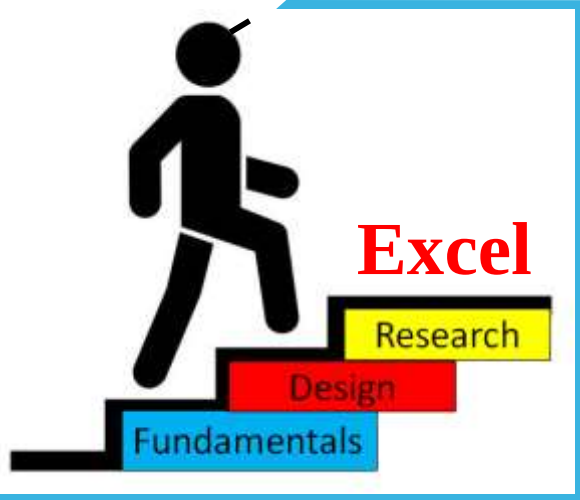
THERMAX 1-2-3

A MODELLING PLATFORM FOR OPTIMISATION ANALYSES OF FLUID-THERMAL SYSTEMS USING MS EXCEL



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Outlines

- Objective, method, and tools
- The Excel-based platform for thermo-fluid analyses
- Highlights
  - Examples of basic analyses
  - Examples of design optimisation analyses
  - Examples of research analyses
- About Thermax
- A Solver-TOPSIS technique for MOO analyses
- Course material

OBJECTIVE, METHOD, AND TOOLS

Objective, method, and tools

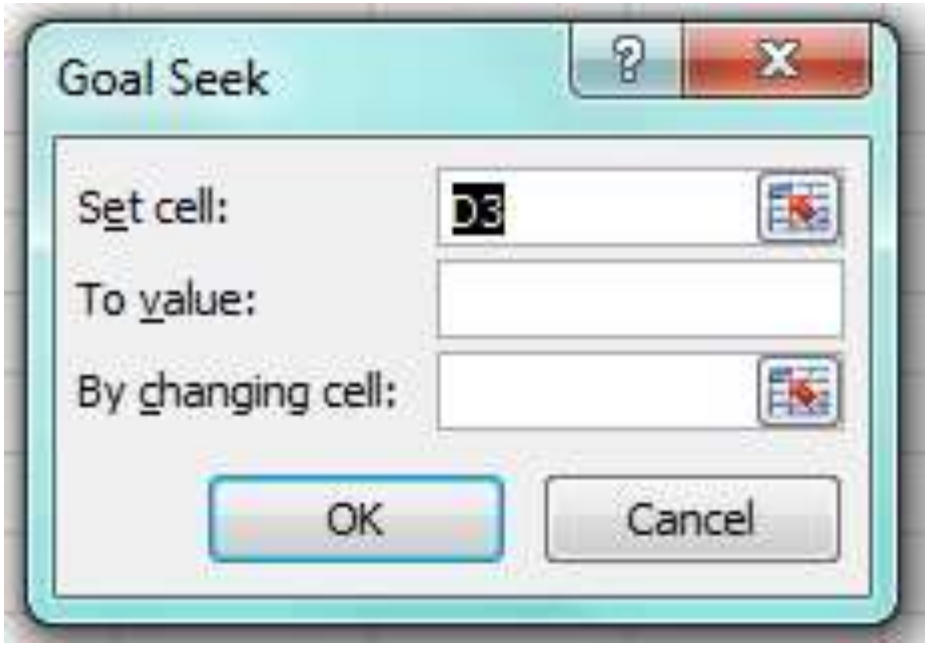
- To describe an effective learning/teaching method for energy-related undergraduate subjects:
  - Thermodynamics
  - Fluid-dynamics
  - Heat-transfer
- Method and tools:
  - Encourage computer-aided analytical methods
  - Enable design analyses of fluid-thermal systems
  - Adopt problem and project-based learning (PBL)
  - Facilitate student research

THE EXCEL-BASED PLATFORM FOR THERMO-FLUID ANALYSES

Excel's Built-in capabilities

- Graphical display of data and analyses results
- Numerous built-in mathematical functions, e.g. statistical, financial, etc.
- Solution of linear systems of equations by the matrix inversion method (**MMULT, MINVERSE**)
- Iterative solutions and solution of non-linear equations:
  - **Internal solver (the iterative calculations option)**
  - **Goal-Seek**

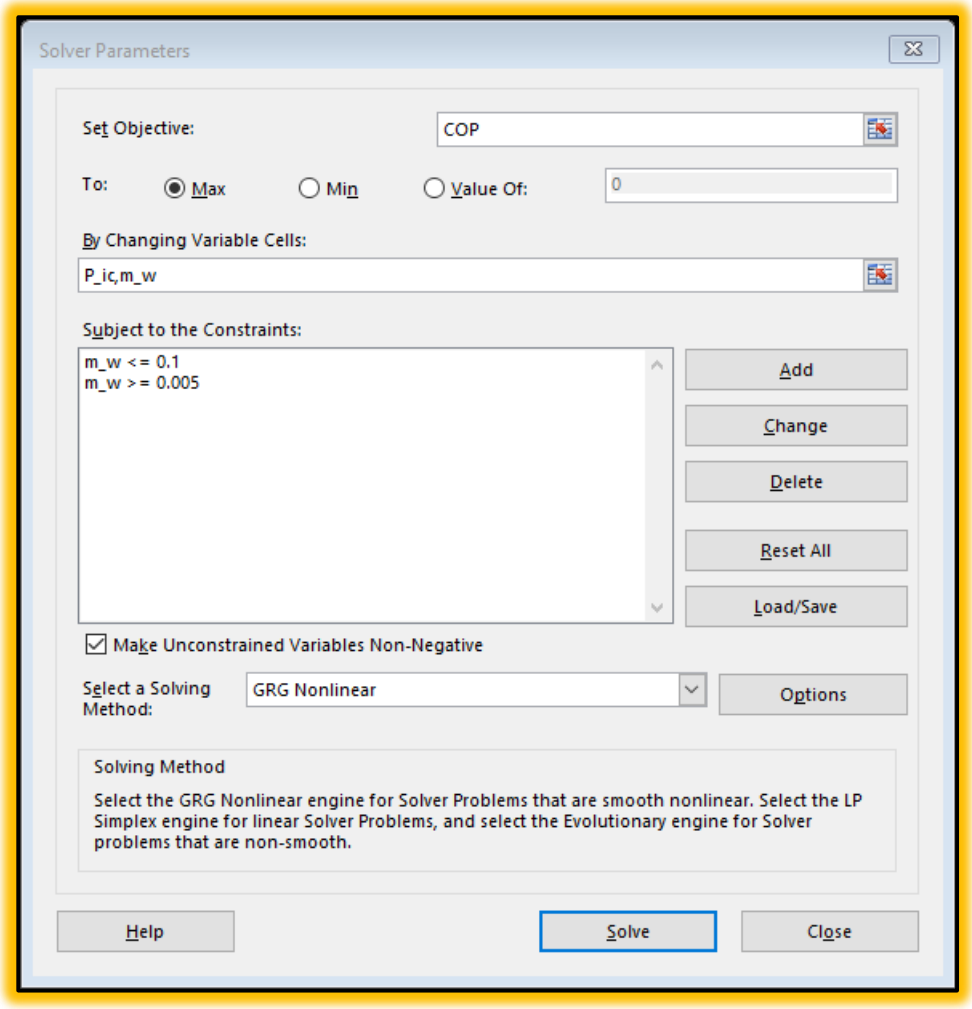
Goal Seek



Tools for thermo-fluid analyses

- Single-objective optimisation (**Solver**)
- Multi-objective optimisation:
  - The **MIDACO** solver
  - **Solver+TOPSIS**
- Various add-ins for fluid properties (e.g. REFPROP, **Thermax**)
- Visual Basic for Applications (**VBA**) for the development of user-defined functions

Solver for S-O and M-O optimisation



Thermax

- Thermodynamic analyses require evaluation of the thermodynamic properties of working fluids at different phases, pressures and temperatures.
- Excel itself doesn't have built-in function for this purpose.
- Thermax has been developed for education purposes.

Thermax functions for fluid properties

#	Substance(s) of the group	Prefix
1	Ideal gases (29)	Gas…
2	Water and steam	Wat…
3	Refrigerants (32)	Ref…
4	Water lithium-bromide solution	Lib…
5	Ammonia-water solution	Nh3...
6	Psychrometry	Psy
7	Fuels and reacting substances (18)	Chm…
8	Air at atmospheric pressure	Air…

Visual Basic for Applications (VBA)

- VBA
- Availability and ease of use
- Development of user-defined functions, e.g. for fluid properties
- Development of Macros and user forms for user-friendliness of developed applications
- Examples:

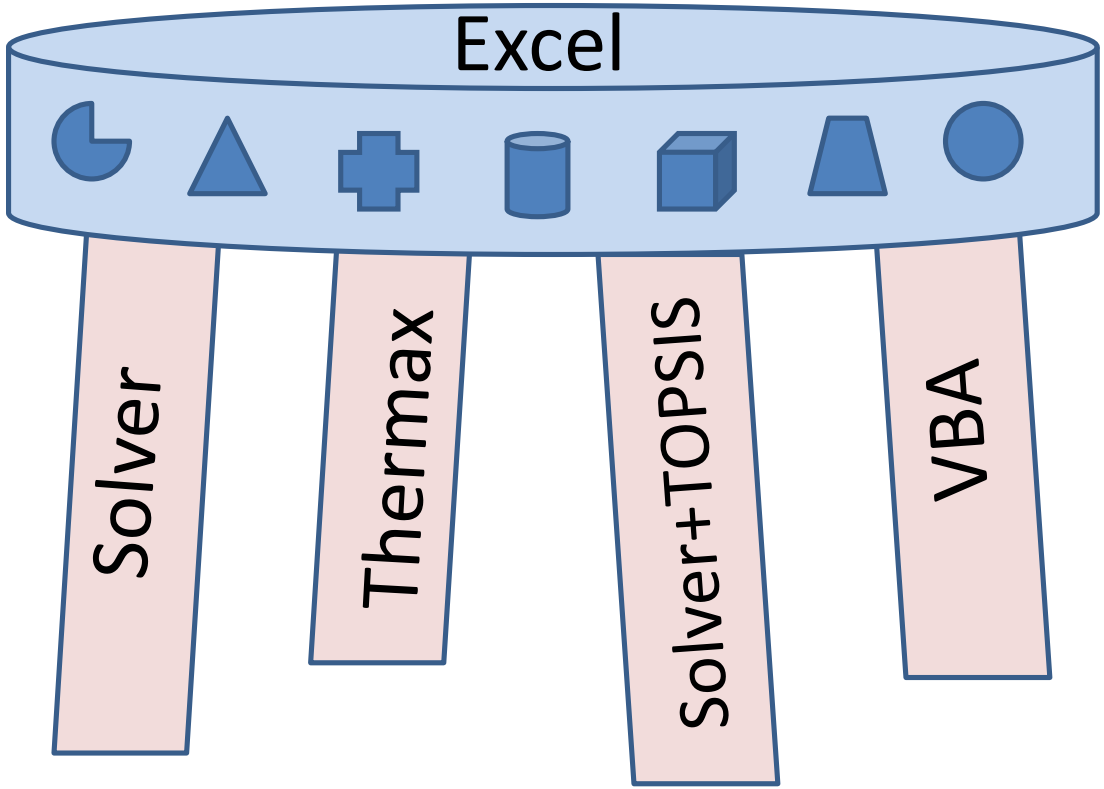
Function GWP(Ref$)

```
Function GWP(Ref$)
If Ref$ = "R23" Then
GWP = 14800
ElseIf Ref$ = "R404A" Then
GWP = 3920
ElseIf Ref$ = "R4104A" Then
GWP = 89
ElseIf Ref$ = "R134a" Then
GWP = 1300
ElseIf Ref$ = "R744" Then
GWP = 1
ElseIf Ref$ = "R152a" Then
GWP = 140
ElseIf Ref$ = "R290" Then
GWP = 5
ElseIf Ref$ = "R717" Then
GWP = 0
End If
End Function
```

Function Schedule40(Diam, index)

```
Function Schedule40(Diam, index)
'Dim A, B, C, D, E, F
a = Array(0.405, 1.029, 0.02242, 0.683, 0.0003947, 0.3664)
b = Array(0.54, 1.372, 0.03033, 0.924, 0.0007227, 0.6706)
c = Array(0.675, 1.714, 0.04108, 1.252, 0.001326, 1.233)
D = Array(0.84, 2.134, 0.05183, 1.58, 0.00211, 1.961)
e = Array(1.05, 2.667, 0.06867, 2.093, 0.003703, 3.441)
F = Array(1.315, 3.34, 0.08742, 2.664, 0.006002, 5.574)
G = Array(1.66, 4.216, 0.115, 3.504, 0.01039, 9.643)
h = Array(1.9, 4.826, 0.1342, 4.09, 0.01414, 13.13)
.
.
If (Diam <= a(index)) Then
Schedule40 = a(index)
ElseIf Diam <= b(index) Then
.
.
End If
End Function
```

The Excel-based modelling platform

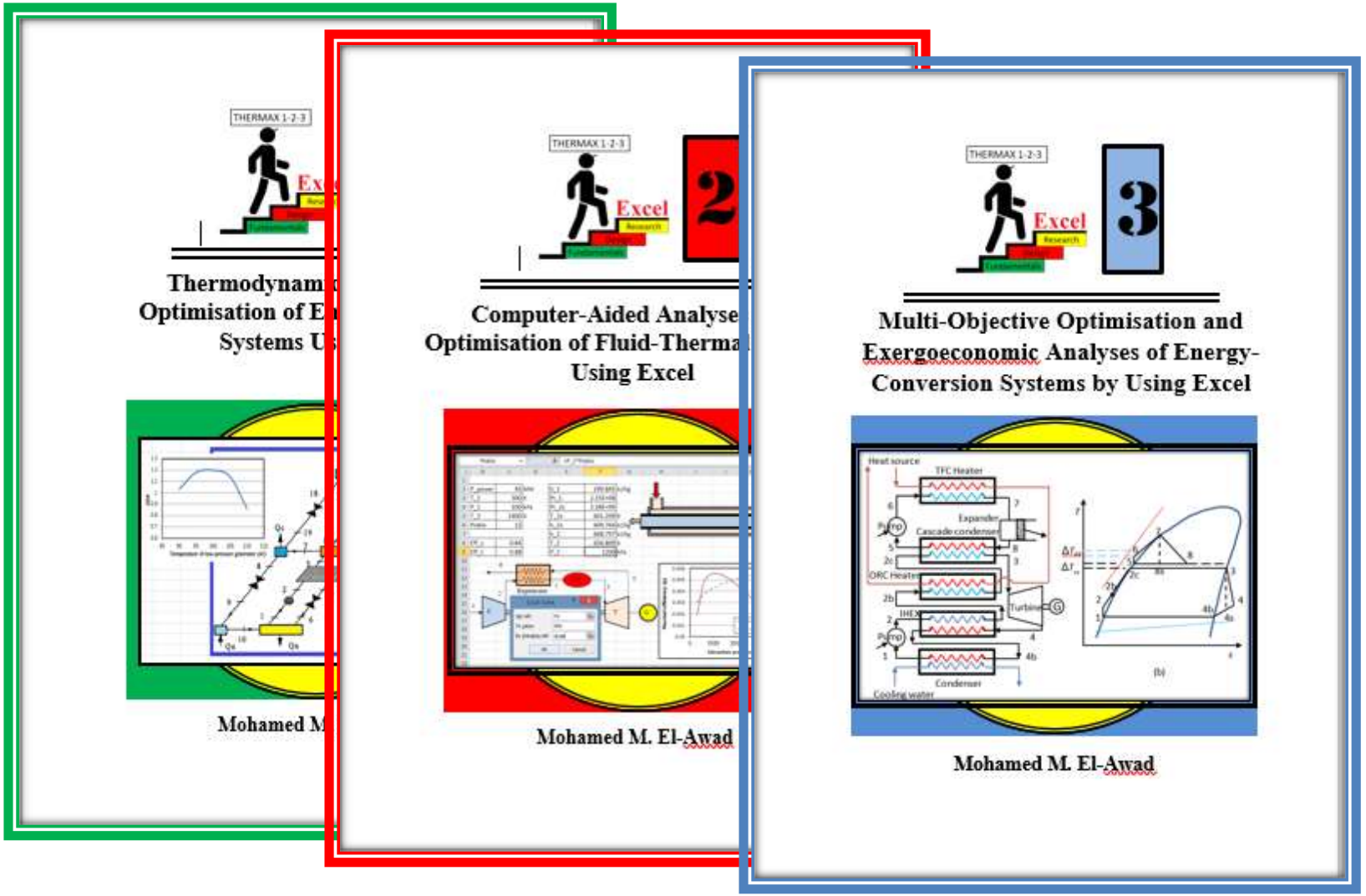


Features

- An Excel-based modelling platform
- An Excel add-in for fluid properties that is adequate for most thermo-fluid analyses (Thermax)
- A technique for using Solver and TOPSIS for multi-objective optimisation analyses
- Three books that can be used at three levels

COURSE MATERIAL AND SUGGESTED COURSES

Three books *(unpublished)*



Three books (*unpublished)*

- Thermodynamic Analyses and Optimisation of Energy-Conversion Systems using Excel - (3rd year - Thermodynamics II, Applied thermodynamics)

  https://www.academia.edu/24381392/Thermodynamic_Analyses_and_Optimisation_of_Energy_Conversion_Systems_Using_Excel?email_work_card=view-paper
- Computer–Aided Analyses and Optimisation of Fluid-Thermal Systems using Excel - Excel (4th year – Computer applications, Elective subject)

  https://www.academia.edu/40015718/Computer_Aided_Analyses_and_Optimisation_of_Fluid_Thermal_Systems_using_Excel?auto=download&email_work_card=download-paper
- Multi-Objective Optimisation and Exergoeconomic Analyses of Energy-Conversion Systems by Using Excel – (5th year UG- Elective subject, 1st year PG- Elective subject)

  https://www.academia.edu/41316679/Multi_Objective_Optimisation_and_Exergoeconomic_Analyses_of_Energy_Conversion_Systems_by_Using_Excel?auto=download&email_work_card=download-paper

References

1. L. W. Anderson and D. R. Krathwohl, eds. *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. New York: Longman, 2001.
2. M. Hofmann, F. Witte, M. Fritz, J. Freissmann, l Tuschy, G. Tsatsaronis. *Free and Open-Source Teaching: Understanding Exergy using Thermal Engineering Systems in Python (TESPy),* Proceedings of ECOS 2023 - the 36th International Conference on **E**fficiency, **C**ost, **O**ptimization, **S**imulation and **E**nvironmental impact of energy systems, 25-30 June, 2023, Las Palmas de Gran Canaria, Spain
3. MIDACO-Solver, http://www.midaco-solver.com/