ASCE eNewsletter

National Capital Section

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eNEWSLETTER

FEBRUARY 2015

DR. Z's CORNER

Conquering the FE & PE exams
Examples / Applications

This month's article features:

- FE Exam topics for Civil Engineering
- Calculator Usage
- Probability and Statistics
- Decimal and Binary Numbers
- Mathematics
- Statics
- Dynamics
- Mechanics of Materials
- Structural Design / Wall Footings

FUNDAMENTALS OF ENGINEERING

EXAM TOPICS / CIVIL ENGINEERING

Computer-Based Test (CBT)

Total Number of Questions: 110
Time: 6 hours

The new Civil FE Computer-Based Test (CBT) consists of 110 multiple-choice questions (Each problem only one question) the examinee will have 6 hours to complete the test.

- **Mathematics** (Approx. 9 questions*)
- **Probability and Statistics** (5 questions)
- **Computational Tools** (5 questions)
- **Ethics and Professional Practice** (5 questions)
- **Engineering Economics** (5 questions)
- **Statics** (9 questions)
- **Dynamics** (5 questions)
- **Mechanics of Materials** (9 questions)
- **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)

CASIO / *fx*-115 ES PLUS

MODE		SHIFT SETUP
(1) COMP		(1) Mth-IO
(2) CMPLX		(2) Line-IO
(3) STAT		(3) Deg
(4) BASE-N		(4) Rad
(5) EQN		(5) Gra
(6) MATRIX		(6) Fix
(7) TABLE		(7) Sci
(8) VECTOR		(8) Norm

Frequently asked two Number Systems:

1- Decimal Number System (base 10)
2- Binary Number System (base 2)

In Decimal System 10 different digits are used to create any number, but in Binary System only 0s and 1s are used to create any number

DECIMAL	BINARY
2	10
3	11
5	101
6	110
8	1000
9	1001
10	1010
12	1100
14	1110
15	1111
19	10011
25	11001

NUMBER SYSTEMS
BINARY & DECIMAL
NCEES Reference Handbook, Page: 213

Binary Number System:

In digital computers, binary number system (the base-2) is used. Conversions from BINARY to DECIMAL or from DECIMAL to BINARY can easily be done using the calculator. Binary (base-2), decimal (base-10).

Problem:

Find the binary equivalent of decimal 25? Here, decimal is base-10.
Turn on your calculator

1) Press MODE
2) Press “4”
3) Enter 25 and press “ **=** ”
4) Make sure to see 25 under **Dec** on the screen
5) Press SHIFT then “log”
6) Answer: 11001

Problem:

Find the decimal equivalent of binary 1111?
Turn on your calculator

1) Press MODE
2) Press “4”
3) Press SHIFT then press “log” key
4) Enter 1111 and then press “ **=** ”
5) Make sure to see 1111 under **Bin** on the screen
6) Press SHIFT then hit “ x^2 ” key
7) Answer: 15

BASIC RELATIONSHIPS

Mean

$$\bar{y} = \frac{\sum y_i}{n}$$

Standard Deviation

$$s_y = \sqrt{\frac{\sum (y_i - \bar{y})^2}{n-1}}$$

Standard Deviation

$$s_y = \sqrt{\frac{\sum y^2{}_i - \left(\sum y_i \right)^2 / n}{n-1}}$$

Variance

$$s_y^2 = \frac{\sum (y_i - y)^2}{n-1}$$

Coefficient of Variation

$$c.v. = \frac{s_y}{\bar{y}} \times 100\ \%$$

FUNDAMENTALS OF ENGINEERING (FE)

PROBABILITY AND STATISTICS

FULL SOLUTION
NEXT PAGE

Problem:

A data set is given as listed below:

8, 25, 7, 5, 8, 3, 10, 12, 9

(1) The mean of this set is most nearly:

(A) 7.98
(B) 8.15
(C) 9.67
(D) 12.85

(2) The standard deviation is most nearly:

(A) 6.32
(B) 7.85
(C) 8.25
(D) 9.14

Problem:

8, 25, 7, 5, 8, 3, 10, 12, 9

Consider the data set given above:

(a) Calculate the mean ($\bar{y}$)
(b) Calculate the Standard Deviation (s_y)

Solution:

The **mean** is the sum of scores divided by n where n is the number of scores.

1. $\bar{y} = \frac{\sum y}{n}$ **= (8+25+7+5+8+3+10+12+9)/9**

   = 9.67

2. the standard deviation may be calculated using the following formula:

$$s_y = \sqrt{\frac{\sum (y_i - \bar{y})^2}{n-1}} \qquad Deviation = (y_i - \bar{y})$$

In order to calculate the values in the standard deviation formula, the following table may be used:

Deviation = Score - Mean

Score	Mean	Deviation	$(\text{Deviation})^2$
8	9.67	- 1.67	2.79
25	9.67	+15.33	235.01
7	9.67	- 2.67	7.13
5	9.67	- 4.67	21.81
8	9.67	- 1.67	2.79
3	9.67	- 6.67	44.49
10	9.67	+ .33	.11
12	9.67	+ 2.33	5.43
9	9.67	- .67	.45

Σ = 320.01

Standard Deviation(S_y)

$$s_y = \sqrt{\frac{\sum (y_i - y)^2}{n-1}} = \sqrt{\frac{320.01}{9-1}} = 6.32$$

$$\boxed{S_y = 6.32}$$

Alternate method for calculating the Standard Deviation: (The Raw Score Method)

Consider the raw scores 8, 25, 7, 5, 8, 3, 10, 12, 9.

1. First, square each of the scores.
2. Determine n, which is the number of scores.
3. Compute the sum of y_i and the sum of y_i^2
4. Then, calculate the standard deviation as illustrated below.

score(y_i)	y_i^2
8	64
25	625
7	49
5	25
8	64
3	9
10	100
12	144
9	81
---	----
87	1161

$n = 9$

$\Sigma y_i = 87$

$\Sigma y_i^2 = 1161$

Standard Deviation(S_y)

$$s_y = \sqrt{\frac{\sum y_i^2 - (\sum y_i)^2 / n}{n-1}}$$ = square root[(1161)-(87*87)/9)/(9-1)]

= square root[(1161-(7569/9)/8)] = 6.32

IN FE-EXAM, YOUR " CASIO FX-115-ES PLUS " CALCULATOR SHOULD BE USED TO SOLVE THIS PROBLEM.

(1) A particle will remain at rest or continue with its motion, unless acted upon by an external force.

(2) The force on an object is equal to its mass multiplied by its acceleration $(F = m.a)$.

(3) Every action has an equal and opposite reaction.

These three laws of motion are known as:

(A) Euler's Laws
(B) Young's Laws
(C) Poisson's Laws
(D) Newton's Laws

Problem:

A sprinter competing in a 100 m race accelerates uniformly for the first 40 meters in 6.0 seconds. She then runs at a constant speed for the remainder of the race. The total time (seconds) elapses when she crosses the finish line is most nearly:

→ (A) 10.5
(B) 11.4
(C) 12.0
(D) 13.4

KINEMATICS OF A PARTICLE

FUNDAMENTALS OF ENGINEERING

$v = (6t^2 + 4t)$ ft/s

The van shown moves in a straight line such that for a short time its velocity is defined by $v = (6t^2 + 4t)$ ft/s. Knowing that t is measured in seconds, answer the following:

(1) The van's position (ft) in t = 4 seconds is most nearly

(A) 75
(B) 90
(C) 150
(D) 160

$s = ?$

(2) The van's acceleration (ft/s^2) in t = 4 seconds is most nearly

(A) 35
(B) 42
(C) 52
(D) 68

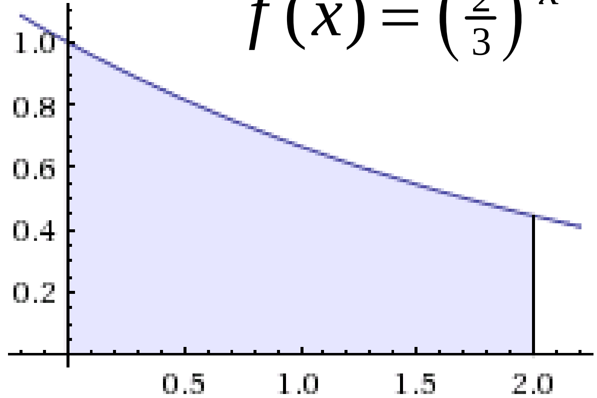
$a = ?$

DYNMCS-120
ZEYTINCI
SPRING 2015

DEFINITE INTEGRALS
AREAS UNDER CURVES
Using CASIO FX-115 ES PLUS

Problem:

$$f(x) = \left(\frac{2}{3}\right)^x$$



The area under the graph shown is most nearly:

(A) 5.06
(B) 4.25
(C) 2.15
(D) 1.37

SAMPLE (FE) PROBLEMS

MORNING SESSION

MATHEMATICS

Problem:

$$I = \int_{0}^{3} x^2 \,.\, (e^{x^2})\, dx$$

The value of the definite integral shown above is most nearly:

(A) **20**

(B) **3986**

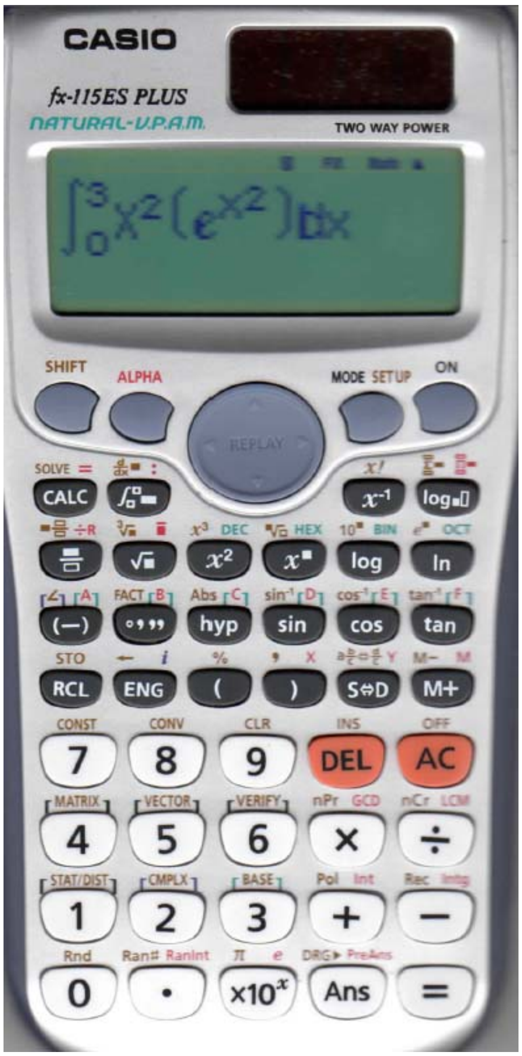
(C) **1112**

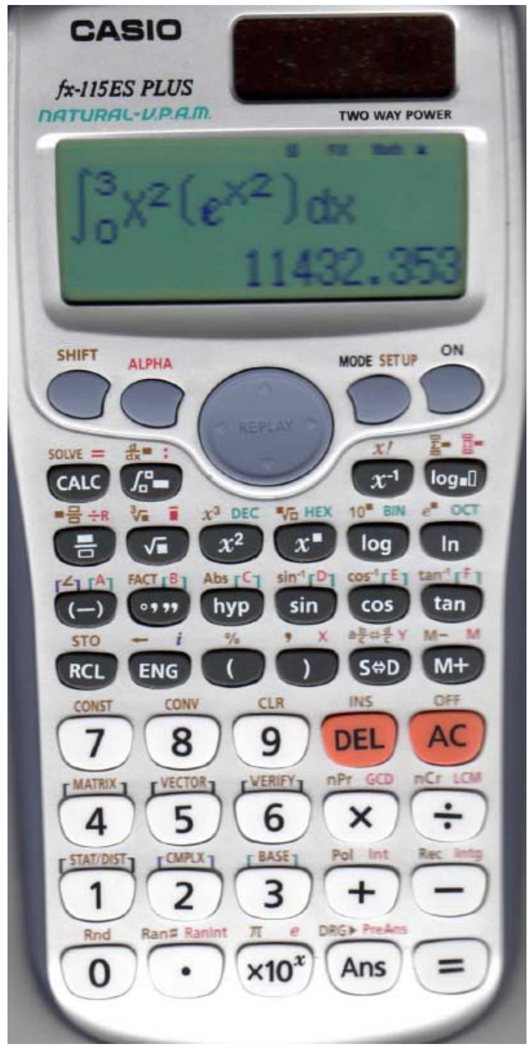
(D) **11432**

Comments:

At first sight, this problem seems highly complex, but it is not. You can easily get the correct answer in exactly 15 seconds. Yes, in 15 seconds!

What can you do with your CASIO FX-115 ES *PLUS* ?





Enter the equation
Into the calculator

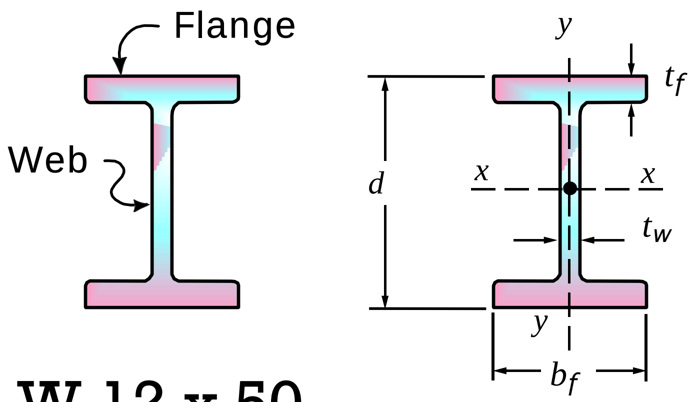
Just hit the = KEY
and wait 15 seconds

Answer =

11432.353

ASCE-420
ZEYTINCI
FALL 2014

W 12 X 50



W 12 x 50

Nominal Depth (12 in.)

Weight 50 lb / ft

THIS SHEET GOES WITH NCEES-REF. HANDBOOK PAGE-155

- A = Area = 14.6 in ^{2}
- d = Depth = 12.2 in.
- b_f = Flange Width = 8.08 in.
- t_f = Flange Thickness= 0.640 in.
- t_w = Web Thickness = 0.370 in.
- I_x = Moment of Inertia = 391 in ^{4}
- I_y = Moment of Inertia = 56.3 in ^{4}
- S_x = Section Modulus (x-x) = 64.2 in ^{3}
- r_x = Radius of Gyration = 5.18 in
- Major axis or strong axis = (x-x)
- Minor axis or weak axis = (y-y)

W12x50
ZEYTINCI
FALL 2014

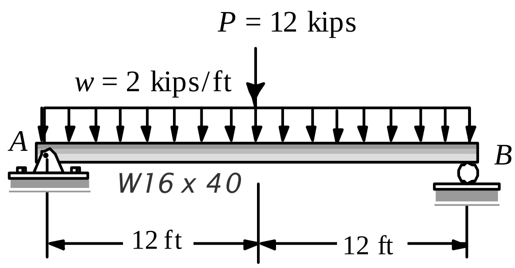
PROFESSIONAL ENGINEERING (PE)

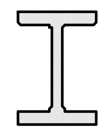
FUNDAMENTALS OF ENGINEERING (FE)

MECHANICS OF MATERIALS

FULL SOLUTION
NEXT PAGE

Problem: (Deflection of Beams)





W16 x 40

E = 29,000 ksi

A determinate beam is loaded as shown. Knowing that the beam weight is included in the uniform load, answer the following questions:

(1) The maximum deflection (inches) is most nearly:

(A) 0.98
(B) 1.15
(C) 1.39
(D) 1.85

$\delta_{max} = ?$

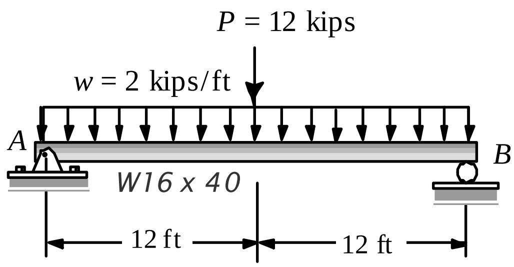
(2) The slope (radians) at support A is most nearly:

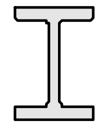
(A) 0.0055
(B) 0.0152
(C) 0.0880
(D) 0.1250

$\theta_A = ?$

MCDEF-216
ZEYTINCI
SPRING 2015

Problem: (Beam Deflections)



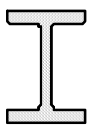


W 16 x 40

E = 29,000 ksi

For the simple beam shown the beam weight is included in the uniform load. Determine the maximum deflection and the slope at A (in radians).

Solution: We will use NCEES-Reference Handbook, page 155 and 81.



W 16 x 40

$I = 518\ \text{in}^4$

FOR DEFLECTIONS : (12^3)

FOR SLOPES : (12^2)

Finding the maximum deflection:

The maximum deflection will be at the midpoint of the span. For quick calculations when using US unit systems, architects and engineers use conversion factors like (12^3) and (12^2). For DEFLECTIONS this conversion factor is (12^3) and for SLOPES the conversion factor will be (12^2).

$$\delta_{max} = \frac{5}{384}\frac{wL^4}{EI} + \frac{1}{48}\frac{PL^3}{EI} = \frac{5}{384}\frac{(2.0)\,(24)^4}{(29{,}000)\,(518)}(12^3) + \frac{1}{48}\frac{(12)\,(24)^3}{(29{,}000)\,(518)}(12^3)$$

$$= 0.994 + 0.397 = \underline{1.391 \text{ inches}}$$

Finding the slope at support A:

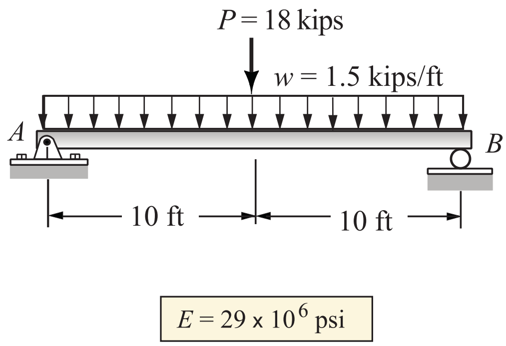
$$\theta_A = \frac{wL^3}{24EI} + \frac{PL^2}{16\,EI} = \frac{1}{24}\frac{(2.0)\,(24)^3}{(29{,}000)\,(518)}(12^2) + \frac{1}{16}\frac{(12)\,(24)^2}{(29{,}000)\,(518)}(12^2)$$

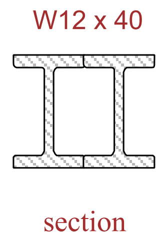
= 0.01104 + 0.00414 = 0.01518 Radians

= <u>0.01518 Radians</u>

DEF-216
ZEYTINCI
FALL 2014

Problem: (Deflections)





A composite beam is made of two W 12 x 40 welded together. The beam weight is included in the uniform load. Using the given beam dimensions and loads answer the following questions:

(1) the max. moment (ft.kips) in the beam is most nearly

(A) 126
(B) 165
(C) 225
(D) 300

(2) the moment of inertia ($in.^4$) about the horizontal centroidal axis is most nearly (I_{cx})

(A) 307
(B) 515
(C) 614
(D) 720

(3) the max. deflection (in.) of the beam is most nearly

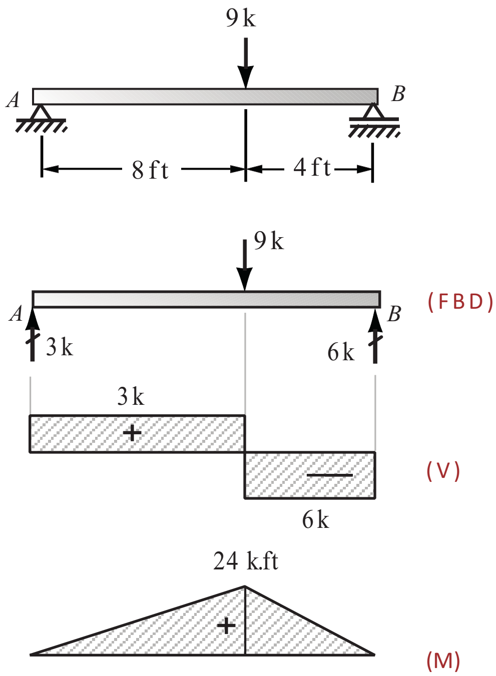
(A) 0.245
(B) 0.363
(C) 0.478
(D) 0.594

(4) the slope (radians) at the left support is most nearly

(A) 0.00985
(B) 0.00768
(C) 0.00643
(D) 0.02250

SHEAR FORCE AND MOMENT DIAGRAMS

1



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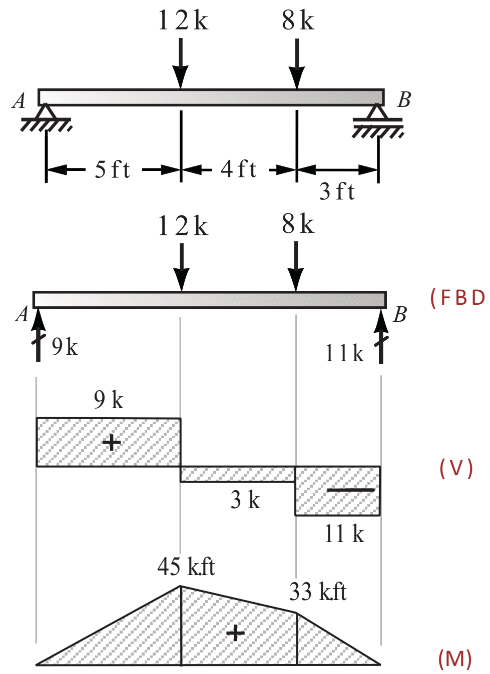

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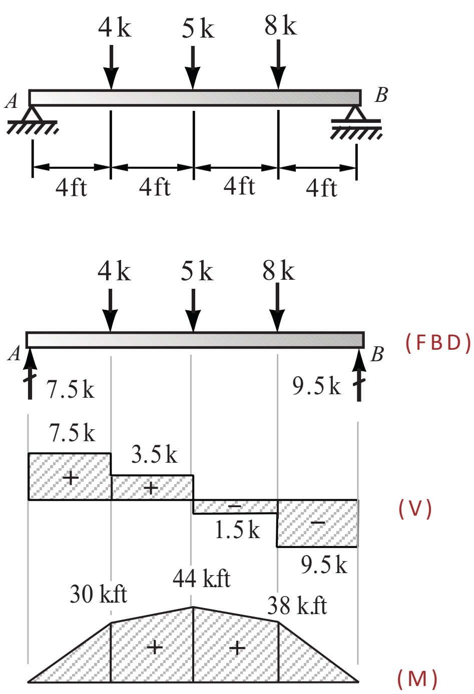

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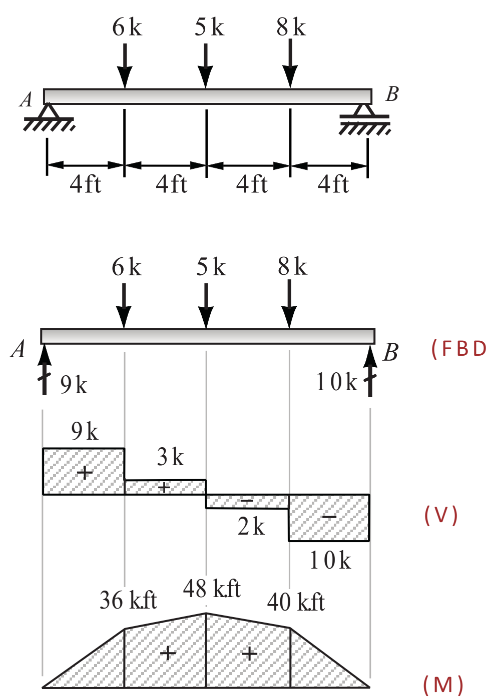
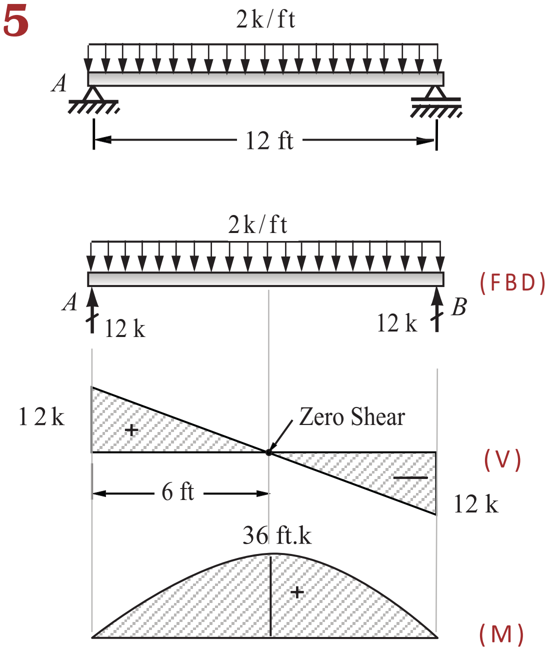


SHEAR AND MOMENT DIAGRAMS

5



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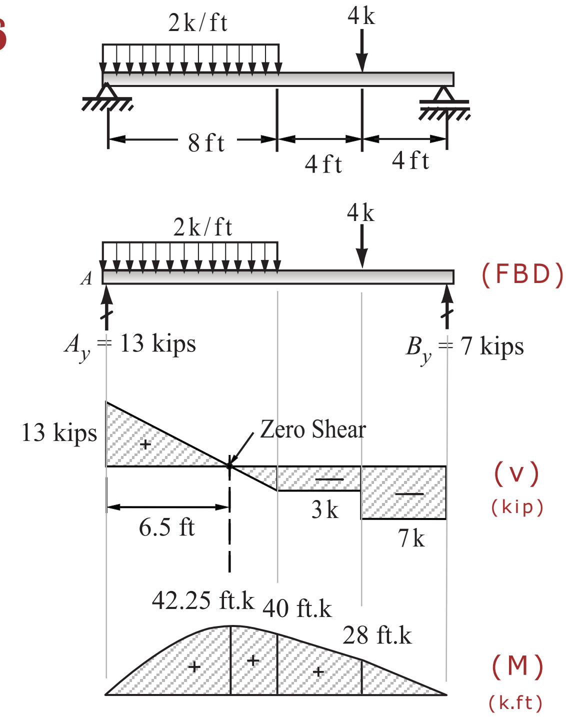

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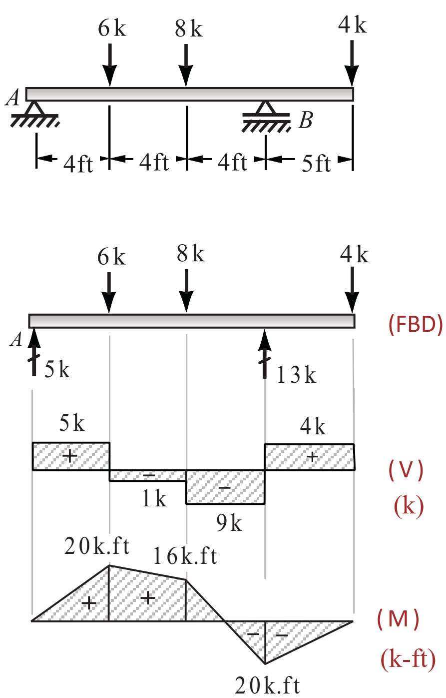

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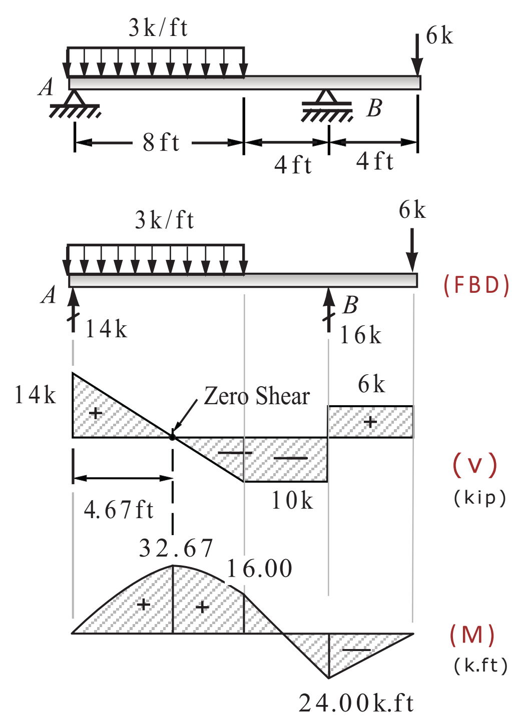

MVN-15
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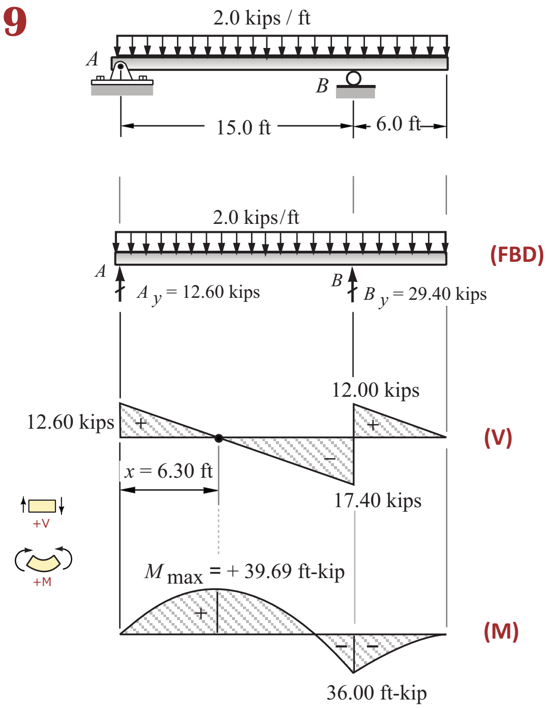
SPRNG 2014

SHEAR AND MOMENT DIAGRAMS

9



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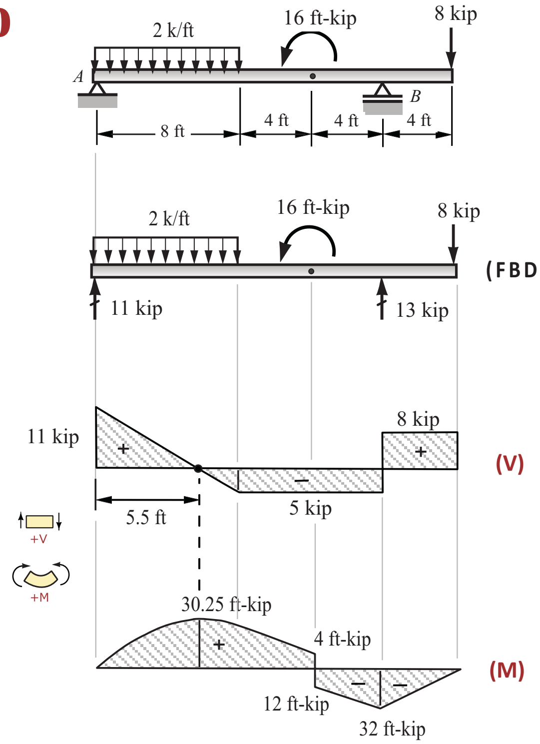

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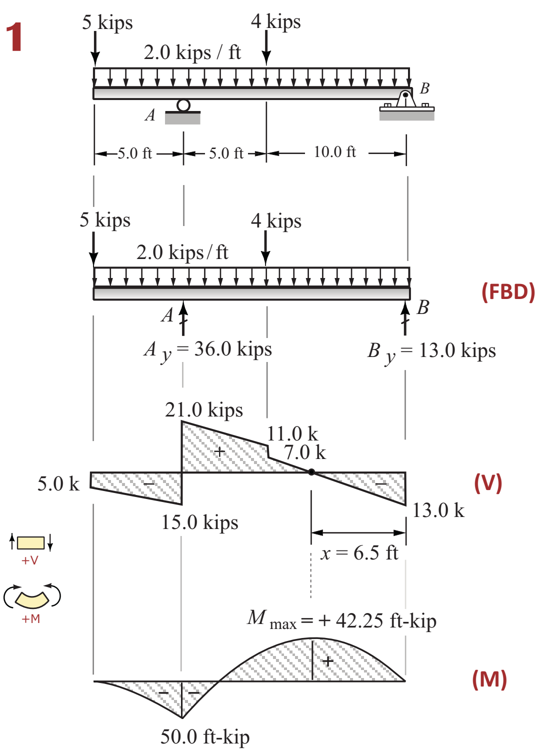

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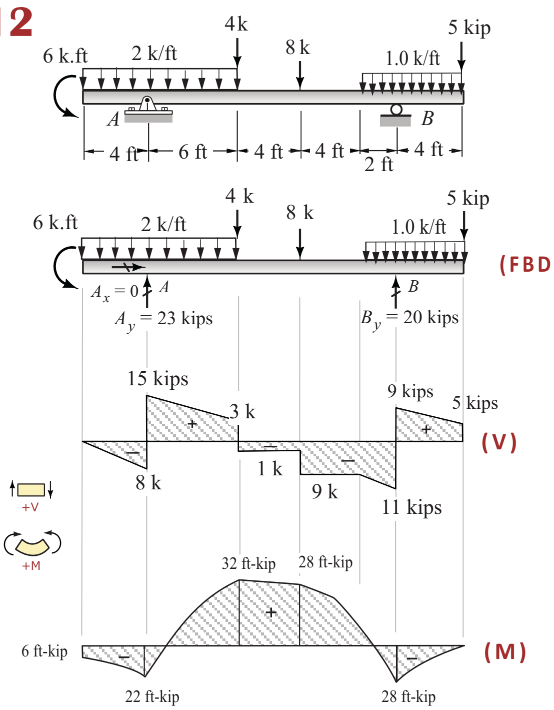
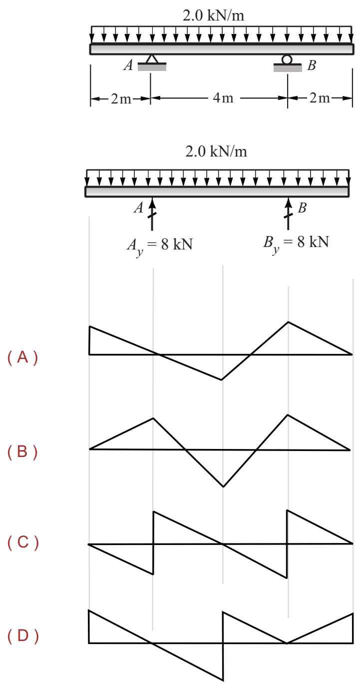


SHEAR FORCE & BENDING MOMENT DIAGRAMS

FE EXAM

1



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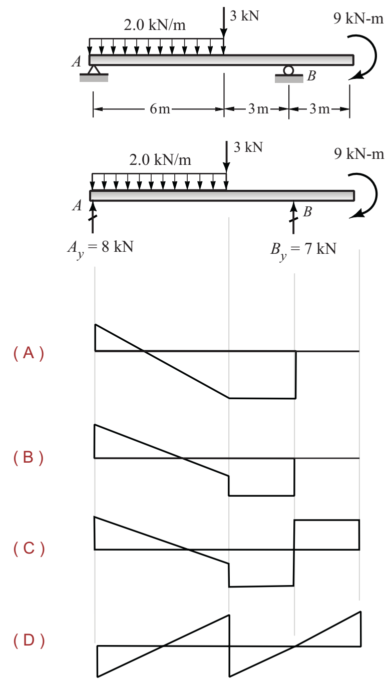

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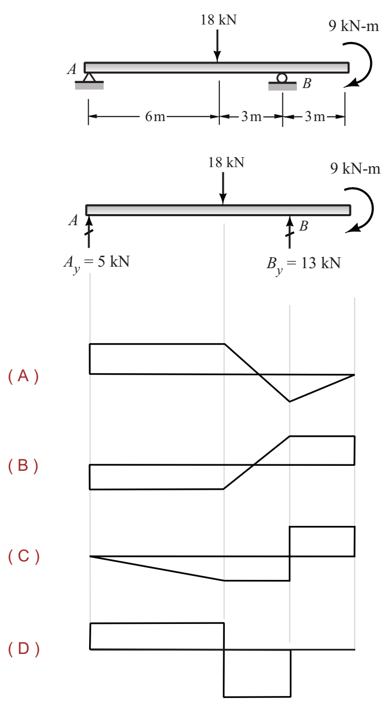

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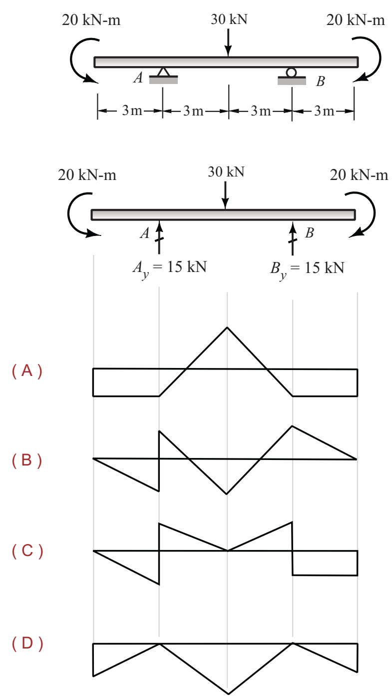


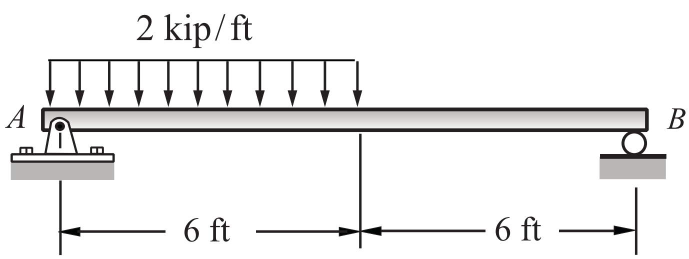
BMLS-312
ZEYTINCI
SPRING 2013

FUNDAMENTALS OF ENGINEERING

DETERMINATE BEAMS

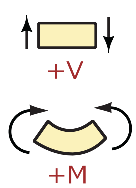
STATICS

FULL SOLUTION NEXT PAGE



Support A :	Pin
Support B :	Roller

A simply supported beam is loaded as shown. Using the given support conditions, the magnitude of maximum bending moment (k-ft) is most nearly:



(A) 42.50
(B) 36.75
(C) 34.25
(D) 20.25

$$M_{max} = ?$$

MCBM-10
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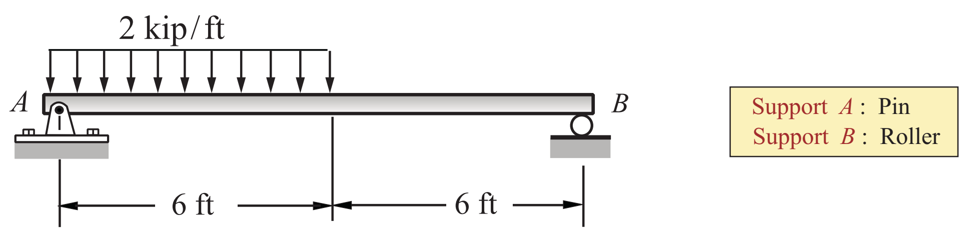
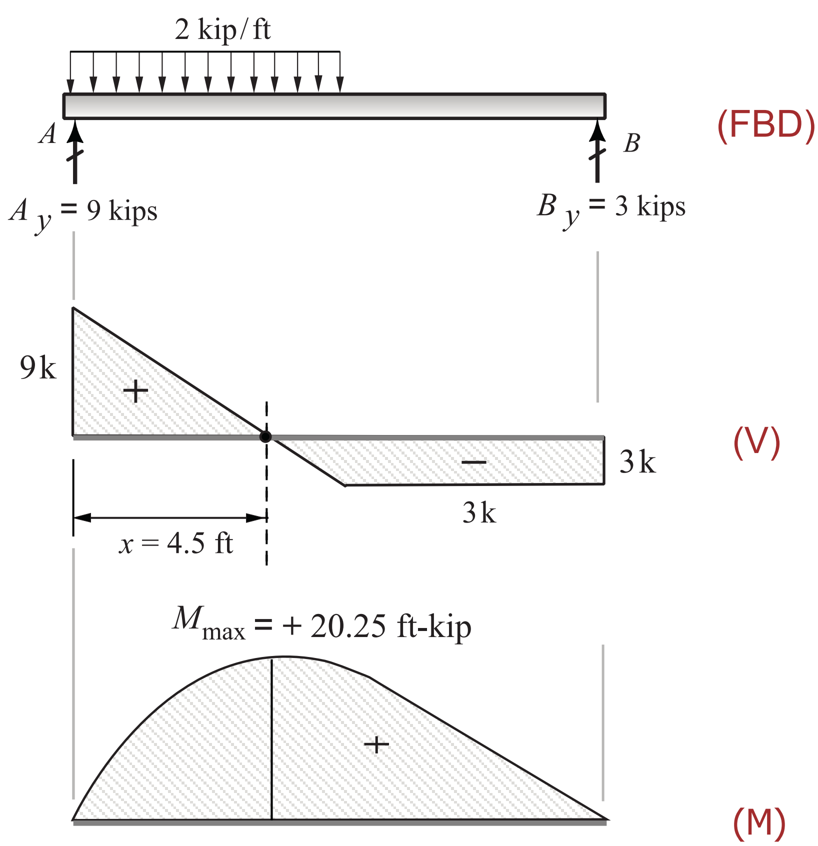
SPRING 2015

FUNDAMENTALS OF ENGINEERING

Shear Force and Bending Moment Diagrams



(a) Determine the support reactions
(b) Draw the shear force diagram
(c) Draw the bending moment diagram



(Diagrams not drawn to scale)

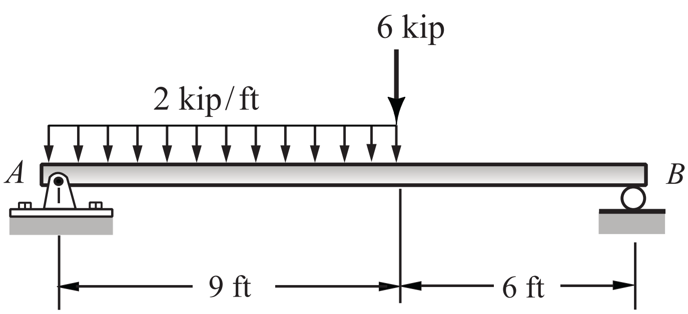
BM-10
ZEYTINCI
SPRING 2015

FUNDAMENTALS OF ENGINEERING

DETERMINATE BEAMS

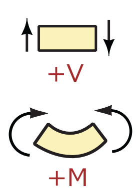
STATICS

FULL SOLUTION
NEXT PAGE



Support A : Pin
Support B : Roller

A simply supported beam is loaded as shown. Using the given support conditions, the maximum bending moment (k-ft) in the beam is most nearly:



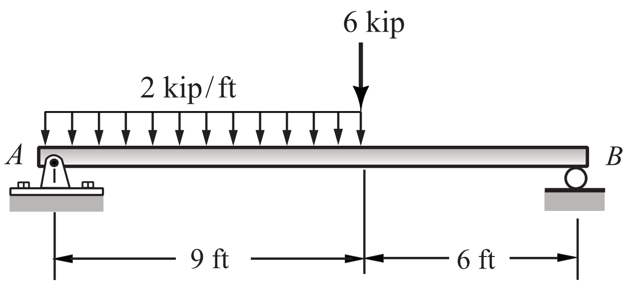
(A) 45.00
(B) 56.25
(C) 64.50
(D) 72.75

$$M_{\max} = ?$$

MCBM-16
ZEYTINCI
SPRING 2015

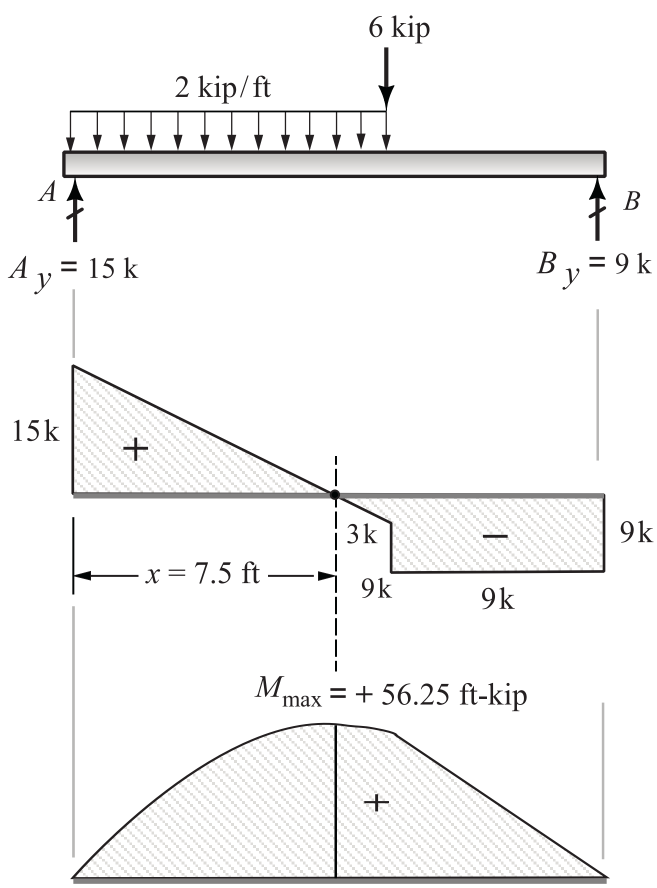
FUNDAMENTALS OF ENGINEERING

Shear Force and Bending Moment Diagrams



Support A : Pin
Support B : Roller

(a) Determine the support reactions
(b) Draw the shear force diagram
(c) Draw the bending moment diagram



(FBD)

(V)

(M)

(Diagrams drawn not to scale)

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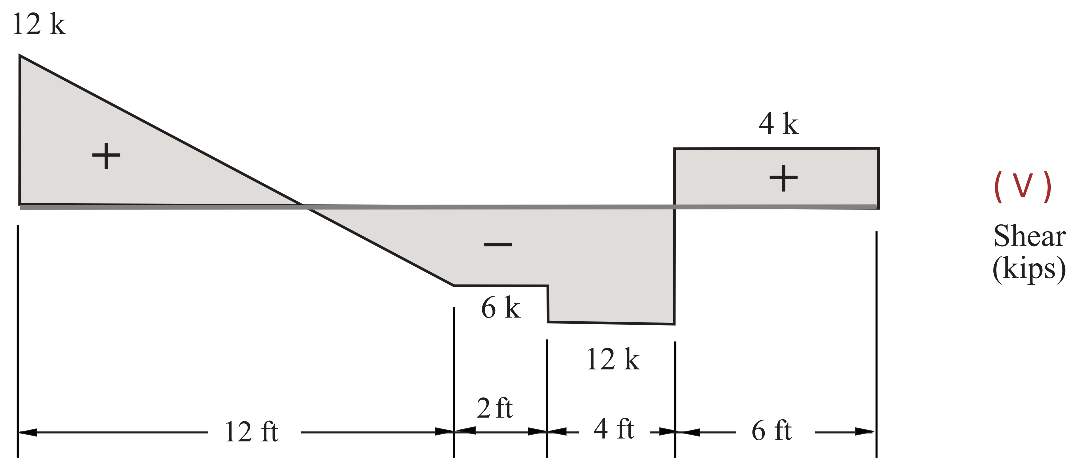
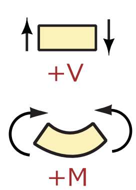
FUNDAMENTALS OF ENGINEERING

MECHANICS OF MATERIALS

SHEAR & MOMENT DIAGRAMS



The shear force diagram of a determinate beam is given as shown. Knowing that all lines in the diagram are straight and there are no concentrated moments (couples) anywhere in the beam, the maximum magnitude of the bending moment (ft-kips) in the beam is most nearly:



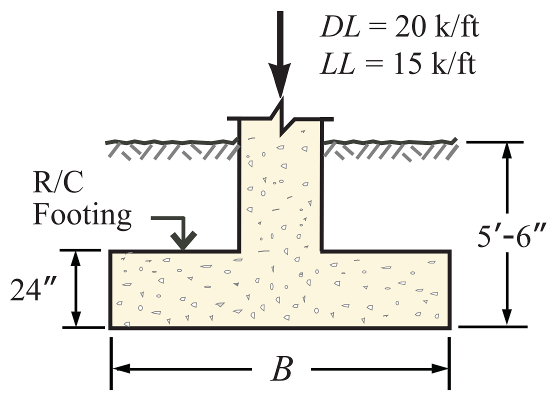
(A) 35.50
(B) 48.00
(C) 54.50
(D) 62.00

$$M_{max} = ?$$

STRUCTURAL DESIGN

WALL FOOTINGS

FULL SOLUTION
NEXT PAGE



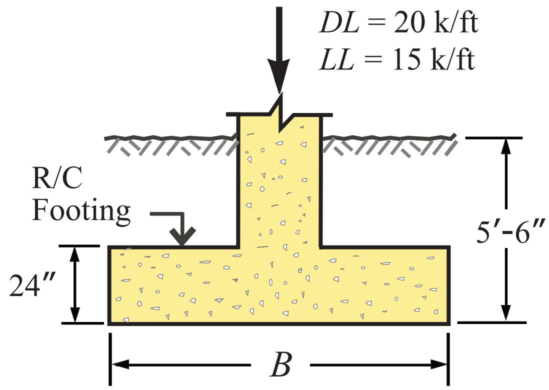
γ_{soil} = 100 lb/ft^3
γ_{con} = 150 lb/ft^3
σ_{allow} = 3,750 lb/ft

A R/C wall footing is loaded as shown. The material charactersitics are given as listed. Using the dimensions shown, the effective soil pressure (k/ft^2) is most nearly:

(A) 4.25
(B) 3.10
(C) 2.84
(D) 2.25

DESIGN OF WALL FOOTINGS

WALL FOOTINGS



$\gamma_{soil} = 100$ lb/ft^3

$\gamma_{con} = 150$ lb/ft^3

Allowable soil pressure: $\sigma_a = 3{,}750$ lb/ft^2

Using the listed data, determine:

(a) The pressure due to the weight of soil fill on top

(b) The pressure due to the weight of R/C footing

(c) The effective soil pressure

Solution:

(a) Pressure due to the weight of soil fill on top: (q_{soil})

$$q_{soil} = (t - h)\,(\gamma_{soil}) = \left(\frac{66 - 24}{12}\right) \times 100 = 3.5' \times 100 = 350 \text{ lb/ft}^2$$

(b) Pressure due to the weight of footing: (q_{ftg})

$$q_{ftg} = (h)\,(\gamma_{con}) = \left(\frac{24}{12}\right) \times 150 = 2' \times 150 = 300 \text{ lb/ft}^2$$

(c) Effective soil pressure: (q_e)

$$q_e = q_a - (q_{soil} + q_{ftg})$$

$$= 3{,}750 - (350 + 300)$$

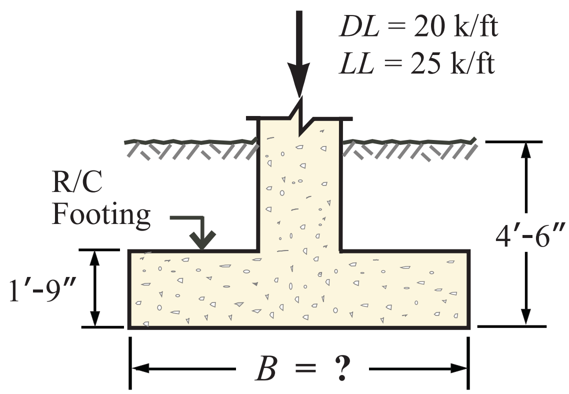
$$= 3{,}100 \text{ lb/ft}^2$$

$$\boxed{q_e = 3.10 \text{ kip/ft}^2}$$

STRUCTURAL DESIGN

FOUNDATIONS

FULL SOLUTION NEXT PAGE



γ_{soil} = 115 lb/ft^3

γ_{con} = 150 lb/ft^3

σ_{allow} = 4,250 lb/ft

A R/C wall footing is loaded as shown. The soil and concrete charactersitics are given as listed. Using the dimensions shown, answer the following questions:

(1) the width (B) of the footing (ft) is most nearly:

(A) 9.5
(B) 12.0
(C) 13.0
(D) 14.5

(2) the bearing pressure (k/ft^2) for strength design is most nearly:

(A) 4.92
(B) 3.18
(C) 2.84
(D) 1.25

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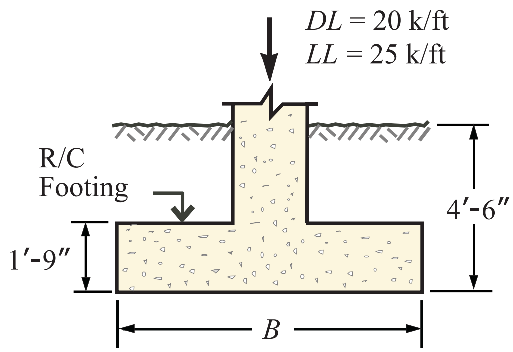
STRUCTURAL DESIGN

WALL FOOTINGS



γ_{soil} = 115 lb/ft^3

γ_{con} = 150 lb/ft^3

σ_{allow} = 4250 lb/ft^2

σ_{allow} = Allowable soil pressure

Using the listed data, determine:

(a) The pressure due to the weight of soil fill on top
(b) The pressure due to the weight of R/C footing
(c) The effective soil pressure
(d) The width of footing (B)
(e) The bearing pressure for stregth design (q_u)

Solution:

(a) Pressure due to the weight of soil fill on top: (q_{soil})

$$q_{soil} = (t - h)\,(\gamma_{soil}) = \left(\frac{54 - 21}{12}\right) \times 115 = 2.75' \times 115 = 316 \text{ lb/ft}^2$$

(b) Pressure due to the weight of footing: (q_{ftg})

$$q_{ftg} = (h)\,(\gamma_{con}) = \left(\frac{21}{12}\right) \times 150 = 1.75' \times 150 = 263 \text{ lb/ft}^2$$

(c) Effective soil pressure: (q_e)

$$q_e = q_a - (q_{soil} + q_{ftg}) = 4{,}250 - (316 + 263) = 3{,}671 \text{ lb/ft}^2 = 3.67 \text{ kip/ft}^2$$

(d) The width of the footing: (B)

$$B = \frac{DL + LL}{q_e} = \frac{20+25}{3.67} = 12.26 \text{ ft} \rightarrow \boxed{B = 13.00 \text{ ft}}$$

(e) The bearing pressure for strength design: (q_u)

$$q_u = \frac{1.2\,DL + 1.6\,LL}{B} = \frac{1.2 \times 20 + 1.6 \times 25}{13.00} = \frac{64.00}{13.00} = 4.92 \text{ kip/ft}^2$$

$$\boxed{q_u = 4.92 \text{ kip/ft}^2}$$