Module (Course Syllabus) Catalogue

2023-2024

College/ Institute	Erbil Technology College
Department	Construction and Materials Engineering Technology Department
Module Name	Strength of Materials
Module Code	STM352
Degree	Technical Diploma ☐ Bachelor ☑ High Diploma ☐ Master ☐ PhD ☐
Semester	5
Qualification	Doctorate
Scientific Title	Lecturer
ECTS (Credits)	7
Module type	Prerequisite ☐ Core ☑ Assist. ☐
Weekly hours	4
Weekly hours (Theory)	(4)hr Class — (171)Total hrs Workload
Number of Weeks	12
Lecturer (Theory)	Dr. Guler Fakhradddin Muhyaddin
E-Mail & Mobile NO.	Guler.muhyaddin@epu.edu.iq
Lecturer (Practical)	
E-Mail & Mobile NO.	0750 4480587
Websites	

Course Book

Course Description	The course named " Strength of Materials" or "Mechanics of Materials" deals with, Concept of stress, Stresses and strains, Axial loading and axial deformation, Hook’s law, statically indeterminate members, Stresses due to temperature, Torsion, Internal forces in beams, pure bending or Beam theory, Transverse loading and shear stresses in beams, beam deflection, Transformation of stresses and strains. Principal stresses and strains, in addition to Axially compressed members and buckling of columns.
Course objectives	1. Be aware of the mathematical background for the different topics of strength of materials introduced in this course. 2. Understanding of stress concept and types of stresses. 3. Understanding of stress strain relationship and solving problems. 4. Understanding of internal forces in beams, how to draw shear force and bending moment diagrams. 5. Understanding of beam analysis, stresses in beams, beam theory and shear stresses. 6. Understanding of torsion in shafts, determination of shear stresses and twisting angle due to torsion. 7. Understanding of methods of calculation beam deflection. 8. Understanding of transformation of stresses and constructing of Mohr’s Circle. 9. Understanding of Axially compressed members and buckling of columns.
Student's obligation	Attending the lecture is a fundamental part of the course. You are responsible for material presented in the lecture whether or not it is discussed in the textbook. You should expect questions on the exams to test your

	understanding of concepts discussed in the lecture and in the homework assignments. It can be very helpful to study with a group. This type of cooperative learning is encouraged; however, be sure that you have a thorough understanding of the concepts besides the mathematical steps used to solve a problem. You must be able to work through the problems on your own.
Required Learning Materials	Data Show, Handout lecture notes and white board notes.

Evaluation

Task		Weight (Marks)	Due Week	Relevant Learning Outcome
Paper Review				
Assignments	Homework	14%		
	Class Activity	2%		
	Report	24%		
	Seminar			
	Essay			
	Project			
Quiz		4%		
Lab.				
Midterm Exam		16%		
Final Exam		40%		
Total		100%		

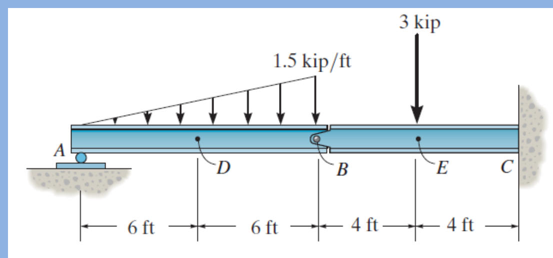
Specific learning outcome:	To establish an understanding of the fundamental concepts of mechanics of deformable solids; including static equilibrium, geometry of deformation, and material constitutive behavior. To provide students with exposure to the systematic methods for solving engineering problems in solid mechanics. To discuss the basic mechanical principles underlying modern approaches for design of various types of structural members subjected to axial load, torsion, bending, transverse shear, and combined loading. To build the necessary theoretical background for further structural analysis and design courses.

Course References:	1. Strength of Materials (Fourth Edition) Ferdinand L. Singer , Andrew Pytel . 2. Mechanics of Materials (sixth Edition) Ferdinand P. Beer, E. Russell Johnston, Jr. 3. Mechanics of Materials (Seventh Edition) R.C. Hibbeler. 4. Intermediate Mechanics of Materials (2001) J.R BARBER. 5. Mechanics of Materials (2002) Madhukar Vable. 6. Mechanics of Materials (Seventh Edition) James M. Gere, Barry J. Goodno. 7. Mechanics of Materials (2000) Anthony Bedford, Kenneth M. Liechti. 8. Introduction to Mechanics of Materials (1989) William F. Riley, Loren W. Zachary. 9. Mechanics of Materials (Fourth Revised Edition) James M. Gere, Stephen P. Timoshenko. 10. Mechanics of Materials (Sixth Edition) William F. Riley, Leroy D. Sturges, Don H. Morris. 11. Mechanics of Materials (Second Revised Edition) Roy R. Craig, Jr. 12. Mechanics of Materials (1985) David Q. Fletcher. 13. Mechanics of Materials (Second Edition) E. P. Popov

Course topics (Theory)	**Week**	**Learning Outcome**
Stress, strain, material properties	1,2,3	Review of equilibrium principles. Concepts of stress and strain. Stress components in Cartesian coordinates. Normal and shear stresses. Safety factors and design. Deformation and strain. Normal and shear strains. Mechanical properties of materials. Constitutive relations. Hooke’s Law
Axially loaded bars	4	Axial deformation. St. Venant's Principle. Statically determinate and indeterminate axial loading assemblies. Composite bars. Thermal stresses.
Torsion	5	Torsional deformation of circular shafts. Torque and angle of twist. Statically determinate and indeterminate torsional loading assemblies. Composite shafts. Thin walled members. Design of shafts
Stresses and deflections in beams	6,7,8,9,10	Pure bending of beams. Second moments of area. Parallel axis theorem. Principal axes and moments of area. Flexure formula. Flexural stresses. Biaxial bending. Eccentric axial load. Composite beams. Derivation of the differential equations for flexural beam deflections. Boundary conditions. Deflection curve. Statically indeterminate beams. Shear stresses in beams. Transverse shear and the shear formula. Limitations of the shear formula. Shear flow and shear center. Design of beams.
Transformation of stress and strain	11	Transformation of stress and strain at a point. Stress transformation equations. Mohr's circle. Principal stresses and maximum in-plane shear stress. Combined loading.
Buckling of columns	12	Stability. Euler buckling load. Issues in column design.

Questions Example Design:

Q1: Determine the resultant internal loadings in the beam at cross sections through points D and E. Point E is just to the right of the 3-kip load.



Solution:

Support Reactions: For member AB

$$\circlearrowleft + \Sigma M_B = 0; \qquad 9.00(4) - A_y(12) = 0 \qquad A_y = 3.00 \text{ kip}$$

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad B_x = 0$$

$$+\uparrow \Sigma F_y = 0; \qquad B_y + 3.00 - 9.00 = 0 \qquad B_y = 6.00 \text{ kip}$$

Equations of Equilibrium: For point D

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad N_D = 0 \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \qquad 3.00 - 2.25 - V_D = 0$$

$$V_D = 0.750 \text{ kip} \qquad \textbf{Ans.}$$

$$\circlearrowleft + \Sigma M_D = 0; \qquad M_D + 2.25(2) - 3.00(6) = 0$$

$$M_D = 13.5 \text{ kip} \cdot \text{ft} \qquad \textbf{Ans.}$$

Equations of Equilibrium: For point E

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad N_E = 0 \qquad \textbf{Ans.}$$

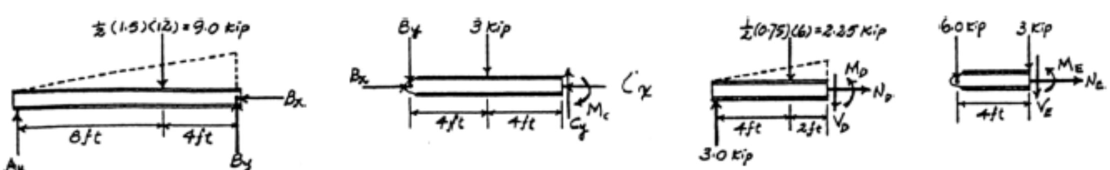
$$+\uparrow \Sigma F_y = 0; \qquad -6.00 - 3 - V_E = 0$$

$$V_E = -9.00 \text{ kip} \qquad \textbf{Ans.}$$

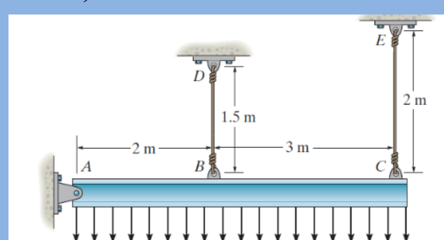
$$\circlearrowleft + \Sigma M_E = 0; \qquad M_E + 6.00(4) = 0$$

$$M_E = -24.0 \text{ kip} \cdot \text{ft} \qquad \textbf{Ans.}$$

Negative signs indicate that M_E and V_E act in the opposite direction to that shown on FBD.



Q2: The rigid beam is supported by a pin at A and wires BD and CE. If the distributed load causes the end C to be displaced 10 mm downward, determine the normal strain developed in wires CE and BD.



Solution:

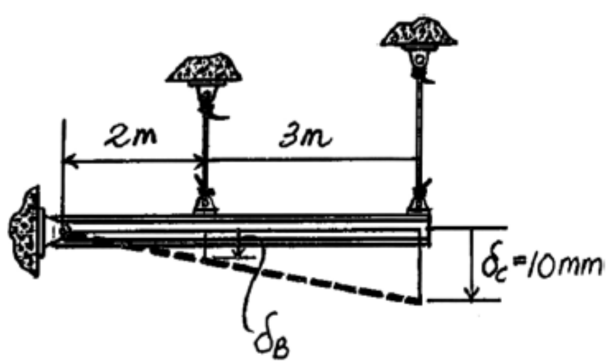
Since the vertical displacement of end C is small compared to the length of member AC, the vertical displacement δ_B of point B, can be approximated by referring to the similar triangle shown in Fig. a

$$\frac{\delta_B}{2} = \frac{10}{5}; \qquad \delta_B = 4 \text{ mm}$$

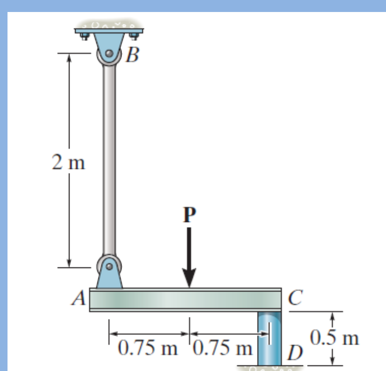
The unstretched lengths of wires BD and CE are $L_{BD} = 1500$ mm and $L_{CE} = 2000$ mm.

$$(\varepsilon_{avg})_{BD} = \frac{\delta_B}{L_{BD}} = \frac{4}{1500} = 0.00267 \text{ mm/mm}$$ **Ans.**

$$(\varepsilon_{avg})_{CE} = \frac{\delta_C}{L_{CE}} = \frac{10}{2000} = 0.005 \text{ mm/mm}$$ **Ans.**



Q3: The stress–strain diagram for a polyester resin is given in the figure. If the rigid beam is supported by a strut AB and post CD, both made from this material, and subjected to a load of P= 80 kN, determine the angle of tilt of the beam when the load is applied. The diameter of the strut is 40 mm and the diameter of the post is 80 mm.



Solution:

From the stress–strain diagram,

$$E = \frac{32.2(10)^6}{0.01} = 3.22(10^9)\text{ Pa}$$

Thus,

$$\sigma_{AB} = \frac{F_{AB}}{A_{AB}} = \frac{40(10^3)}{\frac{\pi}{4}(0.04)^2} = 31.83\text{ MPa}$$

$$\varepsilon_{AB} = \frac{\sigma_{AB}}{E} = \frac{31.83(10^6)}{3.22(10^9)} = 0.009885\text{ mm/mm}$$

$$\sigma_{CD} = \frac{F_{CD}}{A_{CD}} = \frac{40(10^3)}{\frac{\pi}{4}(0.08)^2} = 7.958\text{ MPa}$$

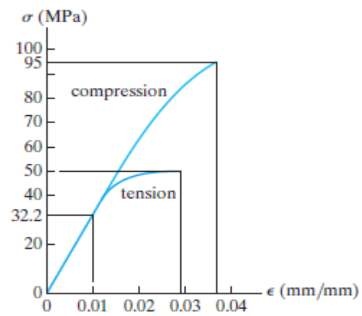
$$\varepsilon_{CD} = \frac{\sigma_{CD}}{E} = \frac{7.958(10^6)}{3.22(10^9)} = 0.002471\text{ mm/mm}$$

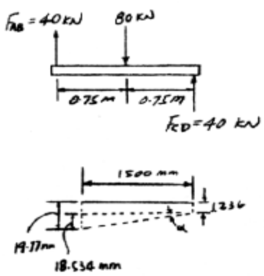
$$\delta_{AB} = \varepsilon_{AB}L_{AB} = 0.009885(2000) = 19.771\text{ mm}$$

$$\delta_{CD} = \varepsilon_{CD}L_{CD} = 0.002471(500) = 1.236\text{ mm}$$

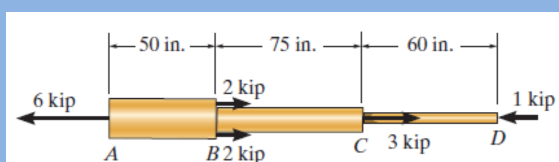
Angle of tilt α:

$$\tan\alpha = \frac{18.535}{1500}; \qquad \alpha = 0.708^\circ$$ **Ans.**





Q4: The copper shaft is subjected to the axial loads shown. Determine the displacement of end A with respect to end D. The diameters of each segment are dBC = 2 in., and dCD = 1 in. Take Ecu = $18(10)^3$ ksi. dAB = 3 in.



Solution:

The normal forces developed in segment AB, BC and CD are shown in the FBDS of each segment in Fig. a, b and c respectively.

The cross-sectional area of segment AB, BC and CD are $A_{AB} = \frac{\pi}{4}(3^2) = 2.25\pi\text{ in}^2$, $A_{BC} = \frac{\pi}{4}(2^2) = \pi\text{ in}^2$ and $A_{CD} = \frac{\pi}{4}(1^2) = 0.25\pi\text{ in}^2$.

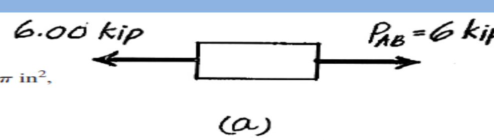
Thus,

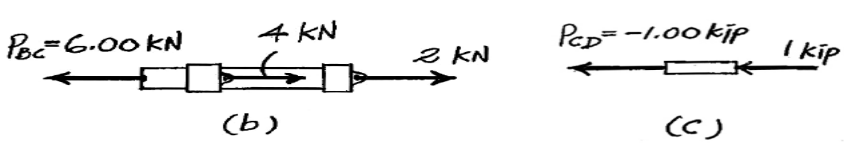
$$\delta_{A/D} = \Sigma\frac{P_iL_i}{A_iE_i} = \frac{P_{AB}L_{AB}}{A_{AB}E_{Cu}} + \frac{P_{BC}L_{BC}}{A_{BC}E_{Cu}} + \frac{P_{CD}L_{CD}}{A_{CD}E_{Cu}}$$

$$= \frac{6.00(50)}{(2.25\pi)[18(10^3)]} + \frac{2.00(75)}{\pi[18(10^3)]} + \frac{-1.00(60)}{(0.25\pi)[18(10^3)]}$$

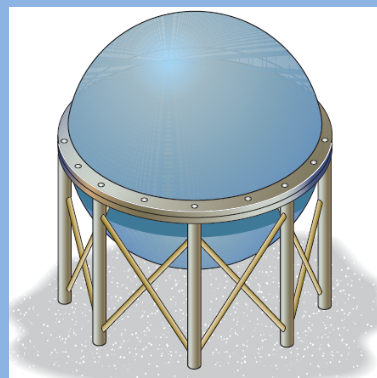
$$= 0.766(10^{-3})\text{ in.}$$ **Ans.**

The positive sign indicates that end A moves away from D.





Q5: The spherical gas tank is fabricated by bolting together two hemispherical thin shells. If the 8-m inner diameter tank is to be designed to withstand a gauge pressure of 2 MPa, determine the minimum wall thickness of the tank and the minimum number of 25-mm diameter bolts that must be used to seal it.The tank and the bolts are made from material having an allowable normal stress of 150 MPa and 250 MPa, respectively.



Solution:

Normal Stress: For the spherical tank's wall,

$$\sigma_{allow} = \frac{pr}{2t}$$

$$150(10^6) = \frac{2(10^6)(4)}{2t}$$

$$t = 0.02667 \text{ m} = 26.7 \text{ mm} \qquad \textbf{Ans.}$$

Since $\frac{r}{t} = \frac{4}{0.02667} = 150 > 10$, thin-wall analysis is valid.

Referring to the free-body diagram shown in Fig. *a*, $P = pA = 2(10^6)\left[\frac{\pi}{4}(8^2)\right] = 32\pi(10^6)$ N. Thus,

$$+\uparrow \Sigma F_y = 0; \qquad 32\pi(10^6) - \frac{n}{2}(P_b)_{allow} - \frac{n}{2}(P_b)_{allow} = 0$$

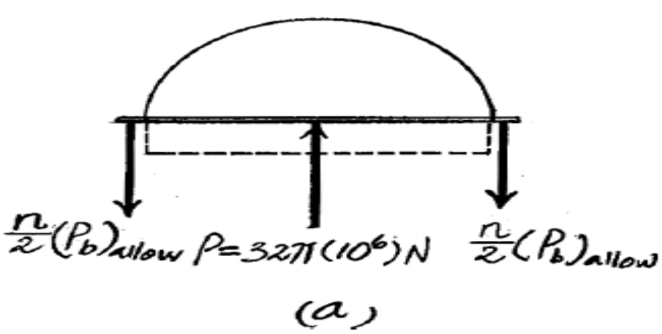
$$n = \frac{32\pi(10^6)}{(P_b)_{allow}} \qquad (1)$$

The allowable tensile force for each bolt is

$$(P_b)_{allow} = \sigma_{allow} A_b = 250(10^6)\left[\frac{\pi}{4}(0.025^2)\right] = 39.0625(10^3)\pi \text{N}$$

Substituting this result into Eq. (1),

$$n = \frac{32\pi(10^6)}{39.0625\pi(10^3)} = 819.2 = 820 \qquad \textbf{Ans.}$$



(a)

Extra notes:
External Evaluator Approved