



HEP World's Classics

**Dialogues Concerning  
Two New Sciences**

**关于两门新科学的对话**

GALILEO GALILEI

TRANSLATED BY

HENRY CREW AND ALFONSO DE SALVIO



HIGHER EDUCATION PRESS

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## 内容简介

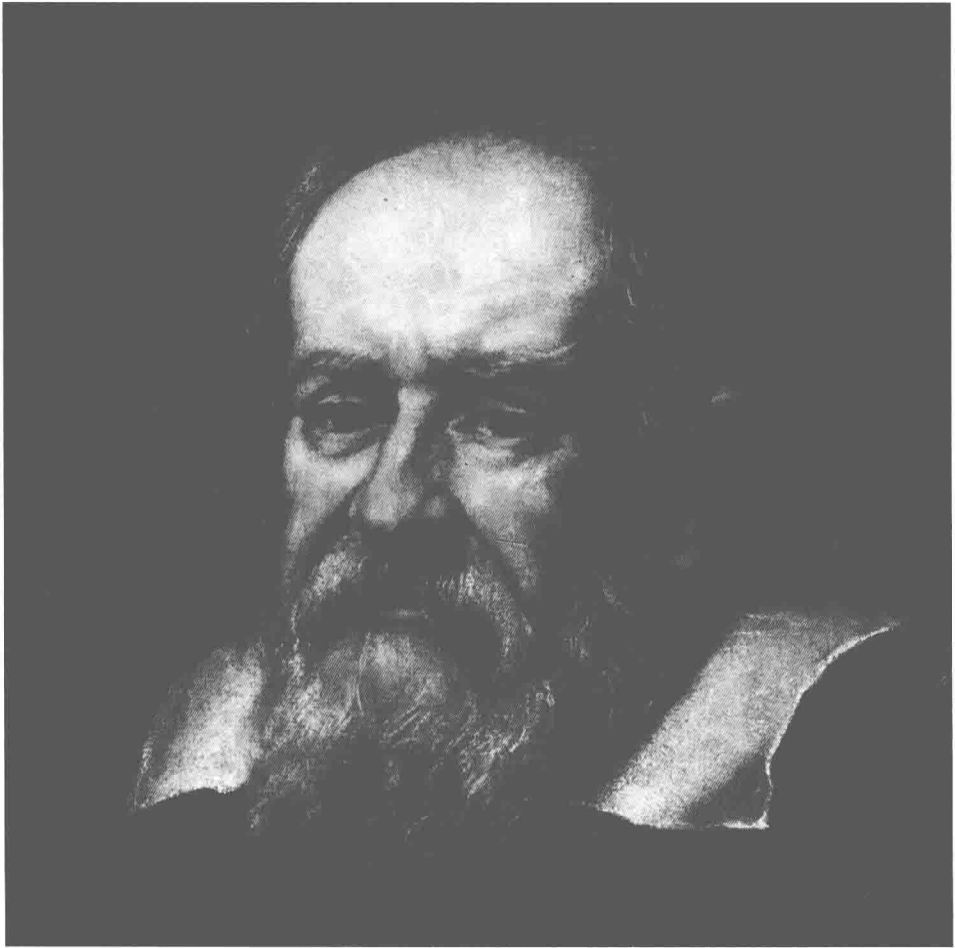
本书所说的两门新科学是指材料力学和动力学。这部书稿在 1636 年就已完成, 由于教会禁止出版伽利略的任何著作, 伽利略只好托一位威尼斯友人秘密携出境外, 1638 年在荷兰莱顿出版。本书是伽利略积数十年之力写成的, 以对话的形式总结了他在材料强度和动力学方面的研究成果, 以及他对力学原理的思考。本书是伽利略最重要的科学论著之一, 也是物理学、力学、数学和哲学方面重要的经典文献, 虽然从出版到现在已有 370 多年的历史, 但读起来仍然令人收获很多。

在科学技术高速发展的今天, 研究分工越来越细, 人们所掌握的知识领域越来越狭窄。当我们重新研读古代大师们的著作时, 大师们的思想常常会启发我们, 使我们跳出分工的狭小圈子, 从更广的角度思考问题, 推动我们的研究。为了追寻力学的早期发展, 作为对力学史有兴趣的学者, 特别是高等学校讲授理论力学和材料力学课程的教师们, 如果他们要了解这两门学科的最早历史、以人类探求真理的艰辛历程去感染学生的话, 伽利略的这本书是不可不读的。书中提出的新概念和新思想, 对后来的科学发展产生了深刻的影响。它可以使我们理解伽利略对科学的贡献以及伽利略时代人们对力学问题的理解。

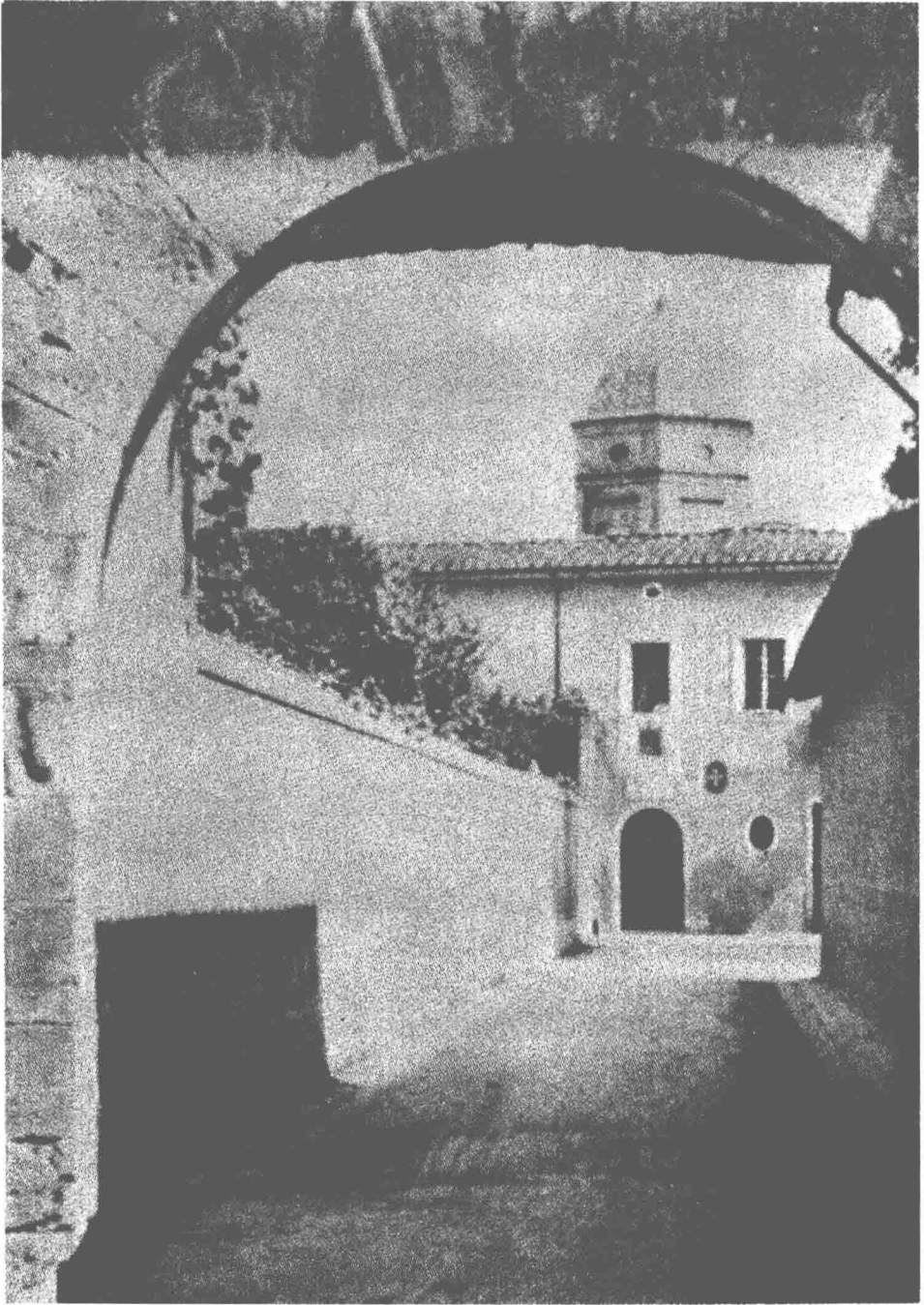
从近代科学的发展水平来看, 不可否认, 伽利略的这本著作中还存在许多错误。不过, 和历史上的许多伟大的发现一样, 在一开始总是在正确的认识中夹杂着许多错误的认识。这大概是科学发展的一般规律。在伽利略所处的时代, 我们可以说, 他是一位在荒野中开辟道路的勇士, 走一些弯路、犯一些错误完全不足为怪且难以避免。这丝毫不损害伽利略在科学史上的伟大形象。

本书可以作为高等学校理工科以及师范院校有关专业师生的教学参考书; 对于从事物理学、力学、天文学、哲学和科学史研究的工作者, 以及对相关论题有兴趣的读者, 是一本具有指导意义的参考书。另外, 从现代科学发展的水平来看, 本书也可作为一本学习物理学、力学和现代科学方法论的启蒙读物, 对具有高中文化水平以上的读者是一本极好的课外阅读书籍。

本书根据 1914 年英译本重排。



伽利略 (Galileo Galilei, 1564.02.15—1642.01.08)



*Galileo's birthplace in Pisa*

**伽利略 (Galileo Galilei, 1564.02.15—1642.01.08)**, 意大利物理学家、天文学家, 近代实验科学的奠基者之一。生于比萨, 卒于阿切特里。

伽利略出身于没落的贵族家庭, 1572 年开始上学。1575 年随全家迁居佛罗伦萨, 进入修道院学习。1581 年他遵父命进比萨大学学医, 但他感兴趣的是数学、物理学和仪器制造。1585 年因家贫退学, 担任家庭教师, 仍奋力自学, 并作出研究成果。1589 年比萨大学聘请他讲授几何学和天文学。1591 年父亲病逝, 他迫于家庭经济负担到威尼斯的帕多瓦大学任教。1609 年回佛罗伦萨。1611 年到罗马并担任林嗣科学院的院士。1633 年以“反对教皇、宣扬邪学”被罗马宗教裁判所判处终生监禁。1638 年以后, 双目逐渐失明, 晚景凄凉。

伽利略的科学成就可分为下列四个方面。

**新的科学思想和科学研究方法** 在伽利略的研究成果得到公认之前, 物理学以至整个自然科学只不过是哲学的一个分支, 没有取得自己的独立地位。当时, 哲学家们被束缚在神学和亚里士多德教条的框框里, 他们苦思巧辩, 得不出符合实际的客观规律。伽利略敢于向传统的权威思想挑战, 不是先臆测事物发生的原因, 而是先观察自然现象, 由此发现自然规律。基于这样的新的科学思想, 伽利略倡导了数学与实验相结合的研究方法。这种研究方法是他在科学上取得伟大成就的源泉, 也是他对近代科学的最重要的贡献。

**物理学** 伽利略是历史上最早对动力学作了定量研究的人。1589—1591 年, 他对物体的自由下落运动作了细致的观察, 从实验和理论上否定了统治近 2000 年的亚里士多德的落体运动观点。伽利略还对物体在斜面上的运动、抛射体的运动等作过实验和观察。在这些研究基础上他提出了加速度的概念及其数学表达式。他曾非正式地提出惯性定律和物体在外力作用下运动的规律, 提出运动相对性原理。这些为牛顿正式提出运动第一、第二定律奠定了基础。在经典力学的建立上伽利略可说是牛顿的先驱。伽利略对摆的运动作过长期的观察和研究, 指出单摆的周期和摆长度的平方根成反比。伽利略还研究了梁的抗弯曲能力和梁尺寸的关系。伽利略在被监禁期间把他在力学方面的成就用三人谈话的形式写成《关于两门新科学的对话》。

**天文学** 伽利略在知道荷兰人已有望远镜后, 亲手制造和改进了望远镜, 并用来巡视天空, 发现许多前所未有的天文现象。他发现所见恒星的数目随着望远镜倍率的增大而增加; 银河是由无数单个的恒星组成的; 月球表面有崎岖不平的现象, 金星也有圆缺的变化; 木星有 4 个卫星 (其实是众多木卫中最大的 4 个)。他还发现太阳黑子, 并且认为黑子是日面上的现象。由黑子在日面上的自转周期, 他得出太阳的自转周期为 28 天 (实际上是 27.35 天)。1637 年在目力很差的情况下, 他还发现了月亮的周日和周月天平动。这一系列的发现轰动了当时的欧洲, 有力地支持了哥白尼的日心体系说。1613 年, 哥白尼的《天体运行

论》被宗教法庭列为禁书，伽利略也受到警告，要他放弃哥白尼学说。伽利略没有接受警告，继续写作，1632年他的另一部著作《关于托勒密和哥白尼两大世界体系的对话》出版。宗教法庭宣判他有罪，禁止此书流传。1633年他被判处终生监禁。

**实验科学** 无论是在动力学、梁的弯曲，还是在天文学的研究中，伽利略都十分重视观察和实验的作用。他善于在观察结果的基础上提出假设，运用数学工具进行演绎推理，看是否符合实验或观察结果。实验和观察要精确，就离不开测量仪器。伽利略往往亲自设计制造仪器。除了上述望远镜外，他设计和制造的仪器还有流体静力称、比例规、温度计、摆式脉搏计等。

伽利略在人类思想解放和文明发展的过程中作出了划时代的贡献。在当时的社会条件下，为争取不受权势和旧传统压制的学术自由，为近代科学的建立，他进行了坚持不懈的斗争，并向全世界发出了振聋发聩的声音。因此，他是科学革命的先驱，也可以说是“近代科学之父”。爱因斯坦曾这样评价：“伽利略的发现，以及他所用的科学推理方法，是人类思想史上最伟大的成就之一，而且标志着物理学的真正的开端！”虽然他晚年被剥夺了人身自由，但他开创新科学的意志并未动摇。他追求科学真理的精神永远为后代所景仰。

摘自《中国大百科全书（第二版）》



## HEP World's Classics

There is a Chinese saying: "It is beneficial to open any book." It is even more fruitful to open and read classic books. The world is keeping on changing, but really fundamental and essential things stay the same since there is nothing new under the sun. Great ideas have been discovered and re-discovered, and they should be learnt and re-learnt. Classic books are our inheritance from all the previous generations and contain the best of knowledge and wisdom of all the people before us. They are timeless and universal. We cannot travel back in time, but we can converse with the originators of current theories through reading their books. Classic books have withstood the test of time. They are reliable and contain a wealth of original ideas. More importantly, they are also books which have not finished what they wanted or hoped to say. Consequently, they contain unearthed treasures and hidden seeds of new theories, which are waiting to be discovered. As it is often said: history is today. Proper understanding of the past work of giants is necessary to carry out properly the current and future researches and to make them to be a part of the history of science and mathematics. Reading classic books is not easy, but it is rewarding. Some modern interpretations and beautiful reformulations of the classics often miss the subtle and crucial points. Reading classics is also more than only accumulating knowledge, and the reader can learn from masters on how they asked questions, how they struggled to come up with new notions and theories to overcome problems, and answers to questions. Above all, probably the best reason to open classic books is the curiosity: what did people know, how did they express and communicate them, why did they do what they did? It can simply be fun!

This series of classic books by Higher Education Press contains a selection of best classic books in natural history, mathematics, physics, chemistry, information technology, geography, etc. from the past two thousand years. They contain masterpieces by the great people such Archimedes, Newton, Lavoisier, Dalton, Gauss, Darwin, Maxwell, and hence give a panorama of science and mathematics. They

have been typeset in modern fonts for easier and more enjoyable reading. To help the reader understand difficult classics better, some volumes contain introductions and commentaries by experts. Though each classic book can stand in its own, reading them together will help the reader gain a bigger perspective of science and mathematics and understand better interconnection between seemingly unrelated topics and subjects.

Higher Education Press has been the largest publisher in China. Besides the long tradition of providing high quality books for proper education and training of university and graduate students, she has also set out to provide research monographs and references books to people at all levels around the world. Higher Education Press considers it her duty to keep the world science and mathematics community informed of what has been achieved in their subjects in easy and accessible formats. This series of classic books is an integral part of this effort.



“La Dynamique est la science des forces accélératrices or retardatrices, et des mouvemens variés qu’elles doivent produire. Cette science est due entièrement aux modernes, et Galilée est celui qui en a jeté les premiers fondemens.” Lagrange *Mec. Anal.* I. 221.

## TRANSLATORS’ PREFACE

[v]



OR more than a century English speaking students have been placed in the anomalous position of hearing Galileo constantly referred to as the founder of modern physical science, without having any chance to read, in their own language, what Galileo himself has to say. Archimedes has been made available by Heath; Huygens’ *Light* has been turned into English by Thompson, while Motte has put the *Principia* of Newton back into the language in which it was conceived. To render the Physics of Galileo also accessible to English and American students is the purpose of the following translation.

The last of the great creators of the Renaissance was not a prophet without honor in his own time; for it was only one group of his country-men that failed to appreciate him. Even during his life time, his *Mechanics* had been rendered into French by one of the leading physicists of the world, Mersenne.

Within twenty-five years after the death of Galileo, his *Dialogues on Astronomy*, and those on *Two New Sciences*, had been done into English by Thomas Salusbury and were worthily printed in two handsome quarto volumes. The *Two New Sciences*, which contains practically all that Galileo has to say on the subject of physics, issued from the English press in 1665. It is supposed that most of the copies were destroyed in the great London fire which occurred in the year following. We are not aware of any copy in America: even that belonging to the

[vi]

British Museum is an imperfect one.

Again in 1730 the *Two New Sciences* was done into English by Thomas Weston; but this book, now nearly two centuries old, is scarce and expensive. Moreover, the literalness with which this translation was made renders many passages either ambiguous or unintelligible to the modern reader. Other than these two, no English version has been made.

Quite recently an eminent Italian scholar, after spending thirty of the best years of his life upon the subject, has brought to completion the great National Edition of the Works of Galileo. We refer to the twenty superb volumes in which Professor Antonio Favaro of Padua has given a definitive presentation of the labors of the man who created the modern science of physics.

The following rendition includes neither *Le Meccaniche* of Galileo nor his paper *De Motu Accelerato*, since the former of these contains little but the Statics which was current before the time of Galileo, and the latter is essentially included in the Dialogue of the Third Day. Dynamics was the one subject to which under various forms, such as Ballistics, Acoustics, Astronomy, he consistently and persistently devoted his whole life. Into the one volume here translated he seems to have gathered, during his last years, practically all that is of value either to the engineer or the physicist. The historian, the philosopher, and the astronomer will find the other volumes replete with interesting material.

It is hardly necessary to add that we have strictly followed the text of the National Edition—essentially the Elzevir edition of 1638. All comments and annotations have been omitted save here and there a foot-note intended to economize the reader's time. To each of these footnotes has been attached the signature [*Trans.*] in order to preserve the original as nearly intact as possible.

[vii]

Much of the value of any historical document lies in the language employed, and this is doubly true when one attempts to trace the rise and growth of any set of concepts such as those employed in modern physics. We have therefore made this translation as literal as is consistent with clearness and modernity. In cases where there is any important deviation from this rule, and in the case of many technical terms where there is no deviation from it, we have given the original Italian or Latin phrase in italics enclosed in square brackets. The intention here is to illustrate the great variety of terms employed by the early physicists to describe a single definite idea, and conversely, to illustrate the numerous senses in which, then as now, a single word is used. For the few explanatory English words which

are placed in square brackets without italics, the translators alone are responsible. The paging of the National Edition is indicated in square brackets inserted along the median line of the page.

The imperfections of the following pages would have been many more but for the aid of three of our colleagues. Professor D. R. Curtiss was kind enough to assist in the translation of those pages which discuss the nature of Infinity; Professor O. H. Basquin gave valuable help in the rendition of the chapter on Strength of Materials; and Professor O. F. Long cleared up the meaning of a number of Latin phrases.

To Professor A. Favaro of the University of Padua the translators share, with every reader, a feeling of sincere obligation for his Introduction.

H. C.  
A. DE S.

EVANSTON ILLINOIS,  
15 *February*, 1914.





## INTRODUCTION

[ix]



WRITING to his faithful friend Elia Diodati, Galileo speaks of the “New Sciences” which he had in mind to print as being “superior to everything else of mine hitherto published”; elsewhere he says “they contain results which I consider the most important of all my studies”; and this opinion which he expressed concerning his own work has been confirmed by posterity: the “New Sciences” are, indeed, the masterpiece of Galileo who at the time when he made the above remarks had spent upon them more than thirty laborious years.

One who wishes to trace the history of this remarkable work will find that the great philosopher laid its foundations during the eighteen best years of his life—those which he spent at Padua. As we learn from his last scholar, Vincenzo Viviani, the numerous results at which Galileo had arrived while in this city, awakened intense admiration in the friends who had witnessed various experiments by means of which he was accustomed to investigate interesting questions in physics. Fra Paolo Sarpi exclaimed: To give us the Science of Motion, God and Nature have joined hands and created the intellect of Galileo. And when the “New Sciences” came from the press one of his foremost pupils, Paolo Aproino, wrote that the volume contained much which he had “already heard from his own lips” during student days at Padua.

Limiting ourselves to only the more important documents which might be cited in support of our statement, it will suffice to mention the letter, written to Guidobaldo del Monte on the 29th of November, 1602, concerning the descent of heavy bodies along the arcs of circles and the chords subtended by them; that to Sarpi, dated 16th of October, 1604, dealing with the free fall of heavy bodies; the letter to Antonio de’ Medici on the 11th of February, 1609, in which he states

[x]

that he has "completed all the theorems and demonstrations pertaining to forces and resistances of beams of various lengths, thicknesses and shapes, proving that they are weaker at the middle than near the ends, that they can carry a greater load when that load is distributed throughout the length of the beam than when concentrated at one point, demonstrating also what shape should be given to a beam in order that it may have the same bending strength at every point," and that he was now engaged "upon some questions dealing with the motion of projectiles"; and finally in the letter to Belisario Vinta, dated 7th of May, 1610, concerning his return from Padua to Florence, he enumerates various pieces of work which were still to be completed, mentioning explicitly three books on an entirely new science dealing with the theory of motion. Although at various times after the return to his native state he devoted considerable thought to the work which, even at that date, he had in mind as is shown by certain fragments which clearly belong to different periods of his life and which have for the first time, been published in the National Edition; and although these studies were always uppermost in his thought it does not appear that he gave himself seriously to them until after the publication of the *Dialogue* and the completion of that trial which was rightly described as the disgrace of the century. In fact as late as October, 1630, he barely mentions to Aggiunti his discoveries in the theory of motion, and only two years later, in a letter to Marsili concerning the motion of projectiles, he hints at a book nearly ready for publication in which he will treat also of this subject; and only a year after this he writes to Arrighetti that he has in hand a treatise on the resistance of solids.

[xi] But the work was given definite form by Galileo during his enforced residence at Siena: in these five months spent quietly with the Archbishop he himself writes that he has completed "a treatise on a new branch of mechanics full of interesting and useful ideas"; so that a few months later he was able to send word to Micanzio that the "work was ready"; as soon as his friends learned of this, they urged its publication. It was, however, no easy matter to print the work of a man already condemned by the Holy Office: and since Galileo could not hope to print it either in Florence or in Rome, he turned to the faithful Micanzio asking him to find out whether this would be possible in Venice, from whence he had received offers to print the *Dialogue on the Principal Systems*, as soon as the news had reached there that he was encountering difficulties. At first everything went smoothly; so that Galileo commenced sending to Micanzio some of the manuscript which

was received by the latter with an enthusiasm in which he was second to none of the warmest admirers of the great philosopher. But when Micanzio consulted the Inquisitor, he received the answer that there was an express order prohibiting the printing or reprinting of any work of Galileo, either in Venice or in any other place, *nullo excepto*.

As soon as Galileo received this discouraging news he began to look with more favor upon offers which had come to him from Germany where his friend, and perhaps also his scholar, Giovanni Battista Pieroni, was in the service of the Emperor, as military engineer; consequently Galileo gave to Prince Mattia de' Medici who was just leaving for Germany the first two Dialogues to be handed to Pieroni who was undecided whether to publish them at Vienna or Prague or at some place in Moravia; in the meantime, however, he had obtained permission to print both at Vienna and at Olmütz. But Galileo recognized danger at every point within reach of the long arm of the Court of Rome; hence, availing himself of the opportunity offered by the arrival of Louis Elzevir in Italy in 1636, also of the friendship between the latter and Micanzio, not to mention a visit at Arcetri, he decided to abandon all other plans and entrust to the Dutch publisher the printing of his new work the manuscript of which, although not complete, Elzevir took with him on his return home.

In the course of the year 1637, the printing was finished, and at the beginning of the following year there was lacking only the index, the title-page and the dedication. This last had, through the good offices of Diodati, been offered to the Count of Noailles, a former scholar of Galileo at Padua, and since 1634 ambassador of France at Rome, a man who did much to alleviate the distressing consequences of the celebrated trial; and the offer was gratefully accepted. The phrasing of the dedication deserves brief comment. Since Galileo was aware, on the one hand, of the prohibition against the printing of his works and since, on the other hand, he did not wish to irritate the Court of Rome from whose hands he was always hoping for complete freedom, he pretends in the dedicatory letter (where, probably through excess of caution, he gives only main outlines) that he had nothing to do with the printing of his book, asserting that he will never again publish any of his researches, and will at most distribute here and there a manuscript copy. He even expresses great surprise that his new Dialogues have fallen into the hands of the Elzevirs and were soon to be published; so that, having been asked to write a dedication, he could think of no man more worthy who could also on this occasion



defend him against his enemies.

As to the title which reads: *Discourses and Mathematical Demonstrations concerning Two New Sciences pertaining to Mechanics and Local Motions*, this only is known, namely, that the title is not the one which Galileo had devised and suggested; in fact he protested against the publishers taking the liberty of changing it and substituting “a low and common title for the noble and dignified one carried upon the title-page.”

In reprinting this work in the National Edition, I have followed the Leyden text of 1638 faithfully but not slavishly, because I wished to utilize the large amount of manuscript material which has come down to us, for the purpose of correcting a considerable number of errors in this first edition, and also for the sake of inserting certain additions desired by the author himself. In the Leyden Edition, the four Dialogues are followed by an “*Appendix containing some theorems and their proofs, dealing with centers of gravity of solid bodies, written by the same Author at an earlier date,*” which has no immediate connection with the subjects treated in the Dialogues; these theorems were found by Galileo, as he tells us, “at the age of twenty-two and after two years study of geometry” and were here inserted only to save them from oblivion.

[xiii]

But it was not the intention of Galileo that the *Dialogues on the New Sciences* should contain only the four Days and the above-mentioned appendix which constitute the Leyden Edition; while, on the one hand, the Elzevirs were hastening the printing and striving to complete it at the earliest possible date, Galileo, on the other hand, kept on speaking of another Day, besides the four, thus embarrassing and perplexing the printers. From the correspondence which went on between author and publisher, it appears that this Fifth Day was to have treated “of the force of percussion and the use of the catenary”; but as the typographical work approached completion, the printer became anxious for the book to issue from the press without further delay; and thus it came to pass that the *Discorsi e Dimostrazioni* appeared containing only the four Days and the Appendix, in spite of the fact that in April, 1638, Galileo had plunged more deeply than ever “into the profound question of percussion” and “had almost reached a complete solution.”

The “New Sciences” now appear in an edition following the text which I, after the most careful and devoted study, determined upon for the National Edition. It appears also in that language in which, above all others, I have desired to see it. In this translation, the last and ripest work of the great philosopher makes its first