1. Traffic can be improved on a stretch of 5 kms along Aurobindo road in Delhi either by installing a metro rail corridor or exclusive bus lanes. The cost and benefits of the two options are given in Rs. 10^6 as:

System Option	Initial cost	O&M/year	Annual benefit
Metro	600, 50 after 15th year	1	15
Exclusive bus lane	200, 2 after every 5 years	.5	5

Assuming a 30 year life for the systems and 8% discount rate
i. Calculate the net present value and benefit cost ratio and IRR for each of these systems.   (6)
ii. If 50% of the initial investment is offered as grant, how does IRR change?   (4)

2. A gravel company has contracts to supply gravel to four construction projects projects.
       1. A highway (1500 tons)
       2. A shopping mall (1000 tons)
       3. A runway extension (1700 tons)
       4. An urban development project (500 tons)
The company owns three gravel pits A, B, C. The marginal cost of producing and shipping a ton of gravel from pit to user is :

	PIT		
Client	A	B	C
1	22	12	17
2	16	22	19
3	25	31	27
4	21	20	18

No more than 40% of any project's gravel may come from pit C. Only 800 tons of gravel are currently available at pit B. The objective is to minimize the cost.
What are the constraints equations?   (4)
Indicate what sensitivity output from LP will answer the following questions:
What is the most we should pay for gravel for project 3.   (1)
How much more would it cost to require that 50 tons of gravel from B be used in project 2? (1)

3. Road traffic fatalities impose significant cost to the society. This depends on the numbers of fatalities and injuries and the monetary value which can be placed on human life or an injury. Define value of human life. Explain human capital approach and willingness to pay approach for estimating cost of accidents.(2, 4)

Bhattacharya et al(2007) have estimated the value of mortality risk reduction in Delhi.
Write the basic model and the proposed hypothesis in the paper. What are the shortcomings and strengths of this model? How does the value estimated by this paper compare with earlier estimates? (4)

4. i. Derive value of travel time based on a discrete mode choice model which is dependent on travel cost and travel time. What are the shortcomings of this model?   (1)
ii. Define subjective value of travel time(SVTT)? Write a model of consumer behaviour along with appropriate constraints for estimating SVTT when utility is a function of consumption expenditure, leisure time, work time and travel time.   (3)

5. Prepare an exhaustive list of costs and benefits of a proposed metro corridor and bus rapid transit corridor. The project life is 30 years. Explain how the required data should be estimated/collected for each item. The list can be presented in a tabular form. Explanations for important items should be provided in addition to the table.   (10)