Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
A Constituent Institution of Manipal University

FIRST SEMESTER M.TECH. (AEROSPACE ENGINEERING)

END SEMESTER EXAMINATIONS, NOV/DEC 2016

SUBJECT: AEROSPACE SYSYEMS MODELLING [ICE 5101]

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A.	Consider the simple mass-spring –damper system subjected to an input force *f*, as shown in **Fig. Q1A**. Obtain transfer function and state space model for this system.	**5**
1B.	Write the differential equations governing the mechanical rotational system as shown in **Fig. Q1B** and obtain the transfer function model	**3**
1C.	List the drawbacks in the conventional transfer function model.	**2**
2A.	A pilot in an aerobatic aircraft performs a loop in 20s at a steady velocity of 100m/s. His seat is located 5m ahead of, and 1m above the CG. What total normal load factor does he experience at the top and at the bottom of the loop?	**5**
2B.	Consider the situation when an aircraft is flying in a steady level coordinated turn at a speed of 250m/s at a bank angle of $60°$. The force acting on the aircraft are shown in **Fig. Q2B**. Calculate the turn rate $\dot{\psi}$, the yaw rate r and the pitch rate q.	**3**
2C.	Illustrate Euler angles and aircraft attitude with neat diagram	**2**
3A.	Derive generalized force equations for a rigid body.	**5**
3B.	Obtain generalized moment equations for an aircraft.	**5**
4A.	Using Cramer's rule, obtain the elevator response transfer function models $\left(\frac{u(s)}{\eta(s)}, \frac{w(s)}{\eta(s)} \text{ and } \frac{\theta(s)}{\eta(s)}\right)$ from the following equations of longitudinal symmetric motion for aircraft system $m\dot{u} - \mathring{F}_{x_u} u - \mathring{F}_{x_{\dot{w}}} \dot{w} - \mathring{F}_{x_w} w - \left(\mathring{F}_{x_q} - mW_e\right) q + mg\theta\cos\theta_e = \mathring{F}_{x_\eta}\eta + \mathring{F}_{x_\tau}\tau$ $-\mathring{F}_{z_u} u + \left(m - \mathring{F}_{z_{\dot{w}}}\right)\dot{w} - \mathring{F}_{z_w} w - \left(\mathring{F}_{z_q} + mU_e\right) q + mg\theta\sin\theta_e = \mathring{F}_{z_\eta}\eta + \mathring{F}_{z_\tau}\tau$ $-\mathring{M}_u u - \mathring{M}_{\dot{w}}\dot{w} - \mathring{M}_w w + I_y\dot{q} - \mathring{M}_q q = \mathring{M}_\eta\eta + \mathring{M}_\tau\tau$ $\dot{\theta} = q$ Notations are standard and provide specific meaning for aircraft system.	**5**
4B.	Using Taylor series, deduce the aerodynamic force and moment terms in axial force equation and moment equation respectively for aircraft system.	**3**
4C.	Write the expression of aerodynamic control derivatives due to elevator, aileron and rudder deflections.	**2**
5A.	Derive the state space and transfer function models for 3 DOF helicopter system.	**5**

5B. Write Euler's equation of motion for the missile systems. Also, deduce the state space equations for the motion variables **3**

5C. Illustrate control surface (ξ, η, ζ) convention for the missile system using neat diagram. **2**

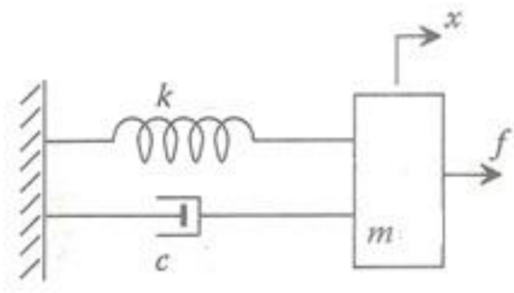

Fig. Q1A

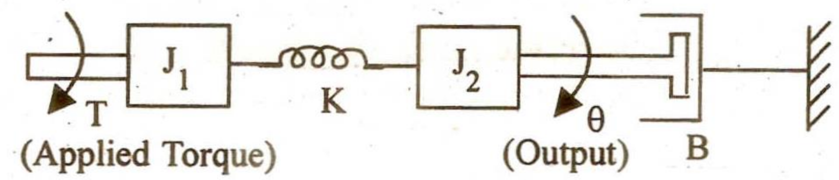

Fig. Q1B

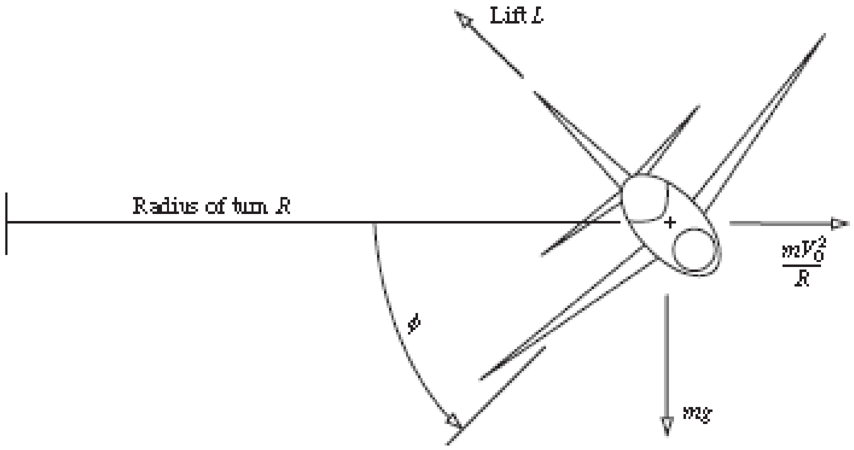

Fig. Q2B

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