Under current labor policies, clerical workers may be assigned to any one of six shifts, some of which overlap. The shifts and salary costs are as follows.

Shift	Daily Cost ($)
2 am–10 am	160
6 am–2 pm	145
10 am–6 pm	148
2 pm–10 pm	154
6 pm–2 am	156
10 pm–6 am	160

(a) Provide the operations manager with a schedule that will deploy enough staff to meet the hourly requirements at the minimum daily total cost.

(b) In the optimal schedule, how many hourly periods are overstaffed?

2.4 Selecting a Portfolio: A portfolio manager has developed a list of six investment alternatives for a multiyear horizon. These are Treasury bills, Common stock, Corporate bonds, Real estate, Growth funds, and Savings and loans. These investments and their various financial factors are described below. In the table, the return is given as an annual percentage, and the length represents the estimated number of years required for the annual return to be realized. The risk coefficient is a subjective estimate representing the manager's appraisal of the relative safety of each alternative, on a scale of 1–10. The growth potential is an estimate of the potential increase in value over the horizon.

	Portfolio Data					
Alternative	TB	CS	CB	RE	GF	SL
Length (years)	4	7	8	6	10	5
Annual return (%)	6	15	12	24	18	9
Risk coefficient	1	5	4	8	6	3
Growth potential (%)	0	18	10	32	20	7

The manager wishes to maximize the return on a $3 million portfolio, subject to the following restrictions:

- The weighted average length should not exceed 7 years.
- The weighted average risk coefficient should not exceed five.
- The weighted average growth potential should be at least 10%.
- The investment in real estate should be no more than twice the investment in stocks and bonds (i.e., in CS, CB, and GF) combined.

(a) What are the optimal return and the optimal allocation of investment funds? (Give the optimal return in dollars and also as a percentage.)

(b) What is the marginal rate of return? In other words, what would be the return on the next dollar invested if there were one more dollar in the portfolio?

(c) For additional investment beyond the original $3 million, how does the optimal allocation change?

2.5 Oil Blending: An oil company produces three brands of oil: regular, multigrade, and supreme. Each brand of oil is composed of one or more of four crude stocks, each having a different lubrication index. The relevant data concerning the crude stocks are as follows.

Crude Stock	Lubrication Index	Cost ($/Barrel)	Daily Supply (Barrels)
1	20	7.1	1000
2	40	8.5	1100
3	30	7.7	1200
4	55	9	1100

Each brand of oil must meet a minimum standard for a lubrication index, and each brand thus sells at a different price. The relevant data concerning the three brands of oil are as follows.

Brand	Minimum Lubrication Index	Selling Price ($/Barrel)	Daily Demand (Barrels)
Regular	25	8.5	2000
Multigrade	35	9	1500
Supreme	50	10	750

The task is to determine an optimal output plan for a single day, assuming that production can be either sold or else stored at negligible cost. The daily demand figures are subject to alternative interpretations. Investigate the following.

(a) The daily demands represent potential sales. In other words, the model should contain demand ceilings (upper limits). What is the optimal profit?

(b) The daily demands are strict obligations. In other words, the model should contain demand constraints that are met precisely. What is the optimal profit?

(c) The daily demands represent minimum sales commitments, but all output can be sold. In other words, the model should permit production to exceed the daily commitments. What is the optimal profit?

2.6 Coffee Blending and Sales: Hill-O-Beans Coffee Company blends four component beans into three final blends of coffee: one is sold to luxury hotels, another to restaurants, and the third to supermarkets for store-label brands. The company has four reliable bean supplies: Argentine Abundo, Peruvian Colmado, Brazilian Maximo, and Chilean Saboro. The table below summarizes the very precise recipes for the final coffee blends, the cost and weekly availability information for the four components, and the wholesale price per pound of the