



Answer the following questions:

Question -1

a- Draw the hydraulic symbols for the following:

(25 Marks)

- 1- Two-port, two-position, normally open valve . spring offset.
- 2- Two-port valve held normally open by a spring . lever operated to close.
- 3- Four-port , three position , spring centered , solenoid controlled , hydraulic pilot operated , with pressure port blocked , A, B and T interconnected in the center condition.
- 4- (2-port , 3- port and priority) pressure compensated FCV's (detailed symbols).
- 5- (Counter balance – brake- sequence and reducing) PCV's.
- 6- Two stage relief valves with vent and two- stage un-loader valve with integral check valve.

(12 Marks)

b)

(5+4+4) Marks

- 1) A double acting hydraulic cylinder has to have the same speed extending and retracting. The speed must be easily adjusted and independent of changes in oil viscosity and the load which always opposes movement. The cylinder must be capable of being positively locked in any position .Any ' Kicks' when restarting would be detrimental. Draw a suitable circuit.
- 2) Two hydraulically powered machines are driven by a single power pack. One machine required a constant supply of 15 L/min , the other has a demand which varies from 4 to 18 L/min. The machines operate at pressures between 80 and 100 bar and may be used separately or at the same time. Draw a suitable pumping circuit and calculate the theoretical motor input power required.
- 3) Draw and explain the characteristic curves for the hydrostatic transmission for both of reversible and irreversible in open and closed systems.

Question -2

(20 Marks)

A cylinder has to exert a forward thrust of 100 kN and a reverse thrust of 10 kN. Meter out ' Flow control for extend speed at 0.5 m/min. as shown in Fig (1) . The retract speed should be approximately 5 m/min utilizing full pump flow . Assume that the max. pump pressure is 160 bar and the pressure drops over the following components and their associated pipework are shown on Fig.(1)

Determine the following:

- a- The cylinder size (assume 2:1 ratio piston area to piston rod area),
- b- Pump size , and
- c- Circuit efficiency through extend and retract strokes.

Table 4.1 Recommended cylinder bore and rod sizes.

Cylinder bore diameter (mm)		40	50	63	80	100	125	140	160	180	200	220	250	280	320
Cylinder rod diameter (mm)	Small	20	28	36	45	56	70	90	100	110	125	140	160	180	200
	Large	28	36	45	56	70	90	100	110	125	140	160	180	200	220

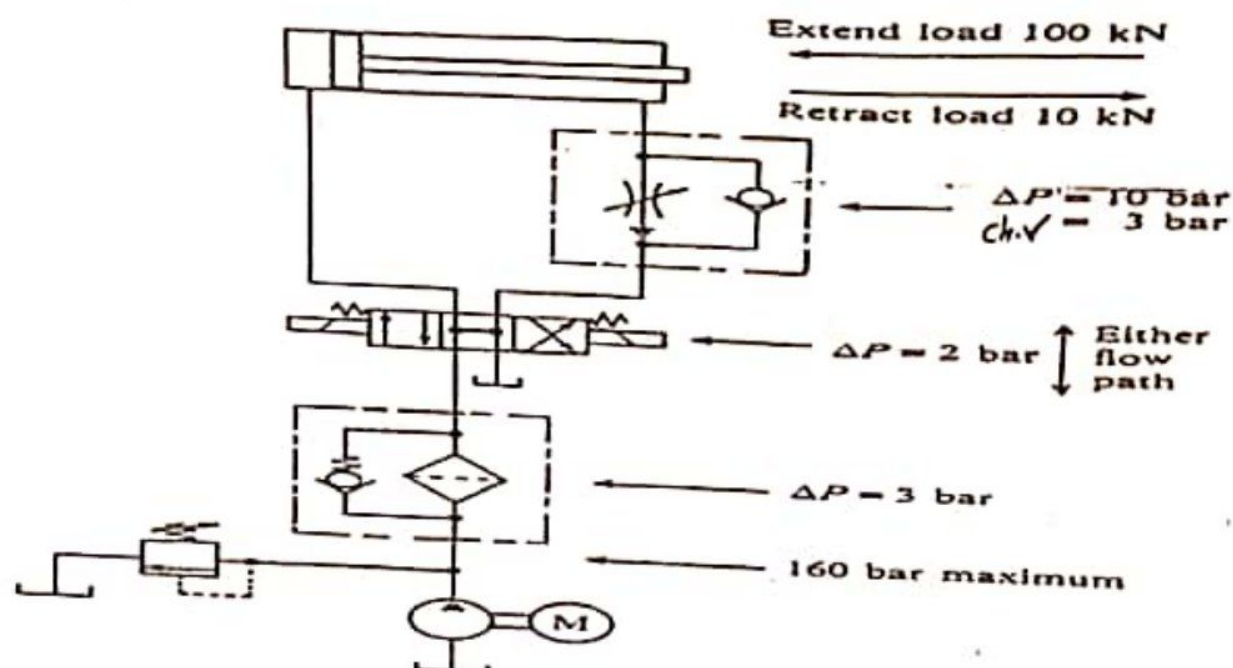


Fig.(1)

Question-3

(12 Marks)

A cylinder has a bore of 125 mm diameter and a rod of 70 mm diameter as shown in Fig. (2). It drives a load of 2000 kg vertically up and down at a max. velocity of 3 m/sec. The lift speed is set by adjusting the pump displacement and the retract speed by a flow control valve. The load is slowed down to rest in the cushion length of 50 mm. If the relief valve is set at 140 bar, determine the average pressure in the cushions on extend and retract. (Neglect pressure drops in pipework and valves).

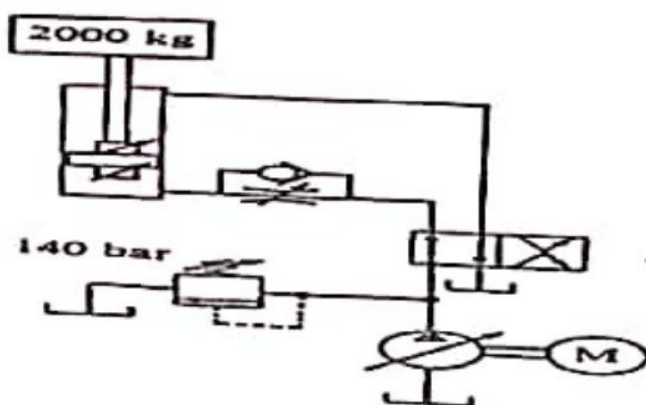


Fig. (2)

Question -4

(15 Marks)

The system shown in Fig. (3) contains a pump delivering high - pressure oil to a hydraulic motor , which drives an external load via a rotating shaft . The following data as:

Pump: $\eta_m = 94\%$, $\eta_v = 92\%$, $V_D = 165 \text{ cm}^3$, $N = 1000 \text{ rpm}$, and Inlet pressure = -0.3 bar

Hydraulic motor : $\eta_m = 92\%$, $\eta_v = 90\%$, $V_D = 131 \text{ cm}^3$, Inlet pressure P_2 required to drive load = 34 bar
motor discharge pressure = 0.34 bar

Pump discharge pipe line : Pipe : 26.4 mm inside diameter, 15 m. long (point 1 to point 2)

Fittings : Two 90° elbows ($K = 0.75$ for each elbow) , One check valve ($K = 4.0$)

Oil : Viscosity = 125 cS and Specific gravity = 0.9

If the hydraulic motor is (6 m.) above the pump , determine the following:

- a. pump flow rate
- b. Pump discharge pressure P_1
- c. Input hp required to drive the pump
- d. Motor speed
- e. Motor output hp
- f. Motor output torque
- g. Overall efficiency of system

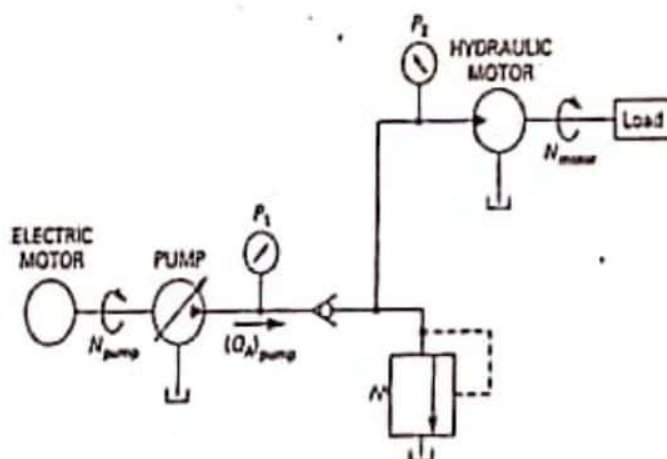


Fig. (3)

Question -5

(18 Marks)

A hydraulic cylinder has to operate with the following time cycle : extend in 5 sec at 25 bar, flow rate 12 Lpm , remain extends for 25 sec at 200 bar , no flow, retract in 4 sec at 35 bar , flow rate 12 Lpm, remain retracted for 26 sec at 200 bar , no flow . If the system to be supplied by one of the two following methods : a single fixed displacement pump circuit or a fixed displacement pump with an hydraulic accumulator . The required:

Draw the proposed of the hydraulic circuit for both of the two methods, then determine the following :

- 1) capacity of the used pump and pressure relief valve setting,
- 2) the suitable size of the accumulator, assuming that the maximum allowable pressure of 235 bar, isothermal compression process and isentropic expansion process.
- 3) The overall system efficiency for both of the two methods.



Answer the following questions:

(6+ 9) Marks

Question-1:

- a) Draw and explain the characteristic curves for the hydrostatic transmission for both of reversible and irreversible in open and closed systems.
- b) A centre lath (مخرطة المركز) head stock is to be driven by a 'constant power' hydrostatic transmission. The variable-displacement non-reversing hydraulic motor is to have speed range of 300 to 2500 rev/min. The maximum power required at the output of the hydraulic motor is 6 kW. The maximum pressure available at the pump delivery is 125 bar and the pressure drop between the pump and motor is 5 bar. The torque and volumetric efficiencies of both the pump and motor may be taken as 0.85. Assuming an open loop transmission, determine the following:
- The ideal motor displacement and the actual pump delivery required,
 - The input power required by the pump.

Question -2 :

(4+ 13) Marks

- a) what are the reasons that leads to appearance of the following phenomena when running the hydraulic systems and how to treat them.
- no discharged fluid in the system and
 - no pressure in the system.
- b) A hydraulic boom (دراع هيدروليكي) is powered by two cylinder (Fig. 1). each cylinder has a stroke of 0.7 m and exerts a maximum thrust of 6 tones on extend and 4 tones on retract. The maximum pump delivery pressure is 200 bar and the pressure drop through the pipes and valves may be taken as 10 bar (including back pressure). Cylinders are to be operated by manual valves. Design the circuit in such a way that only one cylinder may be operated at one time. The extend time for either cylinder is to be 10 seconds. Assume the extended length of the cylinder between pivots is twice the stroke for buckling load calculations. Determine a suitable metric cylinder size and pump delivery. Draw a hydraulic circuit.
Take: $E_s = 2.1 \times 10^6 \text{ kg/cm}^2$, safety buckling factor = 3.5

Question-3:

(3+12) Marks

- a) Explain with sketch, the important of fitting cushions in cylinders. Draw the pressure distribution in cushion length.
- b) A hydraulic circuit with an accumulator employs with cylinder of 150 mm diameter and 100 mm rod diameter to crush a car body (سحق جسم سيارة) into a ball size. The cylinder has a stroke of 1.83 m and the minimum crushing pressure is 172 bar abs., the preload pressure is 35 bar abs., the rod extends in 20 sec and retracts in 40 sec. The time between crushing operations (extend and retract) is 6 min. The maximum operating pump pressure is 207 bar abs. Assuming that, the temperature in the accumulator remains constant.
- Find theoretically the following requirements:
- The capacity of the accumulator.
 - Compare the power required with that required if an accumulator was not used.
 - Draw the proposed of the hydraulic circuit used in the operation of the cylinder.

(5+19) Marks

Question-4:

- a) Explain the function of every element from the following parts in contents of the hydraulic circuit: Pilot-operated check valves- prefill valves -flow divider (Motor type)- Compensator spool in flow control valves - cross line relief valves .
- b) A single acting up stroking moulding press has a cylinder diameter of 400 mm, and a stroke of 250 mm of which 225mm is to close the dies onto the work piece at a cylinder pressure of 20 bar. The final 25 mm stroke is to be at a cylinder pressure of 350 bar. The press is to produce 60 components per hour. The breakdown of the required maximum operating time is:
- | | |
|---|--------------|
| Rapid approach 225mm | =5 seconds |
| Pressing over final 25mm | =5 seconds |
| Cure time (i.e. hold under full thrust) | = 25 seconds |
| Return time | = 10 seconds |
| Unload and reload press | = 15 seconds |
| Total cycle time | = 60 seconds |

The return time is estimated for gravity return. The only times which are absolutely fixed are the cure and the load times. By using a single fixed displacement pump with a side cylinder and a prefill - valve. Estimate the pressures and flow rates required to the hydraulic circuit through the strokes of extend and retract, then draw the suggested hydraulic circuit and tabulate the operation of directional control valves and pressure switch/sequence valve for rapid approach , pressing , cure time extend and retract strokes. Then determine the following:

- i) Standard size of a side cylinder, ii) capacity of the pump,
iii) Setting of both of relief valve and sequence valve, iv) Total energy expended in heating fluid , and v) The overall system efficiency .

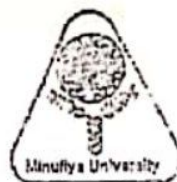
(4+15) Marks

Question-5:

- a) What are advantages of using :
- Dual pump circuit rather than fixed pump circuit for a constant circuit demand?
 - Brake-valve rather than counter balance valve for a constant circuit demand?
- b) Two cylinders operating in two different circuits are shown in Fig. (2) A & B .The load requirements are: rod extends for 40 cm at 0.2 m/sec against 1.0 KN load then rod extends for 20 cm at 0.1 m/sec against 10 KN load. After that, the rod extends for 20 cm at 0.05 m/sec against 20 KN load. Finally, the rod dwells (يسكن) extended for 4 sec against 20 KN load. The cylinder dimensions are (stroke=80cm, blank end area= $20 \times 10^{-4} \text{ m}^2$, rod end area= $12 \times 10^{-4} \text{ m}^2$). By ignoring the losses in the circuits, except in metering orifices and relief valves, draw (sketches) the requirements for P vs. time, Q vs. time and power vs. time. Then, determine the following for both of the two circuits:
- The capacity of the used pump.
 - Relief valve setting ($P_{rel} = 1.1 P_{max}$).
 - The efficiency of the system (for extend stroke only).
 - The hydraulic losses in both of flow control and relief valves.

Table : Recommended cylinder bore and rod size

Piston Diameter (mm)		40	50	63	80	100	125	140	160	180	200	220	250	280	320
Piston rod Diameter (mm)	Small	20	28	36	45	56	70	90	100	110	125	140	160	180	200
	Large	28	36	45	56	70	90	100	110	125	140	160	180	200	220



Answer the following questions:

Question-1 :

(3+10) Marks

- a) A pressure sequence clamp – drill circuit is to be designed to exert a clamping force on the work piece, followed by the advanced of the drill. A counterbalance valve is to be installed at the rod end of the cylinder to prevent chatter and lunging. The drill portion of the cycle should have a rapid regenerative approach followed by a variable slow advance, sequenced by a cam- operated 4-way valve in series with the flow control valve. The circuit should unload when the control valve in the center position. On the return portion of the cycle the drill should retract first, followed by opening of the clamp. A pilot- operated check should be installed at the cap end of the clamp cylinder to prevent the clamp from opening as the drill is retracted. The list of components to construct the circuit are shown in Fig. (1). Draw the suitable circuit.
- b) The given system conditions for the pressure sequence clamp –drill circuit is shown in Fig. (1) are the following : two double acting cylinders with 50 mm diameter bore and 35 mm diameter rod, a minimum clamp force of 6672 N, Clamp closing velocity of 1.5 m/min, Slow advance of 0.15 m/min, Maximum drill force of 3336 N, Minimum return force on drill cylinder of 4448 N, and maximum return force on clamp cylinder of 6672 N, (Assume the effective dynamic thrust is 0.9 of the static thrust), estimate the following:
- Drill sequence valve pressure setting, Clamp sequence valve setting, Drill cylinder rod end counterbalance valve pressure setting (assume no interaction with the flow control valve), pressure relief valve setting, and
 - Pump delivery and pump displacement with 1200 rev/min motor, rapid advance velocity on drill, drill and clamp return velocity, flow control valve setting.

Question-2

(6+12) Marks

- a) A double acting hydraulic cylinder has to have the same speed extending and retracting. The speed must be easily adjusted and independent of changes in oil viscosity and the load which always opposes movement. The cylinder must be capable of being positively locked in any position. Any 'kicks' when restarting would be detrimental. Draw a suitable circuit.
- b) A hydraulic cylinder has to operate with the following time cycle : extend in 5 sec at 25 bar, flow rate 12 Lpm, remain extends for 25 sec at 200 bar, no flow, retract in 4 sec at 35 bar, flow rate 12 Lpm, remain retracted for 26 sec at 200 bar, no flow. If the system to be supplied by one of the two following methods : a single fixed displacement pump circuit or a pressure compensated pump circuit. The required:
- Draw the proposed of the hydraulic circuit for both of the two methods, then determine the capacity of the used pump and pressure relief valve setting,
 - The overall system efficiency for both of the two methods.

Question – 3

(18 Marks)

A single acting up stroking, moulding press has a cylinder diameter of 400 mm, and a stroke of 250 mm of which 225 mm is to close the dies onto the work piece at a cylinder pressure of 20 bar. The final 25 mm stroke is to be at a cylinder pressure of 350 bar. The press is to produce 60 components per hour. The breakdown of the required maximum operating time is:

Rapid approach 225 mm	= 5 sec
Pressing over final 25mm	= 5 sec
Cure time (i.e. hold under full thrust)	= 25 sec
Return time	= 10 sec

Unload and reload press

= 15 sec
= 60 sec

Total cycle time

The return time is estimated for gravity return. The only times which are absolutely fixed are the cure and the load times. By using a low pressure accumulator circuit with pressure compensated pump as shown in Fig. (2). Tabulate the operation of directional control and pressure switches valves for rapid approach, pressing, cure time extend and retract strokes. Then estimate the following:

- i) capacity of the pump and draw the characteristic curve for this pump,
- ii) size of the accumulator, (Assuming iso- thermal process for charging, adiabatic process for discharging and maximum operating charging pressure 30 bar.)
- iii) Setting both of relief and pressure switch valves, iv) Total energy expended in heating fluid,
- v) Draw the curves of p (bar), Q (lit./min.) and E (kW) vs. time of the cycle (sec.), then estimate the overall system efficiency,
- vi) What are the functions of flow controls (FC1 & FC2) and relief valves (RV1 & RV2)? draw the characteristic curves for them, and
- vii) The pump of Fig.(2) is driven by an electric motor having an overall efficiency of 85%. The hydraulic system operates 12 hrs /day for 250 days/year. The cost of electricity is 1.75 LE/Kw.hrs, determine the yearly cost of electricity to operate the hydraulic system and the amount of the yearly cost of electricity that is due to the inefficiencies of the electric motor and pump. Assume the over all efficiency of the pump of 0.90

(6+12) Marks

Question- 4

a) The hydraulic circuit for the hydrostatic unidirectional transmission is shown in Fig. (3). The required, describe the all components that contents of the circuit, then state the function of every part of its theirs.

b) A hydraulic cylinder having a bore of 50 mm with a rod diameter of 32 mm and stroke length is 80 cm. The cylinder have to operate with the following data through extend stroke : rod extends for 40 cm at 0.2 m/sec against one kN load, then extends for 20 cm at 0.10 m/sec against 10 kN load, then rod extends for 20 cm at 0.05 m/sec against 20 KN load, finally rod dwells (يستقر) extended for 4 sec against 20 KN load. To control the piston speed of hydraulic cylinder against varying load, it is used Flow- divider (Motor- type) consists of three motors with capacities of D_1 , D_2 and D_3 in cm^3/rev . The hydraulic circuit for the system is shown in Fig. (4) . Tabulate the operation of directional control valves and limited switch valve for extend and retract strokes. then determine the following:

- i) The capacity of the used pump, ii) Capacities of the motors, iii) Setting of the main and second Relief valves, iv) the retract speed of the cylinder, and v) the efficiency of the hydraulic circuit through the extend stroke. (Neglect any pressure drops in the circuit)

Question-5

(4+2+4+4+4) Marks

- i- Explain the function of every element from the following parts in contents of the hydraulic circuit: Pilot-operated check valves- prefill valves -flow divider (valve type)- shuttle valves- cross line relief valves -un-loader valves – cushion cylinder - reducing valves.
- ii- When the circuit type with fixed displacement pump is best used?
- iii- Draw and explain the characteristic curves for the hydrostatic transmission for both of reversible and irreversible in open and closed systems.
- iv- From the methods that used to control the variable displacement pump (swash plate pump) pressure compensated control and constant power control. The required, explain both of the two methods, showing your answer with drawing both of diagrammatic section and symbols.
- v- Define the term of hydraulic accumulator? Discuss four applications of hydraulic accumulator in hydraulic systems, showing your answer with drawing the hydraulic circuit

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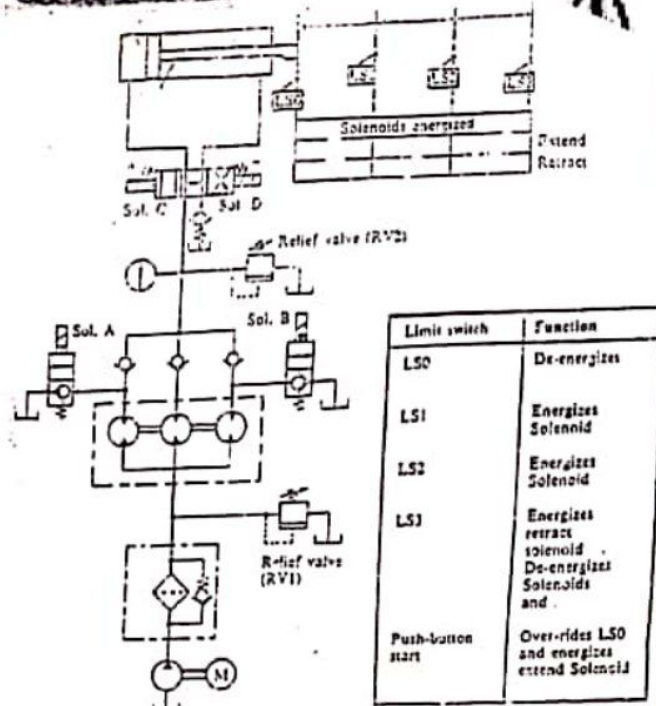
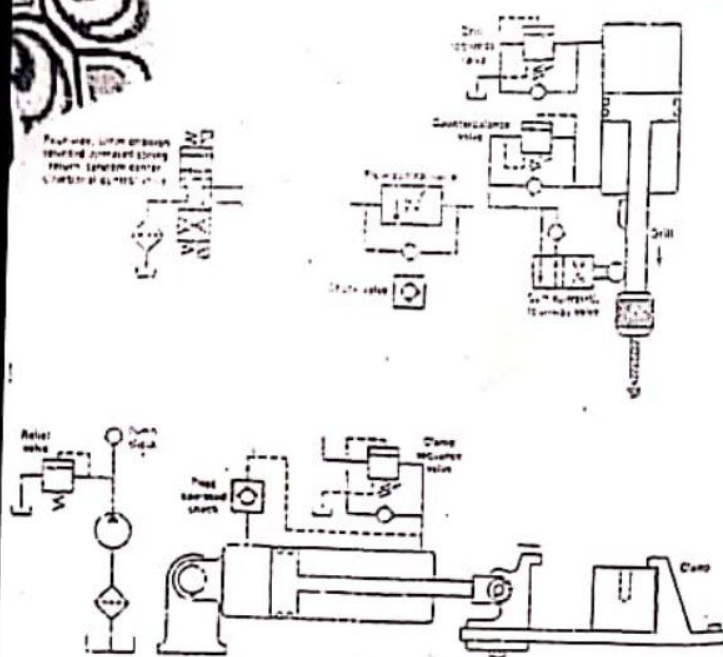


Figure 4 Motor-type flow divider used in a press circuit.

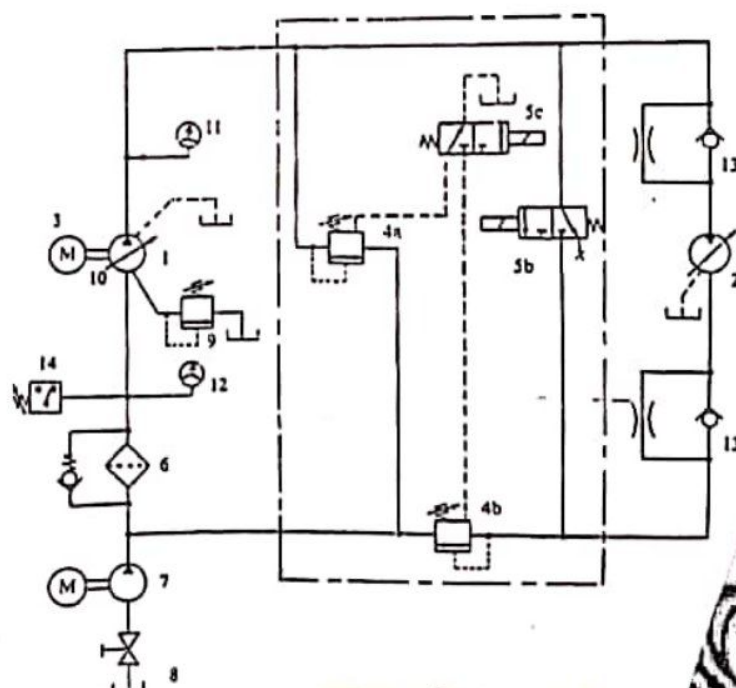
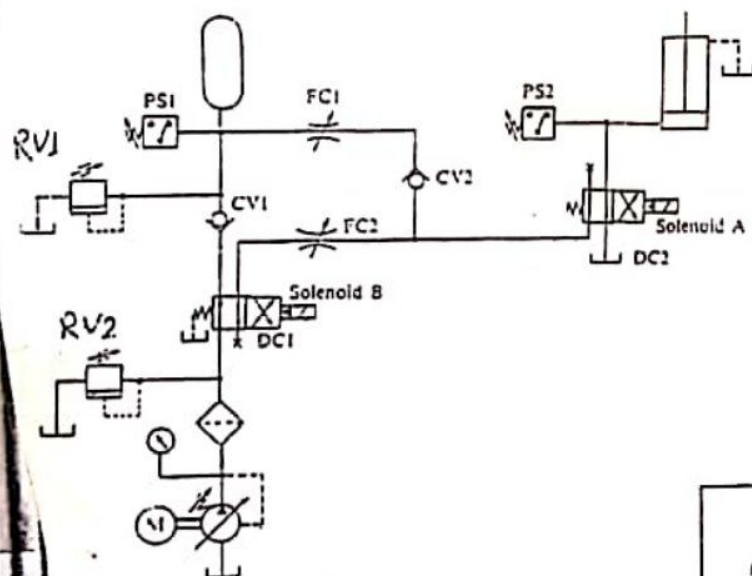


Figure 3 Hydraulic circuit for hydrostatic transmission.





Allowed Tables and Charts: None

Please, Answer all the following Questions

Question (1) (20 Marks)

- (a) What do we mean by a control system? (5 Marks)
- (b) Discuss effects of adding derivative control action into forward path of a control system. (Five only). (5 Marks)

(c) Write the differential equations for the mechanical systems, shown into figure (1). Assume zero initial conditions, draw block diagram for every equation, then obtain the transfer function $\frac{X_2(s)}{F(s)}$

for the numerical values: $k_1=30; k_2=25; f=0.3; f_1=6; f_2=5; m_1=4; m_2=5$. (10 Marks)

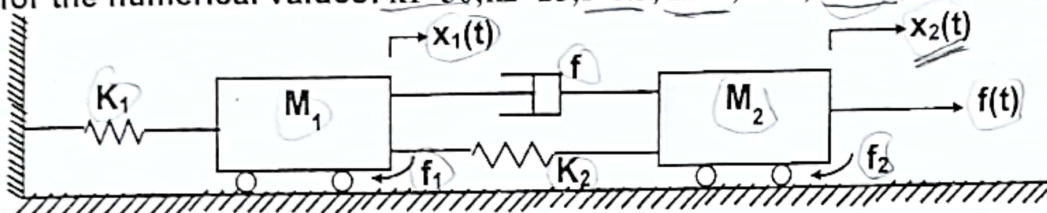


Figure (1)

Question (2) (22 Marks)

- (a) Define the following control terms : Gain-Margin, Phase-Margin, Gain crossover frequency, and Phase crossover frequency. Illustrative plots are appreciated

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- (b) A control system is given by: $G(s) = \frac{250(2s+5)}{(s+0.1)(5s+2)(s^2+3s+100)}$. Draw asymptotes and

exact Bode plots. Then find (from graphs) Gain-Margin, Phase-Margin, Gain crossover frequency, and Phase crossover frequency. Note that: the error plot is given at the end of next page. (14 Marks)

Question (3) (20 Marks)

- (a) Discuss two advantages and two disadvantages of representing a control system into phase-variables form. (4 Marks)

- (b) For the state-variable description

$$\dot{x}(t) = \begin{bmatrix} -1 & -2 & -2 & -1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix} u(t), \text{ and } y = [0 \ 0 \ 1 \ 2]x(t)$$

Draw the whole block diagram of the system, then find the transfer function $Y(s)/U(s)$ and the phase variable representation of the given system. (9 Marks)

- (c) Define the controllability of a any system. Please, test the controllability of the system represented into part (b) of question (3). (7 Marks)



Allowed Tables and Charts: *None*

Question (4) (28 Marks)

(a) Which of the following systems could be described as closed-loop or open-loop control system? Why?: electrical refrigerator, electrical washing machine, electrical drilling machine, servomechanism, remote position control systems, and Voltage and current stabilizers? (6 Marks)

(b) Which of the systems into part (a) could be described as continuous or discontinuous control system? (6 Marks)

(c) The open-loop transfer function of a human posture control system may be approximated by: $G(s)H(s) = \frac{K(s+2)}{s(s+5)(s^2+2s+5)}$

i) Determine the value of the gain (K) when a person's balance is ultimately lost and the system oscillates (critically stable) using Routh array test for closed-loop characteristic equation. (8 Marks)

ii) Calculate the frequency of the oscillation in rad/sec and the four roots of the characteristic equation for the maximum value of K evaluated in part (i). (8 Marks)

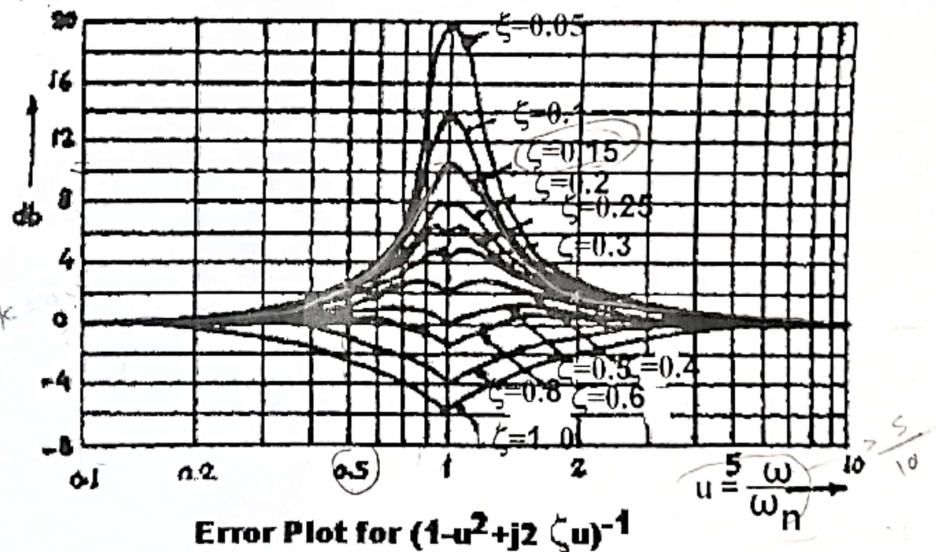
(Hint: Two roots may be evaluated by solving the auxiliary equation)

$$G(s)H(s) = \frac{K(s+2)}{s(s+5)(s^2+2s+5)}$$

$$= \frac{K(s+2)}{s^4 + 7s^3 + 5s^2 + 2s}$$

$$(s^4 + 7s^3 + 5s^2 + 2s) + K(s+2) = 0$$

$$s^4 + 7s^3 + 5s^2 + (2+K)s + 2K = 0$$



derivative **GOOD LUCK**

$$(1 - \tau ds)$$



Allowed Tables and Charts: None

Please, Answer all the following Questions

Question (1) (23 Marks)

(a) Discuss briefly (بإيجاز) the advantages (3 only) of representing physical system into a transfer function.
.....(6 Marks)

(b) Deduce the transfer function $\frac{V_1(s)}{R(s)}$ of the system shown into Fig (1). Then compare the result with following transfer function of an equivalent electrical system to compute the analogy:

$$\frac{V_1(s)}{I(s)} = \frac{C_2 s^2 + \frac{1}{R_1} s + \frac{1}{L}}{(C_2 s^2 + \frac{1}{R_1} s + \frac{1}{L})(C_1 s + \frac{1}{R_1} + \frac{1}{R_2}) - \frac{s}{R_1^2}}$$

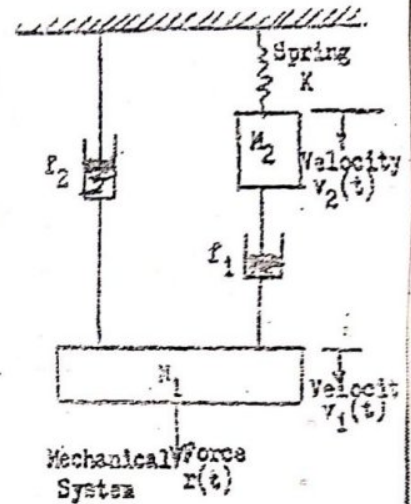


Figure (1)

..... (22 Marks)

Question (2) (20 Marks)

(a) What are the necessary and sufficient conditions, that might be satisfied in Routh method for any control system to be stable?..... (4 Marks)

(b) For a control system, Figure (2), apply Routh stability method to compute the range of values for gain (k), such that the closed loop system is stable.

$$G_p(s) = \frac{k(1+2s)(1+4s)}{s^2(10+2s+s^2)} \quad \text{.....(8 Marks)}$$

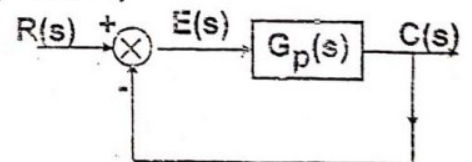


Figure (2)

Select suitable value for k; (if exists), to evaluate the steady-state response and the steady-state error corresponding to different input signals; unit step, unit ramp, and unit parabolic functions.(8 Marks)

Question (3) (20 Marks)

(a) How a frequency response test on a system is performed? (4 Marks)

(b) Please, explain 4 Advantages and one disadvantage of performing frequency response test on a system.
..... (4 Marks)

(c) Determine first the intersections of Polar plot, representing a control system:

$$T(s) = \frac{5}{(20s^2 + 12s + 6)^2} \quad \text{with both real and imaginary axes and asymptotes (if existed), then}$$

select suitable scale to draw this Polar plot.

..... (12 Marks)

Menofia University
Faculty of Engineering
Shebin El-Kom
Department: Mech. Power Eng.
Second Semester Examination
Academic Year: 2017-2018



Subject: Automatic Control
Code: MPE 422
Year: 4th Year
Time Allowed: 3 hours, 90 Marks
Date: 20 May 2018

Allowed Tables and Charts: *None*

Question (4) (22 Marks)

(a) Prove, mathematically, that The feedback physical state variable, k^T , depends, mainly, on the controllability of that system representation. (6 Marks)

(b) For the system represented by state-variables matrix equations:

$$\dot{x} = \begin{bmatrix} 1 & 7 & 2 \\ 6 & 3 & 1 \\ 0 & 5 & 2 \end{bmatrix} x + \begin{bmatrix} 2 \\ 0 \\ 0 \end{bmatrix} u, \text{ and } y = [2 \ 1 \ 5]x$$

Draw the elementary block diagram of the system then find the transfer function $Y(s)/U(s)$ and the phase-variable representation. Find the state feedback controller, k^T , such that the poles of the closed-loop system should be placed at the roots of the following polynomial:

$D_d = s^3 + 6s^2 + 16s + 16$; i.e. $p_d = [-2; -2-2i; -2+2i]$, Controllability properties should be used

..... (16 Marks)

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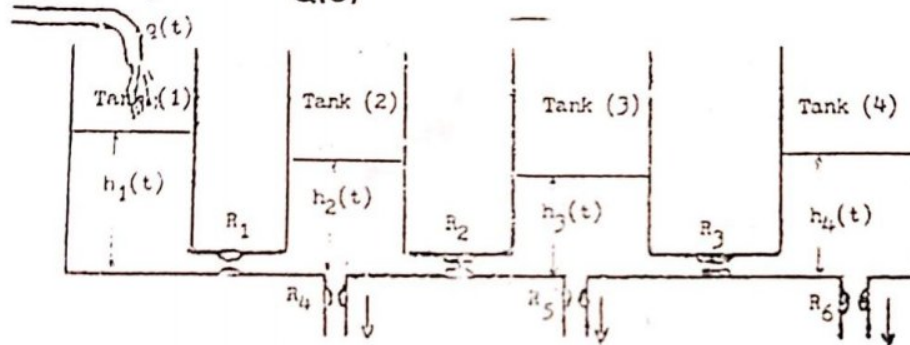


Allowed Tables and Charts: None

Please, Answer all the following Questions

Question (1) (28 Marks)

- (a) Explain, simply, to someone, what do we mean by a control system? And what is a servomechanism as an important example of control system.....(6 Marks)
- (b) Describe 3 advantages of representing a control system into a mathematical model(6 Marks)
- (c) Without adding any new parameter, deduce the mathematical model representing the ratio $\frac{H_4(s)}{Q(s)}$, (draw whole block diagram) for the given tanks system: (16 Marks)



Question (2) (20 Marks)

- (a) Define the following control terms: Resonant Frequency, Resonant Peak, Cut-off frequency, Bandwidth. (Illustrating graphs are appreciated)..... (4 Marks)
- (b) For a control system, represented by a transfer function, what is the main condition to be satisfied (stability theorem) such that the system is absolutely stable?.....(2 Marks)
- (c) Compute the percentage maximum overshoot of a unity negative feedback control system subjected to a unit-step input. If the open-loop transfer function is given by:

$$G_p(s) = \frac{\omega_n^2}{s(s + 2\zeta\omega_n)} \quad \dots (4 \text{ Marks})$$

Note that inverse Laplace transform of

$$\left\{ \frac{\omega_n^2}{s(s^2 + 2\zeta\omega_n s + \omega_n^2)} \right\} = \left(1 + \frac{e^{-\zeta\omega_n t}}{\sqrt{1-\zeta^2}} \sin(\omega_n \sqrt{1-\zeta^2} t - \tan^{-1} \frac{\sqrt{1-\zeta^2}}{-\zeta}) \right).$$

- (d) A unity negative feedback control system is subjected to a unit-step input. The open-loop transfer function of this system is given by: $G(s) = \frac{K}{s(1+0.25s)}$. The gain, K, must be changed in order to decrease the percentage maximum overshoot from 75% to 25%.

Compute the damping ratio, ζ , K, and natural frequency in both cases. Then evaluate the ratio between the values of gain, K, in 1st and 2nd case.(10 Marks)

Question (3)**(20 Marks)**

a) Write only three advantages of using Bode plots..

(3 Marks)b) Draw Bode plots from the following frequency response test results: **(3 Marks)**

ω rad/s	.01	.02	.03	.04	.05	.06	.08	.1	.2	.3	.4	.5
Mag db	68	62	58.39	55.82	53.79	52.1	49.3	47.08	39.09	33.56	29.3	25.97
ϕ degrees	-92.5	-94.9	-97.3	-99.7	-102	-104.3	-108.6	-112.5	-127.0	-134.4	-138	-138.8

ω rad/s	.6	.8	1	2	3	4	5	6	8	10	20	30
Mag db	23.2	18.89	15.67	6.81	2.45	-0.38	-2.5	-4.10	-6.6	-8.48	-13.6	-15.4
ϕ degrees	-138.7	-136.7	-133.7	-120	-112.9	-108.7	-106	-104.7	-103	-102.8	-106.8	-117.4

ω	40	50	60	80	100	200	300	400	500	600	800	1000
Mag db	-15.5	-16.8	-21.9	-31.8	-38.9	-58.5	-69.3	-76.9	-82.8	-87.6	-95	-100.9
ϕ	-139.7	-181	-217	-243.7	-252	-263	-265	-266	-267	-267.7	-268	-269

Estimate the transfer function **(10 Marks)**Find the phase Margin, Gain Margin, and Gain- and phase- crossover frequencies from the graph. **(4 Marks)**Given for second-order factor with two complex poles, the corrections at the corner frequency: $\zeta = 0.1 \ 0.15 \ 0.2 \ 0.25 \ 0.3 \ 0.4$

db = 14 10.4 8 6 4.5 2

Question (4)**(22 Marks)**

The system, in Fig.(1) represents a simplified model of the human respiratory (التنفس) control system. It controls the effective ventilation at lungs (الرئتين), $V_a(s)$. The percentage of Carbon dioxide, $P(s)$, in the circulated blood at chemoreceptor, as a measuring element, is proportional to the effective ventilation, $V_a(s)$. The effective gain, K , of the normal chemoreceptor will be assumed to be 0.1, find the system transfer function $Y(s)/U(s)$.

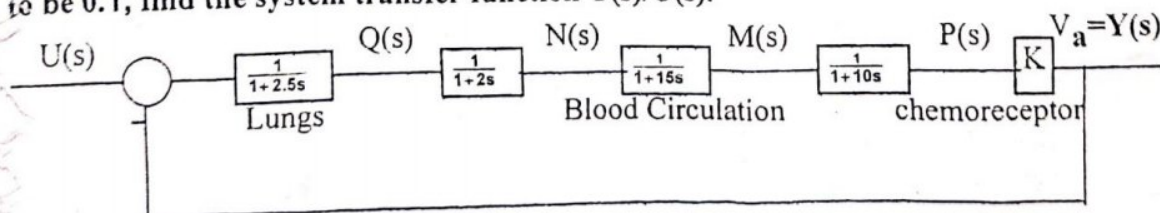



Figure (1)

Find the physical-variable representation using $u(t)$ as the desired ventilation signal, $x_1(t)=p(t)$, $x_2(t)=m(t)$, $x_3(t)=n(t)$, $x_4(t)=q(t)$, and output, $y(t)=v_a(t)$. Also find the phase-variable representation of the same system assuming $x_1(t)=p(t)$. Then find the transformation matrix, T , from phase-variable to physical [i.e. $x(\text{phase})=T \cdot x^*(\text{physical})$].

GOOD LUCK

Menofia University		Subject: MPE 424B Design of Steam and Gas Turbines
Faculty of Engineering		Date: 17-6-2021
Department of Mech. Power Eng.		Time: From 10:20 to 13
Fourth year, Second semester		Total marks: 90

Answer the following questions with assuming any missing data
Steam chart and tables are allowed with student

Question:1

20 marks

- a) Explain the importance of measuring static pressure distribution for turbine blades. (5 marks)
- b) Air enters the test section of a turbine blade cascade tunnel at 120 m/s ($\rho = 1.25 \text{ kg/m}^3$). The inlet and exit angles of blade are 35° and 63° respectively with incidence and deviation angles of 5° and 3° , respectively. The pitch of the cascade is 4 cm and pitch-chord ratio of the cascade is 0.9. The average loss in the stagnation pressure across the cascade is equivalent to 2 cm H_2O . Determine for this cascade:
- The pressure loss coefficient. $\gamma = \frac{\Delta p}{\frac{1}{2} \rho C_m^2}$
 - The drag coefficient. C_D
 - The lift coefficient. C_L
 - Tangential and axial force coefficients $C_{t \text{ per } \text{cm}}$ $C_{a \text{ per } \text{cm}}$

Question:2

25 marks

- a) State and explain the different types of aerodynamic losses through turbine cascade. (10 marks)
- b) A steam turbine stage has an initial pressure of 350 kPa and a temperature of 565°C with negligible initial velocity. At the mean radius, 0.36 m, conditions are as follows:
- | | |
|-----------------------------|------------|
| Nozzle exit flow angle | 22° |
| Nozzle exit static pressure | 207 kPa |
| Stage reaction | 0.2 |
- Determine the work done at the mean radius and the reaction at the hub, radius 0.32 m, at the design speed of 8000 rpm. Also, find the absolute exit velocity at tip radius, given that the stage is to have a free vortex swirl at this speed. You may assume that losses are absent. (15 marks)

Question:3

45 marks

- a) Derive the radial equilibrium equation for a compressible flow with axisymmetric swirl through a turbine stage. (10 marks)
- b) Design of an intermediate stage of a reaction turbine with 0.6 degree of reaction using the initial data:
- | | |
|--|---------|
| Steam flow rate | 50 kg/s |
| Steam pressure before the stage | 10 bar |
| Steam temperature before the stage | 250 C |
| Steam velocity at the entry of the stage | 50 m/s |
| Steam pressure behind the stage | 8 bar |
- Taking into consideration the following data:

$K_1 = 2$ $M = 0.94$ $\delta_{eq} = 0.6 \text{ mm}$
 $\delta_g = 0.5 \text{ mm}$
 $\Delta = 3.5 \text{ mm}$
 $K_m = 0.97$
 $K_b = 0.83$

Exit angle from fixed blade 20° , Discharge coefficients 0.94, Equivalent clearance in banding gland 0.6 mm, Clearance in diaphragm gland 0.5 mm, Overlap distance 3.5 mm, Fixed blade velocity coefficient 0.97, Moving blade velocity coefficient 0.88, Friction coefficient $0.622 \cdot 10^{-3}$, Number of slits 4.

15 marks (35 marks)

Q 1a	Q 1b	Q 3a	Q 2a		
a4-2	a4-1	a4-3	a4-4		
Knowledge & Understanding Skills				Professional Skills	

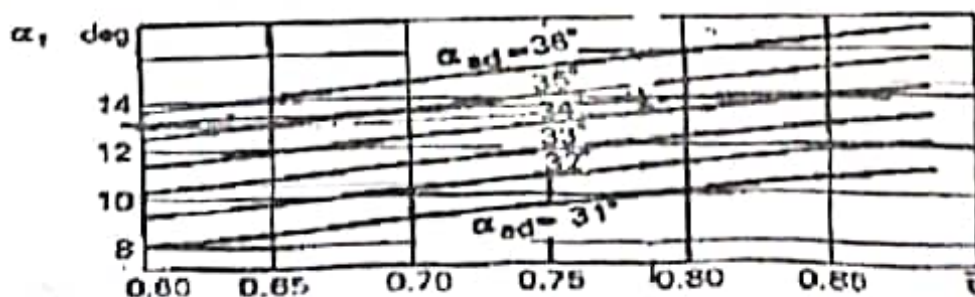
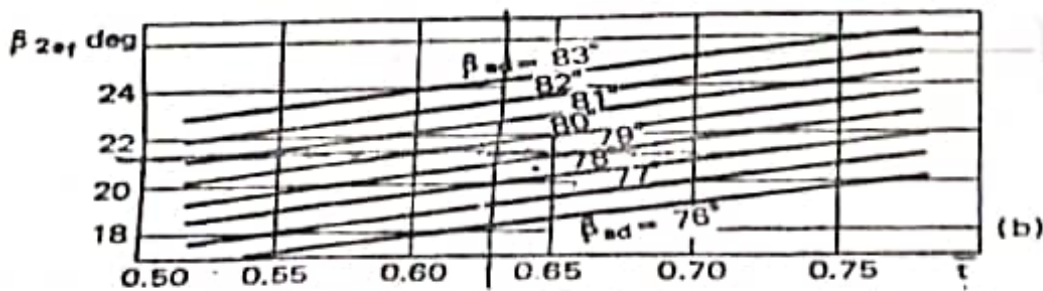
With Our Best Wishes

$$\xi_g = \frac{k_g \mu_g (\pi d_g \delta_g)}{\mu_g A_1 \sqrt{z}} \eta_b$$

$$\xi_b = \frac{(\pi d_g \delta_g)}{A_1} \sqrt{\rho + 1.8 \frac{l}{d}} \eta_b$$

$$\xi_w = \frac{k_w}{\sin \alpha_1} \frac{1 - \varepsilon}{\varepsilon} \left(\frac{u}{c_{10h}} \right)^m$$

$$\xi_{me} = 0.25 \frac{B_1 l u}{A_1 c_{10h}} \eta_b$$





Allowed Tables and Charts (None)

Answer the Following Question:

Question One:

(12 marks)

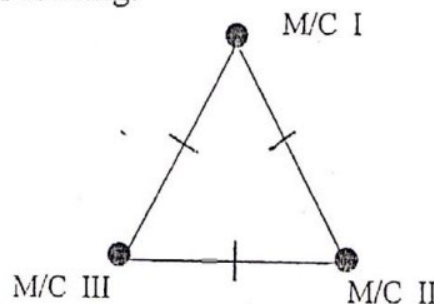
- a. With the aid of neat sketches show the following:
1. A Production system in inputs / outputs model
 2. The material flow patterns used in making a plant layout.
- b. What factors influence the selection of production equipment.
- c. A sporting goods company can purchase certain items at 15 L.E each or produce them (incur here, fixed cost = 45000 L.E and variable cost = 10 L.E per unit).

The management estimates a 70% chance that will be 4000 units and 30% chance that it will be 6000 units. What is the economic advantage of buying the items rather than making them. Show your answer with drawing.

Question Two:

(13 marks)

- a. Discuss with the aid of neat sketch, how the fixed cost affect the make or buy decision.
- b. A work-station consists of three automatic machines are placed at the heads of the equilateral triangle as shown in the figure below. And, to increase the production capacity of this work- station, you need to add a fourth machine, show the appropriate place for this machine with drawing.



c. Define the plant layout and show with neat sketches the different types of plant layout.

d. One of the banks rent one floor in one of the new buildings in shebin El-Kom city, and the manager wants to customize

(Assigned) 5 offices for 5 section heads by the way that achieve the best performance. So, the manger ask each section head about his preference for the available 5 offices and the desires was arranged and introduced to the bank manager according to the next table:-

Office	Section Heads				
	M1	M2	M3	M4	M5
A	1	1	2	3	2
B	5	3	1	2	3
C	4	2	5	1	1
D	3	5	4	4	4
E	2	4	3	5	5

Assign the 5 offices for the 5 section heads if you know that the arrangement No. (1) means the best office from the point of view of section heads.



السؤال الثالث:

(16 درجة)

- الجدول الآتي يبين بعض البيانات الخاصة بأحدى المشروعات والمطلوب هو:
- 1- رسم شبكة الاعمال
 - 2- احسب البدء الاكثر تكييرا و الانتهاء الاكثر تاخيرا
 - 3- حساب طول المسار الحرج
 - 4- حساب الانحراف المعياري للمسار الحرج
 - 5- حساب احتمال تنفيذ المشروع (42-66 - 36 - 26) يوم وايهم افضل

النشاط	الوقائع المرتبطة بالنشاط	الوقت المتشائم	الاكثر احتمالا	المتفائل
أ	-	15	6	3
ب	-	14	5	2
ج	أ	30	12	6
د	أ	8	5	2
هـ	أ	17	11	5
و	د, ج, هـ	15	6	3
س	د, ج, هـ	27	9	3
ص	و, س	7	4	1
ز	ب	28	19	4
ع	ب	19	11	6
ط	ص, ز	21	14	8
م	ص, ز	30	19	8
ق	ع, م	15	11	5
ك	م, ق	17	12	8
ل	و, س, ص	30	21	12

السؤال الرابع:

(15 درجة)

مؤسسة صناعية لها 3 مصانع و 4 مراكز توزيع فإذا كانت طاقات الانتاج للمصانع واحتياجات مراكز التوزيع وأيضا تكلفة نقل الوحدة من أى مصنع الى أى مركز توزيع بالجنيه كما بالجدول، فأوجد التوزيع الذى يحقق اقل تكلفة مقارنة بالحل المبدئى واختبر مثالية الحل على اقل تكلفة توزيع

المتاح	X	Y	Z	M
100	1	4	2	1
170	3	5	6	2
150	7	3	2	5
المطلوب	100	125	150	120

-Z	P	-Z	P	Z	P	Z	P
-0.1	0.4602	-1.6	0.0548	0.0	0.5000	1.6	0.9452
-0.2	0.4207	-1.7	0.0446	0.1	0.5398	1.7	0.9554
-0.3	0.3821	-1.8	0.0356	0.2	0.5793	1.8	0.9641
-0.4	0.3446	-1.9	0.0287	0.3	0.6179	1.9	0.9713
-0.5	0.3085	-2.0	0.0228	0.4	0.6654	2.0	0.9773
-0.6	0.2743	-2.1	0.0179	0.5	0.69157	2.1	0.9821
-0.7	0.2420	-2.2	0.0134	0.6	0.7580	2.2	0.9861
-0.8	0.2119	-2.3	0.0107	0.7	0.7991	2.3	0.9893
-0.9	0.1841	-2.4	0.0082	0.8	0.8159	2.4	0.9918
-1.0	0.1587	-2.5	0.0062	0.9	0.8413	2.5	0.9938
-1.1	0.1357	-2.6	0.0047	1.0	0.8643	2.6	0.9953
-1.2	0.1151	-2.7	0.0035	1.1	0.8849	2.7	0.9965
-1.3	0.0968	-2.8	0.0026	1.2	0.9032	2.8	0.994
-1.4	0.0808	-2.9	0.0019	1.3	0.9192	2.9	0.9981
-1.5	0.0688	-3.0	0.0013	1.4	0.9332	3.0	0.9987

QUESTION Number	This exam measures the following ILOs									
	Q1& Q4			Q2			Q3&Q4			Q3&Q4
	A4-1	A5-1		B7-1			C3-1	C7-1		D1-1
Skills	Knowledge & Understanding Skills			Intellectual Skills			Professional Skills			General Skills



Answer the Following Questions:

Question No [1]:

(10 Marks)

- a – Differentiate between production and productivity.
b- What are the different technology based productivity improvement techniques.
c- A company for manufacturing certain product has the following data through two Weeks:

Week No.	Number of produced unit	Number of workers	Raw materials, Kg
1	300	6	45
2	338	7	46

Assume

- The working hours per week = 40 hrs.
- The labor wage per hour. = 12 L. E
- Material cost per kg. = 6 L.E
- Selling price per unit = 140 L.E
- The overhead cost = 150% of the weekly labor wage.

Required:

- i- Calculate the multiple productivity index for the two weeks.
- ii- Determine the rate of change in the productivity between the two weeks.

Question No [2]:

(15Marks)

- a – Mechanical equipment can be arranged in a number of ways. What are the most common configuration used. Show your answer with drawing.
- b- With the aid of neat sketch show a different types of material flow patterns used in marking a plant layout.
- c- What are the major elements of Manufacturing.
- d- Find the sequence that minimizes the total elapsed time in hours required to complete the following Jobs or two machines M and N in the order NM. Also compute that minimum time, and idle times on machines.

Job	Time required , hrs	
	Machine M	Machine N
A	6	3
B	2	7
C	10	8
D	4	9
E	11	5

Question 3 :-

(15 marks)

Assume a project completion time of thirty - one days , from the data below , perform the following :-

- 1- Draw the PERT network .
- 2- Compute ES , EF , LS and LF .
- 3- Determine the critical path as well as the total slack and free slack per each activity .
- 4- What is the probability the project will be completed within thirty days .
- 5- What is the probability the project will require more than thirty - three days .

Activity	Immediate predecessor	Estimated times (days)		
		a	m	b
A	-	1	2	3
B	A	4	6	8
C	A	7	8	15
D	B	2	5	8
E	C , B	3	6	9
F	E	3	4	11
G	D	9	9	15
H	F , G	4	7	16

Question 4 :

(10 marks)

By using data below , determine the following :

1- The optimum transport schedule .

2- The total transport cost

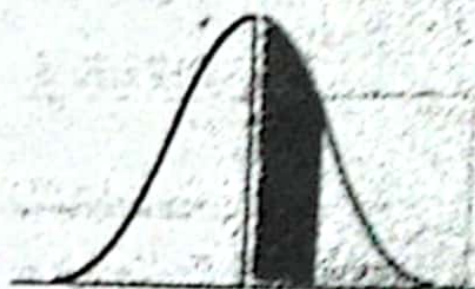
(Applying Vogel's Approximation Method comparing with the Index method)

<div>From \ To</div>	Destination A	Destination B	Destination C	Supply
Source 1	8	9	4	72
Source 2	5	6	8	38
Source 3	7	9	6	46
Source 4	5	3	7	19
Demand	110	34	31	175

3- Check using the Stepping-stone method for optimality?

TABLE 1

Area of a standard normal distribution*



z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2234
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2703	0.2734	0.2764	0.2794	0.2823	0.2855
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3828
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4915
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990

*An entry in the table is the proportion under the entire curve which is between $z=0$ and a positive value of z . Areas for negative values of z are obtained by symmetry.