Introduction

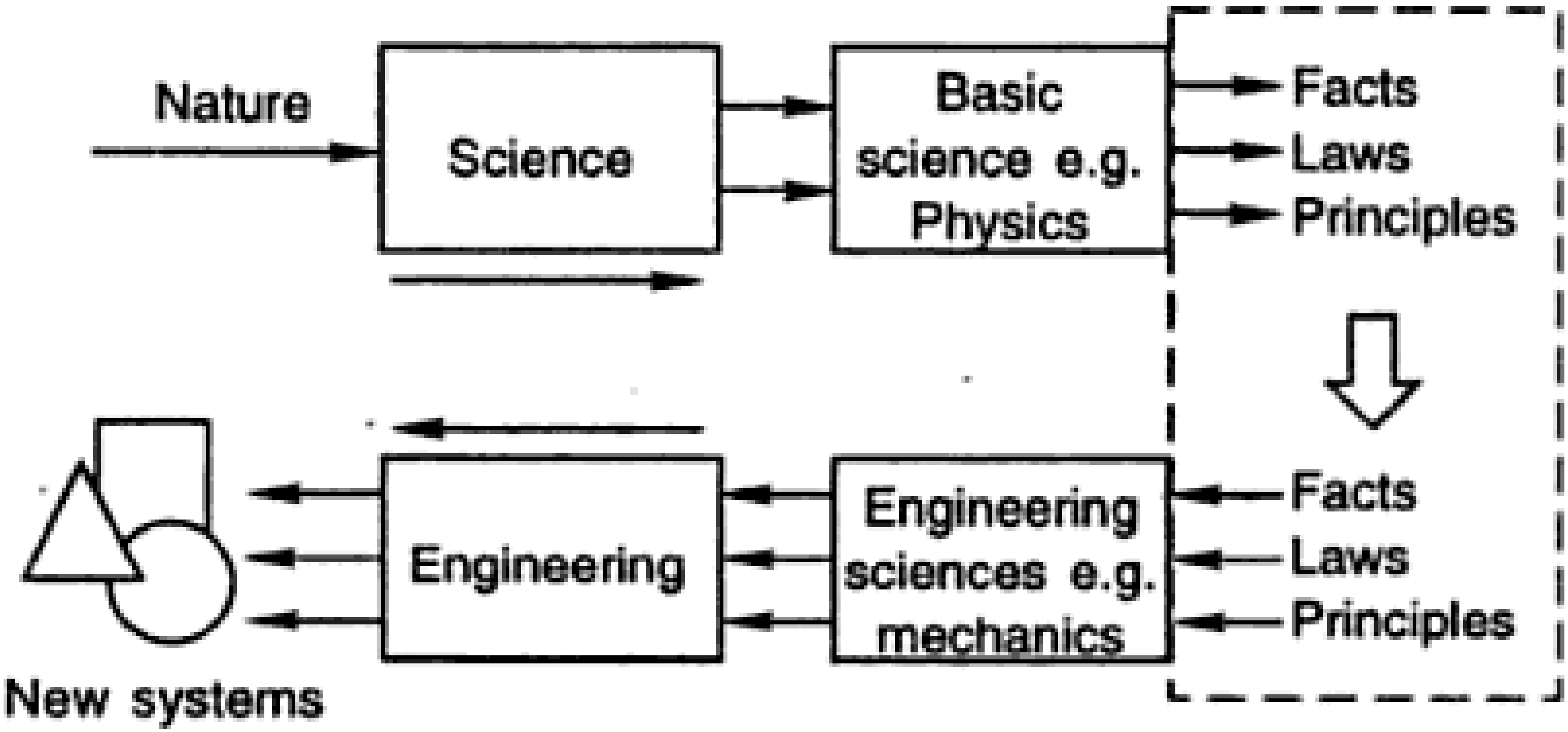
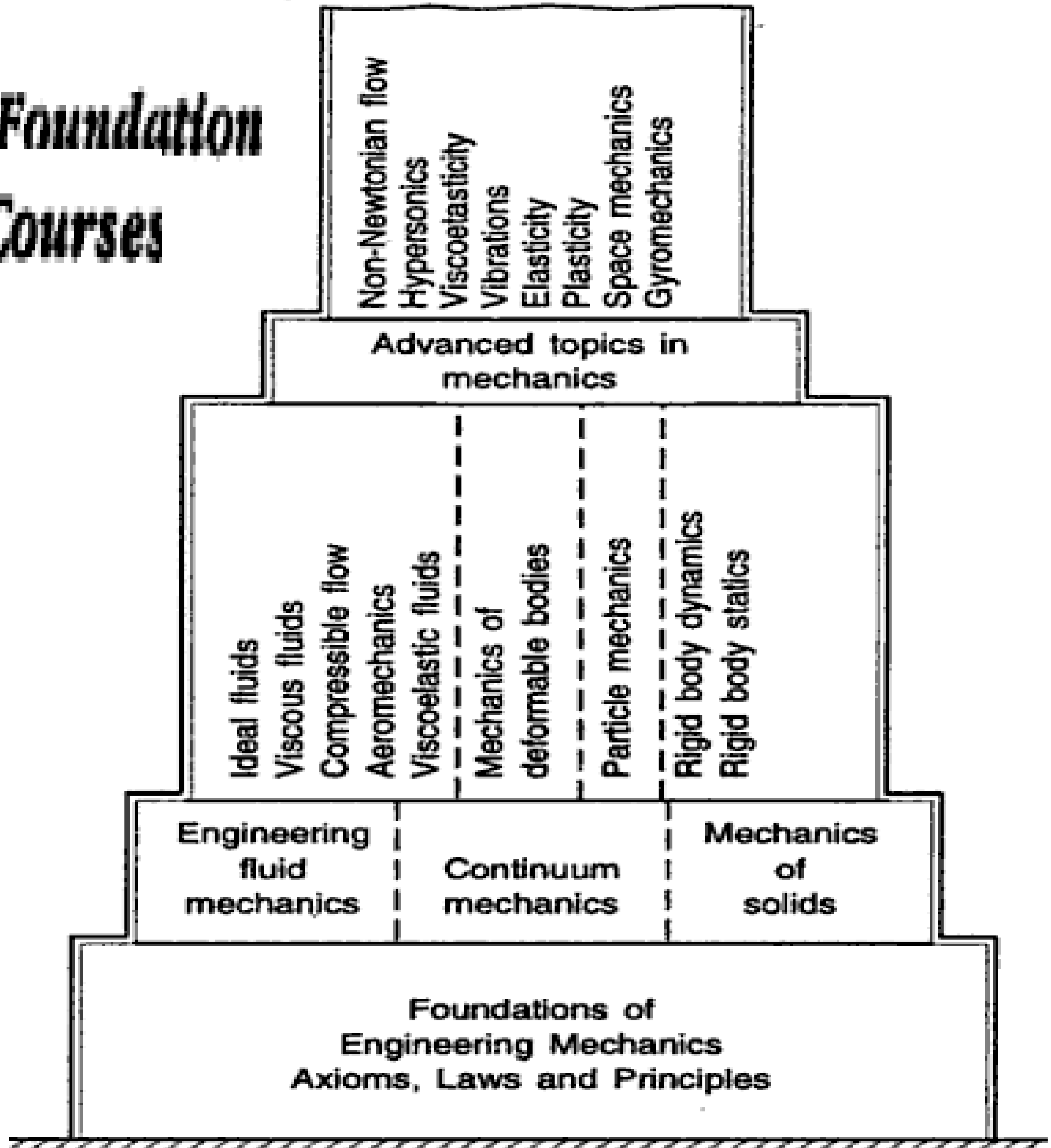


Fig. 1.1 ***Role of Engineering Sciences***

Mechanics as the Foundation of a Number of Courses



Mechanics is a branch of the physical sciences that is concerned with the state of rest or motion of bodies that are subjected to the action of forces.

In general, this subject can be subdivided into three branches: *rigid-body mechanics*, *deformable-body mechanics*, and *fluid mechanics*.

rigid-body mechanics is a basic requirement for the study of the mechanics of deformable bodies and the mechanics of fluids.

What is Mechanics?

Mechanics is a branch of science which deals with bodies at rest or motion under the action of forces.

Furthermore, rigid-body mechanics is essential for the design and analysis of many types of structural members, mechanical components, or electrical devices encountered in engineering.

Rigid-body mechanics is divided into two areas: statics and dynamics.

Statics deals with the equilibrium of bodies, that is, those that are either at rest or move with a constant velocity; whereas *dynamics* is concerned with the accelerated motion of bodies.

According to the main task of mechanics, namely, the investigation of the state of rest or motion under the action of forces,

mechanics may be divided into **statics and dynamics**. **Statics (Latin: status = standing)** deals with the equilibrium of bodies subjected to forces.

Dynamics (Greek: dynamis = force) is subdivided into kinematics and kinetics.

Kinematics (Greek: kinesis = movement) investigates the motion of bodies without referring to forces as a cause or result of the motion.

This means that it deals with the geometry of the motion in time and space, whereas kinetics relates the forces involved and the motion.

Structure of Mechanics

- Applied Mechanics (Mechanics applied to Engg. Problem)
- 1) Mechanics of Rigid Bodies
- 2) Mechanics of Deformable (Things that do not change Bodies shape)
- Statics
- Dynamics
- Kinetics (Forces which causes the motion are considered)
- Kinematics(Forces which causes the motion are not considered)

- 3) Mechanics of Fluids (Things that do change shape)

- Incompressible,

- Compressible

Historical Development. The subject of statics developed very early in history because its principles can be formulated simply from measurements of geometry and force. For example, the writings of Archimedes (287–212 B.C.) deal with the principle of the lever. Studies of the pulley, inclined plane, and wrench are also recorded in ancient writings—at times when the requirements for engineering were limited primarily to building construction.

Since the principles of dynamics depend on an accurate measurement of time, this subject developed much later. Galileo Galilei (1564–1642) was one of the first major contributors to this field. His work consisted of experiments using pendulums and falling bodies. The most significant contributions in dynamics, however, were made by Isaac Newton (1642–1727), who is noted for his formulation of the three fundamental laws of motion and the law of universal gravitational attraction. Shortly after these laws were postulated, important techniques for their application were developed by such notables as Euler, D'Alembert, Lagrange, and others.

The historical origin of mechanics can be traced to ancient Greece, although of course mechanical insight derived from experience had been applied to tools and devices much earlier. Several cornerstones on statics were laid by the works of Archimedes (287– 212): lever and fulcrum, block and tackle, center of gravity and buoyancy. Nothing more of great importance was discovered until the time of the Renaissance. Further progress was then made by Leonardo da Vinci (1452–1519), with his observations of the equilibrium on an inclined plane, and by Simon Stevin (1548– 1620), with his discovery of the law of the composition of forces.

The first investigations on dynamics can be traced back to Galileo Galilei (1564–1642) who discovered the law of gravitation. The laws of planetary motion by Johannes Kepler (1571–1630) and the numerous works of Christian Huygens (1629–1695), finally led to the formulation of the laws of motion by Isaac Newton (1643–1727). At this point, tremendous advancement was initiated, which went hand in hand with the development of analysis and is associated with the Bernoulli family (17th and 18th century), Leonhard Euler (1707–1783), Jean Lerond D’Alembert (1717–1783) and Joseph Louis Lagrange (1736–1813).

As a result of the progress made in analytical and numerical methods – the latter specially boosted by computer technology – mechanics today continues to enlarge its field of application and makes more complex problems accessible to exact analysis. Mechanics also has its place in branches of sciences such as medicine, biology and the social sciences, through the application of modelling and mathematical analysis.

Three forces act on the hook at *A*. Since these forces all meet at a point, then for any force analysis, we can assume the hook to be represented as a particle.

Steel is a common engineering material that does not deform very much under load. Therefore, we can consider this railroad wheel to be a rigid body acted upon by the concentrated force of the rail.

When solving problems, do the work as neatly as possible. Being neat will stimulate clear and orderly thinking, and vice versa.

General Procedure for Analysis

The most effective way of learning the principles of engineering mechanics is to *solve problems*. To be successful at this, it is important to always present the work in a *logical* and *orderly manner*, as suggested by the following sequence of steps:

- Read the problem carefully and try to correlate the actual physical situation with the theory studied.
- Tabulate the problem data and draw any necessary diagrams.
- Apply the relevant principles, generally in mathematical form. When writing any equations, be sure they are dimensionally homogeneous.
- Solve the necessary equations, and report the answer with no more than three significant figures.
- Study the answer with technical judgment and common sense to determine whether or not it seems reasonable.

Important Points

- Statics is the study of bodies that are at rest or move with constant velocity.
- A particle has a mass but a size that can be neglected.
- A rigid body does not deform under load.
- Concentrated forces are assumed to act at a point on a body.
- Newton's three laws of motion should be memorized.
- Mass is measure of a quantity of matter that does not change from one location to another.
- Weight refers to the gravitational attraction of the earth on a body or quantity of mass. Its magnitude depends upon the elevation at which the mass is located.

- In the SI system the unit of force, the newton, is a derived unit. The meter, second, and kilogram are base units.
- Prefixes G, M, k, m, μ, and n are used to represent large and small numerical quantities. Their exponential size should be known, along with the rules for using the SI units.
- Perform numerical calculations with several significant figures, and then report the final answer to three significant figures.
- Algebraic manipulations of an equation can be checked in part by verifying that the equation remains dimensionally homogeneous.
- Know the rules for rounding off numbers.

BASIC QUANTITIES

The four important quantities are used throughout the mechanics

LENGTH

Length is used to locate the position of a point in a space and describe the size of a physical system.

Once a **standard unit of length is defined**,

one can then use it to define distances and geometric properties of a body as multiples of this unit.

Space

associated with the notation of the position of a point P given in terms of three coordinates measured from a reference point or origin.

OR

The unlimited expanse of physical dimensions in which all material objects are located

Space is the geometric region occupied by bodies whose position are described by linear and angular measurement relative to coordinate system

For three dimensions – three coordinates

For two dimensions – two coordinates

TIME

It is a measure of duration between successive events.

Time is conceived as a **succession of events**.

Although the principles of statics are time independent,

this quantity plays an vital role in the study of dynamics.

Mass. *Mass* is a measure of a quantity of matter that is used to compare the action of one body with that of another. This property manifests itself as a gravitational attraction between two bodies and provides a measure of the resistance of matter to a change in velocity.

Fundamental Concepts

Particle

It is an idealized body which may have negligible mass and whose size and shape can be neglected

Matter

Substances that posses weight, occupies space, volume, apprehended by sense.

Body

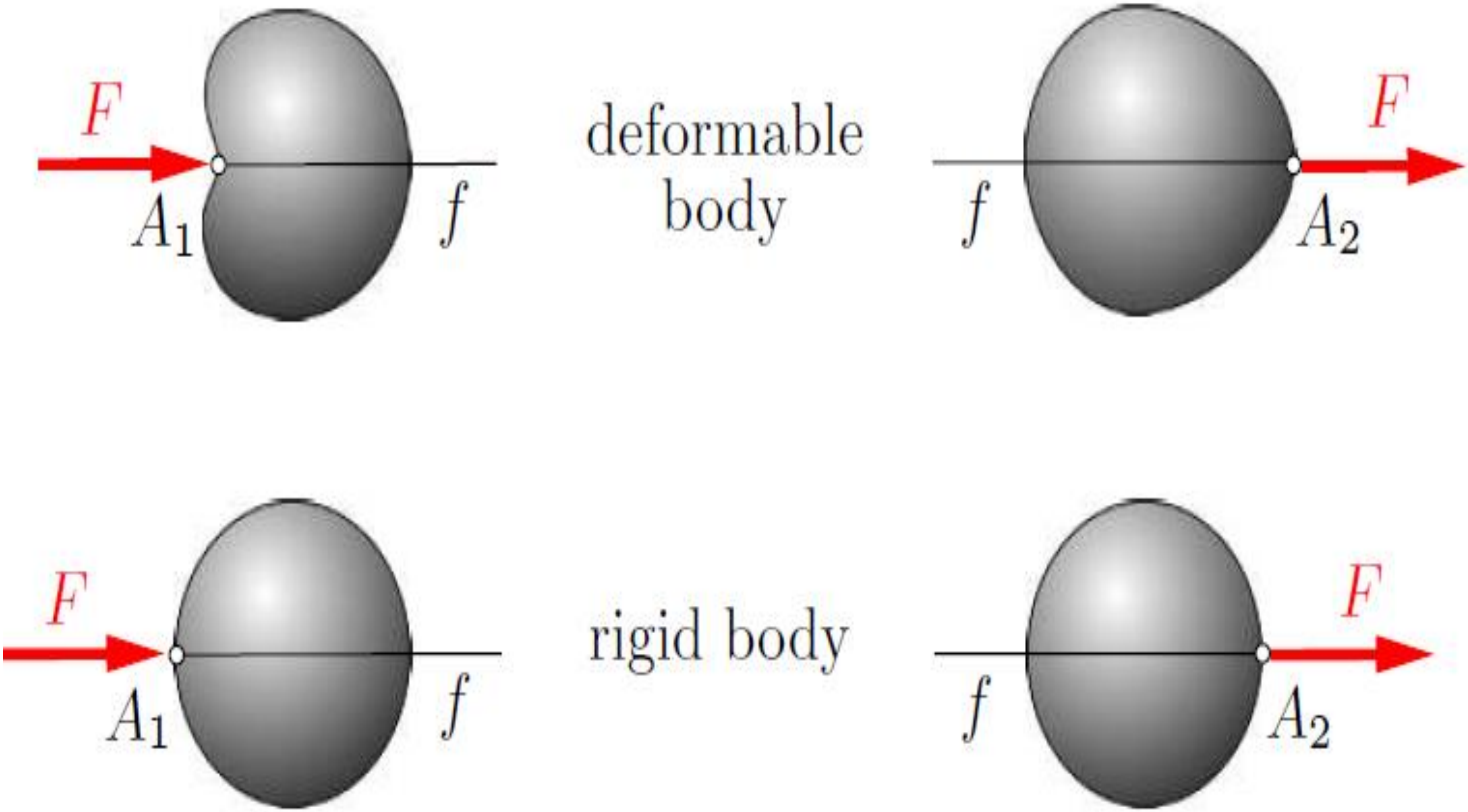
the matter bounded by a closed surface is called body. It is accumulation of large number of particles

Rigid Body

if the relative distance between the particle of the body is same before and after the application of forces.

Deformable body

If the relative distance between the particle of the body is different(change) before and after the application of forces.


F
A_1
f
deformable
body
F
f
A_2
F
A_1
f
rigid body
F
f
A_2

Force - Represents the action of one body on another. A force is characterized by its point of application, magnitude, and direction.

A force is a physical quantity that can be brought into equilibrium with gravity

In Newtonian Mechanics,

space, time, and mass are absolute concepts, independent of each other.

Force, however, is not independent of the other three.

The force acting on a body is related to the mass of the body and the variation of its velocity with time.