KURIKULUM STANDARD SEKOLAH MENENGAH

# MATHEMATICS
## FORM 3

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# Contents

# Introduction

This Form 3 Mathematics Textbook is prepared based on *Kurikulum Standard Sekolah Menengah (KSSM)*. This book contains 9 chapters arranged systematically based on Form 3 Mathematics *Dokumen Standard Kurikulum dan Pentaksiran (DSKP)*.

At the beginning of each chapter, students are introduced to stimulating materials related to daily life to stimulate their thinking about the topic. In addition, Learning Standard and word list also give a visual summary about the chapter's content.

This book contains the following special features:

| | Description |
|---|---|
| What will you learn? | Contains learning standard that students will learn in each chapter. |
| Why do you learn this chapter? | Applications of knowledge in this chapter in related career fields. |
| Exploring Era | History of ancient academy or original exploration of the chapter in Mathematics. |
| WORD BANK | Word list contained in each chapter. |
| Brainstorming<br>Individual In pairs In groups | Helps students to understand the basic mathematical concept via individual, pair or group activities. |
| BULLETIN | Gives additional information about the chapter learned. |
| QUIZ | Questions that test students' capability to understand certain technique in each chapter. |
| REMINDER | Grabs students' attention to additional facts that need to be reminded of, mistakes that students commonly make, and carelessness to be avoided. |
| TIPS | Exposes students to additional knowledge that they need to know. |
| SMART MIND | Presents mind-stimulating questions for enhancement of students' critical and creative thinking. |

| | Description |
|---|---|
| SMART TECHNOLOGY | Exposes students to the use of technological tools in the learning of mathematics. |
| DISCUSSION CORNER | Develops communication skills mathematically. |
| FLASHBACK | Helps students to remember what they have learnt. |
| SMART FINGER | Shows the use of scientific calculators in calculations. |
| PROJECT | Enables students to carry out assignments and then present their completed work in class. |
| MIND TEST | Test students' understanding on the concepts they have learnt. |
| | Indicates HOTS questions to help in developing students' higher order thinking skills. |
| Dynamic Challenge | Prepares more diversified exercises which incorporate the elements of LOTS, HOTS, TIMSS and PISA assessment. |
| | Enables students to scan QR Code using mobile device. |
| EXPLORING MATHEMATICS | Covers applicable concepts of digital tool calculators, hands on activities and games that aim to provides additional activities to effectively enhance students' understanding. |
| CONCEPT MAP | Overall chapter summary that students learnt. |
| SELF-REFLECT | Looks back whether students have achieved the learning standard. |
| Checking Answers | Checks answers with alternative methods. |
| STEM | Activities with elements of Science, Technology, Engineering and Mathematics. |

# Symbols and Formulae

## SYMBOLS

| | |
|---|---|
| $\sqrt{\ }$ | root |
| $\pi$ | pi |
| $a : b$ | ratio of $a$ to $b$ |
| $A \times 10^n$ | standard form where $1 \leqslant A < 10$ and $n$ is an integer |
| $=$ | is equal to |
| $\approx$ | is approximately equal to |
| $\neq$ | is not equal to |
| $>$ | is more than |
| $\geqslant$ | is more than or equal to |
| $<$ | is less than |
| $\leqslant$ | is less than or equal to |
| $\Delta$ | triangle |
| $\angle$ | angle |
| $^\circ$ | degree |
| $'$ | minute |
| $''$ | second |

## FORMULAE

$a^m \times a^n = a^{m+n}$

$a^m \div a^n = a^{m-n}$

$(a^m)^n = a^{mn}$

$a^0 = 1$

$a^{-n} = \frac{1}{a^n}$

$a^{\frac{1}{n}} = \sqrt[n]{a}$

$a^{\frac{m}{n}} = (a^m)^{\frac{1}{n}} = (a^{\frac{1}{n}})^m$

$a^{\frac{m}{n}} = \sqrt[n]{a^m} = (\sqrt[n]{a})^m$

$I = Prt$

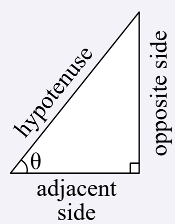
$MV = P(1 + \frac{r}{n})^{nt}$

$A = P + Prt$

$\sin \theta = \dfrac{\text{opposite side}}{\text{hypotenuse}}$

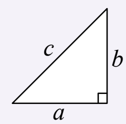
$\cos \theta = \dfrac{\text{adjacent side}}{\text{hypotenuse}}$

$\tan \theta = \dfrac{\text{opposite side}}{\text{adjacent side}}$




$\tan \theta = \dfrac{\sin \theta}{\cos \theta}$

Pythagorean theorem:




$c^2 = a^2 + b^2$

$b^2 = c^2 - a^2$

$a^2 = c^2 - b^2$

Distance between two points $= \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$

Midpoint $= \left(\dfrac{x_1 + x_2}{2}, \dfrac{y_1 + y_2}{2}\right)$

Gradient, $m = \dfrac{\text{vertical distance}}{\text{horizontal distance}}$

$m = \dfrac{y_2 - y_1}{x_2 - x_1}$

$m = -\dfrac{y\text{-intercept}}{x\text{-intercept}}$

http://bukuteksksm.my/Mathematics/F3/Index.html

Download the free *QR Code* scanner to your mobile devices. Scan *QR Code* or visit the website http://bukuteksksm.my/Mathematics/F3/Index.html to download files for brainstorming. Then, save the downloaded file for offline use.

Note: Students can download free *GeoGebra and Geometer's Sketchpad* (*GSP*) software to open related files.

# CHAPTER 2

# Standard Form

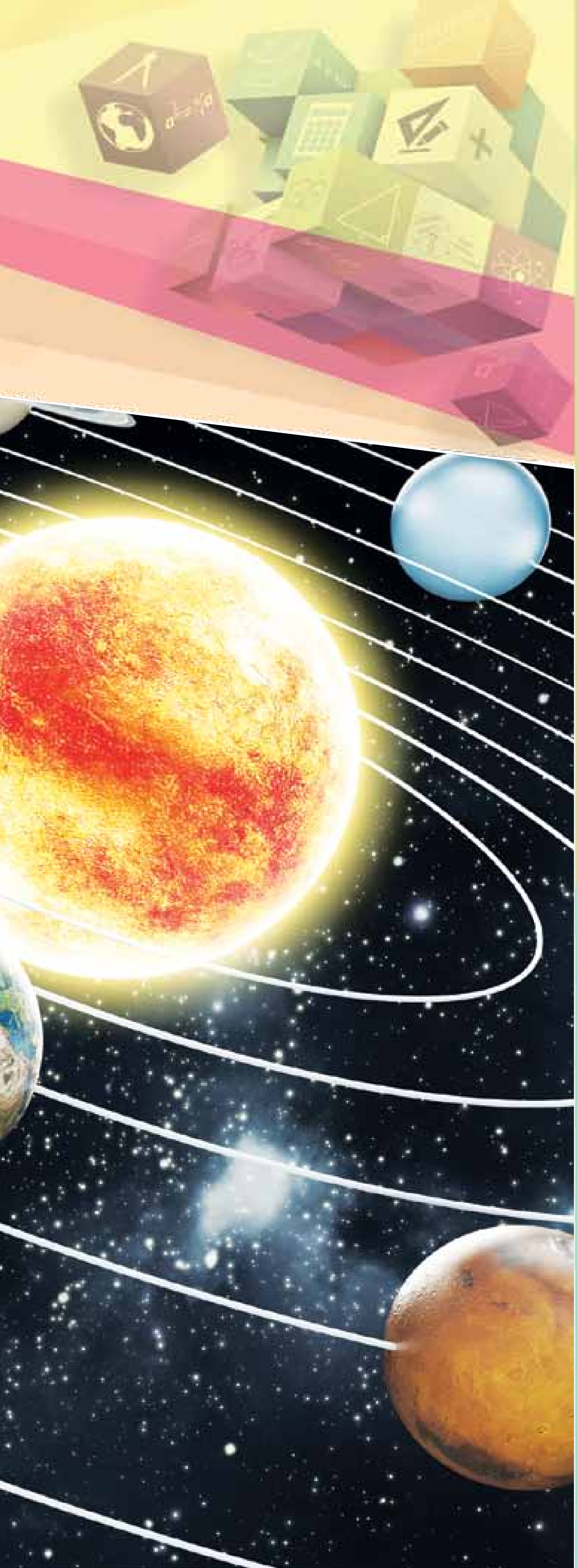
**What will you learn?**



**Why do you learn this chapter?**

- In scientific information, very big or very small numbers are commonly used. For example in astronomy, the distance between two stars is usually millions of kilometres while in the study of particles, the distance between atoms is extremely small.
- Numbers written in standard form are widely used in the field of science, engineering, astronomy and so on.

Distance in outer space, such as the distance between two stars in the galaxy, is measured in light years. One light year is the distance travelled by light in one year. One light year is equal to 9 500 000 000 000 km, that is 9.5 trillion kilometres. Small units such as nanometre are used for distances closer to zero. Do you know that 1 nanometre is equal to 0.000 000 001 metre?



## Exploring Era

The ancient Greeks used a system based on myriad that is ten thousand. Ten myriads is equal to one hundred thousand.

Archimedes (287 BC – 212 BC) created a system of big numbers up to $10^8 \times 10^{16}$.

http://bukutekskssm.my/Mathematics/F3/ExploringEraChapter2.pdf

## WORD BANK

| | |
|---|---|
| • estimation | • *anggaran* |
| • significant figure | • *angka bererti* |
| • standard form | • *bentuk piawai* |
| • accuracy | • *kejituan* |
| • single number | • *nombor tunggal* |
| • round off | • *pembundaran* |
| • approximation | • *penghampiran* |

## 2.1 Significant Figures

### What does significant figure mean and how do you determine the number of significant figures of a number?

**LEARNING STANDARD**

Explain the meaning of significant figure, and hence determine the number of significant figures of a number

We use measurement in many situations in our daily life. Examples of frequently used measurements are length, distance, mass, temperature, area and speed.


The **estimation** of a measurement can be done using **approximation**. For example, the distance between the Earth and the Moon is 384 400 km. This value is an estimation calculated using certain methods and stated as an approximation.

The **degree of approximation** of a measurement to the **actual value** shows the level of accuracy of the measurement. The skill in making estimations and approximations can help you in many situations in daily life.

### Brainstorming 1

In pairs

**Aim:** Determine the importance of making estimations and approximations in daily life.

**Steps:**

1. Read and understand the situations below.

**Situation 1**
Hashim is interested in a shirt sold in a supermarket with a 50% discount. The original price of the shirt is RM47.90. Hashim estimates the price of the shirt after discount and takes it to the cashier. The cashier informs him that the price of the shirt is RM28.70. Hashim argues that his estimation of the price is not more than RM25. Is Hashim's estimation correct?


**Situation 2**
Mrs Tan wants to buy 30 metres of cloth costing RM5.85 per metre to make curtains. She makes an estimation of the total price of the cloth and allocates RM180. Is the money allocated by Mrs Tan sufficient?

**Discussion:**

1. In the two situations above, how did Hashim and Mrs Tan make estimations of the total price?
2. Discuss with your friend the importance of making estimations and approximations.
3. State two other situations that require you to make estimations and approximations.

From Brainstorming 1, it is found that;

Approximating a value to a certain significant figure allows us to make an accurate estimation.

You have understood the importance of making estimation for the purpose of obtaining a value that is near the exact value. Significant figures are used to obtain the approximate value.

The significant figures of an integer or decimal refer to the digits in the number state accurately to a certain degree of accuracy as required. The number of significant numbers is counted starting from a non-zero digit.

## Brainstorming 2

In pairs

**Aim:** Determine the effect of the position of the zero digit in integers and decimals.

**Steps:**

**1.** Study the integer cards below.

| 3 210 | 3 201 | 3 021 | 0 321 |
|---|---|---|---|
| **Card 1** | **Card 2** | **Card 3** | **Card 4** |

Does the position of the zero digit have any effect on the value of digit 3?

**2.** Study the decimal cards below.

| 3.210 | 3.201 | 3.021 | 0.321 |
|---|---|---|---|
| **Card 5** | **Card 6** | **Card 7** | **Card 8** |

Does the position of the zero digit have any effect on the value of digit 3?

**3.** Study the decimal cards below.

| 3.210 | 3.2100 | 3.21000 | 3.210000 |
|---|---|---|---|
| **Card 9** | **Card 10** | **Card 11** | **Card 12** |

Does the position of the zero digit have any effect on the value of digit 2?

**4.** Discuss with your friend the effect of the position of the zero digit on the value of digit 3 in Card 1 to Card 8 and the effect of adding zero digits on the value of digit 2 in Card 9 to Card 12.

**5.** Present the results of your discussion. Compare your results with other pairs.

**Discussion:**

What is your conclusion concerning the position of the zero digit in an integer or decimal?

From Brainstorming 2, it is found that;

(a) Card 1, Card 2, Card 3, Card 5, Card 6 and Card 7
- The position of the zero digit between or at the end of the number, maintains the place value of digit 3.

(b) Card 4 and Card 8
- The position of the zero digit as the first digit has changed the place value of digit 3.

(c) Card 9, Card 10, Card 11 and Card 12
- The position of the zero digit at the end of the decimal does not change the place value of digit 2.

**FLASHBACK**

For digit 9 in the number 5 9 2 7;
- Place value – hundred
- Digit value – 900

In general,

- All non-zero digits are significant figures.
- The digit zero between non-zero digits is a significant figure.
- The digit zero at the end of an integer is a significant figure according to the level of accuracy required.
- The digit zero at the end of a decimal is a significant figure because it determines the level of accuracy of the decimal.
- The digit zero before the first non-zero digit is not a significant figure.

**TIPS**

- Zeros between non-zero digit are significant figures.
  For example,
  (a) 60 007
  (5 significant figures).
  (b) 50.0042
  (6 significant figures).
- For a decimal, all digits before non-zero digit are not significant figures.
  For example,
  (a) 0.007
  (1 significant figure).
  (b) 0.005020
  (4 significant figures).
- For a whole number, zero at the end of the number is not a significant figure unless stated otherwise.
  For example,
  (a) 8 750 = 8 800
  (Rounded off to 2 significant figures).
  (b) 8 750 = 9 000
  (Rounded off to 1 significant figure).

### How do you determine the number of significant figures?

**Decimal**

Not significant figure:
Used only to determine place value of digit 5.

Significant figure:
The digit zero between or at end of decimal is a significant figure.

**0.00501400**

Significant figure:
All non-zero digits are significant figures.

**Integer**

**803 000**

Significant figure.

Significant figure **depending on** level of accuracy required.

**Example 1**

Determine the number of significant figures for the numbers below.

(a) 2 763 (b) 5 008 (c) 7 409 (d) 15 000
(e) 0.7803 (f) 0.0809 (g) 12.051 (h) 1.2700

***Solution:***

(a) 2 763 [4 s.f.]

(b) 5 008 [4 s.f.] → The digit zero between non-zero digit is a significant figure.

(c) 7 409 [4 s.f.] → The digit zero between non-zero digit is a significant figure.

(d) (i) 15 000 [2 s.f.] → If level of accuracy is to the nearest thousand.

(ii) 15 000 [3 s.f.] → If level of accuracy is to the nearest hundred.

(iii) 15 000 [4 s.f.] → If level of accuracy is to the nearest ten.

(iv) 15 000 [5 s.f.] → If level of accuracy is to the nearest one.

(e) 0.7803 [4 s.f.]
(f) 0.0809 [3 s.f.] → The digit zero before first non-zero digit is not significant figure.

(g) 12.051 [5 s.f.]

(h) 1.2700 [5 s.f.] → All zeros after non-zero digit at end of decimal are significant figures.

**MIND TEST 2.1a**

**TIPS**

Significant figure can be written as s.f.

**1.** State the number of significant figures for the following numbers.

(a) 2 600 (b) 30 004 (c) 4 000 600 (d) 0.5003
(e) 0.080 (f) 9.0070 (g) 0.002000 (h) 30.0002

## How do you round off a number to certain numbers of significant figures?

**LEARNING STANDARD**

Round off a number to certain numbers of significant figures.

Do you still remember how to round off a number to a certain place value? The same concept and method are used to round off a number to a certain number of significant figures.

### Example 2

Round off each of the following numbers to 2 significant figures.

(a) 63 479 (b) 2 476 (c) 6 953

**Solution:**

(a)

4 < 5, thus digit 3 remains unchanged.

1 2
63 479

4, 7 and 9 are placed before decimal point. Thus, replace 4, 7 and 9 with zero.

Digit to be rounded off.

Thus, 63 479 = 63 000 (2 s.f.)

(b)

7 > 5, thus add 1 to 4.

1 2
2 476

7 and 6 are placed before decimal point. Thus, replace 7 and 6 with zero.

Digit to be rounded off.

Thus, 2 476 = 2 500 (2 s.f.)

(c)

5 = 5, thus add 1 to 9.

1 2
6 953

5 and 3 are placed before decimal point. Thus, replace 5 and 3 with zero.

Digit to be rounded off.

Thus, 6 953 = 7 000 (2 s.f.)

**TIPS**

For integers, the decimal point is placed behind the last digit

**FLASHBACK**

Round off 38 279 to the
(a) nearest hundred.
(b) nearest thousand.

**Solution:**

(a) 38 279
+1 (7 > 5)
= 38 300

(b) 38 279
(remain unchanged)
= 38 000

**TIPS**

For integers, the first non-zero digit is a significant figure.

### Example 3

Round off 68.79 to

(a) 3 significant figures (b) 1 significant figure

**Solution:**

(a)

9 > 5, thus add 1 to 7.

1 2 3
6 8. 79

Digit 9 is placed after decimal point. Thus, 9 is dropped.

Digit to be rounded off.

Thus, 68.79 = 68.8 (3 s.f.)

**QUIZ**

Why should the digits after the digit that is rounded off in a decimal be dropped?

(b)

8 > 5, thus add 1 to 6.

$\underbrace{6}\,\underbrace{8}.\,79$

Digit to be rounded off.

Digit 8 is placed before decimal point. Thus, 8 is replaced with zero. 7 and 9 are dropped.

Thus, 68.79 = 70 (1s.f.)



**Example 4**

Round off 0.008025 to

(a) 3 significant figures (b) 2 significant figures

**QUIZ**

Round off 10.09 to 1 significant figure and 2 significant figures.

***Solution:***

(a)

5 = 5, thus add 1 to 2.

0.00 8 0 2 5

Digit to be rounded off.

Digit 5 is dropped because it is placed after the decimal point.

Thus, 0.008025 = 0.00803 (3 s.f.)

(b)

2 < 5, thus digit 0 remains unchanged.

0.00 8 0 2 5

Digit to be rounded off.

Digits 2 and 5 are dropped because it is placed after the decimal point.

Thus, 0.008025 = 0.0080 (2 s.f.)

**MIND TEST 2.1b**

**1.** Complete the table below by rounding off each number below to the given significant figure.

| Number | 3 significant figures | 2 significant figures | 1 significant figure |
|---|---|---|---|
| (a) 47 193 | | | |
| (b) 5 261 | | | |
| (c) 305.72 | | | |
| (d) 20.68 | | | |
| (e) 8.595 | | | |
| (f) 5.9 | | | |
| (g) 0.6937 | | | |
| (h) 0.09184 | | | |
| (i) 0.005709 | | | |

**2.** Calculate each operation below. State the answer to the significant figures shown in the brackets.

(a) $2.57 \times 4.5 + 0.45$ [4]

(b) $8.59 \div 2.1 - 1.26$ [3]

(c) $14.23 - 2.6 \times 1.2$ [3]

(d) $15.74 + 20.3 \div 2.5$ [2]

(e) $7.63 \times 0.5 \div 4.2 + 5.7$ [3]

(f) $10.25 \div 0.75 - 4.2 \times 0.2$ [2]

(g) $15.62 - 1.72 \times 0.2 + 6.3$ [1]

(h) $4.94 + 5.76 \div 0.26 \times 1.4$ [3]

## 2.2 Standard Form

### How do you recognise and write numbers in standard form?

**LEARNING STANDARD**

Recognise and write numbers in standard form.

Many scientific fields such as astronomy, biology, physics and engineering frequently use numbers that are too big or too small in their research. These numbers are written in standard form to make writing easier.

**Standard form** is a way to write a **single number** in the form;

$$\boxed{A \times 10^n}$$

where $1 \leq A < 10$ and $n$ is an integer.

For example, the land area of Malaysia is 330 803 000 000 m$^2$. This value can be written as $3.308 \times 10^{11}$ m$^2$ or $3.30803 \times 10^{11}$ m$^2$ or depending on the number of significant figures required.

### How do you change a single number to standard form?

When a single number is changed to standard form;

- Numbers with value more than 1 will be given positive index.
- Numbers with value less than 1 will be given negative index.

**FLASHBACK**

- $a^n$, $n$ is a positive index.
- $a^{-n}$, $-n$ is a negative index.

**Example 5**

Write the following single numbers in standard form.

(a) 28 (b) 280 (c) 2 805.3

***Solution:***

(a) $28 = 2.8 \times 10$

Place value is tens

Decimal point after first non-zero digit.

(b) $280 = 2.80 \times 100$

$= 2.8 \times 10^2$

Place value is hundreds

(c) $2\ 805.3 = 2.8053 \times 1\ 000$

$= 2.8053 \times 10^3$

Place value is thousands

**Example 6**

Write the following decimals in standard form.

(a) 0.325 (b) 0.00325 (c) 0.03025 (d) 0.003005

***Solution:***

(a) $0.325 = 3.25 \times \frac{1}{10}$

$= 3.25 \times 10^{-1}$

Place value is one tenths

(b) $0.00325 = 3.25 \times \frac{1}{1\ 000}$

$= 3.25 \times \frac{1}{10^3}$

$= 3.25 \times 10^{-3}$

Place value is one thousandths

**FLASHBACK**

$$\frac{1}{a^n} = a^{-n}$$

**DISCUSSION CORNER**

Is $5.1 \times 10^0$ a number in standard form? Discuss.

(c) $0.03025 = 3.025 \times \frac{1}{100}$

$= 3.025 \times \frac{1}{10^2}$

$= 3.025 \times 10^{-2}$

Place value is one hundredths

(d) $0.003005 = 3.005 \times \frac{1}{1\ 000}$

$= 3.005 \times \frac{1}{10^3}$

$= 3.005 \times 10^{-3}$

Place value is one thousandths



### How do you change a number in standard form to single number?

When a number in standard form is changed to a single number;
- The number will be equal to 10 or more if the index is positive.
- The number will be less than 1 if the index is negative.

**Example 7**

Write $4.17 \times 10^5$ as a single number.

***Solution:***

$4.17 \times 10^5 = 4.17 \times 100\ 000$
$= 417\ 000$

**FLASHBACK**

$10^5 = 10 \times 10 \times 10 \times 10 \times 10$

$10^{-5} = \frac{1}{10^5}$

**Example 8**

Write $8.063 \times 10^{-5}$ as a single number.

***Solution:***

$8.063 \times 10^{-5} = 8.063 \times \frac{1}{100\ 000}$
$= 0.00008063$

**BULLETIN**

1 tera = 1 000 000 000 000

1 nano = 0.000 000 001

**Example 9**

Determine 3 050 terabytes in bytes. State the answer in standard form.

***Solution:***

3 050 terabytes $= 3\ 050 \times 10^{12}$ bytes
$= (3.05 \times 10^3) \times 10^{12}$ bytes
$= (3.05 \times 10^{3+12})$ bytes
$= 3.05 \times 10^{15}$ bytes

Use index law $a^m \times a^n = a^{m+n}$

**SMART MIND**

What is the value of 1 tera in nano?

**Example 10**

Determine 0.0057 nanometre in metre. State your answer in standard form.

***Solution:***

0.0057 nanometre $= 0.0057 \times 10^{-9}$ metre.
$= (5.7 \times 10^{-3}) \times 10^{-9}$ metre
$= (5.7 \times 10^{-3+(-9)})$ metre
$= (5.7 \times 10^{-3-9})$ metre
$= 5.7 \times 10^{-12}$ metre

Use index law $a^m \times a^n = a^{m+n}$

## Brainstorming 3

In pairs

**Aim:** Write metric measurements in standard form.

**Steps:**

**1.** Complete the table below by writing the single numbers for metric measurements in standard form.

| Prefix | Symbol | Value | |
|---|---|---|---|
| | | Single number | Standard form |
| exa | E | 1 000 000 000 000 000 000 | $1 \times 10^{18}$ |
| peta | P | 1 000 000 000 000 000 | |
| tera | T | 1 000 000 000 000 | |
| giga | G | 1 000 000 000 | |
| mega | M | 1 000 000 | |
| kilo | k | 1 000 | |
| hecto | h | 100 | |
| deca | da | 10 | |
| – | – | 1 | $1 \times 10^{0}$ |
| deci | d | 0.1 | $1 \times 10^{-1}$ |
| centi | c | 0.01 | |
| milli | m | 0.001 | |
| micro | μ | 0.000 001 | |
| nano | n | 0.000 000 001 | |
| pico | p | 0.000 000 000 001 | |
| femto | f | 0.000 000 000 000 001 | |
| atto | a | 0.000 000 000 000 000 001 | |

**Discussion:**

A number with too big or too small value can be written as a single number or in standard form. Which form will you choose for an arithmetic operation? Give your reasons.

From Brainstorming 3, it is found that;

Standard form makes it easier to write very big and very small numbers in a form that is simple and easy to understand.

## MIND TEST 2.2a

**TIPS**

Use data from Brainstorming 3 to solve question 3.

**1.** Write the following single numbers in standard form.

(a) 35 (b) 481 (c) 5 075 (d) 97.25
(e) 3 124.3 (f) 0.9 (g) 0.23 (h) 0.0375

**2.** Change the numbers in standard form to single numbers.

(a) $2.5 \times 10^{0}$ (b) $3.75 \times 10^{1}$ (c) $4.23 \times 10^{2}$
(d) $5.07 \times 10^{3}$ (e) $9.1 \times 10^{4}$ (f) $6.2 \times 10^{-1}$
(g) $7.29 \times 10^{-2}$ (h) $1.034 \times 10^{-3}$ (i) $8.504 \times 10^{-4}$

**3.** Change the following metric measurements to the units given in the brackets. State your answers in standard form.

(a) 1 050 kilometres [metre] (b) 216 gigabytes [byte]
(c) 0.75 teralitre [litre] (d) 95 micrometres [metre]
(e) 123 nanometres [metre] (f) 0.089 femtometre [metre]

## How are basic arithmetic operations involving numbers in standard form performed?

**LEARNING STANDARD**

Perform basic arithmetic operations involving numbers in standard form.

### Add and subtract operations

**Example 11**

Calculate the value of each of the following operations. State your answer in standard form.

(a) $2.73 \times 10^3 + 5.92 \times 10^3$ (b) $4.27 \times 10^5 + 9.35 \times 10^5$

(c) $7.02 \times 10^4 + 2.17 \times 10^5$ (d) $9.45 \times 10^6 - 3.24 \times 10^5$

***Solution:***

(a) $2.73 \times 10^3 + 5.92 \times 10^3$

$= (2.73 + 5.92) \times 10^3$

$= 8.65 \times 10^3$

Factorise $10^3$

(b) $4.27 \times 10^5 + 9.35 \times 10^5$

$= (4.27 + 9.35) \times 10^5$

$= 13.62 \times 10^5$

$= (1.362 \times 10) \times 10^5$

$= 1.362 \times 10^1 \times 10^5$

$= 1.362 \times 10^{1+5}$

$= 1.362 \times 10^6$

**FLASHBACK**

- $5a^n + 7a^n$
  $= (5 + 7)a^n$
  $= 12a^n$
- $5 \times 10^n + 7 \times 10^n$
  $= (5 + 7)10^n$
  $= 12(10^n)$

(c)

**Method 1**

$7.02 \times 10^4 + 2.17 \times \boxed{10^5}$

$= 7.02 \times 10^4 + 2.17 \times \boxed{10^1 \times 10^4}$

$= 7.02 \times 10^4 + 21.7 \times 10^4$

$= (7.02 + 21.7) \times 10^4$

$= 28.72 \times 10^4$

$= 2.872 \times 10^1 \times 10^4$

$= 2.872 \times 10^{1+4}$

$= 2.872 \times 10^5$

$10^5$ change to $10^1 \times 10^4$ to simply calculation.

**Method 2**

$7.02 \times \boxed{10^4} + 2.17 \times 10^5$

$= 7.02 \times \boxed{10^{-1} \times 10^5} + 2.17 \times 10^5$

$= 0.702 \times 10^5 + 2.17 \times 10^5$

$= (0.702 + 2.17) \times 10^5$

$= 2.872 \times 10^5$

**TIPS**

For operations of addition and subtraction, change index with small value to index with large value as in method 2 of example (c) and example (d).

**SMART MIND**

Calculate the following without using a calculator.

- $2.4 \times 10^3 + 1.3 \times 10^5$
- $8.5 \times 10^4 - 1.2 \times 10^2$

(d)

**Method 1**

$9.45 \times \boxed{10^6} - 3.24 \times 10^5$

$= 9.45 \times \boxed{10^1 \times 10^5} - 3.24 \times 10^5$

$= 94.5 \times 10^5 - 3.24 \times 10^5$

$= (94.5 - 3.24) \times 10^5$

$= 91.26 \times 10^5$

$= 9.126 \times 10^1 \times 10^5$

$= 9.126 \times 10^{1+5}$

$= 9.126 \times 10^6$

**Method 2**

$9.45 \times 10^6 - 3.24 \times \boxed{10^5}$

$= 9.45 \times 10^6 - 3.24 \times \boxed{10^{-1} \times 10^6}$

$= 9.45 \times 10^6 - 0.324 \times 10^6$

$= (9.45 - 0.324) \times 10^6$

$= 9.126 \times 10^6$

## Example 12

Calculate the value of each of the following operations. State the answer in standard form.

(a) $3.58 \times 10^{-3} + 9.24 \times 10^{-3}$ (b) $8.21 \times 10^{-4} + 1.49 \times 10^{-5}$
(c) $2.3 \times 10^{-5} - 4.6 \times 10^{-6}$

**Solution:**

(a)
$$\begin{aligned} 3.58 \times 10^{-3} + 9.24 \times 10^{-3} &= (3.58 + 9.24) \times 10^{-3} \\ &= 12.82 \times 10^{-3} \\ &= 1.282 \times 10^{1} \times 10^{-3} \\ &= 1.282 \times 10^{1+(-3)} \\ &= 1.282 \times 10^{-2} \end{aligned}$$

(b) **Method 1**

$$\begin{aligned} &8.21 \times \boxed{10^{-4}} + 1.49 \times 10^{-5} \\ &= 8.21 \times \boxed{10^{1} \times 10^{-5}} + 1.49 \times 10^{-5} \\ &= 82.1 \times 10^{-5} + 1.49 \times 10^{-5} \\ &= (82.1 + 1.49) \times 10^{-5} \\ &= 83.59 \times 10^{-5} \\ &= 8.359 \times 10^{1} \times 10^{-5} \\ &= 8.359 \times 10^{1+(-5)} \\ &= 8.359 \times 10^{-4} \end{aligned}$$

**Method 2**

$$\begin{aligned} &8.21 \times 10^{-4} + 1.49 \times \boxed{10^{-5}} \\ &= 8.21 \times 10^{-4} + 1.49 \times \boxed{10^{-1} \times 10^{-4}} \\ &= 8.21 \times 10^{-4} + 0.149 \times 10^{-4} \\ &= (8.21 + 0.149) \times 10^{-4} \\ &= 8.359 \times 10^{-4} \end{aligned}$$

(c) **Method 1**

$$\begin{aligned} &2.3 \times \boxed{10^{-5}} - 4.6 \times 10^{-6} \\ &= 2.3 \times \boxed{10^{1} \times 10^{-6}} - 4.6 \times 10^{-6} \\ &= 23 \times 10^{-6} - 4.6 \times 10^{-6} \\ &= (23 - 4.6) \times 10^{-6} \\ &= 18.4 \times 10^{-6} \\ &= 1.84 \times 10^{1} \times 10^{-6} \\ &= 1.84 \times 10^{1+(-6)} \\ &= 1.84 \times 10^{-5} \end{aligned}$$

**Method 2**

$$\begin{aligned} &2.3 \times 10^{-5} - 4.6 \times \boxed{10^{-6}} \\ &= 2.3 \times 10^{-5} - 4.6 \times \boxed{10^{-1} \times 10^{-5}} \\ &= 2.3 \times 10^{-5} - 0.46 \times 10^{-5} \\ &= (2.3 - 0.46) \times 10^{-5} \\ &= 1.84 \times 10^{-5} \end{aligned}$$

### SMART TECHNOLOGY

1. Press Mode button a few times until the screen shows:
   Fix Sci Norm
   1 2 3
2. Press 2 to choose Sci, that is standard form.
3. Enter number of significant figures (s.f.) needed, for example 9.
4. Enter the required operation.
   ♦ $3.2 \times 10^5 - 4.2 \times 10^4$
   Press 3.2 Exp 5 − 4.2 Exp 4.

   Screen display:
   3.2 E5 − 4.2 E4
   Press = $2.78 \times 10^5$.

   ♦ $4 \times 10^5 \times 3.7 \times 10^4$
   Press 4 Exp 5 × 3.7 Exp 4.

   Screen display:
   4 Exp 5 × 3.7 Exp 4
   Press = $1.48 \times 10^{10}$.
5. Extend your exploration to other operations involving other standard forms
6. Compare the results produced by calculator and answers obtained through manual calculations.

## MIND TEST 2.2b

1. Calculate the value of each of the following operations. State your answer in standard form.

   (a) $2.4 \times 10^4 + 3.57 \times 10^4$ (b) $8.2 \times 10^6 - 4.27 \times 10^6$
   (c) $5.23 \times 10^7 + 4.98 \times 10^7$ (d) $1.2 \times 10^5 + 3.74 \times 10^4$
   (e) $5.7 \times 10^8 - 2.4 \times 10^7$ (f) $5.7 \times 10^3 + 8.02 \times 10^4$
   (g) $6.5 \times 10^4 - 7.3 \times 10^3$ (h) $5.2 \times 10^{-3} - 4.12 \times 10^{-3}$
   (i) $8.74 \times 10^{-5} - 2.65 \times 10^{-5}$ (j) $4.1 \times 10^{-4} + 9.5 \times 10^{-3}$
   (k) $8.3 \times 10^{-4} - 6.2 \times 10^{-5}$ (l) $9.42 \times 10^{-6} - 7.35 \times 10^{-7}$

## Operations of Multiplication and Division

**Example 13**

Solve the following operations. State your answers in standard form.

(a) $3 \times 10^5 \times 4.9 \times 10^2$

(b) $7.5 \times 10^{-3} \times 5 \times 10^{-6}$

(c) $\dfrac{5.9 \times 10^5}{2 \times 10^2}$

(d) $\dfrac{6.8 \times 10^{-3}}{4 \times 10^{-6}}$

**TIPS**

Law of Indices

- Operation of multiplication
  $(A \times 10^m) \times (B \times 10^n)$
  $= (A \times B) \times 10^{m+n}$
- Operation of division
  $(A \times 10^m) \div (B \times 10^n)$
  $= (A \div B) \times 10^{m-n}$

***Solution:***

(a)
$$\begin{aligned} &3 \times 10^5 \times 4.9 \times 10^2 \\ &= (3 \times 4.9) \times 10^{5+2} \\ &= 14.7 \times 10^7 \\ &= 1.47 \times 10^1 \times 10^7 \\ &= 1.47 \times 10^{1+7} \\ &= 1.47 \times 10^8 \end{aligned}$$

(b)
$$\begin{aligned} &7.5 \times 10^{-3} \times 5 \times 10^{-6} \\ &= (7.5 \times 5) \times 10^{-3+(-6)} \\ &= 37.5 \times 10^{-9} \\ &= 3.75 \times 10^1 \times 10^{-9} \\ &= 3.75 \times 10^{1+(-9)} \\ &= 3.75 \times 10^{-8} \end{aligned}$$

(c)
$$\begin{aligned} &\frac{5.9 \times 10^5}{2 \times 10^2} \\ &= \frac{5.9}{2} \times 10^{5-2} \\ &= 2.95 \times 10^3 \end{aligned}$$

(d)
$$\begin{aligned} &\frac{6.8 \times 10^{-3}}{4 \times 10^{-6}} \\ &= \frac{6.8}{4} \times 10^{-3-(-6)} \\ &= 1.7 \times 10^3 \end{aligned}$$

**MIND TEST 2.2c**

**1.** Calculate the value of each of the following operations. State your answer in standard form.

(a) $4 \times 10^5 \times 3.7 \times 10^2$

(b) $7.5 \times 10^{-3} \times 5 \times 10^{-6}$

(c) $6.3 \times 10^5 \times 4.0 \times 10^2$

(d) $5.3 \times 10^{-3} \times 4 \times 10^5$

(e) $(1.08 \times 10^2) \div (2.4 \times 10^4)$

(f) $(9.6 \times 10^{-2}) \div (1.5 \times 10^{-5})$

(g) $(5.9 \times 10^5) \div (2 \times 10^2)$

(h) $(2.58 \times 10^4) \div (0.3 \times 10^{-4})$

**2.** A mobile swimming pool measures 305 cm × 183 cm × 56 cm. Calculate the maximum volume of water that it can hold in litres. State your answer in standard form and correct to four significant figures.

**BULLETIN**

1 litre = 1 000 $cm^3$
1 litre = 0.001 $m^3$

**3.** Syazwani wants to transfer 2 terabytes of data to pen drives with a capacity of 32 gigabytes. What is the minimum number of 32-gigabyte pen drives needed?

**4.** Given 1 millimetre = $10^{-3}$ metre and 1 micrometre = $10^{-6}$ metre. State 1 millimetre in micrometre.

**DISCUSSION CORNER**

Between operation of addition or subtraction and operation of multiplication or division involving standard form, which operation is easier? Why?

## How do you solve problems involving numbers in standard form?

**LEARNING STANDARD**

Solve problems involving numbers in standard form.

**Example 14**

A ream of paper contains 800 sheets of paper. The thickness of one sheet of paper is $9.4 \times 10^{-3}$ cm. Given the total thickness of $n$ reams of paper is 225.6 em Calculate the value of $n$.

**Solution:**

**Understanding the problem**

Number of sheets in 1 ream = 800
Thickness of 1 sheet = $9.4 \times 10^{-3}$ cm
Thickness of $n$ reams = 225.6 cm

**Planning a strategy**

- Determine the thickness of 1 ream of paper.
- $n = \dfrac{\text{thickness of } n \text{ reams}}{\text{thickness of 1 ream}}$

**Implementing the strategy**

Thickness of 1 ream
$= 800 \times 9.4 \times 10^{-3}$ cm
$= 7.52$ cm

Thus,

$$n = \frac{\text{thickness of } n \text{ reams}}{\text{thickness of 1 ream}}$$

$$n = \frac{225.6 \text{ cm}}{7.52 \text{ cm}}$$

$$n = 30$$

**Making a conclusion**

Number of reams is 30.

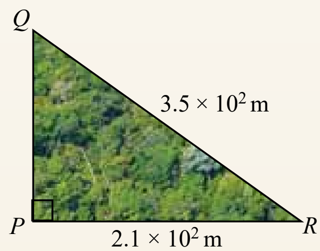


**Example 15**

A property firm bought a piece of land in the shape of a right-angled triangle $PQR$ as shown in the diagram.

(a) Calculate the value of $PQ$, in metres and state your answer in standard form.

(b) If the cost of one square metre of the land is RM45, calculate the total cost of the land in RM.




**Solution:**

**Understanding the problem**

$\Delta PQR$ is a right-angled triangle.
$QR$ is the hypotenuse.

**Planning a strategy**

(a) Calculate $PQ$ using Pythagoras' theorem.
(b) Calculate the area of land in the shape of $\Delta PQR$. Multiply total land area by cost of 1 m² of land.

**Implementing the strategy**

(a)
$$\begin{aligned} PQ^2 &= [(3.5 \times 10^2)^2 - (2.1 \times 10^2)^2] \text{ m}^2 \\ &= [1.225 \times 10^5 - 4.41 \times 10^4] \text{ m}^2 \\ &= (7.84 \times 10^4) \text{ m}^2 \\ PQ &= \sqrt{(7.84 \times 10^4) \text{ m}^2} \\ &= 2.8 \times 10^2 \text{ m} \end{aligned}$$

(b)
$$\begin{aligned} \text{Area of } \Delta PQR &= \frac{1}{2} \times \left(2.1 \times 10^2\right)\text{m} \times \left(2.8 \times 10^2\right)\text{m} \\ &= 2.94 \times 10^4 \text{ m}^2 \\ \text{Cost of land} &= 2.94 \times 10^4 \times \text{RM}45 \\ &= \text{RM}1\ 323\ 000.00 \end{aligned}$$

**Making a conclusion**

(a) Distance $PQ = 2.8 \times 10^2$ m

(b) Total cost of land = RM1 323 000.00

**Example 16**

The picture shows the Earth with a diameter of $1.2742 \times 10^4$ km. Calculate the surface area of the Earth, in km$^2$. State the answer in standard form correct to four significant figures. [Surface area of sphere = $4\pi r^2$ and $\pi = 3.142$]


**Solution:**

**Understanding the problem**

- Earth is a sphere.
- Diameter of Earth is $1.2742 \times 10^4$ km.
- Answer is in standard form correct to four significant figures.

**Planning a strategy**

- Radius = $\dfrac{\text{diameter}}{2}$.
- Use formula for surface area of sphere to calculate surface area of Earth.

**Implementing the strategy**

Radius of Earth $= \left(\dfrac{1.2742 \times 10^4}{2}\right)$ km
$= 6.371 \times 10^3$ km

Surface area of Earth
$= 4\pi r^2$
$= [4(3.142)(6.371 \times 10^3)^2]$ km$^2$
$= 510\ 130\ 608.1$ km$^2$
$= 5.101 \times 10^8$ km$^2$ (4 s.f.)

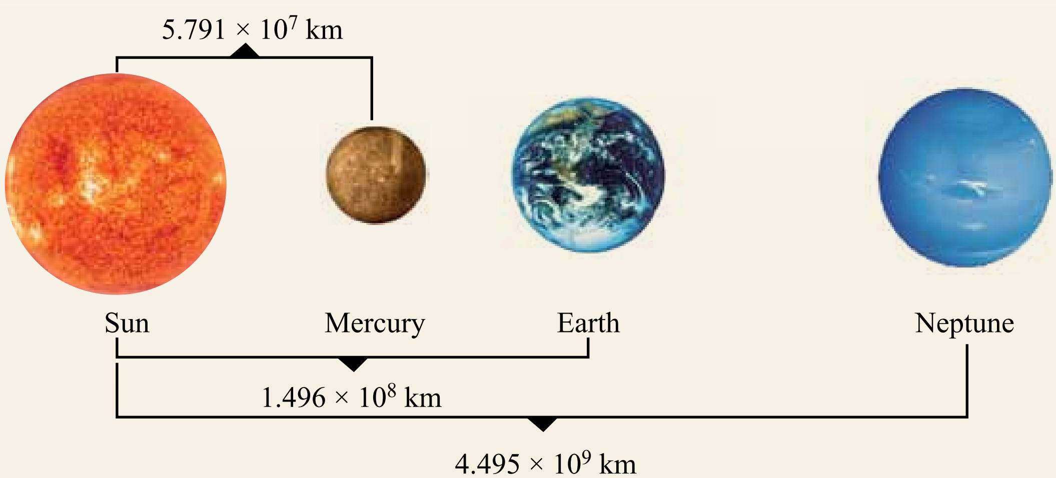
**Making a conclusion**

Surface area of Earth is $5.101 \times 10^8$ km$^2$

**MIND TEST 2.2d**

1. The average daily water consumption in a residential area is 6 950 m$^3$. Calculate the total water consumption, in cubic metres, in the residential area for February 2016. State the answer in standard form correct to three significant figures.

2.




The picture above shows the estimated distance of three planets in the solar system from the Sun on a certain day. Calculate the difference in distance, in km, between

(a) Mercury and Earth (b) Mercury and Neptune (c) Earth and Neptune

State the answers in standard form correct to three significant figures.

## Dynamic Challenge

### Test Yourself

**1.** Round off the following numbers and decimals correct to the significant figures stated in the brackets.

(a) 23 725 [2] (b) 54 299 [4] (c) 8 999 [2] (d) 295 197 [2]

(e) 4 854 [1] (f) 5 [3] (g) 0.2763 [2] (h) 35.074 [1]

(i) 423.575 [2] (j) 10.234 [1] (k) 1.0372 [3] (l) 501.724 [3]

**2.** Given $m = 3.2 \times 10^3$ and $n = 5.43 \times 10^4$. Calculate the values of the following operations. State your answers in standard form correct to three significant figures.

(a) $2mn$ (b) $m + n$ (c) $n - m$ (d) $m^2 + n^2$

(e) $\dfrac{3m}{2n}$ (f) $\dfrac{m+n}{mn}$ (g) $m^{-2} + n^{-3}$ (h) $n - m^{-3}$

**3.** Complete the following.

(a) $2.5 \times 10^2 + 1.35 \times 10^4$
$= 2.5 \times 10^{\square} \times 10^4 + 1.35 \times 10^4$
$= \boxed{\qquad} \times 10^4 + 1.35 \times 10^4$
$= (\boxed{\quad} + \boxed{\quad}) \times 10^4$
$= \boxed{\qquad} \times 10^4$

(b) $5.74 \times 10^{-3} + 3.4 \times 10^{-6}$
$= 5.74 \times 10^{-3} + 3.4 \times 10^{\square} \times 10$
$= 5.74 \times 10^{-3} + \boxed{\qquad} \times 10^{-3}$
$= (\boxed{\quad} + \boxed{\quad}) \times 10^{-3}$
$= \boxed{\qquad} \times 10^{-3}$

(c) $1.75 \times 10^2 - 4.2 \times 10^{-1}$
$= 1.75 \times 10^2 - 4.2 \times 10^{\square} \times 10^2$
$= 1.75 \times 10^2 - \boxed{\qquad} \times 10^2$
$= (\boxed{\quad} + \boxed{\quad}) \times 10^2$
$= \boxed{\qquad} \times 10^2$

(d) $3.7 \times 10^{-2} - 4.3 \times 10^{-5}$
$= 3.7 \times 10^{-2} - 4.3 \times 10^{\square} \times 10^{-2}$
$= 3.7 \times 10^{-2} - \boxed{\qquad} \times 10^{-2}$
$= (\boxed{\quad} - \boxed{\quad}) \times 10^{-2}$
$= \boxed{\qquad} \times 10^{-2}$

**4.** A factory produces 72 thousand packets of chips every week. If the factory operates 6 days a week and 18 hours a day, calculate

(a) the number of packets of chips produced every day. State your answer in standard form.

(b) the average profit per hour if the net profit of one packet of chips is 32 sen. State the answer to the nearest RM.

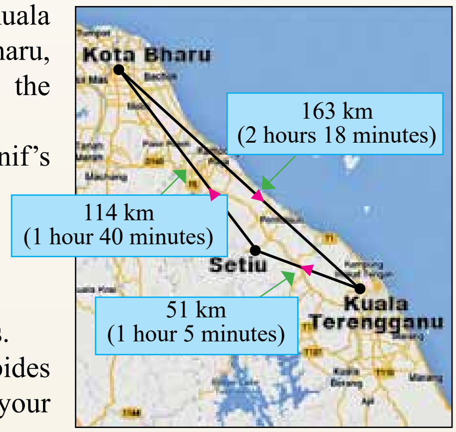
5. The estimated population of Malaysia for 2018 is 32 million. Given Malaysia's land area is 330 803 km$^2$, calculate the population density of Malaysia for each square kilometre for 2018.

State your answer correct to the nearest integer.

## Skills Enhancement

1. A newly built community hall required 6 185 pieces of tiles measuring 30 cm × 30 cm for the floor.
   (a) Calculate the floor area of the hall in square metres. State your answer in standard form correct to three significant figures.
   (b) Given the cost of one piece of tile is RMl.75. Calculate the total cost of the tiles to the nearest RM.

2. Encik Hanif drove his car from Kota Bharu to Kuala Terengganu to visit his son. On the way back to Kota Bharu, Encik Hanif made a stop at Setiu. The map shows the distance and travelling time of Encik Hanif.
   (a) Calculate the average speed, in kmh$^{-1}$, of Encik Hanif's car for the journey
      (i) from Kota Bharu to Kuala Terengganu.
      (ii) from Kuala Terengganu to Setiu.
      (iii) from Setiu to Kota Bharu.
   State the answers correct to three significant figures.
   (b) Encik Hanif is a safety-conscious driver who abides by the speed limit. Is this statement true? State your reasons.




## Self Mastery

1. The picture shows three planets in the Solar System.

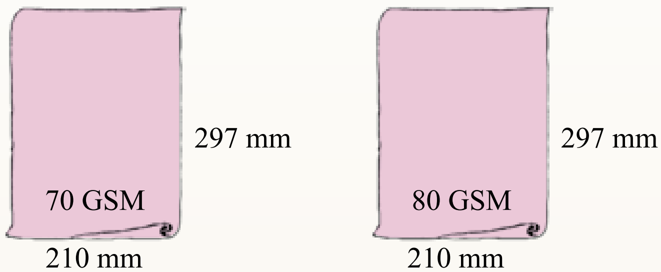
Mercury [Diameter = 4 879 km]

Neptune [Diameter = 49 244 km]

Jupiter [Diameter = 139 822 km]

   (a) Calculate the surface area, in km$^2$, of all three planets. State the answers in standard form correct to three significant figures.
   [Surface area of sphere = $4\pi r^2$ and $\pi = 3.142$]
   (b) Based on your answer in (a), calculate the difference in surface area between the largest and smallest planets in the Solar System. State the answer correct to four significant figures.

**2.**




The diagram above shows two types of A4-sized paper with different masses. GSM means grams per square metre.
Calculate the mass of one piece of A4-sized paper, in grams for

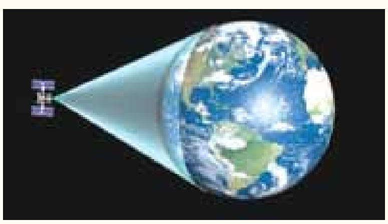
(a) 70 GSM (b) 80 GSM

State the answers in standard form correct to three significant figures.

## PROJECT

1. Look at the pictures below. Obtain the data relevant to the required measurement. Your answers should be in standard form.
2. You can surf various websites or refer to reference books to obtain interesting data related to the pictures below.

(a) Mass



(b) Population

(c) Distance

(d) Magnitude

3. Obtain other interesting facts that involve calculations in standard form.
4. Present your findings using multimedia applications.

## CONCEPT MAP

**Standard Form**

**Significant figure** shows the level of **accuracy** of a measurement.

All digits are significant figures **except the zero before the first non-zero digit**.

(a) 0.023 (2 s.f.) (b) 0.102 (3 s.f.)
(c) 1.200 (4 s.f.) (d) 10 518 (5 s.f.)

For **integers**, the value of the significant figure for **zero** as the last digit depends on the **required level of accuracy**.

(a) 93 000 – 5 s.f. (nearest one)
(b) 93 000 – 4 s.f. (nearest ten)
(c) 93 000 – 3 s.f. (nearest hundred)
(d) 93 000 – 2 s.f. (nearest thousand)

Rounding off a number to a certain number of significant figures.

(a) 2 853
3 000 (1 s.f.)
2 900 (2 s.f.)
2 850 (3 s.f.)

(b) 62.54
60 (1 s.f.)
63 (2 s.f.)
62.5 (3 s.f.)

(c) 0.02704
0.03 (1 s.f.)
0.027 (2 s.f.)
0.0270 (3 s.f.)

**Standard form** is written as $\mathbf{A \times 10^n}$ where $\mathbf{1 \leqslant A < 10}$ and $n$ is an integer.

Changing **single numbers** to **standard form** and vice versa.

(a) $534\ 000 = 5.34 \times 10^5$
(b) $0.000\ 534 = 5.34 \times 10^{-4}$
(c) $2.763 \times 10^4 = 27\ 630$
(d) $2.763 \times 10^{-4} = 0.0\ 002\ 763$

**Basic operations** (+, –, ×, ÷) involving numbers in standard form.

(a) $S \times 10^n + T \times 10^n$
$= (S + T) \times 10^n$

(b) $S \times 10^n - T \times 10^n$
$= (S - T) \times 10^n$

(c) $(S \times 10^m) \times (T \times 10^n)$
$= (S \times T) \times 10^{m+n}$

(d) $(S \times 10^m) \div (T \times 10^n)$
$= (S \div T) \times 10^{m-n}$

## SELF-REFLECT

**At the end of this chapter, I can:**

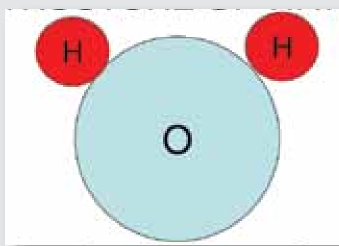
| | | | |
|---|---|---|---|
| **1.** | Explain the meaning of significant figure and thus determine the number of significant figures of a number. | | |
| **2.** | Round off a number to a certain number of significant figures. | | |
| **3.** | Recognise and write numbers in standard form. | | |
| **4.** | Perform basic arithmetic operations involving numbers in standard form. | | |
| **5.** | Solve problems involving numbers in standard form. | | |

## EXPLORING MATHEMATICS

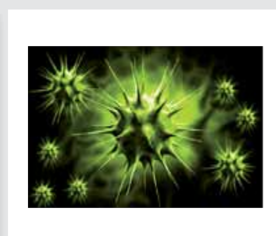
**1.** Get into groups.

**2.** By using the various sources available, identify several measurement values in daily life that are very small or very big. For example,


Hard disk
(1 terabyte)



One water molecule
(0.1 nanometer)


One virus
(1 micrometer)

**3.** Prepare a report on your findings using multimedia applications.

**4.** Present your report.

**5.** Obtain additional information from the presentations by other groups.

**6.** Discuss the advantages of using standard form in various fields.