University of Technology
Department of Laser & Opto-electronic Engineering
Final Examination 2011-2012

Subject: Discharge & Control | **Class: 3rd year**
Division: Laser Eng. | **Time: 3 hours**
Examiner: Dr. Hisham M. Ahmed
Assist. Lec. Wail Y. Nassir
Date: 3 / 6 /2012

Answer five questions only

Q1: Determine the transfer function for the network shown in fig. 1. **(12 Marks)**

Q2: For the system shown in fig. 2, determine if it represents a stable or an unstable system? **(12 Marks)**

Q3: a- Define: 1. *open-loop* 2. *plant* 3. *feedback elements.* **(6 Marks)**

b- Define only three of the following: **(6 Marks)**

1. Inelastic collision.
2. Penning effect.
3. Attachment.
4. Diffusion.

Q4: Estimate the breakdown voltages of hydrogen at pd=0.7, 1, 3, and 10 pa-m then draw the curve of V_B vs. pd given that $A=3.8\ (\text{pa-m})^{-1}$, B=104V/pa-m and $\gamma_{se}=0.1$. **(12 Marks)**

Q5: Find the mean Kinetic energy and r.m.s velocity of a helium atom at 20°C given that the mass of helium atom is 1.67×10^{-27} Kg and $k=1.38 \times 10^{-23}$ J/K. **(12 Marks)**

Q6: By using equations explain the principle of ambipolar diffusion in gas discharge. **(12 Marks)**

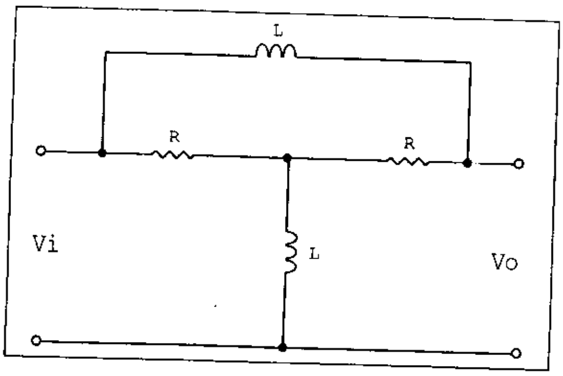


Fig.1

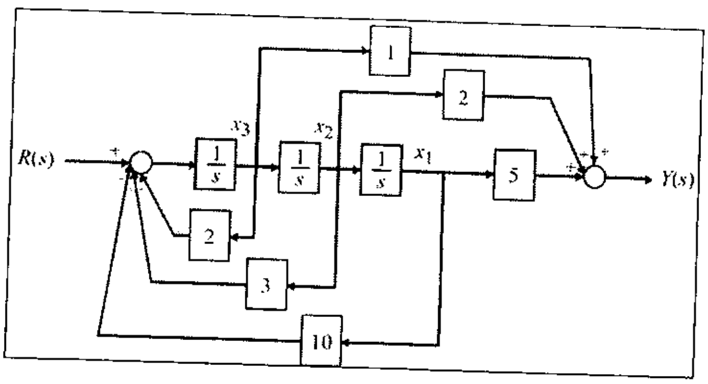
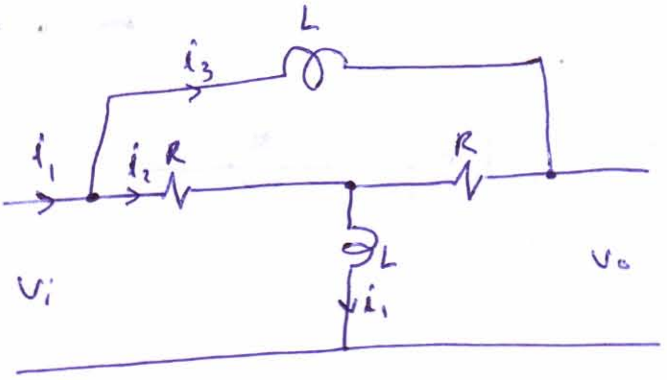


Fig. 2

Good luck

Q1 form 1



$$V_i = R I_2 + sL I_1$$

$$V_o = R I_3 + sL I_1$$

$$I_1 = I_2 + I_3$$

$$R I_2 = (R + sL) I_3 \Rightarrow I_2 = \frac{R+sL}{R} I_3$$

$$I_1 = \frac{2R+sL}{R} I_3$$

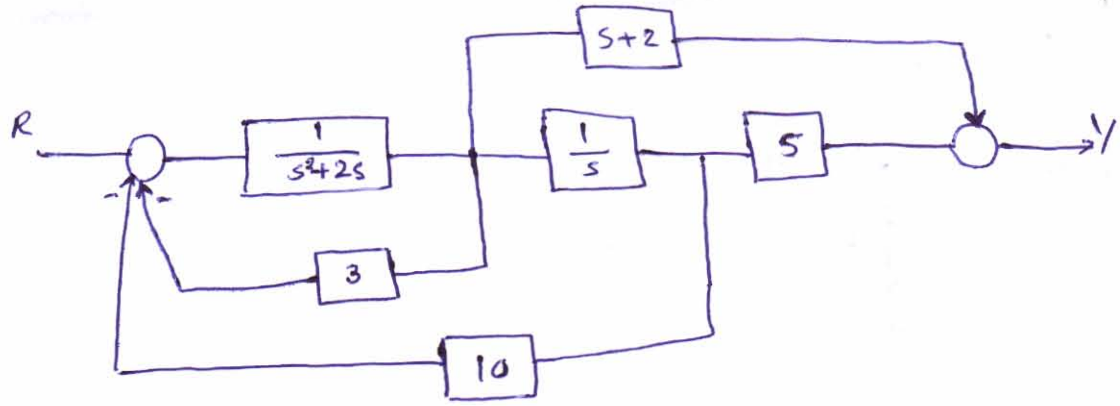
$$V_i = (R+sL) I_3 + \frac{sL(2R+sL)}{R} \cdot I_3$$

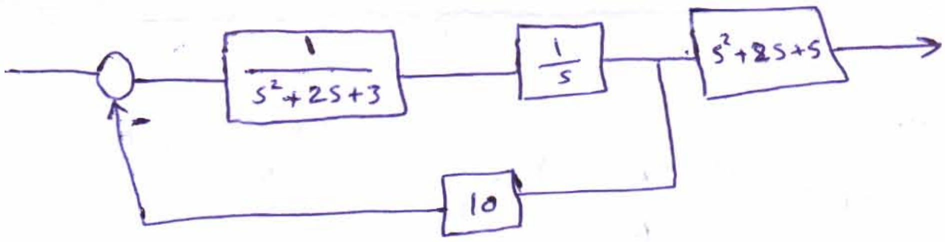
$$V_i = (R^2 + 3RsL + s^2L^2) I_3/R$$

$$V_o = (R^2 + 2R.sL + s^2L^2) I_3/R$$

$$\frac{V_o}{V_i} = \frac{L^2s^2 + 2RLs + R^2}{L^2s^2 + 3RLs + R^2}$$

Q2/





$$\frac{Y}{R} = \frac{s^2+2s+5}{s^3+2s^2+3s+10}$$

s^3	1	3
s^2	2	10
s	-2	0
s^0	10	

The system is unstable

Q3: a-

open-loop control system is one in which the control action is independent of the output.

plant is the system, subsystem, process, or object controlled by the feedback control system.

feedback elements establish the functional relationship between the controlled output c and the primary feedback signal b.

Q3) B-

Inelastic collision: An inelastic collision involves the interchange of the internal energy of excitation or ionization (or, in a molecular gas, dissociation), and the kinetic energy of translation.

Penning effect: The process by which the excited atom can be ionized by virtue of its excitation energy, if the latter is larger than the required ionization energy. This process can be an important agent for discharges in mixtures containing the rare gas, the atoms of which have metastable states of high energy.

Attachment: The process by which an electron, colliding with a neutral ~~atom~~ particle, forms a negative ion. The most familiar example is oxygen.

diffusion: The process by which the condition of equilibrium is reached.

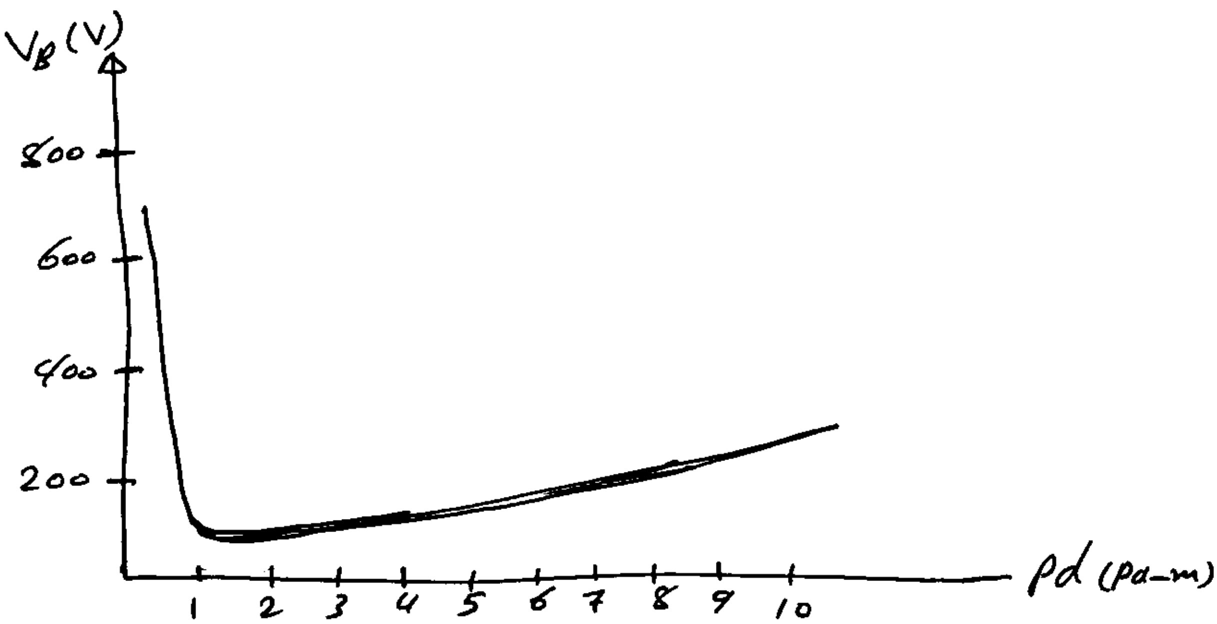
Q4) $$V_B = \frac{BPd}{\ln(APd) - \ln[\ln(1+1/\gamma_{se})]}$$

$$V_B = \frac{104 \times 0.7}{\ln(3.8 \times 0.7) - \ln[\ln(1+1/0.1)]} = 702\ V$$

$$V_B = \frac{104 \times 1}{\ln(3.8 \times 1) - \ln[\ln(1+1/0.1)]} = 226\ V$$

$$V_B = \frac{104 \times 3}{\ln(3.8 \times 3) - \ln[\ln(1+1/0.1)]} = 200\ V$$

$$V_B = \frac{104 \times 10}{\ln(3.8 \times 10) - \ln[\ln(1+1/0.1)]} = 376\ V.$$



Q5) Mean kinetic energy $= \frac{1}{2}mV^2 = \frac{3}{2}KT$

$$= \frac{3}{2} \times 1.38 \times 10^{-23}(273+20)$$

$$= 6.07 \times 10^{-21}\ J$$

$$\therefore \frac{1}{2} \times 1.67 \times 10^{-27} \times V^2 = 6.07 \times 10^{-21}$$

$$V = 1350\ m/S$$

Q6)

For the same net flow of electrons and ions, due to normal diffusion and another due to drift in the electric field; i.e

$$-D_e \frac{dn_e}{dx} - n_e \mu_e E = \Gamma_e = \Gamma_i = -D_i \frac{dn_i}{dx} + n_i \mu_i E \quad (1)$$

for $n_e = n_i = n$

and $\frac{dn_e}{dx} = \frac{dn_i}{dx} = \frac{dn}{dx}$

The flow rate $\Gamma = \Gamma_e = \Gamma_i$

The ambipolar diffusion coefficient D_a such that;

$$\Gamma = -D_a \frac{dn}{dx}$$

Hence $\quad -D_a \frac{dn}{dx} = -D_e \frac{dn}{dx} - n\mu_e = -D_i \frac{dn}{dx} + n\mu_i E \quad (2)$

By eliminating E, then:

$$D_a = \frac{D_e \mu_i + D_i \mu_e}{\mu_i + \mu_e} \quad (3)$$

Since $\mu_e \gg \mu_i$

$$D_a = \frac{D_e \mu_i + D_i \mu_e}{\mu_e}$$

If all particles are at the same temperature, then:

$D_e \mu_i = D_i \mu_e$, from this we get:

$$D_a = \frac{2 D_i \mu_e}{\mu_e} = 2D_i \quad (4)$$

If electron have temperature $T_e \gg T_i$

Then $D_e/\mu_e \gg D_i/\mu_i$ or $D_e \mu_i \gg D_i \mu_e$

so that $\quad D_a = D_e \frac{\mu_i}{\mu_e} = \frac{kT_e}{e} \cdot \mu_i \quad (5)$

The field can be derived from eq.(2)

$$E = \frac{1}{n} \frac{dn}{dx} \left(\frac{D_e - D_i}{\mu_e + \mu_i} \right) \quad (6)$$