# Course Admin Slides

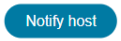
# IE386: Work Analysis and Design I

**Lecture: Math 175, TuTh 9:30a - 10:20a**

**Labs: Stanley Coulter Hall G046, WThF-various times**

Instructor:
Dr. Denny Yu
49-47346
dennyyu@purdue.edu

Office hours
https://purdue.webex.com/meet/dennyyu
(Click "Notify host" button access to the room)




Tuesdays 10:30a-11:30a
& by appointment

Teaching Assistants:
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Jing Yang, yang1847@purdue.edu
*For emails, put [IE386] in subj.*

Office hours:
https://purdue-student.webex.com/meet/jingkun

Wed 2:30-4:30p
& by appointment

# ANNOUNCEMENTS

- Welcome to Fa21 IE386!
- Please work with your IE academic advisors on all enrollment concerns

# SAFETY - MATH EVACUATION

- ***Primary location (should be outside, in an area away from the building):***

  Gather in the sidewalk area near Class of 50 and the Recitation buildings.
  DO NOT remain underneath the breezeway of the MATH building.

- ***Secondary location (should be inside a nearby building in case of inclement weather):***
  In the lobby area of Class of 50.
  Please remember that this is an active class building and keep volume to a minimum. DO NOT remain underneath the breezeway of the MATH building.

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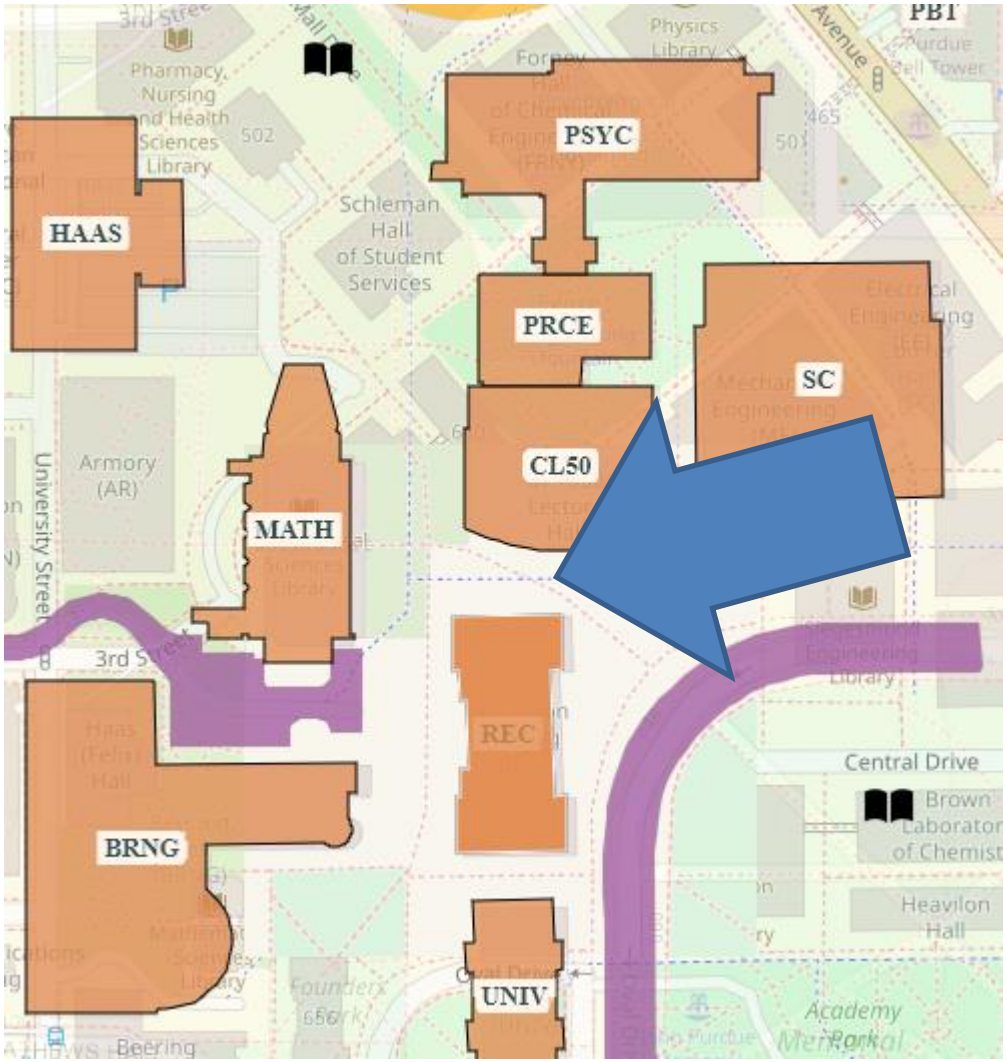
# SAFETY - MATH EMERGENCY ASSEMBLY AREA

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*Review: https://www.math.purdue.edu/files/about/building/MATH_BEP.pdf*

# SAFETY-EVACUATION

**General Evacuation Procedures--If you hear the fire alarm or are instructed to leave the building:**

- You must immediately obey evacuation alarms and orders. Tell others to evacuate.
- No one may remain inside a building when an evacuation is in progress.
- Classes in session must evacuate.
- If involved with hazardous research or doing a dangerous procedure, immediately shut down operations that could create additional hazards if left unattended. Evacuate as soon as possible.
- When you evacuate, take keys, coat, purse and any other critical personal items with you to the EAA. **REMEMBER, IN CASE OF A FIRE, IT IS IMPORTANT TO NOT DELAY EVACUATION.**
- Close doors as rooms are vacated.
- Assist those who need help, but do not put yourself at risk attempting to rescue trapped or injured victims.
- Note location of trapped and injured victims and notify emergency responders.
- Walk calmly but quickly to the nearest emergency exit.
- Use stairways only. **Do not use elevators.**
- Keep to the right side of corridors and stairwells as you exit.
- Proceed directly to your designated EAA. Stay away from the immediate area near the building you evacuated.
- Remain in EAA until roll is taken and instructions are given.
- Do not reenter the building until authorized fire or police department personnel give the "All Clear" instruction.

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*More info at*
*https://www.math.purdue.edu/files/about/building/MATH_BEP.pdf*

# SAFETY-SHELTER IN PLACE


- Tornado:


4) Alertus Alert Beacons
   (i) Alert will be sent to the beacons that are installed in large classrooms. Beacons will alarm audibly for 10 seconds, flash and text alert will be available for 5 minutes.

- Active Shooter
  - Escape if possible
    - If possible while maintaining your safety, leave the area
    - Leave belongings behind
    - Help others escape, if possible
    - Keep your hands visible
  - If escape is not possible, hide
    - Out of view
    - Lock and/or barricade entrance
  - Last resort – take action
    - Only when your life is in imminent danger

| EMERGENCY | SHELTER IN PLACE OPTIONS FOR CONSIDERATION |
|---|---|
| Weather-Related - Tornado Warning | Basement corridors, basement offices, basement restrooms<br>Or the lowest level of the building (stay away from windows and doors) |
| Hazardous Materials (HAZMAT) Release | Remain or find an unaffected office or work area and close windows and doors. |
| Active threat, such as a shooting | Seek a safe location, preferable a room without windows that can be locked or secured by barriers. |

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# WHAT THIS COURSE WILL COVER (KEY TOPICS*)

Anthropometry & work physiology

Workspace design

Lifting analysis

Time studies

Activity sampling

Modeling physical human performance

Task analysis and process mapping

*Additional topics will also be covered

# COURSE OUTCOMES

- The student will be able to **design work stations and tasks** so that they comply with ergonomic and physiological requirements.
- The student will be able to **analyze a lifting task** to determine its safety and desirability.
- The student will be able to **conduct a time study**, using either standard time study methods or synthetic data systems, in a manufacturing or service work setting.
- The student will be able to **conduct work sampling studies** in the workplace to determine the frequency of some effect of interest
- The student will be able to correctly **perform economic analysis** to justify work design and process flow recommendations.
- The student will be able to **conduct regressions to predict human performance**.
- The student will be able to **perform task analysis and process mapping** in a manufacturing or service workplace using industry-accepted methods.
- The student will be able to **effectively write technical reports** regarding work analysis studies and recommendations.
- The student will be able to **effectively present** work analysis and recommendations.

# WHAT THIS COURSE WILL NOT COVER

- Purely cognitive phenomena
- Team behavior
- Worker Compensation
- Personnel selection
- Hand tool design
- Protective equipment, physical hazards

# LAYOUT OF THE COURSE

- The focus of the course is on teaching you tools to use for work analysis, but we must cover some background information first. So we will cover some material on anthropometry and physiology first, then move into application of these principles for analysis and design. For most of the course, this will be a “do things” class and not a “know things” class.
- You will be required to read parts of chapters or notes for class.
- The lectures will supplement the notes and reading with explanations, examples, and exercises.
- Frequently, we will have a short in-class quiz to check if you’ve done your pre-lecture reading assignments.
- There will be **two in-class tests**.
- There will be a ~~**final project and a**~~ **final exam**.

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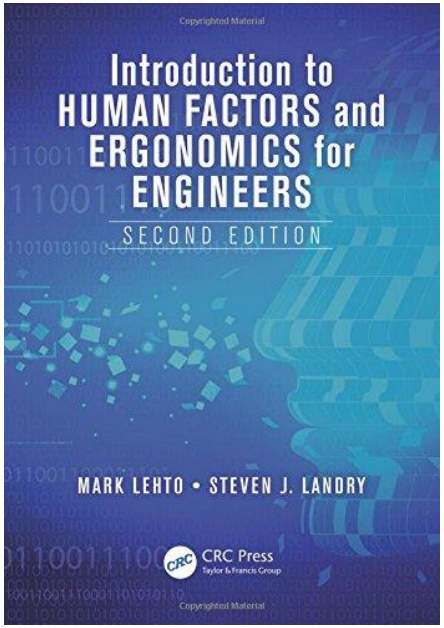
# THE BOOK

- This course is going to require you to read the book, as there are things in there that I will require you to know, but which I will not cover in class. (Usually, this would be things you need to be able to recall.)

- We will be skipping around rather than covering the book sequentially.




Source: images.google

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# OBJECTIVES (1)

- At the beginning of the lectures covering each chapter, I will give you some objectives.
- These objectives will be specific and support the overall course outcomes.
- You are responsible for being able to meet those objectives, and the tests will evaluate these objectives directly. The projects will be evaluated against these objectives.
- For example, one objective may be:
  - Be able to recall without reference the 99$^{th}$ percentile limits on the stature of American men

# OBJECTIVES (2)

In addition to the chapter objectives, the following objectives are considered pass-fail. You must pass these objectives to attain a passing grade in the course:

- Be able to present work analyses in writing and orally
- Work ethically in conducting and reporting on work analyses

Submission and presentation of satisfactory lab reports and quizzes/tests/homework, without plagiarism, cheating, or other types of unethical behavior, will constitute passing these objectives.

If you fail even once to show ethical behavior, you will fail the course. Unethical behavior is not negotiable and will be reported to the Office of the Dean of Students (ODOS). Please familiarize yourself with examples of academic dishonesty at: https://www.purdue.edu/odos/academic-integrity/

# EXAMPLES

Students must submit lab reports and quizzes/tests/homework, without plagiarism, cheating, or other types of unethical behavior

- doing class assignments for someone else
- **plagiarizing published material, class assignments or lab reports**
- using unauthorized notes during an exam
- collaborating with other students on assignments when it is not allowed
- altering answers on a scored test and submitting it for a regrade
- **fabricating data**

**Tips**

- **Do not look around, particularly in the direction of other students' papers, during an exam since it may appear you are trying to copy from others.**
- Know that it is risky to electronically copy or transmit a computer program or file to other students. You could be implicated in a cheating incident if others alter that program and submit it as their own work.
- Protect your computer login identifications and passwords. Other students could use them to access your work and subsequently implicate you in a cheating case.
- Since it is impossible to write everything with complete originality, use quotation marks, footnotes, and parenthetical textual notes to acknowledge other people's words or ideas employed in your paper. Check with your instructor for proper techniques for citations and attribution if you have any doubts.
- **Do not acquire previous papers, lab reports, or assignments used in a course with the intention of copying parts or all of the material.**
- Do not share your current or former assignments, projects, papers, etc., with other students to use as guides for their work**. Such a practice could lead to claims of collaboration if part or all of your work is lifted** by another student. Sometimes friendly assistance may escalate into claims of blatant dishonesty.
- Do not make any marks on a graded exam if there is any chance you may submit it for a regrade. Make all notations on a separate paper.

**If you fail even once to show ethical behavior, you will fail the course. Unethical behavior is not negotiable and will be reported to the Office of the Dean of Students.**

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https://www.purdue.edu/odos/academic-integrity/

# CLASS PREPARATION

- Each class has a topic and associated slides on Blackboard. In addition, the upcoming topics are given at the end of every lecture.

- It is your responsibility to look at the calendar before class and review the slides on the topic of the lecture.

- The first slide in the package will contain an assignment. Generally, the assignments will be to read the slides for that topic and several pages in the text. It will also indicate that there are a few things you should know. Randomly, I will give quizzes in class; these quizzes will check your knowledge of the assignment.

- Quizzes are graded.

- **Quiz grading**
  - **In-person:** 1 point for an answer and 0 pts for no answer.
  - **Online (note time-window):** 1 point for correct answer, 0.5 pts for incorrect answer, and 0 pts for no answer.
  - No make ups for quizzes, bottom two quiz scores dropped.

# EXAMPLE ASSIGNMENT – HUMAN SYSTEMS

- Read the skeletal subsystem section of Chapter 2, pages 40-47
- Read these slides.
- Be able to define:
  - What a tendon does
  - What a ligament does
- *Familiarize* yourself with the motion terminology from Figure 2.8 from the textbook

# GRADING

- Tests (50% of total grade, Final exam grade replaces lowest in-class test **if** advantageous to the student)
  - Two in-class tests (15% each)
  - Cumulative final exam (20%)
- Quizzes (10%)
  - Numerous (about 8-14)
  - Average is worth 10% of your final grade
- Short assignments (15%)
  - ~4-6 assignments based on book and lecture questions
- Technical reports based on labs (25%)
  - Five lab reports
  - Report average worth 20% (**must get passing grade to pass the class**)
  - Lab attendance will be considered when deliberating final grade (5%)
    - However, some labs may require attendance may be required for you to submit the work. (Absent = 0 for that lab)
- ~~Project (10%)~~
  - ~~Final week of class (in-lab presentation and written final report on your work)~~
  - ~~Worth 10% of your grade~~

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# GRADING (REPORTS)

- Late technical reports are **not accepted**. You must get a passing grade on the technical reports to pass the class.

- Technical reports may be submitted by a single student or, if applicable, by a group of students (refer to lab assignment for when pairs/groups are applicable). If an assignment is submitted by a group, all students will receive the *approximately* the same grade. The names of all students must be clearly indicated on the report **at the time of submission**. No names will be added after submission the deadline.

- If a group of students submits >1 reports, the group will receive the lower of the grades.) All submissions must be your and your group's own work. Any "ithenticate" reports >30% will be flagged for plagiarism and reviewed to be sent to ODOS. (exact % subject to change)
    - You are responsible for the entire contents of the submission.

- Credit will only be given for "on paper" answers showing sufficient relevant work. The definition of sufficient relevant work is determined by the grader.

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# GRADING (TESTS)

- No makeups for tests are allowed.  The lowest test grade is replaced with Final Exam if it helps you.

- You must bring your student ID with you to all tests and the final exam.

- Solutions will not be posted. It is your responsibility to make sure you find out how to solve the problems by asking about them in class or office hours.

- All test regrade requests must be submitted in an email (no later than two weeks after grades are posted) to the instructor during office hours or after class. The regrade request must include the entire test and the reason that additional points are being requested. The entire work will be regraded, and your grade may go up or down.

# GRADING (GENERAL)

- The grading boundaries will be no harsher than:

  93 A, 90 A-, 87 B+, 83 B, 80 B-, 77 C+, 73 C, 70 C-, 65 D

- The instructor reserves the right to adjust the grading boundaries to the advantage of students. However only the scale above is *guaranteed*. Student circumstances external to IE386 will not be taken into consideration when determining grade boundaries.

- Due to FERPA regulations and time constraints, it will not be possible to return graded materials in class. You may pick up and view any graded materials during the TA's office hours.

- All students seeking accommodations should coordinate their accommodations in this class through the DRC. Any students requiring additional in-class/lab accommodations should notify me directly.

# TENTATIVE COURSE CALENDAR - AUGUST

| Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| 23 | 24<br>Course admin<br>Introduction | 25 | 26<br>Sensory systems<br>(Vision/lighting) | 27 | 28 | 29 |
| 30 | 31<br>Sensory systems<br>(Hearing/noise) | 1 | 2<br>Human system | 3 | 4 | 5 |
| | | | | | | |

***LAB 1** (1 Sept.-3 Sept.): Lighting and noise*

***Technical report for lab 1 due 10 September 11:30pm***

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# TENTATIVE COURSE CALENDAR - SEPTEMBER

| Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|
| | | | | | | |
| 6<br>*Labor Day* | 7<br>Human system | 8 | 9<br>Anthropometry | 10 | 11 | 12 |
| 13 | 14<br>Anthropometry/ Designing workstations | 15 | 16<br>Designing workstations | 17 | 18 | 19 |
| 20 | 21<br>Designing workstations | 22 | 23<br>Work physiology | 24 | 25 | 26 |
| 27 | 28<br>Work physiology/ Lifting<br>*Review session*<br>*5:30 – 6:30 pm*<br>*Location: TBD* | 29 | 30<br>**Test 1** | | | |
| | | | | | | |

**Assignment 1-Posted (7 Sept)**
**Due 17 Sept at 11:30pm**

***LAB 2** (15-17 Sept.): Ergonomics design*

***Technical report for lab 2 due 24 September 11:30pm***

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# TENTATIVE COURSE CALENDAR - OCTOBER

| Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | 1 | 2 | 3 |
| 4 | 5<br>Lifting | 6 | 7<br>Learning | 8 | 9 | 10 |
| 11<br>*October Break* | 12<br>*October Break* | 13 | 14<br>Time studies | 15 | 16 | 17 |
| 18 | 19<br>Time studies | 20 | 21<br>Economics | 22 | 23 | 24 |
| 25 | 26<br>5S | 27 | 28<br>Methods analysis | 29 | 30 | 31 |

**Assignment 2-Posted 5 Oct**
**Due 22 October at 11:30pm**

**Assignment 3-Posted 26 Oct**
**Due 12 Nov at 11:30pm**

***LAB 3* (6-8 October): Lifting analysis**

***LAB 4* (20-22 October): Time study**

***Technical report for lab 3 due 15 October 11:30pm***
***Technical report for lab 4 due 29 October 11:30pm***

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# TENTATIVE COURSE CALENDAR - NOVEMBER

| Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|
| 1 | 2 Synthetic data systems<br>*Review session*<br>*5:30 – 7:00 pm*<br>*Location: TBA* | 3 | 4<br>**Test 2** | 5 | 6 | 7 |
| 8 | 9<br>Fitts' law | 10 | 11<br>Process mapping | 12 | 13 | 14 |
| 15 | 16<br>Sampling methods | 17 | 18<br>Activity sampling | 19 | 20 | 21 |
| 22 | 23<br>Musculoskeletal injuries | 24 | 25 | 26 | 27 | 28 |
| 29 | 30<br>Musculoskeletal injuries | | | | | |

**Holiday– No Classes**

**Assignment 4-Posted 16 Nov**
**Due 3 Dec at 11:30pm**

**Assignment 5-Posted 30 Nov**
**Due 10 Dec at 11:30pm**

***LAB 5* (9-13 Nov.): TBA**

***Technical report for Lab 5 due 19 November 11:30pm***

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# COURSE CALENDAR - DECEMBER

| Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|
| | | 1 | 2<br>TBD | 3 | 4 | 5 |
| 6 | 7<br>TBD | 8 | 9<br>Final Review | 10 | 11<br>Classes End | 12 |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 20 | 21<br>Grades due | 22 | 23 | | | |
| | | | | | | |

**FINALS WEEK**

~~*Final Project Presentations (during your lab sessions)*~~

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# ENGINEERS VS. TECHNICIANS

- Technicians can apply a well-defined method to a problem for which that method has been shown to produce a solution. They become experts at this.

- Engineers are not super-technicians; their job is different than that of technicians.

- Engineers are given problems to solve for which the correct method to use is unclear, insufficient, or unknown. Engineers reason about a problem and develop solutions. The problems are often complex and ill-defined.
  - I expect you to be able to reason about your work, not just apply a solution methodology and report on the result.
  - I expect you to be able to check the reasonableness of answers, including whether there are any interaction effects not considered as part of the solution.
  - I expect you to be able to solve semi-structured problems.
  - I expect you to be able to estimate when there are uncertainties, and to understand the bounds on that estimate.

# WORK ANALYSIS: WHY DO WE CARE?

- As industrial engineers, some of you will be asked to perform work studies. Some of you will be asked to do process mapping and recommend improvements. Some of you will have to conduct work sampling or task analysis in order to do some other type of analysis (simulation, optimization).

- In IE431, work study/process mapping is the most requested task.

- Our industrial partners tell us this is a skill for which they look when hiring new industrial engineers.

- Work study/process mapping is critical to **reducing waste**
  - Wasted time/effort/motion/energy
  - Errors/injuries
  - Wasted resources (human or material)

# TIME (WORK) STUDY HISTORY: TAYLOR

1900's

- Frederick Taylor applied science to the study of work in the first decade or so of the 20th century. He is best known for "time studies," where analysts measured the time it took for various actions and determined the most effective manner for workers to execute their tasks.

- The classic example relates his work with pig iron laborers. By analyzing patterns of work, he increased the amount of pig iron a laborer could move in one working day from 304 pieces to 1,156 by increasing their pay by 60%.


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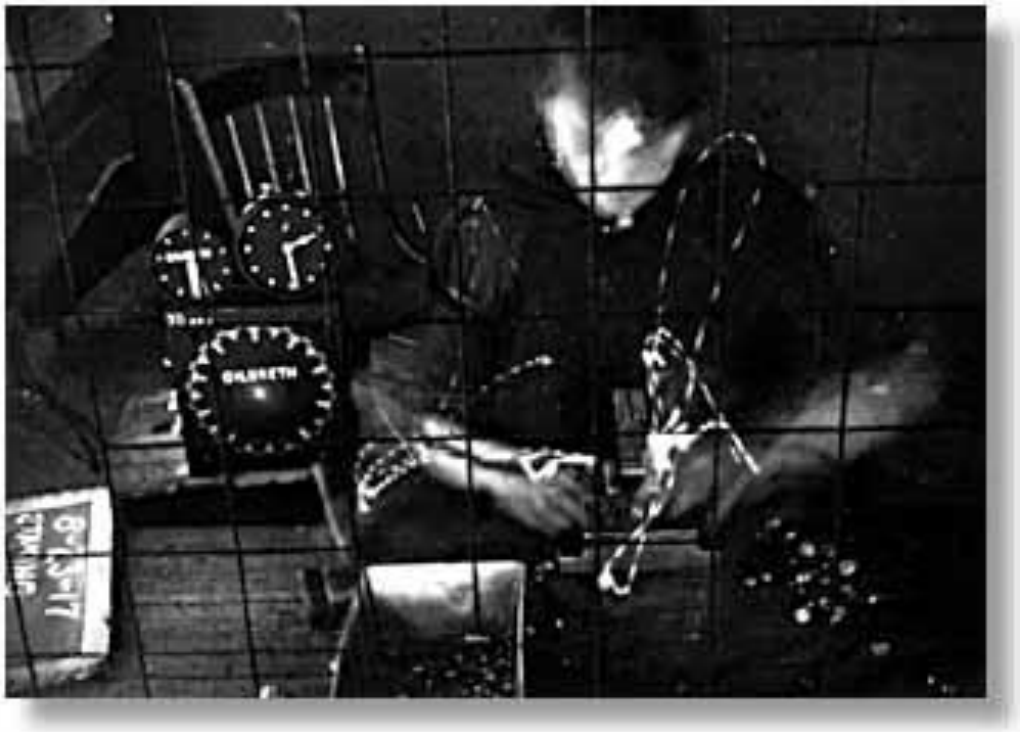
# WORK STUDY HISTORY: GILBRETH

1900's

- The Gilbreths (Frank and Lillian) were successors to Taylor who are known for, among other things, motion studies.

- Frank would carefully photograph an expert worker's motions and find the "one best way" to do the job.  He would then create wire mockups of those motions, and train others to follow those movements.



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# WORK STUDY HISTORY: GILBRETH

1900's

- The most famous example is that of Frank's work with bricklayers, where, by eliminating unneeded motions, he increased the bricks laid from 1000 to 2700

- Lillian continued after her husband's early death, focusing on domestic work and people with physical impairments.

# WORK STUDY HISTORY: ANTHROPOMETRY AND PHYSIOLOGY

- When the primary focus was manufacturing, work study was primarily “work physiology” or “biomechanics.”
- The early focus was on ensuring that humans could operate machines and vehicles, or work effectively in the task environment.
- This work has resulted in a number of principles regarding capability limitations, stature considerations, and for the prevention of injuries.
- Even though the principles were developed a long time ago, they are still very useful, and such analyses are still common tasks for IEs. However, the nature of IE human factors & ergonomics work has broadened considerably.

# WORK STUDY HISTORY: HAWTHORNE EXPERIMENTS

- From 1924 – 1931, a series of experiments examined a number of factors regarding their effect on productivity at AT&T's Western Electric Hawthorne plant in Cicero, Illinois.

- Illumination studies (1924 – 1927)
  - Question: is there a link between lighting intensity and worker efficiency?
  - No identifiable effect of lighting on productivity.

- Relay assembly test room (1927 – 1929)
  - Question: is there a link between other factors and productivity and/or fatigue?
  - Duration of rest and lunch breaks, length of work day, effect of pay incentives tested
  - No identifiable effects

# WORK STUDY HISTORY: HAWTHORNE EXPERIMENTS

Mica-Splitting Test group (1928 – 1930)

- Question: if pay doesn't matter, do work conditions?
- Varied work conditions while keeping pay constant
- Productivity improved 15%
- Conclusion: social dynamics affect productivity

Plant-wide Interview program (1928-1931)

- Interviewed 21,000 employees, surveyed regarding concerns and grievances.
- Conclusion: Work improves when employers listen to employees
- Conclusion: Work and non-work considerations are important
- Conclusion: Norms and groups are important to workers.

Bank Wiring Observation group (1931-1932)

- Recheck the incentive pay finding.
- Gave a small group of coworkers incentive pay.
- Pay had no effect on work product.
- Group members stuck to a "norm" of what work should be done.

# WORK STUDY HISTORY: SHANNON AND FITTS

- World War II exposed a number of deficiencies in engineering complex human-machine systems (such as aircraft). This led to a number of research efforts to rectify this.

- Much of this work was on perceptual, cognitive, and manual control issues. A number of individuals tried to apply information theory, signal detection theory, and control theory to these problems.

- Two of these were Claude Shannon and Paul Fitts. The latter extended the information theory generated by Shannon; in doing so Fitts identified a law relating how long it would take someone to move something (rapidly and accurately) to the information content. This law remains one of the few robust quantitative laws regarding human behavior.

# WORK STUDY HISTORY: TMI

- The Three-Mile Island nuclear accident occurred in 1979, and remains the most serious commercial nuclear plant accident in U.S. history.

- Essentially, the plant had a failure in some feedwater pumps.  Automatic systems kicked in to prevent problems from this, but one of the relief valves failed to close once the situation was stabilized.

- The state of this relief valve was not available to the operators of the plant.  Because of this, the operators were acting without knowledge of the true problem, and ended up making a relatively simple problem much worse -  a meltdown of the nuclear fuel. Fortunately, the melted fuel did not rupture the containment walls or many people may have been killed.

- This problem led to principles for interface design.

# WHY STUDY ERGONOMICS?

Bad design happens…

# WHY STUDY ERGONOMICS?

Even with good designs, breakdowns and inefficiencies can occur in human-machine systems due to the human “components”, which are a great source of uncertainty and variability…

…and sometimes unwise decisions

# IMPACT OF WORK MEASUREMENTS AND DESIGN

- Support human interaction with systems that:
- Enhances performance (greater productivity, fewer errors)
- Increases safety (less risk of accident, disease)
  - Which also means greater productivity (less lost time at work)
- Increases user satisfaction
  - Increased worker productivity
  - Increased product sales, decreased customer support costs