Problem 1 (20 points)

A major fault in your reservoir has strike N35°W and dip 60° from horizontal. S_{hmin} in this area acts along 020°, and in situ stresses are $S_{hmin} = 70$ MPa, $S_{Hmax} = 80$ MPa, $S_v = 65$ MPa. Assume the pore pressure $P_p = 30$ MPa. Is the fault likely to slip if the respective frictional coefficient is $\mu = 0.7$?

Problem 2 (50 points)

Assuming the same reservior conditions as Problem 1, write a computer code that can compute the resolved shear stress magnitude and normal effective stress on a fault characterized by the strike direction and dip angle. Now randomly generate 10000 faults (use a statistical distribution to choose random pairs of strike and dip) and plot the results on a Mohr diagram. Where do near vertical strike-slip faults appear on this diagram? Where do the oblique-slip faults fall?

Problem 3 (10 points)

Repeat Problem 2 but make $S_{hmin} = S_{Hmax} = 45$ MPa (i.e. stress isotropic in the horizontal plane. How has the Mohr diagram changed? Is this still a 3D problem?

Problem 4 (10 points)

a. Using a constitutive model for an isotropic elastic solid that relates strains to applied effective stresses corrected by Biot's coefficient, assume you have a sample in subsurface subjected to overburden, and that confinement in both horizontal principal directions is so large that the horizontal strains are nearly zero. Derive elastic equations for horizontal stresses (use the variables x and y for horizontal directions) in terms of vertical loading as a function of depth (in z direction).

b. Assume you are at depth of 4 km and the pore pressure at that depth is hydrostatic. Using the equations derived in a) above, Biot's parameter of $\alpha = 0.7$, and a Poisson's ratio $\nu = 0.2$, estimate the horizontal stress magnitudes $S_{hmin} = S_{Hmax}$ at that depth.

Problem 5 (30 points)

Bernabe and Brace (1990) in their article "Deformation and fracture of Berea Sandstone" reported a number of triaxial test measurements for Berea sandstone, and some of them are given in the table below (all data in MPa).

S_3 (confining pressure)	P_p (pore pressure)	$S_1 - S_3$ (differential stress)
10	0	116
50	0	227
20	8	119
45	8	183
60	8	206
75	8	228
50	37	120
50	32	141
90	64	161
90	55	187
130	96	186
130	84	207

Fit this data to Mohr-Coulomb criterion to compute unconfined compressive strength C_0 and internal friction coefficient μ_i for Berea sandstone.