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

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2019

Course: Reservoir Geo Mechanics **Semester: II**

Program: M. Tech: Petroleum Engineering **Time 03 hrs.**

Course Code: PEAU 7010 **Max. Marks: 100**

No. of Pages: 3

Instructions: Calculators should not be borrowed

SECTION A (5 x 4 = 20 marks)

S. No.		**Marks**	**CO**
Q 1	Write about Anderson classification theory and explain about different types of faults based on principal stresses	**4**	**CO1**
Q 2	Define stress and strain ? and write the stress equation in matrix form	**4**	**CO2**
Q 3	Define Isotropy and Anisotropy and Write about different types of Anisotropy	**4**	**CO3**
Q 4	Discuss about failure criteria of the rocks using various failure theories	**4**	**CO3**
Q 5	Discuss about the equations governing the stress analysis around the bore hole	**4**	**CO4**

SECTION B (4 x 10 = 40 marks)

Q 6	A plane stress condition exists at a point on the surface of a loaded rock where the stresses have the magnitudes and directions as given σ_x = -6600 psi, σ_y = 1700psi, and σ_z = -2700 psi. Determine the stress acting on an element that is oriented at a clockwise angle of 45 degree with respect to the original element	**10**	**CO1**
Q 7	The data given in Table 1 are the results of a triaxial tests obtained from lime stone samples taken from 500 ft below the seabed in the Persian gulf region. Assume a pore pressure of 0.7 ksi and using the Von Mises failure criterion, (i) Plot the second deviatoric invariant against the effective average stress for the given data (ii) Plot Mohr circle (iii) Evaluate cohesive strength and angle of internal friction	**4+3+3**	**CO2**
Q 8	A water saturated block of quartz sandstone rests on a horizontal surface which has 2.67 gr/cm^3 density and porosity of 20% a) What is the normal stress at the base of 10m tall block of this sandstone? b) Explain how water saturation may affect the total and effective stresses. **OR** Trapped hydrocarbons are flowing through the pore spaces of a shale reservoir rock at a depth of 2000m, with a velocity of 0.01 m/s from a high fluid concentration location with pressure of 6000 psi to a lower pressure location of 5500 psi, 100 m away. Assuming the hydrocarbons dynamic viscosity as 1.2 x 10^{-7} Pa.s. Determine the permeability of shale.	**5+5** **10**	**CO3**

Q 9	The following stress state exists around the a well bore drilled in the north sea σ_x=90 bar, σ_y=70 bar, σ_z =100 bar, τ_{xy}=10 bar, τ_{xz}= τ_{yz}, p_w=p_o=0 a) Determine the Kirsch equations at the wellbore wall b) Plot the resulting stresses as a function of θ	**5+5**	**CO4**
SECTION-C (2 x 20 = 40 marks)			
Q 10	From Table 2 a) Plot the Mohr circles for the data b) Draw the failure line c) Evaluate the quality of the model, if not satisfactory make two failure lines d) Develop equations for the failure model and determine the cohesive strength and angle of internal friction	**5+5+5 +5**	**CO2 and CO3**
Q 11	Assuming the following stress state around the a vertical wellbore as shown in Figure 1 $\sigma_x = \sigma_y$=80 bar, σ_{zz} =100 bar, τ_{xy}= τ_{xz}= τ_{yz} a) Derive the general Kirsch equations b) Assuming the wellbore pressure is on the verge to fracturing at 90 bar, plot the stresses as a function of radius r, Assuming the wellbore pressure is on verge of collapse at 40 bar plot the stresses as a function of radius r. **OR** The following data is given for a deviated well drilled in the gulf of Mexico. σ_v = 100 bar, σ_H = σ_h =90 bar, ϒ=40 degrees, azimuth ø=165 degrees, cohesion strength $\tau_o\{\tau\sigma\}$ =0.3, angle of internal friction is 30 degrees. Determine borehole collapse pressure.	**10+10** **20**	**CO4**

Table 1: Triaxial test data for Persian gulf

Test no.	Minimum compressive test σ_3 (ksi)	Maximum compressive stress σ_1 (ksi)
1	0	10
2	0.6	11.5
3	1	13.5
4	2	15.5

Table 2: Triaxial tests results

Test no.	Confining pressure σ_3 (bar)	Yield Strength σ_1 (bar)
1	507	2616
2	438	2052
3	300	1648
4	162	1308
5	24	600
6	0	313

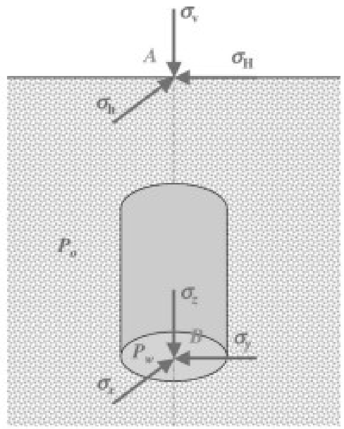

Figure 1

Name: Enrolment No:	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
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Course: Reservoir Geo Mechanics **Semester: II**
Program: M. Tech: Petroleum Engineering **Time 03 hrs.**
Course Code: PEAU 7010 **Max. Marks: 100**
No. of Pages: 2
Instructions: Calculators should not be borrowed

SECTION A (5x4=20 marks)

S. No.		Marks	CO
Q 1	Draw the different types of faults according to Anderson and explain them in terms of principal stresses	**4**	**CO1**
Q 2	A circular solid rock is tested in a compression testing rig to examine its stress/strain behavior. The sample is 6 inches in diameter and 12 inches in length, with the compression load cell imposing constant load of 10000lbf equally at both top and bottom of the rock sample. Assuming a measured reduction in length of 0.02 inches, find the compressive stress and strain of the rock.	**4**	**CO2**
Q 3	Define effective stress and explain with the appropriate equations.	**4**	**CO3**
Q 4	Explain about indirect methods for computing formation fracture gradient using equations.	**4**	**CO3**
Q 5	Write down the steps to find the stresses at the wellbore wall	**4**	**CO4**

SECTION B (4 x 10= 40 marks)

S. No.		Marks	CO
Q 6	The matrix below defines a given stress state. Determine principal stress matrix and directions cosines. 14 2 2 2 11 5 2 5 11	**10**	**CO1**
Q 7	The data given in Table 1 plot the data and derive the Mohr-Coulomb equation	**10**	**CO2**
Q 8	Using the data given in Table 2 and assume Poisson's ratio as 0.25. Estimate the formation fracture gradient at 5000 ft using Eaton method and compare the result with that of Hubbert and Willis methods **OR** Assume the formation pressure at 5000 ft depth is 2400 psi and overburden stress gradient is 1 psi/ft, estimate the formation fracture gradient at 5000 ft using the Hubbert and Willis method.	**10**	**CO3**
Q 9	The following stress state exists around the a well bore drilled in the north sea σ_x=100 bar, σ_y=80 bar, σ_z =110 bar, τ_{xy}=12 bar, τ_{xz}= τ_{yz}, p_w=p_o=0 a) Determine the Kirsch equations at the wellbore wall b) Plot the resulting stresses as a function of θ	**5+5**	**CO4**

SECTION-C (2 x 20 = 40 marks)

Q 10	The strength of the rock samples are given in Table 2, where the well is drilled to a depth of 4480 m. Plot the Von Mises failure plot by assuming the pore pressure.	**20**	**CO2 and CO3**
Q 11	A reference well is drilled in 400 m of water. Assuming the rig floor height, the bulk density and the penetration depth remain unchanged and using the following data, derive a prognosis for a well in 1100m water depth Drill floor height h_f = 25m, Total depth of well 1: d_1 = 900 m, water depth for well 1: H_{w1} = 400 m, Leak of pressure for well 1: G_1 = 1.5 s.g @ 900m, Water depth for well 2: H_{w2} = 1100m, Sea water density = 1.03 s.g. **OR** The following data is given for a deviated well drilled in the gulf of Mexico. σ_v = 110 bar, $\sigma_H = \sigma_h$ =10 bar, ϒ=40 degrees, azimuth ø=175 degrees, cohesion strength τ_o\{τσ\} =60 bar, angle of internal friction is 30 degrees. Determine borehole collapse pressure	**20**	**CO4**

Table 1: Confining pressure and axial load measured data for Berea sand stone

Test no.	Confining pressure σ_3 (psi)	Axial Load at failure σ_1 (psi)
1	7350	31933
2	6350	29756
3	4350	23998
4	2350	18963
5	350	8700
6	0	4538

Table 2: Triaxial tests results

Test no.	Confining pressure σ_3 (bar)	Yield Strength σ_1 (bar)
1	507	2616
2	438	2052
3	300	1648
4	162	1308
5	24	600
6	0	313