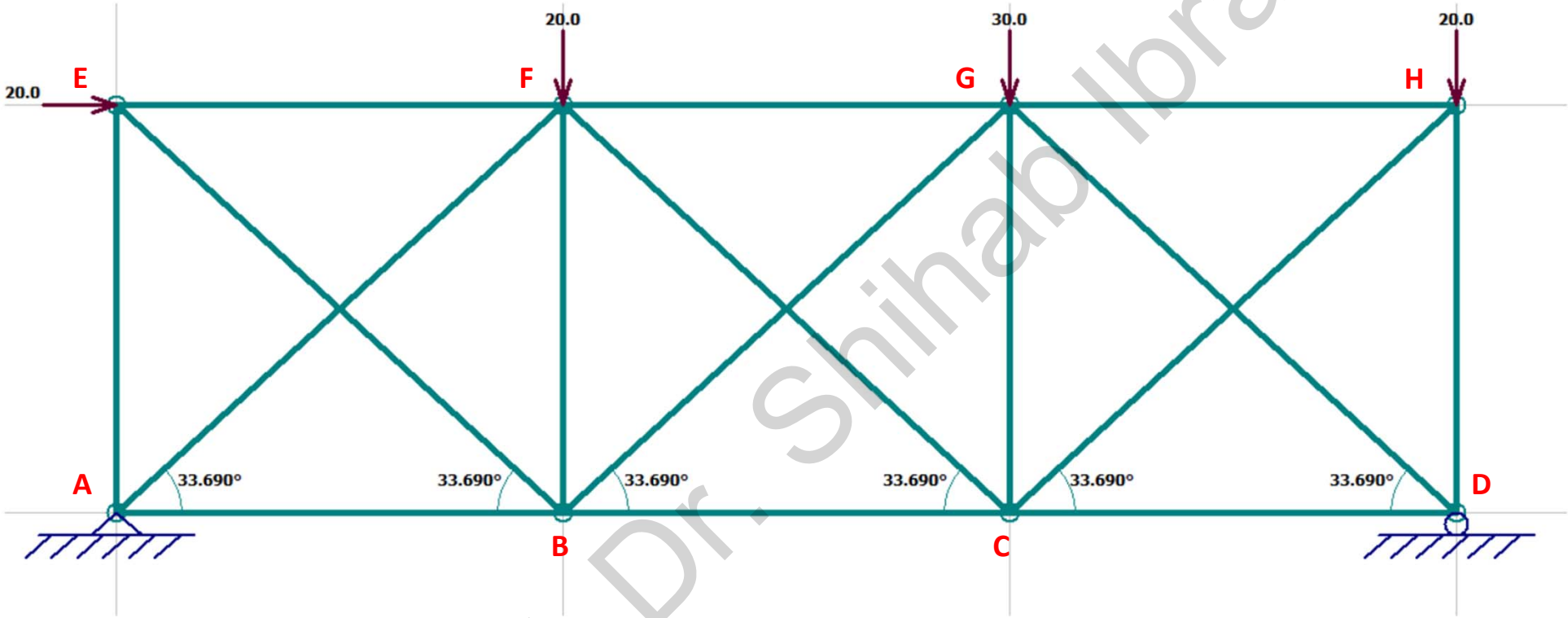
Q) Find the force member in the truss shown below using force method. Area of the members are 300 mm^2 and E=200 Gpa



Solution:

Degree of indeterminacy:

joint=8, reaction =3, and members=16

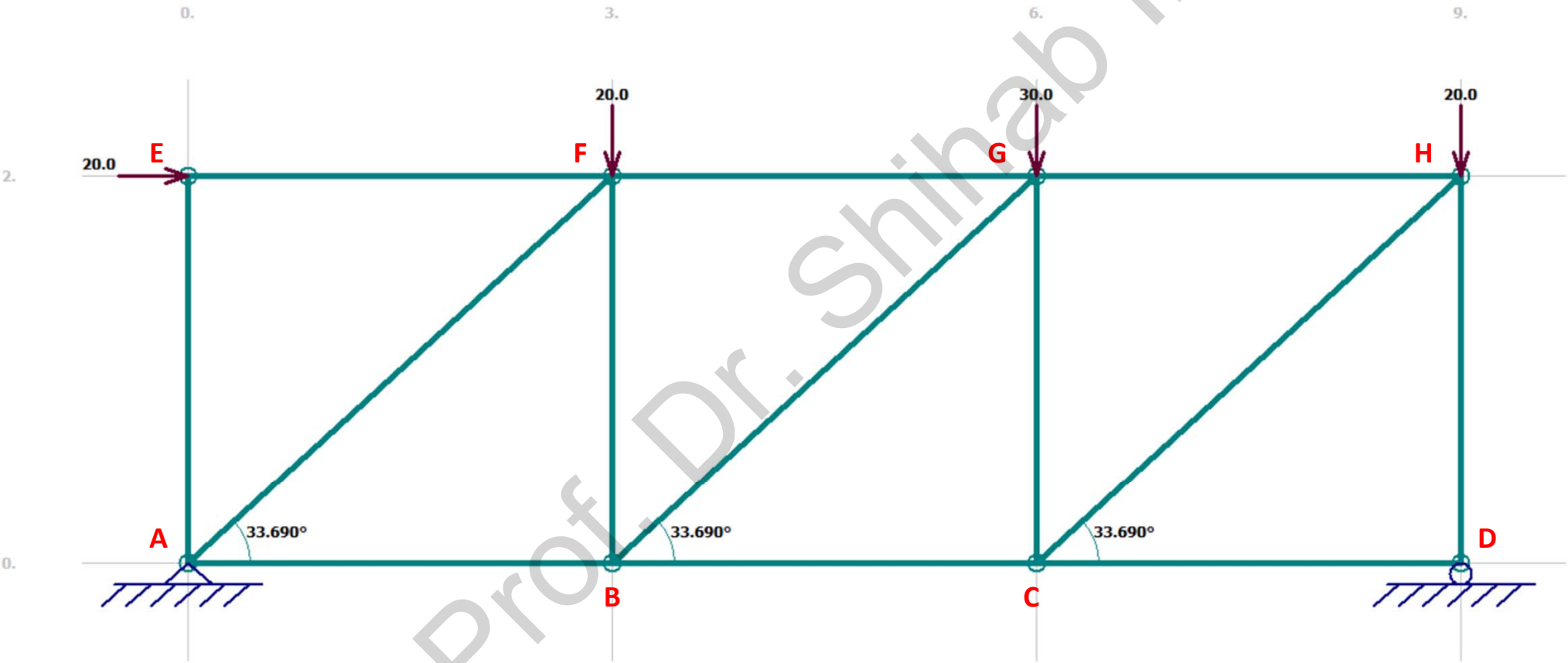
$2*8 < 16+3$

$16 < 19$

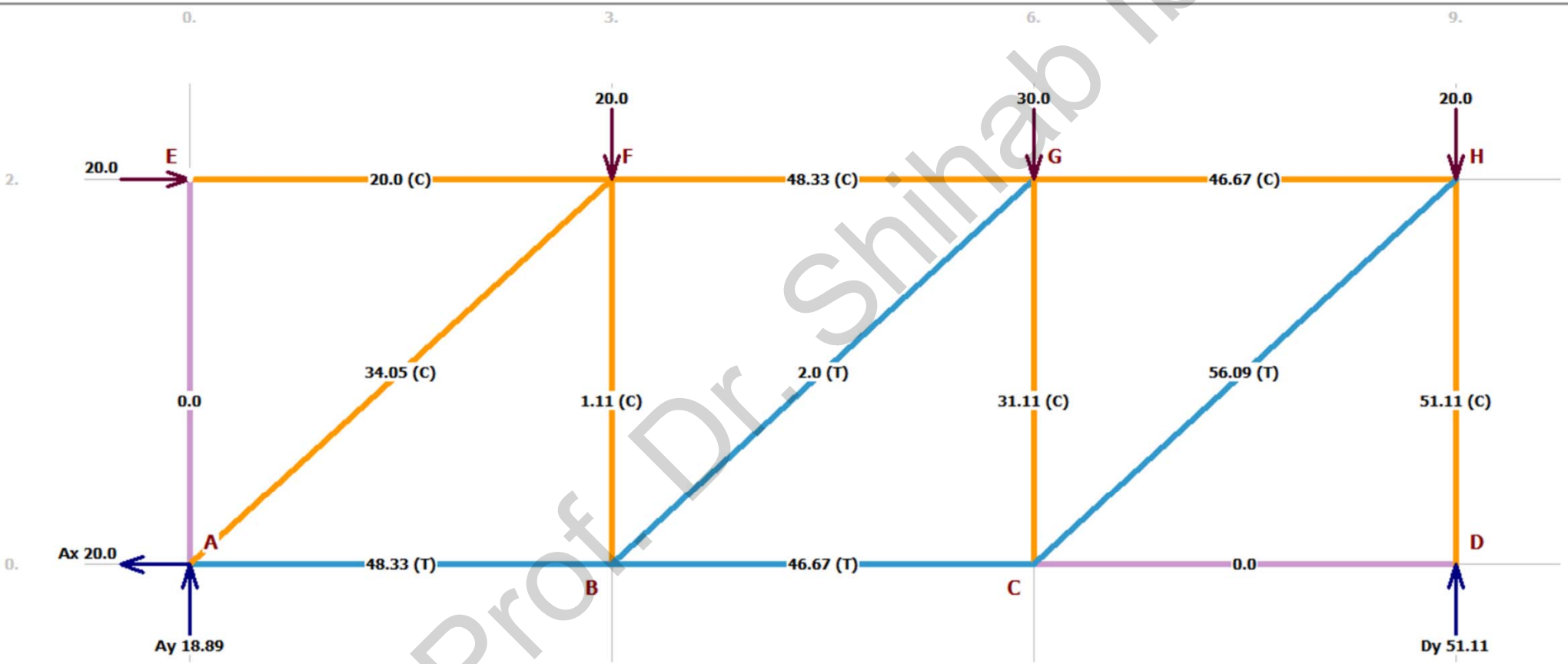
indeterminate to 3rd degree.

in force method, three members must be removed and each will be condisterd as redundant with using virtual work method total of 4 analysis must be performed as shwon in next slides.

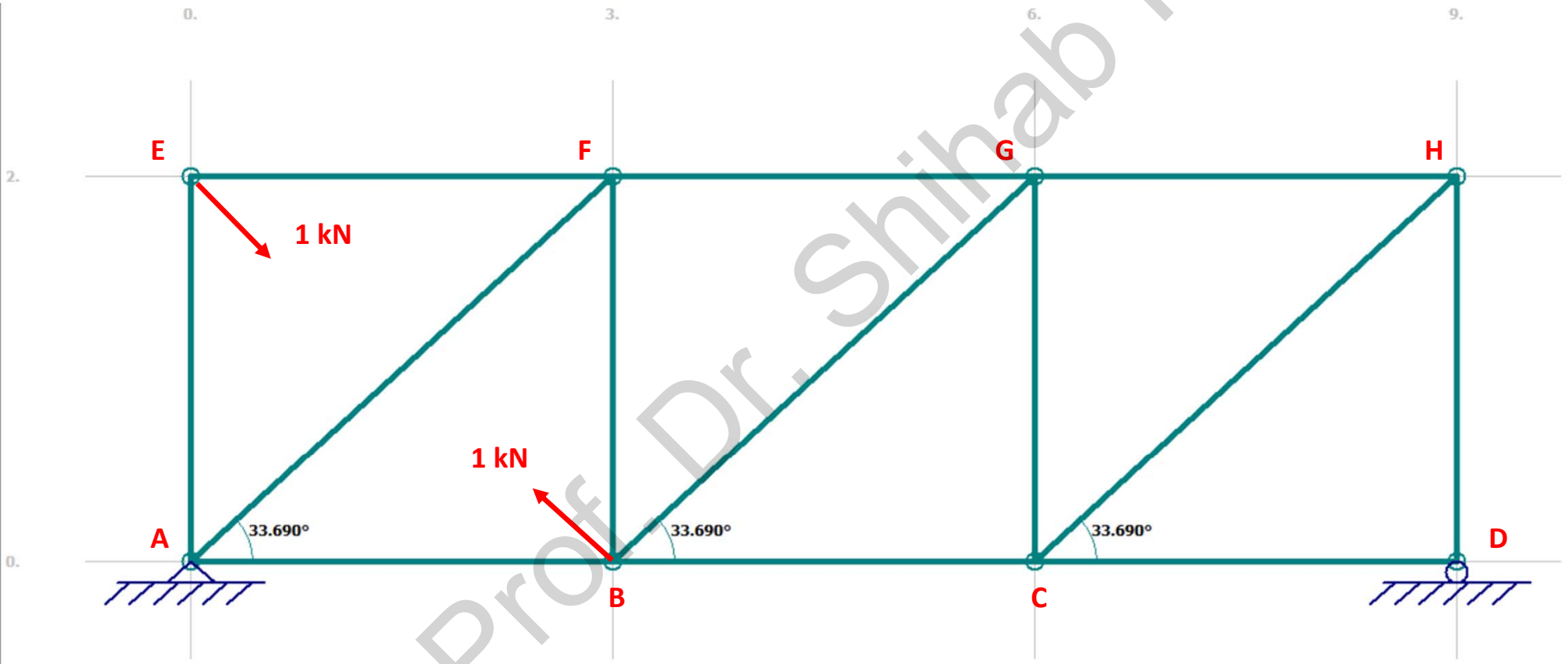
1- Primary Structure (F)



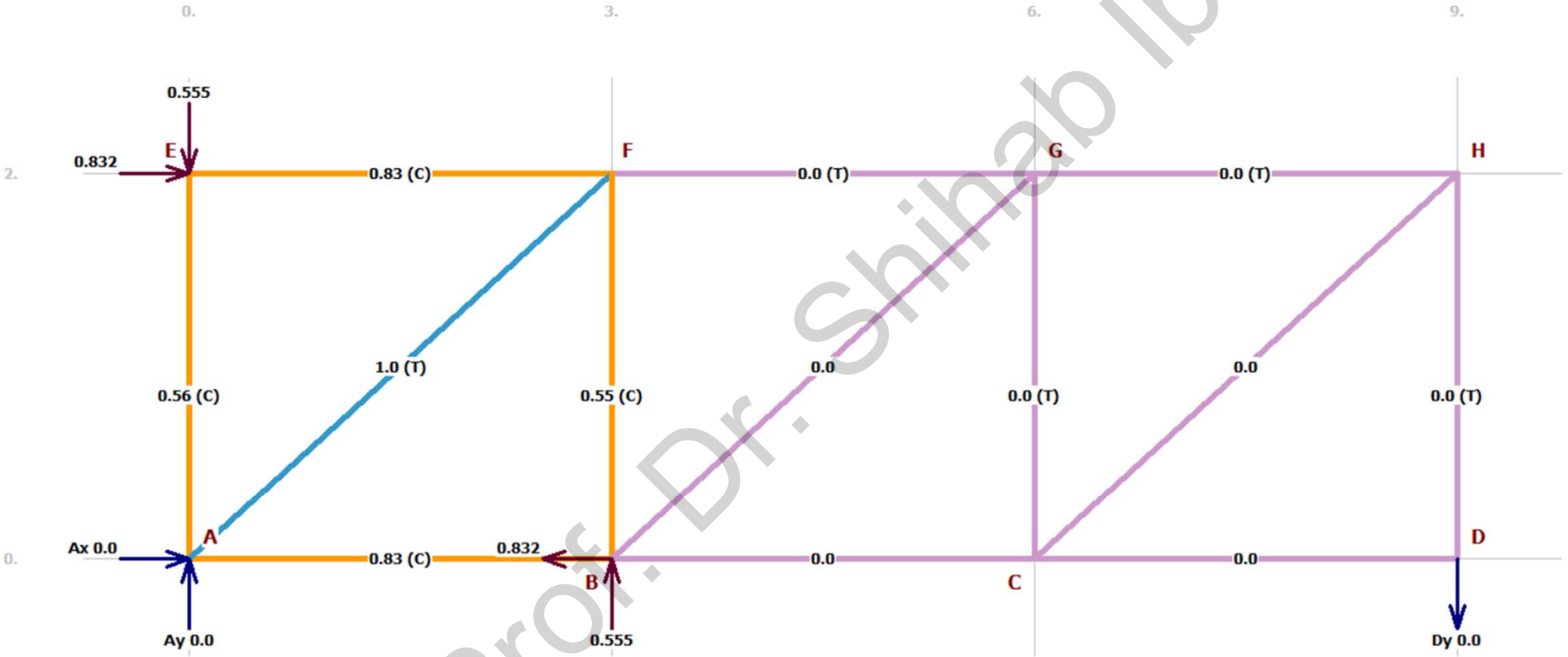
Primary Structure Solution (F)



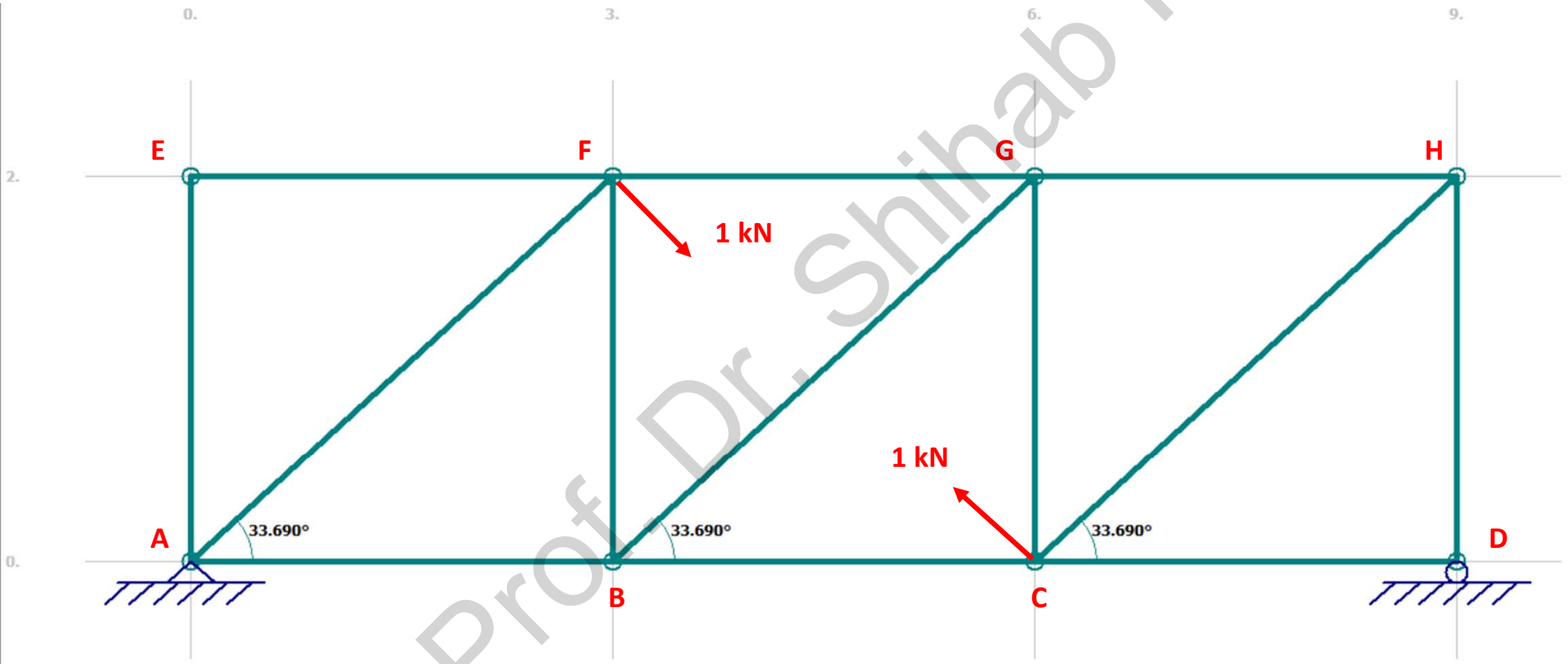
2- Virtual Truss 1 (F_{EB} Redundant)



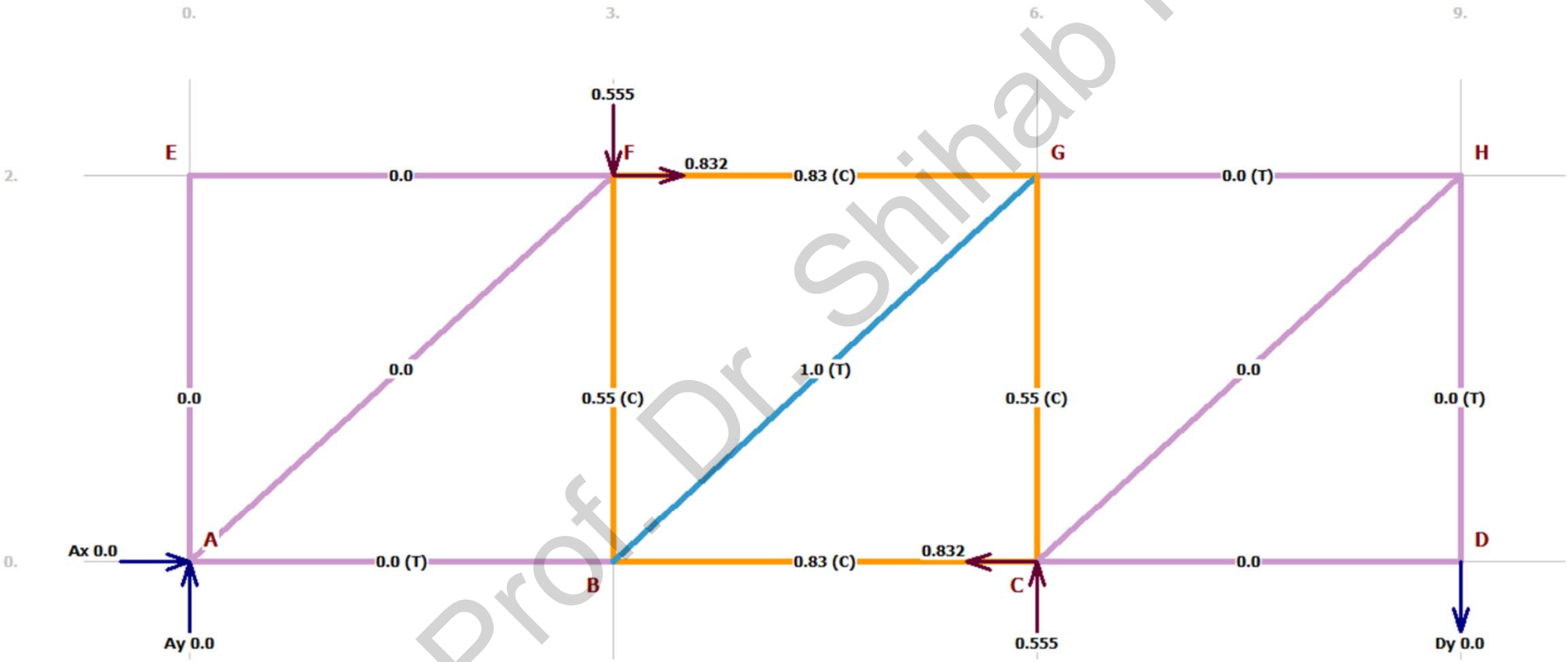
Virtual Truss 1 solution (f1)



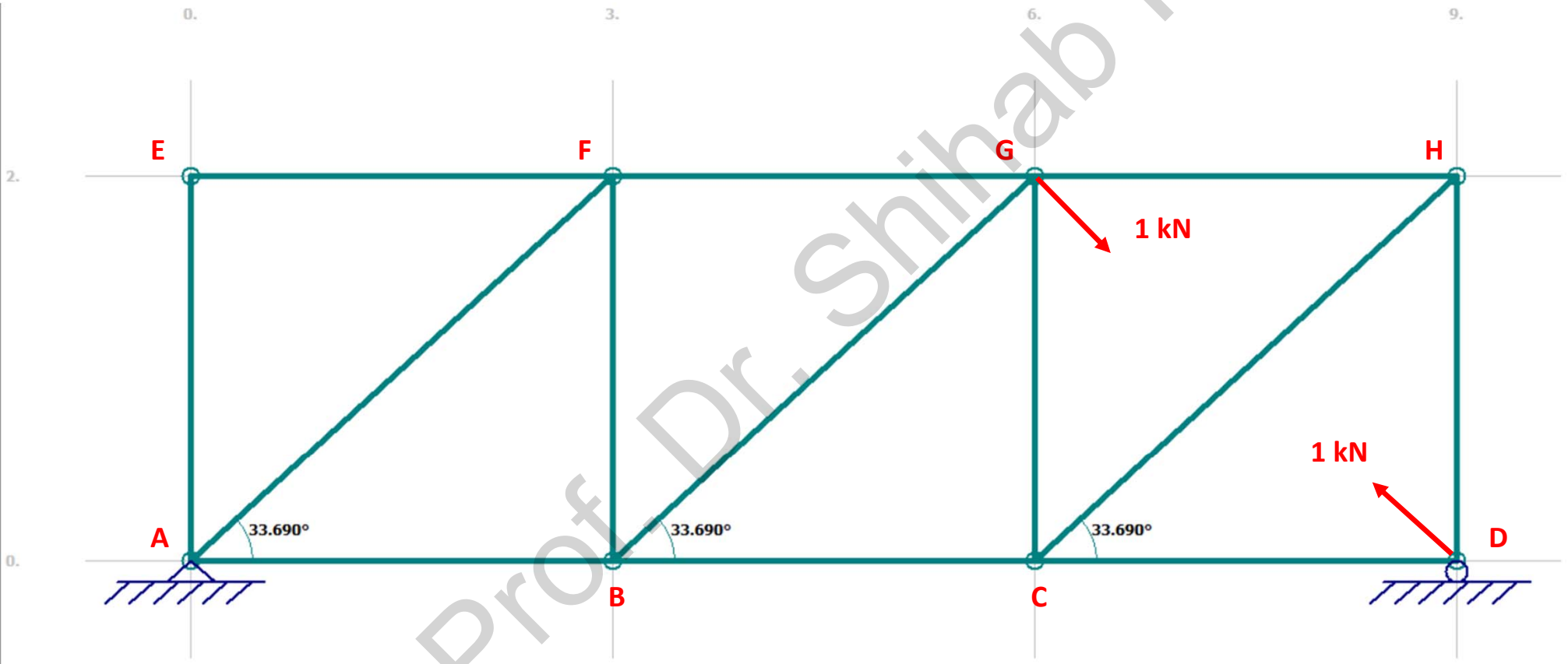
3- Virtual Truss 2 (F_{FC} Redundant)



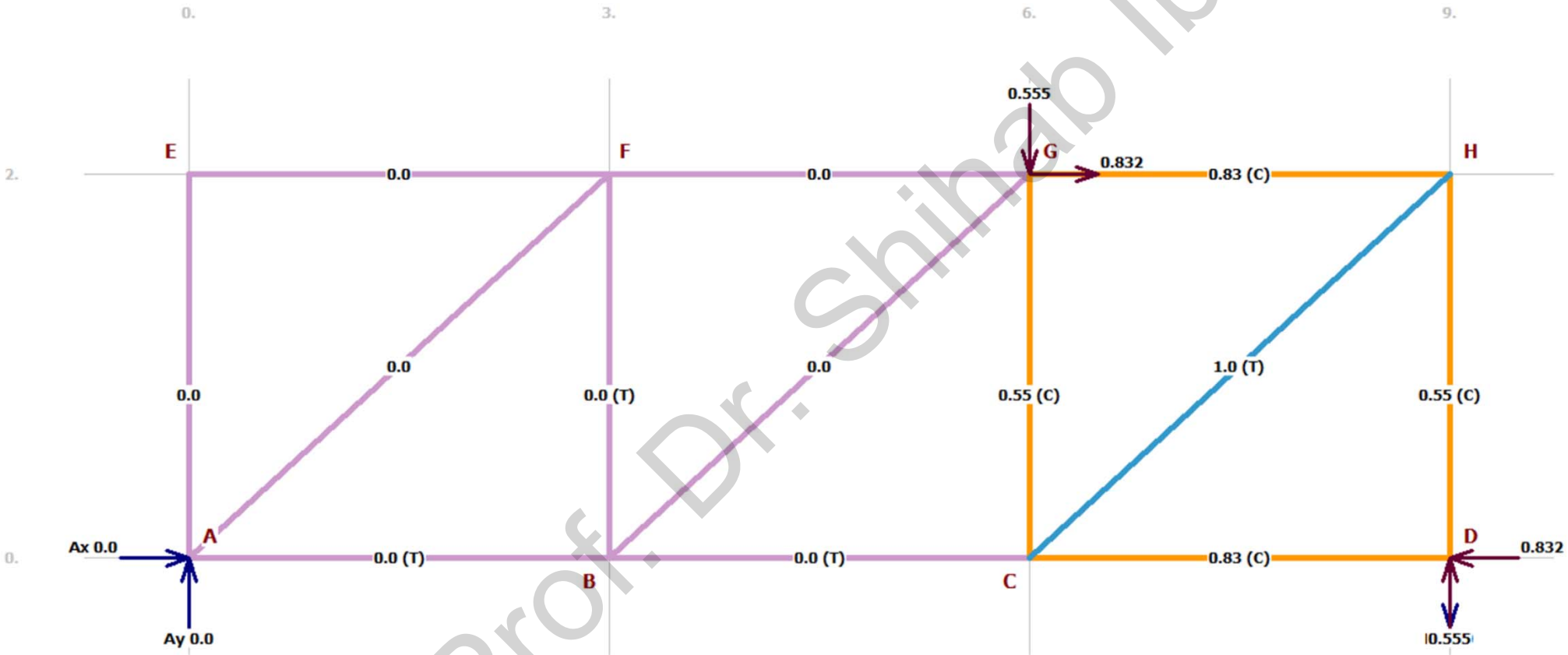
Virtual Truss 2 solution (f2)



4- Virtual Truss 3 (F_{GD} Redundant)



Virtual Truss 3 solution (f3)



5- Displacement Equations

F	f1	f2	f3
Primary	F_{EB} Redundant	F_{FC} Redundant	F_{GD} Redundant
$\Delta'_{F_{EB}} = \sum \frac{F * f1 * L}{A * E}$	$\delta_{F_{EB}F_{EB}} = \sum \frac{f1 * f1 * L}{A * E}$	$\delta_{F_{EB}F_{FC}} = \sum \frac{f1 * f2 * L}{A * E}$	$\delta_{F_{EB}F_{GD}} = \sum \frac{f1 * f3 * L}{A * E}$
$\Delta'_{F_{FC}} = \sum \frac{F * f2 * L}{A * E}$	$\delta_{F_{FC}F_{EB}} = \sum \frac{f2 * f1 * L}{A * E}$	$\delta_{F_{FC}F_{FC}} = \sum \frac{f2 * f2 * L}{A * E}$	$\delta_{F_{FC}F_{GD}} = \sum \frac{f2 * f3 * L}{A * E}$
$\Delta'_{F_{GD}} = \sum \frac{F * f3 * L}{A * E}$	$\delta_{F_{GD}F_{EB}} = \sum \frac{f3 * f1 * L}{A * E}$	$\delta_{F_{GD}F_{FC}} = \sum \frac{f3 * f2 * L}{A * E}$	$\delta_{F_{GD}F_{GD}} = \sum \frac{f3 * f3 * L}{A * E}$

$$0 = \Delta'_{F_{EB}} + F_{EB}\delta_{F_{EB}F_{EB}} + F_{EC}\,\delta_{F_{EB}F_{FC}} + F_{GD}\,\delta_{F_{EB}F_{GD}}$$

$$0 = \Delta'_{F_{FC}} + F_{EB}\,\delta_{F_{FC}F_{EB}} + F_{EC}\,\delta_{F_{EC}F_{FC}} + F_{GD}\,\delta_{F_{FC}F_{GD}}$$

$$0 = \Delta'_{F_{GD}} + F_{EB}\delta_{F_{GD}F_{EB}} + F_{EC}\delta_{F_{GD}F_{FC}} + F_{GD}\,\delta_{F_{GD}F_{GD}}$$

Actual Force Memebr = F + Feb*f1 + Fec*f2 + Fgd*f3

						$\Delta'_{F_{EB}}$	$\Delta'_{F_{FC}}$	$\Delta'_{F_{GD}}$	$\delta_{F_{EB}F_{EB}}$	$\delta_{F_{FC}F_{EB}}$	$\delta_{F_{GD}F_{EB}}$	$\delta_{F_{EB}F_{FC}}$	$\delta_{F_{FC}F_{FC}}$	$\delta_{F_{GD}F_{FC}}$	$\delta_{F_{EB}F_{GD}}$	$\delta_{F_{FC}F_{GD}}$	$\delta_{F_{GD}F_{GD}}$	
Member	**L "m"**	**F "kN"**	**f1 "kN"**	**f2 "kN"**	**f3 "kN"**	**F*f1*L**	**F*f2*L**	**F*f3*L**	**f1*f1*L**	**f2*f1*L**	**f3*f1*L**	**f1*f2*L**	**f2*f2*L**	**f3*f2*L**	**f1*f3*L**	**f2*f3*L**	**f3*f3*L**	**Actual Forces**
AE	2	0	-0.56	0	0	0	0	0	0.63	0	0	0	0	0	0	0	0	-8.63
AB	3	48.33	-0.83	0	0	-120.34	0	0	2.07	0	0	0	0	0	0	0	0	35.54
AF	3.61	-34.05	1	0	0	-122.92	0	0	3.61	0	0	0	0	0	0	0	0	-18.64
BF	2	-1.11	-0.55	-0.55	0	1	1.22	0	0.61	1	0	0.605	0.605	0	0	0	0	-7.99
BC	3	46.67	0	-0.83	0	0	-116.21	0	0	0	0	0	2.0667	0	0	0	0	49.08
BG	3.61	2	0	1	0	0	7.22	0	0	0	0	0	3.61	0	0	0	0	-0.91
CG	2	-31.11	0	-0.55	-0.55	0	34.22	34.22	0	0	0	0	0.605	0.605	0	1	1	-11.68
CD	3	0	0	0	-0.83	0	0	0	0	0	0	0	0	0	0	0	2	26.91
CH	3.61	56.09	0	0	1	0	0	202.48	0	0	0	0	0	0	0	0	4	23.66
DH	2.00	-51.11	0	0	-0.55	0	0	56.22	0	0	0	0	0	0	0	0	1	-33.28
HG	3	-46.67	0	0	-0.83	0	0	116.21	0	0	0	0	0	0	0	0	2	-19.76
GF	3	-48.33	0	-0.83	0	0	120.34	0	0	0	0	0	2.0667	0	0	0	0	-45.92
FE	3	-20	-0.83	0	0	49.80	0	0	2.07	0	0	0	0	0	0	0	0	-32.79
EB	3.61	0	1	0	0	0	0	0	3.61	0	0	0	0	0	0	0	0	15.41
FC	3.61	0	0	1	0	0	0	0	0.00	0	0	0	3.61	0	0	0	0	-2.91
GD	3.61	0	0	0	1	0	0	0	0.00	0	0	0	0	0	0	0	4	-32.43

Sum	-192.24	46.80	409.14	12.59	0.61	0.00	0.61	12.56	0.61	0.00	0.61	12.56
/AE	-0.00320402	0.00077992	0.00681892	0.00020976	0.00001008	0	0.00001008	0.00020939	0.00001008	0	0.00001008	0.00020939

$$-\Delta'_{F_{EB}} = F_{EB}\delta_{F_{EB}F_{EB}} + F_{EC}\,\delta_{F_{EB}F_{FC}} + F_{GD}\,\delta_{F_{EB}F_{GD}}$$

$$-\Delta'_{F_{FC}} = F_{EB}\,\delta_{F_{FC}F_{EB}} + F_{EC}\,\delta_{F_{EC}F_{FC}} + F_{GD}\,\delta_{F_{FC}F_{GD}}$$

$$-\Delta'_{F_{GD}} = F_{EB}\delta_{F_{GD}F_{EB}} + F_{EC}\delta_{F_{GD}F_{FC}} + F_{GD}\,\delta_{F_{GD}F_{GD}}$$

Matrix B

0.00320402
-0.00077992
-0.00681892

Matrix A

0.00020976	0.00001008	0
0.00001008	0.00020939	0.00001008
0	0.00001008	0.00020939

Inverse of Matrix A

4778.4404	-230.6443	11.1068
-230.6443	4798.0106	-231.0518
11.1068	-231.0518	4786.9037

Feb	15.41	kN
Fec	-2.91	kN
Fgd	-32.43	kN