LAB 1: Mechanical Practices in Experimental Science

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Purpose

Introduce the student to mechanical practices used in the design and construction of scientific apparatus through exposure to mechanical drafting and the fundamental operations performed in a machine shop

Reading Assignment

Chapter 1: *Building Scientific Apparatus*, 3rd edition, by John Moore, Christopher Davis and Michael Coplan (Perseus Books, Cambridge MA, 2003) on reserve in the Centennial Livrary. Familiarity with the material in Chapter 2 is useful for future reference.

Background

The experimental scientist must routinely design and construct scientific apparatus in order to conduct research. Advanced undergraduate and graduate students in the sciences typically have an introductory electronics class/lab. Often, however, students are not introduced to the mechanical aspects of designing and constructing scientific apparatus until after they begin their graduate research. The student's research career is greatly facilitated if they acquire the proper foundations in these mechanical practices as an undergraduate.

The mechanical aspects of building scientific apparatus involve conceptualizing the requirement, producing a mechanical drawing that defines the apparatus to fulfill that requirement, and fabricating the apparatus to the necessary specifications. As an advanced undergraduate or graduate student you will often be required to accomplish all of these tasks. As a practicing scientist, most often you will perform tasks one and two and submit task three to a professional machine shop. In either case, understanding the basic principles of metal working, glass blowing, and materials joining will aid you in making mechanical drawings to communicate your needs and designing apparatus to fulfill these needs.

Mechanical Drawing

The book, *Building Scientific Apparatus*, describes the basics of mechanical drawing. More complete treatments[1] can be consulted as your skill levels and needs grow. Modern mechanical drawing is done with the aid of computer programs, referred to a Computer-Aided Drafting (CAD) programs, developed specifically for this task. The limited drawing required for this module will only require pencil, graph paper, a scale, a right triangle, and a compass. Feel free to use computer software to make the drawing if you have some available.

Shop Safety

The first class session on will be spent will be spent in the shop actually applying some of the fabrication techniques about which you have been reading. Of utmost importance is your safety in the shop. While you are working in the shop it is REQUIRED that you:

1. Wear safety glasses at all times
2. Do not wear open-toe shoes such as sandals or flip flops
3. Secure or tie back loose clothing and long hair
4. Remove all jewelry, especially includes rings, watches, and necklaces
5. Only use brushes to remove metal chips from machines
6. Do not use compressed air to clean yourself or the machines
7. Do not use earbuds, iPods, cell phone or other portable devices
8. Do not use machine tool practices that are not approved by the instructor
9. Focus on the work you are doing
10. Do not work in the shop while under the influence of drugs or alcohol. This includes any prescription drugs which could cause drowsiness, lightheadedness, or disorientation.

If you have a question it is much better to ask the shop personnel for help than to proceed with an operation with which you are unfamiliar.

Appended is a form to read and sign acknowledging you have read and understood the aforementioned safety rules. Give the signed form to the shop foreman on your first day of the Mechanical Practices Lab.

Machine Shop Practices

During the first class period you will go to the machine shop and be introduced to the basic equipment by one of the machinists. Over the course of the remaining 4 weeks under the machinist's supervision you will then each fabricate a fun two-slider hand-crank device, of which a 3D CAD drawing is shown below. A mechanical drawing of the hand-crank device assembly and the parts you will fabricate is also appended to this write-up. Print out hard copies of these drawings and bring them with you to the first lab period so you can refer to them while in the shop. Drawings for all parts except two are supplied. You will be responsible for making a complete machine drawing of: 1) The brass knob - for which you will need to include critical dimensions such as major and minor diameter of the 3/8-16 UNC 2A thread and 2) The brass nut which is a 3/8-16 hex jam nut. Use the drawings for the other parts and the *Building Scientific Apparatus* text on reserve in Centennial Library as guides on how to make the drawing of the knob and nut. Refer to the *Machinery's Handbook,*[2] also on reserve in the Centennial Library, for the necessary dimensions and tolerances of the nut and thread on the knob. Complete these drawings and have your instructor check them by no later than the beginning of the 3rd class period.

Fabrication of the hand-crank device will require you will carry out many of the most important operations done in the machine shop using the lathe and milling machine; the machines on which the majority of the work in a machine shop is performed. Completion

of the hand-crank will require most of the remainder of this laboratory module. During this time basic joining processes such as soldering and welding will be demonstrated so that you are familiar with these techniques.

Submit your completed hand-crank to the instructor for examination. If the parts are within tolerance you will have just completed your introduction to mechanical practices in experimental science. You can keep the hand-crank device.

REFERENCES

1) *Technical Drawing*, by F. E. Giesecke et al., 12th edition (Prentice Hall, 2002) ISBN: 0130081833.

This is an updated version of a book that has been a classic in the area for 60 years.

2) *Machinery's Handbook* by Erik Oberg et al, 26th edition (Industrial Press, 2000) ISBN: 0831126663 (CD ROM and Cloth).

This book has a wealth of information and is a standard reference in the metal working industry.