

## Chapter 6: Some Alternative Investment Rules

- 6.1 a. The payback period is the time that it takes for the cumulative undiscounted cash inflows to equal the initial investment.

Project A:

Cumulative Undiscounted Cash Flows Year 1	= \$4,000	= \$4,000
Cumulative Undiscounted Cash Flows Year 2	= \$4,000 + \$3,500	= <b>\$7,500</b>

Payback period = 2

**Project A has a payback period of two years.**

Project B:

Cumulative Undiscounted Cash Flows Year 1	= \$2,500	= \$2,500
Cumulative Undiscounted Cash Flows Year 2	= \$2,500 + \$1,200	= \$3,700
Cumulative Undiscounted Cash Flows Year 3	= \$2,500 + \$1,200 + \$3,000	= <b>\$6,700</b>

Project B's cumulative undiscounted cash flows exceed the initial investment of \$5,000 by the end of year 3. Many companies analyze the payback period in whole years. The payback period for project B is 3 years.

**Project B has a payback period of three years.**

Companies can calculate a more precise value using fractional years. To calculate the fractional payback period, find the fraction of year 3's cash flows that is needed for the company to have cumulative undiscounted cash flows of \$5,000. Divide the difference between the initial investment and the cumulative undiscounted cash flows as of year 2 by the undiscounted cash flow of year 3.

$$\begin{aligned} \text{Payback period} &= 2 + (\$5,000 - \$3,700) / \$3,000 \\ &= \mathbf{2.43} \end{aligned}$$

**Since project A has a shorter payback period than project B has, the company should choose project A.**

- b. Discount each project's cash flows at 15 percent. Choose the project with the highest NPV.

$$\begin{aligned} \text{Project A} &= -\$7,500 + \$4,000 / (1.15) + \$3,500 / (1.15)^2 + \$1,500 / (1.15)^3 \\ &= \mathbf{-\$388.96} \end{aligned}$$

$$\begin{aligned} \text{Project B} &= -\$5,000 + \$2,500 / (1.15) + \$1,200 / (1.15)^2 + \$3,000 / (1.15)^3 \\ &= \mathbf{\$53.83} \end{aligned}$$

**The firm should choose Project B since it has a higher NPV than Project A has.**

- 6.2 a. Find the payback period for the project. Since the cash inflows are constant, divide the initial investment by the annual cash inflow to determine the payback period.

$$\begin{aligned} \text{Payback Period} &= \text{Initial Investment} / \text{Annual Cash Inflow} \\ &= \$1,000,000 / \$150,000 \\ &= \mathbf{6.67} \end{aligned}$$

**The payback period is 6.67 years. Since the payback period is shorter than the cutoff period of ten years, the project should be accepted.**

- b. Find the number of years needed for the discounted cash inflows to equal the initial investment of \$1 million. Apply the annuity formula, discounted at 10 percent, to find the approximate discounted payback period. The approximate discounted payback period is the year *in which* the PV of the initial investment is surpassed.

Since the discounted payback period will always be greater than the undiscounted payback period when there are positive cash inflows, start the approximation at year 7.

Cumulative Discounted Cash Flows Year 7	= \$150,000 $A_{0.1}^7$	= \$730,262.82
Cumulative Discounted Cash Flows Year 8	= \$150,000 $A_{0.1}^8$	= \$800,238.93
Cumulative Discounted Cash Flows Year 9	= \$150,000 $A_{0.1}^9$	= \$863,853.57
Cumulative Discounted Cash Flows Year 10	= \$150,000 $A_{0.1}^{10}$	= \$921,685.07
Cumulative Discounted Cash Flows Year 11	= \$150,000 $A_{0.1}^{11}$	= \$974,259.15
Cumulative Discounted Cash Flows Year 12	= <b>\$150,000 <math>A_{0.1}^{12}</math></b>	= <b>\$1,022,053.77</b>

The cumulative discounted cash flows exceed the initial investment of \$1,000,000 by the end of year 12. Many companies analyze the payback period in whole years. The payback period for the project is 12 years.

**The discounted payback period is 12 years.**

- c. Apply the perpetuity formula, discounted at 10 percent, to calculate the PV of the annual cash inflows.

$$\begin{aligned} \text{NPV} &= -\$1,000,000 + \$150,000 / 0.1 \\ &= \mathbf{\$500,000} \end{aligned}$$

**The NPV of the project is \$500,000.**

- 6.3 a. The *average accounting return* is the average project earnings after taxes, divided by the average book value, or average net investment, of the machine during its life. The book value of the machine is the gross investment minus the accumulated depreciation.

$$\begin{aligned} \text{Average Book Value} &= (\text{Book Value}_0 + \text{Book Value}_1 + \text{Book Value}_2 + \text{Book Value}_3 \\ &\quad + \text{Book Value}_4 + \text{Book Value}_5) / (\text{Economic Life}) \\ &= (\$16,000 + \$12,000 + \$8,000 + \$4,000 + \$0) / (5 \text{ years}) \\ &= \$8,000 \end{aligned}$$

$$\text{Average Project Earnings} = \$4,500$$

Divide the average project earnings by the average book value of the machine to calculate the average accounting return.

$$\begin{aligned} \text{Average Accounting Return} &= \text{Average Project Earnings} / \text{Average Book Value} \\ &= \$4,500 / \$8,000 \\ &= 0.5625 \\ &= \mathbf{56.25\%} \end{aligned}$$

**The average accounting return is 56.25%.**

- b.
1. The average accounting return uses accounting data rather than net cash flows.
  2. The average accounting return uses an arbitrary firm standard as the decision rule. The firm standard is arbitrary because it does not necessarily relate to a market rate of return.
  3. The average accounting return does not consider the timing of cash flows. Hence, it does not consider the time value of money.

6.4 Determine the average book value of the investment. The book value is the gross investment minus accumulated depreciation.

	Purchase	Year 1	Year 2	Year 3	Year 4	Year 0
Gross Investment	\$2,000,000	\$2,000,000	\$2,000,000	\$2,000,000	\$2,000,000	\$2,000,000
Less: Accumulated Depreciation	0	400,000	800,000	1,200,000	1,600,000	2,000,000
Net Investment	\$2,000,000	\$1,600,000	\$1,200,000	\$800,000	\$400,000	\$0

$$\begin{aligned} \text{Average Book Value} &= (\$2,000,000 + \$1,600,000 + \$1,200,000 + \$800,000 \\ &\quad + \$400,000 + \$0) / (6) \\ &= \$1,000,000 \end{aligned}$$

Next, calculate average annual net income.

$$\begin{aligned} \text{Net Income Year 1} &= \$100,000 \\ \text{Net Income Year 2} &= \$100,000 \times (1.07) = \$107,000 \\ \text{Net Income Year 3} &= \$100,000 \times (1.07)^2 = \$114,490 \\ \text{Net Income Year 4} &= \$100,000 \times (1.07)^3 = \$122,504 \\ \text{Net Income Year 5} &= \$100,000 \times (1.07)^4 = \$131,080 \end{aligned}$$

$$\begin{aligned} \text{Average Net Income} &= (\$100,000 + \$107,000 + \$114,490 + \$122,504 + \$131,080) / 5 \\ &= \$115,015 \end{aligned}$$

The average accounting return is the average net income divided by the average book value.

$$\begin{aligned} \text{Average Accounting Return} &= \text{Average Net Income} / \text{Average Book Value} \\ &= \$115,015 / \$1,000,000 \\ &= 0.115 \\ &= \mathbf{11.5\%} \end{aligned}$$

**Since the machine's average accounting return, 11.5%, is below the company's cutoff of 20%, the machine should not be purchased.**

6.5 First determine the average book value of the project. The book value is the gross investment minus accumulated depreciation.

	Purchase Date	Year 1	Year 2	Year 3
Gross Investment	\$8,000	\$8,000	\$8,000	\$8,000
Less: Accumulated Depreciation	0	4,000	6,500	8,000
Net Investment	\$8,000	\$4,000	\$1,500	\$0

$$\begin{aligned}\text{Average Book Value} &= (\$8,000 + \$4,000 + \$1,500 + \$0) / (4 \text{ years}) \\ &= \$3,375\end{aligned}$$

Remember to use the after-tax average net income when calculating the average accounting return.

$$\begin{aligned}\text{Average After-tax Net Income} &= (1 - T_c) \text{ Annual Pre-tax Net Income} \\ &= (1 - 0.25) \$2,000 \\ &= \$1,500\end{aligned}$$

The average accounting return is the average after-tax net income divided by the average book value.

$$\begin{aligned}\text{Average Accounting Return} &= \$1,500 / \$3,375 \\ &= 0.44 \\ &= \mathbf{44\%}\end{aligned}$$

**The average accounting return of the machine is 44%.**

- 6.6 The internal rate of return is the discount rate at which the NPV of the project's cash flows equals zero. Set the project's cash flows, discounted at the internal rate of return (IRR), equal to zero. Solve for the IRR.

$$\begin{aligned}\text{IRR(Project A)} &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 \\ 0 &= -\$3,000 + \$2,500 / (1+\text{IRR}) + \$1,000 / (1+\text{IRR})^2 \\ \text{IRR} &= \mathbf{0.1289}\end{aligned}$$

$$\begin{aligned}\text{IRR(Project B)} &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 \\ 0 &= -\$6,000 + \$5,000 / (1+\text{IRR}) + \$1,000 / (1+\text{IRR})^2 \\ \text{IRR} &= \mathbf{0.1289}\end{aligned}$$

Note that since Project B's cash flows are two times those of Project A, the IRR's of both projects are the same.

**The IRR of both Project A and Project B is 12.89%.**

- 6.7 a. The internal rate of return is the discount rate at which the NPV of the project's cash flows equal zero. Set the project's cash flows, discounted at the internal rate of return (IRR), equal to zero. Solve for the IRR.

$$\begin{aligned}\text{IRR} &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 + C_3 / (1+\text{IRR})^3 \\ 0 &= -\$8,000 + \$4,000 / (1+\text{IRR}) + \$3,000 / (1+\text{IRR})^2 + \$2,000 / (1+\text{IRR})^3 \\ \text{IRR} &= \mathbf{0.0693}\end{aligned}$$

**The IRR is 6.93%.**

- b. **No.** An investing-type project is one with a negative initial cash outflow and positive future cash inflows. One accepts a project when the IRR is greater than the discount rate. Similarly, one rejects the project when the IRR is less than the discount rate. The project should not be accepted because the IRR (6.93%) is less than the discount rate (8%).

- 6.8 Set the project's cash flows, discounted at the internal rate of return (IRR), equal to zero. Solve for the IRR.

$$\begin{aligned} \text{IRR}(\text{Project A}) &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 + C_3 / (1+\text{IRR})^3 \\ 0 &= -\$2,000 + \$2,000 / (1+\text{IRR}) + \$8,000 / (1+\text{IRR})^2 + \$8,000 / (1+\text{IRR})^3 \\ \text{IRR} &= \mathbf{1.88} \end{aligned}$$

$$\begin{aligned} \text{IRR}(\text{Project B}) &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 + C_3 / (1+\text{IRR})^3 \\ 0 &= -\$1,500 + \$500 / (1+\text{IRR}) + \$1,000 / (1+\text{IRR})^2 + \$1,500 / (1+\text{IRR})^3 \\ \text{IRR} &= \mathbf{0.362} \end{aligned}$$

**The IRR for Project A is 188% and the IRR for Project B is 36.2%.**

- 6.9 a. Set the project's cash flows, discounted at the internal rate of return (IRR), equal to zero. Solve for the IRR.

$$\begin{aligned} \text{IRR} &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 + C_3 / (1+\text{IRR})^3 + C_4 / (1+\text{IRR})^4 \\ 0 &= \$5,000 - \$2,500 / (1+\text{IRR}) - \$2,000 / (1+\text{IRR})^2 - \$1,000 / (1+\text{IRR})^3 \\ &\quad - \$1,000 / (1+\text{IRR})^4 \\ \text{IRR} &= \mathbf{0.1399} \end{aligned}$$

**The IRR is 13.99%.**

- b. This problem differs from previous ones because the initial cash flow is positive and all future cash flows are negative. In other words, this is a financing-type project while previous projects were investing-type projects. For financing situations, accept the project when the IRR is less than the discount rate. Reject the project when the IRR is greater than the discount rate.

$$\begin{aligned} \text{IRR} &= 13.99\% \\ \text{Discount Rate} &= 10\% \end{aligned}$$

$$\text{IRR} > \text{Discount Rate}$$

**Reject the offer when the discount rate is less than the IRR.**

- c. 
$$\begin{aligned} \text{IRR} &= 13.99\% \\ \text{Discount Rate} &= 20\% \end{aligned}$$

$$\text{IRR} < \text{Discount Rate}$$

**Accept the offer when the discount rate is greater than the IRR.**

- d. Calculate the NPV when the discount rate is 10 percent.

$$\begin{aligned} \text{NPV} &= \$5,000 - \$2,500 / (1.1) - \$2,000 / (1.1)^2 - \$1,000 / (1.1)^3 - \$1,000 / (1.1)^4 \\ &= \mathbf{-\$359.95} \end{aligned}$$

**When the discount rate is 10 percent, the NPV of the offer is -\$359.95. Reject the offer.**

Calculate the NPV when the discount rate is 20 percent.

$$\begin{aligned} \text{NPV} &= \$5,000 - \$2,500 / (1.2) - \$2,000 / (1.2)^2 - \$1,000 / (1.2)^3 - \$1,000 / (1.2)^4 \\ &= \mathbf{\$466.82} \end{aligned}$$

**When the discount rate is 20 percent, the NPV of the offer is \$466.82. Accept the offer.**

**e. Yes, the decisions under the NPV rule are consistent with the choices made under the IRR rule since the signs of the cash flows change only once.**

6.10 a. Set the project's cash flows, discounted at the internal rate of return (IRR), equal to zero. Solve for the IRR.

$$\begin{aligned} \text{IRR}(\text{Project A}) &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 \\ 0 &= -\$5,000 + \$3,500 / (1+\text{IRR}) + \$3,500 / (1+\text{IRR})^2 \\ \text{IRR} &= \mathbf{0.2569} \end{aligned}$$

**The IRR of project A is 25.69%.**

$$\begin{aligned} \text{IRR}(\text{Project B}) &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 \\ 0 &= -\$100,000 + \$65,000 / (1+\text{IRR}) + \$65,000 / (1+\text{IRR})^2 \\ \text{IRR} &= \mathbf{0.1943} \end{aligned}$$

**The IRR of project B is 19.43%.**

- b. Choose project A because it has a higher IRR than project B.
- c. The difference in scale was ignored. Project B has a substantially larger initial investment than project A has. Thus, the simple IRR calculation may not lead to the best decision.
- d. Calculate the incremental IRR. The incremental IRR is the IRR on the incremental investment from choosing the larger project instead of the smaller project. The incremental cash flows are the differences between the cash flows of project B and those of project A. Always subtract the project with the smaller initial cash outflow from the project with the larger initial cash outflow. In this way, the initial incremental cash flow will be negative.

	Year 0	Year 1	Year 2
Project B Cash Flows	-\$100,000	\$65,000	\$65,000
Project A Cash Flows	-5,000	3,500	3,500
B - A	-\$95,000	\$61,500	\$61,500

Next, find the IRR of those incremental cash flows.

$$\begin{aligned} \text{IRR}(B - A) &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 \\ 0 &= -\$95,000 + \$61,500 / (1+\text{IRR}) + \$61,500 / (1+\text{IRR})^2 \\ \text{IRR} &= \mathbf{0.191} \end{aligned}$$

**The incremental IRR is 19.1%.**

e. For investing-type projects, accept the larger project when the incremental rate of return is greater than the discount rate. Therefore, choose project B since the incremental IRR (19.1%) is greater than the 15 percent discount rate.

- f. Calculate the NPV of each project.

$$\begin{aligned}\text{NPV}(\text{Project A}) &= -\$5,000 + \$3,500 / (1.15) + \$3,500 / (1.15)^2 \\ &= \mathbf{\$689.98}\end{aligned}$$

**The NPV of project A is \$689.98.**

$$\begin{aligned}\text{NPV}(\text{Project B}) &= -\$100,000 + \$65,000 / (1.15) + \$65,000 / (1.15)^2 \\ &= \mathbf{\$5,671.08}\end{aligned}$$

**The NPV of project B is \$5,671.08.**

**Since the NPV of project B, \$5,671.08, is greater than the NPV of project A, \$689.98, choose project B.**

- 6.11 a. Apply the growing perpetuity formula to find the PV of stream A. The perpetuity formula values the stream as of one year before the first payment. Therefore, the growing perpetuity formula values the stream of cash flows as of year 2. Next, discount the PV as of the end of year 2 back two years to find the PV as of today, year 0.

$$\begin{aligned}\text{PV}(A) &= [C_3 / (r - g)] / (1+r)^2 \\ &= [\$5,000 / (0.12 - 0.04)] / (1.12)^2 \\ &= \mathbf{\$49,824.62}\end{aligned}$$

**The PV of stream A is \$49,824.62.**

Apply the perpetuity formula to find the PV of stream B. The perpetuity formula discounts the stream back to year 1, one period prior to the first cash flow. Discount the PV as of the end of year 1 back one year to find the PV as of today, year 0.

$$\begin{aligned}\text{PV}(B) &= [C_2 / (r)] / (1+r) \\ &= [-\$6,000 / (0.12)] / (1.12) \\ &= \mathbf{-\$44,642.86}\end{aligned}$$

**The PV of stream B is -\$44,642.86.**

- b. Streams A and B are combined to form project C.

$$\text{Project A} = [C_3 / (r - g)] / (1+r)^2$$

$$\text{Project B} = [C_2 / (r)] / (1+r)$$

$$\begin{aligned}\text{Project C} &= \text{Project A} + \text{Project B} \\ &= [C_3 / (r - g)] / (1+r)^2 + [C_2 / (r)] / (1+r)\end{aligned}$$

Set the new project's cash flows, discounted at the internal rate of return (IRR), equal to zero. Solve for the IRR. Use a graphing calculator to perform the calculation.

$$\begin{aligned}\text{IRR}(\text{Project C}) &= [C_3 / (\text{IRR} - g)] / (1+\text{IRR})^2 + [C_2 / (\text{IRR})] / (1+\text{IRR}) \\ 0 &= [\$5,000 / (\text{IRR} - 0.04)] / (1+\text{IRR})^2 + [-\$6,000 / (\text{IRR})] / (1+\text{IRR}) \\ \text{IRR} &= \mathbf{0.1465}\end{aligned}$$

**The IRR for project C is 14.65%.**

- c. The correct decision rule for an investing-type project is to accept the project if the discount rate is below the IRR. Since there is one IRR, a decision can be made. At a point in the future, the cash flows from stream A will be greater than those from stream B. Therefore, although there are many cash flows, there will be only one change in sign. When the sign of the cash flows change more than once over the life of the project, there may be multiple internal rates of return. In such cases, there is no correct decision rule for accepting and rejecting projects using the internal rate of return.

- 6.12 **False.** The statement is false. If the cash flows of project B occur early and the cash flows of project A occur late, then for a low discount rate the NPV of A can exceed the NPV of B. Observe the following example.

	C <sub>0</sub>	C <sub>1</sub>	C <sub>2</sub>	IRR	NPV @ 0%
Project A	-\$1,000,000	\$0	\$1,440,000	0.20	\$440,000
Project B	-2,000,000	2,400,000	0	0.20	400,000

However, in one particular case, the statement is true for equally risky projects. If the lives of the two projects are equal and the cash flows of project B are twice the cash flows of project A in every time period, the NPV of project B will be twice the NPV of project A.

- 6.13 a. The profitability index, PI, is the ratio of the present value of the future expected cash flows *after* the initial investment to the amount of the initial investment.

$$\begin{aligned}
 \text{PI}(A) &= [C_1 / (1+r) + C_2 / (1+r)^2 + C_3 / (1+r)^3] / (\text{Initial Investment}) \\
 &= [\$300 / (1.1) + \$700 / (1.1)^2 + \$600 / (1.1)^3] / (\$500) \\
 &= \mathbf{2.6}
 \end{aligned}$$

**The profitability index for project A is 2.6.**

$$\begin{aligned}
 \text{PI}(B) &= [C_1 / (1+r) + C_2 / (1+r)^2 + C_3 / (1+r)^3] / (\text{Initial Investment}) \\
 &= [\$300 / (1.1) + \$1,800 / (1.1)^2 + \$1,700 / (1.1)^3] / (\$2,000) \\
 &= \mathbf{1.5}
 \end{aligned}$$

**The profitability index for project B is 1.5.**

- b. Greenplain should accept both projects A and B. The NPV of a project is positive whenever the profitability index (PI) is greater than one.

- 6.14 Although the profitability index (PI) is higher for project B than for project A, project A should be chosen because it has the greater NPV. Confusion arises because project B requires a smaller investment than project A requires. Since the denominator of the PI ratio is lower for project B than for project A, B can have a higher PI yet have a lower NPV. Only in the case of capital rationing could Global Investments' decision have been incorrect.

- 6.15 a. The profitability index, PI, is the ratio of the present value of the future expected cash flows *after* the initial investment to the amount of the initial investment.

$$\begin{aligned}
 \text{PI}(A) &= [C_1 / (1+r) + C_2 / (1+r)^2] / (\text{Initial Investment}) \\
 &= [\$70,000 / (1.12) + \$70,000 / (1.12)^2] / (\$100,000) \\
 &= \mathbf{1.183}
 \end{aligned}$$

**The profitability index for project A is 1.183.**

$$\begin{aligned}
\text{PI}(B) &= [C_1 / (1+r) + C_2 / (1+r)^2] / (\text{Initial Investment}) \\
&= [\$130,000 / (1.12) + \$130,000 / (1.12)^2] / (\$200,000) \\
&= \mathbf{1.099}
\end{aligned}$$

**The profitability index for project B is 1.099.**

$$\begin{aligned}
\text{PI}(C) &= [C_1 / (1+r) + C_2 / (1+r)^2] / (\text{Initial Investment}) \\
&= [\$75,000 / (1.12) + \$60,000 / (1.12)^2] / (\$100,000) \\
&= \mathbf{1.148}
\end{aligned}$$

**The profitability index for project C is 1.148.**

b. 
$$\begin{aligned}
\text{NPV}(A) &= -\$100,000 + \$70,000 / (1.12) + \$70,000 / (1.12)^2 \\
&= \mathbf{\$18,303.57}
\end{aligned}$$

**The NPV of project A is \$18,303.57.**

$$\begin{aligned}
\text{NPV}(B) &= -\$200,000 + \$130,000 / (1.12) + \$130,000 / (1.12)^2 \\
&= \mathbf{\$19,706.63}
\end{aligned}$$

**The NPV of project B is \$19,706.63.**

$$\begin{aligned}
\text{NPV}(C) &= -\$100,000 + \$75,000 / (1.12) + \$60,000 / (1.12)^2 \\
&= \mathbf{\$14,795.92}
\end{aligned}$$

**The NPV of project C is \$14,795.92.**

c. **Accept projects A, B, and C.** Since the projects are independent, accept all three projects because their respective profitability indices are greater than one.

d. **Accept project B.** Since the projects are mutually exclusive, choose the project with the highest PI, while taking into account the scale of the project.

Because projects A and C have the same initial investment, the problem of scale does not arise when comparing the profitability indices. Based on the profitability index rule, project C can be eliminated because its PI is less than the PI of project A.

Because of the problem of scale, one cannot compare the PIs of projects A and B. However, one can calculate the PI of the incremental cash flows of the two projects.

Project	C <sub>0</sub>	C <sub>1</sub>	C <sub>2</sub>	PI
B – A	-\$100,000	\$60,000	\$60,000	1.014

When calculating incremental cash flows, remember to subtract the cash flows of the project with the smaller initial cash outflow from those of the project with the larger initial cash outflow. This procedure insures that the incremental initial cash outflow will be negative.

The PI calculation is:

$$\begin{aligned}
\text{PI}(B - A) &= [\$60,000 / (1.12) + \$60,000 / (1.12)^2] / (\$100,000) \\
&= \mathbf{1.014}
\end{aligned}$$

Amaro should accept project B since the PI of the incremental cash flows is greater than one.

e. Project B has the highest NPV. Project A has the next highest NPV. Therefore, accept projects B and A.

- 6.16 The PV of the cash inflows subsequent to the initial investment can be calculated using the seven-year annuity formula, discounted at 15 percent. Divide the PV of those cash flows by the initial investment to find the profitability index, PI. Bill should accept the project if the PI is greater than one.

$$\begin{aligned}
 \text{PI} &= [C_1 A^T_r] / (\text{Initial Investment}) \\
 &= [\$40,000 A^7_{0.15}] / (\$160,000) \\
 &= \mathbf{1.04}
 \end{aligned}$$

**Bill should accept the project since it has a profitability index greater than one.**

- 6.17 a. The payback period is the time it takes to recoup the initial investment of a project. Accept any project with a payback period equal to or shorter than the company's standard payback period. Reject all other projects.
- b. The average accounting return (AAR) is defined as the average project earnings divided by the average book value of the investment. Accept projects for which the AAR is equal to or greater than the firm's standard average accounting return. Reject all other projects.
- c. The internal rate of return (IRR) is the discount rate that makes the net present value (NPV) of a project equal to zero. The acceptance and rejection criteria are:
- If  $C_0 < 0$  and all future cash flows are positive, accept the project if the internal rate of return is greater than or equal to the discount rate.
- If  $C_0 < 0$  and all future cash flows are positive, reject the project if the internal rate of return is less than the discount rate.
- If  $C_0 > 0$  and all future cash flows are negative, accept the project if the internal rate of return is less than or equal to the discount rate.
- If  $C_0 > 0$  and all future cash flows are negative, reject the project if the internal rate of return is greater than the discount rate.
- If the project has cash flows with more than one change in sign, there is likely to be more than one positive IRR. In that situation, there is no valid IRR accept/reject rule.
- d. The profitability index (PI) is the present value of the cash flows subsequent to the initial investment divided by the initial investment. Accept any project for which the profitability index is greater than or equal to one. Reject any project that has a PI less than one.
- e. The net present value (NPV) is the sum of the present values of all project cash flows. Accept those projects with NPVs that are greater than or equal to zero. Reject projects with negative NPVs.

- 6.18 a. Payback period for the New Sunday Early Edition:

Use the payback period rule to calculate the number of years that it takes for the cumulative undiscounted cash inflows to equal the initial investment.

Initial Investment		=	-\$1,200
Year 1	= \$600	=	\$600
Year 2	= \$600 + \$550	=	\$1,150
<b>Year 3</b>	<b>= \$600 + \$550 + \$450</b>	<b>=</b>	<b>\$1,600</b>

The undiscounted cash flows exceed the initial investment of \$1,200 by the end of year 3. Many companies analyze the payback period in whole years. The payback period for the project is 3 years.

**The New Sunday Early Edition has a payback period of three years.**

Companies can calculate a more precise value using fractional years. Calculate the fraction of year 3's cash flow that is needed for the company to have cumulative undiscounted cash flows of \$1,200. Find the difference between the initial investment and the cumulative undiscounted cash flows as of year 2, divided by the undiscounted cash flow of year 3.

$$\begin{aligned} \text{Payback Period} &= 2 + (\$1,200 - \$1,150) / \$450 \\ &= \mathbf{2.11} \end{aligned}$$

Payback period for the New Saturday Late Edition:

Use the payback period rule to calculate the number of years that it takes for the cumulative undiscounted cash inflows to equal the initial investment.

$$\begin{aligned} \text{Initial Investment} &= -\$2,100 \\ \text{Year 1} &= \$1,000 &= \$1,000 \\ \text{Year 2} &= \$1,000 + \$900 &= \$1,900 \\ \text{Year 3} &= \mathbf{\$1,000 + \$900 + \$800} &= \mathbf{\$2,700} \end{aligned}$$

In year 3, the undiscounted cash flows exceed the initial investment of \$2,100 by the end of year 3. Many companies analyze the payback period in whole years. The payback period for the project is 3 years.

**The payback period for the New Saturday Late Edition is three years.**

Companies can calculate a more precise value using fractional years. Calculate the fraction of year 3's cash flows that is needed for the company to have cumulative undiscounted cash flows of \$2,100. Find the difference between the initial investment and the cumulative undiscounted cash flows as of year 2, divided by the undiscounted cash flow of year 3.

$$\begin{aligned} \text{Payback Period} &= 2 + (\$2,100 - \$1,900) / \$800 \\ &= \mathbf{2.25} \end{aligned}$$

**Using the whole number payback period, the projects are equally attractive. Using the fractional payback period calculation, the New Sunday Early Edition is more attractive because it has a shorter payback period than does the New Saturday Early Edition.**

b. New Sunday Early Edition IRR

The internal rate of return is the discount rate at which the NPV of the project's cash flows equals zero. Set the project's cash flows, discounted at the internal rate of return (IRR), equal to zero. Solve for the IRR.

$$\begin{aligned} \text{IRR} &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 + C_3 / (1+\text{IRR})^3 \\ 0 &= -\$1,200 + \$600 / (1+\text{IRR}) + \$550 / (1+\text{IRR})^2 + \$450 / (1+\text{IRR})^3 \\ \text{IRR} &= \mathbf{0.1676} \end{aligned}$$

New Saturday Late Edition IRR

The internal rate of return is the discount rate at which the NPV of the project's cash flows equals zero. Set the project's cash flows, discounted at the internal rate of return (IRR), equal to zero. Solve for the IRR.

$$\begin{aligned} \text{IRR} &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 + C_3 / (1+\text{IRR})^3 \\ 0 &= -\$2,100 + \$1,000 / (1+\text{IRR}) + \$900 / (1+\text{IRR})^2 + \$800 / (1+\text{IRR})^3 \\ \text{IRR} &= \mathbf{0.1429} \end{aligned}$$

**The New Sunday Early Edition has a greater IRR than the New Saturday Late Edition.**

- c. Find the IRR of the incremental cash flows. The incremental IRR is the IRR on the incremental investment from choosing the larger project instead of the smaller project. Incremental cash flows are defined as the New Saturday Late Edition's Cash Flows minus the New Sunday Early Edition's cash flows. Remember to subtract the cash flows of the project with the smaller initial investment from those of the project with the larger initial investment, so that the incremental initial investment is negative.

	Year 0	Year 1	Year 2	Year 3
Saturday Edition	-\$2,100	\$1,000	\$900	\$800
Sunday Edition	-1,200	600	550	450
Saturday – Sunday	-\$900	\$400	\$350	\$350

$$\begin{aligned} \text{IRR} &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 + C_3 / (1+\text{IRR})^3 \\ 0 &= -\$900 + \$400 / (1+\text{IRR}) + \$350 / (1+\text{IRR})^2 + \$350 / (1+\text{IRR})^3 \\ \text{IRR} &= \mathbf{0.1102} \end{aligned}$$

**For investing-type projects, accept the larger project when the incremental rate of return is greater than the discount rate. Since the discount rate of 12% is greater than the incremental IRR of 11.02%, choose the new Sunday Edition.**

- d. Average Accounting Return for the New Sunday Early Edition:

First, determine the average book value of the project. The book value is the gross investment minus accumulated depreciation.

$$\begin{aligned} \text{Annual Depreciation} &= \$1,200 / 3 \\ &= \$400 \end{aligned}$$

	Year 0	Year 1	Year 2	Year 3
Gross Investment	\$1,200	\$1,200	\$1,200	\$1,200
Accumulated Depreciation	\$0	\$400	\$800	\$1,200
Book Value	\$1,200	\$800	\$400	\$0

$$\begin{aligned} \text{Average Investment} &= (\$1,200 + \$800 + \$400 + \$0) / (4) \\ &= \$600 \end{aligned}$$

Calculate the average annual income of the project.

$$\begin{aligned} \text{Average Income} &= (\$400 + \$350 + \$300) / 3 \\ &= \$350 \end{aligned}$$

Divide the average project earnings by the average book value of the machine to calculate the average accounting return.

$$\begin{aligned} \text{Average Accounting Return} &= (\text{Average Income}) / (\text{Average Investment}) \\ &= \$350 / \$600 \\ &= \mathbf{0.583} \end{aligned}$$

**The average accounting return for the New Sunday Early Edition is 58.3%.**

Average Accounting Return for the New Saturday Late Edition:

First, determine the average book value of the project. The book value is the gross investment minus accumulated depreciation.

$$\begin{aligned} \text{Annual Depreciation} &= \$2,100 / 3 \\ &= \$700 \end{aligned}$$

	Year 0	Year 1	Year 2	Year 3
Gross Investment	\$2,100	\$2,100	\$2,100	\$2,100
Accumulated Depreciation	\$0	\$700	\$1,400	\$2,100
Book Value	\$2,100	\$1,400	\$700	\$0

$$\begin{aligned} \text{Average Investment} &= (\$2,100 + \$1,400 + \$700 + \$0) / (4) \\ &= \$1,050 \end{aligned}$$

Calculate the average annual income of the project.

$$\begin{aligned} \text{Average Income} &= (\$800 + \$700 + \$600) / 3 \\ &= \$700 \end{aligned}$$

Divide the average project earnings by the average book value of the machine to calculate the average accounting return.

$$\begin{aligned} \text{Average Accounting Return} &= (\text{Average Income}) / (\text{Average Investment}) \\ &= \$700 / \$1,050 \\ &= \mathbf{0.667} \end{aligned}$$

**The average accounting return for the New Saturday Late Edition is 66.7%.**

6.19 a. Discounted Payback Period for Deepwater Fishing:

Find the number of years that it takes for the discounted cash inflows to equal the initial investment of \$600,000. The approximate discounted payback period is the year *in which* the PV of the initial investment is surpassed.

$$\begin{aligned} \text{Cumulative Discounted Cash Flows Year 1} &= \$270,000 / (1.15) &= \$234,782.61 \\ \text{Cumulative Discounted Cash Flows Year 2} &= \$270,000 / (1.15) + \$350,000 / (1.15)^2 \\ &= \$499,432.89 \\ \text{Cumulative Discounted Cash Flows Year 3} &= \mathbf{\$270,000 / (1.15) + \$350,000 / (1.15)^2 +} \\ &\quad \mathbf{\$300,000 / (1.15)^3} &= \mathbf{\$696,687.76} \end{aligned}$$

The cumulative discounted cash flows exceed the initial investment of \$600,000 by the end of year 3. Many companies analyze the payback period in whole years. The payback period for the project is three years.

**The discounted payback period for deepwater fishing is three years.**

Discounted Payback Period for New Submarine Ride:

Find the number of years that it will take the discounted cash inflows to equal the initial investment of \$1,800,000. The approximate discounted payback period is the year *in which* the PV of the initial investment is surpassed.

$$\begin{aligned}\text{Cumulative Discounted Cash Flows Year 1} &= \$1,000,000 / (1.15) &&= \$869,565.22 \\ \text{Cumulative Discounted Cash Flows Year 2} &= \$1,000,000 / (1.15) + \$700,000 / (1.15)^2 \\ & &&= \$1,398,865.78 \\ \text{Cumulative Discounted Cash Flows Year 3} &= \mathbf{\$1,000,000 / (1.15)} + \mathbf{\$700,000 / (1.15)^2} + \\ & &&\mathbf{\$900,000 / (1.15)^3} &&= \mathbf{\$1,990,630.39}\end{aligned}$$

The cumulative discounted cash flows exceed the initial investment of \$1,800,000 by the end of year 3. Many companies analyze the payback period in whole years. The payback period for the project is three years.

**The discounted payback period for the submarine ride is three years.**

**According to the payback period rule, the projects are equally desirable.**

b. Deepwater Fishing IRR:

Set the project's cash flows, discounted at the internal rate of return (IRR), equal to zero. Solve for the IRR.

$$\begin{aligned}\text{IRR} &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 + C_3 / (1+\text{IRR})^3 \\ 0 &= -\$600,000 + \$270,000 / (1+\text{IRR}) + \$350,000 / (1+\text{IRR})^2 + \$300,000 / (1+\text{IRR})^3 \\ \text{IRR} &= \mathbf{0.243}\end{aligned}$$

**The IRR of the deepwater fishing project is 24.3%.**

Submarine Ride IRR:

Set the project's cash flows, discounted at the internal rate of return (IRR), equal to zero. Solve for the IRR.

$$\begin{aligned}\text{IRR} &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 + C_3 / (1+\text{IRR})^3 \\ 0 &= -\$1,800,000 + \$1,000,000 / (1+\text{IRR}) + \$700,000 / (1+\text{IRR})^2 + \\ & \quad \$900,000 / (1+\text{IRR})^3 \\ \text{IRR} &= \mathbf{0.2146}\end{aligned}$$

**The IRR of the submarine ride is 21.46%.**

**Based on the IRR rule, the deepwater fishing project should be chosen because it has the higher IRR.**

- c. Calculate the IRR of the incremental cash flows, defined as the New Saturday Late Edition's Cash Flows minus the New Sunday Early Edition's cash flows. Then calculate the IRR of the incremental cash flows. Remember to subtract the cash flows of the project with the smaller initial investment from those of the project with the larger initial investment, so that the incremental initial investment is negative.

	Year 0	Year 1	Year 2	Year 3
Submarine Ride	-1,800,000	1,000,000	700,000	900,000
Deepwater Fishing	-600,000	270,000	350,000	300,000
Submarine - Fishing	-\$1,200,000	\$730,000	\$350,000	\$600,000

$$\begin{aligned}
\text{IRR} &= C_0 + C_1 / (1+\text{IRR}) + C_2 / (1+\text{IRR})^2 + C_3 / (1+\text{IRR})^3 \\
0 &= -\$1,200,000 + \$730,000 / (1+\text{IRR}) + \$350,000 / (1+\text{IRR})^2 + \\
&\quad \$600,000 / (1+\text{IRR})^3 \\
\text{IRR} &= \mathbf{0.1992}
\end{aligned}$$

**For investing-type projects, accept the larger project when the incremental IRR is greater than the discount rate. Since the incremental IRR, 19.92%, is greater than the required rate of return, 15%, choose the submarine ride project. Note that the choice in part (c) differs from the choice in part (b). The choice in part (b) is flawed because there is a scale problem. That is, the submarine ride has a greater initial investment than does the deepwater fishing project. This problem is corrected only by calculating the IRR of the incremental cash flows.**

$$\begin{aligned}
\text{d. NPV(Deepwater Fishing)} &= -\$600,000 + \$270,000 / (1.15) + \$350,000 / (1.15)^2 + \\
&\quad \$300,000 / (1.15)^3 \\
&= \mathbf{\$96,687.76}
\end{aligned}$$

**The NPV of the deepwater fishing project is \$96,687.76.**

$$\begin{aligned}
\text{NPV(Submarine Ride)} &= -\$1,800,000 + \$1,000,000 / (1.15) + \$700,000 / (1.15)^2 + \\
&\quad \$900,000 / (1.15)^3 \\
&= \mathbf{\$190,630.39}
\end{aligned}$$

**The NPV of the submarine ride project is \$190,630.39.**

**Since the NPV of the submarine ride project is greater than the NPV of the deepwater fishing project, choose the submarine ride project. The NPV rule is always consistent with the incremental IRR rule.**

- 6.20 a. The project involves three cash flows: the initial investment, the annual cash inflows, and the abandonment costs. The mine will generate cash inflows over its 11-year economic life. To express the PV of the annual cash inflows, apply the growing annuity formula, discounted at the IRR and growing at eight percent.

$$\begin{aligned}
\text{PV(Cash Inflows)} &= C_1 \text{GA}_{\text{IRR}, g}^T * \\
&= \$100,000 \text{GA}_{\text{IRR}, 0.08}^{11}
\end{aligned}$$

\* The notation  $\text{GA}_{r, g}^T$  represents a growing annuity consisting of  $T$  payments growing at a rate of  $g$  per payment, discounted at  $r$ .

At the end of 11 years, the Utah Mining Corporate will abandon the mine, incurring a \$50,000 charge. Discount that charge back 11 years at the IRR to express its PV.

$$\begin{aligned}
\text{PV(Abandonment)} &= C_{11} / (1+\text{IRR})^{11} \\
&= -\$50,000 / (1+\text{IRR})^{11}
\end{aligned}$$

Solve the expression that equates the cash flows, discounted at the IRR, with zero. Solve for the IRR. Use a graphing calculator.

$$\begin{aligned}
\text{IRR} &= -\text{Initial Investment} + \text{PV(Cash Inflows)} - \text{PV(Abandonment)} \\
0 &= C_0 + C_1 \text{GA}_{\text{IRR}, g}^T - C_{11} / (1+\text{IRR})^{11} \\
0 &= -\$600,000 + \$100,000 \text{GA}_{\text{IRR}, 0.08}^{11} - \$50,000 / (1+\text{IRR})^{11} \\
\text{IRR} &= \mathbf{0.185565}
\end{aligned}$$

**The IRR of the mining project is approximately 18.56%.**

- b.** **Yes.** Since the mine's IRR exceeds the required return of 10%, the mine should be opened. The correct decision rule for an investment-type project is to accept the project if the discount rate is above the IRR. Anytime there is a second change in sign, there is a possibility for multiple IRRs. By using a graphing calculator, one can determine that in this problem, there is only one IRR. Therefore, a decision can be made.

6-21 a)

	Period	0	1	2	3	4	5	NPV
Worst Case	Cash Flow	\$ (250,000)	0	0	0	0	250,000	
	PV 12% (CF)	= CF (250,000)	= CF/1.12 0	= CF/(1.12) <sup>2</sup> 0	= CF/(1.12) <sup>3</sup> 0	= CF/(1.12) <sup>4</sup> 0	= CF/(1.12) <sup>5</sup> 141,857	

The worst case NPV is -\$108,143 and will occur when the project has no cash flows until year five, when it returns \$250,000.

b) The best case NPV can be an infinite amount. This is because payback period only tells you when you recover your investment. However, the cash flows are not limited to five years and could go on forever.

6.22 a) Payback period for Project A is at year 3.25 and for Project B is at year 1.5.  
Therefore, Totally Electric should select Project B because of the shorter payback period.

b)

	Avg Net Income	Avg Investment	AAR
Project A	\$37,500	\$75,000	.50000
Project B	\$13,250	\$40,000	.33125

Totally Electric should select Project A because it has the highest average accounting return.

c)

	Period	0	1	2	3	4	NPV
Project A	Cash Flow	\$(150,000)	15,000	35,000	50,000	200,000	
	PV 10% (CF)	= CF (150,000)	= CF/1.1 13,636	= CF/(1.1) <sup>2</sup> 28,926	= CF/(1.1) <sup>3</sup> 37,566	= CF/(1.1) <sup>4</sup> 136,603	
Project B	Cash Flow	\$ (80,000)	60,000	40,000	20,000	13,000	
	PV 10% (CF)	= CF (80,000)	= CF/1.1 54,545	= CF/(1.1) <sup>2</sup> 33,058	= CF/(1.1) <sup>3</sup> 15,026	= CF/(1.1) <sup>4</sup> 8,879	

NPV of Project A is \$66,730 and of Project B is \$31,509, so Totally Electric should select Project A because it has a higher NPV.

d)

	PV IRR (CF)	= CF (150,000)	= CF/IRR 12,206	= CF/(IRR) <sup>2</sup> 23,174	= CF/(IRR) <sup>3</sup> 26,939	= CF/(IRR) <sup>4</sup> 87,681	\$0	IRR	22.9%
Project A	PV IRR (CF)	= CF (80,000)	= CF/IRR 44,983	= CF/(IRR) <sup>2</sup> 22,483	= CF/(IRR) <sup>3</sup> 8,428	= CF/(IRR) <sup>4</sup> 4,107	\$0	IRR	33.4%

IRR of Project A is 22.9% and of Project B is 33.4%, so Totally Electric should select Project B because it has a higher IRR.

6.23

	Period	0	1	2	3	Sum of Cash Flow	Profitability Index	NPV
HDTV	Cash Flow	\$(1,000)	1,000	600	300			
	PV 10% (CF)	= CF (1,000)	= CF/1.1 909	= CF/(1.1) <sup>2</sup> 496	= CF/(1.1) <sup>3</sup> 225	\$1,630	1.63	\$630
Plasma	Cash Flow	\$(2,200)	700	1,100	2,200			
	PV 10% (CF)	= CF (2,200)	= CF/1.1 636	= CF/(1.1) <sup>2</sup> 909	= CF/(1.1) <sup>3</sup> 1,653	\$3,198	1.45	\$998

- a) HDTV has a PI of 1.63 and Plasma has a PI of 1.45, therefore, Pinnacle should invest in HDTV technology.  
 b) HDTV has a NPV of \$630 and Plasma has a NPV of \$998, therefore, Pinnacle should invest in Plasma technology.  
 c)

Incremental	Period	0	1	2	3	Cash Flow	PI	NPV
Plasma-HDTV	Cash Flow	\$(1,200)	\$(300)	\$500	\$1,900			
	PV 10% (CF)	= CF (1,200)	= CF/1.1 (273)	= CF/(1.1) <sup>2</sup> 413	= CF/(1.1) <sup>3</sup> 1,427	\$1,568	1.31	\$368

The profitability index, like the IRR, is a ratio and therefore limited by the problem of scale.

Because these investments are mutually exclusive, the Plasma investment should be selected because it has a higher NPV and the incremental PI is greater than 1.

- 6.24 a) Payback period for Board game is in year 1 and for CD-Rom is at year 1.5, so Mario Brothers should select Board game.

b)

	Period	0	1	2	3	NPV
Board game	Cash Flow	\$(300)	400	100	100	
	PV 10% (CF)	= CF (300)	= CF/1.1 364	= CF/(1.1) <sup>2</sup> 83	= CF/(1.1) <sup>3</sup> 75	\$221
CD-Rom	Cash Flow	\$(1,500)	1,100	800	400	
	PV 10% (CF)	= CF (1,500)	= CF/1.1 1,000	= CF/(1.1) <sup>2</sup> 661	= CF/(1.1) <sup>3</sup> 301	\$462

From the analysis, NPV of Board game is \$221 and of CD-Rom is \$462, so Mario Brothers should select CD-Rom.

c)								
Board game	PV IRR (CF)	= CF (300)	= CF/IRR 242	= CF/(IRR) <sup>2</sup> 36	= CF/(IRR) <sup>3</sup> 22	\$0	IRR	65.6%
CD-Rom	PV IRR (CF)	= CF (1,500)	= CF/IRR 846	= CF/(IRR) <sup>2</sup> 473	= CF/(IRR) <sup>3</sup> 182	\$0	IRR	30.1%

From the analysis, IRR of Board game is 65.6% and of CD-Rom is 30.1%, so Mario Brothers should select Board game.

d)								
CD-Rom	Cash flow	\$(1,200)	\$700	\$700	\$300	\$0	IRR	22.6%
	PV IRR (CF)	(1,200)	571	466	163	\$0	IRR	

Because the incremental IRR is 22.6% (>20% required IRR), the CD-Rom project should be selected.

### 6.25

	Period	0	1	2	3	Sum of Cash Flow	Profitability Index	NPV
CDMA	Cash Flow	\$(10)	25	15	5			
	PV 10% (CF)	= CF (10)	= CF/1.1 23	= CF/(1.1) <sup>2</sup> 12	= CF/(1.1) <sup>3</sup> 4	\$39	3.89	\$29
G4	Cash Flow	\$(20)	20	50	40			
	PV 10% (CF)	= CF (20)	= CF/1.1 18	= CF/(1.1) <sup>2</sup> 41	= CF/(1.1) <sup>3</sup> 30	\$90	4.48	\$70
Wi-Fi	Cash Flow	\$(30)	20	40	100			
	PV 10% (CF)	= CF (30)	= CF/1.1 18	= CF/(1.1) <sup>2</sup> 33	= CF/(1.1) <sup>3</sup> 75	\$126	4.21	\$96

a) G4 has a PI of 4.48, Wi-Fi has a PI of 4.21 and CDMA has a PI of 3.89.

b) Wi-Fi has a NPV of \$96, G4 has a NPV of \$70 and CDMA has a NPV of \$29.

c) Combined		Period	0	1	2	3	Cash Flow	PI	NPV
CDMA + G4	Cash Flow		\$(30)	\$45	\$65	\$45			
	PV 10% (CF)		= CF (30)	= CF/1.1 41	= CF/(1.1) <sup>2</sup> 54	= CF/(1.1) <sup>3</sup> 34	\$128	4.28	\$98

Although the Wi-Fi investment has the single largest NPV, this is not the best investment for Hanmi group. Because these investments are independent, and not mutually exclusive, Hanmi can invest in both CDMA (\$10 mil) and G4 (\$20 mil) which has a combined NPV of \$98 (>\$96 for Wi-Fi) and still be within the \$30 million investment budget.

6.26 a) Payback period for AZM is at year 1 and for AZF is at year 2, so project AZM should be taken.

b)		Period	0	1	2	3	SUM
AZM	Cash Flow		(\$200,000)	200,000	150,000	150,000	
	PV 10% (CF)		= CF (\$200,000)	= CF/1.1 181,818	= CF/(1.1) <sup>2</sup> 123,967	= CF/(1.1) <sup>3</sup> 112,697	\$218,482
AZF	Cash Flow		(\$500,000)	200,000	300,000	300,000	
	PV 10% (CF)		= CF (\$500,000)	= CF/1.1 181,818	= CF/(1.1) <sup>2</sup> 247,934	= CF/(1.1) <sup>3</sup> 225,394	\$155,147

From the analysis, NPV of AZM is \$218,482 and of AZF is \$155,147, so project AZM should be taken.

c)		PV IRR (CF)	= CF	= CF/IRR	= CF/(IRR) <sup>2</sup>	= CF/(IRR) <sup>3</sup>	IRR
AZM			(\$200,000)	117,616	51,876	30,507	70%
AZF			(\$500,000)	159,105	189,858	151,037	26%

From the analysis, IRR of AZM is 70% and of AZF is 26%, so project AZM should be taken.

d) Since both NPV and IRR favors project AZM, and AZM is a smaller investment to start out with, it is not necessary to conduct Incremental IRR analysis.

6.27. a) Payback period for Dry Prepreg is at year 2 and for Solvent Prepreg is at year 1, so project Solvent Prepreg should be taken.

b)

	Period	0	1	2	3	SUM
Dry Prepreg	Cash Flow	(\$1,000,000)	600,000	400,000	1,000,000	
	PV 10% (CF)	= CF (\$1,000,000)	= CF/1.10 545,455	= CF/(1.10) <sup>2</sup> 330,579	= CF/(1.10) <sup>3</sup> 751,315	\$627,348
Solvent Prepreg	Cash Flow	(\$500,000)	500,000	300,000	100,000	
	PV 10% (CF)	= CF (\$500,000)	= CF/1.10 454,545	= CF/(1.10) <sup>2</sup> 247,934	= CF/(1.10) <sup>3</sup> 75,131	\$277,611

From the analysis, NPV of Dry Prepreg is \$627,348 and of Solvent Prepreg is \$277,611, so project Dry Prepreg should be taken.

c)

Dry Prepreg	PV IRR (CF)	= CF (\$1,000,000)	= CF/IRR 429,218	= CF/(IRR) <sup>2</sup> 204,698	= CF/(IRR) <sup>3</sup> 366,084	\$0	IRR	40%
Solvent Prepreg	PV IRR (CF)	= CF (\$500,000)	= CF/IRR 335,122	= CF/(IRR) <sup>2</sup> 134,768	= CF/(IRR) <sup>3</sup> 30,109	(\$0)	IRR	49%

From the analysis, IRR of Dry Prepreg is 40% and of Solvent Prepreg is 49%, so project Solvent Prepreg should be taken.

d) Since Solvent Prepreg has a higher IRR, but is relatively smaller in terms of investment and NPV, Incremental IRR analysis is required.

Dry-Solvent	Cash Flow	(\$500,000)	100,000	100,000	900,000		
	PV IRR (CF)	(\$500,000)	74,377	55,319	370,304	\$0	IRR

Because the incremental IRR is 34% (>30% min IRR req.), the Dry Prepreg project should be considered.

6.28

	Period	0	1	2	3	4	5	SUM	IRR/PI
NP-30	Cash Flow	(\$100,000)	40,000	40,000	40,000	40,000	40,000		
	PV 15% (CF)	(\$100,000)	34,783	30,246	26,301	22,870	19,887	\$34,086	
	PV IRR (CF)	-\$100,000	31,092	24,168	18,786	14,603	11,351	\$0	29%
	PI								1.34
NX-20	Cash Flow	(\$30,000)	20,000	23,000	26,450	30,418	34,980		
	PV 15% (CF)	(\$30,000)	17,391	17,391	17,391	17,391	17,391	\$56,957	
	PV IRR (CF)	-\$30,000	11,559	7,683	5,107	3,394	2,256	\$0	73%
	PI								2.90
Incremental NP30- NX20	Cash Flow	(\$70,000)	20,000	17,000	13,550	9,583	5,020		
	PV IRR (CF)	(\$70,000)	20,594	18,026	14,795	10,774	5,812	(\$0)	-3%

6.29

	Period	0	1	2	3	4	5	SUM	IRR/PI
A	Cash Flow	(\$100,000)	50,000	50,000	40,000	30,000	20,000		
	PV 15% (CF)	(\$100,000)	43,478	37,807	26,301	17,153	9,944	\$34,682	
	PV IRR (CF)	-\$100,000	38,085	29,010	17,678	10,099	5,128	\$0	31%
	PI								1.35
B	Cash Flow	(\$200,000)	60,000	60,000	60,000	100,000	200,000		
	PV 15% (CF)	(\$200,000)	52,174	45,369	39,451	57,175	99,435	\$93,604	
	PV IRR (CF)	-\$200,000	46,316	35,754	27,600	35,509	54,821	\$0	30%
	PI								1.47
Incremental B-A	Cash Flow	(\$100,000)	10,000	10,000	20,000	70,000	180,000		
	PV IRR (CF)	(\$100,000)	7,776	6,047	9,404	25,595	51,178	\$0	29%

**Implications**

NPV

Project B should be taken.

IRR

Project A should be taken.

Incremental IRR

Project B should be taken (29% &gt; the minimum acceptable IRR of 25%)

PI

Project B should be taken.

6.30

	Period	0	1	2	SUM	IRR/PI
B	Cash Flow	(\$200,000)	200,000	111,000		
	PV 20% (CF)	(\$200,000)	166,667	77,083	\$43,750	
	PV IRR (CF)	-\$200,000	143,142	56,858	(\$0)	40%
	PI					1.37
C	Cash Flow	(\$100,000)	100,000	100,000		
	PV 20% (CF)	(\$100,000)	83,333	69,444	\$52,778	
	PV IRR (CF)	-\$100,000	61,803	38,197	\$0	62%
	PI					1.74
Incremental B-C	Cash Flow	(\$100,000)	100,000	11,000		
	PV IRR (CF)	(\$100,000)	90,909	9,091	\$0	10%

Clearly, project A will not have a positive NPV and therefore is not a viable project. From the analysis, projects B and C will have the same payback period. However, project C will have a higher NPV and IRR, therefore it should be recommended.

Use 20% discount rate for projects B and C since their risk are greater than the typical core projects of 10%.

6.31 Using Incremental Cash Flows:

Year	Cash Flows for Project Billion – Project Million
0	$-I_0 + 1,500$
1	300
2	300
3	500

PV @ 12% of Cash Flow subsequent to Initial investment = 862.9

For Project Billion to be more attractive,  $862.9/(-I_0 + 1,500) > 1$  (Profitability Index should be greater than 1)

Solving we get  $637.1 < I_0 < 1500$

- 6.32
- a) Project A would have a higher IRR since initial investment for Project A is less than that of Project B, if the cash flows for the two projects are identical.
  - b) False.
  - c) Yes since **both** the cash flows as well as the initial investment are twice that of Project B.