

# Static-Virtual Work

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(Dated: April 18, 2020)

PACS numbers: 03.67.Mn, 03.65.Ud.;

## I. STATIC

**Static:** Mechanics of rigid body is basically classified into three sub-category. Namely

(1) Kinematics; (2) Dynamics; (3) Statics.

We are already familiar with the first two.

The part of Mechanics which deals with forces acting on the body and keep the body at rest w.r.t . some **frame of reference**, is known as Static. The forces are said to be in equilibrium.

The object of static is to find the relations among the forces in equilibrium, or to find the conditions of equilibrium in this scenario.

**Virtual work Lesson Plan :** Work less constraints - examples, virtual displacements and virtual work. The principle of virtual work, Deductions of the necessary and sufficient conditions of equilibrium of an arbitrary force system in plane and space, acting on a rigid body.

### A. Virtual Work

**Definition:** In general if we apply any force  $F$  on a body it will move from position A to B (say). Then the work done is define as  $W = F = \vec{F} \cdot \vec{d}$ . Where  $\mathbf{d}$  is the displacement vector from A to B.

Now if under the action of the force  $\mathbf{F}$  the body actually does not move to B, but is imagined or conceived to move B, then the displacement AB ( $\delta \vec{d}$ ) is called **Virtual Displacement**, and the corresponding Work Done  $\vec{F} \cdot \delta \vec{d}$  is called **virtual Work**.

### B. Basic Principle of Static:

The four basic principle of Static are

- (1) The Principle of Physical Independence of Forces,
- (2) The Principle of Transmissibility of Forces.
- (3) The Principle of Action and Reaction.
- (4) The Principle of Parallelogram of Forces

The first law state that when several forces acting simultaneously on a rigid body the action of any forces is not affected by the presence of the other forces.

The second one states that any force acting at a point of a rigid body may be taken to act at any other point on its line of action which is rigidly attach with the body.



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### C. Principle of Virtual Work

If a system of forces acting on a particle be in equilibrium, then the algebraic sum of the virtual work done by the forces is 0 for any arbitrary virtual displacement.

Mathematically,  $X_1\delta x + Y_1\delta y + Z_1\delta z = 0$ .

We have to find the relations among the forces using given system.

**Theorem 1:** If a Rigid body is in equilibrium under the action of a given system of external forces and the body is given any infinitesimal virtual displacement, consistent with the geometrical condition of the body, the algebraic sum of the virtual work done by the external force is zero.

**Theorem 2:** The principle of virtual work for any system of co-planer forces acting on a rigid body. (state and prove).

### D. Forces do not appear in the equation of virtual work:

- (1) Forces of action and reaction at a smooth joint(friction less).
- (2) Forces of action and reaction between two particles when distance between them is invariable.
- (3) The tension (-) or thrust(+) at the end of in extensible string or Rod when length of string or rod remain unaltered.
- (4) The reaction of smooth and fixed surface, with which the body is contact.

### E. Acting forces in equation of virtual work

All the forces in the problem of virtual work will act into play except the above mentioned ones, regarding the given problems.

We will consider Tension always as negative(-) force and Thrust as positive Force(+), irrespective of the position of fixed point/ line.

If the acting point of force is below the fixed level of measurement then we take it as positive in equation of motion otherwise negative.

### F. Working rule

- (1) Read the problem carefully and identify the job.
- (2) Find all the acting forces.
- (3) Find the fixed level of measurement of the system. This is most important part of VW. (4). Write the equation of VW.  $\sum F.\delta x = 0$
- (5) Mathematical works .

N.B.- General acting forces are weight, tension , thrust.

**Exercise** From the books of S. Mondal (Worked Out Examples): 1-11,15-21,23-29,31-39,47,48  
From M.C.Ghosh (worked out examples)-1-4,(A)1,(B)2-3,5,7-11,Miscellaneous-2,3,9-11,Exercise-1,4,7-9,11,13,15,21,25,28,miss.-10,12,13