CLASS TEST

SL. : 01DLSK_ME_ABCDEFGHIJKMNO_200926

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Strength of Materials

MECHANICAL ENGINEERING

Date of Test : 20/09/2026

ANSWER KEY

1.	(c)	7.	(a)	13.	(a)	19.	(d)	25.	(b)
2.	(d)	8.	(b)	14.	(c)	20.	(d)	26.	(c)
3.	(c)	9.	(a)	15.	(b)	21.	(c)	27.	(d)
4.	(b)	10.	(c)	16.	(b)	22.	(b)	28.	(c)
5.	(a)	11.	(c)	17.	(c)	23.	(a)	29.	(b)
6.	(d)	12.	(b)	18.	(d)	24.	(a)	30.	(a)

DETAILED EXPLANATIONS

1. (c)

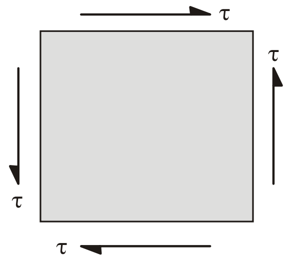
Deflection of a simply supported beam is proportional to,

$$\delta \propto \frac{PL^3}{EI}$$

$\therefore$ Increasing I, decreasing L or P will reduce deflection.

2. (d)

The stress system for an element on the surface is



All normal stresses are zero.

Stress on an inclined plane is given by,

$$\sigma_n = \frac{\sigma_1 + \sigma_2}{2} + \frac{\sigma_1 - \sigma_2}{2}\cos 2\theta + \tau \sin 2\theta$$

$$\sigma_t = \frac{\sigma_1 - \sigma_2}{2}\sin 2\theta - \tau \cos 2\theta$$

Now at $\theta = 45°$,

$\therefore$ $\sigma_n = \tau \sin 90° = \tau$ and σ_t $-\tau \cos 90° = 0$

$\therefore$ 45° plane is the principal plane as shear stress on it is zero. Value of maximum principal stress is 'τ'.

3. (c)

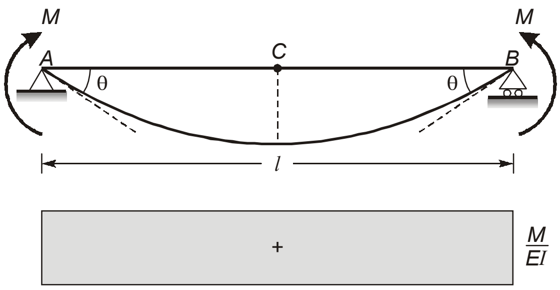
A ductile material fails through a cup and cone type of failure.

4. (b)

Volumetric strain, $\frac{\Delta V}{V} = \frac{\sigma}{E}(1 - 2\mu)$

$$= \frac{180(1 - 2 \times 0.3)}{205 \times 1000} = 3.5 \times 10^{-4} \text{ or } 0.035\%$$

5. (a)



$$\theta_C - \theta_A = \text{Area of } \frac{M}{EI} \text{ diagram}$$

$$0 - \theta_A = +\frac{M}{EI} \times \frac{l}{2} = \frac{Ml}{2EI}$$

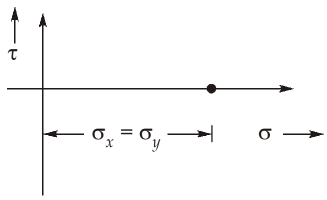
$$\theta_A = -\frac{Ml}{2EI}$$

$$\theta_A = \frac{Ml}{2EI} \text{ (Anti-clockwise)}$$

$$\because \quad \frac{Ml}{EI} = 2\theta_A = 2\theta$$

6. **(d)**

When normal stresses are equal (same magnitude) and of same nature, then Mohr's circle will be reduced to a point.



Ex. Hydrostatic pressure, internal contact pressure in hollow shafts due to press-fitting of bearing.

7. **(a)**

$$\tan 2\theta_{p_1} = \frac{\tau_{xy}}{\left(\frac{\sigma_x - \sigma_y}{2}\right)}$$

$$\theta_{p_1} = \frac{1}{2}\tan^{-1}\left(\frac{2 \times (-5)}{8-5}\right)$$

$$= \frac{1}{2}\tan^{-1}\left(\frac{-10}{3}\right) = \frac{1}{2} \times -73.3 = -36.65°$$

and $\theta_{p_2} = \theta_{p_1} + 90 = -36.65 + 90 = 53.349°$

8. **(b)**

We know that,

$$E = \frac{9KG}{3K+G}$$

$$\Rightarrow \quad 3KE + EG = 9KG$$

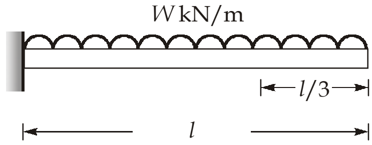
$$\Rightarrow \quad 9KG - 3KE = EG$$

$$\Rightarrow \quad K(9G - 3E) = GE$$

$$\Rightarrow \quad K = \frac{GE}{9G-3E} = \frac{120 \times 42}{9 \times 42 - 3 \times 120}$$

$$= 280 \text{ GPa}$$

9. (a)



Maximum bending will be at fixed end,

i.e. $$M = (Wl) \times \frac{l}{2} = \frac{Wl^2}{2}$$

Bending moment at $\frac{l}{3}$ distance from free end

$$\Rightarrow \quad M' = \left(\frac{Wl}{3}\right) \times \left(\frac{l}{6}\right) = \frac{Wl^2}{18}$$

$$M' = \frac{2}{9} \times \frac{Wl^2}{2} = \frac{M}{9} = 0.1111 = 11.11\% \text{ of M}$$

10. (c)

$$\text{Normal stress, } \sigma_n = \sigma_x \cos^2\theta + \sigma_y \sin^2\theta$$
$$= 80\cos^2 30° + 40\sin^2 30° = 70 \text{ MPa}$$

$$\text{Shear stress, } \tau = -\frac{\sigma_x - \sigma_y}{2}\sin 2\theta = -\frac{80-40}{2}\sin 60°$$

$$\Rightarrow \quad \tau = -17.32 \text{ MPa}$$
$$\tau = 17.32 \text{ MPa (Numerically)}$$
$$\sigma_r = \sqrt{70^2 + 17.32^2} = 72.1 \text{ MPa}$$

11. (c)

Taking moment about 'B'

$$R_a \times l = \frac{wl}{2} \times \frac{2l}{3}$$

$$\therefore \quad R_a = \frac{wl}{3}$$

and $$R_b = \frac{wl}{2} - \frac{wl}{3} = \frac{wl}{6}$$

Intensity of loading at a distance 'x' from end 'B' $= \frac{w}{l}x$

$$\therefore \quad F_x = -R_b + \frac{1}{2}\frac{wx}{l}x = -\frac{wl}{6} + \frac{wx^2}{2l} \qquad \text{(Parabolic)}$$

Shear force is zero at

$$-\frac{wl}{6} + \frac{wx^2}{2l} = 0$$

$$\therefore \quad \frac{wl}{6} = \frac{wx^2}{2l}$$

$$\Rightarrow \quad x = \frac{l}{\sqrt{3}}$$

12. (b)

Bending moment at section 'x'

$$M_x = \frac{wlx}{6} - \frac{wx^2}{2l}.\frac{x}{3}$$

$$M_x = \frac{wlx}{6} - \frac{wx^3}{6l} \qquad \text{(Cubic)}$$

At $x = \frac{l}{\sqrt{3}}$

$$\therefore \qquad M_{max} = \frac{wl}{6} \times \frac{l}{\sqrt{3}} - \frac{w}{6l} \times \left(\frac{l}{\sqrt{3}}\right)^3$$

$$= \frac{wl^2}{9\sqrt{3}}$$

13. (a)

Given, $\sigma_1 = 100$ MPa, $\sigma_2 = 50$ MPa,

$\sigma_3 = 25$ MPa, $S_{yt} = 220$ MPa,

For maximum shear strain energy theory,

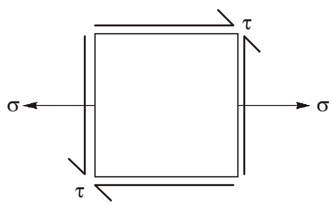
$$(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 \le 2\left(\frac{S_{yt}}{N}\right)^2 \qquad \text{[Where, } N = \text{factor of safety]}$$

$$(100 - 50)^2 + (50 - 25)^2 + (25 - 100)^2 = 2\left(\frac{220}{N}\right)^2$$

After solving,

$\because$ Factor of safety, $N = 3.326 \sim$ **3.33**

14. (c)



State of stress, $\sigma = \frac{P}{2\pi rt}$ (Area of cross-section for a thin tube = $2\pi rt = \pi dt$)

$$\sigma = \text{Simple tensile stress} = \frac{10 \times 10^3}{\pi \times 25 \times 1.6} = 79.6 \text{ N/mm}^2$$

Now, $J = \frac{\pi D^3 t}{8}$ for a thin tube

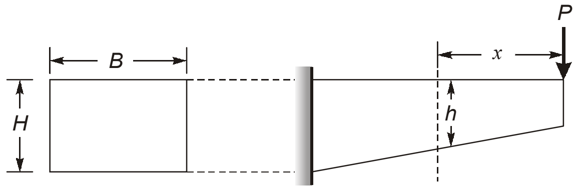
$$\therefore \qquad \tau = \frac{T}{J}r = \frac{8T}{\pi D^3 t} \times \frac{D}{2} = \frac{4T}{\pi D^2 t} = \frac{4 \times 23.5 \times 10^3}{\pi \times 25^2 \times 1.6} = 29.94 \text{ N/mm}^2$$

$$\text{Principal stresses, } \sigma_{1,2} = \frac{\sigma}{2} \pm \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2} = 39.8 \pm \sqrt{39.8^2 + 29.94^2}$$

$$= 39.8 \pm 49.8 = 89.6 \text{ N/mm}^2 \text{ and } -10 \text{ N/mm}^2$$

$\therefore$ Maximum principal stress = 89.6 MPa

15. (b)



$$\text{Stress at support, } \sigma_1 = \frac{M}{Z} = \frac{P \times L}{\left(\frac{B \times H^3}{12}\right)} \times \frac{H}{2} = \frac{6PL}{BH^2}$$

$$\text{Stress at distance } x, \sigma_2 = \frac{M}{Z} = \frac{6P \cdot x}{B \cdot h^2}$$

Equating, $\sigma_1 = \sigma_2$

$$\frac{6PL}{BH^2} = \frac{6P \cdot x}{B \cdot h^2}$$

$$h = \sqrt{\frac{x}{L}} \cdot H$$

16. (b)

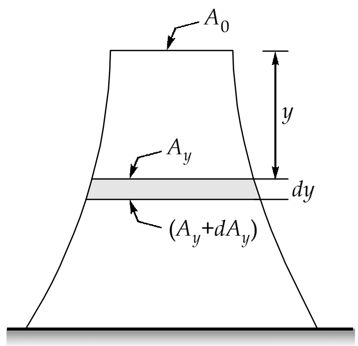
$$\text{Effective length of column } (L_e) = \frac{L}{\sqrt{2}}$$

$$\text{Least radius of gyration } (k) = \sqrt{\frac{I_{min.}}{A}} = \left(\frac{\pi D^4}{64} \times \frac{4}{\pi D^2}\right)^{1/2} = \frac{D}{4}$$

$$\text{Slenderness ratio } (s) = \frac{L_e}{k} = \frac{\left(\frac{L}{\sqrt{2}}\right)}{\left(\frac{D}{4}\right)}$$

$$s = 2\sqrt{2}\frac{L}{D}$$

17. (c)



Let us consider a cross-sectional area A_y at a distance x from top and having thickness dy (as shown)

Force acting due to self weight at section dy

$$\Rightarrow \qquad W_y = \int_0^y \rho g A_y dy$$

Now, taking force balance at the section 'dy'

$$\Rightarrow \qquad \sigma A_y + \int \rho g A_y dy = \sigma(A_y + dA_y) \qquad [\therefore\ \sigma = \text{Constant for uniform strength beam}]$$

$$\Rightarrow \qquad \sigma A_y + \int \rho g A_y dy = \sigma A_y + \sigma dA_y$$

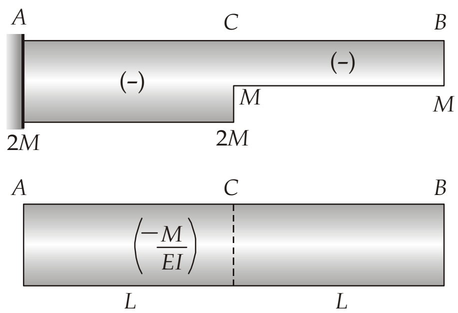
$$\Rightarrow \qquad \int_0^y \rho g dy = \int_{A_0}^{Ay} \frac{\sigma dA_y}{A_y}$$

$$\Rightarrow \qquad \rho g y = \sigma \log\left[\frac{A_y}{A_0}\right]$$

$$\Rightarrow \qquad A_y = A_0 e^{(\rho g y/\sigma)}$$

18. (d)

BMD for the given beam



For deflection at B,

$$\delta_{B/A} = \frac{-M}{EI}\times L\times\frac{L}{2} - \frac{M}{EI}\times L\times\frac{3L}{2}$$

$$= \frac{-ML^2}{EI}\left[\frac{1}{2}+\frac{3}{2}\right] = -\frac{2ML^2}{EI}$$

(–)Ve sign indicates downward deflection.

19. (d)

Effective equivalent length,

$$L_e = \frac{L}{3}$$

As,

$$P_e = \frac{\pi^2 EI}{L_e^2}$$

$$= \frac{\pi^2 EI}{(L/3)^2} = \frac{9\pi^2 EI}{L^2}$$

20. (d)

Actual column is having end constraints as fixed and free but it was considered as fixed and hinged column.

$$(L_{eq})_{actual} = 2L$$

$$\Rightarrow \quad (P_e)_{actual} = \frac{\pi^2 EI}{L_e^2} = \frac{\pi^2 EI}{4L} \quad \text{...(i)}$$

$$(P_e)_{assumed} = \frac{\pi^2 EI}{\left(L/\sqrt{2}\right)^2} \qquad \because \left(L_{eq}\right) = \frac{L}{\sqrt{2}}$$

$$= \frac{2\pi^2 EI}{L^2}$$

$$\%\text{error} = \frac{\text{Error}}{(P_e)_{Actual}} = \frac{\frac{\pi^2 EI}{L^2}\left[2 - \frac{1}{4}\right]}{\frac{\pi^2 EI}{L^2} \times \frac{1}{4}}$$

$$= 700\%$$

21. (c)

$$\text{Inside diameter, } D_i = D_o - 2t = 50 - 2 \times 5 = 40 \text{ mm}$$

$$\text{Permissible stress, } \sigma_y = \frac{240}{3} = 80 \text{ MPa}$$

$$\text{Maximum shear stress, } \tau_{max} = \frac{80}{2} = 40 \text{ MPa}$$

or

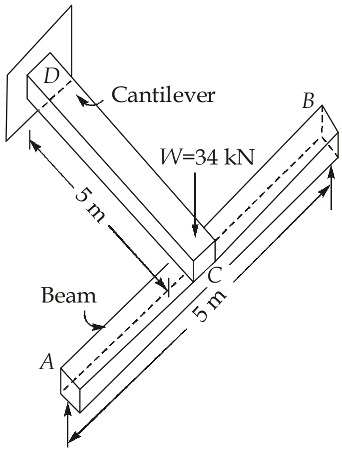
$$\frac{16TD}{\pi\left(D^4 - d^4\right)} = 40$$

$$\frac{16 \times T \times 50}{\pi\left(50^4 - 40^4\right)} = 40$$

$$\therefore \quad T = \frac{40 \times \pi \times \left(50^4 - 40^4\right)}{16 \times 50}$$

$$T = 579.6 \text{ Nm}$$

22. (b)



Let the load shared by the cantilever be 'P'

For the cantilever, $$\Delta_C = \frac{PL^3}{3EI}$$

For the beam, $$\Delta_S = \frac{(W-P)L^3}{48EI}$$

$\therefore$ $$\frac{PL^3}{3EI} = \frac{(W-P)L^3}{48EI}, \text{ on solving we get}$$

$\therefore$ $$P = \frac{W}{17} = \frac{34}{17} = 2 \text{ kN}$$

23. (a)

$$\gamma_{xy} = 2\varepsilon_{45^\circ} - (\varepsilon_0 + \varepsilon_{90^\circ})$$
$$= 2 \times 200 - (-500 + 300)$$
$$\gamma_{xy} = 600\ \mu\text{m/m}$$
$$\varepsilon_1, \varepsilon_2 = \left(\frac{\varepsilon_x + \varepsilon_y}{2}\right) \pm \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$$
$$= \frac{-500+300}{2} \pm \sqrt{\left(\frac{-500-300}{2}\right)^2 + 300^2}$$
$$\varepsilon_{1,2} = -100 \pm 500$$
$$\varepsilon_1 = -600\ \mu\text{m/m}$$
$$\varepsilon_2 = 400\ \mu\text{m/m}$$
$$\sigma_1 = \frac{E}{1-\mu^2}[\varepsilon_1 + \mu\varepsilon_2]$$
$$= \frac{200 \times 10^3}{(1-0.3^2)}[-600 + 0.3 \times 400]$$
$$\sigma_1 = -105.49 \simeq -105 \text{ MPa}$$

24. (a)

$$\sigma_h = \frac{pd}{2t\times\eta_{LJ}} = \frac{6\times150}{2\times12.5\times0.8} = 45 \text{ MPa}$$

$$\sigma_l = \frac{pd}{4t\times\eta_{CJ}} = \frac{6\times150}{4\times12.5\times0.9} = 20 \text{ MPa}$$

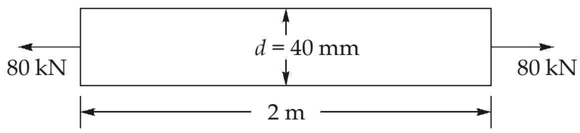
$$\frac{\delta d}{d} = \frac{1}{E}(\sigma_h - \mu\sigma_L) = \frac{1}{200\times10^3}(45-0.25\times20)$$

$$\frac{\delta d}{d} = 0.2\times10^{-3}$$

$$\delta d = 0.2\times150\times10^{-3} \text{ mm}$$

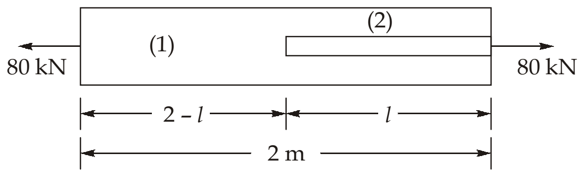
$$\delta d = 0.03 \text{ mm}$$

25. (b)



Elongation of the rod, $\delta l_1 = \frac{PL}{AE} = \frac{80\times1000\times2000}{\frac{\pi}{4}\times40^2\times2\times10^5} = 0.6366$ mm

Let the rod be bored to a length of l meters.



Elongation of the rod after boring,

$$\delta l_2 = 1.2\times\delta l_1 = 1.2\times0.6366 = 0.7639 \text{ mm}$$

$$\delta l_2 = \frac{Pl}{A_2E} + \frac{P(2-l)}{A_1E}$$

$$= \frac{80000}{2\times10^5}\left[\frac{l\times1000}{\frac{\pi}{4}\times\left(40^2-20^2\right)} + \frac{(2-l)\times1000}{\frac{\pi}{4}\times40^2}\right]$$

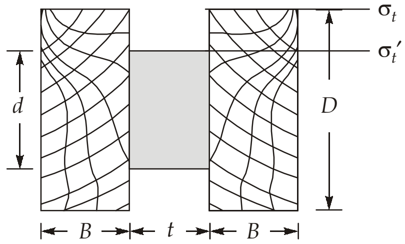
$$= \frac{80000}{2\times10^5}[1.061l + (2-l)0.795]$$

$$= \frac{80000}{2\times10^5}[1.59 + 0.266l] = 0.7639$$

$$l = 1.202 \text{ m}$$

26. (c)

Refer figure,



Let the stress in extreme timber fiber be σ_t

Then the stress in timber at extreme surface of steel,

$$\sigma_t' = \sigma \cdot \frac{d/2}{D/2} = \sigma \cdot \frac{d}{D}$$

Then if the stress in the extreme steel fibre is to reach maximum value,

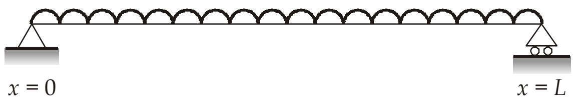
$$\sigma_s = m\sigma_t' \qquad \left[\text{Modular ratio, } m = \frac{E_s}{E_t}\right]$$

$$130 = \frac{210}{12} \times 10 \times \frac{d}{D}$$

or
$$\frac{D}{d} = \frac{210 \times 10}{12 \times 130} = 1.346 \simeq 1.35$$

27. (d)

Given: $y = \dfrac{1}{EI}\left(2x^3 - \dfrac{x^4}{6} - 36x\right)$



In a simply supported beam, bending moment at both the end of beam is zero.

$$M = EI\frac{d^2y}{dx^2} = EI \times \frac{1}{EI} \times \frac{d}{dx}\left(6x^2 - \frac{4x^3}{6} - 36\right)$$

$$= 12x - \frac{12x^2}{6} - 0 = 12x - 2x^2$$

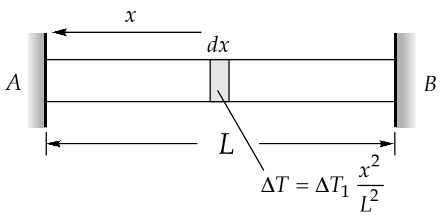
Put $M = 0$, $\quad 12x - 12x^2 = 0$

$2x(6 - x) = 0$

$x = 0, x = 6$

So, the span of the beam is 6 metres.

28. (c)



Induced strain in dx element,

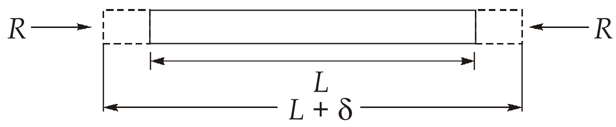
$$\frac{\delta x}{dx} = \alpha\,\Delta T$$

$$\delta x = \alpha \Delta T.dx$$

Total change in length,

$$\int_0^L \delta x = \int_0^L \alpha.\Delta T_1 \cdot \frac{x^2}{L^2} \cdot dx$$

$$\delta = \frac{\alpha\,\Delta T_1\,L^3}{3\,L^2} = \frac{\alpha\,\Delta T_1 L}{3}$$



As the both ends are rigid, no elongation will occur due to rigid support reactions induced R

$$\sigma_{\text{thermal}} = \frac{R}{A} = E.\frac{\delta}{L}$$

$$\sigma_{\text{thermal}} = \frac{E\,\alpha\,\Delta T_1}{3}$$

29. (b)

Given : L = 1 m; W = 600 N; EI = 20 kNm^2

For cantilever beam with transverse shear load W,

$$\delta_1 = \text{Deflection at mid location} = \frac{WL^3}{3EI}$$

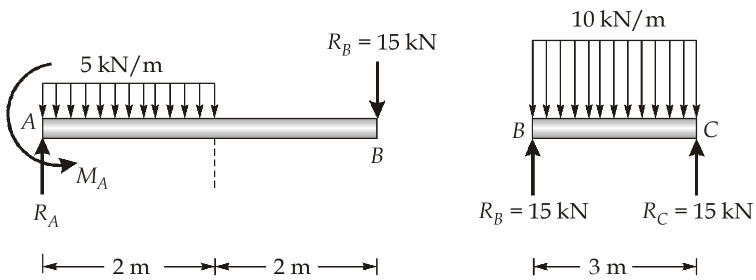
$$\delta_2 = (\text{Slope at mid location}) \times L = \frac{WL^2}{2EI} \times L$$

$$\text{Deflection at the tip, } \delta = \delta_1 + \delta_2$$

$$= \frac{WL^3}{3EI} + \frac{WL^3}{2EI} = \frac{5WL^3}{6EI}$$

$$= \frac{5 \times 600 \times 1^3}{6 \times 20000} = 0.025 \text{ m} = 25 \text{ mm}$$

30. (a)



Taking moment about point A,

$$M_A - (5 \times 2) \times 1 - 15 \times 4 = 0$$

$$\Rightarrow \quad M_A = 10 + 60 = 70 \text{ kNm}$$

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