Documenting an experiment: IMRD

1.0 Introduction

2.0 Methods

3.0 Results

4.0 Discussion

Documents have these four sections. The Introduction describes the problem to be solved and the objective of the experiment. The Methods describes how the experiment was conducted, down to the last detail. A good methods section has enough information that someone could replicate the experiment. The Results shows the data and the analyzed data and typically includes plots and tables. Results are objective. The Discussion has your subjective interpretation of the results. A good example for determining what is a result and what is a discussion is this. “The temperature was 85 degrees F” is a result while, “It was hot” belongs in the discussion because hot is your interpretation of the data.

Writing hints: Write in 1st person active or 3rd person passive. Results written in past tense.

A good document has...

- **Title**
  - **Meaningful and descriptive**
- **Authors, affiliation, date**
- **Citations**

A non-descriptive title is “The beam experiment.” A descriptive title is “Experimentally Determined Elastic Modulus of a Yardstick.”

Citations are very important. If you use an equation or include a figure, cite the source of the equation or figure. The rule is that without a cite, you drew the figure or took the photograph or you derived the equation.

A good document has….

- Clear, simple writing
- No jargon
- Just the right amount of information
- Meaning to the reader
- Pictures and graphics where appropriate
- Meaningful data plots
- No spelling, grammatical errors, typos

I wrapped the tape around the four legs of my dining room table. I counted 133 wraps plus some left over so that meant the tape was 812 ft. long.

Example of a poor methods section for an experiment whose objective was to find the length of a video tape. The description does not have sufficient details to replicate the methods.

I measured the distance around the four legs of my dining room table. To measure the distance, I wrapped a string around the legs, then laid the string tight on a 25 ft. carpenters tape. The distance was 6 ft. 1 in. (to the nearest inch) I then wrapped the video tape around the legs and counted 133 complete wraps plus three feet of tape left over. The total tape length was therefore (133 x 6.083) + 3 = 812 ft. I believe this number is accurate to +- 1.0 ft.

Example of a good methods section. Lots of details and includes estimates of accuracy.

How To Cite

- For credibility, must cite sources
- Common knowledge need not be cited
  - “Water is wet”
  - $F = ma$
- Special knowledge must be cited
  - “There are 780,000 new cases of stroke each year in the U.S.
  - $y = \frac{PL^3}{48EI}$

Academic Paper Example

Design and Simulation of a Pneumatic, Stored-energy, Hybrid Orthosis for Gait Restoration

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Loss of mobility due to lower limb paralysis is a common result of thoracic level spinal cord injury. Functional electrical stimulation (FES) can restore primitive gait in the vicinity of a wheelchair by using electrical stimulation to generate muscle contractions. A new concept for FES-assisted gait is presented that combines

The reciprocating gait orthosis (RGO) links opposite joints so that extension of the hip on one side leads to flexion on the contralateral side [30]. Gharooni et al. proposed that stored spring energy and limb-segment potential energy could be used to replace stimulation of the hip flexors or withdrawal reflex [31]. In their spring brake orthosis (SBO), excess quadriceps energy is stored in a mechanical spring that resists knee extension. Spring release causes knee flexion, which due to inertial properties of the leg forces the hip to flex. Our system goes further to provide decoupled hip extension and flexion that increases gait-assist performance.

Energy Storing Orthosis

The energy storing orthosis (ESO) hybrid FES gait system uses stimulated muscle power to not only move the limb but also to push on the orthosis, storing energy in the process. The stored energy is piped to another joint and released to drive joint motion without having to stimulate additional muscles. The following sections of the paper describe the engineering design for an ESO

Efficiency. Stimulated muscles behave as nonlinear, time-varying actuators with significant power and energy limitations [27,32]. Thus, the mechanical system must minimize energy loss during operation. Of primary concern is the process of storing, channeling, and discharging the energy from the quadriceps. Any

Introduction

The inability to walk because of lower limb paralysis is a common result of a thoracic-level spinal cord injury (SCI). Functional electrical stimulation (FES), which uses electrical stimulation of motor nerves to trigger muscle contractions, is one means of restoring rudimentary standing and gait for limited mobility in the vicinity of a wheelchair to some individuals with SCI [1–7]. The user must have good trunk control and a strong upper body because considerable effort is required from the arms engaging parallel bars, a walker, or crutches for support. Despite these restrictions, successful FES users are able to ambulate for hundreds of meters with many years of use from their system [8,9].

Two limitations of FES-aided gait systems are rapid muscle fatigue and the inability to precisely control joint torques, which leads to erratic stepping trajectories [10]. Hybrid systems that combine electrical stimulation with a lower limb orthotic brace have been developed to address these problems [11–26]. Our lab developed the controlled brake orthosis (CBO), a hybrid FES-aided standing and gait system that contains computer-regulated friction brakes at the knee and hip to lock the joints during stance phase and control motion during swing phase [27,28]. The goal of our present research is to develop an FES-aided gait system that requires only one channel of surface muscle stimulation. This can be achieved by combining FES, a mechanical orthosis, and energy storage. Excess energy generated by electrical stimulation of one muscle is harvested, stored, and transferred to other joints that cannot be conveniently driven by direct muscle stimulation.

The concept of using orthotics to store energy is not new. For example, Van den Bogert used elastic exotendons for gait assist [29]. Greene and Granat utilized a cam-slider mechanism to transfer energy from the knee to the ankle to assist dorsiflexion [24].

Contributed by the Bioengineering Division for publication in the JOURNAL OF BIOMECHANICAL ENGINEERING. Manuscript received by the Bioengineering Division April 7, 2005; revision received July 14, 2005. Associate Editor: Mary Frecker.

orthosis must accommodate −10–25 deg of hip flexion and 0–60 deg of knee flexion.

Muscle Stimulation. The system must stimulate only the quadriceps muscle. Quadriceps stimulation is attractive for several reasons. First, the quadriceps (technically four muscles) are large and relatively large amounts of power can be generated through stimulation. Second, the quadriceps drive knee extension, which undergoes a large excursion during normal gait, simplifying the task of designing an energy capture system. Third, the quadriceps are simple to activate with surface electrodes; users can apply and remove quadriceps electrodes relatively easily. Although completely implanted stimulation systems are the ultimate goal, easy-to-use surface systems have a role as a bridge to implanted systems and for those users who do not want surgery.

Available Energy. All energy to drive the leg comes from the stimulated quadriceps. Additional energy for forward progression can come from the upper body because the system will be used with a walker. The available energy from the quadriceps for one extension cycle moving was estimated from previous work by calculating the area under a typical torque-angle curve from 60 deg of flexion to full extension, resulting in 31.4 J [10]. To be conservative and to maximize the total number of steps before fatigue, the system was designed to extract 14 J from the quadriceps per step cycle.

Efficiency. Stimulated muscles behave as nonlinear, time-varying actuators with significant power and energy limitations [27,32]. Thus, the mechanical system must minimize energy loss during operation. Of primary concern is the process of storing, channeling, and discharging the energy from the quadriceps. Any energy dissipation during this process will increase the amount of energy required from the quadriceps, therefore, increasing their rate of fatigue and limiting the total number of steps that can be taken.

as well as body attachment points for the orthosis. Once these challenges are met, a study can be conducted to evaluate the efficacy of the ESO concept using human subjects.

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Information Sources to Cite

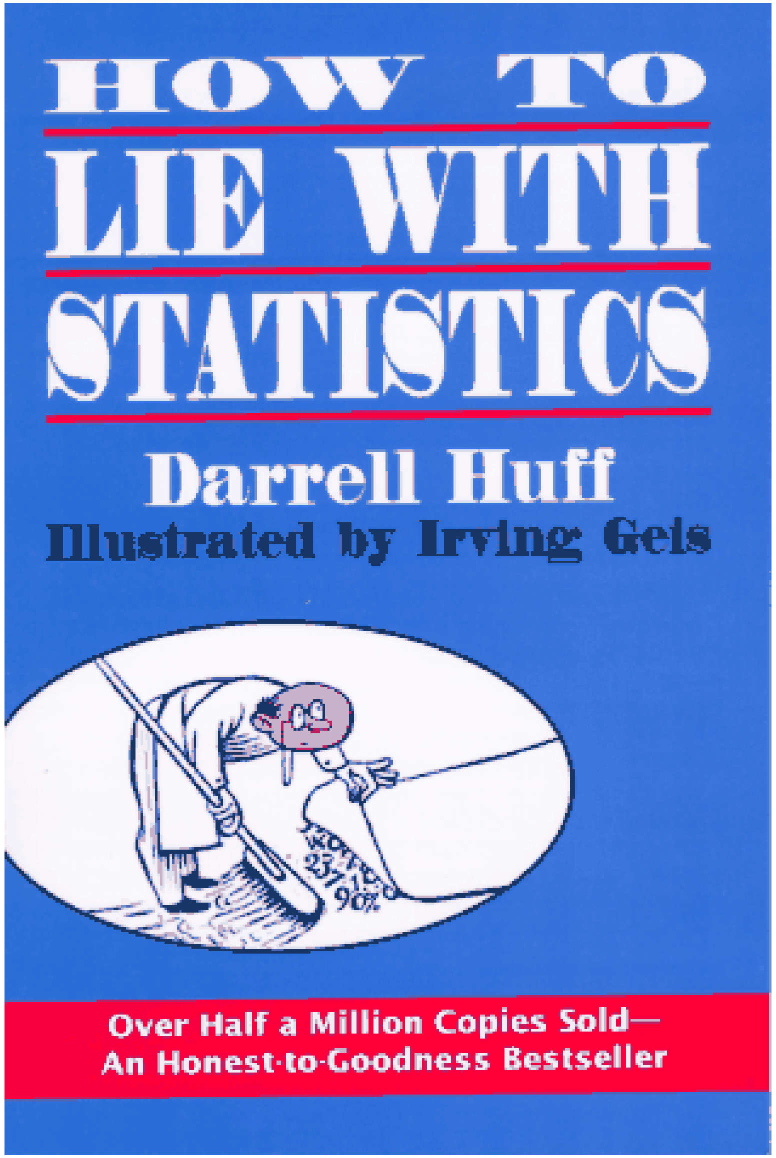
- Academic journal and conference papers
- Text books
- Trade magazine articles
- Catalogs and data sheets
- Manufacturer web sites
- Government web sites

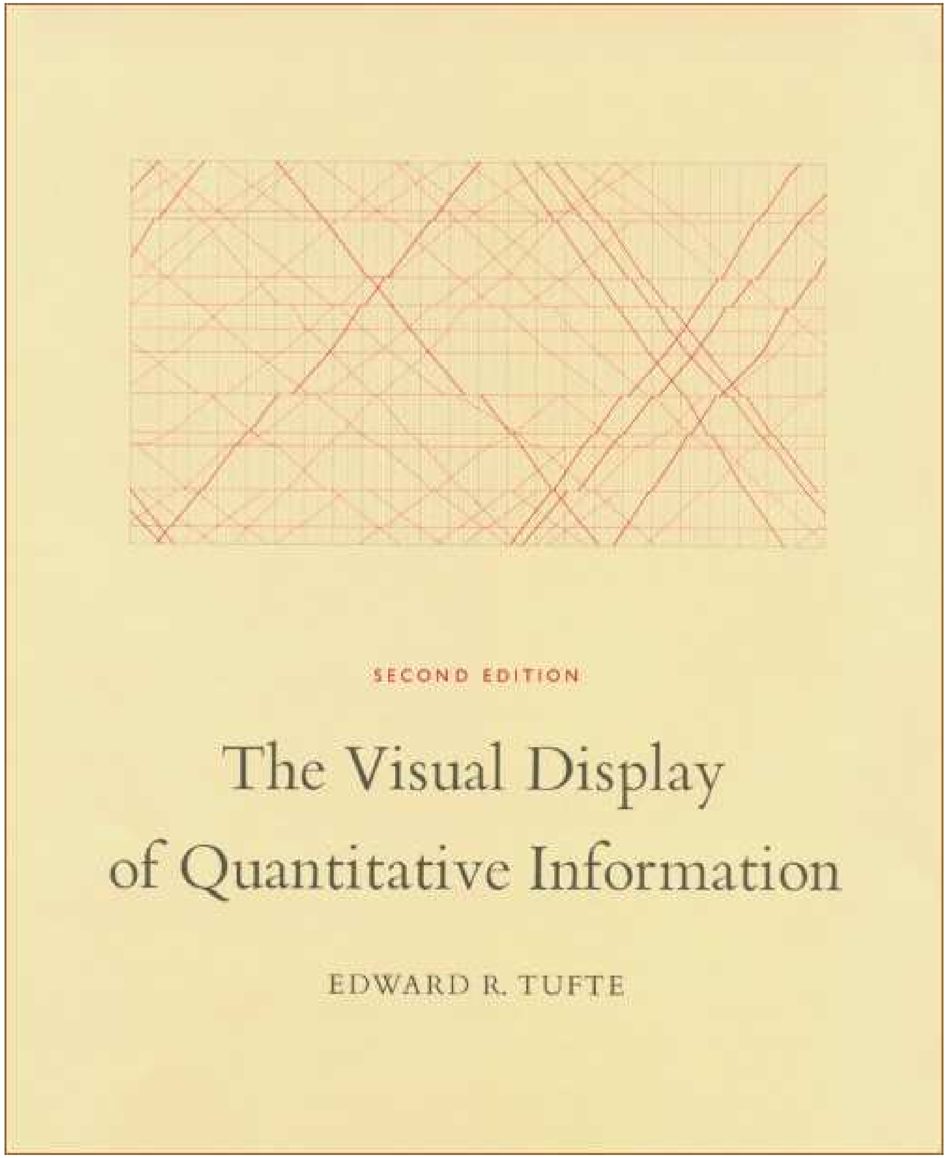
Suggestions

- Use accepted style (ASME, APA, Harvard,…)
- Use RefWorks or EndNote or Zotero to manage citations
- Resources at UMN library and elsewhere
  - RefWorks
    www.lib.umn.edu/site/refworks.phtml
  - Tutorial by UMN library
    http://tutorial.lib.umn.edu/infomachineb5bb.html?moduleID=10
  - Durfee lab engineering writing page
    http://www.me.umn.edu/labs/hmd/lab/writing.html

Data plots

- Understand objectives
- Pick the right data set
- Pick the best plot format
- Format and style
  - Data dominates
  - Label axes, quantity (units)
  - Descriptive title

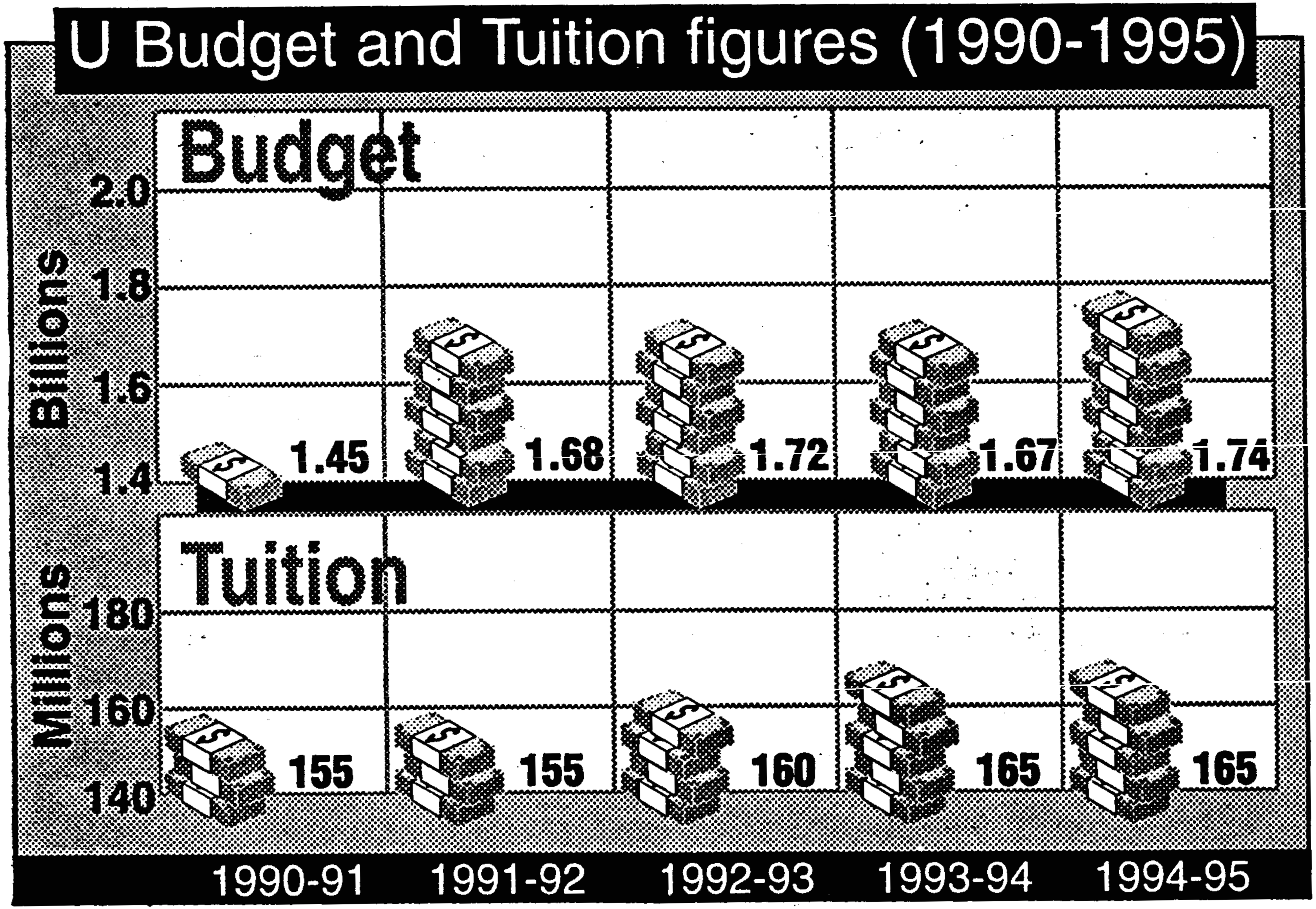




Read these classic books for another take on presenting data.

Be Honest and Keep It Simple

- **Chart must reflect data accurately**
- **Watch out for “Lie Factor”**
  - **(size of graphic effect)/(size of data effect)**
- **Focus on data**
- **Avoid “chartjunk” (Tufte)**



A confusing figure because the dollars come in chunks but the scale is uniform. Plus y-axis anchor is not zero.

Research Note

U.S. Department of Transportation

National Highway Traffic Safety Administration

January 1998

Crash Data and Rates for Age-Sex Groups of Drivers, 1996

Ezio C. Cerrelli

1996 DRIVER CRASH AND FATALITY DATA - ALL DRIVERS

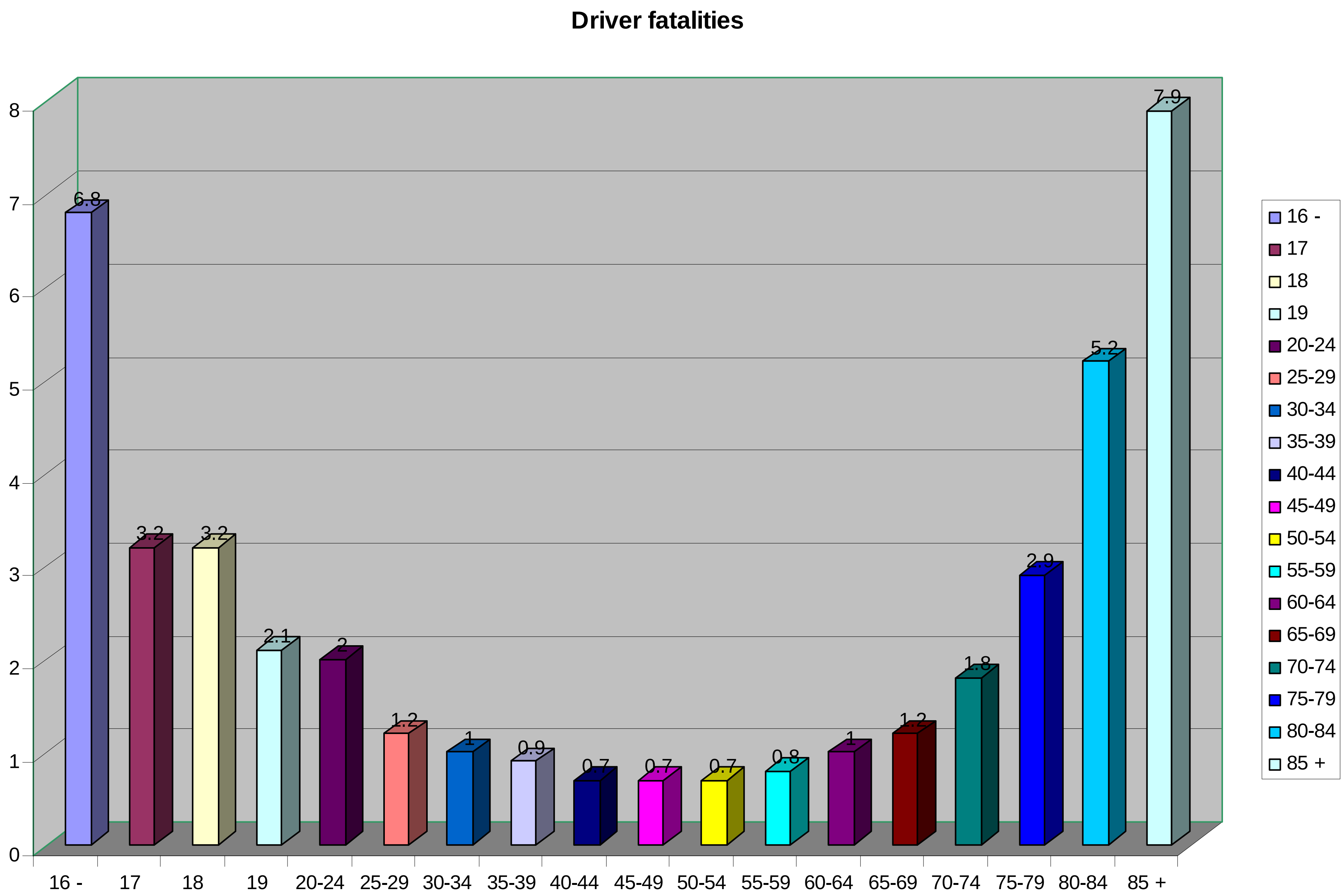
DRIVER AGE GROUP	LICENSED DRIVERS (thousands)	AVERAGE ANNUAL TRAVEL	TOTAL MILES OF TRAVEL (millions)	DRIVERS IN ALL CRASHES (thousands)	DRIVERS IN FATAL CRASHES	DRIVER FATALITIES	CRASH INV. RATE (*) (per VMT)	FAT.INV. RATE (*) (per VMT)	FATALITY RATE (*) (per VMT)	CRASH INV. RATE (*) (per LIC.)	FAT.INV. RATE (per LIC.)	FATALITY RATE (*) (per LIC.)
16 -	1,579	6,445	10,180	422	1,663	696	4,146	16.34	6.8	267	1.05	0.44
17	2,313	7,366	17,037	408	1,427	541	2,396	8.38	3.2	177	0.62	0.23
18	2,554	9,097	23,235	407	1,740	749	1,752	7.49	3.2	159	0.68	0.29
19	2,787	11,737	32,717	375	1,626	698	1,145	4.97	2.1	134	0.58	0.25
20-24	15,259	11,611	177,172	1,569	7,895	3,513	886	4.46	2	103	0.52	0.23
25-29	18,302	12,846	235,110	1,494	6,631	2,743	635	2.82	1.2	82	0.36	0.15
30-34	19,992	13,397	267,822	1,446	6,395	2,613	540	2.39	1	72	0.32	0.13
35-39	20,960	12,939	271,192	1,467	5,917	2,347	541	2.18	0.9	70	0.28	0.11
40-44	19,528	13,771	268,912	1,147	4,743	1,922	427	1.76	0.7	59	0.24	0.1
45-49	17,464	13,424	234,442	1,057	3,892	1,560	451	1.66	0.7	61	0.22	0.09
50-54	13,603	12,214	166,150	637	2,916	1,206	383	1.76	0.7	47	0.21	0.09
55-59	10,599	11,582	122,765	456	2,177	944	371	1.77	0.8	43	0.21	0.09
60-64	9,051	10,422	94,325	351	1,896	907	372	2.01	1	39	0.21	0.1
65-69	8,465	8,997	76,163	312	1,645	882	410	2.16	1.2	37	0.19	0.1
70-74	7,354	7,072	52,005	271	1,605	956	521	3.09	1.8	37	0.22	0.13
75-79	5,279	5,647	29,815	195	1,379	877	654	4.63	2.9	37	0.26	0.17
80-84	2,916	4,655	13,575	106	998	704	782	7.35	5.2	36	0.34	0.24
85 +	1,533	3,907	5,992	55	611	475	912	10.2	7.9	36	0.4	0.31
TOTAL	179,539	11,689	2,098,607	12,173	55,156	24,333	580	2.63	1.2	68	0.31	0.14

(*) **Rates** are per 100,000,000 Vehicle Miles of Travel and per 1,000 Licensed Drivers

Tables make it hard to find the data. Good for appendices but not for the main body or for presentations.

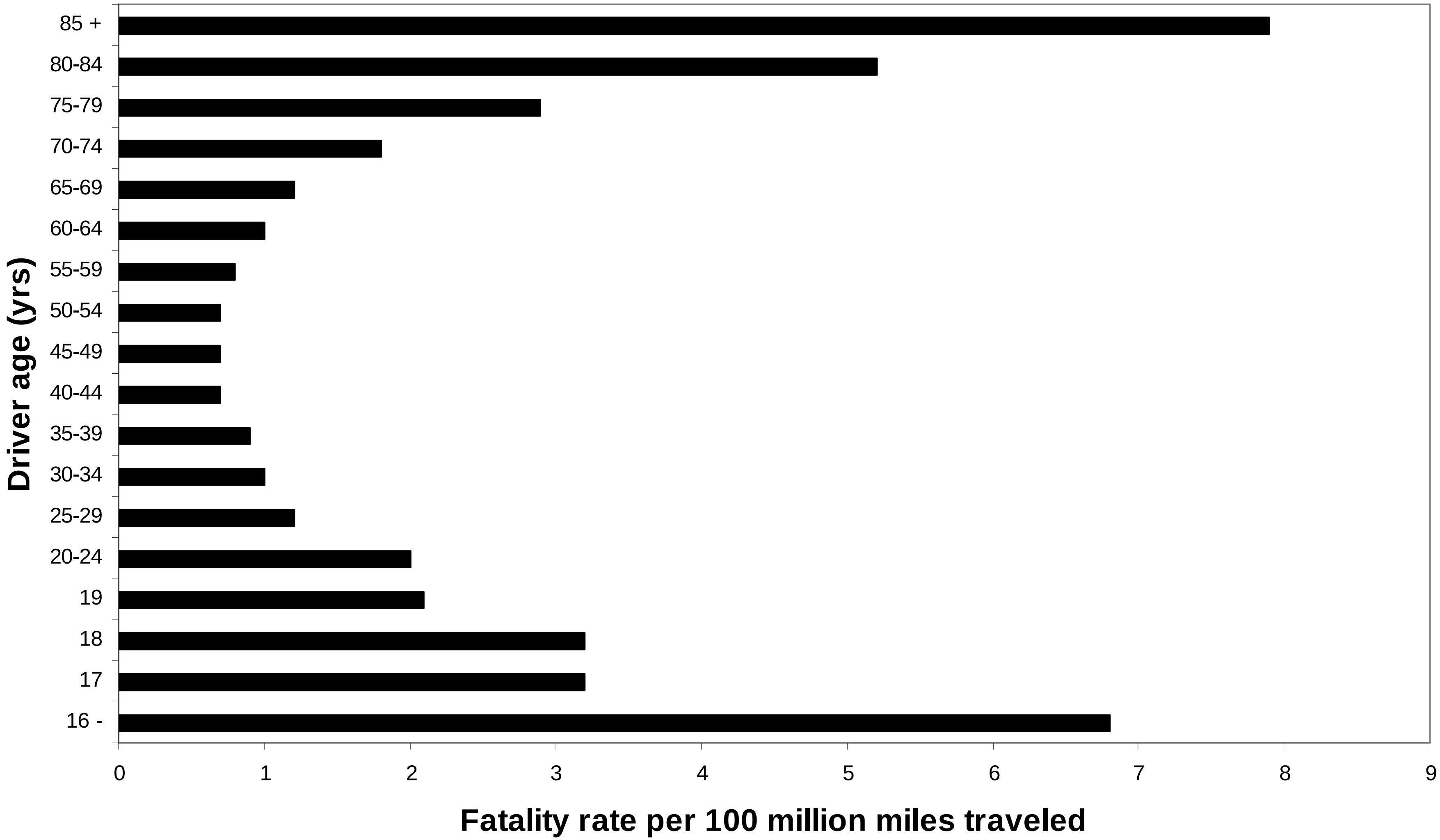
DRIVER AGE GROUP	**FATALITY RATE** (*) (per VMT)
16 -	6.8
17	3.2
18	3.2
19	2.1
20-24	2
25-29	1.2
30-34	1
35-39	0.9
40-44	0.7
45-49	0.7
50-54	0.7
55-59	0.8
60-64	1
65-69	1.2
70-74	1.8
75-79	2.9
80-84	5.2
85 +	7.9

Isolating the data you want helps.

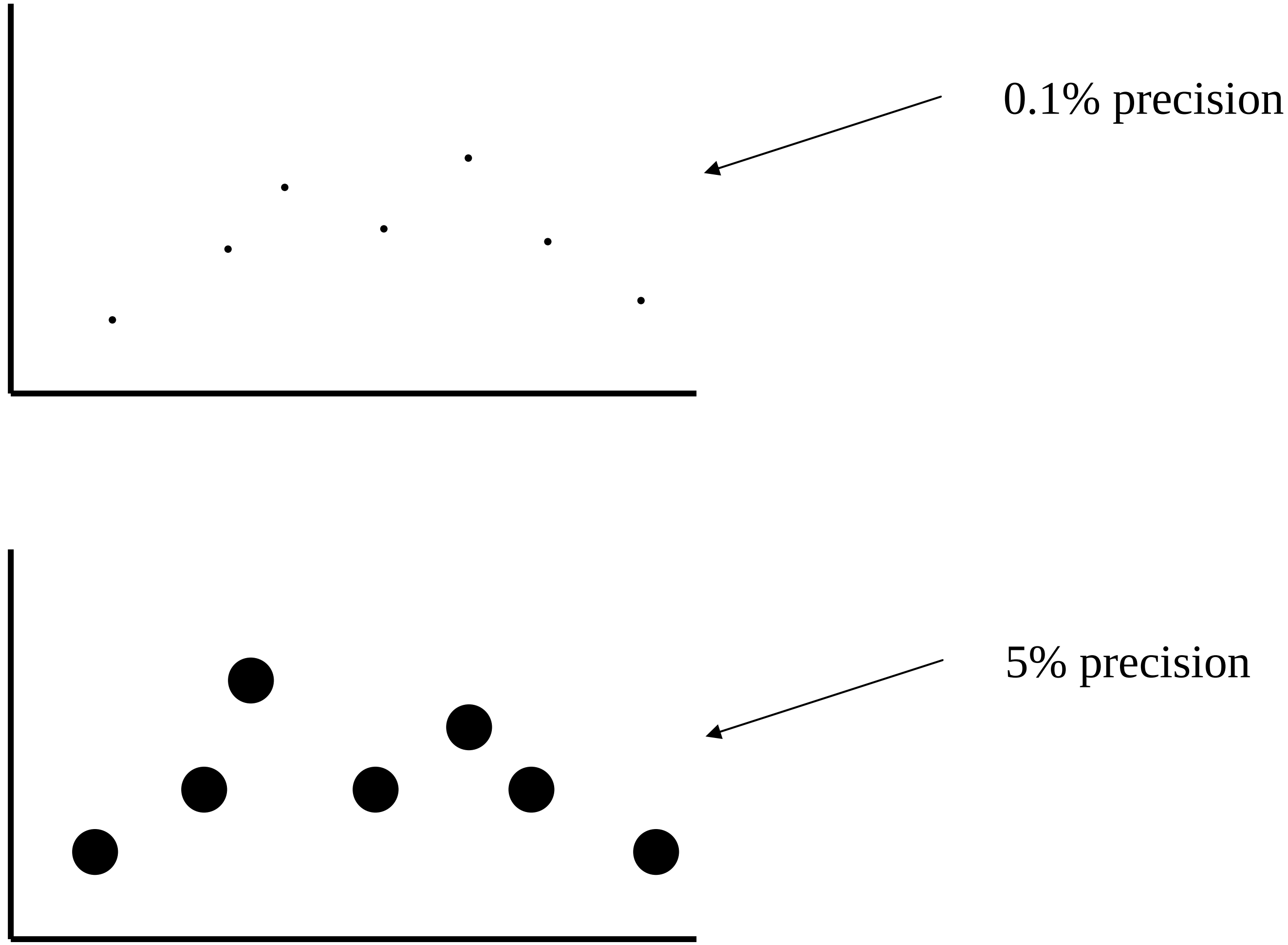


A chart is better. This chart has unnecessary color and 3-D. All you see is the color, not the data.

Driver safety varies with age

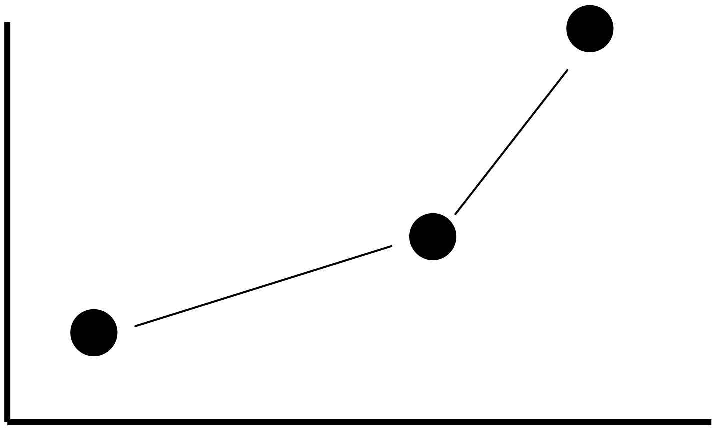


This is a good chart. The title tells the story and the data is clear of “chartjunk”

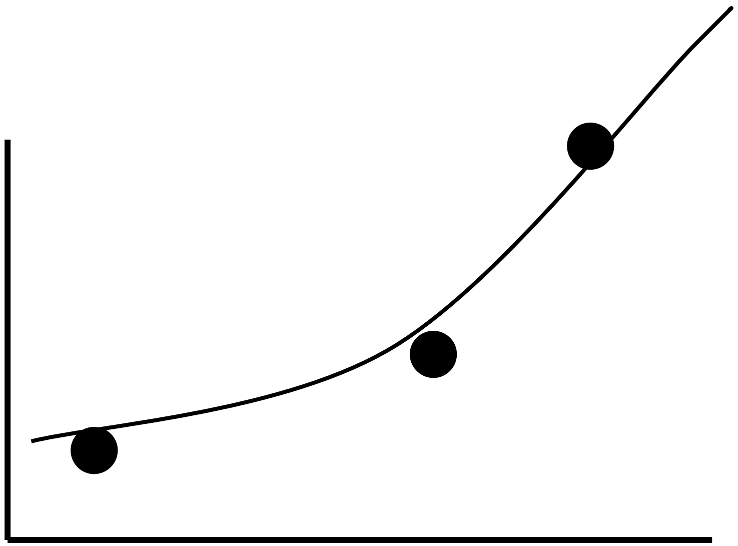


FAT DOTS !

Make sure the reader can see the data.



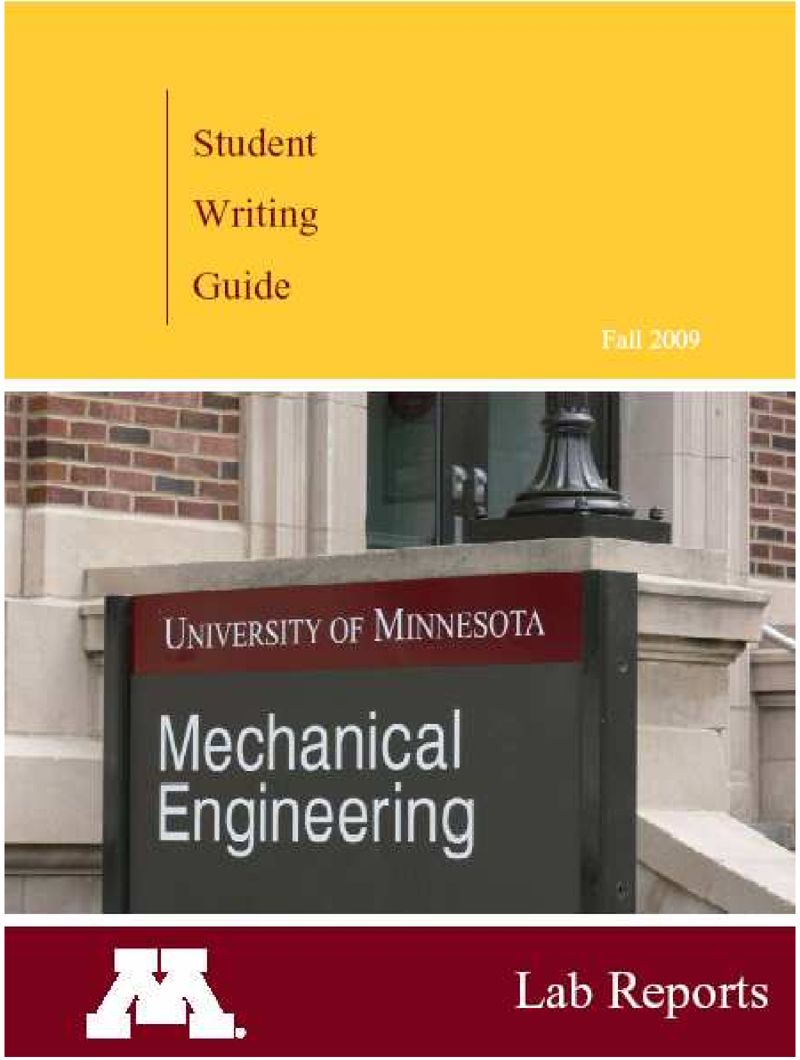
tie points



fit model

Curved lines are fine if you are fitting the data to a model. If the purpose is simply to tie points together, use straight lines.

Lab Report Style Guide



http://me.umn.edu/education/undergraduate/writing.shtml