

The PM's Guide to an A

Learning Curve Problems

Microsoft Excel can be used for learning curve problems to determine how long it takes to produce items in bulk as well as determining cost per unit, the total cost of a production batch, suggested sale price per unit, and the break-even point of a manufacturing project.

Step 1: Set up Excel Spreadsheet

- Create a new spreadsheet and set aside a cell to enter your learning rate. In the picture to the right, this is cell B4.
- Create a numbered list of how many units you plan to produce. In this example, we will be producing 20 units, and we have listed 1 through 20 in cells C6:C25.
- Immediately to the right of this list will be our calculation of how long each unit takes to produce (cells D6:D25). It is up to the PM to enter the time for unit 1. For this example, the time will be entered in cell D6.

	A	B	C	D
1	Learning Curve Problem			
2				
3		Learning Rate		
4				
5				
6		n=	1	
7			2	
8			3	
9			4	
10			5	
11			6	
12			7	
13			8	
14			9	
15			10	
16			11	
17			12	
18			13	
19			14	
20			15	
21			16	
22			17	
23			18	
24			19	
25			20	

Step 2: Enter Formulas

	A	B	C	D
1	Learning Curve Problem			
2				
3		Learning Rate		
4				
5				
6		n=	1	
7			2	=B\$4^(LOG(C7,2))*\$D\$6
8			3	

- The formula to calculate time in a learning curve is:
 - $Y_x = Kx^{\log_2 b}$
 - K is the number of hours to produce the first unit
 - Y is the number of hours to produce the xth unit
 - X is the unit number
 - B is the learning rate
- Therefore, starting with the time cell for unit 2, enter the formula:
 - =B\$4^(LOG(C7,2))*\$D\$6
 - You may need to adjust the cell references for your spreadsheet. However, ensure that the references to the learning rate and the first unit's time are absolute references.
- Extend this formula all the way down to your last unit.
- Select a cell to calculate the total time to produce all items. Use the SUM function to add up all of the time calculations (in this example, =SUM(D6:D25)).

	A	B	C	D
1	Learning Curve Problem			
2				
3		Learning Rate		Total Time to Produce
4				=SUM(D6:D25)
5				
6		n=	1	
7			2	0
8			3	0
9			4	0
10			5	0
11			6	0
12			7	0
13			8	0
14			9	0
15			10	0
16			11	0
17			12	0
18			13	0
19			14	0
20			15	0
21			16	0
22			17	0
23			18	0
24			19	0
25			20	0
26				

Step 3: Enter Data and Determine the Learning Rate

- Typically, you will be given the time to produce the first unit, the number of units produced, and the total time to do so. For our example, 20 units were produced in 350 hours, and the first unit was produced in 40 hours.
- Enter the time to produce the first unit (40) into your spreadsheet (cell D6).
- Click on the Data tab and select What-If under Analysis, then Goal Seek.
- Instruct Goal Seek to set the total time to produce (D4) to the value provided in your problem (350), by changing the learning rate (B4). Click
- The learning rate will be entered into your spreadsheet. In this example, it is approximately 0.7474.

	Learning Rate	Total Time to Produce
3		
4	0.7474	40
5		
6	n=	1
7		2
8		3
9		4
10		5
11		6
12		7
13		8
14		9
15		10
16		11
17		12
18		13
19		14
20		15
21		16

Goal Seek

Set cell:

To value:

By changing cell:

Step 4: Minimum Time Requirements

- No manufacturing job can keep increasing its efficiency forever, so if a minimum time required to produce an item is specified, you will need to manually replace any calculations that fall below this threshold. For example, if our minimum time to produce a unit was 12 hours, then we would replace the times for units 18 through 20 with 12.

16	12.48418791
17	12.17034288
18	12
19	12
20	12

Advanced Problems: Calculating Cost of Production

- If a problem provides you with the cost of parts and labor, you can determine the cost of each unit as well as total cost.
- Select a cell to enter your cost of labor per hour (B9) and the cost of parts per unit (B12).
- Four new columns are added to our calculations: parts cost, labor cost, unit cost, and cumulative cost.
 - Parts cost is an absolute reference to the cost of parts per unit.
 - Labor cost is an absolute reference to the cost of labor per hour multiplied by how long the unit takes to produce.
 - Unit cost is the sum of the parts and labor costs.
 - Cumulative cost is the sum of the unit costs up to the current unit, which shows how much a production line has spent after producing a certain number of units.
- The picture below is a suggested setup for your spreadsheet.

	B	C	D	E	F	G	H
1	Learning Curve Problem						
2							
3	Learning Rate		Total Time to Produce				
4	0.747438195183886		=SUM(D6:D25)				
5				Parts Cost	Labor Cost	Unit Cost	Cum Cost
6	n=	1	40	=\$B\$12	=\$B\$9*D6	=E6+F6	=G6
7		2	=\$B\$4^(LOG(C7,2))*\$D\$6	=\$B\$12	=\$B\$9*D7	=E7+F7	=H6+G7
8	Labor \$/hr	3	=\$B\$4^(LOG(C8,2))*\$D\$6	=\$B\$12	=\$B\$9*D8	=E8+F8	=H7+G8
9		4	=\$B\$4^(LOG(C9,2))*\$D\$6	=\$B\$12	=\$B\$9*D9	=E9+F9	=H8+G9
10		5	=\$B\$4^(LOG(C10,2))*\$D\$6	=\$B\$12	=\$B\$9*D10	=E10+F10	=H9+G10
11	Parts \$/unit	6	=\$B\$4^(LOG(C11,2))*\$D\$6	=\$B\$12	=\$B\$9*D11	=E11+F11	=H10+G11
12		7	=\$B\$4^(LOG(C12,2))*\$D\$6	=\$B\$12	=\$B\$9*D12	=E12+F12	=H11+G12

	B	C	D	E	F	G	H
1	Learning Curve Problem						
2							
3	Learning Rate	Total Time to Produce					
4	0.747438195	351.1364224					
5				Parts Cost	Labor Cost	Unit Cost	Cum Cost
6	n=	40		100	1200	1300	1300
7		29.89752781		100	896.9258342	996.9258342	2296.925834
8	Labor \$/hr	25.21631159		100	756.4893478	856.4893478	3153.415182
9	30	22.34655422		100	670.3966267	770.3966267	3923.811809
10		20.34749258		100	610.4247773	710.4247773	4634.236586
11	Parts \$/unit	18.84763443		100	565.4290328	665.4290328	5299.665619
12	100	17.66611086		100	529.9833259	629.9833259	5929.648945
13		16.70266816		100	501.0800448	601.0800448	6530.728989
14		15.89655926		100	476.8967777	576.8967777	7107.625767
15		15.20849313		100	456.2547938	556.2547938	7663.880561
16		14.61175368		100	438.3526104	538.3526104	8202.233171
17		14.08744186		100	422.6232558	522.6232558	8724.856427
18		13.62175179		100	408.6525538	508.6525538	9233.508981
19		13.20432602		100	396.1297806	496.1297806	9729.638761
20		12.82721782		100	384.8165347	484.8165347	10214.4553
21		12.48421214		100	374.5263643	474.5263643	10688.98166
22		12.17036702		100	365.1110106	465.1110106	11154.09267
23		12		100	360	460	11614.09267
24		12		100	360	460	12074.09267
25		12		100	360	460	12534.09267

- Enter the cost of labor per hour and the cost of parts per unit. In our example, we will use \$30/hour for laborers and \$100/unit for parts.
- You can now see how much each unit costs to produce as well as the cumulative cost at any stage in production. Our 20 unit batch will cost a total of \$12,534.09.

Advanced Problems: Determining Sale Price

- With the size and total cost of a batch known, we can determine a reasonable sale price per unit.
- Divide the cumulative cost of the batch (\$12,534.09) by the number of units produced (20). This gives you an average per-unit cost.
- Any good business will build a profit margin into their price, and your problem might provide you with this number. Multiply the per-unit cost by the profit margin. For example, if we want a 25% profit margin, we multiply our per-unit cost by 1.25.

	B
1	Learning Curve
2	
3	Learning Rate
4	0.747438195
5	
6	n=
7	
8	Labor \$/hr
9	30
10	
11	Parts \$/unit
12	100
13	
14	Per-unit cost
15	626.7046336
16	
17	Profit margin
18	1.25
19	
20	Sale price/unit
21	783.3807919

Advanced Problems : Determining the Breakeven Point

- To determine the breakeven point, add another column to the spreadsheet for total income. This is simply the sale price per unit multiplied by the number of units produced so far. See the picture below for reference.

	B	C	D	E	F	G	H	I
1	Learning Curve Problem							
2								
3	Learning Rate		Total Time to Produce					
4	0.747438195183886		=SUM(D6:D25)					
5				Parts Cost	Labor Cost	Unit Cost	Cum Cost	Total Income
6	n=	1	40	=\$B\$12	=\$B\$9*D6	=E6+F6	=G6	=\$B\$21*C6
7		2	=\$B\$4^(LOG(C7,2))*\$D\$6	=\$B\$12	=\$B\$9*D7	=E7+F7	=H6+G7	=\$B\$21*C7
8	Labor \$/hr	3	=\$B\$4^(LOG(C8,2))*\$D\$6	=\$B\$12	=\$B\$9*D8	=E8+F8	=H7+G8	=\$B\$21*C8
9	30	4	=\$B\$4^(LOG(C9,2))*\$D\$6	=\$B\$12	=\$B\$9*D9	=E9+F9	=H8+G9	=\$B\$21*C9
10		5	=\$B\$4^(LOG(C10,2))*\$D\$6	=\$B\$12	=\$B\$9*D10	=E10+F10	=H9+G10	=\$B\$21*C10
11	Parts \$/unit	6	=\$B\$4^(LOG(C11,2))*\$D\$6	=\$B\$12	=\$B\$9*D11	=E11+F11	=H10+G11	=\$B\$21*C11
12	100	7	=\$B\$4^(LOG(C12,2))*\$D\$6	=\$B\$12	=\$B\$9*D12	=E12+F12	=H11+G12	=\$B\$21*C12
13		8	=\$B\$4^(LOG(C13,2))*\$D\$6	=\$B\$12	=\$B\$9*D13	=E13+F13	=H12+G13	=\$B\$21*C13
14	Per-unit cost	9	=\$B\$4^(LOG(C14,2))*\$D\$6	=\$B\$12	=\$B\$9*D14	=E14+F14	=H13+G14	=\$B\$21*C14
15	=H25/20	10	=\$B\$4^(LOG(C15,2))*\$D\$6	=\$B\$12	=\$B\$9*D15	=E15+F15	=H14+G15	=\$B\$21*C15
16		11	=\$B\$4^(LOG(C16,2))*\$D\$6	=\$B\$12	=\$B\$9*D16	=E16+F16	=H15+G16	=\$B\$21*C16
17	Profit margin	12	=\$B\$4^(LOG(C17,2))*\$D\$6	=\$B\$12	=\$B\$9*D17	=E17+F17	=H16+G17	=\$B\$21*C17
18	1.25	13	=\$B\$4^(LOG(C18,2))*\$D\$6	=\$B\$12	=\$B\$9*D18	=E18+F18	=H17+G18	=\$B\$21*C18
19		14	=\$B\$4^(LOG(C19,2))*\$D\$6	=\$B\$12	=\$B\$9*D19	=E19+F19	=H18+G19	=\$B\$21*C19
20	Sale price/unit	15	=\$B\$4^(LOG(C20,2))*\$D\$6	=\$B\$12	=\$B\$9*D20	=E20+F20	=H19+G20	=\$B\$21*C20
21	=B15*B18	16	=\$B\$4^(LOG(C21,2))*\$D\$6	=\$B\$12	=\$B\$9*D21	=E21+F21	=H20+G21	=\$B\$21*C21
22		17	=\$B\$4^(LOG(C22,2))*\$D\$6	=\$B\$12	=\$B\$9*D22	=E22+F22	=H21+G22	=\$B\$21*C22
23		18	12	=\$B\$12	=\$B\$9*D23	=E23+F23	=H22+G23	=\$B\$21*C23
24		19	12	=\$B\$12	=\$B\$9*D24	=E24+F24	=H23+G24	=\$B\$21*C24
25		20	12	=\$B\$12	=\$B\$9*D25	=E25+F25	=H24+G25	=\$B\$21*C25

- When the total income is equal to or exceeds the cumulative cost, the manufacturing job has reached a break-even point.

	B	C	D	E	F	G	H	I	J
1	Learning Curve Problem								
2									
3	Learning Rate		Total Time to Produce						
4	0.747438195		351.1364224						
5				Parts Cost	Labor Cost	Unit Cost	Cum Cost	Total Income	
6	n=	1	40	\$ 100.00	\$ 1,200.00	\$ 1,300.00	\$ 1,300.00	\$ 783.38	
7		2	29.89752781	\$ 100.00	\$ 896.93	\$ 996.93	\$ 2,296.93	\$ 1,566.76	
8	Labor \$/hr	3	25.21631159	\$ 100.00	\$ 756.49	\$ 856.49	\$ 3,153.42	\$ 2,350.14	
9	30	4	22.34655422	\$ 100.00	\$ 670.40	\$ 770.40	\$ 3,923.81	\$ 3,133.52	
10		5	20.34749258	\$ 100.00	\$ 610.42	\$ 710.42	\$ 4,634.24	\$ 3,916.90	
11	Parts \$/unit	6	18.84763443	\$ 100.00	\$ 565.43	\$ 665.43	\$ 5,299.67	\$ 4,700.28	
12	100	7	17.66611086	\$ 100.00	\$ 529.98	\$ 629.98	\$ 5,929.65	\$ 5,483.67	
13		8	16.70266816	\$ 100.00	\$ 501.08	\$ 601.08	\$ 6,530.73	\$ 6,267.05	
14	Per-unit cost	9	15.89655926	\$ 100.00	\$ 476.90	\$ 576.90	\$ 7,107.63	\$ 7,050.43	
15	626.7046336	10	15.20849313	\$ 100.00	\$ 456.25	\$ 556.25	\$ 7,663.88	\$ 7,833.81	Breakeven
16		11	14.61175368	\$ 100.00	\$ 438.35	\$ 538.35	\$ 8,202.23	\$ 8,617.19	
17	Profit margin	12	14.08744186	\$ 100.00	\$ 422.62	\$ 522.62	\$ 8,724.86	\$ 9,400.57	
18	1.25	13	13.62175179	\$ 100.00	\$ 408.65	\$ 508.65	\$ 9,233.51	\$ 10,183.95	
19		14	13.20432602	\$ 100.00	\$ 396.13	\$ 496.13	\$ 9,729.64	\$ 10,967.33	
20	Sale price/unit	15	12.82721782	\$ 100.00	\$ 384.82	\$ 484.82	\$ 10,214.46	\$ 11,750.71	
21	783.3807919	16	12.48421214	\$ 100.00	\$ 374.53	\$ 474.53	\$ 10,688.98	\$ 12,534.09	
22		17	12.17036702	\$ 100.00	\$ 365.11	\$ 465.11	\$ 11,154.09	\$ 13,317.47	
23		18	12	\$ 100.00	\$ 360.00	\$ 460.00	\$ 11,614.09	\$ 14,100.85	
24		19	12	\$ 100.00	\$ 360.00	\$ 460.00	\$ 12,074.09	\$ 14,884.24	
25		20	12	\$ 100.00	\$ 360.00	\$ 460.00	\$ 12,534.09	\$ 15,667.62	