Chapter 11: Virtual Work

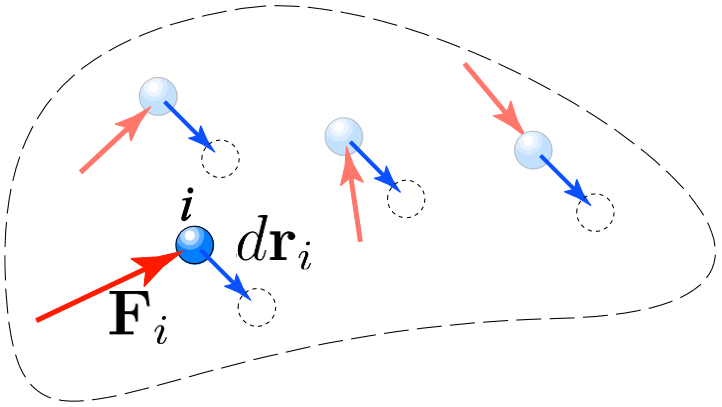
Main goals and learning objectives

- Introduce the principle of virtual work
- Show how it applies to determining the equilibrium configuration of a series of pin-connected members
- Establish the potential energy function and use the potential energy method to investigate the type of equilibrium or stability of a rigid body or configuration

Definition of Work

Work of a force

A force does work when it undergoes a displacement in the direction of the line of action.

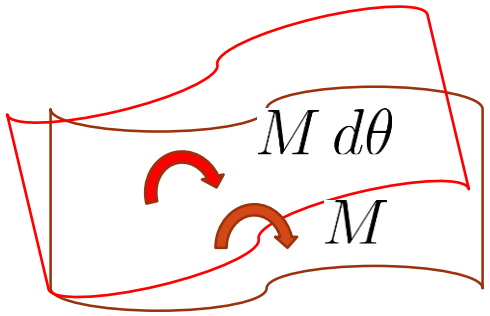


The work dU produced by the force $\boldsymbol{F}$ when it undergoes a differential displacement $\boldsymbol{dr}$ is given by

$$dU = \mathbf{F} \cdot d\mathbf{r}$$

Definition of Work

Work of a couple $dU = M\mathbf{k} \cdot d\theta\,\mathbf{k} = M\,d\theta$

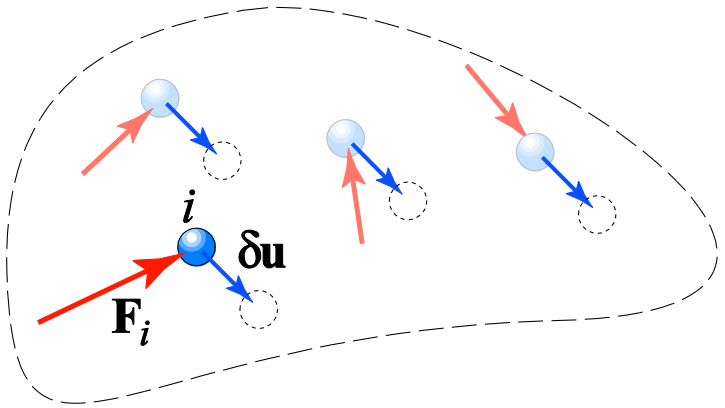


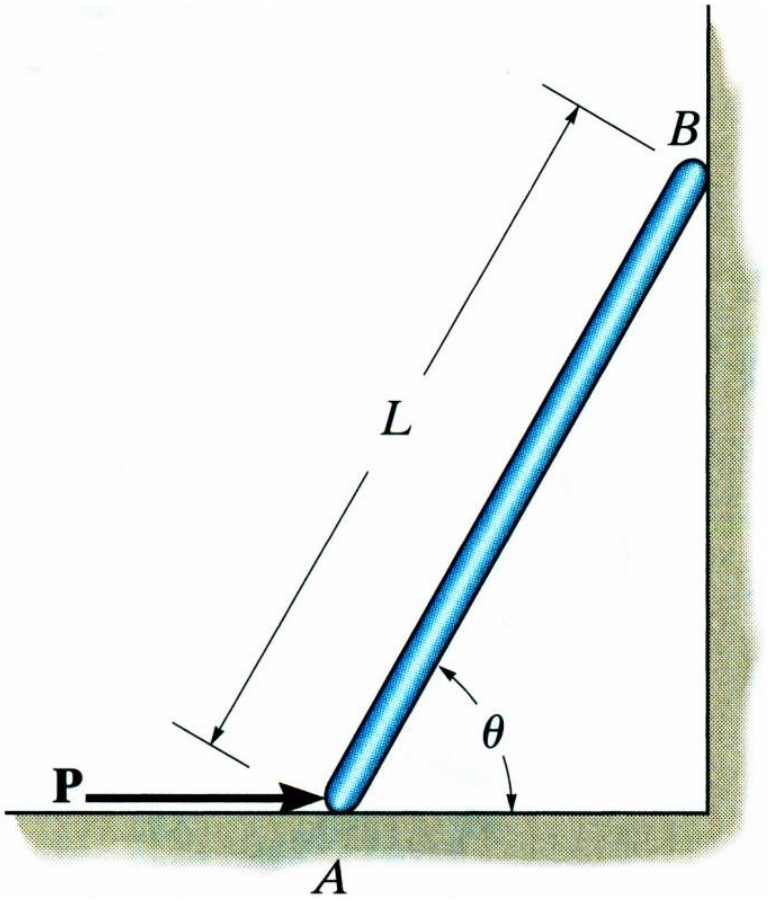
Virtual Displacements

A *virtual displacement* is a conceptually possible displacement *or* rotation of all *or* part of a system of particles. The movement is assumed to be possible, but actually does not exist.

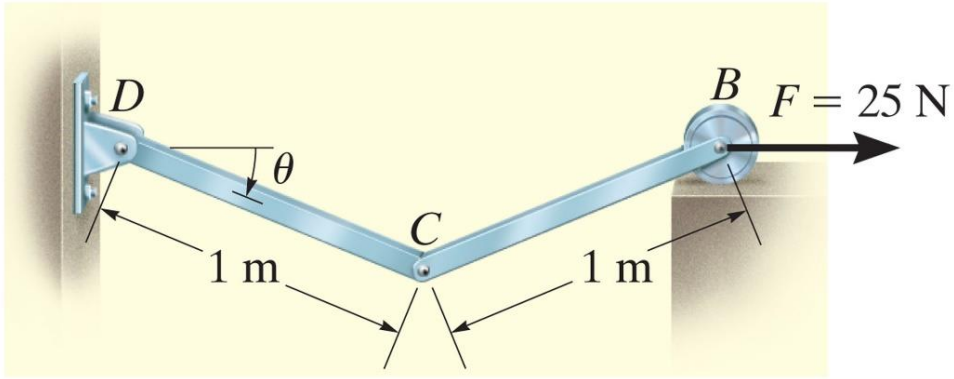
Principle of Virtual Work

The principle of virtual work states that if a body is in equilibrium, then the algebraic sum of the virtual work done by all the forces and couple moments acting on the body is zero for any virtual displacement of the body. Thus,

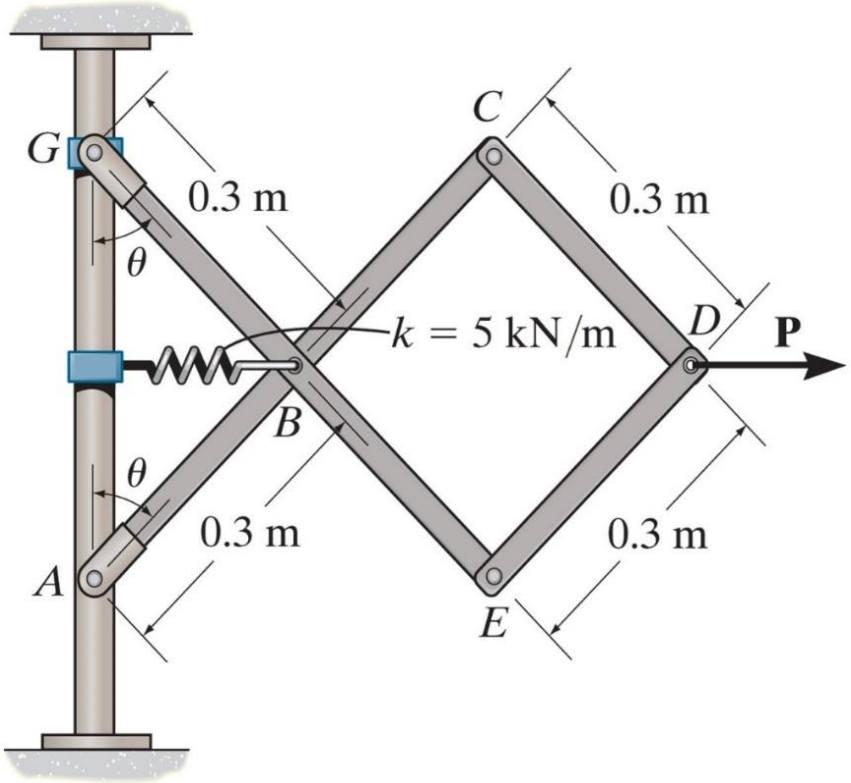




The thin rod of weight W rests against the smooth wall and floor. Determine the magnitude of force P needed to hold it in equilibrium.



Determine the angle for equilibrium of the two-member linkage. Each member has a mass of 10 kg.



Determine the required force P needed to maintain equilibrium of the scissors linkage when the angle is 60 degrees. The spring is unstretched when the angle is 30 degrees.