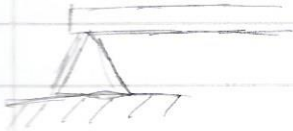
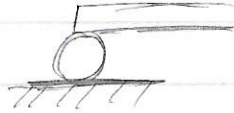


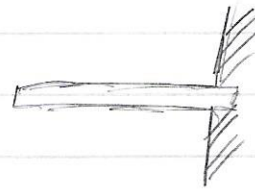
Q1a



Pin Support

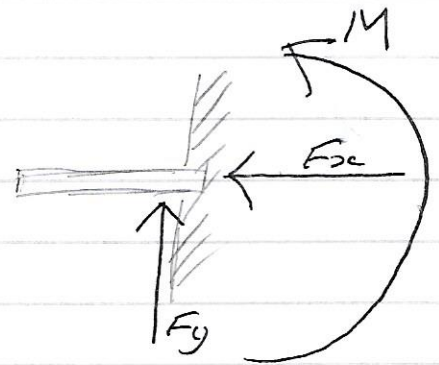
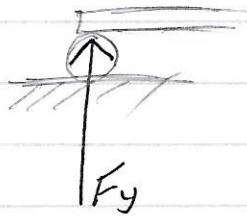
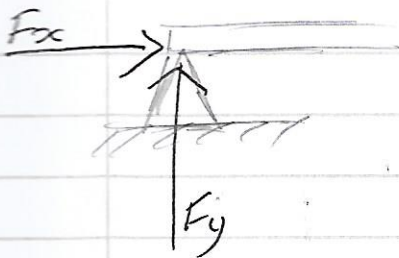


Roller Support



Fixed Support

Q1b



Q1c

Determinate Structures are classified by structures that can be analysed by utilising the equilibrium Equation. Determinate structures can be determined if they satisfy the equation.

Indeterminate structures however do not satisfy the equations and require additional investigation in order to gain equilibrium via the below methods;

- Moment Distribution
- Slope Deflection
- Flexibility Method.

Indeterminate structures will also commonly have more forces acting upon them than beams, this is what makes them fail the equation.

1d) The 3 conditions of static equilibrium is that on each plane (i.e Horizontal, Vertical and Moment) the sum of these forces must equal 0 (i.e for each force there must be an equal and opposite reaction) for equilibrium to be achieved.

$$\sum H = 0, \sum V = 0, \sum M = 0$$

e) $r = 3n$
 $r = \text{R Number of reaction forces}$
 $n = \text{number of members}$

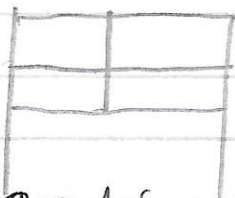
1f) f.1 = $r = 3, n = 1$ $3 = 3 \times 1 \Rightarrow 3 = 3$ (Determinate)

f.2 = $r = 6, n = 2$ $6 = 3 \times 2 \Rightarrow 6 = 6$ (Determinate)

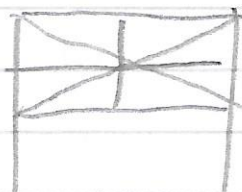
f.3 = $r = 5, n = 2$ $5 = 3 \times 2 \Rightarrow 25 - 3 = 2$ (Indeterminate)
 Second degree

f.4 = $r = 10, n = 3$ $10 = 3 \times 3 = 9$ $10 - 9 = 1$ (Indeterminate)
 first degree

1g) Framed Structures are classified as having a combination of beams, columns and slabs to resist lateral (horizontal) of gravity (downwards) loads. These structures are often used where large loading is expected, such as buildings. These can fall into the two classifications shown below;



Rigid frame
14/1/2022



Braced Structure

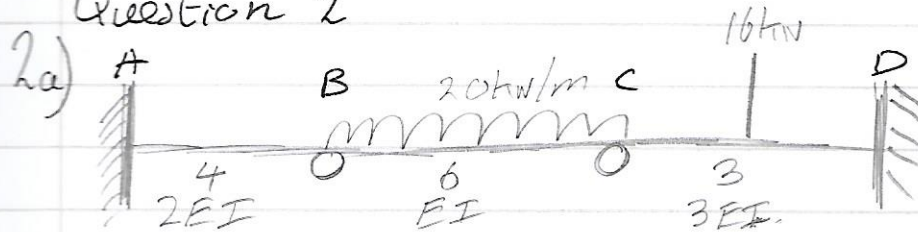
1a) The difference between over rigid and under rigid is determined through an equation. This equation analyses the number of joints and frames. If the number is correct then it is rigid, if below requirement it is under-rigid and more beams are required. If over then it is over-rigid and a beam or member can be removed.

1i) $m = 2j - 3$
 m = Number of Members
 j = Number of Joints

- j) i) Warren Truss
ii) Pratt Truss
iii) Howe truss
iv) K Truss
v) Fink Truss

Section B

Question 2



Member & Joint Stiffness

$$k_{AB} = \frac{2EI}{L} = \frac{2 \times 1}{4} = \frac{2}{4}$$

$$k_{BC} = \frac{EI}{L} = \frac{1}{6} = \frac{1}{6}$$

$$k_{CD} = \frac{3EI}{L} = \frac{3 \times 1}{3} = \frac{3}{3}$$

Distribution factors

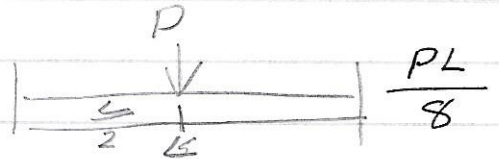
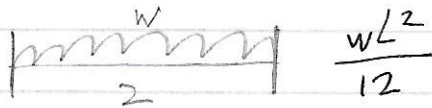
$$\begin{aligned} DF_{BA} &= k_{AB} / (k_{AB} + k_{BC}) \\ &= \frac{2}{4} / \left(\frac{2}{4} + \frac{1}{6} \right) = 0.75 \end{aligned}$$

$$\begin{aligned} DF_{BC} &= k_{BC} / (k_{AB} + k_{BC}) \\ &= \frac{1}{6} / \left(\frac{2}{4} + \frac{1}{6} \right) = 0.25 \end{aligned}$$

$$\begin{aligned} DF_{CB} &= k_{BC} / (k_{BC} + k_{CD}) \\ &= \frac{1}{6} / \left(\frac{1}{6} + \frac{3}{3} \right) = 0.14 \end{aligned}$$

$$\begin{aligned} DF_{CD} &= k_{CD} / (k_{BC} + k_{CD}) \\ &= \frac{3}{3} / \left(\frac{1}{6} + \frac{3}{3} \right) = 0.86 \end{aligned}$$

Fixed end moment



$$FEM_{BC} = \frac{wL^2}{12} = \frac{20 \times 6^2}{12}$$

$$FEM_{CD} = \frac{PL}{8} = \frac{16 \times 8}{8} = 16$$

= 60

Joint	A	B		C		D
Member	AB	BA	BC	CB	CD	DC
DF	0	0.75	0.25	0.14	0.86	0
FM	0	0	+60	-60	+16	-16
$\swarrow \times 0.5$ Bal M	0	$\swarrow \times -45$	$\swarrow \times -15$	$\swarrow \times +6.16$	$\swarrow \times +37.84$	$\swarrow \times 0$
Carry over	-22.5	0	+3.08	-0.75	0	+18.92
Bal M	0	$\swarrow \times -2.31$	$\swarrow \times -0.77$	$\swarrow \times +0.105$	$\swarrow \times +0.6245$	$\swarrow \times 0$
$\swarrow \times 0.5$ Carry over	-1.155	0	+0.05	-0.39	0	+0.32
Bal M	0	$\swarrow \times -0.02$	$\swarrow \times -0.01$	$\swarrow \times +0.05$	$\swarrow \times +0.37$	$\swarrow \times 0$
$\swarrow \times 0.5$ Carry over	-0.02	0	+0.03	-0.005	0	+0.017
Bal M	0	$\swarrow \times -0.02$	$\swarrow \times -0.01$	$\swarrow \times +0.001$	$\swarrow \times +0.004$	$\swarrow \times 0$
Final M	-23.68	-47.32	61.57	-54.83	40.43	3.26

Worth

Working out reactions

AB

$$\sum M_B = 0$$

$$(V_{AB} \times 4) + 23.68 + 47.34 = 0$$

$$4V_{AB} + 71.02 = 0$$

$$V_{AB} = \frac{-71.02}{4} = -17.755$$

$$V_{AB} = 17.755 \downarrow$$

$$\sum M_A = 0$$

$$(-V_{BA} \times 4) + 23.68 + 47.34 = 0$$

$$-4V_{BA} + 71.02 = 0$$

$$-4V_{BA} = -71.02 \Rightarrow V_{BA} = \frac{-71.02}{-4} = +17.755 \uparrow$$

$$\sum M_C = 0$$

$$V_{BC} \times 6 - 61.57 - (20 \times 6 \times 3) + 54.83 = 0$$

$$6V_{BC} - 61.57 - 360 + 54.83 = 0$$

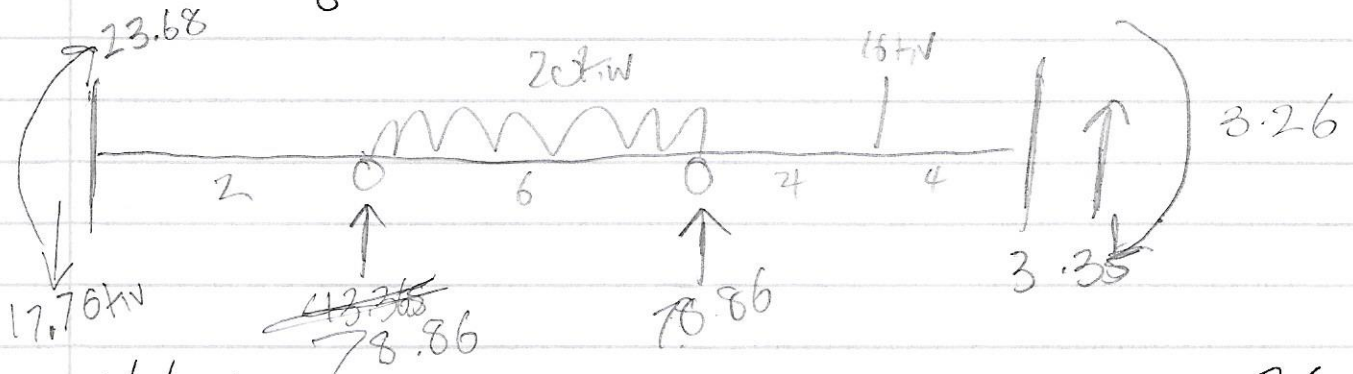
$$V_{BC} = \frac{61.57 + 360 - 54.83}{6} = 61.12 \uparrow$$

$$CD \quad \sum M_D = 0$$

$$(V_{CD} \times 8) - 40.43 - (16 \times 4) - 3.26 = 0$$

$$8V_{CD} - 40.43 - 64 - 3.26 = 0$$

$$V_{CD} = \frac{40.43 + 64 + 3.26}{8} = 11.91 \uparrow$$



14/1/2022

2b)

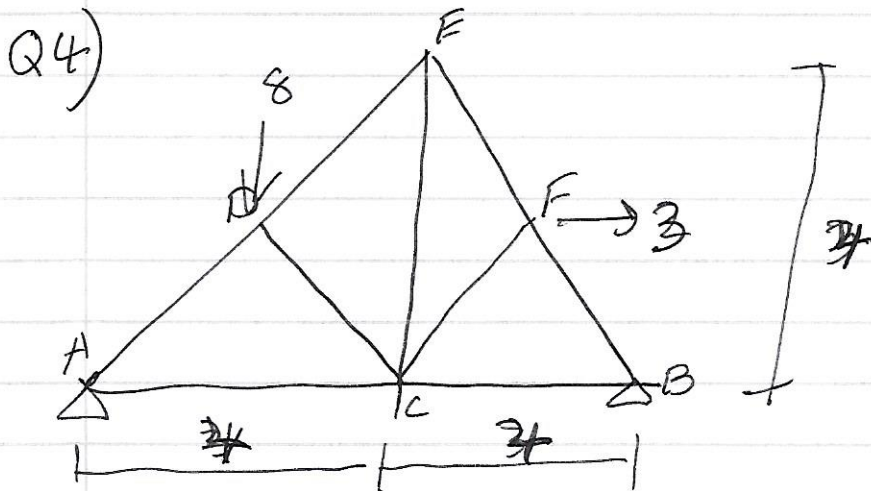
a) point A 0

Shear force
 $SF_0 = 0$ or $+17.76$

Bending
 $= 23.68$

Point B @ 4m from A
 $SF_4 = -17.76 + 48.86$

$BM_4 = 23.68 -$



$\angle CAE$

$$\tan \theta = \frac{4}{4} = 1$$

$$\theta = 45^\circ$$

$$\sum M_A = 0$$

A + B

$$R_B \times (4 \times 4) - 3 \times 2 = 0$$

$$R_B = 10.67 \uparrow$$

$$V_A = 8 - R_B$$

$$= 8 - 10.67$$

$$= -2.67 \downarrow$$

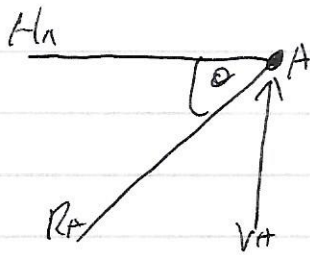
$\leftarrow @ A$

$$H_A = 3 \text{ kN}$$

$$R_A = \sqrt{V_A^2 + H_A^2}$$

$$= \sqrt{-2.67^2 + 3^2}$$

$$= 2.53 \text{ kN}$$

Direction R_A 

$$\tan \theta = \frac{V_A}{H_A} = \frac{2.67}{3}$$

$$\tan \theta = 0.89$$

$$\theta = 41.67^\circ$$

forces in R_A

$$\sum F_y = 0$$

$$F_{AD} \sin 45 + V_A = 0$$

$$0.71 F_{AD} + 2.67 = 0$$

$$F_{AD} = \frac{-2.67}{0.71} = -3.76$$

$$\sum F_x = 0$$

$$F_{AC} + F_{AD} \cos 45 - H_A = 0$$

$$F_{AC} + (-3.76) \times 0.71 - 3 = 0$$

$$F_{AC} = -5.67$$

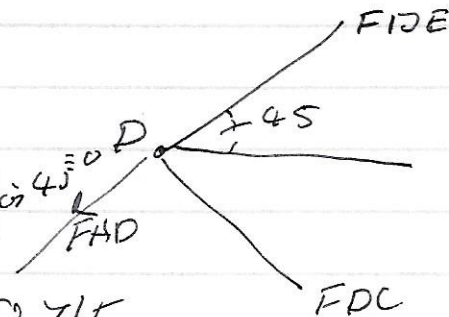
Members DE and DC

$$\sum F = 0$$

$$8 - F_{DE} \sin 45 + F_{DC} \sin 45 - F_{AD} \sin 45 = 0$$

$$8 - 0.71 F_{DE} + 0.71 F_{DC} - 3.76 = 0$$

$$2.67 - 0.71 F_{DE} + 0.71 F_{DC} = 0$$



$$\sum F_x = 0$$

$$F_{AD} \cos 45 + F_{DC} \cos 45 + F_{DE} \cos 45 = 0$$

$$(3.76 \times 0.71) + 0.71 F_{DC} + 0.71 F_{DE} = 0$$

$$2.67 + 0.71 F_{DC} + 0.71 F_{DE} = 0$$

-Unable to continue due to running out of time.

14/1/2022