AE 240/240M/713 Quiz No. 1 Tuesday 02nd February, 2021 Weightage: 10%
Time: 1135 – 1230 Hours (Including Upload) Venue: Moodle Open Notes
Note: Examination is open notes. Only calculator is permitted during examination.

Q.1 It is required to launch a payload with an ideal burnout velocity of 9 km/s. The existing technological limitations restrict the I_{sp} to 300s. If the maximum rocket mass permissible on launch pad is 300 Tons, what is the maximum permissible inert mass of the rocket, if a 5 Ton payload is to be launched? Also, what is the resulting propellant fraction? ($g_0 = 9.81$ m/s^2). (2)

Q.2 A rocket of lift-off mass m_0 and carrying propellant mass of m_p, having specific impulse, I_{sp}, is executing a rectilinear vertical motion under the assumptions of constant sea-level gravity, vacuum and has a propellant burn rate of β_0 at the start. However, due to fault in the engine, this burn rate increases slowly with a small constant rate of increment ($d\beta/dt$). Derive the expression for burnout time, t_b, (both exact and approximate, but correct up to first iteration), mass profile, m(t), and burnout velocity, V_b, using the approximate expression of the burnout time. (4)

Q.3 A rocket with $m_0 = 100$ Tons, $m_p = 80$ Tons ($I_{sp} = 300$ s), moves vertically under constant sea-level gravity (9.81 m/s^2) and constant burn rate $\beta = 0.8$ Tons / sec. Give the applicable expressions for velocity and altitude as functions of burn time, 't' and predict approximate dynamic pressure peak and corresponding altitude. Also, what is the magnitude of the average drag acceleration, as per the rectangular model of drag energy. (Hint: Neglect loss due to drag. Use atmospheric table given below for applicable density values. Solve for V, m & h for 20s, 30s, 40s & 50s. $C_D = 1.0$, $S = 1$ m^2). (4)

PAPER ENDS

H (km)	T (°C)	P (kPa)	ρ (kg m^{-3})
-1	21.5	113.920	1.3470
0	15.0	101.325	1.2250
1	8.5	89.874	1.1116
2	2.0	79.495	1.0065
3	-4.5	70.108	0.9091
4	-11.0	61.640	0.8191
5	-17.5	54.019	0.7361
6	-24.0	47.181	0.6597
7	-30.5	41.060	0.5895
8	-37.0	35.599	0.5252
9	-43.5	30.742	0.4664
10	-50.0	26.436	0.4127
11	-56.5	22.632	0.3639
13	-56.5	16.510	0.2655
15	-56.5	12.044	0.1937
17	-56.5	8.787	0.1423
20	-56.5	5.475	0.0880
25	-51.5	2.511	0.0395
30	-46.5	1.172	0.0180
32	-44.5	0.868	0.0132