Problem: 1 (20 pts)
Draw the complete shear and bending moment diagrams for the frame shown below. The diagrams should be drawn on axes that have the same shape as the frame. You may "explode" the structure for your diagrams to avoid overlap at the corners. Be sure to include numerical values for all maxima, minima values and appropriate slopes.

Problem: 2 (20 pts)
A bridge is composed of two parallel trusses in the configuration shown below. Draw the influence line for: a) the vertical reaction at A, b) member BF. You may assume that a deck/stringer/floor beam system exists so that the load is smoothly transmitted from one panel point to the next along the top chord AD. c) Compute the maximum tension and compressive force for member BF for a uniformly distributed live load of 0.64 k/ft and the wheel loads shown below. The distributed load can act anywhere at any length with the wheel loads and the truck can move in either direction. You may neglect the affects of the dead load.
Problem: 3 (20 pts)
Draw the influence lines for the: a) reaction at A, b) reaction at E, c) moment at D, d) shear at D, e) shear at a section just to the right of support C.

Problem: 4 (20 pts)
Compute the vertical deflection (in mm) at B using the coordinate systems shown for each span. You must use virtual work for your solution. Assume $E = 200$ GPa for all members. The moment of inertia for all members is $4.00 \times 10^8$ mm$^4$.

Problem: 5 (20 pts)
Compute the reactions in the frame shown below using the method of consistent displacements and virtual work. You may not use deflection formulas from the book or any other source. You must use the coordinate system provided for each span.
Problem 1

Shear (K)

Moment (K-ft)

Problem 2

IL RA

IL FBF

\[
A^+ = \frac{1}{2} (24\text{ ft})(6.67\text{ ft}) = 6.67\text{ ft}
\]

\[
A^- = -6.67\text{ ft}
\]

\[ (F_{BF}^+)_{\text{max}}: \text{ place LL from midspan BC to D} \]

Wheel loads as shown:

\[
(F_{BF}^+)_{\text{max}} = (0.64k/A)(6.67\text{ ft}) + (15k)(5/4) + (5k)(5/24)
\]

\[
= 4.27 + 8.33 + 1.04
\]

\[
(F_{BF}^+)_{\text{max}} = 13.64k\text{ T} \quad \text{(for two trusses)}
\]

\[
(F_{BF}^+)_{\text{max}} = 6.82k\text{ T} \quad \text{(total)}
\]

\[
(F_{BF}^-)_{\text{max}}: \text{ by observation, same as } F_{BF}^+ \Rightarrow F_{BF}^- = 6.82k\text{ C}
\]
Problem: 4

"P"-System:

\[ M_{AB} = 10.28X_{AB} \]
\[ M_{BC} = 42.86X_{BC} - 7.5X_{BC}^2 \]

"Q"-System:

\[ \Delta_{By} = \frac{1}{EI} \left[ \int_0^5 M_{AB} M_{ab} X_{ab} + \int_0^4 M_{BC} M_{bc} dX_{bc} \right] \]
\[ = \frac{1}{EI} \left[ \int_0^5 (10.28X \cdot 0.3429X) dX + \int_0^4 (42.86X - 7.5X^2 \cdot 0.4286X) dX \right] \]
\[ = \frac{1}{EI} \left[ \left( 1.175X^3 \right) \bigg|_0^5 + \left( 6.123X^3 - 0.8036X^4 \right) \bigg|_0^4 \right] \]
\[ = \frac{1}{EI} \left( 146.875 + 391.872 - 205.722 \right) \]
\[ = \frac{333.0 \text{ (KN} \cdot \text{m}^3)}{E I} = \frac{333.0 \text{ KN} \cdot \text{m}^3}{(200 \times 10^6 \text{KN/m}^2)(4.00 \times 10^{-4} \text{ m}^4)} \]
\[ \Delta_{By} = 0.00416 \text{ m} = 4.16 \text{ mm} \]

\[ \frac{E}{I} = \frac{220 \times 10^6 \text{ KN/m}^2}{4.00 \times 10^{-4} \text{ m}^4} = 5.5 \times 10^{12} \text{ KN/m}^4 \]
Problem 5

Primary:

\[ \Delta_c = \frac{1}{EI} \int_0^L M_{AB} M_{AB} \, dx_{AB} + \frac{1}{EI} \int_0^L M_{BC} M_{BC} \, dx_{BC} \]

\[ = \frac{1}{EI} \int_0^L \left(-\frac{WX^2}{2}\right) \, dx = \frac{-WL^4}{8EI} \]

\[ \delta_c = \frac{1}{EI} \int_0^L (M_{AB})^2 \, dx_{AB} + \int_0^L (M_{BC})^2 \, dx_{BC} \]

\[ = \frac{1}{EI} \int_0^L (X)^2 \, dx = \frac{L^3}{3EI} \]

Compatibility:

\[ \Delta_c + R_c \delta_c = 0 \]

\[ -\frac{WL^4}{8EI} + \frac{L^3}{3EI} (R_c) = 0 \]

\[ R_c = \frac{3}{8} WL \]

Equilibrium:

\[ \Sigma F_y = 0; \quad -WL + \frac{3}{8} WL + R_a = 0 \Rightarrow R_a = \frac{5}{8} WL \]

\[ \Sigma M = 0; \quad -M_a + WL(L/2) - \frac{3}{8} WL(L) = 0 \Rightarrow M_a = \frac{WL^2}{8} \]

\[ \Sigma F_x = 0; \quad R_{ax} = 0 \]