Roll No.													

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST 1

Sem: Odd Sem 2019-20
Course Code: PET 221
Course Name: DRILLING FLUID AND CEMENTS
Program & Sem: B.Tech (PET) & III

Date: 01.10.2019
Time: 11.00AM to 12.00PM
Max Marks: 40
Weightage: 20%

Instructions:

(i) *Read the question properly and answer accordingly.*
(ii) *Scientific and Non-programmable calculators are permitted*

Part A [Memory Recall Questions]

Answer the Questions. The Questions carries ten marks. **(1Qx10M=10M)**

1. Answer in short (Q.NO.i to x)(C.O.NO.1) [Knowledge]

i. Which property of Drilling fluid is important for proper "Hole cleaning"?
ii. For a drilling fluid yield of clay is 157, then how many bbl of Drilling fluid of 15cP you can prepare from 2000lb of Dry Clay.
iii. Draw a Hoffman's structure.
v. What is value of Zeta potential in the bulk solution?
v. Write any two service provider in Oil industry.
vi Arrange the following cation in the increasing order of BEC: $AlCl_3$, $BaSO_4$, KCl, H_2O, $NaCl$, $LiCl$, $CaCO_3$
vii. What is Peptization?
viii. Why Bentonite is preferred over Attapulgite for Drilling fluid preparation?
ix Write one disadvantage of Pneumatic drilling fluid.
x. Attapulgite belongs to which class of clay?

Part B [Thought Provoking Questions]

Answer all the Questions. Each Question carries two marks. **(2Qx5M=10M)**

2. "C-spacing increases in during crystalline swelling"-Explain.
(C.O.NO.1)[Comprehension]
3. Why mud weight is one of the major parameter of drilling fluid?
(C.O.NO.1)[Comprehension]

4. What are the layers formed around a clay particle when it is kept in a electrolytic solution. (C.O.NO 1)[Comprehension]
5. What are the different particle association observed in Drilling fluid? (C.O.NO.1)[Comprehension]
6. What is API? Convert 60 Specific gravity to API gravity. (C.O.NO.1)[Comprehension]

Part C [Problem Solving Questions]

Answer both the Questions. Each question carries ten marks. (2Qx10M=20M)

7. A wild cat well was drilling near VB-1, Itgalpura. As per the report from Head geologist "Mr S" the formation available are shown in the diagram

Age		Group	Formation
Pleistocene		Alluvium	
TERTIARY	Pliocene	Dihing Group	Dhekiajuli Formation
	Miocene	Dupitila Group	Namsang Formation
		Tipam Group	Girujan Formation
			Tipam Formation
	Oligocene	Barail Group	Argillaceous Unit
			Arenaceous Unit
	Eocene	Jaintia Group	Kopili Formation
			Sylhet Formation
	Palaeocene		Langpar Formation
Pre Cambrian		Basement	

The different characteristics of each formation is as follows [1 bar=14.5 Psi]

Formation	Pressure (Bar)	Characteristics
Dhekiajuli	17	Loose formation
Namsang	100	Aquifer near by
Girujan Argillaceous and Arenaceous	200-300 (expected)	Shale sensitive
Kopili and Sylhet	200	Abnormal Pressure
Langpur	690	UHPHT

Based on your knowledge design a mud plan for all five formation and give justification to the answer. Also calculate the mud weight (ppg) required. (C.O.NO 1) [Knowledge]

8. Compare both Aqueous and Non aqueous Drilling fluid. (C.O.NO.1)[Application]

Annexure- II:

SCHOOL OF ENGINEERING

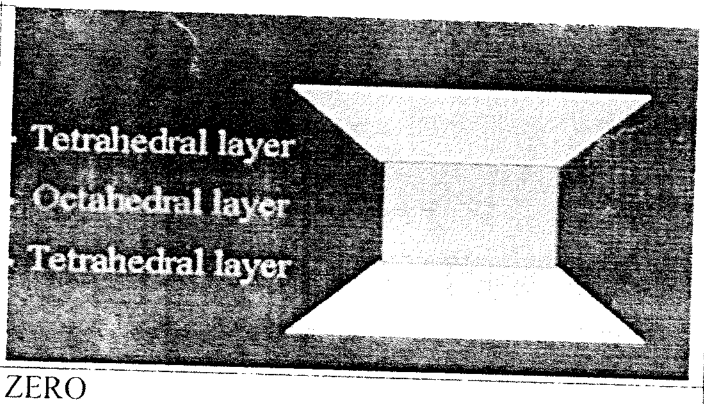
SOLUTION

Semester: 3rd
Course Code: PET 221
Course Name: Drilling Fluid and Cements

Date: 1/10/2019
Time: 11 AM to 12 PM
Max Marks: 40
Weightage: 20%

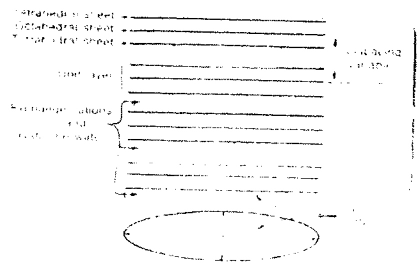
Part A

(1Qx10M=10)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1 a	Gel strength	1	2 min
1 b	157	1	2 min
1 c		1	2 min
1 d	ZERO	1	2 min
1 e	Schlumberger/Weatherford	1	2 min
1 f	$LiCl < NaCl < KCl < CaCO_3 < BaSO_4 < AlCl_3 < H_2O$	1	2 min
1 g	Pentization is also called as Deflocculation.It is the breaking of Edge to face association of clay plates	1	2 min
1 h	Because bentonite has better CEC and colloidal properties	1	2 min
1j	Its is an underbalance condition so here chances of blow out is more	1	2 min

Part B

(5Qx2M=10)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
2	In case of crystalline swelling due to the presence of bigger size ions in the inner layer two unit cell separated from each other so c-spacing increases 	1	4 min
3	• Mud weight is important because it is used to measure HH given by the Drilling fluid • Without proper HH Drilling fluid will fail to give sufficient amount of counterbalance to FP • It will lead to Kick or blowout	2	4 min
4	STERN LAYER AND DIFFUSED Layer	2	4 min
5	1. Flocculation 2. Deflocculating 3. Aggregation 4. Dispersion	2	4 min
6	API: AMERICAN PETROLEUM INSTITUTE 10 API GRAVITY	2	4 min

Part C

(2Qx10M=20)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
7	• Since Dhekiajuli formation is weak so it is recommended to use pneumatic drilling fluid. Based on the formation pressure required mud weight is 3.16 ppg [FP=HH=0.052*Mud Weight*depth] • Namsang formation has an aquifer nearby so it is recommended to use Native mud. If we add polymer it has the potential to contaminate the aquifer. Expected mud weight is 7.967 ppg [FP=HH=0.052*Mud Weight*depth] • Girujan has an abnormal pressure zone. So if is recommended to use high density mud by adding	2+2+2+2+2	10 min

	Barite. Considering maximum FP expected mud weight is 16.7 ppg[FP=HH=0.052*Mud Weight*depth] • Kopili has a clay sensitive zone. So it recommended to use either 100% Oil based mud or KCl polymer based mud. Expected mud weight 8.57 ppg[FP=HH=0.052*Mud Weight*depth] • Borial is a HPHT formation so it is recommended to used OBM or WBM with thermally stable polymer like Lignosulphonate. Expected mud weigh 17.4 ppg[FP=HH=0.052*Mud Weight*depth]		
8	OBM vs. WBM i. OBM has more environmental concern ii. OBM is preferred in HPHT well as it is thermally stable iii. OBM is preferred in a clay sensitive zone as it has less water content iv. OBM has less tendency to corrode downhole equipment v. OBM has more lubricity capacity vi. In OBM oil is continuous phase where WBM water is the continuous phase vii. WBM has better hole cleaning property viii. Fluid loss is more in OBM ix. Hole stability is better in case of WBM because better mud cake x. In offshore drilling WBM is preferred over OBM	1*10=10	10 min

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PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST – 2

Sem & AY: Odd Sem 2019-20 **Date**: 19.11.2019

Course Code: PET 221 **Time**: 11 AM to 12 PM

Course Name: DRILLING FLUID AND CEMENTS **Max Marks**: 40

Program & Sem: B.Tech. (PET) & III Sem **Weightage**: 20%

Instructions:

(i) Read the question properly and answer accordingly.

(ii) Scientific and Non-programmable calculators are permitted.

Part A [Memory Recall Questions]

Answer all the Questions. Each question carries three marks. (5Qx3M=15M)

1. Define viscosity. What is its SI unit? What is the significance of negative sign of velocity gradient for a fluid flowing through a horizontal pipe? (C.O.NO.2)[Knowledge]
2. What is purpose of adding inert phase and reactive phase in drilling fluid? (C.O.NO.2)[Knowledge]
3. What is Yield Point and Plastic viscosity? What are their units? (C.O.NO.2)[Knowledge]
4. What is Reynolds's Number? What is its unit? Based on Reynolds's number what are different classification of fluid flow? (C.O.NO.2)[Knowledge]
5. What are the different additive we used in Drilling fluid? Give example. (C.O.NO.2)[Knowledge]

Part B [Thought Provoking Questions]

Answer both the Questions. Each question carries five marks. (2Qx5M=10M)

6. Write three advantages and two disadvantages of Aphron based drilling fluid. (C.O.NO.2)[Comprehension]
7. Based on your knowledge write two conditions where the following muds can be used
   a. Oil based mud
   b. KCl/Polymer based mud (C.O.NO.2)[Comprehension]

Part C [Problem Solving Questions]

Answer all the Questions. Each question carries five marks. **(3Qx5M=15M)**

8. Write five challenges we faced regarding drilling fluid in HPHT environment. (C.O.NO.2)[Application]
9. The effective viscosity of the drilling fluid using Marsh funnel equation was found to be 30 cP in 50 seconds. Calculate the density of the drilling fluid obtained from Marsh Funnel experiment. (C.O.NO.2)[Application]
10. Two sack of clay is mix with water to prepare a Native mud of density15 ppg. In order to increase the density of the drilling fluid Fly ash (Density 30ppg) is added to the drilling fluid. The new density of the drilling fluid is 20 ppg. Determine the volume of clay mix initially to prepare the sample. [1Sack=94 lb] (C.O.NO.2)[Application]

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

Semester: 3rd

Course Code: PET 221

Course Name: Drilling Fluid and Cements

Date: 19/11/2019

Time: 11 AM to 12 PM

Max Marks: 40

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	2	Unit-2	3									3
2	1	Unit-1	3									3
3	2	Unit-2	3									3
4	2	Unit-2	3									3
5	2	Unit-2	3									3
6	1	Unit-1				5						5
7	1	Unit-1				5						5
8	1	Unit-1							5			5
9	2	Unit-2							5			5
10	2	Unit-2							5			5
	Total Marks		15			10			15			40

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II:

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SOLUTION

Date: 19/11/2019

Semester: 3rd

Time: 11 AM to 12 PM

Course Code: PET 221

Max Marks: 40

Course Name: Drilling Fluid and Cements

Weightage: 20%

Part A **(5Qx3M=15)**

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	Viscosity is the resistance to flow. SI unit of viscosity Pa.S. Negative sign means as radius increases velocity decrease.	1+1+1	3
2	Reactive phase is use to give rheologial properties and inert phase is use to improve mud density	1.5+1.5	3
3	YP is the minimum shear stress after which deformation starts. Unit lb. /100 sq. ft. PV is the slop of Shear stress vs. Shear rate plot. Unit cP	1.5+1.5	3
4	A dimensionless number used in fluid mechanics to indicate whether fluid flow past a body or in a duct is steady or turbulent. It has no unit. Laminar flow/Transient flow/Turbulent flow	1+1+1	3
5	Different additive use in Drilling fluid are, a. Mud thinners: Starch/Lignosulphonate b. Mud thickeners: CMC/Xanthan Gum/Guar Gum	1.5+1.5	3

Part B **(2Qx5M=10)**

Q No	Solution	Scheme of Marking	Max. Time required for each Question
6	Advantage of Aphron Based Drilling fluid a. Can be used to drill weak formation where possibility of fracture is more b. Suitable for low pressure reservoirs c. It is preferable for loss circulation zone	3+2	5

	Disadvantage of Aphron Based Drilling fluid a. Instability of air bubbles b. Hole instability		
7	a. Oil based muds can be used in HPHT environment and Shale sensitive zones b. KCl/Polymer mud can be used in Shale sensitive zones and Formation with high Ca contamination	2.5+2.5	5

Part C **(3Qx5M=15)**

Q No	Solution	Scheme of Marking	Max. Time required for each Question
8	Problems we face while drilling a HPHT well are • Thinner can't work efficiently because of contamination which reduces the pH level of mud. • Bentonite also starts to flocculate the mud more causes poor hole cleaning, low drill cuttings carrying capacity, fill, stuck pipe etc., • Owing to increasing temperature, the continuous reaction between electrolytes and inhibitors in the mud, the degree of dispersion & flocculation is also continuously changing which leads the mud unstable. • Once the mud is degraded, excessive fluid loss may happen which makes thicker mud cake and bore hole becomes much tight. So dragging becomes difficult. • Gel strength of the mud is increased uncomfortably which may lead to loss of circulation. • Water based mud is highly shale sensitive which leads to unstable the well condition by the form of sloughing. Because Water absorbs the clay and start to swell the well bore.	5	10
9	***Given data:*** $\mu_e =$ effective viscosity $= 30\ cp$ $t_m =$ time $= 50\ sec$ ***Required data:*** $\rho_m =$ mud density, g/cm^3 The density of the drilling fluid can calculated using the Eq. (3.8) as: $\rho_m = \frac{\mu_e}{(t_m - 25)} = \frac{30}{(50-25)} = \mathbf{1.2\ g/cm^3}$	5	10
10	2 Sack=188 lb 188/V1=30(20=15)/(30-20) V1=12 Intitial volume of clay=12.53 gal	5	10

Roll No												

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester: 2019 - 20 | **Date**: 27 December 2019

Course Code: PET 221 | **Time**: 1:00 PM to 4:00 PM

Course Name: DRILLING FLUID AND CEMENTS | **Max Marks**: 80

Program & Sem: B.Tech (PET) & III | **Weightage**: 40%

Instructions:

(i) Read the all questions carefully and answer accordingly.

(ii) Scientific and Non-programmable calculators are permitted

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries 1 marks. **(1Qx20M=20M)**

1. Give short answer to the following

i. The most commonly used cement is Class ___________.(Fill up the blanks) (C.O.No.4) [Knowledge]

ii. The stability of Aphron based drilling fluid in HPHT environment is _________ (high/less). (Fill up the blanks) (C.O.No.1) [Knowledge]

iii. Starch is a mud __________________.(Fill up the blank) (C.O.No.2) [Knowledge]

iv. HEC stands for __________________. (Fill up the blank) (C.O.No.2) [Knowledge]

v. Lignosulphonate mud is stable up to temperature ______________degree F. (Fill up the blanks) (C.O.No.2) [Knowledge]

vi. What is the other name for Shear rate? (C.O.No.2) [Knowledge]

vii. Slope of Shear stress and Shear rate graph for a Bingham plastic fluid is called ________. (Fill up the blanks) (C.O.No.2) [Knowledge]

viii. Give two example of cement density inducing agents. (C.O.No.4) [Knowledge]

ix. What is shoe track? (C.O.No.4) [Knowledge]

x. Which central atom present in a tetrahedral lattice structure of a montmorilonite clay? (C.O.No.1) [Knowledge]

xi. What is the unit of YP? (C.O.No.1) [Knowledge]

xii. What is the other name for marsh funnel viscosity? (C.O.No.2) [Knowledge]

xiii. What is the commercial name for $2CaOAl_2O_3Fe_2O_3$? (C.O.No.4) [Knowledge]

xiv. What is the other nane for stage cementer? (C.O.No.4) [Knowledge]

xv. What is the percentage of water in Emulsion based mud? (C.O.No.1) [Knowledge]

xvi. Give one example of montmorilonite clay. (C.O.No.1) [Knowledge]

xvii. What is the CEC value for Attapulgite? (C.O.No.1) [Knowledge]

xviii. Which one is the most commercially used Bentonite? (C.O.No.1) [Knowledge]

xix. What is the distance between different layers in octahedral sheet?

(C.O.No.1) [Knowledge]

xx. What is the purpose of adding inert phase in Drilling fluid? (C.O.No.2) [Knowledge]

Part B [Thought Provoking Questions]

Answer all Questions. Each Question carries 6 marks. (5Qx6M=30M)

2. Give proper justification for ***any three*** of the following statements:

   a. *"Reynolds's number more than 3000 is preferred for a drilling fluid prior to a cementing job"*

   (C.O.No.2) [Comprehension]

   b. *"For a drilling fluid having nano size clay particles has a thin size mud cake as well as less amount of filtrate loss"* (C.O.No.1) [Comprehension]
   c. *"A mud cleaner should be used for weighted mud"* (C.O.No.3) [Comprehension]
   d. *"A spacer fluid should be used ahead of a cement slurry."*

   (C.O.No.4) [Comprehension]

3. Give your solution for the ***any three*** of the following problems

   a. *"While Drilling a highly porous and permeable formation we encounter a high filtrate loss"* (C.O.No.1) [Comprehension]
   b. *"One of the major reason for Deep water horizon blow is poor cementation job."* (C.O.No.4) [Comprehension]
   c. *"While displacing cement behind the casing sometime there may be some space left out through which fluids may migrate"* (C.O.No.4) [Comprehension]
   d. *"Formation damage in a shale sensitive formation."* (C.O.No.2) [Comprehension]

4. Do a comparative study of Aqueous and Non Aqueous based Drilling fluid.

   (C.O.No.2) [Comprehension]

5. What are the precautions to be taken while preparing Drilling fluid for HPHT well?

   (C.O.No.2) [Comprehension]

6. What are the advantages and disadvantages of Aphron based drilling fluid.

   (C.O.No.1) [Comprehension]

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

END TERM FINAL EXAMINATION

Extract of question distribution [outcome wise & level wise]

Q. NO.	C.O.NO (% age of CO)	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels	Thought provoking type [Marks allotted] Bloom's Levels	Problem Solving type [Marks allotted]	Total Marks
			K	C	A	
1	1, 2, 3 & 4	1, 2, 3 & 4	20			20
2	1, 2, 3 & 4	1, 2, 3 & 4		6		6
3	2, 3 & 4	2, 3 & 4		6		6
4	2	2		6		6
5	2	2		6		6
6	1	1		6		6
7	4	4			15	15
8	4	4			15	15
	Total Marks		20	30	30	80

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I hereby certify that all the questions are set as per the above guidelines.

Faculty Signature: Bhairab Ch. Gogoi

Reviewer Commend:

Format of Answer Scheme

SCHOOL OF ENGINEERING

SOLUTION

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

Semester: Odd Sem. 2019-20
Course Code: PET 221
Course Name: Drilling Fluid and Cements
Program & Sem: Petroleum & 3rd Sem

Date: 16.12.2019
Time: 1PM to 4 PM
Max Marks: 80
Weightage: 40%

Part A (1Q x 20M = 20Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question (min)
1 i	H	1	2
1 ii	Less	1	2
1 iii	Thickener	1	2
1 iv	Hydroxyl ethyl cellulose	1	2
1 v	300	1	2
1 vi	Velocity gradient	1	2
1 vii	Plastic Viscosity	1	2
1 viii	Barite & Lignite	1	2
1 ix	Distance between float collar and guide shoe	1	2
1 x	Si	1	2
1 xi	lb./100 sq. ft.	1	2
1 xii	Effective viscosity	1	2
1 xiii	C_2AF	1	2
1 xiv	DV Tool	1	2
1 xv	5-10 %	1	2
1 xvi	Bentonite	1	2
1 xvii	5-99 mili equivalent	1	2
1 xviii	Wyoming Bentonite	1	2
1 xix	9-15 Angstrom	1	2
1 xx	To improve mud weight	1	2

Part B			(5Q x 6M = 30 Marks)
Q No	**Solution**	**Scheme of Marking**	**Max. Time required for each Question**
2	a. Reynolds number is more than 3000 means it is a turbulent flow. Whenever we cements a casing there must have a direct bond between Casing and the formation. As we know that while drilling a mud cake is formed against the permeable formation. So we need to remove the mud cake prior to a cementing job. A turbulent flow help us to remove the mud cake. b. When small size particles are kept together the void space left is less compared to larger size particles. So whenever we prepare drilling fluid with nano size clay particles so the mud cake thickness will be less and permeability also less so less amount of filtrate will escape into the formation. c. A hydro cyclone can't be used for weighted mud since it remove the barite. So we need to find an alternate. A mud cleaner to be used where the removed barite can be reuse. d. A spacer fluid separate Drilling fluid and Cement slurry. If Drilling fluid mixed with cement it will contaminate both. So with contamination the properties will degrade.	2+2+2	15
3	a. In highly porous and permeable formations we can add mud thickener or viscosifier to increase the viscosity of the mud which will prevent the fluid loss. Otherwise we can plug those loss circulation formation by injecting cements and then we can drill the next hole section. b. One of the major reason of Deep water horizon blowout is poor evaluation of the cementing job. If the leak of test was run properly they could have identify about the well integrity. c. If any space is left out behind casing while cementing then immediately we have to perform a squeeze cementing job and fill those gaps. d. In shale sensitive zone either we can use KCl/Polymer based drilling fluid or OBM as these zones are sensitive to water.	2+2+2	15
4	Aqueous (OBM) vs. Non aqueous (WBM) i. OBM has more environmental concern ii. OBM is preferred in HPHT well as it is thermally stable iii. OBM is preferred in a clay sensitive zone as it has less water content iv. OBM has less tendency to corrode downhole equipment v. OBM has more lubricity capacity vi. In OBM oil is continuous phase where WBM water is the continuous phase vii. WBM has better hole cleaning property viii. Fluid loss is more in OBM ix. Hole stability is better in case of WBM because better mud cake x. In offshore drilling WBM is preferred over OBM	6 points; 6 marks	15
5	Where possible, high temperature wells are drilled with oil-based fluids (OBFs) or synthetic-based fluids (SBFs), because of the thermal limitations of most water-based fluids (WBFs). Such limitations of WBFs include: Temperature-induced gelation High risk of CO2 contamination from the formation being drilled and/or from the degradation of organic mud additives Increased solids sensitivity that is related to high temperatures Historically, WBFs have relied on bentonite clay for both rheology and filtration control. When tested at temperatures ≥ 300°F under laboratory	6 points; 6 marks	15

	conditions, bentonite slurries begin to thermally flocculate. Under HP/HT conditions with significantly elevated temperatures, a traditional WBF such as the lignosulfonate system might thicken so much that it no longer is usable or requires drastic and costly dilution and conditioning. The ability to maintain bentonite and other active solids in a deflocculated state is the key to obtaining acceptable rheological and fluid-loss properties for WBFs exposed to high temperatures. Bentonite can be used in relatively low concentrations, if it is supplemented with a high-temperature, high-molecular-weight synthetic polymer for additional carrying capacity. This combination helps to make it possible to maintain 6% by weight of low-gravity solids and a particle-size-distribution (PSD) of these solids in an acceptable micron range. Adding polymeric deflocculant at depths where elevated temperatures are expected assists in rheology control. An HP/HT viscometer typically is used to monitor the temperature stability of the drilling fluid, and to evaluate its rheological properties at up to 500°F and 20,000 psia. This test is especially useful for determining whether high-temperature flocculation occurs in water-based muds. The test results can be presented graphically by plotting the change in viscosity with respect to temperature over the heating and cooling cycle, which establishes a baseline for recognizing indicators of temperature instability. There are a number of ways to minimize problems with temperature gelation, including: Eliminating lignite and lignite derivatives from the WBF formulation Lowering the bentonite concentration Supplementing the high-temperature water-based system with synthetic polymers and copolymers OBFs and SBFs are subject to temperature thinning. Surface density should be corrected on the basis of downhole pressure data from a PWD tool. Hydraulics-modeling software that accurately accounts for fluid compressibility and the effect of temperature can improve the performance of the SBF system by allowing more precise surface conditioning.		
6	Advantage of Aphron Based Drilling fluid a. Can be used to drill weak formation where possibility of fracture is more b. Suitable for low pressure reservoirs c. It is preferable for loss circulation zone Disadvantage of Aphron Based Drilling fluid a. Instability of air bubbles b. Hole instability c. Underbalance condition	6 points; 6 marks	15

Part C (2Q x 15M = 30Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
7	Stage cementing Stage cementing is used to ensure annular fill and seal across selected intervals whenever none of the following cementing applications can be performed: Continuous single-stage Lead and tail Lightweight (foamed, ceramic spheres, etc.) Stage cementing tools	Diagram 4 mark Leveling 2 mark Explanation 9 mark	30

Stage-cementing tools, or differential valve (DV) tools, are used to cement multiple sections behind the same casing string, or to cement a critical long section in multistages. Stage cementing may reduce mud contamination and lessens the possibility of high filtrate loss or formation breakdown caused by high hydrostatic pressures, which is often a cause for lost circulation.

Stage tools are installed at a specific point in the casing string as casing is being run into the hole. The first (or bottom) cement stage is pumped through the tool to the end of the casing and up the annulus to the calculated-fill volume (height). When this stage is completed, a shutoff or bypass plug can be dropped or pumped in the casing to seal the stage tool. A free-falling plug or pumpdown dart is then used to hydraulically set the stage tool and open the side ports, allowing the second cement stage (top stage) to be displaced above the tool. A closing plug is used to close the sliding sleeve over the side ports at the end of the second stage and serves as a check valve to keep the cement from U-tubing above and back through the tool.

Displacement stage cementing

The displacement stage-cementing method is used when the cement is to be placed in the entire annulus from the bottom of the casing up to or above the stage tool. The displacement method is often used in deep or deviated holes in which too much time is needed for a free-falling plug to reach the tool.

Fluid volumes (mud, spacer, cement) must be accurately calculated and prepared on locations and densities closely measured to prevent over- or underdisplacement of the first stage.

Overdisplacement can result in improper opening of the tool to apply the second (upper) stage, resulting in excess pressures or job failure. Underdisplacement creates a gap (void) in the cement column at the stage tool, which results in poor zonal isolation.

Two-stage cementing

Two-stage cementing is the most widely used multiple-stage cementing technique. However, when a cement slurry must be distributed over a long column and hole conditions will not allow circulation in one or two stages, a three-stage method can be used. The same steps are involved as in the two-stage methods, except that there is an additional stage. Obviously, the more stages used in the application, the more complicated the job will become. Although stage cementing was very popular many years ago, new foamed-cement and nonfoamed-ultralightweight-cement technologies have successfully reduced the need for multistage cementing in many operations.

Inner-string cementing

When large-diameter pipe is cemented, tubing or drillpipe is commonly used as an inner string to place the cement. This procedure reduces the cementing time and the volume of cement required to bump the plug. The technique uses modified float shoes, guide shoes, or baffle equipment, with sealing adaptors attached to small-diameter pipe. Cementing through the inner string permits the use of small-diameter cementing plugs. If the casing is equipped with a backpressure valve or latchdown baffle, the inner string can be disengaged and withdrawn from the casing as soon as the plug is seated, while preparations are made to drill deeper.

Outside or annulus cementing
A method commonly used on conductor or surface casing to bring the top of the cement to the surface consists of pumping cement through tubing or small-diameter pipe run between casings or between the casing and the hole. This method is sometimes used for remedial work. Casing can suffer damage when gas sands become charged with high pressure from surrounding wells. In such instances, cementing the annulus between strings through a casinghead connection can repair the casing.

Reverse-circulation cementing
The reverse-circulation cementing technique involves pumping the slurry down the annulus and displacing the drilling fluid back up through the casing. The float equipment, differential fill-up equipment, and wellhead assembly must be modified. This method is used when the cement slurry cannot be pumped in turbulent flow without breaking down the weak zones above the casing shoe. Reverse circulation allows for a wider range in slurry compositions, so heavier or more-retarded cement can be placed at the lower portion of casing, and lighter or accelerated cement can be placed at the top of the annulus. Caliper surveys should be made before the casing is run, to determine the necessary volume of cement and minimize over placement.

Delayed-set cementing
Delayed-set cementing involves placing a retarded cement slurry containing a filtration-control additive in a wellbore before running the casing. This method can help to obtain a more uniform sheath of cement around the casing than may be possible with conventional methods.

The cement is placed by pumping it down the drillpipe and up the annulus.
The drillpipe is then removed from the well, and casing or liner is sealed at the bottom and lowered into the unset cement slurry.
After the cement slurry is set, the well can be completed with conventional methods.
Delayed-set cementing application
This technique has been used in tubingless-completion wells by placing the slurry down one string and lowering multiple tubing strings into the unset cement. When the casing is run into the cement slurry, drilling fluid left in the annulus mixes with the cement slurry. Although not ideal, this development is preferred to leaving the drilling fluid in the annulus as a channel or pocket. The delayed-set cement slurry allows protracted reciprocation of the casing string, which is more likely to ensure a uniform cement sheath.

Delayed-set cementing disadvantage
A disadvantage to delayed-set cementing is the increased water/oil-contact (WOC) time, which could be expensive if a drilling rig is kept on location while the cement sets and gains strength. If the drilling rig can be moved off location and a workover rig can complete the well, the cost can be reduced.

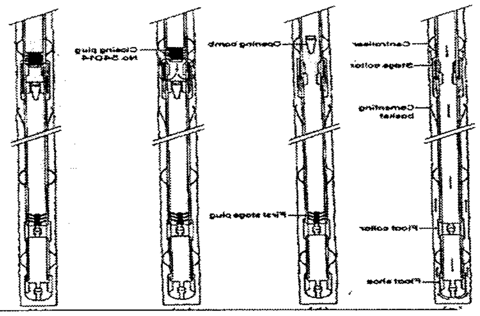
Multiple-string cementing
Multiple-casing completions are used when single or conventional completions are not economically attractive. When multiple strings are placed in a well, each string is usually run independently, and the

longest string is landed first. The first string is set in the hanger and is circulated before the second string is run. After the second string is landed in the hanger, it is circulated while the third string is run. In areas where lost circulation is a known problem, cement can be placed through the longest casing string. Once the cement fill-up has been established, the remainder of the hole is filled with cement slurry through a shorter string.

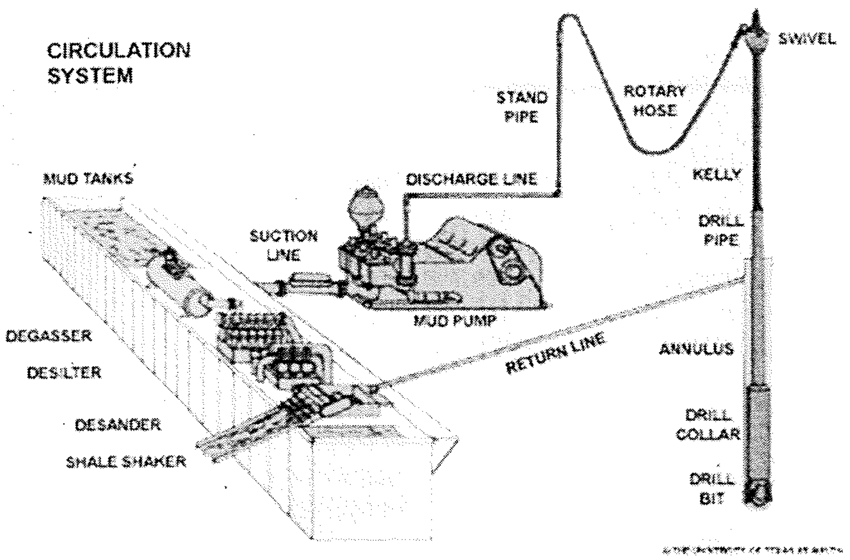
Centralizers are frequently used, one per joint from 100 ft above to 100 ft below productive zones. Other casing equipment in these small-diameter holes includes landing collars for cement wiper plugs, full-opening guide shoes, and limited-rotating scratchers for single completions. All float equipment, centralizers, and scratchers should be able to pass the hanger assembly in the casinghead.

Other factors considered in the design of cement slurry are similar to those considered in the design of slurry for a single string of pipe. The cement is usually pumped down the longest strings simultaneously, although this is not mandatory. The idle strings may be pressured to 1,000 to 2,000 psi during cementing to safeguard against:

Leakage
Thermal buckling
Collapse



OR



Drilling mud is a important part for the drilling work to maintain the wellbore; Cool, lubricate and support the bit and drilling and so on and most important remove cuttings well. Then here it problem, to reuse the drilling mud. Then it is the time for mud circulating system to come here.

In some applications, the mud circulating system is equal to solids control system, but the full mud circulating system in drilling work, contains more. Except for the four phase, five equipments as we know, shale shaker, vacuum degasser, desander and desilter (or mud cleaner), decanter centrifuge. There also include mud pump, electric generator, control panel, chemical reagent treatment unit, and so on.

As you can see in the picture. It is used for the movable drilling rig, and also this system is movable. Usuall solids control equipments can not prevent the loss of the drilling mud. So we also must add chemic to the t tanks to add fresh drilling fluids.mud circulating system Other parts are also very important, centrifugal pump, mud agitator, mud gun.

Drilling fluid is mixed in the mud pits and pumped by the mud pumps through the swivel, through the blow out preventer (not part of the circulation system) down the hollow drill pipe, through holes (Jet Nozzles) in the bit, up the annular space between drill pipe and wellbore (where it lifts the rock cuttings), to the surface, through the Solids Control Equipment (Shale Shaker, Desander, and Desilter), and back to the mud pits. A schematic of the circulation system is shown in Figure 9.05.

In this figure, fresh water-based drilling fluid (mud) is mixed with water from the Water Tank (not shown in Figure 9.05) and components from the Bulk Mud Components Storage (not shown in Figure 9.05) in the Mud Pit. The Mud Pumps then pump the mud through the swivel, kelly, kelly bushing, and rotary table down to the drill string.

The mud pumps on a typical drilling rig are either single-action or double-action Reciprocating (Positive Displacement) Pumps which may contain two pistons-cylinders (duplex pump) or three pistons-cylinders (triplex pump). Figure 9.06 shows schematics of a single piston-cylinder in (A) a single-action and (B) a double-action reciprocating pump.

In these pumps, the positive pressure and negative pressure (suction) in the cylinder cause the valves to open and close (note: the valves in the schematic are simple representations of the actual valves). Due to the high viscosity of the drilling fluid, the inlet side of the pump may require a Charge Pump to keep fluids moving into the cylinders at high pressures and to prevent Cavitation in the pump. From the mud pumps, the drilling fluid goes to the swivel, through the blow out preventer, and down the hollow drill string and bottom-hole assembly. The drilling fluid then goes through jet nozzles in the drill bit; at which point, it begins its return to the surface. The drilling fluid travels up the annular space between the drill pipe and the wellbore, picking up and carrying the drill cuttings up the hole.

Once the drilling fluid reaches the surface, it goes through the mud return line to the gas-mud separator and the solids control equipment. The shale shaker is where the large cuttings from the returning drilling fluid are removed. The shale shaker is a set of vibrating mesh screens that allow the mud to pass through while filtering out cuttings of different size at screen screen mesh sizes. A Mudlogger or a Well-Site Geologist may be stationed at the shale shaker to analyze the cuttings to determine the lithology of the rock and the depth within the Stratigraphic Column at which the well is currently being drilled.

The drilling fluid then passes through the Desander and Desilter. These are hydrocyclones which use centrifugal forces to separate the smaller solids from the drilling fluid. The desander typically removes solids with a diameter in the range of 45 – 74 μm, while the desilter removes solids with a diameter in the range of 15 – 44 μm.

The drilling fluid is then sent through a degasser to remove any gas bubbles that have been picked up during the circulation. These gasses may include natural gas from the subsurface or air acquired during the solids control. Typically, the degasser is a piece of equipment that subjects the drilling fluid to slight vacuum to cause the gas to expand for extraction. The drilling fluid is then returned to the mud pit to start the circulation process over again.

We have discussed the mechanics of how the drilling fluid is circulated during the drilling process, but we have not discussed the role of the drilling fluid. The term "mud" is often used in oil and gas well drilling because historically the most common water-based drilling fluids were mixtures of water and finely ground, bentonite clays which, in fact, are muds.

There are many objectives for using a drilling fluid. These include:

lift drill cuttings from the bottom of the wellbore to the surface;
suspend cuttings to prevent them from falling downhole if circulation is temporarily ceased;
release the cuttings when they are brought to the surface;
stabilize the borehole during drilling operations (exert hydrostatic or hydrodynamic pressure on the borehole to prevent rock caving into the wellbore);

	control formation pore pressures to assure desired well control (apply hydrostatic and hydrodynamic pressures in excess of the formation pore pressures to prevent fluids from entering the wellbore); deposit an impermeable filter cake onto the wellbore walls to further prevent fluids from permeable formations from entering the wellbore; minimize reservoir damage (assure low skin values) when drilling through the reservoir section of the well; cool the drill bit during drilling operations; lubricate the drill bit during drilling operations; allow for pressure signals from Logging While Drilling (LWD) or Measurement While Drilling (MWD) tools to be transmitted to the surface (LWD and MWD data are transmitted to the surface using pressure pulses in the drilling fluid); allow for pressure signals to be sent to the bottom of the well to pressure actuate certain downhole equipment; minimize environmental impact on subsurface natural aquifers. As I stated earlier, historically drilling fluids were mixtures of bentonite clay, water, and certain additives to manipulate the properties of the mud (density, viscosity, fluid loss properties, gelling qualities, etc.). Today, there are several different options available for drilling fluids. These include: water-based muds (WBM) oil-based muds (OBM) foams air Of the listed drilling fluids, the water-based muds and the oil-based muds are the most common; foam drilling and air drilling can only be used under specialized conditions. Of the two liquid based mud systems (water-based muds and oil-based muds), water-based muds are the most common mud system. They are more environmentally friendly and are used almost exclusively to drill the shallow portions of the well where fresh water aquifers exist to minimize any contamination to those aquifers. As this implies, drilling fluids can be – and often are – switched during the course of drilling operations in single well. In addition, water-based muds are cheaper than oil-based muds, so they are used to reduce drilling costs and commonly represent the "default" selection for a drilling fluid. In other words, water-based muds are often used unless there is a specific reason to switch to an oil-based mud. Oil-based muds are formulated with diesel oil, mineral oil, or synthetic oils as a continuous phase and water as a dispersed phase in an emulsion. In addition, additives such as emulsifiers and gelling agents are also used. They were specifically developed to address certain drilling problems encountered with water-based muds. The reasons for using an oil-based mud include: drilling through shales that are susceptible to swelling (in particular, highly smectite-rich shales). Shales contain a large amount of clay material and when these clays come in contact with the water in a water-based mud system, the clays may swell causing the shales to collapse into the hole. Smectite-rich shale formations are often referred to as "Gumbo" or "Gumbo Clays" in the drilling industry; reducing torque and drag problems in deviated wells. Since oil, a lubricant, is the continuous phase in the mud system, the torque and		

	drag between the drill pipe and the wellbore is reduced with oil-based muds; achieving greater thermal stability at greater depths. Oil-based muds have been found to retain their stability (retain their desired properties) at greater down hole temperatures; achieving greater resistance to chemical contamination. Many substances found down-hole (salt, CO2, H2S, etc.) are soluble in water. The introduction of these substances into the water-based mud system may have a deleterious impact on different mud properties (density, viscosity, fluid loss properties, gelling properties, etc.). These substances are not soluble in oil and, therefore, have will not impact oil-based mud properties. The first three bullet points in this list are becoming more common problems in the oil and gas industry. The shale boom in the U.S. has made long horizontal sections in shale reservoirs targets for drilling. In addition, deviated wells and deeper wells are also becoming more common. For these reasons, the use of oil-based muds is also becoming more common. There are also several disadvantages with oil-based muds. These include: high initial costs. Often in an active drilling campaign, if certain depth intervals require an oil-based mud, the mud is stored and reused in different wells; slow rates of penetration. Historically, the rate of penetration has been statistically slower for oil-based muds than it is for water-based muds. The rate of penetration is the speed at which the drilling process progresses (depth versus time) and is a function of many factors other than mud type, including: weight on bit, RPM, lithologies being drilled through, bit type, bit wear, etc.; environmental concerns: oil contamination of subsurface fresh water aquifers, cleaning and disposal of oil contaminated rock cuttings; kick detection. If gas enters the wellbore (a Kick), it may go into solution in the oil in deeper, higher pressure sections of the well and come out of solution closer to the surface; formation evaluation. Some readings from well logs or core analysis may be sensitive to oil entering the formation of interest (for example, if oil from the oil-based mud enters the reservoir in the near-well vicinity, then tools used to detect oil saturation may read artificially high). Other drilling fluids currently in use that were listed earlier are foams and air. In the context of drilling fluids, foams have the consistency of shaving cream. Both foam and air drilling are used in hard rock regions, such as in the Rocky Mountains, where drill bits render the drill cuttings to dust. Thus, the foam or air only needs to lift this dust to the surface. Air drilling is always an environmentally friendly option if it is applicable because environmental contamination by air is never an issue.		
8	a. Weight of the cement: 94 lb Volume of cement: 94/26.18=3.59 gal Weight of water: 42.4 lb Volume of water: 42.3/8.33=5.08 gal Density of the cements slurry is: (94+42.3)/(3.59+5.08)=15.72 ppg	a. 5 marks b. 1.5+1.5 c. 2+1.5+1.5+2	

	b. PV=236-176=60 cP YP=176-60=116 lb/100 sq feet c. Volume of the annulus: 163 cf Volume of the open hole; 2010.64 cf Total volume of cements required: (2010.64+ 163) cf =2173.64 cf = 16258.8272 gal No of sack calculation: 2173.64/1.12=1940.75 sack Time required: 16258.83/200=81.29 min		

Part C [Problem Solving Questions]

Answer both the Questions. Each Question carries 15 marks. **(2Qx15M=30M)**

7. Explain multistage cementing with suitable diagrams. (C.O.No.4) [Application]

OR

Draw a flow chat of the entire mud circulatory system (both surface and subsurface. Write the operational procedure and function of each component. (C.O.No.3) [Application]

8. Solve the following problems

   a. The cement slurry was blended using the following data: i) one sack of class G cement, and ii) 45% fresh water. Determine the slurry density. (Density of Cement is 26.18 ppg)
   b. A rotational viscometer containing cement slurry gives a dial reading of 176 at a rotor speed of 300 RPM and a dial reading of 236 at a rotor speed of 600 RPM. Calculate plastic viscosity and yield point.
   c.

Estimate the slurry volume used to cement the 500 feet cement column in the casing schematic below.

Given,

- Production casing, 9 5/8" OD and 8.681" ID (61 lb/ft)
- Intermediate casing, 13 3/8" OD and 12.347" (54.5 lb/ft)

If hole size is 20" and the target depth is 800 feet then what will the total volume of cement required to fill the entire annulus outside Production casing? How many sacks of cement were used if slurry yield was 1.12 ft3/sack?
If the pumping rate is 200 gpm then what will be total time required to cement the annulus between Intermediate and Production casing.

(C.O.No.4) [Application]