Patrician College of Arts and Science

Department of Mathematics

Statics

Subject Code TAM4B

Semester IV

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Mechanics

The science of mechanics is centered on the study of the motion of a physical object subjected to various types of mechanical loading. From the causality point of view, a mechanical cause (applied load) to a physical object will result in mechanical responses (motion).

Four entities are involved in this causality relationship:

Physical objects – Three common states of physical objects are gas, fluid, and solid. Thus, mechanics studies are often named by their medium, i.e. gas dynamics, fluid mechanics, and solid mechanics. Furthermore, mathematical idealization is adopted to consider physical objects as particles, or as either rigid or non-rigid deformable bodies.

Continuation of Four entities

- Mechanical causes of motion – There are many mechanical causes of motion such as force, moment, work, impulse, and power, etc.
- Mechanical responses – Two types of spatial motion for a physical object are translation and rotation. A general motion consists of these two motion components, which are independent of each other. This lays an important theoretical basis for rigid-body kinematics.

Continuation of Four entities

Cause and effect relationship – The governing physical laws are Newton’s three laws of motion and Euler’s equations. When Newton’s second law of motion is integrated, it becomes either the principle of work and energy or the principle of impulse and momentum. These laws are the foundations of all mechanics studies.

Newton’s Laws

- Statics and dynamics concentrate on Newtonian or classical mechanics. Sir Isaac Newton stated the following laws upon which classical mechanics is based.

I. Every body continues in its state of rest, or of uniform motion in a straight line, unless acted upon by an impressed force(Law of inertia).

Continuation of Newton's Laws

II. The time rate of change of linear momentum of a body is proportional to the force acting upon it and is in the direction in which the force acts (Law of motion)

III. To every action there is an equal and opposite reaction; that is, the mutual forces of two bodies acting upon each other are equal in magnitude, but opposite in direction(Law of action and reaction).

Continuation of Newton's Laws

- An understanding of Newton's laws of motion is easily achieved by applying them to the study of particle motion, where a particle is defined as a mass concentrated at a point.
- When the three basic laws of motion are applied to the motion of a particle, the law of motion (N2) can be expressed by the equation

$$F = ma \ (1)$$

where *m is the mass of the particle*, ***a is its acceleration, F is the applied force. In the SI*** system of units, the force is expressed in Newton (N), the acceleration in meter per second squared (m/sec2), and the mass in kilogram (kg).

Statics

From a Newtonian mechanics point of view, statics problems are a special case of dynamics problems in that the right-hand side of Eq. (1) becomes zero. It should be noted that zero acceleration implies two motion conditions, either zero displacement(stationary) or a uniform velocity motion.

Force Vectors

A physical quantity having a direction and a magnitude is called a *vector*

$$\boldsymbol{F = F\lambda} \quad \boldsymbol{(2)}$$

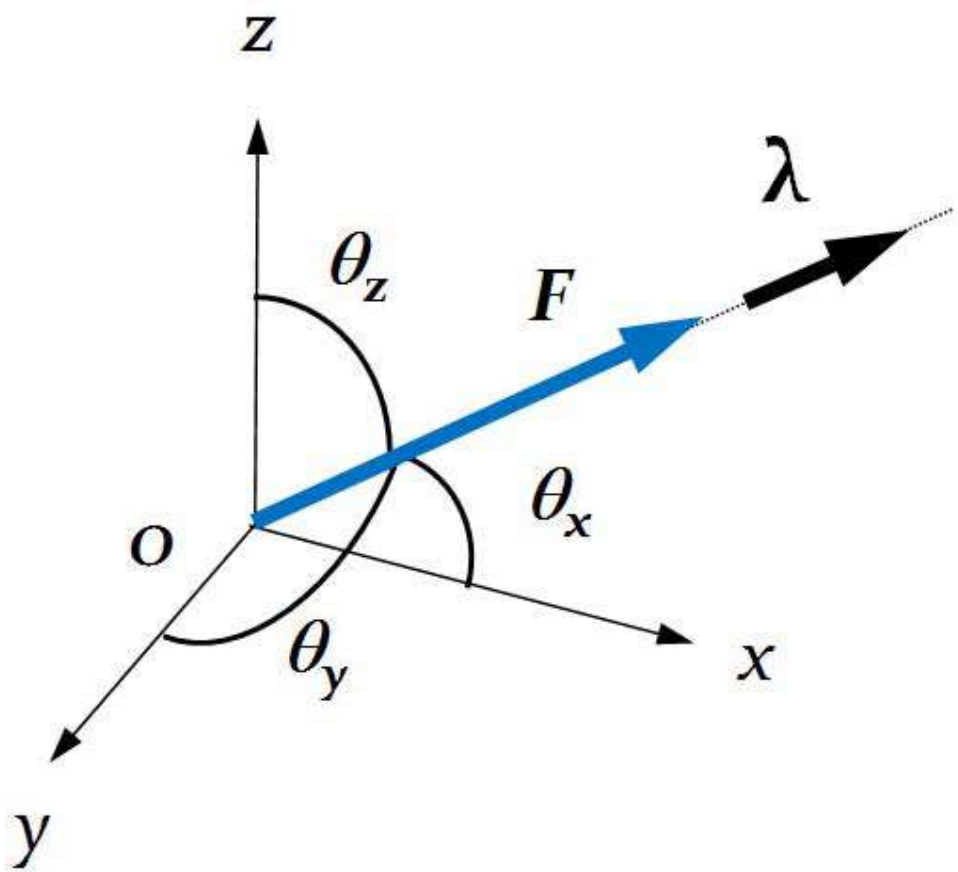
where *F is the magnitude of the vector and λ is the unit direction vector parallel to* ***F*** **.**Unlike scalar quantities, vectors are added up, according to the parallelogram law; that is, the resultant of two force vectors is found by drawing a parallelogram with its diagonal becoming the resultant.

Force vectors are often mathematically represented in a rectangular coordinate system

$$F = F_x + F_y + F_z = F_x\, i + F_y\, j + F_z\, k \qquad (3)$$

where F_x , F_y and F_z ***are rectangular components in x, y, and z directions, respectively,*** Whereas F_x , F_y and F_z *are magnitudes of each rectangular components. The unit* vectors ***i, j, and k are used to represent directions along each rectangular coordinate*** axis.

Rectangular coordinate system



Rectangular coordinate system

Direction cosines are also used to represent a force vector. Mathematically, they are rectangular components of the given unit vector in such a way that

$$F = F\lambda = F\cos\theta_x\, i + F\cos\theta_y\, j + F\cos\theta_z\, k$$

Where $\cos\theta_x, \cos\theta_y$ and $\cos\theta_z$ are the direction cosines and θ_x, θ_y and θ_z are the direction angles

Thank you

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