METRIC SYSTEM IN SECONDARY SCHOOLS

DEPARTMENT OF CURRICULUM, METHODS & TEXTBOOKS
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH & TRAINING

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Handbook for Teachers and Textbook Writers

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FOREWORD

The introduction of the decimal system of coinage and the Metric System of weights and measures urgently calls for orienting school instruction to the changed conditions, especially in the field of mathematics. The new changes have simplified many arithmetical processes ; they also point to a new emphasis on topics like decimals, logarithms and approximation. Their use has also resulted in greater facility in computation. All these things have to be brought home to the student in school through the mathematics textbooks and the day-to-day instruction in the classroom.

The present handbook, which has been prepared by Shri R.C. Sharma, a Senior Research Officer of the Department, aims at assisting the teacher and the textbook-writer in adapting instructional material to suit the new needs and purposes. It covers the requirements of the high school and higher secondary classes and attempts to show in detail how the reform has affected not only the presentation and solution of mathematical problems but the mathematics syllabus as well.

Our grateful thanks are due to Shri P.D. Sharma, Vice-Principal, Regional College of Education, Ajmer, National Council of Educational Research and Training, for his guidance in the preparation of the book. We are equally grateful to Shri Om Prakash, Assistant Director, Metric Measures, in the Ministry of Commerce and Industries, for his very useful suggestions for improvement and also for the help he ungrudgingly gave in the collection of necessary material.

B. *Ghosh*
Head of the Department
of Curriculum, Methods and Textbooks

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CHAPTER I

INTRODUCTION

Need for a Change

The units of money, weights and measures affect everyone of us throughout our lives in one way or the other. Every day innumerable transactions involving calculations of money or weights or measures have to be made. If the system of coinage weights and measures change from one place to another, we have to relearn every differing mode of calculation. Some handicaps as a result of this disparity in the past were the following :

1. The number of different standards of weights and measures in use in the country was incredibly large. Systems prevalent in one part of the country were quite different from those of the other parts. Even different cities in the same State often had different versions of the same unit.

2. A number of purely local measures was used in very small towns and villages.

3. Units used in scientific calculations differed from those used in business. While metric units were being used in the former, in the market either Imperial or Indian units were prevalent. This difference added to the confusion.

4. The same kind of confusion existed in the case of coins as well. Before 1947 many Native States in India had coins of their own, which differed in shape and value from those used in British India.

5. This diversity in the standards of money, weights and measures often resulted in undesirable manipulation in prices and quantities. Dishonest shopkeepers used one set of weights and measures for purchase and another for sale.

Adoption of the New System

It is one of the primary functions of a good government to standardize the units of money, weights and measures in the country. The Government of India was paying serious attention to it even during British rule. In 1939 a law was enacted to standardize weights throughout the country in terms of the 'seer' (of 80 tolas) and the 'pound'. Since then the advantages of the metric system were being considered, and after Independence the idea grew stronger in its favour.

In 1946, the Bangalore session of the Indian Science Congress Association stressed the need for the decimalization of currency, weights and measures. Thereupon the Government of India invited opinion from all the State Governments, and in 1955, The Indian Coinage (Amendment) Act divided the rupee into 100 units.* The Act was brought into force on April 1, 1957. The new coins, it was said, would be one rupee (100 nP), half rupee (50 nP), quarter rupee (25 nP), 10 nP, 5 nP, 2 nP and 1 nP. The weight of the old rupee was one tola and it served the purpose of weighing gold and silver. Accordingly the new rupee coin was given a weight of 10 grammes (now-a-days gold and silver are weighed in grammes and rates are quoted as per 10 grammes). The weights of the other coins are as follows :

50 nP = 5 grammes
25 nP = 2·5 grammes
10 nP = 5 grammes
5 nP = 4 grammes
2 nP = 3 grammes
1 nP = 1·5 grammes

That very year, the Indian Parliament took a bold decision by adopting a resolution to standardize weights and measures in terms of the metric units. Following the acceptance in principle of the metric system by the Lok Sabha, the Government sponsored in the Parliament a bill known as 'The Standards of Weights and Measures Bill', which received the President's assent in December, 1956. This Act defines the primary units of mass and length, units of capacity, time, electric current and luminosity, and the scale of temperature and repeals all previous State Acts establishing

* Since June 1, 1964, the smallest coin is designated as *paisa* instead of *naya paisa*. *Naya paisa* on this and subsequent pages should, therefore, be read as *paisa*.

standards of money, weights and measurement and provides for a gradual transition to the new system within a period of ten years.

Progress Made since the Introduction of the System

(A) Commerce

(*i*) *Money.* All old coins have ceased to be legal tenders. In all Government offices and in the market also, rates are quoted in the new units. Only a few hawkers and petty shop-keepers continue to quote the rates in rupees and annas, but it is a very temporary phase.

(*ii*) *Metric Weights.* The metric weights are also now being used in progressively larger areas in the country in the commercial and industrial fields. From April 1962 only metric weights are being used, and a person using weights other than metric is liable to be prosecuted and punished. Though it has not yet been possible to completely stop the use of old weights, which some petty traders continue to use, the practice will soon cease.

(*iii*) *Metric Measures for Length.* Compulsion to use only metric measures for length has been started from October, 1962. In the cloth market wholesale dealers are using metric measures. Retailers, however, go on using both old and new measures.

(*iv*) *Capacity.* In case of capacity the use of metric measures has become compulsory from April 1963, and the use of units other than metric is now illegal in all commercial transactions.

(B) Industry

In all major industries metric units are being used in buying materials for stores and in selling products. The bulk of the productive equipment (machines, tools, etc.) in industry continues to be on the inch-pound system.

(C) Public Undertakings

Public undertakings have been in the forefront in the matter of this reform. The commercial branches of the Railways, Post and Telegraphs, and Customs and Central Excise departments have all adopted the metric system in their dealings with the public. The metric system is also being gradually brought into use in the Survey, Land Records, and Printing and Stationery departments.

(D) Education

(*i*) *Higher Technical Education.* In this field the change involves the replacement or recalibration of measuring tools and instruments, most of which are not manufactured in India. Another difficulty is the non-availability of textbooks, which are mostly British or American. The inch-pound system of measurement is, therefore, being exclusively used in engineering colleges and higher technical institutions. But a programme has been drawn up for these institutions to replace the old units. According to this programme the metric system was adopted in teaching in the first and second year classes of the five-year integrated course from the academic year 1962-63, and then progressively in the higher classes. From 1970, the metric system will be exclusively used in examinations for recruitment to the All-India Engineering Services. Between 1966 and 1970, both the systems—imperial and metric—will be used in these examinations.

(*ii*) *Non-Technical Education.* Here the difficulty is not so formidable. In the teaching of science the system was already in use. In other subjects efforts are being made by changing the syllabi and by revising textbooks. Sometimes, additional chapters on the metric system are added. But this is not enough. Some suggestions in this regard are given below.

(*iii*) *Metric Units and School Textbooks.* While sufficient progress has been made in the use of the metric system and decimal coins in other fields, in school textbooks the progress is not satisfactory. The addition of an extra chapter on the metric system becomes an extra burden on the pupils and does not imbibe the spirit of the reform. The Government of India has decided to complete the change-over by 1966, but the change is yet imperceptible in school textbooks. The ultimate success of the system will depend upon the young now in schools. There are two obstacles in the way (*a*) existence of old weights and measurements in the market : by the time the students leave schools they will not find the old units in the bazar. Of course, the pound system being a world system may be taught at a later stage in the child's education. (*b*) Change in textbooks : Parliament enacted the legislation in 1955 and the bill received the President's assent in 1956. Since then eight years have passed. A survey of school textbooks carried out by the Ministry of Commerce & Industry on the use of new units reveals that new coins are being used in only 20% to 50% of the textbooks. In all State textbooks new and old coins are being used side by side. In some books purely old units for weights and measures have been used.*

The Implementation of the System

(*i*) *Textbooks.* The All-India Council for Secondary Education in its meeting held in April, 1962, has rightly suggested that all textbooks on arithmetic, geometry, home science, science and geography should be revised by the end of 1963-64, so as to introduce metric system and that the new books should have only the metric units from the lowest to the highest class. Other units that may be necessary may be briefly taught in the secondary classes.

(*ii*) *The Syllabus.* The revision or rewriting of text books alone is not sufficient. A proper reorientation of the school syllabus is an important and urgent task to get the desired result.

(*iii*) *The Teacher.* To make classroom teaching realistic and meaningful teachers will have to understand the implication of the reform. Only a little information on the metric system or mere substitution of old units by new ones will not solve the problem. A new outlook should be given to the teaching of arithmetic.

The following suggestions are worth consideration:

(*a*) Students should be made 'metric-minded' and teachers must help students to appreciate, to appraise and to interpret the new change.

(*b*) Emphasis will have to be given to the teaching of decimals. The metric units of weight and length are the most natural means to initiate the pupils into the decimal representation of numbers.

* For details see *Adoption of Metric System in India—Five years of Progress* (Government of India, Ministry of Commerce and Industry, 1962)

(*c*) All references to old Indian units should be immediately stopped. If new books are not available, new problems involving only metric units should be framed by the teacher for classroom practice as well as for terminal and other examinations.

(*d*) The use of old editions of arithmetic textbooks should be prohibited, for these use only old units of money, weights and measures.

(*iv*) *The Author.* The author also has an important task to perform. All illustrations and examples used by him should be based on the new units. Long tables of indigenous units, often memorized without any understanding, must not be included. Above all, the author should in no case substitute in old examples new units for old. They sometimes become unrealistic and unrelated to life.

Scope of the Present Book

The need for guidance to teachers and textbook-writers in this matter was realized by the Government of India as early as 1957 and accordingly a pamphlet, *A Manual for Teachers*, was prepared that year. It was reprinted in 1959. Copies of this manual were sent to the States also. The Ministry of Commerce and Industry also published articles in its journal, 'Metric Measures'. Yet the desired result was not achieved.

In April 1962, the All-India Council for Secondary Education decided to publish two guide-books on the use of the metric system in schools—one for primary classes and the other for the secondary. The guide-book for primary classes has already been published and the present book is meant for secondary classes.

The purpose of the book is to give suggestions for bringing out proper textbooks using the metric system. It, therefore, deals with metric units and their advantages; suggestions for a change in the mathematics syllabi; problems in mathematics and the effect of the new units on topics in arithmetic and allied subjects. Examples are given on the use of skills and manipulations of the new system to prove how calculations have become much easier and simpler now.

There are also suggestions for teachers on the method of approach. On the whole, it aims at impressing upon both textbook-writers and teachers that the metric system should be taught as a national system which the children will be using in their day-to-day lives and must not, therefore, be limited to the realm of knowledge alone.

CHAPTER II

METRIC UNITS AND THEIR ADVANTAGES

The Standards of Weights and Measures Act of 1956 defines the primary units of mass, length, capacity, time, electricity, current and luminosity and the scale of temperature. Authors of textbooks may include these definitions along with their historical backgrounds for motivation and cultural development.

Primary Units

1. *Metre.* It has been derived from the Latin word 'metrum', meaning measure. In 1875, The International Bureau of Weights and Measures set up by an International Treaty in France called a Metric Convention. This Convention formally approved the 'Prototype Standards of the International Metric System' by the year 1889.

The International Metre, with which all metres are measured throughout the entire world, is the distance at zero degree centigrade under normal atmospheric pressure between the axes of the two median lines traced on a bar of mixture (alloy) of 90 per cent platinum and 10 per cent iridium maintained at the International Bureau of Weights and Measures, Paris. In October, 1960, the eleventh General International Conference on Weights and Measures, taking into consideration that the International Prototype does not define the metre with a precision sufficient for the actual needs of metrology and also that it is on the other hand desirable to adopt a natural and indestructible standard, decided upon the following definition:

The Metre is the length equal to 1650765.73 wavelengths in vacuum of the radiation corresponding to transition between the levels $2P_{10}$ and $5d_5$ of the atom of krypton 86.

2. *Normal atmospheric pressure* means the pressure exercised by 101325 newtons per square metre, a newton being

the force which imparts to a mass of one kilogramme an acceleration of one metre per second per second.

3. *Kilogramme* means the mass of the platinum-iridium cylinder deposited at the International Bureau of Weights and Measures and declared the International Prototype of kilogramme by the first General Conference of Weights and Measures.

4. *Carat* which is the primary unit of mass for precious stones is equal to 1/5000th part of one kilogramme.

5. *Second* which is the primary unit of time means 1/31556925.975 of the length of the tropical year for 1900, the year commencing at 12.00 hours ephemeris time on January 1, 1900.

Note: The Eleventh General Conference of Weights and Measures has ratified the definition as 'The second is the fraction 1/31556925.9747 of the tropical year for 1900 January 0 at 12 hours ephemeris time'.

6. *Square metre* is the primary unit of area.

7. *Cubic metre* is the primary unit of volume.

8. *Litre*, the primary unit of capacity, is the volume occupied by the mass of one kilogramme of pure air-free water at the temperature of its maximum density and under normal atmospheric pressure.

9. *Centigrade scale* is the scale of temperature, otherwise known as Celsius, where the temperature under normal atmospheric pressure is taken to be zero degree at the melting point of ice and one hundred degrees at the boiling point of water.

International Principal Units

No.	Physical Standard	Units of Measure	Abbreviation
1.	Length	Metre	m
2.	Mass	Tonne, Kilogramme, gramme	t, kg, g
3.	Time	Second	s
4.	Temperature	Degree centigrade	c°
5.	Thermodynamic Temperature	Degree Kelvin	°k
6.	Electric current	Ampere	A
7.	Luminous intensity	Candela	cd

Teaching of these definitions. These scientific definitions of the various primary units may not be easily understood by the students of the middle classes. So in these classes only a practical demonstration of the units of weights and lengths will serve the purpose. For the units of time and temperature the use of a clock and a thermometer should respectively be made. In textbooks for the secondary classes the exact definitions may be given and clearly explained both through the textbook and by the teacher.

National Prototypes. As required by law the Central Government keeps in its custody a standard kilogramme and a standard metre, conforming to the definitions and to a very high degree of accuracy. These Prototypes *authenticated* against the International Prototypes maintained by the International Bureau of Weights and Measures, are called the National Prototypes of the metre and kilogramme. The Central Government has the duty of supplying a set of such standards free to each State Government. These standards verified against the National Prototypes by the National Physical Laboratory are called Reference Standards.

Secondary Units

The Central Government has been empowered to declare secondary units with reference to primary units. Every secondary unit should be an integral power of 10, positive or negative, of the corresponding primary unit. The secondary units as notified by the Government in Part II, Section 3, Sub-section (II), of the Gazette of India, dated March 2, 1963, have been given in the appendix at the end of the book.

In commercial transactions all units, primary and secondary, are not used. Long distances are measured in kilometres and in textiles and in measuring short distances the units of metre and centimetre are used. In retail trade by weight the units to be used are kilogramme and gramme. The other weights used are of 1000 grammes (kilogramme), 500 grammes, 200 grammes and 100 grammes. For weighing precious things like ornaments, stones and medicines the use of gramme and its sub-units is made. For liquids the use of litre and half-litre is frequent. In the wholesale trade tonne and quintal are used. The units of area, volume and capacity have been discussed later in Chapter VI. In schools students will have to learn all units because they have to use them all, some in arithmetic, others in geometry and science. *Authors and teachers of arithmetic have to be very careful in framing problems. They should use only suitable units and in the manner suggested.*

Other Units

Primary metric units have been divided and sub-divided into many sub-units, bearing a uniform base of 10. Every sub-unit is an integral power of 10, positive or negative, of another sub-unit.

Some of these units used in trade have been given above. The other units are used only in scientific and technological work. The detailed lists of these units along with the units of area and volume, time, money and of common measures of length and weight used in the market have been given in appendix at the end of the book.

Abbreviations

The abbreviations accepted by the Government of India are based on international practice and should be used in scientific publications, statistical data and in teaching in schools, colleges and technical institutions, *i.e.*, wherever abbreviations have to be used. The approved abbreviations are :

	Denomination	*Abbreviation*
1. Length :	Kilometre	km
	metre	m
	centimetre	cm
	millimetre	mm
	micron	μ
2. Weight :	Tonne	t
	quintal	q
	kilogramme	kg
	gramme	g
	milligramme	mg
	carat (200 mg)	k

3.	Capacity :	kilolitre	kl
		litre	l
		millilitre	ml
4.	Area :	square kilometre	km^2 or sq km*
		square metre	m^2 or sq m*
		square centimetre	cm^2 or sq cm*
		square millimetre	mm^2 or sq mm*
5.	Volume :	cubic metre	m^3 or cu m*
		cubic centimetre	cm^3 or cu cm*
		cubic millimetre	mm^3 or cu mm*

(Please see also the appendix at the end)

Rules for Abbreviations

To ensure the correct use of abbreviations the following rules should be borne in mind :

1. 'S' should not be added to indicate plurality. Write 1 kg, 15 kg, 20 g, 17 km, 2 cm, 20 ml, 32 l, 25 m^2, 69 km^3, 100 cm^3, etc.

2. Avoid capitalization of the abbreviations. 3Kg, 5Km, 20M, 25MM, 30L, 35M^3, etc., are not correct. The right way is to write 3 kg, 5 km, 20 m, 25mm, 30l, 35 m^3, etc.

3. Do not use any other abbreviations except those given above.

Note : In case of money Re should be used for a single rupee and Rs for indicating plurality. For one naya paisa 1 nP and for plurality also nP should be used.

The authors have to be very careful about these abbreviations while writing books and the teachers have to be careful in day-to-day working. The students should not be allowed to form bad habits of using wrong abbreviations. If the habit is once formed it will be very difficult to eradicate it at later stages.

Advantages of the Metric Units

Quite a large number of students will raise the question

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*Both these abbreviations are correct, but the first set should preferably be used, for internationally it is used more commonly.

'Why were metric units adopted by the Government of India ?' It is a natural question and the teacher has to satisfy his students. To bring about this change, the Government had to face many difficulties and also had to declare illegal all old units. So naturally this system must have certain advantages over the old one. These advantages are as under :

1. The metric system is one of the two major international systems of weights and measures recognized everywhere in the world and is used by about 85 per cent of the world population. This very fact speaks of the utility of the system.

   Even the United Kingdom and the United States of America, which have not yet adopted the system, are thinking of adopting it. It is becoming *inevitable* for them on account of the pressure of international trade and commerce.

2. After having once adopted this system, no nation has ever turned back from it. Had *there* been *any* drawbacks in its use, some countries would have gone back to the older system. There is *not a single example of* this type.

3. Scientists all over the world use this system. Much waste of effort can be saved by learning a system which is uniform in every aspect of life.

4. Many commonly used machine-parts and simple calculating machines have been standardized and designed on this system. For a country like India, busy in industrial and technical development, the adoption of the system was thus imperative.

5. The system provides greater facility in calculations, particularly in conjunction with decimals. Computation work becomes much easier. All operations involve mostly decimal fractions which can be done (*a*) just like the operations of integers, (*b*) by using logarithms and (*c*) by using calculating machines. Illustrative examples will be found in the next few pages.

6. The system saves considerable time previously spent on fundamental operations and manipulations of fractions

and compound numbers. Some experts consider this time saved to be 20% of the student's time.

7. Brevity, speed and efficiency will be remarkably improved by the use of this system. These are qualities of decimal fractions which form the basis of metric units.

8. Accuracy of answers is another advantage. It is so because of the simplicity of operations, which is inherent in the manipulation of decimals.

Below is given a comparative study with examples to illustrate certain specific advantages of the metric system over the British and old Indian units.

9. All units and sub-units in the metric system have a homogeneous relationship. Every upper unit is 10 times the lower unit, which is a very simple relation. In the case of area this relationship is based on 100 and in volume on 1000. In the case of money also the units are uniformly related on the base of 100.

On the other hand, the British units are a collection of separate, heterogeneous units which had independent origin and were later welded into a system. The example of units of length will make the point clear.

In the twelfth century a 'yard' was defined as the distance between the 'tip of the nose of His Majesty Henry I of England and the tip of the thumb of his outstretched hand'. The 'foot' was defined in the sixteenth century as the 'average tread of 16 men' and was divided into 12 inches. The legal 'rod' was 16½ feet long. The heterogeneous sub-divisions in the inch system speak of the difficulties in conversion. Then, for long distances 220 yards make a furlong and eight furlongs or 1760 yards make a mile. In case of area and volume these difficulties are doubled and trebled.

In weights also the units are heterogeneous. The money units, pound, shilling, pence and farthing, are not uniformly related either. There are about fifty-three concepts or terms in the British system of weights and measures. The old Indian units of money and weight were also heterogeneous. 3 pies = 1 pice; 4 pice = 1 anna and 16 annas = Re 1. In weights also, the interrelations were not uniform. One maund was equal to 40 seers, a seer contained 16 chhataks and a chhatak was equal to 5 tolas. A tola was further divided into 12 mashas and a masha was equal to 8 rattis.

In the primary classes the child had to solve many problems on reduction—ascending and descending. With these heterogeneous ratios in units the difficulty was very great. The metric system has very much simplified the process. A few examples will clarify it.

(*a*) *Length*

Example 1. (*British units*). How many yards of boundary wire is needed for a road 17 miles, 3 furlongs and 192 yards long, if the boundary is to be marked on both sides of the road ?

Solution :

Miles	Furlongs	Yards
17	3	192
×8	+136	+30580
136 furlongs	139	30772
	×220	
	2780	
	2780	
	30580 yards	

Ans. 30772 yards.

(*b*) *Weight*

Example 2. (*British Units*). Convert 23 tons 13 cwts 2 qrs 23 lbs 9 oz to ounces.

Solution :

Tons	cwt	qr	lb	oz
23	13	2	23	9
×20	+460	+1892	+53032	+848880
460 cwt.	473	1894	53055	848889
	×4	×28	×16	
	1892 qr.	15152	848880 oz	
		3788		
		53032 lb		

Ans. 848889 oz

Example 3. (*Indian Units*). From a state 4 mds 37 srs 14 chs 3 tolas 9 mashas 6 rattis of gold has been collected for the National Defence Fund. Find the price of this gold at the rate of Rs. 11 00 per masha.

Solution :

For finding the price we have to convert the weights into rattis.

md.	sr.	ch.	tola
4	37	14	3
×40	+160	+3152	+15830
160 seers	197	3166	15833
	×16	×5	
	3152 ch.	15830 tolas	

tola	masha	ratti
15833	9	6
×12	+189996	+1520040
189996 mashas	190005	1520046
	×8	
	1520040 rattis	

$\therefore$ Total gold $= \frac{1520046}{8}$ mashas $= \frac{760023}{4}$ mashas

$\therefore$ Price $= \frac{760023}{4} \times$ Rs $11 =$ Rs $\frac{8360253}{4}$

$=$ Rs 2090063.25 nP.

Ans. Rs 2090063.25 nP.

In the above examples huge multiplications have been done. Think of the patience, energy and time required on the part of the pupils when such operations are involved as part of the problems. Then, this is only one aspect of the whole picture. There may be problems

(*a*) involving long divisions (in case of ascending reductions),

(*b*) on areas where the multipliers or the divisors will be 9 or 144 or 64 or 4840 and the like.

(*c*) on volumes where the multipliers or the divisors will be 27 or 1728 or 512 or the like.

It is all due to the heterogeneous nature of the units and sub-units.

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(*a*) *Length*

Example 4. How many metres of boundary wire will be needed for a road 37 km 7 hm 2 dam 9 m long ?

Solution :

	37 km	7 hm	2 dam	9 m=37729 m
or	km	hm	dam	m
	37	7	2	9=37729 m

(*Note.* Put a zero for the unit which is missing as shown in the next example).

(*b*) *Weight*

Example 5. Convert 23 kg 6 g 7 cg 9 mg into milligrams.

Solution :

kg.	hg	dag	g	dg	cg	mg
23	0	0	6	0	7	9=23006079 mg.

Ans. *23006079 mg.*

(*c*) *Money*

Example 6. (*British Units*). The washing charges paid by a person are at the rate of a penny per cloth. If the number of clothes washed during the year be 41732, find the amount spent.

Solution :

The amount spent=41732 d.

Now,

12	41732 d.
20	3427 s.—8 d.
	£173—17 s.

Ans. *£173.17 s..8 d.*

Example 7. (*Old Indian System*). If a balloon costs one pie to a manufacturer, find the number produced at the cost of Rs 526.13 as. 2 p.

Solution :

Rs.	as.	p.
526	13	2
× 16	8416	101148
8416 as.	8429	101150
	× 12	
	101148 p.	

∴ the number of balloons=101150.

Metric System

Example 8. If a balloon costs one naya paisa to a manufacturer, find the number produced at the cost of Rs. 526.87 nP.

Solution : Change Rs. 526 and 87 nP. to naye paise.

Rs.	nP.
526	87

=52687 nP.

∴ The number of balloons=52687.

The facility and simplicity of operations offered by the new system are thus clear. Other examples will be found in other chapters at suitable places. These examples are mostly based on reductions. A question may be raised that in daily life the use of many-step reductions is rare. That is true, but that is true in the case of the metric system also. Examples chosen here are quite parallel. Then one or two-step reductions are often necessary. Suppose, we have to express a distance equal to 59512 feet in miles, yards and feet. We will have first to divide by 3 to get yards and then to divide by 1760 to change yards into miles. Division by 1760 is quite a long process. If the distance had been given in centimetres, we could easily convert it into metres and kilometres. For example, let the distance be 379615 cm, which is a bigger number than the previous one. It will be equal to 3796 metres and 15 centimetres (dividing by 100). Then 3796 m=3·796 km (dividing by 1000). So the distance will be 3 km 796 m 15 cm.

10. Another advantage of the metric system is its coherence —the one-to-one correspondence between the units of length, weight and capacity. The metric system is not merely an exactly related one; it also provides the clearest possible illustration of the relations between the measures, weights and capacity. This relation can be illustrated in the most impressive way. One cubic centimetre of water having one centimetre for its dimensions, weighs one gram, while in the British system one cubic foot of water weighs approximately $62\frac{1}{2}$ pounds. One cubic metre of water weighs one metric tonne. As regards capacity also one cubic decimetre (1000 cm^3) is equal to one litre. In the British system or in our old system such correspondence cannot be found. This

correspondence is of tremendous use for the pupils of secondary classes, for they can easily get the weights and the capacity if they know the volume. Following illustrations will make it very clear.

Weight

Example 1. (*British units*). Find the weight of the water in a tank measuring 4 feet 6 inches by 3 feet 6 inches by 2 feet 6 inches.

Solution :

For finding the weights, first find the volume of the tank.

The volume of the tank

$=4\frac{1}{2}\times 3\frac{1}{2}\times 2\frac{1}{2}$ cu. ft.

$=\frac{9}{2}\times\frac{7}{2}\times\frac{5}{2}$ cu. ft.

$=\frac{315}{8}$ cu. ft.

∴ the weight of water

$=\frac{315}{8}\times 62\frac{1}{2}$ lb.

$=\frac{315\times 125}{8\times 2}$ lb.

$=\frac{315\times 125}{16}$ lb.

$=\frac{39375}{16}$ lb.

$=2460\frac{15}{16}$ lb.

$=$1 ton 1 cwt. 3 qr. $24\frac{15}{16}$ lb.

```
   315        28)2460(87 qr.
 × 125           224
  1575            220
  630             196
 315               24 lb.
 39375

16)39375(2460   4)87 qr.(21 cwt.
   32              84
    73              3 qr.
    64
     97         20)21 cwt.(1 ton
     96            20
      15            1 cwt.
```

The solution involves as many as 69 figures leaving aside the manipulations in the margin, which cannot be avoided.

Example 2. (*Metric System*). Find the weight of the water in a tank measuring 5 m 30 cm by 4 m 60 cm by 3 m 40 cm.

Solution :

The volume in this case will be

$=5.3\times 4.6\times 3.4$ m^3

$=82.892$ m^3

∴ the weight of the water

$=82.892$ t.

$=$82t. 892 kg.

```
    5.3
  × 4.6
    318
   212
  24.38
  × 3.4
   9752
  7314
 82.892
```

Here only 21 figures have been used. There were about 20 operations involving division and multiplication of fractions by fractions and integers in the previous solution, while in the present one there are only six operations of integers. No knowledge of mixed numbers is needed.

Capacity

Example 3. (*British Units*). A tub in the form of a right circular cylinder of height 1 ft. 9 in. has a circular base of diameter 1 ft. 3 in. Find the capacity of the tub in gallon, supposing 1 cu. ft. contains 6.2288 gallons approx. and $\pi = 22/7$ approx.

Solution :

Radius of the tub $= \frac{15}{2}$ in.

$= \frac{15}{24}$ ft.

The volume of the tub $= \pi r^2 h$

$= \frac{22}{7} \times \frac{15}{24} \times \frac{15}{24} \times \frac{21}{12}$ cu. ft.

$= \frac{275}{128}$ cu. ft.

∴ the capacity of the tub

$= \frac{275 \times 6.2288}{128}$ gallons

$= \frac{107.0575}{8}$ gallons

$= \frac{107.06}{8}$ gallons approx.

$= 13.38$ gallons approx.

```
  25      64
 ×11     ×2
 275     128

16)6.2288(.3893
   48
   142
   128
    148
    144
     48     16)128(8
     48        128
     ×          ×

   .3893
   ×275
   19465
  27251
  7786
 107.0575

8)107.06
  13.38
```

Example 4. (*Metric System*). Find the capacity of a tub in the form of a right circular cylinder of height 64 cm and diameter of the base 56 cm.

Solution :

Radius of the tub $= \frac{56}{2}$ cm.
$= 28$ cm.

The volume of the tub $= \pi r^2 h$
$= \frac{22}{7} \times 28 \times 28 \times 64$ cm^3.
$= 157696$ cm^3.

Now, 1000 cm$^3 = 1$ l
$\therefore$ 157696 cm$^3 = (157696 \div 1000) l$
$= 157.696$ l.

$$\begin{array}{r} 88 \\ \times 28 \\ \hline 704 \\ 1760 \\ \hline 2464 \\ \times 64 \\ \hline 9856 \\ 14784 \\ \hline 157696 \end{array}$$

Here also the second case is quite a simple thing involving no multiplication and division of mixed numbers, while in the British System it is very complicated.

11. The metric units have a decimal division. This is by far the greatest advantage. Even before the introduction of this system, British units of length have been decimalized by engineers, mechanics and others where such division was found useful. But the metric system has decimal inter-ratios. Our forefathers in India invented the decimal system and knew its advantages. Full advantage of decimalization can be taken only by adopting metric units. In our whole-number system including percentages the decimal procedure is used which is metric in nature. Most topics in arithmatic involve manipulation and application of numbers, decimal numbers and percentages. Directly or indirectly, we have been following decimal (metric) system in our operations of numbers for hundreds of years but in the fields of measures, weights and capacity we have been following a very heterogeneous system, duodecimal, ternary, binary, quarternary, sexadecimal, etc. Through decimal fractions there becomes a one-to-one correspondence. Acharya Vinoba Bhave said in one of his meetings, 'People represent one and the Government zero. Separately they will not achieve much. But jointly if they stand together their achievements and power will be ten-fold.' Similarly, decimals represent one and the metric system zero. Separately they will not achieve much. But jointly if they stand together their achievements and power will be ten-fold.

CHAPTER III

SYLLABUS IN MATHEMATICS

In the words of Dr. K. L. Shrimali, 'education cannot remain a living force if it does not keep pace with the changes and developments that take place in the social organization and economic life of the people.' The change in the system of money, length and weight has certainly affected the economic life of the people of the country, and education cannot remain unmindful of these changes. The introduction of the metric system has brought change to both sides of education, matter and method. All this points to the pressing necessity of reorganizing the mathematics syllabus.

REORGANIZATION OF THE SYLLABUS

Broadly speaking, two factors are to be considered in this respect. Some topics and features will have to be deleted from the present syllabus ; some will need simplification ; and othesr will have to be added.

I. Deletion and Simplification

A. To be simplified

Many operations will be very much simplified by adopting the metric system. Some of them are :

(*i*) *Reductions* (ascending and descending). Sufficient examples have been given in the previous chapter to prove the ease and facility in reductions when metric units are employed. At the primary stage the four fundamental arithmetical operations will be simplified and much time and energy saved by discarding the rigour of long multiplications and divisions.

(*ii*) *Fractions.* The present syllabus in mathematics is dominated by fractions in almost all topics. Every arithmetic textbook has a chapter on fractions to drill the pupils in their use and manipulation. The use of the metric system will put an end to the use and operation of unnecessary cumbersome fractions.

(iii) H.C.F. and L.C.M. For a smooth passing on to fractions, the child has to run through the H.C.F. and L.C.M. of such large numbers as 305, 531, 2350, 1281. When decimal fractions are introduced. H.C.F. and L.C.M. will have very little importance. H.C.F. and L.C.M. of fractions can also be avoided. Even at present their practical use is very little.

(iv) Square Root. The load in the matter of the square root can also be reduced. The square root of fractions need not be taught and the square roots of integers and decimal fractions can be obtained from the square root tables also. Finding the square root of fractions involves two major processes—firstly, long division for converting the fractions into decimal fractions and secondly, the square root of that decimal fraction.

(v) General. In general, the load in all these topics will be much lighter. To mention one, let us take compound interest. Here, expressions like $\frac{103}{100}\times\frac{103}{100}\times\frac{103}{100}$ or $\frac{26}{25}\times\frac{26}{25}\times\frac{26}{25}$ will no longer find any place. These fractions will be decimalized and operations will be carried out just like integers. Area and volume problems also will, similarly, be simplified.

B. To be eliminated completely

Some topics may not find any mention in the syllabus any longer. They are :—

(i) Continued Fractions. Solution of continued fractions is of no importance. Questions on simplifying fractions like

$$2\div\cfrac{1}{3-\cfrac{2}{1\div\frac{4}{7}}}$$

may be removed from the textbooks.

(ii) Fractions involving Compound Quantities. The following type of questions also should be removed :

Simplify $\dfrac{\text{Rs 6.5as. 4p.}+\text{Rs 37.10as. 8p.}}{\text{Rs 9.8as.}+\text{Rs 12.4as.}}+\dfrac{\text{5mds. 4srs. 8chs.}}{\text{8mds. 12ch.}}$

$-\dfrac{\text{£17.13s.4d.}}{\text{£20.6s. 8d.}}$ of $2\frac{11}{15}$ and express the result as a fraction of $47\frac{1}{4}$.

(*iii*) *Practice.* Questions on Practice will form part of multiplication and division of decimal numbers, *e.g.*, to find the cost of 325 tables at Rs 25.15 nP each, what one has to do is simply to multiply two numbers 325 and 25.15 and the product will be the answer in rupees. It is a case of simple practice. Let us now take compound practice.

Example. Find the cost price of 53m 45cm of woollen cloth at the rate of Rs 28.42 nP. per metre.

Solution :—53m 45cm =53.45m
Rs 28.42nP. =Rs. 28.42

Multiply 53.45 by Rs 28.42 and the product is the answer. There is no need of applying compound practice methods.

II. Additions

Having thus simplified certain topics and omitting others from the mathematics syllabus, we may add something more to it. This may be done as follows :

(A) *To Teach Something More of the same Topics.* At present only an introduction to statistics is given in the higher secondary classes. Some more statistics can now be included in the syllabus.

(B) *To Teach New Topics.* There has been a revolution in the school syllabus of mathematics in the western countries, but the mathematics syllabus in India is the same as it was fifty years back. Some new topics like probability, theory of sets, co-ordinate geometry, solid geometry, etc., may be introduced at the middle and the secondary level.

Some Suggestions

1. The Panel appointed by the Central Committee for Educational Literature of the National Council of Educational Research and Training for preparing textbooks on mathematics has drawn up syllabi in mathematics for primary, middle and secondary classes. This may be consulted, when it is published.

2. Some courses taught in the middle classes at present may easily be transferred to the primary classes, *e.g.*, decimal fractions, average, percentage, area of paths and

carpets, volumes of rectangular solids, interest and problems on work and time.

3. Some courses at present taught in the secondary classes can be taught in the middle classes. In fact, the whole of arithmetic can be completed by the end of the middle stage. In mensuration, areas and volumes of all types of plane and solid figures may be taught here. Only frusta of solids and irregular bodies should be left for the secondary classes.

4. Some courses being taught in the degree classes may be transferred to the secondary stage, *e.g.* differential and integral calculus, statistics, probability, co-ordinate geometry and solid geometry.

5. Some topics may be taken up earlier. Formerly, decimals were taught after simple fractions. Now decimals can be taught without teaching simple fractions at all. Only common fractions, like $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{5}$ may be taught. An idea of decimals can be given in class II and decimal fractions can be taken up in class III. Similarly, some other topics may be started earlier.

6. A list of new topics which may be included in the syllabus is given below for the consideration of educationists, authors and teachers :

(*a*) Middle classes : sets of numbers, mechanics, graphs, approximations, logarithms, collection and representation of statistical data. These are some of the topics the beginning of which may be made in middle classes in addition to the changes suggested in 3.

(*b*) Secondary classes : Sets of numbers and theory of sets, calculus, probability, statistics, elementary analysis, co-ordinate geometry and a more detailed study of the topics suggested in 6(*a*).

Note : As a thorough treatment of decimals is extremely essential, greater emphasis should be placed immediatety on learning the use of decimals at the very earliest stage so that thinking in terms of decimals may start at an earlier age than at present.

7. *British Units.* British units have an important place in international trade. So these units should also be taught, but 'where and when' is the question. Opinions differ on this point. Some suggest that these units may be taught in middle classes ; others say the proper time is the last stage of higher secondary. There appears to be no harm if these units are taught in secondary classes. Their teaching does not mean the teaching of their use in the solution of problems. Only a knowledge of their units and sub-units along with the table of conversion for metric to British units will serve the purpose. Pupils should know the process of conversion. Similarly conversion of Indian currency into important foreign units of money may also be taught to the pupils of secondary classes. For students of middle classes so many scales and units will be a heavy load.

CHAPTER IV

ASPECTS OF A GOOD TEXTBOOK ON MATHEMATICS

Of all the teaching aids the textbook is the most important. The teacher teaches from the book, even illustrative examples are taken from it and so also problems for home-work. Hence our textbooks on arithmetic and allied subjects should be improved, for the present ones continue to deal with old units of weight, measures and also of money.

Till such time when books dealing only with metric units are available, the teacher has to be very careful in the use of mathematics textbooks. He may avoid all such problems as involve the use of old units. Instead, he may frame his own problems using the new units.

Essentials of a Textbook. Many essential things have to be found in a good textbook; but at present we are not concerned with all of them. Here, only the content of the textbook will be considered and that too in relation to the introduction of the metric units. Three broad aspects of a textbook are—

1. Presentation of a topic
2. Solved exercises and examples and
3. Selection of problems.

Let us discuss each briefly.

1. **Presentation of a Topic.** The introduction of new units will affect the presentation of certain topics. Formerly, decimals were taught through common fractions. It should change now. Decimals can be and should be taught through metric units. One naya paisa is the tenth part of a ten naye paise-coin. Similarly, one millimetre and one milligram is the tenth part of one centimetre and one centigram respectively. The former presentation was abstract but the latter is concrete and real, which the child can understand better.

Similarly, percentage can also be taught in a better way. One naya paisa is hundredth part of a rupee. Twenty-seven naye paise thus means 27 per cent of a rupee ; 53 cm means 53 per cent of a metre.

The formula for finding the amount at compound interest can now be stated as $A=P(1+\cdot01r)^n$ instead of $A=P\left(1+\frac{r}{100}\right)^n$. Authors can also change the mode of presentation in some other cases. The use of logarithms and approximations will also bring some change.

2. **Solved Exercises**—(*i*) The actual process of solving problem will be very much changed. So far vulgar fractions have been playing an important part. Now, decimal fractions should replace vulgar fractions.

Example (*OLD*). Find the cost of carpeting a room 8 ft. 3 in. by 6 ft. 4 in. at the rate of Rs 3.6as per sq. ft. of carpet.

Solution :

The area of the floor of the room $=\frac{33}{4}\times\frac{19}{3}$ sq. ft.

$=\frac{208}{4}$ sq. ft.

$\therefore$ The cost of carpeting $=\frac{209}{4}\times$ Rs $\frac{27}{8}$

= Rs $\frac{5643}{32}$

= Rs 170.1a. 6p.

Example (*NEW*). Find the cost of carpeting a room 3 m 60 cm long and 2m 80 cm broad at the rate of Rs 11.25 nP per m^2 of carpet.

The area of the floor of the room $=3.60\times2.80$ m^2

$=3.6\times2.8$ m^2

$\therefore$ The cost of carpeting $=3.6\times2.8\times$ Rs 11.25

= Rs 113.40 nP.

(*ii*) From the very beginning the child must be introduced to decimal fractions to derive the greatest advantage out of the new system. The old practice of changing decimals into vulgar fractions in every operation should now cease and must no longer continue in either a textbook or the classroom.

Example. A tank is 16.4 m long 14 m broad. When some persons dived into the water, the level of the water rose by

30 cm. Find the number of men if the average volume of a man is $\cdot 84 m^3$.

Solution :

Wrong approach

Volume of water displaced

$=\frac{164}{10}\times\frac{14}{1}\times\frac{30m^3}{100}$

Volume of one man

$=.84m^3$

$=\frac{84m}{10..}$

$\therefore$ No. of men diving

$=\frac{164\times 14\times 30}{10\times 100}\div\frac{84}{100}$

$=82$ men. *Ans.*

Solution :

Correct approach

Volume of water displaced

$=16.4\times 14\times .3m^3$

Volume of one man$=.84m^3$

$\therefore$ No. of men

$=\frac{16.4\times 14\times .3}{0.84}$

$=82$ men. *Ans.*

(*iii*) The use of logarithms should be made wherever possible. It will simplify the processes of long multiplication and division.

Example. A man deposited Rs. 1000.00 in a bank. What will be his amount after ten years, if the interest is paid at the rate of 5% and is calculated annually?

Solution :

$$A=1000(1+.05)^{10}$$
$$=1000\times(1.05)^{10}$$
$$\therefore \quad \log A=\log 1000+\log(1.05)^{10}$$
$$=3+10\log 1.05$$
$$=3+10\times .0212$$
$$=3+.212$$
$$=3.212$$

Hence $A=$Rs. 1629.00 nP.

(*iv*) The use of tables (interest, square, square root, etc.) and ready reckoners may also be made in giving the solutions of the problems. These aids will save much of a student's time and energy. Even if he is not able to use them in his daily classroom, there is no harm in making him conversant with the use of these devices. He can use them later in life if he knows how to use.

3. **Selection of Problems.** It is one of the most important part of a textbook on mathematics. In the present context it has become all the more important because the author has to shift his attention from a system that has continued for hundreds of years to a new system. This task can be divided into two parts: (*i*) removal of unwanted old problems from the textbooks and (*ii*) addition of new problems involving metric units.

(*i*) **Removal of Unwanted Problems.** Many problems should not find place in arithmetic textbook snow. Below are given some examples:

(*a*) *Isolated Stereotyped Problems.* In this category can be placed those problems which have traditionally found place in arithmetic books, though they have outgrown their utility as they are not real and practical. For example:

1. Five men working nine hours a day can cut the grass of a field in 16 days; how long will 8 men take working 11 hours a day?
2. *A* can do a piece of work in $16\frac{2}{3}$ days, *B* in 20 days and *C* in 24 days. If *A* works on it for 7 days and *B* for 5 days, how long should *C* work on it to finish it?
3. What will be the compound interest on Rs. 500 at 4% for 1 year if the interest is paid quarterly?
4. 3% stock of value Rs 2400 is sold at $85\frac{1}{8}$. The money got is invested in $4\frac{1}{2}$% stock at $101\frac{7}{8}$. What is the change in the yearly income? Brokerage is $\frac{1}{8}$% of the value of the stock while buying and selling as well.
5. The length of a room is twice its breadth, and its height is 12 ft. 156 yards of paper 2 ft. wide is needed to paper the walls. What will be the matting charges at the rate of 12 nP. per square foot?

(*b*) *Unreal Problems.* Unreal problems are not educationally sound. The rates, standards and other quotations used in the examples must be the same as prevalent in the market. Such problems as given below are unreal :—

1. If the price of 3 cars is Rs 3675, find the price of 15 cars. (You cannot get a car for Rs 1225).

2. The cloth required for 5 shirts is 35.2 m; find the cloth required for 7 shirts. (7.04 m is too much for a shirt).

3. The distance between two towns is 149 km 66 cm (distance between towns is not measured correct up to centimetres).

4. The ration in cereals given to one man in Delhi is 500 gm a day. If the population of Delhi is 150000; find the total ration needed for a day. (The population of Delhi as given in this problem is not correct).

(*c*) *Impractical Problems.* These are like unreal problems. The hypotheses here are taken from real situations, but the answer is unreal. As for example :

1. All problems having their answers in fractions of living beings.

2. All problems with mathematically sound, but actually improbable, answers, *e.g.*, completion of a wall in a day.

3. Problems whose answers involve uncommon fractions such as $\frac{32}{53}$ cm, $9\frac{17}{105}$ mg, Rs $1\frac{167}{273}$ and Rs 15. $2\frac{1}{4}$ nP.

4. Problems in which the rates quoted are in uncommon fractions, such as white-washing at the rate of Rs $2\frac{5}{21}$ per square metre.

(*d*) *Problems using Old Units.* It is very serious. Even in books published in 1960, 1961 or 1962, problems involving the use of old coins and old units of length, weight and capacity are found. Below are given examples :

1. Rectangular field is 330 yards long and 188 yards broad. Find the acreage of the field and also the selling price if half the field is sold at Rs 17. 4 as. 6 p. per acre.

2. If an inch of rain fell on an acre of ground, find its weight when 1 cu.ft. of water weighs 1000 oz.

3. A merchant supplied a dealer with goods at a profit of 20%. The dealer, however, became bankrupt and could pay only 11 as. in the rupee. How much per cent did the merchant lose ?

4. Even in 1963 in an arithmetic question paper of the higher secondary board's examinations as many as four questions have appeared using old units of measurements. One example is given below : A person needs half an acre of rectangular land for building his house. The length of the piece of land should be double the breadth. Find the length and breadth in yards correct to one decimal place.

(*e*) *Problems in which Old Units have merely been Converted into New Units.* Such changes become very unrealistic. An illustration is given below.

The question with old units : If 24 labourers are paid Rs. 4. 6 as. working for 7 hours, what will be the wages of 30 labourers working for 21 hours ?

In changed form : If the wages of 24 labourers working for 7 hours are Rs. 4.37 nP., what will be the wages of 30 labourers working for 21 hours ?

In the first case the solution will be simple and the answer will be Rs 16. 6 as. 6 p. exactly. But in the second case it will be an unreal fraction equal to Rs. 16.3875 nP.

It is a simple case involving coins only. When both metric units and coins are involved, the solution will be all the more heavy and difficult. So it will present a wrong picture of the system.

Below is another example from an arithmetic question paper for 1963.

There is a rectangular ground 100 yards long and 80 yards wide. This has two roads 15 feet wide, one running parallel to the length and the other to the breadth and cutting each other in the middle of the ground. Find the cost of covering the roads at Rs. 35.50 per 1,000 sq. ft.

Originally the rate was Rs. 35.8 as. per 1000 sq. ft. and in that case the answer was Rs. 279. 9 as. But here the old units of money have been simply changed into new ones and the answer comes to Rs. 279 and 56.25 nP. (in the hundredth fraction of a nP).

(*f*) *Invalid Problems* : By invalid problems is meant those problems which were important and meaningful before but have now become invalid or out of date. Examples are given below :

1. Find the square roots of (*i*) 1524155677489, (*ii*) $\frac{456}{217}$.

2. Simplify

$$\frac{\frac{1}{3\frac{1}{2}}+\frac{1}{4\frac{1}{2}}+\frac{1}{5\frac{1}{2}}}{\frac{1}{7}+\frac{1}{9}+\frac{1}{11}}\div\frac{\frac{1}{2}-\frac{1}{3}}{\frac{1}{3}-\frac{1}{4}}+\frac{\frac{2\frac{1}{3}}{3\frac{1}{2}}\text{ of }\frac{\frac{2}{7}}{2\frac{1}{2}}+\frac{3\frac{1}{2}}{1\frac{3}{4}}\div\frac{2\frac{1}{2}}{7\frac{1}{2}}}{\frac{1}{2}+\frac{3}{7}+\frac{5}{14}}$$

3. Simplify

$$2+\cfrac{1}{1-\cfrac{1}{2+\cfrac{2}{1+\frac{3}{4}}}}-\cfrac{2}{1+\cfrac{1}{1+\cfrac{1}{2+\frac{1}{3}}}}$$

4. Simplification of huge fractions involving compound quantities of different systems and also involving all brackets. Problems involving huge fractions should now be deleted from other topics as well.

5. All problems on practice, simple *and compound.*

(*ii*) **Addition of New Problems.** Actually speaking, it is not so much as addition of problems as a selection of useful problems. To select good problems, the aims of teaching mathematics—specially arithmetic in this case—should be taken into consideration. These can be summed up as (*i*) to develop ability to do intricate processes in computation ; (*ii*) to have perfect mastery of the useful arithmetical processes and abilities to apply these in real-life situations. These general aims may take the shape of the following objectives while teaching the new system of money, weights and measures in secondary classes :

1. To help the child to apply mathematical skills and abilities with regard to the metric system of weights, measures and decimal coinage, acquired in primary classes to life situations.

2. To enable the child to have a close familiarity with the decimal system of numbers and to develop 'decimal thinking'.

3. To enable the child to apply the knowledge of the new system and decimals to other related fields of knowledge, *e.g.*, physics, chemistry and geography.
4. To enable them to appreciate the advantages of the metric system over the old systems.

Types of Problems. Problems are generally of two types :

(*i*) Drill Problems which are meant to develop speed and mastery of the rule or formula.

(*ii*) Written Problems which involve the application of the rule or formula.

About the first type of problems authors and teachers have to bear in mind that heavy and cumbersome exercises should not be given for drill work.

These exercises are meant only for the achievement of skill and speed. These problems will include (*i*) oral problems, (*ii*) objective-type questions, (*iii*) activity-type problems and (*iv*) creative-type problems.

Guiding Principles of Written Problems. The following principles may give guidance to authors in the matter of selection of problems :

(*i*) Isolated stereotyped problems should not find place in the present-day textbooks on arithmetic.

(*ii*) Functional problems taken from industry, agriculture, field and factory, should replace the old ones.

(*iii*) Problems should be based on experience and connected directly with daily life. They may involve measuring, constructing, finding capacity and space, budgeting, buying, selling, saving, etc.

(*iv*) Problems should be chosen from the life-situations of the child and should prepare him to face life in its many aspects.

Stages in the Selection of Problems. There can be four stages in the selection of problems :

(*a*) Criteria of good problems

(*b*) Choice of units

(*c*) Use of proper abbreviations

(*d*) Presentation of problems

(*a*) About the criteria of good problems some guiding principles have already been laid down. Motivation is the main consideration for the selection of problems.

(*b*) About the choice of units something has been said in chapter II. The units used should be proper. In textbooks on science, however, all the units may be used.

Examples : 1. A wooden box without a lid is 2 dm 5 cm 1 mm long, 1 dm 5 cm 3 mm wide, 6 cm 5 mm high, externally. The wood is 7.5 mm thick ; find the internal measurements.

2. The weights of some baskets of mangoes are 45 cg, 108 cg, 65 cg, 98 cg respectively. Find their total weight in kg. Here units used are not proper. (*i*) Length of a box is not measured in millimetres and (*ii*) the weight of mangoes is not given in centigrams.

(*c*) A list of abbreviations has also been given in chapter II for the guidance of authors and teachers. These abbreviations are accepted by the Government of India and these should be used in all textbooks.

(*d*) Presentation of problems is very important and should be done in a very clear, precise and effective manner. The language should be intelligible to the students, and there should be no ambiguity anywhere.

A few problems are given below to serve as guides to authors.

MODEL PROBLEMS

RATIO

1. An advertisement claims that a car runs 13 km on 1 litre of petrol, but actually it only does 10 km to a litre. How much more petrol is required for 1950 km than would be needed if the claim were correct ?

2. A flask weighs 64.27g when empty and 150.35g when full of water. Find its weight when it is half full of water.

3. A man leaves his house at 9.15 A.M. and reaches a town 35 km away at 10.55 A.M. Find his average speed in km per hour.

4. A tree which is known to be 25 m high stands on one bank of a river at the water's edge and casts a shadow which just reaches straight across to the other bank and at the same time a one-metre stick casts a 1.25 m shadow. Find the width of the river.

5. A telegram costs Re 1.00 for the first ten words and 10 nP for every additional word. What is the cost of a telegram containing 25 words?

6. Groundnut-oil cake contains 0.08 part nitrogen and castor-oil-cake 0.45 part. A plot of land 2.4 hectares in area requires 1.35 metric tonnes of groundnut-oil-cake as manure. What weight of castor-oil-cake is required for an area of 1.26 hectares?

7. When electricity costs Re. 0.25 a unit, 8 electric lamps each of 40 watts consume Rs 12 worth of electricity in 30 days; What will be the cost of electricity when 10 lamps each of 25 watts are used for 16 days for the same time each day, the cost of electricity being Re 0.20 per unit?

8. Scientists say that when the temperature remains unchanged, the volume of air and the pressure on it vary inversely. When the pressure of air in a tube is 114 cm, the volume of air in it is 1000 cm^3. (*a*) what will be the volume of air when the pressure is 152 cm? (*b*) What will be the pressure of air when the volume is 1250 cm^3?

9. Two ladies went to a cloth shop and together bought 12 m of voile for Rs. 19.42 nP. If one of the ladies bought 5 metres, what price did she pay for it?

10. A man is thrice as good a workman as his son and his wife is twice as good as the son. All the three work on a project which brings them Rs 61.80 nP. What will be the earnings of each separately?

11. Delhi and Aligarh are 128 km apart. A train leaves Delhi at 10.15 A.M. and runs at an average speed of 36 km

per hour. Another train leaves Aligarh at 11.55 A.M. at an speed of 32.km per hour. Find when and where they will meet.

12. A motorist drove his car from home to Delhi a distance of 186 km. He left home at 8.45 A.M. and after driving 102 km, he stopped for lunch at 1.00 P.M. the same day. After breaking for 45 minutes for lunch, he resumed his trip at seven-eighth of the morning average speed ; at what time did he arrive at Delhi ?

13. A man can hire a rickshaw at the rate of Rs 20.00 nP. per week but has to pay a deposit of 25% of hire in advance. How much is the deposit if he takes the rickshaw for 21 days?

14. A bus after covering 50 km meets with an accident and then proceeds at $\frac{4}{5}$ of its former speed and arrives at the terminus 45 minutes late. Had the accident happened 20 km further on, it would have arrived 12 minutes sooner. Find the speed of the bus per hour and also the distance.

15. The diameters of the three taps are 1.2 cm, 1.5 cm and 2 cm. The largest alone can fill a cistern in 2 hrs and 6 mts. Find the time taken by all the three to fill the cistern when opened together if the amount of water that flows into the cistern is proportionate to the squares of the diameters.

16. A monkey, climbing up a greased pole, 34 m high, ascends 9 m and slips down 5 m in the alternate minutes, how long will it take him to get to the top ?

17. A map is drawn to the scale 1 : 5000. What length in kilometres does a length of 2.5 cm represent on the map ?

AVERAGE

18. The average annual rainfall in a town for 10 years was 86.7 cm. If the rainfall during the next two years was 72.3 cm and 91.8 cm, what was the average for 12 years ?

19. A motor car runs for the first 30 minutes at the rate of 22 km 176 m per hour, then for 2 hours 15 minutes at the rate of 36 km per hour. What is the average speed for the whole distance ?

20. The average temperature of a place for Monday, Tuesday, Wednesday and Thursday was 33.2°C and the average temperature for Tuesday, Wednesday and Thursday was 32.8°c. What was the temperature on Monday ?

21. A farmer has a number of cows which give on an average 5.2 litres of milk every day. One of these which has a milking capacity of 2.4 litres a day is sold and another with a milking capacity of 4.8 litres a day is bought. The average daily quantity now becomes 5.4 litres. Find the number of cows.

22. Find the number of centimetres in an inch, if three different straight lines 2.36 in., 3.34 in., and 4.26 in. long measure respectively 6 cm, 8.6 cm and 10.7 cm.

23. Find the average number of grams in an ounce, from the following readings of a spring balance :

Load on spring balance in oz.	Reading of scale in/g.
$\frac{1}{4}$	7.105
$\frac{1}{2}$	14.22
2	56.78
4	113.56

24. The normal temperature at Allahabad on a certain day in March was 23.3°c ; the actual temperatures observed at 6 A.M., 10 A.M., 4 P.M. and 10 P.M. were 16.2°c, 18.4°c, 27.4°c, 19.3°c ; how much was the mean temperature below the normal ?

25. '*n*-carat gold' means that *n* parts of every 24 parts by weight of the material are pure gold. How many grams of pure gold must be mixed with 100 g of 15 carat gold to produce 18-carat gold ?

BUSINESS ARITHMETIC

26. An agent receives $2\frac{1}{2}$% commission on orders under Rs. 25.00 nP. and 5% on other orders. He obtains 12 orders of Rs. 15 each and 9 orders of Rs. 35 each. Find his total commission ?

27. A man buys goods catalogued at Rs 350 subject to successive discounts of 25, 10 and 3.2%. This means that he is allowed to deduct 25% from the catalogued price, then 10% from this reduced price and 3.2% from the last. What does he pay ?

28. The cost of producing an article is made up as follows : cost of labour 65%, cost of material 35%. It is sold at a profit of 50%. If the cost of labour increases by 20%, and if the selling price is increased by 30%, the profit is still 50%. Find the percentage charged in the cost of material.

29. A merchant bought 12 dozens of towels at the rate of Rs 25.50 nP per dozen ; 80 towels at the rate of Rs 11.25 nP per dozen and 40 towels at Re 1.50 nP each. If he sells them at Rs 18.50 nP per dozen what will be his gain or loss per cent ?

30. By selling 33 metres of cloth I gain the amount equal to the selling price of 11 metres. Find my gain per cent.

31. An increase of 10% in the price of tea enables one to purchase 5 kg less for Rs 275.00 nP. Find the increased price and the original price of tea per kg.

32. A manufacturer allows the retailer a discount of 35% on the catalogued prices. What is the catalogued price of a toy for which the retailer pays Rs 2.75 nP ?

33. The engine of a machine is bought for Rs 18000 and on an average a sum of Rs 200 a year is spent on maintaining it. Its value depreciates by 20% every year. What will be the value after four years ?

34. A man wanted to purchase a number of electric bulbs. If each bulb costs Re 1.56 nP, he would require Re 1.75 nP more. He chose bulbs costing Re 1.31 nP each and had Rs 3.25 nP left over. Find the number of bulbs he purchased and the sum of money he had.

35. Interest in the Postal Savings Bank is paid at the rate of 3%. What will be the interest on an account for a year if at the beginning of the year there is a balance of Rs 276.50 nP, 3 months later Rs 50 is taken out, and 4 months after this Rs 120 put in ?

36. I borrow Rs 4000 at 5% per annum. At the end of a year I repay Rs 1500 and a year later Rs 1650. How much of the loan will be left over at the end of the second year?

37. A machine was purchased for a certain sum of money and immediately Rs 1500 were paid. The balance was to be paid after 6 months with an interest of Rs 7.5% per annum; the sum to be paid then is Rs 2593.75 nP. Find the cost price of the machine.

38. A house worth Rs 12000 was mortgaged for half its value and the rate of interest was 10% per annum. As the loan was not returned, as agreed, after 4 years, the money-lender auctioned the house for Rs 9500, took Rs 352.50 nP as expenses connected with the auction and also the sum due to him and gave the owner the balance. What sum did the owner get?

39. The cash price of a Singer sewing machine is Rs 500. If Shrimati Sarla Devi buys it for Rs 540 on an instalment plan, paying Rs 100 cash down and Rs 220 in two six-monthly instalments, find the equivalent yearly rate of interest.

40. A man buys Rs 750 worth of furniture with an initial payment of Rs 75 and 12 subsequent monthly payments of Rs 60 each. What rate per cent of interest does he pay?

41. Find the annual premium on a Rs 10000 life insurance policy when the rate is Rs 32.15 nP per Rs 1000.

42. A man borrows Rs 1000 at 5% per annum compound interest payable yearly and repays Rs 200 at the end of each year. Find the amount of the loan outstanding at the beginning of the third year.

43. A National Savings Certificate worth Rs 100 will be worth Rs 150 after 12 years. Is it true to say that the interest is paid at 4% compound interest? Give reasons for your answer.

44. Find how much a bill-broker gives for a bill of Rs 746 drawn on June 1 for two months, which he discounted on July 6 at 5%.

45. A bill for Rs 2190 drawn on July 4 for 6 months was discounted for Rs 2172 at the rate of 5% per annum. On what day was it discounted?

46. A man invests Rs 4326.00 nP in Indian Iron of which a Rs 10 share is selling at the rate of Rs 21.60 nP. Find the number of shares he has if brokerage is charged at the rate of 3 nP per share.

47. A Rs 25.00 share of Delhi Cloth Mills is being quoted at Rs 48.75 nP. What rate of interest does an investor get if the company declares 12 per cent dividend subject to a deduction of super-tax to the extent of 30% ?

48. After paying an income-tax at the rate of 5 nP per rupee a man's net income is Rs 593.75 nP. What will be his net income if the tax is reduced by 1 nP per rupee ?

49. If a house depreciates in value each year at the rate of 5 per cent. of its value at the beginning of the year, how much was a house worth 2 years ago which is now worth Rs 7220, and what will it be worth after one year ?

50. A fisherman sent to his commission agent 850 kg of fish to be sold. The agent sold 350 kg at Rs 1.75 per kg, 275 kg at Rs 1.50 per kg and the remainder at Rs 1.30 per kg. He deducted 5% commission on sales, Rs 18.50 for freight charges and $1\frac{1}{2}$ nP per kg for storage. Find the amount remitted to the farmer.

51. The true altitude for a certain air density is 5% less than the indicated altitude. What is the true altitude if the indicated altitude is 1400 km ?

AREA

52. The length and breadth of a rectangular garden are in the ratio of 5 : 4. If the length of the garden is 65 m, find the cost of surrounding it with wire at the rate of 31 nP per metre.

53. Find the number of revolutions made by a wheel of diameter 42 cm in covering one kilometre.

54. Find the perimeter of a square plot of ground with an area of 3 ares and $24m^2$.

55. A rectangular sheet of cardboard, 25 cm by 16 cm weighs 18.3 g; an oval piece is cut out of it and is found to weigh 10.2 g. Find the area of the oval to the nearest square centimetre.

56. A room is 6m long, 4.5m broad and 3.5m high. In it there is a door 2.5m by 1.2 m and two windows, each 1.5 m by 8m. Find the cost of (*i*) distempering the walls at 75 nP per m^2 and (*ii*) carpeting the floor at Rs 8.37 nP per m^2.

57. A lawn is 25 m long, 20m wide. A gravel path 1.4 m wide runs parallel to the length of the lawn and another 1.6 m wide runs parallel to the width of the lawn in the centre. Find the area of each path.

58. A donkey is tied by a rope 20 m long to a post in a fenced field 50 metre square. What area of the ground can the donkey cover if the post is (*i*) at a corner of the field or (*ii*) at the middle point of one side of the field ?

59. The area of the sector of a circle of radius 7 cm is 55 cm^2. Find the angle of the sector.

60. The distance from the centre pole of a merry-go-round to a boy in one of the seats is 7 m. The merry-go-round makes 5 revolutions per minute. What distance will the boy travel in 3 minutes' ride ?

61. How many square metres of tin will be needed to build a cylindrical tank that is 25 m high and has a base whose radius is 8m.

62. Find the area of a triangular flower-bed whose sides are 13 m, 14 m and 15 m.

63. A photograph, 16.4 cm wide and 12.7 cm long is mounted on a card 22.6 cm wide and 17.3 cm high. Find the area of the part of the card left uncovered.

64. The parallel sides of a trapezium are 4.36 cm, 3.18 cm and its area is 18.72 cm^2 ; find the distance between the parallel sides.

65. A rectangular plot 24.6 m by 11.4 m is marked out for grass. If a fence is built round it at a distance of 4.2 m away what area lies between the fence and the plot ?

66. 3000 kilograms of water are poured into a rectangular cistern whose base measures 2.4 m and 1.8 m ; how deep is the water (1 cc. weighs 1 gram) ?

67. A packet of Post Cards measures 14 cm by 9 cm by 8 mm. How many packets can be placed in a box 3.5 dm by 2.4 dm by 1.2 dm?

68. A block 12 cm by 8 cm by 6 cm is placed inside a box whose external dimensions are 24 cm by 16 cm which is made of wood ½ cm thick. Find the volume of the vacant space when the lid of the box is closed?

69. During a rainfall of 25 mm, how many litres of water fall per hectare?

70. The inner edge of a circular running track is 400 m long. Find the diameter of this circle to the nearest metre, and the area enclosed by it in hectares to the nearest are. (Take $\pi=3.14$).

VOLUME

71. Water flows through a cylindrical pipe of diameter 25 cm at the rate of 3.5 m per second, the area of the cross-section of the stream in the pipe being .75 of that of the pipe. Find the number of litres discharged per minute.

72. A metal box without a lid is 15 cm long, 11 cm wide, 5 cm high measured externally, and the metal is 5 mm thick. Find the weight of the box, if 1 cm^3 of the metal weighs 7.2 g.

73. The bore of an iron pipe is 7 cm and the iron is 5 mm thick. If the pipe is 40 cm long and if the iron weighs 7.2 g per cm^3, find in kg, correct to .01 kg, the weight of the pipe. (Take $\pi=3.142$).

74. The floor of a hall is 20 m long and 10 m wide. The side walls are 4 m high and the cross section of the ceiling is a semicircle which springs from the side walls. Find the volume of the hall to the nearest cubic metre and area of the ceiling to the nearest are (Take $\pi=3.14$).

75. A well can be pumped dry in 1½ hrs. by two pumps which discharge respectively 360*l* and 540*l* per minute. If the smaller pump is used alone, the water sinks at 2.5 cm per minute. How deep is the well?

76. The surface of the water in a swimming-bath is a

rectangle 52m long, 15m wide, and the depth of the water increases uniformly from 1.5m at one end to 3.5m at the other. Find the volume of water in the bath.

77. A triangular set-square is 5mm thick and its two shorter sides measure 22.5 cm and 38.7 cm. Find its volume.

78. The base of a conical tent is 5m in diameter and the height is 3m. Find (*i*) the volume of the tent and (*ii*) the area of the canvas used for making it.

79. A cylindrical measuring glass contains water equal to 12.6 cm^3. When a solid metal sphere is dropped into it, the water rises to the mark 14.7 cm^3. Find the radius of the sphere.

80. The external diameter of a hollow metal sphere is 12 cm and its thickness is 2cm. Find the radius of a solid sphere made of the same material and having the same weight as the hollow sphere.

81. A block of wood of volume 150cm^3 is floating in water. Find the volume of the submerged portion of the block if its specific gravity is 0.7.

82. A metal sphere weighs 70g in air and appears to weigh 60.5g in water and 61.7g in another liquid. Find the specific gravity of (*i*) the metal and (*ii*) the other liquid.

83. A railway cutting 850 m in length is to have a uniform depth of 4.50 m, and its dimensions across the top and bottom are to be respectively 31.20m and 16.80m. If 470*t* are excavated on an average each day, and 1m^3 weighs 2.25*t*, how much time will the work require?

84. A copper wire 2 mm in diameter is evenly wound about a cylinder whose length is 12cm, and diameter 10cm, so as to cover the curved surface. Find the length and weight of the wire, assuming the specific gravity of copper to be 8.88.

85. A solid metal sphere, 6 cm in diameter, is formed into a tube 10 cm in external diameter and 4 cm in length; find the thickness of the tube.

86. A moat 210m long, 3m wide and 2m deep is to be dug. A certain number of labourers can dig it in 5 days work-

ing 11 hours a day. In how many days will the same men dig another moat 420m long 6m wide and 3m deep working 10 hours a day?

EXCHANGE

87. A person in England has a certain sum invested in $4\frac{1}{2}$ per cent India Government bonds, which, after deducting 2 per cent as agents' charges for drawing and remitting the money and when the rate of exchange is $7\frac{1}{2}$ d. per rupee, brings him an income of £429. 19s. 6d. per annum. Find the amount of the investment in rupees.

88. Find the difference in yards between 5 miles and 8 km (1 km=39370.8 in.).

89. Find to three places of decimals the number of acres in a hectare which is equal to 10000 m^2 (1 metre=39.3708 in.).

90. Assuming that a gram is .0022 of a pound, find the value of a metal at the rate of 5s. 5d. per kg.

91. A cubic metre of water contains 1000 litres and a cubic foot of water contains 6.25 gallons. If a linear metre is 3.2 feet, express correctly to four decimal places a litre as decimal of a gallon.

92. A litre of hydrogen gas weighs .08968 gm, find the volume occupied by 1 lb of this gas (1 kg=2.2046 lbs.)

93. Which is the higher price : 2.25 francs per litre or 7s. 6d. per gallon? (1 litre=1.75 pints and 25 fr.=£1).

94. If 1 metre=39.37 in., what will be the distance in metres of a 100 yards track?

95. Determine the course of exchange between India and England when Indian Money is at a discount of $10\frac{2}{7}\%$ having given that at par Re 1=1*s*. 9*d*.

96. What is the arbitrated rate of exchange of rupees in dollars *via* London when the rate in London on New York is 3.18 dollars per £1 and the rate in London on India is Rs 13.25 nP per £?

97. The normal temperature for a healthy person is 98.6°F. One day Sita's temperature was 36.2°C. How much in centigrades was it lower than the normal temperature ?

GRAPHS

98. Using tables draw the graphs showing the amounts of Rs 100 at any time in the first 5 years at 5% per annum (*i*) at compound interest (*ii*) at simple interest.

99. For a given temperature, C degrees on a centigrade are equal to F degrees on a Fahrenheit thermometer. The following table gives a series of corresponding values of F and C :

C	−10	−5	0	5	10	15	25	40
F	14	23	32	41	50	59	77	104

Draw a graph to show the Fahrenheit reading corresponding to a given centigrade temperature, and find the Fahrenheit readings corresponding to 12.5°C and 31°C.

100. An India-rubber cord was loaded with weights, and a measurement of its length was taken for each load as tabulated. Plot a graph to show the relation between the length of the cord and the loads.

Load in kilograms	4.5	5.4	7.7	9.5	10.4	11.3
Length in Centimeters	36.4	37.7	40.5	43.0	44.3	45.4

CHAPTER V

METRIC SYSTEM AND ITS APPLICATION IN ARITHMETIC

1. BASIC ARITHMETIC

Decimal Fractions. *At present decimal fractions are taught* after simple fractions. But now the teaching of decimal fractions should not depend on the teaching of simple fractions because with the introduction of the new system it becomes easier *to teach decimals than to teach simple fractions.* Authors have to keep in mind that the decimal system is based on 10 on which the whole number system is based. Our new units of money, weight and measure are also based on 10. So the teaching of simple decimal manipulations should proceed concurrently with the teaching of metric units. As already said, exhaustive teaching of decimals for utilizing the new system with advantage is very much needed. *The teacher should prepare the child to* understand that :

(*i*) decimals are easy, simple and useful

(*ii*) the manipulation of decimals is the simplest possible extension of the simple rules for whole numbers

(*iii*) they can be taught before, with or after the rules for fractions have been taught, and with the very slightest reference to common fractions such as 'halves', 'quarters' which are easier than the earliest decimals

(*iv*) their use in calculation is almost universal

(*v*) they give results more accurate, more easily grasped and more easily obtained than any 'fraction' method can ever give.

Some Suggestions

(*a*) While teaching decimals, stress should be laid on the place value of digits. Questions, oral and written, should be set to explain that the place value of a digit becomes tenth, hundredth, thousandth according as it moves one or two or three places to the right of the decimal point and becomes ten, hundred or thousand times if it moves to the left, *e.g.*, in 2345.6, 234.56, 23.456, 2.3456, the place value of 5 has changed from 5 to $\frac{5}{10}$, $\frac{5}{100}$ and $\frac{5}{1000}$ and in the reverse order the place value becomes 10, 100, 1000 times the last value.

(*b*) The importance and significance of 'zero' should be clearly explained. Zero to the extreme left or to extreme right of a decimal fraction has no value and does not change the value of the decimal number, but zero in between the extreme right and left changes the value. For example, 2.312 is the same as 02.3120 ; but 2.3012 and 2.3102 are different in value.

Here students should clearly understand that an integral number becomes 10 times if a zero is placed to its extreme right, *i e.*, 23120 is 10 times of 2312.

(*c*) Students should cultivate the habit of writing decimal fractions up to two places for better understanding of the decimal coins. It will be better to write 3.5 as 3.50 ; because in decimal coins Rs. three and fifty naye paise is written as Rs 3.50 nP. If the student writes Rs 3.5, it might create misunderstanding and confusion. By Rs 3.5 he may take the sense of Rs. three and five naye paise which is wrong, for Rs 3 and 5 nP will be written as Rs 3.05. Various examples should be given to illustrate this point. For writing the fraction of a naya paisa, you have to be careful. Suppose you have to write .4 of one naya paisa, write it as Re 004 instead of writing .4 nP which may be confused for 40 nP. The teachers have to teach all these different ways of writing to their students. It may be extended to the reading and writing of the units of weight, measure and capacity also. But here zero at the end has no meaning. For example, 3.50cm means 3cm and 5mm only ; 2.300 kg means 2 kg 3 hg or 2 kg 30 dg or 2 kg 300 g. These differences may be made clear to the students by putting sufficient number of parallel examples before them for practice. This work may be taken at the earliest opportunity after the students have learnt decimals and the metric units. The practice may be continued even in middle and secondary classes if need be.

(*d*) No comma or dot should be used to separate figures into groups of three. Thus, the older way of writing 2,567, 861 has been done away with.

(*e*) In writing a decimal fraction the decimal point must be used exclusively for separating decimals from integers. The continental practice is to use comma (,). According to the rules of the metric system as introduced in our country, 2,561.34 is not correct. It should be written as 2561.34.

Approximation. A student may sometimes come across sums like Rs 23.576, Rs 5.463, or he may be asked to measure a line or weigh an object. In real life it is not possible to transact business in .006 nP or .003 nP. It is also practically impossible to measure every line and to weigh each object exactly. So we take the approximate true value. The author of a textbook and the teacher in a class should make the importance of app.oximation very clear to his students by giving examples from real-life situations. For concrete cases the teacher may ask the students to measure the length and width of the room with a metre-rod or weigh a book or a pebble and then tell them the importance and necessity of approximations.

Approximation may come after a good practice in decimal fractions. Approximations will bring speed to the students and will save his time. Meaningless results will become meaningful. The usefulness of approximations is clear from the following extract :

'With decimal fractions it is very easy to determine the number of significant digits in measurements and to round approximate answers correctly. With common fractions both operations are considerably more difficult. For example, if the measurement 638.42 ft. has been made by a competent measurer, it may be assumed that the unit of measurement has five significant digits. If this measurement is used in computation with other equally accurate data, the final answer should be rounded to five significant digits.

'If the measurement 246 ft. $7\frac{3}{8}$ in. has been made by a competent measurer, it may be assumed that the unit of measurement is $\frac{1}{8}$ in. and that the maximum error is not greater than $\frac{1}{16}$ in. However, to find the number of significant digits it is necessary to change the measurement to $\frac{1}{8}$ in. Since 246 ft. $7\frac{3}{8}$ in. is equal to 23,675 one-eighth inches, the measurement has five significant digits.

'A considerable amount of computation is required to find the number of significant digits when nondecimal measurements are used. The reverse operation of rounding answers to the correct number of significant digits is much more involved than when decimal measurements are used. Since metric measures are 100 per cent decimal and employ only one unit, they have all the advantages of decimal fractions. The number of significant digits in a measurement can be found without any extra computation.

'Modern textbooks contain many incorrect rules and answers due to the fact that the authors have failed to use the correct rules when other than decimal measurements are employed.'*

Example. The unit of measurement in the metric decimal system is the metre, which is 39.370 inches correct to three decimal places. A length measured correctly to the nearest tenth is given as 486.7 inches. How many metres is this, expressed to the same precision ?

Solution : 39.370 inches = 1 m

$$\therefore \quad 486.7 \text{ inches} = \frac{486.7 \text{ m}}{39.370}$$

$$= 12.362 \text{ m}$$

$$= 12.4 \text{ m correct to the nearest tenth.}$$

Common or Vulgar Fractions. Emphasis on decimal fractions does not mean total elimination of common fractions. Common fractions will continue as they are convenient, evident and understandable. Ordinary thinking is done in common fractions like half, fourth, third, fifth, eighth and tenth. Even in the new system the units have been halved and quartered. The increasing use of decimals means the avoidance of the use of heavy and cumbersome fractions which do not find any real use in the life of a child. Approximation may be very conveniently used here.

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*Shuster, Carl N. 'The advantages of decimal notation', *The Mathematics Teacher*, December, 1962.

An example is given below to show the difference in the solution by the use of old and new systems of units.

The price of 1 kg of apples is Rs 3.64 nP; find the price of 5 kg 125 g of apples.

(*i*) Let us first solve it by the fraction method.

Rs 3 and 64 nP	$=$Rs. $3\frac{64}{100}$
	$=\frac{91}{25}$
5 kg and 125 g	$=5\frac{125}{1000}$ kg
	$=\frac{41}{8}$ kg.
The price of 1 kg	$=$Rs $\frac{91}{25}$
∴ ,, $\frac{41}{8}$ kg	$=$Rs $\frac{91}{25}\times\frac{46}{8}$
	$=$Rs $\frac{3731}{200}$
	$=18\frac{131}{200}$
	$=$Rs 18.65$\frac{1}{2}$ nP
	$=$Rs 18.66 nP approx.

(*ii*) Now let us solve it with decimal fractions.

5 kg and 125 g	$=$5.125 kg
The price of 1 kg	$=$Rs 3.64
∴ ,, ,, 5.125 kg	$=$Rs (3.64×5.125)
	$=$Rs 18.655
	$=$Rs 18.66 nP approx.

The former solution involves many operations of multiplication and division of fractions. There are also mixed fractions. But the second solution involves only one operation, *i.e.* multiplication of integers. So authors should avoid the use of much heavy fractions.

Logarithms. (*a*) At present logarithms are very rarely used in Indian secondary schools. Common logarithms are based on 10 and the units of our new system are also based on 10. So the idea of logarithms can be very conveniently given at an early stage. Logarithms can be easily understood after the whole table of metric units has been learnt. Common legarithms denote the index of the power of the base 10. Metric units are also related by powers of 10, *e.g.*,

$$1\text{ m}=10\text{ dm}=10^2\text{cm}=10^3\text{mm}.$$

(*b*) Secondly, in the new set-up decimal fractions will be mostly used. Decimal fractions being based on 10 are most suitable for logarithms. Logarithmic tables will make our task of multiplication and division very easy and simplify many solutions in commercial arithmetic. Only a four-figure table should be sufficient. Students must be trained to consult the logarithmic and antilogarithmic tables. The theory part of logarithms may be left for a subsequent specialized course. Only the use of the tables is necessary.

Example. Find to 3 figures the value of

$$\frac{(0.05871)^3 \times \sqrt{0.7128}}{5\frac{2}{3} \times (0.3136)^4 \times \sqrt[3]{0.6915}}$$

The solution of this fraction in an ordinary way (without using logarithms) will be difficult for a school student. Logarithms will simplify the process.

Number	Logarithm	
$(0.05871)^3$	$\bar{2}.7687 \times 3$	$\bar{4}.3061$
$\sqrt{(0.7128)}$	$\bar{1}.8530 \times \frac{1}{2}$	$\bar{1}.9265$
Numerator		$\bar{4}.2326$
$5\frac{2}{3} = 5.667$		.7533
$(0.3136)^4$	$\bar{1}.9104 \times 4$	$\bar{1}.6416$
$\sqrt[3]{0.6915}$	$\bar{1}.8398 \times \frac{1}{3}$	$\bar{1}.9466$
Denominator		.3415
Expression		$\bar{5}.8911$

$\therefore$ From anti-logarithmic table, expression = 0.0000778

Percentage. Students must understand that the use of percentage is made for comparison. It is a standardized ratio on a convenient basis of 100. Percentage is, therefore, closely related to fractions, and more to decimal fractions. So the introduction of this topic must be closely related to decimals. Students should be made to understand through various examples that it is nothing new and does not differ from the method of writing and speaking of the decimal fraction—hundredth—commonly used in business and practical affairs.

The presentation of the topic will also undergo change. Our 'naya paisa' coins and the units of the metric system will give percentage a concrete shape. Our rupee has hundred parts—each part being called a 'naya paisa'. A centimetre is the hundredth part of a metre and so is the weight of 10g of a kg. The unit of temperature may also be used; the centigrade thermometer, adopted for measuring temperature has 100°. These facts may frequently be used by authors to motivate the students for the lesson.

Now, the first lesson can be given as follows:

(*i*) Out of 100 naye paise which make one rupee, the teacher can take one. Then he can ask his pupils to express this fact in a number of different ways, as (*a*) 1 out of 100, (*b*) $\frac{1}{100}$, (*c*) .01. Then he can say that there is a fourth way of writing the same as 1%. One per cent means 1 out of 100. The same thing can be explained by taking a centimetre of length on a metre rod. Then he can take 2 nP, 3 nP, 10 nP, etc. The relation between 10 nP and 1 rupee or 100 nP can be written as (*a*) 10 out of 100, (*b*) $\frac{10}{100}$, (*c*) .10, (*d*) 10%. Students have already learnt the way of writing money in decimal form, and the new knowledge can be correlated with it.

(*ii*) The above process will easily lead the children to learn conversion from per cents to decimals and from decimals to per cents. For example, 56% means .56 and .75 means 75%. These decimals must be expressed up to two places, *i.e.* write .30, .80, etc., instead of .3, .8. Here the author can take a parallel question from common fractions. Such conversions in common fractions are not so easy. Let us illustrate by examples.

Express (*a*) $\frac{3}{4}$ as a percentage and (*b*) 56% as a fraction.

(*a*) $\frac{3}{4}$ means 3 out of 4 $=\frac{3}{4}\times 100$ out of $100=75\%$

(*b*) 56% means 56 out of $100=\frac{56}{100}=\frac{14}{25}$

(*Note*: The rates of increase and decrease in population are per thousand).

Examples. The population of England and Wales was 29002000 in 1891 and 32577300 in 1901; that of Scotland was 4025000 in 1891 and 4472000 in 1901. Find which population increased at a higher rate during the period.

Increase in population in the first case

$$=32577300-29002000$$
$$=3575300$$

$\therefore$ Increase per 1000 $=\dfrac{3575300\times 1000}{29002000}$

$$=\frac{3575}{29} \text{ approx.}$$

Increase $=123$ per thousand, approx.

Increase in population in the second case

$$=4472000-4025000$$
$$=447000$$

$\therefore$ Increase per 1000 $=\dfrac{447000\times 1000}{4025000}$

$$=\frac{447000}{4025}$$
$$=\frac{447}{4} \text{ approx.}$$

Or Increase $=112$ per thousand, approx.

$\therefore$ The rate of increase in case of England and Wales was higher. It is a good example on approximation also. Approximations help in simplifying fractions.

Ratio. There is not very much to say here. Authors should remember that our coins are one naya paisa, 2 naye paise, 5 naye paise, 10 naye paise, 25 naye paise, 50 naye paise and 100 naye paise. So the present ratio in our coins is 1 : 2 : 5 : 10 : 25 : 50 : 100. The former coins starting with paisa formed a geometric sequence in 1, 2, 4, 8, 16, 32, 64. The units of the systems of length, weight and capacity form a geometric sequence but not the commonly used units. The commonly used weights are in the ratio of 3 : 2 : 2 : 1. The author should use only those common units which are within the child's comprehension. Unreal things like fractions of naya paisa should also disappear from textbooks.

Example. A purse contains coins of the following denominations : one rupee, 50 nP and 25 nP in the ratio 3 : 4 : 5. If the total value of the money in the purse is Rs 50, find the number of each coin.

Coins : Re : 50 nP : 25 nP

Number : 3 : 4 : 5

Value : Rs 3 : Rs 2 : Rs 1.25

: 12 : Rs 8 : Rs 5 *in integers*

Total = Rs 25

$\therefore$ Value of Rupees $= \text{Rs } \frac{12 \times 50}{25} = \text{Rs } 24$

$\therefore$,, 50 nP $= \text{Rs } \frac{18 \times 50}{25} = \text{Rs } 16$

and value of 25 nP $= \text{Rs } \frac{5 \times 50}{25} = \text{Rs } 10$

$\therefore$ Number of coins = 24, 32 and 40.

or

Let the coins be 3x, 4x and 5x respectively.

$\therefore$ Value in rupees $= 3x + 2x + 1.25x$

$\therefore$ $3x + 2x + 1.25x = 50$

Or $6.25x = 50$

$$\therefore \quad x = \frac{50}{6.25} = \frac{5000}{625} = 8$$

$\therefore$ Number of coins = 24, 32, 40.

2. COMMERCIAL ARITHMETIC

Commercial arithmetic relates to the practical value of teaching arithmetic. It is this part for which the child is taught operations in numbers. This is the application of all the processes learnt in basic arithmetic, *i.e.*, application of (*i*) numbers (integers, decimals and fractions), (*ii*) percentage and (*iii*) ratio.

Under the first head, topics like practice, average, square root, cube root, etc., can be taken; the second covers profit and loss, interest, discount, stocks and shares, insurance, rent, tax and investments, etc., and under the third will be mixture, proportion, rule of three, time and work, time and distance and the like. The general effects on the problems of these topics have been discussed in the last chapter. The two main things to be repeated are—

(*i*) As a general rule authors should take problems from factories, industries, agriculture, mills, trade and commerce and from such other sources, keeping in view the interests of a variety of children (rural and urban; rich and poor; weak and bright).

(*ii*) There should be correlation of the subject with other subjects and with other branches of the same subject in regard to choice of problems.

Practice. As already said, the introduction of the metric system eliminates practice. Problems in both simple and compound practice can be solved through multiplication and division of decimals. For example: Find the price of 23 sacks of sugar at the rate of Re 1 and 19 naye paise per kg when each sack contains 98 kg and 700 g of sugar.

∴ The price of 1 kg	=Rs 1.19 nP
∴ The price of 98.700 kg	=Rs 1.19×98.70
or The price of one sack	=Rs 117.453 (multiplication of integers only)
∴ The price of 23 sacks	=Rs 117.453×23
	=Rs 2701.419 (multiplication of integers only)
	=Rs 2701.42 approx.
	=Rs 2701 and 42 nP.

Note : (*i*) The method is simpler than the old practice method.
(*ii*) It proves the necessity of learning approximations.
(*iii*) The use of logarithms could have still simplified the operations.

Average. Authors should deal with the topic in such a way that pupils may realize its importance. Practical applications, such as, to find the average height, weight of pupils of the class; to read and understand rainfall and temperature charts from newspapers, should be taken up and pupils should be taught how to find the average from given data. Some examples of such problems are: To find the average distance travelled by a train or a horse or a bullock-cart per hour, the average distance travelled by a car on one litre of petrol, the average score of a batsman, the average time taken by a seed to sprout or by a crop to be ready for harvest, the average sale of a shop per day or of an article, the average yield per are, and such others.

Example. The average height, 171.2 cm, of 7 jawans is increased by 2.9 cm when a new jawan is recruited. Find the height of the new jawan.

The total height of 7 jawans $= 171.2 \text{ cm} \times 7 = 1198.4 \text{ cm}$

The new average of 8 jawans $= (171.2 + 2.9) \text{ cm} = 174.1 \text{ cm}$

∴ The total height of 8 jawans

$= 174.1 \text{ cm} \times 8 = 1392.8 \text{ cm}$

∴ The height of the new jawan

$= 194.4 \text{ cm}$ Ans.

Application of Percentages. Shop arithmetic is only an application of percentages. In most of these problems units of money are used. In the selection of problems authors should bear in mind, as has been said in the last chapter, that old units should not be used. Neither should the problems set undesirable examples. Problems on dishonest dealers or problems on a shopkeeper earning a huge amount of profit on provisions of daily use do not suit the present hour, and are likely to produce an unwholesome effect on the minds of children.

Such problems should be given: A shopkeeper was charging profit of 10 p.c. on his goods. But because of the emergency he declared that he would charge only 5% gain. By how much per cent will his income fall?

Example. A bicycle was purchased for Rs 215 00 nP by a retailer and sold to a purchaser at a gain of 10 p.c. After one year this purchaser sold it to a second purchaser at a loss of 7.5%. This second purchaser sold it to a third at a loss of 2%. Find the price the third purchaser paid.

Cost price of the retailer $=$ Rs 215.00 nP

Gain at 10% $=$ Rs 21.50 nP

∴ Cost price for the first purchaser

$=$ Rs 236.50 nP

Loss at 5% $=$ Rs 18. 25 nP }
Loss at $2\frac{1}{2}$% $=$ Rs 9.125 nP } Loss at 7.5%

∴ Cost price for the second purchaser

$=$ Rs 209.125 nP

Loss at 2% $=$ Rs 4.18250 nP

∴ Cost for the third purchaser

=Rs 204.94250 nP

=Rs 204.94 nP approx.

Investments. Arithmetic books at present are full of questions involving formal applications of the interest formulae. Very huge and lengthy questions on compound interest are also found in abundance. But students have little beyond a theoretical knowledge of the subject. The economic aspect of the problems is not brought to their notice. They must be made aware that the rate of interest is always in the ratio of the security and a high rate of interest is the indication of an unsafe investment. Problems to suit students coming from both rural and urban areas should be included.

A student coming from rural areas will be interested in problems of borrowing from the co-operative societies for short terms and in payment on instalment basis. An urban student will like to know something about savings bank account, post office saving banks and such other facilities which are available more in urban areas.

All students should also know about investment in Government securities such as National Savings Certificate, Prize Bonds, National Defence Certificate, Gold Bonds and other Government undertakings.

Problems on rates, taxes, commissions, income tax and life insurance should also be given.

Example. A man's gross income is Rs 8264.00 nP, out of which a sum of Rs 1500 is free of income tax. For the next Rs 3000 he has to pay tax at the rate of 5 nP per rupee and for the rest he has to pay 7 nP in the rupee. Find his net income.

Rate of tax on Rs 1500=Re .00 nP per rupee
Rate of tax on Rs 3000=Re .05 nP " "
Rate of tax on Rs 3764=Re .07 nP " "

∴ Tax on Rs 1500=Rs 1500.00 nP×.00
=Rs 00nP
" " " 3000=Rs 3000.00×.05
=Rs 150.00

Tax on Rs 3764 = Rs 3764.00 × .07
= Rs 263.48

∴ Total tax to be deducted
= Rs 413.48 nP

∴ His net income = Rs 8264.00 — Rs 413.48 nP
= Rs 7850.52 nP

Interest. In problems on interest the popular instalment mode of deposits in a bank and the use of logarithms in case of compound interest should be included in solving problems.

Example. A person saves Rs 100 every year and deposits the sum in the post office saving bank. What will his savings be at the end of 4 years if the post office pays compound interest at the rate of 3% per annum ?

I	II	III	IV
Rs 100	Rs 100	Rs 100	Rs 100

Rs 100 after the first year will yield 3 years' interest, Rs 100 after the second year will yield two years' interest, Rs 100 after the third year will yield one year's interest and Rs 100 at the end of four years will yield no interest.

So amount after 4 years will be
$= \text{Rs } 100\ \{(1.03)^3 + (1.03)^2 + (1.03)^1 + 1\}$

Use logarithms to find the values of $(1.03)^3$ and $(1.03)^2$

∴ The total amount will be
= Rs 100 (1.092727 + 1.0609 + 1.03 + 1.00)
= Rs 100 × 4.1836 nearly
= Rs 418.36 nP
= Rs 418 and 36 naye paise approx.

Discount. Here the idea should be made clear that a man has to pay less than the due amount if he pays earlier. Instalment mode of payment will need special attention here. Then the importance of *commercial* or *trade* discount is also to be stressed.

Example. What sum will discharge a debt of Rs 1000 due after 1 year if it is paid in two equal half-yearly instalments, the rate of simple interest being 5% ?

—6 months— Rs 1000

———1 yr———

Rs 500 Rs 500

In this case the man has to pay Rs 500 after 6 months and Rs 500 after 1 year. He decides to pay the whole sum immediately. So he will pay a sum equal to the present worth of Rs 500 due after 6 months and of another Rs 500 due after one year.

Interest on Rs 100 for 6 months = Rs 2.50

∴ Amount of Rs 100 ,, = Rs 102.50

When the sum due is Rs 102.50, P.W. = Rs 100

,, ,, ,, ,, Rs 500, P.W. $= \frac{\text{Rs } 100 \times 500}{102.50}$

$= \text{Rs } \frac{100 \times 500 \times 100}{10250}$

$= \text{Rs } \frac{20000}{41}$

= Rs 487.805nP

Interest on Rs 100 for 1 yr

= Rs 5.00

∴ Amount of Rs 100 for 1 yr

= Rs 105.00

∴ When the sum due is Rs 105,

P.W. = Rs 100

∴ When the sum due is Rs 500

P.W. $= \text{Rs } \frac{100 \times 500}{105}$

$= \text{Rs } \frac{10000}{21}$

= Rs 476.191 nP

∴ Total sum to be paid

= Rs 487.805 + Rs 476.191

= Rs 963.996 nP

= Rs 964.00 nP approx.

Investment in Banks and Shares. To encourge the younger generation to invest in savings bank and Government securities, problems on investment should mostly be based on these types of investments.

Example 1. An author received Rs 756.00 as royalty on his book from a publisher. He deposited the money in a fixed deposit scheme in the Delhi Co-operative Bank Ltd., Delhi. What will be his amount after 3 years if the rate of interest is 6 p.c. per annum, interest payable annually ?

Now A $=P(1+.01\times r)^n=756\ (1+.06)^3$
$=756\ (1.06)^3$
$\therefore$ log A $=\log 756\ (1.06)^3$
$=\log 756+3\log 1.06$
$=2.8785+3\times .0253$ (From the log tables)
$=2.8785+.0759$
$=2.9544$
$\therefore$ A $=900.40$ (from anti-log tables)
$\therefore$ Amount $=$ Rs 900 and 40 nP.

If we do not apply logarithms the solution will be as follows :

$$A=P\left(1+\frac{r}{100}\right)^n=756\left(1+\frac{6}{100}\right)^3$$
$$=756(1+.06)^3$$
$$=756(1.06)^3$$
$$=756\times 1.06\times 1.06\times 1.06.$$
$$=900.408096 \text{ (on multiplying)}$$

$\therefore$ Amount $=$ Rs 900.41 nP approx.

Note : Logarithms will simplify the problem of multiplication to a great extent. The difference between the two results is less than even one naya paisa.

Example 2. A man invests Rs 5000 in 12 years' National Defence Certificates which are quoted at par. Find the total dividend at the rate of 6.25 per cent.

Money invested	=Rs 5000.00 nP
Rate of dividend	=Rs 6.25%
Dividend at 1%	=Rs 50.00 nP
,, ,,6.25%	=Rs 50×6.25
	=Rs 312.50 nP

Application of Ratio. In this section there will be problems on buying and purchasing, rule of three, allegation, mixture, partnership, work and time, time and distance, races, trains, temperature, rainfall and such other topics. The following general suggestions may be found useful :

(*i*) Only the metric units are to be used. Pounds and gallons should give place to kilograms and litres. In metric units also only the proper units should be used for market purposes. In the field of science and similar other subjects all sub-units may be used.

(*ii*) Decimal fractions are to be chiefly used but common fractions need not be totally avoided. Only huge vulgar fractions should be replaced by either simple common fractions or by decimal fractions.

(*iii*) The rate, size and shape of things should be according to the changed standards in metric units. Railways, post offices, factories, industries and almost all concerns have changed their old rates, sizes, weights and shapes to suit metric units and decimal coinage. A list of a few such standards has been given in the appendix for the guidance of the authors. Some problems are now given below :

Consumption. The daily consumption of wheat by a family is 3 kg 800 g. Find the monthly expenses of wheat if the price of wheat is Rs 48.50 nP per quintal.

Wheat used $= 3.8$ kg $\times 30$
$= 114$ kg
$= 1.14$ quintal

$\therefore$ Price of 1.14 quintal at the rate of Rs 48.50 nP per quintal

$= $ Rs 48.50×1.14
$= $ Rs 55.39 nP
$= $ Rs 55.39 nP

Time and Distance. A motorist left Agra at 7 a.m. and reached Bhopal at 5.50 p.m. On the way he stopped 2 hours for Lunch and twice 10 minutes each time for petrol. If the road distance between Agra and Bhopal is 527 km, find the speed of the driver.

Time taken	=17 hrs 50 mts − 7 hrs
	=10 hrs 50 mts
Time taken in stoppages	=2 hrs + 20 mts
	=2 hrs 20 mts
∴ Actual travelling time	=10 hrs 5 mts − 2 hrs 20 mts
	=8 hrs 30 mts
	=8.50 hrs
Distance travelled	=527 km
∴ Speed per hour	$= \frac{527}{8.5}$ km/h
	=62 km/h

Time and Speed. An aircraft with an air speed of 432 km an hour has enough petrol for 90 minutes' flying. For how many minutes can it fly with a following wind 48 km an hour if it is to be able to get back to its starting point against the same wind ?

The speed for going	=(432 + 48) km/h
	=480 km/h
,, ,, ,, coming down	=(432 − 48) km/h
	=384 km/h

Suppose it flies for x minutes.

Then it comes down in $(90 - x)$ minutes

$$\therefore \quad \frac{x \times 480}{60} = \frac{(90-x) \times 384}{60}$$

From here $x = 40$.

∴ The aircraft flies for 40 minutes.

General. When a strip of magnesium weighing 22.3g is burnt in air, its weight increases to 37.8g. What is the percentage increase in weight and what percentage of the solid left at the end is magnesium ? Answer correct to 3 significant figures.

Increase in weight	=37.8 g − 22.8g
	=15g
∴ Increase %	$= \frac{15 \times 100}{22.8}$
	=65.8
Percentage of magnesium	$= \frac{22.8 \times 100}{37.8}$
	=60.3.

3. ORAL ARITHMETIC.

Oral work makes the foundation strong and helps in bringing mastery over a rule or formula. Authors and teachers should help pupils to discover some simple rules connected with the different types of units with coins like those which existed in the old system. For example : Get as many chhataks for as many annas as you get so many seers for so many rupees or the number of chhataks and the number of annas in purchase tally with the number of seers and the number of rupees in the rate. Its converse is also true. Some such easy rules can be framed here also.

1. The price of a kilogram of ghee is Rs 7.50 ; how much will a customer get for Rs 75 ? (Answer=100.0 g). (Remove the decimal point one place to the left as it has been done in case of money. Its converse is also true).

2. Oranges are being sold at the rate of Rs 12.00 per hundred. Find the price of an orange. (Answer 12 naye Paise) (By removing the point two places to the left).

3. If a cyclist covers 16 km in an hour, how much will he cover in 6 mts ? (Answer 1.6 km) (By shifting the point one place to the left).

4. The average ration given to a soldier per day is .65 kg. Find the ratio needed for 1000 soldiers for 10 days. (Answer=65 quintals). (By shifting the point to the right).

5. What will be the simple interest on Rs 350.00 for a year at the rate of 1% ? (Answer=Rs 3.50 nP). (By shifting the decimal point).

These above-mentioned examples are not rules. They are only examples to which rules have been applied. Authors and teachers can frame the rules. Some more examples and rules can also be thought of.

CHAPTER VI

METRIC UNITS AND MENSURATION

Let us now see how metric units help the learning of mensuration.

1. Metric units have brought about better accuracy in the results. For example, when a length equal to $3\frac{1}{16}$ yards is converted into decimals it will be equal to 3.0625 yards or 3 yards and 2.25 inches. This measure of length is seemingly complicated, for one has to measure up to hundredth part of an inch. On the other hand, a length measuring $3\frac{1}{16}$ m will be equal to 3.0625 m which means 3 m, 6 cm and $2\frac{1}{2}$ mm. The latter measurement is more realistic and practical. We can get better results and can measure more accurately with the new units.

2. The last unit in the old system is the inch, which is more than 2.25 cm. In the new system the centimetre is not the lowest unit. There are two more units lower than this. So for purposes of measurement the new system offers greater accuracy.

3. The fineness in the measure of length can be noticed in calculations of area, volume and capacity also and in a higher degree. The error in area will be in proportion to the square and the error in volume will be in proportion to the cube of the error in linear measure. The error in linear measure is very small in metric units and, therefore, both area and volume will be more accurate.

Example. The surface area of a square flank having each side 1 foot 2 in. long will be 1.361 sq. ft. approximately and the volume of a cube having each side 1 foot 2 in. will be 343/216 cu. ft. = 1.587 cu. ft. nearly. If the side of the flank had been 1 cm 2 mm, the area would have been exactly equal to 1.44 sq cm, *i.e.*, 1 cm^2 44 mm^2 and the volume of the cube having the same side would have been exactly equal to 1.728 cm^3, *i.e.*, 1 cm^3 728 mm^3.

These improvements are very helpful to scientists and engineers. The inch is too large a unit for most of the engineering work. The designer takes a longer time in preparing drawings dimensioned in inches than in those dimensioned in millimetres.

Area. The concept of area is a little difficult for students in schools. The area is generated by a line. The idea can be very clear only after students have done limits and differentiation in calculus. All that teachers and authors can do is to point out to students that the area is a measure of the surface, just as length is a measure of distance. In the beginning he can use a duster or a piece of rectangular cloth or a book to measure the surfaces of tables and blackboards. This will bring home to students the necessity of having standard units of area as there are for lengths. In the case of the metric system these standard units are very simple. Each unit is 100 times the previous one. So they simplify computation. All the four operations can be made as with integers. For conversion from one unit to the next the decimal point has only to be moved two places either to the left or to the right. In the British units there were seperate numbers for each change in unit. For changing square inches into square feet the first number is to be divided by 144 and for changing square feet into square yards the divisor has to be 9. These numbers 9, 144 64, 4840, etc., were very inconvenient for division or multiplication. In the new system the common factor is 100. Even for a higher change it will be either a multiple or a sub-multiple of 100. Authors should explain this convenience in computation when metric units are used.

Example (*i*) *Old.* Find the cost of polishing the surface of the top of a table 35″ long 25″ broad at the rate of 30 nP per square foot.

The surface area of the top of the table

$$= 35 \times 25 \text{ sq. in.}$$

$$= \frac{35 \times 25}{144} \text{ sq. ft. (By conversion into sq. ft.)}$$

$\therefore$ The cost of polishing the table

$$= \frac{35 \times 25 \times 30}{144} \text{ nP}$$

$$= \frac{35 \times 25 \times 5}{24} \text{ nP}$$

$$= \frac{4375}{24} \text{ nP}$$

$$= 182\frac{7}{24} \text{ nP} = \text{Rs } 1.82\frac{7}{24} \text{ nP}$$

= Re. 1.82 nP nearly.

Example (ii) New. Find the cost of polishing the surface of the top of a table 75 cm long 60 cm broad at the rate of Rs 2.80 nP per m^2.

The surface area of the top of the table

$= 75 \times 60 \text{ cm}^2$

$= 4500 \text{ cm}^2$

$= \cdot 45 \text{ m}^2$ (By conversion)

$\therefore$ The cost of polishing the table.

$=$ Rs 2.80 nP $\times .45$

$=$ Rs 1.2600 = Re. 1 and 26 nP.

Subject Matter

The teaching of area starts in primary classes. There students are expected to find the areas of rectangular figures only. In middle classes they have to calculate the areas of paths, carpets, walls and some curved surfaces also. In secondary classes the areas of irregular bodies, frusta, circles, cylindrical and conical bodies may be treated. Scale drawing, calculation of area on a map may also form part of the subject-matter.

Hints for Framing Questions

1. The use of the whole table of units of area from square millimetre to square kilometre is unreal and involving the use of all these units cannot stand the test of practicability. Smaller units for smaller areas and bigger units for larger areas should be used. For example, areas of geometrical figures should be expressed in mm^2 or cm^2 ; the areas of rooms, courts and gardens in m^2 and bigger areas in km^2, are and hectare. Square centimetres are suitable for area of books,

stamps, tea-tables and figures used in the science-laboratory. Intermediary sub-units may be used wherever necessary.

2. Problems should be related to real-life situations. Papering of walls in India is not a real situation. The sizes of carpets, mats, bricks and other important articles should be standard and expressed in metric units. Rates of colouring, white-washing, painting, etc., should approximate current rates.

3. Problems on actual field-work may also be given. Students may be asked to find the area of the place occupied by a tree or a plant or a flower-bed. From this they may go to finding the area covered by a railway line or a metre-gauge or the run-way of an aeroplane or a football field. Here text-book writers should be careful in using only the standard measurements of these grounds in the metric system.

4. A good textbook should contain problems on calculation of the surface area needed for pitching tents, digging roads, making houses, mines and bridges.

These are related to present-day needs.

5. As far as possible all measurements should be given to the nearest whole number but questions involving greater accuracy and approximation may also be included for secondary classes.

Example. A petrol storage tank, cylindrical in shape, with 3.5 m in diameter and 8 m long is to be painted with a paint each litre of which has a maximum coverage of $60 m^2$. If paint of this quality sells for Rs 4.80 nP per litre, find the cost of the paint. (Take $\pi = 22/7$ approx.)

The whole surface of the tank $= 2\pi \times r(h+r)$

$$= 2 \times \frac{22}{7} \times \frac{7}{4}\left(8+\frac{7}{4}\right) m^2$$

(approx.)

$$= 2 \times \frac{22}{7} \times \frac{7}{4} \times \frac{39 m^2}{4}$$

(approx.)

$$= \frac{429 m^2}{4}$$

$$\simeq 107.25\ m^2$$ (approx.)

Now the cost of 60m² $= \text{Rs } 4.80 \text{ nP}$

$\therefore$ The cost of 107.25 m² $= \dfrac{\text{Rs } 4.80 \times 107.25}{60}$

$= \text{Rs } 0.08 \times 107.25$

$= \text{Rs } 8.58 \text{ nP}$

$=$ Rs 8 and 58 nP only.

6. To familiarize students with 'are', 'hectare', 'quintal', 'Tonne', etc., the author should give a good number of problems involving these units of area and weight.

Example. Find the cost of fencing a square field measuring 42 are and 25m² at the rate of Rs 1.15 nP per metre.

Area of the field $=$ 42 are 25m² $=$ 4225m²

$\therefore$ Each side of the field $= \sqrt{4225\text{m}^2}$

$= 65\text{m}$

$\therefore$ Length of fencing required $= 65\text{m} \times 4$

$= 260\text{m}.$

$\therefore$ Cost at Rs 1.15 nP per metre $= \text{Rs } 1.15 \times 260$

$= \text{Re } 1.00 \times 260 + \text{Re } .15 \times 260$

$= \text{Rs } 260 + \text{Rs } 39$

$= \text{Rs } 299.00\text{nP}.$

7. The textbooks should contain all types of problems such as (*a*) Drill Type (*b*) Oral Type (*c*) Appreciative Type and (*d*) Creative Activity Type in addition to written problems. Some sample problems are given below :

(A) Drill Type. Find

(*i*) the area of a playground in ares and hectares when length $=$ 50m and width $=$ 30m.

(*ii*) the area of the curved surface and the whole surface of a cylinder whose height is 20 cm and radius of the base is 10.5cm.

(*iii*) the area of a circle when its radius $=$ 7cm.

(*iv*) the area of the lateral surface of a cone of slant height 15cm and height 12 cm.

(B) Oral Type

(*i*) Find the length of wire needed to make a fence for a square garden of area one are.

(*ii*) The length and breadth of a rectangle are in the ratio of 3 : 2. If the area of the rectangle be $24m^2$, find its perimeter.

(*iii*) A circular road runs round a circular garden. If the difference between the outer and the inner boundaries be 44m, find the width of the road
(Take $\pi=\frac{22}{7}$).

(C) Appreciative Type

To make designs with the help of triangles, sectors, segments and then colouring the different areas: comparison of products in different agricultural fields, making of cones, cylinders, etc., with the help of card-board and wood and then comparing the surfaces occupied.

(D) Creative Activity Type

(*i*) To find the area of a circle, let students cut off equal sectors from the circle and then rearrange them so as to form a rectangle.

(*ii*) The same activity may be carried out for finding the curved surface of a cylinder.

(*iii*) Placing three cones of the same size in a cylinder of the same height and of the same diameter of the base in order to find the volume of the cone from that of the cylinder.

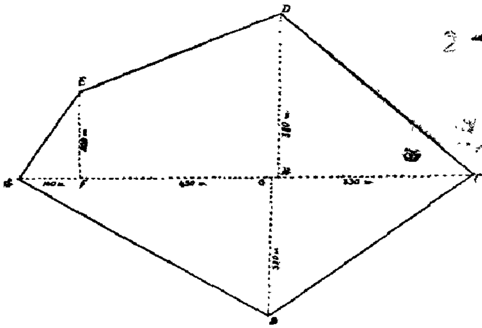
Many other questions of these types can be framed by the teacher for practice.

(E) Problems

Many sample problems have been given in chapter IV for the guidance of the authors and teachers. In this chapter also problems have been included as examples. One more example is added to the list.

Example. A farm has been divided into 4 triangular fields and one trapezoidal field as shown in the adjoining diagram. Find its area.

Area of the field AFE $= \frac{140 \times 200}{2} m^2$
$= 14000 m^2$



Area of the field EFHD $= \frac{1}{2}(200+380) \times 430 m^2$
$= 124700 m^2$

" " " " DHC $= \frac{1}{2}(380 \times 330) m^2$
$= 62700\ m^2$

" " " " ABC $= \frac{1}{2}(140+430+330) \times 320\ m^2$
$= 144000\ m^2$

$\therefore$ Total area of the field $= (14000+124700+62700 + 144000)\ m^2$
$= 345400\ m^2$
$= 3454$ are
$= 34.54$ ha.

It is an illustration for conversion also.

Volume. Just as area is the measure of surface, in the same way volume is the measure of space. This is the definition to be given to school students.

The correct idea can be developed only when the students have understood the concept of area. Volume is generated by a plane area moving in any other direction than in its own plane. Hence it can be defined as the product of the area and he distance it moves. A study of differential calculus and limits will help here also in understanding the concept of volume.

Units of Volume. (*i*) Like the units of area, the units of volume are also very simple. Each unit is 1000 times the preceding unit. To convert the units you have either to multiply or divide by 1000 or a multiple of 1000. Thus, the decimal point is to move three places either to the right or to the left. In actual calculation of volume also the metric units are more advantageous than the British units. Let us take an example :

Example (*Old Units*). Find the volume of water in cu. ft. contained in a cistern $4'.2\frac{1}{2}''$ long, $3'.4''$ broad and $2'.5''$ deep.

The volume of water is $=(4'.2\frac{1}{2}'')\ (3'.4'')\ (2'.5'')$ cu. ft.

$=(4\frac{5}{24})\ (3\frac{1}{3})\ (2\frac{5}{12})$ cu. ft.

(after changing into ft.)

$=\frac{101}{24}\times\frac{10}{3}\times\frac{29}{12}$ cu. ft.

$=\frac{29290}{864}$ cu. ft.

$=33\frac{389}{432}$ cu. ft.

(*New Units*). If the cistern is 4 dm 2.5 cm long, 3 dm 4 cm broad and 2 dm 5 cm deep, the volume will be

$=4.25\times3.4\times2.5\ dm^3$

$=36.125\ dm^3$.

(*ii*) The introduction of metric units makes the calculations of area and volume simple cases of multiplication of decimal numbers either by integers or by decimal numbers. Inverse problems may involve divison of two decimal numbers. The old units did not provide this facility. There :

1 cu. yd. = 27 cu. ft.

1 cu. ft. = 1728 cu. in.

Both these numbers are not fit for decimal operations. Also, computation in these numbers requires time and patience and yet one may not be sure of a correct result.

Subject-Matter. Suggestions made in the case of area may be followed here also. The author should bring variety to the selection of questions. Some of the topics may be : volume of water passing through a ferry ; the number of bricks required for building a wall; the volume of trenches, frusta of cones, cylinders and spheres ; machines ; arms and such other topics which are of common use. The sizes should conform to the standards in the new system.

Example 1. What volume of water falls on an area of 1 ha. when there is a rainfall of 2 cm ? Find the weight of water collected over the area.

Volume = Area × ht. $= 1000000 \times 2$ cu cm

$= 2000000 \text{ cm}^3$

The weight of water $= \frac{2000000}{1000}$ kg

$= 2000$ kg

$= 2$ tonnes.

Example 2. Find the number of bricks required to make a wall 8 m long 6 m wide and 5 m high, the size of the bricks being 20 cm by 10 cm by 10 cm. Find also the cost at Rs 37.25 nP per 1000 bricks together with Rs 4.37 nP per 1000 as cartage.

(*Note* : The standard size of the brick is 19 cm by 9 cm by 9 cm, but with mortar it becomes 20 cm by 10 cm by 10 cm)

The volume of the wall $= 800 \times 600 \times 500 \text{ cm}^3$

" " one brick $= 20 \times 10 \times 10 \text{ cm}^3$

∴ No. of bricks required $= \frac{800 \times 600 \times 500}{20 \times 10 \times 10}$

$= 400 \times 300$

$= 120000$

The cost per 1000 = Rs 37.25 + Rs 4.37

= Rs 41.62 nP

∴ The cost of 120000 = Rs $\frac{41.62 \times 120000}{1000}$

= Rs 4994.40 nP

= Rs 4994 and 40 nP

Specific Gravity. Specific gravity is given in decimal numbers. So here also the present units will be found very useful. Weights of bodies can be easily found by simple multiplication of integers.

Example 1. Calculate the weight of 100 m of wire, diameter 0.021 cm, if 1 cm³ of copper weighs 8.9 g (Take $\pi = 3.14$).

The volume of the copper $= \pi r^2 h = \frac{3.14 \times .021 \times .021 \times 10000}{2.2} \text{ cm}^3$

$= 3.46185 \text{ cm}^3$

∴ The weight of the wire $= 3.46185 \times 8.9$g

$= 30.81$ g approx.

Note : Make use of logarithmic tables for multiplication.

Example 2. Find in kilograms the weight of a bar of gold 10 cm long, 30 mm wide and 25 mm thick, its specific gravity being 19.36.

The volume of the bar $= 10 \times \frac{30}{10} \times \frac{25}{10}$ cm^3 $= 75$ cm^3

Weight of 1000 cm^3 water $= 1$ kg

$\because$ Weight of 1000 cm^3 of gold $= 19.36$ kg

$\therefore$,, ,, 75 cm^3 of gold $= \dfrac{19.36 \times 75 \text{ kg}}{1000}$

$= .1936 \times 7.5$ kg

$= 1.452$ kg

$= 1$ kg 452 g

Capacity. Our students do not get a correct idea of capacity. They solve questions on volume and also on capacity; but do not know what capacity is. Teachers should give practical demonstrations by filling water in a bucket or sand in an empty box. Below is given an extract from *The Teaching of Mathematics in Primary Schools, A Report prepared for the Mathematical Association.* (G. Bell & Sons Ltd., London). This book may be consulted with advantage.

'Capacity shares with length the advantage that its measurement may be effected by visual comparison with a standard unit, although in case of capacity the comparison is indirect, using as an intermediate agent a fluid or some solid, such as sand, possessing the characteristic of a fluid in that it takes up the form of any vessel into which it may be poured'.

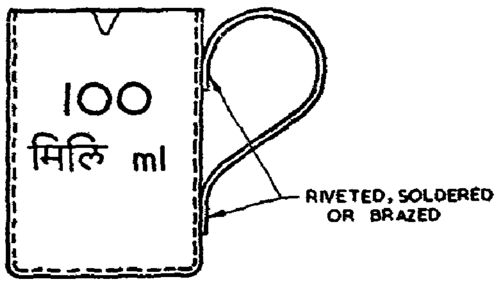
Units. The basic unit for capacity, 'litre', is the volume occupied by one kilogram of pure water at 4°C temperature. The sub-units are multiples or sub-multiples of the basic unit. Here also each unit is 10 times its preceding unit. Authors should very clearly bring it to the notice of students that the ratio between the two successive units of capacity is 10; while in area it is 100 and in volume it is 1000. The complete table has been given at the end of this book.

Measurement of Capacity. In daily life measurement of capacity is done with the help of suitable containers. These containers are of two types; (*i*) Cylindrical (*ii*) Conical. Cylindrical containers are meant for (*a*) dipping and (*b*) pouring.

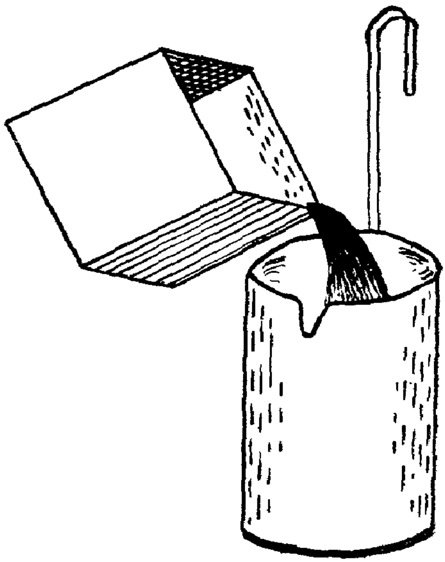
These containers, and the common units used in these three *types be shown to the students.*

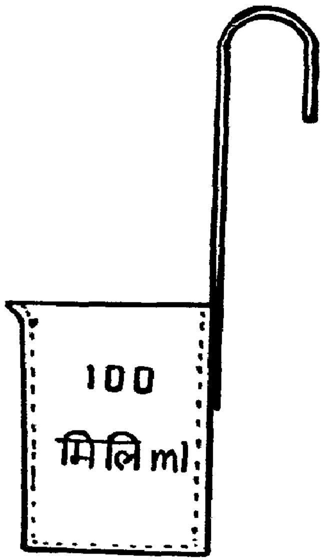
They may be told some uses of these vessels. For example, *conical vessels are used for oil and petroleum. In addition* to these there are three types of dispensing measures:

(1) Conical measures (2) Beaker measures (3) Pipette measures.

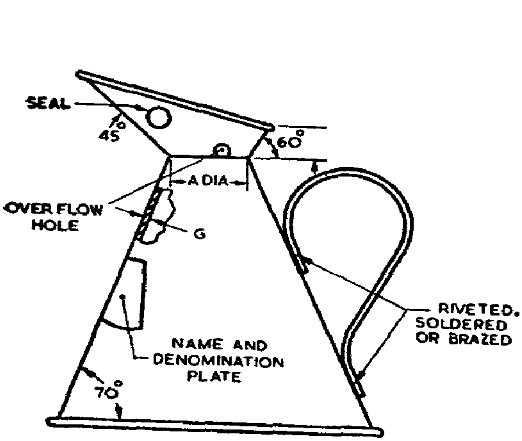


Cylindrical (dipping)



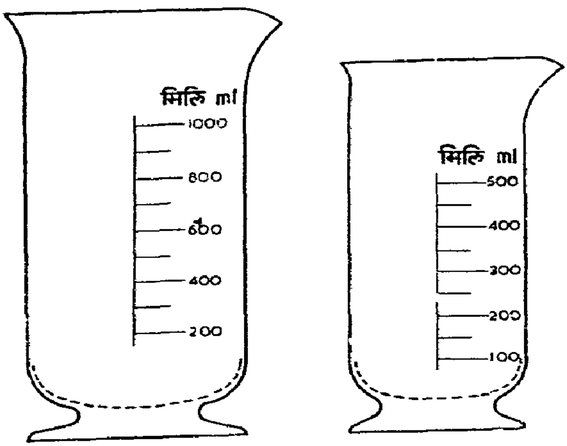


Cylindrical (pouring)

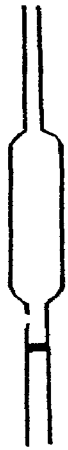


Conical

Dispensing—conical



Beaker



Pipette

Relationship between the units of Volume, Weight and Capacity.

There is one to one correspondence in these three types of units in the metric system. The measures of volume, weight and capacity are very closely connected. The books should display this connection. It has already been said that a kilogram is the mass of 1 dm^3 of water at 4°C temperature.

Thus:

1 dm^3 = 1 litre (approx.)

Weight of 1 litre of pure water = 1 kg

1 metre cube = 1000 litres (approx.)

Weight of 1000 litres of pure water = 1000 kg

The relationship between the corresponding units of volume, weight and capacity may be given in a tabular from as given below:

Table showing the relations between Volume, Capacity and Weight

Volume	m^3	—	—	dm^3	—	—	cm^3
Capacity	kl	hl	dal	l	dl	cl	ml
Weight	Metric tonne or 1000 kg	—	—	kg	hg	dag	g

From the table it is clear that 1 litre = 1dm^3 and 1ml = 1cm^3. These will be helpful in conversions also. Authors and teachers have to put a number of questions in a variety of forms to bring home this relationship to the students. Many drill-type questions for the sake of practice should be given in books. Then teachers should put oral questions in class. Practical experiments for finding the capacity of vessels with the help of the containers may be done by students.

Example 1. A rectangular pot contains a litre of water. If the length and breadth of the pot be 20 cm and 10 cm, find the depth of the water.

Capacity of the pot $=1$ litre.

$\therefore$ Volume of the pot $= 1\ dm^3 = 1000\ cm^3$

Length of the pot $= 20cm$

and width $= 10cm$

$\therefore$ The depth of the water $= \dfrac{1000}{20 \times 10}$ cm

$= 5cm.$

Example 2. A spherical toy balloon has air blown in to increase its diameter from 5cm to 6cm. How much air is blown in? ($\pi = 3.1416$).

The volume of the balloon before blowing

$= \frac{4}{3} \times \pi \times \frac{5}{2} \times \frac{5}{2} \times \frac{5}{2}\ cm^3$

$= \frac{125}{6}\pi\ cm^3$

The volume of the balloon after blowing

$= \frac{4}{3} \times \pi \times 3 \times 3 \times 3\ cm^3$

$= 36\pi cm^3$

$\therefore$ Volume of air blown in $= (36\pi - \frac{125}{6}\pi)\ cm^3$

$= \frac{91}{6}\pi\ cm^3$

$= \frac{91}{6} \times 3.1416\ cm^3$

(putting the value of π)

$= 91 \times .5236\ cm^3$

$= 47.6476\ cm^3.$

CHAPTER VII

METRIC MEASURES AND THEIR APPLICATIONS

The effects of the changeover from the old to the metric system can be noticed in almost all aspects of life. It has brought vast changes in the teaching of arithmetic and has simplified computation. Other fields of knowledge, too, have been equally affected. In the field of science its supremacy is being realized by every country of the world. In other fields also the computational work is very much simplified. The authors of textbooks in physics, chemistry and other subjects should introduce these units and indicate the facility achieved by them. While it is true that the syllabus and teaching of arithmetic need a complete change—rather overhauling, other branches of mathematics also cannot remain untouched. Wherever the old units are being used, the new ones are to be introduced and the authors and teachers have to present the subject-matter in such a way that the advantage of the new over the old may be obvious. In this chapter branches of mathematics other than arithmetic and a few allied subjects as they will be affected by the changeover to the new system will be discussed for the guidance of the authors.

Geometry. Metric units have affected practical part of geometry, e.g.,

(*i*) The new units will bring the percentage of error to a considerably low degree, and thus constructions will be finer and more accurate.

When British units are used, straight lines are measured in inches and tenths of an inch; but they can now be measured in cm and mm, which are much smaller units than the inch. This makes the results more precise and the standard of accuracy is improved.

(*ii*) In all practical problems of geometry the inch is divided into 10 parts which is a natural base in the case of metric units. It is very difficult to draw a straight line equal to $3\frac{1}{8}''$; but there is no difficulty in drawing a straight line equal to 3.8 cm. These smaller units help the construction of complicated figures and also save time.

(*iii*) Another difficulty with the old measurements is that miles, furlongs, yards, feet and inches do not have the same basis for conversion as in the case of metric units. It presents a difficulty in choosing a common scale. For example, if the distance of 45 miles, 3 furlongs and 63 miles, 5 furlongs are to be represented by two straight lines, the distances in miles will be $45\frac{3}{8}$ and $63\frac{5}{8}$ and in furlongs they will be 363 and 509. It is very difficult to find a common scale for representing these two distances in inches. Now if the distances are 45 km 3 hm and 63 km 5 hm, the distances converted into one unit will be 45.3 km and 63.5 km. If 1 mm represents 1 km on paper, the distances can be represented by straight lines, 45.3 mm and 63.5 mm long.

(*iv*) A large single number can be easily and conveniently represented with the help of these units. To represent long distances you have either (*a*) to take a large scale or (*b*) to draw a large figure. Neither is quite suitable for classwork. In the metric system, the lowest unit is the millimetre, which is a very small unit. The advantage will be clear from the example given below.

In a public examination, candidates were asked to divide a straight line in the ratio of 67 : 73. Here, the inch as a unit is too big for the answerbook, for then students will have to draw straight lines 6.7" and 7.3" long. But if they choose metric units they will have to draw only 6.7 cm and 7.3 cm long straight lines, which can be conveniently drawn.

Scales for Drawing. The choice of a proper scale is very essential in scale-drawing. In the reproduction of a design or in surveying, one is faced with the problem of finding the most suitable scale. In the old system the scales are various : 1/8" or 1/4" or 3/8" or 1/2" or 3/4" or 1" to a foot. These are commonly used but other scales are also possible. For survey plans scales may be 1 mile to 16", 200 ft. or 100 ft. or 50 ft. or

20 ft. to an inch and so on. This wide variety of possible scales becomes very confusing to the young student and the draughtsman. In the Metric system one uses only one scale for either structural drawing or survey plans, the ratio between any two consecutive units being 10 or some multiple of 10.

Maps. The importance of map-drawing and map-reading has very much increased in the present day. All maps are based on a particular 'scale'. The use of the metric scales has largely obviated the difficulties existing when old scales were used. Metric units have one to one correspondence and are very helpful in representing distances.

Along with map-reading, students can be systematically taught how to read the co-ordinates of a particular place, to find the representative fractions, or the area of a certain portion and to draw a certain portion of a graph. Authors may use examples from this area while teaching mensuration. The subject is interesting and provides the following types of practical work :

A. Students may be asked to find the distance between two known places. They will first measure the road distance with the help of a thread ; then the length of the thread will be measured in centimetres, and then with the help of the scale they will calculate the actual distance.

B. If the distance is known, students can mark off places, position of places or a road with the help of the scale. This can help in finding out the lengths of mountain-ranges, rivers, railways and the boundaries between two countries. There can thus be a natural correlation between geography and mathematics.

C. Areas, population and the ratio of agricultural products to the area, etc., can also provide interesting exercises.

Example I. On a plan drawn to the scale of 1 : 2500 a rectangular farm measures 20 cm by 3 cm. If it is to be surrounded by a fence at 37 nP per metre, what will be the cost of fencing ?

The owner sows wheat over 1/3 of the field, over 3/5 of tbe reminder he sows gram, and potatoes over the remainder. The average yield per annum is : wheat, 20 q/ha ; gram, 75 q/ha and potatoes, 160 q/ha. Find the total income from the crop if he sells wheat at Rs 48.20 nP per quintal, grams at Rs 40.00 per quintal and potatoes at Rs 22.50 per quintal.

Calculation of the price of the fence

Length of the field $= 20 \text{ cm} \times 2500 = 500 \text{ m}$
Width „ „ „ $= 3 \text{ cm} \times 2500 = 75 \text{ m}$
∴ Fencing required $= 2\ (500 + 75) \text{ m} = 1150 \text{ m}$
∴ Cost of the fencing $= 37 \text{ nP} \times 1150$
$= \text{Rs } 425.50 \text{ nP.}$

(A) Area

(*i*) Area of the field $= 500 \times 75 \text{ m}^2$
$= 3.75 \text{ ha.}$

(*ii*) „ „ Wheat $= \frac{1}{3} \times 3.75 \text{ ha}$
$= 1.25 \text{ ha.}$

Remaining area $= (3.50 - 1.25) \text{ ha}$
$= 2.50 \text{ ha.}$

(*iii*) „ „ gram $= \frac{3}{5} \times (2.50) \text{ ha}$
$= 1.50 \text{ ha.}$

(*iv*) „ „ Potatoes $= (2.50 - 1.50) \text{ ha}$
$= 1.00 \text{ ha.}$

(B) Yield

Wheat $= 20 \text{ q} \times 1.25 = 25 \text{ q.}$
Gram $= 75 \text{ q} \times 1.50 = 112.50 \text{ q.}$
Potatoes $= 160 \text{ q} \times 1.00 = 160 \text{ q.}$

(C) Selling price

Wheat $= \text{Rs } 48.20 \text{ nP} \times 25 = \text{Rs } 1{,}205.00 \text{ nP.}$
Gram $= \text{Rs } 40.00 \times 112.50 = \text{Rs } 4{,}500.00 \text{ nP.}$
Potatoes $= \text{Rs } 22.50 \times 160 = \text{Rs } 3{,}600.00 \text{ nP.}$

∴ Total Income $= \text{Rs } 9{,}305.00 \text{ nP.}$

It is a problem related to life and involves metric units and scale. All operations are in decimal fractions.

Progress in Preparation of Maps in Metric Units

(A) Topographical Maps

(*i*) 1 : 50,000 series with contours at 20 metres interval (500 published)

(*ii*) 1 : 100,000 series with contours at 50 metres interval (60 published)

(*iii*) 1 : 250,000 series with cotours at 100 metres interval

(B) Geographical and General Maps of India

(*i*) 1 : 1,000,000 carte International due Monde Series.

(*ii*) 1 : 1,000,000 Charts the International Civil Aviation Organization.

(*iii*) 1 : 2,000,000 Southern Asia Series.

(*iv*) 40-Mile Road Map of India—The new edition of this map on metric scales (1 : 2,500,000) was published in 1961.

(*v*) 40-Mile Map of India—The metric scale adopted for this map is 1 : 2,500,000.

(*vi*) 67-Mile Railway Map of India—The metric scale adopted for this map is 1 : 3,500,000.

(*vii*) 70-Mile Polititical Map of India—The metric scale adopted for this map is 1 : 4,000,000.

(Note : As an interim measure first edition of this map in metric system will be published on 1/4,500,000 scale)

(*viii*) 78-Mile Physical Map of India on the same scale as above.

(*ix*) 128-Mile Map of India—on the scale 1 : 8,000,000.

(*x*) 192-Mile Map of India—on the scale 1 : 12,000,000.

(*xi*) 250-Mile Map of India—on the scale 1 : 16,000,000.

(*xii*) 1 : 1,000,000 State Maps are already in metric scale.

(*xiii*) A School Atlas has already been published in metric terms.

(C) Guide Maps

(*i*) Delhi Guide Map—Scale 1 : 20,000, published in 1961.

(D) Project Maps

Scales adopted are 1/2,000; 1/5,000; 1/10,000 or 1/25,000 as in the case of cadastral and forest maps. contours intervals may be 1, 2, 5, 5 or 10 metres according to the nature of the country, scale adopted or purpose of the project. Metric system will be introduced in all future project surveys unless indentor specifically asks for surveys in the F.P. system.

(E) Conversion of Books, Pamphlets and Instruments

The new editions of books and pamphlets, etc., with data in metric terms have been either published or are being published.

From the foregoing it will be seen that in the course of few years the country would be well on the way to accomplishing a major portion of the task of conversion of maps, departmental books and instruments to the metric terms.

Algebra. In algebra the topics affected by the adoption of metric units are 'logarithms' and 'graphs'. The case of logarithms has already been discussed in chapter V. Let us discuss graphs here.

Graphs. Everybody realizes the importance of graphs in this modern world. A graph is a symbolical representation of facts and figures, which helps in drawing certain conclusions and in finding other results without going into the details of long processes.

The divisions on the graph paper are on the basis of 10. So the use of decimal numbers in graphical representation is helpful. The other point about the graphs is the selection of a 'pure scale'. Metric units will help in both. What has been said before of map-drawing and map-reading also applies to drawing and reading of graphs.

Inch graph-paper and Centimetre graph-paper

1. In the inch graph-paper, units of one inch are divided into 10 parts; thus each part is 10th part of an inch. In the centimetre graph-paper units of centimetre are divided into 10 parts and each part is a unit called 'millimetre'. This

division is more concrete and easy of understanding. The small square on the second kind of paper (1 mm by 1mm) will represent an area equal to 1 sq. mm, while on the inch graph-paper the area will be $\frac{1}{100}$ sq. inch which is not so easy to understand.

2. As previously mentioned while dealing with scale drawing, longer distances can be more conveniently represented through metric units.

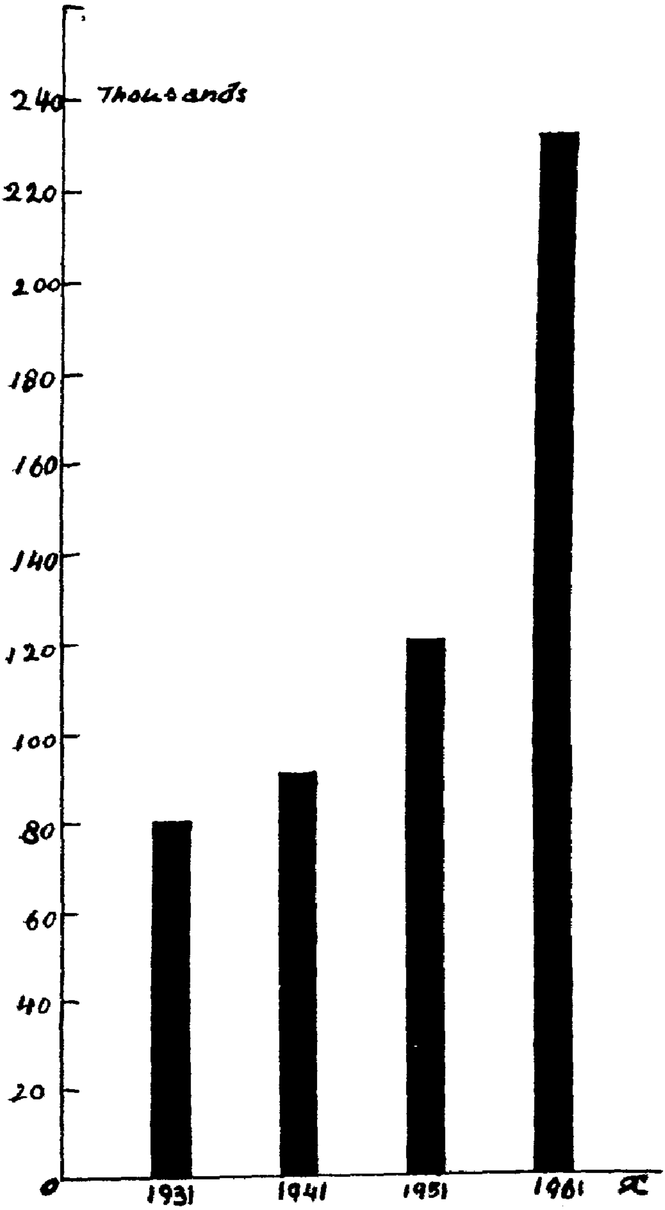
3. A third advantage is that most statistical data are expressed either in decimal numbers or in tens, hundreds, thousands, etc. The basis is 10, which is also the basis of metric units and also of graph-papers. So there will be a direct correspondence between the co-ordinates. For example, the population graph of a certain town is to be drawn. The data given are:

1931 : 80,000,

1941 : 91,000,

1951 : 122,000,

1961 : 232,000.


Thousands
240
220
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1931
1941
1951
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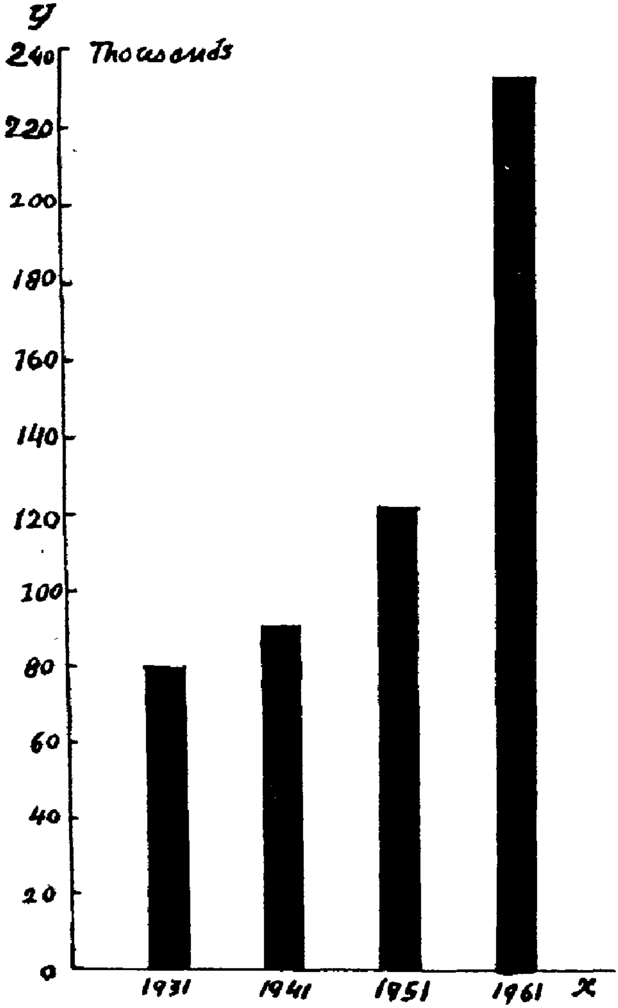


Centimetre-Graph

There are two variables here, time and population. A proper scale is to be chosen. Let 10 years be represented by 5 cm along X-axis and the population of 2000 by 1mm along Y-axis. So along X-axis the length will be 15 cm and along Y-axis, 11.6 cm. The graph can be made still smaller by taking 10 years = 1 cm and 10000 = 1 mm.

For comparison the data have been represented both in inch-scale and centimetre-scale. On the inch-scale graph 91000 and 122000 have not been correctly represented, but on the centimetre-scale the representation is exact.

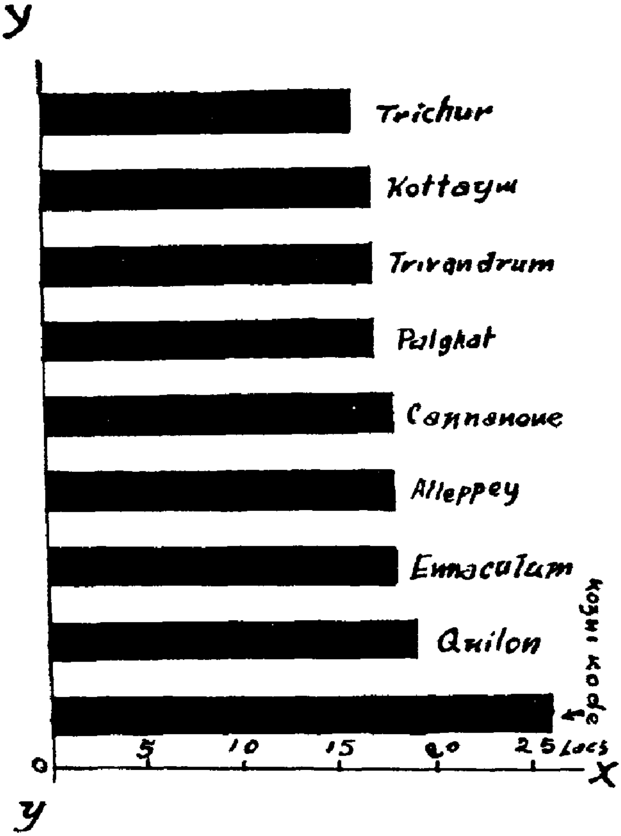
Let us take another example.

Example. The district-wise population of Kerala State is given in lakhs. Represent it graphically for a comparative study.

1. Kozhikode : 26.2
2. Quilon : 19.4
3. Ernaculum : 18.6
4. Alleppey : 18.2
5. Connanore : 18.0
6. Palghat : 17.8
7. Trivandrum : 17.4
8. Kottayam : 17.2
9. Trichur : 16.4

In this case it will be difficult to choose a convenient scale in inches. If the scale 1″ = 1 lakh is chosen, the size of the paper has to be abnormally large and if 10 lakhs be represented by 1″, accuracy will suffer because it is difficult to find out 1.79″, 2.62″, etc., on an ordinary inch graph-paper. But on a centimetre graph-paper it can be easily represented by taking 1 cm = 2 lakhs.

Now look at the graphs. On the centimetre-graph population of each state has been exactly represented; but on the inch-graph it has not been possible. So inch-graph is only approximately representative.


Y
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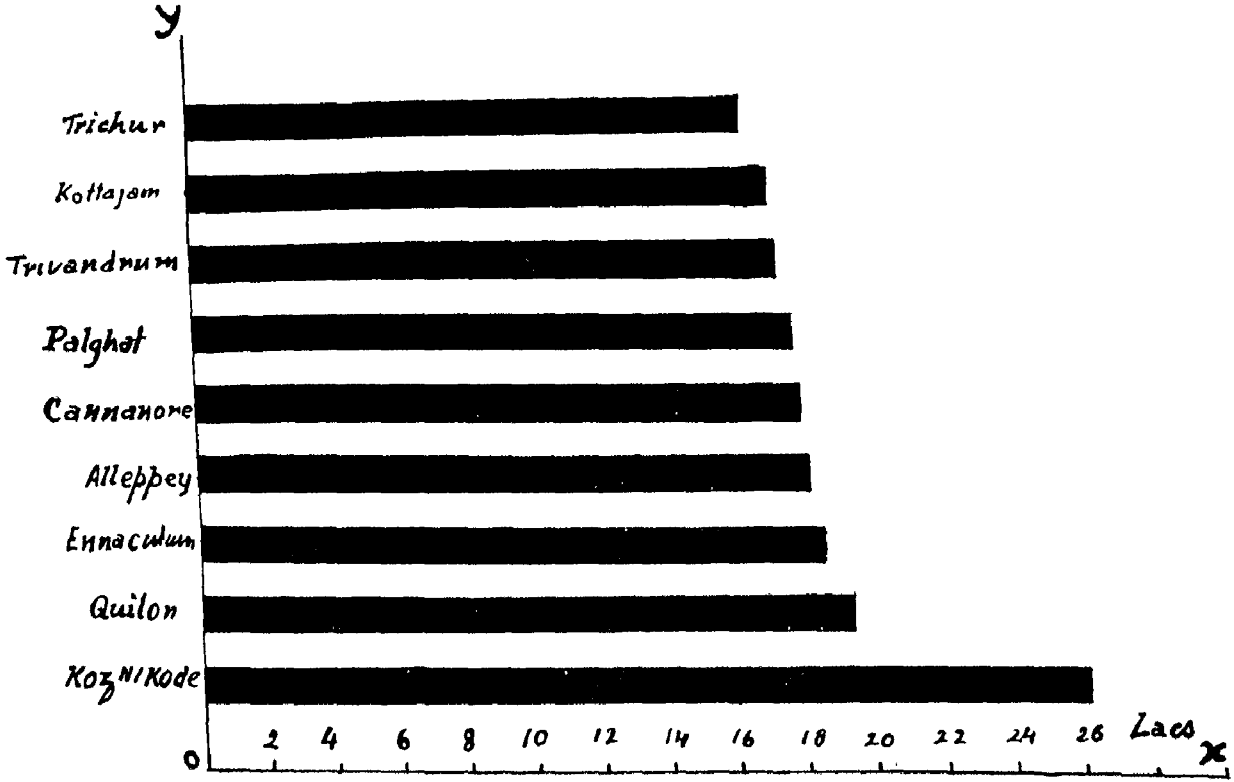
Inch-Graph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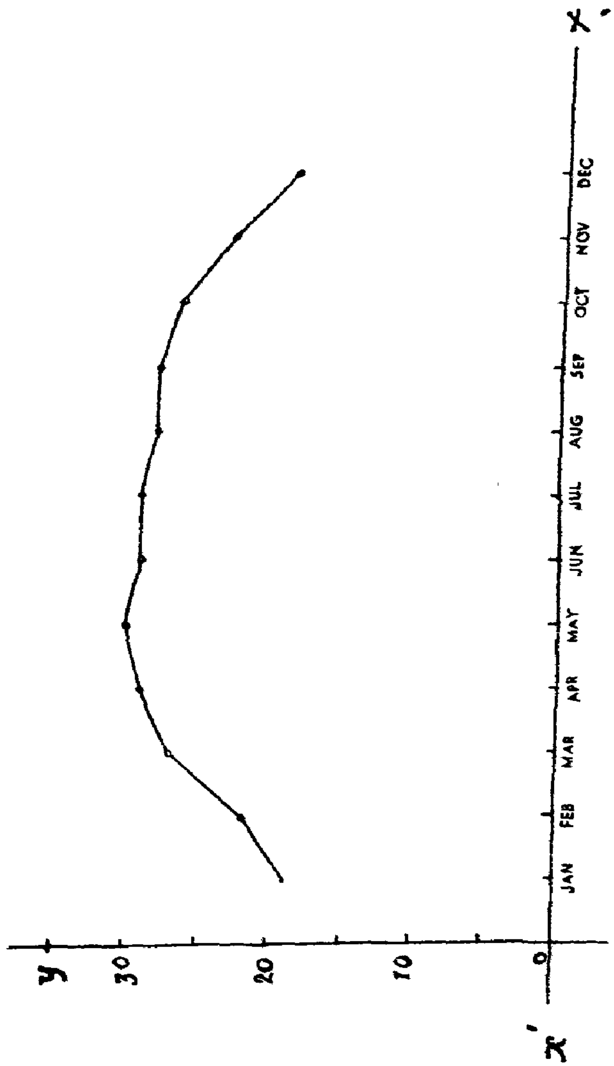
Lacs
x

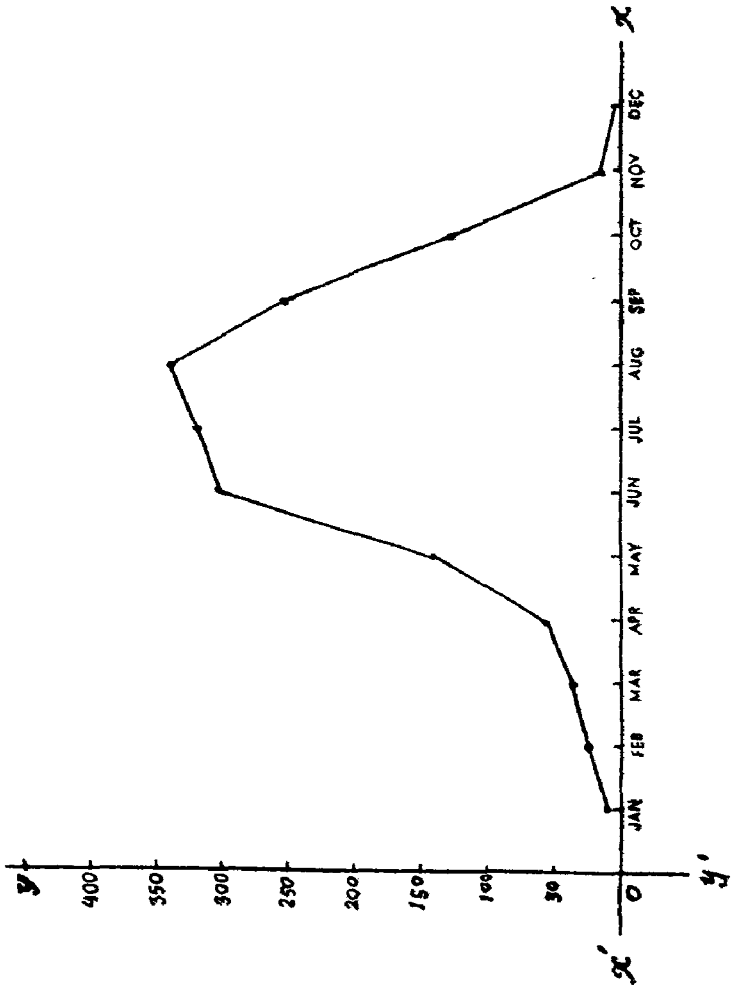
Temperature. In the metric system temperature is measured in centigrade. The freezing point is at 0°C and the boiling point is at 100°C. In the Fahrenheit thermometer, the freezing point is at 32° and the boiling point is at 212°. In between these is 180°, not very convenient for decimal numbers.

Example. The table below gives the month-wise temperature and rainfall of Calcutta during a particular year. Draw the temperature and rainfall graphs from the given data.

Months	Temperature in C°.	Rainfall in mm.
January	19	10
February	22	25
March	27	35
April	29	55
May	30	140
June	29	300
July	29	315
August	28	335
September	28	250
October	27	125
November	23	15
December	19	5



Temperature-graph on centimetre graph paper



Rainfall-graph on centimetre graph paper.

Meteorology. Meteorological bureaus all over the world find it useful to use the same international units for purposes of comparison. In India too, metric units were so long being used to measure temperatures and wind-speed; but at the ground level British units were being used. The changeover to the metric units puts an end to this incongruity. Now, rain is measured in centimeteres and millimetres, temperature in centigrades, pressure of air or water vapour in the barometer in metres and centimetres and millimetres and windspeed in metres per second or kilometres per hour. The Government of India had already introduced the use of metric units in reading barometers some years before their actual introduction in the country for all purposes. The new units have very much facilitated the work of the meteorological department and have saved much computation work also.

Statistics. Statistical data are better expressed in decimal numbers. Temperature, rainfall, agricultural products, etc., should all be expressed in metric units.

Science and Engineering. In science the metric system is already being used all over the world. Even U.K. and U.S.A. which have not yet adopted the metric system use it in all scientific work.

In secondary schools British units are also being used for acceleration, force and velocity, etc. Now they should be replaced by metric units.

Metric unit for acceleration is 'centimetre per second per second' (cm/s^2) and the standard gravity is 980.665 cm/s^2 (exactly). It is conventionally taken as 981 cm/s^2.

The velocity is denoted by 'centimetre per second'. The units of force in the metric system are 'dyne', 'newton' and 'sthene'. The dyne (dyn) is the fundamental unit in the centimeter-gram-second (CGS) system; newton (N) in the metre-kilogram-second (MKS) system and sthene (sn) in the metre-tonne-second (MTS) system. In the British system, the unit of force is poundal. At present in most of the questions the British system is being used and only a passing reference is made to the metric units. But now it should be reversed.

The units of force in metric units ared efined as follows :

Dyne (dyn). Force which, when applied to a body having a mass of one gram, gives it an acceleration of one centimetre per second per second (1 cm/sec^2).

Newton (N). Force which, when applied to a body having a mass of one kilogram, gives it an acceleration of one meter per second per second (1 m/sec^2).

Sthene (sn). Force which, when applied to a body having a mass of one tonne, gives it an acceleration of one metre per second per second (1 m/sec^2).

The technical unit of force in the metric system is 'kilogram-force' (kgf) which is defined as the force which, when applied to a body having a mass of one kilogram gives it an acceleration of 9.80665 metres per second per second. Similarly, the unit of momentum in metric system is 'kilogram metre per second (kg m/s)'.

'Erg' is the unit of work and energy in 'CGS' system and 'joule' is the basic unit for electrical and mechanical work and for energy. The unit of power is watt (W) which is defined as :
Watt (W)=joule per second $=10^7$ erg/s.

The purpose of giving all these units is to give the authors and teachers necessary information about metric units, so that they may freely use them in classrooms and textbooks on all subjects.

Civil engineers can also use the system with advantage. Designing and planning of structures are the most important tasks of a civil engineer. Many calculations will be simplified for him by the use of the metric system. The following example will illustrate.

Example (British Units). A beam of span 10 ft. is freely supported at two ends and carries a uniformly distributed load of 100 lb. per linear foot. Find the required section modulus for the beam, assuming allowable maximum stress = 10 tons per sq. inch.

Maximum bending moment $= \frac{100 \times 10 \times 10}{8}$ ft. lb.

$=1,250$ ft. lb.

$=1,250 \times 12$ lb. in.

$= \frac{1,250 \times 12}{2,240}$ T. in.

$=375,56$ T. in.

$=6.7$ Ton-inches (approx.

$\therefore$ The required section modulus$=6.7/10$ in$^3=0.67$ in^3.

(Metric Units). A beam of span 10 metres is freely supported at two ends and carries a uniformly distributed load of 100 kg per linear metre. Find the required section modulus for the beam, assuming the allowable maximum stress

$=1600$ kg cm^3

Maximum bending moments as before=

$= \frac{100 \times 10 \times 10 \text{ kg metre}}{8}$

$=1,250$ kg metre

$=125,000$ kg cm.

Therefore, section modulus $= \frac{125,000 \text{ cm}^3}{1,600}$

$=78.125$ cm^3.

Conclusion. An attempt has been made to incorporate suggestions which will be useful both to authors and teachers and the suggestions have been fully illustrated with the help of examples. Solutions have been given to show the change in the presentation and actual working of the problems. The ultimate responsibility rests with authors and teachers. The authors have to bring in real change in the presentation of problems in the books and the teachers have to reorient their teaching accordingly. They have to keep in mind that the students reading today in schools will have to face metric system in real life when they leave the schools tomorrow and it is imperative for any good educative process to change with the changes in time and provide worthwhile teaching experiences in the subjects, especially arithmetic, to the students. It is high time that the students in the schools be made thoroughly conversant with the metric system which is the need of the day.

APPENDIX A

ABBREVIATIONS FOR METRIC UNITS

(1) Decimal Multiples and Sub-Multiples

Prefix	Value in Terms of Unit		Abbreviation
Micron	=0.000001	(10^{-6})	μ
Milli	=0.001	(10^{-3})	m
Centi	=0.01	(10^{-2})	c
Deci	=0.1	(10^{-1})	d
Deca	= 10	(10^{1})	da
Hecto	= 100	(10^{2})	h
Kilo	= 1000	(10^{3})	k
Mega	= 1000000	(10^{6})	M

Denomination	Value	Abbreviation
(2) Weights		
tonne	1000 kg=1000000 g	t
quintal	100 kg=1000000 g	q
kilogram	1 kg= 1000 g	kg
gram	1 g= 1 g	g
milligram	1 mg= .001 g	mg
carat	200 mg= .2 g	c
(3) Length		
kilometre	1000 m = 1000 m	km
metre	1 m = 1 m	m
centimetre	1 cm = .01 m	cm
millimetre	1 mm = .001 m	mm
micron	1/1000 mm or 10^{-3} mm=.000001 m	μ

(4) Area

square kilometre	100000 m^2	km^2 or sq km*
square metre	1 m^2	m^2 or sq m*
square centimetre	1 cm^2	cm^2 or sq cm*
square millimetre	1 mm^2	mm^2 or sq mm*

(5) Land Measure

are	100 m^2	a
hectare	100 a = 10000 m^2	ha
centiare	m^2	ca

(6) Volume

cubic metre	m^3	m^3 or cu m*
cubic centimetre	cm^3	cm^3 or cu m*
cubic millimetre	mm^3	mm^3 or cu mm*

(7) Capacity

kilolitre	1000l	kl
litre	1 1	l
millilitre	1 ml =.001 l	ml

* Both these abbreviations are current, but the first set should preferably be used. Internationally the former abbreviation is used more commonly than the latter.

Rules for Abbreviations :

(1) Do not make any change, such as addition of 's' to indicate plurality, e.g., write 1 kg, 10 kg, 20 g. 5 g, 10 t, 20 ml, 27 l, 165 km. 2 mm, 100 cm^3, 66 km^2 ;

(2) Do not capitalize the abbreviations. For example, do not write 1 Kg, 2 Kg, 20 MM, 50 MM ; the right way is to write 1 kg, 2 kg, 20 mm, 50 mm, etc.

(3) No punctuation mark of any kind is used.

(4) Do not use any other abbreviations except those given above.

APPENDIX B

The Metric Weights and Measures to be used in actual practice are as follows :

Solid Metal Weights

Kilogram Series

Cast iron and forged steel weights	Brass and bronze weights
100	20
50	10
20	5
5	2
2	2
1	1

Gram Series

Cast iron and forged steel weights	Brass and bronze weights
500	500
200	200
100	100
	50
	20
	10
	5
	2
	1

Sheet Metal Weights

Milligram Series

500	50	5
200	20	2
100	10	1

Capacity

Cylindrical Measures: Dipping type	Cylindrical Measures: Pouring type	conical Measure
1 litre	2 litres	20 litres
500 millilitres	1 litre	10 litres

200 millilitres	500 millilitres	5 litres
100 millilitres	200 millilitres	2 litres
50 millilitres	100 millilitres	1 litre
20 millilitres	50 millilitres	500 millilitres
	20 millilitres	200 millilitres
		100 millilitres

Linear Measures

Metallic	*Wooden*
1 metre	2 metres
½ metre	—

Long distances are measured in kilometres.

APPENDIX C

TYPICAL METRIC PRICING UNITS FOR WHOLESALE TRANSACTIONS

S. No.	Commodity	Metric Unit
(1)	Gold	10 grams (g).
(2)	Grocery and Confectionery Biscuits, sweetmeats, cardamons. Textiles & Textile Fibres Cotton yarn, damaged and seconds (cut piece) cloth, raw silk, rayon, silk yarn, raw wool, wool manufacturers (when sold by weight). Paints & Chemicals Paint (if sold by weights, indigo, liquid chlorine). Hides, Skins & Leather Raw hides, leather (hides and skins). Metals Silver, aluminium sheets, strips and circles, copper and brass wires and utensils. Miscellaneous Tea, meat, camphor tablets, mica.	1 kilogram (kg)
(3)	Grains and Pulses Rice, wheat, jowar, arhar, moong, masur, gram. Spices Black pepper, mustard, chillies, dhania, dalchini, turmeric betelnuts.	1 quintal (q) (100 kilo-grams)

S. No.	Commodity	Metric Unit
	Plantation Products Rubber, cashewnuts, cashew kernels, tobacco (raw and manufactured). **Forest Products** Lac and lac products, gums, myrobalans, galnuts, soapnuts. **Textiles & Textile Fibres** Raw jute, raw hemp, coir yarn. **Oils, Oilseeds & Oilcakes** Vegetable oils, oilseeds, oil cakes. **Non-Ferrous Metals** Aluminium : ingots, bars, blocks, slabs, billet. Lead : ingots, sheets and strips. Copper : ingots, blooms, slabs, cakes, tiles, bricks, billets, blisterbars and wirebars, rods, sections and pipes, plates, sheets and strips, circles. Brass : ingots, rods, sections, pipes, sheets, strips, circles. Zinc : ingots, sheets, strips. Tin : blocks. **Chemicals** Caustic soda, bleaching powder, glycerine, soaps, paper salt. **Others** Sugar, gur, ice, fish, sugarcane, vegetables, tamarind.	1 quintal (*q*) (100 kilograms)
(4)	**Minerals** Iron ore, manganese ore, bauxite, coal. **Iron & Steel** Pig iron & steel manufacturers, semis (billets for rerolling, etc.)	one metric tonne (t) (1,000 kilograms)

S. No.	*Commodity*	*Metric Unit*
(5)	Cloth (mill, handloom silk, rayon and woollen cloth).	1 metre (*m*)
(6)	Jute carpets, coir mats and mattings, sheet glass.	one square metre (m^2).
(7)	Timber	one cubic metre (m^3)
(8)	Paints (when sold by measures), spirit.	one litre (l)