Chapter 12
The Basics of Capital Budgeting

Learning Objectives

After reading this chapter, students should be able to:

- Discuss capital budgeting.
- Calculate and use the major capital budgeting decision criteria, which are NPV, IRR, MIRR, and payback.
- Explain why NPV is the best criterion and how it overcomes problems inherent in the other methods.

Lecture Suggestions

This is a relatively straight-forward chapter, and, for the most part, it is a direct application of the time value concepts first discussed in Chapter 5. We point out that capital budgeting is to a company what buying stocks or bonds is to an individual—an investment decision, when the company wants to know if the expected value of the cash flows is greater than the cost of the project, and whether or not the expected rate of return on the project exceeds the cost of the funds required to do the project. We cover the standard capital budgeting procedures—NPV, IRR, MIRR, payback and discounted payback.

At this point, students who have not yet mastered time value concepts and how to use their calculator efficiently get another chance. Students who have mastered those tools and concepts have fun, because they can see what is happening and the usefulness of what they are learning.

What we cover, and the way we cover it, can be seen by scanning the slides and Integrated Case solution for Chapter 12, which appears at the end of this chapter's solutions. For other suggestions about the lecture, please see the "Lecture Suggestions" in Chapter 2, where we describe how we conduct our classes.

DAYS ON CHAPTER: 3 OF 56 DAYS (50-minute periods)

Answers to End-of-Chapter Questions

12-1 Project classification schemes can be used to indicate how much analysis is required to evaluate a given project, the level of the executive who must approve the project, and the cost of capital that should be used to calculate the project's NPV. Thus, classification schemes can increase the efficiency of the capital budgeting process.

12-2 The regular payback method has three main flaws: (1) Dollars received in different years are all given the same weight. (2) Cash flows beyond the payback year are given no consideration whatever, regardless of how large they might be. (3) Unlike the NPV, which tells us by how much the project should increase shareholder wealth, and the IRR, which tells us how much a project yields over the cost of capital, the payback merely tells us when we recover our investment. The discounted payback corrects the first flaw, but the other two flaws still remain.

12-3 The NPV is obtained by discounting future cash flows, and the discounting process actually compounds the interest rate over time. Thus, an increase in the discount rate has a much greater impact on a cash flow in Year 5 than on a cash flow in Year 1.

12-4 Mutually exclusive projects are a set of projects in which only one of the projects can be accepted. For example, the installation of a conveyor-belt system in a warehouse and the purchase of a fleet of forklifts for the same warehouse would be mutually exclusive projects—accepting one implies rejection of the other. When choosing between mutually exclusive projects, managers should rank the projects based on the NPV decision rule. The mutually exclusive project with the highest positive NPV should be chosen. The NPV decision rule properly ranks the projects because it assumes the appropriate reinvestment rate is the cost of capital.

12-5 The first question is related to Question 12-3 and the same rationale applies. A high cost of capital favors a shorter-term project. If the cost of capital declined, it would lead firms to invest more in long-term projects. With regard to the last question, the answer is no; the IRR rankings are constant and independent of the firm's cost of capital.

12-6 The statement is true. The NPV and IRR methods result in conflicts only if mutually exclusive projects are being considered since the NPV is positive if and only if the IRR is greater than the cost of capital. If the assumptions were changed so that the firm had mutually exclusive projects, then the IRR and NPV methods could lead to different conclusions. A change in the cost of capital or in the cash flow streams would not lead to conflicts if the projects were independent. Therefore, the IRR method can be used in lieu of the NPV if the projects being considered are independent.

12-7 Payback provides information on how long funds will be tied up in a project. The shorter the payback, other things held constant, the greater the project's liquidity. This factor is often important for smaller firms that don't have ready access to the capital markets. Also, cash flows expected in the distant future are generally riskier than near-term cash flows, so the payback can be used as a risk indicator.

12-8 Project X should be chosen over Project Y. Since the two projects are mutually exclusive, only one project can be accepted. The decision rule that should be used is NPV. Since Project X has the higher NPV, it should be chosen. The cost of capital used in the NPV analysis appropriately includes risk.

12-9 The NPV method assumes reinvestment at the cost of capital, while the IRR method assumes reinvestment at the IRR. MIRR is a modified version of IRR that assumes reinvestment at the cost of capital.

The NPV method assumes that the rate of return that the firm can invest differential cash flows it would receive if it chose a smaller project is the cost of capital. With NPV we are calculating present values and the interest rate or discount rate is the cost of capital. When we find the IRR we are discounting at the rate that causes NPV to equal zero, which means that the IRR method assumes that cash flows can be reinvested at the IRR (the project's rate of return). With MIRR, since positive cash flows are compounded at the cost of capital and negative cash flows are discounted at the cost of capital, the MIRR assumes that the cash flows are reinvested at the cost of capital.

12-10 **a.** In general, the answer is no. The objective of management should be to maximize value, and as we point out in subsequent chapters, stock values are determined by both earnings and growth. The NPV calculation automatically takes this into account, and if the NPV of a long-term project exceeds that of a short-term project, the higher future growth from the long-term project must be more than enough to compensate for the lower earnings in early years.

b. If the same $100 million had been spent on a short-term project—one with a faster payback—reported profits would have been higher for a period of years. This is, of course, another reason why firms sometimes use the payback method.

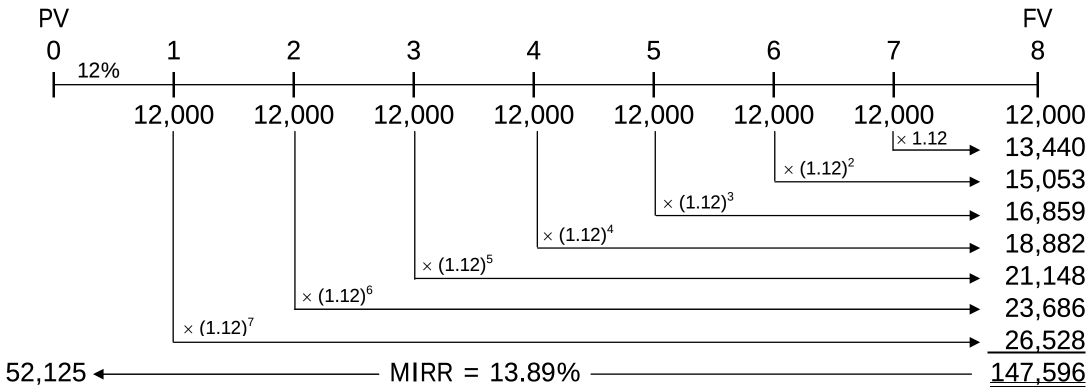
Solutions to End-of-Chapter Problems

12-1 Financial calculator solution: Input CF_0 = -52125, $CF_{1\text{-}8}$ = 12000, I/YR = 12, and then solve for NPV = $7,486.68.

12-2 Financial calculator solution: Input CF_0 = -52125, $CF_{1\text{-}8}$ = 12000, and then solve for IRR = 16%.

12-3 MIRR: PV costs = $52,125.

FV inflows:



Financial calculator solution: Obtain the FVA by inputting N = 8, I/YR = 12, PV = 0, PMT = 12000, and then solve for FV = $147,596. The MIRR can be obtained by inputting N = 8, PV = -52125, PMT = 0, FV = 147596, and then solving for I/YR = 13.89%.

12-4 Since the cash flows are a constant $12,000, calculate the payback period as: $52,125/$12,000 = 4.3438, so the payback is about 4 years.

12-5 Project K's discounted payback period is calculated as follows:

Period	Annual Cash Flows	Discounted @12% Cash Flows	Cumulative
0	($52,125)	($52,125.00)	($52,125.00)
1	12,000	10,714.29	(41,410.71)
2	12,000	9,566.33	(31,844.38)
3	12,000	8,541.36	(23,303.02)
4	12,000	7,626.22	(15,676.80)
5	12,000	6,809.12	(8,867.68)
6	12,000	6,079.57	(2,788.11)
7	12,000	5,428.19	2,640.08
8	12,000	4,846.60	7,486.68

The discounted payback period is $6 + \frac{\$2,788.11}{\$5,428.19}$ years, or 6.51 years.

12-6 **a.** Project A: Using a financial calculator, enter the following:

CF_0 = -25, CF_1 = 5, CF_2 = 10, CF_3 = 17, I/YR = 5; NPV = \$3.52.

Change I/YR = 5 to I/YR = 10; NPV = \$0.58.

Change I/YR = 10 to I/YR = 15; NPV = -\$1.91.

Project B: Using a financial calculator, enter the following:

CF_0 = -20, CF_1 = 10, CF_2 = 9, CF_3 = 6, I/YR = 5; NPV = \$2.87.

Change I/YR = 5 to I/YR = 10; NPV = \$1.04.

Change I/YR = 10 to I/YR = 15; NPV = -\$0.55.

b. Using the data for Project A, enter the cash flows into a financial calculator and solve for IRR_A = 11.10%. The IRR is independent of the WACC, so it doesn't change when the WACC changes.

Using the data for Project B, enter the cash flows into a financial calculator and solve for IRR_B = 13.18%. Again, the IRR is independent of the WACC, so it doesn't change when the WACC changes.

c. At a WACC = 5%, $NPV_A > NPV_B$ so choose Project A.

At a WACC = 10%, $NPV_B > NPV_A$ so choose Project B.

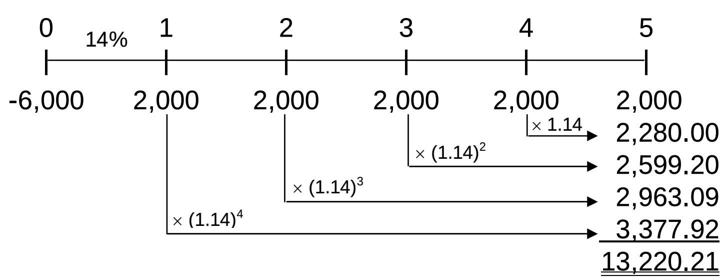
At a WACC = 15%, both NPVs are less than zero, so neither project would be chosen.

12-7 **a.** Project A:

CF_0 = -6000; $CF_{1\text{-}5}$ = 2000; I/YR = 14.

Solve for NPV_A = \$866.16. IRR_A = 19.86%.

MIRR calculation:



Using a financial calculator, enter N = 5; PV = -6000; PMT = 0; FV = 13220.21; and solve for $MIRR_A$ = I/YR = 17.12%.

Payback calculation:

	0	1	2	3	4	5
	-6,000	2,000	2,000	2,000	2,000	2,000
Cumulative CF:	-6,000	-4,000	-2,000	0	2,000	4,000

Regular Payback_A = 3 years.

Discounted payback calculation:

	0 (14%)	1	2	3	4	5
	-6,000	2,000	2,000	2,000	2,000	2,000
Discounted CF:	-6,000	1,754.39	1,538.94	1,349.94	1,184.16	1,038.74
Cumulative CF:	-6,000	-4,245.61	-2,706.67	-1,356.73	-172.57	866.17

Discounted Payback_A = 4 + \$172.57/\$1,038.74 = 4.17 years.

Project B:

CF_0 = -18000; $CF_{1\text{-}5}$ = 5600; I/YR = 14.

Solve for NPV_B = \$1,225.25. IRR_B = 16.80%.

MIRR calculation:

0 (14%)	1	2	3	4	5
-18,000	5,600	5,600	5,600	5,600	5,600
				× 1.14 →	6,384.00
			× $(1.14)^2$ →		7,277.76
		× $(1.14)^3$ →			8,296.65
	× $(1.14)^4$ →				9,458.18
					37,016.59

Using a financial calculator, enter N = 5; PV = -18000; PMT = 0; FV = 37016.59; and solve for $MIRR_B$ = I/YR = 15.51%.

Payback calculation:

	0	1	2	3	4	5
	-18,000	5,600	5,600	5,600	5,600	5,600
Cumulative CF:	-18,000	-12,400	-6,800	-1,200	4,400	10,000

Regular Payback_B = 3 + \$1,200/\$5,600 = 3.21 years.

Discounted payback calculation:

	0	1	2	3	4	5
(14%)	-18,000	5,600	5,600	5,600	5,600	5,600
Discounted CF:	-18,000	4,912.28	4,309.02	3,779.84	3,315.65	2,908.46
Cumulative CF:	-18,000	-13,087.72	-8,778.70	-4,998.86	-1,683.21	1,225.25

Discounted Payback_B = 4 + \$1,683.21/\$2,908.46 = 4.58 years.

Summary of capital budgeting rules results:

	Project A	Project B
NPV	\$866.16	\$1,225.25
IRR	19.86%	16.80%
MIRR	17.12%	15.51%
Payback	3.0 years	3.21 years
Discounted payback	4.17 years	4.58 years

b. If the projects are independent, both projects would be accepted since both of their NPVs are positive.

c. If the projects are mutually exclusive then only one project can be accepted, so the project with the highest positive NPV is chosen. Accept Project B.

d. The conflict between NPV and IRR occurs due to the difference in the size of the projects. Project B is 3 times larger than Project A.

12-8 a. No mitigation analysis (in millions of dollars):

0	1	2	3	4	5
12%					
-60	20	20	20	20	20

Using a financial calculator, enter the data as follows: CF_0 = -60; CF_{1-5} = 20; I/YR = 12. Solve for NPV = \$12.10 million and IRR = 19.86%.

With mitigation analysis (in millions of dollars):

0	1	2	3	4	5
12%					
-70	21	21	21	21	21

Using a financial calculator, enter the data as follows: CF_0 = -70; CF_{1-5} = 21; I/YR = 12. Solve for NPV = \$5.70 million and IRR = 15.24%.

b. The environmental effects if not mitigated could result in additional loss of cash flows and/or fines and penalties due to ill will among customers, community, etc. Therefore, even though the mine is legal without mitigation, the company needs to make sure that they have anticipated <u>all</u> costs from not doing the environmental mitigation in the original analysis.

c. Even when mitigation is considered the project has a positive NPV, so it should be undertaken. The question becomes whether you mitigate or don't mitigate for environmental problems. Under the assumption that all costs have been considered, the company would not mitigate for the environmental impact of the project since its NPV is \$12.10 million vs. \$5.70 million when mitigation costs are included in the analysis.

12-9 **a.** No mitigation analysis (in millions of dollars):

0	1	2	3	4	5
17%					
-240	80	80	80	80	80

Using a financial calculator, enter the data as follows: CF_0 = -240; CF_{1-5} = 80; I/YR = 17. Solve for NPV = \$15.95 million and IRR = 19.86%.

With mitigation analysis (in millions of dollars):

0	1	2	3	4	5
17%					
-280	84	84	84	84	84

Using a financial calculator, enter the data as follows: CF_0 = -280; CF_{1-5} = 84; I/YR = 17. Solve for NPV = -\$11.25 million and IRR = 15.24%.

b. If the utility mitigates for the environmental effects, the project is not acceptable. However, before the company chooses to do the project without mitigation, it needs to make sure that any costs of "ill will" for not mitigating for the environmental effects have been considered in the original analysis.

c. Again, the project should be undertaken only if the company does not mitigate for the environmental effects. However, it wants to make sure that it's done the analysis properly due to any "ill will" and additional "costs" that might result from undertaking the project without concern for the environmental impacts.

12-10 Project A: Using a financial calculator, enter the following data: CF_0 = -400; CF_{1-3} = 55; CF_{4-5} = 225; I/YR = 10. Solve for NPV = \$30.16.

Project B: Using a financial calculator, enter the following data: CF_0 = -600; CF_{1-2} = 300; CF_{3-4} = 50; CF_5 = 49; I/YR = 10. Solve for NPV = \$22.80.

The decision rule for mutually exclusive projects is to accept the project with the highest positive NPV. In this situation, the firm would accept Project A since NPV_A = \$30.16 is greater than NPV_B = \$22.80.

12-11 Project S: Using a financial calculator, enter the following data: CF_0 = -15000; CF_{1-5} = 4500; I/YR = 14. NPV_S = \$448.86.

Project L: Using a financial calculator, enter the following data: CF_0 = -37500; CF_{1-5} = 11100; I/YR = 14. NPV_L = \$607.20.

The decision rule for mutually exclusive projects is to accept the project with the highest positive NPV. In this situation, the firm would accept Project L since NPV_L = $607.20 is greater than NPV_S = $448.86.

12-12 Input the appropriate cash flows into the cash flow register, and then calculate NPV at 10% and the IRR of each of the projects:

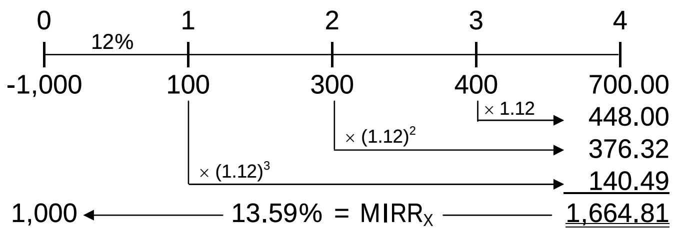
Project S: CF_0 = -1000; CF_1 = 900; CF_2 = 250; CF_{3-4} = 10; I/YR = 10. Solve for NPV_S = $39.14; IRR_S = 13.49%.

Project L: CF_0 = -1000; CF_1 = 0; CF_2 = 250; CF_3 = 400; CF_4 = 800; I/YR = 10. Solve for NPV_L = $53.55; IRR_L = 11.74%.

Since Project L has the higher NPV, it is the better project, even though its IRR is less than Project S's IRR. The IRR of the better project is IRR_L = 11.74%.

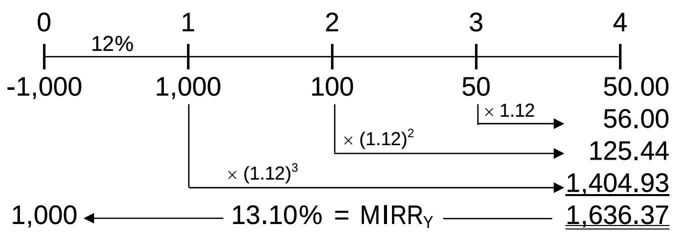
12-13 Because both projects are the same size you can just calculate each project's MIRR and choose the project with the higher MIRR.

Project X:



$1,000 = $1,664.81/(1 + $MIRR_X$)^4.

Project Y:



$1,000 = $1,636.37/(1 + $MIRR_Y$)^4.

Thus, since $MIRR_X > MIRR_Y$, Project X should be chosen.

Alternate step: You could calculate the NPVs, see that Project X has the higher NPV, and just calculate $MIRR_X$.

NPV_X = $58.02 and NPV_Y = $39.94.

12-14 a. HCC: Using a financial calculator, enter the following data: CF_0 = -600000; CF_{1-5} = -50000; I/YR = 7. Solve for NPV = -$805,009.87.

LCC: Using a financial calculator, enter the following data: CF_0 = -100000; CF_{1-5} = -175000; I/YR = 7. Solve for NPV = -$817,534.55.

Since we are examining costs, the unit chosen would be the one that has the lower PV of costs. Since HCC's PV of costs is lower than LCC's, HCC would be chosen.

b. The IRR cannot be calculated because the cash flows are all one sign. A change of sign would be needed in order to calculate the IRR.

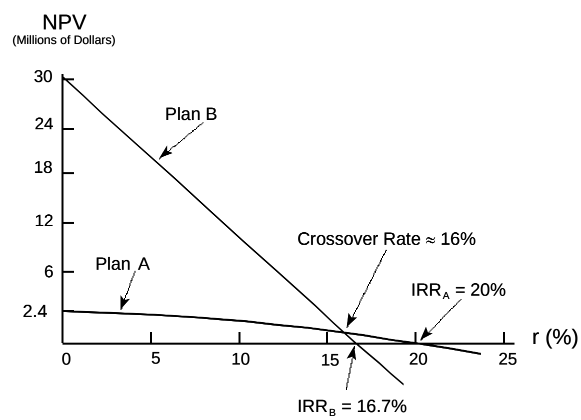
c. HCC: I/YR = 15; solve for NPV = -$767,607.75.

LCC: I/YR = 15; solve for NPV = -$686,627.14.

When the WACC increases from 7% to 15%, the PV of costs are now lower for LCC than HCC. The reason is that when you discount at a higher rate you are making negative CFs smaller and thus improving the results, unknowingly. Thus, if you were trying to risk adjust for a riskier project that consisted just of negative CFs then you would use a lower cost of capital rather than a higher cost of capital and this would properly adjust for the risk of a project with only negative CFs.

12-15 a. Using a financial calculator, calculate NPVs for each plan (as shown in the table below) and graph each plan's NPV profile.

Discount Rate	NPV Plan A	NPV Plan B
0%	$2,400,000	$30,000,000
5	1,714,286	14,170,642
10	1,090,909	5,878,484
12	857,143	3,685,832
15	521,739	1,144,596
16.7	339,332	0
20	0	-1,773,883



The crossover rate is approximately 16%. If the cost of capital is less than the crossover rate, then Plan B should be accepted; if the cost of capital is greater than the crossover rate, then Plan A is preferred. At the crossover rate, the two projects' NPVs are equal.

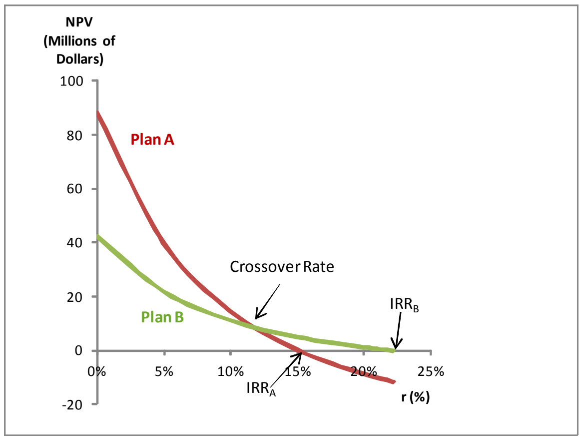
b. Yes. Assuming (1) equal risk among projects, and (2) that the cost of capital is a constant and does not vary with the amount of capital raised, the firm would take on all available projects with returns greater than its 12% WACC. If the firm had invested in all available projects with returns greater than 12%, then its best alternative would be to repay capital. Thus, the WACC is the correct reinvestment rate for evaluating a project's cash flows.

12-16 a. Using a financial calculator, we get:

NPV_A = $14,486,808. NPV_B = $11,156,893.
IRR_A = 15.03%. IRR_B = 22.26%.

b. Using a financial calculator, calculate each plan's NPVs at different discount rates (as shown in the table below) and graph the NPV profiles.

Discount Rate	NPV Plan A	NPV Plan B
0%	$88,000,000	$42,400,000
5	39,758,146	21,897,212
10	14,486,808	11,156,893
15.03	0	4,997,152
20	-8,834,690	1,245,257
22.26	-11,765,254	0



The crossover rate is somewhere between 11% and 12%.

c. To calculate the crossover rate, create Project Δ which represents the cash flow differences between the two projects. Once those cash flows are calculated find the IRR of Project Δ and this is the crossover rate. Enter the data (in millions) for Project Δ as follows:

CF_0 = -28; CF_{1-20} = 3.68; and solve for IRR = 11.71%.

d. The NPV method implicitly assumes that the opportunity exists to reinvest the cash flows generated by a project at the WACC, while use of the IRR method implies the opportunity to reinvest at the IRR. The firm will invest in all independent projects with an NPV > $0. As cash flows come in from these projects, the firm will either pay them out to investors, or use them as a substitute for outside capital which, in this case, costs 10%. Thus, since these cash flows are expected to save the firm 10%, this is their opportunity cost reinvestment rate.

The IRR method assumes reinvestment at the internal rate of return itself, which is an incorrect assumption, given a constant expected future cost of capital, and ready access to capital markets.

12-17 a. Using a financial calculator and entering each project's cash flows into the cash flow registers and entering I/YR = 12, you would calculate each project's NPV. At WACC = 12%, Project A has the greater NPV, specifically $200.41 as compared to Project B's NPV of $145.93.

b. Using a financial calculator and entering each project's cash flows into the cash flow registers, you would calculate each project's IRR. IRR_A = 18.1%; IRR_B = 24.0%.

c. Here is the MIRR for Project A when WACC = 12%:

PV costs = $\$300 + \$387/(1.12)^1 + \$193/(1.12)^2 + \$100/(1.12)^3 + \$180/(1.12)^7 = \$952.00$.

TV inflows = $\$600(1.12)^3 + \$600(1.12)^2 + \$850(1.12)^1 = \$2,547.60$.

MIRR is the discount rate that forces the TV of $2,547.60 in 7 years to equal $952.00.

Using a financial calculator enter the following inputs: N = 7, PV = -952, PMT = 0, and FV = 2547.60. Then, solve for I/YR = $MIRR_A$ = 15.10%.

Here is the MIRR for Project B when WACC = 12%:

PV costs = $405.

TV inflows = $\$134(1.12)^6 + \$134(1.12)^5 + \$134(1.12)^4 + \$134(1.12)^3 + \$134(1.12)^2 + \$134(1.12)$
= $1,217.93.

MIRR is the discount rate that forces the TV of $1,217.93 in 7 years to equal $405.

Using a financial calculator enter the following inputs: N = 7; PV = -405; PMT = 0; and FV = 1217.93. Then, solve for I/YR = $MIRR_B$ = 17.03%.

d. WACC = 12% criteria:

	Project A	Project B
NPV	$200.41	$145.93
IRR	18.1%	24.0%
MIRR	15.1%	17.0%

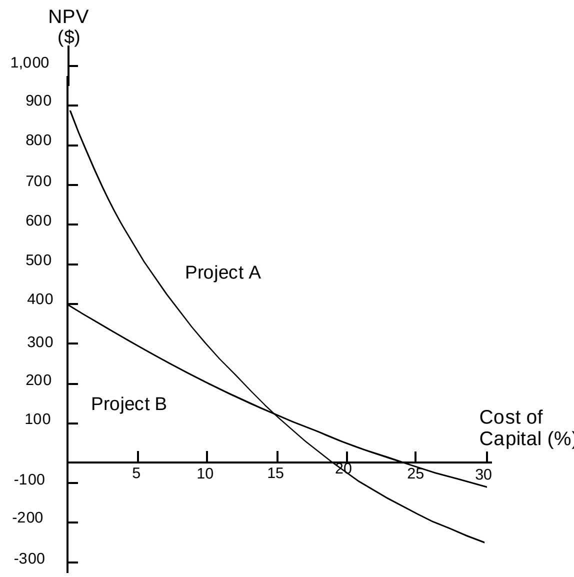
The correct decision is that Project A should be chosen because $NPV_A > NPV_B$.

At WACC = 18%, using your financial calculator enter the cash flows for each project, enter I/YR = WACC = 18, and then solve for each Project's NPV.

NPV_A = $2.66; NPV_B = $63.68.

At WACC = 18%, $NPV_B > NPV_A$ so Project B would be chosen.

e.



Discount Rate	NPV_A	NPV_B
0.0%	$890	$399
10.0	283	179
12.0	200	146
18.1	0	62
20.0	(49)	41
24.0	(138)	0
30.0	(238)	(51)

f. To calculate the crossover rate, create Project Δ which represents the cash flow differences between the two projects. The IRR of Project Δ is the crossover rate.

Year	CF_A	CF_B	$CF_\Delta = CF_A - CF_B$
0	-300	-405	105
1	-387	134	-521
2	-193	134	-327
3	-100	134	-234
4	600	134	466
5	600	134	466
6	850	134	716
7	-180	0	-180

Enter the data for Project Δ into the cash flow registers and solve for IRR_Δ = 14.53%. Note that when using your calculator you may receive an ERROR message. In order to find the IRR, you will need to store a guess for IRR, say 10%, by ■ STO 10 and then calculate IRR, IRR = 14.53%.

g. Here is the MIRR for Project A when WACC = 18%:

PV costs = $\$300 + \$387/(1.18)^1 + \$193/(1.18)^2 + \$100/(1.18)^3 + \$180/(1.18)^7 = \$883.95$.

TV inflows = $\$600(1.18)^3 + \$600(1.18)^2 + \$850(1.18)^1 = \$2,824.26$.

MIRR is the discount rate that forces the TV of $2,824.26 in 7 years to equal $883.95.

Using a financial calculator enter the following inputs: N = 7; PV = -883.95; PMT = 0; and FV = 2824.26. Then, solve for I/YR = $MIRR_A$ = 18.05%.

Here is the MIRR for Project B when WACC = 18%:

PV costs = $405.

TV inflows = $\$134(1.18)^6 + \$134(1.18)^5 + \$134(1.18)^4 + \$134(1.18)^3 + \$134(1.18)^2 + \$134(1.18)$
= $1,492.96.

MIRR is the discount rate that forces the TV of $1,492.96 in 7 years to equal $405.

Using a financial calculator enter the following inputs: N = 7; PV = -405; PMT = 0; and FV = 1492.96. Then, solve for I/YR = $MIRR_B$ = 20.49%.

12-18 Facts: 5 years remaining on lease; rent = $2,000/month; 60 payments left, payment at end of month.

New lease terms: $0/month for 9 months; $2,600/month for 51 months.

WACC = 12% annual (1% per month).

a.

0 (1%)	1	2	• • •	59	60
	-2,000	-2,000		-2,000	-2,000

PV cost of old lease: N = 60; I/YR = 1; PMT = -2000; FV = 0; PV = ? PV = -$89,910.08.

0 (1%)	1	• • •	9	10	• • •	59	60
	0		0	-2,600		-2,600	-2,600

PV cost of new lease: CF_0 = 0, $CF_{1\text{-}9}$ = 0; $CF_{10\text{-}60}$ = -2600; I/YR = 1. NPV = -$94,611.45.

Sharon should not accept the new lease because the present value of its cost is $94,611.45 – $89,910.08 = $4,701.37 greater than the old lease.

b. At t = 9 the FV of the original lease's cost = -$\$89{,}910.08(1.01)^9$ = -$98,333.33. Since lease payments for months 0-9 would be zero, we can calculate the lease payments during the remaining 51 months as follows: N = 51; I/YR = 1; PV = 98333.33; and FV = 0. Solve for PMT = -$2,470.80.

Check:

0 (1%)	1	• • •	9	10	• • •	59	60
	0		0	-2,470.80		-2,470.80	-2,470.80

PV cost of new lease: CF_0 = 0; $CF_{1\text{-}9}$ = 0; $CF_{10\text{-}60}$ = -2470.80; I/YR = 1. NPV = -$89,909.99.

Except for rounding; the PV cost of this lease equals the PV cost of the old lease.

c.

Period	Old Lease	New Lease	ΔLease
0	0	0	0
1-9	-2,000	0	-2,000
10-60	-2,000	-2,600	600

CF_0 = 0; $CF_{1\text{-}9}$ = -2000; $CF_{10\text{-}60}$ = 600; IRR = ? IRR = 1.9113%. This is the periodic rate. To obtain the nominal cost of capital, multiply by 12: 12(0.019113) = 22.94%.

Check: Old lease terms:

N = 60; I/YR = 1.9113; PMT = -2000; FV = 0; PV = ? PV = -$71,039.17.

New lease terms:

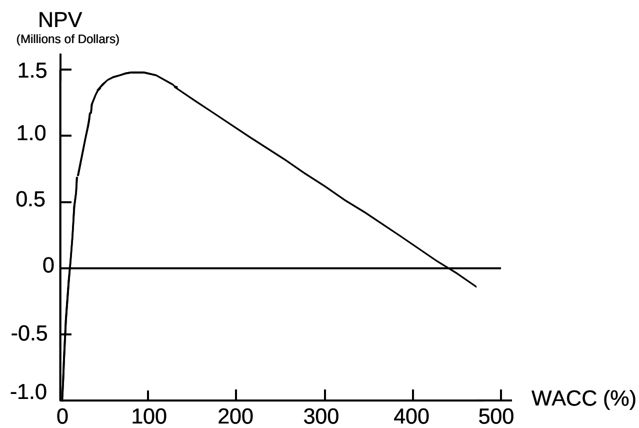
CF_0 = 0; $CF_{1\text{-}9}$ = 0; $CF_{10\text{-}60}$ = -2600; I/YR = 1.9113; NPV = ? NPV = -$71,038.98.

Except for rounding differences; the costs are the same.

12-19 a. The project's expected cash flows are as follows (in millions of dollars):

Time	Net Cash Flow
0	($ 2.0)
1	13.0
2	(12.0)

We can construct the following NPV profile:



WACC	NPV
0%	($1,000,000)
10	(99,174)
50	1,333,333
80	1,518,519
100	1,500,000
200	1,000,000
300	500,000
400	120,000
410	87,659
420	56,213
430	25,632
450	(33,058)

b. If WACC = 10%, reject the project since NPV < \$0. Its NPV at WACC = 10% is equal to -\$99,174. But if WACC = 20%, accept the project because NPV > \$0. Its NPV at WACC = 20% is \$500,000.

c. Other possible projects with multiple rates of return could be nuclear power plants where disposal of radioactive wastes is required at the end of the project's life.

d. MIRR @ WACC = 10%:

PV costs = \$2,000,000 + \$12,000,000/$(1.10)^2$ = \$11,917,355.

FV inflows = \$13,000,000 × 1.10 = \$14,300,000.

Using a financial calculator enter the following data: N = 2; PV = -11917355; PMT = 0; and FV = 14300000. Then solve for I/YR = MIRR = 9.54%. (Reject the project since MIRR < WACC.)

MIRR @ WACC = 20%:

PV costs = \$2,000,000 + \$12,000,000/$(1.20)^2$ = \$10,333,333.

FV inflows = \$13,000,000 × 1.20 = \$15,600,000.

Using a financial calculator enter the following data: N = 2; PV = -10333333; PMT = 0; and FV = 15600000. Then solve for I/YR = MIRR = 22.87%. (Accept the project since MIRR > WACC.)

Looking at the results, this project's MIRR calculations lead to the same decisions as the NPV calculations. However, the MIRR method will not always lead to the same accept/reject decision as the NPV method. Decisions involving two mutually exclusive projects that differ in scale (size) may have MIRRs that conflict with NPV. In those situations, the NPV method should be used.

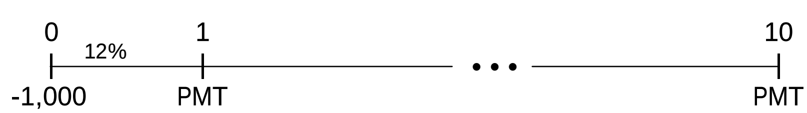
12-20 Since the IRR is the discount rate at which the NPV of a project equals zero, the project's inflows can be evaluated at the IRR and the present value of these inflows must equal the initial investment.

Using a financial calculator enter the following: CF_0 = 0; CF_1 = 7500; N_j = 10; CF_2 = 10000; N_j = 10; I/YR = 10.98. NPV = \$65,002.11.

Therefore, the initial investment for this project is \$65,002.11. Using a calculator, the project's NPV at the firm's WACC can now be solved.

CF_0 = -65002.11; CF_1 = 7500; N_j = 10; CF_2 = 10000; N_j = 10; I/YR = 9. NPV = \$10,239.20.

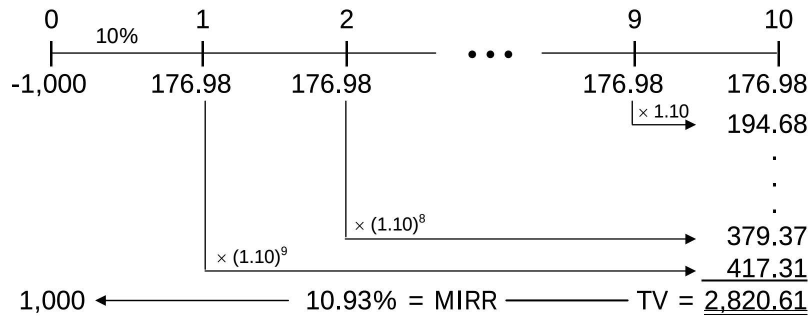
12-21 Step 1: Determine the PMT:



The IRR is the discount rate at which the NPV of a project equals zero. Since we know the project's initial investment, its IRR, the length of time that the cash flows occur, and that each cash flow is the same, then we can determine the project's cash flows by setting it up as a 10-year annuity. With a financial calculator, input N = 10, I/YR = 12, PV = -1000, and FV = 0 to obtain PMT = \$176.98.

Step 2: Since we've been given the WACC, once we have the project's cash flows we can now determine the project's MIRR.

Calculate the project's MIRR:



FV of inflows: With a financial calculator, input N = 10, I/YR = 10, PV = 0, and PMT = -176.98 to obtain FV = $2,820.61.

Calculate MIRR: Then input N = 10, PV = -1000, PMT = 0, and FV = 2820.61 to obtain I/YR = MIRR = 10.93%.

12-22 The MIRR can be solved with a financial calculator by finding the terminal future value of the cash inflows and the initial present value of cash outflows, and solving for the discount rate that equates these two values. In this instance, the MIRR is given, but a cash outflow is missing and must be calculated. Therefore, if the terminal future value of the cash inflows is found, it can be entered into a financial calculator, along with the number of years the project lasts and the MIRR, to solve for the initial present value of the cash outflows. One of these cash outflows occurs in Year 0 and the remaining value must be the present value of the missing cash outflow in Year 2.

Cash Inflows	Compounding Rate	FV in Year 5 @ 10%
CF_1 = $202	$\times (1.10)^4$	$ 295.75
CF_3 = 196	$\times (1.10)^2$	237.16
CF_4 = 350	× 1.10	385.00
CF_5 = 451	× 1.00	451.00
		$1,368.91

Using the financial calculator to solve for the present value of cash outflows: N = 5; I/YR = 14.14; PV = ?; PMT = 0; FV = 1368.91. Solve for PV = $706.62.

The total present value of cash outflows is $706.62, and since the outflow for Year 0 is $500, the present value of the Year 2 cash outflow is $206.62. Therefore, the missing cash outflow for Year 2 is $206.62 $\times (1.1)^2$ = $250.01.

Comprehensive/Spreadsheet Problem

Note to Instructors:
The solution to this problem is <u>not</u> provided to students at the back of their text. Instructors can access the *Excel* file on the textbook's website or the Instructor's Resource CD.

12-23 a. Project A:

Using a financial calculator, enter the following data:

CF_0 = -30; CF_1 = 5; CF_2 = 10; CF_3 = 15; CF_4 = 20; I/YR = 10; and solve for NPV_A = \$7.74; IRR_A = 19.19%.

Calculate $MIRR_A$ at WACC = 10%:

Step 1: Calculate the NPV of the uneven cash flow stream, so its FV can then be calculated. With a financial calculator, enter the cash flow stream into the cash flow registers, then enter I/YR = 10, and solve for NPV = \$37.739.

Step 2: Calculate the FV of the cash flow stream as follows:

Enter N = 4, I/YR = 10, PV = -37.739, and PMT = 0 to solve for FV = \$55.255.

Step 3: Calculate $MIRR_A$ as follows:

Enter N = 4, PV = -30, PMT = 0, and FV = 55.255 to solve for I/YR = 16.50%.

Payback A (cash flows in millions):

Period	Annual Cash Flows	Cumulative
0	(\$30)	(\$30)
1	5	(25)
2	10	(15)
3	15	0
4	20	20

$Payback_A$ = 3 years.

Discounted Payback A (cash flows in millions):

Period	Annual Cash Flows	Discounted @10% Cash Flows	Cumulative Cash Flows
0	(\$30)	(\$30.00)	(\$30.00)
1	5	4.55	(25.45)
2	10	8.26	(17.19)
3	15	11.27	(5.92)
4	20	13.66	7.74

Discounted $Payback_A$ = 3 + \$5.92/\$13.66 = 3.43 years.

Project B:

Using a financial calculator, enter the following data:

CF_0 = -30; CF_1 = 20; CF_2 = 10; CF_3 = 8; CF_4 = 6; I/YR = 10; and solve for NPV_B = \$6.55; IRR_B = 22.52%.

Calculate $MIRR_B$ at WACC = 10%:

Step 1: Calculate the NPV of the uneven cash flow stream, so its FV can then be calculated. With a financial calculator, enter the cash flow stream into the cash flow registers, then enter I/YR = 10, and solve for NPV = $36.55.

Step 2: Calculate the FV of the cash flow stream as follows:

Enter N = 4, I/YR = 10, PV = -36.55, and PMT = 0 to solve for FV = $53.52.

Step 3: Calculate $MIRR_B$ as follows:

Enter N = 4, PV = -30, PMT = 0, and FV = 53.52 to solve for I/YR = 15.57%.

Payback B (cash flows in millions):

Period	Annual Cash Flows	Cumulative
0	($30)	($30)
1	20	(10)
2	10	0
3	8	8
4	6	14

$Payback_B$ = 2 years.

Discounted Payback B (cash flows in millions):

Period	Annual Cash Flows	Discounted @10% Cash Flows	Cumulative Cash Flows
0	($30)	($30.00)	($30.00)
1	20	18.18	(11.82)
2	10	8.26	(3.56)
3	8	6.01	2.45
4	6	4.10	6.55

Discounted $Payback_B$ = 2 + $3.56/$6.01 = 2.59 years.

Summary:

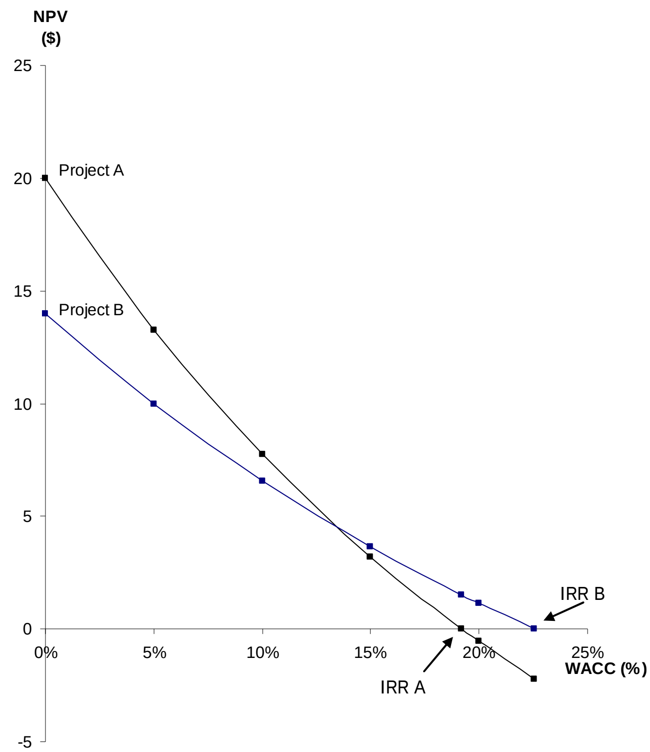
	Project A	Project B
NPV	$7.74	$6.55
IRR	19.19%	22.52%
MIRR	16.50%	15.57%
Payback	3 years	2 years
Discounted Payback	3.43 years	2.59 years

b. If the two projects are independent, both projects will be accepted because their NPVs are greater than zero.

c. If the two projects are mutually exclusive, at WACC = 10% Project A should be chosen since $NPV_A > NPV_B$.

d.

WACC	NPV_A	NPV_B
0%	$20.00	$14.00
5	13.24	9.96
10	7.74	6.55
15	3.21	3.64
19.19	0	1.52
20	(0.56)	1.13
22.52	(2.23)	0



e. At WACC = 5% and the two projects are mutually exclusive, $NPV_A > NPV_B$ so choose Project A. This doesn't change our recommendation. At WACC = 15% and the two projects are mutually exclusive, $NPV_B > NPV_A$ so choose Project B. This does change our recommendation. Both of these decisions can be made from looking at the NPV profile in Part d.

f. The crossover rate is the cost of capital at which the NPV profiles of two projects cross and, thus, at which the projects' NPVs are equal. At a cost of capital less than the crossover rate there is a conflict between NPV and IRR but at a cost of capital greater than the crossover rate there is no conflict between NPV and IRR.

g. It is not possible for conflicts between NPV and IRR when independent projects are being evaluated. NPV is greater than zero at all WACCs < IRR, so the NPV rule would accept these projects. At IRR > WACC, all projects meeting this criterion would be accepted by the IRR rule.

h. Looking at both the payback and discounted payback methods, Project B looks better than A. The faster the payback, the more liquid and less risky the project.

i. The cutoff chosen for both payback periods is arbitrary—but usually based on specific information the firm has on past projects. However, the criteria for the NPV and the IRR methods are not arbitrary.

j. The MIRR is the discount rate at which the present value of a project's cost is equal to the present value of its terminal value, where the terminal value is found as the sum of the future values of the cash inflows, compounded at the firm's cost of capital. The difference between the IRR and MIRR is the reinvestment rate assumption. The reinvestment rate of the IRR is the project's return, while the reinvestment rate of the MIRR is the firm's cost of capital. Consequently, MIRR gives a better idea of the rate of return on the project.

k. Academics prefer NPV to IRR because NPV gives an estimate (a dollar value) of how much a potential project will contribute to shareholder wealth. However, executives tend to like IRR because it gives a measure of the project's "bang for the buck" and gives information concerning a project's safety margin.

Integrated Case

12-24
Yoshikawa Components Company
Basics of Capital Budgeting

You recently went to work for Yoshikawa Components Company, a supplier of auto repair parts used in the after-market with products from Nissan, Honda, Subaru, and other automakers. Your boss, the chief financial officer (CFO), has just handed you the estimated cash flows for two proposed projects. Project L involves adding a new item to the firm's ignition system line; it would take some time to build up the market for this product, so the cash inflows would increase over time. Project S involves an add-on to an existing line, and its cash flows would decrease over time. Both projects have 3-year lives because Yoshikawa is planning to introduce entirely new models after 3 years.

Here are the projects' after-tax cash flows (in thousands of dollars):

	0	1	2	3
Project L	**-100**	**10**	**60**	**80**
Project S	**-100**	**70**	**50**	**20**

Depreciation, salvage values, net operating working capital requirements, and tax effects are all included in these cash flows. The CFO also made subjective risk assessments of each project, and he concluded that both projects have risk characteristics that are similar to the firm's average project. Allied's WACC is 10%. You must determine whether one or both of the projects should be accepted.

A.	**What is capital budgeting? Are there any similarities between a firm's capital budgeting decisions and an individual's investment decisions?**

Answer: **[Show S12-1 through S12-3 here.] Capital budgeting is the process of analyzing additions to fixed assets. Capital budgeting is important because, more than anything else, fixed asset investment decisions chart a company's course for the future. Conceptually, the capital budgeting process is identical to the decision process used by individuals making investment decisions. These steps are involved:**

1. **Estimate the cash flows—interest and maturity value or dividends in the case of bonds and stocks, operating cash flows in the case of capital projects.**
2. **Assess the riskiness of the cash flows.**
3. **Determine the appropriate discount rate, based on the riskiness of the cash flows and the general level of interest rates. This is called the project cost of capital in capital budgeting.**
4. **Find (a) the PV of the expected cash flows and/or (b) the asset's rate of return.**
5. **If the PV of the inflows is greater than the PV of the outflows (the NPV is positive), or if the calculated rate of return (the IRR) is higher than the project cost of capital, accept the project.**

B. **What is the difference between independent and mutually exclusive projects? Between projects with normal and nonnormal cash flows?**

Answer: **[Show S12-4 and S12-5 here.] Projects are independent if the cash flows of one are not affected by the acceptance of the other. Conversely, two projects are mutually exclusive if acceptance of one impacts adversely the cash flows of the other; that is, at most one of two or more such projects may be accepted. Put another way, when projects are mutually exclusive it means that they do**

the same job. For example, a forklift truck versus a conveyor system to move materials, or a bridge versus a ferry boat.

Projects with normal cash flows have outflows, or costs, in the first year (or years) followed by a series of inflows. Projects with nonnormal cash flows have one or more outflows after the inflow stream has begun. Here are some examples:

	Inflow (+) or Outflow (-) in Year					
	0	1	2	3	4	5
Normal	-	+	+	+	+	+
	-	-	+	+	+	+
	-	-	-	+	+	+
Nonnormal	-	+	+	+	+	-
	-	+	+	-	+	-
	+	+	+	-	-	-

C. (1) Define the term net present value (NPV). What is each project's NPV?

Answer: [Show S12-6 through S12-10 here.] The net present value (NPV) is simply the sum of the present values of a project's cash flows:

$$NPV = \sum_{t=0}^{N} \frac{CF_t}{(1+WACC)^t}.$$

Project L's NPV is $18.79:

	0	1	2	3
	10%			
	-100.00	10	60	80
$\times 1/1.10$	9.09	← 10		
$\times 1/(1.10)^2$	49.59		← 60	
$\times 1/(1.10)^3$	60.11			← 80
	18.79 = NPV_L			

NPVs are easy to determine using a calculator with an NPV function. Enter the cash flows sequentially, with outflows entered as negatives; enter the WACC; and then press the NPV button to obtain

the project's NPV, $18.78 (note the penny rounding difference). The NPV of Project S is NPV_S = $19.98.

C. (2) What is the rationale behind the NPV method? According to NPV, which project(s) should be accepted if they are independent? Mutually exclusive?

Answer: [Show S12-11 here.] The rationale behind the NPV method is straightforward: If a project has NPV = $0, then the project generates exactly enough cash flows (1) to recover the cost of the investment and (2) to enable investors to earn their required rates of return (the opportunity cost of capital). If NPV = $0, then in a financial (but not an accounting) sense, the project breaks even. If the NPV is positive, then more than enough cash flow is generated, and conversely if NPV is negative.

Consider Project L's cash inflows, which total $150. They are sufficient (1) to return the $100 initial investment, (2) to provide investors with their 10% aggregate opportunity cost of capital, and (3) to still have $18.78 left over on a present value basis. This $18.78 excess PV belongs to the shareholders—the debtholders' claims are fixed—so the shareholders' wealth will be increased by $18.78 if Project L is accepted. Similarly, Allied's shareholders gain $19.98 in value if Project S is accepted.

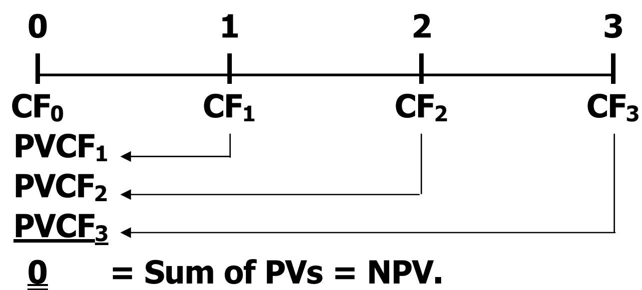
If Projects L and S are <u>independent</u>, then both should be accepted, because both add to shareholders' wealth, hence to the stock price. If the projects are <u>mutually exclusive</u>, then Project S should be chosen over L, because S adds more to the value of the firm than L does.

C.	(3)	**Would the NPVs change if the WACC changed? Explain.**

Answer: The NPV of a project is <u>dependent</u> on the WACC used. Thus, if the WACC changed, the NPV of each project would change. NPV declines as WACC increases, and NPV rises as WACC falls.

D.	(1)	**Define the term <u>internal rate of return (IRR)</u>. What is each project's IRR?**

Answer: [Show S12-12 here.] The <u>internal rate of return (IRR)</u> is that discount rate which forces the NPV of a project to equal zero:



Expressed as an equation, we have:

$$\text{IRR: } \sum_{t=0}^{N} \frac{CF_t}{(1+\text{IRR})^t} = \$0 = \text{NPV}.$$

Note that the IRR equation is the same as the NPV equation, except that to find the IRR the equation is solved for the particular discount rate, IRR, which forces the project's NPV to equal zero (the IRR) rather than using the WACC in the denominator and finding NPV. Thus, the two approaches differ in only one respect: In the NPV method, a discount rate is specified (the project's WACC) and the equation is solved for NPV, while in the IRR method, the NPV is specified to equal zero and the discount rate (IRR) that forces this equality is found.

Project L's IRR is 18.1%:

0	1	2	3
18.1%			
-100.00	10	60	80
8.47 ← × 1/1.181			
43.02 ← × $1/(1.181)^2$			
48.57 ← × $1/(1.181)^3$			
0.06	$0 if IRR_L = 18.1% is used as the discount rate.		

Therefore, $IRR_L \approx$ 18.1%.

A financial calculator is extremely helpful when calculating IRRs. The cash flows are entered sequentially, and then the IRR button is pressed. For Project S, $IRR_S \approx$ 23.6%. Note that with many calculators, you can enter the cash flows into the cash flow register, also enter WACC = I/YR, and then calculate both NPV and IRR by pressing the appropriate buttons.

D. (2) How is the IRR on a project related to the YTM on a bond?

Answer: [Show S12-13 here.] The IRR is to a capital project what the YTM is to a bond—it is the expected rate of return on the project, just as the YTM is the promised rate of return on a bond.

D. (3) What is the logic behind the IRR method? According to IRR, which project(s) should be accepted if they are independent? Mutually exclusive?

Answer: [Show S12-14 here.] IRR measures a project's profitability in the rate of return sense: If a project's IRR equals its cost of capital, then its cash flows are just sufficient to provide investors with their required rates of return. An IRR greater than WACC implies an economic profit, which accrues to the firm's shareholders, while an

IRR less than WACC indicates an economic loss, or a project that will not earn enough to cover its cost of capital.

Projects' IRRs are compared to their costs of capital, or hurdle rates. Since Projects L and S both have a hurdle rate of 10%, and since both have IRRs greater than that hurdle rate, both should be accepted if they are independent. However, if they are mutually exclusive, Project S would be selected, because it has the higher IRR.

D.	**(4)**	**Would the projects' IRRs change if the WACC changed?**

Answer: **IRRs are independent of the WACC. Therefore, neither IRR_S nor IRR_L would change if WACC changed. However, the acceptability of the projects could change—L would be rejected if WACC were greater than 18.1%, and S would be rejected if WACC were greater than 23.6%.**

E.	**(1)**	**Draw NPV profiles for Projects L and S. At what discount rate do the profiles cross?**

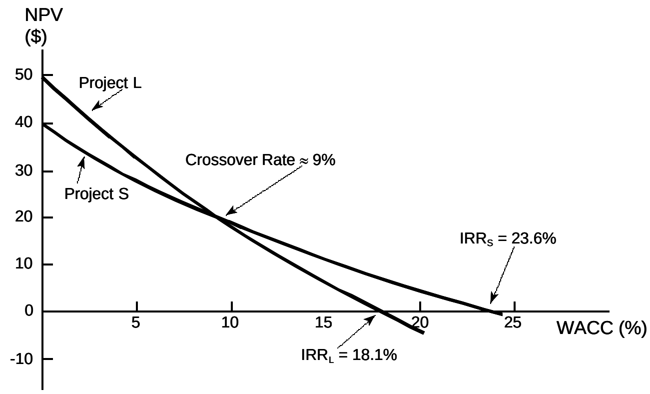
Answer: **[Show S12-15 through S12-18 here.] The NPV profiles are plotted in the figure below. Note the following points:**

1. **The Y-intercept is the project's NPV when WACC = 0%. This is $50 for L and $40 for S.**

2. **The X-intercept is the project's IRR. This is 18.1% for L and 23.6% for S.**

3. **NPV profiles are curves rather than straight lines. To see this, note that these profiles approach cost = -$100 as WACC approaches infinity.**

4. **From the figure below, it appears that the crossover rate is between 8% and 9%.**



<u>WACC</u>	<u>NPV_L</u>	<u>NPV_S</u>
0%	$50	$40
5	33	29
10	19	20
15	7	12
20	(4)	5

E. (2) Look at your NPV profile graph without referring to the actual NPVs and IRRs. Which project(s) should be accepted if they are independent? Mutually exclusive? Explain. Are your answers correct at any WACC less than 23.6%?

Answer: The NPV profiles show that the IRR and NPV criteria lead to the same accept/reject decision for any <u>independent</u> project. Consider Project L. It intersects the X-axis at its IRR, 18.1%. According to the IRR rule, L is acceptable if WACC is less than 18.1%. Also, at any WACC less than 18.1%, L's NPV profile will be above the X-axis, so its NPV will be greater than $0. <u>Thus, for any independent project, NPV and IRR lead to the same accept/reject decision</u>.

Now assume that L and S are mutually exclusive. In this case, a conflict might arise. First, note that IRR_S = 23.6% > 18.1% = IRR_L. Therefore, regardless of the size of WACC, Project S would be ranked higher by the IRR criterion. However, the NPV profiles show that $NPV_L > NPV_S$ if WACC is less than the crossover rate. Therefore, for

any WACC <u>less than</u> the crossover rate, say WACC = 7%, the NPV rule says choose L, but the IRR rule says choose S. <u>Thus, if WACC is less than the crossover rate, a ranking conflict occurs.</u>

F.	**(1)**	**What is the underlying cause of ranking conflicts between NPV and IRR?**

Answer: **[Show S12-19 here.] For normal projects' NPV profiles to cross, one project must have both a higher vertical axis intercept and a steeper slope than the other. A project's vertical axis intercept typically depends on (1) the <u>size</u> of the project and (2) the <u>size and timing pattern of the cash flows</u>—large projects, and ones with large distant cash flows, would generally be expected to have relatively high vertical axis intercepts. The slope of the NPV profile depends entirely on the <u>timing pattern of the cash flows</u>—long-term projects have steeper NPV profiles than short-term projects. Thus, we conclude that NPV profiles can cross in two situations: (1) when mutually exclusive projects differ in <u>scale (or size)</u> and (2) when the projects' cash flows differ in terms of the <u>timing pattern</u> of their cash flows (as for Projects L and S).**

F.	**(2)**	**What is the reinvestment rate assumption, and how does it affect the NPV versus IRR conflict?**

Answer: **[Show S12-20 here.] <u>The underlying cause of ranking conflicts is the reinvestment rate assumption</u>. All DCF methods implicitly assume that cash flows can be reinvested at some rate, regardless of what is actually done with the cash flows. Discounting is the reverse of compounding. Since compounding assumes reinvestment, so does discounting. NPV and IRR are both found by discounting, so they both implicitly assume some discount rate. <u>Inherent in the NPV calculation is the assumption that cash flows can be reinvested at</u>**

the project's cost of capital, while the IRR calculation assumes reinvestment at the IRR rate.

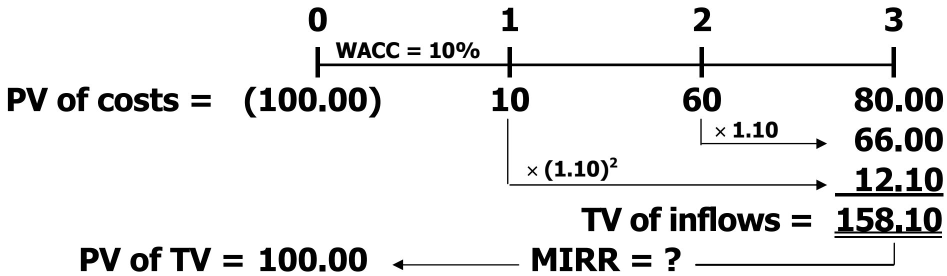
F.	**(3)**	**Which method is the best? Why?**

Answer: **Whether NPV or IRR gives better rankings depends on which has the better reinvestment rate assumption. Normally, the NPV's assumption is better. The reason is as follows: A project's cash inflows are generally used as substitutes for outside capital, that is, projects' cash flows replace outside capital and, hence, save the firm the cost of outside capital. Therefore, in an opportunity cost sense, a project's cash flows are reinvested at the cost of capital.**

Note, however, that NPV and IRR always give the same accept/reject decisions for independent projects, so IRR can be used just as well as NPV when independent projects are being evaluated. The NPV versus IRR conflict arises only if mutually exclusive projects are involved.

G.	**(1)**	**Define the term modified IRR (MIRR). Find the MIRRs for Projects L and S.**

Answer: **[Show S12-21 and S12-22 here.] MIRR is that discount rate which equates the present value of the terminal value of the inflows, compounded at the cost of capital, to the present value of the costs. Here is the setup for calculating Project L's modified IRR:**



$$\$100 = \frac{\$158.10}{(1+\text{MIRR})^3}$$

$$\text{PV costs} = \frac{\text{TV}}{(1+\text{MIRR})^N} = \sum_{t=0}^{N} \frac{\text{COF}_t}{(1+\text{WACC})^t} = \frac{\sum_{t=1}^{N} \text{CIF}_t (1+r)^{N-t}}{(1+\text{MIRR})^N}.$$

After you calculate the TV, enter N = 3, PV = -100, PMT = 0, FV = 158.1, and then press I/YR to get the answer, MIRR_L = 16.5%. We could calculate MIRR_S similarly: MIRR_S = 16.9%. Thus, Project S is ranked higher than L. This result is consistent with the NPV decision.

G. (2) What are the MIRR's advantages and disadvantages vis-à-vis the NPV?

Answer: [Show S12-23 here.] MIRR does not always lead to the same decision as NPV when mutually exclusive projects are being considered. In particular, small projects often have a higher MIRR, but a lower NPV, than larger projects. Thus, MIRR is not a perfect substitute for NPV, and NPV remains the single best decision rule. However, MIRR is superior to the regular IRR, and if a rate of return measure is needed, MIRR should be used.

Business executives agree. Business executives prefer to compare projects' rates of return to comparing their NPVs. This is an empirical fact. As a result, financial managers are substituting MIRR for IRR in their discussions with other corporate executives. This fact was brought out in the October 1989 FMA meetings,

where executives from DuPont and Hershey, among others, all reported a switch from IRR to MIRR.

H. (1) What is the payback period? Find the paybacks for Projects L and S.

Answer: **[Show S12-24 through S12-26 here.] The <u>payback period</u> is the expected number of years required to recover a project's cost. We calculate the payback by developing the <u>cumulative cash flows</u> as shown below for Project L (in thousands of dollars):**

	Expected NCF		
Year	**Annual**	**Cumulative**	
0	**($100)**	**($100)**	
1	**10**	**(90)**	
2	**60**	**(30)**	**Payback is between**
3	**80**	**50 ←**	**t = 2 and t = 3**

0	1	2	3
-100	10	60	80
	-90	-30	50

Project L's $100 investment has not been recovered at the end of Year 2, but it has been more than recovered by the end of Year 3. Thus, the recovery period is between 2 and 3 years. If we assume that the cash flows occur evenly over the year, then the investment is recovered $30/$80 = 0.375 ≈ 0.4 into Year 3. Therefore, $Payback_L$ = 2.4 years. Similarly, $Payback_S$ = 1.6 years.

H. (2) What is the rationale for the payback method? According to the payback criterion, which project(s) should be accepted if the firm's maximum acceptable payback is 2 years, if Projects L and S are independent? If Projects L and S are mutually exclusive?

Answer: **Payback represents a type of <u>"break-even" analysis</u>: The payback period tells us when the project will break even in a cash flow**

sense. With a required payback of 2 years, Project S is acceptable, but Project L is not. Whether the two projects are independent or mutually exclusive makes no difference in this case.

H. (3) What is the difference between the regular and discounted payback methods?

Answer: [Show S12-27 here.] Discounted payback is similar to payback except that discounted rather than raw cash flows are used.

Optional Question

What is Project L's discounted payback, assuming a 10% cost of capital?

Answer:

	Expected Net Cash Flows		
Year	**Raw**	**Discounted**	**Cumulative**
0	($100)	($100.00)	$100.00)
1	10	9.09	(90.91)
2	60	49.59	(41.32)
3	80	60.11	18.79

Discounted payback$_L$ = 2 + ($41.32/$60.11) = 2.69 = 2.7 years. Versus 2.4 years for the regular payback.

H. (4) What are the two main disadvantages of discounted payback? Is the payback method of any real usefulness in capital budgeting decisions? Explain.

Answer: Regular payback has three critical deficiencies: (1) It ignores the time value of money. (2) It ignores the cash flows that occur after the payback period. (3) Unlike the NPV, which tells us by how much the project should increase shareholder wealth, and the IRR, which tells us how much a project yields over the cost of capital, the payback merely tells us when we get our investment back.

Discounted payback does consider the time value of money, but it still fails to consider cash flows after the payback period and it gives us no specific decision rule for acceptance; hence, it has 2 basic flaws. In spite of its deficiency, many firms today still calculate the discounted payback and give some weight to it when making capital budgeting decisions. However, payback is not generally used as the primary decision tool. Rather, it is used as a rough measure of a project's liquidity and riskiness.

I. As a separate project (Project P), the firm is considering sponsoring a pavilion at the upcoming World's Fair. The pavilion would cost \$800,000, and it is expected to result in \$5 million of incremental cash inflows during its 1 year of operation. However, it would then take another year, and \$5 million of costs, to demolish the site and return it to its original condition. Thus, Project P's expected cash flows (in millions of dollars) look like this:

0	1	2
-0.8	5.0	-5.0

The project is estimated to be of average risk, so its WACC is 10%.

I. (1) What is Project P's NPV? What is its IRR? Its MIRR?

Answer: [Show S12-28 here.] Here is the time line for the cash flows, and the NPV:

0	10% → 1	2
-800,000	5,000,000	-5,000,000

NPV_P = -\$386,776.86.

We can find the NPV by entering the cash flows into the cash flow register, entering I/YR = 10, and then pressing the NPV button.

However, calculating the IRR presents a problem. With the cash flows in the register, press the IRR button. An HP-10BII financial calculator will give the message "error-soln." This means that Project P has <u>multiple IRRs</u>. An HP-17BII will ask for a guess. If you guess 10%, the calculator will show IRR = 25%. If you guess a high number, such as 200%, it will show the second IRR, 400%.[1] The MIRR of Project P = 5.6%, and is found by calculating the discount rate that equates the terminal value ($5.5 million) to the present value of costs ($4.93 million).

I.	**(2)**	**Draw Project P's NPV profile. Does Project P have normal or nonnormal cash flows? Should this project be accepted? Explain.**

Answer: [Show S12-29 through S12-31 here.] You could put the cash flows in your calculator and then enter a series of I/YR values, get an NPV for each, and then plot the points to construct the NPV profile. We used a spreadsheet model to automate the process and then to draw the profile. Note that the profile crosses the X-axis twice, at 25% and at 400%, signifying two IRRs. Which IRR is correct? In one sense, they both are—both cause the project's NPV to equal zero. However, in another sense, both are wrong—neither has any economic or financial significance.

Project P has <u>nonnormal cash flows</u>; that is, it has more than one change of signs in the cash flows. Without this nonnormal cash flow pattern, we would not have the multiple IRRs.

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[1] Looking at the figure on the next page, if you guess an IRR to the <u>left</u> of the peak NPV rate, the lower IRR will appear. If you guess IRR > peak NPV rate, the higher IRR will appear.

Since Project P's NPV is negative, the project should be rejected, even though both IRRs (25% and 400%) are greater than the project's 10% WACC. The MIRR of 5.6% also supports the decision that the project should be rejected.