

Chapter 10
The Basics of Capital Budgeting:
Evaluating Cash Flows
ANSWERS TO END-OF-CHAPTER QUESTIONS

- 10-1 a. Capital budgeting is the whole process of analyzing projects and deciding whether they should be included in the capital budget. This process is of fundamental importance to the success or failure of the firm as the fixed asset investment decisions chart the course of a company for many years into the future. The payback, or payback period, is the number of years it takes a firm to recover its project investment. Payback may be calculated with either raw cash flows (regular payback) or discounted cash flows (discounted payback). In either case, payback does not capture a project's entire cash flow stream and is thus not the preferred evaluation method. Note, however, that the payback does measure a project's liquidity, and hence many firms use it as a risk measure.
- b. Mutually exclusive projects cannot be performed at the same time. We can choose either Project 1 or Project 2, or we can reject both, but we cannot accept both projects. Independent projects can be accepted or rejected individually.
- c. The net present value (NPV) and internal rate of return (IRR) techniques are discounted cash flow (DCF) evaluation techniques. These are called DCF methods because they explicitly recognize the time value of money. NPV is the present value of the project's expected future cash flows (both inflows and outflows), discounted at the appropriate cost of capital. NPV is a direct measure of the value of the project to shareholders. The internal rate of return (IRR) is the discount rate that equates the present value of the expected future cash inflows and outflows. IRR measures the rate of return on a project, but it assumes that all cash flows can be reinvested at the IRR rate. The profitability index is the ratio of the present value of future cash flows to the project's initial cost. It shows the relative profitability of any project. A profitability index greater than 1 is equivalent to a positive NPV project.
- d. The modified internal rate of return (MIRR) assumes that cash flows from all projects are reinvested at the cost of capital as opposed to the project's own IRR. This makes the modified internal rate of return a better indicator of a project's true profitability.
- e. An NPV profile is the plot of a project's NPV versus its cost of capital. The crossover rate is the cost of capital at which the NPV profiles for two projects intersect indicating that at that point their NPVs are equal.

- f. Capital projects with nonnormal cash flows have a large cash outflow either sometime during or at the end of their lives. A common problem encountered when evaluating projects with nonnormal cash flows is multiple IRRs. A project has normal cash flows if one or more cash outflows (costs) are followed by a series of cash inflows.
 - g. The mathematics of the NPV method imply that project cash flows are reinvested at the cost of capital while the IRR method assumes reinvestment at the IRR. Since project cash flows can be replaced by new external capital that costs r , the proper reinvestment rate assumption is the cost of capital, and thus the best capital budget decision rule is NPV.
 - h. A replacement chain is a method of comparing mutually exclusive projects that have unequal lives. Each project is replicated such that they will both terminate in a common year. If projects with lives of 3 years and 5 years are being evaluated, the 3-year project would be replicated 5 times and the 5-year project replicated 3 times; thus, both projects would terminate in 15 years. Not all projects maximize their NPV if operated over their engineering lives and therefore it may be best to terminate a project prior to its potential life. The economic life is the number of years a project should be operated to maximize its NPV, and is often less than the maximum potential life. Capital rationing occurs when a firm's management limits its capital expenditures to an amount less than would be required to fund the optimal capital budget. The equivalent annual annuity method is an alternative method of comparing mutually exclusive projects that have unequal lives. This method converts the annual cash flows under the alternative investments into a constant cash flow stream whose NPV is equal to the NPV of the initial stream.
- 10-2 Projects requiring greater investments or that have greater risk should be given detailed analysis the capital budgeting process.
- 10-3 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.
- 10-4 This question is related to Question 10-3 and the same rationale applies. With regard to the second part of the question, the answer is no; the IRR rankings are constant and independent of the firm's cost of capital.

- 10-5 The NPV and IRR methods both involve compound interest, and the mathematics of discounting requires an assumption about reinvestment rates. 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 which assumes reinvestment at the cost of capital.
- 10-6 Generally, the failure to employ common-life analysis in such situations will bias the NPV against the shorter project because it "gets no credit" for profits beyond its initial life, even though it could possibly be "renewed" and thus provide additional NPV.

SOLUTIONS TO END-OF-CHAPTER PROBLEMS

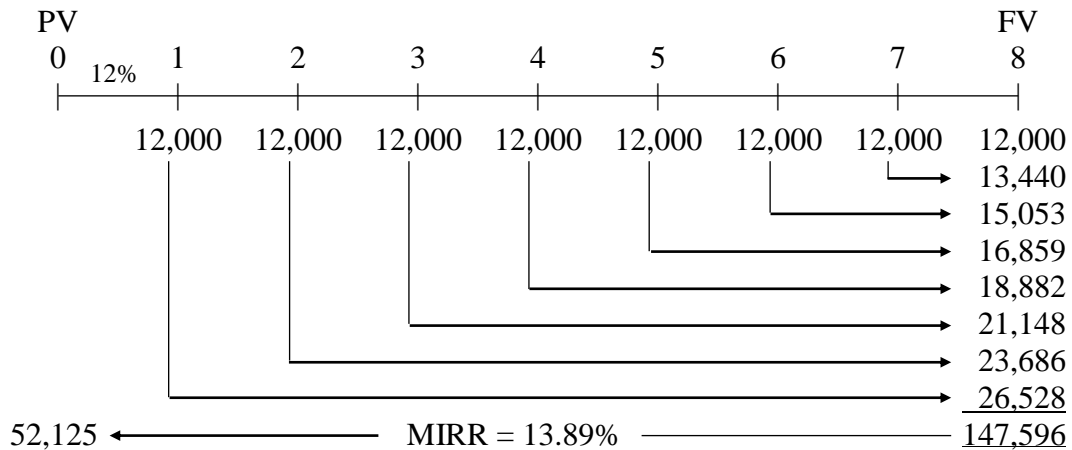
10-1
$$\begin{aligned} \text{NPV} &= -\$52,125 + \$12,000[(1/I) - (1/(I \times (1 + I)^N))] \\ &= -\$52,125 + \$12,000[(1/0.12) - (1/(0.12 \times (1 + 0.12)^8))] \\ &= \$7,486.68. \end{aligned}$$

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

10-2 Financial calculator solution: Input $CF_0 = -52125$, $CF_{1-8} = 12000$, and then solve for $\text{IRR} = 16\%$.

10-3 $\text{MIRR: PV Costs} = \$52,125$.

FV Inflows:



Financial calculator: 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 $I/YR = 13.89\%$.

$$\begin{aligned}
10-4 \quad PV &= \$12,000[(1/I) - (1/(I \times (1 + I)^N))] \\
&= \$12,000[(1/0.12) - (1/(0.12 \times (1 + 0.12)^8))] \\
&= \$59,611.68.
\end{aligned}$$

Financial calculator: Find present value of future cash flows by inputting $N = 8$, $I/YR = 12$, $PMT = -12000$, $FV = 0$, then solve for $PV = \$59,611.68$.

$$\begin{aligned}
PI &= PV \text{ of future cash flows} / \text{Initial cost} \\
&= \$59,611.68 / \$52,125 = 1.14.
\end{aligned}$$

10-5 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.

10-6 The project's discounted payback period is calculated as follows:

<u>Year</u>	<u>Annual CF</u>	<u>Discounted CF</u> <u>(@12%)</u>	<u>Cumulative</u> <u>Discounted CF</u>
0	-52,125		-52,125.00
1	12,000	10,714.29	(41,410.71)
2	12,000	9,566.33	(31,844.39)
3	12,000	8,541.36	(23,303.02)
4	12,000	7,626.22	(15,676.81)
5	12,000	6,809.12	(8,867.69)
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.

10-7 a. Project A: Using a financial calculator, enter the following:

$$\begin{aligned}
CF_0 &= -15000000 \\
CF_1 &= 5000000 \\
CF_2 &= 10000000 \\
CF_3 &= 20000000
\end{aligned}$$

$$I/YR = 10; NPV = \$12,836,213.$$

$$\text{Change } I/YR = 10 \text{ to } I/YR = 5; NPV = \$16,108,952.$$

$$\text{Change } I/YR = 5 \text{ to } I/YR = 15; NPV = \$10,059,587.$$

Financial calculator: Obtain the FVA by inputting $N = 5$, $I/YR = 14$, $PV = 0$, $PMT = 5100$, and then solve for $FV = \$33,712$. The MIRR can be obtained by inputting $N = 5$, $PV = -17100$, $PMT = 0$, $FV = 33712$, and then solving for $I/YR = 14.54\%$.

Pulley:

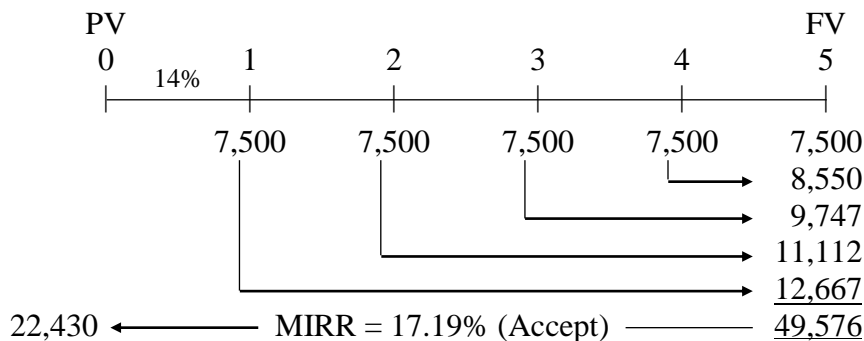
$$\begin{aligned} NPV &= -\$22,430 + \$7,500(3.4331) = -\$22,430 + \$25,748 \\ &= \$3,318. \quad (\text{Accept}) \end{aligned}$$

Financial calculator: Input the appropriate cash flows into the cash flow register, input $I/YR = 14$, and then solve for $NPV = \$3,318$.

Financial calculator: Input the appropriate cash flows into the cash flow register and then solve for $IRR = 20\%$.

MIRR: $PV \text{ Costs} = \$22,430$.

FV Inflows:



Financial calculator: Obtain the FVA by inputting $N = 5$, $I/YR = 14$, $PV = 0$, $PMT = 7500$, and then solve for $FV = \$49,576$. The MIRR can be obtained by inputting $N = 5$, $PV = -22430$, $PMT = 0$, $FV = 49576$, and then solving for $I/YR = 17.19\%$.

10-9 *Electric-powered:*

$$\begin{aligned} \text{NPV}_E &= -\$22,000 + \$6,290[(1/i) - (1/(i \times (1 + i)^n))] \\ &= -\$22,000 + \$6,290[(1/0.12) - (1/(0.12 \times (1 + 0.12)^6))] \\ &= -\$22,000 + \$6,290(4.1114) = -\$22,000 + \$25,861 = \$3,861. \end{aligned}$$

Financial calculator: Input the appropriate cash flows into the cash flow register, input I/YR = 12, and then solve for NPV = \$3,861.

Financial calculator: Input the appropriate cash flows into the cash flow register and then solve for IRR = 18%.

Gas-powered:

$$\begin{aligned} \text{NPV}_G &= -\$17,500 + \$5,000[(1/i) - (1/(i \times (1 + i)^n))] \\ &= -\$17,500 + \$5,000[(1/0.12) - (1/(0.12 \times (1 + 0.12)^6))] \\ &= -\$17,500 + \$5,000(4.1114) = -\$17,500 + \$20,557 = \$3,057. \end{aligned}$$

Financial calculator: Input the appropriate cash flows into the cash flow register, input I/YR = 12, and then solve for NPV = \$3,057.

Financial calculator: Input the appropriate cash flows into the cash flow register and then solve for IRR = 17.97% \approx 18%.

The firm should purchase the electric-powered forklift because it has a higher NPV than the gas-powered forklift. The company gets a high rate of return (18% > r = 12%) on a larger investment.

10-10 Financial calculator solution, NPV:

Project S

	5	12		3000	0
Inputs	N	I/YR	PV	PMT	FV
Output			= -10,814.33		

$$\text{NPV}_S = \$10,814.33 - \$10,000 = \$814.33.$$

Project L

Inputs	5	12		7400	0
	<input type="text" value="N"/>	<input type="text" value="I/YR"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = -26,675.34

$$NPV_L = \$26,675.34 - \$25,000 = \$1,675.34.$$

Financial calculator solution, IRR:

Input $CF_0 = -10000$, $CF_1 = 3000$, $N_j = 5$, $IRR_S = ?$ $IRR_S = 15.24\%$.

Input $CF_0 = -25000$, $CF_1 = 7400$, $N_j = 5$, $IRR_L = ?$ $IRR_L = 14.67\%$.

Financial calculator solution, MIRR:

Project S

Inputs	5	12	0	3000	
	<input type="text" value="N"/>	<input type="text" value="I/YR"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = -19,058.54

$$PV\ costs_S = \$10,000.$$

$$FV\ inflows_S = \$19,058.54.$$

Inputs	5		-10000	0	19058.54
	<input type="text" value="N"/>	<input type="text" value="I/YR"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = 13.77

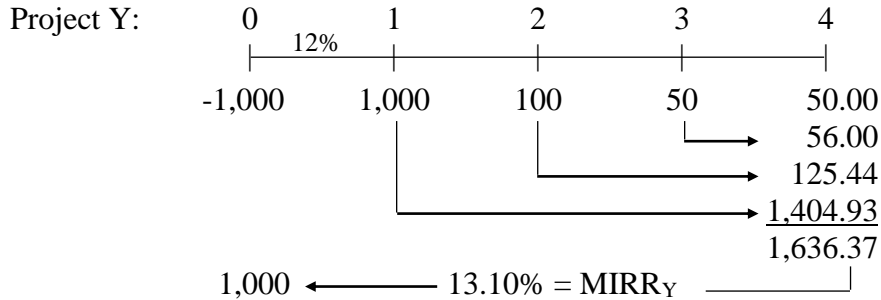
$$MIRR_S = 13.77\%.$$

Project L

Inputs	5	12	0	7400	
	<input type="text" value="N"/>	<input type="text" value="I/YR"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = -47,011.07

$$PV\ costs_L = \$25,000.$$



$$\$1,000 = \$1,636.37 / (1 + \text{MIRR}_Y)^4$$

Thus, since $\text{MIRR}_X > \text{MIRR}_Y$, Project X should be chosen.

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

$$\text{NPV}_X = \$58.02 \text{ and } \text{NPV}_Y = \$39.94.$$

10-12 a.

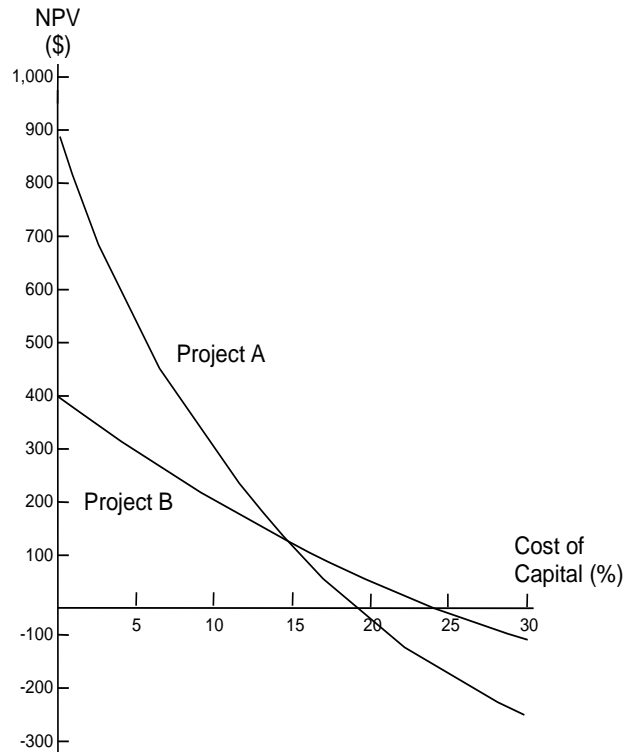
Purchase price	\$ 900,000
Installation	<u>165,000</u>
Initial outlay	<u><u>\$1,065,000</u></u>

$$\text{CF}_0 = -1065000; \text{CF}_{1-5} = 350000; \text{I/YR} = 14; \text{NPV} = ?$$

$$\text{NPV} = \$136,578; \text{IRR} = 19.22\%.$$

- Ignoring environmental concerns, the project should be undertaken because its NPV is positive and its IRR is greater than the firm's cost of capital.
- Environmental effects could be added by estimating penalties or any other cash outflows that might be imposed on the firm to help return the land to its previous state (if possible). These outflows could be so large as to cause the project to have a negative NPV—in which case the project should not be undertaken.

10-13 a.



r	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)

b. $IRR_A = 18.1\%$; $IRR_B = 24.0\%$.

c. At $r = 10\%$, Project A has the greater NPV, specifically \$283.34 as compared to Project B's NPV of \$178.60. Thus, Project A would be selected. At $r = 17\%$, Project B has an NPV of \$75.95 which is higher than Project A's NPV of \$31.05. Thus, choose Project B if $r = 17\%$.

d. Here is the MIRR for Project A when $r = 10\%$:

$$PV \text{ costs} = \$300 + \$387/(1.10)^1 + \$193/(1.10)^2 + \$100/(1.10)^3 + \$180/(1.10)^7 = \$978.82.$$

$$\text{TV inflows} = \$600(1.10)^3 + \$600(1.10)^2 + \$850(1.10)^1 = \$2,459.60.$$

Now, MIRR is that discount rate which forces the TV of \$2,459.60 in 7 years to equal \$978.82:

$$\begin{aligned} \$978.82 &= \$2,459.60(1 + \text{MIRR})^7 \\ \text{MIRR}_A &= 14.07\%. \end{aligned}$$

$$\begin{aligned} \text{Similarly, } \$405 &= \$1,137.28(1 + \text{MIRR})^7 \\ \text{MIRR}_B &= 15.89\%. \end{aligned}$$

$$\begin{aligned} \text{At } r &= 17\%, \\ \text{MIRR}_A &= 17.57\%. \\ \text{MIRR}_B &= 19.91\%. \end{aligned}$$

- e. To find the crossover rate, construct a Project Δ which is the difference in the two projects' cash flows:

<u>Year</u>	<u>Project $\Delta =$ $CF_A - CF_B$</u>
0	\$105
1	(521)
2	(327)
3	(234)
4	466
5	466
6	716
7	(180)

$$\text{IRR}_\Delta = \text{Crossover rate} = 14.53\%.$$

Projects A and B are mutually exclusive, thus, only one of the projects can be chosen. As long as the cost of capital is greater than the crossover rate, both the NPV and IRR methods will lead to the same project selection. However, if the cost of capital is less than the crossover rate the two methods lead to different project selections—a conflict exists. When a conflict exists the NPV method must be used.

Because of the sign changes and the size of the cash flows, Project Δ has multiple IRRs. Thus, a calculator's IRR function will *not work*. One could use the trial and error method of entering different discount rates until NPV = \$0. However, an HP can be "tricked" into giving the roots. After you have keyed Project Delta's cash flows into the CF_j register of an HP-10B, you will see an "Error-Soln" message. Now enter 10 ■ **STO** ■ **IRR/YR** and the 14.53% IRR is found. Then enter 100 ■ **STO** ■ **IRR/YR** to obtain IRR = 456.22%. Similarly, *Excel* can also be used.

10-14 a.

Year	Plan B	Plan A	Incremental Cash Flow (B – A)
0	(\$10,000,000)	(\$10,000,000)	\$ 0
1	1,750,000	12,000,000	(10,250,000)
2-20	1,750,000	0	1,750,000

If the firm goes with Plan B, it will forgo \$10,250,000 in Year 1, but will receive \$1,750,000 per year in Years 2-20.

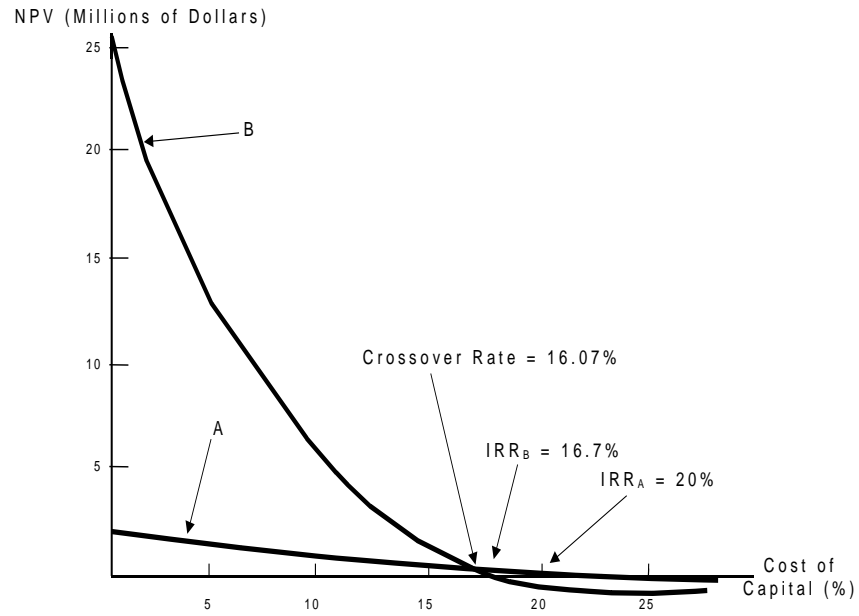
- b. If the firm could invest the incremental \$10,250,000 at a return of 16.07%, it would receive cash flows of \$1,750,000. If we set up an amortization schedule, we would find that payments of \$1,750,000 per year for 19 years would amortize a loan of \$10,250,000 at 16.0665%.

Financial calculator solution:

Inputs	19		-10250000	1750000	0
	N	I/YR	PV	PMT	FV
Output	= 16.0665				

- c. 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.

- d. See graph. If the cost of capital is less than 16.07%, then Plan B should be accepted; if $r > 16.07\%$, then Plan A is preferred.



10-15 a. Financial calculator solution:

Plan A

Inputs	20	10		8000000	0
	<input type="text" value="N"/>	<input type="text" value="I/YR"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = -68,108,510

$$NPV_A = \$68,108,510 - \$50,000,000 = \$18,108,510.$$

Plan B

Inputs	20	10		3400000	0
	<input type="text" value="N"/>	<input type="text" value="I/YR"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = -28,946,117

$$NPV_B = \$28,946,117 - \$15,000,000 = \$13,946,117.$$

Plan A

Inputs	20		-50000000	8000000	0
	<input type="text" value="N"/>	<input type="text" value="I/YR"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = 15.03

$$IRR_A = 15.03\%.$$

Plan B

Inputs	20		-15000000	3400000	0
	<input type="text" value="N"/>	<input type="text" value="I/YR"/>	<input type="text" value="PV"/>	<input type="text" value="PMT"/>	<input type="text" value="FV"/>

Output = 22.26

$$IRR_B = 22.26\%.$$

b. If the company takes Plan A rather than B, its cash flows will be (in millions of dollars):

<u>Cash Flows</u>	<u>Cash Flows</u>	<u>Project Δ</u>	<u>Cash Flows</u>
<u>Year</u>	<u>from A</u>	<u>from B</u>	
0	(\$50)	(\$15.0)	(\$35.0)
1	8	3.4	4.6
2	8	3.4	4.6
–	–	–	–
–	–	–	–
–	–	–	–
20	8	3.4	4.6

So, Project Δ has a "cost" of \$35,000,000 and "inflows" of \$4,600,000 per year for 20 years.

Inputs	20	10	4600000	0
	N	I/YR	PMT	FV

Output = -39,162,393

$$NPV_{\Delta} = \$39,162,393 - \$35,000,000 = \$4,162,393.$$

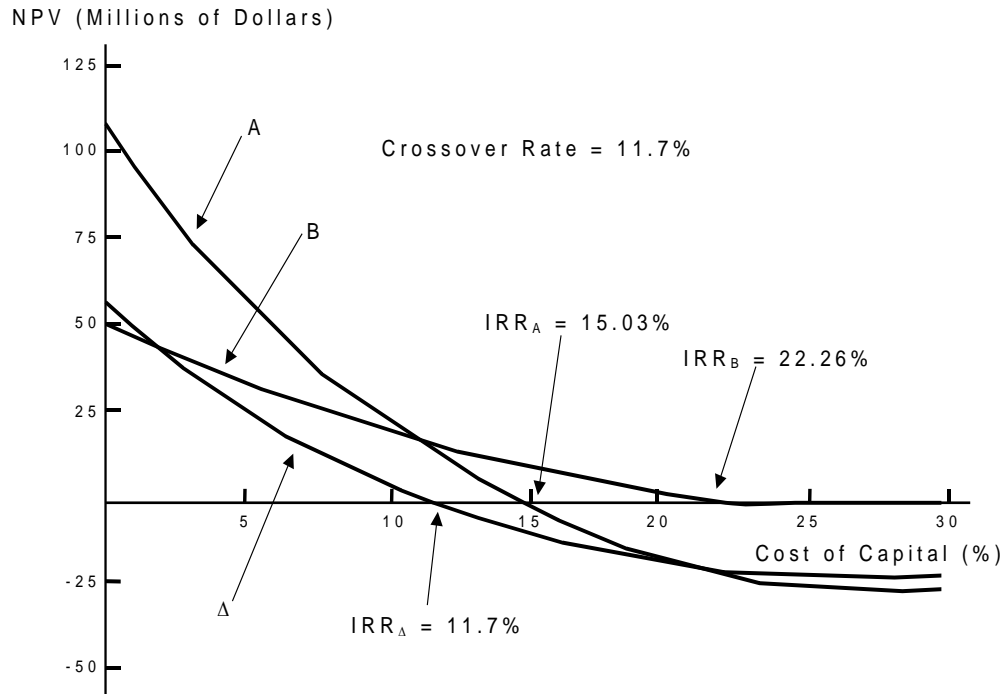
Inputs	20	-35000000	4600000	0
	N	PV	PMT	FV

Output = 11.71

$$IRR_{\Delta} = 11.71\%.$$

Since $IRR_{\Delta} > r$, we should accept Δ. This means we should accept the larger project (Project A). In addition, when dealing with mutually exclusive projects, we use the NPV method for choosing the best project.

c.

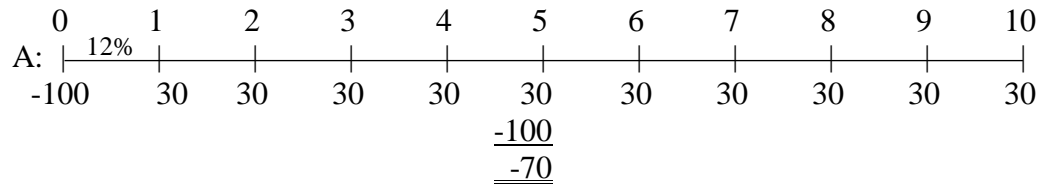


d. The NPV method implicitly assumes that the opportunity exists to reinvest the cash flows generated by a project at the cost of capital, while use of the IRR method implies the opportunity to reinvest at the IRR. If the firm's cost of capital is constant at 10%, all projects with an NPV > 0 will be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

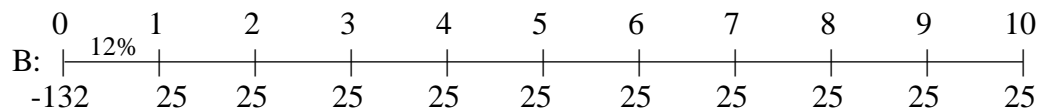
The IRR method assumes reinvestment at the internal rate of return itself, which is an incorrect assumption, given a constant expected future cost of capital, and ready access to capital markets.

10-16 Plane A: Expected life = 5 years; Cost = \$100 million; NCF = \$30 million; COC = 12%.

Plane B: Expected life = 10 years; Cost = \$132 million; NCF = \$25 million; COC = 12%.



Enter these values into the cash flow register: $CF_0 = -100$; $CF_{1-4} = 30$; $CF_5 = -70$; $CF_{6-10} = 30$. Then enter I/YR = 12, and press the NPV key to get $NPV_A = \$12.764$ million.



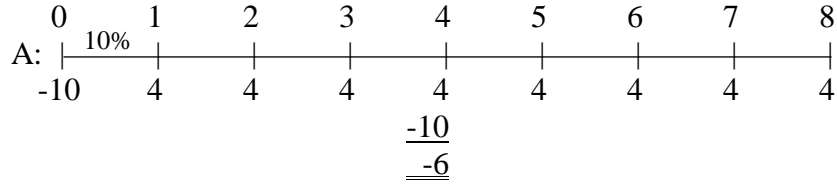
Enter these cash flows into the cash flow register, along with the interest rate, and press the NPV key to get $NPV_B = \$9.256$ million.

Project A is the better project and will increase the company's value by \$12.764 million.

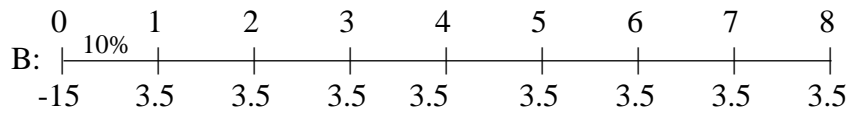
The EAA of plane A is found by first finding the PV: $N = 5$, I/YR = 12, PMT = 30, FV = 0; solve for PV = \$108.143. The NPV is $\$108.143 - \$100 = \$8.143$ million. We convert this to an equivalent annual annuity by inputting: $N = 5$, I/YR = 12, PV = -8.143, FV = 0, and solve for PMT = EAA = \$2.259 million.

For plane B, we already found the NPV of \$9.256 million. We convert this to an equivalent annual annuity by inputting: $N = 10$, I/YR = 12, PV = -9.256, FV = 0, and solve for PMT = EAA = \$1.638 million.

10-17



Machine A's simple NPV is calculated as follows: Enter $CF_0 = -10$ and $CF_{1-4} = 4$. Then enter $I/YR = 10$, and press the NPV key to get $NPV_A = \$2.679$ million. However, this does not consider the fact that the project can be repeated again. Enter these values into the cash flow register: $CF_0 = -10$; $CF_{1-3} = 4$; $CF_4 = -6$; $CF_{5-8} = 4$. Then enter $I/YR = 10$, and press the NPV key to get Extended $NPV_A = \$4.5096 \approx \4.51 million.



For Machine B's NPV, enter these cash flows into the cash flow register, along with the interest rate, and press the NPV key to get $NPV_B = \$3.672 \approx \3.67 million.

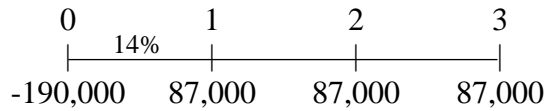
Machine A is the better project and will increase the company's value by \$4.51 million.

The EAA of Machine A is found by first finding the PV: $N = 4$, $I/YR = 10$, $PMT = 4$, $FV = 0$; solve for $PV = \$12.679$. The NPV is $\$12.679 - \$10 = \$2.679$ million. We convert this to an equivalent annual annuity by inputting: $N = 4$, $I/YR = 10$, $PV = -2.679$, $FV = 0$, and solve for $PMT = EAA_A = 0.845 \approx \0.85 million.

For Machine B, we already found the NPV of \$3.672 million. We convert this to an equivalent annual annuity by inputting: $N = 8$, $I/YR = 10$, $PV = -3.672$, $FV = 0$, and solve for $PMT = EAA_B = 0.688 \approx \0.69 million.

Again, the EAA method demonstrates that Machine A is the better project since $EAA_A > EAA_B$.

10-18 Cash flow time line for Machine 190-3:



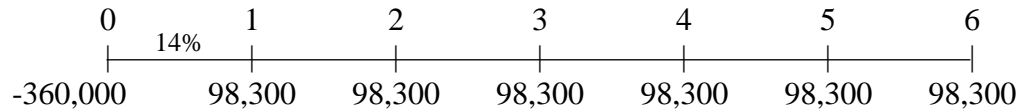
Using a financial calculator, input the following data: $CF_0 = -190000$; $CF_{1-3} = 87000$; $I/YR = 14$; and solve for $NPV_{190-3} = \$11,982$ (for 3 years).

Extended $NPV_{190-3} = \$11,982 + \$11,982/(1.14)^3 = \$20,070$.

EAA_{190-3} : Using a financial calculator, input the following data:

$N = 3$; $I/YR = 14$; $PV = -11982$; and $FV = 0$. Solve for $PMT = EAA = \$5,161$.

Cash flow time line for Machine 360-6:



Using a financial calculator, input the following data: $CF_0 = -360000$; $CF_{1-6} = 98300$; $I/YR = 14$; and solve for $NPV_{360-6} = \$22,256$ (for 6 years).

EAA_{360-6} : Using a financial calculator, input the following data:

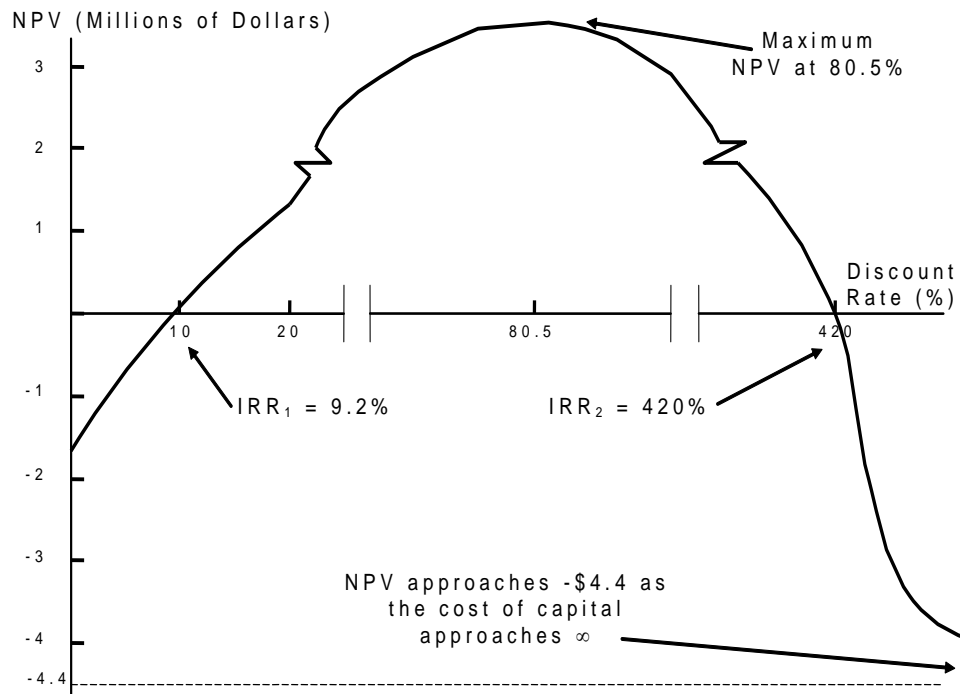
$N = 6$; $I/YR = 14$; $PV = -22256$; and $FV = 0$. Solve for $PMT = EAA = \$5,723$.

Both new machines have positive NPVs; hence, the old machine should be replaced. Further, since its NPV is greater with the replacement chain approach and its EAA is higher than Model 190-3, choose Model 360-6.

10-19 a. The project's expected cash flows are as follows (in millions of dollars):

<u>Time</u>	<u>Net Cash Flow</u>
0	(\$ 4.4)
1	27.7
2	(25.0)

We can construct the following NPV profile:



<u>Discount Rate</u>	<u>NPV</u>
0%	(\$1,700,000)
9	(29,156)
10	120,661
50	2,955,556
100	3,200,000
200	2,055,556
300	962,500
400	140,000
410	70,204
420	2,367
430	(63,581)

The table above was constructed using a financial calculator with the following inputs: $CF_0 = -4400000$, $CF_1 = 27700000$, $CF_2 = -25000000$, and I/YR = discount rate to solve for the NPV.

- b. If $r = 8\%$, reject the project since $NPV < 0$ as shown in the project's NPV profile. But if $r = 14\%$, accept the project because $NPV > 0$ as shown in the project's NPV profile.

- 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, or leveraged leases where the borrowed funds are repaid at the end of the lease life. (See Chapter 18 of *Financial Management, 13th edition* for more information on leases.)
- d. Here is the MIRR for the project when $r = 8\%$:

$$\text{PV costs} = \$4,400,000 + \$25,000,000/(1.08)^2 = \$25,833,470.51.$$

$$\text{TV inflows} = \$27,700,000(1.08)^1 = \$29,916,000.00.$$

Now, MIRR is the discount rate that forces the PV of the TV of \$29,916,000 over 2 years to equal \$25,833,470.51:

$$\$25,833,470.51 = \$29,916,000(\text{PVIF}_{r,2}).$$

Inputs	2		-25833470.51	0	29916000
	N	I/YR	PV	PMT	FV
Output		= 7.61			

$$\text{MIRR} = 7.61\%.$$

At $r = 14\%$, MIRR for the project is calculated as follows:

$$\text{PV costs} = \$4,400,000 + \$25,000,000/(1.14)^2 = \$23,636,688.21.$$

$$\text{TV inflows} = \$27,700,000(1.14)^1 = \$31,578,000.$$

Now, MIRR is that discount rate which forces the PV of the TV of \$31,578,000 over 2 years to equal \$23,636,688.21:

$$\$23,636,688.21 = \$31,578,000(\text{PVIF}_{r,2}).$$

Inputs	2		-23636688.21	0	31578000
	N	I/YR	PV	PMT	FV
Output		= 15.58			

$$\text{MIRR} = 15.58\%.$$

Yes. The MIRR method leads to the same conclusion as the NPV method. Reject the project if $r = 8\%$, which is greater than the corresponding MIRR of 7.61%, and accept the project if $r = 14\%$, which is less than the corresponding MIRR of 15.58%.

- 10-20 a. The IRRs of the two alternatives are undefined. To calculate an IRR, the cash flow stream must include both cash inflows and outflows.
- b. The PV of costs for the conveyor system is (\$911,067), while the PV of costs for the forklift system is (\$838,834). Thus, the forklift system is expected to be (\$838,834) – (\$911,067) = \$72,233 less costly than the conveyor system, and hence the forklift trucks should be used.

Financial calculator solution:

Input: $CF_0 = -500000$, $CF_1 = -120000$, $N_j = 4$, $CF_2 = -20000$, $I/YR = 8$, $NPV_C = ?$
 $NPV_C = -911,067$.

Input: $CF_0 = -200000$, $CF_1 = -160000$, $N_j = 5$, $I/YR = 8$, $NPV_F = ?$ $NPV_F = -838,834$.

- 10-21 a. Payback A (cash flows in thousands):

<u>Period</u>	<u>Annual Cash Flows</u>	<u>Cumulative</u>
0	(\$25,000)	(\$25,000)
1	5,000	(20,000)
2	10,000	(10,000)
3	15,000	5,000
4	20,000	25,000

$Payback_A = 2 + \$10,000/\$15,000 = 2.67$ years.

Payback B (cash flows in thousands):

<u>Period</u>	<u>Annual Cash Flows</u>	<u>Cumulative</u>
0	(\$25,000)	(\$25,000)
1	20,000	(5,000)
2	10,000	5,000
3	8,000	13,000
4	6,000	19,000

$Payback_B = 1 + \$5,000/\$10,000 = 1.50$ years.

b. Discounted Payback A (cash flows in thousands):

<u>Period</u>	<u>Annual Cash Flows</u>	<u>Discounted @ 10% Cash Flows</u>	<u>Cumulative</u>
0	(\$25,000)	(\$25,000.00)	(\$25,000.00)
1	5,000	4,545.45	(20,454.55)
2	10,000	8,264.46	(12,190.09)
3	15,000	11,269.72	(920.37)
4	20,000	13,660.27	12,739.90

Discounted Payback_A = 3 + \$920.37/\$13,660.27 = 3.07 years.

Discounted Payback B (cash flows in thousands):

<u>Period</u>	<u>Annual Cash Flows</u>	<u>Discounted @ 10% Cash Flows</u>	<u>Cumulative</u>
0	(\$25,000)	(\$25,000.00)	(\$25,000.00)
1	20,000	18,181.82	(6,818.18)
2	10,000	8,264.46	1,446.28
3	8,000	6,010.52	7,456.80
4	6,000	4,098.08	11,554.88

Discounted Payback_B = 1 + \$6,818.18/\$8,264.46 = 1.825 years.

- c. NPV_A = \$12,739,908; IRR_A = 27.27%.
 NPV_B = \$11,554,880; IRR_B = 36.15%.

Both projects have positive NPVs, so both projects should be undertaken.

- d. At a discount rate of 5%, NPV_A = \$18,243,813.
 At a discount rate of 5%, NPV_B = \$14,964,829.

At a discount rate of 5%, Project A has the higher NPV; consequently, it should be accepted.

- e. At a discount rate of 15%, NPV_A = \$8,207,071.
 At a discount rate of 15%, NPV_B = \$8,643,390.

At a discount rate of 15%, Project B has the higher NPV; consequently, it should be accepted.

f.

<u>Year</u>	<u>Project $\Delta =$ $CF_A - CF_B$</u>
0	\$ 0
1	(15)
2	0
3	7
4	14

$IRR_{\Delta} = \text{Crossover rate} = 13.5254\% \approx 13.53\%$.

g. Use 3 steps to calculate $MIRR_A$ @ $r = 10\%$:

Step 1: Calculate the NPV of the uneven cash inflow stream, so its FV can then be calculated. With a financial calculator, enter the cash inflow stream into the cash flow registers being sure to enter 0 for CF_0 , then enter $I/YR = 10$, and solve for $NPV = \$37,739,908$.

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

Enter $N = 4$, $I/YR = 10$, $PV = -37739908$, and $PMT = 0$ to solve for $FV = \$55,255,000$.

Step 3: Calculate $MIRR_A$ as follows:

Enter $N = 4$, $PV = -25000000$, $PMT = 0$, and $FV = 55255000$ to solve for $I/YR = 21.93\%$.

Use 3 steps to calculate $MIRR_B$ @ $r = 10\%$:

Step 1: Calculate the NPV of the uneven cash inflow stream, so its FV can then be calculated. With a financial calculator, enter the cash inflow stream into the cash flow registers being sure to enter 0 for CF_0 , then enter $I/YR = 10$, and solve for $NPV = \$36,554,880$.

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

Enter $N = 4$, $I/YR = 10$, $PV = -36554880$, and $PMT = 0$ to solve for $FV = \$53,520,000$.

Step 3: Calculate $MIRR_B$ as follows:

Enter $N = 4$, $PV = -25000000$, $PMT = 0$, and $FV = 53520000$ to solve for $I/YR = 20.96\%$.

According to the MIRR approach, if the 2 projects were mutually exclusive, Project A would be chosen because it has the higher MIRR. This is consistent with the NPV approach.

10-22 a. NPV of termination after Year t:

$$NPV_0 = -\$22,500 + \$22,500 = 0.$$

Using a financial calculator, input the following: $CF_0 = -22500$, $CF_1 = 23750$, and $I/YR = 10$ to solve for $NPV_1 = -\$909.09 \approx -\909 .

Using a financial calculator, input the following: $CF_0 = -22500$, $CF_1 = 6250$, $CF_2 = 20250$, and $I/YR = 10$ to solve for $NPV_2 = -\$82.64 \approx -\83 .

Using a financial calculator, input the following: $CF_0 = -22500$, $CF_1 = 6250$, $N_j = 2$, $CF_3 = 17250$, and $I/YR = 10$ to solve for $NPV_3 = \$1,307.29 \approx \$1,307$.

Using a financial calculator, input the following: $CF_0 = -22500$, $CF_1 = 6250$, $N_j = 3$, $CF_4 = 11250$, and $I/YR = 10$ to solve for $NPV_4 = \$726.73 \approx \727 .

Using a financial calculator, input the following: $CF_0 = -22500$, $CF_1 = 6250$, $N_j = 5$, and $I/YR = 10$ to solve for $NPV_5 = \$1,192.42 \approx \$1,192$.

The firm should operate the truck for 3 years, $NPV_3 = \$1,307$.

b. No. Salvage possibilities could only raise NPV and IRR. The value of the firm is maximized by terminating the project after Year 3.