

# UEP USER GUIDE

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Hover and Control-click to jump to a topic.

Recommendation: If viewing this online, keep this page open so that you can refer to it again without reloading the document. The topics and page numbers link to sections.

## PREFACE

**Utility Elicitation Program** (UEP) is a tool to help a person determine his or her own risk policy as a utility function. An executive might be interesting in establishing an organization's risk policy.

Access UEP using an Internet browser. We do not capture your session data. Those records are stored only and temporarily in your browser's window.

Before proceeding to UEP:

- You should have a general understanding of decision analysis (DA). This process extends traditional analysis by using probability distributions to represent risks and uncertainties. Introductory DA materials are readily available, and several items are at the same page that you use to access UEP (after a simple registration and log-in): <http://www.maxvalue.com/online.htm>
  - “Decision Analysis Overview” (video)
  - “Resolving Decision Dilemmas” (whitepaper)
  - “Decision Analysis in Cost Engineering” (whitepaper)
- You recognize that you are risk-averse and want to craft a conservative **risk policy**. You understand the utility function approach and the features of the “exponential utility function” shape. At the same web page are:
  - “Risk Policy as a Utility Function” (video)
  - “Risk Policy as a Utility Function” (whitepaper)

Both contain questions that will let you experience hypothetical decision situations. Charts and tables convert your assessment values into risk tolerance coefficients ( $r$ ). The shape of the utility function, defined by  $r$ , is sufficient for a logical, consistent risk policy. You then have a guide for making risk versus value trade-offs.

UEP does this better. The program automates an interview session to help you determine your  $r$ . UEP generates random questions, in several formats and scaled to the size decisions that you encounter. Each answer leads to a corresponding  $r$  value. With practice and feedback, you will become calibrated in making decisions with risk. Your  $r$ 's should gradually converge with experience. Once you settle on an  $r$ , this value represents your risk policy.

While UEP will work on a smartphone's browser, use is easier with a larger device.

UEP is offered free except to trainers and consultants, i.e., my competitors. Read the About text for a description of this restriction. Call or write if you are concerned about allowed free use or to obtain authorization.

## QUICK START

Login at <http://www.maxvalue.com/online.htm>. Register, first, if this is your initial visit.

Click the **Utility Elicitation Program** link near the page bottom.

Of course, we attempted to make the user interface intuitive. Short descriptions appear when hovering the mouse over buttons and text fields.

The upper-part of the UEP page is centered, and the lower-part is left-justified (to keep the node graphic aligned with the labels). Zoom or adjust your window width for a pleasing arrangement.

## Two Functions

UEP has two main functions:

- Generating a question. Clicking either <Random Question> or <Next Question> button will generate a question of the question type, transaction perspective, currency units, and maximum typical investment.
- Solving for *risk tolerance coefficient* ( $r$ ) based on your question answer.

## Quick References

These links, near the UEP page top, present various link and pop-up reference pages:

[Help](#) [Symbols](#) [About Revisions](#)  
[\[view session\]](#)

Reference topics refer back to a section in this User Guide. Print all or portions of this document if you want hardcopy.

A record of each answered question is stored (in hidden text) in the browser's page. Clicking [View Session] brings up a page that you can copy and paste into a spreadsheet or other document.

## Question Parameters

Most UEP users will let the program generate random questions. Well, they are not entirely random. Questions come in three Types. And there is a choice of Buy and Sell Perspectives. Further, the outcome values are scaled to be significant yet seldom exceed the Maximum Investment amount (in Currency Units). A random number generator provides a mix of project attributes:

Abbreviation	Description
Ps	Probability of success or the highest <i>NPV</i> outcome ( <i>NPVs</i> ).
NPVs	Net Present Value of success (or best outcome)
NPVf	Net Present Value of failure (or worst outcome)

Some CE type questions will have both NPVs and NPVf positive, and some where both outcomes are negative. Always,  $NPVf < NPVs$ .

## SETTINGS

Question Type       Ps  CE  Share

Perspective       Buy  Sell

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**Currency Settings**

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**Currency Units** \$k

**Max Investment** 40  \$k

UEP first defines the general question parameters with a choice of three Question Type radio buttons:

Parameter Abbreviation	Question Type	Description (Buy and Sell Perspectives)
Ps	Threshold probability of success	What is the minimum probability of success you would require to be just willing to approve the project? -or- What is the lowest probability of success you would require to be just willing to keep the project?
CE	Certain Equivalent	What is the most you would be willing to pay (your <i>CE</i> ) to <i>acquire</i> the project or asset? -or- What is the smallest amount (your <i>CE</i> ) you would be willing to accept to <i>sell</i> the project or asset?
Share	Optimal share or ownership fraction	What is optimal share (fraction) you would like to <i>acquire</i> in a large project or risky asset? -or- What is the smallest share you like to <i>retain</i> in a large project or risky asset?

Next are radio buttons to let you choose between transaction Perspectives:

Perspective	Description (Buy and Sell Perspectives)
Buy	You are buying or investing in the project or risky asset. You are acquiring or increasing your share of a large project.
Sell	You are selling or disposing of the project or risky asset. You are disposing or reducing your share of a large project.

**Currency Units** are “\$k” units (default) at startup. You may replace this label with a currency description of your choice, 1-8 characters. These units measure *NPV* outcome amounts and the calculated risk tolerance coefficient (*r*). Behind the scenes are utility and expected value utility calculations in “risk-neutral” (RN) Currency Units.

Depending upon the amounts involved, you may need to include a multiplier code. As examples: k is common for 1000s, and M may represent millions ( $10^6$ ). B or G are common for billions ( $10^9$ ).

UEP starts with a default label “\$k” for the Currency Units setting. While this label might be appropriate for individuals in the U.S. or other countries using the \$ symbol, it likely is unsuited to corporations and users with other currencies.

The Currency Units label does not affect any calculations. However, if your Max Investment is above 50000, then scale it back by dividing by 1000 or 1 million. Then your Currency Units should include a 'multiplier' suffix.

If your keyboard doesn't have the currency symbol you want, one of these codes may fit your currency:

Name	Symbol	Type Code
Dollar	\$	Alt+36
Euro	€	Alt+0128
GB Pound	£	Alt+156
Yen	¥	Alt+157

To enter a symbol, press and hold down the Alt key while typing the numeric code.

You can find more codes by searching online or by copying and pasting from a document. I haven't found a table of universally-accepted symbols, and some of the incompatibilities may be conflicts with the language default setting in Microsoft Windows.

An alternative to symbols is to use a letters currency abbreviation, such as "EUR".

**Max Investment** is 50 (default) in Currency Units at startup. Replace this amount with the maximum Currency Units that you would typically invest in any single project. UEP uses this to generate hypothetical investments of sizes that are at meaningful to you. For Ps and CE type questions, candidate investments at risk (NPVf) will be approximately in the range of 0.2 to 1.2 times your Max Investment. For Share type questions, NPVf will be substantially larger than Max Investment. To keep the presentation labels to reasonable lengths, UEP requires Max Investment to be in the range 1-50000.

After you enter your answer, press <Enter> or click the green "Go" |> button at the right.

UEP calculates the risk tolerance coefficient (in Currency Units) and returns the value below the question. Any error or warning messages will appear nearby.

## SYMBOLS

Here are the symbols in UEP and brief definitions:

Symbol or Term	Definition
<b>CE</b>	Certain equivalent. This is the cash-in-hand value of a risk.
<b>DROI</b>	Discounted Return on Investment. $DROI = EMV /  -NPVf $ . This is a popular ranking criterion with limited capital.
<b>EMV</b>	Expected Monetary Value = expected value NPV.
<b>EU</b>	Expected (value) Utility.
<b>NPVs</b>	Net Present Value of the Success (or best or bad) outcome.

<b>NPVf</b>	Net Present Value of the Failure (or good or worst) outcome.
	For CE questions and both outcomes are positive:
	$NPVf = \text{good} < \text{best} = NPVs.$
	For CE questions and both outcomes are negative:
	$NPVf = \text{worst} < \text{bad} = NPVs.$
<b>Ps</b>	Probability of success (decimal). Or, probability of the better outcome.
<b>PsBE</b>	Probability of success (decimal) at BreakEven (where $EMV = 0$ ).
<b>P(profit with 10) Ps 10X</b>	The probability of $NPV > 0$ for a portfolio of 10 identical, independent projects like this one. Alternate symbol: "Ps 10X".
<b>r or RTC</b>	Risk Tolerance Coefficient (RTC or r). This the scaling factor for risk policy. Helping you assess r is the purpose and outcome of UEP. Higher r means you are more risk-tolerant.
<b>Share</b>	Fractional ownership (decimal) of a large project or large risky asset. The optimal Share gives you the highest CE.

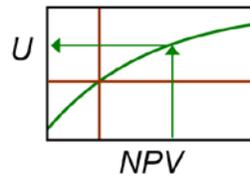
## Utility Equations

UEP uses these utility formulas:<sup>1</sup>

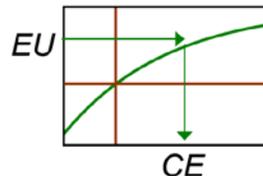
$$U(NPV) = r(1 - e^{-NPV/r})$$

$$CE(EU) = -r \ln\left(1 - \frac{EU}{r}\right)$$

Don't worry about these equations if the math is unfamiliar. A simple chart of the utility equation would work, though with less precision (example in a later section). The top equation translates *NPV* dollars (or your currency) into utility units. The bottom equation converts risk-weighted (expected value) utility back into dollars, your certain equivalent.



top equation



bottom equation

Key relationships:

$$NPVf < CE \leq EMV$$

$$\text{As } r \rightarrow \infty, CE \rightarrow EMV$$

$$\text{As } r \rightarrow 0, CE \rightarrow NPVf$$

## QUESTION FORMS

The risk for your consideration can be a venture, project, or risky asset. For this page, let's call it a project.

UEP presents questions in text form (with probability node and supplemental criteria). There are three general question types:

- **Ps**, where you assess the minimum probability of success before you would approve the project
- **CE**, where you judge your cash-in-hand equivalent to the project. This is your *certain equivalent (CE)*.
- **Share**, where you judge your optimal share of a large project

Question perspectives can be either:

- **Buy**, where you are acquiring or increasing ownership share of the project
- **Sell**, where you are selling or disposing of the risky project

Each question is defined by its Ps, NPVs, and NPVf. For the Ps question, *you* determine the minimum acceptable Ps.

In most decision analysis, the cornerstone criterion is *EMV* = expected monetary value. This is the probability-weighted *NPV* outcome:  $EMV = Ps \times NPVs + (1 - Ps) \times NPVf$

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<sup>1</sup> There are at least two functionally-equivalent formulas, but these work with utility measured in risk-neutral currency units.

The popular EMV decision rule is: “Choose the alternative with the highest *EMV*.”

The EMV decision policy presumes the individual or organization:

1. Is not capital constrained and can get more money to invest. The marginal cost of capital is the NPV discount rate.
2. Is risk-neutral. This means the range of outcome values and their probabilities do not matter—only the *EMV*.

## SUPPLEMENTAL CRITERIA

Some decision makers want to see additional decision criteria to supplement *EMV*. This may be especially important when considering the portfolio.

### Supplemental Decision Metrics

Criterion	Description
PsBE	For Ps type questions, this is the Ps that just makes $EMV = \$0$ . (or whatever your currency units)
DROI	Discounted Return on Investment = $EMV / -NPVf$ . This is the EV <i>NPV</i> gain per unit of investment, where the investment amount is assumed to be $-NPVf$ . The EMV decision maker will approve any project where $DROI > 0$ .
P(Profit with 10 like projects) or Ps 10X	Decision makers are often overly-concerned about risk with one project. What if you had a portfolio of ten identical, but independent projects like this one? This metric is the probability of a positive <i>NPV</i> outcome for the portfolio.

The chance node (as would represent the project in a decision tree) and table at the screen bottom shows these criteria again.

## TABLES

### Ps type question

Criterion	Description
Ps	Your assessment of the minimum probability of success for your <i>CE</i> to be \$0.
EMV	The EV <i>NPV</i> . This would be your project value if you were risk-neutral
DROI	Discounted Return On Investment, which diminishes with decreasing Ps.
Ps10X	The probability of success with ten identical, independent projects with your judged Ps.

## CE type equation

CE questions can assume a variety of circumstances. NPVs and NPVf can have different, or same signs. One outcome may be zero. The risk's EMV may positive, negative or zero.

The *regret* concept is useful for some decision makers:

- Regret is the improvement you would have obtained had you chosen differently.
- Depending upon your risk parameters and your *CE* answer amount, regret (always positive) will occur for either Success outcomes or for Failure outcomes.
- Minimizing EV regret provides the same decisions as maximizing EMV.
- EV regret = *value of perfect information* (VPI).<sup>2</sup>
- EV regret is synonymous with *expected opportunity loss* (EOL).

Criterion	Description
CE	Your assessed value of the risk. If negative and Buy perspective, this is the minimum amount (ignoring the sign) that someone would have to pay you to take the risk. If positive and Sell perspective, this is the maximum amount that you would be willing to pay someone to take away the risk.
Success Regret	If Buy perspective, Regret = CE – NPVf, if positive If Sell perspective, Regret = CE – NPVf, if positive
Failure Regret	If Buy perspective, Regret = NPVf – CE, if positive If Sell perspective, Regret = NPVf – CE, if positive
EV Regret	$P_s \times (\text{Success Regret}) + (1 - P_s) \times (\text{Failure Regret})$
EMV'	EMV – CE

There are five column names in the table above, and the UEP table presently accommodates only four table columns. Most times, one of the Regret columns is all zeros, and that column is left out. When both Success Regret and Failure Regret columns are non-zero, then the EMV column is left out.

## Share type questions

Criterion	Description
Share	Your judged optimal ownership share of this project.
Share NPVgain	Your share of the <i>NPV</i> outcome if the project succeeds. This is the Share fraction x NPVs.
Share NPVloss	Your share of the <i>NPV</i> outcome if the project fails. This is the Share fraction x NPVf.
EMV	EV NPV is you pay (receive) your CE to acquire the project.

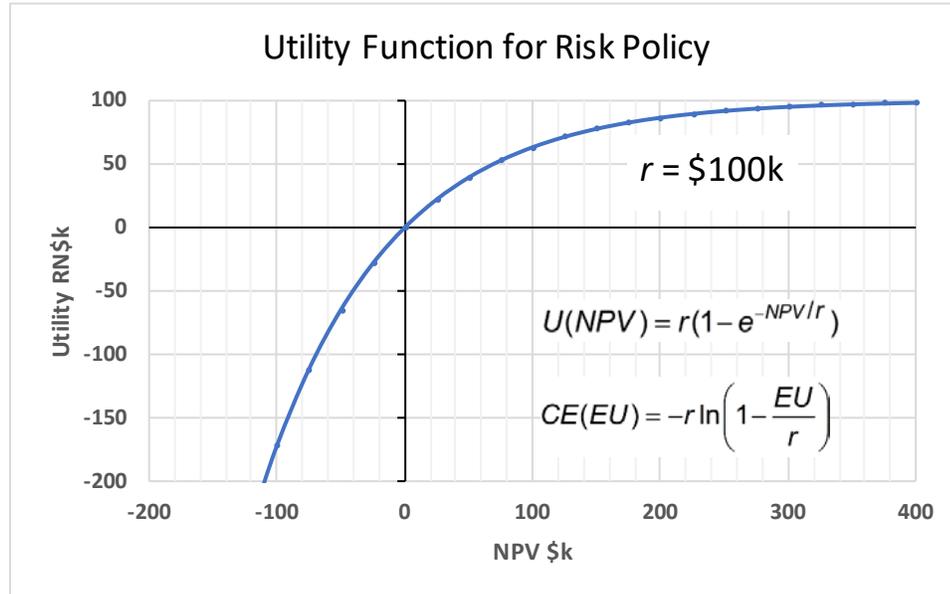
<sup>2</sup> Though numerically the same, these are usually calculated in different ways. EV regret is calculated from a regret table. VPI is calculated by temporarily rearranging a decision tree to put the information event before the decision.

## UTILITY FUNCTION CHART

Once you accept the idea of a utility function for risk policy, the application to decisions is reasonably simple.

Your utility function need not have the exponential shape. However, this shape has several, compelling properties. Please read [“Risk Policy as a Utility Function”](#) pdf document for a detailed discussion. UEP assumes a conservative (“risk-averse”) decision maker with an exponential utility function.

This utility function is for a decision maker whose  $r = \$100k$ . Curves for other values of  $r$  have the same shape; only the scales are changed proportionally.

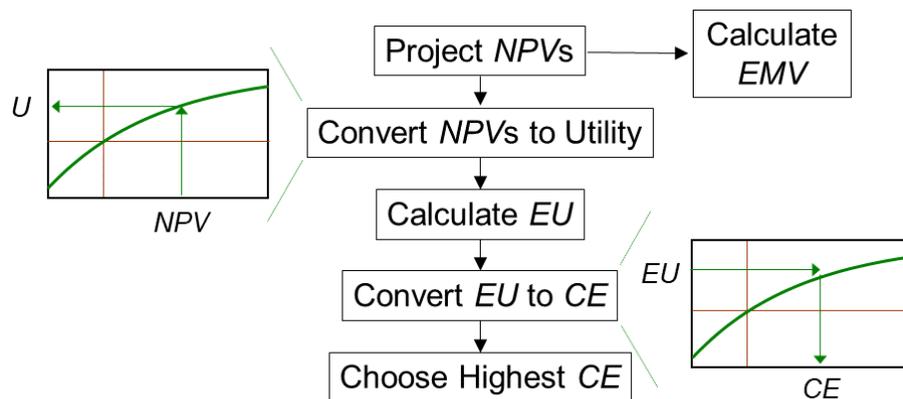


The spreadsheet for this chart is at <http://www.maxvalue.com/UtilityFunction.xlsx>. You can alter the chart for your choice of  $r$  and currency units. When starting to use the utility function formulas, it is helpful to have a utility function chart for checking your calculations.

There is a detailed calculation below, in Utility Calculations.

## UTILITY CALCULATION FLOW

This figure shows the calculation flow when using the utility function:



Variable	Description	
<i>NPV</i>	Net Present Value	Discounted present value of a projected net cashflow stream
<i>EMV</i>	Expected Monetary Value	Expected value of the possible <i>NPV</i> outcomes
<i>EU</i>	Expected Utility	Expected value of the possible <i>NPV</i> outcomes <u>after</u> conversion to utility units. Utility and <i>EU</i> are in risk-neutral dollars (RN\$) (or whatever your currency).
<i>CE</i>	Certain Equivalent (or Certainty Equivalent)	<i>EU</i> converted into actual money. The <i>CE</i> is the cash-in-hand-equivalent to a monetary risk.

## TYPICAL POLICIES

The usual utility-maximizing decision analysis process involves:

1. Modeling the system that produces cashflow, and calculate *NPV*s.  
Recommendation: Convert non-monetary factors into either cashflow or *NPV* equivalents.
2. Representing judgments about risks and uncertainties as probability distributions.
3. Solving for each alternative's expected value *NPV* using Monte Carlo simulation, a decision tree, a payoff table, or some combination.  
 $EV\ NPV = EMV$ .

The EMV decision maker would stop, here, and choose the alternative with the highest *EMV*.

If risk-averse, continue:

4. Translate outcome *NPV*'s into utility units.
5. Calculate expected (value) utility (*EU*) for each alternative.
6. Choose the alternative with the highest expected utility (*EU*).

The next steps are optional, though highly recommended:

7. Convert the *EU* for each alternative into certain equivalents (*CE*'s).
8. Choose the alternative with the highest certain equivalent (*CE*).

Steps 6 and 8 are both called “the expected utility decision rule,” because the choices are always the same.

## UTILITY CALCULATIONS

Use this equation to convert an *NPV* into utility units:

$$U(NPV) = r(1 - e^{-NPV/r})$$

Where  $r$  is the risk tolerance coefficient that UEP helps you determine.

For a convenient label and analogy, I call the utility units “risk neutral dollars” (RN\$). Of course, substitute your currency if not dollars. Here is a real-world analogy that provides some grounding: RN\$100k is 100k times better than \$1.

Once you have an *EU*, convert back into real money using this equation:

$$CE(EU) = -r \ln\left(1 - \frac{EU}{r}\right)$$

Choose the alternative with the highest *CE*.

### Example Calculations in Excel

Microsoft® Excel® is an excellent tool for understanding and experimenting with utility. And, in most organizations, Excel is the dominant platform for cashflow and risk modeling.

The  $U$  and  $CE$  equations may look complicated, but they're really not. Engineering and math students routinely use log and exponential functions. In Excel, they look like:

Converting *NPV* to utility:

$$=rtol*(1-EXP(-NPV/rtol))$$

**rtol** is the name I usually assign to  $r$ , because **r** in Excel is a reserved word for **row**.

And converting *EU* to *CE*:

$$=-rtol*LN(1-EU/rtol)$$

Here is a typical calculation that UEP solves:

		100.0	rtol			
<u>P(x)</u>	<u>Symbol</u>	<u>x = NPV</u>	<u>EMV</u>	<u>U(x)</u>	<u>EU</u>	
0.600	NPVs	150	90.00	77.69	46.61	
0.400	NPVf	-50	-20.00	-64.87	-25.95	
			70.00		20.66	EU
					23.15	CE

This spreadsheet is slightly modified from the Ps tab in the spreadsheet link, below.



A question is defined by 7 initial parameters, separated by commas:

Position	Parameter	Value Choices
1	Question Type	1=Ps, 2=CE, or 3=Share
2	Perspective	1=Buy, or 2=Sell
3	Currency Units	1 to 8 characters describing your desired currency units. This typically include a 'multiplier,' such as k, M, or B.
4	Max Investment	Value 1 to 50000 representing, in Currency Units, the maximum investment (money at risk of loss, NPVf) that you would normally consider risking in any single project or asset.
5	Ps	Decimal fraction for Ps. Does not apply to Ps questions where Ps will be your answer; put in 0.
6	NPVs	NPV outcome value for the success or best case. Must be positive for Ps and Share type questions.
7	NPVf	NPV outcome value for the failure or worst case. Must be negative for Ps and Share type questions.

After you answer a question, UEP adds these to the Question Code sequence:

Position	Parameter	Value Choices
8	Your Answer	Your judgment for Ps, CE, or Optimal Share, according to the question Type.
9	Calculated $r$	A solution risk tolerance coefficient ( $r$ ) defining your degree of risk aversion and the scaling parameter in the utility equation (i.e., <b>your risk policy</b> ).
10	Possible Message	A possible warning or error message returned by UEP. The program will not return an $r$ value if there is a serious problem. That problem may be because UEP cannot calculate $r$ for the particular project parameters and answer.

## Example

This is an example Question Code: **1,1,"\$k",40,0,200,-30**

This code specifies: **1**=Ps question Type, **1**=Buy Perspective, **2**=View Parameter, **"\$k"**=Currency Units (thousands of \$), **40** your Max Investment (in \$k), **0**=for the unused Ps parameter (this is a Ps type question), **200**=\$k success NPV, and **-30**=\$k failure NPV.

We see this as placed in the Question Code box:

Enter Question Code



Press <Enter> or click the Go button to generate the question text, graphic, and table.

Suppose you believe 36% is the minimum  $P_s$  that you would require to be just willing to approve this project. Enter **.36** in the Answer box. Press <Enter> or click the answer green "Go" button.

UEP calculates and displays the risk tolerance coefficient = 70.6 \$k. Your answer and the calculated  $r$  are appended in the Question Code field.

1,1,"\$k",40,0,200,-30,.36,70.6 

Suppose you considering acquiring an investment opportunity or project.

NPV of success = 200 \$k

NPV of failure = -30.0 \$k

EMV > 0 \$k if  $P_s > 0.1304 = P_sBE$

What is the minimum  $P_s$  you would require to approve this project?

your answer    
decimal fraction

risk tolerance coefficient \$k

Question Codes, your answer, and the calculated  $r$  form a record of the question. UEP appends records to a hidden list in your browser's window. At the end of your session, or any time before, you may view your session history by clicking the "[view session]" link near the UEP page top. You may copy these records to your computer's clipboard and then paste them into a file for a permanent record.

Excel allows you to import a "comma-delimited" file, and Excel is a good tool for analyzing your responses. The objective is for your  $r$ 's to converge as you become "calibrated" with practice and feedback.

You can revisit a question at a later time by entering or pasting the first 7 parameters and in the Question Code box.

## Excel Workbook

This Excel workbook is useful in constructing and saving Question Codes: [UEP Question Codes\\_20170919.xlsx](#)

- At the "for Creating questions" tab is a worksheet for building a list of questions. Parameters are arranged in columns. After is a column with the combined text string ready to copy and paste into UEP. Error messages indicate invalid parameters and certain other violations.
- At the "for Saving questions" tab is a worksheet providing a place to save Question Codes for answered questions. The worksheet separates the parameters into columns. We leave it to you to determine how you want to analyze your session(s). You may want to trim off Answer and  $r$  fields and submit Question Codes to retake questions.

After you have used Question Codes a few times, you will likely remember and be able to enter new question parameters directly.