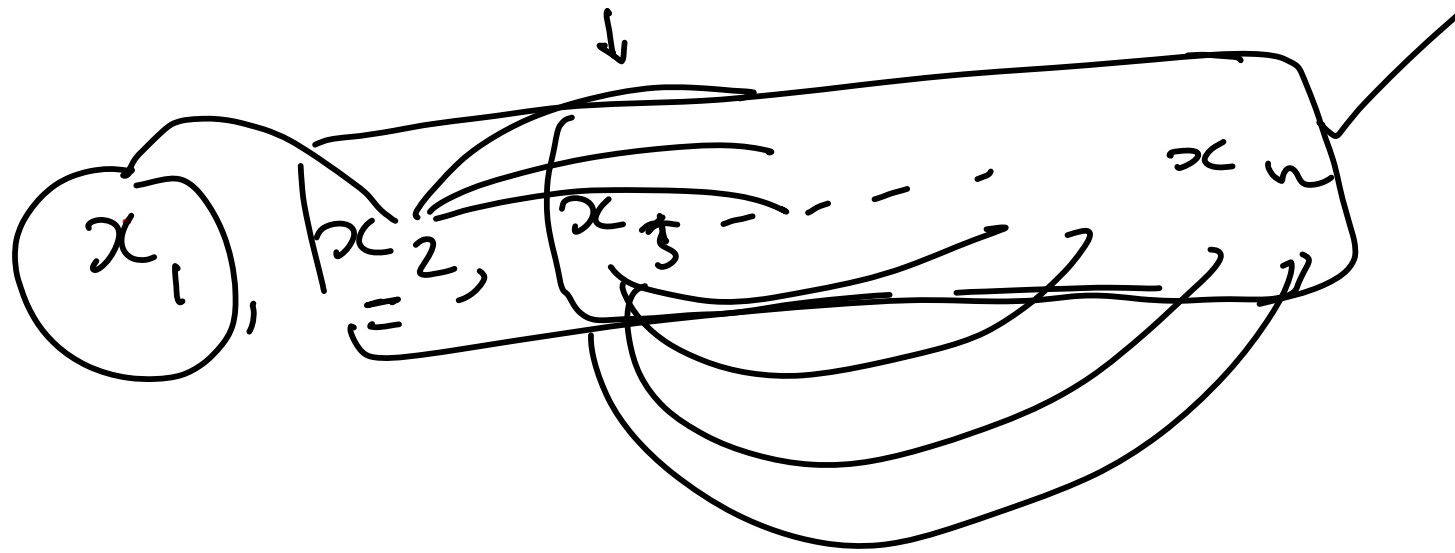


$$\# \text{ of edges} \leq 3n - 6$$

$$\text{Sum of degrees} \leq 6n - 12$$

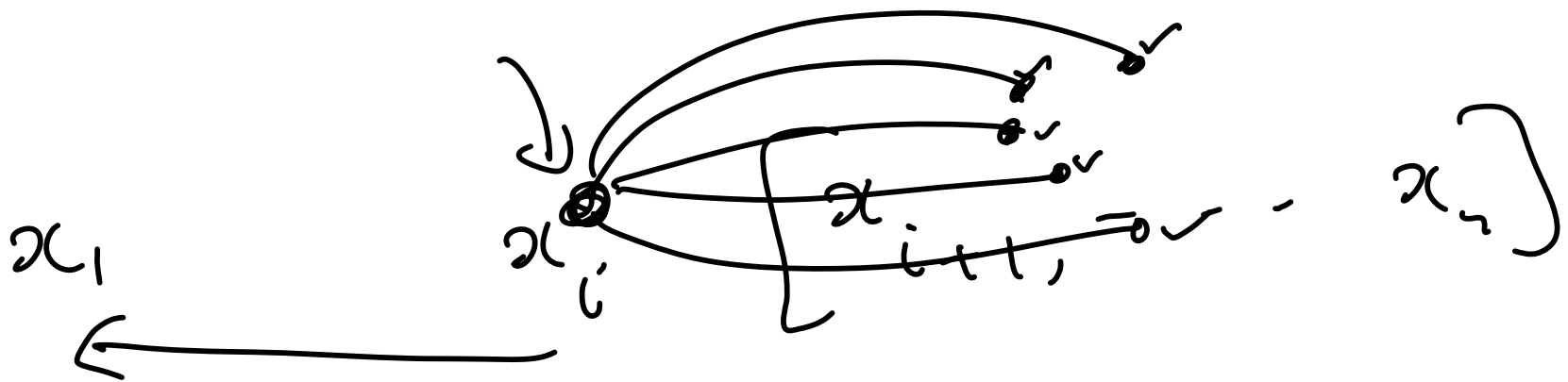
x of degree at most 5 ✓

$$\textcircled{6n} > 6n - 12$$

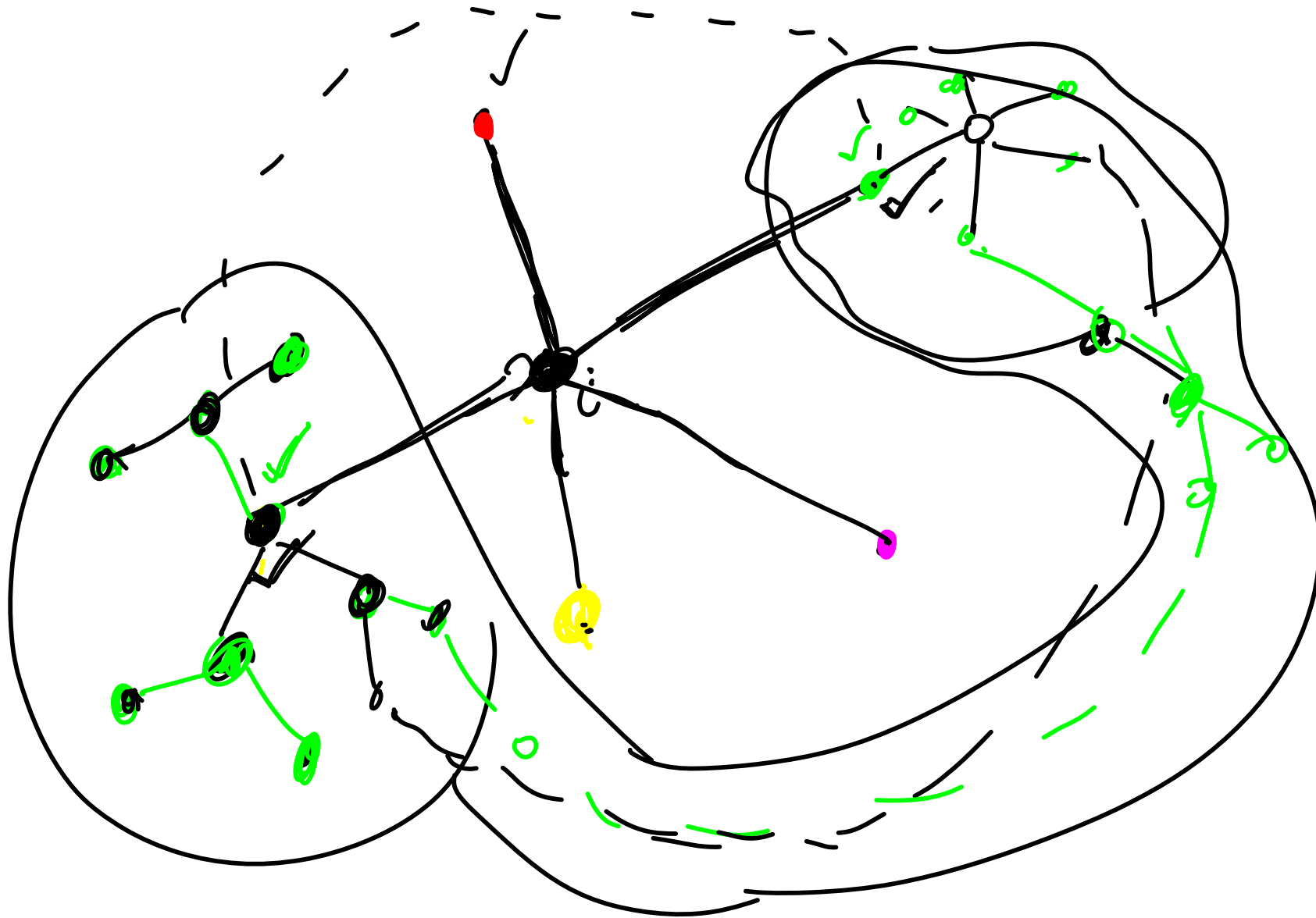


x_i [$x_{i+1}, x_{i+2}, \dots, x_n$]

at most 5



at most 6 colors



H is a minor of G

(1) delete a vertex

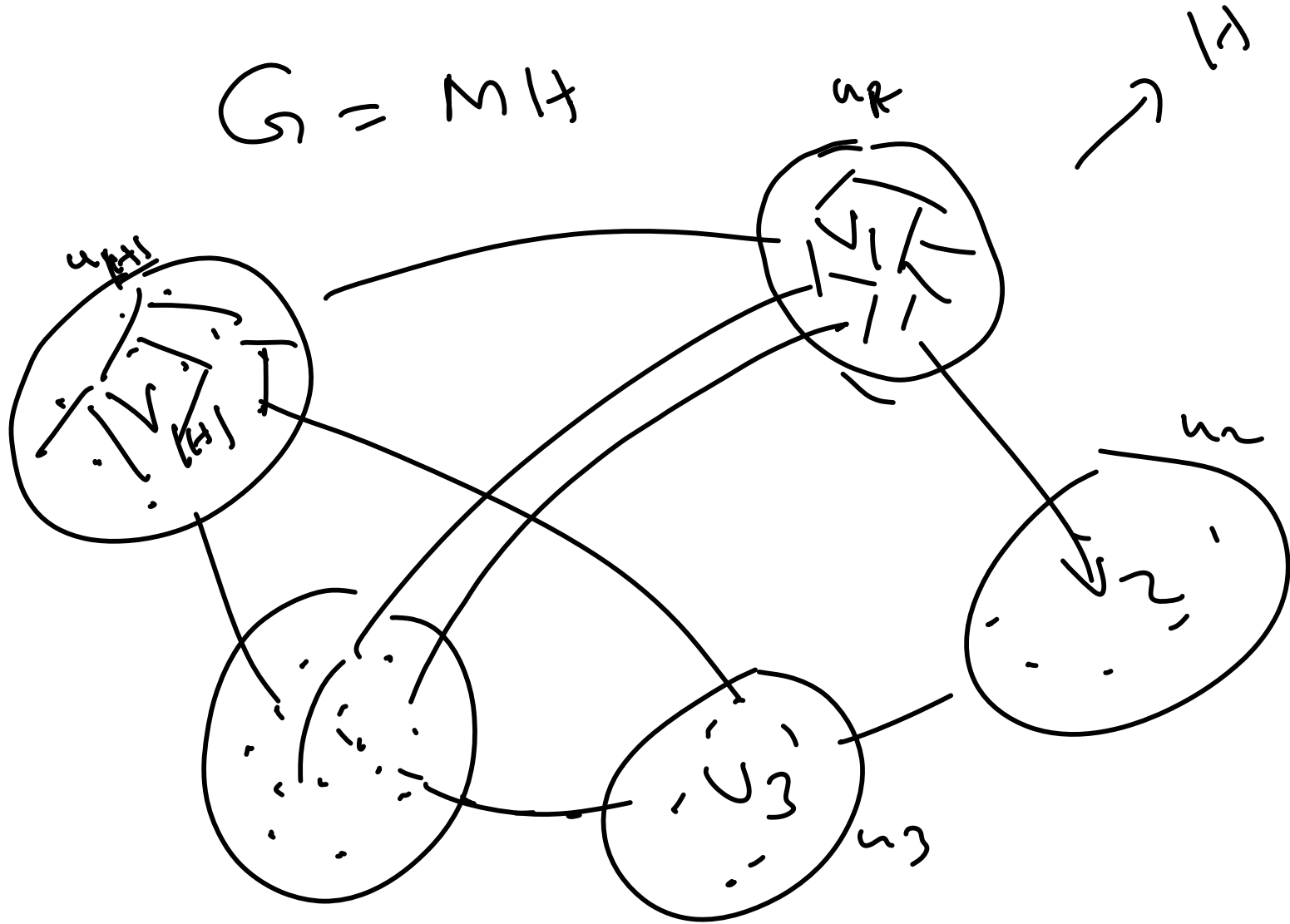
(2) delete an edge

(3) Contract an edge.

$$G \longrightarrow H \checkmark$$

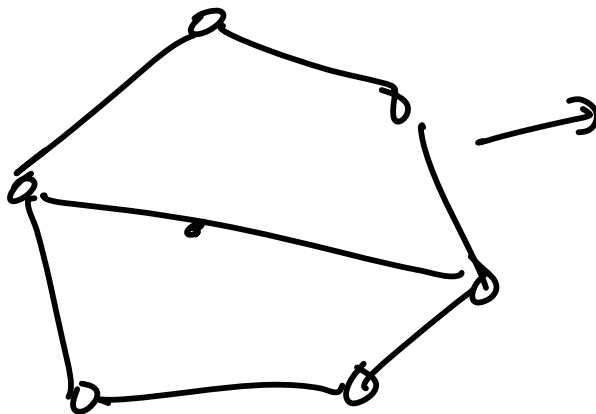
$$G = MH \checkmark$$

$$G = MH$$

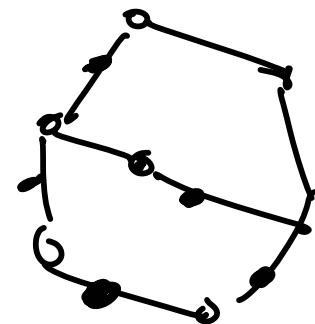


Topological minor

H



H_1



TH

G is planar, then

$$H = K_5 \text{ or } K_{3,3}$$

$$\underline{TK_5} \checkmark$$

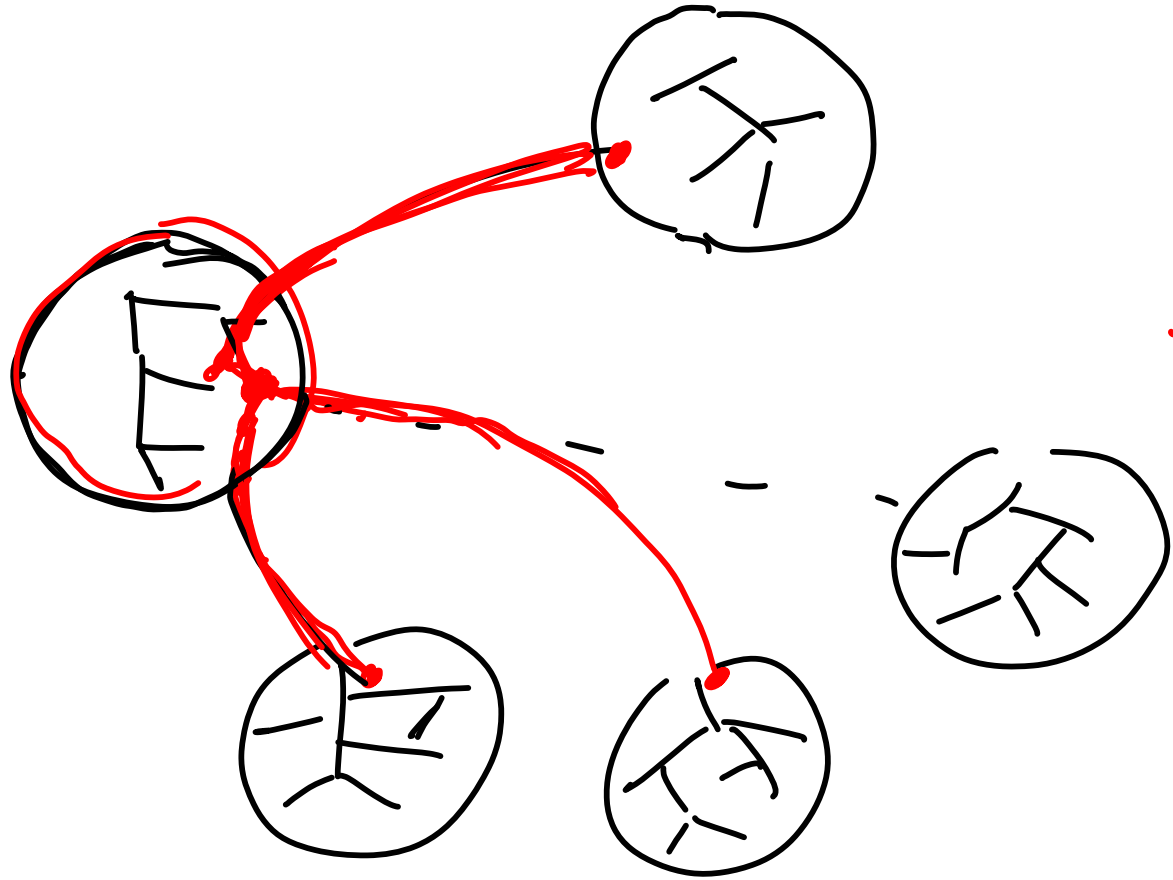
or

$$\underline{TK_{3,3}} \checkmark$$

X with

$$\Delta(X) \leq 3$$

$$X = K_{3,3}$$



$$\underline{X \rightarrow MX}$$

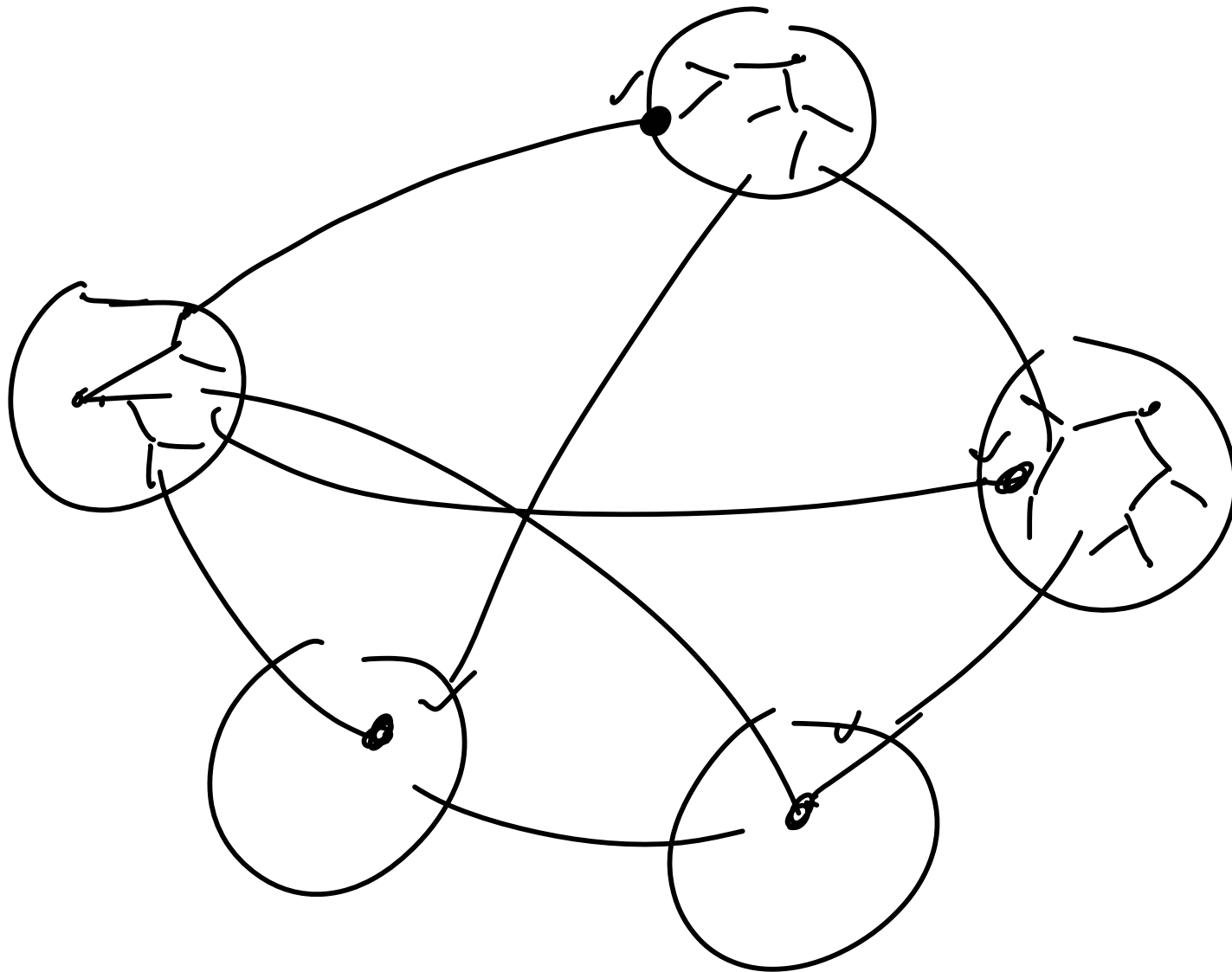


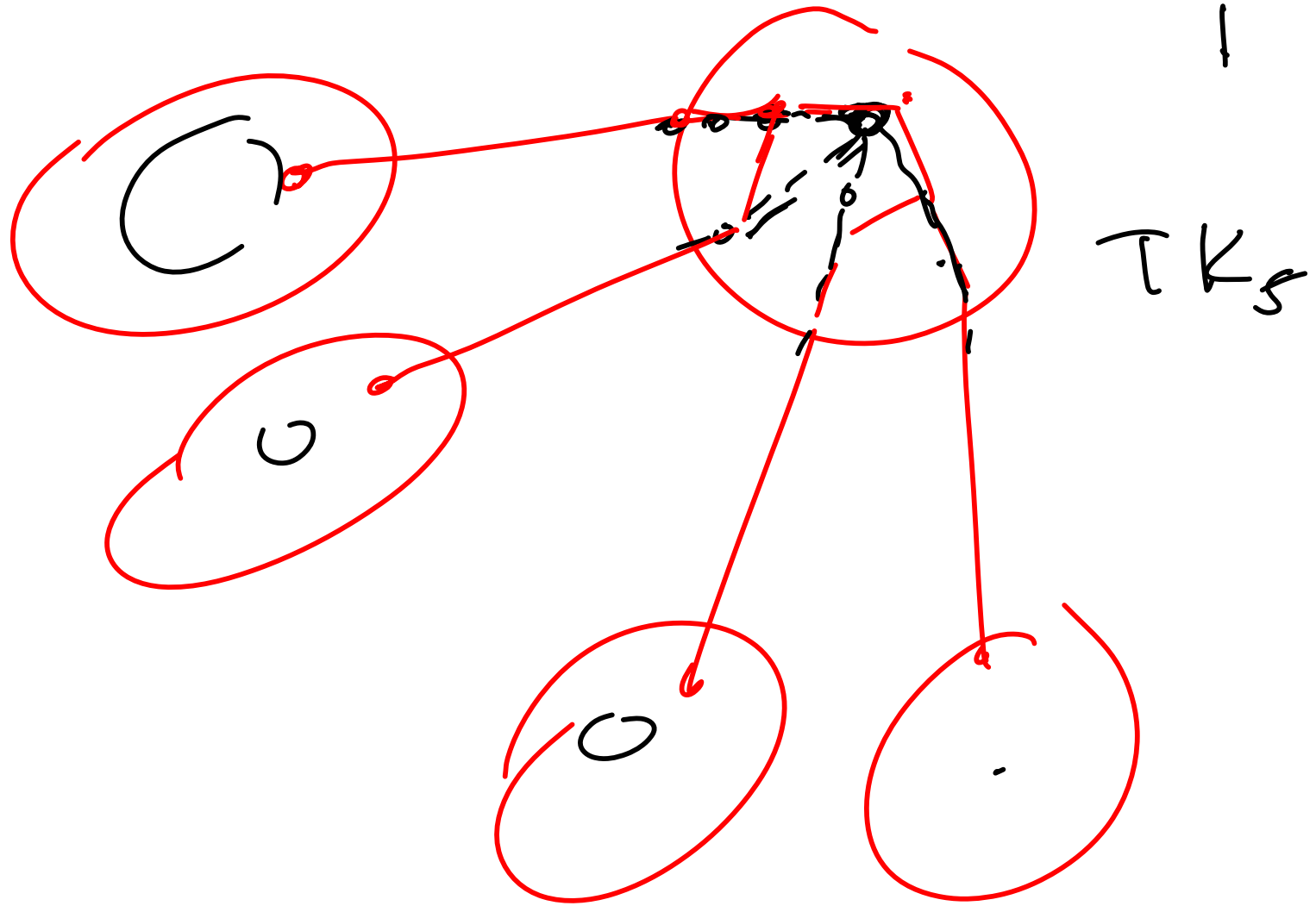
K_5 minor or $K_{3,3}$ minor

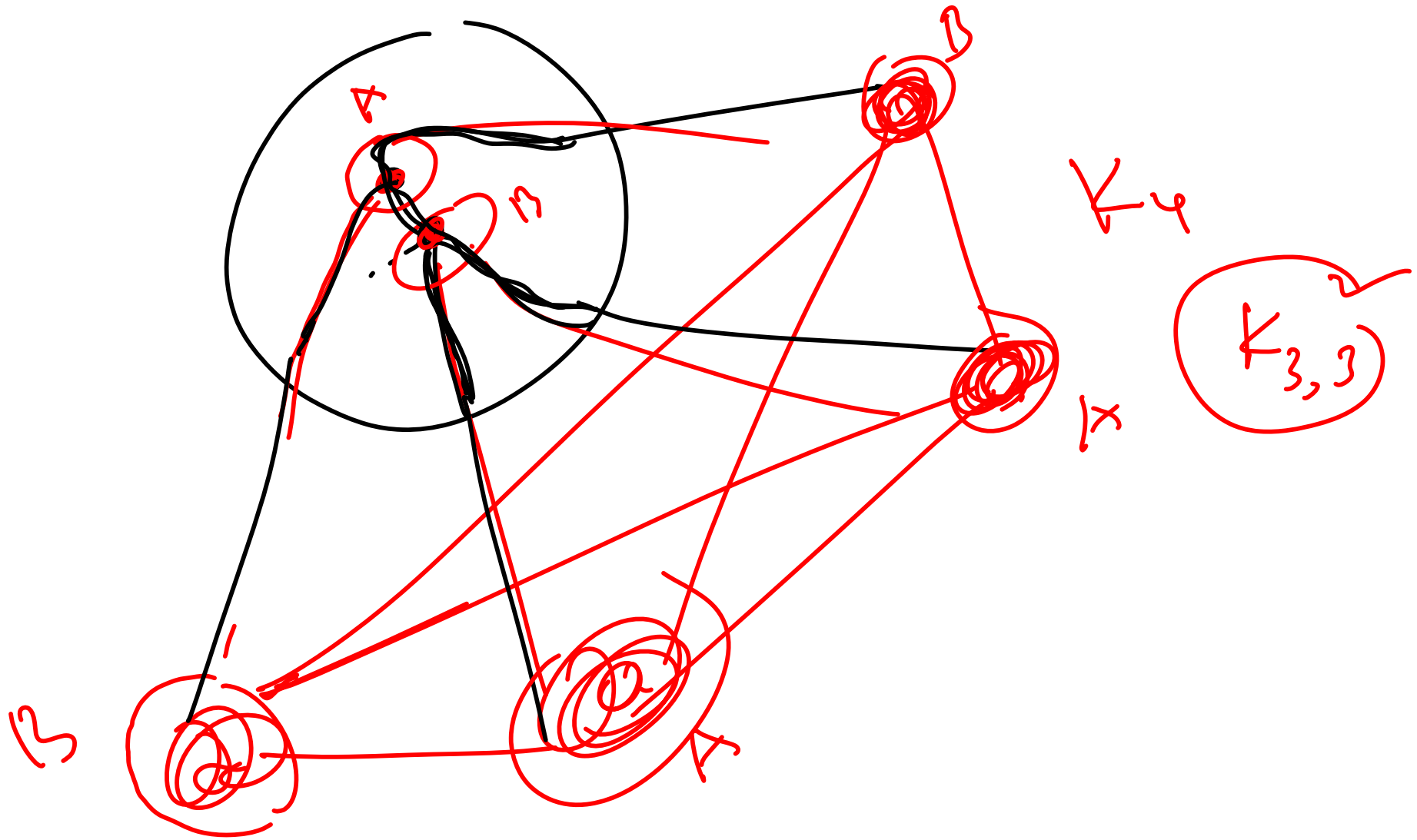
for G , then G has $\chi(G) \geq 2$

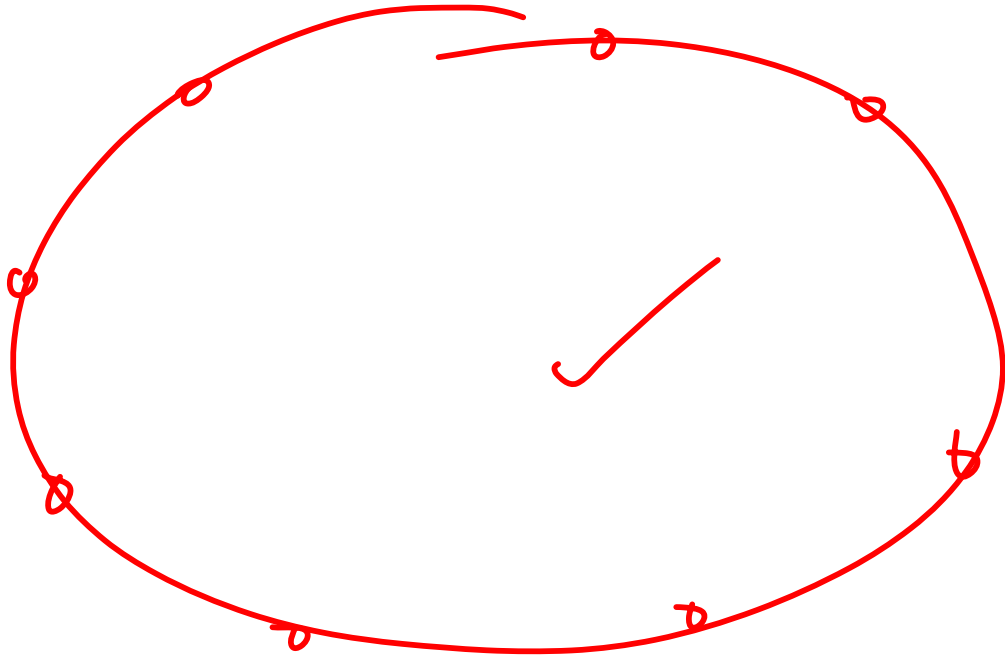
$\hookrightarrow K_5$ topological minor or

$K_{3,3}$ topological minor

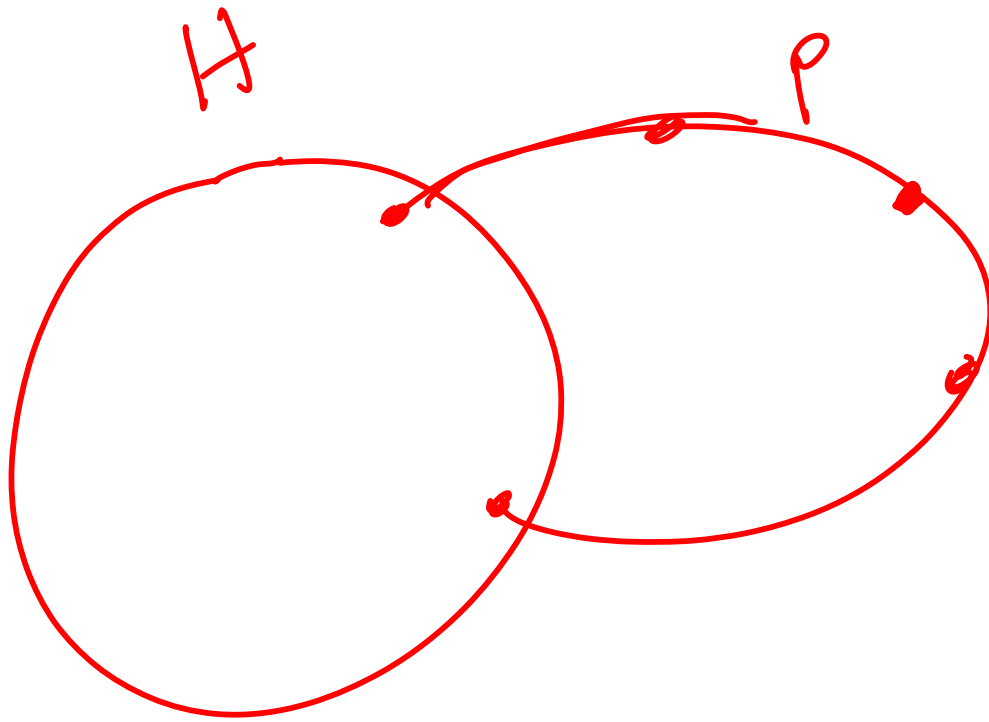




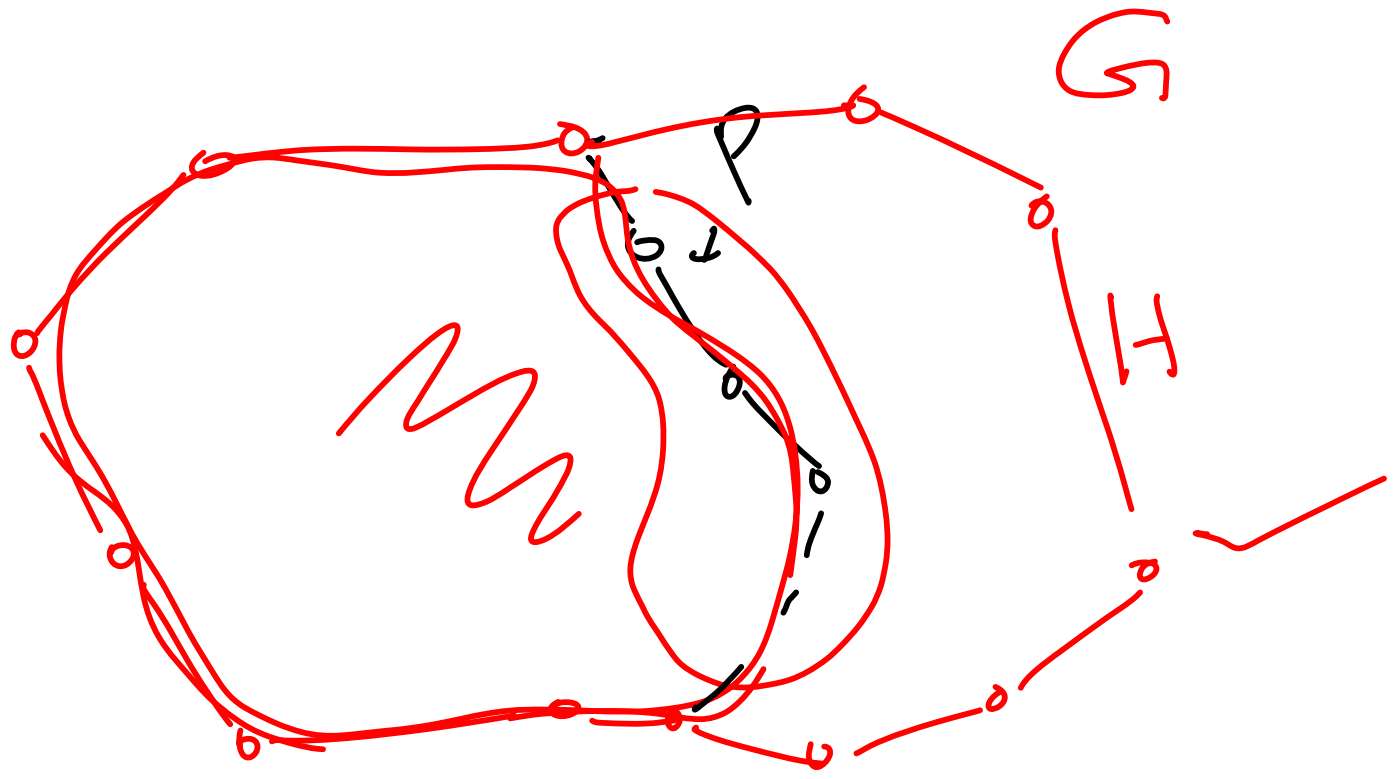




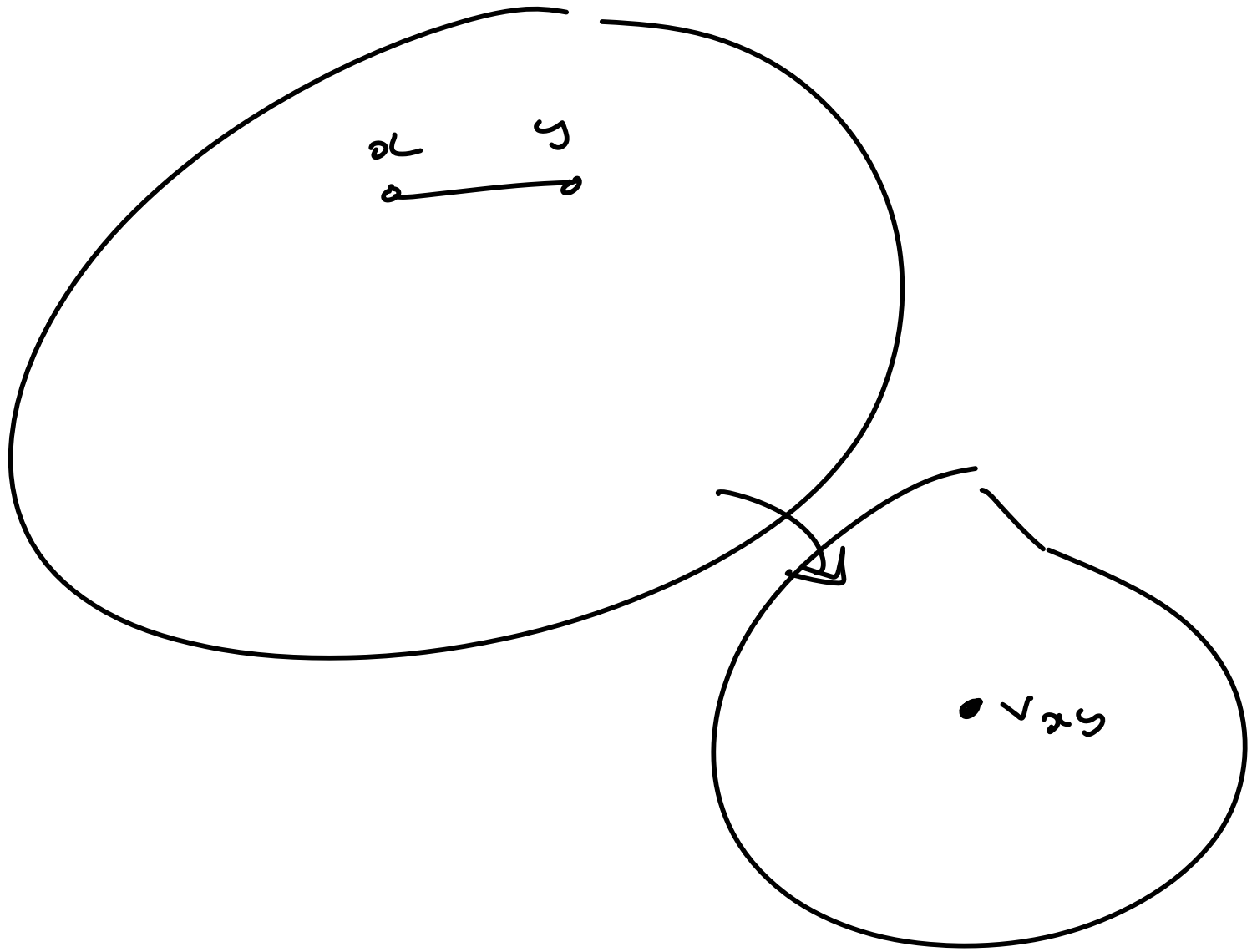
✓

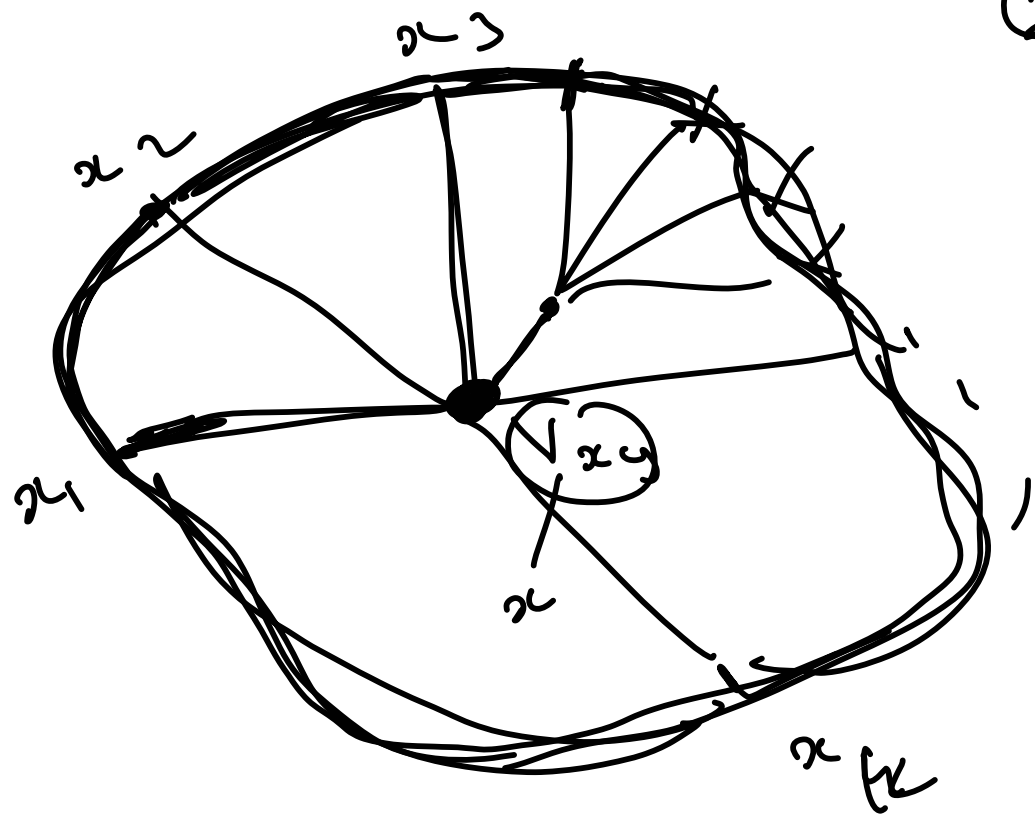


H
G
y



G is 3-connected and without
a K_5 or $K_{3,3}$ minor. Then
it is planar.





③.