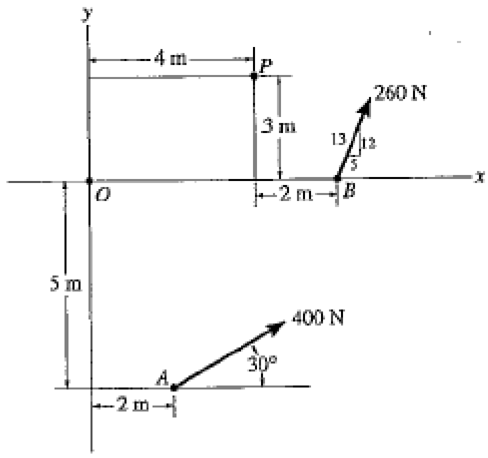
CIVIL ENGINEERING DEPARTEMNT - KFUPM.

CE 202 Statics and Strength of Materials

First Semester: ' 101 Instructor: Dr. Salah Al-Dulaijan

HOME WORK ASSIGNMENT NO. 2 SOLUTION

1. Determine the magnitude and directional sense of the resultant moment of the forces about point P.



Solution:

Sign convention: All clockwise moments are +ve, and counterclockwise moments are –ve

M_pF_y = –260(12/13)(2) + 400sin30°(2)

= 480+400

=-80 Nm

M_pF_x = -260(5/13)(3) – 400cos30°(8)

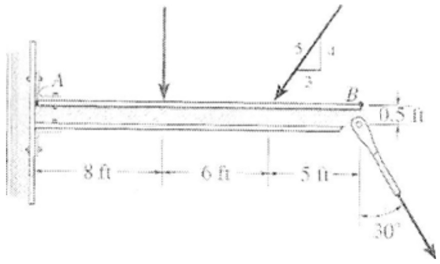
=-300-2771.28 Nm

=-3071.28 Nm

M_p = M_pF_x + M_pF_y = -80 Nm - 3071.28 Nm = -3151.28 Nm

Therefore the magnitude of the resultant moment of the forces about point P is ***3151.28 Nm***, and directional sense is ***counterclockwise***

2. Determine the moment about point B of each of the three forces acting on the beam.



Solution:

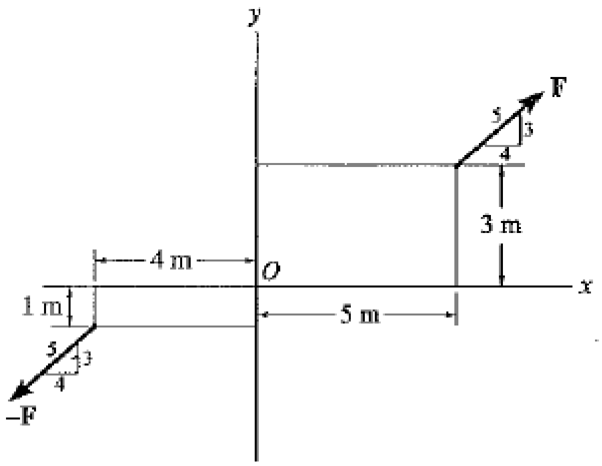
Sign convention: All clockwise moments are +ve, and counterclockwise moments are –ve

F_1: $M_{BF1} = -375 \times 11 = -4125$ lb.ft

F_2: $M_{BF2} = -500 \times (4/5) \times 5 = -2000$ lb.ft

F_3: $M_{BF3} = -160 \times \sin(30°) \times 0.5 = -40$ lb.ft

3. Determine the magnitude and sense of the couple moment. Each force has a magnitude of F = 8 kN.



Solution:

Sign convention: All clockwise moments are +ve, and counterclockwise moments are –ve

F_1: $M_{OF1x} = 8 \times (4/5) \times 3 = 19.2$ KNm

$M_{OF1y} = -8 \times (3/5) \times 5 = -24.0$ KNm

F_2: $M_{OF2x} = 8 \times (4/5) \times 1 = 6.4$ KNm

$M_{OF2y} = -8 \times (3/5) \times 4 = -19.2$ KNm

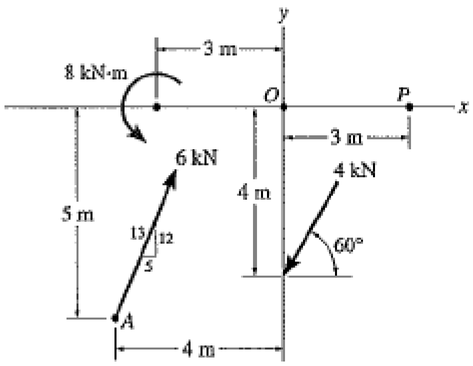
Total Moment, $M_O = M_{OF1x} + M_{OF1y} + M_{OF2x} + M_{OF2y}$

$= 19.2 - 24.0 + 6.4 - 19.2$

$= -17.6$ KNm

Therefore the couple moment has a magnitude of ***17.6 Nm***, and produces a ***counterclockwise*** moment about point O

4. Replace the force and couple system by an equivalent force and couple moment at point O.



Solution:

Sign convention: All clockwise moments are +ve, and counterclockwise moments are –ve

M_1: $M_{OM1} = -8\ KNm$

F_1: $M_{OF1x} = -6 \times (5/13) \times 5 = 150/13\ KNm$

$M_{OF1y} = +6 \times (12/13) \times 4 = -288/13\ KNm$

F_2: $M_{OF2x} = +4 \times \cos(60°) \times 4 = 8\ KNm$

$M_{OF2y} = +4 \times \sin(60°) \times 0 = 0\ KNm$

Total moment about O, $M_O = M_{OM1} + M_{OF1x} + M_{OF1y} + M_{OF2x} + M_{OF2y}$

$= 8 + 150/13 - 288/13 + 8$

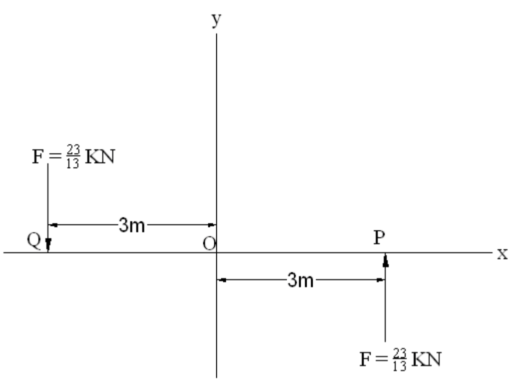
$= -138/13\ KNm, =10.6154\ KNm.$

Therefore we need to provide couple forces F, d metres apart that will create a counterclockwise moment about O. Lets choose points P & Q along the line PQ, then

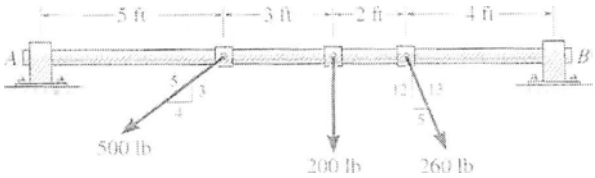
$d = PQ = 6m$

$F = M_O/d = 138/(13\times6) = 23/13\ KN = 1.7692 KN$

The couple will need to be such that will produce a counterclockwise moment as illustrated below



5. Replace the three forces acting on the shaft by a single resultant force. Specify where the force acts, measured from point B.



Solution:

Sign convention: All clockwise moments are +ve, and counterclockwise moments are –ve

Total vertical force, $F_y = -500 \times (3/5) - 200 - 260 \times (12/13) = -740$ lb

Total horizontal force, $F_x = -500 \times (4/5) + 260 \times (5/13) = -300$ lb

$F_R = \sqrt{(F_x^2 + F_y^2)} = \sqrt{(300^2 + 740^2)} = 798.5$ lb

$\theta = \tan^{-1}(740/300) = 67.9°$ to the -ve x-axis,

Take Moment about any point on the system, say B

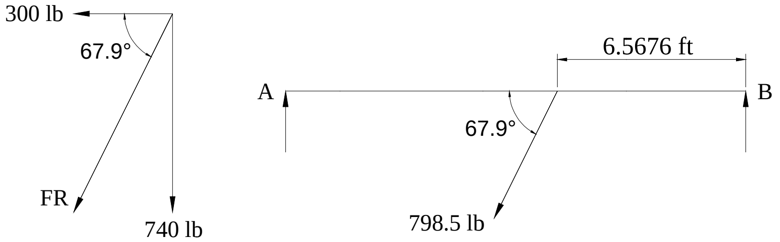
Moment about B is produced only by F_y, thus

$M_B = -500 \times (3/5) \times 9 - 200 \times 6 - 260 \times (12/13) \times 4 = -4860$ lb.ft

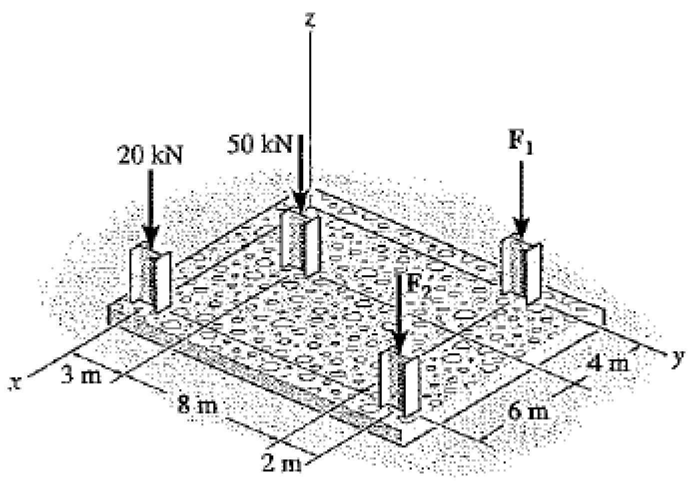
The total moment of all the vertical components of the forces is the same by the moment of the vertical component of the resultant of the forces. Thus

$F_y \times d = -4860$ lb.ft

$-740d = -4860$ lb.ft $\Longrightarrow d = 243/37$ ft $= 6.5676$ ft from end B of the shaft.



6. The building slab is subjected to four parallel column loadings. Determine the equivalent resultant force and specify its location (x,y) on the slab. Take F_1 20 kN, F_2= 50 kN.



Total Force/Force resultant, Fz = −20 − 50 − 20 − 50 = −140 KN, meaning 140 KN downward
Moment about x – axis, Mx = 20(0) + 50(3) + 20(11) + 50(13) = 1020 KNm
Moment about y – axis, My = 20(10) + 50(4) + 20(0) + 50(10) = 900 KNm

Load centre along x, represented by Y is given by

My = Fz × X ⟹ X = My/Fz

X = My/Fz = 900/140 = 45/7 = 6.4286m

Similarly,

Y = Mx/Fz = 1020/140 = 51/7 = 7.2857m

Therefore, the equivalent resultant force = ***140 KN (downward)*** and its location (x,y) relative to the origin is ***(6.4286m,7.2857m)***