GLOBAL EDITION

Fundamentals of Engineering Economics

FOURTH EDITION

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Resources for Success

MyLab Engineering for
Fundamentals of Engineering Economics, 4e

(access code required)

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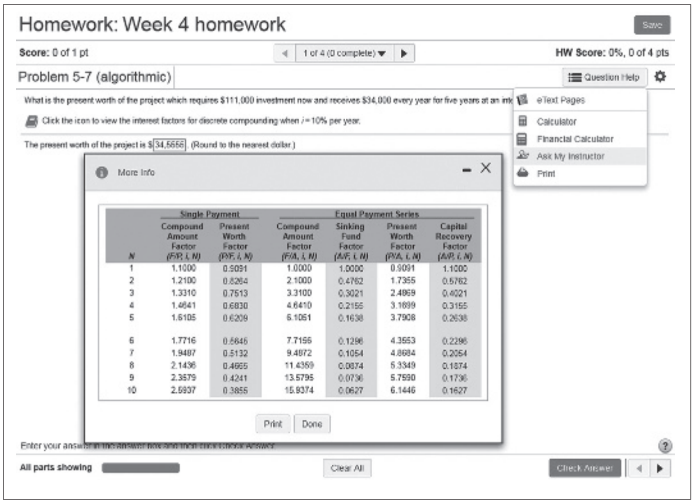

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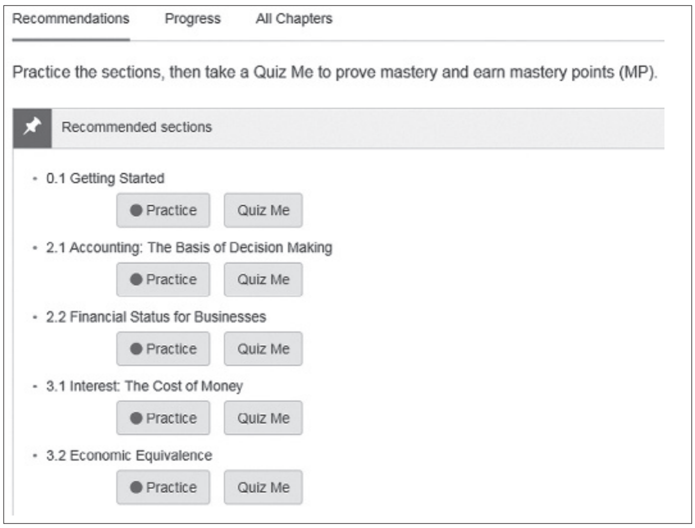
The Study Plan gives students personalized recommendations, practice opportunities, and learning aids to help them stay on track.



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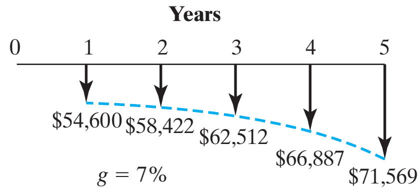
- Option 1:

$g = 7\%$
$i = 12\%$
$N = 5$ years
$A_1 = \$54,600$



$$P_{\text{Option 1}} = \$54,600\left[\frac{1-(1+0.07)^5(1+0.12)^{-5}}{0.12-0.07}\right] = \$222,937$$

- Option 2:

$$\begin{aligned} P_{\text{Option 2}} &= \$54,600(1-0.23)(P/A, 12\%, 5) \\ &= \$42,042(P/A, 12\%, 5) \\ &= \$151,553 \end{aligned}$$

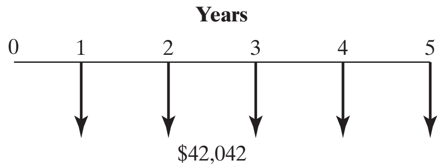


Figure 5.11 Comparing two mutually exclusive options.

EXAMPLE 5.6 Comparing Two Mutually Exclusive Revenue Projects

Monroe Manufacturing owns a warehouse that has been used for storing finished goods for electro-pump products. As the company is phasing out the electro-pump product line, the company is considering modifying the existing structure to use for manufacturing a new product line. Monroe's production engineer feels that the warehouse could be modified to handle one of two new product lines. The cost and revenue data for the two product alternatives are as follows:

	Product A	Product B
Initial cash expenditure:		
• Warehouse modification	$115,000	$189,000
• Equipment	$250,000	$315,000
Annual revenues	$215,000	$289,000
Annual O&M costs	$126,000	$168,000
Product life	8 years	8 years
Salvage value (equipment)	$25,000	$35,000

After eight years, the converted building will be too small for efficient production of either product line. At that time, Monroe plans to use it as a warehouse for storing raw materials as before. Monroe's required return on investment is 15%. Which product should be manufactured?

DISSECTING THE PROBLEM

Note that these are revenue projects, so we need to estimate the revenue streams for both product lines. Since the converted building will be used as a warehouse by the firm, there will be no salvage value associated with the building.

Given: Cash flows for the two products as shown in the proceeding table, analysis period = 8 years, and i = 15% per year.

Find: PW for each product; the preferred alternative.

METHODOLOGY

Construct a cash flow chart comparing the two products Since the service lives are the same for both products, compute the NPW for each product over the analysis period. (See Figure 5.12.)

SOLUTION

$$\begin{aligned} PW(15\%)_A &= -\$365{,}000 + \$89{,}000(P/A, 15\%, 8) \\ &\quad + \$25{,}000(P/F, 15\%, 8) \\ &= \$42{,}544. \end{aligned}$$

$$\begin{aligned} PW(15\%)_B &= -\$504{,}000 + \$121{,}000(P/A, 15\%, 8) \\ &\quad + \$35{,}000(P/F, 15\%, 8) \\ &= \$50{,}407. \end{aligned}$$

For revenue projects, we select the one with the largest NPW, so producing product B is more economical.

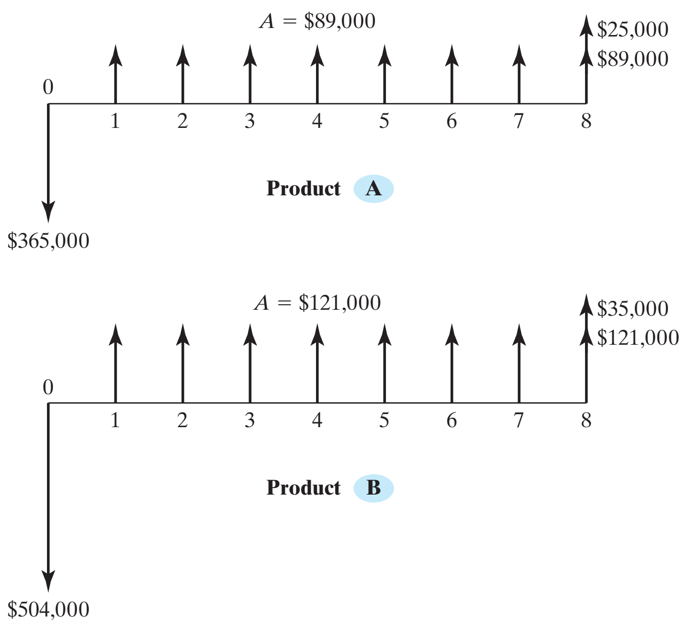


Figure 5.12 Cash flows associated with producing products A and B (revenue projects).

5.4.4 Analysis Period Differs from Project Lives

In Example 5.6, we assumed the simplest scenario possible when analyzing mutually exclusive projects. The projects had useful lives equal to each other and to the required service period. In practice, this is seldom the case. Often project lives do not match the required analysis period or do not match each other. For example, two machines may perform exactly the same function, but one lasts longer than the other, and both of them last longer than the analysis period for which they are being considered. In the upcoming sections and examples, we will develop some techniques for dealing with these complications.

Case I: Project's Life Is Longer than Analysis Period

Consider the case of a firm that undertakes a five-year production project (or plans to phase out the production at the end of five years) when all of the alternative equipment choices have useful lives of seven years. In such a case, we analyze each project only for as long as the required service period (in this case, five years). We are then left with some unused portion of the equipment (in this case, two years' worth), which we include as salvage value in our analysis. **Salvage value** is the amount of money for which the equipment could be sold after its service to the project has been rendered or the dollar measure of its remaining usefulness.

We often find this scenario (project lives that are longer than the analysis period) in the construction industry, where a building project may have a relatively short completion time, but the equipment purchased (power tools, tractors, etc.) has a much longer useful life.

EXAMPLE 5.7 Present-Worth Comparison: Project Lives Longer than the Analysis Period

Allan Company got permission to harvest southern pines from one of its timberland tracts. It is considering purchasing a feller-buncher, which has the ability to hold, saw, and place trees in bunches to be skidded to the log landing. The logging operation on this timberland tract must be completed in *three years*. Allan could speed up the logging operation, but doing so is not desirable because the market demand of the timber does not warrant such haste. Because the logging operation is to be done in wet conditions, this task requires a specially made feller-buncher with high-flotation tires and other devices designed to reduce site impact. There are two possible models of feller-buncher that Allan could purchase for this job: Model A is a two-year old used piece of equipment whereas Model B is a brand-new machine.

- Model A costs $205,000 and has a life of 10,000 hours before it will require any major overhaul. The operating cost will run $50,000 per year for 2,000 hours of operation. At this operational rate, the unit will be operable for five years, and at the end of that time, it is estimated that the salvage value will be $75,000.
- The more efficient Model B costs $275,000, has a life of 14,000 hours before requiring any major overhaul and costs $32,500 to operate for 2,000 hours per year in order to complete the job within three years. The estimated salvage value of Model B, at the end of seven years is $95,000.

Since the lifetime of either model exceeds the required service period of three years, Allan Company has to assume some things about the unused value of the equipment (salvage value) at the end of that time. Therefore, the engineers at Allan estimate that, after three years, the Model A unit could be sold for $130,000 and the Model B unit for $180,000. After considering all tax effects, Allan summarized the resulting cash flows (in thousands of dollars) for the projects as follows:

Period	Model A		Model B	
0		−$205,000		−$275,000
1		−$50,000		−$32,500
2		−$50,000		−$32,500
3	[$130,000]	−$50,000	[$180,000]	−$32,500
4		−$50,000		−$32,500
5	$75,000	−$50,000		−$32,500
6				−$32,500
7			$95,000	−$32,500

Here, the figures in the boxes represent the estimated salvage values at the end of the analysis period (end of year 3). Assuming that the firm's MARR is 15%, which option is more acceptable?

DISSECTING THE PROBLEM

First, note that these projects are service projects, so we can assume the same revenues for both configurations. Since the firm explicitly estimated the salvage values of the assets at the end of the analysis period (three years), we can compare the two models directly. Since the benefits (timber harvesting) are equal, we can concentrate on the costs.

Given: Cash flows for the two alternatives as shown in the preceding table, $i = 15\%$ per year.

Find: PW for each alternative and the preferred alternative.

METHODOLOGY

Construct a cash flow chart comparing the options, and compute the NPW for each model over the analysis period (three years). Any cash flows after the analysis period are irrelevant for both alternatives, and we can safely ignore them in the analysis.

SOLUTION

Concentrate the costs:

$$\begin{aligned} PW(15\%)_A &= -\$205{,}000 - \$50{,}000(P/A, 15\%, 3) \\ &\quad + \$130{,}000(P/F, 15\%, 3) \\ &= -\$233{,}684; \end{aligned}$$

$$\begin{aligned} PW(15\%)_B &= -\$275{,}000 - \$32{,}500(P/A, 15\%, 3) \\ &\quad + \$180{,}000(P/F, 15\%, 3) \\ &= -\$230{,}852. \end{aligned}$$

Model B is cheaper to operate and thus would be preferred. (See Figure 5.13.)

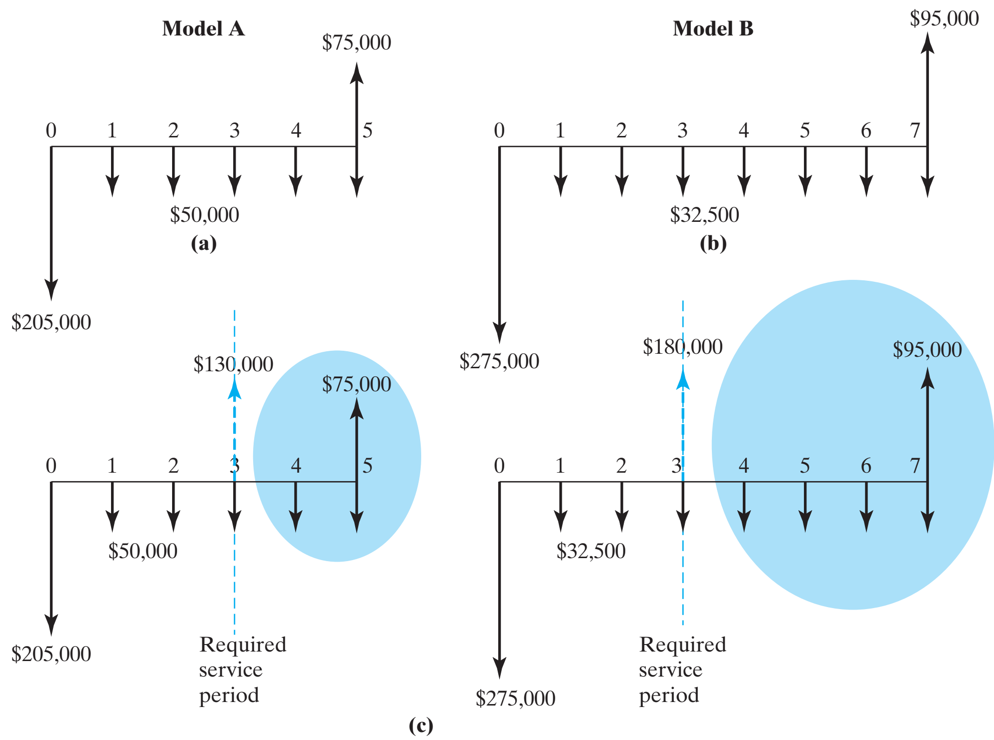


Figure 5.13 (a), (b) If models are not sold after the required service period; (c) if models are sold after the required service period. (Note that cash flows in shaded circle can be ignored in the analysis.)

COMMENTS: The decision heavily depends on the salvage value estimates at the end of the analysis period. Commonly, information about the salvage value of used equipment can be obtained from the equipment vendors because they are familiar with the secondary market for their equipment.

Case II: Project's Life Is Shorter than Analysis Period

When project lives are shorter than the required service period, we must consider how, at the end of a project's life, we will satisfy the rest of the required service period. Replacement projects—implemented when the initial project has reached the limits of its useful life—are needed in such a case. Sufficient replacement projects must be analyzed to match or exceed the required service period.

To simplify our analysis, we could assume that the replacement project will be exactly the same as the initial project with the same corresponding costs and benefits. In the case of an indefinitely ongoing service project, we typically select a finite analysis period by using the **lowest common multiple** of the project's life. For example, if alternative *A* has a three-year useful life and alternative *B* has a four-year useful life, we may select 12 years as the analysis period. Because this assumption is rather unrealistic in most real-world problems, we will not advocate the method in this book. However, if such an analysis is warranted, we will demonstrate how the annual-equivalent approach would simplify the mathematical aspect of the analysis in Example 6.7.

The assumption of an identical future replacement project is not necessary, however. For example, depending on our forecasting skills, we may decide that a different kind of technology—in the form of equipment, materials, or processes—will be a preferable and potential replacement. *Whether we select exactly the same alternative or a new technology as the replacement project, we are ultimately likely to have some unused portion of the equipment to consider as salvage value*, just as in the case when project lives are longer than the analysis period. On the other hand, we may decide to lease the necessary equipment or subcontract the remaining work for the duration of the analysis period. In this case, we can probably exactly match our analysis period and not worry about salvage values.

In any event, we must make some initial predictions at its outset concerning the method of completing the analysis period. Later, when the initial project life is closer to its expiration, we may revise our analysis with a different replacement project. This approach is quite reasonable, since economic analysis is an ongoing activity in the life of a company and an investment project, and we should always use the most reliable, up-to-date data we can reasonably acquire.

EXAMPLE 5.8 Present-Worth Comparison: Project Lives Shorter than the Analysis Period

Phoenix Manufacturing Company is planning to modernize one of its distribution centers located outside Denver, Colorado. Two options to move goods in the distribution center have been under consideration: a conveyor system and forklift trucks. The firm expects that the distribution center will be operational for the next 10 years, and then it will be converted into a factory outlet. The conveyor system would last eight years whereas the forklift trucks would last only six years. The two options will be designed differently but will have identical capacities and will do exactly the same job. The expected cash flows for the two options, including maintenance costs, salvage values, and tax effects, are as follows:

n	Conveyor System	Lift Trucks
0	−\$68,000	−\$40,000
1	−\$13,000	−\$15,000
2	−\$13,000	−\$15,000
3	−\$13,000	−\$15,000
4	−\$13,000	−\$15,000
5	−\$13,000	−\$15,000
6	−\$13,000	−\$15,000 + \$4,000
7	−\$13,000	
8	−\$13,000 + \$5,000	

With this scenario, which option should the firm select at MARR = 12%?