Geography 416-411
Exercise #3
Soil Temperature and Heat Flux
10 points

Name:____________________________

1. For a soil with the properties and two moisture conditions given below, determine the damping depths and plot the envelopes of the daily diurnal temperature range (i.e. plot both max. and min. temps.) from the surface to a depth of 80 cm (use 10 cm intervals). Record your answers in the table and on the graph provided.

a. surface temperature range: minimum 15°C, maximum 45°C
b. the soil is sand with a volume fraction of solids, $X_s = .573$
c. the soil moisture conditions are:
   i) dry, k = .25 W/m°K   ii) $X_w = .10$

2. Repeat the procedures of problem 1 using the same surface temperature range and graphic scale as before, and recording answers in the table and on the graph provided, but for the following:

a. the soil is clay with a volume fraction of solids, $X_s = .570$
b. the soil moisture conditions are:
   i) dry   ii) $X_w = .14$

3. Compare and contrast the results obtained in problems 1 and 2.

a. How would the results differ if the diurnal range at the surface was one half as large?

b. What do you conclude about the significance of the damping depth?

4. For <u>only</u> the dry sand soil conditions used in problem 1, plot the temperature profiles for the following three times (Record your answers in the table and on the graph provided):
   i) 0 hrs.   ii) 6 hrs.   iii) 18 hrs.

5. Given that the times of occurrence of the maximum temperature at 10 cm and 30 cm depths in the soil were 4 hrs. 36 min. apart, what are the values of the thermal diffusivity (α) and the damping depth?

6. Using the soil heat flux equation, determine the heat flux values for the same times and conditions as those used in problem 4. (Record your answers in the table provided.)

P#1 Dry	Trange	Tmax	Tmin	P#1 Wet	Trange	Tmax	Tmin
0 cm				0 cm			
10				10			
20				20			
30				30			
40				40			
50				50			
60				60			
70				70			
80				80			

P#2 Dry	Trange	Tmax	Tmin	P#2 Wet	Trange	Tmax	Tmin
0 cm				0 cm			
10				10			
20				20			
30				30			
40				40			
50				50			
60				60			
70				70			
80				80			

P#4	0 hrs.	6 hrs.	18 hrs.	P#6	0 hrs.	6 hrs.	18 hrs.
0 cm				0 cm			
10				10			
20				20			
30				30			
40				40			
50				50			
60				60			
70				70			
80				80			

Key Equations:

$\omega = 2\pi / p$, p = period (24 h expressed as seconds) **or**
$\omega = \pi / 12$, (when using in a equation with ωt, with t in hours)

$D = (2\alpha / \omega)^{.5}$

$TR_z = TR_{sfc} \exp(-z / D)$

$\ln R = (z_1 - z_2)(\omega / 2\alpha)^{.5}$

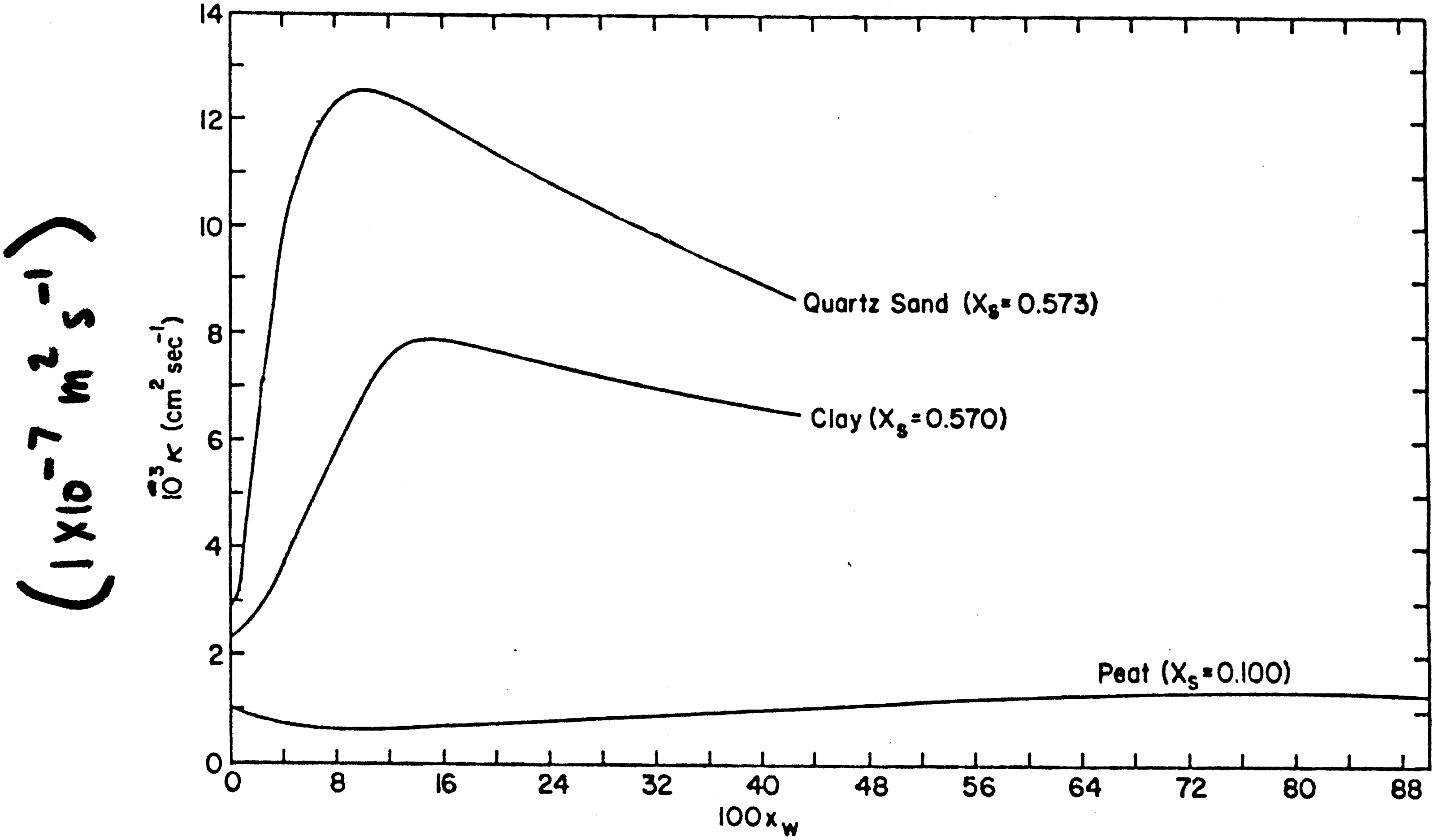
$\alpha = \omega / 2 [\ln R / (z_1 - z_2)]^2$

$\Delta t = (1 / 2\omega\alpha)^{.5} (z_2 - z_1)$

$\alpha = 1 / 2\omega[\Delta t / (z_2 - z_1)]^2$

$T(z,t) = \overline{T} + \Delta T_0 [\exp(-z/D) \sin(\omega t - (z/D))]$ use Radians!

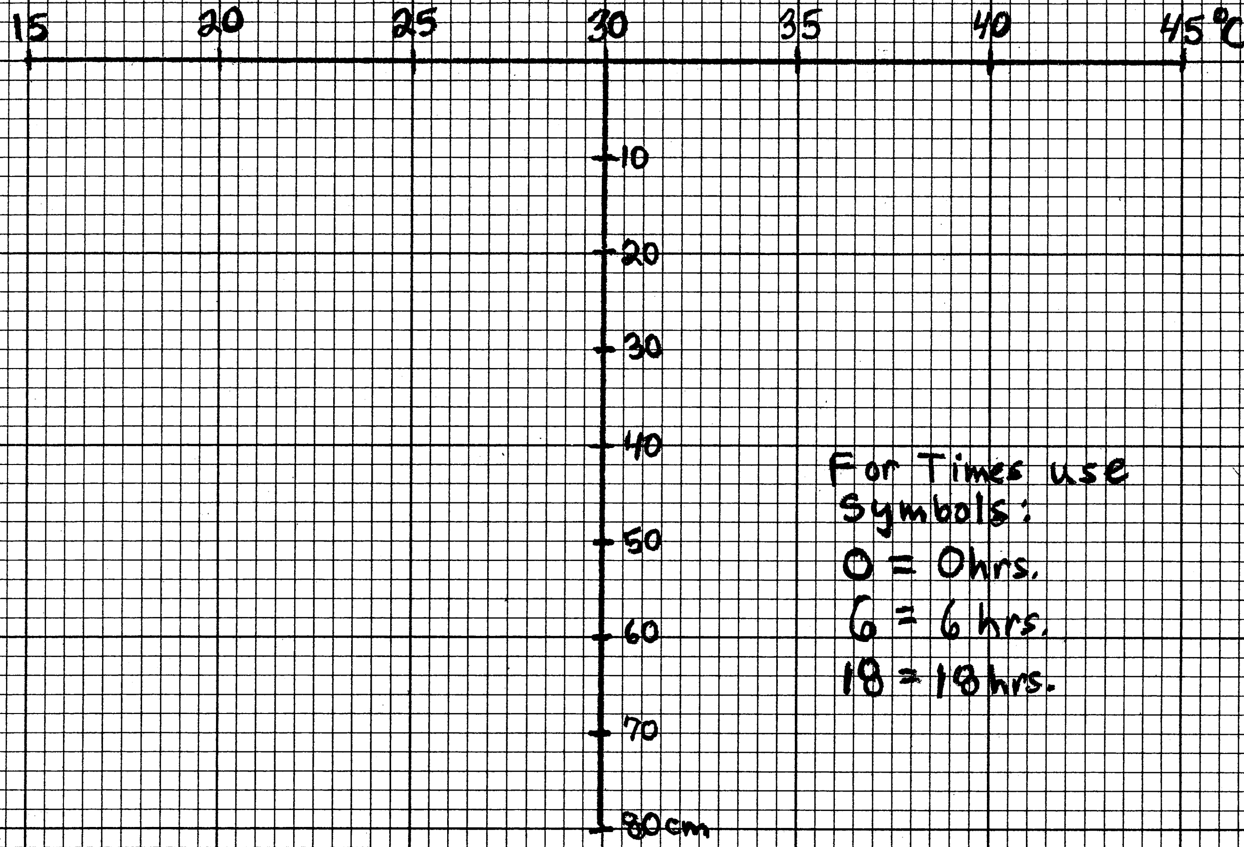
$S(z,t) = -(2^{.5}) (k \Delta T_0 / D) \exp(-z / D) \sin[\omega t - (z / D) + (\pi / 4)]$ use Radians!



Dependence of the thermal diffusivity κ on the volume fraction of water x_w for four different soil types.

(K) or α

PROBLEMS 1 and 4 use symbols X = Dry Sand, ⊙ = Xw.10



PROBLEM 2 use symbols + = Dry Clay, ⊡ = Xw.14