UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, April/May 2018

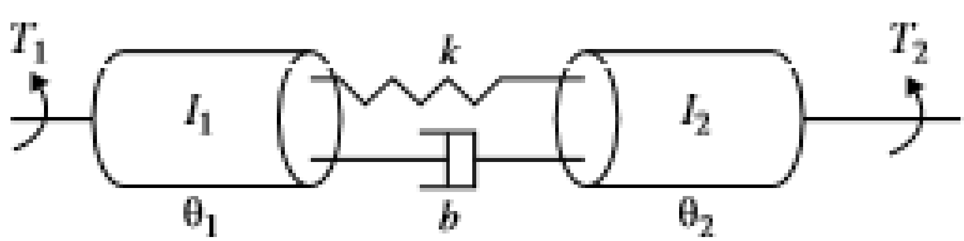
Course: Mathematical Modeling & Simulation of Aerospace Vehicles **Semester: VIII**
Program: B.Tech/ASE+AVE
Time: 03 hrs. **Max. Marks: 100**

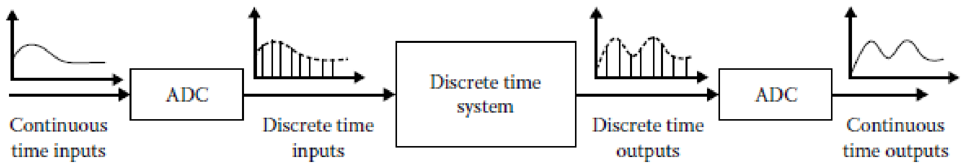
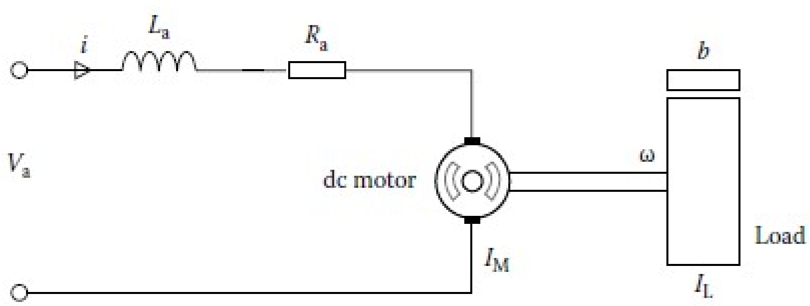
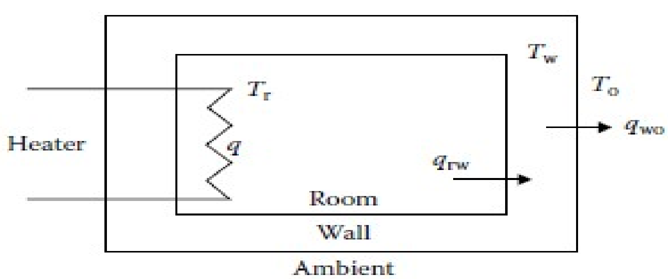
Instructions: Make use of *sketches/plots* to elaborate your answer. Brief and to the point answers are expected.
The Question paper has three sections: Section A, B and C, Section B and C have internal choices.

SECTION A

S. No.		Marks	CO
Q 1	Explain esoteric and manufacturing systems	**04**	**CO 1**
Q 2	Write the body fixed velocity vector for an aircraft and explain with the schematic diagram	**04**	**CO 2**
Q 3	List down the linear state space model for an aircraft under linear perturbation along longitudinal and lateral directions.	**04**	**CO 3**
Q 4	Differentiate between kinetics and kinematics for the system body	**04**	**CO 3**
Q 5	List down the various differences in solving Ordinary differential equation and Partial Differential Equations for the aircraft dynamic system equation.	**04**	**CO 4**

SECTION B

Q 6	The rotational mechanical system is as shown in the Figure 1. Determine the mathematical model to develop the relation between input and output variables.  ***Figure 1***	**10**	**CO 1**
Q 7	Define the term ‘perturbation’. How would you classify the nominal and perturbation values? Write the equation for same. Using this theory, linearize the rigid body kinetics under equilibrium condition. Also, provide the equation of surge using the linearized perturbation theory.	**10**	**CO 2**
Q 8	Discuss the block diagram as shown in Figure 2.	**10**	**CO 3**

	 ***Figure 2***		
Q 9	Define and explain the principle of superposition involved in solving the linear and non-linear partial differential equations for the aircraft dynamics and control. Sketch the schematic diagram for the same. Figure 1	**10**	**CO 4**
	SECTION-C		
Q 10	Figure 3 shows a dc motor circuit with a load connected to the motor shaft. Assume that the shaft is rigid, has negligible mass, and has no torsional spring effect or rotational damping associated with it. Derive an expression for the mathematical model for the system.  ***Figure 3***	**20**	**CO 1**
Q 11	Figure4 shows a room heated with an electric heater. The inside of the room is at temperature Tr and the walls are assumed to be at temperature Tw. If the outside temperature is To, develop a model of the system to show the relationship between the supplied heat q and the room temperature Tr. Write the program to show the thermal variation wrt time.  ***Figure 4***	**20**	**CO 3**

OR

The longitudinal and lateral B-767 state-space models are given below. The state vectors are:

$$\mathbf{x}_{\text{lang}} = \begin{bmatrix} u \text{ (ft/s)} \\ \alpha \text{ (deg)} \\ q \text{ (deg/s)} \\ \theta \text{ (deg)} \end{bmatrix}, \mathbf{x}_{\text{lat}} = \begin{bmatrix} \beta \text{ (deg)} \\ p \text{ (deg/s)} \\ \phi \text{ (deg/s)} \\ r \text{ (deg)} \end{bmatrix}$$

$$\mathbf{u}_{\text{lang}} = \begin{bmatrix} \delta_E \text{ (deg)} \\ \delta_T \text{ (\%)} \end{bmatrix}, \mathbf{u}_{\text{lat}} = \begin{bmatrix} \delta_A \text{ (deg)} \\ \delta_R \text{ (deg)} \end{bmatrix}$$

Equilibrium point:

Speed	$V_T = 890$ ft/s $= 980$ km/h
Altitude	$h = 35\ 000$ ft
Mass	$m = 184\ 000$ lbs
Mach-number	$M = 0.8$

Simulate Longitudinal and Lateral model for the aircraft equations in MATLAB

Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, April/May 2018

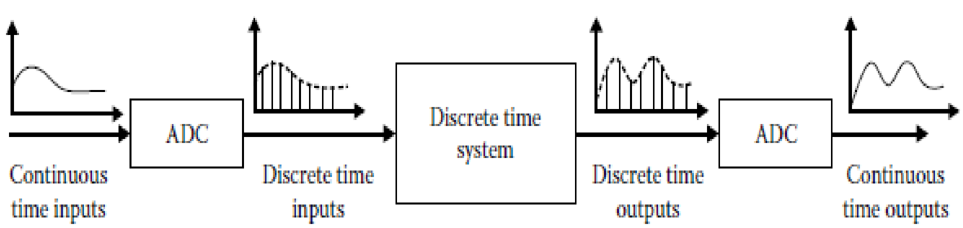
Course: Mathematical Modeling & Simulation of Aerospace Vehicles **Semester: VIII**
Program: B.Tech/ASE+AVE
Time: 03 hrs. **Max. Marks: 100**

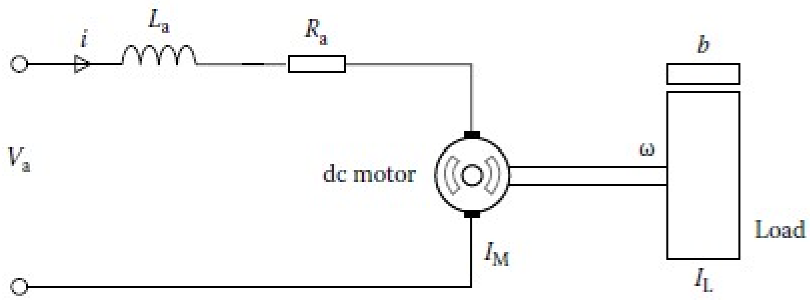
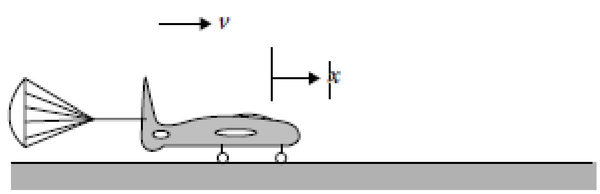
Instructions: Make use of *sketches/plots* to elaborate your answer. Brief and to the point answers are expected.
The Question paper has three sections: Section A, B and C, Section B and C have internal choices.

SECTION A

S. No.		Marks	CO
Q 1	Explain Environmental system and transportation system.	**04**	**CO 1**
Q 2	Explain aircraft state space vectors and body –fixed coordinate systems.	**04**	**CO 2**
Q 3	Define wind and stability axes used for the study and analysis of aircraft modeling	**04**	**CO 3**
Q 4	Describe longitudinal and lateral forces which acts on the aircraft with schematic diagram.	**04**	**CO 3**
Q 5	Differentiate between discrete and time variant systems used for the modeling to simulate the results.	**04**	**CO 4**

SECTION B

Q 6	Define and explain the principle of superposition involved in solving the linear and non-linear partial differential equations for the aircraft dynamics and control. Sketch the schematic diagram for the same.	**10**	**CO 4**
Q 7	Discuss the block diagram as shown in Figure 1.  ***Figure 1***	**10**	**CO 3**
Q 8	Define the term 'perturbation'. How would you classify the nominal and perturbation values? Write the equation for same. Using this theory, linearize the rigid body	**10**	**CO 2**

	kinetics under equilibrium condition. Also, provide the equation of surge using the linearized perturbation theory.		
Q 9	Write the MATLAB code for the system having the ordinary differential equation for the mass, spring and damping factor values for the time span of i) 0-25s, ii) 0-50s and iii) 0-100s.Compare the result over on the pictorial analysis.	**10**	**CO 1**
	SECTION-C		
Q 10	Figure 2 shows a dc motor circuit with a load connected to the motor shaft. Assume that the shaft is rigid, has negligible mass, and has no torsional spring effect or rotational damping associated with it. Derive an expression for the mathematical model for the system.  ***Figure 2***	**20**	**CO 1**
Q 11	An airplane uses a brake parachute and other means of braking as it slows down on the runway after landing as shown in Figure 3. Its acceleration is given by $a = -0.0045\, v^2 - 3$ m/s^2. Consider an airplane with a velocity of 300 km/h that opens its parachute and starts deceleration at $t = 0$ s. Determine: (a) Velocity as function of time from $t = 0$ until airplane stops. (b) Distance that airplane travels as a function of time.  ***Figure 3*** ***OR*** The lateral model of the F-16 .Fighter aircraft. The state vectors are:	**20**	**CO 3**

	$$\mathbf{x}_{\text{lat}} = \begin{bmatrix} \beta \text{ (ft/s)} \\ \phi \text{ (ft/s)} \\ p \text{ (rad/s)} \\ r \text{ (rad)} \\ \delta_A \text{ (rad)} \\ \delta_R \text{ (rad)} \\ r_w \text{ (rad)} \end{bmatrix}, \mathbf{u}_{\text{lat}} = \begin{bmatrix} u_A \text{ (rad)} \\ u_R \text{ (rad)} \end{bmatrix}, \mathbf{y}_{\text{lat}} = \begin{bmatrix} r_w \text{ (deg)} \\ p \text{ (deg/s)} \\ \beta \text{ (deg)} \\ \phi \text{ (deg)} \end{bmatrix}$$ **Equilibrium point:** Speed $V_T = 502 \text{ ft/s} = 552 \text{ km/h}$ Mach-number $M = 0.45$ Calculate the Longitudinal and Lateral values using the equations and simulate in MATLAB.		