9-10 AM **NAME** Solutions.

November 14th 2003

COVER PAGE

UNIFIED QUIZ 4MS

(Quiz M4 Handout (provided); no books, no notes; calculators are allowed)

- Put your name on at least cover page, and each page if you remove the staples.
- Read all questions carefully.
- Do all work on that question on that page. Use back of that page if necessary.
- Show all your work, especially intermediate results. Partial credit cannot be given without intermediate results.
- Show the logical path of your work. Explain clearly your reasoning and what you are doing. *In some cases, the reasoning is worth as much (or more) than the actual answers.*
- Be sure to show the units as well (if necessary). Intermediate answers and final answers are not correct without the units.
- Report significant digits only.
- Box your final answers.

EXAM SCORING

#1 (35%)	
#2 (35%)	
#3 (30%)	
FINAL SCORE	

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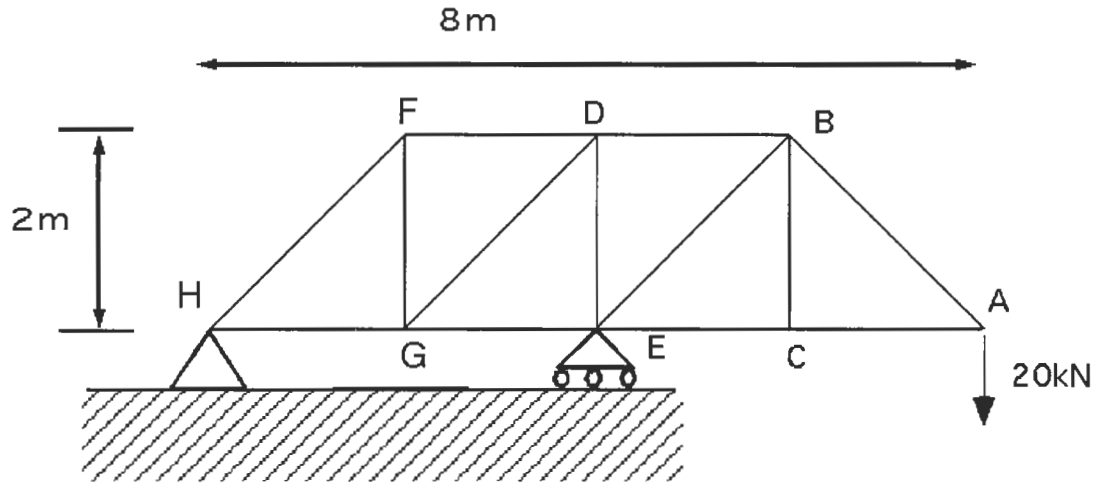
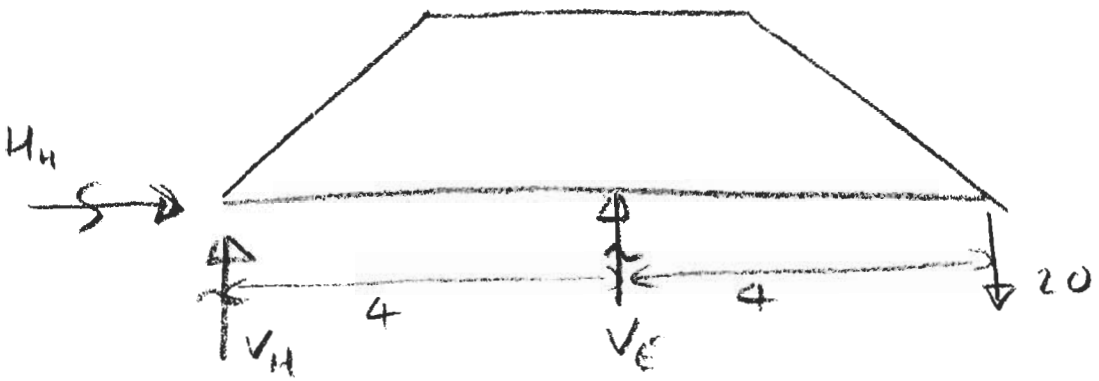
PROBLEM #1 (35%)

a) For the pin jointed truss shown below calculate the reactions at points H and E due to the 20 kN load shown. All the internal angles are 90° or 45°. The truss is made of steel bars, with cross-sectional area 400 mm^2 and a Young's modulus of 210 GPa.





$\sum \vec{F}_x = 0 \quad H_H + 0 = 0 \quad H_H = 0$ ⟸

$\sum F_\uparrow = 0 \quad V_H + V_E - 20 = 0$

$\sum (M_H)_\circlearrowright = 0 \quad V_E \times 4 - 20 \times 8 = 0$

$V_E = +40\ kN$ ⟸

$V_H = -20\ kN$ ⟸

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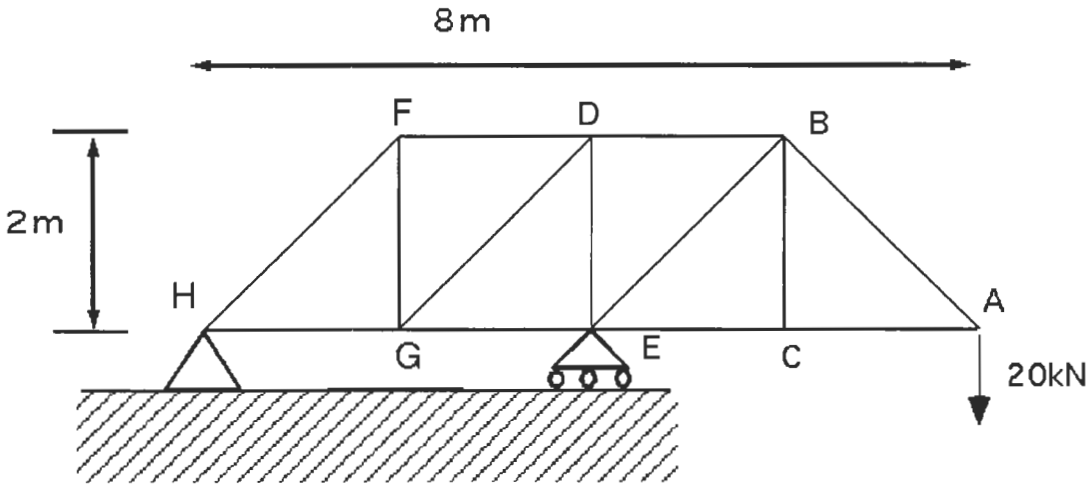
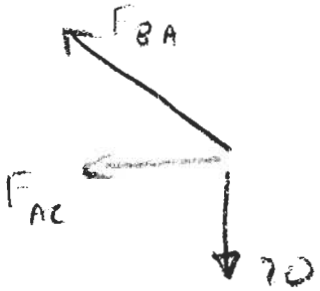
PROBLEM #1 (continued)

(b) For the truss shown in part a) find the forces in bars AC, FD and GD.



AC

M.D @ A



$\sum F_y \uparrow = 0$

$F_{BA} \sin 45^\circ - 20 = 0$

$F_{BA} = +20\sqrt{2}$

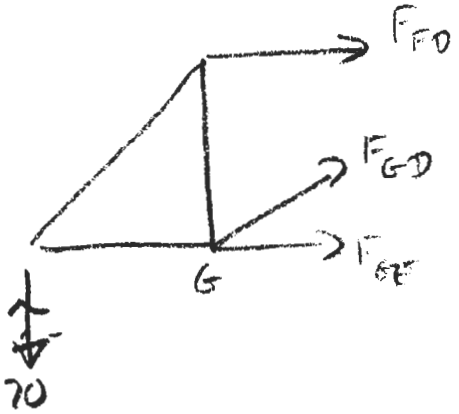
$\sum \vec{F}_x = 0$

$-F_{AC} - F_{BA} \cos 45^\circ = 0$

$F_{AC} = -20\sqrt{2} \cdot \frac{1}{\sqrt{2}} = -20KN$

FD

M.S. @



$\sum M_G = 0$

$20 \cdot 2 - F_{FD} \cdot 2 = 0$

$F_{FD} = +20KN \in$

$\sum M_D = 0$

$20 \cdot 4 + F_{GE} \cdot 2 = 0$ $F_{GE} = -40KN$

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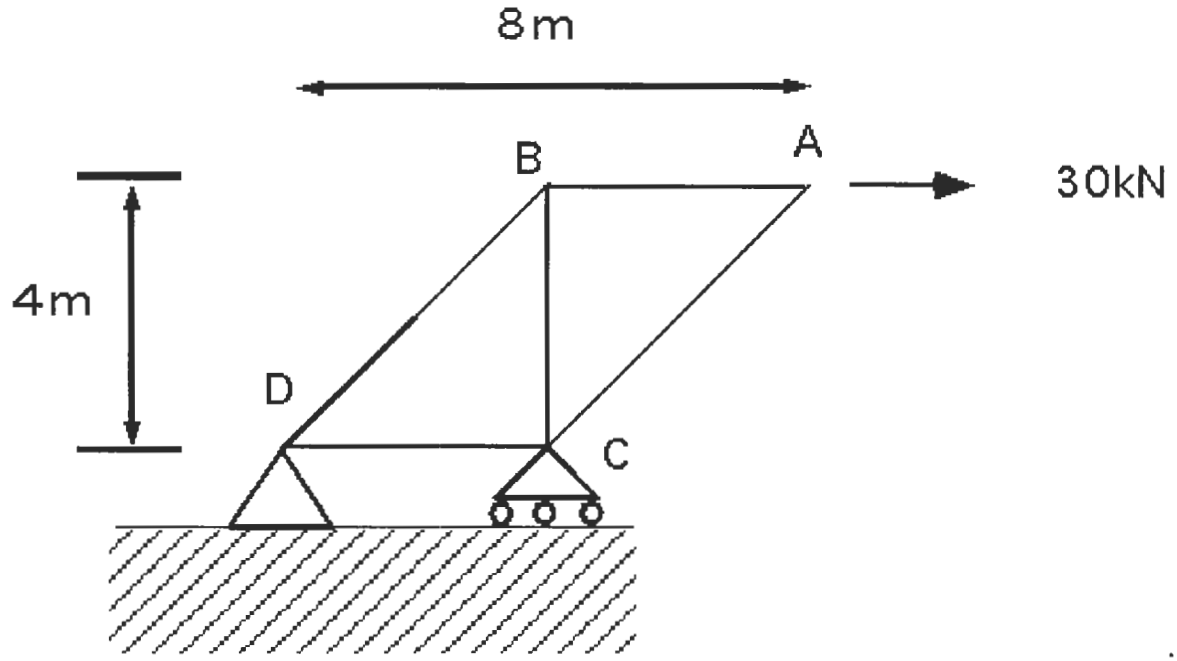
PROBLEM #2 (35%)

The pin jointed truss shown below has been analyzed and the bar forces calculated and are listed in the table below. Positive forces are tensile, negative are compressive. The bars are made of steel, with a modulus of 210 GPA, thermal expansion coefficent of 10^{-6} /K and have a cross sectional area of 500 x 10^{-6} m^2 .

a) Estimate the deflection of point A.

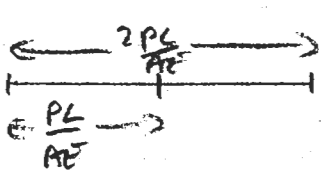


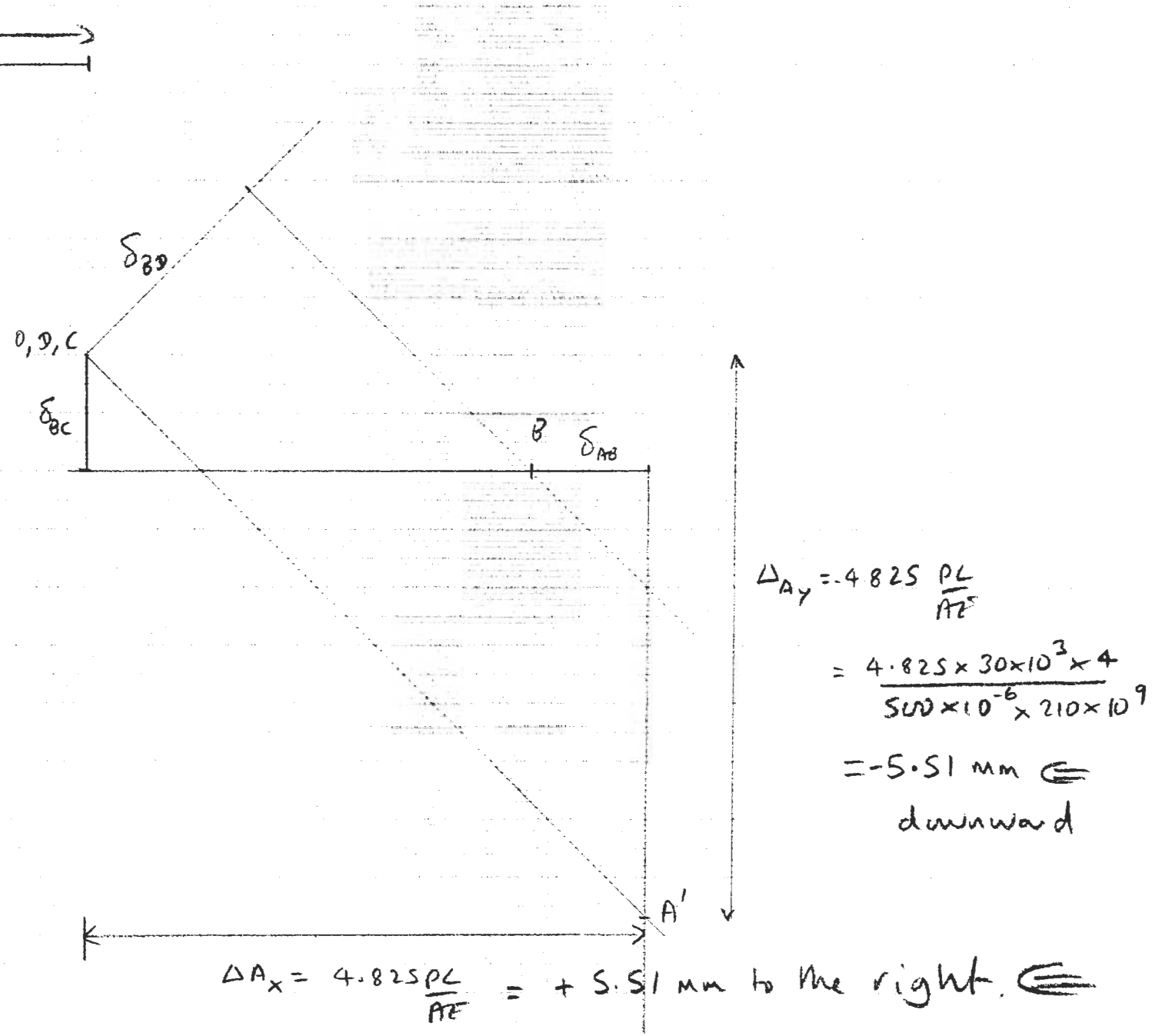
Bar	AB	AC	BC	BD	CD
Force (kN)	+30 P	0	-30 -P	30√2 $\sqrt{2}$P	0

$L = 4m$

Length L $\sqrt{2}L$ L $\sqrt{2}L$ L

$\sum \frac{PL}{AE}$ 1 0 -1 2 0





$\Delta_{Ay} = .4825 \frac{PL}{AE}$

$= \frac{4.825 \times 30 \times 10^3 \times 4}{500 \times 10^{-6} \times 210 \times 10^9}$

$= -5.51$ mm ⇐
downward

$\Delta A_x = 4.825 \frac{PL}{AE} = +5.51$ mm to the right. ⇐

PROBLEM #2 (Continued)

b) How would your answer to 2a) change for each of the following cases:

i) The load on the truss was doubled to 60 kN applied horizontally at point A

The deflections would double

ii) The cross sectional area of all the bars of the truss was doubled to 1000 x 10^{-6} m^2

The deflections would halve

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iii) You are required to limit the ~~lateral~~ deflection of the truss to less than 1mm. If the overall length of the truss is fixed, how might you achieve this. Provide a quantitative answer.

You could increase the area of the bars
- by a factor of 5.5 ✓
ie $500 \times 10^{-6} \times 5.5 = 2.76 \times 10^{-3} m^2$ ✓

An even better answer would be [illegible]
only by [illegible] the [illegible]
area of [illegible] carrying load
- which would save weight

Could also vary E - but need
to specify a suitable material
cannot change it arbitrarily.

Some enterprising student could
ΔT to change deflection.

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PROBLEM #3 (30%)

a) What is meant by the phrase "structural integrity"?

Maintaining requirements for
Failure
Deflection
Longevity

b) What is meant by the phrase "statically indeterminate"

When applied to a structure
implies that it cannot be analyzed
using statics alone (equilibrium)
- Reactions
- Internal forces

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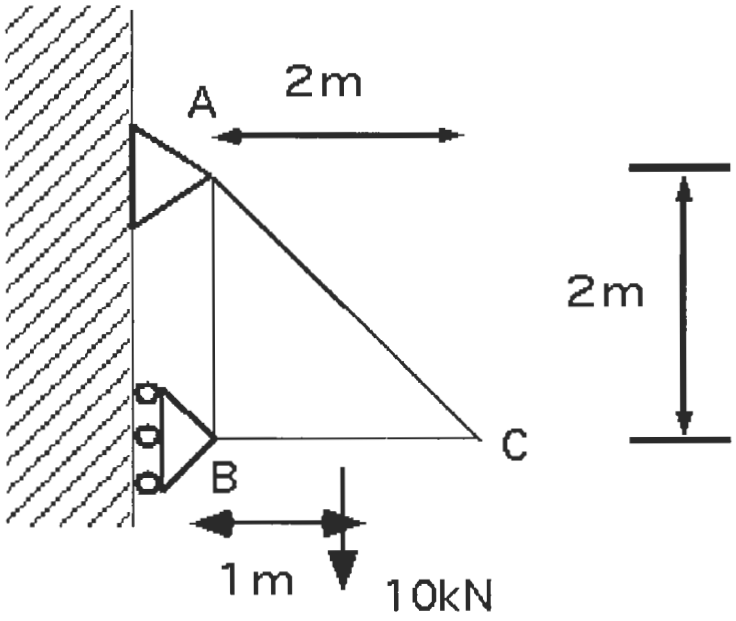
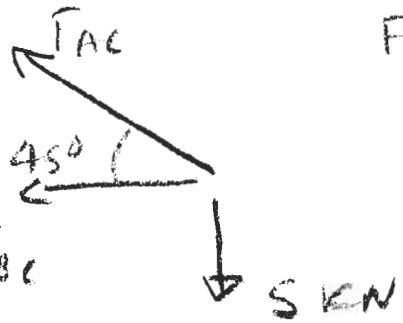
c) For the structure shown, loaded by a load of 10 kN midway between joints B and C, calculate the forces in the bar AC.



For a truss load cannot be applied midway along bar,

- could assume 5kN applied @ each end, Assume structure behaves as a truss



$F_{AC} \sin 45^\circ - 5 = 0$

$F_{AC} = +5\sqrt{2}$

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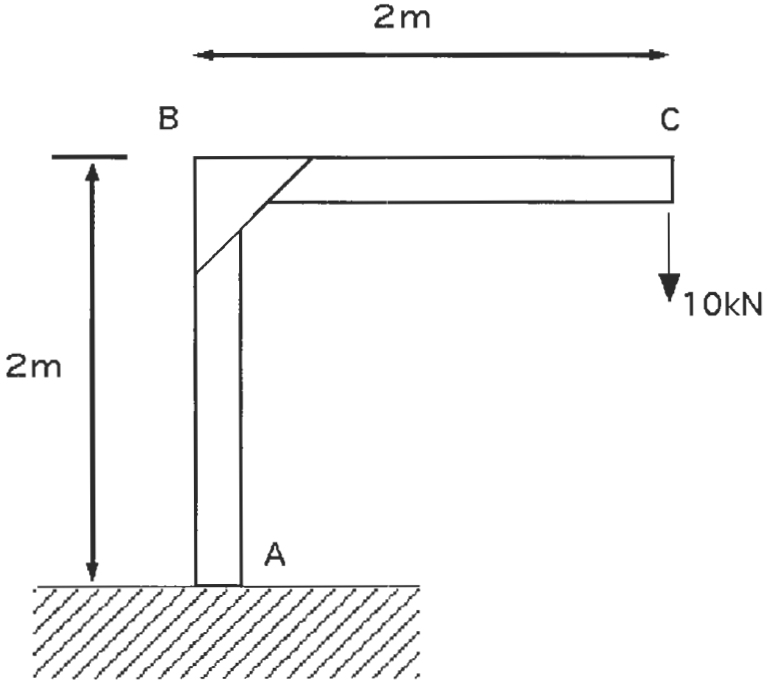
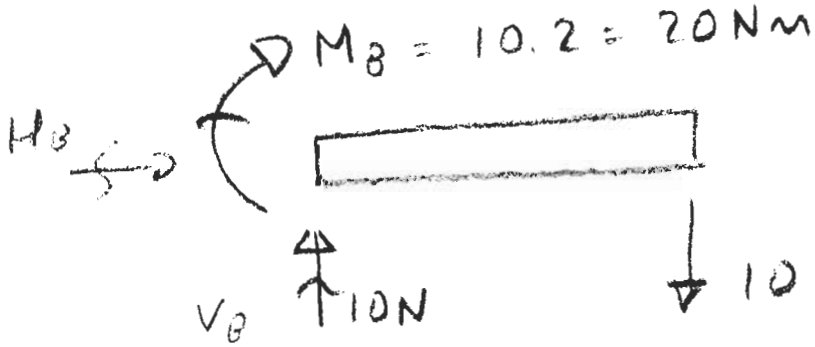
d) For the structure shown below calculate the forces at joint B



Not a truss. - B must behave like a clamp



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e) Explain the principle of operation of a resistance strain gauge and its advantages for measuring strain to a freshman in 16.00

A strain gauge relies on the resistance being determined by resistivity

$$R = \frac{\rho L}{A}$$

∴ changes in length (due to a strain) result in a change in resistance

We can measure changes in resistance very accurately compared to direct measurement of changes in length.