

9-10 AM

NAME Solutions

35-225

November 14<sup>th</sup> 2003

## COVER PAGE

### UNIFIED QUIZ 4MS

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

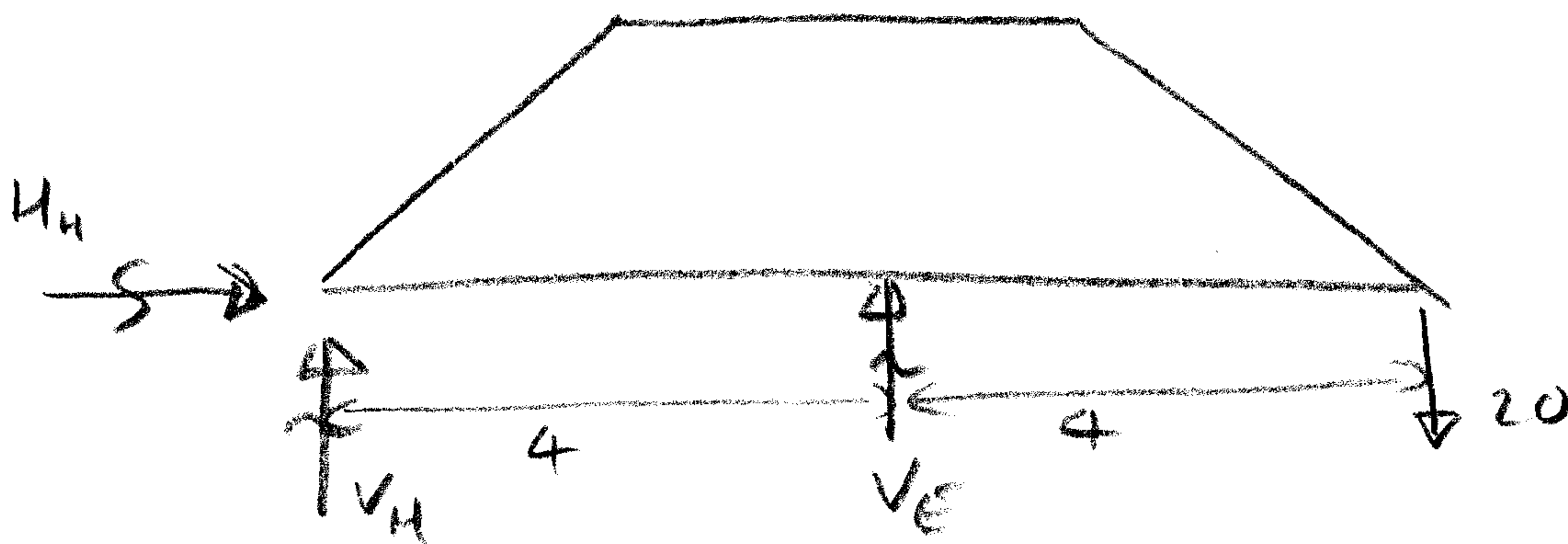
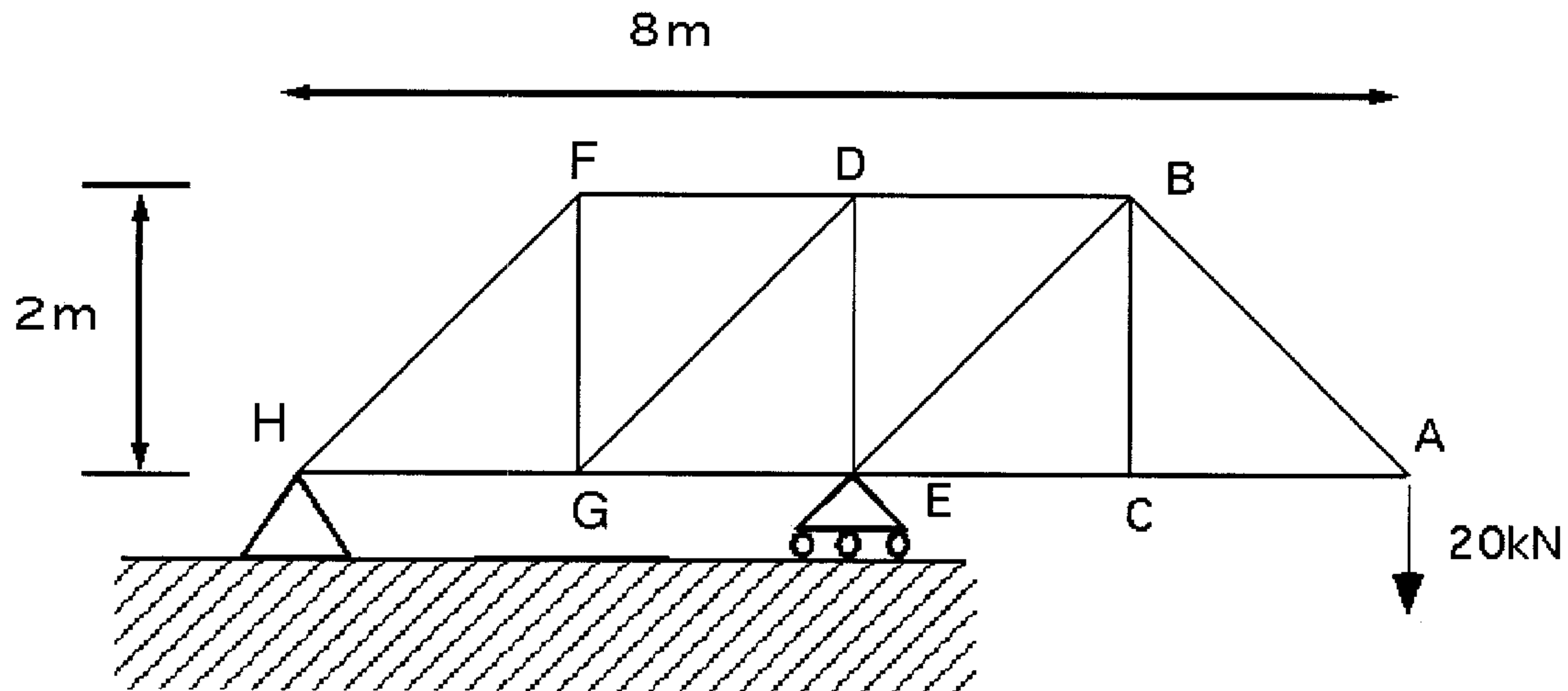
- Put your name on at least cover page, and each page if you remove the staples.
- Read all questions carefully.
- Do all work on that question on that page. Use back of that page if necessary.
- Show all your work, especially intermediate results. Partial credit cannot be given without intermediate 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	

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<sup>2</sup> and a Young's modulus of 210 GPa.



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

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

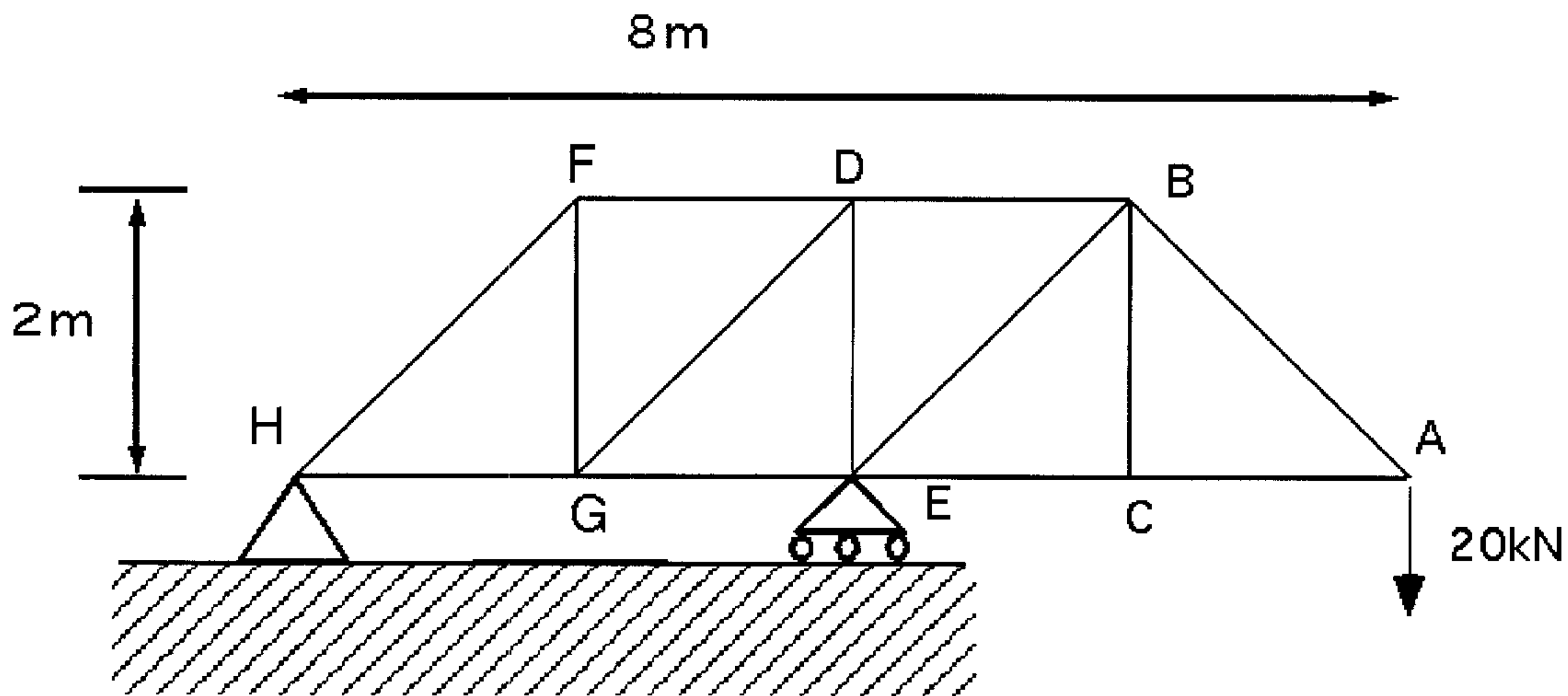
$$\sum (M_H = 0) \quad V_E \times 4 - 20 \times 8 = 0$$

$$V_E = +40 \text{ kN} \quad \Leftarrow$$

$$V_H = -20 \text{ kN} \quad \Leftarrow$$

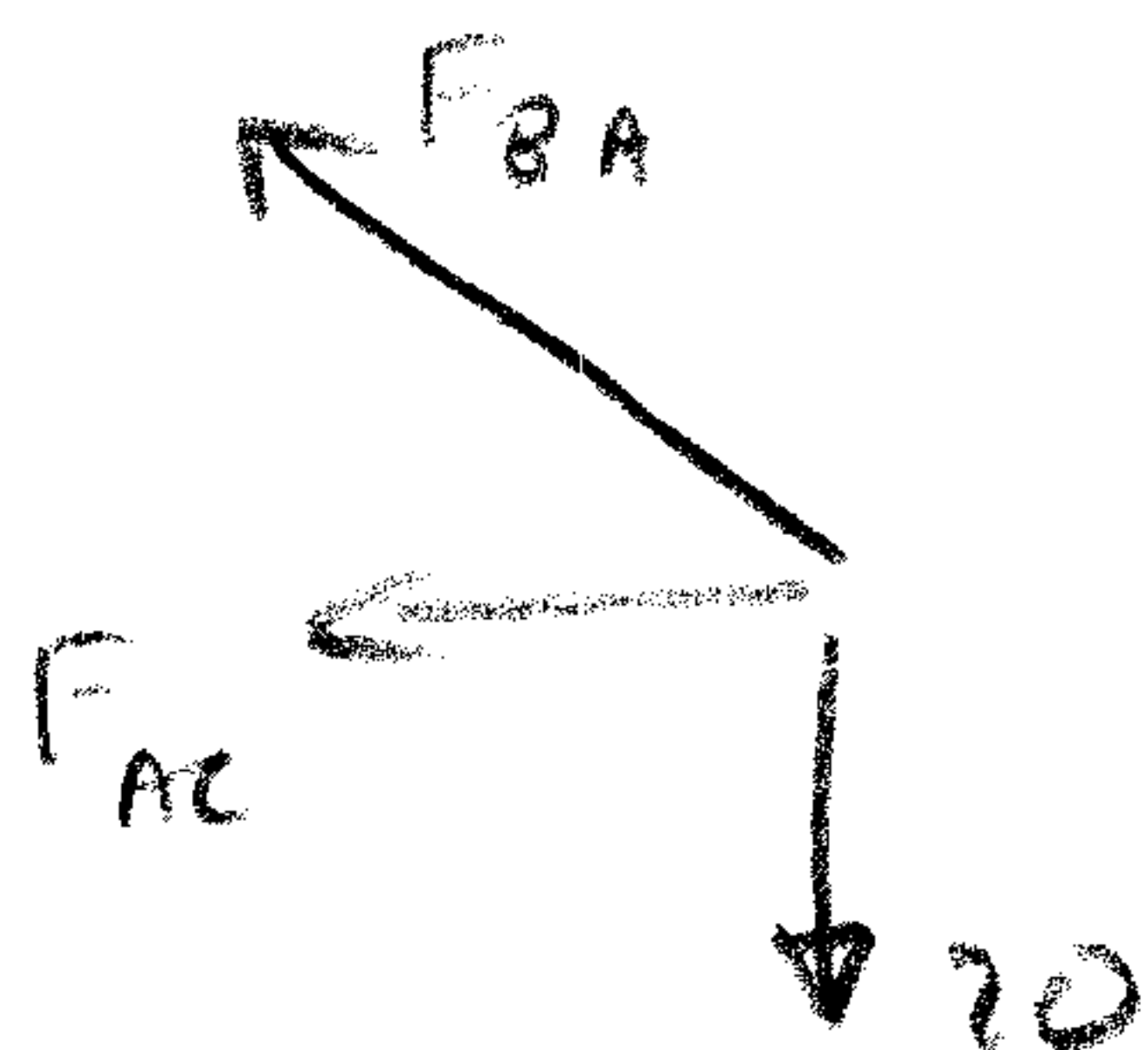
**PROBLEM #1 (continued)**

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



AC

MoJ @ A



$$\sum F_y \uparrow = 0$$

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

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

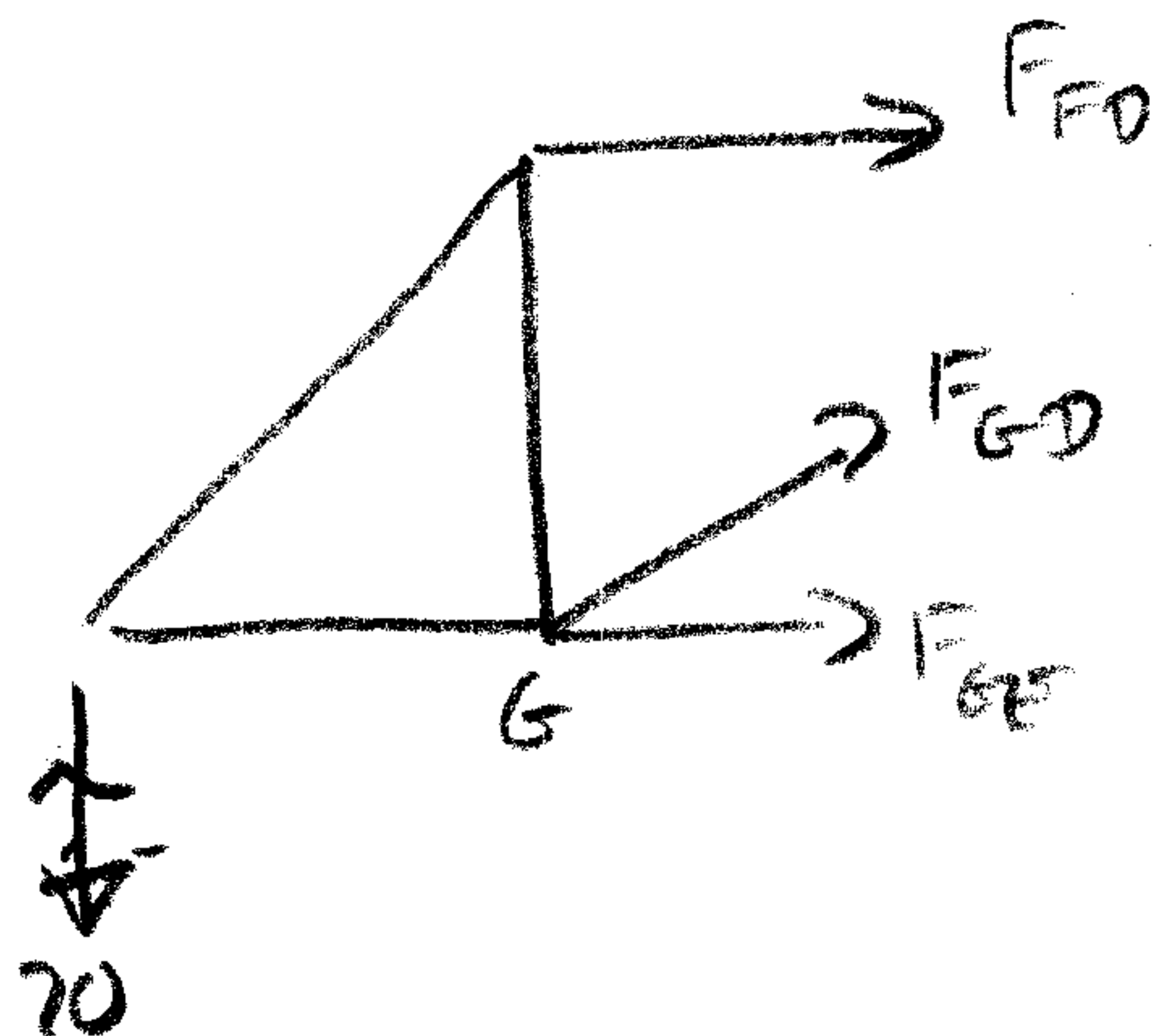
$$\sum \vec{F}_x = 0$$

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

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

FD

MoS @



$$\sum M_G = 0$$

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

$$F_{FD} = +\underline{20\text{KN}}$$

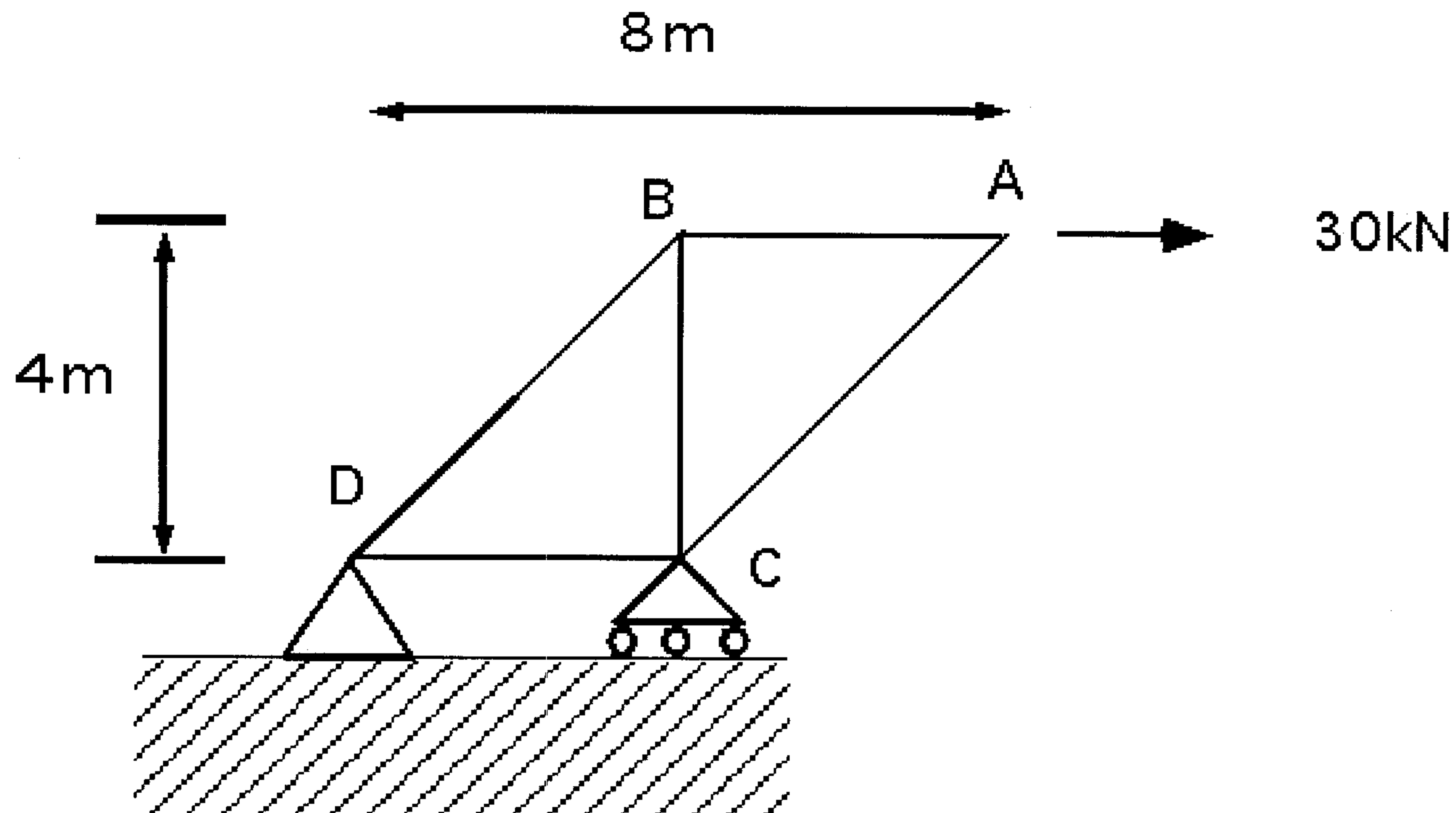
$$\sum M_D = 0$$

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

**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 coefficient of  $10^{-6} /K$  and have a cross sectional area of  $500 \times 10^{-6} \text{ m}^2$ .

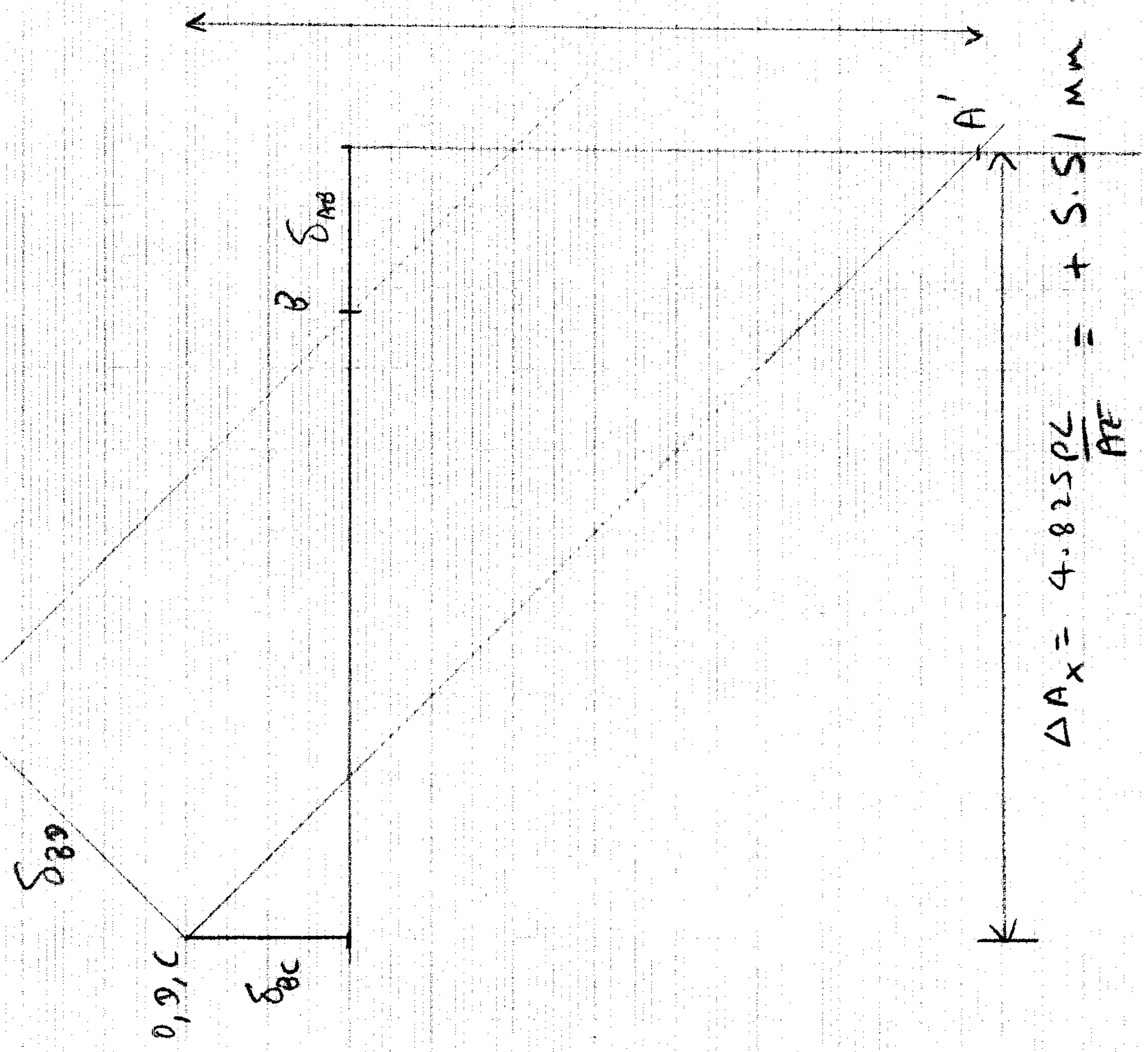
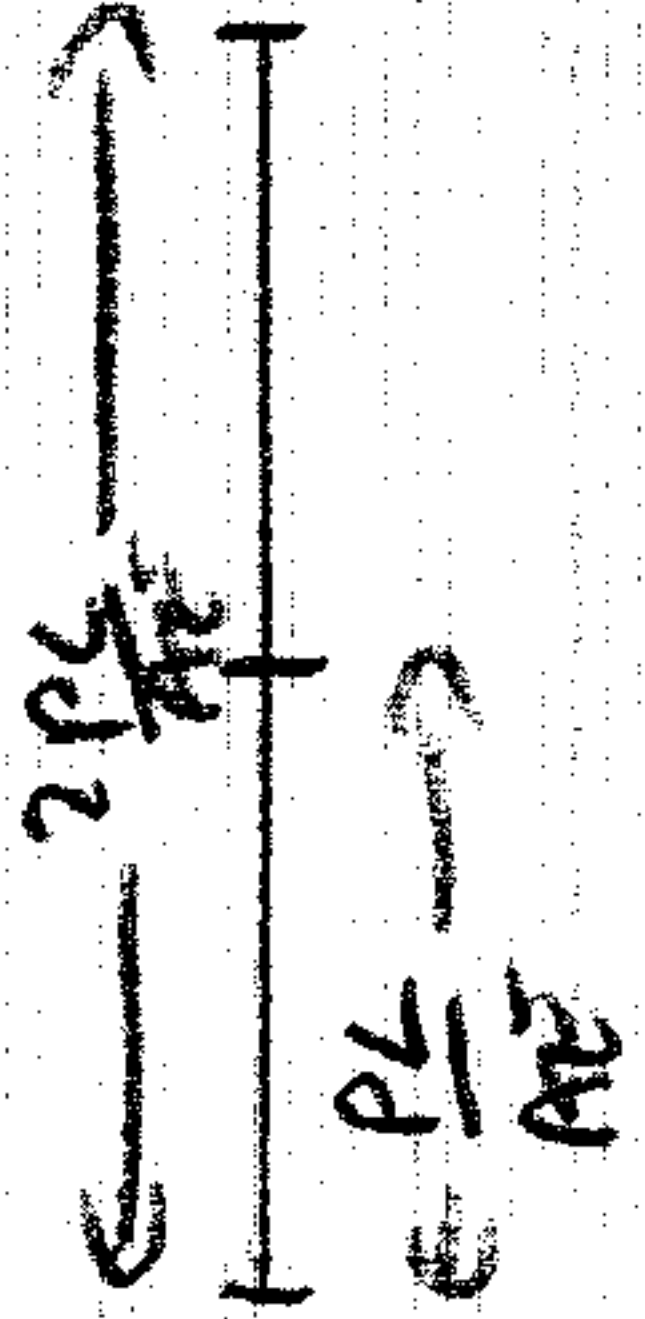
a) Estimate the deflection of point A.



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

$L = 4m$

Length	$L$	$\sqrt{2}L$	$L$	$\sqrt{2}L$	$L$
$\frac{\Delta PL}{AE}$	1	0	-1	2	0



$$\Delta_{Ay} = 4.825 \frac{PL}{AE}$$

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

$$= -5.51 \text{ mm} \quad \Downarrow$$

downward

$$\Delta_{Ax} = 4.825 \frac{PL}{AE} = +5.51 \text{ mm to the right.} \quad \Leftarrow$$

**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  $1000 \times 10^{-6} \text{ m}^2$

The deflections would halve

- iii) You are required to limit the <sup>Horizontal</sup> 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 5.51

$$1.8 \cdot 500 \times 10^{-6} \times 5.5 = 2.76 \times 10^{-3} \text{ m}^2 \quad \epsilon$$

An even better answer would be to only increase the cross-sectional area of those bars carrying load - which would save weight

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

Some enterprising students varied  $\Delta T$  to change deflection.

**PROBLEM #3 (30%)**

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

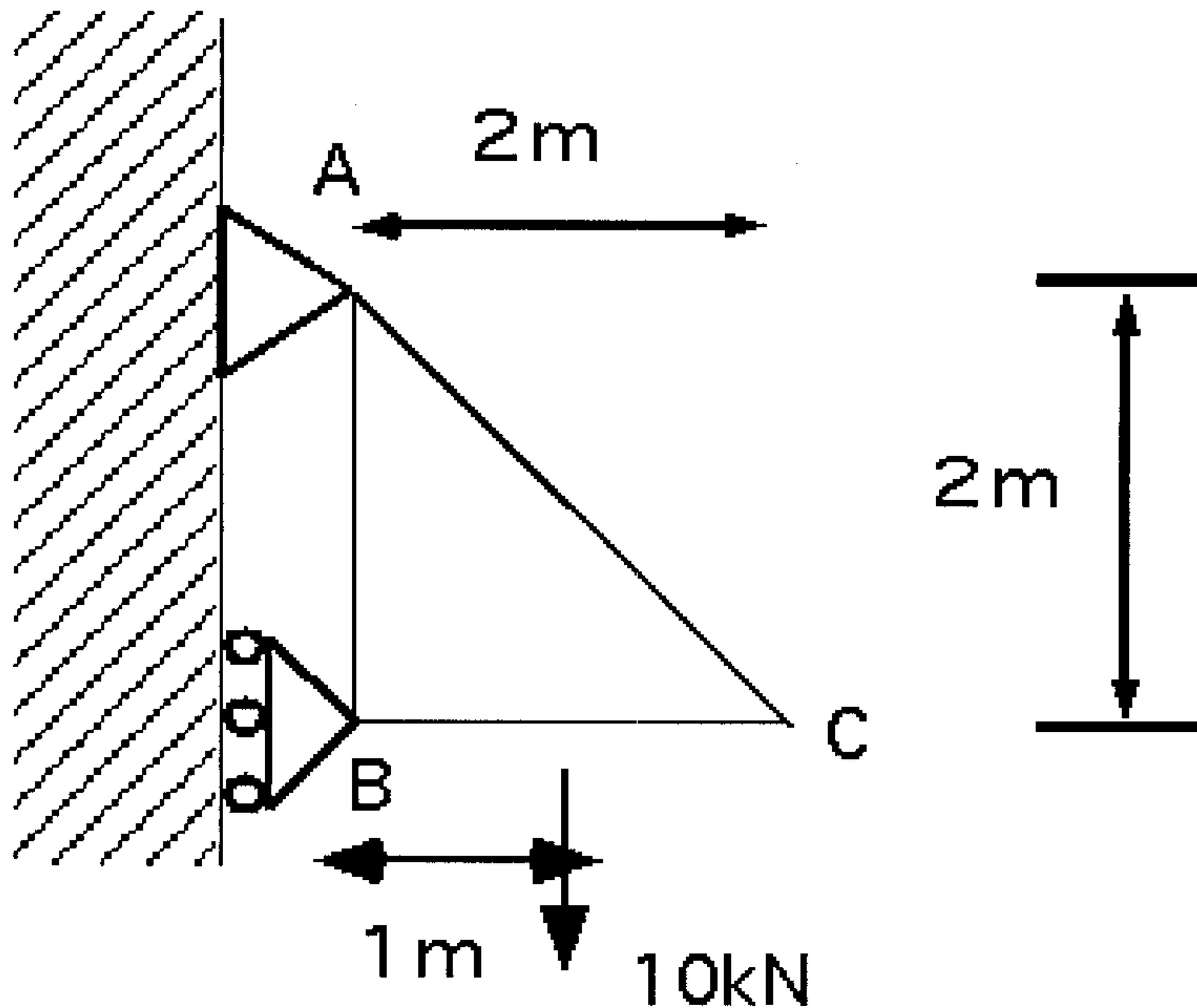
Maintaining requirements for  
Failure  
Deflection  
Longevity

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.



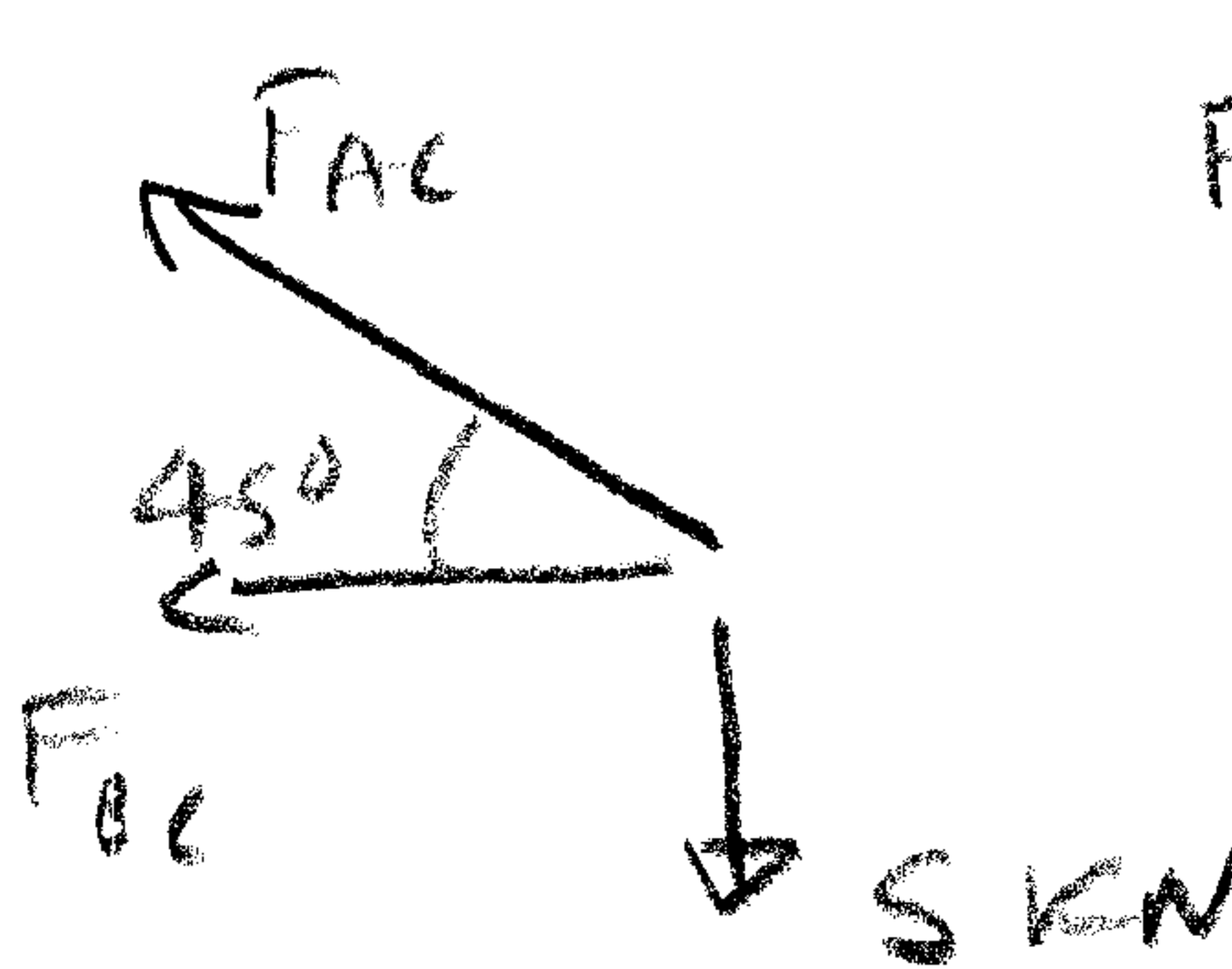
c) For the structure shown, loaded by a load of 10 kN midway between joints B and C, calculate the forces in the bar AC.



For a mass load cannot be applied midway along bar,

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

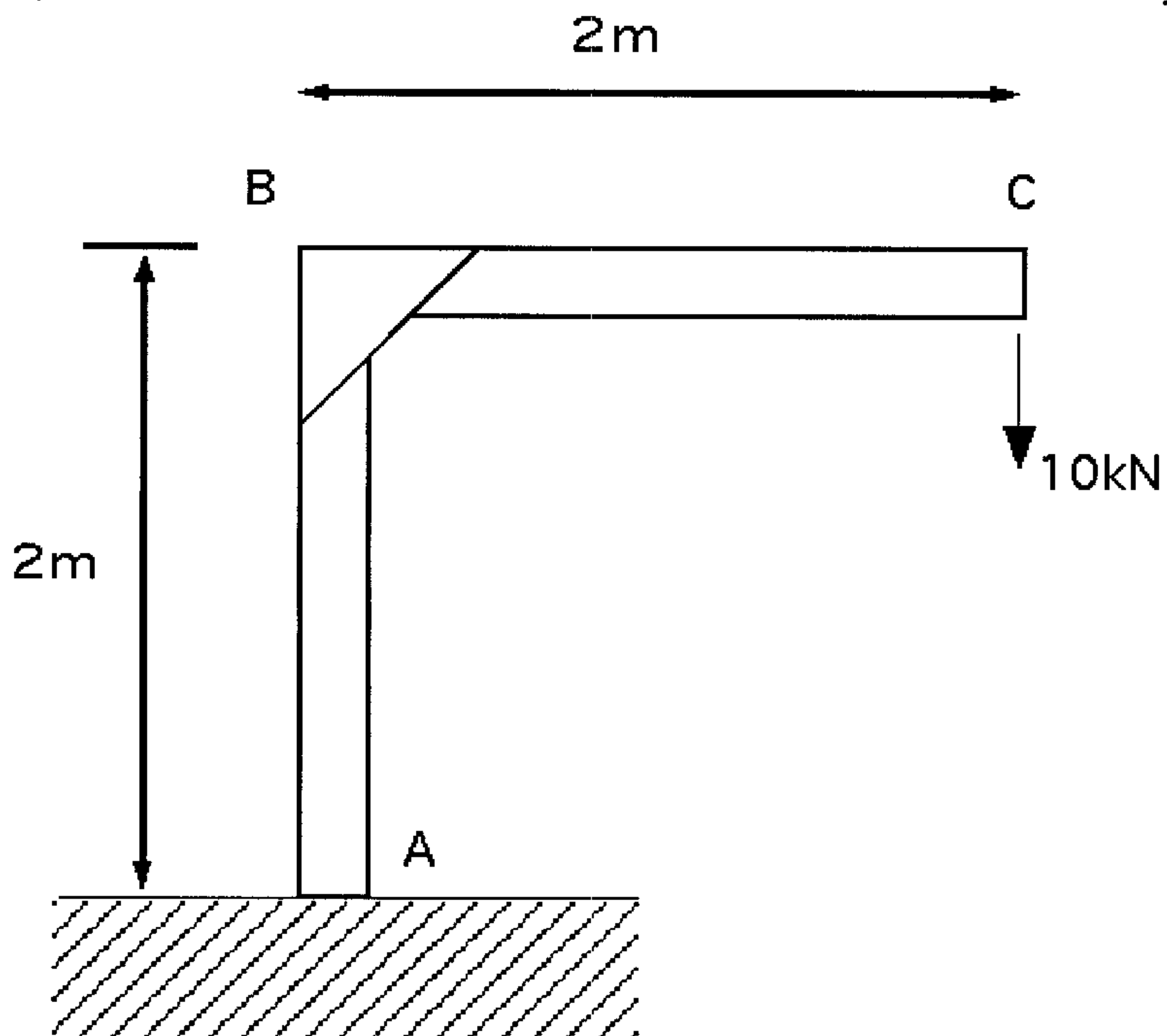
as a truss



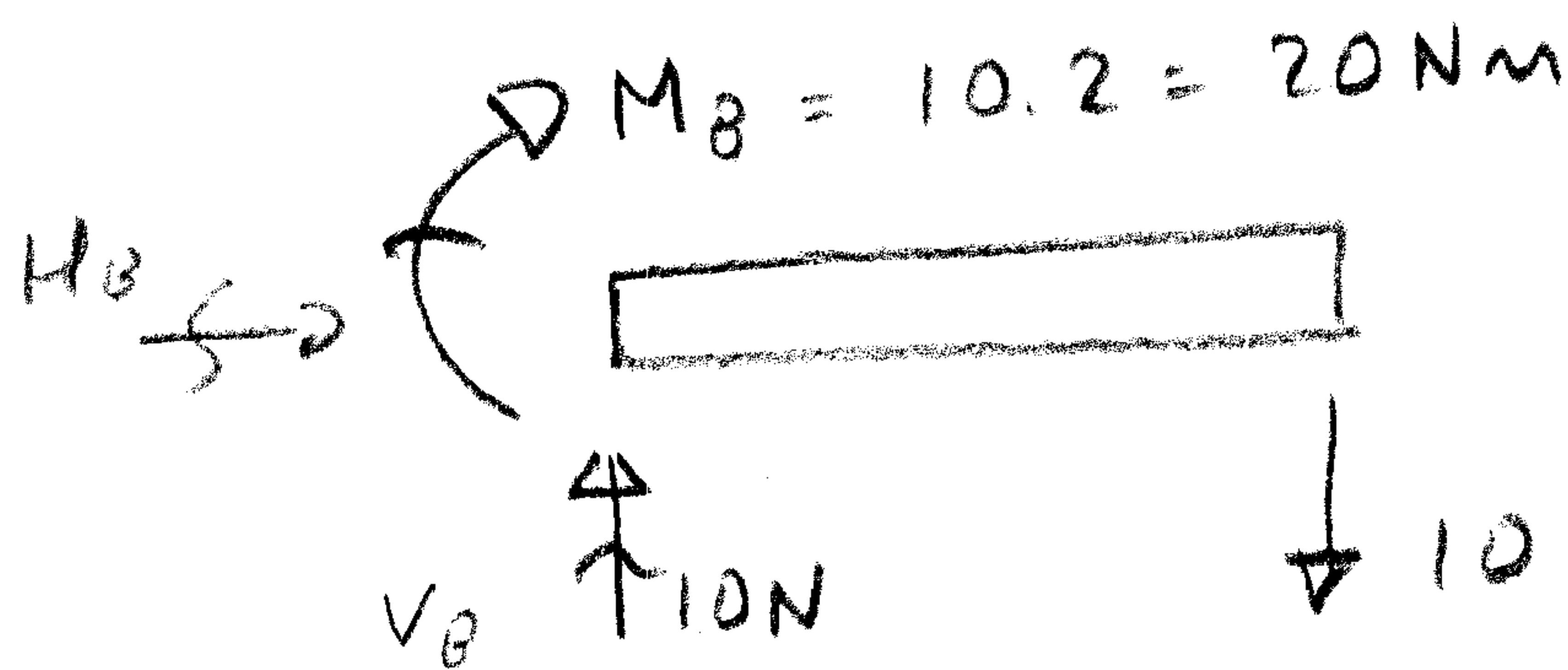
$$F_{AC} \sin 45^\circ - 5 = 0$$

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

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



Not a truss. - B must behave like a clamp



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.