	Ulegh
Name:	
Roll No.:	To Change Carlo State Conference
Invigilator's Signature :	

MECHATRONIC SYSTEM DESIGN

Time Allotted: 3 Hours Full Marks: 70

The figures in the margin indicate full marks.

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

Answer any *five* questions taking at least *one* question from each Part.

PART - A

- 1. a) State the factors which affect the cylinder piston acceleration.
 - b) Distinguish between 'repeatable error' and 'tracking error'.
 - c) Calculate the tube thickness of a hyraulic cylinder having dimensions as given below :

Tensile strength of cylinder material = 7300 kgf / cm 2 .

Cylinder bore = 50 mm

System pressure = $200 \text{ kgf} / \text{cm}^2$

Factor of safety = 4.

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- d) Determine the safe load for a double acting hydraulic cylinder with two ends pivoted and guided and piston diameter = 140 mm, rod diameter = 70 mm, equivalent length = 1000 mm, factor of safety = 4, modulus of elasticity = 24×10^{5} N/cm².
- a) Draw and explain the working principle of a ladder diagram for a dual cylinder sequencing circuit with two limit switches.
 - b) Draw a hydraulic circuit which has been designed to crush a car body into a bale size. For supply of emergency pressurized fluid an accumulator may be incorporated. In that circuit take a 160 mm diameter hydraulic cylinder which is to extend 3.0 m during a period of 20 secs. The time between crushing strokes is 8 minutes.



The following accumulator gas absorb pressures are given:

 P_1 = Gas charge pressure = 90 bars

 P_2 = Gas charge pressure when pump is turned on = 180 bar abs pressure relief valve setting.

 P_3 = Minimum pressure required to actuate load = 100 bars abs.

- i) Calculate the required size of the accumulator.
- ii) What are the pump hydraulic kW power and flow required with or without an accumulator.8

PART - B

- 3. a) Write the general statement for constant optimization problem.
 - b) Minimize $f = -4x_1 5x_2$

subject to

$$-x_1 + x_2 \le 4$$

$$x_1 + x_2 \le 6$$

$$x_1 \ge 0, x_2 \ge 0.$$

Use simplex method to solve the problem.

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- 4. a) State the optimality criterion for gradient based search method.
 - b) Minimize $f(x_1, x_2) = 12.09$

$$x_1^2 + 21.504 x_2^2 - 1.732 x_1 - x_2$$

starting from the point $\bar{X} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

Show two iterations.

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PART - C

- 5. a) Consider a 4-bar linkage with its shortest link of 3 cm length. The link opposite to the shortest one is 10 cm long. The links adjacent to the shortest one are 12 cm and 8 cm long. Find all the inversions of the chain.
 - b) If a flat belt is being driven by a flat pulley, prove that $\frac{T_1}{T_2}=e^{\mu\theta}$,

where T_1 and T_2 are the tensions in belt in the tight and loose side, θ is the angle of wrap and μ is the coefficient of friction between belt and pulley.

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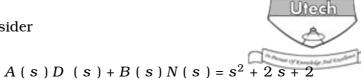


- 6. a) What is the inherent problem in a chain-sprocket drive and how is the problem kept under control?
 - b) Draw the profile of a cam operating a knife-edge follower having a lift of 30 mm. The cam raises the follower with SHM for 150° of the rotation followed by a period of dwell of 60°. The follower descends for the next 100° rotation of the cam with uniform velocity, again followed by a dwell period. The cam rotates at a uniform angular velocity of 60 rpm and has a least radius of 30 mm. What will be the maximum acceleration of the follower during the lift and descent?

PART - D

- 7. a) State the iff conditions for internal stability of LTI system.
 - b) Check the internal stability of the following system :
 - i) Nominal plant model $G(s) = \frac{s-2}{s}$
 - ii) Cascade compensator $C(s) = \frac{1}{s-2}$
 - iii) Feedback compensator F(s) = 1.

c) Consider



where D(s) and N(s) are given polynomials.

Do solutions A(s) and B(s) exist in the equation when $D(s) = s^2 - 1$ and N(s) = s - 2.

d)

Fig.

In the unity feedback configuration as shown;

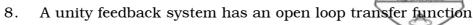
$$G(s) = \frac{N(s)}{D(s)}$$
 and $T(s) = \frac{s(s)}{R(s)}$.

- i) Show that the closed loop transfer function $G_o(s)$ is implementable if and only if $G_o(s)$ and T(s) are proper and stable.
- ii) For $G(s) = \frac{(s+2)(s-1)}{s(s^2-2s+2)}$ and $G_o(s) = \frac{(s-1)}{(s+3)(s+1)}$

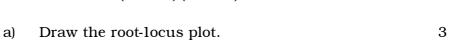
Check whether $G_o(s)$ is implementable. 2

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$$G(s) = \frac{k}{s(s+1)(s+5)}$$
.



b) Determine the value of k to give a damping ratio of 0.3.

Now a network of transfer function

$$\frac{10(1+10s)}{(1+100s)}$$

is introduced in tandem.

- c) Find new value of k which gives the same damping ratio for the closed loop response. 4
- d) Compare the velocity error constant and settling time of the original and the compensated system.4

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