Evening Exam I, October 9

Notes:
1. All problems weighted equally
2. Bold quantities are vectors and matrices
3. Equation sheet at end
4. All answers and work must be shown on these pages. Box answers.

Problem 1: Indicate by circling the correct answer whether each matrix below could be a stiffness matrix for a truss. If not, state why.

\[
\begin{bmatrix}
10 & 2 & -8 & 0 & -2 & -2 \\
2 & 2 & 0 & 0 & -2 & -2 \\
-8 & 0 & 8 & 0 & 0 & 0 \\
0 & 0 & 0 & 8 & 0 & -8 \\
-2 & 4 & 0 & 0 & 2 & 2 \\
-2 & -2 & 0 & -8 & 2 & 10
\end{bmatrix}
\]

YES / NO

\[
\begin{bmatrix}
10 & 2 & -8 & 0 & -2 & -2 \\
2 & 2 & 0 & 0 & -2 & -2 \\
-8 & 0 & 8 & 0 & 0 & 0 \\
0 & 0 & 0 & 8 & 0 & -8 \\
-2 & -2 & 0 & 0 & 2 & 2 \\
-2 & -2 & 0 & -8 & 2 & 10
\end{bmatrix}
\]

YES / NO

\[
\begin{bmatrix}
10 & 2 & -8 & 0 & -2 & -2 \\
2 & 2 & 0 & 0 & -2 & -2 \\
-8 & 0 & 8 & 0 & 0 & 0 \\
0 & 0 & 0 & 8 & 2 & -8 \\
-2 & -2 & 0 & 0 & -8 & 2
\end{bmatrix}
\]

YES / NO
Problem 2: For the trusses shown below, label the degrees of freedom.
Problem 3: For the truss shown:

Determine $\theta_x$, $\theta_y$, $\lambda_x$, and $\lambda_y$ for element 12.
**Problem 4:** The stiffness matrix for the truss shown below is given. Calculate the unknown displacements $D_u$ and the reactions $Q_u$.

\[
E = 29,000 \text{ kips/in} \\
A = .5 \text{ in}^2
\]

\[
K = \begin{bmatrix}
1 & 2 & 3 & 4 & 5 & 6 \\
151 & 0 & 0 & 0 & -151 & 0 \\
0 & 151 & 0 & -151 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 \\
0 & -151 & 0 & 151 & 0 & 0 \\
-151 & 0 & 0 & 0 & 151 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 \\
\end{bmatrix}
\]
Problem 5: Below is shown a MASTAN model of a truss that gave an “unstable structure” error. Identify as many possible sources of this error as you can in the image.
**Problem 6**: Calculate using the method of approximate truss analysis the force in members AB and AD. Assume that diagonals can carry both tension and compression. Clearly indicate which forces are tension and which are compression. Let $b = 10'$, $h = 12'$ and $P = 2$ kips
Workspace Cont.
**Problem 7:** For the truss shown below, state whether member 1 is in tension or compression. Do the same for member 2. Also indicate whether you would do exact or approximate method of sections analysis of this truss. You should not need to do any calculation for this problem.
Problem 8: The diagram below is of a flat plate flooring system. The squares indicate columns. The live load specified is 50 psf. Using the concept of tributary area, calculate the amount of live load that accumulates to column 5.
Reference equations

Direction cosines

\[ \lambda_x = \cos(\theta_x), \quad \lambda_y = \cos(\theta_y) \]

Truss element stiffness matrix in local/element coordinates

\[ k' = \frac{EA}{L} \begin{bmatrix} N_{x'} & F_{x'} \\ -1 & 1 \end{bmatrix} \begin{bmatrix} N_{x'} \\ F_{x'} \end{bmatrix} \]

Truss element stiffness matrix in global coordinates

\[
k = \frac{EA}{L} \begin{bmatrix} N_x & N_y & F_x & F_y \\ \lambda_x^2 & \lambda_x \lambda_y & -\lambda_x^2 & -\lambda_x \lambda_y \\ \lambda_x \lambda_y & \lambda_y^2 & -\lambda_x \lambda_y & -\lambda_y^2 \\ -\lambda_x^2 & -\lambda_x \lambda_y & \lambda_x \lambda_y & \lambda_y^2 \end{bmatrix} \begin{bmatrix} N_x \\ N_y \\ F_x \\ F_y \end{bmatrix}
\]

Matrix stiffness equations for a truss element in global coordinates

\[ q = kd \]

Matrix stiffness equations for a truss in global coordinates

\[ Q = KD \]

Partitioned matrix stiffness equations for a truss

\[
\begin{bmatrix} Q_k \\ Q_u \end{bmatrix} = \begin{bmatrix} K_{11} & K_{12} \\ K_{21} & K_{22} \end{bmatrix} \begin{bmatrix} D_u \\ D_k \end{bmatrix}
\]

Matrix inverse

\[
\begin{bmatrix} a & b \\ c & d \end{bmatrix}^{-1} = \frac{1}{ad - bc} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}
\]

Equilibrium equations

\[ \sum F_x = 0, \quad \sum F_y = 0, \quad \sum M = 0 \]

Design wind pressure

\[ p_s = \lambda K_{zt} I p_{s30} \]