Review for Midterm Exam #1

Zhao section (1:30-2:20)

2024.02.26

- Students must exhibit highest standard of honor. Any misconduct of academic integrity will be addressed.
- The exam is closed-book and closed-notes. There will be three full-length problems and one multiple-choice problem with multiple parts.
- Equation Sheet is posted on course blog and will be handed out in the exam.
- Calculator: please bring the allowed type of calculator as described in syllabus: TI-30X and TI-36X models, fx-115 and fx-991 models.
- **Exam Date & Time: Feb 28, 2024. Time: 8:00 – 10:00 PM**
- Exam will cover all topics discussed in class and on the syllabus to the end of lecture of shear force and bending moment diagrams (Lectures 1-16).
- **Exam Room: PHYS114.**
- Please arrive to exam room at least 15 minutes prior to the start of exam.
- Exam Submission Window (30 Minutes): When you complete your exam, you may use your phone to scan your solution and upload to Gradescope. Specifically, your solutions will be scanned and submitted to Gradescope session “ME 323 - Spring 2024 - Exams”. You are responsible for scanning your exam into a single PDF and uploading your exam into Gradescope immediately after completion of your exam. To accommodate the time needed to do this, the deadline to have your exam scanned and uploaded to Gradescope will be 10:30PM (EST), giving 30 minutes to complete this process. The time limit will be strictly enforced.
- Assigning Pages for Your Exam: As part of the submission process, you will need to identify the page numbers for Problem 1, 2, ... separately. If you need extra papers, please use your own but make sure to arrange the pages in the correct order in your submission. Do not submit the equation sheet.

Coverage

ME 323 - MECHANICS OF MATERIALS

Schedule for Spring 2024

PER	***DATE***	***TOPIC***	***READING****	***HWK DUE***
1 M	08-Jan	Introduction; Static equilibrium	Chap. 1	
2 W	10-Jan	Normal stress and strain; Mechanical properties	Chap. 2	
3 F	12-Jan	Shear stress and strain – direct shear	Chap. 3	
M	15-Jan	***MLK Birthday: no class***		
4 W	17-Jan	Stress – introduction to design of deformable bodies	Chap. 4	
5 F	19-Jan	Stress and strain – general definitions	Chap. 5	HW. 1
6 M	22-Jan	Axial members – determinate structures	Chap. 6	
7 W	24-Jan	Axial members – indeterminate structures	Chap. 6	
8 F	26-Jan	Axial members – planar trusses	Chap. 6	HW. 2
9 M	29-Jan	Axial members – thermal effects	Chap. 7	
10 W	31-Jan	Torsion members – stresses in circular bars	Chap. 8	
11 F	2-Feb	Torsion members – statically determinate structures	Chap. 8	HW. 3
12 M	5-Feb	Torsion members – statically indeterminate structures	Chap. 8	
13 W	7-Feb	Beam stresses – equilibrium and flexural stresses	Chap. 10	
14 F	9-Feb	Beam stresses – flexural and shear stresses	Chap. 10	HW. 4
15 M	12-Feb	Beam stresses – shear stresses	Chap. 10	
16 W	14-Feb	Shear force/bending moment diagrams – determinate structures	Chap. 9	

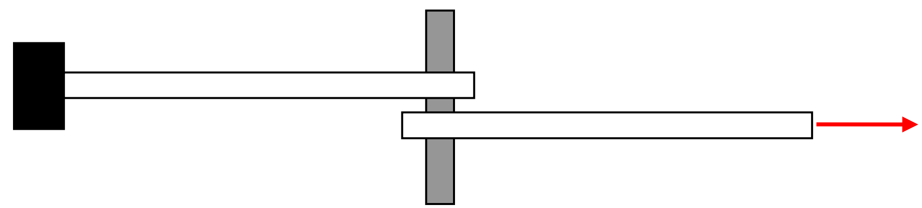
Stresses and strains

Static equilibrium $\sum \mathrm{F} = 0 \qquad \left(\sum \mathrm{M}\right)_0 = 0$

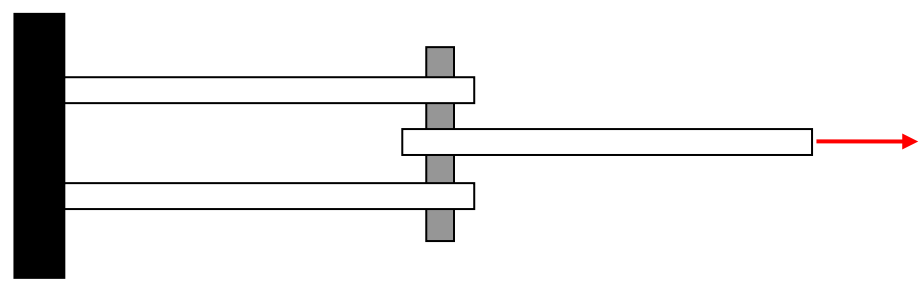
Normal stress $\sigma_{avg} = \dfrac{P}{A}$

$$FS = \frac{Failure\ or\ yield\ stress}{Max.\ allowable\ stress}$$

Normal strain $\varepsilon_{avg} = \dfrac{\Delta L}{L}$



Thermal strain $\varepsilon_T = \alpha \Delta T$



Shear stress $\tau_{avg} = \dfrac{V}{A}$

Shear strain $\gamma = \dfrac{\pi}{2} - \theta^* \approx \tan\left(\dfrac{\pi}{2} - \theta^*\right) = \dfrac{\delta_s}{L_s}$

Stress-strain relationship: Hooke's law

$$\varepsilon_{xx} = \frac{\sigma_{xx}}{E} - \upsilon\frac{\sigma_{yy}}{E} - \upsilon\frac{\sigma_{zz}}{E} + \alpha\Delta T = \frac{1}{E}\left[\sigma_{xx} - \upsilon(\sigma_{yy} + \sigma_{zz})\right] + \alpha\Delta T$$

$$\varepsilon_{yy} = \frac{\sigma_{yy}}{E} - \upsilon\frac{\sigma_{xx}}{E} - \upsilon\frac{\sigma_{zz}}{E} + \alpha\Delta T = \frac{1}{E}\left[\sigma_{yy} - \upsilon(\sigma_{xx} + \sigma_{zz})\right] + \alpha\Delta T$$

$$\varepsilon_{zz} = \frac{\sigma_{zz}}{E} - \upsilon\frac{\sigma_{xx}}{E} - \upsilon\frac{\sigma_{yy}}{E} + \alpha\Delta T = \frac{1}{E}\left[\sigma_{zz} - \upsilon(\sigma_{xx} + \sigma_{yy})\right] + \alpha\Delta T$$

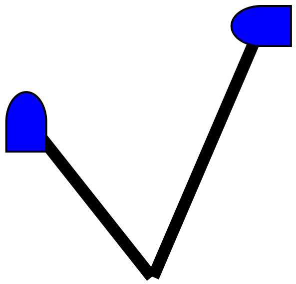
$$\gamma_{xy} = \frac{1}{G}\tau_{xy} \quad \gamma_{yz} = \frac{1}{G}\tau_{yz} \quad \gamma_{zx} = \frac{1}{G}\tau_{zx}$$

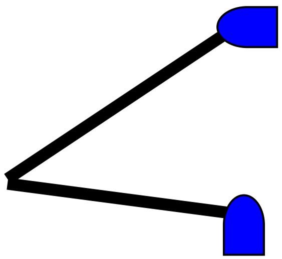
Uniaxial load

Force-elongation relationship: $$e = \frac{FL}{EA} + \alpha \Delta T L$$

Trusses $$e = u\cos(\theta) + v\sin(\theta)$$

Find out θ





Statically determinate problem vs statically indeterminate problem

Torsion

Strain-twist relationship: $\gamma(x, \rho) = \rho \frac{d\phi(x)}{dx}$

Stress-strain relationship: $\tau = G\gamma$

Stress-torque relationship: $\tau(x, \rho) = \frac{T(x)\rho}{I_p(x)}$

where $I_p = \int_A \rho^2 \, dA$ is the

Torque-twist relationship: $\frac{d\phi}{dx} = \frac{T(x)}{GI_p(x)}$ $\phi = \frac{T_i L}{GJ}$

Twist angle $\phi_B = \phi_A + \phi_{AB}$

Statically determinate problem vs statically indeterminate problem

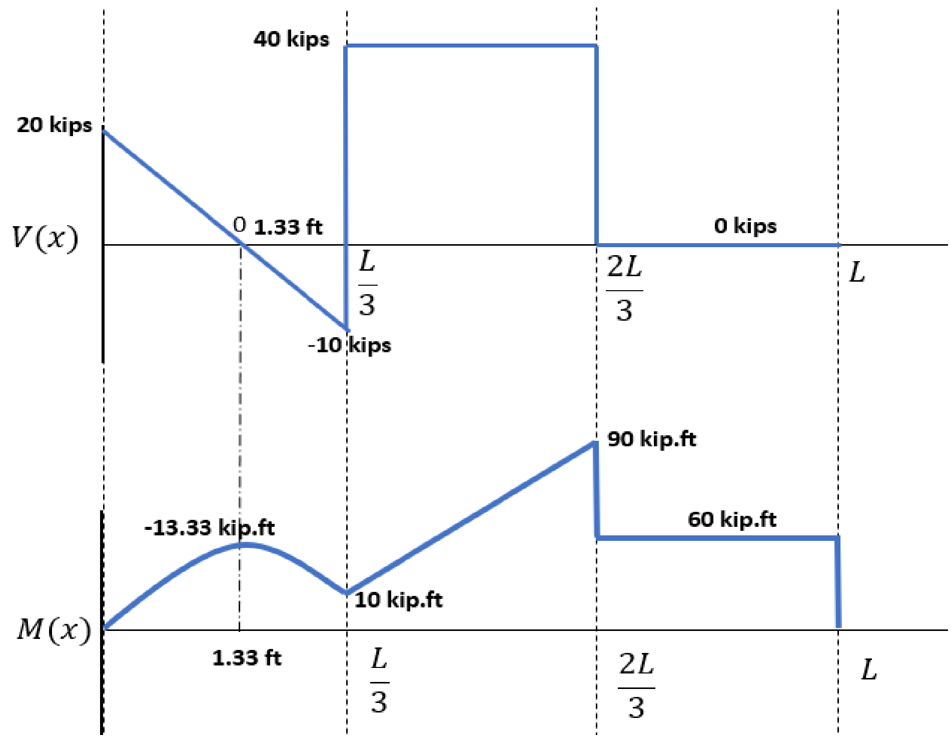
Equilibrium of beams

$$\frac{dV}{dx} = p(x) \quad \Rightarrow \quad V(x) = V(x_0) + \int_{x_0}^{x} p(x)\,dx$$

$$\frac{dM}{dx} = V(x) \quad \Rightarrow \quad M(x) = M(x_0) + \int_{x_0}^{x} V(x)\,dx$$

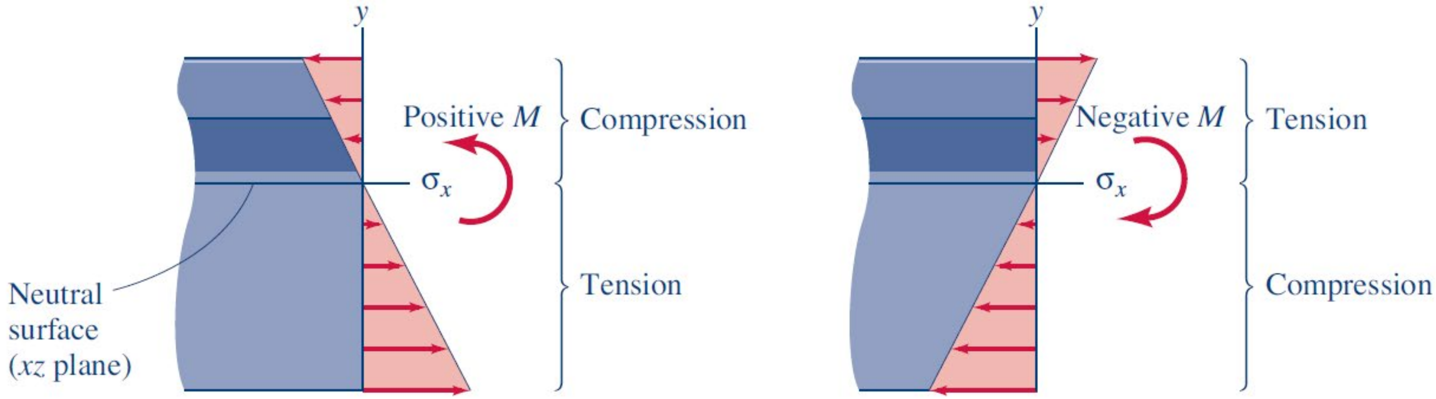
$$V\left(x^+\right) = V\left(x^-\right) + P_0$$

$$M\left(x^+\right) = M\left(x^-\right) - M_0$$



Stress in beams

Flexural stress $\sigma_x = -\dfrac{My}{I}$ $I = \dfrac{bh^3}{12}$ (rectangle) $I = \dfrac{\pi r^4}{4}$ (circle)



Shear stress

$$\tau(x, y) = \frac{V(x)Q(y)}{It} \qquad Q = A'\overline{y}'$$

$$\tau_{max} = \frac{3}{2}\frac{V}{A} \;\; ; \;\; \textit{rectangle}$$

$$\tau_{max} = \frac{4}{3}\frac{V}{A} \;\; ; \;\; \textit{circle}$$