FACULTY NOTES

The LTAs and Spinoffs are designed so that each professor can implement them in a way that is consistent with his/her teaching style and course objectives. This may range from using the materials as out-of-class projects with minimal in-class guidance to doing most of the work in class. The LTAs and Spinoffs are amenable to small group cooperative work and typically benefit from the use of some learning technology. Since the objective of the LTAs and Spinoffs is to support the specific academic goals you have set for your students, the Faculty Notes are not intended to be prescriptive. The purpose of the Faculty Notes is to provide information that assists you to take full advantage of the LTAs and Spinoffs. This includes suggestions for instruction as well as answers for the exercises.

FACULTY NOTES

SPINOFF 8D

At What Cost?
High Versus Low Pressure K-Bottles for the Space Shuttle

This Spinoff is suitable for a precalculus class. It involves a comparison of two different types of K-bottles, each under different pressure. The two bottles cost different amounts to fill and contain different amounts of air under the lower air pressure of the instrument compartment. Students will need to complete the main LTA first since they will need to use the results of that activity. They will have to do the calculations over for the new type of K-bottle. However, rather than doing the same calculations and developing the formula from them, encourage students to work with a variable flow rate, x, and develop the formula using the same strategy they used in the original calculations. Once they have a formula, directions are given for using the List feature of the graphing calculator in order to create tables to compare the number and cost of the K-bottles for a given flow rate. Since the results are not very straightforward, this is a good exercise in decision making. Be sure to ask students to think about why they might recommend one type of bottle over the other.

Part 3 of this Spinoff extends the analysis to using more than one compartment for the equipment, first with the same flow rate for each compartment, then with different flow rates for each compartment. The use of a two-dimensional table, where all entries may not be valid for the given situation provides students with additional practice in decision making. This may be the first time students have worked with tables of this sort, so you may want to help them get started filling them in. You may find you need to spend some time ensuring that they fully understand and can articulate what the interior values represent. This part is optional if time is a problem. It may be also be done separately at a later date.

Solutions

Part 1 - A Different Kind of K-Bottle

1) $P_1V_1 = P_2V_2 \qquad V_2 = \dfrac{P_1V_1}{P_2} = \dfrac{(3600\ \frac{\text{lbs}}{\text{in}^2})(1.5\ \text{ft}^3)}{14.8\ \frac{\text{lbs}}{\text{in}^2}} = 364.8648649\ \text{ft}^3$

This implies that $V_2 = (364.8648649\ \text{ft}^3)\left(\dfrac{1728\ \text{in}^3}{1\ \text{ft}^3}\right)\div\left(\dfrac{2.54^3\ \text{cm}^3}{1\ \text{in}^3}\right) = 10{,}331{,}822.41\ \text{cm}^3$

2) Let y = number of bottles. Formula for number of bottles, without 10% safety factor:

$$y = \frac{7}{\left(\dfrac{V}{x}\right)\div 86400} = \frac{7}{\dfrac{V}{86400x}} = \frac{7\times 86400x}{10{,}331{,}822.41} = 0.06x$$

Formula for number of bottles with 10% safety factor: $y = (1.1)(0.06x) = 0.066x$

3) **Table 1**

Flow rate (y)	Number of bottles from formula (y)	Whole number of bottles
60	3.96	4
100	6.6	7
120	7.92	8

Part 2 - Cost

1) We rounded up because K-bottles are not available in fractional parts.

2) Consider the first row of Table 1. iPart(3.96)+1 = 4

3) **Table 2**

Flow rate	Number of low-pressure bottles	Cost for low-pressure bottles	Number of high-pressure bottles	Cost for high-pressure bottles	Which bottle is cheaper? (L or H)
20	3	75	2	80	L
30	4	100	2	80	H
40	5	125	3	120	H
50	6	150	4	160	L
60	7	175	4	160	H
70	8	200	5	200	Same
80	9	225	6	240	L
90	10	250	6	240	H
100	*11	275	7	280	L
110	13	325	8	320	H
120	14	350	8	320	H
130	15	375	9	360	H
140	16	400	10	400	Same
150	17	425	10	400	H
160	18	450	11	440	H
170	19	475	12	480	L
180	20	500	12	480	H
190	21	525	13	520	H
200	*22	550	14	560	L

Note: Items with asterisks are not determined by the formula; they are found separately.

4) The relationship between cost and flow rate is not precisely linear. For both the low pressure and high pressure bottles, when the flow rate increases by 10, the cost does not always increase by the same amount.

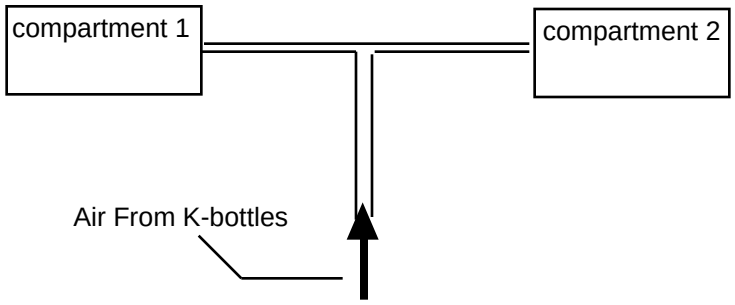
5) Refer to Table 2.

6) Answers will vary.

7) This is a brief memo based on Exercise 6.

Part 3 - More Compartments

Sketch of K-bottles purging more than one compartment.



1) $100 \frac{cm^3}{sec}$

2) 11 low pressure or 7 high pressure K-bottles

3) $170 \frac{cm^3}{sec}$

4) 19 low pressure or 12 high pressure K-bottles

5) Minimum flow rate = $80 \frac{cm^3}{sec}$. This flow rate would demand either 9 low pressure or 6 high pressure K-bottles.

Maximum flow rate = $180 \frac{cm^3}{sec}$. This flow rate would demand either 20 low pressure or 12 high pressure K-bottles. However, the constraint of no more than 12 K-bottles means that you must use high pressure bottles.

6) **Table 3**

	Flow Rate for Compartment 1						
		50	60	70	80	90	100
Flow Rate for Compartment 2	30	80	90	100	110	120	130
	40	90	100	110	120	130	140
	50	100	110	120	130	140	150
	60	110	120	130	140	150	160
	70	120	130	140	150	160	170
	80	130	140	150	160	170	180

The numbers within Table 3 represent the total flow rate in cubic centimeters per second demanded by the two compartments.

7) **Table 4**

	Flow Rate for Compartment 1					
	50	60	70	80	90	100
30	9\225	10\250	11\275	13\325	14\350	15\375
Flow Rate 40	10\250	11\275	13\325	14\350	15\375	16\400
for 50	11\275	13\325	14\350	15\375	16\400	17\425
Compartment 2 60	13\325	14\350	15\375	16\400	17\425	18\450
70	14\350	15\375	16\400	17\425	18\450	19\475
80	15\375	16\400	17\425	18\450	19\475	20\500

The first numbers within Table 4 represent the number of low pressure K-bottles needed to satisfy several combinations of possible flow rates required by each compartment. The second numbers are the costs of the K-bottles. Since no more than 12 K-bottles can be attached to the manifold of the crawler, only six combinations in the upper left corner of the table are valid.

8) **Table 5**

		Flow Rate for Compartment 1				
	50	60	70	80	90	100
30	6\240	6\240	7\280	8\320	8\320	9\360
Flow Rate 40	6\240	7\280	8\320	8\320	9\360	10\400
for 50	7\280	8\320	8\320	9\360	10\400	10\400
Compartment 2 60	8\320	8\320	9\360	10\400	10\400	11\440
70	8\320	9\360	10\400	10\400	11\440	12\480
80	9\360	10\400	10\400	11\440	12\480	12\480

The first numbers within Table 5 represent the number of high pressure K- bottles needed to satisfy several combinations of possible flow rates required by each compartment. The second numbers are the costs of the K-bottles.

9) Answers will vary from group to group.

10) This is a Project Report.