Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May-June 2021

Course: Supersonic and Hypersonic Flows **Semester: II**
Program: M.Tech CFD **Time 03 hrs.**
Course Code: ASEG 7034P **Max. Marks: 100**

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

SECTION A

S. No.		Marks	CO
Q1.	Discuss various properties of hypersonic flow.	**5**	**CO1**
Q2.	List the parameters which determines the strength of a shock wave.	**5**	**CO2**
Q3.	"Stagnation pressure remains constant across an expansion fan" Whether the above sentence is true or false. Give reason for your answer.	**5**	**CO3**
Q4.	Discuss about small perturbation theory and its advantages.	**5**	**CO4**
Q5.	Discuss the limitations of linearized velocity potential equation.	**5**	**CO4**
Q6.	Define critical Mach number. What is the value of critical Mach number for a flat plate at zero angle of attack?	**5**	**CO5**

SECTION B

Q7.	Discuss on the severity of aerothermodynamics effects on a hypersonic vehicles and discuss about its control methods.	**10**	**CO1**
Q8	Consider the flow over a 22.2° half-angle wedge. If the Mach number, pressure and temperature upstream of the shock wave are 2.5, 1 atm, and 300 K respectively, then calculate the wave angle and corresponding flow properties downstream of shock wave.	**10**	**CO2**
Q9	Consider a flow with pressure and temperature of 1 atm and 288 K. A Pitot tube is inserted into this flow and measures a pressure of 1.555 atm. What is the velocity of the flow?	**10**	**CO2**
Q10	Consider the supersonic flow over an expansion corner. The deflection angle θ = 23.38^0. If the flow upstream of the corner is given by $M_1 = 2$, $P_1 = 0.7$ atm and T_1 = 350 K, then calculate M_2, P_2, T_2, ρ_2, $P_{0,2}$, and $T_{0,2}$ downstream of the corner. Also, obtain the angles the forward and rearward Mach lines make with respect to the upstream direction.	**10**	**CO3**
Q11	Derive velocity potential equation for compressible flow.	**10**	**CO4**

SECTION-C

Q 12	Consider a diamond-wedge airfoil with a half-angle $\varepsilon = 10^\circ$. The airfoil is at an angle of attack $\alpha = 15^\circ$ to a Mach 3 freestream. Calculate the lift and wave-drag coefficients for the airfoil.	**20**	**CO5**

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