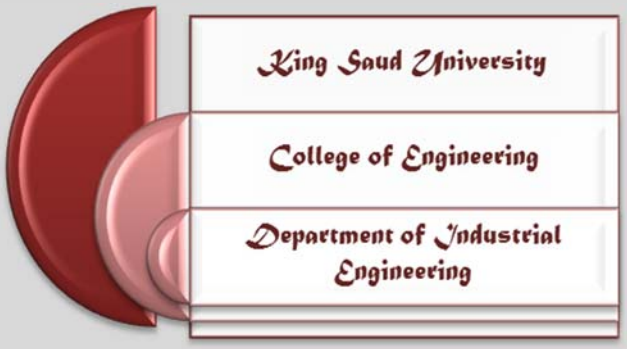

IE342
WORK Analysis and Design Laboratory Manual

Prepared by:
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Preface

This manual is intended for undergraduate industrial engineering students as well as for beginners in Work Analysis and Design. It provides the broad knowledge about the areas of methods, measurement, and management of work. The experiments are designed with standard procedures. The first two experiments are designed to train the students to observe a process and utilize charting methods in documentation. The third experiment is designed to develop student's practical experience in observing and designing a new method that reduces or eliminates ineffective motions. The last three experiments are designed to train the student to utilize three different techniques in order to determine task time.

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Acknowledgment

The writer would like to thank Dr. Mohamed Zaki Ramadan who significantly contributed to the completion of this manual.

Vision

The vision of the work measurement laboratory is to support teaching and research in work methods engineering, and time and motion study.

Mission

The mission of the work measurement laboratory is to provide an environment to enhance the learning experience by teaching through the use of work measurement tools, techniques and equipment.

Courses supported

IE342 – Work Analysis and Design M

Lab safety instructions

1. Determine the purpose and procedure of the experiment by reading the experiment completely before actually beginning.

2. Wear proper protective equipment, e.g. safety goggles, lab coats, safety shoes.

3. Be aware of the dangers of long hair, long sleeves, and loose clothing.

4. Keep sleeves from interfering with activity.

5. Laboratory groups will be assigned. Remain in your lab group throughout the experiment. Lab activities are team efforts.

6. Do the experiments as assigned and in the manner prescribed. Unauthorized experimentation is not permitted.

7. Keep your lab and other working areas neat and clean during lab sessions.

8. Stay on-task and maintain quiet behavior during lab sessions. Loud and boisterous behavior is not acceptable.

9. Dispose of materials in the proper containers as instructed by your teacher. This rule is extremely specific in reference to the disposal of chemicals.

10. To avoid poisoning and/or contamination, no eating or drinking is allowed in the laboratory.

11. Know the location and proper use of the emergency safety materials such as

    a) the fire blanket

    b) eyewash station, and

    c) the fire extinguisher.

    d) emergency exit

12. The teacher must be notified immediately of any accident, even if minor.

13. All laboratory equipment must be properly cleaned, dried and put away at the end of the lab session. this includes goggles, general lab areas, and sinks.

14. No phones or I-pods may be used while in the lab. Distractions can cause accidents. These items will be confiscated and may require all students to turn them OFF before any work can continue.

Table of Contents

LAB 1: Flow PROCESS CHART

I. Objective

The objective of this laboratory activity is to develop the students' practical experience of how to prepare a flow process chart, which is one of the very important charting techniques. The table below shows the symbols that are used in the flow process chart.

Symbol	Title	Description
o	Operation	A main step, where part, material or product usually is modified or changed. Occurs when an object is intentionally changed in one or more of its characteristics.
⇨	Transport	Occurs when an object is moved from one place to another, e.g. movement of people or things. May be accompanied by a distance measurement.
D	Delay	Occurs when the immediate performance of the next planned action does not take place, e.g. idle time of people or machines, or temporary storage of materials.
∇	Storage	Controlled storage in which material is received into or issued from a store, or an item is retained for reference purpose, e.g. storage of materials or other items.
□	Inspection	Occurs when an object is examined for identification or is compared with a standard, e.g. checking of items to ensure correct quality or quantity.

Combined symbols:

Two symbols may be combined whenever their corresponding activities are performed at the same workplace or when they are performed concurrently as one activity; in such case the main activity the outside symbol. For example, the large circle within a square represents a combined operation and inspection where the main activity is inspection.

II. Lab Procedures

1. Choose to do one of the workplaces list below (or think of one on your own):
    a. Engineering college canteen: process is to get breakfast or lunch.
    b. Dr. Café coffee shop: process is to get coffee.
    c. Central library: process is to issue a book to a student from library.
    d. Grocery store: process is to purchase one item.
    e. Panda shop: process is to purchase one item.
    f. Jarir bookstore: process is to purchase a book.
2. Identify the process to be charted and the objective for charting it.
3. Identify the symbol set to be used.
4. Record the steps of the process as they happen, starting at the top of the page, with symbols on the left overlaying vertical line a vertical line with appropriate notes about what is happening to the right. Try to record significant activities which are generally of approximately equal size (unless the problem is at the details level, do not try to capture too much details).

- You can also make the diagram more useful by such tricks as numbering the different action types in sequence. You can also put the time taken in each activity to the left of the symbol.

5. If you are watching the process as it happens, you may want to repeat the analysis several times to ensure that you have captured the normal chain of events.
6. Analyze the final chart, for example, totaling times spent in non-value-adding activities such as storage, movement and inspection.

III. Format of the Lab Report

1. Cover page is the title page in any format.
2. Introduction to process charting advantages – 5 to 7 lines.
3. Process chart for present method.
4. Discussion: analyze the present method and suggest recommendations.
5. Conclusion: what is concluded from the process charting and analyzing the present method?

Work Sheet #					
Present Method □ Proposed Method □			**Process Chart**		
Activity Charted				Date:	
Department				Chart By:	
Operator				Chart No:	
No	Dist.	Time	Chart Symbol	Process Description	

Summary

		Present Method	Proposed Method	Difference
Operation	o			
Transportation	⇨			
Inspection	□			
Storage	∇			
Delay	D			
Dist. Travelled				

Lab 2: Operation Analysis

I. Objective

The objective of this laboratory activity is to give the students some practical experience in observing and documenting a hand-intensive task, analyzing the task's value adding and non-value adding motions.

II. Introduction

The operator process chart (Operation Chart or Left-hand/Right-hand Chart) is used to record observations during a motion study. This operation chart and motion study are used to improve the balance of the workload between hands, eliminate or reduce inefficient movements, train new operators, and document and explain new methods.
The principle purpose of such chart is to assist in finding a better way of performing the task. This chart also has definite value in training operators. Operation chart is an essential tool for anyone concerned with the design of methods, tooling and equipment, material handling facilities, work cell layout and human motion study. It can be used for all types of operations, but it is most applicable for short cycle, large volume production, and uniform method jobs.

III. Lab Procedures

1. Familiarize yourself with motion analysis.
2. Observe the *Pin Board* assembly task performed by the person in front of you in the lab.
3. Draw a sketch of workplace for current work method, indicating the contents of the bins and the location of tools and materials.
4. Watch the operator and make a note of her/his motion while doing the assembly with the predominant hand and record the total time required to accomplish the assembly task.
5. Record the motions or elements of the predominant hand on its designated side of the analysis sheet.
6. Watch the operator and make a note of her/his motion while repeating the assembly with both hands and record the total time required to accomplish the assembly task.
7. Similarly, record the motions or elements of, each on its designated side of the analysis sheet.
8. Because it is hardly ever possible to get the motions of the two hands in proper relationship in the first draft, it is usually necessary to redraw the chart.
9. If you are watching the operation as it happens, you may want to repeat the analysis several times to ensure you have captured the normal chain of events.
10. Analyze the final chart for non-value adding activities such as search, unnecessary movements, storage and inspection.
11. Discuss aspects of current method that can be improved.

IV. Format of the Lab Report

1. Cover page is the title page in any format.
2. Introduction to operation analysis.
3. Brief introduction that explains the task being studied.
4. Current method information:
   - Sketch of layout.
   - Operator process chart (operation chart).
   - Determine the value adding and non-value adding activities.
5. Analysis: explain aspects of the current method that can be improved (on basis of principles of motion economy).
6. Conclusion: what is concluded from operation analysis?

V. Operation Analysis (work sheet)

Layout of the Pin Board assembly:

VI. Left Hand – Wright Hand Chart

MICROMOTION STUDY ANALYSIS SHEET					
Part: bolt and washer assembly			Date:		
Operation: assemble two washers on bolt			Op. No.:		
Operator:			Sheet No.:		
Time	**Symbol**	**Description Left Hand**	**Time**	**Symbol**	**Description Right Hand**

LAB 3: METHOD IMPROVEMENT

I. Objective

The objective of this laboratory activity is to develop the students' practical experience in observing and designing a new method (including workstation layout) that reduces or eliminates ineffective motions.

II. Lab Procedures

1. Observe the bolt and washer assembly task performed by the person in front of you in Lab #2.
2. Analyze the final charts made in Lab #2 for non-value-adding activities (i.e. unnecessary movements, storage, inspection, etc.).
3. Review the current method for opportunities of improvement and describe the aspects of the current method that can be improved.
4. Describe modified work method:
    a. Draw a sketch of the layout of workstation for revised method.
    b. Create an operation chart for revised method.

When designing a new workstation layout or a method, keep in mind the principles of motion economy. The following are some suggestions:

a. There should be a definite and fixed place for all tools and materials.
b. Tools, materials, and controls should be located close to the area of use.
c. Gravity feed bins and containers should be used to deliver materials close to the area of use.
d. Materials and tools should be properly located in order to permit the best sequence of motions.
e. The main objective is to eliminate idle or hold time for any of the hands.
f. Jigs and fixtures should be used wherever possible to improve productivity.

III. Format of the Lab Report

1. Cover page is title page in any format.
2. Introduction to operations analysis and methods improvement.
3. Revised method information as explained above:
    - Sketch of layout.
    - Operator process chart (operation chart).
    - Determine the value adding and non-value adding activities.
4. Analysis: compare the current and revised method on the basis of principles of motion economy. Explain why you expect the revised method to improve productivity.
5. Conclusion: what to be concluded from operations analysis and method improvement.

IV. Operation Analysis (work sheet)

Layout of bolt and washer assembly (improved method):

V. Left Hand – Wright Hand Chart

MICROMOTION STUDY ANALYSIS SHEET					
Part: bolt and washer assembly			Date:		
Operation: assemble two washers on bolt			Op. No.:		
Operator:			Sheet No.:		
Time	**Symbol**	**Description Left Hand**	**Time**	**Symbol**	**Description Right Hand**

LAB 4: TIME STUDY

I. Objective

The objective of this laboratory activity is to develop the students' practical experience in time study. Students will watch a video of a short time repetitive task, divide that task into elements, collect pilot data, and then process that data to find standard time for the task.

II. Introduction

Time study is used to determine the time required by a qualified and well-trained person working at a normal pace to do a specified task. Time study is the technique for establishing an allowed standard time to perform a given task. This technique is based on the measurement of the work content of the prescribed method, with due allowance for fatigue, and for personal and unavoidable delays. The result of time study is the time that a person suited to the job and fully trained in the specified method will need to perform the job if he works at a normal or standard speed. This is called standard time.

III. Lab Procedures

1. Familiarize students with the stopwatch (or windows movie maker software).
2. Observe the task (video)
3. Divide all manual work into elements (fundamental hand motion - Therbligs), and write down on your time study form.
4. Collect the pilot data. Make sure to make appropriate notation about any parts of the task that are not usual.

IV. Data Analysis

1. Determine mean time and standard deviation for each element.
2. Based on this pilot data, determine the number of cycles to observe for a full time study:
3. How many cycles should you study for 95% confidence level and a precision of ±5%.
4. How many cycles should you study for 95% confidence level and a precision of ±10%.
5. Assume that an actual time study has been conducted and the average cycle time obtained turned out to be the same as in the pilot study.
6. Performance rating is a part of the time study process. What rating would you provide to supplement the time data collected? (i.e. how much has the operator produced during the time study relative to what would be expected from a normal operator?) show your work.
7. In order to calculate the standard time for the task, allowances are typically added. What allowances should be included for this particular task? (briefly explain your response.)
8. Calculate the standard time for the task. (show all your work in details.)

9. What would be the hourly production rate for one operator? (show all your work in details.)

V. Format of the Lab Report

1. Cover page is title page in any format.
2. Introduction to time study (not more than 5 lines).
3. Methodology.
4. Data Analysis.
5. Details about performance rating and allowance considered for this time study.
6. Calculations.
7. Results.
8. Conclusion.

VI. Time Study Sheet for Pilot Data

Date:	**Time Study Sheet for Pilot Data**		Page of
Operation:			Part No
Machine:			Tooling
Worker:			Worker No
Analyst:	Start Time	Finish Time	Elapsed Time

Work Elements, Machine Settings, and Observations				Cycle No (regular elements)											
No	Element Description	Feed	Speed		1	2	3	4	5	6	7	8	9	10	*Avg* T_n
				T_{obs}											
				PR											
				T_n											
				T_{obs}											
				PR											
				T_n											
				T_{obs}											
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				T_{obs}											
				PR											
				T_n											
				T_{obs}											
				PR											
				T_n											
Normal time = Sum of T_n (regular work elements)															

No	Irregular Element Description	Freq	T_0	T_f	*PR*	T_n		Calculation of Standard Time T_{std}	
								Sum of T_n (regular work elements)	
								Sum of freq x T_n (irregular elements)	
								Total T_n per cycle	
								PDF allowance A_{pdf}	
								Standard time $T_{std} = T_n (1 + A_{pdf})$	

Additional Notes

Lab 5: MOST

I. Objective

The objective of this assignment is to familiarize students with the software version of MOST, by utilizing the software to develop a normal time estimate for performing computer mouse assembly task.

II. Introduction

MOST stands for Maynard Operation Sequence Techniques. MOST is a predetermined time system which allows the analysis of any manual operation and several equipment operations. MOST uses fundamental activities, which are combinations of motions to analyze movement of objects. The basic patterns of movements are described in normal, pre-defined sequences. Time values are expressed as index values, which represent a range of times. These indexes are then assigned to the fundamental activities to allow analysis of operations. MOST is based on the principle of work, which is defined in physics as (Force x Distance). Time units used in MOST are called time measurement units (TMU). One TMU equals 0.00001 hours.

MOST technique is of the following basic pre-defined sequence models:

1. General Move: sequence for the spatial movement of an object freely through the air.
   Example: walk three steps to pick up a bolt from the floor level, arise, and place it in the hole.
2. Controlled Move: sequence for the movement of an object when it remains in contact with a surface or is attached to another object during the movement.
   Example: engage a feed lever on a milling machine.
3. Tool Use: sequence for the use of common hand tools.
   Example: use of a wrench.

III. Advantages of MOST

1. Time reflects a 100% performance level.
2. Fast to apply.
3. Easy to understand and learn.
4. Consistent rules.

IV. Applications of MOST

1. Determine the total labor cost of the product.
2. Determine the number of production workers required.
3. Determine the number of machines required.
4. Determine the delivery time for a product.
5. Determine the overall production schedule.
6. Set realistic production goals.
7. Determine the actual cost of production.

V. Lab Procedure

1. Students will be introduced to the MOST software and get a chance to explore it.
2. They will use MOST to determine the normal time for the mouse assembly task.
3. In order to do this, they will need to divide up the assembly job into activities based on moving objects (pieces of the mouse and the screwdriver).
4. They will then describe each of these activities using appropriate MOST sequence models.
5. They will end up with a series of models that describe the entire assembly process, such that when adding up the time from each model they will have the normal time for the mouse assembly task.
6. Students will have to complete the construction of the series of MOST models during the lab.

VI. Format of the Lab Report

1. Introduction: brief introduction to MOST and to the activity to which you applied MOST.
2. Your MOST analysis: for each activity to which you applied a MOST sequence model, provide a brief description and include any assumptions you made in selecting the particular sequence model or parameter index values.
3. Provide descriptive and quantitative comparisons between your MOST analysis and your previous time study analysis.
4. Discuss any significant differences between the two analyses (do the measured and predicted times match? If so, why or why not?)

VII. MOST Sheet

	MOST SHEET	DATE: ANALYST: PAGE:

DESCRIPTION

INSTRUCTIONS APPLICATOR OPERATOR SAFETY

UNIT OF MEASURE

TMU FROM PREVIOUS PAGE

STEP No	HAND L/R	METHOD STEP DESCRIPTION	SEQUENCE MODEL	PF	FR	SIMO	TMU

TOTAL TIME HOURS:_______ MINUTES:_______ SECONDS:_______
TMU:_______

LAB 6: Work Sampling

I. Objectives

The objective of this laboratory activity is to develop the students' practical experience in work sampling.

II. Introduction

Work sampling is based upon the laws of probability. A sample taken at random from a large group tends to have the same pattern of distribution as the large group or universe. If the sample is large enough, the characteristics of the sample will differ but little from the characteristics of the group. Sample is the term used for the large group. Obtaining and analyzing only a part of the universe is known as sampling (Barnes 1980).

III. Methodology

The bars in figure 1 represent to scale the 240 minutes of the forenoon and the afternoon for five consecutive working days (Monday through Friday) a full 40-hour week (2400-minutes). The results of a continuous time study of one operator for one week are shown. "White" represents working time while "Black" represents idle time. The total actual working time for the week from the time study is 2035 minutes while the total idle time for the week from the time study is 365 minutes.

Percentage of working time $= \frac{2035}{2400} \times 100 = 84.8\ \%$

Percentage of idle time $= \frac{365}{2400} \times 100 = 15.82\ \%$

Now see how you can obtain similar information by the use of random sampling. You can make your own random observations by following the instructions below:

1. Draw at random 20 vertical marks across each of the ten bars shown on the given sheet. Do not space the marks at regular intervals (space marks randomly along the entire length of the line).

2. These marks represent 20 random observations made of the operator during the forenoon and the afternoon.

3. Now count the number of times your marks intersects with the black portion of the bars and write this number in the box at the end of the line.

4. Then add the number of idle observations and divide this total by 200. This gives you the percentage of the week that the operator was idle by the random sampling procedure.

5. Now compare your answer with the actual idle percentage of 15.2 %, which was originally obtained by time study.

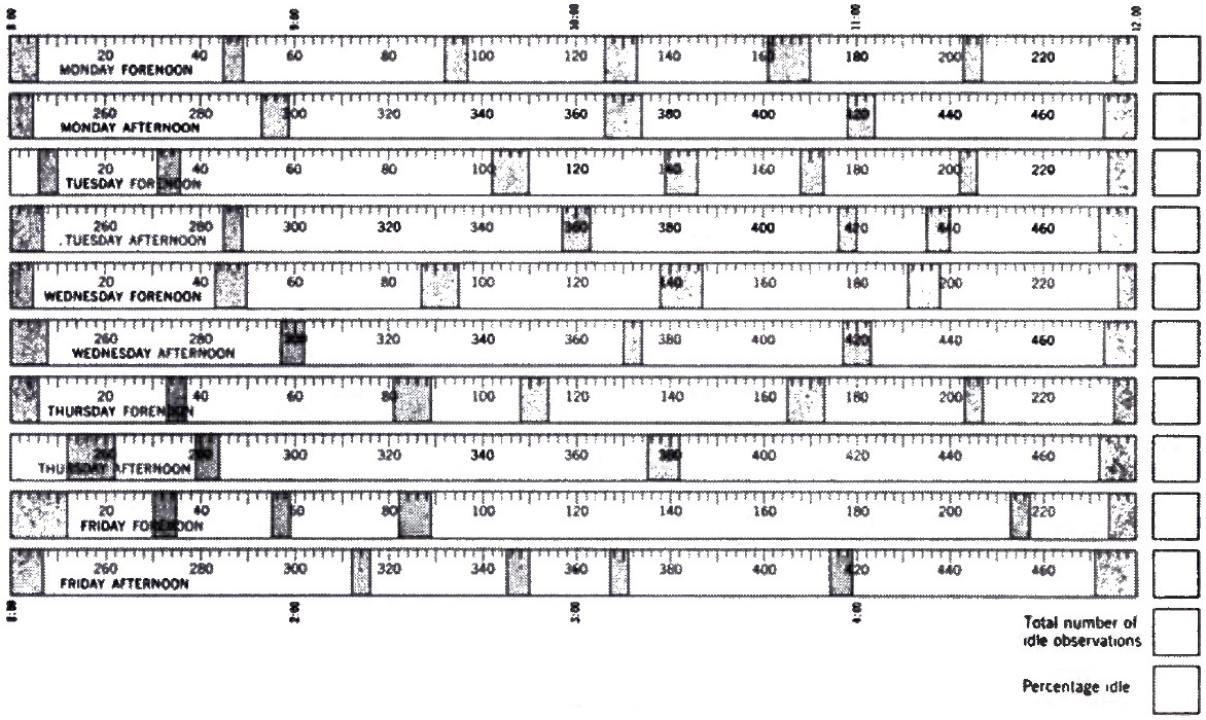

Figure 1: Working time and idle time for one operator for five consecutive working days.

Figure 2 shows a simple work sampling study. results of random observations shown on the bars represent one working day.

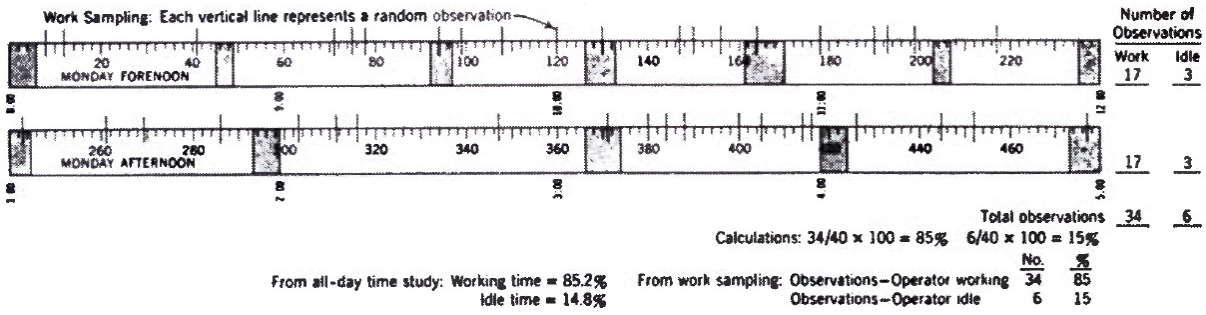

Figure 2: simple work sampling study for one working day

IV. Calculations:

1. Determination of the Accuracy of a given number of observations:

   After the study is completed, a calculation is made to determine whether the results are within the desired accuracy (consider a confidence level of 95%). This can be done by calculating *c* in the following formula:

$$c = Z_{\propto/2} \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} \times 100$$

   Where:
   $Z = standard\ score$
   $\propto = probability\ of\ type\ I\ error\ [confidence\ level\ is\ (1-\propto)]$
   $\hat{p} = proportion\ of\ total\ number\ of\ observations\ of\ an\ activity\ of\ interest$
   $n = total\ number\ of\ observation$

2. Determination of the number of observations require for a given accuracy

   Assume that the confidence level is 95% and the accuracy is ±5%, calculate the sample size required using the following formula:

$$n = \frac{(Z_{\propto/2})^2\ \hat{p}\ (1-\hat{p})}{c^2}$$

   Where:
   $Z = standard\ score$
   $\propto = probability\ of\ type\ I\ error\ [confidence\ level\ is\ (1-\propto)]$
   $\hat{p} = proportion\ of\ total\ number\ of\ observations\ of\ an\ activity\ of\ interest$
   $n = total\ number\ of\ observation$

3. Determining standard time using work sampling:

   Assume total work time is 2400 minutes per week, number of parts produced per day is 330, actual working time in percent is obtained from sampling sheet, the average performance rating for the worker is 110%, and the total allowances are 15%. Follow procedures provided in the lecture notes for determining the standard time per part.

V. Format of the Lab Report

1. Cover page is title page in any format.
2. Introduction to work sampling (5 to 7 lines).
3. Methodology (10 to 15 lines).
4. Calculations.
5. Results.
6. Conclusion.
7. Attach Sampling sheet.