D' Alembert's Principle :-

Newton's second law of motion and Principle of virtual work for a system of Particles is applicable to the statics, which was formed by D'Alembert's and known as D'Alembert's Principle.

According to Newton's 2nd law of motion, the force is the rate of change of momentum,

$$\vec{F_i} = \frac{d\vec{p_i}}{dt} = \dot{\vec{p_i}} \Rightarrow \vec{F_i} - \dot{\vec{p_i}} = 0 \quad \text{— (1)}$$

According to the above equation, a moving system of Particles will be equilibrium under the force $(\vec{F_i} - \dot{\vec{p_i}})$ i.e., the acutual force $\vec{F_i}$ plus an additional force $(-\dot{\vec{p_i}})$, known as reversed effective force on ith particle.

Thus, $\sum_i (\vec{F_i} - \dot{\vec{p_i}}) \cdot \delta\vec{r_i} = 0$ If forces of constraint present, then $\vec{F_i} = \vec{F_i}^a + \vec{f_i}$

$$\Rightarrow \sum_i \left[(\vec{f_i} + \vec{F_i}^a) - \dot{\vec{p_i}} \right] \cdot \delta\vec{r_i} = 0$$

$$\Rightarrow \sum_i \vec{f_i} \cdot \delta\vec{r_i} + \sum_i (\vec{F_i}^a - \dot{\vec{p_i}}) \cdot \delta\vec{r_i} = 0 \quad \text{— (2)}$$

For a system, where the virtual workdone by the forces of constraints is zero, i.e., $\sum_i \vec{f_i} \cdot \delta\vec{r_i} = 0$

then eq^n (2) reduces to -

$$\boxed{\sum_i (\vec{F_i}^a - \dot{\vec{p_i}}) \cdot \delta\vec{r_i} = 0}$$

which is known as D'Alembert's Principle.