1. Download the file LostHills.xls. At every depth data point along the vertical well:
   a. Compute total vertical stress as a function of depth (you may assume homogeneous rock above 1750 ft), and compute overpressure parameter.
   b. Compute dynamic Poisson's ratio and dynamic Young's modulus from compressive and shear slowness (be careful with unit conversion).
   c. Compute static Young's modulus using a coefficient $E_{static} = 0.65*E_{dynamic}$
   d. Compute static plane strain modulus $E'_{static} = E_{static} / (1-\nu^2)$ (Poisson ratio remains the same with depth).
   e. Compute total maximum and minimum horizontal stress assuming theory of elasticity and $\varepsilon_{Hmax}=0.0015$ and $\varepsilon_{hmin}=0$.
   f. The pay-zone is between 2,100 ft and 2,450 ft. A hydraulic fracture is planned to be executed with a vertical well at a depth between 2,130 ft and 2,160 ft. What will be the height of this fracture? Will it reach out to the entire pay zone?

2. A single hydraulic fracture treatment will be performed in a tight sandstone. The hydraulic fracture height is expected to be h_f = 170 ft. The tight sandstone has a plane-strain modulus E' = 8.9 MMpsi. The (two-wing) injection rate will be 50 bbl/min (constant) during 1 hour. The fracturing fluid has a viscosity 2 cP.
   Compute:
   a. The expected fracture half-length x_f, fracture width at the wellbore $w_{w,0}$, and net pressure p_n as a function of time with the PKN model (no leak-off).
   b. The total amount of water (volume) and sand (weight) required assuming a constant volume ratio 90% water-10% sand. How many water swimming pools (100,000 L) and sand trucks (10 metric tons) are needed to complete the hydraulic fracturing job?
Hint: convert all quantities to the SI system first

3. Consider the design of a completion job with horizontal wellbores and multistage hydraulic fracturing in the Barnett shale at 8,200 ft with pore pressure of 4100 psi (NF).
   a. What is the direction of horizontal wellbores that maximize drainage area using multistage fractures? (You may need to check the US stress map)
   b. Sketch a horizontal well with 10 fracture stages spaced every 200ft from a top view. Fracture half-length is ~500ft.
   c. Calculate a lower bound (absolute minimum) of the pressure needed to propagate hydraulic fractures using the theory of elasticity (ν=0.25) and limit equilibrium of faults (q~3.5). Perforations will be done, so you may ignore the effect of near-wellbore stresses.
   d. Draw the "path" of wellbore orientation on a semi-sphere projection. The wellbore starts vertical on the surface and deviates close to the pay zone until it gets horizontal.

4. The following figures correspond to microseismicity images from hydraulic fracturing stimulation in the Barnett shale (Hydraulic Fracturing Insights from Microseismic Monitoring – SLB Oilfield Review https://www.slb.com/~/media/Files/resources/oilfield_review/ors16/May2016/02-microseismic.pdf).
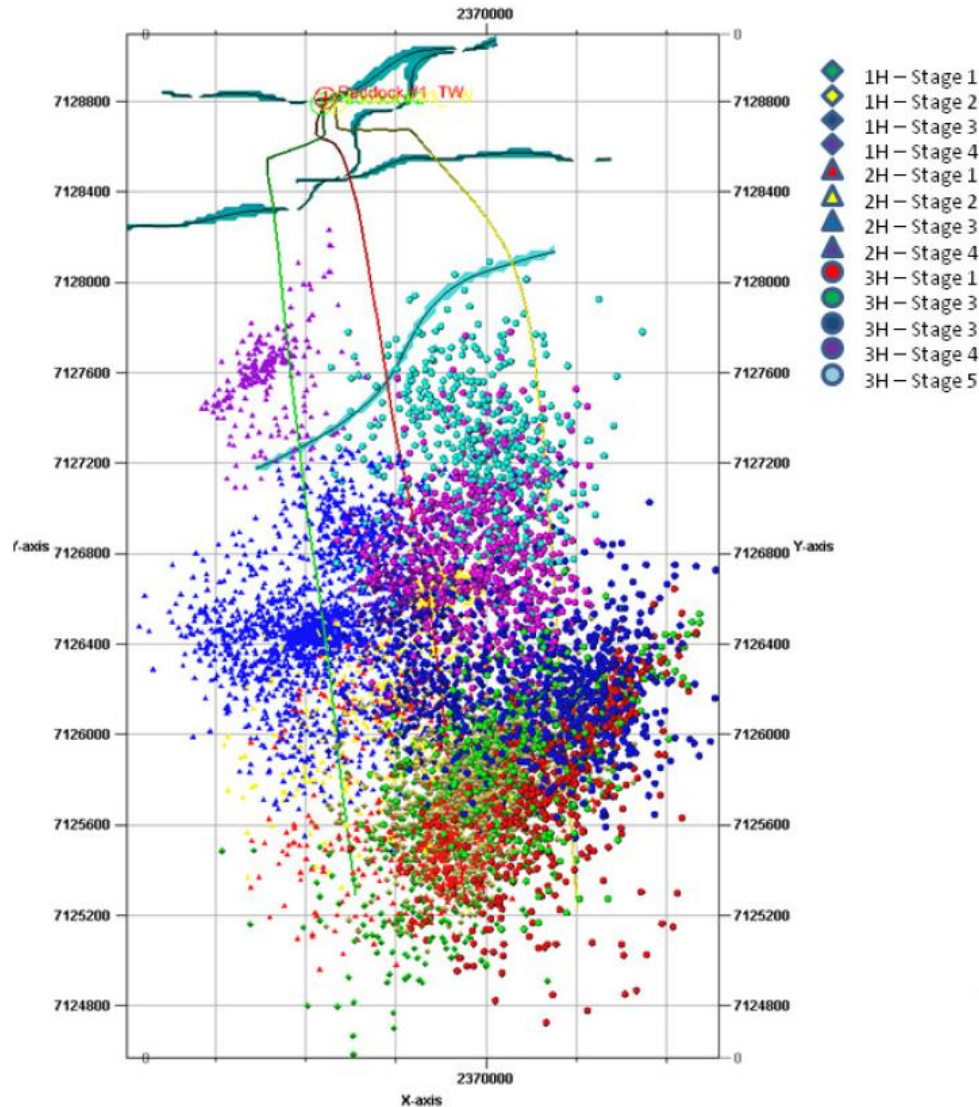
"Stimulation process performed on the three horizontal wells using plug-and-perf and slickwater treatment with fault traces mapped at laterals depth interval in cyan. The zipper-style frac performed on the 1H (central well in red) and the 3H (east well in yellow) was monitored from 2H (west well in green). The four stimulation stages performed on the 2H were monitored from the 3H."

a) What is the length of the laterals? What is the distance between laterals? What is the approximate distance between stages? (axis units: feet) Note: 1H is 80 ft higher in elevation than 2H and 3H.

b) What is the strike of the hydraulic fractures at the toe of the laterals? How does the strike interpreted from microseismicity compare to the strike obtained in problem 3?

c) What is the average fracture half-length x_f as interpreted from the microseismic cloud?

d) Assuming a pay zone thickness of 200 ft, what is the Stimulated Reservoir Volume [ft^3]?