FEExamClick

# Free FE Mechanical Practice Exam

20 exam-style questions across the NCEES FE Mechanical knowledge areas, with an answer key and a worked solution for every question.

| 20 | 48 min | 110 |
| --- | --- | --- |
| questions | suggested time | questions on the real exam |

## How to take it

1. Set a timer for 48 minutes, about 2.4 minutes a question. The real exam gives 5 h 20 min for 110 questions, about 2.9.
2. Use only the NCEES FE Reference Handbook (free from your MyNCEES account) and an NCEES-approved calculator.
3. Answer every question: the real exam has no penalty for wrong answers.
4. Check your answers with the key after question 20, then read every worked solution, including the ones you got right.

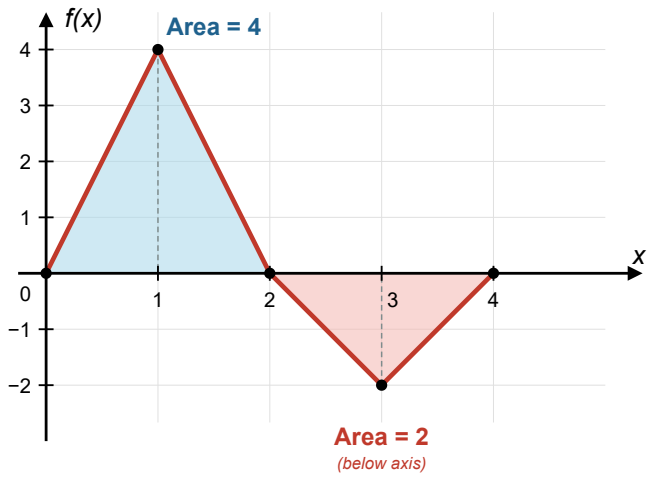
## The real exam is on a computer

The FE is computer-based, with the Handbook on screen. To practise the same 20 questions in that interface, with a countdown and your score by topic, take the free online version at feexamclick.com/fe-mechanical-practice-exam.

Original questions written to the NCEES FE Mechanical exam specification; NCEES does not publish its exam questions. © 2026 FEExamClick, feexamclick.com.

## Question 1 Mathematics

The figure shows f(x). Calculate $\int_0^4 f(x)dx$ using the geometric areas shown.




**A** 6

**B** 2

**C** 4

**D** 0

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## Question 2 Probability and Statistics

An engineer must choose between two designs. Design A costs $\$100{,}000$ and has a 90% success probability (profit $\$200{,}000$). Design B costs $\$50{,}000$ and has a 70% success probability (profit $\$150{,}000$). Failure in either design yields zero revenue. The expected net profit for Design A is most nearly:

**A** $\$55{,}000$

**B** $\$100{,}000$

**C** $\$80{,}000$

**D** $\$180{,}000$

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## Question 3 Ethics and Professional Practice

An engineer working for a manufacturing company discovers that emissions from the plant slightly exceed EPA limits during peak production hours. Management states that average daily emissions are within limits. The engineer should:

**A** Accept management's interpretation since average daily emissions comply

**B** Document the exceedances and recommend corrective actions to bring peak emissions into compliance

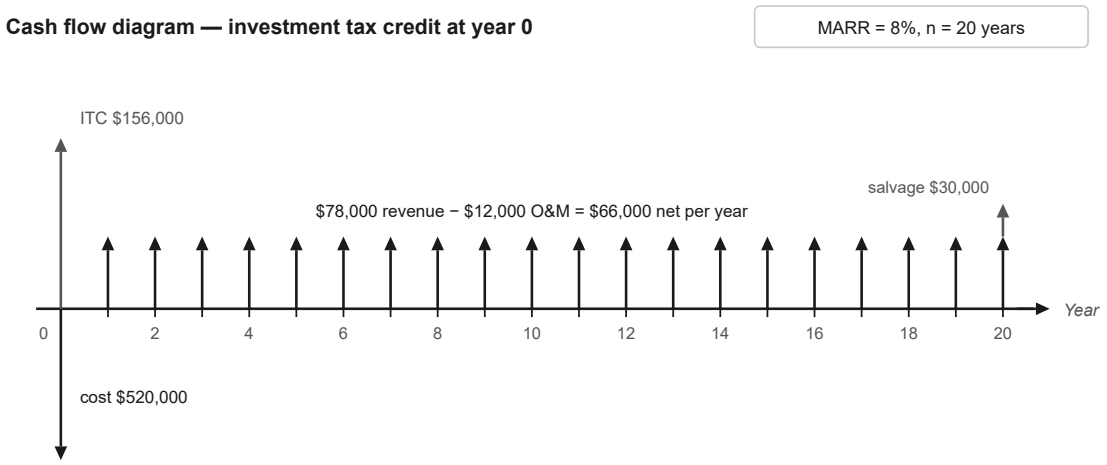
**C** Immediately contact the media to expose the violation

**D** Ignore the issue since it is an environmental matter outside engineering scope

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## Question 4 Engineering Economics

A combined heat and power (CHP) system has an initial cost of $\$520{,}000$, annual O&M of $\$12{,}000$, annual energy revenue of $\$78{,}000$, and qualifies for a 30% investment tax credit (ITC) applied at year 0, as shown. The system has a 20-year life, salvage value of $\$30{,}000$, and MARR = 8%. What is the present worth of this investment after the ITC?




Both the purchase and the tax credit occur at year 0. Inflows and outflows use separate vertical scales.

**A** $\$134{,}430$

**B** $\$408{,}247$

**C** $\$167{,}892$

**D** $\$290{,}430$

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### Question 5 Electricity and Magnetism

A three-phase motor draws 10 A line current at 480 V with a power factor of 0.85. The total real power consumed is most nearly:

**A** 4.08 kW

**B** 2.36 kW

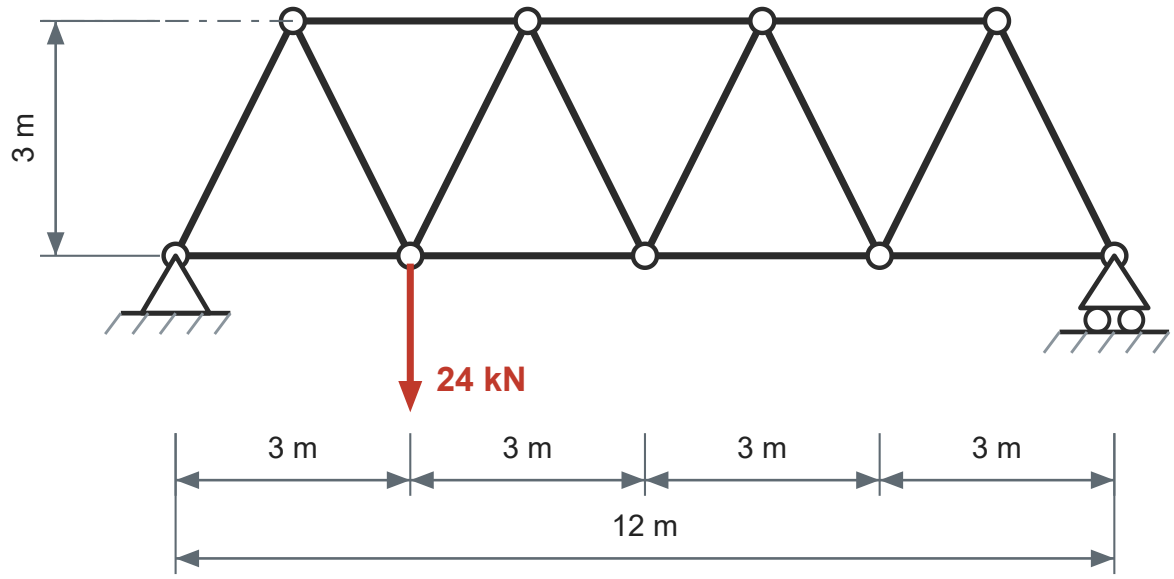
**C** 8.31 kW

**D** 7.06 kW

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### Question 6 Statics

A Warren truss spans 12 m in four equal bottom panels of 3 m and is 3 m deep; its top joints sit above the panel midpoints. A 24 kN downward load acts at the bottom joint 3 m from the left support. Using the method of sections, the force (kN) in the bottom chord of the second panel (from 3 m to 6 m) is most nearly:




**A** 9

**B** 15

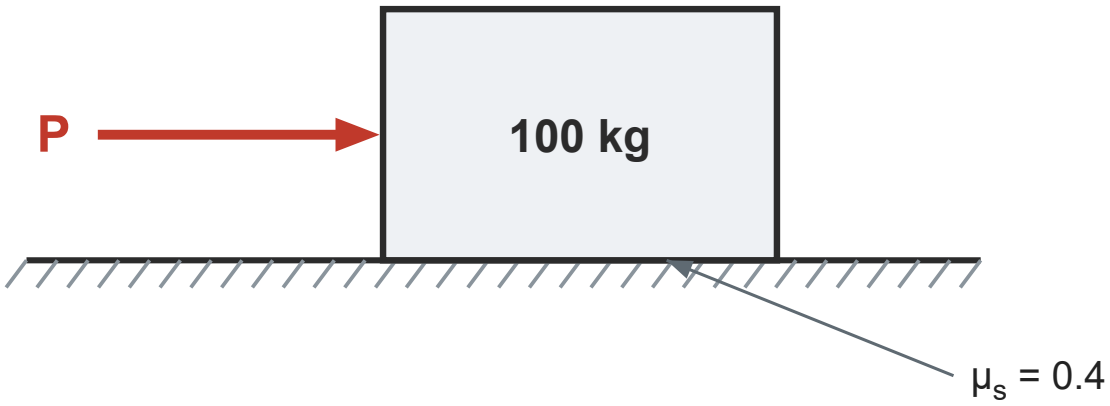
**C** 18

**D** 24

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**Question 7** Statics

A 100 kg block rests on a horizontal surface with coefficient of static friction μs = 0.4. What is the maximum horizontal force that can be applied before the block moves?




**A** 980 N

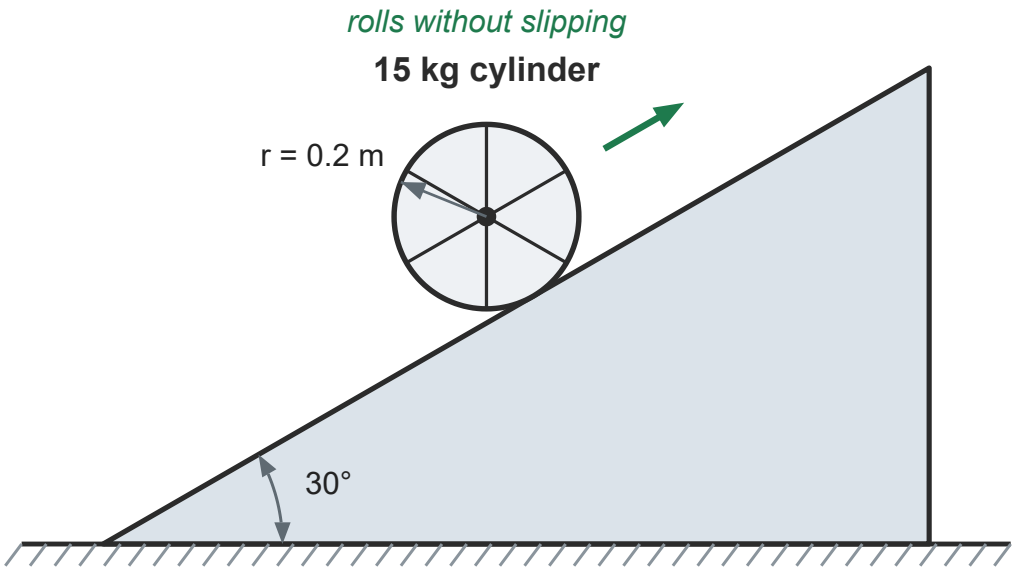
**B** 400 N

**C** 392 N

**D** 250 N

**Question 8** Dynamics, Kinematics, and Vibrations

A solid cylinder of mass 15 kg and radius 0.2 m rolls without slipping down a 30-degree incline. The acceleration ($m/s^2$) of the center of the cylinder is most nearly: ($g = 9.81\ m/s^2$)




**A** 4.91

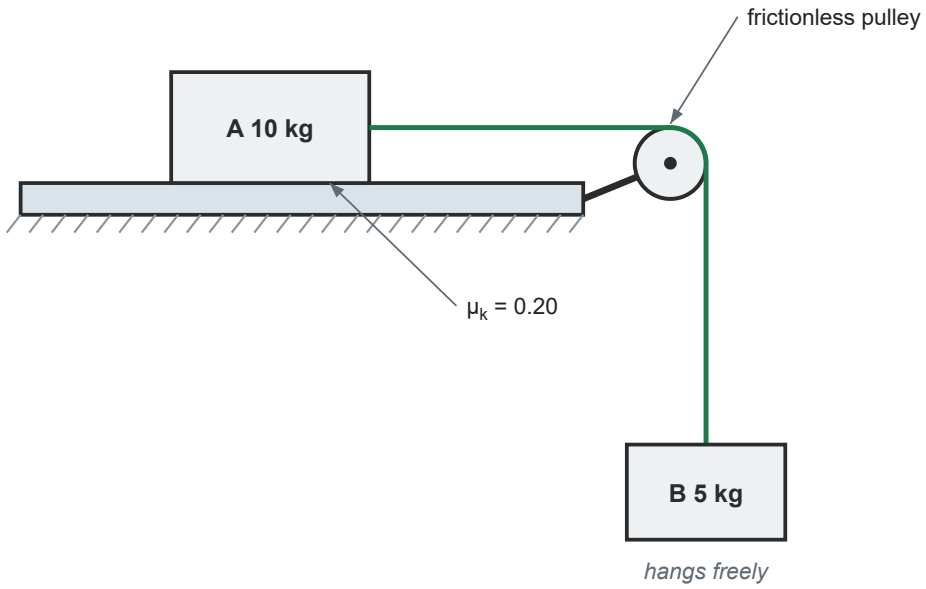
**B** 2.45

**C** 6.54

**D** 3.27

**Question 9** Dynamics, Kinematics, and Vibrations

Two blocks A (10 kg) and B (5 kg) are connected by a cable over a frictionless pulley as shown in the figure. Block A rests on a horizontal surface with $\mu_k$ = 0.20, and Block B hangs vertically. The acceleration (m/s$^2$) of the system is most nearly: (g = 9.81 m/s$^2$)




**A** 0.65

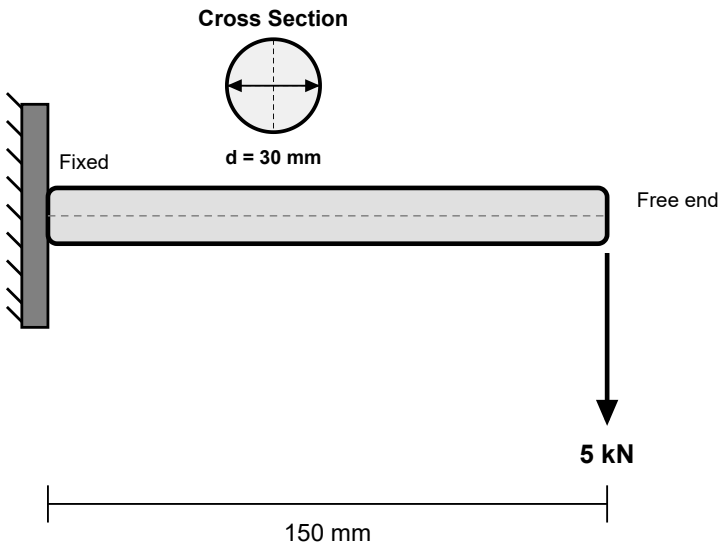
**B** 4.90

**C** 1.96

**D** 3.27

## Question 10 Mechanics of Materials

A horizontal cantilever arm 150 mm long with a solid circular cross section (d = 30 mm) is fixed at the left wall. A vertical load of 5 kN is applied downward at the free right end. At the top of the cross section at the wall, the bending stress (MPa) is most nearly:




**A** 283

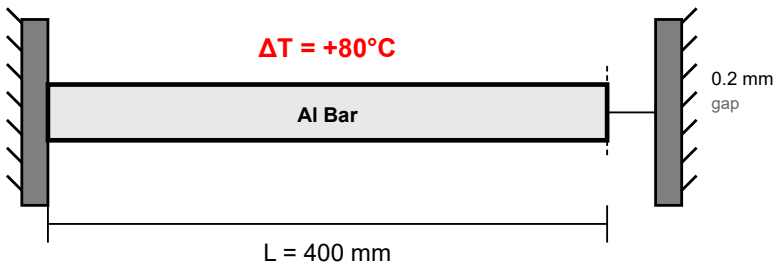
**B** 566

**C** 141

**D** 71

### Question 11 Mechanics of Materials

An aluminum bar ($\alpha = 23 \times 10^{-6}$/°C, E = 70 GPa) is 400 mm long and has a cross-sectional area of 200 mm$^2$. It is heated by 80°C while being constrained between rigid walls with an initial gap of 0.2 mm at one end. The compressive stress (MPa) in the bar is most nearly:




**A** 128.8

**B** 163.8

**C** 93.8

**D** 35.0

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### Question 12 Material Properties and Processing

A tensile specimen has an original gauge length of 50 mm and a diameter of 12.5 mm. After fracture, the gauge length is 64 mm and the minimum diameter at the neck is 8.0 mm. The percent reduction in area is most nearly:

**A** 59%

**B** 28%

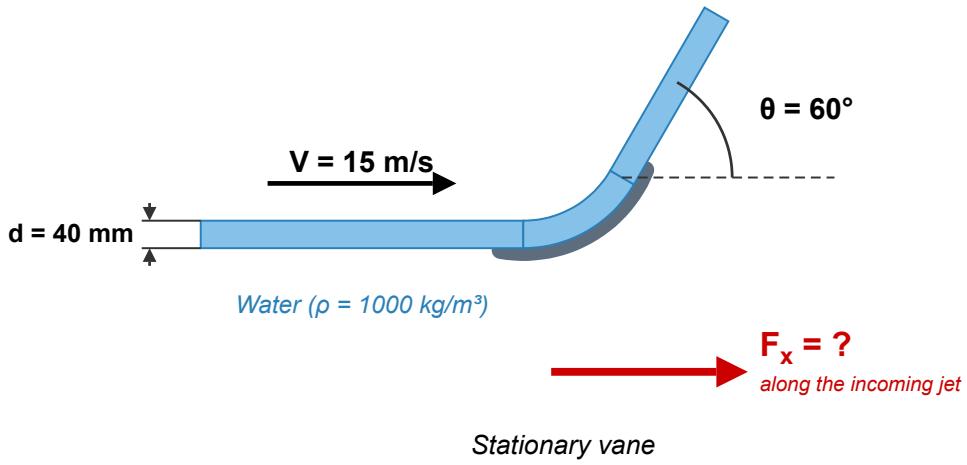
**C** 64%

**D** 41%

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**Question 13** Fluid Mechanics

A water jet at 15 m/s with a 40-mm diameter is deflected 60° by a stationary curved vane. The component of force (N) on the vane in the direction of the incoming jet is most nearly:




**A** 71

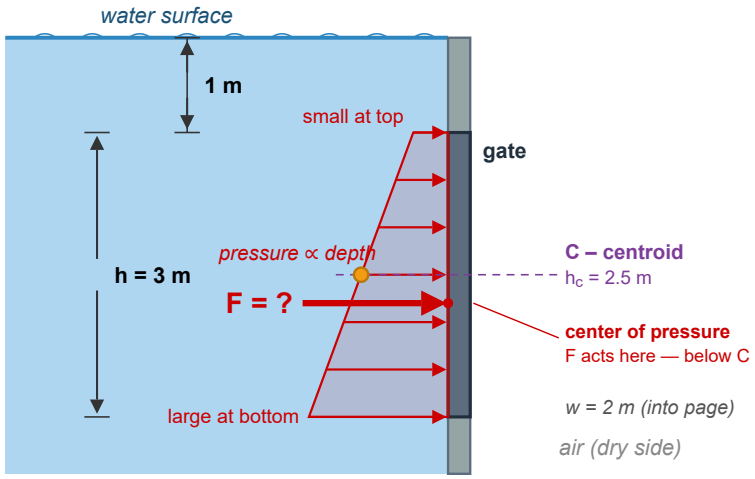
**B** 141

**C** 283

**D** 245

## Question 14 Fluid Mechanics

A rectangular gate 2 m wide and 3 m high is submerged vertically in water with its top edge 1 m below the surface. What is the hydrostatic force on the gate?




**A** 117.7 kN

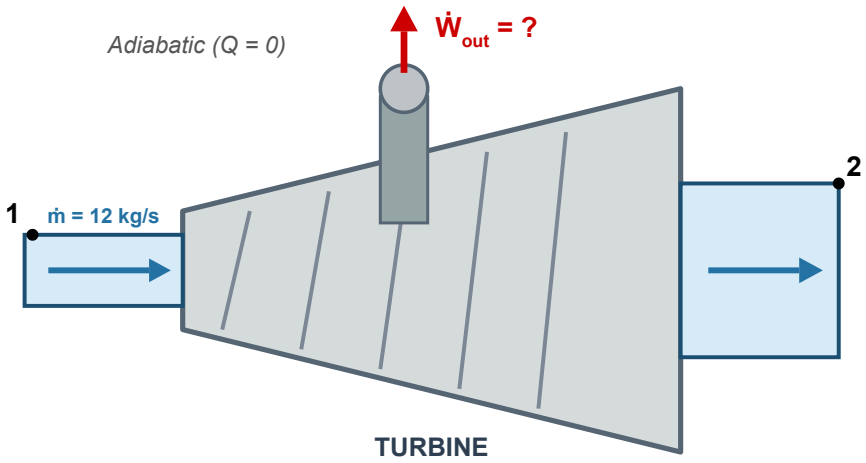
**B** 147.2 kN

**C** 88.3 kN

**D** 176.6 kN

## Question 15 Thermodynamics

Steam enters an adiabatic turbine at 6 MPa and 500°C ($h_1$ = 3423.1 kJ/kg) and exits at 50 kPa ($h_2$ = 2682.4 kJ/kg). The mass flow rate is 12 kg/s. The turbine power output (MW) is most nearly:




**Inlet (1)**
$P_1$ = 6 MPa
$T_1$ = 500°C
$h_1$ = 3423.1 kJ/kg

**Exit (2)**
$P_2$ = 50 kPa
$h_2$ = 2682.4 kJ/kg

**A** 10.2

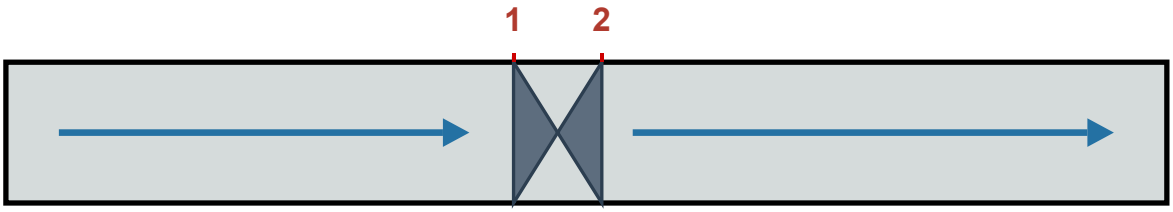
**B** 7.41

**C** 6.54

**D** 8.89

## Question 16 Thermodynamics

Steam at 500 kPa and 200°C (h = 2855.8 kJ/kg) passes through a throttling valve and exits at 100 kPa. The exit temperature (°C) is most nearly:




*Throttling valve*

**Inlet (1)**
$P_1$ = 500 kPa
$T_1$ = 200°C
$h_1$ = 2855.8 kJ/kg

**Exit (2)**
$P_2$ = 100 kPa
**$T_2$ = ?**

**A** 190

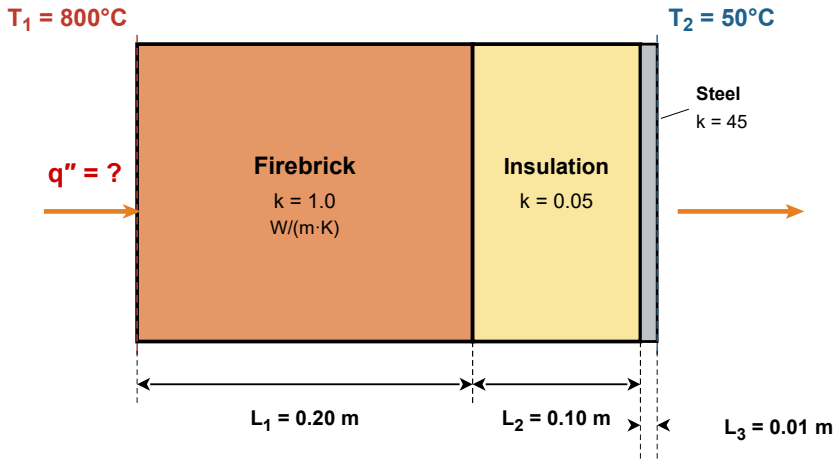
**B** 200

**C** 152

**D** 100

## Question 17 Heat Transfer

A furnace wall has three layers in series: firebrick (k = 1.0 W/(m·K), L = 0.20 m), insulation (k = 0.05 W/(m·K), L = 0.10 m), and steel casing (k = 45 W/(m·K), L = 0.01 m). The inner surface is at 800°C and the outer surface is at 50°C. The heat flux (W/m$^2$) through the wall is most nearly:




**A** 170

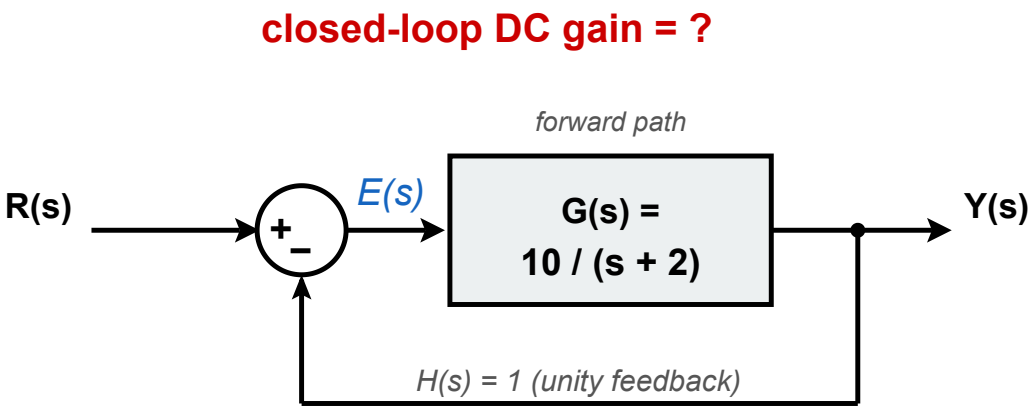
**B** 1,500

**C** 341

**D** 750

**Question 18** Measurements, Instrumentation, and Controls

A system with open-loop transfer function $G(s) = 10/(s+2)$ is placed in the **negative** unity feedback configuration shown. Its closed-loop DC gain is:




**A** 0.833

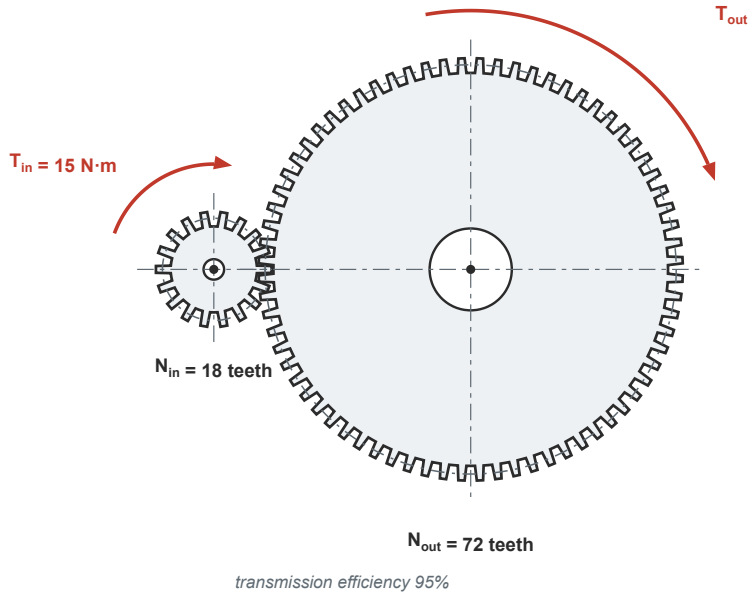
**B** 5.0

**C** 1.0

**D** 10.0

## Question 19 Mechanical Design and Analysis

A gear train has an input gear with 18 teeth driving an output gear with 72 teeth. If the input torque is 15 N·m and efficiency is 95%, what is the output torque?




**A** 60.0 N·m

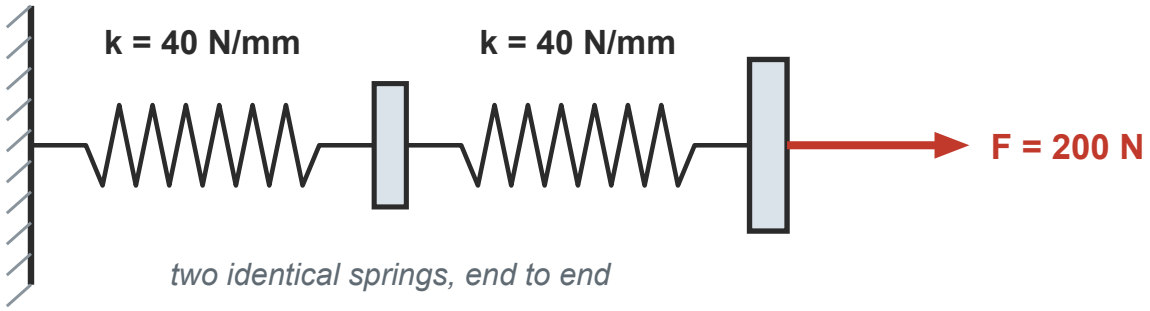
**B** 45.6 N·m

**C** 63.2 N·m

**D** 57.0 N·m

**Question 20** Mechanical Design and Analysis

Two identical helical compression springs, each with a spring rate of 40 N/mm, are connected in series. A load of 200 N is applied. The total deflection (mm) is most nearly:




**A** 10.0

**B** 20.0

**C** 5.0

**D** 2.5

# Answer key

| Question | Answer | NCEES knowledge area |
|---|---|---|
| 1 | **B** | Mathematics |
| 2 | **C** | Probability and Statistics |
| 3 | **B** | Ethics and Professional Practice |
| 4 | **D** | Engineering Economics |
| 5 | **D** | Electricity and Magnetism |
| 6 | **B** | Statics |
| 7 | **C** | Statics |
| 8 | **D** | Dynamics, Kinematics, and Vibrations |
| 9 | **C** | Dynamics, Kinematics, and Vibrations |
| 10 | **A** | Mechanics of Materials |
| 11 | **C** | Mechanics of Materials |
| 12 | **A** | Material Properties and Processing |
| 13 | **B** | Fluid Mechanics |
| 14 | **B** | Fluid Mechanics |
| 15 | **D** | Thermodynamics |
| 16 | **A** | Thermodynamics |
| 17 | **C** | Heat Transfer |
| 18 | **A** | Measurements, Instrumentation, and Controls |
| 19 | **D** | Mechanical Design and Analysis |
| 20 | **A** | Mechanical Design and Analysis |

Worked solutions start on the next page.

# Worked solutions

### Question 1 · Answer B

From the graph:
- From $x = 0$ to $x = 2$: Area above x-axis = 4 (positive)
- From $x = 2$ to $x = 4$: Area below x-axis = 2 (negative)

$\int_0^4 f(x)\,dx$ = (Area above) - (Area below)

$$= 4 - 2 = 2$$

Note: Areas below the x-axis contribute negative values to the integral.

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### Question 2 · Answer C

Refer to the Dispersion, Mean, Median, and Mode Values section in the Engineering Probability and Statistics chapter of the FE Reference Handbook.

Design A:
Expected revenue = $0.90 \times 200{,}000 + 0.10 \times 0 = 180{,}000$
Expected net profit = $180{,}000 - 100{,}000 = \$80{,}000$

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### Question 3 · Answer B

Refer to the Obligations to the Public (Section A) section in the Ethics and Professional Practice chapter of the FE Reference Handbook.

Engineers have an obligation to protect public health and the environment. Emissions limits typically apply on a continuous basis, not just as daily averages. The engineer should document the violations and recommend corrective actions to management. If management fails to act, the engineer should notify appropriate authorities.

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### Question 4 · Answer D

**Handbook:** FE Reference Handbook 10.6, Engineering Economics — the (P/A) and (P/F) factors on p. 235, and the **i = 8% table on p. 241**, whose n = 20 row gives P/A = 9.8181 and P/F = 0.2145.

**Step 1 – Net the year-0 flows.** The credit arrives at the same instant as the purchase, so no discounting applies to it — the two simply add:

$$\text{ITC} = 0.30(520{,}000) = \$156{,}000$$

$$P_{\text{net}} = 520{,}000 - 156{,}000 = \$364{,}000$$

**Step 2 – Net the annual flows.** Revenue and O&M both recur every year, so combine them into one annuity rather than discounting each separately:

$$A = 78{,}000 - 12{,}000 = \$66{,}000 \text{ per year}$$

**Step 3 – Discount everything to year 0.**

$$PW = -364{,}000 + 66{,}000(9.8181) + 30{,}000(0.2145)$$

$$PW = -364{,}000 + 647{,}995 + 6{,}435 = \mathbf{\$290{,}430}$$

**Step 4 – Answer: (D)**.

**What the credit is worth.** Without the ITC the present worth would be $\$134{,}430$; with it, $\$290{,}430$. The credit contributes its full $\$156{,}000$ because it lands at year 0 — every dollar of it survives undiscounted. That is why the timing of a tax credit matters as much as its size, and why the stem specifies "applied at year 0."

Note also how little the salvage contributes: $\$30{,}000$ twenty years out is worth only $\$6{,}435$ today, about 2% of the present worth. At 8%, distant money is nearly weightless.

**Step 5 – Eliminate the distractors:**

(A) $\$134{,}430$ is the calculation with the ITC ignored: $-520{,}000 + 647{,}995 + 6{,}435$. Everything else is right; the credit is simply never applied. The gap between (A) and (D) is exactly the $\$156{,}000$ credit.

(B) $\$408{,}247$ discounts the $\$78{,}000$ of gross revenue and never subtracts the $\$12{,}000$ of O&M: $-364{,}000 + 78{,}000(9.8181) + 6{,}435$. Twenty years of a $\$12{,}000$ oversight is worth $\$117{,}800$ in present terms.

(C) $\$167{,}892$ treats the credit as if it arrived at the *end* of the 20-year life: $156{,}000(0.2145) = \$33{,}462$ instead of $\$156{,}000$. Discounting a year-0 amount strips away 79% of its value — the opposite of what the stem states.

---

**Question 5 · Answer D**

For a three-phase system:

$$P = \sqrt{3} V_L I_L \cos\theta$$

$$P = \sqrt{3} \times 480 \times 10 \times 0.85$$

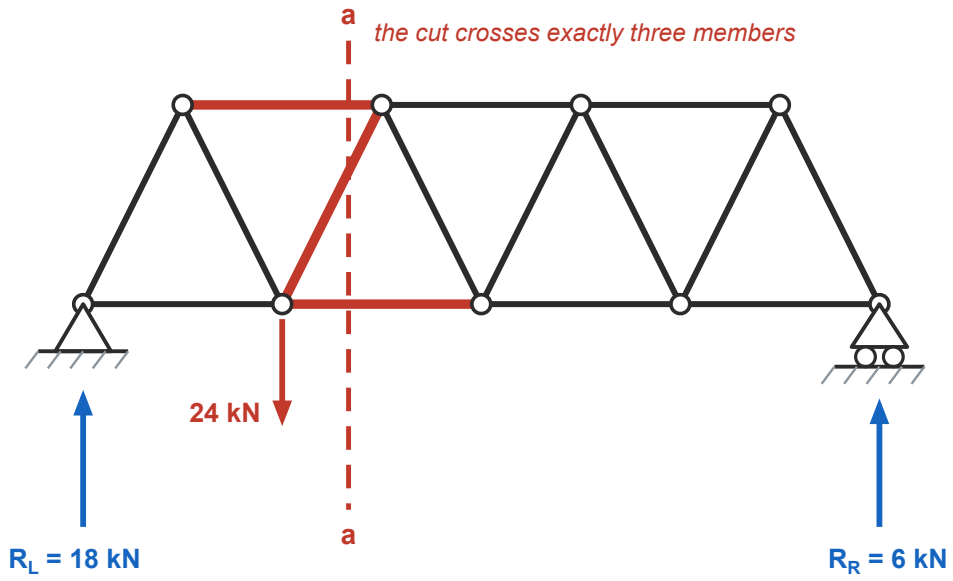
$$P = 1.732 \times 480 \times 10 \times 0.85$$

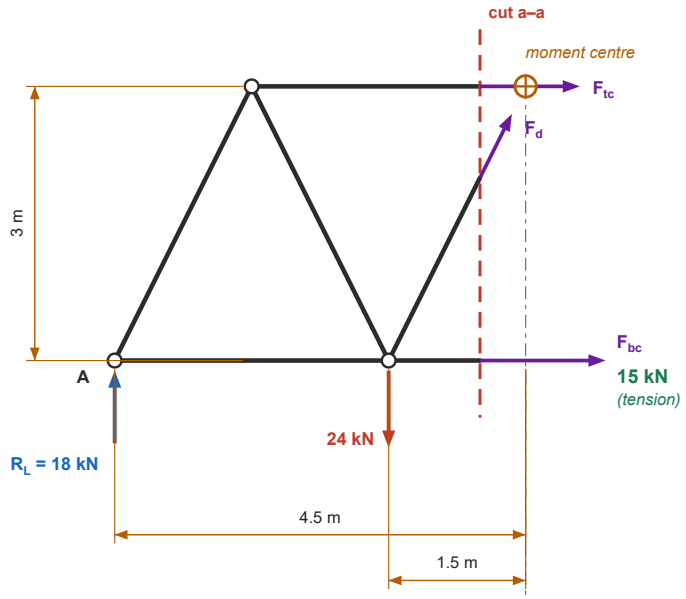
$$P = 7066 \text{ W} = 7.06 \text{ kW}$$

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**Question 6 · Answer B**

Refer to the Plane Truss: Method of Sections section (p. 98) in the Statics chapter of the FE Reference Handbook.




Reactions: $\Sigma M_{right} = 0$: $R_L(12) = 24(9) \Rightarrow R_L = 18$ kN up, and $R_R = 6$ kN up.

Cut the truss vertically through the second panel. The cut crosses the top chord, one diagonal and the bottom chord. In a Warren truss the top joints are at the panel midpoints, so the top chord and that diagonal both pass through the top joint at $x$ = 4.5 m. Taking moments about that joint therefore leaves only the bottom chord force:

$\Sigma M = 0$: $R_L(4.5) - 24(4.5 - 3) - F_{bc}(3) = 0$
$18(4.5) - 24(1.5) = 3F_{bc}$
$81 - 36 = 45 = 3F_{bc}$
$F_{bc} = 15$ kN (tension - the bottom chord of a simply supported truss stretches)

Distractor A (9) is the bottom chord of the THIRD panel, found by taking moments about the top joint at $x$ = 7.5 m.
Distractor C (18) is the left reaction.
Distractor D (24) is the applied load.

---

### Question 7 · Answer C

The maximum static friction force is:

$$F_{max} = \mu_s N$$

where N is the normal force.

For a horizontal surface:
$N = mg = 100 \times 9.81 = 981$ N

$F_{max} = 0.4 \times 981 = 392.4$ N

$$\boxed{F_{max} \approx 392 \text{ N}}$$

This is the limiting friction - the maximum force before motion begins.

---

### Question 8 · Answer D

Refer to the Rigid Body Dynamics section in the Dynamics chapter of the FE Reference Handbook.

For a solid cylinder rolling without slip:
$a = g \times \sin(\theta)/(1 + I/(m \times r^2))$

For solid cylinder: I = (1/2)*m*r^2, so I/(m*r^2) = 1/2

$$\boxed{a = g \times \sin(30)/(1 + 1/2) = 9.81 \times 0.5/1.5 = 4.905/1.5 = 3.27 m/s^2}$$

---

### Question 9 · Answer C

Refer to the Kinetics section in the Dynamics chapter of the FE Reference Handbook.

For Block B (hanging): $m_B g - T = m_B a$
For Block A (on surface): T - $\mu_k$*m_A*g = m_A*a

Adding both equations:
$m_B \times g - \mu_k \times m_A \times g = (m_A + m_B) \times a$

$a = g \times (m_B - \mu_k \times m_A)/(m_A + m_B)$
$a = 9.81 \times (5 - 0.20 \times 10)/(10 + 5)$
$a = 9.81 \times (5 - 2)/15$
$a = 9.81 \times 3/15$
$\boxed{a = 9.81 \times (3/15) = 1.962 m/s^2}$

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### Question 10 · Answer A

Refer to the Stresses in Beams section in the Mechanics of Materials chapter of the FE Reference Handbook.

Maximum bending moment at the wall: M = PL = (5,000 N)(150 mm) = 750,000 N·mm

$$c = d/2 = 15mm$$

$$I = \pi d^4/64 = \pi(30)^4/64 = 39,761 mm^4$$

$$\boxed{\sigma = Mc/I = (750,000)(15)/39,761 = 11,250,000/39,761 = 283 MPa}$$

Distractor C (141) uses M/S with wrong S. Distractor B (566) uses L = 300 mm.

---

### Question 11 · Answer C

Refer to the Thermal Deformations section in the Mechanics of Materials chapter of the FE Reference Handbook.

Free thermal expansion: $\delta_T = \alpha L \Delta T = (23 \times 10^{-6})(400)(80) = 0.736 mm$

Since δ_T (0.736 mm) > gap (0.2 mm), the bar contacts the wall.

The net deformation that must be prevented by the wall reaction:

$$\delta_T - gap = \delta_{mechanical}$$

$$0.736 - 0.2 = 0.536 mm$$

$$\boxed{\sigma = E \times \delta_{mechanical}/L = (70 \times 10^3)(0.536)/(400) = 37,520/400 = 93.8 MPa (compressive)}$$

Distractor A (128.8) ignores the gap entirely. Distractor D (35.0) uses gap = 0.536 mm.

---

### Question 12 · Answer A

Refer to the Uniaxial Stress-Strain section (p. 130) in the Mechanics of Materials chapter of the FE Reference Handbook.

Percent reduction in area:

$$\%RA = (A_0 - A_f)/A_0 \times 100$$

Original area: $A_0 = \pi/4 \times (12.5)^2 = 122.72 mm^2$

Final area at neck: $A_f = \pi/4 \times (8.0)^2 = 50.27 mm^2$

$$\boxed{\%RA = (122.72 - 50.27)/122.72 \times 100 = 72.45/122.72 \times 100 = 59.0\%}$$

Note: Percent elongation = (64 - 50)/50 * 100 = 28%, which is a different ductility measure.

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**Question 13 · Answer B**

**Momentum in the jet (x) direction.**

The vane is stationary and losses are neglected, so the water keeps its speed $V$; only its direction changes. The force on the vane along the incoming jet equals the rate of change of the jet's x-momentum:

$$F_x = \dot{m}\,(V_{x,in} - V_{x,out}) = \dot{m}\,(V - V\cos\theta) = \dot{m}\,V(1 - \cos\theta)$$

**Step 1 – Mass flow.**

$$A = \frac{\pi D^2}{4} = \frac{\pi (0.04)^2}{4} = 1.257 \times 10^{-3}\ \text{m}^2$$

$$\dot{m} = \rho A V = 1000(1.257 \times 10^{-3})(15) = 18.85\ \text{kg/s}$$

**Step 2 – x-component of force.**

$$F_x = 18.85 \times 15 \times (1 - \cos 60^\circ) = 282.7 \times 0.5 = 141\ \text{N}$$

**Why the other options fail:**
• **245 N** is the *y*-component, $\dot{m}V\sin\theta = 282.7 \times 0.866$ — the force perpendicular to the jet, not along it. Read which component is asked.
• **283 N** is $\dot{m}V$ with no $(1 - \cos\theta)$ — the value only if the jet were stopped dead (90° onto a flat plate). A 60° turn removes just half the forward momentum. (It is also the resultant magnitude here, since at 60° $\sqrt{(1-\cos\theta)^2 + \sin^2\theta} = 1$ — but that is the total force, still not the x-component.)
• **71 N** is half the correct value (a further factor slip).

**Correct answer: (B)**

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**Question 14 · Answer B**

**Step 1 – Depth of the centroid.**

The magnitude of the resultant on a plane surface uses the pressure at the *centroid*. The gate's top edge is 1 m deep and it is 3 m tall, so its centroid sits at

$$h_c = 1 + \frac{3}{2} = 2.5\ \text{m}$$

**Step 2 – Area.**

$$A = w \times h = 2 \times 3 = 6 \text{ m}^2$$

**Step 3 – Resultant force.**

$$F = \rho g h_c A$$

$$F = (1000)(9.81)(2.5)(6) = 147{,}150 \text{ N} \approx 147.2 \text{ kN}$$

**Where the force acts (what the figure shows).**

Pressure grows linearly with depth, so more of the load is carried by the lower half of the gate. The resultant therefore acts *below* the centroid, at the center of pressure:

$$y_{cp} = h_c + \frac{I}{h_c A} = 2.5 + \frac{(2)(3^3)/12}{(2.5)(6)} = 2.5 + 0.3 = 2.8 \text{ m}$$

This does not change the magnitude — it is where a single equivalent force would be applied. Placing the resultant at the centroid is the most common mistake in this topic.

**Why the other options fail — each uses the wrong depth:**
• **117.7 kN** uses $h_c = 2.0$ m, the depth of the *top* edge — forgetting to add half the gate height.
• **88.3 kN** uses $h_c = 1.5$ m — taking only half the height and forgetting the 1 m of submergence.
• **176.6 kN** uses $h_c = 3.0$ m, the depth of the *bottom* edge.
The whole question turns on one thing: the pressure is evaluated at the centroid depth, $h_c = 2.5$ m.

**Correct answer: (B)**

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### Question 15 · Answer D

Refer to the Special Cases of Steady-Flow Energy Equation section (p. 149) in the Thermodynamics chapter of the FE Reference Handbook.

For an adiabatic turbine (Q = 0), neglecting KE and PE changes:

$$\dot{W} = \dot{m}(h_1 - h_2)$$

$$\dot{W} = 12 \times (3423.1 - 2682.4) = 12 \times 740.7 = 8888.4 kW \approx 8.89 MW$$

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### Question 16 · Answer A

Refer to the throttling / First-Law discussion and the superheated-steam tables in the Thermodynamics chapter of the FE Reference Handbook.

**A throttling valve is isenthalpic.** It is adiabatic, does no work, and the kinetic- and potential-energy changes are negligible, so the steady-flow energy balance collapses to:
$h_2 = h_1 = 2855.8 \text{ kJ/kg}$

**Phase at the exit (100 kPa):** the saturated-vapour enthalpy is $h_g = 2675.0 \text{ kJ/kg}$. Since $h_2 = 2855.8 > h_g$, the steam leaves **superheated** (not a wet mixture), so the temperature is read from the superheated table — not fixed at saturation.

**Interpolate in the 100 kPa superheated table** at $h = 2855.8\ \text{kJ/kg}$:

$h(150\,^\circ\text{C}) = 2776.6, \qquad h(200\,^\circ\text{C}) = 2875.4$

$$T_2 = 150 + \frac{2855.8 - 2776.6}{2875.4 - 2776.6}\,(50) \approx 190\,^\circ\text{C}$$

The steam cools by about 10°C — the real-gas Joule–Thomson effect. Throttling is exactly isothermal only for an *ideal* gas.

**Why the other options fail:**

• **200°C** assumes the temperature does not change at all (the ideal-gas result). Real steam drops ~10°C.

• **152°C** is $T_{\text{sat}}$ at the *inlet* pressure (500 kPa); the steam is superheated, not on the saturation line.

• **100°C** is $T_{\text{sat}}$ at the *exit* pressure (100 kPa); the exit is superheated ($h > h_g$), well above saturation.

**Correct answer: (A) 190°C**

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### Question 17 · Answer C

Refer to the Conduction section in the Heat Transfer chapter of the FE Reference Handbook.

Total thermal resistance per unit area:

$R'' = L_1/k_1 + L_2/k_2 + L_3/k_3$

$R'' = 0.20/1.0 + 0.10/0.05 + 0.01/45$

$R'' = 0.200 + 2.000 + 0.000222$

$R'' = 2.200 m^2 \cdot K/W$

Heat flux:

$q = \Delta T/R'' = (800 - 50)/2.200$

$q = 750/2.200 = 341 W/m^2$

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### Question 18 · Answer A

**Step 1 – What "DC gain" means.**

DC means zero frequency, i.e. a constant input. The steady-state value of the response to a constant input is obtained by evaluating the closed-loop transfer function at $s = 0$ (final value theorem). So the quantity asked for is $T(0)$, not $T(s)$.

**Step 2 – Close the loop.**

For negative unity feedback ($H(s) = 1$):

$$T(s) = \frac{G(s)}{1 + G(s)}$$

$$T(s) = \frac{\dfrac{10}{s+2}}{1 + \dfrac{10}{s+2}}$$

**Step 3 – Clear the compound fraction.**

Multiply numerator and denominator by $(s+2)$:

$$T(s) = \frac{10}{(s+2)+10} = \frac{10}{s+12}$$

**Step 4 – Evaluate at $s = 0$.**

$$T(0) = \frac{10}{12} = 0.833$$

**Why the other options fail:**
• **5.0** is the *open-loop* DC gain, $G(0) = 10/2 = 5$. The stem hands you the open-loop transfer function, so this is the easy trap: the loop was never closed.
• **1.0** is the limit of $G/(1+G)$ as the gain grows without bound. Here the loop gain is only 5, nowhere near large enough for the output to track the input one-to-one.
• **10.0** is just the numerator constant, which is not a gain of anything on its own.

**What the feedback actually did:** the pole moved from $s = -2$ open-loop to $s = -12$ closed-loop, so the system responds about six times faster, while the DC gain dropped from 5 to 0.833. Trading steady-state gain for speed is the characteristic effect of negative feedback.

**Correct answer: (A)**

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### Question 19 · Answer D

The gear ratio:

$$GR = \frac{N_{output}}{N_{input}} = \frac{72}{18} = 4$$

With efficiency $\eta = 95\%$:

$$T_{output} = \eta \times GR \times T_{input}$$

$$T_{output} = 0.95 \times 4 \times 15 = 57.0 \text{ N}\cdot\text{m}$$

$$\boxed{T_{output} = 57.0 \text{ N}\cdot\text{m}}$$

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### Question 20 · Answer A

Refer to the Springs section (p. 436) in the Mechanical Engineering chapter of the FE Reference Handbook.

For springs in series:
$\frac{1}{k_{eq}} = \frac{1}{k_1} + \frac{1}{k_2} = \frac{1}{40} + \frac{1}{40} = \frac{1}{20}$

$k_{eq} = 20$ N/mm

Total deflection:
$\delta = F/k_{eq} = 200/20 = 10.0$ mm