Ref. No .Ex PG/ME/T/116F/24/2017

MME 1st semester Examination 2017

MASTER OF CONTROL SYS. ENGINEERING EXAMINATION, 2017

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. Design tests of the landing sequence for the lunar excursion module (Figure 1) are conducted using the pendulum model suspended by the parallel wires A and B. If the model has a mass of 10kg with mass centre at G, and if $\dot{\theta} = 2\ rad/s$ when $\theta = 60^o$ calculate the tension in each of the string.

[16]

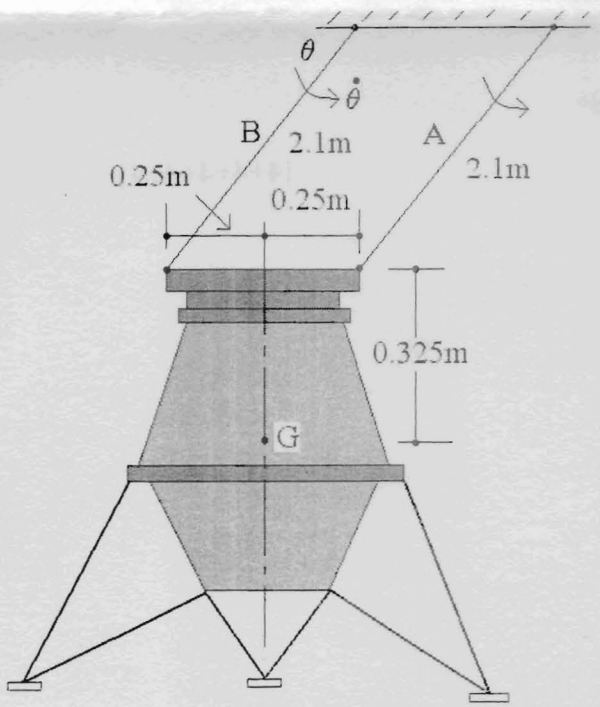

Figure 1

Q2. Consider a particle whose position can be best expressed in terms of a reference frame, which rotates about the inertial Z axis.

Derive $\bar{v} = \bar{v}_{rel} + \bar{\omega} \times \bar{\rho}$

$\bar{a} = \bar{a}_{rel} + \bar{\omega} \times (\bar{\omega} \times \bar{\rho}) + \bar{\alpha} \times \bar{\rho} + 2\bar{\omega} \times \bar{v}$

[16]

Q3. Explain Euler angles using neat sketches.

Indicate the step-wise procedure for derivation of Euler equations from moment-angular momentum relation for a rigid body.

[16]

Q4.

(a) What do you mean by torque free motion?

(b) Is torque free motion a steady precession?

(c) Show that for torque free motion

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

Where the symbols have their standard meanings

[4+4+4+4+4]

PART II

(Answer question no. 1 and any two from the rest)

1a. Can lift exist without drag? Justify your statement.

b. What do you mean by 'induced drag'? How is it generated? 5 + 5

2. Explain the working principles of primary control surfaces associated to the longitudinal, lateral and directional control of an airplane.

Explain with neat figures the two necessary criteria for Longitudinal Static Stability of an airplane. 10 + 10

3. Find out the contribution of wing and tail to the total pitching moment about the centre of gravity of an airplane and find out the expression for the co - efficient of the same. 20

4. A wing - body model is tested in a subsonic wind tunnel. The lift is found to be zero at a geometric angle of attack $\alpha = -1.8°$. At $\alpha = 5°$, the lift co - efficient is measured as 0.6. Also at $\alpha = 2.10°$ and 7.88°, the moment coefficients about the centre of gravity are measured as - 0.014 and 0.07, respectively. The centre of gravity located at $0.3c$. The area and chord of the wing are 0.1 m^2 and 0.15 m respectively. A horizontal tail is attached to the model having an area of 0.02 m^2, tail setting angle 2.7°, tail lift slope 0.11 per degree. The tail's aerodynamic centre is 0.17 m behind the centre of gravity of the model. From experimental measurement, $\varepsilon = 0$ and $\delta\varepsilon/\delta\alpha = 0.32$ [notations have usual meanings]. Does this model have longitudinal static stability and balanced.