13-1  a. The capital budget outlines the planned expenditures on fixed assets. 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. Strategic business plan is a long-run plan which outlines in broad terms the firm’s basic strategy for the next 5 to 10 years.

b. 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.

c. 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.

d. 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.

e. 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.

f. 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. The profitability index is found by dividing the project's PV of future cash flows by its initial cost. A profitability index greater than 1 is equivalent to a positive NPV project.

g. 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.
h. 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.

i. The hurdle rate is the project cost of capital, or discount rate. It is the rate used in discounting future cash flows in the NPV method, and it is the rate that is compared to the IRR.

j. 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 which costs k, the proper reinvestment rate assumption is the cost of capital, and thus the best capital budget decision rule is NPV.

k. The post-audit is the final aspect of the capital budgeting process. The post-audit is a feedback process in which the actual results are compared with those predicted in the original capital budgeting analysis. The post-audit has several purposes, the most important being to improve forecasts and improve operations.

13-2 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.

13-3 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.

13-4 This question is related to Question 13-3 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.

13-5 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.

13-6 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.

13-7 Yes, if the cash position of the firm is poor and if it has limited access to additional outside financing. But even here, the relationship between present value and cost would be a better decision tool.

13-8 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.
13-1 \$52,125/\$12,000 = 4.3438, so the payback is about 4 years.

13-2 Financial calculator: Input the appropriate cash flows into the cash flow register, input I = 12, and then solve for NPV = \$7,486.68.

13-3 Financial calculator: Input the appropriate cash flows into the cash flow register and then solve for IRR = 16%.

13-5 MIRR: PV Costs = \$52,125.

FV Inflows:

\[
\begin{array}{cccccccc}
0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\
\text{PV} & 12,000 & 12,000 & 12,000 & 12,000 & 12,000 & 12,000 & 12,000 & 12,000 \\
\text{FV} & 13,440 & 15,053 & 16,859 & 18,882 & 21,148 & 23,686 & 26,528 & 147,596 \\
\end{array}
\]

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

13-6 Project A:

Using a financial calculator, enter the following:

\[
\begin{align*}
    CF_0 &= -15000000 \\
    CF_1 &= 5000000 \\
    CF_2 &= 10000000 \\
    CF_3 &= 20000000 \\
    I &= 10; \ NPV = \$12,836,213.
\end{align*}
\]
Change $I = 10$ to $I = 5$; NPV = $16,108,952$.

Change $I = 5$ to $I = 15$; NPV = $10,059,587$.

**Project B:**

Using a financial calculator, enter the following:

\[
\begin{align*}
CF_0 &= -15000000 \\
CF_1 &= 20000000 \\
CF_2 &= 10000000 \\
CF_3 &= 6000000 \\
\end{align*}
\]

$I = 10$; NPV = $15,954,170$.

Change $I = 10$ to $I = 5$; NPV = $18,300,939$.

Change $I = 5$ to $I = 15$; NPV = $13,897,838$.

**13-7 Using a financial calculator, enter the following:**

\[
\begin{align*}
CF_0 &= -200 \\
CF_1 &= 235 \\
CF_2 &= -65 \\
CF_3 &= 300 \\
\end{align*}
\]

$I = 11.5$; NPV = $174.90$.

**13-8 Truck:**

Financial calculator: Input the appropriate cash flows into the cash flow register, input $I = 14$, and then solve for NPV = $409$.

Financial calculator: Input the appropriate cash flows into the cash flow register and then solve for IRR = 14.99% 15%.

**MIRR:** PV Costs = $17,100$.

**FV Inflows:**

\[
\begin{array}{cccccc}
| PV | 14% | 1 | 2 | 3 | 4 | 5 | FV \\
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>14%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5,100</td>
</tr>
<tr>
<td>5,100</td>
<td>14%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5,100</td>
</tr>
<tr>
<td>5,100</td>
<td>14%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5,100</td>
</tr>
<tr>
<td>5,100</td>
<td>14%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5,100</td>
</tr>
</tbody>
</table>
\end{array}
\]

$17,100 \quad \text{MIRR} = 14.54\% \quad \text{(Accept)} \quad 33,712$
Financial calculator: Obtain the FVA by inputting $N = 5$, $I = 14$, $PV = 0$, $PMT = 5100$, 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 $I = 14.54\%$.

**Pulley:**

Financial calculator: Input the appropriate cash flows into the cash flow register, input $I = 14$, 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:** $PV$ Costs $= $22,430.

**FV Inflows:**

```
<table>
<thead>
<tr>
<th>PV</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7,500</td>
<td>7,500</td>
<td>7,500</td>
<td>7,500</td>
<td>7,500</td>
<td>8,550</td>
<td>9,747</td>
<td>11,112</td>
<td>12,667</td>
</tr>
<tr>
<td>22,430</td>
<td>MIRR = 17.19% (Accept)</td>
<td>49,576</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

Financial calculator: Obtain the FVA by inputting $N = 5$, $I = 14$, $PV = 0$, $PMT = 7500$, 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 $I = 17.19\%$.

**Electric-powered:**

Financial calculator: Input the appropriate cash flows into the cash flow register, input $I = 12$, 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:**

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

Financial calculator: Input the appropriate cash flows into the cash flow register and then solve for $IRR = 17.97\%$ 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 ($18\% > k = 12\%$) on a larger investment.
13-10 Financial calculator solution, NPV:

**Project S**

Inputs: $N = 5$, $I = 12$, $PV = 3000$, $PMT = 0$

Output: $= -10,814.33$

$NPV_S = $10,814.33 - $10,000 = $814.33.$

**Project L**

Inputs: $N = 5$, $I = 12$, $PV = 7400$, $PMT = 0$

Output: $= -26,675.34$

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

Financial calculator solution, IRR:

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

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

Financial calculator solution, MIRR:

**Project S**

Inputs: $N = 5$, $I = 12$, $PV = 0$, $FV = 3000$

Output: $= -19,058.54$

$PV costs_S = $10,000.$

$FV inflows_S = $19,058.54.$

Inputs: $N = 5$, $I = -10000$, $PMT = 0$, $FV = 19058.54$

Output: $= 13.77$

$MIRR_S = 13.77\%.$

**Project L**
Inputs  5  12  0  7400

Output = -47,011.07

PV costs_L = $25,000.
FV inflows_L = $47,011.07.

Inputs  5  -25000  0  47011.07

Output  = 13.46

MIRR_L = 13.46%.

PIS = $1,0814.33
$10,000

PI_L = $26,675.34
$25,000

Thus, NPV_L > NPV_S, IRR_S > IRR_L, MIRR_S > MIRR_L, and PI_S > PI_L. The scale difference between Projects S and L result in the IRR, MIRR, and PI favoring S over L. However, NPV favors Project L, and hence L should be chosen.

13-11 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 -$556,717, while the PV of costs for the forklift system is -$493,407. Thus, the forklift system is expected to be -$493,407 - (-$556,717) = $63,310 less costly than the conveyor system, and hence the forklifts should be used.

Note: If the PVIFA interest factors are used, then PV_C = -$556,720 and PV_F = -$493,411.

13-13 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: NPV_S = $39.14; IRR_S = 13.49%.

Project L: NPV_L = $53.55; IRR_L = 11.74%.

Since Project L has the higher NPV, it is the better project.

13-15 a. Purchase price $ 900,000
Installation 165,000
Initial outlay $1,065,000

CF_0 = -1065000; CF_1-5 = 350000; I = 14; NPV = ?
NPV = $136,578; IRR = 19.22%.

b. 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.

c. 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.

13-16 a. Year Sales Royalties Marketing Net
0 (20,000) (20,000)
1 75,000 (5,000) (10,000) 60,000
2 52,500 (3,500) (10,000) 39,000
3 22,500 (1,500) 21,000

Payback period = $20,000/$60,000 = 0.33 years.

NPV = $60,000/(1.11)^1 + $39,000/(1.11)^2 + $21,000/(1.11)^3 - $20,000
= $81,062.35.

IRR = 261.90%.

b. Finance theory dictates that this investment should be accepted. However, ask your students "Does this service encourage cheating?" If yes, does a businessperson have a social responsibility not to make this service available?

13-19 a. Incremental Cash Flow (B - A)
Year Plan B Plan A $ 0
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 17500000 0
N I 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 $k > 16.07\%$, then Plan A is preferred.
a. Financial calculator solution:

**Plan A**

Inputs: 20, 10, 8000000, 0

Output: \(-68,108,510\)

NPV\(_A\) = \$68,108,510 - \$50,000,000 = \$18,108,510.

**Plan B**

Inputs: 20, 10, 3400000, 0

Output: \(-28,946,117\)

NPV\(_B\) = \$28,946,117 - \$15,000,000 = \$13,946,117.

**Plan A**

Inputs: 20, -50000000, 8000000, 0

Output: 15.03

IRR\(_A\) = 15.03\%.

**Plan B**

Inputs: 20, -15000000, 3400000, 0

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):

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash Flows from A</th>
<th>Cash Flows from B</th>
<th>Project Δ Cash Flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>($50)</td>
<td>($15.0)</td>
<td>($35.0)</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>3.4</td>
<td>4.6</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>3.4</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>8</td>
<td>3.4</td>
<td>4.6</td>
</tr>
</tbody>
</table>
So, Project Δ has a "cost" of $35,000,000 and "inflows" of $4,600,000 per year for 20 years.

\[ \text{Inputs } 20 \quad 10 \quad 4600000 \quad 0 \]

Output = $35,000,000 - $4,162,393 = $39,162,393.

\[ \text{Npv} = -39,162,393 \]

\[ \text{Inputs } 2 \quad -3500000 \quad 4600000 \quad 0 \]

Output = 11.71

\[ \text{IRR} = 11.71\% \]

Since IRR > k, and since we should accept Δ. This means accept the larger project (Project A). In addition, when dealing with mutually exclusive projects, we use the NPV method for choosing the best project.

\[ \begin{array}{c|c|c|c|c|c}
\text{NPV (Millions of Dollars)} & \text{Crossover Rate } = 11.7\% \\
\hline
\text{Cost of Capital } \% & 5 & 10 & 15 & 20 & 25 & 30 \\
\hline
\text{IRR}_A & 15.03\% & & & & & \\
\text{IRR}_B & 22.26\% & & & & & \\
\hline
\text{IRR}_A & 11.7\% & & & & &
\end{array} \]
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 percent, all projects with an NPV > 0 will be accepted by the firm. 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 costs 10 percent. Thus, since these cash flows are expected to save the firm 10 percent, 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.

13-21 a. The project's expected cash flows are as follows (in millions of dollars):

<table>
<thead>
<tr>
<th>Time</th>
<th>Net Cash Flow ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-4.4</td>
</tr>
<tr>
<td>1</td>
<td>27.7</td>
</tr>
<tr>
<td>2</td>
<td>-25.0</td>
</tr>
</tbody>
</table>

We can construct the following NPV profile:

<table>
<thead>
<tr>
<th>Discount Rate (%)</th>
<th>NPV (Millions of Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$1,700,000</td>
</tr>
<tr>
<td>9</td>
<td>29,156</td>
</tr>
<tr>
<td>10</td>
<td>120,661</td>
</tr>
</tbody>
</table>

NPV approaches -$4.0 as the cost of capital approaches ∞.

NPV approaches $420% at 80.5% discount rate.

IRR₁ = 9.2%
IRR₂ = 420%
The table above was constructed using a financial calculator with the following inputs: $CF_0 = -4400000$, $CF_1 = 27700000$, $CF_2 = -25000000$, and I = discount rate to solve for the NPV.

b. If k = 8%, reject the project since NPV < 0. But if k = 14%, accept the project because NPV > 0.

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 19 for more information on leases.)

13-22 Determine cash flows:

t = 0: The firm must borrow the entire $2,000,000 in order to invest in the casino project, since the casino will not generate any funds until the end of the second year. However, the loan must be repaid at the end of the first year, therefore, the firm must use the extra $1 million to provide the funds needed to repay the loan.

t = 1: Repay $2 million loan, plus 10 percent interest ($200,000), plus $700,000 fee: Net cash out flow = $2.9 million.

t = 2: Receive $2 million from sale of casino.

Work out NPV profile:

$$NPV = +$1,000,000 - \frac{2,900,000}{(1 + k)^2} + \frac{2,000,000}{(1 + k)^3}.$$ 

Solve at different values of k:

<table>
<thead>
<tr>
<th>k</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>$100,000</td>
</tr>
<tr>
<td>10</td>
<td>16,529</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>(78)</td>
</tr>
<tr>
<td>25</td>
<td>(40,000)</td>
</tr>
<tr>
<td>35</td>
<td>(50,754)</td>
</tr>
<tr>
<td>50</td>
<td>(44,444)</td>
</tr>
<tr>
<td>77</td>
<td>(32)</td>
</tr>
<tr>
<td>100</td>
<td>50,000</td>
</tr>
</tbody>
</table>
The table above was constructed using a financial calculator with the following inputs: \( CF_0 = 1000000 \), \( CF_1 = -2900000 \), \( CF_2 = 2000000 \), and \( I = \) discount rate to solve for the NPV.

As the graph indicates, the NPV is positive at any \( k \) less than 13 percent or greater than 77 percent; within that range, the NPV is negative.

The deal really amounts to a loan plus a construction project. If the firm could borrow at low rates (less than 13 percent), then the project would be profitable because the profit on the sale of the casino ($1 million) would more than cover the interest and fee on the loan. Or, if the firm had such good investment opportunities that the firm could make over 76 percent on the $1 million made available by the deal, it would be profitable. In between, it is not a good project.

13-23 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:  \( CF_0 = -500000 \),  \( CF_1 = -120000 \),  \( N_j = 4 \),  \( CF_2 = -20000 \),  \( I = 8 \),
\( NPV_C = ? \)  \( NPV_C = -911,067 \).

Input:  \( CF_0 = -200000 \),  \( CF_1 = -160000 \),  \( N = 5 \),  \( I = 8 \),  \( C = ? \)  \( = -838,834 \).