

● 大学英语拓展课程系列

拓展课程

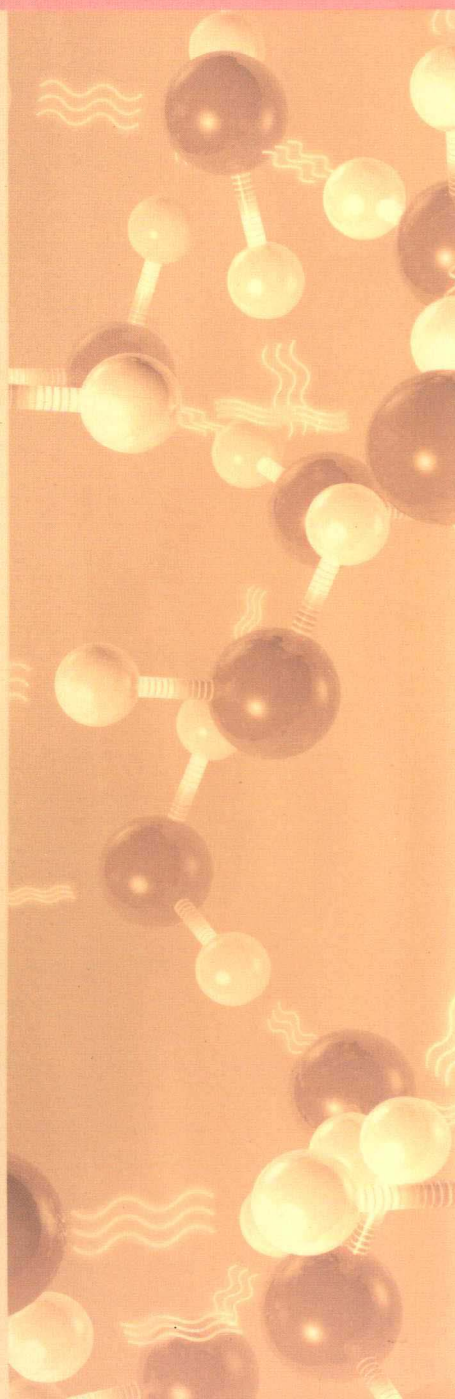


Advanced Physics through Diagrams

牛津物理学英语图示教程

Stephen Pople

 上海外语教育出版社
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叶谋仁 注释



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虽然很多高校多年来一直尝试开设选修课，专家学者也进行了理论研究，但目前此类课程在大学英语教学中所占比重并不大，仍处于探索阶段。多数教学专家对大学英语选修课程的具体教学目标和教学内容范围未形成统一认识，教育主管部门亦未出台具体的选修课教学要求。为了进一步推动大学英语选修课教学的发展，外教社在多年选修课教材使用情况调研的基础上，结合专家学者的最新研究成果和建议，充分考虑我国目前的大学英语教学现状、师资条件、实际需求等因素，重新策划编写了“大学英语拓展课程系列”，该系列教材包括EAP、ESP和EOP三个子系列。

- EAP (English for Academic Purposes)

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除了重新修订已出版的教材外，我们还通过邀请更多海内外英语教学专家参与编写、和国外出版社合作出版等方式，扩大本系列教材的选题规模，以满足各专业大学生的学习需求。本系列教材具有时代感强、实用性强、课堂可操作性强等特点，相信会给我国大学英语教学带来新风向。

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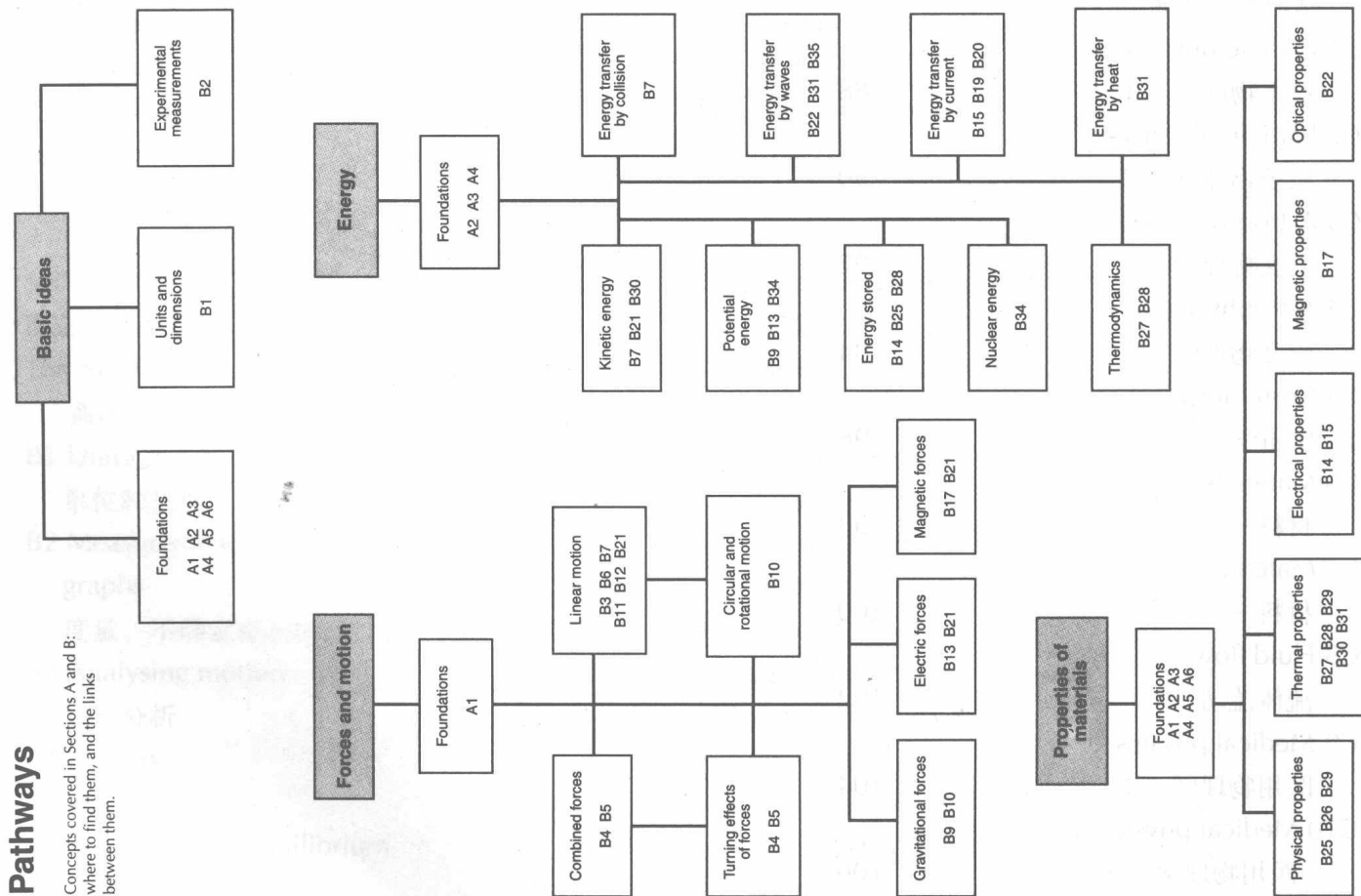
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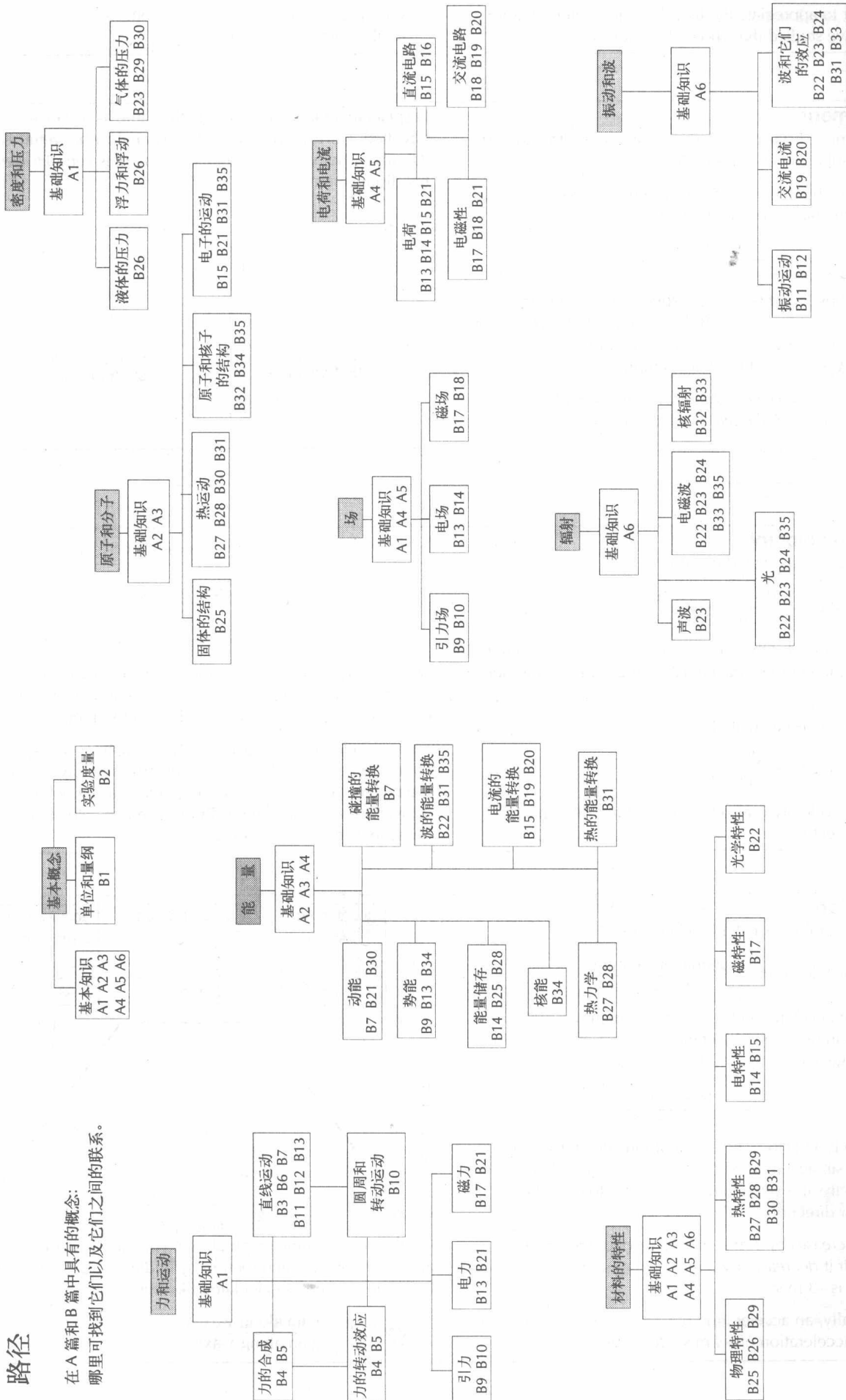
Pathways

Concepts covered in Sections A and B: where to find them, and the links between them.



路径

在 A 篇和 B 篇中具有的概念：哪里可找到它们以及它们之间的联系。



A1 Motion, mass, and forces

Units of measurement

Scientists make measurements using SI units such as the metre, kilogram, second, and newton. These and their abbreviations are covered in detail in B1. However, you may find it easier to appreciate the links between different units after you have studied the whole of section A.

For simplicity, units will be excluded from some stages of the calculations in this book, as in this example:

$$\text{total length} = 2 + 3 = 5 \text{ m}$$

Strictly speaking, this should be written:

$$\text{total length} = 2 \text{ m} + 3 \text{ m} = 5 \text{ m}$$

Displacement

Displacement is distance moved in a particular direction. The SI unit of displacement is the **metre** (m).

Quantities, such as displacement, which have both magnitude (size) and direction, are called **vectors**.

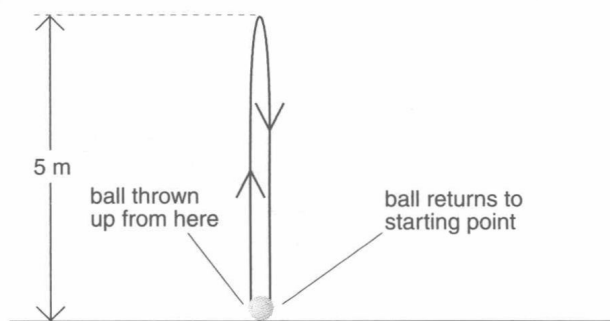


The arrow above represents the displacement of a particle which moves 12 m from A to B. However, with horizontal or vertical motion, it is often more convenient to use a '+' or '-' to show the vector direction. For example:

Movement of 12 m *to the right*: displacement = +12 m

Movement of 12 m *to the left*: displacement = -12 m

Displacement is not necessarily the same as distance travelled. For example, when the ball below has returned to its starting point, its vertical displacement is zero. However, the distance travelled is 10 m.



Speed and velocity

Average speed is calculated like this:

$$\text{average speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

The SI unit of speed is the metre/second, abbreviated as m s^{-1} . For example, if an object travels 12 m in 2 s, its average speed is 6 m s^{-1} .

Average velocity is calculated like this:

$$\text{average velocity} = \frac{\text{displacement}}{\text{time taken}}$$

The SI unit of velocity is also the m s^{-1} . But unlike speed, velocity is a vector.



The velocity vector above is for a particle moving to the right at 6 m s^{-1} . However, as with displacement, it is often more convenient to use a '+' or '-' for the vector direction.

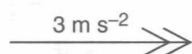
Average velocity is not necessarily the same as average speed. For example, if a ball is thrown upwards and travels a total distance of 10 m before returning to its starting point 2 s later, its average speed is 5 m s^{-1} . But its average velocity is zero, because its displacement is zero.

Acceleration

Average acceleration is calculated like this:

$$\text{average acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

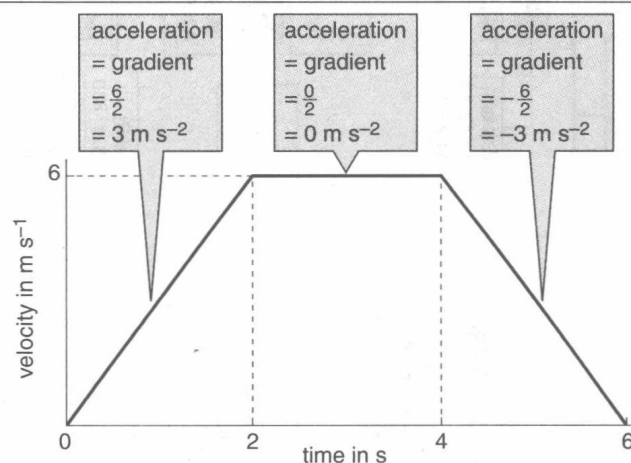
The SI unit of acceleration is the m s^{-2} (sometimes written m/s^2). For example, if an object gains 6 m s^{-1} of velocity in 2 s, its average acceleration is 3 m s^{-2} .



Acceleration is a vector. The acceleration vector above is for a particle with an acceleration of 3 m s^{-2} to the right. However, as with velocity, it is often more convenient to use a '+' or '-' for the vector direction.

If velocity *increases* by 3 m s^{-1} every second, the acceleration is $+3 \text{ m s}^{-2}$. If it *decreases* by 3 m s^{-1} every second, the acceleration is -3 m s^{-2} .

Mathematically, an acceleration of -3 m s^{-2} *to the right* is the same as an acceleration of $+3 \text{ m s}^{-2}$ *to the left*.



On the velocity-time graph above, you can work out the acceleration over each section by finding the *gradient* of the line. The gradient is calculated like this:

$$\text{gradient} = \frac{\text{gain along y-axis}}{\text{gain along x-axis}}$$

Force

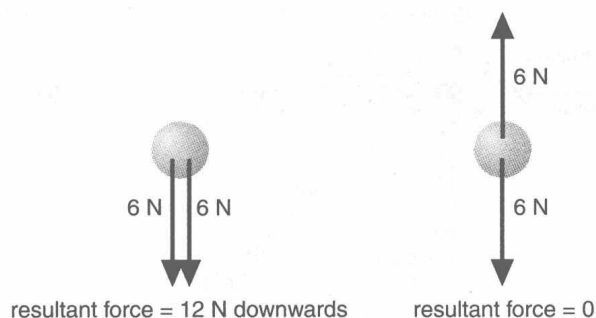
Force is a vector. The SI unit is the **newton (N)**.

If two or more forces act on something, their combined effect is called the **resultant force**. Two simple examples are shown below. In the right-hand example, the resultant force is zero because the forces are **balanced**.

A resultant force acting on a mass causes an acceleration. The force, mass, and acceleration are linked like this:

$$\text{resultant force} = \text{mass} \times \text{acceleration} \quad F = ma$$

For example, a 1 N resultant force gives a 1 kg mass an acceleration of 1 m s^{-2} . (The newton is defined in this way.)



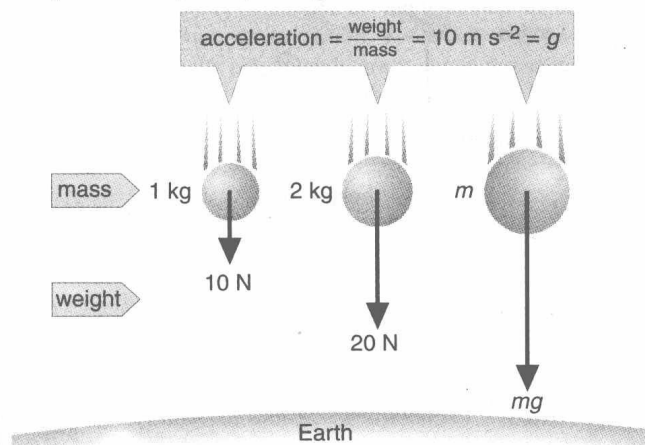
The more mass something has, the more force is needed to produce any given acceleration.

When balanced forces act on something, its acceleration is zero. This means that it is *either stationary or moving at a steady velocity (steady speed in a straight line)*.

Weight and g

On Earth, everything feels the downward force of gravity. This gravitational force is called **weight**. As for other forces, its SI unit is the newton (N).

Near the Earth's surface, the gravitational force on each kg is about 10 N: the **gravitational field strength** is 10 N kg^{-1} . This is represented by the symbol g .



In the diagram above, all the masses are falling freely (gravity is the only force acting). From $F = ma$, it follows that all the masses have the same downward acceleration, g . This is the **acceleration of free fall**.

You can think of g :

either as a gravitational field strength of 10 N kg^{-1}

or as an acceleration of free fall of 10 m s^{-2}

In more accurate calculations, the value of g is normally taken to be 9.81, rather than 10.

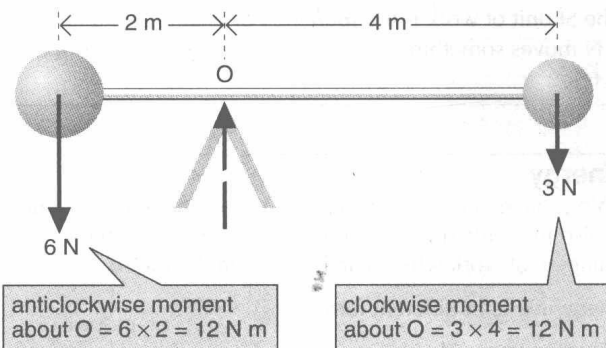
Moments and balance

The turning effect of a force is called a **moment**:

$$\text{moment of force about a point} = \text{force} \times \text{perpendicular distance* from point}$$

* measured from the line of action of the force.

The dumb-bell below balances at point O because the two moments about O are equal but opposite.



The dumb-bell is made up of smaller parts, each with its own weight. Together, these are equivalent to a single force, the total weight, acting through O. O is the **centre of gravity** of the dumb-bell.

Density

The density of an object is calculated like this:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

The SI unit of density is the kilogram/cubic metre (kg m^{-3}).

For example, 2000 kg of water occupies a volume of 2 m^3 . So the density of water is 1000 kg m^{-3} .

Density values, in kg m^{-3}

alcohol	800	iron	7 900
aluminium	2 700	lead	11 300

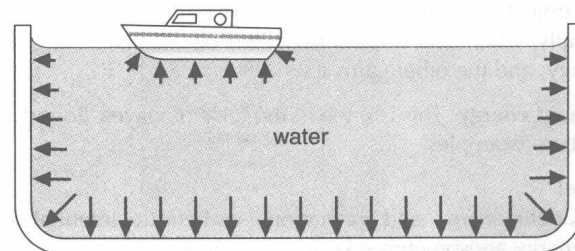
Pressure

Pressure is calculated like this:

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

The SI unit of pressure is the newton/square metre, also called the **pascal (Pa)**. For example, if a force of 12 N acts over an area of 3 m^2 , the pressure is 4 Pa.

Liquids and gases are called **fluids**.



In a fluid:

- Pressure acts in all directions. The force produced is always at right-angles to the surface under pressure.
- Pressure increases with depth.

A2 Work, energy, and power

Work

Work is done whenever a force makes something move. It is calculated like this:

$$\text{work done} = \text{force} \times \begin{matrix} \text{distance moved} \\ \text{in direction of force} \end{matrix}$$

The SI unit of work is the **joule** (J). For example, if a force of 2 N moves something a distance of 3 m, then the work done is 6 J.

Energy

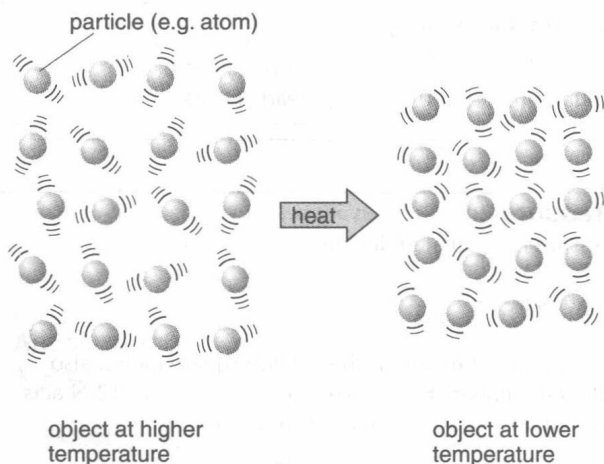
Things have energy if they can do work. The SI unit of energy is also the joule (J). You can think of energy as a 'bank balance' of work which can be done in the future.

Energy exists in different forms:

Kinetic energy This is energy which something has because it is moving.

Potential energy This is energy which something has because of its **position**, shape, or state. A stone about to fall from a cliff has **gravitational** potential energy. A stretched spring has **elastic** potential energy. Foods and fuels have **chemical** potential energy. Charge from a battery has **electrical** potential energy. Particles from the nucleus (centre) of an atom have **nuclear** potential energy.

Internal energy Matter is made up of tiny particles (e.g. atoms or molecules) which are in random motion. They have kinetic energy because of their motion, and potential energy because of the forces of attraction trying to pull them together. An object's internal energy is the total kinetic and potential energy of its particles.



Heat (thermal energy) This is the energy transferred from one object to another because of a temperature difference. Usually, when heat is transferred, one object loses internal energy, and the other gains it.

Radiant energy This is often in the form of waves. Sound and light are examples.

Note:

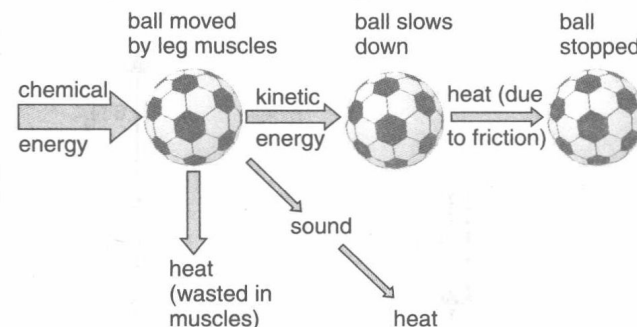
- Kinetic energy, and gravitational and elastic potential energy are sometimes known as **mechanical energy**. They are the forms of energy most associated with machines and motion.
- Gravitational potential energy is sometimes just called potential energy (or PE), even though there are other forms of potential energy as described above.

Energy changes

According to the **law of conservation of energy**:

Energy cannot be made or destroyed, but it can be changed from one form to another.

The diagram below shows the sequence of energy changes which occur when a ball is kicked along the ground. At every stage, energy is lost as heat. Even the sound waves heat the air as they die away. As in other energy chains, all the energy eventually becomes internal energy.



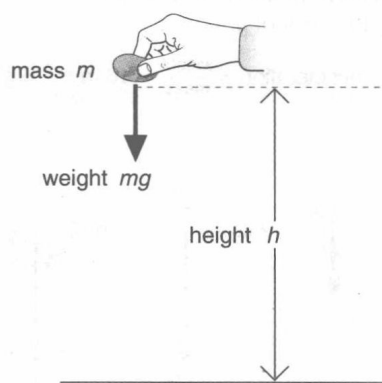
Whenever there is an energy change, work is done – although this may not always be obvious. For example, when a car's brakes are applied, the car slows down and the brakes heat up, so kinetic energy is being changed into internal energy. Work is done because tiny forces are making the particles of the brake materials move faster.

An energy change is sometimes called an energy transformation. Whenever it takes place:

$$\text{work done} = \text{energy transformed}$$

So, for each 1 J of energy transformed, 1 J of work is done.

Calculating potential energy (PE)



The stone above has potential energy. This is equal to the work done in lifting it to a height h above the ground.

The stone, mass m , has a weight of mg . So the force needed to overcome gravity and lift it is mg .

As the stone is lifted through a height h :

$$\text{work done} = \text{force} \times \text{distance moved} = mg \times h$$

So **potential energy = mgh**

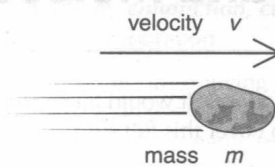
For example, if a 2 kg stone is 5 m above the ground, and g is 10 N kg^{-1} , then the stone's PE = $2 \times 10 \times 5 = 100 \text{ J}$.

Calculating kinetic energy (KE)

The stone on the right has kinetic energy. This is equal to the work done in increasing the velocity from zero to v . B7 shows you how to calculate this. The result is:

$$\text{kinetic energy} = \frac{1}{2}mv^2$$

For example, if a 2 kg stone has a speed of 10 m s^{-1} , its $\text{KE} = \frac{1}{2} \times 2 \times 10^2 = 100 \text{ J}$



PE to KE

The diagram on the right shows how PE is changed into KE when something falls. The stone in this example starts with 100 J of PE. Air resistance is assumed to be zero, so no energy is lost to the air as the stone falls.

By the time the stone is about to hit the ground (with velocity v), all of its potential energy has been changed into kinetic energy. So:

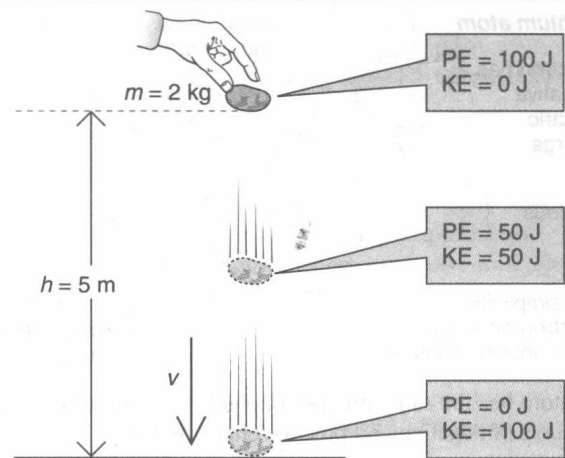
$$\frac{1}{2}mv^2 = mgh$$

Dividing both sides by m and rearranging:

$$v = \sqrt{2gh}$$

In this example, $v = \sqrt{2 \times 10 \times 5} = 10 \text{ m s}^{-1}$.

Note that v does not depend on m . A heavy stone hits the ground at exactly the same speed as a light one.

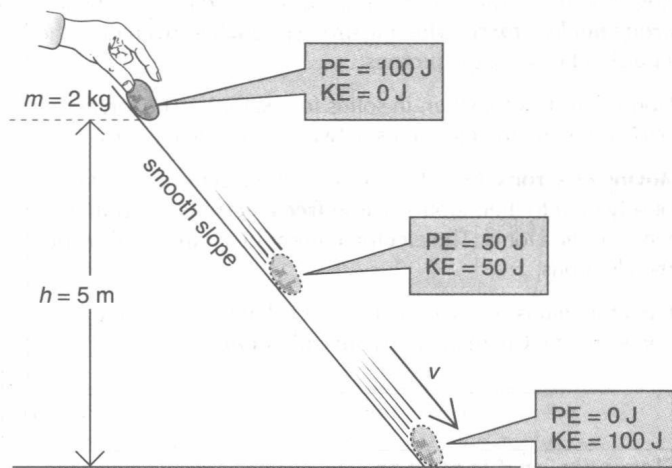


Vectors, scalars, and energy

Vectors have magnitude and direction. When adding vectors, you must allow for their direction. In A1, for example, there are diagrams showing two 6 N forces being added. In one, the resultant is 12 N. In the other, it is zero.

Scalars are quantities which have magnitude but no direction. Examples include mass, volume, energy, and work. Scalar addition is simple. If 6 kg of mass is added to 6 kg of mass, the result is always 12 kg. Similarly, if an object has 6 J of PE and 6 J of KE, the total energy is 12 J.

As energy is a scalar, PE and KE can be added without allowing for direction. The stone on the right has the same total PE + KE throughout its motion. As it starts with the same PE as the stone in the previous diagram, it has the same KE (and speed) when it is about to hit the ground.



Power

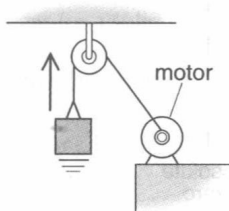
Power is calculated like this:

$$\text{power} = \frac{\text{energy transferred}}{\text{time taken}} \quad \text{or} \quad \text{power} = \frac{\text{work done}}{\text{time taken}}$$

The SI unit of power is the **watt** (W). A power of 1 W means that energy is being transformed at the rate of 1 joule/second (J s^{-1}), so work is being done at the rate of 1 J s^{-1} .

Below, you can see how to calculate the power output of an electric motor which raises a mass of 2 kg through a height of 12 m in 3 s:

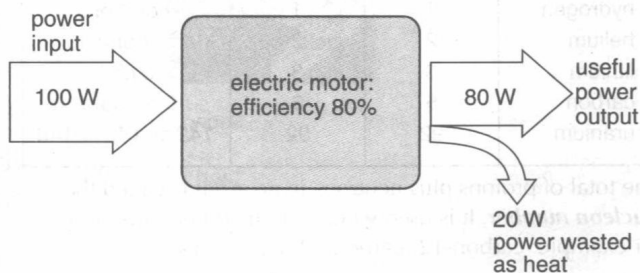
$$\begin{aligned} \text{PE gained} &= mgh \\ &= 2 \times 10 \times 12 = 240 \text{ J} \\ \text{power} &= \frac{\text{energy transferred}}{\text{time taken}} \\ &= \frac{240}{3} = 80 \text{ W} \end{aligned}$$



Efficiency

Energy changers such as motors waste some of the energy supplied to them. Their **efficiency** is calculated like this:

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} = \frac{\text{useful power output}}{\text{power input}}$$



For example, if an electric motor's power input is 100 W, and its useful power output (mechanical) is 80 W, then its efficiency is 0.8. This can be expressed as 80%.