4

FORCE AND MEASUREMENTS
力 和 测 量

吴水礼　译

科 学 普 及

出 版 说 明

当前，在实现四个现代化的新长征途中，广大青少年正在努力学习现代科学文化知识，为祖国的社会主义建设事业，增长才干，积蓄力量。编译出版《自然科学初级读物》的目的，就是为初学自然科学和英语的读者，提供一套浅近而有趣的参考书籍。

全套读物共有16个选题，细目见各书封底。英语部分采自FEP INTERNATIONAL PRIVATE LIMITED 出版的 BASIC SCIENCE SERIES（修订版）。

为了便于阅读，对全书重新作了编排，绘制了插图，并附了参考译文。书中还配有相当数量的简单实验，使读者通过实验，加深理解有关科学内容。

由于编者水平所限，错误不当之处在所难免，请批评指正。

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INTRODUCTION

In our everyday life we see many moving things. We see cars, bicycles, buses, lorries and vans moving along the roads. We see aeroplanes flying in the sky and ships sailing in the sea. These are only a few examples of moving things.

Do you know what causes things to move? The answer is **force**. A force can be a push or a pull. If you exert a force on a cart it will start to move. If you increase the force, the cart will move faster and faster. This is called **acceleration**. If you stop pushing or pulling the cart, it will keep moving for some time before it stops. It is the same when we ride a bicycle. The bicycle will stop moving after some time if we do not keep on pedalling.

引　　言

在日常生活中，我们看到许多运动着的物体。我们看到沿马路行驶的汽车、自行车、公共汽车、卡车和蓬车。我们看到飞机在空中飞翔，轮船在海中航行。这些只是运动物体的几个实例。

你知道是什么引起物体运动的吗？答案是力。力可以是推力或拉力。如果你对一辆手推车施加力，它就会开始运动。如果增大施加的力，车子就会运动得越来越快。这就叫做加速度。如果你停止推或拉，这辆车子将继续运动一段时间才停下来。我们骑自行车时也一样。如果我们不继续蹬车，过一段时间自行车就会停止运动。
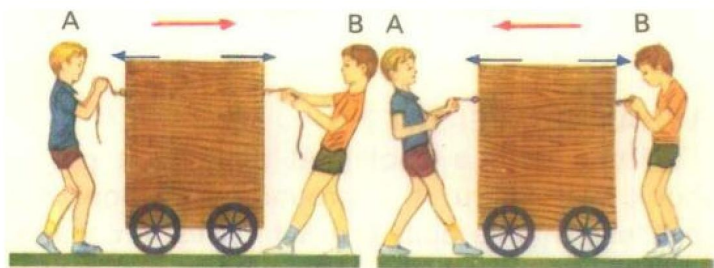
2

Force is needed to (a) move an object.
(b) stop a moving object.

需要力去 1. 移动一个物体或 2. 停住一个运动着的物体。

Direction of
moving cart
车运动方向

Direction of
force applied
作用力方向
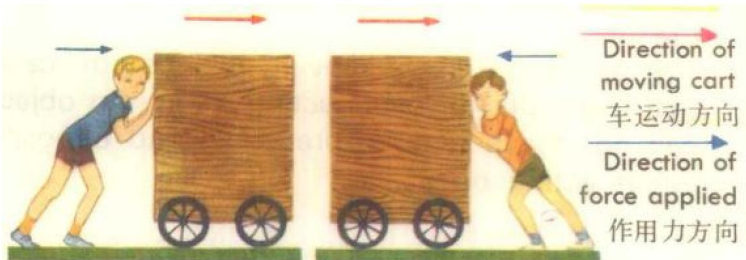
What happens when equal and opposite forces act on an object?
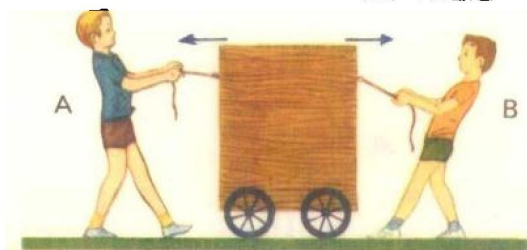
当大小相等、方向相反的力作用于一个物体时，会发生什么现象？

B pulls harder than A
B 的拉力超过 A

A pulls harder than B
A 的拉力超过 B

A and B pull with an equal force   A 和 B 的拉力相等

If you want to stop a moving cart, you must exert a force on it. In the same way if you want to stop your moving bicycle you apply the brake.

If an object is not moving it does not mean that there are no forces acting on it. An object will not move if there are equal and opposite forces acting on it.

如果你要使运动着的车子停下来，你必须对它施加力。同样道理，如果你要使运动着的自行车停下来，你就要用闸。

如果物体不动，这并不意味着没有力作用于这个物体。如果物体所受的作用力大小相等、方向相反，它就不会运动。

WHAT IS WEIGHT?

If you hold a book and then let it go, the book will fall to the ground. The book falls because a force pulls it down. This force is due to the Earth's gravity. The Earth's gravitational pull on an object is called its **weight**. A smaller gravitational force acts on a lighter object and a bigger force acts on a heavier object.

什 么 是 重 量

如果你拿住一本书，然后松手一放，书就会落到地上。书之所以会落下是因为有一股力把它向下拉。这股力是由地球的引力引起的。作用于物体上的地球引力叫物体的**重量**。作用于较轻物体上的引力小，而作用于较重物体上的引力大。

4

WEIGHING MACHINES

Weighing machines are used to find out the **weights** of objects or to compare the weights of different objects. There are many kinds of weighing machines. Next time you go shopping or marketing, find out the different ways in which shop-keepers weigh things.

Now let's find out more about the weighing of things and weighing machines. First, let us find out about a **see-saw**, which can be used as a simple weighing machine. Then we will find out how to make simple weighing machines and how to use them.

衡　　器

衡器用于称出物体的重量或比较不同物体的重量。衡器有很多种。下次你到商店或市场买东西时，了解一下售货员用哪些不同的方法来称东西。

现在让我们进一步弄清称量物体的方法和衡器。首先，让我们弄明白跷跷板的作用，它可以用作简单的衡器。然后我们就会知道怎样制作简单的衡器和怎样使用衡器。
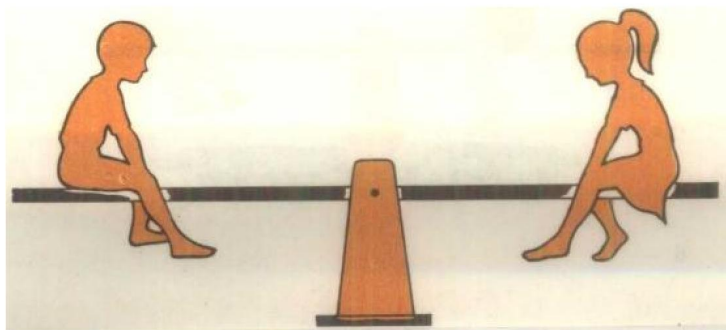
A SEE-SAW

Two boys, both of the same weight, sit on opposite sides of a see-saw. How far must they be from the centre in order to keep the see-saw balanced?
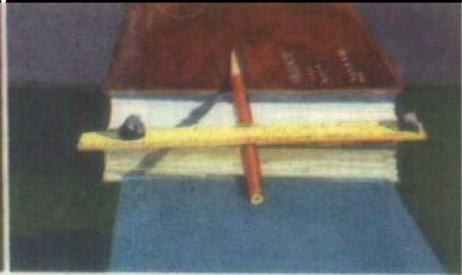
By moving to different positions, they will soon find out that they have to sit at equal distances from the centre. Now, if one of them is heavier, the heavier boy has to be nearer to the centre to make the see-saw balance.

跷 跷 板

体重相同的两个男孩分别坐在跷跷板的两侧。为了保持跷跷板平衡，他们必须离中心多远？

通过挪动到几个不同位置，他们很快就会发现，他们必须坐在距离中心点相等的地方。如果其中一个体重较重，那么，较重的孩子必须靠近中心一些，才能使跷跷板保持平衡。

Things to Do

Take a stone in each hand. Can you find out which stone is heavier? If the two stones are about the same size, you may not be able to tell which one is heavier. But you can use a see-saw to find out which one is heavier.

Place a pencil on two piles of books and balance a ruler on it. Now place one stone on each side of the ruler and move them until the ruler is balanced. Find out how far each stone is from the pencil. The stone nearer to the pencil is the heavier one. Now you know how a simple weighing machine works.

动 手 做

两手各拿一块石头。你能发现哪一块石块较重吗？如果这两块石块大小相仿，你或许分不出哪一块较重。可是你可以利用跷跷板来发现哪一块较重。

把铅笔架在两堆书上，在铅笔上平衡地放一把直尺。现在，在直尺的两端各放一块石块，挪动石块直到直尺平衡为止。看看每块石块离铅笔多远。离铅笔较近的那块石块是较重的一块。现在你知道简单的衡器是怎样工作了。

SIMPLE WEIGHING MACHINES

There are very simple weighing machines which we can make. One is a **clamp balance** and the other is a **balloon strip balance**. These weighing machines are not very accurate. They do not give us the exact weight of an object. Complicated weighing machines are used in shops and factories. Mostly they are very accurate. Some are used for weighing meat, fish, peanuts, vegetables and other things, while some are used for weighing people.

简　单　衡　器

有一些很简单的衡器我们可以自己制作。一种是**夹钳天平**，另一种是**橡皮筋秤**。这些衡器并不很准确，它们不能告诉我们物体的确切重量。复杂的衡器用于商店和工厂。它们多数是很准确的。有些用来称肉、鱼、花生、蔬菜和其他东西，另一些则用来称体重。

Things to Do

(i)　Let's make a simple weighing machine called a clamp balance. For your clamp balance, you will need a clamp, a wooden rod about 1 metre long, a round pencil, two similar tin lids, each with three small holes, and a piece of thin string.

8

First of all, put one end of the pencil under some heavy books so that the other end juts out over the edge of a desk. Next, put the two wire holes of the clamp on to the pencil so that the clamp swings freely. By opening and shutting the clamp, place the wooden rod in a position where it balances. Make pencil marks at each end of the rod at equal distances from the clamp. Using a razor blade, make a little groove at each pencil mark. The grooves are for keeping the strings in place.

动 手 做

一、让我们做一个叫夹钳天平的简单衡器。做一台夹钳天平，你需要一个夹钳、一根约一米长的木棍、一支圆铅笔、两个同样的罐头盖（每个罐头盖有三个小孔），和一根细线。

首先，把铅笔的一端压在一些沉重的书本下面，使另一端伸出桌子外沿。然后，把夹钳的两个钢丝孔套在铅笔上，使夹钳能自由摆动。用夹钳来夹木棍的不同部位，直到使木棍处于平衡为止。在木棍两端，离夹钳等距离处，用铅笔做好标记。在有铅笔标记处用刀片各刻一小槽。这些槽是用于固定细线的。

A clamp balance
夹钳天平
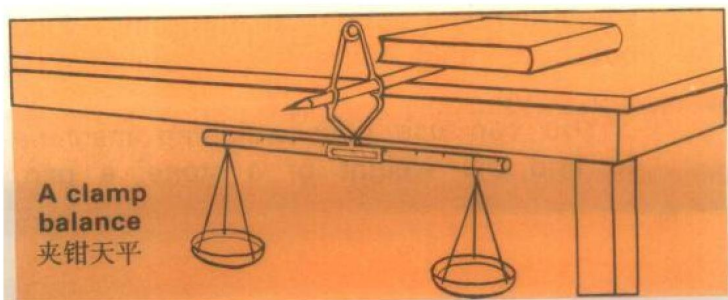
Now, to make the scale pans, tie the thin string to the three holes in the tin lids. Next, hang the scale pans from the grooves, first making sure that the rod is level. The pans must be placed at equal distances from the clamp. Do the pans balance? If they do not, stick some plasticine on the lighter pan. Now your clamp balance is ready for use.

Use your weighing machine to compare the weights of some objects such as peanuts, rubber, chalk and small stones. Place these objects on the scale pans and balance them with other objects. Find out which objects are heavier and which are lighter.

(ii) To compare the weights of different objects properly, we must have standard weights. We can make our own standard weights by filling bottle-tops with plasti-cine. Now balance these bottle-tops against one another. Make sure they all weigh the same by taking away or adding plasticine to them. We will call these standard weights 'sprogs'.

Place a sprog on one scale pan and some identical buttons on the other. Find out how many buttons are balanced by one sprog.

You can use your weighing machine to find the weight of a stone, a pen,

a small ruler and so on. Place the object in one scale pan and put sprogs in the other until the balance is level. Record the weight of the object in sprogs. Now replace the sprogs with blocks. Record the weight of the object in blocks also.

现在来做秤盘。把细线系在罐头盖的三个小孔里。然后，把两个秤盘挂在小槽里，但必须先把秤杆放平。秤盘必须放在离夹钳相等距离处。秤盘平衡吗？如果不平衡，就在较轻的秤盘里粘一些橡皮泥。现在你的夹钳天平就可以使用了。

用你的衡器去比较一些物体的重量，例如花生、橡皮、粉笔和小石子。把这些物体放在秤盘里，并用其它物体平衡它们。找出哪些物体较重，哪些较轻。

二、要恰当地比较不同物体的重量，我们必须有标准重量。我们可以在瓶盖里填橡皮泥，来制造我们自己的标准重量。现在要使这些瓶盖互相保持平衡。用增减橡皮泥的办法确保它们的重量一致。我们把这些标准重量叫做"砝码"。

在一个秤盘里放一个砝码，在另一个秤盘里放一些同样大小的扣子。看看一个砝码能平衡多少个扣子。

你能用你的衡器称出一块石块、一支钢笔、一支小直尺等等的重量。把物体放在一个秤盘里，把砝码放在另一个秤盘里，直到天平平衡为止。用砝码数记录物体的重量。现在再用木块代替砝码，并用木块数记录物体的重量。

(iii) We can make another simple weighing machine called a rubber strip balance. Cut a rubber strip 1 cm wide and 10 cm long. Tie one end of the rubber strip to a stick and the other end to a scale pan as shown in the picture. Attach a paper clip pointer at the place where the scale pan is tied to the rubber strip.

Hang your rubber strip balance over the side of a desk and put a heavy weight on the stick to hold it firmly. Now pin a piece of cardboard on the side of the desk so that a scale can be marked on it.

You can mark the scale in this way. Mark the position on the cardboard where the pointer lies when there is no sprog on the scale pan. Write 0 (zero) against this mark. Now place one sprog on the pan. You will find that the pan moves down a little. Mark the new position of the pointer on the cardboard. Write 1 for '1 sprog' against the new mark. Add more sprogs one by one and mark the position of the pointer each time. Write 2, 3, and so on against the marks. Now remove the sprogs one by one and check that the marks are still cor- rect. Now you have made a rubber strip balance.
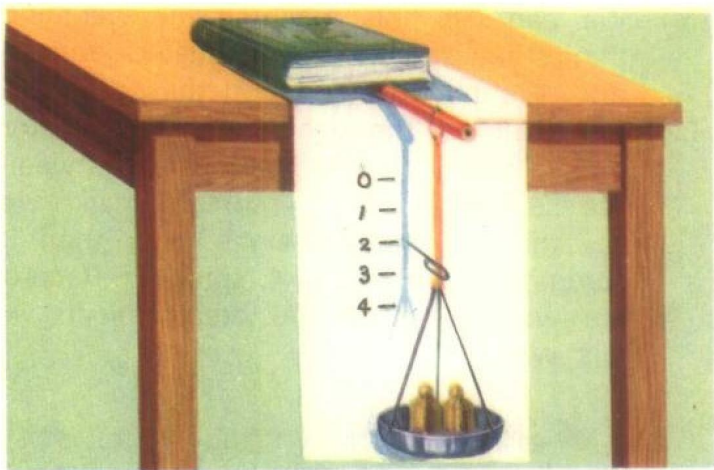
三、我们还可以做一种叫做橡皮筋秤的简单衡器。截取一条长10厘米、宽1厘米的橡皮筋。象图中所示的那样，把橡皮筋的一头结在小棍上，另一头结在秤盘上。在秤盘和橡皮筋结扎处固定一个回形针做的指针。

把你的橡皮筋秤挂在桌子旁边，用重物压住小棍，使它固定不动。然后在桌子边上钉一张纸板，使纸板上可以标出刻度。

你可以这样来标刻度：当秤盘里没有砝码时，在纸板上标出指针所处的位置。对着这一标记写上"0"。现在，在秤盘上放一个砝码。你会看到，秤盘向下移动了一点。在纸板上标出指针新的位置。对着新的标记写上"1"，代表"一个砝码"。一个一个地添加砝码，每一次都标出指针的位置。对着各个标记写上"2"、"3"等等。现在把砝码一个一个地拿走，核对这些标记是否仍然正确。这样你就做成了一台橡皮筋秤。

(iv) We can use this machine for weighing things like stones, books, dusters and so on. We put the stone on the scale pan and read off the position of the pointer on the scale. If the pointer lies between the '3 sprogs' and '4 sprogs' mark, we say that the stone weighs more than 3 sprogs but less than 4 sprogs. Record the weights of all the other objects in this way.

　　四、我们能用这个秤来称东西了，如石块、书本、掸帚等等。我们把石块放在秤盘上，读出指针在标尺上的位置。如果指针处于"三个砝码"和"四个砝码"的标记之间，我们说，石块重于三个砝码、但轻于四个砝码。用这种方法记录所有其它物体的重量。

WHAT IS WORK?

When you push against a big rock and if it does not move, then in the language of Science, you are not doing any work. Can you consider yourself working when you are studying or talking?

In Science, work is only done when a force moves something that has weight through a distance.

Work = force × distance moved

The unit of work is in **joules**, if the force is measured in **newtons** and distance in **metres**.

14