Ref. No: **Ex/PG/ME/T/116F/2018**

MME 1st semester Examination 2018

SUBJECT: Flight Dynamics

Time: Three hours

Full Marks 100

USE SEPARATE ANSWERSCRIPT FOR EACH PART

PART I

Answer any three

2 marks for neatness

Q1. Consider a particle whose position can be best expressed in terms of a reference frame, which rotates about the inertial Z axis.

a) Derive $\bar{a} = \bar{a}_{rel} + \bar{\omega} \times (\bar{\omega} \times \bar{\rho}) + \bar{\alpha} \times \bar{\rho}$ [16]

Q2.

a) Explain Euler angles using neat sketches.

b) Derive of Euler equations from moment-angular momentum relation for a rigid body (mention the steps).

c) What is the form of angular velocity vector in terms of Euler angles (and their derivatives) for steady precession?

[6+6+4]

Q3.

a) What do you mean by steady precession?

b) Show that torque free motion a steady precession?

c) For torque free motion prove that

$$\dot{\psi} = \frac{I_{zz}\dot{\phi}}{(I_{xx} - I_{zz})\cos\theta}$$

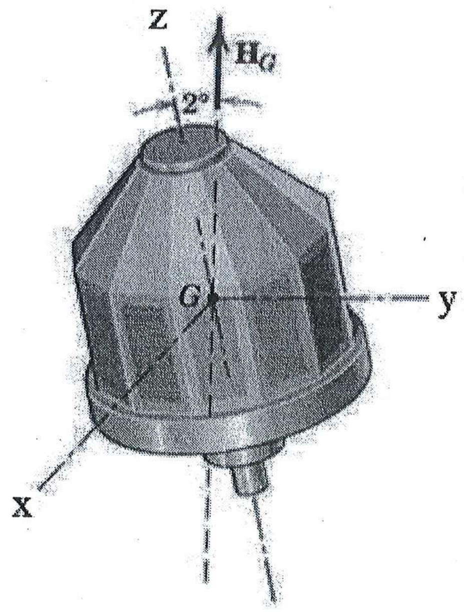
Where the symbols have their standard meanings

[4+4+8]

Q4.

The spacecraft shown is symmetrical about its z axis and has a radius of gyration of $720mm$ about this axis. The radii of gyration about the x and y axes through the mass center are both equal to $540mm$. When moving in space, the z axis is observed to generate a cone with a total vertex angle of 4 degrees as it precesses about the axis of total angular momentum. If the spacecraft has a spin velocity $\dot{\emptyset}$ about its z axis of 1.5 rad/s, compute the period τ of each full precession. Is the spin vector in positive or negative direction?

[16]



PART II

Answer any Two

1a. When do you call an airplane motion to be 'trimmed'? Explain the necessary conditions of stability for an airplane in motion in such a condition.

b. Explain the working principle of primary control surfaces of an airplane.

(4+12)+9

2a. Derive the expression for the total pitching moment about the centre of gravity of an airplane.

b. A wing-body model is tested in a subsonic wind tunnel. The lift is found to be zero at geometric angle of attack of α = -1.5°, and for α = 4° the lift co-efficient is found to be 0.5. Also at α = 1.0° and α = 7.88°, the moment co-efficients about c.g. are measured as -0.01 and 0.05 respectively. The centre of gravity is located at 0.35*c*, *c* being the chord length of the wing measured to be 0.1m. The area of the wing is $0.1m^2$. A horizontal tail of area $0.02\ m^2$ is added to the model at a tail-setting angle of 2.7°, the tail lift slope being 0.11 per degree, while experimental data provides ε_0=0 and $\delta\varepsilon/\delta\alpha$=0.35 [notations have usual meanings]. The distance from the airplanes centre of gravity to tail's aerodynamic centre is 0.17m. Does this model has longitudinal static stability and balance?

12+13

3. Write short notes on: a. Aerodynamic centre, b. Canard configuration, c. Neutral point of an airplane, d. Centre of pressure e. Tail setting angle 5x5