QUIZ GT101
Soil Classification and Grain Size

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► PROBLEMS

PROBLEM 1

Below, we have the particle size distributions for two soils A and B. Classify the soils according to the USDA textural classification system.

Particle-Size Distribution (%)	Soil	
	A	B
Gravel	0	18
Sand	15	33
Silt	30	30
Clay	55	19

A) Soil A is a clay and soil B is a silty loam.
B) Soil A is a clay and soil B is a gravelly loam.
C) Soil A is a clay loam and soil B is a silty loam.
D) Soil A is a clay loam and soil B is a gravelly loam.

PROBLEM 2A

Classify the following soils in the Unified Soil Classification System.

Soil	Sieve analysis – Percent finer		Liquid limit	Plasticity index	C_U	C_C
	No. 4	No. 200				
A	70	30	33	21	–	–
B	71	11	32	16	4.8	2.9

A) Soil A is a silty sand with gravel and soil B is a clayey sand with gravel.
B) Soil A is a silty sand with gravel and soil B is a poorly graded sand with clay and gravel.
C) Soil A is a clayey sand with gravel and soil B is a clayey sand with gravel.
D) Soil A is a clayey sand with gravel and soil B is a poorly graded sand with clay and gravel.

PROBLEM 2B

Classify the following soils in the Unified Soil Classification System. Consider the soils to be inorganic.

Soil	Sieve analysis – Percent finer		Liquid limit	Plasticity index	C_U	C_C
	No. 4	No. 200				
C	100	74	35	21	–	–
D	88	78	69	38	–	–

A) Soil C is a lean clay with sand and soil D is a fat clay with sand.
B) Soil C is a lean clay with sand and soil D is a fat clay with gravel.
C) Soil C is a lean clay with gravel and soil D is a fat clay with sand.
D) Soil C is a lean clay with gravel and soil D is a fat clay with gravel.

PROBLEM 3A

Classify the following soils in the AASHTO classification system.

Soil	Sieve analysis – Percent finer			Liquid limit	Plasticity Index
	No. 10	No. 40	No. 200		
A	80	68	48	30	11
B	100	78	82	32	12

A) Soil A is classified as A-6 and soil B is classified as A-6.
B) Soil A is classified as A-6 and soil B is classified as A-7-5.
C) Soil A is classified as A-7-6 and soil B is classified as A-6.
D) Soil A is classified as A-7-6 and soil B is classified as A-7-5.

PROBLEM 3B

Classify the following soils in the AASHTO classification system.

Soil	Sieve analysis – Percent finer			Liquid limit	Plasticity Index
	No. 10	No. 40	No. 200		
C	42	35	20	25	5
D	98	80	72	52	21

A) Soil A is classified as A-1-a and soil B is classified as A-7-5.
B) Soil A is classified as A-1-a and soil B is classified as A-7-6.
C) Soil A is classified as A-1-b and soil B is classified as A-7-5.
D) Soil A is classified as A-1-b and soil B is classified as A-7-6.

PROBLEM 3C

Find the group index for the soils introduced in the previous problem.
A) For soil C, GI = 0; for soil D, GI = 7.
B) For soil C, GI = 0; for soil D, GI = 16.
C) For soil C, GI = 2; for soil D, GI = 7.
D) For soil C, GI = 2; for soil D, GI = 16.

PROBLEM 4A

For an inorganic soil, the following grain size analysis is given. For this soil, LL = 23 and PL = 19. Classify the soil in the Unified Soil Classification System.

US sieve No.	Percent passing
4	100
10	90
20	64
40	38
80	18
200	13

A) The soil has group symbol SC and group name clayey sand.
B) The soil has group symbol SC and group name clayey sand with gravel.
C) The soil has group symbol SC-SM and group name silty clayey sand.
D) The soil has group symbol SC-SM and group name silty clayey sand with gravel.

PROBLEM 4B

Classify the soil introduced in the previous problem using the AASHTO soil classification system.

A) The soil belongs to category A-1-a.
B) The soil belongs to category A-1-b.
C) The soil belongs to category A-3.
D) The soil belongs to category A-2-4.

PROBLEM 5A

The following are results of a sieve analysis. Regarding the grain size distribution of this soil, which of the following statements is false?

US sieve no.	Mass of soil retained on each sieve (g)
4	0
10	22.1
20	50.0
40	103.4
60	89.4
100	96.2
200	60.5
Pan	32.1

A) The particle size at 10% finer is $D_{10} \approx 0.09$ mm.
B) The particle size at 30% finer is $D_{30} \approx 0.19$ mm.
C) The particle size at 60% finer is $D_{60} \approx 0.30$ mm.
D) The particle size at 75% finer is $D_{75} \approx 0.56$ mm.

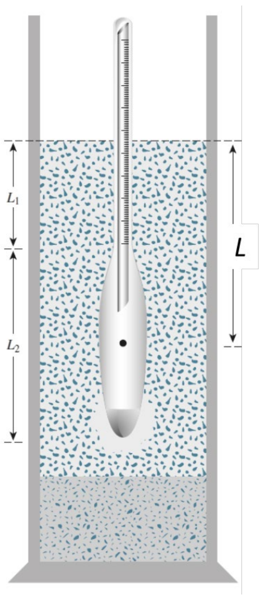
PROBLEM 5B

Compute the uniformity coefficient and the coefficient of gradation for the soil considered in the previous problem.

A) $C_U = 4.67$ and $C_C = 0.21$
B) $C_U = 4.67$ and $C_C = 0.96$
C) $C_U = 6.22$ and $C_C = 0.21$
D) $C_U = 6.22$ and $C_C = 0.96$

PROBLEM 6A

A hydrometer test has the following results: $G_s = 2.7$, temperature of water = 24°C, L = 9.2 cm at 60 minutes after the start of sedimentation. What is the diameter D of the smallest-size particles that have settled beyond the zone of measurement at that time (that is, at t = 60 min)?



A) D = 0.002 mm
B) D = 0.003 mm
C) D = 0.004 mm
D) D = 0.005 mm

PROBLEM 6B

Repeat the previous problem with the following values: G_s = 2.75, temperature of water = 23°C, t = 100 min., and L = 12.8 cm.

A) D = 0.0046 mm
B) D = 0.0058 mm
C) D = 0.0064 mm
D) D = 0.0077 mm

▸ ADDITIONAL INFORMATION

Figure 1 US Department of Agriculture textural classification.

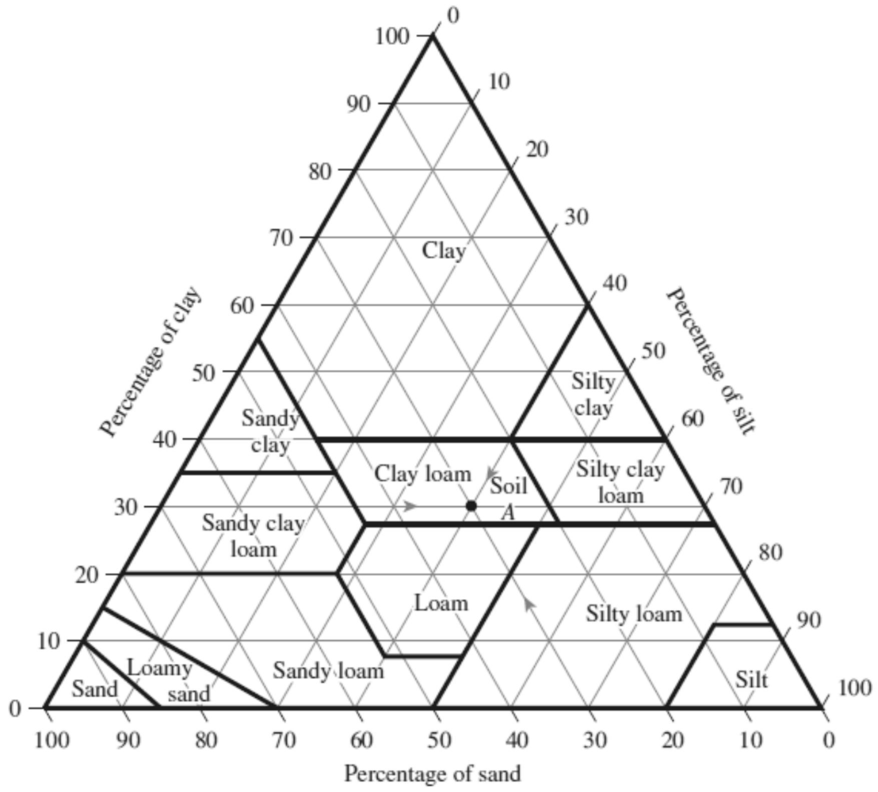


Figure 2 USCS/ASTM soil classification with the Unified Soil Classification System (USCS). [This chart and those of Figures 3 to 6 are reproduced with permission of ASTM International, 100 Barr Harbor, West Conshohocken, PA 19428.]

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
COARSE-GRAINED SOILS More than 50 % retained on No. 200 sieve	Gravels (More than 50 % of coarse fraction retained on No. 4 sieve)	Clean Gravels (Less than 5 % fines[C])	Cu ≥ 4 and 1 ≤ Cc ≤ 3[D]	GW	Well-graded gravel[E]
			Cu < 4 and/or [Cc < 1 or Cc > 3][D]	GP	Poorly graded gravel[E]
		Gravels with Fines (More than 12 % fines[C])	Fines classify as ML or MH	GM	Silty gravel[E,F,G]
			Fines classify as CL or CH	GC	Clayey gravel[E,F,G]
	Sands (50 % or more of coarse fraction passes No. 4 sieve)	Clean Sands (Less than 5 % fines[H])	Cu ≥ 6 and 1 ≤ Cc ≤ 3[D]	SW	Well-graded sand[I]
			Cu < 6 and/or [Cc < 1 or Cc > 3][D]	SP	Poorly graded sand[I]
		Sands with Fines (More than 12 % fines[H])	Fines classify as ML or MH	SM	Silty sand[F,G,I]
			Fines classify as CL or CH	SC	Clayey sand[F,G,I]
FINE-GRAINED SOILS 50 % or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OL	Organic clay[K,L,M,N] Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OH	Organic clay[K,L,M,P] Organic silt[K,L,M,Q]
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12 % fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D] $Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[E] If soil contains ≥15 % sand, add "with sand" to group name.
[F] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[G] If fines are organic, add "with organic fines" to group name.
[H] Sands with 5 to 12 % fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[I] If soil contains ≥15 % gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to <30 % plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥30 % plus No. 200, predominantly sand, add "sand" to group name.
[M] If soil contains ≥30 % plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.

Figure 3 USCS/ASTM flowchart for classifying fine-grained soil (50% or more passes No. 200 sieve).

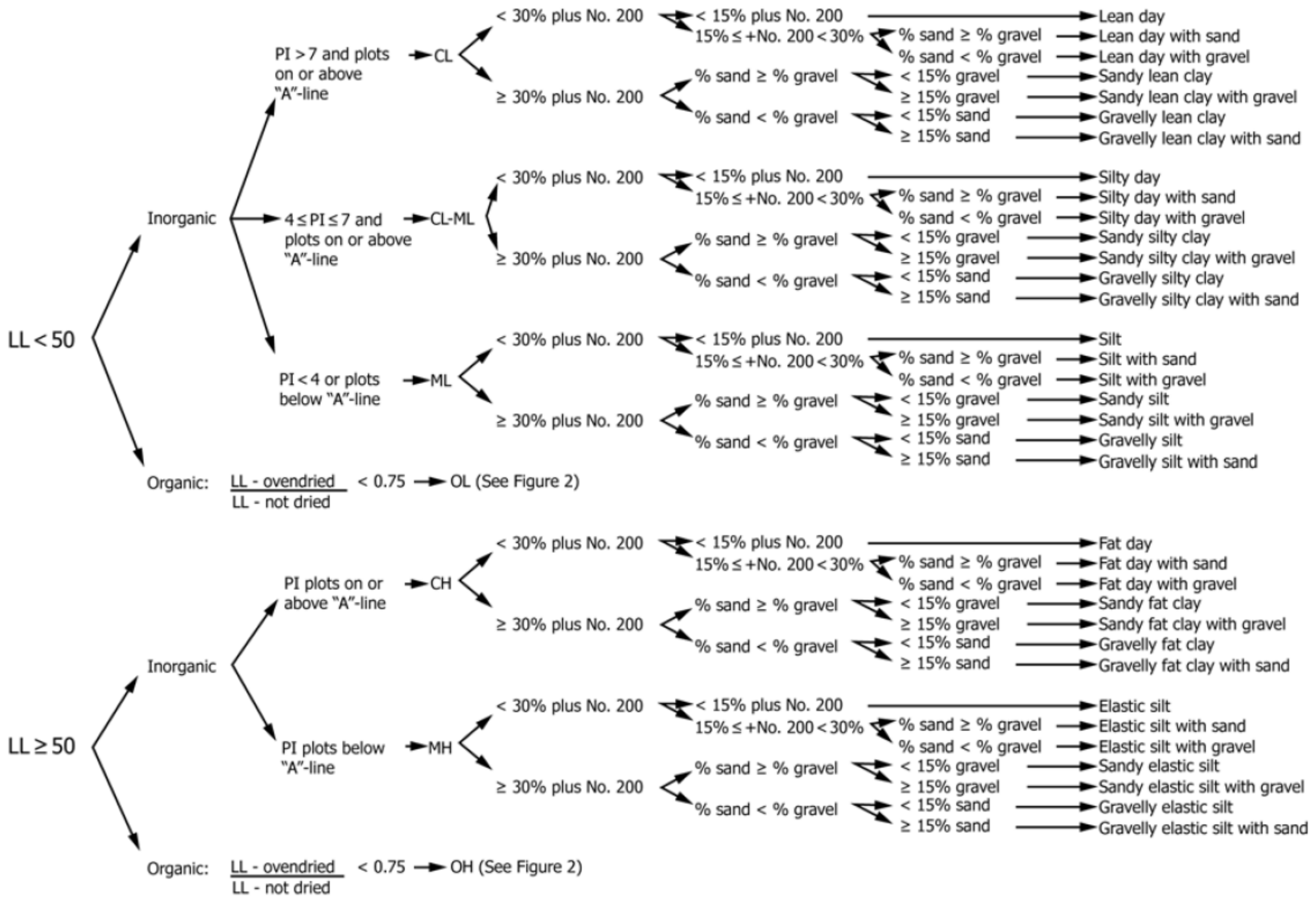


Figure 4 USCS/ASTM flowchart for classifying fine-grained soil (50% or more passes No. 200 sieve).

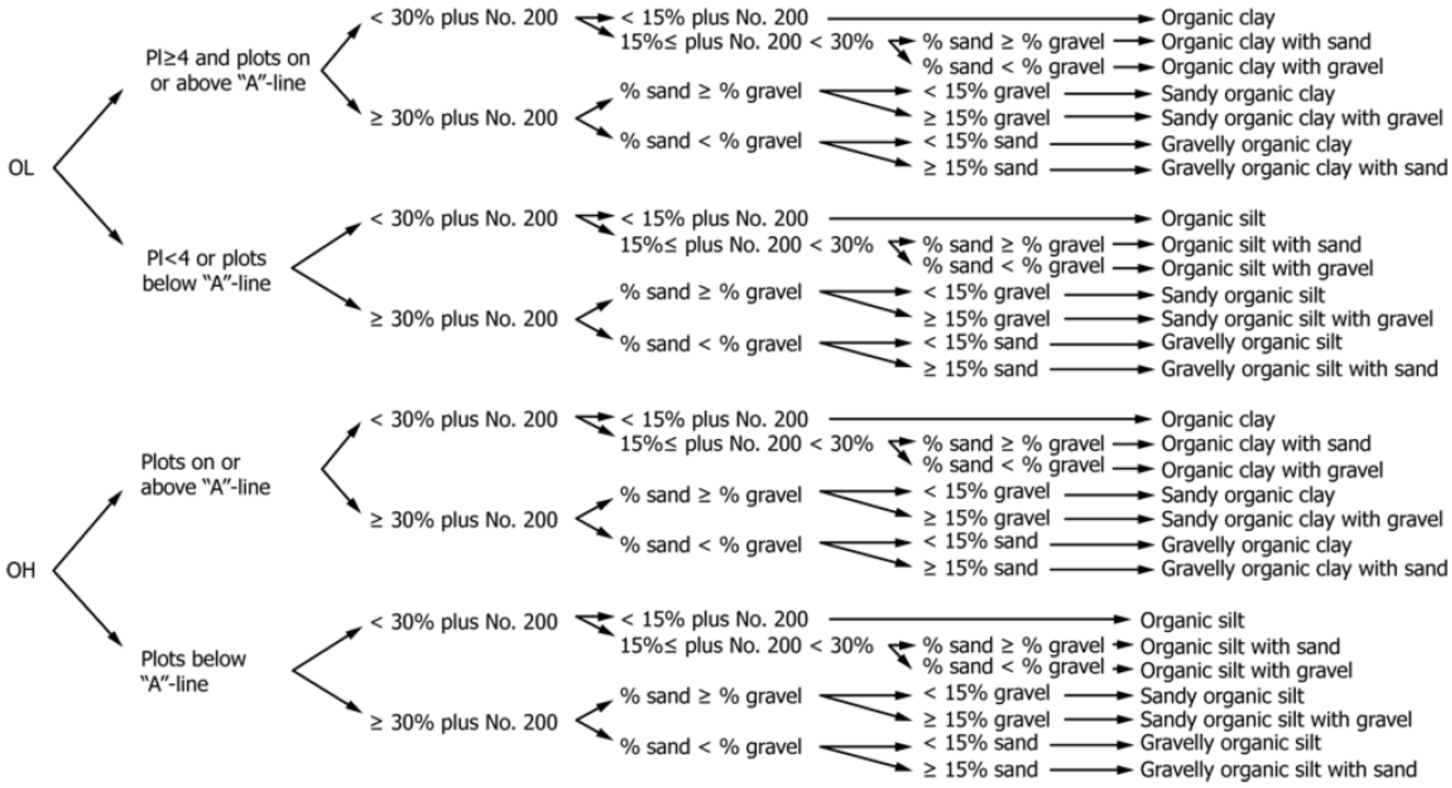


Figure 5 USCS/ASTM flowchart for classifying coarse-grained soils (more than 50% retained on No. 200 sieve).

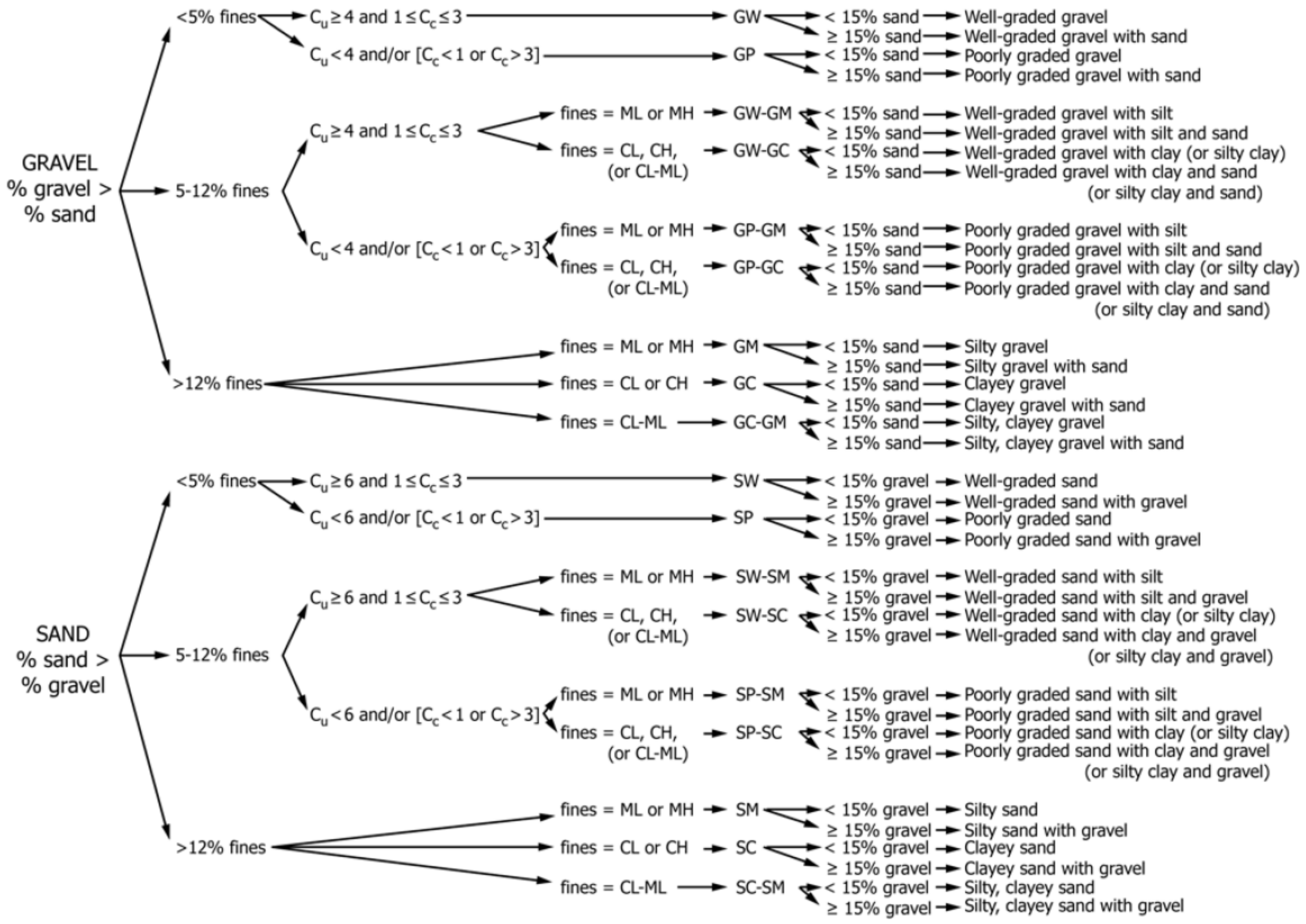


Figure 6 Plasticity chart for use with the USCS/ASTM soil classification system.

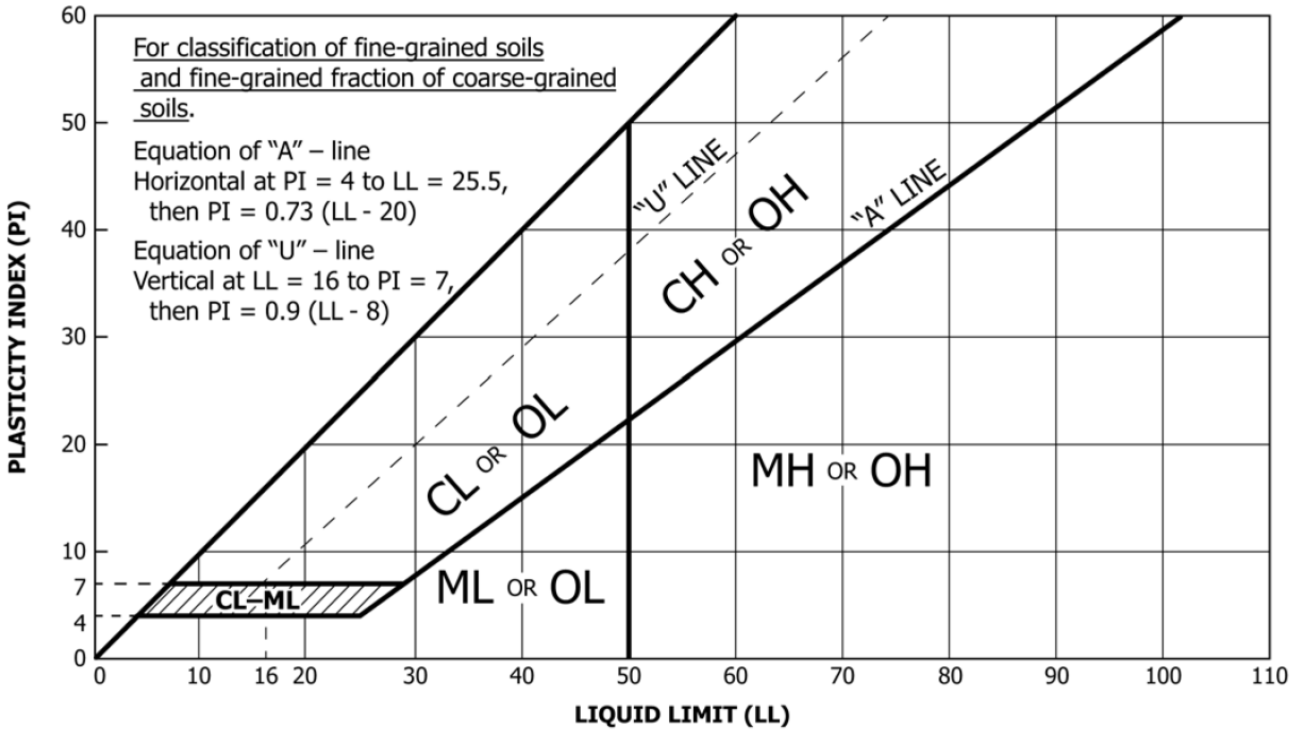


Figure 7 Classification of highway subgrade materials as conceived by the American Association of State Highway and Transportation Officials (AASHTO).

General classification	Granular materials (35% or less of total sample passing No. 200)						
	A-1			A-2			
Group classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7
Sieve analysis (percentage passing)							
No. 10	50 max.						
No. 40	30 max.	50 max.	51 min.				
No. 200	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.
Characteristics of fraction passing No. 40							
Liquid limit				40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		NP	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Stone fragments, gravel, and sand		Fine sand	Silty or clayey gravel and sand			
General subgrade rating	Excellent to good						

General classification	Silt-clay materials (more than 35% of total sample passing No. 200)			
Group classification	A-4	A-5	A-6	A-7 A-7-5[a] A-7-6[b]
Sieve analysis (percentage passing)				
No. 10				
No. 40				
No. 200	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 40				
Liquid limit	40 max.	41 min.	40 max.	41 min.
Plasticity index	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Silty soils		Clayey soils	
General subgrade rating	Fair to poor			

[a]For A-7-5, $PI \leq LL - 30$

[b]For A-7-6, $PI > LL - 30$

Table 1 Values of coefficient *K* for use with the hydrometer analysis equation*

Temperature (°C)	Specific Gravity				
	2.55	2.60	2.65	2.70	2.75
22	0.01374	0.01353	0.01332	0.01312	0.01294
23	0.01358	0.01337	0.01317	0.01297	0.01279
24	0.01342	0.01321	0.01301	0.01282	0.01264
25	0.01327	0.01306	0.01286	0.01267	0.01249
26	0.01312	0.01291	0.01272	0.01253	0.01235

*The equation in question is

$$D = \sqrt{\frac{18\mu}{(G_s - 1)}}\sqrt{\frac{L}{t}}$$

with *D* in mm, *L* in cm, and *t* in minutes. The first factor on the right-hand side is a function of the viscosity of water and the specific gravity of the soil. These variables can be tabulated and represented by a single factor *K*, thus reducing the equation to

$$D = K\sqrt{\frac{L}{t}}$$

The values of *K* are given in the preceding table.

▶ SOLUTIONS

P.1 ■ Solution

Before anything else, we have to calculate the modified percentages of sand, gravel, and silt by means of the formula

$$\%\ \text{Modified}\ \{\text{sand, silt, clay}\} = \frac{\%\{\text{sand, silt, clay}\}}{100 - \%\text{gravel}} \times 100\%$$

Application of this equation to soil A is elementary,

$$\%\text{Modified Sand} = \frac{15}{100-0} \times 100 = 15\%$$

$$\%\text{Modified Silt} = \frac{30}{100-0} \times 100 = 30\%$$

$$\%\text{Modified Clay} = \frac{55}{100-0} \times 100 = 55\%$$

Referring to the USDA textural classification chart (Figure 1), we conclude that soil A is a clay, as outlined by the red arrows in the following figure.

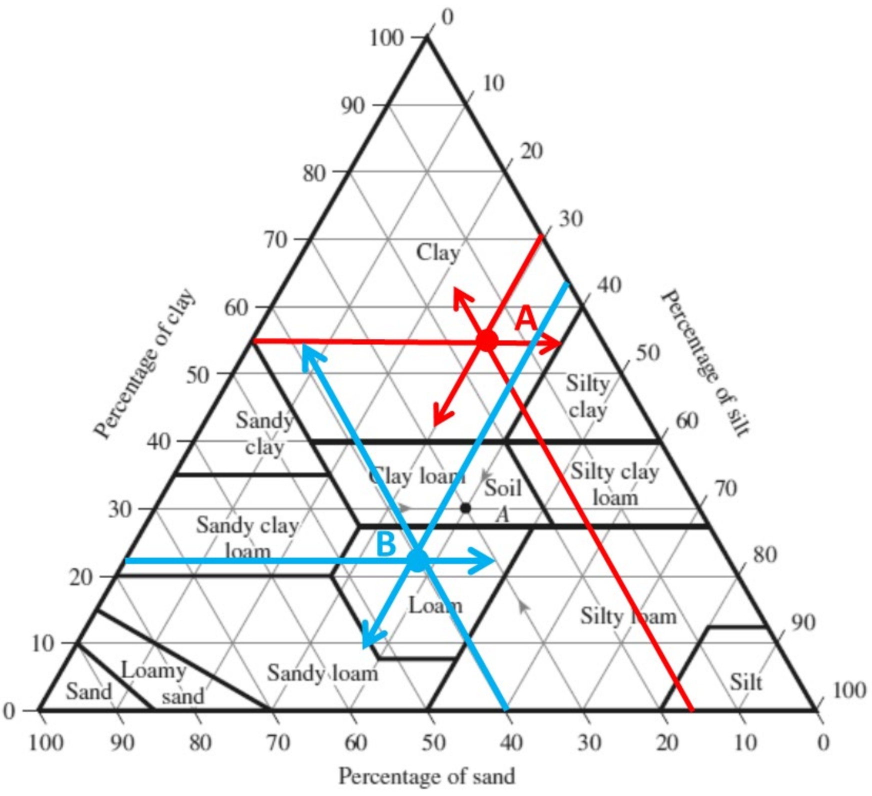
Next, we attempt to classify soil B. As before, the modified percentages of sand, silt and clay are calculated as

$$\%\text{Modified Sand} = \frac{33}{100-18} \times 100 = 40\%$$

$$\%\text{Modifed Silt} = \frac{30}{100-18} \times 100 = 36.6\%$$

$$\%\text{Modified Clay} = \frac{19}{100-18} \times 100 = 23.2\%$$

Mapping these values onto the textural classification chart, we read that soil B is a loam, or, if we take into account the presence of gravel, a gravelly loam, as indicated by the blue arrows in the following figure.



▶ The correct answer is **B**.

P.2 ■ Solution

Part A: Consider soil A. First, we calculate the coarse fraction,

$$\text{Coarse fraction} = 100 - 30 = 70\%$$

The gravel fraction, in turn, is

$$\text{Fraction of gravel} = 100 - 70 = 30\%$$

Next, we calculate the sand fraction,

$$\text{Fraction of sand} = 70 - 30 = 40\%$$

Finally, the fine fraction is

$$\text{Fine fraction} = 30\%$$

More than 50% of the soil is retained on the no. 200 sieve, which implies, according to Figure 2, that the soil is coarse-grained. More than 50% of soil is retained on the No. 4 sieve, and hence the soil belongs to the sands category. Since the soil has more than 12% fines, the soil belongs to the sands with fines category. The plasticity index is greater than 7 and plots above the A-line, which, as per Figure 2, means that the soil has group symbol SC. With the aid of Figure 5, and knowing that the gravel fraction > 15%, we conclude that the soil is designated as a clayey sand with gravel.

Next, consider soil B. The coarse fraction is

$$\text{Coarse fraction} = 100 - 11 = 89\%$$

The gravel fraction is

$$\text{Fraction of gravel} = 100 - 71 = 29\%$$

The sand fraction is

$$\text{Fraction of sand} = 89 - 29 = 60\%$$

Finally, the fine fraction is determined as

$$\text{Fine fraction} = 11\%$$

From Figure 2, considering that more than 50% of soil is retained in the no. 200 sieve, the soil is classified as coarse-grained. Since more than 50% coarse fraction passes the no. 4 sieve, the soil belongs to sands. This is a sand with percentage of fines ranging between 5 and 12%, and as such is categorized with dual symbols (SW-SM, SW-SC, SP-SM, or SP-SC). The value of C_u is less than 6 and the value of C_c is between 1 and 3, hence the first symbol is SP. The plasticity index is more than 7 and plots above the A-line, so the second symbol is SC. Accordingly, the group symbol is SP-SC. Referring to Figure 5, we conclude that the soil is a poorly graded sand with clay and gravel or silty clay and gravel.

► The correct answer is **D**.

Part B: We begin by computing the coarse fraction,

$$\text{Coarse fraction} = 100 - 74 = 26\%$$

The gravel fraction is

$$\text{Fraction of gravel} = 100 - 100 = 0\%$$

and the sand fraction is

$$\text{Fraction of sand} = 26 - 0 = 26\%$$

More than 50% of soil passes the no. 200 sieve, so, in accordance with Figure 2, the soil is fine-grained. The liquid limit is less than 50, the soil is inorganic and plots above the A line, so the group symbol for the soil is CL. We know that less than 30% of soil is retained in the no. 200 sieve and that the percentage of sand surpasses the percentage of gravel. Then, following Figure 3, the group name for the soil is lean clay with sand.

Let us move on to soil D. The coarse fraction is

$$\text{Coarse fraction} = 100 - 78 = 22\%$$

The gravel fraction is

$$\text{Fraction of gravel} = 100 - 88 = 12\%$$

and the sand fraction follows as

$$\text{Fraction of sand} = 22 - 12 = 10\%$$

Since more than 50% passes the no. 200 sieve, we establish, with the aid of Figure 2, that the soil is fine-grained. The liquid limit is greater than 50, the soil is inorganic, and the *PI* plots above the A line, so the group symbol for this soil is CH. Using Figure 3 and knowing that less than 30% is retained in the no. 200 sieve, 15–29% is retained on the no. 200 sieve, and that the percentage of sand is less than the percentage of gravel, we conclude that the group name for this soil is fat clay with gravel.

► The correct answer is **B**.

P.3 ■ Solution

Part A: Consider soil A. Since more than 35% passes the no. 200 sieve, this is a silty clay soil. Hence, the soil is classed in one of the categories from A-4 to A-7. Working from left to right in Figure 7, we start with type A-4. In order for the soil to belong to this category, it must have a plasticity index of 10 at most, which automatically excludes our soil since *PI* = 11. Moving on to category A-5, the soil must have a minimum liquid limit of 41, which also excludes our soil, for which we have *PI* = 30. We then move forward to category A-6, which requires that $F_{200} \geq 36$, a condition that is verified in the present soil ($F_{200} = 48\%$). In addition, the soil must have a minimum *PI* = 11, which applies to our soil (since *PI* is exactly 11). Finally, the liquid limit must be no higher than 40, another requisite filled by our soil (*LL* = 30). We conclude that soil A belongs to category A-6.

Proceeding similarly with soil B, the student should conclude that it also belongs to category A-6.

► The correct answer is **A**.

Part B: Consider soil C. Since 20% (i.e., less than 35%) of soil is passing the no. 200 sieve, the soil is granular in nature. Hence, it may be classified as A-1, A-2, or A-3. Referring to Figure 7 and moving from left to right, we see that, for designation A-1-a to be attributed to the soil, the percent passing the no. 40 sieve must be no greater than 30%, thus eliminating the present soil (since F_{40} = 35). Now, for the soil to belong to class A-1-b, we must have $F_{40} < 50$, which is the case of the present soil. In addition, the percentage passing the no. 200 sieve must be 25 at most, which is also the case for this soil ($F_{200} = 20$). Finally, the plasticity index must be no greater than 6, yet another condition that is followed by our soil (PI = 5). Soil C satisfies all the constraints for category A-1-b and is therefore classed as such.

Proceeding similarly with soil D, the student should conclude that soil D is included in category A-7-5.

► The correct answer is **C**.

Part C: To compute the group index, we appeal to the formula

$$GI = (F_{200} - 35)[0.2 + 0.005(LL - 40)] + 0.01(F_{200} - 15)(PI - 10)$$

For soil C, we have F_{200} = 20%, LL = 25% and PI = 5%. Hence,

$$GI = (20 - 35)[0.2 + 0.005(25 - 40)] + 0.01(20 - 15)(5 - 10) = -2.13$$

According to one of the rules associated with the computation of the group index, the value of *GI* should be taken as zero if the calculation result turns out to be negative. Hence, we have *GI* = 0 for soil C.

Next, let us consider soil D. In this case, we have F_{200} = 72%, LL = 52%, and PI = 21%. Substituting in the pertaining formula gives

$$GI = (72 - 35)[0.2 + 0.005(52 - 40)] + 0.01(72 - 15)(21 - 10) = 15.89$$

According to one of the rules of the group index computation, the value obtained in the calculation of *GI* should be rounded to the nearest integer. It follows, then, that *GI* = 16 for soil D.

► The correct answer is **B**.

P.4 ■ Solution

Part A: The coarse fraction is given by

$$\text{Coarse fraction} = 100 - F_{200}$$

where F_{200} is the percentage passing the no. 200 sieve. In this case, F_{200} = 13%. Therefore,

$$\text{Coarse fraction} = 100 - 13 = 87\%$$

Next, we calculate the gravel fraction from the expression

$$\text{Fraction of gravel} = 100 - F_4$$

where F_4 is the percentage passing the no. 4 sieve. Substituting 100% for F_4, we obtain

$$\text{Fraction of gravel} = 100 - 100 = 0\%$$

Next, the sand fraction follows from the equation

$$\text{Fraction of sand} = \text{Coarse fraction} - \text{Fraction of gravel}$$

Substituting 87% for coarse fraction and 0% for gravel fraction, we find that

$$\text{Fraction of sand} = 87 - 0 = 87\%$$

The liquid limit is LL = 23%, and the plasticity index is PI = 23 – 19 = 4%. Referring to Figures 2 and 6, we conclude that the group symbol for the soil is SC-SM. Then, we resort to Figure 5 and, considering that the percentage of gravel is less than 15%, conclude that the soil is a silty clayey sand.

► The correct answer is **C**.

Part B: Since 13% of the soil passes through the no. 200 sieve, the soil is a granular material. 38% of the soil passes through the no. 40 sieve, and 90% of the soil passes through the no. 10 sieve. Furthermore, we see that the plastic index $PI = LL - PL$ = 23−19 = 4. For the soil to belong to the A-1-a category, the percentage passing the no. 10 sieve must be no greater than 50%, thus excluding the present soil. We move on to category A-1-b, which requires the percentage passing the no. 40 sieve to be no greater than 50% and the percentage passing the no. 200 sieve to be no greater than 25%. Both of these conditions are satisfied for this soil. In addition, the plasticity index of the soil must be not greater than 6, yet another condition that our soil does satisfy. We conclude that the soil belongs to category A-1-b.

► The correct answer is **B**.

P.5 ■ Solution

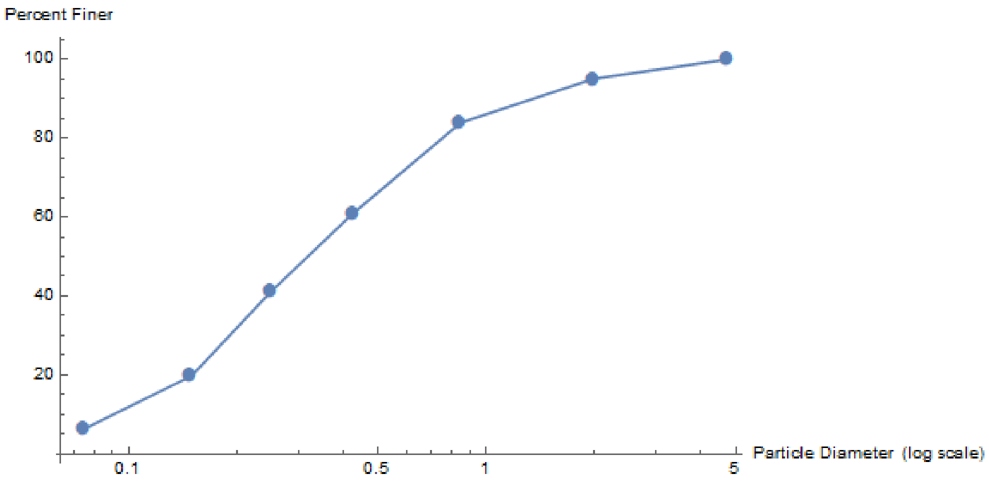
The following table is prepared.

US Sieve	Opening (mm)	Mass retained on each sieve (g)	Cumulative mass retained on each sieve (g)	Percent finer
4	4,75	0	0	100.00
10	2	22.1	22.1	95.09
20	0.85	50	72.1	83.98
40	0,425	103.4	175.5	61.00
60	0.25	89.4	264.9	41.13
100	0.15	96.2	361.1	19.76
200	0.075	60.5	421.6	6.31
Pan	-	28.4	$450 = \Sigma M$	-

Note that the percent finer is computed by the following equation,

$$\text{Percent finer} = \frac{\Sigma M - \text{Cumulative mass retained on each sieve}}{\Sigma M} \times 100$$

We can then plot the grain size distribution curve, as shown in continuation.



Using this curve, we can extract diameters D_{10}, D_{30}, D_{60}, and D_{75},

$$D_{10} = 0.09 \text{ mm}$$
$$D_{30} = 0.19 \text{ mm}$$
$$D_{60} = 0.42 \text{ mm}$$
$$D_{75} = 0.56 \text{ mm}$$

Because diameter $D_{60} = 0.42 \neq 0.30$, we verify that *C* is the false statement.

► The false statement is **C**.

Part B: The uniformity coefficient is such that

$$C_u = \frac{D_{60}}{D_{10}} = \frac{0.42}{0.09} = \boxed{4.67}$$

The coefficient of gradation, in turn, is given by

$$C_c = \frac{D_{30}^2}{D_{60}D_{10}} = \frac{0.19^2}{0.42 \times 0.09} = \boxed{0.96}$$

► The correct answer is **B**.

P.6 ■ Solution

Part A: The diameter of the smallest size particles that have settled beyond the zone of measurement at the time of 60 min is, in mm,

$$D[\text{mm}] = K\sqrt{\frac{L[\text{cm}]}{t[\text{min}]}}$$

From Table 1, coefficient *K* is established as 0.01282. Also, we have G_s = 2.7, *L* = 9.2 cm and *t* = 60 min. Accordingly,

$$D = K\sqrt{\frac{L}{t}} = 0.01282 \times \sqrt{\frac{9.2}{60}} = 0.005 \text{ mm}$$

► The correct answer is **D**.

Part B: In this case, we have G_s = 2.75, temperature of water = 23°C, *t* = 100 min, and *L* = 12.8 cm. Referring to Table 1, we find that *K* = 0.01279. Substituting in the pertaining formula gives

$$D = 0.01279 \times \sqrt{\frac{12.8}{100}} = 0.00458 \text{ mm} \approx 0.0046 \text{ mm}$$

► The correct answer is **A**.

ANSWER SUMMARY

Problem 1		B
Problem 2	2A	D
	2B	B
Problem 3	3A	A
	3B	C
	3C	B
Problem 4	4A	C
	4B	B
Problem 5		B
Problem 6	6A	D
	6B	A

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