Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2018

Course: Pipeline Transportation of Oil and Gas **Semester:** 1

Programme: B. Tech. Applied Petroleum Engineering with specialization in gas **Time:** 03 hrs.

CODE: CHGS 3007 **Max. Marks: 100**

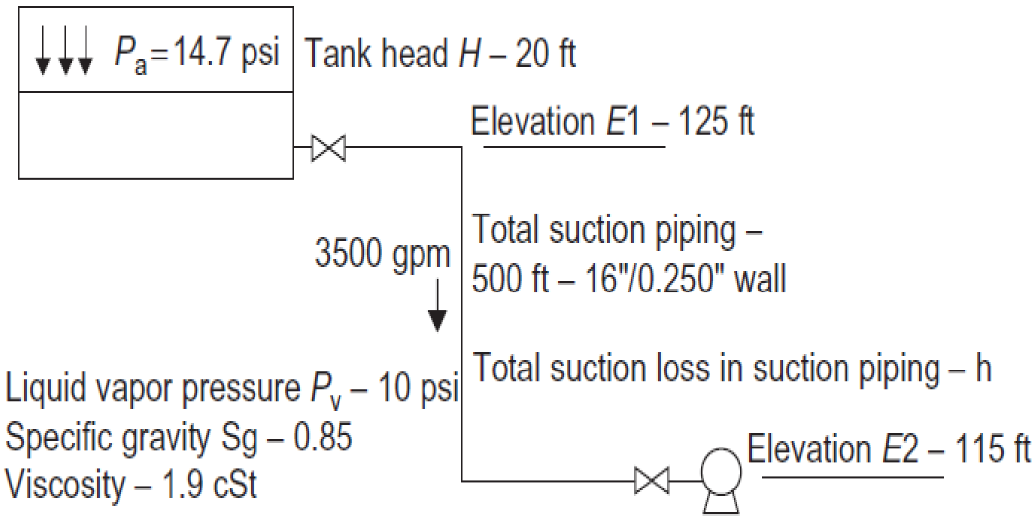
Instructions: ***i.*** Attempt all questions. ***ii.*** Missing data can be suitably assumed

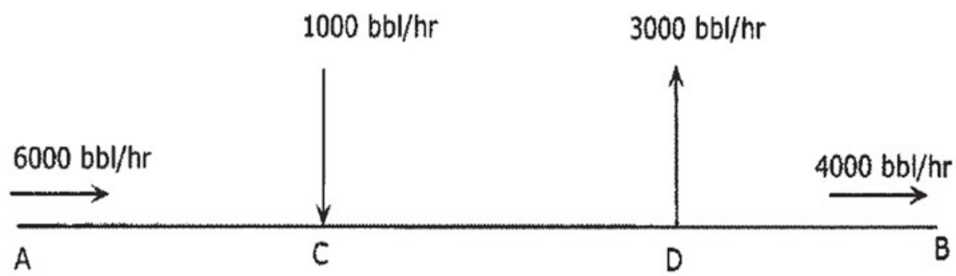
SECTION A

S. No.		**Marks**	**CO**
Q1	Explain the variation in water performance curves while transporting crude oil through pipelines	**5**	**CO1**
Q2	Differentiate between $NPSH_A$ and $NPSH_R$	**5**	**CO2**
Q3	Explain Line Pack volume and Line Fill Volume	**5**	**CO2**
Q4	Explain the term "Adiabatic efficiency" and hydraulic balance in compressors.	**5**	**CO3**

SECTION B

Q5	Explain the various components and functions of SCADA systems	**10**	**CO5**
Q6	A 16 in. crude oil pipeline (0.250 in. wall thickness) having internal roughness of 0.002 inches, is 30 miles long from point A to point B. The flow rate at the inlet A is 4000 bbl. / hr. The crude oil properties are specific gravity of 0.85 and viscosity of 10 cSt at a flowing temperature of 70° F. **(a)** Calculate the pressure required at A without any pipe loop. Assume, 50 psi, delivery pressure at the terminus B and a flat pipeline elevation profile. **(b)** If a 10 mile, portion CD, starting at milepost 10 is, looped with an identical 16 in. pipeline, calculate the reduced pressure at A.	**10**	**CO1, CO2**
Q7	A centrifugal pump, pumps liquid from a storage tank through 500 feet of NPS 16 suction piping as shown in Figure 1. The head loss in the suction piping is estimated to be 12.5 feet. **(i)** Calculate the NPSH available at a flow rate of 3500 gal/min. **(ii)** The pump data indicate NPSHR = 24 feet at 3500 gal/min and 52 feet at 4500 gal/min. Can this piping system handle the higher flow rate without the pump cavitating? **(iii)** If cavitation is a problem in, (ii) above, what changes are required to	**10**	**CO3**

	be done to the piping system to prevent pump cavitation at 4500 gal/min?  **FIGURE- 1**		
Q8	Explain the reasons for the two-phase flow in pipelines. Also, explain with figures the different flow patterns observed in two-phase flow. Explain the Bakers Chart to identify the flow pattern in multiphase flow	**10**	**CO5**
SECTION-C			
Q9	In the **Figure 2**, shown below, the pipeline from station A to station B is 48 miles long and is 18 in. in nominal diameter, with 0.281 in. wall thickness. It is, constructed of 5LX-65 grade steel. At station A, crude oil of specific gravity, 0.85 and 10 cSt viscosity enters the pipeline at a flow rate of 6000 barrel per hour. At station, C (milepost-22) a new stream of crude oil with specific gravity of 0.82 and 3.5 cSt viscosity enters the pipeline at a flow rate of 1000 barrel per hour. The mixed stream then continues to station D (milepost 32) where 3000 barrel per hour is, stripped off the pipeline. The remaining volume continues to the end of the pipeline at point B. **a)** Calculate the pressure required at dispatch station A to deliver the crude oil at station B at a minimum delivery pressure of 50 psi. Also calculate the specific gravity and viscosity of crude oil delivered at station B. Assume elevations at A,C,D and B to be 100, 150, 250 and 300 feet respectively. Use, Colebrook-White	**20**	**CO2, CO3, CO4**

	equation for pressure drop calculation and assume pipe roughness of 0.002 in. (**b)** Calculate the BHP required to- maintain 6000 barrel per hour of 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, that itself receives the liquid at 50 psi, and has 80% efficiency what pressure and HP is required at C?  **FIGURE 2**		
Q10	A natural gas pipeline runs 140 miles from Dadri to Panipat. The pipeline is of NPS 16, 0.250 in. wall thickness. Through calculations, it was found that the pipeline should not be operated at a pressure above 1200 psig. The gas specific gravity and viscosity were found to be 0.6 and 8×10^{-6} lb. per feet per second, respectively. The pipe roughness is assumed 700μ inch, and the base pressure and base temperature are 14.7 psia. and 60°F, respectively. The gas flow rate is 175 MMSCFD at 80°F, and the delivery pressure required at Panipat is 800 psig. **a)** Calculate the pressure required at Dadri to deliver the gas at Panipat at the desired pressure of 800 psig. **b)** The pipeline operator arbitrary choses to install the compressor station at the midpoint of the pipeline. Show through calculations if the location of compressor station at mid- point is optimum. If not, calculate the exact location of compressor station. Assume ***Z*= 0.85.**	**20**	**CO2, CO3, CO4**

APPENDIX

All Notations have their usual meaning and units

1. Reynolds Equation for Gas Pipelines:

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

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

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

3. Pressure Drop per unit length for oil pipelines (USCS)

$$Pm = 0.0605\, fQ^2 (Sg/D^5)$$

Pm = pressure drop due to friction (psi/mile); Q= Liquid flow rate (bbl. per day); D = Pipe Internal- diameter, in.

4. Modified Colebrook White Equation

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{e}{3.7D} + \frac{2.51}{Re\sqrt{f}}\right)$$

5. Coversion Equations for SSU to Centistokes

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

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

6. **Horsepower required to compress gas in compressor** $SSU \succ 100$

7.
$$HP = 0.0857\left(\frac{\gamma}{\gamma-1}\right)QT_1\left(\frac{Z_1+Z_2}{2}\right)\left(\frac{1}{\eta_a}\right)\left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}-1\right]$$

Adiabatic Efficienecy of Compressor

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

8. **BHP required to pump the liquid**

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

Q=flow rate (bbl./hr.); **P**=Differentia pressure (psi)

9. **Relation between Head and Pressure drop in liquid pipelines**

$$H(feet) = \frac{2.31psi}{G}$$