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## Solutions to Chapter 2 Problems

**A Note To Instructors:** Because of volatile energy prices in today's world, the instructor is encouraged to vary energy prices in affected problems (e.g. the price of a gallon of gasoline) plus and minus 50 percent and ask students to determine whether this range of prices changes the recommendation in the problem. This should make for stimulating in-class discussion of the results.

**2-1** The total mileage driven would have to be specified (assumed) in addition to the variable cost of fuel per unit (e.g. $ per gallon). Also, the fixed cost of both engine blocks would need to be assumed. The efficiency of the traditional engine and the composite engine would also need to be specified

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**2-2**

| | Fixed | Variable |
|---|---|---|
| Raw Materials | | X |
| Direct Labor | | X |
| Supplies | | X |
| Utilities* | X | X |
| Property Taxes | X | |
| Administrative Salaries | X | |
| Payroll Taxes | X | X |
| Insurance-Building and Equipment | X | |
| Clerical Salaries | X | |
| Sales Commissions | | X |
| Rent | X | |
| Interest on Borrowed Money | X | |

* Classification is situation dependent

**2-3** (a) $$\# \text{ cows} = \frac{1{,}000{,}000 \text{ miles/year}}{(365 \text{ days/year})(15 \text{ miles/day})} = 182.6 \text{ or } 183 \text{ cows}$$

Annual cost = (1,000,000 miles/year)($5 / 60 miles) = $83,333 per year

(b) $$\text{Annual cost of gasoline} = \frac{1{,}000{,}000 \text{ miles/year}}{30 \text{ miles/gallon}}(\$3/\text{gallon}) = \$100{,}000 \text{ per year}$$

It would cost $16,667 more per year to fuel the fleet of cars with gasoline.

**2-4**

| Cost | Site A | Site B |
|---|---|---|
| Rent<br>Hauling | = \$5,000<br>(4)(200,000)(\$1.50) = \$1,200,000 | = \$100,000<br>(3)(200,000)(\$1.50) = \$900,000 |
| Total | \$1,205,000 | \$1,000,000 |

Note that the revenue of \$8.00/yd$^3$ is independent of the site selected. Thus, we can maximize profit by minimizing total cost. The solid waste site should be located in Site B.

**2-5** Stan's asking price of $4,000 is probably too high because the new transmission adds little value to the N.A.D.A. estimate of the car's worth. (Low mileage is a typical consideration that may inflate the N.A.D.A. estimate.) If Stan can get $3,000 for his car, he should accept this offer. Then the $4,000 - $3,000 = $1,000 "loss" on his car is a sunk cost.

**2-6** The $97 you spent on a passport is a sunk cost because you cannot get your money back. If you decide to take a trip out of the U.S. at a later date, the passport's cost becomes part of the fixed cost of making the trip (just as the cost of new luggage would be).

**2-7** If the value of the re-machining option ($60,000) is reasonably certain, this option should be chosen. Even if the re-machined parts can be sold for only $45,001, this option is attractive. If management is highly risk adverse (they can tolerate little or no risk), the second-hand market is the way to proceed to guarantee $15,000 on the transaction.

**2-8** The certainty of making \$200,000 - \$120,000 = \$80,000 net income is not particularly good. If your friend keeps her present job, she is turning away from a risky \$80,000 gain. This "opportunity cost" of \$80,000 balanced in favor of a sure \$60,000 would indicate your friend is risk averse and does not want to work hard as an independent consultant to make an extra \$20,000 next year.

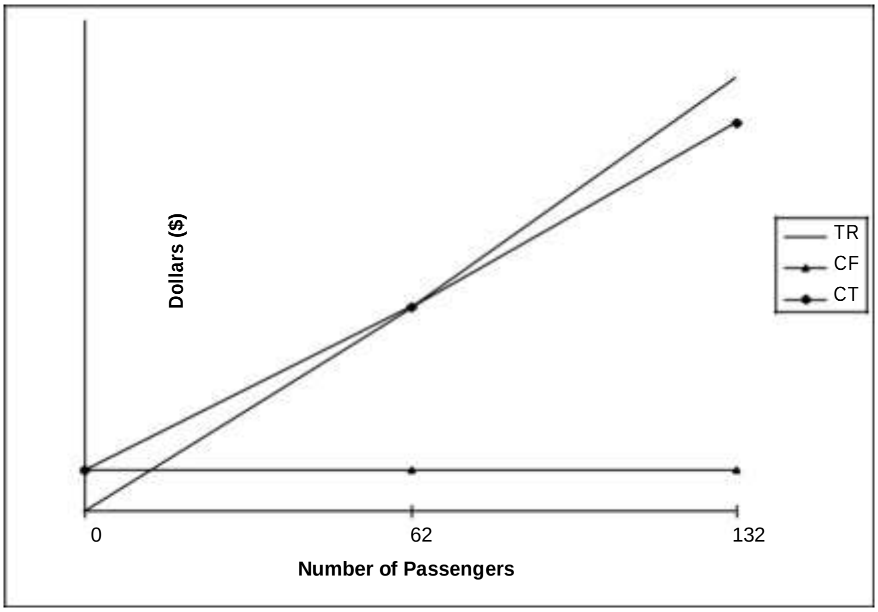
**2-9** **(a)** If you purchase a new car, you are turning away from a risky 20% per year return. If you are a risk taker, your opportunity cost is 20%, otherwise; it is 6% per year.

**(b)** When you invest in the high tech company's common stock, the next best return you've given up is 6% per year. This is your opportunity cost in situation (b).

**2-10** **(a)** The life cycle cost concept encompasses a time horizon for a product, structure, system, or service from the initial needs assessment to final phaseout and disposal activities. Definition of requirements; conceptual design, advanced development, and prototype testing; detailed design and resource acquisition for production or construction; actual production or construction; and operation and customer use, and maintenance and support are other primary activities involved during the life cycle.

**(b)** The acquisition phase includes the definitions of requirements as well as the conceptual and detailed design activities. It is during these activities that the future costs to produce (or construct), operate, and maintain a product, structure, system, or service are predetermined. Since these future costs (during the operation phase) are 80-90 percent of the life cycle costs, the greatest potential for lowering life cycle costs is during the acquisition phase (in the definition of requirements and design activities).

**2-11 (a)**




**(b)** Fixed costs that could change the BE point from 62 passengers to a lower number include: reduced aircraft insurance costs (by re-negotiating premiums with the existing insurance company or a new company), lower administrative expenses in the front office, increased health insurance costs for the employees (i.e. lowering the cost of the premiums to the airline company) by raising the deductibles on the group policy.

**(c)** Variable costs that could be reduced to lower the BE point include: no more meals on flights, less external air circulated throughout the cabin, fewer flight attendants. Note: One big cost is fuel, which is fixed for a given flight but variable with air speed. The captain can fly the aircraft at a lower speed to save fuel.

**2-12** Re-write the price-demand equation as follows: $p = 2{,}000 - 0.1D$. Then,

$$TR = p \cdot D = 2{,}000D - 0.1D^2.$$

The first derivative of TR with respect to D is

$$d(TR) / dD = 2{,}000 - 0.2D$$

This, set equal to zero, yields the $D$ that maximizes TR. Thus,

$$2{,}000 - 0.2\,D = 0$$

$$D = 10{,}000 \text{ units per month}$$

What is needed to determine maximum monthly profit is the fixed cost per month and the variable cost per lash adjuster.

**2-13** $p = 150 - 0.01D$ $C_F = \$50{,}000$ $c_V = \$40/\text{unit}$

Profit $= 150D - 0.01D^2 - 50{,}000 - 40D = 110D - 0.01D^2 -$

$50{,}000$ $d(\text{Profit})/dD = 110 - 0.02D = 0$

$D = 5{,}500$ units per year, which is less than maximum anticipated demand

At $D = 5{,}500$ units per year, Profit = \$252,500 and $p = \$150 - 0.01(5{,}500) = \$95/\text{unit}$.

**2-14** **(a)** $p = 600 - 0.05D$; $C_F = \$800{,}000/\text{month}$; $c_v = \$155.50$ per unit

The unit demand, D, is one thousand board feet.

$$D^* = \frac{a - c_v}{2b} = \frac{600 - 155.50}{2(0.05)} = \underline{4{,}445 \text{ units/month}} \qquad \text{(Eqn. 2-10)}$$

$$\begin{aligned} \text{Profit (loss)} &= 600D - 0.05D^2 - (800{,}000 + 155.50D) \\ &= [600(4{,}445) - 0.05(4{,}445)^2] - [\$800{,}000 + \$155.50(4{,}445)] \\ &= \$187{,}901.25 \text{ / month} \qquad \text{(maximum profit)} \end{aligned}$$

**(b)** $$D' = \frac{444.5 \pm \sqrt{(444.5)^2 - 4(0.05)(800{,}000)}}{2(0.05)}$$

$$D'_1 = \frac{444.5 - 193.86}{\phantom{x}} = 2{,}506 \text{ units/month}$$

$$D'_2 = \frac{444.5 + 193.86}{\phantom{x}} = 6{,}383 \text{ units/month}$$

Range of profitable demand is 2,506 units to 6,383 units per month.

**2-15** **(a)** $\text{Profit} = \left[38 + \frac{2700}{D} - \frac{5000}{D^2}\right] D - 1000 - 40D$

$$= 38D + 2700 - \frac{5000}{D} - 1000 - 40D$$

$$\text{Profit} = -2D - \frac{5000}{D} + 1700$$

$$\frac{d(\text{Profit})}{dD} = -2 + \frac{5000}{D^2} = 0$$

or, $D^2 = \frac{5000}{2} = 2500$ and $D^* = 50$ units per month

**(b)** $\frac{d^2(\text{Profit})}{dD^2} = \frac{-10{,}000}{D^3} < 0$ for $D > 1$

Therefore, $D^* = 50$ is a point of maximum profit.

**2-16** Profit = Total revenue - Total cost

$= (15X - 0.2X^2) - (12 + 0.3X + 0.27X^2)$

$= 14.7X - 0.47X^2 - 12$

$$\frac{d\text{Profit}}{dX} = 0 = 14.7 - 0.94X$$

X = <u>15.64 megawatts</u>

Note: $\frac{d^2\text{Profit}}{dX^2} = -0.94$ thus, X = 15.64 megawatts maximizes profit

**2-17** Breakeven point in units of production:

$C_F$ = \$100,000/yr; $C_V$ = \$140,000/yr (70% of capacity)
Sales = \$280,000/yr (70% of capacity); p = \$40/unit
Annual Sales (units) = \$280,000/\$40 = 7,000 units/yr (70% capacity)

$c_V$ = \$140,000/7,000 = \$20/unit

$$D' = \frac{C_F}{p - c_v} = \frac{\$100{,}000}{(\$40 - \$20)} = \underline{5{,}000 \text{ units/yr}}$$

or in terms of capacity, we have: 7,000units/0.7 = x units/1.0

Thus, x (100% capacity) = 7,000/0.7 = 10,000 units/yr

$$D' \text{ (\% of capacity)} = \frac{\$5{,}000}{(10{,}000} = \underline{0.5 \text{ or } 50\%} \text{ of capacity}$$

**2-18** 20,000 tons/yr. (2,000 pounds / ton) = 40,000,000 pounds per year of zinc are produced.

The variable cost per pound is \$20,000,000 / 40,000,000 pounds = \$0.50 per pound.

**(a)** Profit/yr = (40,000,000 pounds / year) (\$1.00 - \$0.50) - \$17,000,000
= \$20,000,000 - \$17,000,000
= \$3,000,000 per year

The mine is expected to be profitable.

**(b)** If only 17,000 tons (= 34,000,000 pounds) are produced, then Profit/yr =

(34,000,000 pounds/year)(\$1.00 - \$0.50) - \$17,000,000 = 0

Because Profit =0, 17,000 tons per year is the breakeven point production level for this mine. A loss would occur for production levels < 17,000 tons/year and a profit for levels > 17,000 tons per year.

**2-19** **(a)** BE = \$1,500,000 / (\$39.95 − \$20.00) = 75,188 customers per month

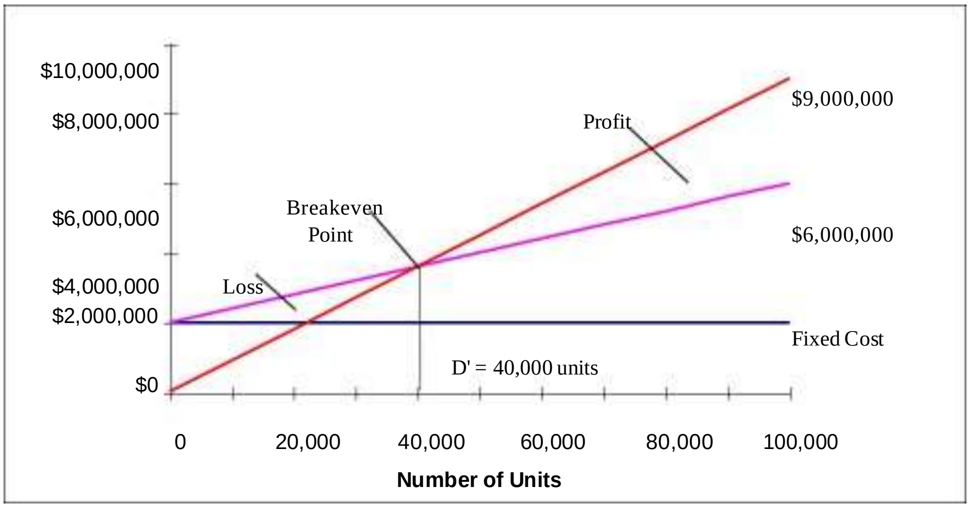
**(b)** New BE point = \$1,500,000 / (\$49.95 − \$25.00) = 60,120 per month

**(c)** For 63,000 subscribers per month, profit equals

63,000 (\$49.95 − \$25.00) − \$1,500,000 = \$71,850 per month

This improves on the monthly loss experienced in part (a).

**2-20 (a)** $D' = \frac{C_F}{p - c_v} = \frac{\$2{,}000{,}000}{(\$90 - \$40) / \text{unit}} = \underline{40{,}000 \text{ units per year}}$




**(b)** Profit (Loss) = Total Revenue - Total Cost

(90% Capacity) = 90,000 ($90) - [$2,000,000 + 90,000 ($40)]
= $2,500,000 per year

(100% Capacity) = [90,000($90) + 10,000($70)] - [$2,000,000 + 100,000($40)]
= $2,800,000 per year

**2-21** Annual savings are at least equal to (\$60/lb)(600 lb) = \$36,000. So the company can spend no more than \$36,000 (conservative) and still be economical. Other factors include ease of maintenance / cleaning, passenger comfort and aesthetic appeal of the improvements. Yes, this proposal appears to have merit so it should be supported.

**2-22** Jerry's logic is correct if the AC system does not degrade in the next ten years (very unlikely). Because the leak will probably get worse, two or more refrigerant re-charges per year may soon become necessary. Jerry's strategy could be to continue re-charging his AC system until two re-charges are required in a single year. Then he should consider repairing the evaporator (and possibly other faulty parts of his system).

**2-23** Over 81,000 miles, the gasoline-only car will consume 2,700 gallons of fuel. The flex-fueled car will use 3,000 gallons of E85. So we have

$$(3{,}000 \text{ gallons})(X) + \$1{,}000 = (2{,}700 \text{ gallons})(\$3.89/\text{gal})$$

and

$$X = \$3.17 \text{ per gallon}$$

This is 18.5% less expensive than gasoline. Can our farmers pull it off – maybe with government subsidies?

**2-24 (a)** Total Annual Cost (TAC) = Fixed cost + Cost of Heat Loss = $450X + 50 + \dfrac{4.80}{X^{1/2}}$

$$\frac{d\,(TAC)}{dX} = 0 = 450 - \frac{2.40}{X^{3/2}}$$

$$X^{3/2} = \frac{2.40}{450} = 0.00533$$

$X^{*}$ = <u>0.0305 meters</u>

**(b)** $$\frac{d^2(TAC)}{dX^2} = \frac{3.6}{X^{5/2}} > 0 \quad \text{for } X > 0.$$

Since the second derivative is positive, $X^{*}$ = 0.0305 meters is a minimum cost thickness.

**(c)** The cost of the extra insulation (a directly varying cost) is being traded-off against the value of reduction in lost heat (an indirectly varying cost).

**2-25** Annual Profit/Loss = Revenue – (Fixed Costs + Variable Costs)

= \$300,000 – [\$200,000 + (0.60)(\$300,000)]

= \$300,000 – \$380,000

= –\$80,000

So the correct choice is (d).

**2-26**

$$C_T = C_o + C_c = knv^2 + \frac{\$1{,}500n}{v}$$

$$\frac{dC_T}{dv} = 0 = 2kv - \frac{1{,}500}{v^2} = kv^3 - 750$$

$$v = \sqrt[3]{\frac{750}{k}}$$

To find k, we know that

$$\frac{C_o}{n} = \$100\text{/mile at } v = 12 \text{ miles/hr}$$

$$\frac{C_o}{n} = kv^2 = k(12)^2 = 100$$

and

$$k = 100 / 144 = 0.6944$$

so, $$v = \sqrt[3]{\frac{750}{0.6944}} = 10.25 \text{ miles / hr}.$$

The ship should be operated at an average velocity of 10.25 mph to minimize the total cost of operation and perishable cargo.

Note: The second derivative of the cost model with respect to velocity is:

$$\frac{d^2 C_T}{dv^2} = 1.388n + 3{,}000\frac{n}{v^3}$$

The value of the second derivative will be greater than 0 for n > 0 and v > 0. Thus we have found a minimum cost velocity.

**2-27**

| | R11 | R19 | R30 | R38 |
|---|---|---|---|---|
| A. Investment cost | \$1,800 | \$2,700 | \$3,900 | \$4,800 |
| B. Annual Heating Load ($10^6$ Btu/yr) | 74 | 69.8 | 67.2 | 66.2 |
| C. Cost of heat loss/yr | \$1,609.50 | \$1,518.15 | \$1,461.60 | \$1,439.85 |
| D. Cost of heat loss over 25 years | \$40,238 | \$37,954 | \$36,540 | \$35,996 |
| E. Total Life Cycle Cost = A + D | \$42,038 | \$40,654 | \$40,440 | \$40,796 |

R30 is the most economical insulation thickness.

**2-28** (293 kWh/$10^6$ Btu)($0.15/kWh) = $43.95/$10^6$ Btu

| | R11 | R19 | R30 | R38 |
|---|---|---|---|---|
| A. Investment cost | $2,400 | $3,600 | $5,200 | $6,400 |
| B. Annual Heating Load ($10^6$ Btu/yr) | 74 | 69.8 | 67.2 | 66.2 |
| C. Cost of heat loss/yr | $3,252 | $3,068 | $2,953 | $2,909 |
| D. Cost of heat loss over 25 years | $81,308 | $76,693 | $73,836 | $72,737 |
| E. Total Life Cycle Cost = A + D | $83,708 | $80,293 | $79,036 | $79,137 |

Select R30 to minimize total life cycle cost.

**2-29 (a)** $$\frac{dC}{d\lambda} = -\frac{C_I}{\lambda^2} + C_R t = 0$$

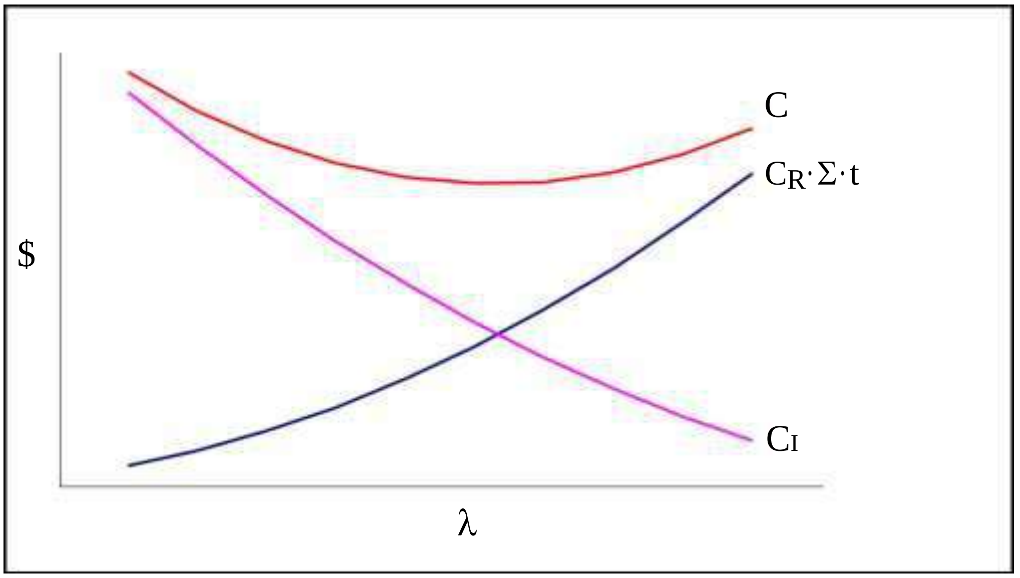
or, $\lambda^2 = C_I/C_R t$

and, $\lambda^* = (C_I/C_R t)^{1/2}$; we are only interested in the positive root.

**(b)** $$\frac{d^2C}{d\lambda^2} = \frac{2C_I}{\lambda^3} > 0 \text{ for } \lambda > 0$$

Therefore, $\lambda^*$ results in a minimum life-cycle cost value.

**(c)** Investment cost versus total repair cost



**2-30** $\left(\frac{100{,}000}{22\text{mpg}} - \frac{100{,}000}{28\text{mpg}}\right)(\$3.00/\text{gallon}) = \$3{,}896$

Total extra amount = $2,500 + $3,896 = <u>$6,396</u>

Assume the time value of money can be ignored and that comfort and aesthetics are comparable for the two cars.

**2-31** **(a)** With Dynolube you will average (20 mpg)(1.01) = 20.2 miles per gallon (a 1% improvement). Over 50,000 miles of driving, you will save

$$\frac{50{,}000 \text{ miles}}{20 \text{ mpg}} - \frac{50{,}000 \text{ miles}}{20.2 \text{ mpg}} = 24.75 \text{ gallons of gasoline.}$$

This will save (24.75 gallons)($4.00 per gallon) = $99.

**(b)** Yes, the Dynolube is an economically sound choice.

**2-32** The cost of tires containing compressed air is ($200 / 50,000 miles) = $0.004 per mile. Similarly, the cost of tires filled with 100% nitrogen is ($220 / 62,500 miles) = $0.00352 per mile. On the face of it, this appears to be a good deal if the claims are all true (a big assumption). But recall that air is 78% nitrogen, so this whole thing may be a gimmick to take advantage of a gullible public. At 200,000 miles of driving, one original set of tires and three replacements would be needed for compressed-air tires. One original set and two replacements (close enough) would be required for the 100% nitrogen-filled tires. What other assumptions are being made?

**2-33**

| Cost Factor | Brass-Copper Alloy | Plastic Molding |
|---|---|---|
| Casting / pc | (25 lb)($3.35/lb) = $83.75 | (20 lb)($7.40/lb) = $148.00 |
| Machining /pc | $ 6.00 | 0.00 |
| Weight Penalty / pc | (25 lb - 20 lb)($6/lb) = $30.00 | 0.00 |
| Total Cost /pc | $119.75 | $148.00 |

The Brass-Copper alloy should be selected to save $148.00 - $119.75 = $28.25 over the life cycle of each radiator.

**2-34** **(a)** Machine A

Non-defective units/day = (100 units/hr)(7 hrs/day)(1 - 0.25)(1 - 0.03)
$\approx$ 509 units/day

Note: 3 months = (52 weeks/year)/4 = 13 weeks

Non-defective units/3-months = (13 weeks)(5 days/week)(509 units/day)
= 33,085 units (> 30,000 required)

Machine B

Non-defective units/day = (130 units/hr)(6 hrs/day)(1 - 0.25)(1 - 0.10)
$\approx$ 526 units/day

Non-defective units/3-months = (13 weeks)(5 days/week)(526 units/day)
= 34,190 units (> 30,000 required)

Either machine will produce the required 30,000 non-defective units/3-months

**(b)** Strategy: Select the machine that minimizes costs per non-defective unit since revenue for 30,000 units over 3-months is not affected by the choice of the machine (Rule 2). Also assume capacity reductions affect material costs but not labor costs.

Machine A

Total cost/day = (100 units/hr)(7 hrs/day)(1 - 0.25)($6/unit)
+ ($15/hr + $5/hr)(7 hrs/day)
= $3,290/day

Cost/non-defective unit = ($3,290/day)/(509 non-defective units/day)
= $6.46/unit

Machine B

Total cost/day = (130 units/hr)(6 hrs/day)(1 - 0.25)($6/unit)
+ ($15/hr + $5/hr)(6 hrs/day)
= $3,630/day

Cost/non-defective unit = ($3,630/day)/(526 non-defective units/day)
= $6.90/unit

Select Machine A.

**2-35** Strategy: Select the design which minimizes total cost for 125,000 units/year (Rule 2). Ignore the sunk costs because they do not affect the analysis of future costs.

**(a)** Design A

Total cost/125,000 units = (12 hrs/1,000 units)($18.60/hr)(125,000)
+ (5 hrs/1,000 units)($16.90/hr)(125,000)
= $38,463, or $0.3077/unit

Design B

Total cost/125,000 units = (7 hrs/1,000 units)($18.60/hr)(125,000)
+ (7 hrs/1,000 units)($16.90/hr)(125,000)
= $33,175, or $0.2654/unit

Select Design B

**(b)** Savings of Design B over Design A are:

Annual savings (125,000 units) = $38,463 − $33,175 = $5,288

Or, savings/unit = $0.3077 − $0.2654 = $0.0423/unit.

**2-36** Profit per day = Revenue per day – Cost per day

= (Production rate)(Production time)($30/part)[1-(% rejected+% tested)/100]

– (Production rate)(Production time)($4/part) – (Production time)($40/hr)

Process 1: Profit per day = (35 parts/hr)(4 hrs/day)($30/part)(1-0.2) –

(35 parts/hr)(4 hrs/day)($4/part) – (4 hrs/day)($40/hr)

= $2640/day

Process 2: Profit per day = (15 parts/hr)(7 hrs/day)($30/part) (1-0.09) –

(15 parts/hr)(7 hrs/day)($4/part) – (7 hrs/day)($40/hr)

= $2155.60/day

Process 1 should be chosen to maximize profit per day.

**2-37** At 70 mph your car gets 0.8 (30 mpg) = 24 mpg and at 80 mph it gets 0.6(30 mpg) = 18 mpg. The extra cost of fuel at 80 mph is:

$$(400 \text{ miles}/18\text{mpg} - 400 \text{ miles}/24 \text{ mpg})(\$4.00 \text{ per gallon}) = \$22.22$$

The reduced time to make the trip at 80 mph is about 45 minutes. Is this a good tradeoff in your opinion? What other factors are involved?

**2-38** $5(4X + 3Y) = 4(3X + 5Y)$ where X= units of profit per day from an 85-octane pump and Y= units of profit per day from an 89-octane pump. Setting them equal simplifies to $8X = 5Y$, so the 89-octane pump is more profitable for the store.

**2-39** When electricity costs \$0.15/kWh and operating hours = 4,000:

$Cost_{ABC}$ = (100 hp/0.80)(0.746 kW/hp)(\$0.15/kWh)(4,000 h/yr) +\$2,900 +\$170 = \$59,020

$Cost_{XYZ}$ = (100 hp/0.90)(0.746 kW/hp)(\$0.15/kWh)(4,000 h/yr) +\$6,200 +\$510 = \$56,443

Select pump XYZ.

When electricity costs \$0.15/kWh and operating hours = 4,000:

$Cost_{ABC}$ = (100 hp/0.80)(0.746 kW/hp)(\$0.15/kWh)(3,000 h/yr) +\$2,900 +\$170 = \$45,033

$Cost_{XYZ}$ = (100 hp/0.90)(0.746 kW/hp)(\$0.15/kWh)(3,000 h/yr) +\$6,200 +\$510 = \$44,010

Select pump XYZ.

**2-40** Option A (Purchase):

$C_T$ = (10,000 items)($8.50/item) = $85,000

Option B (Manufacture):

| | |
|---|---|
| Direct Materials | =$5.00/item |
| Direct Labor | =$1.50/item |
| Overhead | =$3.00/item |
| | $9.50/item |

$C_T$ = (10,000 items)($9.50/item) = $95,000

Choose Option A (Purchase Item).

**2-41** Assume you cannot stand the anxiety associated with the chance of running out of gasoline if you elect to return the car with no gas in it. Therefore, suppose you leave three gallons in the tank as "insurance" that a tow-truck will not be needed should you run out of gas in an unfamiliar city. The cost (i.e., the security blanket) will be ($3.50 + $0.50 = $4.00) x 3 gallons = $12.00. If you bring back the car with a full tank of gasoline, the extra cost will be $0.50 x the capacity, in gallons, of the tank. Assuming a 15-gallon tank, this option will cost you $7.50. Hence, you will save $12.00 – $7.50 = $4.50 by bringing back the car with a full tank of gasoline.

**2-42** Assumptions: You can sell all the metal that is recovered

Method 1:

| | | |
|---|---|---|
| Recovered ore | = (0.62)(100,000 tons) | = 62,000 tons |
| Removal cost | = (62,000 tons)($23/ton) | = $1,426,000 |
| Processing cost | = (62,000 tons)($40/ton) | = $2,480,000 |
| Recovered metal | = (300 lbs/ton)(62,000 tons) | = 18,600,000 lbs |
| Revenues | = (18,600,000 lbs)($0.8 / lb) | = $14,880,000 |

Profit = Revenues - Cost = $14,880,000 - ($1,426,000 + $2,480,000)
= $10,974,000

Method 2:

| | | |
|---|---|---|
| Recovered ore | = (0.5)(100,000 tons) | = 50,000 tons |
| Removal cost | = (50,000 tons)($15/ton) | = $750,000 |
| Processing cost | = (50,000 tons)($40/ton) | = $2,000,000 |
| Recovered metal | = (300 lbs/ton)(50,000 tons) | = 15,000,000 lbs |
| Revenues | = (15,000,000 lbs)($0.8 / lb) | = $12,000,000 |

Profit = Revenues - Cost = $12,000,000 - ($750,000 + $2,000,000)
= $9,250,000

Select Method 1 (62% recovered) to maximize total profit from the mine.

**2-43** Profit per ounce (Method A) = $1,750 - $550 / [(0.90 oz. per ton)(0.90)] = $1,750 - $679

= $1,071 per ounce

Profit per ounce (Method B) = $1,750 - $400 / [(0.9 oz. per ton)(0.60) =$1,750 -

$741 = $1,009 per ounce

Therefore, by a slim margin we should recommend Method A.

**2-44** **(a)** False; **(d)** False; **(g)** False; **(j)** False; **(m)** True;
**(p)** False; **(s)** False
**(b)** False; **(e)** True; **(h)** True; **(k)** True; **(n)** True; **(q)** True;
**(c)** True; **(f)** True; **(i)** True; **(l)** False; **(o)** True; **(r)** True;

**2-45** **(a)** $$\text{Loss} = \frac{(1{,}750{,}000 \text{ Btu})\left(\dfrac{\text{lb coal}}{12{,}000 \text{ Btu}}\right)}{0.30} = 486 \text{ lbs of coal}$$

**(b)** 486 pounds of coal produces (486)(1.83) = 889 pounds of $CO_2$ in a year.

**2-46** **(a)** Let X = breakeven point in miles

Fuel cost (car dealer option) = ($2.00/gal)(1 gal/20 miles) = $0.10/mile

Motor Pool Cost = Car Dealer Cost

$$(\$0.36/\text{mi})X = (6\text{ days})(\$30/\text{day}) + (\$0.20/\text{mi} + \$0.10/\text{mi})X$$

$$\$0.36X = 180 + \$0.30X \qquad \text{and} \qquad X = \underline{3{,}000\text{ miles}}$$

**(b)** 6 days (100 miles/day) = 600 free miles

If the total driving distance is less than 600 miles, then the breakeven point equation is given by:

$$(\$0.36/\text{mi})X = (6\text{ days})(\$30/\text{day}) + (\$0.10/\text{mi})X$$
$$X = 692.3\text{ miles} > 600\text{ miles}$$

This is outside of the range [0, 600], thus renting from State Tech Motor Pool is best for distances less than 600 miles.

If driving more than 600 miles, then the breakeven point can be determined using the following equation:

$$(\$0.36/\text{mi})X = (6\text{ days})(\$30/\text{day}) + (\$0.20/\text{mi})(X - 600\text{ mi}) + (\$0.10/\text{mi})X$$

$X = \underline{1{,}000\text{ miles}}$ The true breakeven point is 1000 miles.

**(c)** The car dealer was correct in stating that there is a breakeven point at 750 miles. If driving less than 900 miles, the breakeven point is:

$$(\$0.34/\text{mi})X = (6\text{ days})(\$30/\text{day}) + (\$0.10/\text{mi})X$$
$$X = 750\text{ miles} < 900\text{ miles}$$

However, if driving more than 900 miles, there is another breakeven point.

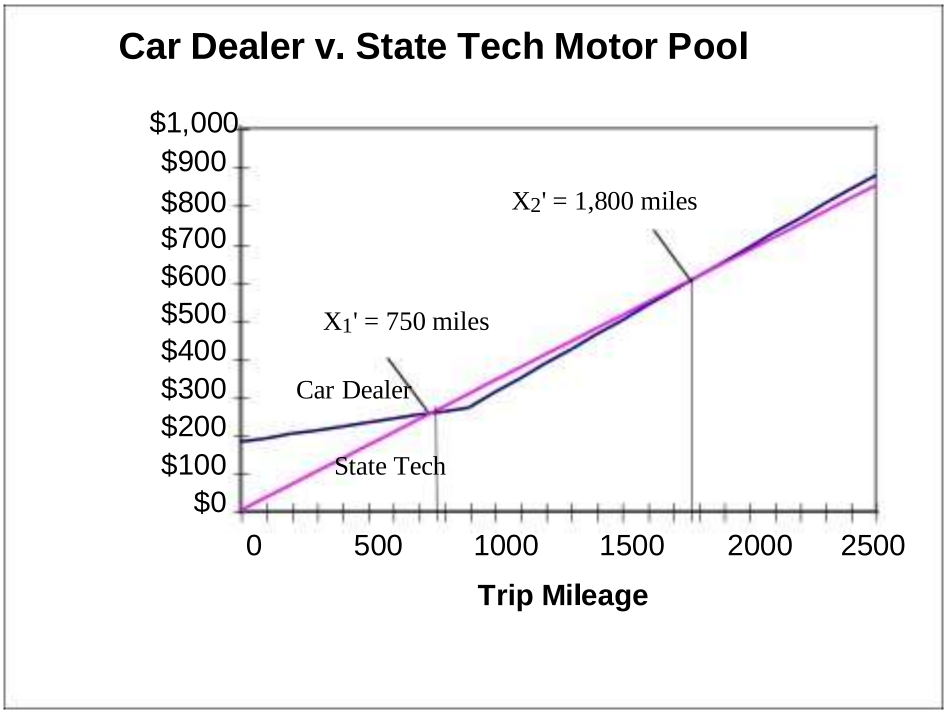
$$(\$0.34/\text{mi})X = (6\text{ days})(\$30/\text{day}) + (\$0.28/\text{mi})(X-900\text{ mi}) + (\$0.10/\text{mi})X$$

$$X = 1800\text{ miles} > 900\text{ miles}$$

The car dealer is correct, but only if the group travels in the range between 750 miles and 1,800 miles. Since the group is traveling more than 1,800 miles, it is better for them to rent from State Tech Motor Pool.

This problem is unique in that there are two breakeven points. The following graph shows the two points.

**2-46** ***continued***

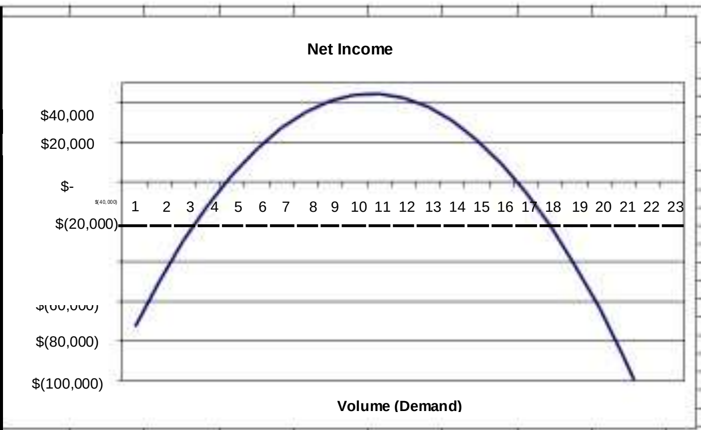


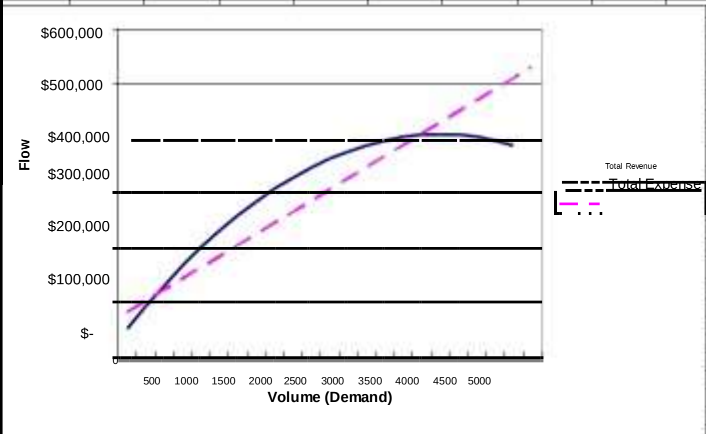
**2-47** This problem is location specific. We'll assume the problem setting is in Tennessee. The eight years (\$2,400 / \$300) to recover the initial investment in the stove is expensive (i.e. excessive) by traditional measures. But the annual cost savings could increase due to inflation. Taking pride in being "green" is one factor that may affect the homeowner's decision to purchase a corn-burning stove.

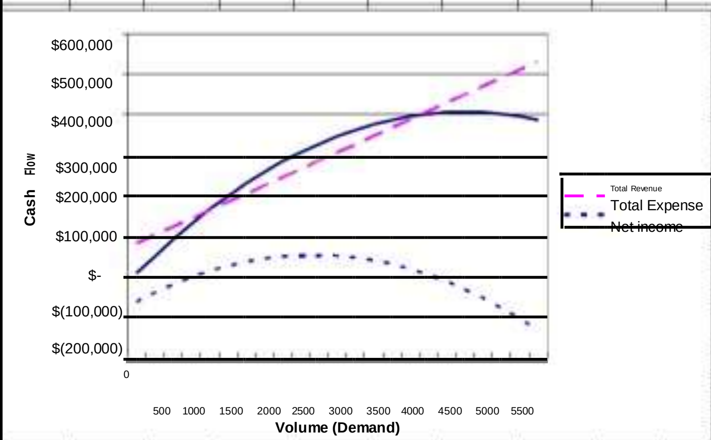
# Solutions to Spreadsheet Exercises

## 2-48

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | Fixed cost/ mo. = | $ 73,000 | | Demand Start point (D) = | 0 |
| 2 | Variable cost/unit = | $ 83 | | Demand Increment = | 250 |
| 3 | a = | $ 180 | | | |
| 4 | b = | $ 0.02 | | | |
| 5 | | | | | |
| 6 | Monthly Demand | Price per Unit | Total Revenue | Total | Net income |
| 7 | 0 | $ 180 | $ - | $ 73,000 | $ (73,000) |
| 8 | 250 | $ 175 | $ 43,750 | $ 93,750 | $ (50,000) |
| 9 | 500 | $ 170 | $ 85,000 | $ 114,500 | $ (29,500) |
| 10 | 750 | $ 165 | $ 123,750 | $ 135,250 | $ (11,500) |
| 11 | 1000 | $ 160 | $ 160,000 | $ 156,000 | $ 4,000 |
| 12 | 1250 | $ 155 | $ 193,750 | $ 176,750 | $ 17,000 |
| 13 | 1500 | $ 150 | $ 225,000 | $ 197,500 | $ 27,500 |
| 14 | 1750 | $ 145 | $ 253,750 | $ 218,250 | $ 35,500 |
| 15 | 2000 | $ 140 | $ 280,000 | $ 239,000 | $ 41,000 |
| 16 | 2250 | $ 135 | $ 303,750 | $ 259,750 | $ 44,000 |
| 17 | 2500 | $ 130 | $ 325,000 | $ 280,500 | $ 44,500 |
| 18 | 2750 | $ 125 | $ 343,750 | $ 301,250 | $ 42,500 |
| 19 | 3000 | $ 120 | $ 360,000 | $ 322,000 | $ 38,000 |
| 20 | 3250 | $ 115 | $ 373,750 | $ 342,750 | $ 31,000 |
| 21 | 3500 | $ 110 | $ 385,000 | $ 363,500 | $ 21,500 |
| 22 | 3750 | $ 105 | $ 393,750 | $ 384,250 | $ 9,500 |
| 23 | 4000 | $ 100 | $ 400,000 | $ 405,000 | $ (5,000) |
| 24 | 4250 | $ 95 | $ 403,750 | $ 425,750 | $ (22,000) |
| 25 | 4500 | $ 90 | $ 405,000 | $ 446,500 | $ (41,500) |
| 26 | 4750 | $ 85 | $ 403,750 | $ 467,250 | $ (63,500) |
| 27 | 5000 | $ 80 | $ 400,000 | $ 488,000 | $ (88,000) |
| 28 | 5250 | $ 75 | $ 393,750 | $ 508,750 | $ (115,000) |
| 29 | 5500 | $ 70 | $ 385,000 | $ 529,500 | $ (144,500) |
| 30 | | | | | |
| 31 | | | | | |
| 32 | Summary of impact of changes in cost components on optimum | | | | |
| 33 | demand and profitable range of demand. | | | | |
| 34 | | | | | |
| 35 | Percent Change | | | | |
| 36 | $C_F$ | $c_V$ | D* | $D_1$' | $D_2$' |
| 37 | -10% | -10% | 2,633 | 724 | 4541 |
| 38 | 0% | -10% | 2,633 | 824 | 4443 |
| 39 | 10% | -10% | 2,633 | 928 | 4339 |
| 40 | -10% | 0% | 2,425 | 816 | 4036 |
| 41 | 0% | 0% | 2,425 | 932 | 3918 |
| 42 | 10% | 0% | 2,425 | 1060 | 3790 |
| 43 | -10% | 10% | 2,218 | 940 | 3495 |
| 44 | 0% | 10% | 2,218 | 1092 | 3343 |
| 45 | 10% | 10% | 2,218 | 1268 | 3167 |
| 46 | | | | | |
| 47 | | | | | |




Reducing fixed costs has no impact on the optimum demand value, but does broaden the profitable range of demand. Reducing variable costs increase the optimum demand value as well as the range of profitable demand.

**2-49** New annual heating load = (230 days)(72 °F – 46 °F) = 5,980 degree days. Now, $136.7 \times 10^6$ Btu are lost with no insulation. The following U-factors were used in determining the new heating load for the various insulation thicknesses.

| | U-factor | Heating Load |
|---|---|---|
| R11 | 0.2940 | $101.3 \times 10^6$ Btu |
| R19 | 0.2773 | $95.5 \times 10^6$ Btu |
| R30 | 0.2670 | $92 \times 10^6$ Btu |
| R38 | 0.2630 | $90.6 \times 10^6$ Btu |

| | \$/kWhr | \$/$10^6$ Btu |
|---|---|---|
| Energy Cost | \$0.086 | \$25.20 |

| | R11 | R19 | R30 | R38 |
|---|---|---|---|---|
| Investment Cost | \$ 900 | \$ 1,350 | \$ 1,950 | \$ 2,400 |
| Annual Heating Load ($10^6$ Btu) | 101.3 | 95.5 | 92 | 90.6 |
| Cost of Heat Loss/yr | \$2,553 | \$2,406 | \$2,318 | \$2,283 |
| Cost of Heat Loss over 25 years | \$63,814 | \$60,160 | \$57,955 | \$57,073 |
| Total Life Cycle Cost | \$64,714 | \$61,510 | \$59,905 | \$59,473 |

## Solutions to Case Study Exercises

**2-50** In this problem we observe that "an ounce of prevention is worth a pound of cure." The ounce of prevention is the total annual cost of daylight use of headlights, and the pound of cure is postponement of an auto accident because of continuous use of headlights. Clearly, we desire to postpone an accident forever for a very small cost.

The key factors in the case study are the cost of an auto accident and the frequency of an auto accident. By avoiding an accident, a driver "saves" its cost. In postponing an accident for as long as possible, the "annual cost" of an accident is reduced, which is a good thing. So as the cost of an accident increases, for example, a driver can afford to spend more money each year to prevent it from happening through continuous use of headlights. Similarly, as the acceptable frequency of an accident is lowered, the total annual cost of prevention (daytime use of headlights) can also decrease, perhaps by purchasing less expensive headlights or driving less mileage each year.

Based on the assumptions given in the case study, the cost of fuel has a modest impact on the cost of continuous use of headlights. The same can be said for fuel efficiency. If a vehicle gets only 15 miles to the gallon of fuel, the total annual cost would increase by about 65%. This would then reduce the acceptable value of an accident to "at least one accident being avoided during the next 16 years." To increase this value to a more acceptable level, we would need to reduce the cost of fuel, for instance. Many other scenarios can be developed.

**2-51** Suppose my local car dealer tells me that it costs no more than \$0.03 per gallon of fuel to drive with my headlights on all the time. For the case study, this amounts to (500 gallons of fuel per year) x \$0.03 per gallon = \$15 per year. So the cost effectiveness of continuous use of headlights is roughly six times better than for the situation in the case study.

## Solutions to FE Practice Problems

**2-52** $p = 400 - D^2$

$TR = p \cdot D = (400 - D^2)\,D = 400D - D^3$

$TC = \$1125 + \$100 \cdot D$

Total Profit / month $= TR - TC = 400D - D^3 - \$1125 - \$100D$

$= -D^3 + 300D - 1125$

$$\frac{dTP}{dD} = -3D^2 + 300 = 0 \;\bigstar\; D^2 = 100 \;\bigstar\; D^* = \underline{10\text{ units}}$$

$$\frac{d^2TP}{dD^2} = -6D; \text{ at } D = D^*, \quad \frac{d^2TP}{dD^2} = -60$$

Negative, therefore maximizes profit.

<u>Select (a)</u>

**2-53** $-D^3 + 300D - 1125 = 0$ for breakeven

At <u>D = 15 units</u>; $-15^3 + 300(15) - 1125 = 0$

<u>Select (b)</u>

**2-54** $C_F$ = \$100,000 + \$20,000 = \$120,000 per year
$C_V$ = \$15 + \$10 = \$25 per unit
p = \$40 per unit

$$D' = \frac{C_F}{p - c_v} = \frac{\$120{,}000}{(\$40 - \$25)} = \underline{8{,}000 \text{ units/yr}}$$

Select (c)

**2-55** Profit = $pD - (C_F + C_V D)$

At D = 10,000 units/yr,

Profit/yr = (40)(10,000) – [120,000 + (25)(10,000)] = <u>$30,000</u>

<u>Select (e)</u>

**2-56** Profit = $pD - (C_F + C_V D)$

$60{,}000 = 35D - (120{,}000 + 25D)$

$180{,}000 = 10D$; $D =$ <u>18,000 units/yr</u>

Select (d)

**2-57** Annual profit/loss = Revenue - (Fixed costs + Variable costs)

$$= \$300,000 – [\$200,000 + (0.60)(\$300,000)]$$
$$= \$300,000 – \$380,000$$
$$= –\$80,000$$

<u>Select (d)</u>

**2-58** Savings in first year = (7,900,000 chips) (0.01 min/chip) (1 hr/60 min) (\$8/hr + 5.50/hr) = \$17,775

Select (d)

# Solutions to Problems in Appendix 2-A

**2-A-1** **(a)** Details of transactions

(a) Smith invested $35,000 cash to start the business.
(b) Purchased $350 of office supplies on account.
(c) Paid $30,000 to acquire land as a future building site.
(d) Earned service revenue and received cash of $1,900.
(e) Paid $100 on account.
(f) Paid for a personal vacation, which is not a transaction of the business.
(g) Paid cash expenses for rent, $400, and utilities, $100.
(h) Sold office supplies for cost of $150.
(i) Withdrew $1,200 cash for personal use.

Analysis of Transactions:

| | ASSETS | | | | LIABILITIES | OWNER'S EQUITY | Type of Owner's Equity Transaction |
|---|---|---|---|---|---|---|---|
| | Cash | +Office Supplies+ | Land | | Payable | + Capital | |
| **(a)** | +35,000 | | | | | +35,000 | Owner investment |
| **(b)** | | +350 | | | + 350 | | |
| **(c)** | −30,000 | | +30,000 | | | | |
| **(d)** | + 1,900 | | | | | +1,900 | Service revenue |
| **(e)** | − 100 | | | = | − 100 | | |
| **(f)** | N/A | | | | | | |
| **(g)** | − 400 | | | | | −400 | Rent expense |
| | − 100 | | | | | −100 | Utilities expense |
| **(h)** | + 150 | −150 | | | | | |
| **(i)** | − 1,200 | | | | | −1,200 | Owner withdrawal |
| **Bal.** | 5,250 | 200 | 30,000 | | 250 | 35,200 | |
| | | 35,450 | | | 35,450 | | |

**(b)** Financial Statements of Campus Apartments Locators

Income Statement
Month Ended July 31, 2010

| | | |
|---|---|---|
| Revenue: | | |
| Service revenue ……………………………………………………. | | $1,900 |
| Expenses: | | |
| Rent expense ……………………………………………………. | $400 | |
| Utilities expense …………………………………………………… | 100 | |
| Total expenses ……………………………………………………... | | 500 |
| Net income ……………………………………………………………… | | $1,400 |

## 2-A-1 *continued*

Statement of Owner's Equity
Month Ended July 31, 2015

| | |
|---|---|
| Jill Smith, capital, July 1, 2015 ……………………………………………… | $ 0 |
| Add: Investment by owner ………………………………………………… | 35,000 |
| Net income for the month …………………………………………… | 1,400 |
| | 36,400 |
| Less: Withdrawals by owner ……………………………………………. | (1,200) |
| Jill Smith, capital, July 31, 2015 ……………………………………………. | $35,200 |

Balance Sheet
July 31, 2015

| Assets | | Liabilities | |
|---|---|---|---|
| Cash ………………………. | $5,250 | Accounts payable …………..……….. | $ 250 |
| Office supplies …………… | 200 | | |
| Land ……………………… | 30,000 | Owner's Equity | |
| | | Jill Smith, capital ……………………. | 35,200 |
| | | Total liabilities and | |
| Total assets ………………. | 35,450 | owner's equity ………………….. | $35,450 |

**2-A-2**

| | ASSETS | | | | = LIABILITIES | + OWNER'S EQUITY | |
|---|---|---|---|---|---|---|---|
| | CASH+ | ACCOUNTS RECEIVABLE+ | SUPPLIES + | LAND = | ACCOUNTS PAYABLE + | DANIEL LEAVY, CAPITAL | TYPE OF OWNER'S EQUITY TRANSACTION |
| Bal. | 1,720 | 3,240 | | 24,100 | 5,400 | 23,660 | |
| a) | 12,000 | | | | | 12,000 | Owner investment |
| Bal. | 13,720 | 3,240 | | 24,100 | 5,400 | 35,660 | |
| b) | -5,400 | | | | -5,400 | 0 | |
| Bal. | 8,320 | 3,240 | | 24,100 | 0 | 35,660 | |
| c) | 1,100 | | | | | 1,100 | Service revenue |
| Bal. | 9,420 | 3,240 | | 24,100 | 0 | 36,760 | |
| d) | 750 | -750 | | | | 0 | |
| Bal. | 10,170 | 2,490 | | 24,100 | 0 | 36,760 | |
| e) | | | 720 | | 720 | 0 | |
| Bal. | 10,170 | 2,490 | 720 | 24,100 | 720 | 36,760 | |
| f) | | 5000 | | | | 5,000 | Service revenue |
| Bal. | 10,170 | 7,490 | 720 | 24,100 | 720 | 41,760 | |
| g) | 1700 | | | | | 1,700 | Owner investment |
| Bal. | 11,870 | 7,490 | 720 | 24,100 | 720 | 43,460 | |
| h) | -1200 | | | | | -1,200 | Rent expense |
| | -660 | | | | | -660 | Advertising expense |
| Bal. | 10,010 | 7,490 | 720 | 24,100 | 720 | 41,600 | |
| i) | 80 | | -80 | | | 0 | |
| Bal. | 10,090 | 7,490 | 640 | 24,100 | 720 | 41,600 | |
| j) | -4000 | | | | | -4,000 | Owner withdrawal |
| Bal. | 6,090 | 7,490 | 640 | 24,100 | 720 | 37,600 | |

38,320 38,320

**2-A-2** ***continued***

| Peavy Design<br>Income Statement<br>Month Ended May 31, 2015 | | |
|---|---|---|
| Revenues: | | |
| Service revenue ($1,100 + $5,000) | | $ 6,100 |
| Expenses: | | |
| Rent expense | $1,200 | |
| Advertising expense | 660 | |
| Total expenses | | 1,860 |
| Net income | | $ 4,240 |

| Peavy Design Statement of Owner's Equity Month Ended May 31, 2015 | |
|---|---|
| Daniel Peavy, capital, April 30, 2015 | $ 23,660 |
| Add: Investments by owner ($12,000 + $1,700) | 13,700 |
| Net income for the month | 4,240 |
| | 41,600 |
| Less: Withdrawals by owner | (4,000) |
| Daniel Peavy, capital, May 31, 2015 | $ 37,600 |

| Peavy Design<br>Balance Sheet<br>May 31, 2015 | | | |
|---|---|---|---|
| ASSETS | | LIABILITIES | |
| Cash | $ 6,090 | Accounts payable | $ 720 |
| Accounts receivable | 7,490 | | |
| Supplies | 640 | OWNER'S EQUITY | |
| Land | 24,100 | Daniel Peavy, capital | 37,600 |
| Total assets | $ 38,320 | Total liabilities and owner's equity | $ 38,230 |

**2-A-3** 1. Overhead

| | |
|---|---|
| Compensation for non-chargeable time, 0.15 x $3,600,000 | $ 540,000 |
| Other costs | 1,449,000 |
| (a) Total overhead | $1,989,000 |
| (b) Direct labor, 0.85 x $3,600,000 | $3,060,000 |
| Overhead application rate, (a) ÷ (b) | 65% |

2. Hourly rate:

| | |
|---|---|
| $60,000 ÷ (48 x 40) = $60,000 ÷ 1,920 | $31.25 |

Many students will forget that "his work there" includes an overhead application:

| | |
|---|---|
| Direct labor, 10 x $31.25 | $312.50 |
| Applied overhead, $312.50 x 0.65 | 203.13 |
| Total costs applied | $515.63 |

We point out that direct-labor time on a job is usually compiled for all classes of engineers and then applied at their different compensation rates. Overhead is usually not applied on the piecemeal basis demonstrated here. Instead, it is applied in one step after all the labor costs of the job have been accumulated.