Chapter 5: Project evaluation techniques (Numerical problems)

1. For each of the following cash flows:

(a) Calculate the payback period for each project.

(b) Determine whether it is meaningful to calculate a payback period for project D.

(c) Assuming that calculate the discounted payback period for each project.

	Project's Cash Flow ($)			
n	**A**	**B**	**C**	**D**
0	-$1,500	-$4,000	-$4,500	-$3,000
1	300	2,000	2,000	5,000
2	300	1,500	2,000	3,000
3	300	1,500	2,000	-2,000
4	300	500	2,000	1,000
5	300	500	5,000	1,000
6	300	1,500	5,000	2,000
7	300			3,000
8	300			

2. You need to know whether the building of a new warehouse is justified under the following conditions:
The proposal is for a warehouse costing $100,000. The warehouse has an expected useful life of 35 years and a net salvage value (net proceeds from sale after tax adjustments) of $25,000. Annual receipts of $17,000 are expected, annual maintenance and administrative costs will be $4,000/year, and annual income taxes are $2,000.
Given the foregoing data, which of the following statements are correct?
(a) The proposal is justified for a MARR of 9%.
(b) The proposal has a net present worth of $62,730.50, when 6% is used as the interest rate.
(c) The proposal is acceptable, as long as MARR $\leq$ 10.77%.
(d) All of the above are correct.

3. A large food-processing corporation is considering using laser technology to speed up and eliminate waste in the potato-peeling process. To implement the system, the company anticipates needing $3 million to purchase the industrial strength lasers. The system will save $1,200,000 per year in labor and materials. However, it will require an additional operating and maintenance cost of $250,000. Annual income taxes will also increase by $150,000. The system is expected to have a 10-year service life and will have a salvage value of about $200,000. If the company's MARR is 18%, use the NPW method to justify the economics of the project.

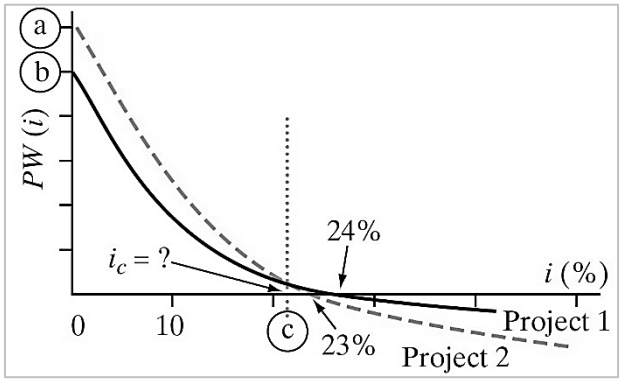
4. Consider the following project balances for a typical investment project with a service life of four years:

a) Construct the original cash flows of the project.
(b) Determine the interest rate used in computing the project balance.
(c) Would the project be acceptable at i = 15% ?

n	A_n	Project Balance
0	−$1,000	−$1,000
1	( )	−1,100
2	( )	−800
3	460	−500
4	( )	0

5. Consider the following cash flows and present-worth profile:

Year	Net Cash Flows ($) Project 1	Project 2
0	−$1,000	−$1,000
1	400	300
2	800	*Y*
3	*X*	800



(a) Determine the values of *X* and *Y*.
(b) Calculate the terminal project balance of project 1 at MARR = 24%.
(c) Find the values of *a*, *b*, and *c* in the NPW plot.

6. Consider the following sets of investment projects, all of which have a three-year investment life:

Compute the future worth for each project at *i* =10%.

n	Project's Cash Flow ($) A	B	C	D
0	−$1,500	−$1,200	−$1,600	−$3,100
1	0	600	−1,800	800
2	0	800	800	1,900
3	3,000	1,500	2,500	2,300

7. A newly constructed bridge costs $5,000,000. The same bridge is estimated to need renovation every 15 years at a cost of $1,000,000. Annual repairs and maintenance are estimated to be $100,000 per year.
(a) If the interest rate is 5%, determine the capitalized cost of the bridge.
(b) Suppose that, in (a), the bridge must be renovated every 20 years, not every 15 years. What is the capitalized cost of the bridge?
(c) Repeat (a) and (b) with an interest rate of 10%. What have you to say about the effect of interest on the results?

8. Consider the following two mutually exclusive investment projects, each with MARR = 15%:
(a) On the basis of the NPW criterion, which project would be selected?
(b) Sketch the *PW* (*i*) function for each alternative on the same chart between 0% and 50%. For what range of i would you prefer project B?

n	Project's Cash Flow A	B
0	−$6,000	−$8,000
1	800	11,500
2	14,000	400

9. Two methods of carrying away surface runoff water from a new subdivision are being evaluated:
Method A. Dig a ditch. The first cost would be $30,000, and $10,000 of re-digging and shaping would be required at five-year intervals forever.
Method B. Lay concrete pipe. The first cost would be $75,000, and a replacement would be required at 50-year intervals at a net cost of $90,000 forever.
At *i* = 12%, which method is the better one?

10. An electric motor is rated at 10 horsepower (HP) and costs $800. Its full load efficiency is specified to be 85%. A newly designed high-efficiency motor of the same size has an efficiency of 90%, but costs $1,200. It is estimated that the motors will operate at a rated 10 HP output for 1,500 hours a year, and the cost of energy will be $0.07 per kilowatt-hour. Each motor is expected to have a 15-year life. At the end of 15 years, the first motor will have a salvage value of $50 and the second motor will have a salvage value of $100. Consider the MARR to be 8%. (Note: 1 HP = 0.7457 kW)

(a) Use the NPW criterion to determine which motor should be installed.

(b) In (a), what if the motors operated 2,500 hours a year instead of 1,500 hours a year? Would the motor you chose in (a) still be the choice?

11. Consider the following two mutually exclusive investment projects, which have unequal service lives:

(a) What assumption(s) do you need in order to compare a set of mutually exclusive investments with unequal service lives?

(b) With the assumption(s) defined in (a) and using determine which project should be selected.

$i = 10\%$,

(c) If your analysis period (study period) is just three years, what should be the salvage value of project A2 at the end of year 3 to make the two alternatives economically indifferent?

	Project's Cash Flow	
n	A1	A2
0	−$900	−$1,800
1	−400	−300
2	−400	−300
3	−400 + 200	−300
4		−300
5		−300
6		−300
7		−300
8		−300 + 500

12. Consider the following cash flows for two types of models:

Both models will have no salvage value upon their disposal (at the end of their respective service lives). The firm's MARR is known to be 15%.

	Project's Cash Flow	
n	Model A	Model B
0	−$6,000	−$15,000
1	3,500	10,000
2	3,500	10,000
3	3,500	

(a) Notice that the models have different service lives. However, model A will be available in the future with the same cash flows. Model B is available at one time only. If you select model B now, you will have to replace it with model A at the end of year 2. If your firm uses the present worth as a decision criterion, which model should be selected, assuming that the firm will need either model for an indefinite period?

(b) Suppose that your firm will need either model for only two years. Determine the salvage value of model A at the end of year 2 that makes both models indifferent (equally likely).

13. An electrical utility is experiencing a sharp power demand that continues to grow at a high rate in a certain local area. Two alternatives are under consideration. Each is designed to provide

enough capacity during the next 25 years, and both will consume the same amount of fuel, so fuel cost is not considered in the analysis.

• **Alternative A.** Increase the generating capacity now so that the ultimate demand can be met with additional expenditures later. An initial investment of $30 million would be required, and it is estimated that this plant facility would be in service for 25 years and have a salvage value of $0.85 million. The annual operating and maintenance costs (including income taxes) would be $0.4 million.

• **Alternative B.** Spend $10 million now and follow this expenditure with future additions during the 10th year and the 15th year. These additions would cost $18 million and $12 million, respectively. The facility would be sold 25 years from now, with a salvage value of $1.5 million. The annual operating and maintenance costs (including income taxes) initially will be $250,000 and will increase to $0.35 million after the second addition (from the 11th year to the 15th year) and to $0.45 million during the final 10 years. (Assume that these costs begin 1 year subsequent to the actual addition.) On the basis of the present-worth criterion, if the firm uses 15% as a MARR, which alternative should be undertaken?

14. A large refinery–petrochemical complex is to manufacture caustic soda, which will use feed-water of 10,000 gallons per day. Two types of feed-water storage installation are being considered over the 40 years of their useful life.

Option 1. Build a 20,000-gallon tank on a tower. The cost of installing the tank and tower is estimated to be $164,000. The salvage value is estimated to be negligible.

Option 2. Place a tank of 20,000-gallon capacity on a hill, which is 150 yards away from the refinery. The cost of installing the tank on the hill, including the extra length of service lines, is estimated to be $120,000, with negligible salvage value. Because of the tank's location on the hill, an additional investment of $12,000 in pumping equipment is required. The pumping equipment is expected to have a service life of 20 years, with a salvage value of $1,000 at the end of that time. The annual operating and maintenance cost (including any income tax effects) for the pumping operation is estimated at $1,000. If the firm's MARR is known to be 12%, which option is better, on the basis of the present-worth criterion?

15. Apex Corporation requires a chemical finishing process for a product under contract for a period of six years. Three options are available. Neither Option 1 nor Option 2 can be repeated after its process life. However, Option 3 will always be available from H&H Chemical Corporation at the same cost during the period that the contract is operative. Here are the options:

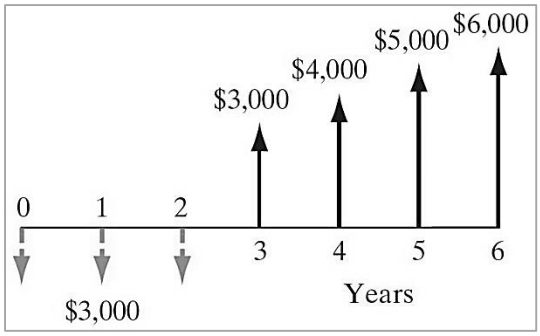
• **Option 1.** Process device A, which costs $100,000, has annual operating and labor costs of $60,000 and a useful service life of four years with an estimated salvage value of $10,000.

• **Option 2.** Process device B, which costs $150,000, has annual operating and labor costs of $50,000 and a useful service life of six years with an estimated salvage value of $30,000.

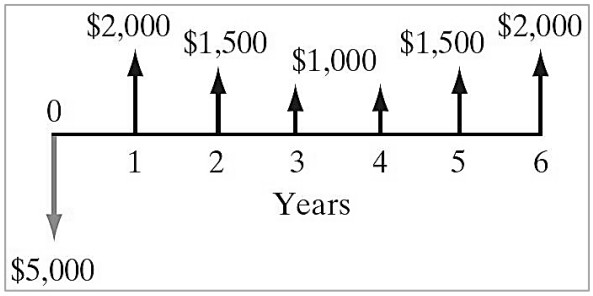
• **Option 3.** Subcontract out the process at a cost of $100,000 per year.

According to the present-worth criterion, which option would you recommend at $i = 12\%$?

16. Consider the accompanying cash flow diagram. Compute the equivalent annual worth at i = 10%.



17. Consider the accompanying cash flow diagram. Compute the equivalent annual worth at i = 8%.



18. A construction firm is considering establishing an engineering computing center. The center will be equipped with three engineering workstations that cost $25,000 each, and each has a service life of five years. The expected salvage value of each workstation is $2,000. The annual operating and maintenance cost would be $15,000 for each workstation. At a MARR of 15%, determine the equivalent annual cost for operating the engineering center.

19. Two 150-horsepower (HP) motors are being considered for installation at a municipal sewage-treatment plant. The first costs $4,500 and has an operating efficiency of 83%. The second costs $3,600 and has an efficiency of 80%. Both motors are projected to have zero salvage value after a life of 10 years. If all the annual charges, such as insurance, maintenance, etc., amount to a total of 15% of the original cost of each motor, and if power costs are a flat 5 cents per kilowatt-hour, how many minimum hours of full-load operation per year are necessary to justify purchasing the more expensive motor at i = 6% (A conversion factor you might find useful is 1 HP = 746 watts = 0.746 kilowatts.)

20. An automobile that runs on electricity can be purchased for $25,000. The automobile is estimated to have a life of 12 years with annual travel of 20,000 miles. Every 3 years, a new set of batteries will have to be purchased at a cost of $3,000. Annual maintenance of the vehicle is estimated to cost $700. The cost of recharging the batteries is estimated at $0.015 per mile. The salvage value of the batteries and the vehicle at the end of 12 years is estimated to be $2,000. Suppose the MARR is 7%. What is the cost per mile to own and operate this vehicle, based on the preceding estimates? The $3,000 cost of the batteries is a net value, with the old batteries traded in for the new ones.

21. The following cash flows represent the potential annual savings associated with two different types of production processes, each of which requires an investment of $12,000:

n	Process A	Process B
0	−$12,000	−$12,000
1	9,120	6,350
2	6,840	6,350
3	4,560	6,350
4	2,280	6,350

Assuming an interest rate of 15%,

(a) Determine the equivalent annual savings for each process.

(b) Determine the hourly savings for each process if it is in operation 2,000 hours per year.

(c) Which process should be selected?

22. Consider the cash flows for the following investment projects MARR = 15%:

	Project's Cash Flow		
n	A	B	C
0	−$2,500	−$4,000	−$5,000
1	1,000	1,600	1,800
2	1,800	1,500	1,800
3	1,000	1,500	2,000
4	400	1,500	2,000

(a) Suppose that projects A and B are mutually exclusive. Which project would you select, based on the AE criterion?

(b) Assume that projects B and C are mutually exclusive. Which project would you select, based on the AE criterion?

23. Consider four investments with the following sequences of cash flows:

	Net Cash Flow			
n	Project A	Project B	Project C	Project D
0	−$18,000	−$30,000	$34,578	−$56,500
1	30,000	32,000	−18,000	2,500
2	20,000	32,000	−18,000	6,459
3	10,000	−22,000	−18,000	−78,345

(a) Identify all the simple investments.

(b) Identify all the non-simple investments.

(c) Compute i^* for each investment.

(d) Which project has no rate of return?

24. Consider the following investment projects:

(a) Classify each project as either simple or non-simple.
(b) Use the quadratic equation to compute i^* for project A.
(c) Obtain the rate(s) of return for each project by plotting the NPW as a function of the interest rate.

	Project Cash Flow				
n	A	B	C	D	E
0	−$100	−$100	−$200	−$50	−$50
1	60	70	$20	120	−100
2	150	70	10	40	−50
3		40	5	40	0
4		40	−180	−20	150
5			60	40	150
6			50	30	100
7			400		100

25. Consider two investments, A and B, with the following sequences of cash flows:

(a) Compute i^* for each investment.
(b) Plot the present-worth curve for each project on the same chart, and find the interest rate that makes the two projects equivalent.

	Net Cash Flow	
n	Project A	Project B
0	−$25,000	−$25,000
1	2,000	10,000
2	6,000	10,000
3	12,000	10,000
4	24,000	10,000
5	28,000	5,000

26. Consider the following cash flow of a certain project:

If the project's IRR is 10%,
(a) Find the value of X.
(b) Is this project acceptable at MARR = 8%?

n	Net Cash Flow
0	−$2,000
1	800
2	900
3	X

27. You are considering two types of automobiles. Model A costs $18,000 and model B costs $15,624. Although the two models are essentially the same, after four years of use model A can be sold for $9,000, while model B can be sold for $6,500. Model A commands a better resale value because its styling is popular among young college students. Determine the rate of return on the incremental investment of $2,376. For what range of values of your MARR is model A preferable?

28. Fulton National Hospital is reviewing ways of cutting the cost of stocking medical supplies. Two new stockless systems are being considered, to lower the hospital's holding and handling costs. The hospital's industrial engineer has compiled the relevant financial data for each system as follows (dollar values are in millions):

	Current Practice	Just-in-Time System	Stockless Supply System
Start-up cost	$0	$2.5	$5
Annual stock holding cost	$3	$1.4	$0.2
Annual operating cost	$2	$1.5	$1.2
System life	8 years	8 years	8 years

The system life of eight years represents the period that the contract with the medical suppliers is in force. If the hospital's MARR is 10%, which system is more economical?

29. Consider the cash flows for the following investment projects: Assume that the MARR = 12%.

	Project Cash Flow				
n	A	B	C	D	E
0	−$1,000	−$1,000	−$2,000	$1,000	−$1,200
1	900	600	900	−300	400
2	500	500	900	−300	400
3	100	500	900	−300	400
4	50	100	900	−300	400

(a) Suppose A, B, and C are mutually exclusive projects. Which project would be selected on the basis of the IRR criterion?
(b) What is the borrowing rate of return (BRR) for project D?
(c) Would you accept project D at MARR = 20%?
(d) Assume that projects C and E are mutually exclusive. Using the IRR criterion, which project would you select?

30. A manufacturer of electronic circuit boards is considering six mutually exclusive cost-reduction projects for its PC-board manufacturing plant. All have lives of 10 years and zero salvage values. The required investment and the estimated after-tax reduction in annual disbursements for each alternative are as follows, along with computed rates of return on incremental investments:

Proposal	Required After-Tax		Rate of
A_j	Investment	Savings	Return (%)
A_1	$60,000	$22,000	35.0%
A_2	100,000	28,200	25.2
A_3	110,000	32,600	27.0
A_4	120,000	33,600	25.0
A_5	140,000	38,400	24.0
A_6	150,000	42,200	25.1

Incremental Investment	Incremental Rate of Return (%)
$A_2 - A_1$	9.0%
$A_3 - A_2$	42.8
$A_4 - A_3$	0.0
$A_5 - A_4$	20.2
$A_6 - A_5$	36.3

If the MARR is 15%, which project would you select, based on the rate of return on incremental investment?

31. Consider the following two mutually exclusive investment projects for which MARR = 15%:

On the basis of the IRR criterion, which project would be selected under an infinite planning horizon with project repeatability likely?

	Net Cash Flow	
n	Project A	Project B
0	−$100	−$200
1	60	120
2	50	150
3	50	
IRR	28.89%	21.65%