8/26/06

In-Class Laboratory Exercise #2
(Turn in after completing)

Name:

____

Hand in this page with answers to the following:

Question 1: What is the average time for Element 1? ___________

Question 5: What is Standard time for the entire assembly task? _______

Question 9: What is the time in system? _________

Question 11: What is the time in system in minutes? ______

Question 14: What did you get for:

Question 16: If a kit requires 86 components, how many hours do you expect assembly to take? _______________

Question 17: What do you get for the loan amount of the $400 payment? __________

Question 18: How much now can you spend on a car (down payment plus loan amount)? ___________________

In-Class Laboratory Exercise #2

In this lab you will learn to:

Model some engineering problems

- work measurement,
- queuing,
- prediction using regression, and
- time value of money problems

Apply Excel manipulation skills learned previously

Make more use of the "fill handle"

Name cells to document your model and to ease its manipulation

Write Excel expressions

Part 1: Work Measurement: How long does it take?

Background:

Engineers measure the efficiency of the firms based on some knowledge of how long it should take to make a product or produce a service. Without an indication of the time requirements it is difficult to estimate costs and thus quote a price, develop a budget, determine capacity, evaluate employees' performance and compensate them accordingly, and develop incentive plans and merit increases.

One of the accepted methods to measure the time required to perform a job is Time Study. Time study was formalized by Frederick W. Taylor in 1881. A time study is generally made with a (electronic) stopwatch. Typically, the job to be studied is broken down into a set of sequential tasks (job elements). Each element is timed individually. After a number of repetitions, the collected times are averaged, rated, given allowance, and added together. The total time is an estimate for how long it takes for the operator to perform this job.

Formulas:

To use this time measurement for all operators, a measure of speed or performance rating needs to be included to "normalize" the task. The application of a rating factor produces the "normal time":

normal time = observed performance time * performance rating.

There are other considerations: personal time such as coffee breaks, unavoidable work delays such as equipment breakdown, and operator fatigue. These are called “allowances” and are aggregated as a percentage of the normal time. Once allowances are added to the normal time, the result is referred to as “standard time”.

standard time = normal time *(1+ allowances).

Standard times are used for capacity planning, budgeting, scheduling, and other mentioned applications.

Step 1: Copy “InClassLab02.xls” from *Workspace->Common* to your own account and open it in Excel. Look at the worksheet in “Part 1” tab. This worksheet contains record of observations by a time study of an assembly task as seen in Table 1. The task has been divided into 6 elements. We have observed 10 cycles of the task. The stopwatch is run continuously for each cycle and the time reading, in minutes, for the completion of each element is registered. The stopwatch is reset to 0 after each cycle.

Table 1: 10 Cycles of the Task

	Cycle (Minutes)									
	1	2	3	4	5	6	7	8	9	10
Element 1	7.23	9.69	5.32	11.04	6.76	6	9.65	4.78	6.68	13.07
Element 2	23.18	16.32	18.71	21.37	14.95	15.28	22.81	17.14	20.55	32.94
Element 3	38.35	50.63	33.13	42.09	48.68	26.45	42.36	47.39	35.85	55.01
Element 4	52.36	68.78	52.63	66.44	62.02	38.04	57.48	57.52	48.06	68.17
Element 5	70.52	95.33	72.71	86.08	76.87	58.58	87.84	79.12	72.82	100.01
Element 6	82.88	108.48	86.82	93.41	89.23	66.86	101.81	84.48	86.18	109.66

Step 2: From this table you need to compute the “time” for each element in each cycle. Although we did this incrementally in the previous InClass lab, let’s do it quickly.

First copy **B3:L9** to **B12**.(use *Ctrl-**)

In **C14** enter “`=C5-C4`” (use pointing)

Copy **C14** down to **C18 (**use the “fill handle”)

Copy **C14:C18** across to column **L**.

Step 3: Add the text “Total” in **M12**, “Average” in **N12**, “Normal” in **O12**, and “Standard” in **P12**. Center the text and use Arial 12 Bold for the font.\

Normal time and Standard time for Element 1:

Step 4: Use AutoSum to compute the total (across the row) for **C13**

Step 5: Double click the fill handle to copy the formula down the columns to **M18**.

Step 6: Highlight **M12:P18** and use *Insert->Name->Create* to define a named range. The word **Total** refers to the range of **M13:M18**. We will be able to use these names in formulas to reduce errors as well as make it more readable.

Step 7: In **N13**, enter "=", then point to **M13** and then "/10".

Question 1: What is the average time for Element 1? ___________

Step 8: It is observed that this operator is 10% faster than expected for a typical operator. You need to increase your observed time to the expected average by this performance. The normal performance would be 100% and since these observations are 10% above normal, the performance rating is 110%.

In cell **N3**, put the text "Rating".

Using *Insert->Name->Define* name cell **N4** "Rating" and put the value 110% in it making sure to format the cell using the either the *Format Cell* menu or the % toolbar button. Now we can use the word **rating** and it will refer to the cell **N4** is therefore the same as an absolute address.

Normal Time for this element would be in **M17** as `=Average * Rating`. Note: addressing a cell by its name is same as addressing a cell using absolute addressing.

Question 2: What is the normal time for Element 1? _______________

Step 9: There are components of the work day not being observed such as breaks, interruptions, etc. In consideration of these, we add an allowance of 15% to the normal time.

In cell **O3**, put the text "Allowance"

Name cell **O4** "Allowance" by writing it directly into the "name" and put the value 15% in the cell.

Compute the Standard Time for Element 1 by adding the "Allowance" to the Normal Time (**O13**) making sure use the named ranges. (Remember that allowance is added.)

Question 3: What is the Standard time for element 1? _________________

> ***Step 10:*** Now highlight **M13:P13** and double clicking the fill handle to copy down from **M13:P13** to row **18**, which will compute the values for all "elemental times"..

Question 4: What is the Standard time for element 6? _________

> ***Step 11:*** Also only show two digits of precision (why?)

> ***Step 12:*** Compute the sum of elements for the Average, Normal, and Standard times. (use "`autosum`" for Average and copy this total to Normal and Standard).

Question 5: What is Standard time for the entire assembly task? _______

Part 2: Queuing: How long do I have to wait?

Hillsborough Community bank is considering opening a drive-in window for customer service. The drive-in window will be assigned to one teller who will give that service priority. Now you are being asked to determine:

> how busy the teller will be providing that service,
>
> how long (on the average) will the customers wait at the drive-in window to start service,
>
> how large is the waiting line expected be, and
>
> how long customers are expected to be in the system (waiting plus service).

Presently we expect about 10 arrivals to our drive-in window per hour. The service is expected to last about 4 minutes on the average.

Background:

Queuing is a description of waiting in a line. You go to the bank or to get lunch or to pick up tickets for a football game or go to the doctor's office or just about any place, you will have to wait!

There is some theory, called "Queuing Theory," that will allow you to compute characteristics of a waiting line if you are willing to make some assumptions about how the arrivals to the line and services from the line take place. Let's assume you accept those assumptions (you may learn more about them in a later class).

Formulas:

Assume now the arrival rate (as in people per hour) is given by the symbol λ. The service rate (as in people per hour) is given by the symbol μ. When there is one waiting line and one server, queuing theory tells us:

- Utilization of the server: $\frac{\lambda}{\mu}$
- Average waiting time in line: $\frac{\lambda}{\mu(\mu-\lambda)}$
- Average number in the waiting line: $\frac{\lambda^2}{\mu(\mu-\lambda)}$ or Average waiting time * λ
- Average time in the system (waiting plus service): $\frac{1}{\mu-\lambda}$

Notice that only λ and μ are needed!

Step 1: Insert a new a new worksheet, using *Insert->Worksheet*, to this workbook. Name it "Part 2."

Step 2: On the worksheet set up cells as shown below (You can insert symbols by *Insert-Symbol*):

	A	B	C
1	λ		arrivals/hour
2	μ		services/hour
3			
4	Utilization		
5	Waiting Time		hours
6	Number Waiting		customers
7	Time In System		hours

Step 3: Name cells **B1** and **B2** for λ and μ. Enter into **B1** the value 10 (arrivals per hour) and into **B2** the value of =60/4 (services per hour). In column C, place the units in text. Then add the Excel formulas to **B4**, **B5**, **B6** and **B7** according to mathematical formulas shown earlier. Be sure to use the "named" variables.

Question 6: What is the utilization of the teller? ______

Question 7: What is the waiting time (in hours)? _______

Question 8: What is the number waiting? _________

Question 9: What is the time in system? _________

Question 10: What is the waiting time in minutes? _______

Question 11: What is the time in system in minutes? ______

<u>Part 3:</u> Can we predict the value? (Breaking a Problem Apart)

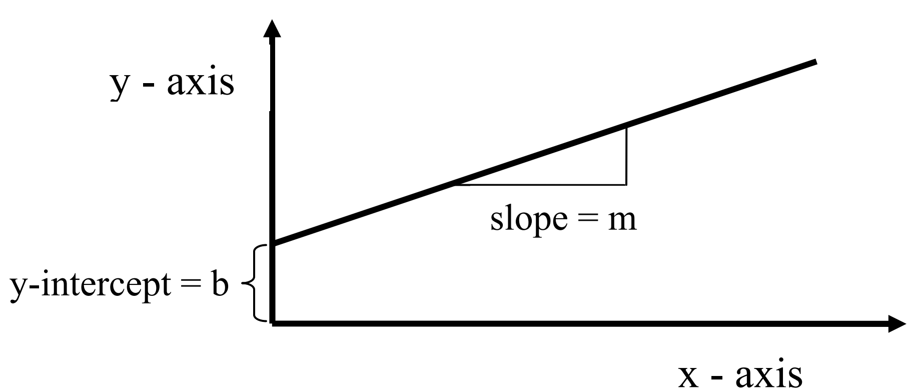
Electronic kits are assembled from various components. The number of labor hours needed to assemble the kit is needed to determine a cost for a kit. However, each kit is different and so the number of hours cannot be directly determined. The company has kept some records on the number of components and the assembly hours required.

<u>Background:</u>

A simple model of the affect of one variable, say x, on another, say y, is a simple linear equation:

$$y = \mathrm{m}x + \mathrm{b}.$$

Here y is the dependent variable and x is the independent variable. The parameter "b" is the intercept on the y-axis and parameter "m" is the slope. Graphically, the relationship is:



If that relationship appears appropriate, the question is how to estimate the parameters "m" and "b".

Formulas:

Fortunately, there are statistical methods for this problem called "linear regression" (which you will learn about in statistics classes). The results provide an estimate m and b from the following equations:

$$m = \frac{\sum_{i=1}^{n} x_i y_i - n\bar{X}\bar{Y}}{\sum_{i=1}^{n} x_i^2 - n\bar{X}^2}$$

$$b = \bar{Y} - m\bar{X}$$

The x_i and the y_i and the observations of the independent and dependent variables. The $\bar{X}$ and the $\bar{Y}$ are the averages of the respective variables. As an engineer, you should break a problem into simpler portions and solve those portions. This reduces the chance of introducing errors into the solution.

An Aside: Are you familiar with the $\sum$ sign? It is called the "summation sign" and it means you want to sum a series. Here are some examples:

$$\sum_{i=1}^{10} i = 1+2+3+...+10 \qquad \sum_{j=1}^{4} x_j = x_1 + x_2 + x_3 + x_4$$

$$\sum_{i=3}^{n} z_i^3 = z_3^3 + z_4^3 + z_5^3 + ... + z_n^3 \qquad \sum_{m=0}^{100} 2^m = 2^0 + 2^1 + 2^2 + ... + 2^{100}$$

$$\sum_{i=1}^{3}\sum_{j=1}^{2} x_i y_j = x_1y_1 + x_1y_2 + x_2y_1 + x_2y_2 + x_3y_1 + x_3y_2$$

Sometimes the limits of the sum are implied by the applications such as $\sum xy$ means to sum the product *x* times *y* over their values. You'll see examples below.

Step 1: Go to the worksheet named "Part 3". In this worksheet the computational framework has been created. Also the data on the number of components (x) and the labor hours (y).

Step 2: Select all of the *x* and *y* values and name the columns **x** and **y**.

Step 3: Compute the **D2** and **E2** as labeled using the named ranges (**x** and **y**).

Question 12: In row **2**, what did you get for:

x*y: __________

x^2 ____________

Step 4: Now double click the fill handle to copy formula down the **D2:E2** to row **26**. Name these data ranges using *Insert->Name->Create*. (Note the name of the x^2 column.)

Step 5: Compute n from `COUNT()` and the sums using `SUM()`. Use the named ranges.

Question 13: What did you get for:

n: _________________

Σx: _______________

Σy: _______________

Σxy: _______________

Σx^2: _______________

Step 6: Using *Insert->Name->Create* to add names in their associated cells for A29:E29**.**

Step 7: Using the names, create Excel expressions is **C34** and **C35** for “m” and “b” from the formulas given for linear regression.

Question 14: What did you get for:

m: ______________

b: ______________

Step 8: Name these cells as “m” and “b”.

Question 15: Write down the complete linear equation that obtains the expected hours (y) for a given number of components (x):

Question 16: If a kit requires 86 components, how many hours do you expect assembly to take? _______________

Part 4: How much Car can you afford?

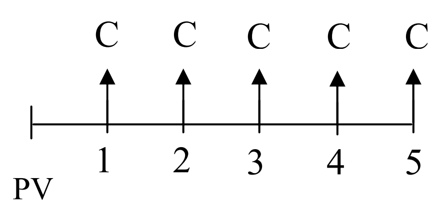
You want to buy a car. However you don't have much money, so you will have make car payments. Suppose you have $2000 to put down on a car. You might be able to make payments of $400 per month. Your bank will make you a car loan at 6% interest per year for four years. How much car can you afford?

Background:

Fortunately (or unfortunately) this is a common problem in finance and engineering economy (something you will learn more about). Essentially we must recognize the "time value of money." This means that $1 saved with an interest of 10% per year is worth $1.10 after the first year (assuming we "compound it only at the end of the year). Likewise when you borrow money you pay back more than you borrow because the loan has interest to be paid. So if you borrowed $1 now, you would owe $1.10 at the end of the year to pay back that $1. If you waited two years to pay it back you would owe $1.21 because you have to pay interest on the interest (compounding).

Formulas:

Essentially the question is the "present worth" of a series of payments that earns a given percent of interest. This problem can be expressed with a "cash flow diagram" as:



If we make *C* payments at the end of each of *N* periods and the interest rate is *i*, then the present value (PV) of this series is:

$$PV = C\sum_{t=1}^{n}\frac{1}{(1+i)^t} = C\left[\frac{1-(1+i)^{-N}}{i}\right]$$

Although Excel has built-in function to handle such formulas, it is useful to be able to compute it directly.

Step 1: Insert a new worksheet and call it "Part 4".

Step 2: Set up your worksheet as shown below. Name cells **B1**, **B2**, **B3**, and **B5** with the names whose text is in column **A**. Name **E1** "Down". (Notice that names are "global" in the sense that they apply to all worksheets in a workbook)

	A	B	C	D	E
1	Periods	48		Down	$2,000
2	Interest	0.005			
3	Payment	$400			
4					
5	Loan			Car Cost	

In general we set up our spreadsheet to work from left-to-right and top-to-bottom.

Step 3: There are 12 months in a year and we will use monthly time periods. Thus, the value in **B1** is `=4*12`. The value in **B2** is `=6%/12`. The value in **B3** is `=$400`. In **E1** enter $2000.

Step 4: In **B5**, compute the present value (loan amount) from the mathematical formula given. In **E5**, compute the amount that you can spend on the car (down payment + loan amount).

Question 17: What do you get for the loan amount of the $400 payment? __________

Question 18: How much now can you spend on a car (down payment plus loan amount)? ___________________

Question 19: "What if" you can only make $300 per month payments? How much can you now spend on a car? ______________

<u>**Part 5:**</u> Things to do on your own:

Step 1: Experiment with "naming". First try to name **B1** in "Part 4", the name "N".

Question 20: Why can't you name it "N"? ____________________

Question 21: Why can't you name **B3**, namely the payment, "C"? ___________

Question 22: What can't you use the name "X1"? ______________

Step 2: You can obtain a listing of the "named" ranges within your workbook. Insert a new worksheet called "Part 5". With **B2** selected, do *Insert->Name->Paste…* and select "Paste List".

Question 23: How many names are in your workbook? __________

Question 24: What is the address of the named range *λ*? __________

Question 25: What does the "$" mean? ______________________

Step 3: You can "audit" the formulas you created in your worksheets. Invoke the worksheet called "Part 2" in the workbook. Next invoke *Tools->Formula Auditing->Show Auditing Mode*.

Question 26: How did your worksheet change? _______________

Question 27: What is the formula in **B4**? __________________

Step 4: Select the cell **B6** and invoke *Tools->Formula Auditing->Trace Precedents*

Question 28: What are the precedents for **B6**? _______________

Step 5: Next select cell **D5**. Now invoke *Tools->Formula Auditing->Evaluate Formula.*

Question 29: Click the "Evaluate" button to show the steps in evaluation.
What does step 1 do? _______________
What does step 2 do? __________________________

Step 6: Now invoke *Tools->Formula Auditing->Show Formula Auditing Toolbar*. Now you can see all the options.

Step 7: Click **D5** and then on the "comment" tool. Add the comment "This is my waiting time."

Step 8: Now click off auditing by clicking *Tools->Formula Auditing->Show Auditing Mode* again.

Step 9: Note that the "comment" now shows. You can "turn off" the showing of comments by either clicking the "Show all comment" tool on the toolbar or by *View->Comments*.

Question 30: If you now click on the red diamond in the top right part of **D5**, what happens? ______________________