



Faculty of Energy Systems and Nuclear Science

Reactor Control (ENGR4730U/G)

Midterm Exam

Monday 14-Feb-2011 [9:15 - 10:45 am]

Location: UA1240

Instructor: Dr. H.A.Gabbar

Instructions

Please answer all questions. If you have any doubt, please state in your answer the assumptions used in the answer. It is allowed to use calculator and formula sheet of two pages (4 sides), which must be returned along with the exam sheet at the end of the exam. Please ensure that your name and student ID are written in all pages. Extra pages are available at the end of this exam booklet.

Question	Mark	Total Mark
1		15
2		15
3		20
4		20
5		30

Time Completed: -----

Good Luck!

1. [15] Draw a block diagram of a simple control system which automatically turns on a room lamp at dusk, and turns it off in daylight. A simple system that accomplishes this task is shown in the figure below. The light intensity in the room must be maintained at a level greater than or equal to a pre-specified level.

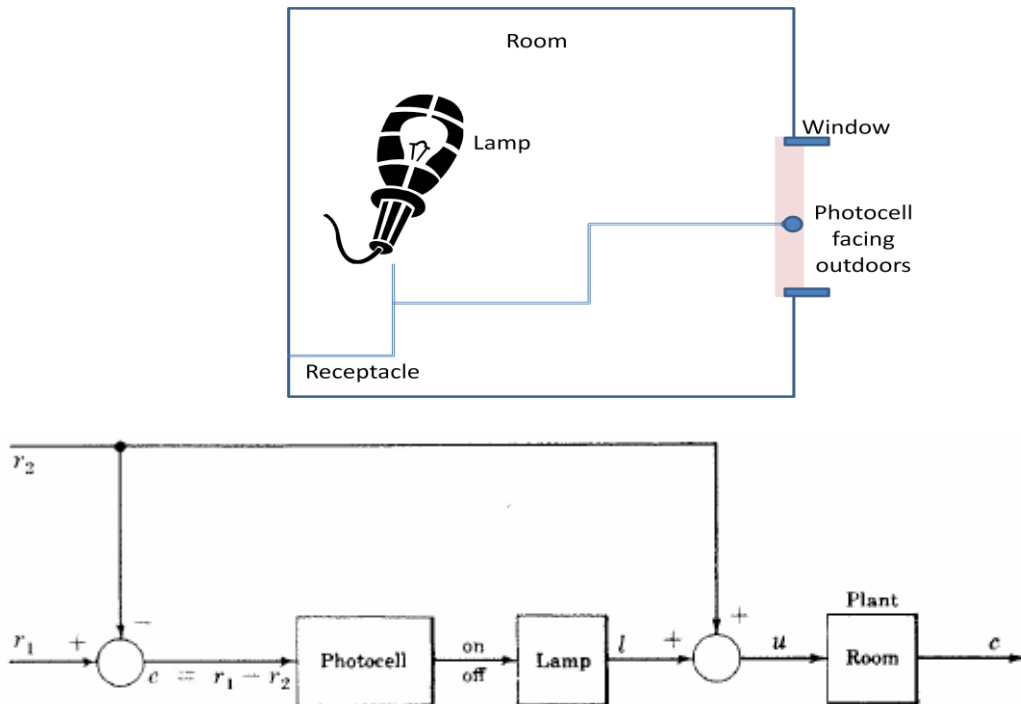
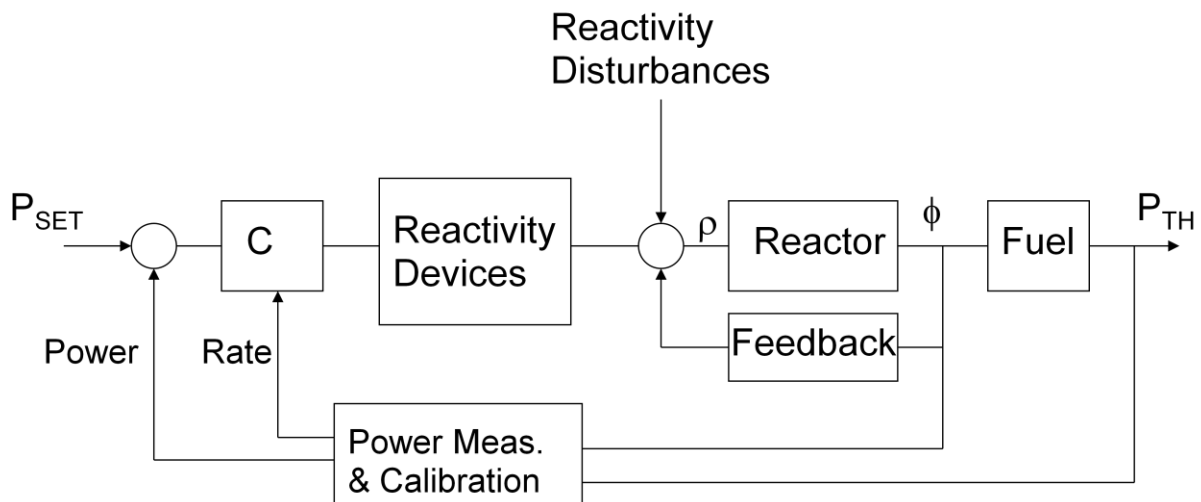
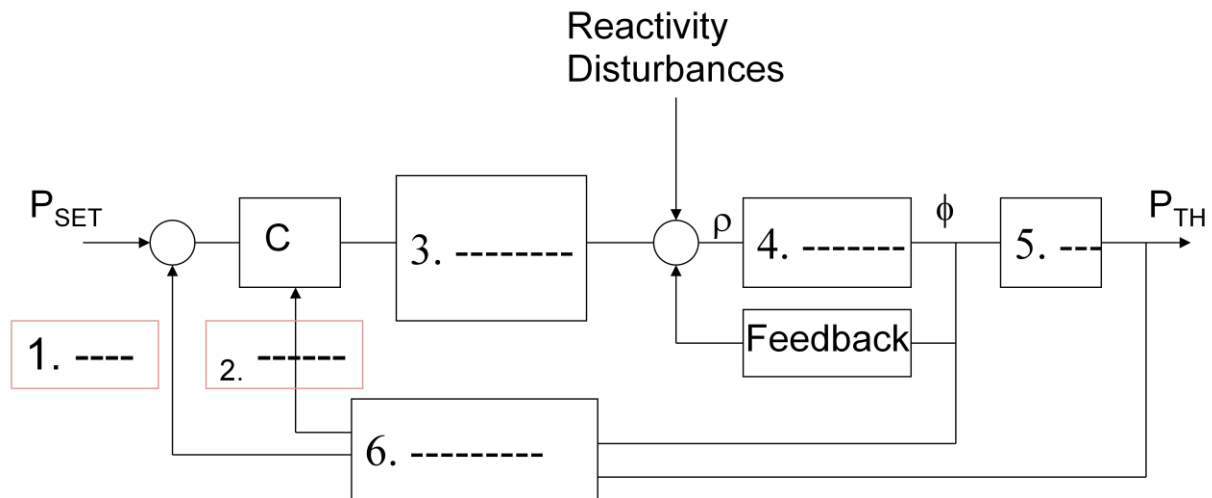


Fig. 2-42

2. [15] In RRS control loop, complete the empty boxes in the following control block diagram. Select from: [Power], [Rate], [Power Measurement & Calibration Devices], [Reactivity Devices], [Reactor], and [Fuel]:



3. [20] What is the transfer function (Y/U) of the following system, whose inputs (Y) and outputs (U) are related by the differential equation (consider all initial conditions are 0):

$$\frac{d^2y}{dt^2} + 6\frac{dy}{dt} + 5y = u + 3\frac{du}{dt}$$

Solution

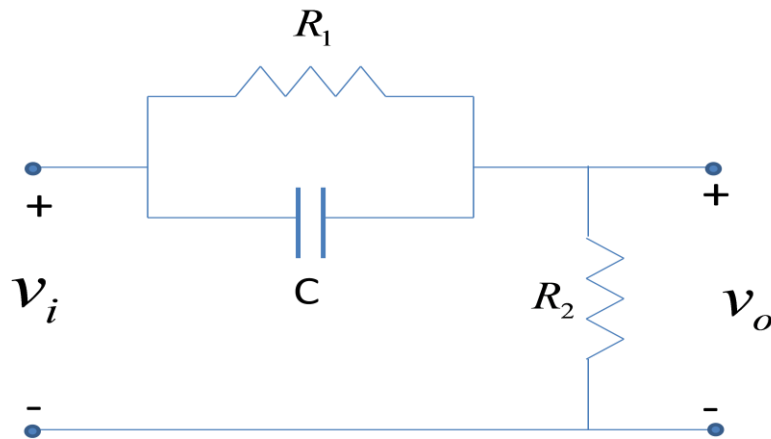
Take Laplace transform of this equation, ignoring terms due initial conditions, we obtain

$$s^2Y(s) + 6sY(s) + 5Y(s) = U(s) + 3sU(s)$$

$$Y(s) = ((3s+1)/(s^2 + 6s + 5))U(s)$$

$$P(s) = (3s+1)/(s^2 + 6s + 5)$$

4. [20] Find the transfer function of the following R-C circuit.



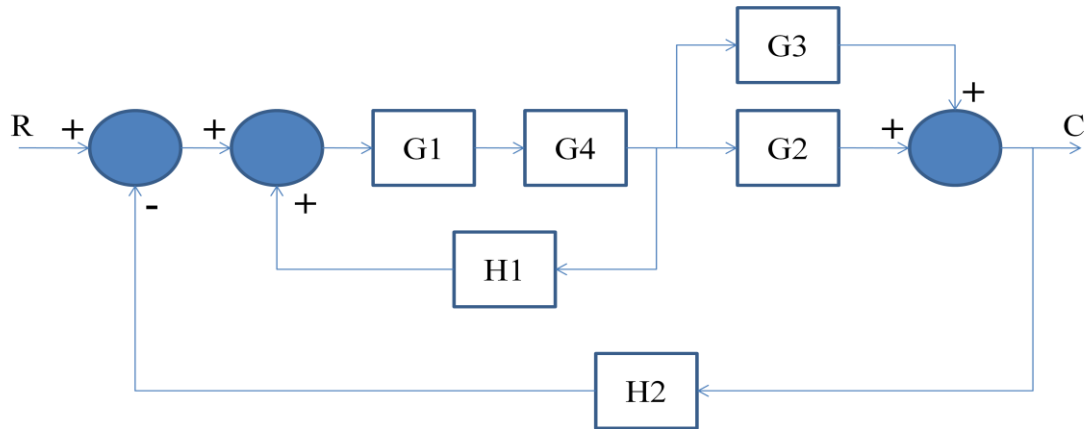
$$C \frac{d}{dt} (v_i - v_o) + \frac{1}{R_1} (v_i - v_o) = \frac{1}{R_2} v_o$$

Laplace

$$Cs [V_i - V_o] + \frac{1}{R_1} [V_i - V_o] = \frac{1}{R_2} V_o$$

$$P_{load} = \frac{V_o}{V_i} = \frac{Cs + 1/R_1}{Cs + 1/R_1 + 1/R_2} = \frac{s+a}{s+b}$$

5. [30] Simplify the transfer function using a. Block diagram simplification; and b. Signal flow graph.



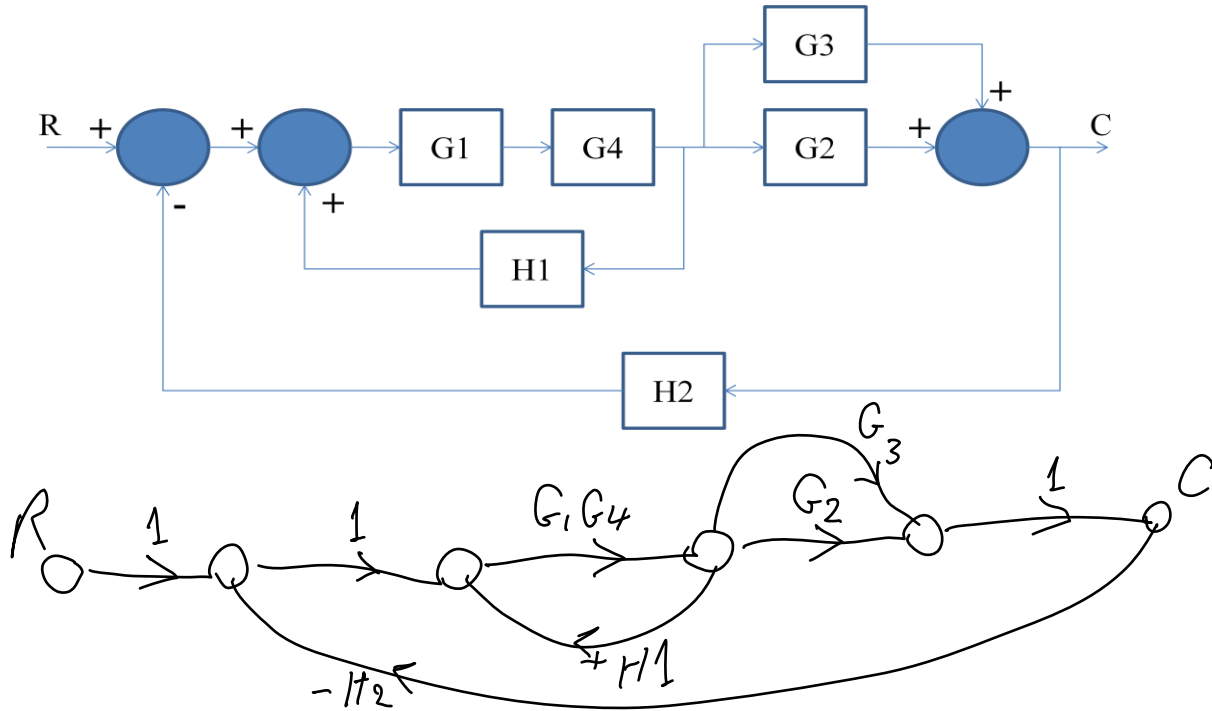
$$\boxed{G_1} - \boxed{G_4} \equiv \boxed{G_1 G_4}$$

$$\begin{array}{c} \boxed{G_3} \\ \downarrow \\ \boxed{G_2} \end{array} \begin{array}{c} \downarrow \\ \downarrow \end{array} \begin{array}{c} + \\ - \end{array} \equiv \boxed{G_2 + G_3}$$

$$\begin{array}{c} \text{Summing junction} \\ \uparrow \downarrow \\ \boxed{G_1 G_4} \\ \uparrow \\ \boxed{H_1} \end{array} \equiv \frac{G_1 G_4}{1 - H_1 G_1 G_4} = G_{x1}$$

$$\begin{array}{c} R \rightarrow \text{Summing junction} \rightarrow \boxed{G_{x1}} \rightarrow \boxed{G_2 + G_3} \rightarrow C \\ \uparrow \downarrow \\ \boxed{H_2} \end{array} = \frac{G_1 G_4 (G_2 + G_3)}{1 - G_1 G_4 H_1} = \frac{G_1 G_4 (G_2 + G_3)}{1 + H_2 G_1 G_4 (G_2 + G_3) - G_1 G_4 H_1}$$

Signal Flow Graph



$$P_1 = G_1 G_4 G_2$$

$$L_1 = G_1 G_4 H_1$$

$$L_2 = -H_2 G_1 G_4 G_2$$

$$P_2 = G_1 G_4 G_3$$

$$L_3 = -H_2 G_1 G_4 G_3$$

$$\Delta = 1 - (L_1 + L_2 + L_3) + (\phi) = 1 - G_1 G_4 H_1 + H_2 G_1 G_4 G_2 + H_2 G_1 G_4 G_3$$

$$\Delta_1 = 1, \quad \Delta_2 = 1$$

$$T = \frac{\Delta_1 P_1 + \Delta_2 P_2}{\Delta} = \frac{G_1 G_4 G_2 + G_1 G_4 G_3}{1 - G_1 G_4 H_1 + H_2 G_1 G_4 (G_2 + G_3)}$$

Midterm Exam
Student ID: -----

Reactor Control ENGR 4730U/G
Student Name: -----

14-Feb-2011

Extra Sheet