Drilling Engineering Past Papers

Please note some questions in these past papers are no longer relevant, those questions have been highlighted in grey bold italics.

Course:- **28117**
Class:- **289053**

HERIOT-WATT UNIVERSITY
DEPARTMENT OF PETROLEUM ENGINEERING

Examination for the Degree of
MEng in Petroleum Engineering

Drilling Engineering

Thursday 7 January 1999
09.30 - 12.30

NOTES FOR CANDIDATES

1. This is a Closed Book Examination.

2. 15 minutes reading time is provided from 09.15 - 09.30.

3. Examination Papers will be marked anonymously. See separate instructions for completion of Script Book front covers and attachment of loose pages. Do not write your name on any loose pages which are submitted as part of your answer.

4. This Paper consists of 3 Sections:- A, B and C.

5. Section A:- Attempt 4 numbered Questions
   Section B:- ***Attempt 1 numbered Question***
   Section C:- Attempt 3 numbered Questions

6. Section A:- 32% of marks [8% per Question]
   Section B:- ***8% of marks***
   Section C:- 60% of marks [20% per Question]

   Marks for Question parts are indicated in [brackets]

7. This Examination represents 100% of the Class assessment.

8 State clearly any assumptions used and intermediate calculations made in numerical questions. No marks can be given for an incorrect answer if the method of calculation is not presented.

9. Answers must be written in separate, coloured books as follows:-

Section A:-	Blue
Section B:-	GreenSection
Section C:-	Yellow

Section A

A1

(a) List and describe the function of each of the component parts of the hoisting system on a conventional land drilling rig.

[5]

(b) Calculate the tension on the fast line and the dead line and the vertical load on the derrick when the following drillstring is pulled from the well.

Buoyant weight of string	150,000 lbs
Weight of travelling Block and hook	10,000 lbs
Number of Lines strung between crown and travelling block	8
Efficiency of sheave system	81.4%

[3]

A2

(a) Describe three reasons for using Drillcollars in the drillstring string.

[5]

(b) Calculate, using the tables provided in Attachment 1, the length of 9 1/2" x 2 13/16" drillcollars that would be required to ensure that the entire length of the following drillpipe string is in tension in 12 ppg mud:

8000 ft of 5" 19.5 lb/ft Grade G drillpipe with 4 1/2" IF connections.

[3]

A3

(a) Describe the mechanisms which result in an improvement in the "drillability" of an overpressured formation and which should be considered when calculating the "d" exponent.

[4]

(b) List and describe three other indicators, other than the "d" exponent, which might suggest that an overpressured shale had been encountered.

[4]

A4

(a) A milled tooth roller cone drillbit is pulled from the borehole and graded with the following grading (the IADC dull grading system is given in Attachment 2).

4 4 BT A F 1/8 PB PR

Discuss your interpretation of this grading and what features you would suggest should be considered in selecting the next bit to be run in the well.

[3]

(b) Calculate the cost per foot of the bit run on the basis of the following information:

COST (£)	DEPTH IN (FT.)	DEPTH OUT (FT.)	TIME ON BOTTOM (HR.)
3500	7100	7306	14.9

Assuming:
Trip Time = 8 hrs
Rig rate = £48000/day.

[2]

(c) In what ways is the cost per foot equation used when planning the well and during the well drilling operation

[3]

A5

(a) List the steps in the procedure for conducting a leak off test.

[2]

(b) The results from a Leak off test which has been conducted below the 9 5/8” casing shoe of a well are presented below. Calculate the maximum allowable mudweight which can be used in the hole section below the 9 5/8” casing shoe:

TVD of 9 5/8" Shoe	:	6500 ft.
Mudweight in hole	:	10 ppg

Vol. pumped bbls	Surface Pressure psi
0.5	30
1.0	110
1.5	205
2.0	295
2.5	390
3.0	475
3.5	570
4.0	655
4.5	760
5.0	800
5.25	820

[4]

(c) Calculate the MAASP for the subsequent hole section when the mud weight is 11 ppg.

[2]

A6

(a) List and briefly describe three of the warning signs that a driller should see if a gas influx had occurred downhole.

[4]

(b) Describe the operations which must be undertaken when a kick is detected whilst drilling.

[3]

(c) In the case of a gas influx, why must the well killing operation be started as soon as possible? [1]

Section B

B7 For a given depth, well orientation and rock type, it is usually possible to select a mud weight which is appropriate from a rock mechanics point of view, i.e. wellbore failure is prevented. Explain why this is possible, addressing all types of wellbore failure in your answer.

[8]

B8 Tests conducted on a rock type gave the following data:

Triaxial factor	*2.8*
In situ strength enhancement	*0.10MPa*
In situ unconfined compressive strength	*4MPa*

Determine the minimum mud weight required to prevent wellbore failure in this rock while drilling through it at 5000m depth with a vertical well, where the pore pressure is 60MPa and the stress ratio is 0.85. A data sheet (Attachment 5) is provided.

[8]

Section C

C9

(a) Describe the main factors which influence the pressure loss when circulating fluid through the drillstring and annulus when drilling?

[6]

(b) How is the onset of turbulence identified when using non-Newtonian drilling fluids in annuli?

[4]

(c) Select the optimum flowrate and nozzle sizes for the next bit run if prior to pulling a dulled bit from the hole the pressure losses in the circulation system are calculated to be as follows :

Flowrate GPM	Ptotal psi	Pbit psi	Pcirc. psi
860	4400	2400	2000
680	2890	1590	1300
500	1650	910	740
350	845	465	380

Density of Drilling Fluid = 0.65 psi/ft.
Maximum Pumping Pressure = 4700 psi

Note: i. Use the attached log-log paper and Table 1 and 2 (Attachment 3)

ii. $$\text{Nozzle Area} = \frac{Q_{opt}}{23.75}\sqrt{\frac{\rho_{mud}}{P_{max.} - P_{circ.opt.}}}$$

[7]

(d) Describe the way in which the pressure losses in the system change as the hole section is deepened and how this affects the optimisation of the hydraulics of the system.

[3]

C10

(a) State the principal functions of the following casing strings:

conductor;
surface;
intermediate; and
production casing.

[8]

(b) Calculate the burst and collapse loading which will be used in the selection of casing for the following production casing string:

Top of Production Packer	:	7200 ft
Formation Fluid Density	:	9 ppg
Expected gas gradient	:	0.115 psi/ft
Depth of Production Interval (TVD)	:	7350-7750ft
Max. expected pressure in production intervals	:	3700 psi
Packer fluid density	:	9 ppg
Design Factors (burst)	:	1.1
(collapse)	:	1.0

Note : Gaslift may be used at a later stage in the life of this well.

[10]

(c) Describe the effect of tensile loading on the burst and collapse rating of casing?

[2]

C11

(a) Describe, with the aid of diagrams, the Tangential and Balanced tangential mathematical models used to describe and calculate the trajectory of a well.

[5]

(b) What are the sources of error when determining the position of the wellbore.

[3]

(c) Whilst drilling a deviated well to a target at 11000 ft. TVD. The following data is recorded at station No. 37 (The target bearing is 132^{o})

STATION	MD	INC.	AZI.	N	E	TVD	VS
36	8400	35	124	-328	1044	7900	1005
37	8600	38	125				

Calculate the North and East co-ordinates, TVD and vertical section of station No. 37 using the average angle method.

[12]

C12 The 13 3/8” intermediate casing string of a well is to be cemented in place with a two stage cement job. The details of the job are as follows :

Previous Casing Shoe (20")	:	1800 ft
13 3/8" 72 lb/ft Casing Setting Depth	:	5100 ft
17 1/2" open hole Depth (Calipered @ 18" average)	:	5130 ft
Multi-Stage Collar Depth	:	1750 ft
Shoetrack	:	60 ft

<u>Cement stage 1</u> (5100-3300 ft.)

Class ‘G’ + 0.2% D13R (retarder)	:	15.8 ppg
Yield of Class ‘G’ + 0.2% D13R	:	1.15 ft^3/sk
Mixwater Requirements	:	0.67 ft^3/sk

<u>Cement stage 2</u> (1750-1250 ft.)

Class ‘G’ + 8% bentonite + 0.1% D13R	:	13.2 ppg
Yield of Class ‘G’ + 8% bentonite + 0.1% D13R	:	1.89 ft^3/sk
Mixwater Requirements	:	1.37 ft^3/sk

(a) Calculate the following (See Attachment 4 for capacities):

(i) The required number of sacks of cement for the 1st stage and 2nd stage of the job (Allow 20% excess in open hole).
(ii) The volume of mixwater required for each stage.
(iii) The displacement volume for each stage.

[10]

(b) Calculate the static bottomhole pressures generated during the above cementing operations.

[2]

(c) Would the above pressure accurately represent the pressures on the bottom of the well when the cementing operation is being conducted?

[2]

(d) Prepare a program for a two stage cementing operation and describe the ways in which a good cement bond can be achieved.

[6]

End of Paper

Attachment 1

CAPACITY AND DISPLACEMENT OF DRILLPIPE

SIZE AND CONN.	NOMINAL WEIGHT LB/FT	GRADE	APPROX WEIGHT LB/FT	CAPACITY L/M	CAPACITY GALL/FT	OPEN END DISPLACEMENT L/M	OPEN END DISPLACEMENT GALL/FT	CLOSED END DISPLACEMENT L/M	CLOSED END DISPLACEMENT GALL/FT
$2^3/_8$									
		E75	7.00			1.39	0.107	3.01	0.242
$2^3/_8$	6.65	X95	7.08	1.68	0.135	1.34	0.108	3.02	0.243
IF		G105	7.08			1.34	0.108	3.02	0.243
NC26									
$2^7/_8$									
		E75	10.82			2.05	0.165	4.41	0.355
$2^7/_8$	10.4	X95	10.89	2.36	0.190	2.06	0.166	4.42	0.356
IF		G105	10.89			2.06	0.166	4.42	0.356
NC 31		S135	11.20			2.12	0.171	4.48	0.361
	9.5	E75	10.39	4.54	0.366	1.97	0.159	6.51	0.525
$3^1/_2$		E75	13.86	3.88	0.312	2.63	0.212	6.51	0.524
	13.3	X95	14.32	3.96	0.319	2.71	0.218	6.67	0.537
$3^1/_2$		G105	14.38	3.87	0.312	2.73	0.220	6.60	0.532
IF		E75	16.42			3.11	0.250	6.57	0.529
NC38	15.5	X95	16.54	3.46	0.279	3.14	0.253	6.60	0.532
		G105	16.61			3.15	0.254	6.61	0.533
		E75	20.99			3.98	0.320	13.14	1.058
5		X95	21.09			4.00	0.322	13.16	1.070
	19.5	G105	21.50	9.16	0.738	4.08	0.329	13.24	1.087
$4^1/_2$		S135	22.09			4.19	0.337	13.35	1.075
IF		E75	27.01	8.11	0.653	5.12	0.412	13.23	1.065
NC50	25.6	X95	28.30	8.10	0.652	5.36	0.432	13.46	1.084
		G105	28.11	8.09	0.651	5.33	0.429	13.42	1.080

1 Barrel = 42 US Gallons

DRILL COLLAR WEIGHTS (STEEL) POUNDS PER FOOT

lbs/ft = 2.67 (OD^2 - ID^2)

Collar O.D.	BORE OF COLLAR 1-1/2	1-3/4	2	2-1/4	2-1/2	2-13/16	3	3-1/4	3-1/2	3-3/4	4
3-3/8	24.4	22.2									
3-1/2	26.7	24.5									
3-3/4	31.5	29.3									
3-7/8	34.0	31.9	29.4	26.5							
4	36.7	34.5	32.0	29.2							
4-1/8	39.4	37.2	34.7	31.9							
4-1/4	42.2	40.0	37.5	34.7							
4-1/2	48.0	45.8	43.3	40.5							
4-3/4	54.2	52.0	49.5	46.7	43.5						
5	60.2	58.5	55.9	53.1	49.9						
5-1/4	67.5	65.3	62.8	59.9	56.8	53.3					
5-1/2	74.7	72.5	69.9	67.2	63.9	60.5	56.7				
5-3/4	82.1	79.9	77.5	74.6	71.5	67.9	64.1				
6	89.9	87.8	85.3	82.5	79.3	75.8	71.9	67.8	63.3		
6-1/4	98.1	95.9	93.5	90.6	87.5	83.9	80.1	75.9	71.5		
6-1/2	106.6	104.5	101.9	99.1	95.9	92.5	88.6	84.5	79.9		
6-3/4	115.5	113.3	110.8	107.9	104.8	101.3	97.5	93.3	88.8		
7	124.6	122.5	119.9	117.1	113.9	110.5	106.6	102.5	97.9	93.1	87.9
7-1/4	134.1	131.9	129.5	126.6	123.5	119.9	116.1	111.9	107.5	102.6	97.5
7-1/2	143.9	141.7	139.3	136.5	133.3	129.8	125.9	121.8	117.3	112.5	107.3
7-3/4	154.1	151.9	149.5	146.6	143.5	139.9	136.1	131.9	127.5	122.6	117.5
8	164.6	162.5	149.9	157.1	153.9	150.5	146.6	142.5	137.9	133.1	127.9
8-1/4	175.4	173.3	170.8	167.9	164.8	161.3	157.5	153.3	148.8	143.9	138.8
8-1/2	186.6	184.4	181.9	179.1	175.9	168.6	172.5	164.5	159.9	155.1	149.9
8-3/4	198.1	195.9	193.9	190.6	187.4	183.9	180.1	175.9	171.4	166.6	161.5
9		207.8	205.3	202.4	199.3	195.8	191.9	187.8	183.3	178.5	173.3
9-1/2		232.4	229.9	227.1	223.9	220.4	216.6	212.4	297.9	203.1	197.9
10			255.9	253.1	249.9	246.4	242.6	238.4	233.9	229.1	223.9
10-1/2			283.3	280.4	277.3	273.8	269.9	265.8	261.3	256.4	251.3
11					305.9	302.4	298.6	294.4	289.9	285.1	279.9

MUD DENSITY, GRADIENT AND BUOYANCY FACTOR

NOTE: Buoyancy factor is for STEEL only

Mud density			Gradient psi/ft	Buoyancy Factor	Mud density			Gradient psi/ft	Buoyancy Factor
kg/m^3	lb/gall	lb/ft^3			kg/m^3	lb/gall	lb/ft^3		
1000	8.34	62.4	.433	.873	1800	15.0	112	.779	.771
1010	8.40	62.8	.436	.872	1820	15.2	114	.790	.768
1030	8.50	64.3	.447	.869	1850	15.4	115	.800	.765
1060	8.80	65.8	.457	.866	1870	15.6	117	.810	.762
1080	9.00	67.3	.468	.862	1890	15.8	118	.821	.759
1100	9.20	68.8	.478	.860	1920	16.0	120	.831	.755
1130	9.40	70.3	.488	.856	1940	16.2	121	.842	.753
1150	9.60	71.8	.499	.853	1970	16.4	123	.852	.749
1154	9.625	72.0	.500	.853	1990	16.6	124	.862	.746
1180	9.80	73.3	.509	.850	2010	16.8	126	.873	.743
1200	10.0	74.8	.519	.847	2040	17.0	127	.883	.740
1220	10.2	76.3	.530	.844	2060	17.2	129	,894	.737
1250	10.4	77.8	.540	.841	2090	17.4	130	.904	.734
1270	10.6	79.3	.551	.838	2110	17.6	132	.914	.731
1290	10.8	80,8	.561	.835	2130	17.8	133	.925	.728
1320	11.0	82.3	.571	.832	2160	18.0	135	.935	.725
1340	11.2	83.8	.582	.829	2180	18.2	136	.945	.722
1370	11.4	85.3	.592	.826	2210	18.4	138	.956	.719
1390	11.6	86.8	.603	.823	2230	18.6	139	.966	.716
1410	11.8	88.3	.613	.820	2250	18.8	141	.977	.713
1440	12.0	89.8	.623	.817	2280	19.0	142	.987	.710
1460	12.2	91.3	.634	.814	2300	19.2	144	.997	.707
1490	12.4	92.8	.644	.810	2330	19.4	145	1.01	.704
1510	12.6	94.3	.655	.808	2350	19.6	147	1.02	.701
1530	12.8	95.8	.665	.804	2370	19.8	148	1.03	.698
1560	13.0	97.3	.675	.801	2400	20.0	150	1.04	.694
1580	13.2	98.7	.686	.798	2420	20.2	151	1.05	.692
1610	13.4	100	.696	.795	2450	20.4	153	1.06	.688
1630	13.6	102	.706	.792	2470	20.6	154	1.07	.685
1650	13.8	103	.717	.789	2490	20.8	156	1.08	.682
1680	14.0	105	.727	.786	2520	21.0	157	1.09	.679
1700	14.2	106	.738	.783	2540	21.2	159	1.10	.676
1730	14.4	108	.748	.780	2570	21.4	160	1.11	.673
1750	14.6	109	.758	.777	2590	21.6	162	1.12	.670
1770	14.8	111	.769	.774	2610	21.8	163	1.13	.667

Attachment 2

IADC DULL BIT GRADING

CUTTING STRUCTURE				BEARINGS/ SEALS	GAGE	OTHER DULL CHAR.	REASON PULLED
INNER	OUTER	DULL CHAR.	LOCATION				
1	2	3	4	5	6	7	8

ORDER CODE #6320-2/3M

(1) INNER CUTTING STRUCTURE (All inner rows.)

(2) OUTER CUTTING STRUCTURE (Gage row only.)

In columns *1* and *2* a linear scale from 0 to 8 is used to describe the condition of the cutting structure according to the following:

STEEL TOOTH BITS

A measure of lost tooth height due to abrasion and/or damage.

0 - NO LOSS OF TOOTH HEIGHT.
8 - TOTAL LOSS OF TOOTH HEIGHT.

INSERT BITS

A measure of total cutting structure reduction due to lost, worn and/or broken inserts.

0 - NO LOST, WORN AND/OR BROKEN INSERTS.
8 - ALL INSERTS LOST, WORN AND/OR BROKEN.

FIXED CUTTER BITS

A measure of lost, worn and/or broken cutting structure.

0 - NO LOST, WORN AND/OR BROKEN CUTTING STRUCTURE.
8 - ALL OF CUTTING STRUCTURE LOST, WORN AND/OR BROKEN.

(3) DULL CHARACTERISTICS

(Use only cutting structure related codes.)

- * BC - Broken Cone
- BT - Broken Teeth/Cutters
- BU - Balled Up Bit
- * CC - Cracked Cone
- * CD - Cone Dragged
- CI - Cone Interference
- CR - Cored
- CT - Chipped Teeth/Cutters
- ER - Erosion
- FC - Flat Crested Wear
- HC - Heat Checking
- JD - Junk Damage
- * LC - Lost Cone
- LN - Lost Nozzle
- LT - Lost Teeth/Cutters
- OC - Off Center Wear
- PB - Pinched Bit
- PN - Plugged Nozzle/Flow Passage
- RG - Rounded Gage
- RO - Ring Out
- SD - Shirttail Damage
- SS - Self Sharpening Wear
- TR - Tracking
- WO - Washed Out Bit
- WT - Worn Teeth/Cutters
- NO - No Dull Characteristic

*Show cone # or #'s under location (4).

(4) LOCATION

ROLLER CONE

	CONE #
N - Nose Row	1
M - Middle Row	2
G - Gage Row	3
A - All Rows	

FIXED CUTTER

- C - Cone
- N - Nose
- T - Taper
- S - Shoulder
- G - Gage
- A - All Areas

(5) BEARINGS / SEALS

NON-SEALED BEARINGS

A linear scale estimating bearing life used. (**0** - No life used, **8** - All life used, ie. no bearing life remaining.)

SEALED BEARINGS

- E - seals effective
- F - seals failed
- X - fixed cutter bit (bearingless)

(6) GAGE

Measure in fractions of an inch.

- I - in gage
- 1/16 - 1/16" out of gage
- 1/8 - 1/8" out of gage
- 1/4 - 1/4" out of gage

(7) OTHER DULL CHARACTERISTIC

Refer to column *3* codes.

(8) REASON PULLED OR RUN TERMINATED

- BHA - Change Bottom Hole Assembly
- DMF - Downhole Motor Failure
- DTF - Downhole Tool Failure
- DSF - Drill String Failure
- DST - Drill Stem Test
- DP - Drill Plug
- CM - Condition Mud
- CP - Core Point
- FM - Formation Change
- HP - Hole Problems
- LIH - Left In Hole
- HR - Hours On Bit
- LOG - Run Logs
- PP - Pump Pressure
- PR - Penetration Rate
- RIG - Rig Repair
- TD - Total Depth/Casing Depth
- TW - Twist Off
- TQ - Torque
- WC - Weather Conditions

FOR ADDITIONAL INFORMATION CONTACT YOUR LOCAL SECURITY REPRESENTATIVE OR SECURITY DIVISION IN DALLAS, TEXAS. (214) 333-3211

n	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0
W IF	0.50	0.51	0.53	0.54	0.56	0.57	0.59	0.61	0.60	0.65	0.67
W HHP	0.33	0.34	0.36	0.37	0.38	0.40	0.42	0.43	0.45	0.48	0.50

NOZZLE SIZE	**NOZZLE AREA (in.^{2})**
18-18-18	**0.75**
18-19-17	**0.72**
18-17-17	**0.69**
17-17-17	**0.67**
17-17-16	**0.64**
17-16-16	**0.61**
16-16-16	**0.59**
16-16-15	**0.57**
16-15-15	**0.54**
15-15-15	**0.52**
15-15-14	**0.50**
15-14-14	**0.47**
14-14-14	**0.45**
14-14-13	**0.43**
14-13-13	**0.41**
13-13-13	**0.39**
13-13-12	**0.37**
13-12-12	**0.35**
12-12-12	**0.33**
12-12-11	**0.31**
12-11-11	**0.30**
11-11-11	**0.28**
11-11-10	**0.26**
11-10-10	**0.25**
10-10-10	**0.23**
10-10-9	**0.22**
10-9-9	**0.20**
9-9-9	**0.19**
9-9-8	**0.17**
9-8-8	**0.16**

VOLUMETRIC CAPACITIES

	bbls/ft	**ft^3/ft**
Casing		
13 3/8” 72 lb/ft Casing:	0.1480	0.8314
Open Hole		
18" Hole	0.3147	1.7671
Annular Spaces		
20” Casing x 13 3/8" Casing	0.1815	1.0190
18” Hole x 13 3/8” Casing	0.1410	0.7914

The Adaptation of Wilson's Equations to Wellbore Stability Prediction

Wilsons's equations have been adapted to the prediction of wellbore stability by allowing for:

(1) Pore pressure within the host rock (via concept of effective stress)
(2) The orientation of the wellbore at some angle other than 90º to the horizontal stresses, i.e. hole deviation from 0 to 90º
(3) Non-hydrostatic stress fields

Thus for a vertical well, the radius to the outer limit of the yield zone is given by the equation below.

The equation predicting the yield zone radius in a thick production zone is:

$$\frac{r_e}{a} = \left\{ \frac{2_q - \sigma_o + p'(k+1)}{(p+p')(k+1)} \right\}^{\frac{1}{k-1}}$$

Where

r_e = Radius to outer limit of yield zone
a = Radius of borehole
k = Triaxial factor for rock

$$= \left\{ \frac{1+\sin\phi}{1-\sin\phi} \right\}, \phi \text{ being the angle of internal friction for the rock}$$

σ_o = In situ unconformed compressive strength
p = Effective stress applied to the sides of the wellbore
= Mud pressure - pore pressure

$$p' = \frac{\sigma'_o}{k-1}, \sigma'_o \text{ being found from the equation } \sigma'_1 = \sigma'_o + k\sigma'_3$$

for broken rock in the yield zone

= 0.1 mP_a or 15 psi typically for soft rock

q = Effective hydrostatic stress remote from the opening
= (overburden stress x stress ratio) - pore pressure

Course:- 28-137
Class:- 289DE3

HERIOT-WATT UNIVERSITY
DEPARTMENT OF PETROLEUM ENGINEERING

Examination for the Degree of
MSc/Diploma Distance Learning course in Petroleum Engineering

Drilling Engineering

Monday 10th January 2000
09.30 - 12.30

NOTES FOR CANDIDATES

1. This is a Closed Book Examination.

2. 15 minutes reading time is provided from 09.15 - 09.30.

3. Examination Papers will be marked anonymously. See separate instructions for completion of Script Book front covers and attachment of loose pages. Do not write your name on any loose pages which are submitted as part of your answer.

4. This Paper consists of 2 Sections:- A and B.

5. Section A:- Attempt 5 numbered Questions
   Section B:- Attempt 3 numbered Question

6. Section A:- 40% of marks [8% per Question]
   Section B:- 60% of marks

   Marks for Question parts are indicated in brackets

7. This Examination represents 100% of the Class assessment.

8 State clearly any assumptions used and intermediate calculations made in numerical questions. No marks can be given for an incorrect answer if the method of calculation is not presented.

9. Answers must be written in separate, coloured books as follows:-

   Section A:- Blue
   Section B:- Green

Section A

A1

(a) List and briefly discuss three functions of the drill collars used in the BHA of drillstrings.

[3]

(b) List and describe the function of two other components (other than drillcollars) of the BHA.

[5]

A2

(a) List and discuss three elements of the design of a PDC bit which would be suitable for a soft claystone formation.

[3]

(b) Briefly describe the structure and content of the IADC dull grading system.

[5]

3

a) List and discuss the major considerations when selecting/designing a drilling fluid for a particular well.

[5]

(b) What are the advantages and disadvantages of oil based mud as opposed to water based mud?

[3]

A4

(a) Discuss the reasons for conducting a leakoff test when drilling out of a casing shoe.

[2]

(b) List and describe the procedure for conducting such a test and the calculations that are conducted when the results are obtained.

[6]

A5

(a) Draw and annotate the shear stress vs. Shear rate diagram for a: Power law and; Bingham Plastic Drilling Fluid.

[3]

(b) Write the mathematical model for each of the models discussed above.

[2]

(c) Draw the friction factor vs. Reynolds number relationship for a Power law Fluid and show the impact of the non-Newtonian index on the relationship.

[4]

A6

(a) List and describe the surface and subsurface components of an MWD system.

[6]

(b) Describe two of the modes of data transmission used in mud pulse telemetry systems.

[2]

A7

(a) A typical casing string may be described by the following terms:

9 5/8” 47 lb/ft L-80 VAM

Explain the meaning of each of the terms in this description. Use examples of alternatives to highlight the attributes of this particular casing.

[8]

A8

(a) List and discuss the constraints on the trajectory of a wellbore which must be considered when designing the wellpath of a deviated well.

[3]

(b) Given that the rig position and target location are often fixed, what control does the engineer exercise when designing the geometry of the wellpath. Discuss the practical/operational limitations on the geometry of the wellpath?

[5]

Section B

B9 The intermediate casing of a development well is to be cemented in place using a two stage cement job.

13 3/8” Setting Depth	: 5900 ft.
17 Ω” Hole (Calipered to 18”)	: 5930 ft
Previous Shoe Depth (20”)	: 1500 ft.
Formation Fluid Density	: 9 ppg
Shoetrack	: 60 ft

Cement stage 1 (5930-4500 ft.)	
Class ‘G’ + 0.2% D13R (retarder)	: 15.8 ppg
Yield of Class ‘G’ + 0.2% D13R	: 1.15 ft^3/sk
Mixwater Requirements	: 0.67 ft^3/sk

Cement stage 2 (1500-1000 ft.)	
Class ‘G’ + 8% bentonite + 0.1% D13R	: 13.2 ppg
Yield of Class ‘G’ + 8% bentonite + 0.1% D13R	: 1.89 ft^3/sk
Mixwater Requirements	: 1.37 ft^3/sk

(a) Calculate the following (See Attachment 1 for capacities):

(i) The required number of sacks of cement for the 1st stage and 2nd stage of the job (Allow 10% excess over caliper in open hole).

(ii) The volume of mixwater required for each stage.

(iii) The displacement volume for each stage.

[12]

(b) List and discuss three properties of cement which would be specified when designing the cementation operation.

[6]

(c) Discuss the possible reasons why a two stage cementation job was programmed for this casing.

[2]

B10 Whilst drilling the 12 1/4" hole section of a vertical well with a mudweight of 11 ppg the driller detects a kick. The well is shut in and the following information is gathered

Surface Readings :

Shut in Drillpipe Pressure	: 700 psi
Shut in Annulus Pressure	: 900 psi
Pit Gain	: 29 bbls

Hole / Drillstring Data :

Hole Size		: 12 1/4 "
Depth of kick		: 6500 ft.
Previous Casing Shoe		: 13 3/8", 54.5 lb/ft
Depth 13 3/8" shoe		: 3500 ft. TVD
BHA :	Bit	: 12 1/4"
	Drillcollars	: 500 ft of 9" x 2 13/16"
	Drillpipe	: 5", 19.5 lb/ft

(a) Calculate and discuss the following :

(i) The type of fluid that has entered the wellbore ?

(ii) The mudweight required to kill the well.

(iii) The volume of kill mud that would be required to kill the well.

[10]

(b) Briefly explain how and why the wellbore pressure is monitored and controlled throughout the well killing operation (assuming that the 'one circulation method' is to be used).

[6]

(c) Briefly explain why the 'one circulation method' is considered to be safer than the drillers method for killing a well.

[4]

B11 The 9 5/8" production casing string of a well is to be designed for burst and collapse on the basis of the following data.

Setting Depth of 9 5/8" Casing	: 8320 ft
Top of Production Packer	: 7500 ft
Formation Fluid Density	: 9 ppg
Expected gas gradient	: 0.115 psi/ft
Depth of Production Interval (TVD)	: 7750 - 8220 ft
Maximum expected pressure in production intervals	: 4650 psi
Packer fluid density	: 9 ppg
Design Factors (burst)	: 1.1
(collapse)	: 1.1

Casing Available (See Attachment 2 for specifications of this casing):

9 5/8" 47 lb/ft P-110 VAM
9 5/8" 53.5 lb/ft P - 110 VAM

Note :
1. Only one weight and grade of casing is to be used in the string

(a) Design the casing for Burst and Collapse loads (do not consider the tensile loads). Discuss **critically** the scenarios considered when determining the loading conditions used in the above design process.

[8]

(b) List and describe four (4) of the tensile loads which would be considered when designing the casing for tension.

[6]

(c) List and discuss the operations involved in running casing, from the point at which it arrives on the rig, to the point at which the cementing operation is about to commence.

[6]

B12 It has been decided to drill a deviated well to a target at 8700 ft. TVD. The well is to be kicked off just below the 13 3/8" casing at 2000 ft. The well is to have a build and hold profile. The details of the well profile are as follows :

KOP	: 2000 ft.
Target Depth (TVD)	: 8700 ft.
Horizontal Departure of Target	: 3200 ft.
Buildup Rate	: 2^o/100ft

(a) Calculate the Following :
  (i) The drift angle of the well.
  (ii) The along hole depth at the end of the build up section.
  (iii) The along hole depth at the target.

[12]

(b) List and discuss the advantages and disadvantages of the various types of surveying systems that could be used to survey this well whilst drilling.

[4]

(c) List and discuss two types of tool or techniques that could be used to alter the direction of this well if it were found to be deviating from the designed course.

[4]

End of Paper

Attachment I

VOLUMETRIC CAPACITIES

	bbls/ft	ft^3/ft
Drillpipe		
5" drillpipe :	0.01776	0.0997
Drillcollars		
9" x 2 $^{13}/_{16}$" Drill collar:	0.0077	0.0431
Casing		
13 3/8" 72 lb/ft Casing:	0.1480	0.8314
Open Hole		
18" Hole	0.3147	1.7671
Annular Spaces		
13 3/8" casing x 5" drillpipe:	0.1302	0.7315
12 1/4" hole x 5" drillpipe:	0.1215	0.6821
12 1/4" hole x 9" drillcollars:	0.0671	0.3767
18" hole x 13 3/8" Casing:	0.1410	0.7914
20" Casing x 13 3/8" Casing:	0.1815	1.0190

Attachment 2

CASING LOAD RATINGS

	Burst (psi)	Collapse (psi)	Tension (lbs)
9 5/8" 47 lb/ft P-110 VAM	9440	5310	1493000
9 5/8" 53.5 lb/ft P - 110 VAM	10900	7930	1710000