Mansoura University Faculty of Engineering Dept. of Power Mech. Eng. Course Title: Automatic Control. Course Code:		4^{th} Mechanical Eng. May 2013 Exam Type: Final Time: 3 Hours Full Mark: 90

Attempt all questions

Question 1 **[18 Marks]**

A)In the figure is shown a tank in which flow is supplied at rate of Q. Construct the fluid circuit representation for this system. Determine the equation of the pressure P (head H=P/ρ) as a function of P1 and Q. **(8 Marks)**

B) The oven shown in Figure is supplied with heat from an electric source. The rate of heat supplied Q is proportion to the voltage Qs = K1E. The rate at which the heat lost Q is proportional to the difference in the oven temperature T and the ambient temperature Ta, thus Q = k2(T-Ta). The rate of change of temperature of the oven is Dt = k3(Qs-Q). Construct the block diagram representation for this oven. Determine the differential equation which relates the temperature T to the voltage Es and the ambient temperature Ta. What is the time constant τ.

(10 Marks)

Question 2 **[20 Marks]**

A)For subsonic flow of air through a restriction, the mass rte of flow is $M=1.05A[(P1-P2)P2/T]^{0.5}$. The area A of the restriction and temperature T are constant. Determine the linear approximation for m due to a change p1-p2 in the pressure drop across the restriction and due to a change p2 in the downstream pressure. Express this variation m in terms of the reference value Mi.

B)For the mechanical system shown in figure

i-Draw the grounded chi diagram

ii) determine the equation relating f with x and f with y .

Question 3 **[20 Marks]**

A system for controlling flow is shown in figure. Increasing the desired flow setting increases the compression of spring K1, which causes x and the position e of the balanced valve to move up. This in turns causes the flow valve to move down, which increases the flow. The amount of flow out is measured by a venture-type flow meter, so that the pressure drop P1-P2 is a function of Go. The diaphragm prevents leakage from the high pressure P1 to the low pressuireP2, but it permits motion, just as a piston would. The effective area of the diaphragm is Ad. The flow Qo is seen to be a function of the flow valve opening Y and the supply pressure Ps. Determine the overall block diagram representation for this system.

Question 4 **[16 Marks]**

A)The steady state operating curves for a unity feed back system ($K_H=1$) are shown in figure. Construct the block diagram that described the steady state operation of this system. **(9 Marks)**

B)The block diagram for an industrial temperature control is shown in figure. At the reference operating point, Vi=Ci=100, Mi=40, and Ui=20.The Ui = 20 load line is shown in the figure. Insert values on the C axis of the figure where the question marks appear such that it has the correct slope. Draw the U=30 load line . Determine the value of K1 such that when V=Vi the change of controlled variable c will be 1 unit when U changes from 20 to 30. Determine A such that the coefficient of v term in the equation for steady state operation is unity. **(7 marks)**

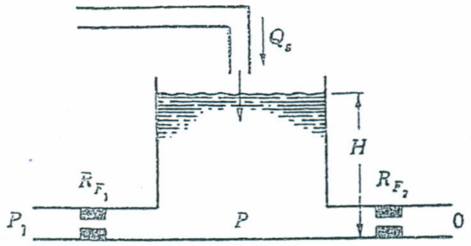
Question 5 **[16 Marks]**

Determine the solution of the following differential equation where $f(t) = 2e^{-t}$ and all initial conditions are zero $(D^3+4D^2+5D+2)y(t) = f(t)$

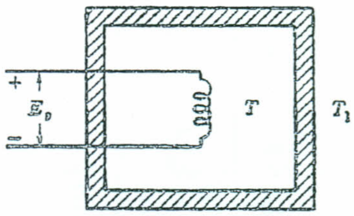
Laplace transform pairs	
$f(t)$	$F(s)$
$\delta(t)$	1
u(t)	$\frac{1}{s}$
t	$\frac{1}{s^2}$
e^{at}	$\frac{1}{s-a}$
t^n	$\frac{n!}{s^{n+1}}$
$t^n e^{at}$	$\frac{n!}{(s-a)^{n+1}}$
$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t$	$\frac{s}{s^2+\omega^2}$
$e^{at}\sin \omega t$	$\frac{\omega}{(s-a)^2+\omega^2}$
$e^{at}\cos \omega t$	$\frac{s-a}{(s-a)^2+\omega^2}$

Laplace transform properties	
Time function	Laplace transform
$kf(t)$	$kF(s)$
$f_1(t) \pm f_2(t)$	$F_1(s) \pm F_2(s)$
$f'(t)$	$sF(s) - f(0)$
$f''(t)$	$s^2F(s) - sf(0) - f'(0)$
$f^n(t)$	$s^nF(s) - s^{n-1}f(0) - \cdots - f^{n-1}(0)$
$f^{(-1)}(t)$	$\frac{F(s)}{s} + \frac{f^{(-1)}(0)}{s}$
$f^{(-n)}(t)$	$\frac{F(s)}{s^n} + \frac{f^{(-1)}(0)}{s^n} + \cdots + \frac{f^{(-n)}(0)}{s}$
$f(at)$	$\frac{1}{a} F\left(\frac{s}{a}\right)$
$e^{at}f(t)$	$F(s-a)$
$t^n f(t)$	$(-1)^n \frac{d^n}{ds^n} F(s)$
$f(\tau) = f(t-t_0)$	$e^{-t_0 s}F(s)$
$\int_0^t f(\lambda)\, g(t-\lambda)\, d\lambda$	$F(s)G(s)$

Problem (1)



(A)



FIGURE

(B)

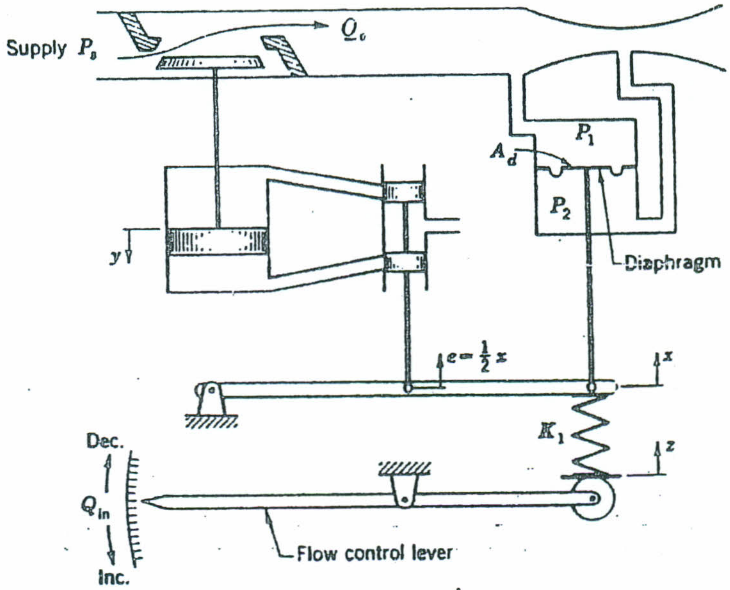
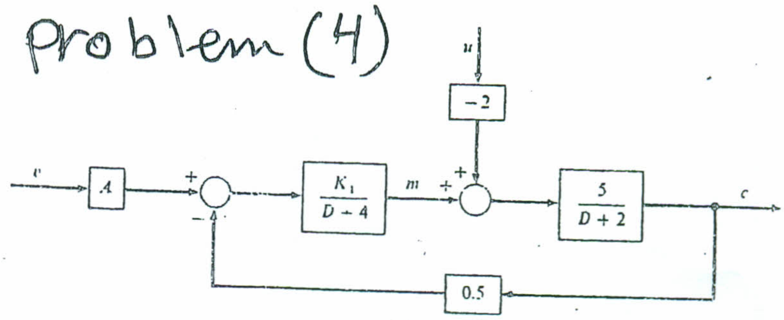


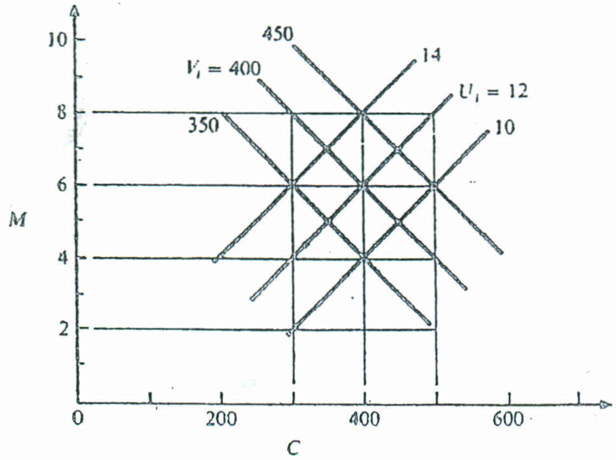
FIGURE P3.53

Problem (3)

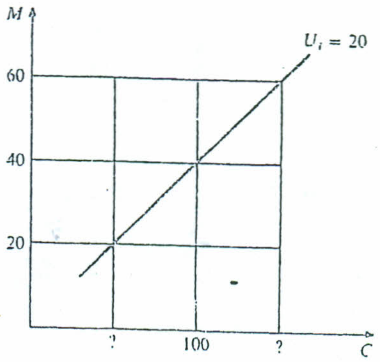
Problem (4)



(a)



(A)



(b)

(B)