Solutions to Chapter 1 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.

1-1 Because each pound of CO_2 has a penalty of \$0.20,

$$\text{Savings} = (15 \text{ gallons} \times \$0.10/\text{gallon}) - (8 \text{ lb})(\$0.20/\text{lb}) = \$1.34$$

If Stan can drive his car for less than \$1.34/8 = \$0.1675 per mile, he should make the trip. The cost of gasoline only for the trip is (8 miles ÷ 25 miles/gallon)(\$3.90/gallon) = \$1.25, but other costs of driving, such as insurance, maintenance, and depreciation, may also influence Stan's decision. What is the cost of an accident, should Stan have one during his weekly trip to purchase less expensive gasoline? If Stan makes the trip weekly for a year, should this influence his decision?

1-2 Principle 1 would lead to numerous other means for launching payloads into space. For example, using private U.S. or foreign firms are other viable options.

Principle 2 forces differences in costs and benefits of alternative launching methods to be identified and measured.

Principle 3 establishes a consistent viewpoint to be utilized in the analysis of launching methods (e.g. the perspective of the U.S. government).

Principle 4 reduces the costs and benefits identified by Principal 2 to a common unit of comparison, expressed in dollars (or other monetary units).

Principal 5 ensures that no significant criteria in evaluating alternatives are overlooked.

Principle 6 identifies risks associated with each alternative-- including them in the analysis is of critical importance.

Principal 7 allows the analyst to determine how a good (or poor) decision was made and why. This should impact on subsequent decision making.

1-3 Cost per Watt-hour = \$0.75/1.5 Watt-hours = \$0.50 per Watt-hour

At a cost of \$0.50 per Watt-hour, it would cost (1,000)(\$0.50 per Watt-hour) = \$500 per kilo Watt-hour for power from a single AAA battery. This is 5,000 times more costly than energy from your local utility. No wonder we turn off our battery operated devices when we're not using them!

1-4 At first glance, Tyler's options seem to be: (1) immediately pay \$803 to the owner of the other person's car or (2) submit a claim to the insurance company. If Tyler keeps his Nissan for five more years (an assumption), the cost of option 2 is \$500 + (\$60 × 2 payments/year) × 5 years = \$1,100. This amount is more than paying \$803 out-of-pocket, so Tyler appears to have made the most economical choice.

What we don't know in this problem is the age and condition of the other person's car. If we assume it's a clunker, another option for Tyler is to offer to buy the other person's car and fix it himself and then sell it over the internet. Or Tyler could donate the unrepaired (or repaired) car to his favorite charity.

1-5 **(a)** 15,000 miles per year / 25 mpg = 600 gallons per year of E20
Savings = 600 gallons per year ($4.00 − $3.37) = $378 per year

(b) Gasoline saved = 0.20 (600 gal/yr)(1,000,000 people) = 120 million gallons per year

1-6 The environmental impact on the villagers is unknown, but their spring and summer crop yields could be affected by more than normal snow melt. Let's assume this cost is $10 million. Then the total cost of the plan is $6 million (180 million rubles) plus $10 million and the plan is no longer cost-effective when this additional externality is considered.

1-7 There are numerous other options including a nuclear plant, a 100% gas-fired plant and a windmill bank at a nearby mountain pass. Also, solar farms are becoming more cost competitive nowadays.

1-8 Increased lifetime earnings of a college graduate = $1,200,000(0.75) = $900,000

1-9 Strategy 1: Change oil every 3,000 miles. Cost = (15,000/3,000)($30) = $150 / year
Strategy 2: Change oil every 5,000 miles. Cost = (15,000/5,000)($30) = $90 / year

Savings = $60 per year

1-10 In six months you will spend approximately (180)(2)($1.15) = $414 on bottled water. The cost of the filter is $60, so you will save $354 every six months. This amounts to $708 over a year, and you don't need to bother recycling all those plastic bottles! An up-front expenditure of $60 can indeed save a lot of money each year.

1-11 110 gallons x $4.00 per gallon = $440 saved over 55,000 miles of driving. This comes down to $440 / 55,000 = $0.008 per mile driven. So Brand A saves 8/10 of a penny for each mile driven.

1-12 **(a)** Problem: To find the least expensive method for setting up capacity to produce drill bits.

(b) Assumptions: The revenue per unit will be the same for either machine; startup costs are negligible; breakdowns are not frequent; previous employee's data are correct; drill bits are manufactured the same way regardless of the alternative chosen; in-house technicians can modify the old machine so its life span will match that of the new machine; neither machine has any resale value; there is no union to lobby for in-house work; etc.

(c) Alternatives: (1) Modify the old machine for producing the new drill bit (using in-house technicians); (2) Buy a new machine for $450,000; (3) Get McDonald Inc. to modify the machine; (4) Outsource the work to another company.

(d) Criterion: Least cost in dollars for the anticipated production runs, given that quality and delivery time are essentially unaffected (i.e., not compromised).

(e) Risks: The old machine could be less reliable than a new one; the old machine could cause environmental hazards; fixing the old machine in-house could prove to be unsatisfactory; the old machine could be less safe than a new one; etc.

(f) Non-monetary Considerations: Safety; environmental concerns; quality/reliability differences; "flexibility" of a new machine; job security for in-house work; image to outside companies by having a new technology (machine); etc.

(g) Post Audit: Did either machine (or outsourcing) fail to deliver high quality product on time? Were maintenance costs of the machines acceptable? Did the total production costs allow an acceptable profit to be made?

1-13 **(a)** Problem A: Subject to time, grade point average and energy that Mary is willing/able to exert, Problem A might be "How can Mary survive the senior year and graduate during the coming year (earn a college degree)?"

Problem B: Subject to knowledge of the job market, mobility and professional ambition, Mary's Problem B could be "How can I use my brother's entry-level job as a spring board into a higher-paying position with a career advancement opportunity (maybe no college degree)?"

(b) Problem A - Some feasible solutions for Problem A would include:

(1) Get a loan from her brother and take fewer courses per term, possibly graduating in the summer.

(2) Quit partying and devote her extra time and limited funds to the task of graduating in the spring term (maybe Mary could get a scholarship to help with tuition, room and board).

Problem B - Some feasible solutions for Problem B would include:

(1) Work for her brother and take over the company to enable him to start another entrepreneurial venture.

(2) Work part-time for her brother and continue to take courses over the next couple of years in order to graduate.

(3) Work for her brother for one or two semesters to build up funds for her senior year. While interviewing, bring up the real life working experience and request a higher starting salary.

1-14 A Typical Discussion/Solution:

(a) One problem involves how to satisfy the hunger of three students -- assume a piping hot delicious pizza will satisfy this need. (Another problem is to learn enough about Engineering Economy to pass -- or better yet earn an "A" or a "B" -- on the final examination and ace the course. Maybe a pizza will solve this problem too?) Let's use "hunger satisfaction with a pizza" as the problem/need definition.

(b) *Principle 1 - Develop the Alternatives*

i) Alternative A is to order a pizza from "Pick-Up Sticks"
ii) Alternative B is to order a pizza from "Fred's"

Other options probably exist but we'll stick to these two alternatives

Principle 2 - Focus on the Differences
Difference in delivery time could be an issue. A perceived difference in the quality of the ingredients used to make the pizza could be another factor to consider. We'll concentrate our attention on cost differences in part (c) to follow.

Principle 3 - Use a Consistent Viewpoint
Consider your problem from the perspective of three customers wanting to get a good deal. Does it make sense to buy a pizza having a crust that your dog enjoys, or ordering a pizza from a shop that employs only college students? Use the customer's point of view in this situation rather than that of the owner of the pizza shop or the driver of the delivery vehicle.

Principle 4 - Use a Common Unit of Measure
Most people use "dollars" as one of the most important measures for examining differences between alternatives. In deciding which pizza to order, we'll use a cost-based metric in part (c).

Principle 5 - Consider All Relevant Criteria
Factors other than cost may affect the decision about which pizza to order. For example, variety and quality of toppings and delivery time may be extremely important to your choice. Dynamics of group decision making may also introduce various "political" considerations into the final selection (can you name a couple?)

Principle 6 - Make Uncertainty Explicit
The variability in quality of the pizza, its delivery time and even its price should be carefully examined in making your selection. (Advertised prices are often valid under special conditions -- call first to check on this!)

Principle 7 - Revisit Your Decision
After you've consumed your pizza and returned to studying for the final exam, were you pleased with the taste of the toppings? On the downside, was the crust like cardboard? You'll keep these sorts of things in mind (good and bad) when you order your next pizza!

1-14 ***continued***

(c) Finally some numbers to crunch -- don't forget to list any key assumptions that underpin your analysis to minimize the cost per unit volume (Principles 1, 2, 3, 4 and 6 are integral to this comparison)

Assumptions: (i) weight is directly proportional to volume (to avoid a "meringue" pizza with lots of fluff but meager substance), (ii) you and your study companions will eat the entire pizza (avoids variable amounts of discarded leftovers and hence difficult-to-predict cost of cubic inch consumed) and (iii) data provided in the Example Problem are accurate (the numbers have been confirmed by phone calls).

Analysis:

Alternative A "Pick-Up-Sticks"
Volume = 20″ x 20″ x 1 ¼″ = 500 in.^3
Total Cost = \$15 (1.05) + \$1.50 = \$17.25
Cost per in.^3 = \$0.035

Alternative B "Fred's"
Volume = $(3.1416)(10'')^2\ (1.75'')$ = 550 in.^3
Total Cost = \$17.25 (1.05) = \$18.11
Cost per in.^3 = \$0.033

Therefore, order the pizza from "Fred's" to minimize total cost per cubic inch.

(d) Typical other criteria you and your friends could consider are: (i) cost per square inch of pizza (select "Pick-Up-Sticks"), (ii) minimize total cost regardless of area or volume (select "Pick-Up-Sticks"), and (iii) "Fred's" can deliver in 30 minutes but "Pick-Up-Sticks" cannot deliver for one hour because one of their ovens is not working properly (select "Fred's").

1-15 Definition of Need

Some homeowners need to determine (confirm) whether a storm door could fix their problem. If yes, install a storm door. If it will not basically solve the problem, proceed with the problem formulation activity.

Problem Formulation

The homeowner's problem seems to be one of heat loss and/or aesthetic appearance of their house. Hence, one problem formulation could be:

> "To find different alternatives to prevent heat loss from the house."

Alternatives

- Caulking of windows
- Weather stripping
- Better heating equipment
- Install a storm door
- More insulation in the walls, ceiling, etc. of the house
- Various combinations of the above

1-16 *STEP 1—Define the Problem*: Your basic problem is that you need transportation. Further evaluation leads to the elimination of walking, riding a bicycle, and taking a bus as feasible alternatives.

STEP 2—Develop Your Alternatives (Principle 1 is used here.): Your problem has been reduced to either replacing or repairing your automobile. The alternatives would appear to be

1. Sell the wrecked car for $2,000 to the wholesaler and spend this money, the $1,000 insurance check, and all of your $7,000 savings account on a newer car. The total amount paid out of your savings account is $7,000, and the car will have 28,000 miles of prior use.
2. Spend the $1,000 insurance check and $1,000 of savings to fix the car. The total amount paid out of your savings is $1,000, and the car will have 58,000 miles of prior use.
3. Spend the $1,000 insurance check and $1,000 of your savings to fix the car and then sell the car for $4,500. Spend the $4,500 plus $5,500 of additional savings to buy the newer car. The total amount paid out of savings is $6,500, and the car will have 28,000 miles.
4. Give the car to a part-time mechanic, who will repair it for $1,100 ($1,000 insurance and $100 of your savings), but will take an additional month of repair time. You will also have to rent a car for that time at $400/month (paid out of savings). The total amount paid out of savings is $500, and the car will have 58,000 miles on the odometer.
5. Same as Alternative 4, but you then sell the car for $4,500 and use this money plus $5,500 of additional savings to buy the newer car. The total amount paid out of savings is $6,000, and the newer car will have 28,000 miles of prior use.

ASSUMPTIONS:
1. The less reliable repair shop in Alternatives 4 and 5 will not take longer than one extra month to repair the car.
2. Each car will perform at a satisfactory operating condition (as it was originally intended) and will provide the same total mileage before being sold or salvaged.
3. Interest earned on money remaining in savings is negligible.

STEP 3—Estimate the Cash Flows for Each Alternative (Principle 2 should be adhered to in this step.)

1. Alternative 1 varies from all others because the car is not to be repaired at all but merely sold. This eliminates the benefit of the $500 increase in the value of the car when it is repaired and then sold. Also this alternative leaves no money in your savings account. There is a cash flow of −$8,000 to gain a newer car valued at $10,000.
2. Alternative 2 varies from Alternative 1 because it allows the old car to be repaired. Alternative 2 differs from Alternatives 4 and 5 because it utilizes a more expensive ($500 more) and less risky repair facility. It also varies from Alternatives 3 and 5 because the car will be kept. The cash flow is −$2,000 and the repaired car can be sold for $4,500.
3. Alternative 3 gains an additional $500 by repairing the car and selling it to buy the same car as in Alternative 1. The cash flow is −$7,500 to gain the newer car valued at $10,000.
4. Alternative 4 uses the same idea as Alternative 2, but involves a less expensive repair shop. The repair shop is more risky in the quality of its end product, but will only cost $1,100 in repairs and $400 in an additional month's rental of a car. The cash flow is −$1,500 to keep the older car valued at $4,500.
5. Alternative 5 is the same as Alternative 4, but gains an additional $500 by selling the repaired car and purchasing a newer car as in Alternatives 1 and 3. The cash flow is −$7,000 to obtain the newer car valued at $10,000.

1-16 ***continued***

STEP 4—Select a Criterion: It is very important to use a consistent viewpoint (Principle 3) and a common unit of measure (Principle 4) in performing this step. The viewpoint in this situation is yours (the owner of the wrecked car).

The value of the car to the owner is its market value (i.e., \$10,000 for the newer car and \$4,500 for the repaired car). Hence, the dollar is used as the consistent value against which everything is measured. This reduces all decisions to a quantitative level, which can then be reviewed later with qualitative factors that may carry their own dollar value (e.g., how much is low mileage or a reliable repair shop worth?).

STEP 5—Analyze and Compare the Alternatives: Make sure you consider all relevant criteria (Principle 5).

1. Alternative 1 is eliminated, because Alternative 3 gains the same end result and would also provide the car owner with \$500 more cash. This is experienced with no change in the risk to the owner. (Car value = \$10,000, savings = 0, total worth = \$10,000.)
2. Alternative 2 is a good alternative to consider, because it spends the least amount of cash, leaving \$6,000 in the bank. Alternative 2 provides the same end result as Alternative 4, but costs \$500 more to repair. Therefore, Alternative 2 is eliminated. (Car value = \$4,500, savings = \$6,000, total worth = \$10,500.)
3. Alternative 3 is eliminated, because Alternative 5 also repairs the car but at a lower out-of-savings cost (\$500 difference), and both Alternatives 3 and 5 have the same end result of buying the newer car. (Car value = \$10,000, savings = \$500, total worth = \$10,500.)
4. Alternative 4 is a good alternative, because it saves \$500 by using a cheaper repair facility, provided that the risk of a poor repair job is judged to be small. (Car value = \$4,500, savings = \$6,500, total worth = \$11,000.)
5. Alternative 5 repairs the car at a lower cost (\$500 cheaper) and eliminates the risk of breakdown by selling the car to someone else at an additional \$500 gain. (Car value = \$10,000, savings = \$1,000, total worth = \$11,000.)

STEP 6—Select the Best Alternative: When performing this step of the procedure, you should make uncertainty explicit (Principle 6). Among the uncertainties that can be found in this problem, the following are the most relevant to the decision. If the original car is repaired and kept, there is a possibility that it would have a higher frequency of breakdowns (based on personal experience). If a cheaper repair facility is used, the chance of a later breakdown is even greater (based on personal experience). Buying a newer car will use up most of your savings. Also, the newer car purchased may be too expensive, based on the additional price paid (which is at least \$6,000/30,000 miles = 20 cents per mile). Finally, the newer car may also have been in an accident and could have a worse repair history than the presently owned car.

Based on the information in all previous steps, *Alternative 5* was actually chosen.

STEP 7—Monitor the Performance of Your Choice

This step goes hand-in-hand with Principle 7 (revisit your decisions). The newer car turned out after being "test driven" for 20,000 miles to be a real beauty. Mileage was great, and no repairs were needed. The systematic process of identifying and analyzing alternative solutions to this problem really paid off!

1-17 Imprudent use of electronic mail, for example, can involve legal issues, confidential financial data, trade secrets, regulatory issues, public relations goofs, etc. These matters are difficult to "dollarize" but add to the $30,000 annual savings cited in the problem. Surfing the web inappropriately can lead to legal prosecution for pornography violations.

1-18 **(a)** Value of metal in collection = (5,000/130 lb)(0.95)($3.50/lb)
+ (5,000/130 lb)(0.05)($1.00/lb) = $129.81

Each penny is worth about 2.6 cents for its metal content. The numismatic value of each coin is most likely much greater. Note: It is illegal to melt down coins.

(b) This answer is left to the individual student. In general, the cost of purchases would go up slightly. The inflation rate would be adversely affected if all purchases were rounded up to the nearest nickel. Additional note: The cost of producing a nickel is almost 10 cents. Maybe the U.S. government should get out of the business of minting coins and turn over the minting operation to privately-owned subcontractors.

1-19 Left to student.

1-20 Left to student.

1-21 A one degree difference in thermostat setting will reduce energy use by up to five percent when the heat loss in the winter and the heat gain in the summer are roughly equal. This assumes the efficiency of the heating system is about the same as that of the cooling system.