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

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2019

Course: Pipeline Transportation of Oil and Gas
Semester: VII
Program: B. Tech. APE UPSTREAM **Time 03 hrs.**
Course Code: PTEG - 443 **Max. Marks: 100**
Instructions: Attempt All Questions
No. of Pages:4

SECTION A

S. No.		Marks	CO
Q.1	Discuss the difference between $NPSH_A$ and $NPSH_R$.	**5**	**CO1**
Q.2	Illustrate the effect of compressor piping losses in calculating the compressor ratio.	**5**	**CO4**
Q.3	Explain the term 'Best Efficiency Point'.	**5**	**CO1**
Q.4	Describe 'Affinity Law' for centrifugal pumps.	**5**	**CO3**
Q.5	Illustrate the method to calculate the number of pumps required to pump crude oil in a cross-country pipeline.	**5**	**CO2**
Q.6	Define the term "Adiabatic efficiency" and hydraulic balance in compressors.	**5**	**CO2**

SECTION B

Q.7	Illustrate the various components and functions of a SCADA system.	**10**	**CO4**
Q.8	A gas pipeline is used for transporting gas between the two stations. Applying the fundamental knowledge for horse power calculations, **calculate** the compressor horsepower required for an adiabatic compression of 106 MMSCFD gas with inlet temperature of 68°F and 725 psia pressures. The discharge pressure is 1305 psia. Assume the compressibility factors at suction and discharge conditions to be $Z_1 = 1.0$ and $Z_2 = 0.85$, respectively, and the adiabatic exponent = 1.4, with the adiabatic efficiency = 0.8. If the mechanical efficiency of the compressor driver is 0.95, what BHP is required? Also, **calculate** the outlet temperature of the gas.	**5+5 =10**	**CO5**

Q.9	Discuss the reasons for the two-phase formation in pipelines. Also, illustrate with figures the different flow patterns observed in two-phase flow and Bakers Chart to identify the flow pattern in multiphase flow.	**5+5 =10**	**CO4**
	SECTION-C		
Q.10	A pipeline from origin station A to delivery point B is 48 miles long and is 18 inch in nominal diameter, with a 0.281 inches wall thickness. It is, constructed of 5LX-65 grade steel. At origin station A, crude oil of specific gravity 0.85 and 10 cSt viscosity enters the pipeline at a flow rate of 6000 bbl./hr. At first intermediate station C (milepost 22) a new stream of crude oil with a specific gravity of 0.82 and 3.5 cSt viscosity enters the pipeline at a flow rate of 1000 bbl./hour. The mixed stream then continues to another intermediate station D (milepost 32) where 3000 bbl./hour is stripped off the pipeline. The remaining volume continues to the end of the pipeline at delivery station B. **(a)** Evaluate the pressure required at origin station A and the composition of the crude oil arriving at terminus B at a minimum delivery pressure of 50 psi. Assume elevations at A, C, D, and B to be 100, 150, 250, and 300 feet, respectively. Use the Modified Colebrook-White equation for pressure drop calculations and assume a pipe roughness of 0.002 in. **(b)** Calculate the pump HP will be required to maintain this flow rate at A, assuming 50 psi pump suction pressure at A and 80% pump efficiency? **(c)** If a positive displacement (PD) pump is used to inject the stream at C, solve for pressure and HP are required at C?	**10+5+5 =20**	**CO3**
Q11	A natural gas pipeline, 140 miles long from Dover to Leeds, is constructed of NPS 16, 0.250 in. wall thickness pipe, with an MOP of 1200 psig. The gas specific gravity and viscosity are 0.6 and 8×10^{-6} lb/ft-s, respectively. The pipe roughness can be assumed 700 micro inches and the base pressure and base temperature are 14.7 psia and 60°F,	**5+5+5+ 5 = 20**	**CO5**

	respectively. The gas flow rate is 175 MMSCFD at 80°F, and the delivery pressure required at Leeds is 800 psig. **a)** Evaluate the pressure required at inlet to deliver the gas at Leeds ? **b)** Analyze, if the gas can be delivered at the calculated inlet pressure from Dover? If not, mention the reasons. **c)** Assuming if only one intermediate compressor is installed at mid-point of the pipeline at Kent, will it be able to deliver the gas at Leeds at delivery pressure. Mention reasons. **d)** If not calculate the exact location of compressor. Also for this location, calculate the suction pressure and compression ratio at Kent. Assume *Z*= 0.85		

All Notations have their usual meaning and units

1. Reynolds Equation for Gas Pipelines:

$$\mathrm{Re} = 0.5134\left(\frac{P_b}{T_b}\right)\left(\frac{GQ}{\mu D}\right) \qquad \text{(SI)}$$

$$\mathrm{Re} = 0.0004778\left(\frac{P_b}{T_b}\right)\left(\frac{GQ}{\mu D}\right) \qquad \text{(USCS)}$$

2. Reynolds No. for Crude Oil Pipelines

a) R=92.24 Q/ (ν D)

Where: Q=Flow rate, bbl/day; D=Internal diameter, in.; ν = Kinematic viscosity, cSt

b) **R=353,678 Q/(νD)**

Where: Q=Flow rate, m^3/hr.; D=Internal diameter, mm; ν= Kinematic viscosity, cSt

D=Pipe internal diameter, in.

3. Modified Colebrook White Equation

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{e}{3.7D} + \frac{2.825}{\mathrm{Re}\sqrt{f}}\right)$$

4. Coversion Equations for SSU to Centistokes

$$Centistokes = 0.226(SSU) - \frac{195}{SSU} \qquad 32 \le SSU \le 100$$

$$Centistokes == 0.220(SSU) - \frac{135}{SSU} \qquad SSU \succ 100$$

5. Horsepower required to compress gas in compressor

$$HP = 0.0857\left(\frac{\gamma}{\gamma-1}\right)QT_1\left(\frac{Z_1+Z_2}{2}\right)\left(\frac{1}{\eta_a}\right)\left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]$$

6. Adiabatic Efficiency of Compressor

$$\eta_a = \left(\frac{T_1}{T_2 - T_1}\right)\left[\left(\frac{z_1}{z_2}\right)\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]$$

7. BHP required to pump the liquid

$$BHP = \frac{QP}{2449E}$$

Q = flow rate (barrel per hr.) **P** = Differentia pressure (psi)