**Chapter02 02.pptx**

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| Solutions Manual Number |  | PowerPoint Number |
| P2.1 |  | E2.2–1 |
| P2.2 |  | E2.2–2 |
| P2.4 |  | E2.2–3 |

**Chapter02 03.pptx**

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| Solutions Manual Number |  | PowerPoint Number |
| P2.9 |  | E2.3–1 |
| P2.10 |  | E2.3–2 |
| P2.13 |  | E2.3–3 |

**Chapter02 04.pptx**

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| Solutions Manual Number |  | PowerPoint Number |
| P2.15 |  | E2.4–1 |
| P2.17 |  | E2.4–2 |
| P2.18 |  | E2.4–3 |

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| **P2.1** When an axial load is applied to the ends of the bar shown in Fig. P2.1, the total elongation of the bar between joints *A* and *C* is 0.15 in. In segment (2), the normal strain is measured as 1,300 in./in. Determine:   * 1. the elongation of segment (2).   2. the normal strain in segment (1) of the bar. | P02 |
|  | Fig. P2.1 |

### Solution

(a) From the definition of normal strain, the elongation in segment (2) can be computed as

 **Ans.**

(b) The combined elongations of segments (1) and (2) is given as 0.15 in. Therefore, the elongation that occurs in segment (1) must be



The strain in segment (1) can now be computed:

 **Ans.**

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| **P2.2** A rigid steel bar is supported by three rods, as shown in Fig. P2.2. There is no strain in the rods before the load *P* is applied. After load *P* is applied, the normal strain in rod (2) is 1,080 in./in. Assume initial rod lengths of *L*1 = 130 in. and *L*2 = 75 in. Determine:  (a) the normal strain in rods (1).  (b) the normal strain in rods (1) if there is a 1/32-in. gap in the connections between the rigid bar and rods (1) at joints *A* and *C* before the load is applied.  (c) the normal strain in rods (1) if there is a 1/32-in. gap in the connection between the rigid bar and rod (2) at joint *B* before the load is applied. | S02 |
|  | Fig. P2.2 |

### Solution

(a) From the normal strain in rod (2) and its length, the deformation of rod (2) can be calculated:



Since rod (2) is assumed to be connected to the rigid bar with a perfect connection, the rigid bar must move downward by an amount equal to the deformation of rod (2); therefore,



By symmetry, the rigid bar must remain horizontal as it moves downward, and thus, *vB* = *vA* = *vC*. Rods (1) are connected to the rigid bar at *A* and *C*, and again, perfect connections are assumed. The deformation of rod (1) must be equal to the deflection of joint *A* (or *C*); thus, **1 = 0.0810 in. The normal strain in rods (1) can now be calculated as:

 **Ans.**

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| (b) We can assume that the bolted connection at *B* is perfect; therefore, *vB* = 0.0810 in. (downward). Further, the rigid bar must remain horizontal as it deflects downward by virtue of symmetry. Therefore, the deflection downward of joints *A* and *C* is still equal to 0.0810 in.  *What effect is caused by the gap at A and C?* When joint *A* (or *C*) moves downward by 0.0810 in., the first 1/32-in. of this downward movement does not stretch rod (1)—it just closes the gap. Therefore, rod (1) only gets elongated by the amount | S02 |

This deformation creates a strain in rod (1) of:

 **Ans.**

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| (c) The gap is now at joint *B*. We know the strain in rod (2); hence, we know its deformation must be 0.0810 in. However, the first 1/32-in. of downward movement by the rigid bar does not elongate the rod—it simply closes the gap. To elongate rod (2) by 0.0810 in., joint *B* must move down:    Again, since the rigid bar remains horizontal, *vB* = *vA* = *vC*. The joints at *A* and *C* are assumed to be perfect; thus, | S02 |

and the normal strain in rod (1) is:

 **Ans.**

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| **P2.4** A rigid bar *ABCD* is supported by two bars as shown in Fig. P2.4. There is no strain in the vertical bars before load *P* is applied. After load *P* is applied, the normal strain in rod (1) is −570 m/m. Determine:   1. the normal strain in rod (2). 2. the normal strain in rod (2) if there is a 1-mm gap in the connection at pin *C* before the load is applied. 3. the normal strain in rod (2) if there is a 1-mm gap in the connection at pin *B* before the load is applied. | P02  Fig. P2.4 |

### Solution

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| (a) From the strain given for rod (1)    Therefore, *vB* = 0.5130 mm (downward).  From the deformation diagram of rigid bar *ABCD* | S02 |

Therefore, **2 = 1.2825 mm (elongation), and thus, from the definition of strain:

 **Ans.**

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| (b) The 1-mm gap at *C* doesn’t affect rod (1); therefore, **1 = −0.5130 mm. The rigid bar deformation diagram is unaffected; thus, *vB* = 0.5130 mm (downward) and *vC* = 1.2825 mm (downward).  The rigid bar must move downward 1 mm at *C* before it begins to elongate member (2). Therefore, the elongation of member (2) is | S02 |

and so the strain in member (2) is

 **Ans.**

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| (c) From the strain given for rod (1), **1 = −0.5130 mm. In order to contract rod (1) by this amount, the rigid bar must move downward at *B* by    From deformation diagram of rigid bar *ABCD* | S02 |

and so



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| **P2.9** The 16 × 22 × 25-mm rubber blocks shown in Fig. P2.9 are used in a double U shear mount to isolate the vibration of a machine from its supports. An applied load of *P* = 690 N causes the upper frame to be deflected downward by 7 mm. Determine the average shear strain and the shear stress in the rubber blocks. | P02 |
|  | Fig. P2.9 |

### Solution

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| Consider the deformation of one block. After a downward deflection of 7 mm:    and thus, the shear strain in the block is  **Ans.** Note that the small angle approximation most definitely does not apply here! | S02 |

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| The applied load of 690 N is carried by two blocks; therefore, the shear force applied to one block is *V* = 345 N. The area subjected to shear stress is the area that is parallel to the direction of the shear force; that is, the 22 mm by 25 mm surface of the block. The shear stress is  **Ans.** | **S02** |

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| **P2.10** A thin polymer plate *PQR* is deformed such that corner *Q* is displaced downward 1/16-in. to new position *Q’* as shown in Fig. P2.10. Determine the shear strain at *Q’* associated with the two edges (*PQ* and *QR*). | S02 |
|  | Fig. P2.10 |

### Solution

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| Before deformation, the angle of the plate at *Q* was 90° or **/2 radians. We must now determine the plate angle at *Q′* after deformation. The difference between these angles is the shear strain.  After point *Q* displaces downward by 1/16-in., the angle *′* is    and the angle *′* is | S02 |

After deformation, the angle of the plate at *Q′* is



The difference in the plate angle at *Q* before and after deformation is the shear strain:

 **Ans.**

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| **P2.13** A thin rectangular plate is uniformly deformed as shown in Fig. P2.13. Determine the shear strain *xy* at *P*. | S02Fig. P2.13 |

### Solution

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| Before deformation, the angle of the plate at *P* was 90° or **/2 radians. We must now determine the plate angle at *P* after deformation. The difference between these angles is the shear strain.  After deformation, the angle that side *PQ* makes with the horizontal axis is    and the angle that side *PR* makes with the vertical axis is    By inspection, the angle of the plate at *P* has been increased by ** and decreased by **; thus, the angle at *P* after deformation is: | S02 |



The angle in the plate at *P* that was initially 90° has been increased to 90.111404° = 1.572741 rad. The shear strain in the plate at *P* is thus

 **Ans.**

**Note:** Since these angles are small, we could have just as well used tan ** ≈ ** and tan ** ≈ ** and saved the extra steps involved in using the inverse tangent functions. Thus,





By inspection, the angle of the plate at *P* has been increased by ** and decreased by **; thus, the angle at *P* after deformation is:



Therefore, the shear strain in the plate at *P* is *P* = −0.001944 rad = −1,944 rad. **Ans.**

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| **P2.15** An airplane has a half-wingspan of 33 m. Determine the change in length of the aluminum alloy [*A* = 22.5×10-6/°C] wing spar if the plane leaves the ground at a temperature of 15°C and climbs to an altitude where the temperature is –55°C. |

### Solution

The change in temperature between the ground and the altitude in flight is



The thermal strain is given by



and thus the deformation in the 33-m wing is

 **Ans.**

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| **P2.17** A cast iron pipe has an inside diameter of *d* = 208 mm and an outside diameter of *D* = 236 mm. The length of the pipe is *L* = 3.0 m. The coefficient of thermal expansion for cast iron is *I* = 12.1×10-6/°C. Determine the dimension changes caused by an increase in temperature of 70°C. |

### Solution

The thermal strain caused by a temperature increase of 70°C is given by



The dimension changes caused by a temperature increase of 70°C are

 **Ans.**

 **Ans.**

 **Ans.**

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| **P2.18** At a temperature of 40°F, a 0.08-in. gap exists between the ends of the two bars shown in Fig. P2.18. Bar (1) is an aluminum alloy [** = 12.5 × 10−6/°F] and bar (2) is stainless steel [** = 9.6 × 10−6/°F]. The supports at *A* and *C* are rigid. Determine the lowest temperature at which the two bars contact each other. | S02 |
|  | Fig. P2.18 |

### Solution

Write expressions for the temperature-induced deformations and set this equal to the 0.08-in. gap:



Since the initial temperature is 40°F, the temperature at which the gap is closed is 117.8°F. **Ans.**