

双语教学辅导

物理 · 化学

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内 容 提 要

本丛书是中学双语教学材料,由上海中学双语教材编写组从多种原版教材中精选精编而成。原稿已在上海中学多次试用。考虑到目前双语教学发展的不平衡态势,每个单元由词汇、课文和习题三部分内容组成,以适合初、中、高不同层次的需要。词汇部分概括了本章的要点,课文和习题反映了本章的知识。丛书包括数学、理化和环境科学三册。

丛书的课文全部选自原版教材,内容上不增加新的知识点。表述为典范科技英文,语言规范简洁,为了方便教学,作者根据教学经验对于语言上的难点略作了注释。

本册是理化分册,讲述中学物理的力学、气体分子学和电磁学,化学部分讲述中学化学的基本知识,如物质命名、化学反应的速率与平衡、酸和碱、氧化与还原等。

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Contents

Part I Physics	1
Ch. 1 Forces and Motion	3
Glossary	3
§ 1 Acceleration	5
§ 2 First Law of Motion	6
Ch. 2 Two Dimensional Motion	11
Glossary	11
§ 1 Range of a Projectile	13
§ 2 Description of Circular Motion	15
Ch. 3 Momentum	19
Glossary	19
§ 1 Impulse	20
§ 2 Conservation of Momentum	22
Ch. 4 Work and Energy	28
Glossary	28
§ 1 Work	30
§ 2 Kinetic Energy	31
Ch. 5 Properties of Gases	36
Glossary	36
§ 1 Boyle's Law	37
§ 2 Charles' Law	38
§ 3 General Gas Law	40
Ch. 6 Coulomb's Law and Electric Fields	43
Glossary	43
§ 1 Coulomb's Law	45
§ 2 Electric Fields	47
§ 3 Fields of Force Between Two Charged Bodies	53
Ch. 7 Electric Current and Resistance	58
Glossary	58
§ 1 Current and Drift Velocity	60
§ 2 Ohm's Law and Resistance	62
Ch. 8 Magnetism and Magnetic Fields	67
Glossary	67
§ 1 Magnetic Fields	69
§ 2 Magnetic Field Around a Current	73

Part II Chemistry	79
Ch. 1 Structure and Interactions of Matter	81
Glossary	81
§ 1 What is Chemistry ?	83
§ 2 Symbols and Formulas	84
§ 3 Reading Periodic Table	85
Ch. 2 Stoichiometry	90
Glossary	90
§ 1 Nomenclature	92
§ 2 Stoichiometry	93
§ 3 Expressing Concentration—Molarity	98
§ 4 Chemical Sentences; Equations	100
§ 5 The Search for an Accurate Value	102
Ch. 3 Chemical Rates and Equilibrium	105
Glossary	105
§ 1 Reaction Rates	107
§ 2 Concentration of Reactants and Reaction Rate	109
§ 3 Saturated, Unsaturated and Supersaturated Solutions	111
§ 4 Reversible Reactions and Equilibrium	115
§ 5 The Haber Process	117
Ch. 4 Acids and Bases	121
Glossary	121
§ 1 Ionization of Water	123
§ 2 Acids and Bases	124
§ 3 Hard Water and Precipitation	125
§ 4 Acid Rain	128
§ 5 Acid-Base Indicators	129
Ch. 5 Oxidation and Reduction	133
Glossary	133
§ 1 Oxygen; Abundant and Essential	134
§ 2 Oxidation, Reduction and Living Things	135
§ 3 Oxidation Number	136
§ 4 Electrolysis of Molten Sodium Chloride	139
§ 4 How do You Get Metals from Ores ?	140

Part I

Physics

Ch. 1 Forces and Motion

Glossary

measurement	测量	international system of units	国际单位制
Ampere	安培	Kelvin	开尔文
Candela	堪德拉	electric current	电流
basic units	基本单位	Mole	摩尔
significant figures	有效数字	decimal system	十进制
scientific notation	科学计数法	exponential	指数的
power	幂	order of magnitude	数量级
elastic limit	弹性限度	weight	重力
specific gravity	比重	Hooker's Law	胡克定律
at rest	静止	Newton	牛顿
reference point	参照点	density	密度
velocity	速度	motion	运动
instantaneous speed	瞬时速率	with respect to	相对于
scalar	标量	frame of reference	参照系
uniform motion	匀速运动	speed	速率
deceleration	减速	acceleration	加速度
linear motion	直线运动	average speed	平均速率
slope	斜率	vector	矢量
displacement	位移	accelerated motion	变速运动
arrowhead	箭头	uniformly accelerated motion	匀变速运动
vector sum	矢量和	freely falling bodies	自由落体物体
precision	精确度	horizontal axis	横轴
equilibrium	平衡	magnitude	大小
perpendicular component	正交分量	resultant	合力
dynamics	动力学	vector triangle	矢量三角形
unbalanced force	不平衡力	equilibrant	平衡力
action	作用力	resolution	分解
stationary	静止的	kinematics	运动学
sliding friction	滑动摩擦	the law of inertia	惯性定律
normal force	弹力	acceleration	加速度

reaction 反作用力

rolling friction 滚动摩擦

static friction 静摩擦

fluid friction 流体摩擦

the coefficient of friction 摩擦系数

Main Conclusions

- Average speed is the total distance traveled divided by the elapsed time interval.
- Velocity has direction as well as magnitude.
- Instantaneous velocity is the limiting value of $\Delta x/\Delta t$ as Δt becomes vanishingly small; Alternatively, it is the slope of the tangent to the displacement-time curve at a point.
- The area under the velocity-time curve between two time intervals is equivalent to the displacement during that time interval.
- Average acceleration is the change in velocity divided by the time required for the change.
- All bodies fall with the same acceleration due to gravity, $g=9.8\text{m/s/s}$. If released from rest and if air resistance is not important, they travel the same distance in the same amount of time.
- Newton's laws tell us that a body in motion stays in motion at constant velocity along a straight line unless acted upon by an external force; that a net force applied to a body causes it to change its motion by accelerating, and similarly, an accelerating body does so because a net force is applied; and that every action has an equal and opposite reaction, applied to different bodies.

§ 1 Acceleration

We can change the state of motion of an object by changing its speed, its direction of motion, or both. Any of these changes is a change in velocity. Sometimes we are interested in how fast the velocity is changing. A driver on a two-lane road who wants to pass another car would like to be able to speed up and pass in the shortest possible time. The rate at which the velocity is changing is called **acceleration**. Because acceleration is a rate, it is a measure of how the velocity is changing with respect to time.

$$\text{acceleration} = \frac{\text{change of velocity}}{\text{time interval}}$$

We are familiar with acceleration in an automobile. The driver depresses the gas pedal, which is appropriately called the accelerator. The passengers then experience acceleration, or “pickup” as it is sometimes called, as they are pressed into their seats. The key idea that defines acceleration is *change*. Whenever we change our state of motion, we are accelerating. A car that can accelerate well has the ability to change its velocity rapidly. A car that can go from zero to 60 km/h in 5 seconds has a greater acceleration than another car that can go from zero to 80 km/h in 10 seconds. So having good acceleration means being able to change velocity quickly and does not necessarily refer to how fast something is moving. ^[1]

[1] 所以,加速度大是指速度变化快,不一定是速度快。

In physics, the term *acceleration* applies to decreases as well as increases in speed. The brakes of a car can produce large retarding accelerations, that is, they can produce a large decrease per second in the speed. This is often called *deceleration*, or *negative acceleration*. We experience deceleration when the driver of a bus or car slams on the brakes and we tend to hurtle forward.

Acceleration applies to changes in *direction* as well as changes in speed. If you ride around a curve at a constant speed of 50 km/h, you feel the effects of acceleration as your body tends to move outward toward the outside of the curve. You may round the curve at constant speed, but your

velocity is not constant, because your direction is changing every instant. Your state of motion is changing: you are accelerating. Now you can see why it is important to distinguish between speed and velocity and why acceleration is defined as the rate of change in *velocity*, rather than *speed*. Acceleration, like velocity, is directional. If we change either speed or direction, or both, we change velocity and we accelerate.

In much of this book we will be concerned only with motion along a straight line. When straight-line motion is considered, it is common to use speed and velocity interchangeably. When the direction is not changing, acceleration may be expressed as the rate at which *speed* changes.

$$\text{acceleration (along a straight line)} = \frac{\text{change in speed}}{\text{time interval}}$$

Speed and velocity are measured in units of distance per time. The units of acceleration are a bit more complicated. Since acceleration is the change in velocity or speed per time interval, its units are those of speed per time. If we speed up, without changing direction, from zero to 10 km/h in 1 second, our change in speed is 10 km/h in a time interval of 1 s. Our acceleration along a straight line is

$$\text{acceleration} = \frac{\text{change in speed}}{\text{time interval}} = \frac{10 \text{ km/h}}{1 \text{ s}} = 10 \text{ km/h} \cdot \text{s}$$

The acceleration is 10 km/h · s, which is read as “10 kilometers per hour-second.” Note that a unit for time enters twice: once for the unit of speed and again for the interval of time in which the speed is changing. [1]

[1] 注意时间单位出现两次: 一次是作为速率的单位, 另一次是速率发生变化需要的时间段的单位。

§ 2 First Law of Motion

Law of Inertia

Although this law is generally credited to Newton, it was first recognized by Galileo. It states:

When no net or resultant force acts upon it, a body at rest remains at rest and a body in motion continues to move in the same direction in a straight line with constant speed.

According to this law, a body naturally tends to continue in whatever state of motion or rest it is at any instant and

tends to resist any changes. *The extent to which a body resists changes in its state of rest or motion is characteristic of the body and is called its inertia.* We frequently experience the effects of inertia in trips in the family car. When the car starts suddenly, we are thrown backward against the seats. Since we were at rest, we tend to remain at rest even when the car surges forward. When the car is moving and slows down or stops suddenly, we find ourselves thrown forward. Our inertia tends to keep us moving forward at the same speed, even though the car is slowing down. Again, when a car makes a sharp right turn, we are thrown to the left.

Inertia causes buildings to collapse during an earthquake because the buildings tend to stay at rest while the earth under them moves.

Thought Experiment Leading to the First Law

The condition in which no net force acts upon a body can often be approximated but never attained.^[1] Every body we observe has a net force acting on it. Even a body at rest on the earth's surface is acted upon by the unbalanced gravitational force of the sun, which keeps it and the earth orbiting around the sun.

[1] 物体完全不受外力作用的情形,通常只是近似的,不可能真的存在。

How then can we find out how a body would move when there is not net force acting on it? Here, physicists imagine a situation in which the unattainable conditions exist and experiment with it in thought. Galileo used this approach in arriving at the principle of inertia.

First Galileo observed that a ball allowed to roll down one hill and up a second hill reaches practically the same horizontal level from which it started. (See Fig. 1.1). He

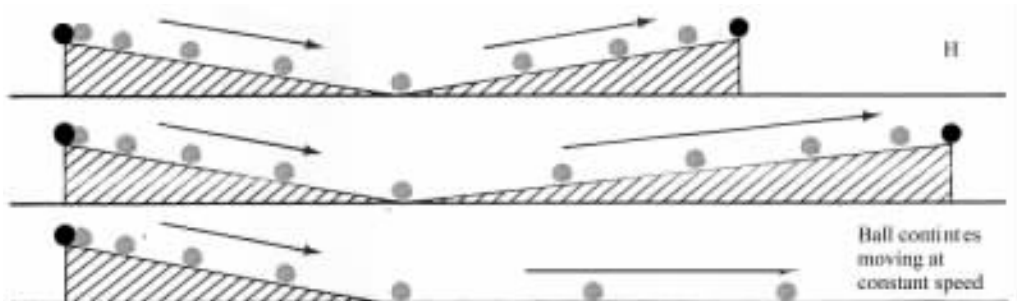


Fig. 1.1 Thought experiment that suggested the law of inertia.

resistance.

- b. After the ball reaches the top and begins its return back down, by how much does its speed increase each second?
 - c. Compare the times going up and coming down.
7. A ball is thrown straight up. What will be the instantaneous velocity at the top of its path? What will be its acceleration at the top? Why are your answers different?
 8. An object weighs 300 N on Earth and 50 N on the moon. Does the object also have less inertia on the moon?
 9. In a cheerleading act, two cheerleaders with masses of 55 kg and 63 kg, respectively, are thrown from the same height vertically upward with the same initial speed of 3.6 m/s. What is the maximum height above the point of release reached by each?
 10. A 1500 kg automobile travels at a speed of 90 km/h along a straight concrete highway. Faced with an emergency situation, the driver jams on the brakes and skids to a stop. What will the stopping distance be for (a) dry pavement and (b) wet pavement?
 11. A 4.0 kg block initially at rest at a height of 1.8 m on a frictionless inclined plane slides 2.5 m to the bottom of the plane and out on to a level surface. If the block experiences a constant frictional force of 2.5 N on the level surface, how far from the bottom of the inclined plane does the block travel before coming to rest?
 12. A jet catapult on an aircraft carrier accelerates a plane weighing one metric ton uniformly from rest to a launch speed of 320 km/h in 2.00 s. What is the magnitude of the net force on the plane?
 13. Two blocks of ice, weighing 80 N and 50 N, sit side by side in contact with each other on a horizontal surface. (a) If a constant horizontal force of 40 N is applied to one of the blocks in the direction of the other block, what is the resulting acceleration?

(Neglect friction.) (b) If the force is applied to the block at an angle of 25° below the horizontal, what would be the acceleration?

14. A 1.5 kg object moves up the y axis with a constant speed. When it reaches the origin, the forces $F_1 = 5.0 \text{ N}$ at 37° relative to the positive x axis (first quadrant), $F_2 = (2.5 \text{ N})x$, $F_3 = 3.5 \text{ N}$ at 45° relative to the negative x axis (third quadrant), and $F_4 = (-1.5 \text{ N})y$ are applied to it. (a) Will the object maintain a path along the y axis? (b) If not, what simultaneously applied force will keep it moving along the y axis with a constant speed?

Ch. 2 Two Dimensional Motion

Glossary

two-dimensional motion 两维运动

projectile 抛体

horizontal motion 水平运动

vertical plane 竖直平面

circular orbit 圆轨道

centripetal acceleration 向心加速度

vibrations 振动

pendulum 摆

frequency 频率

Hertz 赫兹

plane 平面

circular motion 圆周运动

vertically downward movement 竖直向下运动

curved surface 曲面

period 周期

radius 半径

centripetal force 向心力

oscillation 振动

amplitude 振幅

equilibrium position 平衡位置

Main Conclusions

- We can determine the sum of two vectors by using geometry, algebra, or trigonometry. However, it is a good idea, especially at the outset, to always make a scale drawing.
- Vectors are added graphically by making a scale drawing and adding the vectors head to tail.
- Many bodies remain in the same plane while they are moving. Their motion can therefore be described in two dimensions.
- In the discussion of projectile motion, we have made several simplifying assumptions. Among these are the following: (1) The Effect of air resistance can be neglected. (2) The earth may be considered a flat rather than a curved surface when the distance traveled by the projectile is small. (3) For these small distances, the direction in which the earth's gravity accelerates the projectile remains virtually the same. (4) The projectile remains in the same vertical plane throughout its flight. In reality, none of these assumptions is exactly true.
- A very important type of motion is that of a body moving in a circle at constant speed. The time taken by a body moving in a circle to go around the circle once and return to its starting point is called the period.
- Many motions take the form of vibrations or oscillations. Although these motions take place in a straight line, they are closely related to uniform circular motion. In describing the vibrational motion of a body, we generally refer to its amplitude, its period, and its

frequency.

- In simple harmonic motion, the acceleration is proportional to the displacement of a body from the center of vibration and directed toward that center. Examples of simple harmonic motion are the vibrations of a body attached to a spring and the vibrations of the bob of a pendulum.

§ 1 Range of a Projectile

The horizontal **range** of a projectile is the horizontal distance traveled during the time the projectile rises and returns to its initial height. If we can ignore the effects of air resistance, we can show that the range depends on the initial velocity (both the magnitude and the launch angle) in a relatively simple way.

Fig. 2.1 depicts the parabolic path of a football projected upward. The football's initial velocity v_0 makes an angle θ with the horizontal. The horizontal component of velocity is $v_0 \cos\theta$ and is constant because there is no horizontal acceleration. (As usual, we have neglected air resistance.) The initial vertical or y component of velocity is $v_0 \sin\theta$. The vertical component of velocity changes with time as a result of gravitational acceleration. As the object rises, it slows down and its vertical component of velocity v_y at any time t is

$$v_y = v_0 \sin\theta - gt,$$

where the initial vertical velocity is $v_0 \sin\theta$ and the acceleration is $-g$.

The time for an object thrown upward from the ground to reach its maximum height and the time for it to fall to the ground again are the same, provided the initial height and final height are the same. This symmetry in the upward and downward part of the path results from the fact that the acceleration of gravity, g , is the same for upward and downward motion at any height. The total time, T , that the object is in the air is then twice the time required for it to reach its maximum height. At the maximum height, the vertical component of velocity becomes zero; that is, the projectile stops rising before it begins to fall down. (It continues moving horizontally at this point.) Thus at the maximum height, $v_y = 0, t = T/2$, and the velocity equation in the vertical direction becomes

$$0 = v_0 \sin\theta - g \frac{T}{2}.$$

Upon rearranging, we find the time T to be

$$T = \frac{2v_0 \sin\theta}{g}.$$

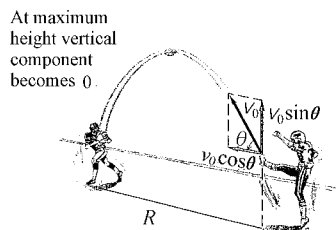


Fig. 2.1 Range of a projectile (football) with initial velocity v_0 directed at an angle θ with respect to the horizontal.

The range R , indicated in Fig. 2. 1, is the horizontal distance traveled in the time T during which the projectile returns to the height of its initial position. The range is given by $v_x t$, with $v_x = v_0 \cos\theta$ and $t = T$:

$$R = v_0 (\cos\theta) T.$$

If the previous equation is used for the time T , the expression for the range becomes

$$R = \frac{2v_0^2}{g} \sin\theta \cos\theta.$$

Making use of the trigonometric identity $2 \sin\theta \cos\theta = \sin 2\theta$, we can express the range as

$$R = \frac{v_0^2}{g} \sin 2\theta. \tag{2. 1}$$

Eq. (2. 1) gives the range of a projectile thrown upward with an initial speed v_0 at an angle θ with respect to the horizontal. In cases where air resistance plays a role, the range is usually less than the amount given by this expression. An obvious exception is the Frisbee, a light disk that acquires a lifting force from the air passing over its surface.

Fig. 2. 2 shows the paths of an object projected upward at various angles with the same initial speed. Fig. 2. 3 is a graphical representation of Eq. (2. 1). From either figure we can see that the maximum range occurs when $\theta = 45^\circ$. (At this value of θ , $\sin 2\theta$ has its maximum value of 1.) The expression for the maximum range R_{\max} is then

$$R_{\max} = \frac{v_0^2}{g}$$

Example 1

How far will a stone travel over level ground if it is thrown upward at an angle of 30.0° with respect to the horizontal and with a speed of 12.0 m/s ? What is the maximum range that could be achieved with the same initial speed?

Solution

Using Eq. (2. 1), we have

$$R = \frac{v_0^2}{g} \sin 2\theta = \frac{(12.0 \text{ m/s})^2 \sin(2 \times 30.0^\circ)}{9.80 \text{ m/s}^2} = 12.7 \text{ m}.$$

Throwing at an angle of 45.0° , we get the range

$$R_{\max} = \frac{v_0^2}{g} = 14.7 \text{ m}.$$

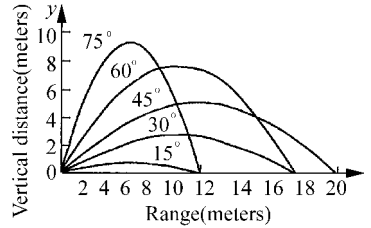


Fig. 2. 2 Trajectories of an object thrown upward with the same initial speed at various angles of inclination.

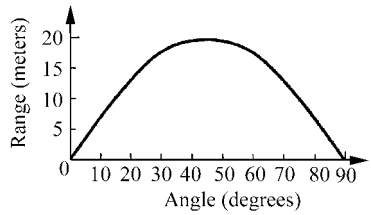


Fig. 2. 3 Range versus angle with respect to the horizontal for the same initial speed.