Creating Individualized Self-Scoring Assessments for Agricultural Economics Undergraduates

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Creating Individualized Self-Scoring Assessments for Agricultural Economics Undergraduates

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What is an individualized self-scoring assessment for an agricultural economics major? It is a homework assignment that is unique for each student in the class and provides immediate feedback to the student on the correctness of the work. The principle is to generate unique problems, whether it is as simple as the basic intercept and slope of supply and demand equations for an introductory economics class, the parameters of a production function for a production economics, or the interest rate for agricultural finance.

The use of spreadsheets as an instructional technology has been well-documented in numerous disciplines (Baker and Sugden). The advantages are summarized by quoting from Beare: "Firstly they facilitate a variety of learning styles which can be characterised by the terms: open-ended, problem-oriented, constructivist, investigative, discovery oriented, active and student-centred. In addition they offer the following additional benefits: they are interactive; they give immediate feedback to changing data or formulae; they enable data, formulae and graphical output to be available on the screen at once; they give students a large measure of control and ownership over their learning; and they can solve complex problems and handle large amounts of data without any need for programming." From a numerical analysis perspective, Wan Wyk cites the advantages of ease of programming using relative references, automatic renaming of cell addresses as rows and columns are altered. He also points out the disadvantages of variable naming, and dubious properties of floating-point arithmetic. A further advantage of spreadsheets is the ready availability of applications in a common format such as Erich Neuwirth's website, http://sunsite.univie.ac.at/Spreadsite/ .

One must be aware in constructing the generator algorithms for problem parameters that any necessary conditions will be satisfied a priori such as downward sloping demand, concavity or convexity for maximization or minimization. However, there are advantages to being not careful in this regard. For example, with increasing returns to scale and pure competition with respect to output price, there will be no solution to the unconstrained profit maximization. The student can not arrive at a solution and will hopefully inquire as to the problem, creating a ”teachable moment” that can be shared with the class.

These assignments are created in an Excel spreadsheet format. Once the basic template is created, the process for self-scoring immediate feedback is relatively easy. Create a copy of the original uncompleted problem sheet in the same workbook and provide the correct formulae to serve as a key. Create a second copy to serve as a check page and replace the formulae with an IF statement comparing the value or formula in the original to the second. It is best to provide some tolerance in the comparison such as checking that the absolute difference in the original and second sheet is less than some critical value. This is especially true for optimization problems as the answer provided by the student will depend on initial starting values, convergence criteria, and search method.   By hiding the key worksheet and protecting the workbook structure, students can not access the correct formulae. However, if the correct formulae or number is entered in the problem sheet, the student can view the check worksheet to see if the answer is correct. A simple GETFORMULA add-in allows the worksheet to check model setups in optimization problems.

An Example

Create and complete the exercise as shown in Figure 1. Begin by keying the problem’s parameters off a unique identifier for each student, in this case a six digit number the student will enter in C1. This number is parsed by the formulae in D1:I1. If necessary, zero values are eliminated in D2:I2. Typically, this is done in a part of the worksheet not displayed further right or even in columns that can be hidden to avoid distracting the students

The parameters of the Cobb-Douglas like and quadratic production function are created from these non-zero values. These appear in B6:B7 and B36:B38. By specifying the parameters in unique cells, all students would have identical formulae in their responses. Alternatively, by concatenating strings, a specific equation can be displayed as shown in D5 and D35. By using this alternative display, students must enter specific parameter values for their equations, and could not just copy formulae from another student. Output and input prices can also be based on these parsed values.

In this example, students are expected to calculate values over a range of values. By creating an X increment holder in B8 and B39, and allowing starting values in A11 and A42, the range of X for each problem will automatically be created in the subsequent rows (See formulae in A12:A22 and A43:A53). This facilitates construction of graphs to the right that will be completed as the student fills in the table.

Figure 2a. shows the initial setup of the worksheet with correct formula entered and the resulting numerical values needed for profit maximization. The initial columns were completed in a previous assignment. The accompanying graphs are shown in Figure 2b. Figure 2c shows the underlying formulae that produce the numerical results with some key exceptions to be noted later. The correct formulae are now entered, and the graphs created. By using unique cells for the parameter values, the key values will always be correct. Even if you choose to display the equations with parameter values included, it is important to continue to keep the parameters located, so that the key formulae will always be correct.

Now use Edit – Move or Copy Sheet to create a copy of the worksheet and rename the sheet KEY as shown in Figure 3. In the KEY worksheet, it is critical to use the values that the student will enter in the worksheet they are completing (PMAX in this example). Cells A86, A92, and B68 will especially be dependent on the student's solution. If the student could specify a different initial value than 0 in A70, this should also point to the student sheet. It is not necessary to get the production function parameters in B65:B67 from PMAX unless you allow the student the possibility to alter them from the original parsed from the identifier. In the event of difficulties in obtaining a solution, this will allow a quick fix however and maintain the correctness of the KEY worksheet.

Ultimately, the formulae in the new worksheet that the student will complete need to be cleared from the appropriate cells. However, by saving this to the last step, one can create and verify a CHECK worksheet before releasing the assignment. Using the Edit-Move or Copy Sheet with the create copy checked, a third worksheet is created (Figure 4a). This CHECK worksheet compares the answers and formulae in the student worksheet with those in the KEY worksheet, providing the student with immediate feedback. Enter the formula "=IF(pmax!G71=key!G71,1,0)" if you desire an exact match in the numerical values of the student sheet and the key. However, experience indicates a little tolerance will avoid problems across different microprocessors or from floating-point problems discussed earlier. Instead, the formula “=IF(ABS(pmax!G71-key!G71,1,0))<.001,1,0)” will verify that the student’s numerical answer is within the appropriate range of the key value by comparing the absolute value of the difference with the tolerance of 0.001 in the formula. This tolerance level could be stored in a separate cell as well, substituting in the fixed cell address for .001 in the formula. In either case, it is a simple matter of copying this formula to all other cells where you wish to compare numerical values.

In the case of optimization, the students employ the Solver tool add-in. A space is provided on the worksheet for them to save the model (part of the Solver options) in cells M86:M88 for output maximization and N86:N88 for profit maximization. Instead of checking numerical values, the goal is to verify the student has correctly identified the objective and solution variables for the problem. A simple function GETFORMULA is created in the worksheet(http://www.mvps.org/dmcritchie/excel/formula.htm) as shown by McRitchie. Using the Visual Basic editor, enter the following:

```
Function GetFormula(Cell as Range) as String
  GetFormula = Cell.Formula
End Function
```

In the profit maximization example (Figure 5a), the correct formula for Cell N86 is “=MAX(K92)” which identifies profits in K92 as the cell to be maximized. The correct formula for Cell N87 is “=COUNT(A92)”, which is the cell identified in the Solver setup as the cell(s) that can be changed. Cell N88 verifies the Solver options used in the problem (Figure 5b).

In some cases, you may provide contextual feedback by replacing the last 0 in the IF statement with the appropriate phrase. In this case, the CHECK worksheet formula in Cell N86 is “=IF(getformula(pmax!N86)=getformula(key!N86),1,0)”. However, the formula could readily be modified to read “=IF(getformula(pmax!N86)=getformula(key!N86),1,”Target cell or goal incorrect”), indicating where the error might occur. One could further refine the feedback to check the first part of the formula for “MAX” or the latter part for K92 to provide more specific feedback on the error.

Since Solver may not converge to an exact solution, Cells M61, N36 and N61 check the first order conditions to be close to zero. By using GETFORMULA, the target cell and optimization (max or min), and cell(s) to be changed can be checked. The check in cells M59, N34 and N59 verify the constraints are the same, and the next cells down check the Solver option setup. I also include a check of first- and second-order conditions directly on the worksheet (G92=H92 and E92<0, for example) to help avoid the “black box” of the Solver add-in, giving an additional emphasis to the importance of these conditions.

Return to the original worksheet and select all cells in the worksheet. Using Format Cells, lock all cells (Figure 6a). Then highlight only those cells that you want the students to complete and unlock those cells. The process will need to be repeated for every non-contiguous cell or range. At the same time, Edit – Clear –Contents will create a blank workspace. Select a different background color for these unlocked cells to indicate to the students where their input is needed.

Now protect the workbook and KEY and CHECK worksheets with a password (Figures 6b, 6c). You may choose whether to allow students to select locked cells. In some examples, I often include a correct formula that they can select, and the ability to select locked cells permits this. Allowing formatting is also useful to allow displaying results of different magnitudes or precision. The student worksheet (PMAX) must not be protected in order to use the Solver add-in.

Grading and Scoring

The real advantage of using spreadsheet-based assignments is how quickly they can be graded. Rather than open each student’s worksheet, the critical values can be extracted from the individual workbooks by linking to the appropriate cells in the individual workbooks. Figure 7 illustrates how this can be done. All student assignments are submitted via Blackboard which provides a compressed file containing all the students’ submitted workbooks, prefaced by a unique identifier. I simply uncompress this file into a unique folder and use a bulk file renaming utility to strip any extra characters beyond the identifier.

I open one of the assignments and identify the values I wish to consider for grading. By separating these, I can identify where problems might be occurring. In the example, I sum all the values in G71:K86 to check the large table, G86:K86 for the output maximization formulae, and G92:K92 for the profit maximization formula. M86:M88 and N86:N88 check the model setups, and I also verify that first- and second-order conditions are satisified. The sum of the points is readily computed and it is quite easy to assign different weights to the respective components.

Conclusions

The key advantage of this technique to the students is the immediate feedback. Also by generating unique assignments, students can cooperate and learn among themselves without being able to directly copy from their peers. Additionally, graphical representations of their problems can often be provided simultaneously. Lastly, the students find that their spreadsheet skills are greatly enhanced. From the instructor perspective, the assessments are already scored when submitted. Students will seek help prior to turning in the assignment. And there is little need to sacrifice complexity to create problems that work out to neat answers. Empirical evidence of improvement in student evaluations indicates the technique is successful.

References:

Baker, John E, and Sugden, Stephen J (2003) “Spreadsheets in Education–The First 25 Years”, electronic Journal of Spreadsheets in Education (eJSiE) 1(1):18-43

Beare, R. (1993). How spreadsheets can aid a variety of mathematical learning activities from primary to tertiary level. Technology in Mathematics Teaching: A Bridge Between Teaching and Learning. B. Jaworski. Birmingham, U.K.: 117—124

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Sher, D. B. (1997). Spreadsheets for Applying the Harvard Approach to Precollege Algebra. Eastern Regional NCTM conference, Long Island, NY

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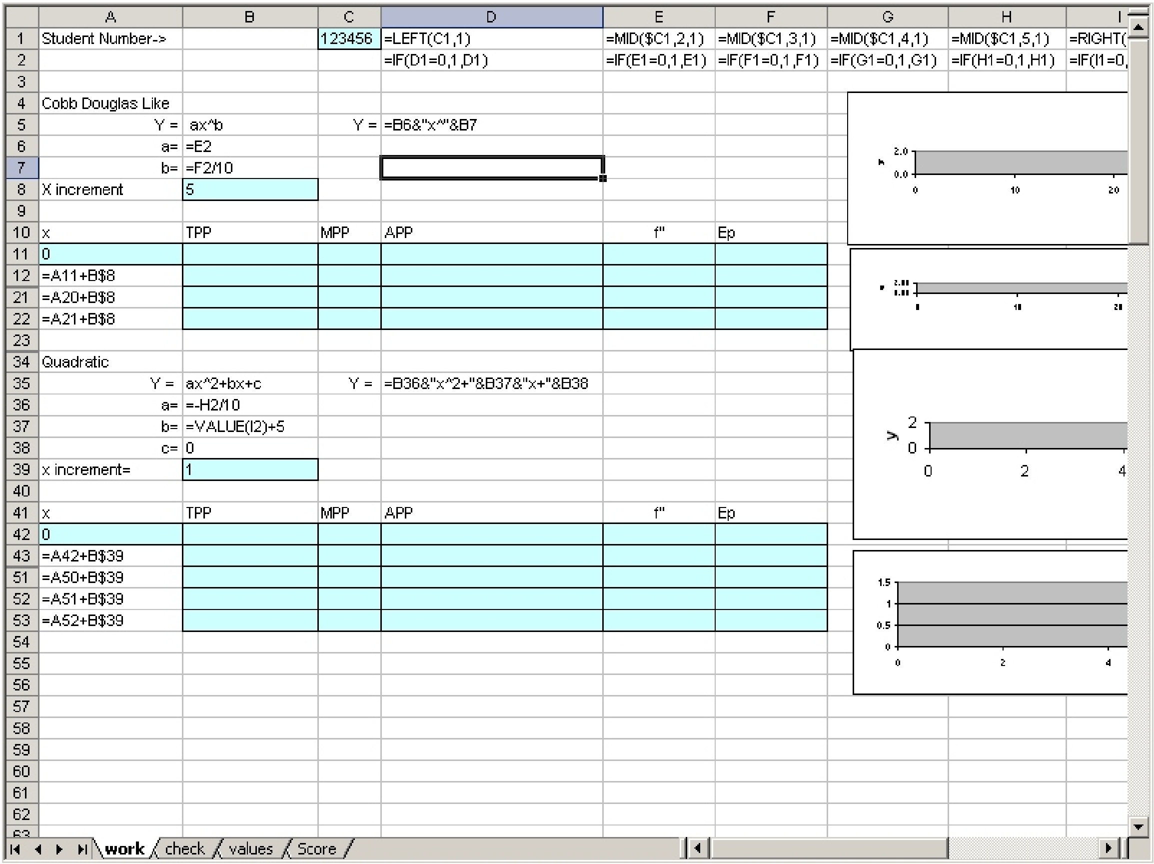
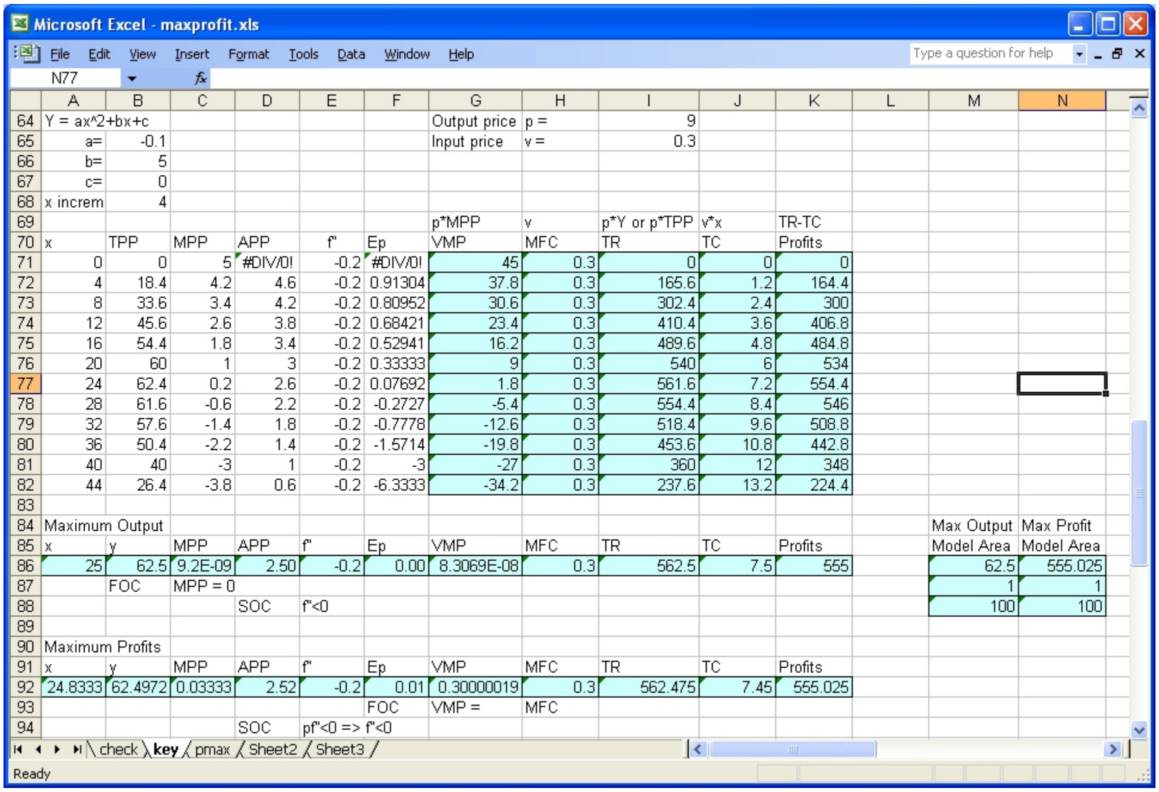
Figure 1. Initial Assignment



	A	B	C	D	E	F	G	H	I
1	Student Number->		123456	=LEFT(C1,1)	=MID($C1,2,1)	=MID($C1,3,1)	=MID($C1,4,1)	=MID($C1,5,1)	=RIGHT(
2				=IF(D1=0,1,D1)	=IF(E1=0,1,E1)	=IF(F1=0,1,F1)	=IF(G1=0,1,G1)	=IF(H1=0,1,H1)	=IF(I1=0,
3									
4	Cobb Douglas Like								
5	Y =	ax^b	Y =	=B6&"x^"&B7					
6	a=	=E2							
7	b=	=F2/10							
8	X increment	5							
9									
10	x	TPP	MPP	APP	f"	Ep			
11	0								
12	=A11+B$8								
21	=A20+B$8								
22	=A21+B$8								
23									
34	Quadratic								
35	Y =	ax^2+bx+c	Y =	=B36&"x^2+"&B37&"x+"&B38					
36	a=	=-H2/10							
37	b=	=VALUE(I2)+5							
38	c=	0							
39	x increment=	1							
40									
41	x	TPP	MPP	APP	f"	Ep			
42	0								
43	=A42+B$39								
51	=A50+B$39								
52	=A51+B$39								
53	=A52+B$39								

Figure 2a. Profit maximization key worksheet



Microsoft Excel - maxprofit.xls

File Edit View Insert Format Tools Data Window Help

N77

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
64	Y = ax^2+bx+c						Output price	p =	9					
65	a=	-0.1					Input price	v =	0.3					
66	b=	5												
67	c=	0												
68	x increm	4												
69							p*MPP	v	p*Y or p*TPP	v*x	TR-TC			
70	x	TPP	MPP	APP	f"	Ep	VMP	MFC	TR	TC	Profits			
71	0	0	5	#DIV/0!	-0.2	#DIV/0!	45	0.3	0	0	0			
72	4	18.4	4.2	4.6	-0.2	0.91304	37.8	0.3	165.6	1.2	164.4			
73	8	33.6	3.4	4.2	-0.2	0.80952	30.6	0.3	302.4	2.4	300			
74	12	45.6	2.6	3.8	-0.2	0.68421	23.4	0.3	410.4	3.6	406.8			
75	16	54.4	1.8	3.4	-0.2	0.52941	16.2	0.3	489.6	4.8	484.8			
76	20	60	1	3	-0.2	0.33333	9	0.3	540	6	534			
77	24	62.4	0.2	2.6	-0.2	0.07692	1.8	0.3	561.6	7.2	554.4			
78	28	61.6	-0.6	2.2	-0.2	-0.2727	-5.4	0.3	554.4	8.4	546			
79	32	57.6	-1.4	1.8	-0.2	-0.7778	-12.6	0.3	518.4	9.6	508.8			
80	36	50.4	-2.2	1.4	-0.2	-1.5714	-19.8	0.3	453.6	10.8	442.8			
81	40	40	-3	1	-0.2	-3	-27	0.3	360	12	348			
82	44	26.4	-3.8	0.6	-0.2	-6.3333	-34.2	0.3	237.6	13.2	224.4			
83														
84	Maximum Output												Max Output	Max Profit
85	x	y	MPP	APP	f"	Ep	VMP	MFC	TR	TC	Profits		Model Area	Model Area
86	25	62.5	9.2E-09	2.50	-0.2	0.00	8.3069E-08	0.3	562.5	7.5	555		62.5	555.025
87		FOC	MPP = 0										1	1
88				SOC	f"<0								100	100
89														
90	Maximum Profits													
91	x	y	MPP	APP	f"	Ep	VMP	MFC	TR	TC	Profits			
92	24.8333	62.4972	0.03333	2.52	-0.2	0.01	0.30000019	0.3	562.475	7.45	555.025			
93						FOC	VMP =	MFC						
94				SOC	pf"<0 => f"<0									

check key pmax Sheet2 Sheet3

Ready

Figure 2b. Profit maximization graphs

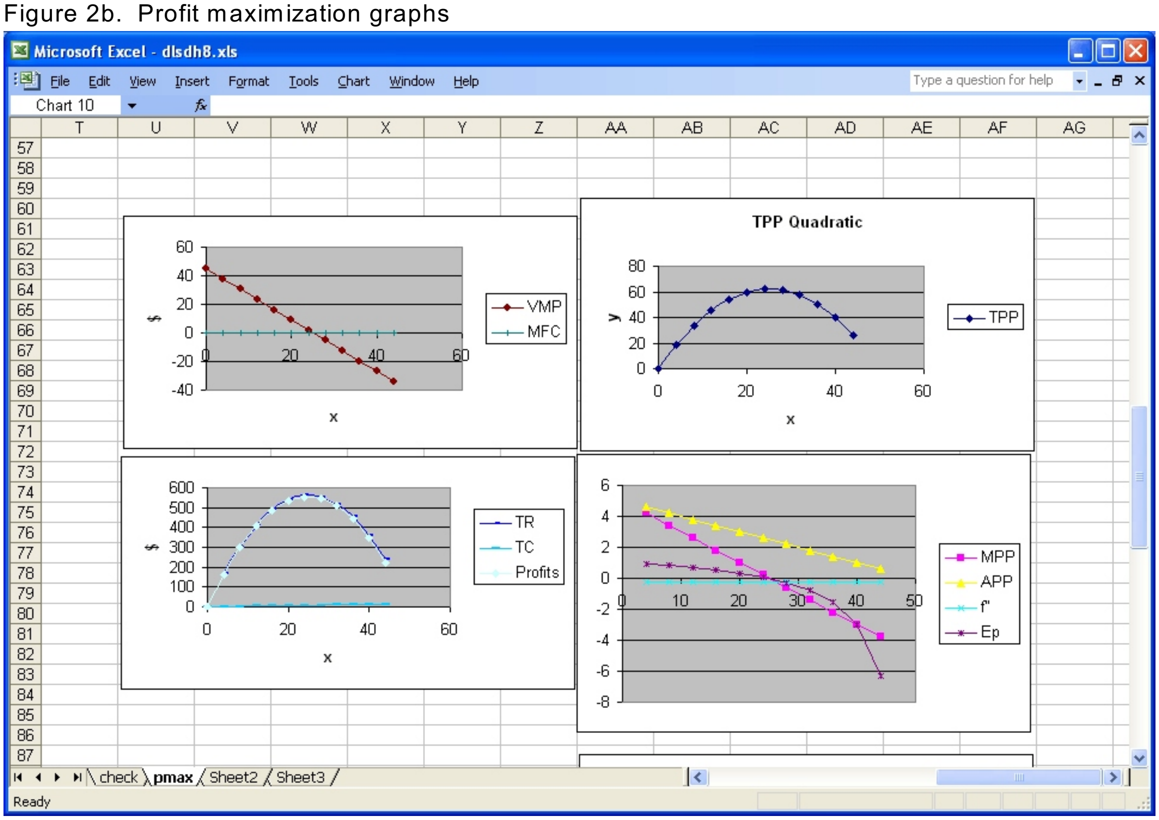


Figure 2c. Profit maximization formulae.

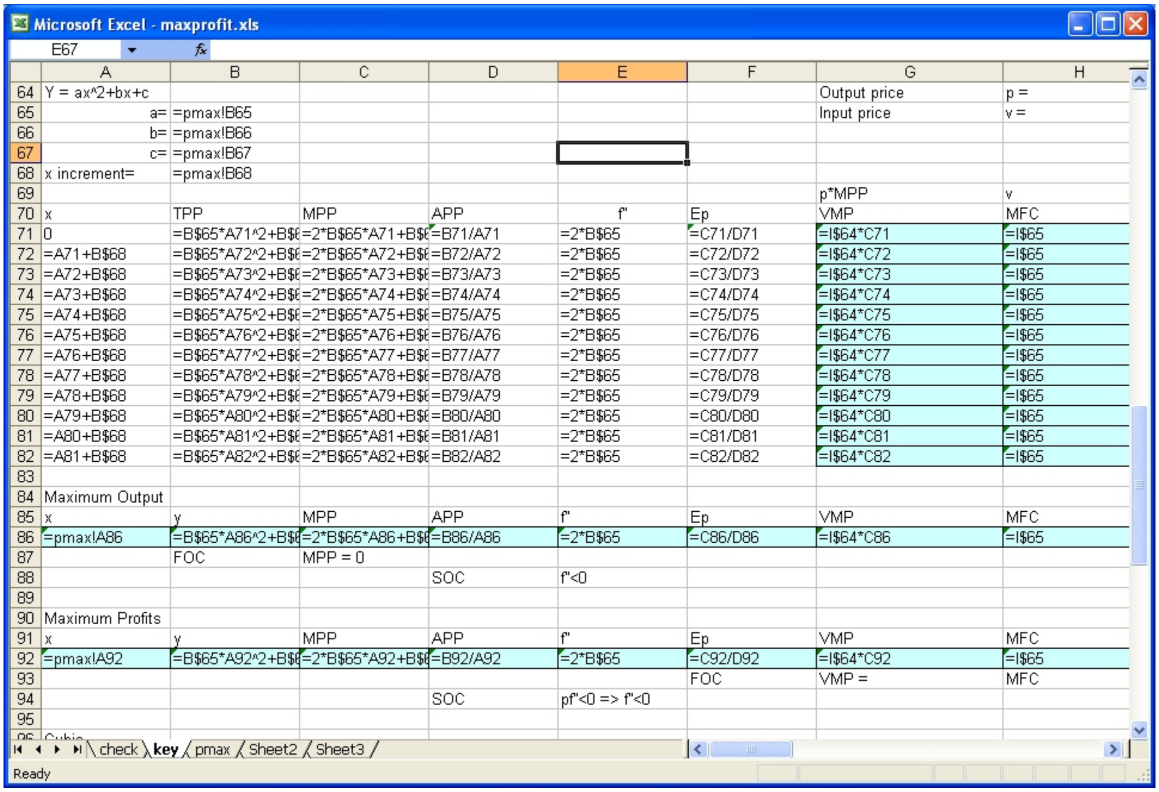


Figure 3. Copying the initial worksheet.

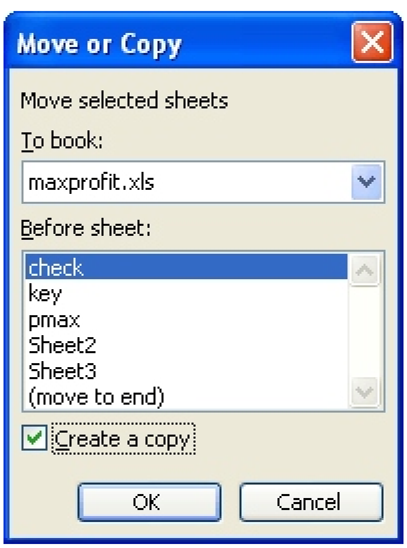
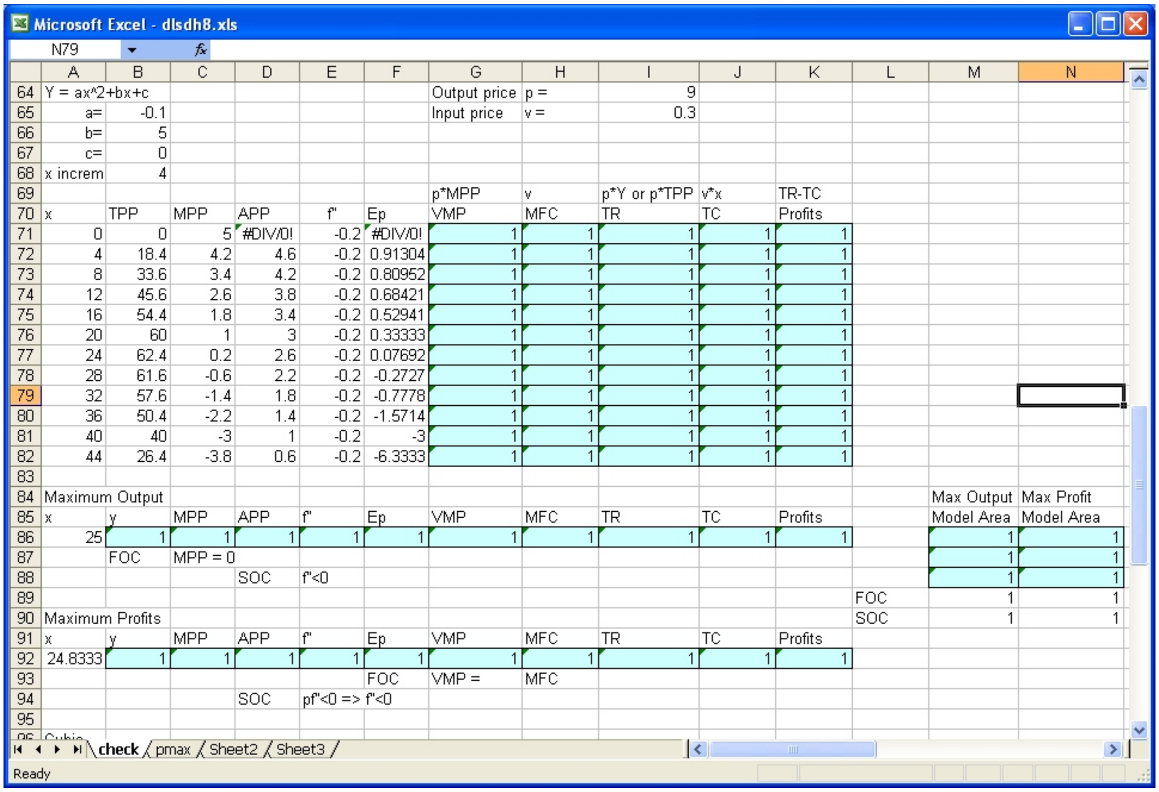


Figure 4a. CHECK worksheet.



Microsoft Excel - dlsdh8.xls

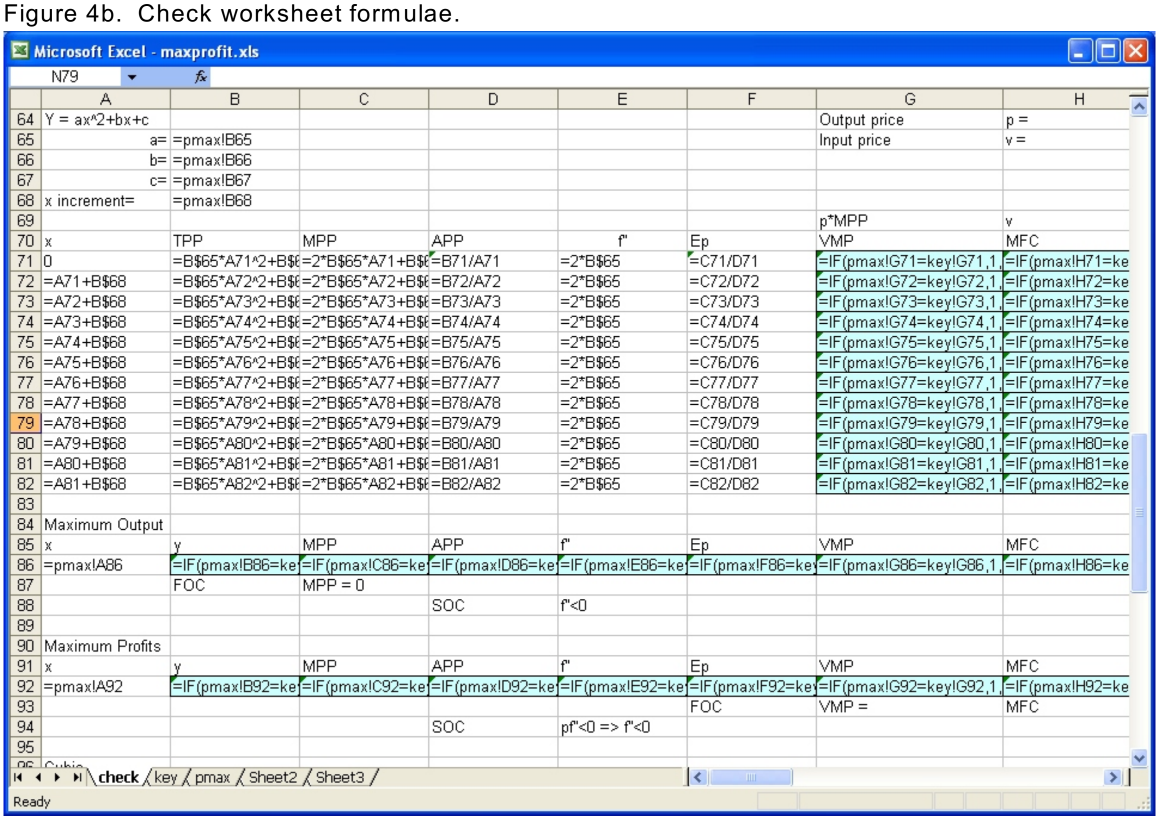
N79

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
64	Y = ax^2+bx+c						Output price	p =	9					
65	a=	-0.1					Input price	v =	0.3					
66	b=	5												
67	c=	0												
68	x increm	4												
69							p*MPP	v	p*Y or p*TPP	v*x	TR-TC			
70	x	TPP	MPP	APP	f"	Ep	VMP	MFC	TR	TC	Profits			
71	0	0	5	#DIV/0!	-0.2	#DIV/0!	1	1	1	1	1			
72	4	18.4	4.2	4.6	-0.2	0.91304	1	1	1	1	1			
73	8	33.6	3.4	4.2	-0.2	0.80952	1	1	1	1	1			
74	12	45.6	2.6	3.8	-0.2	0.68421	1	1	1	1	1			
75	16	54.4	1.8	3.4	-0.2	0.52941	1	1	1	1	1			
76	20	60	1	3	-0.2	0.33333	1	1	1	1	1			
77	24	62.4	0.2	2.6	-0.2	0.07692	1	1	1	1	1			
78	28	61.6	-0.6	2.2	-0.2	-0.2727	1	1	1	1	1			
79	32	57.6	-1.4	1.8	-0.2	-0.7778	1	1	1	1	1			
80	36	50.4	-2.2	1.4	-0.2	-1.5714	1	1	1	1	1			
81	40	40	-3	1	-0.2	-3	1	1	1	1	1			
82	44	26.4	-3.8	0.6	-0.2	-6.3333	1	1	1	1	1			
83														
84	Maximum Output												Max Output	Max Profit
85	x	y	MPP	APP	f"	Ep	VMP	MFC	TR	TC	Profits		Model Area	Model Area
86	25	1	1	1	1	1	1	1	1	1	1		1	1
87		FOC	MPP = 0										1	1
88				SOC	f"<0								1	1
89												FOC	1	1
90	Maximum Profits											SOC	1	1
91	x	y	MPP	APP	f"	Ep	VMP	MFC	TR	TC	Profits			
92	24.8333	1	1	1	1	1	1	1	1	1	1			
93						FOC	VMP =	MFC						
94				SOC	pf"<0 => f"<0									
95														

check / pmax / Sheet2 / Sheet3

Ready

Figure 4b. Check worksheet formulae.



Microsoft Excel - maxprofit.xls

N79

	A	B	C	D	E	F	G	H
64	Y = ax^2+bx+c						Output price	p =
65	a=	=pmax!B65					Input price	v =
66	b=	=pmax!B66						
67	c=	=pmax!B67						
68	x increment=	=pmax!B68						
69							p*MPP	v
70	x	TPP	MPP	APP	f"	Ep	VMP	MFC
71	0	=B$65*A71^2+B$6	=2*B$65*A71+B$6	=B71/A71	=2*B$65	=C71/D71	=IF(pmax!G71=key!G71,1,	=IF(pmax!H71=ke
72	=A71+B$68	=B$65*A72^2+B$6	=2*B$65*A72+B$6	=B72/A72	=2*B$65	=C72/D72	=IF(pmax!G72=key!G72,1,	=IF(pmax!H72=ke
73	=A72+B$68	=B$65*A73^2+B$6	=2*B$65*A73+B$6	=B73/A73	=2*B$65	=C73/D73	=IF(pmax!G73=key!G73,1,	=IF(pmax!H73=ke
74	=A73+B$68	=B$65*A74^2+B$6	=2*B$65*A74+B$6	=B74/A74	=2*B$65	=C74/D74	=IF(pmax!G74=key!G74,1,	=IF(pmax!H74=ke
75	=A74+B$68	=B$65*A75^2+B$6	=2*B$65*A75+B$6	=B75/A75	=2*B$65	=C75/D75	=IF(pmax!G75=key!G75,1,	=IF(pmax!H75=ke
76	=A75+B$68	=B$65*A76^2+B$6	=2*B$65*A76+B$6	=B76/A76	=2*B$65	=C76/D76	=IF(pmax!G76=key!G76,1,	=IF(pmax!H76=ke
77	=A76+B$68	=B$65*A77^2+B$6	=2*B$65*A77+B$6	=B77/A77	=2*B$65	=C77/D77	=IF(pmax!G77=key!G77,1,	=IF(pmax!H77=ke
78	=A77+B$68	=B$65*A78^2+B$6	=2*B$65*A78+B$6	=B78/A78	=2*B$65	=C78/D78	=IF(pmax!G78=key!G78,1,	=IF(pmax!H78=ke
79	=A78+B$68	=B$65*A79^2+B$6	=2*B$65*A79+B$6	=B79/A79	=2*B$65	=C79/D79	=IF(pmax!G79=key!G79,1,	=IF(pmax!H79=ke
80	=A79+B$68	=B$65*A80^2+B$6	=2*B$65*A80+B$6	=B80/A80	=2*B$65	=C80/D80	=IF(pmax!G80=key!G80,1,	=IF(pmax!H80=ke
81	=A80+B$68	=B$65*A81^2+B$6	=2*B$65*A81+B$6	=B81/A81	=2*B$65	=C81/D81	=IF(pmax!G81=key!G81,1,	=IF(pmax!H81=ke
82	=A81+B$68	=B$65*A82^2+B$6	=2*B$65*A82+B$6	=B82/A82	=2*B$65	=C82/D82	=IF(pmax!G82=key!G82,1,	=IF(pmax!H82=ke
83								
84	Maximum Output							
85	x	y	MPP	APP	f"	Ep	VMP	MFC
86	=pmax!A86	=IF(pmax!B86=ke	=IF(pmax!C86=ke	=IF(pmax!D86=ke	=IF(pmax!E86=ke	=IF(pmax!F86=key	=IF(pmax!G86=key!G86,1,	=IF(pmax!H86=ke
87		FOC	MPP = 0					
88				SOC	f"<0			
89								
90	Maximum Profits							
91	x	y	MPP	APP	f"	Ep	VMP	MFC
92	=pmax!A92	=IF(pmax!B92=ke	=IF(pmax!C92=ke	=IF(pmax!D92=ke	=IF(pmax!E92=ke	=IF(pmax!F92=key	=IF(pmax!G92=key!G92,1,	=IF(pmax!H92=ke
93						FOC	VMP =	MFC
94				SOC	pf"<0 => f"<0			
95								

check / key / pmax / Sheet2 / Sheet3

Ready

Figure 5a. Solver setup

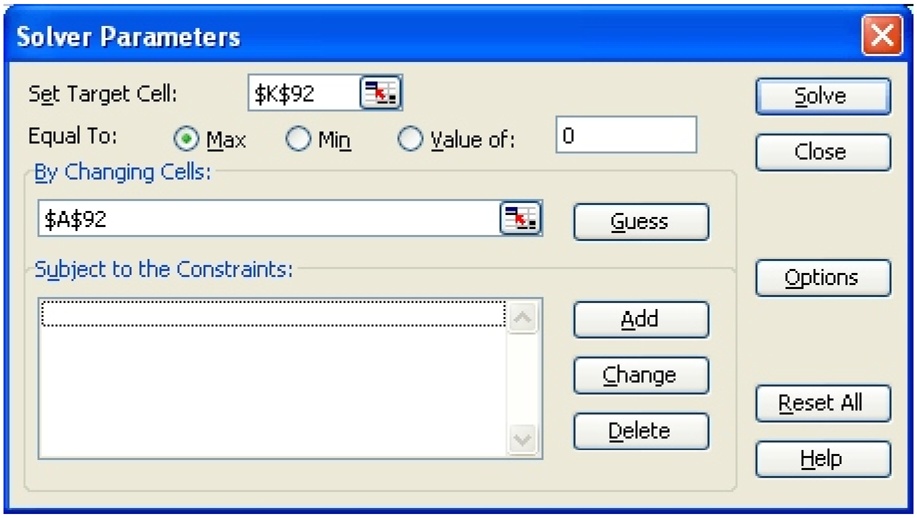


Figure 5b. Solver options.

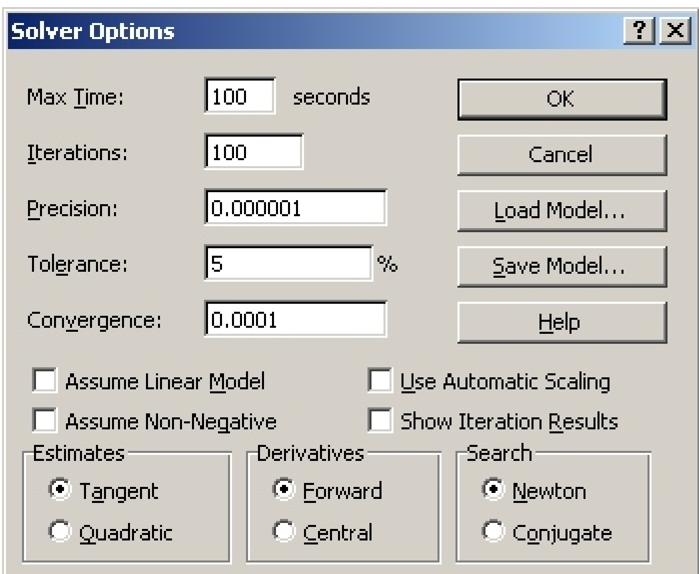


Figure 6a. Locking Cells.

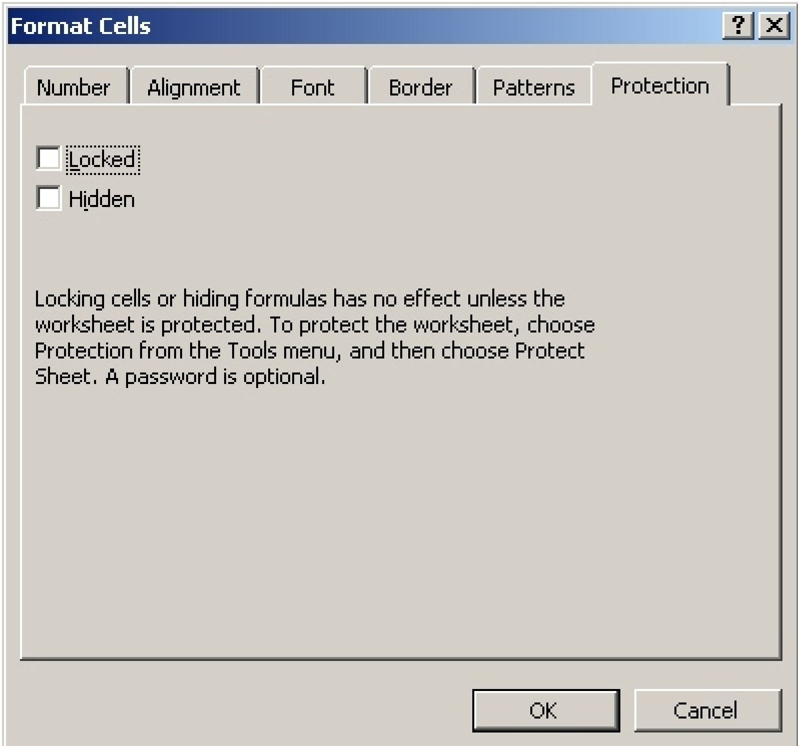


Figure 6b. Protecting the workbook.

Figure 6c. Protecting the worksheet.

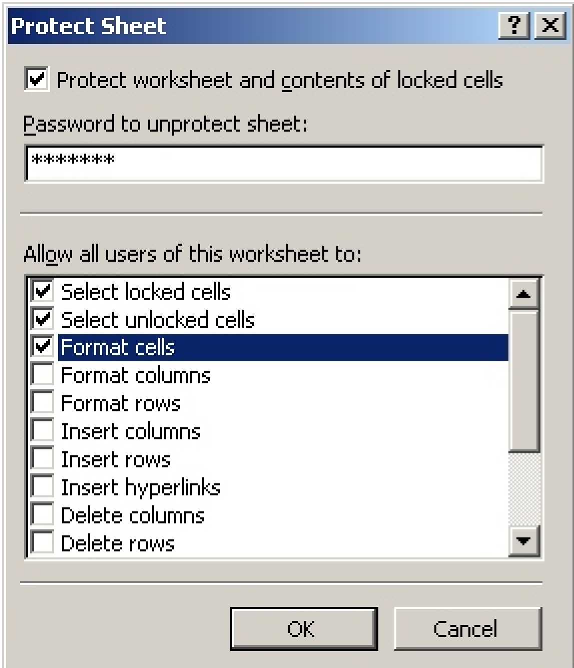
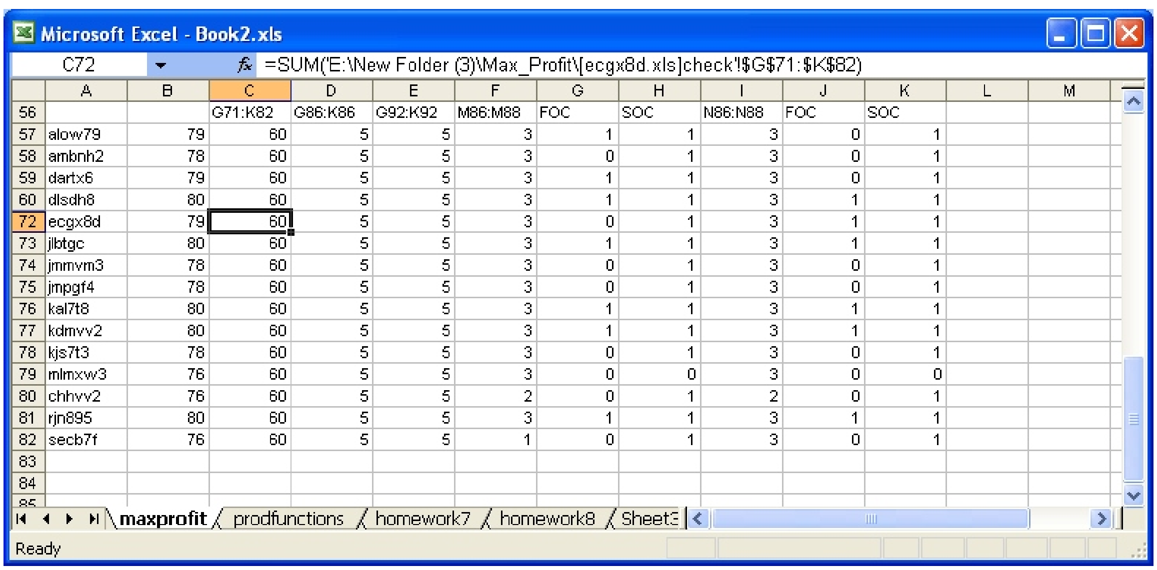


Figure 7. Scoring and Grading Worksheet.



	A	B	C	D	E	F	G	H	I	J	K	L	M
56			G71:K82	G86:K86	G92:K92	M86:M88	FOC	SOC	N86:N88	FOC	SOC		
57	alow79	79	60	5	5	3	1	1	3	0	1		
58	ambnh2	78	60	5	5	3	0	1	3	0	1		
59	dartx6	79	60	5	5	3	1	1	3	0	1		
60	dlsdh8	80	60	5	5	3	1	1	3	1	1		
72	ecgx8d	79	60	5	5	3	0	1	3	1	1		
73	jlbtgc	80	60	5	5	3	1	1	3	1	1		
74	jmmvm3	78	60	5	5	3	0	1	3	0	1		
75	jmpgf4	78	60	5	5	3	0	1	3	0	1		
76	kal7t8	80	60	5	5	3	1	1	3	1	1		
77	kdmvv2	80	60	5	5	3	1	1	3	1	1		
78	kjs7t3	78	60	5	5	3	0	1	3	0	1		
79	mlmxw3	76	60	5	5	3	0	0	3	0	0		
80	chhvv2	76	60	5	5	2	0	1	2	0	1		
81	rjn895	80	60	5	5	3	1	1	3	1	1		
82	secb7f	76	60	5	5	1	0	1	3	0	1		
83													
84													