21.1.

LT Rate	5%										
ST Rate	7%										
Savings Interest	3%										
Start Balance	1		(all cash figures in millions of dollars)								
Minimum Cash	0.5										
	Cash	LT	ST	LT	ST	LT	ST	Savings			Minimum
Year	Flow	Loan	Loan	Interest	Interest	Payback	Payback	Interest	Balance		Balance
2014	-8	7.50	0.00						0.50	>=	0.50
2015	-2		2.36	-0.38	0.00		0.00	0.02	0.50	>=	0.50
2016	-4		6.89	-0.38	-0.17		-2.36	0.01	0.50	>=	0.50
2017	3		4.73	-0.38	-0.48		-6.89	0.02	0.50	>=	0.50
2018	6		0.00	-0.38	-0.33		-4.73	0.01	1.08	>=	0.50
2019	3		0	-0.38	0.00		0.00	0.03	3.74	>=	0.50
2020	-4		1.02	-0.38	0		0	0.11	0.50	>=	0.50
2021	7		0	-0.38	-0.07		-1.02	0.01	6.04	>=	0.50
2022	-2		0	-0.38	0		0	0.18	3.85	>=	0.50
2023	10		0	-0.38	0		0	0.12	13.59	>=	0.50
2024				-0.38	0	-7.50	0	0.41	6.12	>=	0.50

21.2.

(a) The COO will need to know how many of each product to produce. Thus, the decisions are how many end tables, how many coffee tables, and how many dining room tables to produce. The objective is to maximize total profit.

(b) Pine wood used = (3 end tables)(8 pounds/end table)
+ (3 dining room tables)(80 pounds/dining room table)
= 264 pounds

Labor used = (3 end tables)(1 hour/end table)
+ (3 dining room tables)(4 hours/dining room table)
= 15 hours

(c)

	End Tables	Coffee Tables	Dining Room Tables			
Unit Profit						
	Resource Used per unit Produced			Total Used		Available
Pine Wood					<=	
Labor					<=	
	End Tables	Coffee Tables	Dining Room Tables			Total Profit
Units Produced						

(d)

	End Tables	Coffee Tables	Dining Room Tables			
Unit Profit	$50	$100	$220			
	Resource Used per unit Produced			Total Used		Available
Pine Wood	8	15	80	3000	<=	3000
Labor	1	2	4	200	<=	200
	End Tables	Coffee Tables	Dining Room Tables			Total Profit
Units Produced	0	40	30			$10,600

21.3.

(a) Top management will need to know how much to produce in each quarter. Thus, the decisions are the production levels in quarters 1, 2, 3, and 4. The objective is to maximize the net profit.

(b)

$$\begin{aligned}
\text{Ending Inventory(Q1)} &= \text{Starting Inventory(Q1)} + \text{Production(Q1)} - \text{Sales(Q1)} \\
&= 1,000 + 5,000 - 3,000 = 3,000 \\
\text{Ending Inventory(Q2)} &= \text{Starting Inventory(Q2)} + \text{Production(Q2)} - \text{Sales(Q2)} \\
&= 3,000 + 5,000 - 4,000 = 4,000 \\
\text{Profit from Sales(Q1)} &= \text{Sales(Q1)} \times (\$20) = 3,000 \times (\$20) = \$60,000 \\
\text{Profit from Sales(Q2)} &= \text{Sales(Q2)} \times (\$20) = 4,000 \times (\$20) = \$80,000 \\
\text{Inventory Cost(Q1)} &= \text{Ending Inventory(Q1)} \times (\$8) = 3,000 \times (\$8) = \$24,000 \\
\text{Inventory Cost(Q2)} &= \text{Ending Inventory(Q2)} \times (\$8) = 4,000 \times (\$8) = \$32,000
\end{aligned}$$

(c)

Inventory Holding Cost												
Gross Profit from Sales												
	Starting Inventory	Production		Maximum Production		Demand/ Sales	Ending Inventory			Inventory Cost	Gross Profit from Sales	
Quarter 1			<=					>=				
Quarter 2			<=					>=				
Quarter 3			<=					>=				
Quarter 4			<=					>=				
										Net Profit		

(d)

Inventory Holding Cost		$8										
Gross Profit from Sales		$20										
	Starting Inventory	Production		Maximum Production		Demand/ Sales	Ending Inventory				Inventory Cost	Gross Profit from Sales
Quarter 1	1,000	2,000	<=	6,000		3,000	0	>=	0		$0	$60,000
Quarter 2	0	4,000	<=	6,000		4,000	0	>=	0		$0	$80,000
										Totals	$0	$140,000
											Net Profit	$140,000

(e)

Inventory Holding Cost		$8										
Gross Profit from Sales		$20										
	Starting Inventory	Production		Maximum Production		Demand/ Sales	Ending Inventory				Inventory Cost	Gross Profit from Sales
Quarter 1	1,000	3,000	<=	6,000		3,000	1,000	>=	0		$8,000	$60,000
Quarter 2	1,000	6,000	<=	6,000		4,000	3,000	>=	0		$24,000	$80,000
Quarter 3	3,000	6,000	<=	6,000		8,000	1,000	>=	0		$8,000	$160,000
Quarter 4	1,000	6,000	<=	6,000		7,000	0	>=	0		$0	$140,000
										Totals	$40,000	$440,000
											Net Profit	$400,000

21.4.

(a) Fairwinds needs to know how much to participate in each of the three projects and what their ending balances will be. The decisions to be made are how much to participate in each of the three projects. The objective is to maximize the ending balance at the end of six years.

(b)

$$\begin{aligned}\text{Ending Balance(Y1)} &= \text{Starting Balance} + \text{Project A} + \text{Project C} + \text{Other Projects} \\ &= 10 + (100\%)(-4) + (50\%)(-10) + 6 = \$7 \text{ million}\end{aligned}$$

$$\begin{aligned}\text{Ending Balance(Y2)} &= \text{Starting Balance} + \text{Project A} + \text{Project C} + \text{Other Projects} \\ &= 7 + (100\%)(-6) + (50\%)(-7) + 6 = \$3.5 \text{ million}\end{aligned}$$

(c)

Starting Cash									
				Total					
	Cash Flow (at full participation, $million)			Cash Flow	Other	Ending		Minimum	
Year	Project A	Project B	Project C	From ABC	Projects	Balance		Balance	
1							>=		
2							>=		
3							>=		
4							>=		
5							>=		
6							>=		
Participation									
	<=	<=	<=						
	100%	100%	100%						

(d)

Starting Cash	10		all cash numbers are in $millions					
				Total				
	Cash Flow (at full participation, $million)			Cash Flow	Other	Ending		Minimum
Year	Project A	Project B	Project C	From ABC	Projects	Balance		Balance
1	-4	-8	-10	0	6	16	>=	1
2	-6	-8	-7	0	6	22	>=	1
Participation	0%	0%	0%					
	<=	<=	<=					
	100%	100%	100%					

(e)

Starting Cash	10		all cash numbers are in $millions					
				Total				
	Cash Flow (at full participation, $million)			Cash Flow	Other	Ending		Minimum
Year	Project A	Project B	Project C	From ABC	Projects	Balance		Balance
1	-4	-8	-10	-10.75	6	5.25	>=	1
2	-6	-8	-7	-8.125	6	3.125	>=	1
3	-6	-4	-7	-8.125	6	1	>=	1
4	24	-4	-5	-0.5	6	6.5	>=	1
5	0	30	-3	-3	6	9.5	>=	1
6	0	0	44	44	6	59.5	>=	1
Participation	18.75%	0%	100%					
	<=	<=	<=					
	100%	100%	100%					

21.5.

(a) Web Mercantile needs to know each month how many square feet to lease and for how long. The decisions therefore are for each month how many square feet to lease for one month, two months, three months, etc. The objective is to minimize the overall leasing cost.

(b) Total Cost = (30,000 sq feet)($190/sq foot) + (20,000 sq feet)($100/sq foot) = $7.7 million

(c)

	Month Covered by Lease?														Total		Space
Month of Lease:	1	1	1	1	1	2	2	2	2	3	3	3	4	4	5	Leased		Required
Length of Lease:	1	2	3	4	5	1	2	3	4	1	2	3	1	2	1	(sq. ft.)		(sq. ft.)
Month 1																	>=	
Month 2																	>=	
Month 3																	>=	
Month 4																	>=	
Month 5																	>=	
Cost of Lease																		
(per sq. ft.)																		
																		Total Cost
Lease (sq. ft.)																		

(d)

	Month Covered by Lease?			Total		Space
Month of Lease:	1	1	2	Leased		Required
Length of Lease:	1	2	1	(sq. ft.)		(sq. ft.)
Month 1	1	1		30,000	>=	30,000
Month 2		1	1	20,000	>=	20,000
Cost of Lease	$65	$100	$65			
(per sq. ft.)						
						Total Cost
Lease (sq. ft.)	10,000	20,000	0			$2,650,000

(e)

	Month Covered by Lease?															Total		Space
Month of Lease:	1	1	1	1	1	2	2	2	2	3	3	3	4	4	5	Leased		Required
Length of Lease:	1	2	3	4	5	1	2	3	4	1	2	3	1	2	1	(sq. ft.)		(sq. ft.)
Month 1	1	1	1	1	1											30,000	>=	30,000
Month 2		1	1	1	1	1	1	1	1							30,000	>=	20,000
Month 3			1	1	1		1	1	1	1	1	1				40,000	>=	40,000
Month 4				1	1			1	1		1	1	1	1		30,000	>=	10,000
Month 5					1				1			1		1	1	50,000	>=	50,000
Cost of Lease	$65	$100	$135	$160	$190	$65	$100	$135	$160	$65	$100	$135	$65	$100	$65			
(per sq. ft.)																		
																		Total Cost
Lease (sq. ft.)	0	0	0	0	30,000	0	0	0	0	10,000	0	0	0	0	20,000			$7,650,000

21.6.

(a) Larry needs to know how many employees should work each possible shift. Therefore, the decision variables are the number of employees that work each shift. The objective is to minimize the total cost of the employees.

(b) Working 8 A.M.-noon: $3 \text{ FT morning} + 3 \text{ PT} = 6$

Working Noon-4 P.M.: $3 \text{ FT morning} + 2 \text{ FT afternoon} + 3 \text{ PT} = 8$

Working 4 P.M-8 P.M: $2 \text{ FT afternoon} + 4 \text{ FT evening} + 3 \text{ PT} = 9$

Working 8 P.M-midnight: $4 \text{ FT evening} + 3 \text{ PT} = 7$

Total cost per day $= (9 \text{ FT})(8 \text{ hrs})(\$40/\text{hr}) + (12 \text{ PT})(4 \text{ hrs})(\$30/\text{hr}) = \$4,320$

(c)

	Full Time 8am-4pm	Full Time noon-8pm	Full Time 4pm-midnight	Part Time 8am-noon	Part Time noon-4pm	Part Time 4pm-8pm	Part Time 8pm-midnight			
Cost per Shift										
								Total Working		Total Needed
			Shift Covers Time of Day? (1=yes, 0=no)							
8am-noon									>=	
noon-4pm									>=	
4pm-8pm									>=	
8pm-midnight									>=	
Workers per Shift										
	Total		Times Total				Total			
Time of Day	Full Time		Part Time				Cost			
8am-noon		>=								
noon-4pm		>=								
4pm-8pm		>=								
8pm-midnight		>=								

(d)

	Full Time 8am-4pm	Full Time noon-8pm	Full Time 4pm-midnight	Part Time 8am-noon	Part Time noon-4pm	Part Time 4pm-8pm	Part Time 8pm-midnight			
Cost per Shift	$320	$320	$320	$120	$120	$120	$120			
								Total Working		Total Needed
			Shift Covers Time of Day? (1=yes, 0=no)							
8am-noon	1			1				4	>=	4
noon-4pm	1	1			1			8	>=	8
4pm-8pm		1	1			1		10	>=	10
8pm-midnight			1				1	6	>=	6
Workers per Shift	3	3	4	1	2	3	2			
			2							
	Total		Times Total				Total			
Time of Day	Full Time		Part Time				Cost			
8am-noon	3	>=	2				$4,160			
noon-4pm	6	>=	4							
4pm-8pm	7	>=	6							
8pm-midnight	4	>=	4							

21.7.

(a) Al will need to know how much to invest in each possible investment each year. Thus, the decisions are how much to invest in investment A in year 1, 2, 3, and 4; how much to invest in B in year 1, 2, and 3; how much to invest in C in year 2; and how much to invest in D in year 5. The objective is to accumulate the maximum amount of money by the beginning of year 6.

(b)

Ending Cash(Y1) = ($60,000)(Starting Balance)-($20,000)(A in Y1) = $40,000
Ending Cash(Y2) = ($40,000)(Starting Balance)-($20,000)(B in Y2)-($20,000)(C in Y2) = $0
Ending Cash(Y3) = ($0)(Starting Balance)+($20,000)(1.4)(investment A) = $28,000
Ending Cash(Y4) = ($28,000)(Starting Balance)
Ending Cash(Y5) = ($28,000)(Starting Balance)+($20,000)(1.7)(investment B) = $62,000
Ending Cash(Y6) = ($62,000)(Starting Balance)+($20,000)(1.9)(investment C) = $100,000

(c)

Beginning Balance												
Minimum Balance												
Investment	A	A	A	A	B	B	B	C	D	Ending		Minimum
Year	1	2	3	4	1	2	3	2	5	Balance		Balance
Year 1											>=	
Year 2											>=	
Year 3											>=	
Year 4											>=	
Year 5											>=	
Year 6											>=	
Dollars Invested												

(d)

Beginning Balance	$60,000										
Minimum Balance	$0										
Investment	A	A	A	B	B	B	C	Ending		Minimum	
Year	1	2	3	1	2	3	2	Balance		Balance	
Year 1	-1			-1				$0	>=	$0	
Year 2		-1			-1		-1	$0	>=	$0	
Year 3	1.4		-1			-1		$84,000	>=	$0	
Dollars Invested	$60,000	$0	$0	$0	$0	$0	$0				

(e)

Beginning Balance	$60,000											
Minimum Balance	$0											
Investment	A	A	A	A	B	B	B	C	D	Ending		Minimum
Year	1	2	3	4	1	2	3	2	5	Balance		Balance
Year 1	-1				-1					$0	>=	$0
Year 2		-1				-1		-1		$0	>=	$0
Year 3	1.4		-1				-1			$0	>=	$0
Year 4		1.4		-1	1.7					$0	>=	$0
Year 5			1.4			1.7			-1	$0	>=	$0
Year 6				1.4			1.7	1.9	1.3	$152,880	>=	$0
Dollars Invested	$60,000	$0	$84,000	$0	$0	$0	$0	$0	$117,600			

21.8.

In the poor formulation, the data are not separated from the formula - they are buried inside the equations in column C. In contrast, the spreadsheet in Figure 21.6 separates all of the data in their own cells, and then the formulas for hours used and total profit refer to these data cells.

In the poor formulation, no range names are used. The spreadsheet in Figure 21.6 uses range names for UnitProfit, HoursUsed, TotalProfit, etc.

The poor formulation uses no borders, shading, or colors to distinguish between cell types. The spreadsheet in Figure 21.6 uses borders and shading to distinguish the data cells, changing cells, and target cell.

The poor formulation does not show the entire model on the spreadsheet. There is no indication of the constraints on the spreadsheet (they are only displayed in the Solver dialogue box). Furthermore, the right-hand-sides of the constraints are not on the spreadsheet, but buried in the Solver dialogue box. The spreadsheet in Figure 21.6 shows all of the constraints of the model in three adjacent cells on the spreadsheet.

21.9.

Cell F16 has -0.23 for LT Interest, rather than -LTRate*LTLoan.

Cell G14 for the 2017 ST Interest uses the LT Loan amount rather than the ST Loan amount.

Cell H21 for the LT Payback refers to the 2017 ST Loan rather than the LT Loan to determine the payback amount.

21.10.

Cell G21 for the 2024 ST Interest uses LTRate instead of STRate.

Cell H21 for the LT Payback in 2024 has -4.65 instead of -LTLoan.

Cell I15 for ST Payback in 2018 has -LTLoan instead of -E14 (STLoan for 2017).

CASES

CASE 21.1 Prudent Provisions for Pensions

(a) PFS needs to know how many units of each of the four bonds to purchase, how much to invest in the money market, and their ending balance in the money market fund each year after paying the pensions. The decisions are how many units of each bond to purchase, as well as the initial investment in 2014 in the money market. The objective is to minimize the overall initial investment necessary in 2014 in order to meet the pension payments through 2023.

(b)

$$\begin{aligned}\text{Payment received from Bond 1 (2015)} &= (10{,}000 \text{ units})(\$1{,}000 \text{ face value}) \\ &\quad + (10{,}000 \text{ units})(\$1{,}000 \text{ face value})(0.04) \\ &= \$10.4 \text{ million}\end{aligned}$$

$$\text{Payment received from Bond 1 (2016)} = \$0$$

$$\begin{aligned}\text{Payment received from Bond 2 (2015)} &= (10{,}000 \text{ units})(\$1{,}000 \text{ face value})(0.02) \\ &= \$0.2 \text{ million}\end{aligned}$$

$$\begin{aligned}\text{Payment received from Bond 2 (2016)} &= (10{,}000 \text{ units})(\$1{,}000 \text{ face value})(0.02) \\ &= \$0.2 \text{ million}\end{aligned}$$

$$\begin{aligned}\text{Balance in money market fund (2014)} &= \$28 \text{ million (initial investment)} \\ &\quad - \$8 \text{ million (pension payment)} \\ &= \$20 \text{ million}\end{aligned}$$

$$\begin{aligned}\text{Balance in money market fund (2015)} &= \$20 \text{ million (starting balance)} \\ &\quad + \$10.4 \text{ million (payment from Bond 1)} \\ &\quad + \$0.2 \text{ million (payment from Bond 2)} \\ &\quad - \$12 \text{ million (pension payment)} \\ &\quad + \$0.4 \text{ million (money market interest)} \\ &= \$19 \text{ million}\end{aligned}$$

$$\begin{aligned}\text{Balance in money market fund (2016)} &= \$19 \text{ million (starting balance)} \\ &\quad + \$0.2 \text{ million (payment from Bond 2)} \\ &\quad - \$13 \text{ million (pension payment)} \\ &\quad + \$0.38 \text{ million (money market interest)} \\ &= \$6.58 \text{ million}\end{aligned}$$

(c) PFS will need to track the flow of cash from bond investments, the initial investment, the required pension payments, interest from the money market, and the money market balance. The decisions are the number of units to purchase of each bond. Data for the problem include the yearly cash flows from the bonds (per unit purchased), the money market rate, and the minimum required balance in the money market fund at the end of each year. A sketch of a spreadsheet model might appear as follows.

						Money Market Rate					
						Minimum Required Balance					
							Required	Money	Money		
	Bond Cash Flows (per unit)				Bond	Initial	Pension	Market	Market		
	Bond 1	Bond 2	Bond 3	Bond 4	Flow	Investment	Flow	Interest	Balance		
2014										>=	0
2015										>=	0
2016										>=	0
2017										>=	0
2018										>=	0
2019										>=	0
2020										>=	0
2021										>=	0
2022										>=	0
2023										>=	0
Units Purchased											

(d) The bond cash flows (per unit) are calculated in B7:E9. For example, one unit of Bond 1 costs \$0.98 in 2014, and returns the face value (\$1) plus the coupon rate (\$0.04) in 2015. The total cash flow from bonds is then calculated in column F. The Initial Investment (G7) is both a decision variable and the target cell. It includes all money invested on January 1, 2014 (including enough to pay for the bonds and pension payment in 2014, as well as any initial investment in the money market).

If just years 2014 through 2016 are considered, then 23.79 thousand units of Bond 1 should be purchased at a cost of \$23.32 million, along with an initial \$8 million investment in the money market fund on January 1, 2014.

						Money Market Rate	2%				
						Minimum Required Balance	0				
							Required	Money	Money		
	Bond Cash Flows (per unit)				Bond	Initial	Pension	Market	Market		
	Bond 1	Bond 2	Bond 3	Bond 4	Flow	Investment	Flow	Interest	Balance		
2014	-0.98	-0.92	-0.75	-0.80	-23.32	31.32	-8		0.00	>=	0
2015	1.04	0.02		0.03	24.75		-12	0.00	12.75	>=	0
2016		0.02		0.03	0.00		-13	0.25	0.00	>=	0
Units Purchased	23.79	0	0	0		**all cash figures in \$millions**					
(thousands)											
Cost of Bonds	0.98	0.92	0.75	0.8							

(e) Expanded to consider all years through 2023, the spreadsheet is as shown below. PFS should purchase 20.26 thousand units of Bond 1, 26.53 thousand units of Bond 2, 52.89 thousand units of Bond 3, and 44.20 thousand units of Bond 4 (at a cost of $119.29 million), and invest an additional $8 million in the money market on January 1, 2014.

							Money Market Rate	2%			
							Minimum Required Balance	0			
							Required	Money	Money		
	Bond Cash Flows (per unit)				Bond	Initial	Pension	Market	Market		
	Bond 1	Bond 2	Bond 3	Bond 4	Flow	Investment	Flow	Interest	Balance		
2014	-0.98	-0.92	-0.75	-0.80	-119.29	127.29	-8		0.00	>=	0
2015	1.04	0.02		0.03	22.92		-12	0.00	10.92	>=	0
2016		0.02		0.03	1.86		-13	0.22	0.00	>=	0
2017		1.02		0.03	28.39		-14	0.00	14.39	>=	0
2018				0.03	1.33		-16	0.29	0.00	>=	0
2019			1.00	0.03	54.22		-17	0.00	37.22	>=	0
2020				0.03	1.33		-20	0.74	19.29	>=	0
2021				0.03	1.33		-21	0.39	0.00	>=	0
2022				1.03	45.53		-22	0.00	23.53	>=	0
2023					0.00		-24	0.47	0.00	>=	0
Units Purchased	20.26	26.53	52.89	44.20		**all cash figures in $millions**					
(thousands)											