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

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, MAY 2021

Course: Pipeline Transportation of Oil and Gas — **Semester: VIII**
Program: B. Tech. Chemical Engineering — **Time 03 hrs.**
Course Code: CHGS3007P — **Max. Marks: 100**
Instructions: Attempt All Questions

SECTION A

S. No.	ATTEMPT ALL QUESTIONS- APPENDIX ON PAGE NO. 5-7 (5*6=30 MARKS)	Marks	CO
Q.1	Illustrate the term 'Erosional Velocity' in pipelines	**5**	**CO1**
Q.2	Explain the methodology adopted to calculate the 'Number of Pumps' required to transport oil.	**5**	**CO4**
Q.3	Discuss 'Line Pack Volume'.	**5**	**CO1**
Q.4	Discuss the difference between Reciprocating pumps and Centrifugal pumps with their limitations.	**5**	**CO3**
Q.5	Discuss the term 'MAOP' in oil and gas pipelines	**5**	**CO2**
Q.6	Explain the difference between NPSHA and NPSHR	**5**	**CO4**

SECTION B
(ATTEMPT ALL QUESTIONS)

Q.7	Explain the purpose and types of PIGS used in the pipeline industry.	**10**	**CO2**
Q.8	Explain performance curves for centrifugal pumps	**10**	**CO5**
Q.9	(a) Illustrate the term 'Class location in compressors'. (b) Explain the specific speed of pumps.	**10**	**CO4**
Q.10	If the total pressure required to pump the liquid is 2000 psi and the suction pressure of each pump is 50 psi, then calculate the number of pumping stations required with 1050-psi discharge pressure.	**10**	**CO3**
Q.11	Explain in short the pipeline construction activities	**10**	**CO2**

<table>
<tr><td colspan="4" align="center">SECTION-C
(ATTEMPT ANY ONE QUESTION)
MISSING DATA ARE TO BE SUITABLY ASSUMED</td></tr>
<tr><td>Q.12</td><td>The Salaya – Mathura pipeline is used for transporting oil from Salaya to Mathura refinery. There are two intermediate stations, one at Viramgram and the other one at Koyli. The length of Salaya- Mathura pipeline is 48 miles and is of 18 inch in diameter, with 0.281 inch wall thickness. It is constructed of 5LX-65 grade steel. At origin station Salaya, 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 Viramgram (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 Koyli (milepost 32) where 3000 bbl. / hour is stripped off the pipeline. The remaining volume continues to the end of the pipeline at delivery station Mathura.

(a) Evaluate the pressure required at origin station Salaya and the composition of the crude oil arriving at terminus Mathura at a minimum delivery pressure of 50 psi. Assume elevations at Salaya, Viramgram, Koyli, and Mathura 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 inches.

(b) Evaluate the pump HP that will be required at Salaya to maintain this flow rate, assuming 50-psi pump suction pressure at Salaya and 80% pump efficiency?

(c) If a positive displacement (PD) pump is used to inject the stream at Viramgram, solve for pressure and HP are required at Viramgram?</td><td>20</td><td>CO5</td></tr>
<tr><td>Q13</td><td>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 to be 700μin. and the base pressure and base temperature are 14.7 psia and 60°F,</td><td>20</td><td>CO3</td></tr>
</table>

	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 the 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 the compressor. Also, for this location, calculate the suction pressure and compression ratio at Kent. Assume Z= 0.85		

APPENDIX

All Notations have their usual meaning and units

1. Frictional Pressure drop equation in oil pipelines

$$\mathbf{Pm = 0.0605fQ^2(Sg/D^5)}$$

2. Pressure drop equation for gas pipelines

$$Q = 77.54\left(\frac{T_b}{P_b}\right)\left(\frac{P_1^2 - P_2^2}{GT_f LZf}\right)^{0.5} D^{2.5}$$

3. Reynolds Equation for Gas Pipelines

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

(SI)

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

4. 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.

5. Modified Colebrook White Equation

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

6. Coversion Equations for SSU to Centistokes

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

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

7. Horsepower required to compress gas in compressor

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

8. Adiabatic Efficiency of Compressor

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

9. BHP required to pump the liquid

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

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

10. Equivalent diameter equation

$$D_e = D_1\left[\left(\frac{1+Const}{Const}\right)^2\right]^{1/5} \qquad Const = \sqrt{\left(\frac{D_1}{D_2}\right)^5\left(\frac{L_2}{L_1}\right)}$$

11. Head to pressure conversion:

$$Head = \frac{2.31psig}{G}(USCS)$$

12. Specific gravity of blended liquids

$$S_b = \frac{Q_1S_1 + Q_2S_2 + \ldots\ldots Q_nS_n}{Q_1 + Q_2 + \ldots.Q_n}$$

13. Viscosity of blended liquids

$$\sqrt{v_b} = \frac{Q_1 + Q_2 + Q_3 \ldots.}{\left(\frac{Q_1}{\sqrt{v_1}} + \frac{Q_2}{\sqrt{v_2}} + \frac{Q_3}{\sqrt{v_3}} \ldots..\right)}$$