#1

HW 3, Winter 2002, Formulation due on 30 Jan. class.

Formulate the foloowing problem using an LP model. Return your formulation in the calss on 30 Jan. to be greded as HW.

Later you are asked to solve the same problem using AMPL software, and write a report on the optimum solution to be implemented. Your report should contain (1) Model and data files for solving this problem using AMPL, (2) output sheet containing AMPL output and (3) A report written by you interpreting the optimum sol. to implement from AMPL output and any other useful planning information that you can get from the AMPL output.

You can discuss this process with others, but you have to solve the problem by yourself, and write the report too by yourself.

The final project report is due on 8 April 2002 in class.

Oil Refinery Optimization A refinery has a distillation capacity of 100,000 barrels of crude/day in its fractionater. Here crude oil is basically heated and as the temperature increases different products called DN (distillation naptha), DHO (distillation heating oil), DGO (distillation gas oil), and P (pitch), are given off in vapor form, and are collected at various levels. The refinery gets crude oil from three different countries, these are called crudes 1, 2, 3. All the crudes and the various products are measured by volume in barrels. The output statistics from the distillation of each of the available crudes are tabulated below.

Distillation output	Yield (barrels/barrel) from distillation of		
	Crude 1	Crude 2	Crude 3
DN	0.19	0.16	0.02
DHO	0.27	0.32	0.24
DGO	0.38	0.27	0.26
P	0.05	0.13	0.39
Price ($/barrel)	23.25	22.00	20.50
Available (barrels/day)	60,000	90,000	80,000

It can be verified that the total volume of outputs from the distillation of one barrel of crude is < 1. The loss is due to evaporation and unusable heavy residuals.

DHO can be sold directly as heating oil. DGO can be sold directly as diesel fuel. Sale prices of these products are given below.

DHO and DGO can also be processed further in a catalytic cracker. The catalytic cracker can either process a maximum of 100,000 barrels/day of DHO, or a maximum of 50,000 barrels/day of DGO, or a combination of these in proportion of these levels adding up to 1. Also, when processing DHO the catalytic cracker can be run either at a normal level or at a high severity level. The high severity level helps to convert more of the DHO into naptha as seen from the table below. In processing DGO the catalytic cracker is run at normal level only and never on high severity level.

Catalytic cracker outputs	Output (barrels/barrel of feed)		
	DHO normal level	DHO high severity level	DGO normal level
Catalytic naptha (CN)	0.18	0.32	0.48
Catalytic heating oil (CHO)	0.80	0.69	0.52
Pitch (P)	0.11	0.10	0. 15

The cracking process converts the feed into products whose density is smaller than that of the feed, that's why the volume of outputs from this process is greater than the feed volume.

The pitch (from fractionater and catalytic cracker) can be combined with CHO (two parts of CHO to 17 parts of pitch) and sold as heavy fuel oil. DN and CN can be combined (20 parts of DN with 17 parts or greater of CN) and sold as gasoline. The quality of the gasoline improves with the proportion of CN in this blend. The following table gives the selling prices and demand for the various final products.

Final product	Selling price ($/barrel)	Daily demand
Gasoline	43.25	Up to 40,000 barrels
Heating oil	39.75	Up to 40,000 barrels
Diesel fuel	39.00	Any amount
Heavy fuel oil	30.00	Any amount

The processing cost on the fractionater is estimated to be $0.60/barrel of crude processed. On the catalytic cracker the processing costs are $1.50/barrel of fresh feed at the high severity level, and $0.95/barrel of fresh feed at the normal level. Formulate the problem of determining how much of each final product to produce daily in order to maximize daily net profit, as an LP.

#2. Prove the following properties.

Important Properties

1. Sum of convex functions is convex.

2. Positive combination of convex functions is convex.

3. Pointwise supremum of convex functions is convex.