SPECIALITY ENGLISH

物理专业英语

ENGLISH IN PHYSICS

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哈尔滨工业大学出版社

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内 容 提 要

本书为高等院校物理及相关专业英语基础教材，也适用于从事物理方面理论研究的读者参考。本书共设 12 个单元，主要内容涉及：力学、热学、光学、电磁学、近代物理等物理学中的五大部分等具有代表性的内容以及一些经典的科普阅读材料。另外，本书的词汇表中列出了基本专业术语的英文解释，便于读者了解和查阅。

图书在版编目(CIP)数据

物理专业英语/李淑侠主编．—哈尔滨：哈尔滨工业大学出版社，2005.2

ISBN 7-5603-2063-5

Ⅰ．物…　Ⅱ．李…　Ⅲ．物理－英语－高等学校－教材　Ⅳ．H31

中国版本图书馆 CIP 数据核字(2005)第 013685 号

出版发行　哈尔滨工业大学出版社
社　　址　哈尔滨市南岗区复华四道街 10 号　邮编 150006
传　　真　0451-86414749
印　　刷　肇东粮食印刷厂
开　　本　880×1230　1/32　印张 9.375　字数 240 千字
版　　次　2005 年 2 月第 1 版　2005 年 2 月第 1 次印刷
书　　号　ISBN 7-5603-2063-5/O·171
印　　数　1~5 000
定　　价　15.00 元

前　　言

物理专业英语是为提高物理学专业学生专业英文文献的读写能力而开设的必修课，是大学英语学习的重要环节。通过本课程的学习，可以进一步增加学生对专业英语词汇、语法和结构的了解，为拓宽专业知识面并从事专业方面英文资料的查阅、翻译和写作打下坚实的基础。

随着物理学相关学科的理论研究及应用技术的发展，各类专业信息的交流日益广泛，这就要求物理专业人员应具备英文文献熟练获取和共享信息资源的能力。

因而，既具有专业特点，又兼顾通用性的专业英语教材就成为必需。本书正是适合这一需要，经黑龙江大学教师总结多年教学经验而编写的。本书具有以下特点：

1.有较强的系统性和完整性，内容编排由浅入深，符合教学规律，且涵盖了物理学科各个部分，使学习物理学知识和掌握专业英语融为一体。

2.信息涵盖面大，既包括物理学基本知识、基本理论，也涉及相关的课外阅读材料和专业英语词汇。

3.突出了适用性和灵活性，学生可结合自身实际，有针对性地选择学习内容。

4.附有单词表，以方便查阅和对照。

本书内容广泛，知识介绍循序渐进，涵盖了物理学的多个领域，既可作为高等院校物理学各专业本、专科学生的专业英语教

材,也可作为物理学领域广大研究人员英语学习的参考书。

书中部分材料参考了一些国外文献,并由作者进行了修改和整理,因篇幅有限,无法一一注释说明,在此一并向原文作者表示谢意!

本书是为解决教学之急需编写的,限于编者水平,尽管做了最大努力,但书中仍难免有疏漏和其他不妥之处,恳请读者提出宝贵意见,以便完善。

编　者

2005 年 1 月

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PART 1
THE PHYSICAL FUNDAMENTALS of MECHANICS

1

Kinematics

MECHANICAL PROLOGUE

Mechanics is the study of the motion of material bodies. Historically, it was one of the earliest exact sciences to be developed. Some mechanical principles were known to Greek scientists in the third century B. C.. The tremendous growth of physics since the 1600's began with the discovery of the laws of mechanics by Galileo and Newton. Early successes were in predicting the motions of the moon, the earth, the planets and their satellites(celestial mechanics).

Now we apply some principles to the motions of artificial satellites such as an orbiting Space Shuttle. In general, the principles of mechanics can be applied to

(a) the motions of celestial objects so as to accurately predict events, in some cases many years before they happen, for example, the return of Halley's comet;

(b) the motions of ordinary objects on Earth, for example, an automobile or a thrown baseball;

(c) the behavior of atoms, atomic particles, and subatomic particles, with considerable success.

The term classical mechanics is generally used to differentiate these principles from those newer physical theories, such as relativistic mechanics and quantum mechanics.

Mechanics greatly influenced the growth of later sciences such as sound and electricity. It may be said that mechanics furnishes the basic concepts of the whole physics, so quite naturally, the study of physics begins here.

1.1 MECHANICAL MOTION

Mechanical motion is the simplest form motion of matter. It consists in the movement of bodies or their parts relative to one another. We can see movements of bodies everywhere in our ordinary life. This is why mechanical notions are so clear. This also explains the fact that mechanics was the first of all the natural sciences to be developed very broadly.

A combination of bodies separated for consideration is called a mechanical system. The bodies to be included in a system depend on the nature of the problem being solved. In a particular case, a system may consist of a single body.

It was indicated above that motion in mechanics is defined as the change in the mutual arrangement of the bodies. If we imagine a separate isolated body in a space where no other bodies are present, then we cannot speak of the motion of the body because there is nothing with respect to which the body could change its position. It thus follows that if we intend to study the motion of a body, then we must indicate with respect to what other bodies the given motion occurs.

Motion occurs both in space and in time (space and time are inalienable forms of existence of matter). Consequently, to describe motion, we must also determine time. We use a timepiece (watch or clock) for this purpose.

A combination of bodies that are stationary relative to one another with respect to which motion is being considered and a timepiece indicating the time forms a reference frame.

The motion of the same body relative to different reference frames may have a different nature. For example, let us imagine a train gaining speed. Suppose that a passenger is walking with a constant velocity along the corridor of one of the cars of the train. The motion of the passenger relative to the car will be uniform, and relative to the Earth's surface it will be accelerated.

To describe the motion of a body means to indicate for every moment of time the position of the body in space and its velocity. To set the state of a mechanical system, we must indicate the positions and the velocities of all the bodies forming the system. A typical problem of mechanics consists in determining the states of a system at all the following moments of time t when we know the state of the system at a certain initial moment to and also the laws governing the motion.

It must be noted that no physical problem can be solved absolutely exactly. An approximate solution is always obtained. The degree of approximation is determined by the nature of the problem and the object to be achieved. In solving a problem approximately, we disregard the factors that are not significant in the given case. For example, we may often disregard the dimensions of the body whose motion is being studied. For instance, it is quite possible to disregard the earth's dimensions when treating its motion about the sun. This allows us to considerably simplify our description of the motion because the earth's position in space can be determined by a single point.

A body whose dimension may be disregarded in the conditions of a given problem is called a **point particle** (or simply a **particle**). Whether or not we may consider a given body as a particle depends not on the dimensions of the body, but on the conditions of the problem. The same body in some cases may be treated as a particle, but in others it must be considered as a extended body.

When speaking about a body as a particle, we disengage ourselves from its dimensions. Another abstraction which we have to do with in mechanics is a perfectly rigid body. Absolutely undeformable bodies do not exist in nature. Any body deforms to a greater or smaller extent, i.e. changes its shape and dimensions, under the action of forces applied to it. The deformations of bodies when considering their movements may often be disregarded, however. If this is done, the body is called perfectly rigid. Thus, a body whose deformations may be disregarded in the conditions of a given problem is called a perfectly rigid, or simply a rigid body.

Any motion of a rigid body can be resolved into two basic kinds of motion translational motion and circular motion.

Translational motion(translation) is defined as motion in which any straight line associated with the moving body remains parallel to itself (Fig.1.1).

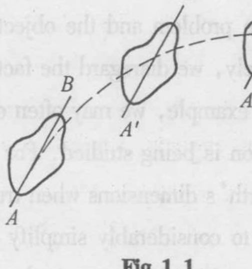

Fig.1.1

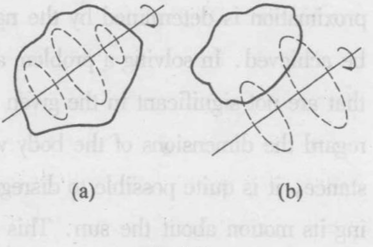

Fig.1.2

In circular motion(rotation), all the points of a body move in circles whose centers are on a single straight line called the axis of rotation(Fig. 1.2). The axis of rotation can be outside a body(Fig. 1.2).

Since when treating a body is a particle we ignore its length, the concept of circular motion about an axis passing through such a body can not be applied to it.

To acquire the possibility of describing motion quantitatively, we have to associate a coordinate system (for example a Cartesian one) with the bodies forming a reference frame. Hence, the position of a particle can be determined by setting the three numbers x, y, and z—the Cartesian coordinates of the particle. A coordinates system can be made by forming a rectangular lattice from identical rods or rules graduated to a definite scale (Fig. 1.3). Identical clocks system can be made by forming a rectangular lattice form identical rods or rules graduated to a definite scale (Fig. 1.3). Identical clocks synchronized with one another must be placed at the lattice points. The position of a particle and the moment of time corresponding to this position are recorded on the graduated rods and the clock closest to the particle.

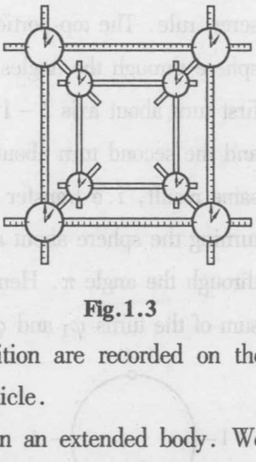

Fig.1.3

It is simpler to treat a point particle than an extended body. We shall therefore first study the mechanics of a particle, and then go over to the mechanics of a rigid body. We shall start with kinematics, and then delve into dynamics. We remind our reader that kinematics studies the motion of bodies without regard to what causes this motion. Dynamics studies the motion of bodies with a view to what causes this motion to have the nature it does, i.e. with a view to the interactions between bodies.

1.2 VECTORS

Vectors are defined as quantities characterized by a numerical value and a direction and, also, as ones that are added according to the triangle or parallelogram method. The last requirement is a very significant one. We can indicate quantities characterized by a numerical value and a sense of direction, but that are added in a different way than vectors. We shall take as an example the rotation of a body about an axis through the finite angle φ. Such rotation can be depicted in the form of a segment of length φ directed along the axis about which rotation is occurring and pointing in a direction associated with what of rotation according to the right-hand screw rule. The top portion of Fig.1.4 shows two consecutive turns of the sphere through the angles $\pi/2$ depicted by the segments φ_1 and φ_2. The first turn about axis 1 – 1 transfers point A of the sphere to position A', and the second turn about axis 2 – 2 transfers it to the position A''. The same result, i.e transfer of point A to position A'', can be achieved by turning the sphere about axis 3 – 3 (see the bottom portion of Fig. 1.4) through the angle π. Hence, such a turn should be considered as the sum of the turns φ_1 and φ_2. It cannot be obtained from the segments and

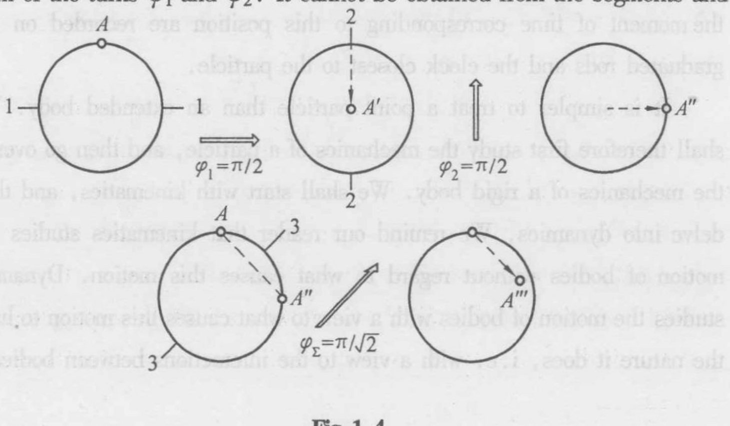

Fig.1.4

however, by adding them according to the parallelogram method. Such addition gives a segment of length $\pi/\sqrt{2}$ instead of the required length π. Rotation through the angle transfers point A to point A'''. It thus follows that the turns through finite angles depicted by the directed segments do not have the properties of vectors.

The numerical value of a vectors is called its magnitude. Figuratively speaking, the magnitude of a vector indicates its length. The magnitude of a vector is a scalar, and always a positive one.

Vectors are represented graphically by arrows. The length of an arrow determines to the established scale the magnitude of the relevant vector, and the arrow points in the direction of the vector.

Vectors are customarily distinguished by setting their symbols in boldface type, for example, $\boldsymbol{a}$, $\boldsymbol{b}$, $\boldsymbol{v}$ and $\boldsymbol{F}$. The same symbols set in italics signify the magnitude of the relevant vectors, for example, a is the magnitude of the vector $\boldsymbol{a}$. It is sometimes necessary to express the magnitude by placing a vertical bar (an absolute value sign) on each side of the symbol for the vector. Thus, $|\boldsymbol{a}|$ is the magnitude of the vector $\boldsymbol{a}$. This representation is used, for example, to show the magnitude of the sum of the vectors $\boldsymbol{a}_1$ and $\boldsymbol{a}_2$:

$$|\boldsymbol{a}_1 + \boldsymbol{a}_2| = \text{magnitude of the vector } (\boldsymbol{a}_1 + \boldsymbol{a}_2) \qquad (1.1)$$

In this case, the notation $\boldsymbol{a}_1 + \boldsymbol{a}_2$ signifies the sum of the magnitudes of the vectors being added, which in general does not equal the magnitude of the sum of vectors (the two sums will be equal only when the vectors being added have the same direction).

Vectors directed along parallel straight lines (in the same or in opposite directions) are called collinear. Vectors in parallel planes are called coplanar.

Collinear vectors can be arranged along the same straight line and coplanar vectors can be brought into one plane by parallel translation. Collinear vectors equal in magnitude and having the same direction are considered to equal each other.

Vectors addition and subtraction. It is more convenient to add vectors in practice without constructing a parallelogram. Examination of Fig. 1.5 shows that we can achieve the same result if we bring the tail of the second vector in contact with the tip of the first one, and then draw the resultant vector from the tail of the first vector to the tip of the second one. It is very good to use this procedure when we have to add more than two vectors (Fig. 1.6).

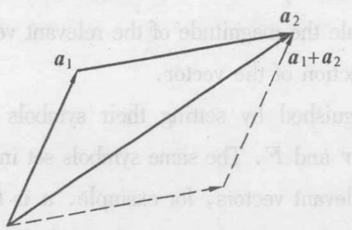

Fig.1.5

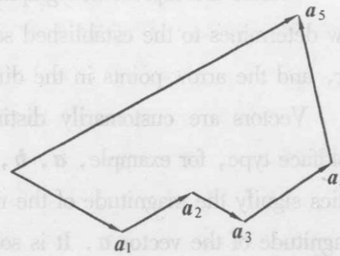

Fig.1.6

The magnitude of the difference of two vector, like the magnitude of a sum [see Eq. 1.1] may be written only with the aid of vertical bars:

$$|\boldsymbol{a}_1 - \boldsymbol{a}_2| = \text{magnitude of the vector } (\boldsymbol{a}_1 - \boldsymbol{a}_2) \qquad (1.2)$$

Because the notation $a_1 - a_2$ signifies the difference of magnitudes of the vectors $\boldsymbol{a}_1$ and $\boldsymbol{a}_2$, which generally speaking does not equal the magnitude of the vector difference.

1.3 VELOCITY AND SPEED

A point particle in motion travels along a certain line. The latter is called its path or trajectory. Depending on the shape of a trajectory, we distinguish rectilinear or straight motion, circular motion, curvilinear motion, etc.

Assume that a point particle (in the following we shall call it simply a particle for brevity's sake) traveled along a certain trajectory from point 1 to 2 (Fig. 1.7). The path between points 1 and 2 measured along the trajectory is called the distance traveled by the particle. We shall denote it by the symbol s.

The straight line between points 1 and 2, i.e. the shortest distance between these points, is called the displacement of the particle. We shall denote it by the symbol $\boldsymbol{r}_{12}$. Let us assume that a particle completes two successive displacements $\boldsymbol{r}_{12}$ and $\boldsymbol{r}_{13}$ (Fig. 1.8). It is natural to call such a displacement $\boldsymbol{r}_{13}$ the sum of the first two that lead to the same result as they do together. Thus, displacement are characterized by magnitude and direction and, besides, are added by using the parallelogram method. Hence, it follows that displacement is a vector.

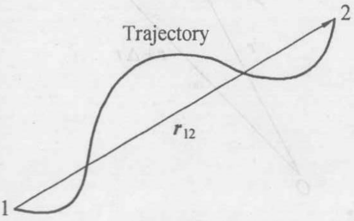

Fig. 1.7

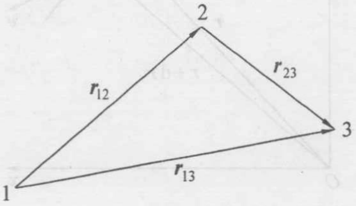

Fig. 1.8

In everyday life, we use the terms speed and velocity interchangeably, but in physics there is an important distinction between them. Speed depends on the distance travelled, and velocity on the displacement. Speed is the distance travelled by a particle in unit time. If a particle travels identical distances during equal time intervals that may be as small as desired, its motion is called uniform. In this case, the speed of the particle at each moment can be calculated by dividing the distance s by the time t.

Velocity is a vector quantity characterizing not only how fast a particle travels along its trajectory, but also the direction in which the particle