Chapter 1 Methodology

1.1 Introduction

Today is 20211211, and I deciede to note down all of my knowledge about physics in this notebook. Actually we think for a while whether to seperatre the knowledge into different documents.

1.2 Preference

1.2.1 Volabulary

orthogonal matrix, 正交矩阵

1.3 History

1.4 观点

1.4.1 Videos

牛顿经典力学，场论定域论，最小作用量原理，都可以解释从 A 到 B 的路径，是等效的。So I made the hypothesis often that the laws are going to turn out to be, in the end, simple like the checkerboard, and that all the complexity is from size.

If you will not say that it is true in a region that you have not looked at, you do not know anything.

We always must make statements about the regions that we have not seen.

The mass of an object changes when it moves.

1.4.2 需要再确认的观点

1.4.2.1 行星和卫星公转轨道为什么是椭圆？

一个焦点位于原点的圆锥曲线 $\frac{1}{r} = C\left[1 + e\cos(\theta - \theta')\right]$ $f = -\frac{k}{r^2}$， $V = -\frac{k}{r}$ 只考虑 2 体，角动量守恒求出轨道方程，角动量 l 与 E 看做常数，

$$\frac{1}{r} = \frac{mk}{l^2}\left(1 + \sqrt{1 + \frac{2El^2}{mk^2}}\cos(\theta - \theta')\right)$$

离心率 e<1 椭圆，等于 1 是抛物线，大于 1 是双曲线。$e = \sqrt{1 + \frac{2El^2}{mk^2}}$

Chapter 2 Mechanics

2.1 Classical Mechanics

2.1.1 Center of Mass

Algebra defination $\boldsymbol{r}_c := \frac{\sum m_i \boldsymbol{r}_i}{\sum m_i}$, it relays to the choice of the coordinate system. If the map of the two coordinate systems is $T : S \to S'$, the matrix is orthogonal matrix, and m_i has no inflence to the space, $\boldsymbol{r}'_c = T\boldsymbol{r}_c$.

The operator $\boldsymbol{r}_c$ simplifies the calculation, $(\sum m_i)\boldsymbol{r}_c = \sum m_i \boldsymbol{r}_i$. We define the energy of the system like this, the whole energy $E_{all} := \sum \frac{1}{2} m_i \boldsymbol{v}_i^2$, the explicit energy $E_{ext} = \frac{1}{2}(\sum m_i)\boldsymbol{v}_c^2$, the intrenal energy $E_{int} := \sum \frac{1}{2} m_i (\boldsymbol{v}_i - \boldsymbol{v}_c)^2$, because $\sum m_i \boldsymbol{v}_c^2 - 2\sum m_i \boldsymbol{v}_i \boldsymbol{v}_c = -\boldsymbol{v}_c^2 \sum m_i$, we have $E_{int} = E_{all} - E_{ext}$.

2.1.2 Momentum

$\sum m_i \ddot{\boldsymbol{r}}_i = \sum(\boldsymbol{F}_i + \sum \delta_{ij} \boldsymbol{f}_{i \leftarrow j}) = \sum \boldsymbol{F}_i$. We define momentum $\sum \boldsymbol{P}_i = \sum m_i \dot{\boldsymbol{r}}_i$, therefore, $\frac{d}{dt} \sum \boldsymbol{P}_i = \sum \boldsymbol{F}_i$. [So the speed of light is always a const number, means that no other force can be applied to light?]

$\int \frac{d\boldsymbol{p}}{dt} = \boldsymbol{F}$, so $\int \boldsymbol{dp} = \int \boldsymbol{F} dt$.

2.1.3 Rigid Body

A rigid body changes from one position and orientation to another, the general movement can be represented as $\boldsymbol{v} = \boldsymbol{\omega} \times \boldsymbol{r}$.

Proposition 2.1 (One fixed rotation axis). *Proof that the transformation of a rigid body has one fixed rotation axis.*

As shown in the figure, supposed that point A and B are on a sphere, and are transformed to A' and B', and two perpendicular bisector lines meets at point N, the point N can be transformed to N', because that $\triangle ABN \cong \triangle A'B'N'$, and moving on the orientable surface the triangular *cannot transfered from $\triangle ABC$ into $\triangle ACB$, we say $N = N'$, the line ON is the axis that doesn't move during the transformation.*

The basis of the coordinate system $\boldsymbol{Z}^T := [e_1, e_2, e_3]$, represented as one line and three columns. The transformation of the basis $\boldsymbol{Z}' = \boldsymbol{Z}\boldsymbol{\Gamma}$, $\boldsymbol{Z}\boldsymbol{\Gamma}\boldsymbol{r}' = \boldsymbol{Z}\boldsymbol{r}$, so $\boldsymbol{r}' = \boldsymbol{\Gamma}^{-1}\boldsymbol{r}$, $\boldsymbol{\Gamma}\boldsymbol{\Gamma}^{-1} = \boldsymbol{I}$ is easy to say when we write left in detail and considering that the $\boldsymbol{\Gamma}$ is the unit orthogonal base. Then the $\boldsymbol{\Gamma} \in SO_3$.

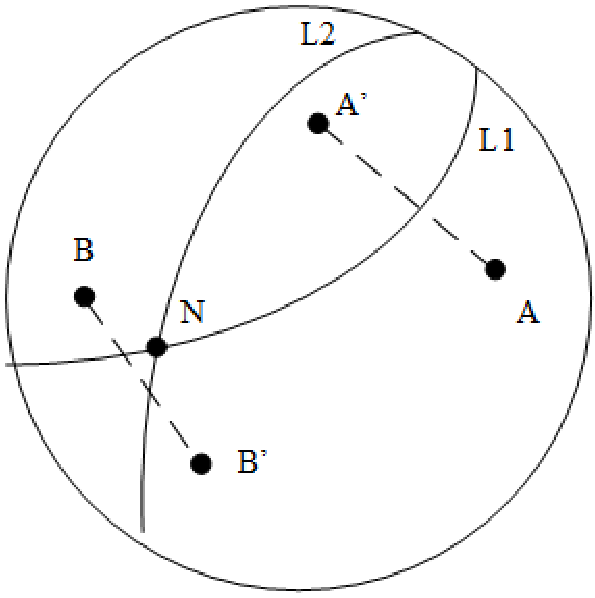

Figure 2.1: [T0004:ProvehasOneAxis]

The eigen value of $\boldsymbol{\Gamma}$, $|\boldsymbol{\Gamma} - \boldsymbol{\lambda}\boldsymbol{I}| = \boldsymbol{0}$, so $-x^3 + \alpha x^2 + \beta x + 1 = 0$, since the image of the function is continuous through $(-\infty, +\infty)$, it must have one root. 1 is one of the root. If the three roots are all real, they are all 1, or 1,-1,-1. If the rest two roots are virtual, they are $e^{i\theta}, e^{-i\theta}$, so $T\phi = e^{i\theta}\phi$.

$$
\begin{aligned}
&\Gamma(\phi_1 + i\phi_2) = e^{i\theta}(\phi_1 + i\phi_2),\\
&\Gamma(\phi_1 - i\phi_2) = e^{-i\theta}(\phi_1 - i\phi_2)\\
&therefore:\\
&\Gamma(\phi_1) = \cos(\theta)\phi_1 - \sin(\theta)\phi_2,\\
&\Gamma(\phi_2) = \sin(\theta)\phi_1 + \cos(\theta)\phi_2
\end{aligned}
\tag{2.1}
$$

θ is the rotation angle.

2.1.4 Anglar Momentum

$\boldsymbol{L}_i := \boldsymbol{r}_i \times \boldsymbol{p}_i$, with the defination of $\boldsymbol{p}$, we have $\sum \boldsymbol{L}_i = \sum m_i \boldsymbol{r}_i \times \boldsymbol{v}_i$, and $\sum \boldsymbol{L}_i = \sum \boldsymbol{r}_i \times \boldsymbol{F}_i + \sum \boldsymbol{r}_i \times \sum_j \boldsymbol{f}_{i \leftarrow j}$. Since $\sum (\boldsymbol{r}_i - \boldsymbol{r}_j) \times \boldsymbol{f}_{i \leftarrow j} = 0$, we have $\sum \boldsymbol{L}_i = \sum \boldsymbol{r}_i \times \boldsymbol{F}_i$. We also call that Torque.

2.2 Reference

2.2.1 Todo

2.2.2 Tmeplate

2.2.2.1 Tmeplate

Theorem 2.1 (均值不等式)**.** *设 A, B 是两个实数, 则 $2AB \le 2A^2 + B^2$.*

均值不等式. 设 A, B 是两个实数, 则 $2AB \le 2A^2 + B^2$.

$\square$

The free fall ball ends at $[1 - |(\mu k)^{-1} \pmod 2) - 1|]kH$

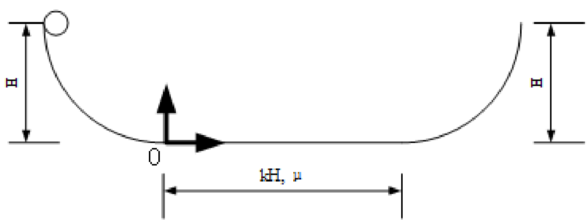

Figure 2.2: [T0001:]

Chapter 3 Electromagnetics

注重发现的过程，物理思想。研究对象变化导致需要新的概念、手段。

3.1 Preference

The energy is flowing through the space around the conductor.

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3.2 电学

3.2.1 静电场

3.2.1.1 库仑定律和场强叠加原理

观察现象，提出问题，猜测，实验，规律，新物理量，公式（定量表述），成立条件，适用范围，精度，理论地位，发展，应用。

物理定律的内涵和外延。

电力，非接触，和引力、电磁力一样非接触，最好先研究点电荷。猜测电力和距离平方成反比，因为均匀球壳中不受力，就像均匀球壳中心不受引力。1785 库伦扭秤实验测电斥力。力弱，漏电。测电引力，类比单摆周期和到质心距离成正比，做单摆实验。物理规律有层次，空间对称性层次高。

从特称判断到全称判断，从特殊到一般。

库伦定理，真空（可以不真空），静止（必须，可以是相对于静止电荷对运动电核的作用，）运动电荷产生的场和速度有关，静电荷和动电荷之间的相互作用不遵循牛顿第三定律，牛三本质是动量守恒，说明除了两个电荷，还有第三者参与了且第三者的动量也变化了，这个第三者是场。在某个参考系中可能 2 电荷相对静止，只有库仑力，换个参考系 2 电荷运动，产生磁场，点作用 + 磁作用。电磁现象联系紧密。

成立的尺度范围：原子级别，原子核内部可能有问题。大尺度到太阳星系范围可能也没有问题。

库伦定理是迄今为止物理学中最精确的实验定律之一，电磁力和距离的 -2 ± 10^{-16} 次方成正比（1971 年测量数据）。因为这个比例系数和光子的静止质量有关，电磁波没有静止质量。

$$\boldsymbol{F}_{ab}=\frac{1}{4\pi\varepsilon_0}\frac{q_a\cdot q_b}{r^2}\hat{\boldsymbol{r}}$$

电荷性质：守恒性，量子性，非相对论性。电荷有正负，引力只有正，电荷可以屏蔽，引力不能。

电场强度 $\boldsymbol{E}=\boldsymbol{F}/q_0$

用试探电荷来描绘要测量的某点电荷的场强分布，因而试探电荷电量要小来减少对测量电荷场强分布的影响，尺寸要小来描绘精确。

场强线性叠加

$$\boldsymbol{E}=\int d\boldsymbol{E}=\frac{1}{4\pi\varepsilon_0}\int\frac{\hat{\boldsymbol{r}}}{r^2}dq$$

3.2.1.2 高斯定理，环路定理，电势

非接触力的机制，这种作用是怎么进行的，有媒介物吗？有传递时间吗？

先研究静态的力场，然后研究动态的力场，然后研究力场与其中电荷的相互作用。把场作为研究的对象。

场：一定空间中连续分布的物体。如矢量场，标量场。

静电场的几何描述：电场线，切线方向表示电场方向。如何从整体上描述一个场，或较容易一下子区分不同的场？因为电场线画出来眼花缭乱的。最早是麦克斯韦做的，用类比的方法。看看流体力学怎么做的。不可压缩流体的恒定流动可以画出流速场，流体力学抓住了何处有源、汇，何时有旋，并且发现可以用通量的概念描述这种特征，包围源的通量大于 0，包围汇的通量小于 0，其余情况等于 0。

$\vec{A}\cdot d\vec{s}=A\cos\theta ds$,$\vec{A}$ 可取 $\vec{v},\vec{E},\vec{B}$

$$\begin{aligned}&\oiint_S\vec{E}d\vec{s}=\frac{1}{\varepsilon}\sum_{S_{in}}q_i,\text{高斯定理, 有源场，通量不等于 }0\\&\oint_l\vec{E}d\vec{l}=0,\text{无旋场，闭合环路积分等于 }0\end{aligned}\tag{3.1}$$

定义电势：$U_p=\int_p^\infty\vec{E}\cdot d\vec{l}$

场强和电势都可叠加，即 $\vec{E}=\int d\vec{E},U=\int dU$

电场线和等势面的关系：处处正交，$\vec{E}$ 指向 U 减小的方向，两者的关系：$\vec{E}=-\nabla U=-(\frac{\partial U}{\partial x},\frac{\partial U}{\partial y},\frac{\partial U}{\partial z})$

小结：

$$\text{计算场强的 3 种方法：}\begin{cases}\oiint_S \vec{E}d\vec{s}=\dfrac{1}{\varepsilon}\sum\limits_{S_{in}}q_i\\ \boldsymbol{E}=\displaystyle\int d\boldsymbol{E}=\frac{1}{4\pi\varepsilon_0}\int\frac{\hat{\boldsymbol{r}}}{r^2}dq\\ \vec{E}=-\nabla U=-(\dfrac{\partial U}{\partial x},\dfrac{\partial U}{\partial y},\dfrac{\partial U}{\partial z})\end{cases} \tag{3.2}$$

$$\text{计算电势的 2 种方法：}\begin{cases}U_p=\displaystyle\int_p^{\infty}\vec{E}\cdot d\vec{l}\\ U=\displaystyle\int dU=\frac{1}{4\pi\varepsilon_0}\int\frac{dq}{r}\end{cases} \tag{3.3}$$

3.2.1.3 导体和电容

场与物质的相互作用。导体和绝缘体解释，提出自由电荷、束缚（极化）电荷。

Chapter 4 Quantum