Operations according to significant figures

(a) Addition / subtraction
First do the addition/subtraction in normal manner.
Then round off all quantities to the decimal place of least accurate quantity

(b) Rules for Multiply / Division
Multiply divide in normal manner.
Round off the answer to the weakest link (number having least S.F.)

Rules of Rounding off

1. If removable digit is less than 5 (50%) ; drop it.
2. If removable digit is greater than 5(50%), increase the last digit by 1.
3. If removable digit is exactly 5 then
    a. Last number is even drop 5
    b. Last number is odd increase last digit by 1.

Least count

Smallest reading from the instrument is defined as least count of that instrument.

PERMISSIBLE ERROR

Error in measurement due to the limitation (least count) of the instrument, is called permissible error.
From mm scale -› we can measure upto 1 mm accuracy (least count = 1mm).

From this we will get measurement like L = 34 mm
Max uncertainty can be 1 mm. Max permissible error (ΔL) = 1 mm.

But if from any other instrument, we get L = 34.5 mm then max permissible error (ΔL) = 0.1 mm
and if from a more accurate instrument,
we get L = 34.527 mm then max permissible error (ΔL) = 0.001 mm = place value of last number

Max permissible error in a measured quantity = least count of the measuring instrument and if nothing is given about least count then Max permissible error = place value of the last number

Errors in averaging:

Suppose to measure some quantity, we take several observations, a1, a2, a3... an.

To find the absolute error in each measurement and percentage error, we have to follow these steps

a. First of all mean of all the observations is calculated:
a(mean)= (a, + a, +a; + ...+ an) / n.
The mean of these values is taken as the best possible value of the quantity under the given conditions of measurements.

b. Absolute Error: The magnitude of the difference between the best possible or mean value of the quantity and the individual measurement value is called the absolute error of the measurement. The absolute error in an individual measured value is:

$|\Delta a_1| = |a_1 - a(\text{mean})|$
$|\Delta a_2| = |a_2 - a(\text{mean})|$
.
.
$|\Delta a_n| = |a_n - a(\text{mean})|$

c. Relative and Percentage Error
Relative error is the ratio of the mean absolute error and arithmetic mean.
Relative error = Δa(mean)/a
When the relative error is expressed in percent, it is called the percentage error. Thus,
Percentage error = Δa(mean)/a x 100%

In some observations, value of 'g' are coming as 9.81, 9.80, 9.82, 9.79, 9.78, 9.84, 9.79, 9.78, 9.79 and 9.80 m/s^2. Calculate absolute errors and percentage error in g.

S.N.	Value of g	Absolute error $\Delta g = \lvert g_i - \bar{g} \rvert$
1	9.81	0.01
2	9.80	0.00
3	9.82	0.02
4	9.79	0.01
5	9.78	0.02
6	9.84	0.04
7	9.79	0.01
8	9.78	0.02
9	9.79	0.01
10	9.80	0.00
	$g_{mean} = 9.80$	$\Delta g_{mean} = \frac{\sum \Delta g}{10} = \frac{0.14}{10} = 0.014$

percentage error = $\frac{\Delta g_{mean}}{g_{mean}} \times 100 = \frac{0.014}{9.80} \times 100\ \% = 0.14\ \%$

so 'g' = (9.80 ± 0.014) m/s^2