ASCE NATIONAL CAPITAL SECTION eNewsletter
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e NEWSLETTER

MARCH 2015

DR. Z's CORNER

Conquering the FE & PE exams
Examples / Applications

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**

PRINCIPLES AND PRACTICE OF ENGINEERING (*PE*) EXAM

CIVIL BREADTH (*AM*)
CONSTRUCTION DEPTH (*PM*)

Effective Beginning with April 2015 Examination

Total Number of Questions: 80
Total 8 hours: AM 4 hours, PM 4 hours

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

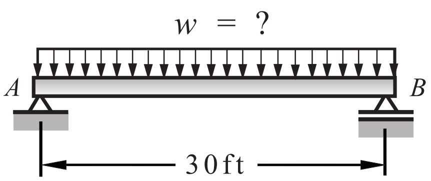
- **Project Planning** (Approx. 4 questions*)
- **Means and Methods** (3 questions)
- **Soil Mechanics** (6 questions)
- **Structural Mechanics** (6 questions)
- **Hydraulics and Hydrology** (7 questions)
- **Geometrics** (3 questions)
- **Materials** (6 questions)
- **Site Development** (5 questions)

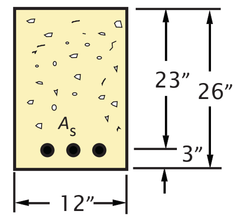
PE - CIVIL-CONSTRUCTION DEPTH
(Afternoon Session)
Exam Specifications

- **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)





f'_c = 4,000 psi

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_{crack})

$$M_{crack} = \frac{f_r\, I_g}{y_t} = \frac{474 \times 17{,}576}{13} = 640{,}848 \text{ in.-lb}$$

$$M_{crack} = \frac{640{,}848}{12 \times 1000} = 53.40 \text{ ft-kip}$$

The Weight of the Beam (w_{beam})

$$w_{beam} = \text{Area} \times g = \frac{12 \times 26}{144}(150) = 325 \text{ lb/ft}$$

Total Uniform Load (w_{total})

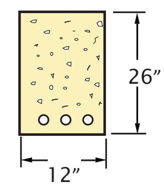
$$M_{max} = \frac{wL^2}{8} \rightarrow w_{total} = \frac{8\,M}{L^2} = \frac{8 \times 53.40}{30^2} = 0.475 \text{ kip/ft}$$

Uniform Load (w_{load})

$$w_{total} = w_{beam} + w_{load}$$

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

$$\boxed{w_{load} = 150 \text{ lb/ft}}$$



(12 x 26)

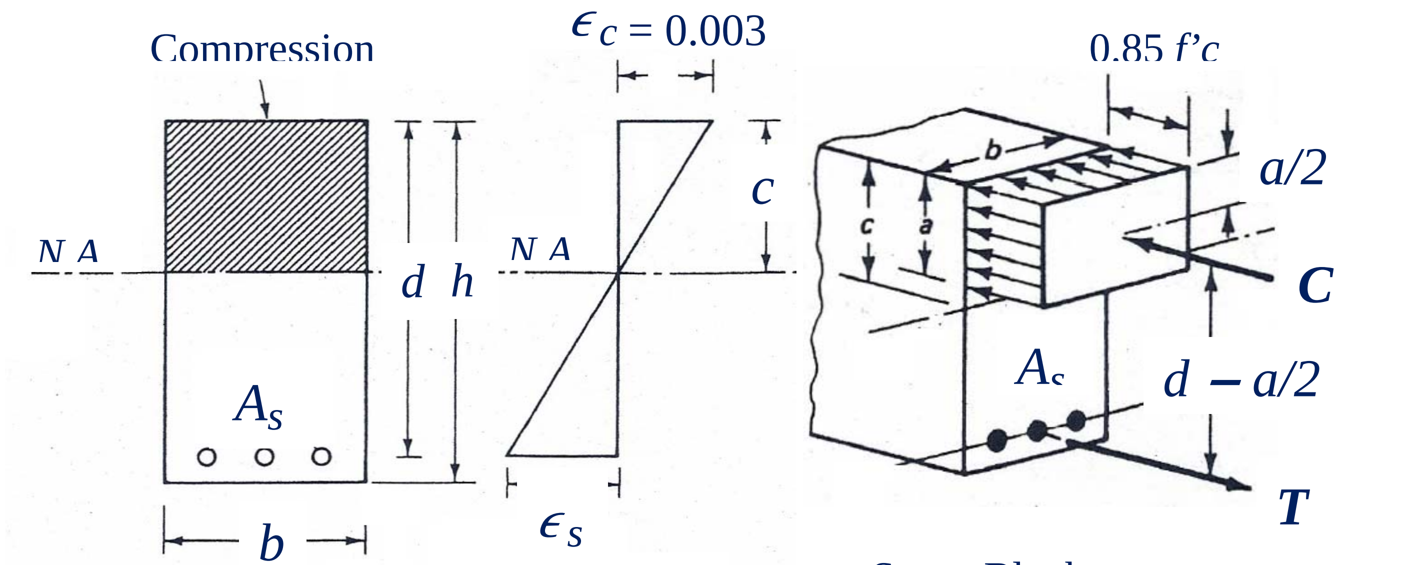
For the area and the moment of inertia (I) consider the whole cross-section:

Area = 12 x 26 = 312 in^2

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

REINFORCED CONCRETE BEAM

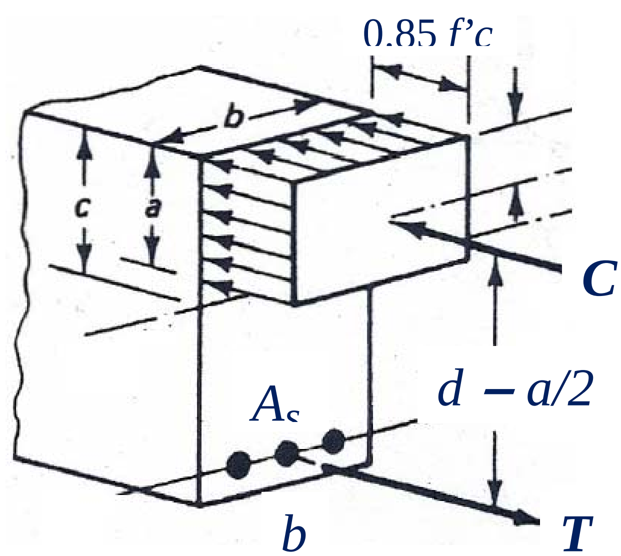
STRAIN & STRESS PROFILES

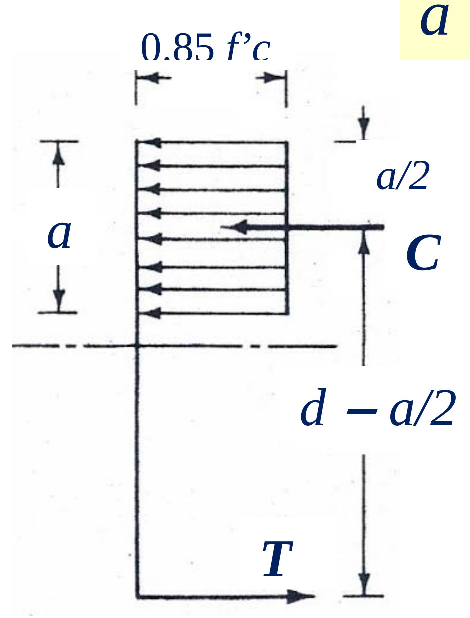


Strain Profile

Stress Block

$$a = \beta_1 . c$$





Stress Profile

$$a = \beta_1 . c$$

$$C = 0.85\, f'_c\, b.a$$

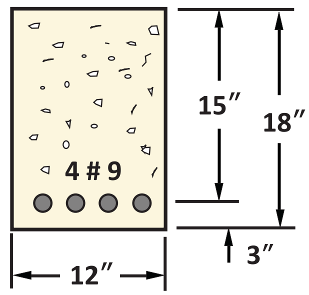
$$T = A_s\, f_y$$

DESIGN OF CONCRETE STRUCTURES

CRACKING MOMENT

Problem:

FE/PE EXAM



f'_c = 4,000 psi
f_y = 60,000 psi
γ_c = 150 lb/ft^3

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:

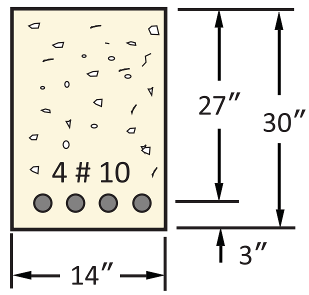
(A) 16.5
(B) 22.5
(C) 30.5
(D) 34.8

REINFORCED CONCRETE STRUCTURES

DESIGN STRENGTH

Problem:

FE/PE
EXAM



f'_c = 4,000 psi
f_y = 60,000 psi
γ_c = 150 lb/ft^3

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

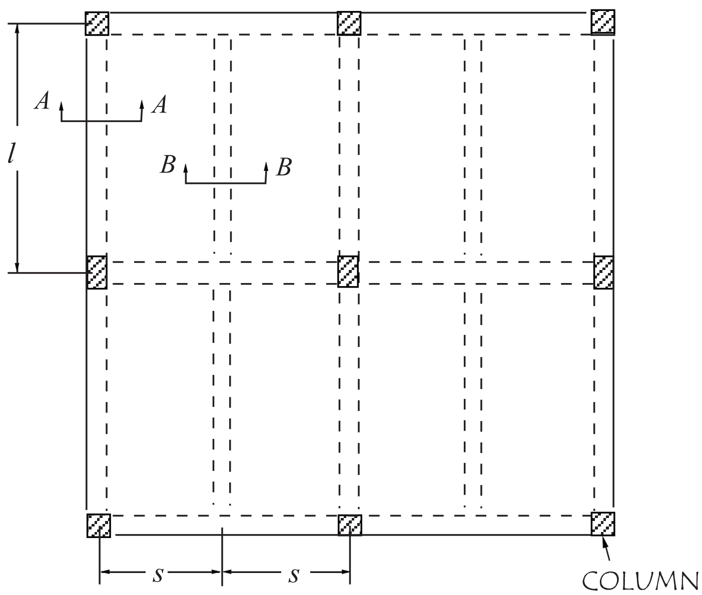
The design strength (ft-kips) is most nearly:

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

$$\phi\, M_n = ?$$

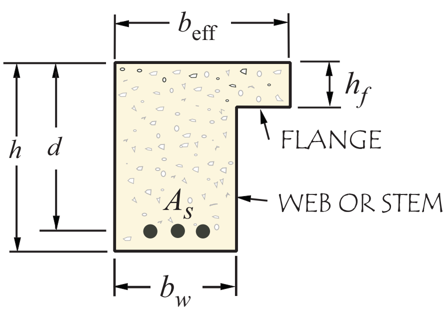
REINFORCED CONCRETE

EFFECTIVE FLANGE WIDTHS FOR T & L BEAMS

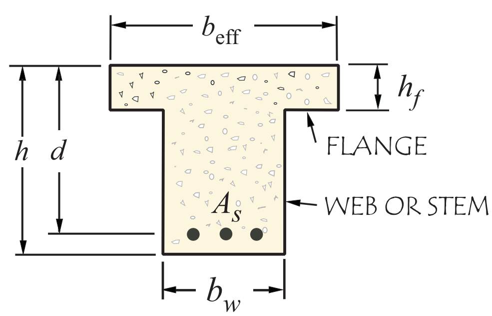


l: span
s: spacing

FLOOR FRAMING PLAN



Section (A-A)



Section (B-B)

Effective Flange Widths:

For *T*-beams:

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

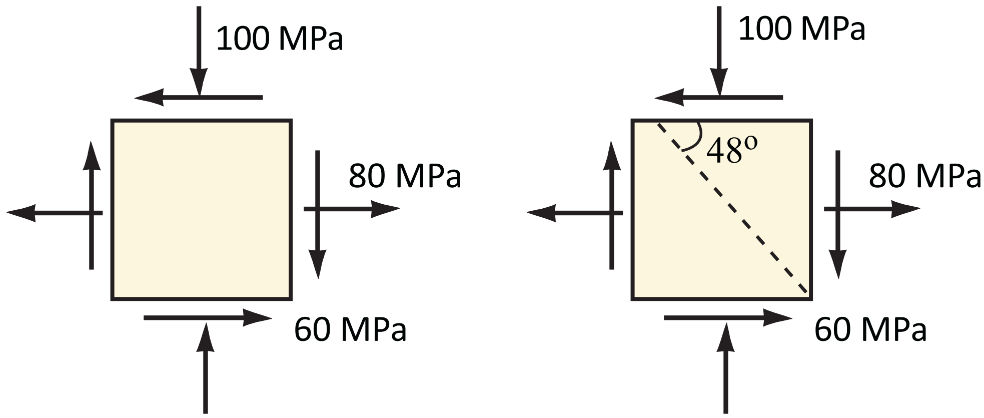
For L-beams:

$$b_{eff} = \min \left\{ b_w + \frac{l}{12},\ b_w + 6\,h_f,\ \frac{b_w + s}{2} \right\}$$

MECHANICS OF SOLIDS

PLANE STRESS

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

$\sigma_n = ?$

(2) the shearing stress (MPa) on plane *AB* is most nearly

(A) -80.65
(B) +80.65
(C) -95.85
(D) + 95.85

$\tau_n = ?$

STRSS-120
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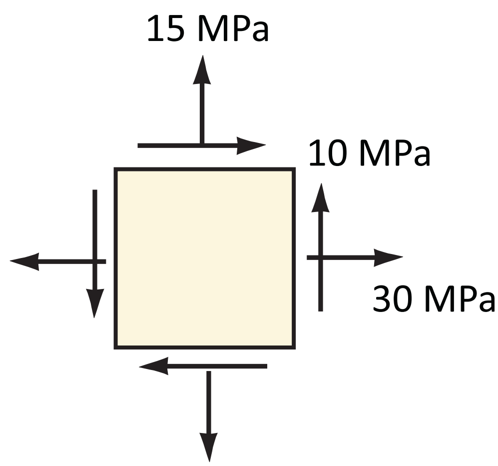
MECHANICS OF SOLIDS

PLANE STRESS

Problem:

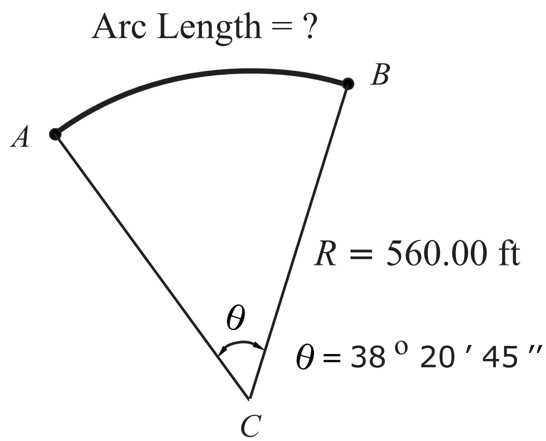


The stresses shown in the figure act at a point in a machine part. Using the given stress element, the maximum inplane shear stress (MPa) in the element is most nearly:

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

$\tau_{max} = ?$

Problem: (Bearings & Azimuths) HK



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

(1) the central angle (radians) is most nearly, θ

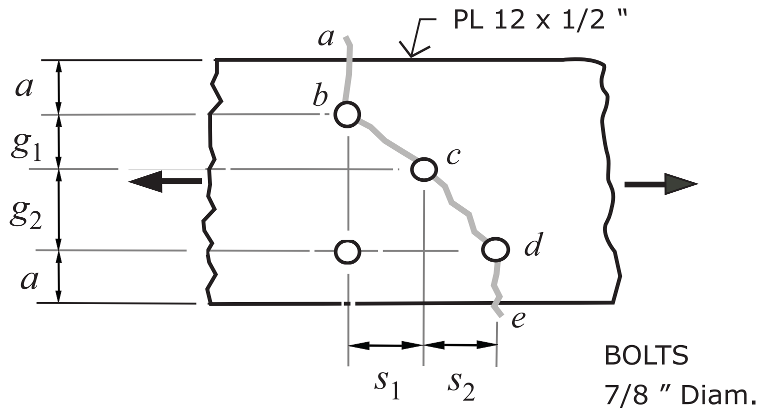
(A) 0.469
(B) 0.513
(C) 0.669
(D) 0.725

(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



s = stagger (pitch)
g = gage (transverse spacing)
s = stagger is always parallel to the applied load.

NCEES, REF.HANDBOOK
VERSION 9.1
PAGE-154

The effective hole diameter: (d_{hole})

$$d_{hole} = d_{bolt} + 1/16''$$

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

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

$$w_{net} = w_{gross} - \Sigma\, d_{hole} + \Sigma\, s^2/4g$$

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

The effective net area: (A_{net})

$$A_{net} = w_{net} \times \text{Plate Thickness}$$

$$A_{net} = w_{net} \times t_{plate}$$

IMPORTANT COLUMN FORMULAS

$$P_u \le \phi_c P_n$$

$$P_u \le \phi_c P_n$$

$$\phi_c P_n = \phi_c F_{cr} A_g$$

$$\sqrt{\frac{E}{F_y}} = \sqrt{(29{,}000/50)} = \sqrt{580} = 28.03$$

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

$KL/r_{min} =$ slenderness ratio

$$\frac{KL}{r} \le 4.71\sqrt{\frac{E}{F_y}}$$

$$F_{cr} = 0.658^{\left(\frac{F_y}{F_e}\right)} F_y$$

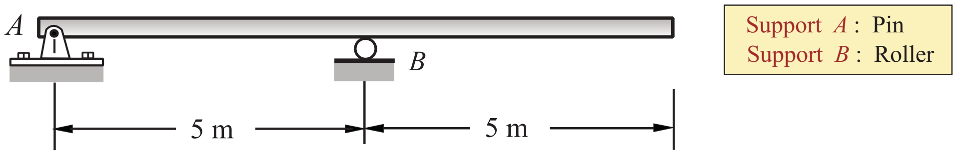
$$\frac{KL}{r} > 4.71\sqrt{\frac{E}{F_y}}$$

$$F_{cr} = 0.877\ F_e$$

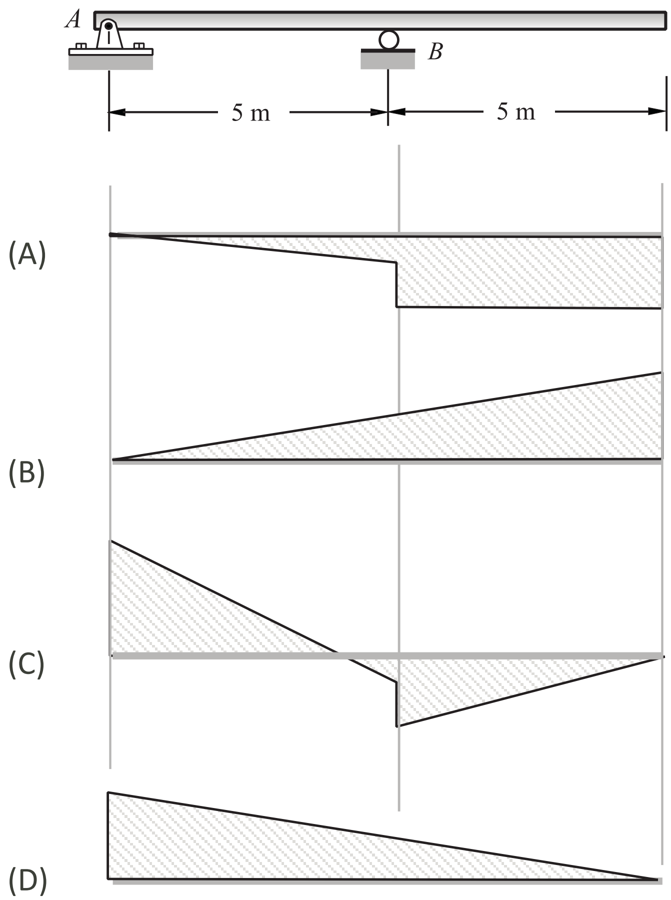
K = effective length factor (AISC)
L = column length
KL = effective column length
KL/r = slenderness ratio
r = radius of gyration
F_y = yield stress of steel
F_e = Euler stress
F_{cr} = critical stress
E = modulus of elasticity of steel

STRUCTURES / ANALYSIS

INFLUENCE LINES



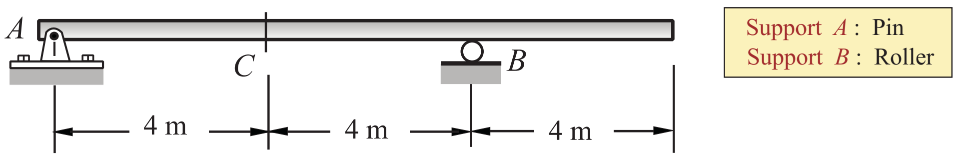
A determinate beam is given as shown in the figure. The shape of the ***influence line*** for the vertical support reaction at *B* is most nearly:



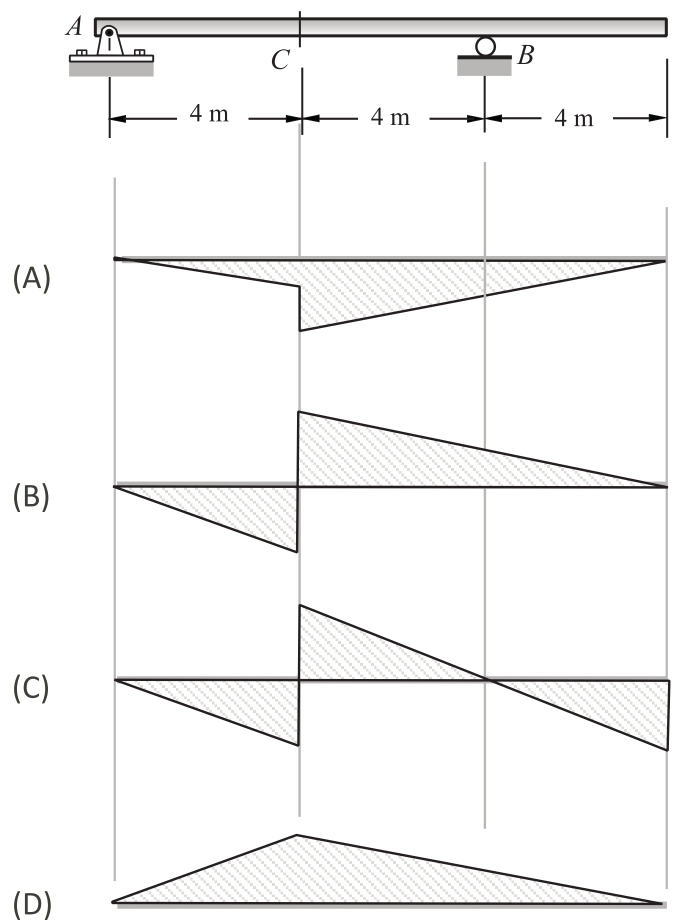
(Diagrams drawn not to scale)

STRUCTURES / ANALYSIS

INFLUENCE LINES



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)

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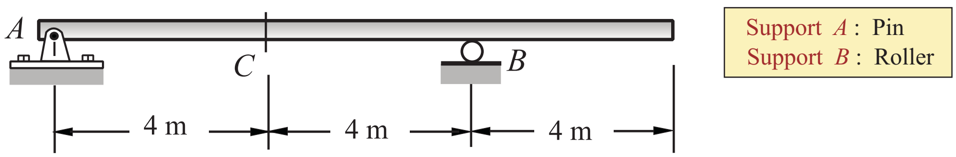
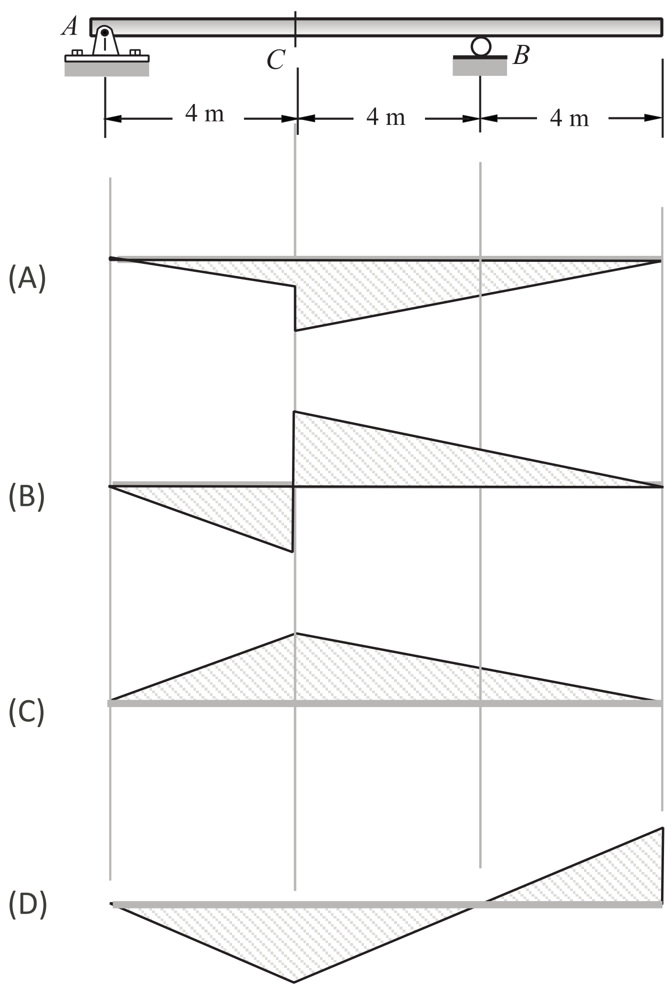
STRUCTURES / ANALYSIS

INFLUENCE LINES



A determinate beam is given as shown in the figure. The shape of the influence line for the ***bending moment*** at *section C* is most nearly:



(Diagrams drawn not to scale)

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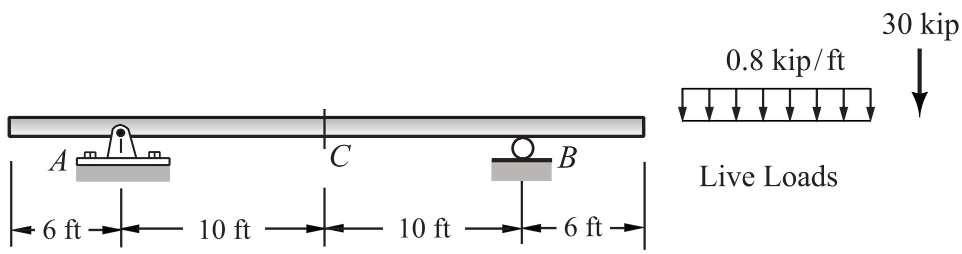
STRUCTURAL ANALYSIS

INFLUENCE LINES



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

$(M_C)_{max} = ?$

INFL-150
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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 **a**
$|\mathbf{b}|$: the magnitude (length) of vector **b**
θ : the angle between **a** and **b**

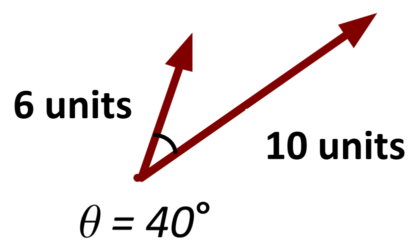
Example: (Using Magnitudes / Angle)

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

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

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

$\mathbf{a} \cdot \mathbf{b} = 45.96$ units



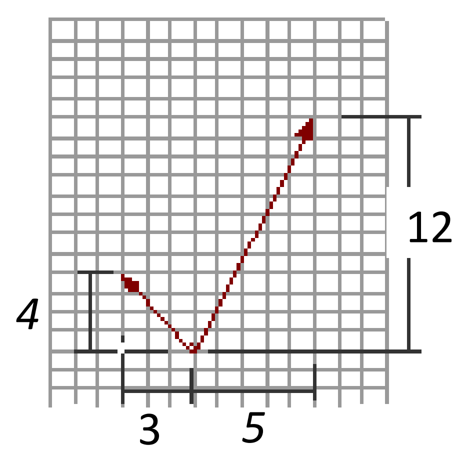
Example: (Using Components)

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

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

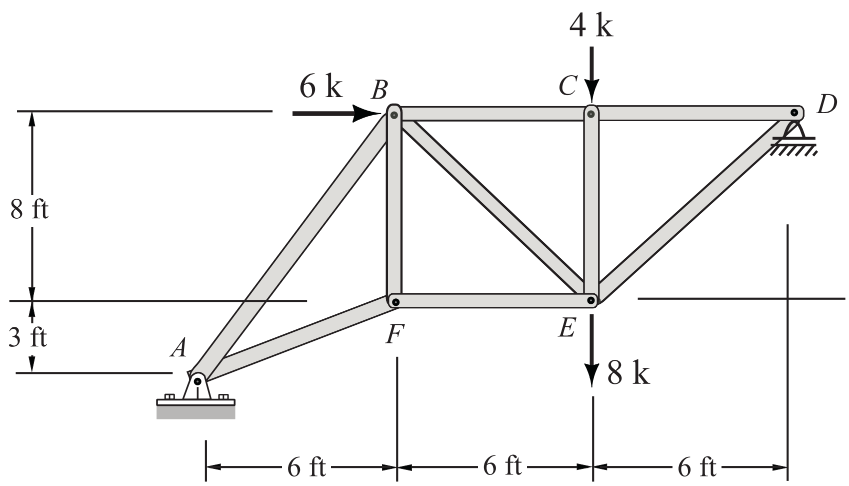
$\mathbf{a} \cdot \mathbf{b} = -15 + 48$

$\mathbf{a} \cdot \mathbf{b} = 33$ units



STRUCTURAL ANALYSIS

PLANE TRUSSES



Support A : Hinge
Support D : Roller

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)

$(F_{FE}) = ?$

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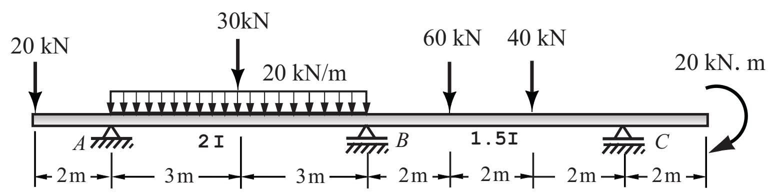
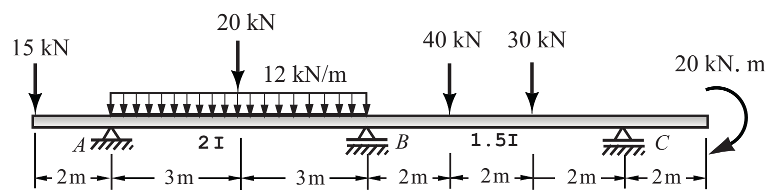
THEORY OF STRUCTURES

INDETERMINATE BEAMS

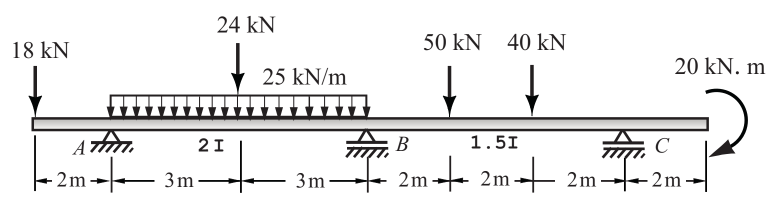
(A)



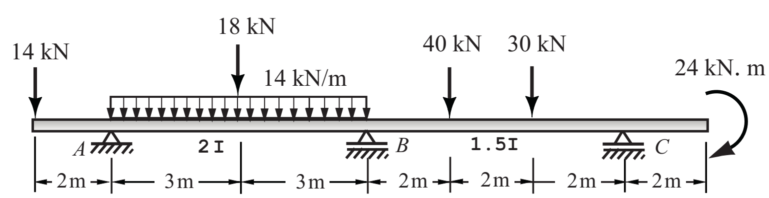
(B)



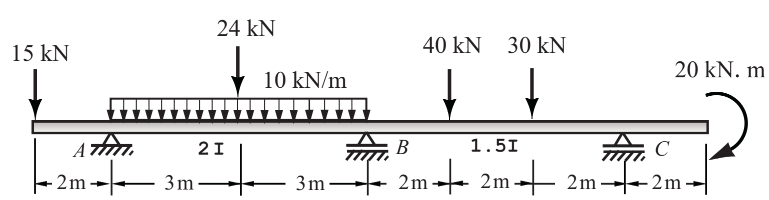
(C)



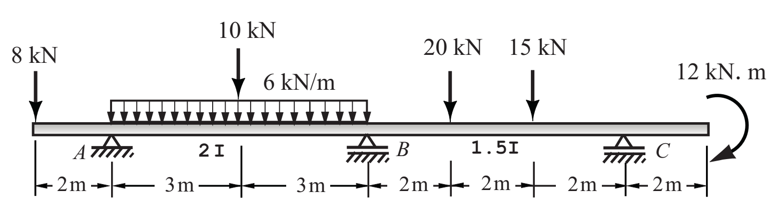
(D)



(E)

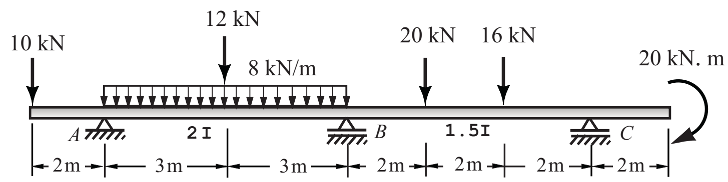


(F)

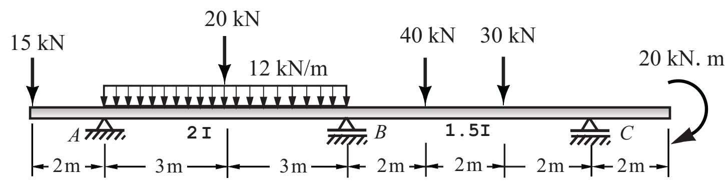


Note: These custom-made problems are created for your convenience. Choose your own beam and analyze it using any method, such as, Slope Deflection or Moment Distribution. Verify your results using BEAM-2D or any other software.

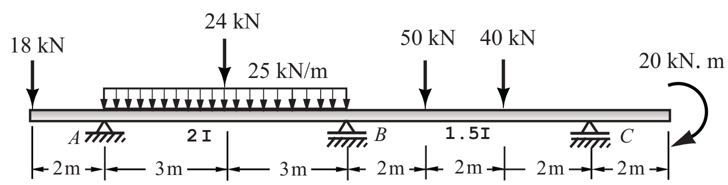
(G)



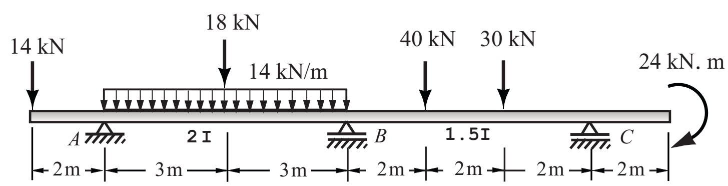
(H)



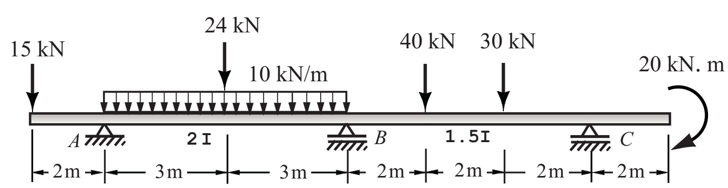
(J)



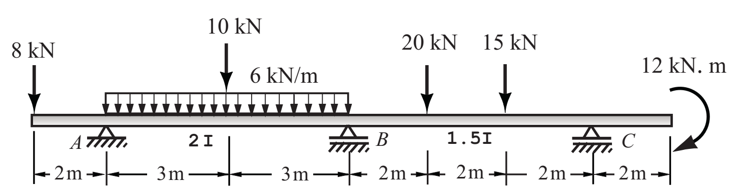
(K)



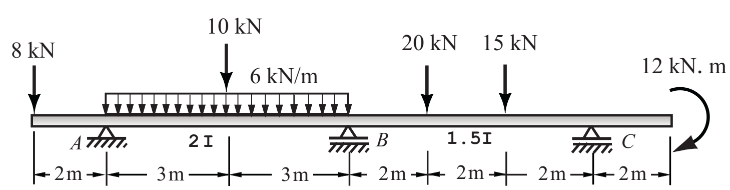
(L)



(M)



(N)



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