## Lab Manual Tables Wilfrid Laurier University

Terry Sturtevant

Wilfrid Laurier University

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## Overview

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## Overview

In this document, you'll learn:

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## Overview

In this document, you'll learn:

• what the different lab manual tables are for

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The tables in the lab manual template sections are mostly the same, because the *kind* of information collected in any experiment is the same.

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Overview	List of quantities
Reference information tables	Calculated quantities
Data tables	Reference information for common instruments
Recap	Experimental uncertainty factors and bounds

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Overview	List of quantities
Reference information tables	Calculated quantities
Data tables	Reference information for common instruments
Recap	Experimental uncertainty factors and bounds

• Every *quantity* in an experiment needs to be identified.

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Overview	List of quantities
Reference information tables	Calculated quantities
Data tables	Reference information for common instruments
Recap	Experimental uncertainty factors and bounds

- Every *quantity* in an experiment needs to be identified.
- Every *instrument* used for measurements needs to be identified.

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Overview	List of quantities
Reference information tables	Calculated quantities
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Recap	Experimental uncertainty factors and bounds

- Every *quantity* in an experiment needs to be identified.
- Every *instrument* used for measurements needs to be identified.
- Every *experimental factor* which potentially introduces uncertainty into the experiment needs to be identified.

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Overview	List of quantities
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- Every *quantity* in an experiment needs to be identified.
- Every *instrument* used for measurements needs to be identified.
- Every *experimental factor* which potentially introduces uncertainty into the experiment needs to be identified.

The lab manual has several tables to include all of this information.

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

## Type of Quantities

Every quantity in an experiment is either:

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

## Type of Quantities

Every quantity in an experiment is either:

• a constant (i.e. given);

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

## Type of Quantities

Every quantity in an experiment is either:

- a constant (i.e. given);
- something which is *measured*;

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

## Type of Quantities

Every *quantity* in an experiment is either:

- a constant (i.e. given);
- something which is *measured*;
- something which is *calculated* from other quantities

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

## Type of Quantities

Every quantity in an experiment is either:

- a constant (i.e. given);
- something which is *measured*;
- something which is calculated from other quantities

There are two tables for this information.

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List of quantities Calculated quantities

Reference information for common instruments Experimental uncertainty factors and bounds

## List of (non-calculated) quantities

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

## List of (non-calculated) quantities

quantity	symbo	ol	single/
		given/	single/ repeated/
		mine	$\operatorname{constant}$
Not in	equations		

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

# List of (non-calculated) quantities

quantity	symbo	ol	single/
		given/	repeated/
		mine	$\operatorname{constant}$
Not in	equations		

In addition to what has already mentioned, this table keeps track of whether the symbol is "mine" (i.e. not from the manual), and whether it is measured once or multiple times.

List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

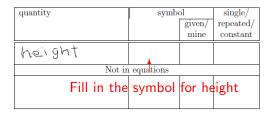
# List of (non-calculated) quantities

quantity	symbo	ol	single/
		given/	repeated/
		mine	constant
height			
Not in	equations		

In addition to what has already mentioned, this table keeps track of whether the symbol is "mine" (i.e. not from the manual), and whether it is measured once or multiple times.

List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

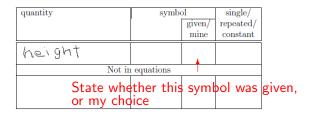
# List of (non-calculated) quantities



In addition to what has already mentioned, this table keeps track of whether the symbol is "mine" (i.e. not from the manual), and whether it is measured once or multiple times.

List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

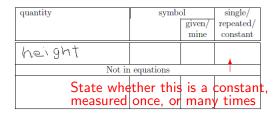
# List of (non-calculated) quantities



In addition to what has already mentioned, this table keeps track of whether the symbol is "mine" (i.e. not from the manual), and whether it is measured once or multiple times.

List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

# List of (non-calculated) quantities



In addition to what has already mentioned, this table keeps track of whether the symbol is "mine" (i.e. not from the manual), and whether it is measured once or multiple times.

Overview	List of quantities
Reference information tables	Calculated quantities
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Overview	List of quantities
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• a symbol which is used for it in the manual or a report;

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Overview	List of quantities
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- a symbol which is used for it in the manual or a report;
- an equation to calculate it from measured quantities;

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Overview	List of quantities
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- a symbol which is used for it in the manual or a report;
- an equation to calculate it from measured quantities;
- an uncertainty equation to calculate its uncertainty given the uncertainties in all of the measured quantities;

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Overview	List of quantities
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- a symbol which is used for it in the manual or a report;
- an equation to calculate it from measured quantities;
- an uncertainty equation to calculate its uncertainty given the uncertainties in all of the measured quantities;
- It makes sense to have a table just for this information.

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

### Calculated quantities

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#### Calculated quantities

quantity	symbol	equation	uncertainty

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

### Calculated quantities

quantity	symbol	equation	uncertainty
acceleration due	.9		
to gravity	0		

First fill in the symbol.

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

### Calculated quantities

quantity	symbol	equation	uncertainty
acceleration due	.9	9=	
to gravity	0		

Put in the equation for the quantity to be calculated.

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

### Calculated quantities

quantity	symbol	equation	uncertainty
acceleration due to gravity	9	J =	△9=

Put in the equation for the *uncertainty* in the quantity.

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Overview	List of quantities
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#### • its *name*;

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Overview	List of quantities
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- its name;
- the units in which it measures;

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Overview	List of quantities
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- its name;
- the *units* in which it measures;
- the precision measure of measurements from it

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Overview	List of quantities
Reference information tables	Calculated quantities
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Every instrument used for measurements needs to include

- its name;
- the *units* in which it measures;
- the precision measure of measurements from it
- (If there is a *zero error* associated with it, that should be recorded as well.)

Overview	List of quantities
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Every instrument used for measurements needs to include

- its name;
- the *units* in which it measures;
- the precision measure of measurements from it
- (If there is a *zero error* associated with it, that should be recorded as well.)

If the same instrument is used for many experiments, it makes sense to have a table just for this information so that it doesn't need to be recreated for every experiment.

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# Reference information for common instruments

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#### Reference information for common instruments

ref. #	measuring instrument	precision measure	range	units
A1				
A2				
A3				
A 4				
A4				
A5				
Að				
A6				
AU				

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

#### Reference information for common instruments

ref. #	measuring instrument	precision measure	range	units
A1	st opwatch			
A2				
A3				
A4				
A5				
A6				

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

#### Reference information for common instruments

ref. #	measuring instrument	precision measure	range	units
A1	st opwatch			
A2		•		
A3	Fill in t	he precision	meas	ure
A4				
A5				
A6				

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#### Reference information for common instruments

ref. #	measuring instrument	precision measure	range	units
A1	st opwatch			
A2				1
A3	Don't f	orget the un	its	
A4				
A5				
A6				

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

#### Reference information for common instruments

ref. #	measuring instrument	precision measure	range	units
A1	st opwatch			
A2			1	
A3				
A4	This is	good for refe essential.	erenc	e,
A5	but not	<del>cosciitiai.</del>		
A6				

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

#### Reference information for common instruments

ref. #	measuring instrument	precision measure	range	units
A1	st opwatch			
A2				
A3				
A4				
A5				
A6				

The *reference* allows a shorthand way of referring to this instrument in other tables without having to write out the whole name each time.

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• the *quantity* it affects;

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Overview	List of quantities
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- the *quantity* it affects;
- its *description*;

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Overview	List of quantities
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- the *quantity* it affects;
- its *description*;
- an estimated *bound* on the uncertainty introduced by it;

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Overview	List of quantities
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- the *quantity* it affects;
- its *description*;
- an estimated *bound* on the uncertainty introduced by it;
- an indication of whether this uncertainty would be random or systematic;

Overview	List of quantities
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- the *quantity* it affects;
- its *description*;
- an estimated *bound* on the uncertainty introduced by it;
- an indication of whether this uncertainty would be random or systematic;
- (since this will indicate how the uncertainty can potentially be reduced.)

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Overview	List of quantities
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Recap	Experimental uncertainty factors and bounds

- the *quantity* it affects;
- its *description*;
- an estimated *bound* on the uncertainty introduced by it;
- an indication of whether this uncertainty would be random or systematic;
- (since this will indicate how the uncertainty can potentially be reduced.)
- It makes sense to have a table just for this information.

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List of quantities Calculated quantities Reference information for common instruments **Experimental uncertainty factors and bounds** 

# Experimental uncertainty factors and bounds

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List of quantities Calculated quantities Reference information for common instruments Experimental uncertainty factors and bounds

#### Experimental uncertainty factors and bounds

symbol	factor	bound	units
	Sources of systematic error	or	
	Sources of random error		

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List of quantities Calculated quantities Reference information for common instruments **Experimental uncertainty factors and bounds** 

# Experimental uncertainty factors and bounds

symbol	factor	bound	units
	Sources of systematic error	or	
h			
	Sources of random error		

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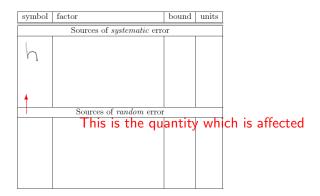
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List of quantities Calculated quantities Reference information for common instruments **Experimental uncertainty factors and bounds** 

# Experimental uncertainty factors and bounds



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List of quantities Calculated quantities Reference information for common instruments **Experimental uncertainty factors and bounds** 

# Experimental uncertainty factors and bounds

symbol	factor	bound	units
	Sources of systematic error	or	
h	bend in tape menure		
	Sources of random error		

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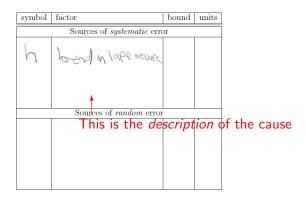
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List of quantities Calculated quantities Reference information for common instruments **Experimental uncertainty factors and bounds** 

## Experimental uncertainty factors and bounds



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List of quantities Calculated quantities Reference information for common instruments **Experimental uncertainty factors and bounds** 

# Experimental uncertainty factors and bounds

symbol	factor	bound	units
	Sources of systematic error	or	
h	bend in tape menure		
	Sources of random error		

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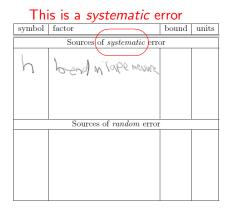
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List of quantities Calculated quantities Reference information for common instruments **Experimental uncertainty factors and bounds** 

# Experimental uncertainty factors and bounds



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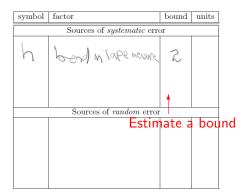
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List of quantities Calculated quantities Reference information for common instruments **Experimental uncertainty factors and bounds** 

# Experimental uncertainty factors and bounds



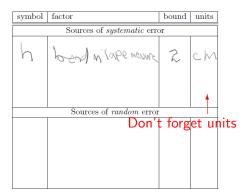
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List of quantities Calculated quantities Reference information for common instruments **Experimental uncertainty factors and bounds** 

#### Experimental uncertainty factors and bounds



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 Overview
 Quantities with a single value, given or measured

 Reference information tables
 Experiment specific tables

 Data tables
 Recap

Each quantity which is given or only measure once can be entered in this table with:

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Overview Reference information tables Data tables Recap	Quantities with a single value, given or measured Experiment specific tables Statistical quantities
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• the symbol which is used for it in the manual or a report;

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Overview Reference information tables Data tables Recap	Quantities with a single value, given or measured Experiment specific tables Statistical quantities
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- the symbol which is used for it in the manual or a report;
- the *value* of the quantity;

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Overview Reference information tables Data tables Recap	Quantities with a single value, given or measured Experiment specific tables Statistical quantities
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- the symbol which is used for it in the manual or a report;
- the *value* of the quantity;
- the units of the quantity;

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Overview Reference information tables Data tables Recap	Quantities with a single value, given or measured Experiment specific tables Statistical quantities
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- the symbol which is used for it in the manual or a report;
- the *value* of the quantity;
- the *units* of the quantity;

In addition, if it's a *measured* quantity, then the table includes:

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Overview Reference information tables Data tables Recap	Quantities with a single value, given or measured Experiment specific tables Statistical quantities
--	---

- the symbol which is used for it in the manual or a report;
- the *value* of the quantity;
- the *units* of the quantity;

In addition, if it's a *measured* quantity, then the table includes:

• the *instrument* used to measure it;

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- the symbol which is used for it in the manual or a report;
- the *value* of the quantity;
- the *units* of the quantity;

In addition, if it's a *measured* quantity, then the table includes:

- the *instrument* used to measure it;
- the *precision measure* of the instrument (for convenience);

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- the symbol which is used for it in the manual or a report;
- the *value* of the quantity;
- the *units* of the quantity;

In addition, if it's a *measured* quantity, then the table includes:

- the *instrument* used to measure it;
- the precision measure of the instrument (for convenience);
- the zero error of the instrument (if applicable);

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- the symbol which is used for it in the manual or a report;
- the *value* of the quantity;
- the *units* of the quantity;

In addition, if it's a *measured* quantity, then the table includes:

- the *instrument* used to measure it;
- the precision measure of the instrument (for convenience);
- the zero error of the instrument (if applicable);
- the *effective uncertainty* if some experimental factor must be considered.

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- the symbol which is used for it in the manual or a report;
- the *value* of the quantity;
- the *units* of the quantity;

In addition, if it's a *measured* quantity, then the table includes:

- the *instrument* used to measure it;
- the precision measure of the instrument (for convenience);
- the zero error of the instrument (if applicable);
- the *effective uncertainty* if some experimental factor must be considered.

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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

# Quantities with a single value, given or measured

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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

## Quantities with a single value, given or measured

[	$\operatorname{symbol}$	value	units	instrument			effective
				reference	precision	zero	uncertainty
				(e.g. A.1)	measure	$\operatorname{error}$	
[							
				Not in equ	ations		

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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

## Quantities with a single value, given or measured

[	$\operatorname{symbol}$	value	units	ins	instrument		
				reference	precision	zero	uncertainty
				(e.g. A.1)	measure	$\operatorname{error}$	
	h						
ĺ				Not in equ	ations		

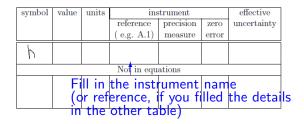
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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

## Quantities with a single value, given or measured



If you use a reference instead of a name, make sure it matches the other table.  $\bigcirc$  Go to table

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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

## Quantities with a single value, given or measured

symbol	value	units	ins	$\operatorname{strument}$		effective
			reference	precision	zero	uncertainty
			(e.g. A.1)	measure	$\operatorname{error}$	
h						
	1		Not in equ	ations		
Fil	l in <sup>.</sup>	the v	alue for	height		

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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

## Quantities with a single value, given or measured

symbol value units			instrument			effective
			reference	precision	zero	uncertainty
			(e.g. A.1)	measure	$\operatorname{error}$	
h						
		1	Not in equ	ations		
	Don	't fo	rget the	units		

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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

## Quantities with a single value, given or measured

symbol	value	units	ins	instrument		
			reference	precision	zero	uncertainty
			(e.g. A.1)	measure	$\operatorname{error}$	
h						
			Not in equ	ations		
	Fill	in th	e precisi	on mea	sure	

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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

## Quantities with a single value, given or measured

[	symbol	value	units	instrument			effective
				reference	precision	zero	uncertainty
				(e.g. A.1)	measure	$\operatorname{error}$	
	h						
ĺ				Not in equ	ations	1	
		Fill	in th	e zero e	rror (if	appl	icable)

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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

## Quantities with a single value, given or measured

symbol	value	units	instrument			effec	tive	
			reference	precision	zero	uncert	tainty	
			(e.g. A.1)	measure	$\operatorname{error}$			
h								
			Not in equ	ations				
	If th	ere's	an effe	ctive ur	icert	ainy	BIG	GER
	thar	ı the	precisio	n meas	ure			

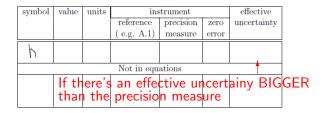
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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

# Quantities with a single value, given or measured



If you fill in a value here, it must be explained in the *"Experimental uncertainty factors and bounds"* table. • Go to table

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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

#### Data for ball drops

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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

#### Data for ball drops

		Instru	ment		
reference					
(or name)					
units					
precision					
measure					
zero					
error					
			Times		
		Ball	one		Ball two
		(	)		()
	A di	ropping	B drop	ping	
i	gofer(B)	dropper(A)	dropper(B)	goter(A)	
1					
2					
3					
3					
4					
4					
5					
average					
g					
σ					
α					
$\Delta(\bar{t})$					

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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

## Data for ball drops

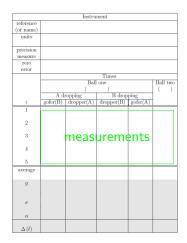
		Instrument									
reference											
(or name)											
units											
		instrument used									
precision											
measure											
zero											
error			Times								
		D-11	one		Ball two						
		( Dall	one		Dall two						
	A di	ropping	) B drop	ning	()						
i	gofer(B)	dropper(A)	dropper(B)	gofer(A)							
1	80101(15)	aropper(ii)	aroppor(b)	Borot (11)							
2											
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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

#### Data for ball drops

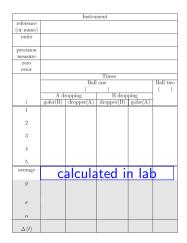


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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

#### Data for ball drops



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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

#### Data for ball drops

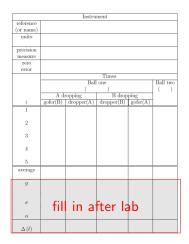


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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

### Data for ball drops



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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

# Statistical quantities

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Quantities with a single value, given or measured Experiment specific tables Statistical quantities

## Statistical quantities

	Instru	iment	
reference			
(or name)			
units			
precision			
measure			
Trial #	time	time-average time	$(t - \bar{t})^2$
		$t-\overline{t}$	
1			
2			
3 M	easuremen	t <mark>s</mark> Calculatio	ns 📋
4			-
5			
	average	$\overline{t}$	
	sum	$\sum (time - average)^2$	
1	lard deviation	$\sigma = \sqrt{\frac{sum}{n-1}}$	
standard d	eviation of the mean	$\alpha = \frac{\sigma}{\sqrt{n}}$	

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# Recap

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## Recap

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# Recap

- For any experiment, many of the same types of things need to be recorded.
- 2 Many things need to be recorded in the lab, while some others can be determined later.

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