

# ME 395 ENGG. ECONOMICS

## EXERCISES

## PRACTICE PROBLEMS FROM ENGG DESIGN BY HYMAN.

- ✓ 1. Machine A costs \$8,500 and has an annual operating cost of \$4,500. Machine B costs \$7,000 and has an annual operating cost of \$4,800. Each machine has an economic life of 10 years. What is the annual rate of return on the additional investment in machine A?

◆ Source: Dieter, p. 680.

2. You are designing a piece of equipment for a client who ignores the time value of money in making investment decisions. You have narrowed your design choices down to two options: A and B. You estimate option A has an initial cost of \$8,000, and annual operating costs of \$400. You expect option B to have an initial cost of \$6,500, and annual operating costs of \$800. Each machine has an economic life of 10 years. Estimate the payback period for your client's potential additional investment in design A.

- ✓ 3. As chief engineer for a small manufacturing firm, you are considering whether to invest \$40,000 in a new piece of equipment that will save \$3,000 annually in operating costs. If the equipment has an expected lifetime of 20 years and a salvage value of \$5,000, is this an attractive investment at the discount rate of 15% using the present value criterion?

4. Redo the analysis summarized in Table 8-2 using a 10% discount rate.

- ✓ 5. A company is faced with the decision of selecting either machine A or B, both of which are capable of doing the same kind of job. Machine A costs \$1,250 with annual maintenance

and operating costs of \$150 for the first 10 years and \$180 for the following 10 years. Machine B costs \$1,500 and annual operating and maintenance expenses are \$100 for the 20-year period. Both machines have zero salvage value at the end of their economic lives. By how much should the manufacturer of machine A increase or decrease the purchase price of the machine so that it is competitive with machine B at a discount rate of 15%?

6. An electric utility company has determined that it needs to bring 600 mW of new generating capacity on-line six years from now to meet anticipated peak loads during the heating season. The utility has narrowed down the choices to a coal power plant or a set of combustion turbines fired by natural gas. The coal plant, which takes six years to build, has a capital cost of \$1,200/kW. The combustion turbines can be erected in two years and cost \$250/kW. The projected operating costs in six years are 2.1 cents/kWh for the coal plant and 5.7 cents/kWh for the combustion turbine. Each plant is expected to operate at full capacity for 3,000 hrs annually throughout its 20-year lifetime. The above quoted capital and operating costs are expressed in terms of today's dollars. The operating costs of the combustion turbine are expected to keep pace with inflation, which is estimated to average 3% annually over the lifetime of the project. However, the prospects of increasingly stringent regulations dealing with acid rain indicate that coal plant operating costs will probably increase 1% a year over and above inflation. Since the utility in question is municipally owned, it pays no income taxes. Using a real discount rate of 3%, should the utility start building the coal plant now or wait four years to begin building the gas turbine plant? How much does the expected annual plant usage have to change before it affects the choice?

- ✓ 7. Redo Exercise 3 using an equivalent annual cost analysis.

8. The Environmental Protection Agency has ordered your oil refinery to process its waste liquids before discharging them into the local bay. You estimate that it will cost you \$30,000 to satisfy this requirement this year. However, by gradually making no-cost adjustments in the refining process, you estimate you can reduce waste processing costs by 5% annually over the next 10 years, which is the remaining life-time of the refinery. On the other hand, an outside company has offered to process your waste for you every year for the next ten years at an annual fee of \$15,000. If your company uses a 10% discount rate, which is the preferred course of action?

- ✓ 9. You are considering upgrading some manufacturing facilities by purchasing one of three different machines, each with the same production capacity. Machine A costs \$30,000, has a life of 40 years, annual maintenance costs of \$1,500, and salvage value of \$5,000. Machine B costs \$20,000, has a life of 20 years, annual maintenance of \$2,000, and salvage value of \$3,000. Machine C costs \$10,000, has a life of 10 years, annual maintenance of \$4,000, and no salvage value. Determine the most economical choice based on minimizing the present value of total costs. Use an annual discount rate of 10%. Assume that initial costs, annual maintenance, and discount rates are constant throughout the analysis period.

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 SOLUTION TO PRACTICE PROBLEMS

# 1.

	A	B
initial cost	8500	7000
Annual cost	4500	4800

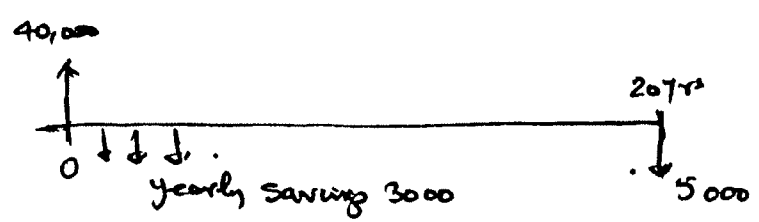
Life = 10 yrs.

Additional investment =  $8500 - 7000 = 1500$

Annual benefit = 300

Avg. Annual Rate of return =  $\frac{300}{1500} \times 100 = \underline{\underline{20\%}}$   
 Ans.

# 3.



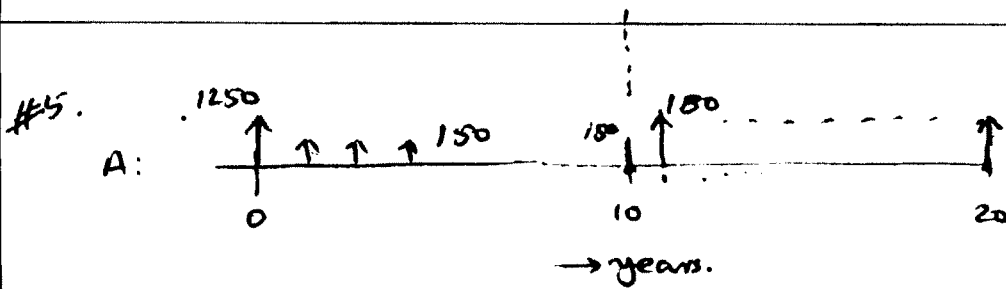
$i = 15\%$

PV. of yearly savings  $P = (3000) \left[ \frac{(1+0.15)^{20} - 1}{(0.15)(1+0.15)^{20}} \right]$   
 $= (3000) (6.259) = 18,778.$

PV. of Salvage  $P = \frac{5000}{(1+0.15)^{20}}$   
 $= (5000)(.0611) = 305.50 \approx 306.$

NPV of this investment =  $40,000 - 18,778 - 306 = 20,916$

Since the NPV of Costs  $> 0$ , this is not an attractive investment.

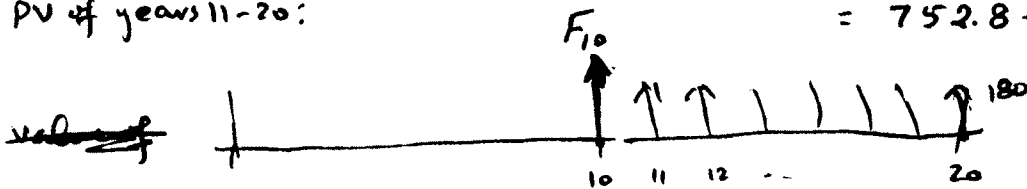


PV of operating cost for first 10 yrs

$$= (150) \left( \frac{(1.15)^{10} - 1}{.15(1.15)^{10}} \right) = (150)(5.019)$$

PV of years 11-20:

$$= 752.8 \rightarrow 753$$



Step 1: find value of series at the end of 10 yrs,  $F_{10}$

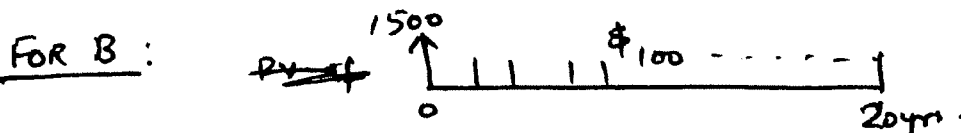
$$F_{10} = (180) \cdot \left[ \frac{(1.15)^{10} - 1}{.15(1.15)^{10}} \right] = 180(5.019) = \$903$$

Step 2: Now find PV of  $F_{10}$ :

$$P = \frac{F_{10}}{(1+.15)^{10}} = \frac{(903)}{4.046} = 223$$

$\therefore$  PV of operating costs for A =  $753 + 223 = \$976$

PV of all costs for A =  $1250 + 976 = \underline{\underline{\$2226}}$ .



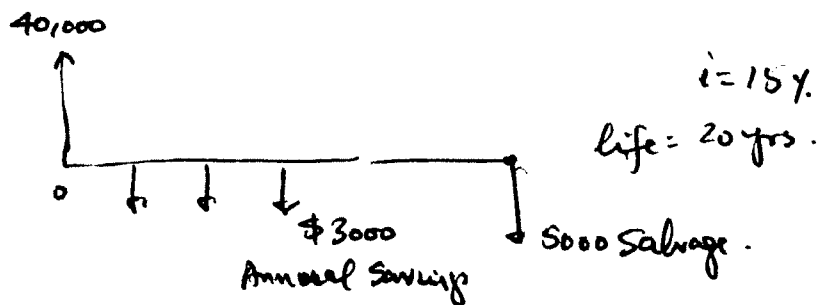
$$\text{PV of op. costs} = (100) \left( \frac{1.15^{20} - 1}{.15(1.15)^{20}} \right) = 100 \left( \frac{16.366 - 1}{.15(16.366)} \right)$$

$$= 100(6.26) = \$626$$

PV of all costs B =  $1500 + 626 = \underline{\underline{\$2126}}$

$\therefore$  Purchase price of A should be lowered by  $(2226 - 2126) = \$100$ .

#7.



we want to find the equivalent annual cost and see if it is +ve (ie a cash outflow) or -ve (a net cash inflow). An attractive choice would be one for which the annual cost was  $\leq 0$ .

1. 40,000 initial cost:

$$40,000 = U \cdot \left[ \frac{(1+0.15)^{20} - 1}{0.15(1.15)^{20}} \right] = U \cdot [6.26]$$

we solve for U:  $U = \$6390$ .

2. Salvage: we annualize in two steps:

Step 1 find PV of Salvage:

$$P = \frac{5000}{(1+0.15)^{20}} = \$306$$

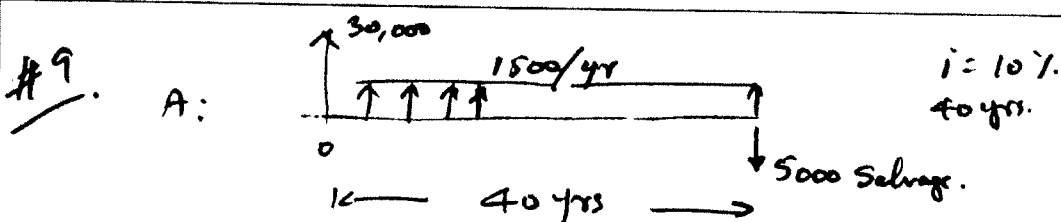
Step 2: find equivalent U:

$$306 = U \cdot \left[ \frac{1.15^{20} - 1}{0.15(1.15)^{20}} \right] = U(6.26)$$

$$U = \$49$$

$$\text{Total annualized costs} = (6390 - 3000 - 49) = \$3341$$

Since this is  $> 0$ , this option is not attractive.



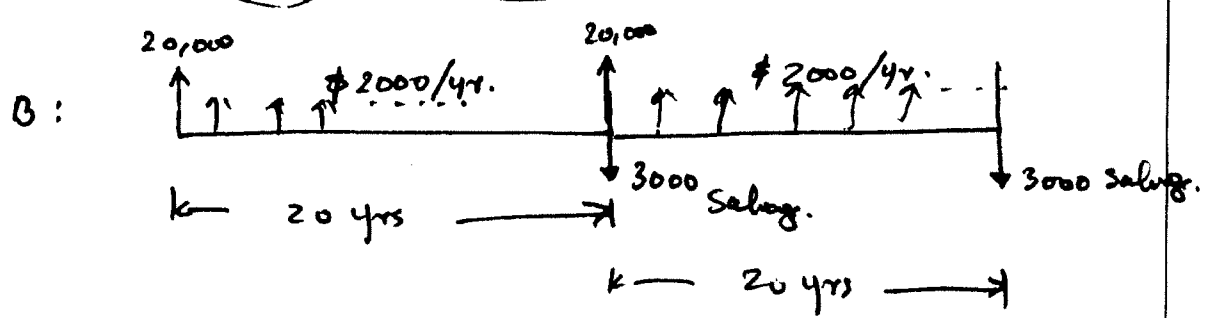
$$PV \text{ of maint. costs} = (1500) \cdot \frac{(1.1)^{40} - 1}{.1(1.1)^{40}} = 1500 \left( \frac{45.26 - 1}{.1(45.26)} \right)$$

note, only options A and B are compared here. PV for C is found to be 55,030.

$$= 1500(9.779) = \$14,669.$$

$$PV \text{ of Salvage} = \frac{(5000)}{(1.1)^{40}} = \frac{5000}{45.26} = \$110.$$

$$\therefore PV \text{ of all costs} = 30,000 + 14,669 - 110 = \underline{\underline{44,559}}$$



we assume machine B is replaced at 20 yrs so that we have a 40 yr. period to compare with A.

Now:

$$PV \text{ of operating costs (40 yrs)} = (2000) \cdot (9.779) = 19558$$

$$PV \text{ of replacement cost @ 20 yrs (20,000 - 3000 sal.)} = \frac{17,000}{(1.1)^{20}} = \frac{17,000}{6.727} = 2527$$

$$PV \text{ of Salvage @ 40 yrs} = \frac{3000}{(1.1)^{40}} = \frac{3000}{45.26} = \$66.$$

$$PV \text{ of all costs} = 20,000 + 19558 + 2527 - 66 = \underline{\underline{42019}}$$

$\therefore$  B is preferred to A (lower PV of all costs).