Technical reports

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Like other means of communication, a technical report is written for a specific *purpose* and is aimed at a specific *audience*. Technical reports can be divided into four types: Primary research, technical background, feasibility, and proposal reports. **Primary research reports** present original research data obtained from experiments and tests, as well as typically start by describing the background or problem motivating the research, a description of the methods and equipment used, the results obtained, and the conclusions drawn from the results. **Technical background reports** provide only that information on a technical topic that is needed for a particular audience to make a particular decisions. **Feasibility reports** aim to determine whether an idea or technology can provide an adequate solution for a particular problem. **Proposal reports**, as their name implies, identify and compare potential technical solutions to a problem in order to make recommendations to decision-makers.

Technical reports follow a conventional structure specified by the American National Standards Institute (ANSI) for layout and formatting (Figure 1). As shown in the figure, technical reports can include certain front and back matter that would not be necessary in the short lab reports that you will write for this course.

For example, you will most likely not need any pages containing front matter, such as *table of contents* or *list of tables and figures*, nor will you need a page listing *symbols, abbreviations and acronyms*.

In order to help you in organizing your reports, the following pages describe the content and language features characteristic of each of the main "text" sections (shown above in yellow) of the report.

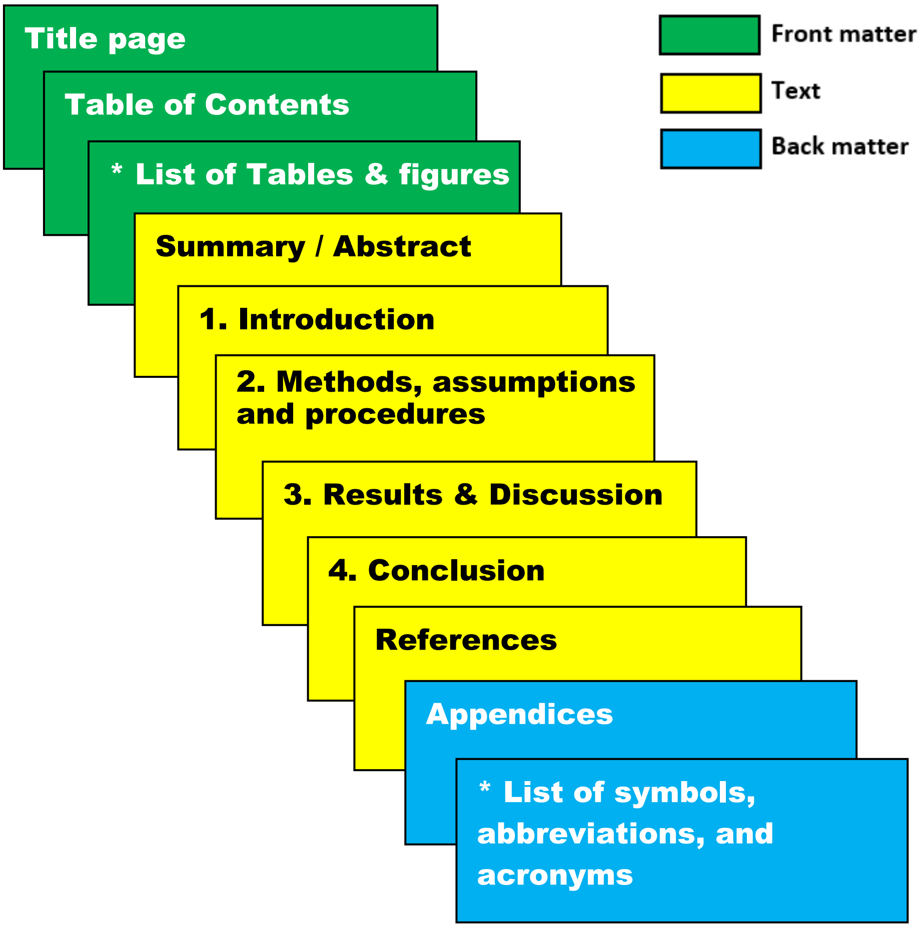


Figure 1. Structure of a technical report as specified by ANSI.

The Abstract / Summary

Menu

The abstract summarizes the contents of the reports. It should include the aim (i.e., *purpose*, *objective*, *goal*, *target*) of the report, details of what you did to obtain your results, how you did it, the main results, the conclusions that were reached and any recommendations that you make.

The abstract must be concise yet informative, as its purpose is to enable a potential reader to decide whether they want to read of your whole report; that is, is your work relevant and of interest to them. For this course, it should not be longer than one paragraph. Wait until after the whole report is written before writing the abstract. One strategy for writing the abstract is to write one summarizing sentence for each section in the report.

Please note that the example report has been numbered using red superscripted numbering to aid only in discussion of the text and is not a normal feature of reports. Do not use superscripted numbering in your own report!

BUCKLING FORCE OF A BEAM STRUCTURE

name

SUMMARY

[1]This report evaluates two different methods for determining the buckling force of a beam structure. [2]The first method is based on a simplified engineering model and hand calculation. [3]The second method uses a non-linear beam theory and a numerical model. [4]The results of both methods are validated against experimental data. [5]Comparison of the results indicate that both approaches predict the buckling force within engineering accuracy.

Which function (***aim***, ***methods***, ***result***, ***conclusion***, *or* ***recommendation***) is communicated in each of the sentences in the summary for our example report?

Function?

Sentence 1 ………………………………..

Sentence 2 ………………………………..

Sentence 3 ………………………………..

Sentence 4 ………………………………..

Sentence 5 ………………………………..

1. The Introduction section

Menu

The introduction section should provide a general background to the subject that includes

1.1 the **relevance** and **importance** of the phenomenon,

1.2 a brief overview of **current solutions** and references to any previous work on the topic,

1.3 a **problem** (weaknesses or drawbacks) in the current solutions that motivates the report,

1.4 the main **aim** and **scope** of the report,

1.5 The **methods** used to achieve the aim

1.6 a brief outline of the **structure** of the report (i.e., the *content* and *purposes* of the remaining sections in the report)

Read the introduction to the example report (Sentences 6-18).
Identify which sentences correspond to each of these six functions in the text?

1.3 Identifying problems

The most common way of showing the motivation for a report is to present a ***negative evaluation*** of some feature in current solutions. This is often signaled by words expressing a ***contrast*** or ***negative evaluation***:

CONTRAST	QUANTITY	VERBS		ADJECTIVES	
However	✗ few	fail	limit	complex	ineffective
Unfortunately	less	ignore	restrict	difficult	inconclusive
Although	✗ little	neglect	hinder	laborious	uncertain
Despite	no	overlook	hamper	restricted	unclear
but	none	impede	deter	inefficient	time-consuming
yet	not	prevent	prevent	unreliable	unsatisfactory

1.4 Stating the aim

The following sentence patterns are typically used to express the purpose of a report.

The	purpose aim goal objective	of **this**	report study work	is **to**	develop determine identify model optimize	[your contribution]	**in order to** …[why?] **for –ing** …[why?] **that /which can**… **by –ing**… [how?] **using**… [how?] **in** … [where?]

Therefore, **In order to…,**	**this**	report study work	develops models	[your contribution]	**for –ing** …[why?] **in** … [where?]
			determines assesses evaluates	the feasibility of… the potential of…	

1.5 Describing the methodology

One effective **"bridge"** for smoothly moving between the purpose and the methods is to use a **purpose clause** (**"*In order to* + verb", "*to* + verb"**, **"*for* + verb*ing*"**, or **"*For this purpose*")**:

In order to **To**	**accomplish** **achieve**	**this**	**aim,** **goal,** **objective,**	<u>**the**</u> **report**	<u>**will**</u> compare *(future tense)* compare<u>**s**</u> *(present tense)*
	develop	**this**	**solution,**	<u>**the**</u> **report**	

For this purpose, <u>**the**</u> **report**	**will** compare *(future tense)* compare<u>**s**</u> *(present tense)*

or

This	**aim** **goal** **objective**	**will** <u>**be**</u> <u>**is**</u>	**accomplish**<u>**ed**</u> **achiev**<u>**ed**</u>	**by** compar**ing** **using**

1.6 Outlining the report structure

First introduce the structure using a **topic sentence**:

The **rest**/ **remainder** of this **report** / **work** <u>is organized</u> as follows.
This **report** <u>is structured</u> as follows.
The **remainder** of this **report** <u>is divided</u> into five sections.

Next, you have three alternative structures that you can use to describe the content and purpose of each **section** in your report (Always start with Section 2!):

Section 3 <u>*describes*</u> the framework used to... **(Section as actor)**
Section 4 <u>*presents*</u> the model used to...

In Section 3, **we** *describe* the framework used to... **(Author as actor)**
In Section 4, **we** *present* the model used to...

In Section 3, **a framework** *is described* that... **(Content as subject)**
In Section 4, **a model** *is presented* for …

A quick-n-dirty analysis revealed the following 21 verbs to be common in engineering for outlining the structure of reports:

analyze	**discuss**	**introduce**	**report**
assess	**evaluate**	**outline**	**review**
define	**examine**	**present**	**summarize**
derive	**explain**	**propose**	**survey**
describe	**explore**	**provide**	**validate**
			verify

After the introduction section, the main body of the report is likely to contain the following sections: **methods**, **results** and **discussion** of the results, and **conclusion**. Each of these sections will be described in terms of their structure and language features in the following pages.

This section explains how you carried out your work. For example, it will describe the research methods (**analysis**) and steps that you took to obtain your results (**procedures**), as well as the equipment used (experimental **set-up**), a description of the object, system or model studied (**scope**) and any theoretical aspects (**theory**) explaining these.

In science and technology, two main language structures, **Result-Means** and **Means-Purpose**, have been shown to comprise 40% of the methods statements in research articles [1].

Means-Purpose

1a. The simulation results	**were** compar**ed** **are** compar**ed**	with field test data	**to** validate **in order to** validate	the model.
2a. FEM simulation	**was** us**ed** **is** us**ed**	**to** verify **in order to** verify **for** verify**ing** **in** verify**ing**	the analytical results.	

Result-Means

1b. The model **was** validat**ed** **by** compar**ing** the simulation results and field test data.

2b. The analytical results **were** verifi**ed** **using** FEM simulation.

Note in the examples above how these two patterns can be used to move the topical focus from the **result** (outcome) to the **purpose** of the methodological step, and vice versa, in order to maintain cohesion between sentences:

2a. FEM simulation **was** us**ed** **to verify** the analytical results. [**Means-Purpose**]

2b. The analytical results **were** verifi**ed** **using** FEM simulation. [**Result-Means**]

A common grammatical mistake made by Finnish writers is to use "**with**" rather than "**by**" when describing the means used to carry out procedures and methods:

1b. The model **was** validat**ed** ~~**with**~~ compar**ison** of the simulation results and field test data.

1b. The model **was** validat**ed** **by** compar**ing** the simulation results and field test data.

[1] Ian Bruce, 2008. "Cognitive genre structures in Methods sections of research articles: A corpus study." **Journal of English for Academic Purposes**, vol. 7, pp. 38-54.

How to express “Means”?

One function that is fundamental to all description of methods is expressing **"how"** the researchers was able to carry out their research in that particular way. This **how**, also known as the **"means"** (Finnish: *keinot*), forms an important element in methodological statements and is used to describe the **procedures**, **tools**, **equipment**, and **materials** used to implement a process. A preliminary analysis of IEEE journals based on the number of “hits” using Google Scholar revealed that the following twelve prepositional structures were used to signal the ***actions*** or ***tools*** used in describing methods (Pennington and McAnsh, 2006). The results are listed in descending order of frequency in Table 1.

Table 1. Relative frequency of twelve strategies for expressing “means” in IEEE research articles

[RESULT(S)]	was / were	obtained	**using** + [TOOL] / [PROCEDURE]	**42%**
	is / are	measured	**by** + [ACTION] / [PROCEDURE]	**34%**
		calculated	**with** + [TOOL]	**13%**
		computed	**by using** + [TOOL]	**3%**
		verified	**through** + [ACTION]	**2%**
			via + [PROCEDURE]	**2%**
			on + [TOOL]	**1.5%**
			by means of + [PROCEDURE]	**1%**
			through the use of + [TOOL]	**> 1%**
			by the use of + [TOOL]	**> 1%**
			with the aid / help of + [TOOL]	**> 1%**
			with the use of + [TOOL]	**> 1%**

USING + [TOOL 90%] / [PROCEDURE 10%]

TOOL:

Tools include *devices, machinery, software* and other *equipment* needed to carry out research.

> The layout **was designed** **using** the **Symbad CAD** **tool**.

BY + [ACTION 81%] / [PROCEDURE 19%]

ACTION:

The **preposition** is the second most common preposition used to introduce the *means*. When used to express actions, **"by"** most often occurs with the gerund (-*ing*) form of a verb.

> High dielectric constant composites **may be obtained** **by** increas**ing** the ceramic content in the polymer matrix.

PROCEDURE:

Both **"using"** and **"by"** can be used to introduce *methods, processes, techniques* and other *procedures*.

> The samples **were measured** **by** the guarded heat flow meter **method**.
>
> Thin-film Ta2N resistors **have been developed and deposited** on polyimide flex **using** a **horizontal batch process** [1].

Let's return to our example report. As stated previously in the introduction (Sentences 14-18), the writer has divided the body of the example report into three sections: Section 2 describes the investigated system. Sections 3 and 4 describe the theory used for analyzing buckling behavior in the simplified and non-linear methods, respectively. Section 5 presents the method used to obtain experimental values for evaluating the simplified and non-linear methods.

Introducing equations

Note that Sections 3 and 4 also introduce and discuss a number of equations. An analysis of IEEE journal articles reveals that the following structures are typically used to introduce equations:

… can be **…is**	**approximated** **calculated** **computed** **deduced** **derived** **determined** **defined** **estimated** **expressed** **formulated** **generated** **given** **modelled** **obtained** **represented** **written**	**as** **as follows:** **from** (x) **as** **from** (x) **as follows:** **by**

Examples:

[29]For the beam structure in Figure 1, the axial force N acting on the beam **can be deduced from** the equilibrium of the moving joint of hinge B **as**

$$N\cos\alpha = F. \qquad (1)$$

[30]The buckling force yielded by the engineering model **is given by**

$$N_{\mathrm{cr}} = \pi^2 \frac{EI}{L^2}. \qquad (2)$$

[35]In variational form, the planar beam problem **can be** stated **as follows** [3]**:** Find the corresponding displacement components $u(x)$ and $v(x)$ in the directions of the X- and Y-axes (Figure 1), such that

$$\delta W = -\int_{x_A}^{x_B} (\delta\varepsilon EA\varepsilon + \delta\kappa EI\kappa)dx - \delta u_B F = 0 \qquad (3)$$

for all δu and δv. [36]With the Lagrange notation for a derivative with respect to the material coordinate x along the axis of the beam, the Green-Lagrange strain ε and curvature κ in the virtual work expression **are defined by**

$$\varepsilon = u' + \frac{1}{2}u'^2 + \frac{1}{2}v'^2 \qquad (4)$$

and

$$\kappa = \frac{v'u'' - (1+u')v''}{[(1+u')^2 + v'^2]^{3/2}}. \qquad (5)$$

Introducing figures and tables

In engineering, the most important means for communicating results are ***figures*** and **tables**. Therefore, it is important that before describing the trends seen in your results that you clearly point your reader to the ***location*** where the data is represented in graphical form.

Many data commentary sections in Results-Discussion sections begin with a sentence containing a **location** element and a brief **summary**, as shown in Table 2. Location elements refer readers to the where they can find information in a ***table*** or other ***figure***.

Table 2. Starting a Data Commentary (Adapted from *Swales and Feak 1994*)

Location (active verbs)	**Summary** (the ***topic*** or ***content***)
a. **Table 5 shows**	the final recognition results for the proposed method.
b. **Table 2 provides**	a comparison between the various algorithms.
c. **Figure 4 gives**	the simulation results for this system.
d. **Figure 2 plots**	the flux and torque linkage trajectory.

Summary (the ***topic*** or ***content***)	**Location** (passive verbs)
a. The final recognition results	**are shown** in **Table 5**.
b. A comparison between the various algorithms	**is provided** in **Table 2**.
c. Simulation results for this system	**are given** in **Figure 4.2**.
d. The flux and torque linkage trajectory	**is plotted** in **Figure 2**.

As shown in Table 2, location elements are characterized by two language features. First, like other types of metalanguage, location elements are always expressed in the ***present tense***. Second, both the **active** and **passive** forms are appropriate in English. However, a number of languages, including Finnish, Estonian and Korean, find it unnatural to state that an **inanimate agent** (e.g., a *table or figure*) could *reveal*, *present* or *suggest* something:

Taulukossa 2 kuvataan *uusiutuvan energian käytön kehittyminen sähköntuotannossa Suomessa viime vuosina.*

~~In **Table 2** is described the recent development of renewable energy use in the electricity production of Finland.~~

Table 2 **describes** the recent development of renewable energy use in the electricity production of Finland.

Verbs introducing figures and tables

Ken Hyland (2000) used a corpus of 80,000 words comprising 80 research articles from biology, physics, electrical engineering, mechanical engineering, marketing, applied linguistics, sociology, and philosophy to determine which verbs are most frequently used in full sentences to refer to *figures* and *tables*. Figure 1 presents the results for verbs commonly expressed in the ***active voice*** and ***present tense***.

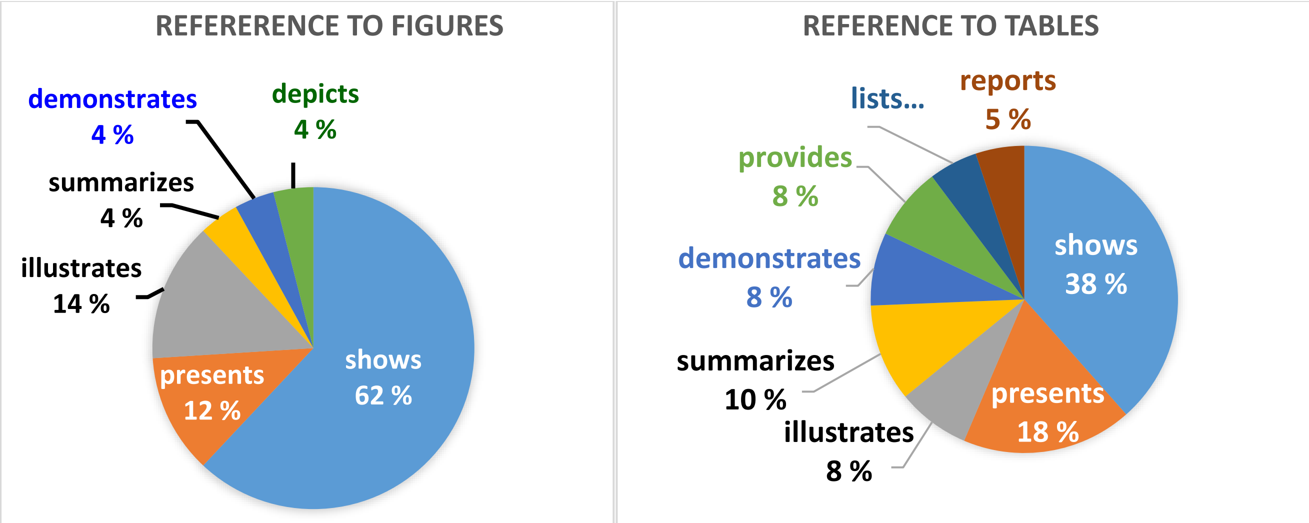


Figure 1. Verbs used in the ***active voice*** for referring to figures and tables (*Swales & Feak 1994*)

From our example text, the ***active voice*** was used in two sentences:

> [41]**Figure 2** **shows** the force F acting on node B as a function of the displacement…
> [52]**Table 2** **shows** the critical force values given by the simplified engineering model…

The verbs commonly used in the **passive voice** to refer to figures and tables are given in Fig. 2. Only one sentence used the passive voice in our example text:

> [45]The set-up of the buckling experiment **is shown** schematically **in Figure 3**.

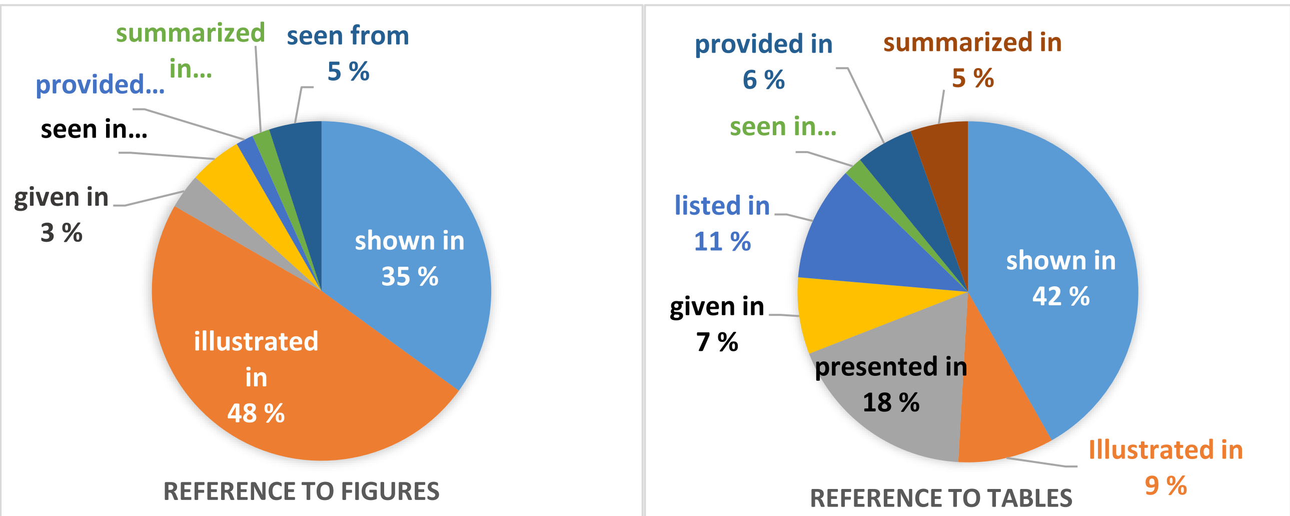


Figure 2. Verbs used in the ***passive voice*** for referring to figures and tables (Swales & Feak 1994)

Stating Results

A common strategy used in engineering for is to use the **dummy "it"** subject together with the passive form of verbs having the meaning of **"find"** or **"see"**.

DUMMY "it" (Past tense)

It was	**found** (74%) **observed** (16%)	**that**…

DUMMY "it" (can be)

It can be	**seen** (74%) **observed** (16%) **noted** (5%) **concluded** (2%) **inferred** (2%) **discerned** (1%)	**from**	Figure 1 Table 1	**that**…

From Figure 1**, it can be seen that**…

[43]**From the figure, it can be observed that** buckling occurs with a small displacement at $dF / du_F = 0$.

Linking *AS*-clauses

In addition to *Dummy "it"*, one of the most common methods is to use linking ***as*-clauses**. Note how the same examples in Table 6 can easily be changed into linking *as*-clauses:

> ***As shown in Table 5,*** the recognition rate increased with an increase in window size.
>
> The amount of polystyrene formed was strongly dependent on the amount of adsorbed surfactant***, as clearly illustrated in Fig. 4.***

These linking clauses (where ***as*** ≠ *since* or *because)* are exceptional in English grammar because they have **no subject**. A common mistake is to use an *active* rather than the correct *passive* form without a subject.

> **As ~~Figure 4 shows~~,** simulation results agree well with theoretical calculations.
>
> **As ~~it is~~ shown in Figure 4,** simulation results agree well with theoretical calculations.
>
> **As Ø shown in Figure 4,** simulation results agree well with theoretical calculations.

Seven **verbs** are most commonly associated with **linking *as*-clauses**:

As	**shown** (91%) **seen** (8%)	**in**	Figure 1, … Table 1, …
As can be	**seen** (95%) **observed** (4%) **noted** (1%)	**in**	Figure 1, … Table 1, …
As can be	**seen** (91%) **observed** (6%) **inferred** (1%) **noted** (1%) **concluded** **discerned**	**from**	Figure 1, … Table 1, …

[53]**As can be seen from the table,** the predictions by the two models yielded results that are in fair agreement and well within the precision needed for design.

The partitive "of"

When reporting numerical results, novice writers often simply **"label"** the results using the verb ***"to be"*** similar to an **equal sign (=)**. Unfortunately, this moves the focus of the sentence away from the real topic by putting **new information** into subject position: the variable that was measured (e.g., *thickness*). To avoid this overuse of the verb ***"to be"***, use the **partitive "of"** to report **numerical results**.

The **thickness** of the **copper cladding** on both sides of the dielectric **was** **35 mm**. (The text is not about "thickness"!)

The **copper cladding** on both sides of the dielectric **had a thickness of** **35 mm**. (The text is about "copper cladding" or "the dielectric"!)

[25]The beam is composed of high strength steel and **has a Young's modulus of** E = **210GPa** and a Poisson's ratio of v = **0.3**.

Expected results

Similar results can help support or corroborate the writer's claims, whereas **different** (unexpected) findings require **explanation**.

Pattern 1 (Agree)

Comparison with other methods:

The experimental results	agree	well closely relatively well reasonably well favorably poorly	with	the simulation results the numerical results

Pattern 2 (Agreement)

Comparison with other methods:

The experimental results	are in	perfect excellent complete good close reasonable poor	agreement with	the simulation results the numerical results

Pattern 3 (Show)

The experimental results	show	excellent complete good close reasonable	agreement with	the simulation results

Unexpected results

Pattern 4 (Differ)

Comparison between two data sets:

The calculated results	differ	↓ slightly	from	the	simulation	results
These results	deviate	somewhat			measurement	
		marginally			analytical	
		considerably			experimental	
		significantly			theoretical	
		substantially			numerical	
		greatly				
		markedly				

Explaining unexpected results

Unexpected results always require an explanation of the possible reasons for why they may have happened. For this purpose, science has developed specific language:

Pattern 5

This	result	↓ can	be **explained** by	[reason]
	observation	could	be **attributed** to	
	finding	may	be **due** to	
	error	might	be **caused** by	
	discrepancy	↓ most likely	**resulted** from	
	difference	could have	been **caused** by	
		may have	been **due to**	
		might have		

Pattern 6

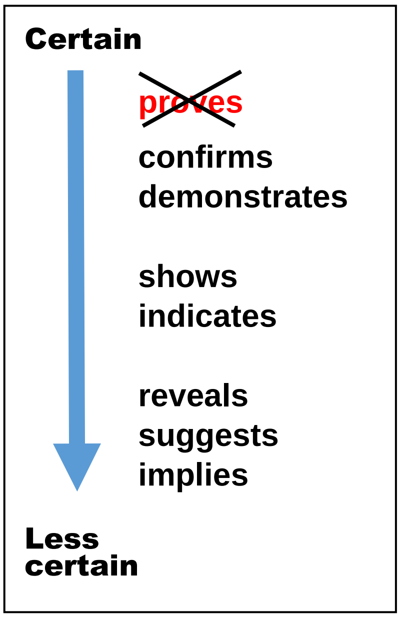
One explanation for	this	**result**	↓ can	be …	[reason]
		error	could	be that …	
		discrepancy	might		
		difference			

Note that the examples of **location elements** presented earlier in Table 2 only provided **general summaries** of a table/figure, since they only summarize either the ***content*** or the ***topic*** area. We have been told nothing yet about *what* the *results* might be, *what* differences were found between the algorithms, *what* trends were evident from the *trajectory,* or *what* the results of the simulation were. In order to focus on **individual results** or to **interpret** what the results mean (i.e., make a ***"claim"***), the writer would need to follow the verb with the conjunction **that**, as in the following.

Table 3. Using *that*-clauses to introduce claims and interpretations drawn from data presented in figures and tables. (Swales & Feak 1994)

Location (active verbs)		**Interpretation / Claims**
a. **Table 5 shows**	**that**	the recognition rate increases with an increase in window size.
b. **Table 2 illustrates**	**that**	the honeybee algorithm can perform consistently better than the other algorithms as system diversity increases.
c. **Figure 4 suggests**	**that**	the simulation accuracy could be still improved.
d. **Figure 2 confirms**	**that**	the low bandwidth modulation schemes do not suffer from additional outage degradation due to second-order PMD.

Note that the above sentences using *that*-clauses (Table 3) differ from those introduced earlier (Table 2) in that these *that*-clauses cannot easily be changed into the passive voice. The choice of verb used is also important in order to show the strength of your claim. For this purpose, science uses **epistemic verbs** to indicate the degree of *certainty*, or *strength*, of your claim:



A. EPISTEMIC VERBS

Figure 1 **This result**	**confirms** **demonstrates** **shows** **indicates** **reveals** **suggests**	**that**...

B. EPISTEMIC ADJECTIVES

It is	**clear** **evident** **interesting** to note **important** to note especially **notable**	**from**	Figure 1	**that**...

From Figure 1,	**It is**	**clear** **evident**	**that**...

C. INCLUSIVE "we"

We (can) **see from Figure 1 that**...

Figure 3. Common structures used together with *that*-clauses to introduce claims and interpretations drawn from results presented in figures and tables.

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