FORCE COUPLES

Learning Objectives

1). To determine a resultant torque of a system of *force couples*.

2). To determine an *equivalent force-couple* of a system of forces and moments.

3). To do an *engineering estimate* of this quantity.

Definition

Force Couple: a pair of forces which are (i) equal in magnitude, (ii) parallel and (iii) opposite in direction.

$$|\overline{M}| = |\overline{F}|\, d$$

where d = perpendicular distance between the lines of action of the forces forming the couple.

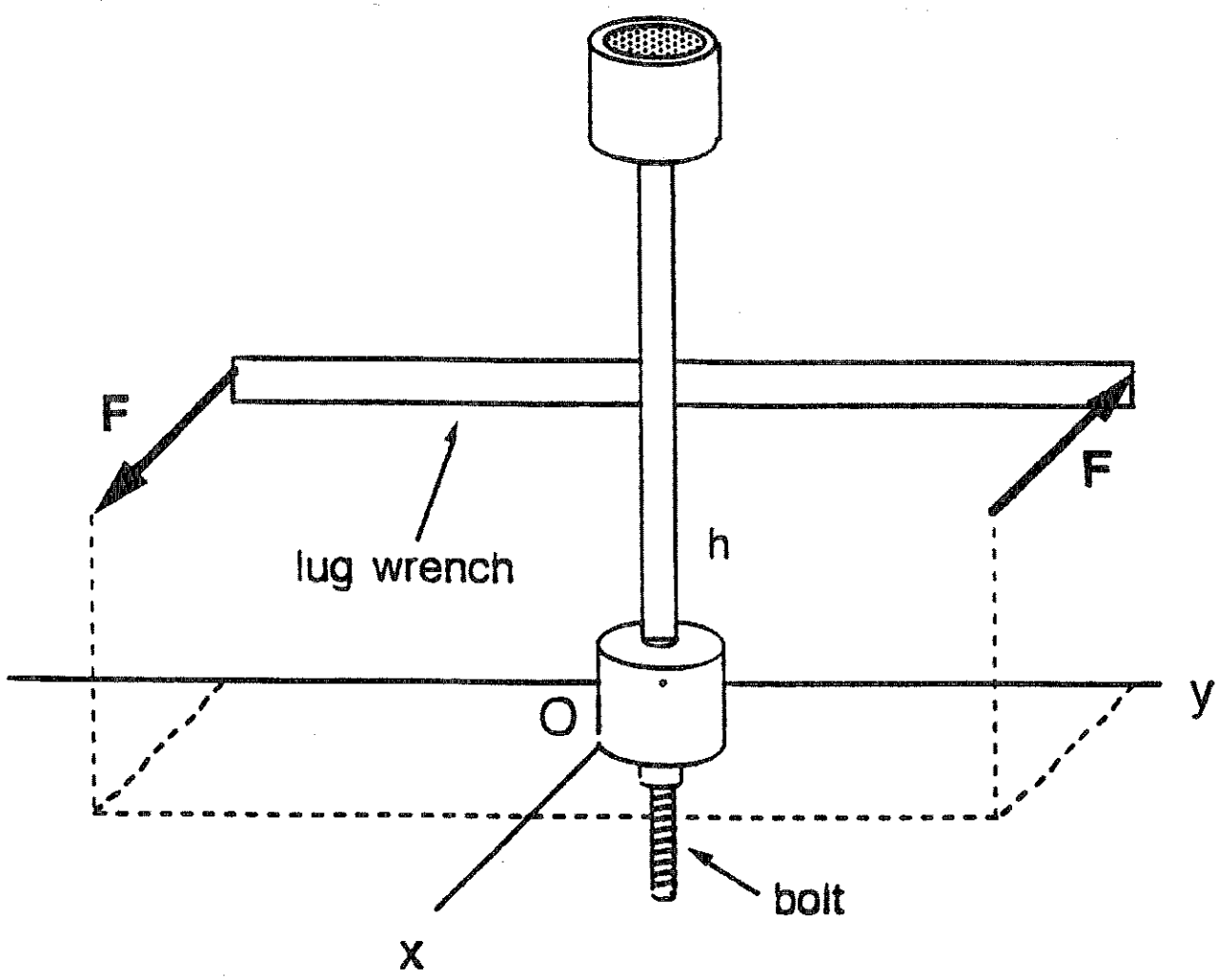
$$\overline{M} = \overline{r}_{AB} \times \overline{F}$$

where $\overline{r}_{AB}$ = any position vector between the lines of action of the forces forming the couple.

Comments

1). Force couples cause *no net force* (i.e., $\sum \overline{F} = 0$).

2). The moment due to a force couple is the *same* regardless of the point the moment is summed about. (This not true of a non-couple).


F
F
lug wrench
h
O
y
x
bolt

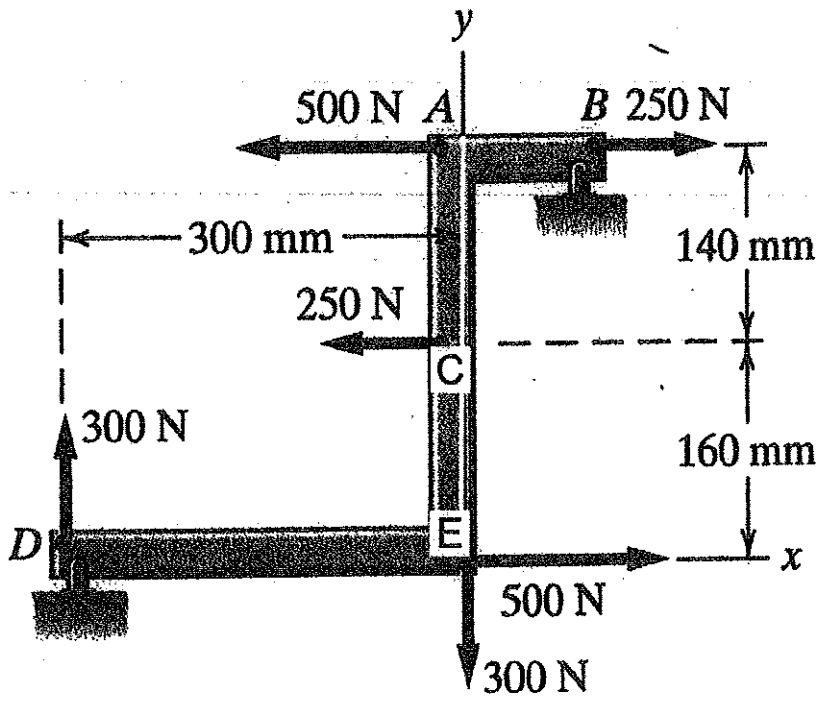
Force Couples
Example 1

Given: Angled bar ABCDE is loaded with several force couples as shown.

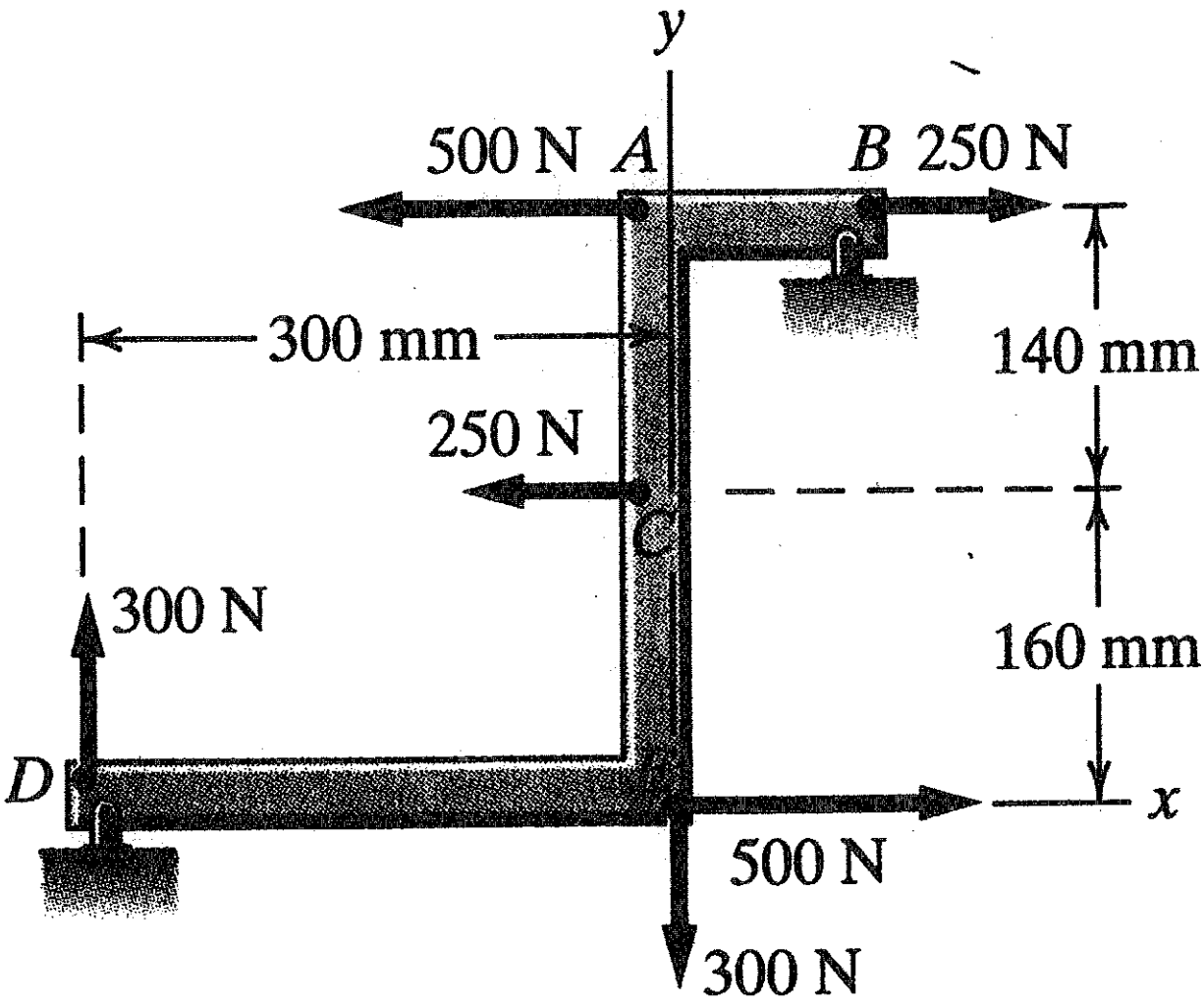
Find:

a) Determine the magnitude and direction of each force couple pair.

b) Determine the equivalent moment and direction of all of the force couples combined.



Solution:

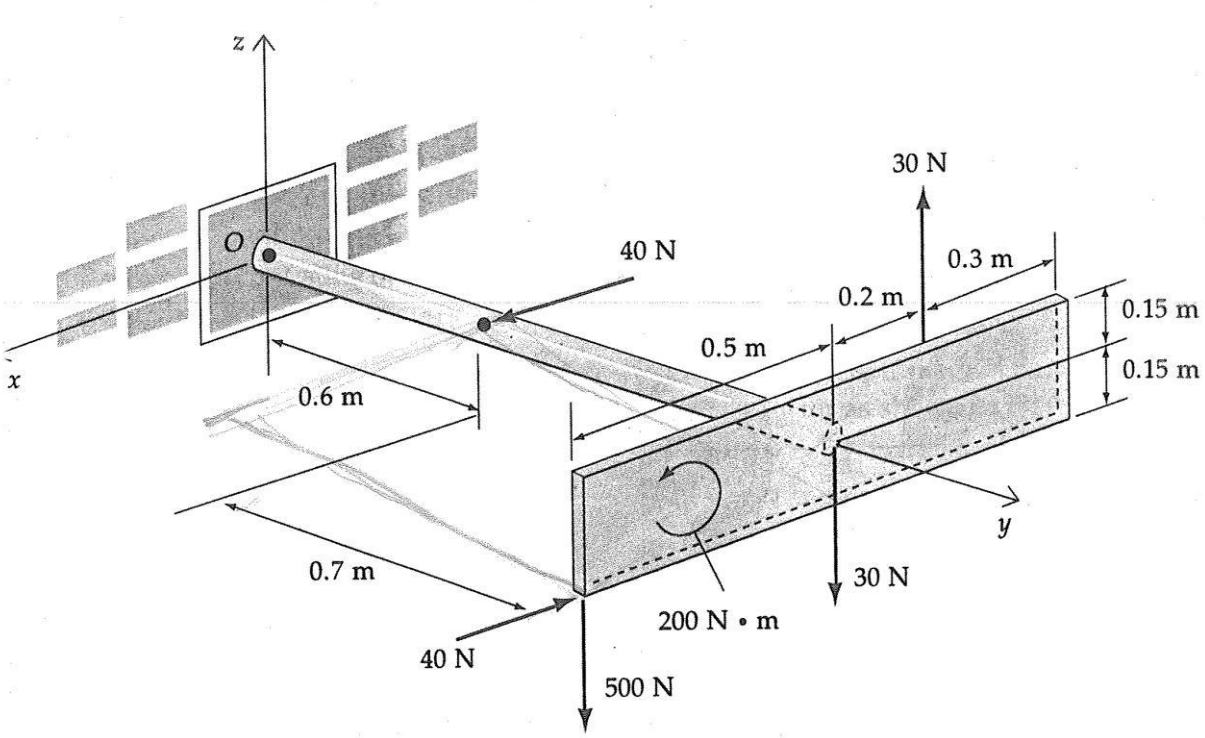

y
500 N
A
B
250 N
300 mm
140 mm
250 N
C
300 N
160 mm
D
x
500 N
300 N

Force Couples
Example 2

Given: The rod and plate system is loaded by several force couples.

Find:

a) Determine the equivalent magnitude and direction of each force couple.



Solution:

EQUIVALENT SYSTEMS

Learning Objectives

1). To determine an *equivalent force-couple* of a system of forces and moments.

2). To do an *engineering estimate* of this quantity.

Definition

Equivalent Systems: two force-couple systems which exert i) the same net force on a body and ii) the same net moment (or torque).

Force Condition: $(\sum \overline{F})_1 = (\sum \overline{F})_2$

Moment Condition: $(\sum M_P)_1 = (\sum M_P)_2$

Note: Selection of point P is arbitrary. Thus, choose a point that will simplify the moment equation.

Force-Couple Equivalent

Force: $\overline{R} = \sum \overline{F} = \overline{F_1} + \overline{F_2} + \overline{F_3} + \ldots$

Moment:

$$\overline{M_{rP}} = \sum \overline{M_P} = (\overline{r_1} \times \overline{F_1}) + \ldots + (\overline{r_2} \times \overline{F_2}) + (\overline{r_3} + \overline{F_3}) + \ldots + \overline{C_1} + \overline{C_2} + \ldots$$

$$= \sum_{i=1}^{N_F} (\overline{r_i} \times \overline{F_i}) + \sum_{i=1}^{N_c} \overline{C_i}$$

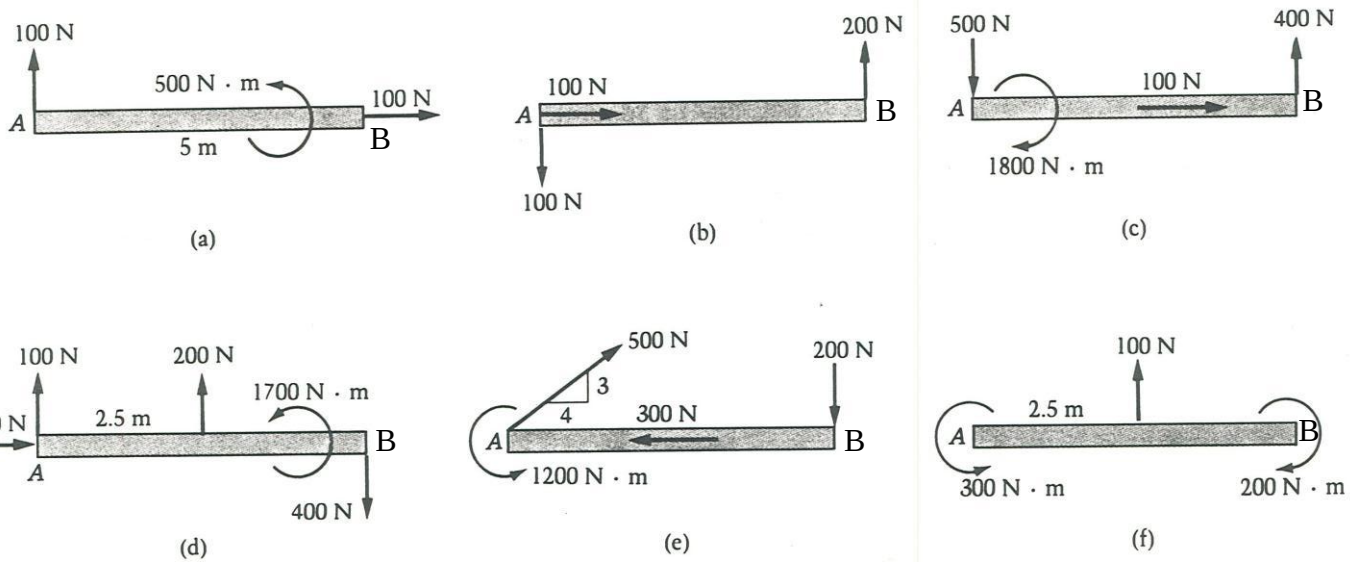
$\therefore$ *Equivalent Force-Couple System*: $\overline{F_R}$, $\overline{M_{R_O}}$ (about point P).

Equivalent Force-Couple Systems
Example 1

Given: Below are six system of forces and couples acting on bar AB.

Find:

a) Which of these system of forces and couples are equivalent?



Solution:

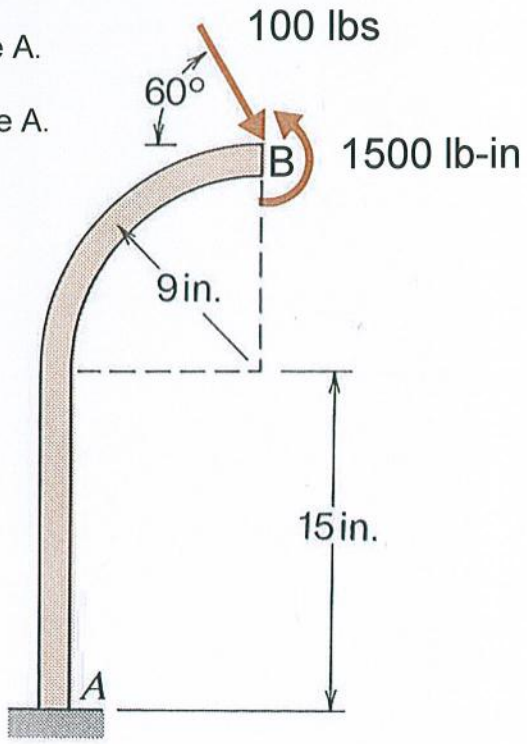
Equivalent Force-Couple Systems
Example 2

Given: Curved bar AB is loaded with a 100 lb force and a 1500 lb-in couple as shown.

Find:

a) Estimate the equivalent force-couple system at base A.

b) Calculate the equivalent force-couple system at base A.



Solution:

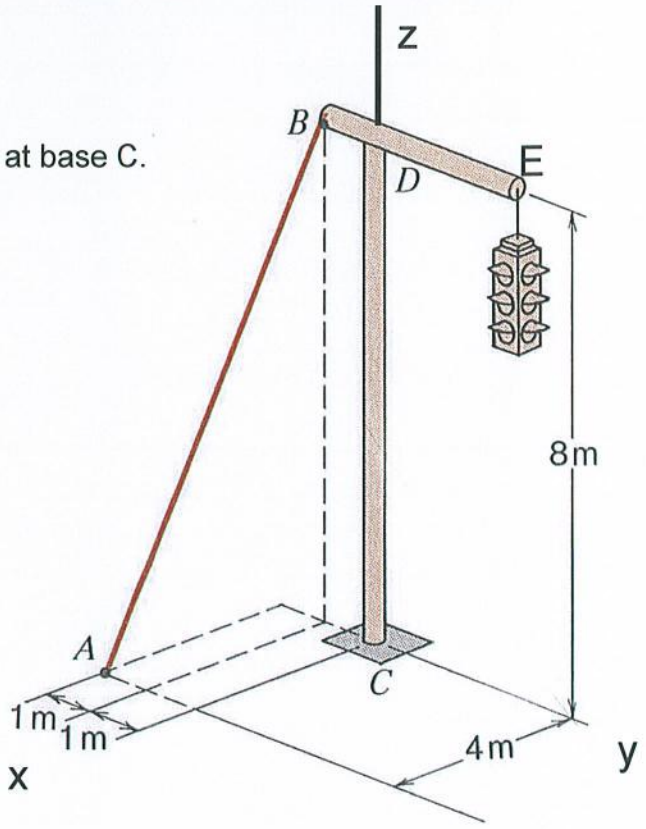
Equivalent Force-Couple Systems

Example 3

Given: Traffic light pole BCDE is loaded with a 200 N traffic light at E and partially supported by cable BA. (DE = 3m)

Find:

a) Determine the equivalent force-couple system at base C.



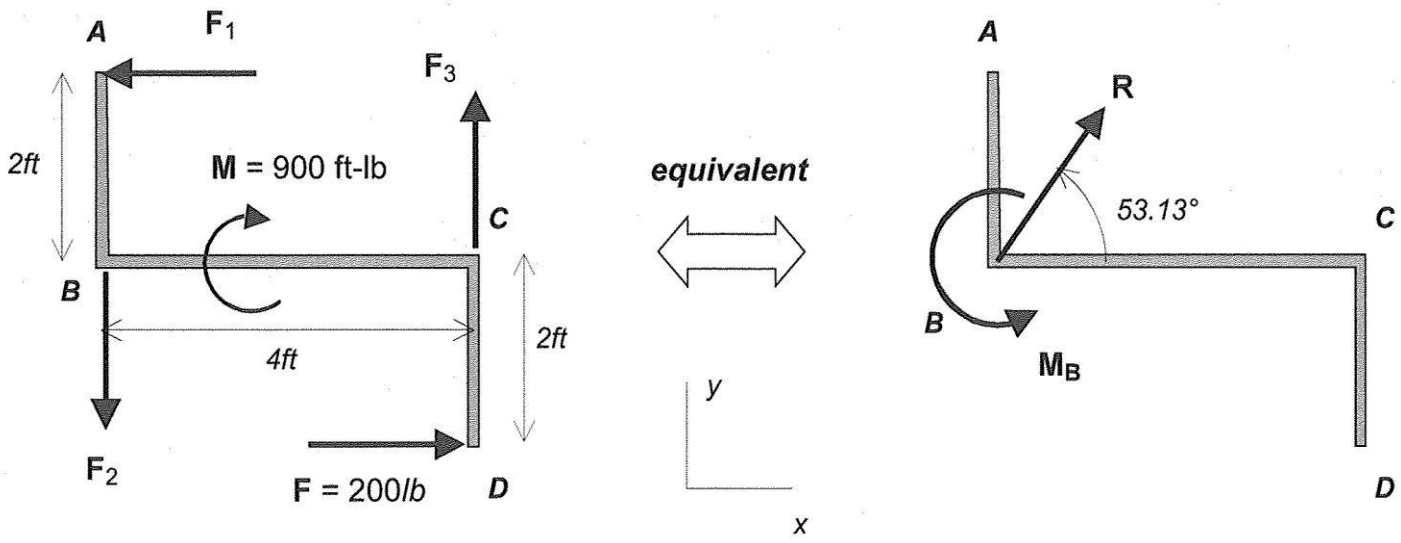
Solution:

Equivalent Force-Couple Systems
Example 4

Given: Force-couple system I shown *below left* is made up of four forces F_1, F_2, F_3, and F acting at points A, B, C, and D, respectively, in addition to a couple *M*. Force *F* and couple *M* are *known* to have magnitudes of 200 lb and 900 ft-lb, respectively.

Force-couple system II shown *below right* is made up of a force R at B and a couple M_B, with *R* and M_B, having *known* magnitudes of 300 lb and 600 ft-lb, respectively.

Find: If System II is to be the *equivalent force-couple* of System I, what are the magnitudes of the forces F_1, F_2, and F_3?



Solution:

Equivalent Force-Couple Systems
Group Quiz

Group #: _____ Group Members: 1) _____
(Present Only)

Date: _____ Period: _____ 2) _____

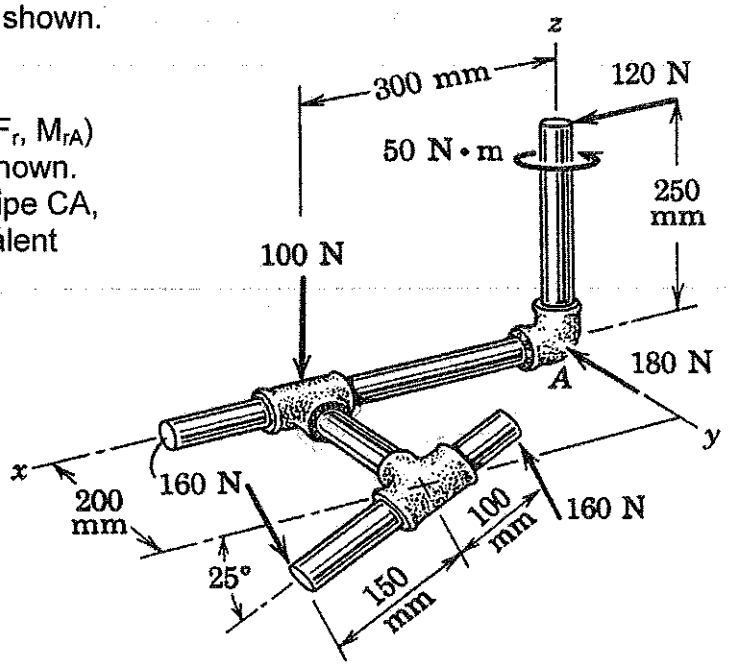
3) _____

4) _____

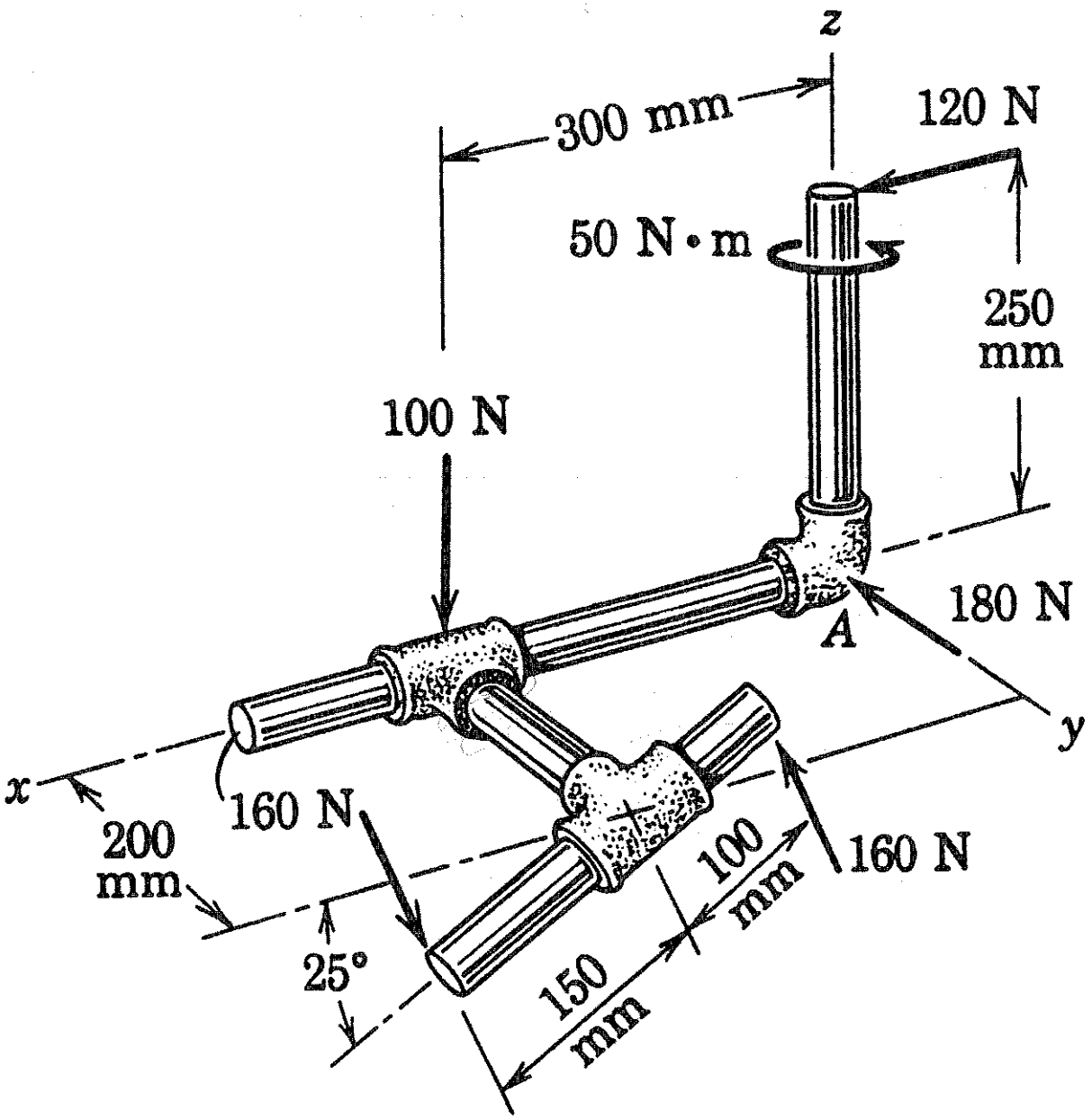
Given: A pipe assembly has a force system shown.

Find:

a) Find a force-couple resultant at point A (F_r, M_{rA}) which is equivalent to the force system shown.
b) If the 50N-m couple were shifted down pipe CA, what effect would this have on the equivalent force-couple system at point A?



Solution:



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