

Using Excel to Solve Complex Problems

Microsoft Excel can be used to solve complex problems. For example, suppose a manufacturing firm has four main jobs and twenty employees who need to be assigned to those jobs. As shown in table 1 below, their managers have evaluated each employee's competency score, on a scale of one-to-ten, for the four jobs. The employer of course wants to maximize the firm's productivity.

The employer also wants to maximize employees' job satisfaction, provided it does not ruin productivity. Table 2 is from an employee survey that shows each employee's satisfaction with the four jobs. Your job is to help them by setting up an Excel spreadsheet that can maximize both productivity (competence) and employee satisfaction.

Table 1: Competency Scores

Worker	Job 1	Job 2	Job 3	Job 4
1	9	8	6	8
2	10	0	5	6
3	5	8	10	5
4	4	0	5	2
5	9	10	4	5
6	5	2	7	3
7	8	3	1	2
8	2	2	9	2
9	8	7	6	3
10	7	0	1	8
11	8	1	6	6
12	0	7	1	2
13	9	0	5	4
14	9	2	2	7
15	1	3	8	4
16	9	6	4	5
17	8	0	5	0
18	6	7	6	3
19	3	4	5	4
20	3	9	4	4

Table 2: Satisfaction Scores

Worker	Job 1	Job 2	Job 3	Job 4
1	1	2	6	7
2	9	6	7	4
3	1	7	7	3
4	9	1	0	3
5	9	8	8	3
6	2	8	1	5
7	1	8	2	2
8	8	3	1	6
9	4	3	4	1
10	4	1	5	4
11	2	0	9	3
12	5	2	1	1
13	3	0	7	8
14	1	1	2	10
15	9	8	6	8
16	5	7	8	8
17	5	7	2	4
18	2	4	1	6
19	8	7	6	6
20	2	2	2	3

Step-by-Step Exercises

Exercise 1: Enhance the labels

In this exercise you will open an Excel file that has the worker numbers and their job scores. You will then enhance the labels using some custom number formats, bolding, borders, and by merging cells.

- 1) Download the [Solver_Start.xlsx](#) file.
- 2) Bold the data in **A2:I2**.
- 3) Format the job numbers with the word "job".
 - a) Select **B2:I4**.
 - b) Press **Ctrl + 1** to display the Format Cells dialog box.
 - c) On the Number tab, in the Type well, enter the following code:

```
"Job "#,##0_)
```

Note: the use of the following characters:

- The text in quotes is literal text that will appear before the number.
- The pound signs represent optional digits that appear if needed.
- The comma represents the thousands separator.
- The zero represents a required digit.
- The underscore and parenthesis are optional. They add extra space that is the width of a single closed parenthesis. They are often used to align a positive number with negative numbers that are displayed with parenthesis.

- 4) Bold the labels in **B1** and **F1**.
- 5) Add borders:
 - a) Select **A1:I22**.
 - b) From the ribbon, choose **Home > Font > Borders > All Borders**.
- 6) Select cells **B1:E1** then merge them together via **Home > Alignment > Merge & Center > Merge Cells**.
- 7) Select cells **F1:I1** then merge them together via **Home > Alignment > Merge & Center > Merge Cells**.
- 8) Select cells **A1:A2** then merge them together via **Home > Alignment > Merge & Center > Merge Cells**.

Exercise 2: Add columns for scores and the assigned group.

In this exercise you will add new columns and labels that will be used to assign workers to different jobs and for showing the related results scores.

- 1) Insert a new column **F**.
- 2) Enter **C Score** in cell **F2**.
- 3) Enter **S Score** in cell **K2**.
- 4) If needed, bold both **F2** and **K2**.
- 5) Add borders to **F2** and **K2**.
 - a) Select **F2** and **K2**.
 - b) Press **Ctrl + 1** to display the **Format Cells** dialog box.
 - c) Select the **Border** tab.
 - d) Click on the left border to remove it.
 - e) Click **OK**.
- 6) Use the Calculation style to identify the location of the score calculations.
 - a) Select cells **F3:F22**.
 - b) From the ribbon, choose **Home > Styles > Calculation**.
 - c) Select cells **K3:K22**.
 - d) From the ribbon, choose **Home > Styles > Calculation**.
- 7) Enter **Assigned Group** in cell **L1**.
- 8) Bold the text in **L1**.
- 9) Wrap the text in cell **L1**.
From the ribbon, choose **Home > Alignment > Wrap Text**.
- 10) Merge cells **L1** and **L2** by selecting **L1:L2**, then merge them together via **Home > Alignment > Merge & Center > Merge Cells**.
- 11) If needed, bottom align the text in cell **L1**.
- 12) If needed, add all borders to **L1**.

13) Use the input style to identify the location of the input cells.

- a) Select cells **L3:L22**.
- b) From the ribbon, choose **Home > Styles > Input**.

14) Save your work.

Exercise 3: Add score calculations

In this exercise you will enter the score calculations.

1) Temporarily assign jobs to the first four workers by entering the following values:

L3	1
L4	2
L5	1
L6	4

2) To simplify formula creation, create two named ranges to represent the Job Competence Scores and the Satisfaction Scores.

- a) Select cells **B2:E22**.
- b) In the name box, enter **CJobs**.
- c) Select cells **G2:K22**.
- d) In the name box, enter **SJobs**.

3) In cell **F3** enter the following formula:

```
=IFERROR(HLOOKUP($L3,CJobs,$A3+1),"")
```

The formula uses the **HLookup** function to look up the job score value of cell **L3** in the **CJobs** list and then returns the value that corresponds to the worker # (**A3**). The +1 is included because the worker number is one row below the top of the **CJobs** list.

The formula also uses the **IfError** function to fix errors that would occur with the **HLookup** function when the Assigned Group is blank.

4) Autofill the formula in **F3**, by double clicking its bottom right corner.

5) In cell **K3**, enter the following formula:

```
=IFERROR(HLOOKUP($L3,SJobs,$A3+1),"")
```

This formula also uses the HLookup and IfError functions in a similar fashion to get the satisfaction scores for the worker's assigned group.

- 6) Autofill the formula in **K3**, by double clicking its bottom right corner.
- 7) Save your work.

Exercise 4: Summarize all the scores

In this exercise you will summarize all the scores and count the number of employees assigned to each job.

- 1) In cell **F1**, enter the following formula to add up all the C Scores.

```
=SUM(F2:F22)
```

- 2) Use format painter to copy the cell format of **F3** to **F1**.
- 3) In cell **K1**, enter the following formula to add up all the C Scores.

```
=SUM(K2:K22)
```

- 4) Use format painter to copy the cell format of **K3** to **K1**.
- 5) If desired, use the following custom number format to add three spaces after the calculated score in cells **F1:F22** and **K1:K22**.

```
#,##0 ;
```

- 6) Save your work.

Exercise 5: Count the number of assigned jobs

In this exercise you will count the number of employees assigned to each job.

- 1) Enter the following values in cells **O2:P6**.

Cell	Value
O2	Job
O3	1
O4	2

O5	3
O6	4
P2	Assigned

- 2) Bold the values in O2:P6.
- 3) Add borders to cells O2:P6.
- 4) In cells P3:P6 apply the **Calculation** style.
- 5) Create a named range the Assigned Job List.
 - a) Select cells L3:L22.
 - b) In the name box, enter **AssignedJobList**.
- 6) In cell P3 enter the following formula:

```
=COUNTIF(AssignedJobList,$O3)
```

This formula uses the Countif function to count the number of employees that were assigned to each job.

- 8) Autofill the formula in P3, by double clicking its bottom right corner.
- 7) Optional: Experiment assigning different employees to different jobs in the **AssignedJobList**.

Exercise 6: Display Penalties

The company wants to ensure that at least three employees are assigned to each job, and that no job has more than seven employees. Therefore, in this exercise you will add a penalty to each job that violates these rules. You will also add a penalty message that will identify the reason for the penalty.

- 1) Enter **Penalty** in cell Q2.
- 2) Bold cell Q2.
- 3) Enter the following formula in cell Q3.

```
=IF(OR(P3<3,P3>7),1,0)
```

This formula uses the OR and IF functions. If **P3** is under three OR over seven then a one is assigned. If not, a zero is assigned.

- 4) Autofill the formula in **Q3**, by double clicking its bottom right corner.
- 5) Enter **Total Penalty** in cell **P7**.
- 6) Bold and right justify cell **P7**.
- 7) Sum the penalties by entering the following formula in cell **Q7**.

```
=SUM(Q3:Q6)
```

- 8) Apply the Calculation style to cells **Q3:Q7**.
- 9) Enter the following formula to alert the user with an appropriate message if a penalty has been assigned.

```
=SWITCH(TRUE,P3<3,"Assigned is less than 3", P3>7,"Assigned is greater than 7","")
```

Optional: Instead of entering a long one-line formula, you may use **Alt + Enter** at the end of each line to create a multi-line formula as shown below.

```
=SWITCH(TRUE,  
    P3<3,"Assigned is less than 3",  
    P3>7,"Assigned is greater than 7",  
    "")
```

This formula uses the Switch function. The switch function is used to evaluate multiple conditions. When the first argument is TRUE the Switch function acts like multiple IF statements.

- In our case the first pair determines if **P3** is less than 3, and if so, returns the message "Assigned is less that 3".
- In our formula the second pair determines if **P3** is greater than 7. If so, the "Assigned is greater than 7" message is returned.
- If none of the conditions are met, then the final argument, "", is returned.

- 10) Autofill the formula in **R3**, by double clicking its bottom right corner.
- 11) Apply the **Calculation** style to cells **R3:R6**.

12) Merge cells **Q2:T2** into one cell.

13) Merge cells **R3:T6** into four cells by doing the following:

a) Select cells **R3:T6**.

b) From the ribbon choose **Home > Alignment > Merge & Center > Merge Across**.

14) Add all borders to cells **O2:T6**.

15) Test the penalties by adding a **1** in cell **L7**.

16) Save your work.

Understanding the Solve Add-In

Microsoft's free Excel Solver Add-In can help users find the best possible solution to a complex problem. It does so by changing one or more input cells, subject to business constraints that you identify. The solver is often used as a what-if tool to analyze, optimize, and help you solve business, science, engineering and/or economics problems.

What Solver Does

Solver works by:

- **Changing decision variables** (input cells you choose),
- To **optimize an objective cell** (maximize, minimize, or set to a specific value),
- **Subject to constraints** (limits or rules the solution must obey).

For example, Solver can be used to:

- Maximize profit given production constraints
- Minimize costs while meeting demand
- Allocate budgets or resources optimally
- Schedule work subject to time or capacity limits

Key Components Users Should Know

When using Solver, students must identify:

1. An **Objective Cell** – the result to optimize (e.g., total profit)
2. **Variable Cells** – the inputs Solver is allowed to change
3. **Constraints** – rules such as limits, minimums, maximums, or integers

Exercise 7: Use the Solver to assign employees to their jobs

In this final exercise you will use the Solver Add-in to let Excel assign the employees to the various jobs with the goal of both maximizing competence and employee satisfaction.

- 1) Verify that the Solver add-in is installed:
 - a) From the ribbon select **File > Options > Add-ins**.
 - b) Next to the Manage drop down click the **Go...** button.
 - c) If necessary, check the **Solver Add-In** option.
 - d) Click **OK**.
 - e) From the ribbon, click on the **Data** tab.
 - f) Verify you have an **Analyze** group that now includes the **Solver** button.
- 2) Enter the following values with the desired formatting in columns **P:T**.

Cell	Value	Formats
P10	Total Competence	Right justified
P11	Total Satisfaction	Right justified
P12	'- Total Penalty	Right justified
P13	Total Score	Right justified Bold

Cell	Value	Formats
R9	Multiplier	Bold
S9	Score	Bold

- 3) Enter the following formulas / values with the desired formatting in columns **O:S**.

Cell	Formula	Formats
Q10	=F1	Calculation Style
Q11	=L1	Calculation Style
Q12	=-Q7	Calculation Style
S10	=Q10*R10	Calculation Style General Number format
S11	=Q11*R11	Calculation Style General Number format
S12	=Q12*R12	Calculation Style General Number format
S13	=SUM(S10:S12)	Calculation Style General Number format

Cell	Value	Formats
R10	3	Input Style
R11	1	Input Style
R12	1000	Input Style

You will now use the solver to maximize the total score (cell S13) provided that the employee assignments are for a job number between 1 and 4.

- 4) Select cell **S13**.
- 5) From the ribbon select **Data > Analyze > Solver**.
- 6) For the **Set Objective** choose cell **S13**.
- 7) For the **To:** option choose **Max**.
- 8) For the **By Changing Variable Cells:** option choose **AssignJobList**.
- 9) For the **Subject to the Constraints:**
 - a) Click the **Add** button.
 - b) For the **Cell Reference:** choose **AssignJobList**.
 - c) Set the operator drop-down to **<=**.
 - d) For the **Constraint** enter **4**.
 - e) Click the **Add** button.
 - f) For the **Cell Reference:** choose **AssignJobList**.
 - g) Set the operator drop-down to **>=**.
 - h) For the **Constraint** enter **1**.

- i) Click the **Add** button.
- j) For the **Cell Reference:** choose **AssignJobList**.
- k) Set the operator drop-down to **int**.
- l) Click **OK**.
- m) For the **Select a Solving Method:** choose **Evolutionary**.
- n) Click the **Solve** button.
- o) Allow the solver to run for about 60 to 90 seconds.
- p) When the **Solver Results** dialog box is displayed, choose **Keep Solver Solution** and then click **OK**.