Due Date: **This period – drop it off for marking**

Problem Solving – Structural Analysis

Grade 12 Technological Design

CONTENTS

1 Analysis of Statically Determinate Structures Which are in Static Equilibrium

Statics is the study of objects – or a system of members – which do not move. (Note that we are leaving aside the issue of objects that are moving at a constant velocity, ie moving but not accelerating.) We are simply assuming in our Structures work in this course that the objects are stationary – not moving or spinning around.

1.1 Eight Steps in Structural Analysis

First review these fundamentals:

1. Simplify… simplify… simplify, ie make reasonable assumptions:
    a. Beware – the more simplifications you make, the more uncertainty you will have in your solution.
    b. This may involve simplifying:
        i. a joint (where two or more members are connected together, whether an external load is applied to it or not)
        ii. a reaction (the "place" at an extremity of the structure that is "holding up / out / in" the structure to "stop it" from moving or spinning around)
        iii. a member and its loading
    c. For example reduce the system to actions (forces) and reactions in a single plane – eg XY plane only. This is effectively assuming some symmetry in the Z direction
    d. However, be sure that your simplified system is stable – ie there are enough triangles or rigid beams to ensure that the structure does not collapse
        i. Note: In our course work we will even simplify a beam
    e. Simplify the loading, but you should assume a "worst case" situation for the loads
2. Draw a sketch of the simplified physical system, stating, below your sketch, the assumptions that you had made
3. Either
    a. Isolate a member for analysis or
    b. Choose a joint or reaction which you wish to analyze and isolate it by making an imaginary "cut" through members (3 members at most)

4. Draw the free body diagram of the joint or reaction or member, indicating the known or assumed direction of external forces and internal forces acting at the joint or reaction or on the member
5. Choose a planar coordinate reference system that is most convenient
    a. It could very well be that you can simply rotate the horizontal and vertical frame of reference at some angle in order to minimize the use of trigonometric ratios. Note that even though you rotated the coordinate system, you can still call it "XY".
6. Break down a force into two components along the axes of your planar reference system (eg into components along the X and Y axes)
7. State the equations for equilibrium of the joint / reaction – we will only consider three equations in this course work.
    a. Sum of the forces in the X direction is zero
    b. Sum of the forces in the Y direction is zero
    c. Sum of the "Moments" or torques about a given point is zero
8. Solve for the unknowns
    a. In our work, there must be a maximum of three unknowns because we have only 3 equations available in our system

Now do the Structural Analysis Moodle quizzes at http://thinkproblemsolving.org/.

2 Sample – Simplifying a Very Complex Structure

Consider the model shown below – a very simplified sketch of one half of a very simplified symmetrical suspension bridge. Units are in feet. The sketch is definitely not to scale.

Answer the following questions.

1. Match the labels with the parts of the structure that can be used to build a 36 foot long model of the central span of the Menai Suspension bridge.

    1 Suspension cable
    2 Deckbeam
    3 Weight of cable, loading on the deck and most of the deadweight of the deckbeam itself
    4 Portion of the weight of the Deckbeam and its loading
    5 Tower
    6 Support for the end of the deckbeam
    7 Anchor cable
    8 Counterweight
    9 Fulcrum

2. Given the loads and geometry shown, how heavy must the counterweight be to just balance the system on the fulcrum?

3. What is the tension force in member 1?

4. If members 1 and 7 are continuous as if rolling over the peak of the tower on a pulley wheel, what is the tension force in member 7?

5. What is the compression force in member 2?

6. Write a 300 word summary of "how this design works" as a model of a simplified suspension bridge. Comment on the assumptions and simplifications that have been made and whether or not these simplifications are reasonable. Address the impact that this model can have on the design of your subsystem. Comment on the beam that must be bending (a more complex stressing of the member). How would you reinforce this beam?