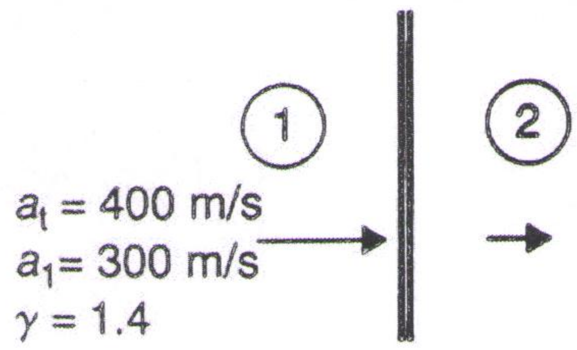
AE341: Airbreathing Propulsion
Quiz-1
Date: 03/02/2020
Duration: 30 minutes.
Total marks = 100 points (No partial marking)

Name:
Roll No.:

1. A normal shock flow is characterized by stagnation speed of sound at and speed of sound a as shown. Calculate: (a) M1 (b) M^*_2

25+25=50 points



M1: (a) The options are: [A] 1.97-1.98 [B] 1.95-1.96 [C] 1.99-2.0 [D] 2.01-2.03

The correct answer is [A]

M^*_2: (b) The options are: [A] 0.61-0.62 [B] 0.59-0.60 [C] 0.63-0.64 [D] 0.65-0.66

The correct answer is [A]

(a) $$\frac{a^2}{\gamma-1} + \frac{u^2}{2} = \frac{a_t^2}{\gamma-1} = CA.$$

Rearranging & solving for u_1

$\Rightarrow$ $u_1 = 591.6$ m/s

To get, M_1 , $M_1 = \frac{u_1}{a_1} = 1.972$

(b) Need to find M_2 of the flow,

using N-S table , (for $\gamma = 1.4$)

$M_2 \approx 0.58$, for $M_1 = 1.972$

Now,

$$M_2^{*2} = \frac{(\gamma+1)M_2^2}{2+(\gamma-1)M_2^2}$$

$M_2^* \simeq 0.615$

2. A turbojet engine is powering a fighter airplane. Its cruise altitude and Mach number are 10 km and 0.8, respectively. The exhaust gases leave the nozzle at a speed of 570 m/s and a pressure of 0.67 bar. The exhaust nozzle is characterized by the ratio $A_e / \dot{m}_a = 0.006$ m^2 · s/kg. The fuel-to-air ratio is 0.02. Calculate -

(a) The specific thrust ($T / \dot{m}_a$) in N-s/kg.

(b) The propulsive efficiency (%)

25+25=50 points

(a) The options are: [A] 587-589 [B] 580-582 [C] 583-585 [D] 590-592

The correct answer is C

(b) The options are: [A] 98-99 [B] 101-103 [C] 104-106 [D] 95-97

The correct answer is B

(a) At h = 10 km, $T_a = 223.3$ K, $P_a = 0.265$ bar

$u = M\sqrt{\gamma R T_a} = 239.6$ m/s.

$$\frac{T}{\dot{m}_a} = \left[(1+f)u_e - u\right] + (P_e - P_a)\frac{A_e}{\dot{m}_a}$$

$$= (1.02 \times 570 - 239.6) + 0.006 \times (0.67 - 0.265) \times 10^5$$

$$= 584.77 \text{ N-s/kg}$$

(b) $$\eta_p = \frac{2(T/m_a)u}{(1+f)u_e^2 - u^2}$$

$$= \frac{2 \times 584.77 \times 239.6}{1.02 \times 570^2 - (239.6)^2}$$

$$= 1.022 = 102.2\ \%.$$

Means, this expression must not be used if the nozzle is choked.

M_1	M_2	T_2/T_1	p_2/p_1	ρ_2/ρ_1	p_{t2}/p_{t1}	p_{t2}/p_1	$\Delta s/R$
1.76	0.6146	1.3861E+00	3.3712E+00	2.4322E+00	8.1914E−01	4.2808E+00	1.9950E−01
1.78	0.6097	1.3974E+00	3.4512E+00	2.4698E+00	8.0970E−01	4.3660E+00	2.1109E−01
1.8	0.6048	1.4087E+00	3.5322E+00	2.5074E+00	8.0015E−01	4.4523E+00	2.2296E−01
1.82	0.6001	1.4201E+00	3.6140E+00	2.5448E+00	7.9049E−01	4.5396E+00	2.3510E−01
1.84	0.5955	1.4317E+00	3.6968E+00	2.5821E+00	7.8074E−01	4.6278E+00	2.4752E−01
1.86	0.5911	1.4433E+00	3.7804E+00	2.6193E+00	7.7090E−01	4.7171E+00	2.6019E−01
1.88	0.5867	1.4550E+00	3.8650E+00	2.6563E+00	7.6100E−01	4.8074E+00	2.7313E−01
1.9	0.5825	1.4668E+00	3.9504E+00	2.6932E+00	7.5103E−01	4.8987E+00	2.8631E−01
1.92	0.5784	1.4788E+00	4.0368E+00	2.7299E+00	7.4101E−01	4.9909E+00	2.9975E−01
1.94	0.5744	1.4908E+00	4.1241E+00	2.7664E+00	7.3094E−01	5.0842E+00	3.1342E−01
1.96	0.5704	1.5029E+00	4.2122E+00	2.8028E+00	7.2084E−01	5.1785E+00	3.2733E−01
1.98	0.5666	1.5151E+00	4.3013E+00	2.8390E+00	7.1072E−01	5.2738E+00	3.4148E−01
2	0.5629	1.5274E+00	4.3913E+00	2.8750E+00	7.0058E−01	5.3700E+00	3.5585E−01
2.02	0.5592	1.5398E+00	4.4822E+00	2.9108E+00	6.9043E−01	5.4673E+00	3.7043E−01
2.04	0.5557	1.5523E+00	4.5740E+00	2.9465E+00	6.8029E−01	5.5656E+00	3.8524E−01
2.06	0.5522	1.5650E+00	4.6667E+00	2.9820E+00	6.7015E−01	5.6648E+00	4.0025E−01
2.08	0.5488	1.5777E+00	4.7603E+00	3.0173E+00	6.6003E−01	5.7651E+00	4.1548E−01
2.1	0.5455	1.5905E+00	4.8548E+00	3.0524E+00	6.4993E−01	5.8663E+00	4.3090E−01
2.12	0.5423	1.6034E+00	4.9502E+00	3.0873E+00	6.3985E−01	5.9685E+00	4.4651E−01
2.14	0.5391	1.6165E+00	5.0465E+00	3.1219E+00	6.2982E−01	6.0718E+00	4.6232E−01
2.16	0.5361	1.6296E+00	5.1437E+00	3.1564E+00	6.1983E−01	6.1760E+00	4.7831E−01
2.18	0.5331	1.6428E+00	5.2418E+00	3.1907E+00	6.0988E−01	6.2812E+00	4.9449E−01
2.2	0.5301	1.6562E+00	5.3409E+00	3.2248E+00	5.9999E−01	6.3873E+00	5.1084E−01
2.22	0.5272	1.6696E+00	5.4408E+00	3.2587E+00	5.9016E−01	6.4945E+00	5.2736E−01
2.24	0.5244	1.6832E+00	5.5416E+00	3.2923E+00	5.8039E−01	6.6027E+00	5.4406E−01
2.26	0.5217	1.6969E+00	5.6434E+00	3.3257E+00	5.7069E−01	6.7118E+00	5.6091E−01
2.28	0.5190	1.7106E+00	5.7460E+00	3.3590E+00	5.6106E−01	6.8220E+00	5.7792E−01
2.3	0.5163	1.7245E+00	5.8496E+00	3.3920E+00	5.5151E−01	6.9331E+00	5.9509E−01
2.32	0.5138	1.7385E+00	5.9540E+00	3.4248E+00	5.4204E−01	7.0452E+00	6.1241E−01
2.34	0.5112	1.7526E+00	6.0594E+00	3.4573E+00	5.3266E−01	7.1583E+00	6.2987E−01
2.36	0.5088	1.7668E+00	6.1656E+00	3.4896E+00	5.2336E−01	7.2724E+00	6.4748E−01
2.38	0.5064	1.7812E+00	6.2728E+00	3.5218E+00	5.1416E−01	7.3874E+00	6.6523E−01
2.4	0.5040	1.7956E+00	6.3809E+00	3.5536E+00	5.0505E−01	7.5035E+00	6.8310E−01
2.42	0.5017	1.8101E+00	6.4898E+00	3.5853E+00	4.9603E−01	7.6205E+00	7.0111E−01
2.44	0.4994	1.8248E+00	6.5997E+00	3.6167E+00	4.8712E−01	7.7385E+00	7.1925E−01
2.46	0.4972	1.8395E+00	6.7105E+00	3.6479E+00	4.7830E−01	7.8575E+00	7.3751E−01
2.48	0.4950	1.8544E+00	6.8222E+00	3.6789E+00	4.6959E−01	7.9775E+00	7.5589E−01
2.5	0.4929	1.8694E+00	6.9348E+00	3.7097E+00	4.6099E−01	8.0985E+00	7.7438E−01
2.52	0.4908	1.8845E+00	7.0483E+00	3.7402E+00	4.5249E−01	8.2204E+00	7.9299E−01
2.54	0.4888	1.8997E+00	7.1627E+00	3.7705E+00	4.4410E−01	8.3433E+00	8.1171E−01

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