APPENDIX 2

INTRODUCTION TO MATHEMATICAL MODELLING

A2.1 Introduction

Right from your earlier classes, you have been solving problems related to the real-world around you. For example, you have solved problems in simple interest using the formula for finding it. The formula (or equation) is a relation between the interest and the other three quantities that are related to it, the principal, the rate of interest and the period. This formula is an example of a **mathematical model**. A **mathematical model** is a mathematical relation that describes some real-life situation.

Mathematical models are used to solve many real-life situations like:

- launching a satellite.
- predicting the arrival of the monsoon.
- controlling pollution due to vehicles.
- reducing traffic jams in big cities.

In this chapter, we will introduce you to the process of constructing mathematical models, which is called **mathematical modelling**. In mathematical modelling, we take a real-world problem and write it as an equivalent mathematical problem. We then solve the mathematical problem, and interpret its solution in terms of the real-world problem. After this we see to what extent the solution is valid in the context of the real-world problem. So, the *stages* involved in mathematical modelling are formulation, solution, interpretation and validation.

We will start by looking at the process you undertake when solving word problems, in Section A2.2. Here, we will discuss some word problems that are similar to the ones you have solved in your earlier classes. We will see later that the steps that are used for solving word problems are some of those used in mathematical modelling also.

In the next section, that is Section A2.3, we will discuss some simple models.

In Section A2.4, we will discuss the overall process of modelling, its advantages and some of its limitations.

A2.2 Review of Word Problems

In this section, we will discuss some word problems that are similar to the ones that you have solved in your earlier classes. Let us start with a problem on direct variation.

Example 1 : I travelled 432 kilometres on 48 litres of petrol in my car. I have to go by my car to a place which is 180 km away. How much petrol do I need?

Solution : We will list the steps involved in solving the problem.

Step 1 : Formulation : You know that farther we travel, the more petrol we require, that is, the amount of petrol we need varies directly with the distance we travel.

Petrol needed for travelling 432 km = 48 litres

Petrol needed for travelling 180 km = ?

Mathematical Description : Let

$x =$ distance I travel

$y =$ petrol I need

y varies directly with x.

So, $y = kx$, where k is a constant.

I can travel 432 kilometres with 48 litres of petrol.

So, $y = 48, x = 432$.

Therefore, $k = \frac{y}{x} = \frac{48}{432} = \frac{1}{9}$.

Since $y = kx$,

therefore, $y = \frac{1}{9}x$ (1)

Equation or Formula (1) describes the relationship between the petrol needed and distance travelled.

Step 2 : Solution : We want to find the petrol we need to travel 180 kilometres; so, we have to find the value of y when $x = 180$. Putting $x = 180$ in (1), we have

$$y = \frac{180}{9} = 20 .$$

Step 3 : Interpretation : Since y = 20, we need 20 litres of petrol to travel 180 kilometres.

Did it occur to you that you may not be able to use the formula (1) in all situations? For example, suppose the 432 kilometres route is through mountains and the 180 kilometres route is through flat plains. The car will use up petrol at a faster rate in the first route, so we cannot use the same rate for the 180 kilometres route, where the petrol will be used up at a slower rate. So the formula works if all such conditions that affect the rate at which petrol is used are the same in both the trips. Or, if there is a difference in conditions, the effect of the difference on the amount of petrol needed for the car should be very small. The petrol used will vary directly with the distance travelled only in such a situation. We assumed this while solving the problem.

Example 2 : Suppose Sudhir has invested ₹ 15,000 at 8% simple interest per year. With the return from the investment, he wants to buy a washing machine that costs ₹ 19,000. For what period should he invest ₹ 15,000 so that he has enough money to buy a washing machine?

Solution : Step 1 : Formulation of the problem : Here, we know the principal and the rate of interest. The interest is the amount Sudhir needs in addition to 15,000 to buy the washing machine. We have to find the number of years.

Mathematical Description : The formula for simple interest is $I = \frac{Pnr}{100}$,

where
P = Principal,
n = Number of years,
r % = Rate of interest
I = Interest earned

Here, the principal = ₹ 15,000

The money required by Sudhir for buying a washing machine = ₹ 19,000

So, the interest to be earned = ₹ (19,000 – 15,000)

= ₹ 4,000

The number of years for which ₹ 15,000 is deposited = n

The interest on ₹ 15,000 for n years at the rate of 8% = I

Then,
$$I = \frac{15000 \times n \times 8}{100}$$

So, $$I = 1200n \tag{1}$$

gives the relationship between the number of years and interest, if ₹ 15000 is invested at an annual interest rate of 8%.

We have to find the period in which the interest earned is ₹ 4000. Putting I = 4000 in (1), we have

$$4000 = 1200n \tag{2}$$

Step 2 : Solution of the problem : Solving Equation (2), we get

$$n = \frac{4000}{1200} = 3\frac{1}{3}.$$

Step 3 : Interpretation : Since $n = 3\frac{1}{3}$ and one third of a year is 4 months, Sudhir can buy a washing machine after 3 years and 4 months.

Can you guess the assumptions that you have to make in the example above? We have to assume that the interest rate remains the same for the period for which we calculate the interest. Otherwise, the formula $I = \frac{Pnr}{100}$ will not be valid. We have also assumed that the price of the washing machine does not increase by the time Sudhir has gathered the money.

Example 3 : A motorboat goes upstream on a river and covers the distance between two towns on the riverbank in six hours. It covers this distance downstream in five hours. If the speed of the stream is 2 km/h, find the speed of the boat in still water.

Solution : Step 1 : Formulation : We know the speed of the river and the time taken to cover the distance between two places. We have to find the speed of the boat in still water.

Mathematical Description : Let us write x for the speed of the boat, t for the time taken and y for the distance travelled. Then

$$y = tx \tag{1}$$

Let d be the distance between the two places.

While going upstream, the actual speed of the boat

= speed of the boat – speed of the river,

because the boat is travelling against the flow of the river.

So, the speed of the boat upstream = $(x – 2)$ km/h

It takes 6 hours to cover the distance between the towns upstream. So, from (1), we get

$$d = 6(x - 2) \tag{2}$$

When going downstream, the speed of the river has to be *added* to the speed of the boat.

So, the speed of the boat downstream = $(x + 2)$ km/h

The boat takes 5 hours to cover the same distance downstream. So,

$$d = 5(x + 2) \qquad (3)$$

From (2) and (3), we have

$$5(x + 2) = 6(x - 2) \qquad (4)$$

Step 2 : Finding the Solution

Solving for x in Equation (4), we get $x = 22$.

Step 3 : Interpretation

Since $x = 22$, therefore the speed of the motorboat in still water is 22 km/h.

In the example above, we know that the speed of the river is not the same everywhere. It flows slowly near the shore and faster at the middle. The boat starts at the shore and moves to the middle of the river. When it is close to the destination, it will slow down and move closer to the shore. So, there is a small difference between the speed of the boat at the middle and the speed at the shore. Since it will be close to the shore for a small amount of time, this difference in speed of the river will affect the speed only for a small period. So, we can ignore this difference in the speed of the river. We can also ignore the small variations in speed of the boat. Also, apart from the speed of the river, the friction between the water and surface of the boat will also affect the actual speed of the boat. We also assume that this effect is very small.

So, we have assumed that

1. The speed of the river and the boat remains constant all the time.
2. The effect of friction between the boat and water and the friction due to air is negligible.

We have found the speed of the boat in still water with the *assumptions* (*hypotheses*) above.

As we have seen in the word problems above, there are 3 *steps in solving a word problem. These are*

1. **Formulation :** We analyse the problem and see which factors have a major influence on the solution to the problem. These are the **relevant factors**. In our first example, the relevant factors are the distance travelled and petrol consumed. We ignored the other factors like the nature of the route, driving speed, etc. Otherwise, the problem would have been more difficult to solve. The factors that we ignore are the **irrelevant factors**.

We then describe the problem mathematically, in the form of one or more mathematical equations.

2. **Solution :** We find the solution of the problem by solving the mathematical equations obtained in Step 1 using some suitable method.

3. **Interpretation :** We see what the solution obtained in Step 2 means in the context of the original word problem.

Here are some exercises for you. You may like to check your understanding of the steps involved in solving word problems by carrying out the three steps above for the following problems.

EXERCISE A 2.1

In each of the following problems, clearly state what the relevant and irrelevant factors are while going through Steps 1, 2 and 3 given above.

1. Suppose a company needs a computer for some period of time. The company can either hire a computer for ₹ 2,000 per month or buy one for ₹ 25,000. If the company has to use the computer for a long period, the company will pay such a high rent, that buying a computer will be cheaper. On the other hand, if the company has to use the computer for say, just one month, then hiring a computer will be cheaper. Find the number of months beyond which it will be cheaper to buy a computer.

2. Suppose a car starts from a place A and travels at a speed of 40 km/h towards another place B. At the same instance, another car starts from B and travels towards A at a speed of 30 km/h. If the distance between A and B is 100 km, after how much time will the cars meet?

3. The moon is about 3,84,000 km from the earth, and its path around the earth is nearly circular. Find the speed at which it orbits the earth, assuming that it orbits the earth in 24 hours. (Use $\pi = 3.14$)

4. A family pays ₹ 1000 for electricity on an average in those months in which it does not use a water heater. In the months in which it uses a water heater, the average electricity bill is ₹ 1240. The cost of using the water heater is ₹ 8.00 per hour. Find the average number of hours the water heater is used in a day.

A2.3 Some Mathematical Models

So far, nothing was new in our discussion. In this section, we are going to add another step to the three steps that we have discussed earlier. This step is called *validation*. What does validation mean? Let us see. In a real-life situation, we cannot accept a model that gives us an answer that does not match the reality. This process of checking the answer against reality, and modifying the mathematical description if necessary, is called *validation*. This is a very important step in modelling. We will introduce you to this step in this section.

First, let us look at an example, where we do not have to modify our model after validation.

Example 4 : Suppose you have a room of length 6 m and breadth 5 m. You want to cover the floor of the room with square mosaic tiles of side 30 cm. How many tiles will you need? Solve this by constructing a mathematical model.

Solution : Formulation : We have to consider the area of the room and the area of a tile for solving the problem. The side of the tile is 0.3 m. Since the length is 6 m, we can fit in $\frac{6}{0.3} = 20$ tiles along the length of the room in one row (see Fig. A2.1.).

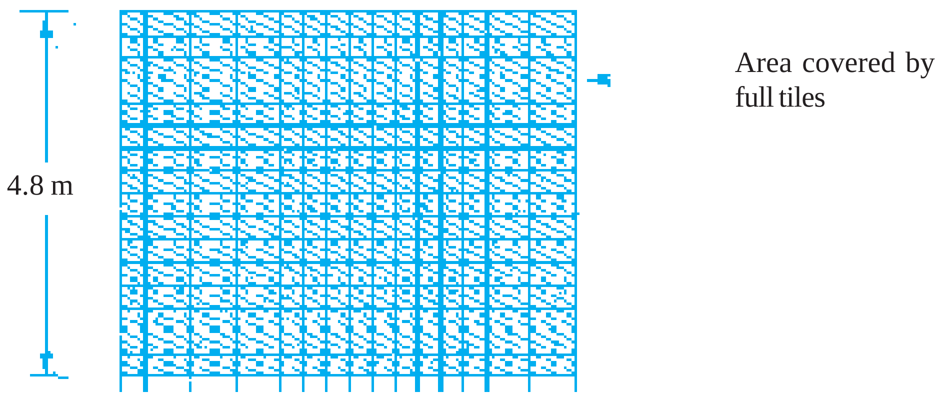

Fig. A2.1

Since the breadth of the room is 5 metres, we have $\frac{5}{0.3} = 16.67$. So, we can fit in 16 tiles in a column. Since $16 \times 0.3 = 4.8$, $5 - 4.8 = 0.2$ metres along the breadth will not be covered by tiles. This part will have to be covered by cutting the other tiles. The breadth of the floor left uncovered, 0.2 metres, is more than half the length of a tile, which is 0.3 m. So we cannot break a tile into two equal halves and use both the halves to cover the remaining portion.

Mathematical Description : We have:

Total number of tiles required = (Number of tiles along the length × Number of tiles along the breadth) + Number of tiles along the uncovered area (1)

Solution : As we said above, the number of tiles along the length is 20 and the number of tiles along the breadth is 16. We need 20 more tiles for the last row. Substituting these values in (1), we get $(20 \times 16) + 20 = 320 + 20 = 340$.

Interpretation : We need 340 tiles to cover the floor.

Validation : In real-life, your mason may ask you to buy some extra tiles to replace those that get damaged while cutting them to size. This number will of course depend upon the skill of your mason! But, we need not modify Equation (1) for this. This gives you a rough idea of the number of tiles required. So, we can stop here.

Let us now look at another situation now.

Example 5 : In the year 2000, 191 member countries of the U.N. signed a declaration. In this declaration, the countries agreed to achieve certain development goals by the year 2015. These are called the *millennium development goals*. One of these goals is to promote gender equality. One indicator for deciding whether this goal has been achieved is the ratio of girls to boys in primary, secondary and tertiary education. India, as a signatory to the declaration, is committed to improve this ratio. The data for the percentage of girls who are enrolled in primary schools is given in Table A2.1.

Table A2.1

Year	Enrolment (in %)
1991-92	41.9
1992-93	42.6
1993-94	42.7
1994-95	42.9
1995-96	43.1
1996-97	43.2
1997-98	43.5
1998-99	43.5
1999-2000	43.6*
2000-01	43.7*
2001-02	44.1*

Source : *Educational statistics, webpage of Department of Education, GOI.*

* *indicates that the data is provisional.*

Using this data, mathematically describe the rate at which the proportion of girls enrolled in primary schools grew. Also, estimate the year by which the enrolment of girls will reach 50%.

Solution : Let us first convert the problem into a mathematical problem.

Step 1 : Formulation : Table A2.1 gives the enrolment for the years 1991-92, 1992-93, etc. Since the students join at the beginning of an academic year, we can take the years as 1991, 1992, etc. Let us assume that the percentage of girls who join primary schools will continue to grow at the same rate as the rate in Table A2.1. So, the number of years is important, not the specific years. (To give a similar situation, when we find the simple interest for, say, ₹ 1500 at the rate of 8% for three years, it does not matter whether the three-year period is from 1999 to 2002 or from 2001 to 2004. What is important is the interest rate in the years being considered). Here also, we will see how the enrolment grows after 1991 by comparing the number of years that has passed after 1991 and the enrolment. Let us take 1991 as the 0th year, and write 1 for 1992 since 1 year has passed in 1992 after 1991. Similarly, we will write 2 for 1993, 3 for 1994, etc. So, Table A2.1 will now look like as Table A2.2.

Table A2.2

Year	Enrolment (in %)
0	41.9
1	42.6
2	42.7
3	42.9
4	43.1
5	43.2
6	43.5
7	43.5
8	43.6
9	43.7
10	44.1

The increase in enrolment is given in the following table :

Table A2.3

Year	Enrolment (in %)	Increase
0	41.9	0
1	42.6	0.7
2	42.7	0.1
3	42.9	0.2
4	43.1	0.2
5	43.2	0.1
6	43.5	0.3
7	43.5	0
8	43.6	0.1
9	43.7	0.1
10	44.1	0.4

At the end of the one-year period from 1991 to 1992, the enrolment has increased by 0.7% from 41.9% to 42.6%. At the end of the second year, this has increased by 0.1%, from 42.6% to 42.7%. From the table above, we cannot find a definite relationship between the number of years and percentage. But the increase is fairly steady. Only in the first year and in the 10th year there is a jump. The mean of the values is

$$\frac{0.7 + 0.1 + 0.2 + 0.2 + 0.1 + 0.3 + 0 + 0.1 + 0.1 + 0.4}{10} = 0.22$$

Let us assume that the enrolment steadily increases at the rate of 0.22 per cent.

Mathematical Description : We have assumed that the enrolment increases steadily at the rate of 0.22% per year.

So, the Enrolment Percentage (EP) in the first year = 41.9 + 0.22

EP in the second year = 41.9 + 0.22 + 0.22 = 41.9 + 2 × 0.22

EP in the third year = 41.9 + 0.22 + 0.22 + 0.22 = 41.9 + 3 × 0.22

So, the enrolment percentage in the nth year = 41.9 + 0.22n, for $n \geq 1$. (1)

Now, we also have to find the number of years by which the enrolment will reach 50%. So, we have to find the value of *n* in the equation or formula

$$50 = 41.9 + 0.22n \qquad (2)$$

Step 2 : Solution : Solving (2) for *n*, we get

$$n = \frac{50 - 41.9}{0.22} = \frac{8.1}{0.22} = 36.8$$

Step 3 : Interpretation : Since the number of years is an integral value, we will take the next higher integer, 37. So, the enrolment percentage will reach 50% in 1991 + 37 = 2028.

In a word problem, we generally stop here. But, since we are dealing with a real-life situation, we have to see to what extent this value matches the real situation.

Step 4 : Validation: Let us check if Formula (2) is in agreement with the reality. Let us find the values for the years we already know, using Formula (2), and compare it with the known values by finding the difference. The values are given in Table A2.4.

Table A2.4

Year	Enrolment (in %)	Values given by (2) (in %)	Difference (in %)
0	41.9	41.90	0
1	42.6	42.12	0.48
2	42.7	42.34	0.36
3	42.9	42.56	0.34
4	43.1	42.78	0.32
5	43.2	43.00	0.20
6	43.5	43.22	0.28
7	43.5	43.44	0.06
8	43.6	43.66	–0.06
9	43.7	43.88	–0.18
10	44.1	44.10	0.00

As you can see, some of the values given by Formula (2) are less than the actual values by about 0.3% or even by 0.5%. This can give rise to a difference of about 3 to 5 years since the increase per year is actually 1% to 2%. We may decide that this much of a difference is acceptable and stop here. In this case, (2) is our mathematical model.

Suppose we decide that this error is quite large, and we have to improve this model. Then we have to go back to Step 1, the formulation, and change Equation (2). Let us do so.

Step 1 : Reformulation : We still assume that the values increase steadily by 0.22%, but we will now introduce a correction factor to reduce the error. For this, we find the mean of all the errors. This is

$$\frac{0 + 0.48 + 0.36 + 0.34 + 0.32 + 0.2 + 0.28 + 0.06 - 0.06 - 0.18 + 0}{10} = 0.18$$

We take the mean of the errors, and correct our formula by this value.

Revised Mathematical Description : Let us now add the mean of the errors to our formula for enrolment percentage given in (2). So, our corrected formula is:

Enrolment percentage in the nth year = $41.9 + 0.22n + 0.18 = 42.08 + 0.22n$, for $n \geq 1$ (3)

We will also modify Equation (2) appropriately. The new equation for n is:

$$50 = 42.08 + 0.22n \qquad (4)$$

Step 2 : Altered Solution : Solving Equation (4) for n, we get

$$n = \frac{50 - 42.08}{0.22} = \frac{7.92}{0.22} = 36$$

Step 3 : Interpretation: Since $n = 36$, the enrolment of girls in primary schools will reach 50% in the year 1991 + 36 = 2027.

Step 4 : Validation: Once again, let us compare the values got by using Formula (4) with the actual values. Table A2.5 gives the comparison.

Table A2.5

Year	Enrolment (in %)	Values given by (2)	Difference between values	Values given by (4)	Difference between values
0	41.9	41.90	0	41.9	0
1	42.6	42.12	0.48	42.3	0.3
2	42.7	42.34	0.36	42.52	0.18
3	42.9	42.56	0.34	42.74	0.16
4	43.1	42.78	0.32	42.96	0.14
5	43.2	43.00	0.2	43.18	0.02
6	43.5	43.22	0.28	43.4	0.1
7	43.5	43.44	0.06	43.62	– 0.12
8	43.6	43.66	– 0.06	43.84	– 0.24
9	43.7	43.88	– 0.18	44.06	– 0.36
10	44.1	44.10	0	44.28	– 0.18

As you can see, many of the values that (4) gives are closer to the actual value than the values that (2) gives. The mean of the errors is 0 in this case.

We will stop our process here. So, Equation (4) is our mathematical description that gives a mathematical relationship between years and the percentage of enrolment of girls of the total enrolment. We have constructed a mathematical model that describes the growth.

The process that we have followed in the situation above is called mathematical modelling.

We have tried to construct a mathematical model with the mathematical tools that we already have. There are better mathematical tools for making predictions from the data we have. But, they are beyond the scope of this course. Our aim in constructing this model is to explain the process of modelling to you, not to make accurate predictions at this stage.

You may now like to model some real-life situations to check your understanding of our discussion so far. Here is an Exercise for you to try.

EXERCISE A2.2

1. We have given the timings of the gold medalists in the 400-metre race from the time the event was included in the Olympics, in the table below. Construct a mathematical model relating the years and timings. Use it to estimate the timing in the next Olympics.

Table A2.6

Year	Timing (in seconds)
1964	52.01
1968	52.03
1972	51.08
1976	49.28
1980	48.88
1984	48.83
1988	48.65
1992	48.83
1996	48.25
2000	49.11
2004	49.41

A2.4 The Process of Modelling, its Advantages and Limitations

Let us now conclude our discussion by drawing out aspects of mathematical modelling that show up in the examples we have discussed. With the background of the earlier sections, we are now in a position to give a brief overview of the steps involved in modelling.

Step 1 : Formulation : You would have noticed the difference between the formulation part of Example 1 in Section A2.2 and the formulation part of the model we discussed in A2.3. In Example 1, all the information is in a readily usable form. But, in the model given in A2.3 this is not so. Further, it took us some time to find a mathematical description. We tested our first formula, but found that it was not as good as the second one we got. This is usually true in general, i.e. when trying to model real-life situations; the first model usually needs to be revised. When we are solving a real-life problem, formulation can require a lot of time. For example, Newton's three laws of motion, which are mathematical descriptions of motion, are simple enough to state. But, Newton arrived at these laws after studying a large amount of data and the work the scientists before him had done.

Formulation involves the following three steps :

(i) Stating the problem : Often, the problem is stated vaguely. For example, the broad goal is to ensure that the enrolment of boys and girls are equal. This may mean that 50% of the total number of boys of the school-going age and 50% of the girls of the school-going age should be enrolled. The other way is to ensure that 50% of the school-going children are girls. In our problem, we have used the second approach.

(ii) Identifying relevant factors : Decide which quantities and relationships are important for our problem and which are unimportant and can be neglected. For example, in our problem regarding primary schools enrolment, the percentage of girls enrolled in the previous year can influence the number of girls enrolled this year. This is because, as more and more girls enrol in schools, many more parents will feel they also have to put their daughters in schools. But, we have ignored this factor because this may become important only after the enrolment crosses a certain percentage. Also, adding this factor may make our model more complicated.

(iii) Mathematical Description : Now suppose we are clear about what the problem is and what aspects of it are more relevant than the others. Then we have to find a relationship between the aspects involved in the form of an equation, a graph or any other suitable mathematical description. If it is an equation, then every important aspect should be represented by a variable in our mathematical equation.

Step 2 : Finding the solution : The mathematical formulation does not give the solution. We have to solve this mathematical equivalent of the problem. This is where your mathematical knowledge comes in useful.

Step 3 : Interpretating the solution : The mathematical solution is some value or values of the variables in the model. We have to go back to the real-life problem and see what these values mean in the problem.

Step 4 : Validating the solution : As we saw in A2.3, after finding the solution we will have to check whether the solution matches the reality. If it matches, then the mathematical model is acceptable. If the mathematical solution does not match, *we go back to the formulation step* again and try to improve our model.

This step in the process is one major difference between solving word problems and mathematical modelling. This is one of the most important step in modelling that is missing in word problems. Of course, it is possible that in some real-life situations, we do not need to validate our answer because the problem is simple and we get the correct solution right away. This was so in the first model we considered in A2.3.

We have given a summary of the order in which the steps in mathematical modelling are carried out in Fig. A2.2 below. Movement from the validation step to the formulation step is shown using a **dotted arrow**. This is because it may not be necessary to carry out this step again.

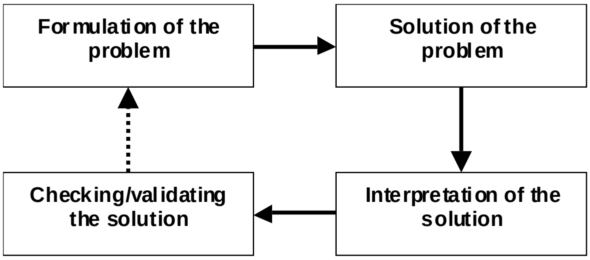

Fig.A2.2

Now that you have studied the stages involved in mathematical modelling, let us discuss some of its aspects.

The *aim* of mathematical modelling is to get some useful information about a real-world problem by converting it into a mathematical problem. This is especially useful when it is not possible or very expensive to get information by other means such as direct observation or by conducting experiments.

You may also wonder why we should undertake mathematical modelling? Let us look at some **advantages of modelling**. Suppose we want to study the corrosive effect of the discharge of the Mathura refinery on the Taj Mahal. We would not like to carry out experiments on the Taj Mahal directly since it may not be safe to do so. Of course, we can use a scaled down physical model, but we may need special facilities for this, which may be expensive. Here is where mathematical modelling can be of great use.

Again, suppose we want to know how many primary schools we will need after 5 years. Then, we can only solve this problem by using a mathematical model. Similarly, it is only through modelling that scientists have been able to explain the existence of so many phenomena.

You saw in Section A2.3, that we could have tried to improve the answer in the second example with better methods. But we stopped because we do not have the mathematical tools. This can happen in real-life also. Often, we have to be satisfied with very approximate answers, because mathematical tools are not available. For example, the model equations used in modelling weather are so complex that mathematical tools to find exact solutions are not available.

You may wonder to what extent we should try to improve our model. Usually, to improve it, we need to take into account more factors. When we do this, we add more variables to our mathematical equations. We may then have a very complicated model that is difficult to use. A model must be simple enough to use. A good model balances two factors:

1. Accuracy, i.e., how close it is to reality.
2. Ease of use.

For example, Newton's laws of motion are very simple, but powerful enough to model many physical situations.

So, is mathematical modelling the answer to all our problems? Not quite! It has its limitations.

Thus, we should keep in mind that a model is *only a simplification* of a real-world problem, and the two are not the same. It is something like the difference between a map that gives the physical features of a country, and the country itself. We can find the height of a place above the sea level from this map, but we cannot find the characteristics of the people from it. So, we should use a model only for the purpose it is supposed to serve, remembering all the factors we have neglected while constructing it. We should apply the model only within the limits where it is applicable. In the later classes, we shall discuss this aspect a little more.

EXERCISE A2.3

1. How are the solving of word problems that you come across in textbooks different from the process of mathematical modelling?

2. Suppose you want to minimise the waiting time of vehicles at a traffic junction of four roads. Which of these factors are important and which are not?

(i) Price of petrol.

(ii) The rate at which the vehicles arrive in the four different roads.

(iii) The proportion of slow-moving vehicles like cycles and rickshaws and fast moving vehicles like cars and motorcycles.

A2.5 Summary

In this Appendix, you have studied the following points :

1. The steps involved in solving word problems.

2. Construction of some mathematical models.

3. The steps involved in mathematical modelling given in the box below.

1. **Formulation :**
   (i) Stating the question
   (ii) Identifying the relevant factors
   (iii) Mathematical description
2. **Finding the solution.**
3. **Interpretation of the solution in the context of the real-world problem.**
4. **Checking/validating to what extent the model is a good representation of the problem being studied.**

4. The aims, advantages and limitations of mathematical modelling.