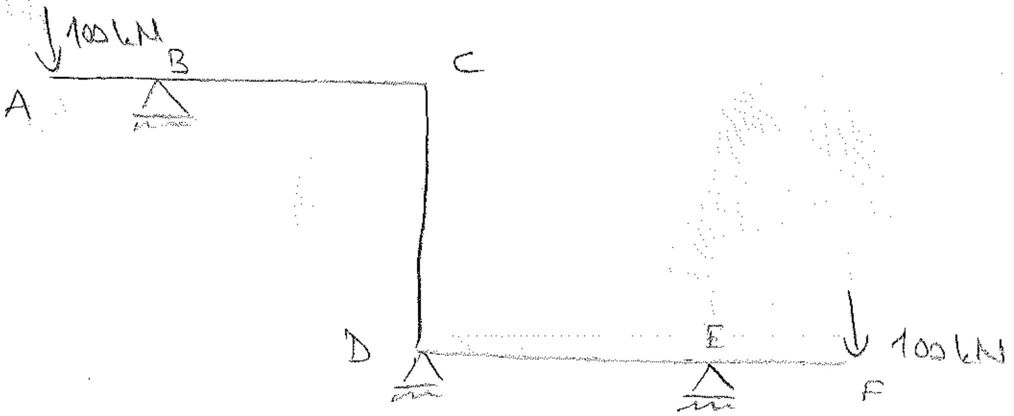
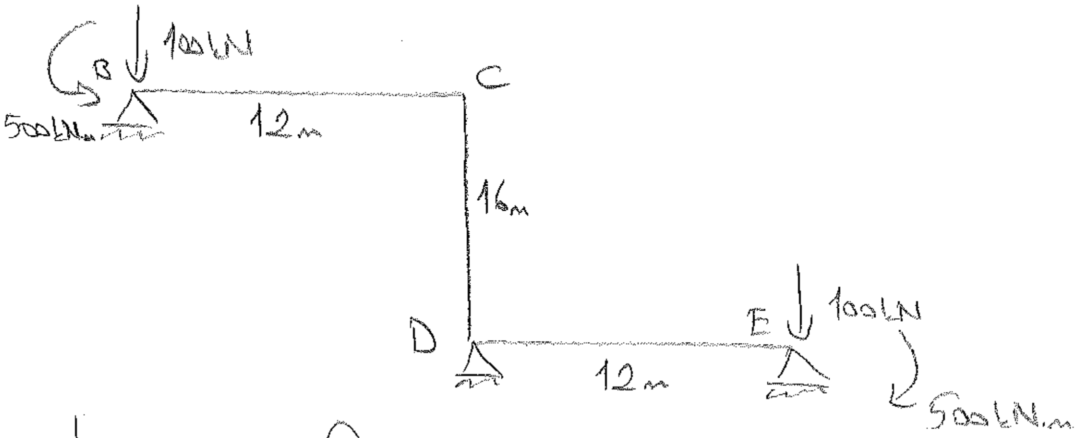
1)



Simplify it.



$k_{BC} = 0$ // for pin support

$k_{CB} = \frac{4EI}{12} = \frac{EI}{3}$ //

$k_{CD} = \frac{4EI}{16} = \frac{EI}{4}$ //

$k_{DC} = \frac{4EI}{16} = \frac{EI}{4}$ //

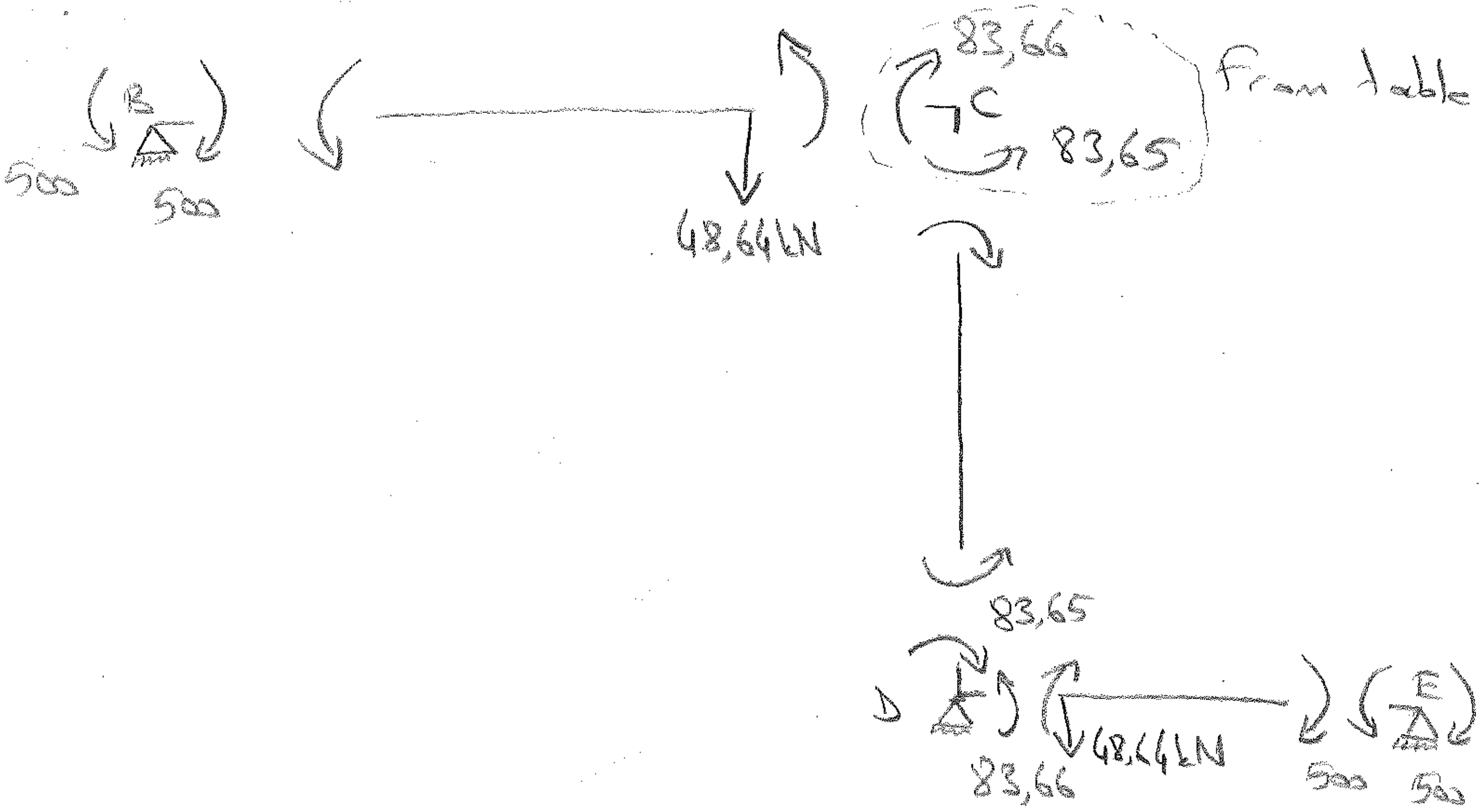
$k_{DE} = \frac{4EI}{12} = \frac{EI}{3}$ //

Calculate the distribution factors.

$D_{CB} = \frac{EI/3}{EI/3 + EI/4} = 0{,}57$ // $\Rightarrow D_{CD} = 1 - D_{CB} = 0{,}43$ //

$D_{DC} = \frac{EI/4}{EI/3 + EI/4} = 0{,}43$ // $\Rightarrow D_{DE} = 1 - D_{DC} = 0{,}57$ //

		B		C		D	E	
DF	0	1	0,57	0,43	0,43	0,57	1	0
	Pin	BC	CB	CD	DC	DE	ED	Pin
FEM	-500	0	0	0	0	0	0	500
Dist.		500	0	0	0	0	-500	
Co		0	250	0	0	-250	0	
Dist.		0	-142,5	-107,5	107,5	142,5	0	
Co		-71,25	0	53,75	-53,75	0	71,25	
Dist.		71,25	-30,64	-23,11	23,11	30,64	-71,25	
Co		-15,32	35,63	11,56	-11,56	-35,63	15,32	
Dist.		15,32	-26,9	-20,3	20,3	26,9	-15,32	
Co		-13,45	7,66	10,15	-10,15	-7,66	13,45	
Dist.		13,45	-10,15	-7,66	7,66	10,15	-13,45	
Co		-5,08	6,73	3,83	-3,83	-6,73	5,08	
Dist.		5,08	-6,02	-4,54	4,54	6,02	-5,08	
Co		-3,01	2,54	2,27	-2,27	2,54	3,01	
Dist.		3,01	-2,74	-2,07	2,07	2,74	-3,01	
Co		-1,37	1,51	1,04	-1,04	-1,51	1,37	
Dist.		-1,37	-1,45	-1,1	1,1	1,45	-1,37	
Co		-0,73	0,69	0,55	-0,55	-0,69	0,73	
Dist.		0,73	-0,71	-0,53	0,53	0,71	-0,73	
Co		-0,36	0,37	0,27	-0,27	0,37	0,36	
Dist.		0,36	-0,36	-0,26	0,26	0,36	-0,36	
M_f		500	83,66	-83,65	83,65	-83,66	-500	



$$R_D = 2 \cdot 48{,}64 = 97{,}28 \text{ kN}$$

II. way: Use modified stiffness coefficients while calculating distribution factors.

$$k_{CB} = \frac{3EI}{12} = \frac{EI}{4} \qquad k_{DC} = \frac{EI}{4}$$

$$k_{CD} = \frac{4EI}{16} = \frac{EI}{4} \qquad k_{DE} = \frac{3EI}{12} = \frac{EI}{4}$$

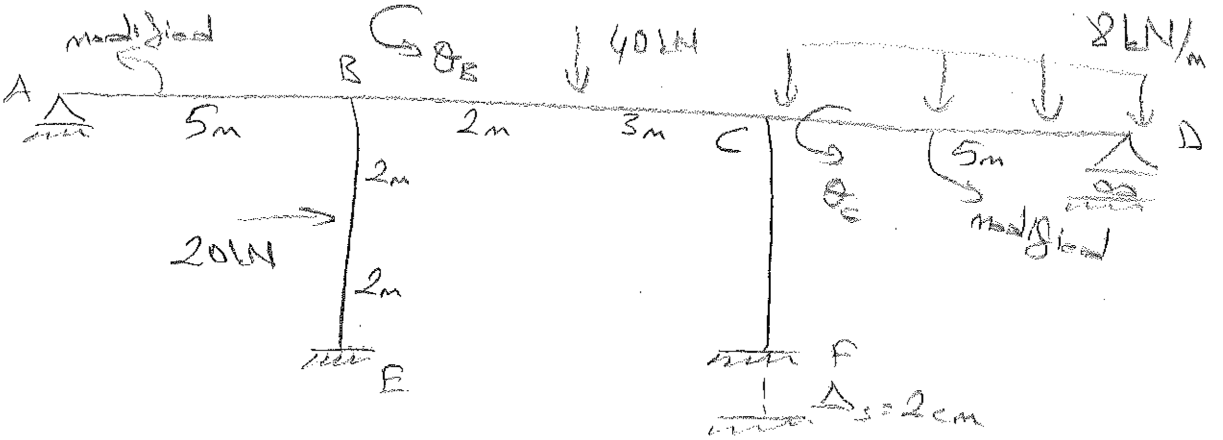
$$D_{CB} = \frac{EI/4}{EI/4 + EI/4} = 0{,}5 \Rightarrow D_{CD} = 1 - 0{,}5 = 0{,}5$$

$$D_{DC} = \frac{EI/4}{EI/4 + EI/4} = 0{,}5 \Rightarrow D_{DE} = 1 - 0{,}5 = 0{,}5$$

	B		C		D		E	
DF	0	1	0,5	0,5	0,5	0,5	1	0
	Pin	BC	CB	CD	DC	DE	ED	Pin
FEM	-500	0	0	0	0	0	0	500
Dist.	500		0	0	0	0	-500	
CO	No		250	0	0	-250	No	
Dist.	—		-125	-125	125	125	—	
CO	—		0	62,5	-62,5	0	—	
Dist.	—		-31,25	-31,25	31,25	31,25	—	
CO	—		0	15,63	-15,63	0	—	
Dist.	—		-7,81	-7,81	7,81	7,81	—	
CO	—		0	3,91	-3,91	0	—	
Dist.	—		-1,96	-1,96	1,96	1,96	—	
CO	—		0	0,98	-0,98	0	—	
Dist.	—		-0,49	-0,49	0,49	0,49	—	
CO	—		0	0,25	-0,25	0	—	
Dist.	—		-0,13	-0,13	0,13	0,13	—	
M_f	500		83,36	-83,37	83,37	-83,36	-500	

$$R_D = 2 \cdot \frac{500 + 83,36}{12} = 97,23\,kN \downarrow$$

2) a)



There are two unknown displacements θ_B and θ_c.

$$\Sigma M_B = 0 \Rightarrow M_{BA} + M_{BC} + M_{BE} = 0$$

$$\underbrace{\frac{3EI}{5}\cdot\left(\theta_B\right)}_{M_{BA}} + \underbrace{\frac{2EI}{5}\cdot\left(2\theta_B + \theta_c + \frac{3.0{,}02}{5}\right) + \frac{40.3^2.2}{5^2}}_{M_{BC}} +$$

$$\underbrace{\frac{2EI}{4}\cdot\left(2\theta_B + 0\right) - \frac{20.4}{8}}_{M_{BE}} = 0$$

$$48.000.\theta_B + 8000.\theta_c = -114{,}8 \quad (1)$$

$$\Sigma M_c = 0 \Rightarrow M_{CB} + M_{CD} + M_{CF} = 0$$

$$\underbrace{\frac{2EI}{5}\cdot\left(2\theta_c + \theta_B + \frac{3.0{,}02}{5}\right) - \frac{40.2^2.3}{5^2}}_{M_{CB}} + \underbrace{\frac{3EI}{5}\cdot\left(\theta_c - \frac{0{,}02}{5}\right)}_{M_{CD}} +$$

$$\frac{8.5^2}{8} + \underbrace{\frac{2EI}{4}\cdot\left(2\theta_c + 0\right)}_{M_{CF}} = 0$$

$$8000.\theta_B + 48.000.\theta_c = -53{,}8 \quad (2)$$

Solve (1) and (2) simultaneously.

$\theta_B = 2,268 \cdot 10^{-3}$ rad

$\theta_C = -7,429 \cdot 10^{-4}$ rad

$M_{AB} = 0$ N.m

$M_{BA} = -27,216$ kN.m

$M_{BC} = 82,569$ kN.m

$M_{BE} = -55,36$ kN.m

$M_{EB} = -12,68$ kN.m

$M_{CB} = 46,77$ kN.m

$M_{CD} = -31,915$ kN.m

$M_{DC} = 0$ N.m

$M_{CF} = -14,858$ kN.m

$M_{FC} = -7,429$ kN.m

b) Resolve the same structure by using moment distribution method.

$k_{BA} = \frac{3EI}{5}$

$k_{BE} = \frac{4EI}{4}$

$k_{BC} = \frac{4EI}{5}$

$Df_{BA} = 0,25$

$Df_{BE} = 0,417$

$Df_{BC} = 0,333$

$Df_{AB} = 1$ for pin support

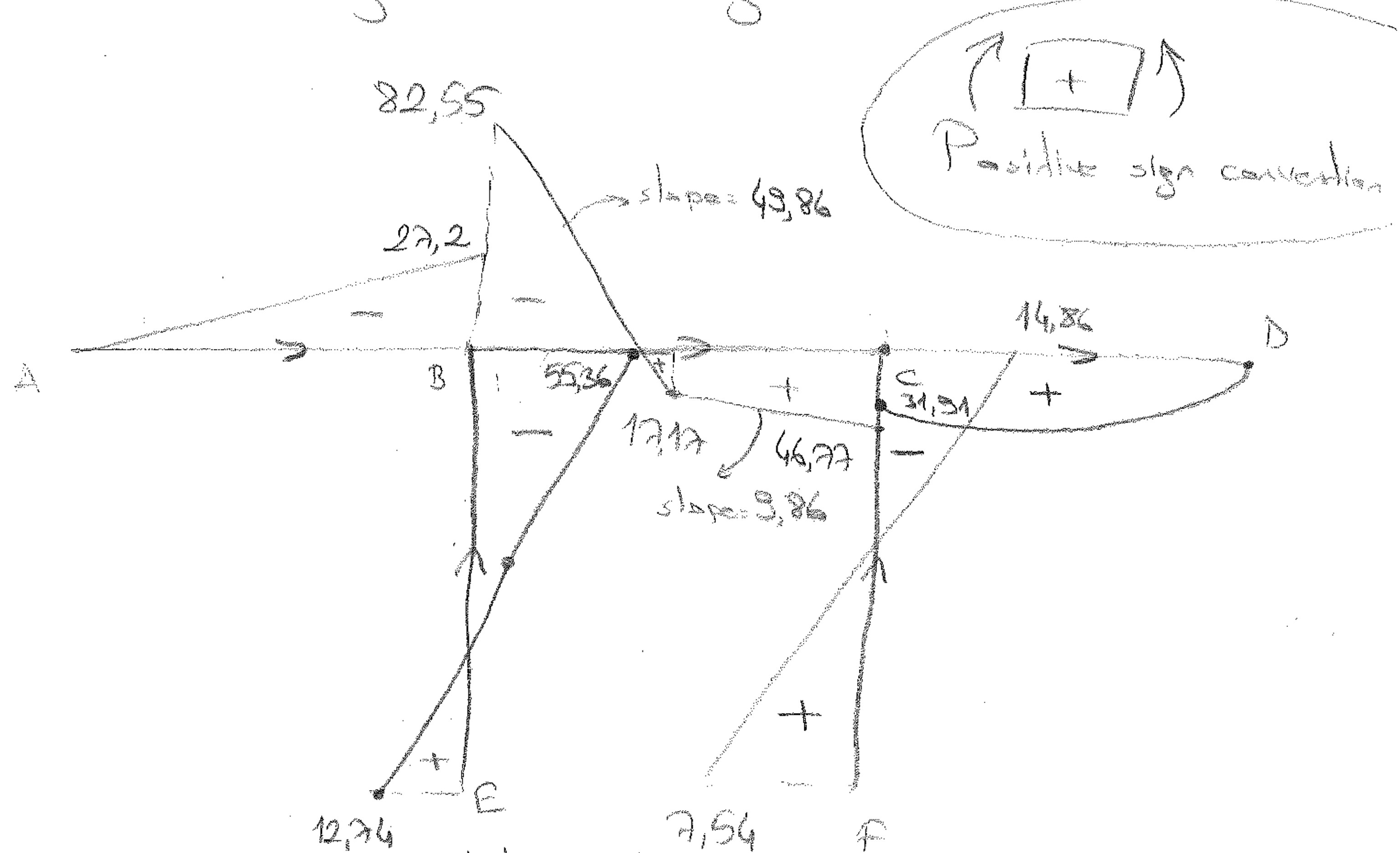
$Df_{DC} = 1$ for pin support

	A	BA	BC	CB	CD	DC
DF	$\boxed{0}\boxed{1}$ Pin	$\boxed{0,25}$	$\boxed{0,33}$	$\boxed{0,33}$	$\boxed{0,25}$	$\boxed{1}\boxed{0}$ Pin
FEM	$\boxed{0}\boxed{0}$	0	124,8	76,8	-23	$\boxed{0}\boxed{0}$
Dist	0	-28,7	-38,23	-17,92	-13,45	0
CO	M_0	0	-8,56	-13,12	0	M_0
Dist	—	2,24	2,98	6,37	4,78	—
CO	—	0	3,19	1,43	0	—
Dist.	—	-0,80	-1,06	-0,50	-0,37	—
CO	—	0	-0,25	-0,53	0	—
Dist.	—	0,06	0,08	0,18	0,13	—
M_t	0	-27,2	82,55	46,77	-31,91	0

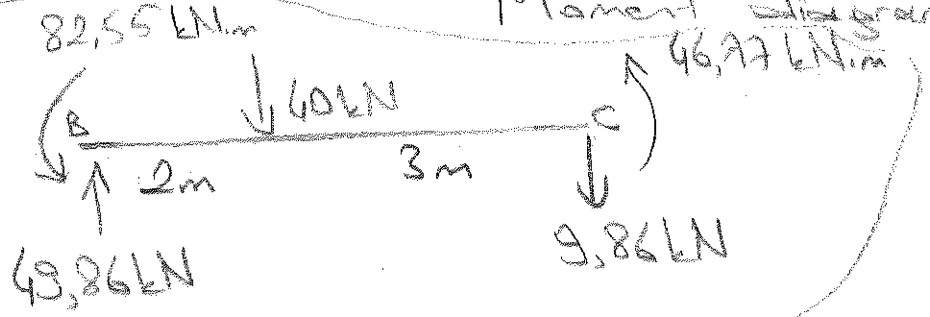
	BE $\boxed{0,417}$	EB $\boxed{0}\boxed{1}$ Fix		CF $\boxed{0,417}$	FC $\boxed{0}\boxed{1}$
FEM	-10	10	FEM	0	0
Dist	-47,87	0	Dist	-22,43	0
CO	0	-23,94	CO	0	-11,22
Dist	3,74	0	Dist	7,37	0
CO	0	1,87	CO	0	3,33
Dist	-1,33	0	Dist	-0,62	0
CO	0	-0,67	CO	0	-0,31
Dist	0,10	0	Dist	0,22	0
M_t	-55,36	-12,74	M_t	-14,86	-7,54

The member end moments are shown as M_t in the above table.

c) The bending moment diagram will be



Moment diagram



Note: The positive sign convention for SAP2000 is that M3 is positive when it creates compression on the positive 2 axis.