Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL

A Constituent Institution of Manipal University

FIRST SEMESTER M.TECH. (AEROSPACE ENGINEERING)

END SEMESTER EXAMINATIONS, DEC - 2017

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.
- Notations are standard and provide specific meaning for aerospace system.

1A. Illustrate linear system with neat block diagram. Obtain the state-space model of the mechanical system as shown in **Fig. Q1A** by choosing the minimum of three state variables. **5**

1B. Consider the satellite attitude system shown in **Fig. Q1B**. The diagram shows the control of only the yaw angle θ. Small jets apply reaction forces to rotate the satellite body into the desired attitude. The two skew symmetrically placed jets denoted by A or B operate in pairs. Assume that each jet thrust is $F/2$ and a torque $T = Fl$ is applied to the system. The jets are applied for a certain time duration and thus the torque can be written as $T(t)$.The moment of inertia about the axis of rotation at the center of mass is J. Obtain the state space model of this satellite attitude system **3**

1C. The state model of a linear time invariant system is given by **2**

$$\dot{X}(t) = AX(t) + BU(t)$$
$$Y(t) = CX(t) + Du(t)$$

Obtain the expression for transfer function of the system.

2A. Establish the most general form of the dimensional decoupled equations of longitudinal symmetric motion referred to aeroplane body axes. **5**

2B. Establish the relationship between the aircraft body rates and the attitude rates using angular quantities transformation **3**

2C. Establish relationship between geopotential and geometric altitudes. **2**

3A. Derive mathematical model of a six DOF non-linear missile. **5**

3B. Derive Bernoulli's equation. **3**

3C. Illustrate control surface (ξ, η, ζ) convention for the missile system using neat diagram. **2**

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 **5**

$$\begin{aligned} m\dot{u} - F^{\circ}{}_{x_u} u - F^{\circ}{}_{x_{\dot{w}}} \dot{w} - F^{\circ}{}_{x_w} w - \left(F^{\circ}{}_{x_q} - mW_e\right) q + mg\theta \cos\theta_e \\ = F^{\circ}{}_{x_\eta} \eta + F^{\circ}{}_{x_\tau} \tau \end{aligned}$$

$$\begin{aligned} -F^{\circ}{}_{z_u} u + \left(m - F^{\circ}{}_{z_{\dot{w}}}\right)\dot{w} - F^{\circ}{}_{z_w} w - \left(F^{\circ}{}_{z_q} + mU_e\right) q + mg\theta \sin\theta_e \\ = F^{\circ}{}_{z_\eta} \eta + F^{\circ}{}_{z_\tau} \tau \end{aligned}$$

$$-M^{\circ}_{u}u - M^{\circ}_{\dot{w}}\dot{w} - M^{\circ}_{w}w + I_{y}\dot{q} - M^{\circ}_{q}q = M^{\circ}_{\eta}\eta + M^{\circ}_{\tau}\tau$$
$$\dot{\theta} = q$$

4B. Derive continuity equation for steady fluid flow. **3**

4C. Illustrate Euler angles and aircraft attitude with neat diagram **2**

5A. Establish the equation of motions for quadrotor model. **5**

5B. Resolve the velocity of the aircraft through both the incidence angle and the sideslip angle into aircraft axes. The situation prevailing is assumed to be steady and is shown in Fig. **Q5B**. **3**

5C. Write short note on standared atmoshphere. **2**

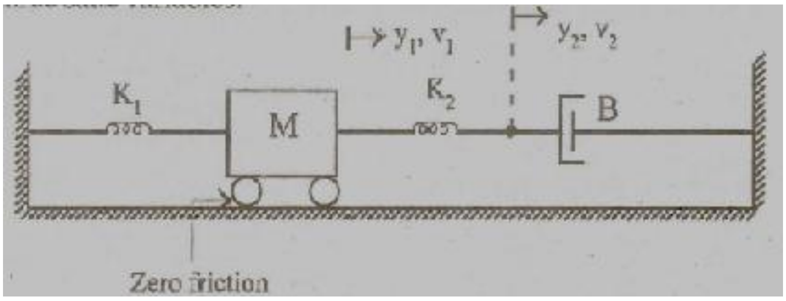

Fig. Q1A

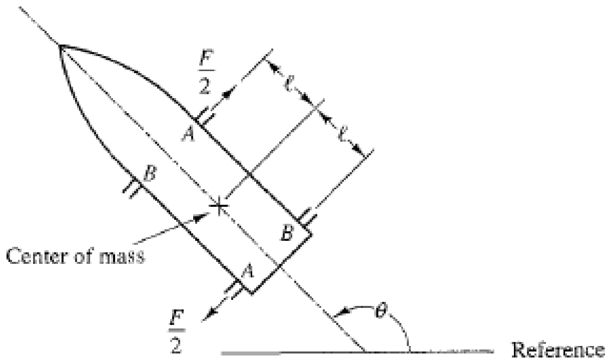

Fig. Q1B

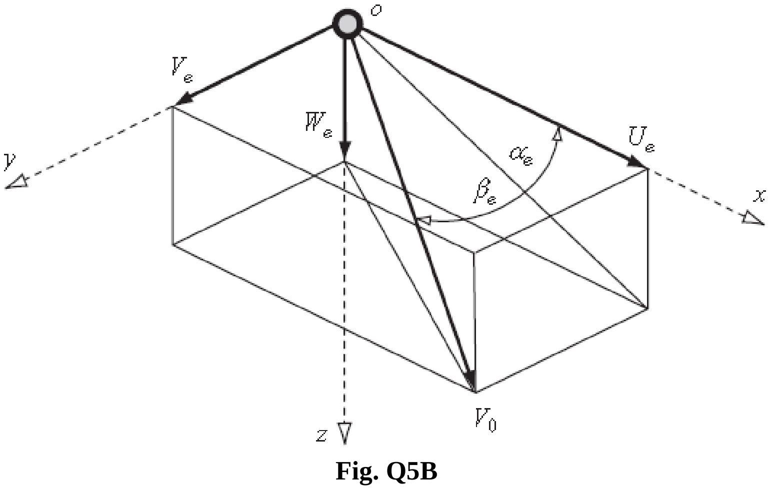

Fig. Q5B