

# 《经典力学》

## 图书基本信息

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# 《经典力学》

## 前言

The first edition of this text appeared in 1950, and it was so well received that it went through a second printing the very next year. Throughout the next three decades it maintained its position as the acknowledged standard text for the introductory Classical Mechanics course in graduate level physics curricula throughout the United States, and in many other countries around the world. Some major institutions also used it for senior level undergraduate Mechanics. Thirty years later, in 1980, a second edition appeared which was "a through-going revision of the first edition." The preface to the second edition contains the following statement: "I have tried to retain, as much as possible, the advantages of the first edition while taking into account the developments of the subject itself, its position in the curriculum, and its applications to other fields." This is the philosophy which has guided the preparation of this third edition twenty more years later. The second edition introduced one additional chapter on Perturbation Theory, and changed the ordering of the chapter on Small Oscillations. In addition it added a significant amount of new material which increased the number of pages by about 68%. This third edition adds still one more new chapter on Nonlinear Dynamics or Chaos, but counterbalances this by reducing the amount of material in several of the other chapters, by shortening the space allocated to appendices, by considerably reducing the bibliography, and by omitting the long lists of symbols. Thus the third edition is comparable in size to the second.

# 《经典力学》

## 内容概要

《经典力学(第3版·影印版)》是一本有着很高知名度的经典力学教材，长期以来被世界上多所大学选用。本影印版是2002年出版的第3版。与前两版相比，第3版在保留基本经典力学内容的基础上，做了不少调整。例如，增加了混沌一章；引入了一些对新研究问题的方法的讨论，例如张量、群论的等；对于第二版中的一些内容做了适当的压缩和调整。

全书共13章，可作为为物理类专业经典力学课程的教材，尤其适合开展双语教学的学校，对于有志出国深造的人员也是一本必不可少的参考书。

# 《经典力学》

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## 章节摘录

插图：Suppose a charged particle drifts in the direction of increasing  $B$ ; by Eq. (12.117), the kinetic energy of rotation increases. As the total kinetic energy is conserved, the kinetic energy of longitudinal drift, along the lines of force must decrease. Eventually, the drift velocity goes to zero and the motion reverses in direction. If it can be arranged that  $B$  eventually increases in the other direction, the charged particle will remain confined, drifting back and forth between the two ends—the principle of the so-called mirror confinement. The mirror principle is used to contain hot plasmas for thermonuclear energy generation. The complete story is of course more complicated, but the significance of the adiabatic invariance of  $M$  is clearly demonstrated. We have seen that almost all phenomena of small oscillations about steady state or steady motion can be described in terms of harmonic oscillators. In consequence, there is a good deal of practical interest in questions of the invariance of  $J$  for a harmonic oscillator under slow, and not so slow, variations of a parameter. The study of oscillations in charged particle accelerators, for example, has led to a number of new insights. It has been possible to sketch here only the highlights of the subject of adiabatic invariants. The ramifications of the field go into many areas of classical and quantum physics and of mathematics.



# 《经典力学》

## 编辑推荐

《经典力学(第3版·影印版)》：海外优秀理科类系列教材

# 《经典力学》

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## 章节试读

### 1、《经典力学》的笔记-新的力

#### 与引力同时存在的力——自身力

##### 引言

物体在外力作用下运动形式发生变化，根据《功能原理》能量不增加也不减少。可是物体在本身力的作用下能量发生变化；变化的原因在“斜面与杠杆的统一”，即一个斜面不仅起着斜面的作用，同时还起着杠杆的作用。

摘要：根据《功能原理》可知，当物体沿斜面向上运动时需要外力做功。本文探讨的是当“斜面与杠杆统一”时物体沿斜面向上运动就不需要外力了。斜面与杠杆的统一指的是：斜面有杠杆的功能，杠杆有斜面的作用。物体在这样的斜面上（杠杆）产生的正压力通过杠杆（斜面）变成对物体本身向上的牵引力。根据杠杆原理，物体在斜面上得到的牵引力随着杠长度增加而增大。通过推理，可得，在这样的机械上物体能够沿斜面向上运动。强调一下，“自身力”是物体在斜面上本身产生的，不是外力，在这里找不到用《功能原理》衡量的地方。

关键词：1机械结构；2自身力的存在；3上升高度。

##### 1机械结构

1.1对图1说明：1是杠杆支点，2是杠杆同时也是斜面（下同）。3是重物。4是绳子。5是定滑轮。6是平衡物，它的作用是杠杆没有放重物时，使杠杆保持平衡状态。

1.2对图2说明：圆O1的半径为R，半径为r的小齿轮与圆O1在同一个圆心上，且固定在一起。大齿轮O2半径为R，L是固定在大齿轮O2圆心上的杠杆（同时也是斜面，下同）。物体M在杠杆L上，D点在圆O1圆周上，C点在物体M上，DC是绳子且过A、B二个定滑轮。G是重物，它的作用是使杠L在没有物体时始终保持平衡状态。7是弹簧秤。

##### 2齿轮半径比

2.1为了实验方便，做实验时杠杆长要适当。大齿轮半径是小齿轮半径的5到10倍(若大于100倍时物体沿斜面向上运动)。

2.2计算时两个齿轮的半径比是 $r : R = 1 : x$ ，其中 $x > 1000$ ，当“ $x < 100$ ”时同样可行，最小值是多少可以确定。X取1000为下面证明方便。

2.3制作机械时半径比大于100较好。

##### 3实验

3.1对图1做实验：把重物放在杠杆上，看到重物及杠杆同时沿顺时针转动，B点的绳子向下运动。

3.2对图2做实验：

3.21若半径比值小于10倍时：把物体M放在杠杆上，看到弹簧秤读数发生变化，杠杆轻微沿逆时针转动，重物M沿杠杆向下滑动。

3.22若半径比值大于100时物体沿斜面向上运动。

4实验得出的结论：

4.1对图1做实验时没有外力影响，只是物体本身的质量对杠杆一端产生作用，所以杠沿顺时针转动。

4.2 实验2.21时弹簧秤读数发生变化，说明绳子对弹簧秤施加了力，这个力是物体M与圆O1同时给的。根据作用力与反作用力关系，物体M在斜面上得到一个向上的牵引力，这个实验没有外力，根据机械结构可知，这个力是由物体在斜面上的正压力提供的。

4.3实验2.21时杠沿逆时针转动，物体M在杠上向下滑动，说明杠最下端得到一个力（否则杠沿顺时针转动），这个实验没有外力，根据机械结构可知这个力是由斜面上物体M提供的。根据作用力与反作用力关系可知：物体M在斜面上得到一个向上的牵引力，这个力是由正压力提供的。

4.4对图1做实验为了衬托对图2的实验，显示斜面与杠统一的特殊性。

##### 5自身力的定义

物体在斜面上产生的正压力，通过机械装置转变成对物体本身向上的牵引力，向上的牵引力是物体本

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身产生的，把物体对本身产生的向上的牵引力叫自身力。

## 6自身力的大小

物体M在图2的杠杆上运动，阻力、下滑力（重力的分力，下同）、正压力都是定值。根据杠杆原理杠杆越长在绳子DC得到的力就越大，物体M得到的向上的牵引力就越大。所以自身力的大小是由杠杆长度确定的，与杠杆长度成正比（自身力不等于正压力）。

7临界点：物体M在斜面上的下滑力与阻力之和等于自身力时所在那点位置叫临界点。

7.1力的传输过程：用这个机械装置，物体M在斜面上产生的正压力通过杠杆L 齿轮 绳子CD 转到物体M上。物体M得到一个沿斜面向上的牵引力。

7.2绳子CD得到的力：杠杠初始时与水平面成的角度为  $\alpha$ 。物体M在杠杠L上产生的正压力F， $F = Mg\cos\alpha$ 。物体M在斜面上与O2的距离为S。根据杠杠原理，绳子CD得到的力f， $f = FScos\alpha / R = SMgcos^2\alpha / R$ 。

7.3物体沿斜面向上运动时受到的阻力：

物体向上运动时受到的阻力有摩擦力和下滑力。

7.4摩擦力：本机械装置由2个齿轮、2个定滑轮、物体在斜面上用到的4个轮子和绳子组成的摩擦力，显然摩擦系数合小于十分之一，即产生的摩擦力N1， $N1 < Mg/10$ ，取 $N1 = Mg/10$

7.5 下滑力：物体的下滑力N2， $N2 = Mgsin\alpha$ ，（ $\alpha$  的值在一定范围内，若接近90度没有意义。 $\alpha$  的取值在后文探讨）

7.6 阻力N： $N = N1 + N2 = Mg/10 + Mgsin\alpha < Mg$ ，取 $N = Mg$

7.7临界点的位置：这点位置与O2距离为S，根据杠杠原理有 $FScos\alpha = RN$ ， $MgScos^2\alpha = RMg$ ， $S = R/cos^2\alpha$ 。

## 8自身力的作用

由于自身力的作用，杠杠与平面在一定角度范围内物体M能够沿斜面向上运动，且高度增加。

### 8.1物体能够沿斜面向上运动

物体在斜面上首先在临界点位置，接着才能沿斜面向上运动

当圆O2(也是杠杠)沿顺时针转动  $\alpha$  度时，临界点转动的弧长L1， $L1 = 2 S / 360$ 。这时D点在圆周上转动的方向是逆时针，转动弧长（也是物体沿斜面向上运动的长度）L2， $L2 = 2 Rx / 360$ ，所以 $L2 - L1 = 2 Rx / 360 - 2 S / 360 = 2 Rx / 360 - 2 R / 360cos^2\alpha = 2 R (xcos^2\alpha - 1) / 360 cos^2\alpha$

当  $\alpha$  在一定值域内（ $L2 - L1 > 0$ ），如当 $10^\circ < \alpha < 45^\circ$ ， $0^\circ < \alpha < 10^\circ$ ，时（ $L2 - L1 > 0$ ）。说明这时物体M沿斜面向上运动的长度大于临界点应转动的弧长，物体能够沿斜面向上运动。

### 8.2物体沿斜面向上运动时高度增加

杠杠转动前物体所在垂直高度H1， $H1 = Ssin\alpha$ ，杠杠沿顺时针转动  $\alpha$  度后，物体M在杠杠上与O2的距离约等于(S + L2)。这时物体所在垂直高度H2， $H2 = (S + L2)sin(\alpha - \alpha)$ ，向上运动后增加高度H， $H = H2 - H1 = (S + L2)sin(\alpha - \alpha) - Ssin\alpha$ ，当 $\alpha > 10^\circ$ 时， $\alpha - \alpha > 0$ ，在某一个值域范围内 $H > 0$ ，如当 $10^\circ < \alpha < 45^\circ$ ， $0^\circ < \alpha < 10^\circ$ 时 $H > 0$ 。所以当圆O2沿顺时针转动  $\alpha$  度时物体高度增加，增加高度是H

8.3当杠杠沿逆时针转动  $\alpha$  度时同理可证。

## 9结论

通过以上实验得出存在“自身力”，而且随着杠杠长度的增加自身力同时增大。通过证明得出在自身力的作用下，物体能够沿杠杠向上运动，这样自身力可以应用。

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