PROBLEMS

Note: *Unless otherwise stated, all cash flows are after-tax cash flows. The interest rate (MARR) is also given on an after-tax basis.*

Identifying Cash Inflows and Outflows

5.1 Business at your design engineering firm has been brisk. To keep up with the increasing workload, you are considering the purchase of a new state-of-the-art CAD/CAM system costing $300,000, which would provide 5000 hours of productive time per year. Your firm puts a lot of effort into drawing new product designs. At present, this is all done by design engineers on an old CAD/CAM system installed five years ago. If you purchase the system, 40% of the productive time will be devoted to drawing (CAD) and the remainder to CAM. While drawing, the system is expected to out-produce the old CAD/CAM system by a factor of 3 : 1. You estimate that the additional annual out-of-pocket cost of maintaining the new CAD/CAM system will be $175,000, including any tax effects. The expected useful life of the system is eight years, after which the equipment will have no residual value. As an alternative, you could hire more design engineers. Each normally works 2000 hours per year, and 60% of this time is productive. The total cost for a design engineer is $45 per hour. There are five design egineers) Identify the net cash flows (benefits and costs) associated with the drawing activities if the CAD/CAM system is purchased instead of hiring more design engineers.

5.2 Camptown Togs, Inc., a children's clothing manufacturer, has always found payroll processing to be costly because it must be done by a clerk. The number of piece–goods coupons received by each employee are collected and the types of tasks performed by each employee are calculated. Not long ago, an industrial engineer designed a system that partially automates the process by means of a scanner that reads the piece–goods coupons. Management is enthusiastic about this system, because it utilizes some personal computer systems that were purchased recently. It is expected that this new automated system will save $45,000 per year in labor. The new system will cost about $30,000 to build and test prior to operation. It is expected that operating costs, including income taxes, will be about $5,000 per year. The system will have a five-year useful life. The expected net salvage value of the system is estimated to be $3,000.

(a) Identify the cash inflows over the life of the project.

(b) Identify the cash outflows over the life of the project.

(c) Determine the net cash flows over the life of the project.

Payback Period

Unless otherwise mentioned, problems use "payback period" to mean "conventional payback period."

***5.3** If a project costs $100,000 and is expected to return $25,000 annually, how long does it take to recover the initial investment? What would be the discounted payback period at $i = 15\%$?

5.4 Refer to Problem 5.2, and answer the following questions:

(a) How long does it take to recover the investment?

(b) If the firm's interest rate is 15% after taxes, what would be the discounted payback period for this project?

5.5 Consider the following cash flows in Table P5.5.

TABLE P5.5

	Project's Cash Flow ($)			
n	A	B	C	D
0	−$3,500	−$5,000	−$7,500	−$4,000
1	800	2,000	2,000	5,000
2	800	1,500	2,000	3,000
3	800	1,500	2,000	−2,500
4	800	500	4,000	−1,000
5	800	500	5,000	1,000
6	800	1,500		2,000
7	800			3,000
8	800			

(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 $i = 12\%$, calculate the discounted payback period for each project.

***5.6** A project costs \$120,000 and the expected annual returns are as given in Table P5.6.

TABLE P5.6

Year	Cash Flows
1	\$18,500
2	\$25,500
3	\$27,980
4	\$32,660
5	\$40,230

(a) What is the payback period of the project?
(b) What is the discounted payback period at an interest rate of 15%?

NPW Criterion

5.7 What is the present worth of the project which requires \$100,000 investment now and receives \$30,000 every year for five years at an interest rate of 12%?

***5.8** Larson Manufacturing is considering purchasing a new injection-molding machine for \$250,000 to expand its production capacity. It will cost an additional \$20,000 to do the site preparation. With the new injection-molding machine installed, Larson Manufacturing expects to increase its revenue by \$90,000. The machine will be used for five years, with an expected salvage value of \$75,000. At an interest rate of 12%, would the purchase of the injection-molding machine be justified?

5.9 Consider the investment projects, in Table P5.9 all of which have a four-year investment life:

(a) Compute the net present worth of each project at $i = 10\%$.
(b) Plot the present worth as a function of the interest rate (from 0% to 30%) for project B.

5.10 You need to know whether the building of a new warehouse is justified under the following conditions.

TABLE P5.9

	Project's Cash Flow (\$)			
n	A	B	C	D
0	−\$3,500	−\$6,500	−\$2,800	−\$4,300
1	0	1,600	−1,800	−1,000
2	0	1,800	−900	1,900
3	0	1,500	2,500	2,300
4	4,200	2,200	3,500	1,500

- The proposal is for a warehouse costing \$250,000.
- The warehouse has an expected useful life of 35 years and a net salvage value (net proceeds from sale after tax adjustments) of \$50,000.
- Annual receipts of \$67,000 are expected, annual maintenance and administrative costs will be \$12,000/year, and annual income taxes are \$15,000.

Given the foregoing data, which of the following statements are correct?

(a) The proposal is justified for a MARR of 15%.
(b) The proposal has a net present worth of −\$50,254 when 20% is used as the interest rate.
(c) The proposal is acceptable, as long as MARR $\leq$ 15.93%.
(d) All of the preceding are correct.

***5.11** Your firm is considering purchasing an old office building with an estimated remaining service life of 25 years. Recently, the tenants signed long-term leases, which leads you to believe that the current rental income of \$250,000 per year will remain constant for the first five years. Then the rental income will increase by 10% for every five-year interval over the remaining life of the asset. That is, the annual rental income would be \$275,000 for years 6 through 10, \$302,500 for years 11 through 15, \$332,750 for years 16 through 20, and \$366,025 for years 21 through 25. You estimate that operating expenses, including income taxes, will be \$85,000 for the first year and that they will increase by \$5,000 each year thereafter. You also estimate that razing the building and selling the lot on which it stands will realize a net amount of \$50,000 at the end of the 25-year period. If you had the opportunity

to invest your money elsewhere and thereby earn interest at the rate of 12% per annum, what would be the maximum amount you would be willing to pay for the building and lot at the present time?

5.12 Consider the following investment project.

TABLE P5.12

n	A_n	i
0	−$42,000	10%
1	32,400	11
2	33,400	13
3	32,500	15
4	32,500	12
5	33,000	10

Suppose the company's reinvestment opportunities change over the life of the project as shown in Table P5.12 (i.e., the firm's MARR changes over the life of the project). For example, the company can invest funds available now at 10% for the first year, 11% for the second year, and so forth. Calculate the net present worth of this investment and determine the acceptability of the investment.

5.13 FootballComm LLC is a manufacturer of devices for football coaches and their coaching staffs that enable them to quickly and effectively communicate with one another during a game through a wireless sideline headset system. Currently, the company purchases all of the headsets included in their systems from a China-based supplier, but they have experienced a significant decrease in overall headset quality. To correct the problem, the company is considering producing their own headsets in-house. The company estimates that the transition will take place over 12 months. The system is expected to have an eight-year service life and produce savings and expenditures given in Table P5.13.

If the firm's MARR is 15%, use the NPW method to calculate the economic worth of producing the headsets in house.

TABLE P5.13

In-House Headset Manufacturing	
Investment	
Now (building)	$500,000
First year (equipment and facilities)	$2,200,000
Annual savings in materials and quality inspection	$5,000,000
Incremental annual expenses	$1,500,000
Incremental annual income taxes	$800,000
Economic service life	8 years
Net salvage value	$1,500,000

***5.14** 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 $3.5 million to purchase the industrial-strength lasers. The system will save $1,550,000 per year in labor and materials. However, it will require an additional operating and maintenance cost of $350,000. 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 project.

5.15 You are considering purchasing a new injection-molding machine. This machine will have an estimated service life of 10 years with a negligible after-tax salvage value. Its annual net after-tax operating cash flows are estimated to be $60,000. To expect a 15% rate of return on investment, what would be the maximum amount that should be spent on purchasing the injection-molding machine?

Future Worth and Project Balance

5.16 Right now, you have $10,000 to invest over five years. The interest rate in the United States is 4% for invested Dollars. The interest rate in Europe is 5% for invested Euros. The interest rate in Japan is 6% for invested Yen. Assume that these interest rates are expected to remain unchanged over the

next five years. The current and expected exchange rates are given in Table P5.16.

TABLE P5.16

Current Exchange Rates	Expected Exchange Rates Five Years from Now
$1 = 0.735 Euro	$1 = 0.880 Euro
$1 = 97.50 Yen	$1 = 110 Yen

Which of the following options (if any) will maximize your wealth in US$ at the end of five years?

(a) Investing in the United States
(b) Investing in Europe
(c) Investing in Japan

5.17 Consider the sets of investment projects in Table P5.17, all of which have a three-year investment life.

TABLE P5.17

Period	Project's Cash Flow			
(n)	A	B	C	D
0	−$12,500	−11,000	12,500	−13,000
1	5,400	−3,000	−7,000	5,500
2	14,400	21,000	−2,000	5,500
3	7,200	13,000	4,000	8,500

(a) Compute the net present worth of each project at $i = 15\%$.
(b) Compute the net future worth of each project at $i = 15\%$.

Which project or projects are acceptable?

5.18 Which of the following investment options will maximize your future wealth at the end of 20 years? Assume any funds that remain invested will earn a nominal rate of 12% compounded monthly.

(a) deposit $5,000 now
(b) deposit $80 at the end of each month for the first 10 years
(c) deposit $50 at the end of each month for 20 years
(d) deposit a lump sum in the amount of $15,000 at the end of year 10

5.19 Consider the project balances in Table P5.19 for a typical investment project with a service life of four years.

TABLE P5.19

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

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

***5.20** Your R&D group has developed and tested a computer software package that helps engineers control the proper chemical mix for various process-manufacturing industries. If you decide to market the software, your first-year operating net cash flow is estimated to be $1,200,000. Because of market competition, product life will be about four years, and the product's market share will decrease by 25% each year over the previous year's share. You are approached by a big software house which wants to purchase the right to manufacture and distribute the product. Assuming that your interest rate is 15%, for what minimum price would you be willing to sell the software?

5.21 Consider the accompanying project balance diagram for a typical investment project with a service life of five years. The numbers in the figure indicate the beginning project balances.

(a) From the project balance diagram, reconstruct the project's original cash flows.
(b) What is the project's conventional payback period (without interest)?

5.22 Consider the following cash flows and present-worth profile.

(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.

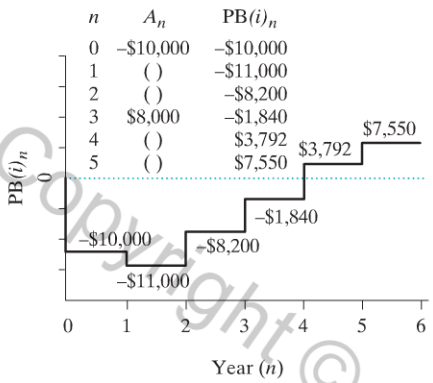

Figure P5.21

TABLE P5.22

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

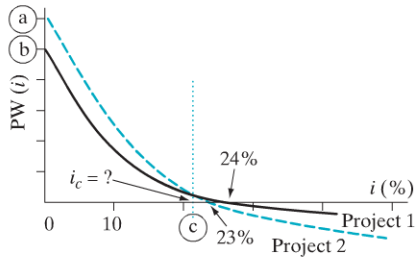

Figure P5.22

5.23 Consider the project balances for a typical investment project with a service life of five years, as shown in Table P5.23.

(a) Determine the interest rate used in the project balance calculation, and compute the present worth of this project at the computed interest rate.

(b) Construct the original cash flows of the project and the terminal balance, and fill in the blanks in Table P5.23.

TABLE P5.23 Investment Project Balances

n	A_n	Project Balance
0	−$3,000	−$3,000
1	ⓐ	−2,700
2	1,470	−1,500
3	ⓑ	0
4	ⓒ	−300
5	600	ⓓ

5.24 Refer to Problem 5.5 and answer the following questions.

(a) Graph the project balances (at $i = 10\%$) of each project as a function of n.

(b) By examining the graphical results in part (a), determine which project appears to be the safest to undertake if there is some possibility of premature termination of the projects at the end of year 2.

5.25 Consider the following investment projects using the information in Table P5.25.

(a) Compute the future worth at the end of life for each project at $i = 12\%$.

(b) Determine the acceptability of each project.

5.26 Refer to Problem 5.25 and answer the following questions.

(a) Plot the future worth for each project as a function of the interest rate (0% to 50%).

(b) Compute the project balance of each project at $i = 12\%$.

(c) Compare the terminal project balances calculated in (b) with the results obtained in Problem 5.25(a). Without using the interest factor tables, compute the future worth on the basis of the project balance concept.

***5.27** Covington Corporation purchased a vibratory finishing machine for $20,000 in year 0. The useful life of the machine is 10 years, at the end of which the machine is estimated to have a salvage value of zero. The machine generates net annual revenues of $6,000. The annual operating and maintenance expenses are estimated to be $1,000. If Covington's MARR is 15%, how many years will it take before this machine becomes profitable?

TABLE P5.25

	Project's Cash Flow				
n	A	B	C	D	E
0	−$2,200	−$4,500	−$3,200	−$5,400	−$7,200
1	−500	1,500	1,200	1,500	2,500
2	900	−4,000	0	1,000	2,800
3	1,500	5,000	4,000	3,000	3,500
4	3,200	6,000	7,000	3,000	—
5	−700	3,000	2,000	2,400	—

5.28 Gene Research, Inc., just finished a four-year program of R&D and clinical trials. It expects a quick approval from the Food and Drug Administration. If Gene markets the product on its own, the company will require $30 million immediately $(n = 0)$ to build a new manufacturing facility, and it is expected to have a 10-year product life. The R&D expenditure in the previous years and the anticipated revenues that the company can generate over the next 10 years are summarized in Table P5.28.

TABLE P5.28

Period (*n*)	Cash Flow (Unit: $ million)
−4	−$10
−3	−10
−2	−10
−1	−10
0	−10 − 30
1–10	100

Merck, a large drug company, is interested in purchasing the R&D project and the right to commercialize the product from Gene Research, Inc.; it wants to do so immediately $(n = 0)$. What would be a starting negotiating price for the project from Merck? Assume that Gene's MARR = 20%.

5.29 Consider the independent investment projects in Table P5.29.

Assume that MARR = 12% and answer the following questions.

(a) Compute the net present worth for each project, and determine the acceptability of each.

(b) Compute the net future worth of each project at the end of each project period, and determine the acceptability of each project.

(c) Compute the project worth of each project at the end of six years with variable MARRs as follows: 10% for $n = 0$ to $n = 3$ and 15% for $n = 4$ to $n = 6$.

TABLE P5.29

	Project Cash Flows		
n	A	B	C
0	−$800	−$500	$200
1	150	150	−40
2	150	150	−60
3	350	150	−140
4	−200	100	—
5	500	100	—
6	400	—	—

5.30 Consider the project balance profiles shown in Table P5.30 for proposed investment projects.

TABLE P5.30 Profiles for Proposed Investment Projects

	Project Balances		
n	A	B	C
0	−$1,000	−$1,000	−$1,000
1	−1,000	−650	−1,200
2	−900	−348	−1,440
3	−690	−100	−1,328
4	−359	85	−1,194
5	105	198	−1,000
Interest rate used	10%	?	20%
NPW	?	$79.57	?

Project balance figures are rounded to nearest dollars.

(a) Compute the net present worth of projects A and C.
(b) Determine the cash flows for project A.
(c) Identify the net future worth of project C.
(d) What interest rate would be used in the project balance calculations for project B?

5.31 Consider the project balance profiles for proposed investment projects in Table P5.31.

Project balance figures are rounded to the nearest dollar.

(a) Compute the net present worth of each investment.
(b) Determine the project balance for project C at the end of period 2 if $A_2 = \$500$.
(c) Determine the cash flows for each project.
(d) Identify the net future worth of each project.

TABLE P5.31 Profiles for Proposed Investment Projects

	Project Balances		
n	A	B	C
0	−$1,000	−$1,000	−$1,000
1	−800	−680	−530
2	−600	−302	*X*
3	−400	−57	−211
4	−200	233	−89
5	0	575	0
Interest rate used	0%	18%	12%

Capitalized Equivalent Worth

***5.32** Maintenance money for a new building has been sought. Mr. Kendall would like to make a donation to cover all future expected maintenance costs for the building. These maintenance costs are expected to be $100,000 each year for the first five years, $130,000 each year for years 6 through 10, and $150,000 each year after that. (The building has an indefinite service life.)

(a) If the money is placed in an account that will pay 13% interest compounded annually, how large should the gift be?

(b) What is the equivalent annual maintenance cost over the infinite service life of the building?

5.33 Geo-Star Manufacturing Company is considering a new investment in a punch-press machine that will cost $100,000 and has an annual maintenance cost of $10,000. There is also an additional overhauling cost of $20,000 for the equipment once every four years. Assuming that this equipment will last infinitely under these conditions, what is the capitalized equivalent cost of this investment at an interest rate of 10%?

***5.34** Consider an investment project, the cash flow pattern of which repeats itself every five years forever, as shown in the accompanying diagram. At an interest rate of 15%, compute the capitalized equivalent amount for this project.

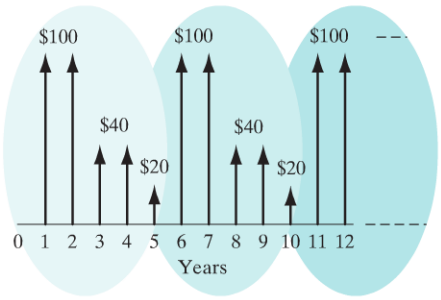

Figure P5.34

5.35 A group of concerned citizens has established a trust fund that pays 5% interest, compounded monthly, to preserve a historical building by providing annual maintenance funds of $80,000 forever. Compute the capitalized equivalent amount for these building maintenance expenses.

5.36 A newly constructed bridge costs $15,000,000. The same bridge is estimated to need renovation every 15 years at a cost of $3,000,000. Annual repairs and maintenance are estimated to be $1,000,000 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 can you say about the effect of interest on the results?

5.37 To decrease the costs of operating a lock in a large river, a new system of operation is proposed. The system will cost $830,000 to design and build. It is estimated that it will have to be reworked every 10 years at a cost of $120,000. In addition, an expenditure of $80,000 will have to be made at the end of the fifth year for a new type of gear that will not be available until then. Annual operating costs are expected to be $70,000 for the first 15 years and $100,000 a year thereafter. Compute the capitalized cost of perpetual service at $i = 7\%$.

Mutually Exclusive Alternatives

5.38 You are considering two investment options. In option A, you have to invest $5,000 now and $1,000 three years from now. In option B, you have to invest $3,500 now, $1,500 a year from now, and $1,000 three years from now. In both options, you will receive four annual payments of $2,000 each. (You will get the first payment a year from now.) Which of these options would you choose based on (a) the conventional payback criterion, and (b) the present worth criterion, assuming 10% interest?

***5.39** Consider the cash flow data in Table P5.39 for two competing investment projects.

At $i = 12\%$, which of the two projects would be a better choice?

5.40 Consider the cash flows in Table P5.40 for the following investment projects.

(a) Suppose projects A and B are mutually exclusive. On the basis of the NPW criterion, which

TABLE P5.39

	Cash Flow Data (Unit: $ thousand)	
n	Project A	Project B
0	−$1,000	−$2,800
1	−1,300	−660
2	−435	820
3	875	820
4	875	1,180
5	1,475	1,880
6	1,775	1,600
7	675	880
8	675	780
9	375	380
10	660	840

TABLE P5.40

	Project's Cash Flow				
n	A	B	C	D	E
0	−$1,800	−$1,500	−$4,000	$1,400	−$1,500
1	1,150	1,200	1,500	−450	500
2	700	700	*X*	−450	500
3	200	700	1,800	−450	500
4	200	100	*X*	−450	500

project would be selected? Assume that MARR = 15%.

(b) Repeat part (a), using the NFW criterion.

(c) Find the minimum value of *X* that makes project C acceptable, still using MARR = 15%.

(d) Would you accept project D at i = 18%?

(e) Assume that projects D and E are mutually exclusive. On the basis of the NPW criterion, which project would you select?

5.41 Consider two mutually exclusive investment projects, each with MARR = 12%, as shown in Table P5.41.

TABLE P5.41 Two Mutually Exclusive Investment Projects

	Project's Cash Flow	
n	A	B
1	−$17,500	−$15,900
1	13,610	13,210
2	14,930	13,720
3	14,300	13,500

(a) On the basis of the NPW criterion, which alternative would be selected?

(b) On the basis of the NFW criterion, which alternative would be selected?

5.42 Consider the two mutually exclusive investment projects in Table P5.42, 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 across the range between 0% and 50%. For what range of i would you prefer project B?

TABLE P5.42

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

5.43 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 $60,000, and $25,000 of redigging and shaping would be required at five-year intervals forever.

Method B. Lay concrete pipe. The first cost would be $150,000, and a replacement would be required at 50-year intervals at a net cost of $180,000 forever.

At i = 12%, which method is the better one?

5.44 A local car dealer is advertising a standard 24-month lease of $1,150 per month for its new XT 3000 series sports car. The standard lease requires a down payment of $4,500, plus a $1,000 refundable initial deposit *now*. The first lease payment is due at the end of month 1. In addition, the company offers a 24-month lease plan that has a single up-front payment of $30,500, plus a refundable initial deposit of $1,000. Under both options, the initial deposit will be refunded at the end of month 24. Assume an interest rate of 6% compounded monthly. With the present-worth criterion, which option is preferred?

5.45 You are considering two types of machines for a manufacturing process.

- **Machine A** has a first cost of $75,200, and its salvage value at the end of six years of estimated service life is $21,000. The operating costs of this machine are estimated to be $6,800 per year. Extra income taxes are estimated at $2,400 per year.
- **Machine B** has a first cost of $44,000, and its salvage value at the end of six years' service is estimated to be negligible. The annual operating costs will be $11,500.

Compare these two mutually exclusive alternatives by the present-worth method at i = 13%.

***5.46** An electric motor is rated at 10 horsepower (HP) and costs $1,200. 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 it costs $1,600. It is estimated that the motors will operate at a rated 10 HP output for 2,000 hours a year, and the cost of energy will be $0.09 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 part (a), what if the motors operated 1,000 hours a year instead of 2,000 hours a year? Would the motor you chose in part (a) still be the best choice?

5.47 Consider the two mutually exclusive investment projects in Table P5.47.

On the basis of the NPW criterion, which project would be selected if you use an infinite planning

TABLE P5.47

	Project's Cash Flow	
n	A	B
0	−$20,000	−$25,000
1	17,500	25,500
2	17,000	18,000
3	15,000	—