PRAYAS

JEE 2025

Lecture - 01

Physics

Error & measurement

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Topics to be covered

1. Significant figure
2. Round off , addition substraction
3. multiplication & devision.
4.

Errors

→ The difference between true value and measured value of a quantity.

Whenever an experiment is performed, two kinds of errors can appear in the measured quantity.

(1) Random and (2) Systematic Errors

exact = 11 − 3 = 8 cm.

Real = 11 cm

(1) Random errors appear randomly because of operator, fluctuations in external conditions and variability of measuring instruments. The effect of random error can be some what reduced by taking the average of measured values. Random errors have no fixed sign or size.

(2) Systematic errors occur due to error in the procedure, or miscalibration of the instrument etc. Such errors have same size and sign for all the measurement. Such errors can be determined

Significant figure

- Larger the no. of significant figure obtained in a measurement larger will be its accuracy.

find no. of significant fig in following no.

5332 → 4

532 → 3

43425 → 5

4204 → 4

43007 → 5

23003 → 5

152·3 → 4

152·32 → 5

152·320 → 6

5·3 → 2

5·30 → 3

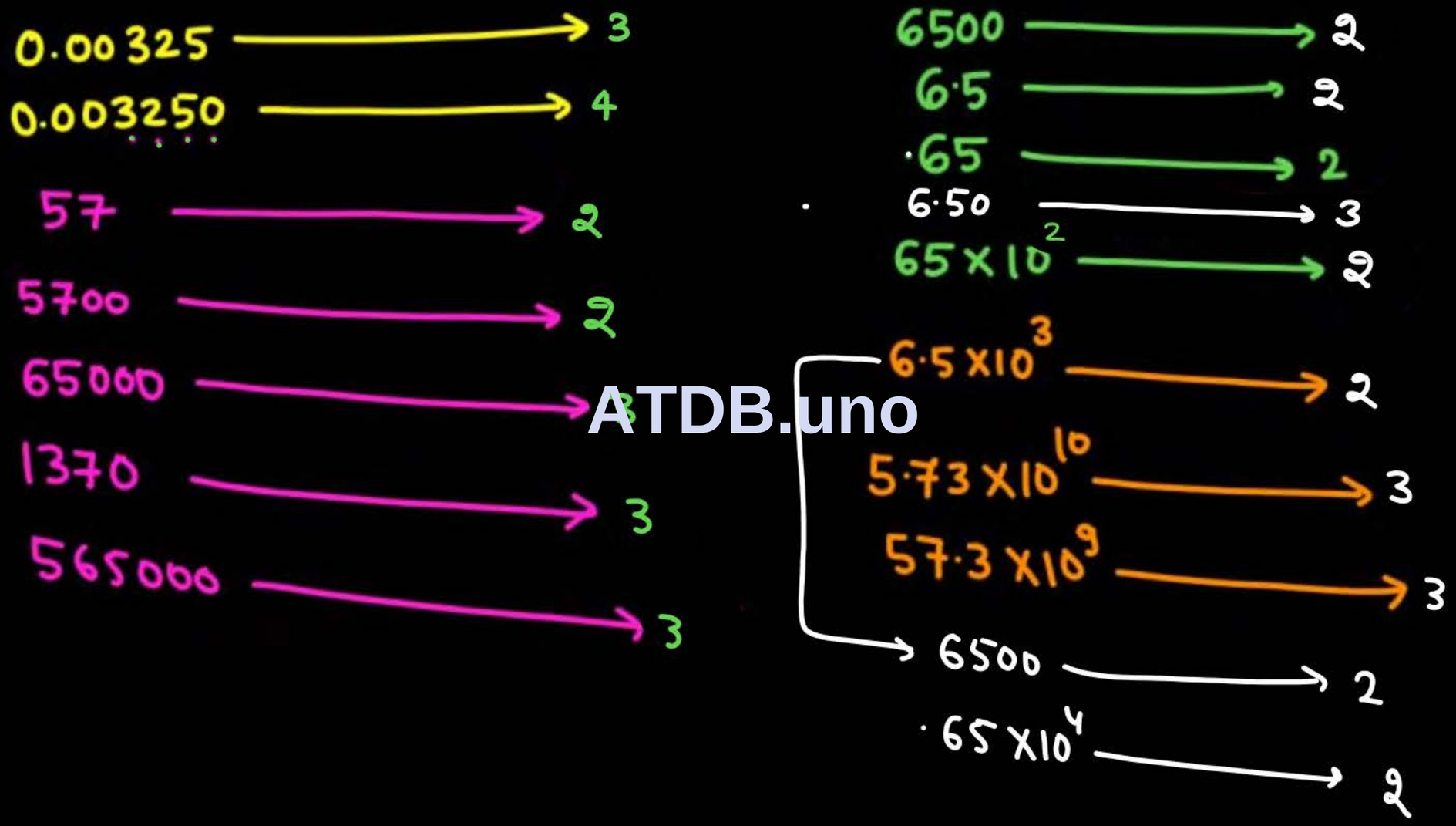
5·300 → 4

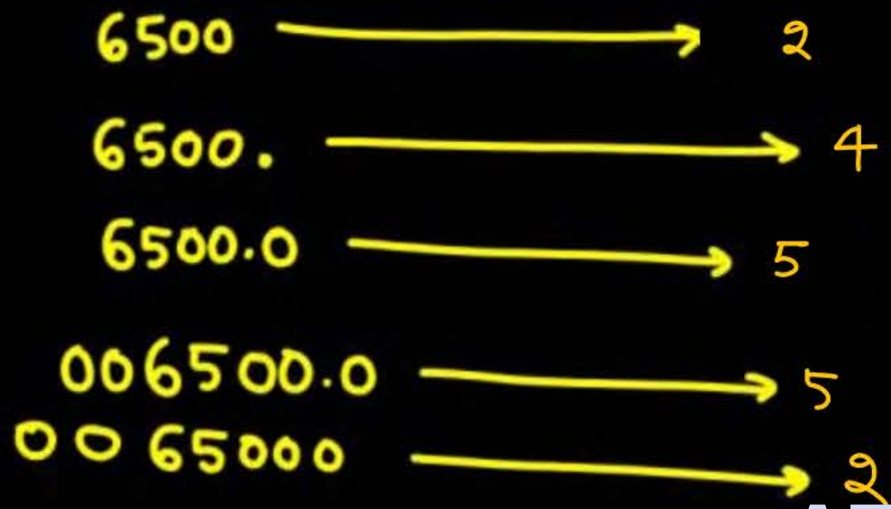
5·30040 → 6

0067 → 2

00675 → 3

·0067 → 2





Rules

* All the non zero digits are significant. Ex 2573 ⟶ (3)
* All the zeros between two non-zero digits are significant. 200703 ⟶ (6)
* All the leading zeros (zero before 1st non-zero digit) are insignificant. Ex .0023 ⟶ (2), 00235 ⟶ (3)

* The trailing zeros (zero to the right of last non-zero digit) in a number With decimal points are significant

1.020 ⟶ 4

1.02000 ⟶ 6

- The trailing zeros in a number without a decimal point are not significant.

35000 ⟶ 2

14200 ⟶ 3

- (X) Changing the units does not change the no. of significant digits.

5.03 m ⟶ 3

503 c.m ⟶ 3

- No. of sig. digit does not depends on system of units and it also does not change with scientific notation

32×10^5 ⟶ 2

320×10^4 ⟶ 2

3.2×10^6 ⟶ 2

Q No. of significant figure for the numbers 23.023, 0.0003, and 2.1×10^{-3} are

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(A) 5, 1, 2

(B) 5, 1, 5

(C) 5, 5, 2

(D) 4, 4, 2

How do I know ho many Sig Figs?

Zeros

Leading zeros – never count

Zeros at the beginning of a number are not significant; they act only to locate the decimal point.

Thus,

0.0834 cm ahs **three** significant figures,

0.02927 mL has **four** significant figures, and

0.0025 has **two** significant figures.

How many Sig Figs?

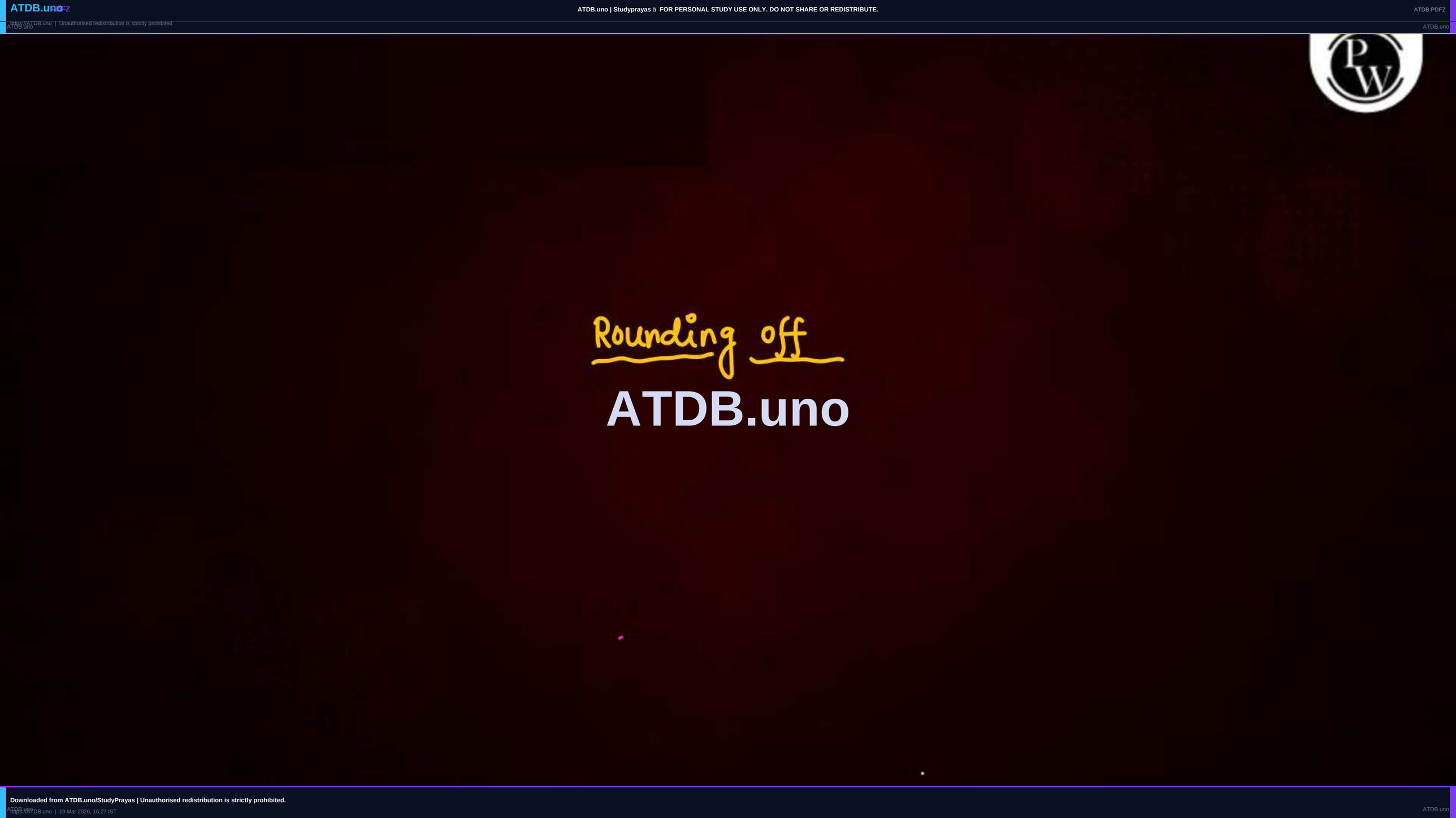
45.8736	6	All digits count
.000239	3	Leading 0's don't'
.00023900	5	Trailing 0's do
48000	5	0's co[illegible] decimal form
48000	2	0's don't count w/o decimal
3.982×10^6	4	All digits count
1.00040	6	0's between digits count as well as trailing in decimal form

How many Sig Figs?

- 7 — 1
- 40 — 1
- 0.5 — 1
- 0.00003 — 1
- 7×10^5 — 1
- 7000000 — 1

How many Sig Figs here?

- 1.2 — 2
- 2100 — 2
- 56.76 — 4
- 4.00 — 3
- 0.0792 — 3
- 7083000000 — 4



Rules for rounding off digits :

There are a set of conventional rules for rounding off :

1. Determine according to the rule what the last reported digit should be.
2. Consider the digit to the right of the last reported digit.
3. If the digit to the right of the last reported digit is less than 5 round it and all digits to its right off.
4. If the digit to the right of the last reported digit is greater than 5 round it and all digits to its right off and increased the last reported digit by one.

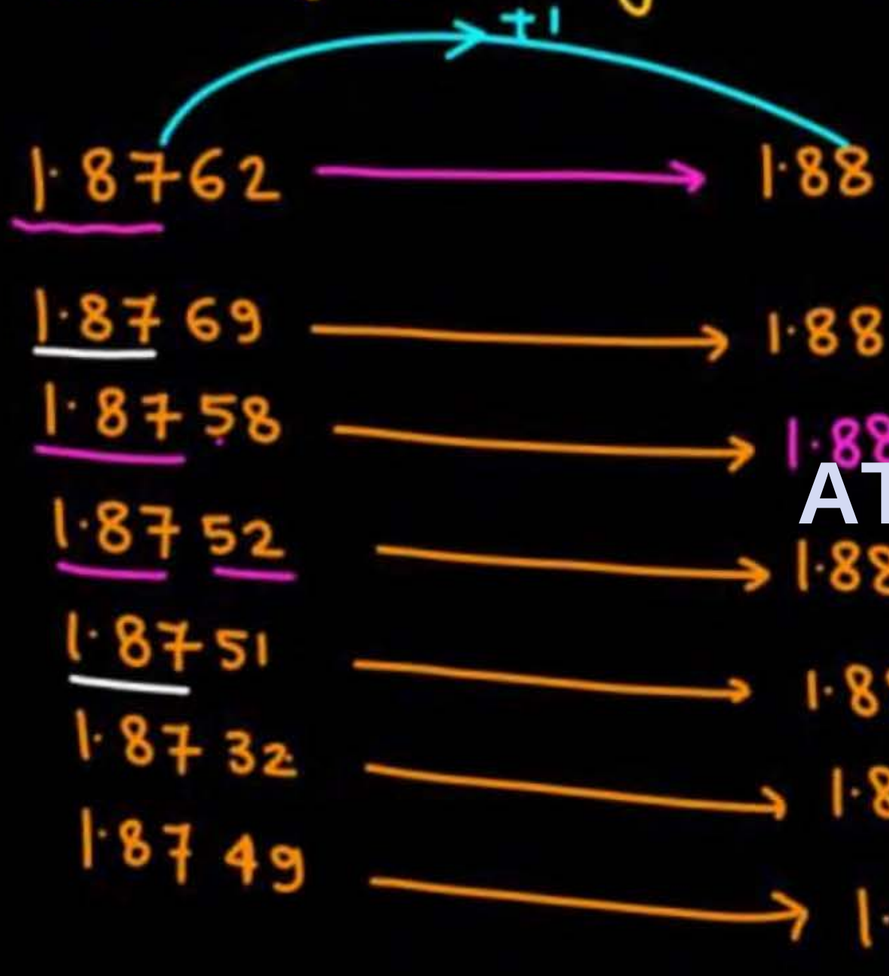
5. If the digit to the right of the last reported digit is a 5 followed by either no other digits or all zeros, round it and all digits to its right off and if the last reported digit is odd round up to the next even digit. If the last reported digit is even then leave it as is.

For example if we wish to round off the following number to 3 significant digits: 18.3682

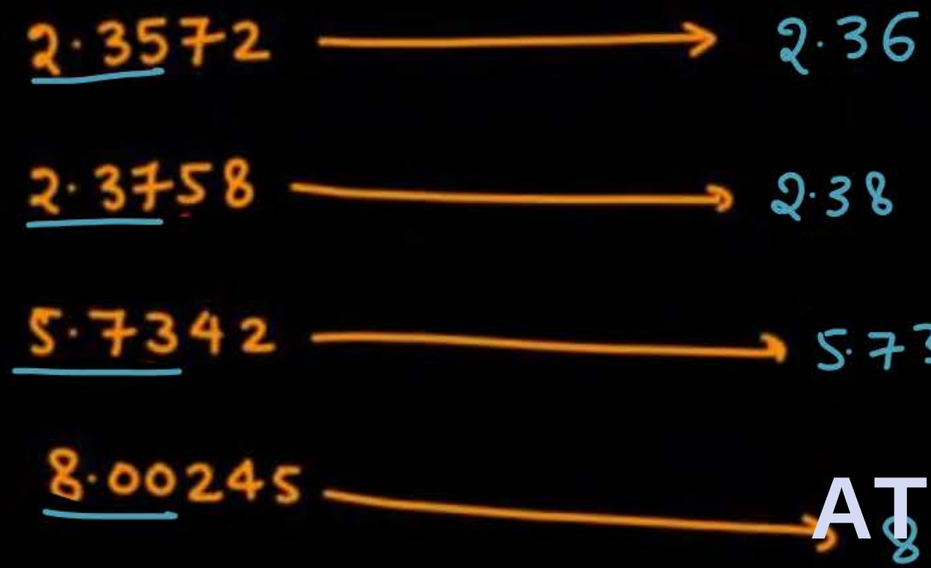
The last reported digits would be the 3. The digit to its right is a 6 which is greater than 5. According to the Rule-4 above, the digit 3 is increased by one and the answer is: 18.4

Round off following number into 3 Sig. figure

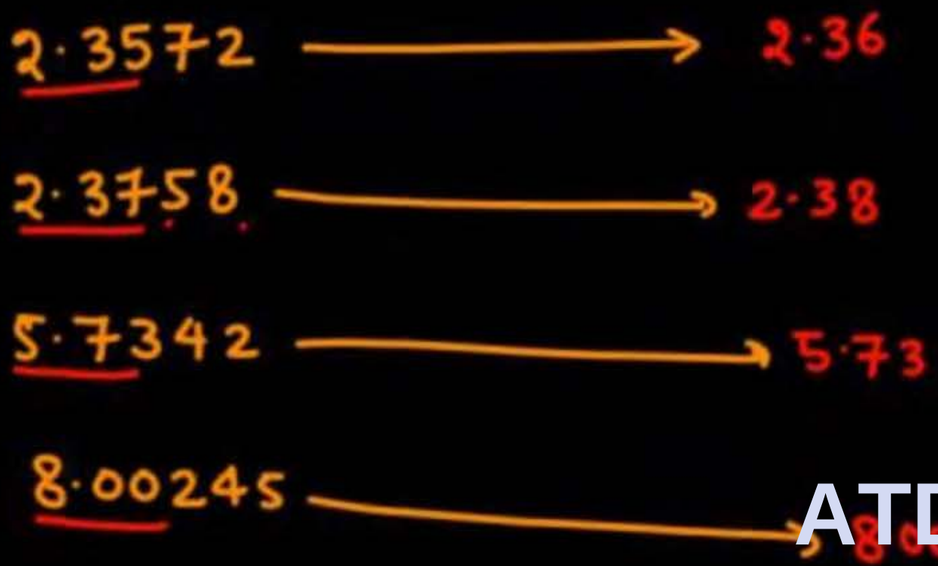
Round off following number into 3 Sig. figure



3 sig digit



3 Sig digit



Another Example :

Round off 4.565 to three significant digits.

The last reported digit would be the 6. The digit to the right is a 5 followed by nothing. Therefore according to Rule-5 above since the 6 is even it remains so and the answer would be 4.56.

4·56

4·565 → 4·56

4·575 → 4·58

Practice

Make the following into a 3 Sig Fig. number :

1. $1.5587 \longrightarrow 1.56$
2. $0.0037421 \longrightarrow 0.00374$
3. $1.6683 \times 10^6 \longrightarrow 1.67 \times 10^6$
4. $1367 \longrightarrow 137$ ✗
   - $\longrightarrow 1370$
5. $128522 \longrightarrow 129000$
6. $5867523 \longrightarrow 5870000$

$1367 = 1.367 \times 10^{3} \longrightarrow 1.37 \times 10^{3} = 1370$

Practice

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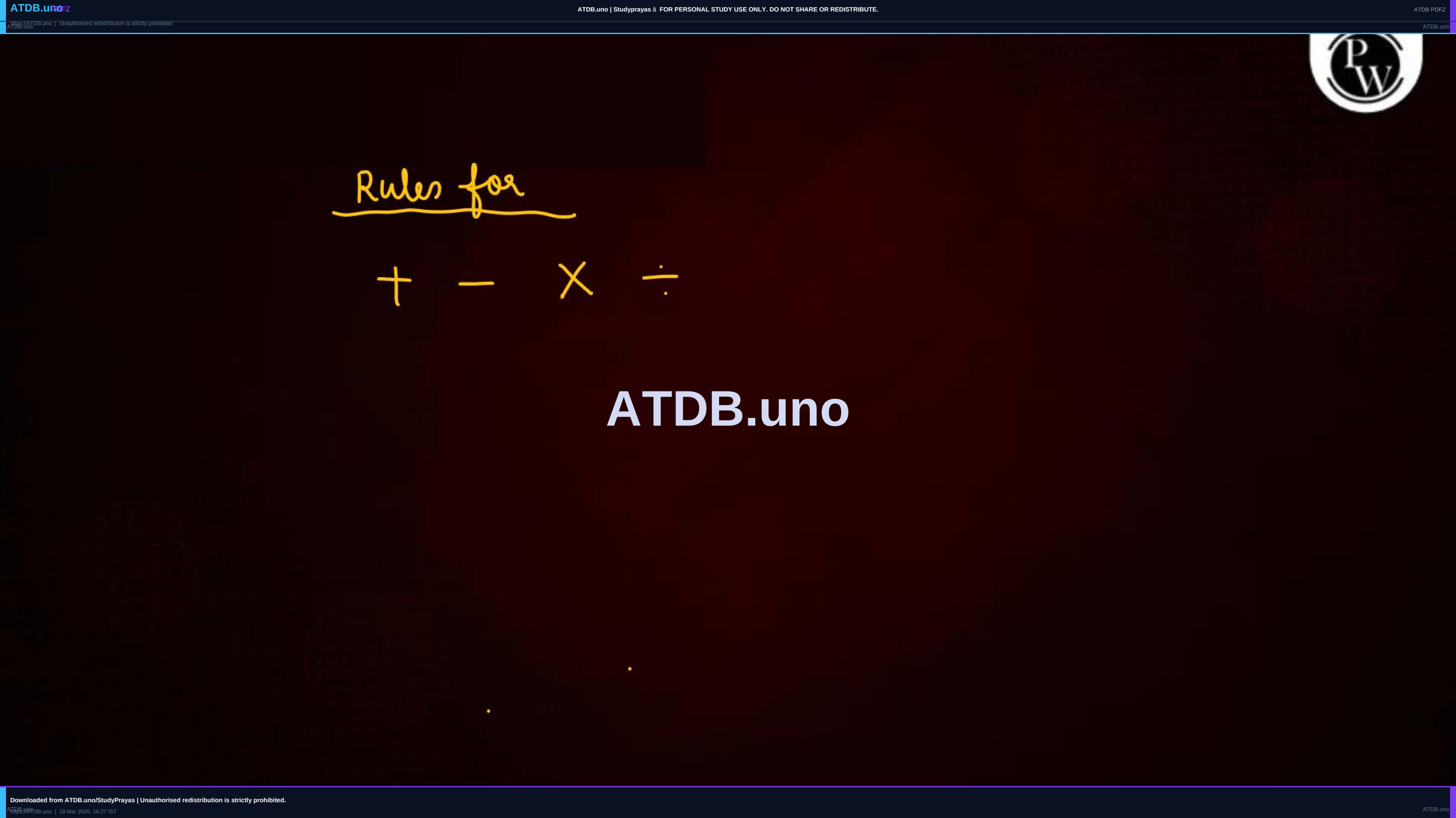
5. $128522 \longrightarrow 129000$
6. $58675 23 \longrightarrow 587$ ✗
   - $\longrightarrow 5870000$



Rules for addition & substraction (in correct no. of sig fig)

$3.4\underline{78}$ → 3 digit after decimal

$+\ 4.\underline{2}$ → 1 " " "

7.678

Ans 7.7

Ans will have 1 digit after decimal

Rules for multiplication & divisim (In correc no. of sig. fig)

$\underline{6.321} \times \underline{5.87} = 37.10427$

4 Sig fig 3 Sig fig

final answer will have 3 sig fig

$\underline{37.10427} \longrightarrow 37.1$

$R_1 = 7.3428$ ⟶ 4 digit aft decimal

$R_2 = 2.347$ ⟶ 3 " " "

$R_3 = +\ 2.03$ ⟶ (2) " " "

11.7198 ⟶ (calc)

इस form में Ans

Ans ⟶ 11.72

$R_1\ R_2\ R_3$ ⟶ Series

$R_{eq} = ?$

Rules for addition & substraction (in correct no. of sig fig)

3.478 ------→ 3
+ 4.2 ------ 1
7.678 Calc

decimal 1 digit form

But Ans → 7.7

Rules for multiplication & division (In correc no. of sig. fig)

6.321 x 5.87 = 37.10427 (Calc)

6.321 → 4 sig. fig

5.87 → 3 sig fig

Round off into 3 sig dig → 37.1

Q

2.73×5.2

2.73 → 3 sig fig

5.2 → 2 sig. fig

14.196 (calc)

Round off → 14

2 Sig dig.

Q

$l = 3.734$

$b = 4.32$

Area = ?

3.734×4.32

3.734 → ④

4.32 → ③

16.13088 → Calc

Ans = 16.1

Q If $R_1 = 5.272$

$R_2 = 3.41$

find R_{eq} if they are connected in series

(A) 8.682 ✗

(B) 8.68 ✓

(C) 8.7 ✗

(D) 9 ✗

$R_{eq} = R_1 + R_2$

$= 8.682$ Calc

Ans 8.68

Q

$$\begin{array}{r} 2.4732 \\ 1.834 \\ +\ 2.03 \\ \hline 6.3372 \end{array}$$

Ans 6.34 Ans

Q

$$\begin{array}{r} 5.9987 \\ -\ 2.07 \\ \hline 3.9287 \end{array}$$

Ans → 3.93

$T_f = 5.9987\ ^\circ C$

$T_i = 2.07\ ^\circ C$

$\Delta T = T_f - T_i$

Q

$$\begin{array}{r} 2.47\,32 \\ 1.834 \\ +\ 2.03 \\ \hline 6.33\,72 \end{array}$$

Ans $\boxed{6.34}$

Q

$$\begin{array}{r} 5.9987 \\ -\ 2.07 \\ \hline 3.9287 \end{array}$$

Ans 3.93

The product or quotient will be reported as having as many significant digits as the number involved in the operation with the least number of significant digits.

For example : 0.000170 × 100.40 = 0.017068

The product could be expressed with no more that three significant digits since 0.000170 has only three significant digits, and 100.40 has five. So according to the rule the product answer could only be expressed with three significant digits. Thus the answer should be 0.0171 (after rounding off)

Rule for expressing the correct number of significant digits in an addition or substraction :

The rule for expressing a sum or difference is considerably different than the one for multiplication of division. The sum or difference can be no more precise than the least precise number involved in the mathematical operation. Precision has to do with the number of positions to the RIGHT of the decimal. The more position to the right of the decimal, the more precise the number. So a sum or difference can have no more indicated positions to the right of the decimal as the number involved in the operation with the LEAST indicated positions to the right of its decimal.

For example : 160.45 + 6.732 = 167.18 (after rounding off)

Some more Examples

- 2.45 cm + 1.2 cm = 3.65 cm, Round off = 3.6 cm

One decimal place

Calc

2·35 + 1·2 → 3·55 → 3·6

AW

even

- 7.432 cm + 2 cm = 9.432 cm, Round off = 9 cm

no decimal place

- 0.56 + 0.153 = 0.713 Round off = 0.71

Two decimal place

- 82000 + 5.32 = 82005.32 Round off = 82005

No decimal place

- 10.0 – 9.8742 = 0.12580 Round off = 0.1

One decimal place

- 10 – 9.8742 = 0.12580 Round off = 0

No decimal place

Practice

Calculation	Calculator says	Answer
3.24 m + 7.0 m	10.24 m	10.2 m
100.0 g – 23.73 g	76.27 g	76.3 g
0.02 cm + 2.371 m	2.391 cm	2.39 cm
713.3 L – 3.872 L	709.228 L	709.2 L
1818.2 lb + 3.37 lb	1821.57 lb	1821.6lb.ft
1.030 g × 2.87 mL	2.9561 g/mL	2.96 g/mL

Multiplication and Division

- **Rule – 2 :** In carrying out a multiplication or division, the answer cannot have more significant figures than either of the original numbers.

Calc ≡ 23·760684 ≡ 23·8

Three significant figures

Three significant figures

$$\frac{278\,\text{mi}}{11.70\,\text{gal}} = 23.8\,\text{mi/gal}$$

(3) (4)

Four significant figures

Multiplication and division

- $56.78\ \text{cm} \times 2.45\ \text{cm} = 139.111\ \text{cm}^2$ (Three SF) — Round off = $139\ \text{cm}^2$
- $75.8\ \text{cm} \times 9.6\ \text{cm} = 727.68\ \text{cm}^2$ (Two SF) — Round off = $730\ \text{cm}^2$
- $32.27 \times 1.54 = 49.6958$ (Three SF) — Round off = 49.7
- $3.68 \div 0.07925 = 46.4353312$ — Round off = 46.4
- $1.750 \times 0.0342000 = 0.05985$ (Four SF) — Round off = 0.05985 (Four SF)
- $3.2650 \times 10^6 \times 4.858 = 1.586137 \times 10^7$ — Round off = 1.586×10^7
- $6.022 \times 10^{23} \times 1.661 \times 10^{-24} = 1.000000$ — Round off = 1.000

Practice

Calculation	Calculator says	Answer
$3.24\ m \times 7.0\ m$	$22.68\ m^2$	$23\ m^2$
$100.0\ g \div 23.7\ cm^3$	$4.219409283\ g/cm^3$	$4.22\ g/cm^3$
$0.02\ cm \times 2.371\ cm$	$0.04742\ cm^2$	$0.05\ cm^2$
$710\ m \div 3.0\ s$	$236.6666667\ m/s$	$240\ m/s$
$1818.2\ lb \times 3.23\ ft$	$5872.786\ lb.ft$	$5870\ lb.ft$
$1.030\ g \times 2.87\ mL$	$2.9561\ g/mL$	$2.96\ g/mL$

A ohm's law exp., reading of voltmeter across the resistor is 12.5 V and reading of current I = 0.20 Amp. Estimate the resistance in correct S.F.

$V = 12.5$ → (3)

$i = 0.20$ → (2)

Ans : 62Ω

$V = iR$

$R = \frac{V}{i} = \frac{12.5}{0.20} = 62.5$

Round off

62

(A) ~~62.5 Ω~~

(B) 63 Ω

(C) ~~62 Ω~~

(D) 61 Ω