Economics for Engineers
Depreciation

9.1 Introduction

Any equipment which is purchased today will not work for ever. This may be due to wear and tear of the equipment or obsolescence of technology. Hence, it is to be replaced at the proper time for continuance of any business. The replacement of the equipment at the end of its life involves money. This must be internally generated from the earnings of the equipment. The recovery of money from the earnings of an equipment for its replacement purpose is called *depreciation fund* since we make an assumption that the value of the equipment decreases with the passage of time. Thus, the word "depreciation" means *decrease* in value of any physical asset with the passage of time.

9.2 Methods of Depreciation

There are several methods of accounting depreciation fund. These are as follows:

1. Straight line method of depreciation
2. Declining balance method of depreciation
3. Sum of the years—digits method of depreciation
4. Sinking-fund method of depreciation
5. Service output method of depreciation. These are now discussed in detail.

9.3 Straight Line Method of Depreciation

In this method of depreciation, a fixed sum is charged as the depreciation amount throughout the lifetime of an asset such that the accumulated sum at the end of the life of the asset is exactly equal to the purchase value of the asset.
Here, we make an important assumption that inflation is absent.

P = first cost of the asset, F = salvage value of the asset,

n = life of the asset,

B_t = book value of the asset at the end of the period t, D_t = depreciation amount for the period t.

The formulae for depreciation and book value are as follows:

$$D_t = (P - F)/n$$

$$B_t = B_{t-1} - D_t = P - t\ [(P - F)/n]$$

EXAMPLE 9.1 A company has purchased an equipment whose first cost is Rs. 1,00,000 with an estimated life of eight years. The estimated salvage value of the equipment at the end of its lifetime is Rs. 20,000. Determine the depreciation charge and book value at the end of various years using the straight line method of depreciation.

Solution

P = Rs. 1,00,000 F = Rs. 20,000 n = 8 years

$$D_t = (P - F)/n$$

$$= (1,00,000 - 20,000)/8$$

$$= \text{Rs. } 10,000$$

In this method of depreciation, the value of D_t is the same for all the years. The calculations pertaining to B_t for different values of t are summarized in Table 9.1.

Table 9.1 D_t and B_t Values under Straight line Method of Depreciation

End of year (t)	*Depreciation* (D_t)	*Book value* ($B_t = B_{t-1} - D_t$)
0		1,00,000
1	10,000	90,000
2	10,000	80,000
3	10,000	70,000
4	10,000	60,000
5	10,000	50,000
6	10,000	40,000
7	10,000	30,000
8	10,000	20,000

If we are interested in computing D_t and B_t for a specific period (t), the formulae can be used. In this approach, it should be noted that the depreciation is the same for all the periods.

EXAMPLE 9.2 Consider Example 9.1 and compute the depreciation and the book value for period 5.

P = Rs. 1,00,000 F = Rs. 20,000 n = 8

years

$D_5 = (P - F)/n$

= (1,00,000 – 20,000)/8

= Rs. 10,000 (This is independent of the time period.)

$B_t = P - t\ (P - F)/n$

B_5 = 1,00,000 – 5 (1,00,000 – 20,000)/8

= Rs. 50,000

9.4 Accounting Depreciation

The acquisition of fixed assets is an important activity for a business organization, whether the organization is starting up or acquiring new assets to remain competitive. The systematic allocation of the initial cost of an asset in parts over a time known as its depreciable life is what we mean by *accounting depreciation.* Because accounting depreciation is the standard of the business world, we sometimes refer to it more generally as *asset depreciation*.

9.5 Asset Depreciation

The process of depreciating an asset requires that we make several preliminary determinations:

1. *What can be depreciable?* Depreciable property includes buildings, machinery, equipment, and vehicles. Inventories are not depreciable property because they are held primarily for sale to customers in the ordinary course of business. If an asset has no definite service life, the asset cannot be depreciated. For example, *you can never depreciate land*.

2. *What cost base should be used in asset depreciation?* The *cost base* of an asset represents the total cost that is claimed as an expense over an asset's life, that is, the sum of the annual depreciation expenses. The cost base generally includes the actual cost of the asset and all the other incidental expenses, such as freight, site preparation, and installation. This total cost, rather than the cost of the asset only, must be the depreciation base charged as an expense over the asset's life.

3. *What is the asset's value at the end of its useful life?* The salvage value is an asset's value at the end of its life; it is the amount eventually recovered through sale, trade-in, or salvage. The eventual salvage value of an asset must be estimated when the depreciation schedule for the asset is established. If this estimate subsequently proves to be inaccurate, then an adjustment must be made.

4. *What is the depreciable life of the asset?* Historically, depreciation accounting included choosing a depreciable life that was based on the service life of an asset. Determining the service life of an asset, however, was often very difficult, and the uncertainty of these estimates often led to disputes between taxpayers and the IRS. To alleviate the problems, the IRS published guidelines on lives for categories of assets known as *Asset Depreciation Ranges*, or ADRs. These guidelines specified a range of lives for classes of assets based on historical data, and taxpayers were free to choose a depreciable life within the specified range for a given asset.

5. *What method of depreciation do we choose?* Companies generally calculate depreciation one way when figuring taxes and another way when reporting income (profit) to investors: (1) they use the straight-line method (or declining balance or sum-of-years' digits) for investors and (2) they use the fastest rate permitted by law (known as "modified accelerated cost recovery system [MACRS]") for tax purposes. Under the straight-line method, for an asset with a 5-year life which costs $10,000 and has a $1000 salvage value, the annual depreciation charge is ($10,000 – $1000)/5 = $1800. For tax purposes, Congress created several classes of assets, each with a more or less arbitrarily prescribed life called a *recovery period* or *class life*. The depreciable base is not adjusted for salvage value, which is the estimated market value of the asset at the end of its useful life. Table 17.4.1 describes what types of property fit into

the different class life groups and the allowed depreciation percentages. Congress developed these recovery allowance percentages based on the declining balance method, with a switch to straight-line depreciation at some point in the asset's life. The MACRS recovery percentages as shown in Table 17.4.1 also employ the half-year convention — that is, they assume that all assets are put into service at midyear and, hence, generate a half-year's depreciation.

9.6 Corporate Income Taxes

Corporate taxable income is defined as follows:

taxable income = gross income revenues( )

− (cost of goods sold + depreciation + operating expenses)

Once taxable income is calculated, income taxes are determined by

income taxes = (tax rate) × (taxable income) The corporate tax rate structure for 1996 is relatively simple. There are four basic rate brackets (ranging from 15 to 35%) plus two surtax rates (5 and 3%) based on taxable incomes, and businesses with lower taxable incomes continue to be taxed at lower rates than those with higher taxable incomes.

9.7 Tax Treatment of Gains or Losses for Depreciable Assets

When a depreciable asset used in business is sold for an amount different from its book value, this gain or loss has an important effect on income taxes. An asset's book value at any given time is determined by where the salvage value represents the proceeds from the sale less any selling expense or removal cost. These gains, commonly known as *depreciation recapture*, are taxed as ordinary income. In the unlikely event that if an asset is sold for an amount greater than its initial cost, the gains (salvage value – book value) are divided into two parts (ordinary gains and capital gains) for tax purposes.

9.7.1 After-Tax Cash Flow Analysis

In developing an after-tax flow, we are concerned only with those cash flows that result directly from the project. These cash flows, called *incremental cash flows*, represent the change in the firm's total cash flows that occurs as a direct result of undertaking the project. There are several elements that contribute toward the project cash flows. In preparing the cash flow statement which shows sources and uses of cash in project undertaking, we may group them into three areas: (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 this grouping 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 revenue, cost of goods sold, operating expense, 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 when determining net income, and it is included in the operating activities. Since we will usually look only at yearly flows, it is logical to express all cash flows on a yearly basis. We can determine the net cash flow from operations either (1) based on net income or (2) based on cash flow by computing income taxes directly. When we use net income as the starting point for cash flow determination, we should add any noncash expenses (mainly depreciation) back to net income to compute the net cash flow.

Approach 1	**Approach 2**
Cash revenues (savings)	Cash revenues (savings)
–Cost of goods sold	–Cost of goods sold
–Depreciation	
–Operating expense	–Operating expense
–Interest expense	–Interest expense
Taxable income	
–Income taxes	–Income taxes

Thus net operating cash flow = net income + noncash expenses (depreciation)

Net income + depreciation	Operating cash flow

In business practice, accountants usually prepare the cash flow statements based on the net income, namely, using Approach 1, whereas Approach 2 is commonly used in many traditional engineering economic texts. If you learn only Approach 2, it is more than likely that you need to be retrained to learn Approach 1 to communicate with the financing and accounting professionals

within your organization. Therefore, we will use the income statement approach (Approach 1) whenever possible throughout this section.

- ***Investing Activities:*** Three types of investment flows are associated with buying a piece of equipment: the original investment, salvage value at the end of its useful life, and working capital investment[1] or recovery.[2] We will assume that our outflow for both capital investment and working capital investment is as if they take place in year 0. It is quite possible that both investments will not occur 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) repayment of principal. Recall that interest payments are tax deductible expenses so that they are usually classified as operating, not financing, activities.

Then, net cash flow for a given year is simply the sum of the net cash flows from these three activities. A computerized machining center has been proposed for a small tool manufacturing company. If the new system costing $125,000 is installed, it will generate annual revenues of $100,000 and require $20,000 in annual labor, $12,000 in annual material expenses, and another $8000 in annual overhead (power and utility) expenses. The automation facility would be classified as a 7-year MACRS property. The company expects to phase out the facility at the end of 5 years, at which time it will be sold for $50,000. The machining center will require an investment of $23,331 in working capital (mainly spare parts inventory), which will be recovered in full amount at the end of the project life. Assume that $62,500 of the $125,000 paid for the investment is obtained through a bank loan which is to be repaid in equal annual installments at 10% interest over 5 years. The remaining $62,500 will be provided by equity (for example, from retained earnings). Find the year-by-year after-tax net cash flow for the project at a 40%

marginal tax rate based on the net income (Approach 1), and determine the after-tax net present worth of the project at the company's MARR of 15%.

Discussion. We will use the business convention that no signs (positive or negative) are used in preparing the income statement, except in the situation where we have a negative taxable income or tax savings. However, in preparing the cash flow statement, we will observe explicitly the sign convention: a positive sign indicating cash inflow, a negative sign or (-, +) indicating cash outflow.