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1.1 PARTICLES AND FIELDS

CLASSICAL FIELDS

CHAPTER 1
1-2. DISCRETE AND CONTINUOUS MECHANICAL SYSTEMS

In the formulation of Lagrange's equations, the corresponding equations of motion are obtained by applying the principle of least action to the system. The equations of motion are then solved to find the position and velocity of the system. The solution to these equations provides information about the behavior of the system under various conditions.

\[ \mathbf{x}(t) = \mathbf{a} + \int_{t_0}^{t} \mathbf{v}(\tau) \, d\tau \]

where \( \mathbf{x}(t) \) is the displacement of the particle, \( \mathbf{a} \) is the initial position, \( \mathbf{v}(\tau) \) is the velocity at time \( \tau \), and \( t \) is the current time.

In the presence of forces, the equations of motion take the form:

\[ \mathbf{F} = m \mathbf{a} \]

where \( \mathbf{F} \) is the net force acting on the particle, \( m \) is the mass of the particle, and \( \mathbf{a} \) is the acceleration.

The principles of dynamics are used to analyze the behavior of mechanical systems under various conditions. These principles include the laws of motion, the concept of forces, and the conservation of energy.

In the next section, we will explore the transition from discrete to continuous systems and discuss the implications for engineering applications.
In the next section, we will discuss the concept of the covariant derivative, which is a generalization of the ordinary derivative to vector fields. The covariant derivative of a vector field $\mathbf{A}$ with respect to a vector field $\mathbf{X}$ is defined as:

$$
\frac{\partial \mathbf{A}}{\partial \mathbf{X}} = \nabla_{\mathbf{X}} \mathbf{A}
$$

where $\nabla_{\mathbf{X}}$ is the covariant derivative operator.

The covariant derivative is a fundamental concept in differential geometry and general relativity.

### 1-2 Classical Scalar Fields

Potential energy densities $\phi$ or $V(x)$ can be obtained respectively by defining the kinetic and potential energy densities. By definition, the kinetic energy density is given by:

$$
\frac{1}{2} \mathbf{A} \cdot \mathbf{A}
$$

The potential energy density is given by:

$$
\Phi = -\mathbf{A} \cdot \mathbf{B}
$$

where $\mathbf{B}$ is the magnetic field.

The total energy density is then given by:

$$
\epsilon_{total} = \frac{1}{2} \mathbf{A} \cdot \mathbf{A} + \Phi
$$

We can express the total energy density in terms of the scalar potential $\phi$ as:

$$
\epsilon_{total} = \frac{1}{2} \mathbf{A} \cdot \mathbf{A} + \phi
$$

We can then write the Lagrangian density as:

$$
\mathcal{L} = \frac{1}{2} \mathbf{A} \cdot \mathbf{A} - \phi
$$

We can then use the Euler-Lagrange equations to derive the equations of motion.

$$
\frac{\partial \mathcal{L}}{\partial \phi} = \frac{\partial \mathcal{L}}{\partial \phi} = 0
$$

We can then write the equations of motion in the form:

$$
\frac{\partial \mathcal{L}}{\partial \phi} = \frac{\partial \mathcal{L}}{\partial \phi} = 0
$$

We can then use the Hamilton's principle to derive the equations of motion.

$$
\frac{\partial \mathcal{L}}{\partial \dot{\phi}} = \frac{\partial \mathcal{L}}{\partial \dot{\phi}} = 0
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\[ \phi_\mu = \phi \cdot n - \phi \square \]

The field equation is thus:

\[ \phi_\mu = \phi \cdot n - \phi \square \]

where \( \phi \) is the source density, which is in general a function of space.

\[ \phi_\mu = \nabla \phi \]

where \( \phi \) is the source density, which, by definition, is a divergence of a vector field.

\[ \phi_\mu = \nabla \phi \]

This is the field equation for a free field, which, by definition, is a divergence of a vector field.

\[ \phi_\mu = \nabla \phi \]

The parameter \( \mu \) is the dimension of inverse length, and \( \phi \) is a constant, as we consider boundary-stable solutions.

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