Mid-Semester Exam.

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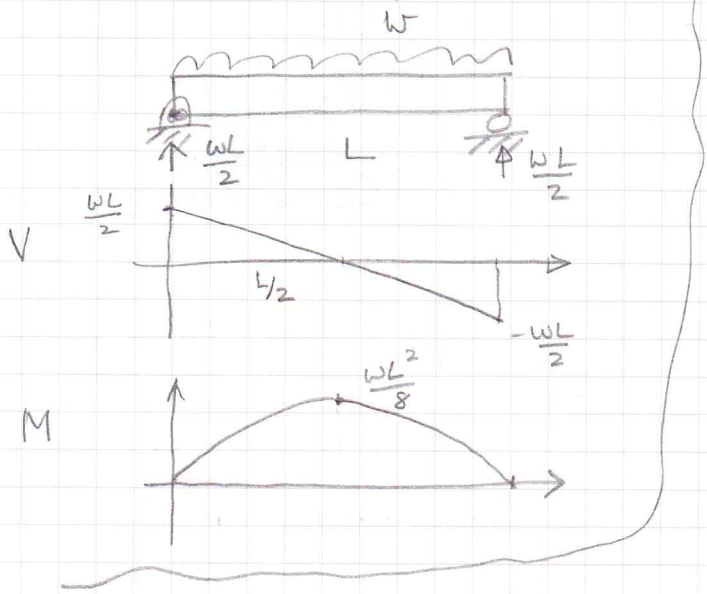
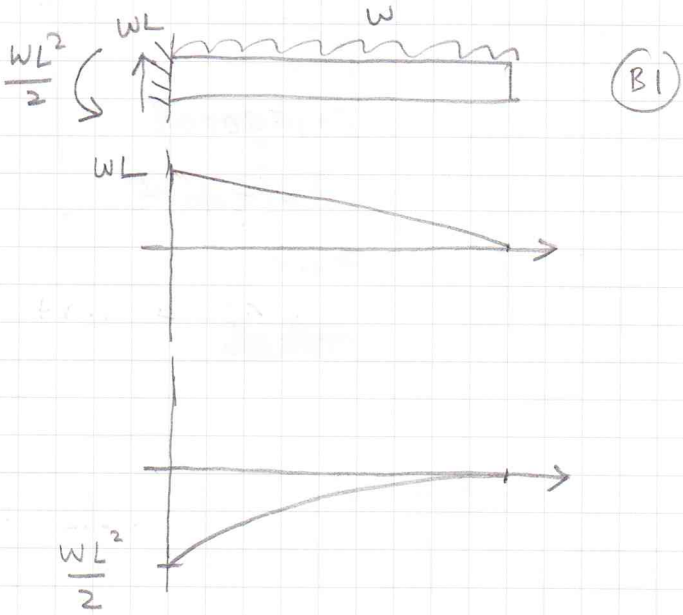
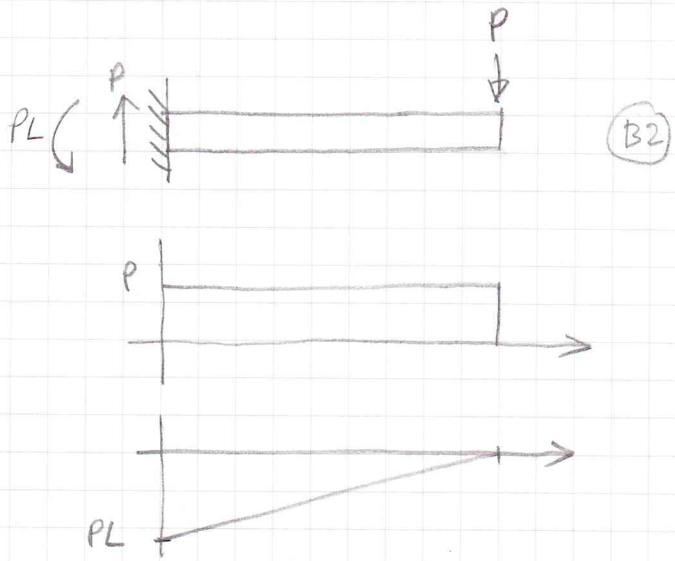
(A) Simply Supported beam

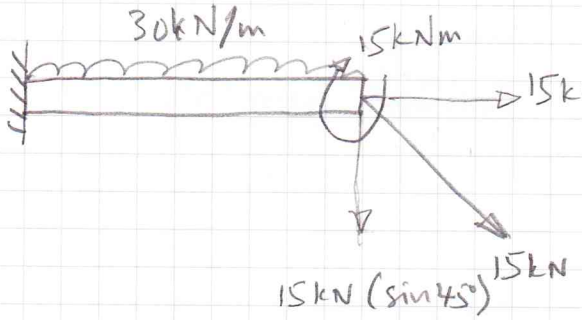


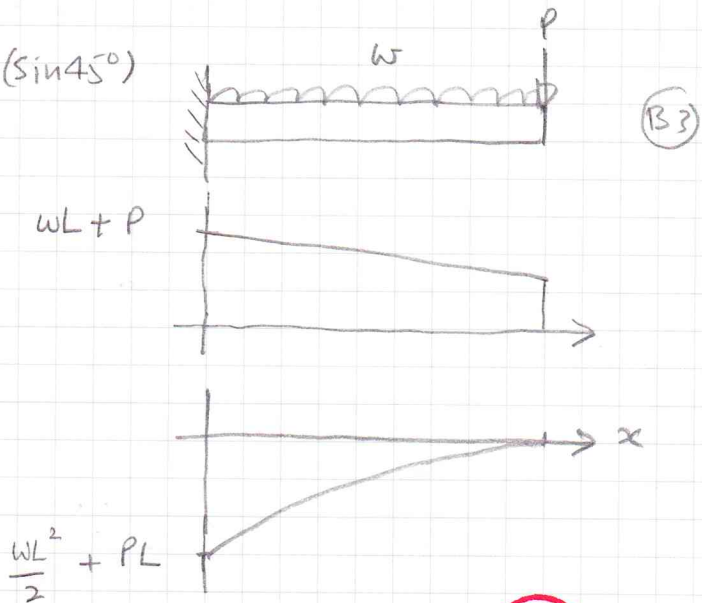
(B) cantilevered beam



Given
- w = 30 kN/m
- T = 15 kNm
- L = 3m
- ρ = 2.79 Mg/m³
- E = 73.1 GPa
- σ_Y = 414 MPa
- ⌀ = 150 mm







Define
1) External loading
2) Body force
3) reaction
4) internal loading

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The beam is under bending (1), axial (2), torsional (3) and transverse shear loading (4)

① Bending loading.

Using B3 diagram, maximum shear force and maximum moment can be calculated.

$$M_{max} = \frac{wL^2}{2} + PL$$

$$= \frac{(30 \times 10^3)(3)^2}{2} + (15 \times 10^3)(\sin 45^\circ)(3)$$

$$= 135 \times 10^3 + 31.82 \times 10^3$$

$$= 166.82 \times 10^3$$

$$= 166.82 \text{ kNm}$$

$$V_{max} = wL + P$$

$$= (30 \times 10^3)(3) + (15 \times 10^3)(\sin 45^\circ)$$

$$= 90 \times 10^3 + 10.61 \times 10^3$$

$$= 100.61 \times 10^3$$

$$= 100.61 \text{ kN}$$

(10)

Bending stress ; $\sigma_b = \frac{M_{max} \cdot c}{I}$

$$I = \frac{\pi}{64}\phi^4$$

$$= \frac{\pi}{64}(0.15)^4$$

$$= 24.85 \times 10^{-6} \text{ m}^4$$

$$c = 0.15/2$$

$$= 0.075 \text{ m}$$

Bending stress

$$\sigma_{max} = \frac{166.82(10^3)(0.075)}{24.85 \times 10^{-6}}$$

$$= 503.48 \text{ MPa}$$

(5) ~~(6)~~

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② Axial loading, $\sigma_a = P/A$

$$= \frac{10.61 \times 10^3}{\frac{\pi}{4}(0.15)^2}$$

$$= 600.4 \text{ kN/m}^2$$ (5)

③ Torsional loading, $\tau_{max} = \frac{Tr}{J}$

$$J = \frac{\pi \phi^4}{32}$$

$$= \frac{\pi}{32}(0.15)^4$$

$$= 49.7 \times 10^{-6} \text{ m}^4$$

$$\tau_{max} = \frac{Tr}{J} =$$

$$= \frac{(15 \times 10^3)(0.075)}{49.7 \times 10^{-6}}$$

$$= 22.64 \text{ MPa}$$ (15)

④ Transverse shear

$$\tau_V = 1.5 \frac{V}{A}$$

$$= \frac{1.5 \times 100.61 \times 10^3}{\frac{\pi}{4}(0.15)^2}$$

$$= 8.54 \text{ MPa}$$ (5)

Total stresses, $\sigma_T = \sigma_a \pm \sigma_b + \tau_{max} + \tau_V$

$$= 0.6004 \pm 503.48 + 22.64 + 8.5$$

$$= 535.26 \text{ MPa} \quad \text{tension}$$

and -471.76 MPa compression

Therefore the beam is anticipating failure since (15)
the stresses are more than the yield stress

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New $I = 61.2 \times 10^{6}\ mm^4$ or $61.2 \times 10^{-6}\ m^4$

Bending stress $= \dfrac{166.82\,(10^3)(0.075)}{61.2 \times 10^{-6}}$ assume c is similar

$= 204.44$ MPa

Total stress $= 236.22$ MPa Tension

and -172.44 MPa Compression

The beam is safe since both stresses are below the yield stress.

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