

Lesson 1 Basic Concepts in Mechanics

The branch of scientific analysis which deals with motions, time, and forces is called mechanics and is made up of two parts, statics and dynamics. Statics deals with the analysis of stationary systems, i. e., those in which time is not a factor, and dynamics deals with systems which change with time.

When a number of bodies are connected together to form a group or system, the forces of action and reaction between any two of the connecting bodies are called constraint forces. These forces constrain the bodies to behave in a specific manner. Forces external to this system of bodies are called applied forces.

Forces are transmitted into machine members through mating surfaces, e. g., from a gear to a shaft or from one gear through meshing teeth to another gear (see Fig. 1.1), from a V-belt to a pulley, or from a cam to a follower. It is necessary to know the magnitudes of these forces for a variety of reasons. For example, if the force operating on^[1] a journal bearing becomes too high, it will squeeze out the oil film and cause metal to metal contact, overheating, and rapid failure of the bearing. If the forces between

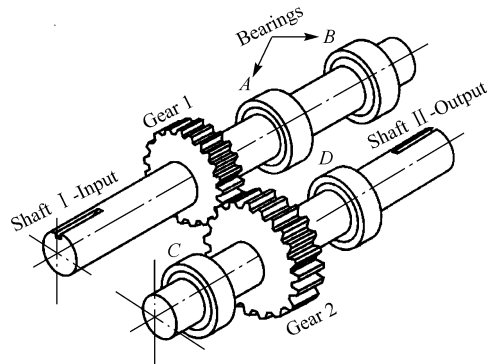


Figure 1.1 Two shafts carrying gears in mesh

gear teeth are too large, the oil film may be squeezed out from between them. This could result in spalling of the metal, noise, and eventual failure. In the study of mechanics, we are principally interested in determining the magnitude, direction, and location of the forces.

Some of the terms used in mechanics are defined below.

Force Our earliest ideas concerning forces arose because of our desire to push, lift, or pull various objects. So force is the action of one body on another. Our intuitive concept of force includes such ideas as place of application, direction, and magnitude, and these are called the characteristics of a force.

Couple Two equal and opposite forces acting along two non-coincident parallel straight lines in a body cannot be combined to obtain a single resultant force. Any two such forces acting on a body constitute a couple (see Fig. 1.2). The only effect of a couple is to produce a rotation or tendency of rotation in a specified direction. .

Mass Mass is a measure of the quantity of matter that a body or an object contains. The mass of the body is not dependent on gravity and therefore is different from but proportional to its weight. Thus, a moon rock has a certain constant amount of substance, even though its

moon weight is different from its earth weight. This constant amount of substance is called the mass of the rock.

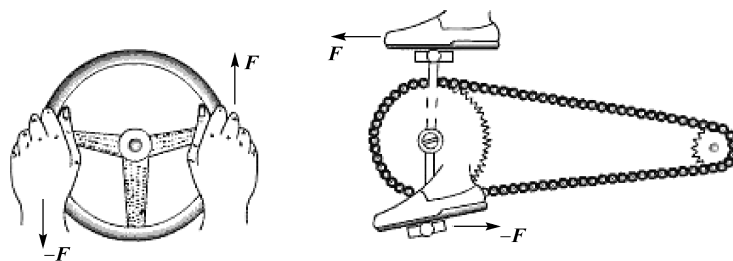


Figure 1.2 Common examples of couples

Inertia Inertia is the property of a body that causes it to resist any effort to change its motion.

Weight Weight is the force with which a body is attracted to the earth or another celestial body, equal to the product of the object's mass and the acceleration of gravity.

Particle A particle^[2] is a body whose dimensions are so small that they may be neglected.

Rigid Body A rigid body does not change size and shape under the action of forces. Actually, all bodies are either elastic or plastic and will be deformed if acted upon by forces. When the deformation of such bodies is small, they are frequently assumed to be rigid, i.e., incapable of deformation, in order to simplify the analysis. A rigid body is an idealization of a real body.

Deformable Body The rigid body assumption cannot be used when internal stresses and strains due to the applied forces are to be analyzed. Thus we consider the body to be capable of deforming. Such analysis is frequently called elastic body analysis, using the additional assumption that the body remains elastic within the range of the applied forces.

Newton's Laws of Motion Newton's three laws are:

Law 1 If all the forces acting on a body are balanced, the body will either remain at rest or will continue to move in a straight line at a uniform velocity.

Law 2 If the forces acting on a body are not balanced, the body will experience an acceleration. The acceleration will be in the direction of the resultant force, and the magnitude of the acceleration will be proportional to the magnitude of the resultant force and inversely proportional to the mass of the body.

Law 3 The forces of action and reaction between interacting bodies are equal in magnitude, opposite in direction, and have the same line of action.

Mechanics deals with two kinds of quantities: scalars and vectors. Scalar quantities are those with which a magnitude alone is associated. Examples of scalar quantities in mechanics are time, volume, density, speed, energy, and mass. Vector quantities, on the other hand, possess direction as well as magnitude. Examples of vectors are displacement, velocity, acceleration, force, moment, and momentum.

Words and Expressions

mechanics [mi'kæniks] *n.* 力学, 机械学

statics [ˈstætɪks] *n.* 静力学

dynamics [daɪˈnæmɪks] *n.* 动力学

i. e. 那就是, 即 (that is)

gravitational [ˌɡrævɪˈteɪʃənəl] *a.* 重力的

mating surface 啮合表面, 配合表面, 接触表面

e. g. 例如 (for example)

gear [ɡiə] *n.* 齿轮 (轮缘上有齿能连续啮合传递运动和动力的机械零件)

shaft [ʃɑ:ft] *n.* 轴 (支承转动件, 传递运动或动力的机械零件)

meshing [ˈmeʃɪŋ] *n.* 啮合 (一对带有齿状部分的零件在传动过程中的相互连接)

bearing [ˈbeərɪŋ] *n.* 轴承 (用于确定旋转轴与其他零件相对运动位置, 起支承或导向作用的零部件), 支承, 承载

pulley [ˈpʊli] *n.* 滑轮, 带轮

cam [kæm] *n.* 凸轮 (具有曲线或曲面轮廓且作为高副元素的构件)

magnitude [ˈmæɡnɪtju:d] *n.* 大小, 尺寸, 量度, 数值

journal [ˈdʒɔ:nl] *n.* 轴颈 (轴上被径向轴承支承着的, 在其中旋转的部分)

journal bearing 滑动轴承, 径向滑动轴承 (承受径向载荷的滑动轴承)

squeeze [skwi:z] out 挤出, 压出

spalling [ˈspɔ:lɪŋ] *n.* 剥落 (疲劳磨损时从摩擦表面以鳞片形式分离出磨屑的现象)

resultant [rɪˈzʌltənt] *a.* 合的, 组合的, 总的; *n.* 合力, 合成矢量, 组合

couple 力偶 (大小相等、方向相反、不作用在同一直线上的两个力所组成的力系)

noncoincident [ˌnɒnkəʊˈɪnsɪdənt] *a.* 不重合的, 不一致的, 不符合的

parallel [ˈpærəleɪ] *a.* 并行的, 平行的, 相同的; *n.* 平行线

inertia [ɪˈnɜ:ʃjə] *n.* 惯性 (物体抵抗其运动状态被改变的性质), 惯量, 惰性

celestial [siˈlestʃəl] body 天体 (宇宙中各种实体的统称)

incapable [ɪnˈkeɪpəbl] *a.* 无能力的, 不能的, 无用的, 无资格的

deformation [ˌdi:fɔ:ˈmeɪʃən] *n.* 变形 (物体在外来因素作用下产生的形状和尺寸的改变)

deformable [diˈfɔ:məbl] *a.* 可变形的, 应变的

acceleration [ækɪsələˈreɪʃən] *n.* 加速度 (速度对时间的变化率)

stress [stres] *n.* 应力 (内力的集度, 即单位面积上的内力)

strain [streɪn] *n.* 应变 (由外力使物体尺寸或形状发生相对变化的现象)

scalar [ˈskeɪlə] *n.*; *a.* 数量 (的), 标量 (的)

vector [ˈvektə] *n.* 矢量, 向量

displacement [dɪsˈpleɪsmənt] *n.* 位移 (物体或质点从初位置到末位置的有向线段)

moment [ˈməʊmənt] *n.* 力矩 (力和力臂的乘积)

momentum [məʊˈmentəm] *n.* 动量 (物体的质量和速度的乘积)

Notes

[1] operate on 意为“对……起作用, 影响”。

[2] particle 意为“质点, 动力学中用来代替物体的有质量的点, 是一个理想化模型”。