Exercise 2.1 (a) What are the three layers that make up the earth's internal structure?
(b) What is the composition of each of the layers?

Solution 2.1

a) The core, the mantle and the crust
b) Studies from elastic waves generated by earthquakes showed that the earth has a core of heavy metals mostly iron. The mantle consists of two parts; upper mantle which is solid rock and lower mantle which is molten rock. Above the upper mantle is the crust. The materials that compose the earth's crust are sediments and rock.

Exercise 2.2 **(a)** Describe the differences among the three key groups of rocks.
(b) Explain why sedimentary rocks are of particular importance to geotechnical engineers.
(c) Are rock masses homogeneous and continuous? Explain.

Solution 2.2

a) There are three main groups of rocks;
   i. Igneous rocks. They are formed from magma emitted from volcanoes that have cooled and solidified.
   ii. Sedimentary rocks. They are formed from sediments animals and plant materials that are deposited in the water or on land on the earth's surface and then subjected to pressures and heat.
   iii. Metamorphic rocks. They are formed deep within the earth's crust from the transformation of igneous, sedimentary, and even existing metamorphic rocks into denser rocks.

b) They cover 75% of the earth's surface area with an average thickness of 0.8 km.

c) Rock masses are seldom homogeneous and continuous.

Exercise 2.3 **(a)** How are soils formed?
(b) What are the agents responsible for weathering of rocks?

Solution 2.3

a) Soils are formed from the physical and chemical weathering of rocks.
   a. Physical weathering involves reduction of size without any change in the original composition of the parent rock.
   b. Chemical weathering causes both reductions in size and chemical alteration of the original parent rock
b) Main agents responsible for physical weathering are; exfoliation, unloading, erosion, freezing and thawing. Main agents responsible for chemical weathering are; hydration, carbonation, and oxidation

Exercise 2.4 (a) What is a mineral?
(b) Describe the differences among the three main soil minerals.
(c) Why are silicates the most common minerals?

Solution 2.4

a) Minerals are crystalline materials and make up the solids constituent of a soil.
b) Clays are composed of three main types of mineral—kaolinite, illite, and montmorillonite. The clay minerals consist of silica and alumina sheets that are combined to form layers. The bonds between layers play a very important role in the mechanical behavior of clays. The bond between the layers in montmorillonite is very weak compared with kaolinite and illite. Water can easily enter between the layers in montmorillonite, causing swelling.
c) Silicates are by far the most common minerals in the earth's crust and mantle.

Exercise 2.5 Why does Montmorillonite undergo large volume change in contact with water?

Solution 2.5

Montmorillonite layers are held together by weak Van der waals forces and exchangeable ions. Water can easily enter the bond and separate the layers in montmorillonite, causing swelling.

Exercise 2.8 (a) What is soil fabric?
(b) What is the name for the spaces between mineral particles?
(c) Why are the spaces between mineral particles important to geo-engineers?
(d) Explain the differences between a flocculated and a dispersed structure?

Solution 2.8

a) During deposition, the mineral particles are arranged into structural frameworks that is called soil fabric
b) The spaces between the mineral particles are called voids.
c) Voids occupy a large proportion of the soil volume. As an example; the amount of settlement depends on how much we compress the volume of voids. The rate at which the settlement occurs depends on the interconnectivity of the voids.
d) A flocculated structure, formed under a freshwater environment, results when many particles tend to orient perpendicular to each other. A dispersed structure is the result when a majority of the particles orient parallel to each other.

Exercise 2.9 (a) What are the six categories of soil types identified in the ASTM classification system?
(b) For which soil type is surface forces important? Why?
(c) What is adsorbed water?
(d) Can you remove the adsorbed water by oven drying at 105°C? Explain.

Solution 2.9

a) Clay, Silt, Sand, Gravel, Cobbles and Boulders
b) Surface forces on fine-grained soils are important. Because they have larger surface areas than coarse-grained soils
c) A thin layer of water, called absorbed water, is bonded to the mineral surfaces of soils.
d) No. Drying of most soils, with the exception of gypsum, using an oven for which the standard temperature is 105 ± 5° C, cannot remove the adsorbed water.

Exercise 2.10 A particle size analysis on a soil sample yields the following data.

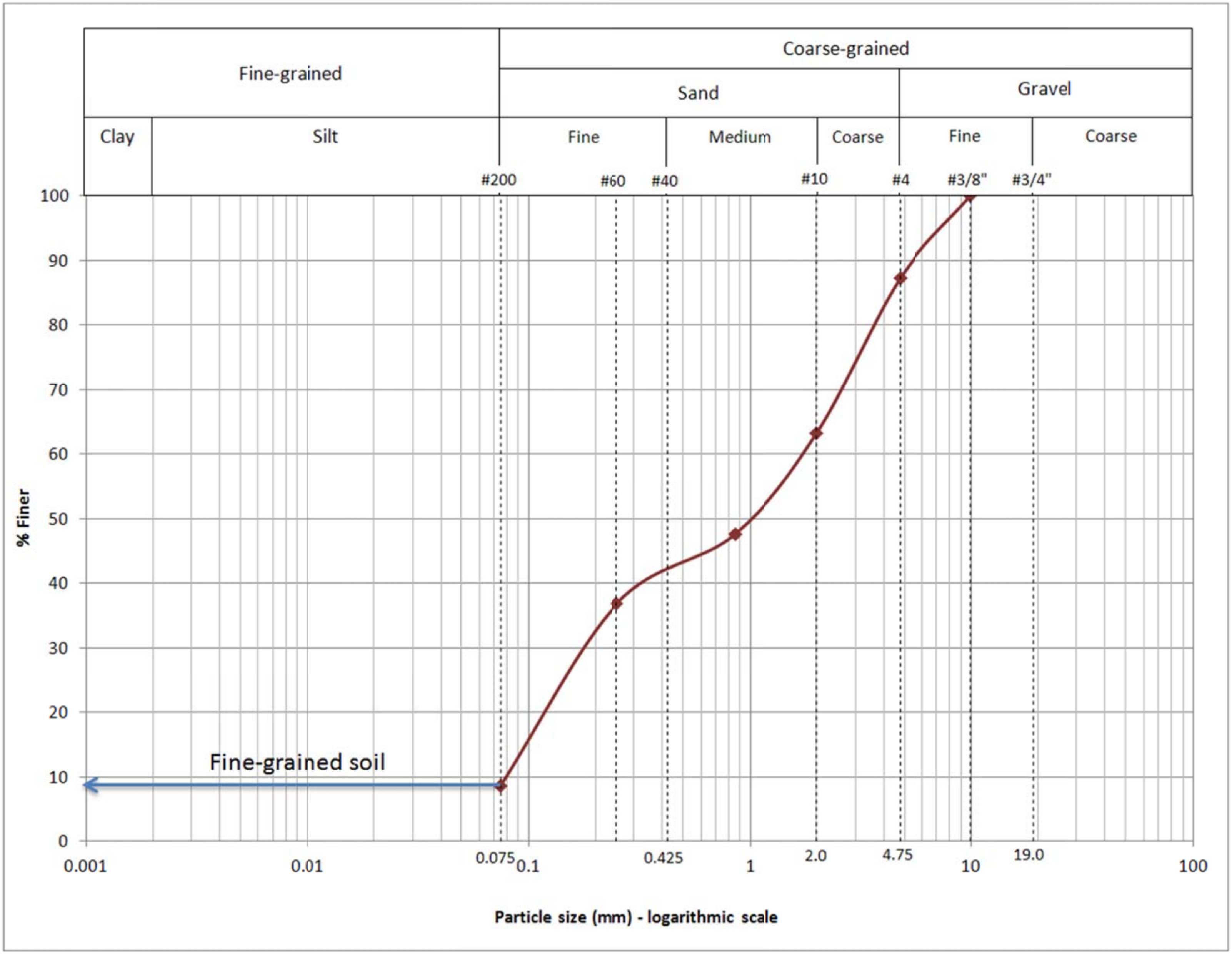
Sieve no.	**3/8”**	**4**	**10**	**20**	**60**	**200**	**Pan**
Sieve size (mm)	9.53	4.75	2.0	0.84	0.25	0.074	—
Mass retained (grams)	0	310	580	380	260	680	210

(a) Plot the particle size distribution curve.
(b) Determine the amount of coarse-grained and fine-grained soils in the soil.

Solution 2.10

A	B	C	D	E	F
Sieve no.	Opening (mm)	Mass retained (grams)	% retained (%)	Σ% retained (%)	% Finer (%)
		M_r	100 x M_r/M_t	Σ column D	100 - column E
3/8"	9.93	0	0.0	0.0	100.0
4	4.75	310	12.8	12.8	87.2
10	2	580	24.0	36.8	63.2
20	0.85	380	15.7	52.5	47.5
60	0.25	260	10.7	63.2	36.8
200	0.075	680	28.1	91.3	8.7
Pan		210	8.7		
	SUM	2420	100.0		
	M_t =	2420			

b) Fine-grained soils = 8.7% and coarse-grained soils = 91.3%


Fine-grained
Coarse-grained
Sand
Gravel
Clay
Silt
Fine
Medium
Coarse
Fine
Coarse
#200
#60
#40
#10
#4
#3/8"
#3/4"
% Finer
Fine-grained soil
0.001
0.01
0.075
0.1
0.425
1
2.0
4.75
10
19.0
100
Particle size (mm) - logarithmic scale

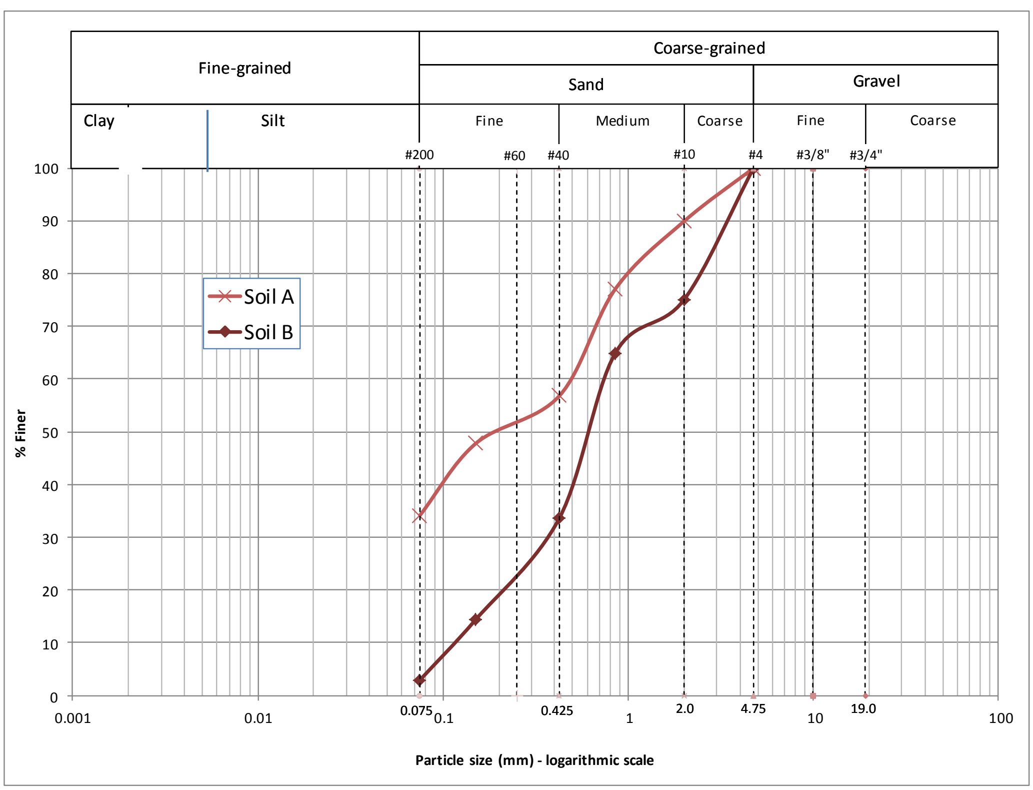
Exercise 2.11 The following results were obtained from sieve analyses of two soils.

Sieve no.	Opening (mm)	Soil A	Soil B
4	4.75	0	0
10	2.00	20.2	48.2
20	0.85	25.7	19.6
40	0.425	40.4	60.3
100	0.15	18.1	37.2
200	0.075	27.2	22.1
Pan		68.2	5.6

Hydrometer tests of these soils give the following results. Soil A: % finer than 0.002 mm = 48%; Soil B: % finer than 0.002 mm = 2%.

(a) Plot the gradation curve for each soil on the same graph.
(b) How much coarse-grained and fine-grained soils are in each soil?
(c) What are the percentages of clay and silt in each soil?
(d) Determine D_{10} for each soil.
(e) Determine the uniformity coefficient and the coefficient of concavity for each soil.
(f) Describe the gradation curve (e.g. well graded) for each soil?

Solution 2.11



SOIL A

Sieve no.	4	10	20	40	100	200	Pan
Opening (mm)	4.75	2	0.85	0.425	0.15	0.075	
Mass retained (grams)	0	20.2	25.7	40.4	18.1	27.2	68.2

A	B	C	D	E	F
Sieve no.	Opening (mm)	Mass retained (grams)	% retained (%)	Σ% retained (%)	% Finer (%)
		M_r	100 x M_r/M_t	Σ column D	100 - column E
4	4.75	0	0.0	0.0	100.0
10	2	20.2	10.1	10.1	89.9
20	0.85	25.7	12.9	23.0	77.0
40	0.425	40.4	20.2	43.2	56.8
100	0.15	18.1	9.1	52.3	47.7
200	0.075	27.2	13.6	65.9	34.1
Pan		68.2	34.1		
	SUM	199.8	100.0		
	M_t =	199.8			

SOIL B

Sieve no.	4	10	20	40	100	200	Pan
Opening (mm)	4.75	2	0.85	0.425	0.15	0.075	
Mass retained (grams)	0	48.2	19.6	60.3	37.2	22.1	5.6

A	B	C	D	E	F
Sieve no.	Opening (mm)	Mass retained (grams)	% retained (%)	Σ% retained (%)	% Finer (%)
		M_r	100 x M_r/M_t	Σ column D	100 - column E
4	4.75	0	0.0	0.0	100.0
10	2	48.2	25.0	25.0	75.0

20	0.85	19.6	10.2	35.1	64.9
40	0.425	60.3	31.2	66.4	33.6
100	0.15	37.2	19.3	85.6	14.4
200	0.075	22.1	11.5	97.1	2.9
Pan		5.6	2.9		
	SUM	193	100.0		
	M_t =	193			

b)

Soil A – 68.2 grams fine-grained soil – 131.6 grams coarse-grained soil

Soil B – 5.6 grams fine-grained soil – 187.4 grams coarse-grained soil

c)

Soil A – 34.1% fine-grained (clay and silt)

Soil B – 2.9% fine-grained (clay and silt)

d-e)

Soil A

Gravel (%)	0.0
Sand (%)	65.9
Silt + Clay (%)	34.1
D_{60}	0.5
D_{10}	0
D_{30}	0

Soil B

Gravel (%)	0.0
Sand (%)	97.1
Silt + Clay (%)	2.9
D_{60}	0.73
D_{10}	0.12
D_{30}	0.38
C_u	6.1
C_c	1.65

f) Both soils might be described as well-graded.