CM3215

Fundamentals of Chemical Engineering Laboratory

Professor Faith Morrison

Department of Chemical Engineering
Michigan Technological University

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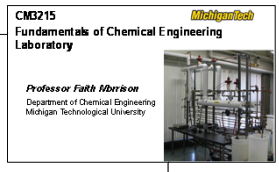
EMERGENCY EVACUATION PROCEDURES



Important: The Michigan Bureau of Fire Services has adopted new rules for colleges and universities effective 2015

1. Only residence halls are required to hold fire and tornado drills.
2. In lieu of fire drills in other university buildings all faculty and instructional staff are required to do the following on the first day of class:
   - Explain the university fire evacuation procedures to the class (see below).
   - Explain the locations of the primary and secondary exit routes for your class location.
   - Explain your designated safe location where the class will meet after evacuating the building.
3. The class instructor is responsible for directing the class during a building evacuation.

General evacuation procedure:

- Use the nearest safe exit route to exit the building. **The nearest safe exit from room 19-104A is the front (south) entrance that is close to the MUB circle. The secondary exit is in the middle of the building, either the west or east entrance (both are equally close).**
- Close all doors on the way out to prevent the spread of smoke and fire.
- After exiting, immediately proceed to a safe location at least 100 feet from the building. **Our designated safe location is at the mailbox near the entrance to parking lot 12 (near the MUB small parking lot).**
- Do not re-enter the building until the all-clear is given by Public Safety or the fire department.

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CM3215 Fundamentals of Chemical Engineering Laboratory

Course Description: An introduction to basic laboratory methods and instrumentation used in the measurement of fluid flow and heat transfer

Skills:

- Lab Safety
- Viscosity, density measurement
- Differential pressure measurement
- Use of control valves
- Fluid flow measurement
- Heat transfer measurement
- Process modeling
- Pumping
- Visio for Piping & Instr. Diagram
- Teamwork
- Good lab practice
- Data presentation
- Statistical analysis/Error Anal
- Report writing
- Computer skills

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CM3215 Fundamentals of Chemical Engineering Laboratory

Course Structure:

- **Monday and Wednesday 2pm (lecture/lab)**
- **Tuesday in lab 9-11am**
- **Lab groups of two persons; assigned by Dr. Morrison**
- **Lab reports due, in person, the week after lab session (Wed)**
- **6 lab reports (5-10-15%); 8 assignments+1 quiz grade (30%); lab performance (10%)**

Lab Materials:

- **Bring bound laboratory notebook to lab every lab day starting Tomorrow (Start TOC; tape P&ID sketch into notebook)**
- **Bring blue or black pen (not pencil)**
- **Safety glasses are provided**
- **Do not wear shorts, sandals; follow dress code**

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CM3215 Fundamentals of Chemical Engineering Laboratory

CM3215 Spring 2016 Course Schedule

week	Monday 1 hour Lecture		Tuesday 2 hour lab A groups	Wednesday Lecture	peer evals	Reports due	Assmts due	Friday Assmts due	week
1	Intro reports, memos		Excel P&ID	DP Meter (& Error 1 Replicates)	prelab			P&ID Assmt 1 due	1
2	MLK Day no class		Pressure Replicates	Viscosity lec (& Error 2 Viscosity)				Replicate Assmt 2 due	2
3	Error 3: Calib Error	prelab	Viscosity	no lecture		Pressure Report 1 due			3
4	Error 4: Error Propagation		Calib Error	Error 5a: LINEST		Viscosity Report 2 due			4
5	Error 5b LINEST		Error Propagation Project	Flowmeter Calib. Lecture	peer evals			Calib Error Assmt 3 due	5
6	no lecture	prelab	Rotameter	Control Valve Lecture				Error Propagation Assmt 4 due	6
7	no lecture	prelab	late start Contr Valve	Friction in Pipes Lecture		Rotameter Report 3 due			7
8	no lecture	prelab	Friction	System Curve Lecture			Control Valve Assmt 5 due		8
	SPRING BREAK								
9	no lecture		no lab	Heat Exchanger Lecture		Friction Report 4 due			9
10	peer evals	prelab	Heat Exchanger	no lecture				System Curve Assmt 6 due	10
11	RTD Modeling Lecture	prelab	late start RTD	Pumping lecture		Heat Exchgr Report 5 due			11
12	no lecture	prelab	late start Pump	Heat Transfer Model Fit Lect.			RTD Modeling Assmt 7 due		12
13	no lecture	prelab	late start Heat Xfer	no lecture		Lossy Pump Report 6 due			13
14	no lecture		no lab	safety meeting	peer evals		Heat Xfer Fit Assmt 8 due		14
15	Finals								15

Lab handouts are on the class website:
www.chem.mtu.edu/~fmorriso/cm3215/cm3215.html

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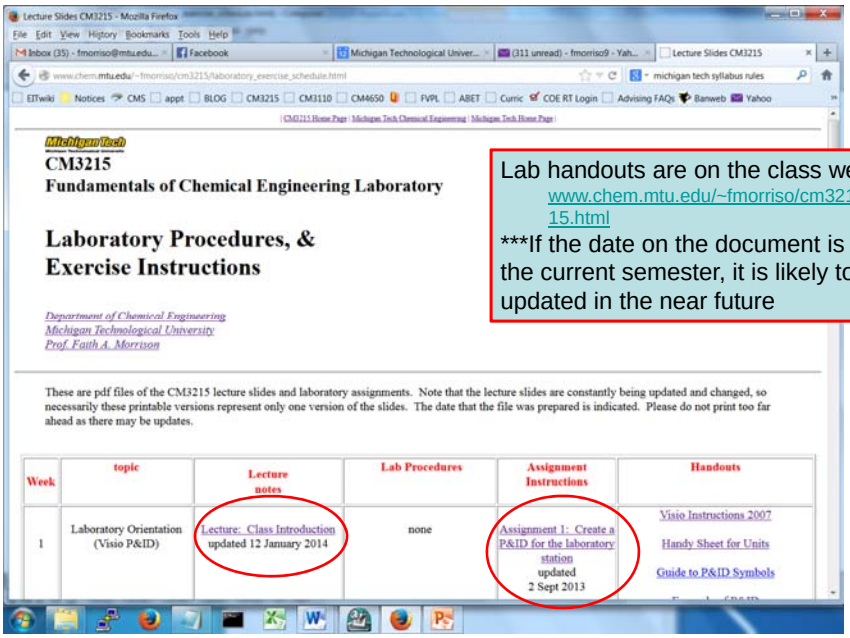

Lab handouts are on the class website:
www.chem.mtu.edu/~fmorriso/cm3215/cm3215.html
***If the date on the document is not the current semester, it is likely to be updated in the near future

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- Lab groups assigned by instructor
- Serve as safety team once or twice in the semester
- Station assignment depends on student number assigned in lab

1pm

Lab Group and Safety

station cycle 1	station cycle 2	station cycle 3	student number	safety assignment	week (A)	week (B)
10	10	10	1	Pump	10	10
10	2	3	2	Special Topic: MIOSHA	13	13
2	2	2	3	Viscosity	3	4
2	3	4	4	Viscosity	3	4
3	3	3	5	Special Topic: MIOSHA	13	13
3	4	5	6	Rotameter	6	5
4	4	4	7	Rotameter	6	5
4	5	6	8	Control Valve	7	7
5	5	5	9	Control Valve	7	7
5	6	7	10	Friction	9	8
6	6	6	11	Friction	9	8
6	7	8	12	Heat Exchanger	12	11
7	7	7	13	Ladder safety	3	3
7	8	9	14	Ladder safety	3	3
8	8	8	15	Heat Exchanger	12	11
8	9	10	16	Pump	10	10
9	9	9	17	Pressure	2	2
9	10	2	18	Pressure	2	2

See:
www.chem.mtu.edu/~fmorriso/cm3215/safetyandlabgroups.html

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Email in a Professional Setting

- Include a salutation (Good Morning, Good Afternoon, etc.)
- Include sentences, punctuation
- Leave off emoticons
- Be conscious of tone
- Include units with data
- Sign your name(s), group #
- Avoid attachments, especially if ASCII (plain) text would do

From: Jane Stewart" <janest@mtu.edu>
Subject: Lab 04, Group 3 Viscosity Data
Date: Thu, September 20, 2007 11:01 am
To: fmorriso@mtu.edu

Good Morning Dr. Morrison,
As you requested, we are sending your our viscosity data from lab 3.

soln
conc T Viscosity (cP)
0% @ 23C: 0.932
0% @ 40C: 0.664

40% @ 23C: 5.252
40% @40C: 3.149
40% @ 60C: 1.998

65% @ 23C: 103.647
65% @ 40C: 41.346

Thank you,
Jane and Yangsoo
Group 4 Lab section L02

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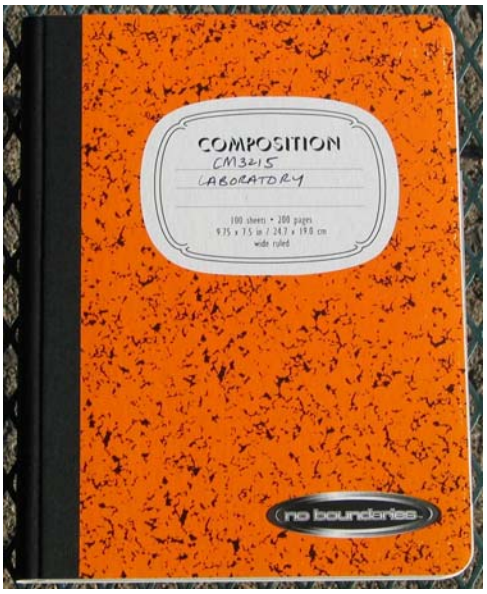
Laboratory Notebook

- Bound – preserves the order of events, keeps things organized
- Cross out pages or items that need to be deleted – do not remove pages
- Use black or blue pen, not pencil (this is meant to be an archival record of your activities; colored inks fade and pencil smudges)



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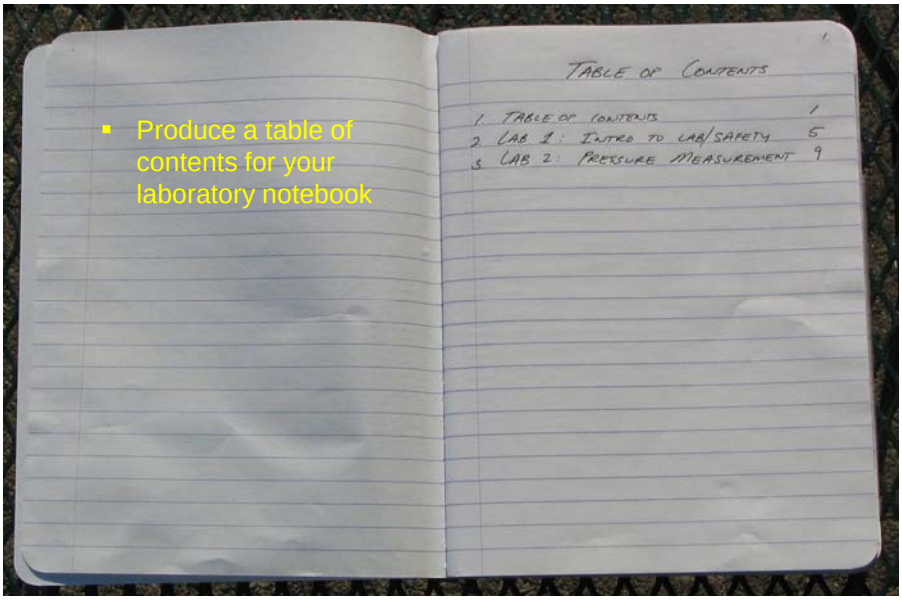
- Produce a table of contents for your laboratory notebook



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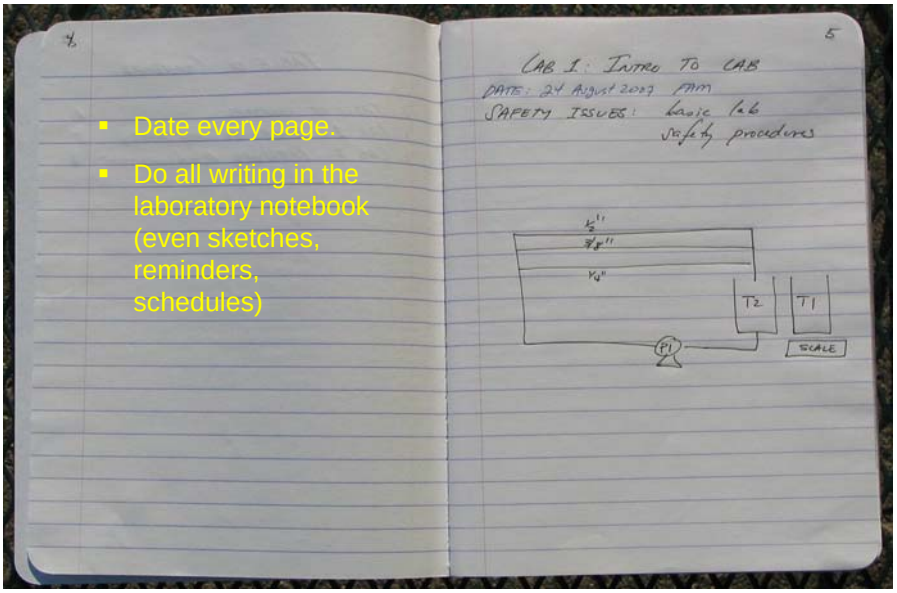

- Date every page.
- Do all writing in the laboratory notebook (even sketches, reminders, schedules)

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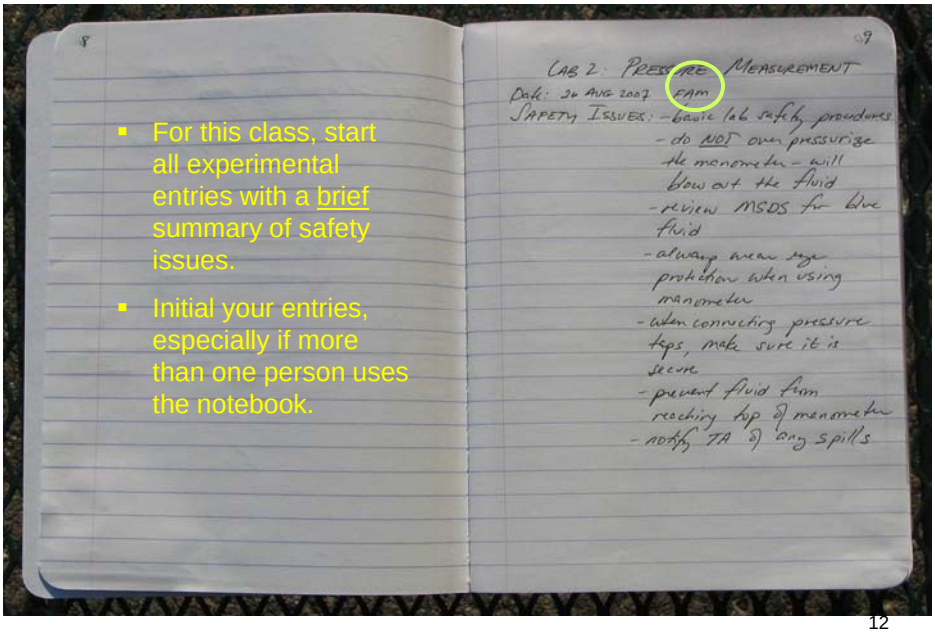

- For this class, start all experimental entries with a brief summary of safety issues.
- Initial your entries, especially if more than one person uses the notebook.

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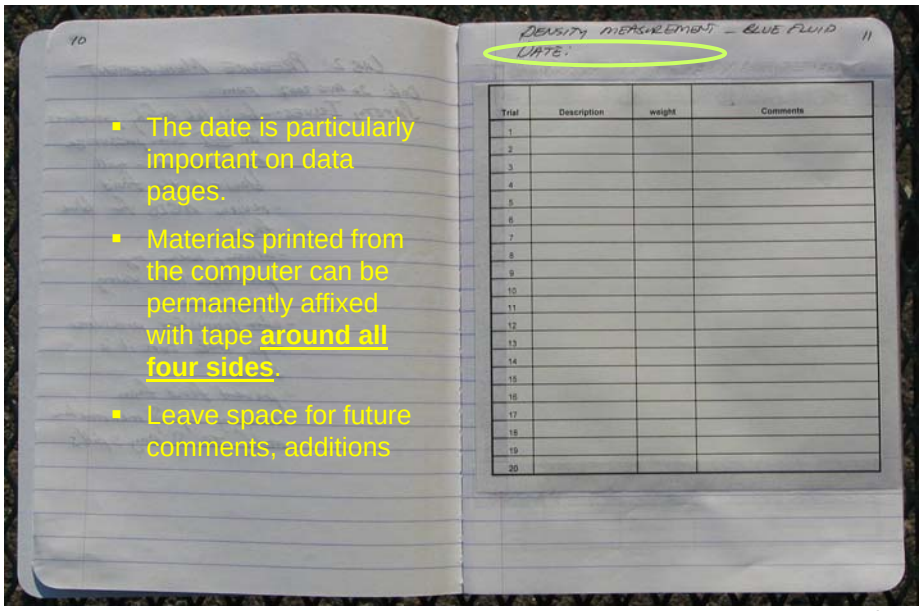

- The date is particularly important on data pages.
- Materials printed from the computer can be permanently affixed with tape **around all four sides**.
- Leave space for future comments, additions

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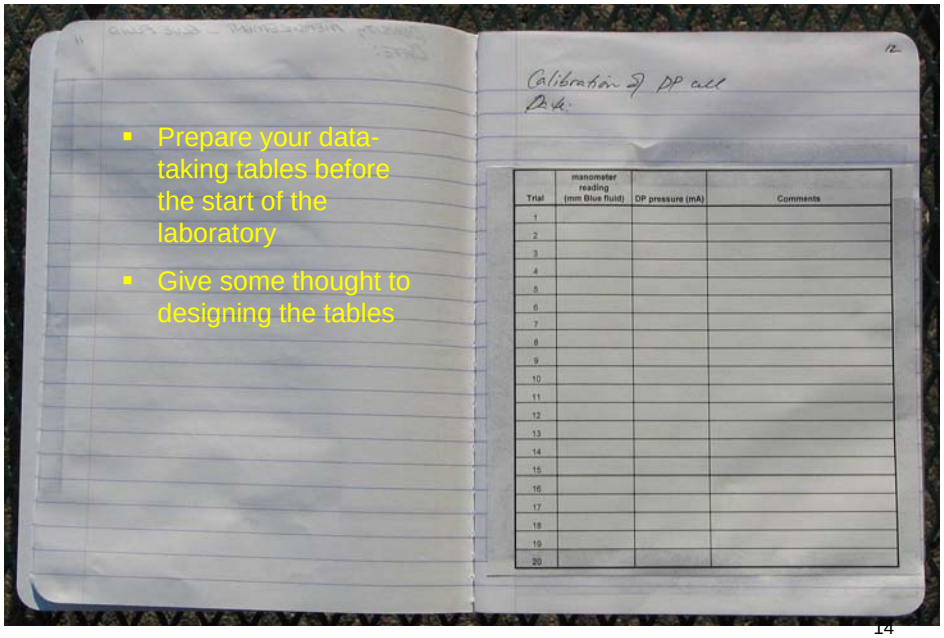

- Prepare your data-taking tables before the start of the laboratory
- Give some thought to designing the tables

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Letter (memo) of Transmittal

- Purpose is to "transmit" an item
- Short, simple; gets reasons for submission down on paper

Memo

To: Professor Faith Morrison

From: Silvia Smith

Date: September 4, 2007

Subject: Report on Status of 30-Gallon Reactor

Attached please find my report on the current status of the 30-gallon reactor in B001. Per your request of 5 August 2007, we have inspected the instrument and determined what steps are necessary for putting it into service. The details are found in the attached report.

If you have any questions, please contact me at ssmith@industry.com or 906-487-2050.

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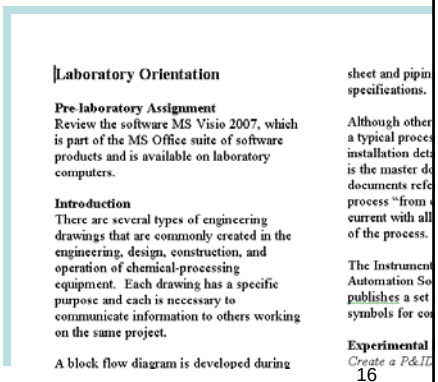
Assignment 1: *(group assignment)*

- Create P&ID Diagram for the CM3215 Laboratory Station; you may consult with other groups; submit your own team work
- In your cover memo, list all the valves and devices in the path that would direct water from the feed tank, through the ¼" line and back to the discharge tank.
- Submit to your results with memo of transmittal (Due this Friday, 9:05am, Homework Box A, 2nd floor ChemSci)
- Affix a copy of P&ID in your lab notebook
- Affix a copy of unit conversion table to your lab notebook: www.chem.mtu.edu/~fmorriso/cm310/convert.pdf



Laboratory Orientation

Pre-laboratory Assignment
Review the software MS Visio 2007, which is part of the MS Office suite of software products and is available on laboratory computers.

Introduction
There are several types of engineering drawings that are commonly created in the engineering, design, construction, and operation of chemical-processing equipment. Each drawing has a specific purpose and each is necessary to communicate information to others working on the same project.

A block flow diagram is developed during

sheet and pipin
specifications.

Although other
a typical proces
installation det
is the master d
documents refe
process "from
current with all
of the process.

The Instrument
Automation So
publishes a set
symbols for co

Experimental
Create a P&ID

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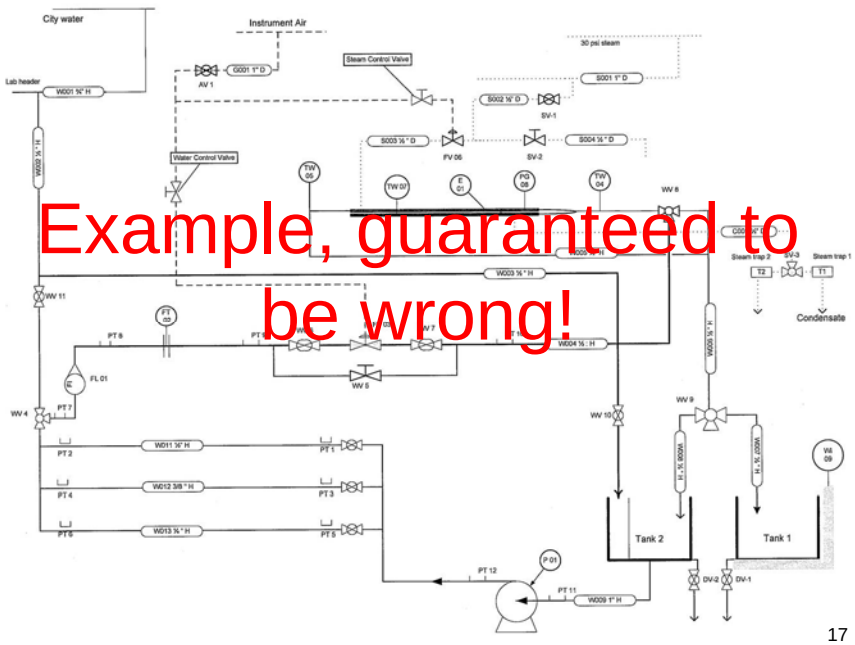

Example, guaranteed to be wrong!

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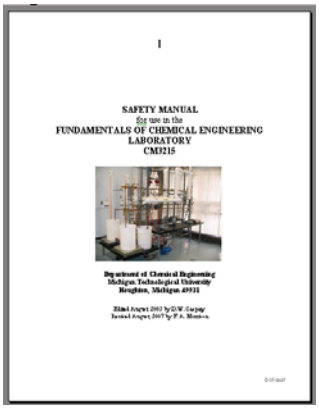
Safety

- **Laboratory Safety Manual is on the web (PRINT IT)**
  www.chem.mtu.edu/~fmorriso/cm3215/CM3215SafetyManual2007.pdf
- **You must follow all instructions in the Safety Manual at all times**
- **Required:**
  - Wear Safety glasses/goggles
  - Name tag
- **Prohibited:**
  - Open-toed and open shoes
  - Shorts, skirts
  - Eating, drinking, water bottles
  - Backpacks on the floor


SAFETY MANUAL
for use in the
FUNDAMENTALS OF CHEMICAL ENGINEERING
LABORATORY
CM3215

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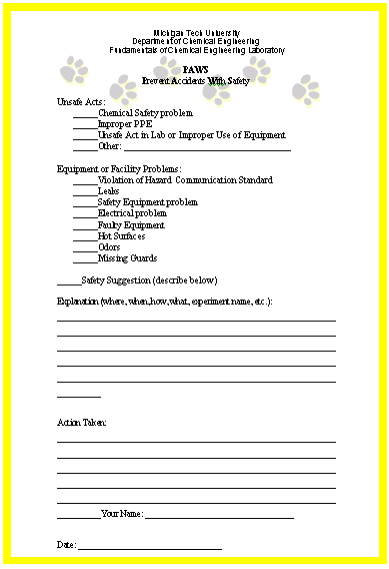
CM3215 Fundamentals of Chemical Engineering Laboratory

PAWS Program

- *Prevent Accidents with Safety*
- Read up on it in Safety Manual
- Goal: prevention
- Report unsafe acts/conditions
- A more in-depth version is followed in Unit Operations Lab



Michigan Tech University
Department Of Chemical Engineering
Fundamentals Of Chemical Engineering Laboratory

PAWS
Prevent Accidents With Safety

Unsafe Acts:
_____Chemical Safety problem
_____Improper PPE
_____Unsafe Act in Lab or Improper Use of Equipment
_____Other: _____

Equipment or Facility Problems:
_____Violation of Hazard Communication Standard
_____Leaks
_____Safety Equipment problem
_____Electrical problem
_____Faulty Equipment
_____Hot Surfaces
_____Odors
_____Missing Guards

_____Safety Suggestion (describe below)

Explanation (where, when, how, what, experiment name, etc.):

Action Taken:

_____Your Name: _____

Date: _____

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PAWS Program

Safety Team

- Responsible for presenting a summary of safety points at the beginning of a lab day
- Responsible for taking a special interest in hazards and safe operation of all the laboratory stations
- Reviews PAWS reports, follows up on open PAWS reports
- Team must submit separate printed one-page ***Safety report*** (memo) to TA (due same day and time as reports) ***(there is a sample safety report on the website)***

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Chemical Handling at Michigan Tech

Michigan Technological University follows all national and state laws for the labeling of hazardous chemicals.

Students, faculty, and staff in the Department of Chemical Engineering are required to follow Departmental, University, State, and National rules for safe handling of chemicals.

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UNITED STATES DEPARTMENT OF LABOR

Occupational Safety and Heath Administration (OSHA)

Hazard Communication Standard

- Provides a common and coherent approach to classifying chemicals and communicating hazard information on labels and safety data sheets.
- Mandates that employers (including Michigan Tech) have a Hazard Communication program that includes:

1. Chemical inventory
2. Safety data sheets **(SDS)** on chemicals
3. Container labels
4. Training
5. A written program that details the above

⇒ **Hazard Communication Plan**

www.osha.gov/dsg/hazcom/

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www.mtu.edu/oshs/safety-programs/required/hazard-communication/

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Globally Harmonized System of Classification and Labeling of Chemicals (GHS)

- International standard (UN sponsored)
- Replaces national classifications/labeling standards
- Began in 1992
- OSHA published the final rule on 26 March 2012 for implementation of GHS.
- Product manufacturers required to adopt the standard by 1 June 2015
- Product distributors required to adopt the standard by 1 December 2015

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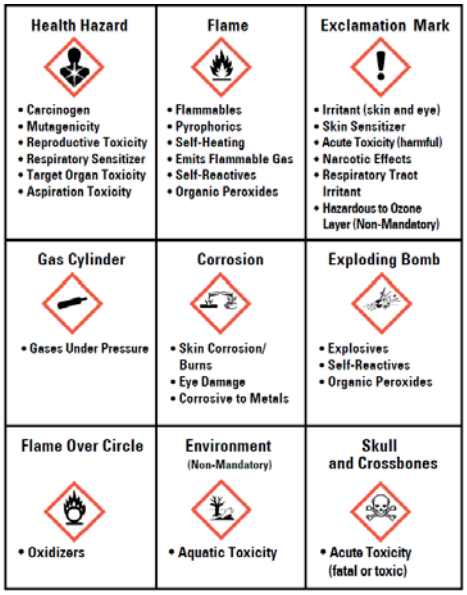

Hazard Communication Standard (HCS) Pictograms

- 9 pictograms depict hazards (physical, health)
- Within each hazard, there are multiple categories
- Category 1 is the most severe hazard

The pictograms appear on safety data sheets (SDS) and labels on chemical containers

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Hazard Communication Standard (HCS) Pictograms (OSHA)

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Safety Data Sheets (SDS, formerly MSDS)

16 mandated sections:

Section 1: Identification of the substance/mixture and of the company/undertaking
Section 2: Hazards identification
Section 3: Composition/information on ingredients
Section 4: First aid measures
Section 5: Firefighting measures
Section 6: Accidental release measures
Section 7: Handling and storage
Section 8: Exposure controls/personal protection
Section 9: Physical and chemical properties
Section 10: Stability and reactivity
Section 11: Toxicological information
Section 12: Ecological information
Section 13: Disposal considerations
Section 14: Transport information
Section 15: Regulatory information
Section 16: Other information

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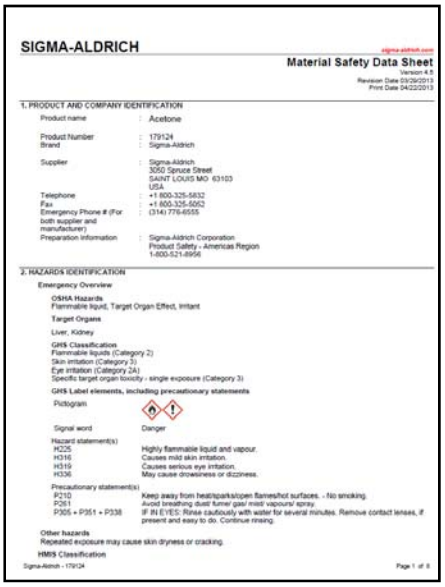
Safety Data Sheets (SDS, formerly MSDS)



SIGMA-ALDRICH

Material Safety Data Sheet

Version 4.5
Revision Date 03/26/2013
Print Date 04/22/2013

1. PRODUCT AND COMPANY IDENTIFICATION

Product name : Acetone

Product Number : 179124
Brand : Sigma-Aldrich

Supplier : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA

Telephone : +1 800-325-5832
Fax : +1 800-325-5052
Emergency Phone # (For both supplier and manufacturer) : (314) 776-6555

Preparation Information : Sigma-Aldrich Corporation
Product Safety - Americas Region
1-800-521-8956

2. HAZARDS IDENTIFICATION

Emergency Overview

OSHA Hazards
Flammable liquid, Target Organ Effect, Irritant

Target Organs
Liver, Kidney

GHS Classification
Flammable liquids (Category 2)
Skin irritation (Category 3)
Eye irritation (Category 2A)
Specific target organ toxicity - single exposure (Category 3)

GHS Label elements, including precautionary statements

Pictogram

Signal word Danger

Hazard statement(s)
H225 Highly flammable liquid and vapour.
H316 Causes mild skin irritation.
H319 Causes serious eye irritation.
H336 May cause drowsiness or dizziness.

Precautionary statement(s)
P210 Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P261 Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.
P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

Other hazards
Repeated exposure may cause skin dryness or cracking.

HMIS Classification

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Acetone
(used for cleaning glassware)

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2. HAZARDS IDENTIFICATION

Emergency Overview

OSHA Hazards
Flammable liquid, Target Organ Effect, Irritant

Target Organs

Liver, Kidney

GHS Classification
Flammable liquids (Category 2)
Skin irritation (Category 3)
Eye irritation (Category 2A)
Specific target organ toxicity - single exposure (Category 3)

GHS Label elements, including precautionary statements

Pictogram

Signal word: Danger

Hazard statement(s)

H225	Highly flammable liquid and vapour.
H316	Causes mild skin irritation.
H319	Causes serious eye irritation.
H336	May cause drowsiness or dizziness.

Precautionary statement(s)

P210	Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P261	Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

Other hazards
Repeated exposure may cause skin dryness or cracking.

HMIS Classification

Sigma-Aldrich - 179124 Page 1 of 8

Questions:
- What are the two pictograms for acetone?
- What do they mean for acetone?

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SDS are stored in a binder in each lab or online.

For CM3215 they are in the binder in lab and on our course website.

Accessing Safety Data Sheets at Michigan Tech

Digital copies of the Safety Data Sheets for chemicals and other hazardous materials used at Michigan Tech are available online through MSDSonline.

- The MSDSonline database can be accessed from: The navigation bar at the bottom of most MTU homepages. Click **MSDS ONLINE** under the **NEED TO KNOW** column.

- By typing www.mtu.edu/sds in the address bar of your browser.
- Scanning the QR code at the entrance to laboratories and other rooms where chemicals are used or stored.
- If computer or network systems are not available call 1-888-362-7416 and provide the name of the product and the manufacturer and a FAX number where the information can be sent.

Michigan Tech MSDSonline

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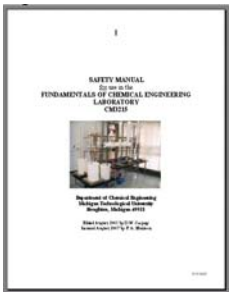
Safety Summary

We have multiple goals, being addressed in parallel:

- Be safe in CM3215 lab
- Learn good safety habits for a lifetime
- Learn about safety practices in use in the chemical industry
- Be part of continuous improvement of CM3215 and Michigan Tech chemical safety programs



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Report Writing

- A Team Technical Memorandum report is due for six labs (6 reports, 60%)
- Report 1 (5%), Reports 2-5 (10%), Report 6 (15%) (no rewrites)
- Be sure to use report feedback to make subsequent reports better
- Grading standards rise throughout the semester

Overarching principle:

You must prepare a report that addresses your objectives.

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Report Writing

Overarching principle:

You must prepare a report that addresses your objectives.

1. Determine what your objectives are.
2. Address them.
3. Write a report that clearly, and in an organized way, communicates what your objectives were, what you did to address them, and how it turned out.

Sample report (starting with sample objectives):
www.chem.mtu.edu/~fmorriso/cm3215/SampleReport.html

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Report Writing: Technical Memo Report

5 sections:

1. ***Introduction***
2. ***Experimental*** ***(Strategy)***
3. ***Results*** ***(text, graphs tables, begin error analysis)***
4. ***Discussion*** ***(discuss your results; expand on error analysis; finish addressing objectives)***
5. ***Conclusions***

Introduction: Explain what your objectives are. Be complete. Do not include anything other than your objectives.

Experimental: Describe your experimental strategy for addressing your objectives. Do not repeat or summarize the provided procedure. Do explain what your strategy was in addressing your objectives.

Experimental section is like giving a tour to a visitor

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Report Writing (continued)

5 sections:

1. ***Introduction***
2. ***Experimental*** *(Strategy)*
3. ***Results*** *(text, graphs tables, begin error analysis)*
4. ***Discussion*** *(discuss your results; expand on error analysis; finish addressing objectives)*
5. ***Conclusions***

Results: Present your results; present your equations; introduce your tables and graphs with a narrative. Introduce your error analysis.

Discussion: Discuss your results. Refer back to your tables and graphs and tell the reader what you have discovered as a result of your work. Be quantitative. Anything you want to say in your conclusions must first be discussed here. Finish addressing objectives.

Conclusions: Report on how well you met each of your objectives; be complete; do not introduce anything new. Be quantitative, complete.

Checklist to use before turning in reports:
www.chem.mtu.edu/~fmorriso/cm3215/checklist_reports.html

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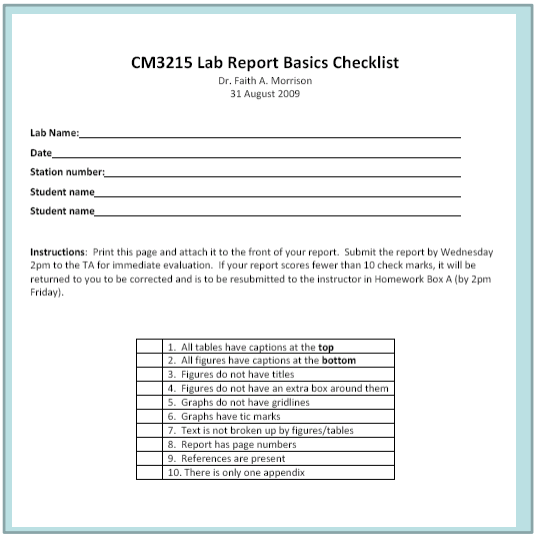
Report Writing (continued)

•Attach the Basics Checklist to reports 1-4

•Turn report in to TA/Instructor *in person* on Wednesday at lecture time. *First report is due week 3.*

•TA/Instructor will immediately check the checklist and return all reports with problems

Explanation of basics violations:
www.chem.mtu.edu/~fmorriso/cm3215/BasicsChecklistInstructions.pdf



CM3215 Lab Report Basics Checklist

Dr. Faith A. Morrison
31 August 2009

Lab Name:_____
Date_____
Station number:_____
Student name_____
Student name_____

Instructions: Print this page and attach it to the front of your report. Submit the report by Wednesday 2pm to the TA for immediate evaluation. If your report scores fewer than 10 check marks, it will be returned to you to be corrected and is to be resubmitted to the instructor in Homework Box A (by 2pm Friday).

	1. All tables have captions at the **top**
	2. All figures have captions at the **bottom**
	3. Figures do not have titles
	4. Figures do not have an extra box around them
	5. Graphs do not have gridlines
	6. Graphs have tic marks
	7. Text is not broken up by figures/tables
	8. Report has page numbers
	9. References are present
	10. There is only one appendix

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CM3215 Fundamentals of Chemical Engineering Laboratory

Report Writing (continued)

In this class and in your career you will be judged on the clarity and quality of your writing.

- Good grammar and punctuation is a given
- Only include what is needed to make your point (test every sentence – is it needed? Plot out your story.)
- Begin each paragraph with a topic sentence (check before submitting
- Do not leave out anything that you need to make your point (make sure you back-up your statements)
- Assume the appendix will be separated from the report (it's for back-up material only)
- Be persuasive – lead your reader along – it is important that they follow your argument

Engineers need to communicate well!

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CM3215 Fundamentals of Chemical Engineering Laboratory

Report Writing

Overarching principle:
You must prepare a report that addresses your objectives.

Every report is different

Writing reports is practice making a thousand decisions

The only way to learn to do this is to do it

The answer to "*what goes in this section?*" is: "*It depends.*"

The goal is not the production of the report; the goal is the experience of writing the report

Sample report (starting with sample objectives):
www.chem.mtu.edu/~fmorriso/cm3215/SampleReport.html

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CM3215 Fundamentals of Chemical Engineering Laboratory

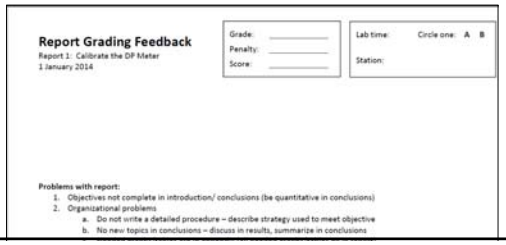
Report Writing

Overarching principle:
You must prepare a report that addresses your objectives.

Tip: Check out the **Report Feedback Sheet** as you prepare your report. Avoid these common mistakes.

www.chem.mtu.edu/~fmorriso/cm3215/ReportGradingFeedback.pdf

www.chem.mtu.edu/~fmorriso/cm3215/ReportGradingFeedbackExplanation.pdf



Report Grading Feedback

Report 1: Calibrate the DP Meter
1 January 2014

Grade:
Penalty:
Score:

Lab time: Circle one: A B
Station:

Problems with report:
1. Objectives not complete in introduction/ conclusions (be quantitative in conclusions)
2. Organizational problems
   a. Do not write a detailed procedure – describe strategy used to meet objective
   b. No new topics in conclusions – discuss in results, summarize in conclusions

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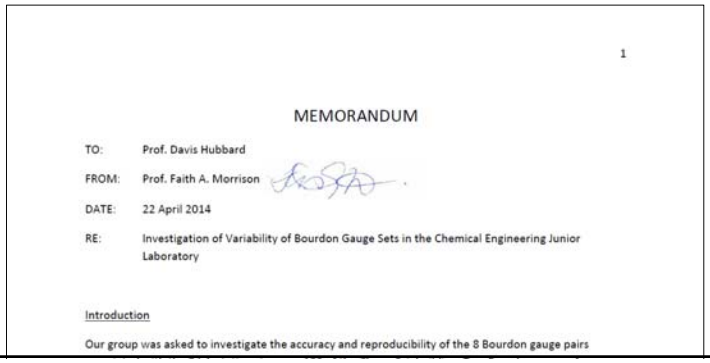
CM3215 Fundamentals of Chemical Engineering Laboratory

Report Writing

Overarching principle:
You must prepare a report that addresses your objectives.

Note that since the Technical Memo has a memo header, it does not require a separate memo of transmittal



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MEMORANDUM

TO: Prof. Davis Hubbard

FROM: Prof. Faith A. Morrison

DATE: 22 April 2014

RE: Investigation of Variability of Bourdon Gauge Sets in the Chemical Engineering Junior Laboratory

Introduction

Our group was asked to investigate the accuracy and reproducibility of the 8 Bourdon gauge pairs

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CM3215

Fundamentals of Chemical Engineering Laboratory

Summary

- Come dressed for lab tomorrow
- Bring bound lab notebook with table of contents, units page, page numbers, your name
- Print out safety manual and review

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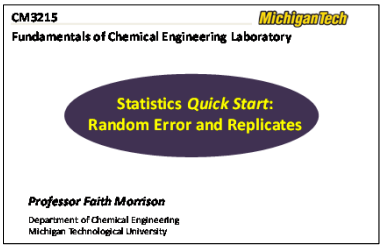
Now, on to Error Analysis Lecture 1: Random Error and Replicates



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