Exam 1

Mar. 27, 2012

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| Problem 2 | _____/ 36 |
| Problem 3 | _____/ 36 |
| **Total** | _____/ 100 |

Show all work for full credit! For problems involving the application of equilibrium this includes drawing a complete and correct free body diagram and showing a logical incorporation of the diagram in your analysis.

Helpful hint: Work in symbols for as long as you can, crunching numbers last!
Problem 1 (28 points)

(a) Consider the bar shown below, which consists of a rod made of Material A butt welded to a rod made of Material B. The coefficient of thermal expansion of Material A is $\alpha_A = 6.6 \times 10^{-6}/{^\circ}{\text{F}}$ and the coefficient of thermal expansion of Material B is $\alpha_B = 9.6 \times 10^{-6}/{^\circ}{\text{F}}$. The system is $L = 1$ m long at room temperature. If we increase the temperature of the system by $100^\circ{\text{F}}$, how much longer will the entire system be? (Ignore any effects due to the weld.)

(b) The graph below schematically shows a stress-strain curve. Label the appropriate locations on the graph by putting the letters a-f in the boxes in the diagram. You should use each letter exactly once.
(c) The figure below shows a force that originates at A and points towards B. Find:

i. a unit vector that points in the direction from A to B, and

ii. the force vector shown in the figure, assuming that the magnitude of the force is 50 N. Express your answer in component form.

(d) Suppose we have three forces and we know that their resultant is zero. The three forces are given by

\[ \vec{F}_1 = 100 \, N \, (1\hat{i} + 2\hat{j} + 3\hat{k}) \]

\[ \vec{F}_2 = \underline{\text{_____}} \hat{i} + \underline{\text{_____}} \hat{j} + 300 \hat{k} \, N \]

\[ \vec{F}_3 = 100 \hat{i} - 400 \hat{j} + \underline{\text{_____}} \hat{k} \, N \]

Fill in the missing terms in the forces.
The block A \((m_A = 5 \, \text{kg})\) is attached to a massless, frictionless pulley and both are suspended by a rope between points B and D. At point D there is a knot that ties the vertical rope CD and the horizontal rope DE to the rope BD. Determine the tension in each of the three ropes, \(T_{DB}, T_{DC}\) and \(T_{DE}\), and the angle \(\beta\). You may neglect the weight of the ropes.
Problem 3 (36 points)

The compound bar shown below is made of a light, strong material with $E = 70,000 \text{ N/mm}^2$. Two forces are applied to the rigid plates connecting the bars. The yield strength is $\sigma_y = 200 \text{ N/mm}^2$. The bar has a rectangular cross section with height $H = 12.5 \text{ mm}$ and thickness $t = 1.0 \text{ mm}$. You may neglect the weight of the bars.

(a) Calculate the x-direction internal force in segments AB and BC of the compound bar. **Show all work.**
(b) Calculate the total length change of the compound bar.
(c) The plane 1-2 represents a lap joint. Calculate the normal stress on the lap joint.