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FE

mechanical

practice exam

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CONTENTS

PRACTICE EXAM

13. A professional engineer was originally licensed 30 years ago and is still currently licensed. The engineer's employer asks the engineer to evaluate a newly developed computerized control system for public transportation. The employer requires that a currently licensed engineer evaluate the system. The engineer may accept the assignment under which conditions?

- ○ A. The engineer is competent in modern control systems.
- ○ B. The engineer supervises two recent graduates who have passed the FE exam.
- ○ C. The engineer studied transportation systems in college.
- ○ D. The engineer has regularly attended meetings of a professional engineering society.

14. An engineering firm has overall design responsibility for a large multifaceted construction project. The state in which the work is being conducted requires civil, structural, environmental, electrical, and mechanical engineering plans to be prepared and stamped by a professional engineer. Which of the following statements are true?

Select **all** that apply.

- ☐ A. Responsibility for the coordination of the entire project can be accepted by the firm's senior engineer, who is responsible for signing and sealing all the submitted plans.
- ☐ B. Responsibility for coordination of the entire project can be accepted by the firm's senior engineer if each technical submittal is signed and sealed by the qualified engineer assigned to that segment.
- ☐ C. The foremost responsibility of the professional engineer is to safeguard the health, safety, and welfare of the public when performing services for clients and employers.
- ☐ D. The technical competence of the professional engineers on the project is not as important as their responsibility to disclose to their employers or clients all known or potential conflicts of interest or other circumstances that could influence or appear to influence their judgment or the quality of their professional service or engagement.
- ☐ E. Licensing laws and rules governing engineering professional practice may vary in each of the jurisdictions in which a licensee practices.

15. A printer costs $900. Its salvage value after 5 years is $300. Annual maintenance is $50. If the interest rate is 8%, the equivalent uniform annual cost is ____________.

Enter your response in the blank. Answer to the nearest integer.

16. Economic analysis will be used to compute an equivalent value today for an estimated constant monthly expense that is projected to occur each month over the next three years.

Select the column in the factor table that contains the value that could be used for the analysis.

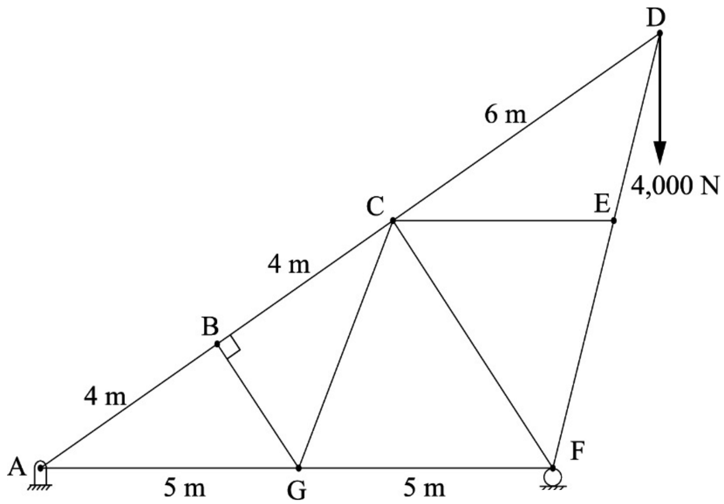
Factor Table – *i* = 2.00%

n	*P/F*	*P/A*	*P/G*	*F/P*	*F/A*	*A/P*	*A/F*	*A/G*
1	0.9804	0.9804	0.0000	1.0200	1.0000	1.0200	1.0000	0.0000
2	0.9612	1.9416	0.9612	1.0404	2.0200	0.5150	0.4950	0.4950
3	0.9423	2.8839	2.8458	1.0612	3.0604	0.3468	0.3268	0.9868
4	0.9238	3.8077	5.6173	1.0824	4.1216	0.2626	0.2426	1.4752
5	**0.9057**	**4.7135**	**9.2403**	**1.1041**	**5.2040**	**0.2122**	**0.1922**	**1.9604**
6	0.8880	5.6014	13.6801	1.1262	6.3081	0.1785	0.1585	2.4423
7	0.8706	6.4720	18.9035	1.1487	7.4343	0.1545	0.1345	2.9208
8	0.8535	7.3255	24.8779	1.1717	8.5830	0.1365	0.1165	3.3961
9	0.8368	8.1622	31.5720	1.1951	9.7546	0.1225	0.1025	3.8681
10	**0.8203**	**8.9826**	**38.9551**	**1.2190**	**10.9497**	**0.1113**	**0.0913**	**4.3367**
11	0.8043	9.7868	46.9977	1.2434	12.1687	0.1022	0.0822	4.8021
12	0.7885	10.5753	55.6712	1.2682	13.4121	0.0946	0.0746	5.2642
13	0.7730	11.3484	64.9475	1.2936	14.6803	0.0881	0.0681	5.7231
14	0.7579	12.1062	74.7999	1.3195	15.9739	0.0826	0.0626	6.1786
15	**0.7430**	**12.8493**	**85.2021**	**1.3459**	**17.2934**	**0.0778**	**0.0578**	**6.6309**
16	0.7284	13.5777	96.1288	1.3728	18.6393	0.0737	0.0537	7.0799
17	0.7142	14.2919	107.5554	1.4002	20.0121	0.0700	0.0500	7.5256
18	0.7002	14.9920	119.4581	1.4282	21.4123	0.0677	0.0467	7.9681
19	0.6864	15.6785	131.8139	1.4568	22.8406	0.0638	0.0438	8.4073
20	**0.6730**	**16.3514**	**144.6003**	**1.4859**	**24.2974**	**0.0612**	**0.0412**	**8.8433**
21	0.6598	17.0112	157.7959	1.5157	25.7833	0.0588	0.0388	9.2760
22	0.6468	17.6580	171.3795	1.5460	27.2990	0.0566	0.0366	9.7055
23	0.6342	18.2922	185.3309	1.5769	28.8450	0.0547	0.0347	10.1317
24	0.6217	18.9139	199.6305	1.6084	30.4219	0.0529	0.0329	10.5547
25	**0.6095**	**19.5235**	**214.2592**	**1.6406**	**32.0303**	**0.0512**	**0.0312**	**10.9745**
30	0.5521	22.3965	291.7164	1.8114	40.5681	0.0446	0.0246	13.0251
40	0.4529	27.3555	461.9931	2.2080	60.4020	0.0366	0.0166	16.8885
50	0.3715	31.4236	642.3606	2.6916	84.5794	0.0318	0.0118	20.4420
60	0.3048	34.7609	823.6975	3.2810	114.0515	0.0288	0.0088	23.6961
100	**0.1380**	**43.0984**	**1,464.7527**	**7.2446**	**312.2323**	**0.0232**	**0.0032**	**33.9863**

17. A business owner wants to build a reserve fund. To have $50,000 in the fund at the end of 10 years, the amount the owner will need to invest annually, assuming an annual return of 5%, is most nearly:

- ○ A. $951
- ○ B. $1,535
- ○ C. $2,500
- ○ D. $3,975

28. Mark all of the zero-force members of the simple truss below.



29. Evaluate the center of gravity in each figure below. Arrange the figures in increasing order of y-axis center of gravity. All bars are 1 unit wide.

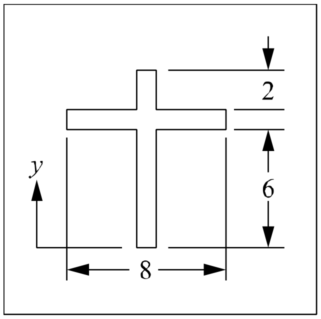


FIGURE A

______________ Lowest

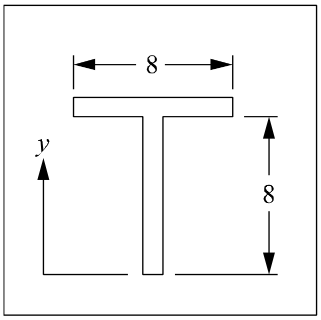


FIGURE B

____

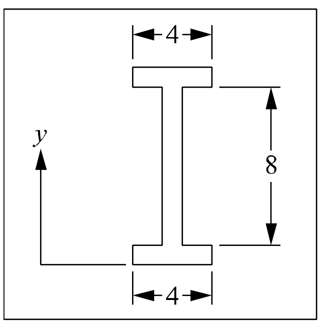


FIGURE C

____

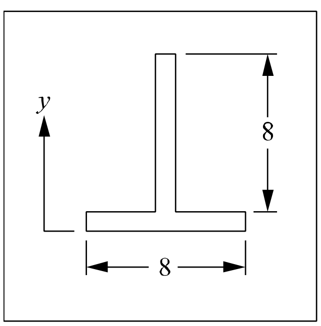


FIGURE D

____

______________ Highest

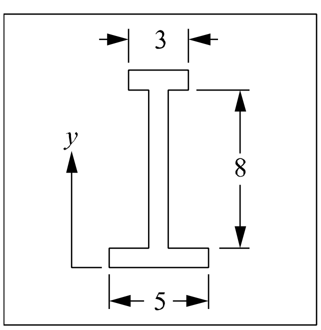


FIGURE E

90. The transfer function relating a step input to the output of a control system is:

$$\frac{16}{s^3 + 0.8s^2 + 16s}$$

The natural frequency ω_n of the system and the damping ratio ς are most nearly:

- A. $\omega_n = 2$ rad/s; $\varsigma = 0.1$
- B. $\omega_n = 2$ rad/s; $\varsigma = 0.2$
- C. $\omega_n = 4$ rad/s; $\varsigma = 0.1$
- D. $\omega_n = 4$ rad/s; $\varsigma = 0.2$

91. Yielding is considered failure for the ductile beam shown. The following data apply:

Yielding first occurs at Point X.
$S_y = 34$ ksi
$\sigma_2 = 0$ ksi

The table below shows various calculated values for σ_1 and σ_3.

Select the columns that show the values at which failures will occur.

Stress	A	B	C	D	E	F
σ_1 (ksi)	35	24	45	60	18	82
σ_3 (ksi)	– 35	0	–35	24	–62	62

92. A helical compression spring has a wire diameter of 2.34 mm and an outside diameter of 15 mm. For a spring load of 150 N, the shear stress (MPa) in the spring is most nearly:

- ○ A. 342
- ○ B. 377
- ○ C. 412
- ○ D. 577

93. A helical compression spring has a spring constant of 38.525 N/mm and a free length of 190 mm. The force (N) required to compress the spring to a length of 125 mm is most nearly:

- ○ A. 1,500
- ○ B. 2,500
- ○ C. 4,800
- ○ D. 6,500

94. The pressure gauge in an air cylinder reads 1,680 kPa. The cylinder is constructed of a 12-mm rolled-steel plate with an internal diameter of 700 mm. The tangential (hoop) stress (MPa) inside the tank is most nearly:

- ○ A. 25
- ○ B. 50
- ○ C. 77
- ○ D. 100

SOLUTIONS

13. Refer to the Ethics chapter of the *FE Reference Handbook*.

The Rules of Professional Conduct, Section B.1, states that licensees may undertake assignments only in the fields in which they are qualified by education or experience.

THE CORRECT ANSWER IS: A

14. Refer to the Rules of Professional Conduct, Section B.1, in the Ethics chapter of the *FE Reference Handbook*.

Option A: Not true. Licensees may accept assignments and assume responsibility for coordination of an entire project, provided that each technical segment is signed and sealed by the licensee responsible for preparation of that technical segment.

Option B: True: See above.

Option C: True. The first and foremost responsibility of licensees is to safeguard the health, safety, and welfare of the public when performing services for clients and employers.

Option D: Not true. Licensees must disclose to their employers or clients all known or potential conflicts of interest or other circumstances that could influence or appear to influence their judgment or the quality of their professional service or engagement.

Option E: True. Licensees must comply with the licensing laws and rules governing their professional practice in each of the jurisdictions in which they practice.

THE CORRECT ANSWERS ARE: B, C, E

15. Refer to the Engineering Economics chapter of the FE Reference Handbook.

Annual cost: = cost + maintenance – salvage

$$\begin{aligned}\text{Annual cost:}\ &= \$900(A/P, 8\%, 5) + \$50 - \$300(A/F, 8\%, 5)\\ &= \$900(0.2505) + \$50 - \$300(0.1705)\\ &= \$225.45 + \$50 - \$51.15\\ &= \$224.30\end{aligned}$$

THE CORRECT ANSWER IS: 224 OR 225

16. Compute *P* (present value) given *A* (the periodic value) for *P*/*A*. Uniform series present worth factors are described in the Engineering Economics chapter of the *FE Reference Handbook*.

Factor Table –*i* = 2.00%

n	*P/F*	*P/A*	*P/G*	*F/P*	*F/A*	*A/P*	*A/F*	*A/G*
1	0.9804	0.9804	0.0000	1.0200	1.0000	1.0200	1.0000	0.0000
2	0.9612	1.9416	0.9612	1.0404	2.0200	0.5150	0.4950	0.4950
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7	0.8706	6.4720	18.9035	1.1487	7.4343	0.1545	0.1345	2.9208
8	0.8535	7.3255	24.8779	1.1717	8.5830	0.1365	0.1165	3.3961
9	0.8368	8.1622	31.5720	1.1951	9.7546	0.1225	0.1025	3.8681
10	**0.8203**	**8.9826**	**38.9551**	**1.2190**	**10.9497**	**0.1113**	**0.0913**	**4.3367**
11	0.8043	9.7868	46.9977	1.2434	12.1687	0.1022	0.0822	4.8021
12	0.7885	10.5753	55.6712	1.2682	13.4121	0.0946	0.0746	5.2642
13	0.7730	11.3484	64.9475	1.2936	14.6803	0.0881	0.0681	5.7231
14	0.7579	12.1062	74.7999	1.3195	15.9739	0.0826	0.0626	6.1786
15	**0.7430**	**12.8493**	**85.2021**	**1.3459**	**17.2934**	**0.0778**	**0.0578**	**6.6309**
16	0.7284	13.5777	96.1288	1.3728	18.6393	0.0737	0.0537	7.0799
17	0.7142	14.2919	107.5554	1.4002	20.0121	0.0700	0.0500	7.5256
18	0.7002	14.9920	119.4581	1.4282	21.4123	0.0677	0.0467	7.9681
19	0.6864	15.6785	131.8139	1.4568	22.8406	0.0638	0.0438	8.4073
20	**0.6730**	**16.3514**	**144.6003**	**1.4859**	**24.2974**	**0.0612**	**0.0412**	**8.8433**
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22	0.6468	17.6580	171.3795	1.5460	27.2990	0.0566	0.0366	9.7055
23	0.6342	18.2922	185.3309	1.5769	28.8450	0.0547	0.0347	10.1317
24	0.6217	18.9139	199.6305	1.6084	30.4219	0.0529	0.0329	10.5547
25	**0.6095**	**19.5235**	**214.2592**	**1.6406**	**32.0303**	**0.0512**	**0.0312**	**10.9745**
30	0.5521	22.3965	291.7164	1.8114	40.5681	0.0446	0.0246	13.0251
40	0.4529	27.3555	461.9931	2.2080	60.4020	0.0366	0.0166	16.8885
50	0.3715	31.4236	642.3606	2.6916	84.5794	0.0318	0.0118	20.4420
60	0.3048	34.7609	823.6975	3.2810	114.0515	0.0288	0.0088	23.6961
100	**0.1380**	**43.0984**	**1,464.7527**	**7.2446**	**312.2323**	**0.0232**	**0.0032**	**33.9863**

THE CORRECT ANSWER IS SHADED ABOVE.

17. Refer to the Uniform Series Sinking Fund equation in the Engineering Economics chapter of the *FE Reference Handbook.*

$n = 10$

$i = 0.058$

$$A = F \bullet \frac{A}{F} = \$50,000 \bullet \frac{i}{(1+i)^n - 1}$$

$$A = \$50,000 \bullet \frac{0.05}{(1+0.05)^{10} - 1}$$

$A = \$3,975$

THE CORRECT ANSWER IS: D

18. Ignore depreciation, interest, etc. The initial cost was \$50,000. Net profit from each unit sale is \$40 – \$25 = \$15.

In Year 1: 1,000 units × \$15 = \$15,000 (cumulative \$15,000 at end of Year 1)

In Year 2: 750 units × \$15 = \$11,250 (cumulative \$26,250)

In Year 3: 750 units × \$15 = \$11,250 (cumulative \$37,500)

In Year 4: 500 units × \$15 = \$7,500 (cumulative \$45,000)

In Year 5: 500 units × \$15 = \$7,500 (cumulative \$52,500)

Sometime during Year 5 the project is paid back.

THE CORRECT ANSWER IS: 5

19. Refer to Complex Power in the Electrical and Computer Engineering chapter of the *FE Reference Handbook* for the equation.

$$P = V_{\text{rms}}\, I_{\text{rms}} \cos\theta$$

$$pf = \cos\theta = \frac{P}{V_{\text{rms}}\, I_{\text{rms}}}$$

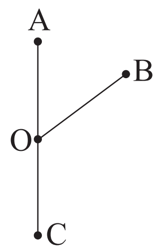
$$= \frac{1,500}{(115)(15)}$$

$$= 0.87$$

THE CORRECT ANSWER IS: D

28. Refer to the Statically Determinate Truss section in the Statics chapter of the *FE Reference Handbook*.

Where members are aligned as follows with no external loads, zero force members occur.



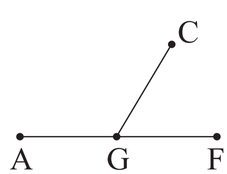
That is, joints where two members are along the same line (OA and OC) and the third member is at some arbitrary angle create zero-force members. That member (OB) is a zero-force member because the forces in OA and OC must be equal and opposite.

For this specific problem, we immediately examine Joints B and E:

BG is a zero-force member

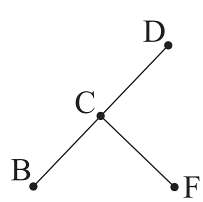
CE is a zero-force member

Now, examine Joint G. Since BG is zero-force member, the joint effectively looks like:

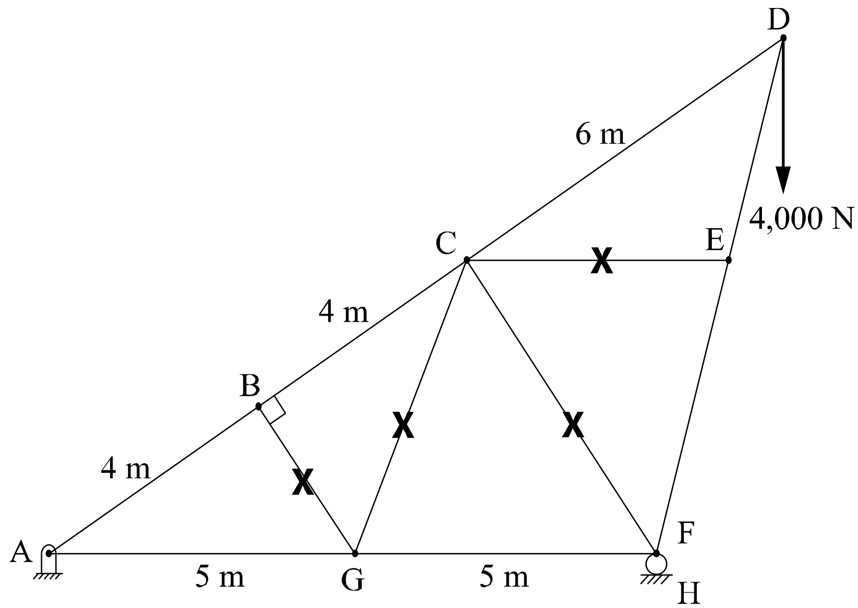


and, therefore, CG is another zero-force member.

Finally, examine Joint C. Since both CG and CE are zero-force members, the joint effectively looks like:



28. **(Continued)**
and, therefore, CF is another zero-force member. Thus, BG, CE, CG, and CF are the zero-force members.



THE CORRECT ANSWERS ARE MARKED ABOVE.

29. Refer to the Centroids of Masses, Areas, Lengths, and Volumes section in the Statics chapter of the *FE Reference Handbook*.

A. Determination of Y = 5.38
$[(6 \times 1)(3) + (8 \times 1)(6.5) + (2 \times 1)(8)]/16$

B. Determination of Y = 6.25
$[(8 \times 1)(4) + (8 \times 1)(8.5)]/16$

C. Determination of Y = 5.00
$[(4 \times 1)(0.5) + (8 \times 1)(5) + (4 \times 1)(9.5)]/16$

D. Determination of Y = 2.75
$[(8 \times 1)(0.5) + (8 \times 1)(5)]/16$

E. Determination of Y = 4.44
$[(5 \times 1)(0.50) + (8 \times 1)(5.0) + (3 \times 1)(9.5)]/16$

THE CORRECT ORDER IS: D, E, C, A, B

90. Refer to the Second-Order Control System Models section in the Instrumentation, Measurement, and Controls chapter of the *FE Reference Handbook*.

The equation of the system can be written as $\dfrac{16}{s\left(s^2+0.8s+16\right)}$ which is in the form

$$\frac{16}{s\left(s^2+2\zeta\omega_n\, s+\omega_n{}^2\right)}$$

thus $\omega_n{}^2=16$ or $\omega_n=4$

and $2\zeta\,\omega_n=0.8$ or $\zeta=\dfrac{0.8}{2\omega_n}=0.1$

THE CORRECT ANSWER IS: C

91. Refer to the Static Loading Failure Theories section in the Mechanical Engineering chapter of the *FE Reference Handbook*.

Maximum shear stress theory is used for the ductile material.

Calculate $\tau_{\max}=(\sigma_1-\sigma_3)/2$ and compare with $S_y/2$.

Stress	A	B	C	D	E	F
Calculated τ_{max}	35	12	40	18	40	10
$\tau_{max} > 17$?	fails	12–ok	fails	fails	fails	10–ok

THE CORRECT ANSWERS ARE: A, C, D, E

92. Refer to the Mechanical Springs section in the Mechanical Engineering chapter of the *FE Reference Handbook*.

$$\tau = K_s \frac{8FD}{\pi d^3}$$

where

$d = 2.34 \text{ mm}$

$d_o = 15 \text{ mm}$

$D = d_o - d = 15 - 2.34 = 12.66 \text{ mm}$

$$C = \frac{D}{d} = \frac{12.66}{2.34} = 5.410$$

$$K_s = \frac{2C+1}{2C} = \frac{2(5.410)+1}{2(5.410)} = 1.0924$$

$$\tau = 1.0924 \frac{(8)(150 \text{ N})(12.66 \text{ mm})}{\pi(2.34)^3} = 412.3 \text{ MPa}$$

THE CORRECT ANSWER IS: C

93. Refer to the Mechanical Springs section in the Mechanical Engineering chapter of the *FE Reference Handbook*.

The force required to displace a spring an amount δ from its free length is $F = k\delta$, where k is the spring constant or rate. In this case:

δ = free length – compressed length

= 190 mm – 125 mm

= 65 mm

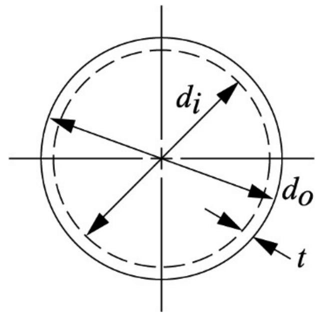
The force required to deflect the spring this amount is:

$F = k\delta = (38.525 \text{ N/mm})(65 \text{ mm}) = 2{,}504 \text{ N}$

THE CORRECT ANSWER IS: B

94. Refer to the Cylindrical Pressure Vessel section in the Mechanics of Materials chapter of the *FE Reference Handbook.*

The cylinder can be considered thin-walled if $t < d_o/20$. In this case, t = 12 mm and $r_o = d_o/2 = 362$ mm. Thus,



$$\sigma_t = \frac{P_i r}{t}$$

where $r = \dfrac{r_i + r_o}{2} = \dfrac{350 + 362}{2} = 356 \text{ mm}$

$$\sigma_t = \frac{(1.680 \text{ MPa})(356 \text{ mm})}{12 \text{ mm}} = 49.8 \text{ MPa}$$

THE CORRECT ANSWER IS: B

95. Refer to the Hooke's Law section in the Mechanics of Materials chapter of the *FE Reference Handbook*.

The formula for the total longitudinal strain without a temperature rise is:

$$\varepsilon_{\text{axial}} = \frac{1}{E}\left(\sigma_l - v\left(\sigma_t + \sigma_r\right)\right) = \frac{1}{210 \times 10^3 \text{ MPa}}\left(23.1 \text{ MPa} - 0.24\left(46.2 \text{ MPa} + 0\right)\right) = 5.72 \times 10^{-6}$$

This must be converted to displacement using the following formula:

$\varepsilon_{\text{axial}} = \dfrac{\delta l}{l}$, where l is the length of the section under consideration

$$\delta l = \varepsilon_{\text{axial}} \times l$$

$$= 5.72 \times 10^{-6} \times 1{,}000 \text{ mm}$$

$$= 0.0572 \text{ mm}$$

THE CORRECT ANSWER IS: A

