

CEE518 Homework #6  
Systems and Optimization  
Show all work for full credit.

1. Problem 11.2 from Rao. Please use Solver in Excel or comparable program.  
A system consists of  $N$  stages in parallel with  $n_j$  components in series in stage  $j$ ;  $j = 1, 2, \dots, N$ . Each component of stage  $j$  costs  $c_j$ , weighs  $w_j$  and has reliability of  $R_j$ .

- a) Formulate the problem of maximizing the reliability of the system subject to constraints on the cost and weight of the system.
- b) Solve the problem formulated in part a for the following data:

Stage $j$	$R_j$	$c_j$	$w_j$
1	0.9	5	3
2	0.7	6	1
3	0.8	8	2

Maximum cost permitted: 100. Maximum weight permitted: 50.

2. Concrete beam optimization problem. Find the optimal size of a beam for the minimum and maximum areas of steel, respectively, given that the reliability must be greater than or equal to 0.999.

The moment capacity is given by

$$M_n = A_s f_y d \left( 1 - 0.59 \frac{A_s f_y}{b d f_c'} \right)$$

The beam is simply supported and uniformly loaded with a “demand” moment  $M_u$  with a mean of 1800 in-kips and a COV of 0.10.

Other information:

$f_c'$  is lognormally distributed with a mean of 5 ksi and COV of 0.15.

$f_y$  is lognormally distributed with a mean of 60 ksi and COV of 0.08.

Cost of concrete is 0.002 \$/in<sup>3</sup>.

Cost of steel is 0.25 \$/in<sup>3</sup>.

$$\frac{200bd}{f_y} \leq A_s \leq 0.75 \rho_b bd$$

$$\rho_b = \frac{0.85 \beta_1 f_c'}{f_y} \left( \frac{87000}{87000 + f_y} \right)$$

Assume  $\beta_1 = 0.85$ .

Assume  $d = 1.5b$ .