Principle of the balance 7

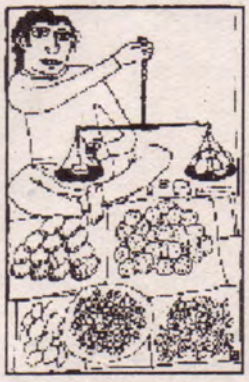
When we hold things up with our hands and release them, they fall down. Why? (1)

The force with which a body is pulled downwards is called its weight. You have done some experiments on this subject, in class 6, in the chapter 'Force and Weight'. You had also learnt that this force on a body is due to the earth's attraction.

A lot of things like gold, silver, groceries, dals, sugar, vegetables, salt, oil, etc. are bought and sold by weight.

When you go to the market to buy or sell these things, what units do the traders use to weigh them? (2)

Weight is measured in units of gram weight, kilogram weight, quintals, etc. In brief we will call them gram and kilogram. There are 1000 grams in one kilogram (or one kilo) and 100 kilos in one quintal.



How many grams are there in one quintal? (3)

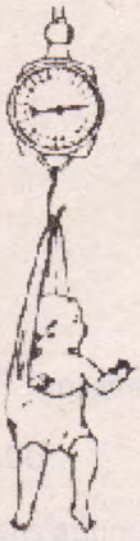
Milli means a 1000th part. If a gram is divided into a 1000 equal parts, then one such part is called a milligram.

How many milligrams are there in one gram? (4)
How many milligrams would there be in one kilo? (5)

1 quintal	=	100 kilograms (kilos)
1 kilogram	=	1000 grams
1 gram	=	1000 milligrams

In the past, gold and silver were measured in units called *tola, masha, ratti* , etc. But these days all things are measured in milligrams, grams, kilograms and quintals.

Do you know of any other units for measuring weight? Write them down. (6)
How many grams are there in a *tola* ? (7)



A general balance

How many grams are there in a *masha* ? Find out from someone. (8)

Find out how many grams there are in the other units of weight. (9)

Based on the answers to questions 3-9, which units do you think are more convenient for measuring weight? Why? (10)

Different kinds of weighing balance

You can see various kinds of instruments for measuring weight in shops in the market, at a goldsmith's, the post office, the railway station and the grain market.

Explore on your own

Go to all these places and take a look at these instruments to see how they work. Make a sketch of each in your note book. (11)

Weighing balance in the kit

There is a weighing balance in your kit with weights from 1 to 200 grams. Examine the balance and each of the weights carefully. There are two identical pans; their weights should be equal. Each pan has three equally spaced holes. Attached to these holes are chains of equal length. The chains of each pan are attached to hooks. These hooks, in turn, are attached to the two ends of the beam of the balance. The weight of these hooks should also be equal.

Does your balance also have a rider? (12)

Try to guess why a rider is used in a balance? (13)

We will discuss the importance of the rider later. For the moment, look carefully at the beam of the balance. The beam can freely move on a pivot.

What effect would it have on your balance if the beam did not move freely on its pivot? (14)

The purpose of the ring hanging from the middle of the beam is to see if the beam is balanced or not.

When holding up an empty balance by its handle, if -

-the beam of the balance is leaning one way, or
-one pan of the balance is down and the other up, or
-the needle of the balance is not pointing to the centre,

then would you call it a proper balance ? (15)

If not, then what makes a proper balance ? (16)

If objects of equal weights are placed in each pan of the balance, then what should be the position of the arm of the balance ? (17)

In this situation, the instrument is said to be balanced.

What is the position of the needle when the shopkeeper says his instrument is balanced? (18)

Under balanced conditions, we should be able to shift the contents of the left pan to the right and the contents of the right pan to the left and the instrument should still remain balanced.

Empty the pans of the balance in the kit and lift it up by it handle.

Did it balance? (19)

Now place a 1 gram weight in one of the pans of the balance.

Is it balanced? (20)
Can you weigh 1 gram weight with this balance? (21)

On the beam, it says "to weigh 200 gms." What this means is that, with this balance, you should not weigh more than 200 grams.

If you weigh objects of more than 200 grams, the balance will be ruined.

If it gets ruined, could you still weigh 1 gram? (22)

To find the answer to this question look at question (14) again.

Look carefully at the ends of the beam. There are holes at these ends. The pans are hung by their hooks through these holes. The inner edges of these holes are sharp.

Take a measuring tape and thread. The pans hang from two particular points in the holes at both ends of the beam.

Measure the distance of these points from the middle of the beam (the pivot). (23)
What did you find? (24)

You have just seen the essential characteristics of a two-pan weighing balance.

The weights

You must have seen shopkeepers weighing goods with scales. They have weights of different measures. In your kit there are different weights—200 grams, 100 grams, 50 grams, 20 grams, 10 grasm, 5 grams and 1 gram. Using these, you can weigh anything from 1 to 200 grams with your scale. However, only one balance and one set of weights are given in your kit for the whole class. Therefore, to do your experiments, you will have to make your own balance and weights.

For the teacher

There is only one balance and one set of weights in the kit. Therefore, you must get each team to make its own balance and a set of weights. For this, it is recommended that in their free time, each team be allowed to use the balance and weights in the kit.

Make your own weights

Using the balance and weights given in the kit, you will be able to make your own weights. A few ways of making your own weights are given below. You may use whichever method suits you best.

8 grams 5 gm 2.5 gm

(1) Each kind of coin has a fixed weight. Weigh different coins to find out their weights. Now put as many coins as you need to get the desired weight. Put these coins in a polythene bag and tie it up. Be sure to label the bag with its weight in grams. Try to use new coins.

(2) You can make a weight from broken tiles or bricks by rubbing pieces of them or from pieces of dry wood by shaving them off till they are the desired weight.

(3) You can make weights by putting heavy things like nails, pebbles, sand, cycle ball bearings, nuts and bolts, marbles etc. in a polythene bag and adding or removing things till the bag is the desired weight.

(4) You can collect polished pebbles of suitable sizes from a river to use them as weights.

Besides the suggestions given above, there can be many other methods of making weights. For the experiments that follow, each team will need a set of weights. In addition to the 1 and 200 grams weights, you will need two weights each of 20 grams, 30 grams, 40 grams, 50 grams, 60 grams and 100 grams. Be sure to make all of this set of 14 weights.

Make your own balance

You must have made some sort of weighing balances while playing. By now you have learnt to identify the important features of such a balance. Now you can make your own balances with all the qualities that are required to make it weigh accurately.

For pans, you can use bowls, tin containers, caps, plastic bottle caps or the like. Make sure that you use identical things for your two pans. How will you make the beam? Think what materials are available in your village or town for this. Perhaps you could request an ironsmith or a mechanic to make an iron beam for you. Otherwise, you could shave off a bamboo stick and make grooves or holes in it. If you have a wooden beam in mind, then ask a carpenter for help. If

you can manage to make a pivot to balance the beam, it would be all the better. If you try hard, you can make an excellent balance.

Look for material so that your balance will be able to weigh at least 1 gram and at most 200 grams. If you have trouble doing so, you can build two balances, one for measuring light things and the other for heavier things.

Now let us ask some questions about your balances. Why did this matter of making two balance come up at all?

You all know that a jeweller does not weigh gold on the grain merchant's balance. Similarly, groceries are not weighed in the jeweller's balance .

Explain, why is this so? (25)

What special features must a balance for weighing light items possess? (26)

What special features must a balance for weighing heavy items have? (27)

If you have made two such balances, then from your experiences, tell what differences there are in the materials you used in each of them. Write these differences in the form of a table. (28)

You are going to use your own balances and weights for several experiments. Therefore, they must be strong and accurate. To help you, pictures of balance made by other students are given here.

Your balance — how true, how false

Hold your balance by the handle and take a look at it. While holding it, push down on one end of the beam with your finger, then let go.

Did the beam return to its original position? (29)

The beam of the balance should be able to swing easily about its midpoint. It should not get stuck. Every time you move the beam, it should return smoothly to its original position. If this does not happen, mend your balance.

Experiment-1

Fixing the rider

Lift up your balance once again.

Is it balanced? (30)

If it is not balanced, then fix a rider on it on one side to balance it.

By using the rider, which problem of your scale have you taken care of? (31)

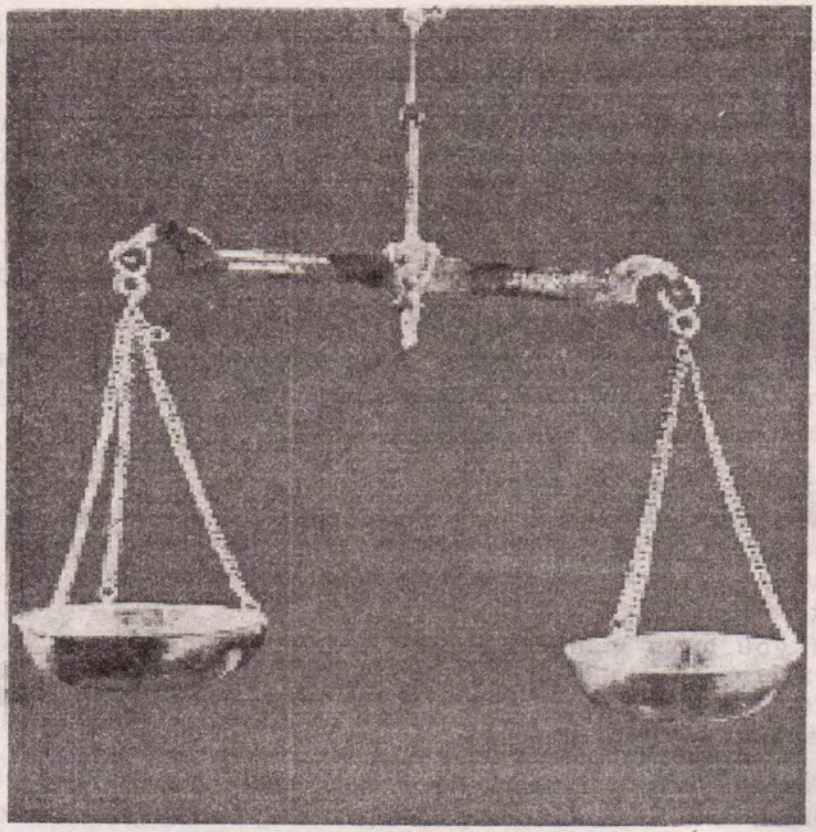


Figure-1a Weighing balance in the kit

Experiment-2

A sure way to test your balance

Put a 100 gram weight in each pan of the balance. Is your balance still balanced?

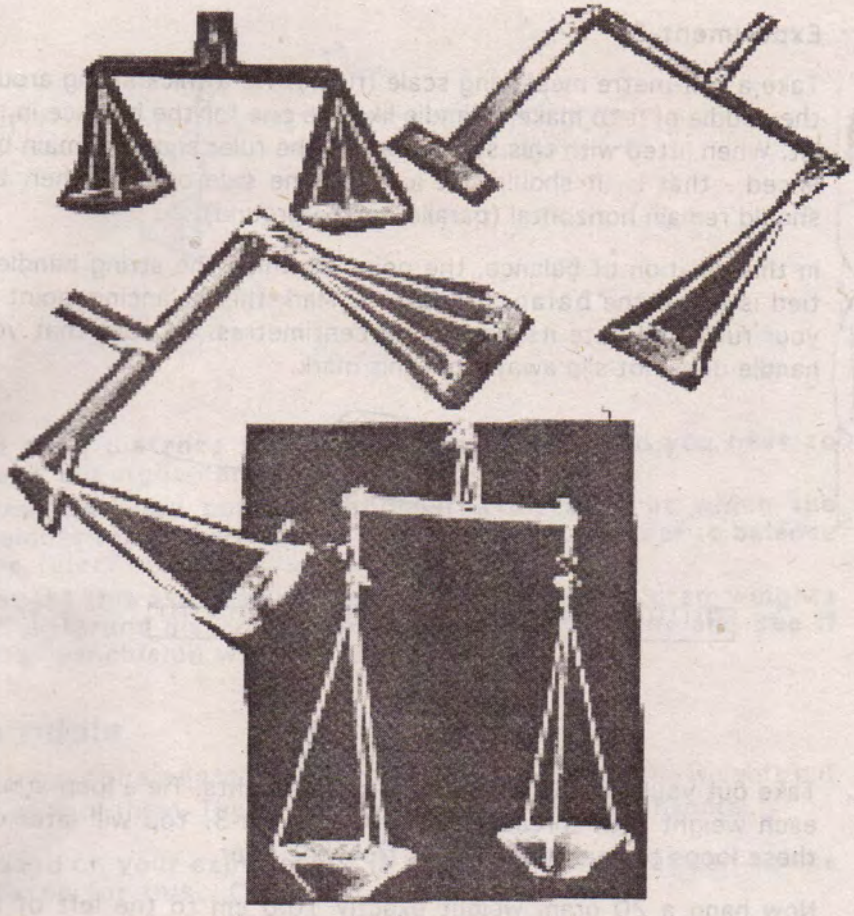
If yes, then your balance has been constructed correctly.

Putting equal weights in each pan of any balance is a sure way to find out if it is true or not. In the experiments ahead, use this test whenever you have to test a balance.

Even if your balance has been made correctly, you will still have to do the following experiments to understand the principles of the balance. Studying the incorrect balance made by some of your class-mates will help you in understanding the principles of a balance.

There are three possible reasons for a balance not being true in the above experiment:

* there might be a problem with your weights, or
* there might be something wrong with your balance, or
* both your weights and your balance may not be true.



Weighing balance built by students.

Figure-1b

Notice the things that have been used to make the balance pans. You too can use such things to make your own balances.

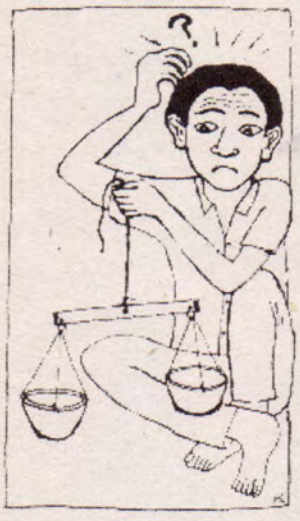
Check all the weights you made using the balance and weights in the kit.

If your weights are incorrect, mend them. Test your balance once again by putting weights in both the pans.

If your balance is still not balanced, it clearly means that the fault cannot be due to any problem with the weights. The problem must be with the balance itself. Also, it is a problem which cannot be corrected by using a rider.

So, just what could be causing the problem?

In order to understand this, you will have to understand the principle of the balance. So, let us do some experiments.



Experiment-3

Take a half-metre measuring scale (ruler). Tie a thick string around the middle of it to make a handle like the one for the balance in the kit. When lifted with this string handle, the ruler should remain balanced - that is, it should not lean on one side or the other, but should remain horizontal (parallel to the ground).

In this position of balance, the point at which the string handle is tied is called the **balancing point**. Mark this balancing point on your ruler and note its position in centimetres. Be sure that your handle does not slip away from this mark.

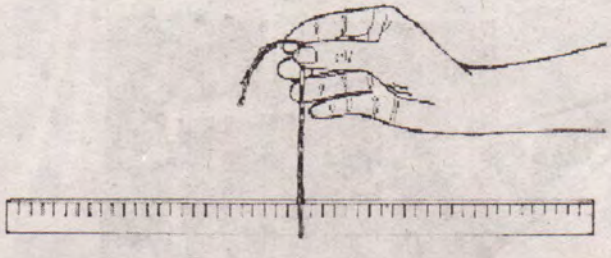


Figure-2

Take out your 20, 30, 40, and 50 gram weights. Tie a loop around each weight with thread as shown in Figure-3. You will later use these loops to hang the weights from the ruler.

Now hang a 20 gram weight exactly 10.0 cm to the left of the balancing point on your ruler. The loop of your weight should hang straight over the mark on the ruler. The correct way to hang the weight is shown in Figure-4.

Figure-3

Hang the other 20 gram weight on the right side of the ruler at such a distance that the ruler is balanced when you lift it by the handle.

How far from the balancing point did you have to hang it? (32)

Now hang the left-hand weight 5.0 cm from the balancing point. Slide the right-hand weight until the ruler is balanced.

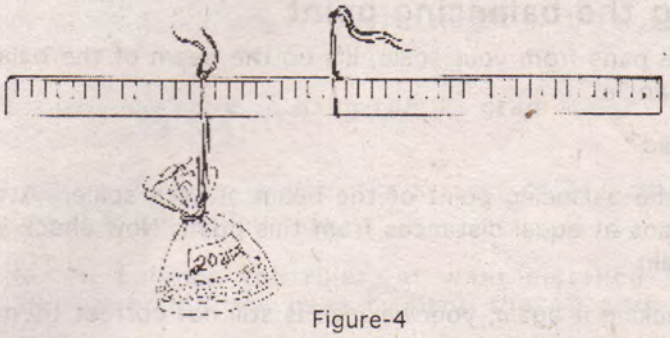


Figure-4

At what distance from the balancing point did you have to hang the right-hand weight this time? (33)

What can you conclude about the distance at which the weights should be from the balancing point in order to balance the ruler? (34)

Repeat this experiment hanging 30, 40, and 50 gram weights at different distances from the balancing point and see if your conclusion was correct . (35)

A riddle

The pans of a balance are of the same weight as are the weights put in each of them. The arm of the balance is still not hrizontal.

Based on your experiences in experiment 3, what can be the reason for this. (36)

Mending the error in your balance

Measure the distance of each pan from the balancing point on your balance. Are both distances equal? If not, make the distances equal. Is your balance correct now? Check it out.

Experiment 4

Let us return to the arrangement you had in experiment 3. Slide the string handle tied to your ruler 1 cm either to the right or to the left of the balancing point. With the handle in this new position, hang a 20 gram weight on each side at a distance of 20.0 cm from the handle.

Is the ruler now balanced? (37)
Why is this so? (38)

After completing experiment 3, you had measured the distances at which the pans of your balance were hung from the balancing point and verified that they were equal.

If the weighing balance you have made is still not corrected, then on the basis of experiment 4, say what might be the cause of the problem now. (39)

Checking the balancing point

Remove the pans from your scale, lift up the beam of the balance using the handle.

Is it balanced?

If not, fix the balancing point of the beam of your scale. Attach both the pans at equal distances from this point. Now check your balance again.

If upon checking it again, your balance is still not correct then the only possibility which remains is that your rider is not correctly placed. Correct the rider on your balance. Now your balance should be accurate.

Do not lose courage

If, after doing all this, your balance still poses problems, then you must have erred in choosing the balancing point, or in setting the pans at equal distances from the balancing point or in fixing the rider. Go back and look for your error to fix your balance.

How useful is your balance

What is the smallest weight your balance can weigh? Find it out experimentally. (40)

By your estimation, what is the heaviest weight you would be able to weigh with it? (41)

Experiment-5

Your balance is ready. Now let us get down to weighing a few things with it. In your kit there are three aluminium blocks of different sizes.

Weigh these blocks with on your balance and record their weights in your note book. (42)

A Warning

Your balance and weights are to be used only for experiments. Don't use them for buying or selling things in the market. It is a legal offence to use scales and weights for trade without the stamp of the Inspector of Weights and Measures.

Experiment-6

A closer look at the principle of balance

In experiment 3, you used weights of equal quantities. Now we shall repeat the same experiment with different weights.

Balance the ruler by sliding the string handle back to the balancing point.

Hang a 20 gram weight 16.0 cm. from the balancing point on the left side of the ruler. Hang a 40 gram weight on the right side and balance the ruler.

How far did you have to hang the 40 gram weight from the balancing point? (43)

Now hang the 20 gram weight at a distance of 24.0 cm from the balancing point on the left side.

In order to balance the ruler, at what distance from the balancing point did you have to hang the 40 gram weight? (44)

Now hang the 40 gram weight at 7.0 cm. on the right. Guess where you would have to hang the 20 gram weight for balance? (45)

Check your answer experimentally.

If you hang the 40 gram weight on the left 11.0 cm away from the balancing point, where would you have to hang the 20 gram weight to balance it? (46)

Repeat experiment 6 with a 30 gram weight on one side and a 60 gram weight on the other.

Explain the conclusion drawn from this experiment. (47)

Experiment-7

The products of balancing

Combining the conclusions of experiment 3 and experiment 6, we arrive at the principle on which this weighing balance works. Let us perform this experiment in even finer detail to explore and understand this principle.

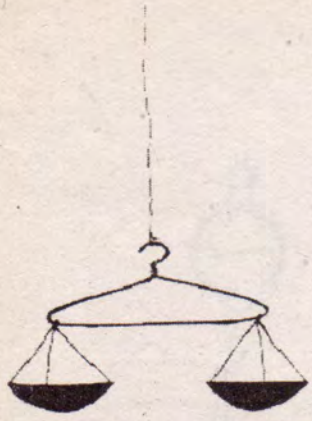
First, copy the table given on the next page in your note book and fill in the data from experiments 3 and 6. (48)

Hang a 20 gram weight 10.0 cm away from the balancing point to the right on the ruler. Hang a10 gram weight on the left side of the ruler and balance it. Enter your results in the table.

Hang a 20 gram weight 20.0 cm from the balancing point to the right on the ruler. Balance the ruler using 30, 40, 50 and 60 gram weights, hanging them one at a time. Record your results in the table.

Now hang a 50 gram weight on the left side at a distance of 7.0 cm. On the right side hang, one by one, 20, 30 and 40 gram weights and balance the ruler. Record your results in the table.

Now do some calculations and fill in the 'product' column. To show



you how to do this, some products are entered in the table. Compare the products on the left side of the table with the ones on the right side.

	No.	Left Side			Right Side		
		weight (gram)	dist.from balance pt. (cm)	product (gram cm)	weight (gram)	dist.from balance pt. (cm)	product (gram cm)
Ex.3	1	20	10.0	200.0	20		
	2	20	15.0	300.0	20		
Ex.6	1	20	16.0	320.0	40		
	2	20	24.0	480.0	20		
	3	40	7.0	280.0	20		
	4	40	11.0	440.0	20		
Ex.7	1	10			20	10.0	200.0
	2	30			20	20.0	400.0
	3	40			20	20.0	400.0
	4	50			20	20.0	400.0
	5	60			20	20.0	400.0
	6	50	7.0	350.0	20		

What did you find in each experiment? (49)

Do you now understand the principle that emerges from the three experiments? Discuss this principle with your teacher and write it down in detail. (50)

Equation of balance

You must have solved many equations in mathematics. To show equality, we use the equality sign '='.

In these experiments, the product on the left side was --

(weight on left side) x (distance of the weight from the balancing point)

and the product on the right side was --

(weight on right side) x (distance of the weight from the balancing point)

Now write your principle in the form of an equation. (51)

This is the equation for the principle of a balance.

Experiment 8

Weighing heavy objects with small weights - Using the formula

Look at your conclusions from experiment 7. Suppose you have a half-metre ruler with a string handle tied to its balancing point.

If you are given a 40 gram weight, could you use it to weigh the largest aluminium block given in the kit? Explain. (52)

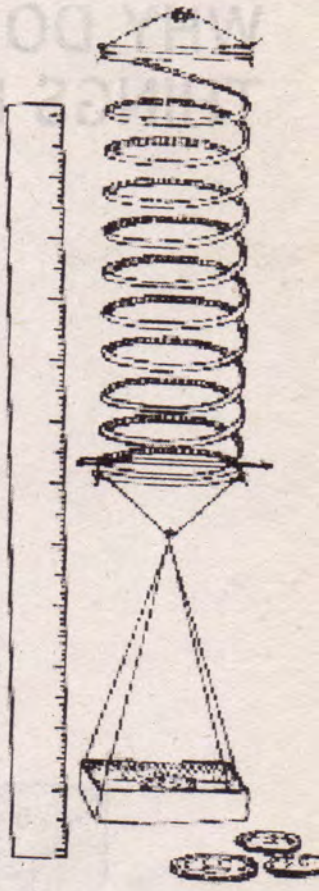
Hang this aluminium block 4.0 cm from the balancing point to the left side of the ruler. Now hang the 40 gram weight on the right side and balance the ruler.

Write down the distance of the 40 gram weight from the balancing point, in the balanced position. (53)

What is the product of the weight and distance on the right side of the ruler? (54)

This product will be equal to the corresponding product on the left side in which the weight of the block is unknown.

Now use the equation of balance to find the weight of the block. (55)



NEW WORDS:

rider
horizontal
balance
imbalance
balancing point