2,941,886 |
| 6 | France | 2,829,192[n 8] |
| 7 | Brazil | 2,346,118 |
| | *Eurasian Union*[n 4] | 2,174,616[9] |
| 8 | Italy | 2,144,338 |
| 9 | India | 2,066,902 |
| 10 | Russia | 1,860,598[n 5] |
| 11 | Canada | 1,786,655 |
| 12 | Australia | 1,453,770 |
| 13 | South Korea | 1,410,383 |
| 14 | Spain | 1,404,307 |
| 15 | Mexico | 1,282,720 |
| 16 | Indonesia | 888,538 |
| 17 | Netherlands | 869,508 |
| 18 | Turkey | 799,535 |
| 19 | Saudi Arabia | 746,249 |
| 20 | Switzerland | 685,434 |

GDP in Millions of US $ (Data from the World Bank (2014))

**GDP Per Capita:**

GDP Per Capita is the total output divided by the number of people in the population, so you can get a figure of the average output of each person, i.e., the average amount of money each person makes.

Example,

1. GDP per capita of INDIA – 7,393/1.252 = $ 5,904.95

2. GDP per capita of USA – 17,419/0.3189 = $ 54,622

- Gross domestic product is a macroeconomic measure of output. This measure helps analysts and investors get a better feel for whether a country is more or less productive and in turn whether it is headed for a recession.
- The per capita measure of GDP indicates whether the country's workforce is generally becoming more or less productive -- that is, whether the country's workforce is efficiently producing goods and services that consumer’s want.

Historically, India has classified and tracked its economy and GDP as three sectors — agriculture, industry and services.

i.) Agriculture includes crops, horticulture, milk and animal husbandry, aquaculture, fishing, sericulture, aviculture, forestry and related activities.

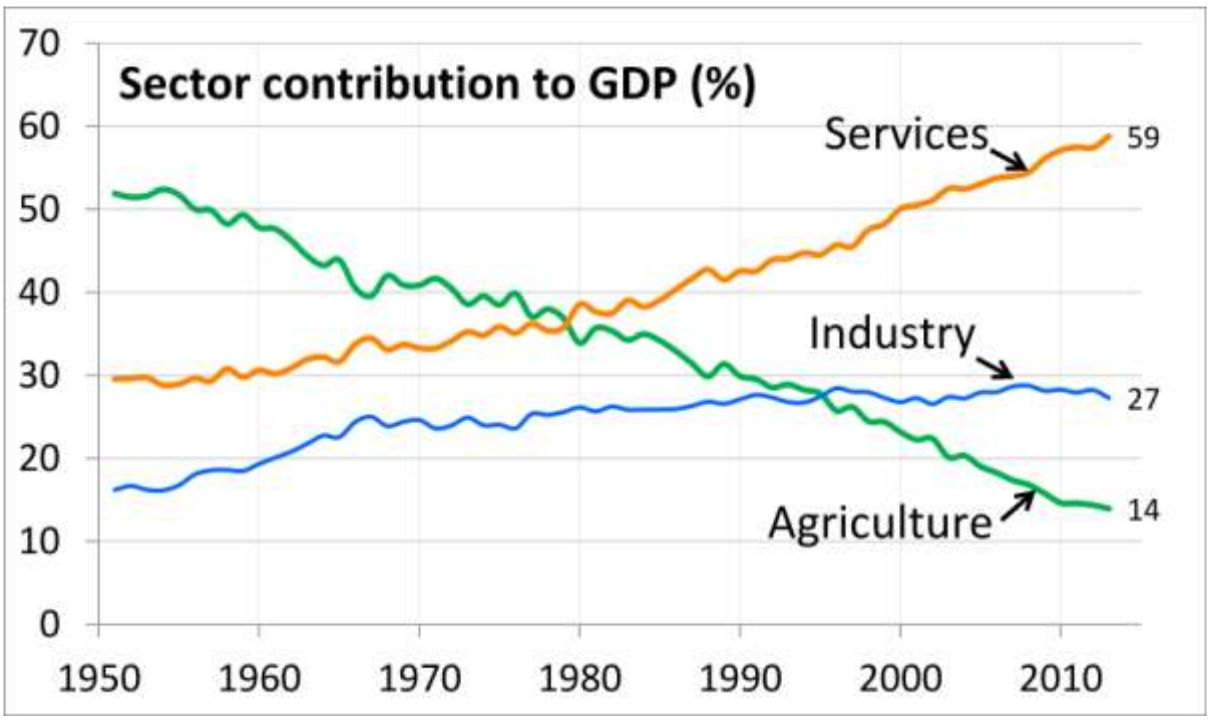
ii.) Industry includes various manufacturing sub-sectors.

iii.) India's definition of services sector includes its construction, retail, software, IT, communications, hospitality, infrastructure operations, education, health care, banking and insurance, and many other economic activities.

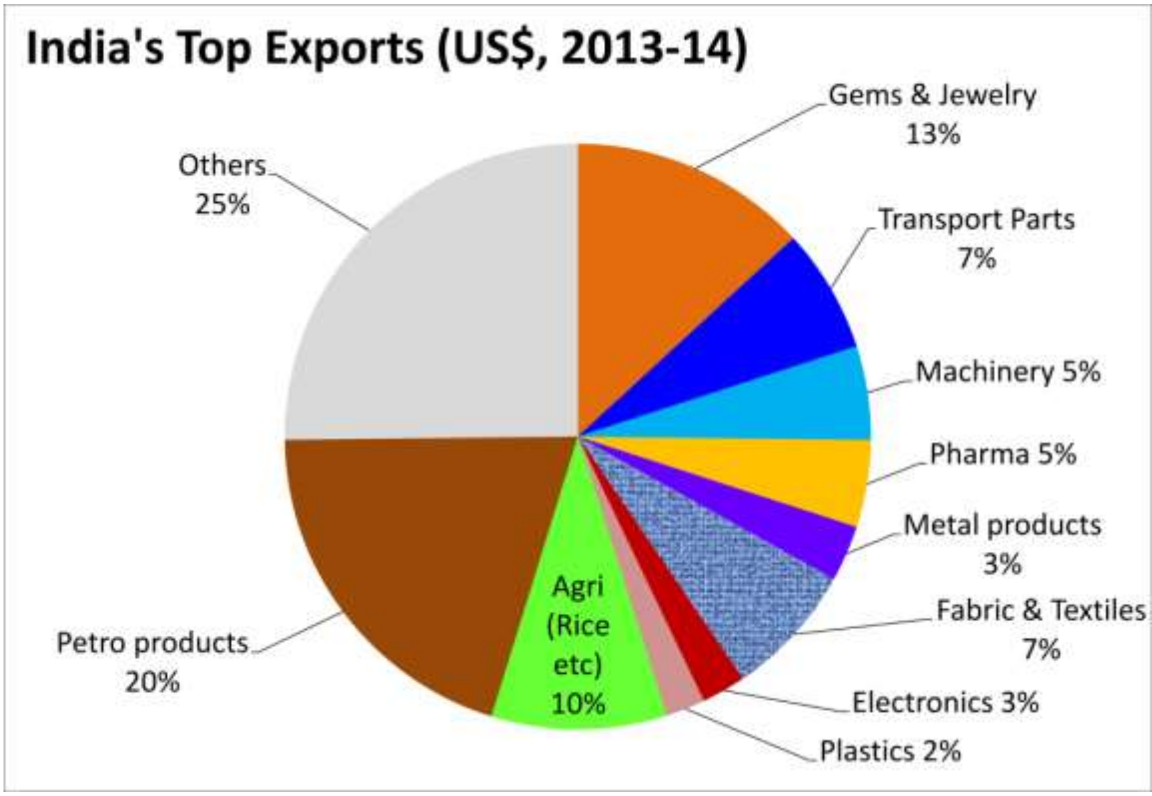
**Industry (Manufacturing Sector)**

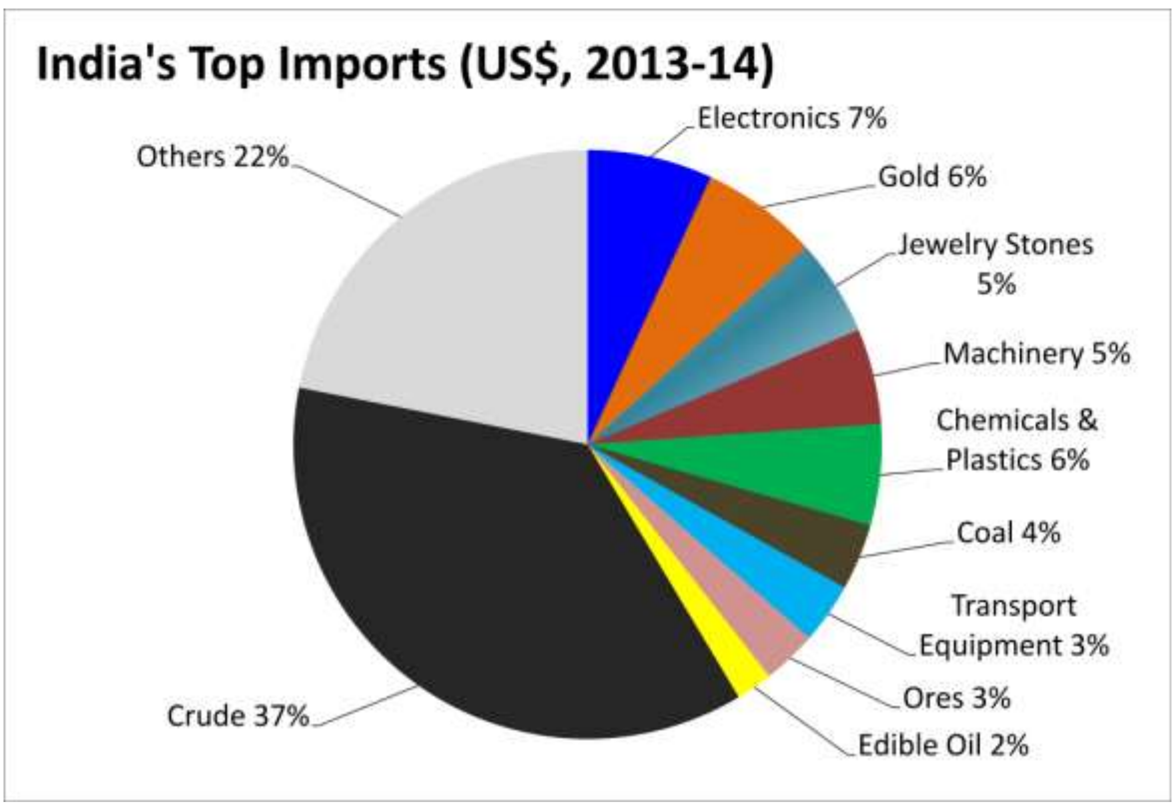
Industry accounts for 26% of GDP and employs 22% of the total workforce. According to the World Bank, India's industrial manufacturing GDP output in 2014 was 9th largest in the world on current US dollar basis ($239.5 billion) The Indian industrial sector underwent significant changes as a result of the economic liberalisation in India economic reforms of 1991, which removed import restrictions, brought in foreign competition, led to the privatisation of certain government owned public sector industries, liberalised the FDI regime, improved infrastructure and led to an expansion in the production of fast moving consumer goods. Post-liberalisation, the Indian private sector was faced with increasing domestic as well as foreign competition, including the threat of cheaper Chinese imports. It has since handled the change by squeezing costs, revamping management, and relying on cheap labour and new technology.

However, this has also reduced employment generation even by smaller manufacturers who earlier relied on relatively labour-intensive processes.




The GDP contribution of various sectors of Indian economy have evolved between 1951 to 2013, as its economy has diversified and developed.


India's Top Exports (US$, 2013-14)
Gems & Jewelry 13%
Transport Parts 7%
Machinery 5%
Pharma 5%
Metal products 3%
Fabric & Textiles 7%
Electronics 3%
Plastics 2%
Agri (Rice etc) 10%
Petro products 20%
Others 25%


India's Top Imports (US$, 2013-14)
Electronics 7%
Gold 6%
Jewelry Stones 5%
Machinery 5%
Chemicals & Plastics 6%
Coal 4%
Transport Equipment 3%
Ores 3%
Edible Oil 2%
Crude 37%
Others 22%

References:


1. An Introduction to Mechanical Engineering, Third Edition Jonathan Wickert, Iowa State University, Kemper Lewis, University at Buffalo—SUNY, Cengage Learning.
2. Roger Timings, Basic Manufacturing, Third edition, Newnes, An imprint of Elsevier, 2010.