

THE *ENGINEERING ECONOMIC ANALYSIS (ENGINEA)* SOFTWARE: ENHANCING TEACHING AND APPLICATION OF ECONOMIC ANALYSIS TECHNIQUES

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Abstract

The *ENGINEERING Economic Analysis (ENGINEA)* software is developed to help engineering and business students solve problems in engineering economic analysis and financial management courses. The software provides users the ability to perform cash flow analysis, depreciation analysis, and replacement analysis. Other modules are interest factor calculations, loan/mortgage evaluation, and evaluation of investment alternatives using internal rate of return and benefit/cost ratio analyses. This software is unique because of its many capabilities; it is a one-stop shop of techniques for solving engineering economic analysis problems.

Keywords

Economic analysis software, cash flow analysis, depreciation analysis, replacement analysis, interest factor calculator, evaluation of alternatives, loan and mortgage evaluations.

Introduction

Several innovative ideas, including the use of computer spreadsheets and software, have been developed over the last decade to enhance the teaching and application of economic analysis techniques both in the classrooms and in the real world [3]. According to Alloway [1], some of the problems engineers encounter in applying these techniques in the industry includes the time it takes to apply them, non-availability of the right tools to help with a speedy implementation, and the complexity involved. He then suggested that an appropriate software

will minimize, if not eliminate, many of these problems. Therefore, the use and importance of software tools in engineering economic evaluation, especially spreadsheet functions, has been emphasized in the literature[1],[4]. Spreadsheets provides rapid solution and the results of the analyses can be saved for easy presentation and references. However, the time and complexity involved in formatting the computer spreadsheet motivate the development of this software. This paper presents *ENGINEA* software developed to help students and engineers in the application of economic analysis techniques.

The types of software used for economic analysis can be categorized into spreadsheets, application software, or decision-support based software. Spreadsheet based software offers a lot of advantages but it has associated disadvantages as stated above. Decision-support software has not been widely used in economic analysis but it has practical applications for the future. Application software can be either decision-support based or non decision-support based. Decision-support based applications give users an idea for the processes involved in arriving at the final results, even though some of these processes are not explicitly stated in the solution window. Such software enhances students understanding of the concept being used while saving them the mathematical rigor involved. Non-decision support application software is problem specific and is usually developed and used for special type of projects; it is usually regarded as "black box."

The ENGINEA Software

The ENGINEA software is an MDI (multiple-document-interface) decision-based application developed using Visual Basic to help students and engineers perform several economic analyses. It is an MDI software because users can work with several documents (cases) simultaneously. The ENGINEA software is developed to target three major audiences: undergraduate students, graduate students, and instructors teaching both engineering economic analysis and financial management courses. In addition, the software should also be useful to students in upper undergraduate and graduate classes, engineering practitioners in the industry for training engineers and financial analysts, and recruiters for promoting the advancement of economic analysis. Therefore, the objectives of the ENGINEA software are:

- To introduce to engineering economic analysis and financial management students a creative way of using hands-on approach for solving complex economic analysis problems;
- To provide a tool devoted to solving engineering economic analysis problems;
- To demonstrate how engineers use computer tools for developing decision-support modules; and
- To enhance the teaching and dissemination of techniques for engineering economic analysis problems.

Useful functionality and user friendliness were two major factors considered when designing the ENGINEA application. Hardcopy results are valuable for future references; therefore, the ability to print the inputs and the results is available for all modules. The outputs can be saved to a file at any time for future references. Example files are provided in the software installation, which can be loaded by the user for their references. A standard menu bar allows the user to open the modules, save, and print the output. In addition, a graphical toolbar containing recognizable icons is available for

the user to perform the same functions available in the menu bar. The application is stable in the current release. No errors in the application are known at this time. All invalid user inputs are handled appropriately. The user can open as many components in the application desktop as desired, which gives the user the ability to easily compare results.

Instructional Design

The ENGINEA application can be used to enhance the users' knowledge of cash flow analysis, benefit/cost ratio, rate of return, replacement analysis, and depreciation analysis problems in engineering economy and financial management courses. These analyses are the core areas of the ENGINEA software. A factor interest calculator is also available for finding factor values more rapidly and easily.

Cash Flow Analysis

As the user enters cash flow values for each period, they can see how the cash flow diagram is constructed. This is one of the unique features of the software. In addition, they can see how their input affects the present worth, the annual worth, and the future worth of the cash flow profile. The interest rate can also be change at any time, so the user can learn how changing interest rates affect the present worth, the annual worth, and the future worth values. A screenshot of a cash flow analysis example is shown in Figure 1.

Figure 1 shows the cash flow diagram, the present worth (PW), the future worth (FW), the annual worth (AW), and the interest rate. The user is presented with a large scrollable area for the cash flow diagram, since the diagram is a vital portion of most cash flow problems. The user can add, update, and remove cash flow values using the appropriate buttons. The user also has the ability to move to any period using the left and right arrow buttons, and the currently selected cash flow period is highlighted in the diagram. The maximum

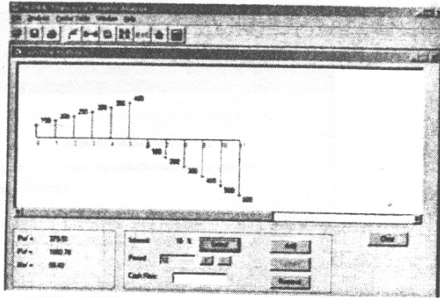


Figure 1: Cash flow analysis screenshot

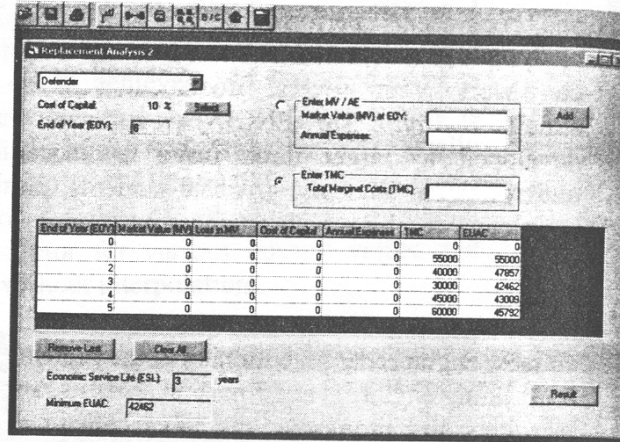
number of periods allowed is 32. The interest rate can also be updated for sensitivity analysis. In all cases, the PW, AW, and FW are updated automatically. As stated above, this profile can be saved for future references or usage and it can also be printed for reporting purposes.

Replacement Analysis

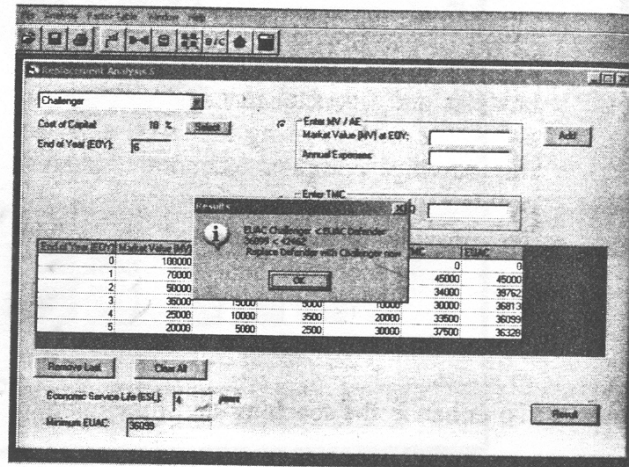
In the Replacement Analysis module, the Equivalent Uniform Annual Cost (EUAC), the economic Service Life, and the Minimum EUAC are dynamically calculated as the user enters Market Value, Annual Expenses, and Total Marginal Cost values of either the challenger or the defender. The users can see how the values they enter affect the minimum EUAC and ultimately the result of the analysis. When the user chooses to view the result of the analysis, it will display the result, which is either to keep defender or replace the defender with the challenger as shown in Figure 2.

The replacement analysis can be done by inputting either both the market value (MV) and the annual expenses (AE), as shown in Figure 2a, or the total marginal cost (TMC), as shown in Figure 2b, for both the challenger and the defender. Figure 2a is the replacement analysis table for the defender; while Figure 2b is replacement analysis table for the challenger. The result of the decision of the replacement analysis generated after clicking on the result button is also shown. Replacement analysis is computationally intensive; therefore, students can easily make mistakes. This software can help students check their results easily. For this

module, the challenger and defender use the same input screen; therefore, a dropdown list is provided to select either the challenger or the defender.



(a)

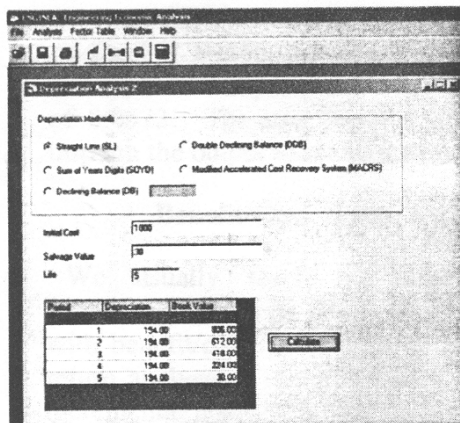


(b)

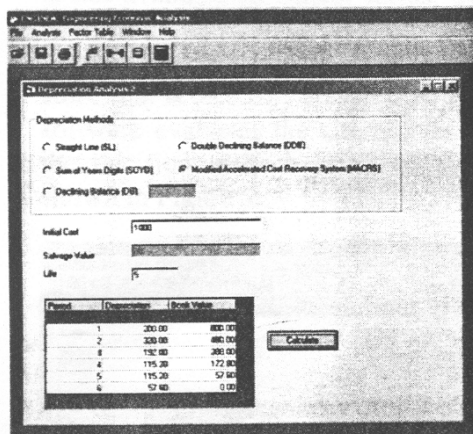
Figure 2: Replacement analysis platform screenshots

Depreciation Analysis

This module (Figure 3) allows the user to manipulate the initial cost, salvage value, and useful life of a depreciable asset using any of the major depreciation methods. The depreciation methods supported by the software are straight line, sum-of-years digit, declining balance (with the opportunity to specify the depreciation rate), double declining balance, and modified accelerated cost recovery system.



(a)



(b)

Figure 3: Depreciation analysis screenshots

Figure 3a and b are the tabular representation of the depreciation amounts and the corresponding book values for straight line and modified accelerated cost recovery system depreciation methods respectively. The depreciation analysis component is structured so that the user can use any of the depreciation methods by entering the asset initial cost, salvage value, and useful life. Salvage value is only active if Straight Line or Sum-of-Years Digits methods is selected, since these are the only two methods that use salvage value in their equations. The application will also display a friendly error message to correct an undefined asset recovery period if MACRS is selected. For example, if a useful life of six years was inputted, the application will display an error

message that such recovery period is not applicable for the chosen method.

Interest Calculator

One of the most difficult steps in economic analysis is interpolating between tabulated interest rates. In cases where such interpolation can be easily achieved, the assumption of a linear relationship between tabulated values is not realistic in economic analysis and usually results in up to 5% errors. The interest factor calculator (Figure 4) allows users to obtain interest factor for various interest values and periods without interpolation.

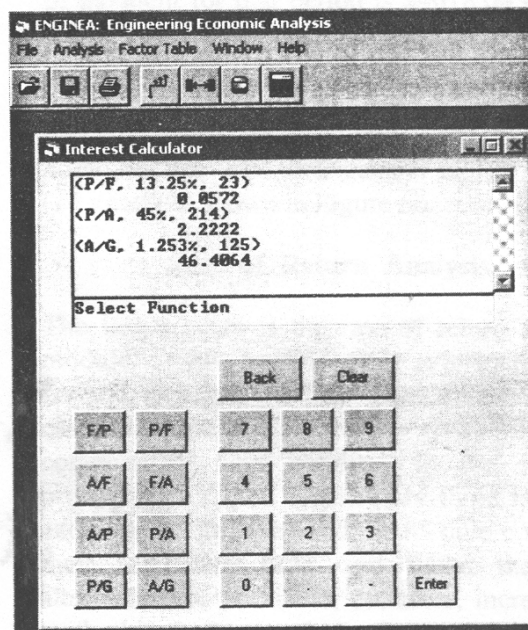


Figure 4: Interest calculator module

The interest factor calculator screenshot in Figure 4 gives the values for three factors: P/F, P/A, and A/G. Ordinarily the interest rates and number of periods shown in this screenshot cannot be easily determined using tabulated factor tables but they are now easily obtainable using the ENGINEA software. The interest calculator was designed to look and operate like a standard calculator, except for the engineering economy capabilities. To use the calculator, the user must first select a function before entering the interest value and periods. For example, to

compute (P/F, 13.25%, 23), the user will click on the P/F button, type 13.25 and press enter, and type 23 and press enter again for the result of 0.0572. The user has the ability to scroll through the output to see past results.

Benefit/Cost Ratio Analysis

We usually teach our students to use incremental analysis when evaluating projects with benefit/cost (B/C) ratio or internal rate of return analyses. The ENGINEA software uses incremental analysis for B/C ratio. The module uses annual cost and benefits; therefore, if data is not available in annual forms, the cash flow analysis module, described above, can be used to get the appropriate annual cost and benefits since that is basically a cash flow problem. The software evaluates the alternatives and displays the decision at each stage of the process as shown in Figure 5.

Alternative	Benefit	Cost	B/C Ratio	Status
Project A	20000	77250	0.54	
Project B	70000	80000	0.88	
Project B - Project A	50000	22750	1.06	Keep Project B
Project C	80000	127000	0.60	
Project C - Project B	10000	47000	0.21	Keep Project B

Figure 5: Benefit/cost ratio analysis module

Loan/Mortgage Analysis

The loan/mortgage analysis module computes the amortization of capital using the initial loan amount, the nominal interest rate, and the length of the loan. The legend to the column titles is shown at the bottom of the analysis table. This analysis is based on the amortization of capital equations as presented by Badiru[2]. This module calculates the unpaid balance, the monthly payment, total installment payment, the cumulative equity, and the interest charge per period. In addition, the module calculates the breakeven point for the loan being analyzed

when the graph button is clicked. It displays a plot of unpaid balance versus cumulative equity and show the breakeven point. This breakeven point is the period when the unpaid balance on a loan equals the cumulative equity on the loan [2]. This point is very important for loan/mortgage analysis. Figure 6 presents a portion of an output for a \$500,000 loan at 10% for 15 years. The results show a monthly payment of \$5373.03 (the A(t) column) and after the 15th month payment, the balance on the loan is \$480,809.96 (the U(t) column), the equity portion of payment for that period is \$1354.98 (the E(t) column), the interest portion of payment for that period is \$4018.04 (the I(t) column), total payment made on the loan up to the 15th month is \$80,595.38 (the C(t) column) of which only \$19,190.04 (the S(t) column) is the total equity to that date. The breakeven point for this loan arrangement is 120 months (10 years) as shown in Figure 6b.

Rate of Return Analysis

The last module is the rate of return analysis module. This module also uses incremental method to select the best alternatives. It uses cash flow information and the given MARR to compute the final results. In the example presented in Figure 7, there are three mutually exclusive alternatives and the module computes their respective ROR and found the three alternatives to be viable; therefore, incremental method is used to break the tie. A portion of the output results is shown in Figure 7.

To use this module, the MARR is stated; the alternative name, the initial cost, annual cash flow, salvage value, and useful life for each alternative are inputted. Then the user click on the set cash flow button for the software to store the data; he clicks on the add button to generate the rate of return for that alternative. The insert button can be use to add more cash flows after the set cash flow button has been clicked. This step is repeated for other alternatives. If the computed rate of return for each alternative is greater than the given MARR, the alternative is retained in the analysis; otherwise it is eliminated. If there are more than one

ENGINEEA: Engineering Economic Analysis

File Analysis Factor Table Window Help

Loan / Mortgage Analysis 1

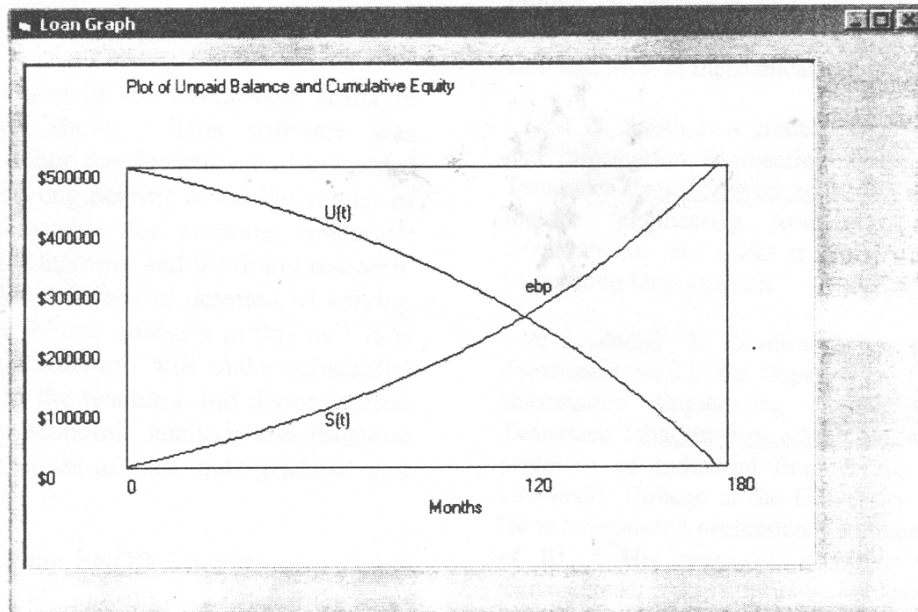
Loan Amount: 500000
 Annual Nominal Interest Rate: 10 %
 Length: 15 years

Calculate Graph

t	UR	AR	ER	IR	CR	OR	SR	PR	FR	RR
1	498793.64	5373.03	1206.36	4166.67	5373.03	4166.67	1206.36	77.55	77.55	22.45
2	497577.23	5373.03	1216.41	4156.61	10746.05	8323.28	2422.77	77.36	77.45	22.64
3	496350.68	5373.03	1226.55	4146.48	16119.08	12469.75	3649.32	77.17	77.36	22.83
4	495113.91	5373.03	1236.77	4136.26	21492.10	16606.01	4866.09	76.98	77.27	23.02
5	493866.84	5373.03	1247.08	4125.95	26865.13	20731.96	6133.17	76.79	77.17	23.21
6	492609.37	5373.03	1257.47	4115.56	32238.15	24847.52	7390.63	76.60	77.07	23.40
7	491341.42	5373.03	1267.95	4105.09	37611.18	28952.60	8658.58	76.40	76.98	23.60
8	490062.91	5373.03	1278.51	4094.51	42964.20	33047.11	9937.10	76.21	76.88	23.80
9	488773.74	5373.03	1289.17	4083.86	48357.23	37130.97	11226.26	76.01	76.78	23.99
10	487473.83	5373.03	1299.91	4073.11	53730.26	41204.08	12526.17	75.81	76.69	24.19
11	486163.08	5373.03	1310.74	4062.28	59103.28	45266.36	13836.32	75.61	76.59	24.39
12	484841.42	5373.03	1321.67	4051.36	64476.31	49317.72	15158.59	75.40	76.49	24.60
13	483508.74	5373.03	1332.68	4040.35	69849.33	53358.07	16491.27	75.20	76.39	24.80
14	482164.95	5373.03	1343.79	4029.24	75222.36	57387.31	17835.05	74.99	76.29	25.01
15	480809.96	5373.03	1354.98	4018.04	80595.38	61405.35	19190.04	74.78	76.19	25.22
16	479443.69	5373.03	1366.28	4006.75	85968.41	65412.10	20566.31	74.57	76.09	25.43

t: Month
 UR: Unpaid Balance
 AR: Monthly Payment
 ER: Equity Portion of the Payment
 IR: Interest Charge Contained in the Payment
 CR: Total Payment to Date
 OR: Total Equity to Date
 SR: Percentage of Interest Charge
 PR: Percentage of Cumulative Interest Charge

(a)



(b)

Figure 6: Loan/ Mortgage analysis screenshots

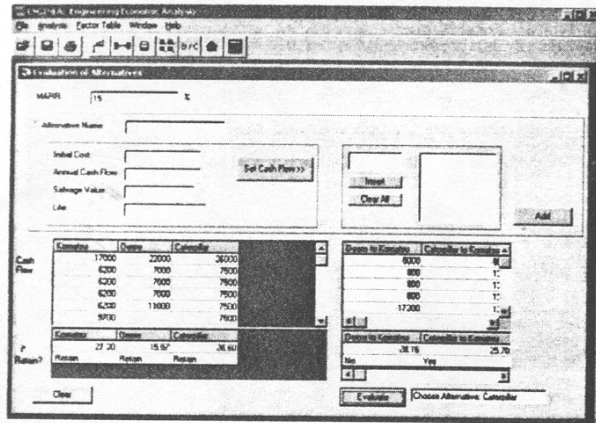


Figure 7: Rate of return analysis module output

alternative with rate of return greater than the MARR, incremental method is applied. To initialize the incremental method process, the user clicks on the evaluate button and the analysis is carried out automatically leaving out all alternatives with rate of return lesser than the MARR. The final result of the incremental method is shown in the window besides the evaluate button.

Conclusion

The first version of the ENGINEA software was described above. This software was developed to honor the department of industrial and information engineering at the University of Tennessee, Knoxville for creating conducive environment for learning and for doing research. The ENGINEA software is devoted to solving engineering economic analysis problems. It is hoped that this software will make substantial contributions to the teaching and dissemination of engineering economic analysis and financial management courses at both undergraduate and graduate levels.

For a copy of the ENGINEA software, please send email to Olufemi Omitaomu at omitaomu@utk.edu.

References

1. Alloway, J.A. Jr. (1994). Spreadsheets: enhancing learning and application of

engineering economy techniques. *The Engineering Economist*, 3(39), 263-274.

2. Badiru, Adedeji B. (1996). *Project Management in Manufacturing and High Technology Operations*, 2nd edition, New York: John Wiley & Sons.
3. Badiru, Adedeji B. and Olufemi Omitaomu (2003). Design and Analysis of Tent Cash Flow Models for Engineering Economy Lectures. *The Engineering Economist*, 48(4), 363-374.
4. Lavelle, J.P. (1996). Reader's forum: enhancing engineering economy concepts with computer spreadsheets. *The Engineering Economist*, 4(41), 381-386.

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CONTENTS

<i>Introducing Project Management Skills Via An Autonomous Robot Laboratory</i> by Dillard	2
<i>The Pedagogical Advantages of Using the Pong Video Game for Problem-Based Learning in an Introductory Assembly-Language Programming Course</i> by Sprunt	9
<i>Techniques for Supporting Diversity in a Core Information Technology Course</i> by Carver, Jr.	26
<i>The ENGINEering Economic Analysis (ENGINEA) Software: Enhancing Teaching and Application of Economic Analysis Techniques</i> by Omitaomu, Smith and Badiru	32
<i>Blackboard™ Collaboration: Consolidation of On-Line Course Materials And Assessment for Multiple Sections Using Blackboard</i> by Lo, Gregg, Waldron and Robinson.	39
<i>OMEN: An Online Grader for Engineering Programming Courses</i> by Walker and Goodman	47
<i>Programming the Palm Tungsten</i> by Wiggins	53
<i>An Efficient Method for Complex Digital Systems Design Using Verilog</i> by Lu	58
<i>Low-Cost Internet Synchronous Distance Education Using Open-Source Software</i> by Pullen and McAndrews	64
<i>Undergraduate Research: Novel Integration of PDAs, GPS and Bar Code Scanner via an Embedded Visual Basic Program for a Utility Asset Management System</i> by Jansson, Tisa and Garwood	72
<i>Development of a Symmetrical Extended-Classroom Facility</i> by Thai	79
<i>Integration of Digital Rights Management into Learning Content Management System</i> by Liu and Yang	87
<i>The Use of Powerworld to Conduct Load Flow Analysis and Power Factor Correction on Stevenson's 5 Bus System</i> by Carbajal, Gast, Fleck, Podolsky, Berry, Dinkelaker, Patel, Jha, and Grigg	95
<i>A Remote Controlled Vehicle for Interdisciplinary Research and Education</i> by Steidley, Bachnak, Lohachit, Sadovski, Ross and Jeffress	99
<i>Software and Hardware for Web-Based Education</i> by Steidley and Bachnak	104
<i>Newsletter</i>	112

