MIMLI DAS

Lecturer, Mechanical Engineering

ENGINEERING MECHANICS

CHAPTER 4: COPLANAR NON-CONCURRENT FORCES

Lecture 1:

4.1 Condition of equilibrium of non concurrent coplanar forces, Resultant of funicular or Link polygon. Problems

Condition of equilibrium of non concurrent coplanar forces:

We Consider a body acted upon by a number of coplanar non-concurrent forces. A little consideration will show, that as a result of these forces, the body may have any one of the following states:

- The body may move in any one direction.
- The body may rotate about itself without moving.
- The body may move in any one direction and at the same time it may also rotate about itself.
- The body may be completely at rest.

Now we shall study the above mentioned four states one by one.

- If the body moves in any direction, it means that there is a resultant force acting on it. A little consideration will show, that if the body is to be at rest or in equilibrium, the resultant force causing movement must be zero. Or in other words, the horizontal component of all the forces ($\sum$ H) and vertical component of all the forces ($\sum$V) must be zero.

  Mathematically, $\sum H = 0$ and $\sum V = 0$
- If the body rotates about itself, without moving, it means that there is a single resultant couple acting on it with no resultant force. A little consideration will show, that if the body is to be at rest or in equilibrium, the moment of the couple causing rotation must be zero. Or in other words, the resultant moment of all the forces ($\sum$ M) must be zero.

  Mathematically, $\sum M = 0$
- If the body moves in any direction and at the same time it rotates about itself, if means that there is a resultant force and also a resultant couple acting on it. A little consideration will show, that if the body is to be at rest or in equilibrium, the resultant force causing movements and the resultant moment of the couple causing rotation must be zero. Or in other words, horizontal component of all the

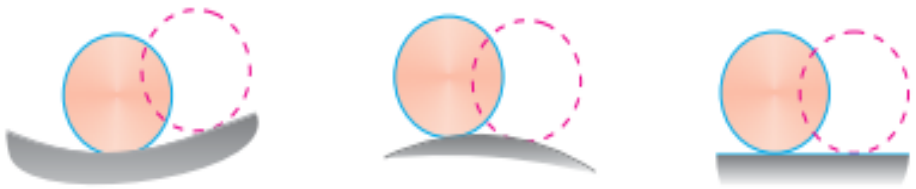
forces (∑ H), vertical component of all the forces (∑ V) and resultant moment of all the forces (∑ M) must be zero.

Mathematically, ∑ H = 0 , ∑ V = 0 and ∑ M =0

- If the body is completely at rest, it necessarily means that there is neither a resultant force nor a couple acting on it. A little consideration will show, that in this case the following conditions are already satisfied **: ∑ H = 0, ∑ V = 0 and ∑ M = 0. The above mentioned three equations are known as the conditions of equilibrium.**

Types of equilibrium:

A) Stable equilibrium
B) Unstable equilibrium
C) Neutral equilibrium



(*a*) Stable (b) Unstable (*c*) Neutral

A) Stable equilibrium: A body is said to be in stable equilibrium, if it returns back to its original position, after it is slightly displaced from its position of rest. A smooth cylinder, lying in a curved surface, is in stable equilibrium.

B) Unstable equilibrium: A body is said to be in an unstable equilibrium, if it does not return back to its original position, and heels farther away, after slightly displaced from its position of rest. A smooth cylinder lying on a convex surface is in unstable equilibrium.

C) Neutral equilibrium: A body is said to be in a neutral equilibrium, if it occupies a new position (and remains at rest in this position) after slightly displaced from its position of rest. A smooth cylinder lying on a horizontal plane is in neutral equilibrium.