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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, Dec 2020

Course: Aerodynamics – II **Semester: V**
Program: B.Tech, ASE/ASE+AVE **Time 03 hrs.**
Course Code: ASEG 3011 **Max. Marks: 100**

Note: Required graph and tables are provided at the end of question paper.

SECTION A

S. No.		Marks	CO
Q1.	The value of total pressure in an adiabatic flow always remains constant. Is the above statement true or false?	**5**	**CO1**
Q2.	The total pressure across an expansion fan: a. Increases b. Decreases c. Remain constant d. Depend on the upstream Mach number	**5**	**CO1**
Q3.	When placed in a supersonic freestream of air, the pressure reading measured by the pitot tube represents the stagnation pressure of the freestream. Is the above statement true or false?	**5**	**CO2**
Q4.	Which of the following compression process is more efficient? a. Compression through mechanical compressor b. Compression through single normal shock wave c. Compression through series of oblique and normal shock wave d. Compression through compression wave	**5**	**CO3**
Q5.	The strength of shock wave depends on: a. Upstream Mach number b. Wave angle c. Downstream Mach number d. Both a and b e. Both a and c	**5**	**CO3**
Q6.	Drag divergence Mach number comes just before critical Mach number. Is the above statement true or false?	**5**	**CO5**

SECTION B

Q7.	Derive the relation between flow properties ahead and behind a normal shock wave. **OR** The flow just upstream of a normal shock wave is given by p_1 = 1 atm, T_1 = 288 K, and M_1 = 2.6. Calculate the following properties just downstream of the shock: p_2, T_2, ρ_2, M_2, $p_{0,2}$, $T_{0,2}$, and the change in entropy across the shock.	**10**	**CO1**
Q8	Consider an oblique shock wave with a wave angle of 30^0 in a Mach 4 flow. The upstream pressure and temperature are 2.65×10^4 N/m^2 and 223.3 K, respectively.	**10**	**CO3**

	Calculate the pressure, temperature, Mach number, total pressure, and total temperature behind the wave and the entropy increase across the wave. **For $M_1 = 2$** $M_2 = 0.5774$ $P_2 / P_1 = 4.5$ $T_2 / T_1 = 1.687$ **For $M_1 = 4$ and wave angle = 30^0** Flow deflection angle = 17.7^0		
Q9	A supersonic flow at $M_1 = 1.58$ and $p_1 = 1$ atm expands around a sharp corner. If the pressure downstream of the corner is 0.1306 atm. Calculate the deflection angle of the corner.	**10**	**CO2**
Q10	Derive velocity potential equation and focus on its application.	**10**	**CO5**
Q11	Emphasis on the application of following and support your answer with scientific explanation. i. Whitcomb's Area Rule ii. Supercritical Airfoils	**10**	**CO5**
	SECTION-C		
Q 12	Discuss the application of shock expansion theory and hence derive the relation for aerodynamic forces on flat plate place at positive angle of attack in supersonic freestream. Calculate the lift and drag coefficients for a flat plate at a 5^0 angle of attack in a Mach 3 flow. OR Derive the relation for aerodynamic forces on a diamond wedge airfoil place at zero angle of attack in supersonic freestream of air. Consider a diamond-wedge airfoil, with a half-angle $\varepsilon = 10^0$. The airfoil is at zero angle of attack to a Mach 3 freestream. Calculate the wave-drag coefficients for the airfoil.	**20**	**CO4**

Prandtl-Meyer Function and Mach Angle

M	ν	μ	*M*	ν	μ
0.1000 + 01	0.0000	0.9000 + 02	0.1600 + 01	0.1486 + 02	0.3868 + 02
0.1020 + 01	0.1257 + 00	0.7864 + 02	0.1620 + 01	0.1545 + 02	0.3812 + 02
0.1040 + 01	0.3510 + 00	0.7406 + 02	0.1640 + 01	0.1604 + 02	0.3757 + 02
0.1060 + 01	0.6367 + 00	0.7063 + 02	0.1660 + 01	0.1663 + 02	0.3704 + 02
0.1080 + 01	0.9680 + 00	0.6781 + 02	0.1680 + 01	0.1722 + 02	0.3653 + 02
0.1100 + 01	0.1336 + 01	0.6538 + 02	0.1700 + 01	0.1781 + 02	0.3603 + 02
0.1120 + 01	0.1735 + 01	0.6323 + 02	0.1720 + 01	0.1840 + 02	0.3555 + 02
0.1140 + 01	0.2160 + 01	0.6131 + 02	0.1740 + 01	0.1898 + 02	0.3508 + 02
0.1160 + 01	0.2607 + 01	0.5955 + 02	0.1760 + 01	0.1956 + 02	0.3462 + 02
0.1180 + 01	0.3074 + 01	0.5794 + 02	0.1780 + 01	0.2015 + 02	0.3418 + 02
0.1200 + 01	0.3558 + 01	0.5644 + 02	0.1800 + 01	0.2073 + 02	0.3375 + 02
0.1220 + 01	0.4057 + 01	0.5505 + 02	0.1820 + 01	0.2130 + 02	0.3333 + 02
0.1240 + 01	0.4569 + 01	0.5375 + 02	0.1840 + 01	0.2188 + 02	0.3292 + 02
0.1260 + 01	0.5093 + 01	0.5253 + 02	0.1860 + 01	0.2245 + 02	0.3252 + 02
0.1280 + 01	0.5627 + 01	0.5138 + 02	0.1880 + 01	0.2302 + 02	0.3213 + 02
0.1300 + 01	0.6170 + 01	0.5028 + 02	0.1900 + 01	0.2359 + 02	0.3176 + 02
0.1320 + 01	0.6721 + 01	0.4925 + 02	0.1920 + 01	0.2415 + 02	0.3139 + 02
0.1340 + 01	0.7279 + 01	0.4827 + 02	0.1940 + 01	0.2471 + 02	0.3103 + 02
0.1360 + 01	0.7844 + 01	0.4733 + 02	0.1960 + 01	0.2527 + 02	0.3068 + 02
0.1380 + 01	0.8413 + 01	0.4644 + 02	0.1980 + 01	0.2583 + 02	0.3033 + 02
0.1400 + 01	0.8987 + 01	0.4558 + 02	0.2000 + 01	0.2638 + 02	0.3000 + 02
0.1420 + 01	0.9565 + 01	0.4477 + 02	0.2050 + 01	0.2775 + 02	0.2920 + 02
0.1440 + 01	0.1015 + 02	0.4398 + 02	0.2100 + 01	0.2910 + 02	0.2844 + 02
0.1460 + 01	0.1073 + 02	0.4323 + 02	0.2150 + 01	0.3043 + 02	0.2772 + 02
0.1480 + 01	0.1132 + 02	0.4251 + 02	0.2200 + 01	0.3173 + 02	0.2704 + 02
0.1500 + 01	0.1191 + 02	0.4181 + 02	0.2250 + 01	0.3302 + 02	0.2639 + 02
0.1520 + 01	0.1249 + 02	0.4114 + 02	0.2300 + 01	0.3428 + 02	0.2577 + 02
0.1540 + 01	0.1309 + 02	0.4049 + 02	0.2350 + 01	0.3553 + 02	0.2518 + 02
0.1560 + 01	0.1368 + 02	0.3987 + 02	0.2400 + 01	0.3675 + 02	0.2462 + 02
0.1580 + 01	0.1427 + 02	0.3927 + 02	0.2450 + 01	0.3795 + 02	0.2409 + 02

M	ν	μ	M	ν	μ
0.2500 + 01	0.3912 + 02	0.2358 + 02	0.5000 + 01	0.7692 + 02	0.1154 + 02
0.2550 + 01	0.4028 + 02	0.2309 + 02	0.5100 + 01	0.7784 + 02	0.1131 + 02
0.2600 + 01	0.4141 + 02	0.2262 + 02	0.5200 + 01	0.7873 + 02	0.1109 + 02
0.2650 + 01	0.4253 + 02	0.2217 + 02	0.5300 + 01	0.7960 + 02	0.1088 + 02
0.2700 + 01	0.4362 + 02	0.2174 + 02	0.5400 + 01	0.8043 + 02	0.1067 + 02
0.2750 + 01	0.4469 + 02	0.2132 + 02	0.5500 + 01	0.8124 + 02	0.1048 + 02
0.2800 + 01	0.4575 + 02	0.2092 + 02	0.5600 + 01	0.8203 + 02	0.1029 + 02
0.2850 + 01	0.4678 + 02	0.2054 + 02	0.5700 + 01	0.8280 + 02	0.1010 + 02
0.2900 + 01	0.4779 + 02	0.2017 + 02	0.5800 + 01	0.8354 + 02	0.9928 + 01
0.2950 + 01	0.4878 + 02	0.1981 + 02	0.5900 + 01	0.8426 + 02	0.9758 + 01
0.3000 + 01	0.4976 + 02	0.1947 + 02	0.6000 + 01	0.8496 + 02	0.9594 + 01
0.3050 + 01	0.5071 + 02	0.1914 + 02	0.6100 + 01	0.8563 + 02	0.9435 + 01
0.3100 + 01	0.5165 + 02	0.1882 + 02	0.6200 + 01	0.8629 + 02	0.9282 + 01
0.3150 + 01	0.5257 + 02	0.1851 + 02	0.6300 + 01	0.8694 + 02	0.9133 + 01
0.3200 + 01	0.5347 + 02	0.1821 + 02	0.6400 + 01	0.8756 + 02	0.8989 + 01
0.3250 + 01	0.5435 + 02	0.1792 + 02	0.6500 + 01	0.8817 + 02	0.8850 + 01
0.3300 + 01	0.5522 + 02	0.1764 + 02	0.6600 + 01	0.8876 + 02	0.8715 + 01
0.3350 + 01	0.5607 + 02	0.1737 + 02	0.6700 + 01	0.8933 + 02	0.8584 + 01
0.3400 + 01	0.5691 + 02	0.1710 + 02	0.6800 + 01	0.8989 + 02	0.8457 + 01
0.3450 + 01	0.5773 + 02	0.1685 + 02	0.6900 + 01	0.9044 + 02	0.8333 + 01
0.3500 + 01	0.5853 + 02	0.1660 + 02	0.7000 + 01	0.9097 + 02	0.8213 + 01
0.3550 + 01	0.5932 + 02	0.1636 + 02	0.7100 + 01	0.9149 + 02	0.8097 + 01
0.3600 + 01	0.6009 + 02	0.1613 + 02	0.7200 + 01	0.9200 + 02	0.7984 + 01
0.3650 + 01	0.6085 + 02	0.1590 + 02	0.7300 + 01	0.9249 + 02	0.7873 + 01
0.3700 + 01	0.6160 + 02	0.1568 + 02	0.7400 + 01	0.9297 + 02	0.7766 + 01
0.3750 + 01	0.6233 + 02	0.1547 + 02	0.7500 + 01	0.9344 + 02	0.7662 + 01
0.3800 + 01	0.6304 + 02	0.1526 + 02	0.7600 + 01	0.9390 + 02	0.7561 + 01
0.3850 + 01	0.6375 + 02	0.1505 + 02	0.7700 + 01	0.9434 + 02	0.7462 + 01
0.3900 + 01	0.6444 + 02	0.1486 + 02	0.7800 + 01	0.9478 + 02	0.7366 + 01
0.3950 + 01	0.6512 + 02	0.1466 + 02	0.7900 + 01	0.9521 + 02	0.7272 + 01
0.4000 + 01	0.6578 + 02	0.1448 + 02	0.8000 + 01	0.9562 + 02	0.7181 + 01
0.4050 + 01	0.6644 + 02	0.1429 + 02	0.9000 + 01	0.9932 + 02	0.6379 + 01
0.4100 + 01	0.6708 + 02	0.1412 + 02	0.1000 + 02	0.1023 + 03	0.5739 + 01
0.4150 + 01	0.6771 + 02	0.1394 + 02	0.1100 + 02	0.1048 + 03	0.5216 + 01
0.4200 + 01	0.6833 + 02	0.1377 + 02	0.1200 + 02	0.1069 + 03	0.4780 + 01
0.4250 + 01	0.6894 + 02	0.1361 + 02	0.1300 + 02	0.1087 + 03	0.4412 + 01
0.4300 + 01	0.6954 + 02	0.1345 + 02	0.1400 + 02	0.1102 + 03	0.4096 + 01
0.4350 + 01	0.7013 + 02	0.1329 + 02	0.1500 + 02	0.1115 + 03	0.3823 + 01
0.4400 + 01	0.7071 + 02	0.1314 + 02	0.1600 + 02	0.1127 + 03	0.3583 + 01
0.4450 + 01	0.7127 + 02	0.1299 + 02	0.1700 + 02	0.1137 + 03	0.3372 + 01
0.4500 + 01	0.7183 + 02	0.1284 + 02	0.1800 + 02	0.1146 + 03	0.3185 + 01
0.4550 + 01	0.7238 + 02	0.1270 + 02	0.1900 + 02	0.1155 + 03	0.3017 + 01
0.4600 + 01	0.7292 + 02	0.1256 + 02	0.2000 + 02	0.1162 + 03	0.2866 + 01
0.4650 + 01	0.7345 + 02	0.1242 + 02	0.2200 + 02	0.1175 + 03	0.2605 + 01
0.4700 + 01	0.7397 + 02	0.1228 + 02	0.2400 + 02	0.1186 + 03	0.2388 + 01
0.4750 + 01	0.7448 + 02	0.1215 + 02	0.2600 + 02	0.1195 + 03	0.2204 + 01
0.4800 + 01	0.7499 + 02	0.1202 + 02	0.2800 + 02	0.1202 + 03	0.2047 + 01
0.4850 + 01	0.7548 + 02	0.1190 + 02	0.3000 + 02	0.1209 + 03	0.1910 + 01
0.4900 + 01	0.7597 + 02	0.1178 + 02	0.3200 + 02	0.1215 + 03	0.1791 + 01
0.4950 + 01	0.7645 + 02	0.1166 + 02	0.3400 + 02	0.1220 + 03	0.1685 + 01

$\theta - \beta - M$ Relationship