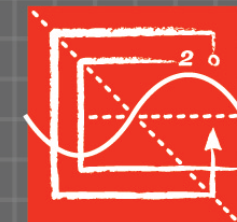


# TRANSITION OF PROFESSIONAL EXAMS TO CBT

Lehmon Dekle, P.E.

NCEES Project Manager of Computer-Based Exams



**NCEES**

*advancing licensure for  
engineers and surveyors*

# Overview

- Computer-based testing (CBT) transition update
- CBT exam formats
- Examinee references in CBT
- Alternative item types (AITs)
- CBT transition schedule

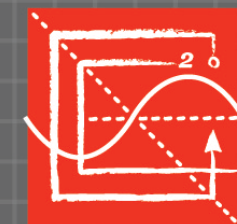
# Learning objectives

- After attending this workshop, participants should be able to
  - Name at least two benefits of CBT
  - Explain how references are being provided to examinees on CBT exams
  - Identify the first two professional exams being converted to CBT



*(There will be a quiz!)*

# CBT PROGRESS TO DATE



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# CBT progress to date

- Why CBT?

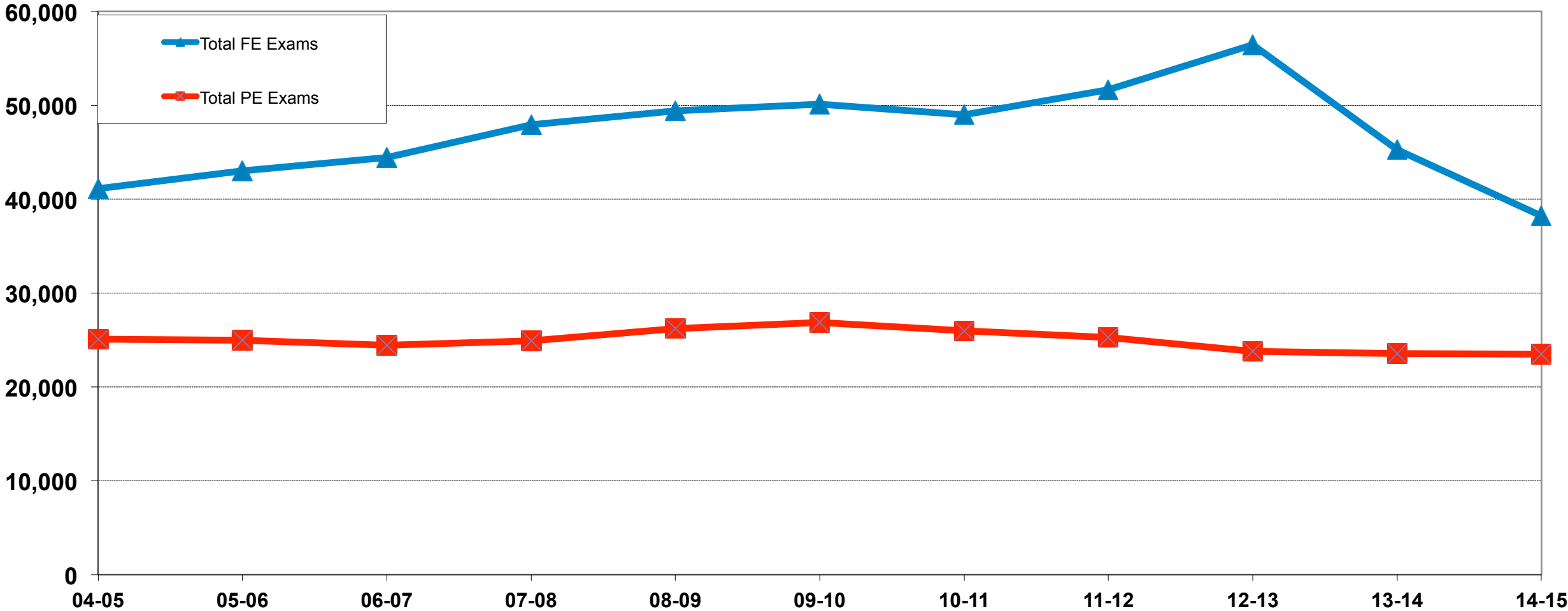


# CBT progress to date

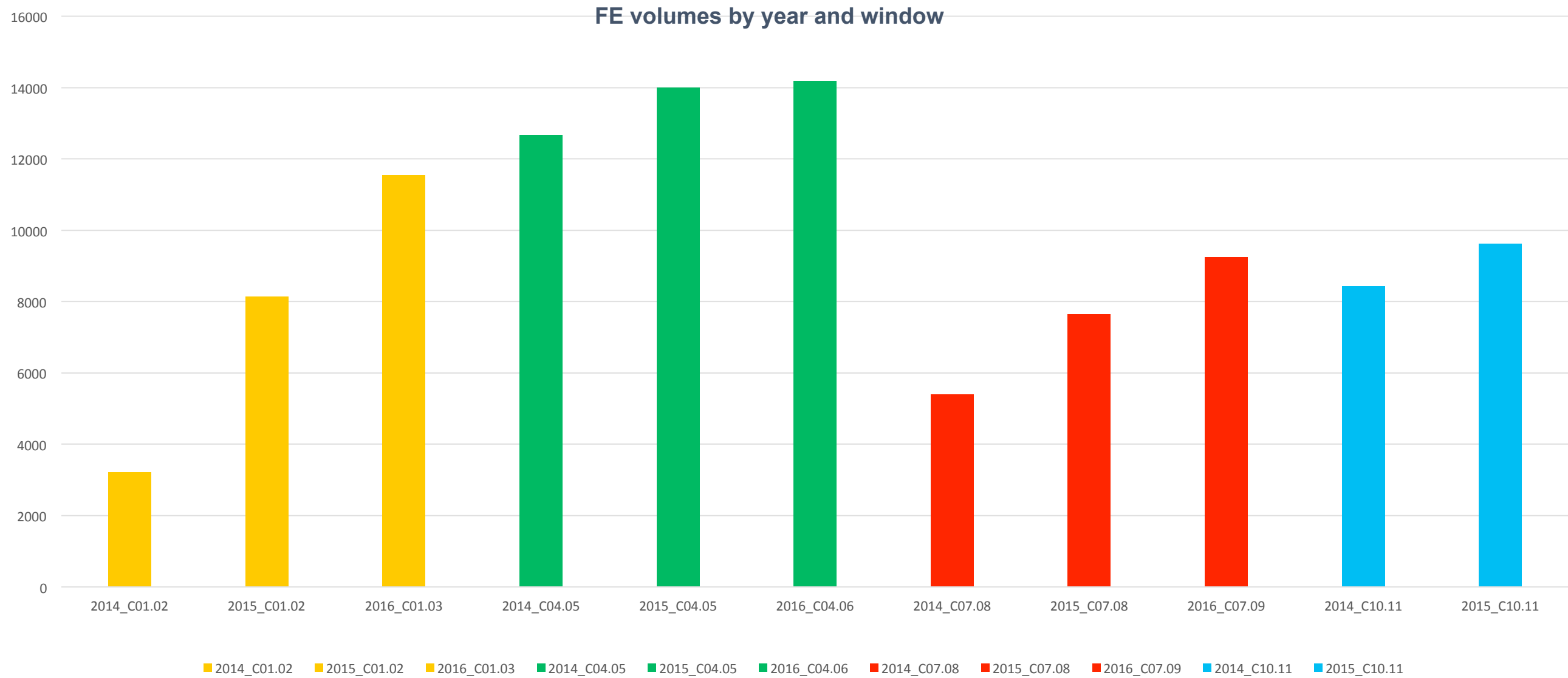
- At the 2012 annual meeting, NCEES voted to convert the FE/FS exams to CBT.
- CBT exam administration began January 2, 2014.
  - Over 95,000 FE/FS exams administered through June 2016
  - Very positive examinee feedback

# FE exam trends

## FE and PE exam usage



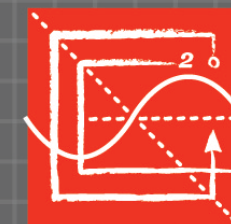
# FE exam windows trend



# FE exam pass rates

	2013 October	2014 C01.05	2014 C07.11	2015 C01.05	2015 C07.11	2016 C01.06
<b>Total number of examinees</b>	22,825	15,880	13,812	22,133	17,261	25,293
<b>Number of first-time examinees</b>	17,439	13,348	10,827	18,517	13,453	20,874
<b>First-time pass rate</b>	73%	78%	74%	73%	70%	72%
<b>Repeat pass rate</b>	30%	34%	34%	34%	34%	34%

# CBT EXAM FORMATS



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# CBT exam formats

- Different CBT formats are based on examinee population.
- All CBT formats offer benefits to
  - NCEES
  - Examinees

# CBT exam formats

- Key benefits, NCEES perspective
  - Improved security (not just collusion)
  - Consistent testing environment
- Key benefits, examinee perspective
  - Flexible scheduling
  - Searchable handbook
  - Quicker results

# CBT exam formats

- LOFT—Linear On the Fly Test
  - These exams have large examinee volumes.
  - Every examinee receives a different, but statistically equivalent, exam form.
  - Each exam is the same length but covers the same topics.
- LOFT benefits
  - Flexible scheduling
  - Quick results turnaround (7–10 days)

# CBT exam format

- NCEES exams/disciplines with enough volume for LOFT
  - FE (7 disciplines)
  - FS
  - PE Chemical
  - PE Civil (5 disciplines)
  - PE Electrical and Computer (Power discipline only)
  - PE Environmental
  - PE Mechanical (3 disciplines)
  - PS

# CBT exam formats

- LFF—Linear Fixed Form
  - These exams are not large enough for LOFT.
  - Every examinee receives the same items (like pencil-and-paper exams but administered on computer).
  - LFF are single-day testing “events” (like today).
- LFF benefits in CBT
  - Quicker results turnaround (all exams)
  - More precise psychometric model (*4 italicized exams*)

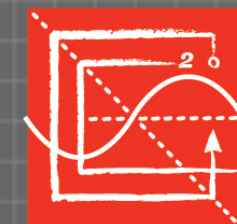
# CBT exam format

- NCEES exams/disciplines using LFF in CBT
  - PE Agricultural and Biological
  - PE Architectural
  - *PE Control Systems*
  - PE Electrical and Computer (Computer discipline)
  - *PE Electrical and Computer (Electrical and Electronics discipline)*
  - *PE Fire Protection*

# CBT exam format

- NCEES exams/disciplines using LFF in CBT (continued)
  - PE Industrial and Systems
  - PE Metallurgical and Materials
  - PE Mining and Mineral Processing
  - PE Naval Architecture and Marine
  - PE Nuclear
  - *PE Petroleum*
  - PE Software

# CBT EXAMINEE REFERENCES



**NCEES**

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# Professional exam references

- What is a reference?
  - Content that must be provided to answer a test question
- Currently, examinees provide their own references.
- References will be provided on screen in CBT.
  - Just like CBT FE/FS exams

# Professional exam references

- Four CBT reference alternatives:
  - ~~Open book (existing pencil-and-paper exams)~~
  - Reference handbook (written by exam committee)
  - Exhibits (embedded in specific questions)
  - Supplemental references (typically codes/standards)

# CBT exam screen with handbook

Test - Candidate Name

Time Remaining 05:18:10

12 of 110

Calculator

Flag for Review Normal Font

**FE REFERENCE HANDBOOK**

**UNITS**

The FE exam and this handbook use both the metric system of units and the U.S. Customary System (USCS). In the USCS system of units, both force and mass are called pounds. Therefore, one must distinguish the pound-force (lbf) from the pound-mass (lbm). The pound-force is that force which accelerates one pound-mass at 32.174 ft/sec<sup>2</sup>. Thus, 1 lbf = 32.174 lbm-ft/sec<sup>2</sup>. The expression 32.174 lbm-ft/(lbf-sec<sup>2</sup>) is designated as  $g_c$  and is used to resolve expressions involving both mass and force expressed as pounds. For instance, in writing Newton's second law, the equation would be written as  $F = ma/g_c$ , where  $F$  is in lbf,  $m$  in lbm, and  $a$  is in ft/sec<sup>2</sup>. Similar expressions exist for other quantities. Kinetic Energy,  $KE = mv^2/2g_c$ , with  $KE$  in (ft-lbf); Potential Energy,  $PE = mgh/g_c$ , with  $PE$  in (ft-lbf); Fluid Pressure,  $p = \rho gh/g_c$ , with  $p$  in (lbf/ft<sup>2</sup>); Specific Weight,  $SW = \rho g/g_c$ , in (lbf/ft<sup>3</sup>); Shear Stress,  $\tau = (\mu/g_c)(dv/dy)$ , with shear stress in (lbf/ft<sup>2</sup>). In all these examples,  $g_c$  should be regarded as a unit conversion factor. It is frequently not written explicitly in engineering equations. However, its use is required to produce a consistent set of units.

Note that the conversion factor  $g_c$  [lbm-ft/(lbf-sec<sup>2</sup>)] should not be confused with the local acceleration of gravity  $g$ , which has different units (m/s<sup>2</sup> or ft/sec<sup>2</sup>) and may be either its standard value (9.807 m/s<sup>2</sup> or 32.174 ft/sec<sup>2</sup>) or some other local value.

If the problem is presented in USCS units, it may be necessary to use the constant  $g_c$  in the equation to have a consistent set of units.

METRIC PREFIXES			COMMONLY USED EQUIVALENTS	
Multiple	Prefix	Symbol		
10 <sup>-18</sup>	atto	a		
10 <sup>-15</sup>	femto	f	1 gallon of water weighs	8.34 lbf
10 <sup>-12</sup>	pico	p	1 cubic foot of water weighs	62.4 lbf
10 <sup>-9</sup>	nano	n	1 cubic inch of mercury weighs	0.491 lbf
10 <sup>-6</sup>	micro	$\mu$	The mass of 1 cubic meter of water is	1,000 kilograms
10 <sup>-3</sup>	milli	m	1 mg/L is	8.34 lbf/Mgal
10 <sup>-2</sup>	centi	c		
10 <sup>-1</sup>	deci	d		
10 <sup>1</sup>	deka	da		
10 <sup>2</sup>	hecto	h		
10 <sup>3</sup>	kilo	k		
10 <sup>6</sup>	mega	M		
10 <sup>9</sup>	giga	G		
10 <sup>12</sup>	tera	T		
10 <sup>15</sup>	peta	P		
10 <sup>18</sup>	exa	E		

**TEMPERATURE CONVERSIONS**

$^{\circ}\text{F} = 1.8 (^{\circ}\text{C}) + 32$   
 $^{\circ}\text{C} = (^{\circ}\text{F} - 32)/1.8$   
 $^{\circ}\text{R} = ^{\circ}\text{F} + 459.69$   
 $\text{K} = ^{\circ}\text{C} + 273.15$

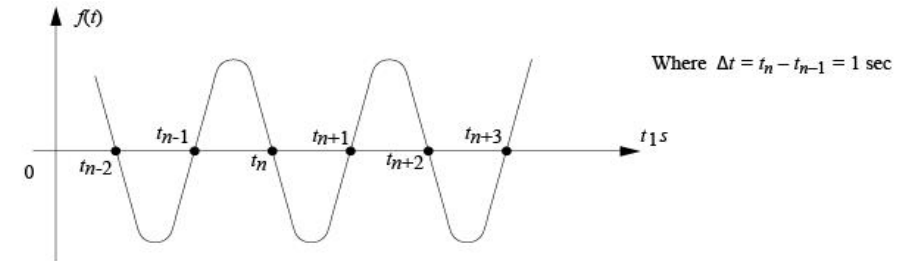
**IDEAL GAS CONSTANTS**

The universal gas constant, designated as  $\bar{R}$  in the table below, relates pressure, volume, temperature, and number of moles of an ideal gas. When that universal constant,  $\bar{R}$ , is divided by the molecular weight of the gas, the result, often designated as  $R$ , has units of energy per degree per unit mass [kJ/(kg·K) or ft-lbf/(lbm·°R)] and becomes characteristic of the particular gas. Some disciplines, notably chemical engineering, often use the symbol  $R$  to refer to the universal gas constant  $\bar{R}$ .

**FUNDAMENTAL CONSTANTS**

Quantity	Symbol	Value	Units
electron charge	$e$	$1.6022 \times 10^{-19}$	C (coulombs)
Faraday constant	$F$	96,485	coulombs/(mol)
gas constant	$\bar{R}$	8,314	J/(kmol·K)
gas constant	$\bar{R}$	8,314	kPa·m <sup>3</sup> /(kmol·K)
gas constant	$\bar{R}$	1,545	ft-lbf/(lb mole·°R)
gas constant	$\bar{R}$	0.08206	L-atm/(mole·K)

The continuous harmonic data signal is given below:



The minimum sample frequency  $f_s$  required to properly reconstruct the continuous signal is:

- A. 1 sample per 4 sec
- B. 1 sample per 2 sec
- C. 1 sample per 1 sec
- D. 2 samples per 1 sec

# CBT exam screen—exhibits

**PHYSICS**  
 Lens equation:  

$$\frac{1}{o} + \frac{1}{i} = \frac{1}{f}$$
 where:  
 o = Object distance  
 i = Image distance  
 f = Focal length  
 Snell's laws:  
 $n \sin \phi = n' \sin \phi'$ 
 where:  
 n = Refractive index  
 $\phi$  = Angle of incidence

**GEODESY**  
 Ellipsoid  
 a = Semimajor axis  
 b = Semiminor axis  
 Flattening,  $f = \frac{a-b}{a}$  (usually published as 1/f)  
 Eccentricity,  $e^2 = \frac{a^2 - b^2}{a^2}$   
 Radius in meridian,  $M = \frac{a(1-e^2)}{(1-e^2 \sin^2 \phi)^{3/2}}$   
 Radius in prime vertical,  $N = \frac{a}{(1-e^2 \sin^2 \phi)^{1/2}}$

Exhibit



**FEMA**

$n \approx H + N$   
 where:

## Exhibits

This tests the use of exhibits in stems, options, and solutions. The Display As Exhibit check box allows you to mark the image to be shown as a popup for QTI Exams on the Pearson VUE player.

This is a multipage pdf exhibit (15 pages, 1,671 kb):

[View Pdf](#)

This is a single page reference:

Thermodynamic Data for Dry Air

Pressure (MPa)	200	300	500	1000	2000	5000	10000
v	0.0196	0.0214	0.0232	0.0250	0.0277	0.0304	0.0438
w	191.0	206.1	243.8	281.0	338.4	515.9	431.7
h	270.2	291.7	344.6	397.0	449.7	501.5	600.9
s	0.0131	0.0142	0.0169	0.0194	0.0220	0.0245	0.0294
u	184.5	200.4	239.0	277.6	315.1	353.6	430.4
h	285.1	291.6	330.4	369.0	407.1	445.0	500.8
v	0.0090	0.0107	0.0127	0.0147	0.0166	0.0185	0.0223
w	182.3	198.1	237.4	275.5	313.7	351.8	428.3
h	280.8	283.7	319.0	353.1	386.5	419.8	496.7
v	0.0070	0.0086	0.0102	0.0118	0.0134	0.0149	0.0180
w	177.9	194.4	234.5	273.3	311.3	349.0	426.6
h	256.4	270.9	316.5	351.3	385.3	419.0	496.0

$v = m^3/kg, w = kJ/kg, h = kJ/kg$

[Click to Enlarge](#)

- A. 2.3
- B. 2
- C. 4
- D. 6

# CBT exam screen—handbook and codes

Reference Display Options - Candidate Name 3328

Calculator Normal Font

Handbook Codes-1

### FE REFERENCE HANDBOOK

#### UNITS

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10 <sup>1</sup>	deka	da		
10 <sup>2</sup>	hecto	h		
10 <sup>3</sup>	kilo	k		
10 <sup>6</sup>	mega	M		
10 <sup>9</sup>	giga	G		
10 <sup>12</sup>	tera	T		
10 <sup>15</sup>	peta	P		
10 <sup>18</sup>	exa	E		

#### TEMPERATURE CONVERSIONS

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#### IDEAL GAS CONSTANTS

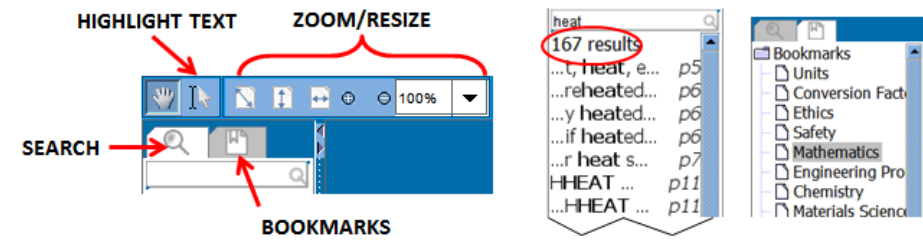
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#### FUNDAMENTAL CONSTANTS

### Split-screen References

For FE and FS exams, the reference manual is on the left side of the screen and the exam content is on the right side of the screen. The reference PDF is searchable and adjustable, similar to search features in Adobe PDF.

The PDF viewer contains a toolbar that has several features:



**Search:**  
The search function is the first tab on the second row on the toolbar. The PDF viewer allows searches for strings of characters, such as words or partial words. Examinees must click the enter key on the keyboard to launch the search. Items returned in the search list are hyperlinks to the locations in the document.

In the example above, "heat" returned 167 results when searched in the *FE Reference Handbook*. The search returned every instance of "heat" including parts of words and capitalized words.

**Highlight text:**  
The highlight text tool on the top row allows examinees to highlight text in the reference, copy the text, and paste the copied text in the search box.

**Zoom/Resize:**  
The zoom feature allows you to change the size of the reference material.

**Bookmarks:**  
Bookmark links to each section in the reference material are located on the second tab of the second row in the reference toolbar. Examinees can click a bookmark link to navigate quickly between chapters.

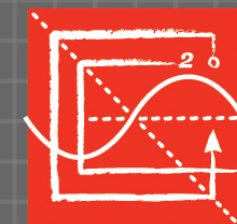
? Help   End Exam   ← Previous   Next →

# Professional exam references

- When converting PE exams to CBT, the exam committees' major challenge is references.
  - Bank items already exist.
  - NCEES-supplied references do not.



# ALTERNATIVE ITEM TYPES



**NCEES**  
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engineers and surveyors*

# Alternative item types

- What is an alternative item type (AIT)?
  - An item format that cannot be supported on paper exam formats but can be supported on a computer screen
- AIT formats we'll be using
  - Point and click (two types): identify a spot on a drawing/figure
  - Drag and drop: move tokens onto targets
  - Fill in the blank
  - Multiple choice, multiple select

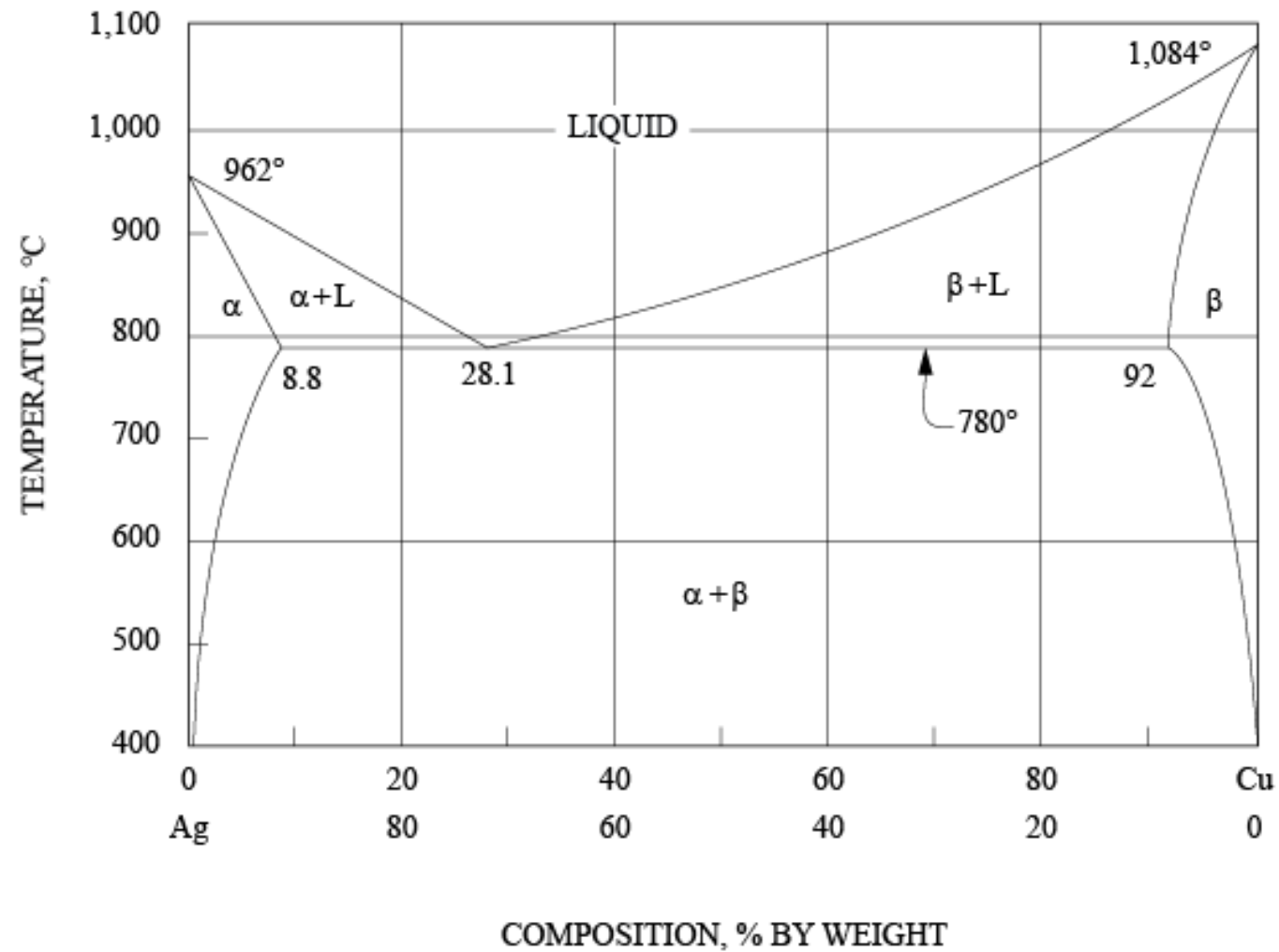
# Alternative item types

- **Question:** When should alternative items be used?
- **Answer:** When they're the best tool for the job (testing minimum competence)



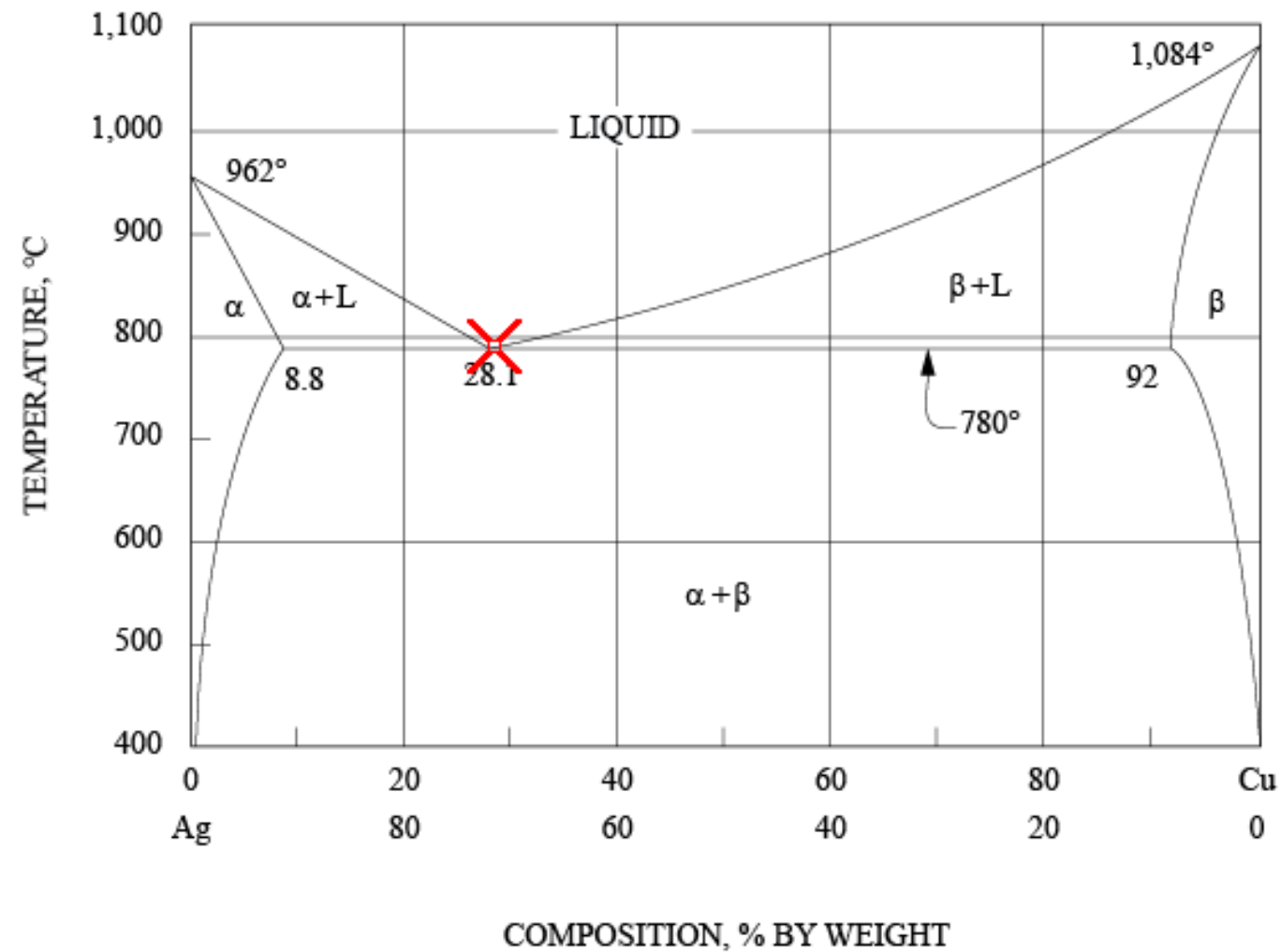
# Point and click (hot spot)

The Ag-Cu binary phase diagram is shown below. Select the eutectic point on the diagram.



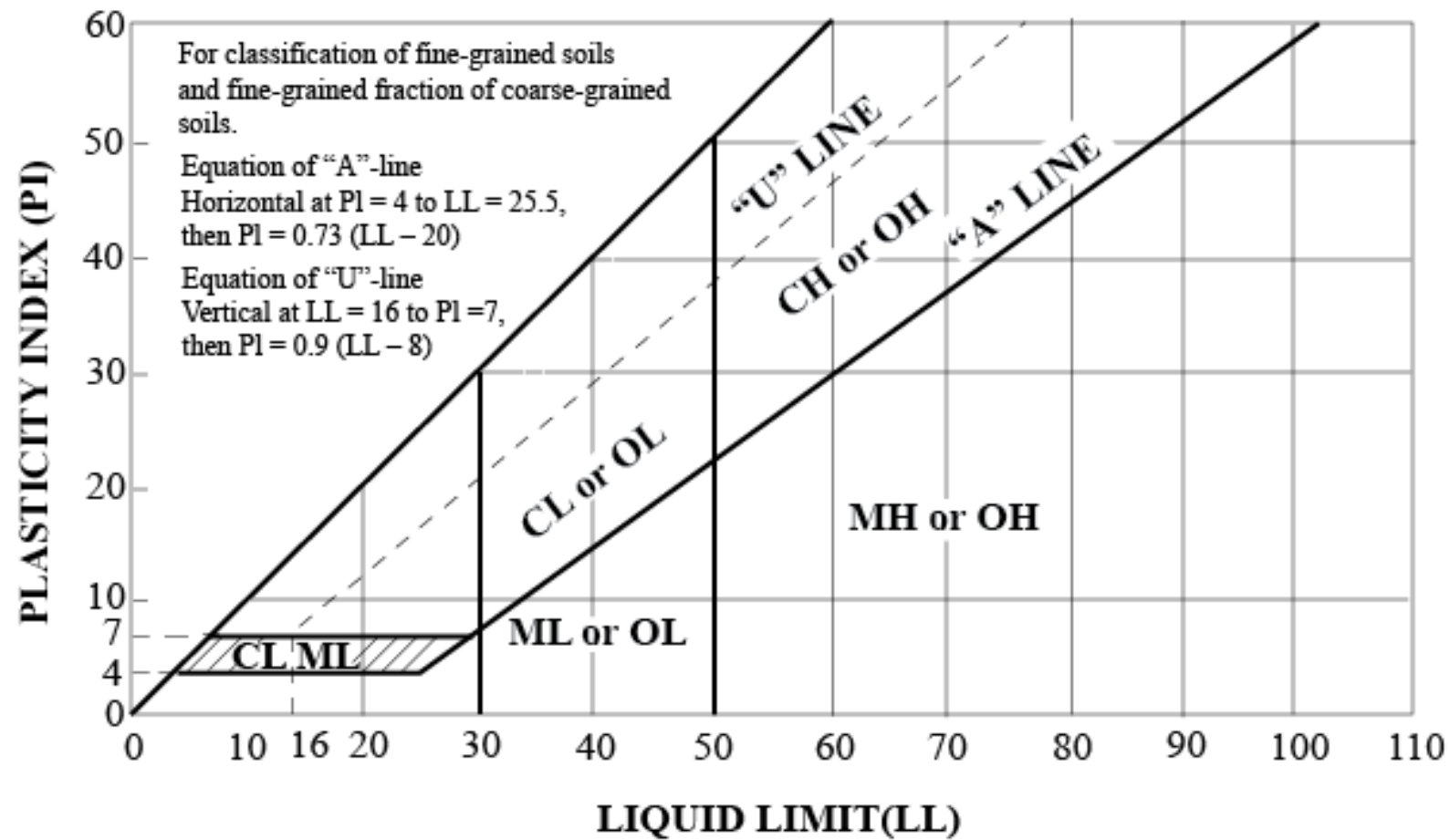
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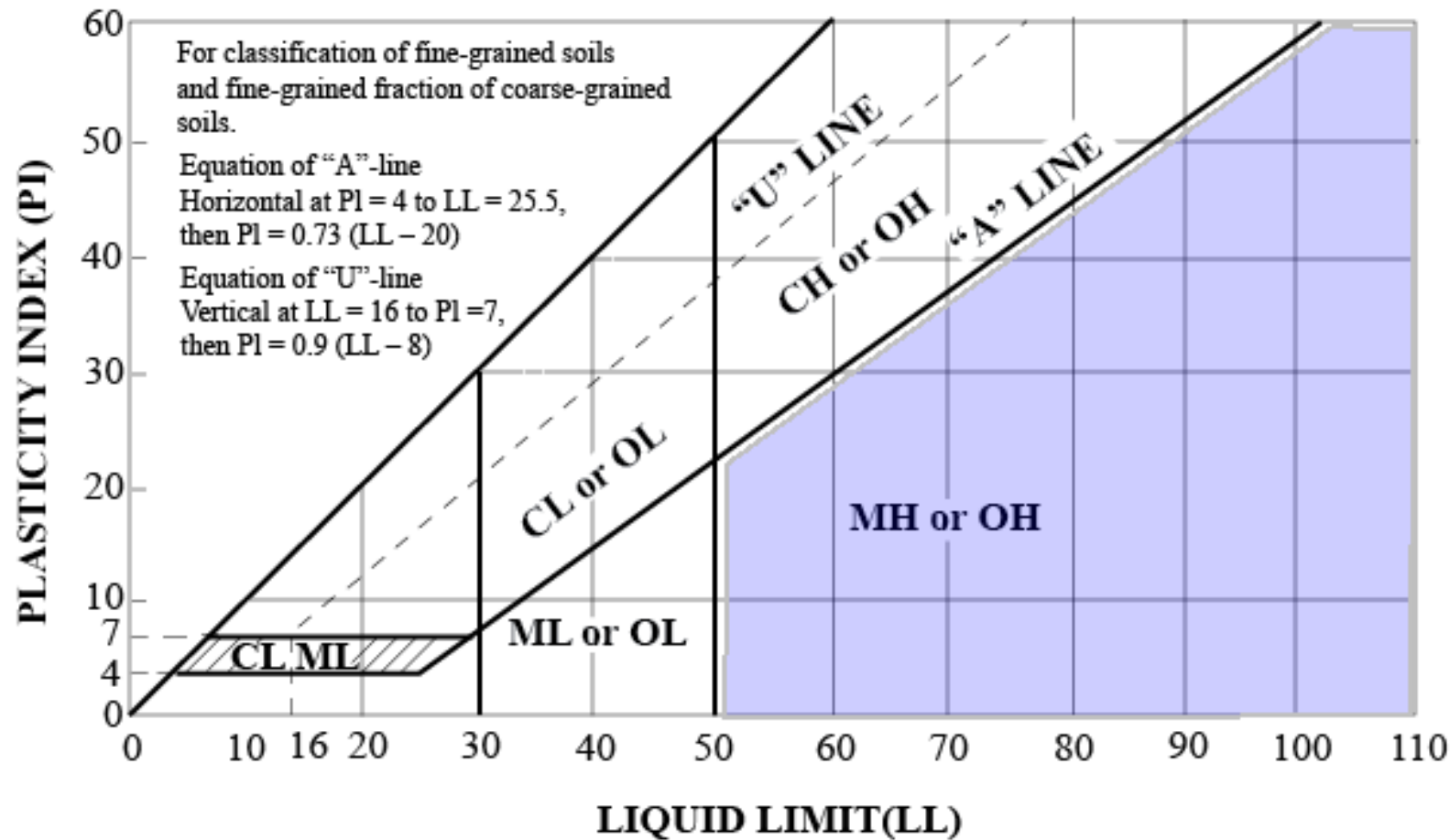
# Point and click (hot area)

Click the area of the Atterberg chart provided that is associated with an elastic, non-organic silt.



# Point and click (hot area)

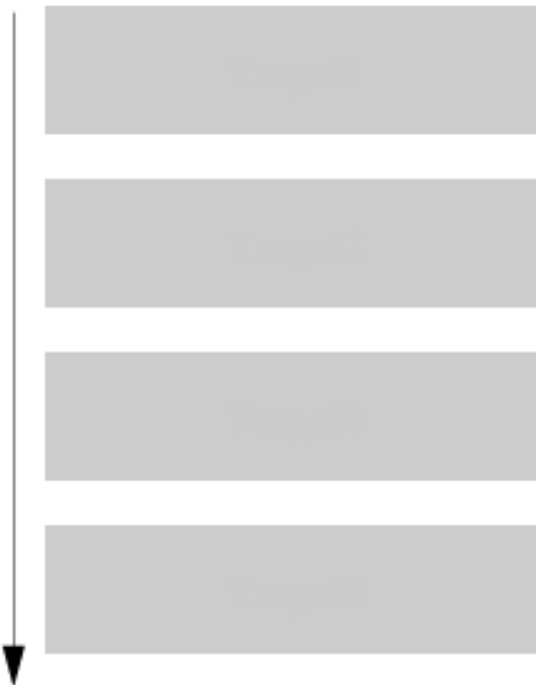
Click the area of the Atterberg chart provided that is associated with an elastic, non-organic silt.



# Drag and drop

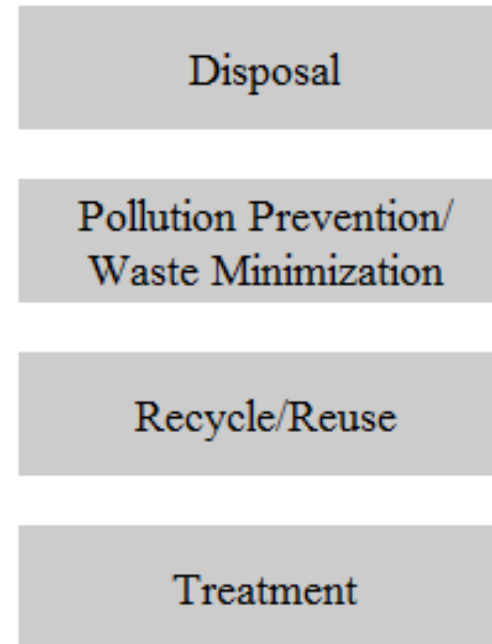
USEPA preferred strategies for the management of waste materials are listed. Place these in the correct hierarchy from most to least desirable.

Most Desirable



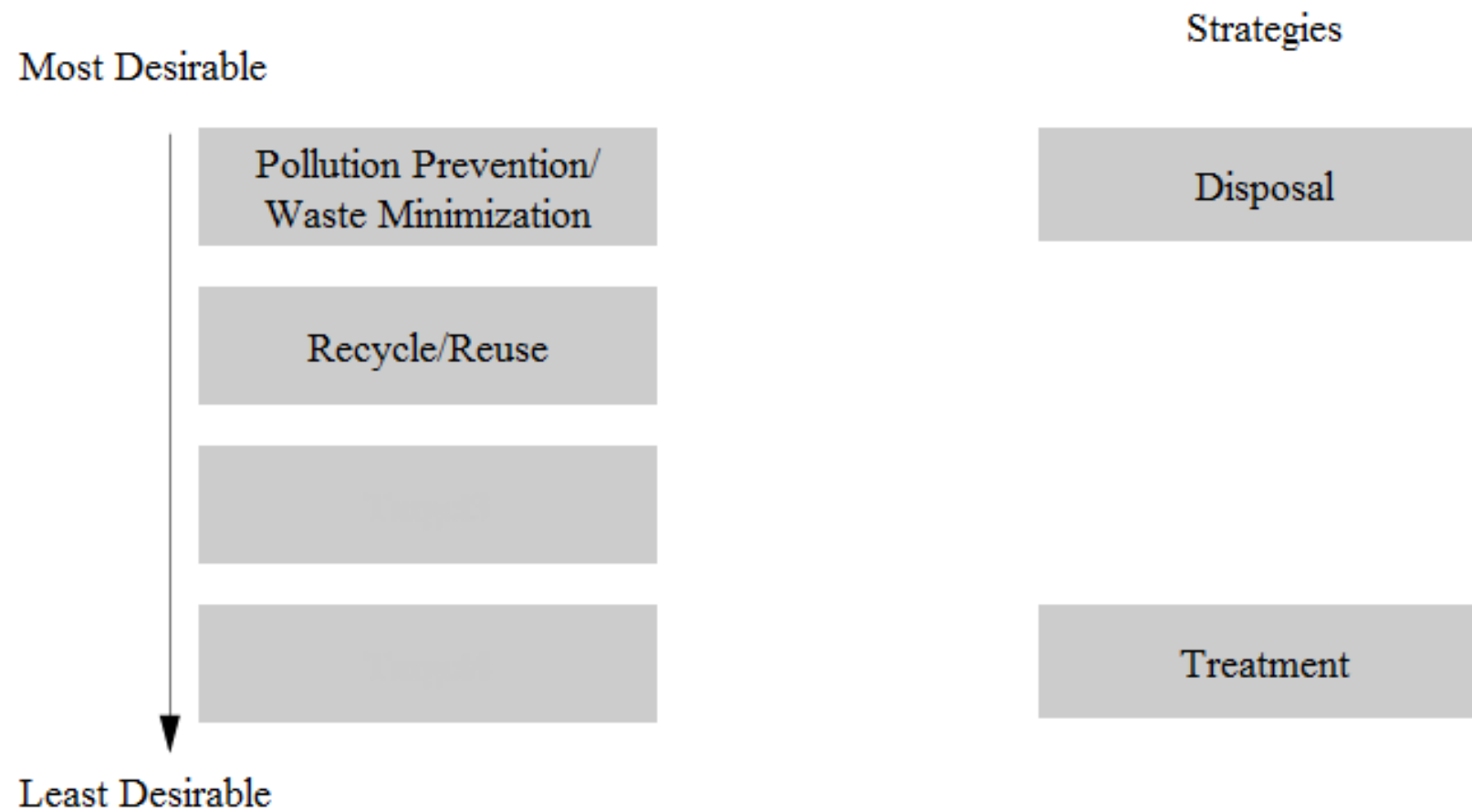
Least Desirable

Strategies



# Drag and drop

USEPA preferred strategies for the management of waste materials are listed. Place these in the correct hierarchy from most to least desirable.



# Fill in the blank

The molecular (or atomic) weight (g/mole) of sulfuric acid ( $\text{H}_2\text{SO}_4$ ) is .

Answer to the nearest integer.

# Fill in the blank

The molecular (or atomic) weight (g/mole) of sulfuric acid ( $\text{H}_2\text{SO}_4$ ) is .

Answer to the nearest integer.

# Multiple choice, multiple select

Which of the following are oxidation-reduction reactions?

Select all that apply.

- A.  $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$
- B.  $\text{CO}_2 + \text{C} \rightarrow 2\text{CO}$
- C.  $\text{Fe} + \text{S} \rightarrow \text{FeS}$
- D.  $2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$
- E.  $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$

# Multiple choice, multiple select

Which of the following are oxidation-reduction reactions?

Select all that apply.

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# Alternative item types

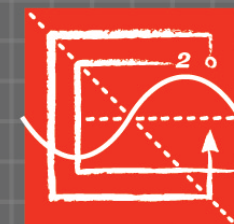
- **Question:** When should alternative item types be used?
- **Answer:** When they're the best tool for the job (testing minimum competence)



# Alternative item types

- AIT integration schedule
  - PS: October 2016 (initial CBT exam)
  - FE (7 disciplines): July 2017
  - FS: July 2017
  - PE Chemical: January 2018 (initial CBT exam)
  - All others: with initial CBT exam

# CBT TRANSITION SCHEDULE



**NCEES**

*advancing licensure for  
engineers and surveyors*

# General transition timeline

- The last major NCEES exam transition was the 1996–2002 migration from essay exams to multiple choice.
- What can we learn from that transition?
  - Over five years, 16 exams converted to multiple choice.
  - The schedule averaged three exams per year.

# General transition timeline

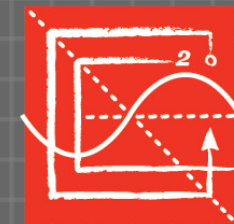
- Currently, 16 PE exams remain paper-based.
- CBT transition schedule concept approved by EPE:
  - Convert three exams annually over six years, beginning in 2018.
  - Transition order will depend on readiness.

# Potential PS/PE CBT transition schedule

	Group 1 exams	Group 2 exams	Total this year
2014	Council vote: Convert “as soon as feasible”		
2017–18 (year 1)	CHE, PS	NUC	3
2019 (year 2)	ELEC (3), ENV, MEC (3)	FPE, MIN (?)	3
2020–21 (years 3–4)		AGR, ARC, CSE, IND, MET, NAME, PET, SWE	6
2022 (year 5)			CIV (5)
2023 (year 6)	<b>STR?</b>		2 <b>(3)</b>
Totals	5 <b>(6)</b>	11	17 <b>(18)</b>

Approved by EPS/EPE in January/October 2015, respectively

# REVIEW LEARNING OBJECTIVES



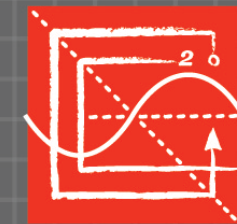
**NCEES**

*advancing licensure for  
engineers and surveyors*

# Learning objectives

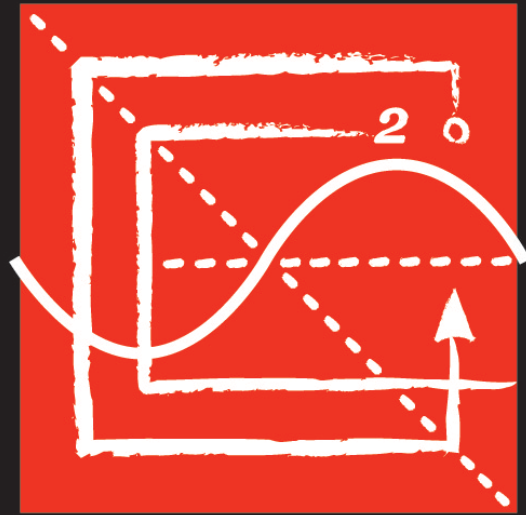
- After attending this workshop, participants should be able to
  - Explain how references are being provided to examinees on CBT exams
  - Name at least two benefits of CBT
  - Identify the first two professional exams being converted to CBT

# QUESTIONS AND DISCUSSION



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