ENCE353: Introduction to Structural Analysis
Exam #1

Name: Solution

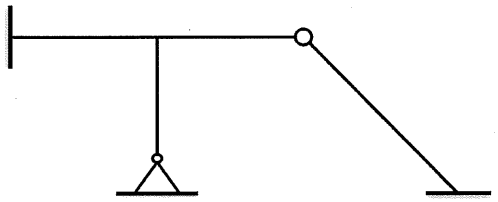
CSI 3117: 9:00-9:50AM, October 7, 2013
Closed book, closed notes, one sheet of notes allowed
Show all work

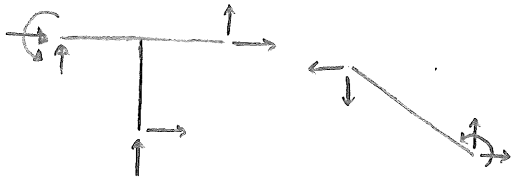
Problem	Points	Score
1	10	10
2	15	15
3	25	25
Total	50	50

Problem 1 (10 Points)

Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy. (Circles represent hinges)

Part A (5 Points)





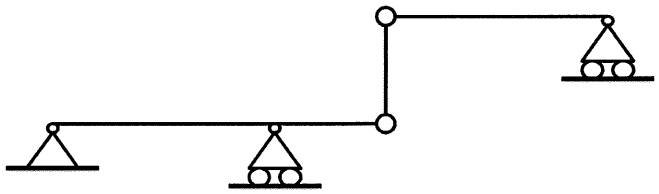
$r = 10$

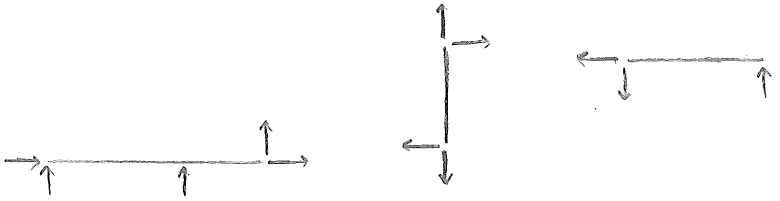
$n = 2$

$r - 3n = 10 - 3(2) = 4$

Answer: statically indeterminate, 4th degree

Part B (5 Points)





$r = 8$

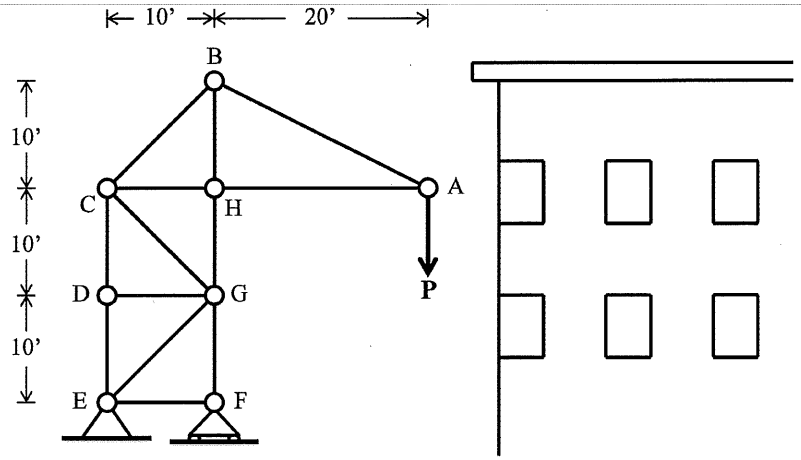
$n = 3$

$r - 3n = 8 - 3(3) = -1 < 0$

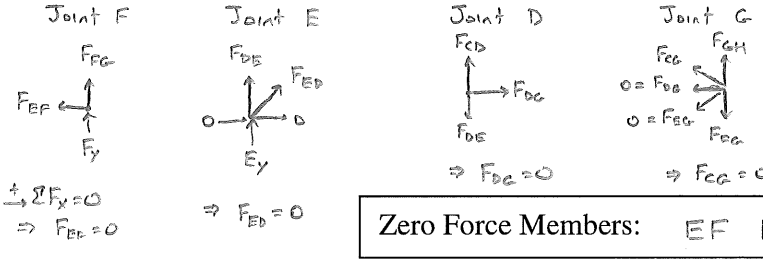
Answer: Unstable

Problem 2 (15 Points)

Caitlin somehow managed to get herself locked *inside* her apartment. The only way she can now access puppies is by having them sent up in a basket and delivered through her window (at Point A). A truss structure has been built to help make this possible. (Pin at E, roller at F)

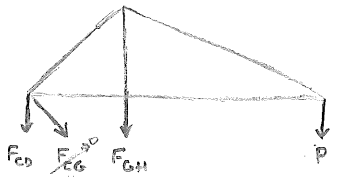


Part A: Determine all zero-force members (5 Points)



Zero Force Members:	EF EG DG CG

Part B: Members CD, CG, and GH can each support 250 lb in tension and 200 lb in compression. If each puppy weighs 10 lb, what is the maximum number of puppies that can be sent up at once? Ignore the weight of the basket. Only full puppies count. (10 Points)



$\circlearrowleft \Sigma M_C = 0$: $-F_{GH}(10) - P(30) = 0$

$\Rightarrow F_{GH} = -3P$ compression

$+\uparrow \Sigma F_y = 0$: $-F_{CD} - F_{GH} - P = 0$

$\Rightarrow F_{CD} = -F_{GH} - P = -(-3P) - P = 2P$

$F_{CD} = 2P$ tension

$F_{GH} = -3P = -200 \Rightarrow P = 66.67$ lb ← max allowable

$F_{CD} = 2P = 250 \Rightarrow P = 125$ lb

number of puppies $= \frac{P_{max}}{10\text{ lb}} = \frac{66.67}{10} = 6.67 \Rightarrow$ 6 puppies

Number of Puppies:	6

Problem 3 (25 Points)

Part A: Determine the support reactions (8 Points)

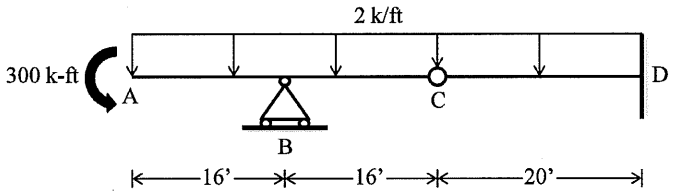
Part B: Determine shear and moment equations as functions of length of the beam (8 Points)

Part C: Draw shear and moment diagrams (9 Points)

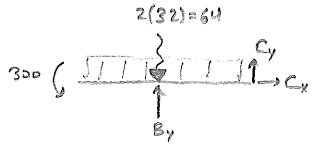
Show whether positive or negative for shear, show curvature for moment

Label maximum and minimum values and their locations

(Applied moment at A, roller at B, hinge at C, fixed support at D, distributed load across the length of the beam)

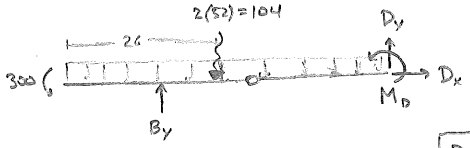


Part A



$\circlearrowleft \Sigma M_c = 0$: $300 + 64(16) - B_y(16) = 0$

$\Rightarrow \boxed{B_y = 82.75\ k}$



$+\uparrow \Sigma F_y = 0$: $B_y - 104 + D_y = 0 \Rightarrow \boxed{D_y = 21.25\ k}$

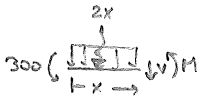
$\circlearrowleft \Sigma M_D = 0$: $300 - B_y(36) + 104(26) + M_D = 0$

$\Rightarrow \boxed{M_D = -25\ k\text{-}ft \text{ or } 25\ k\text{-}ft \circlearrowright}$

$\rightarrow \Sigma F_x = 0$: $\boxed{D_x = 0}$

Part B

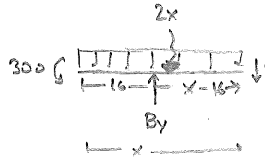
AB $0 \le x \le 16$



$+\uparrow \Sigma F_y = 0$: $-2x - V = 0 \Rightarrow V = -2x$

$\circlearrowleft \Sigma M_o = 0$: $300 + 2x\left(\frac{x}{2}\right) + M = 0 \Rightarrow M = -x^2 - 300$

BCD $16 \le x \le 52$



$+\uparrow \Sigma F_y = 0$: $B_y - 2x - V = 0 \Rightarrow V = -2x + 82.75$

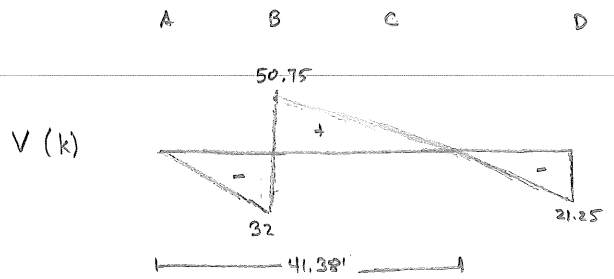
$\circlearrowleft \Sigma M_o = 0$: $300 - B_y(x-16) + 2x\left(\frac{x}{2}\right) + M = 0$

$\Rightarrow M = -x^2 + 82.75x - 1624$

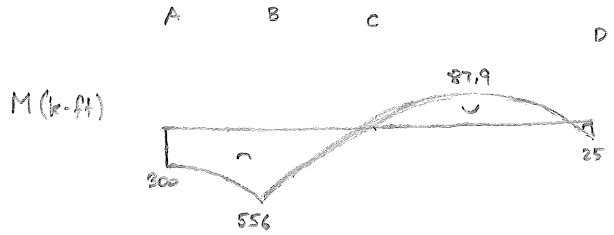
$$V = \begin{cases} -2x & 0 \le x \le 16 \\ -2x + 82.75 & 16 \le x \le 52 \end{cases} \qquad M = \begin{cases} -x^2 - 300 & 0 \le x \le 16 \\ -x^2 + 82.75x - 1624 & 16 \le x \le 52 \end{cases}$$

Problem 3 (Continued)

Part C



$V=0$ at $-2x+82.75=0 \Rightarrow x=41.38'$



M_{max} at $V=0 \rightarrow x=41.38$

$= -(41.38)^2 + 82.75(41.38) - 1624$

$\Rightarrow M_{max} = 87.89$ k·ft