

Introduction to Mechanics

Mechanics is a branch of the physical sciences concerned with the state of rest or motion of bodies that are subjected to the action of forces. The study of mechanics involves many more subject areas. However, initial study is usually split into two areas; *statics* and *dynamics*.

Statics is concerned with bodies that are either at rest or move with a constant speed in a fixed direction. **Dynamics** deals with the accelerated motion of bodies. Statics can therefore be considered as a special case of dynamics where the acceleration is zero. In engineering, since many objects are designed with the intention that they are at rest or their motion remains constant, statics deserves special treatment.

Scalars and vectors

In mechanics, as elsewhere, some quantities are scalar quantities and some are vector quantities. It is important to understand the difference between the two.

Scalars

Scalar quantities are quantities that only have a magnitude (size). Scalar quantities are useful, but for some quantities in mechanics we need more information; to this end we introduce vectors.

Vectors

Vector quantities are quantities that possess direction, as well as magnitude. Vectors are usually referred to in bold type. The 'Engineering Maths First Aid Kit' contains more leaflets on Vectors (6.1), the Scalar Product (6.2) and the Vector Product (6.3) that can be downloaded from:

Vectors (6.1): http://www.mathcentre.ac.uk/resources/leaflets/firstaidkits/6_1.pdf

Scalar Product (6.2): http://www.mathcentre.ac.uk/resources/leaflets/firstaidkits/6_2.pdf

Vector Product (6.3): http://www.mathcentre.ac.uk/resources/leaflets/firstaidkits/6_3.pdf

Basic concepts

Basic quantities

Time is the measure of a succession of events and is a basic quantity in dynamics. Time is not involved in the analysis of statics problems. Time is a *scalar* quantity.

Length is needed to locate the position of a point in space and describes the size of a physical system. Once a standard unit of length has been defined, it is possible to define distances and geometric properties of a body as a multiple of the unit of length. Length is a *scalar* quantity.

Volume is a measurement of the physical size of an object. It refers to how much space an object takes up. Volume is a *scalar* quantity.

Mass is a different measurement of the size of an object. The mass, measured in kilograms, depends only on the amount of matter forming the body. Mass is a *scalar* quantity.

Density is related to mass and volume. It is defined as the mass per unit volume. This means that an object that has a large mass but a small volume will have a large density. Density is a *scalar* quantity.

Speed is a measure of how quickly a body is moving. It is defined as distance travelled per unit time. Speed is a *scalar* quantity.

Forces are influences on a body or system which, acting alone, would cause the motion of that body or system to change. A system or body at rest and then subjected to a force will start to move. To work with forces we need to know the magnitude (size), direction and the point of application of the force. Forces are *vector* quantities.

Displacement is a measure of distance in a particular direction. Displacement is a *vector* quantity.

Velocity is the rate of change of displacement with respect to time. Velocity is a *vector* quantity.

Acceleration is the rate of change of velocity with respect to time. Acceleration is a *vector* quantity.

Momentum is defined as the product of an object's mass and its velocity. This is a very important quantity in mechanics. It arises in many problems particularly those involving collisions. Momentum is a *vector* quantity.

Idealisations

In mechanics we look at real life situations and try to predict what will happen. The problem with real life is that it is often quite complicated. When studying problems in mechanics we often make idealisations of real life situations that simplify the problem. There are many commonly used idealisations that we will introduce in later sheets. Here follows a list of some common idealisations that are used in mechanics.

Particles are bodies which can be treated as a point mass in a given context. For example, when modelling the motion of the planets around the Sun, the planets and Sun can be treated as particles. Much of basic mechanics study is concerned with objects that can be treated as particles.

Connected particles arise in problems where two objects are attached in some way and both objects can be treated as particles. For example, two masses, connected by a string which passes over a pulley could be modelled as connected particles.

Rigid bodies can be considered as combinations of particles in which all the particles remain at a fixed distance from one another both before and after applying a force i.e. there is no bending or stretching. For example a brick can in most circumstances be thought of as a rigid body. Many real life objects can be considered to be rigid bodies to a good approximation.

Exercise

Identify which of the following are vector quantities and which are scalar quantities:

a) The length of a swimming pool. b) The acceleration of a rocket. c) The tension in a bungee rope. d) The friction between a car and the road.

Solutions a) Scalar quantity. b) Vector quantity. c) Vector quantity. d) Vector quantity.