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- (vi) Critical path in a project network indicates
 - (a) path to be decided by the project engineer
 - (b) longest path through the network
 - (c) shortest path through the network
 - (d) fixed path until the project completion.
- (vii) Design capacity of a plant should be

a) break-even capacity	(b) less than the break - even capacity
c) more than the break-even capacity	(d) twice the break-even capacity

- (viii) In PERT chart of network analysis, the normal deviation Z = 0, the probability of completing a job corresponds to
 (a) 100%
 (b) 75%
 (c) 50%
 (d) 25%.
- (ix) Optimal production rate signifies

(a) maximum rate of production for given fixed cost(b) minimum production cost for a given production capacity

- (c) maximum profit for a given total capital expenditure
- (d) minimum inventory cost for a given production capacity.
- (x) Pinch technology provides an improvement in regard to energy utilisation in a process due to
 - (a) provision of advanced unit operations
 - (b) generation of heat integration scheme
 - (c) supply of external heat sources at a temperature below the pinch point
 - (d) removal of heat from the process by cooling at a temperature above the pinch point.

Group – B

- 2. (a) Differentiate between fixed capital and fixed cost.
 - (b) State the role of a project engineer in development of a project.
 - (c) How would you make an estimate of annual manufacturing cost in a chemical process plant?
 - (d) Establish a relation between nominal interest rate and effective interest rate when the interest is compounded 'm' times in a year.

3 + 3 + 3 + 3 = 12

3. (a) A company borrows `.100 lacs at an interest rate of 6%. The company wishes to pay off the debt in 10 years by making equal payments at the end of each year, determine how much the company will have to pay each year.

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(b) For a catalytic reaction, the catalyst must be regenerated periodically due to fall in efficiency of the catalyst. The cost of one regeneration is `. 56000/-. The feed rate to the reactor is 150 kg per day. The cost of feed material is `. 175/- per kg. The daily cost of operation is `. 21000/- and fixed charges and general over head costs are `. 7×10^{6} per year. The yield of product per kg of feed is 0.87 / (T_d)^{0.25}, where T_d is time of operation in days. The time required for shut down, replace the catalyst and start up the unit is negligible. The value of the product is `. 980/- per kg. The plant operates 300 days in a year. What is the Maximum annual profit that can be obtained under these conditions?

4 + 8 = 12

Group – E

- 8. (a) Define Work Breakdown Structure.
 - (b) Consider the following network where the nodes numbered 1 to 8 represent the events chronologically and the arrows represent the activity times logically in a project.
 - (c) Determine from it the total float, free float and independent float. [The activity durations are given along the arrows.]



- 3 + 9 = 12
- 9. (a) A piece of equipment is made up of two parts 'P' & 'Q', which are to be assembled together before they are dispatched. Part P is made of cast steel which needs a pattern and mold. This also needs to be heat treated for imparting better mechanical strength before assembly and part Q is a machined item made on a special machine 'M' which needs to be purchased and installed.

Draw a bar chart for the above project.

(b) How would you perform time estimates in the PERT network methodology assuming beta distribution unimodal curve by plotting the probability of outcome vs. the time?

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Time Allotted : 3 hrs

Full Marks: 70

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and <u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A (Multiple Choice Type Questions)

1. Choose the correct alternative for the following:

10 × 1 = 10

- (i) Depreciation cost for each year during useful service life will be equal if depreciation is calculated by
- (a) sinking fund method
- (b) declining balance method

(c) sum-of-the-years digit method (d) multiple straight line method.

(ii) Discounted cash-flow rate of return is equivalent to

- (a) interest rate at which money is available for funding the project
- (b) maximum interest rate at which money can be borrowed to finance the project
- (c) average rate of return from the project
- (d) rate of return on investment after taxes.

(iii) Accounts receivable is a component of

- (a) fixed capital investment(c) annual manufacturing cost
- (b) working capital investment
 - (d) pre-operative cost.

(iv) Payout period is the time by which

- (a) total capital invested is paid back
- (b) working capital invested is paid back
- (c) depreciable fixed capital invested is paid pack

(d) none of these.

- (v) A project engineer for a project plant should have
- (a) working knowledge of chemical engineering
- (b) working knowledge on management
- (c) thorough knowledge of chemical engineering and working knowledge of
- all branches of engineering & management

(d) experience of more than 10 years in a chemical process plant.

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- Deduce an expression for annual depreciation cost by sinking fund (b) method in terms of original cost, salvage value, useful service life and interest rate. Also find the expression for book value at the end of ath year.
- Initial cost of an equipment is `. 35.0 lacs. Its useful service life is 20 years. (c) The salvage value of the equipment at end of its service life has been estimated to be `.2.8 lacs. Income-tax laws do not permit annual depreciation greater than twice the annual depreciation by straight line method. Would the annual depreciation calculation by text-book declining balance method be acceptable for income-tax purpose?

4 + 4 + 4 = 12

Group – C

4. (a) A company is using a piece of equipment the installed cost of which was 21.0 lacs with estimated service life of 10 years and zero salvage value. The equipment has been in use for 5 years and at the present time it has been estimated that the equipment can be used for 3 more years or it can be sold for `. 4.2 lacs. Operating cost with existing equipment is `. 15.4 lacs per year.

It has been proposed to replace the old equipment by a new one costing .28.0 lacs. The service life of the new equipment would be 10 years with zero salvage value. Operating cost with the new equipment would be 10.50 lacs per year. Should the replacement be made if the company requires a 10% return on any capital investment?

- A profit producing plant has an initial value of `.250 lacs, service life of (b) 10 years and zero salvage value. By how much would annual profit before taxes be increased, if 5% sinking-fund method was used to determine depreciation cost instead of straight line method.
- Deduce Matheson formula of calculation of depreciation cost by (c) declining balance method. What is the limitation of the formula?

4 + 4 + (3 + 1) = 12

The reactor for an extremely exothermic reaction has been proposed to 5. (a) be thermally insulated for minimising heat loss. The insulation is available in thicknesses of 25 mm, 50 mm, 75 mm and 100 mm. The following data have been determined for the different insulation thicknesses:

Thickness (mm)	25	50	75
Kcal/hr saved	3,00,000	3,50,000	3,70,000
Cost of installed insulation(`.)	168000	240000	252000
Annual fixed charges	10%	10%	10%
2	3		

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The value of heat saved is `. 42 per million kcal. An annual return of 15% on the fixed capital investment is required for any capital put into this type of investment. The reactor operates 300 days per year. What thickness of insulation should be used?

5. (b) A company has a choice of three alternative investments which are being considered. The following data for the three alternatives are available:

Investment No.	1	2	3
Initial fixed capital investment (`. In lacs)	70	119	147
Working capital (`. In lacs)	7.0	7.0	10.5
Salvage value (`. In lacs)	7.0	10.5	14.0
Service life (yr)	5	7	8
Annual cash flow to project after taxes (`. In lacs)	25.2	36.4	41.3

By comparing payout period, determine which alternative should be chosen.

8 + 4 = 12

Group – D

- What are the general procedures for design optimisation? 6. (a)
 - A firm uses milling machines, grinding machines and lathes to produce (b) two motor parts. The manufacturing times required for each part, the machining times available on different machines and the profit on each motor part are given below:

Types of Machines	Machining time r motor part (Min	equired. for the utes)	Maximum time available per week (Minutes)
	Motor Part I	Motor Part II	
Milling Machine	10	4	2,000
Grinding Machine	3	2	900
Lathes	6	12	3,000
Profit/ Unit (`.)	100	40	

Determine the number of parts I & parts II to be manufactured per week to maximise profit.

4

Express the break-even point (BEP) in terms of Unit Sales (X) and (c) revenue and margin of safety considering the linear Cost-Volume-Profit Analysis model.

3 + 5 + 4 = 12

Find an expression for the optimum outside diameter of insulation on a 7. (a) wire for maximum heat loss in terms of mean thermal conductivity of insulation and surface heat transfer coefficient.