

Analysis of a Machine

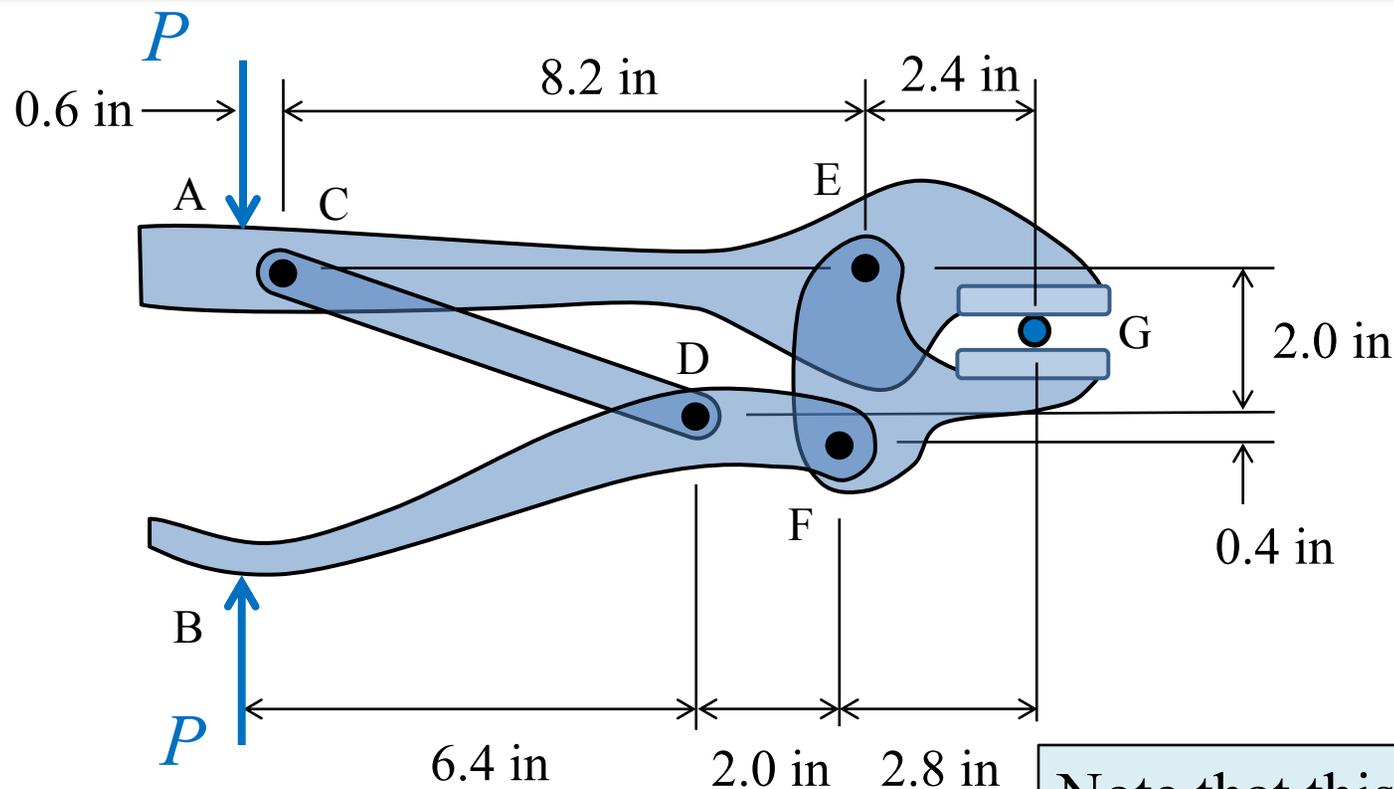
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The pliers shown below consist of four pieces connected by pins at points C, D, E, and F. For the input force, P , applied at the grips of the pliers, find:

1. The output force that is clamping the piece held at point G.
2. The total force on each pin;

The weight of the pieces is negligible.

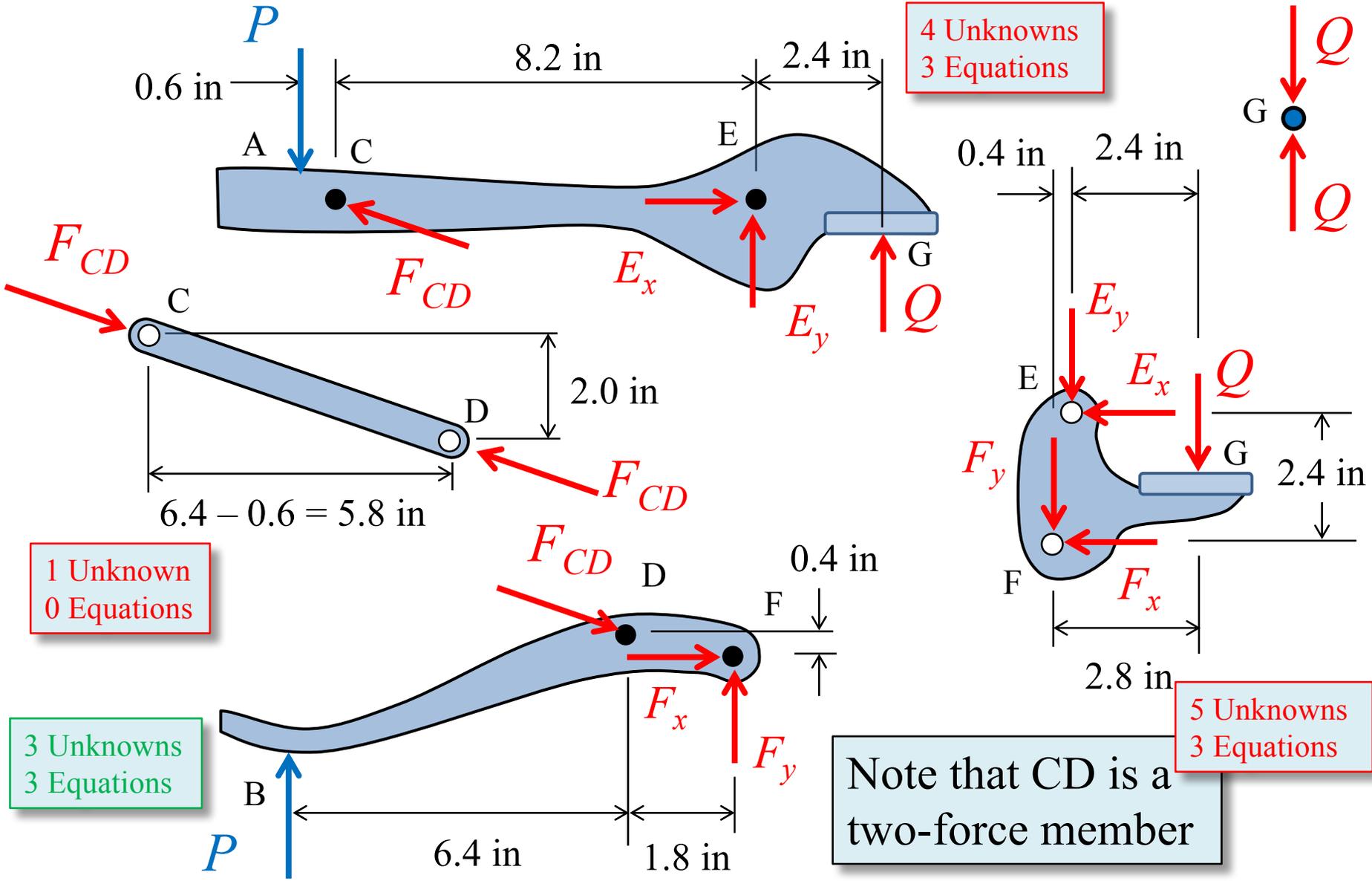


Note that this is a FBD

FBD of Each Piece of the Pliers

1 Unknown
0 Equations

4 Unknowns
3 Equations



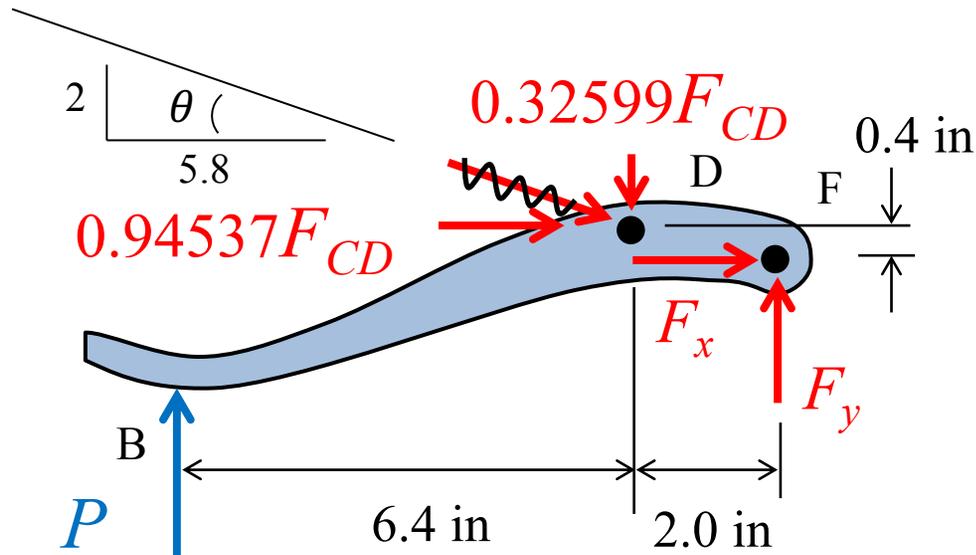
1 Unknown
0 Equations

3 Unknowns
3 Equations

5 Unknowns
3 Equations

Note that CD is a two-force member

Start with Analysis of Piece BDF



$$\theta = \tan^{-1} \left(\frac{2}{5.8} \right) = 19.0256^\circ$$

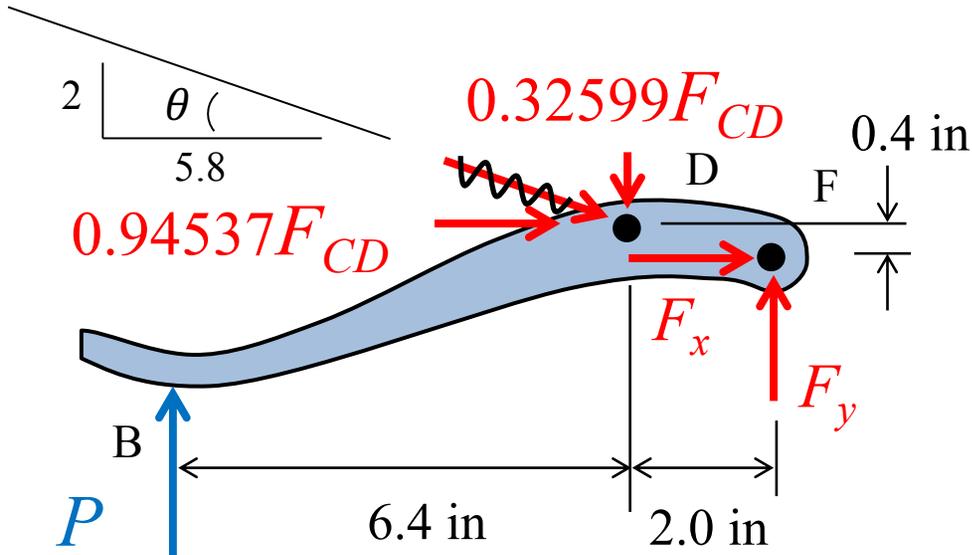
$$\cos \theta = 0.94537$$

$$\sin \theta = 0.32599$$

$$\sum M_F = 0$$

$$F_{CD} = 30.626P$$

Analysis of Piece BDF



$$\theta = \tan^{-1} \left(\frac{2}{5.8} \right) = 19.0256^\circ$$

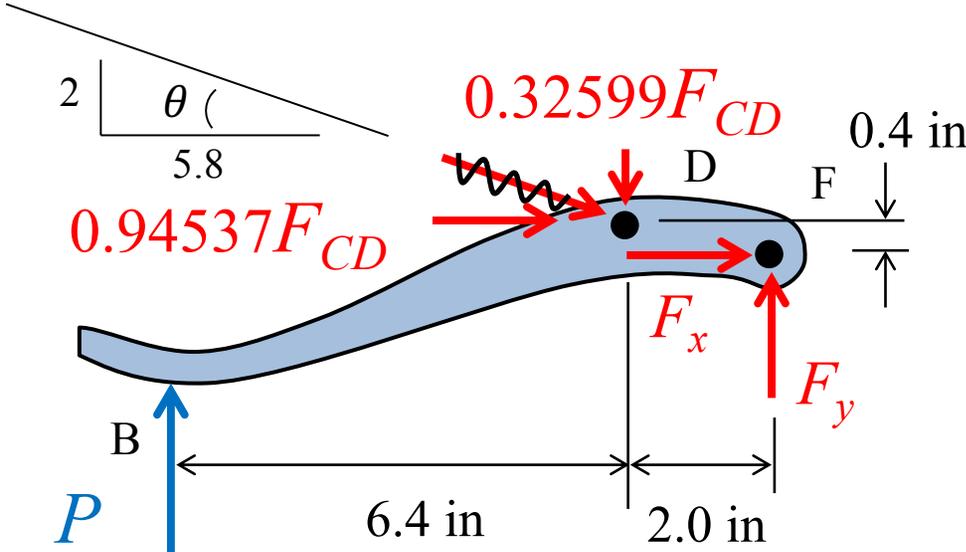
$$\cos \theta = 0.94537$$

$$\sin \theta = 0.32599$$

$$+\uparrow \sum F_y = 0$$

$$F_y = 9.0P$$

Analysis of Piece BDF



$$\theta = \tan^{-1}\left(\frac{2}{5.8}\right) = 19.0256^\circ$$

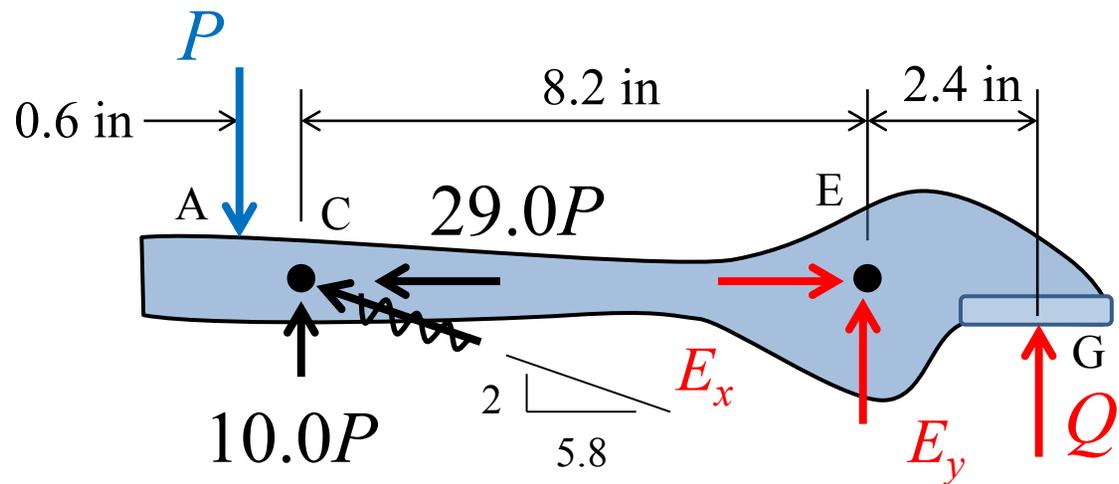
$$\cos \theta = 0.94537$$

$$\sin \theta = 0.32599$$

$$\overset{+}{\rightarrow} \sum F_x = 0$$

$$F_x = -29.0P$$

Next Analyze Piece ACEG



$$F_{CD} = 30.626P$$

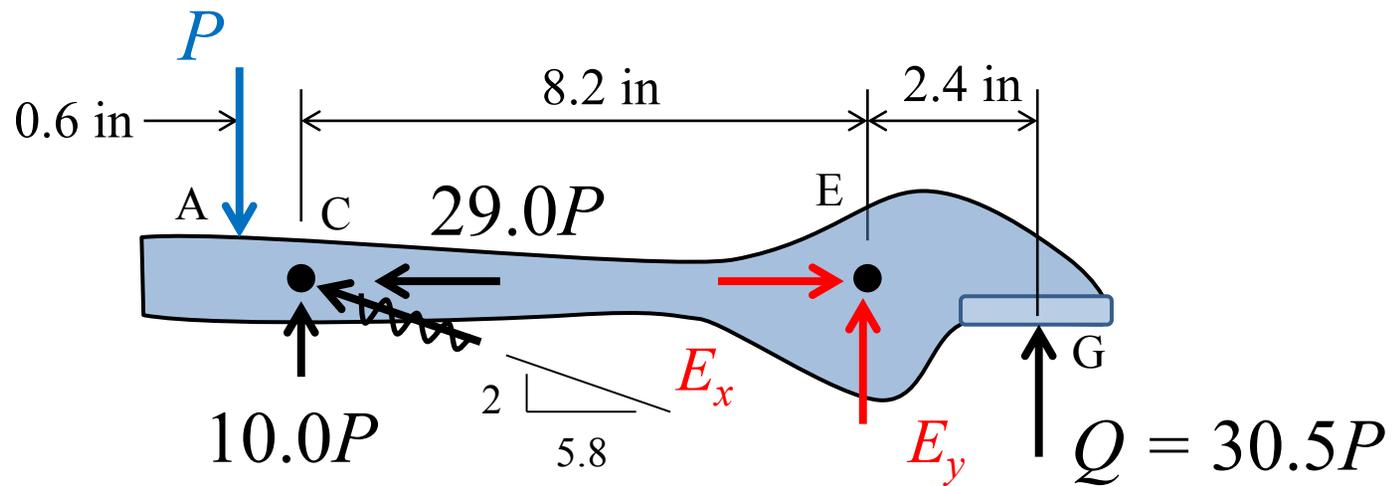
$$0.32599(30.626P) = 10.0P$$

$$0.94537(30.626P) = 29.0P$$

$$\sum M_E = 0$$

$$Q = 30.5P$$

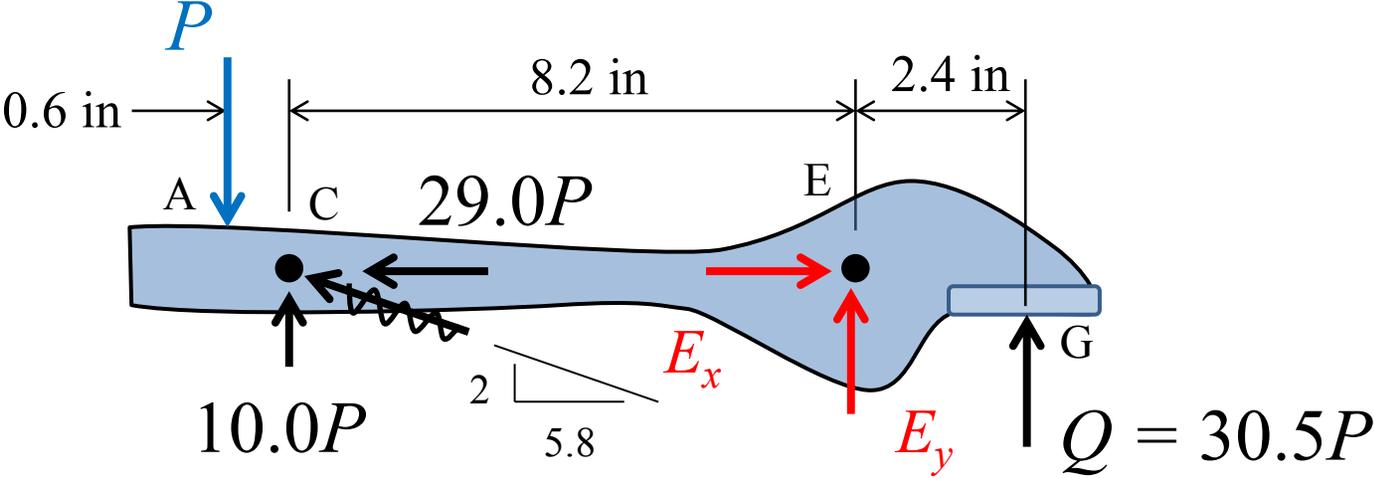
Analyze Piece ACEG



$$+\uparrow \sum F_y = 0$$

$$E_y = -39.5P$$

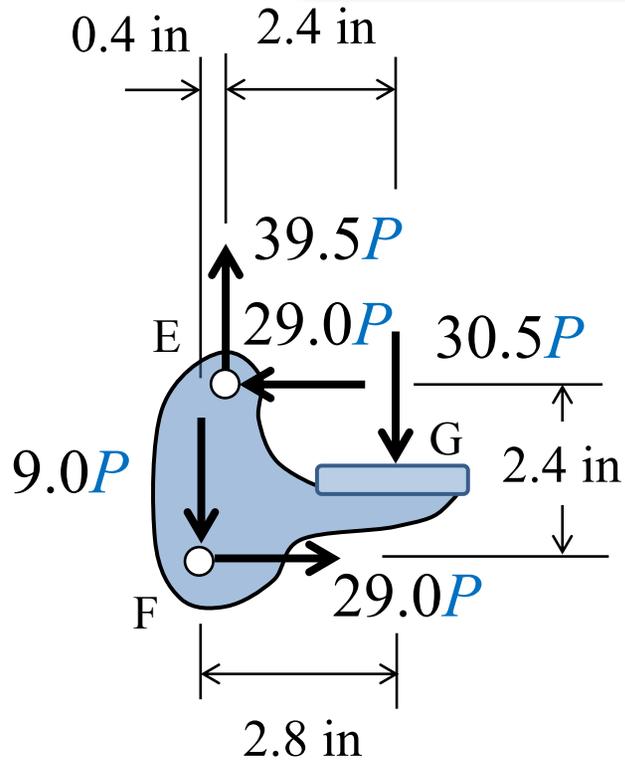
Analyze Piece ACEG



$$\overset{+}{\rightarrow} \sum F_x = 0$$

$$E_x = 29.0P$$

Check Equilibrium of Piece EFG

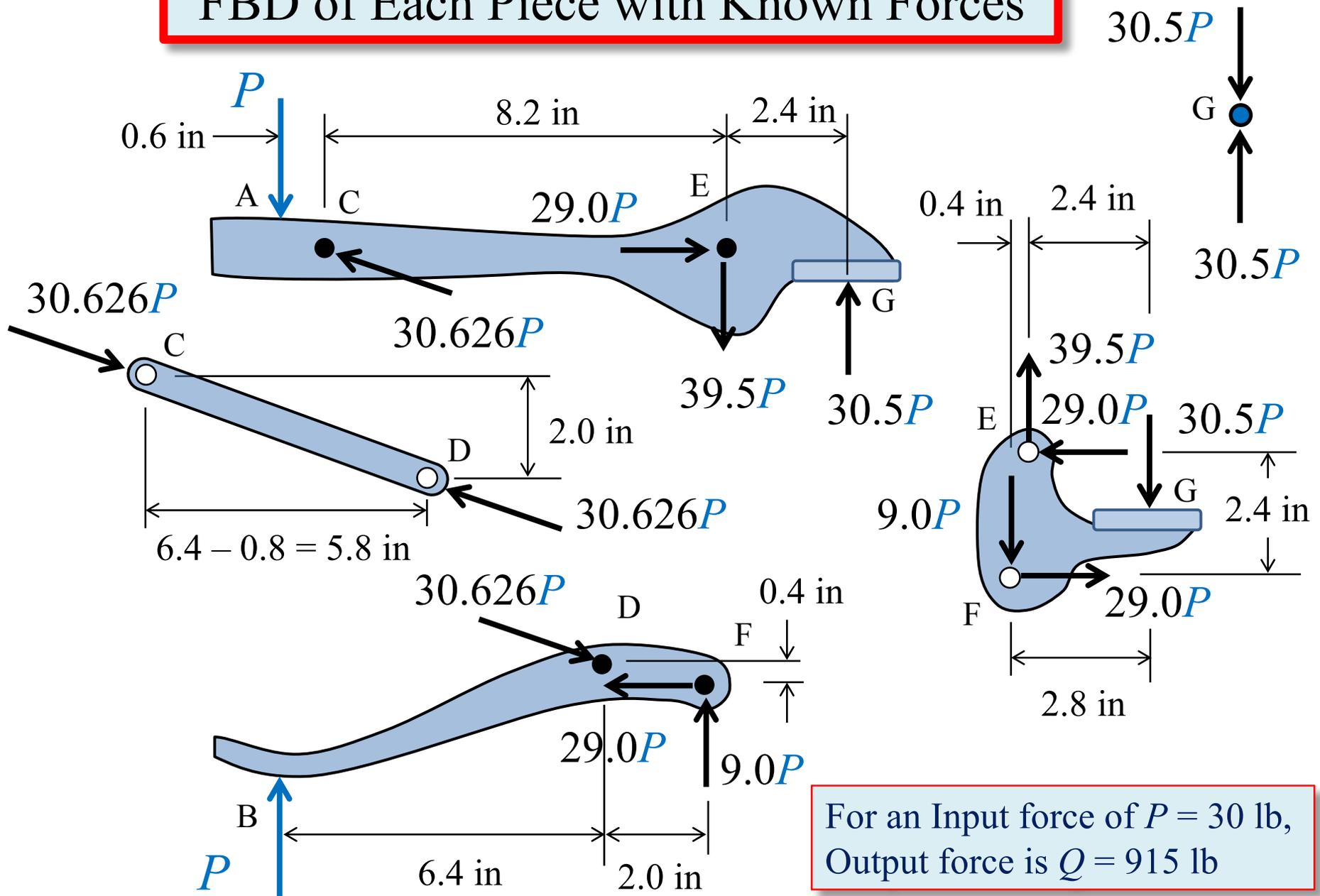


$$\curvearrowright + \sum M_E = 0$$

$$+\uparrow \sum F_y = 0$$

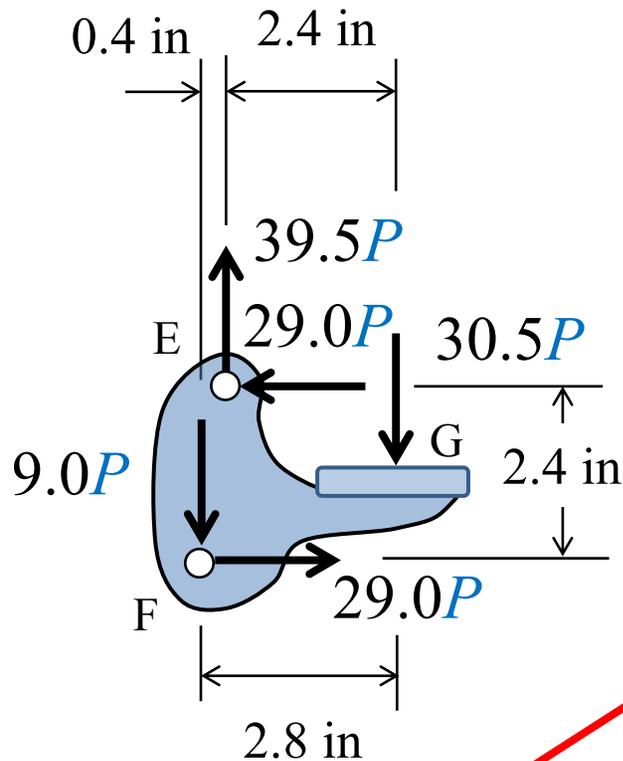
$$\rightarrow + \sum F_x = 0$$

FBD of Each Piece with Known Forces



For an Input force of $P = 30$ lb,
Output force is $Q = 915$ lb

Find the Maximum Total Force on Each Pin



Pin C and Pin D

$$R_C = R_D = 30.626P$$

Pin E

$$R_E = \sqrt{(29.0P)^2 + (39.5P)^2} = 49.0P$$

Pin F

$$R_F = \sqrt{(29.0P)^2 + (9.0P)^2} = 30.36P$$

Maximum Force
is on Pin E

For an input force of $P = 30$ lb,
Pin E must resist a total force of $R_E = 1470$ lb