$\int dw = 1$ · dw = dif. prob.

prob. density ρ

$dw = \rho(p, q; t)\, dp\, dq$

$p = p_1, p_2 \cdots p_s$ 3d: $s = 3N$

$q = q_1, q_2 \cdots q_s$

$dp = dp_1\, dp_2 \cdots dp_s$

$dq = dq_1 \cdots dq_s$

f = some quantity

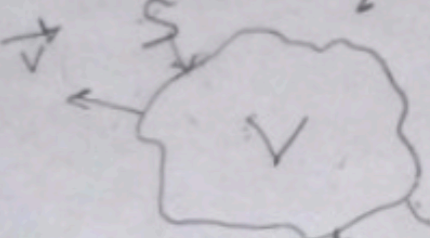
$$\bar{f}(t) = \int f(p, q)\, \rho(p, q; t)\, dp\, dq$$

mostly $f \neq f(t)$

Liouville's theorem:

conservation of # part.

review "Eq. of continuity"



$$M = \int d^3r\, \rho(r)$$

volume V

mass $= \rho(\vec{r})\, \vec{v}$

$$\dot{M} = \int d^3r \frac{\partial \rho(r, t)}{\partial t} = -\int d\vec{S} \cdot \rho \vec{v}$$

volume element arb.

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{v}) = 0 \quad \text{eq of cont.}$$

generalize: $\rho \to \rho(p, q; t)$

$$\frac{\partial \rho}{\partial t} + \underbrace{\sum_{i=1}^{s} \frac{\partial}{\partial q_i}(\rho \dot{q}_i) + \sum_{i=1}^{s} \frac{\partial}{\partial p_i}(\rho \dot{p}_i)}_{\sum_i \left[\frac{\partial \rho}{\partial q_i} \dot{q}_i + \rho \frac{\partial \dot{q}_i}{\partial q_i} + \frac{\partial \rho}{\partial p_i} \dot{p}_i + \rho \frac{\partial \dot{p}_i}{\partial p_i} \right]} = 0$$

$$\frac{\partial H}{\partial p_i} = \dot{q}_i \; ; \; \frac{\partial H}{\partial q_i} = -\dot{p}_i$$

$$\frac{\partial \dot{q}_i}{\partial q_i} = \frac{\partial^2 H}{\partial q_i \partial p_i} \; ; \; \frac{\partial \dot{p}_i}{\partial q_i} = -\frac{\partial^2 H}{\partial q_i \partial p_i}$$

$$\frac{\partial \rho}{\partial t} + \sum_i \frac{\partial \rho}{\partial q_i} \dot{q}_i + \sum_i \frac{\partial \rho}{\partial p_i} \dot{p}_i = 0$$

$$\boxed{\frac{d\rho(t; p, q)}{dt} = 0}$$

th