CHAPTER TEN

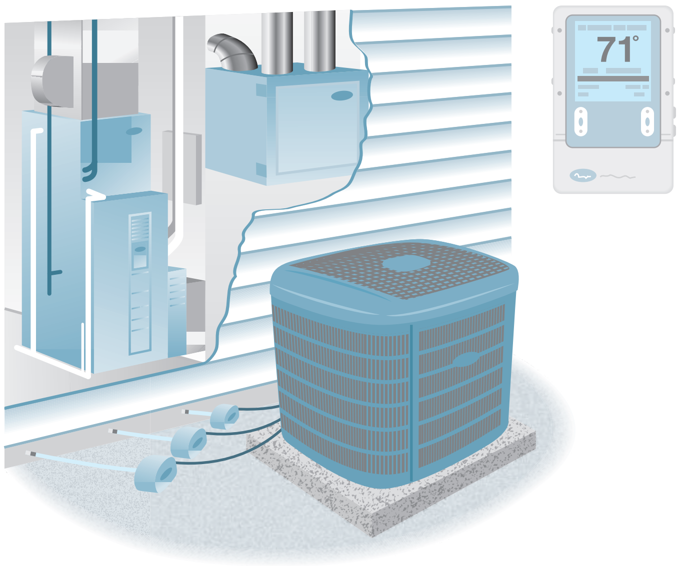
Developing Project Cash Flows

New Incentives for Being Green[1] Appliance makers are gearing up to push new energy-efficient systems in the wake of the energy bill passed in July 2005 that offers tax credits to homeowners who upgrade to electricity-saving appliances. In air-conditioning, industry giant **Carrier** Corporation says it has invested $250 million in developing new heat exchangers—a major component in air-conditioners—that use less energy and are about 20% smaller and 30% lighter than current energy-saving versions. Carrier's current energy-efficient models are almost double the size of its regular central air-conditioning units. The company speculates [that] this model's bulk may have been a deterrent for homeowners. The new air-conditioners were expected to hit the market in the first quarter of 2006.

Cooling efficiency is measured by a standard called SEER: Seasonal Energy Efficiency Ratio. It's kind of like the gas mileage system used on cars—the higher the number, the more money you save. Older systems had SEER numbers as low as 8; the new Carrier systems are rated at 18! (Federal standards required a minimum SEER of 13 from January 2006.) Translated into operating costs, this means that for every $100 you used to spend on electricity for cooling, you now can spend just $39.

There are several issues involved in Carrier's pushing more efficient air-conditioning units. First, the market demand is difficult to estimate. Second, it is even more difficult to predict the useful life of the product, as market competition is ever increasing. Carrier's gross margin is about 25%, its operating margin is 8.3%, and its net margin is 7.45%. The expected retail price of the Delux Puron unit is about $4,236.

[1] "New Incentives for Being Green," Cheryl Lu-Lien Tan, *The Wall Street Journal*, Thursday, August 4, 2005, p. D1.



Of course, the main issue is how Carrier justified the capital investment of $250 million when it first decided to launch the product.

Clearly, Carrier's first step would be to estimate the magnitude of the revenue stream over the life of the product. In doing so, the final number of units sold would be the basis for possible revenue projections. The number of potential units sold is correlated with two important factors: housing market trends and how well their competitors are doing in terms of bringing more energy efficient products to market. Although the product is priced at $4,236 initially, there is no way of knowing how long Carrier will be able to sustain their desired profit margin. Under this circumstance, any project's justification depends upon the ability to estimate potential cash flows.

Projecting cash flows is the most important—and the most difficult—step in the analysis of a capital project. Typically, a capital project initially requires investment outlays and only later produces annual net cash inflows. A great many variables are involved in forecasting cash flows, and many individuals, ranging from engineers to cost accountants and marketing people, participate in the process. This chapter provides the general principles on which the determination of a project's cash flows are based.

To help us imagine the range of activities that are typically initiated by project proposals, we begin the chapter with an overview in Section 10.1 of how firms classify projects. A variety of projects exists, each having its own characteristic set of economic concerns. Section 10.2 then defines the typical cash flow elements of engineering projects. Once we have defined these elements, we will examine how to develop cash flow statements that are used to analyze the economic value of projects. In Section 10.3, we use several examples to demonstrate the development of after-tax project cash flow statements. Then, Section 10.4 presents some alternative techniques for developing a cash flow statement based on a generalized cash flow approach. By the time you have finished this chapter, not only will you understand the format and significance of after-tax cash flow statements, but also you will know how to develop them yourself.

CHAPTER LEARNING OBJECTIVES

After completing this chapter, you should understand the following concepts:

- What constitutes project cash flow elements.
- The use of the income statement approach in developing a project cash flow.
- How to treat the gains and losses related to disposal of an asset in the project cash flow statement.
- How to determine the working capital requirement and its impact on project cash flows.
- How to incorporate the cost associated with financing a project in developing the project's cash flow statement.
- How to develop a generalized cash flow model.
- The analysis of a lease-or-buy decision on an after-tax basis.

10.1 Cost–Benefit Estimation for Engineering Projects

Before the economics of an engineering project can be evaluated, it is necessary to estimate the various cost and revenue components that describe the project. Engineering projects may range from something as simple as the purchase of a new milling machine to the design and construction of a multibillion-dollar process or resource recovery complex.

The engineering projects appearing in this book as examples and problems already include the necessary cost and revenue estimates. Developing adequate estimates for these quantities is extremely important and can be a time-consuming activity. Although cost-estimating techniques are not the focus of this book, it is worthwhile to mention some of the approaches that are taken. Some are used in the context of simple projects that are straightforward and involve little or no engineering design; others are employed on complex projects that tend to be large and may involve many thousands of hours of engineering design. Obviously, there are also projects that fall between these extremes, and some combination of approaches may be appropriate in these cases.

10.1.1 Simple Projects

Projects in this category usually involve a single "off-the-shelf" component or a series of such components that are integrated together in a simple manner. The acquisition of a new milling machine is an example.

The installed cost is the price of the equipment as determined from catalogues or supplier quotations, shipping and handling charges, and the cost of building modifications and changes to utility requirements. The latter may call for some design effort to define the scope of the work, which is the basis for contractor quotations.

Project benefits are in the form of new revenue and/or cost reduction. Estimating new revenue requires agreement on the total number of units produced and the selling price per unit. These quantities are related through supply and demand considerations in the marketplace. In highly competitive product markets, sophisticated marketing studies are often required to establish price–volume relationships. These studies are undertaken as one of the first steps in an effort to define the appropriate scale for the project.

The ongoing costs required to operate and maintain equipment can be estimated at various levels of detail and accuracy. Familiarity with the cost–volume relationships for similar facilities allows the engineer to establish a "ballpark" cost. Some of this information may be used in conjunction with more detailed estimates in other areas. For example, maintenance costs may be estimated as a percentage of the installed cost. Such percentages are derived from historical data and are frequently available from equipment suppliers. Other costs, such as the cost of manpower and energy, may be estimated in detail to reflect specific local considerations. The most comprehensive and time-consuming type of estimate is a set of detailed estimates around each type of cost associated with the project.

10.1.2 Complex Projects

The estimates developed for complex projects involve the same general considerations as those which apply to simple projects. However, complex projects usually include specialized equipment that is not "off the shelf" and must be fabricated from detailed engineering drawings. For certain projects, such drawings are not even available until after a commitment has been made to proceed with the project. The typical phases of a project are as follows:

- Development.
- Conceptual design.
- Preliminary design.
- Detailed design.

Depending upon the project, some phases may be combined. Project economics is performed during each of these phases to confirm the attractiveness of the project and the incentive to continue working on it. The types of estimates and estimating techniques are a function of the stage of the project.

When the project involves the total or partial replacement of an existing facility, the benefits of the project are usually well known at the outset in terms of pricing–volume relationships or cost reduction potential. In the case of natural-resource projects, however, oil, gas, and mineral price forecasts are subject to considerable uncertainty.

At the development phase, work is undertaken to identify technologies that may be needed and to confirm their technical viability. Installed cost estimates and operating estimates are based on evaluations of the cost of similar existing facilities or their parts.

Conceptual design examines the issues of the scale of the project and alternative technologies. Again, estimates tend to be based on large pieces of, or processes within, the overall project that correspond to similar facilities already in operation elsewhere.

Preliminary design takes the most attractive alternative from the conceptual design phase to a level of detail that yields specific sizing and layout estimates for the actual equipment and associated infrastructure. Estimates at this stage tend to be based on individual pieces of equipment. Once more, the estimating basis is similar pieces of equipment in use elsewhere.

For very large projects, the cost of undertaking detailed engineering is prohibitive unless the project is going forward. At this stage, detailed fabrication and construction drawings that provide the basis for an actual vendor quotation become available.

The accuracy of the estimates improves with each phase as the project becomes defined in greater detail. Normally, the installed cost estimate from each phase includes a contingency that is some fraction of the actual estimate calculated. The contingency at the development phase can be 50 to 100%; after preliminary design, it decreases to something on the order of 10%.

More information on cost-estimating techniques can be found in reference books on project management and cost engineering. Industry-specific data books are also available for some sectors, for which costs are summarized on some normalized basis, such as dollars per square foot of building space or dollars per tonne of material moved in operating mines. In these cases, the data are categorized by type of building and type of mine. Engineering design companies maintain extensive databases of such cost information.

10.2 Incremental Cash Flows

When a company purchases a fixed asset such as equipment, it makes an investment. The company commits funds today in the expectation of earning a return on those funds in the future. Such investments are similar to those made by a bank when it lends money. In the case of a bank loan, the future cash flow consists of interest plus repayment of the principal. For a fixed asset, the future return is in the form of cash flows generated by the profitable use of the asset. In evaluating a capital investment, we are concerned only with those cash flows which result directly from the investment. These cash flows, called **differential** or **incremental cash flows**, represent the change in the firm's total cash flow that occurs as a direct result of the investment. In this section, we will look into some of the cash flow elements that are common to most investments.

10.2.1 Elements of Cash Outflows

We first consider the potential uses of cash in undertaking an investment project:

- **Purchase of New Equipment.** A typical project usually involves a cash outflow in the form of an initial investment in equipment. The relevant investment costs are incremental ones, such as the cost of the asset, shipping and installation costs, and the cost of training employees to use the new asset. If the purchase of a new asset results in the sale of an existing asset, the net proceeds from this sale reduce the amount of the incremental investment. In other words, the incremental investment represents the total amount of additional funds that must be committed to the investment project. When existing equipment is sold, the transaction results in an accounting gain or loss, which is dependent on whether the amount realized from the sale is greater or less than the equipment's book value. In either case, when existing assets are disposed of, the relevant amount by which the new investment is reduced consists of the proceeds of the sale, adjusted for tax effects.

- **Investments in Working Capital.** Some projects require an investment in nondepreciable assets. If, for example, a project increases a firm's revenues, then more funds will be needed to support the higher level of operation. Investment in nondepreciable assets is often called **investment in working capital**. In accounting, working capital is the amount carried in cash, accounts receivable, and inventory that is available to meet day-to-day operating needs. For example, additional working capital may be needed to meet the greater volume of business that will be generated by a project. Part of this increase in current assets may be supplied from increased accounts payable, but the remainder must come from permanent capital. This additional working capital is as much a part of the initial investment as the equipment itself. (We explain the amount of working capital required for a typical investment project in Section 10.3.2.)

Working capital measures how much in liquid assets a company has available to build its business.

- **Manufacturing, Operating, and Maintenance Costs.** The costs associated with manufacturing a new product need to be determined. Typical manufacturing costs include labor, materials, and overhead costs, the last of which cover items such as power, water, and indirect labor. Investments in fixed assets normally require periodic outlays for repairs and maintenance and for additional operating costs, all of which must be considered in investment analysis.
- **Leasing Expenses.** When a piece of equipment or a building is leased (instead of purchased) for business use, leasing expenses become cash outflows. Many firms lease computers, automobiles, industrial equipment, and other items that are subject to technological obsolescence.
- **Interest and Repayment of Borrowed Funds.** When we borrow money to finance a project, we need to make interest payments as well as payments on the principal. Proceeds from both short-term borrowing (bank loans) and long-term borrowing (bonds) are treated as cash inflows, but repayments of debts (both principal and interest) are classified as cash outflows.
- **Income Taxes and Tax Credits.** Any income tax payments following profitable operations should be treated as cash outflows for capital budgeting purposes. As we learned in Chapter 9, when an investment is made in depreciable assets, depreciation is an expense that offsets part of what would otherwise be additional taxable income. This strategy is called a **tax shield**, or **tax savings**, and we must take it into account when calculating income taxes. If any investment **tax credit** is allowed, it will directly reduce income taxes, resulting in cash inflows.

10.2.2 Elements of Cash Inflows

The following are potential sources of cash inflow over the project life:

- **Borrowed Funds.** If you finance your investment by borrowing, the borrowed funds will appear as cash inflow to the project at the time they are borrowed. From these funds, the purchase of new equipment or any other investment will be paid out.

- **Operating Revenues.** If the primary purpose of undertaking the project is to increase production or service capacity to meet increased demand, the new project will be bringing in additional revenues.
- **Cost Savings (or Cost Reduction).** If the primary purpose of undertaking a new project is to reduce operating costs, the amount involved should be treated as a cash inflow for capital budgeting purposes. A reduction in costs is equivalent to an increase in revenues, even though the actual sales revenues may remain unchanged.
- **Salvage Value.** In many cases, the estimated salvage value of a proposed asset is so small and occurs so far in the future that it may have no significant effect on the decision to undertake a project. Furthermore, any salvage value that is realized may be offset by removal and dismantling costs. In situations where the estimated salvage value is significant, the net salvage value is viewed as a cash inflow at the time of disposal. The **net salvage value** of the existing asset is the selling price of the asset, minus any costs incurred in selling, dismantling, and removing it, and this value is subject to taxable gain or loss.
- **Working-Capital Release.** As a project approaches termination, inventories are sold off and receivables are collected. That is, at the end of the project, these items can be liquidated at their cost. As this occurs, the company experiences an end-of-project cash flow that is equal to the net working-capital investment that was made when the project began. This recovery of working capital is not taxable income, since it merely represents a return of investment funds to the company.

Figure 10.1 sums up the various types of cash flows that are common in engineering investment projects.

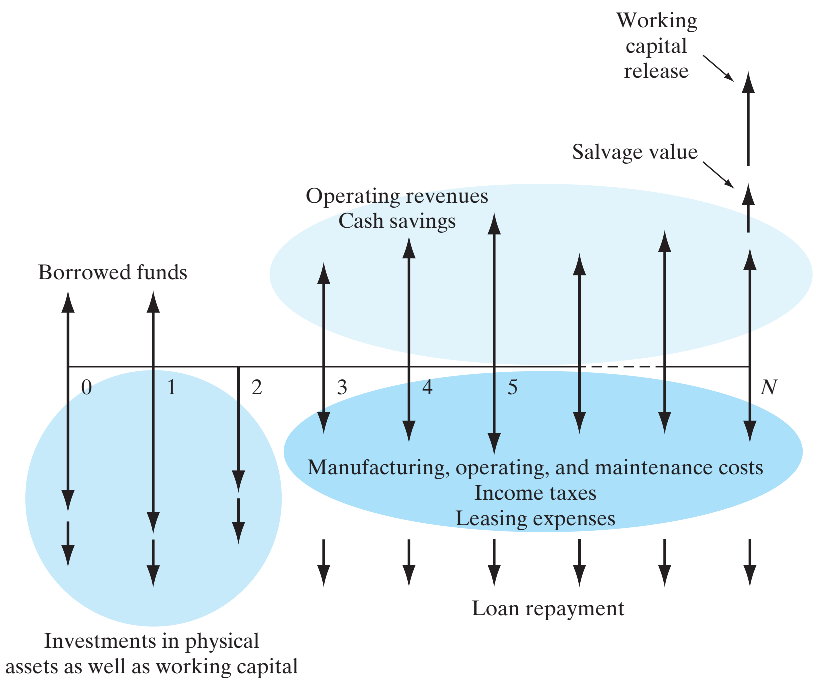


Figure 10.1 Types of cash flow elements used in project analysis.

10.2.3 Classification of Cash Flow Elements

Once the cash flow elements (both inflows and outflows) are determined, we may group them into three categories: (1) cash flow elements associated with operations, (2) cash flow elements associated with investment activities (capital expenditures), and (3) cash flow elements associated with project financing (such as borrowing). The main purpose of grouping cash flows this way is to provide information about the operating, investing, and financing activities of a project.

Operating Activities

In general, cash flows from operations include current sales revenues, the cost of goods sold, operating expenses, and income taxes. Cash flows from operations should generally reflect the cash effects of transactions entering into the determination of net income. The interest portion of a loan repayment is a deductible expense that is allowed in determining net income, and it is included in operating activities. Since we usually look only at yearly flows, it is logical to express all cash flows on a yearly basis.

As mentioned in Chapter 9, we can determine the net cash flow from operations on the basis of either (1) net income or (2) cash flow as determined by computing income taxes in a separate step. When we use net income as the starting point for cash flow determination, we should add any noncash expenses (mainly depreciation and amortization expenses) to net income to estimate the net cash flow from the operation. Recall that depreciation (or amortization) is not a cash flow, but is deducted, along with operating expenses and lease costs, from gross income to find taxable income and therefore taxes. Accountants calculate net income by subtracting taxes from taxable income, but depreciation—which is not a cash flow—was already subtracted to find taxable income, so it must be added back to taxable income if we wish to use the net-income figure as an intermediate step along the path to after-tax cash flow. Mathematically, it is easy to show that the two approaches are identical. Thus,

$$\text{Cash flow from operation} = \text{Net income} + (\text{Depreciation or amortization}).$$

Investing Activities

In general, three types of investment flows are associated with buying a piece of equipment: the original investment, the salvage value at the end of the useful life of the equipment, and the working-capital investment or recovery. We will assume that our outflow for both capital investment and working-capital investment take place in year 0. It is possible, however, that both investments will occur, not instantaneously, but rather, over a few months as the project gets into gear; we could then use year 1 as an investment year. (Capital expenditures may occur over several years before a large investment project becomes fully operational. In this case, we should enter all expenditures as they occur.) For a small project, either method of timing these flows is satisfactory, because the numerical differences are likely to be insignificant.

Financing Activities

Cash flows classified as financing activities include (1) the amount of borrowing and (2) the repayment of principal. Recall that interest payments are tax-deductible expenses, so they are classified as operating, not financing, activities.

The net cash flow for a given year is simply the sum of the net cash flows from operating, investing, and financing activities. Table 10.1 can be used as a checklist when you

TABLE 10.1 **Classifying Cash Flow Elements and Their Equivalent Terms as Practiced in Business**

Cash Flow Element	Other Terms Used in Business
Operating activities:	
Gross income	Gross revenue, sales revenue, gross profit, operating revenue
Cost savings	Cost reduction
Manufacturing expenses	Cost of goods sold, cost of revenue
Operations and maintenance cost	Operating expenses
Operating income	Operating profit, gross margin
Interest expenses	Interest payments, debt cost
Income taxes	Income taxes owed
Investing activities:	
Capital investment	Purchase of new equipment, capital expenditure
Salvage value	Net selling price, disposal value, resale value
Investment in working capital	Working-capital requirement
Release of working capital	Working-capital recovery
Gains taxes	Capital gains taxes, ordinary gains taxes
Financing activities:	
Borrowed funds	Borrowed amounts, loan amount
Repayment of principal	Loan repayment

set up a cash flow statement, because it classifies each type of cash flow element as an operating, investing, or financing activity.

10.3 Developing Cash Flow Statements

In this section, we will illustrate, through a series of numerical examples, how we actually prepare a project's cash flow statement; a generic version is shown in Figure 10.2, in which we first determine the net income from operations and then adjust the net income by adding any noncash expenses, mainly depreciation (or amortization). We will also consider a case in which a project generates a negative taxable income for an operating year.

10.3.1 When Projects Require Only Operating and Investing Activities

We will start with the simple case of generating after-tax cash flows for an investment project with only operating and investment activities. In the sections ahead, we will add complexities to this problem by including working-capital investments (Section 10.3.2) and borrowing activities (Section 10.3.3).

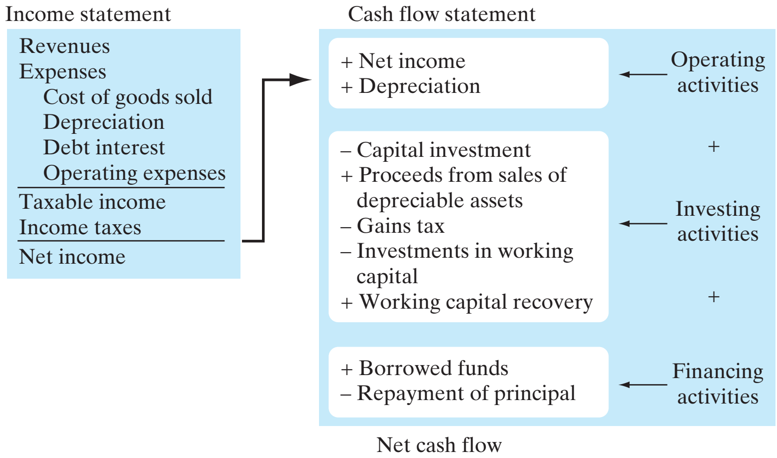


Figure 10.2 A popular format used for presenting a cash flow statement.

EXAMPLE 10.1 Cash Flow Statement: Operating and Investing Activities for an Expansion Project

A computerized machining center has been proposed for a small tool manufacturing company. If the new system, which costs \$125,000, is installed, it will generate annual revenues of \$100,000 and will require \$20,000 in annual labor, \$12,000 in annual material expenses, and another \$8,000 in annual overhead (power and utility) expenses. The automation facility would be classified as a seven-year MACRS property.

The company expects to phase out the facility at the end of five years, at which time it will be sold for \$50,000. Find the year-by-year after-tax net cash flow for the project at a 40% marginal tax rate based on the net income and determine the after-tax net present worth of the project at the company's MARR of 15%.

DISCUSSION: We can approach the problem in two steps by using the format shown in Figure 10.2 to generate an income statement and then a cash flow statement. We will follow this form in our subsequent listing of givens and unknowns. In year 0 (that is, at present) we have an investment cost of \$125,000 for the equipment.[2] This cost will be depreciated in years 1 to 5. The revenues and costs are uniform annual flows in years 1 to 5. We can see that once we find depreciation allowances for each year, we can easily compute the results for years 1 to 4, which have fixed revenue and expense entries along with the variable depreciation charges. In year 5, we will need to incorporate the salvage value of the asset and any gains tax from its disposal.

We will use the business convention that no signs (positive or negative) be used in preparing the income statement, except in the situation where we have a negative taxable income or tax savings. In that situation, we will use parentheses to denote a

[2] We will assume that the asset is purchased and placed in service at the beginning of year 1 (or the end of year 0), and the first year's depreciation will be claimed at the end of year 1.

negative entry. However, in preparing the cash flow statement, we will explicitly observe the sign convention: A positive sign indicates a cash inflow; a negative sign or parentheses indicate a cash outflow.

SOLUTION

Given: Preceding cash flow information.

Find: After-tax cash flow.

Before presenting the cash flow table, we need to do some preliminary calculations. The following notes explain the essential items in Table 10.2:

- Calculation of depreciation

  1. If, contrary to expectations, the asset is held for eight years, we can depreciate a seven-year property in respective percentages of 14.29%, 24.49%, 17.49%, 12.49%, 8.93%, 8.92%, 8.93%, and 4.46%. (See Table 9.3.)

TABLE 10.2 **Cash Flow Statement for the Automated Machining Center Project Using the Income Statement Approach (Example 10.1)**

Year	0	1	2	3	4	5
Income Statement						
Revenues		$100,000	$100,000	$100,000	$100,000	$100,000
Expenses						
Labor		20,000	20,000	20,000	20,000	20,000
Material		12,000	12,000	12,000	12,000	12,000
Overhead		8,000	8,000	8,000	8,000	8,000
Depreciation		17,863	30,613	21,863	15,613	5,581
Taxable income		$ 42,137	$ 29,387	$ 38,137	$ 44,387	$ 54,419
Income taxes (40%)		16,855	11,755	15,255	17,755	21,768
Net income		$ 25,282	$ 17,632	$ 22,882	$ 26,632	$ 32,651
Cash Flow Statement						
Operating activities						
Net income		25,282	17,632	22,882	26,632	32,651
Depreciation		17,863	30,613	21,863	15,613	5,581
Investment activities						
Investment	(125,000)					
Salvage						50,000
Gains tax						(6,613)
Net cash flow	$(125,000)	$ 43,145	$ 48,245	$ 44,745	$ 42,245	$ 81,619

2. If the asset is sold at the end of the fifth tax year (during the recovery period), the applicable depreciation amounts would be \$17,863, \$30,613, \$21,863, \$15,613, and \$5,581. Since the asset is disposed of in the fifth tax year, the last year's depreciation, which would ordinarily be \$11,163, is halved due to the half-year convention.

- Salvage value and gain taxes

  In year 5, we must deal with two aspects of the asset's disposal: salvage value and gains (both ordinary as well as capital). We list the estimated salvage value as a positive cash flow. Taxable gains are calculated as follows:

  1. The total depreciation in years 1 to 5 is \$17,863 + \$30,613 + \$21,863 + \$15,613 + \$5,581 = \$91,533.
  2. The book value at the end of period 5 is the cost basis minus the total depreciation, or \$125,000 − \$91,533 = \$33,467.
  3. The gains on the sale are the salvage value minus the book value, or \$50,000 − \$33,467 = \$16,533. (The salvage value is less than the cost basis, so the gains are ordinary gains.)
  4. The tax on the ordinary gains is \$16,533 × 40% = \$6,613. This is the amount placed in the table under "gains tax."

  Table 10.2 presents a summary of the cash flow profile.[3]

- Investment analysis

  Once we obtain the project's after-tax net cash flows, we can determine their equivalent present worth at the firm's interest rate. The after-tax cash flow series from the cash flow statement is shown in Figure 10.3. Since this series

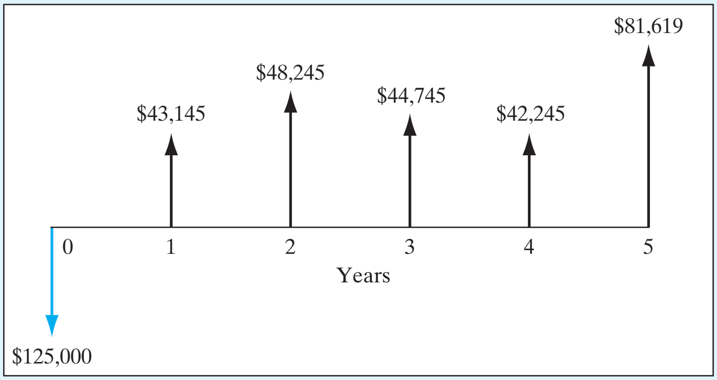


Figure 10.3 Cash flow diagram (Example 10.1).

[3] Even though gains from equipment disposal have an effect on income tax calculations, they should not be viewed as ordinary operating income. Therefore, in preparing the income statement, capital expenditures and related items such as gains tax and salvage value are not included. Nevertheless, these items represent actual cash flows in the year they occur and must be shown in the cash flow statement.

does not contain any patterns to simplify our calculations, we must find the net present worth of each payment. Using $i = 15\%$, we have

$$\begin{aligned} \mathrm{PW}(15\%) &= -\$125{,}000 + \$43{,}145(P/F, 15\%, 1) \\ &\quad + \$48{,}245(P/F, 15\%, 2) + \$44{,}745(P/F, 15\%, 3) \\ &\quad + \$42{,}245(P/F, 15\%, 4) + \$81{,}619(P/F, 15\%, 5) \\ &= \$43{,}152. \end{aligned}$$

This means that investing \$125,000 in this automated facility would bring in enough revenue to recover the initial investment and the cost of funds, with a surplus of \$43,152.

10.3.2 When Projects Require Working-Capital Investments

In many cases, changing a production process by replacing old equipment or by adding a new product line will have an impact on cash balances, accounts receivable, inventory, and accounts payable. For example, if a company is going to market a new product, inventories of the product and larger inventories of raw materials will be needed. Accounts receivable from sales will increase, and management might also decide to carry more cash because of the higher volume of activities. These investments in working capital are investments just like those in depreciable assets, except that they have no tax effects: The flows always sum to zero over the life of a project, but the inflows and outflows are shifted in time, so they do affect net present worth.

Consider the case of a firm that is planning a new product line. The new product will require a two-month's supply of raw materials at a cost of \$40,000. The firm could provide \$40,000 in cash on hand to pay them. Alternatively, the firm could finance these raw materials via a \$30,000 increase in accounts payable (60-day purchases) by buying on credit. The balance of \$10,000 represents the amount of net working capital that must be invested.

Working-capital requirements differ according to the nature of the investment project. For example, larger projects may require greater average investments in inventories and accounts receivable than would smaller ones. Projects involving the acquisition of improved equipment entail different considerations. If the new equipment produces more rapidly than the old equipment, the firm may be able to decrease its average inventory holdings because new orders can be filled faster as a result of using the new equipment. (One of the main advantages cited in installing advanced manufacturing systems, such as flexible manufacturing systems, is the reduction in inventory made possible by the ability to respond to market demand more quickly.) Therefore, it is also possible for working-capital needs to decrease because of an investment. If inventory levels were to decrease at the start of a project, the decrease would be considered a cash inflow, since the cash freed up from inventory could be put to use in other places. (See Example 10.5.)

Two examples illustrate the effects of working capital on a project's cash flows. Example 10.2 shows how the net working-capital requirement is computed, and Example 10.3 examines the effects of working capital on the automated machining center project discussed in Example 10.1.

EXAMPLE 10.2 Working-Capital Requirements

Suppose that in Example 10.1 the tool-manufacturing company's annual revenue projection of $100,000 is based on an annual volume of 10,000 units (or 833 units per month). Assume the following accounting information:

Price (revenue) per unit	$10
Unit variable manufacturing costs:	
Labor	$2
Material	$1.20
Overhead	$0.80
Monthly volume	833 units
Finished-goods inventory to maintain	2-month supply
Raw-materials inventory to maintain	1-month supply
Accounts payable	30 days
Accounts receivable	60 days

The accounts receivable period of 60 days means that revenues from the current month's sales will be collected two months later. Similarly, accounts payable of 30 days indicates that payment for materials will be made approximately one month after the materials are received. Determine the working-capital requirement for this operation.

SOLUTION

Given: Preceding information.

Find: Working-capital requirement.

Figure 10.4 illustrates the working-capital requirements for the first 12-month period.

During year 1

	Income/Expense reported	Actual cash received/paid	Difference
Sales	$100,000 (10,000 units)	$83,333	–$16,666
Expenses	$40,000 (10,000 units)	$46,665 (11,667 units)	+$6,665
Income taxes	$16,855	$16,855	0
Net amount	$43,145	$19,814	–$23,333

This differential amount must be invested at the beginning of the year

Figure 10.4 Illustration of working-capital requirements (Example 10.2).

Accounts receivable of \$16,666 (2 months' sales) means that in year 1 the company will have cash inflows of \$83,333, less than the projected sales of \$100,000 (\$8,333 × 12). In years 2 to 5, collections will be \$100,000, equal to sales, because the beginning and ending accounts receivable will be \$16,666, with sales of \$100,000. Collection of the final accounts receivable of \$16,666 would occur in the first 2 months of year 6, but can be added to the year-5 revenue to simplify the calculations. The important point is that cash inflow lags sales by \$16,666 in the first year.

Assuming that the company wishes to build up 2 months' inventory during the first year, it must produce 833 × 2 = 1,666 more units than are sold the first year. The extra cost of these goods in the first year is 1,666 units (\$4 variable cost per unit), or \$6,665. The finished-goods inventory of \$6,665 represents the variable cost incurred to produce 1,666 more units than are sold in the first year. In years 2 to 4, the company will produce and sell 10,000 units per year, while maintaining its 1,666-unit supply of finished goods. In the final year of operations, the company will produce only 8,334 units (for 10 months) and will use up the finished-goods inventory. As 1,666 units of the finished-goods inventory get liquidated during the last year (exactly, in the first 2 months of year 6), a working capital in the amount of \$6,665 will be released. Along with the collection of the final accounts receivable of \$16,666, a total working-capital release of \$23,331 will remain when the project terminates. Now we can calculate the working-capital requirements as follows:

Accounts receivable	
(833 units/month × 2 months × \$10)	\$16,666
Finished-goods inventory	
(833 units/month × 2 months × \$4)	6,665
Raw-materials inventory	
(833 units/month × 1 month × \$1.20)	1,000
Accounts payable (purchase of raw materials)	
(833 units/month × 1 month × \$1.20)	(1,000)
Net change in working capital	\$23,331

COMMENTS: During the first year, the company produces 11,666 units to maintain two months' finished-goods inventory, but it sells only 10,000 units. On what basis should the company calculate the net income during the first year (i.e., use 10,000 or 11,666 units)? *Any* increases in inventory expenses will reduce the taxable income; therefore, this calculation is based on 10,000 units. The reason is that the accounting measure of net income is based on the **matching concept**. If we report revenue when it is *earned* (whether it is actually received or not), and we report expenses when they are *incurred* (whether they are paid or not), we are using the *accrual method* of accounting. By tax law, this method *must* be used for purchases and sales whenever business transactions involve an inventory. Therefore, most manufacturing and merchandising businesses use the accrual basis in recording revenues and expenses. Any cash inventory expenses not accounted for in the net-income calculation will be reflected in changes in working capital.

EXAMPLE 10.3 Cash Flow Statement, Including Working Capital

Update the after-tax cash flows for the automated machining center project of Example 10.1 by including a working-capital requirement of $23,331 in year 0 and full recovery of the working capital at the end of year 5.

SOLUTION

Given: Flows as in Example 10.1, with the addition of a $23,331 working-capital requirement.

Find: Net after-tax cash flows with working capital and present worth.

Using the procedure just outlined, we group the net after-tax cash flows for this machining center project as shown in Table 10.3. As the table indicates, investments in working capital are cash outflows when they are expected to occur, and recoveries

TABLE 10.3 Cash Flow Statement for Automated Machining Center Project with Working-Capital Requirement (Example 10.3)

Year	0	1	2	3	4	5
Income Statement						
Revenues		$100,000	$100,000	$100,000	$100,000	$100,000
Expenses						
Labor		20,000	20,000	20,000	20,000	20,000
Material		12,000	12,000	12,000	12,000	12,000
Overhead		8,000	8,000	8,000	8,000	8,000
Depreciation		17,863	30,613	21,863	15,613	5,581
Taxable income		$ 42,137	$ 29,387	$ 38,137	$ 44,387	$ 54,419
Income taxes (40%)		16,855	11,755	15,255	17,755	21,768
Net income		$ 25,282	$ 17,632	$ 22,882	$ 26,632	$ 32,651
Cash Flow Statement						
Operating activities						
Net income		25,282	17,632	22,882	26,632	32,651
Depreciation		17,863	30,613	21,863	15,613	5,581
Investment activities						
Investment	(125,000)					
Salvage						50,000
Gains tax						(6,613)
Working capital	(23,331)					23,331
Net cash flow	$(148,331)	$ 43,145	$ 48,245	$ 44,745	$ 42,245	$104,950

are treated as cash inflows at the times they are expected to materialize. In this example, we assume that the investment in working capital made at period 0 will be recovered at the end of the project's life. (See Figure 10.5.)[4] Moreover, we also assume a full recovery of the initial working capital. However, in many situations, the investment in working capital may not be fully recovered (e.g., inventories may deteriorate in value or become obsolete). The equivalent net present worth of the after-tax cash flows, including the effects of working capital, is calculated as

$$\begin{aligned} PW(15\%) &= -\$148{,}331 + \$43{,}145(P/F, 15\%, 1) + \cdots \\ &\quad + \$104{,}950(P/F, 15\%, 5) \\ &= \$31{,}420. \end{aligned}$$

This present-worth value is \$11,732 less than that in the situation with no working-capital requirement (Example 10.1), demonstrating that working-capital requirements play a critical role in assessing a project's worth.

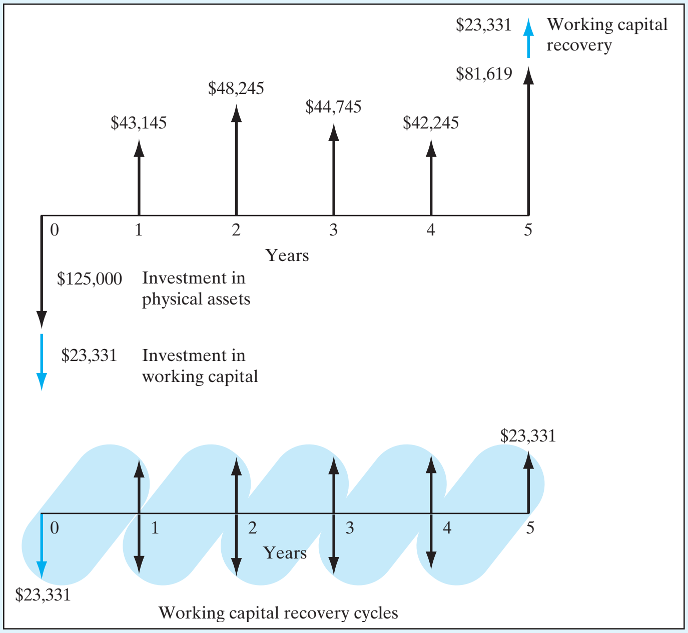


Figure 10.5 Cash flow diagram (Example 10.3).

[4] In fact, we could assume that the investment in working capital would be recovered at the end of the first operating cycle (say, year 1). However, the same amount of investment in working capital has to be made again at the beginning of year 2 for the second operating cycle, and the process repeats until the project terminates. Therefore, the net cash flow transaction looks as though the initial working capital will be recovered at the end of the project's life:

Period	0	1	2	3	4	5
Investment	−\$23,331	−\$23,331	−\$23,331	−\$23,331	−\$23,331	0
Recovery	0	23,331	23,331	23,331	23,331	23,331
Net flow	−\$23,331	0	0	0	0	\$23,331

COMMENT: The \$11,732 reduction in present worth is just the present worth of an annual series of 15% interest payments on the working capital, which is borrowed by the project at time 0 and repaid at the end of year 5:

$$\$23{,}331(15\%)(P/A, 15\%, 5) = \$11{,}732.$$

The investment tied up in working capital results in lost earnings.

10.3.3 When Projects Are Financed with Borrowed Funds

Many companies use a mixture of debt and equity to finance their physical plant and equipment. The ratio of total debt to total investment, generally called the **debt ratio**, represents the percentage of the total initial investment provided by borrowed funds. For example, a debt ratio of 0.3 indicates that 30% of the initial investment is borrowed and the rest is provided from the company's earnings (also known as **equity**). Since interest is a tax-deductible expense, companies in high tax brackets may incur lower after-tax financing costs by financing through debt. (Along with the effect of debt on taxes, the method of repaying the loan can have a significant impact. We will discuss the issue of project financing in Chapter 15.)

Debt ratio: Debt capital divided by total assets. This will tell you how much the company relies on debt to finance assets.

EXAMPLE 10.4 Cash Flow Statement with Financing (Borrowing)

Rework Example 10.3, assuming that \$62,500 of the \$125,000 paid for the investment is obtained through debt financing (debt ratio = 0.5). The loan is to be repaid in equal annual installments at 10% interest over five years. The remaining \$62,500 will be provided by equity (e.g., from retained earnings).

SOLUTION

Given: Same as in Example 10.3, but \$62,500 is borrowed and then repaid in equal installments over five years at 10% interest.

Find: Net after-tax cash flows in each year.

We first need to compute the size of the annual loan repayment installments:

$$\$62{,}500(A/P, 10\%, 5) = \$16{,}487.$$

Next, we determine the repayment schedule of the loan by itemizing both the interest and principal represented in each annual repayment:

Year	Beginning Balance	Interest Payment	Principal Payment	Ending Balance
1	\$62,500	\$6,250	\$10,237	\$52,263
2	52,263	5,226	11,261	41,002
3	41,002	4,100	12,387	28,615
4	28,615	2,861	13,626	14,989
5	14,989	1,499	14,988	0

The resulting after-tax cash flow is detailed in Table 10.4. The present-value equivalent of the after-tax cash flow series is

$$\begin{aligned} \mathrm{PW}(15\%) &= -\$85{,}351 + \$29{,}158(P/F, 15\%, 1) + \cdots \\ &\quad + \$89{,}063(P/F, 15\%, 5) \\ &= \$44{,}439. \end{aligned}$$

When this amount is compared with the amount found in the case when there was no borrowing ($31,420), we see that debt financing actually increases the present worth

TABLE 10.4 **Cash Flow Statement for Automated Machining Center Project with Debt Financing (Example 10.4)**

Year	0	1	2	3	4	5
Income Statement						
Revenues		$100,000	$100,000	$100,000	$100,000	$100,000
Expenses						
Labor		20,000	20,000	20,000	20,000	20,000
Material		12,000	12,000	12,000	12,000	12,000
Overhead		8,000	8,000	8,000	8,000	8,000
Depreciation		17,863	30,613	21,863	15,613	5,581
Debt interest		6,250	5,226	4,100	2,861	1,499
Taxable income		$ 35,887	$ 24,161	$ 34,037	$ 41,526	$ 52,920
Income taxes (40%)		14,355	12,664	13,615	16,610	21,168
Net income		$ 21,532	$ 14,497	$ 20,422	$ 24,916	$ 31,752
Cash Flow Statement						
Operating activities						
Net income		21,532	14,497	20,422	24,916	31,752
Depreciation		17,863	30,613	21,863	15,613	5,581
Investment activities						
Investment	(125,000)					
Salvage						50,000
Gains tax						(6,613)
Working capital	(23,331)					23,331
Financing activities						
Borrowed funds	62,500					
Repayment of principal		(10,237)	(11,261)	(12,387)	(13,626)	(14,988)
Net cash flow	$ (85,831)	$ 29,158	$ 33,849	$ 29,898	$ 26,903	$ 89,063

by $13,019. This surprising result is largely caused by the firm's being able to borrow the funds at a cheaper rate (10%) than its MARR (opportunity cost rate) of 15%. We should be careful in interpreting the result, however: It is true, to some extent, that firms can usually borrow money at lower rates than their MARR, but if the firm can borrow money at a significantly lower rate, that also affects its MARR, because the borrowing rate is one of the elements determining the MARR. Therefore, a significant difference in present values between "with borrowings" and "without borrowings" is not expected in practice. We will also address this important issue in Chapter 15.

10.3.4 When Projects Result in Negative Taxable Income

In a typical project year, revenues may not be large enough to offset expenses, thereby resulting in a negative taxable income. Now, a negative taxable income does *not* mean that a firm does not need to pay income tax; rather, the negative figure can be used to reduce the taxable incomes generated by other business operations.[5] Therefore, a negative taxable income usually results in a **tax savings**. When we evaluate an investment project with the use of an incremental tax rate, we also assume that the firm has sufficient taxable income from other activities, so that changes due to the project under consideration will not change the incremental tax rate.

Tex savings (shield): The reduction in income taxes that results from taking an allowable deduction from taxable income.

When we compare **cost-only** mutually exclusive projects (service projects), we have no revenues to consider in their cash flow analysis. In this situation, we typically assume no revenue (zero), but proceed as before in constructing the after-tax cash flow statement. With no revenue to match expenses, we have a negative taxable income, again resulting in tax savings. Example 10.5 illustrates how we may develop an after-tax cash flow statement for this type of project.

EXAMPLE 10.5 Project Cash Flows for a Cost-Only Project

Alcoa Aluminum's McCook plant produces aluminum coils, sheets, and plates. Its annual production runs at 400 million pounds. In an effort to improve McCook's current production system, an engineering team, led by the divisional vice-president, went on a fact-finding tour of Japanese aluminum and steel companies to observe their production systems and methods. Cited among the team's observations were large fans which the Japanese companies used to reduce the time that coils need to cool down after various processing operations. Cooling the hot process coils with the fans was estimated to significantly reduce the queue or work-in-process (WIP) inventory buildup allowed for cooling. The approach also reduced production lead time and improved delivery performance. The possibility of reducing production time and, as a consequence, the WIP inventory, excited the team members, particularly the vice-president. After the trip, Neal Donaldson, the plant engineer, was asked to

[5] Even if the firm does not have any other taxable income to offset in the current tax year, the operating loss can be carried back to each of the preceding 3 years and forward for the next 15 years to offset taxable income in those years.

investigate the economic feasibility of installing cooling fans at the McCook plant. Neal's job is to justify the purchase of cooling fans for his plant. He was given one week to prove that the idea was a good one. Essentially, all he knew was the number of fans, their locations, and the project cost. Everything else was left to Neal's devices. Suppose that he compiled the following financial data:

- The project will require an investment of \$536,000 in cooling fans now.
- The cooling fans would provide 16 years of service with no appreciable salvage values, considering the removal costs.
- It is expected that the amount of time required between hot rolling and the next operation would be reduced from five days to two days. Cold-rolling queue time also would be reduced, from two days to one day for each cold-roll pass. The net effect of these changes would be a reduction in the WIP inventory at a value of \$2,121,000. Because of the lead time involved in installing the fans, as well as the consumption of stockpiled WIP inventory, this working-capital release will be realized one year after the fans are installed.
- The cooling fans will be depreciated according to seven-year MACRS.
- Annual electricity costs are estimated to rise by \$86,000.
- The firm's after-tax required rate of return is known to be 20% for this type of cost reduction project.

Develop the project cash flows over the service period of the fans, and determine whether the investment is a wise one, based on 20% interest.

SOLUTION

Given: Required investment = \$536,000; service period = 16 years; salvage value = \$0; depreciation method for cooling fans = 7-year MACRS; working-capital release = \$2,121,000 1 year later; annual operating cost (electricity) = \$86,000.

Find: (a) annual after-tax cash flows; (b) make the investment decision on the basis of the NPW; and (c) make the investment decision on the basis of the IRR.

(a) Because we can assume that the annual revenues would stay the same as they were before and after the installation of the cooling fans, we can treat these unknown revenue figures as zero. Table 10.5 summarizes the cash flow statement for the cooling-fan project. With no revenue to offset the expenses, the taxable income will be negative, resulting in tax savings. Note that the working-capital recovery (as opposed to working-capital investment for a typical investment project) is shown in year 1. Note also that there is no gains tax, because the cooling fans are fully depreciated with a zero salvage value.

(b) At $i = 20\%$, the NPW of this investment would be

$$\begin{aligned} \text{PW}(20\%) &= -\$536{,}000 + \$2{,}100{,}038(P/F, 20\%, 1) \\ &\quad + \$906(P/F, 20\%, 2) + \ldots \\ &\quad - \$2{,}172{,}600(P/F, 20\%, 16) \\ &= \$991{,}008. \end{aligned}$$

TABLE 10.5 **Cash Flow Statement for the Cooling Fan Project without Revenue (Example 10.5)**

Year	0	1	2	3	4	5	6	7	8	9–15	16
Income Statement											
Revenues											
Expenses											
Depreciation		$ 76,594	$131,266	$ 93,746	$ 66,946	$ 47,865	$ 47,811	$ 47,865	$ 23,906		
Electricity cost		86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000	86,000
Taxable income		(162,594)	(217,266)	(179,746)	(152,946)	(133,865)	(133,811)	(133,865)	(109,906)	(86,000)	(86,000)
Income taxes		(65,038)	(86,906)	(71,898)	(61,178)	(53,546)	(53,524)	(53,546)	(43,962)	(34,400)	(34,400)
Net income		$ (97,556)	$(130,360)	$(107,848)	$ (91,768)	$ (80,319)	$ (80,287)	$ (80,319)	$ (65,944)	$ (51,600)	$ (51,600)
Cash Flow Statement											
Operating activities											
Net income		(97,556)	(130,360)	(107,848)	(91,768)	(80,319)	(80,287)	(80,319)	(65,944)	(51,600)	(51,600)
Depreciation		76,594	131,266	93,746	66,946	47,865	47,811	47,865	23,906	0	0
Investment activities											
Cooling fans	(536,000)										
Salvage value											
Gains tax											
Working capital		2,121,000									(2,121,000)
Net cash flow	$ (536,000)	$2,100,038	$ 906	$ (14,102)	$ (24,822)	$ (32,454)	$ (32,476)	$ (32,454)	$ (42,038)	$ (51,600)	$ (2,172,600)

Note: The working-capital release attributable to a reduction in work-in-process inventories will be realized at the end of year 1.

Even with only one time savings in WIP, this cooling-fan project is economically justifiable.

(c) If we are to justify the investment on the basis of the internal rate of return, we first need to determine whether the investment is a simple or nonsimple one. Since there are more than one sign changes in the cash flow series, this is not a simple investment, indicating the possibility of multiple rates of return. In fact, as shown in Figure 10.6, the project has two rates of return, one at 4.24% and the other at 291.56%. Neither is a true rate of return, as we learned in Section 7.3.2, so we may proceed to abandon the rate-of-return approach and use the NPW criterion. If you desire to find the true IRR for this project, you need to follow the procedures outlined in Section 7.3.4. At a MARR of 20%, the true IRR (or return on invested capital) is 241.87%, which is significantly larger than the MARR and indicates acceptance of the investment. Note that this is the same conclusion that we reached in (b).

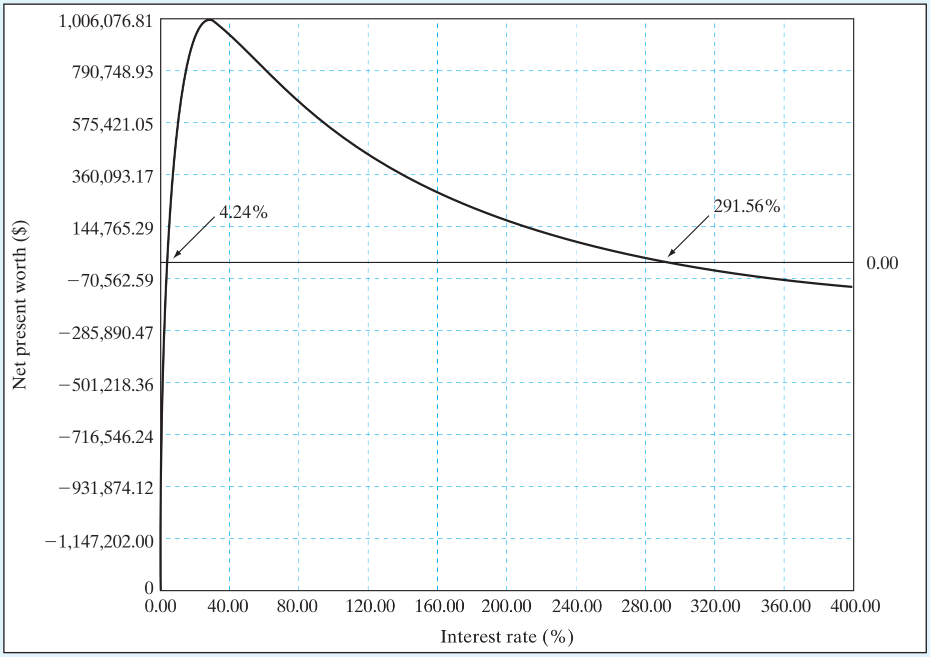


Figure 10.6 NPW plot for the cooling-fan project (Example 10.5).

COMMENTS: As the cooling fans reach the end of their service lives, we need to add the working-capital investment ($2,120,000) at the end of year 16, working under the assumption that the plant will return to the former system without the cooling fans and thus will require the additional investment in working capital.

If the new system has proven to be effective, and the plant will remain in service, we need to make another investment to purchase a new set of cooling fans at the end of year 16. As a consequence of this new investment, there will be a working-capital release in the amount of $2,120,000. However, this investment should bring benefits to the second cycle of the operation, so that it should be charged against the cash flows for the second cycle, not the first cycle.

10.3.5 When Projects Require Multiple Assets

Up to this point, our examples have been limited to situations in which only one asset was employed in a project. In many situations, however, a project may require the purchase of multiple assets with different property classes. For example, a typical engineering project may involve more than just the purchase of equipment: It may need a building in which to carry out manufacturing operations. The various assets may even be placed in service at different points in time. What we then have to do is itemize the timing of the investment requirement and the depreciation allowances according to the placement of the assets. Example 10.6 illustrates the development of project cash flows that require multiple assets.

EXAMPLE 10.6 A Project Requiring Multiple Assets

Langley Manufacturing Company (LMC), a manufacturer of fabricated metal products, is considering purchasing a new computer-controlled milling machine to produce a custom-ordered metal product. The following summarizes the relevant financial data related to the project:

- The machine costs \$90,000. The costs for its installation, site preparation, and wiring are expected to be \$10,000. The machine also needs special jigs and dies, which will cost \$12,000. The milling machine is expected to last 10 years, the jigs and dies 5 years. The machine will have a \$10,000 salvage value at the end of its life. The special jigs and dies are worth only \$1,000 as scrap metal at any time in their lives. The milling machine is classified as a 7-year MACRS property and the jigs and dies as a 3-year MACRS property.
- LMC needs to either purchase or build an 8,000-ft^2 warehouse in which to store the product before it is shipped to the customer. LMC has decided to purchase a building near the plant at a cost of \$160,000. For depreciation purposes, the warehouse cost of \$160,000 is divided into \$120,000 for the building (39-year real property) and \$40,000 for land. At the end of 10 years, the building will have a salvage value of \$80,000, but the value of the land will have appreciated to \$110,000.
- The revenue from increased production is expected to be \$150,000 per year. The additional annual production costs are estimated as follows: materials, \$22,000; labor, \$32,000; energy \$3,500; and other miscellaneous costs, \$2,500.
- For the analysis, a 10-year life will be used. LMC has a marginal tax rate of 40% and a MARR of 18%. No money is borrowed to finance the project. Capital gains will also be taxed at 40%.[6]

[6] Capital gains for corporations are taxed at a maximum rate of 35%. However, capital gains are also subject to state taxes, so the combined tax rate will be approximately 40%.

DISCUSSION: Three types of assets are to be considered in this problem: the milling machine, the jigs and dies, and the warehouse. The first two assets are personal properties and the last is a real property. The cost basis for each asset has to be determined separately. For the milling machine, we need to add the site-preparation expense to the cost basis, whereas we need to subtract the land cost from the warehouse cost to establish the correct cost basis for the real property. The various cost bases are as follows:

- The milling machine: $90,000 + $10,000 = $100,000.
- Jigs and dies: $12,000.
- Warehouse (building): $120,000.
- Warehouse (land): $40,000.

Since the jigs and dies last only five years, we need to make a specific assumption regarding the replacement cost at the end of that time. In this problem, we will assume that the replacement cost would be approximately equal to the cost of the initial purchase. We will also assume that the warehouse property will be placed in service in January, which indicates that the first year's depreciation percentage will be 2.4573%. (See Table 9.4.)

SOLUTION

Given: Preceding cash flow elements, $t_m = 40\%$, and MARR $= 18\%$.
Find: Net after-tax cash flow and NPW.

Table 10.6 and Figure 10.7 summarize the net after-tax cash flows associated with the multiple-asset investment. In the table, we see that the milling machine and the jigs and dies are fully depreciated during the project life, whereas the building is not. We need to calculate the book value of the building at the end of the project life. We assume that the building will be disposed of December 31 in the 10th year, so that the midmonth convention also applies to the book-value calculation:

$$B_{10} = \$120{,}000 - (\$2{,}949 + \$3{,}077 \times 8 + \$2{,}949) = \$89{,}486.$$

Then the gains (losses) are

$$\text{Salvage value} - \text{book value} = \$80{,}000 - \$89{,}486 = (\$9{,}486).$$

We can now calculate the gains or losses associated with the disposal of each asset as follows:

Property (Asset)	Cost Basis	Salvage Value	Book Value	Gains (Losses)	Gains Taxes
Land	$40,000	$110,000	$40,000	$70,000	$28,000
Building	120,000	80,000	89,486	(9,486)	(3,794)
Milling machine	100,000	10,000	0	10,000	4,000
Jigs and dies	12,000	1,000	0	1,000	400

TABLE 10.6 **Cash Flow Statement for LMC's Machining Center Project with Multiple Assets (Example 10.6)**

Year	0	1	2	3	4	5	6	7	8	9	10
Income Statement											
Revenues		$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000
Expenses											
Materials		22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000
Labor		32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000
Energy		3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
Other		2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Depreciation											
Building		2,949	3,077	3,077	3,077	3,077	3,077	3,077	3,077	3,077	2,949
Machines		14,290	24,490	17,490	12,490	8,930	8,920	8,930	4,460		
Tools		4,000	5,333	1,778	889		4,000	5,333	1,778	889	
Taxable income		68,761	57,100	67,655	73,544	77,993	74,003	72,660	80,685	86,034	87,051
Income taxes		27,504	22,840	27,062	29,418	31,197	29,601	29,064	32,274	34,414	34,820
Net income		$ 41,257	$ 34,260	$ 40,593	$ 44,126	$ 46,796	$ 44,402	$ 43,596	$ 48,411	$ 51,620	$ 52,231
Cash Flow Statement											
Operating activities:											
Net income		41,257	34,260	40,593	44,126	46,796	44,402	43,596	48,411	51,620	52,231
Depreciation		21,239	32,900	22,345	16,456	12,007	15,997	17,340	9,315	3,966	2,949
Investment activities:											
Land	(40,000)										110,000
Building	(120,000)										80,000
Machines	(100,000)										10,000
Tools (first cycle)	(12,000)					1,000					
Tools (second cycle)						(12,000)					1,000
Gains tax:											
Land									(28,000)		
Building											3,794
Machines											(4,000)
Tools						(400)					(400)
Net cash flow	$ (272,000)	$ 62,496	$ 67,160	$ 62,938	$ 60,582	$ 47,403	$ 60,399	$ 60,936	$ 57,726	$ 55,586	$227,574

Note: Investment in tools (jigs and dies) will be repeated at the end of year 5, at the cost of the initial purchase.

The NPW of the project is

$$\begin{aligned} PW(18\%) &= -\$272{,}000 + \$62{,}496(P/F, 18\%, 1) + \$67{,}160(P/F, 18\%, 2) \\ &\quad + \ldots + \$227{,}574(P/F, 18\%, 10) \\ &= \$32{,}343 > 0. \end{aligned}$$

and the IRR for this investment is about 21%, which exceeds the MARR. Therefore, the project is acceptable.

COMMENT: Note that the gains (losses) posted in the preceding table can be classified into two types: ordinary gains (losses) and capital gains. Only the $70,000 for land represents true capital gains, whereas the other figures represent ordinary gains (losses).

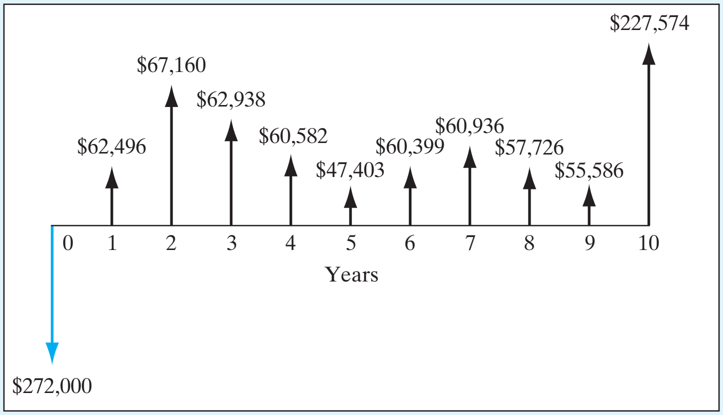


Figure 10.7 Cash flow diagram (Example 10.6).

10.4 Generalized Cash Flow Approach

If we analyze project cash flows for a corporation that consistently operates in the highest tax bracket, we can assume that the firm's marginal tax rate will remain the same, whether the project is accepted or rejected. In this situation, we may apply the top marginal tax rate (currently 35%) to each taxable item in the cash profile, thus obtaining the after-tax cash flows. By aggregating individual items, we obtain the project's net cash flows. This approach is referred to as the **generalized cash flow approach**. As we shall see in later chapters, it affords several analytical advantages. In particular, when we compare service projects, the generalized cash flow method is computationally efficient. (Examples are given in Chapters 12 and 14.)

10.4.1 Setting up Net Cash Flow Equations

To produce a generalized cash flow table, we first examine each cash flow element. We can do this as follows, using the scheme for classifying cash flows that we have just developed:

$$A_n = \left.\begin{array}{l} +\text{Revenues at time } n,\ (R_n) \\ -\text{Expenses (excluding depreciation and} \\ \quad \text{debt interest) at time } n,\ (E_n) \\ -\text{Debt interest at time } n,\ (\text{IP}_n) \\ -\text{Income taxes at time } n,\ (T_n) \end{array}\right\}\ \text{Operating activities}$$

$$\left.\begin{array}{l} -\text{Investment at time } n,\ (I_n) \\ +\text{Net proceeds from sale at time } n,\ (S_n - G_n) \\ -\text{Working capital investment at time } n,\ (W_n) \end{array}\right\}\ \text{Investing activities}$$

$$\left.\begin{array}{l} +\text{Proceeds from loan } n,\ (B_n) \\ -\text{Repayment of principal } n,\ (\text{PP}_n), \end{array}\right\}\ \text{Borrowing activities.}$$

Here, A_n is the net after-tax cash flow at the end of period n.

Depreciation (D_n) is *not* a cash flow and is therefore excluded from E_n (although it must be considered in calculating income taxes). Note that $(S_n - G_n)$ represents the net salvage value after adjustments for gains tax or loss credits (G_n). Not all terms are relevant in calculating a cash flow in every year; for example, the term $(S_n - G_n)$ appears only when the asset is disposed of.

In terms of symbols, we can express A_n as

$$\begin{aligned} A_n = \;& R_n - E_n - \text{IP}_n - T_n && \leftarrow \text{Operating activities} \\ & -I_n + (S_n - G_n) - W_n && \leftarrow \text{Investing activities} \\ & +B_n - \text{PP}_\text{n} && \leftarrow \text{Financing activities.} \end{aligned} \tag{10.1}$$

If we designate T_n as the total income taxes paid at time n and t_m as the marginal tax rate, income taxes on this project are

$$\begin{aligned} T_n &= (\text{Taxable income})(\text{marginal tax rate}) \\ &= (R_n - E_n - \text{IP}_n - D_n)t_m \\ &= (R_n - E_n - \text{IP}_n)t_m - D_n t_m \\ &= (R_n - E_n)t_m - (\text{IP}_n + D_n)t_m. \end{aligned} \tag{10.2}$$

The term $(\mathrm{IP}_n + D_n)t_m$ is known as the tax shield (or tax savings) from financing and asset depreciation. Now substituting the result of Eq. (10.2) into Eq. (10.1), we obtain

$$\begin{aligned} A_n = {} & (R_n - E_n - \mathrm{IP}_n)(1 - t_m) + t_m D_n \\ & - I_n + (S_n - G_n) - W_n \\ & + B_n - \mathrm{PP}_n. \end{aligned} \tag{10.3}$$

10.4.2 Presenting Cash Flows in Compact Tabular Formats

After-tax cash flow components over the project life can be grouped by type of activity in a compact tabular format as follows:

Cash Flow Elements	End of Period 0	1	2	. . . N
Investment activities:				
$-I_n$				
$+S_n - G_n$				
$-W_n$				
Operating activities:				
$+(1 - t_m)(R_n)$				
$-(1 - t_m)(E_n)$				
$-(1 - t_m)(\mathrm{IP}_n)$				
$+t_m D_n$				
Financing activities:				
$+B_n$				
$-\mathrm{PP}_n$				
Net cash flow				
A_n				

However, in preparing their after-tax cash flow, most business firms adopt the income statement approach presented in previous sections, because they want to know the accounting income along with the cash flow statement.

EXAMPLE 10.7 Generalized Cash Flow Approach

Consider again Example 10.4. Use the generalized cash flow approach to obtain the after-tax cash flows:

SOLUTION

Given:

Investment cost $(I_0) = \$125{,}000$,

Investment in working capital $(W_n) = \$23{,}331$,
Annual revenues $(R_n) = \$100{,}000$,
Annual expenses other than depreciation and debt interest $(E_n) = \$40{,}000$,
Debt interest (IP_n), years 1 to 5 = \$6,250, \$5,226, \$4,100, \$2,861, \$1,499, respectively,
Principal repayment (PP_n), years 1 to 5 = \$10,237, \$11,261, \$12,387, \$13,626, \$14,988, respectively,
Depreciation (D_n), years 1 to 5 = \$17,863, \$30,613, \$21,863, \$15,613, \$5,581, respectively,
Marginal tax rate $(t_m) = 40\%$, and
Salvage value $(S_n) = \$50{,}000$.

Find: Annual after-tax cash flows (A_n).

Step 1: Find the cash flow at year 0:

1. Investment in depreciable asset $(I_0) = -\$125{,}000$.
2. Investment in working capital $(W_0) = -\$23{,}331$.
3. Borrowed funds $(\mathrm{PP}_0) = \$62{,}500$.
4. Net cash flow $(A_0) = -\$125{,}000 - \$23{,}331 + \$62{,}500 = -\$85{,}831$.

Step 2: Find the cash flow in years 1 to 4:

$$A_n = (R_n - E_n - \mathrm{IP}_n)(1 - t_m) + D_n t_m - \mathrm{PP_n}.$$

n	Net Operating Cash Flow (\$)
1	$(100{,}000 - 40{,}000 - 6{,}250)(0.60) + 17{,}863(0.40) - 10{,}237 = \$29{,}158$
2	$(100{,}000 - 40{,}000 - 5{,}226)(0.60) + 30{,}613(0.40) - 11{,}261 = \$33{,}849$
3	$(100{,}000 - 40{,}000 - 4{,}100)(0.60) + 21{,}863(0.40) - 12{,}387 = \$29{,}898$
4	$(100{,}000 - 40{,}000 - 2{,}861)(0.60) + 15{,}613(0.40) - 13{,}626 = \$26{,}903$

Step 3: Find the cash flow for year 5:

1. Operating cash flow:
   $(100{,}000 - 40{,}000 - 1{,}499)(0.60) + 5{,}581(0.40) - 14{,}988 = \$22{,}345$.
2. Net salvage value
   (as calculated in Example 10.1) $= \$50{,}000 - \$6{,}613 = \$43{,}387$.
3. Recovery of working capital, $W_5 = \$23{,}331$.
4. Net cash flow in year 5, $A_5 = \$22{,}345 + \$43{,}387 + \$23{,}331 = \$89{,}063$.

TABLE 10.7 **Cash Flow Statement for Example 10.4 Using the Generalized Cash Flow Approach (Example 10.8)**

	0	1	2	3	4	5
Investment	$(125,000)					
Net proceeds from sale						$43,387
Investment in working capital	(23,331)					
Recovery of working capital						23,331
$(1 - 0.40)$ (Revenue)		$ 60,000	$ 60,000	$ 60,000	$ 60,000	$ 60,000
$-(1 - 0.40)$ (Expenses)		(24,000)	(24,000)	(24,000)	(24,000)	(24,000)
$-(1 - 0.40)$ (Debt interest)		(3,750)	(3,136)	(2,460)	(1,717)	(899)
$+(0.40)$ (Depreciation)		7,145	12,245	8,745	6,245	2,232
Borrowed funds	62,500					
Repayment of principal		(10,237)	(11,261)	(12,387)	(13,626)	(14,988)
Net cash flow	$ (85,831)	$ 29,158	$ 33,849	$ 29,898	$ 26,903	$ 89,063

Our results and overall calculations are summarized in Table 10.7. Checking them against the results we obtained in Table 10.4 confirms them.

10.4.3 Lease-or-Buy Decision

A lease-or-buy decision begins only after a company has decided that the acquisition of a piece of equipment is necessary to carry out an investment project. Having made this decision, the company may be faced with several alternative methods of financing the acquisition: cash purchase, debt purchase, or acquisition via a lease.

With a debt purchase, the present-worth expression is similar to that for a cash purchase, except that it has additional items: loan repayments and a tax shield on interest payments. The only way that the lessee can evaluate the cost of a lease is to compare it against the best available estimate of what the cost would be if the lessee owned the equipment.

To lay the groundwork for a more general analysis, we shall first consider how to analyze the lease-or-buy decision for a project with a single fixed asset for which the company expects a service life of N periods. Since the net after-tax revenue is the same for both alternatives, we need only consider the incremental cost of owning the asset and the incremental cost of leasing. Using the generalized cash flow approach, we may express the incremental cost of owning the asset by borrowing as

$$\begin{aligned} PW(i)_{\text{Buy}} = \; & + \text{ PW of loan repayment} \\ & + \text{ PW of after-tax O\&M costs} \\ & - \text{ PW of tax credit on depreciation and interest} \\ & - \text{ PW of net proceeds from sale.} \end{aligned} \qquad (10.4)$$

Note that the acquisition (investment) cost of the asset is offset by the same amount of borrowing at time 0, so that we need to consider only the loan repayment series.

Suppose that the firm can lease the asset at a constant amount per period. Then the project's incremental cost of leasing becomes

$$\text{PW}(i)_{\text{Lease}} = \text{PW of after-tax lease expenses.}$$

If the lease does not provide for the maintenance of the equipment leased, then the lessee must assume this responsibility. In that situation, the maintenance term in Eq. (10.4) can be dropped in the calculation of the incremental cost of owning the asset.

The criterion for the decision to lease as opposed to purchasing the asset thus reduces to a comparison between $\text{PW}(i)_{\text{Buy}}$ and $\text{PW}(i)_{\text{Lease}}$. Purchasing is preferred if the combined present value of the loan repayment series and the after-tax O&M expense, reduced by the present values of the depreciation tax shield and the net proceeds from disposal of the asset, is less than the present value of the net lease costs.

EXAMPLE 10.8 Lease-or-Buy Decision

The Dallas Electronics Company is considering replacing an old, 1,000-pound-capacity industrial forklift truck. The truck has been used primarily to move goods from production machines into storage. The company is working nearly at capacity and is operating on a two-shift basis six days per week. Dallas management is considering owning or leasing the new truck. The plant engineer has compiled the following data for management:

- The initial cost of a gas-powered truck is $20,000. The new truck would use about 8 gallons of gasoline (in a single shift of 8 hours per day) at a cost of $2.35 per gallon. If the truck is operated 16 hours per day, its expected life will be four years, and an engine overhaul at a cost of $1,500 will be required at the end of two years.
- The Austin Industrial Truck Company was servicing the old forklift truck, and Dallas would buy the new truck through Austin, which offers a service agreement to users of its trucks. The agreement costs $120 per month and provides for a monthly visit by an experienced service representative to lubricate and tune the truck. Insurance and property taxes for the truck are $650 per year.
- The truck is classified as five-year property under MACRS and will be depreciated accordingly. Dallas is in the 40% marginal tax bracket; the estimated resale value of the truck at the end of four years will be 15% of the original cost.
- Austin also has offered to lease a truck to Dallas. Austin will maintain the equipment and will guarantee to keep the truck in serviceable condition at all times. In the event of a major breakdown, Austin will provide a replacement truck at its expense. The cost of the operating lease plan is $850 per month. The contract term is three years at a minimum, with the option to cancel on 30 days' notice thereafter.
- On the basis of recent experience, the company expects that funds committed to new investments should earn at least a 12% rate of return after taxes.

Compare the cost of owning versus leasing the truck.

DISCUSSION: We may calculate the fuel costs for two-shift operation as

$$(8 \text{ gallons/shift})(2 \text{ shifts/day})(\$2.35/\text{gallon}) = \$37.60 \text{ per day.}$$

The truck will operate 300 days per year, so the annual fuel cost will be $11,280. However, both alternatives require the company to supply its own fuel, so the fuel cost is not relevant to our decision making. Therefore, we may drop this common cost item from our calculations.

SOLUTION

Given: Preceding cost information, MARR = 12%, and marginal tax rate = 40%.
Find: Incremental cost of owning versus leasing the truck.

(a) Incremental cost of owning the truck.

To compare the incremental cost of ownership with the incremental cost of leasing, we make the following additional estimates and assumptions:

- **Step 1.** The preventive-maintenance contract, which costs $120 per month (or $1,440 per year), will be adopted. With annual insurance and taxes of $650, the equivalent present worth of the after-tax O&M is

$$P_1 = (\$1{,}440 + \$650)(1 - 0.40)(P/A, 12\%, 4) = \$3{,}809.$$

- **Step 2.** The engine overhaul is not expected to increase either the salvage value or the service life of the truck. Therefore, the overhaul cost ($1,500) will be expensed all at once rather than capitalized. The equivalent present worth of this after-tax overhaul expense is

$$P_2 = \$1{,}500(1 - 0.40)(P/F, 12\%, 2) = \$717.$$

- **Step 3.** If Dallas decided to purchase the truck through debt financing, the first step in determining financing costs would be to compute the annual installments of the debt repayment schedule. Assuming that the entire investment of $20,000 is financed at a 10% interest rate, the annual payment would be

$$A = \$20{,}000(A/P, 10\%, 4) = \$6{,}309.$$

The equivalent present worth of this loan payment series is

$$P_3 = \$6{,}309\ (P/A, 12\%, 4) = \$19{,}163.$$

- **Step 4.** The interest payment each year (10% of the beginning balance) is calculated as follows:

Year	Beginning Balance	Interest Charged	Annual Payment	Ending Balance
1	$20,000	$2,000	−$6,309	$15,691
2	15,691	1,569	−6,309	10,951
3	10,951	1,095	−6,309	5,737
4	5,737	573	−6,309	0

With the five-year MACRS depreciation schedule, the combined tax savings due to depreciation expenses and interest payments can be calculated as follows:

n	D_n	I_n	Combined Tax Savings
1	\$4,000	\$2,000	\$6,000(0.40) = \$2,400
2	6,400	1,569	7,969(0.40) = 3,188
3	3,840	1,095	4,935(0.40) = 1,974
4	1,152	573	1,725(0.40) = 690

Therefore, the equivalent present worth of the combined tax credit is

$$\begin{aligned} P_4 &= \$2{,}400(P/F, 12\%, 1) + \$3{,}188(P/F, 12\%, 2) \\ &\quad + \$1.974(P/F, 12\%, 3) + \$690(P/F, 12\%, 4) \\ &= \$6{,}527. \end{aligned}$$

- **Step 5.** With the estimated salvage value of 15% of the initial investment (\$3,000) and with the five-year MACRS depreciation schedule given, we compute the net proceeds from the sale of the truck at the end of four years as follows:

$$\begin{aligned} \text{Book value} &= \$20{,}000 - \$15{,}392 = \$4{,}608, \\ \text{Gains (losses)} &= \$3{,}000 - \$4{,}608 = (\$1{,}608), \\ \text{Tax savings} &= 0.40(\$1{,}608) = \$643, \\ \text{Net proceeds from sale} &= \$3{,}000 + \$643 = \$3{,}643. \end{aligned}$$

The present equivalent amount of the net salvage value is

$$P_5 = \$3{,}643(P/F, 12\%, 4) = \$2{,}315.$$

- **Step 6.** Therefore, the net incremental cost of owning the truck through 100% debt financing is

$$\begin{aligned} \text{PW}(12\%)_{\text{Buy}} &= P_1 + P_2 + P_3 - P_4 - P_5 \\ &= \$14{,}847. \end{aligned}$$

(b) Incremental cost of leasing the truck.

How does the cost of acquiring a forklift truck under the lease compare with the cost of owning the truck?

- **Step 1.** The lease payment is also a tax-deductible expense; however, the net cost of leasing has to be computed explicitly on an after-tax basis. The calculation of the annual incremental leasing costs is as follows:

$$\begin{aligned} \text{Annual lease payments (12 months)} &= \$10{,}200, \\ \text{Less 40\% taxes} &= 4{,}080, \\ \text{Annual net costs after taxes} &= \$6{,}120. \end{aligned}$$

- **Step 2.** The total net present equivalent incremental cost of leasing is

$$\begin{aligned} PW(12\%)_{\text{Lease}} &= \$6{,}120(P/A, 12\%, 4) \\ &= \$18{,}589. \end{aligned}$$

Purchasing the truck with debt financing would save Dallas \$3,742 in NPW.

- **Step 3.** Here, we have assumed that the lease payments occur at the end of the period; however, many leasing contracts require the payments to be made at the beginning of each period. In the latter situation, we can easily modify the present-worth expression of the lease expense to reflect this cash-flow timing:

$$\begin{aligned} PW(12\%)_{\text{Lease}} &= \$6{,}120 + \$6{,}120(P/A, 12\%, 3) \\ &= \$20{,}819. \end{aligned}$$

COMMENTS: In our example, leasing the truck appears to be more expensive than purchasing the truck with debt financing. You should not conclude, however, that leasing is *always* more expensive than owning. In many cases, analysis favors a lease option. The interest rate, salvage value, lease payment schedule, and debt financing all have an important effect on decision making.

SUMMARY

- Identifying and estimating relevant project cash flows is perhaps the most challenging aspect of engineering economic analysis. All cash flows can be organized into one of the following three categories:

  1. Operating activities.

  2. Investing activities.

  3. Financing activities.

- The following types of cash flow are the most common flows a project may generate:

  1. New investment and disposal of existing assets.

  2. Salvage value (or net selling price).

  3. Working capital.

  4. Working-capital release.

  5. Cash revenues or savings.

  6. Manufacturing, operating, and maintenance costs.

  7. Interest and loan payments.

  8. Taxes and tax credits.

  In addition, although not cash flows, the following elements may exist in a project analysis, and they must be accounted for:

  1. Depreciation expenses.

  2. Amortization expenses.

Table 10.1 summarizes these elements and organizes them as investment, financing, or operating elements.

- The **income statement approach** is typically used in organizing project cash flows. This approach groups cash flows according to whether they are operating, investing, or financing functions.
- The **generalized cash flow approach** (shown in Table 10.7) to organizing cash flows can be used when a project does not change a company's marginal tax rate. The cash flows can be generated more quickly and the formatting of the results is less elaborate than with the income statement approach. There are also analytical advantages, which we will discover in later chapters. However, the generalized approach is less intuitive and not commonly understood by businesspeople.

PROBLEMS

Generating Net Cash Flows

10.1 You are considering a luxury apartment building project that requires an investment of $12,500,000. The building has 50 units. You expect the maintenance cost for the apartment building to be $250,000 the first year and $300,000 the second year, after which it will continue to increase by $50,000 in subsequent years. The cost to hire a manager for the building is estimated to be $80,000 per year. After five years of operation, the apartment building can be sold for $14,000,000. What is the annual rent per apartment unit that will provide a return on investment of 15% after tax? Assume that the building will remain fully occupied during the five years. Assume also that your tax rate is 35%. The building will be depreciated according to 39-year MACRS and will be placed in service in January during the first year of ownership and sold in December during the fifth year of ownership.

10.2 An automobile-manufacturing company is considering purchasing an industrial robot to do spot welding, which is currently done by skilled labor. The initial cost of the robot is $185,000, and the annual labor savings are projected to be $120,000. If purchased, the robot will be depreciated under MACRS as a five-year recovery property. The robot will be used for seven years, at the end of which time the firm expects to sell it for $40,000. The company's marginal tax rate is 35% over the project period. Determine the net after-tax cash flows for each period over the project life.

10.3 A firm is considering purchasing a machine that costs $55,000. It will be used for six years, and the salvage value at that time is expected to be zero. The machine will save $25,000 per year in labor, but it will incur $7,000 operating and maintenance costs each year. The machine will be depreciated according to five-year MACRS. The firm's tax rate is 40% and its after-tax MARR is 15%. Should the machine be bought?

10.4 A Los Angeles company is planning to market an answering device for people working alone who want the prestige that comes with having a secretary, but who cannot afford one. The device, called Tele-Receptionist, is similar to a voice-mail system. It uses digital recording technology to create the illusion that a person is operating the switchboard at a busy office. The company purchased a 40,000-ft^2

building and converted it to an assembly plant for $600,000 ($100,000 worth of land and $500,000 worth of building). Installation of the assembly equipment worth $500,000 was completed on December 31. The plant will begin operation on January 1. The company expects to have a gross annual income of $2,500,000 over the next 5 years. Annual manufacturing costs and all other operating expenses (excluding depreciation) are projected to be $1,280,000. For depreciation purposes, the assembly plant building will be classified as 39-year real property and the assembly equipment as a 7-year MACRS property. The property value of the land and the building at the end of year 5 would appreciate as much as 15% over the initial purchase cost. The residual value of the assembly equipment is estimated to be about $50,000 at the end of year 5. The firm's marginal tax rate is expected to be about 40% over the project period. Determine the project's after-tax cash flows over the period of 5 years.

10.5 A highway contractor is considering buying a new trench excavator that costs $200,000 and can dig a 3-foot-wide trench at the rate of 16 feet per hour. With the machine adequately maintained, its production rate will remain constant for the first 1,200 hours of operation and then decrease by 2 feet per hour for each additional 400 hours thereafter. The expected average annual use is 400 hours, and maintenance and operating costs will be $15 per hour. The contractor will depreciate the equipment in accordance with a five-year MACRS. At the end of five years, the excavator will be sold for $40,000. Assuming that the contractor's marginal tax rate is 34% per year, determine the annual after-tax cash flow.

10.6 A small children's clothing manufacturer is considering an investment to computerize its management information system for material requirement planning, piece-goods coupon printing, and invoice and payroll. An outside consultant has been retained to estimate the initial hardware requirement and installation costs. He suggests the following:

PC systems	
(15 PCs, 4 printers)	$85,000
Local area networking system	15,000
System installation and testing	4,000

The expected life of the computer system is five years, with no expected salvage value. The proposed system is classified as a five-year property under the MACRS depreciation system. A group of computer consultants needs to be hired to develop various customized software packages to run on the system. Software development costs will be $20,000 and can be expensed during the first tax year. The new system will eliminate two clerks, whose combined annual payroll expenses are $52,000. Additional annual expenses to run this computerized system are expected to be $12,000. Borrowing is not considered an option for this investment, nor is a tax credit available for the system. The firm's expected marginal tax rate over the next six years will be 35%. The firm's interest rate is 13%. Compute the after-tax cash flows over the life of the investment.

10.7 A firm has been paying a print shop $18,000 annually to print the company's monthly newsletter. The agreement with this print shop has now expired, but it could be renewed for a further five years. The new subcontracting charges are expected to be 12% higher than they were under the previous contract. The company is also considering the purchase of a desktop publishing system with a high-quality laser printer driven by a microcomputer. With appropriate text and graphics software, the newsletter can be composed and printed in near-typeset quality. A special device is also required to print photos in the newsletter. The following estimates have been quoted by a computer vendor:

Personal computer	$4,500
Color laser printer	6,500
Photo device/scanner	5,000
Software	2,500
Total cost basis	$18,500
Annual O&M costs	10,000

The salvage value of each piece of equipment at the end of five years is expected to be only 10% of the original cost. The company's marginal tax rate is 40%, and the desktop publishing system will be depreciated by MACRS under its five-year property class.

(a) Determine the projected net after-tax cash flows for the investment.

(b) Compute the IRR for this project.

(c) Is the project justifiable at MARR = 12%?

10.8 An asset in the five-year MACRS property class costs $120,000 and has a zero estimated salvage value after six years of use. The asset will generate annual revenues of $300,000 and will require $80,000 in annual labor and $50,000 in annual material expenses. There are no other revenues and expenses. Assume a tax rate of 40%.

(a) Compute the after-tax cash flows over the project life.

(b) Compute the NPW at MARR = 12%. Is the investment acceptable?

10.9 An automaker is considering installing a three-dimensional (3-D) computerized car-styling system at a cost of $200,000 (including hardware and software). With the 3-D computer modeling system, designers will have the ability to view their design from many angles and to fully account for the space required for the engine and passengers. The digital information used to create the computer model can be revised in consultation with engineers, and the data can be used to run milling machines that make physical models quickly and precisely. The automaker expects to decrease the turnaround time for designing a new automobile model (from configuration to final design) by 22%. The expected savings in dollars is $250,000 per year. The training and operating maintenance cost for the new system is expected to be $50,000 per year. The system has a five-year useful life and can be depreciated according to five-year MACRS class. The system will have an estimated salvage value of $5,000. The automaker's marginal tax rate is 40%. Determine the annual cash flows for this investment. What is the return on investment for the project?

10.10 A facilities engineer is considering a $50,000 investment in an energy management system (EMS). The system is expected to save $10,000 annually in utility bills for *N* years. After *N* years, the EMS will have a zero salvage value. In an after-tax analysis, what would *N* need to be in order for the investment to earn a 10% return? Assume MACRS depreciation with a three-year class life and a 35% tax rate.

10.11 A corporation is considering purchasing a machine that will save $130,000 per year before taxes. The cost of operating the machine, including maintenance, is $20,000 per year. The machine will be needed for five years, after which it will have a zero salvage value. MACRS depreciation will be used, assuming a three-year class life. The marginal income tax rate is 40%. If the firm wants 12% IRR after taxes, how much can it afford to pay for this machine?

Investment in Working Capital

10.12 The Doraville Machinery Company is planning to expand its current spindle product line. The required machinery would cost $500,000. The building that will house the new production facility would cost $1.5 million. The land would cost $250,000, and $150,000 working capital would be required. The product is expected to result in additional sales of $675,000 per year for 10 years, at which time the land can be sold for $500,000, the building for $700,000, and the equipment for $50,000. All of the working capital will be recovered. The annual disbursements for labor, materials, and all other expenses are estimated to be $425,000. The firm's income tax rate is 40%, and any capital gains will be taxed at 35%. The building will be depreciated according to a 39-year property class. The manufacturing facility will be classified as a 7-year MACRS. The firm's MARR is known to be 15% after taxes.

(a) Determine the projected net after-tax cash flows from this investment. Is the expansion justified?

(b) Compare the IRR of this project with that of a situation with no working capital.

10.13 An industrial engineer proposed the purchase of scanning equipment for the company's warehouse and weave rooms. The engineer felt that the purchase would provide a better system of locating cartons in the warehouse by recording the locations of the cartons and storing the data in the computer.

The estimated investment, annual operating and maintenance costs, and expected annual savings are as follows:

- Cost of equipment and installation: $65,500.
- Project life: 6 years.
- Expected salvage value: $3,000.
- Investment in working capital (fully recoverable at the end of the project life): $10,000.
- Expected annual savings on labor and materials: $55,800.
- Expected annual expenses: $8,120.
- Depreciation method: 5-year MACRS.

The firm's marginal tax rate is 35%.

(a) Determine the net after-tax cash flows over the project life.
(b) Compute the IRR for this investment.
(c) At MARR = 18%, is the project acceptable?

10.14 Delaware Chemical Corporation is considering investing in a new composite material. R&D engineers are investigating exotic metal–ceramic and ceramic–ceramic composites to develop materials that will withstand high temperatures, such as those to be encountered in the next generation of jet fighter engines. The company expects a 3-year R&D period before these new materials can be applied to commercial products.

The following financial information is presented for management review:

- **R&D cost.** $5 million over a 3-year period. Annual R&D expenditure of $0.5 million at the beginning of year 1, $2.5 million at the beginning of year 2, and $2 million at the beginning of year 3. For tax purposes, these R&D expenditures will be expensed rather than amortized.
- **Capital investment.** $5 million at the beginning of year 4. This investment consists of $2 million in a building and $3 million in plant equipment. The company already owns a piece of land as the building site.
- **Depreciation method.** The building (39-year real property class with the asset placed in service in January) and plant equipment (7-year MACRS recovery class).
- **Project life.** 10 years after a 3-year R&D period.
- **Salvage value.** 10% of the initial capital investment for the equipment and 50% for the building (at the end of the project life).
- **Total sales.** $50 million (at the end of year 4), with an annual sales growth rate of 10% per year (compound growth) during the next 5 years (year 5 through year 9) and −10% (negative compound growth) per year for the remaining project life.
- **Out-of-pocket expenditures.** 80% of annual sales.
- **Working capital.** 10% of annual sales (considered as an investment at the beginning of each production year and investments fully recovered at the end of the project life).
- **Marginal tax rate.** 40%.

(a) Determine the net after-tax cash flows over the project life.
(b) Determine the IRR for this investment.
(c) Determine the equivalent annual worth for the investment at MARR = 20%.

Effects of Borrowing

10.15 Refer to the data in Problem 10.1. If the firm expects to borrow the initial investment ($12,500,000) at 10% over five years (paying back the loan in equal annual payments of $3,297,469), determine the project's net cash flows.

10.16 In Problem 10.2, to finance the industrial robot, the company will borrow the entire amount from a local bank, and the loan will be paid off at the rate of $37,000 per year, plus 10% on the unpaid balance. Determine the net after-tax cash flows over the project life.

10.17 Refer to the financial data in Problem 10.9. Suppose that 50% of the initial investment of \$200,000 will be borrowed from a local bank at an interest rate of 11% over five years (to be paid off in five equal annual payments). Recompute the after-tax cash flow.

10.18 A special-purpose machine tool set would cost \$20,000. The tool set will be financed by a \$10,000 bank loan repayable in two equal annual installments at 10% compounded annually. The tool is expected to provide annual (material) savings of \$30,000 for two years and is to be depreciated by the MACRS three-year recovery period. The tool will require annual O&M costs in the amount of \$5,000. The salvage value at the end of the two years is expected to be \$8,000. Assuming a marginal tax rate of 40% and MARR of 15%, what is the net present worth of this project? You may use the following worksheet in your calculation:

Cash Flow Statement	**0**	**1**	**2**
Operating activities			
Net income		10,400	12,019
Depreciation		6,666	4,445
Investment activities			
Investment	−20,000		
Salvage			8,000
Gains tax (40%)			
Financial activities			
Borrowed funds	10,000		
Principal repayment	0		
Net cash flow	−\$10,000		

10.19 A.M.I. Company is considering installing a new process machine for the firm's manufacturing facility. The machine costs \$200,000 installed, will generate additional revenues of \$80,000 per year, and will save \$55,000 per year in labor and material costs. The machine will be financed by a \$150,000 bank loan repayable in three equal annual principal installments, plus 9% interest on the outstanding balance. The machine will be depreciated using 7-year MACRS. The useful life of the machine is 10 years, after which it will be sold for \$20,000. The combined marginal tax rate is 40%.

(a) Find the year-by-year after-tax cash flow for the project.

(b) Compute the IRR for this investment.

(c) At MARR = 18%, is the project economically justifiable?

10.20 Consider the following financial information about a retooling project at a computer manufacturing company:

- The project costs \$2 million and has a five-year service life.
- The retooling project can be classified as seven-year property under the MACRS rule.

- At the end of the fifth year, any assets held for the project will be sold. The expected salvage value will be about 10% of the initial project cost.
- The firm will finance 40% of the project money from an outside financial institution at an interest rate of 10%. The firm is required to repay the loan with five equal annual payments.
- The firm's incremental (marginal) tax rate on the investment is 35%.
- The firm's MARR is 18%.
- With the preceding financial information,

  (a) Determine the after-tax cash flows.

  (b) Compute the annual equivalent worth for this project.

10.21 A fully automatic chucker and bar machine is to be purchased for \$35,000, to be borrowed with the stipulation that it be repaid with six equal end-of-year payments at 12% compounded annually. The machine is expected to provide an annual revenue of \$10,000 for six years and is to be depreciated by the MACRS seven-year recovery period. The salvage value at the end of six years is expected to be \$3,000. Assume a marginal tax rate of 36% and a MARR of 15%.

(a) Determine the after-tax cash flow for this asset over six years.

(b) Determine whether the project is acceptable on the basis of the IRR criterion.

10.22 A manufacturing company is considering acquiring a new injection molding machine at a cost of \$100,000. Because of a rapid change in product mix, the need for this particular machine is expected to last only eight years, after which time the machine is expected to have a salvage value of \$10,000. The annual operating cost is estimated to be \$5,000. The addition of the machine to the current production facility is expected to generate an annual revenue of \$40,000. The firm has only \$60,000 available from its equity funds, so it must borrow the additional \$40,000 required at an interest rate of 10% per year, with repayment of principal and interest in eight equal annual amounts. The applicable marginal income tax rate for the firm is 40%. Assume that the asset qualifies for a seven-year MACRS property class.

(a) Determine the after-tax cash flows.

(b) Determine the NPW of this project at MARR = 14%.

Generalized Cash Flow Method

10.23 Suppose an asset has a first cost of \$6,000, a life of five years, a salvage value of \$2,000 at the end of five years, and a net annual before-tax revenue of \$1,500. The firm's marginal tax rate is 35%. The asset will be depreciated by three-year MACRS.

(a) Using the generalized cash flow approach, determine the cash flow after taxes.

(b) Rework part (a), assuming that the entire investment would be financed by a bank loan at an interest rate of 9%.

(c) Given a choice between the financing methods of parts (a) and (b), show calculations to justify your choice of which is the better one at an interest rate of 9%.

10.24 A construction company is considering acquiring a new earthmover. The purchase price is \$100,000, and an additional \$25,000 is required to modify the equipment for special use by the company. The equipment falls into the MACRS seven-year classification (the tax life), and it will be sold after five years (the project life) for \$50,000. The purchase of the earthmover will have no effect on revenues, but the machine is expected to save the firm $60,000 per year in before-tax operating costs, mainly labor. The firm's marginal tax rate is 40%. Assume that the initial investment is to be financed by a bank loan at an interest rate of 10%, payable annually. Determine the after-tax cash flows by using the generalized cash flow approach and the worth of the investment for this project if the firm's MARR is known to be 12%.

10.25 Air South, a leading regional airline that is now carrying 54% of all the passengers that pass through the Southeast, is considering adding a new long-range aircraft to its fleet. The aircraft being considered for purchase is the McDonnell Douglas DC-9-532 "Funjet," which is quoted at $60 million per unit. McDonnell Douglas requires a 10% down payment at the time of delivery, and the balance is to be paid over a 10-year period at an interest rate of 12% compounded annually. The actual payment schedule calls for only interest payments over the 10-year period, with the original principal amount to be paid off at the end of the 10th year. Air South expects to generate $35 million per year by adding this aircraft to its current fleet, but also estimates an operating and maintenance cost of $20 million per year. The aircraft is expected to have a 15-year service life with a salvage value of 15% of the original purchase price. If the aircraft is bought, it will be depreciated by the 7-year MACRS property classifications. The firm's combined federal and state marginal tax rate is 38%, and its required minimum attractive rate of return is 18%.

(a) Use the generalized cash flow approach to determine the cash flow associated with the debt financing.

(b) Is this project acceptable?

Comparing Mutually Exclusive Alternatives

10.26 The Pittsburgh Division of Vermont Machinery, Inc., manufactures drill bits. One of the production processes of a drill bit requires tipping, whereby carbide tips are inserted into the bit to make it stronger and more durable. The tipping process usually requires four or five operators, depending on the weekly workload. The same operators are assigned to the stamping operation, in which the size of the drill bit and the company's logo are imprinted into the bit. Vermont is considering acquiring three automatic tipping machines to replace the manual tipping and stamping operations. If the tipping process is automated, Vermont engineers will have to redesign the shapes of the carbide tips to be used in the machines. The new design requires less carbide, resulting in a savings of material. The following financial data have been compiled:

- Project life: six years.
- Expected annual savings: reduced labor, $56,000; reduced material, $75,000; other benefits (reduction in carpal tunnel syndrome and related problems), $28,000; reduced overhead, $15,000.
- Expected annual O&M costs: $22,000.
- Tipping machines and site preparation: equipment costs (three machines), including delivery, $180,000; site preparation, $20,000.
- Salvage value: $30,000 (three machines) at the end of six years.
- Depreciation method: seven-year MACRS.

- Investment in working capital: \$25,000 at the beginning of the project year, and that same amount will be fully recovered at the end of the project year.
- Other accounting data: marginal tax rate of 39% and MARR of 18%.

To raise \$200,000, Vermont is considering the following financing options:

- **Option 1.** Use the retained earnings of the tipping machines to finance them.
- **Option 2.** Secure a 12% term loan over six years (to be paid off in six equal annual installments).
- **Option 3.** Lease the tipping machines. Vermont can obtain a six-year financial lease on the equipment (with, however, no maintenance service) for payments of \$55,000 at the *beginning* of each year.

(a) Determine the net after-tax cash flows for each financing option.
(b) What is Vermont's present-value cost of owning the equipment by borrowing?
(c) What is Vermont's present-value cost of leasing the equipment?
(d) Recommend the best course of action for Vermont.

10.27 The headquarters building owned by a rapidly growing company is not large enough for the company's current needs. A search for larger quarters revealed two new alternatives that would provide sufficient room, enough parking, and the desired appearance and location. The company now has three options:

- **Option 1.** Lease the new quarters for \$144,000 per year.
- **Option 2.** Purchase the new quarters for \$800,000, including a \$150,000 cost for land.
- **Option 3.** Remodel the current headquarters building.

It is believed that land values will not decrease over the ownership period, but the value of all structures will decline to 10% of the purchase price in 30 years. Annual property tax payments are expected to be 5% of the purchase price. The present headquarters building is already paid for and is now valued at \$300,000. The land it is on is appraised at \$60,000. The structure can be remodeled at a cost of \$300,000 to make it comparable to other alternatives. However, the remodeling will occupy part of the existing parking lot. An adjacent, privately owned parking lot can be leased for 30 years under an agreement that the first year's rental of \$9,000 will increase by \$500 each year. The annual property taxes on the remodeled property will again be 5% of the present valuation, plus the cost of remodeling. The new quarters are expected to have a service life of 30 years, and the desired rate of return on investments is 12%. Assume that the firm's marginal tax rate is 40% and that the new building and remodeled structure will be depreciated under MACRS, using a real-property recovery period of 39 years. If the annual upkeep costs are the same for all three alternatives, which one is preferable?

10.28 An international manufacturer of prepared food items needs 50,000,000 kWh of electrical energy a year, with a maximum demand of 10,000 kW. The local utility currently charges \$0.085 per kWh, a rate considered high throughout the industry. Because the firm's power consumption is so large, its engineers are considering installing a 10,000-kW steam-turbine plant. Three types of plant have been proposed (units in thousands of dollars):

	Plant A	Plant B	Plant C
Average station heat rate (BTU/kWh)	16,500	14,500	13,000
Total investment (boiler/turbine/electrical/structures)	$8,530	$9,498	$10,546
Annual operating cost:			
Fuel	1,128	930	828
Labor	616	616	616
O&M	150	126	114
Supplies	60	60	60
Insurance and property taxes	10	12	14

The service life of each plant is expected to be 20 years. The plant investment will be subject to a 20-year MACRS property classification. The expected salvage value of the plant at the end of its useful life is about 10% of its original investment. The firm's MARR is known to be 12%. The firm's marginal income tax rate is 39%.

(a) Determine the unit power cost ($/kWh) for each plant.

(b) Which plant would provide the most economical power?

Lease-versus-Buy Decisions

10.29 The Jacob Company needs to acquire a new lift truck for transporting its final product to the warehouse. One alternative is to purchase the truck for $40,000, which will be financed by the bank at an interest rate of 12%. The loan must be repaid in four equal installments, payable at the end of each year. Under the borrow-to-purchase arrangement, Jacob would have to maintain the truck at a cost of $1,200, payable at year-end. Alternatively, Jacob could lease the truck under a four-year contract for a lease payment of $11,000 per year. Each annual lease payment must be made at the beginning of each year. The truck would be maintained by the lessor. The truck falls into the five-year MACRS classification, and it has a salvage value of $10,000, which is the expected market value after four years, at which time Jacob plans to replace the truck irrespective of whether it leases or buys. Jacob has a marginal tax rate of 40% and a MARR of 15%.

(a) What is Jacob's cost of leasing, in present worth?

(b) What is Jacob's cost of owning, in present worth?

(c) Should the truck be leased or purchased?

This is an operating lease, so the truck would be maintained by the lessor.

10.30 Janet Wigandt, an electrical engineer for Instrument Control, Inc. (ICI), has been asked to perform a lease–buy analysis of a new pin-inserting machine for ICI's PC-board manufacturing.

- **Buy Option.** The equipment costs $120,000. To purchase it, ICI could obtain a term loan for the full amount at 10% interest, payable in four equal end-of-year annual installments. The machine falls into a five-year MACRS property classification. Annual revenues of $200,000 and operating costs of $40,000 are anticipated. The machine requires annual maintenance at a cost of $10,000. Because technology is changing rapidly in pin-inserting machinery, the salvage value of the machine is expected to be only $20,000.

- **Lease Option.** Business Leasing, Inc. (BLI), is willing to write a four-year operating lease on the equipment for payments of $44,000 at the beginning of each year. Under this arrangement, BLI will maintain the asset, so that the annual maintenance cost of $10,000 will be saved. ICI's marginal tax rate is 40%, and its MARR is 15% during the analysis period.

(a) What is ICI's present-value (incremental) cost of owning the equipment?
(b) What is ICI's present-value (incremental) cost of leasing the equipment?
(c) Should ICI buy or lease the equipment?

10.31 Consider the following lease-versus-borrow-and-purchase problem:

- **Borrow-and-purchase option:**

1. Jensen Manufacturing Company plans to acquire sets of special industrial tools with a four-year life and a cost of $200,000, delivered and installed. The tools will be depreciated by the MACRS three-year classification.
2. Jensen can borrow the required $200,000 at a rate of 10% over four years. Four equal end-of-year annual payments would be made in the amount of $63,094 = $200,000(A/P, 10%, 4). The annual interest and principal payment schedule, along with the equivalent present worth of these payments, is as follows:

End of Year	Interest	Principal
1	$20,000	$43,094
2	15,961	47,403
3	10,950	52,144
4	5,736	57,358

3. The estimated salvage value for the tool sets at the end of four years is $20,000.
4. If Jensen borrows and buys, it will have to bear the cost of maintenance, which will be performed by the tool manufacturer at a fixed contract rate of $10,000 per year.

- **Lease option:**

1. Jensen can lease the tools for four years at an annual rental charge of $70,000, payable at the end of each year.
2. The lease contract specifies that the lessor will maintain the tools at no additional charge to Jensen.

Jensen's tax rate is 40%. Any gains will also be taxed at 40%.

(a) What is Jensen's PW of after-tax cash flow of leasing at $i = 15\%$?
(b) What is Jensen's PW of after-tax cash flow of owning at $i = 15\%$?

10.32 Tom Hagstrom has decided to acquire a new car for his business. One alternative is to purchase the car outright for $16,170, financing the car with a bank loan for the net purchase price. The bank loan calls for 36 equal monthly payments of $541.72 at an interest rate of 12.6% compounded monthly. Payments must be made at the end of each month. The terms of each alternative are as follows:

Buy	Lease
$16,170	$425 per month
	36-month open-end lease
	Annual mileage allowed = 15,000 miles

If Tom takes the lease option, he is required to pay $500 for a security deposit, refundable at the end of the lease, and $425 a month at the beginning of each month for 36 months. If the car is purchased, it will be depreciated according to a five-year MACRS property classification. The car has a salvage value of $5,800, which is the expected market value after three years, at which time Tom plans to replace the car irrespective of whether he leases or buys. Tom's marginal tax rate is 35%. His MARR is known to be 13% per year.

(a) Determine the annual cash flows for each option.

(b) Which option is better?

10.33 The Boggs Machine Tool Company has decided to acquire a pressing machine. One alternative is to lease the machine under a three-year contract for a lease payment of $15,000 per year, with payments to be made at the beginning of each year. The lease would include maintenance. The second alternative is to purchase the machine outright for $100,000, financing the machine with a bank loan for the net purchase price and amortizing the loan over a three-year period at an interest rate of 12% per year (annual payment = $41,635).

Under the borrow-to-purchase arrangement, the company would have to maintain the machine at an annual cost of $5,000, payable at year-end. The machine falls into a five-year MACRS classification and has a salvage value of $50,000, which is the expected market value at the end of year 3, at which time the company plans to replace the machine irrespective of whether it leases or buys. Boggs has a tax rate of 40% and a MARR of 15%.

(a) What is Boggs' PW cost of leasing?

(b) What is Boggs' PW cost of owning?

(c) From the financing analysis in (a) and (b), what are the advantages and disadvantages of leasing and owning?

10.34 An asset is to be purchased for $25,000. The asset is expected to provide revenue of $10,000 a year and have operating costs of $2,500 a year. The asset is considered to be a seven-year MACRS property. The company is planning to sell the asset at the end of year 5 for $5,000. Given that the company's marginal tax rate is 30% and that it has a MARR of 10% for any project undertaken, answer the following questions:

(a) What is the net cash flow for each year, given that the asset is purchased with borrowed funds at an interest rate of 12%, with repayment in five equal end-of-year payments?
(b) What is the net cash flow for each year, given that the asset is leased at a rate of $3,500 a year (a financial lease)?
(c) Which method (if either) should be used to obtain the new asset?

10.35 Enterprise Capital Leasing Company is in the business of leasing tractors to construction companies. The firm wants to set a three-year lease payment schedule for a tractor purchased at $53,000 from the equipment manufacturer. The asset is classified as a five-year MACRS property. The tractor is expected to have a salvage value of $22,000 at the end of three years' rental. Enterprise will require a lessee to make a security deposit in the amount of $1,500 that is refundable at the end of the lease term. Enterprise's marginal tax rate is 35%. If Enterprise wants an after-tax return of 10%, what lease payment schedule should be set?

Short Case Studies

ST10.1 American Aluminum Company is considering making a major investment of $150 million ($5 million for land, $45 million for buildings, and $100 million for manufacturing equipment and facilities) to develop a stronger, lighter material, called aluminum lithium, that will make aircraft sturdier and more fuel efficient. Aluminum lithium, which has been sold commercially for only a few years as an alternative to composite materials, will likely be the material of choice for the next generation of commercial and military aircraft, because it is so much lighter than conventional aluminum alloys, which use a combination of copper, nickel, and magnesium to harden aluminum. Another advantage of aluminum lithium is that it is cheaper than composites. The firm predicts that aluminum lithium will account for about 5% of the structural weight of the average commercial aircraft within 5 years and 10% within 10 years. The proposed plant, which has an estimated service life of 12 years, would have a capacity of about 10 million pounds of aluminum lithium, although domestic consumption of the material is expected to be only 3 million pounds during the first 4 years, 5 million for the next 3 years, and 8 million for the remaining life of the plant. Aluminum lithium costs $12 a pound to produce, and the firm would expect to sell it at $17 a pound. The building will be depreciated according to the 39-year MACRS real property class, with the building placed in service July 1 of the first year. All manufacturing equipment and facilities will be classified as 7-year MACRS property. At the end of the project life, the land will be worth $8 million, the building $30 million, and the equipment $10 million. Assuming that the firm's marginal tax rate is 40% and its capital gains tax rate is 35%,

(a) Determine the net after-tax cash flows.
(b) Determine the IRR for this investment.
(c) Determine whether the project is acceptable if the firm's MARR is 15%.

ST10.2 Morgantown Mining Company is considering a new mining method at its Blacksville mine. The method, called longwall mining, is carried out by a robot. Coal is removed by the robot, not by tunneling like a worm through an apple, which leaves more of the target coal than is removed, but rather by methodically shuttling back and forth across the width of the deposit and devouring nearly everything. The method can extract about 75% of the available coal, compared with 50% for conventional mining, which is done largely with machines that dig tunnels. Moreover, the coal can be recovered far more inexpensively. Currently, at Blacksville alone, the company mines 5 million tons a year with 2,200 workers. By installing two longwall robot machines, the company can mine 5 million tons with only 860 workers. (A robot miner can dig more than 6 tons a minute.) Despite the loss of employment, the United Mine Workers union generally favors longwall mines, for two reasons: The union officials are quoted as saying, (1) "It would be far better to have highly productive operations that were able to pay our folks good wages and benefits than to have 2,200 shovelers living in poverty," and (2) "Longwall mines are inherently safer in their design." The company projects the following financial data upon installation of the longwall mining:

Robot installation (2 units)	$19.3 million
Total amount of coal deposit	50 million tons
Annual mining capacity	5 million tons
Project life	10 years
Estimated salvage value	$0.5 million
Working capital requirement	$2.5 million
Expected additional revenues:	
Labor savings	$6.5 million
Accident prevention	$0.5 million
Productivity gain	$2.5 million
Expected additional expenses:	
O&M costs	$2.4 million

(a) Estimate the firm's net after-tax cash flows over the project life if the firm uses the unit-production method to depreciate assets. The firm's marginal tax rate is 40%.

(b) Estimate the firm's net after-tax cash flows if the firm chooses to depreciate the robots on the basis of MACRS (seven-year property classification).

ST10.3 National Parts, Inc., an auto-parts manufacturer, is considering purchasing a rapid prototyping system to reduce prototyping time for form, fit, and function applications in automobile-parts manufacturing. An outside consultant has been called in to estimate the initial hardware requirement and installation costs. He suggests the following:

- Prototyping equipment: $187,000.
- Posturing apparatus: $10,000.

- Software: $15,000.
- Maintenance: $36,000 per year by the equipment manufacturer.
- Resin: Annual liquid polymer consumption of 400 gallons at $350 per gallon.
- Site preparation: Some facility changes are required for the installation of the rapid prototyping system (e.g., certain liquid resins contain a toxic substance, so the work area must be well vented).

The expected life of the system is six years, with an estimated salvage value of $30,000. The proposed system is classified as a five-year MACRS property. A group of computer consultants must be hired to develop customized software to run on the system. Software development costs will be $20,000 and can be expensed during the first tax year. The new system will reduce prototype development time by 75% and material waste (resin) by 25%. This reduction in development time and material waste will save the firm $114,000 and $35,000 annually, respectively. The firm's expected marginal tax rate over the next six years will be 40%. The firm's interest rate is 20%.

(a) Assuming that the entire initial investment will be financed from the firm's retained earnings (equity financing), determine the after-tax cash flows over the life of the investment. Compute the NPW of this investment.

(b) Assuming that the entire initial investment will be financed through a local bank at an interest rate of 13% compounded annually, determine the net after-tax cash flows for the project. Compute the NPW of the investment.

(c) Suppose that a financial lease is available for the prototype system at $62,560 per year, payable at the beginning of each year. Compute the NPW of the investment with lease financing.

(d) Select the best financing option, based on the rate of return on incremental investment.

ST10.4 National Office Automation, Inc. (NOAI), is a leading developer of imaging systems, controllers, and related accessories. The company's product line consists of systems for desktop publishing, automatic identification, advanced imaging, and office information markets. The firm's manufacturing plant in Ann Arbor, Michigan, consists of eight different functions: cable assembly, board assembly, mechanical assembly, controller integration, printer integration, production repair, customer repair, and shipping. The process to be considered is the transportation of pallets loaded with eight packaged desktop printers from printer integration to the shipping department. Several alternatives for minimizing operating and maintenance costs have been examined. The two most feasible alternatives are the following:

- **Option 1.** Use gas-powered lift trucks to transport pallets of packaged printers from printer integration to shipping. The truck also can be used to return printers that must be reworked. The trucks can be leased at a cost of $5,465 per year. With a maintenance contract costing $6,317 per year, the dealer will maintain the trucks. A fuel cost of $1,660 per year is expected. The truck requires a driver for each of the three shifts, at a total cost of $58,653 per year for labor. It is estimated that transportation by truck would cause damages to material and equipment totaling $10,000 per year.
- **Option 2.** Install an automatic guided vehicle system (AGVS) to transport pallets of packaged printers from printer integration to shipping and to return

products that require rework. The AGVS, using an electrical powered cart and embedded wire-guidance system, would do the same job that the truck currently does, but without drivers. The total investment costs, including installation, are itemized as follows:

Vehicle and system installation	$97,255
Staging conveyor	24,000
Power supply lines	5,000
Transformers	2,500
Floor surface repair	6,000
Batteries and charger	10,775
Shipping	6,500
Sales tax	6,970
Total AGVS system cost	$159,000

NOAI could obtain a term loan for the full investment amount ($159,000) at a 10% interest rate. The loan would be amortized over 5 years, with payments made at the end of each year. The AGVS falls into the 7-year MACRS classification, and it has an estimated service life of 10 years and no salvage value. If the AGVS is installed, a maintenance contract would be obtained at a cost of $20,000, payable at the beginning of each year. The firm's marginal tax rate is 35% and its MARR is 15%.

(a) Determine the net cash flows for each alternative over 10 years.

(b) Compute the incremental cash flows (Option 2 − Option 1), and determine the rate of return on this incremental investment.

(c) Determine the best course of action, based on the rate-of-return criterion.

Note: Assume a zero salvage value for the AGVS.