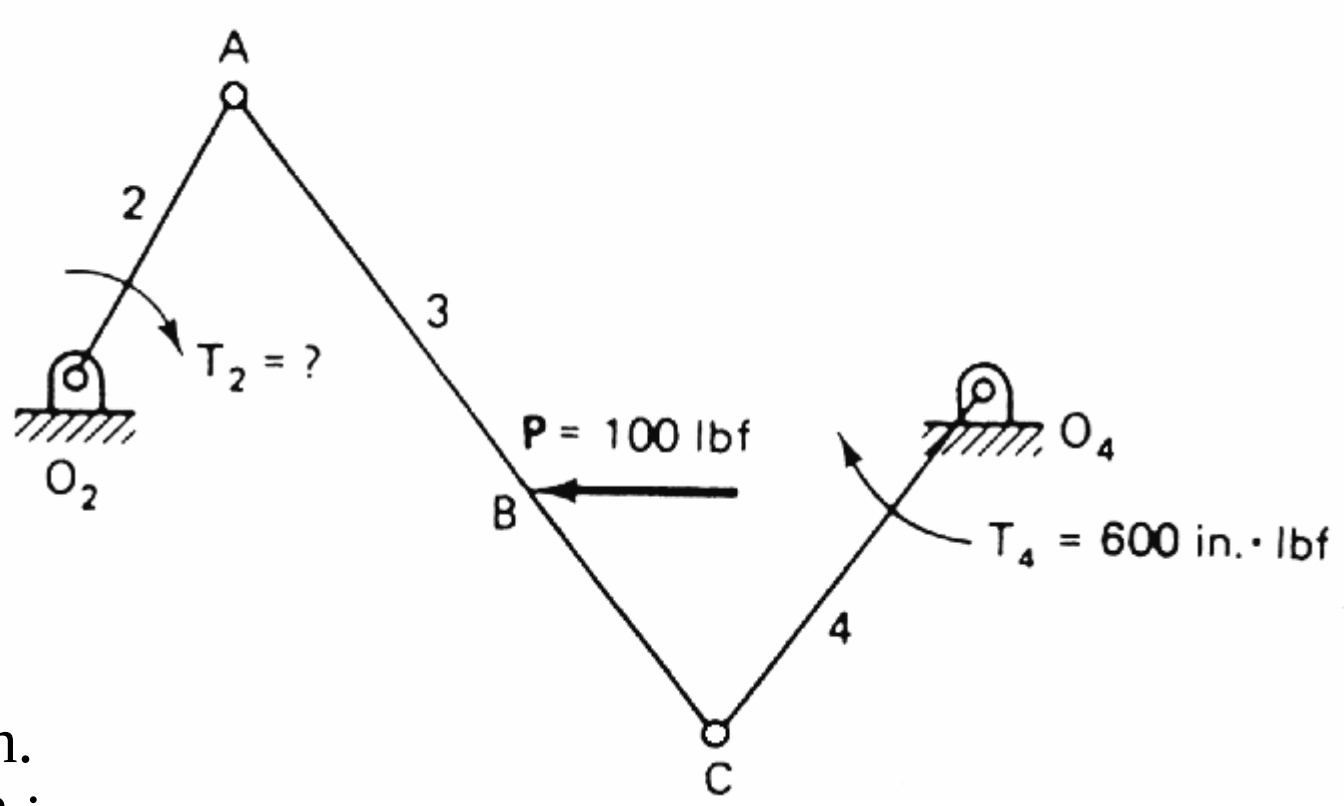
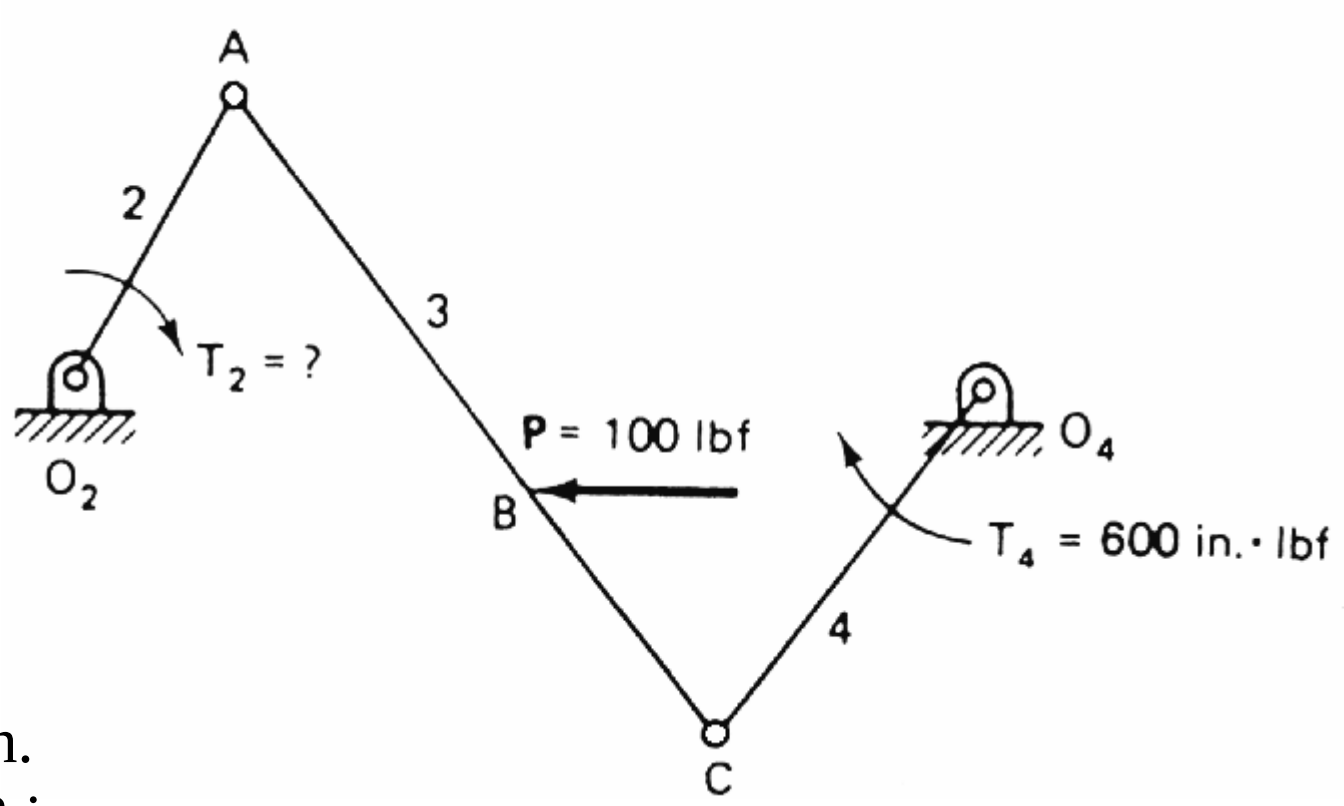
1)



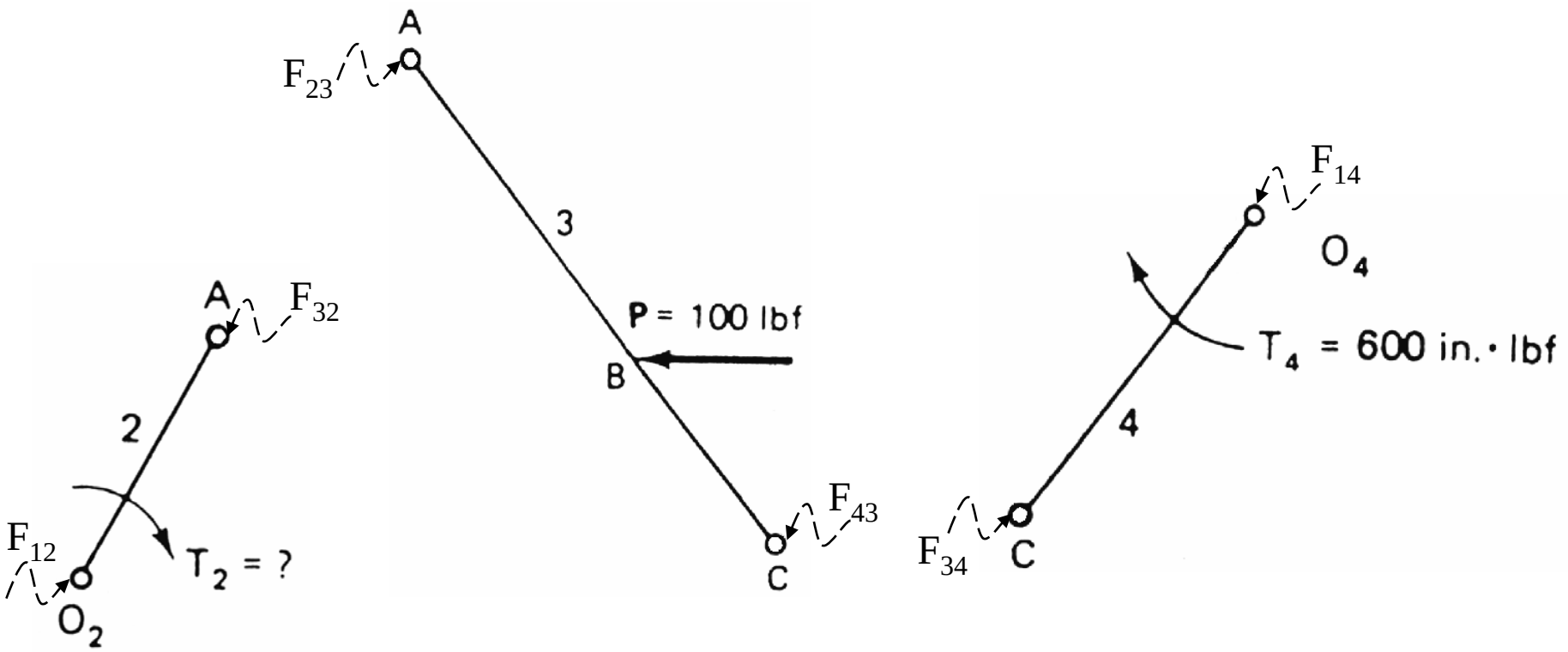
O_2A = 6 in.
AB = 9 in.
AC = 15 in.
O_4C = 8.25 in.
O_2O_4 = 17.13 in.

For the mechanism shown below, determine the value of the torque T_2 needed to hold the mechanism in place.



O_2A = 6 in.
AB = 9 in.
AC = 15 in.
O_4C = 8.25 in.
O_2O_4 = 17.13 in.

The free body diagram of each link is shown below. Because a torque acts on links 2 and 4, only link 3 can be identified as a 3-force member. As the magnitudes and directions of all pin forces are unknown, use the free body diagram of link 4 to determine the transverse component of F_{34}.

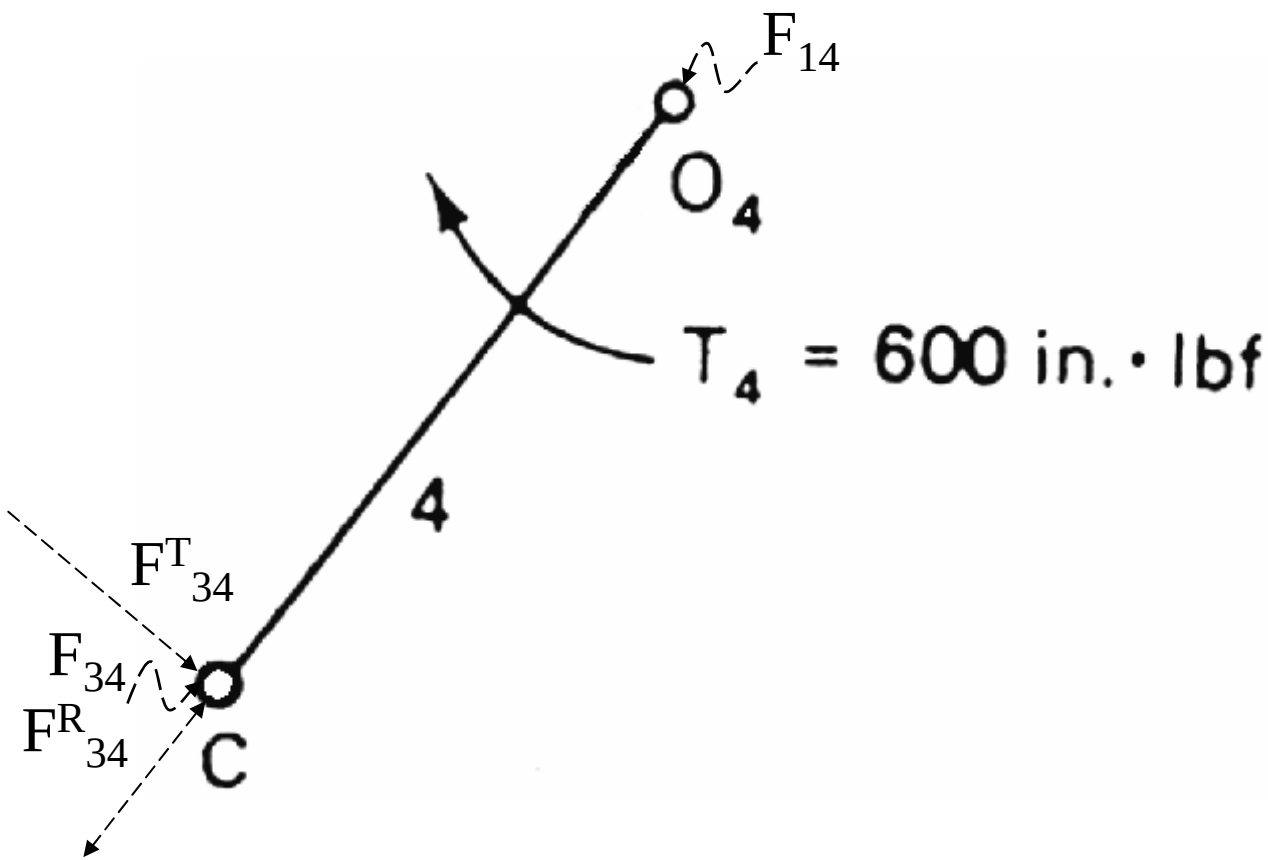


Resolve F_{34} into components along link 4, F^R_{34}, and perpendicular to link 4, F^T_{34}.

As $\Sigma M_{O4} = 0 = F^T_{34} * O_4C - T_4$, we can find F^T_{34} from

$$F^T_{34} = T_4 / O_4C$$

$$F^T_{34} = 72.7 \text{ lbf}$$



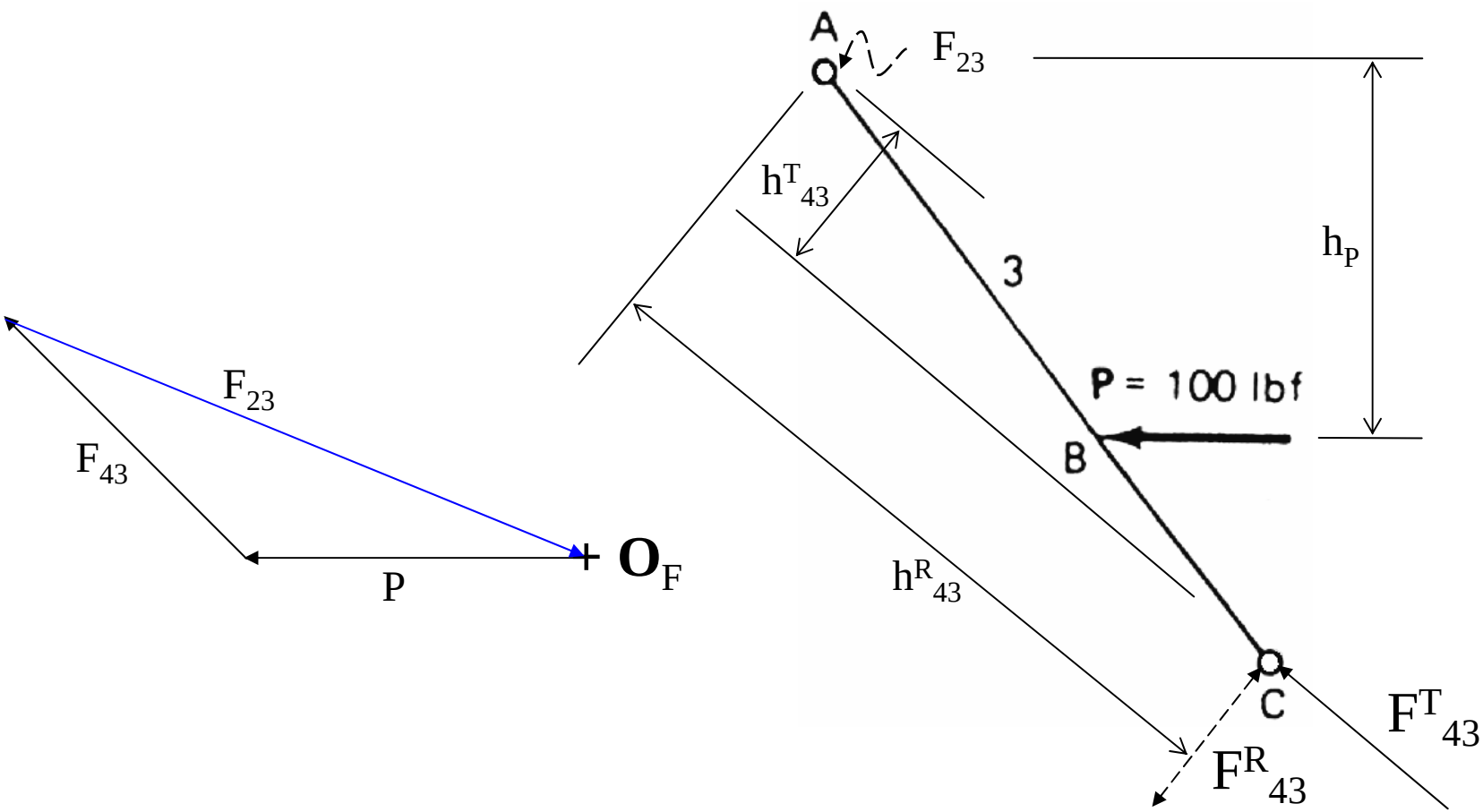
To determine F^R_{43} , use $\Sigma M_A = F^R_{43}*h^R_{43} - F^T_{43}*h^T_{43} - P*h_P = 0$

-OR-

$$F^R_{43} = (P*h_P + F^T_{43}*h^T_{43})/h^R_{43} = 69.4 \text{ lbf}$$

$$F_{43} = [(F^R_{43})^2 + (F^R_{43})^2]^{0.5} = 100.5 \text{ lbf}$$

A force polygon is used to find F_{23} = 155 lbf (1 in. = 50 lbf)

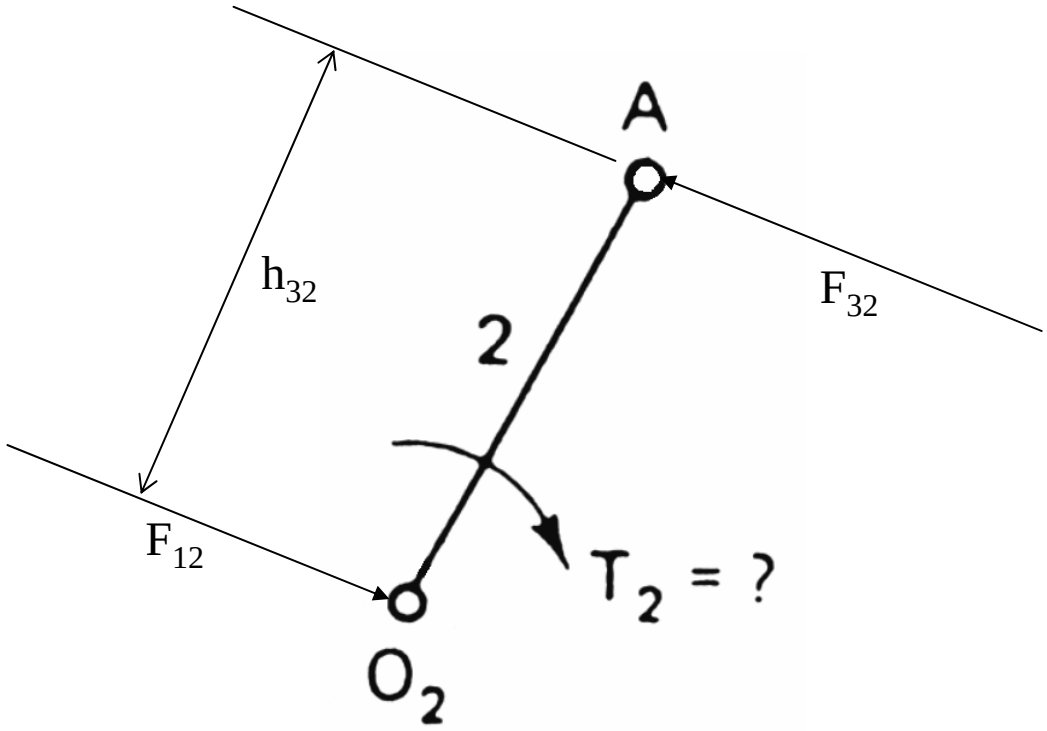


The value of the torque T_2 is obtained from

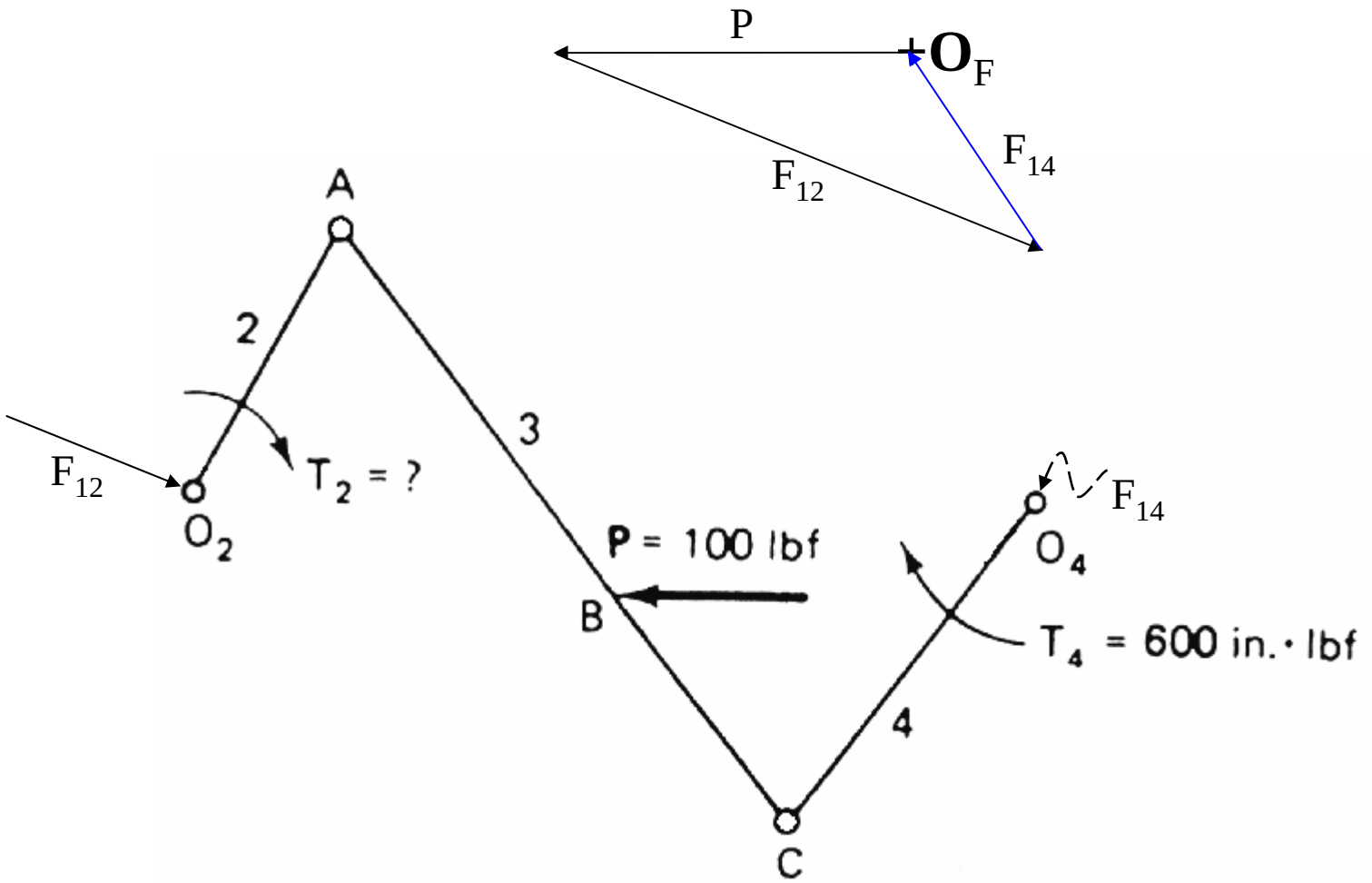
$$T_2 = -F_{32} * h_{32}$$

and

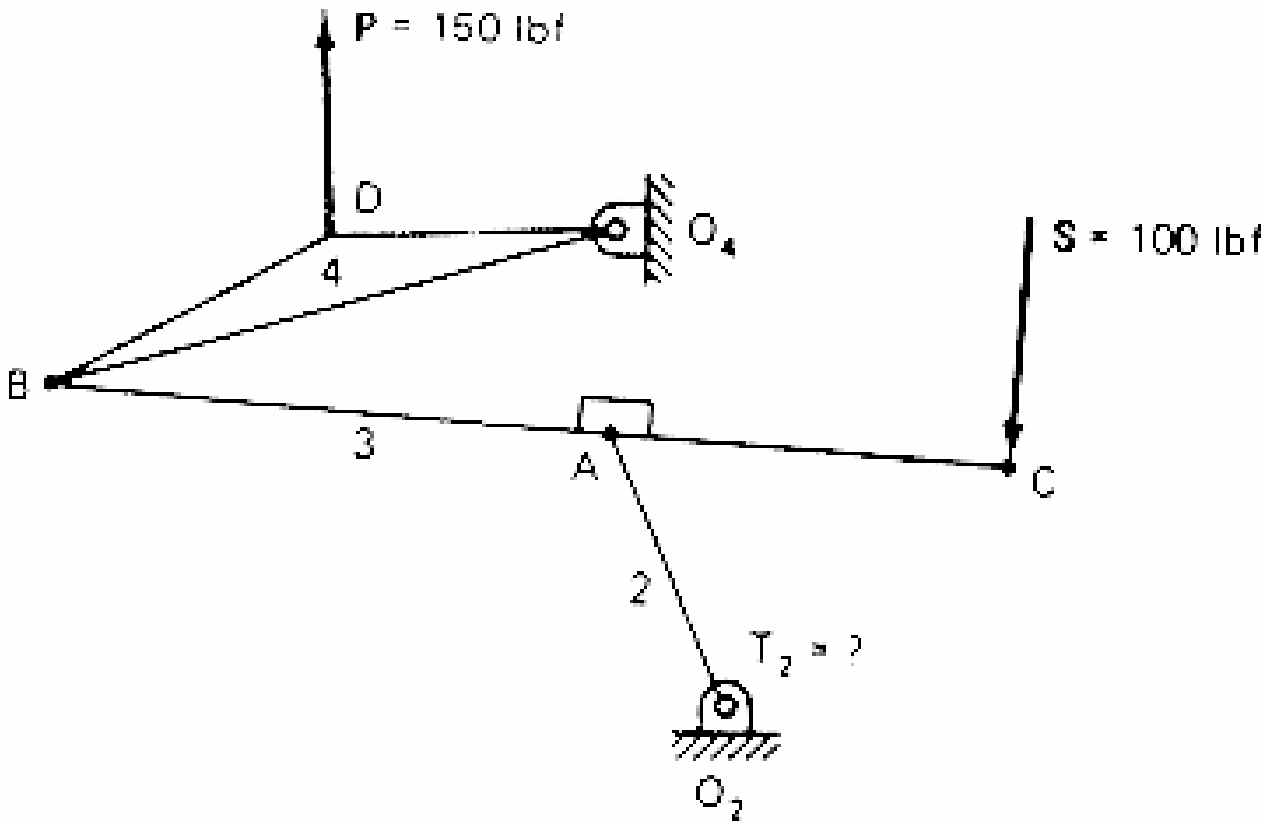
$$F_{12} = -F_{32}$$



A force polygon for the entire mechanism is used to determine F_{14} = 81.3 lbf (1 in. = 50 lbf)

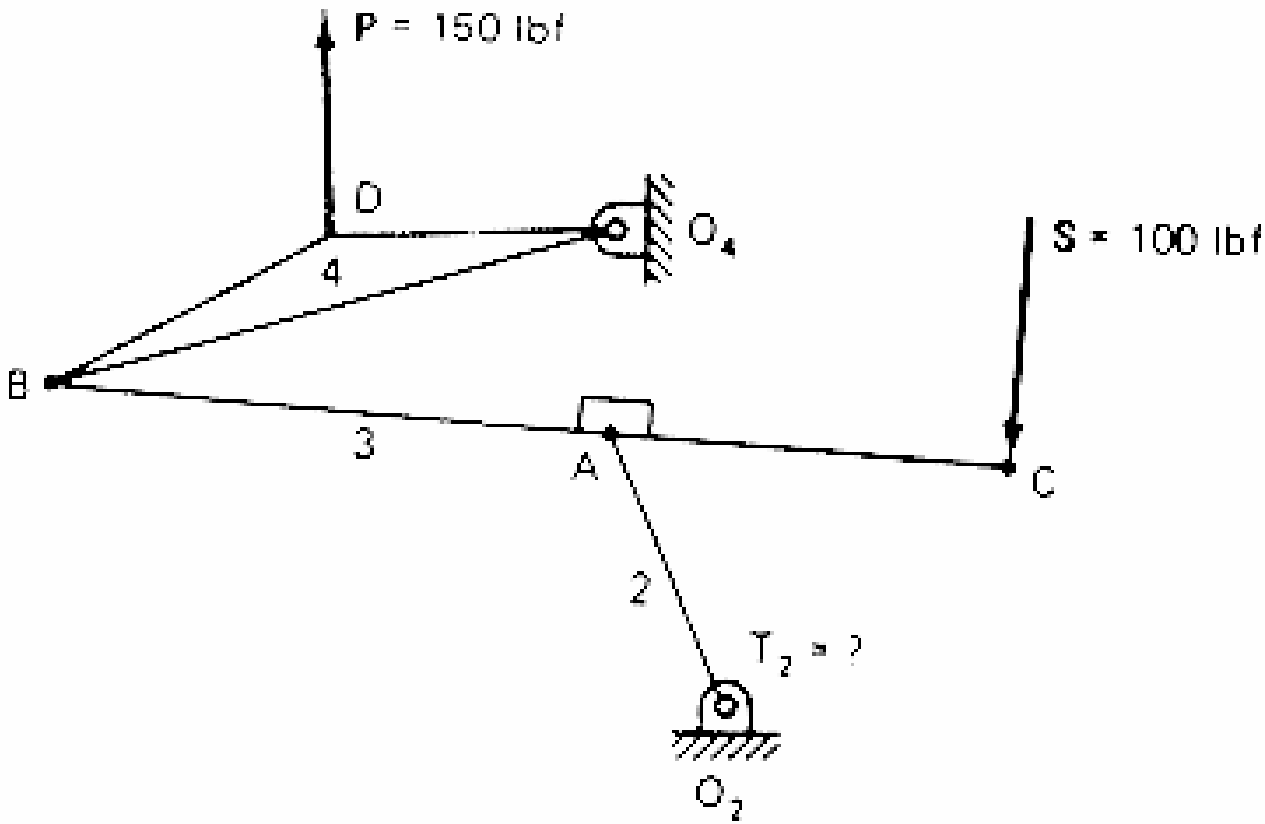


2)



AB = 9.375 in.
BD = 5.25 in.
DO_4 = 5 in.
BO_4 = 10 in.
AC = 7 in.
AO_2 = 5 in.

To determine T_2, we first identify links 3 and 4 as 3-force members which specifies the directions of the line of action of the third force once the other two directions are known.



AB = 9.375 in.
BD = 5.25 in.
DO_4 = 5 in.
BO_4 = 10 in.
AC = 7 in.
AO_2 = 5 in.

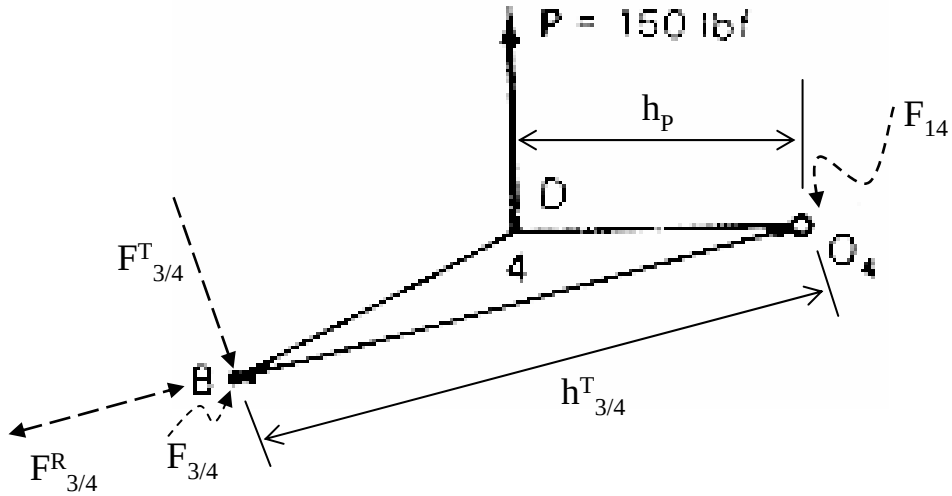
The free body diagram of link 4 is shown below where the forces F_{14} and F_{34} are unknown in magnitude and direction.

To solve for T_2 we first replace F_{34} with the components F^T_{34} and F^R_{34} so that their directions are known to be along and transverse to O_4B.

We now want to evaluate $\Sigma M_{O_4} = 0 = h^T_{34} * F^T_{34} - h_P * P$ or

$$F^T_{34} = P(h_P/h^T_{34}) = 75 \text{ lbf} \searrow$$

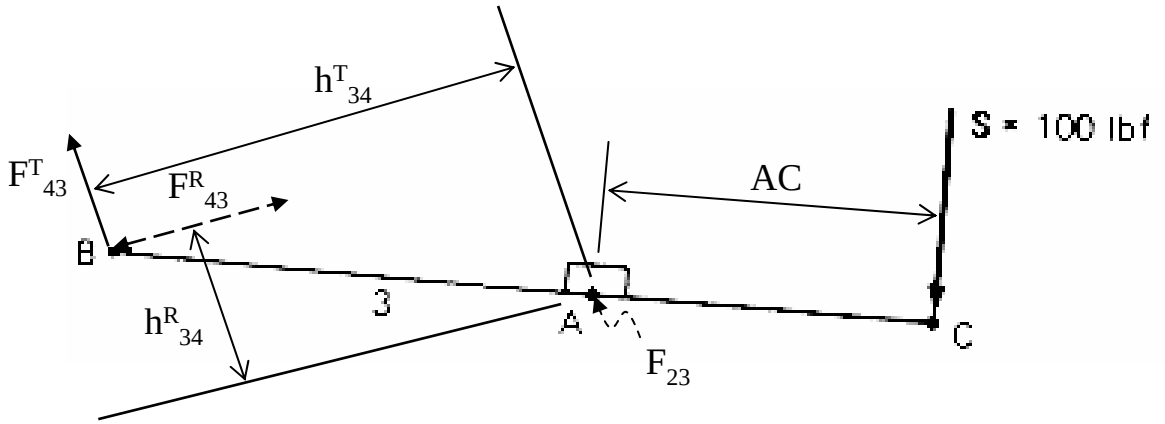
To determine F^R_{34} in magnitude and direction we must move to the free body diagram of link 3.

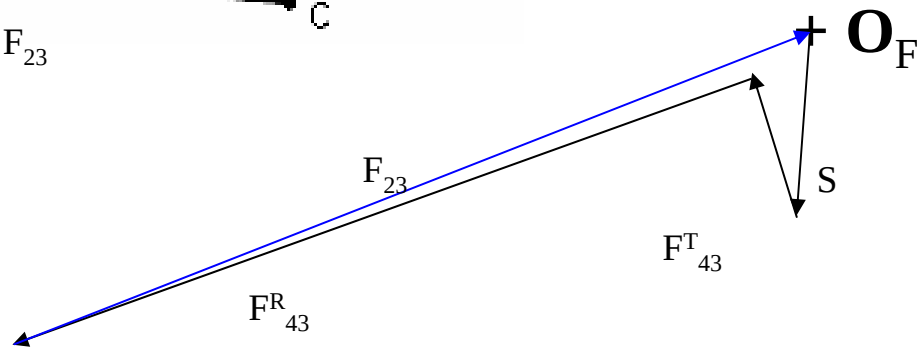


Shown below is the free body diagram of link 3. The forces at B are F^T_{43} (which has the same magnitude but opposite direction of F^T_{34}) and F^R_{43} which is unknown in magnitude. The force at A (F_{23}) is unknown in magnitude and direction.

To solve for F^R_{43} we use $\Sigma M_A = 0 = F^R_{43}*h^R_{43} - F^T_{43}*h^T_{43} - S*AC$ or

$$F^R_{43} = (F^T_{43}*h^T_{43} + S*AC)/h^R_{43} = 408.7 \text{ lbf}$$





A force polygon gives

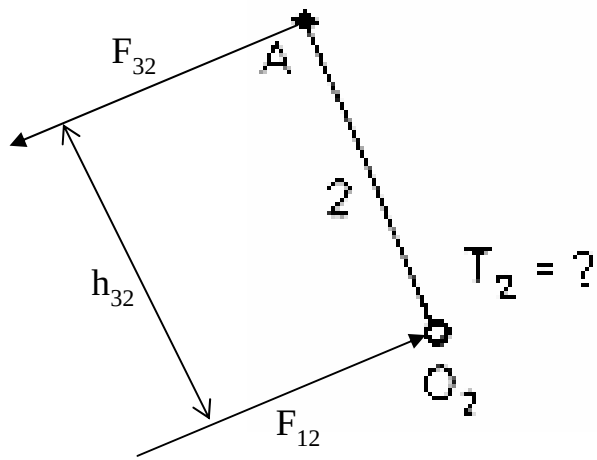
F_{23} = 445.9 lbf (1 in. = 100 lbf)

To determine the magnitude and direction of T_2 we use

$$T_2 = - F_{32} * h_{32}$$

-OR-

$$T_2 = 2229.5 \text{ in-lbf CW}$$



From a force polygon for the entire mechanism

F_{14} = 462.2 lbf (1 in. = 100 lbf)

