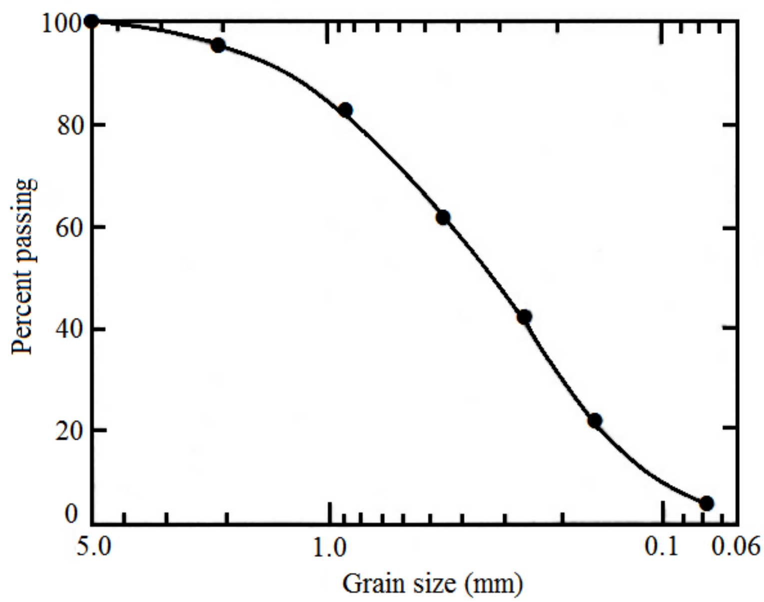
Chapter 2

2.1 a.

Sieve No.	Mass of soil retained on each sieve (g)	Percent retained on each sieve	Percent finer
4	0.0	0.0	**100.0**
10	18.5	4.4	**95.6**
20	53.2	12.6	**83.0**
40	90.5	21.5	**61.5**
60	81.8	19.4	**42.1**
100	92.2	21.9	**20.2**
200	58.5	13.9	**6.3**
Pan	26.5	6.3	**0**
	Σ421.2 g		

The grain-size distribution is shown.



b. From the graph, D_{60} = **0.4 mm**; D_{30} = **0.22 mm**; D_{10} = **0.12 mm**

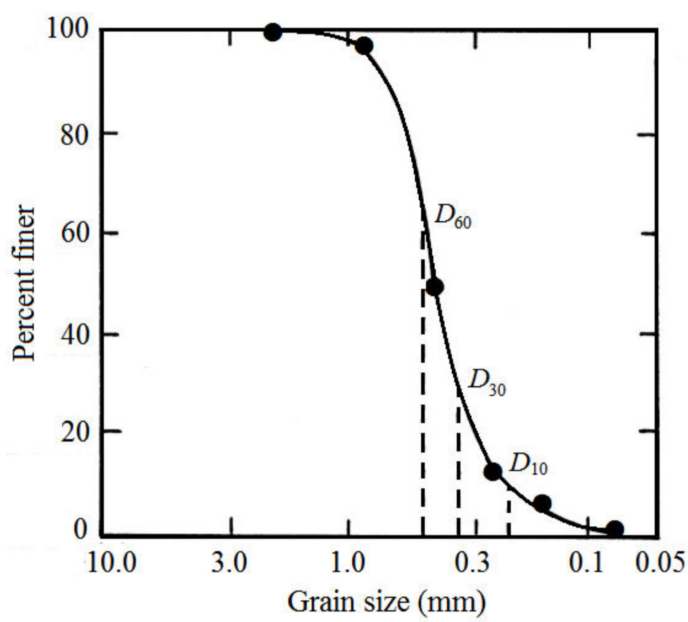
c. $C_u = \frac{D_{60}}{D_{10}} = \frac{0.4}{0.12} = \mathbf{3.33}$

d. $C_c = \frac{(D_{30})^2}{(D_{10})(D_{60})} = \frac{(0.22)^2}{(0.4)(0.12)} = \mathbf{1.01}$

2.2 a.

Sieve No.	Mass of soil retained on each sieve (g)	Percent retained on each sieve	Percent finer
4	0	0	**100**
6	0	0	**100**
10	0	0	**100**
20	9.1	1.82	**98.18**
40	249.4	49.88	**48.3**
60	179.8	35.96	**12.34**
100	22.7	4.54	**7.8**
200	15.5	3.10	**4.7**
Pan	23.5	4.70	**0**
	Σ500 g		

The grain-size distribution is shown.



b. From the graph, D_{60} = **0.48 mm**, D_{30} = **0.33 mm**, D_{10} = **0.23 mm**

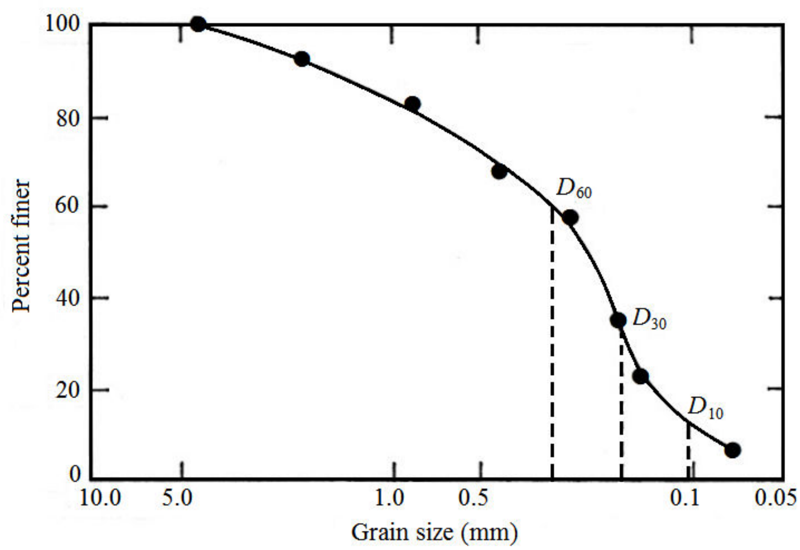
c. $C_u = \frac{0.48}{0.23} = \mathbf{2.09}$

d. $C_c = \frac{(0.33)^2}{(0.48)(0.23)} = \mathbf{0.99}$

2.3 a.

Sieve No.	Mass of soil retained on each sieve (g)	Percent retained on each sieve	Percent finer
4	0	0	**100**
10	44	7.99	**92.01**
20	56	10.16	**81.85**
40	82	14.88	**66.97**
60	51	9.26	**57.71**
80	106	19.24	**38.47**
100	92	16.70	**21.77**
200	85	15.43	**6.34**
Pan	35	5.34	**0**
	Σ 551 g		

The grain-size distribution is shown.



b. From the graph, D_{60} = **0.3 mm**; D_{30} = **0.17 mm**; D_{10} = **0.11 mm**

c. $C_u = \frac{0.3}{0.11} = \mathbf{2.73}$

d. $C_c = \frac{(0.17)^2}{(0.11)(0.3)} = \mathbf{0.88}$

2.4 $C_u = \frac{D_{60}}{D_{10}} = \frac{0.41}{0.08} = \mathbf{5.13}$

$$C_c = \frac{(D_{30})^2}{(D_{10})(D_{60})} = \frac{(0.22)^2}{(0.08)(0.41)} = \mathbf{1.48}$$

2.5 $C_u = \frac{D_{60}}{D_{10}} = \frac{1.81}{0.24} = \mathbf{7.54}$

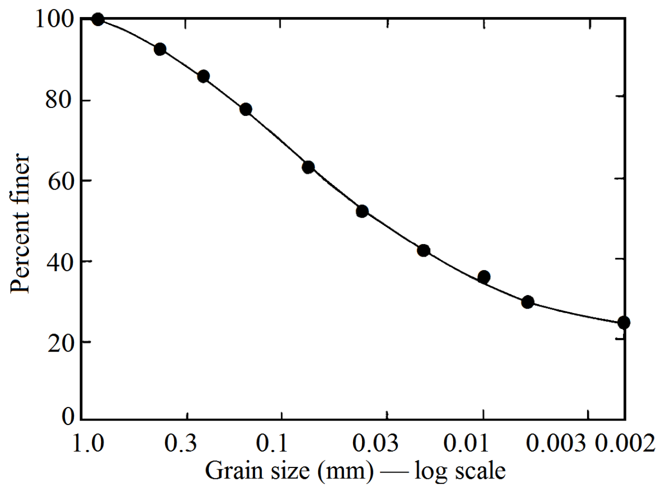
$$C_c = \frac{(D_{30})^2}{(D_{10})(D_{60})} = \frac{(0.82)^2}{(0.24)(1.81)} = \mathbf{1.55}$$

2.6
a. **True**
b. **False**
c. **True**
d. **True**
e. **True**

2.7 In Soil A,
Percent passing 75 mm sieve = 100; i.e., percent of gravel + sand + fines = 100
Percent passing 4.75 mm (No. 4) sieve = 67.5; i.e., percent of sand + fines = 67.5
Therefore, percent of gravel = 32.5
Percent passing 0.075 mm (No. 200) sieve = 8.5
Therefore percent of fines = 8.5 and percent of sand = 59.0
Soil A contains 32.5% gravel, 59.0 % sand and 8.5% fines.

In Soil B, following the same method,
Percent of gravel + sand + fines = 100
Percent of sand + fines = 100
Percent of fines = 0
Soil B consists of 100% sand.

2.8 The grain-size distribution is shown.



From the graph, percent passing 2 mm = 100%; percent passing 0.06 mm = 58%; percent passing 0.002 mm = 23%. See Table 2.3, so

Gravel:	**0%**
Sand:	100 – 58 = **42%**
Silt:	58 – 23 = **35%**
Clay:	23 – 0 = **23%**

2.9 Refer to the graph for Problem 2.8 and Table 2.3. From the graph, percent passing 2 mm = 100%; percent passing 0.075 mm = 62%; percent passing 0.002 mm = 23%.

Gravel:	**0%**
Sand:	100 – 62 = **38%**
Silt:	62 – 23 = **39%**
Clay:	23 – 0 = **23%**

2.10 Refer to the graph for Problem 2.8. From the graph, percent passing 2 mm = 100%; percent passing 0.05 mm = 54%; percent passing 0.002 mm = 23%. See Table 2.3, so

Gravel:	**0%**
Sand:	100 – 54 = **46%**
Silt:	54 – 23 = **31%**
Clay:	23 – 0 = **23%**

2.11 $G_s = 2.60$; temperature = 24°; hydrometer reading = 43; time = 60 min. Referring to Table 2.10, $L = 9.2$ cm.

Eq. (2.6): $D\ (\text{mm}) = K\sqrt{\dfrac{L\ (\text{cm})}{t\ (\text{min})}}$

From Table 2.9, for $G_s = 2.60$ and temperature = 24°, $K = 0.0132$.

$D = 0.0132\sqrt{\dfrac{9.2}{60}} =$ **0.0052 mm**

2.12 For $G_s = 2.70$ and temperature = 23°, $K = 0.013$ (Table 2.9), $L = 12.2$ (Table 2.10).

$D\ (\text{mm}) = K\sqrt{\dfrac{L\ (\text{cm})}{t\ (\text{min})}} = 0.013\sqrt{\dfrac{12.2}{120}} =$ **0.0041 mm**

2.13 a. **Soil A has the largest (50%) percentage of gravel**
b. **Soil C is entirely sand, with grains in the size range of 0.2-4.75 mm**.
c. **Only Soil D contains clay fraction (less than 0.002 mm) of about 35%.**
d. **In Soil A, there are no grains in the size range of 0.2–5.0 mm**. It is known as gap graded soil.

2.14 Percent of gravel + sand + fines = 100
Percent of sand + fines = 63
Percent of fines = 16
Percentages of gravel, sand and fines within the soil are 37, 47, and 16, respectively.

CRITICAL THINKING PROBLEM

2.15 a. $n = 0.5$

$$10 = \left(\frac{D_{10}}{D_{max}}\right)^{0.5} \times 100 \qquad \text{(a)}$$

$$30 = \left(\frac{D_{30}}{D_{max}}\right)^{0.5} \times 100 \qquad \text{(b)}$$

$$60 = \left(\frac{D_{60}}{D_{max}}\right)^{0.5} \times 100 \qquad \text{(c)}$$

$$\frac{\text{Eq. (c)}}{\text{Eq. (a)}} \text{ gives } 6 = \left(\frac{D_{60}}{D_{10}}\right)^{0.5}$$

$$C_u = \frac{D_{60}}{D_{10}} = 36$$

Similarly, $\dfrac{[\text{Eq. (b)}]^2}{[\text{Eq. (a)} \times \text{Eq. (c)}]}$ gives $\dfrac{30 \times 30}{10 \times 60} = \left(\dfrac{D_{30}^2}{D_{10} \times D_{60}}\right)^{0.5}$

$$C_c = \frac{D_{30}^2}{D_{10} \times D_{60}} = 2.25$$

The soil is well graded.

b. $n = 0.5$ and $D_{max} = 19.0$ mm

For percentage of fines, $D = 0.075$ mm; for sand and fines, $D = 4.75$ mm (Unified Soil Classification System).

$$p_{0.075} = \left(\frac{0.075}{19.0}\right)^{0.5} \times 100 = 6.3\% \text{ (per cent of fines)}$$

$$p_{4.75} = \left(\frac{4.75}{19.0}\right)^{0.5} \times 100 = 50.0\% \text{ (per cent of sand and fines)}$$

The soil contains 50% gravel, 43.7% sand and 6.3% fines.