Name: Enrolment No:	UPES

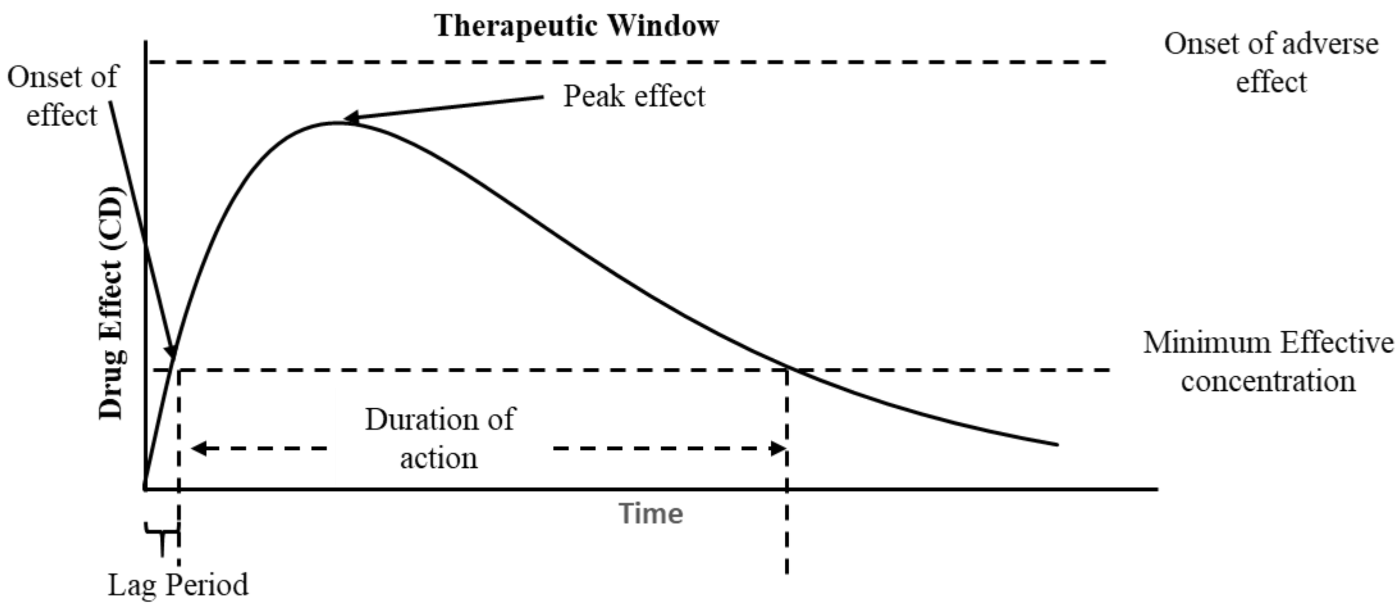
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2020

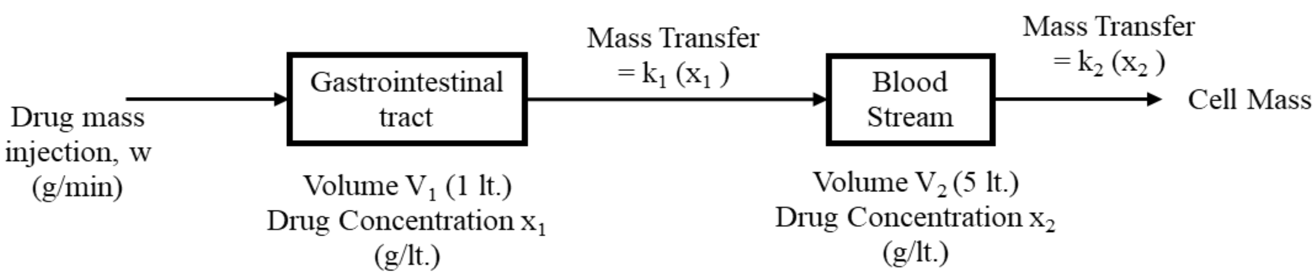
Programme Name: B. Tech. CERP — **Semester : VI**
Course Name : Process Dynamics Instrumentation and Control — **Time : 03 hrs**
Course Code : CHCE 3007 — **Max. Marks : 100**
Nos. of page(s) : 3
Instructions: This is an OPEN BOOK exam. Use MS-Excel/Open office as much as possible

Case Study of Drug delivery for Developing and Analyzing the Process Dynamics

The human body is a complex biochemical process. An analogy can be made with a tradition chemical process. The dynamics of body with the ingestion to drug can be helpful in designing an open loop control (control based on model dynamics). There is a therapeutic window for a drug to be active. The figure below is self-explanatory.



The process of drug ingestion and subsequent metabolism in an individual may be represented by a simplified diagram in the figure given below



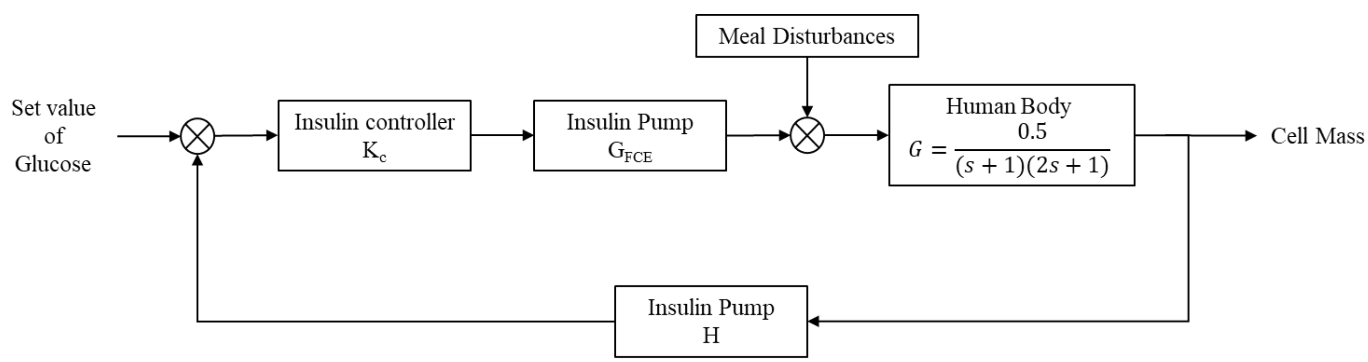
S. No.		Marks	CO
Q 1.1	Develop dynamic model for the gastrointestinal tract and the blood stream and get the overall transfer function for $X_2(s)/W(s)$.	**8**	**CO1**
Q 1.2	Consider k_1 = 10 dL/min; k_2 = 25 dL/min; V_1 = 10 dL.; V_2 = 50 dL. Draw the diagram of dynamic response of drug concertation in blood if 5 mg of drug is taken (impulse input of $A\delta(t)$) = 4 mg). (Suggestion: Use excel for all the calculations and making graph)	**10**	**CO1-CO2**
Q 1.3	Assume that the maximum drug concentration for adverse effect is 1 mg/dL Design the drug dose (example of open loop control) such that peak effect in drug concentration in blood is with 20% of margin at 0.8 mg/dL.	**12**	**CO2**

Case Study of controlled Drug Delivery for analysis and design

"Diabetes is a disease that affects the body's ability to regulate glucose concentration. There are two main types of diabetes: Types 1 and 2 diabetes. In Type 1 diabetes (also called juvenile diabetes or insulin-dependent diabetes), the pancreas produces insufficient insulin, and exogenous insulin is required to be infused at an appropriate rate to maintain blood sugar levels at normal levels. According to the Diabetes Control and Complications Trial (DCCT) (DCCT, 1993), blood glucose should be controlled within the range of 60–120 mg/dL. If insulin is supplied in excess, the blood glucose level can go well below normal (<60 mg/dL), a condition known as hypoglycemia. On the other hand, if insulin is not supplied sufficiently, the blood glucose level is elevated above normal (>120 mg/dL), a condition known as hyperglycemia. Both hypo- and hyperglycemia can be harmful to an individual's health. The effects of hypoglycemia are critical on short-term basis, which can lead to diabetic coma and possibly death, while those of hyperglycemia have long-term impacts that have been linked to nephropathy, retinopathy, and other tissue damage. Hence, it is very important to control the level of blood glucose in the body to within a reasonable range"

Source: Dua, P., & Pistikopoulos, E. N. (2005). Modelling and control of drug delivery systems. Computers & chemical engineering, 29(11-12), 2290-2296.

A block diagram of a simplified control system for drug delivery of Type-1 is given below



Q 2.1	Get the overall transfer function for the servo and regulator problem.	**8**	**CO3**

	Consider: $G_{FCE} = 1$; $H = 1$		
Q 2.2	Assume that the set value of glucose level is 70 mg/dL. The steady state value is also 70 mg/dL. The patient has taken a meal. The meal has 200 mg of sugar (impulse input of $A\delta(t)$) = 200 mg). Now there are two scenarios 1) The meal is taken without any feedback control system 2) The meal is taken with the feedback control shown in figure Draw the diagram for scenario 1. (Use MS Excel for help) Draw the diagrams of scenario 2 with Kc = 5 and 15 (Use MS Excel for help) Make observations and give suggestions how can you avoid the problem at $K_c = 15$ with or without changing the controller.	**12**	**CO3**
Q 2.3	Assume $G_{FCE} = e^{-0.08s}$ (transportation lag = 0.08 min); $H = e^{-0.12s}$ (transportation lag = 0.12 min). Apply 1st order approximation for transportation lag. Write the characteristic equation. Check the stability at Kc = 5. Find what will be the maximum value of K_c for stable response	**15**	**CO4**
Q 2.4	Frequency response without any approximation for transportation lag Find out the corner frequencies. Draw the BODE diagram using MS Excel. Find out crossover frequency, gain margin and phase margin for $K_c = 5$	**10**	**CO5**
Q2.5	Design the P, PI and PID controller for the above problem using Ziegler-Nichols controller settings.	**10**	**CO5**
	Instrumentation		
Q3	Write the answer of any three out of the five questions a) Differentiate between accuracy and precision b) Differentiate between reproducibility and repeatability c) Differentiate between drift and hysteresis d) Differentiate between fidelity and speed of response e) Explain fail to safe and fail to open and tell in which scenario which option should be used	**15**	**CO6**