UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, /May 2018

Course: FLUID DYNAMICS & HEAT TRANSFER (NSAT7009) **Semester: 2**
Program: NUCLEAR SCIENCE & TECHNOLOGY
Time: 03 hrs. **Max. Marks: 100**

SECTION A (ATTEMPT ALL QUESTIONS)			
S. No.		**Marks**	**CO**
Q 1	Explain the Langrangian and Eulerian approach for solving the fluid flow problems.	**4**	**CO1**
Q 2	Explain the term 'Class Location' in a fluid carrying Pipeline.	**4**	**CO1, CO5**
Q.3	Define Erosional velocity and Maximum Allowable operating pressure in compressible fluid flow.	**4**	**CO5**
Q.4	Discuss the types of Partial Differential Eqns. with examples.	**4**	**CO3**
Q.5	Discuss the Mechanism of heat transfer through conduction, convection and radiation	**4**	**CO4**
SECTION B (ATTEMPT ALL QUESTIONS)			
Q.6	A fluid having density ρ, kinematic viscosity ν, and gravity force per unit mass of fluid B, flows in an open channel. Show that the motion of the fluid can be described by the following equation: $$\frac{DV}{Dt} = B - \frac{1}{\rho} grad.p + \nu.\nabla^2 V$$	**10**	**CO2**
Q.7	A steel pipeline of 500mm outside diameter, 10mm wall thickness is used to transport heavy crude oil at a flow rate of 800 m^3/hr. at 100^0C. Using the Shell MIT equation, calculate the friction loss per km of pipe assuming an internal pipe roughness of 0.05 mm. The heavy crude oil has a specific gravity of 0.89 and viscosity of 120 cSt at 100^0C.	**10**	**CO1, CO5**
Q.8	Prove that for incompressible fluid flow in pipelines, the equation of continuity at steady state is obtained from the following equation:	**10**	**CO1, CO2, CO5**

	$$\frac{v_r}{r}+\frac{\partial}{\partial r}(v_r)+\frac{\partial}{r\partial\theta}(v_\theta)=0$$ In the above equation, v_r is the velocity in radial direction, v_Θ is the velocity in tangential direction and 'r' is the distance of element from origin		
Q.9	Explain in short: Finite difference method (FDM), Finite Volume Method (FVM) and Finite Element method (FEM).	**10**	**CO3**
	SECTION-C **(Attempt ANY two questions**		
Q.10	A gas pipeline, NPS 16 with 0.250 in. wall thickness, 50 mi long, transports natural gas (specific gravity=0.6 and viscosity =0.000008 lb/ft-s) at a flow rate of 100 MMSCFD at an inlet temperature of 60°F. Assuming isothermal flow, calculate the inlet pressure required if the required delivery pressure at the pipeline terminus is 870 psig. The base pressure and base temperature are 14.7 psia and 60°F, respectively. Use the Colebrook equation with pipe roughness of 0.0007 in. **Case A**: Consider horizontal pipeline with no elevation. **Case B**: Consider elevation changes as follows: inlet elevation of 100 ft. and elevation at delivery point of 450 ft., with elevation at the midpoint of 250 ft. For easy calculation, assume a compressibility factor of 0.8666 throughout for this case. As an initial approximation use average pressure as 110 % times the output pressure in psia. Use 'Generalized Flow Equations' and 'Colebrook White' friction factor equations. Solve until the inlet pressure is within ± 2.5 psia.	**20**	**CO1, CO5**
Q.11	In a gas distribution pipeline, 60 MMSCFD enters the pipeline at A, as shown in **(Figure 1).** If the delivery at B is increased from 20 MMSCFD to 30 MMSCFD by increasing the inlet flow at A, keeping all downstream flow rates the same**(Figure 2),**calculate the looping necessary if entire length AB is looped to ensure pressures are not changed throughout the pipeline.	**20**	**CO1, CO5**

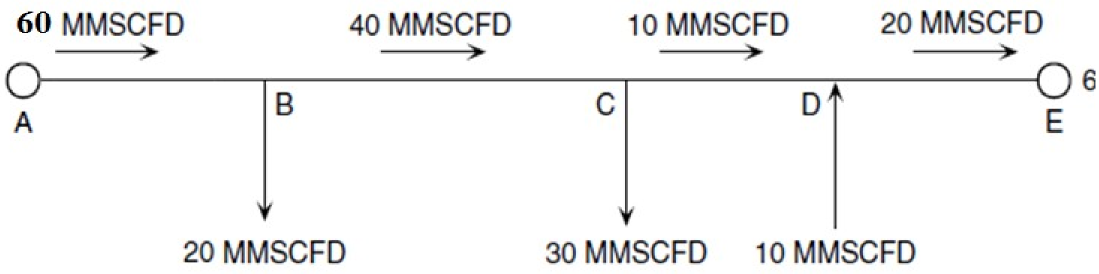


FIGURE: 1

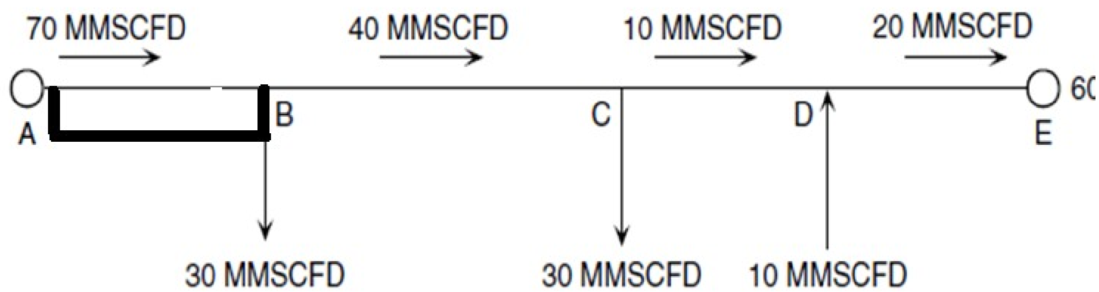


FIGURE: 2

Pipe AB is NPS 14, 0.250 in. wall thickness; BC is NPS 12, 0.250 in. wall thickness; CD is NPS 10, 0.250 in. wall thickness; and DE is NPS 12, 0.250 in. wall thickness. The delivery pressure at E is fixed at 600 psig. The pipe lengths are as follow: AB=12 miles; BC=18 miles; CD=20 miles; DE =8 miles. The gas gravity is 0.60, and the flow temperature is 60°F. The compressibility factor and transmission factor can be assumed 0.85 and 20, respectively, throughout the pipeline. The base pressure and base temperature are 14.7 psia and 60°F, respectively.

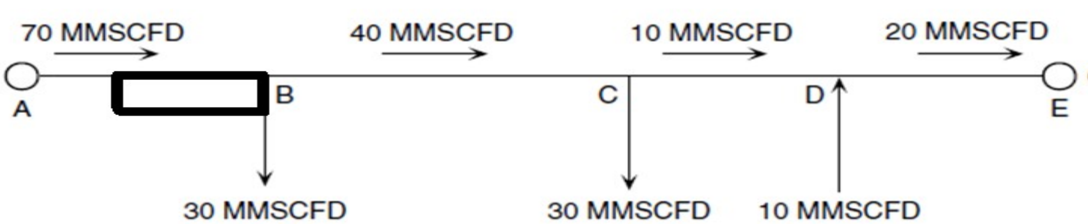
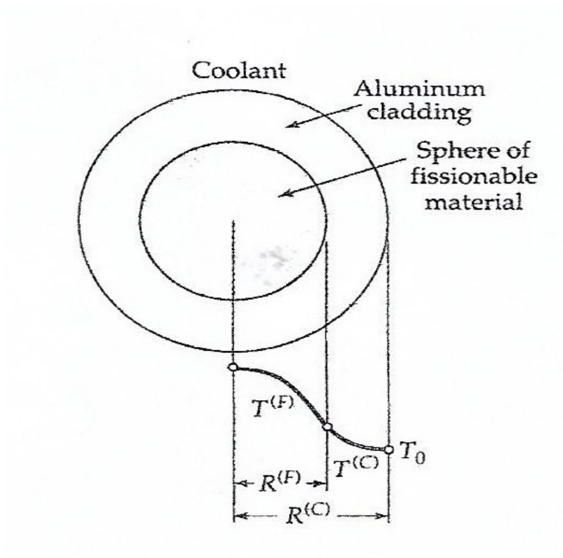


FIGURE: 3

Also, calculate the loop length, as shown in (Figure 3), if a particular length of AB

	is looped with a diameter of 10 NPS and 0.25-inch wall thickness.		
Q.12	Consider a spherical nuclear reactor as shown in **(Figure 4).** It consists of a sphere of fissionable material with radius $R^{(F)}$, surrounded by a spherical shell of aluminum cladding with outer radius $R^{(C)}$.  **FIGURE:4** Inside the fuel element, fission fragments are produced that have very high kinetic energies. Collision between these fragments and the atoms of the fissionable material provides the major source of thermal energy in the reactor. Such a volume source of thermal energy resulting from nuclear fission is taken as SH. This source is not uniform throughout the sphere of fissionable material; it is smallest at the center of the sphere. Hence it is assumed that the source can be approximated by a simple parabolic function: $$S_n = S_{n0}\left[1 + b\left(\frac{r}{R^{(F)}}\right)^2\right].$$ Here, S_{n0} is the volume rate of heat production at the center of the sphere, and 'b' is a dimensionless positive constant. Show that the temperature profile is obtained from the following expressions:	**20**	**CO4**

	$T^{(F)} = \frac{S_{n0}R^{(F)2}}{6k^{(F)}}\left\{\left[1-\left(\frac{r}{R^{(F)}}\right)^2\right]\right\}+\frac{3}{10}b\left[1-\left(\frac{r}{R^{(F)}}\right)^4\right]+\frac{S_{n0}R^{(F)2}}{6k^{(C)}}\left(1+\frac{3b}{5}\right)\left(1-\frac{R^{(F)}}{R^{(C)}}\right)$ $T^{(F)} = \frac{S_{n0}R^{(F)2}}{3k^{(C)}}\left(1+\frac{3b}{5}\right)\left(\frac{R^{(F)}}{r}-\frac{R^{(F)}}{R^{(C)}}\right)$		

APPENDIX

1. CNGA Equation:

$$z = \frac{1}{\left[1+\frac{\left(P_{av}\times 344,400\times 10^{1.785G}\right)}{T_f^{\,3.825}}\right]}$$

2. Colebrook – White Equation:

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

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. Slope factor to be used in Generalized Flow Equation (USCS Units)

$$L_e = L\left(\frac{e^s-1}{s}\right); \qquad s = 0.0375G\left(\frac{H_2-H_1}{T_f Z}\right)$$

$$j_i = \left(\frac{e^{s_i}-1}{s_i}\right); \qquad L_e = j_1L_1 + j_2L_2e^{s_1} + j_3L_3e^{s_2}\ldots.$$

5. **Equivalent Diameter**

$$D_e = D_1 \left[\left(\frac{1+K}{K} \right)^2 \right]^{1/5} \quad ; \quad K = \left(\left(\frac{D_1}{D_2} \right)^5 \left(\frac{L_2}{L_1} \right) \right)^{0.5}$$

6. **Shell MIT Equations**

i. **Reynolds No. :** $R = 353678 \times \left(\frac{Q}{\nu D} \right)$

ii. **Modified Reynolds Number :** $R_m = \frac{R}{7742}$

iii. **Friction factor for laminar flow:** $f = \frac{0.00207}{R_m}$

iv. **Friction factor for turbulent flow :** $f = 0.0018 + 0.00662 \left(\frac{1}{R_m} \right)^{0.355}$

v. **Pressure drop in crude oil pipelines:** $P_m = 6.2191 \times 10^{10} \times \left(\frac{f \times S_g \times Q^2}{D^5} \right)$

Where, Q= m^3/hr.; D= mm; Pm= kPa/km; ν =cSt

vi. **Reynolds Number for gases in USCS:** $\mathrm{Re} = 0.0004778 \left(\frac{P_b}{T_b} \right) \left(\frac{GQ}{\mu D} \right)$