This month’s topics:

- PE Exam Specifications
- Mechanics of Materials
- Statics
- Structural Analysis (Influence Lines)
- Structural Design (Reinforced Concrete)
- Structural Design (Steel Design)
- Foundation Design
- Transportation
The PE exam is an 8-hour *open-book* exam. It contains 40 multiple-choice questions in the 4-hour AM session, and 40 multiple-choice questions in the 4-hour PM session. The PE exam uses both the International System of Units (SI) and the US Customary System (USCS).

**CIVIL BREADTH (Morning Session)**

Exam Specifications

- **Project Planning** (Approx. 4 questions*)
- **Means and Methods** (3 questions)
- **Soil Mechanics** (6 questions)
- **Structural Mechanics** (6 questions)
- **Hydraulics and Hydrology** (7 questions)
- **Geometrics** (3 questions)
- **Materials** (6 questions)
- **Site Development** (5 questions)
PE - CIVIL-CONSTRUCTION DEPTH  
(Afternoon Session)  
Exam Specifications  

- Civil Engineering Materials (5 questions)  
- Fluid Mechanics (5 questions)  
- Hydraulics and Hydrologic Systems (10 questions)  
- Structural Analysis (8 questions)  
- Structural Design (8 questions)  
- Geotechnical Engineering (12 questions)  
- Transportation Engineering (10 questions)  
- Environmental Engineering (8 questions)  

* Here the number of questions are the average values taken from the NCEES Reference Handbook (Version 9.1 / Computer-Based Test)
PROBLEM (Reinforced Concrete Beam)

A simply supported R/C beam is loaded as shown in the figure. Determine the uniform load \( w \), in addition to the weight of the beam, which will cause the sections to begin to crack.

Solution:

**The Modulus of Rupture \( f_r \)**

\[
f_r = 7.5 \sqrt{f'_c} = 7.5 \sqrt{4,000} = 474 \text{ psi}
\]

**Moment of Inertia \( I_g \)**

\[
I_g = \frac{bh^3}{12} = \frac{12 \times 26^3}{12} = 17,576 \text{ in}^4
\]

**The Cracking Moment \( M_{\text{crack}} \)**

\[
M_{\text{crack}} = \frac{f_r I_g}{y_t} = \frac{474 \times 17,576}{13} = 640,848 \text{ in} \cdot \text{lb}
\]

\[
M_{\text{crack}} = \frac{640,848}{12 \times 1000} = 53.40 \text{ ft} \cdot \text{kip}
\]

**The Weight of the Beam \( w_{\text{beam}} \)**

\[
w_{\text{beam}} = \text{Area} \times g = \frac{12 \times 26}{144} \times 386 = 325 \text{ lb/ft}
\]

**Total Uniform Load \( w_{\text{total}} \)**

\[
M_{\text{max}} = \frac{wL^2}{8} \Rightarrow w_{\text{total}} = \frac{8M}{L^2} = \frac{8 	imes 53.40}{30^2} = 0.475 \text{ kip/ft}
\]

**Uniform Load \( w_{\text{load}} \)**

\[
w_{\text{total}} = w_{\text{beam}} + w_{\text{load}}
\]

\[
w_{\text{load}} = w_{\text{total}} - w_{\text{beam}} = 475 - 325 = 150 \text{ lb/ft}
\]

\[
w_{\text{load}} = 150 \text{ lb/ft}
\]
REINFORCED CONCRETE BEAM

STRAIN & STRESS PROFILES

\[ a = \beta_1 \cdot c \]

\[ C = 0.85 f'_c b \cdot a \]

\[ T = A_s f_y \]
The dimensions of a R/C beam section is given as shown. Using the listed data answer the following:

The cracking moment (ft-kips) is most nearly:

(A) 16.5  
(B) 22.5  
(C) 30.5  
(D) 34.8
REINFORCED CONCRETE STRUCTURES

DESIGN STRENGTH

Problem:

\[ \phi M_n = ? \]

The dimensions of a R/C beam section is given as shown. Using the listed data answer the following question:

The design strength (ft-kips) is most nearly:

(A) 620
(B) 544
(C) 485
(D) 450

\[ f'_c = 4,000 \text{ psi} \]
\[ f_y = 60,000 \text{ psi} \]
\[ \gamma_c = 150 \text{ lb/ft}^3 \]
REINFORCED CONCRETE
EFFECTIVE FLANGE WIDTHS FOR T & L BEAMS

Effective Flange Widths:

For T-beams:

\[ b_{\text{eff}} = \min \left\{ \frac{l}{4}, b_w + 16h_f, s \right\} \]

For L-beams:

\[ b_{\text{eff}} = \min \left\{ b_w + \frac{1}{12}, b_w + 6h_f, \frac{b_w + s}{2} \right\} \]
Problem:

The stresses shown in the figures act at a point in a machine part and plane $AB$ is defined as shown (48° from horizontal):

1. The normal stress (MPa) on plane $AB$ is most nearly
   
   (A) +60.25
   (B) -60.25
   (C) +55.60
   (D) -55.60

2. The shearing stress (MPa) on plane $AB$ is most nearly
   
   (A) -80.65
   (B) +80.65
   (C) -95.85
   (D) +95.85
Problem:

The stresses shown in the figure act at a point in a machine part. Using the given stress element, the maximum inplane shear stress (MPa) in the element is most nearly:

(A) 26.50
(B) 22.25
(C) 15.60
(D) 12.50

\[ \tau_{\text{max}} = ? \]
Problem: (Bearings & Azimuths) HK

![Diagram of a circular arc with points A, B, and C, and angle θ]

A circular arc has a radius of 560.00 ft and a central angle of $38^\circ 20' 45''$. Using the listed data and the figure, answer the following questions:

1. the central angle (radians) is most nearly, $\theta$
   (A) 0.469
   (B) 0.513
   (C) 0.669
   (D) 0.725

2. the arc length $AB$ (feet) is most nearly, $s$
   (A) 486.7
   (B) 374.8
   (C) 312.0
   (D) 286.5
**DESIGN OF STEEL STRUCTURES**

**STAGGERED FASTENERS**

![Diagram of staggered fasteners]

\[ s = \text{stagger (pitch)} \]
\[ g = \text{gage (transverse spacing)} \]
\[ s = \text{stagger is always parallel to the applied load.} \]

**The effective hole diameter:** \( d_{\text{hole}} \)

\[ d_{\text{hole}} = d_{\text{bolt}} + 1/16" \]

**Failure Line (abcde) (3 holes, 2 inclined lines)**

**The effective net width:** \( w_{\text{net}} \)

\[ w_{\text{net}} = w_{\text{gross}} - \sum d_{\text{hole}} + \sum s^2 / 4 g \]

\[ w_{\text{net}} = w_{\text{gross}} - 3 d_{\text{hole}} + (s_1^2 / 4 g_1 + s_2^2 / 4 g_2) \]

**The effective net area:** \( A_{\text{net}} \)

\[ A_{\text{net}} = w_{\text{net}} \times \text{Plate Thickness} \]

\[ A_{\text{net}} = w_{\text{net}} \times t_{\text{plate}} \]
**IMPORTANT COLUMN FORMULAS**

\[
P_u \leq \phi P_c n
\]

\[
\phi P_c n = \phi F_{cr} A
\]

\[
F_e = \frac{\pi^2 E}{(KL/r)^2}
\]

\[
KL/r \leq 4.71 \sqrt{\frac{E}{F_y}}
\]

\[
KL/r > 4.71 \sqrt{\frac{E}{F_y}}
\]

\[
\sqrt{\frac{E}{F_y}} = \sqrt{\frac{29,000/50}{580}} = 28.03
\]

\[
F_{cr} = 0.658 \left(\frac{F_y}{F_e}\right) F_y
\]

\[
F_{cr} = 0.877 F_e
\]

- \(K\) = effective length factor (AISC)
- \(L\) = column length
- \(KL\) = effective column length
- \(KL/r\) = slenderness ratio
- \(r\) = radius of gyration
- \(F_y\) = yield stress of steel
- \(F_e\) = Euler stress
- \(F_{cr}\) = critical stress
- \(E\) = modulus of elasticity of steel
A determinate beam is given as shown in the figure. The shape of the influence line for the vertical support reaction at B is most nearly:
A determinate beam is given as shown in the figure. The shape of the influence line for the shear force at section C is most nearly:

(Diagrams drawn not to scale)
A determinate beam is given as shown in the figure. The shape of the influence line for the \textit{bending moment} at section $C$ is most nearly:

(Diagrams drawn not to scale)
An overhanging beam is given as shown in the figure. Knowing that the given live loads can act anywhere on the beam, the maximum positive bending moment (ft-kip) due to the given live loads at section C is most nearly:

(A) 222  
(B) 150  
(C) 180  
(D) 190

\[ (M_C)_{\text{max}} = ? \]
MATHEMATICS  
VECTORS

Dot Product of Two Vectors:

\[ \mathbf{a} \cdot \mathbf{b} = |\mathbf{a}| \times |\mathbf{b}| \times \cos(\theta) \]

The result of the dot product is a scalar.

| \( |\mathbf{a}| \) : the magnitude (length) of vector \( \mathbf{a} \)  
| \( |\mathbf{b}| \) : the magnitude (length) of vector \( \mathbf{b} \)  
| \( \theta \) : the angle between \( \mathbf{a} \) and \( \mathbf{b} \) |

**Example:** (Using Magnitudes / Angle)

\[ \mathbf{a} \cdot \mathbf{b} = |\mathbf{a}| \times |\mathbf{b}| \times \cos(\theta) \]

\[ \mathbf{a} \cdot \mathbf{b} = 6 \times 10 \times \cos(40^\circ) \]

\[ \mathbf{a} \cdot \mathbf{b} = 6 \times 10 \times 0.766 \]

\[ \mathbf{a} \cdot \mathbf{b} = 45.96 \text{ units} \]

**Example:** (Using Components)

\[ \mathbf{a} \cdot \mathbf{b} = a_x \times b_x + a_y \times b_y \]

\[ \mathbf{a} \cdot \mathbf{b} = -3 \times 5 + 4 \times 12 \]

\[ \mathbf{a} \cdot \mathbf{b} = -15 + 48 \]

\[ \mathbf{a} \cdot \mathbf{b} = 33 \text{ units} \]
A determinate plane truss is loaded as shown in the figure. Using the given loads and the support conditions, answer the following questions:

(1) The magnitude of the member force (kips) in member $BC$ is most nearly.

(A) 6.50 (T)  
(B) 7.75 (C)  
(C) 8.75 (C)  
(D) 7.75 (T)  

\[ F_{BC} = ? \]

(2) The magnitude of the member force (kips) in member $FE$ is most nearly.

(A) 6.50 (T)  
(B) 7.75 (T)  
(C) 8.75 (C)  
(D) 8.50 (T)  

\[ F_{FE} = ? \]
THEORY OF STRUCTURES
INDETERMINATE BEAMS

Note: These custom-made problems are created for your convenience. Choose your own beam and analyze it using any method, such as, Slope Deflection or Moment Distribution. Verify your results using BEAM-2D or any other software.
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